Good news: Even under the most pessimistic rainfall scenario, a substantial portion of the existing stormwater systems at both study sites were still sized adequately.

More good news: Green infrastructure helps increase community resilience to future climate uncertainty. In built-out communities like Minneapolis, low impact development practices were predicted to reduce the overall costs of adaptation efforts. In Victoria, the existing green infrastructure network stored a substantial volume of flooding and significantly lowered the total anticipated adaptation costs. This highlights the importance of zoning and community planning in preserving connectivity between streams, wetlands, and other low-lying areas, to enhance overall community resilience to extreme events.

The other news: Flood risk increased in all extreme rain event scenarios, requiring adaptive action. There is no one-size-fits-all when it comes to adapting communities to manage increasingly frequent extreme rainfall events. The types of adaptive measures and how they are implemented will vary from community to community.

COMMUNITY ADAPTATION PLANNING FOR CHANGING LANDSCAPES & CLIMATE

Defining terms

- **Community Adaptation**: A planning process designed to improve the capacity of local communities to adapt to changing conditions. It requires an integrated approach that combines technical knowledge with innovative strategies that not only address current vulnerabilities but also build the resilience of people to face new and dynamic challenges. It also aims to protect and sustain the ecosystems that people depend on.

- **Low Impact Development**: A comprehensive stormwater management and site-design technique that mimics predevelopment conditions. This is achieved by using design techniques that infiltrate, filter, evaporate, and store stormwater close to its source through a variety of small, cost-effective landscape features located on-site.

- **Green Infrastructure**: Uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by looking up and storing water.

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- **MINNEHAHA CREEK WATERSHED DISTRICT**: A local government organization responsible for managing the watershed of the Minnehaha Creek, which flows through Minneapolis and Hennepin County, Minnesota. The district is responsible for maintaining and improving the creek's water quality, habitat, and public access.

- **ANTIOCH UNIVERSITY NEW ENGLAND**: A private university located in Goffstown, New Hampshire, offering programs in environmental science, public health, business, and other fields.

- **UNIVERSITY OF MINNESOTA**: A public research university located in Minneapolis, Minnesota, offering undergraduate, graduate, and professional degree programs in various fields.

- **MINNEAPOLIS**: The largest city in Minnesota, located on the Mississippi River. It is known for its vibrant arts scene, museums, and parks.

- **VICTORIA**: A city in Minnesota, located southwest of Minneapolis. It is known for its small-town charm and outdoor recreation opportunities.

- **MINNEAPOLIS CLIMATE PROGRAM OFFICE**: A department of the City of Minneapolis, responsible for climate change mitigation and adaptation efforts.

- **GREEN INFRASTRUCTURE**: Uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by looking up and storing water.

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- **DEFINITIONS**: For more information visit www.minnehahacreek.org/WET

- **ASSESSING STORMWATER CAPACITY AND ABILITY TO ADAPT IN TWO MINNESOTA COMMUNITIES – MINNEAPOLIS AND VICTORIA**: Minnesota has been hit by a number of “Mega Rain” events during the last 30 years. In fact, extreme weather events are increasing in frequency across the country, with some of the largest increases in the Upper Midwest as seen in the figure (upper right), which shows changes in very heavy precipitation from 1958-2011. Preparing to manage the risks of these extreme rain events requires that our communities understand their vulnerabilities and capacity to adapt, both from a technical and social standpoint. To demonstrate this process, the Minnehaha Creek Watershed District partnered on a study with Syntectic International, Antioch University New England, the University of Minnesota and two communities in the Twin Cities area – Minneapolis and Victoria. Funded by a grant from the National Oceanic and Atmospheric Administration’s Climate Program Office, the study had two overarching goals: assess vulnerability to both land use and rainfall changes, and build capacity to support community adaptation. This was done through both climate and hydrologic modeling and a community-driven planning process in which technical assessments of impacts were incorporated into collaborative planning to understand opportunities and barriers for adaptation.
In this study, we focused on changes in what is often called the 10-year storm, that is, the amount of rainfall in a 24-hour period that has a 10% probability of occurring in a location in any given year. This storm, which is equivalent to about 4 inches in the Twin Cities area, is often used to design much of the infrastructure intended to control flooding. As indicated in the figure above, the study predicted the magnitude of this storm to change by as little as 10% to as much as 150% by the middle of this century. The calculations were derived using an innovative technique to register different Global Climate Models.

**Results from this vulnerability assessment included**

1. Identifying frequent extreme rainfall, growing communities, and regions of issues surrounding more frequent flooding is limited to recreational and other natural elements that serve to buffer flooding; promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding; promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding; promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding; promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding; promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding.

2. **Stormwater infrastructure and low impact development are the most cost-effective solutions for water quality and flood control within the context of new development and on-street parking, and other sustainable solutions cannot be managed by allowing excess water to pond in streets and existing low-lying areas.** Although this may be a low-cost adaptation option, it would require ongoing commitment to current policies and evaluation of public perceptions of street flooding.

According to a study of the Chester Creek Watershed in Duluth, MN, which was severely damaged by flooding in 2012, the benefits of incorporating green infrastructure—such as reducing water infiltration, permeable pavement, underground storage, and other green infrastructure—could help the city realize $1.63 million in savings through 2035. Other potential benefits, including improved water quality, additional wildlife habitat, and green spaces, and increased property values related to increased property values, and increased property values were not included in the study.

**Graph Source:** Economic Assessment of Green Infrastructure Strategies for Climate Change Adaptation. North Dakota, May 2017

**Reduced Post Storm Land Restoration Costs**

Chester Creek watershed, Duluth, MN

$263,400

Reduced Storm Sewer Infrastructure Costs

$158,600

**Other Potential Benefits, Including Improved Water Quality, Additional Wildlife Habitat, and Green Spaces, and Increased Property Values Related to Increased Property Values Were Not Included in the Study.**

**WHAT CAN BE SAVED BY USING GREEN INFRASTRUCTURE?**

**ECONOMIC BENEFITS**

**Change Adaptation: Pilot Studies in the Great Lakes Region, May 2014**

**PROJECTED SAVINGS THROUGH 2035**

$1.63 M

($89,000/YEAR)

**HOW MUCH MONEY CAN BE SAVED BY USING GREEN INFRASTRUCTURE?**

**Through 2035**

$1.63 million in savings through 2035 (see figure to left). Other potential benefits, including improved water quality, additional wildlife habitat and green spaces, and increased property values, were not included in the study.

**Reduced Building Damages**

$1,029,000

$326,000

$1,920,000

**Increased Recreational Use**

$266,600

**Reduced Post Storm Land Restoration Costs**

$263,400

**Reduced Storm Sewer Infrastructure Costs**

$158,600

We applied cost estimates, using local cost data when possible, to determine the economic costs of implementing adaptive strategies in each community. As expected, total costs were higher in the Minneapolis study site due to the larger volume of flooding predicted there, and the higher costs of communications due to density and existing infrastructure. But per unit costs of flood mitigation structures were similar between the two sites. Flooding in the Victoria site could be managed by installing stormwater tree trenches to prevent stormwater from ponding in streets and existing low-lying areas. Although this may be a low-cost adaptation option, it would require ongoing commitment to current policies and evaluation of public perceptions of street flooding.
In this study, we focused on changes in what is often called the 10-year storm, that is, the amount of rainfall in a 24-hour period that has a 1% probability of occurring in a location in any given year. This storm, which is equivalent to about 4 inches in the Twin Cities area, is often used to design much of the infrastructure intended to control flooding. As indicated in the figure above, the study predicted the magnitude of this storm to change by as little as 10% to as much as 150% by the middle of this century. The calculations were derived using an innovative technique to regionalized different Global Climate Models.

We used hydrologic models to assess how the two test communities flood risk would be impacted by these anticipated changes (rainfall, as well as future land use changes), and identified included at no cost options to stormwater infrastructure, 1) deploy added flood storage, and 2) utilize low impact development options to mitigate flood volumes. This study also relied on a community-led process in which stakeholders were convened to build social capacity and identify local and regional actions related to a depression planning, and low barriers and constraints to their implementation. Out of these sessions, four priority action areas emerged:

1. Education and outreach to raise awareness and consensus among policy makers for managing risk;
2. Land use planning to improve policies for policies that promote preservation of natural hydrologic corridors, wetlands, and other natural elements that serve to buffer flooding;
3. Stormwater infrastructure and low impact development to identify options for water quality and flood control within the context of new and redevelopment; and
4. Sustainable funding to assess financing sources and needs for region-wide infrastructure and identify opportunities for proactive adaptive management.

4. Resource management was the key to informing community-led discussions of issues surrounding more frequent extreme rainfall, growing communities, and other natural elements that serve to buffer flooding. As expected, total costs were higher in the Minneapolis study site due to the larger volume of flooding predicted there, and the higher costs of construction for updating infrastructure and identifying opportunities for proactive adaptive management.

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The process was two-fold: identify the preferred adaptive strategies; and, 2) assess a community’s capacity to implement decisions. A community was identified as having the capacity to implement decisions if it was able to do nothing, to design stormwater infrastructure, to develop additional flood storage, and to utilize low impact development options to mitigate flood volumes. This study also relied on a community-led process in which stakeholders were convened to build social capacity and identify local and regional issues related to adaptation planning, and the barriers and constraints to their implementation. Out of these sessions, four priority action areas emerged: a) do nothing, b) upsize existing stormwater infrastructure, c) develop additional flood storage, and d) utilize low impact development options to increase resilience.

We used hydrologic models to assess how the two test communities’ flood risk would be impacted by these anticipated changes in rainfall, as well as future land use changes (backpack conditions). What we found is that vulnerability to flooding in a densely populated neighborhood in South Minneapolis was quite different from a still-growing community such as Victoria, where projected flood risk is limited to recreational and natural green space (see figure to right). Results from this vulnerability assessment were used to inform community-led discussions of issues surrounding more frequent extreme rainfall, growing communities, and regional actions related to adaptation planning, and the barriers and constraints to their implementation. Out of these sessions, four priority action areas emerged: a) do nothing, b) upsize existing stormwater infrastructure, c) develop additional flood storage, and d) utilize low impact development options to increase resilience.

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**Good news:** Even under the most pessimistic rainfall scenario, a substantial portion of the existing stormwater systems at both study sites were still sized adequately.

**More good news:** Green infrastructure helps increase community resilience to future climate uncertainty. In built-out communities like Minneapolis, low-impact development practices were predicted to reduce the overall costs of adaptation efforts. In Victoria, the existing green infrastructure network stored a substantial volume of flooding and significantly lowered the total anticipated adaptation costs. This highlights the importance of zoning and community planning in preserving connectivity between streams, wetlands, and other low-lying areas, to enhance overall community resilience to extreme events.

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### IMPLICATIONS FOR TAKING ACTION

**KEY FINDINGS**

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KEY FINDINGS & IMPLICATIONS FOR TAKING ACTION

**DEFINITIONS**

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