Water Resilient Cities

Climate Change, Infrastructure, Economies, and Governance in the Great Lakes Basin

April 21 & 22, 2016

Conference Proceedings

Maxine Goodman Levin College of Urban Affairs

Note from the Conference Chair Dr. Wendy Kellogg

We are very pleased to provide a summary of the Water Resilient Conference held in April 2016 at the Levin College of Urban Affairs. We urge you to review the conference web page for film and power points for the sessions described in this report.

I wish to thank many people who made the conference possible: our advisory committee, who provided ongoing guidance on themes, logistics and participants (listed below); the organizational partners that provided in-kind contributions and guidance; and our sponsors which each provided generously to allow us to organize and stage the conference and produce the web page, videos and this report.

We are most grateful for their confidence in our capacity and their commitment to the topic of water resilient cities. Finally, I want to thank the staff and students at the Levin College, listed below, who each, in his or her own way, contributed to the success of this conference.

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1.0 Introduction

1.1 Purpose of the Conference

Cities and their metropolitan regions around the globe are now the habitat for the majority of people on the planet and are the locus of most of the economic production and consumption. As such, cities will profoundly influence water management over this century (Whitler and Warner, 2014; The City Upstream and Down, 2015). One of the most significant advancements in our thinking about water in the early 21st century is the recognition of two important conditions. First, much of the world will face water stresses during this century, either because of inherent limits, such as in arid regions, increasing population, and/or increasing income levels and economic development, both of which may increase demand for water and generate higher levels of pollution without technological improvements. Secondly, professionals who manage water and researchers who seek to understand and support that management increasingly recognize that the challenges of water stresses need to be addressed through adoption of more integrated policy and management frameworks implemented through cross-disciplinary and cross-sector collaboration.

The Water Resilient Cities conference that took place in April 2016 focused on the Great Lakes ecosystem and the cities in the basin. Our special place in the Great Lakes basin ecosystem imports a somewhat different setting than for many cities. Here, we have an abundance of water, but as we have learned, protecting the quality of the water and managing its use is critical to ensuring a secure supply of water, now and into the future (Michigan Land Use Institute, 2003; Gregg et al., 2012). Our cities are often labeled legacy cities to recognize the history of manufacturing and pollution and aging infrastructures built for many more people (The American Assembly, 2011). Revitalization efforts here will require reinvestment in aging public infrastructure, including water and wastewater.

These realities gave inspiration to the purpose and organization of the Water Resilient Cities Conference, which was to explore how cities can manage water collaboratively to become resilient to the disruptions of climate change as these affect water-dependent ecosystem services and water security for urban populations. We organized a two-day conference at the Levin College of Urban Affairs at Cleveland State University, framing the conference using resilience themes and an integrated approach to knowledge and management. The resilience themes are described more fully below, but the overall purpose was to bring water professionals, land planners and researchers together for a conversation about “water and cities” and how, by working collaboratively, cities can be planned and managed to ensure that water is available for people, for economic production, and to preserve vital natural areas and their ecosystem services in metropolitan regions in the face of climate change and weather disruptions.

More practically, the objectives were to:
1) convene a broad range of people in water and land management professions together as participants;
2) engage the conference attendees in using resilience as a framework to think about managing water resources;
3) foster formal and informal conversations to share best practices and identify industry and research needs; and

4) provide access to water related scientific and technical information to the general public and the broader community of professionals and researchers across the Great Lakes basin.

For our first objective, we targeted specific attendees across water-related fields of practice. Our goal was to ensure that the attendees were people already working in water management and related fields, experts who could offer insights and suggestions based on their practice. We targeted people from academic disciplines and professional fields of practice to achieve a "one water" perspective, or as is often sought in appreciative inquiry facilitation, to have "the whole system in the room" (Cooperrider and Srivastva 1987) when planning for change.

More than 140 people attended the conference as registered participants, including professionals from the fields of city and regional planning, drinking and waste water operations, storm water management, watershed management, water technology development, economic development, port operations, and coastal management, and a range of local government associations, regional government entities, and elected local officials. Participants came from across the Great Lakes basin, preponderantly from northeast Ohio, but from all but one Great Lakes state. Several attendees were from Washington DC and states outside the basin. Faculty researchers and students from across the Great Lakes basin attended as well, and a cadre of CSU students assisted in note taking at sessions throughout the two days.

A post conference survey was sent to all conference registrants. The survey garnered a response rate of 18%. Twenty five percent of the respondents were from a university setting, followed by public waste water entities and non-university think tank or research organization (8.3%), and 2.5% from private sector engineering firms. Other respondents were affiliated with public water agencies, watershed nongovernmental organizations, city or county planning agencies, private sector planning or architectural firms, water technology firms, and economic development agencies. The overall feedback from the conference was positive; 75% of the survey respondents strongly agreed that a multi-disciplinary orientation is needed to address climate disruption and water issues and 66% strongly agreed that the conference themes of infrastructure, economies and governance were relevant to their professional practice/research.

About the overall experience of the conference one participant remarked, "Thought [this] was one of the better conferences I have been to on the topic. Came away feeling more knowledgeable and challenged to think about water resiliency.....holistic thinking." Another stated, "I thought it was excellent. I got to interact with others interested in the Great Lakes and its resilience to climate change and are looking forward to attending future events."

1.2 Conference Agenda Overview

The conference was organized as a series of keynote and panel presentations, attendee participant presentations (chosen through an abstract solicitation process), and facilitated workshop sessions to foster conversations and knowledge sharing (See Appendix 1 for the conference schedule). Expert presentations for the opening plenary introduced resilience concepts (Dr. Wendy Kellogg), trends on climate change research focused on the Great Lakes (Ms. Elizabeth Gibbons), economic value of water (Mr. John Austin), and transitioning to integrated water management or "one water" for cities (Ms. Carol Howe). The Eaton Water Innovation key note speaker (Professor. Hillary Brown) presented on integrated and synergistic public water infrastructures. A set of presentations from attendees illustrated these concepts through case studies of practice. Two parallel best practices and

research sessions, each with three tracks, featured conference participants presenting best practices and current research. A discussion of resilience themes from these presentations followed each session. A Breakout Work Session, organized into three tracks, brought participants together in facilitated discussions organized on the basis of what they had learned from the presentations implied for their professional practice in terms of economic development, urban land use and design, and governance of water in the city. A final session of all conference participants focused on Strategies for Research and Practice.

Outreach for the conference to generate interest and attendees includes a web page and emails targeted to over 200 organizations across the Great Lakes basin. These included environmental consultants, water-technology oriented private companies, foundations, academic colleges and universities, environmental and water focused research organizations, water and wastewater related professional associations (water environment associations, wastewater associations/agencies, etc.), state chapters of American Planning Association in the GL basin, state level agencies (environmental protection agency, department of natural resources, etc.), city and county level planning departments and commissions, city utility departments, regional waste water and stormwater management districts/departments, local elected and public officials, regional and national level environmental and water focused research organizations, national and regional non-profit research and advocacy organizations.

Post-conference reporting includes a web page, twitter, linked in, and emails announcing the distribution of conference materials. The presentations are all available as power points and as recordings on the post-conference web page https://www.csuohio.edu/urban/events/Water-Resilient-Cities-Conference. The best practices and research session power points are also available on the site. The keynote presentation by Professor Hillary Brown was offered as a Levin Forum, open to the general public as well as conference attendees.

2.0 Water Resilient Cities: Conference Framework

2.1 Water and Great Lakes Cities

Climate scientists have been researching the effect of climate change on the Great Lakes for decades. Plausible scenarios for the next 50 to 100 years indicate an overall decrease in water levels in the Great Lakes due to increased evaporation and less frequent ice coverage, with more frequent extreme storm events, generating increased flooding and stormwater volumes exceeding current infrastructure capacities (Kahl and Stirratt, n.d.; Kling et al., 2003). The urban built form and ecosystem services will be disrupted by climate change, including amplified need to address stormwater with more frequent severe storms and flooding issues (Backus et al., 2012; Hoornweg et al., 2010). Redesign of these systems needs to include greater flexibility to respond to changing conditions. Changing climate conditions, changing invasive species threats because of it, and increased eutrophication may dramatically change access to clean water by raising costs for treatment. Increased energy costs may also shift conditions in the Great Lakes basin (Hinderer and Murray, 2011). Changing lake levels may adversely affect transportation, commercial shipping, recreational uses, and water intake infrastructure (Kahl and Stirratt, n.d.). Financing water infrastructure is already challenging for communities; how will communities pay for a more adaptable water infrastructure?

Governance and the participation across the basin are and will continue to be critical to ensure stewardship and sustainable use of water resources (NOAA's Next Generation Strategic Plan, 2010; Simonsen et al., 2014). Revitalization of Great Lakes cities depends upon continued sustainable governance of the lakes systems and of the waterways that flow into them (Manno and Krantzberg, n.d.).

It is the manner in which problems are framed (e.g., water as waste vs. water as resource), in part based on the ways in which stakeholders conceptualize the value of water, which shapes public policy (Head, Frodin, and Nastar, 2012; Groenfeldt and Schmidt, 2013). Governance systems will need to change to become more flexible, more anticipatory of change (Quay, 2010) while maintaining regulations and incentives to support the overall health of urban waterways in the Great Lakes.

2.2 Resilience

Every city in the Great Lakes basin is part of a complex social-ecological system (SES), constituted by the natural aspects of the Great Lakes basin, the built form of urban center itself, and the social systems that operate across them. These social systems include government, private entities, our economy, and civil society. In an SES, natural and human systems exist in a reciprocal, interdependent relationship (Walker and Salt, 2006), and disturbances fast or slow, large or small, in any of the subsystems can precipitate change across the entire system (Resilience Alliance, 2010; Walker and Salt, 2006). The complex nature of these SESs and their relationships imply uncertainty and non-linear changes to disruptions. It is uncertainty that is the hallmark of climate change scenarios, and it is under conditions of uncertainty that public responses to climate change will occur (Resilience Alliance, 2010; Simonsen et al., 2014).

A key aspect of this uncertainty is how society can know what will happen in the future, what changes are plausible or likely, in order to plan. Resilience to disruption and uncertainty requires new knowledge, but more importantly, requires new approaches to planning and management (Liu et al., 2007; Simonsen at al., 2014). Planning and management will need to account for the uncertainty in the system, to anticipate as best is possible, but to put infrastructure and management systems in place that can respond and be more flexible as the future unfolds (Simonsen at al., 2014).

In each metropolitan region in the Great Lakes basin, multiple organizations "govern" water in all its stages in the hydrological cycle. Today each region has multiple public utilities that manage drinking water, sanitary waste water, storm water and watersheds. Each of these areas of practice has its own professional community, and it is not common for these professionals to interact in more than a cursory way. Each of these organizations also operates in a nested hierarchy of geographic scale and intertwined organizational networks (Liu et al., 2007; Pahl-Wostl et al., 2007). For example, a water utility in a small community is subject to federal and state regulations, uniting the local level to larger regions and levels higher in the bureaucracy. The small community may be part of a larger geography in terms of how its waste water is managed as well. It also is part of an economic market which likely does not conform in its boundaries to water-focused regulations or governance. These overlapping geographies and hierarchies make organized anticipation and response difficult (Kaufman, 2008).

In terms of the broader system, this complexity can amplify or constrain disturbances and uncertainties, and give rise to the need for changing governance regimes to have greater communication and feedback, and change over time as conditions change (Westley et al., 2011)).

Adaptive capacity of human management systems is the basis of resilience to future disruptions and supports the ability of the system to maintain its function or transform. Capacity to adapt is based on acquisition of knowledge and understanding that is relevant to new conditions that can effectively support decision making. Adaptive planning and management is the basis of our response to uncertainty, including governance, but also implies using the strength of market mechanisms to drive changes in technology and industry as conditions change (Backus et al., 2012; Simonsen et al., 2013).

Overall an approach that embodies resilience implies *efforts to reduce exposure to hazards*, thereby reducing risk to human populations and the economy. It also implies *anticipatory management* that adjusts over time as uncertain states become know. It may also imply rethinking the *utility of reliance on hard infrastructure* with a 50-year project life span when conditions may change more rapidly than in the past. It also implies a *more flexible governance system* that can adapt more readily and find innovative solutions.

2.3 Urban Resilience

We are in a new area for urban planning and city management scholarship and practice. As the Resilience Alliance (http://www.resalliance.org/index.php/urban_resilience) notes, we need to understand better the major challenges facing urban systems and the landscapes they comprise. Urban resilience is based on the concept that cities must be planned, organized and managed to ensure they can respond or transform to an increasingly uncertain physical environment. Rather than assume the world will be as it has been and plan to achieve a set of goals, governance of cities assumes the world may change in unpredictable ways and plan to strengthen the adaptive capacity to respond to changes and transform key aspects of cities as needed. The Kresge Foundation (2013), in its report *Bounce Forward: Urban Resilience in the Era of Climate Change*, defines resilience as "the capacity of a community to anticipate, plan for, and mitigate the risks—and seize the opportunities—associated with environmental and social change" (p. 11). Several major urban-oriented think tanks and institutes point to water, water infrastructure and surface water as key issues to be addressed in a "new urban agenda" focused on resilience and climate change (Rockefeller Foundation 2015; United Nations Habitat III 2016; Mulroy 2008; American Planning Association 2016).

A resilience approach implies efforts to *reduce exposure* to hazards, thereby reducing risk to human populations, but also *anticipation* of the plausible changes that may occur and thinking through the implications to adapt urban systems more appropriately. It implies that we don't simply "bounce back" from disruption, perhaps reinforcing old patterns and systems that may not be desirable or effective. Instead, the approach also suggest we seize disruption as an opportunity to rethink the underlying relationships among urban systems (natural and social) and move cities forward so they become are more effective in responding and grappling with change overall. The lesson of exposure and changing conditions was recently perhaps best illustrated by the impact of near-hurricane Sandy on the New Jersey and NYC coast. Do we simply rebuild in place, or do we adapt different practices and prepare? Such a shift in management and policy frameworks will likely be needed on a continuing basis over the next 100 years as climate conditions change

Knowledge of the mechanisms that will sustain cities includes the interconnected systems of metabolic flows, the built environment, social dynamics and governance networks. In short, resilience and adaptability of these systems together constitutes the "how to" of urban sustainability (Backus et al., 2012; The Kresge Foundation, 2013).

Water is a key aspect of urban resilience in each of these themes. The urban built form and the ecosystem services in the built environment will be disrupted by climate change implications for water. In coastal areas, issues of sea rise and more severe storms will shape infrastructure planning and management. Continued needs to address stormwater will intensify with more frequent severe storms and flooding issues, but the redesign of these systems needs to include greater flexibility to respond to changing conditions, meaning bigger pipes are likely not the answer.

In terms of metabolic flows, access to clean water for drinking and processing does not appear to us as a problem in the Great Lakes, yet changing climate conditions, and changing invasive species threats because of it, may dramatically change the way we clean water. This was made very clear when harmful algal blooms (HABs) in Lake Erie shifted toward Toledo and shut down drinking water supply for nearly half a million people in August, 2014. The Toledo incident illustrated well the vulnerability of Great Lakes cities to nutrient pollutants, the insufficient preparation for such events, and lack of regulations to prevent them. Changing climate conditions will aggravate these conditions, as more furious storms wash nutrients in to streams from farmland in the Maumee River and other watersheds more frequently. These events suggest a different business model for agriculture and new and more expensive ways for treating wastewater and purifying water for drinking. Toledo also makes clear the connection of natural systems (the lake), rural areas (the Maumee basin) and cities (Toledo) in a complex and shared SES. Changes in hydrology from climate change may aggravate this situation, including those that give rise the HABs. Expected increases in energy costs, much of which is used to clean and move water, may also shift conditions here in the Great Lakes basin. In addition, access to our large bodies of water is a valuable economic resource, and can be leveraged into the future if water quality is maintained. According to Ohio SeaGrant, tourism in and around Lake Erie contributes $11 billion of visitor spending each year to the Ohio economy (OSU/SeaGrant Extension, 2011). However, Lake Erie once again has problems with nutrients, which threatens tourism and other economic uses of the water.

Governance and the participation across social systems are and will continue to be critical to ensure the wise and sustainable use of water resources and their protection. Our group believes that revitalization of Great Lakes cities depends upon continued sustainable governance of the lakes systems.

2.4 Integrated Water Resources Management through Integrated Knowledge

Integrated water management is an approach to coordinate across the entire system of management agencies and entities that influence water resources, as well as with land use and other systems in urban environments. IWRM is a widely accepted approach today in many countries. The United Nations Environment Program defined IWRM as “a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems' (UNEP-DHI, 2009). The basis for this approach is that water is a finite resource, and it connects to virtually all aspects of human society. The interdependencies of drinking water, waste water, agriculture, industry and ecosystem services requires systemic thinking that bridges sectors and requires bottom up collaborative management arrangements. The Global Water Partnership notes the four aspects of water: water for people, water for life, water for nature, and water for industry and other uses.

IWRM is being applied across scales to include river basin management (GWP 2009) and down to urban districts (Howe, Vairavamoorthy and van der Steen, 2011).

Given this background, some of the key questions that this conference focused on were: What are current practices in the United States and in the Great Lakes basin? Are city and regional government agencies making plans across the various water sectors? Is the best research from academic institutions and public agencies being used to guide decision making across the public and private sectors? Are researchers taking the ongoing and likely future needs of decision makers into their research portfolios? Are researchers and policy practitioners using the best metrics to frame their understanding and decision-making?

3.0 Conference Presentations Summaries

3.1. Plenary Speakers

To begin the conference, Dr. Wendy Kellogg, Professor Urban Planning and Environmental Studies at the Levin College, and conference chair and organizer, reviewed the conference themes related to resilience and water. The concept of resilience focused on management of urban systems and the degree to which these can organize, anticipate, learn and adapt to recover from disruption or intentionally shift to new ways of operating. These urban systems are both natural and social, in other words social-ecological systems (SESs), signifying interdependent and reciprocal relationships. SESs are constantly reorganizing, with properties or behaviors emerging from response to disruption. If the disruption is severe enough in magnitude or of sufficient length of time, the entire system can reach a tipping point or threshold, which, once crossed, can alter the performance of the system itself. The changed system will be different, but not necessarily to the benefit of people. Urban resilience reflects the function of four inter-related systems: metabolic flows, governance networks, social dynamics and the built environment, all of which have implications for water security and stewardship. Planning and management of cities using a resilience framework, may allow decision makers to anticipate change, avoid risks, and guide the city toward positive shifts in its SES (Kellogg: Resilience Framework).

Ms. Elizabeth Gibbons, Director of the Climate Center at the University of Michigan, presented the current research results about conditions in the Great Lakes that will plausibly occur over the next 50 to 100 years. We asked her to address issues of what scientists know with some certainty, what is not known, or is only known at a relatively low level of certainty and to identify the biochemical changes that are anticipated and how these may play out. The presentation began with evidence of the rapid increase in temperatures and co-varying increases in greenhouse gases (GHG) in the environment and the anticipated changes to high heat days, observed extreme precipitation patterns, the changing patterns of snow and lake freezing in the basin, lake warming, and the overall impacts of these changes on water, energy, forests, agriculture, biodiversity, public health, transportation, fish and wildlife and recreation. The level of uncertainty about what will happen in the Great Lakes basin is higher than for global predictions (through global climate projection models), as “downscaling” global climate models for smaller geographies leads to less certainty about trends. However, Ms. Gibbons offered a decision rubric designed to integrate knowledge about not only averages, but the need to plan for extreme events and seasonal variation at the regional scale (Resilient Waters, Resilient Cities).

Mr. John Austin, Director of the Michigan Economic Center and a non-resident Senior Fellow at the Brookings Institution, spoke about the major economic benefits of this Great Lakes system and how continued stewardship of the lakes provides benefits to our economies. He spoke about the "blue economy", which combined with greening cities, can serve as the basis of a regeneration of economic prosperity in Great Lakes cities. Our growing understanding of this potential has given rise to an understanding of the value of water in the basin, both for direct economic production and for water as the basis of secondary economic development in cities. Mr. Austin described five ways that water and water innovation can create jobs and drive economies: as blue highways (200,000 jobs), blue resources (5.3 million jobs), blue businesses (1.2 million jobs), blue research and innovation ($2 billion in water R & D at Great Lakes Universities) and blue places (1 million jobs and $50 billion in boating, fishing and recreation). He spoke about threats to our economy and economic development opportunities from climate change, including those related to shipping and ports, water-enabled economic development, and water technology companies that could work to address climate change issues Water is Our Past-Water is Our Future).

Ms. Carol Howe, director of ForEvaSolutions, spoke about the benefits from integrated water management that cities in the Great Lakes might find helpful in addressing climate change. After defining integrated water management, Ms. Howe offered a set of strategies to move cities toward this "one water" paradigm for management. She described transitions to integrated water management in several major American and global cities. Transition to one water requires shifts in how organizations and governments work together, provides economic benefits and cost savings, and requires implementation through regulations and incentives. She emphasized data management and benchmarking and illustrated how integrated water management and best practices relate to concepts of adaptive capacity, working under uncertainty and other resilience themes (Transitioning to Integrated Water Management).

3.2 Eaton Corporation Water Innovation Keynote Address

Ms. Hillary Brown, Professor of Architecture at the Spitzer School of Architecture, City College of New York, spoke about how we can change the design and implementation of infrastructure systems to better respond to climate change and make these systems more resilient. Ms. Brown described the national imperative to renew our infrastructure, including water infrastructure, to remain competitive with the world's leading economic areas, including Europe, China and India. The United States spends less than 1% of its total GPD on infrastructure each year, compared to 4%, 9% and 8% of these regions, respectively. Renewal of infrastructure should be done keeping the complexity of urban systems in mind, integrating investments to account for the interdependencies of energy, water, waste and agriculture upon which cities depend. Such integration depends on understanding "infrastructure ecologies," the opportunistic relationships that exist among the many water-related ecosystem services of the city (water purification, waste digestion, and biomass production, for example). Integration can reduce costs, improve performance and reduce ecological impacts. This will require public works and utilities that are multifaceted, work with natural processes, improve community contexts, reduce global warming and are resilient and responsive so they can adapt to a changing world. Ms. Brown offered many examples of cities around the world that have designed and implemented new infrastructure projects using this framework (Future-proofing Infrastructure for the Anthropocene).

About 95% of the post conference survey respondents agreed that they learned about innovative ideas and practices from the plenary session presentations and the keynote address. Although 82% of the respondents were familiar with the resilience framework, 12.5% respondents noted that they leant about the resilience framework through their participation at the conference. Respondents (87%) agreed that the resilience presentations (plenary and keynote) set the context for other speakers at the conference.

4.0 Variations on Conference Themes

This session offered five presentations that conference organizers felt best exemplified and illustrated the themes of resilience: systems, feedback and adaptive capacity. (These presentations are videoed and available on the post-conference web site.)

Katy Lackey of the Water Environmental Research Foundation presented case studies of how water and waste water utilities were addressing extreme events brought on by climate change. These include implementing adaptive strategies to manage risk and address short term and long term needs at the local level by engaging stakeholders.

Tom Denbow of Biohabitats spoke about regenerative design as a framework to encourage adaptability and biomimetic systems to address stormwater. These systems use principles of nature to "re-establish ecosystem processes/services at different scales, taking into account ongoing human and biological influences which have the power to degrade ecosystem process/services over time and prevent nature systems from re- establishing themselves."

Dr. Derek Kauneckis and Jacqueline Kloepfer of the Voinovich School at Ohio University presented research on the range of approaches to water policy being used by cities in the Great Lakes basin, noting the significance of the local role in addressing climate change. They found that local governments are including resilience in how they are planning to address climate change impacts in their communities.

Bryan Stubbs, director of the Cleveland Water Alliance, spoke about the value of water for economic development, particularly the potential of water as an industrial attraction strategy for northeast Ohio. Water availability is a critical component to many aspects of the economy, including for production, and the Great Lakes region offers an abundant source of water that, if protected, can spur investment and economic growth in the region. His presentation noted the connections of water-related economic activities across the region.

Finally, Dr. Sanda Kaufman of the Levin College of Urban Affairs described the use of scenarios for planning robust watershed decisions under conditions of high uncertainty. Her presentation focused on collective decisions that will be necessary to respond to complexity, emerging threats and opportunities. This implies shorter-term frameworks for decisions, generating if-then scenarios to allow for adaptation to new opportunities and conditions, and arraying plausible future conditions and learning to respond to these rather than planning for only one future goal.

5.0 Best Practices and Research Presentations (by Resilience Themes)

The conference featured two sessions in each of three tracks that were organized according to three themes inherent in resilience-based planning and management:

- Systems—Cross Sector, Scale and Time: systems and how they function across sectors, scales and time frames;
- Decision Support & Feedback Loops: the need for continually renewed information and knowledge generation needed to find the most appropriate interventions such as policies and management practices; and
- Adaptive Capacity: the ability of the human management systems to adapt practices over time and reorganize efforts in response to new knowledge and to ongoing changes to the natural world resulting from climate change.

Each session contained four or five presentations by water-related professionals and academic researchers. The purpose of each session was to share practices and research were being carried out across the Great Lakes that illustrated the theme of the session. After the presentations, participants were lead through a series of four questions to stimulate discussion of the presentations and the themes. These question focused on emergent practices, challenges, assets that were being used to resolve these challenges, and what the participants considered to be the most significant points or concepts in the presentations. Of the post conference survey respondents 29% strongly agreed and 41% somewhat agreed that the discussion questions following the presentations in each of the break-out sessions helped them to relate their work and presentations to the resilience themes. The following sections of the report combine the results of the two repeated sessions. Appendix 3 presents the notes from the sessions. All presentations for these sessions described in Section 5 are available on the post conference Water Resilient Cities web site.

5.1 Systems: Cross Sector, Scale and Time

As noted before, SESs function across geographies and hierarchies, which are often nested and overlapping. In order to understand and assess the resilience of a system, one must identify the focal system as well as its connections in various ways to a hierarchy of nested systems (geography, economy and markets, utility systems, etc.) that function across multiple space and time scales. In addition, mapping the changes that these systems undergo overtime is key to reveal patterns of past disturbances and responses and to identify the critical variables or drivers that shape system dynamics. Understanding the systems, scales, interactions/connections, and critical variables/drivers provides insights into what has shaped the system dynamics in the past and the current focal system, and where the system might go in the future (Resilience Alliance, 2010).

The presentations in this session focused on the theme of systems and how they function across sectors, scales and time frames. The key connections and drivers/variables were also discussed. Several presenters talked about the focal systems in their work and the interconnections with other systems such as connecting private and public sectors to leverage funding opportunities, working at the scale of communities and facilitating community access to various projects (such as infrastructure upgrades, planning, restoration, etc.), connecting physical infrastructure with the social fabric of communities through key policy drivers such as zoning

codes, and collaborative planning and management.

The variables that could act or are acting as stressors for the system were identified as: aging infrastructure, longevity of projects, identification of the right roles for planning and management, lack of maintenance of newer projects (could be a potential area of cross-sector collaboration), and uncertainty related to climate change induced impacts and resultant limitations in strategies.

Participation and engagement in management, getting the right people and connections (through tools such as network analysis), leveraging connections through partnerships and collaboration, reframing of issues (to reveal multiple connections to several system variables), and using education for change (encouraging citizenship and stewardship) are some of the key variables that emerged in the discussions that could be leveraged to manage and adapt the system. Presenters recognized the need to proactively manage system dynamics and drivers of change through identification of key and potential connections, anticipating change through the use of knowledge tools, and integrating this knowledge in planning and management of systems.

Many presenters discussed connecting with the community and enabling people in communities with more access to projects. This was shown in Patekka Bannister's presentation, in which the city of Toledo developed a "community dashboard "through which citizens view water quality data on a daily basis. Charles Frederick from the Kent State Landscape Architecture program discussed a project in East Cleveland in which redevelopment concepts for a park were presented to the community, and the community members took action and cleaned up/changed the park

Another consistent theme was connecting public and private sectors in order to fund projects, especially Green Infrastructure (GI) projects. This theme was illustrated by presentations about Mentor, Ohio and Toledo, Ohio, where birding areas are a boon for tourism-based revenue. The Northeast Ohio Regional Sewer District presented examples of partnerships with private spaces and popular business districts- such as golf courses and the West Side Market- to install GI and address Cleveland's combined sewer overflow problem beyond the user-fee funded projects.

Several presenters brought up the concept of making GI and resilience projects specific to community needs and places. For example, Shaun O'Rourke from Trust for Public Land described projects that are part of TPL's Climate Smart Cities. These projects "greened" urban spaces through a variety of mechanisms, including updating zoning codes, building in greenspaces, protecting water and using green and water to reduce heat island effect. . The projects then are linked though an online app to data from cities, like heat index info, to addressing specific needs of the community and address multiple planning problems at once. Abe Bruckman of the City of Mentor discussed framing Mentor's problems as a public health and safety issue, while Katie Hall of Great Lakes Commons discussed systems-thinking approach in a program in which the organization partnered with YMCA to teach children how to swim- addressing "other ways of knowing water" other than just as a resource/weather issue. Both Bruckman and Hall mentioned the creation of community and collaborative spaces to address water issues.

Another common theme was building capacity for projects over time to respond to climate change. Michael Hall of Advanced Drainage Systems discussed incorporating long-term planning for GI is just as important as installing the GI itself, as John Hazlett mentioned creating

a “manual” for people to maintain GI projects.

Emergent practices brought up in discussion were communication—targeting local leaders in order to carry out practices more efficiently, as well as cross-sector communication. One attendee brought up using “social network analysis and governance theory to think through local networks,” figuring out the “right” people/decision makers to address certain issues. This attendee mentioned that sometimes a regional organizational alliance is often not the best messenger because they can’t reach local governance groups like city council.

A NEORSD affiliate mentioned how public understanding of the Sewer District’s issues was actually enhanced by a lawsuit brought against the group—although this was not the intention. Attendees of this session brought up how education is a crucial component of projects, not only for implementation of GI but also for building citizenship and stewardship in younger people. Also mentioned were ways that GI projects could be inherently low-maintenance- as in Toledo, where buffalo grass was planted, which makes buy-in easier for residents and homeowners. A similar strategy was mentioned by the Sewer District- in which schools incorporated GI literacy into education and will get credit off of their stormwater bill.

Major challenges discussed in this session were aging infrastructure and communication. Some participants’ also commented on the longevity of projects and challenges identifying the roles and responsibilities of city and organizations. One attendee mentioned a problem in the City of Solon, Ohio, in which the transference of private properties, such as pervious parking lots, can result in the lack of maintenance of GI projects. Often times the burden of this maintenance is shifted back to the public sector.

Some attendees mentioned the challenge of climate change disbelief as a major barrier to responding to planning problems. The uncertainty of climate change impacts was also noted as a barrier- being that it is a limitation on creating a strategy to respond to specific problem. Another attendee mentioned that climate change or no, projects still have to improve and handle water in their confines better than the last- this could be achieved by working with zoning codes. One attendee addressed this disbelief issue by presenting projects based solely on their non-climate related assets, which helped moved projects into completion.

Another challenge mentioned was the pace of change happening faster than the pace we are able to adapt to. Also mentioned was the difficulty of addressing problems on a watershed (or any cross-jurisdictional) level; this requires communities to work together when they are often in siloes. Just getting neighboring cities with contrasting practices to work together is often a challenge.

Assets identified in the discussion were partnerships among public/private/nonprofit organizations working together on a large scale. Also noted was that the data available is a huge asset, but that it needs to be presented well and simply. One attendee mentioned that the senior citizen population should be viewed as an asset, to help with grey to green organization. Another attendee mentioned that faith communities can be used as an asset.

Table 1. Summary of Session on Systems

Emergent Themes and Assets	*Emergent Challenges (System stressors)*

- *increased community access to projects and building community connections*
- *connecting private and public sectors to leverage funding*
- *connecting physical infrastructure with the social fabric of communities through key policy drivers such as zoning codes, and collaborative planning and management.*
- *availability of scientific data - needs to be made accessible and well presented for wider public use*
- *senior citizens and faith communities could be potential assets in community organizing around water*
- *aging infrastructure*
- *sustenance and longevity of projects*
- *identification of right roles for planning and management*
- *lack of maintenance of newer projects (could be a potential area of cross-sector collaboration)*
- *uncertainty related to climate change induced impacts and resultant limitations in strategies*
- *lack of collaboration between cities and other political jurisdictions*

5.2 Decision Support & Feedback Loops Session Summary

"Decision support" is any data-focused mechanism or process that assists decision makers to make better decisions. Since scales (geographic, governance, markets, etc.) are interconnected in SESs, there exists 'feedback loops' among different parts or components of a system. Feedback loops could either be reinforcing (positive) or dampening (negative). Managing feedback is crucial to keep the system functioning in a manner that it provides adequate ecosystem services, and identification of critical thresholds, which might flip the system to a desirable or undesirable state. Feedbacks are critical because it is through these that systems respond to change, self-organize, emerge into new configurations, and adapt to change. Once the key variables in a system are identified (refer to previous section), feedbacks that maintain a desirable state could be strengthened and actions that obscure feedbacks could be avoided. Chief among feedbacks is knowledge, analysis and monitoring information – incorporating decision support tools – to avoid changes in system state that is detrimental, and establishing governance structures that can facilitate more informed decision making (The Kresge Foundation, 2013; Resilience Alliance, 2010; Simonsen et al., 2014).

Much of the presenter information in this session focused on technological tools used to not only better capture climate-related data, but also disperse that data to relevant actors and geographies, and make it available where it is needed. Decision support tools to gather information, identify environment stressors and disperse climate related knowledge included smart water quality monitoring projects, how data is used (not just produced), and "locally intelligible" information tools, etc. The second's day's focus on this session with the same theme focused more on creation of governance mechanisms to support and facilitate innovative decision support tools that could be useful to manage feedbacks. These mechanisms included emergent practices such as "watershed trusts." Closing research gaps and identifying where research is needed is also key, so that there is better alignment of institutional support and funding to problem "hot spots." Climate change, as a critical stressor, and uncertainty regarding it, was a major point of discussion in this session. There was general concern over understanding

climate induced effects enough so that focusing on assets (strengthening feedbacks) could be used to maintain desirable regimes.

Tools like the "I-Tree" model are created with built-in capacity for change; they are able to run multiple hypothetical scenarios to demonstrate how changing environmental conditions will impact, for example, water quality and flow. Many of the tools collect data on a continuous basis and store the information so it's available when needed, or use the information to address pressing environmental issues. In the case of Dr. Ben Clark's water quality monitoring project, cities are using existing 311 call systems in smartphone apps to create a database to help communities monitor environmental issues or problems. Citizens input data or requests through their smartphones, which speeds up the process and also readily geocodes that information.

In the discussion portion of this session, many challenges were noted on sensor- system technology, although challenges were also discussed later. Julie M. Barrett O'Neill brought up the challenge of using water quality sensors, in that if the sensors are only being used to detect E. coli, it may be missing other pathogens. Although the data is being generated, using it "fluently" will be a challenge.

Duane Verner added to this point by stating that although that data may be plentiful, components of how it is used and who is using it need to be addressed as well. He mentioned that in his field of climate change, the sheer large quantity of data was a challenge, even for professionals. Marcus Quigley stated that the best way to use the data-generating services discussed in the presentations is just to find it when the need arises. He said that a good system can run on its own, and doesn't need to be watched. Julie M. Barrett O'Neill added that this is huge shift for this to happen, it's very difficult for these systems to run remotely.

Gary Hunter discussed how information- gathered by sensors through one of these tools will likely be overwhelming in volume but needs to be "locally intelligible" to be useful. The issue, to summarize his comment, is providing users "standard information" when and how it is wanted. In a "trillion-sensor world" efforts should aim to create a system that has distributive intelligence and is not overwhelming. He used the example of cars as interfaces for the user- systems that check "everything all at once" and something like a check engine light indicates when it should be taken to a professional. In the same way, big data for users should not be presented as a detailed diagnostic that a mechanic (or specialized water professional) would need.

Dr. Sudhir Kshirsagar brought up that the biggest challenge with sensor systems is creating strong cyber security, while maintaining "open doors." Another attendee mentioned that the sensor systems work in water but not in municipal settings. The advantage of these systems are in that they free up time to work on bigger projects. One of the presenters followed up on this comment, adding that technology has freed up time, but also created more work by forcing folks to look at the data (spending years working on spreadsheets).

In the second day's sessions, a noted emergent practice was the idea of a "watershed trust"—aggregating stormwater and wastewater utilities; an idea that grew out of Mississippi nutrient dialogues. This concept would mean such a trust would target investments not covered by current programs. Another practice noted by an attendee was that of merging services related to water- like resurfacing that may not be part of the regular program.

Adding to these comments, an attendee from the Sewer District discussed using services in a compliance environment, and the difficulties of this due to the varying nature of services. She used the example of planting trees, but that this service can't be used in compliance because trees are difficult to conceptualize as a commodity that can be regulated.

A challenge noted by another attendee in this discussion was that the volume of tools to sustain becomes "white noise," so being at a conference learning about all that is happening is refreshing. This attendee also brought up the idea of sponge cities. The US has impactful water-related NGOs, and can be an example for other countries, such as China where water problems are drier and water regulations are not in place.

One attendee, returning to the idea that trees can (or can't be) regulated for storm water fees, mentioned that there are good modeling tools used to determine what trees are doing in the landscape. Another attendee mentioned that this can also be used in water quality trading; it is difficult to find a model that can be used for compliance. Another attendee asked about the SWMM (Storm Water Management Model) and the Sewer District employee explained that it is an EPA general compliance tool, but something different should be used.

Challenges discussed in the first day's session were costs of implementing changes and keeping records that go along with different programs. One attendee mentioned the challenge of whether the data that sensors and programs are producing has to be double-checked by a municipality, or if it can be used, avoiding an extra step. Duane Verner answered that this is a reasonable step, being that everything else is also expensive, but that this expense is also a challenge. Although the combined sewer-overflow program requires record-keeping to be performed, it doesn't happen often because it is costly. Another challenge mentioned by Verner is that the total process of monitoring, controlling, and looking at feedback from a project on CSOs takes a lot of time. This can sometimes lead to a leap-frogging optimization to new technologies, and that those should be accounted for by regulatory agencies.

The moderator of the session added to this discussion by pointing out that the EPA requires the "best available technology" when dealing with CSOs. Julie M. Barrett O'Neill commented that from a regulatory standpoint some programs are difficult to implement because of the legal terminology. For example, defining a "typical year" to predict when a combined-sewer overflow will occur is difficult and this impacts the ability to implement the "best available technology" as required by the EPA. Samar Khourey also mentioned that a "50-year model" doesn't include climate change and it should, there should be a paradigm shift to this thinking that includes accounting for externalities.

A challenge noted by Tom Denbow in the second day session was that there is a disconnect of addressing issues; when algal blooms occurred, money was given to water utilities to increase the amount of treatment facilities, but other aspects of the problem, like land use, were not connected to this solution. He stated that water strategies are critical and should be included in the climate change context. Julie M. Barrett O'Neill mentioned that Smartgrowth analysis, which measures the density and spread of metropolitan regions contributing to impervious cover, should be applied to these issues, and is happening in other states like New York.

Another attendee mentioned that management needs to be included in funding to provide the infrastructure for sustainable/resilience projects. Another participant mentioned that there is no standard practice of benchmarking for these projects. Additionally, there is "no research to

find out where research is needed." In other words, large institutions are not aligning with the "hot spots" where issues are arising, thus these places lack funding. John Hornbeek added that there should be a central mechanism for escalating findings and getting concrete results. Julie M. Barrett O'Neill commented on the lack of user-friendly projects that make it difficult for them to be implemented, especially with academic or institutional partners.

Assets mentioned were the National Climate Assessment toolkit, and general increases in technology to allow for inexpensive monitoring. For example, Dr. Sudhir Kshirsagar brought up that BACs (blood alcohol content devices) used by police, are available on phones. As such technology is being slowly integrated, the EPA could require something of the same par, and they could be more easily accessible for maintaining data. Another commenter mentioned that green infrastructure has to be considered an asset by the sewage department, but that we are failing in "applying and monitoring systems to make an impact." Tom Denbow also mentioned that the Erie basin is an asset as a transport mechanism for the pollutant load, and it needs more attention.

When discussing other significant topics, Duane Verner noted that climate change work is complex, and that this leads to confusion over what to do with research, being that the past does not necessarily predict the future. He stated that the simple message of climate change is difficult to communicate, and this is a problem as climate change- issues are worsening. The moderator brought up it doesn't have to be called climate change to show that health and environmental problems are worsening. Taking this approach could be effective. Duane Verner responded by saying that people are more capable of understanding complexities and negatives should be emphasized, while the moderator stated that thinking on an individual level should be occurring.

Julie M. Barrett O'Neil brought up that people should understand the responsibility of engineers, and get them to buy into green infrastructure, do to their role and responsibility in shaping structures. She also mentioned that schools should be preparing engineers for this role. Dr. Kshirsagar added that many people are not learning about climate change, instead they are being given antiquated lessons which don't adapt to the changes we are seeing. This is the biggest challenge.

Table 2. Summary of Session on Decision Support and Feedback

Emergent Themes and Assets (Strengthening feedback)	Emergent Challenges (System stressors)
• *smart water quality monitoring projects and scenario modeling*	• *creation of a facilitative compliance environment at the local level*
• *innovative and "locally intelligible" use of scientific data and innovation*	• *matching models and modeling tools with compliance options*

- *focus on emergent management practices such as "watershed trusts"*
- *regulatory practices to account for externalities, including land-use in water management funding*
- *smart growth analysis*
- *developing a standard practice of benchmarking for sustainable infrastructure projects*
- *costs of implementing changes and related recordkeeping for different programs (to increase efficiencies)*
- *accounting for connections and feedbacks in system for policy and public finance tools*
- *National Climate Assessment toolkit*
- *leap-frogging optimization to new technologies (for monitoring, controlling, and looking at feedback) should be accounted for by regulatory agencies*
- *paradigm shift to the thinking (in planning and management by agencies and municipalities) that includes accounting for externalities*
- *no standard practice of benchmarking for infrastructure for sustainable/resilience projects*
- *public education and outreach with a built in adaptation component to climate and environmental changes (with specific focus on health)*

5.3 Adaptive Capacity

Adaptive capacity is the ability of the human management systems to adapt practices over time and reorganize efforts in response to new knowledge and to ongoing changes to the natural world resulting from climate change. This includes revising existing knowledge to enable adaptive strategies and approaches to management, integrating learning as a part of decision-making, recognizing that knowledge is incomplete and there is uncertainty (including climate science), among other things. Critical for building adaptive capacity is learning by doing with an explicit focus on sharing of knowledge between actors, boosting learning through knowledge sharing across organizational and institutional scale, and collaborative processes and broader participation that stimulates learning among different groups (Resilience Alliance, 2010).

Presenter topics in this session focused on themes of restoration and community resilience, as well as equitable distribution of programs and tools, or tools that helped measure the specific vulnerability of different areas in order to allocate resources efficiently. Presenters covered a range of practices and efforts currently underway, such as development of institutional tools that improve knowledge and collaboration and dissemination of information collected through the tools, aid in learning about different aspects of vulnerability, and community collaboration to gain knowledge about infrastructure development. The sessions also served as forums for different actors to share knowledge and strategies regarding building adaptive capacity. Sharing of emergent practices and technologies, and challenges and roadblocks in resilience planning and management (scale issues, lack of leadership, education, compliance with regulation, etc.) by the presenters through their respective cases and discussions is also a key aspect of collaborative learning that characterizes adaptive capacity. Discussion on the efforts towards building adaptive capacity and recognition of challenges is a key aspect of learning (for adaptive governance) and an integral part of planning and decision-making.

Scott Hardy, of the Ohio Sea Grant, discussed community vulnerability and resilience and

Sea Grant's efforts to analyze community storm hazard vulnerability through the creation and distribution of a Storm Hazards Vulnerability Index. Elements of the index include social and socioeconomic information, environmental vulnerability and resilience indicators that lead to an understanding of hazards as well as resources, and help facilitate collaboration. Hardy also brought up the importance of community investment and education. Samuel Molnar of the Great Lakes Commission presented on a similar Vulnerability Index, which is a GIS-based tool used for planning that focuses on physical, personal, socioeconomic, and built environment aspects of vulnerability. The index allows adaptions to occur "justly, not equally" and to be specific to place as well as people in that place. Matt Schmidt of the Northeast Ohio Regional Sewer District's *Project Clean Lake* discussed a "listening campaign" to identify areas to place grey (tunnel systems) and green (parks, walking trails) infrastructure in Cleveland communities. The project is part of an effort to solve the NEORSD's sewer infrastructure problems, while mitigating the impact of construction and disruption in communities.

Jim White, of the Port of Cleveland, discussed "sediment choreography" and management, and its impact on the regional economy. A challenge mentioned was that changing weather patterns are increasing sediment production and erosion, as well as creating less stable floodplain dynamics. The Port of Cleveland is addressing the environmental issues caused by the increased sediment by "changing how sediment is valued"- as a harvestable commodity instead of a waste product to be dealt with. Mr. White described a system that the Port has devised to capture marketable sediments. Todd Danielson of Avon Lake Regional Water discussed the city's Water Utility Adaptation strategy and their efforts to increase adaptive capacity through tools that detect water quality, increased storage for filtered water, and improved filters.

In the discussion portion of the session, some emergent practices mentioned were the retrofitting of old technologies, like putting a filter on a pipe that would drain into a stream, and increased "scientific" practices of fertilizer application from farmers, such as drone application or non-blanket applications. Another practice mentioned by an attendee was the emergence of citizen science projects, that there are many of these but could be more, to help with stream phase monitoring (discussed by presenter Joel Bingham of Enviroscience) to support and carry out project efforts.

Challenges mentioned from the first session were that many state, local and other agencies are still in denial of climate change, and that there is a lack of leadership in engaging people in resilience planning and design. A related issue is that city managers have historically adapted to extreme weather, not climate change, and this is a major stumbling block. Also identified was a lack of up-to-date information in the hands of decision makers-which makes it more difficult to achieve goals related to climate change preparedness. A similar comment was about the tendency for "looking at the short-term", nothing further than the next election cycle in making funding decisions, and this can lead to a shortage of funding needed. Another commenter mentioned the "silo culture" of governance, and that often people work in an environment where roles are passed around but they are never at the same table.

Another challenge mentioned was that the EPA has started to accept integrated water management, but only for large scale projects. The attendee stated that a consent decree is needed for smaller areas and not just large cities. Another attendee mentioned, however, that larger consent decrees are better for consistent watershed management and that when communities have different zoning codes it can lead to "hodgepodge" management strategies, which the consent decree helps to address. Also on the topic of zoning, several attendees brought

up challenges of the time needed to create zoning codes and the enforcement of zoning codes. Other challenges discussed were funding—with tight budgets, communities cannot take risks without guaranteed insurance—and collaboration, where not enough is happening cross-sector. Also mentioned was that ideas of vulnerability are shifting design challenges to management and maintenance. This places more responsibility on engineers, who are to blame if a design lacks endurance, and who are then more likely to be conservative in their design decisions. Another attendee mentioned that many community decision makers are not up to speed on issues, and that small communities don't have enough decision makers making change, that leaders need to be engaged and pushing issues in order for things to happen.

Challenges mentioned in the second session were education, compliance with coastal zone management plans, and the court processes. The Port of Cleveland presenter, Jim White, mentioned that educating people from their field is a huge challenge. Some attendees mentioned that the court process is timely, and in some circumstances the process of the court reviewing a plan is longer than the process of creating a plan. Another challenge mentioned was that the Great Lakes are unique because they are utilized as a drinking water source, so dredging practices should be as unique and specific.

Other significant topics mentioned were, by Joel Bingham, real "goals" (instead of aesthetic value as the only goal) being a part of restoration practices. Anthony Body, from NEORSD mentioned that this could occur through education and also through visiting underutilized green spaces and parks and spaces that already exist. Table 3 summarizes outcomes of the sessions.

Table 3. Summary of Adaptive Capacity Sessions

Emergent Themes and Assets	Emergent Challenges
• *restoration and community resilience* • *equitable distribution of programs and tools* • *efficient allocation of resources (based on vulnerability assessment tools)* • *development of institutional tools that improve knowledge and collaboration and dissemination of information collected through the tools*	• *challenges and roadblocks in resilience planning and management - scale issues, lack of leadership, education, compliance with regulation, etc.* • *challenges of the time needed to create zoning codes and the enforcement of zoning codes* • *not enough cross-sector collaboration* • *engineers risk averse with design*

- *ideas of vulnerability shifting design challenges to management and maintenance*
- *community collaboration to gain knowledge about infrastructure development*

decisions

- *community decision makers/leadership not up to speed on issues; small communities lack decision makers making change*

6.0 Working Sessions Summaries

6.1. Break out Sessions Organized by Communities of Practice

After two sessions of presentations from conference attendees on day one and the morning of day two of the conference, attendees split into three break-out workshops. The topics for these workshops were designed to encourage discussion among professionals and academics in three different communities of practice: *economic aspects of water resilience; physical/landscape aspects; and governance*. Each session was designed to encourage responses to the following questions:

- What are the issues of concern related to vulnerabilities from climate change in your field or practice;
- What is the current state of adaptive capacity to respond to these issues; and
- What strategies are you using, did you hear about at the conference thus far or from others in your profession that can address the issues and build adaptive capacity?

Each session was facilitated, with participants ranging from 10 to 30 people. Participants engaged in small group discussion to suggest issues of concern, with the entire group setting priorities. The process included rating the relative sensitivity of their sector (economic, physical and governance) to specific vulnerabilities, and the current adaptive capacity for each. Conference participants that responded to the post conference survey (39%) noted that they attended the session that best fit their field of professional practice (sector of work). The exercise was based on workshops designed by Petersen, Hals, Rot, Bell, Miller, Parks, Stults (2014). The three sessions focused on the water economy, waterscapes and the physical city, and governing the water commons.

For the session focused on the *Water Economy*, facilitators led a discussion based on questions of what strategies can industries use to respond to climate change disruptions? How can they adapt or leverage new opportunities for climate mitigation? What economic development opportunities might exist from impacts of climate change? What are the barriers to effective collaboration of industry and technology companies with governance entities? What new markets may form? What workforce development might arise?

Key issues that were identified as most vulnerable to climate change included changing water quality conditions that might negatively affect economic activities such as use of water for production, recreation industry and agriculture. The group focused on health of the water (chemical, physical and biological) and extreme weather events as having the greatest impact on the region's economy. It noted that existing management systems to address water chemistry were adaptive, but physical infrastructure systems were not. The group suggested strategies for

improving the capacity to respond, including increased focus on nutrient pollution reduction, state-level action on agricultural runoff, local zoning to protect waterways and integration of the information used for decision making between state and local governments and on a watershed basis.

In the session focused on Water-scapes and the Physical City, discussion questions focused on what strategies can infrastructure be adapted to respond to climate change disruptions? What land use adjustments will be needed? How can water become a design resource to ameliorate the worst effects of climate change in cities? Is climate change in the rest of the country a driver for repopulation of Great Lakes cities? What equity issues inhere in water planning and management?

Key issues that came forward in this session included extreme weather events and storms, vulnerability of aging water and waste water infrastructure, and water quality for human consumption. Strategies suggested included attention to stormwater infrastructure and financing these through public –private partnerships, the need to include longer-term issues not just crisis situations in planning decisions, and the need to identify barriers to implementation of green infrastructure at a scale to have an effect on water chemistry and algal blooms.

Finally, in the session focused on *Governing the Commons* facilitators asked through what strategies can stakeholders work more effectively together? What are the implications of using an integrated water management approach? What institutional/organizational changes do we need increased collaboration to respond to climate change disruptions? What are the role of state and federal governments vis a vis cities in moving toward integrated planning and responses regarding water? How can governance networks respond to issues of scale?

Key issues for this group were many, including flooding, drinking water infrastructure, communications between governments, failure of local governments to accept the need for climate change plans, urban stormwater runoff. To address infrastructure and algal governance the group suggested greater collaboration across different aspects of water sectors, and regional leadership. The group also stressed the importance of a watershed scale and land use practices in the development process, with local governments incentivizing practices to reduce storm water runoff.

6.2 Strategies for Research and Practice

For this final session, each breakout group from the sessions summarized their work to the entire conference attendees, and posed strategies for moving forward.

Water Economy

This group had discussed facets of water quality, including chemical, physical, ecological facets as well as the relationship of these to climate change. This group chose to focus strategies on issues related to the chemical aspects of water quality:

- tackle nonpoint source pollution by reducing “Total Maximum Daily Load” (TMDL) goals at major industry of chemical prescriptions, factory chemicals, and phosphorous. To reach this goal, it was noted that partnerships with farmers and the farm industry, legislators, and community members would need to be established. It was also noted that this would be difficult to undertake as a long-term goal, and that education would need to

be involved in some respect. Another strategy posed was creating a watershed utility, which would streamline multiple issues into one entity.

- differentiate between natural and human impacts and adaptability. Human components and their multiple systems and layer—nonprofits, economics, local businesses, state partnerships—complicate nature's natural adaptive capacity, which, on its own, is very high. However, using all of these human facets across silos—namely the economic and nonprofit sector—can be very effective. All sectors need to be involved to find any solution.

Waterscapes and the Physical City

This group discussed strategies for adapting Great Lakes cities to climate change. The group discussed the challenges of dealing with "meta issues" first, and also the "chronic vs. crisis" aspect of many problems facing the region. Another problem was mentioned was the link between water quality and health, and a final issue was the barriers to large infrastructure and ways around these barriers. An example given to illustrate the "chronic vs. crisis" nature was the events of water contamination in Flint, MI, and how this was dealt with when the crisis arose, rather than as a long-term problem that builds over time.

A major theme the group identified was cross-sector collaboration. They discussed the steps of research, cross-institutional work, and communicating this to the public. They also mentioned the importance of public-private partnerships, and the general discussion of climate change, with suggested strategies to include.

- biomimicry, and anything that "gets us to adapt green infrastructure to particular places...more on the human side than the technology side;"
- monitoring water quality up and downstream. A question posed to the group by Dr. Kellogg was where and when to monitor water quality, and whether to do so before or after weather events. In addition, early warning systems for water quality detection (connections of human fecal matter to where overflow occurs) could work well in terms of cross-sector collaboration, so strategies for this topic should be discussed further.
- Determining what health data to use if the data first identified as necessary for a problem cannot be collected. A suggestion made was that sharing this health data—rather than reinventing the wheel—would be a way around the time, cost and logistics of collecting new data. Interagency groups that share and access data have a lot of data content that could be discussed and disseminated.
- how can communities adapt legal structures to enable more reliable monitoring? What, in terms of water quality, is being monitored, that the process of monitoring is too costly. Areas that have better long-term control plans with green infrastructure have stronger systems. In some places, regulations for storm water retrofitting do not exist, and this is another obstacle.

Governance

The following issues were brought forward by this group:

- dredging, and its consequential erosion and sedimentation. The corresponding strategy is to change dredging practices, restore stream bank, and create land banks with existing sediment and bedload interceptors. These schemes could be achieved through cross-sector collaboration of agencies and businesses;
- algal blooms. Suggested strategies were more research, use of biomimicry, sustainable agriculture practices, and steps to phosphorus runoff reduction. Mentioned here was collaboration with farming agencies, increased education and public outreach.
- urban infrastructure and how inter-organizational communication about utilities can increase resilience. This can be assisted by government incentivizing as well as education, and streamlined infrastructure.
- regional flooding problems. The strategy suggested to tackle flooding would involve land-use planning, at a watershed scale, as well as incentivizing and better disaster management.

7.0 Outcomes and Next Steps

7.1 Key Comments and Recommendations Emerging from Conference

A question posed by Dr. Kellogg, the conference chair, was how well is the information and research—regarding Great Lakes biochemical science—being shared with decision makers and managers, and how accessible is it? This transfer of information is critical. Julie M. Barrett O'Neill responded that the engineering community, who are responsible for infrastructure, have access to new technology but do not get enough training about climate change.

Dr. Kellogg then mentioned that time frames (long and short-term) can impact approaches to solutions as well as scale—local, regional, state and federal. She then asked the attendees how they feel they are able to balance planning and management decisions in reference to these different time frames. She also asked whether there are mechanisms within attendee's organizations that can help address this potential. Responses included:

- green infrastructure helps one look at long-term impacts, and economic analysis demonstrates that. Sustainable practices like biomimicry or tree-planting can be sold and invested in this way, as something that is more valuable over time.
- Another comment was made regarding scale. If regional information is available on a local level it is often more successful to help local management skills. Examples of this are the i-Tree system from the Davey Tree company.
- the creation of management tool that would project different schemes and metrics —such as canopy cover—in order to see the potential impacts and benefits a strategy or policy would have. This tool could help bridge the disconnect between conceptions of climate change and policy creation.
- thinking regionally in order to act locally. An attendee stated, "Erasing the boundaries gives people a chance to think across boundaries and allows for further collaboration." This is especially pertinent for elected officials who can look at different scenarios, the impacts of each, and tie the impacts to the tax base of different communities to garner awareness. The creation of a monetary bottom line in relation to the environment helps people see the importance of environmental issues. Morrison then asked if there are tools that can make this process more efficient.

- what role the city has to play as a locus in climate action, noting that urban centers have more cultural infrastructure and experience with water problems, which water quality partnerships may not have. The presence of many different watershed groups creates a scattered plan rather than a holistic one. Barrett mentioned the use of an ombudsman to connect needs of many communities and benefit from the scale of the city. Another comment was made, in response to Barrett's, stating that cities can leverage powers of land use jurisdiction.

Dr. Kellogg suggested that future events offered by the Water Resilient Cities Program would focus on small workshop events—with around 30 attendees, with more focused topics to zero in on some of the many issues discussed at the conference. She asked attendees what topics should be discussed at these events and who should be involved.

- workshops should include the arts and humanities, and that they should be facilitated in a way that is dynamic. This attendee gave an example of a facilitator at a conference who graphically illustrated comments and ideas, which enhanced the communication at the conference.
- A final comment was made about a potential biomimicry-focused workshop as a way to tackle water issues. Some work on this topic already exists at the University of Akron with the Cleveland Water Alliance.

The recommendations and suggestions emerging from the best practices and research sessions and the post conference survey have been summarized and organized into Table 4 below. Conference participants provided their views and ideas through their presentations and discussions. The following table outlines the key resilience themes and ideas that emerged conceptually throughout the sessions and the emergent variables/measures that could be used to track the key themes associated with the broader resilience dimensions.

Table 4. Summary of Key Resilience Dimensions

Resilience Dimensions	Key Ideas/Themes	Emergent Variables/Measures
Systems: Cross Sector, Scale and Time	Connection between systems and hierarchy of nested systems	understanding key connections; collaborations across institutions to remove planning, organizational, and knowledge barriers; multi-jurisdictional water management efforts; consolidation/simplification of teams and programs; systems thinking and scalable frameworks across professional disciplines
	Identification of disturbances and critical variables	identifying links between ecosystem functions (eg. climate change and health); municipal management of stormwater and climate change; water management perspectives from targeted end

		users; multi-disciplinary collaborations
Decision Support and Feedback Loops	Knowledge, learning, and monitoring related decision support tools to inform policies and management practices	bridging gap between climate science and climate adaptation strategies and communities; opportunities in workforce development in climate resilience planning; multidisciplinary inputs to water resource management; invasive species management; linking cities to ecosystem processes through regenerative design; interdisciplinary approach for crisis management; matching emerging technologies with infrastructural issues; estimates such as future precipitation frequency
	Governance and institutional structures to either manage or avoid regime shifts	building institutional capacity and integration for regional planning and management; implementation of climate change adaptation at local level; urban planning as potential focal point of multi-disciplinary teams; lessons from local governments plans and programs; evaluation of present policies and plans (helping or hindering); orchestration of initiatives at an agency or institutional level; greater integration of water infrastructure in the urban area; building capacity for outreach/education in climate resiliency
Adaptive Capacity	Adapting practices including learning, organizational, and collaboration	integration of climate information in planning and design; cities building capacity to export blue economy solutions; cities taking an adaptive approach to climate change; public engagement and education; need for collaboration; sharing and education about successful projects using IWRM; regional efforts to build adaptive capacity

Additionally, following are some key recommendations that emerged from the conference that could be used both for integrated management of water resources and using resilience as a framework for building capacity for adaptive governance (research, planning and policy, and practice):

- There is gap between climate science and the practitioners that need to use the science to bring about change in the built environment. Currently these two groups are speaking completely different languages. Most city infrastructure designed by engineers hasn't adapted to alter its guidelines based on the changing climate (e.g. increased precipitation, increased heat, etc.). There should be more focus on this aspect.
- Need for supportive legislation and funding sources at all levels of government
- Although climate change is viewed by many as a negative, its impact on the region may be a benefit in terms of economic development, as long as it is addressed carefully considering the impact of possible population growth, environmental consequences and proper infrastructure planning. Public awareness and education programs should be pursued.
- How can new businesses be attracted to water abundant regions? Learning more about the concept of 'regenerative design' and how even smaller cities could practically implement this design could be useful.
- Water resilience depends on not only infrastructure but also optimal operation of current facilities. Broadening topics for optimal operations (management) of facilities (structures) in watersheds could be useful.
- The economic risks/opportunities is an area that needs to be explored further.
- Distinctions between drinking water, storm water and waste water: do they need different approaches for resiliency?
- Bringing educators – from higher ed. and K-12 – into the dialogue to talk about ways to create water resilience - literate audience.
- Community design responses to water resiliency including more case studies on what communities are doing in order to continue the conversation on how Great Lakes communities are responding.
- Established funding sources for research related to water/climate resiliency.

7.2 Next Steps for Water Resilient Cities Program

The Levin College has established a Program on Water Resilient Cities that is within the Urban Centers unit of the college. Dr. Kellogg is directing that program. This program will coordinate across campus and into the community to continue the focus on water resilient cities.

Next steps for the WRC program include distribution of this report to the conference participants and to a wider group of professionals and researchers associated with water and land management. The conference outreach will target university students and the general public in

the future. We also anticipate working with water professional organizations in Northern Ohio in organizing smaller local/regional workshops/briefings to local utilities, city planners and managers, and water professionals following the conference to broaden the distribution of the results and to gather additional information on best practices using an integrated water management approach.

Our partners and sponsors (http://www.csuohio.edu/urban/events/Water-Resilient-Cities-Conference) will assist in dissemination of the materials produced through their networks much as they have done for the advertising of the conference. This summary report, and other smaller items generated from it, will be disseminated on the Levin College web site, and will be shared electronically through the networks of conference sponsors and partners (more than a dozen with access to thousands).

The participants of the conference will be connected through the Water Resilient Cities Network (facilitated through a professional Linkedin group and through Twitter) to connect, network, and share research and best practices and to take forward and/or collaborate on the various ideas generated through the conference.

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