Great Lakes Commission

Value of Great Lakes Water Initiative: Final Report

Rebecca Pearson, Great Lakes Commission
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Acknowledgments

The Great Lakes Commission's involvement in this project reflects its long-term interest in Great Lakes water resources management activities consistent with its mandate to "promote the orderly, integrated and comprehensive development, use and conservation of the water resources of the Great Lakes basin" (Article I, 1955 Great Lakes Basin Compact). Furthermore, this project is designed to inform states and provinces as they begin to implement water conservation and efficiency programs required by the Great Lakes-St. Lawrence River Water Resources Compact and Agreement as well as utilities that are looking to implement more sustainable practices in providing water.

Ongoing project consultation and oversight has been provided by a project team comprised of representatives from federal, state and local agencies, academic interests and other non-profit groups. This final report has benefited from the significant input and collaboration of the members of this group. The membership list is included in the Appendix.

The Commission also extends its appreciation to the staff of the Great Lakes Protection Fund for the guidance, input and support throughout the project.

Introduction

The United Nations has declared the decade 2005-2015 the Water Decade, highlighting the growing concern that water resources today are facing several threats, and most particularly water quality and over-consumption. In the Great Lakes region, the apparent abundance of water can be a significant barrier in efforts to prevent or address such threats. In January 2010, the Great Lakes Commission and its partners decided to join efforts and launched the Value of Great Lakes Water Initiative (VGLWI) with support from the Great Lakes Protection Fund, to look at the current state of water resources and potential measures to influence consumption habits. A special focus was given to the value of water, and how price could be used as a market tool to affect customers' behaviors and encourage conservation.

The VGLWI was originally intended to be a multi-phased project to test the following hypothesis:

> ***Water revenue structures that more closely reflect the full cost of water production and use are an effective tool that will reduce cumulative water use impacts under the proper conditions.***

Through Phase I, the planning phase, the project partners explored the possibility of conducting a demonstration project (Phase II). In an attempt to better understand pricing trends in the region, the project partners aimed to identify the economic, environmental, social and institutional drivers in Phase I. This exploration included the following tasks: 1) a literature review on pricing structures for water services; 2) an ecological sensitivity analysis of the Great Lakes watersheds; 3) a survey of water rates in the region; 4) four workshops to assess utility managers' knowledge of pricing alternatives as well as their interest in implementing innovative, efficiency-oriented rates; and 5) the development of recommendations to advance pricing of public water that makes economic sense to utilities and leads toward more ecologically sustainable consumption patterns by end users. The final products of these tasks are available from the VGLWI webpage at http://www.glc.org/wateruse/watervalue.

The Phase I findings helped to determine the feasibility of testing the hypothesis in a Phase II demonstration project. It was envisioned that the Phase II demonstration project would be comprised of 2-3 pilot areas across the basin where water conservation will most likely make an impact on the ecological health of a local watershed. This report documents the findings of Phase I and presents some initial ideas for Phase II.

Literature Review

The current state of research on the influence of water rate structures and pricing on water usage was assessed. With a special focus on water pricing in the public supply sector, the review mainly explores the different rate structures and their potential effect on consumption, their use for watershed protection, and the challenges facing utilities in maintaining revenue stability in a depressed economy.[1]

Overall, the literature review indicates that water pricing can have an impact on consumption habits and can encourage more sustainable water use. When volumetric rates are charged (i.e., when water bills increase as proportionally with consumption levels) users will be inclined to change their habits to pay less. This typical economic behavior is somewhat affected by the inelasticity of demand for water. Freshwater is a basic need that cannot be substituted by any other good. For that reason, a consumer's reaction to price increases is somewhat limited. Different price structures can address inelasticity demand for water to a certain extent. For example, instead of uniform rates, block prices set rates that increase or decrease as consumers change consumption ranges. While the first block satisfies basic needs and shows the inelasticity of water, different economic patterns can be observed at higher ranges of consumption.[2]

The literature review highlighted the fact that little research has been done on the relationship between water pricing and watershed protection. There are few cases where the price of water incorporated the costs of protecting the local watershed, except for the implementation of an environmental tax by some cities such as San Carlos in the Philippines and New York City. There is, however, a growing interest in the potential of leveraging the price of water to benefit the environment. Postel and Thompson, two authors who studied the question, make the following recommendations for the efficient implementation of such measures:

1. Designate watershed protection to be a responsibility of water suppliers and bridge institutional divisions that separate watershed decisions from the provision of safe drinking water;
2. Design water supply regulations that recognize the value of natural watershed services as cost-effective alternatives to technological treatment methods. In particular, institute water user fees or water-rate structures that build the costs of watershed protection into urban water supply systems.[3]

Based on the conclusion that water rates have an impact on water consumption and could be designed in a way that promotes conservation, the literature review raises considerations that could inform further research. First, the appropriate rate structure should be neither too high nor too low. The price should reflect the full cost of providing the service and allow utilities to cover their long-term costs, including infrastructure maintenance and technological innovation and upgrading. Price-setting is thus a complex process that requires a thorough evaluation of a service area's characteristics. Second, since water demand is generally higher during warmer seasons, when the supply might be less available or

[1] The Literature Review can be accessed through the VGLWI workpage: http://wiki.glin.net/display/VGLWI/Home; Task 2: *Conduct a literature review of the influence of water revenue structures on water usage and associated benefits.*
[2] See the reviewed article by Olmstead et al (2003) for more information on that matter. Seems like the articles should be directly credited in these footnotes rather than just redirecting people to the Wiki.
[3] See the reviewed article by Postel and Thompson (2005).

more limited, the implementation of a pricing structure that could be adjusted seasonally could be a good way of communicating information about the state of the water supply or the additional expense to meeting demand to customers. Finally, affordability needs to be taken into consideration when pricing public water. Water rate design can account for essential water use for low-income households.

The literature review was an important first step to the VGLWI project since it allowed a better understanding of the current state of knowledge and theoretical framework supporting water pricing for conservation purposes.[4] It also showed the complexity of the rate setting process, and the sustainability challenges public utilities face such as the current economic downturn decreasing their industrial customer based that has affected the Great Lakes region.

Hydrologically Stressed Watersheds

In scoping a pilot project, major Great Lakes watersheds that may be hydrologically stressed due to current water use, estimated water availability and projected urban growth were identified. A committee composed of staff from the Great Lakes Commission, U.S. Geological Survey, Michigan Technological University (MTU) and The Nature Conservancy analyzed available data that characterize the hydrologic conditions within each major Great Lakes watershed, and developed metrics to screen for areas that would most benefit from implementing innovative price structures. After experimenting with various methods of assessing hydrologically stressed watersheds, an approach was chosen that ranked watersheds based on current water withdrawals, groundwater recharge rates, historic surface water low flows, and future urbanization stress. This process is described in further detail below.

Four metrics were initially identified to assess the level of stress for the major Great Lakes watershed (for detailed information on these metrics, see the appended metric profiles):

1. **Relative Water Withdrawal Stress:** Water flow in a watershed varies from year to year and from season to season. Extreme low flows often occur during the summer months when water consumption is at its peak. By calculating the ratio of water withdrawals to an extreme observation of low flow, it is possible to determine whether a watershed is over-allocated. Detailed data on withdrawal categories can reveal which uses have the greatest impact.
2. **Fish Sensitivity:** Fish populations are extremely sensitive to changes in their environment, including temperatures and flows. This metric shows the proportion of cool, cold and warm streams in each Great Lakes watershed. Biological communities in cool streams tend to be most sensitive to changes in flows and temperature that may result from water withdrawal stress.
3. **Groundwater Vulnerability:** Groundwater is subject to more stress than surface water because it requires more time to recharge and is more prone to contamination. A groundwater source that is being pumped at a greater rate than its recharge rate suggests a risk of hydrologic stress to the watershed, particularly when aquifers feed streams and other surface waters.

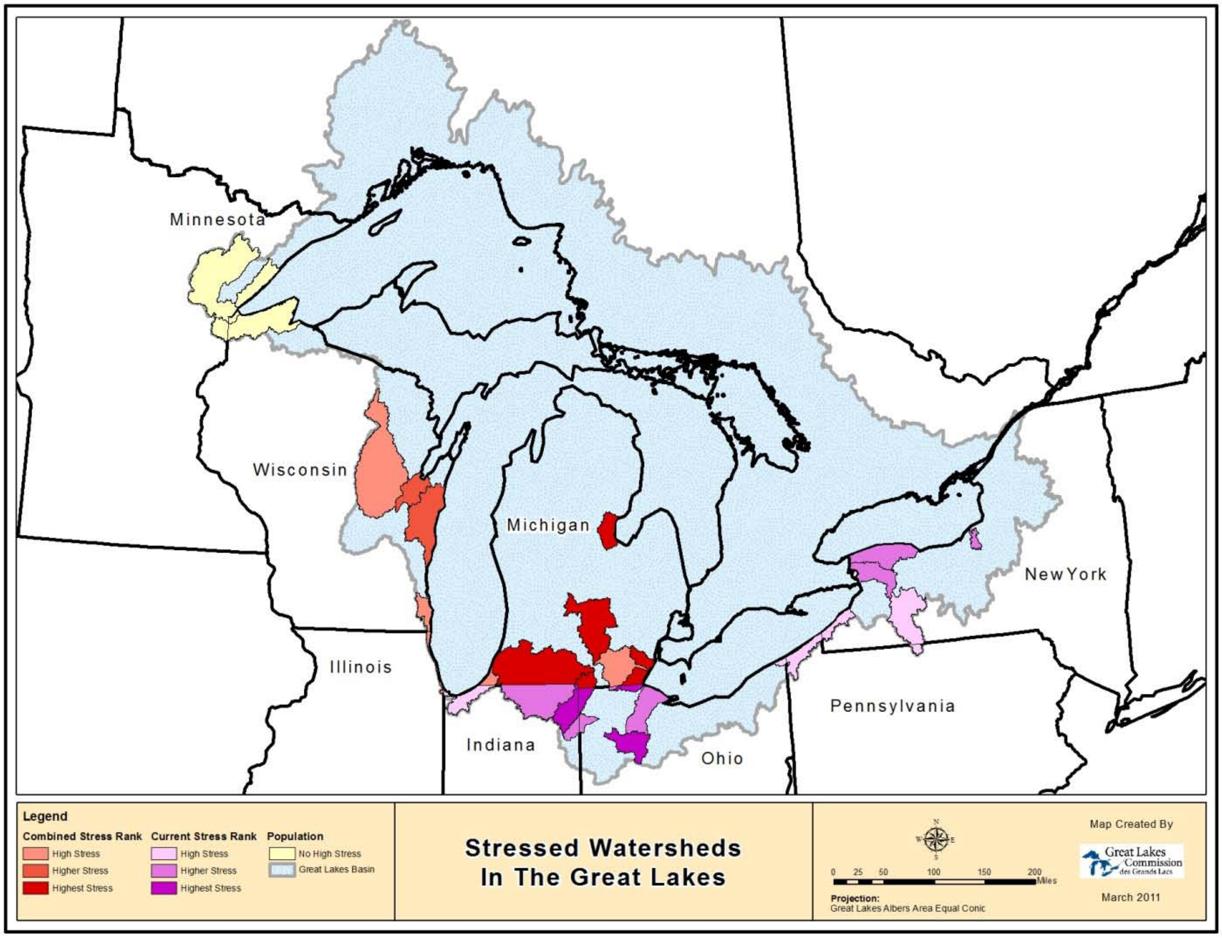
[4] See the reviewed article by Rawls and Brisova (2009).

4. **Predicted Land Development Stress:** Land development implies an increase in population as well as an increase in urban infrastructure (e.g., water main lines, water treatment facilities, roads, parking lots) to support the growing population. While water consumption for agricultural purposes decreases when urban development occurs, other uses such as water used for energy production, residential use or industrial uses will likely increase. In watersheds where the water supply is currently under stress from surface and/or groundwater withdrawals, future potential stress from land development is of even greater concern. Additionally, changing land cover from agriculture to urban will also change the stream flow. Increased runoff from impervious surfaces will contribute to flashier stream flow, meaning that the flow during storm events rises very quickly and then drops very quickly, during the spring and fall. As a result, the stream ecology may change to adapt to an altered stream flow. Furthermore, urbanization will decrease the recharge rates of groundwater aquifers due to the increase in impervious surfaces.

Metric 2, Fish Sensitivity, was not an indicator of stress but rather a measure of ecological sensitivity to stress; thus, this metric was not considered in comparing watershed stress and instead was used to inform the process of choosing pilot watersheds for testing alternative rate structures.

Each watershed was assigned a relative ranking for each of the three remaining metrics. The rankings for Metrics 1 and 3 were combined, with equal weight, to determine an overall current stress ranking. Ranks for predicted land development stress were used as a proxy for future stress in those states for which predicted land use change data were available. Those watersheds with current or future stress above the 50th percentile of all watersheds were classified as being relatively highly stressed in that category. The watershed rankings are presented below and show the top three most stressed watersheds in each state (for only those states that currently contain highly stressed watersheds).

States	Highly-Stressed Watersheds
Indiana	St. Joseph, Little Calumet-Galien
Michigan	St. Joseph, Upper Grand River, Kawkawlin-Pine
Minnesota	Beartrap-Nemadji, Beaver-Lester
New York	Oswego, Niagara, Oak Orchard-Twelvemile
Ohio	Raisin, Cedar-Portage, Blanchard, Ottawa-Stony Island
Pennsylvania	Upper Genesee, Chautauquat-Conneaut
Wisconsin	St. Louis, Lower Fox, Manitowoc, Wolf



As with any quantitative analysis, there are inherent limitations to this method. In some cases there are uncertainties in the data. For instance, withdrawal data are from a 2005 report and may not reflect recent changes in water sources or withdrawal rates within each watershed. In other cases, such as with the predicted land development stress metric, the geographic coverage of the data is limited or inconsistent across the Great Lakes basin. For a detailed discussion of metric limitations, see the metric profiles in the Appendix. In general, it must be noted that these metrics and their underlying data do not represent a complete picture of hydrologic stress in Great Lakes watersheds. There are many other factors that, with more time and resources, should be examined and considered. Despite these caveats, this screening method provides a good basis to identify Great Lakes watersheds facing stress that might benefit from alternative pricing.

Survey of Water Rates

To understand the current pricing trends of public water in the Great Lakes region, a survey was conducted by the Michigan State University Institute for Public Utilities. The survey focused on the 10 largest systems, based on service population, in each of the eight Great Lakes states: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin. It highlighted the variations in rate structures, billing practices and other ratemaking policies.

For most of the systems, water pricing information (rates or their equivalent) were readily available. Data related to billing practices, rate structures and monthly water charges based on meter size were gathered. For a few water systems in the sample, online information about rates was very limited and for nine systems (in five states), no rate information could be acquired from online sources. In these cases, rate schedules were obtained from knowledgeable contacts at the water utilities.

The survey provides insight into present ratemaking practices for larger systems in the region. Its findings cover a variety of issues: 1) trends in rate structure types, 2) variability of water service costs, and 3) communicating water price to consumers.

First, water rates in the region are somewhat conservative in terms of continued reliance on more traditional decreasing-block and uniform-rate forms. This finding may be justified in part by the relative abundance of water in the region and other favorable cost conditions. Nonetheless, many systems in the region are providing information about conservation to their customers and some have introduced rates that are considered more efficiency-oriented. Seasonal rates are used by a few utilities in the region and present an opportunity for the region. The use of peaking-factor rates was an especially salient finding.

Second, what customers pay for water service is highly variable. Some customers pay relatively higher fixed charges, in many cases to support the cost of fire protection. Structural variables, particularly system ownership, influence rate structures and levels. Charges by private water companies are comparatively higher. Scale economies, although considered important at the lower end of the spectrum, may be less relevant to systems already large in size.

Third, the research process itself was revealing. While most tariffs were relatively easy to secure, much room for improvement can be found in the presentation and communication of tariff information to customers. Average water customers should be able to readily find and interpret the rates that determine their water bills. Sample bills and bill calculators are useful, as is an understandable narrative explaining costs, rates and system intentions.

Finally, the cost analysis reveals that water conservation is empirically associated with higher residential water bills, although these bills should be less than they would be without beneficial efficiency improvements and lesser still over the long run if avoided operating and capital costs are substantial.

Water Rate Workshops

Four workshops were conducted to receive input and feedback from utility managers, local politicians, local watershed groups and water users. The primary objectives were to:

1. Better understand the rationale for current water pricing (state/provincial regulations, culture and local politics) in the region.
2. Identify state and provincial regulations/policies for utilities rates and other revenue streams.
3. Identify and examine external economic drivers that influence water utility pricing.

The three workshops were geographically distributed across the Great Lakes basin and were held as follows: Ann Arbor, Michigan, on October 12, 2010, with 21 attendees; Racine, Wisconsin, on November 8, 2010, with 23 attendees; and Buffalo, New York, on November 1, 2010, with 23 attendees. Of the 67 overall participants across the three workshops, they represented 54 different stakeholders. Thirty-four of the participants were water utilities. A fourth workshop was added in Chicago with 48 attendees on February 4, 2011, in conjunction with the Center for Neighborhood Technology.

The workshops consisted of presentations on rate making, findings from the survey on water rates in the Great Lakes region as well as the Water Pricing Primer written by Dr. Janice Beecher of Michigan State University. The primer's main purpose was to brief workshop participants on the basic principles of different water rates and how they can be used to achieve various water management goals. The primer condenses information on water rates into a reader-friendly format, and presents water rate structures that are currently implemented in the region that were collected by a survey conducted under another task of the project. The primer provides an introduction of the concept of water rates as a tool to manage or reduce water use, summarizes the types of water rates in practice, and describes the associated benefits and expected outcomes. The Water Pricing Primer is available from the Great Lakes Commission's website at http://glc.org/wateruse/watervalue/pdf/GL%20Rates%20Primer%20FINAL.pdf.

The workshop participants were very vocal about their concerns and issues within their community. The following observations were provided by workshop attendees about rate setting:

- Declining block and flat rates are still prevalent in the region.
- Wholesalers have very different issues than retailers.
- The recession is affecting ability to accurately forecast demand.
- Many water utilities have excess capacity to sell.
- Loss of revenue and revenue stability are the biggest issues.

Perceived barriers to implementing efficiency-oriented rates that were discussed by workshop attendees include:

- The lack of political will and the resistance to change.
- Consumers are not well educated on water issues and do not understand why rates need to increase.
- The media are usually unwilling to research the facts.
- Management and elected officials often have opposing goals.
- Interest exists in efficiency-oriented rate structures but, without help, the fear of revenue loss will prevent the adoption of anything progressive.

Recommendations

Below are recommendations that were developed by the VGLWI Project Team. They were informed by the Initiative's findings from a regional water rate survey and four workshops. They are organized by and directed toward stakeholder groups: states, utilities, researchers (including academics, consultants and nonprofits), and the federal government. The last category, general education, is not directed to any one stakeholder group. Recommendations under general education could be implemented by any stakeholder or organization.

States

1. State agencies that manage the water conservation program required by the Great Lakes-St. Lawrence River Sustainable Water Resources Compact should encourage utilities to set rates that reflect full costs of providing service; allocate those costs equitably to customers; and reduce peak demand by providing technical resources such as:
   - The Water Pricing Primer
   - Sponsoring rate setting workshops or webinars for utility managers, local water board members and local officials.
   - Other educational programs and technical manuals such as the AWWA M1 Manual

Rationale: To help achieve the Compact's water conservation and efficiency objective to "adopt and implement supply and demand management to promote efficient use and conservation of water resources[5]," states can provide technical resources to water utilities on market-based approaches to manage water demand, especially during the dry summer months where peak demand may be reaching the system's capacity. See related recommendation #6 and its rationale directed toward water utilities.

2. States should promote transparency in water rate setting by institutional mechanisms such as the promotion of national standards or the implementation of state regulations. A regulatory framework should include the following elements:
   - Uniform system of accounts
   - An annual yearly financial report to be filed by the utility
   - Public Service Commission approval of rate changes
   - A Certificate of Need requirement before new capacity is added

Rational: Institutional mechanisms provide a pathway to pricing water at its true costs. Regulations provide uniformity, accountability and transparency in rate setting.

3. States legislators and agencies should consider legislative or administrative policies encouraging concurrency and Integrated Water Resources Management (IWRM) [which includes planning and

[5] http://www.glslregionalbody.org/Docs/Misc/ConservationEfficiency_Objectives.pdf

implementation] among local land use planning, water supply, stormwater and wastewater service programs. Such legislation should support the following strategies:

- Allow local utilities to cooperate in planning and administration of water supply, wastewater and stormwater management.
- Incentivize local communities to design their own governance structure for water, wastewater and stormwater management that reflects the need to provide adequate safe water for consumers *and* to achieve aquatic ecosystem protection goals.
- Require, or develop incentive programs to ensure, that funding to pay for new or improved facilities, public services and/or infrastructure needed to support new commercial, industrial and residential development (e.g., roads, sewers, emergency services) is in place before or at the same time that new development occurs.
- Require concurrency as part of comprehensive land use planning where it exists.
- Develop and implement a state comprehensive land use planning law that has a water, wastewater and storm water components.
- Building capacity among utility engineers and consultants to do IWRP/sustainability planning through training workshops led by a group of "expert consultants."

Rationale: Concurrency together with IWRM can be an effective way to ensure that new growth does not overwhelm the existing or planned public services, facilities and infrastructure. It helps local governments by providing a mechanism for sound fiscal planning and development of public infrastructure and services. It enables new development to occur in a way that is consistent with capital improvement plans and that is financially sound and thereby can avoid the pitfalls—notably local government liabilities—associated with allowing new development to occur where funds are inadequate or unavailable to pay for the public infrastructure and services that are necessary to support that development.

IWRM is defined by the Technical Committee of the Global Water Partnership (GWP) as "a process which promotes the coordinated development and management of water, land, and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems." Coordination of land use planning with all aspects of managing municipal water systems (freshwater supply, wastewater treatment and disposal, and stormwater management) can reduce costs, improve total system efficiency and reduce impacts on, or even improve the quality of, aquatic ecosystems.

4. States should consider funding mechanisms similar to Public Benefit Funds (PBF) to support utility water conservation projects that are promoted by the states' Compact water conservation program.

Rationale: As an example of a funding mechanism, PBFs are typically funded through a charge on customers' utility bills based on their energy usage, or through a flat fee and managed by a state public service commission. Policymakers see PBFs as a useful funding mechanism for energy efficiency, renewable energy, and low-income assistance programs and projects. They can be easily adaptable to water utilities. Six of the eight Great Lakes states have some sort of PBF (Indiana and Ohio do not).

5. The State Revolving Fund (SRF) for both drinking water and wastewater should be leveraged to incentivize local communities to implement Integrated Water Resource Planning, water conservation programs, and watershed protection activities by:

   - Strengthening the SRF implementing regulations to support such programs.
   - Ensuring state and local coordination through the SRF administrative mechanism.

Rationale: SRFs provide low interest loans for water infrastructure projects. Water conservation and reuse activities/projects can also be funded. Making most efficient use of current water and waste water infrastructure as well as green infrastructure (the network of natural space that provides ecosystem services such as flood control, groundwater filtration and water resource protection) will help defer or avoid the need to make costly capital improvements to both water and wastewater systems. To obtain SRF funding for these activities/projects, they must be specified in the state's Intended Use Plan which provides loan applicants with direction regarding the intended uses of the SRF.

Utilities

6. Utilities should use rates that reflect full costs of providing service; allocate those costs equitably to customers; and reduce peak demand.

Rationale: Water utilities need adequate revenue to cover the cost of doing business. Basing their rates on actual costs of service is essential to sustain utility operations and performance over time. Seasonal peaks in water demand can be significant cost drivers for the water utilities. Seasonal peaks set the capacity threshold for water supply systems so that these systems can meet the peak demand at any time. The consequence of ensuring that adequate water is always available for peak demand is that there is excess water capacity for most of the year that is unneeded and goes unutilized in the off season. Extra capacity increases costs to all users. Reducing peak demand in return reduces long-term costs. Outdoor use is a significant driver of peak demand. Because outdoor water use is more discretionary and price sensitive, a basic two-tier or seasonal rate has potential to reflect extra capacity costs, reduce peak demand, associated operating costs, and improve efficiency and load management.

7. Utilities should improve consumer understanding of the price of their water use by:
   - Making water rate information available online and/or in the water bill.
   - Providing online water bill calculators and sample bills.

Rationale: According to a Great Lakes water rate survey conducted in 2010 for the VGLWI project, information about water prices is relatively easy to obtain, however there is room for improvement in how price information is presented and communicated to customers. The average customer should be able to readily find and interpret the rates that determine price on their water bills.

8. Water Utilities should meter water to aid in reducing water loss.

Rationale: Water cannot be managed unless it is measured. The Drinking Water State Revolving Fund may be a good funding source for such an activity.

9. Utility managers should employ a "no surprises" doctrine and communicate regularly with customers and elected officials through billing inserts, newsletters, the local newspaper and local government (e.g., city council) meetings.

Rationale: A communication/educational campaign for ratepayers, utility managers, public officials and the media will help overcome barriers for implementing efficiency-oriented rate structures.

Researchers

10. The research community should evaluate how advanced metering may improve consumer understanding of water use and cost, and any resulting water conservation behavior.

11. The research community should examine other systems that have adopted a more regional approach to water, wastewater and stormwater utilities to identify benefits of such an approach and improve how those benefits are communicated at the local level.

Rationale: Advanced metering and regionalizing water services may yield economic and environmental benefits to the Great Lakes region and need further investigation.

12. The research community should explore the implications of shifts in demands to utility operations and economic stability.

Rationale: According to the *2011 the Value of Great Lakes Water Initiative Report on the Workshops Held: Findings and Recommendation*, water demand is deduced by recessionary economic conditions that have industries reducing shifts and homes being foreclosed. Thus, if it is difficult to forecast demand accurately, it is difficult to predict accurately how much revenue will be collected to meet utility system fixed charges. Moreover, the report finds that utility rate structures designed in a growth economy no longer are as effective in a recessionary one.

13. The research community should evaluate benefits IWRM, develop IWRM decision support tools and conduct pilots on IWRM

Rationale: IWRM will require coordination between the entities involved in land use planning and planning of freshwater supply, treatment and distribution; wastewater treatment and disposal; and stormwater management systems. Adoption of this new planning paradigm across the Great Lakes will require advances in several areas. First, the economic, political and ecological benefits of IWRM; the potential political barriers to IWRM; and solutions for overcoming these barriers need to be identified. Second, decision support tools need to be developed that can allow the planning entities to simultaneously consider the impact of land-use change and water system development. Third, application of IWRM pilot programs in several communities across the Great Lakes basin will help to test the decision support tools and to hone the IWRM "message."

Federal Government

14. Federal funding to support water efficiency programs should be expanded.

Rationale: Water efficiency programs can delay costly water and wastewater infrastructure investments, which in turn impacts the price of water to consumers. The federal government can promote water efficiency and conservation by supporting consumer rebates and tax incentives for installing water efficiency products as well as supporting water efficiency research.

General Education

15. An education program (in the form of a toolkit or primer) should be developed for water utility managers and boards so that they can make the right decisions on pricing public water. The program should emphasize increasing efficiency, reducing water loss (I&I), good/smart pricing, improved load management, and improved revenue stability. The program should be distributed at local workshops. The following elements should be included:
    - Comprehensive asset management
    - Five-year financial management plan
    - Scenarios of water demand that reflect sustainability goals –20 years out
    - Long-term infrastructure plans that integrate items 1 and 3 above
    - Long-term utility master plan reflecting all of above

16. An educational tool for elected officials should be developed that can help them understand the importance of correctly pricing public water for the sustainability of their water system. This tool should be disseminated at local workshops. A modified Water Pricing Primer is an example of such a tool.

17. Educational opportunities should be provided for ratepayers, utility managers, public officials and the media. Educational opportunities for the media include press releases and invitations to the same events as other stakeholders. An example is a rate analysis that can be conducted together with consumers and elected officials in order to educate them and to seek their buy-in of the results. The analysis will
    - help them understand the evolution of their own system infrastructure;
    - compare rising costs of water to rising costs of other comparable services;
    - show how short term investments can avoid long term costs and therefore long term rate hikes; and
    - emphasize load management in rate design.

Rationale for Recommendations 15-17: Education programs for ratepayers, utility managers, public officials and the media will help overcome barriers for implementing efficiency-oriented rate structures. The following barriers were noted in the water rate workshops:

- Lack of political will and fear of change
- Consumers are not well educated on water issues and do not understand why rates need to be increased
- Media are usually unwilling to research the facts
- Management and elected officials often have opposing goals
- Fear of revenue loss

Next Steps

The Value of Great Lakes Water Initiative examined the price of municipal water in the Great Lakes region and whether price could incentivize water conservation to the extent that the water savings would have a measurable impact on the local watershed ecosystem.

While the VGLWI advanced the knowledge of how and why water rates are set in the Great Lakes region, the VGLWI Project Team noted the difficulty in linking ecological benefits to the price of water. Generally, water utilities are only one water user within a given Great Lakes watershed, and sometimes an insignificant one compared to agriculture, industry, energy and the overall volume of the Great Lakes. Furthermore, pricing only influences the quantity consumed, which may influence the quality of the resource, but this connection is not certain. There are innumerable variables that influence the quality of water and the overall health of aquatic habitats and organisms. In a system of vast water volumes like the Great Lakes, it is nearly impossible to determine improvements in ecological health that are directly connected to changes in water quantity alone. Observable changes in ecological health must consider water quantity in light of other factors that affect water quality. A promising way to observe how changes in water quantity management might result in improvements in aquatic ecology is to observe those water bodies in the Great Lakes basin ecosystem where

a) water quantity is a limiting factor (e.g., subject to seasonal or localized water shortages), and

b) inherent vulnerabilities or sensitivities to changes in water quantity exist (e.g., sensitive species or habitats; water quality conditions that would be exacerbated by changes in water quantity, such as temperature, or contaminant loadings).

The way communities grow and manage their water resources can impact vulnerable watersheds. For instance, increased water demand from residences and businesses will add further stress on the local or regional water resources and the aquatic habitats that depend on them. This is true especially during the driest months of the year when stream flows are at their lowest. Moreover, community development generally leads to more roads, parking lots and other paved surfaces that will decrease the amount of water that can recharge groundwater aquifers and warm surface waters. As a result, decreased groundwater levels may impact groundwater-fed streams, and increased runoff during large storm events will add additional and new pollutants to rivers and other water bodies.

Using an Integrated Water Resources Management (IWRM), water and wastewater utilities can play a leadership role in improving the Great Lakes ecosystem to address wastewater, sewer overflows, a growing water demand and stormwater management on a watershed basis. In Phase II, the Great Lakes Commission will lead a pilot to evaluate the benefits of IWRM and develop IWRM decision support tools (refer to recommendation 13, page 11). If successful, this pilot will serve as a model for other communities, both big and small, in the Great Lakes region. This pilot will engage a larger audience of water resource and land-use planning practitioners and state and local decisionmakers who can emulate the successes of the pilot in their own jurisdictions.

What is Integrated Water Resources Management?

Integrated water resource management supports the management of the whole urban water cycle in order to achieve sustainable development, including protecting and restoring the natural water cycle. The urban water cycle includes the three water streams: potable water, wastewater and stormwater.

Appendix A – Project Team

FEDERAL

Howard Reeves, Research Hydrologist
U.S. Geological Survey
6520 Mercantile Way, Suite 5
Lansing, MI 48911-5991
Phone: 517-887-8914
hwreeves@usgs.gov

Jana Stewart,
Great Lakes Aquatic GAP Project Coordinator
U.S. Geological Survey
8505 Research Way
Middleton, Wisconsin 53562
Phone: 608-821-3855
jsstewar@usgs.gov

Paul Seelbach
Chief, Ecosystems and Restoration Branch
USGS, Great Lakes Science Center
1451 Green Road
Ann Arbor, MI 48105
Phone: 734-214-7253
pseelbach@usgs.gov

STATE

Jim Japs, Assistant Director
(alternate: Julie Ekman)
Minnesota Department of Natural Resources
500 Lafayette Road - Box 32
St. Paul, MN 55155-4032
Phone: 651-259-5656
james.japs@state.mn.us

Jeff Ripp, Water Conservation Coordinator
Wisconsin Public Service Commission
610 North Whitney Way.
P.O. Box 7854
Madison, Wisconsin 53707-7854
Phone: 608-267-9813
jeff.ripp@psc.state.wis.us

LOCAL

Melissa Soline, Program Manager
Great Lakes-St. Lawrence Cities Initiative
177 North State Street, Suite 500
Chicago, Illinois 60601
Phone: 312-201-4517
melissa.soline@glslcities.org

ACADEMIC

Janice Beecher, Director
Institute of Public Utilities
Michigan State University
W157 Owen Graduate Hall East Lansing, Michigan 48825-1109
Phone: 517-355-1876
beecher@msu.edu

Alex Mayer, Director
Center for Water and Society
Michigan Technological University
1400 Townsend Drive
Houghton, Michigan, 49931-1295
Phone: 906-487-3372
asmayer@mtu.edu

Sheila Olmstead, Professor
Yale School of Forestry &
Environmental Studies
195 Prospect Street
New Haven, CT 06511
Phone: 203-432-6247
sheila.olmstead@yale.edu

UTILITIES

Carrie Lewis, Superintendent
Milwaukee Water Works
841 North Broadway, Room 409
Milwaukee, WI 53202
Phone: 414-286-2801
Carrie.M.Lewis@milwaukee.gov

Sue McCormick, Public Services Administrator
City of Ann Arbor
City Center Building
220 East Huron
Ann Arbor, MI 48104
Phone: 734-994-2897
smccormick@a2gov.org

ASSOCIATIONS

Phil Zollinger
American Water Works Association, MN Section
St. Paul Regional Water Services
1900 Rice St.
Saint Paul, MN 55113-6810
Phil.Zollinger@ci.stpaul.mn.us

Jon Eaton (Alternate)
American Water Works Association, MN Section
City of Bloomington
9300 Poplar Bridge Road
Bloomington, Minnesota 55437
jeaton@ci.bloomington.mn.us

NON-PROFITS

Mary Ann Dickinson, President & C.E.O.
(alternate: Bill Christiansen)
Alliance for Water Efficiency
P.O. Box 804127
Chicago, IL 60680
Phone: 773-360-5100
maryann@a4we.org

Ed Glatfelter, Director of Conservation Programs
Alliance for the Great Lakes
17 N. State St., Suite 1390
Chicago, IL 60602
Phone: 312-939-0838x 235
h2oed04@comcast.net

Cheryl Nenn, Riverkeeper
Milwaukee Riverkeeper
1845 N. Farwell Avenue, Suite 100
Milwaukee, WI 53202
Phone: (414) 287-0207 ext. 229
cheryl_nenn@milwaukeeriverkeeper.org

Scott Sowa, Great Lakes Senior Aquatic Ecologist
The Nature Conservancy
101 East Grand River
Lansing, MI 48906
Phone: 517-316-2255
ssowa@tnc.org

Nick Schroeck, Executive Director
Great Lakes Environmental Law Center
440 Burroughs Street, Suite 120, Box 70
Detroit, Michigan 48202
Phone: 313-820-7797
nschroeck@wayne.edu

GREAT LAKES COMMISSION STAFF

Tom Crane, Deputy Director, tcrane@glc.org

Victoria Pebbles, Program Director,
vpebbles@glc.org

Becky Pearson, Sr. Program Specialist,
bpearson@glc.org

2805 S. Industrial Hwy, Suite 100
Ann Arbor, MI 48104-6791
Phone: 734-971-9135
Fax: 734-971-915

Appendix B – Metric Profiles

Metric 1: Relative Water Withdrawal Stress

Question of Interest: Which HUC8 watersheds are at risk of hydrologic stress due to withdrawals during times of extreme low flow?

Description/Units: Ratio of total monthly withdrawals for HUC8 watersheds to 5th lowest flow for HUC8 watersheds:

$$\text{Total monthly withdrawals for HUC8 watershed} / \text{5th lowest flow for HUC8 watershed}$$

- Calculations related to monthly withdrawals, consumptive uses and flows are limited to only the months of July, August, and September, which represent the driest months of the year when demand is also high. For this analysis, we chose to use data from the month of August because this month consistently represented the most extreme conditions across most of the watersheds.
- Monthly withdrawal = (average monthly withdrawal) x (monthly factor per water use category).
- The U.S. Geological Survey (USGS) water use categories include public supply, industrial, thermoelectric, golf course irrigation, other irrigation, livestock, aquaculture, commercial and mining (Shaffer 2009).
- Average flows calculated over 1948-1999 (Croley 2002).
- 5th lowest flow is determined by sorting monthly flows over period 1948-1999 (Croley 2002) and taking the 5th lowest flow. The 5th lowest flow was arbitrarily chosen to represent an extreme flow condition in the watershed. The 5th lowest flow could reoccur once every 10 years.

Water Supply Source: Surface water

Impacted Water Source: Surface water

Reason for Metric Selection (i.e., why was this metric chosen as an identifier of watersheds that may be under hydrologic stress?): This metric identifies those watersheds in which the amount of water withdrawn is high enough relative to the amount of water flowing in the watershed to significantly alter the hydrologic regime, particularly in extreme low-flow conditions.

Initially, four submetrics were combined to represent an overall water stress index. These submetrics were based on either withdrawal or consumption data, and either average flow or 5th low flow; thus, the four submetrics were ratios of 1) withdrawal to average flow, 2) withdrawal to 5th low flow, 3) consumption to average flow, and 4) consumption to 5th low flow. Simple correlation analyses, run on each pairwise combination of these submetrics, revealed that all four were highly correlated with one another. Thus, it was determined that one submetric should be chosen to represent the overall water stress metric.

We have higher confidence in the withdrawal data than the consumptive use data, because calculation of consumptive use involved significantly more assumptions and thus greater uncertainty. Given the greater confidence in the withdrawal data and the importance of low flow conditions to our question of interest, the team chose to focus on the withdrawal to 5th lowest flow ratio.

Which values of this metric (e.g., high vs. low) identify a stressed watershed? Higher values of this metric represent greater stress in the watershed.

Degree of Confidence in Underlying Data: The confidence level is moderate for withdrawals because withdrawals were estimated in 2005. Thus, some of the water withdrawals data may not necessarily reflect current water demand within certain watersheds. For instance, the withdrawal source for public supply within the Lower Fox watershed of Wisconsin has changed from groundwater to Lake Michigan surface water. The confidence level is moderate for flows because these data were obtained through calibrated model simulations, rather than observations.

- *Overall Confidence Rating: Moderate*

Metric Reliability Rating (i.e., what is the level of confidence in the metric to address the question of interest, both spatially and temporally?): The water stress index in general may indicate that some HUC8 watersheds are over-allocated based on water withdrawals estimated for 2005. Over-allocated watersheds may not account for the amount of storage in the form of reservoirs that are located within the watershed boundary. This storage could be used for thermoelectric cooling or other purposes.

Despite these limitations, the geographic extent and underlying degree of confidence in the data used for this metric increase its suitability to address water stress in inland rivers at the HUC8 level across the entire basin.

- *Overall Reliability Rating: Moderate*

Data Supplied By: Alex Mayer, Michigan Technological University

Data Source (e.g., citation of report, website, etc.): Monthly low flows for HUC8 watersheds are based on National Oceanic and Atmospheric Administration-Great Lakes Environmental Research Laboratory Large Basin Runoff Model simulations for monthly flows over the period 1948-1999:

Croley, T. E. II. 2002. Large basin runoff model. Chapter 17 in Mathematical Models of Large Watershed Hydrology, V. Singh, D. Frevert and S. Meyer Eds., Water Resources Publications, Highlands Ranch, CO, pp. 717-770.

Monthly water withdrawals are based on monthly variations by use category in USGS report:

Shaffer, K.H. 2009. Variations in withdrawal, return flow, and consumptive use of water in Ohio and Indiana, with selected data from Wisconsin, 1999–2004. U.S. Geological Survey Scientific Investigations Report 2009–5096, 93 p.

Monthly consumptive coefficients by use category are based on USGS report:

Shaffer, K.H. 2009. Variations in withdrawal, return flow, and consumptive use of water in Ohio and Indiana, with selected data from Wisconsin, 1999–2004. U.S. Geological Survey Scientific Investigations Report 2009–5096, 93 p.

Data Manipulation/Alteration **(e.g., were calculations or conversions performed?):** See "description/units" above.

Geographic Extent of Available Data (Great Lakes basin-wide or other): Great Lakes basin-wide

If not by HUC8 watershed, how were these data originally spatially organized? What manipulations were made to the data in order to organize them by HUC8? Not applicable.

Other spatial manipulations/calculations performed to produce the map? Tabular data were joined to HUC8 polygonal data to display values calculated for this metric (Figure 1).

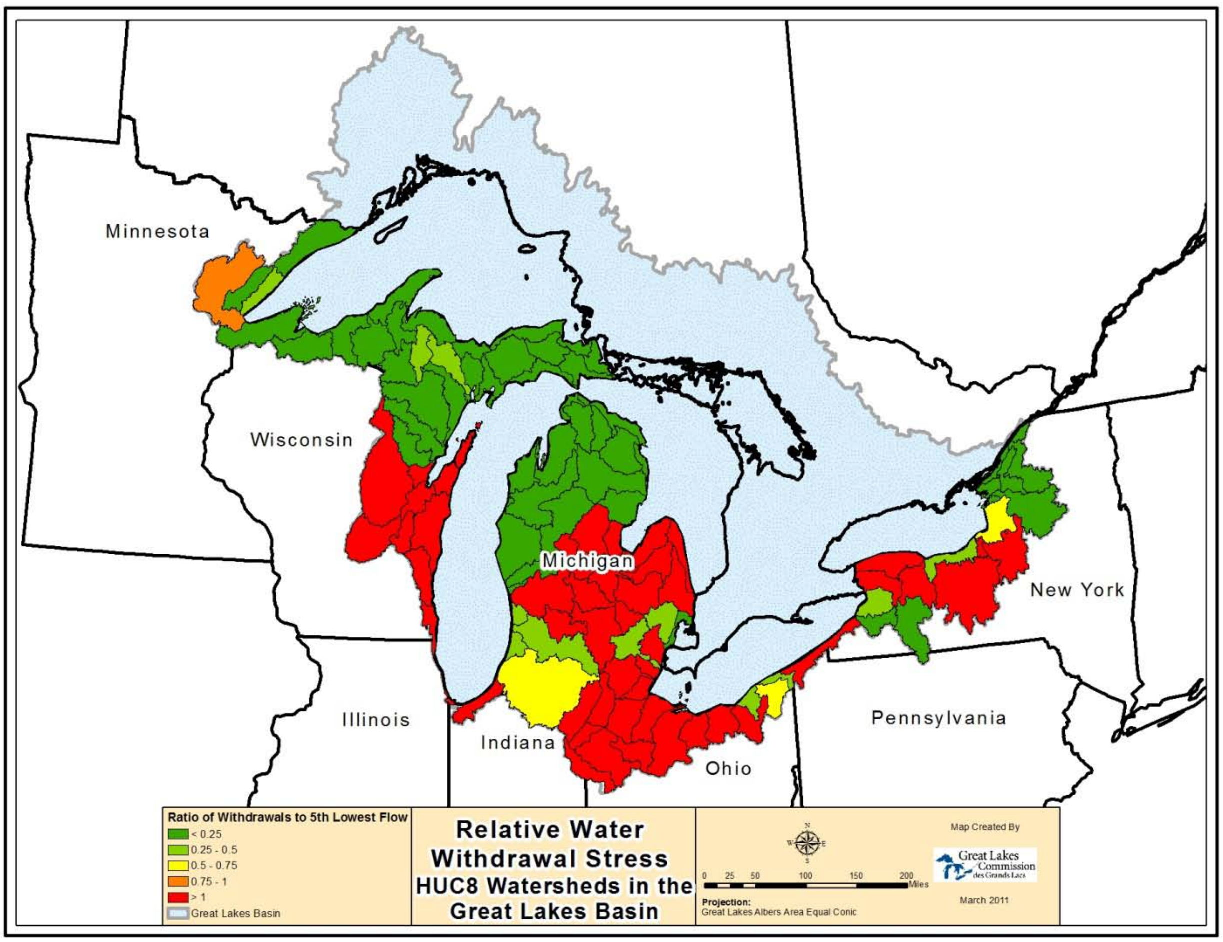


Figure 1: Relative water withdrawal stress, as measured by a ratio of withdrawals to 5th lowest flow, in HUC8 watersheds in the Great Lakes basin.

What other information is necessary to report regarding this metric? Water withdrawal (as opposed to consumptive use) reflects not just changes in water quantity, but also water returned to the watershed that may affect water quality (e.g., through pollution or changes in temperature, dissolved oxygen, etc

Metric 2: Fish Sensitivity

Question of Interest: Which HUC8 watersheds may contain fish communities that would be sensitive to hydrologic and water quality changes resulting from withdrawals?

Description/Units: Ratio of cool or cold stream miles to total miles of all streams (e.g., cool, cold, and warm) per HUC8 watershed. This index has 2 subcomponents:

Proportion of Cold Streams = $^{\text{Total miles of cold streams for HUC8 watershed}} / _{\text{Total miles of all streams for HUC8 watershed}}$

Proportion of Cool Streams = $^{\text{Total miles of cool streams for HUC8 watershed}} / _{\text{Total miles of all streams for HUC8 watershed}}$

Water Supply Source: Groundwater

Impacted Water Source: Surface water

Reason for Metric Selection (i.e., why was this metric chosen as an identifier of watersheds that may be under hydrologic stress?) Cold transition, and in this case cool, streams are identified as the stream types most sensitive to changes in hydrology that could impact the fish assemblages in such ecosystems. The occurrence and abundance of fishes in Great Lakes streams is determined largely by stream flow and water temperature.

Which values of this metric (e.g., high vs. low) identify a stressed watershed?Higher values of this metric indicate a watershed that is at greater risk of hydrologic stress, because that watershed contains more miles of sensitive stream types relative to the total number of stream miles within the watershed.

Degree of Confidence in Underlying Data: Although the underlying degree of confidence is good, consistent data was not available across the basin; thus, more detailed data from Michigan and Wisconsin were aggregated to maintain consistency with the rest of the basin. This results in some loss of detail.

- *Overall Confidence Rating: Moderate*

Metric Reliability Rating (i.e., what is our level of confidence in the metric to address the question of interest, both spatially and temporally?): This metric is based on the assumption that stream temperature is a proxy for fish vulnerability. While this may be a valid assumption, our HUC8 watershed-level approach required us to make broader generalizations about the streams in a specific watershed, even if that watershed contained streams in various temperature classes. This led to our method of summing stream miles in each watershed and using the proportion of cool or cold stream miles as our metric, which provides only a general idea of the thermal vulnerability of the watershed as a whole. Other factors would be important to take into account when examining thermal vulnerability of streams, including climate and land cover (e.g., percentage of forested land in the watershed). These caveats, combined with the moderate degree of confidence in the underlying data, limit this metric's ability to address the question of fish sensitivity in inland streams at the HUC8 watershed level.

- *Overall Reliability Ranking: Low*

Data Supplied By: Jana Stewart, U.S. Geological Survey

Data Source: (e.g., citation of report, website, etc.) Classification of streams into size classes was based on the upstream contributing drainage area and came from the following source:

Drainage Area Size Class Categories:

Olivero, A.P. and M.G. Anderson. 2008. Northeast Aquatic Habitat Classification System. The Nature Conservancy, 88 p.

Classification of streams into temperature classes based on predicted stream temperature came from the following sources:

Lyons et al. 2009. Defining and characterizing coolwater streams and their fish assemblages in Michigan and Wisconsin, USA. *North American Journal of Fisheries Management* 29: 1130-1151. DOI: 10.1577/M08-118.1

Stream Temperature Predictions that were categorized into stream temperature class categories (Lyons et al. 2009) were based on methods described in the following publications:

1. Wisconsin:

Stewart, J., M. Mitro, E.A. Roehl, Jr., and J. Risley. 2006. Numerically optimized empirical modeling of highly dynamic, spatially expansive, and behaviorally heterogeneous hydrologic systems – Part 2. In: Hydroinformatics: Proceedings of the 7th International Conference, Nice, France, September 2006.

2. Michigan:

Wehrly, K.E., T.O. Brenden, and L. Wang. 2009. A comparison of statistical approaches for predicting regional stream temperatures from landscape features. *Journal of the American Water Resources Association* 45: 986-997.

3. New York, Minnesota, Indiana, and Ohio:

McKenna J.E. Jr., R.S. Butryn, and R.P. McDonald. 2010. Summer Stream Water Temperature Models for Great Lakes Streams: New York. *Transactions of the American Fisheries Society* 139: 1399 - 1414.

4. Illinois:

Hinz, L., and A. Holtrop (personal communication).

Data Manipulation/Alteration (e.g., were calculations or conversions performed?)

Cool streams in Michigan and Wisconsin were originally classified into two separate categories: cool-cold transitional and cool-warm transitional (Table 1, Figure 2). To maintain consistency with the basin-wide data, streams in these two states in the cool-cold category and cool-warm categories were aggregated into one category: cool. These three classifications are mapped basin-wide in Figure 3.

Table 1: Stream temperature Classes (Lyons and others, 2009)

Class	subclass	July mean (degrees C)
coldwater		< 17.5
coolwater		17.5 - 21
	cool cold transition	17.5 - 19.5
	cool warm transition	19.5 – 21
warmwater		> 21

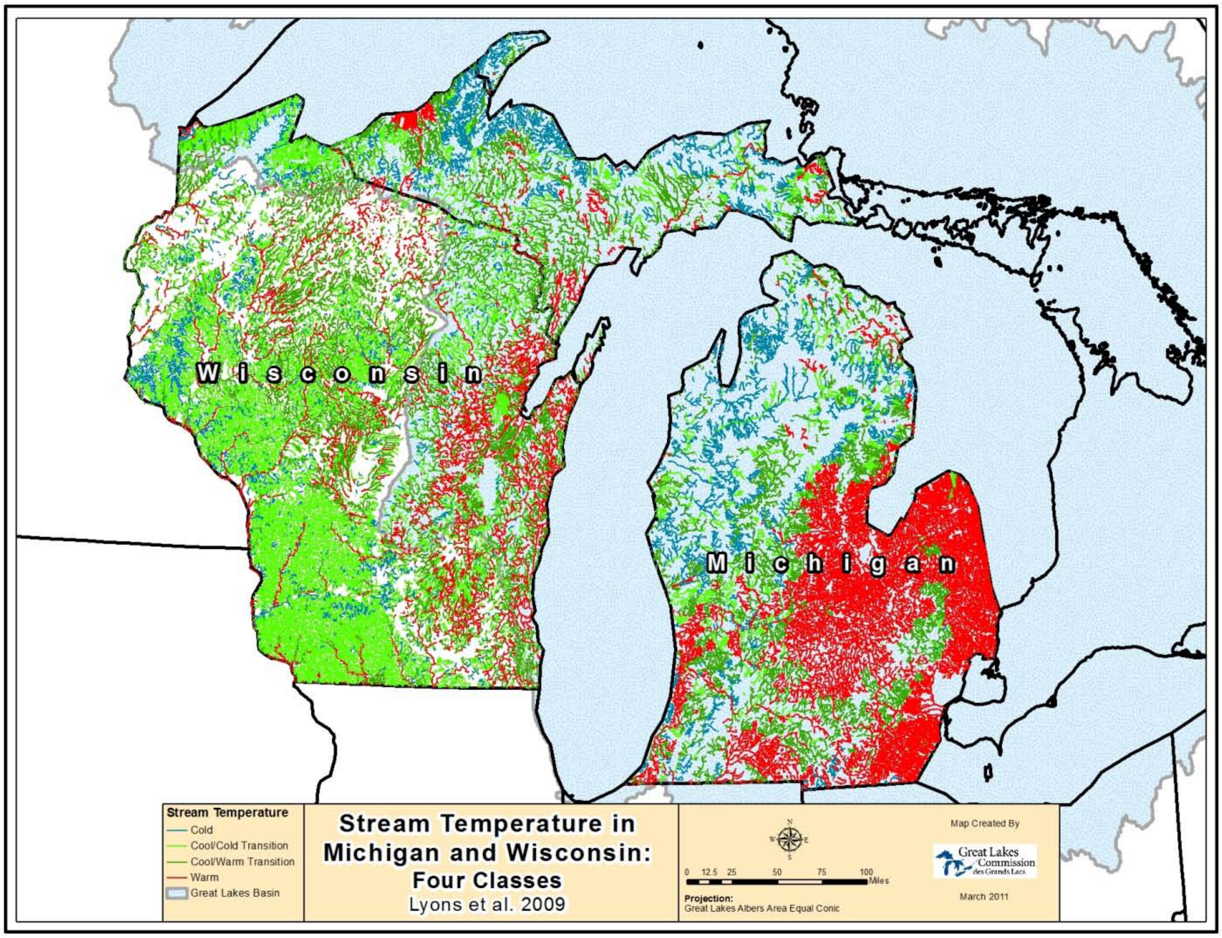


Figure 2: **Stream temperature in Michigan and Wisconsin according to the four classifications in Lyons et al. 2009**

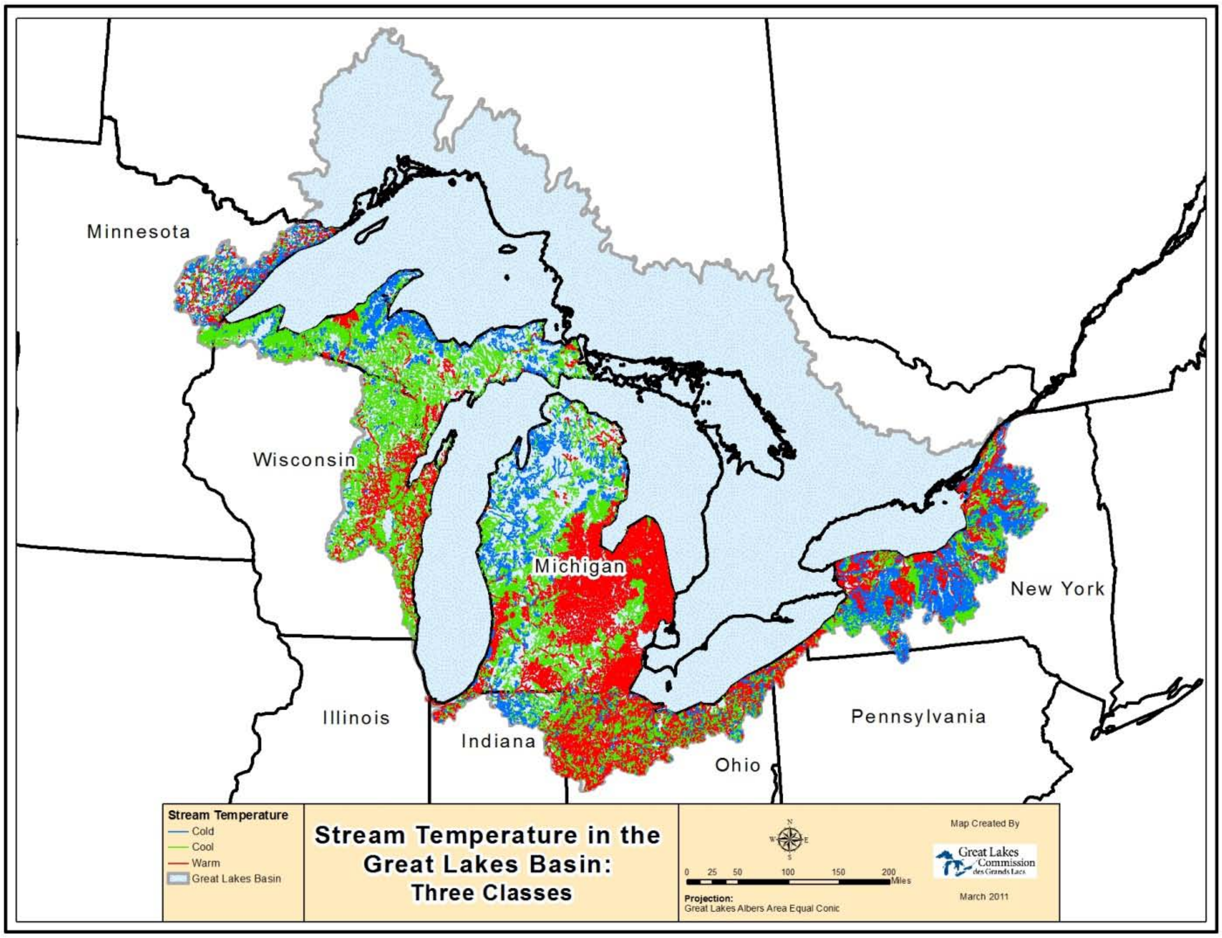


Figure 3: Stream temperature in the Great Lakes basin using three classifications

Geographic Extent of Available Data (Great Lakes basin wide or other): Great Lakes basin wide.

If not by HUC8 watershed, how were these data originally spatially organized? What manipulations were made to the data in order to organize them by HUC8? Originally, these data were line features of streams, mapped to the 1:100,000 scale National Hydrography Data and classified into the three categories of cold, cool, and warm. Watersheds were given one of three classifications based on the majority of stream miles within their boundaries. Thus, watersheds with cold stream miles making up greater than 50% of total stream miles were assigned in the "cold" class, those with greater than 50% cool stream miles were designated "cool," and all remaining watersheds were categorized as "other." These categories were then mapped at the HUC8 watershed level (Figure 4).

Other spatial manipulations/calculations performed to produce the map? None

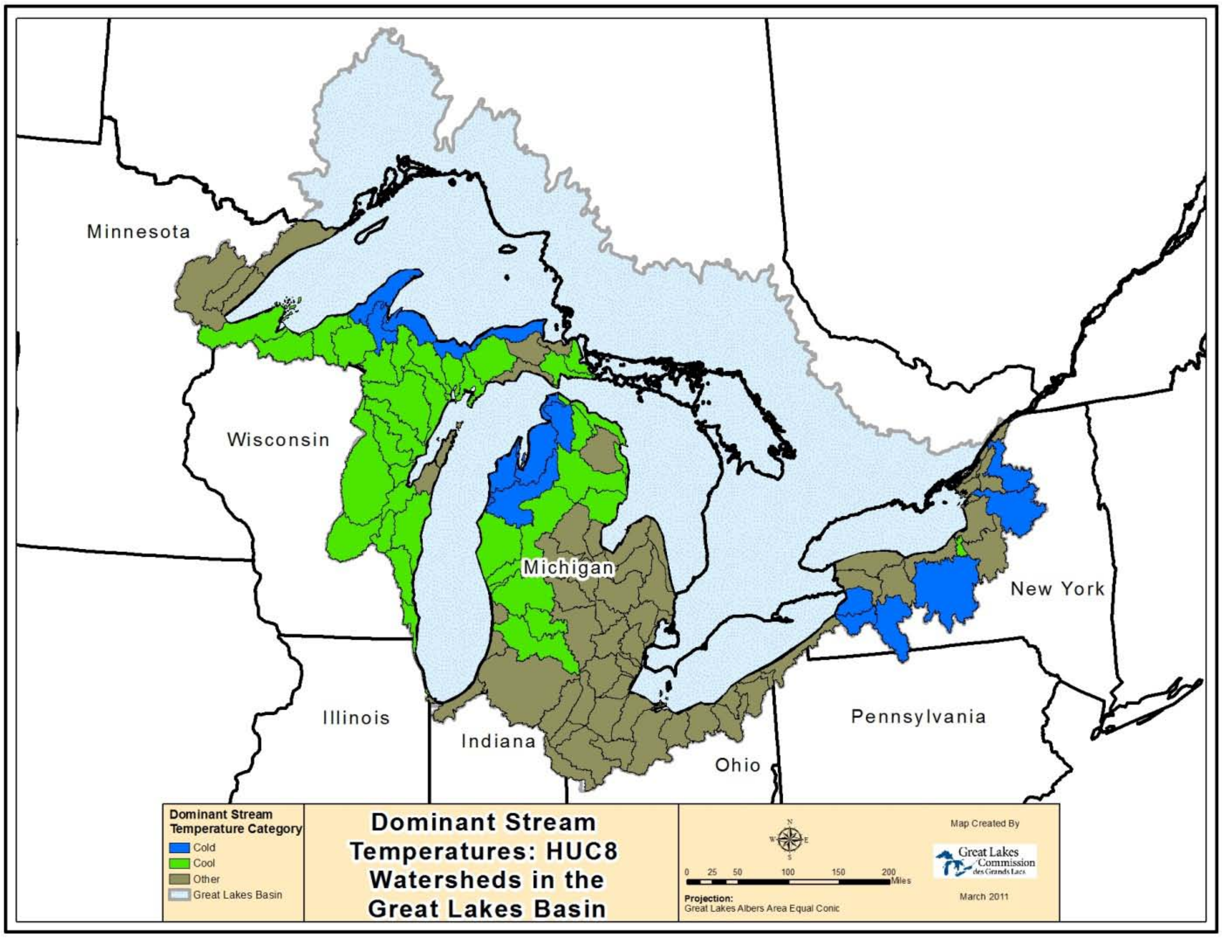


Figure 4: **Dominant stream temperatures in HUC8 watersheds in the Great Lakes basin.**

What other information is necessary to report regarding this metric? None.

Metric 3: Groundwater Vulnerability

Question of Interest: Which HUC8 watersheds are at risk of hydrologic stress due to a high ratio of groundwater withdrawal relative to groundwater recharge?

Description/Units: Groundwater withdrawal to groundwater recharge ratio by HUC8 watershed

= Groundwater withdrawal in millions of cubic ft. per year / Total groundwater recharge in millions of cubic ft. per year

Water Supply Source: Groundwater

Impacted Water Source: Surface water

Reason for Metric Selection (i.e., why was this metric chosen as an identifier of watersheds that may be under hydrologic stress?) Watersheds with high groundwater withdrawals relative to groundwater recharge rates will be at greater risk of hydrologic stress during extreme low flow conditions, particularly as withdrawals increase and aquifer recharge decreases with increased urban development or irrigation. It is important to consider deeper aquifers that are being depleted. This could be a serious water quality issue, especially because it takes longer to recharge deep aquifers. Also, as groundwater is depleted, it takes more energy to pump the water.

Which values of this metric (e.g., high vs. low) identify a stressed watershed? Higher values of this metric identify stressed watersheds.

Degree of Confidence in Underlying Data: Recharge estimates are based on USGS report results where baseflow recession models were fit to streamflows, assuming that baseflow in a given stream is equal to the amount of shallow ground-water recharge to the surrounding watershed, minus losses to evapotranspiration. The confidence level in the recharge estimates is moderate, because although there are inherent uncertainties in the recharge estimates, it is likely that the errors introduced by these uncertainties are similar across HUC8 watersheds. In other words, confidence in the accuracy of the data may be low to moderate, but confidence in the consistency of the data is high. The confidence level is moderate for withdrawals because withdrawals were estimated in 2005. Thus, some of the water withdrawals data may not necessarily reflect current water demand within certain watersheds. For instance, the withdrawal source for public supply within Lower Fox watershed of Wisconsin has changed from groundwater to Lake Michigan surface water.

- *Overall Confidence Rating: Moderate*

Metric Reliability Rating (i.e., what is our level of confidence in the metric to address the question of interest, both spatially and temporally?): Withdrawal data comes from a 2005 report reflecting data collected between 1999 and 2004 and withdrawals may have changed since this period. However, groundwater recharge has likely changed little. The degree of confidence in the underlying data and its basin wide extent give this metric a moderately high degree of reliability in addressing groundwater recharge ratios in HUC8 watersheds across the Great Lakes basin.

- *Overall Reliability Rating: Moderate*

Data Supplied By: Great Lakes Commission

Data Source (e.g., citation of report, website, etc.): Estimates of shallow groundwater recharge by HUC8 watershed are from the USGS report:

Neff, B.P., A.R. Piggott, and R.A. Sheets. 2005. Estimation of shallow ground-water recharge in the Great Lakes Basin. U.S. Geological Survey Scientific Investigations Report 2005-5284, 20 p. http://pubs.usgs.gov/sir/2005/5284/pdf/SIR_2005_5284-Web.pdf

Water withdrawal data are from the USGS report:

Mills, P.C., and J.B. Sharpe. 2010. Estimated withdrawals and other elements of water use in the Great Lakes Basin of the United States in 2005. U.S. Geological Survey Scientific Investigations Report 2010–5031, 95 p. http://pubs.usgs.gov/sir/2010/5031/

Data Manipulation/Alteration (e.g., were calculations or conversions performed?) A simple metric conversion was performed for both:

- Groundwater recharge (from inches per year to millions of cubic feet per year) and
- Groundwater withdrawal (from millions of gallons per day to cubic feet per year).

Geographic Extent of Available Data (Great Lakes basin wide or other): Great Lakes basin wide

If not by HUC8 watershed, how were these data originally spatially organized? What manipulations were made to the data in order to organize them by HUC8? Not applicable

What, if any, other spatial manipulations/calculations were made to the data in order to produce the map? Tabular data were joined to HUC8 polygonal data to display values calculated for this metric (Figure 5).

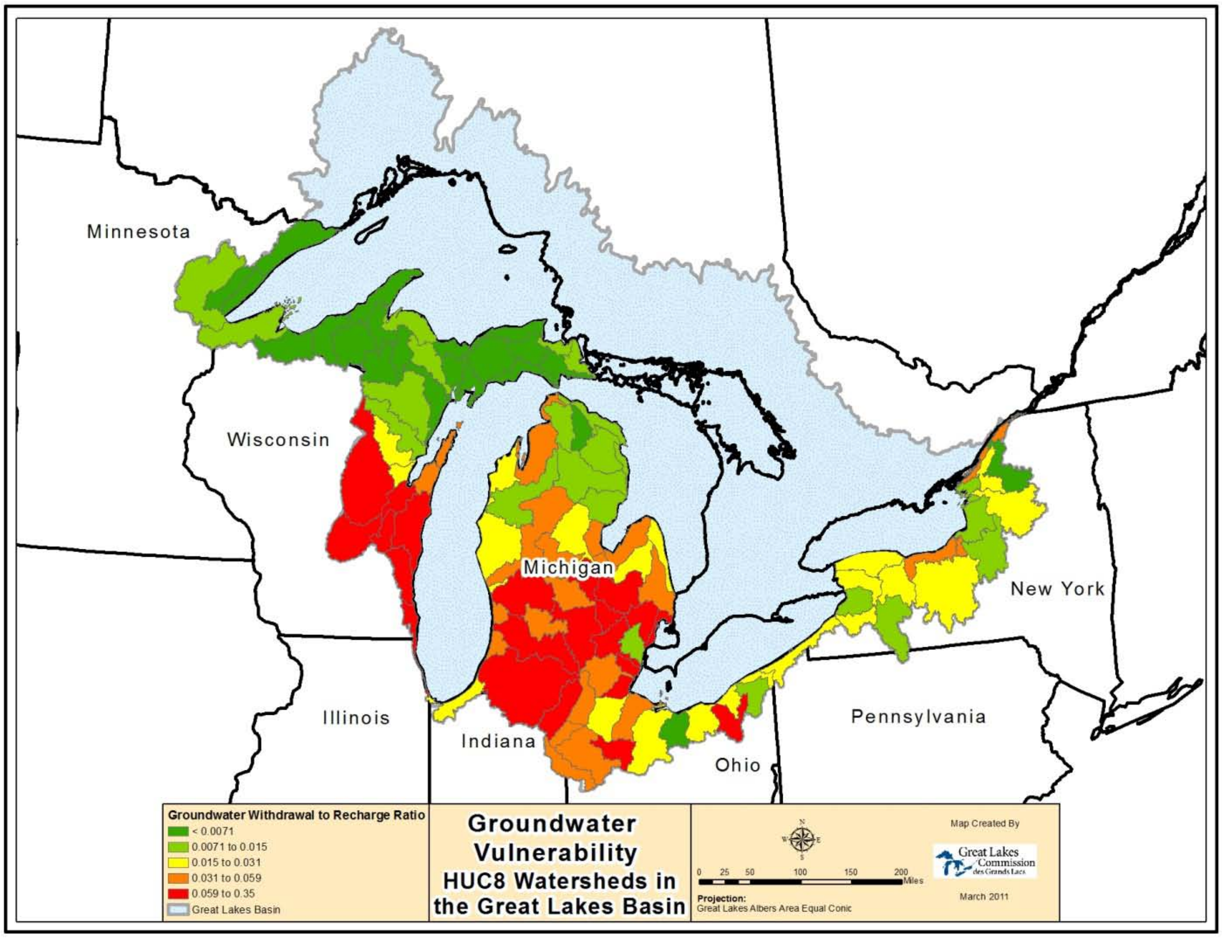


Figure 5 Groundwater vulnerability, as measured by ratio of withdrawals to groundwater recharge, in HUC8 watersheds in the Great Lakes basin

What other information is necessary to report regarding this metric? None.

Metric 4: Predicted Land Development Stress

Question of Interest: Which HUC8 watersheds are at risk of hydrologic stress due to projected urbanization?

Description/Units: Predicted percent change in land cover from less developed or natural to more developed from 2010-2030.

Water Supply Source: Surface water or groundwater

Impacted Water Source: Surface water or groundwater

Reason for Metric Selection (i.e., why was this metric chosen as an identifier of watersheds that may be under hydrologic stress?): Watersheds with high predicted land use change will have increasingly greater withdrawal needs over time; flashier stream flows as well as lower groundwater recharge, especially in areas of predicted urbanization.

Which values of this metric (e.g., high vs. low) identify a stressed watershed? Higher values of this metric suggest a watershed that could be subject to hydrologic stress in the future.

Degree of Confidence in Underlying Data: The 2030 data are based on model outputs; data were spatially manipulated in order to represent at the HUC8 spatial scale.

- *Overall Confidence Rating: Moderate*

Metric Reliability Rating (i.e., what is our level of confidence in the metric to address the question of interest, both spatially and temporally?): In addition to the lower degree of confidence in the data underlying this metric, data are only available for three states in the Great Lakes Basin. This limits the metric's ability to address land development stress in inland streams basin-wide.

- *Overall Reliability Rating: Low*

Data Supplied By: Bryan C. Pijanowski, Purdue University

Data source: (e.g., citation of report, website, etc.) Purdue University EPA STAR ILWIMI Project – see http://ltm.agriculture.purdue.edu/ilwimi/

Data Manipulation/Alteration (e.g., were calculations or conversions performed?): An urban change value was created using the measures of developed/urban area from the 2010 and 2030 generations of the EPA STAR ILWIMI Project data . The percentage urban change was generated using the calculation ((Urban 2030 –Urban 2010)/ Urban 2010)*100.

Geographic Extent of Available Data (Great Lakes basin wide or other): Jurisdictional boundaries of Illinois, Michigan, and Wisconsin.

If not by HUC8 watershed, how were these data originally spatially organized? What manipulations were made to the data in order to organize them by HUC8?The land use/land cover raster data from 2010 and the projected land use/land cover for 2030 were cross-tabulated with the HUC8 polygonal data to calculate areal values of developed/urban land classes per HUC (Figure 6).

What, if any, other spatial manipulations/calculations were made to the data in order to produce the map? None.

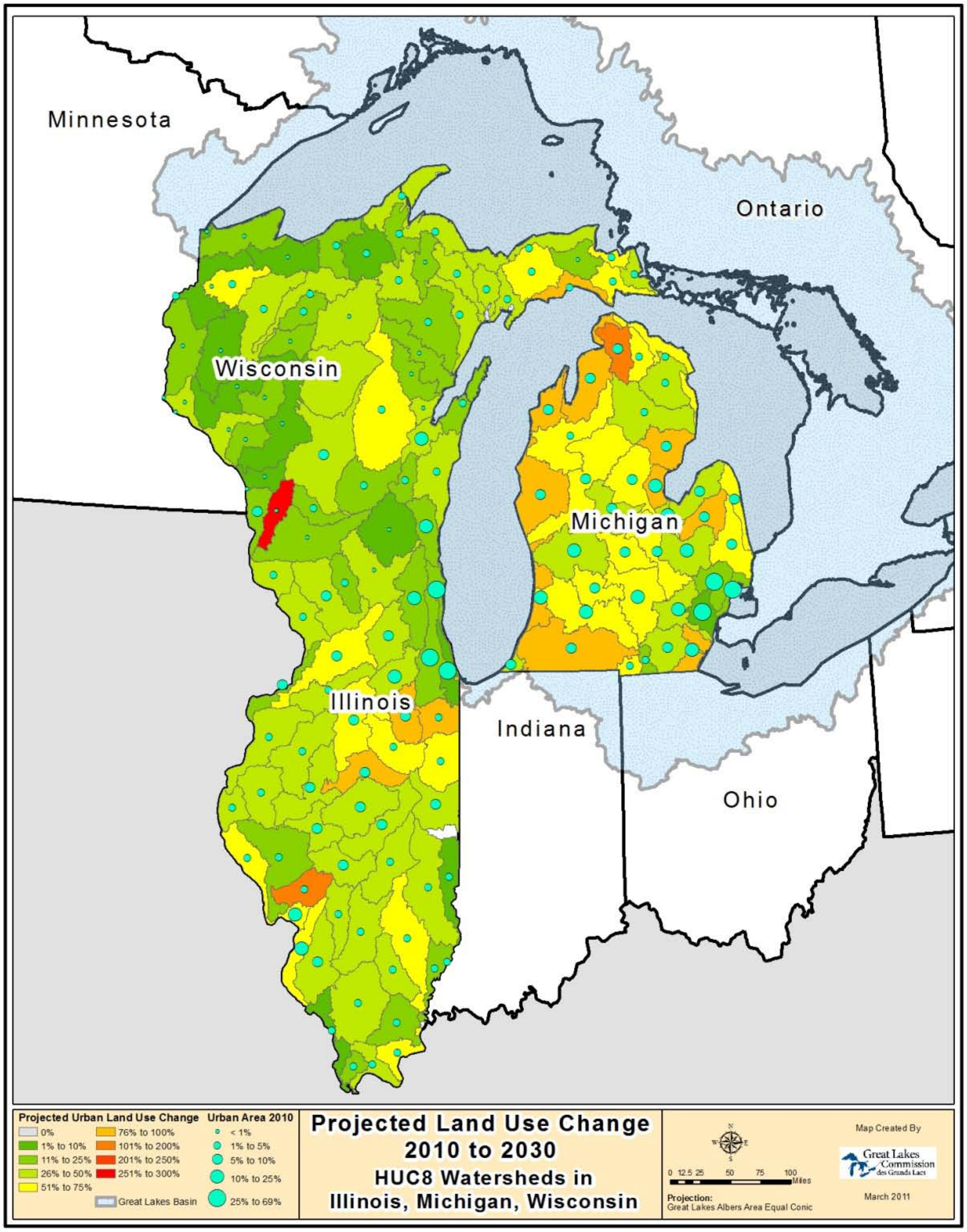


Figure 6: Projected urban land use change from 2010 to 2030 for HUC8 watersheds in Illinois, Michigan, and Wisconsin

What other information is necessary to report regarding this metric? None.