Marquette Area Climate and Health Adaptation Guidebook

Volume I: Stakeholder Engagement and Visual Design Imaging

Marquette County, MI

Michigan State University

December 2018

MICHIGAN STATE UNIVERSITY

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*All photos, unless otherwise noted, are courtesy of the MSU SPDC

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Preface

Volume I of III

Purpose

The Marquette Area Climate and Health Adaptation Guidebook (the Guidebook) is the result of a pilot project to build climate adaptive capacity at the local level by integrating public health considerations into existing community and climate adaptation planning initiatives. Though the Guidebook is focused on Marquette, the innovative process was developed with the goal to be usable or replicable by other communities from small to large, wholly or in part, depending on their resources and needs.

The Guidebook is structured in three volumes. Each is intended to stand alone as a resource but also build upon each other to provide a detailed accounting of the process and results.

Volume Structure

Volume I: Stakeholder Engagement and Visual Design Imaging

Establishes the community's concerns and priorities related to climate and health as expressed by community stakeholder groups. Uses current and potential future images of vulnerable locations in Marquette and surrounding areas to visualize how the built environment could be redesigned to address these climate-related public health concerns.

Volume II: Policy Recommendations for Enacting Adaptive Built Environment Changes

A comprehensive reference guide for community leaders and technical decision makers describing potential policy tools that could stimulate adaptive community planning and the implementation of the built environment design changes developed in Volume I. Includes health-related metrics associated with each policy tool for users to track and evaluate their own planning activities.

Volume III: Prioritizing and Implementing Recommendations

Outlines further stakeholder engagement to prioritize the recommendations from Volume II and establish ownership for implementation. Provides further refined guidance for implementing priority policies and built environment design changes.

Acknowledgements

Centers for Disease Control and Prevention

The Centers for Disease Control and Prevention (CDC)'s Climate and Health Program is helping state and city health departments prepare for the specific health impacts of climate change that their communities will face. This publication was supported by Cooperative Agreement Number 1 NUE 1EH1324, funded by the Centers for Disease Control and Prevention. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the Centers for Disease Control and Prevention or the US Department of Health and Human Services.

Michigan Department of Health and Human Services

The Michigan Climate and Health Program (MICHAP) of the Michigan Department of Health and Human Services (MDHHS) is led by principal investigator Lorraine Cameron, with support from program manager Aaron Ferguson and epidemiologist Yonathan Kefelegen. MICHAP provided funding for this project through their CDC grant while also providing oversight and technical guidance. This report does not necessarily represent the official views of MDHHS.

Michigan State University School of Planning, Design and Construction
Michigan State University Extension

The project team at Michigan State University (MSU) and the School of Planning, Design and Construction (SPDC) is led by co-principal investigators Wayne Beyea and Pat Crawford, MSU Extension Educator Brad Neumann, Design Assistants Amal Shabaan and Wei Li and Research Assistants Elena Cangelosi and Joel Arnold.

Local Partners

Marquette County, including the Marquette County Health Department, the Marquette County Climate Adaptation Task Force (CATF), and numerous community stakeholder groups all held vital roles in the MICHAP and MSU process to examine Marquette area climate and health impacts.

Special Thanks

The MSU Project Team would like to express their gratitude to the various stakeholders who attended the community stakeholder meetings, Community Visioning Meeting, Preliminary Design Meeting and/or provided feedback during this process to make this project possible.

MICHIGAN STATE UNIVERSITY | School of Planning, Design and Construction

MICHIGAN STATE UNIVERSITY | Extension

MARQUETTE COUNTY Michigan

MCHD Marquette County Health Department *Inspiring Superior Health*

Introduction

Overview

The Marquette Area Climate & Health Adaptation Guidebook (the Guidebook) is the product of a pilot project demonstrating how local adaptive capacity can be built to reduce or prevent the health impacts from climate change. The project is novel in the field of climate and health adaptation in that it utilizes a multi-disciplinary approach to conduct stakeholder education and engagement through a health and equity lens, provides experts and the public an opportunity to establish their vision of a climate adapted community, and then connects the health and built environment components through policy analysis and community planning. Although Marquette is the primary audience for this Guidebook, it is intended that the process, some of the results, and lessons learned can be applied to other communities across the state and region.

Being the largest county in Michigan covering 1,873 square miles of land area, and sitting along the shores of Lake Superior, Marquette boasts urban, rural, and wilderness settings as shown in Figure 1. Each area faces unique, though not always exclusive, challenges from climate change such as increased extreme precipitation events and periods of drought. Fortunately, community leaders are addressing many of the issues through multiple climate adaptation initiatives across varying scales from the city to Lake Superior watershed level.

Though these plans are extensive in their assessment of environmental and economic impacts from climate change, a gap was identified concerning health. This was recognized by community leaders and became a catalyst for their involvement to develop this Guidebook. It examines the health impacts from climate change and how built environment adaptations could address them.

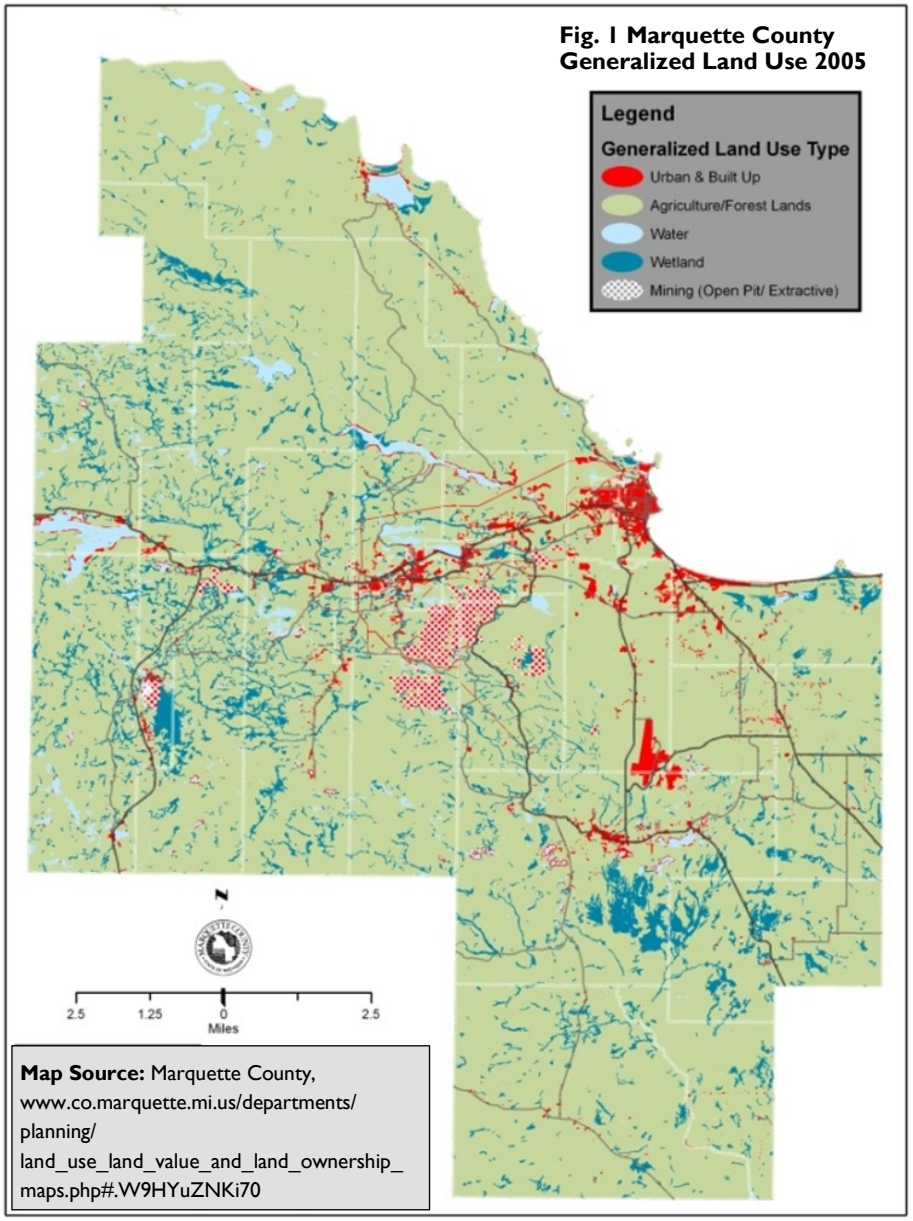


Fig. 1 Marquette County Generalized Land Use 2005

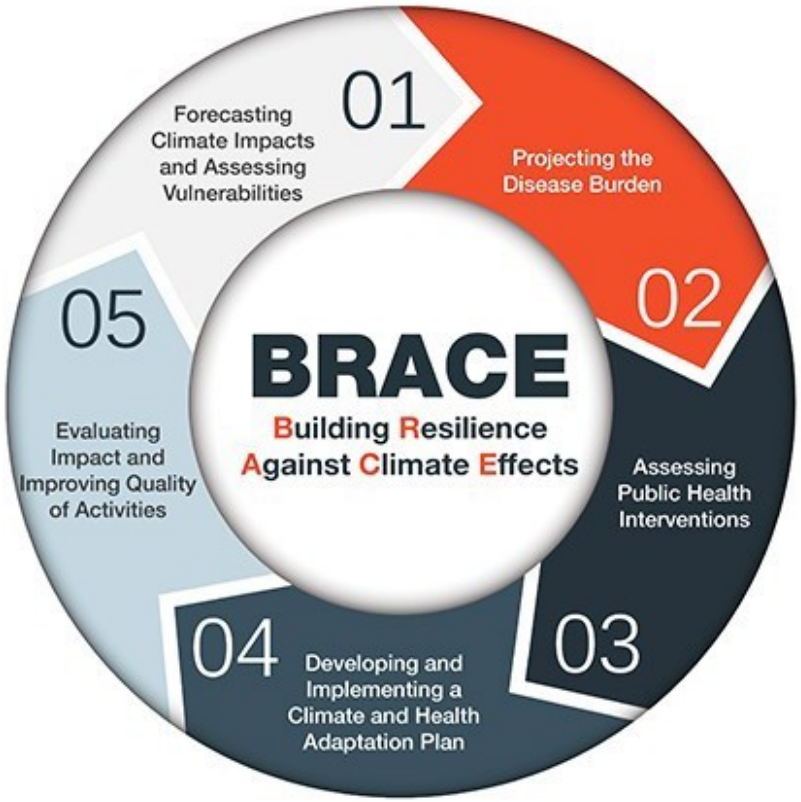
Map Source: Marquette County, www.co.marquette.mi.us/departments/planning/land_use_land_value_and_land_ownership_maps.php#.W9HYuZNKi70

Project Background

Following the CDC's Building Resilience Against Climate Effects framework (BRACE), shown in Figure 2, MICHAP is building a climate-resilient public health system for Michigan at the state and local levels by following three main principles: 1. Climate change is recognized as a public health issue and is integrated into public health practice, 2. Public health agencies and stakeholder organizations have the tools, resources and activities to respond to climate change impacts within existing programs, and 3. Vulnerable populations are explicitly considered in programs and policies addressing climate change impacts.

This Guidebook project is part of MICHAP's larger state-wide Climate and Health Adaptation Plan (MDHHS, 2016) to develop, pilot, and evaluate activities that increase the adaptive capacity of communities to prevent or reduce the health effects of climate change. Four types of adaptive strategies were identified in the state-wide plan and used to frame the Guidebook development process and its recommendations. Those are: 1. Education and inclusion: Ensure diverse stakeholders including representatives of vulnerable populations and social service providers are engaged when identifying issues and developing solutions. 2. Landscape actions: Work with land use and built environment decision makers to consider the climate and health impacts and benefits of the action. 3. Policy: Coordinate climate adaptation and public health best practices and metrics by tying them into a community's existing planning initiatives or ordinances. 4. Surveillance and tracking: Increase capacity for collection and analysis of local environmental health and climate related data. Develop local indicators for a community to track impacts over time and incorporate into cost/ benefit risk analyses or health impact assessments.

Fig. 2. Centers for Disease Control and Prevention- Climate and Health Program BRACE Framework



The BRACE framework is a five-step process laid out by the CDC to help states and community health departments address the public health concerns of climate change in their communities. As part of the CDC's Climate-Ready States and Cities Initiative (CRSCI) MICHAP uses this framework to address climate health concerns in Michigan.

Image source: www.cdc.gov/climateandhealth/BRACE.htm

Project Partners

Developing this Guidebook was a collaborative effort requiring diverse perspectives from the technical to local. The project was led by the Michigan Climate and Health Adaptation Program (MICHAP), the Michigan State University (MSU) School of Planning, Design and Construction (SPDC), and the MSU Extension (MSUE) program. However, the success of the project was largely dependent upon the existing capacity, knowledge, and networks of several local groups including the Marquette County Health Department (MCHD) and the Marquette Climate Adaptation Task Force (CATF). Through this process a diverse group of stakeholders, including vulnerable populations, had multiple opportunities to indicate their priority climate related health concerns and a chance to visualize potential adaptive built environment design changes. That feedback led to four major themes which guided further engagement and recommendation development: 1. Vector Awareness, 2. Air Quality, 3. Emergency Response/Extreme Events, and 4. Water Related issues.

MSU School of Planning, Design and Construction and MSU Extension

To address the built environment concerns related to climate change, the Michigan State University (MSU) School of Planning, Design and Construction (SPDC) offers the Sustainable Built Environment Initiative (SBEI) in partnership with MSU Extension (MSUE). The SBEI provides planning and design assistance to communities within a sustainability framework focused on resiliency and climate adaptation. The program helps build local consensus and generate physical design plans to address challenging sustainability concerns. The partnership allows for an integrated approach to solving complex community problems through the diverse expertise found within the SPDC along with MSUE's institutes and Extension educators.

Marquette County Health Department

The MCHD is Marquette's local health authority. It works to enrich lives in the community by preventing disease, promoting healthy lifestyles, and protecting the environment. Its vision is a community where people achieve the highest quality of life through healthy living by caring for themselves, one another and the environment. MCHD worked with the local MSUE office to bring key local representatives from the medical/ health field and from vulnerable populations into the project discussions, as well as contributing its own expertise.

Marquette Climate Adaptation Task Force

The CATF based in Marquette was created to help local leaders and the public think proactively about the effects of climate change and develop strategies that will make the Upper Peninsula more resilient. The seventeen members are drawn from a diverse group of current and former elected and appointed city, township and county leaders, representatives of energy and industry, university officials and environmental groups. CATF proceeds on the assumption that climate change and extreme weather events are occurring and that they will have an impact on the local area. Its members help to coordinate ongoing assessments of how climate change will affect their communities and have a focus on implantation of recommendations from the various climate planning initiatives that are ongoing in the area.

Climate and Health

Climate change can affect public health in numerous ways. With changing temperature and precipitation patterns also come changes to extreme weather such as increases in heavy precipitation and higher temperatures. Combined, they can lead directly to several negative health impacts including injury, waterborne diseases and heat related illnesses. Indirectly, health can be impacted by increases in drought, flooding, wildfires, expansion of vector borne disease habitats and more, as shown in Figure 3. Extreme weather caused by climate change is especially impactful to the health of vulnerable populations. Figure 4 summarizes how the changes in precipitation patterns and extreme weather can directly and indirectly lead to several negative health outcomes.

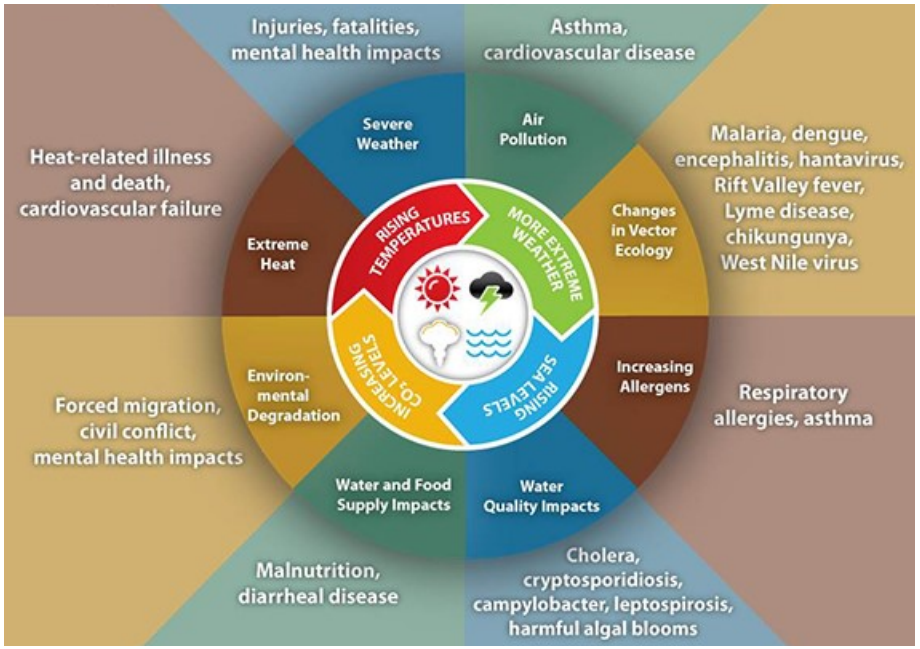
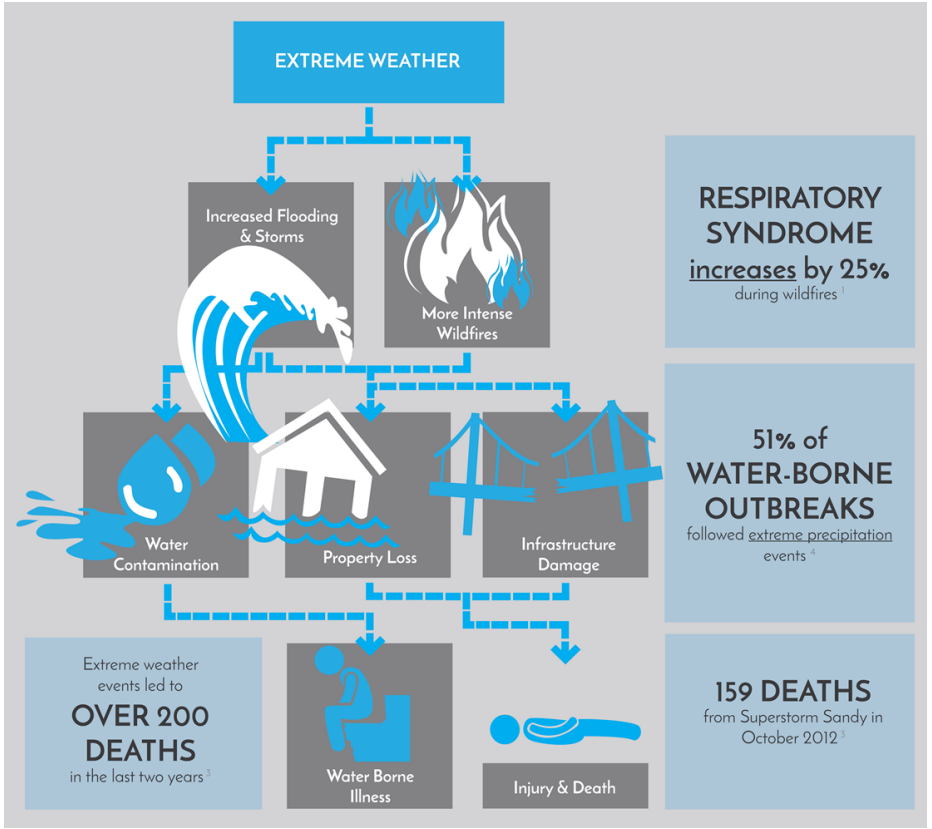


Fig. 3. Climate related health outcomes causal pathway diagram

Fig. 4. Causal pathway from extreme weather to disease, injury and death



Above Source: American Public Health Association (2012), https://www.apha.org/news-and-media/multimedia/infographics/how-climate-change-affects-your-health

Sources used in the graphic from top to bottom and left to right:
https://www.cdc.gov/mmwr/preview/mmwrhtml/mm5727a2.htm
https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1446745/
www.ncdc.noaa.gov/billions/events/US/1980-2018
www.ncdc.noaa.gov/billions/events/US/1980-2018

Left Image Source: Centers for Disease Control and Prevention, http://www.cdc.gov/climateandhealth/effects/default.htm

A Changing Climate in the Marquette Area

Compared to average temperature and precipitation levels of the early to mid-20th century, the Midwest region and Michigan have both warmed and received more precipitation overall as shown in Figures 5 and 6.

Marquette's climate has undergone similar though not completely identical changes. Residents are experiencing higher overall temperatures, with most dramatic increases occurring in the winter, as displayed in Table 1. However, unlike most of the region Marquette has seen decreased levels of annual precipitation driven primarily by drier springs and summers as shown in Table 2.

At the same time the Great Lakes region has experienced more frequent and intense extreme weather events like heavy rains and periods of drought (Great Lakes Integrated Sciences and Assessments (GLISA), n.d.). Those events have contributed to damaging infrastructure and impacting health. Examples include: floods impacting roads and water treatment plants; wildfires cutting off power and access to services; cold snaps freezing pipes; stream and beach contamination from storm water runoff; and diminishing aquifer recharge leading to water shortage.

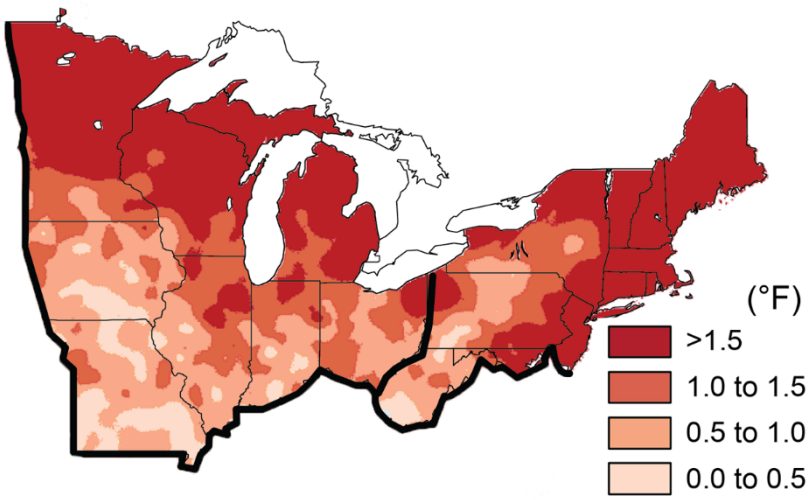


Fig. 5. Midwest temperature changes, 1991-2012 average compared to the 1901-1960 average.

Table 1: Change in Temperature from 1951 to 2017 (°F) in Western Upper Michigan

Annual	**+2.7**
Winter	+3.9
Spring	+2.5
Summer	+2.1
Fall	+2.5

Western Upper Peninsula includes: Baraga, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Marquette, Menominee, and Ontonagon Counties.

climate data source: GLISA, http://glisa.umich.edu/division/mi01

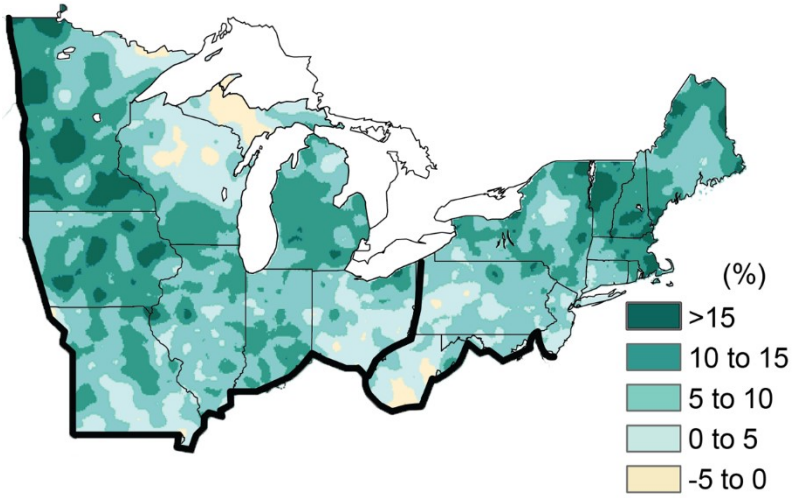


Fig. 6. Midwest annual total precipitation changes, 1991-2012 average compared to the 1901-1960 average.

Table 2: Change in Precipitation from 1951 to 2017 in Western Upper Michigan

	in.	%
Annual	-0.4	-1.21
Winter	+0.5	10.11
Spring	-0.4	-4.95
Summer	-1.7	-15.70
Fall	+1.3	14.95

Western Upper Peninsula includes: Baraga, Dickinson, Gogebic, Houghton, Iron, Keweenaw, Marquette, Menominee, and Ontonagon Counties.

climate data source: GLISA, http://glisa.umich.edu/division/mi01

Vulnerability and Readiness of the Marquette Area

Climate vulnerability is a measure of a community's risk of being negatively impacted by climate change. The degree to which it is vulnerable depends on three variables, as shown in Figure 7. Exposure is the severity and types of changes to an area's climate. Marquette's is discussed on the previous page. Sensitivity considers the population and their health and living conditions. Adaptive capacity is the expertise, plans, programs, or resources a community has in place to prevent or reduce negative impacts.

In Marquette the groups considered particularly sensitive include the aging, young children, those in poverty, the homeless, those without access to health care or other essential services, people with chronic diseases and mental stress, and socially isolated individuals and towns. Table 3 lists a subset of key socio-economic and health related indicators of vulnerability for Marquette County compared to the rest of the state.

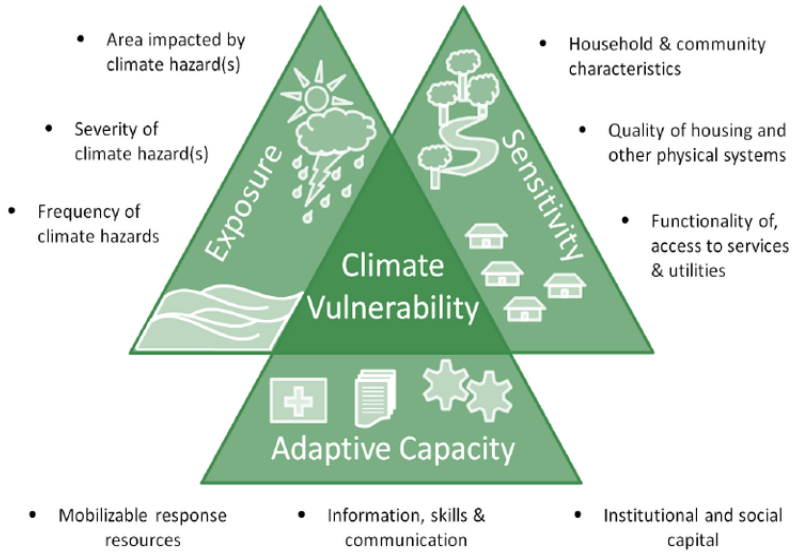


Fig. 7. Components of Climate Vulnerability

Source: Trundle & Mcevoy, 2015, www.researchgate.net/publication/283243489_Greater_Port_Vila_Climate_Vulnerability_Assessment_-_Full_Report

Table 3: Socio-economic Vulnerability Factors (from U.S. Census 2016 estimates)

	Marquette County (%)	**State of Michigan** (%)
Age under 5 yrs.	4.8	5.8
Age 65 yrs. and over	18.0	16.2
Population in Poverty	15.0	15.8
Elevated Rates of Chronic Health Conditions in Marquette County vs. Michigan (from Behavioral Risk Factor Survey: http://www.michigan.gov/brfs)		
Disability	30.3	25.2
Asthma (Still)	14.6	10.9
Asthma (Ever)	26.3*	15.9
Obesity	36.5	31.1
Arthritis	34.8	31.1
*significantly elevated		

Marquette's existing *adaptive capacity* was a key indicator of community readiness to take on this project.

Marquette is unique in comparison to other communities of its size, and even those much larger, in terms of the number and sophistication of climate adaptation activities already under way and the breadth of stakeholders who are participating. Climate plans have been created and are being implemented for the Lake Superior Watershed (Superior Watershed Partnership, 2012) Marquette County (Superior Watershed Partnership, 2013) and the City of Marquette (MSUE & MSUSPDC, 2013). Groups such as CATF and the Superior Watershed Partnership & Land Trust (SWP) have been instrumental in laying the foundation of climate change awareness and understanding while also building a broad network.

Along with demonstrated health related vulnerabilities, Marquette was selected due to that existing adaptive capacity. With assessments of the environment and infrastructure completed and access to local expertise, this project focused on building relationships with vulnerable populations and exploring the complex connections between climate, health, and the built environment. This Guidebook supplements the existing adaptation efforts by recommending policies and metrics that are supportive of health as well as economic and environmental goals.

Adaptation

What is adaptation and how do we use it to build resilience?

Definition – Actions that build the capacity of the community to address and interrupt climate change from impacting people's health.

Examples of adaptive actions from MICHAP Strategic Plan Update: 2016-2022:

Education and inclusion: Develop communication plans and messaging about community wide resources and protective personal behaviors that particularly target those most vulnerable.

Landscape and built environment: Promote land-use and infrastructure solutions that sustainably address climate impacts while also benefiting community health.

Policy: Coordinate adaptations with ongoing community development and public health activities by tying them into the community's existing decision-making processes such as the master plan or health improvement plan.

Surveillance and Tracking: Increase capacity for collection, analysis, and sharing of environmental and health related data.

Adaptation planning allows the community to strategically address the climate concerns of the community in a measured and collaborative manner.

Green Infrastructure and low impact development are landscape and built environment adaptations that can be used to build resilience. This poster was presented to the community at the kickoff meeting in November 2017.
Source: Amal Shabaan, PhD Student, MSU SPDC, adapted from the City of Philadelphia Green Streets Design Manual

Methods

Process

This multi-year project is being executed in three phases. Each phase has different objectives that move the project toward the larger goal of preventing or reducing human health impacts from climate change in Marquette County.

Phase I

2017 Identify potential partner communities and establish a foundation for intervention by engaging stakeholders and understanding concerns

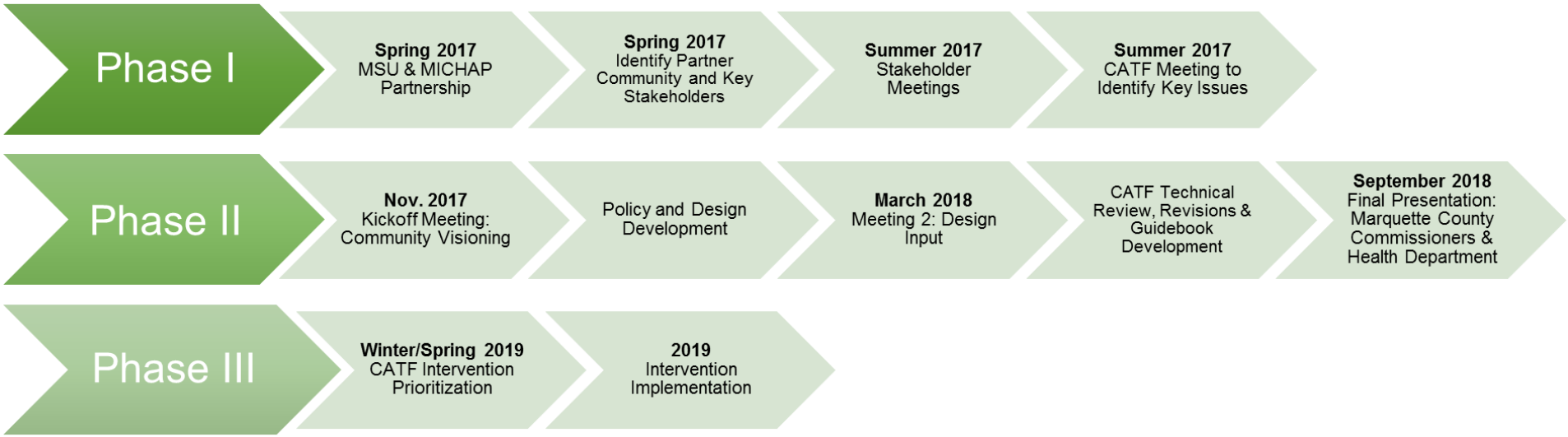
Phase II

2018 Develop interventions, recommendations, and metrics; obtain feedback; and develop guidebook

Phase III

2019 Engage community to prioritize recommendations and establish ownership for implementing the recommendations

Project Timeline



Focus Groups and Site Visits

From July through October of 2017, the project team held focus groups with nearly 25 stakeholder groups representing a range of knowledge, perspectives and roles in the community, as shown in Table 4. To facilitate open and honest discussion the meetings were scheduled in person at a location of the groups' choosing when possible. The questions were open ended but health oriented and encouraged participants to describe how climate change is affecting their lives and professions, the challenges they face, physical locations the team should focus on, and what solutions they want to see in their community. The results were summarized and presented to CATF, as shown in Appendix A, which reviewed how climate change affects different groups in Marquette, then helped the team identify six priority issues: flooding, water shortage, road access, wildfires, ticks, and air quality.

Table 4. Stakeholder groups engaged

Climate Change	Local Government
• Superior Watershed Partnership • Climate Reality Project • MSU Extension – Greening MI Institute • Climate Adaptation Task Force (CATF)	• Marquette County • City of Marquette • Marquette Twp. • Chocolay Twp. • Humboldt Twp. • Sawyer • Area Chambers of Commerce • Public Utilities
Health	**Vulnerable Populations**
• Marquette County Health Dept. • MSU College of Human Medicine – UPHS • MSU Extension – Health & Nutrition Inst. • NMU – Community Health Education • Area Physicians • Emergency Response Officials	• Community Action Alger-Marquette • Aging Services • Veterans Affairs • Homeless & Shelter Services • Continuum of Care

The results of the focus groups also provided a list of example sites around Marquette County that were identified as having been impacted by climate related events, such as flooding. Those sites were photographed for use in Phase II to develop before and after design renderings of potential built environment adaptations. To ensure the sites were representative of the issues and various populations the project team considered each in terms of the type of built environment structure it represented, what type of climate impacts it received, the geographic spread, and relation to vulnerable populations. Having examples of climate adaptation that the stakeholders were familiar with was critical in grounding the issues for the community.

Community Meetings

Meeting One: Community Visioning

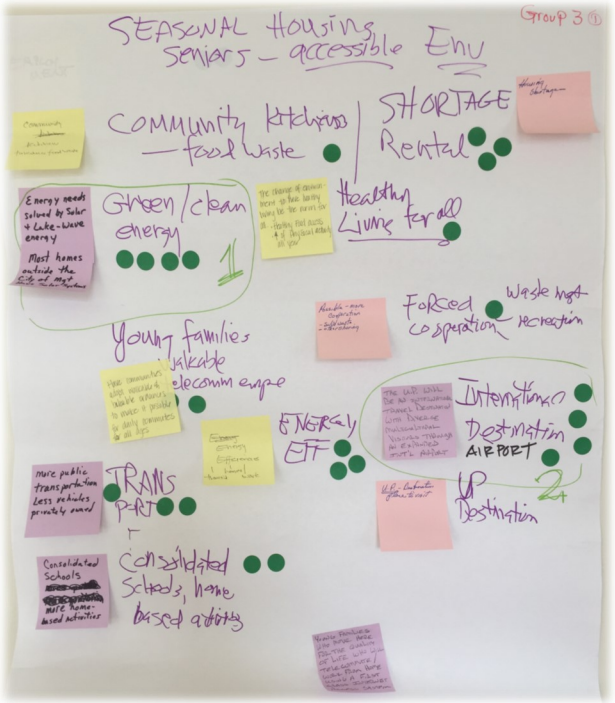
On November 2, 2017, the stakeholder feedback was summarized and presented to community members at an official kick-off event. Through targeted questions, group discussion, and interactive activity using sticky notes, easel pads, colored dots for prioritization, and maps, the team gathered further input on both individual and group concerns from the residents. The team asked the community:

- Individually, "What do you think are the biggest climate and health threats facing Marquette County? Think in terms of priority threats previously identified such as water quality, flooding, water shortage, and wildfires. You may identify other relevant threats as well."
- In groups, "Imagine that you have been away for 20 years and you just came back. With the best hope for your community, how has it changed? What does this area look like in 20 years after the climate and health impacts have been fully addressed? Who lives there? What are they doing? What is housing like? How are people getting around? What amenities and infrastructure are there?"
- In groups, rank the major climate change and health priorities of Marquette County.

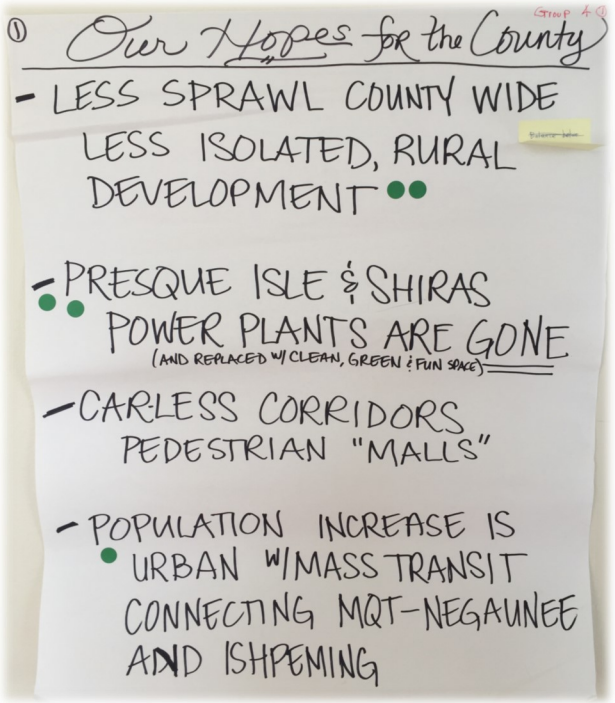
Community concerns centered around the state of mass transportation and evacuation systems, inadequate energy systems, a lack of affordable housing, and inadequate infrastructure. Over fifty visions for the future of the community were made. These responses reflect the high level of engagement and commitment to addressing climate change concerns felt in the Marquette area community. Frequently heard ideas included regional cooperation, planning and authority, improved mass transit and road connectivity, walkable and bikeable communities, and clean/green energy, among others. Appendix B provides the full collection of responses.

Meeting One: Community Visioning Feedback Examples

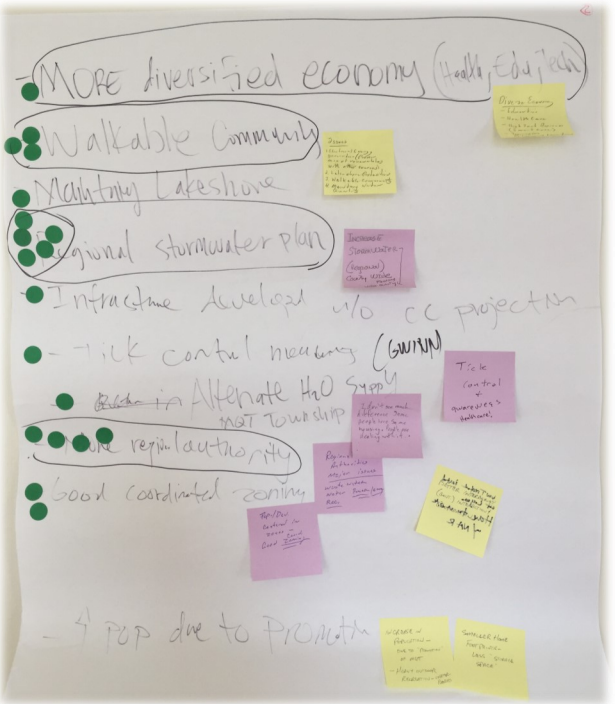
At Meeting 1 community members sat in four groups and responded to visioning prompts by writing concerns and ideas on easel pads and sticky notes, and prioritizing using green and red dot stickers. Each member was given stickers to indicate support to the written ideas within their group. Green indicated support for the concern or hope, and red indicated a differing opinion. Very few red stickers were used. Below are examples of some of the easel pad group responses with summaries of what is written. The feedback helped the team further develop recommendations to match the concerns and priorities of the community.



Input emphasized the desire for clean, renewable energy, developing the UP as an international destination, and the experience of the housing shortage in the community.



Hopes for the community included climate-friendly zoning, public lakefront access, and a zero-waste community.



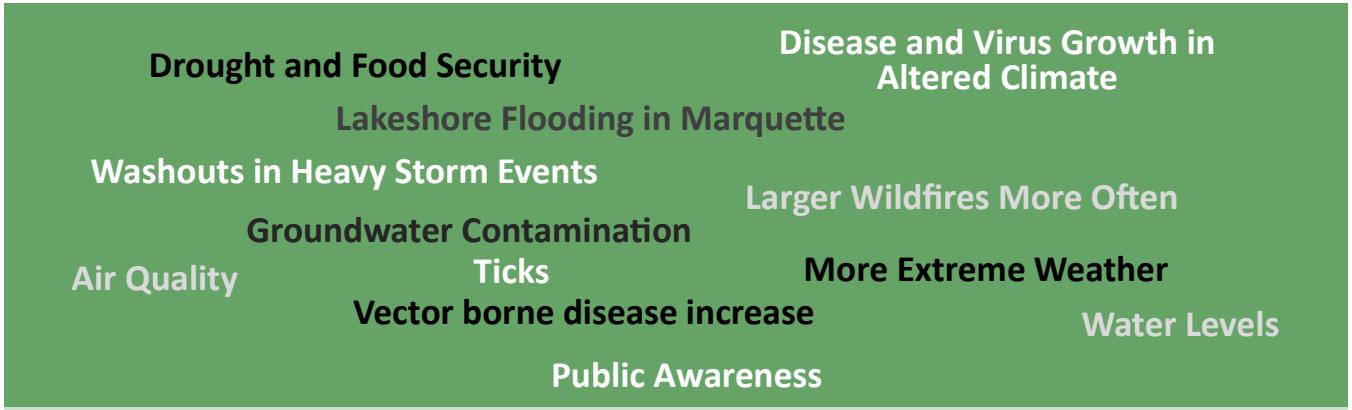
Prioritized desires pointed to regional storm water plans, more regional authority, and walkable communities.

Community Visioning Summary

The community's feedback is illustrated in Figure 8. The word clouds provide community feedback in a visual way, with the largest font size representing the most frequently heard idea.

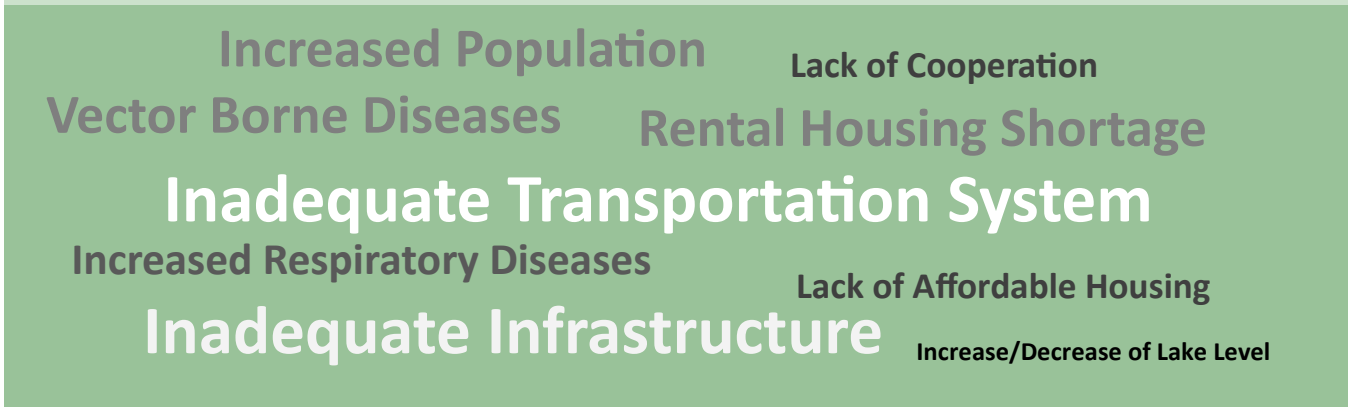
Fig. 8. Word Cloud: Feedback from Community Meeting I

Individually, "What do you think are the biggest climate and health threats facing Marquette County? Think in terms of priority threats previously identified such as water quality, flooding, water shortage, and wildfires. You may identify other relevant threats as well."



In groups, "Imagine that you have been away for 20 years and you just came back. With the best hope for your community, how has it changed? What does this area look like in 20 years after the climate and health impacts have been fully addressed?"

In groups, rank the major climate change and health priorities of Marquette County.



Community Meetings Cont.

Meeting Two: Design Input & Summary

The MSU SPDC team took the feedback from the first community meeting along with the imagery captured during site visits and created before and after designs of the selected locations. The before images show the area as it exists today. The after images were edited by the SPDC team to incorporate adaptations that would address the climate and health concerns the community faces, and also align with the community vision for a climate adapted future. Some of the *after* images included symbols to associate the design change to the specific health concern it was meant to address, along with sample metrics and policy tools that could enable the design changes to be implemented. Feedback on the sample metrics and policy tools were incorporated into Volume II of the Guidebook. On March 26, 2018 the team hosted a second meeting in the City of Marquette to present their design options and imaging surrounding those designs. Over forty residents attended and provided general written feedback on worksheets and detailed design feedback with sticky notes directly on the images. Those responses are summarized in Table 5 below. Residents were asked to respond to three questions:

- "What do you like about the designs interventions?"
- "What is missing from the design interventions?"
- "What suggestions do you have to improve the designs, policies, and metrics presented today?"

Designs with increased vegetation, as well as the storm water runoff reduction from green infrastructure drew large praise. Energy grid changes and energy efficiency designs found strong support. Concerns centered around overly-constructed designs in natural areas and green infrastructure's potentially poor success rate in cold climates. The team used the comments to further develop the design recommendations to meet the community's needs.

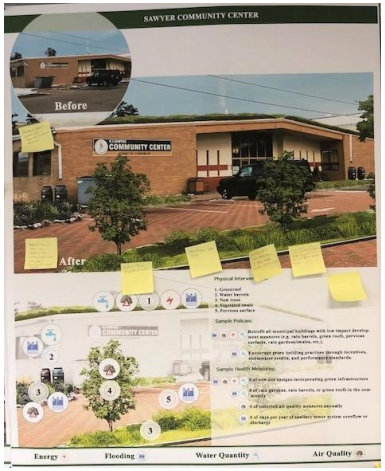
Design Input Summary

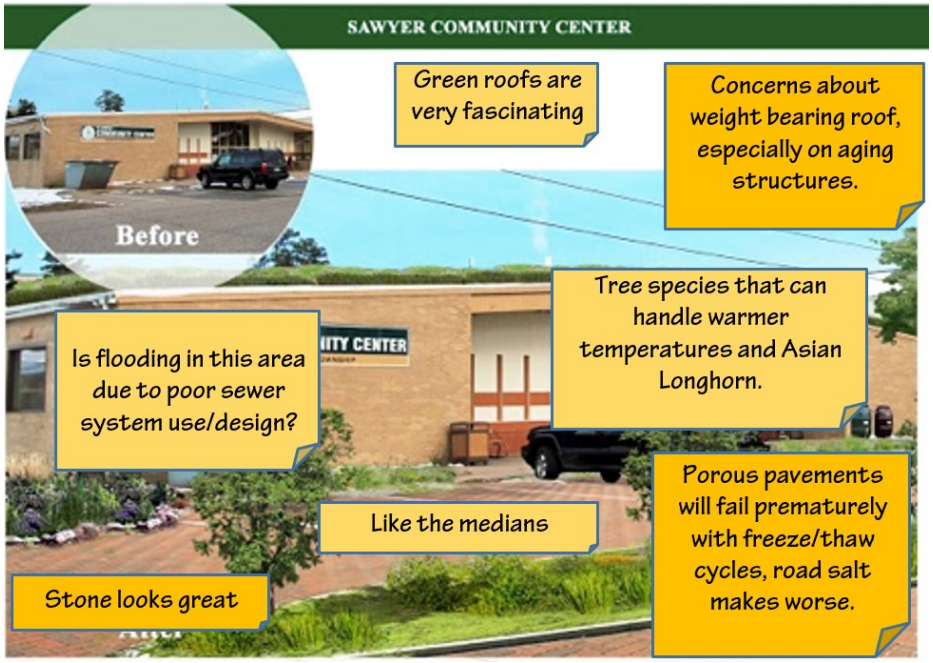
Table 5. Meeting Two community feedback of before and after adaptive design images

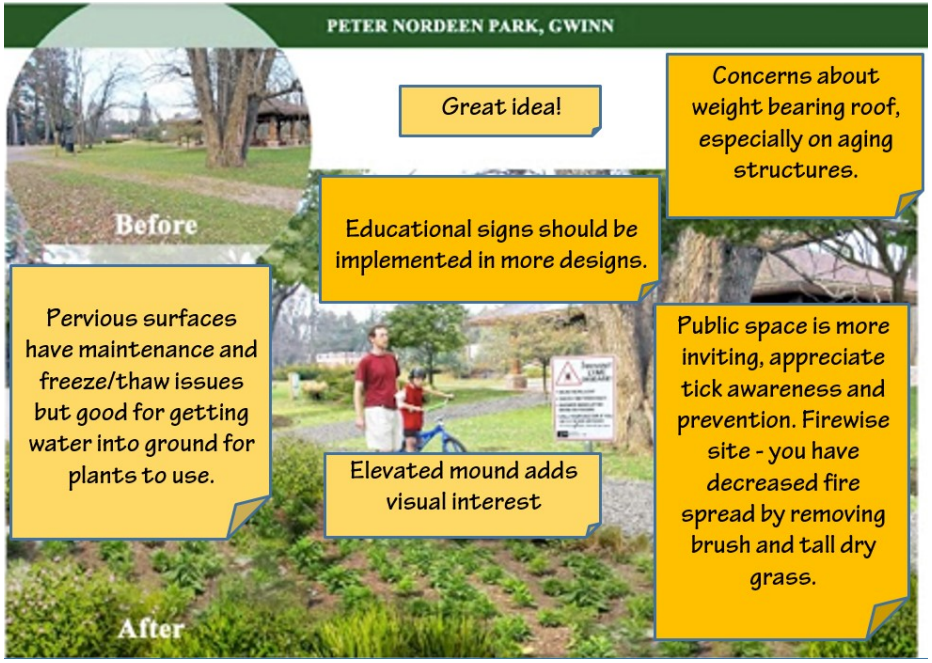
What do you like about the design interventions?	What is missing from the design interventions?	What suggestions do you have to improve the designs, policies, and metrics presented today?	Additional thoughts or comments?
* Beautification aspects of the designs * Increased greenery, vegetation, and green spaces * Interventions appear affordable * Street designs for pedestrians rather than cars * Green infrastructure including green roofs, rain gardens, tree plantings, and pervious pavement * Increased services to isolated communities (like KI Sawyer) * Soil stabilization aspects * Solar panels	* Who will maintain them? * Increased curbing can get in the way of snow plows * Community food gardens to address food insecurity * Large scale solutions * City of Marquette downtown improvements * Funding sources * Local opinions * Environmental impacts of interventions * Public interaction spaces * Energy efficient housing, transportation, buildings, and industry * Community services including mental health and community coherence promotion * Ishpeming interventions	* Leave the lakeshore natural/ untouched * Salt-tolerant plants should be used * New trees should be able to handle increased temperatures * Consider edible landscapes * Interventions won't address large-scale flooding—design solutions should be related to building construction, water supply, well construction, road systems, and wastewater systems in floodplains * Are these practical for the community? * Has the team considered physical water diversions?	* General support for designs and for community engagement processes * Need to incorporate more outlying areas into design recommendations * Increase engagement for local residents in areas with proposed design interventions * Consider retaining grey infrastructure in some locations if it makes sense * Focus more on future of the energy sector with less carbon * Diversify recommendations beyond rain gardens

Meeting Two: Design Feedback Examples

At Meeting 2, community members individually interacted with and responded directly to the input prompts about the design renderings by adding their feedback directly onto the images with sticky notes. The feedback helped the design team further develop the designs to match the preferences of the community. *Appendix C* presents all responses.







Marquette Area Climate Health Categories

Health Categories

The primary and secondary concerns expressed during phase I of the process were evaluated by MSU and MICHAP against the existing climate and health literature and vulnerability assessments of Marquette to ensure there were no significant impacts excluded. The list of concerns was also reviewed by a CATF workgroup of technical experts on climate, health, and the built environment. Out of the reviews the original six primary concerns were grouped into four overarching health categories: Vector Awareness, Air Quality, Emergency Response/Extreme Events, and Water Related issues. Figures 9, 10, 11, and 12 below summarize the exposure pathways that link climate change drivers to each of the health outcome categories of concern. These pathways can be used to understand the risk and where adaptations can be directed to interrupt that pathway. The symbols used to indicate the various health outcomes next to each pathway are used in the before and after design images also. They are explained below and in the Design Considerations section of this Volume I.

Fig. 9. Vector-Borne Disease Exposure Pathway (Vector Awareness)

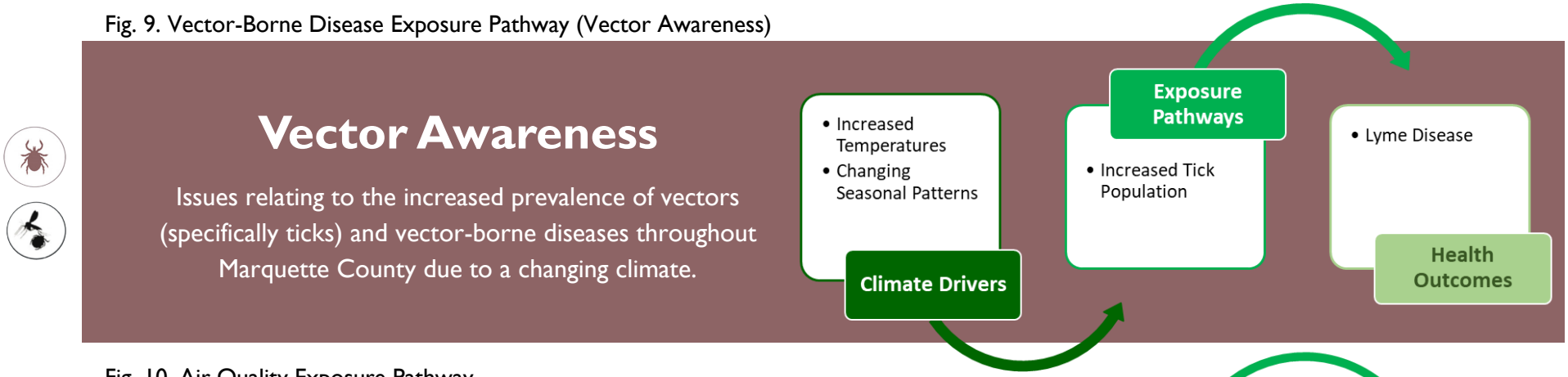
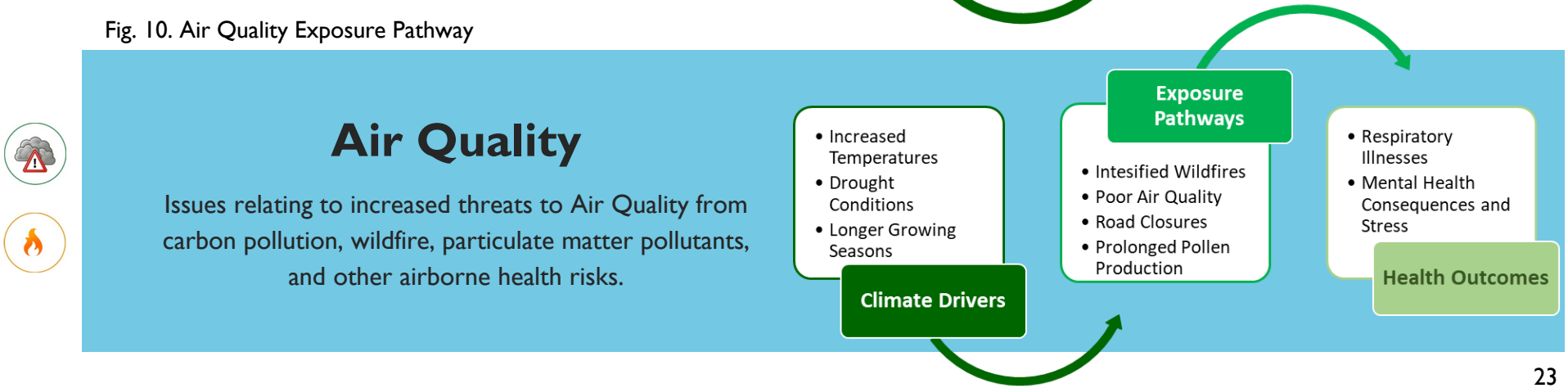


Fig. 10. Air Quality Exposure Pathway



Health Categories Cont.

Fig. 11. Emergency Response and Extreme Events Exposure Pathway

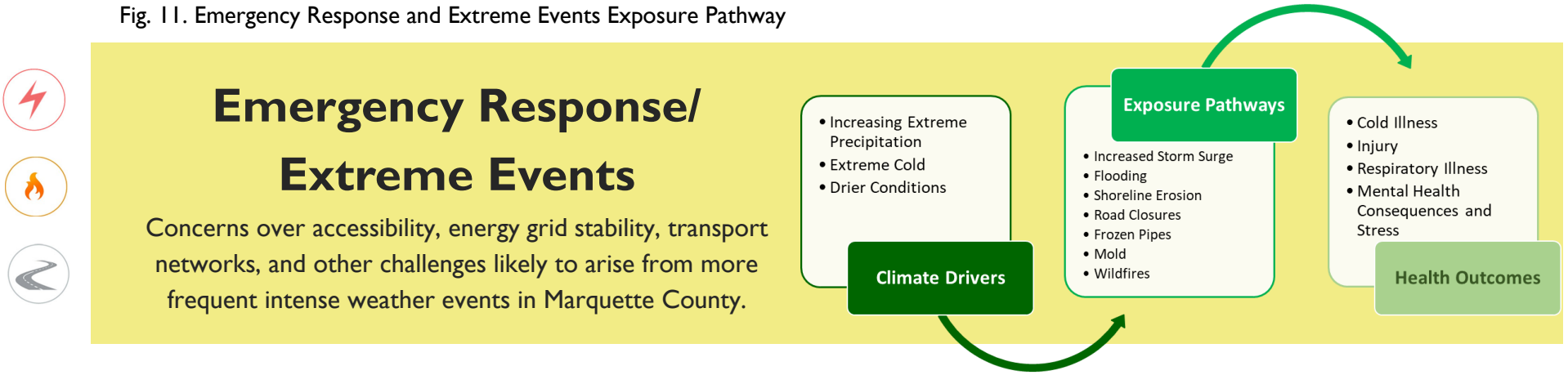
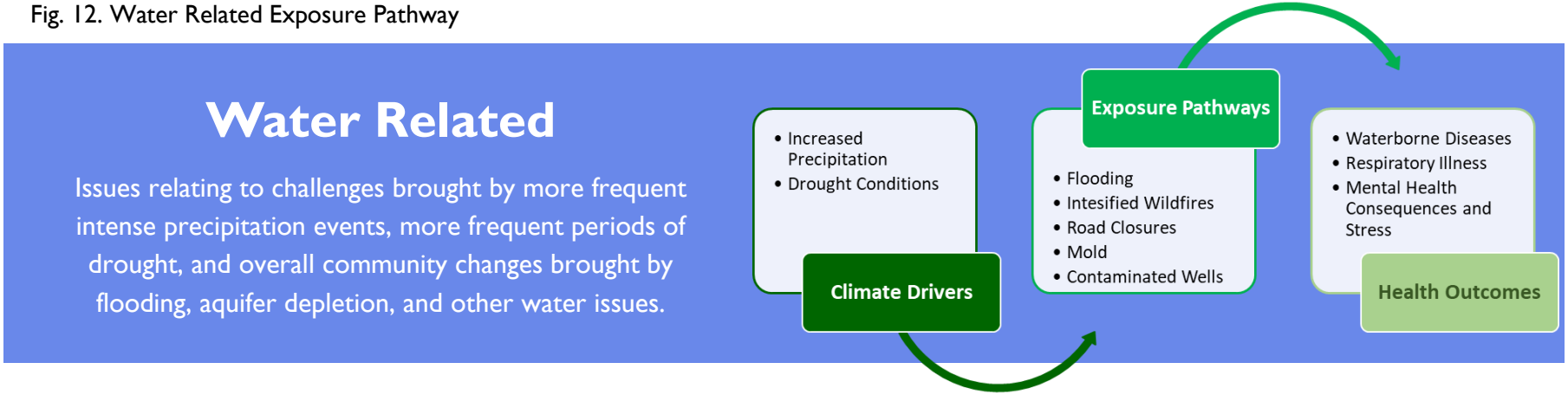


Fig. 12. Water Related Exposure Pathway



Design Considerations

Design Considerations

In developing the designs, the team considered the four categories of health concerns voiced by the community. The goal was to identify built environment designs that were climate adaptations and would interrupt the pathway between a climate change driver and one or more of the health concerns. Within each health concern category many physical design concepts were identified that could be protective of the community's health. Some of the design concepts are listed below for each health category. The practices often have far-reaching benefits across multiple health concerns. This information was also considered when developing policy recommendations in Volume II of the Guidebook.

Vector Awareness

* Enhance and maintain buffer between humans and tick habitats to limit exposure
* Increase awareness of tick exposure-risk and prevention throughout community

Air Quality

* Encourage adoption of Firewise standards throughout area
* Encourage the principles of Placemaking and EPA Green Streets
* Limit CO_2 emissions and expand absorption
* Encourage low-pollen vegetation use
* Enhance clean air educational materials throughout county

Design Considerations

Emergency Response/Extreme Events

* Enhance green infrastructure development to reduce shoreline and inland flooding
* Reduce road access barriers, erosion, and property damage along Lake Superior
* Promote extreme weather and wildfire caution, preparedness, and awareness
* Ensure road access for emergency response in the event of extreme events
* Encourage principles of Placemaking and more accessible development patterns that limit rural community dependence on distant sources for critical needs
* Promote localized measures to limit damage and danger of extreme events to public infrastructure
* Limit human exposure to the dangers of extreme weather
* Enhance infrastructure and property through Firewise techniques to decrease the risk of and exposure to wildfires

Water Related

* Protect water quality through reduced runoff
* Protect private wells from increased risk of groundwater contamination
* Reduce beach contamination sources upstream
* Protect surface and groundwater from septic contamination
* Discourage water waste and encourage conservation through green infrastructure
* Encourage principles of Smart Growth in design

Design Recommendations: Visualization and Policy

Design Recommendations

What to look for in design and policy recommendations

With the community input, health categories, and design considerations in mind, the team developed several visual renderings of adaptation designs in various locations throughout Marquette County. These designs are meant to show adaptation possibilities throughout the area to help the community members visually connect with what adaptation looks like and how those concepts could be applied in their community. The designs do not consider existing regulations, ordinances, etc. in individual communities as the adaptations could be implemented region-wide. They are representative of a broad array of different measures, which will be explored in greater detail in Volume II, intended to educate users of the Guidebook on how the given adaptation measure connects to health.

In viewing the design recommendations and sample policies, readers will see before and after images of various locations throughout Marquette County. The before image shows the current state of the location as an example of an area where adaptation is needed to address one or more of the four over-arching health categories as synthesized from the community meetings. The after image shows what the area looks like with the adaptation in place.

Next to several of the images is a list of the physical Sample Policies the community could adopt to enable or encourage implementation of the adaptation design concept. Sample Health Measures are included to show potential metrics that could be used to evaluate how well each adaptation accomplished its intended goal. Corresponding symbols quickly show the user which health concerns are addressed by the adaptations in each after image. A full set of policies and measures can be found in Volume II of the Guidebook.

Icons

- Ticks
- Vector Awareness
- Air Quality
- Energy
- Road Access
- Wildfires
- Flooding
- Water Quality

SAWYER COMMUNITY CENTER

Physical Interventions

1. Green Roof
2. Rain Barrels
3. Vegetated Swale
4. New Trees
5. Pervious Surface

Sample Policies

"Lead-by-example" in municipal development. Include retrofitting all municipal buildings with low impact development (LID) measures (e.g. rain barrels, green roofs, pervious surfaces, rain gardens, etc.).

Adopt guidelines to ensure that municipal tree -plantings and landscaping use low-pollen-producing species. Include list of allergy friendly trees for developers.

Sample Health Measures

Gallons of runoff diverted by LID

Number of low-pollen-producing tree species planted

Energy **Flooding** **Water Quantity** **Air Quality**

GWINN NEIGHBORHOOD

Physical Intervention

1. Solar Panels
2. "Tick-Safe" landscaping (short mown grass)
3. Rain Gardens

Sample Policies

Pursue development of microgrids (energy independent of the main grid) for local areas to enhance grid redundancy.

Encourage residential adoption of Firewise standard through public information campaigns; the promotion of localized programs and resources; and grant programs.

Develop communication and messaging plans to encourage resident action on water conservation.

Sample Health Measures

Number of sites in Marquette County listed on the Firewise USA map

Extent of development of microgrids in local area

Number of households contacted via new communication outreach plans

Energy **Flooding** **Water Quantity** **Wildfires** **Ticks**

PETER NORDEEN PARK, GWINN

Physical Intervention

1. Educational Signage
2. Low-fire risk vegetation
3. Vegetated Swale

Sample Policies

Increase educational signage in public places on tick awareness and prevention.

Enhance countywide wildland urban interface (WUI) codes and ordinances based on Firewise USA standards.

Set green infrastructure standards for public spaces that ensure the use of native, low-water-dependent landscaping on public properties.

Sample Health Measures

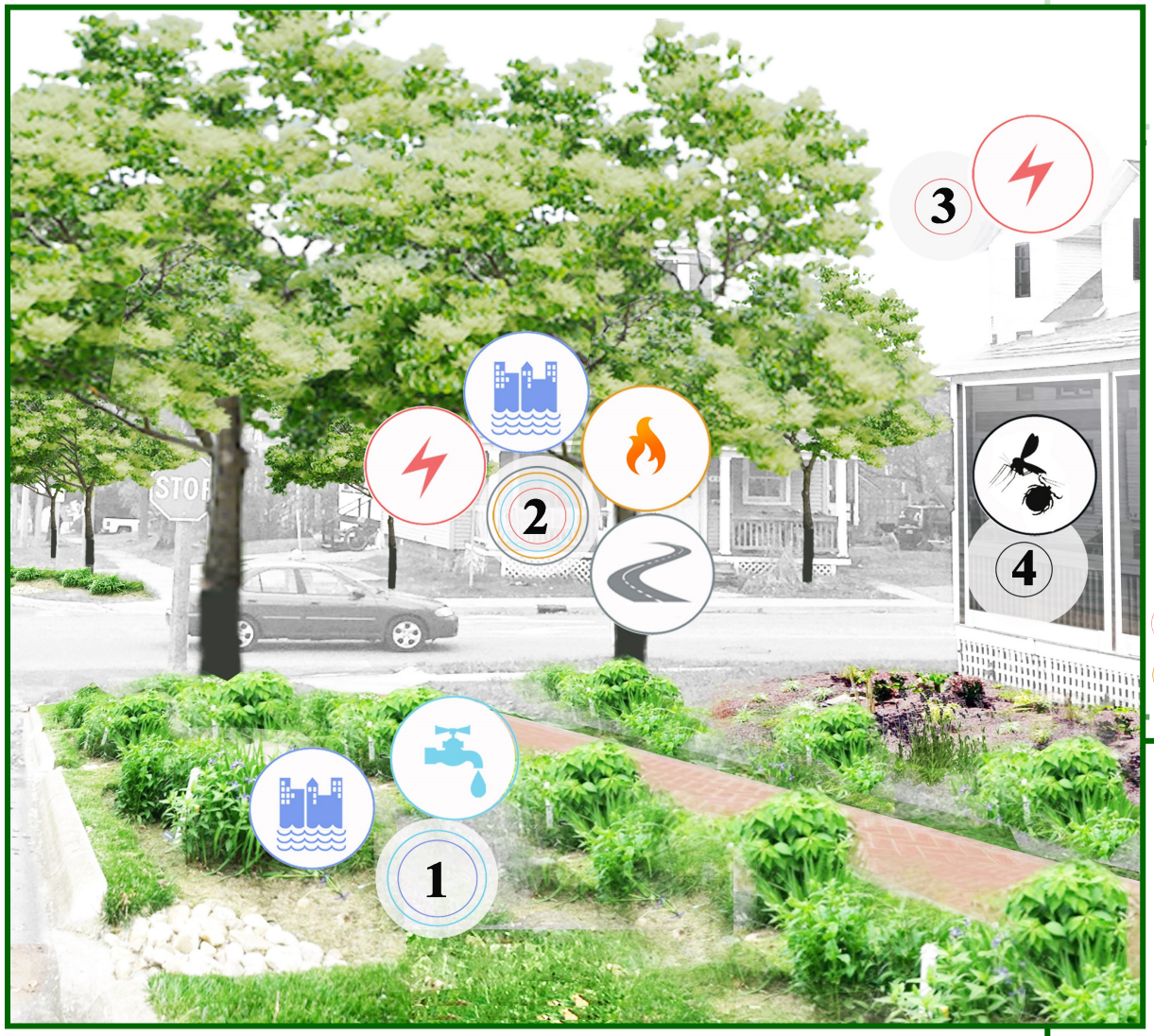
Number of tick-specific educational signs in public places

Number of new developments in WUI

Change in the number of municipal properties with LID practices

Flooding **Water Quantity** **Wildfires** **Ticks**

MARQUETTE NEIGHBORHOOD



Physical Intervention

1. Vegetated Swale
2. Mixed-Use Living Pattern
3. Burial of Power Lines
4. Screens

Sample Policies

Consider burial of power lines for protection in major weather events and plan for the life cycle of energy infrastructure investments to better display the full-life savings of green infrastructure.

Encourage LID practices, greywater reuse, and low-water dependent landscaping by private owners and developers.

Adopt zoning to encourage market-supported, mixed use development of appropriate density and scale for the location and community.

Sample Health Measures

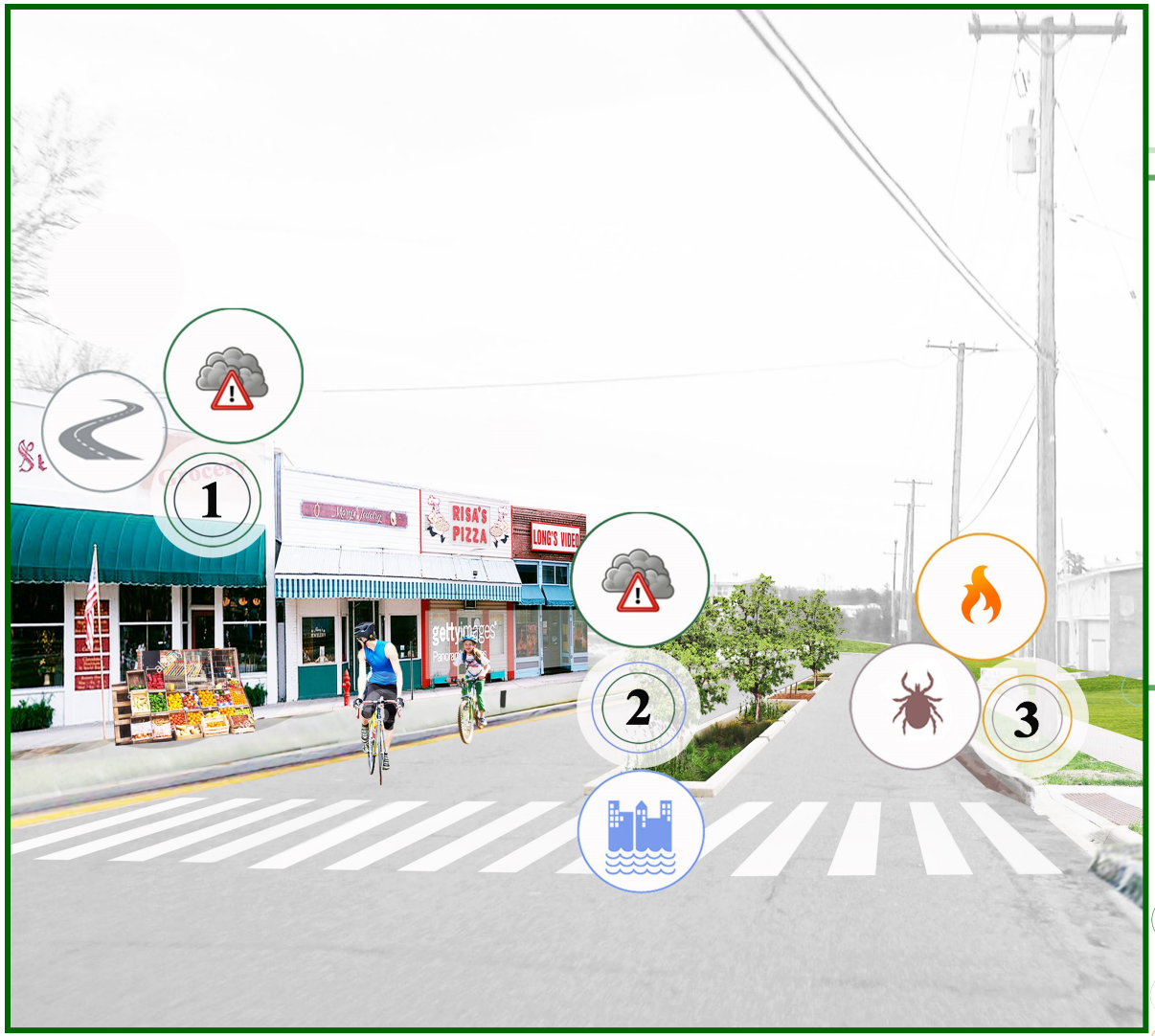
Percentage of local power lines buried by the utility

Number of LID adoptions by private property owners

Percentage of local dense, developed area covered by zoning which encourages mixed uses

Energy **Flooding** **Water Quantity** **Vectorborne diseases** **Road Access**

K.I. SAWYER COMMUNITY



Physical Intervention

1. Mixed-Use Development
2. Vegetated Swale
3. Short Mown Grass

Sample Policies

Encourage "Tick-Safe-Yards" practices such as short mown grass and debris free yards.

Expand the development of walkable and bikeable options throughout county.

Promote Placemaking and incentivize market-supported, mixed-use development which include businesses that meet the basic needs of the community residents (e.g. grocery stores, health centers, etc.) within walking distance.

Sample Health Measures

Number of individuals reached by public education campaign

Miles of bike lanes and safely bikeable and walkable routes throughout county

Number of residents within one-mile of businesses that meet basic needs

Ticks **Flooding** **Wildfires** **Road Access** **Air Quality**

LAKESHORE ROAD, MARQUETTE

Physical Intervention

1. Trail
2. Vegetated Swale
3. Pervious Pavement
4. New Trees

Sample Policies

Adopt integrated pest management strategies for public spaces such as parks and schools that include strategies for landscape management (ex. widened walking trails and regularly mowed grass).

Prioritize projects that offer protection from wave action, changing water levels, and storm surge while also helping manage runoff and creating habitat. Emphasize the incorporation of green infrastructure and natural shoreline restoration in any coastal zone development .

Sample Health Measures

Number of sites with integrated pest management strategies

Number of road closures, other damage due to flooding

Ticks **Flooding** **Road Access** **Water Quantity**

Design Recommendations: Adaptations Explained

Design Recommendations

Adaptations Explained

Before and *After* Images

Like the previous adaptation design images, the images in this section are based on conversations with the community in focus groups and community meetings. They are meant to help in visualizing adaptation possibilities throughout the area. This will help stakeholders better understand climate adaptation as it relates to their lives and help them prioritize what adaptation techniques they prefer. Similarly to the previous section, readers will see before and after images of various locations throughout Marquette County. The before image shows a setting where an adaptation could address the Vector Awareness, Air Quality, Emergency Response/Extreme Events, and Water Related concerns heard at the meetings. The after image includes physical adaptation designs that can address those concerns.

However, instead of being connected to a list of interventions, sample policies, and health metrics, each image is paired with a detailed explanation of how the adaptations pictured in the after image addresses the climate change concerns voiced by the community and presented in the before image. Corresponding symbols are again used to show the reader what concerns are addressed in each image. Other useful information related to the adaptation is provided in pop-out boxes, as explained in Figure 13. They provide additional context about the adaptation as well as in-depth resources to pursue. The references for these pages can be found in Appendix D of this report.

Fig. 13. Pop-out Boxes Explained

Pop-out boxes

Tips
These boxes include information on a variety of climate change adaptation related topics, ranging from community development co-benefits of adaptations to common myths about adaptation techniques. These were based on concerns gathered from the stakeholder and community meetings about the community in general or concerns about design interventions.

Case Studies
These boxes include case studies of other communities that have adopted similar climate change adaptation measures as shown in some of the designs.

Community voices
These boxes include quotes heard and recorded at Community Meetings One and Two. Most are community comments on the accompanying design.

Empty lots with little vegetation can be key locations for adaptive measures in reducing runoff and flooding. Mixed use development that meets vital community needs strategically located in areas vulnerable to road flooding is a strategy that not only addresses the consequences of extreme weather but also increases walkability.[1] Encouraging energy efficient buildings with on-site energy production, decreases reliance on the energy grid system, reducing the consequences of power outages in the system. Burying power lines can also help the system become more resilient to outages caused by extreme events.[2]

Low impact development utilizes green infrastructure such as trees, plants, and permeable pavement to reduce runoff and help prevent flooding. The plant roots absorb rainfall and decrease the risk of water contamination from traditional hard-surface runoff. Plants can also improve air quality by absorbing harmful particulates.[3] Energy efficient building practices also improve air quality through the reduction of the amount of harmful fossil fuels necessary for operation.[2, 3]

[1] Planning for Community Resilience in Michigan, 2017
[2] US Green Building Council, 2016
[3] United States Environmental Protection Agency, 2018a

Underutilized spaces such as corner lots and alleyways can be used strategically to reduce flooding, improve water and air quality, and also enhance a sense of place in the community where residents can gather.[1] Plants and trees reduce flooding by absorbing rainwater while also improving air quality by capturing harmful particulates. This is especially helpful in areas of denser development where air quality and flooding issues can be exacerbated due to a reduction of natural space resulting from hard-surface development.[2, 3]

Placemaking

Placemaking, the practice of shaping communities where people want to live, work, and play through the creation of a "sense of place," can be used to restore lost spaces such as vacant lots to an area loved and utilized regularly by the community. Not only does the reclamation of these spaces add to the economic vitality of a community, but the draw of attractive public spaces can help bring community members together. This creates opportunity for organic social interaction which can strengthen community bonds (Wyckoff et al., 2015).

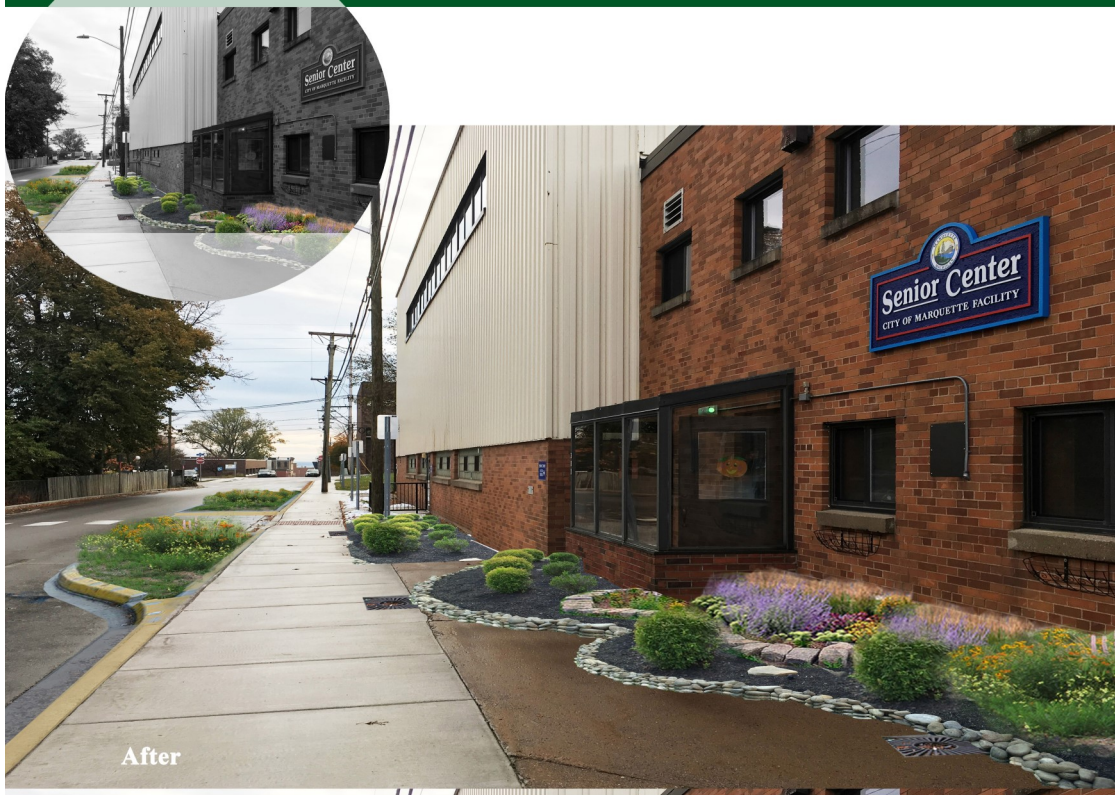
[1] Wyckoff et al., 2015
[2] Planning for Resilience in Michigan, 2017
[3] United States Environmental Protection Agency, 2018a

Bioretention in Lansing, Michigan

The City of Lansing installed 27 bioretention facilities inside concrete planter boxes while updating the city's controlled sewer overflow system as a means to control, clean, and disperse storm water in an urban environment. Additionally, the city improved sidewalks with clay pavers, rain garden plants, and ornamental fences as part of its Michigan Avenue corridor enhancement project. The planter boxes receive storm water runoff from nearby roads and sidewalks which helps provide flooding protection for Michigan Avenue as well as protects the Grand River from pollutants such as sediment, nutrients, and heavy metals carried in storm water runoff. The planter boxes also help to reduce water temperatures and promote infiltration (SEMCOG, 2008).

Image Source: SEMCOG Low Impact Development (LID) Manual for Michigan

CITY OF MARQUETTE DOWNTOWN



Water Quality **Road Access** **Flooding**

CITY OF MARQUETTE DOWNTOWN

Increasing vegetation in the downtown area helps to reduce runoff in rain events. This decreases the risks of flooding, instances of limited road access due to road washouts, and water contamination from runoff.[1] Bioswales, as seen in the road bulb-out in the after image, reduce the amount of rainwater going directly into the sewer system during and after heavy rain.[1] Bioswales allow water to be retained, filtered, and then drain more slowly into the sewer system while simultaneously providing water for the contained plants.[2]

Road bulb-outs can also slow vehicle traffic in the area. This increases the safety of the sidewalks and roads and thereby increases the appeal to pedestrians and bicyclists. These changes can help not only to increase the walkability of an area, but also build community by encouraging pedestrian activity and increasing the opportunities for unplanned social interactions.[3]

Lastly, more trees and plants increase the absorption of carbon dioxide and other pollutants in the air, improving local air quality.[2]

[1] Planning for Community Resilience in Michigan, 2017
[2] United States Environmental Protection Agency, 2018a
[3] NACTO, Urban Bikeway Design Guide

Excessive runoff carries contaminants into fresh water and increases the risk of harmful bacterial growth downstream and throughout the watershed system, such as on the beaches of Lake Superior.[1] This risk is exacerbated by the average temperature increases caused by climate change. Native plants that are adapted to wet conditions can filter and absorb some of this runoff, reducing some of the contaminants from reaching fresh water sources or beaches.[2] Higher absorption rates can also prevent roads from flooding and limiting road access in extreme weather events. An increase in vegetation also improves air quality through higher air pollutant absorption rates.[2] Tick barriers, such as gravel or pavement between vegetation and walking paths or roads, can help prevent tick borne illnesses in people through exposure reduction.[2, 3]

Economic Benefits of Low Impact Development (LID)

The Environmental Protection Agency reports that LID practices significantly reduce the cost of property development compared to conventional methods and also increase property values and selling prices. Additionally, LID improves community aesthetics, reduces drinking water treatment costs, and decreases costs associated with flooding, among many other benefits (USEPA, 2012b).

[1] United States Environmental Protection Agency, 2012a
[2] United States Environmental Protection Agency, 2018a
[3] The Connecticut Agricultural Experiment Station, 2007

LAKESHORE ROAD, MARQUETTE

Ticks | Flooding | Road Access | Water Quantity

Pokagonek Edawat Housing Development in Dowagiac, Michigan

The Dowagiac River Watershed Management Plan was used as the basis for the design principles in this residential development which led to the use of nine LID techniques in the project.

Housing units were developed in loops and incorporated pervious pavement, rain gardens, and bioswales in order to maximize storm water infiltration to groundwater. Housing developers also clustered homes in order to conserve open space and reduce infrastructure costs. Keeping homes close also allowed for shared bioswales to be used between homes, which manages runoff and reduces lawn maintenance (SEMCOG, 2008).

Image Source: SEMCOG Low Impact Development (LID) Manual

Impermeable surfaces, such as parking lots, sidewalks, and traditional grey infrastructure can block rainwater from filtering into the ground, leading to flooding and drinking water contamination caused by excessive runoff.[1] Permeable surfaces such as stones and permeable pavement allow water to drain and filter through the soil rather than washing into the sewer system.[1] Some soil and plants help filter out harmful contaminants before they reach the water basin.[1] More plants and trees also help absorb harmful pollutants from the air, improving the air quality of an area.[1] This is particularly important for vulnerable populations such as the elderly, small children, and people with asthma.

Permeable Pavers and Winter Weather

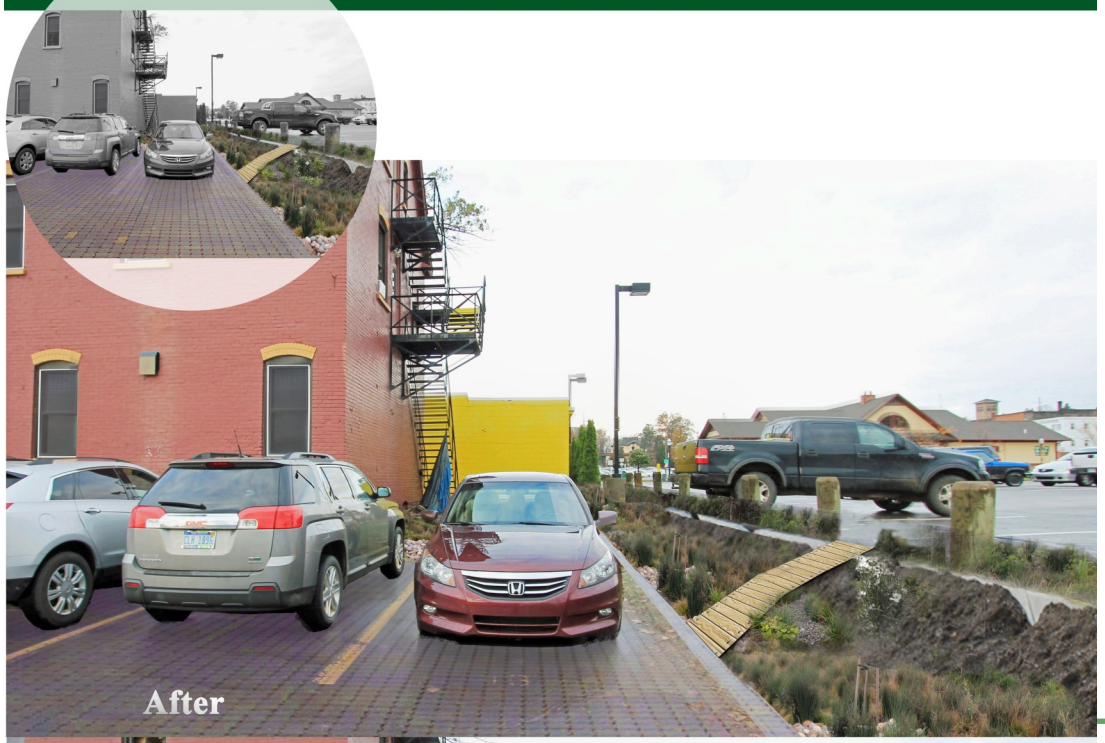
A common misconception is that permeable pavement types cannot withstand the freeze-thaw cycles of winter climates. While minimal regular maintenance is required, when installed correctly, this form of pavement holds up well to freeze-thaw cycles, allowing space for water to expand upon freezing (SEMCOG, 2008). Permeable pavement also reduces the amount of salt needed to melt ice on pavement by up to 75% (Roseen et al, 2014).

SENIOR CENTER, MARQUETTE

Flooding | Air Quality | Water Quantity

[1] United States Environmental Protection Agency, 2018a

JENZEN HOUSE, MARQUETTE



Flooding | Ticks | Water Quantity

Hard surfaces often found in developed areas can lead to flooding and water contamination as runoff picks up pollutants in rain events and carries them unfiltered into the water system.[1] Permeable pavement allows water to drain into the ground and filter through gravel and soil.[1] These also allow for increased on-site drainage in the event of intense rain events, reducing the risk of flooding.[1]

Buffers between vegetation such as gravel can help limit human exposure to tick habitats, reducing the risk of tick borne disease contraction.[2]

Green Building at LTU

The A. Alfred Taubman Center at Lawrence Technological University (LTU) in Southfield, MI was designed with green building elements meeting Leadership in Energy and Environmental Design (LEED) standards. Its green roof, vegetation system, and built water retention techniques prevent up to 60 percent of rainwater from entering the Rouge River, reducing storm water runoff. Its closed-loop geothermal heating and cooling system meet the building's needs onsite (Adamus, 2008).

[1] United States Environmental Protection Agency, 2018a
[2] The Connecticut Agricultural Experiment Station, 2007

Trees, plants, and rain garden installations help absorb and filter storm water runoff from rooftops and parking lots helping to prevent excessive flooding and protect surface and ground water sources from contamination.[1] Bioretention islands or rain gardens, pictured in the parking lot after image, allow rainwater to filter slowly into the ground, which decreases the burden on the sewer system during heavy rain events. Additionally, increased vegetation helps absorb harmful particulates from the air, improving overall air quality.[1]

Rooftops can be used as a prime location for solar panels. On-site power generation and storage can help increase resilience to power outages during severe weather at certain locations and reduce reliance on polluting fossil fuels.[2]

Community voices

"Like the plant island in the parking lot. Solar panels—added bonus"

[1] United States Environmental Protection Agency, 2018a
[2] U.S. Department of Energy Better Buildings Solution Center, 2017

Biorention cells and vegetated islands, roadways and other impervious surfaces can be adapted to reduce or slow storm water runoff during rain events. This can alleviate flooding and combined sewer overflow events; both sources of surface and groundwater contamination.[1]

Plants and trees also help remove harmful particulates from the air, improving the air quality of the area.[2]

Solar panels with storage can be used to power signage or street lights. This can be a benefit by limiting a community's reliance on a traditional, more vulnerable energy grid and reduce fossil fuel reliance across the community.[3]

Solar Panels and Snow

While snow cover can present a problem for solar panel energy production by limiting solar penetration as well as by its weight when present, snow can actually act as a cleaning mechanism on frameless panels that allow snow to slide off, helping panels reach higher absorption efficiency, according to the U.S. Office of Energy Efficiency & Renewable Energy (U.S. EERE, 2017).

[1] NACTO, Urban Street Stormwater Guide
[2] United States Environmental Protection Agency, 2018a
[3] U.S. Department of Energy Better Buildings Solution Center, 2017

Runoff from roads and parking lots can carry pollutants that can lead to water-borne disease and other harmful effects to humans and the environment.[1] Certain plants and soil can filter and absorb harmful pollutants from runoff before the water reaches the larger water system. All vegetation, but especially those adapted to wet environments can also help to prevent flooding by soaking up more rainwater when used to replace impervious surfaces. This is particularly important considering the projected increase in extreme rain events from climate change.[1]

Certain plants also filter exhaust from cars, mitigating the impact of harmful car emissions on people. [1]

Tick barriers, such as gravel or pavement between vegetation and walking paths or roads can help prevent tick borne illnesses in people through exposure reduction.[2]

Community voices

"Utilizes natural drain water. Looks great!"

"Wonderful appearance—low maintenance"

[1] United States Environmental Protection Agency, 2018a

[2] The Connecticut Agricultural Experiment Station, 2007

While native plants, trees, and vegetated landscaping can all help absorb storm water to improve water quality, community gardens can accomplish similar goals with the added bonuses of improving social well-being in communities and increasing sources for local fresh produce.[1] Additionally, gardening encourages healthy activity and eating habits. Plants also not only improve air quality by absorbing harmful particulates from the air, but local community gardens reduce residents' need to drive long distances for fresh produce, limiting car emissions released into the air.[2]

Community Gardens and Social Cohesion

A concern voiced by the Marquette area community that did not fit neatly into a health category was that of social cohesion in relation to future population increases believed to be predicted. Community gardens, while useful for built environment adaptations, can also be used as a means for building community. Research indicates that community gardens bring together people of diverse backgrounds to share one common interest, and promote interactions that build social capital (Firth et al, 2011).

[1] Centers for Disease Control and Prevention (CDC), 2010
[2] European Climate Adaptation Platform (Climate-ADAPT), 2015

Rain Gardens in Washtenaw County, MI

In 2005, Washtenaw County began a countywide Rain Garden Program through their County Water Resources Office. Through the help of volunteers and funding assistance from the Michigan Department of Environmental Quality, the county has appointed a Rain Garden Coordinator, developed a Master Rain Gardener training program and free webinar, and installed over 250 rain gardens throughout the county. The program protects the Huron River from fertilizers, chemicals and damaging runoff. The average rain garden collects 600 gallons of water per inch of rainfall, with the collective county raingardens capturing 2 million gallons per inch of rain (Fair, 2015; Office of the Washtenaw County Water Resources Commissioners, 2018).

Image Source: Fair, 2015

Dense residential areas can have relatively large areas covered with impervious surfaces. This can lead to flooding and contaminated runoff into surface waters.[1] Green infrastructure and permeable pavement are all effective built environment strategies that can be used to reduce storm water runoff from entering the watershed.[1]

Trees can also help homeowners conserve energy by shading homes in warmer temperatures,[2] reducing the need to use energy derived from fossil fuels to cool the structure. Solar panels on rooftops can produce energy for homes, also reducing the amount of fossil fuels burned for energy production. When combined with onsite storage, they can lessen the building's dependence on the traditional grid system.[3]

On-Site Energy Storage—Declining Costs

One concern raised by residents has been the variability of renewable energy generation. Often times the sun is not shining and therefore could present limits to expansion of reliable solar energy development. On-site storage and battery technologies have seen a dramatic cost reduction in recent years however, and appear to be on track to continue that cost decline, reducing the price of such investments (IRENA, 2017).

[1] United States Environmental Protection Agency, 2018a
[2] Planning for Community Resilience in Michigan, 2017
[3] United States Department of Energy Better Buildings Solution Center, 2017

Some flooding along rivers can be abated with increased amounts of vegetation, including plants with deep and/or vast root systems. Green infrastructure also has the benefit of stabilizing banks and reducing erosion. This can improve riparian habitats along streams in addition to reducing flooding risks.[1]

Installing rain barrels on drain pipes can help prevent unfiltered roof runoff from reaching the water, helping to reduce risks of contamination to fresh drinking water sources. They can also act as an easy system for reusing rainwater for gardens and landscaping, conserving private well and public water for essential necessities.[1]

Following Firewise techniques to reduce the ignition potential of property during wildfires can help limit the damage of wildfires to residents, a danger exacerbated by drier conditions seen with climate change.[2]

[1] United States Environmental Protection Agency, 2018a
[2] National Fire Protection Association, 2018

Lessons Learned

The lessons reported here share what our team discovered through the Marquette Area Climate and Health Adaptation Project and related research in Marquette, MI and Benton Harbor, MI (Crawford et al., 2018). We hope they are useful to community leaders, health officials, planners, and others who use a process similar to ours to incorporate climate and health adaptation action into their communities.

- **Identifying the potential health impacts from climate change is challenging.** While some negative health outcomes can be directly linked to climate change, many are caused indirectly. For example, in Marquette increasing extreme precipitation events can lead directly to greater risk of injury and exposure to water-borne disease through flooding. Extreme precipitation can also indirectly impact health through flooding that damages roads, resulting in loss of access to critical resources and increased stress for more isolated populations.
- **Framing climate adaptation around health and the built environment expands the opportunities for diverse stakeholder participation.** Bringing public health perspectives into any planning initiative, particularly climate adaptation, increases adaptive capacity and overall resilience. A local health department, a leading authority on the community's vulnerabilities, can be a valuable partner in adaptation planning. The Marquette County Health Department (MCHD) connected the project team with some of the area's vulnerable populations and agencies serving them. Due to their trust in MCHD, the stakeholders were willing to discuss how climate change was affecting them and what solutions they thought were needed.
- **Using visualizations of local, relevant adaptation designs can be effective for providing a gateway to understanding the complexities and relationship of climate and health adaptation.** Before and after images of real locations from the Marquette area were used to show how climate change can have an impact on health and what the benefits from adaptation look like. This approach made the proposed solutions to the issues relevant to stakeholders' easier to understand, imagine, and react to.
- **Working through a multidisciplinary group representing a variety of views, skills, and geographic areas is critical for long-term coordination and implementation.** The Marquette Climate Adaptation Task Force (CATF) was already involved in many planning initiatives through a broad network of stakeholders. They helped translate the information collected from the stakeholder outreach process into locally relevant design and policy recommendations. CATF is committed to building adaptive capacity across Marquette and is willing to help move those recommendations toward implementation.

Index

Appendices

Appendix A: Full Stakeholder Response Summary

Figure 1: Common Climate Change Concerns Raised by Stakeholders Categorized into Four Focus Group Meetings

Climate Change	Public Health	Emergency Preparedness	Local Government
Wildfires		Wildfires	
Aging Population/ Stress of Change			Stress of Change/ Long Winters
Vector Borne Disease through Ticks	Vector Borne Disease through Ticks	Vector Borne Disease through Ticks	Vector Borne Disease through Ticks
Rising Temperature		Rising Temperature/ Extremes	
Climate Migration	Climate Migration		Climate Migration
Flooding	Flooding	Flooding	Flooding
Energy Outages	Energy Outages	Energy Outages	
Resource Allocation			
Economic Impact			
	Air Quality		Air Quality
	Water Shortages		Water Shortages
	Road Access		
	Emergency Preparedness		
		Evacuation	
			Opioids Epidemic
			Water Quality/ Lake Contamination

Figure 2: Common Climate Change Concerns Raised by Stakeholders Categorized by exposure, infrastructure, social/economic issues, and health outcomes

Identified Climate Health Issues	Stakeholder Groups				
	Climate Change	Public Health	Emergency Preparedness/ Undeserved	Local Government	Economic Development
Exposure					
Wildfires	X		X	X	
Flooding	X	X	X	X	
Water Shortage	X	X		X	X
Air Quality		X		X	X
Ticks	X	X		X	
Lake Contamination				X	
Extreme Weather			X	X	X
Infrastructure					
Access	X	X	X	X	
Energy	X	X	X		X
Social/Economic					
Migration	X	X		X	X
Social Conflict	X				
Economic Impact	X				X
Resource Allocation	X				
Health Outcomes					
Mental Health	X		X	X	
Respiratory Illness		X		X	
Substance Abuse				X	
Vector Borne Disease	X	X		X	

Primary Priorities
Flooding
Water Shortage
Access
Wildfires

Secondary Priorities
Ticks
Air Quality

Appendix B: Meeting One, Full Visioning Input

Question 1: Biggest Climate Health Threats Facing Marquette County	
Area	**Specific Concern**
ROAD ACCESS	Washouts in heavy storm events, for example 94 washout
	Road access to homes and small communities in the wetland interface as severe weather incidents increase
	Infrastructure damage due to increased storm intensity
FLOODING	Lakeshore flooding in Marquette
	Extreme weather events
	Water levels
	Storm waste management and ordinances
	Infrastructure in both townships and cities
	Causes road access issues
WATER SHORTAGE	Drought and food security
	Water for agriculture and food production
	Water storage and aquifers drying up
	Drought
	Ground water contamination
	Unfunded clean up efforts
	Water for drinking
	Decreased ground water supply despite rain this year
WILDFIRE	State forest/large land tracts
	Larger wildfires more often
	Wildfires in townships
	Increased fire risk
	Air quality
	Wildfires due to drier climate

(Question 1 continued)	
Area	**Specific Concern**
OTHER	Public awareness
	Population increase
	Higher water tables
	Lack of public understanding
	Lack of public evacuation plans
	Apathy public awareness
	Lack of communication between agencies
	Lack of public support for action
	Lack of notification systems for rural homes and cabin owners for extreme weather and wildfire events
	Walkable/bikeable communities
	Disease and virus growth in altered climate
	Changes in insect populations bringing risk of diseases, e.g. west Nile, Lyme, etc.
	More vectors
	Vector borne disease increase
	Ticks
	Water quality and the growth of bacteria in warmer water
	More extreme weather events
	Healthy food
	Altered growing seasons with less yield
	Longer growing season resulting in pollen increase and increase of respiratory illnesses
	Freeze and thaw events in the winter
	Transportation for all
	More lakeshore erosion

Appendix B: Meeting One, Full Visioning Input

The question 2 visioning responses broke down into two categories: visions and concerns, reflected in the wordclouds in the body of Volume I.

Green dots were used by individuals to vote for their top visioning items. *Red dots* were used to vote against items that were not perceived to be a priority.

Group	Vision/Concern	Green Dots	Red Dots	Rank, if given	Notes
1	Infrastructure	7		2	Expanded power, water, and sewer redundancy and stability. Currently inadequate, deteriorated from age and freezing.
	Transportation	4		1	Need for expanded and improved road connectivity, mass transit, evacuation strategies for rural areas
	Increased population	3		3	Climate refugees and influx from rural to urban
	Increased respiratory diseases	2			Countywide need of ordinances and more governmental controls. In need of university research. Developers need education.
	Vector-borne disease	0		4	Mosquitos and ticks
	More affordable housing	0			
2	Clean/green energy	4		1	Solar energy, lake-wave energy. Most homes outside the city of Marquette have solar systems. Solar farms.
	International Destination	4		2	The UP could be an international travel destination with diverse and multicultural visitors through an expanded international airport.
	Transportation	3		3	(Healthy Communities) more public transportation and less privately owned vehicles.
	Less motorized vehicle dependent	3		3	(Healthy Communities) Communities adopt walkable and bikeable ordinances to make it possible for daily commutes for all ages. Young families who move here for the quality of life will telecommunicate/ work from home using first class internet access.
	Health programming	3		3	(Healthy Communities) Health programming and accessibility for all.
	Energy efficiency	3			In homes, work, and transportation.
	Rental housing shortage	3			Housing shortage.
	Transportation	3			In need of mass transportation to lower reliance on privately owned cars.
	Variety of opportunities	2		3	(Healthy Communities) Employment opportunities.
	Consolidated schools, home based activities	2		3	(Healthy Communities)
	Cooperation	1			Regional cooperation in waste management, recreation, etc.
	Healthy living for all	1		3	(Healthy Communities) The change of the environment to have healthy living to be the norm through, for example, healthy food access, more physical activity all year.
	Seasonal housing	1			
	Senior-accessible environment	1			
	Lack of cooperation	1			Waste management and recreation.
	Climate dynamics	1			Effects of climate change on logging, farming, etc.
	Community kitchens and less food waste	1		3	(Healthy Communities)

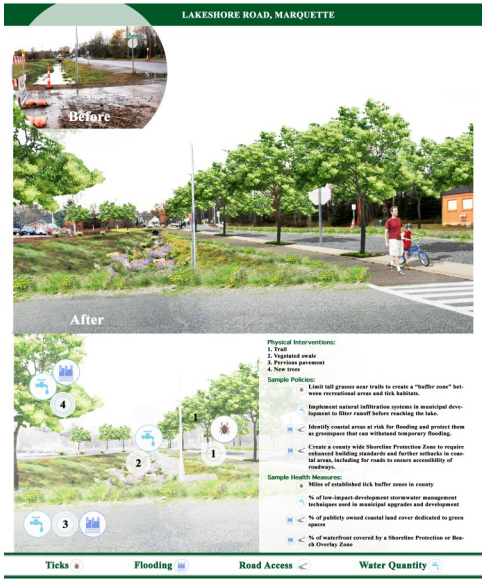
Appendix B: Meeting One, Full Visioning Input

Group	Vision/Concern	Green Dots	Red Dots	Rank, if given	Notes
3	Climate friendly zoning	5			For new developments and infill developments, with the recognition of increased flood risk in design.
3	Public lakefront access	4			The lakefront is still public space.
3	Use less water & collect more water	3			Consider grey water and rainwater capture systems.
3	Zero waste or 100% recyclable	3			
3	Less sprawl	2			Less sprawl countywide and less rural development fragmentation. Dense in-fill developments.
3	Improved transportation	1			Population increase is urban with mass transit connecting Marquette to Neguanee and Ishpeming.
3	Removal of some power plants	1			The removal of Presque Isle & Shiras power plants and replacing them with clean, green, and fun spaces.
3	Decentralized energy network & renewables	1			
3	More green infrastructure	1			The use of more permeable surfaces on downtown streets.
3	KI Sawyer is a high-tech industry hub	1			
3	Moving roads inland away from shoreline	1			
3	More mixed-used developments	1			More mixed-use and mixed income housing and work spaces and community spaces.
3	More residential solar	0			
3	Walkable communities	0			Carless corridors and pedestrian friendly malls.
3	More human health services	0			
3	Wetland storm surge and buffer zones	0			
3	Expansion of conservation zones & ease-ments	0			
3	ORE dock is redesigned and redeveloped	0			
3	Defensible spaces around homes & residenc-es	0			
3	Lake interdependence is part of Lake Superi-or	0			
3	EPA is back & bigger than ever	0			
3	Dark stores are dark	0			

Appendix B: Meeting One, Full Visioning Input

Group	Vision/Concern	Green Dots	Red Dots	Rank, if given	Notes
4	Regional stormwater plan	6		1	Consider county wide plans and regional water quality.
4	More regional authority	4		2	Regional authorities to deal with major issues, such as water waste, water recs, and energy. Better interaction/cooperation between the different governmental agencies.
4	Walkable community	3		3	
4	Good coordinated zoning	2			People and development centered in zoning ordinances.
4	Improved transportation	1			Replace exhausted infrastructure and create less demand on existing infrastructure
4	Lakeshore protection	1			
4	Water quantity	1			Alternate water supply for Marquette Township.
4	More diversified economy	1		4	Including education, healthcare, high-tech businesses, tourism, industries, and retirement locations.
4	Population increase due to promotion	1			Due to the promotion of Marquette and the heavy outdoor, water-based recreation. Increased population leads to smaller home footprint and less storage space.
4	Tick control	1			Tick control and awareness healthcare, especially in Gwinn
4	Less demand on infrastructure	0			Overbuilt
4	Replaced infrastructure	0			
4	Deeper wells or municipal supply in Chocolay	0			
4	What will new mine look like?	0			
4	Infrastructure developed without climate change projection	1			
4	Lagoon by Casino		1		

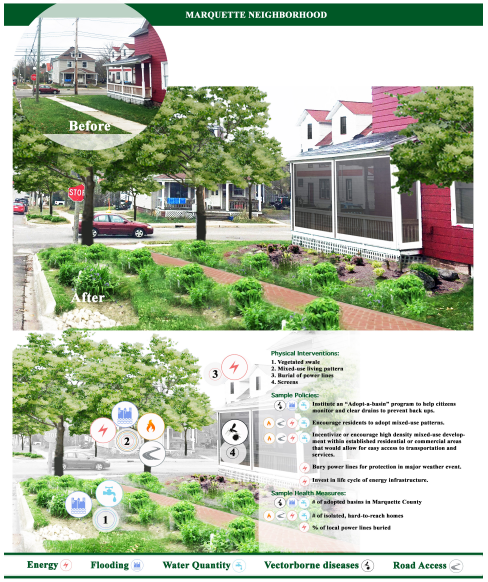
Appendix C: Meeting Two, Full Imaging Feedback



1. Utilizing natural drain water for plants.
2. I enjoy the sidewalk, making it very appealing to pedestrians. They can feel safe.
3. I like this idea, hopefully native plants will be used.
4. Appreciate the tick buffer and filter runoff before reaching the lake, this design would have greater pedestrian use and health benefits.
5. Having concrete barriers between pavements seems counterproductive, block flow and water.
6. Love the trees in the middle of the road. Amazing!

1. Concerns about weight bearing roof, especially on aging structures.
2. Porous pavements will fail prematurely with freeze/thaw cycles, road salt makes worse.
3. Like the medians.
4. Stone looks great.
5. Is flooding in this area due to poor sewer system use/design?
6. Tree species that can handle warmer temperatures and Asian longhorn.
7. Green roofs are very fascinating.

1. Need a winter image or two. Before and after both inter.
2. Looks a lot better.
3. Zoning wouldn't allow this.
4. How is it kept affordable buying?
5. Median with trees is nice.
6. Looks great! But does this make sense for the current community?
7. This is most expensive to implement. Mixed-use development to meet communities' basics needs would have greatest community impact. Appreciate tick buffer.
8. Property maintenance policies (rental, homeowner, etc.).
9. What about these buildings? To the right.
10. Streets as a rule are narrow in this location-rebuild of streets?
11. Extreme heat. What about extreme cold (winters 2014/2015)? Rapid thaw of snow pack (2013 spring).
12. Nice concept if businesses could be native.
13. Local grocery brings healthy foods and jobs to town, but how do we get natural foods there to begin with? Food desert with no money?



1. Tree in front of stop sign.
2. We are likely to have increased rain events when the soil is frozen, making gardens seem less effective.
3. Plants are great! More throughout town.

Appendix C: Meeting Two, Full Imaging Feedback

1. We need to see a separate image for rural home with Firewise techniques implemented. Or perhaps do this with the Ishpeming Senior Center.
2. Great use of solar panels.
3. Microgrid particularly good in rural neighborhoods.
4. How durable are pervious surfaces with freeze thaw happening through winter?
5. Use of solar power is awesome. Looks inviting/atmosphere looks very clean.

1. More appealing design than original.
2. Opportunity for food forest?
3. Where is the option from the presentation? It's better!
4. More appealing design, maybe incorporate a drain system to filter water down.
5. Looks a lot more appealing.
6. Looks a lot more natural and pleasing for the eyes.
7. Stone walls look fantastic with uniform bushes.

1. Great idea!
2. Pervious surfaces have maintenance and freeze thaw issues but good for getting water into ground for plants to use.
3. Elevated mound adds visual interest.
4. Public space is more inviting, appreciate tick awareness and prevention. Firewise site you have decreased fire spread by removing brush and tall dry grass.
5. Clean!
6. Educational signs should be implemented in more designs. People don't care unless they are educated and have a reason to.
7. The sidewalk could be better, but great job!
8. Like paths that don't get muddy.
9. Public education sign is nice.

1. Like getting rid of standing water.
2. Natural drainage system for plant watering, effective and environmentally friendly.
3. Plant species that are able to absorb toxic chemicals, etc.
4. Appreciate flooding reduction, removing standing water makes this less attractive form of vector habitat- mosquitoes and ticks.
5. Low cost project. Great project-common sense!
6. Mowing grass an issue manpower and equipment. No shoulder concern very nice project idea, looks very nice and green opposed to what is already there.
7. Use salt-tolerant plant species-lots of road salt in the winter.
8. This design much more practical than in slideshow.
9. Great job with grass.
10. This is incredible. I like the trees in the middle of the road.
11. I like the grass idea, it makes it more appealing versus before.

Appendix C: Meeting Two, Raw Imaging Feedback

1. Exposed dirt seems like it would erode quickly.
2. Possibly a small boardwalk going across?
3. This look dangerous drop off.

1. Are these worth cost/energy in long run in low sun area?
2. Marquette power and light is designing a rate structure which disadvantages private solar arrays.
3. Plow drivers will find every obstruction you put in the way.
4. The plant island is a nice touch for the parking lot as well as the solar panels on the buildings.
5. Like the plant island in the parking lot, solar panels added bonus.
6. Great functionality and visual appeal.
7. Great use of space.
8. More greenery always is more appealing.
9. Enhance the sidewalks a little more.
10. Native species

1. Utilizing natural drain water.
2. Landscape is appealing.
3. Landscaping working with runoff not against.
4. Utilizes natural drain water. Looks great!
5. Wonderful appearance-low maintenance.
6. These flowers would probably get plowed over, yet pretty.
7. Very welcoming and organic feel.
8. This is an important area. Priority due to development. Showcase our community.
9. Gutters
10. I really like the idea behind this.
11. Beautiful
12. This design is very welcoming.

1. Looks a lot more appealing.
2. Adopt-a-rain garden to pick up trash.
3. Looks a lot more appealing, use of native plants? (that don't need to be planted every year)
4. Let's add to images more bikes, bike lanes, pedestrians and buses, this will add to the sustainability theme.
5. Flat roof, lots of snow, how does that work?

Appendix C: Meeting Two, Full Imaging Feedback

1. The rocks are a nice touch to this area.
2. Channeling water at one point increases water speed and pressure downstream.
3. These rocks are good idea.
4. I like this design the best.
5. Retaining wall will improve erosion.

1. Solar paneling
2. Sidewalks are a great idea, but who will upkeep them? Home owner? City?
3. Wind energies as well?
4. Good use of solar panels.
5. The grass could be greener.
6. Grass covered sidewalks will make snow removal difficult (shoveling) consider upkeep too.
7. Marquette power and light is designing a rate structure which increases monthly prices/fees and decreases kwh changes disincentivizing customer conservation.
8. Have barrier higher up on decline opposed to at bottom.
9. The grass covered sidewalk is cool.

1. This does not look very natural.
2. Trout habitat?
3. Looks a bit dangerous. Inhibits less moving folks to visit terraces, not accessible.
4. Does not feel natural. Looks too renovated. Keep the local. Fish population? Effected?
5. How about natural channel design? -root balls. etc.
6. Looks too constructed.
7. But could be nice place for concerts!

1. Is rip-rap the right idea?
2. Not sure it would be a good idea to get rid of the native beach grass and replace it with grass and rocks.
3. U.S. Corps of Engineers is considering moving Lakeshore Dr.
4. Don't get rid of the native beach grass, leave as is.
5. Looks vulnerable to wash outs? But better than existing! What about the beach. Will there still be enough space?
6. Not pleasing to the eyes, is grass so close to the water possible?
7. How does that help? Sand and native grasses allow water to seep in just fine.

Appendix D: References

Throughout the development of this document, the following publicly available local plans, current practices guides, comparable community plans, and national guidelines were referenced in order to create the recommendations and policy interventions noted in this guidebook.

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Appendix E: Expert Resources for Further Information

Overall

- Planning for Community Resilience in Michigan: A Comprehensive Handbook - http://www.resilientmichigan.org/downloads/michigan_resiliency_handbook_web.pdf
- NOAA: Great Lakes Coastal Resilience Planning Guide - http://greatlakesresilience.org/

Regional Climate Change Predictions

- Great Lakes Integrated Science and Assessment Center (GLISA)—http://glisa.umich.edu/
- National Oceanic and Atmospheric Administration (NOAA)—http://www.noaa.gov/

Vector-Borne Disease

- Center for Disease Control and Prevention (CDC) National Center for Emerging and Zoonotic Infectious Disease (NCEZID) Division of Vector-Borne Diseases (DVBD)—https://www.cdc.gov/ncezid/dvbd/index.html

Wildfires

- National Fire Protection Association - Firewise - https://www.nfpa.org/Public-Education/By-topic/Wildfire/Firewise-USA
- US Forest Service - https://www.fs.fed.us/

Air Quality

- Michigan Department of Environmental Quality - Air Quality - https://www.michigan.gov/deq/0,4561,7-135-3310---,00.html

Extreme Rainfall

- Naturally Resilient Communities - http://nrcsolutions.org/strategies/?fwp_hazards=coastal#solutions
- USEPA Green Infrastructure - https://www.epa.gov/green-infrastructure

Extreme Heat

- USEPA Reduce Urban Heat Island Effect - https://www.epa.gov/green-infrastructure/reduce-urban-heat-island-effect#resources
- USEPA Green Infrastructure - https://www.epa.gov/green-infrastructure

Water Quality

- USEPA Green Infrastructure - https://www.epa.gov/green-infrastructure
- NACTO Urban Street Stormwater Guide - https://nacto.org/publication/urban-street-stormwater-guide/stormwater-elements/green-infrastructure-configurations/
- MSU Land Policy Institute: Rural Water Quality Protection, A Planning and Zoning Guide for Local Officials - http://www.canr.msu.edu/landpolicy/uploads/files/Resources/Publications__Presentations/Books/GLRI/2012/Rural_Water_Quality_Protection_Guidebook/ruralwaterqualityprotection_glrigdbk_lpi_december2012_chapter1intro.pdf

Energy

- Planning for Community Resilience in Michigan: A Comprehensive Handbook - http://www.resilientmichigan.org/downloads/michigan_resiliency_handbook_web.pdf

Placemaking

- Michigan Municipal League - http://placemaking.mml.org/
- Project for Public Spaces - https://www.pps.org/