Final Report
September 19, 2005

Great Lakes Region
Water Sustainability Research Workshop

April 5 - 6, 2005
University of Michigan, Ann Arbor, MI

Sponsored by:
The Sustainable Water Resources Roundtable
http://water.usgs.gov/wicp/acwi/swrr

Hosted by:
University of Michigan ETC
(Environmental Technology Council)

Co-chairs:

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WEF, SWRR &
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Acknowledgments

This workshop was a success because of the efforts by many individuals and organizations. First we want to acknowledge the support of the Sustainable Water Resources Roundtable (http://water.usgs.gov/wicp/acwi/swpp) and the encouragement and support of the SWRR Steering Committee. In particular we want to acknowledge:

David Berry, Manager and Facilitator of SWRR.

David was instrumental in designing the structure for the breakout sessions and providing support and guidance to the various facilitated breakout sessions.

We want to thank our local host and cosponsor The University of Michigan College of Engineering – Environmental Technology Council (http://www.engin.umich.edu/research/etc/beta), for supporting the workshop and donating facilities and hosting the attendees so well.

Among individuals who helped organize the workshop, we want to especially thank the various stakeholder session conveners:

***Power*: Robert Goldstein**, Electric Power Research Institute

***Agriculture & Forestry*: Jon Bartholic**, Michigan State University; **Steve John**, Agricultural Watershed Institute; **Tad Slawecki**, Limno-Tech Inc.

***Manufacturing & Industry*: Peter Adriaens**, University of Michigan; **George Kuper**, Council of Great Lakes Industries

***Urban Issues*: Jennifer Warner**, AwwaRF; **Linda Blankenship**, WERF

***Ecologic Protection*: Al Steinman**, Annis WRI Grand Valley State University, **Lucinda Johnson** NRRI, University Of Minnesota

They recruited outstanding speakers and participants for the workshop. Additionally they facilitated highly productive breakout discussions and wrote very succinct, informative summaries for this report.

We want to also thank the speakers (listed in the Appendix along with copies of their presentations). All the speakers provided highly relevant talks, well focused in the limited times they had for their speaking slots.

Last we want to thank all the participants who all donated their time, and intellect to contribute to very thought-provoking discussions about research priorities for water sustainability.

Sincerely:
Co-chairs

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1. Executive Summary

1.1. Background

The Sustainable Water Resource Roundtable (SWRR) is a national forum of water resource experts. It was designed to help develop and share information and perspectives that promote better decision making in the U.S. on sustainable development and use of our water resources. The SWRR was established under the umbrella authority of the Federal Advisory Committee on Water Information (ACWI) that advises Federal agencies. One objective of SWRR is to explore research needs that promote sustainability. To this end, a workshop of experts was convened in April 2005 to explore research priorities with an emphasis on water resources sustainability in the Great Lakes region.

Hosted by SWRR and the University of Michigan, 75 experts convened for a two-day workshop on April 5 and 6, 2005 in Ann Arbor Michigan. The workshop consisted of over 25 technical presentations on sustainability research by leading experts from six perspectives:

- Power Generation
- Agriculture and Forestry
- Urban issues (Water supply, storm water, wastewater, land use, etc.)
- Manufacturing/Industry
- Ecological Protection and In-Stream Uses
- Ethics, Law and Policy

The workshop also included breakout discussion groups on the above topical categories, with the exception of Ethics, Law & Policy, for which discussions were merged into the other five. Each group was charged with examining research needs from their special perspective and reporting to the reconvened entire group. In the plenary session, the reconvened entire group held discussions examining the differences, similarities and commonalities of their separate discussions.

1.2. Key Findings

Short reports on the identified research priorities for each of the five categorized sectors were provided. Details on these are not summarized herein, but the reader is referred to the individual chapters in this report. Several key observations were apparent, however, in reviewing and analyzing the reports and the workshop discussions. Consensus points and common observations among the groups and from plenary discussions (in no particular order) were:

- Need to improve our understanding of critical water resource processes and their impact on sustainability;
- Need for decision support models/tools;
- Need for a better inventory of critical data;

- Need for new monitoring technologies;
- Need to develop an approach to quantifying the "value" of water;
- Need for new policies and law to manage water on a regional basis; and
- Need to solve the forecasted decline and shortfall in water management specialists.

Each is briefly described below.

Process Research: All groups recommended that a better understanding was needed of the cause and effect of natural water processes and those human actions that impact sustainability, although the specifics often differed. However, one specific common issue was the need to better understand the link between land uses and water quantity, quality and ecological health.

Decision Support Tools: Although often using different terminology, all of the groups recognized a priority need for the development and use of analytical tools and models to support better policy decisions for sustainability relevant to policy decisions. Each of the groups highlighted a priority to develop, improve, and more widely use decision support tools/models. Specifically, the groups saw a need to increase the use of scientific knowledge and insights in policy decision-making in a quantitative fashion. In this sense, quantitative refers to quality, quantity, uses and valuation.

Data Inventory: Each group recognized that predicting the future and making important policy decisions require a more comprehensive understanding of current conditions. Each group emphasized the need to build a better inventory of current and baseline conditions, but here again they each focused on different elements, including better database management, better inventory of land uses and water data, better understanding of natural baseline variability and existing conditions, as well as better information concerning new stressors (including new pollutants).

Technologies: There was broad agreement on the need for new monitoring technologies both for water quantity and quality. In particular, traditional contaminants such as nutrients and bacteria, as well as newer contaminants such as pharmaceuticals and viruses, need new monitoring technologies that might include wireless and remote sensing. Individual groups suggested the need for advanced treatment and water use efficiency technologies.

Value of Water in Policy Decisions: All the groups recognized that as a society and an economy we have poor quantitative understanding of the "value" of water and rarely incorporate this concept in policy decisions. Here again, there was a consensus that developing approaches that recognize the value of water in its various states and uses by different stakeholders was a key to guiding decision-making for sustainability, to protect all uses. The value of water must be incorporated into policy decisions.

Better Law & Policies: All of the groups recognized that new regional and national policy is needed to better promote sustainability. How those policies would be created or implemented was not an area of consensus, and in fact was an area of disagreement. The group did, however, express two areas of strong agreement. First, policy is needed to promote sustainability and research through integration and better use of existing operations of individual government agencies and creation of new approaches. Second, managing water resource sustainability must have a regional focus and needs to come from an understanding of hydrology that transcends political boundaries, which make it more difficult to administer.

Human Resources: A surprising area of consensus discussion by the group of experts was the recognition that sustainability is threatened by a current forecast indicating a shortage of knowledgeable and experienced water professionals. The experts recognized that universities are producing fewer environmental scientists and engineers with relevant specialization than in the past, and that over the next ten years a major segment of professionals with key knowledge would be retiring. Research is needed to identify how these critical human resources and knowledge base can be sustained.

Collaboration: One final area of commonality in all of the group discussions among the experts was the need to encourage more collaboration. Collaboration is needed among agencies, industry, governments, environmental non-governmental organizations (ENGOs, and research institutions. The group felt strongly that there were many shared interests, and that our overall effectiveness would be greatly enhanced by more collaboration, whether by voluntary encouragement, or supported by economic incentives and/or policy/law changes.

The above were the overarching and consensus research recommendations of the experts; however, the reader should also review the detailed and specific recommendations provided by the individual groups. It is interesting to note that although the five groups were organized to evaluate research needs in the context of separate stakeholder perspectives, in the end there was considerable commonality to their separately conceived priorities. These underline the realization that sustainability is a common interest and a vehicle for collaboration, not confrontation, among different users. Researching and promoting sustainability can best be realized by collaborative efforts.

2. Background and Workshop Structure

This report describes a two-day symposium and workshop in Ann Arbor, Michigan, April 5 & 6 of 2005, that explored and prioritized research needs on sustainable water resources with particular emphasis in the Midwest and Great Lakes region. It was conducted under the joint sponsorship of the Sustainable Water Resources Roundtable (SWRR) and the University of Michigan. This report section provides a brief summary of the justification, format, and expectations for the workshop.

2.1. Background:

The Sustainable Water Resources Roundtable (SWRR) is a national forum designed to develop and share information and perspectives that promote better decision-making in the U.S. on sustainable development and use of our nation's water resources (http://water.usgs.gov/wicp/acwi/swrr). It has been established under the umbrella of the Federal Advisory Committee on Water Information (ACWI) that advises Federal Agencies. Participation in SWRR is open and intended to include a wide range of interests and views. Members and participants come from government, industry, commerce, research and academia, as well as professional and environmental organizations. The SWRR is one of four Resource Roundtables; the others work on forests, rangelands, minerals and energy. The White House Council on Environmental Quality is currently creating a system to integrate information and indicators from all four Roundtables

One objective of the SWRR Roundtable is to explore research needs that promote sustainability. This workshop supported this goal. This goal is also central to various programs at the University of Michigan concerned with sustainability including College of Engineering (COE) Environmental Technology Council (ETC), The Center for Sustainable Systems, Michigan Sea Grant, and the Corporate Environmental Management Program. These programs interact with an emerging umbrella structure, the University of Michigan Sustainability Initiative. The workshop was co-sponsored by the ETC, a structure within the COE (encompassing the expertise of 35-80 faculty and staff), which seeks to integrate engineering technologies related to water and energy with policy and business objectives.

2.2. Objectives:

The workshop and symposia were designed to provide a select group of professionals and researchers with a forum to share information and develop ideas about research needs to define and explore sustainable use objectives. Participants were selected and invited based on the recognition that they were experienced practitioners or researchers with interests and expertise in various fields of study or stakeholder interest critically dependent on water resources.

The workshop was organized around “use sectors” with participant invitations, panel sessions, and break-out session based on five stakeholder groups:

- Power generation

- Agriculture and forestry
- Urban issues (Water supply, storm water, wastewater, land use, etc.)
- Manufacturing/industry
- Ecological Protection and In-stream uses

The intent was to examine the issue of sustainability in the context of separate stakeholder interests and to identify stakeholder group-specific research priorities and issues. These findings would be then shared with the entire group, to examine the differences, similarities and commonalties.

The first outcome for this meeting was to compile information about research needs for the various stakeholder interests. This information is documented by a compilation of PowerPoint presentations expressing their viewpoints on research needs and challenges to sustainability. Beyond the information provided by individual presenters, the workshop also was designed to develop a consensus list of research priorities from the view point of the five stakeholder user groups. This is documented in this report by summary documents written by session conveners. Last, a third workshop objective was to evaluate the commonalities and differences in the stakeholder views of research priorities. This is documented by an analytical review (written by the workshop chairs) of the five stakeholder reports integrated with the overall workshop discussion of findings.

Overall, this meeting served to define an initial agenda for research on sustainable water resources in the Midwest and Great Lakes region, as well as helping to establish a framework to discuss priorities nationwide. This report has been distributed by the Sustainable Water Resources Roundtable (SWRR) to several hundred practioners involved in the Roundtable and Sustainability. The report was also used as the basis for a chapter in a separate report on SWRR findings submitted by SWRR to the Federal Advisory Committee on Water Information (ACWI). Information compiled and discussed at the workshop was also used as input to the Sustainable Development Team of the Great Lakes Regional Collaboration effort initiated by the Federal government to develop plans for protection and restoration of the Great Lakes. Finally, the report and its outcomes will be used by the ETC as a template for developing a technology- and policy-based research agenda on the water-energy nexus for submission to State and Federal Agencies. A follow-up 2006 workshop jointly hosted by the COE-ETC and the Business School's Erb Institute for Global Sustainable Enterprise will serve to translate the research needs identified here into a focused Center proposal.

2.3. Content and Format:

A two-day workshop and symposium was held on April 5 and 6 of 2005 at the University of Michigan in Ann Arbor, Michigan, to explore research needs in sustainability of water resources. The first day was conducted in general sessions presenting information on the current status of research and challenging issues, and the second day was structured primarily as working sessions exploring the priority research needs.

The first day was broken up into a series of sessions focused around segregated water use sectors important in sustainability considerations. The sessions were:

- Power generation
- Agriculture and forestry
- Urban issues (Water supply, storm water, wastewater, land use, etc)
- Manufacturing/industry
- Ecological Protection and In-stream uses

Each session was organized by session convener(s) who invited speakers and attendees, as well as moderated discussions and produced reports on the sessions. The first day was broken into a series of approximately 75-minute sessions each, with three to four, 15-minute presentations, followed by a short panel discussion. The sessions served to educate the entire group on the status of research and some of the challenges in all the areas of consideration. It also provided a foundation for workshop discussions on the second day.

The second day of the meeting was designed to involve concurrent workgroups deliberating on and discussing the research needs in the topic sessions considered on Day 1. In addition, there were two general sessions on:

- Water Policy, Law and Ethics
- National trends and indicators

These overarching topics have relevance to each of the specific water use sessions, as they pose challenges and issues for stakeholder-specific needs and prioritization.

In addition to the overarching presentations, on the second day each water use group, constituted by their collection of experts and interested individuals and moderated by the session conveners, met separately and developed a list of the top priority research topics in its respective area. Each group was posed three questions:

1) What critical problems exist in your area of interest that warrant high-priority research to help promote sustainability of water resources?
2) What areas of cooperation and research collaboration do you see as promoting funding and achieving success in sustainability research as they relate to the issues you identified?
3) For a cabinet secretary or CEO of a large national corporation/organization concerned with long-term sustainability, what big picture issues do you see as the highest priories for research?

The afternoon was focused on sharing these discussions and integrating them into a broader context. The various groups also critically reviewed ongoing efforts by the SWRR to develop a national set of indicators of sustainability. A report on the development of sustainability indicators is under separate development for submittal to SWRR and ACWI.

2.4. Report Structure:

This report summarizes the findings of the workshop followed by compilations of the individual reports from the separate stakeholder sessions. In the appendices are the PowerPoint presentations presented at the workshop, the workshop agenda and speaker list, and the workshop participants list.

3. Overview of Research Recommendations

This section provides a summary of the recommendations, commonalities and differences resulting from the breakout session discussions and perspectives gained based on the presentations made by each of the stakeholder experts in the five targeted areas. An overview of the research recommendations is summarized in Table 1, which provides a matrix of research areas (Process Understanding, Inventory, Tools, Technology, Policy, and Law) mapped against the relevant sectors. For further, stakeholder group-specific recommendations, please refer to subsequent chapters which include their individual reports.

3.1. Process Research:

This area of research needs was defined primarily by the understanding of the intersection and interaction between land use, water quantity and quality, ecosystem impacts, economic forces and potentials.

A commonality across all discussion groups was that any sustainability policies have to be based on a science-based holistic analysis of the system, rather than on sector-specific uses. The participants in their separate groups and in collective discussions argued that more research was needed to understand the linkage between land use and water use as well as on water quantity, quality and ecologic health. Specific recommendations from individual sessions in this common research theme included consideration of hydrological cycling (Agri/Forestry), long term responses to landscape change (Agri/Forestry), need to better understand regional hydrology (Power), quantification of stressor and receptor interactions in the system (Ecology), and better understanding to predict lake levels (Industry).

A number of different issues were identified within the various groups in this research area, particularly with respect to emphasis on specific recommendations. For example, the urban and industry sector (bottling industry) heavily emphasized water quality impacts research, whereas all other sectors and the shipping industry emphasized the need for better quantification of water quantity (too much, too little, altered flow patterns, hydroperiods) as a stressor on water use. The power and industry sector further heavily emphasized the need to incorporate water reuse (e.g. advanced cooling, closed-loop systems) and conservation efforts in policy decisions for water allocation. Lastly, the in-stream ecology group identified the need for further research in the effectiveness of best management practices (BMPs).

3.2. Tools

The discussion of research needs on tools emphasizes ‘software’ or models, as opposed to the technology section which refers to ‘hardware’.

The need for better and more transparent decision-support tools (i.e. models) was a common major research recommendation for water resource sustainability (How do we value, how do we decide, under which conditions, water allocation?). The need to tie decision-support models to economic and social valuation of water was also a significant impetus for these tools. The challenge with developing criteria based on

both valuations is the incorporation of quantitative and qualitative metrics for goal-setting and decision-making. Discussions also indicated that the tools will need to be probabilistic, and should allow for alternative forecasting capabilities that can be understood by non-scientific stakeholders as well ('social landscaping').

Some of the different observations of the experts referred to specific modeling needs for selected target areas, such as scalable models for lake level prediction (industry), biogeochemical cycling in watersheds (power), spatial implementation of BMPs with respect to ecological improvement (ecology), and TMDL calculations, allocations, and implementation (power).

3.3. Inventory

This area of research needs refers to database development for both quantitative and qualitative endpoints.

Across all sectors, the quantification of competing water uses and water inventories was identified as a key research need to inform water allocation, and to define a baseline of current use. This baseline, and the water allocation based thereon, has to incorporate intraregional differences in the economic and social use of water (i.e. land-use). Data inventory needs included water uses, land use, water quantity/availability and water quality.

As in the previous section, some different emphases were noted between and within sectors. For example, water quality database information was deemed to be a key research need in the urban, industry, and agricultural/forestry sectors. In particular they identified research needs related to emerging contaminants (e.g. pharmaceuticals, endocrine-disrupting compounds) derived from the urban water cycle, antibiotics from agricultural runoff, and both general water quality indicators as well as target compounds in the drinking water and bottling industry. Lastly, pertaining to water quantity, the urban sector discussed the need for research on what constitutes a tolerable water loss for the drinking water utilities.

3.4. Technology

Recommendations in this area refer to hardware needs in support of all aspects of the water research needs.

The common thread emphasized improvements on monitoring tools and infrastructure, with slight differences in emphasis depending on the specific requirements in each sector. Ecology emphasized the need for special focus on ecological parameters and inflows to lakes and wetlands. Manufacturing and industry emphasized the entire water cycle (source, use, disposal), with maximization of distributed networks to avoid reliance on single point measurements to inform large-scale impacts of activities (both discharge and source waters). The urban sector identified the need to update monitoring technologies, but maintain simplicity in its use, for pathogens and chemical contaminants.

Interesting differences in the discussion of needs emerged in this area, as industry and power strongly emphasized technology needs for process efficiency: cooling,

combined cycle, renewable generation, cost-effective storage of water and electric power, membranes for closed loop systems, and technologies for metal removal. Research on these technologies was not discussed in other individual groups but was discussed in the plenary group where the individual groups convened as a larger group.

3.5. Policy

The policy research recommendations encompass a broad swath of issues pertaining to decision-making and education, and the issues called out are closely linked to aforementioned research topics.

A common research need discussed in this area is that of water valuation, both economically and from a societal/ecological perspective, and how this should guide policy of resource allocation, land and water management decisions, public education and promoting market-based solutions. This combination of narrative and numeric criteria, as well as direct and indirect subsidies, challenges method development to assess and measure the 'true' value of water.

Further agreements in the policy area pertain to the need for educated professionals to replace the loss of institutional knowledge. The urban sector called out the challenging task of recruiting new talent, as water and wastewater disciplines are not producing sufficient graduates in this area to replace retirees. This was also discussed in the power session and the overall plenary session.

There were some differences emphasized in the individual group sessions. The power sector focused on the implications of water withdrawal shifting from riparian-based to governmentally appropriated, when water resources become more stressed, as well as on the development of economic incentives to encourage power and water conservation. Similarly, the industry sector focused on incentives (cap and trade?) for implementation of best available technologies (BAT), and on business-to-business (B to B) opportunities based on water quality requirements.

3.6. Law

Research needs in this area emphasized both the overhaul of perhaps outdated laws, and advanced new regulatory frameworks

Closely linked to the policy recommendations, there was substantial agreement on creating incentives for change, whether through land-use taxation or volunteer-based programs (e.g. cap and trade). However, the specifics of the needs/recommendations were closely tied to the respective sectors. For example, the urban sector focused on researching the option of taxation as a means to control growth. The ecology sector did not call for more laws, but rather focused on whether existing laws can be used more effectively for water sustainability. Industry argued for translating regulatory barriers into increased opportunities for BAT implementation (e.g. deployment of BAT as opposed to emissions credits, tax relief or Business to Business efficiencies).

3.7. Collaboration

Another opportunity commonly expressed was for increased collaboration. All sectors emphasized the need to collaborate across government, university, industry and ENGOs on the one hand, and local, State and Federal levels on the other hand. A sampling of issues with respect to collaboration is provided below:

- Understand existing infrastructure to promote programmatic collaboration. Many ties already exist, but are not used effectively.
- Do not try to reinvent the wheel. Several water sustainability indicator development efforts are already underway.
- Scientists and engineers need to be more effective in communicating and demonstrating the value of research, as well as explaining emerging issues.
- Collaborative research is needed between scientists, social scientists, economists, and the public.
- Because of competitive pressures, the business case needs to be made for collaboration among competing industries or sectors.
- Need to develop a common research agenda (stakeholder, scientific community and government) for mutually supportive decision-making.
- Integrate water sustainability research with energy programs to better frame the critical need and big picture issues driving these recommendations.

3.8. Conclusions

The above were the overarching research recommendations of the experts; however, the reader should also review the details and specific recommendations provided by the individual groups. This overview provides only an abstracted summary focusing mostly on commonalities and differences between the stakeholder groups. It is interesting to note that although the five groups were organized to evaluate research needs in the context of separate stakeholder perspectives, in the end there was considerable commonality. This underlines the realization that sustainability is a common interest and a vehicle for collaboration, not confrontation among different users. Researching and promoting sustainability needs to be realized by collaborative effort across sectors, as well as through the integration of technology and policy objectives.

Table 1: Abstracted Summary of Sector Discussions on Research Needs for Sustainability

Urban	Power	Industry	Agri/Forestry	Ecology
Process				
• Tolerable loss of water • Population & land use impacts on quantity and quality	• Regional hydrology	• Factors that determine lake levels	• Soil loss • Economic links to sustainability • Effects of land use changes	• Quantification of stressors & receptors • Definition of baseline conditions • Resistance & resilience • Resistance & resilience • Effectiveness of BMPs
Tools				
• Metrics to determine "value" of water	• Decision-support tools • Better methods for TMDL analysis • Watershed, hydrology & biogeochemical models	• Predictive models • Tools to understand and predict lake levels	• Decision-support tools	• Decision-support tools • Improved criteria
Inventory				
• Comprehensive data base of all uses • Inventory of available water	• Aquifer data base • Regional hydrology • Technologies for water treatment and efficiency	• Inventory of baseline conditions • Data base of emerging pollutants	• Database of land use • Data base of emerging pollutants	• Comprehensive data base of all uses • Inventory of baseline conditions
Technology				
• New monitoring technologies (quantity and quality)	• Water treatment technologies • Freshwater conservation	• New monitoring technologies (quantity and quality) • Conservation and reuse technologies	• Riparian management effectiveness & approaches	• New monitoring technologies (quantity and quality) • Effectiveness of BMPs
Policy				
• Value of water • Shortage of appropriate engineers and scientists • Stakeholder involvement • Management structure • Social landscapes • Use allocation	• Value of water • Shortage of appropriate scientists and engineers	• Lake level management • Promote collaboration	• Valuation • Science based policy • Relation between economic factors and sustainability • Public perceptions	• Criteria for social valuation • Better defined goals • Better collaboration
Law				
• Land use taxation	• Water rights • Integrated planning among overlapping agencies	• Regulatory incentives	• Policy tools	• Water withdrawal laws (indicator based)

4. Power Generation Session

4.1. List of Convenors & Speakers

Convener

- Robert Goldstein, Electric Power Research Institute

Speakers

- Dave Michaud, WE Energies
- Dennis Leonard, Detroit Edison
- Tom Feeley, National Energy Technology Laboratory
- John Gasper, Argonne National Laboratory
- Kent Zammit, Electric Power Research Institute

4.2. Report

The first two speakers, Dave Michaud and Dennis Leonard, represent Great Lakes Region electric power companies. They presented the perspective of energy/water sustainability from the perspective of thermoelectric power generators. The next two speakers, Tom Feeley and John Gasper, represent national energy laboratories, and the provided a national perspective with respect to the dependencies of energy sustainability on water and water sustainability on energy. The last speaker, Kent Zammit, represented a national research organization supported by the power industry. He discussed the research being conducted by EPRI to reduce the dependency of electric power on fresh, clean water withdrawals.

All speakers agreed that thermoelectric power generation was strongly dependent on water for cooling. Michaud pointed out the uniqueness of the Great Lakes and their significance to the region. He pointed out how the biological and hydrological characteristics of the Lakes have changed with time and described how these changes affect the power plants situated on the lakes. He also discussed implications of new regulations concerning the use of water by the power plants, called for integrated multimedia environmental assessments and identified key research issues.

Leonard posited that the Lakes can no longer be considered natural systems and described the many human activities and environmental factors that affect them. As did Michaud, he emphasized the dynamic nature of Lake properties; e.g., water level. He discussed four major factors that influence a new power plant's use of water: paragraph 316 of the Clean Water Act, the Great Lakes Annex, federal energy efficiency policy, and economic competition. He then identified approaches to harmonizing these factors, including: broadly scoped innovation to achieve the goals of both economic growth and environmental stewardship, and regulations that promote innovative solutions.

Feeley stated that providing sufficient water for power generation was a national issue. He recognized how all sectors of our society depend on fresh, clean water and pointed out how generation demands are increasing dramatically in many regions of the U. S. Analyses at NETL indicate little percentage, if any, increase in water withdrawals by thermoelectric plants over the next two decades. This analysis is

based on the assumption that new plants with greater water use efficiency will replace older less efficient plants. In contrast to withdrawals, the percentage increase of water consumption by thermoelectric plants may, according to the NETL analysis, dramatically change. It should be noted that these results are for a national aggregate. Regional changes may differ significantly from the national change and it is regional changes that essentially determine the severity of the issue of water availability. Feeley then went on to describe the current NETL research program and future plans.

Gaspar emphasized the interdependencies of water and energy supply and demand. He pointed out the need for new technologies to reduce energy requirements to access non-traditional supplies of water. He discussed legal and institutional barriers that limit the availability of water for energy, and how water and energy availability depend on economic activity, weather and climate. He pointed out the role and opportunities for new science and technology to address energy/water sustainability issues, and concluded by discussing activities that are occurring at the federal level to address the issues. He echoed Feeley's sentiment that water/energy sustainability was a national priority.

Zammit discussed recent EPRI research to improve water use efficiency of thermoelectric generation through the use of advanced cooling systems and the use degraded water to replace the withdrawals of fresh, clean water. Advanced cooling may make use of dry and combinations of wet and dry systems. There are energy efficiency and operational issues associated with dry cooling that are being addressed by the EPRI research. A significant portion of the EPRI research is funded by NETL and California Energy Commission (CEC) funding.

During the question and answer period, a question was raised as to what was being done regarding the subject of mercury contamination of water bodies associated with fossil fuel burning power plants. Goldstein responded that EPRI has been conducting mercury research for over a quarter of a century. The research was multifaceted and contained elements on source quantification, atmospheric emissions control, atmospheric transport and deposition, and watershed biogeochemical cycling.

4.3. Summary of Power Sector Breakout

The discussion covered three topics: critical issues, areas of research, and collaborative opportunities. One major theme to emerge was the lack of understanding of regional hydrology. Many poorly defined water transfers may exist within any given region. Many government agencies with different objectives are involved in water management within a region. A lack of integrated planning exists among government agencies within and among different governmental levels (local, State and Federal). Conflicting objectives make it difficult for power companies to develop long-term water use strategies. Regional hydrologic databases and models are needed to get a better grasp on the regional water cycle and to provide support for regional decision-making. Integrative regional models using quantifiable metrics will help resolve potential conflicts among government agencies and other stakeholders. The movement of electricity throughout the region is influenced by and influences the movement of water; hence, it is important to relate the regional hydrologic model to an electric power flow model. In addressing the water/energy nexus within a region, one must be cognizant of non-uniformity of conditions; hence, a strategy to address water/energy sustainability should allow for intraregional differences in the environment, economic and social structure. Within a region, urban areas have different needs than rural areas. Many small communities lack any understanding of Federal incentive programs to address water issues.

Water use may be limited by not only quantity but also quality; hence, the need for further research on advanced water treatment technologies; watershed biogeochemical cycling modeling; and TMDL calculation, allocation and implementation. Societal utilization of water is influenced by so many direct and indirect subsidies that there is no clear agreement on the value of water in non-subsidized regional markets. A methodology needs to be developed that can be used to assess the “true” economic value of water.

New technologies and science tools are needed to support higher water use efficiency in power production. An understanding of the strengths and limitations of each technology and science tool is required. Use of individual tools will be region-specific. Technologies include advanced cooling systems, systems to use sources of degraded water for cooling purposes, combined cycle plants, renewable generation, and distributed generation. Science/economic tools include decision-support models. Research and development are needed to develop new power generation systems that support energy and water sustainability in an economically efficient manner. Market forces and fuel availability needs to be considered, especially where fuel delivery currently depends on water transport.

In the Great Lakes region, water withdrawal rights are currently riparian-based. In the emerging environment where water resources are more highly stressed, water rights may be governmentally appropriated. The implications of such a change for the power industry need to be studied.

Research is needed on the quantification of groundwater aquifers and technologies for their effective use and recharge; economic incentives to encourage electric power and

water conservation; and advanced cost-efficient storage technologies for water and electric power.

All panel members supported the concept of collaborative research and joint funding that would include government, industry, power companies and ENGOs, But all sectors of society are cutting research funding. Scientists and engineers need to be more effective in communicating and demonstrating the value of research, as well as explaining the critical emerging issues. There is developing a shortage in the training of scientists and engineers with expertise in the issues of energy/water sustainability. Federal government requirements for cost sharing with respect to solicited research proposals penalize nonprofit research organization. National laboratories feel disadvantaged with respect to Federal research solicitations that limit their participation.

5. Agriculture and Forestry Session

5.1. List of Convenors & Speakers

Convenors:

- Jon Bartholic, Michigan State University
- Tad Slawecki, Limno-Tech, Inc.
- Steve John, Agricultural Watershed Institute

Speakers:

- George Ice, National Council on Air and Stream Improvement
- Terry Howell, U.S. Dept. of Agriculture, Agricultural Research Services
- Sandra Batie, Michigan State University Agricultural Economics
- Randy Kolka, USDA Forest Service, NC Research Station

5.2. Report

Dr. George Ice (NCASI) spoke about **Forest Water Resource Research Needs** and discussed the forest water research cycle. This cycle links hydrology and water quality to disturbance ecology, BMP effectiveness and economics, and modeling. Key questions include:

- What are the basic pathways and intrinsic potential of forest waterbodies?
- How does disturbance shape forests and watersheds?
- How effective are BMPs, and are they economically sustainable?
- How can we model forest watersheds?

Dr. Terry Howell (USDA-ARS) spoke about **Agricultural Water Conservation for Irrigated Agriculture.** He noted that, though declining, irrigated agriculture is the dominant use of fresh water in the United States, and that the 16% of cropland irrigated provides more than half of the nation's crop values. Also, irrigated agriculture is moving away from the Great Plains towards California and the Eastern U.S. Irrigation is under pressure from other water consumption and needs, which may be met by reallocation of existing water through water transfers or water markets. Agriculture is THE largest water user (of high-quality and inexpensive water), so it is the most likely segment to see impacts of future water shortages.

Dr. Sandra Batie (MSU) spoke about **Status of Research and Challenging Issues: Agriculture.** She defined sustainability as informed thinking about the future, and suggested that sustainable agriculture should include a populated countryside with healthy, vibrant communities, inhabited with friendly people who are good stewards and receive a good living. It might also be clean, unpolluted, unpolluting, uncrowded environment, with a source of healthy, safe food and excellent wildlife habitat that is attractive to visit, with appealing visual amenities. Research to achieve "System Equilibrium" should consider social institutions and systems, ecological systems, and

cultural identity. Developing indicators and institutions to act on them is a significant challenge, as is incorporating the principles of sustainability into everyday actions.

Randy Kolka (USDA-USFS) spoke about **Great Lakes Water Research in the USDA Forest Service.** Current issues for National Forests include watershed health and assessment, as well as the need to build partnerships to accommodate mixed land uses. State and private concerns look at watershed management as the principal issue. The Forest Service operates a number of Experimental Forests throughout the U.S., including some actively related to water issues. These forests provide long-term databases, reference systems, and the opportunity to do manipulative experiments at the watershed scale. Current research areas include traditionally forested landscapes (BMPs, waterbodies, indicators); mixed use landscapes (landscape change/fragmentation, transition to urban, social sciences, modeling); and restoration. Issues of scale, cumulative impacts, and terrestrial/aquatic interactions are being considered, as are the relationships between people, riparian areas, and aquatic systems.

During Q&A, Dr. Howell clarified that the high irrigated crop values are largely due to increased irrigation of higher value horticultural crops (orchards, vineyards, vegetables) although irrigation of commodity grain type crops has also increased.

5.3. Summary of Agriculture & Forestry Sector Breakout

As directed, participants first engaged in brainstorming on Critical Problems Warranting Research. Review of the initial ideas identified several broad categories where research was thought to be needed:

- **Landscape/land use change**, including (1) consideration of effects on the hydrologic cycle; (2) hydrologic changes from use of tile drainage; (3) importance of the spatial pattern of landscape structure, such as connectivity and patch size in a watershed with regard to functional benefit; (4) long-term responses to landscape change and BMPs; (5) addressing legacy conditions such as roads in valleys, no-burn areas, clear-cut down to streams (examples taken from forestry).
- **Transparent decision-making tools** to compare across multiple types of values (more than just economics) for a range of alternative futures. Several participants strongly advocated the application of a systems science framework that supports comparison of multiple measures. The understanding of the value of water to the economy was also stressed, along with multifunctional values of agricultural and forest lands and public perception of value. This calls for research in the social sciences towards human attitudes and valuation of ecosystem services and non-priced ecological benefits, so that cost-benefit analyses take place on a level playing field. A discussion of performance-based versus market-based measures was also suggested.
- **Importance of science-based policy** must be established so that decisions can be made rationally. Research into riparian area management and processes, such as nutrient, sediment, energy retention and exchange in hyporheic zone, was suggested as an example topic.

- **Economic and resource-based sustainability** to answer agronomic questions, like whether current cropping patterns in the Midwest are sustainable, or is there a need or opportunity to consider or develop perennial crops that reduce the need for tile drainage and associated erosion and water quality impacts? Understanding of the ecological value and consequences of agriculture will help answer these questions. The importance of agricultural and forested lands for their wildlife habitat value, hunting, and agrotourism should be considered, especially as sprawl threatens to convert more and more to urban lands.

Other high-ranking areas of concern included:

- Soil loss, which threatens the sustainability of agriculture and forestry.
- Emerging pollutants, such as antibiotics in agricultural runoff.
- Identification of effective policy tools to influence individual landowners.
- Impending loss of LANDSAT TM and its high-value land use data capabilities.

These areas were then recast in terms of processes, inventories, and tools:

- Research is needed into the underlying **processes** that define the structure and function of agricultural and forested lands. This research should consider the intersections of land use, water quality/quantity, ecosystem, economic forces and potentials
- Understanding of processes must be supported by a comprehensive **inventory** of data that characterize agricultural and forested lands and that can be used to assess current state as well as trends. Research into appropriate indicators is necessary, as well as a commitment to continual monitoring, to cataloging of legacy infrastructure such as tiles, and to appropriate, efficient organization and dissemination of all data. Reporting of agricultural and agronomic data at a finer scale than county-level is highly desirable.
- Decision support and active resource management for sustainability requires multifaceted, open source-based **tools** for scenario analysis. These tools need to be developed to include achievable policies and instruments that bridge spatial/temporal interests while providing incentives and accountability.

Participants then considered **areas of potentially fruitful collaboration**. There was extended discussion of coordinated activities in the State of Washington, where forest product industry works with State agencies and environmental groups to develop a common research agenda that makes funding easier. The forest industry is also a proponent of the systems science approach, which provides a framework for demonstrating the ability to work together and supports decision-making. Consensus was also reached on the importance of stakeholder/science collaboration and a holistic view.

Possible funding sources included the usual sources—DOE, EPA, DOI/USGS, NOAA, USDA—as well as foundations like the Green Lands/Blue Water initiative, NCASI, EPRI, and others. Research that looks at watershed protection may be able to

leverage participation by affected utilities and industrial water users into additional funding. Certain situations may provide additional incentives to agencies for funding, including Gulf of Mexico hypoxia, Chesapeake Bay, the Great Lakes Initiative, San Joaquin Valley, or the downward trend in water quality expected because of the relentless increase of nonpoint sources. Mention was also made of the importance of energy use in programs to realize sustainability, and of possible benefits from coordination with the LTER/NEON and Hydrologic Observatories programs.

A short-term opportunity exists with the new (2007?) Farm Bill, which might provide a mechanism to fund a collaborative effort that incorporates some or all of the following: fertilizer and tile use, restoration of wetlands and streams, food and water safety, incentives and technology for efficient water use, global drivers, and information or tools to support local stakeholder watershed decision-making by autonomous landowners who maintain consistency with environmental goals. This would require development of a technical approach and of appropriate USDA and Congressional staff contacts over the next 12-18 months.

Finally, participants identified land use/land cover changes, their impact on water quantity and quality, and their drivers as possible "**big-picture issues**." Framing this as water security—securing the future of the economy, environment and public health through improved knowledge and management of this fundamental resource—might provide a good talking point.

6. Urban Issues Session

(Water supply, storm water, wastewater, land use, etc.)

6.1. List of Convenors & Speakers

Convenors:

- Jennifer Warner, AwwaRF
- Linda Blankenship, WERF

Speakers:

- Kent Thornton, FTN
- Steve Allbee, USEPA
- Janice Skadsen, City of Ann Arbor
- Peter Adriaens, University of Michigan

6.2. Report

The urban issues presentation session of the Sustainable Water Resources Roundtable workshop was represented by four speakers with unique points of view: a water resources private consultant, a Federal regulator, a water quality manager at a publicly owned drinking water utility, and a water resources engineering academic.

Issues identified during the session ranged from specific research needs to big-picture concerns. A few key issues expressed included the need for comprehensive monitoring of Best Management Practices (BMP) applications; improved public educational tools for conservation (i.e. what is the value of water? do rate-based conservation initiatives work?); training for the additional skills required to manage a sustainable water business (e.g. leadership and governance skills, business system and data skills, and asset management skills); and the identification of new/emerging contaminants and their human and aquatic health effects.

Other general concerns included the need for an improved understanding of the interaction between surface and groundwaters. There is a disconnect in the regulatory arena as well as in the water supply community that surface and groundwaters are separate and unique from one another. Mental models and social landscapes need to be researched to define current social values with respect to water and how this impacts decision-making and public support.

There was a strong sentiment expressed that society has much of the information needed to resolve urban water issues. The information, however, has not been synthesized, integrated, and used to solve these issues.

6.3. Summary of Urban Issues Sector Breakout

The breakout session was attended by 11 participants, and all engaged in the discussion and provided input to three primary questions: 1) What critical problem(s) exist in your organization that research could help?; 2) What are collaborative opportunities to get the research accomplished?; and 3) What big-picture issues are out there regarding water sustainability (imagine you have the ear of a cabinet

secretary or CEO)? Nine research focus areas were identified as described below. The focus areas are not provided in any particular order of importance or relevance.

1. **Competing uses of water** – There is a need to identify and understand the many competing uses for water supply. Some key questions to be answered include:
    a. How are the competing needs for water supply determined and prioritized? Prioritization must be multi-faceted.
    b. If you cannot identify and prioritize the needs, what are the decision mechanisms to allocate supply? Equally important is the need to understand how much water is available and how it can be used.
    c. What is a tolerable loss? A common target for drinking water utilities is to keep "unaccounted for" water no more than 15% of the total volume delivered.
    d. How can stakeholders better communicate and collaborate with respect to mutually acceptable use of finite resources? Water supply does not follow political boundaries.

2. **True value of water** – There is a need to develop metrics to value water for various applications, including formulation of water policy, allocation between competing uses, evaluating impacts of land and water management decisions, public education, and promoting market-based solutions for sustainability.

    The group discussed the merits of estimating the true value of water using a return-on-investment approach. There are two primary considerations to the estimations: 1) the direct aspects of production such as operations and maintenance and capital to produce the commodity; and 2) everything else—jobs, social values, community business development, etc. There is currently no standard for assessing and measuring the true value of water. There was discussion of a great deal of literature available on the topic that needs to be sifted through to obtain common themes and suggested approaches.

3. **Multi-stakeholder source water protection efforts** – How can water resource planners help potentially disinterested parties to get involved in source water protection for downstream needs? NYCDEP's source water protection (SWP) program was discussed at length as an example. NYCDEP spent a great deal of money in upstate New York to protect land, but their actions had no immediate effect. Their successful SWP program came about following roughly ten years of effort with the many landowner and multi-stakeholder associations that were established.

    There are inter-generational issues to consider with the development of successful SWP plans. Such plans cannot be economically driven, but instead a social/cultural discourse is required. There is a need to model the social landscape of the stakeholders in a watershed. How do water resources planners get stakeholders thinking in "watershed" terms?

4. **Land use taxation** – There is a need to further consider the concept of taxing land based upon it use: the concept of taxing land based upon its value separate from the value of improvements on the land. Research is needed to evaluate the influence of land use taxation on urban growth. Urban growth is happening, and it is important to determine how to control it. There is currently no robust way of quantifying the economic impact of development. The concept of "alternative futures analysis" is needed in the toolbox of a water resources planner. This type of analysis is consistent with policy evaluation and the concept of adaptive management.

5. **Aging infrastructure/loss of institutional knowledge** – The water supply community has been losing knowledge due to succession for several years, and is finding the recruitment of new talent challenging. Academia is not shunting new talent to water and wastewater disciplines as frequently as in the past. The 1970s produced a great deal of new talent, and it is speculated that there was a clear, definitive crisis to "save the Earth." Some argue that there is no current apparent crisis and perhaps that "sustainability" should be viewed as a crisis. How do you make water an important issue?

6. **Alternative water supply management structure** – There is a need to identify and evaluate different management and/or organizational structures for the water supply community. This evaluation would need to include well and non-community supplies. There was discussion about smaller utilities being challenged by lack of technical competence and funding.

7. **Connecting water quality, water quantity, land use, and population** – Educational tools are needed to make the intuitive connections between human population and its development/land use with water quality and quantity. This would have great value in getting "non-water" people into the discussion and decision-making at a watershed level.

8. **Model social landscapes** –To understand many of the issues and challenges discussed herein, social landscapes and mental models must be researched. Models for alternative futures are needed with clear outputs that non-water stakeholders can understand. Once social values are understood, there may be an opportunity to begin redefining them to work toward water sustainability. There is a need for all stakeholders to understand that water is water and the public paranoia of "tap to toilet/toilet to tap" phenomenon is misunderstood.

9. **Monitoring** – Current monitoring tools for pathogens and chemical contaminants may be outdated. There is a great deal of new technology being developed (e.g. sensor technology from outside water supply community) with no societal use identified (or rarely). Regulations as currently promulgated can be viewed as disincentives for innovation (i.e. "meet the Rule, now we are done"). Identified technology must also be simplified so strong technical skills (e.g. a Ph.D. chemist) are not required to use the technology.

Collaboration opportunities were not given a great deal of discussion, but a running list of organizations was initiated to include pertinent Federal entities (e.g. USDA, CDC, USEPA, USGS, etc.), Land and Sea Grant Institutions, agricultural associations, pertinent NGOs (e.g. International City/County Management Association, AWWA Research Foundation, Water Environment Research Foundation), economists, and social scientists.

If the group had the ear of a Cabinet Secretary or corporate CEO, the development of metrics to value water would be given the most discussion.

7. Manufacturing & Industry Session

7.1. List of Convenors & Speakers

Conveners:

- Peter Adriaens, University of Michigan
- George Kuper, Council of Great Lakes Industries

Speakers:

- Doug McLaughlin, N. Council on Air and Stream Improvement of the Pulp and Paper Industry
- Glen G. Nekvasil, Great Lakes Carrier Association
- James Volanski, USS Great Lakes Steel Works
- Brian McCord, Coca Cola

7.2. Report

Glen Nekvasil (Great Lakes Carriers Association) addressed the research needs to promote Great Lakes shipping. Four topics were discussed: economic impact; environmental benefits; non-indigenous species in ballast water; and dredged sediment. On the first topic, it was argued that there is no comprehensive economic analysis to tie the value to shipping and job creation to water management (i.e. impact of increase or decrease of shipping). Second, the point was made that shipping has limited environmental impact from the perspective of fuel use and emissions when compared with other economically sensitive transportation (i.e. rail and trucks), and indigenous species. It is misunderstood that not all shipping causes introduction of invasive species; since the Great Lakes carriers are confined to the Lakes, the aquatic ecosystem is contained. For shipping not confined to the Great Lakes basin, efforts are being made to filter ballast water, and to research opportunities for better secondary treatment. Because shipping relies on water quantity (i.e. depth), it is intrinsically linked to dredging. With CDFs reaching saturation, there are research needs to reconsider open Lake disposal, and to increase opportunities for shore restoration and beach nourishment.

Brian McCord (The Coca Cola Company) discussed the needs for an industry reliant on consistent quality of freshwater resources, since it is the main ingredient in their product, there is a fiduciary obligation to address water risks, and the limitations to growth presented by overuse/poor management present limitations to growth. Coca Cola has addressed these issues internally through a globally implemented four goals program: increasing efficiency by minimizing water usage and wastewater production; the formation of community partnerships to ensure access to clean water in communities; supporting the protection of watersheds in regions where they operate (through hydrology and hydrogeology research); and mobilizing the international community through media and ENGO engagement initiatives. Water R&D is integral to Coca Cola's global water initiative aimed at identifying and

mitigating risks, increasing quality, lowering costs, providing stewardship, and ensuring sustainability.

James Volanski (American Iron and Steel Institute) provided an overview of the steel-making industry and the role for water in heat dissipation and rinsing processes, and the impact of these processes on pollution discharge permitting. Whereas substantial progress in the steel-making industry's environmental record was noted (e.g. steel recycling, mercury/PCB reduction, Brownfield cleanup), substantial research needs are recognized. There is a need for holistic approaches to emissions and water management ('regulate what is controllable'), specifically environmental regulations pertaining to intake structures, air/solid waste, and detection limits in emissions streams. Whereas regulations are driving industries towards closed-loop systems to replace once-through cooling, the issue of evaporative losses as the result of closed-loop systems needs addressing. Lastly, research is needed on the issue of competitiveness of the steel industry and the economic impact of Great Lakes levels on productivity.

Doug McLaughlin (NCASI) framed the research challenges for paper-making along three questions: What is sustainable water resources management? How do we know when we have achieved this objective? and What is it worth? Arguments were presented to reframe the objective towards incremental changes within reasonable economic boundaries and to move towards minimal adverse environmental impact (as opposed to 'no impact'). The research needs were defined along two tracks: environmental impact in terms of fate and transport of contaminants (in situ, in vitro and modeling), and water quantity (pollution prevention, water reuse, and adverse environmental impacts to aquatic and terrestrial life). Specific emphasis was placed on wastewater volume reduction strategies, and effluent quality mitigation from the perspective of oxygen demand and adsorbable organohalogen (AOX) metrics.

7.3. Summary of Manufacturing & Industry Sector Breakout

I. Research Priorities

Three main research priorities were defined: Water quality monitoring, Water conservation and re-use, and Water quantity.

1. Water quality monitoring

The panel understands that water quality as impacted by industrial activities is a high priority requiring accurate monitoring, not only in source and receiving waters, but as the water is used in the facility or system.

First, to allow for the monitoring to be as effective as possible, the panel strongly supported the **development and use of new monitoring technologies** for the entire water cycle (source, use, disposal). Particularly, maximization of distributed monitoring networks as well as multiple endpoints was encouraged, to avoid reliance on single point measurements and single indicators of quality, and to minimize reliance on insufficient information for large-scale impact. On the other hand,

industries such as Coca Cola are concerned about water quality for carbonated drinks; several instances have been reported where the regional or country-wide water quality is below specifications for this application. Hence, water quality monitoring has a substantial direct economic impact on some industries as it influences markets.

Second, there is a need to **understand baseline conditions** on a temporal and spatial scale, to avoid confusion between water quality impacts from natural perturbations relative to industrial interference. Clearly, multiple and proper baseline indicators have to be considered for policy-making and remedial requirements. Reference was made to opportunities to link up with the National Science Foundation's CLEANER (Collaborative Large-Scale Engineering Assessment Network for Environmental Research) program. Its objective is to develop and integrate instrumentation for systematic and dynamic evaluation of ecosystems' conditions and flows across and within media aimed at improving management strategies for ecosystems by controlling anthropogenic inputs and applying remediation techniques.

Third, it is understood that any policy decisions from water quality monitoring have to be made within an uncertainty-based data framework. From this perspective, the panel strongly supports the development and integration of **predictive modeling tools** properly scaled for industrial water uses under consideration (e.g. rinsing and cooling, discharge impacts, drinking water).

2. *Water conservation + reuse in manufacturing*

Industries are increasingly recognizing the benefits of, and are moving towards closed-loop (near-zero emissions) water systems. The benefits result from less need for permitting requirements and cost-reduction from decreased use. For example, depending on the source water, the steel industry has moved away from once-through (single use) systems to closed-loop (requiring the need for make-up water only) systems for cooling and rinsing needs. However, there is a need for **new technology** development toward achieving higher rates of re-use, including membrane technologies and heavy metal removal technologies.

Best available technologies (BAT) tend to be capital-intensive, resulting in resistance from industry to invest. Hence, **incentives for their implementation** need to be identified (perhaps analogous to cap and trade system for air quality). Further, **regulatory barriers** to technology implementation need to be addressed and translated into opportunities. For example, imposition of a BAT may not be the best approach to addressing emission problems, considering the process improvements and technology evolution that may occur during the time gap between the technology identification and its implementation. Lastly, business-to-business opportunities have to be recognized in water use, as water quality standards are not the same for each application (i.e. can one industry's effluent be used as another's source water?).

3. *Ensuring adequate availability of sufficient quantity or quality of water and/or prediction methods*

Water quantity impacts all industrial sectors, including lake carriers. Hence, further research is needed in the area of **lake level prediction**, impact assessment, and policy decision-making for lake depth management through **dredging**. Considering the

multi-stakeholder use of the lakes, decisions based solely on ecological impact may have a negative impact of industrial withdrawals and regional economic growth. Hence, there is a need for multivariate analysis of **factors potentially limiting supply**.

II. Collaboration

The panel recognized the need for better integrated collaboration at local, State, and Federal levels for water quality and quantity management among industrial sectors. However, due to competitive pressures, the **business case needs to be made** for collaboration among competing industries or sectors. For example, can new markets be identified (such as business-to-business opportunities for water use), or **incentives provided** (emissions credits, tax relief, etc…)? There needs to be more active research on these opportunities, focusing on the business environment, rather than theoretical inquiries, isolated at universities and policy institutes.

III. Mega-themes

The mega-themes that emerged from the discussion were: **ensuring constant quantity and quality of water**, and need for establishment of an **effective discussion "table.**"

8. Ecological Protection and In-stream uses Session

8.1. List of Convenors & Speakers

Convenors:

- Al Steinman, Annis Water Resources Institute, Grand Valley State University
- Lucinda Johnson, Natural Resources Research Institute, University of Minnesota-Duluth

Speakers:

- Lucinda Johnson, Natural Resources Research Institute, University of Minnesota-Duluth
- David Allan, University of Michigan
- Brian Hill, USEPA
- Andy Warner, The Nature Conservancy

8.2. Report

Considerable attention has been devoted to the establishment of fresh water ecological indicators in the United States and Great Lakes basin. These indicators include physical (e.g. flow regime), chemical (e.g. macronutrients), and biological (e.g. algae, macroinvertebrates, fish) parameters. However, it is also apparent that the relationship between indicators and system response is not always straightforward. Confounding considerations include: 1) teasing apart direct from indirect effects (e.g. a decline response in trout populations that is associated with increased impervious surface in a watershed is mediated through the increased sediment load); 2) identifying the influence of spatial and temporal variation in system response (e.g. parent lithology will influence relationships between biotic response and water nutrient concentration across a broad landscape); 3) linear vs. non-linear system responses to ecological stress (there may be a threshold response); 4) difficulty in accurately quantifying stress-response relationships in natural environments (as opposed to laboratory settings), due to multiple stressors impinging most systems; and 5) moving forward even though our information is neither complete nor perfect.

Identifying and applying conceptual and predictive models that are tractable and understandable to the general public will be important tools in the utilization of fresh water ecological indicators. The flow regime concept, which includes the key descriptors of flow magnitude, frequency, duration, timing, and rate of change, and the Limits of Hydrologic Alteration (LOHA) method, which incorporates the flow regime concept in its approach, are two such models. Both models emphasize that the one-size-fits-all approach is inappropriate for characterizing stream responses, and that flow criteria for either individual streams or streams within watersheds or across ecoregions must be tailored to the natural flows of that specific geographic entity.

It also was emphasized that ecological indicators, while valuable tools, are not enough to ensure sustainability of freshwater resources, for at least two reasons. First, on an operational level, indicators measure the symptom, not the problem; we

must identify the stressors that result in that symptom to prescribe corrective action. In addition, we need to understand how indicators scale-up to the system-level, where conflicts regarding competing demands for water are ultimately resolved. Second, and clearly related to the prior concern, indicators can inform us about ecosystem condition, but they alone can not tell us how our freshwater resources should be allocated in the face of competing water demands by industry, utilities, agriculture, and the environment,.

Human activities (e.g. land uses such as urban development, agriculture, forest harvest) clearly result in stressors to ecological systems. The implementation of remedial actions and best management practices can reduce the impact of stressors resulting from human activities; however, there is insufficient knowledge regarding the long-term effects of such practices, particularly with respect to the recovery of biological communities and functions. Such research is sorely needed.

8.3. Summary of Ecology Sector Breakout

What critical problems exist in your area of interest that warrant high priority research to help us promote sustainability of water resources? The following list aggregates an extensive list of research questions into four categories. The full list of research priorities, as defined by the full break-out group, is included in Attachment 1.

1) **Understand baseline conditions**: Baseline conditions form the basis for comparison with current conditions. The time frame for establishing baseline conditions must be defined by society with specific goals in mind. For example, pre-European settlement vegetation cover is frequently used as an historic baseline for quantifying land use change; however, historic water quality conditions are best determined using paleolimnological techniques, (e.g. diatoms from sediment cores). Important components related to the identification of baseline conditions include quantification of:
   a) Natural disturbance regimes (e.g. frequency & magnitude of fire, flood, hurricane, windthrow, debris torrent).
   b) Historic land use and land use legacies (the current manifestation(s) of historic land use).
   c) Scales of responses (e.g. baseline conditions must be bounded by the question or goal, and these boundaries are characterized by both temporal and spatial scales).
2) **Quantify relationships between Stressors and Responses**: Sustainability of water resources cannot be quantified without appropriate knowledge of how particular stressors influence ecological endpoints of interest. While dose-response relationships are routinely established in laboratory settings, the quantification of stressor-response relationships in the environment is difficult due to the presence of multiple stressors impinging on the system, interactions between temporal and spatial scales of responses (i.e. due to lag times, thresholds, etc.), and distinguishing responses to background (natural) environmental

variation versus anthropogenic sources of stress. Particular areas of research that were deemed important in this category include:

a) Characterizing and quantifying components of the hydrologic regime as stressors: while much attention has been devoted to addressing water quality issues, water quantity (too much, too little, altered flow patterns and hydroperiods) as a stressor is poorly studied, particularly with regard to ecological impacts.
b) Best Management Practices: BMP effectiveness is poorly understood. In particular, the questions: What is the temporal and spatial scale of effectiveness of a given practice? How does the trajectory of habitat improvement relate to improvement in the condition of the biological community? How does the spatial position of BMPs influence the outcome?
c) Cumulative impacts: The "tyranny of small decisions" is an adage that applies, in particular, with respect to the effects of human activities on water resources. This area of research begs for approaches that address both the social (i.e. planning and policy) and environmental aspects of the problem.
d) Resistance and resilience: Ecosystems (and biotic communities) exhibit fundamental responses to disturbance that influence their response to disturbance and recovery dynamics. While some ecosystems and disturbance types have been relatively well-studied, others are poorly understood.
e) Quantify human vs. natural responses: Effects of human disturbance must be separated from natural variation in ecosystems due to climatic, geologic, and other underlying factors. Furthermore, regional variation must also be understood and quantified.

3) Policy Issues:
   a) Narrative vs. numeric criteria (see also 4b).
   b) Relate criteria to valued attributes as defined by stakeholder values.
   c) Laws: For example, how can existing laws be used more effectively to promote water sustainability?
   d) Identify and understand the social values of water resources.
4) Methods Development
   a) Decision-Support Systems are useful tools for implementing management objectives, yet need further development in the area of water resource sustainability. (How do we decide, and under what conditions, where water goes?)
   b) Criteria Characterization: Quantitative versus qualitative criteria must be developed to ensure that environmental goals can be understood and effectively implemented by all users of the resource.
   c) Define a process by which society can effectively define goals. Since goals change over time, and in response to prevailing knowledge, goal-setting methodologies that incorporate adaptive management techniques will allow goals and objectives to respond to new knowledge acquisition.
   d) Monitoring Technology: Technologies for monitoring (in particular, ecological parameters) at inflows to lakes and wetlands are especially lacking, compared to those established for riverine systems.
   e) Quantify both natural and anthropogenic consumptive uses (e.g. ET).

f) Gain a better predictive understanding of the impacts of groundwater withdrawal on water-dependent natural features.

What areas of cooperation and research collaboration do you see as fruitful in promoting funding and achieving success in sustainability research as it relates to the issues you identified?

a) Water quantity and quality issues affect different users. How does this affect actions among users from different sectors? How can these actions be better integrated?
b) Perform an integrated assessment of impacts on important endpoints across sectors of society.
c) Develop decision-support systems to use the information generated in the assessment (see above).
d) Define the effect of water quantity on uses by different societal sectors.
e) Develop and implement a goal-setting process.
f) Address goals at appropriate spatial scales (i.e. local (e.g. townships), regional (e.g. state)); incorporate both political and ecological entities (e.g. watersheds, ecoregions).
g) Quantify the flow/hydrology to provide baseline information to end users.
h) Understand the existing infrastructure to promote programmatic collaboration. Many of these ties already exist, but are not used effectively (e.g. use the GAO's report for the Great Lakes).
i) Cross-walk existing indicator development efforts, e.g. SOLEC (Great Lakes), Heinz Center (national), EPA (national), GLNPO Wetland Consortium, and Great Lakes Environmental Indicators (Univ MN Duluth) indicator efforts. Do not try to reinvent the wheel.
j) Development and evaluation of BMPs (as they relate to ecological impacts) for each sector.
k) Develop new methods for encouraging collaborative interactions among scientists, social scientists, economists, and the public.
l) Conduct economic valuation study to obtain full-cost accounting of water-dependent ecosystem goods and services

For a cabinet secretary or CEO of a large multinational corporation considering long-term sustainability, what *big-picture* issues do you see as the highest priorities for research for the U.S. to better achieve sustainable water resources?

1. Long-term sustainable funding for water resource research and monitoring.
2. USGS gauging stations.
3. Quantify consumptive uses.
4. Quantify the real cost (i.e. full cost accounting) of the resource (see above).
5. How much can I take (water quantity) before I get in trouble?
6. How much resource alteration (i.e. water quality) can be sustained before I get in trouble? (refer to resource use and inputs).

7. Will there be enough water to meet our needs (considering all sectors of society and ecosystems)?
8. Develop a funding and communication network for responding to issues that integrates government, university, and industry groups. Objective would be to promote collaborative relationships. Promote adaptive management.
9. Develop new methods for encouraging collaborative interactions among scientists, economists, and the public.

Discussion: Define ecological sustainability:

A. CEOs want to know about where they will get water in the future.
B. What are the qualities of sustainability that a CEO would care about?
C. Recommend that we list the components of sustainability- instead of defining sustainability. Also list what sustainability is NOT.
D. Importance of clarity in water use, withdrawal, and diversion regulations. What can and cannot be done? Is there consistency in the regulations among sectors?

Attachment A.

Specific suggestions regarding research needs:

- Research regarding quantitative links between groundwater, flow regime (hydrology and hydraulics) and lake levels to ecological endpoints of concern.
- Identify thresholds in flow regimes that influence ecosystem responses. (e.g. expand on knowledge e.g. cottonwood responses). Quantify role of alterations of natural flow fluctuations to invasive species establishment.
- Quantify geomorphic context on ecological endpoints of concern.
- Quantify historic disturbance regimes and historic conditions.
- How do human activities and climate change interact to affect water quantity, and how does water quantity affect valued ecological attributes in ecosystems (aquatic and terrestrial)?
- How do ecosystems respond under natural disturbance regimes?
- How do state laws incorporate the best ecological standards and indicators in water withdrawal laws?
- Cumulative impacts of water withdrawals on ecosystems? What is the scale at which cumulative effects need to be considered?
- For Lakes: Development of monitoring technologies for monitoring (ecological parameters and) inflows to lakes and wetlands.
- What are the appropriate things to monitor with the above technologies?
- Quantify reliance and resistance in ecosystems for better refinement of indicators.

- How can water sustainability issues be integrated with those of the other groups? What kind of decision-support can be implemented to prioritize and optimize valued societal attributes for water uses?
- Quantify effectiveness of BMPs, and determine the spatial and temporal scale at which BMPs must be deployed to be effective. (Noah: BMPs for Ag are geared to reducing water use.)
- Improve understanding about consumptive uses (including natural factors, e.g. ET)

Main points that emerged during the discussion:

- What areas of research were mentioned as needing attention to enhance the sustainability of water resources in the U.S. or a region or watershed?
- What suggestions emerged for collaboration on crosscutting or big picture projects?
- Who are the potential collaborators?
- What support can SWRR give to encourage follow up on these possibilities?

9. Ethics, Law and Policy Session

Convenors:

- Peter Adriaens, University of Michigan

Speakers:

- David Urban, Land and Water Resources, Inc., Rosemount IL
- Noah Hall, Great Lakes Natural Resource Center, National Wildlife Federation, Ann Arbor, MI; currently: Wayne State University Law School, Detroit

David Urban discussed three approaches to water policy, focusing on the opportunities for market-based solutions to help sustain water resources in the Great Lakes basin by improving distribution, allocation and ecosystem health. Current policy for the Midwest and Eastern states is defined under a "commons" system of water management for both surface and groundwater. This regional approach to water rests upon the reality that States east of the Mississippi have traditionally been blessed with an abundance of water. Under this regime, property owners can use the water that flows through their land without worry or constraint, as long as the downstream user is not adversely affected by the upstream use. In addition, groundwater has traditionally been viewed as separate from surface water, and freely available to any who drill for it. The Great Lakes are at a point where many people are wrestling with how to rework environmental water policy with respected to multi-stakeholder water use. For example, the Great Lakes Charter Annex, in its attempt to create regulations water use, is incorporating a wide range of different viewpoints (protection, free use, etc.). These regulations have to be reconciled with the 1986 Water Resource Development Act, which delegated to the States the power to agree on water diversions, even though the Great Lakes should fall under Federal purview due to the Commerce Clause of the Constitution. International trade laws, such as GATT, also have legal implications as to what can and cannot be done with Great Lakes water.

A pertinent case study was presented to illustrate how wetland management evolved from a 'command and control approach' (which failed to protect wetlands from development) to a wetland mitigation banking system (which has restored large-scale ecosystems while maintaining development). This example was used to argue for a sustainable approach to supporting both human use and ecosystems through a regulated market mechanism which requires an assignment and guarantee of "value" for the market to succeed. Hence, this approach hinges on the proper valuation of water, to create a supply and demand market.

Noah Hall discussed a proposal based on the legal enforcement of standards for resource protection to address water use and resource governance. Addressing the potentially competing pressures of economic development and environmental protection is only part of the challenge. The real struggle has been in governance: how is management of an international transboundary resource best accomplished under the legal and political limitations of Constitutional federalism? This question is not unique to the Great Lakes. With the Federal government stepping back (or being

pushed back) from environmental protection, States need to explore new options for managing regional resources and environmental problems that cross political boundaries.

A proposal being considered by the Great Lakes States and Provinces takes a new approach to interstate environmental protection. Under the proposed Great Lakes Basin Water Resources Compact and companion Great Lakes Basin Sustainable Water Resources Agreement, the world's largest freshwater resource would be protected and managed pursuant to minimum standards administered primarily under the authority of individual states and provinces. The proposed Compact and Agreement put riparian water use rules and environmental protection standards into a proactive public law regime in eight States and two Canadian Provinces. The standards represent numerous advances in the development of water use law, including uniform treatment for groundwater and surface water withdrawals, water conservation, return flow, and prevention of environmental impacts. This approach incorporates more of a command and control mechanism (rather than a market-based solution) to manage the Great Lakes resource according to accepted or negotiated standards.

Appendix 1

Great Lakes Region

Water Sustainability Research Workshop

Agenda

Agenda
Sustainable Water Resources Roundtable
Great Lakes Region Research Priorities Workshop
April 5 & 6, 2005
University of Michigan
Ann Arbor, MI

Day 1, Tuesday, April 5

8:00	Coffee and continental breakfast
8:30	Greeting, workshop background and objectives
9:00	Session 1: Power Generation
10:15	Break
10:30	Session 2: Agriculture & Forestry
11:45	Lunch & introductions by participants
12:15	Federal & Great Lakes Regional Collaboration
12:45	Session 3: Manufacturing & Industry
2:00	Break
2:15	Session 4: Urban Issues
3:25	Session 5: Ecologic Protection & Instream Uses
4:40	Role of Renewable Resources
5:00	Day's recap and Adjourn

Day 2, Wednesday, April 6

8:00	Coffee and continental breakfast
8:30	Water Policy Law & Ethics
9:10	Charge to Break-out Discussion Groups
9:20	Concurrent meetings of 5 break-out groups
10:30	Break
10:45	Break-out session resume
12:00	Lunch & presentation on SWRR –Draft National Sustainability Indicators
1:00	Break-out groups report back to entire workshop
2:00	Open discussion on integration of research priorities
3:00	Break
3:15	Workgroup discussion on Draft National Sustainability Indicators
4:15	Report back on Indicator Discussions
4:50	Closing comments
5:00	Adjourn

Appendix 2
Speaker Contact Information

Speaker Contact Information
Sustainability Water Resources Roundtable
Symposium and Research Workshop
April 2005
Ann Arbor, Michigan

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Appendix 3
Participant List & Session Participation

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Appendix 4
Workshop Presentations

The pdfs containing these presentations are available on SWWR's web site:
http://water.usgs.gov/wicp/acwi/swrr

- Power Generation
- Agriculture and Forestry
- Urban Issues
- Manufacturing and Industry
- Ecological Protection and In-stream Uses
- Ethics, Law & Policy

Appendix 5
Sustainable Water Resources
Contact Information

Sustainable Water Resources Roundtable

SWRR Purpose:

Serve as a forum to share information and perspectives that will promote better decision making in the U.S. regarding the sustainable development of our nation's water resources.

The SWRR serves as a national forum to share information and promote indicators and research for sustaining water and related resources. SWRR is an authorized working group of the Advisory Committee on Water Information (ACWI) that advises Federal Agencies. Participation in SWRR is open and intended to include a wide range of interests and views.

The SWRR is one of four Resource Roundtables; the others work on forests, rangelands, and minerals and energy. The White House Council on Environmental Quality is currently creating a system to integrate environmental information and indicators from all four Roundtables contribute to that effort.

Over two hundred people have participated in SWRR meetings. Between meetings, a steering committee of volunteers meets in subgroups and moves the work forward.

For More Information:

Additional information on the Michigan meeting of the Sustainable Water Resources Roundtable is available at http://water.usgs.gov/wicp/acwi/swrr or by contacting:

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