CLIMATE ADAPTATION

THE STATE OF PRACTICE IN U.S. COMMUNITIES

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The Kresge Foundation is a $3.6 billion private, national foundation that works to expand opportunities in America's cities through grantmaking and social investing in arts and culture, education, environment, health, human services, and, community development in Detroit.

Abt Associates is a mission-driven, global leader in research, evaluation, and program implementation in the fields of health, social and environmental policy, and international development. Known for its rigorous approach to solving complex challenges, Abt Associates is regularly ranked as one of the top 20 global research firms and one of the top 40 international development innovators. The company has multiple offices in the U.S. and program offices in more than 40 countries.

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Foreword

As members of the Project Advisory Committee (PAC) for this research effort, *Climate Adaptation: The State of Practice in U.S. Communities*, we represent diverse fields, including climate adaptation, natural hazards mitigation, land-use and municipal planning, environmental justice, natural resource management, insurance, community engagement, and communications.

We all identify as climate change adaptation professionals. That is, we are professionally engaged in helping communities understand and adapt to changing climate risks. We provided advice and guidance to The Kresge Foundation and the Abt Associates research team on the objectives, conduct, and findings of this project.

We strongly recommend this report as essential reading for those working to create more resilient local and regional communities. It provides valuable insights into the practice of climate change adaptation in the United States, including how to support the many community-based champions working to reduce their communities' vulnerability to climate change impacts.

While our support of the report does not imply our individual endorsement of each finding, we believe there is great value for the adaptation field. In particular, we find that the report makes the following contributions:

- Provides 17 case studies of communities taking action to prepare for climate change, climate variability, or extreme events. The local experiences documented in the case studies are invaluable at this stage of the development of the adaptation field.
- Demonstrates that the practice of adapting to climate variability, extreme events, and climate change has been occurring for many years, even if those taking such action did not explicitly label it adaptation. The formal practice of climate adaptation, however, remains emergent.
- Assesses what has worked in preparing for and responding to extreme events so it can be applied to the threats from climate change.
- Identifies that mechanisms for coordinating adaptation action across the U.S. are growing, yet remain in early stages of development. As such, until those mechanisms mature, many communities are working on adaptation in parallel and learning as they go.

This project is timely. It taps the experience of communities across the U.S. to explore how adaptation is coming into practice and the gains that are being made. It also helps us consider how we can all advance the field of adaptation by pointing out where more work is needed. Given this, we recommend the report to you.

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Executive Summary

Communities in the U.S. are undertaking a rich array of climate adaptation actions that are making them more resilient to climate impacts. These actions provide models and lessons that can immediately help other communities better protect themselves from climate risks like flooding, heat waves, wildfires, and severe storms. In aggregate, these activities demonstrate that more U.S. communities are attempting to prepare for climate risks than previously thought (Melillo et al., 2014).

However, many of these promising practices are piecemeal and fail to comprehensively address climate change and its associated uncertainties. This suggests that, despite the many concrete vulnerability reductions achieved by our case study communities, much more work is needed for communities to holistically reduce their vulnerability to climate variability, extreme events, and climate change.

This research project was motivated by the immense challenges posed by climate change, the need for communities to adapt to those challenges, and the opportunity to learn from communities that have already begun adapting. Through this project, we identified many actions that U.S. communities have taken to prepare for and build resilience to climate variability, extreme events, and climate change.

Our research methodology included a review of selected technical and professional literature aimed at evaluating the state-of-the-practice of climate adaptation; interviews with 50 thought leaders from a variety of fields relevant to community-based adaptation—including climate adaptation, natural hazards mitigation, planning, environmental justice, natural resource management, insurance, and community engagement and communications; and primary research that involved selecting, examining, and profiling 17 communities that have taken particular actions to attempt to tangibly reduce their vulnerability to climate variability, extreme events, and climate change.

Within this report, we document our findings, profiling a single activity or small subset of adaptation activities undertaken in each of the 17 communities, paying specific attention to findings that hold across multiple case study communities. While this analysis did not aim to comprehensively assess all of the adaptation activities unfolding in each of the case study communities, we believe results from this analysis provide useful information for community-based champions of adaptation action and adaptation professionals looking to design locally appropriate vulnerability reduction activities.

After two years of research on the state of community-based adaptation and the particular actions taken by these 17 communities, we found that communities have many of the tools needed to plan for and respond to climate change; they just need to get started.

Key Questions

During the course of the project, we examined four key questions.

1. **What motivates communities to take adaptive action?**
   FINDINGS: Most adaptation actions draw upon, promote, and sustain multiple community values. Climate change was not typically the exclusive justification for community-based adaptation in the cases we studied. However, experiencing extreme climate events commonly initiated or accelerated adaptation efforts.

2. **What are communities doing to adapt?**
   FINDINGS: Most of the profiled communities are attempting to tangibly reduce their vulnerability to climate variability, extreme events, and climate change. In a few cases, these communities are taking action to reduce exposure; more often their work is aimed at reducing sensitivity and building adaptive capacity.

3. **How are communities implementing adaptation actions?**
   FINDINGS: Communities use diverse strategies to implement adaptation actions—from deploying conventional policy tools to mainstreaming adaptation into existing efforts to developing new decision-making processes. These strategies often capitalize on effective leadership and consciously build community support.

4. **What are communities achieving through adaptation?**
   FINDINGS: The communities we examined are reducing their vulnerability to current climate impacts; a few are also explicitly reducing their vulnerability to future climate impacts. Sometimes these vulnerability reductions are limited in temporal or spatial scope or address only a particular vulnerability type (e.g., only drought). Adaptation actions frequently go hand-in-hand with progress on other community priorities.

Our Conclusions

Based on the totality of work completed in support of this project, we draw the following conclusions:

1. Adaptation actions at the community level are reducing vulnerability to climate variability and extreme events, and possibly to climate change.
2. Addressing only climate variability and extreme events may constrain the effectiveness of long-term climate adaptation.
3. Communities can begin addressing climate change risks now.
4. Communities can overcome barriers to action, identify opportunities, and begin implementing adaptation measures.
5. Adaptation actions explicitly addressing climate change are in a formative stage.
6. Through our case study communities, we have identified components of a hypothetical, well-adapted community (see graphic below).
7. Community-based champions of adaptation action and adaptation professionals should use vulnerability reduction as a key baseline to assess and facilitate progress in adaptation.

Tactical Recommendations

Based on our research and analysis, we offer the following recommendations to community-based champions and adaptation professionals seeking to advance adaptation and vulnerability reduction within communities.

Start Now: Community development is an on-going process, climate vulnerability already exists, and climate change is increasing these vulnerabilities. Waiting does not guarantee more or better information, but it does

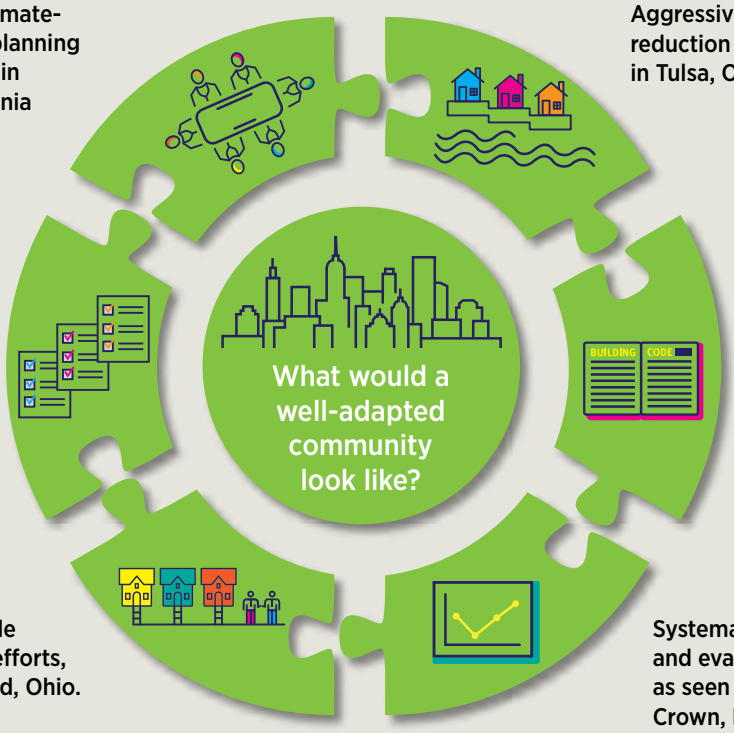
A HYPOTHETICAL, WELL-ADAPTED COMMUNITY

Over the course of this two-year project, we found an abundance of bold, successful community-based adaptation underway now and, in some cases, already tangibly reducing community vulnerability. However, as many of the leaders in our case study communities agree, even our profiled communities must do more to adapt to climate change.

We cannot say what a perfectly adapted community would look like. Nonetheless, if the types of actions that each of our case study communities took were combined into a single hypothetical community effort, it would arguably comprise an impressive climate change adaptation program (see below). We believe this hypothetical community can serve as an aspirational target for ambitious local champions who are working to build local resilience and protect their communities from the impacts of climate change.

Comprehensive, climate-change-informed planning processes, as seen in Chula Vista, California

Aggressive exposure-reduction policies, as seen in Tulsa, Oklahoma



Mainstreaming climate considerations into existing decision-making processes, as seen in Seattle, Washington

Creative use of existing regulatory powers, as seen in Boston, Massachusetts

Neighborhood-scale capacity-building efforts, as seen in Cleveland, Ohio.

Systematic monitoring and evaluation processes, as seen in the Southwest Crown, Montana

waste valuable time as vulnerability reduction is a long-term process. Thus, communities can and should work now to reduce current and future risks to climate.

Look for Co-Benefits, Cross-Sector Leveraging, and Opportunities to Piggyback Climate Adaptation onto Other Salient Community Issues: Climate adaptation actions that also address longstanding problematic conditions—for example, decaying infrastructure or weakened ecosystems—can help win important allies, enhance community support, and facilitate progress.

Employ Commonly Used Policy Tools to Mainstream Adaptation: Many of the tools needed to reduce vulnerability—including standard measures such as ordinances, permits, bonds, utility fees, easements, zoning, and hazard mitigation planning—already exist and can be brought to bear to move adaptation forward.

Use Windows of Opportunity to Advance Climate Adaptation: Windows of opportunity, such as response to natural disasters or scheduled updates to municipal plans, present an opening to advance public discourse, galvanize community support, and facilitate progress.

Build Flexibility into Policies, Projects, and Programs: Given the uncertainties around the effects of climate change, municipal programs should be designed to evolve and adapt to changing conditions.

Consider the Needs and Capabilities of More-Vulnerable Populations: Climate adaptation actions should reflect and address the varying needs of different groups or populations, paying particular attention to populations that are most vulnerable, which are often the poorest, those already overburdened by pollution, those who lack economic opportunity, and individuals facing disenfranchisement and racism.

Consider Natural Systems in Adaptation: Climate change is often experienced through a community's interaction with natural systems, such as forests, rivers, coastlines, and floodplains. These natural systems can also play a vital role in reducing the impact of climate change on community infrastructure and resources.

Craft Outreach or Engagement Efforts, as Needed, to Build Community Support: Well-focused outreach campaigns enhance public buy-in for adaptation actions. Furthermore, engaging a community in the development of adaptation actions is a more time intensive, but potentially more productive means of building community buy-in and support.

Take Prudent Risks and Adjust Over Time: To successfully reduce risk to communities through adaptation requires innovation, experimentation, and some level of risk-taking. Adaptation policies, projects, and programs will likely need to be adjusted over time.

Consider Local Context When Determining Whether to Explicitly Frame Actions in Terms of "Climate Change": Explicit articulation of climate change can constrain action in some settings, while galvanizing action in others; communities should recognize this reality and respond accordingly.

Provide Leadership: While leadership was an important aspect of making adaptation progress across all of the communities we profiled, that leadership came from many places. The most conventional sources of leadership came from a proactive mayor, city council, county commission, or senior municipal or departmental executive. But our case studies indicate that non-governmental organizations, grassroots activists, and non-senior municipal staff can also provide the leadership necessary to initiate and sustain climate adaptation actions.

Use Partnerships to Advance Adaptation: Working with other like-minded individuals and organizations can amplify the effectiveness of an adaptation action. Singular actors often face limited capacity and financial resources.

We strongly encourage our readers to dive deeply into the full report to examine our findings, recommendations, and, in particular, the 17 case studies at the heart of the project. Each case study represents a piece of one community's path to climate adaptation—a path that can inspire ongoing, forward-thinking action and that can serve as a guiding example for other communities and adaptation professionals as they work to reduce climate vulnerability and advance the field of climate adaptation.

CHAPTER 1

Introduction

Adaptation is an emerging field that is growing quickly as citizens and leaders become aware of the impacts climate change will have on their communities. Consequently, we approached this empirical assessment of community-based adaptation explicitly to empower community-based champions and to advance the state-of-the-practice. Our goal was to take a snapshot in time of community-based adaptation and learn as much as we could from the realities of on-the-ground community action to reduce climate vulnerability. We framed our work within the overarching theme of reducing community vulnerability to climate impacts.

We strongly encourage our readers to dive deeply into the full report to examine our findings, conclusions, recommendations, and, in particular, the 17 case studies at the heart of the project. Each case study represents one community's path to climate adaptation—a path that can inspire ongoing, forward-thinking action and that can serve as a guiding example for other communities and adaptation professionals as they reduce climate vulnerability and advance the field of climate adaptation.

Over the last 10 to 15 years, adaptation to climate change has experienced a substantial increase in interest and activity (Hughes, 2015; Shi et al., 2015; Meerow et al., 2016). It has become a major topic of international negotiations (e.g., UNFCCC, 2014); bilateral and multilateral development agencies annually pledge billions of dollars to address climate adaptation (e.g., MDB, 2012); the federal government has encouraged and even required climate adaptation through executive orders, agency-specific planning, and post-disaster recovery grant requirements (e.g., Bierbaum et al., 2013); states have engaged in climate adaptation planning (e.g., Ray and Grannis, 2015); nongovernmental organizations and charitable foundations have supported communities in addressing climate risks (e.g., Rapson, 2013); and hundreds of U.S. communities are considering how climate change might affect them (e.g., Carmin et al., 2012).

Over this period, many community-based champions of adaptation and adaptation professionals have shifted their focus from hazard mitigation and recovery to more comprehensive and systematic efforts to prepare for and build resilience to climate variability, extreme events, and climate change (e.g., Higbee, 2014; Meerow et al., 2016). This shift began around the time of Hurricane Katrina in 2005—an event that became the costliest natural disaster in recent U.S. history—and was further fueled by events such as Superstorm Sandy and the California drought. Despite the growth and evolving focus in the field of climate change adaptation, specific questions remain for those serving as community-based champions of adaptation, such as:

We address two audiences throughout this report, whom we call **"community-based champions"** of adaptation and **"adaptation professionals."** A community-based champion is a person who initiates action within a community to address its current and future climate vulnerabilities. These people are typically grounded in a particular community as elected officials, municipal staff, grassroots activists, community organizers, or interested citizens. Adaptation professionals, on the other hand, self-identify as experts on the issue of adapting to climate change across many communities. They may come from disciplines as varied as climate adaptation, natural hazards mitigation, land use and municipal planning, environmental justice, natural resource management, insurance, community engagement, and communications. There is overlap between these two audiences, but we found it useful to consider them separately as they have different motivations, identifications, skill sets, and needs.

Project caveats

Over the course of this project we made several key decisions for both practical and substantive reasons that limited the scope of our work. We recount here some key issues we feel compelled to state explicitly for the reader:

1. Our portfolio of 17 case studies is relatively small. Including more communities could bring additional insights to our cross case analysis discussed in Chapter 2.
2. Each case study is structured around a single policy action taken by that community. Consequently, the case studies do not provide insight into the totality of climate-related actions taken by any single case study community.
3. The case studies were purposefully sampled and are not intended to be representative of any population.
4. In focusing on specific actions in each community and the outcome of reduced vulnerability, we biased our portfolio of case studies toward single-sector actions. We tried to compensate by purposefully selecting several case study communities that appeared to be implementing a more holistic, cross-sectoral approach.
5. This research is not intended as a set of best practices, and we do not claim that our case studies are models of adaptation. The project was designed to be exploratory and empirical.

- What motivates communities to take adaptive action?
- What are communities doing to adapt?
- How are communities implementing adaptation actions?
- What are communities achieving through adaptation?

This project provides a critical assessment of community-based adaptation to climate vulnerability. Many surveys of adaptation actions have covered dozens or even hundreds of communities (e.g., Kauneckis and Cuffe, 2011; Carmin at al., 2012; Finzi Hart et al., 2012; Thayer et al., 2013; Shi et al., 2015). Although these surveys provided breadth of coverage, they tended to assess work at a broad level and offered only limited explorations of the complex interacting factors that explain why and how communities have addressed climate vulnerabilities. On the other end of the spectrum are specific, place-based adaptation case studies. These case studies tend to focus on a single community or a very small number of communities, diving deeply into processes and lessons. But, this narrow focus is less conducive to comparative analysis (e.g., Srivastava and Laurian, 2006; Dow et al., 2013; Ekstrom and Moser, 2014). As recognized in the Third National Climate Assessment (nca2014.globalchange.gov), this means there is a shortage of multi-community adaptation case studies and cross-case analyses in the adaptation literature (Melillo et al., 2014). This research effort was intended to fill this gap.

Here, we present the results of our research effort—an in-depth, case-based critical assessment of community-based adaptation—that can provide insight to community-based champions to help reduce vulnerability in their own communities and make evidence-based proposals for adaptation professionals to advance the state-of-the-practice. You can find the full case studies that form the empirical backbone of this project after chapter 3.

What We Did

This report summarizes the results of a two-year research effort conducted by Abt Associates,[1] with funding from The Kresge Foundation, and which was supported by a group of experts, including our project technical advisors and a Project Advisory Committee (PAC; see the report acknowledgments for a list of all project participants). The intent of the project was to conduct a critical assessment of community-based adaptation through a project that had both methodological breadth and depth. We surveyed the field of climate adaptation through a review of selected technical and professional literature that aimed to evaluate the state-of-the-practice (e.g., NRC, 2010; Bierbaum et al., 2013; Carmin et al., 2012; Hansen et al., 2013; Thayer et al., 2013; and Melillo et al., 2014). We supplemented this effort with interviews of 50 thought leaders from a variety of fields relevant to climate adaptation (see Appendix C). This allowed us to understand self-assessments by adaptation professionals of the state-of-the-practice. We then engaged in primary research by developing case studies of specific adaptation efforts in 17 U.S. communities, through site visits, archival reviews, and interviews for each community (see Exhibit 1.1 for a summary of our research design and methods and Appendix B for a more thorough explanation of our methods).

The intent of the project was to conduct a critical assessment of community-based adaptation through a project that had both methodological breadth and depth.

At the beginning of this project, we articulated the assumptions and normative perspectives that would underpin our work, enable progress, align the perspectives of multiple researchers, and ensure transparency of our research approach. The five most important assumptions and normative perspectives are described in the following five sections. As a project team, we repeatedly reviewed these considerations, requesting input from our technical advisors and the PAC.

A Selective and Practical Assessment

Our purpose in conducting an empirical assessment was to develop a sense of the state-of-the-practice of climate change adaptation through a review of selected technical and professional literature that aimed to evaluate the state-of-the-practice (e.g., NRC, 2010; Bierbaum et al., 2013; Carmin et al., 2012; Hansen et al., 2013; Thayer et al., 2013; and Melillo et al., 2014). We supplemented this selected literature review with 50 interviews of thought leaders from a variety of disciplines related to community-based climate vulnerability reduction. Building off this work, we then documented and assessed the empirical experiences of 17 communities engaged in a particular action that tangibly reduced their vulnerability to climate impacts. Our purpose was to generate insight into what it means to implement climate adaptation on-the-ground in communities, to tell 17 stories of community-based adaptation, and to develop a sense of what helps communities make progress through a cross-case analysis.

This critical assessment was intended to be selective, not comprehensive. We purposefully chose communities that had achieved or were likely to achieve tangible vulnerability reduction (described below). We were motivated to generate insight into how to make progress at a community-level by examining community-based action and facilitating peer-to-peer learning.

A Community-Based Focus

Action at many levels can address climate vulnerability. For example, local and state laws, federal regulations, private industry or market actions, and household decisions can all facilitate or impede climate adaptation. Although all of these levels are important, our project focused on action taken at the community level. We define community as a group of people living together

1. The Kresge Foundation provided a grant for this project to Stratus Consulting Inc., which merged with Abt Associates during the course of the project.

EXHIBIT 1.1. RESEARCH DESIGN AND METHODS

Activity Stream 1: Understand community-based adaptation state-of-the-practice

- Conducted a targeted literature review
- Interviewed 50 thought leaders

Activity Stream 2: Develop an analytical framework

- Created a case study selection protocol
- Developed a research protocol for case study development

Activity Stream 3: Obtain external expert guidance

- Engaged a PAC of experts in climate adaptation and related fields
- Rounded out project team with three leading experts in climate adaptation as technical advisors

Activity Stream 4: Develop case studies

- Selected 17 communities for case studies out of 110 candidate communities
- Conducted background research
- Undertook site visits and interviews
- Developed case study
- Conducted follow-up interviews
- Case studies reviewed by interviewees, project team, technical advisors, and PAC

Activity Stream 5: Compare case studies

- Developed cross-case findings
- Developed and tested cross-case narratives
- Analysis performed by project technical leads
- Extensive review performed by project team, technical advisors, and PAC

Activity Stream 6: Share project findings

- Wrote final project report
- Finalized 17 case studies
- Developed companion website
- Hosted webinars and delivered conference presentations
- Developed popular and peer-reviewed publications

Note that some of these activities were conducted in parallel. Refer to Appendix B for a more detailed discussion of our methods.

in a common geographic area, typically under a municipal jurisdiction such as a city or county, but sometimes defined by a watershed or other geographic characteristic. We chose this focus for four reasons:

1. Communities have been leaders in addressing adaptation; communities began addressing adaptation before states and the federal government (Rosenzweig et al., 2010; Bierbaum et al., 2013).
2. The community level provides a direct path to observing tangible vulnerability reductions.
3. It is at this local level that community-based champions have the detailed knowledge of local circumstances, the individual and collective motivation, and the sense of responsibility needed to implement cohesive adaptation actions.
4. The real-life experiences of communities are integral to advancing the state-of-the-practice of climate adaptation. By exploring a relatively large and diverse set of case study communities, we are able to provide evidence-based insights and a critical assessment of community-based adaptation.

Including Responses to Climate Variability, Extreme Events, and Climate Change

There is extensive literature discussing the definition and nature of climate adaptation (e.g., Smit et al., 2000; Adger et al., 2005; Brunner and Lynch, 2010; Moser and Boykoff, 2013; IPCC, 2014). For our research, we included responses to climate variability, extreme events, and climate change all within the rubric of climate adaptation. We did so for the following reasons:

1. It is not clear where climate variability ends and climate change begins. Although it is unequivocal that the climate is changing (IPCC, 2013), scientific attribution of individual events to climate change is an emerging science.
2. Extreme events and climate variability typically involve weather or climatic conditions similar to those that scientists expect will become more frequent or intense with climate change.
3. The tools, policies, and strategies deployed to address extreme events and climate variability are often similar or can be modified by communities aiming to adapt to climate change.
4. Community-based champions often do not label or parse their activities by the stringent terms of some academic disciplines. Climate change adaptation, natural hazards mitigation, and the normal day-to-day management of climate variability were often considered collectively or as part of a continuum of potential policy emphasis.

For our research, we included responses to climate variability, extreme events, and climate change all within the rubric of climate adaptation.

Avoiding Pre-Judging "Adaptation"

For the empirical portion of this project, we accepted case study interviewees' perspectives on the adequacy or appropriateness of given adaptation actions without pre-judgment of what counted as an "adaptation" or an "adequate" adaptation in a particular case study. We looked at community adaptation actions through this inclusive lens in order to allow a more diverse set of communities to inform our critical assessment than if we had explicitly required particular traits or qualities (e.g., explicitly considering climate change) for a community to count as having engaged in adaptation. We only passed judgment as to whether a particular adaptation action was likely to lead to tangible vulnerability reduction, as described below. As a result, we included cases in this project that are variously motivated by or responsive to climate variability, extreme events, climate change, sustainable development, or a combination of these factors. In Chapter 3, we apply our own judgment when we discuss our conclusions and tactical recommendations.

Community-based champions often do not label or parse their activities by the stringent terms of some academic disciplines. Climate change adaptation, natural hazards mitigation, and the normal day-to-day management of climate variability were often considered collectively or as part of a continuum of potential policy emphasis.

Focusing on Reducing Vulnerability to Climate Impacts

Although we accepted case study interviewees' perspectives regarding the applicability or adequacy of the adaptation actions undertaken in their communities, we were nevertheless careful to select only cases with distinct outcomes that already have resulted or are likely to result in tangible reductions of vulnerability to climate variability, extreme events, or climate change. We chose vulnerability reduction as a filter by which to

select case studies because one of the key objectives of adaptation—as well as of greenhouse gas mitigation—is to reduce vulnerability. As such, across our case study portfolio, we focused on actions that reduced exposure, reduced sensitivity, or enhanced adaptive capacity—all of which ultimately can contribute to reducing a community's vulnerability to climate impacts. We use the Intergovernmental Panel on Climate Change definition of vulnerability, which contains three components—exposure, sensitivity, and adaptive capacity—to categorize the actions the case study communities have taken to reduce their vulnerability (see Exhibit 1.2).

We focused on actions that reduced exposure, reduced sensitivity, or enhanced adaptive capacity—all of which ultimately can contribute to reducing a community's vulnerability to climate impacts.

EXHIBIT 1.2. WHAT IS VULNERABILITY?

Vulnerability: The degree to which a system is susceptible to, and unable to cope with, the adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity.

Exposure: The presence of people or assets in locations that could be adversely affected by climate impacts.

Sensitivity: The degree to which a system is affected, either adversely or beneficially, by climate variability or change. Sensitivity is about what happens to a system once it is exposed to a climate impact.

Adaptive capacity: The ability of a system to adjust to climate change (including climate variability and extremes) or to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

See the Appendix A glossary for more detailed definitions.

CHAPTER 2

Case Studies and Cross-Case Findings

As discussed in Chapter 1, four central questions guided our work: What motivates communities to take adaptive action? What are communities doing to adapt? How are communities implementing adaptation actions? And what are communities achieving through adaptation? Using these questions as our guide, we conducted a cross-case analysis of our 17 detailed case studies and found:

- **Motivations:** Most adaptation actions draw upon, promote, and sustain multiple community values. Climate change was not typically the exclusive justification for community-based adaptation in the cases we studied. However, experiencing extreme climate events commonly initiated or accelerated adaptation efforts.
- **Actions:** Most of the profiled communities are attempting to tangibly reduce their vulnerability to climate variability, extreme events, and climate change. In a few cases, these communities are taking action to reduce exposure; more often, their work is aimed at reducing sensitivity and building adaptive capacity.
- **Implementation:** Communities use diverse strategies to implement adaptation actions—from deploying conventional policy tools to mainstreaming adaptation into existing efforts to developing new decision-making processes. These strategies often capitalize on effective leadership and consciously build community support.
- **Achievements:** The communities we examined are reducing their vulnerability to current climate impacts; a few are also explicitly reducing their vulnerability to future climate impacts. Sometimes these vulnerability reductions are limited in temporal or spatial scope or address only a particular vulnerability type (e.g., only drought). Adaptation actions frequently go hand-in-hand with progress on other community priorities.

In the following sections, we detail the cross-case findings, commonalities, differences, and other noteworthy observations developed through multiple independent streams of analytical activity. Although this summary of our cross-case findings speaks to the common themes we identified, each case study represents a single community's path to climate adaptation. These paths can inspire forward-thinking action by other communities and climate adaptation professionals. Because of the detailed and useful information embedded in each case study, we encourage readers to read each of the 17 case studies included in this report after Chapter 3. We summarize these case studies in Exhibit 2 below.

EXHIBIT 2. CASE STUDY SUMMARIES

Report Page Number	Case study community	Action profiled	Brief case description
Page 48	Avalon, NJ	Comprehensive Shoreline Protection Strategy	Avalon developed a number of physical shoreline barriers, bought damaged shoreline properties, purchased additional undeveloped land, limited shoreline development, and created and maintained extensive shorefront sand dunes to protect the borough's property and tourism industry from coastal storms.
Page 61	Baltimore, MD	Integrating Climate Change Adaptation into an *All-Hazard Mitigation Plan*	In 2012, city staff used a periodic update of the city's *All-Hazards Mitigation Plan* as an opportunity to integrate a climate change risk and vulnerability assessment into the new *Disaster Preparedness Project and Plan*. This case focuses on 2 out of the 231 actions identified: the disaster preparedness initiative, *Make a Plan, Build a Kit, Help Each Other;* and the capacity-building initiative, *Resiliency Hubs.*

EXHIBIT 2. CASE STUDY SUMMARIES

Report Page Number	Case study community	Action profiled	Brief case description
Page 76	Boston, MA	Climate Change Preparedness and Resiliency Checklist	With a focus on sea level rise and coastal and inland flooding, the Boston Redevelopment Authority mandated that climate change be considered as part of the review process for large new developments (over 20,000 square feet) and large renovation projects (over 100,000 square feet).
Page 87	Chula Vista, CA	Cool Roofs Ordinance and Shade Trees Policy	Chula Vista implemented a stakeholder-driven climate planning process to develop a suite of climate adaptation actions. Two specific actions focused on addressing rising temperatures in the San Diego region are profiled in this case: Chula Vista's cool roofs ordinance, and Chula Vista's shade trees policy.
Page 98	Cleveland, OH	Neighborhood Climate Action Toolkit and Climate Action Fund	Cleveland tied its climate change efforts to date to neighborhood revitalization through a citywide climate action plan and the *Cleveland Neighborhood Climate Action Toolkit,* which helps neighborhoods leverage existing assets to fight economic decline, increase adaptive capacity, reduce greenhouse gas emissions, and prepare for a climate-altered future.
Page 109	El Paso County, TX	Kay Bailey Hutchison Inland Desalination Facility	El Paso Water Utilities' project focused on addressing the combined challenges of population growth and drought. El Paso Water Utilities, in an unusual alliance with the U.S. Army military base Fort Bliss, constructed the Kay Bailey Hutchison Desalination Plant to convert formerly unusable brackish water into drinking water.
Page 121	Flagstaff, AZ	Flagstaff Watershed Protection Project	In response to the 2010 Schultz fire and subsequent flooding, voters in Flagstaff passed a $10 million bond measure to use city funding to reduce catastrophic fire risk in critical but hard-to-treat areas on U.S. Forest Service lands.
Page 132	Fort Collins, CO	Water Demand Management	In response to severe drought events, Fort Collins updated its Water Supply and Demand Management Policy to: (1) outline specific regulatory measures to reduce water use quickly during a severe drought, and (2) reduce water use through water conservation programs.
Page 140	Grand Rapids, MI	Vital Streets and Sidewalks Spending Guidelines	Flooding, aging stormwater infrastructure, and public discontent about the state of the roads led Grand Rapids to create the Vital Streets and Sidewalk Spending Guidelines, which mandate green infrastructure use during upgrades. In a 2014 election, 66 percent of voters supported the guidelines and a tax to fund implementation.
Page 150	Miami-Dade County, FL	Integrating Climate Change Adaptation into a Comprehensive Development Master Plan	In 2013, the Board of County Commissioners approved integrating climate change considerations into multiple elements of the Comprehensive Development Master Plan. These changes will require county departments to consider climate change during processes such as capital improvement projects.
Page 163	Mobile County, AL	Oyster Reef Restoration	The cultural and economic impacts of coastal ecosystem degradation have generated support for restoration actions in Alabama's Mobile Bay. In 2009, The Nature Conservancy received a grant through the American Recovery and Reinvestment Act to rebuild oyster reefs along a stretch of degraded coastline in Mobile Bay.

EXHIBIT 2. CASE STUDY SUMMARIES

Report Page Number	Case study community	Action profiled	Brief case description
Page 173	Norfolk, VA	Coastal Resilience Strategy	Norfolk passed changes to its flood and coastal zone ordinance following increases in severe coastal flooding and in anticipation of potential sea level rise. The ordinance requires that new structures in coastal flood zones must be built at least 3 feet above the 100 year floodplain (i.e., a 3-foot freeboard); certain existing structures must also meet this standard.
Page 183	Oakland, CA	Oakland Climate Action Coalition Moves Climate Change Adaptation Forward	In 2009, 30 organizations interested in advancing policies on sea level rise, environment, public health, and social justice issues came together to form the Oakland Climate Action Coalition. This coalition has become a community-led platform for supporting climate change adaptation strategy and action through a social justice lens.
Page 197	Seattle, WA	Mainstreaming Climate Change Into Internal Planning and Decision Making	Seattle Public Utilities integrated climate considerations into the four levels of their internal planning and operations: (1) organization-wide strategic planning, (2) planning at the water division and drainage and sewer division levels, (3) capital investment decision making, and (4) day-to-day operational decision making.
Page 211	Southwest Crown, MT	Forest Restoration	In response to more severe and longer wildfire seasons anticipated to worsen under climate change, the community used federal funding to conduct forest and watershed restoration, including forest thinning and prescribed fires, to reestablish natural wildfire dynamics and reduce the risk of catastrophic wildfire.
Page 223	Spartanburg, SC	Mainstreaming Climate Change into Programs, Management Actions, and Culture	Droughts, extreme rainfall, and concern about climate change led Spartanburg Water to integrate climate change into the utility's operations, culture, programs, and actions and helped increase the capacity of staff concerning climate variability and impacts.
Page 231	Tulsa, OK	Acquisition and Relocation	After several severe flooding events, Tulsa began an extensive program to acquire repeatedly flooded properties, remove or relocate buildings on those properties, and convert repetitively flooded properties into parks and other public uses. Since the 1970s, Tulsa has acquired more than 1,000 repetitively flooded properties.

These 17 case studies, each of which profiled a particular action taken to reduce climate vulnerability, form the heart of this project. As we address the key questions below, we provide example cases in each subsection that illustrate findings particularly well. In most subsections, there are several other examples among our case studies that could also illustrate that point. The case studies should be seen as illustrative examples for each of the points made in this chapter, not as a comprehensive accounting of all relevant case examples. For the sake of brevity, we reference the name of the community in which an adaptation action occurred, rather than a detailed description of the action profiled. For convenience, Exhibit 2 provides a table of the 17 case studies for reference when reading this chapter.

What Motivates Communities to Take Adaptive Action?

Across our 17 case studies, a wide variety of motivations drove communities to address climate vulnerabilities, including extreme climate events, shared community values, planning for climate change, and government mandates. These motivating forces often raised awareness of community-level vulnerability to climate impacts, as well as the opportunity to take action. Sometimes, adaptation actions were part of a broader policy effort aimed at community priorities beyond reducing climate vulnerabilities.

Extreme Climate Events

The incidence of extreme climate events—like hurricanes, severe storms, droughts, and catastrophic wildfires—was a common theme across all of our case studies. The relative importance of the extreme event varied significantly, but in almost every case, an extreme event played an important role in raising awareness of climate vulnerability or in motivating action directly. In some cases, a single event, such as a hurricane, wildfire, or drought, had such severe impacts that it served as a "wake-up call" to motivate action. In other cases, repeated extreme events built on one another to generate action or break loose stalled deliberations. Extreme events often sensitized people to climate vulnerabilities, increased public engagement, changed attitudes about addressing climate vulnerability, galvanized support for actions that moved beyond the status quo, and provided windows of opportunity to implement significant policy action that might not have been politically feasible, otherwise. In some cases, extreme events raised awareness about vulnerability specifically associated with climate change.

- **Avalon, NJ,** began its shoreline protection efforts because of damage wrought by the 1962 Nor'easter. Progress slowed over time, and only accelerated after Hurricane Gloria damaged the borough's property and thriving summer tourism industry in 1985.
- **Chula Vista, CA,** experienced severe wildfire in 2003 and 2007 that helped motivate the community to tackle the broader issue of climate adaptation across multiple hazards. The fires burned to the city limits, providing a visible reminder of climate vulnerability to all citizens.
- **Flagstaff, AZ,** experienced a series of record-breaking fires throughout the 1990s and 2000s that sensitized people to wildfire vulnerability. However, the 2010 Schultz fire and the subsequent flooding convinced Flagstaff's leadership and citizens to self-fund forest fire mitigation projects through a bond issue.
- **Tulsa, OK,** started its property acquisition and relocation program in response to floods in 1974 and 1976; however, efforts stalled until the Memorial Day Flood of 1984 brought new life to Tulsa's acquisition and relocation efforts.

Multi-hazard adaptations. The prevalence of severe events did, in certain case study communities, help to keep stakeholders and the public aware of climate change as an evolving issue and an important area of political focus.

- **Chula Vista, CA,** experienced severe wildfires that helped motivate its stakeholder engagement process for climate adaptation. However, Chula Vista's process extended beyond wildfire to identify adaptation actions across a number of climate vulnerabilities.
- **Tulsa, OK,** started out addressing only inland flooding, but that experience eventually helped city leaders develop the capacity to address other community vulnerabilities, such as tornadoes and terrorism.

Shared Community Values

Community identification with nearby natural resources or ecosystems, community cohesion and social equity, and the desire to revitalize, maintain, or enhance socioeconomic conditions are examples of shared community values that motivated action. These shared values extended beyond, while remaining consistent with, the motivation to reduce community vulnerability to climate impacts. These shared values often emerged as bundles of multiple, sometimes interacting, motivations, which served to bring together diverse policy participants and enable action.

Community identification with nearby natural resources or ecosystems, community cohesion and social equity, and the desire to revitalize, maintain, or enhance socioeconomic conditions are examples of shared community values that motivated action.

Community identification with nearby natural resources or ecosystems. The economy, social welfare, and cultural identity of some communities depend on natural resources; protecting these resources galvanize some communities to take action.

- In **Flagstaff, AZ,** citizens approved a bond to fund fire mitigation activities because forests were central to the identity of the community, providing critical goods and services such as clean water and recreational opportunities.
- In **Mobile County, AL,** the Nature Conservancy gained the buy-in necessary to implement oyster reef restoration because the community identified with fishing as a way of life threatened by storm inundation. The restoration effort helped protect valued local wetlands, the health of local fisheries, and the sustainability of livelihoods that depend on coastal resources.
- In **Southwestern Crown, MT,** communities implemented fire mitigation because they valued the forests they lived in, the local timber resources they provided, watershed health, and the terrestrial and aquatic habitats supported by a healthy forest.

Community cohesion and social equity. Some actions emphasized the additional strain that climate change may place on entrenched social and economic conditions such as poverty, economic inequality, and social or environmental justice issues.

- **Cleveland, OH,** chose to closely tie its climate adaptation efforts to the revitalization of neighborhoods. The city aims to provide residents with safe and stable neighborhoods that have economic opportunities, viewing stronger neighborhoods as enabling conditions supportive of adaptation.
- **Baltimore, MD,** chose to work directly with community members, educating them on climate vulnerabilities and helping residents and neighborhoods prepare for and potentially respond to extreme events, such as flooding or heat waves.
- In **Oakland, CA,** the Oakland Climate Action Coalition came together to advance local climate adaptation that reflected the community's priorities and social justice concerns.

Desire to revitalize, maintain, or enhance socioeconomic conditions. In some communities the desire to improve economic or social conditions motivated action. This often emerged from a sense of civic pride and community identity.

- **El Paso County, TX,** has been aware of and managing for the potential effects of drought for decades. However, when the closure of Fort Bliss came under discussion through the Department of Defense's base realignment and closure process—along with the pressures of a growing population, limited low-cost water supply options, and few additional options to lower water demand—a new partnership was born. The local utility and its allies worked together to successfully lobby for the funding and cross-jurisdictional cooperation necessary to develop a desalination facility in partnership with Fort Bliss.
- In **Fort Collins, CO,** city leaders realized that an acute water shortage that might affect water delivery to major industries, especially their thriving brewing industry, would be a serious threat to the city's economy and identity.
- In **Boston, MA,** many commercial developers had property in areas that were hit by Hurricane Sandy. As a result of direct financial losses from Sandy—and, for some, the perception of increased potential for future financial losses—the development community largely

accepted voluntary requirements under Boston's Zoning Article 80. Despite likely increases to the cost of construction, the requirements are intended to reduce future economic losses from inundation and extreme heat.

- Repetitive flooding in **Tulsa, OK,** adversely affected the city's physical infrastructure, its economy, and the lives and livelihoods of its citizens. The community's support to address this persistent threat to Tulsa's prosperity eventually overcame resistance by the Home Builders Association, which viewed flood-control measures as anti-development in a pro-development political climate.

Desire to Address Climate Change

Some communities appeared to take action out of a desire to demonstrate innovation concerning climate change. In some cases information about climate change, alone, appeared to raise the awareness of potential climate impacts and drive adaptation actions.

Demonstrate innovation concerning climate change. Many of the communities in this category have been leaders and early movers in efforts to address greenhouse gas mitigation or sustainability, and subsequently extended their efforts to climate adaptation. Furthermore, peer learning and friendly competition seem to lead some communities to take action (*see the peer-to-peer networking finding on page 33*).

- **Miami-Dade County, FL,** has a long history of environmental action, including its 1993 *Urban CO_2 Reduction Plan*. The county expanded into adaptation in 2006, when the county commissioners appointed the Climate Change Advisory Task Force to bring climate impacts, especially sea level rise, into public discourse. This consistent leadership on environmental issues has enabled county staff to integrate climate change and climate vulnerability throughout the county's Comprehensive Development Master Plan.
- **Chula Vista, CA,** started working on climate change in the early 1990s and adopted its first Climate Action Plan to mitigate greenhouse gas emissions in 2000. Chula Vista revised this plan in 2008 to include climate change mitigation measures; a second revision, in 2011, evaluated how the city could prepare itself for climate change impacts.
- In **Boston, MA,** former Mayor Thomas Menino first championed a green building agenda to reduce the energy footprint of Boston's buildings in the late 1990s and early 2000s. Mayor Menino undertook this work under Zoning Article 80, which was later used to implement the Climate Change Preparedness and Resiliency Checklist to assess how climate change and extreme weather conditions could affect new development and redevelopment over their design life.

Information about the effects of climate change. In some of our case studies, climate change information raised awareness and drove action in two main ways. First, the publication of regional, national, or international assessments focused attention on the issue of climate change and provided a rationale for taking action. Second, tailored climate information from academics or other climate change experts informed decision-makers and provided the necessary background and understanding of climate impacts to facilitate and motivate action.

- Leaders in **Seattle, WA,** used international and regional reports—such as various Intergovernmental Panel on Climate Change assessments, and the first *Pacific Northwest Assessment on Climate Change*—to raise awareness among the general public and city leadership about the effects of climate change and to build political support for taking action. This complemented independent and proactive assessments by SPU staff that did not wait for permission from political leaders to begin climate impacts assessment work.
- The San Diego Foundation's *Focus 2050 Report* provided **Chula Vista, CA,** with downscaled climate change impact data in a digestible report that raised awareness and motivated policymakers and city staff to tackle climate adaptation.
- In **Norfolk, VA,** regional sea level rise projections through 2100 convinced the Planning Commission that adopting a higher freeboard standard than Department of City Planning staff initially recommended was imperative to protecting the safety of the city's infrastructure.

Government Mandates and Existing Regulation

Government mandates, regulations, or enforcement actions generally did not drive action in the communities, with the exception described below. However, we call it out here because government mandates can serve as a significant motivating force in the future. Note that the lack of community actions driven by government mandates may be due to the case study selection. There are many cases, for example, of combined sewer overflows (CSO) enforcement actions. But the range of actions driven by government mandates seems limited to us.

- **Grand Rapids, MI,** addressed its vulnerability to flooding along the Grand River, at least in part, because the state of Michigan began citing the city for being in violation of water quality requirements. During heavy rainfall events, the city's combined sewer and storm water system became overwhelmed, and untreated sewage was flowing into the Grand River.

What Are Communities Doing to Adapt?

In this section, we examine our case studies to provide some answers to the question of what communities are doing to adapt to climate change and climate variability. We group our findings under the three main components of vulnerability identified by the Intergovernmental Panel on Climate Change definition of vulnerability, which are discussed in Chapter 1.

Reducing exposure means moving human populations and valued asset or activities out of harm's way… We found examples of reducing exposure to climate vulnerability through: (1) land-use regulations and (2) property buy-outs and relocation.

Reduce Climate Exposure

Exposure is the presence of people or assets in places that could be adversely affected by climate impacts. Reducing exposure means moving human populations and valued assets or activities out of harm's way. In our case studies, we found examples of reducing exposure to climate vulnerability through: (1) land-use regulations and (2) property buy-outs and relocation. These strategies were employed in only two communities. Interestingly, both communities originally took action with the motivation of addressing climate impacts from extreme weather events. The actions they took, however, reduced vulnerability to changes in climate such as potential increases in precipitation, flooding, and coastal storm surge.

Land-use regulations

- In the 1960s, **Avalon, NJ,** undertook a number of actions that limited shoreline development, including restricting residential and commercial development and developing a shoreline setback policy. This prevented development that would have been vulnerable to storm surge and future sea-level rise.
- **Tulsa, OK,** adopted regulatory floodplain maps that exceeded Federal Emergency Management Agency requirements to limit development in flood-prone areas. Tulsa's floodplain maps were one part of a comprehensive strategy to reduce the community's exposure to flooding.
- In **Boston, MA,** developers are now required to complete a "Climate Change Preparedness and Resiliency Checklist" as a prerequisite to development of new buildings over 20,000 square feet and renovations over 100,000 square feet.

Property buy-outs and relocation

- After the 1962 Nor'easter, **Avalon, NJ,** started a property-exchange or buy-out program to acquire properties as borough land and compensate landowners who lost their homes in the storm.
- Since the 1970s, **Tulsa, OK,** has acquired more than 1,000 repeatedly flooded properties, removed or relocated associated buildings, and converted the properties to

public parks; these actions have reduced the exposure of buildings and people to riverine flooding, and is proving beneficial now in light of the prospects of more extensive flooding anticipated from climate change.

Reduce Sensitivity to Climate Impacts

In our case studies, we found a diversity of actions that reduced sensitivity to climate impacts. The Intergovernmental Panel on Climate Change defines sensitivity as the degree that a system is affected by climate variability or change. Efforts to address climate sensitivity seek to reduce the consequences of a climate impact. The communities in our case studies reduced their climate sensitivity through widely applied municipal policy actions or tools, managing ecosystems or natural resources, and infrastructure-related actions.

Efforts to address climate sensitivity seek to reduce the consequences of a climate impact. The communities in our case studies reduced their sensitivity through widely applied municipal policy actions or tools, managing ecosystems or natural resources, and infrastructure-related actions.

Municipal policy actions or tools. Zoning and municipal ordinances were popular amongst the 17 case study communities as a way to reduce the sensitivity of different sectors to climate impacts.

- In **Boston, MA,** developers are now required to complete a "Climate Change Preparedness and Resiliency Checklist" that assesses how climate change and extreme weather conditions could affect the development of new buildings over 20,000 square feet or proposed renovations over 100,000 square feet. As a result of this checklist, nearly all projects now locate critical systems above flood levels, reducing sensitivity to flooding.
- **Chula Vista, CA,** developed a cool roofs ordinance and a shade trees policy to reduce the urban heat island effect and the city's sensitivity to extreme heat events.
- **Norfolk, VA,** changed its flood and coastal zone ordinance, implementing a three-foot freeboard standard for new structures in flood and coastal zones to reduce the sensitivity of those structures to tidal and coastal flooding, as well as to sea-level rise.

Managing ecosystems or natural resources. Other cases study communities chose to reduce their sensitivity by carefully managing their natural ecosystems.

- **Flagstaff, AZ,** and the **Southwestern Crown, MT,** improved forest management through forest-thinning treatments and prescribed burns; these efforts reduced the communities' sensitivity to catastrophic wildfire. In the case of Flagstaff, these efforts also addressed vulnerabilities to flooding.
- In **Mobile County, AL,** oyster reefs were restored to reduce sensitivity to storm surge following Hurricane Katrina.

Green and gray infrastructure-related actions. Some case study communities focused on employing infrastructure—conventional "gray" infrastructure, as well as "green" infrastructure[2] —to reduce sensitivity to climate impacts. Many communities combined these sensitivity-reducing strategies with actions to reduce exposure.

- **Avalon, NJ,** has engaged in extensive dune restoration and beach nourishment, both of which reduce the borough's sensitivity to coastal storms. These actions were part of Avalon's comprehensive shoreline protection strategy, which also included exposure reduction, such as property buy-outs, and educational programs and flood insurance to enhance adaptive capacity (see below).
- **El Paso County, TX,** constructed an inland desalination facility. With this facility, El Paso is able to convert formerly unusable brackish groundwater into drinking water for the community, reducing the community's sensitivity to droughts.

2. We use "green infrastructure" to refer to the use of vegetation, soils, native species, ecosystems, or natural processes to provide a valued community function, such as vulnerability reduction; green spaces for public use, recreational opportunities, or improved ecosystem health; and natural resource enhancement.

- **Grand Rapids, MI,** created "Vital Streets and Sidewalk Spending Guidelines," mandating the use of green infrastructure when upgrading road and stormwater infrastructure. These guidelines reduce the city's sensitivity to inland flooding.

Enhance Adaptive Capacity

Some community actions increased adaptive capacity —a system's ability to prepare for and adjust to climate change (including climate variability and extremes), for example, by educating vulnerable populations, improving social networks at the neighborhood level, or protecting natural resources and watersheds. These actions stemmed from an understanding of the need to develop and bolster human, social, and natural capital; develop and build technical capacity; and use existing and develop new institutional capacity to engage in climate-specific planning and implementation.

Develop and bolster human and social capital. These actions helped case study communities alleviate both vulnerability to climate impacts and long-standing socioeconomic issues in neighborhoods and communities.

- **Baltimore, MD,** implemented actions to build the adaptive capacity of residents and neighborhoods. *Make a Plan, Build a Kit, Help Each Other* is a disaster preparedness initiative for residents and *Resiliency Hubs* aims to improve neighborhoods' capacity to prepare for and respond to hazardous events.
- **Cleveland, OH,** designed and implemented the *Cleveland Neighborhood Climate Action Toolkit* to build social cohesion in neighborhoods, which is a critical aspect of adaptive capacity; the toolkit focuses on addressing baseline socioeconomic conditions, even though specific consideration of climate vulnerability is required. Interestingly, Cleveland is the only case in our study that clearly falls into this "generic," non-climate adaptive capacity category.
- In **Oakland, CA,** the Oakland Climate Action Coalition—a community-led coalition of 30 organizations—spurred a comprehensive public engagement process on climate mitigation and adaptation planning. The coalition now conducts community education and outreach concerning Oakland's vulnerability to extreme heat, wildfires, coastal flooding from sea level rise, and air quality, as well as future food, water, and electricity prices.

Develop and build technical capacity. Other communities relied on municipal, government, private industry, academic, or public sector leaders to build a better understanding of climate vulnerabilities and what they mean for an individual's project or job functions.

- **Chula Vista, CA,** worked with academics and The San Diego Foundation to use the *Focus 2050 Report* to build capacity among staff and stakeholders to understand the projected impacts of climate change as part of their planning process.
- Seattle Public Utilities in **Seattle, WA,** created an internal Climate Resiliency Group in the late-2000s, in part to build up staff capacity for climate adaptation. This included a major self-education effort, engagement with the Water Utility Climate Alliance, commissioning and conducting tailored research, and participation in the National Climate Assessment.

Use existing or develop new institutional capacity. Some communities used planning processes as a way to build on existing staff or community capacity to address climate vulnerabilities.

- **Chula Vista, CA,** developed a stakeholder-driven climate planning process to identify, evaluate, and implement a suite of climate adaptation actions. City staff, working with the stakeholder group, reviewed 180 potential adaptation actions and ultimately recommended 11 climate adaptation actions to the City Council.
- **Miami-Dade County, FL,** integrated climate change considerations into its Comprehensive Development Master Plan—including land use; transportation; conservation, aquifer recharge, and drainage; water, sewer and solid waste; coastal management; and intergovernmental coordination. This helped the county mainstream climate considerations across county functions.
- Seattle Public Utilities in **Seattle, WA,** integrated climate change into internal planning to ensure that climate was considered as a matter of course in strategic business planning, department-wide planning, and capital improvements.

How Are Communities Implementing Adaptation Actions?

Our case studies profile actions that use a diversity of strategies to achieve reductions in vulnerability; understanding how actions succeed or fail depends on the community and its ability to capitalize on effective leadership, to build community support, and other approaches to facilitate implementation. Some of the strategies in this section can occur at various points in the process: during the planning stages, after leaders have chosen an action and need to secure support, or during implementation.

Leadership is a critical component of enacting change… We focus on three key aspects of successful leadership: the ability to identify needs and supply a vision for change; the ability to work in a coalition; and the ability to sustain efforts over a long period of time to enact to change.

Capitalize on Effective Leadership

Leadership is a critical component of enacting change. Nearly all of our case narratives highlight the importance of leaders and leadership to establish meaningful, ongoing, community-scale, climate adaptation efforts. However, the case narratives also illustrate that no single type or approach to leadership will be appropriate for all circumstances or occasions. Some case narratives show the effectiveness of top-down leadership (e.g., Boston, El Paso), while others tell a story of leadership that evolved from the bottom-up (e.g., Flagstaff, Oakland, Seattle). Here, we focus on three key aspects of successful leadership: the ability to identify needs and supply a vision for change; the ability to work in a coalition; and the ability to sustain efforts over a long period of time to enact change.

Ability to identify needs and supply a vision for change. An important manifestation of leadership is the ability to identify a need for change and articulate a vision for an alternative future. Implementation of a suite of adaptation actions will require complex leadership capabilities, such as: (1) high-level leadership from elected officials, department heads, or organizational executives to articulate a vision and inspire change; (2) leadership from mid-level managers to translate the vision into specific action items or technical specifications; and (3) citizen-facing leaders willing to communicate persuasively with the public.

- In **Miami-Dade County, FL,** former County Commissioner Harvey Ruvin began to push for more action on climate change, including the organization of an ad hoc committee on climate adaptation, years before the county took actual steps toward implementation. The committee made a number of recommendations, including actions to address flood protection, saltwater intrusion, and Everglades restoration.
- **Boston, MA,** faced growing vulnerabilities from sea-level rise and coastal storms. In response, Mayor Thomas M. Menino started a series of initiatives to "green" the built environment. These efforts paid off in 2013, when the Boston Redevelopment Authority Board mandated that climate change be considered as part of the review process for large new developments and large renovation projects.
- In **Seattle, WA,** Paul Fleming worked with colleagues to promote the consideration of climate change within Seattle Public Utilities, among peer utilities, and among colleagues at SPU. His leadership has played an important role in making Seattle a leader on climate change adaptation.
- In **Oakland, CA,** the Oakland Climate Action Coalition, made up of environmental and social justice organizations, developed into a grassroots force advocating for climate mitigation initiatives in the city's official plan.

Ability to work in a coalition. Among our cases, adaptation is rarely implemented single-handedly. Leaders often needed to rally the support of a broader coalition of citizens, nongovernmental organizations, elected officials, municipal staff, the private sector, consultants, and

state or federal agencies. Leadership in some cases is manifested as collaboration across multiple individuals and groups driving a joint agenda.

- In **El Paso County, TX,** the president and chief executive officer of the water utility, Edmund Archuleta, had a key role in identifying the opportunity for and eventually constructing the inland desalination facility. However, collaboration with Fort Bliss personnel, other Department of Army officials, and members of the U.S. Congress was necessary to overcome jurisdictional and financial hurdles.
- In **Flagstaff, AZ,** the city's fire management officer, Paul Summerfelt, pitched an approach to city manager Kevin Burke to support forest management. The city manager was supportive of the idea, and saw an expiring city bond as a potential avenue for funding. Flagstaff had an existing team of citizens working on forest management issues who joined in support of the idea and helped propose it to the City Council. These same citizens later organized a Political Action Committee to raise support for the measure. Once the community passed the bond extension, a collaborative partnership among the city, the U.S. Forest Service, the county, and local tribes has formed to ensure coordination during project implementation.
- In **Oakland, CA,** the city's intention to develop a climate change mitigation plan generated interest from local environmental and social justice organizations to help shape the plan through community engagement. The various organizations developed a formal partnership, the Oakland Climate Action Coalition, to provide community-based leadership on Oakland's climate initiatives.
- In **Mobile County, AL,** The Nature Conservancy received federal funding to restore Mobile Bay's oyster reefs; however, collaboration among multiple groups—including nongovernmental organizations, academic researchers, citizens, and state and federal governments—was crucial to the design and implementation of The Nature Conservancy oyster reef project.

Ability to sustain effectiveness over a long period of time to enact change. In a few of our case studies, adaptation actions are implemented quickly. However, in most of our cases, enduring leadership was needed. This extended commitment by an individual or group appears to be critical to making progress. In some cases, the mantle of leadership can be passed from one individual or one group to another, particularly between formal institutions.

- In **Miami-Dade County, FL,** Mr. Ruvin played an important role over decades, pushing a climate change mitigation program that evolved into a climate adaptation agenda. This agenda has been carried out by dedicated and long-serving county staff, in part through their involvement in the South Florida Regional Climate Change Compact. The Compact itself has enabled county leaders to take a more aggressive stance on climate issues than would otherwise be the case, including newer voices in Miami-Dade County, such as Commissioner Rebecca Sosa, Commissioner Daniella Levine Cava and Mayor Carlos A. Gimenez.
- Following **Tulsa, OK's** 1974 and 1976 flooding events, project champions—particularly Ann Patton, Ron Flanagan, and J.D. Metcalfe—began to move a comprehensive flood management program from conception to implementation. However, it was not until the city's worst flooding event—the 1984 Memorial Day flood—when project champions, including the new Mayor Terry Young, were able to use momentum from that flooding event, as well as established partnerships and previous work in developing and advocating sophisticated solutions to flood mitigation, to fully implement a comprehensive flood-management program along the city's tributary streams. Two of these project champions continue to work today on flood management. In addition, newer project champions are also continuing the work through Tulsa Partners, Inc.
- A small group of staff at Seattle Public Utilities in **Seattle, WA**—including Paul Fleming, Joan Kersnar, and Alan Chinn—worked together for almost a decade to push a climate adaptation agenda forward, including the most recent effort to integrate climate change into long range supply planning.

Build Community Support

In many of our case studies, strong community support for an issue was as instrumental—and varied—as effective leadership. Community support came in different forms and at different times. Here, we discuss leveraging support after extreme events; broadening support through a focus on co-benefits; tailoring discussion of climate change to fit with the politics and attitudes of the public; enhancing support through grassroots or community organizations; and focusing, or not focusing, on engagement of more-vulnerable populations.

Use extreme events to build support. In many case studies, leaders leveraged the consensus that "something needs to be done" after an extreme event to push for policy changes to reduce vulnerability to future extreme events. The strategic move in the aftermath of an extreme event can capitalize on a short window of opportunity before the event starts to fade from community memory.

- In **Flagstaff, AZ,** leaders of the bond initiative were able to appeal to the personal experience of citizens and garner community support for the proposed "Flagstaff Watershed Protection Plan" because the area had experienced a string of wildfires, culminating in the Schultz fire and subsequent flooding.
- In **Avalon, NJ,** a history of coastal storms threatened the borough's property and thriving summer tourism industry, which led the city to undertake shoreline protection efforts. Smaller storms helped to make the case for ongoing shoreline protection efforts, such as beach nourishment and community education efforts.
- **Tulsa, OK,** advanced comprehensive flood management after the 1984 Memorial Day flood by relying on: (1) established partnerships among grassroots citizens, technical experts, and public-sector officials—relationships that were developed during earlier flooding events; and (2) the community's previous work in developing and advocating for sophisticated solutions to flood mitigation. Once the 1984 Memorial Day Flood hit, the community was able to "seize [the] moment and execute bold plans" (Patton, 2009, p. 89).

Broadening support through a focus on co-benefits. An action aimed at reducing vulnerability to a particular climate impact often provides other benefits that may more strongly motivate some citizens to understand the value of taking action. Building community support around those other benefits can broaden support for an adaptation action.

- **Grand Rapids, MI,** understood that by appealing to the benefits of improving dilapidated roads, and making multi-modal transportation improvements, they could attract a broader coalition of interests in support of developing green infrastructure to address flooding from stormwater.
- In **El Paso, TX,** the water utility, the Chamber of Commerce, and local elected officials all advocated for the development of a desalination plant, not just to increase available water sources in the county, but also to help keep U.S. Army Base Fort Bliss operating. The fort is a major economic driver in the community.
- **Chula Vista, CA,** prioritized climate adaptation actions with multiple co-benefits. For example, Chula Vista's stakeholder working group recommended the implementation of a shade trees policy because of its significant co-benefits for the city: the shade trees not only acted as a natural cooling mechanism for urban areas, but they also provided habitat for wildlife, reduced storm water runoff, and increased property values.

In many of our case studies, strong community support for an issue was as instrumental—and varied—as effective leadership.

Tailoring discussion of "climate change" to fit with the local politics and attitudes of the public. Politics and public attitudes/local values affect whether communities explicitly discussed climate change in the context of their vulnerability reduction efforts. Our case studies demonstrate that community leaders made intentional choices about whether, when, and how to bring climate change into the discussion about an adaptation action.

Politics and public attitudes / local values affect whether communities explicitly discussed climate change in the context of their vulnerability reduction efforts.

- In **Seattle, WA; Baltimore, MD; Boston, MA; Chula Vista, CA; Oakland, CA; and Miami-Dade County, FL,** leaders explicitly cited climate change as a primary reason for the adaptation action taken. In these cases, the general public and community leadership often pressed for action because of widespread support for addressing the issue of climate change.
- In **Norfolk, VA; Cleveland, OH; and Grand Rapids, MI,** leaders discussed climate change explicitly, but not as a primary motivator for adaptation actions. Typically, benefits such as economic development or the impacts of climate variability were the primary point of discussion.
- **Spartanburg Water, SC,** made a conscious effort to tailor its communications to its audience. The utility's chief financial officer, Rebecca West, found that addressing the immediate and future effects of droughts and flooding was a more effective way to communicate than using the phrase "climate change," which some residents perceived as a politically loaded term.
- Some communities avoided the term "climate change" entirely. Although **Fort Collins, CO,** has committed to reduce its greenhouse gas emissions and vulnerability to climate change, the water utility did not discuss climate change explicitly in its current supply management plans because it could trigger the permitting process for Halligan Reservoir to start over. This bureaucratic requirement silenced a proactive community when it came to explicitly addressing climate change in the design of a long-lived infrastructure asset as well as other water projects that might arise from the supply management plan.
- **Tulsa, OK;** and **Mobile County, AL,** did not discuss climate change at all, potentially because of a difficult political environment or because of a focus on different community priorities. In the early stages of the Tulsa case, climate change was not discussed because these efforts began before climate change became a public policy concern, but it is notable that climate change still has not become a priority concern for this ongoing case of vulnerability reduction.

Enhancing support through grassroots or community organizations. In some cases, progress on adaptation actions was a result of collaboration with grassroots community organizations. Such collaboration may even have been central to success.

- In **Oakland, CA,** the Oakland Climate Action Coalition developed into a grassroots force advocating for climate mitigation initiatives in the city's official plan. The coalition also ensured that community member voices were heard in Oakland climate adaptation initiatives, moving forward.
- **Cleveland, OH,** worked with community development corporations to understand what the pressing issues were on a neighborhood-by-neighborhood basis to prioritize actions that would provide the most benefit and buy-in at that level.
- In **Flagstaff, AZ,** citizens formed a political action committee to lobby for the passage of their respective tax initiatives to fund adaptation actions.

In some case studies, the issues of environmental justice and social equity played a significant role; in others, it was considered, but it did not drive the process. In still others, the issue did not arise at all.

Engagement of more-vulnerable populations.[3] In some case studies, the issues of environmental justice and social equity played a significant role; in others, it was considered, but did not drive the process. In still others, the issue did not arise at all.

- In some communities, like **Baltimore, MD; Cleveland, OH;** and **Oakland, CA;** more-vulnerable populations got involved or were brought into the planning process and then played a central role in the adaptation action taken.
- In some communities, like **Flagstaff, AZ,** more-vulnerable populations were considered, but their needs or positions were not considered in a way that fundamentally altered the adaptation action implemented.
- In still other communities, like **Fort Collins, CO;** and **Spartanburg Water, SC,** more-vulnerable populations were not considered at all. In these and other case studies, it appears that the issue was not addressed because leaders wanted to apply a uniform rule to all people regardless of circumstances. For example, it seems that Fort Collins leaders may have felt that all citizens should have the same water-service levels and rates.

Other Approaches to Facilitate Implementation

Implementing adaptation actions was achieved in the case study communities through a variety of facilitating mechanisms, including mainstreaming adaptation into existing efforts; starting small and scaling up; developing new forums for dialogue, learning, and collaboration; using diverse strategies to secure funding; using peer-to-peer networking and learning; and collaborating within and across government.

Mainstreaming adaptation into existing efforts. Some adaptation efforts involved integrating adaptation into strategic planning, comprehensive planning processes, capital improvements planning, and other decision-making processes to ensure that leadership would consider climate as a matter of course across dozens or hundreds of decisions moving into the future. Often it also included deploying existing policy tools in creative ways. In many of our case studies, community actors were able to negotiate existing initiatives and policy tools to find creative ways to implement an adaptation action.

- **Miami-Dade County, FL,** integrated climate change considerations into multiple elements of its Comprehensive Development Master Plan, including land use; transportation; conservation, aquifer recharge and drainage; water, sewer and solid waste; coastal management; and intergovernmental coordination.
- In **Boston, MA,** Mayor Menino and his staff used Zoning Article 80 as a way to require private parties to fill out a Climate Change Preparedness and Resiliency Checklist to ensure developers considered the climate vulnerability of proposed development and redevelopment.
- Seattle Public Utilities in **Seattle, WA,** integrated climate change into its Stage Gates process for reviewing and implementing infrastructure projects. This process requires specific questions, including questions about climate change, to be answered before a proposed project can advance to the next stage of consideration for funding.
- When the **Baltimore, MD,** All-Hazard Mitigation Plan was due for a periodic update, city staff decided to use the opportunity to integrate climate vulnerability analyses into the updated plan—the Disaster Preparedness Project and Plan.
- In **Norfolk, VA,** policymakers used a floodplain ordinance to propose a freeboard standard to reduce climate vulnerability to storm surge and coastal flooding.

Developing new forums for dialogue, learning, and collaboration. Some actions required significant modifications to existing decision-making processes or developing new ones. These adaptation actions are perhaps the most ambitious strategies because they require new mechanisms or significant modification of existing mechanisms through which to tackle the issue of climate change more holistically.

- Seattle Public Utilities in **Seattle, WA,** created a staff-run Climate Resiliency Group to integrate climate change into internal planning to ensure that climate was a part of strategic business planning, department-wide planning, and capital improvements.

3. We define "more-vulnerable populations" as those populations that have greater exposure to climate vulnerabilities (e.g., are located in vulnerable areas, lack access to air conditioning) and who are more sensitive to those climate impacts (e.g., have fewer financial resources to recover from a disaster, have pre-existing medical conditions).

Many of our cases indicate the importance of learning from other communities or programs in similar situations.

- **Chula Vista, CA,** developed a climate change stakeholder group of community members to identify, evaluate, and select climate adaptation actions. This effective process went beyond standard community engagement.

Starting small and scaling up. Several of our case studies illustrate that using an incremental and phased approach facilitated the adoption of more ambitious programs down the line.

- **Southwestern Crown, MT,** started by developing "zones of agreement" that allowed each community to start out with actions upon which they agreed on. In this case study, different parties began with the agreement that they did not want homes to burn in catastrophic wildfires; this point of agreement allowed the group to start with fuel-reduction projects around homes. Once the group understood the science and the process through taking this incremental step, it became easier to agree on more projects, as well as a broader range of projects, including projects focused on climate adaptation.
- **Boston, MA,** began its green building efforts by first implementing them on government buildings, an action known as "LEEDing by example," before applying these efforts to commercial buildings. City leaders also began working with commercial developers on climate vulnerability, first through informal questionnaires that did not inform permitting decisions, then through an online survey, and then finally by developing the checklist as a formal requirement under Zoning Article 80.

Using diverse strategies to secure funding. Funding is often cited as a primary barrier to taking adaptation action. Some of our cases show significant creativity in funding adaptation actions. Some actions were self-funded by communities, others were supported by charitable foundations, and yet others tapped into state and federal resources. Notably, once a community acquired one source of funding, other sources of funding followed.

- In **Flagstaff, AZ,** city leadership recognized the expiration of an existing bond as an opportunity to generate momentum and funding to address the risk of catastrophic wildfire. Flagstaff decided to self-finance approximately $10 million for wildfire mitigation through a citizen vote on a bond question. Once this funding was secured, the U.S. Forest Service added $1.6 million; the State of Arizona, Coconino County, Northern Arizona University, and local citizens pitched in $400,000.
- **Grand Rapids, MI,** extended an income tax that was about to expire, using the funds to finance needed repairs to roads and develop green infrastructure to reduce flood vulnerability.
- **Avalon, NJ,** secured an estimated $50 million in federal, state, and local funding to implement much of its shoreline protection strategy over many years. In years when state and federal resources have been insufficient, the borough has relied on local taxes and bonds to cover the shortfall.
- **Tulsa, OK,** established a storm-water utility fee on citizens' water bills. These funds have provided approximately $24 million annually to the City of Tulsa. This funding has been used for planning processes, acquiring repeatedly flooded properties, maintaining existing facilities, completing small drainage projects, and providing matching funds for federal grants.

Using peer-to-peer networking and learning. Many of our cases indicate the importance of learning from other communities or programs in similar situations. This peer-to-peer learning can take place at different points in the policy process and appears to be a key strategy for learning, planning, and taking adaptation action. This learning often included what kinds of action were being taken, how to implement such actions, information sharing, and more.

- **Fort Collins, CO,** looked at the approaches of other water utilities in the region, such as Denver Water, which is part of a water utility network called the Water Utility Climate Alliance. Reviewing the actions of neighboring utilities allowed Fort Colling to devise its own response to critical water shortages.

- **Miami-Dade County, FL; Chula Vista, CA; Boston, MA; Baltimore, MD; Cleveland, OH; Oakland, CA;** and **Flagstaff, AZ**, are members of multi-jurisdictional, collaborative, peer-learning groups such as the Urban Sustainability Directors Network, C-40, the Western Adaptation Alliance, the South Florida Regional Climate Compact, the San Diego Foundation Climate Program, ICLEI USA, and others. These groups share information about climate change, planning processes, implementation strategies, and, more importantly, provided opportunities for real human-to-human interaction about how to get things done in comparable municipal contexts.
- Leaders in **El Paso County, TX,** toured desalinization plants in Florida to begin to understand the scope of building their own inland desalinization facility.
- **Flagstaff, AZ,** learned about citizen willingness-to-pay for wildfire mitigation when leaders from Santa Fe, NM, shared their experience at a wildfire conference.

Collaborating within and across government. Adaptation actions often required implementers to move outside their particular agency, division, or area of expertise. In some cases, implementers worked across multiple divisions or expertise areas within a department or agency. In others, implementers worked with different departments, agencies, or external partners, such as nongovernmental organizations or academic institutions. Such collaboration was often difficult to accomplish due to a variety of governance, perception, and self-interest barriers that disincentivize collaboration. But those who implemented adaptation actions overcame a range of barriers by engaging in such collaborations; for example, they gained legal authority, community trust, technical expertise, and enhanced political support.

Adaptation actions often required implementers to move outside their particular agency, division, or area of expertise.

- **Norfolk, VA** and **Boston, MA,** provide examples of adaptation actions that were led by a specific municipal or utility department, but required collaboration across departmental divisions or practice areas that might not normally communicate with one another.
- **El Paso County, TX; Avalon, NJ;** and **Grand Rapids, MI,** provide examples of adaptation actions that required collaboration across administrative jurisdictional boundaries (e.g., municipal departments or levels of government) that spanned traditional patterns of authority or went beyond standard operating procedures. For example, El Paso Water Utilities needed to coordinate with personnel from the U.S. Army at Fort Bliss to cost-effectively develop and manage a desalinization plant.
- **Flagstaff, AZ; Southwest Crown, MT;** and **Mobile County, AL,** offer examples of adaptation actions that required collaboration across jurisdictional boundaries and across different types of institutions to work at the scale of a natural system. For example, Flagstaff, AZ, required collaboration across city, federal (U.S. Forest Service), county, and tribal jurisdictions to address wildfire risks. Mobile County, AL required collaboration across nongovernmental organizations, federal funders, and local governments.

What Are Communities Achieving through Adaptation?

After an adaptation action is identified and implemented, what effect does it actually have on the community? To understand achievements in community-based adaptations, we looked for: tangible reductions in vulnerability; innovative types of vulnerability reduction; limitations to vulnerability reduction; co-benefits of community-based adaptation; and monitoring and evaluation of approaches, frameworks, or tools.

Vulnerability Reduction

Some communities have reduced their vulnerability to climate variability and extreme events in a measurable or obvious way. While it is not possible to empirically assess whether this progress has also reduced vulnerability to

projected climate change impacts, the tangible vulnerability reduction is notable.

- **El Paso County, TX,** increased the operation of its desalinization facility from 10 percent to full capacity during the recent Texas drought; this minimized the drought's effects on the community by ensuring sufficient water for citizens and businesses.
- **Fort Collins, CO,** realized long-term water savings from its conservation programs and supply-shortage response plan. According to Fort Collins staff, further water-use restrictions were not necessary during the most recent drought because of this long-term reduction in water use.
- **Tulsa, OK,** has not suffered significant flood damages to managed floodplain areas since project implementation, despite several 25-year flooding events.

Prospective vulnerability reduction to current or future climate impacts. Some adaptation actions are expected to reduce vulnerability, even though they have not yet proven themselves. In some communities, this is because climate impacts have not tested the action or climate change has not yet reached a magnitude to test the action; in others, the community has not fully implemented the action. How long any effort reduces overall vulnerability depends on the nature of the effort, how extensively it is taken up, and the speed of climate change. The research team applied our professional judgment to affirm such prospective vulnerability reduction.

- **Grand Rapids, MI,** is still in the process of constructing green infrastructure projects in tandem with transportation improvements. However, once a sufficient amount of green infrastructure is in place, this action can be expected to reduce effects from periodic storm-water floods.
- Although **Flagstaff, AZ,** has passed and funded its watershed protection project, it has not yet implemented the project because the community is awaiting the completion of an environmental impact statement. Once it is complete, the proposed forest management work is expected to reduce wildfire hazards.
- In **Miami-Dade County, FL,** changes to the comprehensive plan called for the county to consider climate change through regular decision-making processes. For example, new roadway siting and designs are expected to reduce exposure and sensitivity to storm surge and sea level rise, thus reducing the county's vulnerability to climate change over time.

Increasing adaptive capacity. Some adaptation actions increase both generic and specific adaptive capacity (Eakin et al., 2014), thereby changing the nature of vulnerability for particular places or populations. As discussed on page 27, adaptive capacity is a factor in the Intergovernmental Panel on Climate Change's three-fold definition of vulnerability. Adaptive capacity can include addressing the baseline socioeconomic conditions that lead to vulnerability—such as poverty or an aging housing stock. Addressing underlying conditions can enhance the resources a community can use to reduce its climate vulnerability or respond to extreme events. Other approaches focus on strengthening neighborhood networks to improve response to extreme events; and improving technical skills, such as training municipal staff to understand climate impacts on the systems they manage.

- In **Baltimore, MD,** two campaigns were created to educate community members about local climate hazards and the options to prepare for and respond to these hazards. The campaigns are expected to enhance community capabilities to respond to extreme events.
- In **Oakland, CA,** the city and a coalition of community-based organizations are in the process of developing adaptation strategies that incorporate social justice. In the meantime, a number of community-based organizations have begun to educate their respective audiences on local climate hazards and appropriate approaches to prepare and respond.

Adaptive capacity can include addressing baseline socioeconomic conditions that lead to vulnerability—such as poverty or an aging housing stock.

Co-Benefits of Community-Based Adaptation Action

Many communities implement adaptation actions for reasons beyond climate vulnerability reduction. Many interviewees across our case studies cited progress on non-vulnerability outcomes, what we call co-benefits, as an important sign of success. Communities viewed recognizing non-climate vulnerability outcomes as a significant dimension of what they achieved through adaptation action. These co-benefits are often closely tied to the non-climatic motivations that encouraged action in the first place.

Outcomes beyond climate vulnerability reduction.

- **Grand Rapids, MI** supported efforts to develop a multi-modal transportation system and improve road maintenance as well as reduce the effects of inland flooding through a single income tax extension.
- **Cleveland, OH** has supported community and neighborhood redevelopment through its adaptation program. This meant that actions to support neighborhood climate adaptation sometimes included initiatives that could seem, to some, tangential to climate change adaptation, such as the promotion of local foods and businesses. However, these were important co-benefits for the city and its residents.
- In **El Paso, TX,** the promise of expanded water resources contributed to the retention and eventual growth of Fort Bliss. Because Fort Bliss is a major economic driver in the community, this was seen as a major co-benefit related to the development of the city's desalination facility.
- **Avalon, NJ** helped protect their summer tourism industry through particular vulnerability reduction actions. For example, the community has accelerated efforts to rebuild eroding sand dunes or segments of shoreline, ahead of partner agencies' schedules, to ensure a profitable summer tourist season for local businesses.

Limitations to Vulnerability Reduction

Several of our case studies involved implementation of actions whose vulnerability-reduction benefits may erode over time. In some cases, a small and discreet adaptation action achieved tangible or indirect vulnerability reductions, but those reductions may become less effective over time or may have only a narrow effect. We felt it was important to note these potential limitations for the sake of transparency.

Become less effective over time. Because some projects did not factor in climate change or other forms of social or environmental change, the level of vulnerability reduction they provide will likely degrade over time in the face of a changing climate. For example, actions that provide a particular level of protection against storm surge will provide less protection as sea levels rise.

- In **Mobile County, AL,** restoration project managers have observed wave attenuation behind the restored oyster reefs, which indicates that reefs are providing protection from storm surge. However, reefs in this area have sunk over time because of land subsidence; as sea level continues to rise, the reefs will become less effective in reducing storm surge before it reaches the coast.
- In **Norfolk, VA,** the three-foot freeboard standard will provide a decreasing buffer from storm surge as sea levels rise. Eventually, the level at which construction is built above the 100-year floodplain will be overwhelmed by sea level rise.
- In **Avalon, NJ,** the natural buffer of dunes and beaches only provides a natural buffer if the borough periodically nourishes the beaches and dunes. This is because small weather events and extreme events wash away the sand. Beach nourishment will be required on a more frequent basis as sea levels rise and coastal storms intensify, eventually becoming untenable as climate change progresses.

Because some projects did not factor in climate change or other forms of social or environmental change, the level of vulnerability reduction they provide will likely degrade over time in the face of a changing climate.

Narrow effectiveness. Although adaptation actions in some of our case study communities have tangibly reduced vulnerability, they address only a specific aspect of overall community vulnerability. As such, the vulnerability reductions achieved by such actions may be insufficient to mitigate the climate impacts they are intended to address. In some cases where an individual adaptation action stood alone, the action may prove less effective than it would have been as part of a portfolio of actions.

- **Norfolk, VA,** for example, passed a three-foot freeboard requirement for new buildings developed in coastal and flood zones. Although this action helped Norfolk address the effects of sea level rise and tidal flooding on new buildings, it did not address new public infrastructure, such as sewer lines and the public streets necessary to serve buildings in flood and coastal zones, nor did it address existing structures at risk prior to their being damaged.
- The **Boston, MA,** climate change preparedness and resiliency checklist requires the consideration of climate change only for new commercial development over 20,000 square feet and renovations over 100,000 square feet. Hence, smaller developments and residential development are not subject to the checklist. It remains to be seen whether Boston will extend and strengthen use of the checklist or use other approaches to ensure the resilience of smaller-scale development projects.

Monitoring and Evaluation of Approaches, Frameworks, or Tools

Monitoring and evaluation is commonly discussed as a critical component of climate adaptation, and indeed any policy process. Nonetheless, evaluation is often neglected, and we found this reflected in our study. In most of our case study communities, local actors evaluated progress anecdotally; however, formal evaluation programs occurred in only a few communities.

Local actors evaluated progress anecdotally. In nearly every case study, we asked interviewees to identify progress, lack of progress, and next steps. Typically, interviewees cited a variety of factors that they used as indicators of progress relative to a historical baseline (e.g., community buy-in, use of a program, increased issue awareness). These factors tended to be subjectively chosen and assessed. However, local actors found them sufficient to evaluate progress and make adjustments for the practical purpose of recalibrating the adaptation action before taking further steps.

- In **Avalon, NJ,** local officials tout a statement from Assistant Secretary of the Army Jo-Ellen Darcy, who after Hurricane Sandy said, "...The property behind the beaches in Avalon were well protected... where there has been no federal beach project, the community didn't fare that well." They take this as an indication that their shoreline protection efforts are effective and should continue.
- Oyster reef restoration project managers in coastal **Mobile County, AL,** have observed wave-energy attenuation behind the reefs, in addition to ecological benefits such as improved reef habitat and greater presence of marine life. Restoration leaders also describe an increase in public awareness about the value of healthy coastal ecosystems, particularly to coastal cultures and livelihoods; the leaders work with volunteers at restoration events and thus are in a position to monitor such increases. Anecdotal evidence of restoration effectiveness is strong, but project staff recognize the importance of monitoring and adaptive management for maintaining long-term benefits, and they are pursuing funding for monitoring existing restoration sites.

Formal evaluation programs occurred in some communities. We did observe some indication of formal monitoring and evaluation to measure progress toward stated objectives for climate adaptation.

- In the **Southwestern Crown, MT,** the community collaborative decided early on that monitoring the effects of forest treatments was a high priority and the collaborative set aside 10 percent of its budget to use for monitoring. The collaborative has an adaptive management framework that relies on this monitoring program to change management activities and to tailor resource expenditures.
- **Fort Collins, CO,** tracks water use in gallons per capita per day. This has enabled the city to monitor

the effectiveness of its conservation programs and water-supply shortage response plan. The city attributes long-term water savings to the effectiveness of both conservation and regulatory programs.

- In **Baltimore, MD,** city staff used a relatively simple scale to measure their progress in implementing climate adaptation and hazards-mitigation initiatives. The scale does not address program effectiveness or performance, but it is an important tool to help track implementation progress.

Conclusion

The case studies and cross-case findings discussed in this chapter represent the empirical and analytical heart of this project. Each case study represents a step in a single community's path to climate adaptation—a path that can inspire forward-thinking action by other communities and climate adaptation professionals. And the cross-case findings represent the collective wisdom that our research team could gather across this portfolio of 17 unique cases of adaptation to climate impacts. In an important sense, the cross-case findings presented here provide a baseline of the state of community-based adaptation in the United States. This baseline should be assessed and evaluated against the real-world experiences of other community-based champions and adaptation professionals. If found practical, these findings should be disseminated and adapted by other communities to facilitate efforts in their own communities to reduce vulnerability to climate impacts.

CHAPTER 3

Conclusions and Tactical Recommendations

As recently as 2014, the U.S. National Climate Assessment observed that "substantial adaptation planning is occurring…however, few measures have been implemented" (Melillo et al., 2014). Although accurate in many respects, this message may obscure important progress being made to reduce vulnerability to climate risks at the community level.

Through the course of this study, we have found that when one considers actions to address climate variability and climate-related extreme events—as well as actions to address long-term climate change—one finds many communities have implemented actions designed to reduce vulnerability to current and future climate risks. These actions that communities are taking provide a rich trove of models and lessons that can inform future adaptation activities. Adaptation professionals should continue to observe and critically analyze these actions and others. And community-based champions can use these actions as a basis for expanding vulnerability-reduction activities in their own communities.

While much can be learned from these community-based actions, it is our strong impression that none of the communities profiled in this study have comprehensively addressed the climate change or extreme weather vulnerabilities that they do or will face, particularly if evaluated in terms of principles of adaptation such as those outlined in Exhibit 3.1. This means that while progress is being made on reducing vulnerability to climate impacts, in our view, much more must be done.

In this chapter we share conclusions synthesized from our case study research and analysis, thought leader interviews, and a review of selected technical and professional literature that aimed to evaluate the state of the practice of climate adaptation. Along with these conclusions, we provide a series of tactical recommendations framed for community-based champions seeking to initiate and expand climate adaptation programs in their own communities.

EXHIBIT 3.1. PRINCIPLES OF CLIMATE CHANGE ADAPTATION

1. Go beyond climate variability and extreme events; address the anticipated impacts of climate change (e.g., Solecki et al., 2011).
2. Incorporate climate change systematically in relevant decision-making processes (e.g., Haywood et al., 2014).
3. Design decision processes to adjust over time in response to changing climate conditions (e.g., Quay 2010).
4. Avoid measures that result in an increase in vulnerability to changing climate risks (e.g., Bours et al., 2014).
5. Consider the implications of an adaptation action both over the near- and long-term to ensure an action is effective over time (Kates et al., 2012).
6. Avoid adaptations that shift vulnerability from one sector or community to other locations, sectors, or natural systems unless there are clear net benefits and compensations (e.g., Barnett and O'Neil, 2010).
7. Ensure that the needs of more-vulnerable populations are addressed (e.g., Schrock et al., 2015).
8. Consistently build adaptive capacity across populations within a community, particularly the most vulnerable (e.g., Smit and Wandel, 2006).
9. Engage in monitoring and evaluation of climate change adaptation progress (e.g., Bierbaum et al., 2013).
10. Ensure that climate change adaptation and mitigation actions are consistent with and supportive of each other (e.g., Laukkonen et al., 2009).

These principles were collectively informed by the thought leaders who advised this project through our Project Advisory Committee (PAC). We have added citations to ground these ideas from our PAC in the adaptation literature.

Conclusions

Adaptation Actions at the Community Level Are Reducing Vulnerability to Climate Variability and Extreme Events, and Possibly to Climate Change

The communities profiled appear to be achieving real vulnerability reductions. In some cases, communities are already seeing the benefits of action in response to current climate impacts. In other cases, adaptation actions have not have been tested by an extreme weather event, but are sound investments given current understanding of the risks. While many of the actions we addressed respond to climate vulnerability rather than climate change, we anticipate the benefits will carry over and evolve over time to address vulnerability due to climate change.

However, planning solely based on current or historic climate exposure, the most intense extreme event on record, or the most recent extreme event experienced will likely leave a community under-prepared for a climate-altered future (Adger et al., 2011).

Addressing Only Climate Variability and Extreme Events May Constrain the Effectiveness of Long-Term Climate Adaptation.

This report profiles actions undertaken to address observed climate variability and extreme events as well as climate change. We made this choice because 1) it is generally not clear where climate variability ends and climate change begins; 2) extreme events and climate variability typically involve conditions similar to those expected under scenarios of climate change; 3) the tools, policies, and strategies deployed to address extreme events and climate variability may help communities begin adapting to climate change; and 4) community-level practitioners often consider climate change adaptation, natural hazards mitigation, and preparation for climate variability as part of a continuum of potential policy and management actions. However, planning solely based on current or historic climate exposure, the most intense extreme event on record, or the most recent extreme event experienced will likely leave a community underprepared for a climate-altered future (Adger et al., 2011). Given that climate change is increasing the frequency and intensity of some extreme events and is likely to introduce new vulnerabilities due to slow-onset climate changes, it is important for policies and practices that address only climate variability or extreme events to evolve and address climate change as well (NRC 2010, Solecki et al., 2011). In some cases, such as long-term infrastructure investment decisions, the time to consider climate change is already upon us.

Communities Can Begin Addressing Climate Change Risks Now

Our research indicates that municipal staff and community leaders in a variety of organizations are becoming increasingly aware of the need to incorporate climate-related risks into their planning and operational routines and, in many cases, already have the tools needed to begin implementing climate vulnerability reduction efforts and climate change initiatives. Local champions and policy entrepreneurs have successfully brought the issue of climate impacts and/or climate change to bear in operational and strategic decision making across a range of community service streams, including housing, infrastructure development, public utilities, natural resource protection, social services, and hazard mitigation planning (Carlson and McCormick, 2015; Viguié and Hallegatte, 2012). This includes embedding climate adaptation initiatives within routine municipal activities, such as comprehensive planning, multi-hazard mitigation planning, long-term water supply planning, and permitting review procedures. Given the progress that has been made across our 17 case study communities, we believe that any community can make meaningful progress by getting started now.

Communities Can Overcome Barriers to Action, Identify Opportunities, and Begin Implementing Adaptation Measures

The adaptation literature and thought leaders interviewed for this study identify a long list of potential barriers to climate adaptation, including limited funding, lack of actionable information, hostile political environments, and limited technical capacity, among others (e.g., Bierbaum et al., 2013, Carmin et al 2012, Moser and Ekstrom 2010, Ekstrom and Moser 2014, Adger et al 2009, Brody et al 2010). Although these barriers remain prevalent, our case studies demonstrate a variety of opportunities to overcoming them, including developing new or repurposing existing funding streams to support climate vulnerability reduction and climate change initiatives, mainstreaming climate change into existing community programs (Eisenack et al., 2014), and developing programs that enhance overall community social capital and adaptive capacity to set the stage for climate adaptation. Whereas previously published work has postulated the possibility of overcoming such barriers (Moser and Ekstrom 2010, Adger et al 2009, GAO 2009), this study emphasizes how a variety of strategies used across our case study communities have allowed them to actually implement adaptation actions by using well established opportunities to overcome barriers that are often more perceived than real.

Community-based adaptation that explicitly addresses climate change is still in a formative stage.

Adaptation Actions Explicitly Addressing Climate Change Are in a Formative Stage

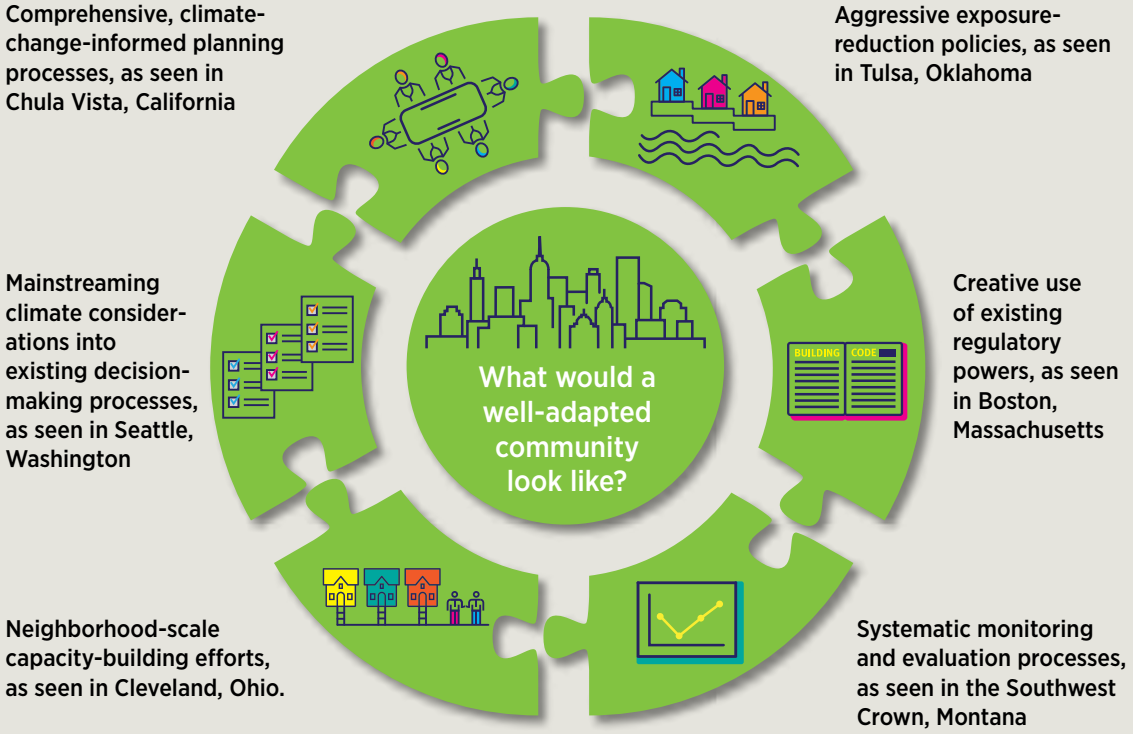
Community-based adaptation that explicitly addresses climate change is still in a formative stage, with many small-scale innovations and policy experiments occurring in a variety of geographical, political, and other contexts. This conclusion is in agreement with findings from the peer-reviewed literature (Berrang-Ford et al., 2011; Smith et al., 2009; Tompkins et al., 2010). Some of our case study communities have embarked on comparatively ambitious and comprehensive efforts to address climate change by developing standalone climate action plans or implementing programs to alter community level decision-making processes so that climate change is considered as a matter of course. Others have implemented climate change adaptation actions intended to reduce sector or impact-specific vulnerabilities. It is not yet clear that initiatives focused on climate change have tangibly reduced vulnerability. But the promise of doing so is potentially greater than policy actions that respond just to climate variability or a particular extreme event (Berrang-Ford et al., 2011; IPCC 2012). Implementation of these climate change adaptation processes is in a formative stage, so we cannot draw meaningful conclusions about the ultimate effectiveness of any particular process structure or their relative effectiveness compared to more incremental efforts focused on climate variability or extreme events.

Through Our Case Study Communities We Have Identified Components of A Hypothetical, Well-Adapted Community

Over the course of this two-year project, we found an abundance of bold and successful community-based adaptation—underway now and, in some cases, already tangibly reducing community vulnerability. However, as many of the leaders in our case study communities would agree, even our profiled communities must do more to adapt to climate change.

We cannot say what a perfectly adapted community would look like. Nonetheless, if the types of actions that each of our individual case study communities took were combined into a single hypothetical community effort, it would arguably comprise an impressive climate change adaptation program. We believe this hypothetical community can serve as an aspirational target for ambitious local champions who are working to build local resilience and protect their communities from the impacts of climate change. At this point, we believe, no single community in the United States approaches the breadth and depth of this hypothetical community. As such, we hope this hypothetical community can serve as a model for communities looking for the next pragmatic step in adapting to climate change.

A HYPOTHETICAL, WELL-ADAPTED COMMUNITY



Community-Based Champions of Adaptation Action and Adaptation Professionals Should Use Vulnerability Reduction as a Key Baseline to Assess and Facilitate Progress in Adaptation

Our case studies lend empirical credence to Moser and Boykoff (2013, p. xxii), who state, "There still is not, and likely never will be *one* answer that adequately addresses all of the intersecting dimensions of adaptation success." In fact, most adaptation professionals believe that climate adaptation is a process, not an end-state, which may preclude defining ultimate success. Nevertheless, it is critical that current efforts to address climate change, climate variability, and extreme events be monitored and evaluated against some metric of progress so as to:

- Provide community-based champions with a baseline against which to set goals and assess progress;
- Provide adaptation professionals with a frame of reference through which to assess what works and does not work and, as appropriate, make improvements;
- Identify innovative approaches that deserve further investment and investigation; and
- Identify opportunities for scaling up or diffusing promising practices.

Given our experience during the course of this project, we recommend that adaptation professionals and community-based champions use vulnerability reduction as one key aspect of assessing the effectiveness of adaptation actions. We emphasize here that we do not propose vulnerability reduction as the exclusive dimension of progress because other dimensions may be important or even the principal factor in assessing

adaptation progress in any given context. Other dimensions might include:

- sustainability—the ability of an adaptation to endure over time,
- breadth—the range of vulnerabilities addressed by an adaptation action, or
- flexibility—the ability of an adaptation action to adjust to different social, environmental, or policy conditions (e.g., Adger et al., 2011).

We recommend that adaptation professionals and community-based champions use vulnerability reduction as one key aspect of assessing the effectiveness of adaptation actions.

Tactical Recommendations

Based on our research and analysis, we offer these specific recommendations to community-based champions and adaptation professionals seeking to advance adaptation and vulnerability reduction within communities.

Start Now: Communities should not give in to the temptation to put their adaptation efforts on hold and wait for improved information, shifts in the political environment, or other changes in circumstance. The time to start an adaptation initiative is now. Here is why:

- **Community development is an ongoing process.** A choice not to think about adaptation now means allowing current development patterns to continue, potentially increasing climate vulnerability.
- **Climate vulnerability already exists, and climate change is increasing these vulnerabilities.** Reducing current vulnerabilities and considering how they may change yields benefits now and into the future.
- **Waiting does not guarantee more or better information.** Projections of climate change suffer from several important uncertainties, some of which are not likely to be resolved soon—such as future development trajectories, energy use profiles, land-use patterns, and uncertainty associated with natural climate variability (Hallegatte, 2009).
- **Real vulnerability reduction takes time.** Whether it is moving people and property out of harm's way, protecting vulnerable areas, or developing capacity in neighborhoods to respond to extreme events, adaptation can take years to decades to implement. Beginning to address climate vulnerability now, even in a limited way, builds the foundation to take more ambitious and comprehensive action in the future.

Look for Co-Benefits, Cross-Sector Leveraging, and Opportunities to Piggyback Climate Adaptation onto Other Salient Community Issues: Climate adaptation actions that also address longstanding problematic conditions—for example, decaying infrastructure or weakened ecosystems—can help win important allies, enhance community support, and facilitate progress (Tompkins et al., 2010). Similarly, support for adaptation can grow when communities understand that there can be multiple reasons for engaging in adaptation and that adaptation actions can be beneficial across multiple sectors. Linking adaptation to established community issues in this way is motivating; it helps make climate change tangible, familiar, and local.

Employ Commonly Used Policy Tools to Mainstream Adaptation: The tools that our case study communities most commonly employed to reduce vulnerability included standard and proven policy tools such as ordinances, permits, bonds, utility fees, easements, zoning, and hazard mitigation planning. Some communities used creative mixtures of mutually reinforcing policy tools to address climate vulnerabilities, given the unique local context. Thus, while policy innovation may be useful, it may not always be necessary for initiating adaptation activities.

Use Windows of Opportunity to Advance Climate Adaptation: Windows of opportunity, such as response to natural disasters or scheduled updates to municipal plans, present an opening to advance public discourse,

galvanize community support, and facilitate progress (Kingdon 1995). To fully take advantage of such windows, communities need to have ideas generated and plans in place for rapid deployment when an opportunity arises (Berrang-Ford et al., 2011). For example, a community should consider developing a plan to respond to an extreme event by not just putting things back the way they were, but by "building it back better" (e.g., incorporating consideration of climate change into infrastructure design in risky locations or rebuilding in less vulnerable locations). Other windows of opportunity may include fulfilling administrative requirements (e.g., Baltimore's All-Hazards Mitigation Plan update), capitalizing on economic development opportunities (e.g., Cleveland's efforts to tie climate adaptation to neighborhood revitalization through Community Development Corporations), responding to state or federal mandates (e.g., State of Michigan citing Grand Rapids for violation of water-quality requirements), addressing federal policy initiatives (e.g., the Southwest Crown's use of the Collaborative Forest Landscape Restoration Program to develop a collaborative to address wildfire mitigation), or pursuing funding opportunities (e.g., Tulsa using FEMA grants to support its acquisition program).

Build Flexibility into Policies, Projects, and Programs: Given the uncertainties around the effects of climate change, municipal programs should be designed to evolve and adapt to changing conditions. This means avoiding irreversible outcomes, such as infrastructure design that precludes modification or that does not account for projected changes in climate. It can mean keeping options open such as purchasing or setting aside land that may be needed in the future for adaptation. It also means avoiding policies likely to create additional climate vulnerabilities, such as committing to development in areas that are already known to be prone to wildfire or flooding and likely to face increasing risks.

Consider the Needs and Capabilities of More Vulnerable Populations: Climate adaptation actions should reflect and address the varying needs of different groups or populations, and involve these people in the decision-making process. Adaptation actions should pay particular attention to populations that are the most vulnerable, which are often the poorest, those already overburdened by pollution, those who lack economic opportunity, and individuals facing disenfranchisement and racism (Schrock et al., 2015; Morello-Frosch et al. 2009; Park 2009). More specifically, communities must leverage existing efforts to build community stability and social connectedness—a critical prerequisite for effectively tackling climate change. Simply put, widespread poverty and social and racial disparity impede efforts to reduce climate vulnerability.

Simply put, widespread poverty and social and racial disparity impede efforts to reduce climate vulnerability.

Consider Natural Systems in Adaptation: Climate change is often experienced through a community's interaction with natural systems, such as forests, rivers, coastlines, and floodplains. These natural systems can also play a vital role in reducing the impact of climate change on community infrastructure and resources. Conversely, poor natural system health can exacerbate impacts. Action to restore or maintain natural system function can be a cost-effective, long-term adaptation action and should be considered alongside socioeconomic and infrastructural actions.

Craft Outreach or Engagement Efforts, as Needed, to Build Community Support: Well-focused communications and outreach campaigns enhance public buy-in for adaptation actions (Carlson and McCormick, 2015; Hughes, 2015; Few et al, 2006). An outreach campaign may be necessary when:

- Adaptation actions will affect a resource valued and used by a range of community members
- Public support is needed for an action to be adopted, e.g., the funding for an action depends on a bond issue or another publicly determined measure.

In structuring outreach efforts, it is important to do so in ways that include and facilitate the participation of the most affected and the otherwise least able to participate. However, a formal outreach campaign may

be unnecessary when actions lie within the purview of agency operations or staff-level decision-making. As such, practitioners should use public outreach efforts strategically to help build support for key climate adaptation related issues. However, outreach efforts can also be used to develop adaptation actions in collaboration with the community, rather than asking for community support for pre-determined actions. This is more appropriately a form of community engagement, which is a more time intensive, but potentially more productive means of building community buy-in and support.

Take Prudent Risks and Adjust Over Time: Climate change is a complex issue affecting many sectors and communities across the country and the world. To successfully reduce risk to communities through adaptation requires innovation, experimentation, and some level of risk-taking. Some of these efforts are bound to fail. The lessons learned from those failures are as important as the lessons learned from successful innovations. Local champions and practitioners should be aware that what they are putting in place will likely need to be adjusted over time and be willing to share what is working and not working on the ground.

Consider Local Context When Determining Whether to Explicitly Frame Actions in Terms of "Climate Change": Explicit articulation of climate change can constrain action in some settings, while galvanizing action in others; communities should recognize this reality and respond accordingly. For some communities, it makes more sense to approach routine municipal renewal, public works, and resource-management projects in a manner that considers future climate vulnerabilities, without making climate change the rationale for the action. For other communities, speaking explicitly about climate change can draw upon existing social or political support to pursue an adaptation action.

Provide Leadership: While leadership was an important aspect of making adaptation progress across all of the communities we profiled, that leadership came from many places. The most conventional sources of leadership across the communities we profiled came from a proactive mayor, city council, county commission, or senior municipal or departmental executive. But our case studies indicate that non-governmental organizations, grass roots activists, and non-senior municipal staff can also provide the leadership necessary to initiate and sustain climate adaptation actions. In fact, it is often the work of these less conventional leaders that facilitates progress even where there is also a proactive senior executive, or when such executives serve their communities for only a limited term.

Use Partnerships to Advance Adaptation: Working with other like-minded individuals and organizations can amplify the effectiveness of an adaptation action. Singular actors often face limited capacity and financial resources. But by banding together with others—other communities in a region, other departments within your municipality, other organizations in a community, universities and academics, and more—resources can be leveraged to improve adaptation actions and enhance accomplishments. While implementation is often required at a municipal or a departmental level, partnership can still provide needed support, motivation, information sharing, and resource pooling.

Summary

This research project was motivated by the immense challenges posed by climate change, the need for communities to adapt to those challenges, and the opportunity to learn from communities that have already begun adapting. After two years of research on the state of community-based adaptation and the particular actions taken by 17 communities, we found that communities have many of the tools needed to plan for and respond to climate change; they just need to get started. As such, we hope that the conclusions and tactical recommendations in this chapter will help community-based champions make tangible and immediate progress on climate vulnerability reduction. We offer these conclusions and recommendations as a way to support the diffusion and adoption of the promising practices identified in our case studies to other communities across the United States. We hope that other adaptation professionals will join us in circulating and elaborating on these conclusions and recommendations with the practical purpose of empowering community-based champions to make progress in their own communities.

Avalon, New Jersey

Comprehensive Shoreline Protection Strategy

AVALON, NEW JERSEY

AUTHORS: Alexis St. Juliana, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- The role of strong municipal leadership
- The importance of ongoing activities (non-complacency) and implementing actions as feasible
- Ongoing public education and engagement
- Communicating across levels of government

Case Study Summary

The borough of Avalon comprises a portion of a slender barrier island at the far southern end of New Jersey (Exhibit 1). It regularly experiences extreme weather events such as nor'easters and hurricanes. These events threaten the borough's property and thriving summer tourism industry. After a severe nor'easter in 1962, Avalon developed a number of physical shoreline barriers. The borough also created a number of policies that set the stage for future action in Avalon. These policies allowed the borough to buy damaged shoreline properties and turn them into borough property, purchase additional undeveloped land, and limit shoreline development. With these policies in place, Avalon developed extensive sand dunes to protect the borough from the impacts of coastal storms. In the 1980s, the borough renewed efforts to construct natural barriers, hard physical barriers, and emergency response programs. Over time, these shoreline protection efforts have required extensive maintenance. The borough has relied on local, state, and federal support to develop and maintain protective structures. Avalon's work has not extensively considered climate change, yet it has experienced few structural losses and has been able to rebound quickly from recent storms, such as Hurricane Sandy. In addition, the borough is considering incorporating sea level rise projections in its design of new breakwaters. Avalon has received a number of accolades for its work, and regularly shares information about its efforts with coastal communities around the United States. Avalon continues to plan and prepare for coastal storms. Future work includes the possible development of several "T"-shaped breakwaters perpendicular to the shore. The borough expects that these structures will help protect beaches and reduce the frequency of beach nourishment activities.

Broader Context

Avalon has implemented a variety of shoreline protection efforts since the 1960s, including the construction of protective infrastructure, the build-up of natural barriers, and the development of effective hazards mitigation and communication plans. Moreover, the borough has worked to maintain these shoreline protection efforts over this period. Maintenance of Avalon's efforts is possible through strong leadership that works with community members and elected officials to foster ongoing support and financing.

Nevertheless, Avalon does not have an official shoreline protection strategy. Rather, its strategy has come about through a confluence of other planning efforts. For instance, the community has completed a number of shoreline protection efforts to garner points on the National Flood Insurance Program's Community Rating System (CRS) to earn lower flood insurance premiums for its residents, which it joined in 1996 (FEMA, 2014). These CRS efforts are guided by Avalon's Flood Management Plan, which it evaluates annually (Borough of Avalon, 2013). The borough's Dune Management Plan, finished in 2009, serves as a guide for dune monitoring and maintenance (Borough of Avalon, 2009). Also, Avalon prepared its first hazards mitigation plan in 1983, the Storm Mitigation Planning report (Farrell and Sinton, 1983). Since then, there have been several iterations of this plan. The last plan was finalized in 2010 and as of 2015 the borough is working on another update. These plans, in addition to the borough leadership's ongoing push for action, have helped Avalon to piece together a comprehensive shoreline protection strategy. This case study highlights Avalon's efforts to develop and maintain a comprehensive shoreline protection strategy. Exhibit 2 provides a timeline of actions in Avalon.

Why and How Avalon Developed and Maintained its Shoreline Protection Strategy

Avalon has a long history of preparing for and responding to coastal storms. A number of major storms motivated the borough to take notice and begin to plan and prepare for future storms. Strong leadership has maintained motivation to continue shoreline protection efforts. These motivators are described in more detail later in this section. They also helped to form Avalon's shoreline protection efforts, which include three general types of activities.

Exhibit 1. Map of Avalon and beaches.

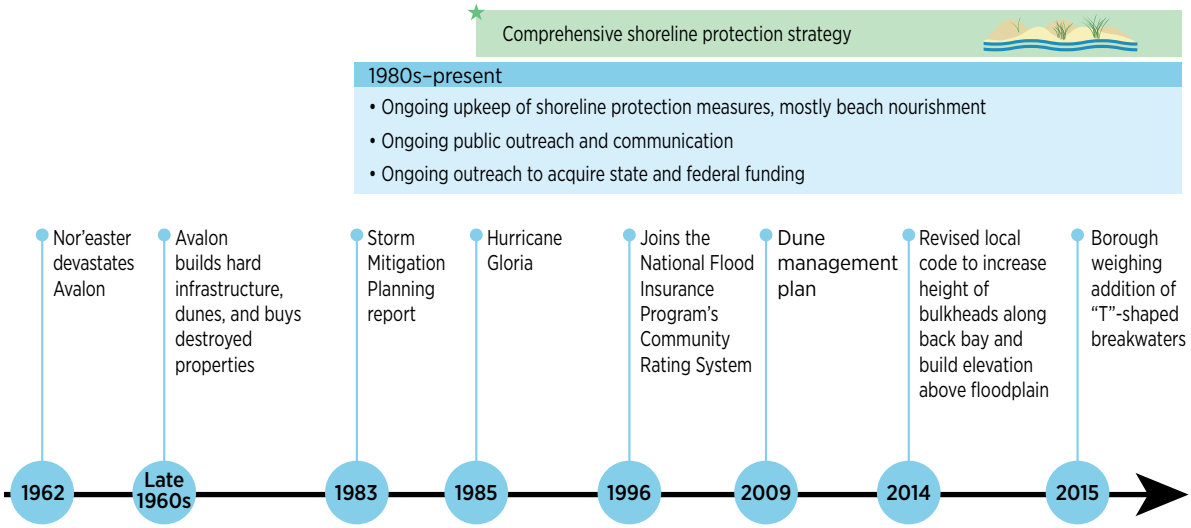


Exhibit 2. Timeline of actions in Avalon.

1. Protective Infrastructure

After the 1962 nor'easter, the borough invested in several structural barriers, including a seawall, a 4,500-foot bulkhead, and a jetty at the north end of the island (Farrell and Sinton, 1983; Perez, 2013). These types of barriers help to mitigate the impact of coastal storms, and reduce damage and flooding. Avalon has worked to maintain these barriers, create additional barriers, and improve building codes. Representative examples of the maintenance these structures have required over time include $14 million in 2003 ($18 million in $2014) from the Army Corps of Engineers to reconstruct the seawall built after the 1962 storm, $1.5 million in repairs to the 8th Street jetty in 1991 ($2.6 million in $2014), and a 1,400-foot expansion of the jetty in 2002 (Barlas, 1991; The Times, 2003).

The borough has also worked to protect hard infrastructure through building codes. For example, Avalon recently increased the lowest elevation at which structures can be built in order to reduce flood potential. Due to vulnerability concerns along Avalon's back bay, the borough also adopted a higher bulkhead standard to protect bayside homes from waves.

The borough has willingly become a testing ground for certain storm mitigation techniques. Tests of both hard and natural barriers have been coordinated with and monitored by the Richard Stockton College of New Jersey, Rutgers University, the Army Corps of Engineers, and others (e.g., Farrell and Sinton, 1983; Nordstrom et al., 2002). For example, the borough tested whether an artificial reef would reduce wave energy and beach erosion in 1993 (Page, 1993). In 1995, the borough tested the installation of geo-tubes (large cylindrical tubes filled with sand and covered in a flexible porous material), which stretch along the shoreline and serve as the foundation for small dunes. While not permanent, these structures have successfully worked to slow or break waves during storms in Avalon (Press of Atlantic City, 1995).

2. Natural Buffers and Soft Structural Approaches

Sand dunes are an important shoreline protection barrier in Avalon. Avalon made several important decisions in the 1960s to limit immediate shoreline development and construct an expansive dune system. The dune system provides a protective barrier from storm surge, wind, and flooding associated with coastal storms. In some places,

the dunes stand 20–25 feet tall (Dean, 2012; Richard Stockton College Coastal Research Center, 2013). These dunes were expanded in the 1980s to protect more of Avalon's shoreline. Managing these dunes has required much time and attention by the borough's Environmental Commission. The borough has worked with specialists at the Cape May County Extension Office of the Federal Department of Agriculture to select appropriate plants and grasses to build the dune system's root structure, including the development of a specialized "Cape Dune Grass" that is suitable for Avalon and other areas of the country with similar climate and soil conditions. Local nurseries and the Department of Public Works propagate these grasses, which are planted by volunteers on scheduled dune maintenance days. The dunes must also be maintained after storm events. Currently there is a dune template (i.e., blueprint) approved by the Army Corps of Engineers that the borough must comply with when conducting any maintenance efforts (deButts, 2015; Pagliughi, 2015; Wahl, 2015).

Replenishing beaches with sand is another important aspect of Avalon's shoreline protection efforts. Beaches along Avalon's northern shoreline regularly lose sand due to storms, tides, currents, and an eddy created by the 8th Street jetty. This sand is washed to southern points on the island, where the beaches are actually widening. Beach erosion is a problem for the borough because sand is vital for both storm protection and tourism. When permits and sand volume allow, beach fills are completed with sand dredged from the Townsend Inlet or from the south end of Avalon. Beach fills are an expensive endeavor, often costing more than $100,000. To more systematically address the problem, Avalon entered into a $62 million ($80 million in $2014), 50-year agreement with the Army Corps of Engineers in 2003 for scheduled beach nourishment activities (replenishing beaches with sand) every three to five years. Unfortunately, the Army Corps of Engineers fell several years behind schedule and has since been working with Avalon to conduct beach nourishment activities after storm events rather than at a specified schedule.

Interviewees note that regulations have become a barrier to dune maintenance and beach fill activities. Avalon previously managed its own nourishment activities; however, regulations have prohibited the borough from independently conducting activities due to environmental concerns in recent years, such as the protection of the piping plover that is listed as "endangered" under the New Jersey Department of Environmental Protection's Endangered and Nongame Species Program and "threatened" under the federal Endangered Species Act (U.S. Fish and Wildlife Service, 2012; New Jersey Department of Environmental Protection, 2015; Pagliughi, 2015). In certain cases, Avalon has been able to obtain temporary legal exemptions to these regulations. Avalon officials feel that the regulations are overly invasive because its beach nourishment activities benefit both wildlife and tourism (deButts, 2015; Pagliughi, 2015; Wahl, 2015). Regulations have also prevented Avalon from implementing beach nourishment approaches when and where borough officials feel they are needed.

3. Hazard Mitigation Planning and Communication

Avalon Business Administrator Scott Wahl insists that the number-one goal of all its shoreline protection efforts is to save lives. It also tries to learn from storms, even ones that do not occur in Avalon. Scott Wahl shared that "every event is an education." As such, Avalon has invested in a number of strategies to improve its capacity to share information and respond to storms. These efforts are outlined in the borough's 2010 hazards mitigation plan, which it is working to revise as of 2015. Avalon has an online and social media presence to share up-to-date information when storms occur. It has a reverse 911 system to contact residents with emergency information, as well as a dedicated AM radio station. Telephone poles throughout the borough also display tide markers, so individuals know what a certain level of tide means and can prepare appropriately. Avalon recently acquired a mobile animal shelter after witnessing that residents were reluctant to leave their homes during storms.

1962 Nor'easter Motivates Avalon to Create Policies Supporting Development of Natural Dune System

On Ash Wednesday in 1962, a large nor'easter hit the New Jersey coast. At the time, Avalon was not a tourist

Exhibit 3. Avalon's sand dune system.
Source: Borough of Avalon, 2009.

destination and was not as developed as it is today. Nevertheless, the storm devastated structures and the shoreline. News articles and reports stated that up to six feet of sand had moved 1,000 feet inland; homes were gutted and some were picked up and moved from their foundations. There were vacant tracts of land where homes once stood (Gabbet, 1962; New York Times, 1963; Farrell and Sinton, 1983).

This storm motivated Avalon to take some important steps to prepare for future storms. Some efforts took more than a decade to put in place. The first major effort was the development of physical infrastructure. Avalon built a seawall, a 4,500-foot bulkhead, a jetty at the north end of the island, and four groins perpendicular to the sea wall about 1,500 feet apart (Farrell and Sinton, 1983; Perez, 2013).

Avalon's second major effort to prepare for future storms was changing development codes to reduce the potential impact of future storms. For example, Avalon restricted the number of motels and controlled the size of private homes (Sullivan, 1966). In 1962, Avalon also started a property exchange or buy-out program to acquire properties as borough land and compensate land owners who lost their homes in the storm (Ianieri, 2009). As noted in a news piece, Avalon zoning official Frank McCall shared that in the late 1960s, Avalon created Dune Line Ordinance 442, which created a no-build zone along the beachfront and set properties back from the ocean (Barlow, 2012). In 1968, Avalon bought hundreds of acres of beachfront to create a 500-foot buffer between its dunes and its first row of homes (Hanley, 1998). Finally, in 1979, Avalon created its first master development plan to help articulate its long-term growth plans. Avalon developed this plan later than neighboring communities and, according to Mayor Pagliughi, this enabled the borough to learn from their experience. For example, Avalon's lot sizes are bigger than neighboring communities, which helps control the quantity of structures, stormwater runoff, and flooding potential.

The third, and most important, action further prepared Avalon for future storms by developing a sand dune system (Exhibit 3). These dunes were constructed by the borough on vacated portions of land (Ianieri, 2009). As

Exhibit 4. Avalon's maritime forest.
Source: Borough of Avalon, 2009.

a concession, Avalon allowed a four-block section of the borough to be developed in order to preserve the larger dunes (Sullivan, 1966). Today, these dunes have been expanded and have naturally developed into maritime forests in some locations (Exhibit 4). While most of these dunes are owned by the borough, there are cases where individuals have retained ownership of dune-covered land. These owners never officially accepted Avalon's buy-out, and pay nominal property taxes each year (less than $1; Ianieri, 2007).

Private property ownership of some of the dunes has created some problems for the borough. For example, in 2012, the Avalon was ordered to pay one couple $284,000 ($292,834 in $2014) to compensate them for their property, which they had intended to rebuild decades after the 1962 nor'easter (Ianieri, 2007; Leach, 2010; Associated Press, 2012). In other parts of Avalon, housing was allowed to remain. In the north end of Avalon, an extensive dune system was never planned or established, and development exists just behind the seawall (Farrell and Sinton, 1983). This area remains highly vulnerable to coastal storms even with a number of natural and hard barriers.

Hurricane Gloria Motivates Avalon to Renew its Shoreline Protection Efforts

Despite the development of dunes, a seawall, and a jetty after the 1962 nor'easter, Mayor Pagliughi shared that the borough still needed to use "stop-gap" measures to mitigate the damage of individual storms, particularly along the north end of the borough where dunes were not established. After these protections were put in place, Avalon did not work to intensively maintain or build upon these efforts. When Hurricane Gloria hit in late September 1985, the borough experienced extensive damage. A portion of the dune system, valued at $821,000 to replace ($1.8 million in $2014), blew away (Sullivan, 1985). Borough officials identified this time as critical for renewed shoreline protection efforts. Mayor

Martin Pagliughi said, "We concentrated on the beach front as the primary focus (of our efforts) because in 1985 and 1986 water was running through the living rooms of the houses. There was zero protection. We said 'We've got to look at something here.' Nobody else is going to do it. They're not going to come to you and say this is what you've gotta do. The town's gotta come up with it. We've got to find a solution."

Long-Serving Leadership Maintains Momentum

The leadership of Avalon has changed little over the past 25 years. Mayor Martin Pagliughi served on the Borough Council for four years before being elected as mayor in 1991 (State News Service, 2014), and has been serving as mayor ever since. Several borough staff have been active for nearly as long, including semi-retired Public Works Director Harry deButts, who now serves as the borough's Deputy Emergency Manager. These individuals helped to develop and oversee shoreline protection in Avalon; rally public, state, and federal support; and ensure that necessary funding is there to maintain the borough's various protection efforts in a timely manner.

Building and Maintaining Community Buy-in

Avalon's shoreline protection efforts involve an ongoing public education and outreach campaign. Scott Wahl put it quite simply, "Dunes and beaches provide an overwhelming benefit to the town." Avalon engages the community in a number of ways. The borough holds annual talks with the Avalon Home and Land Owner Association to explain the role the dunes and hard infrastructure play in protecting the borough. Additionally, the borough reminds residents that its shoreline protection efforts have a direct benefit to them through lower flood insurance premiums. Shoreline protection is also incorporated into the local school curriculum. Children help to grow seeds at the borough's greenhouse and later plant Avalon's specialized variety of dune grass with the borough's Public Works Department. Borough officials feel that children are the best and most invested advocates for Avalon's dune system and protection efforts. Each spring the borough's Environmental Commission holds a volunteer dune grass planting event, or "Dune Grass Planting Party." This event usually brings in a range of groups, including the Avalon Home and Land Owner Association and scout troops. The volunteers plant grasses and learn about Avalon's dune system. The Wetlands Institute, a local nonprofit, also conducts weekly tours of the dune system in summer months for tourists. The Avalon Environmental Commission has developed educational placards along the beach access paths. Finally, the borough uses severe events as an opportunity to remind the community about the importance of Avalon's shoreline protection efforts. As a result of these public education and outreach activities, there is broad community support for shoreline protection projects, even when local taxes are needed to fund protection efforts.

Maintaining Shoreline Protection Infrastructure for Ongoing Resiliency to Storms

Avalon sees shoreline protection as vital to protect human life as well as to maintain its built infrastructure and tourism industry. Officials stress that Avalon cannot rely entirely on state or federal dollars given the importance of these efforts and the need to act quickly. Waiting to receive outside funding would leave Avalon vulnerable to storms and could jeopardize its beach tourism economy. Avalon officials stated that they do not get frustrated with the near-constant need for repairs. They see maintenance as part of their job, and something that needs to be planned and budgeted for. Scott Wahl said, "The beach is an investment, not an expense." Avalon budgets 5–10 years into the future, with maintenance efforts usually occurring every few years and after storms.

Funding Shoreline Protection

Avalon officials recognize that diverse funding has been a crucial resource for Avalon's efforts. Over the past 25 years, the borough has used tens of millions of dollars on beach nourishment activities. Locally, Avalon's funding has come from a combination of local taxes and bonds acquired by the borough. Avalon is a relatively wealthy community with a strong property tax base, which can be used for its comprehensive shoreline protection strategy. At times, even after major storms, state and federal funding have failed to come through, pushing Avalon to rely on its own tax base.

Beginning in 1992 and 1993, the borough hired consultants to navigate funding opportunities and lobby for pressing shoreline protection measures at the state and federal levels. Lobbyists have helped Avalon access more funding than if it had tried to identify and pursue funding avenues on its own. Lobbyists also give the borough a presence in Washington, DC, freeing it to focus on local matters. Key borough officials, such as the mayor, also make trips to Trenton, NJ, and Washington, DC, from time to time to advocate for shoreline protection efforts in Avalon. This includes several meetings and presentations with high-level staff in the Congress and Executive Branch. Avalon estimates that over time it has obtained more than $50 million in federal, state, and local funding to support natural buffers, hard infrastructure, and other hazard mitigation activities. For state and federal funding, Avalon almost always needs to provide matching funding or meet certain requirements to be eligible. For federal funding, the borough typically needs to contribute 9 percent of the total project cost (deButts, 2015).

A key challenge for Avalon is convincing others of the importance of shoreline protection. Particular pushback has come from the federal Office of Management and Budget (OMB). Borough staff reported that OMB is trying to increase coastal communities' share of the cost of Army Corps of Engineer beachfill projects. To work against these barriers, borough officials inform agency staff and elected officials that $1 invested by the federal government for beach protection results in $320 ($376 in $2014) in federal tax revenue from beach tourism (Houston, 2008). Borough staff also emphasize the importance of beach tourism as a national economic driver.

Accomplishments of Avalon's Shoreline Protection Efforts

Avalon's dune system has helped the borough weather a number of storms with minimal property damage. While mostly tied to anecdotal evidence, all those interviewed for this case study agree that Avalon's work has helped protect it from storm damage and is a model for other communities. One measure of this is that after Hurricane Sandy, Avalon did not have a single total loss property in the entire borough (though many homes experienced flooding) (Pagliughi, 2015; Wahl, 2015). Borough officials also tout a statement from Assistant Secretary of the Army Jo-Ellen Darcy after Hurricane Sandy that "... the property behind the beaches in Avalon were well protected...where there has been no federal beach project, the community didn't fare that well." However, Cape May County and Avalon were not among the hardest-hit counties in the state (O'Dea, 2013). Avalon officials see its efforts as necessary for the survival of the community. These efforts "keep (Avalon) from washing off the face of the Earth," says Mayor Pagliughi. However, Avalon officials admit that they cannot protect Avalon from every storm. While officials feel they are doing everything they can to prepare for storms, even potentially more severe ones that might come with climate change, they know that a truly severe storm still has the potential to inflict serious damage. Nevertheless, borough officials have not seriously considered new potential impacts of climate change such as sea level rise.

Avalon's efforts have helped it earn a number of achievements and accolades. First, Avalon has the best rating on the National Flood Insurance Program's CRS among coastal communities in New Jersey. This low rating gives residents a reduced flood insurance rate. Avalon has carried out a number of activities to specifically address components of the program to achieve this rate. For example, Avalon is "increasing building heights; getting easements on the beach; maintaining a large dune system; having a flood warning system for residents; completing beach replenishment projects; installing 14 pumping stations to remove water; requiring flood vents on homes to prevent houses from being pushed off their foundation; maintaining drainage systems; setting up an emergency evacuation center in Cumberland County; and preserving open space" (Degener, 2013). Second, Avalon has a Standard & Poor's AAA bond insurance rating (deButts, 2015; Pagliughi, 2015). This high rating means Avalon is a good investment. It helps the borough to secure better financing rates on loans when it aims to carry out shoreline protection measures. Third, in 1996 Avalon earned recognition from the Insurance Institute for Property Loss Reduction with a Community Spotlight Award (Press of Atlantic City, 1996). Finally, in 1997 Avalon won the Hurricane Mitigation Award during the National Hurricane Conference—an event sponsored

by the U.S. Federal Emergency Management Agency (FEMA), the American Red Cross, the National Weather Service, and the National Oceanic and Atmospheric Administration (Keough, 1997).

Avalon officials regularly share information on their community's shoreline protection efforts, indicating that they have spoken with counterparts in places such as Anchorage, AK; Galveston, TX; Saco, ME; as well as nearby communities. Additionally, they have presented at national conferences, and held meetings and presentations with high-level staff in the Congress and Executive Branch. The borough is eager to share its story with other communities that can learn from Avalon's efforts. Officials encourage other communities to reach out to them.

Moving Forward

Despite its efforts to protect itself against storms, Avalon still has a number of vulnerabilities. As already described, since Avalon sits on a barrier island, flooding and storm surge pose a threat to back-bay properties, which are not protected by natural barriers. However, several pump stations were recently installed to address this issue. The borough also recently passed an ordinance to heighten bulkheads as properties are redeveloped or undergo significant improvements. Borough officials, including Mayor Pagliughi, acknowledge that these bulkheads will not prevent flooding, but instead will reduce the impacts of waves during storms. It will take 15–30 years before most of the bulkheads along Avalon's back bay meet the new height requirements.

The north end of the borough is also still quite vulnerable, despite the installation of rip rap and a small dune system. Avalon continually re-evaluates its options for protecting this area, but acknowledges it will likely remain the most vulnerable section of the borough, even with significant improvements.

Limited storm evacuation routes also contribute to Avalon's vulnerability. There is only one bridge leading to the island. The bridge has sufficient capacity to cope with an evacuation in winter months, when the population level is low. However, during the summer, the bridge presents a critical vulnerability to quickly evacuate tens of thousands of visitors in both Avalon and Stone Harbor.

Exhibit 5. Japanese black pines in Avalon's dune system.
Source: Alexis St. Juliana, Stratus Consulting.

Avalon's next big project is the probable development of several "T"-shaped breakwaters perpendicular to the shore. The borough expects that these structures will reduce beach loss and the need for expensive beach nourishment activities by the Army Corps of Engineers—helping to save money in the long run. Sea level rise is being considered in the development of the design of the breakwaters. The height will be adjusted based on

mid-range projections for the region. The major concern among Avalon residents with this project is the aesthetics of the breakwaters, which the project consultant intends to address in the final recommendation report. Other alternatives were considered, but the breakwaters have emerged as the most feasible option considering both cost and engineering. In the meantime, the Borough Council recently approved a $12 million beach nourishment project to address beach lost during Hurricane Sandy (Nevitt, 2015). It has garnered support from the community despite the cost. Future action might also include the elevation of properties (not just structures), when significant redevelopment occurs.

The Environmental Commission is also leading efforts to populate the dunes with native plants and grasses for further dune maintenance and storm protection. When the dunes were first developed, Japanese black pines were the optimal choice to develop a strong root system and resist pests (Exhibit 5). However, the pines are invasive, susceptible to pests, and present a fire hazard. The Environmental Commission is working with the Avalon Home and Land Owner Association and others to remove the invasive species. The borough's Dune Management Plan, finished in 2009, serves as a guide for selecting desirable plants and carrying out the invasive removal and re-vegetation in an appropriate manner (Borough of Avalon, 2009). Communities in New Jersey and Delaware have expressed an interest in the dune vegetation management plan as a model for their beach and dune management efforts. Avalon's nearest neighbor, Stone Harbor, recently adopted a similar plan.

Another challenge for Avalon is an impending change in leadership. The mayor has been in office for over 20 years, and its long-time Public Works director retired several years ago. While there have been some efforts to groom current borough staff for leadership roles in the future, it is hard to know if strong leaders exist to fill this void. Current officials in Avalon point to the fact that anyone involved in borough government plays a number of roles due the borough's small size; this helps to build dedication and a positive culture in Avalon government.

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- **Martin Pagliughi,** Mayor of Avalon and Cape May County Emergency Manager
- **Harry deButts,** Avalon Deputy Emergency Manager (former Public Works Director)
- **Brian Reynolds,** Chair of the Avalon Environmental Commission
- **Thomas Thornton,** Hatch Mott MacDonald hired as Avalon's Borough Engineer
- **Scott Wahl,** Avalon Business Administrator (former Public Information Officer).

Bibliography

American Community Survey. 2012. American Community Survey. American FactFinder. U.S. Census Bureau. Available: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 19, 2013.

Associated Press. 2012. After 50 years, couple wins beach house suit. The Times (Trenton). April 7.

Barlas, T. 1991. Storm's cost nears $27M / Final damage estimate expected to top $30M, Cape Officials say. The Press of Atlantic City. November 5.

Barlas, T. 1993. Cape May point officials say persistence got reef funding. The Press of Atlantic City. August 12.

Barlow, B. 2012. Are we ready for next time? Changes in forecasting, building codes mean better safety, but most agree there's always another storm. Shore News Today. March 7.

Borough of Avalon. 2009. Dune Vegetation Management Plan. Lomax Consulting Group. December 16. Available: http://www.avalonboro.org/news/dune-vegetation-plan/Website%2012_16_09%20Dune%20Veg%20Mgmt%20Plan.pdf. Accessed March 9, 2015.

Borough of Avalon. 2013. Flood Mitigation Plan Progress Report. September. Available: http://avalonboro.net/wp-content/uploads/2012/09/2013-Progress-Report.Final_.pdf. Accessed March 10, 2015.

Dean, C. 2012. Costs of shoring up coastal communities. The New York Time. November 5.

deButts, H. 2015. Interview with Harry deButts, Borough of Avalon. February 26.

Degener, R. 1994. Storms steal shore towns' sand. The Press of Atlantic City. March 5.

Degener, R. 2013. Avalon builds foot higher to save on insurance. The Press of Atlantic City. July 26.

Dowling, J. 1998. A stormy relationship / for decades, Barrier-Island communities and the tumultuous ocean have been entangled in a delicate dance of man vs. nature. The Press of Atlantic City. February 15.

Farrell, S. and J. Sinton. 1983. Storm Mitigation Planning for Avalon, New Jersey. Stockton Center for Environmental Research. Available: http://www.gpo.gov/fdsys/pkg/CZIC-qc944-f37-1983/pdf/CZIC-qc944-f37-1983.pdf. Accessed January 22, 2015.

FEMA. 2014. Community Rating System. June 1. Available: http://www.fema.gov/media-library-data/1408050845935-ee33e56e-81c3aa3f26e569ff6b248fa7/19_crs_508_oct2014.pdf. Accessed April 8, 2015.

Gabbett, H. 1962. Storm-spawned 30-foot seas wreck large sections of coastal resort. The Washington Post, Times Herald (1959–1973). March 8.

Hanley, R. 1998. As beaches erode, a debate on who'll pay for repairs. New York Times. April 20.

Houston, J. 2008. The economic value of beaches —A 2008 update. Shore & Beach 72(3):22–26. Available: http://www.lee-county.com/gov/dept/naturalresources/documents/economic_value_of_beaches_%282008%29_coe_jhouston.pdf. Accessed March 11, 2015.

Ianieri, B. 2006. Avalon at sea about much-needed beach replenishment. Press of Atlantic City. January 19.

Ianieri, B. 2007. Couple wants to rebuild Avalon House washed away in '62 storm. Press of Atlantic City. January 30.

Ianieri, B. 2009. Appeals court says Avalon can keep property from '62 storm. Press of Atlantic City. July 29.

Kaskey, J. 1998. The next step / officials begin to survey damage to (Cape May) county. The Press of Atlantic City. February 6.

Keough, W.F. 1997. Avalon takes national award by storm. The Press of Atlantic City. April 18.

Leach, B. 2010. Avalon must pay for land seized in '60s. The Press of Atlantic City. June 23.

Nevitt, C. 2015. Avalon approves $12 million beach fill project. The Press of Atlantic City. February 12. Available: http://www.pressofatlanticcity.com/news/breaking/avalon-approves-million-beach-fill-project/article_5bba6d56-b2fb-11e4-98f5-834ba76f9bd0.html. Accessed March 16, 2015.

New Jersey Department of Environmental Protection. 2015. New Jersey's Endangered and Threatened Wildlife. Available: http://www.njfishandwildlife.com/tandespp.htm. Accessed July 14, 2015.

New York Times. 1963. Storm Damage of 1962 Is Repaired in Jersey Areas: Jersey Shoreline Gets a New Look. May 14.

Nordstrom, K.F., N.L. Jackson, M.S. Bruno, and H.A. De Butts. 2002. Municipal initiatives for managing dunes in coastal residential areas: A case study of Avalon, New Jersey, USA. Geomorphology 47:137–152.

O'Dea, C. 2013. Interactive Map: Assessing Damage from Superstorm Sandy. NJ Spotlight. March 15. Available: http://www.njspotlight.com/stories/13/03/14/assessing-damage-from-super-storm-sandy/. Accessed March 16, 2015.

Page, P. 1993. Stopping shifting sands. The Times (Trenton). July 15.

Pagliughi, M. 2015. Interview with Martin Pagliughi, Borough of Avalon. February 26.

Parry, W. 1998. Coastal towns love shore-up efforts—Skeptics call beach rebuilding too costly. The Star-Ledger. May 17.

Perez, I. 2013. Jersey Shore Town Makes Its 'Own Luck' and Escapes Sandy. E&E Publishing. May 9.

The Press of Atlantic City. 1995. The Sand Trap/Shore Towns Try to Fill the Funding Gap. March 5.

The Press of Atlantic City. 1996. Avalon Honored/Defending the Dunes. July 2.

The Press of Atlantic City. 1997. Speaking of Hurricanes.../Avalon's Dunes. April 23.

The Press of Atlantic City. 1999. Keeping Sand in its Place/Cape May Point's Artificial Reefs Halt Tide of Beach Erosion. March 7.

Richard Stockton College Coastal Research Center. 2013. New Jersey Beach Profile Network 2012 Annual Report on Shoreline Changes in New Jersey's Four Coastal Counties Raritan Bay to Delaware Bay Spring of 2011 Through Fall of 2012. Richard Stockton College of New Jersey. July 31.

Smith, V. 1991. Storms help shift opinion on dunes. The Press of Atlantic City. November 18.

State News Service. 2014. Disaster Awareness is a Priority for Avalon Mayor, Cape May County OEM. State News Service. August 11.

Strawley, G. 1993. Avalon pushes for federal funds to protect coast. The Press of Atlantic City. February 7.

Sullivan, J.F. 1985. Politics; plans for fund to aid beaches are pressed. New York Times. October 6.

Sullivan, R. 1966. New Jersey's Avalon faces an era of change. New York Times. August 21.

The Times. 2003. Expert: Storms take toll, but beaches are resilient. The Times (Trenton). May 21.

U.S. Fish and Wildlife Service. 2012. Piping Plover, Atlantic Coast Population. Available: http://www.fws.gov/northeast/pipingplover/overview.html. Accessed July 14, 2015.

Wahl, S. 2015. Interview with Scott Wahl, Borough of Avalon. February 26. Case Study Summary

Baltimore, Maryland

Integrating Climate Change Adaptation into an All-Hazards Mitigation Plan

BALTIMORE, MARYLAND

AUTHORS: Alexis St. Juliana, Karen Carney, and Jason Vogel

In this case study, you will learn about:

- Using an existing process to integrate climate change adaptation into practice
- Community engagement processes, including advisory committees, town hall events, and community meetings
- Strategies for engaging in meaningful discourse at community events
- Easing the transition from planning to implementation by identifying links between existing programs and future work
- Using existing community leaders to help spread key messages and engage others
- Using grant funding to support initiatives

Case Study Summary

The City of Baltimore is a large, diverse city; it is vulnerable to a number of climate threats, including heavy precipitation, drought, wind storms, hurricanes or tropical storms, storm surge, coastal inundation, sea level rise, extreme heat, and degraded air quality. In 2012, the city's *All-Hazards Mitigation Plan* was due for a periodic update. City staff used this opportunity to integrate a climate change risk and vulnerability analysis into the updated plan – the *Disaster Preparedness Project and Plan* (DP3). To develop the DP3, city staff conducted a variety of engagement strategies to gather input from the community. They felt that a thorough and intentional engagement process would help build a plan with feasible actions that had community member support. The plan's vulnerability analysis identified flooding, extreme heat, and multiple types of storms as the greatest threats to Baltimore. The DP3 included 50 strategies and 231 actions intended to help Baltimore reduce its vulnerability to current hazards and future changes in climate.

Baltimore staff also believed that educating community members on existing hazards and climate change would help residents and neighborhoods be better prepared to respond to extreme events and climate hazards. Building off of the process and the consensus that DP3 generated, the city quickly transitioned from developing the DP3 to implementing vulnerability reduction actions, with a specific focus on reducing vulnerability to flooding, storms, and extreme heat. These actions included the city's new disaster preparedness initiative for residents, called Make a Plan, Build a Kit, Help Each Other, and the city's effort to improve neighborhoods' capacity to prepare and respond to hazardous events, called Resiliency Hubs (see below for a detailed exploration of these two actions).

In 2015, the city's comprehensive adaptation planning and implementation efforts earned Baltimore the American Society of Adaptation Professionals' Prize for Progress in Adaptation. However, it remains to be seen whether building the capacity of residents and neighborhoods will reduce the city's vulnerability to climate impacts.

The Broader Context of Community-Based Adaptation in Baltimore

Baltimore has been working on environmental sustainability endeavors for nearly a decade; these efforts laid the groundwork for its all-hazards mitigation and climate change adaptation efforts (Exhibit 1). Many of the same people who were involved in early efforts remained involved as the city began to address climate change adaptation.

One of the city's first sustainability efforts was The Baltimore Sustainability Plan. Development of the plan began in 2006, when three Baltimore leaders spurred the city to begin thinking more critically about environmental sustainability. These leaders included Mayor Shelia Dixon, City Council Member Jim Kraft, and Beth Strommen in the Department of Planning (Baja, 2015; Heller, 2015). By 2007, with the support and actions of these leaders, the City Council approved the creation of a new Baltimore Commission on Sustainability (Baltimore city Council, 2007a, 2007b). In 2009, the city released The Baltimore Sustainability Plan (Baltimore Office of Sustainability, 2009).

In 2007, the city created the Office of Sustainability, which now leads Baltimore's all-hazards mitigation and climate change adaptation planning efforts, as well as many other sustainability-related initiatives. The Office of Sustainability grew from two people in 2007 to 12 in 2015 (Kennedy, 2015). Staff actively seek grants from a variety of sources including state funding and foundations; this has helped them to develop plans and projects, and to fund staff positions. As discussed later in this case study, many of Baltimore's sustainability, climate change mitigation, all-hazards mitigation, and climate change adaptation activities are funded through grants (Baja, 2015; Kennedy, 2015).

In 2012, the Office of Sustainability and the Baltimore Climate Action Plan (CAP) Advisory Committee guided the development of the CAP, which focused on greenhouse gas mitigation efforts (Baltimore Office of Sustainability, 2013). Climate change adaptation priorities appeared in the CAP as an area for future work. In 2011, at the same time that Office of Sustainability staff were drafting the CAP, Baltimore's 2006 All-Hazards

Exhibit 1. Timeline of actions in Baltimore, MD.

Mitigation Plan was due for its five-year update—as mandated by the Federal Emergency Management Agency (FEMA). Staff requested and received a one-year extension from FEMA so that they could integrate risk analysis, vulnerability assessment, and climate change adaptation planning. This process yielded 231 actions to reduce Baltimore's vulnerability to current hazards and future changes. Of the actions in the DP3, this case study focuses on two of the early and ongoing actions implemented by Baltimore that help build capacity in residents and neighborhoods—Make a Plan, Build a Kit, Help Each Other and Resiliency Hubs. The city has completed a number of these actions in order to reduce its vulnerability (see text box).

Why and How Baltimore Integrated Climate Change Adaptation into the DP3

City Staff Seized Opportunity to Include Adaptation in an All-Hazards Mitigation Plan Update

As discussed above, Baltimore and its Office of Sustainability had a long history in working on climate change mitigation and sustainability. During its efforts on the CAP, staff in the Office of Sustainability had originally wanted to include an in-depth coverage of climate change adaptation. However, they were ultimately only able to include a short discussion of future adaptation planning. Thus, the staff decided to include comprehensive adaptation planning within the DP3. This seemed like a natural fit to the staff, given their feeling that climate change adaptation planning should align closely with all-hazards mitigation and climate change mitigation (Baja, 2015; Kennedy, 2015). Kristin Baja said, "Everything that you do with a climate adaptation plan, like a risk assessment, a vulnerability assessment, needs to be done in an All-Hazards Mitigation Plan. Both of these things were coming up at the same time… they were so similar. We thought it made more sense to combine these efforts and make the connection with… climate mitigation, so that all of these plans are more comprehensive, working together, and complementing each other" (Baja, 2015). To develop and integrate adaptation into the DP3, staff Beth Strommen and Kristin Baja obtained additional funding from the Maryland Department of Natural Resources and the Maryland Emergency Management Agency (MEMA; Baja, 2015).

Analysis of Climate Change Risks and Vulnerabilities Shaped the Plan

The DP3 included analyses of climate change risks, vulnerabilities across Baltimore, and Geographic Information Systems information. These assessments were integral to developing the strategies and actions in the DP3.

EXAMPLES OF OTHER ADAPTATION ACTIONS RESULTING FROM DP3

Adoption of a new floodplain code—Baltimore now regulates to the 0.2 percent chance of a flood citywide (or, a flood once in 500 years), has a Flood Resilience Area in tidal zones, and enforces a two-foot freeboard requirement. Multiple new and redeveloped structures have been flood-proofed or elevated to reduce risk to people and property.

Adoption of the International Green Construction Code, Electrical Code, and Plumbing Code— The city considers energy efficiency, greening, and stormwater management for building permits citywide.

Development of the Growing Green Initiative— The initiative transforms vacant land to green space, reduces stormwater runoff, grows food, and creates community spaces. Seven major projects are currently being implemented.

Capital Improvement Process—The city requires all departments to explain how their project takes climate change into account and makes the city more resilient.

Removal of impervious surface and planting of trees—The city and partners are using these efforts to manage flooding and high heat. Thousands of trees have been planted and many sections of impervious surface have been removed.

Sources: City of Baltimore, 2015; City of Baltimore, 2014.

Climate change risk analysis: Two types of information influenced Baltimore's climate change risk assessment. First, city staff consulted information from FEMA, MEMA, and the National Oceanic and Atmospheric Administration (NOAA) to develop a list of key local climate hazards or risks (Exhibit 2), described the risks in detail, and shared information on historic events or trends related to those risks. Second, the city located information on future climate conditions, such as more extreme events and events not experienced in the past. City staff relied on readily available climate data from experts including Rich Foot, a local climate scientist, and agencies and organizations including NOAA, the National Climate Assessment, the Maryland Department of Natural Resources, MEMA, the Union of Concerned Scientists, and the Intergovernmental Panel on Climate Change (IPCC). As an example, the city used sea level rise projection ranges from the Maryland Climate Change Commission and the IPCC. Temperature and precipitation projections came from the IPCC (City of Baltimore, 2013). However, the IPCC projections were for a very broad region. City staff understood this was a limitation; data were not available at a local scale and the city did not have the resources for new modeling efforts.

EXHIBIT 2. HAZARDS ADDRESSED IN THE DP3

Poor air quality
Coastal storms
Dam failures
Droughts
Earthquakes
Extreme heat events
Floods
Hurricanes/tropical storms
Landslides/land slumps
Sea level rise
Severe winter storms
Storm surge/coastal inundation
Tornadoes
Tsunamis
Windstorms
Winter Storms and Nor'Easters
Thunderstorms (lightning and hail)

Source: City of Baltimore, 2013.

Vulnerability analysis: City staff developed an in-house Vulnerability Assessment Tool for Advisory Committee members to rank possible hazards in terms of probability of occurrence, human impact, property impact, economic impact, and the city's level of preparedness. This

tool showed that extreme heat, as well as multiple types of storms presented the greatest risks for Baltimore (City of Baltimore, 2013).

Geographic Information System analysis: The city also carried out an in-house geographic information system analyses. One component of this was a Community Asset Inventory to identify physical and societal vulnerabilities. This inventory mapped major employers, cultural assets, and specific segments of the population such as children, elderly, and residents who did not speak English. Additional assessments mapped potential climate risks or current land use to help identify the community assets that were most vulnerable to a given hazard (see for example, Exhibit 3; City of Baltimore, 2013). For example, using FEMA's Hazus-Multi-Hazards tool, the city mapped wind, storm surge, and sea level rise vulnerability across the city.

Broad Scale Community Engagement Influenced the Plan

To ensure the actions in the plan were feasible and had community member support, city staff aimed to educate community members and gather input on disaster preparedness and climate change adaptation during the development of the DP3. To accomplish this, they developed an intentional community engagement process. They wanted the DP3 process to start a dialogue that would continue after the development of the plan. This community engagement process went beyond what the city had done in the past for efforts like the Sustainability Plan or CAP; the engagement process was central to building support for the DP3. The three main engagement pathways included an Advisory Committee, town hall meetings, and community meetings.

Advisory committee and sub-committees: The DP3 Advisory Committee consisted of 35 representatives from city agencies, emergency response entities, public utilities, public health agencies, hospitals, businesses, neighborhoods, local non-profits, and other entities. Initially, city staff wanted to have nearly 60 members on the advisory committee, but decided to cap participation at 35 members and involve additional individuals through subcommittees (Baja, 2015). Subject matter experts and stakeholders served on infrastructure, buildings, natural systems, and public services subcommittees. The full committee met five times throughout the development of the DP3. City staff helped keep the advisory committee informed and connected between meetings.

Part of the city's strategy in selecting the advisory committee was to bring in community liaisons that could effectively inform the community of the city's plans. At the same time, the advisory committee allowed representatives of various community entities to contribute to the plan in a forum where their ideas were weighed equally and not readily dismissed (Baja, 2015). Inez Robb served on the Advisory Committee for the Sandtown-Winchester neighborhood and said that she joined because, "I thought it would educate the community. It would help me to help others to understand. I believe in it genuinely, I know it is important. …I have to look at all angles…to help me to have a better quality of life and the people I know." She felt that many of her contributions were accepted by the Advisory Committee, such as her suggestion to include telephone numbers in all outreach documents because not all community members have access to email. She also felt that the Advisory Committee was an effective body overall. The committee members were engaged and willing to work through differences to reach consensus (Robb, 2015). Gene Taylor, the Chief Security Officer at Baltimore's National Aquarium, has contributed to several emergency management activities in the city and served on the building sub-committee for the DP3. The aquarium is located adjacent to water in the city's Inner Harbor and is highly vulnerable to storms, such as Hurricane Isabel in 2003. Kristin Baja, also the city's Floodplain Manager, put the builder of a new downtown facility in touch with Gene Taylor to share guidance. With his advice, the builder ultimately installed floodgates and other storm protection measures (Taylor, 2015).

Town Hall meetings: City staff coordinated two town hall meetings as part of the DP3. These meetings are typical of community engagement processes in the city; similar events were held to develop the CAP (Baja, 2015; Kennedy, 2015). To encourage meeting attendance, the city offered transportation support, childcare, and refreshments (Baja, 2015). A total of 153 people attended

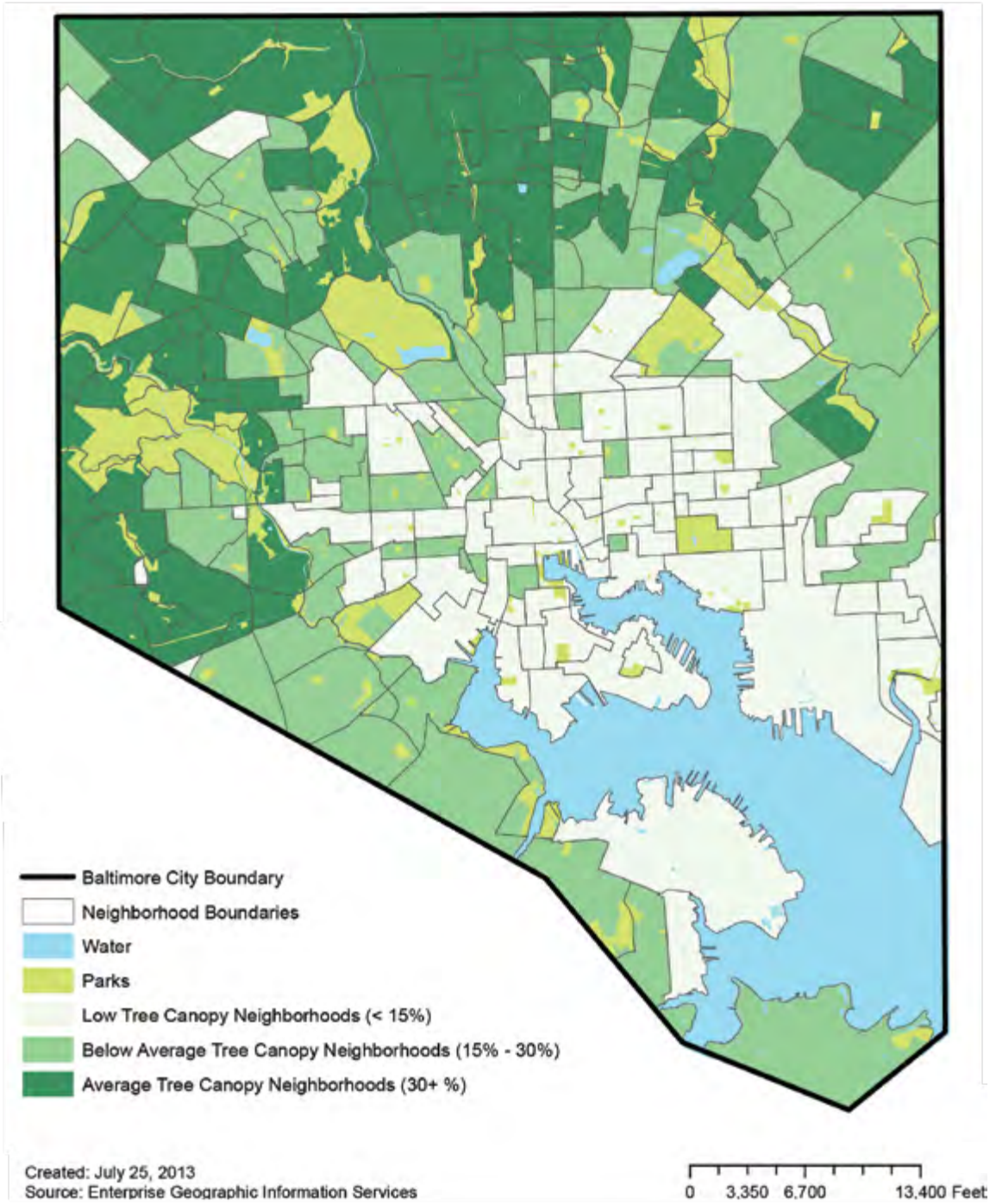

Exhibit 3. Baltimore City tree canopy map developed to determine community assets susceptible to extreme heat.

Source: City of Baltimore, 2013.

the two meetings (City of Baltimore, 2013). In addition to sharing information about climate hazards and preparedness and gathering input from dialogue with community members, staff conducted two participatory exercises (City of Baltimore, 2013):

Each participant was given 500 "DP3 Dollars" and asked where the city should spend the $500 to create resilience. Participants' spending reflected:

- 22 percent on stormwater infrastructure
- 21 percent on resilient energy systems
- 19 percent on transportation infrastructure
- 15 percent on human health programs
- 12 percent on trees and greening
- 10 percent on building codes

Each participant was given six stickers to place next to individual strategies he or she felt were important (Exhibit 4). From most selected to least selected, community members chose:

- Integrate resiliency, redundancy, and structural stability into the city's drinking and water system to ensure safe and reliable water storage and distribution
- Modify urban landscaping requirements and increase permeable surfaces to reduce stormwater runoff
- Create an interconnected network of green spaces to support biodiversity and watershed based water quality management
- Use green corridors and parks to help protect surrounding communities from the impacts of hazard events.

Community meetings: City staff coordinated several smaller community meetings with typically 20 or fewer people in residents' homes, churches, community centers, or libraries (City of Baltimore, 2013). These meetings focused on climate changes, including flood risk or extreme heat, and educated community members about the risks in their neighborhood. The sessions identified and shared preparedness measures and the actions participants could take to reduce the chance of injury or damage if a hazard occurred. The sessions also helped inform the strategies and actions established for the DP3. City staff targeted these meetings in neighborhoods most vulnerable to impacts and worked with a community member or liaison to identify participants and host the event (Baja, 2015).

Exhibit 4. Community member voting in a town hall participatory exercise.
Source: City of Baltimore, 2013.

Kiesha Allen hosted one of the events in her home (Exhibit 5). She felt that it was important for her and her neighbors to learn about flood risk because several waterways separate their neighborhood from the rest of Baltimore, they are far from some emergency services, there is no natural community meeting-place in the event of a disaster, and the June 2012 derecho storm had heightened their concerns about natural disasters (Allen, 2015).[4] Kiesha Allen said, "It ended up being 15 people in my dining room…just to get together and brainstorm and answer questions… We used software…to determine our risk factor on flooding. Where I live, it wasn't a surprise. It was a surprise for people that lived on the higher land. They thought they were safe. They realized 'Oh, so we're not safe.' We wouldn't have known otherwise" (Allen, 2015). She felt that she and her neighbors learned a lot about current flood risk in their neighborhood and future flood risk from climate change, as depicted using the software tools. The meeting included information on how to prepare for flood events by elevating appliances and

4. A derecho is "a widespread, long-lived wind storm. Derechos are associated with bands of rapidly moving showers or thunderstorms" (NOAA, 2015). The derecho produced approximately 60- to 70-mile-an-hour winds, caused major wind damage, and knocked out power to nearly 900,000 homes in Maryland. Because the power outages occurred during the hottest portion of the year, a lack of air conditioning contributed to several heat-related deaths (U.S. DOC, 2013).

waterproofing basements. She felt that flood insurance, in particular, is not a viable option for everyone because of the cost (Allen, 2015; City of Baltimore, 2013).

As a result of the multiple engagement activities, the Advisory Committee and city staff developed 50 strategies and 231 actions to reduce Baltimore's vulnerability to current hazards and future changes in climate. The Advisory Committee and city staff considered and prioritized each action's feasibility and a number of other criteria (Baja, 2015). Exhibit 6 represents a subset of strategies and actions with high-priority scores.

Exhibit 5. One of several community meetings.
Source: City of Baltimore, 2013.

EXHIBIT 6. SAMPLE STRATEGIES AND ACTIONS FROM THE DP3.

Strategy Infrastructure-1: Protect and enhance the resiliency and redundancy of electricity system

- Action: Partner with utility to evaluate protecting power and utility lines from all hazards
- Action: Determine low-lying substation vulnerability and outline options for adaptation and mitigation

Strategy Buildings-2: Enhance city building codes that regulate building within a floodplain or near the waterfront

- Action: Develop Construction Best Practices for development within floodplains
- Action: Encourage green roof installations to include vegetative and reflective technologies for all new commercial, industrial, multifamily, and city-owned development

Strategy Natural Systems-2: Utilize green corridors and parks to help protect surrounding communities from the impacts of hazard events

- Action: Anticipate the impacts of future changes in temperature and weather on the urban forest by developing a comprehensive list of plant and tree species known to have a broad range of environmental tolerances
- Action: Establish a comprehensive maintenance program that includes pruning for sound structure and the removal of hazardous limbs and trees. First focus on areas where vulnerable infrastructure is nearby such as energy supply and roads

Strategy Public Services-3: Designate community leaders and organizations that can assist and provide support during hazard events

- Action: Identify and evaluate plans already in place and work to improve utilization of community-based leaders to assist in preparedness and response

Strategy Public Services-8: Conduct climate, resiliency, and emergency planning education and outreach

- Action: Educate and train community groups to participate in responding to hazards
- Action: Generate a comprehensive community-specific all-hazards outreach campaign

Source: City of Baltimore, 2013.

City Staff Moved Quickly from Drafting the DP3 to Implementation

Once the DP3 was complete, implementation began immediately. One item that Kristin Baja identified as facilitating this transition was cross walking the strategies and actions with existing plans and projects in the city, state, and among stakeholder groups (Baja, 2015). She said, "Implementation is not solely on the city. Because stakeholders developed the plan and overlapped plan elements with existing projects, this made it more likely that they will embrace the plan and try to integrate climate change into future thinking" (Baja, 2015). Make a Plan, Build a Kit, Help Each Other and Resiliency Hubs are two examples of high-priority climate change adaptation actions that helped Baltimore meet DP3 goals.

Make a Plan, Build a Kit, Help Each Other: This program is the city's disaster preparedness initiative for residents, which relies on multiple avenues to educate and prepare citizens. The program kicked off in April 2014 at a large event with 300 participants. Since then, Office of Sustainability staff, including Kristin Baja, Zane Hadzick, and Alice Kennedy, have conducted approximately 40 smaller meetings throughout Baltimore, reaching more than 1,450 community members (Baja, 2015; Hadzick, 2015, Kennedy, 2015). Meetings occur in neighborhoods that have requested participation in the program or are particularly vulnerable to certain impacts (Baja, 2015; Hadzick, 2015). Staff tailor the discussion to each neighborhood's relative risks or vulnerabilities (Baja, 2015; Hadzick, 2015). The staff shared three specific principles that they use to conduct the meetings.

Staff do not use a presentation or slides to share information on existing hazards and climate change risks, vulnerability, or preparedness. This information is in the room on posters and handouts, and staff are prepared to speak to these topics. Staff prefer to begin a dialogue with the participants to learn how recent events have affected residents and what they perceive as the biggest risks in their neighborhood (Exhibit 7). This leads to a discussion on how climate change might alter the types of risks the neighborhood faces, or the frequency or intensity of existing hazards. In many cases, community members point to changes that are already taking place (e.g., the frequency or intensity of rainfall).

Participants make emergency plans with the assistance of city staff. The plans help community members collect important contact information, identify an evacuation route and meeting place, and list neighbors who might need assistance in an emergency. Then participants make emergency kits. The kits are not prepared in advance; participants visit stations throughout the meeting space to learn about each item that goes into a kit. Staff have a few selected community members build their kits at the end of the meeting to ensure attendance through the full event.

Staff emphasize building trust with community members. Many of the participants have had few interactions with city staff, or have historically had negative interactions with city officials. Staff members try to change that by taking citizen concerns seriously. If a community member identifies a specific problem on their property or in the neighborhood, no matter its relation to the topic at hand, staff make sure to convey it to the relevant city department and follow up until the problem is addressed. Staff hold themselves accountable for making these connections across city agencies and stakeholder groups (Baja, 2015; Hadzick, 2015, Kennedy, 2015).

Resiliency Hubs: This program is a new initiative of the Office of Sustainability; the program's focus is to build neighborhood resiliency to climate change and other hazards. From city staff perspective, these hubs should be a neighborhood building that can serve as a daily community center and a go-to location in the event of a disaster. The location would not be a city-owned building, but rather the building of a trusted neighborhood organization, like a non-profit. Ideally, the hubs already operate as neighborhood institutions that are used for a wide range of purposes throughout the year. Over time, the hope is that the hubs can meet additional or changing neighborhood needs in addition to helping reduce the vulnerability of neighborhoods to climate change. Additional criteria include capacity to store or collect emergency food and supplies, accessibility, multiple spaces to assist people in the event of a disaster, and a strong liaison to lead the hub. Elements that the project brings to the hubs include increased communication and energy capacity through solar power and back-up batteries. Ideally, the hubs would also be environmentally

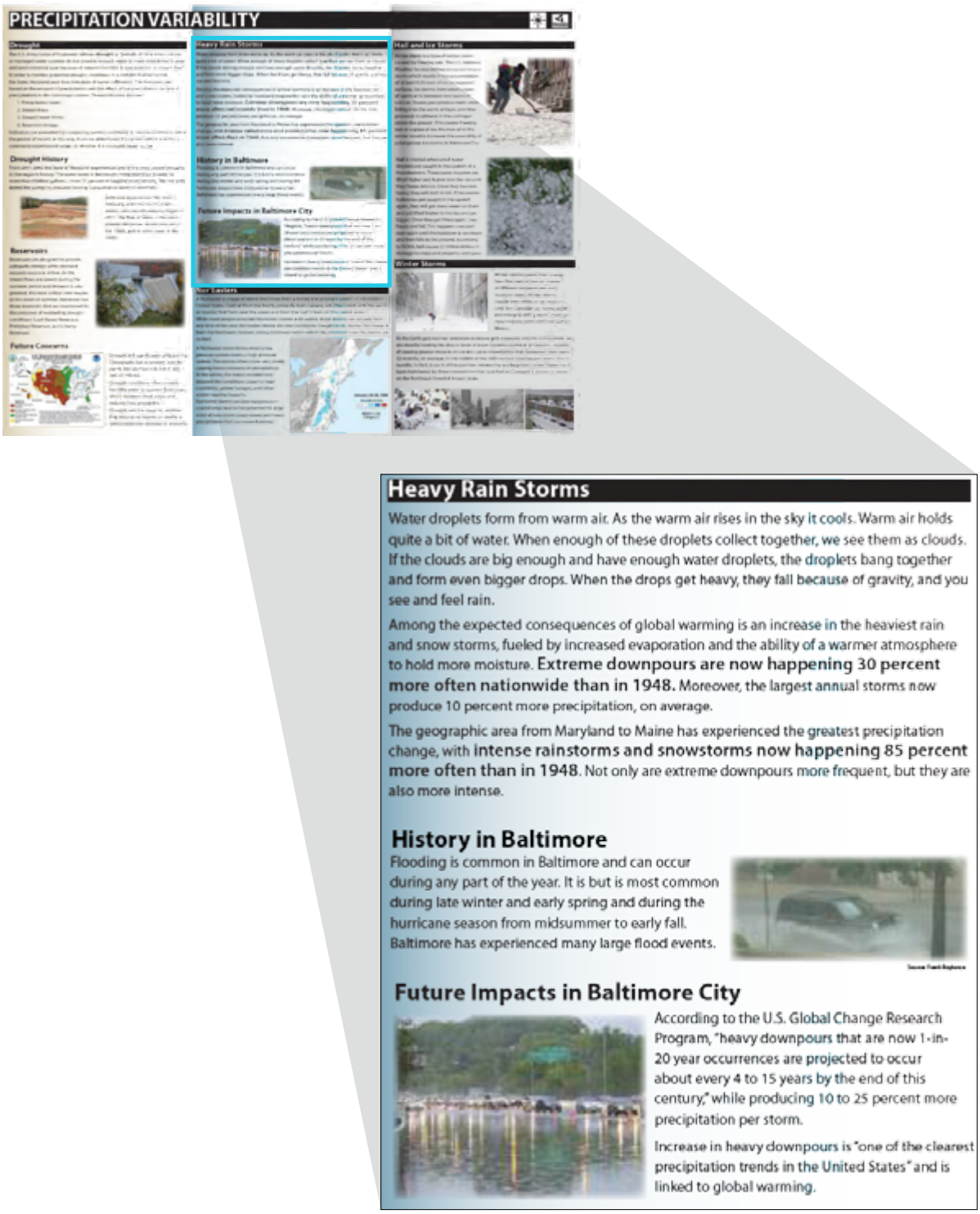

Exhibit 7. Sample poster used at various community events.
Source: City of Baltimore, 2013.

sustainable and limit energy and water use, and contribute to urban agriculture and neighborhood stormwater management (Baja, 2015). City staff believe these hubs help improve the capacity of entire neighborhoods to prepare and respond to extreme events or climate hazards. For example, the hubs serve as a meeting place for residents to come together, which can help them build connections and work together to respond to or recover from an event.

Community member Earl Johnson serves on the Baltimore Sustainability Commission and is a trained Community Emergency Response Team (CERT) member. He had a similar idea for "Sustainable Blocks," and idea which closely resembles the city's vision for Resiliency Hubs. Johnson said, "It was important for me for our blocks to be more sustainable when it comes down to bad weather.... I wanted to figure out a way for the community members who respond on the ground to be more prepared. If things really went bad, who do people turn to? Will they be prepared? That is where we started to think about how do we make our blocks more sustainable and connect people" (Johnson, 2015). The city is now working with Johnson to align his ideas with Resiliency Hubs. Some of Johnson's sustainable blocks criteria that the city is considering are:

- Being or becoming aware of basic city services and who to contact with problems (e.g., trash pickup and recycling)
- Making sure the blocks are clean
- Identifying who is at risk in the neighborhood, such as seniors, people with medical conditions, and parents with young children
- Identifying who on the block can help manage that at-risk population
- Identifying infrastructure issues (e.g., basements vulnerable to flooding, storm drainage issues)
- Identifying evacuation needs
- Ensuring that individuals are prepared for disasters and have sufficient food and water (Johnson, 2015).

Accomplishments

Those interviewed for this case study agree that Baltimore is headed in the right direction to reduce its vulnerability to climate change. In addition to developing the DP3 and educating stakeholders through the DP3 process, the city has completed a number of the plan's 231 actions to reduce its vulnerability to existing hazards and climate change.

Considering the three priority climate change concerns for Baltimore—extreme heat, flooding, and storms—Baltimore's actions help reduce vulnerability in a number or ways. For example, city staff believe that Make a Plan, Build a Kit, Help Each Other and Resiliency Hubs help improve residents' ability to appropriately prepare and respond to climate change impacts, including extreme heat, storms, and other events. Similarly, city staff feel that the city's new floodplain code will, over time, help ensure that structures are less vulnerable to flooding. Likewise, staff identify the Growing Green Initiative, removing impervious surface, and tree planting as efforts that will help the city better manage stormwater and lessen impacts from extreme heat events.

Make Plan, Build Kit, Help Each Other, and Resiliency Hubs are making progress to help Baltimore reach its goals within the DP3. Since Make a Plan, Build a Kit, Help Each Other began, the city hasn't had a significant climate-related disaster. However, there are anecdotal stories of the program's pervasiveness. Earl Johnson regularly brings up preparedness topics at monthly meetings for his neighborhood, Oliver, and surrounding neighborhoods. As a result of this work, he said that his neighbors, "...know there are options. They are changing knowing that there is more than one option. The option they typically had was, 'Make this decision by myself, I'm alone—I don't know what to do.' Now we collectively make decisions when it comes down to emergencies." Staff are planning to revisit the neighborhoods where they have hosted events to refresh community members' knowledge and answer further questions (Hadzick, 2015). Resiliency Hubs has also made progress on a pilot project, having established a back-up power source and

Exhibit 8. Cool roof installation at the Resiliency Hubs pilot.
Source: City of Baltimore, 2015.

a "cool roof" with The Door, a local nonprofit (Exhibit 8). However, Make a Plan, Build a Kit, Help Each Other faces a major challenge; its current grant funding ends in 2015 and future funding remains uncertain (Baja, 2015). Resiliency Hubs also face several challenges; for example, some city officials are reluctant to invest in facilities not owned by the city. As a result, Office of Sustainability staff are seeking outside funding for activities. In addition, more work needs to done to train the hub liaisons (Baja, 2015).

City staff annually track the progress of each of the DP3's 231 actions along a continuum—pending, very early stage, early stage, mid stage, advanced stage, or implemented (Baja, 2015; Exhibit 9). For example, "Develop stricter flood regulations for critical facilities," part of strategy Buildings-1, is noted as "implemented" because staff successfully changed the floodplain code (Baja, 2015). However, city staff acknowledge it can be difficult to track the success of educating community members through programs such as Make a Plan, Build a Kit, Help Each Other (Baja, 2015). They are trying to identify new and better indicators through a collaboration with the Urban Sustainability Directors Network (Baja, 2015). They hope to have these new indicators developed by winter 2015–2016. In a separate effort, the city is working with George Mason University to develop a more rigorous and analytical method for determining the effectiveness of its efforts. Specifically, the city wants to be sure it asks residents appropriate baseline questions so that it can later assess improved knowledge of concepts and the effectiveness of its capacity-building programs.

Exhibit 9. Summary of the status of the 231 DP3 Actions

Pending	62
Very early	85
Early	44
Mid	23
Advanced	7
Implemented/ongoing	10

Source: City of Baltimore, 2014.

Moving Forward

To further reduce the vulnerability of residents to existing hazards and the impact of climate change, city staff plan to continue to implement the 231 actions in the DP3. The actions and strategies within the DP3 were designed with multiple criteria, including feasibility, in mind. Despite this, city staff recognize that they cannot implement all 231 actions at one time (Baja, 2015). See Exhibit 10 for a summary of the status of the actions as of 2014. Some of the actions have a lower priority, are higher cost, or are targeted for a later date. These actions will take longer to accomplish. A few priority activities exist in the near-term:

Continue to make headway on Resiliency Hubs. Just one pilot hub is in progress, but staff envision hubs throughout the city. Resiliency Hubs may also serve as an extension of Make a Plan, Build a Kit, Help Each Other. The current funding for Make a Plan, Build a Kit, Help Each Other will run out in 2015, but city staff see scaling up from individual preparedness to neighborhood preparedness as a natural continuation of this action, and one that might attract new funding (Baja, 2015).

Ongoing work to revitalize vacant lots and remove impervious surfaces. Like Resiliency Hubs, revitalizing vacant lots and removing impervious surfaces are activities that have been started, but that staff plan to continue as a way to help manage stormwater.

Protect cultural and historic assets against climate change. Protecting cultural and historic assets was not a major element of the DP3, but the importance of these assets was acknowledged. Staff hope to include retrofitting and protecting historic assets into the DP3 within the next year. They feel the plan is flexible enough to meet these emerging needs (Baja, 2015).

Continue to effectively earn grant funding for adaptation. Many of the actions in the DP3 will only be achievable with outside support. In this, the Office of Sustainability staff recognize that they might need to be flexible, or make modest adjustments to their DP3 climate change adaptation prioritization to earn grant funding.

Strengthen public-private partnerships. City staff are proud of the work they have done to engage private entities through the DP3 process. They plan to continue to engage these entities and help them adapt to climate change. For example, the city is starting an outreach campaign with waterfront and industrial businesses.

Use three principles to guide ongoing work. (1) ensure that social equity continues to be a core value in planning and implementation efforts, (2) continue to collaborate with regional and national networks to enhance climate change adaptation efforts and learn best practices, and (3) prioritize actions that have both climate change mitigation and adaptation benefits.

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- Zane Hadzick—Baltimore City Department of Planning, environmental planner
- Lynn Heller—Abell Foundation, vice president; and Baltimore Sustainability Commission member
- Earl Johnson—Resident and trained CERT member
- Alice Kennedy—Baltimore City Department of Planning, sustainability coordinator
- Inez Robb—Resident and DP3 Advisory Committee member
- Gene Taylor—National Aquarium Baltimore, chief security officer; and DP3 Sub-committee member.

Bibliography

Allen, K. 2015. Interview with Keisha Allen, Resident. June 24.

Baja, K. 2015. Interview with Kristin Baja, Baltimore City Department of Planning. June 24.

Baltimore City Council. 2007a. 06-0506: Baltimore City Office of Sustainability for the Purpose of Establishing the Baltimore City Office of Sustainability; Providing for the Appointment of an Executive Director and Staff for the Office; Providing for the Establishment and Implementation of an Environmental Management Program; Specifying the Powers and duties of the Office and the Executive Director; and Generally Relating to an Office of Sustainability. Available: https://baltimore.legistar.com/LegislationDetail.aspx?ID=2175270&GUID=DC369803-D559-417B-957F-9B67FB291A51&Options=ID|Text|&Search=sustainability. Accessed July 2, 2015.

Baltimore City Council. 2007b. 07-0582: Resource Sustainability FOR the Purpose of Renaming the Commission on Resource Conservation and Recycling to be the Commission on Resource Sustainability; Reconstituting the Commission's Membership; Restating and Modifying the Commission's Duties; Expanding the Information to be included by City Agencies in their Annual Energy Consumption Reports; Requiring City Agencies to Submit an Annual Greenhouse Gas Emissions Reduction Report; Providing for the Commission to Develop a Comprehensive Recycling Plan for the City; and Generally Relating to Resource Conservation, Recycling, and Sustainability. Available: https://baltimore.legistar.com/LegislationDetail.aspx?ID=2175413&GUID=0E16EC60-1BE1-4DF6-A94A-673E828AAB74&Options=ID|Text|&Search=07-0582. Accessed July 2, 2015.

Baltimore City Council. 2007c. 07-0834: Baltimore City's Membership in the International Council for Local Environmental Initiatives (ICLEI)'s Cities for Climate Protection Campaign for the Purpose of Expressing Approval for the City of Baltimore to Join ICLEI as a Full Member, to Participate in the Cities for Climate Protection Campaign, and, as a Participant, to Pledge to Take a Leadership Role in Promoting Public Awareness about the Causes and Impacts of Climate Change; and Providing for a Special Effective Date. Available: https://baltimore.legistar.com/LegislationDetail.aspx?ID=2175805&GUID=CCAD11AC-5979-4032-935D-0B5F807DCC94&Options=ID|Text|&Search=sustainability. Accessed July 2, 2015.

Baltimore Office of Sustainability. 2009. The Baltimore Sustainability Plan. Baltimore Office of Sustainability, MD. Available: http://www.baltimoresustainability.org/sites/baltimoresustainability.org/files/Baltimore%20Sustainability%20Plan%20FINAL.pdf. Accessed July 2, 2015.

Baltimore Office of Sustainability. 2013. Baltimore Climate Action Plan. Available: http://www.baltimoresustainability.org/sites/baltimoresustainability.org/files/BaltimoreCAP_FINAL_130415.pdf. Accessed July 7, 2015.

Baltimore Office of Sustainability. 2014. The 2014 Annual Sustainability Town Hall—A Success!! March 31. Available: https://baltimorehazards.wordpress.com/2014/03/31/join-us-at-the-annual-town-hall-event/. Accessed July 6, 2015.

City of Baltimore. 2006. All-Hazards Plan for Baltimore City: A Master Plan to Mitigate Natural Hazards. City of Baltimore Department of Planning, MD. November 11. Available: http://emergency.baltimorecity.gov/Portals/Emergency/documents/Baltimore%20City%20Mitigation%20Plan.pdf. Accessed July 2, 2015.

City of Baltimore. 2013. City of Baltimore Disaster Preparedness and Planning Project: Disaster Preparedness and Planning Project. October 15. Available: https://www.dropbox.com/sh/kgfosha0v04pm0p/AADc1tnWqP7yKGndIrUmRUHda/Baltimore_DP3Plan2013_Spreads_LowRes.pdf?dl=0. Accessed June 26, 2015.

City of Baltimore. 2014. 2014 Annual Sustainability Report. Available: http://baltimoresustainability.org/sites/baltimoresustainability.org/files/Annual_Report_2014_Pages_Web_2.pdf. Accessed August 20, 2015.

City of Baltimore. 2015. Climate Resilience: A Combined Hazard Mitigation and Climate Adaption Process. Submission for the ASAP Prize for Progress in Adaptation.

Hadzick, Z. 2015. Interview with Zane Hadzick, Baltimore City Department of Planning. June 24.

Heller, L. 2015. Interview with Lynn Heller, Abell Foundation. June 24.

Johnson, E. 2015. Interview with Earl Johnson, Resident. June 24.

Kennedy, A. 2015. Interview with Alice Kennedy, Baltimore City Department of Planning. June 24.

NOAA. 2015. About Derechos. Storm Prediction Center. U.S. National Oceanic and Atmospheric Administration, National Weather Service, National Centers for Environmental Prediction. June 9. Available: http://www.spc.noaa.gov/misc/AbtDerechos/derechofacts.htm. Accessed August 6, 2015.

Robb, I. 2015. Interview with Inez Robb, Resident. June 24.

Taylor, G. 2015. Interview with Gene Taylor, National Aquarium Baltimore. June 24.

U.S. DOC. 2013. The Historic Derecho of June 29, 2012. U.S. Department of Commerce, National Oceanic and Atmospheric Administration National Weather Service, Silver Spring, MD. Available: http://www.nws.noaa.gov/os/assessments/pdfs/derecho12.pdf. Accessed August 6, 2015.

Boston, Massachusetts

Climate Change Preparedness and Resiliency Checklist

BOSTON, MASSACHUSETTS

AUTHORS: Missy Stults, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- Techniques to ensure public and private-sector building projects are preparing for climate change
- Building partnerships with the private sector to ensure strategies are appropriate and to enhance compliance with implementing key strategies
- How Boston is using green buildings as a launch pad for larger community-wide actions related to reducing vulnerability and enhancing overall resilience

Case Study Summary

The City of Boston has historically been shielded from severe impacts associated with extreme weather events thanks to its location and the protection afforded by the 34 harbor islands, which substantially dampen and dissipate storm surges. According to the Boston Living With Water Design Competition, the downside of this strategic location is that "approximately 30 percent of Boston (our filled tidelands) lie within 8' of today's high tide and, without intervention, will be at risk of chronic saltwater flooding by 2100" (City of Boston, 2015c). The possibility of this breech, as well as more inland flooding, is growing due to climate change. More specifically, climate change projections for the Boston area indicate that flooding, particularly flooding related to sea level rise, is very likely to increase over the coming decades.

In the face of this threat, Boston Mayor Thomas M. Menino started a series of initiatives to "green" the built environment that culminated in 2013 when the Boston Redevelopment Authority (BRA) Board mandated that climate change be considered as part of the review process of large new developments and large renovation projects. This mandate revised Article 80 of the Boston Zoning Code to require all private property owners proposing to develop new buildings over 20,000 square feet or proposing renovations over 100,000 square feet to "identify changes in the climate and environment and how such changes will affect the project's environmental impacts including survivability, integrity, and safety of the project and its inhabitants" (BRA, 2013). This mandate has been implemented by requiring developers to complete a Climate Change Preparedness and Resiliency Checklist (Checklist). The purpose of this Checklist is to assess how climate change and extreme weather conditions could affect a building over its design life. The completed Checklist is submitted to the BRA as part of a project's Article 80 Review and is factored into decisions regarding whether or not to permit a project for development. To date, a number of projects have been redesigned to accommodate projected changes in climate and nearly all projects now locate systems above flood levels. One example is the Spaulding Rehabilitation Hospital, profiled below. Overall, however, the time lag between proposing a new development and completing the project means that the full impact of the Checklist and the larger change to Article 80 cannot yet be fully assessed.

Broader Context

As the largest city in New England, Boston has and continues to be a major center of economic activity, cultural diversity, and social opportunity. Its location on the coast affords it numerous advantages but also poses serious threats in the form of issues such sea level rise, coastal and inland flooding, and severe weather such as Nor'easters. These threats have been getting more intense, frequent, and of longer duration over the last few decades, and these trends are projected to continue due to climate change (Melillo et al., 2014).

According to the National Climate Assessment (Melillo et al., 2014) and the *Massachusetts Climate Change Adaptation Report* (Commonwealth of Massachusetts, 2011), the average annual temperature in the Northeast is projected to rise between 3°F and 10°F by 2080, with the number of days over 90°F in Boston rising from the current average of 10 to between 31 and 62 per year due to climate change. Climate projections also suggest that while the absolute amount of precipitation falling per year will stay close to current levels, this precipitation will fall in fewer, more intense storms (City of Boston, 2013). Additionally, Boston is subject to significant changes in sea levels. This is due to both rises in global sea levels and the fact that Boston's land mass is subsiding, or sinking, at about six inches per century (City of Boston, 2013).

These changing weather conditions, combined with a growing population, caused the City of Boston to begin a comprehensive program to address climate change. Initially, this effort focused on reducing the city's contribution to climate change by mitigating city and community-wide greenhouse gas emissions. Over time, however, this work evolved to include efforts to prepare for the risks and impacts associated with a changing climate. These climate preparedness efforts began to crystallize in 2007, when Mayor Menino issued an Executive Order directing all city offices to incorporate climate change into municipal and community planning, projects, permitting, and review processes (City of Boston, 2013). In 2010, the Mayor's Climate Action Leadership Committee, building on the 2007 Executive Order, recommended that "every city government department and agency undertake a formal review of the possible implications of climate change

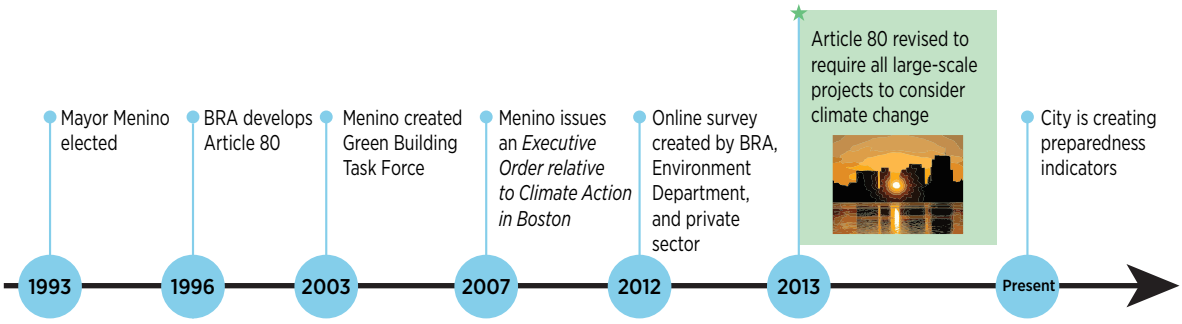


Exhibit 1. Case study timeline.

for its on-going programs and infrastructure in the next ten years, and implement changes or establish programs and policies based on that review" (City of Boston, 2013). Based partly on this recommendation, the City of Boston decided to integrate a comprehensive climate adaptation framework into the 2011 Boston Climate Action Plan update (City of Boston, 2011).

Today, the City of Boston is working on a number of initiatives to create a more resilient and prepared city, including the Complete Streets program, green infrastructure installations, an urban forestry program, numerous educational initiatives to help businesses and citizens understand their vulnerabilities, and updates to its wetland and floodplain ordinances. In addition, the city now requires that developers consider climate change when designing new large developments or when undertaking large renovations of existing buildings. This effort is the focus of this case study.

Why and How Boston Created the Checklist

Article 80 of Boston Zoning Code Created to Address Unique Review Requirements for Large-Scale Projects

Boston has and continues to be a major center of economic development and innovation for the region. Recognizing the importance of the city and the impacts of post war urban-flight, in 1957, the Boston City Council and the Massachusetts Legislature created the BRA (see Exhibit 1). Today, the BRA is Boston's planning and economic development agency and is tasked with overseeing development within the City of Boston (BRA, 2015a). For the majority of its history, the BRA utilized formal and informal guidelines including the zoning code for how development and redevelopment projects were reviewed by the city. As projects became larger and more complicated, in 1996 the BRA officially adopted Zoning Article 80, which codified policy and practices to "provide clear guidelines for the development review process relating to large projects (adding more than 50,000 square feet), small projects (greater than 20,000 square feet), planned development areas (new overlay zoning districts for project areas larger than 1 acre), and institutional master plans (projects relating to academic and medical campuses)" (BRA, 2015b).

Innovation Around Green Building and Climate Action Emerges in the Public Sector

From its inception, Article 80 of the Boston Zoning Code has been used to improve the performance of Boston's building stock. The work to significantly scale-up the environmental performance of buildings subject to Article 80, as well as other buildings, gained traction; however, shortly after the election of Mayor Menino in 1993, the Mayor and his staff began working on a number of initiatives focused on greening the built environment, including reducing energy consumption in city buildings,

installing onsite renewable energy installations, and purchasing renewable energy offsets (Hunt, 2006). In the early 2000s, Boston's green building efforts became more sophisticated when city staff approached the mayor with an idea of "developing more formal green building standards" following the guidance provided in the recently released U.S. Green Building Council's (USGBC's) Leadership in Energy and Environmental Design (LEED) standard (Dalzell, 2014). In response to the suggestion, Mayor Menino created a Green Building Task Force in 2003 to explore what a formal green building standard for the city could look like and to identify barriers to building green in Boston (City of Boston, 2003; Hunt, 2006).

In November 2004, Mayor Menino announced a three-year mandatory implementation plan for how the city would implement the Green Building Task Force's 10 recommendations (Hunt, 2006). Included within the Action Plan was the requirement that any new city buildings achieve LEED certification. This action was known as LEEDing by Example. The Mayor's Action Plan also required that all projects receiving financial support from the city meet LEED certifiability requirements (i.e., new, non-city of Boston buildings receiving financial support from the city had to demonstrate that they could meet LEED requirements but they did not have to go through the official certification process) (City of Boston, 2007a).

Shortly thereafter in 2007, Mayor Menino issued an Executive Order, *An Executive Order Relative to Climate Action in Boston,* focusing explicitly on mitigating and adapting to climate change (City of Boston, 2007c). Among the many things included in the Executive Order, the most pertinent to the city's climate adaptation efforts was a mandate that all city departments and agencies include climate projections in their planning and project-review efforts (Spector, 2014; City of Boston, 2015b). "Effectively, this Executive Order began the process of integrating climate change into everything the city does," noted Carl Spector, Director of Climate and Environmental Planning in the Boston Environment Department (2014).

According to Carl Spector, the impetus for including climate change into city operations was the increasing frequency of flooding and extreme heat events, combined with growing information about projected future climate impacts in Boston. In particular, work coming out of organizations such as the Union of Concerned Scientists and the National Climate Assessment demonstrated how the climate in Massachusetts could change (e.g., Massachusetts could feel more like New Jersey by mid-century), as well as how Boston could be impacted (e.g., Boston will likely experience 2.5 feet of sea level rise by mid-century), were strong motivators for action (City of Boston, 2007b, 2013).

Both the LEEDing by Example program and the requirements from *An Executive Order Relative to Climate Action in Boston* affirmed the city's commitment to greening the public sector. These actions also set a precedent that the city would eventually build upon to promote voluntary, and eventually mandatory, green building efforts in the private sector (City of Boston, 2007a, 2007c).

Partnering with the Private Sector to Bring Climate Considerations to Bear in Development Planning

As mentioned above, until the late 2000s, Boston's adaptation efforts within the built environment focused on government buildings or buildings that received financial support from the city. However, city staff decided that in order for Boston to become more sustainable and resilient in the long-term, the private sector, and private developers in particular, would need to both mitigate and adapt (Dalzell, 2014; Spector, 2014).

The first step in this process was a requirement that all private developers subject to Article 80 of the Boston Zoning Code demonstrate that their projects were LEED certifiable. The specific green building requirement of the Zoning Code, known as Article 37, requires developers to demonstrate to the BRA and the Boston Environment Department that their proposed projects could achieve LEED certification utilizing the most appropriate LEED Rating System(s). Although USGBC certification is not required, most projects seek certification, especially at the Silver, Gold, and Platinum performance levels, to fully demonstrate their leadership and realize market value (Dalzell, 2014). According to John Dalzell, a senior

architect at the BRA, this work was essential as it merged the "regulatory tools and the leadership process to transform market practices" and "allowed us to start a conversation with our community about how to build better buildings" (2014).

Given the success of using Article 80 to transform building practices, combined with growing awareness about the impacts of climate change, BRA and Boston Environment Department staff decided to explore strategies for getting the private sector to also adapt to projected climate impacts. To initiate this process, staff began intermittently asking developers during the project review process if and how they were integrating climate change considerations into their designs for new buildings or their operations of existing buildings (Spector, 2014). These questions were asked informally and responses were not used to inform decisions about permitting. Since developers were not required to answer these questions, no changes to Article 80 of the Boston Zoning Code were needed.

> **"We want to see buildings that are resilient for the occupants. It gets into core strategies of resilience—we don't want to lose businesses, employment opportunities or endanger our residents."**
>
> JOHN DALZELL

Nevertheless, the answers to these informal questions provided insight to city staff about private developers' thinking as it pertained to preparing for climate change; in addition, these questions provided the city with feedback about "what developers saw as their responsibilities and capacity to take action" (Spector, 2014). Asking these questions also provided the city with an opportunity to set the expectation with the development community that climate change was a city priority and should be considered during project design.

While the informal questions during project review provided some useful information, BRA and Boston Environment Department staff wanted more specifics about (1) what developers had already done to prepare their buildings, (2) what developers were planning to do, and (3) what developers saw as the city's responsibility in regards to preparing for climate change (Dalzell, 2014; Spector, 2014). To that end, in 2012 the BRA and the Boston Environment Department collaborated with real estate associations and other development partners to create an online survey to deepen their understanding of and how climate change was being considered in development and redevelopment projects. Collaboration with the development community from the onset helped ensure the questions were clear for builders and developers and helped enhance the number of survey respondents (Dalzell, 2014; Spector, 2014). Initially, the survey was only sent to a select number of building owners and developers, with a particular focus on those near the coast. Over time, however, the survey was given to all applicants for new projects. Carl Spector points out that "the survey was still informal and completion of it was optional, albeit strongly encouraged. However, we were clear to point out that there were no right or wrong answers" (2014).

In part, the development community was willing to engage in these informal discussions between 2009 and 2012 because the timing coincided with a heightened awareness about the threats of extreme weather and climate change to the built environment. In particular, many of the developers that operate in Boston also have operations in New York City, which were affected by Superstorm Sandy.

Integrating Climate Change Consideration Into Article 80 and Requiring Completion of the Checklist

By late 2013, the BRA Board, driven by the work of BRA and Boston Environment Department staff, decided to formally require that all large-scale projects consider climate change impacts (Dalzell, 2014). This was officially achieved in November 2013 through a policy revision to Article 80 of the Boston Zoning Code review process that required all new development projects over 20,000 square feet and all major renovations over 100,000

square feet (i.e., those subject to review under Article 80) to utilize the best available science to "identify changes in the climate and environment and how such changes will affect the project's environmental impacts including survivability, integrity, and safety of the project and its inhabitants" (BRA 2013).

To help developers meet this requirement, BRA and Boston Environment Department staff updated their informal questionnaire and created the Checklist. Developers are now required to complete the Checklist as part of their project review application. The Checklist "requires all projects to consider the impacts of future climate conditions, over the expected life of the project, due to Extreme Heat and Weather and, for projects in or near floodplains or areas prone to flooding, due to Rising Sea-Levels. For any environmental impacts due to climate change that are identified, [respondents must] describe planning, design, and / or construction strategies that will be employed to avoid, eliminate or mitigate any adverse impacts" (BRA, 2013).

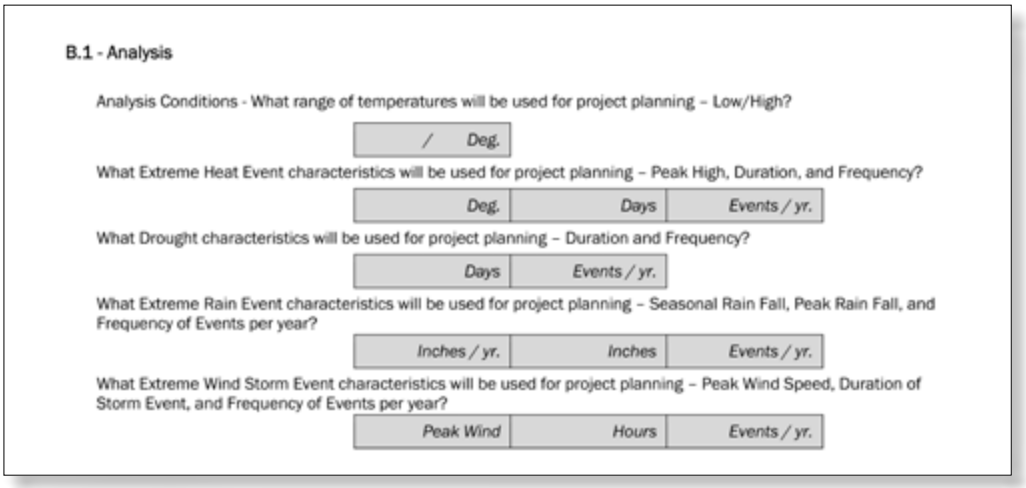
Exhibit 2 provides an example of climate adaptation-related questions into the Checklist. According to the instructions accompanying the Checklist, respondents have to answer questions pertaining to how both direct impacts (e.g., sea level rise, higher maximum and mean temperatures), as well as cascading impacts (e.g., longer interruptions of utility services or disruptions to transportation systems), could impact their proposed projects (BRA, 2013).

Exhibit 3 provides a general schematic of the project review process for projects subject to Article 80.

Leveraging Strong Leaders and Strategic Partnerships

The process to embed climate adaptation considerations into the Boston Zoning Code unfolded over nearly 10 years. During that time, the city worked closely with a number of partners to ensure their proposed path was realistic, manageable, and achievable. One of the key elements of their work, according to John Dalzell, was ensuring that the city was first to act. The city's leadership and innovation in preparing the built environment for climate impacts was evident through both the LEEDing by Example program and Mayor Menino's 2007 Executive Order on Climate Action. What both of these initiatives did was change how internal government operations were unfolding, thereby demonstrating to private developers that preparing for climate change was feasible.

During the development and initial implementation of the Checklist, Brian Sweat was the Director of the Boston Environment Department. He came to the city from Boston Properties, the largest commercial property owner in Boston, where he worked on the organization's sustainability team. His experience with property development in Boston gave him credibility both within government as well as with private developers. Because



B.1 - Analysis

Analysis Conditions - What range of temperatures will be used for project planning – Low/High?

/ Deg.

What Extreme Heat Event characteristics will be used for project planning – Peak High, Duration, and Frequency?

Deg.	Days	Events / yr.

What Drought characteristics will be used for project planning – Duration and Frequency?

Days	Events / yr.

What Extreme Rain Event characteristics will be used for project planning – Seasonal Rain Fall, Peak Rain Fall, and Frequency of Events per year?

Inches / yr.	Inches	Events / yr.

What Extreme Wind Storm Event characteristics will be used for project planning – Peak Wind Speed, Duration of Storm Event, and Frequency of Events per year?

Peak Wind	Hours	Events / yr.

Exhibit 2. Snapshot of Boston's Checklist.

of his wealth of experience, if a developer were to claim that certain activities simply were not feasible, he could draw upon his experience to counter their claims, pointing out examples of work that he had done or that he knew about which refuted such claims. According to Carl Spector, Brian Sweat's experience allowed him to "identify areas where it was practical to move more aggressively than we might have otherwise" (2014). He was a trusted source of information for the private sector and helped to bridge the divide between the city and private developers.

> **"Developing in the city is complex and there are often tradeoffs. By embedding climate adaptation concerns in the development process, we are sending a signal that climate adaptation is an important element that needs to be considered on par with other development concerns."**
>
> CARL SPECTOR

Opposition to Boston's efforts did and continues to exist. The opposition focused on how expensive it would be and who would be responsible for paying for the requisite adaptive measures. Additionally, property developers want to know that the city is taking action within the public realm to ensure the resilience of services such as transportation, electric, sewer, and other public infrastructure. As noted by one developer, "if I make all these changes to my building but my tenants aren't able to get to the facility because the roads or subway is flooded, why should I bother?" (Spector, 2014). This is why, as noted by John Dalzell, it was imperative that the city go first and demonstrate that integrating climate adaptation considerations into built environments was feasible and cost effective.

Using the Checklist to Reduce Vulnerability in Boston

Boston is in the process of implementing the revisions to Article 80 and the requirement to complete the Checklist. BRA and Boston Environment Department staff are quick, however, to point out that the city does not prescribe solutions when a climate impact affects the viability of a development or redevelopment project. The Checklist does, however, reference promising practices that developers are encouraged to consider. What this means is that developers have the flexibility to determine how best to respond to projected climate impacts. For example, for a site facing sea level rise in the coming decades, the developer may choose to raise the base elevation of a building. Alternatively, a builder may decide that the first floor could be sacrificed and design the building with breakaway walls and windows. By leaving the implementation flexible, the City of Boston is giving developers the option of designing solutions that are context specific. According to John Dalzell, "we recognize that there is no one solution, that solutions need to be site and context specific" (2014).

While the BRA and the Boston Environment Department provide developers with flexibility, they can still require changes through the permitting process if the solution proposed by the developer is deemed insufficient. For example, a building proposed for development near the coast or in a Federal Emergency Management Agency (FEMA) floodplain will be required to adhere to practices that ensure the building is capable of withstanding flooding. If the city feels that the proposed practices are insufficient, it can require the developer to consider alternative options. Similarly, if developers fail to address climate change in their applications and the project reviewers believe their proposed projects are likely to be vulnerable, the city can require that applicants redo their Checklists. If a project still fails to address climate change, the reviewers can deny the project, thereby removing it from development consideration. This type of intervention has been rare to date. More commonly, the Checklist provides a foundation for meaningful discussions and brainstorming with project developers about how they can ensure their facilities are maintained for the full lifecycle of the building (Dalzell, 2014; Spector, 2014).

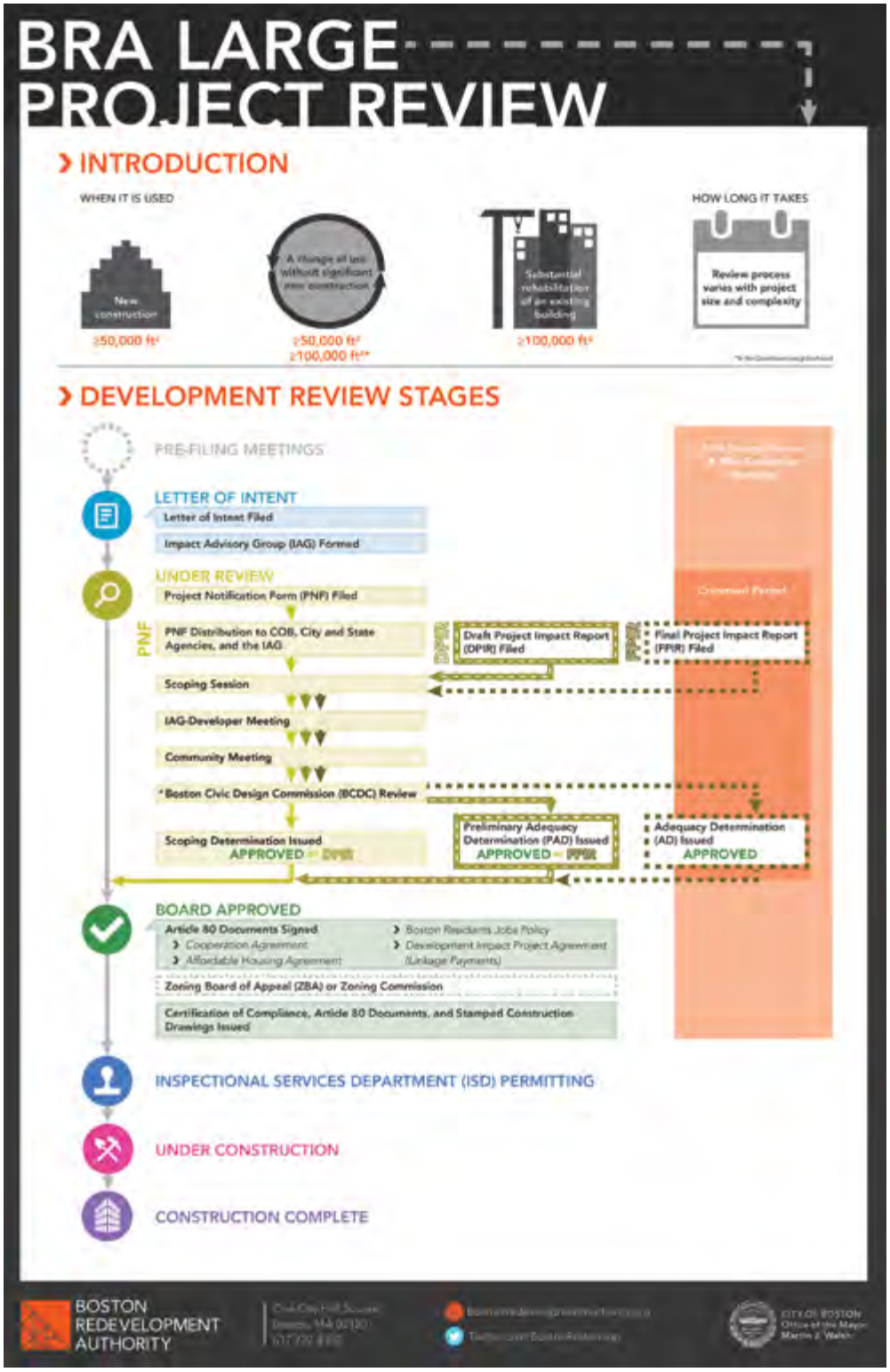


Exhibit 3. BRA large project review process.

> **"The requirement in Article 80 design review guidelines does not specify what builders should do, but it gives a strong signal that something needs to be done while recognizing that there are lots of different approaches to address climate concerns."**
>
> CARL SPECTOR

There are not many projects that have been built since this change in Boston has taken place, meaning that few projects have had to adhere to the climate adaptation requirements in the Checklist. Part of the reason for this is the newness of the requirement as well as the long timeline associated with moving a project from conception to completion. One project that has factored climate change into its major renovation is the Spaulding Rehabilitation Hospital. Spaulding, located on the edge of the Charlestown Navy Yard, had been looking to make a series of upgrades to its facility. But after Hurricane Katrina struck the Gulf Coast, the organization realized that it had to rethink its design in order to ensure the safety of patients and staff in extreme weather situations. Working with the city, Spaulding identified a series of activities, including raising all critical power equipment to higher floors, ensuring that all patient windows are operable, and putting backup power generators on the roof, to help ensure the hospital could stay operational and safe in the case of extreme weather conditions. When making decisions about what actions to take, the Spaulding design team "looked at the worst-case scenario of flooding during a major coastal storm —not just today, but at any point over the next century" (Wickersham, 2012). The results, according to Carl Spector, are one model for how climate change can and should be factored into building design and renovations.

Accomplishments of Boston's Checklist

While clear metrics for gauging the impacts of embedding climate adaptation considerations into Article 80 of the Boston zoning code do not yet exist, what is clear is that the requirement has not slowed down development in the city. According to Carl Spector, the requirement has also led to an increase in awareness and the overall education level of the development community (2014). This can be seen in the increasing quality and depth of responses to Checklist questions that have emerged over time (Spector, 2014).

When asked if the city's work in this area has been a success, John Dalzell and Carl Spector note that Boston's efforts are a work in progress. "I'm reluctant to call it a success yet, but I say it's certainly a productive step," notes Carl Spector. John Dalzell comments, "our work is still nascent but we are making good progress." Perhaps the most important sign that the change to Article 80 and the requirement to complete the Checklist is working is that "it's both changing practice and providing information today so that we can iteratively change practice in the future" (Dalzell, 2014). Ultimately, the requirement is about transforming practice and making climate change considerations part of the mainstream way to develop in Boston, which appears to be happening (Spector, 2014).

Moving Forward

Going forward, the BRA and the Boston Environment Department plan to revise the Checklist to ensure that questions are as clear and direct as possible. In particular, a thorough review of responses received from Checklists indicated that some of the questions were ambiguously worded, leading to some questionable responses. Given this, the city is trying to do a better job of writing clear and direct questions.

The city is also working to develop more specific recommendations on promising practices that developers will be encouraged to consider. For example, instead of

providing a reference to the National Climate Assessment, which the city currently does in the Checklist, Boston is working to extract promising practices from the assessment that it can provide directly to developers. This should streamline the time required to complete the Checklist while also sending a much stronger signal that these promising practices are the types of things Boston is looking for its development community to consider. John Dalzell notes that, "we are already starting to push for other practices that are dual purpose or that have multiple benefits. For example, one of the big things relevant to keeping buildings occupiable or functional is maintaining a reliable source of energy. As such, we are encouraging developers to look at onsite renewable and or clean energy generation. The goal is to be clean and resilient, which is sustainable and financially attractive" (Dalzell, 2014).

In regards to larger next steps, the city is focused on implementing the various strategies included in the *Greenovate Boston: 2014 Climate Action Plan Update.* In particular, the goal of "ensuring public and private sector developments and major capital projects are prepared for expected climate change over their projected life" is likely to drive much of the city's culture adaptation work (City of Boston, 2014). Specific actions that fall under this goal area include (City of Boston, 2014):

- "Work[ing] with property owners, neighborhood groups, and other stakeholders to establish building preparedness priorities, best practices, guidelines for implementation, and cost/benefit information
- Explor[ing] mechanisms to provide property owners financial and technical support for increasing climate preparedness
- Work[ing] with the Commonwealth, the insurance and finance sectors, and property owners to identify modifications to building codes in accordance with, and align insurance policies and incentives and loan underwriting with best practices in building resiliency."

To track progress in these areas as well as the other climate adaptation actions identified in *Greenovate Boston: 2014 Climate Action Plan Update*, the city is creating a set of preparedness indicators. These indicators are being designed as "quantitative measures of the preparedness of the Boston community, [which will help the city] set goals..., and [allow the city] to report on [their progress] annually" (City of Boston, 2014).

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Bibliography

BRA. 2013. Climate Change Preparedness and Resiliency Guidelines. Boston Redevelopment Authority, City of Boston, MA.

BRA. 2015a. A History of the BRA. Boston Redevelopment Authority. Available: http://www.bostonredevelopmentauthority.org/about-us/bra-history. Accessed March 2, 2015.

BRA. 2015b. Boston's Article 80 Review Process. Boston Redevelopment Authority. Available: http://www.bostonredevelopmentauthority.org/projects/development-review/what-is-article-80. Accessed January 15, 2015.

City of Boston. 2003. Menino Announces Green Building Task Force. June 18. Available: http://www.cityofboston.gov/news/Default.aspx?id=1734. Accessed April 16, 2015.

City of Boston. 2007a. Article 37: Green Buildings. Article inserted on January 10. Available: http://www.bostonredevelopmentauthority.org/getattachment/7fb975b2-e811-4a5d-98cf-48c20469c70c. Accessed March 2, 2015.

City of Boston. 2007b. Climate Change. The City of Boston's Climate Action Plan. City of Boston, MA.

City of Boston. 2007c. Executive Order of Mayor Thomas M. Menino: An Order Relative to Climate Action in Boston. Available: http://www.cityofboston.gov/images_documents/Clim_Action_Exec_Or_tcm3-3890.pdf. Accessed January 15, 2015.

City of Boston. 2011. A Climate of Progress: City of Boston Climate Action Plan Update. Available: http://www.cityofboston.gov/images_documents/A%20Climate%20of%20Progress%20-%20CAP%20Update%202011_tcm3-25020.pdf. Accessed March 6, 2015.

City of Boston. 2013. Climate Ready Boston. City of Boston, MA.

City of Boston. 2014. Greenovate Boston: 2014 Climate Action Plan Update. Summary Report. Available: http://www.cityofboston.gov/images_documents/Greenovate%20Boston%202014%20CAP%20Update_Summary_tcm3-49733.pdf. Accessed March 6 2015.

City of Boston. 2015a. 2014 Draft Climate Action Plan: For Public Comment. City of Boston. Available: http://www.cityofboston.gov/images_documents/Draft%202014%20CAP%20Update%20For%20Public%20Comment_12NovFINAL2_tcm3-48598.pdf. Accessed March 2, 2015.

City of Boston. 2015b. Archives Guide—Planning Board (4030). Available: http://www.cityofboston.gov/archivesandrecords/guide/planning.asp. Accessed March 2, 2015.

City of Boston. 2015c. Boston Living With Water. Available: http://www.bostonlivingwithwater.org/. Accessed March 6, 2015.

Dalzell, J. 2014. Interview with John Dalzell, Senior Architect, Boston Redevelopment Authority. December 5.

Hunt, III, J. 2006. Sustainable Boston: A Greenprint for Our Future. Available: http://www.usmayors.org/energysummit/atlanta06/presentations/friday/hunt.ppt. Accessed December 2, 2014.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. doi: 10.7930/J0Z31WJ2.

Spector, C. 2014. Interview with Carl Spector, Director of Climate and Environmental Planning with the Boston Environment. December 5.

Commonwealth of Massachusetts. 2011. Massachusetts Climate Change Adaptation Report: September 2011. Submitted by the Executive Office of Energy and Environmental Affairs. Available: http://www.mass.gov/eea/docs/eea/energy/cca/eea-climate-adaptation-report.pdf. Accessed August 4, 2015.

Wickersham, J. 2012. Spaulding Rehab puts climate change in concrete terms. The Boston Globe. April 20. Available: http://www.bostonglobe.com/opinion/2012/04/19/spaulding-rehab-puts-climate-change-concrete-terms-preparing-for-great-flood/VIv8s4C42oWkFX0wFaVuil/story.html. Accessed March 2, 2015.

Chula Vista, California

Cool Roofs Ordinance and Shade Trees Policy

CHULA VISTA, CALIFORNIA

AUTHORS: Heather Hosterman, Karen Carney, and Jason Vogel

In this case study, you will learn about:

- Implementation of a climate change adaptation process to engage the community in selecting adaptation options
- Reducing vulnerability to warming temperatures and the urban heat island effect through a cool roofs ordinance and a shade tree policy

Case Study Summary

The City of Chula Vista, the second largest city in the San Diego metropolitan area, developed a stakeholder-driven climate planning process to identify, evaluate, and implement a suite of climate adaptation actions. The suite of actions targets energy use; the urban heat island effect; public health; coastal resources; water supply and reuse; and the local, green economy (Reed, 2014). In this case study, we focus on two specific actions intended to address warming temperatures in the San Diego region (City of Chula Vista, 2011):

- Chula Vista's cool roofs ordinance mandates the use of reflective or "cool" materials for roofs in new residential developments to reduce urban heat island effects (City of Chula Vista, 2011). From 2012 to 2013, Chula Vista required cool roofs on all new inland residential developments (Reed, 2014, 2015). The city is currently revising its cools roofs program to meet California building standards; the city expects to expand the cool roofs policy to new residential buildings in the entire city (Reed, 2015).
- Chula Vista's shade trees policy mandates the planting of shade trees in new parking lot projects to reduce urban heat island effects; these plantings must achieve 50 percent canopy cover over parking stalls within 5 to 15 years of planting (City of Chula Vista, 2012; Reed, 2014).

Chula Vista developed policies that require the integration of these actions into new development projects in 2010; these policies were approved by the City Council in October 2010. According to Brendan Reed, Chula Vista's Environmental Resource Manager, city staff are now working with developers to implement these policies. Between 2012 and 2013, Chula Vista had incorporated some cool roofs into new developments; since 2013, the program has been on hold while the city evaluates how its green building standards will meet California's new building codes (Reed, 2015). As of March 2015, the city had not incorporated shade trees into new developments, but city staff are working with developers to ensure their inclusion in future projects (Radley, 2015). Although it will take more time to know the full impact of Chula Vista's actions, community members feel that the implemented actions will reduce the city's vulnerability to the urban heat island effect.

Broader Context

The City of Chula Vista started working on climate change in the early 1990s.[5] Chula Vista was the first local government of fewer than one million residents to become a founding member of the International Council for Local Environmental Initiatives (ICLEI; Reed et al., 2005). The city adopted a Climate Action Plan in 2000 to address the threat of climate change to their community (City of Chula Vista, 2000). The Climate Action Plan identified Chula Vista's carbon dioxide (CO2) emissions and mitigation measures to reduce CO2 emissions (City of Chula Vista, 2000). In 2008 and 2011, Chula Vista revised its Climate Action Plan to incorporate climate change mitigation and climate change adaptation, respectfully.

To revise and implement the city's Climate Action Plan, Chula Vista developed and implemented a stakeholder-driven climate planning process. This process involved several steps:

Step 1. Develop a roadmap. City staff developed a roadmap that (1) clearly outlined the tasks for the Climate Change Working Group (CCWG); (2) established a timeline for the tasks; and (3) listed community sectors that should be represented through the process. In essence, the roadmap established the ground rules for identifying and evaluating climate adaptation actions.

Step 2. Engage stakeholders. City staff used the sectors identified in the roadmap to invite residents, businesses, and community representatives to the CCWG. The City recruited 16 members from organizations that would be vulnerable to the local impacts of climate change (or that had constituents who would be) as well as organizations in a position to help implement climate adaptation strategies. Over a one-year time period, city staff worked with the CCWG and the community to identify and evaluate

5. Interviewees were unable to specify why the city started working on climate change in the early 1990s. However, they believe that the City of Chula Vista had a baseload power plant in its jurisdiction at that time and environmental justice issues around the power plant were a motivator for involvement in climate change (Reed, 2015).

climate mitigation or adaptation actions to present to the City Council. The CCWG also helped city staff host public workshops on the planning process that engage other residents and encourage other community members to contribute to the planning effort at City Council or commission meetings.

Step 3. Gather information. Throughout the year, the CCWG gathered technical information, such as projected climate change impacts for the region and a range of potential mitigation or adaptation actions to mitigate or adapt to those impacts. The CCWG also invited technical experts in the region to present regional climate change data and information.

Step 4. Analyze options. The CCWG, with input from city staff, then analyzed the options. The public was often involved in providing comments on the options.

Step 5. Select and recommend options. Finally, the CCWG prioritized and selected the final options to include in the Climate Action Plan. The selected options were then recommended to the City Council and the community. The CCWG participated in city commission meetings, City Council meetings, and public workshops to introduce the city's climate adaptation risks and recommend adaptation actions to address those risks.

In 2008, the CCWG used this process to review over 90 climate change mitigation measures designed to reduce greenhouse gas emissions in Chula Vista's municipal operations and the broader Chula Vista community. The CCWG ultimately recommended seven climate mitigation measures, which the City Council approved and are implementing (Exhibit 1).

Recognizing that even with mitigation efforts, the climate will still change, the City Council directed staff to reconvene the CCWG to look at how the city could prepare itself for climate change impacts and create a climate adaptation strategy. The CCWG reviewed 180 potential adaptation actions and ultimately recommended 11 climate adaptation actions. See Appendix A for information about the climate adaptation matrix used to quantify climate risks, categorize the 180 potential adaptation actions, and score the adaptation actions. In October 2010, the City Council accepted the CCWG's recommendation to implement the 11 climate adaptation

Exhibit 1. List of Chula Vista climate mitigation measures and climate adaptation actions

Climate mitigation measures:	Climate adaptation actions:
• Clean vehicle replacement policy for city fleet	• Cool paving[a]
• Clean vehicle replacement policy for city-contracted fleets	• Shade trees[a]
• Business energy evaluations	• Cool roofs[a]
• Green building standard	• Local water supply and reuse
• Solar and energy-efficiency conversion program	• Stormwater pollution prevention and reuse
• Smart growth around trolley stations	• Education and wildfires
• Turf lawn conversion program	• Extreme heat plans
	• Open space management[a]
	• Wetlands preservation[a]
	• Sea level rise and land development codes
	• Green economy[a]

a. These measures have the potential for both mitigation and adaptation benefits.
Sources: City of Chula Vista, 2008, 2011.

actions, including a cool roofs ordinance and shade trees policy in new development projects to reduce vulnerability to urban heat island effect (Exhibit 1). We focus this case study on these two programs.

In addition to Chula Vista's work on climate change, Chula Vista is part of a larger, regional collaborative in San Diego—the San Diego Regional Climate Collaborative (Climate Collaborative). The Climate Collaborative was established in 2011 to provide a forum for public agencies to share experiences, leverage resources, and advance solutions on climate change planning (Hedge, 2015). The mission of the Climate Collaborative is "to be a network for public agencies that serve the San Diego region by sharing expertise, leveraging resources, and advancing comprehensive solutions to facilitate climate change planning" (Climate Collaborative, 2014). Climate Collaborative members include public agencies—for example, the cities of Chula Vista and San Diego and the San Diego Airport Authority—and supporting members—for example, the San Diego Foundation and San Diego Gas & Electric (Climate Collaborative, 2014). Chula Vista is involved in the Climate Collaborative's efforts to develop a Multi-Jurisdictional Hazards Management Plan that incorporates climate change risks (Reed, 2015).

How and Why Chula Vista Implemented Its Suite of Adaptation Actions, Specifically the Cool Roofs Ordinance and Shade Trees Policy

As we describe below, several factors led to Chula Vista's implementation of the cool roofs ordinance and shade trees policy to reduce the city's vulnerability to urban heat island effect. Exhibit 2 shows the timeline of factors leading to community action.

Chula Vista Citizens Sensitized to Climate Change through Climate Hazards

Climate hazards are already affecting the Chula Vista community. The San Diego region is prone to wildfires (San Diego Foundation, 2008) –persistent dry weather and low moisture, combined with Santa Ana winds, created fire-conducive conditions that enabled the 2003 wildfire in the San Diego region to spread rapidly and may have enabled the 2007 wildfire (Exhibit 3; Viswanathan et al., 2006). These wildfires burned approximately 745,600 acres in San Diego County, destroyed more than 4,200 homes and many other structures, killed 25 people, and resulted in significant local firefighting

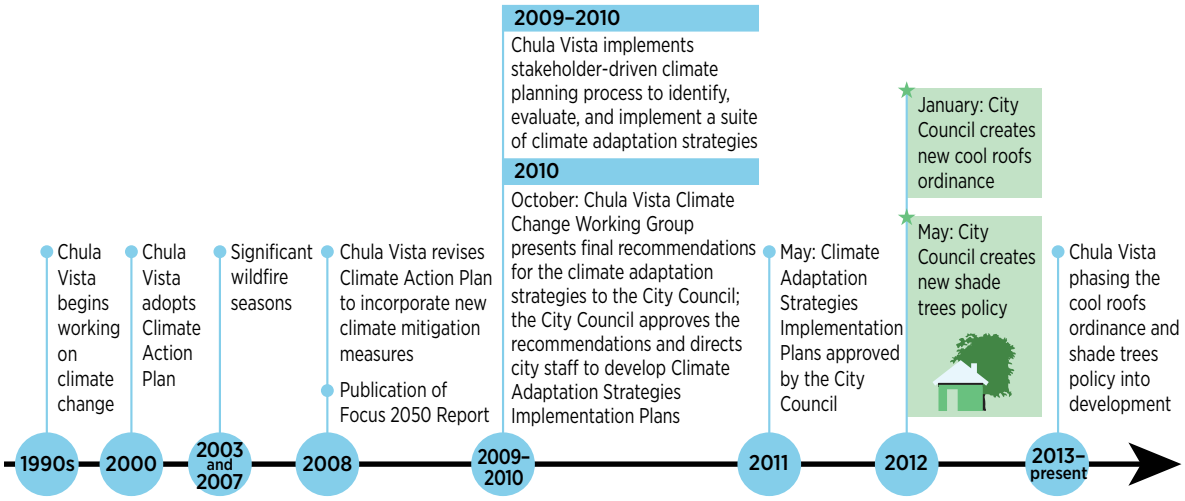

Exhibit 2. Chula Vista timeline of factors that lead to community action.

Exhibit 3. Harris Fire in San Diego County in 2007.
Source: David S. Roberts.

costs—upwards of $80 million for the 2007 wildfire (San Diego State University Foundation, Undated). In addition to wildfires, the region has experienced warming temperatures. In 2013, temperatures were 1.7°F above the historical average (San Diego Foundation, 2014).

These types of events may become more frequent and severe in the future (San Diego Foundation, 2008). Recent catastrophic wildfires and gradually warmer temperatures are raising awareness about potential climate impacts in the region, which is generating awareness of climate change. Brendan Reed indicated that wildfires, which burned on the eastern edge of Chula Vista, were "visual hazards" for the community (Exhibit 3). Increased awareness of climate change from these visual hazards prompted the San Diego Foundation to increase its focus on climate change. According to Nicola Hedge, Director of Environment Initiatives at the San Diego Foundation, wildfires were catalytic in increasing the San Diego Foundation's role in climate change and developing the report, San Diego's Changing Climate: A Regional Wake-up Call (Focus 2050 Report; San Diego Foundation, 2008; Hedge, 2015), described below. In addition, by 2050, scientists expect annual average temperatures will be between 1.5 and 4.5°F warmer (San Diego Foundation, 2014). Increased awareness of climate hazards, combined with other factors, focused Chula Vista's climate adaptation actions on specific climate risks, such as the cool roofs ordinance and shade trees policy to address warming temperatures.

The Focus 2050 Report Empowers City Staff to Take Action

The Focus 2050 Report, commissioned by the San Diego Foundation, further spurred Chula Vista's interest in "better understanding the potential vulnerability of its infrastructure, economy, and public health to climate change" (Reed, 2014, p. 47). The report presented downscaled climate change impact data for the region in a short and digestible report that was accessible to resource practitioners and policymakers (Exhibit 4; Reed, 2015). The report also identified adaptation as a necessary part of climate action (Reed, 2015). As Brendan Reed stated, "I can't say enough of the importance of this report in providing digestible information to city staff and politicians. I'm not a climate scientist, so having digestible climate information is critical in being able to take action" (Reed, 2015).

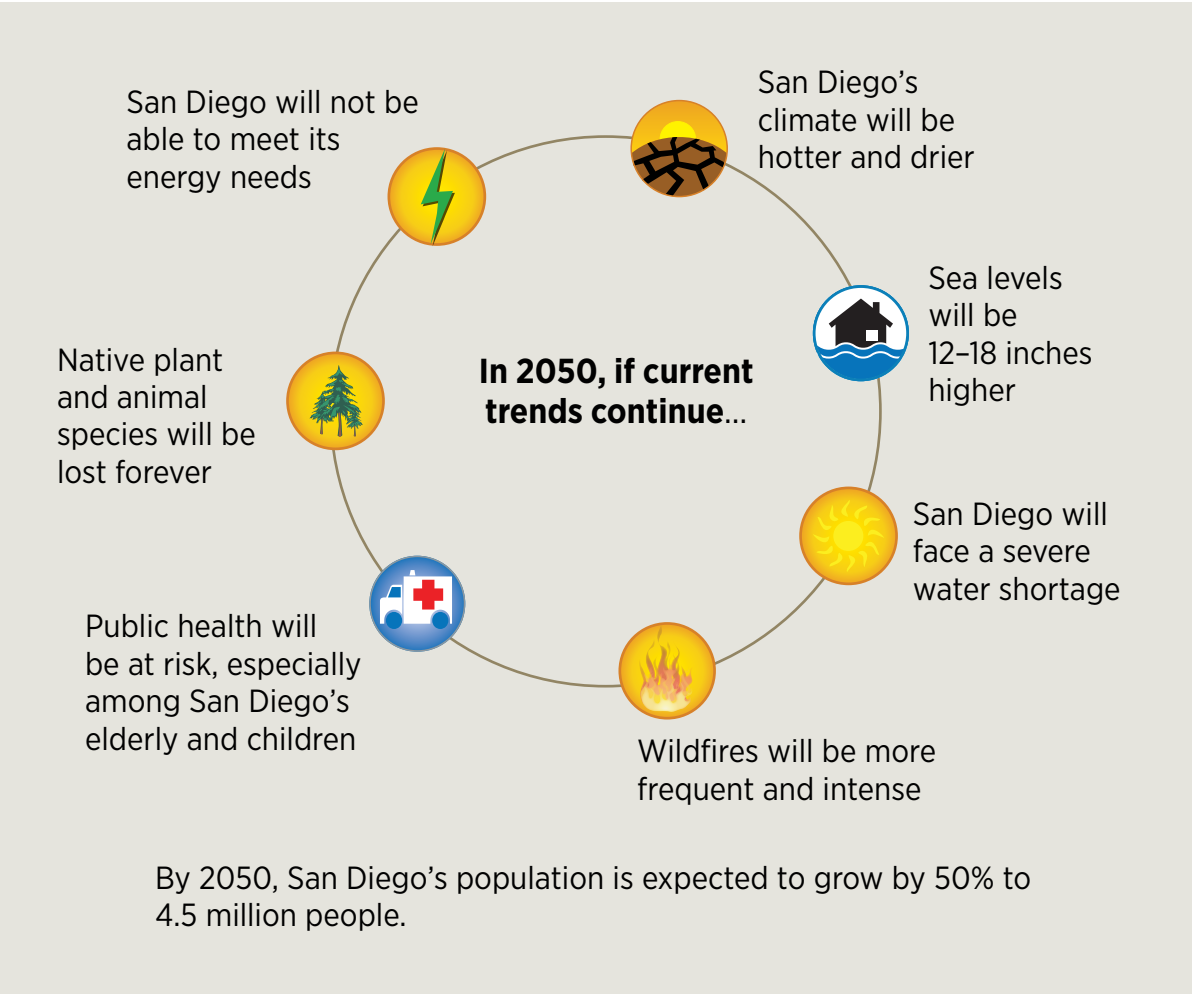

Exhibit 4. San Diego's changing climate.
Source: San Diego Foundation, 2008.

The Focus 2050 Report was modeled after a similar report in King County, Washington and was produced with input, guidance and expertise from more than 40 local scientists, as well as community and technical experts (Hedge, 2015). Before developing the Focus 2050 Report, The San Diego Foundation worked with other community partners to invite Ron Sims, a former King County Executive, to speak with Foundation staff and other local leaders regarding how King County and other regions can tackle the challenge of climate change (Snover et al., 2007; Hedge, 2015). The 25-page Focus 2050 Report was presented to city councils and nonprofits in the region, and disseminated through local media (Hedge, 2015). The highlights from the Focus 2050 Report were later incorporated into the State of California's Climate Adaptation Strategy in 2009 and have been used by several local agencies and decision-makers to inform climate action efforts (California Natural Resources Agency, 2009; Reed, 2014). Given the utility of the first report, the fast changing landscape of climate action and new climate science available through regional research institutions, the Foundation recently collaborated with other organizations in a project called Climate Education Partners to publish an updated version of the Focus 2050 Report (Hedge, 2015).

Chula Vista Develops Plans for the Cool Roofs Ordinance and Shade Trees Policy

As described in the broader context section, the City of Chula Vista undertook the climate planning process to evaluate how the city could prepare itself for climate change impacts. The climate planning process resulted in a recommendation for 11 climate adaptation actions, including mandating cool roofs and shade trees for new development projects:

- For cool roofs, the CCWG suggested creating a new ordinance that required the use of cool roofs (i.e., roofs with colors that improve solar reflectance) on new residential developments
- For shade trees, the CCWG suggested the city adopt a new shade tree policy that required the incorporation of shade trees into all municipal projects and all private development parking lot projects.

Once the climate planning process was complete, city staff developed Climate Adaptation Strategies Implementation Plans; these plans were approved by the City Council in May 2011 (City of Chula Vista, 2011). Although the planning process was different for each adaptation action, these implementation plans tended to include information on implementation steps, economic costs, performance metrics, and timelines (City of Chula Vista, 2011; Reed, 2015):

- To inform the cool roofs adaptation strategy, for example, the city conducted a cost-effectiveness study that compared the cost of traditional roofs versus the cost of cool roofs, and the payback period for the energy savings from the cool roofs (Reed, 2014). The study concluded that cool roofs would be cost-effective for inland homes, where temperatures are higher, because the energy savings would pay back the incremental costs of the cool roof over its lifetime (Reed, 2014). As such, new inland developments were required to install cool roofs.
- To inform the shade trees adaptation strategy, a working group of city staff and landscape architect consultants was convened to develop an achievable shade trees policy. According to Mary Radley, landscape architect for Chula Vista, this working group looked at existing policies, such as the landscape design manual and planning documents, and tackled concerns about "turning parking lots into forests instead of their functional use of parking for cars" and ensuring the policy conformed with tree growth estimates for parking lots (Radley, 2015). This working group shifted the focus of the new policy from shading 50 percent of the full parking lot to shading 50 percent of parking spaces, which was considered achievable and acceptable to city staff (Radley, 2015).

In developing the Climate Adaptation Strategies Implementation Plans, city staff created mechanisms to phase in the use of cool roofs and shade trees in new developments:

- For the cool roofs adaptation action, the City Council created an ordinance in January 2012 to require new homes in its eastern area to use cool roofing materials; Chula Vista's building code was amended in March 2012 to implement the ordinance as outlined in California's green building guidelines (Reed, 2014). However, when the State of California updated its energy code in 2013, Chula Vista's energy codes were voided. As such, Chula Vista is in the process of redoing the cool roof cost-effectiveness analysis. Based on preliminary results, the city expects to expand the cool roofs policy to new residential buildings in the entire city (Reed, 2015).
- For the shade trees adaptation action, the City Council implemented a new policy in May 2012 that required shade trees for new parking lots that achieve 50 percent canopy cover over parking spaces within 5 to 15 years of planting (City of Chula Vista, 2012). The policy also allows for flexibility in alternative compliance methods such as light colored or "cool" paving or solar carport shade structures, and provides extra credit for retaining healthy, mature trees (City of Chula Vista, 2012). The shade tree working group also updated the Chula Vista Landscape Manual to align it with the new Shade Tree Policy and ensured that the Chula Vista Design Manual was consistent with the new Shade Tree Policy (Radley, 2015).

Chula Vista is currently phasing the cool roofs ordinance and shade trees policy into development.

Accomplishments from Implementing the Cool Roofs Ordinance and Shade Trees Policy

By November 2013, Chula Vista completed all implementation progress steps it outlined for the cool roofs ordinance and shade trees policy (City of Chula Vista, 2013). According to Brendan Reed, these steps will reduce Chula Vista's vulnerability to heat over the long-term (Reed, 2015). To track the performance of each adaptation strategy, Chula Vista developed performance metrics. The cool roofs strategy uses the "number of new residential units that incorporate cool roofs" to quantify its performance and the shade trees strategy uses the "number of new projects that incorporate the new shade trees standard" (City of Chula Vista, 2011, pp. 9 and 12). Starting in 2012, some new homes had been constructed with cool roofs; however, as mentioned above, the cool roofs strategy is currently under review. In addition, the city is currently working to ensure that all new development projects comply with the new shade trees policy; however, it has not officially tracked compliance rates (Radley, 2015). According to Mary Radley, the impact of the shade trees policy is likely to be limited, even with full compliance: "it will improve parking lots by providing more shade; however, it is not a radical improvement" (Radley, 2015).

> **"Mitigation is a 5K, while adaptation is the marathon. For adaptation, we are institutionalizing climate change and climate adaptation into the city's policies now—expecting big returns later."**
>
> BRENDAN REED

Interviewees agreed that Chula Vista was successful in integrating climate change adaptation into the city's planning, management, and operations. Pamela Bensoussan, Chula Vista's city council member and deputy mayor, pointed to fact that climate change is increasingly being integrated into all aspects of life in Chula Vista—education programs on climate change are integrated into schools, residential xeriscape gardens are becoming common, and infrastructure for electric vehicles is widespread (Bensoussan, 2015). Brendan Reed suggested that Chula Vista has shown leadership in creating actionable climate change plans, and the city has taken more of a deep dive into action than most communities (Reed, 2015). Nicola Hedge indicated that the San Diego Foundation and other regional communities often point to Chula Vista as a leader in the region in taking tangible, discrete actions, and reporting back to their City Council on their progress (Hedge, 2015).

Over the years, Chula Vista received many acknowledgements and accolades for its work on climate change. Most recently, Chula Vista received the U.S. Environmental Protection Agency's 2014 Climate Leadership Award for providing climate action leadership to their peers, competitors, and partners. According to Pamela Bensoussan, "these awards are constant positive reinforcements to elected officials to continue doing [climate change] work" and these awards help to guarantee political will to act on climate change (Bensoussan, 2015).

Moving Forward

Chula Vista continues to implement and improve its adaptation actions. For the shade trees policy, the city is working with developers to ensure compliance in all new development projects. For the cool roofs ordinance, the city is in the process of redoing its cost-effectiveness analysis under the new California energy codes. City personnel hope to expand the cool roofs policy from only inland structures to the entire city (Reed, 2015).

Moreover, the San Diego Foundation is very active in the regional climate change issues. For example, the San Diego Foundation is investing in building the capacity of local researchers to conduct a population vulnerability assessment for the entire San Diego region to identify and map those populations most vulnerable to climate change impacts (Hedge, 2015; for more information, see Exhibit 5). Climate change will likely have more

immediate and significant impacts on vulnerable communities; the Foundation expects that the vulnerability mapping information will empower these vulnerable communities to increase their capacity to prepare for the effects of climate change (Hedge, 2015). The Foundation expects this information will be available to communities by the end of 2015 (Hedge, 2015).

EXHIBIT 5. IDENTIFYING AND MAPPING IMPACTS OF CLIMATE CHANGE ON VULNERABLE COMMUNITIES IN SAN DIEGO

Drs. Stigler-Granados and Gersberg conducted a population vulnerability assessment at the census tract level for San Diego County to better understand the distributional and equity implications of climate change. Results from the vulnerability assessment indicated that several communities in the county were at high or elevated risk to the negative impacts of climate change such as heat stress, displacement due to sea level rise and increased illness. The most vulnerable populations were mostly located in inner city neighborhoods and along the U.S.-Mexico border.

Based on these findings, the researchers conclude that:

- New initiatives could be developed that integrate the priorities and needs of communities vulnerable to the effects of climate change. For example, public health planners could develop early warning systems in appropriate languages.
- Increased surveillance and monitoring of identified areas can be helpful for reducing overall population impacts.
- Leaders from these communities can assist in appropriate adaptation strategy planning.

Source: Stigler-Granados and Gersberg, Undated.

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- **Pamela Bensoussan,** City Council member and deputy mayor, City of Chula Vista
- **Nicola Hedge,** director of environment initiatives, San Diego Foundation.

Bibliography

Associated Press. 2014. Southern California Swelters in Heat Wave. USA Today. September 15. Available: http://www.usatoday.com/story/weather/2014/09/15/southern-california-heat-wave/15689051/. Accessed March 10, 2015.

Bensoussan, P. 2015. Interview with Pamela Bensoussan, City Council Member and Deputy Mayor, City of Chula Vista. March 4.

California Natural Resources Agency. 2009. 2009 California Climate Adaptation Strategy. A Report to the Governor of the State of California in Response to Executive Order S-13-2008. Available: http://resources.ca.gov/docs/climate/Statewide_Adaptation_Strategy.pdf. Accessed March 10, 2015.

City of Chula Vista. 2000. Chula Vista CO2 Reduction Plan. Adopted November 14. Available: http://38.106.5.202/home/showdocument?id=5445. Accessed April 14, 2015.

City of Chula Vista. 2008. Climate Change Working Group Measures. Implementation Plans. July. Available: http://38.106.5.202/home/showdocument?id=5433. Accessed April 3, 2015.

City of Chula Vista. 2011. Climate Adaptation Strategies. Implementation Plans. May. Available: http://38.106.5.202/home/showdocument?id=5443. Accessed March 9, 2015.

City of Chula Vista. 2012. Shade Tree Policy. Policy Number 576-19. January 3. Available: http://www.chulavistaca.gov/home/showdocument?id=8093. Accessed March 9, 2015.

City of Chula Vista. 2013. Climate Action Plan. Implementation Progress Report. November. Available: http://38.106.5.202/home/showdocument?id=5441. Accessed March 12, 2015.

Climate Collaborative. 2014. San Diego Regional Climate Collaborative. Available: http://sdclimatecollaborative.org/. Accessed April 14, 2015.

Hedge, N. 2015. Interview with Nicola Hedge, Director of Environment Initiatives, San Diego Foundation. March 4.

Politico. 2012. 2012 Presidential Election. Available: http://www.politico.com/2012-election/results/map/#/President/2012/. Accessed February 4, 2013.

Radley, M. 2015. Interview with Mary Radley, Landscape Architect, City of Chula Vista. March 4.

Reed, B. 2014. Leveraging climate adaptation planning for heat island mitigation. Sustain, A Journal of Environmental and Sustainability Issues. 29:47–49. The Kentucky Institute for the Environment and Sustainable Development. Available: http://louisville.edu/kiesd/sustain-magazine/SUSTAIN-29rev.pdf. Accessed March 10, 2015.

Reed, B. 2015. Interview with Brendan Reed, Environmental Resource Manager, City of Chula Vista. March 4.

Reed, B., M. Meacham, and R. Partida-Lopez. 2005. 2005 Greenhouse Gas Emissions Inventory. City of Chula Vista. Available: https://sphinx.chulavistaca.gov/clean/conservation/climate/documents/GHG_InventoryReport_Final.pdf?s=3D1B-67956F94EE4C8EAC34649038918E483B5EBA. Accessed March 10, 2015.

San Diego Foundation. 2008. San Diego's Changing Climate: A Regional Wake-up Call. A Summary of the Focus 2050 Study Presented by the San Diego Foundation. Available: http://www.sdfoundation.org/Portals/0/Newsroom/PDF/Reports/Focus2050glossySDF-ClimateReport.pdf. Accessed April 17, 2015.

San Diego Foundation. 2014. San Diego, 2050 Is Calling. How Will We Answer? Available: http://www.sandiego.edu/2050/. Accessed March 10, 2015.

San Diego State University Foundation. Undated. The San Diego Wildfires Education Project. San Diego State University. Available: http://interwork.sdsu.edu/fire/purpose.htm. Accessed March 10, 2015.

Snover, A.K., L. Whitely Binder, J. Lopez, E. Willmott, J. Kay, D. Howell, and J. Simmonds. 2007. Preparing for Climate Change: A Guidebook for Local, Regional, and State Governments. The Climate Impacts Group and King County Washington. In association with and published by ICLEI—Local Governments for Sustainability.

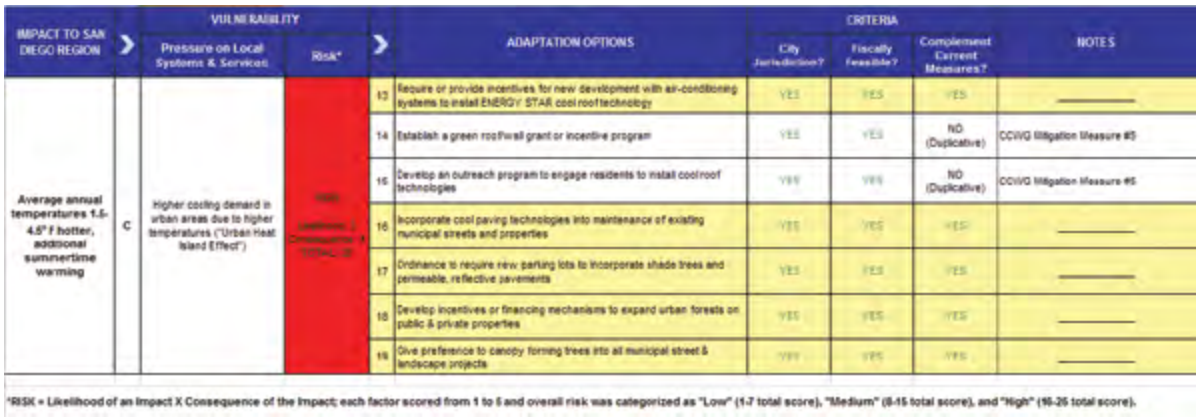
Stigler-Granados, P. and R. Gersberg. Undated. Identifying and Mapping Impacts of Climate Change on Vulnerable Communities in San Diego, CA. Research Poster. San Diego State University.

U.S. Census Bureau. 2013a. B19013: Median Household Income in the Past 12 Months (in 2013 inflation-adjusted dollars). 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. Census Bureau. 2013b. DP05: Demographic and Housing Estimates. 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. EPA. 2014. Heat Island Effect. United States Environmental Protection Agency. Available: http://www.epa.gov/heatisland/. Accessed March 9, 2015.

Viswanathan. S., L. Eria, N. Diunugala, J. Johnson, and C. McClean. 2006. An analysis of effects of San Diego wildlife on ambient air quality. Journal of the Air & Waste Management Association 6:56–67.



IMPACT TO SAN DIEGO REGION		VULNERABILITY			ADAPTATION OPTIONS	CRITERIA			NOTES
		Pressure on Local Systems & Services	Risk*			City Jurisdiction?	Fiscally Feasible?	Complement Current Measures?	
Average annual temperatures 1.5-4.5° F hotter, additional summertime warming	C	Higher cooling demand in urban areas due to higher temperatures ("Urban Heat Island Effect")	[illegible]	13	Require or provide incentives for new development with air-conditioning systems to install ENERGY STAR cool roof technology	YES	YES	YES	———
				14	Establish a green roof/wall grant or incentive program	YES	YES	NO (Duplicative)	CCWG Mitigation Measure #5
				15	Develop an outreach program to engage residents to install cool roof technologies	YES	YES	NO (Duplicative)	CCWG Mitigation Measure #6
				16	Incorporate cool paving technologies into maintenance of existing municipal streets and properties	YES	YES	YES	———
				17	Ordinance to require new parking lots to incorporate shade trees and permeable, reflective pavements	YES	YES	YES	———
				18	Develop incentives or financing mechanisms to expand urban forests on public & private properties	YES	YES	YES	———
				19	Give preference to canopy forming trees into all municipal street & landscape projects	YES	YES	YES	———

*RISK = Likelihood of an Impact X Consequence of the Impact; each factor scored from 1 to 5 and overall risk was categorized as "Low" (1-7 total score), "Medium" (8-15 total score), and "High" (16-25 total score).

Appendix A. Chula Vista Climate Adaptation Planning Process

Chula Vista city staff developed adaptation matrices to quantify climate risks and categorize climate adaptation actions. Above is the matrix for projected warming air temperatures.

The risks were described as the product of the likeliness of an impact occurring and the consequence of that impact on the local community. Each factor was scored from one to five and overall risk was categorized as "low," "medium," or "high." The CCWG, with help from city staff, then evaluated the adaptation options for the specific risk using the following screening criteria:

- Is the action in the city's jurisdiction? For example, the city has an external water provider and, therefore, the city has limited influence on actions that look at water supply and conveyance.
- Is the action fiscally feasible? For example, the action does not rely on General Fund support for implementation.
- Does the action complement current measures? For example, the city did not want the adaptation action to contradict or duplicate current mitigation measures.

As shown in this matrix, Chula Vista ranked projected warming air temperatures as a high vulnerability risk (scoring 20 out of 25 points) and considered several adaptation options as in the city's jurisdiction, fiscally feasible, and complementary of current measures.

Cleveland, Ohio

The Neighborhood Climate Action Toolkit and Climate Action Fund

CLEVELAND, OHIO

AUTHORS: Missy Stults, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- Strategies for engaging citizens in low income areas
- Building neighborhood cohesion and stability to create the adaptive capacity needed to address climate change
- How Cleveland is navigating the challenge of quantifying vulnerability reductions when climate change is mainstreamed within discussions of broader community concerns (e.g. economic development, human health)

Case Study Summary

Once a city with a strong manufacturing economy, Cleveland has seen a stark decline in this economic base, yielding increased poverty rates and growing economic disparity. In recent years, the city has also experienced increases in the frequency and duration of high heat days and heavy precipitation events, trends that are expected to continue or worsen under future climate change.

Despite recent rebounds in some core neighborhoods, Cleveland has the second highest rate of poverty among major U.S. cities, with more than 35 percent of the population residing in poverty (up to 65 percent in certain neighborhoods). As such, the city has closely tied its climate change efforts to the revitalization of its neighborhoods. The city believes that helping provide residents with safe and stable neighborhoods that have economic opportunities will build the enabling conditions needed to have a more adaptive citizenry that is able to incorporate climate change into their thinking and actions.

The city's work on this began in earnest in 2009 with the Sustainable Cleveland 2019 initiative, and was continued through a detailed citywide climate action plan and the development and rollout of the Cleveland Neighborhood Climate Action Toolkit (Toolkit). Designed and implemented in tandem with Community Development Corporations (CDCs), the Toolkit helps neighborhoods leverage existing assets to fight economic decline, increase adaptive capacity, reduce greenhouse gas emissions, and prepare for a climate-altered future. Through the Toolkit, residents are given an opportunity to identify what assets make their neighborhoods strong and what challenges they currently face that need attention. After participating in a workshop, during which they complete the Toolkit, residents are able to apply for funding from the City's Climate Action Fund to implement specific projects. While still in its infancy, the Toolkit is designed to build social cohesion, a critical aspect of adaptive capacity in Cleveland's view, in pilot neighborhoods. If, and to what degree, the Toolkit and the associated Climate Action Fund will lead to reductions in the city's vulnerability to climate impacts still remains to be seen.

> **We know that a connected community is a more resilient community.**
>
> APARNA BOLE, MD, FAAP.
> Sustainability Manager, University Hospitals (UH)
> Medical Director, Community Integration, UH
> Rainbow Babies & Children's Hospital

The Broader Context of the Cleveland Toolkit and Climate Action Fund

When the Great Recession of 2007 hit, Cleveland was already struggling economically and socially, having not yet rallied from the urban decline of the 1960s and 1970s that disproportionately impacted low-income neighborhoods. According to Krumholz and Hexter (2012, p. 1), the "neighborhood crisis of the 1970s … was a reaction to the urban renewal and highway programs of the 1960s, school desegregation and white flight, the unresponsiveness of city services, and the redlining by banks and insurance companies." The dearth of investment in poor urban neighborhoods during this time left many neighborhoods disconnected and fragmented from one another and from city government. When the Great Recession struck, the city, and in particular the historically marginalized neighborhoods and their residents had very little capacity to cope with the economic perturbations brought on by the crisis. For example, between early 2008 and 2014, Cleveland lost 13,000 jobs and saw the community-wide poverty rate rise to more than 35 percent (Perkins, 2015; U.S. Census, 2015).

This rapidly deteriorating state of life for residents spurred Cleveland Mayor Frank G. Jackson and his staff to initiate a process to re-envision the future for the city, which crystallized into Sustainable Cleveland 2019 (Sustainable Cleveland 2019, 2015). The goal of Sustainable Cleveland 2019 is to "develop a 10-year initiative that engages people from all walks of life, working together to design and develop a thriving and resilient Cleveland region that leverages its wealth of

assets to build economic, social, and environmental well-being for all" (Sustainable Cleveland 2019, 2015). One of the key components of the Sustainable Cleveland 2019 platform is an annual Summit in which "a diverse group of people vested in and dedicated to Cleveland … use their vast knowledge and imagination to create an action plan for building a green economy for Cleveland's future" (Sustainable Cleveland 2019, 2015). Each Summit is built around one of nine topics determined by citizens to be essential to creating a more sustainable Cleveland: energy efficiency, local foods, advanced and renewable energy, zero waste, clean water, sustainable transportation, vibrant green space, vital neighborhoods, and people (Sustainable Cleveland 2019, 2015). According to Jenita McGowan, Cleveland's chief of sustainability, the Sustainable Cleveland 2019 initiative focuses on "reinventing the community as a sustainable city writ large; it's as broad as sustainability can be, ensuring everyone can participate and benefit from our work" (McGowan, 2015).

2012 was the warmest year ever in Cleveland, since record keeping began in 1871.

MATT GRAY

While the annual summits have been useful in pulling together diverse stakeholders, "the city needed a more detailed plan for how to achieve many of the components of economic, environmental, and social sustainability" (Gray, 2015). This led to the creation of the Cleveland Climate Action Plan (CCAP). The CCAP took the ideas within Sustainable Cleveland 2019 that were specifically focused on climate adaptation and mitigation and provided structured guidance for what needs to be done, by whom, when, and how.

To create the CCAP, the Mayor's Office of Sustainability convened a 50-member Climate Action Advisory Committee composed of commercial, industrial, educational, government, and non-profit stakeholders from around Cleveland (Sustainable Cleveland 2019, 2015). Together, the stakeholders created a plan that outlines 33 actions, spilt into 6 focus areas: energy efficiency and green building, advanced and renewable energy, sustainable mobility, waste reduction and resource conservation, land use and clean water, and community engagement and public health.

Even if climate change was not a factor, taking the actions laid out in this plan would still make sense from an economic, environmental, and equity perspective; climate change adds urgency.

CCAP

Three of the 33 actions specifically address adaptation: (1) recognize capacity of neighborhoods and community groups to implement climate mitigation and adaptation initiatives; (2) conduct climate change vulnerability assessment and integrate projected impacts into existing plans; and (3) develop and implement an urban tree plan to increase tree canopy (CCAP, 2013). Cleveland's progress toward implementing the CCAP overall has been "piecemeal, focusing on areas where we have partners ready to act, funding readily available, or internal momentum" (McGowan, 2015). As of mid-2015, 11 of the 33 actions are underway or on track to be completed in short order (McGowan, 2015). However, the city has made progress on the first adaptation-related action by developing the Cleveland Toolkit and the Climate Action Fund, which are the focus of this case.

Why and how Cleveland Developed the Toolkit and Climate Action Fund

The Emergence of CDCs in Cleveland

The City of Cleveland has more than 25 distinct CDCs that provide an array of support services, information, and resources to neighborhoods throughout the city. The specific activities and services offered by each CDC vary,

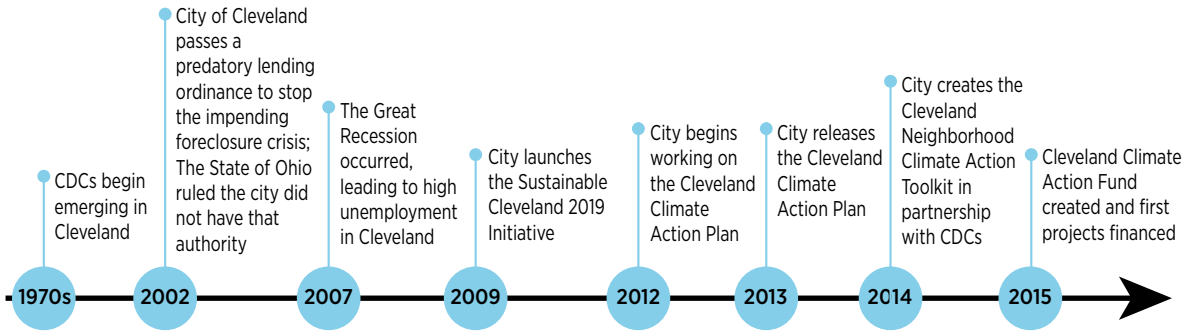


Exhibit 1. Timeline of actions in Cleveland, OH.

"depending on the needs, opportunities, and available assets of the particular neighborhoods" being served by each CDC (Krumholz and Hexter, 2012, p. 7).

The origin of the community development movement in Cleveland stemmed from the "neighborhood crisis of the 1970s" as described in the broader context section above (Exhibit 1). During this time, resources and investments were being transferred out of poor urban neighborhoods into the suburbs south and west of the city. This dearth of investment, resources, and support led to the emergence of community development organizations, principally those focused on "rebuilding and revitalizing communities through the use of available resources including the social, human, cultural, and economic capital of neighborhood residents" (Krumholz and Hexter, 2012, p. 1). During this period, many of the emerging CDCs built strong bases of support through techniques such as community organizing, skills development, sweat equity, and the creation of cooperative businesses (Krumholz and Hexter, 2012).

Early victories made by Cleveland's CDCs to combat redlining and market disinvestment in neighborhoods included work on affordable housing, such as placing "controls on home heating and fuel costs for low-income households … (the enhancement of) mortgage subsidies, tool rental programs and cleanup campaigns to improve neighborhood appearance in the hope that doing so would attract new homeowners and lead to healthier neighborhoods" (Krumholz and Hexter, 2012, p. 2). In the last two decades, the work of CDCs has been instrumental in the creation of thousands of new and rehabilitated housing units as well as the development of new retail, commercial and industrial space, and economic opportunity (Krumholz and Hexter, 2012).

> **People power is the answer to true and lasting climate action in Cleveland. This means that a citizen-centered approach is needed to align climate action with the assets, capacities, and priorities of Cleveland residents.**
>
> SUSTAINABLE CLEVELAND 2019

Partnering to Develop Concrete Actions Via the Toolkit

Recognizing the importance of neighborhood investment and neighborhood engagement, the City of Cleveland was eager to engage "neighborhood and community groups to implement climate change mitigation and adaptation initiatives" (CCAP, 2013, p. 74). The city jumpstarted this effort by working with the partners engaged in the three EcoDistricts in Cleveland: Enterprise Community Partners and neighborhood-based CDCs

from the Kinsman, Detroit Shoreway, and Glenville neighborhoods. The partners worked to identify the types of climate-related activities that were already underway in their neighborhoods and what additional types of support were needed to increase climate and sustainability activities. In selecting partners, the city deliberately focused on CDCs that represented Cleveland's diverse neighborhoods including those that primarily served African-American and low-income neighborhoods, as well as neighborhoods with a high population of seniors and citizens with asthma (McGowan, 2015). The result was the Cleveland Toolkit, a resource that includes multiple tools and guidance materials that CDCs, neighborhood associations, or individuals can use to "identify and scale up local action that's good for people and the planet" (Sustainable Cleveland 2019, 2015).

Projects that build on local assets inspire greater participation and ownership and are tailored to the neighborhood, resulting in more creative climate action that better addresses neighborhood aspirations.

CLEVELAND TOOLKIT

The Toolkit is designed to help neighborhoods and residents:

- Learn about Cleveland's Climate Action Plan
- Identify neighborhood assets and concerns and relate them to climate action
- Develop neighborhood climate action project ideas
- Develop a neighborhood climate action project proposal that they can use to secure funding to implement their climate action project ideas.

Included in the Cleveland Toolkit are resources and tools to help neighborhoods achieve the aforementioned goals and, more specifically, to "build on their strengths, or assets, to engage residents in developing creative climate action projects that people will care about, get involved in, and lead" (Sustainable Cleveland 2019, 2015). The Toolkit was built upon the principles of Asset-Based Community Development and developed with the assistance of Jenny Hirsch, a consultant from the Asset-Based Community Development Institute (McGowan, 2015). Exhibit 2 provides a summary of the four steps in the Toolkit as well as the resources available to help achieve each step.

One of the core elements of the Toolkit is an acknowledgement that each neighborhood already has an array of assets that make it strong and that can be drawn upon to increase community-wide adaptive capacity. Examples in the toolkit of community assets that can be enhanced to make the neighborhood stronger include local organizations, block clubs, book clubs, people's skills and passions, historical buildings, popular gathering places, natural areas, family traditions (of saving/being frugal, gardening, sharing, etc.), and a community history of coming together to address big challenges.

The Cleveland Neighborhood Climate Action Toolkit has been developed to help neighborhoods and residents incorporate the climate actions into their local work in ways that advance neighborhood visions while meeting CAP goals at the same time.

MATT GRAY

The Toolkit is designed to address more than just climate change. The Toolkit and the climate action projects that emerge from it are encouraged to address neighborhood-level concerns, which could include youth development, safety, job training, passing down cultural traditions, employment opportunities, green space development, and more (Sustainable Cleveland 2019,

EXHIBIT 2. CLEVELAND TOOLKIT STEPS AND SUPPORTING TOOLS (STEP AND TOOLS)

1. Learn about climate change and the CCAP

- "Climate Action and Cleveland: Building a Green City on a Blue Lake" Presentation
- Climate Action Videos that demonstrate how everyday Clevelanders are taking action in their homes, at work, and in their neighborhoods

2. Identify neighborhood assets and concerns, and relate them to climate action

- Climate Action Visual Collages that demonstrate Clevelanders taking climate friendly actions across the city
- Neighborhood Climate Action Case Studies
- "I am Sustainable Cleveland" poster campaign, which includes posters submitted by Clevelanders of actions they are taking to advance Cleveland's climate goals
- Neighborhood Climate and Sustainability Action Reports that provide detailed information about Cleveland's two ecodistrict neighborhoods
- Neighborhood Carbon Footprint Calculator

3. Develop a Neighborhood Climate Action Project idea

- Workshop Facilitator's Guide: *Develop Your Own Neighborhood Climate Action Project*, which provides guidelines for bringing together neighborhood stakeholders to participate in a climate action workshop
- Sustainable Cleveland Website: Get Involved in Your Community
- Neighborhood Carbon Reduction Calculator

4. Submit a Neighborhood Climate Action Project Proposal

- Cleveland Climate Action Fund Proposal template

2015). However, residents also must relate their key areas of concern to climate action and, specifically, to one of the goals outlined in the CCAP. Through this process, the city hopes to ensure that neighborhoods are selecting actions that address their priorities, but also align with citywide efforts to mitigate and adapt to climate change.

Exhibit 3 provides an example of a neighborhood asset mapping exercise conducted in the Kinsman neighborhood. Using the example of the Bridgeport Café, the city was able to demonstrate the utility of their asset-based community development process, which shows how an asset builds on existing resources, addresses current concerns, uses outside support, and connects to climate change. The Bridgeport Café is a local business that sells healthy food, employs local residents, and serves as a community gathering place. In addition to its brick-and-mortar location, the Café recently started a Mobile Market and now accepts EBT cards for payment, allowing it to travel to and serve areas of Cleveland that have historically not had access to healthy food options (Bridgeport Café, 2015). By combining economic development and local food production with the distribution of healthy food options, the Bridgeport Café is contributing to improved access to local, nutritious and healthy food, reduced vulnerability to disruptions in food supply, and enhanced economic wellbeing. Cleveland believes that these kinds of neighborhood level projects increase the adaptive capacity of residents to cope with climate related impacts (e.g., natural disasters).

Implementing Strategies that Build Neighborhood-Level Adaptive Capacity

Because of the diversity and uniqueness of Cleveland's neighborhoods, solutions for building adaptive capacity are based in the interests, needs, and existing assets within each neighborhood. This had led to a diversity

of strategies being identified and implemented, including the incorporation of sustainability standards into affordable housing designs, updated zoning laws that allow for urban farming and green energy production, the emergence of new social ventures focused on issues like local food production and distribution, and programs focused on reducing neighborhood crime (Sustainable Cleveland 2019, 2015). Together, these projects are leading to safer and closer-knit neighborhoods, increasing home ownership rates, greater investments in neighborhood infrastructure such as parks, and lower unemployment rates (Sustainable Cleveland 2019, 2015). Cleveland sees building these ties and increasing the quality of life of its residents as crucial to enabling future action on climate change, even if these actions do not directly reduce vulnerability in and of themselves. Exhibit 4 provides more examples of neighborhood-based projects that are helping increase the adaptive capacity of Cleveland residents.

EXHIBIT 3. ASSET MAPPING FOR KINSMAN NEIGHBORHOOD — EXAMPLE: BRIDGEPORT CAFÉ

Build on neighborhood assets

- Engaged residents
- Available commercial space
- Shared community vision

Address neighborhood concerns

- Alternatives to fast food
- Health and nutrition
- Community gathering spaces
- Access to fruits and vegetables

Use outside support

- U.S. Department of Health and Human Services
- Local funders

Take climate action

- Community engagement—public health
- Sustainable mobility

Creation of the Cleveland Climate Action Fund

Unfortunately, funding to implement neighborhood-level climate initiatives has historically been hard to find. To remedy this, the City of Cleveland's Office of Sustainability, in partnership with the Green City Blue Lake Institute, The Cleveland Clinic, The Gund Foundation, the Cleveland Foundation, and others, has initiated the Cleveland Climate Action Fund. The Climate Action Fund is designed to simultaneously provide training and financing for neighborhood level activities while also providing a means for Cleveland's largest employers to mitigate their carbon footprint by investing in neighborhood-level climate action (McGowan, 2015). Neighborhoods that have demonstrably used the Toolkit are encouraged to submit their project ideas to the Climate Action Fund. Through a competitive grant application process, Climate Action Fund administrators select the top projects to finance. To date, the Climate Action Fund has provided $46,000 to twelve projects, including one focused on hiring and training youth to provide zero-emissions landscaping services, another focused on enhancing community composting, one aimed at local food production, and two to support solar panel installations (Cleveland Climate Action Fund). "In the future, the goal is to secure additional financing so that significantly more projects can be started" (Gray, 2015).

Building and Maintaining Community Support

The idea for and the process to develop the Cleveland Toolkit and the Climate Action Fund emerged from engagement with the local community. In particular, the city's close partnership with many of the CDCs, and their collaboration in visioning, developing, testing, and implementing the Toolkit has helped the city quickly move from conception to implementation (McGowan, 2015). According to Jane Fumich, Director of Aging and Donnald Heckelmoser, Community Development Department, the CDCs have also been great partners for ensuring that residents know about and have access to other climate adaptation-related resources such as the city's home weatherization program and the heating assistance program (Fumich, 2015).

Exhibit 4. Examples of climate action at the neighborhood level as highlighted in the Cleveland Toolkit.

In addition to the CDCs, members of the Mayor's Climate Action Advisory Committee were also involved in developing and providing input into the development of the Toolkit as well as all other strategies included in the city's Climate Action Plan (Pietro, 2015). According to Matt Pietro, Sustainability Specialist at UH, "the Neighborhood Climate Action Toolkit was one of the most important items included in the CCAP and we wanted to make sure that it was designed with language that is relatable to community members who aren't necessarily versed in the science behind climate change. The Toolkit was designed to let them know how climate change could impact their everyday lives and what they can do to be prepared" (Pietro, 2015). The Toolkit has been used to fund adaptive capacity enhancement efforts in a number of neighborhoods throughout the city.

In terms of broad community awareness, the city uses community events, an annual sustainability summit, and quarterly meetings, as well social media such as e-newsletters, Twitter, and Facebook to keep residents appraised of sustainability and climate-related activities and accomplishments. The city also invites residents to write blog posts about the actions they are taking to "help build a green city on a blue lake" (Sustainable Cleveland 2019, 2015). These posts are then shared with the wider public. Additionally, the "I am Sustainable, Cleveland" poster campaign affords residents, businesses, neighborhoods, students, and others a chance to show visually how they are contributing to making Cleveland a more sustainable community (Exhibit 5). So far, more than 100 posters have been created by residents (McGowan, 2015). These interactive engagement techniques appear to be helping Cleveland maintain interest and momentum around sustainability and climate action while also allowing the city build a repository of examples of climate activity that can be used to encourage others to join in the climate action movement. However, no quantifiable assessment of the amount of vulnerability reduction has yet been conducted, making it hard for the city to know exactly what impacts their efforts have had.

Exhibit 5. Examples from the "I am Sustainable, Cleveland" poster campaign.

Accomplishments of Cleveland's Toolkit and Climate Action Fund

Assessing the accomplishments of Cleveland's Toolkit and the associated climate action projects is challenging due to (1) the distributed nature of the effort, (2) the limited funding available to support project implementation, and (3) limited staff capacity to track progress. That said, neighborhood social cohesion does appear to be on the rise and interest in climate action remains stable, if not growing, based on the level of inquiries received to host Neighborhood Climate Workshops (Gray, 2015). As noted by Dr. Aparna Bole, "a connected community is a more resilient community, and in Cleveland, we have a lot of issues with disconnected communities, especially with those identified in our CCAP as being the most vulnerable. Issues such as high foreclosure rates or high turnover might limit the ability of communities to be resilient. So if there are things we can do to enhance social cohesion and encourage people to work together, then chances are we are helping their communities to become more resilient" (Bole, 2015). Matt Gray agrees, "Resilience in Cleveland is about being prepared for external shocks. That includes weather and climate-related shocks, but also economic shocks. In Cleveland, you can't disconnect these issues" (Gray, 2015).

A further sign of the city's accomplishments to date is the fact that multiple CDCs and neighborhood leaders have used the Toolkit to start community discussions about existing and future climate change impacts as well as opportunities for mitigating (Gray, 2015). "Without the Toolkit as a catalyst, it's unclear if these conversations would be taking place" (McGowan, 2015). One barrier to progress has been the need for more funding to implement projects. A second barrier is the effective assessment and measurement of adaptation actions. Nevertheless, the fact that a wide range of activities have been accomplished with limited financing indicates that the Toolkit and its process have been successful in engaging neighborhoods and building the social cohesion Cleveland believes necessary to bolster adaptive capacity.

Unfortunately, the city has struggled to convince most external funders that resilience in Cleveland is best achieved by marrying social cohesion, economic development, and climate preparedness. For example, the city has applied three times without success to major resilience initiatives to undertake actions such as vulnerability assessment and resilience planning and to improve the urban tree canopy. "This is frustrating," notes Jenita McGowan, "because this ignores the realities of where we are and what we need as a city … our applications for these programs demonstrates that we

are incredibly poor and that climate is the straw that will soon break the camel's back. This hasn't yet resonated with most organizations who are funding resilience work" (McGowan, 2015). Below is an excerpt from a recent application from the city that explains how they view the connection between resilience, social cohesion, and poverty reduction (McGowan, 2015):

> The traditional long-term impacts of poverty include higher instances of chronic disease, high levels of chronic stress, living in unsafe and substandard housing, lack of educational opportunity, lack of job readiness, and lack of access to affordable healthy foods. Poverty and inequality affect Cleveland's children in greater proportion with 51 percent of children living in poverty. A majority of Cleveland's poor live in housing stock built prior to 1940, most of which is energy inefficient, expensive to heat and cool, and located in areas with a low tree canopy cover. We anticipate that traditional long-term poverty impacts will be exacerbated by greater prevalence of high heat days and urban heat island effect, greater intensity of storms and flooding, increased food and fuel prices, and disruptions to systems of particular importance to those living at or below the poverty level including public transit, emergency services, and social services.

Creating connectivity is not sexy in a technical way, but I think it is critically important and research supports this.

JENITA MCGOWAN

Moving Forward

Recently, Cleveland has partnered with Cleveland Neighborhood Progress on a Climate Resiliency and Urban Opportunities plan with the support of The Kresge Foundation. The city has also partnered with local nonprofits on the creation of a Cleveland Tree Plan which notes that restoring Cleveland's tree canopy is one of the most important climate adaptation strategies for managing stormwater and cooling the city. The plan takes an equity approach to trees as a climate adaptation, public health, and quality-of-life strategy for Cleveland's neighborhoods.

Going forward, the city will continue to seek funding to support more neighborhoods in using the Toolkit and additional funding for the Climate Action Fund so that neighborhood-level projects can be implemented (McGowan, 2015). In fact, the goal of the Climate Action Fund is to hold workshops and fund projects in every Cleveland neighborhood by 2017 (McGowan, 2015).

Another priority area for action is finding funding to support the development of a detailed vulnerability assessment that identifies the specific needs and areas for intervention within the City, the second element of the CCAP that addresses adaptation. Once completed, the vulnerability assessment will provide the city with a roadmap for future, city-led projects (Gray, 2015).

Partnering with the county and surrounding municipalities is also a high priority. Cleveland is only one of 59 municipalities within Cuyahoga County, meaning that regional efforts to reduce vulnerability may need to be coordinated at higher levels of governance (Gray, 2015). The city is interested in helping foster that collaboration and coordination, but is waiting for clear signals from surrounding municipalities and the county that such collaboration would be welcome (McGowan, 2015).

A final area of focus for the city pertains to the use of language and overall community education. According to Aparna Bole (2015), "the language of climate change has become very political in our country. This means that we sometimes have to choose our language so that we engage the right leaders in the right away. Talking about resilience, air quality, and extreme events in a really data-driven manner appears to work for us." The city will continue to explore various ways of framing climate resilience and adaptation so that they reach the widest array of stakeholders as possible. By starting with alternative language that resonates with stakeholders, the city believes it can build trust and rapport with individuals that can later be leveraged to have a more open and frank community discussion about climate change.

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- **Matthew Pietro,** sustainability specialist, UH
- **Jane Fumich,** director, Cleveland Department of Aging
- **Donnald Heckelmoser,** program administrator, Cleveland Department of Community Development.

Bibliography

Bole, A. 2015. Interview with Dr. Aparna Bole, Sustainability Manager at University Hospitals. February 9, 2015.

Bridgeport Café. 2015. About us. Available: http://www.bridgeportcafe.com/about-us/. Accessed November 16, 2015.

CCAP. 2013. Cleveland Climate Action Plan: Building Thriving and Healthy Neighborhoods. Available: http://www.sustainablecleveland.org/wp-content/uploads/2013/10/Cleveland-Climate-Action-Plan-Final2013-web.pdf. Accessed January 30, 2015.

Cleveland Climate Action Fund. 2015. Cleveland Climate Action Fund. Available: http://www.cleveland-climateaction.org/. Accessed February 19, 2015.

Fumich, J. 2015. Interview with Jane Fumich, Director of the Cleveland Department of Aging. February 9.

Gray, M. 2015. Interview with Matt Gray, Director of the Mayor's Office of Sustainability with the City of Cleveland. February 10.

Heckelmoser, D. 2015. Interview with Donnald Heckelmoser, Program Administrator in the Cleveland Department of Community Development. February 9.

Krumholz, N. and K.W. Hexter. 2012. Re-Thinking the Future of Cleveland's Neighborhood Developers: Interim Report. Center for Community Planning and Development, Maxine Goodman Levin College of Urban Affairs, Cleveland State University. March.

McGowan, J. 2015. Interview with Jenita McGowan, Chief of Sustainability, City of Cleveland. February 10.

Perkins, O. 2015. Cleveland Area Won't Regain Jobs Lost during Recession until 2019, Forecast Says. January 22. Available: http://www.cleveland.com/business/index.ssf/2015/01/cleveland_area_wont_regain_job.html. Accessed February 12, 2015.

Pietro, M. 2015. Interview with Matthew Pietro, Sustainability Specialist at University Hospitals. February 9.

Sustainable Cleveland 2019. 2015. FAQ. Available: http://www.sustainablecleveland.org/about/faq/. Accessed February 12, 2015.

U.S. Census. 2015. State and County Quick Facts. Available: http://quickfacts.census.gov/qfd/states/39/3916000.html. Accessed February 12, 2015.

El Paso County, Texas

Kay Bailey Hutchison Inland Desalination Facility

EL PASO COUNTY, TEXAS

AUTHORS: Alexis St. Juliana and Jason Vogel

In this case study, you will learn about:

- Robust water management planning with multiple strategies
- Addressing financially feasible strategies in the near term and re-evaluating next steps periodically
- Engaging in dialogue with decision makers (local, state, and federal)
- The role of strong leadership
- Sharing information with other communities

Case Study Summary

El Paso's water utility, an independent utility from the city and county with budgetary discretion, had been aware for years of the combined potential impacts of the growing population and drought on El Paso's water resources. Since the 1960s, they have worked to reduce consumption and increase system efficiency. In 1991, they developed a comprehensive Water Resource Management Plan, which included a variety of strategies to conserve water and acquire backup water sources. In line with this plan, El Paso Water Utilities (EPWU)[6] finished construction of the 27.5-million-gallon-per-day Kay Bailey Hutchison inland desalination facility in 2007 (on the cover). The development of the facility resulted from proactive planning efforts and a confluence of various external drivers, including freshwater wells becoming brackish, a lower price threshold for desalination membrane technology, a drought between 2003 and 2004, and the U.S. Department of Defense (DoD) Base Realignment and Closure process. EPWU is now able to convert formerly unusable brackish water into a drinking water resource for their community. The development of the facility also helped to alleviate DoD concerns about future water supply reliability in El Paso —The Department changed from targeting Fort Bliss for closure to seeing it as a valuable resource and expanding it. The U.S. Army removed personnel restrictions at the base, growing the base population roughly 4 times to 32,000. This growth is an asset to El Paso's local economy and would not have taken place without the desalination plant. Additionally, the facility helped to reduce the area's vulnerability during a period of drought in 2012 and in 2011 when a historic freeze impacted the city's reservoirs; EPWU relied on brackish water during surface water shortages. The desalination facility and EPWU's other water resource management efforts are projected to reduce El Paso's vulnerability to climate change for the next 50 years. Exhibit 1 presents a timeline of activities in El Paso.

The Broader Context of Adaptation in El Paso

The City of El Paso is located in the Chihuahua desert and is at the end of the line for surface water supplies from the Rio Grande. As such, it has been aware of the potential impact of drought for decades. The city has also become more aware of flooding after a 2006 event and extreme temperatures after a freezing event in 2011 (Baldwin; 2015, Montoya, 2015). To address these impacts, the city is involved in several climate change adaptation initiatives. First, El Paso is part of the Rockefeller Foundation's 100 Resilient Cities initiative that intends to focus on local drought, flooding, extreme temperatures, economic opportunity, and hazards preparedness concerns (Baldwin, 2015; 100 Resilient Cities, 2015). Second, the city's Office of Resiliency and Sustainability is working with Climate Solution University to finalize a climate change adaptation plan in December 2015. Potential adaptation activities include green

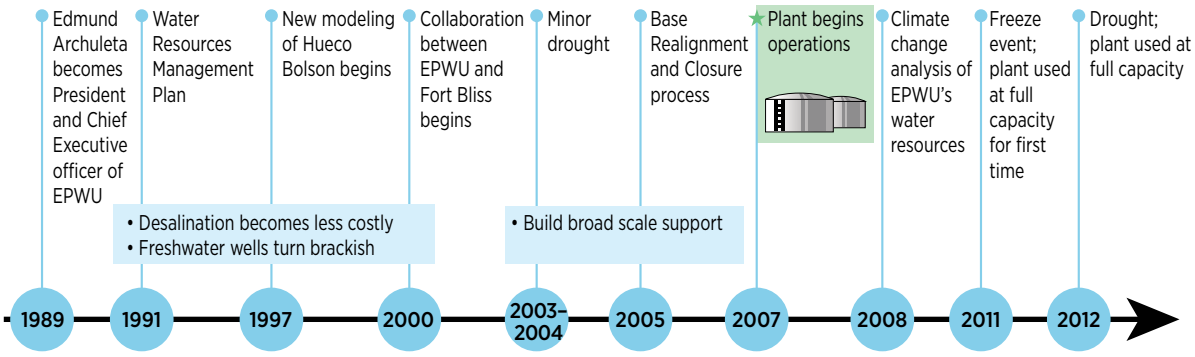

Exhibit 1. Timeline of activities in El Paso.

6. EPWU is an independent entity from the City of El Paso, with its own governing board. Its revenue and expenditures are all managed internally. EPWU serves the City of El Paso and most of El Paso County (EPWU, 2007b). Outside its service area, EPWU provides technical support to colonias (unincorporated settlements) to write and manage grants that would fund improved water supply and waste water management options (Reinert, 2015).

infrastructure projects to reduce flooding, the development of an innovation district for clean energy and water, and a tree planting campaign to minimize urban heat island effects (Baldwin, 2015). In fact, the city is already in discussions with the Texas Trees Foundation to complete a more thorough analysis of El Paso's tree canopy. Finally, this office also leads a number of climate change mitigation activities related to their 2009 Sustainability Plan. These activities include energy conservation and efforts to reduce traffic congestion by improving transportation options (Baldwin, 2015; City of El Paso, 2015).

EPWU is an important player in El Paso's climate adaptation, particularly with regard to flooding and drought. EPWU's stormwater management activities began after a flooding event in 2006 when the city council created a stormwater management utility with discrete funding, to be managed by EPWU (Montoya, 2015). The new utility developed the city's first Stormwater Master Plan in 2009 with over 100 projects to create new and improve existing stormwater infrastructure throughout EPWU's management area (EPWU, 2007d; Montoya, 2015). It completed several multi-million dollar stormwater projects and is working on a $22-million pump station and $12-million pond system to mitigate flooding (Montoya, 2015). In 2011, the region experienced a freezing event resulting in major power outages, even shutting down some water supply facilities. During this event, EPWU relied on the Kay Bailey Hutchison Desalination Plant to provide another water source. In response to the impacts of the freezing event on the overall water supply system, EPWU began a new project to install back-up generators and insulate equipment to minimize disruptions from cold or freezing weather in the future (Montoya, 2015).

To address water shortages or drought, EPWU has extensive water conservation, reclamation, and water supply diversification programs. EPWU's comprehensive conservation plan includes measures such as:

- Universal metering
- Landscaping rebate program
- Education and outreach
- Rebate, retrofit, and incentive programs (rebates for WaterSense appliances, etc.)
- Water reuse/reclaimed water
- Measures to determine and control water loss and continuous leak detection program
- Enforcement (EPWU, 2014a).

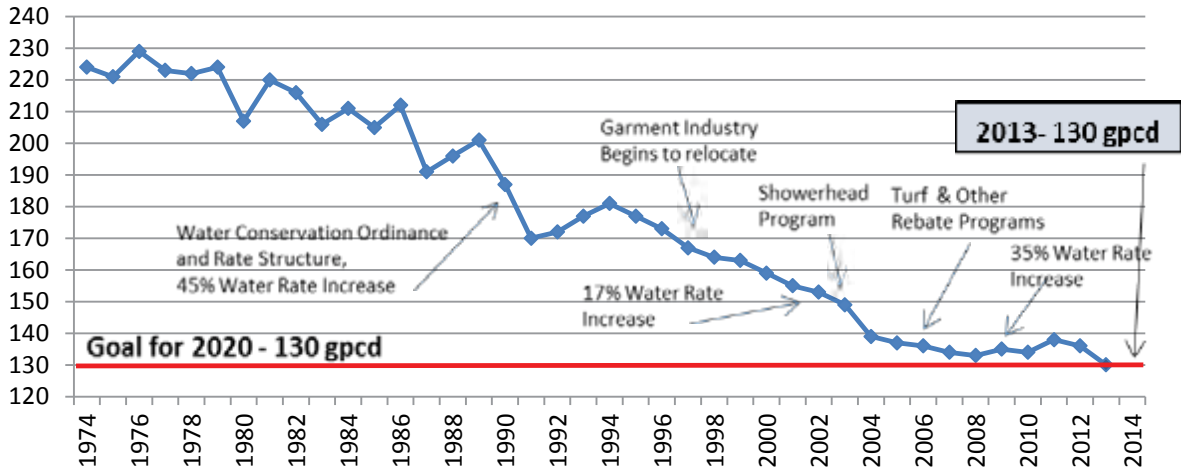

Exhibit 2. Per capita water consumption in El Paso, TX, from 1974 to 2014, in gallons per capita per day (gpcd).

Source: EPWU, 2014a.

In particular, EPWU has been using reclaimed water since 1963 and has attained international recognition for its innovative and extensive use of recycled water (EPWU, 2007a). EPWU now operates one of the most extensive and advanced reclaimed water systems in Texas for industrial use and landscape irrigation (EPWU, 2007a). As a result of all these efforts, EPWU has been able to reduce its per capita water consumption values (Exhibit 2). In addition to water conservation the utility has worked extensively to diversify water sources to include groundwater, surface water, and brackish groundwater. In October 2014, EPWU earned the Sustainable Water Utility Management Award from the Association of Metropolitan Water Agencies for proactive water management strategy focused on policy, planning, and technology (EPWU, 2014b). This case study focuses on the development of El Paso's desalination facility as a piece of El Paso's overall water supply planning efforts.

Why and How EPWU Developed the Kay Bailey Hutchison Desalination Facility

EPWU Develops an Effective Water Resources Management Plan that Phases in Alternate Water Resources

In 1989 Edmund Archuleta began managing EPWU as President and Chief Executive Officer. At this time, EPWU was relying almost entirely on groundwater resources in the Mesilla Bolson and Hueco Bolson aquifers (Exhibit 3). Demands on these aquifers from withdrawals by El Paso (TX), Las Cruces (NM), and Ciudad Juarez (Mexico) were beginning to show; water levels were dropping with withdrawals exceeding natural recharge rates (Department of the Army, 2004; Hutchison, 2004; Archuleta, 2015). El Paso was also in an ongoing legal battle with New Mexico over water rights to these aquifers. Considering

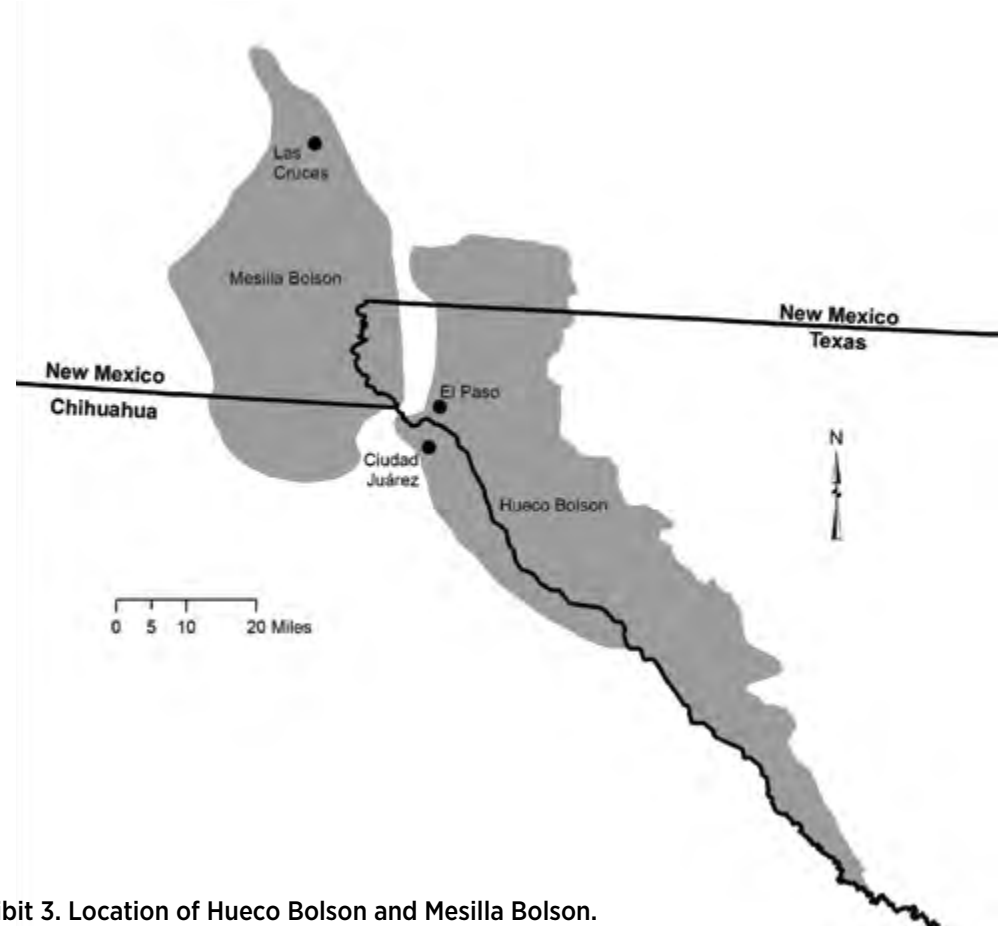

Exhibit 3. Location of Hueco Bolson and Mesilla Bolson.

all these factors, Mr. Archuleta determined that the EPWU Public Service Board needed to develop a Water Resource Management Plan. The plan aimed to diversify the community's water resources to preserve the freshwater that remained in the aquifers for future need. This 1991 plan presented several options for El Paso's next 50 years of water management:[7]

- Use of surface water—rely on allocations from the Elephant Butte Reservoir and the Rio Grande
- Conservation—limit water use through education, restrictions, enforcement, incentives/rebates, and higher rates
- Additional reclamation of water—treat wastewater for non-potable uses such as irrigation or industry
- Importation of water—acquire water ranches (land and associated water rights) outside El Paso and construct pipelines
- Inland desalination (Archuleta, 2004).

The first three of these options were of immediate interest to the utility. Over time, the utility was able to lower per-capita water consumption through conservation from about 225 to 130 gallons of water per person per day; this work continues today even though further reductions are becoming more difficult to attain (EPWU, 2014a). EPWU was also able to construct a new water treatment plant, the necessary infrastructure, and rights to use surface water from the Elephant Butte Reservoir and the Rio Grande. In general, the utility switched strategies to preserve groundwater resources. This consisted of conserving water, reclaiming water, and relying on "renewable" surface water (as long as there were not drought conditions). Prior to the 1991 plan, surface water was an almost non-existent part of EPWU's water supply. EPWU determined it was an important untapped source of water. System upgrades, made over many years, were finally completed between 2008 and 2009 (Hutchison, 2015). The last two options from the 1991 plan were not immediately feasible due to the high cost of installing pipelines and desalination technology. However, EPWU invested in understanding desalination options through tours of Florida desalination facilities, developed several small-scale desalination pilot projects, and purchased water ranches over 100 miles away from the community as future water resources.

Brackish Water Intruding into Freshwater Wells Motivates El Paso to More Seriously Consider Desalination

As early as the 1980s, EPWU knew that brackish water and freshwater sources were migrating within its aquifers, but it had not completed a comprehensive analysis. In 1997, with support from the U.S. Geological Survey, EPWU engaged in new hydrologic modeling to better analyze and understand its groundwater resources (Archuleta et al., Forthcoming). Then, in the late 1990s and early 2000s, EPWU began to notice a significant problem with some of its wells. The water in those wells was becoming brackish and did not meet drinking water quality standards. The U.S. Geological Survey's modeling and EPWU's drilling and sampling data showed that El Paso's and Ciudad Juarez's current pumping were causing brackish water to intrude EPWU's freshwater wells. EPWU notified officials at Fort Bliss that they should be aware of this issue in their own wells. EPWU began reconsidering the option of inland desalination at this juncture. In addition, between 2003 and 2004, El Paso experienced a drought that resulted in use restrictions for surface water resources.

Technological Advances Make Desalination a Financially Feasible Option

In the late 1990s and early 2000s, EPWU found that the cost of desalination had decreased. Since the early 1990s, new providers created competition in the reverse osmosis membrane market. Additionally, improvements in technology made desalination less energy intensive and less costly to operate (Archuleta, 2004; see the text box). The cost of constructing and operating a desalination facility was now a more viable option, although still costly. Based on the size of the Hueco Bolson and estimates of future need, EPWU estimated it could construct a 20 million-gallon-per-day treatment facility. Fort Bliss officials knew that EPWU was considering desalination and felt it could work for Fort Bliss too. Fort Bliss and Army Corps of Engineer officials considered a separate 7.5-million-gallon-per-day facility to help meet water needs.

7. Beginning in 1997, the Texas Water Development Board implemented a new requirement that 16 multi-county regions (comprising the entire state) develop water supply plans. EPWU now works with its regional counterparts on water supply plans in addition to its own planning activities. The most recent plan was completed in 2011.

WHAT ABOUT THE ENERGY COSTS ASSOCIATED WITH DESALINATION?

Desalination is a very energy-intensive process. However, desalination of brackish water is less energy intensive than desalination of ocean water. The brackish water in the Hueco Bolson aquifer is less salty than ocean water so less treatment is required. Specifically, the salinity of the plant's source wells range from 2,000 to 4,000 mg/l (milligrams per liter) while ocean water's is 33,000 mg/l. Additionally, the Kay Bailey Hutchison facility does not run at full capacity. It is primarily intended to meet El Paso's water needs in times of drought or otherwise reduced surface water flows. These factors combined made the facility a cost-effective option at the time the facility was constructed over the next best alternative—importing water from ranches 100 miles away.

Use of Brackish Water Presents a Unique Water Management Opportunity

Those interviewed for this case study indicated that freshwater pumping by both EPWU and Fort Bliss caused brackish water to migrate to freshwater supply wells. The increased salinity was high enough that the water was not suitable for distribution without additional treatment. EPWU hydrology staff were concerned that two desalination facilities in close proximity would exacerbate the current problem of brackish water migration. Instead, officials felt that a single desalination facility in the right location could help to draw brackish water for treatment, while preserving fresh groundwater in the aquifer. EPWU modeling showed that the best location for the plant was on Fort Bliss' property. This location was in proximity to freshwater wells that had become saline, existing water lines and storage tanks, and water to dilute the desalination concentrate.[8]

EPWU and Fort Bliss Form a Critical Partnership

Prior to the partnership to develop the desalination plant there had been limited collaboration between Fort Bliss and EPWU. EPWU had treated Fort Bliss wastewater and supplied about 20–25 percent of its drinking water (Perez, 2001; Archuleta, 2015).

EPWU officials said that they felt the development of a joint desalination facility would be beneficial for the community and Fort Bliss. Constructing a single 27.5-million-gallon-per-day facility would be less expensive than building two individual plants. However, locating the desalination facility on Fort Bliss property required a great deal of negotiating. EPWU took on the task of convincing Fort Bliss and DoD officials. EPWU brought to the table several bargaining pieces. EPWU would:

- Drill test and source wells
- Design and construct the facility
- Design and construct the 22-mile desalination concentrate pipeline and deep injection wells
- Operate the facility
- Sell water to Fort Bliss at a negotiated price.

In exchange, EPWU asked that Fort Bliss:

- Complete the Environmental Impact Statement required under the National Environmental Policy Act
- Drill test wells for concentrate disposal
- Lease its land to EPWU for the plant, pipeline, and injection wells.

In this arrangement, Fort Bliss and the DoD would take on a smaller portion of the $91 million in capital costs than EPWU, while increasing water supply reliability (Exhibit 4). This reliability meant both greater water security and ongoing operations at Fort Bliss. Housing the plant on Fort Bliss property also helped to address U.S. Army security and terrorism concerns, as with any water treatment facility. The U.S. Army felt that the facility would be better protected on Army land (Barrera, 2015). Additionally, as a federal entity, the U.S. Army

8. Most desalination facilities dispose of their waste (or concentrate) in the ocean. Since El Paso's desalination plant is an inland facility, it had to devise an alternative. El Paso opted for deep well injection of the diluted concentrate, which required a lengthy regulatory approval process. For detailed information see Archuleta et al. (Forthcoming).

felt it made the most sense for Fort Bliss to lead the Environmental Impact Statement process. The arrangement gave EPWU the necessary land and easements to construct the operation, possibly helped the project navigate the Environmental Impact Statement with greater ease, helped EPWU to manage groundwater hydrology in order to preserve freshwater resources, and increased El Paso's water supply reliability. However, leasing the land from Fort Bliss was a challenge. An agreement was necessary to even conduct initial surveys on Fort Bliss property. The final negotiated 50-year lease allowed EPWU to preliminarily construct the facility, the desalination concentrate disposal pipeline, and concentrate disposal injection wells (Archuleta, 2015; Barrera, 2015). The lease also allows for ongoing operations of the plant. However, the arrangement does not grant Fort Bliss free treated water—Fort Bliss has a negotiated wholesale water rate with EPWU.

Exhibit 4. Capital costs to develop the Kay Bailey Hutchison desalination facility (in millions)

Item	Cost
Production wells	$32
Plant and pipeline	$40
Concentrate disposal wells and pipeline	$19
Total	$91

Source: Reinert, 2014.

2005 Base Realignment and Closure Process Builds Momentum for Desalination

The DoD scheduled a periodic Base Realignment and Closure process for 2005. In this process, the DoD determines what military facilities are no longer needed or can be consolidated. Fort Bliss and all other facilities were considered for closure. Fort Bliss was in some jeopardy of closure, despite being one of the larger facilities in the United States (1.1-million acres; DoD, Undated). The U.S. Army's Director of Environmental Programs had serious concerns about the reliability of water supplies at the facility and had even capped the population at Fort Bliss based on this concern (Cushing, 2015; Dayoub, 2015).

El Paso was concerned about the potential loss of Fort Bliss; Fort Bliss is a major economic driver in the community. The development of the desalination facility could reassure the DoD of El Paso's long-term water supply reliability and could actually increase the number of people stationed at Fort Bliss, bringing economic benefits to El Paso.

EPWU Builds Broad-Scale Support

Local Leadership

Interviewees and news articles indicated that EPWU, the Greater El Paso Chamber of Commerce, former Mayor Carlos Ramirez, former Mayor Joe Wardy, and others went to Washington, DC, to speak with members of Congress and DoD officials (Perez, 2001). Early on, conversations were aimed at building DoD's support for the project, and sought access to Fort Bliss and financing. Once the Base Realignment and Closure process was announced, local leadership made the case for keeping and strengthening Fort Bliss. A critical part of these conversations was the planned desalination facility and long-term water supply reliability. At this time, EPWU had already begun designing the desalination facility, which was vital for demonstrating the promise of the facility. The Base Realignment and Closure process may have expedited the development of the facility and provided local leaders a platform to advocate for the plant.

Political Allies

EPWU relied heavily on allies in Congress and the DoD to help make the plant happen. In particular, U.S. Senator Kay Bailey Hutchison (Texas) who sat on the appropriations Subcommittee on Military Construction, Veterans Affairs, and Related Agencies played an integral role in securing $26 million for the plant (Exhibit 5). All military construction projects over a certain dollar threshold must go through this subcommittee. Additionally, U.S. Congressman Sylvester Reyes (Texas) advocated for the facility and helped secure funding (Department of the Army, 2004). Congressman Reyes pushed for EPWU and Fort Bliss to develop the plant together as it would be difficult to get funding for two desalination plants in one Congressional District (Barrera, 2015). By working together, EPWU and Fort Bliss felt they had better opportunities for state and federal funding. EPWU's significant

investment in the plant also had a large influence on the congressional appropriation. If the military were to build its own plant at Fort Bliss, it would likely cost more than the $26 million appropriation—the plant would address the critical concern of water supply reliability for less money than if Fort Bliss had attempted to construct the plant on its own. Additionally, Fort Bliss officials made the case for the plant to be operated by EPWU, which had extensive expertise in water operations. Considering this, the plant would help to keep Fort Bliss open and the U.S. Army could continue to use its vast training grounds.

Exhibit 5. Contributions to the development of the Kay Bailey Hutchison desalination facility (in millions)

Funding sources	Amount
EPWU bond and cash	$60.7
Congressional appropriation	$26.0
U.S. Army in-kind (Environmental Impact Statement and drilling for feasibility of injection wells)	$3.3
Texas Water Development Board interest-free loan	$1.0
Total	**$91.0**

Several other elected officials expressed support for the facility, including U.S. Senator John Cornyn (Texas), and Texas State Senators Eliot Shapleigh and Frank Madla (Department of the Army, 2004).

Community Buy-in

Those interviewed for this case study felt that the El Paso community was supportive of EPWU's decision to pursue desalination. With EPWU educating the community on water conservation for nearly 15 years, most people, industries, and organizations recognized the need for future water supply reliability. Additionally, since the plant and injection wells are contained on the Fort Bliss property, few residents were directly affected by the development or operation of the facility.

Fort Bliss staff led the development of the Environmental Impact Statement. Public meetings that were part of this process yielded few critical concerns over the plant, although there were some objections. The primary example was the proposed alternative for concentrate disposal. EPWU and Fort Bliss had always indicated that their preferred option for concentrate disposal was deep well injection. As an alternative, evaporative ponds were also considered. Several individuals objected to the construction of such evaporative ponds because of the land area they would occupy (nearly 700 acres) and the potential harmful effects on birds and other wildlife (Department of the Army, 2004). The Trans-Pecos Audubon Society felt that, managed properly, such ponds could potentially benefit wildlife. However, since the cost of the deep well injection was much lower, EPWU and Fort Bliss pursued the deep well injection option. Other concerns included the risk of seismic activity from deep well injection and desalination concentrate contaminating privately held freshwater wells in the area (Department of the Army, 2004). Fort Bliss responded to all written comments as part of the Environmental Impact Statement process. However, the comments did not dramatically change the project plans.

Accomplishments of the Desalination Facility

Those interviewed for this study agree that the Kay Bailey Hutchison inland desalination facility is a success. Not only was an unusable water resource converted into a potable water supply, the desalination facility is the largest inland plant worldwide. Additionally, EPWU was the first utility to use deep well injection of desalination concentrate. Elza Cushing who was an EPWU Public Service Board member and also worked at Fort Bliss stated, "In my career I think that [the development of the desalination facility] is the most important thing I've ever done." In general, interviewees noted that the development of the desalination facility has met five important goals for El Paso and Fort Bliss:

1. Short-term water supply reliability—In 2011 during a freeze event and in 2012 during a period of drought the desalination facility operated at full capacity (Crowder, 2012; Montoya, 2015). In both cases it

Exhibit 6. El Paso's 2009–2013 municipal water demand (millions of gallons)

	2009	2010	2011	2012	2013
Peak day	152.6	158.5	163.5	163.2	161.1
Average day	101.6	102.4	106.4	104.3	99.8

Source: EPWU, 2014a.

supplemented pumping at El Paso's groundwater facilities. In particular, in 2012 the utility was not able to use surface water from the Elephant Butte Reservoir. The plant allowed El Paso to avoid mandatory water restrictions, although EPWU still asked residents to voluntarily cut down on their water use. EPWU officials see desalination as a "drought-proof" option due to the reserves of brackish water in the Hueco Bolson aquifer.

El Paso uses roughly 100 million gallons of water per day (Exhibit 6). The 27.5-million-gallon-per-day desalination facility has the potential to meet a significant portion of El Paso's water needs when surface supplies are limited. EPWU's current groundwater capacity is 164 million gallons of water per day (including the desalination facility) and surface water capacity is 100 million gallons of water per day (EPWU, 2014a). While there are sufficient water resources in a normal year, the 27.5-million-gallon-per-day desalination facility provides much-needed reliability when water supplies are low.

2. Long-term water supply reliability—state water planning requires planning for the drought of record. There is no requirement to plan for future or worse drought due to climate change. In 2007, State Senator Eliot Shapleigh helped pass Senate Bill 1762 that required the Far West Texas regional water planning area to conduct a climate change analysis (The Portal to Texas History, 2007; Texas Water Development Board, 2008). As a result, in 2008 an EPWU employee conducted a climate change analysis of El Paso water supplies. This analysis found that EPWU's current plans are sufficient for the projected climate over the next 50 years (Hutchison, 2008).

3. Long-term groundwater management—the plant has seized an opportunity to ensure that fresh groundwater resources are protected and available in the future. The plant was developed in a strategic location to manage groundwater flows. The utility sees value in operating the plant to help manage the flow of water resources in the Hueco Bolson aquifer. Strategic pumping can help to maintain unique reserves of fresh and brackish water into the future, even if there are not immediate drought conditions that require the use of the desalination facility (Hutchison, 2015; Reinert, 2015). Additionally, the relative high-quality of the concentrate being injected into the deep wells (the concentrate is less saline than the groundwater in that location) could create a future water source, as technology allows.

4. Economic growth—as a result of the desalination plant, Fort Bliss has been able to grow substantially (Dayoub, 2015). Fort Bliss is about four times larger since the plant was developed. Fort Bliss grew from approximately 8,000 military personnel in 2005 to 32,000 in 2015, not including family members or civilian workers (DoD, Undated; Barrera, 2015; Dayoub, 2015; Archuleta, 2015). This is a significant economic gain for El Paso. Specifically, those stationed at Fort Bliss bring their families and spend money in El Paso, which boosts the local economy. Interestingly, this growth also brings more water users into a drought-prone region, potentially exacerbating El Paso's vulnerability to drought. However, this impact is relatively modest at this point; the additional 24,000 users brought in to Fort Bliss by the plant represents a 3 percent increase from the estimated total number of users in 2013 (EWPU, 2014a).

5. Leading peers in the water industry—EPWU staff and Edmund Archuleta (now retired from EPWU) are regularly asked to speak about their work on the desalination facility and overall water supply management activities. According to Edmund Archuleta, Scott Reinert of EPWU, and others, the uniqueness of the inland desalination facility draws interest from communities worldwide to learn about desalination potential in their communities. The plant serves as the primary public education center for the utility with its TecH2O visitor center. Staff at EPWU regularly give tours and talk about the plant to officials from other communities. Other Texas communities such as Austin, San Antonio, the Lower Rio Grande valley, the Lower Wilcox, and Bexar County are considering or moving forward with desalination, learning from El Paso's experience. Additionally, those interviewed mentioned that EPWU has borne the initial burden of getting the proper permits for deep well injection of the desalination concentrate (see Archuleta et al., Forthcoming); future inland desalination facilities might experience fewer regulatory hurdles, and can learn from EPWU's experience. In particular, San Antonio has begun construction on a desalination facility that will use deep well injection and the permitting process has been less burdensome (Archuleta, 2015).

Moving Forward

While El Paso's desalination facility and other water management measures are expected to provide sufficient supplies for years to come, EPWU continues to re-evaluate and plan. Where groundwater and surface water supplies have always been El Paso's most affordable water sources, desalination, purified water, and reclaimed water present attractive alternatives, although at a higher cost. In particular, EPWU identified purified water as the next best step for ongoing water supply reliability. Purified water is treated wastewater that undergoes an advanced purification process before it is distributed. However, one interviewee suggested that increased use of reclaimed water and the potential use of purified water present problems for El Paso's parks and conservation areas. These plans would divert water at the potential detriment to wildlife. In addition to these alternatives currently or soon to be available, EPWU is planning for the future and is working to ensure that is has options for importing water from up to 100 miles away. Slowly, EPWU is putting in place the necessary easements to import water from Dell City. If, and when, this becomes a viable option for El Paso (probably no sooner than 2040), the water would need to be desalinated since it is brackish (Archuleta, 2015; Barrera, 2015; Mrkvicka, 2013; Crowder, 2014). However, EPWU recognizes importing is one of its highest cost water supply options so it will continue to work to conserve water and identify additional alternatives.

The city's involvement in the 100 Resilient Cities initiative and adaptation planning through Climate Solutions University have the potential to lead to actions which will reduce El Paso's vulnerability to drought, flooding, and extreme temperatures. Next steps include finalizing planning efforts, a possible greenway project to mitigate flooding, work with the Texas Trees Foundation to conduct a tree canopy assessment and eventually planting trees to mitigate urban heat island effects, and a number of preparedness outreach activities with both residents and businesses. Implementation of these actions could begin as early as January 2016 (Baldwin, 2015).

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- **Bill Hutchison,** independent groundwater consultant (formerly EPWU)
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Bibliography

100 Resilient Cities. 2015. El Paso's Resilience Challenge. Available: http://www.100resilientcities.org/cities/entry/el-pasos-resilience-challenge#/-_/. Accessed April 8, 2015.

American Community Survey. 2012. American Community Survey. American FactFinder. U.S. Census Bureau. Available: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 19, 2013.

Archuleta, E. 2004. Desalination of brackish groundwater in El Paso, Texas. In The Future of Desalination in Texas. Volume 2: Biennial Report on Seawater Desalination. Texas Water Development Board, Austin, TX. December. Available: https://www.twdb.texas.gov/publications/reports/numbered_reports/doc/R363/main.pdf. Accessed December 29, 2014.

Archuleta, E. 2015. Interview with Edmund Archuleta, former EPWU. February 23.

Archuleta, E., M. Fahy, S. Reinert, H. Gonzalez, R.S. Raucher, J. Clements, J. Oxenford, M. Mickley, W. Dugat, M. Cappelle, T. Davis, A. Tarquin, W. Hargrove, A. Michelsen, Z. Sheng, R. Lacewell, and A. Fernald. Forthcoming. El Paso Water Utilities' Kay Bailey Hutchison Desalination Plant, Texas. In Desalination Concentrate Management Policy Analysis for the Arid West. WateReuse Research Foundation. Alexandria, VA.

Baldwin, L. 2015. Interview with Lauren Baldwin, Sustainability Program Specialist. July 29.

Barrera, J. 2015. Response to Comments from John Barrera, Fort Bliss. April 6.

City of El Paso. 2015. Programs: Office of Resilience and Sustainability. Available: http://www.elpasotexas.gov/sustainability/programs. Accessed April 8, 2015.

Crowder, D. 2012. Desal Plan Running Near Capacity. El Paso Inc. May 27.

Crowder, D. 2014. EPWU Looks to Hudspeth County for Water: Drought on Rio Grande Speeds up Plans to Import Water. El Paso Inc. December 22. Available http://www.elpasoinc.com/news/local_news/article_49234be8-89f4-11e4-aa04-c762d27c90a0.html. Accessed August 13, 2015.

Cushing, E. 2015. Interview with Elza Cushing, former Fort Bliss. February 25. Dayoub, R. 2015. Interview with Richard Dayoub, The Greater El Paso Chamber of Commerce. February 23.

Department of the Army. 2004. Proposed Leading of Lands at Fort Bliss, Texas, for the Proposed Siting, Construction, and Operation by the City of El Paso of a Brackish Water Desalination Plant and Support Facilities. Available: https://www.bliss.army.mil/DPW/Environmental/documents/FORT%20BLISS%20DESAL%20FEIS.pdf. Accessed January 26, 2015.

DoD. Undated. Fort Bliss, Texas. U.S. Department of Defense. Available http://www.militaryinstallations.dod.mil/pls/psgprod/f?p=132:CONTENT:0::NO::P4_INST_ID,P4_INST_TYPE:4375%2CINSTALLATION. Accessed March 13, 2015.

EPWU. 2007a. Reclaimed Water: Water Shouldn't Only Be Used Once! Available: http://www.epwu.org/reclaimed_water/. Accessed February 13, 2015.

EPWU. 2007b. Water: Past and Present Water Supplies. Available: http://www.epwu.org/water/water_resources.html. Accessed February 13, 2015.

EPWU. 2007c. Water: Setting the State for the Future. Available: http://www.epwu.org/water/desal_info.html. Accessed February 13, 2015.

EPWU. 2007d. El Paso County Stormwater Master Plan. Available http://www.epwu.org/stormwater/master_plan.html. Accessed July 29, 2015.

EPWU. 2014a. El Paso Water Utilities 2014 Water Conservation Plan As per Rule 363.15 Required Water Conservation Plan Texas Water Development Board. Available: http://www.epwu.org/conservation/pdf/Conservation_Plan_2014.pdf. Accessed February 13, 2015.

EPWU. 2014b. Public Information: El Paso Water

Utilities Receives National Award for Sustainable Water Management. October 22. Available: http://www.epwu.org/public_information/news_releases/nr_141022-01.html. Accessed February 13, 2015.

Far West Texas Water Planning Group. 2011. 2011 Far West Texas Water Plan. Prepared for the Texas Water Development Board by LBG-Guyton Associates, Austin and Houston, TX. January.

Hutchison, B. 2004. Water Desalination and Reuse Strategies for New Mexico. New Mexico Water Resources Research Institute. September.

Hutchison, B. 2008. Climate Change Impacts on Municipal Water Management in El Paso, Texas. Presented at the Far West Texas Climate Change Conference. June 17. Available http://www.groundwater-conference.uci.edu/files/Chapter1/2008_conf_Hutchison,%20WR.pdf. Accessed March 2, 2015.

Hutchison, B. 2015. Interview with Bill Hutchison, independent groundwater consultant. February 16.

Hutchison, W.R. 2009. Desalination of brackish groundwater and deep well injection of concentrate in El Paso, Texas. In Proceedings of the World Environment and Water Resources Congress 2009. Kansas City, MO. Sponsored by EWRI. May 17–21.

Montoya, C. 2015. Interview with Christina Montoya, Vice President-Marketing and Communication. July 29.

Mrkvicka, M. 2013. Behind the Dell City Water Deal. El Paso Inc. March 14–20. Available http://texas-livingwaters.org/wp-content/uploads/2013/04/tlw-news-3-14-04.pdf. Accessed August 13, 2015.

Perez, D. 2001. Desalination Plant Would Be Largest in U.S. El Paso Time. April 23.

Reinert, S. 2014. Overview of the El Paso Kay Bailey Hutchison Desalination Plant. Presented at the Multi-State Salinity Coalition. Las Vegas, Nevada. February 20.

Reinert, S. 2015. Interview with Scott Reinert, El Paso Water Utilities. February 23 and July 29.

Stratus Consulting. 2011. El Paso Triple Bottom Line: Desalination and Reuse Water. Stratus Consulting Inc., Boulder, CO. October 13.

Texas Water Development Board. 2008. Far West Texas Climate Change Conference: Study Findings and Conference Proceedings. December. Available: http://www.twdb.texas.gov/publications/reports/special_legislative_reports/doc/climatechange.pdf. Accessed March 13, 2015.

Texas Water Development Board. Undated. Worth Its Salt: El Paso Water Utilities—Kay Bailey Hutchison Desalination Plant. Available http://www.twdb.texas.gov/innovativewater/desal/worthitssalt/doc/Worth_Its_Salt_Jan2014_ KBH.pdf. Accessed February 13, 2015.

The Portal to Texas History. 2007. 80th Texas Legislature, Regular Session, Senate Bill 1762, Chapter 575. June 15. Available: http://texashistory.unt.edu/ark:/67531/metapth155764/m1/1/. Accessed March 13, 2015.

Flagstaff, Arizona

Flagstaff Watershed Protection Project

FLAGSTAFF, ARIZONA

AUTHORS: Megan O'Grady, Karen Carney, and Jason Vogel

In this case study, you will learn about:

- Using a bond to raise funds to reduce vulnerability
- Securing public support for actions that reduce vulnerability
- A successful partnership between multiple jurisdictions at different government levels

Case Study Summary

Since the 1990s, northern Arizona has experienced several catastrophic wildfires. Damage from one of these fires, the 2010 Schultz fire, also contributed to severe flooding during heavy rains shortly after the fire. Increased temperatures and more intense precipitation due to climate change could lead to similar or even more damaging events in the future.

In November 2012, voters in Flagstaff passed a $10 million bond measure to fund forest-thinning activities to reduce the risk of catastrophic wildfire in the watersheds around Flagstaff, thus creating the Flagstaff Watershed Protection Project (FWPP). The FWPP involves forest-thinning treatments in critical but hard-to-treat areas of the forests around Flagstaff, including in the city's two main watersheds, Rio de Flag and Lake Mary/Mormon Mountain. The majority of the project area is comprised of National Forest (approximately 10,544 acres), but Arizona state and city lands are also included. The U.S. Forest Service (USFS), the City of Flagstaff, and the Arizona State Division of Forestry have conducted treatments in pre-approved areas and the USFS is conducting a treatment analyses on the remaining acres through the National Environmental Policy Act (NEPA) process. Although most of the specific projects planned under the FWPP are waiting for a NEPA review, the FWPP project has generated a lot of good will among stakeholders, has received decisive political support in the ballot box, and has attracted additional funding to supplement the $10 million bond.

Broader Context

Flagstaff's economy and culture are closely linked to its nearby forests. The city is located in the foothills of the San Francisco Peaks among one of the largest contiguous pine forests on Earth. The forest provides a wide range of recreational opportunities, such as skiing, camping, hiking, and mountain biking, which draw nearly 5 million visitors annually. The city also depends on nearby forests for most of its drinking water (City of Flagstaff, 2014b). Because forests are so important to the city culturally and economically, Flagstaff has invested in a wide range of activities to protect the forests' integrity over the long-term.

One of these activities began in 1997 when individuals from the Coconino National Forest of the USFS, the City of Flagstaff, Northern Arizona University, and environmental and business groups came together and formed the Greater Flagstaff Forests Partnership (Greater Flagstaff Forests Partnership, 2014; see Appendix A for a list of GFFP partners). The primary goals of the GFFP are to:

- "Restore natural ecosystem structures, function, and composition of ponderosa pine forests
- Manage forest fuels to reduce the probability of catastrophic fire
- Research, test, develop, and demonstrate key ecological, economic, and social dimensions of restoration efforts." (Greater Flagstaff Forests Partnership, 2014).

In the same year, the City of Flagstaff created its Wildland Fire Management division with the mission to, "promote, create and maintain a sustainable healthy forest ecosystem and a FireWise community, thereby protecting and enhancing public safety and community well-being" (City of Flagstaff, 2014c). These organizations and their activities helped raise awareness about the need to manage wildfire risk and they specifically identified key areas in need of treatment. Today, treatment is conducted by multiple entities, including the GFFP, the City of Flagstaff, the State of Arizona, and the USFS. These entities coordinate their work to ensure that all of the forests around Flagstaff are treated in a consistently and comprehensively manner, regardless of who owns the forest land.

While there are many different forest management efforts in and around Flagstaff, this case study focuses on the FWPP and its efforts to reduce vulnerability to catastrophic wildfire. While the area affected by the FWPP is relatively small, it targets critical areas not otherwise designated for treatment by other efforts due to steep slopes, challenging terrain, unique vegetation types, and the presence of the threatened Mexican spotted owl.

Over the last decade Flagstaff has also become increasingly aware of the potential effects of climate change on their community and the forests. In 2006, the City Council signed on to the U.S. Mayors Climate Protection Agreement, and in 2007 the council hired a full-time Sustainability Director, Nicole Woodman (Smith, 2012). Among other activities, Ms. Woodman led the development of a climate change vulnerability assessment for the city, which identified whether and how climate might threaten key city sectors and issues. The assessment identified catastrophic wildfire risk in the city's watersheds as one of Flagstaff's main vulnerabilities (City of Flagstaff, 2012b). However, even though Flagstaff has engaged in climate change adaptation planning, interviewees stated that vulnerability reduction activities implemented under FWPP were not directly informed or motivated by Flagstaff's adaptation efforts, although they did state that this work will help improve the resilience of forests to changing conditions.

Why and How Flagstaff Implemented the FWPP

Flagstaff and the Forest

Flagstaff sits in the middle of a large contiguous ponderosa pine forest. In the 1990s, these forests faced a series of significant wildfires that began to increase community awareness about how past management practices had increased the forests' susceptibility to large-scale, intense, and devastating fires (photo on cover). Other factors, such as the bark beetle outbreak, had contributed to the declining health of the area's forests.

Flagstaff's economy and culture are closely linked to the forests, so local experts took action. In 1997, the same year the GFFP was formed, the City of Flagstaff created its Wildland Fire Management division. GFFP began to raise awareness about the importance of forest management and identify key areas in need of treatment.

> **"The reality of climate change, drought, and the increasing threat of destructive wildfires and insect outbreaks to our forested watersheds challenge us to examine our approach to forest management and take bold action to restore the resilience and health of Arizona's forests, and protect forest values for future generations."**
>
> GOVERNOR'S FOREST HEALTH COUNCILS, 2007

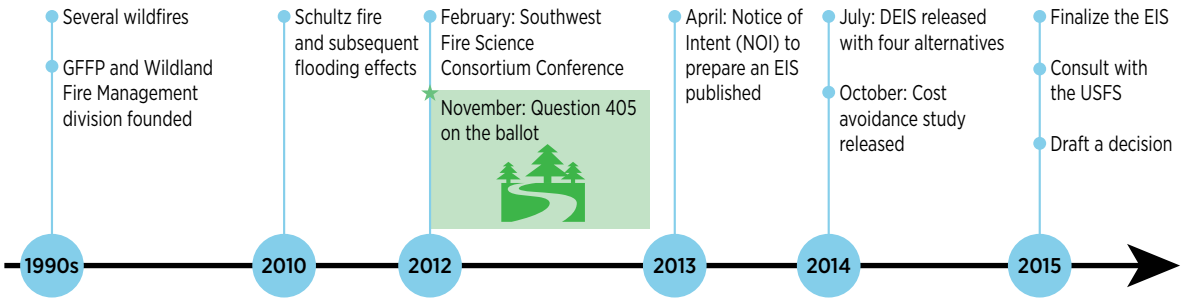

Exhibit 1. FWPP timeline.
DEIS: Draft Environmental Impact Statement; EIS: Environmental Impact Statement.

Schultz Fire and Subsequent Flooding

Following a series of record-breaking fires throughout the 2000s, in 2010 an abandoned campfire started the Schultz fire in the Coconino National Forest just north of Flagstaff. The fire burned over 15,000 acres. A month after the fire was contained, Flagstaff and the surrounding area experienced the fourth wettest monsoon event on record. The Schultz fire had damaged vegetation and ground cover, diminishing the forest's capacity to absorb much of the rain that fell. Thirty million gallons of water ran off the Schultz fire hillsides, resulting in severe flooding as far away as 10 miles from the fire site (Klassen and Howard, 2011; Youberg et al., 2011). The flooding affected several residential areas; damaged a main water pipeline, cutting off approximately 20 percent of the city's water supply; damaged 320 Native American cultural sites; and killed a 12-year-old girl (Klassen and Howard, 2011; Youberg et al., 2011; Brehl et al., 2014).

According to interviewees, Flagstaff residents became more aware of their vulnerability to wildfire following the Schultz fire; residents also came to recognize a fire's secondary effects, such as flooding, erosion, and impacts to their water supplies. Every individual interviewed for this case study believed that the Schultz fire and subsequent flooding were major factors in the formation and support of the FWPP (Brehl et al., 2014; Elson and Phelps, 2014).

Peer Learning from Santa Fe at the Southwest Fire Science Consortium

In late February 2012, GFFP representatives attended a conference in Santa Fe, New Mexico, sponsored by the Southwest Fire Science Consortium. According to the interviewees, at this conference they heard a presentation about an effort in Santa Fe to identify the community's willingness-to-pay to help protect their watershed resources from catastrophic fire damage. Santa Fe had secured a grant to conduct the Payment for Watershed Services (PWS) approach to forest management, which included a significant amount of community outreach and education (Brehl et al., 2014). Paul Summerfelt, the city's Fire Management Officer, and GFFP President at the time, attended the conference and realized that the GFFP and others in Flagstaff could motivate their community to help fund critical forest management as well.

Developing a Bond Measure and Building Support among Stakeholders

WORKING WITH THE NAVAJO NATION AND OTHER NATIVE TRIBES

As part of the FWPP, officials considered all individuals who were impacted by the Shultz fire and flood. This included the Navajo Nation because several Navajo Nation cultural sites were destroyed in the Shultz fire. The Navajo also own a 140-acre parcel in the Dry Lake Hills FWPP project area. As part of the FWPP, the City of Flagstaff and representatives from the Navajo Nation developed an agreement where some of the bond funds will be used to conduct treatment on tribal land. The treatment will be conducted in phases and the Navajo Nation will review and provide a permit for each phase. Native tribes who hold the San Francisco Peaks as Traditional Cultural Property have also been consulted as part of the NEPA planning process regarding treatment on USFS lands.

When Paul Summerfelt and his colleagues returned to Flagstaff, they organized a local workshop to pitch the idea of the PWS approach to the sustainability commissioners, city staff, department heads, and the City Manager, Kevin Burke. Kevin Burke was supportive of the idea but proposed that Flagstaff raise funds for its forest management project in a different way; he knew of a city bond that was set to expire later that fall. If the city allowed the bond to expire, it would decrease Flagstaff residents' taxes. However, Kevin Burke proposed that the city renew this bond and redirect the funds to wildfire management, which would provide support for forest management without increasing taxes (Brehl et al., 2014). The bond would raise $10 million for the management of approximately 15,000 acres of forest around Flagstaff that was not currently covered under other projects (Nielsen and Solop, 2013); this land included the Coconino National Forest, and Arizona state and city lands.

Although transferring the bond funds would legally require both the City Council and a city-wide vote of approval, it would create community ownership of the work and allow Flagstaff to access the funds quickly. Using bond funding would avoid the need for the city to conduct a costly and lengthy willingness-to-pay study. This idea was presented to the City Council for vote in spring 2012. The council voted in favor of the initiative, and bond question 405 was created for the ballot of the next fall's city-wide election. As soon as the City Council approved putting the bond on the ballot, a small team of individual Flagstaff citizens organized a Political Action Committee (PAC) in support of the measure. They spoke with a campaign consultant and raised $8,000–9,000 (Brehl et al., 2014). According to interviewees, the PAC conducted a hands-on, on-the-ground campaign that included distributing yard signs, soliciting support door-to-door, and handing out flyers at local events and farmers' markets.

In November 2012, bond question 405 was presented to the voters. The bond would provide support for forest management "[t]o prevent flood damage to the City of Flagstaff and to protect the city water supply from damages which occur from large-scale and/or severe wildfire(s) in town watersheds in the city" (City of Flagstaff, 2012a, slide 5). Money raised through the bond would support activities on city, state, and federal lands. Each agency would be in charge of treatment on their land, but treatment options would be explored collaboratively through a partnership. The bond funding would be held by the city and distributed as needed to other agencies. For example, the USFS would retain decision-making authority on what activities would be allowed on National Forest land, but the city would maintain decision-making authority on the bond dollar (i.e., what the money would fund). The initiative passed with 73 percent voter approval (Nielsen and Solop, 2013).

Exit polling conducted by Eric Nielsen and Fred Solop at Northern Arizona revealed that the majority of voters supporting the bond issue were primarily concerned with decreasing the risk of post-fire flooding and protecting city water resources. The majority of supporters also "strongly agreed" or "agreed" that the project "partnership is a model of how to accelerate needed forest restoration" (84 percent) and that the "Forest Service would be accountable to the City" of Flagstaff with this project design (70 percent) (Nielsen and Solop, 2013; Figure 1).

The planning effort on the National Forest is now led by the FWPP Interdisciplinary Team (IDT), which is comprised of approximately 16 core members and 8 consulting members, including a representative from the City of Flagstaff. The city was granted Cooperating Agency status early in the planning process to enable Flagstaff to have a seat at the planning table. An executive committee is also in place to discuss overarching decisions related to FWPP, including funding and implementation. The executive committee is comprised of representatives from the USFS, the city, Coconino County, and the Arizona State Department of Forestry. The committee meets once monthly to help facilitate overall project coordination (see "Moving Forward" below).

Accomplishments of the FWPP

Although large-scale implementation of the FWPP has not yet begun, interviewees reported on several project successes. With 73 percent voter approval, the bond issue was remarkably successful in the election, and that high level of public interest and involvement has carried through to the planning process. Those involved with the campaign and FWPP members credit its high voter-approval rating in part with the strength of public engagement, in addition to the still-fresh memory of the Schultz fire (Brehl et al., 2014; Elson and Phelps, 2014). This widespread support is even more meaningful considering that the Ecological Restoration Institute's exit polling found that the majority of voters incorrectly believed that the bond was going to increase their taxes (Nielsen and Solop, 2013).

Interviewees reported that the high voter-approval rating has continued to be important to the project because it demonstrated strong public support for the project and empowered the community to take ownership of it; this high level of public support has potentially influenced those opposed to the FWPP; and has sent a signal to national, state, and local leaders that the community

is dedicated to the project's success. This has also led the project team to continuously inform the public and encourage public input into the project as much as possible, well beyond what is required by law (Brehl et al., 2014; Elson and Phelps, 2014). For example, the FWPP has developed a monitoring plan to track whether and how key goals of the project are being achieved over time. According to interviewees, the public noted the importance of such a plan, and key themes to address in it, during the bond campaign. The FWPP has held 20 public workshops to refine the plan and ensure that key voter concerns have been included (FWPP, 2014d).

In the two years following the passage of the bond, the project raised an additional $2 million in direct and in-kind funding. The formal partnership between Flagstaff and the USFS, which was established soon after the bond passed, has led to substantial USFS contributions to the project; as of fall 2014, the USFS has contributed approximately $1.6 million to cover planning costs, wildlife surveys, hand thinning, prescribed burning, archaeological surveys, noxious weed surveys and treatments, and road work (Elson and Phelps, 2014). An additional $400,000 has come from the State of Arizona, Coconino County, Northern Arizona University, volunteers, and local citizens (FWPP, 2014b; Summerfelt, 2014).

Moving Forward

Although the project idea and public support came together quickly, interviewees said that treatment work in the Rio de Flag and Lake Mary watersheds could take up to 8 to 10 years to fully complete based on the complexity of the project, legal and contracting processes, and seasonal operating limitations.

As mentioned previously, Flagstaff has decision-making authority over the bond dollars and the USFS has decision-making authority over what occurs in the National Forest. However, there is a wide diversity of stakeholders involved in the FWPP. The immediate focus of the FWPP IDT is to finalize a treatment plan through a Record of Decision (ROD) so that large-scale treatment work can begin on the National Forest as soon as possible. To that end, the NEPA planning process that began in November 2012 is expected to end with the release of the Final ROD in September 2015; this is roughly half the time it typically takes for a project of this scale (Summerfelt, 2014).

In April 2013, a Notice of Intent to prepare an EIS was published in the Federal Register, and the FWPP IDT released a Proposed Action to the citizens of Flagstaff outlining different treatment options. Based on comments the FWPP team received, the USFS released a DEIS in July 2014, which analyzed four treatment alternatives: no action, minimal treatment, proposed action with cable logging, and proposed action without cable logging (e.g., using helicopter logging and specialized steep-slope equipment) (see Appendix B).

The DEIS was open for public comment for 45 days. Simultaneously, the FWPP team also held public meetings and outreach events to raise awareness and solicit public feedback. Between these events, and email and hard-copy submissions, the team received comments from 107 individuals who raised 530 separate issues. Every comment was in support of the project as a whole, but the responses raised various concerns about how the treatments would be conducted. It helped the team realize that there was a need to create a transparent and widely publicized implementation plan to address public concerns regarding contractor oversight, mitigation measures, and area closures. In the fall of 2014, the FWPP IDT drafted this plan along with a decision that addressed public comments by developing a blend of all three treatment alternatives. The IDT also finalized the EIS and conducted a formal consultation with the U.S. Fish and Wildlife Service for activities related to the Mexican spotted owl.

In the meantime, the USFS has been able to conduct some work on portions of FWPP lands that were previously approved for treatment through the NEPA process. Treatment methods already used include controlled burns, hand thinning, and piling of cut material (i.e., slash; see Exhibit 3). The state conducted a mechanical treatment operation on a parcel of state land, and the city has been engaged doing hand thinning and controlled burning on a number of City and private land parcels. This work has allowed the FWPP team the opportunity to provide visual examples of treatment options to help further inform the public.

Exhibit 3. Two treatment demonstration areas in the Coconino National Forest: a controlled burn area (left) and a burn pile of cut debris (i.e., slash) (right).
Photograph source: Megan O'Grady, Stratus Consulting.

Most recently, in October 2014, the Rural Policy Institute of Northern Arizona University released a Cost Avoidance Study that estimated the amount of financial impact avoided by implementing the FWPP project. The study results estimate a range of potential losses from catastrophic wildfire and post-fire flooding to be between $573 million and $1.2 billion dollars if no treatment is done to the forests. While the FWPP project will not eliminate these risks entirely, the estimated project treatment costs of $10 million compare highly favorably to these potential losses (Arizona Rural Policy Institute, 2014).

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Bibliography

Arizona Daily Sun. 2014a. Extreme fires deserve more prevention tools. September 18. Available: http://azdailysun.com/news/opinion/editorial/extreme-fires-deserve-more-prevention-tools/article_c2a550eb-0413-53a9-abe9-85b37a1d790f.html. Accessed October 20, 2014.

Arizona Daily Sun. 2014b. Watershed protection means drastically altering forest. July 13. Available: http://azdailysun.com/news/opinion/editorial/watershed-protection-means-drastically-altering-forest/article_b5ded800-0a43-11e4-adb6-0019bb2963f4.html. Accessed October 20, 2014.

Arizona Rural Policy Institute. 2014. Flagstaff Watershed Protection Project: Cost Avoidance Study. October. Available: http://www.flagstaffwatershedprotection.org/wp-content/uploads/2014/10/Final-FWPP-Cost-Avoidance-October-27.pdf. Accessed October 20, 2014.

Bacon, J. 2010. Shultz fire, day 3. Arizona Daily Sun. June 23. Available: http://azdailysun.com/news/local/schultz-fire-day/collection_be2f256c-7ecb-11df-9e5b-001cc4c03286.html#0. Accessed October 20, 2014.

Betz, E. 2011. Southwest spring dries with climate change. Arizona Daily Sun. May 10. Available: http://azdailysun.com/news/local/southwest-spring-dries-with-climate-change/article_ba31463a-f4da-57ec-a528-c953d707a78b.html. Accessed October 20, 2014.

Brehl, M., A. Mottek Lucas, P. Summerfelt, D. Vosick, and N. Woodman. 2014. Interview with Mark Brehl, Wildland Fire Management, City of Flagstaff, AZ; Anne Motek Lucas, Mottek Consulting; Paul Summerfelt, Wildland Fire Management, City of Flagstaff, AZ; Diane Vosick, Northern Arizona University; and Nicole Woodman, Sustainability Manager, City of Flagstaff, AZ. Flagstaff, AZ. October 21.

CAKE. 2014. Climate Adaptation Knowledge Exchange: Flagstaff Search. Available: http://www.cakex.org/search/apachesolr_search/Flagstaff. Accessed October 20, 2014.

Caravona, B. 2011. Memorandum to CAC re: Framing "Restoration." City of Flagstaff. February 1. Available: http://www.flagstaff.az.gov/documentcenter/view/13121. Accessed October 20, 2014.

City of Flagstaff. 2012a. City of Flagstaff Bond Question. Forest Health & Water Supply Protection Project. November. Available: http://www.flagstaff.az.gov/documentcenter/view/40301. Accessed October 20, 2014.

City of Flagstaff. 2012b. City of Flagstaff Resiliency and Preparedness Study. September. Available: http://www.flagstaff.az.gov/DocumentCenter/Home/View/38841. Accessed June 18, 2015.

City of Flagstaff. 2012c. Forest Health and Water Supply Protection Project. Ballot Question #405. Question & Answer Sheet #2. September 25. Available: http://www.flagstaff.az.gov/documentcenter/view/41050. Accessed October 20, 2014.

City of Flagstaff. 2014a. Climate Adaptation and Management. Available: http://flagstaff.az.gov/index.aspx?nid=1732. Accessed October 20, 2014.

City of Flagstaff. 2014b. Community Profile. Available: http://www.flagstaff.az.gov/index.aspx?NID=2. Accessed October 20, 2014.

City of Flagstaff. 2014c. Wildland Fire Management. Available: http://www.flagstaff.az.gov/index.aspx-?SID=361. Accessed October 20, 2014.

CLIMAS. 2013. Advancing Climate Adaptation in Flagstaff: Expert Discussion Session. Climate Assessment for the Southwest. August 20. Available: http://www.climas.arizona.edu/event/advancing-climate-adaptation-flagstaff-expert-discussion-session. Accessed October 20, 2014.

Elson, M. and E. Phelps. 2014. Interview with Mike Elson and Erin Phelps, Coconino National Forest. Flagstaff, AZ. October 21.

FWPP. 2014a. About the Flagstaff Watershed Protection Project. Timeline. Available: http://www.flagstaffwatershedprotection.org/faqs/#timeline. Accessed October 20, 2014.

FWPP. 2014b. Frequently Asked Questions. Flagstaff Watershed Protection Project. Available: http://www.flagstaffwatershedprotection.org/faqs/. Accessed October 20, 2014.

FWPP. 2014c. FWPP DEIS Comparison Summary document. Available: http://www.flagstaffwatershedprotection.org/wp-content/uploads/2014/07/FWPP-DEIS-Comparison-Summary.pdf. Assessed April 20, 2015.

FWPP. 2014d. FWPP Monitoring Plan. Available: http://www.flagstaffwatershedprotection.org/wp-content/uploads/2013/03/FWPP-Monitoring-Plan.pdf. Accessed April 20, 2015.

Governor's Forest Health Councils. 2007. Statewide Strategy for Restoring Arizona's Forests, E. Aumack, T. Sisk, and J. Palumbo (eds.). Published by Arizona Public Service. Phoenix, AZ. June. Available: http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5137128.pdf. Accessed October 20, 2014.

Greater Flagstaff Forests Partnership. 2014. Greater Flagstaff Forests Partnership. Available: www.gffp.org. Accessed October 20, 2014.

Kelly, J. Undated. Flagstaff's City Wide Resiliency Study. Institute for Sustainable Communities. Available: http://sustainablecommunitiesleadershipacademy.org/resource_files/documents/flagstaffs-city-wide-resiliency-study.pdf. Accessed October 20, 2014.

Klassen, K. and D. Howard. 2011. The Shultz fire & subsequent flooding. Firefighter Nation. January 1. Available: http://www.firefighternation.com/article/features-0/schultz-fire-subsequent-flooding. Accessed October 20, 2014.

Melillo, J.M., T. Richmond, and G.W. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

Mindock, C. 2013. Flagstaff moves forward on the watershed protection project. Arizona Daily Sun. April 30. Available: http://azdailysun.com/news/local/flagstaff-moves-forward-on-the-watershed-protection-project/article_80695e24-b1c6-11e2-b3e9-001a4bcf887a.html. Accessed October 20, 2014.

Nielsen, E. and F. Solop. 2013. Forest Health and Water Supply Protection Project Ballot Measure: Exit Poll Results. May. Available: http://www.flagstaffwatershedprotection.org/wp-content/uploads/2013/06/Prop405_ExitPoll_FactSheet_May20131.pdf. Accessed October 20, 2014.

Politico. 2012. 2012 Presidential Election. Available: http://www.politico.com/2012-election/results/map/#/President/2012/. Accessed February 4, 2013.

Rasker, R. 2014. Email to Jason Vogel, Stratus Consulting re: Flagstaff Contacts. Headwaters Economics, Bozeman, MT. October 20.

Smith, D.M. 2012. Flagstaff sustainability chief Nicole Woodman keeps cool head as temperatures rise. Grist. October 5. Available: http://grist.org/cities/flagstaff-sustainability-chief-nicole-woodman-keeps-a-cool-head-as-temperatures-rise/. Accessed October 20, 2014.

Summerfelt, P. 2014. Email to Megan O'Grady, Stratus Consulting re: Study Follow-up Questions. City of Flagstaff, Flagstaff, AZ. December 6.

U.S. Census Bureau. 2013a. B19013: Median Household Income in the Past 12 Months (in 2013 inflation-adjusted dollars). 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. Census Bureau. 2013b. DP05: Demographic and Housing Estimates. 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

USDA Forest Service. 2014. FS Seeks Public Comments on Flagstaff Watershed Protection Project; Public Meetings Invitation. July 3. Available: http://www.fs.usda.gov/detail/coconino/news-events/?cid=STELPRD3807109. Accessed October 20, 2014.

U.S. EPA. 2013. Climate Impacts in the Southwest. U.S. Environmental Protection Agency. Last updated September 9. Available: http://www.epa.gov/climatechange/impacts-adaptation/southwest.html. Accessed October 20, 2014.

Youberg, A., K. Koestner, and D. Neary. 2011. Wildfire, rain and floods: A case study of the June 2010 Schultz wildfire, Flagstaff, Arizona. Arizona Geology. Available: http://www.azgs.az.gov/arizona_geology/winter10/article_feature.html. Accessed October 20, 2014.

Appendix A. Members of the Greater Flagstaff Forests Partnership

Voting members

- Arizona Game & Fish Department
- Arizona Forest Restoration Products
- Arizona State—Forestry Division
- City of Flagstaff—Fire Department
- Coconino County—Community Development Department
- Coconino Natural Resource Conservation District
- Coconino Rural Environment Corps
- Ecological Restoration Institute at Northern Arizona University
- Mottek Consulting, LLC
- Northern Arizona University—School of Forestry
- The Arboretum at Flagstaff
- The Nature Conservancy
- U.S. Fish and Wildlife Service—Region 2
- Wildwood Consulting, LLC

Associates

- Arizona Public Service
- National Park Service—Flagstaff Area National Monuments

Cooperators

- Ponderosa Fire Advisory Council
- USDA Coconino National Forest

Appendix B. Summary of Treatment Options Outlined in the DEIS

Actions	Alternative 1: No treatment	Alternative 2: Proposed action with cable logging	Alternative 3: Proposed action without cable logging	Alternative 4: Minimal treatment
Total treatment acres	Jack Smith Schultz/ Eastsidea	8,937 acres 5,963 acres DLH 2,975 acres MM	8,937 acres 5,963 acres DLH 2,975 acres MM	5,802 acres 3,459 acres DLH 2,343 acres MM
Percentage of total project area to be treated	0 percent	85 percent 79 percent DLH 100 percent MM	85 percent 79 percent DLH 100 percent MM	55 percent 46 percent DLH 79 percent MM
Acres to be hand thinned	0 acres	846 acres 699 acres DLH 147 acres MM	832 acres 652 acres DLH 180 acres MM	438 acres 438 acres DLH 0 acres MM
Acres to be mechanically thinned	0 acres	7,124 acres 4,697 acres DLH[b] 2,427 acres MM	7,137 acres 4,743 acres DLH 2,394 acres MM	5,264 acres 2,953 acres DLH 2,311 acres MM
Acres to be helicopter logged	0 acres	0 acres	973 acres 973 acres DLH 0 acres MM	0 acres
Acres to be cable logged	0 acres	1,242 acres 1,169 acres DLH 73 acres MM	0 acres	0 acres
Acres to be prescribed burned	0 acres	8,937 acres 5,963 acres DLH 2,975 acres MM	8,937 acres 5,963 acres DLH 2,975 acres MM	5,802 acres 3,459 acres DLH 2,343 acres MM

a. Past projects with acreages within the FWPP boundary that could be implemented.
b. Includes cable logging areas that could be cut by hand.

DLH: Dry Lake Hills.

MM: Mormon Mountain.

Source: FWPP, 2014c.

Fort Collins, Colorado

PHOTO: City of Fort Collins

Water Demand Management

FORT COLLINS, COLORADO

AUTHORS: Lorine Giangola and Jason Vogel

In this case study, you will learn about:

- Achieving water-use reductions through combined regulatory actions and voluntary conservation programs
- Taking quick action after an extreme event to advance drought management
- Protecting a key economic sector
- Limitations to drought management in the West
- Leveraging community support for demand management actions

Case Study Summary

Like most communities in the arid intermountain west, Fort Collins is accustomed to managing water shortages and responding to drought. Severe drought events in the last few decades have increased the urgency of efforts to reduce the city's vulnerability to future water shortages. Furthermore, under climate change, warming temperatures and shifting precipitation patterns could lead to more frequent or more intense drought events.

In 2012, Fort Collins updated its Water Supply and Demand Management Policy, which requires the water utility to maintain a water supply that can meet a demand of 150 gallons per capita per day (gpcd) during a 1-in-50 year drought. This case focuses on two key, interactive elements of the policy: (1) The Water Supply Shortage Response Plan, which outlines specific regulatory measures that reduce water use quickly during a severe drought; and (2) the city's water conservation programs, which aim to achieve reductions in water use that are sustained even in times of water abundance.

These strategies have allowed water managers to reduce the community's total water use and to quickly reduce demand even further during water shortages. In fact, water managers believe that their efforts to decrease overall water use have reduced the need to enact restrictions under the Water Supply Shortage Response Plan. They also agree that their integrated approach to supply and demand management has decreased their vulnerability to short-term drought. Still, the city's decision-makers are concerned about Fort Collins' ability to cope with long-term droughts, and their economic impacts, if the city does not increase its water storage capacity. Although climate change has not explicitly motivated these particular actions, city staff are well aware of climate change risks and Fort Collins' strategies have achieved lasting water savings and tangible reductions in vulnerability to future climate change-related drought.

Broader Context

Water resource management in the West is complex and challenging, and recent severe droughts have drawn more attention to communities' vulnerabilities and to the need to prepare for increasing climate variability and uncertainty about water availability. Colorado has a long history of drought and water shortages. While climate change models do not project decreases in total precipitation in Colorado, drought conditions could worsen as a result of earlier snowmelt and warmer summers; simultaneously, water demand is expected to increase as the population grows (Gordon et al., 2015, Lukas and Gordon, 2015). Colorado faces additional challenges in dealing with multiple, interrelated climate impacts. For example, wildfire risk increases under drought conditions, and flood risk increases when heavy precipitation falls on dry or scorched land that is less able to absorb and retain water—as has been seen in recent years along Colorado's Front Range. Water resource managers face these complex dynamics as they try to prepare for potentially more severe and prolonged droughts in the future.

Fort Collins' leaders recognize and understand the potential impacts of climate change on the city's vulnerability, and the community has made significant progress toward cutting its greenhouse gas (GHG) emissions since it developed its first GHG reduction plan in 1999. As of early 2015, the city had reduced its GHG emissions to levels that are 5 percent below 2005 emissions, despite a population increase of 16 percent. Over the same time period, the city has experienced a 22 percent increase in economic growth (City of Fort Collins, 2015). On March 3, 2015, the City Council unanimously approved the city's latest plan to reduce GHG emissions to levels that will make the city carbon neutral by 2050.

In recent years, the city has expanded its climate portfolio to include climate change adaptation planning, and has engaged in adaptation initiatives at the regional level, through the Western Adaptation Alliance, and at the national level. In 2013, former Fort Collins Mayor Karen Weitkunat was appointed to the President's Climate Preparedness and Resilience Task Force, which convened state, local, and tribal leaders from around the United States to develop recommendations for effective federal government response to community-level impacts of climate change. Fort Collins' involvement in climate change adaptation discussions at the national level has spurred action on local adaptation initiatives and has

made it easier to engage city staff at upper levels of management in adaptation planning (Smith, 2015). City staff have worked with consultants to conduct vulnerability and risk assessments for each city department and to identify potential adaptation strategies.

Fort Collins has been a national leader in climate change mitigation, and climate change adaptation planning is underway across multiple city departments. However, the city's adaptation actions are still in the planning stages, and are therefore not a specific focus of this case study. Instead, this case study focuses on the city's water conservation programs and the Water Supply Shortage Response Plan, which prescribes the concrete actions that water managers in Fort Collins take to reduce their vulnerability to drought.

Why and How Fort Collins Developed Its Water Supply and Demand Management Strategies

Severe Drought Motivates Fort Collins to Address Water Supply Shortages

A series of droughts in the last few decades has motivated water utilities managers to restrict water use and intensify conservation efforts, eventually prompting the city to formalize a regulatory action plan for reducing water use during drought. In 1977 a serious drought left reservoirs nearly empty, leading the Fort Collins water utility to enact lawn watering restrictions for the first time, and spurring the city to create a part-time water conservation position to develop its first water conservation initiatives (Exhibit 1). As the city's population continued to grow in the 1980s, Fort Collins worked to acquire more water rights and increase its water storage capacity. Rapid water resource development and concern about future water shortages, similar to the 1977 drought, prompted a review of the city's water policies in 1987, and in December 1988, Fort Collins adopted its Water Supply Policy to guide future water supply acquisition and management. In April 1992, after upgrading the water conservation manager position to full-time, the city developed and adopted a Water Demand Management Policy, which outlined water-use goals and measures for meeting those goals.

Another severe drought in 2002 again led the utility to enact water-use restrictions late in the summer. At the time, the city's water management plans did not formally outline these restrictions, and the utility did not conduct any extensive study in developing its 2002 restrictions plan. Water managers looked to what other utilities in the region, like Denver Water, were doing to restrict

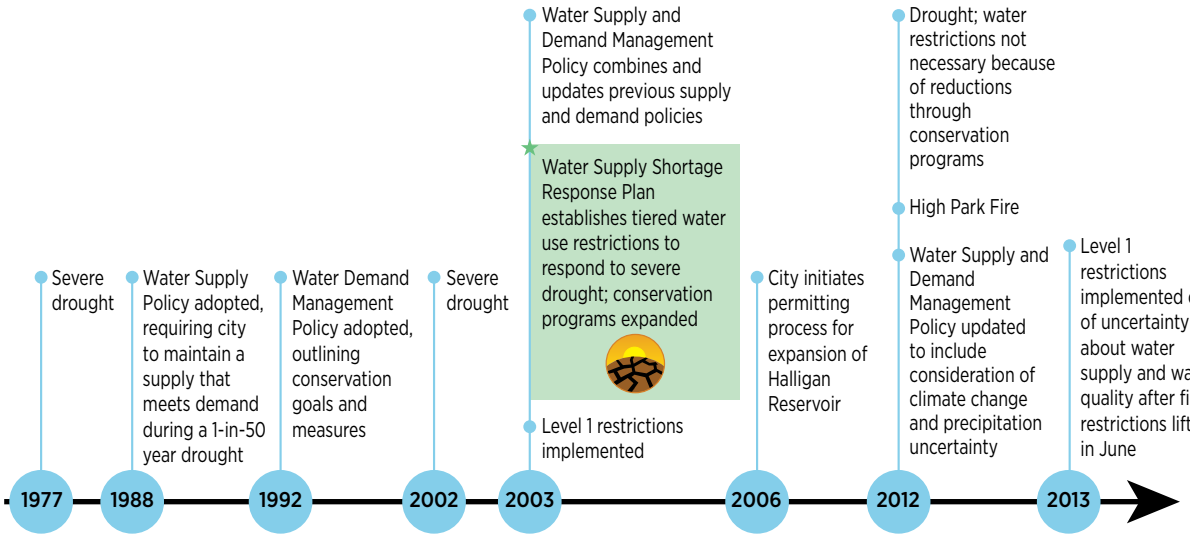

Exhibit 1. Timeline of Drought Management Actions in Ft. Collins.

water use so that they could quickly formulate their own restrictions, recalls Donnie Dustin, Water Resources Manager at Fort Collins Utilities. The severity of the 2002 drought made water managers realize that they needed to formalize these measures for future responses, and the utility set out to design new, tiered restrictions, which it outlined in its 2003 Water Supply Shortage Response Plan. The response plan was then embedded in the 2003 Water Supply and Demand Management Policy, which updated and combined the 1988 and 1992 plans into one comprehensive document at the request of the City Council. In early 2003, the utility enacted the new Level 1 restrictions, but heavy spring snowfall eased drought conditions, and the utility lifted the restrictions in September.

The drought not only motivated the city's decision-makers to formalize drought plans and actions, but it also motivated the Fort Collins community to increase its participation in conservation programs and to change its water-use habits. The city's conservation efforts intensified and water managers developed new conservation programs after the 2002 drought; community engagement increased when residents recognized the importance of saving water during severe drought (D'Audney, 2015). Water managers believe that the water-use restrictions enacted during the drought underscored the need to take water conservation seriously, and that these regulatory measures were a factor in motivating the increase in voluntary conservation actions (D'Audney, 2015; Dustin, 2015; Smith, 2015).

Economic Concerns Motivate Fort Collins to Address Water Supply Shortages

Fort Collins' decision-makers are very concerned about economic impacts of future droughts. The city's 16 breweries and Avago, a large company that manufactures computer components, all depend on a reliable and clean water supply. The city's three largest breweries—Anheuser-Busch, New Belgium Brewing Co., and Odell Brewing Co.—collectively use over one billion gallons of water each year (Kyle, 2015). Although the Water Supply Shortage Response Plan does not restrict water use for brewing operations, Fort Collins' breweries have recognized the need to increase water-use efficiency in the industry, and they are taking voluntary actions to reduce their total water use and the amount of water used to produce each unit of beer (Kyle, 2015).

A severe or long-term water supply shortage that would require the city to reduce the amount of water delivered to its breweries would threaten the viability of the industry in Fort Collins. The city has never implemented water restrictions for industries, but after the 2012 High Park Fire in the foothills west of the city, "the breweries really paid attention" to water quantity and quality threats from drought and subsequent wildfires, says Katy Bigner, Environmental Planner for Fort Collins. Bruce Hendee, former Chief Sustainability Officer for the City of Fort Collins, who served from January 2010 to February 2015, agrees that, "We are heavily, heavily at risk if we have even a five-year-in-a-row drought. Our brewing industry is really big…If we went too long without water storage, that's a serious economic threat."

Insufficient Water Storage Capacity Limits Options for Drought Management

Storage is a major limitation to increasing the city's resilience to drought and a primary motivation for conserving and protecting existing supplies. Utility managers and city administrators agree that storage is the city's most significant need in preparing for future droughts, and that the city will continue to be vulnerable until storage capacity is increased. Fort Collins has been involved in the permitting process for expanding Halligan Reservoir, which lies in the foothills northwest of the city, since 2006 (cover image). This 100-year old reservoir currently holds about 6,400 acre-feet, and the city needs to acquire at least an additional 8,125 acre-feet to meet its supply requirements (Duggan, 2014). If the city attains a permit from the U.S. Army Corps of Engineers, and if the City Council ultimately approves the project, construction likely will not begin until 2018 or 2019 (Webb, 2015). Adding storage capacity will allow the city to increase the amount of water it collects during wet or average years so that more water is available later, especially during droughts. Water managers have not adjusted their water supply modeling specifically for climate change, mainly for the practical reason that the city has been engaged in the permitting process for

the expansion of the Halligan Reservoir since 2006, and any change the utility makes to its supply calculations or projections must be reviewed, further prolonging the permitting process (Dustin, 2015).

In addition to inadequate storage infrastructure, reduced natural water storage capacity contributes to the vulnerability of water supplies in Colorado's Front Range communities. Declining forest health (most visibly caused by pine and spruce beetle epidemics and severe fires) and altered hydrology in forested watersheds diminish the forests' natural capacity for water storage. Forests play an important role in capturing and protecting water supplies, but "our forests are not doing well," says Bruce Hendee. Since the High Park Fire, the water utility has engaged with regional watershed protection initiatives that work toward making Fort Collins' watershed more resilient to wildfire and to other supply redundancy threats (Webb, 2015). Diminished natural water storage capacity increases the city's reliance on voluntary conservation programs and regulatory strategies to meet supply requirements established in the Water Supply and Demand Management Policy.

City Decision-Makers Leverage Community Support for Demand Management

Extreme events like the 2002 drought and the 2012 High Park Fire, despite the hardships they impose, create opportunities to build support for government actions, and can motivate citizens to take an interest in water management planning. When Fort Collins was updating its Water Supply and Demand Management Policy in 2012, decision-makers and hired facilitators held stakeholder meetings with environmental groups, farmers, and other citizens interested in water management issues. The updated Water Supply and Demand Management Policy passed quickly in 2012, after residents experienced firsthand some of the previously identified uncertainties about water supply shortages (Bigner, 2015). The Fort Collins community generally has responded very positively to water-use restrictions and to utility projects that enhance water storage and treatment capacities. Managers attribute the community's support to an educated and informed citizenry that has experienced severe drought and that understands the impacts of drought and the need to reduce vulnerability (Dustin, 2015; Smith, 2015; Webb, 2015; Weinheimer, 2015; Weitkunat, 2015).

Accomplishments of Fort Collins' Demand Management Strategies

Fort Collins decision-makers agree that current demand management approaches have decreased the city's vulnerability during short-term water shortages and increased its resilience to drought. Significantly reducing demand, in anticipation of shortages and also during drought, allows water managers to retain more water in storage for drought years. Slowing the drawdown of stored supplies, and having more water left at the end of a drought, helps the city recover and return to normal water-use levels more quickly and easily.

The utility has used the Water Supply Shortage Response Plan not only to respond to drought, but also to respond to wildfire impacts on water supply. During the dry summer of 2012, a lightning strike ignited the High Park Fire, which devastated the mountain communities in Larimer County west of Fort Collins and had major impacts on the city's watershed. The fire burned over 87,000 acres of forest and destroyed over 250 homes. Early in 2013 the utility again enacted Level 1 restrictions because of uncertainty about water supply and water quality after the fire. Precipitation events in the spring of 2013 eased these concerns, and the utility lifted the restrictions in June.

Enacting water-use restrictions has been an effective drought response strategy in Colorado's Front Range communities, including in Fort Collins (Kenney et al., 2004), and conservation programs have produced lasting water-use reductions in the city. Between 2003 and 2012, Fort Collins experienced a significant drop in water use—from about 200 gpcd to about 150 gpcd—despite population growth (Dustin, 2015; Webb, 2015). Residential outdoor water use has dropped by 50 percent since the 2002 drought (D'Audney, 2015), and businesses' and city operations' water use has also declined (City of Fort Collins, 2013; Weitkunat, 2015). The city's decision-makers attribute the demand decrease

to the combination of regulations and conservation outreach during the 2002 drought. "My sense was that people were motivated by the drought and were provided tools" for changing their water use habits, says Lucinda Smith, the city's Director of Environmental Services. The region experienced another drought in 2012, though less severe than the 2002 drought, and the utility would have needed to impose restrictions again in 2012 if not for the conservation programs, says Laurie D'Audney, former water conservation manager at Fort Collins Utilities. These water-use trends suggest that combining regulatory measures with ongoing conservation outreach can produce longer-lasting water savings during droughts than can short-term restrictions alone.

Still, the city's managers have serious concerns about Fort Collins' vulnerability, and economic resilience, to potentially more severe and long-term drought. While city administrators and utility managers feel prepared to manage relatively short-term droughts through their current policies, "We haven't been tested, in my opinion, for some of these severe droughts, like in California and Texas," says Katy Bigner. Bruce Hendee agrees that, "We might get through a five-year drought, but I don't think we'd get through a seven-year drought. When I read about super-droughts, like in the Dust Bowl era, I get really worried about our ability to last much longer than that because I don't think we can deliver water to our major companies."

According to these assessments, Fort Collins water managers have been successful in managing a certain level of vulnerability to drought, and demand management strategies have increased the community's resilience during a drought of an anticipated degree of severity. The Water Supply Shortage Response Plan has been effective for responding to relatively short-term drought, and it increases the city's adaptive capacity for responding to more severe drought in the future. Conservation programs have produced lasting water-use reductions, but these measures can only reduce water use to a certain point after which it becomes much more difficult to reduce water use. Fort Collins remains vulnerable to drought that is more severe than 1-in-50 years, and to long-term drought that would require more drastic response measures than those outlined in the response plan, or that would require more extreme conservation measures. At that point, the city's water supply will be depleted unless the city increases it storage capacity to a level that can meet critical demand during a very severe and/or prolonged drought.

Moving Forward

Fort Collins' decision makers believe that increasing water storage will be the most effective way to enhance the community's resilience to drought, and the city has been pursuing a permit for expansion of the Halligan Reservoir for several years. But building resilience to drought, especially by building more storage, can be expensive. "Cost will be the biggest barrier," says Bruce Hendee. The Halligan expansion could cost $35 million more than what the city has spent to date; half of these funds are already in reserve, and the utility plans to acquire the rest through projected development in the utility's water service area over the next few decades (Dustin, 2015). The city does, however, already own enough water rights, so costs will be associated mainly with infrastructure development and improvements.

While the Fort Collins community has generally been supportive of the city's water and drought management strategies, utility managers do hear from citizens who oppose parts of the Water Supply and Demand Management Policy. Some residents think that conservation program resources would be better spent on increasing storage capacity, says Laurie D'Audney. On the other hand, "We have people who oppose things such as storage," says Donnie Dustin. Despite conflicting values among some community members, decision-makers believe that they have been successful in integrating public input into water management planning, and in leveraging public support in order to take action after extreme events. Due to the overall success of water demand management programs and community outreach since the 2002 drought, the utility has set a goal of reducing water use even more—from the current 150 gpcd to 140 gpcd by 2020.

Although climate change was not an initial motivation for Fort Collins' drought management strategies or for developing its Water Supply Shortage Response Plan or

conservation programs—"We're steeped in variability, regardless of climate change," says Donnie Dustin—there is awareness in the Utilities Department that climate change could make the city's resource management challenges more difficult. In 2012 the city's Water Supply and Demand Management Policy was updated to include language about climate and precipitation uncertainty, and to highlight the need to consider climate change effects on water supplies. The policy states that "the city will continue to monitor climate change information and, if necessary, will revise its water supply planning criteria and assumptions to ensure future water supply reliability."

Yet, according to water managers, drought planning and climate change adaptation are one and the same. "Climate adaptation planning is just good planning. It's hard to separate it…Because that's the way we do business, some of these elements have already been integrated into our regular planning," says Carol Webb, the utilities' Water Resources and Treatment Operations Manager. "Even though we haven't necessarily labeled it as climate [change] adaptation planning, it resulted in that." Katy Bigner agrees that, "Utilities already plans to the extremes. If anything, [climate adaptation] validates the approaches we already have."

Although water managers currently do not anticipate a need for new or separate plans to prepare specifically for climate change, the water utility is engaged in city-wide climate adaptation planning initiatives, which aim to reduce the expense of responding to climate-related disasters and to decrease vulnerability to future climate change (City of Fort Collins, 2014). "The bottom line is, responding to disaster is expensive. Planning for disaster is doable," says former Mayor Weitkunat. The city is working with consultants to conduct risk and vulnerability assessments for all city departments, and to outline goals, strategies, and decision processes for adaptation actions. In 2013, Brendle Group, in coordination with the Geos Institute, facilitated climate adaptation workshops with city decision-makers, where they reviewed climate science, discussed adaptation, and identified and prioritized vulnerabilities of each city department (City of Fort Collins, 2014). "One of the main goals is to institutionalize, in each department, ways to consider climate change in long-range plans," says Lucinda Smith.

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- **Bruce Hendee,** former chief sustainability officer, City of Fort Collins
- **Lucinda Smith,** director, environmental services department, City of Fort Collins
- **Carol Webb,** water resources and treatment operations manager, City of Fort Collins Utilities
- **Dan Weinheimer,** legislative policy manager, City of Fort Collins
- **Karen Weitkunat,** former mayor, City of Fort Collins.

Bibliography

Bigner, K. 2015. Interview with Katy Bigner, Environmental Planner, City of Fort Collins. February 20, 2015.

City of Fort Collins. 2009. Water Conservation Plan. Available: http://www.fcgov.com/utilities/img/site_specific/uploads/conservation-plan.pdf. March 26, 2015.

City of Fort Collins. 2013. Municipal Sustainability Annual Report. Available: http://www.fcgov.com/climateprotection/pdf/2013AR_092314_web.pdf?1419444197. Accessed March 26, 2015.

City of Fort Collins. 2014. Summary of Current Efforts & Next Steps: Climate Change Adaptation. August 26. Available: http://www.fcgov.com/enviro/pdf/climate-change-adaptation-final.pdf?1420049264. Accessed March 26, 2015.

City of Fort Collins. 2015. Draft 2015 Climate Action Plan: Framework. February 25. Available: http://www.fcgov.com/climateprotection/pdf/draft-cap-feb25.pdf. Accessed April 6, 2015.

D'Audney, L. 2015. Interview with Laurie D'Audney, former Water Conservation Manager, City of Fort Collins Utilities. March 2.

Duggan, K. 2014. Fort Collins loses partner in Halligan Reservoir expansion. Coloradoan. February 13. Available: http://archive.coloradoan.com/article/20140212/NEWS01/302120097/Fort-Collins-loses-partner-Halligan-Reservoir-expansion. Accessed April 21, 2015.

Dustin, D. 2015. Interview with Donnie Dustin, Water Resources Manager, City of Fort Collins Utilities. February 24.

Fort Collins Utilities. 2015a. Map of Upper Cache La Poudre River Watershed and Colorado-Big Thompson project. Available: http://www.fcgov.com/utilities/what-we-do/water/water-quality. Accessed March 26, 2015.

Fort Collins Utilities. 2015b. Photo of Halligan Reservoir. Available: http://www.fcgov.com/utilities/what-we-do/water/halligan-water-supply-project. Accessed April 21, 2015.

Gordon, E., R. Klein, V. Deheza, and S. McNeeley. 2015. Chapter 5—Water Sector. In Colorado Climate Change Vulnerability Study, E. Gordon and D. Ojima (eds.). University of Colorado, Boulder, CO and Colorado State University, Fort Collins, CO.

Hendee, B., 2015. Interview with Bruce Hendee, former Chief Sustainability Officer, City of Fort Collins. February 17.

Kenney, D.S., R.A. Klein, and M.P. Clark. 2004. Use and effectiveness of municipal water restrictions during drought in Colorado. Journal of the American Water Resources Association 40(1):77–87.

Kyle, S.J. 2015. Fort Collins brewers bottle up excess water use. Coloradoan. February 16. Available: http://www.coloradoan.com/story/money/2015/02/16/fort-collins-brewers-bottle-excess-water-use/23368057/. Accessed April 21, 2015.

Lukas, J. and E. Gordon. 2015. Colorado's climate: Past and future. Chapter 2 in Colorado Climate Change Vulnerability Study, E. Gordon and D. Ojima (eds.). University of Colorado, Boulder, CO and Colorado State University, Fort Collins, CO.

Politico. 2012. 2012 Presidential Election. Available: http://www.politico.com/2012-election/results/map/#/President/2012/. Accessed February 4, 2013.

Smith, L. 2015. Interview with Lucinda Smith, Director, Environmental Services Department, City of Fort Collins. March 4.

U.S. Census Bureau. 2013a. B19013: Median Household Income in the Past 12 Months (in 2013 inflation-adjusted dollars). 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. Census Bureau. 2013b. DP05: Demographic and Housing Estimates. 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

Webb, C., 2015. Interview with Carol Webb, Water Resources and Treatment Operations Manager, City of Fort Collins Utilities. February 17.

Weinheimer, D. 2015. Interview with Dan Weinheimer, Legislative Policy Manager, City of Fort Collins. March 4.

Weitkunat, K. 2015. Interview with Karen Weitkunat, former Mayor, City of Fort Collins. March 4.

Grand Rapids, Michigan

Vital Streets and Sidewalks Spending Guidelines

GRAND RAPIDS, MICHIGAN

AUTHORS: Missy Stults, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- Leveraging existing community concerns to reduce vulnerability to climate change
- Tackling flooding through changes in street design policy and practice
- Using public-private partnerships to achieve community and government goals

Case Study Summary

For the last 30 years, the City of Grand Rapids has been devising solutions to manage stormwater. However, recent flooding events, combined with aging stormwater infrastructure and growing public discontent about the dilapidated state of roads, presented an opportunity to rethink how stormwater was managed in the city. To address these concerns, the city created the Vital Streets and Sidewalk Spending Guidelines (Guidelines) mandating the use of green infrastructure when upgrading road and stormwater infrastructure. Through extensive public engagement combined with the deteriorating state of roads, the Guidelines and funding to implement them passed with 66 percent of voter support in early 2014 (LaFurgey, 2014).

As of mid-2014, all upgrades to existing road or stormwater infrastructure, as well as any new road or stormwater projects in Grand Rapids, are required to prioritize green infrastructure techniques or justify why these techniques are not technically feasible. According to stakeholders in Grand Rapids, the Guidelines and the associated move to a greener infrastructure are helping to change the culture of stormwater management in the city while simultaneously enhancing local water quality, replenishing the city's aquifer, cleaning the local air, reducing the urban heat island effect, and enhancing the overall sense of community.

Broader Context

When it rains, it pours. At least, that seems to be the case recently in Grand Rapids and across the Midwest. According to the National Climate Assessment (Melillo et al., 2014), between 1958 and 2012, the amount of precipitation falling in the Midwest during the heaviest storms (the 1 percent storms) has increased by 37 percent. This increase in precipitation had led to serious riverine and inland flooding events, disrupted economic activities, endangered lives, and destroyed homes, crops, infrastructure, and businesses. Moreover, climate change projections for Michigan estimate that precipitation will increase between 20 percent and 70 percent more by the end of the century (Melillo et al., 2014) and the Grand Rapids Climate Resiliency Report estimates that "precipitation is expected to increase from a baseline average of 7.6 cm to 7.8 cm and 8.3 cm in 2022 and 2042, respectively" (West Michigan Environmental Action Council, 2013, p. 9). In light of these significant changes, municipalities throughout the Midwest are looking for strategies to more effectively manage precipitation.

The City of Grand Rapids has a long history of taking climate change and sustainability action as demonstrated by the fact that the city boasts the highest per capita number of Leadership in Energy and Environmental Design (LEED) buildings in the nation, and was the first city to be recognized by the United Nations University as a Regional Centre of Expertise for Education on Sustainable Development (West Michigan Environmental Action Council, 2013). The city also has a nationally recognized sustainability plan, the Grand Rapids Sustainability Plan, which aims to achieve "an economic, social, and environmentally sustainability future" for the city and its citizens (City of Grand Rapids Office of Energy and Sustainability, 2015). Included in the Sustainability Plan are 231 targets in 14 goal areas, including goals focused on a strong economy, great neighborhoods, healthy lifestyles and healthy environments, energy and climate protection, and environmental quality and natural systems. As of fiscal year 2014, the city has successfully completed 155 of their targets (66.5 percent; City of Grand Rapids Office of Energy and Sustainability, 2015).

Recently, the City of Grand Rapids, in partnership with the West Michigan Environmental Action Council (WMEAC) undertook a climate change vulnerability assessment to identify how climate change could impact the city. The results showed that one of the most serious threats facing the city was flooding associated with increased precipitation events (West Michigan Environmental Action Council, 2013). This finding confirmed the city's suspicion and added fodder to efforts aimed at proactively managing water throughout Grand Rapids.

Today, the City of Grand Rapids has a number of initiatives that have recently been completed or are underway to reduce the impact of heavy precipitation events, including the separation of all combined sewer systems; an urban forestry program; significant investments in

green infrastructure such as bioswales, rain gardens, porous pavement, and green roofs; incentives for homeowners to install rain barrels and rain gardens; and water conservation and reuse programs. One of the more innovative programs currently being pursued, however, is a public-private partnership focused on simultaneously preventing flooding and enhancing the quality of roads throughout the city: the Grand Rapids Guidelines. This initiative is the focus of this case study.

Why and How Grand Rapids Implemented Its Guidelines

A Long History of Flooding and State Water Quality Mandates Pushed the City toward Grey Stormwater Infrastructure

From as early as 1883, documents show that major flooding on the Grand River, which runs through downtown Grand Rapids (from events such as log jams, spring snowmelt, ice jams, and heavy rains), damaged homes, businesses, and roads primarily along the city's west side (Olson, 2014). Following a major flood at the turn of the century (1904), the city built its first floodwalls in 1911 with additional floodwalls built in 1927, 1934, and 1936 (Clark, 2014). In 2003 the city completed its most recent floodwall project, which raised all existing floodwalls and embankments one foot above the 100-year flood mark established in the 1904 flood (Clark, 2014). Despite these investments in physical infrastructure, the Grand River has continued to overflow, with a historic flooding event occurring in April 2013 (Exhibit 1).

The legacy of inundation led the city to investigate strategies in addition to floodwalls for minimizing the threat of both riverine and inland flooding. This work gained traction roughly 30 years ago when Grand Rapids began efforts to remove all existing combined sewer systems and replace them with separate sanitary sewer and stormwater systems (Alibasic, 2014). Motivation for this change came from the State of Michigan, which was actively working with the city to reduce the amount of sewage being discharged into the Grand River (Lunn, 2014).

When heavy rainfall events occur, combined sewer systems can get overwhelmed, making them unable to effectively manage and treat sewer and stormwater waste separately. In these cases, excess sewer combines with stormwater and flows directly into discharge basins. In Grand Rapids, this discharge basin is the Grand River. In the early 1980s, the State of Michigan began citing the city as being in violation of water-quality requirements (Lunn, 2014). In response, the city began working with

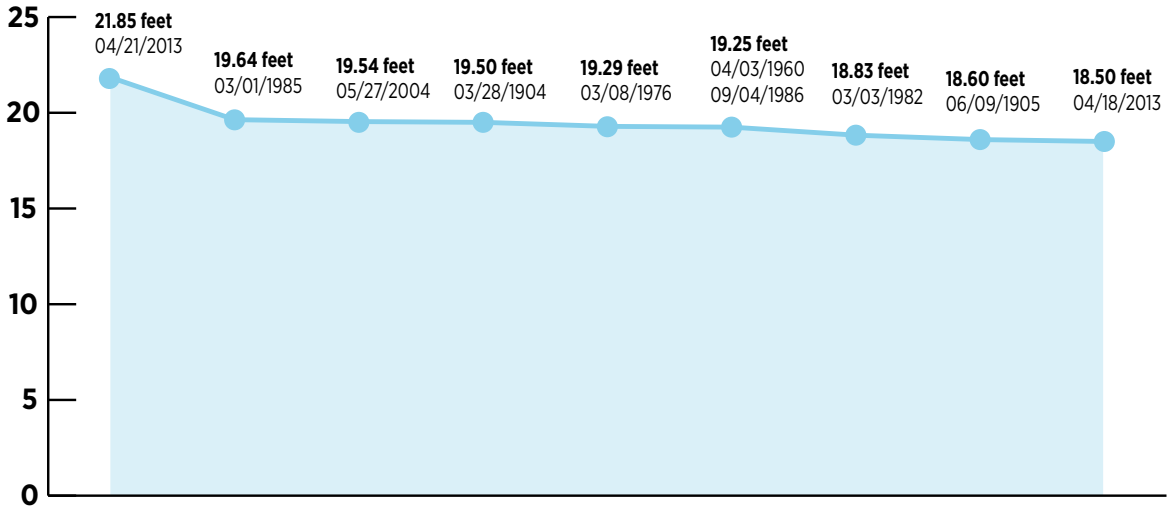

Exhibit 1. Highest Grand River crests on record for the City of Grand Rapids.
Source: Clark, 2014.

the state to devise a strategy to reduce the amount of combined sewer and stormwater entering the Grand River. The result was the creation of a stormwater management plan in 1988 that called for the division of the Grand Rapids combined sewer systems into separate stormwater and sewer systems. To date, over 99.2 percent of the combined sewer pipelines have been replaced (58 out of 59 in system overflow points), and plans are underway for eliminating the one remaining combined sewer and stormwater system by 2016 (Lunn, 2014).

Continued Flooding Ignites Support for Green Infrastructure

To date, the city has invested hundreds of millions of dollars in the transition to a separate sewer and sanitary system and has successfully reduced the amount of sewage entering the Grand River (Lunn, 2014). This work, however, has not eliminated the growing threat of localized flooding. In fact, a U.S. Environmental Protection Agency 2008 report found that in the Great Lakes region, "projected long-term (2060–2099) changes in precipitation suggest that if combined sewer overflow (CSO) mitigation efforts are designed based on historical precipitation, many systems could experience increases in the frequency of CSO events beyond their design capacity resulting in increases in overflow volume discharged to receiving waters" (U.S. EPA, 2008, p. 2). This realization, combined with the fact that localized flooding was occurring more frequently, led a number of citizens, nonprofits, and city staff to seek alternative strategies for managing stormwater.

According to Haris Alibasic, the director of the City of Grand Rapids Office of Energy and Sustainability, the movement to rethink how stormwater was managed in Grand Rapids crystallized during a series of community stormwater discussions held in partnership between the city and the WMEAC (2014). Initiated in the late 2000s, these meetings were held with businesses, nonprofits, neighborhood associations, residents, and city commissioners to explore stormwater best management practices from around the country and devise a plan for how Grand Rapids could integrate relevant practices into its operations. Haris Alibasic indicated that in addition to public meetings, a survey was administered to more than 600 residents to assess whether there was support for undertaking and financing improvements to the existing stormwater system (2014). This effort, known as the Community Stormwater Master Planning Initiative, culminated in a 2012 report entitled, *Sustainably Managing Stormwater in Grand Rapids* (West Michigan Environmental Action Council, 2012).

The *Sustainably Managing Stormwater in Grand Rapids* report identified five priorities for the city, most notably, the prioritization of green infrastructure over traditional hard physical infrastructure. Upon the report's release, organizations such as the Chamber of Commerce requested a more detailed look at what infrastructure improvements were needed (both grey and green), where they were needed, and how they would be funded (Occhipinti, 2014). Based on this feedback, the City of Grand Rapids hired an engineering consulting firm, for approximately $450,000, to help (1) create a Stormwater Asset Management Plan, (2) create a Stormwater Capital Improvement Plan, (3) update the city's Stormwater Technical Reference Manual, and (4) create an asset management software tool that allows the city to visually see where improvements to the stormwater system are needed (Occhipinti, 2014). The results from these deliverables confirmed that significant investments were needed to upgrade the city's deteriorating stormwater infrastructure and that green infrastructure could, in many cases, provide an alternative to traditional grey infrastructure in meeting both stormwater needs and other community-wide goals. In addition to the work done by the engineering consulting firm, a series of other reports, as denoted in Exhibit 2, were instrumental in laying the foundation for community support of green infrastructure.

Green Infrastructure Included in Road Improvements through Creation of Grand Rapids' Guidelines

The next issue was how to begin implementing and financing key infrastructure improvements. In Grand Rapids, and throughout Michigan, street infrastructure has been in dwindling disrepair for years. With the intense winter of 2013 leading to even more potholes and damaged roads, residents and businesses united in demanding the city invest in major repairs to city streets (Occhipinti, 2014).

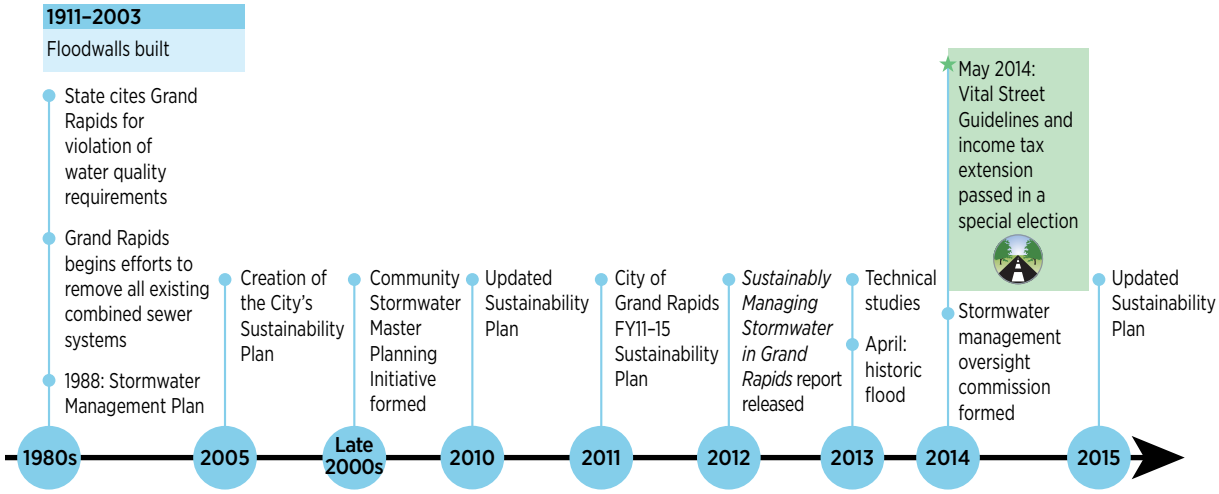

Exhibit 2. Key dates and actions related to green infrastructure transition in Grand Rapids.

Nick Occhipinti, director of policy and activism at WMEAC, said that he recognized that the "smartest time to do stormwater upgrades is when you're working on streets;" he notes that WMEAC worked with the city to leverage the political interest and will around street repairs to also update stormwater infrastructure. One idea for funding this work that quickly gained traction was the extension of an income tax that was about to expire (Occhipinti, 2014). City staff, elected officials, non-profits such as WMEAC, and many businesses agreed that pursuing an extension to the income tax was a politically viable solution for financing needed repairs. As such, the city set to work drafting specific details for how the income tax extension, combined with other city funds, could be used to simultaneously repair streets and upgrade key stormwater infrastructure.

The result of these efforts was the Grand Rapids Guidelines, which specify how the income tax extension as well as other city funding would be spent, establish stormwater performance standards, and create a stormwater oversight commission to help guide the implementation of the Guidelines. Perhaps most importantly, the Guidelines require that, whenever feasible, the city must invest in green infrastructure as opposed to traditional hard infrastructure. In situations where green infrastructure is deemed technically unfeasible, the city must justify why this is the case and identify ways that green infrastructure can be used to supplement more traditional hard infrastructure approaches.

Building and Maintaining Community Support for Green Stormwater Management

The Guidelines and the associated income tax extension did face some opposition. A group of citizens actively opposed new, large-scale stormwater investments and the movement to create the Guidelines (Occhipinti, 2014). This opposition group included constituents who supported the transition to green infrastructure but did not think the city was investing enough in making the requisite changes.

To navigate citizen opposition, said Nick Occhipinti, the city, WMEAC, and other partners "did our best to sit down with opponents and explain, in detail, why this is an issue, what the need is, and why we care about it. We also did public advocacy and education including an intentional citizen outreach effort in which we worked directly with community leaders to discuss the need" (2014). In addition, public meetings, listening sessions, and dozens of presentations were delivered to community stakeholders to help educate people on the need for stormwater

upgrades and build support for the Guidelines. In the end, stakeholders came to a general consensus that (1) stormwater management is important; (2) investments in stormwater are going to be critical; and (3) to effectively manage stormwater, the city needed to have a solid understanding of what infrastructure currently exists, what state it is in, what needs to be done to properly manage it, and what upgrades are needed (Alibasic, 2014; Lunn, 2014). Moreover, by combining discussions about stormwater upgrades with road repair, the city was able to make a more holistic case about why public investment in critical infrastructure was essential.

To maintain support for the Guidelines and their implementation, the city uses hands-on events where city commissioners and the public get together to plant trees, clean bio-retention islands, and help maintain rain gardens. As Mike Lunn notes, "We try to involve the community as much as we can and really highlight our projects that exist as stormwater amenities. We try to give people ownership over these projects so they feel invested and engaged" (2014).

While a number of individuals were supportive of stormwater management efforts and, more specifically, the move toward green infrastructure, a few elected and appointed officials and staff were particularly instrumental; these included Mayor George Heartwell; Commissioner Ruth Kelly; Deputy Mayor Eric Delong; Haris Alibasic, the director of the City of Grand Rapids Office of Energy and Sustainability; Mike Lunn, the director of the City of Grand Rapids Department of Environmental Services; Suzanne Schulz, the director of the City of Grand Rapids Planning Department; and WMEAC members (Occhipinti, 2014).

Through these extensive engagement and outreach efforts, the City of Grand Rapids was able to successfully pass both the Guidelines and the income tax extension needed to help finance the implementation of the Guidelines. These two efforts passed with 66 percent of voter support during a special May 2014 election (LaFurgey, 2014). While the clear and growing need for updated streets was a strong motivator for action, public education and outreach around the need for stormwater upgrades, including efforts such as public service announcements and community forums, helped to build the critical support needed to pass the Guidelines (Lunn, 2014).

Accomplishments of Grand Rapids' Guidelines

The City of Grand Rapids is now implementing the Guidelines. According to Nick Occhipinti, the city's Environmental Services Department is "already experiencing better funding for stormwater" (2014). Haris Alibasic said, "It makes sense to have these projects done using green infrastructure. Ultimately it also helps communities (residents, businesses) to better understand the value of green infrastructure. When you have a project like Joe Taylor Park, where you can incorporate green infrastructure elements, certainly the community can appreciate the value of onsite stormwater management" (see Exhibit 3; 2014). The Grand Rapids community is also experiencing some co-benefits associated with the use of green infrastructure. For example, better water quality, replenishment of the city's aquifer, cleaner air, heightened walkability, heat island reduction, improved aesthetics, and energy savings are all co-benefits associated with green infrastructure that the city is already experiencing or believes it will face in the future (Alibasic, 2014; Occhipinti, 2014).

> **Stormwater isn't sexy… but its solutions can be.**
>
> NICK OCCHIPINTI

Has the transition to green infrastructure been a success? "Yes and no," says Nick Occhipinti. "We are not done yet" (2014). Haris Alibasic shares this sentiment, noting "there are always opportunities for progress in everything that we do. We have to continually invest and evaluate our progress as opposed to saying that we have succeeded. In this case, I couldn't call our work a failure; I wouldn't call it a complete success. I would call it a positive step in the right direction" (2014).

Mike Lunn, director of Environmental Services for the City of Grand Rapids, notes that, "Yes, I think we are very successful around stormwater and we are starting—especially with Joe Taylor Park, Mary Waters, and Tremont Parks—to have a lot of things to talk about. We just don't talk about them enough" (2014). Measuring success is hard, but for Mike Lunn and his team, one simple strategy is to see if "three years later, we still have vegetated solutions in place and they are still working, and if they are, then chances are they are going to continue working for much longer" (2014).

Even though the city does not currently have specific metrics to track the success of green infrastructure, it does use two screens to measure the success of any project (Alibasic, 2014): Did the strategy reduce greenhouse gas emissions and was the strategy financially sound? While these metrics do not embody all of the possible ways of measuring success, they do provide a litmus test for ensuring projects are in alignment with broader city goals. In addition, Haris Alibasic notes that the city is currently looking for metrics of resilience that can be incorporated into the next round of updates to the Grand Rapids Sustainability Plan, the city's guiding document pertaining to all aspects of social, environmental, and economic sustainability, and these new metrics are likely to include more specific measurement related to stormwater management (Alibasic, 2014). Perhaps more than any physical metric of success, the indicator that Grand Rapids is doing something right is the fact that, despite extremely limited staffing, green stormwater management appears to "be a part of the city's culture" (Lunn, 2014).

Moving Forward

While climate change has not yet been explicitly integrated into stormwater management efforts in Grand Rapids, Haris Alibasic and Mike Lunn both note that climate change was and remains an underlying theme that drives the city's investment decisions (2014). As noted by Mike Lunn, the city has been incorporating future projections into stormwater planning for years by doing things such as "designing to a 25- or 100-year storm as opposed to a 10-year storm" (2014). According to Haris Alibasic, "We did not use exact projections in our work to date. That's why we are moving to the next phase where we are looking at the exact science and future projections and incorporating these into our stormwater management planning initiatives" (2014).

> **The idea is to try to get the rain to stay where it lands. And we know that the climate always changes so we prefer using green infrastructure because it will help us keep the water out of the river and lessen our impact on the environment.**
>
> MIKE LUNN

According to all the interviewees, the city recognized this need and, in response, extended a contract with the engineering consultancy firm Tetra Tech to assess key issues such as how climate change could affect rainfall patterns and what areas of infrastructure are the most vulnerable to issues such as extreme weather and increased precipitation. The final product developed by Tetra Tech is meant to help guide the City of Grand Rapids in making decisions on which projects to undertake, how best to integrate green infrastructure into these projects, and when the projects should be undertaken to optimize the efficiency of the system.

"There is a recognition that climate change will inevitably have an impact on stormwater infrastructure," said Haris Alibasic. "And the way that infrastructure is planned in Grand Rapids is about taking into consideration the long-term as opposed to the short-term view and perspective. This goes along with climate change resilience preparedness, preparation, and planning because it affords us an opportunity to look at projections of climate change and integrate them into our infrastructure planning" (2014).

Even though climate change was not explicitly factored into the city's existing stormwater management plans,

EXHIBIT 3. JOE TAYLOR PARK. THE PICTURE ON THE LEFT IS THE OLD PARK. THE PICTURE ON THE RIGHT IS THE NEWLY REMODELED PARK.

Situated in the east side of Grand Rapids, Joe Taylor Park was created in 2011 and is one of the city's newest parks. Originally noted as being "park poor" or underserved when it came to park space, the Baxter neighborhood and surrounding area had been flagged as in need of park space for years. In addition, localized flooding in the area had been raised as a concern necessitating action.

Initially, to address flooding-related concerns, the city looked at installing a 10-million-gallon concrete holding basin. However, through a series of stakeholder meetings and reviews, the city decided, instead, to install an infiltration basin composed of green infrastructure. A pervious parking lot, light-emitting diode (LED) security lighting, and a cistern to capture rainwater from the park to irrigate the park's trees and lawn were also installed (Harger, 2011; Lunn, 2014).

In addition to the installation of stormwater features, Harger said, "city officials asked neighbors to help design a kid-friendly park" (Harger, 2011). Through this process, residents requested a picnic shelter, playground, seating areas, and a water park. The park caters to smaller children as well as families and single residents. More recently, residents installed a series of urban gardens.

Today, Joe Taylor Park is 2.2 acres of what was once blighted land that now creates an urban landscape more accessible and comfortable to the residents abutting the area. In addition, the site collects, treats, and drains stormwater from the entire neighborhood (approximately 40 acres) and is able to manage the first inch of water falling during a storm directly onsite (Harger, 2011; Lunn, 2014).

Joe Taylor Park before renovation

Newly remodeled Joe Taylor Park

Grand Rapids does have a Resilience Report that has been helping lay the foundation for integrating climate change into other city planning efforts (West Michigan Environmental Action Council, 2013). The Grand Rapids Resilience Report was created by WMEAC in partnership with the city and was instrumental in helping the city acquire localized climate data that have been and will continue to be important in driving stormwater management efforts in the city (Haris Alibasic, 2014). The Resilience Report discusses 22 sectors or topics within Grand Rapids likely to be affected by climate change, one of which is stormwater. To make the findings of the Resilience Report more applicable, Haris Alibasic and his team in the Office of Energy and Sustainability are

working to integrate key findings from the report into the updated Grand Rapids Sustainability Plan (due to be released before the end of 2015).

> **The more successful you are, the more opportunities you get to continue doing these things.**
>
> MIKE LUNN

Moving forward, the city has three priorities: (1) installing a greener infrastructure while maintaining what already exists, (2) formally integrating climate change and resilience into citywide plans and operations, and (3) finding additional funding to complete the needed upgrades to the stormwater system. The city's newly created (summer 2014) stormwater management oversight commission will play a key role in helping to ensure these priorities are achieved. In addition, an opportunity exists for more regional work, but what this opportunity looks like and how it is seized remains to be seen (Lunn, 2014).

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- **Mike Lunn,** director of the City of Grand Rapids Department of Environmental Services
- **Nick Occhipinti,** director of policy and activism, WMEAC.

Bibliography

Alibasic, H. 2014. Interview with Dr. Haris Alibasic, Director of the Grand Rapids Office of Energy and Sustainability. October 27.

City of Grand Rapids Office of Energy and Sustainability. 2015. Sustainability Plan: Fourth Year Progress Report. Available: www.sustainablegr.org. Accessed July 27, 2015.

Clark, C. 2014. 2013 Flood: Experts Describe How Close Grand Rapids Was to Crippling Floodwall Breach. Available: http://www.mlive.com/news/grand-rapids/index.ssf/2014/01/2013_flood_experts_describe_ho.html. Accessed November 3, 2014.

Ellison, G. 2013. Great Flood of 1904 Revisited: The Grand River Has a Long History of Overflowing its Banks. April 18. Available: http://www.mlive.com/news/grand-rapids/index.ssf/2013/04/grand_river_flood_1904.html. Accessed November 3, 2014.

Harger, J. 2011. Grand Rapids Opens Joe Taylor Park; an Oasis for Kids in a Once-Blighted Neighborhood. June 28. Available: http://www.mlive.com/news/grand-rapids/index.ssf/2011/06/grand_rapids_opens_joe_taylor.html. Accessed November 4, 2014.

LaFurgey, J. 2014. GR Road Tax Extension Passes. Available: http://woodtv.com/2014/05/06/turnout-low-for-gr-road-tax-vote/. Accessed November 3, 2014.

Lunn, M. 2014. Interview with Mike Lunn, Director of the Grand Rapids Environmental Services Department. October 27.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

NWS. 2014. Weather Forecast Office Grand Rapids, MI. National Weather Service. Available: http://water.weather.gov/ahps2/hydrograph.php?wfo = grr&gage = gdrm4. Accessed November 3, 2014.

Occhipinti, N. 2014. Interview with Nick Occhipinti, Director of Policy and Activism at the West Michigan Environmental Action Council. October 27.

Olson, G. 2014. A Short History Grand Rapids, Michigan. Available: http://grcity.us/administrative-services/customer-service/Pages/A-Short-History-of-Grand-Rapids.aspx. Accessed November 3, 2014.

Politico. 2012. 2012 Presidential Election. Available: http://www.politico.com/2012-election/results/map/#/President/2012/. Accessed February 4, 2015.

U.S. Census Bureau. 2013a. B19013: Median Household Income in the Past 12 Months (in 2013 inflation-adjusted dollars). 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. Census Bureau. 2013b. DP05: Demographic and Housing Estimates. 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. EPA. 2008. A Screening Assessment of the Potential Impacts of Climate Change on Combined Sewer Overflow (CSO) Mitigation in the Great Lakes and New England Region. National Center for Environmental Assessment. Office of Research and Development, Washington, DC.

West Michigan Environmental Action Council. 2012. Sustainably Managing Stormwater in Grand Rapids: A Report of the Grand Rapids Community Based Stormwater Planning Initiative. Available: http://grcity.us/enterprise-services/Environment-Services/SOC%20Resources/sustainably-managing-stormwater-in-grand-rapids1.pdf. Accessed: November 3, 2014.

West Michigan Environmental Action Council. 2013. Grand Rapids Climate Resiliency Report. West Michigan Environmental Action Council. Grand Rapids, Michigan.

Miami-Dade, Florida

Integrating Climate Change Adaptation into a Comprehensive Development Master Plan

MIAMI-DADE, FLORIDA

AUTHORS: Alexis St. Juliana, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- Strong and consistent leadership on climate change issues
- Regional collaboration and peer learning
- Integration of adaptation into comprehensive planning
- The importance of reliable and defensible climate change information

Case Study Summary

Miami-Dade County in Florida is vulnerable to a range of climate change impacts including coastal storms and sea level rise. In particular, county officials consider sea level rise a serious and pressing threat. In some locations, streets already flood during high tides. Future sea level rise also threatens the county's drinking water sources and important infrastructure, like water treatment facilities. In 2006, the county created a Climate Change Advisory Task Force to look into climate change mitigation and adaptation opportunities. Stemming from this and the county's long history of environmental action, the Department of Regulatory and Economic Resources, including the Planning Division, identified climate change adaptation as a new issue to address in its Comprehensive Development Master Plan (CDMP). In 2013, the Board of County Commissioners approved integrating climate change considerations into multiple elements of the CDMP (i.e. Land Use; Transportation; Conservation, Aquifer Recharge and Drainage; Water, Sewer & Solid Waste; Coastal Management; and Intergovernmental Coordination). These changes will require county departments to take climate change into consideration during capital improvement projects and other decision-making processes. Although integration of climate change into the CDMP has occurred, the county has not had sufficient time to incorporate these climate change aspects of the CDMP into departmental procedures. Additionally, staff in the Planning Division feel they need to provide county departments with more detailed projections of climate change impacts, specifically developed for Miami-Dade, before the departments can make informed decisions on how to effectively adapt.

The Broader Context of Climate Change Adaptation in Miami-Dade County

Miami-Dade County has a long history of environmental action. In the 1980s and 1990s, these efforts were spurred by Harvey Ruvin, then commissioner, now Clerk of the Courts. Under Ruvin's leadership and as a founding member of ICLEI-Local Government for Sustainability (formerly International Council for Local Environmental Initiatives), Miami-Dade began work on a number of environmental sustainability initiatives (Miami-Dade County, 2011). For example, in 1993 the county began its Urban CO2 Reduction Plan to mitigate climate change (Miami-Dade County, 2013b).

Around 2003, Harvey Ruvin began to push for more concrete action on climate change, including the organization of an ad hoc committee on climate change adaptation. In 2006, the Board of County Commissioners officially appointed a Climate Change Advisory Task Force led by Ruvin and 25 community stakeholders or topic area experts to identify the anticipated impacts of climate change in Miami-Dade County (Miami-Dade County, 2011, 2014a, 2014i, 2015b-g). In 2008, this task force recommended further study of sea level rise, expanding efforts to reduce greenhouse gas emissions, and developing mechanisms for future consideration of climate change adaptation (Miami-Dade County, 2008, 2010a).

A number of more recent county actions demonstrate ongoing interest in these issues. In 2009, the county joined the four-county Southeast Florida Regional Climate Change Compact (the Compact). Planning Division staff Nichole Hefty and Mark Woerner serve on the Compact's steering committee representing Miami-Dade County. They contribute to regional strategies and partnerships to address climate change. In 2010, county staff incorporated the Climate Change Advisory Task Force's work into GreenPrint, the county's sustainability plan, which outlines climate change emissions mitigation and environmental sustainability activities (see the Moving Forward section for more information). In 2013, the Board of County Commissioners created a Sea Level Rise Task Force, also led by Harvey Ruvin, to assess the potential impacts of sea level rise in the county (Miami-Dade County, 2014g). In July 2014, the Task Force issued six recommendations for action on sea level rise (see the text box).

The county continued its climate change-related work under the leadership of then Commission Chair, Rebeca Sosa (Miami-Dade County, 2015a). In 2014, Commissioner Sosa sponsored an amendment to the CDMP which requires the integration of climate change and sea level rise into water facilities planning (Miami-Dade County, 2014a–i). In January 2015, she brought six resolutions corresponding to the recommendations of the Sea Level

SEA LEVEL RISE TASK FORCE RECOMMENDATIONS

The Sea Level Rise Task Force recommends accelerating the adaptation planning process by seeking and formally selecting the engineering and other relevant expertise needed.

The Sea Level Rise Task Force recommends that the Miami-Dade Board of County Commissioners direct county administration to establish formal oversight, and dedicate sufficient resources and staffing to ensure implementation and update of the specific Climate Change Advisory Task Force recommendations.

The Sea Level Rise Task Force recommends that Miami-Dade County implement the Adaptation Action Areas called for in the CDMP and incorporate sea level rise and storm surge risks utilizing best available data.

While recognizing the recent efforts to address flood protection and saltwater intrusion by the South Florida Water Management District and Miami-Dade County, the Sea Level Rise Task Force recommends that Miami-Dade County work jointly with the District and the Southeast Florida Regional Climate Change Compact partners to conduct a comprehensive study and develop adaptation strategies to address potential flood damage reduction and saltwater intrusion associated with sea level rise. This strategy should expeditiously address rising sea levels, a time frame for implementation, and a potential funding mechanism.

The Sea Level Rise Task Force recommends that Miami-Dade County's resiliency efforts must incorporate support for Everglades restoration, including making restoration a top priority for county lobbying efforts, and must strategically utilize and fully fund both acquisition and management needs for the county's Environmentally Endangered Lands Program.

Recognizing the need to develop insurance mechanisms that will provide real help to the victims of climate change impacts, The Sea Level Rise Task Force recommends that Miami-Dade County consider initiating discussions with private insurance and reinsurance professional organizations, member local governments in the Southeast Florida Climate Change Compact and the Florida Office of Insurance Regulation in the Department of Financial Services to develop long-term risk management solutions (Miami-Dade County, 2014h).

Rise Task Force to the Commission in order to establish these as law, as she felt this was important step to further implementation of the recommendations (Miami-Dade County, 2015b-g). County Commissioner Daniella Levine Cava and Mayor Carlos A. Gimenez have also provided recent leadership on climate change issues.

In this context, the Planning Division identified climate change adaptation as a new issue to address in a 2013 update of the CDMP. The integration of climate change considerations into multiple elements of the CDMP is just one of the multiple approaches that the county is using to adapt to climate change. It is the focus of this case study because of the extent to which climate change adaptation now appears in the CDMP. Exhibit 1 shares a timeline of these actions in Miami-Dade County.

How and Why Miami-Dade County Integrated Climate Change into Its Comprehensive Plan

Regular CDMP Review Provides an Opportunity to Identify Climate Change as an Important Issue

The Florida State Statutes (Chapter 163) require that each county update its comprehensive plan every

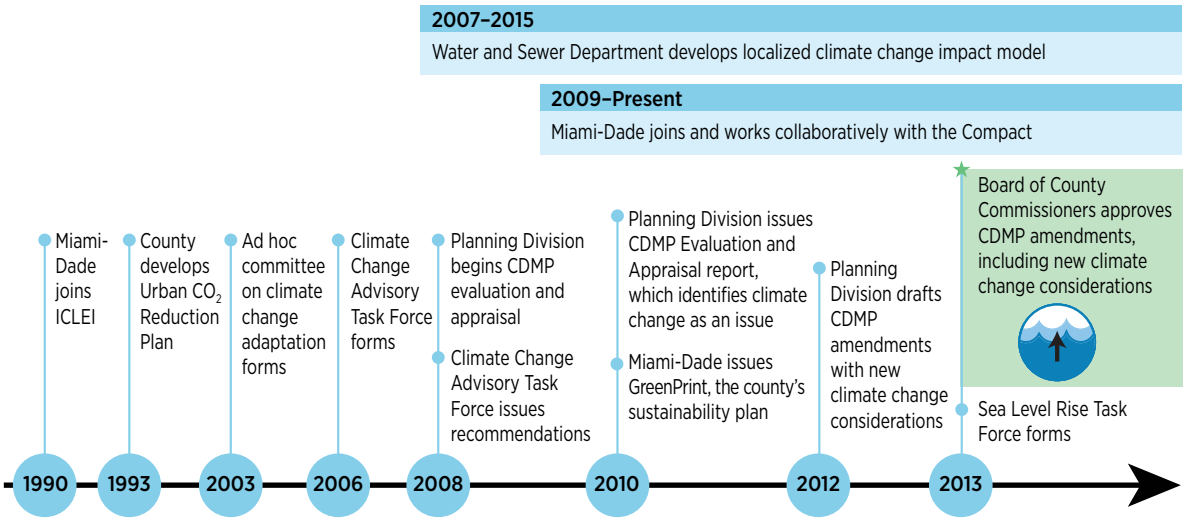

Exhibit 1. Timeline of actions in Miami-Dade County.

seven years (Miami-Dade County, 2014b. Miami-Dade's CDMP is used by developers, individual applicants, and all county departments in planning decisions. Any new development or proposed zoning change must be consistent with the CDMP. The state-required Evaluation and Appraisal process yields a report that is ultimately approved by both the Board of County Commissioners and the State of Florida. The report does not actually change the county's CDMP, but documents major issues and the types of changes the county intends to make.

Beginning in 2008, the Planning Division began to prepare its Evaluation and Appraisal report, due in 2010. A confluence of factors led the division's staff to include climate change as a new issue in this report. First, the Climate Change Advisory Task Force came out with its initial recommendations in 2008, which included a number of climate change mitigation and adaptation measures. Second, the Planning Division had a long history of working on energy conservation. This was not always motivated by climate change mitigation, but rather by concerns regarding water and air-quality issues.

The CDMP has served as a tool to tackle these issues by controlling how Miami-Dade County develops its urban core. For example, the CDMP can help ensure access to alternative transportation (e.g., walking or bicycling) or mass transit, and encourage compact, mixed-use footprints for new developments. In this sense, the division was already working in a way that was sensitive to the environment, pollution control, and water supply protection. Third, Department of Regulatory and Economic Resources staff members that had been involved with the Climate Change Advisory Task Force and GreenPrint and were therefore familiar with the climate change adaptation priorities in those efforts. Finally, in 2009, Miami-Dade County joined the Compact. While Miami-Dade was thinking about climate change adaptation before joining the Compact, this new collaborative effort may have further contributed to the desire to include consideration of climate change in the CDMP.

The 2010 report includes several explicit county motivations for incorporating climate change within the CDMP (see the text box).

EXPLICIT MOTIVATIONS FOR INCORPORATING CLIMATE CHANGE WITHIN THE MIAMI-DADE CDMP

"Projections of future growth and the planned locations of such growth must be assessed for vulnerability to sea level rise, storm surge and other climate change impacts. For these reasons, climate change is addressed as a major issue in the county's CDMP." (p. 1.2-5)

"Costs to adapt to these anticipated climate-related challenges will be much higher if incremental investments are not made now to prepare for the future. It is not in the county's interests, fiscal, social, economic, environmental, or otherwise, to delay investment in planning and projects that will solve existing problems, such as drainage, that will worsen and become even more unmanageable, as climate change conditions intensify." (p. 1.2-18)

Source: Miami-Dade County, 2011.

The Evaluation and Appraisal report indicates how the county intends to change the CDMP by amending elements of the plan. The report outlined a number of existing CDMP elements that already related to (but did not necessarily mention) climate change:

- Land Use
- Transportation
- Housing
- Recreation and Open Space
- Conservation, Aquifer Recharge, and Drainage
- Coastal Management
- Intergovernmental Coordination
- Capital Improvements
- Educational

Miami-Dade's Planning Division Integrates Climate Change into Relevant Elements of its 2013 Amendments to the CDMP

With approval of the 2010 Evaluation and Appraisal Report, the Planning Division began the process of amending the CDMP. This process takes one full year; it began in the fall of 2012 and ended in the fall of 2013 (Exhibit 2). During the year, the appointed Planning Advisory Board held a series of meetings to discuss the changes with the Planning Division. Additionally, the county held several public meetings to share the changes and gather public feedback. The Planning Advisory Board formally approved the proposed changes to the CDMP. Following this, the Board of County Commissioners voted to approve the CDMP amendments in October 2013. County staff point out that currently, several of the county commissioners advocate for climate change mitigation and adaptation actions; Commissioner Rebeca Sosa was noted as a particularly important supporter of climate change action. At the same time there were few vocal opponents of climate change mitigation and adaptation on the commission. Changes to the CDMP are adopted as a package and address a wide range of issues.

Mark Woerner, the assistant director in Miami-Dade's Planning Division, guided the CDMP amendment process and worked with staff to integrate proposed policy language into relevant elements of the plan (Land Use; Transportation; Conservation, Aquifer Recharge and Drainage; Water, Sewer & Solid Waste; Coastal Management; and Intergovernmental Coordination). Examples of the specific policy language included in the CDMP updates are provided in Exhibit 3. To develop this new language, Woerner and staff determined where there were natural linkages to climate change within existing elements, even though they did not have any existing protocol or tools at the time to guide them in this process. According to Woerner, "Something as important as climate change and sea level rise needs to permeate throughout the whole plan. It affects so many different components. If you have it all in one element, for example, the public works director may not read that element. He's only looking at his…It's better to not call attention to it in one element, but to really integrate it into many elements of the plan."

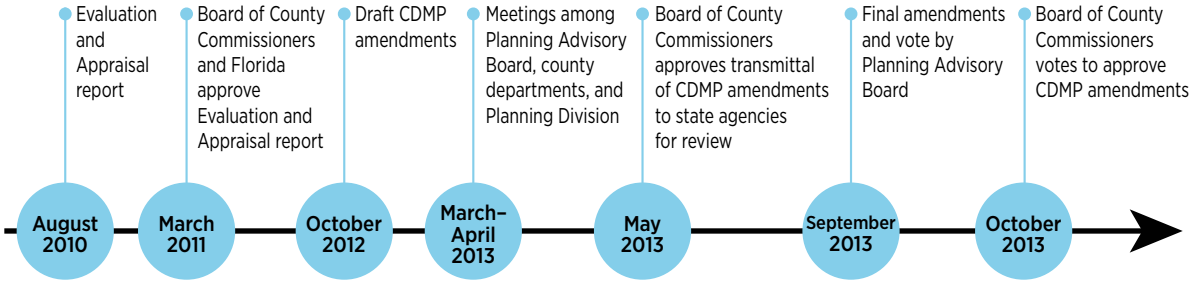

Exhibit 2. CDMP amendment process.
Source: Miami-Dade County, 2014b.

It is also likely that the county's participation in the development of the Compact's Regional Climate Action Plan influenced CDMP changes. Both Mark Woerner and Nichole Hefty, Chief of the Department of Regulatory and Economic Resource's Office of Sustainability, sit on the Regional Climate Action Plan Staff Steering Committee and helped amend the CDMP (Compact, 2012). However, because the two efforts occurred simultaneously, it is difficult to discern the impact of the Compact's plan on the CDMP.

To Implement CDMP Elements, Miami-Dade Develops Tailored Models to Inform Decision-Making

While Miami-Dade has included climate change considerations in its CDMP, these considerations have not yet been fully implemented. Some of the reasons for this include that the changes were recently adopted and it can take time to implement new plans, and that staff in the Planning Division feel that county departments need better information on climate change impacts in order to make informed decisions. Two factors led Miami-Dade County to develop a localized climate change impact model on the interaction of groundwater and surface water: (1) its unique hydrology, and (2) a lack of existing climate change impact models or tools that incorporated the county's unique hydrology.

1. The primary factor for developing an integrated groundwater-surface water model was the fact that the county faces a unique combination of climatic, geologic, and hydrologic conditions. Miami-Dade County and much of South Florida are vulnerable to sea level rise, storm surge, and saltwater intrusion into freshwater aquifers. This latter vulnerability is of particular concern in the county, and there are several local characteristics that contribute to it. First, the county sits on a very porous calcium carbonate substrate. Once saltwater reaches a freshwater source, there is there is a natural tendency for them to mix. Second, Florida's freshwater sources are relatively close to the ground surface, making them especially vulnerable to inundation and salinization. Third, Miami-Dade has an extensive gravity-driven drainage and canal system; however, with sea level rise, saltwater will move into these canals and impede or prevent their drainage. This will pose an additional threat during storm surges; impeded drainage creates a flooding hazard. In some cases, sea gates or pumps have already been installed to help manage water flow in the canals.

2. The second major factor motivating the development of tailored climate change analyses was concern over the county's initial use of inundation information. Initially, the county relied on The Compact's high-level sea level rise inundation vulnerability assessment. These maps were not able to consider some of Southeast Florida's unique features, failing to identify known at-risk areas under current conditions, as shown on the county's Stormwater Management Masterplan and current Federal Emergency Management Agency Digital Flood Insurance Rate Maps. Therefore, county stormwater modelers felt

EXHIBIT 3. EXAMPLES OF CLIMATE CHANGE CONSIDERATIONS IN MIAMI-DADE COUNTY'S CDMP ELEMENTS (MIAMI-DADE COUNTY, 2013a)

Land Use

By 2017, Miami-Dade County shall develop a Development Impact Tool or criteria to assess how proposed development and redevelopment project features including location, site design, land use types, density and intensity of uses, landscaping, and building design, will help mitigate climate impacts or may exacerbate climate related hazards. The tool would also assess each development's projected level of risk of exposure to climate change impacts, such as inland flooding (LU-3F).

Miami-Dade County shall, by 2017, analyze and identify public infrastructure vulnerable to sea level rise and other climate change-related impacts. This analysis shall include public buildings, water and waste water treatment plants, transmission lines and pump stations, stormwater systems, roads, rail, bridges, transit facilities and infrastructure, airport and seaport infrastructure, libraries, fire and police stations and facilities (LU-3G).

By 2017, Miami-Dade County shall determine the feasibility of designating areas in the unincorporated area of the county as Adaptation Action Areas as provided by Section 163.3177(6)(g)(10), Florida Statute, in order to determine those areas vulnerable to coastal storm surge and sea level rise impacts for the purpose of developing policies for adaptation and enhance the funding potential of infrastructure adaptation projects (LU-3K).

Transportation

The county shall avoid transportation improvements which encourage or subsidize increased development in coastal high hazard areas, environmentally sensitive areas identified in the Coastal Management and Conservation, Aquifer Recharge and Drainage Elements, and areas of high risk of significant inland flooding (TC-6A).

New roadways shall be designed to prevent and control soil erosion, minimize clearing and grubbing operations, minimize storm runoff, minimize exposure and risk of climate change impacts such as increased flood conditions, and avoid unnecessary changes in drainage patterns (TC-6D).

Conservation, Aquifer Recharge, and Drainage

When building, expanding or planning for new facilities such as water treatment plants, Miami-Dade County shall consider areas that will be impacted by sea level rise (CON-5I).

Water, Sewer, and Solid Waste

The Miami-Dade County Water, Wastewater, and Reuse Integrated Master Plan, the primary vehicle for planning for water, sewer, and reuse facilities, shall continue to be updated on a regular basis. The integrated Master Plan shall include initiatives to address climate change and sea level rise that would impact the water and sewer infrastructure and drinking water supplies (WS-3F).

Miami-Dade County shall coordinate with municipalities and the State of Florida to monitor existing septic tanks that are currently at risk of malfunctioning due to high groundwater levels or flooding and shall develop and implement programs to abandon these systems and/or connect users to the public sewer system. The county shall also coordinate to identify which systems will be adversely impacted by projected sea level rise and additional storm surge associated with climate change and shall plan to target those systems to protect public health, natural resources, and the region's tourism industry (WS-4H).

EXHIBIT 3. (CONTINUED).
EXAMPLES OF CLIMATE CHANGE CONSIDERATIONS IN MIAMI-DADE COUNTY'S CDMP ELEMENTS (MIAMI-DADE COUNTY, 2013a)

Coastal Management

Rise in sea level projected by the federal government, and refined by the Southeast Florida Regional Climate Change Compact, shall be taken into consideration in all future decisions regarding the design, location, and development of infrastructure and public facilities in the county (CM-9H).

Intergovernmental Coordination

The county shall continue participation in the Southeast Florida Regional Climate Change Compact and shall coordinate with other agencies, local municipalities, and the private sector to develop initiatives and goals to address climate change mitigation and adaptation. Climate change-related goals that support regional climate change objectives shall be integrated into the CDMP as appropriate (ICE-5F).

the need to improve upon the Compact's inundation maps to produce a more accurate vulnerability assessment. An additional issue identified, related to sharing any type of sea level rise map, is their potential to affect property values in vulnerable areas and related investment decisions.

Since initial mapping tools did not consider some of the unique features and vulnerabilities of Miami-Dade County, the county pursued the development of more robust and defensible tools. In 2007, the Water and Sewer Department, including staff member Dr. Virginia Walsh, partnered with the U.S. Geological Survey to develop a new climate change and hydrological modeling tool unique to Miami-Dade County (U.S. Geological Survey, 2014). The new integrated groundwater-surface water modeling tool took several years to develop and went through an extensive third-party verification process. It generates maps using future ranges of precipitation, sea level rise, and saltwater intrusion based on the county's geology, hydrology, and infrastructure.

Thus far, the modeling tool has only been used internally by the Water and Sewer Department, but the county intends for other departments to rely on it for land-use planning, infrastructure, and other decisions. Planning Division staff feel that the information produced by the modeling tool will be an integral piece of the information and guidance they provide to departments. They also feel that county departments need best-available climate change data in order to make informed decisions. For example, Planning Division staff believe that departments need to know the magnitude of potential sea level rise in order to make informed decisions about how best to plan and respond.

There has been some concern regarding the amount of time it has taken to develop the model and the speed at which adaptation is taking place because of the county's reliance on location-specific data. Mark Woerner shared, "Before you act too quickly you need to take a measured approach. The tools have to be reliable and valid or they'll be more subject to challenge and doubt…You have to make sure that the guidance you're giving is the best available. Decisions will be made to grant people the right to develop or not. You better be right if you're asking someone to adapt infrastructure and it's going to cost $10 billion, $20 billion, or $1 billion." However, he also acknowledges that "climate change and sea level rise data are not static; they are dynamic and continuously changing. Therefore, planning for climate change and sea level rise needs to take this into account and needs to be technically defensible."

The Accomplishments of Miami-Dade County's Integration of Climate Change into the CDMP

Those interviewed for this study agree that Miami-Dade's new considerations of climate change in the CDMP are a success, and are an example of the county's leadership in climate change adaptation. Additionally, stakeholder groups generally supported the changes. For example, there was no discussion about the integration of climate change in the CDMP elements during the final Board of County Commissioners hearing. County staff attribute this to previous public hearings and the Planning Advisory Board's endorsement.

However, county staff also feel it is too early to point to decisions or on-the-ground actions that have changed as a result of the changes to the CDMP. There are two reasons for this. First, the changes to the CDMP were recently adopted and, in a large county like Miami-Dade, it can take time to implement new plans. For example, each county department has its own 5–10 year plan. It will take time for these department-level plans to incorporate relevant climate change considerations from the CDMP. Similarly, several of the new considerations call for a 2017 timeline or additional studies. Second, staff in the Planning Division feel that county departments need more precise climate change data in order to make informed capital infrastructure planning decisions. For example, the Transit Department needs to know the anticipated levels of sea level rise to inform improvements. As such, the Planning Division staff feel that the modeling efforts led by the Water and Sewer Department will be vital in order to share actionable data.

There is a set amendment process to adjust the CDMP in the future. New climate change considerations, based on newer or more reliable information, might need to be included. Additionally, the set Evaluation and Appraisal process will assess if departments are implementing CDMP provisions.

Moving Forward

There is agreement that Miami-Dade County is moving in the right direction. However, there are also concerns about whether the county is acting quickly enough on climate change adaptation. While it will take time to fully discern the impact of integrating climate change into the CDMP on the county's adaptation activities, there are several ongoing efforts in the county that will contribute to climate change vulnerability reductions. We describe them briefly here.

GreenPrint — GreenPrint is Miami-Dade's community-wide sustainability plan developed between 2009 and 2010. It covers climate change mitigation and adaptation, as well as other initiatives (e.g., developing green jobs). GreenPrint was influenced by the Climate Change Advisory Task Force, the Compact, and ICLEI, incorporating relevant recommendations from these and other sources. Nichole Hefty supported the effort to develop GreenPrint and shared that "The primary goal of both GreenPrint and the Regional Climate Action Plan is to integrate (climate change) into existing programs and processes so it's not a separate thing. As people do their daily job or planning, they're thinking about them through the lens of sustainability and the lens of climate change."

GreenPrint contains climate change adaptation provisions that support related analyses and monitoring. These provisions include "(1) Track local and regional climate change indicators and trends, (2) Develop local and regional climate change scenarios depicting various impacts and time frames, and (3) Integrate future climate change impacts into community and government decision-making for capital, operational, and land-use issues" (Miami-Dade County, 2010b, p. 76). Nichole Hefty says, "At the time, we still had a lot of questions. Our climate change goal area was focused on trying to gain more knowledge to better inform our planning. A lot of the initiatives in that goal area are looking at gathering more data and developing tools to help inform the process." The county has made some progress in developing tools, but it still lacks some critical information, such as more accurate inundation maps.

There have been a number of challenges pursuing all the actions contained in GreenPrint. First, the grant that supported its development ended. Second, county leadership turned over. The mayor was successfully recalled and subsequently more than 40 county departments were consolidated into 25. Both of these factors resulted in the loss of multiple staff members who had been involved in GreenPrint. Third, two county commissioners who championed the effort left office. Fourth, the economic recession severely contracted the county's budget, affecting its ability to invest in some of the GreenPrint projects and processes. While county staff feel that there is renewed momentum for GreenPrint, there will still be challenges developing the 2016 update with fewer staff, for example.

Division of Environmental Resources Management (DERM) — DERM is involved in a number of efforts that have the potential to reduce the impacts of storm surge, improve drainage, and reduce flooding. For example, DERM is reseeding mangroves, preserving coastal wetlands, acquiring new conservation land through its Environmentally Endangered Lands Program, conducting erosion control and beach renourishment, and implementing other natural resource restoration projects (Miami-Dade County, 2014e).

Water and Sewer Department — In addition to leading Miami-Dade County's climate impact modeling efforts, the Water and Sewer Department is evaluating upgrades to its three wastewater treatment facilities against climate change impacts. This evaluation was motivated by a U.S. Environmental Protection Agency enforcement action for sewer overflows and discharges (U.S. EPA, 2013). In a sense, the enforcement action has presented an opportunity for the Water and Sewer Department to consider climate change and implement adaptation actions as it makes improvements to come into compliance with its consent decree.

The Water and Sewer Department's consideration of climate change predated its efforts to develop a climate change impact modeling tool. The department conducted a storm surge analysis that added the storm surge from Hurricane Andrew, high tide plus three feet of sea level rise. This was the equivalent to a 21-foot storm surge and Category 5 hurricane. With this information, the department assessed the elevation of plant components to determine their vulnerability. To protect the treatment plants, the department evaluated three options: (1) construct new facilities, (2) elevate electrical and instrumentation systems, and (3) harden facilities through elevating and shuttering plant components (Miami-Dade County, 2013b). The least-cost option for the county was elevating and shuttering plant components for $30 million (Miami-Dade County, 2013c).

Dr. Doug Yoder, the deputy director of the Water and Sewer Department, shared that they "don't want to overinvest in facilities." The department is looking at when climate change risks will become a real issue, and preparing for that time. As the current wastewater treatment facilities reach the end of their usable life, the Water and Sewer Department will re-evaluate climate change considerations for new facilities, which will most likely include moving new facilities further inland. The department plans to use the more comprehensive climate change and hydrological impact modeling tool to design and locate these new facilities.

Local Mitigation Strategy — Miami-Dade has a Local Mitigation Strategy to address minimizing the impacts of coastal storms, flooding, and other hazards. This strategy was first developed in 1998, with 1992's Hurricane Andrew in recent memory. The strategy is implemented by staff in the Miami-Dade Office of Emergency Management (Miami-Dade County, 2014c). The 2014 update of the strategy lists climate change as a hazard, and specifically calls out sea level rise, but the Office has not had sufficient time to implement these new aspects of the strategy (Miami-Dade County, 2014c). Cathie Perkins, the county's Emergency Management Planner, shared that "we needed to look to see what other things have we had not incorporated or considered, and obviously sea level rise and the impact of climate change needed to be looked at."

Still, several ongoing actions decrease Miami-Dade County's vulnerability to climate change. For example, the county has a robust program to mitigate wind and flood damage. The wind mitigation program not only targets critical facilities like hospitals, schools, and homeless

shelters, but also works with low-income or elderly residents to install shutters, hurricane glass, or reinforce roofs. County staff feel that Miami-Dade is well-prepared for hurricane force winds. Funding from the Federal Emergency Management Agency has supported most of these efforts (Miami-Dade County, 2014d).

The county has also taken several steps to reduce its vulnerability to floods. For example, the county participates in the National Flood Insurance Program's Community Rating System. It conducts numerous activities to prevent flooding and has one of the best ratings in the country, resulting in significant reductions in flood insurance premiums for residents. Roughly half of Miami-Dade's municipalities also participate in the program. The county helps municipalities qualify for lower flood insurance premiums by providing multiple types of support. Support activities include education and outreach to help residents prepare for and prevent flooding; environmental programs and regulation to reduce flooding; flood mapping to identify at-risk areas for future flood mitigation; installing, inspecting, and maintaining flood level benchmarks which validate flood maps; and developing topographical, boundary, and other survey information to better understand flood risk. The county is also a Federal Emergency Management Agency Cooperative Technical Partner, both providing the agency with the county's mapping needs, and sharing topographical survey and modeling information for flood zone map updates with the agency.

Other flood mitigation actions include an emergency detention basin to divert water during storms, dredging and shaping a canal to improve overall flow and pumping efficacy, widening and restructuring canal banks, and the installation of large pumps in a couple of areas along the county's canal system to move water over gates when high tides preclude the gravity-designed system's gates from opening (Miami-Dade County, 2014d).

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Bibliography

Compact. 2012. A Region Responds to a Changing Climate: Southeast Florida Regional Climate Change Compact Counties. Regional Climate Action Plan. October. Available: http://isc.ksepartners.info/wp-content/uploads/2014/09/regional-climate-action-plan-final-ada-compliant.pdf. Accessed March 30, 2015.

Miami-Dade County. 2008. Second Report and Initial Recommendations. Miami-Dade County Climate Change Advisory Task Force. April. Available: http://www.miamidade.gov/environment/library/brochures/08-10-04-ccatf-recommendations.pdf. Accessed March 30, 2015.

Miami-Dade County. 2010a. Climate Change Advisory Task Force Status of Recommendations. August. Available: http://www.miamidade.gov/environment/library/reports/climate-change-recommendations-october-10.pdf. Accessed March 30, 2015.

Miami-Dade County. 2010b. GreenPrint: Our Design for a Sustainable Future. December. Available: http://www.miamidade.gov/GreenPrint/pdf/plan.pdf. Accessed April 2, 2015.

Miami-Dade County. 2011. CDMP major issues: UDB capacity and expansion. Chapter 1 in Evaluation and Appraisal Report, 2010. Available: http://www.miamidade.gov/planning/ear2010/library/2010EARChapter1.pdf. Accessed March 30, 2015.

Miami-Dade County. 2013a. Comprehensive Development Master Plan (CDMP): Adopted Components. Available: http://www.miamidade.gov/planning/cdmp-adopted.asp. Accessed March 30, 2015.

Miami-Dade County. 2013b. Ocean Outfall Legislation. Compliance Plan. Miami-Date Water and Sewer Department. June 28. Available: http://www.miamidade.gov/water/library/reports/ocean-outfall-legislation.pdf. Accessed April 3, 2015.

Miami-Dade County. 2013c. Urban CO2 Reduction Plan. Available: http://www.miamidade.gov/environment/co2-reduction.asp. Accessed March 30, 2015.

Miami-Dade County. 2014a. Climate Change Advisory Task Force. Available: http://www.miamidade.gov/environment/boards/climate-change-task-force.asp. Accessed March 30, 2015.

Miami-Dade County. 2014b. Evaluation and Appraisal Report (EAR) 2010. Available: http://www.miamidade.gov/planning/cdmp-ear.asp. Accessed March 31, 2015.

Miami-Dade County. 2014c. Local Mitigation Strategy. Whole Community Hazard Mitigation Part 1: The Strategy. November. Available: http://www.miamidade.gov/fire/library/OEM/part-1.pdf. Accessed April 1, 2015.

Miami-Dade County. 2014d. Local Mitigation Strategy. Whole Community Hazard Mitigation Part 6: Completed Projects. Available: http://www.miamidade.gov/fire/library/OEM/part-6.pdf. Accessed April 1, 2015.

Miami-Dade County. 2014e. Miami-Dade Legislative Item File Number: 061152. 06-113. Ordinance Creating the Miami-Dade County Climate Change Advisory Task Force; Providing for Membership, Organization and Procedure, Appointment and Tenure, Function And Responsibility; Providing Severability, Inclusion in the Code, and an Effective Date [see Agenda Item No. 12B2]. Available: http://www.miamidade.gov/govaction/matter.asp?matter=061152&file=true&yearFolder=Y2006. Accessed March 30, 2015.

Miami-Dade County. 2014f. Miami-Dade Legislative Item File Number: 142497. R-1024-14. Resolution Pertaining to May 2014 Cycle Applications Requesting Amendments to the Comprehensive Development Master Plan; Directing the Mayor or Designee to Act in Accordance with the Transmittal Instructions included in This Resolution Related to Application No. 7, Amending the Text of the Water, Sewer and Solid Waste Element of the CDMP; Requesting State Land Planning Agency to Review Application No. 7; Reserving the Right to Take Final Action at a Later Date; and Declaring Intent to Conduct One or More Subsequent Public Hearings. Available: http://www.miamidade.gov/govaction/matter.asp?matter=142497&file=true&yearFolder=Y2014. Accessed July 14, 2015.

Miami-Dade County. 2014g. Miami-Dade Sea Level Rise Task Force Report and Recommendations. July 1. Available: http://www.miamidade.gov/planning/library/reports/sea-level-rise-final-report.pdf. Accessed April 3, 2015.

Miami-Dade County. 2014h. Preserving our Natural Resource Resilience. Sea Level Rise Task Force Meeting. March 7. Available: http://www.miamidade.gov/planning/library/presentations/2014-03-07-preserving-our-natural-resilience.pdf. Accessed April 2, 2015.

Miami-Dade County. 2014i. Sea Level Rise Task Force. Available: http://www.miamidade.gov/planning/boards-sea-level-rise.asp. Accessed April 2, 2015.

Miami-Dade County. 2015a. About Commissioner Rebeca Sosa. Available: http://www.miamidade.gov/district06/about-commissioner-sosa.asp. Accessed July 14, 2015.

Miami-Dade County. 2015b. Miami-Dade Legislative Item File Number: 150048. R-44-15. Resolution Directing the Mayor or Designee to Study the Feasibility of Designating Climate Change Adaptation Action Areas as Recommended in the Comprehensive Development Master Plan [See Original Item under File No. 142560] Available: http://www.miamidade.gov/govaction/matter.asp?matter=150048&file=true&yearFolder=Y2015. Accessed July 14, 2015.

Miami-Dade County. 2015c. Miami-Dade Legislative Item File Number: 150049. R-45-15. Resolution Directing the Mayor or Mayor's Designee to Prepare an Action Plan and Report to Implement the Miami-Dade County Climate Change Advisory Task Force Recommendations of (i) Establishing Departmental Oversight for the Implementation of the Task Force Recommendations and (ii) Dedicating Sufficient Resources and Staffing to Review, Update, and Implement the Miami-Dade County Climate Change Advisory Task Force Recommendations [See Original under File No. 142561]. Available: http://www.miamidade.gov/govaction/matter.asp?matter=150049&file=true&yearFolder=Y2015. Accessed July 14, 2015.

Miami-Dade County. 2015d. Miami-Dade Legislative Item File Number: 150051. R-46-15. Resolution Directing the Mayor or Mayor's Designee to Prepare an Action Plan and Report to Accelerate the Climate Change Adaptation Planning Process by Evaluating the Engineering and Other Relevant Expertise Needed to Develop an Enhanced Capital Plan that Includes But Is Not Limited to Flood Protection, Salinity Structures, Pump Stations, and Road and Bridge Designs, and to Determine the Costs of Retaining the Experts Needed [see Original Item under File No. 142562]. Available: http://www.miamidade.gov/govaction/matter.asp?matter=150051&file=true&yearFolder=Y2015. Accessed July 14, 2015.

Miami-Dade County. 2015e. Miami-Dade Legislative Item File Number: 150052. R-47-15. Resolution Directing the Mayor or Mayor's Designee to Continue Strategic Implementation of Miami-Dade County's Environmentally Endangered Lands (EEL) Program, Consistent with Program Objectives as Approved by the Voters, and to Identify Potential Additional Long-Term Funding Sources for the Continued Acquisition and Management of EEL Lands [See Original Item under File No. 142564]. Available: http://www.miamidade.gov/govaction/matter.asp?matter=150052&file=true&yearFolder=Y2015. Accessed July 14, 2015.

Miami-Dade County. 2015f. Miami-Dade Legislative Item File Number: 150053. R-48-15. Resolution Requesting that the South Florida Water Management District, the United States Geological Survey, and the Southeast Florida Regional Climate Change Compact Partners Work with Miami-Dade County on Issues of Climate Change and Sea Level Rise, and Directing the Mayor or Mayor's Designee in Conjunction with the Office of Intergovernmental Affairs to Work Jointly with these Entities to Conduct a Comprehensive Study and Develop Adaptation Strategies to Address Potential Flood Damage Reduction and Saltwater Intrusion Associated with Sea Level Rise and Put Forth a Time Frame for Implementation and Potential Funding Mechanisms. January 21. Available: http://www.miamidade.gov/govaction/matter.asp?matter=150053&file=true&yearFolder=Y2015. Accessed April 3, 2015.

Miami-Dade County. 2015g. Miami-Dade Legislative Item File Number: 150054. R-49-15. Resolution Directing the Mayor or Designee in Conjunction with the Office of Intergovernmental Affairs to Initiate Discussions Related to Climate Change with Private Insurance and Reinsurance Professional Organizations, Member Local Governments in the Southeast Florida Climate Change Compact, The Florida Office of Insurance Regulation's Department of Financial Services, and Other Key Stakeholders to Develop Long-Term Risk Management Solutions [See Original Item under File No. 142567]. Available: http://www.miamidade.gov/govaction/matter.asp?matter=150054&file=true&yearFolder=Y2015. Accessed July 14, 2015.

U.S. EPA. 2013. Miami-Dade County Clean Water Act Settlement. June 6. Available: http://www2.epa.gov/enforcement/miami-dade-county-clean-water-act-settlement. Accessed April 3, 2015.

U.S. Geological Survey. 2014. Origins and Delineation of Saltwater Intrusion in the Biscayne Aquifer and Changes in the Distribution of Saltwater in Miami-Dade County, Florida. Scientific Investigations Report 2014–5025. Available: http://pubs.usgs.gov/sir/2014/5025/pdf/sir2014-5025.pdf. Accessed April 2, 2015.

Coastal Mobile County, Alabama

Oyster Reef Restoration

COASTAL MOBILE COUNTY, ALABAMA

AUTHORS: Lorine Giangola and Jason Vogel

In this case study, you will learn about:

- Restoring coastal ecosystems and reducing storm and human impacts through oyster reef restoration
- Cultural and economic motivations to preserve coastal ways of life
- Taking advantage of timely funding opportunities
- Leveraging community support for restoration projects after an environmental disaster

Case Study Summary

Mobile County lies in the southwestern corner of Alabama, between the Mississippi border and Mobile Bay. It is the second most populous county in the state, and a quarter of its total area is water. Because of its coastal location, Mobile County experiences damages from tropical storms and hurricanes such as Katrina, and from coastal development. Human activities, especially the channelization of river systems and shipping activity, have degraded the wetland and estuarine ecosystems that can help protect coastal communities from storm impacts. The decline in coastal ecosystem integrity threatens fisheries and the livelihoods that depend on these natural resources. Exhibit 1 provides a timeline of actions in Mobile County.

The cultural and economic impacts of coastal ecosystem degradation have generated support for restoration actions in Alabama's Mobile Bay. In 2009, The Nature Conservancy (TNC) in Alabama received a grant from the National Oceanic and Atmospheric Administration (NOAA), through the American Recovery and Reinvestment Act (ARRA), to rebuild oyster reefs along two sections of degraded coastline in the bay (see Exhibit 2). Since then, multiple groups have partnered with Alabama's coastal communities to implement additional oyster reef restoration projects. Project managers have observed wave energy attenuation at the reef sites, and the restoration efforts have received national recognition for decreasing coastal communities' vulnerability to storms and human impacts.

The Broader Context of Coastal Restoration in Coastal Alabama

Human activities have altered Gulf Coast ecosystems dramatically over the last several decades. Although channeling river systems and building flood protection infrastructure has reduced flood risks for many inland communities, these projects have fundamentally altered hydrology, water quality, and the natural sediment-delivery processes that build and replenish coastal marshes and wetlands. The U.S. Fish and Wildlife Service estimates that over half of the Gulf's wetlands were lost between 1790 and 1980. From 1998–2004, nearly 400,000 acres of the Gulf's freshwater wetlands

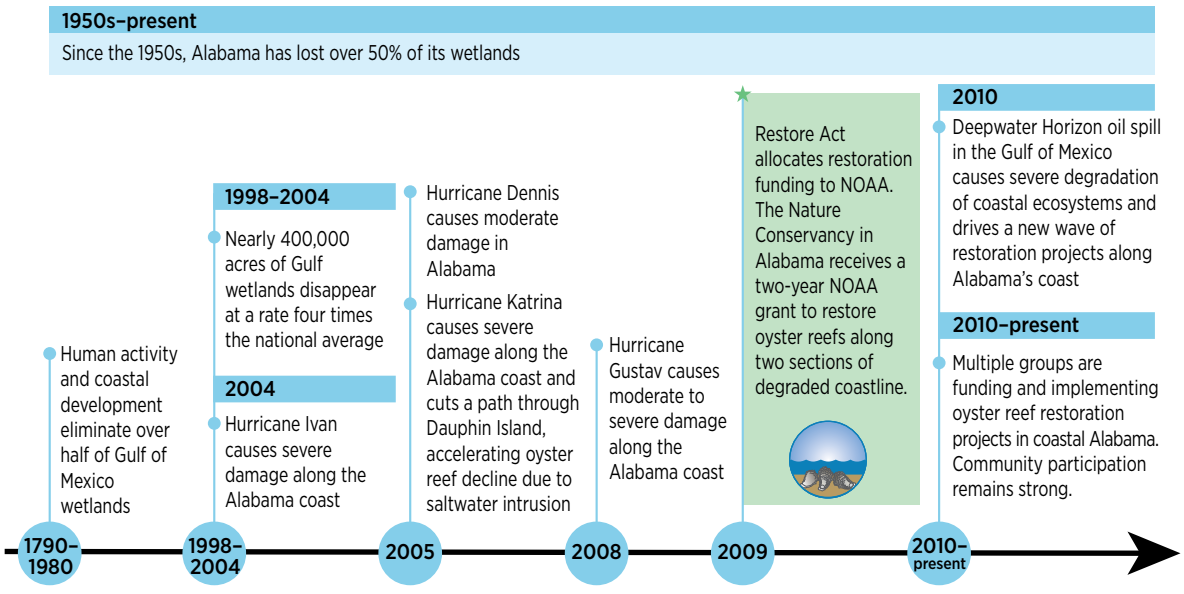

Exhibit 1. Timeline of actions in Mobile County.

disappeared at a rate four times the national average (MBNEP, 2015). Since the 1950s, Alabama has lost 36,468 acres (54.4 percent) of its coastal wetlands (Handley et al., 2007), and the decline of these coastal ecosystems threatens fisheries and leaves coastal communities more vulnerable to storm impacts.

The health of the Gulf's oyster reefs, and the benefits they provide for estuarine ecosystems, are also at risk. After Hurricane Katrina cut a path through Dauphin Island, a barrier island off the coast of Mobile County, oyster reef decline accelerated due to saltwater intrusion. Higher salinity levels in coastal estuaries provided favorable conditions for oyster drills, snails that prey on and decimate oyster reefs. Reefs play an important role in reducing wave energy and protecting estuaries and shorelines, and losses of oyster reefs lead to increased erosion, decreased water quality, and a decline in habitat availability for the estuarine plants and animals that live on reefs (NOAA, 2015b). This case study focuses on restoring oyster reefs in Alabama's Mobile Bay to reduce vulnerability to storm and human impacts and to improve coastal ecosystem health.

Exhibit 2. TNC's NOAA-funded oyster reef restoration projects.
Source: TNC, 2015.

The value of natural barriers, like wetlands and oyster reefs, in reducing storm impacts is well understood, but difficult to quantify. A classic study by the U.S. Army Corps of Engineers estimates that every 2.7 miles of wetland between the sea and the land reduces storm surge by one foot (USACE, 1963). However, the protective effects of coastal ecosystems vary considerably based on site characteristics and the nature of the storm (Wamsley et al., 2010). For example, Sheng et al. (2012) estimate that coastal vegetation can reduce inland flooding by 5 to 40 percent, depending on storm and wetland characteristics. Similarly, oyster reefs attenuate wave energy and reduce shoreline erosion, although their effectiveness also varies by site (Dame and Patten, 1981; Meyer et al., 1997; Piazza et al., 2005; Scyphers et al., 2011).

Coastal communities experience the effects of coastal degradation firsthand, and community investment in restoration in Alabama has been strong, especially since the Deepwater Horizon oil spill in the Gulf of Mexico in 2010. Citizen volunteers have come out in huge numbers to participate in the restoration work; over 600 volunteers joined a single restoration event in April 2013 (Lankford, 2013). Some waterfront residents volunteer for the Mobile Bay Oyster Gardening Program by growing oysters on their piers, and program organizers collect the oysters each fall and plant them on restored oyster reefs in Mobile Bay. The volunteer oyster gardeners have produced almost 700,000 oysters since the program began in 2001 (Mobile Bay Oyster Gardening Program, 2015). Volunteer workers and oyster gardeners provide huge cost savings to restoration groups; without this community participation, the costs and scales of these projects would become prohibitive for many groups.

Climate change has not been an explicit motivation for the surge in restoration projects on Mobile Bay; the communities are focused on protecting the coastline from boat wakes, making it more resilient to storms, and helping coastal ecosystems and wildlife recover from

the Deepwater Horizon oil spill. "A discussion around climate resilience or climate vulnerability is, among most of the public, a non-starter. We focus much more on specific hazards that we then can link to the science on those hazards. We know that people are very aware of storms. A lot of the decisions they make link to their personal experiences with storms, related to the shoreline or related to their house itself," says Steven Scyphers, a postdoctoral researcher at Northeastern University who did his doctoral research on ecological and socioeconomic dynamics and community perceptions of restoration in Mobile Bay.

Why and How Mobile County Restored Oyster Reefs

Coastal Community Motivated to Preserve Culture and Economy

The communities of coastal Alabama consider the degradation of coastal ecosystems, and the associated impacts on coastal livelihoods, to be threats to their cultural identity and economic security. Long-time residents have witnessed the decline of coastal ecosystem health and rising sea level—about 13.5 inches in the last 150 years (Haner, 2015)—and many residents want to restore the coast to its more natural condition. "They're talking about this change that they've seen. ...They have pictures literally from when cameras were invented....so they can see the change through the generations," says Judy Haner, director of Marine and Freshwater Programs at TNC's Alabama Coastal Program. "They know what it was like when they grew up. Their father and their father's father told them about what it was like, and they want that back. They want to catch fish off their docks and swim in the water....They have a picture in their head." "These older residents...know they want it better for their grandkids," adds Steven Scyphers.

Coastal residents and industries have experienced economic hardships from storm impacts and declining ecosystem health. The seafood industry provides over 8,000 jobs in Alabama (Gulf Coast Seafood, 2015) and generates $499 million in economic activity for the state each year (Alabama Gulf Seafood, 2015). But the industry is vulnerable to storm damages and to environmental quality problems that reduce ecosystem productivity, like water contamination from runoff, erosion, or spills. After Hurricane Katrina alone, initial seafood production losses in Alabama (not including infrastructure damages) were estimated around $200 million (CRS, 2005). Residents and seafood industry workers have begun to discuss these vulnerabilities in public meetings, and they challenge elected officials with questions about long-term sustainability of fisheries and seafood processors, and about the likelihood that their children will be able to find viable jobs in the seafood industry (Haner, 2015). These residents want greater protection for the coastal resources that sustain their livelihoods.

Hurricane damages over the last decade have renewed interest in restoring natural storm buffers like wetlands and oyster reefs. Mobile County has experienced repeated storm impacts, including storm surges, flooding, and extensive infrastructure damage; the most recent severe impacts resulted from Hurricanes Ivan (2004), Dennis (2005), Katrina (2005), and Gustav (2008).

Collaboration Supports Restoration Projects

An extensive network of partnerships among nongovernmental organizations (NGOs), academic researchers, citizens, and state and federal governments helped to support the TNC oyster reef project and facilitate communication among restoration practitioners in coastal Alabama. Collaboration among these groups was crucial to the design and implementation of the TNC oyster reef project (Haner, 2015). Before this NOAA-funded reef restoration project began, the Dauphin Island Sea Lab had built several reefs along the coast, and TNC worked with the Sea Lab team on those projects. The groups worked to identify best practices for reef restoration, and TNC built one oyster reef before winning the NOAA grant in 2009. The Mobile Bay National Estuary Program (MBNEP), established in 1995 under the U.S. Environmental Protection Agency (EPA)-funded National Estuary Program, serves as an umbrella group for coordinating much of the conservation work in the Mobile Bay estuary, and MBNEP's Comprehensive Conservation Management Plan guides conservation work in Mobile Bay. While TNC did not work with local governments on the NOAA-funded reefs, networking and information

sharing among restoration practitioners and the participation of citizen volunteers were essential to the success of the project.

Recovery Act Provides New Source of Funding for Restoration Projects

Funding is often a limitation for restoration projects, especially for non-profit organizations and for local governments that want to implement relatively large-scale projects. TNC and other NGOs in the Gulf often piece together funding through a combination of private donations, state and federal government grants, and partnerships with other NGOs. Local governments in coastal Alabama generally do not have the funding or technical resources necessary to implement large or technically complex restoration projects (Haner, 2015).

ARRA presented an opportunity for TNC to secure funding for oyster reef restoration from a single source. ARRA was a federal economic stimulus package intended to save and create jobs and drive economic activity during the Great Recession. The ARRA allocated $830 million to NOAA to support projects related to the agency's mission; $167 million was set aside to fund coastal habitat restoration (NOAA, 2015a). NOAA issued a call for project proposals and selected fifty high-priority projects that would create jobs in coastal communities and restore fisheries and coastal ecosystem resilience. Eight TNC projects were funded through NOAA's ARRA grants, including the coastal Alabama oyster reef project. TNC and NOAA have partnered on coastal restoration projects since 2001 (TNC, 2015), so the ARRA-funded reef project added to a list of nearly 100 TNC-NOAA restoration projects in coastal states.

Deepwater Horizon Oil Spill Adds Urgency to Restoration and Motivates Community Engagement

The Deepwater Horizon oil spill occurred in April 2010, in the middle of the TNC oyster reef restoration project. Although the spill was not an initial motivating factor for the project, the severity of the ecological impacts motivated the community to join the clean-up response and the subsequent restoration projects in huge numbers. The visible and dramatic impacts of the spill, and the intensity of the response, provided an opportunity for public outreach and education about the impacts of coastal ecosystem degradation, and restoration groups have leveraged community support for spill recovery actions and have developed a new wave of restoration initiatives that rely on citizen volunteers (Lankford, 2013; Haner, 2015; Restore Coastal Alabama, 2015; Scyphers, 2015; TNC, 2015).

Accomplishments of Mobile County's Oyster Reef Restoration Projects

Restoration project leaders from TNC's Coastal Programs Office consider the reef restoration projects to be a success so far (see Exhibit 3 for a map of the restoration sites). "We're providing habitat and oysters, fish love it, there is wave energy breaking," says Judy Haner. But practitioners acknowledge that the effectiveness of oyster reefs as barriers can be reduced over time as reefs settle and sink below the surface, and as sea level continues to rise above the height of the reefs. The TNC oyster reefs have not been in place long enough to evaluate their ability to protect the shoreline over the long term, but observing even short-term changes in reef function has helped practitioners learn more about effective reef design. "I think that we, as a society and as a scientific practitioner community, need to be very realistic in how we portray that and not be embarrassed that we're learning along the way. Because that's what we do, and that's what science is about. We're not going to get nature right the first time," says Judy Haner. "That's what I think is exciting—we're learning this and it's not taking us twenty years to learn this. In the course of just a handful of years, we've seen some changes that we now know we can improve upon without huge secondary investments."

In addition to the NOAA-funded TNC reefs, other groups have partnered to build reefs on multiple sites along the Mobile County coast and Mobile Bay (see site map below). About 2.2 miles of oyster reef have been constructed since 2005, with about $9.37 million from multiple groups in the region, including TNC, Mississippi-Alabama SeaGrant, Dauphin Island Sea Lab, Alabama Department of Conservation and Natural Resources, and the MBNEP (Haner, 2015).

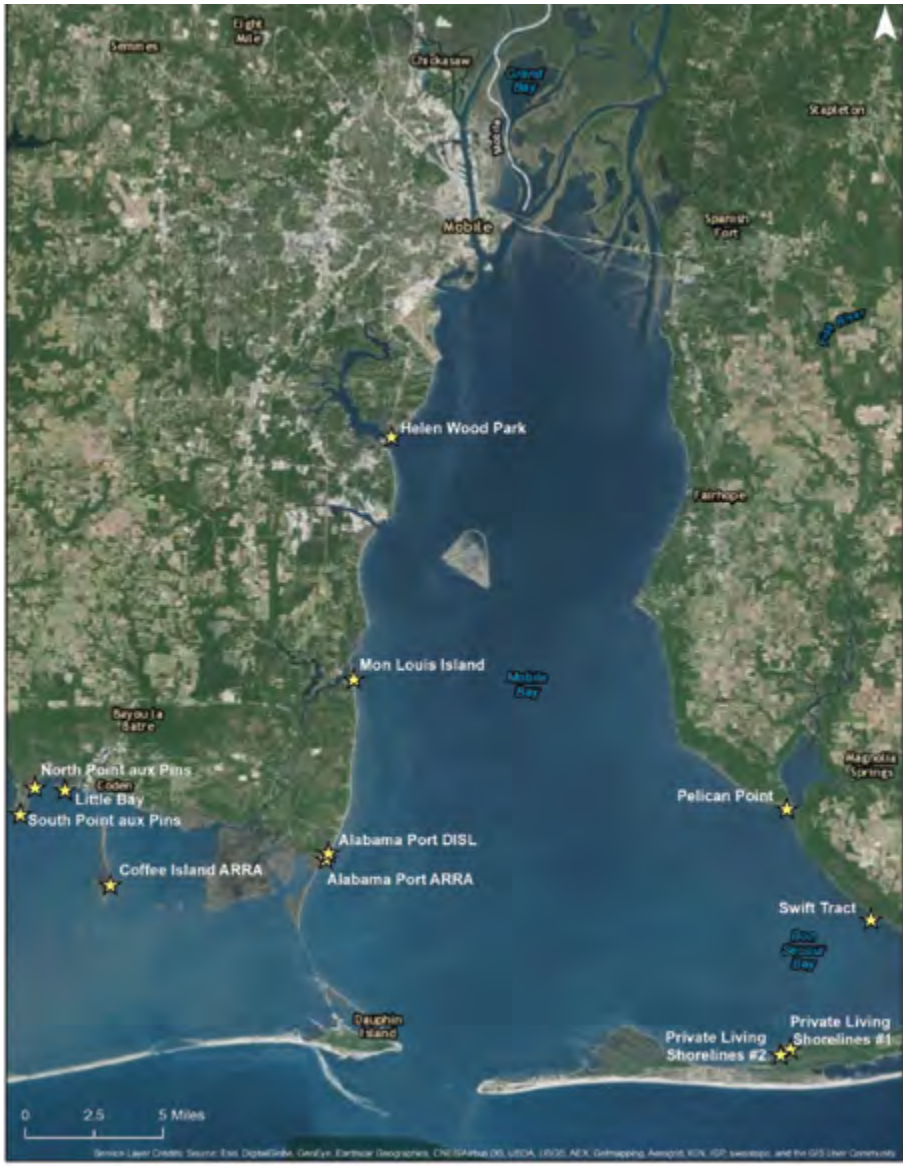

Exhibit 3. Coastal Alabama oyster reef restoration sites.

Project managers stress the need for continuous monitoring of the sites and ongoing data analysis; the current lack of monitoring will create a major gap in our understanding of the effectiveness of oyster reef restoration as a long-term approach to coastal protection (Haner, 2015) and will prevent a comprehensive assessment of restoration accomplishments. TNC is currently seeking funding to support the synthesis of existing data from the Alabama reef sites. "If we had information that showed a range of times that these reefs had been in, and the range of technologies and structures that were used, and what was monitored, and if we were able to look at this reef at ten years [after construction] and this reef at one month, and look at salinity regimes and differences, I think we could learn a lot about how to place [them]…By analyzing these things and synthesizing the information, that's the only way to figure this out," says Judy Haner.

TNC in Alabama has worked closely with Mobile County coastal communities in its oyster reef restoration projects. The NOAA-funded TNC project provided 35-40 permanent jobs over the course of the two-year project, most of which were filled by Mobile County residents (Haner, 2015), and TNC has hired additional residents for other reef-building projects since then. TNC also supports local seafood processing houses by purchasing oyster shells to build the reefs.

The Alabama oyster reefs have received national recognition for their effectiveness in addressing coastal vulnerability. In March 2015, the American Society of Adaptation Professionals (ASAP) announced that TNC's oyster reef restoration projects, under the 100-1000:Restore Coastal Alabama program, were one of four finalists for the 2015 ASAP Prize for Progress.

The coastal Alabama oyster reef restoration projects are widely considered to be a success story, but building oyster reefs cannot compensate for the loss of so much wetland and marsh area in the Gulf and the natural protection they provide. Natural, healthy coastal ecosystems are replenished with sediment from creeks and rivers, but most of the river systems in the Gulf have been dredged and channelized, so sediment no longer flows into the marshes. While living shorelines can serve an important function in protecting coastal environments, in addition to providing many other ecosystem services, reducing vulnerability to climate and human impacts on the Alabama coast will require an even more extensive and complex approach to ecosystem restoration.

Moving Forward

TNC and other groups and agencies are currently building more reefs and working to identify new project sites. The Deepwater Horizon oil spill brought a new sense of urgency to protecting coastal and estuary ecosystems, and the spill has driven a wave of major restoration initiatives. Since the spill, TNC, along with the Alabama Coastal Foundation, Mobile Baykeeper, and The Ocean Foundation, with support from other governmental, NGO, and private research partners, has set a new goal of restoring 100 miles of oyster reef and protecting 1,000 acres of seagrass and marsh through the 100-1000: Restore Coastal Alabama project. The success of these new projects will depend on continuous community participation in order to maintain the momentum of restoration actions in coastal Alabama.

In addition to relying on volunteers, Gulf restoration groups are currently working together to train a new generation of workers to sustain conservation efforts in Gulf communities. The Corps Network (TCN), a national youth development organization that provides job training and leadership training through community and environmental service projects, launched its Gulf Coast Restoration Initiative (GCRI) and Climb Conservation Corps programs in the fall of 2014, in partnership with TNC and with other youth development programs. In this pilot project, TNC scientists trained young adults from local communities to collect water quality and ecological data in restoration sites in Mississippi, helping to build local capacity to manage environmental quality and supporting community resiliency by training local workers instead of outsourcing restoration work.

Many of TCN's youth participants come from underserved areas, and TCN provides on-the-job training, education training, job placement assistance, life skills training, and access to post-secondary education. These experiences "empower individuals to earn a livable wage and begin a career path that leads to economic and personal self-sufficiency" (Hosey, 2015), in addition to providing valuable service to their communities. Post-project surveys of participants reveal improved technical understanding of environmental monitoring, and an understanding of how stream health affects communities. The surveys found that 100 percent of participants now have an interest in "a career, training program, or degree" in an area related to their environmental and conservation work (Hosey, 2015).

Traditionally, conservation and environmental movements have not effectively engaged disadvantaged populations, even though they often suffer the greatest impacts of environmental degradation and natural disasters. TCN is working to increase engagement of disadvantaged populations in the national environmental movement, by engaging young adults in restoration work and providing the knowledge and training to be

their own environmental stewards (Hosey, 2015). Strong engagement and successful outcomes have encouraged TCN to begin to expand its conservation programs for underserved youth across all Gulf states and across additional conservation skill areas, including invasive species management, marsh restoration, oyster reef restoration, coastal stream monitoring, and community outreach (Hosey, 2015). This new generation of local conservation workers can help sustain long-term restoration efforts and can help reduce reliance on outsourced workers.

Although TNC did not work closely with municipalities or other local governments in its NOAA-funded reef restoration project, engaging local governments is a current goal, and partnerships are starting to develop (Haner, 2015). Some local governments want to build reefs, but do not have the funding or technical expertise; TNC helps them identify sites and potential funding sources through grants.

Large amounts of money and staff and volunteer time have gone into building the existing oyster reef projects in coastal Alabama, and so far these projects have constructed about 2.2 miles of reef, a relatively small portion of Alabama's coast. If restoration groups want to increase the total amount of protected shoreline, they will need to work with private landowners on the coast. "In Alabama about 80 percent of our shoreline is privately owned, so if we want to do anything—enhance community and coastal resilience—we've got to work with these individuals," says Judy Haner. Steven Scyphers and his colleagues have studied these residents' perceptions of restoration work and the incentives necessary for waterfront residents to install green infrastructure instead of a physical shoreline protection structure. "From the survey data we have, there's definitely a range of willingness to do different restoration techniques across residents—from extremely unwilling to change, to people that are willing but may not be aware of different alternatives," says Scyphers. The community surveys have helped guide TNC's restoration projects on private land. The survey results "made us think about how we approach projects and [how we] approach doing a demonstration in an area where we can get the neighbors talking. Because word of mouth is probably going to do as much as anything," says Judy Haner. Haner adds that simplifying the current regulatory process for permitting living shorelines will help sustain restoration momentum and prevent waterfront residents from "defaulting" to building a bulkhead just because it's easier. While physical infrastructure protects private shorelines, it does not provide any of the ecological and environmental quality benefits that living shorelines provide.

The Deepwater Horizon oil spill not only increased the urgency of coastal ecosystem restoration actions and motivated community involvement, but it is also reshaping the funding environment and creating new opportunities and new challenges for restoration groups in the Gulf. Gulf coast states are starting to receive large sums of money from spill damages, and some coastal communities are expecting a new wave of funding for coastal recovery projects. However, the Alabama Gulf Coast Recovery Council has directed the first round of payments ($56 million) to economic and infrastructure projects, in part because of the support already dedicated to ecological recovery projects (Finch, 2014). Some groups argue that this use of oil spill penalties does not comply with the RESTORE Act (Lankford, 2014; Haner, 2015), which Congress passed after the Deepwater Horizon spill in order to direct money from civil penalties to Gulf coast states. But TNC Alabama does not view the decision unfavorably. "We are behind stormwater [infrastructure improvements] 100 percent. We want you to retrofit those leaky, failing utilities. We want you to upgrade," says Judy Haner. Still, the sudden influx of oil spill money has the potential to create conflict among groups who have different goals for coastal communities. While relationships among local governments, NGOs, and Gulf coast residents have generally been congenial, "A big pulse of the restoration money might change that," says Steven Scyphers.

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- **Mary Kate Brown,** coastal conservation specialist at TNC's Alabama Coastal Program.

Bibliography

Alabama Gulf Seafood. 2015. Always Ask, Never Settle: How to Avoid Mislabeled Gulf Seafood. March 26. Available: http://eatalabamaseafood.com/articles/always-ask-never-settle-how-to-avoid-mislabeled-gulf-seafood/. Accessed April 1, 2015.

CRS. 2015. Hurricanes Katrina and Rita: Fishing and Aquaculture Industries—Damage and Recovery. Congressional Research Service. October 13. Available: http://fpc.state.gov/documents/organization/57873.pdf. Accessed March 30, 2015.

Dame, R.F. and B.C. Patten. 1981. Analysis of energy flows in an intertidal oyster reef. Marine Ecology Progress Series 5:115–124.

Finch, M. 2014. Alabama Recovery Council Directs First $56 Million to Economic and Infrastructure Projects. Alabama Media Group. December 17. Updated January 7, 2015. Available: http://www.al.com/business/index.ssf/2014/12/alabama_recovery_council_direc.html. Accessed April 8, 2015.

Gulf Coast Seafood. 2015. Member States. Available: http://eatgulfseafood.com/about/member-states/. Accessed April 1, 2015.

Handley, L., K. Spear, S. Jones, and C. Thatcher. 2007. Statewide summary for Alabama. In Seagrass Status and Trends in the Northern Gulf of Mexico: 1940–2002. U.S. Geological Survey Scientific Investigations Report 2006-5287 and U.S. Environmental Protection Agency 855-R-04-003. Available: http://gom.usgs.gov/documents/Chapter_J_StateSummForAL.pdf. Accessed April 16, 2015.

Haner, J. 2015. Interview with Judy Haner, Director of Marine and Freshwater Programs at The Nature Conservancy's Alabama Coastal Program. March 17.

Hosey, J. 2015. Interview with John Hosey, Gulf Coast Restoration Corps Director of Development. August 17.

Lankford, K. 2013. Restoring Mobile Bay with 600 of our closest friends. Ocean Conservancy. April 11. Available: http://blog.oceanconservancy.org/2013/04/11/restoring-mobile-bay-with-600-of-our-closest-friends/. Accessed April 1, 2015.

Lankford, K. 2014. Fund Projects Focusing on Economic and Environmental Health as a Whole. Letters to the editor. Lagniappe Weekly. December 23. Available: http://lagniappemobile.com/fund-projects-focusing-economic-environmental-health-whole/. Accessed April 8, 2015.

MBNEP. 2015. The Coast: Wetlands. Mobile Bay National Estuary Program. Available: http://www.mobilebaynep.com/mobile_bay_watershed/the_alabama_coast/. Accessed April 1, 2015.

Meyer, D.L., E.C. Townsend, and G.W. Thayer. 1997. Stabilization and erosion control value of oyster cultch for intertidal marsh. Restoration Ecology 5:93–99.

Mobile Bay Oyster Gardening Program. 2015. Oyster Gardening on Mobile Bay. Available: http://oyster-gardening.org/. Accessed April 8, 2015.

NOAA. 2015a. NOAA Information Related to the American Recovery and Reinvestment Act of 2009. National Oceanic and Atmospheric Administration. Available: http://www.noaa.gov/recovery/. Accessed April 16, 2015.

NOAA. 2015b. Oyster Reefs. National Oceanic and Atmospheric Administration. Available: http://chesapeakebay.noaa.gov/oysters/oyster-reefs. Accessed April 16, 2015.

Piazza, B.P., P.D. Banks, and M.K. La Peyre. 2005. The potential for created oyster shell reefs as a sustainable shoreline protection strategy in Louisiana. Restoration Ecology 13:499–506.

Restore Coastal Alabama, 2015. Restoring Coastal Alabama One Mile at a Time. Available: http://100-1000.org/. Accessed April 8, 2015.

Scyphers, S. 2015. Interview with Steven Scyphers, Postdoctoral Researcher at Northeastern University's Marine Science Center. April 6.

Scyphers, S., S.P. Powers, K.L. Heck, and D. Byron. 2011. Oyster reefs as natural breakwaters mitigate shoreline loss and facilitate fisheries. PLoS One 6(8):e22396.

Sheng, Y.P., A. Lapetina, and G. Ma. 2012. The reduction of storm surge by vegetation canopies: Three-dimensional simulations. Geophysical Research Letters 39(20):L20601.

TNC. 2015. Oceans and Coasts. How We Work: Partnering with NOAA. The Nature Conservancy. Available: http://www.nature.org/ourinitiatives/habitats/oceanscoasts/howwework/noaa-partnership.xml. Accessed April 16, 2015.

USACE. 1963. Interim Survey Report, Morgan City, Louisiana and Vicinity, Serial No. 63. U.S. Army Corps of Engineers, U.S. Army Engineer District, New Orleans, LA.

Wamsley, T.V., M.A. Cialone, J.M. Smith, J.H. Atkinson, and J.D. Rosati. 2010. The potential of wetlands in reducing storm surge. Ocean Engineering 37(2010):59–68.

Norfolk, Virginia

Coastal Resilience Strategy

NORFOLK, VIRGINIA

AUTHORS: Alexis St. Juliana and Jason Vogel

In this case study, you will learn about:

- Engaging in no-regrets/low risk actions
- Using climate change projections to inform decision making
- Sharing information and advice on activities with other communities

Case Study Summary

The City of Norfolk is located on the coast of Virginia. Norfolk experiences coastal flooding regularly, but community members report that it has become more frequent, more severe, and now occurs in areas where flooding has not traditionally been a problem. Extreme weather events such as nor'easters and hurricanes generate large storm surges and heavy precipitation that exacerbate tidal flooding. As a result, the City of Norfolk passed changes to its flood and coastal zone ordinance to reduce the city's vulnerability to coastal flooding. Beginning in 2014, new structures in flood and coastal zones must be built with their lowest level at least three feet above the 100-year floodplain; existing structures that experience two floods that damage the equivalent of 25 percent or more of their value must also be elevated to meet this standard (City of Norfolk, 2013a). This standard was selected based on examination of projections of sea level rise. Newly constructed properties are complying with the new standard; however, it will take more time to know the full impact of Norfolk's action. City staff and appointees feel that the standards will reduce the city's vulnerability for several decades into the future. However, the city is considering additional actions to create a more robust response to projected increases in coastal flooding.

The Broader Context of Community-Based Adaptation in Norfolk

ADAPTATION ACTIVITIES IN NORFOLK

- Brambleton Avenue, Colley Avenue, and Surrey Crescent road elevation projects
- Studies for an engineered shoreline at Ocean View Beach
- Living shoreline efforts along Haven Creek
- Replacing and elevating a bulkhead
- 1.5–2 feet above the existing bulkhead
- Installing a mobile pump to deal with tidal flooding at Lea View and 15th Street
- Multiple localized neighborhood level drainage improvements

Sources: Georgetown Climate Center, forthcoming; Schechtman and Brady, 2013; Applegate, 2014; City of Norfolk, 2014a, 2014c.

The City of Norfolk has been struggling with the impacts of both recurrent tidal flooding and inland flooding for decades. In an effort to characterize the problem and identify solutions to flooding, the city funded a series of studies beginning in 2007. These included the Preliminary City-Wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development, a City-Wide Drainage Master Plan, and long-term tidal and precipitation flooding analyses (City of Norfolk, 2012; Fugro, 2012; Timmons Group, 2012; City of Norfolk et al., 2013). These studies recommend close to $1 billion in infrastructure improvements such as floodwalls, tide gates, berm construction, and pump stations; drainage improvements; and road elevation and structural elevation projects (City of Norfolk, 2014b).

The city is beginning to invest in flood mitigation efforts. In its 2012–2016 Capital Improvement Plan, the city budgeted $4.5 million to address street flooding citywide, and $6.5 million to fund beach stabilization and shoreline erosion control (see the text box). In 2014, the city also established a $1 stormwater fee to fund flood mitigation activities (Georgetown Climate Center, Forthcoming). However, additional investment is needed for large infrastructure projects. Potential sources of funding for this work include the National Disaster Resilience Competition through the U.S. Department of Housing and Urban Development or the U.S. Federal Emergency Management Agency (FEMA; Morris, 2015).

The city is also addressing tidal and inland flooding concerns through the Rockefeller Foundation's 100 Resilient Cities and RE.invest initiatives. These efforts aim to improve the city's (1) strategy for managing

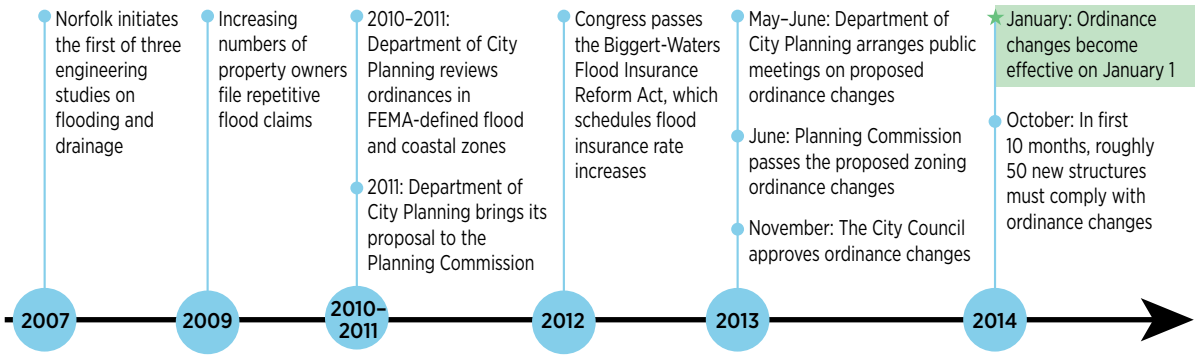

Exhibit 1. Timeline of the development of Norfolk's revised flood and coastal zone ordinance.

coastal resiliency issues, (2) diversity of economic development opportunities, and (3) poverty challenges. As part of these efforts, Norfolk is reconsidering land-use planning priorities. For instance, when Norfolk is ready to implement larger-scale flooding solutions personnel will also consider how to revitalize and re-connect cut-off portions of the city (Morris, 2015). This strategy also feeds into goals for neighborhood cohesion and poverty reduction. City staff are sharing a strategy with non-profits, churches, civic leagues, and neighborhood associations to build connections with vulnerable community members such as the elderly, disabled, or those without transportation. These organizations will serve as initial points of contact during hazardous events or even times of personal difficulty (Morris, 2015).

Finally, flood mitigation is a component in two city strategy documents. First, the city's comprehensive plan, *plaNorfolk2030*, encourages the integration of sea level rise into development activities (Schechtman and Brady, 2013). Second, this city's Coastal Resilience Strategy outlines a general approach for managing coastal flooding: plan, prepare, mitigate, and communicate (City of Norfolk, 2014b). The strategy highlights elevating new construction as one measure to prepare for coastal flooding (City of Norfolk, 2014b). This measure and several related zoning ordinance changes are the focus of this case study because they have advanced past planning stages and become part of local standards. Additionally, they apply to significant portions of the city in flood and coastal zones. See Exhibit 1 for a timeline of events related to Norfolk's work to revise its flood and coastal zone ordinance.

Why and How Norfolk Implemented its Flood and Coastal Zone Ordinance

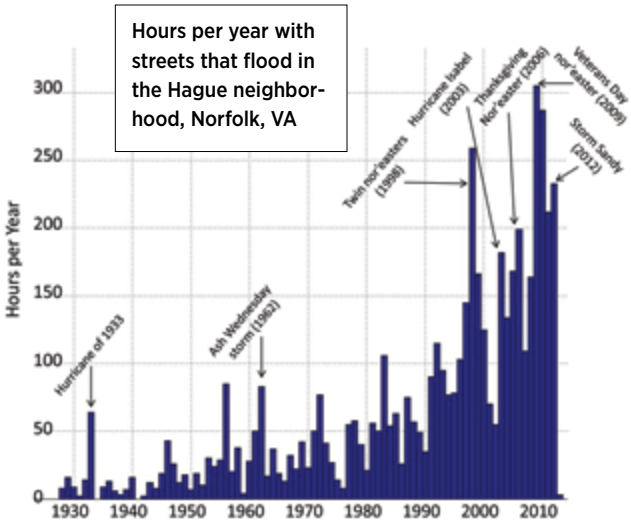

Exhibit 2. Street flooding in Norfolk caused by extreme high tides or storm surge.
Source: Atkinson et al., 2013.

Increased Flooding Builds Motivation for Action in Norfolk

Due to subsidence and sea level rise, episodes of tidal flooding are becoming more frequent, more severe, and are occurring in areas where flooding has not traditionally been a problem in Norfolk. For example, certain streets now flood regularly with high tides, including streets that did not flood in the past (Exhibit 2). In 2014, there were several heavy rain storms that shut down traffic across the city for hours at a time due to roadway flooding. These heavy rainfall events exacerbate flooding at high tide, when many drainage or outflow pipes are submerged or partially submerged and rainwater cannot properly drain.

Increased Flood Insurance Claims Motivate Norfolk's Department of City Planning to Take Action

Beginning in 2009, Norfolk's Department of City Planning saw an increase in insurance claims to FEMA's National Flood Insurance Program (NFIP; Exhibit 3). The Department of City Planning is the link between the City of Norfolk and the NFIP. The department manages Norfolk's overall flood mitigation strategy, floodplain, and coastal zone mapping activities, as well as efforts to raise awareness on Norfolk's flooding issues, although several other city departments and regional entities play a role.

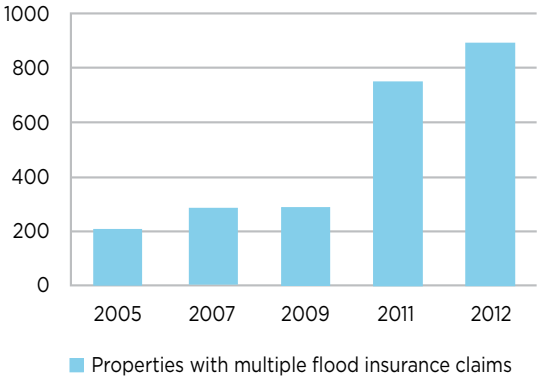

Exhibit 3. FEMA repetitive flood claim records.
Source: Adapted from City of Norfolk, 2013b

Exhibit 4. Example flood insurance premiums for a home below, at, and above base flood elevation.
Source: FEMA, 2013b.

Staff in Norfolk's Department of City Planning shared that the increase in flood insurance claims was a very serious concern for several reasons. First, they were concerned about Norfolk's citizens and the impact of flooding on their lives and properties. The department wanted to find a way to minimize impacts to properties so that owners would be protected from worsening flooding. Second, they were concerned about Norfolk's rating within the NFIP Community Rating System (CRS) and the insurance premiums available to Norfolk property owners under that program. The Department of City Planning wanted to ensure that flood insurance for its residents was affordable for all residents so they would be properly insured in the event of a serious flood. Third, the city was aware of citizens' concerns that flooding was getting worse and that action needed to be taken. Finally, in 2012 Congress passed the Biggert-Waters Flood Insurance Reform Act (the Act), which reformed the NFIP and included a schedule to reduce flood insurance premium subsidies in 2014 (FEMA, 2013a). Norfolk was already exploring options to improve its CRS rating and maintain or lower flood insurance premiums when the Act was passed, but the Act possibly sped up the city's actions. Exhibit 4 shows insurance premiums for a home below, at, and above base flood elevation.

Norfolk's Department of City Planning Drafts Proposed Ordinance Changes

In 2010 and 2011, the Department of City Planning reviewed options for changing the current ordinances in FEMA-defined flood and coastal zones. As part of this review, the department also consulted sea level rise projections from the Virginia Institute of Marine Sciences. The department devised a series of proposed changes, which would protect citizens from flooding and reduce flood insurance premiums by improving Norfolk's status on the CRS. Although there were several proposed changes, the key changes are outlined in Exhibit 5.

EXHIBIT 5. SELECTED PROPOSED CHANGES TO NORFOLK'S ZONING ORDINANCE BY THE DEPARTMENT OF CITY PLANNING

Existing regulation

- Require the first floor level be elevated one (1) foot above the anticipated flood level
- Require existing buildings come into compliance with current regulations if **damage or improvements from a single event exceeds 50 percent** of market value of the structure

Proposed regulation

- Require the first floor level be elevated two (2) feet above the anticipated flood level
- Require existing buildings come into compliance with current regulations once the **sum of damage and/or improvements exceeds 50 percent** of market value of structure over a 10-year period (Cumulative Loss/Improvement)

Or

- If flood damage from two events, on average, each equals or exceeds 25 percent the market value of the structure (Repetitive Loss)

Source: Adapted from City of Norfolk, 2013c.

To explain in further detail, increasing the city's standard from one foot above base flood elevation (the 100-year floodplain) to two feet above base flood elevation means that the lowest level of new construction would need to be built two feet above FEMA's mapped base flood elevation; this structural elevation is also called "freeboard." The second provision would change regulations on existing buildings in flood and coastal zones. Previously, a one-foot freeboard was required when a property incurred a single damage event or implemented improvements worth 50 percent of the building's insurance replacement value. The new provision would look at cumulative damages and improvements over a 10-year period to determine if

a building should come into compliance with a two-foot freeboard. The Department of City Planning proposed two catalysts: (1) damages and improvements totaling 50 percent of the building's insurance replacement value, or (2) two flood damage events each totaling 25 percent or more of the building's insurance replacement value.

Planning Commission Considers Climate Change and Revises Proposed Standards

In 2011, the Department of City Planning brought its proposal to the appointed Planning Commission. The department presented background information, including sea level rise projections (Exhibit 6). The Planning Commission reviewed the department's recommendations and recommended one change: that the two-foot freeboard standard be raised to three feet based on sea level rise projections for Virginia. In particular, Commissioner Martin Thomas, Jr. suggested that two feet of freeboard was insufficient to protect structures in flood and coastal zones based on the available sea level rise projections (Thomas, 2014). He felt that raising their current standard by just one foot would only benefit the city for the next 15–20 years, and that by increasing the freeboard standard to three feet, there was a greater potential to protect properties for a longer time period. The Planning Commission unanimously agreed to increase the proposed standard to include three feet of freeboard for structures in flood or coastal zones.

Norfolk Seeks Stakeholder Feedback and Revises the Ordinance

With the Planning Commission's recommendations, the Department of City Planning arranged a series of public meetings in May and June 2013 to discuss the proposed changes. Through this process, the city heard several concerns from a few attendees about the proposed changes. For instance, the Tidewater Builders Association (TBA), the Willoughby Civic League, the Hampton Roads Realtor

Association and others were concerned about the 10-year cumulative damage and improvement provision (City of Norfolk, 2013c; Willoughby Civic League, 2013). There were several arguments against this. First, with an estimated average cost of $100,000 to raise a structure, most property owners could not afford to comply.

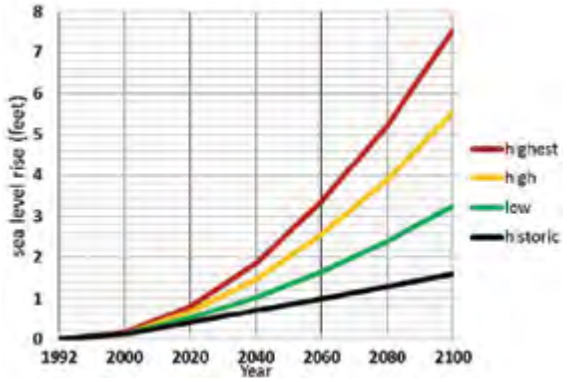

Exhibit 6. Southeast Virginia sea level rise scenarios.
Source: City of Norfolk, 2013b; Virginia Institute of Marine Sciences, Undated.

Second, property owners making improvements unrelated to flood damage (including damage from other natural events like high winds) would not be eligible for federal assistance. Third, damage or improvement values would be transferred to new property owners. For example, if a property owner made improvements worth 35 percent of a building's value, then when a new owner attempts to repair damage or make improvements worth 15 percent or greater, the building would need to come into compliance. Disclosure of such damages or improvements are not required at the time of sale. Fourth, TBA had concerns about the cost to developers and buyers associated with the three-foot freeboard. The additional height contributes to higher building costs. There were also concerns about the historic character of buildings and neighborhoods with structural elevation (City of Norfolk, 2013c). However, even with these concerns, all parties recognized that Norfolk should take action to reduce flood damage and improve its CRS rating. The concerned parties felt that the city could improve the rating through other means.

The Department of City Planning revised the proposed zoning ordinance based on public discourse and internal decision-making. In particular, they removed the 10-year cumulative loss provision in favor of a requirement that "existing buildings come into compliance with current regulations if flood damage from two events, on average, each equals or exceeds 25 percent the market value of the structure and the building is structurally damaged

or altered" (City of Norfolk, 2013a, p. 1). This meant that existing structures that incur two flood damage events worth 25 percent or more of their value must be elevated. In addition to the concerns expressed at public meetings, the Department of City Planning realized that they did not have an effective mechanism to track cumulative losses and improvements to properties. From here, the Planning Commission voted and passed the proposed zoning ordinance changes on June 27, 2013. The City Council formally approved the changes on November 26, 2013, which became effective on January 1, 2014 (Council, 2013). The text box summarizes the final provisions of the zoning ordinance changes.

SUMMARY OF NEW FLOOD AND COASTAL ZONE REGULATIONS IN NORFOLK

- Three feet of freeboard
- Measure the height of structures from the Design Flood Elevation or the ground level at the entrance of the structure, whichever is greater
- Require Elevation Certificates based on proposed construction with new development and additions in the Special Flood Hazard Area
- Require all development within a 0.2 percent annual chance of flood to have a finished floor or be floodproofed 18 inches above grade
- Require a twenty-foot setback from the landward edge of mean high water for principal structures
- Prohibit the construction of subgrade crawl spaces within a Special Flood Hazard Area
- Prohibit the use of breakaway walls in Coastal High Hazard and Coastal Floodplain districts
- Identify Coastal Floodplain Districts and provide regulations to match construction requirements for Coastal High Hazard District
- Require existing buildings to come into compliance with current regulations if flood damage from two events, on average, each equals or exceeds 25 percent the market value of the structure and the building is structurally damaged or altered

Source: City of Norfolk, 2013a.

Accomplishments of Norfolk's Freeboard Standard

Those interviewed for this study agree that the revised zoning ordinance is a success and that Norfolk is headed in the right direction, but there is more work to do. The revised ordinances are part of what will hopefully become a more robust coastal and inland flooding strategy. They feel that the new standards will help to protect structures and are evidence that the city is working to address a very real problem. Three feet of freeboard will take Norfolk an estimated 60 or 65 years into the future, giving the city time to find big-picture solutions to recurrent tidal flooding.

Norfolk's revised flood and coastal zone ordinance went into effect January 1, 2014. As of October 2014, over 50 new construction buildings have had to comply. The number of existing structures with two flood damage events worth 25 percent or more of their value is not available. These types of claims are reported to the city by FEMA, but cannot be made public. Those interviewed for this study agree that it will take some time to gauge the new regulations' effectiveness. One person mentioned that it may take 30 years to know if these actions were well-founded; the degree of sea level rise will determine the regulations' efficacy. Still, Department of City Planning staff have anecdotal evidence of a new construction home selling more quickly due to a lower flood insurance premium relative to other properties in the flood or coastal zones, despite the additional construction cost.

Other cities in the region have looked to Norfolk as a leader on coastal flood mitigation issues. Several communities have raised their freeboard standards to three feet including Hampton (City of Hampton, 2014; Hampton Roads Regional CRS Workgroup, 2014). Examples of similar ordinances that are being considered or have passed include:

- City of Portsmouth (considering a three-foot freeboard; Hampton Roads Regional CRS Workgroup, 2014)
- City of Newport News (considering a two-foot freeboard; Hampton Roads Regional CRS Workgroup, 2014)

- City of Poquoson (three-foot freeboard; Hampton Roads Regional CRS Workgroup, 2014)
- Gloucester County (two-foot freeboard; Gloucester County, 2011)
- City of Chesapeake (one-and-a-half-foot freeboard; City of Chesapeake, 2013).

Notably, Virginia Beach tried to raise its freeboard standard to three feet, but could only achieve a two-foot standard due to pressure from the building industry. Virginia Beach has more undeveloped land and the building industry sees an additional foot of freeboard as a more significant cost than in Norfolk. Also, Virginia Beach's more conservative planning commission was less willing to consider climate change.

Moving Forward

Although Norfolk is strengthening its protection measures against coastal inundation and greater losses due to projections of sea level rise, there are concerns about the effectiveness of the city's revised standards when considering Norfolk's overall vulnerability to flooding. Wetlands Watch, an environmental advocacy group in the region, felt that adaptation will occur very slowly. Since Norfolk's flood and coastal zones are very built-up, there is a limited amount of new construction that will need to comply; instead, adaptation will occur in a piecemeal way as existing structures are elevated. A second concern from Wetlands Watch is FEMA's ability to disperse funds in a timely manner; property owners could wait for years for funds to elevate their structures. Wetlands Watch estimates that if FEMA continues to disperse funding at its current rate, repetitive loss property owners already waiting for FEMA funds (for repairs or elevation) could wait 188 years, not including new property owners that are added to the list (Stiles et al., 2014). In the meantime, property owners could experience additional flooding events with limited means to repair their properties. Wetlands Watch's final concern is that the revised standards only focus on structures and will not address the greater flooding problems in Norfolk. Buildings may be safe, but the city will still flood, leaving some properties as virtual islands among flooded areas.

As well, Wetlands Watch and TBA noted that zoning ordinances are not a topic of high public interest and there were relatively few people actively engaged or aware of the topic. They felt this might change in the future as existing structures need to come into compliance.

The city has also considered implementing transfers of development rights, which would equate to buyouts of properties in the most flood-prone neighborhoods in the city. However, this is a difficult action to take because despite flooding, properties adjacent to the water still have high property values and bring in significant tax dollars; plus, some property owners may be unwilling to relocate.

The city has an array of possible infrastructure projects to consider, but it needs federal support to help fund these. Some of those interviewed are hopeful that federal funds will reach Norfolk due to the large U.S. Naval presence in the area, and its reliance on sound infrastructure in and around Norfolk to maintain its operations. In a similar vein, some of those interviewed felt that if the U.S. Navy were to take concrete action on adaptation or request the city to take some concrete action, that would help move the Norfolk adaptation process forward as the Naval base brings significant economic activity and influence to the region. If funding comes to Norfolk, plans are in place to thoughtfully consider viable infrastructure solutions alongside neighborhood vitality in terms of economic development, adaptation to future inland or tidal flooding, and improving the lives of residents.

Acknowledgments

We would like to thank the following individuals for participating in interviews as part of this case study:

- **Joshua Clark,** Tidewater Builders Association
- **Michelle Covi,** Old Dominion University
- **Christine Morris,** City of Norfolk
- **William (Skip) Stiles,** Wetlands Watch
- **Robert Tajan,** City of Norfolk
- **Martin Thomas,** Jr., Norfolk Planning Commission.

Bibliography

American Community Survey. 2012. American Community Survey. American FactFinder. U.S. Census Bureau. Available: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 19, 2013.

Applegate, A. 2014. For City of Norfolk, park becomes wetlands once again. The Virginian Pilot. February 20. Available: http://hamptonroads.com/2014/02/city-norfolk-park-becomes-wetlands-once-again#. Accessed November 4, 2014.

Atkinson, L.P., T. Ezer, and E. Smith. 2013. Sea level rise and flooding risk in Virginia. Sea Grant Law and Policy Journal 5(2):3–14. Available: http://www.ccpo.odu.edu/~tezer/PAPERS/2013_SGLPJ_Atkinson_SLR.pdf. Accessed November 3, 2014.

City of Chesapeake. 2013. Memorandum to Chesapeake Planning Commissioners re: An Ordinance amending Chapter 26 of the Chesapeake City Code, entitled "Environment," Article IV, Floodplain Management, by amending Sections 26–86 through 26–105 to affirm floodplain districts, require the issuance of permits for residential and commercial development and redevelopment, imposing development restrictions on new and existing residential and commercial construction, establishing enforcement and penalties for violations, and standards for considering variances. June 3. Available: http://www.cityofchesapeake.net/Assets/supporting_docs/actions_planning/2013/2013-06-12/ta-z-11-10_staff_report.pdf. Accessed November 3, 2014.

City of Hampton. 2014. Ordinance to Amend and Re-Enact Chapter 2.1 of the Zoning Ordinance of the City of Hampton, Virginia Entitled "Definitions" By Amending Section 2.1-2 Pertaining to the Definition of Height, Chapter 17.3, Article V of the Zoning Ordinance of the City of Hampton, Virginia Entitled "Flood Zone District" by amending sections 17.3–31.2, 17.3–32, 17.3–33.1, 17.3–33.2, 17.3–33.3, 17.3–34.1, 17.3–34.2, 17.3–34.3, 17.3–34.8 and Adding a New Section 17.3–34.9 Pertaining to Construction Requirements for New Construction and Substantial Improvements for Properties Located Within Flood Zone Districts. September 10. Available: http://council.hampton.gov/Documents/ Document.aspx-?q=sEDpEXYoG8JgDF8Ziq6NZWTYsXpHhyWzt8KM0xHafKTXFXhtVRuifwl9DiobA%2B5F. Accessed November 4, 2014.

City of Norfolk. 2012. Norfolk Flooding Strategy Update. March 27. Available: http://va-norfolk.civicplus.com/documentcenter/view/1751. Accessed November 3, 2014.

City of Norfolk. 2013a. Flood Zone Regulation Changes. December 6. Available: http://www.norfolk.gov/DocumentCenter/View/12688. Accessed November 3, 2014.

City of Norfolk. 2013b. Revisions to Floodplain Regulations. July 23. Available: http://www.norfolk.gov/documentcenter/view/9106. Accessed November 3, 2014.

City of Norfolk. 2013c. Zoning Ordinance Text Amendment to Chapters 2, "Definitions," and 11–3, "Floodplain/Coastal Hazard Overlay District (FPCHO)," to Amend Terms, Simplify Language, and to Add Requirements for Properties Located within the Floodplain and to Revise Standards for Calculating Building Height.

City of Norfolk. 2014a. Brambleton Avenue and Colley Avenue Improvements. Available: http://www.norfolk.gov/index.aspx?NID=203. Accessed November 3, 2014.

City of Norfolk. 2014b. Coastal Resilience Strategy. Available: http://www.norfolk.gov/DocumentCenter/View/16292. Accessed November 3, 2014.

City of Norfolk. 2014c. Ocean View Shoreline Project Update. January 7. Available: http://www.norfolk.gov/DocumentCenter/View/12969. Accessed November 3, 2014.

City of Norfolk, Moffat & Michol, and Fugro. 2013. City of Norfolk Coastal Flood Mitigation Program. March 13. Available: http://www.norfolk.gov/DocumentCenter/View/3774. Accessed November 3, 2014.

Council, J. 2013. Norfolk raises standards in its floodplain law. Inside Business. November 27. Available: http://insidebiz.com/news/norfolk-raises-standards-its-floodplain-law. Accessed November 3, 2014.

FEMA. 2013a. Biggert-Waters Flood Insurance Reform Act of 2012 (BW12) Timeline. U.S. Department of Homeland Security. April 17. Available: http://www.fema.gov/media-library-data/20130726-1912-25045-8239/bw_timeline_table_04172013.pdf. Accessed November 3, 2014.

FEMA. 2013b. If Your Home or Business Has Been Flooded Build Back Safer and Stronger: What You Need to Know. January. Available: http://www.fema.gov/media-library-data/20130726-1858-25045-7797/build_back_stronger02_2013.pdf. Accessed December 22, 2014.

FEMA. 2014. Freeboard. U.S. Department of Homeland Security. Available: http://www.fema.gov/floodplain-management/freeboard. Accessed November 3, 2014.

Fugro. 2012. Preliminary City-Wide Coastal Flooding Mitigation Concept Evaluation and Master Plan Development. City of Norfolk City-Wide Coastal Flooding Contract No. 13062. Work Order No. 4. Fugro Atlantic, Norfolk, VA. May. Available: http://www.norfolk.gov/DocumentCenter/View/7614. Accessed November 3, 2014.

Georgetown Climate Center. Forthcoming. Elevating Roads in Norfolk Virginia.

Gloucester County. 2011. Disaster Preparedness Guide: Preparedness Begins with You. Summer. Available: http://www.gloucesterva.info/Portals/0/es/documents/hurricane2011.pdf. Accessed November 3, 2014.

Hampton Roads Regional CRS Workgroup. 2014. Bi-Monthly Newsletter. December.

Morris, C. 2015. Interview with Christine Morris, City of Norfolk, July 23.

Schechtman, J. and M. Brady. 2013. Cost-Efficient Climate Change Adaptation in the North Atlantic. National Oceanic and Atmospheric Administration, Sea Grant and North Atlantic Regional Team. Available: http://www.regions.noaa.gov/north-atlantic/wp-content/uploads/2013/07/CEANA-Final-V11.pdf. Accessed November 4, 2014.

Stiles, W., S.H. Jarbeau, S. Hughes, and M.-C. Stiff. 2014. The Challenge of Mitigating Virginia's Flooding and Sea Level Rise Impacts. Wetlands Watch. November. Available: http://www.wetlandswatch.org/Portals/3/WW%20documents/sea-level-rise/ww_flood_white-paper1-1.pdf. Accessed December 1, 2014.

Thomas Jr., M. 2014. Interview with Martin Thomas, Jr., Norfolk Planning Commission, October 29.

Timmons Group. 2012. City-Wide Drainage Master Plan. Final Submittal. November 8. Available: http://www.norfolk.gov/DocumentCenter/View/3641. Accessed November 3, 2014.

Virginia Institute of Marine Sciences. Undated. Sea-Level-Rise Scenarios. Available: http://www.vims.edu/newsandevents/topstories/slr_scenarios.php. Accessed December 9, 2014.

Willoughby Civic League. 2013. Minutes of the Regular Meeting. September 12.

Oakland, California

Oakland Climate Action Coalition Moves Climate Change Adaptation Forward

OAKLAND, CALIFORNIA

AUTHORS: Alexis St. Juliana, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- The Oakland Climate Action Coalition as a model for bringing together community groups
- Community organizations as important actors in advancing local climate change adaptation
- Bottom-up community climate change policy recommendations
- Incorporating vulnerability analyses into policy recommendations
- Barriers to adaptation
- Examples of adaptation actions led by non-governmental actors

Case Study Summary

The prevalence and prominence of community-based organizations makes the city of Oakland unique compared to many other communities. A number of these organizations have worked directly on climate change related topics since the 1990s, and many more approach climate change and environmental topics through a social justice lens. In 2009, 30 organizations—including those addressing sea level rise, environment, public health, and social justice topics—came together to form the Oakland Climate Action Coalition (OCAC). The OCAC has become a community platform for supporting climate change adaptation strategy and action; the coalition is now seen as a leading organization on climate change adaptation in Oakland.

Initially, the OCAC came together with the goal of influencing the Oakland Energy and Climate Action Plan (ECAP), the city's climate change mitigation plan. The OCAC successfully spurred a more comprehensive public engagement process for the plan and ultimately guided half of the plan's proposed actions (Garzón, 2015; Fitzgerald, 2015).

At roughly the same time as the ECAP effort, the OCAC partnered with the Pacific Institute as the institute developed a climate change vulnerability and adaptation assessment for Oakland. With OCAC input, the Pacific Institute developed a climate change vulnerability analysis, adaptation recommendations that account for equity concerns, and generated greater awareness of these issues which could be applied to future adaptation efforts.

Although the ECAP and the Pacific Institute assessment have concluded, the OCAC continues to be a key player in climate change adaptation in Oakland. The OCAC and its members conduct community education and outreach to address Oakland's vulnerability to extreme heat, wildfires, coastal flooding from sea level rise, air quality, and future food, water, and electricity prices. Additionally, the OCAC was involved in Oakland's successful bids to earn grants from The Kresge Foundation's Climate Resilience and Urban Opportunity Initiative and the Rockefeller Foundation's 100 Resilient Cities initiative. While the city of Oakland and Oakland's community-based organizations have been working on exemplary climate change adaptation planning efforts, implementation has been limited to a small number of capacity building exercises.

The OCAC has been and continues to be an effective and innovative means of bringing community-based organizational input to Oakland's climate change adaptation efforts. The OCAC may also serve as a model for other communities that seek to involve community-based organizations in climate change adaptation initiatives.

The Broader Context of Community-Based Adaptation in Oakland

The Oakland community-based organizations that form the backbone of OCAC have been working on climate change analyses since the 1990s (Exhibit 1). The prevalence and prominence of these organizations makes Oakland unique compared to many other communities. Some of these organizations approach adaptation through the lens of climate change topics, such as sea level rise, whereas some combine environmental awareness with social justice, energy use, energy cost, or health concerns. In addition to the examples included here, there are many other examples of environmental action in Oakland motivated by combined environmental awareness and concern for other community needs (see box below).

Sea level rise

In 1990, the Pacific Institute, an Oakland-based environmental research institute, conducted an early and influential analysis of sea level rise for the San Francisco Bay (Gleick and Maurer, 1990; Cooley, 2015). This initial study spurred the Pacific Institute to continue its analyses of sea level rise, as well as conduct a 2009 evaluation for the entire State of California (Heberger et al., 2009). As part of this 2009 effort, the Pacific Institute conducted a demographic analysis and found that in the San Francisco Bay area, large numbers of low-income residents and communities of color were vulnerable to the impacts of climate change (Cooley,

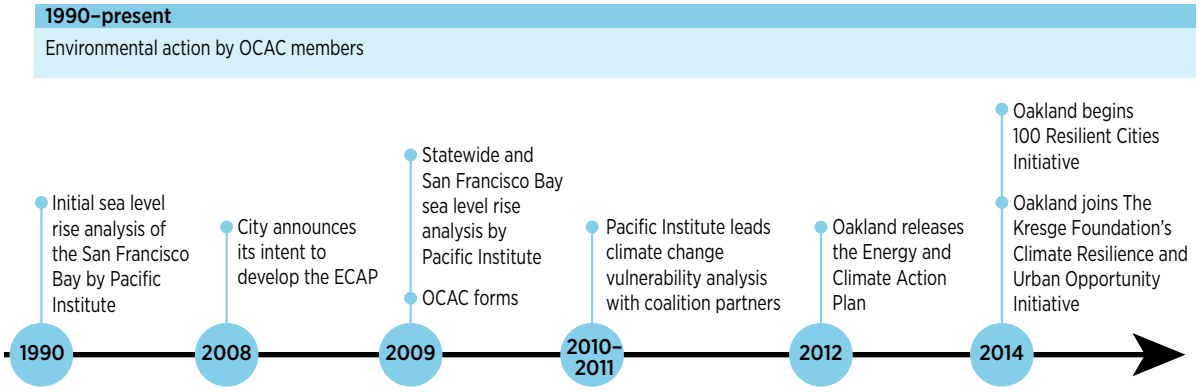

Exhibit 1. Timeline of actions in Oakland, CA.

2015). Other regional entities have also been involved in sea level rise analyses. These include the San Francisco Bay Conservation and Development Commission, a State commission dedicated to protecting the San Francisco Bay. The Commission also leads Adapting to Rising Tides, a regional collaboration of organizations working on adaptation to sea level rise and flooding. Additionally, the San Francisco Estuary Institute actively studies sea level rise in the region.

Air pollution

Air quality concerns spawned the West Oakland Environmental indicators Project (WOEIP) to work with the Port of Oakland to change freight trucking practices and reduce nearby residents' exposure to air pollution (WOEIP, 2011; Gordon, 2015).

Poverty reduction

The Ella Baker Center spearheaded a green jobs program to help create opportunities for Oakland residents in poverty (Ella Baker Center, Undated).

Climate resiliency

In 2014, two separate opportunities pushed the City of Oakland and Oakland's community-based organizations to develop resiliency plans. Both opportunities have strong ties with OCAC. The first opportunity was The Kresge Foundation's Climate Resilience and Urban Opportunity Initiative, which funded the OCAC to support the development of a climate change resiliency plan with the expertise of active community-based organizations. In particular, this effort aims to improve the climate change resiliency of low-income residents (The Kresge Foundation, 2014). The second opportunity was the Rockefeller Foundation's 100 Resilient Cities Initiative. The OCAC helped the city apply for and win funding under this initiative, which focuses on climate change and other issues to build community resilience. Initial assessments identified earthquakes, flooding, affordable housing, and social inequity as primary resilience challenges (100 Resilient Cities, 2015).

On the whole, climate change efforts in Oakland have emphasized greenhouse gas mitigation or climate change adaptation planning. While adaptation planning efforts are underway, the OCAC, many member groups, and the city have begun to implement adaptation actions to reduce vulnerability to climate change (see the text box for examples of adaptation actions in Oakland). Most of these actions are led by community-based organizations. This case study focuses on how the OCAC developed, and how it has endured to move climate change adaptation policy and practice forward in Oakland, CA.

Why and How the OCAC Developed and Informed Climate Change Adaptation in Oakland

To understand the OCAC's contributions, it is helpful to explore its creation, its work with the Pacific Institute on climate change vulnerability and adaptation, the reasons the OCAC has been effective, and how it successfully influenced the ECAP.

Ella Baker Center Spearheaded Creation of OCAC to Influence Oakland's ECAP

The Ella Baker Center is an Oakland non-profit organization focused on social justice issues. In 2006, with the help of grant funding, the center launched a green jobs campaign to improve employment prospects for Oakland residents and to keep them out of poverty (Ella Baker Center, Undated). In 2009, the center learned that the city planned to develop a climate change mitigation plan, called the ECAP. Ella Baker Center staff felt this was a prime opportunity to integrate green jobs goals within city plans (Fitzgerald, 2015). Additionally, Ella Baker Center staff "reached out to a wide variety of community organizations focused on green, social justice, housing, green business, and related issues—organizations either already working on or potentially interested in local energy and climate issues. The Ella Baker Center proposed that interested organizations form a coalition to share ideas and give coordinated input to the city" (Fitzgerald, 2015). After initial meetings, the various organizations decided to develop a more formal partnership, the OCAC.

Groups joined the OCAC for various reasons. WOEIP Co-Director Brian Beveridge shared that his group joined the OCAC because "We join everything" (Beveridge, 2015). His colleague, Margaret Gordon added that "Anything about the community, we have to investigate... Eight years ago [we learned] climate change was coming ... and no one was talking about the justice piece, climate justice. That's when we started to say, 'Okay, this is something WOEIP needs to be engaged in.'... It was a good thing for us to do" (Gordon, 2015). Beveridge and Gordon felt the ECAP development process would intersect with several of their organization's interests, including the environment, economy, and urban development. Additionally, because WOEIP had worked with the Ella Baker Center on the green jobs program, they had already built the necessary trust to work together and engage with the city on the ECAP (Beveridge, 2015). Bay Localize was another organization that advocated for the creation of the coalition (Schwind, 2015). Kirsten Schwind, Bay Localize co-founder and senior strategist, said that her group joined because they were concerned that the ECAP process wouldn't reflect the breadth and depth of grassroots organizing in Oakland; they had worked with city energy staff on past projects that did not have genuine community engagement. Schwind said, "The OCAC had the potential to improve the ECAP; it had the potential to bridge the climate world and social justice work" (Schwind, 2015).

Pacific Institute and the OCAC Partnered to Identify Community Vulnerabilities and Climate Change Adaptation Recommendations

In 2010, approximately a year after the OCAC had formed, the Pacific Institute was awarded a grant from the California Energy Commission's California Climate Change Center to develop a climate change vulnerability assessment and associated adaptation recommendations for Oakland (Garzón et al,. 2012). This effort was separate from the city's efforts to develop the ECAP and the OCAC's work to influence the ECAP, but the two efforts coincided for a period of time and indirectly influenced each other. The Pacific Institute intended to use a participatory research process that engaged community members in identifying community vulnerabilities and equitable adaptation solutions. The Pacific Institute staff felt that the OCAC, already organized, focused on climate change, and representing an engaged set of community groups, was a natural fit for the Pacific Institute's participatory research process.

Pacific Institute staff approached the OCAC steering committee about their study and how it related to the OCAC's goals. Many OCAC member groups were interested and willing to participate in the study (Garzón et al., 2012). To make it easier for OCAC members to participate in the Pacific Institute's process, the Institute

EXAMPLES OF ADAPTATION ACTIONS IN OAKLAND

- The OCAC holds ongoing workshops on climate impacts such as extreme heat, flooding and wildfire. It also developed pocket guides with appropriate actions in those emergencies and preparedness measures for limited water availability, limited food access, rising electricity costs, traffic congestion, and poor air quality (OCAC, 2014; Schwind, 2015).
- In January 2014, the OCAC held a workshop sharing the needs of vulnerable community members with emergency responders and educating community members on what to do in emergency situations (Garzón, 2015; Schwind, 2015).
- Bay Localize is helping to organize a regional coalition of actors around climate change adaptation (Schwind, 2015).
- Bay Localize, with funding from the U.S. Department of Housing and Urban Development, is working on a project called Map My Future, which identifies resiliency strongpoints across the city (Schwind, 2015).
- The OCAC and other partners are working on a community energy choice aggregation project to give residents the option for clean energy supply sources. An additional goal of the effort is to create green jobs in the county (OCAC, 2012; Beveridge, 2015; Gordon, 2015; Schwind, 2015; Fitzgerald, 2015; Hamilton, 2015).
- OCAC members on the Food Justice sub-committee have been working to develop "edible parks" in Oakland. This efforts aim dedicate public land food production so that food production can become more localized (Gordon, 2015; Schwind, 2015).
- The city has an Adopt-a-Drain program to mitigate flooding. Residents or business owners volunteer to clean out storm drains prior to precipitation events to help minimize flooding (Hamilton, 2015). The OCAC help to spread the work on this initiative and encourage individuals to volunteer (OCAC, 2015).
- The city is evaluating adaptation options at the Port of Oakland (which includes the airport) to mitigate the impacts of sea level rise. This work is still in the planning phases (Hamilton, 2015).
- WOEIP worked with students at University of California, Berkeley to map climate impacts in areas of Oakland that are being considered for new development (Gordon, 2015).

arranged six separate sessions around OCAC events. Additionally, the OCAC invited Catalina Garzón of the Pacific Institute to sit on the Adaptation and Resilience sub-committee, further integrating the coalition's work on the ECAP and on the Pacific Institute's study.

The Pacific Institute had planned to evaluate extreme heat, wildfires, coastal flooding from sea level rise, and particulate matter concentration (an indicator of air quality) in their vulnerability assessment. OCAC members indicated a strong interest in understanding how climate change would affect future food, water, and electricity prices. The Pacific Institute integrated these concerns into its study (Cooley, 2015; Garzón et al., 2012) using Intergovernmental Panel on Climate Change greenhouse gas emissions scenarios as a basis. To understand vulnerabilities in Oakland, the research team developed a vulnerability index consisting of 19 separate vulnerability factors. The specific vulnerability factors and indictors developed by the Pacific Institute research team are in Exhibit 2. The research team then mapped climate impacts and social vulnerability to identify priority areas for adaptation (Exhibit 3). Data for these factors came from a variety of sources, but primarily the U.S. Census Bureau's American Community Survey (Garzón et al., 2012)

EXHIBIT 2. FACTORS INCLUDED IN THE OAKLAND VULNERABILITY INDEX

VULNERABILITY FACTOR AND INDICATOR

- Households with air conditioning
  - Households with an air conditioning unit
- Population over 25 with a diploma
  - People over age 25 who have a high school diploma
- Born outside the U.S.
  - People who were born outside the United States
- Impervious areas
  - Land in the area that has an impervious surface (e.g., sidewalk or roof)
- Residents living in institutions
  - Population living in "group quarters," including institutions like correctional facilities, nursing homes, mental hospitals, college dormitories, military barracks, group homes, missions, and shelters
- Households with limited English
  - Population 5 years old and older who answered that they speak English less than "very well"
- Households with no vehicle
  - Percentage of households with no vehicle available
- People of color
  - People identifying as any other race or ethnicity besides white.
- Households in poverty
  - Households with an income that is below 200 percent of the official federal poverty level
- Pre-term births
  - Infants that were born before completing 37 weeks (about 8.5 months) of pregnancy
- Renter-occupied households
  - Percent of households where people are renting
- Over 65 and living alone
  - Percent of households occupied by someone over age 65 who lives alone
- Tree canopy cover
  - Land covered by tree canopy
- Under age 18
  - Population under age 18
- Unemployment
  - Population 16 years and over able to work who are unemployed
- Have jobs working outdoors
  - Percent of workers who work in agriculture, forestry, mining, or construction
- Pregnancy
  - Percentage of women 15 to 50 years old who gave birth in the past 12 months
- Food access
  - Access to full-service supermarkets according to Low Access Area measurement tool
- Youth fitness
  - Fraction of children that are overweight or obese in tract (i.e., fraction over 85th percentile for age and gender based on the CDC growth curves)

Adapted from Garzón et al., 2012.

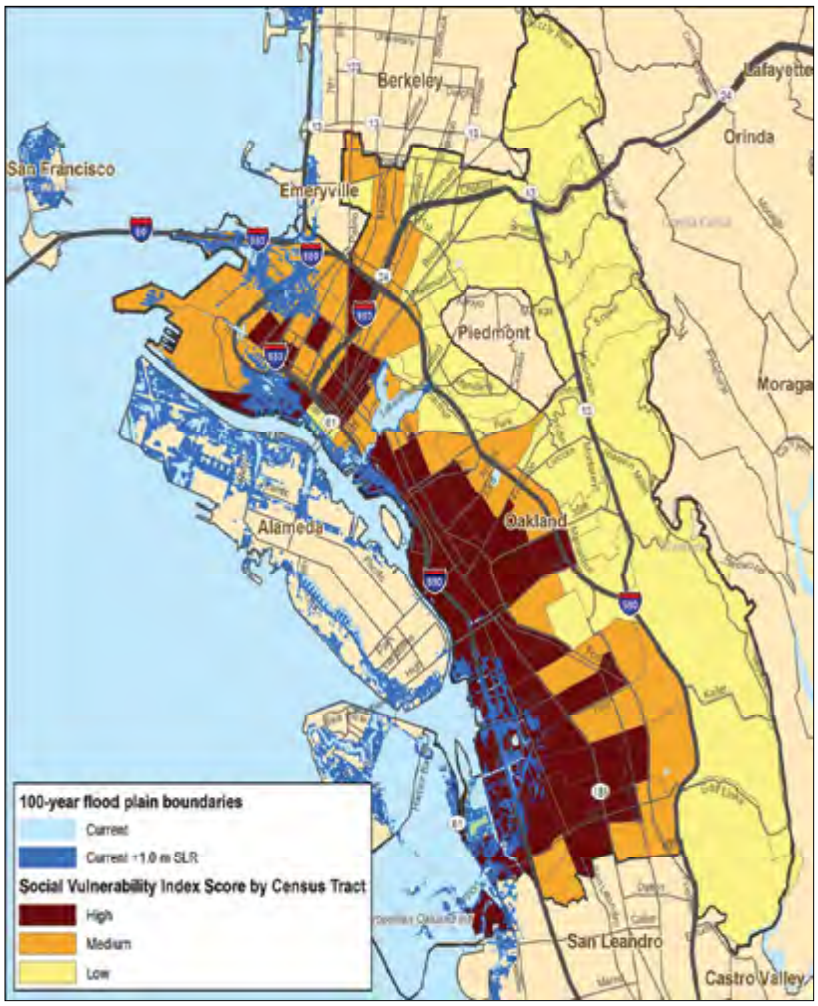

Exhibit 3. Sea level rise and social vulnerability map.
Source: Garzón et al., 2012.

In addition to identifying climate impacts and social vulnerabilities, the Pacific Institute worked with the OCAC to develop a set of nearly 50 adaptation recommendations for extreme heat, flooding, wildfires, rising utility and food costs, and poor air quality. Each of the recommendations has an associated social equity concern and multiple policy solutions (Exhibit 4).

The Pacific Institute faced a number of challenges in carrying out this research. First, The California Energy Commission's California Climate Change Center policies were such that grant funds could not be used to compensate the OCAC or its member groups for the their time and participation (Garzón, 2015; Cooley, 2015). This made it more difficult for some groups to participate. Second, the Pacific Institute's work ended after the ECAP was complete. Therefore, the climate change adaptation recommendations in their study did not directly influence the ECAP (Cooley, 2015). Even though the timing was off, the Pacific Institute's work with the OCAC on adaptation did influence the ECAP indirectly. The city was aware of the Pacific Institute's work and the two efforts coincided for a period of time. Additionally, since the ECAP was intended to be updated periodically, most OCAC participants were aware that there would be an opportunity, at a later date, to revisit climate change adaptation topics.

EXHIBIT 4. SAMPLE ADAPTATION RECOMMENDATIONS (GARZÓN ET AL., 2012)

EXTREME HEAT:
PLANT TREES/INCREASE GREEN SPACE

Description: Plant trees and other vegetation to help cool urban environment by providing shade and increasing evapotranspiration

Advantage: Provides multiple benefits, e.g., aesthetic, stormwater runoff reduction, energy savings on cooling, air quality improvements, carbon sequestration, etc.; generally has positive costs/benefit ratios due to co-benefits

Disadvantage: Requires ongoing maintenance and, in some cases, water

Equity concern: Focused installation only in wealthier areas of the city; gentrification; displacement of homeless populations with the rejuvenation or ecological objectives of new green space; gentrification related to neighborhood greening efforts

Policy solution:

- Prioritize neighborhoods with greatest need for tree planting programs
- Promote planting of native trees and plants to reduce water requirements
- Ensure neighborhoods retain affordable or low-income housing options
- Develop mixed-use, mixed-income area with high levels of community input, engagement, and involvement in the planning process
- Train Oakland youth and/or young adults to plant trees as part of the Oakland summer jobs program

RISING UTILITY AND FOOD COSTS:
DEVELOP AND SUPPORT LOCAL FOOD SYSTEMS

Description: Grow food locally to reduce impact of disasters by supporting local, diverse, and resilient food systems

Advantage: Cultivates local skills and knowledge, builds local economy, can save money and generate income

Disadvantage: Requires skill and time for ongoing labor and maintenance

Equity concern: Local or organic food frequently very expensive; farmers markets often do not accept food stamps; pesticide use can be hazardous and can cause severe health problems for neighbors with certain respiratory and neurological conditions

Policy solution:

- Partner with the city and local organizations to refund produce vendors for food stamps in order to double the value of produce purchased in order to encourage and enable the purchase of locally produced health foods
- Subsidize local agriculture to keep down consumer costs
- Conduct community outreach and education to expand access to food stamps and healthy food distribution programs
- Expand access to public and privately owned land for local food production
- Change permitting requirements and regulations that pose barriers to community food security strategies such as street food vending and selling home-cooked foods
- Invest in commercial food kitchens run in partnership with local community organizations to meet community food needs
- Develop healthy food distribution systems to make available and incentivize the purchase of healthy foods in local stores
- Support food local food systems that do not involve the use of chemical pesticides

Coalition Structure Proved to be Effective for Supporting Ongoing Trust and Collaboration

The structure of the OCAC has helped it endure past its initial efforts to influence the ECAP and support the Pacific Institute's assessment. This structure ensures that all groups' ideas were heard, that it reached consensus recommendations, and that it built a foundation for future work.

The basic structure of the OCAC consists of four subcommittees on the topics of Adaptation and Resilience, Food Justice, Transportation and Land Use, and Renewable Energy (Gordon, 2015; OCAC, Undated). Each of the roughly 30 member organizations participates in one or more of the subcommittees that aligns with their organization's primary goals or interests. During the development of the ECAP, these subcommittees met frequently to develop specific recommendations for the plan; all decisions are reached by consensus (Garzón, 2015; Schwind, 2015). The OCAC also has a steering committee comprised of two representatives of each of the subcommittees (Schwind, 2015). For the ECAP efforts, this steering committee worked to review the recommendations from each of the subgroups, identify key priorities, and address any overlap between subcommittee recommendations. Finally, the OCAC holds quarterly general membership meetings in which all subcommittees and member organizations participate (Garzón, 2015).

Early on, the OCAC developed a formal set of procedures to guide what types of entities could join the coalition, the responsibilities of member organizations, and how decisions would be made (OCAC, Undated). For example, member organizations must be non-profits, represent faith-based congregations, or represent neighborhood associations (Gordon, 2015).

EXAMPLES OF OCAC ENGAGEMENT ACTIVITIES

- Steering committee
- Sub-committees: Adaptation and Resilience, Food Justice, Transportation and Land Use, Renewable Energy
- General member meetings
- Attendance at city hearings
- Community workshops to gather community member feedback
- Workshops to share information or expertise
- Rallies
- Information booths at community events

Sources: Cooley, 2015; Fitzgerald 2015; Garzón 2015; Gordon, 2015; Schwind, 2015.

OCAC members also commit to attending a certain number of meetings and to devoting a certain amount of time to coalition activities (see the text box). During the development of the ECAP, the OCAC hosted several workshops to gather public recommendations for the plan (Garzón, 2015). The coalition also educates community members on climate impacts, such as extreme heat and flooding. The OCAC holds workshops on these topics and also offers pocket guides with appropriate actions for specific situations. In January 2014, the coalition held a workshop to share the needs of vulnerable community members with emergency responders and to educate vulnerable community members on what to do in emergency situations (Garzón, 2015). The OCAC considers many of these coalition activities to be climate change adaptation actions, which help build community members' ability to prepare and respond to climate impacts. Finally, the OCAC encourages its member organizations to attend city hearings on relevant topics, such as the public hearings that were held to develop the ECAP (Garzón, 2015).Overall, the structure of the OCAC and the participation of member groups have helped the coalition build trust among members and endure through time.

One drawback to OCAC's approach is that member organizations must balance their primary organizational goals (e.g., social justice, housing) with their involvement with the OCAC. Because of this challenge, OCAC members have changed over the course of the coalition's existence, and individual partners' engagement has waxed and waned as their organization's needs fluctuate.

OCAC Efforts Successfully Influenced the ECAP

The OCAC influenced the final ECAP in two ways. First, OCAC participation changed the level of community engagement associated with the plan. Second, the OCAC helped guide much of the plan's content.

Regarding the first point, initial public engagement plans for the ECAP included an expert panel and public hearings at City Hall (Schwind, 2015; Fitzgerald, 2015). Garrett Fitzgerald, the city's sustainability program manager, who led the ECAP process, shared that "the city had initially planned to use a pretty standard public input process to gather input for the ECAP, primarily involving public meetings at City Hall and an online comment period. We didn't allocate capacity to host public workshops or attend meetings of other organizations throughout the city" (Fitzgerald, 2015). However, Kirsten Schwind at Bay Localize, said "The OCAC organized politically to the point where the city couldn't ignore it" (Schwind, 2015). Fitzgerald was willing to change course and work more closely with the OCAC to garner public input; this included attending OCAC meetings on his own time (Schwind, 2015). Fitzgerald said, "The process was transformative. Initially, we had intended to draft the ECAP, gather some input, and make some edits. City staff soon discovered that these community organizations had a lot of good ideas for local action and the capacity to help make the process and resulting plan much smarter and stronger" (Fitzgerald, 2015).

The content of Oakland's final ECAP includes many contributions from the OCAC. Several of the people involved estimate that nearly half of the actions in the final document came from the OCAC (Fitzgerald, 2015; Garzón, 2015). Daniel Hamilton, who became Oakland's Sustainability Program Manager in 2014, noted that the public engagement with the OCAC helped to develop a unique plan. He said that OCAC partners "were directly responsible for several of the focus areas, including urban food systems and community cohesion…Many of the policies and actions were specific to, and in some cases written by, members of the OCAC" (Hamilton, 2015). Additionally, Hamilton noted that the ECAP was unique because many of the actions within the ECAP were not intended to be led by the city. Hamilton said, "Many of these [actions] were crafted specifically by folks like the OCAC with the idea that the OCAC would maintain ownership of them. Even though this is a city policy document, a lot of these things we institutionalize in our greenhouse gas reduction strategy were things led by the community, things that had nothing to do with the city. I think that is unique. Cities are used to only putting in policies that they are accountable for, that they're going to report on. Essentially they're telling themselves what to do and sometimes getting community input about how they should do it. In this case, Oakland went about saying 'no, this document is, in part, about city strategy, but this is more about a formulation of a city goal and we acknowledge that aspects of that are rightfully led by the community, not by the city, and we're not going to exclude these parts simply because we are not in charge of them.'" Being listed in the ECAP as an implementing organization was one way in which the OCAC and its members groups will continue to be engaged in climate change action moving forward.

The city felt that it used a transparent process to score and identify priority climate change mitigation actions. This process was designed to maximize positive outcomes for the community and produce measurable results given limited resources. The city feels this prioritization helped it to make significant strides on climate change mitigation quickly, with existing resources.

However, many of the OCAC's recommendations do not appear in the final ECAP (Garzón, 2015; Gordon, 2015; Beveridge, 2015). For example, the final document does not have a robust adaptation section; but several OCAC members would have liked a more detailed adaptation discussion. The city made a conscious decision to focus on climate change mitigation. The city felt that climate change adaptation is only necessary because of greenhouse gas emissions. Therefore, climate change mitigation must come before adaptation. Ultimately, the members understood that the ECAP was a climate change mitigation plan, and that adaptation would come later (Garzón, 2015). Garzón stated that "Adaptation was seen as outside the scope" (Garzón, 2015).

Additionally, some coalition members felt that the city did not go far enough to address some of the OCAC's

concerns with the final plan. Brian Beveridge of WOEIP said, "the city took our recommendations and did what they wanted. The city wrote the policy based on their interests within our recommendations. The parts that they didn't find interesting like adaptation and neighborhood resilience got one paragraph and no implementation ideas. The parts that would save the city money, they embraced those. They also prioritized them in their own way. They said 'here are the things that are free and easy, and those we'll work on first. Here are the things that will take some resources, so that's going to be our five year plan. Here's the stuff that's really innovative, but would cost money; that will be our 20 year plan.' It was an opportunity for the OCAC to advocate strongly for a very innovate set of initiatives to address greenhouse gas reduction and climate, but for some of us it fell pretty far short of a true peer relationship in which we were treated as equals with city staff" (Beveridge, 2015).

WOEIP felt that this disregard for some of the priorities identified through the OCAC reflect long-standing tensions and mistrust between Oakland residents and government. Margaret Gordon thought four key items that were missing from the final ECAP (1) language about protecting people, (2) identifying social vulnerabilities, (3) a plan for infrastructure, and 4) funding to invest in those three items (Gordon, 2015). Additionally, she noted that the plan did not result in a standing structure for engagement on these issues, because of a lack of funding and staff. Still, she said that the city sustainability staff were more interested and sensitive to these concerns than staff in other city departments (Gordon, 2015).

Through the OCAC's work on the ECAP, the coalition was able to influence a number of the plan's priorities, include itself and member groups within the plan, and raise the profile of adaptation in the plan. The effectiveness of the coalition on these fronts has helped it establish itself as a vital actor in the community and will help it continue to influence climate change mitigation and adaption efforts in Oakland.

Accomplishments

The creation of the OCAC and its work resulted in three major accomplishments:

1. Engaging community groups to implement adaptation actions and reduce vulnerability to climate change

   The OCAC, member groups, and the city have all begun to implement adaptation actions to reduce vulnerability to extreme heat, wildfires, coastal flooding from sea level rise, and poor air quality, as well as future food, water, and electricity prices. Many of these actions help to build community members' ability to prepare and respond to climate impacts, which coalition members believe will help reduce Oakland's vulnerability to climate impacts. However, most of the actions are in the early stages, and therefore have not begun to substantially reduce Oakland's vulnerability to climate change. Still, the OCAC serves as a platform to support climate change adaptation in Oakland.

2. The OCAC endures beyond the ECAP and is an integral part of climate change adaptation efforts in the city

   Even though the ECAP was published and began implementation in 2012, and the initial funding through the Ella Baker Center ended, the OCAC continues to operate and address climate change adaptation in Oakland, with the potential to reduce the community's vulnerability to climate change. Of note, the OCAC helped the city apply for the 100 Resilient Cities initiative which began work in Oakland in 2014 (Gordon, 2015). A representative from the coalition also sat on the committee to help select the city's new Chief Resiliency Officer, the local project leader for 100 Resilient Cities (Garzón, 2015). Additionally, the OCAC itself earned a grant from The Kresge Foundation's Climate Resilience and Urban Opportunity Initiative. Current funding is for climate change adaptation planning, but the OCAC has the potential to qualify for implementation funding as a second phase of the project.

3. Creating a new model for community engagement in Oakland on climate issues

   The OCAC's work to influence the Oakland's ECAP was a novel approach. It involved 30 separate community groups and developed a process to reach internal consensus and then work with the city to develop a plan that reflected community considerations. This approach represents a model for future work in Oakland, and possibly in other communities. Oakland's multitude of engaged community groups and its defined structure helped to make this approach effective.

Moving Forward

Oakland has momentum to take on climate change adaptation. The OCAC, its member groups, and the city have already made significant progress. In addition to that ongoing progress, Oakland has other promising efforts underway.

The Kresge Foundation's Climate Resilience and Urban Opportunity Initiative and the Rockefeller Foundation's 100 Resilient Cities Initiative offer strong opportunities to plan and implement climate change adaptation actions. The Kresge Foundation's Climate Resilience and Urban Opportunity Initiative aims to improve the climate change resiliency of low-income residents (The Kresge Foundation, 2014). The 100 Resilient Cities Initiative intends to build community resiliency around earthquakes, flooding, affordable housing, and social inequity (100 Resilient Cities, 2015).

Additionally, the city hired a new Sustainability Program Manager to help guide the implementation and update of the ECAP. This position had been vacant for roughly two years, impeding the progress of implementing and updating the ECAP in the city. Although the initial ECAP identifies adaptation as a future action, updating the plan presents an opportunity to reprioritize adaptation actions. City staff feel both climate change mitigation and adaptation are essential components of a comprehensive climate change strategy (Hamilton, 2015).

At the same time, a number of challenges exist. With regard to the Kresge and Rockefeller Foundation and initiatives, members of the OCAC are struggling to build bridges across the two efforts. These struggles stem from the different structures of the programs: the Kresge Foundation work has a bottom-up structure, while the 100 Resilient Cities work is being directed by the city. The groups are finding it difficult to align the two processes and make in-roads on potentially parallel efforts. Within each individual effort there are additional challenges. For example, the Kresge Foundation project funded the OCAC; with so many members in the coalition, the funding does not adequately cover the time and costs for members' participation. This closely mirrors the ongoing struggle for coalition members to balance their staff's everyday work with OCAC commitments.

Some long-standing systemic problems exist between the community and the city. The city needs sufficient funding to develop plans, fund staff, and invest in adaptation. City staff struggle to address climate change adaptation along with their regular responsibilities, particularly in departments that are not highly involved in climate change discussions. In addition, the city views climate change mitigation as a higher priority than adaptation (Hamilton, 2015), a point with which the OCAC disagrees. Finally, a long-standing legacy of cooperation between the city and community members does not exist. Community members often feel that the city does not have effective feedback mechanisms to hear community member input and that the city does not put community member or community group input on a level playing field with city priorities. However, new city council members and a new mayor are working to improve the city's outreach and engagement with citizens. Additionally, the city's collaboration with the OCAC and new initiatives such as the Oakland Sustainable Neighborhood Initiative are laying the ground work for further positive collaboration.

In summary, the OCAC has been a largely successful and innovative means of engaging community-based organizations to launch their own climate change adaptation planning and implantation efforts, in addition to bringing input into City of Oakland efforts to address

climate change. The OCAC may serve as a model for other communities and community-based organizations that seek to improve grass-roots involvement in city-led climate change initiatives.

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- **Margaret Gordon,** co-director, WOEIP
- **Daniel Hamilton,** sustainability program manager, City of Oakland
- **Kirsten Schwind,** co-founder and senior strategist, Bay Localize.

Bibliography

100 Resilient Cities. 2015. Oakland's Resilience Challenge. Available: http://www.100resilientcities.org/cities/entry/oaklands-resilience-challenge#/-_/. Accessed July 28. 2015.

Beveridge, B. 2015. Interview with Brian Beveridge, West Oakland Environmental Indicators Project. July 23.

City of Oakland. 2012. Energy and Climate Action Plan. December 4. Available: http://www2.oaklandnet.com/oakca1/groups/pwa/documents/report/oak039056.pdf. Accessed July 24, 2015.

Cooley, H. 2015. Interview with Heather Cooley, Pacific Institute. July 16.

Ella Baker Center. Undated. Green-Collar Jobs Campaign Basics. Ella Baker Center for Human Rights, Oakland, CA. Available: http://ellabakercenter.org/green-collar-jobs/green-collar-jobs-campaign-basics. Accessed July 28. 2015.

Fitzgerald, G. 2015. Interview with Garrett Fitzgerald, Urban Sustainability Directors Network. June 10.

Garzón, C. 2015. Interview with Catalina Garzón, Community Research and Education in Action for True Empowerment. June 25.

Garzón, C., H. Cooley, M. Heberger, E. Moore, L. Allen, E. Matalon, A. Doty, and the Oakland Climate Action Coalition. 2012. Community-Based Climate Adaptation Planning: Case Study of Oakland, California. Pacific Institute. California Energy Commission Publication number: CEC-500-2012-038. Available: http://pacinst.org/wp-content/uploads/sites/21/2014/04/community-based-climate-planning-Oakland.pdf. Accessed July 24, 2015.

Gleick, P.H. and E.P. Maurer. 1990. Assessing the Costs of Adapting to Sea-Level Rise: A Case Study of San Francisco Bay. Pacific Institute, Oakland, California.

Gordon, M. 2015. Interview with Margaret Gordon, West Oakland Environmental Indicators Project. July 23.

Hamilton, D. 2015. Interview with Daniel Hamilton, City of Oakland. July 23.

Heberger, M., H. Cooley, P. Herrera, P.H. Gleick, and E. Moore. 2009. The Impacts of Sea-Level Rise on the California Coast. California Energy Commission. May. CEC-500-2009-024-F. Available: http://pacinst.org/wp-content/uploads/sites/21/2014/04/sea-level-rise.pdf. Accessed July 28, 2015.

OCAC. 2012. How can Oakland Improve Energy Efficiency? Oakland Climate Action Coalition.

OCAC. 2014. Oakland Community Action Coalition Guide. Oakland Climate Action Coalition.

OCAC. 2015. How will Illegal Dumping Impact Oakland? Oakland Climate Action Coalition.

OCAC. Undated. Oakland Climate Action Coalition. Available: http://oaklandclimateaction.org/. Accessed July 29 2015.

Schwind, K. 2015. Interview with Kirsten Schwind, Bay Localize. July 20.

The Kresge Foundation. 2014. $1.7M in Grants Support Climate-Resilience Efforts Focused on Low-Income Communities. November 20. Available: http://kresge.org/news/17m-grants-support-climate-resilience-efforts-focused-low-income-communities#sthash.7xlcOg5M.dpuf. Accessed July 28. 2015.

WOEIP. 2011. Air Quality. West Oakland Environmental Indicators Project. Available: http://www.woeip.org/air-quality/. Accessed July 28. 2015.

Seattle, Washington

Mainstreaming Climate Change into Internal Planning and Decision-Making

SEATTLE, WASHINGTON

AUTHORS: Missy Stults, Karen Carney, and Jason Vogel

In this case study, you will learn about:

- How SPU is integrating climate change into operational, planning, capital improvement, and strategic decision-making
- Strategies for engaging with academic institutions to build capacity and knowledge
- Developing learning, adaptive information networks to ensure decisions are based on the most up-to-date information
- Leveraging previous extreme events to prepare for future changes in weather and climate

Case Study Summary

Seattle Public Utilities (SPU) serves "652,000 Seattle residential and 64,000 business customers with drinking water, sewer, drainage, garbage, and recycling… and suppl[ies] over 700,000 customers in other Puget Sound area cities with drinking water" (SPU, 2014, p. 6). The utility "has two mountain watersheds, 193 miles of drinking water transmission pipelines, 1,680 miles of distribution mains, and 400 million gallons of transmissions and distribution reservoir storage…[along with] 448 miles of regular sanitary sewers and a combined sewer system [mostly in the City of Seattle]…and two garbage and recycling transfer stations" that process 6,100 tons of garbage weekly (SPU, 2014, p. 6). As the region's main provider of drinking water, drainage, and waste disposal, SPU is vulnerable to fluctuations in weather.

Throughout the 1990s and the 2000s, a series of extreme rainfall events and droughts affected SPU's operations, including the utility's water supply and drainage operations. These events, combined with growing scientific evidence about climate change, led SPU to begin studying how climate change could affect the organization's mission and daily operations. Over time, this work evolved into the formal integration of climate considerations into the four levels of SPU's internal planning and operations: (1) organization-wide strategic planning, (2) planning at the water division and drainage and sewer-division levels, (3) capital investment decision-making, and (4) day-to-day operational decision-making.

Today, SPU has developed a system where dozens of ordinary, day-to-day decision-making processes are required to consider climate change and/or climate variability. Interviewees note that SPU's work has helped to reduce vulnerability by integrating climate into organization and division-level planning, and by increasing the capacity of staff to understand and respond to climate variability and change. Despite SPU's extensive work to modify internal planning, few projects have been modified based on projected changes in climate. Paul Fleming, the lead of the Climate Resiliency Group at SPU, points out that "some projects may not need to be modified as changes in climate may not impact them or alternatively, plans could be made to make changes in the future, as the impacts of climate change become more evident" (Fleming, 2015). Regardless of how changes in projects manifest, more work is needed to understand whether and how SPU's approach will help make its operations and the populations it serves less vulnerable to extreme weather and climate change over the long-term.

The Broader Context for Mainstreaming Climate Change throughout SPU's Internal Planning and Decision-Making

Water management in the Pacific Northwest is a complex issue and, with a changing climate, "water resource managers and planners will encounter new risks, vulnerabilities, and opportunities that may not be properly managed within existing practices" (Mellilo et al., 2014). Fortunately, a number of utilities are investing in methodologies to plan for a climate-altered future. One such utility, SPU, has become a national leader in ensuring that it is able to meet current and future water-related demands of its customers.

Late in the 20th century, SPU began to realize that its methods for managing water supply were being challenged by extreme climate variability. This was most evident between the mid-1980s and mid-1990s when SPU experienced a major drought (in 1987), heavy precipitation and flooding throughout the watershed (in 1990, 1995, and 1996), and low snowpack (in 1992), all resulting in either too much water or too little. In light of these extremes, SPU embarked on an effort to more fully understand climate variability within the watershed and plan for potential changes (Exhibit 1).

Today, SPU undertakes a variety of activities to reduce its vulnerability to changes in climate, some of which preceded the emergence of climate change as an issue of concern or which have non-climate factors as the primary driver. The utility invested in green infrastructure to manage water quality, and is now exploring it as a way to manage flooding by expanding the capacity of the piped storm water system. SPU has an extensive water

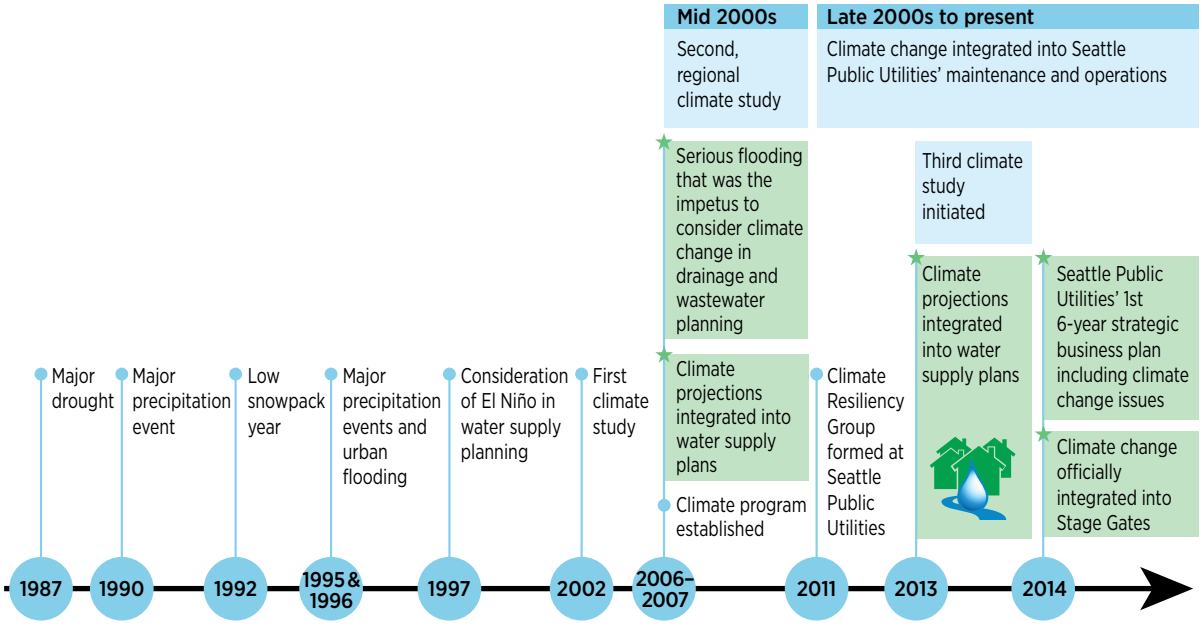

Exhibit 1. Timeline of mainstreaming climate change into internal planning and decision-making at SPU.

conservation and reuse program, works with homeowners and private developers to manage stormwater where it falls, executes an extensive water education program, and works to maintain and improve land quality throughout its watershed. SPU is also a founding member of the Water Utility Climate Alliance, a consortium of some of the nation's largest water utilities focused on "providing leadership and collaboration on climate change issues affecting the country's water agencies" (Water Utilities Climate Alliance, 2015).

More recently, SPU has undertaken a series of initiatives to ensure that climate change is factored into all levels of utility planning and decision-making. This work includes innovative modeling, the creation of climate-related screening tools, and one-on-one engagement with SPU employees about climate-related issues. This case profiles some of this work at SPU, highlighting strategies and techniques being used by the utility to ensure that climate change is factored into all levels of organizational operations and decision-making.

Why and How SPU Mainstreamed Climate Change into Internal Planning and Decision-Making

Increasing Intensity and Frequency of Extreme Events Raises Staff Awareness about Climate Variability

In the later portion of the 20th century, a series of extreme weather events began raising concern regarding the long-term sustainability of the city's water supply. A major drought, potentially the worst on record according to Joan Kersnar, drinking water planning manager for SPU, struck the region in 1987. This led the Seattle Water Department (which merged with the Seattle Engineering Department in 1997 to form SPU) to "start improving some of our sources; we also installed a pump plant to access more storage and drilled more wells" (Kersnar, 2015). Exacerbating the impacts of the drought, however, was the high water demand in the Seattle service area—"around 170+ million gallons per day, which is more

than what we estimate our firm yield [the maximum yield that could be delivered without failure during the second worst historical drought of record] to be" (Kersnar, 2015).

This drought was followed by a major precipitation event in November 1990, which led to significant flooding down the watershed (Kersnar, 2015). This, in turn, led SPU to explore additional options for managing water storage to prevent future extreme flooding scenarios. In 1992, the region experienced a low snowpack year, but because the utility was "operating for flood management, meaning we were releasing water in order to keep reservoir levels low enough to capture any extreme rainfall that could fall in the region, we were in a situation where we had less supply than planned" (Kersnar, 2015). When the snowfall turned out to be low and significant rains did not materialize, the utility was forced to mandate water-use curtailments the following summer (Kersnar, 2015). In both 1995 and 1996, the region was again affected by two heavy precipitation events, leading to significant flooding in major rivers and communities downstream.

> **"After a few major extreme weather events, we started to look down the road and ask how often these events were going to happen in the future and what this could mean for our water supply."**
>
> JAMES RUFO-HILL

In 1997, the conversation about the viability of the city's water supply became more sophisticated due in part to projections of a strong El Niño for the 1997–1998 time period. Staff in the water supply division of SPU were curious to know what El Niño conditions meant for Seattle's water supply and began working with researchers at the University of Washington (UW) to identify potential impacts and strategies to mitigate them (Chinn, 2015). One technique used to understand potential impacts was an analysis of the city's records to identify water supply availability during previous El Niño-like years. These results showed that, in general, El Niño years, especially strong El Niño years, are likely to cause warmer temperatures in the winter, leading to more precipitation falling in the mountain watersheds as rain as opposed to snow (Chinn, 2015). Having this information "put staff in a position where we could understand and communicate to our city council and other stakeholders just what it [El Niño] could mean in terms of a risk to our water supply" (Chinn, 2015). This information also enabled staff to prepare a proactive plan with various steps outlining what could be done during the transition from fall to winter if snowpack was expected to be low, to ensure the adequate supply of water during the following year (Kersnar, 2015). The information gleaned from UW, combined with knowledge obtained through SPU's analysis of historical El Niño years, laid the foundation for a deeper understanding of how climate variability has historically affected and could continue to affect the city's water supply and flood management objectives in the future.

Partnerships Form to Understand Climate Impacts Specific to SPU

SPU's first climate change study was driven by staff's appreciation that climate change was an issue that SPU needed to understand. This preceded public concern or engagement on the issue and illustrates the foresight of SPU staff. SPU continued to engage with researchers at UW to generate specific information about how climate change could impact water resources in the Seattle area. In addition, SPU began engaging with two other water utilities in the region, Everett and Tacoma, as well as stakeholders in King County, to determine the future of water supply throughout the entire area (Kersnar, 2015). In the mid-2000s, downscaled climatological data were generated for water utilities in Tacoma, Seattle, and Everett. The utilities ran this information through their own models in order to generate the 2009 Outlook, which provided a long-range view of what future water demand may be in the three-county region. "The downscaled meteorological data was also integrated into each utility's supply-side modeling to determine what water supply in the future could look like. This allowed us to identify what shortages might exist, especially under a future altered by climate change" (Kersnar, 2015).

> **"How do you think about climate change from a broad perspective? Part of my job is to try to make climate change part and parcel of what we do as an organization."**
>
> PAUL FLEMING

Climate Science and Impact Reports Illuminate Potential Risks

According to Joan Kersnar, drinking water planning manager and Alan Chinn, water resources engineer supervisor at SPU, it did not take long for these informal conversations on climate variability to grow into more formal discussions about long-term climate change (Chinn, 2015; Kersnar, 2015). Part of the reason for this transition was the emergence of an increasing body of literature about climate change, including reports like the Intergovernmental Panel on Climate Change's Assessments and the first Pacific Northwest Assessment on Climate Change, which identified projected changes in climate and high-level impacts that could affect the region.

The findings from these assessments were shared in local and regional media and led to more public awareness about climate change's potential impacts on water supply. This led some local politicians to raise "alarms with regards to our water supply system" (Rufo-Hill, 2015). According to Paul Fleming, Lead of the Climate Resiliency Group at SPU, "climate change became this point of pain for us... the concept had stirred up enough attention that it was creating turbulence for the organization" (Fleming, 2015). Notably, this "point of pain" came after SPU had initiated and largely completed their first local climate change study.

SPU Creates Climate Resiliency Group to Integrate Climate Change into Internal Planning and Decision-Making

Through this work, it became apparent that climate change was likely to impact SPU's operations in modest ways over the short-term and potentially in more significant ways in the future (Hoffman, 2015). To build the capacity of the utility to respond, SPU management created an internal Climate Resiliency Group. This group was formalized in the late-2000s and tasked with helping SPU understand its exposure and sensitivity to climate change and to build up SPU's capacity to adapt (achieving carbon neutrality was added in 2014; Fleming, 2015). Two full-time staff currently make up the Climate Resiliency Group: Paul Fleming and James Rufo-Hill.

According to Paul Fleming, one of the main foci for the Climate Resiliency Group is figuring out how to embed climate change into all relevant decision-making processes and planning efforts (Fleming, 2015). This has led to a goal of "mainstreaming climate change into what we do at SPU" (Rufo-Hill, 2015). Initially, this work focused on planning within the water division, since this division had a long track record of thinking about how climate variability and change could affect the city's water supply. Eventually, the Climate Resiliency Group took the lead in working with other staff to figure out how to integrate climate considerations into: (1) organization-wide strategic planning, (2) planning at

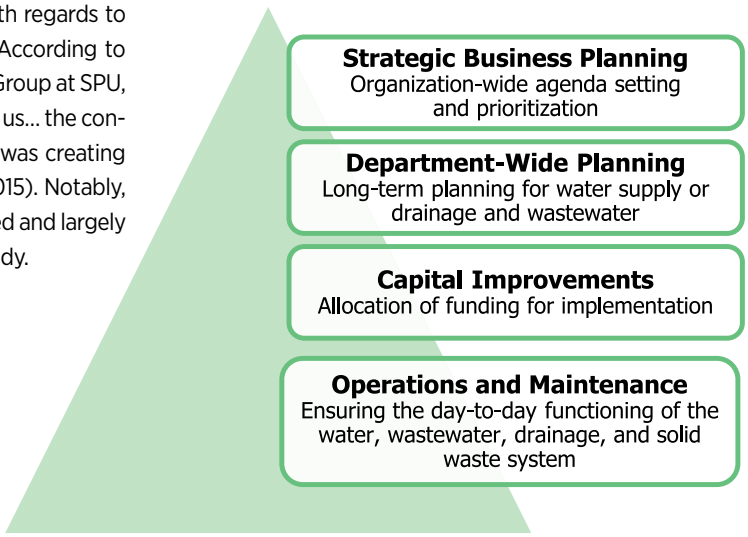

Exhibit 2. Model of mainstreaming climate change into all scales of decision-making at SPU.

the water division and drainage and sewer division levels, (3) capital investment decision-making, and (4) day-to-day operational decision-making. According to Paul Fleming, SPU is trying to "embed what we are learning about climate change in what we do, wherever it makes sense" (Exhibit 2; Fleming, 2015).

Climate Change Integrated into SPU Strategic Business Plan

SPU is a complex organization with responsibility for water supply, drainage, wastewater management, and solid waste services for the Seattle metropolitan area. In 2014, SPU created its first six-year strategic business plan, which is used to allocate funding and describes how the organization will ensure the delivery of high-quality services, while also protecting human health and the environment. The impetus to create the plan stemmed from Seattle City Council members, who were impressed by Seattle City Light's strategic planning efforts and wanted SPU to emulate the practice.

To complete the plan, SPU engaged a Mayoral and Seattle City Council-appointed customer panel composed of nine individuals from industry, retail, and environmental organizations; small and large commercial organizations; and low-income communities. The panel met for 3 hours twice monthly over 18 months, and were tasked with conducting outreach to other customer segments to identify what SPU customers generally wanted the utility to focus on in the coming years. In addition, the utility held a series of internal meetings and conducted a survey that asked SPU employees to identify strengths, weaknesses, opportunities, and threats (SWOT) for SPU over the coming decade. The point of this SWOT analysis, according to Ray Hoffman, was to "identify our deficiencies, gaps, and opportunities for growth. We know we aren't as efficient as we'd like to be, we aren't doing all the best practices in the field and there are strategic opportunities to do better" (Hoffman, 2015).

During the 18-month process of creating the plan, "climate change came up multiple times through multiple different ideas and priorities" (Hoffman, 2015), and thus it was explicitly integrated in the plan's first focal area: "Better protecting your health and our environment." Specifically, the SPU Business Plan calls for SPU to "prepare for water supply and utility system threats that may occur from climate change" by "increas[ing] reliability of drinking water supply through system improvements" (SPU, 2014, p. 13). The plan also aims to ensure that "utility systems… are climate resilient and environmentally friendly." Toward that end, the plan specifies that SPU will manage "700 million gallons of runoff annually with green stormwater infrastructure by 2025" (SPU, 2014, p. 23).

The fact that funding is directly tied to the priorities identified in SPU's Strategic Business Plan means that the inclusion of issues such as climate change will continue to affect how SPU does business. "[The plan] has real weight, it's a living document because our rates are tied to it and we are being held accountable to it" (Fleming, 2015). Ray Hoffman, Director at SPU, notes that the strategies identified in the plan "are things we, as a utility, with input from our customers, identified as being a priority and those are the things we are now accountable to moving forward, including preparing for climate change" (Hoffman, 2015).

Opposition to the Strategic Business Plan and, more specifically, the strategies included in the plan, did exist. According to Ray Hoffman, two types of opponents emerged: those who thought SPU was doing too little and those who thought SPU was doing too much (Hoffman, 2015). For the former, SPU used monetary justifications to make the case for why certain actions were included and others, while important, could not be

prioritized at this time. "We let our stakeholders know that this is how much money we have to spend: period. This has to cover both existing operations and infrastructure improvements as well as anything new" (Hoffman, 2015). For opponents who thought SPU was doing too much, the conversation centered on the importance of ensuring the long-term viability of its services, especially water delivery, in the face of an uncertain future. The Strategic Business Plan was officially approved by the mayor and the Seattle City Council in the summer of 2014, and SPU is currently working to implement the specific climate-related actions identified in the plan.

Climate Change Integrated into Division-Level Planning

SPU is composed of three lines of business: (1) water, (2) drainage and wastewater, and (3) solid waste services. Each of these divisions is responsible for both day-to-day operations as well as creating long-term plans of operation. Water Supply and Drainage and Wastewater are the two lines of business most directly tied to SPU's adaptation efforts. The following sections describe how each of these divisions is working to integrate climate change into their long-term planning.

> **"As appropriate, decisions, plans, and investments are hopefully considered in light of exposure and sensitivity to climate change, and adjusted, as appropriate, given that consideration."**
>
> PAUL FLEMING

Climate Change Integrated into Water Supply Plan

The State of Washington requires water utilities to create water supply plans every 6 years and mandates that these plans outline key priorities and actions for the next 20 years (Kersnar, 2015). The intent of these plans is to devise a strategy for how best to meet future water supply needs. While the inclusion of climate projections in these plans is not required, SPU integrated projections to understand future water supply in both its 2007 and 2013 plans (Kersnar, 2015). This move largely stemmed from the growing quantity of climate-related information emerging from UW and other research hubs as well as growing public concern about climate change impacts to the city's water supply (see previous sections).

One way that climate change is embedded into SPU's water supply plan is through the use of climate ensembles. Rather than depend on a single climate model or greenhouse gas emissions scenario, ensembles integrate information across a range of models and scenarios, which better brackets the range of potential climate impacts. More specifically, the water division has been using climate ensembles to analyze potential future climatic conditions and model how those climate conditions could impact the utility's water supply. The 2007 and 2013 water system plans each used three to four scenarios that were developed through a partnership with UW (Hoffman, 2015). Today, the Climate Resiliency Group worked with the water division and climate scientists at the Climate Impacts Research Consortium [a climate research center for the Pacific Northwest supported by the National Oceanic and Atmospheric Administration (NOAA)] to create a broader set of 40 scenarios that have been downscaled to several point locations in SPU's watersheds. The results from the downscaled models have been and are being fed into SPU's internal models (e.g., its hydrology model and utility system model), so that the utility can assess how supply could be affected under the different scenarios. According to Paul Fleming, "this enables us to test our system under different plausible futures" (Fleming, 2015). This work is happening under the auspices of a project known as the Pilot Utility Modeling Application (PUMA) project.[9] PUMA focuses on getting the "next generation of climate data which can then be fed into our internal processes to update our understanding of climate-related impacts on supply" (Fleming, 2015). The results from PUMA will be integrated into the next update to SPU's water supply plan and used to update SPU's adaptation options.

9. More information about the PUMA project can be found at http://www.watersupplyforum.org/home/outlook/.

Two key stakeholders involved in the historical and current integration of climate change into water supply planning are Joan Kersnar and Alan Chinn (Fleming, 2015; Rufo-Hill, 2015). According to Paul Fleming, these two individuals have long been driving an organization-wide transition to become a learning, adaptive utility that is capable of integrating the best emerging science into planning and decision-making (Fleming, 2015). While no specific individuals were identified as opponents to the integration of climate change into water supply planning, Joan Kersnar and Alan Chinn commented that it is a constant battle to get people comfortable with the inherent uncertainty associated with climate modeling and not using that uncertainty as a justification for inaction (Chinn, 2015; Kersnar, 2015). As discussed in the Moving Forward section later in this document, dealing with uncertainty remains a common challenge across SPU.

Climate Change Integrated into Drainage and Sewer Division's Long-Term Control Plan

The integration of climate change into drainage and wastewater planning is more nascent than it is for water supply planning. According to Dave Jacobs, System Operations Planning & Analysis Manager at SPU, "We only recently really got involved in the climate change conversation in order to understand the impact of climate change on urban flooding. This really stemmed from some serious flooding events we had in 2006 and 2007. Prior to that, we didn't fully understand the extent of the urban flooding issues" (Jacobs, 2015). Dave Jacobs noted that several factors contributed to this transition: (1) increased data availability regarding current and historical operations, (2) more frequent extreme weather events, and (3) increased awareness concerns from residents about localized flooding (Jacobs, 2015).

Today, the drainage and wastewater line of business is working to integrate climate concerns into their updated Long-Term Control Plan, which examines how best to maintain and upgrade SPU's infrastructure and operations, specifically as it pertains to combined sewer overflows. Climate change is being integrated into the plan through a number of venues, most notably the decision to apply "a scaling factor on our historical rainfall estimates to account for future climate change" (Jacobs, 2015). Part of the challenge for SPU is that it is not clear how the region's precipitation will change. Overall, annual precipitation is likely to remain the same, but how and when the rain falls is less certain (Fleming, 2015). The region may experience more intense, shorter-duration storms or storms of longer duration may be more common (Melillo et al., 2014). Dave Jacobs notes, "One of the things we try to do is look at both options [intense short-duration events and long-duration storms] to see how our system would respond. We add a 6 percent increase to our historical rainfall records when we do our long-term model simulations of our system. The rainfall scaling allows us to see how this increase could impact the system in both high-volume scenarios as well as peak intensity scenarios" (Jacobs, 2015).

> **"The projects identified in the Long-Term Control Plan that we are preparing to implement have actually changed because of our increased knowledge of projected climate impacts."**
>
> DAVE JACOBS

The results from the climate change modeling have been incorporated into the Long-Term Control Plan and show two key areas of concern for SPU: (1) that high-volume, longer duration storms tend to be at the end of the wastewater conveyance line and thus more green infrastructure may be needed to cope with water-quality issues in these areas; and (2) short-duration storms tend to hit neighborhoods in the urban core where there are smaller pipes for conveyance, suggesting that onsite natural drainage may need to be increased. These findings have directly affected the types of strategies that SPU is recommending for implementation in its Long-Term Control Plan (Jacobs, 2015).

Dave Jacobs notes that SPU's efforts to embed climate change into Capital Improvement Projects have been a

long time in the works and it still remains unclear how this work will materialize into changes in on-the-ground projects. Clear opposition to this work has not emerged, but internal hurdles and the legacy of doing things a "certain way" present challenges to SPU's work in this area (Jacobs, 2015). In particular, the uncertainty associated with climate change presents a challenge to figuring out how to design systems. This uncertainty, combined with "pressure to get projects through, can lead to a common situation where teams want singular direction on what they are required to account for in planning and design phases of projects" (Jacobs, 2015). To help staff overcome this hurdle, Dave Jacobs and his colleagues in the Climate Resiliency Group are helping staff in the drainage and wastewater divisions (as well as staff in the water division) navigate future uncertainty by identifying projects that are economically viable over their full lifespan. The techniques used to engage with and educate staff are informal: face-to-face conversations and personal or small group trainings (Fleming, 2015).

Climate Change Integrated into Capital Improvement Programs and Investments

SPU spends nearly a billion dollars a year on operations and maintenance and in investments to improve its system. The majority of these investments are designed to provide a certain level of service for decades into the future. Given the long lifespan and large expense of infrastructure projects, the Climate Resiliency Group proposed to SPU management that the capital funding process be changed to mandate that all project proposers seeking funding demonstrate that they have considered how climate change could affect their proposed projects over their lifetimes (Fleming, 2015). This has been done through SPU's capital improvement program review process: Stage Gates.

Stage Gates is a five-step system that projects seeking funding must undergo in order to ensure they are designed appropriately and in alignment with SPU's core values, such as race and social justice and efficiency (Serwold, 2015). In 2014, SPU officially integrated climate change considerations into the first two gates, or review phases, of the process. Staff in the Climate Resiliency Group designed the questions with the assistance of consultants and with input from other utilities. All projects seeking funding through the Capital Improvements Program are required to answer the questions pertaining to climate change. According to Kim Serwold in the Office of Utility Services at SPU, what this means is that "Whenever a project is being proposed to address an issue of concern, project managers need to identify how climate change could affect the project: this is the first gate. Once a project concept clears the first gate, the second gate requires the evaluation of alternative options that could meet an identified need. Here, project managers are also required to identify how changes in future climate could affect the identified options" (Serwold, 2015).

Once project managers complete the requisite Stage Gate form, the responses are reviewed by a series of staff, including senior-level management, to ensure that projects are appropriately integrating climate considerations into their project designs. If a project were to be proposed and fail to integrate climate considerations that were of relevance, the project proposer would be asked to reevaluate the project proposal, factoring in climate change (Hoffman, 2015). If needed, staff in the Climate Resiliency Group are available to help the project proposer complete the Stage Gates questions (Rufo-Hill, 2015).

One project currently going through the Stage Gates process is a new pump station in the South Park neighborhood, a traditionally underserved, historically industrial, low-income area of the city adjacent to the Duwamish River and in proximity to Elliot Bay. The project was originally designed a few years ago, but recent analysis shows that the area around the pump station is subject to flooding. The reason for this is that the streets around this particular pump station do not have pipes, meaning that when significant rain falls or a King Tide (an extremely high tide) event occurs, the streets flood, leaving standing water for hours. Without pipes, this floodwater cannot be transported to the pump station or other facilities for treatment and discharge. Looking at the system as a whole, the project proposers realized that to address the localized flooding issue and safely remove water, pipes would need to be installed and the pump station and treatment facility would need

to be built (Harrison, 2015). Today the plan is to build the pump station two-feet higher to deal with sea level rise and include shutoff valves in case sea levels rise further. Then, a separate project will be submitted for the active conveyance and treatment of floodwater when it impacts the region.

> **"The main change has been that we're more rigorous in thinking about climate change and really integrating it into projects like our conveyance system. The inclusion of climate considerations into Stages Gates is focusing a deeper conversation around preparing for things like sea level rise."**
>
> SHEILA HARRISON

Opposition to integrating climate change into the Stage Gates process emerged around two issues: (1) the additional demand being placed on project managers, and (2) uncertainty about exactly what data and climate projections to use to complete the Stage Gates forms. In regards to the first point, staff already felt that the Stage Gates review process was cumbersome so adding a new requirement around climate change presented yet another hurdle to getting a project rapidly approved (Harrison, 2015). The second point of opposition focused on the lack of clarity around which climate change projections or future scenarios for precipitation and sea level rise to use in planning. According to Dave Jacobs, staff going through the Stage Gates process would often comment that, "If science doesn't know what's going to happen in the future, how do we know what we should be designing for?" (Jacobs, 2015). To date there is no plan to provide specific climate change projections for project managers to use. Instead, staff in the Climate Resiliency Group are trying to educate staff about robust decision-making so that project proposers are comfortable making educated decisions about which climate scenarios to use in their designs. Paul Fleming comments that, "much work in this area still needs to be done to ensure that staff across SPU are comfortable with making decisions in the face of uncertainty" (Fleming, 2015).

Climate Change Integrated into SPU's Operations

SPU is responsible for the operations and maintenance of 193 miles of drinking water transmission pipelines, 1,680 miles of distribution mains, 400 million gallons of transmission and distribution reservoir storage, and 448 miles of regular sanitary sewers and combined sewer systems (SPU, 2014). All day, every day, SPU must ensure that these systems are operating as designed in order to ensure that Seattle residents, as well as residents of the greater Puget Sound area, are receiving water and sewer services (Hoffman, 2015).

At the operations and maintenance level, weather and climate variability are major issues of concern. As such, the Climate Resiliency Group is tasked with translating climate and weather information into formats that can be integrated into day-to-day and week-by-week decision-making (Fleming, 2015). One way this happens is by "constantly scanning the forecasts to identify problems that might arise due to things such as flooding, both in urban areas and in the watersheds, or looking for high tides that could be problematic for our tidally influenced assets" (Rufo-Hill, 2015). In addition to this forward-looking component, the Climate Resiliency Group is also responsible for a forensic investigation of historical storms and impacts to help SPU understand what happened, why infrastructure failed, why a flood occurred, or more generally, what went wrong. This information is then fed back to operations staff so that lessons learned about thresholds and system sensitivity can be addressed immediately. In addition, this information is shared with staff working on long-term planning to ensure that systems which are already vulnerable are getting the attention they need and that solutions for systems likely to be vulnerable in the future are being identified in division-level planning.

> **"We try to keep people on track with what is happening today and get them to think about how they are going to respond in the future."**
>
> JAMES RUFO-HILL

Integrating climate change concerns into SPU's daily operations and maintenance is perhaps "the largest challenge we face in our efforts to mainstream climate change," notes James Rufo-Hill (Rufo-Hill, 2015). At the same time, SPU has focused on operational adjustments as the starting point when thinking about adaptation, with SPU's dynamic operational rule curve for its reservoirs as one example of how changing operations can serve as an adaptation strategy. The reason for this is that the timeframe for operations and maintenance is not "synced up with the time frame of climate change. Operations is the here and now, climate change is the future" (Fleming, 2015). To bridge this divide, James Rufo-Hill and Paul Fleming use weather and climate variability, particularly the extremes in both situations, to demonstrate what future operations for SPU might look like in a climate-altered world. As an example, James Rufo-Hill notes that "there was a period of time where there wasn't a water resources meeting where I wasn't talking about the 'blob'—an anomalous region of warm water in the Pacific that was fueling storms and keeping us warm…I talked about it both because it could impact our daily operational decisions but it also presented a way for me to couch climate change into our conversations…this blob could be a normal part of our future, meaning the way you are adjusting your operations now might be our new normal mode of operations in the future" (Rufo-Hill, 2015). Finding examples of changes in weather that could be demonstrative of a future altered by climate change is one way that SPU staff are trying to integrate climate change into the utility's operations and maintenance culture. However, Paul Fleming indicated that more work in this area is needed (Fleming, 2015).

Accomplishments of SPU's Efforts to Mainstream Climate Change into Internal Planning and Decision-Making

SPU is hoping that its efforts at integrating climate into multiple levels of planning and decision-making will make the utility's infrastructure, service delivery, and programs less vulnerable to climate variability and change. However, other than the work of the water division, SPU's efforts in this area are still nascent. As such, there are few projects that SPU can point to that have fundamentally changed because of the requirement to consider climate in its design or operations.

When asked if work to date has helped to reduce the vulnerability of SPU to climate change, James Rufo-Hill stated, "We are making progress in building the capacity of staff to respond to climate variability and change and I think that is a sign of vulnerability reduction" (Rufo-Hill, 2015). Paul Fleming comments, "I think our work on assessment and adaptive capacity enhancement is really essential. My hope is that when we have to make tough adaptation decisions, we've put in place the knowledge to help make sure those decisions are right" (Fleming, 2015). Ray Hoffman further commented that you "can see [SPU's] progress by looking at how successful we've been in integrating climate considerations into our organization-level and division-level planning. These efforts, if not yet, will very soon translate to projects on the ground that reduce SPU's vulnerability to climate change" (Hoffman, 2015).

> **"When I look at where we are at in relation to the industry, I'm really happy. That said, when I look at where we are in relation to where we could be, we have room for improvement, room to do more."**
>
> RAY HOFFMAN

In addition, multiple interviewees noted one of the greatest accomplishments of SPU's work to date is its transformation to being a data-driven, transparent organization (Chinn, 2015; Hoffman, 2015; Rufo-Hill, 2015). This is perhaps best displayed in SPU's desire to base its decisions on ever-improving scientific information, much of which is commissioned. This scientific foundation was noted as constantly evolving, flexible, and adaptive, meaning that as new information on climate change becomes available, it can readily be integrated into organizational tools and resources for daily and long-term decision-making. This readiness to integrate new information into planning and operational decision-making is due to SPU's larger efforts to integrate climate change into all levels of the organization. As Paul Fleming notes, SPU "has built, or is in the process of building, a culture where mainstreaming climate change into all levels of what we do is becoming the norm" (Fleming, 2015).

> **"We've become a learning organization—constantly taking new data, learning from it, from weather events or extreme events and trying to constantly prepare."**
>
> ALAN CHINN

A number of tangible activities demonstrate how SPU's work to mainstream consideration of climate change into operations has made a notable difference. For example, the Water Resources and Watershed Divisions at SPU have made significant investments in additional watershed snow, weather, and streamflow monitoring and data collection systems to ensure they understand, in real-time, how their water supply is changing. The utility has also made investments towards UW's high resolution weather forecasting system and other tools that are specific to SPU's operational needs while also using NOAA's family of services to understand how short-term changes in weather could affect daily operations. Additionally, SPU made investments to allow 3 more feet of reliable reservoir water storage behind Masonry Dam and has made significant investments in the Morse Lake Pump Plant project to ensure water supply reliability into the future (Chinn, 2015).

Despite these successes, James Rufo-Hill notes: "it's been hard to build up appropriate documentation to make sure we know how often projects are discussing climate change, which projects are effective once implemented, and how effective they are. It's been good on one hand to know the process is working as designed, but I have no sense for how well it's working or how seriously people are taking it" (Rufo-Hill, 2015). Paul Fleming shares this sentiment, noting that SPU's effort is conceptually strong, but it is "unclear if we are definitively protecting our investments" (Fleming, 2015). To remedy this, SPU is currently exploring options to evaluate the impact that embedding climate change considerations has had on projects and daily operations and maintenance (Rufo-Hill, 2015).

> **"Utilities are making decision on infrastructure that has a long life. The question on hand is are we really okay with the decisions we are making under various scenarios of what our future could hold? Are our decisions robust enough for multiple different futures?"**
>
> JOAN KERSNAR

Moving Forward

Going forward, SPU will focus on continuing to build momentum at all levels of the organization around climate preparedness (Fleming, 2015). This includes supporting and educating top-level executives and field staff about the need to make decisions that are robust

under current and future climates. To do this, staff in the Climate Resiliency Group will: (1) continue to hold weather and climate trainings, (2) continue to publish blog posts about weather and climate issues of relevance to the utility, and (3) conduct personal outreach to key stakeholders throughout SPU to build "more climate champions" (Fleming, 2015).

Another area of continued focus for SPU is helping staff effectively address the uncertainty associated with climate change projections. According to Alan Chinn, "there is real pressure to take the median or to take one of the scenarios we are using and base all decisions on that scenario" (Chinn, 2015). More specifically, many interviewees noted a tendency for people to want to know exactly what they should be planning for. In the case of Stage Gates (capital improvement funding), project managers want to know exactly what range of temperature, precipitation, or sea level rise you want them to plan for (Harrison, 2015). Since SPU is not currently planning on providing this level of specificity, staff in the Climate Resiliency Group are working on techniques to help other staff become more comfortable with uncertainly and be able to make their own informed decisions about which future climate projections to use in their planning. According to Paul Fleming, "the goal is to understand and embrace uncertainty so that you can make informed decisions that are robust under multiple potential futures" (Fleming, 2015).

An additional area of future emphasis for SPU is the creation of metrics to evaluate how successful the utility is in increasing resilience or reducing its vulnerability. According to James Rufo-Hill, SPU needs to improve its efforts to document and monitor the effectiveness of its operations, decision-making, and planning processes (Rufo-Hill, 2015). Without these metrics, SPU is unable to provide robust analyses that demonstrate whether and how its efforts have reduced the utility's vulnerability to climate change. Having clear benchmarks and metrics could provide important insights regarding how effective different approaches have been, as well as specifics regarding areas for future growth.

> **"Ultimately, we are trying to protect the community from future risks we are aware of."**
>
> DAVE JACOBS

Finally, when asked about challenges for SPU, Paul Fleming commented, "One of our challenges is that we tend to focus on a single project at a time. Of course, with issues such as sea level rise, you ultimately need to be thinking about a suite of projects in a given area. So if you are going to add a pump station in one area and you think about sea level rise and its impacts just to that station but fail to think about sea level rises' impact to the surrounding infrastructure, you are creating an isolated solution that won't be sustained" (Fleming, 2015). Transitioning from project-level planning to more holistic, system-level planning for climate change is a challenge, particularly when investment decisions are done on a project-by-project basis. This, however, is where comprehensive, system-wide planning comes in. For SPU, the work of the water division to integrate climate considerations into its system-wide water supply plan is one signal that SPU is transitioning to thinking more holistically about its systems and how climate change could affect their operations.

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- **Sheila Harrison,** project manager, SPU
- **Ray Hoffman,** director, SPU
- **Dave Jacobs,** system operations planning & analysis manager, SPU

- **Joan Kersnar,** drinking water planning manager, SPU
- **James Rufo-Hill,** climate adaptation specialist and operational meteorologist, SPU
- **Kim Serwold,** office of utility services, SPU.

Bibliography

Bierbaum, R.M., J.B. Smith, A. Lee, M. Blair, L. Carter, S. Chapin III, P. Fleming, S. Ruffo, M. Stults, S. McNeeley, E. Wasley, and L. Verduzco. 2013. A comprehensive review of climate adaptation in the United States: More than before, but less than needed. Journal of Mitigation and Adaptation Strategies for Global Change 18(3):361–406. doi: 10.1007/s11027-012-9423-1.

Chinn, A. 2015. Interview with Alan Chinn, Water Resources Engineer Supervisor at Seattle Public Utilities. February 5.

Dictionary.com. 2015. Mainstream. Dictionary.com, LLC. Available: http://dictionary.reference.com/browse/mainstream. Accessed February 28, 2015.

Faulds, P. 2015. Interview with Paul Faulds, Water Resources Manager, Seattle Public Utilities. February 5.

Fleming, P. 2015. Interview with Paul Fleming, Lead, Climate Resiliency Group, Seattle Public Utilities. February 5.

Harrison, S. 2015. Interview with Sheila Harrison, Project Manager, Seattle Public Utilities. February 6.

Hoffman, R. 2015. Interview with Ray Hoffman, Director, Seattle Public Utilities. February 6.

Jacobs, D. 2015. Interview with Dave Jacobs, System Operations Planning & Analysis Manager, Seattle Public Utilities. February 5.

Kersnar, J. 2015. Interview with Joan Kersnar, Drinking Water Planning Manager at Seattle Public Utilities. February 5.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. Climate Change Impacts in the United States: The Third National Climate Assessment. U.S. Global Change Research Program. doi: 10.7930/J0Z31WJ2.

Rufo-Hill, J. 2015. Interview with James Rufo-Hill, Climate Adaptation Specialist and Operational Meteorologist, Seattle Public Utilities. February 5.

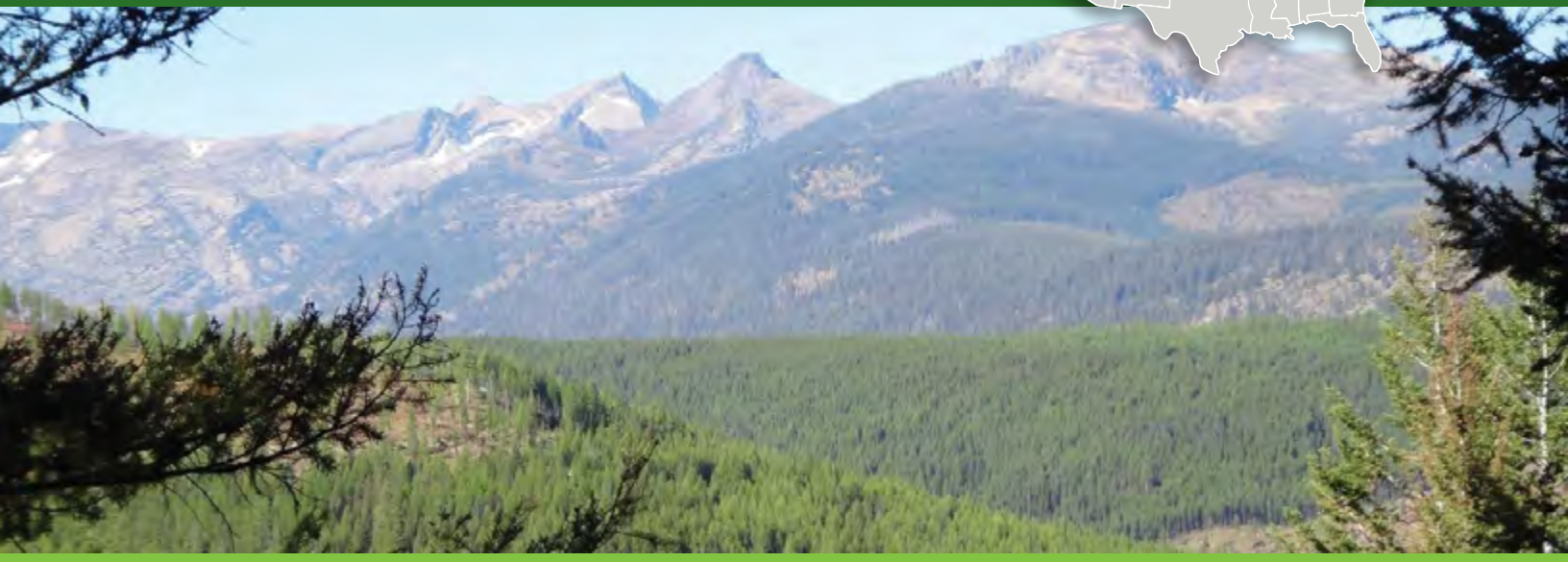
Serwold, K. 2015. Interview with Kim Serwold, Office of Utility Services, Seattle Public Utilities. February 5.

SPU. 2014. Seattle Public Utilities Strategic Business Plan: 2015–2020. Seattle Public Utilities, Seattle, WA.

SPU. 2015. Seattle Public Utilities: About Us. Available: http://www.seattle.gov/util/AboutUs/index.htm. Accessed on February 28, 2015.

Water Utilities Climate Alliance. 2015. About Us. Available: http://www.wucaonline.org/html/about_us.html. Accessed on August 4, 2015.

Southwestern Crown, Montana



Forest Restoration

SOUTHWESTERN CROWN, MONTANA

AUTHORS: Heather Hosterman, Jason Vogel, and Karen Carney

In this case study, you will learn about:

- A public-private partnership aimed at increasing the ecological integrity of a landscape and providing economic and social community benefits
- An adaptive management approach to restoration that uses monitoring results to inform future management practices
- The value of taking incremental steps where there is agreement, and building on the understanding gained through those small actions to implement larger projects.

Case Study Summary

The Southwestern Crown region covers approximately 1.5 million acres of "working ranches, private timberlands, craggy mountain peaks, abundant wildlife, and pristine lakes and streams" in northwest Montana (SWCC, 2015a). The landscape is home to several small, rural communities—Condon, Seeley Lake, Greenough, Ovando, Helmville, Potomac, and Lincoln (Exhibit 1)—and provides prime habitat for various species, including grizzly bears, gray wolves, wolverines, lynx, and bull trout. Although the ecological integrity of the Southwestern Crown is high compared to many other landscapes, land management practices and climate change are widely believed to have affected the region's forest and stream ecosystems (SWCC, 2010a). In particular, fire suppression and other past management practices have increased the landscapes' susceptibility to large-scale, intense wildfires. The Southwestern Crown is experiencing more severe and longer wildfire seasons, as described in more detail below (Westerling et al., 2006), and the community expects these wildlife dynamics to be further exacerbated under future climate change (SWCC, 2010b). As such, the Southwestern Crown community acquired federal funding to conduct forest and watershed restoration, including forest thinning and prescribed fires, the aim of which is to reestablish natural wildfire dynamics in the area's ecosystems and reduce the risk of catastrophic wildfire. Reductions in wildfire frequency and intensity will help protect: (1) local timber resources, (2) overall watershed health, and (3) terrestrial and aquatic habitats (SWCC, 2010b). From 2010 to 2014, 13,113 acres of forest have been treated using forest thinning and prescribed fires in the wildland-urban interface (WUI), and 8,534 acres of forest have been treated in the non-WUI. By 2019, the community aims to reduce fire risk on 27,000 acres of high-risk WUI lands and 46,000 acres on non-WUI lands (SWCC, 2015b).

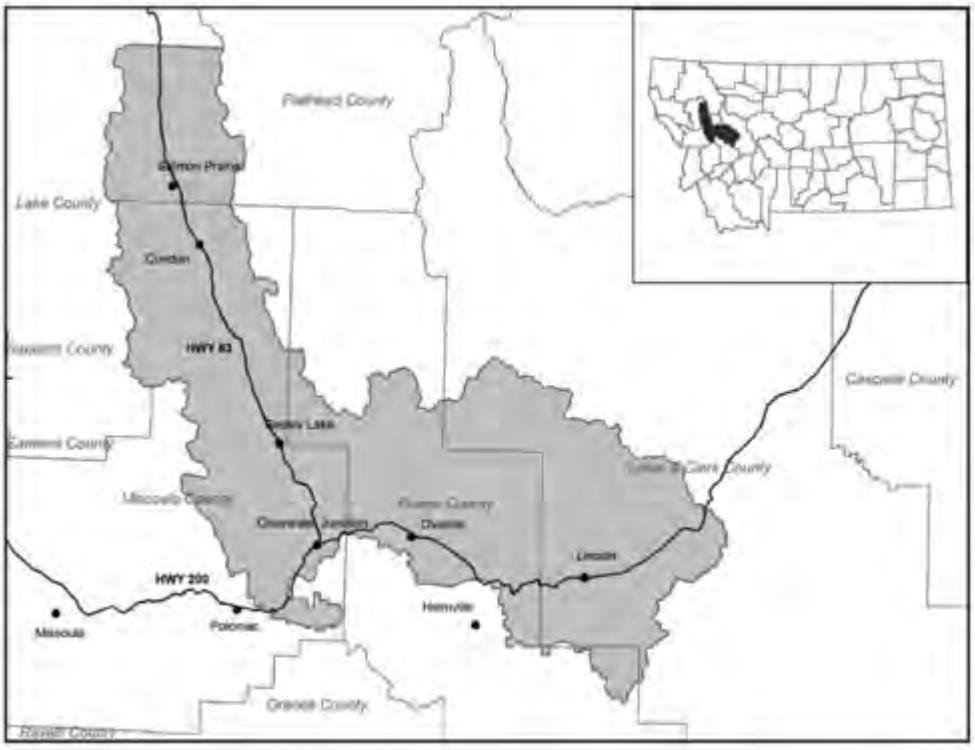


Exhibit 1. Location of the Southwestern Crown.
Source: Mehl et al., 2012.

The Broader Context of Vulnerability Reduction in the Southwestern Crown, MT

Starting in the 1980s, controversy and litigation led to significant reductions in timber harvests and slowed the implementation of forest restoration projects in the Southwestern Crown region (Austin, 2015; Parker, 2015). Environmental groups were concerned about environmental degradation and the responsiveness of the U.S. Forest Service (USFS) to public input on public forest management, while local communities and loggers were concerned about forest-related employment opportunities. By the 1990s, the decline in timber harvests was reducing employment in the region and leading to increased hostilities among environmentalists, the USFS, and loggers (Red Lodge Clearinghouse, 2010). To promote civil discourse, Rod Ash, a conservationist and member of the Condon community, began a collaborative process, the Southwestern Crown Collaborative (SWCC), in the early 1990s to bring together the community members to find positive solutions (Red Lodge Clearinghouse, 2010). As part of this effort, community members established local committees in the Swan, Blackfoot, and Clearwater valleys to help encourage discourse and collaboration during forest restoration planning and project implementation (Parker, 2015).

EXHIBIT 2. MFRC'S 13 PRINCIPLES[a]

MFRC believes that these principles should be applied to planning and implementation of forest restoration work on national forest lands in Montana:

- Restore functioning ecosystems by enhancing ecological processes
- Apply an adaptive management approach
- Use the appropriate scale of integrated analysis to prioritize and design restoration activities
- Monitor restoration outcomes
- Reestablish fire as a natural process on the landscape
- Consider social constraints and seek public support for reintroducing fire on the landscape
- Engage community and interested parties in the restoration process
- Improve terrestrial and aquatic habitats and connectivity
- Emphasize ecosystem goods and services and sustainable land management practices
- Integrate restoration with socioeconomic wellbeing
- Enhance education and recreation activities to build support for restoration
- Protect and improve overall watershed health, including stream health, soil quality and function, and riparian function
- Establish and maintain a safe road and trail system that is ecologically sustainable.

a. These 13 principles now include an appendix on restoring forests for the future, which includes climate change considerations and adaptation strategies for forest restoration projects. For more information, see http://www.montanarestoration.org/climate.

Source: MFRC, 2007.

In parallel with these efforts, the Montana Forest Restoration Committee (MFRC) was formed in 2007. The MFRC is a volunteer, consensus-based collaborative entity that helps guide restoration activities in Montana's National Forests. A central component of the MFRC is a suite of 13 principles that help ensure that key stakeholder concerns are addressed and all interested parties are appropriately engaged throughout the design and implementation of forest restoration activities (Exhibit 2; MFRC, 2007).

These community dynamics and collaborative efforts provided a solid foundation for establishing a community collaborative to provide ecosystem, economic,

and social benefits to its rural community. The SWCC—described in more detail below—is working to creating a landscape approach to implement forest restoration and fuel management activities, restore fish and wildlife habitat, remove unnecessary roads, improve recreational activities, and support the local economy by creating a sustainable forest products industry. This case study focuses on its forest restoration efforts to reduce vulnerability to catastrophic wildfires.

The Southwest Crown's ecological resilience is largely threatened by the absence of natural fire regimes and the effects of climate change may exacerbate wildfire risk. Reestablishing natural wildfire dynamics in the area's ecosystems and reducing the risk of catastrophic wildfire can reduce wildfire frequency and intensity and provide economic, ecological, and social benefits.

Why and How the Southwestern Crown Reduced Catastrophic Wildfire Risk

As we describe below, several factors led to the Southwestern Crown's implementation of wildfire restoration projects to reduce the landscape's vulnerability to wildfire risk. Exhibit 3 shows the timeline of factors leading to community action.

More Intense and Frequent Wildfires Motivate Citizens to Take Action

The Southwestern Crown is experiencing more frequent and intense wildfire than in the past (SWCC, 2010a; Maradeo et al., 2013; Austin, 2015). Over the past century, fire suppression allowed the growth of dense understories that provide large amounts of fuel for wildfires (SWCC, 2010b). In addition, Southwestern Crown is experiencing higher air temperatures, earlier spring snowmelts, and declining stream flows, all of which can lead to drier forests that are more likely to burn (Fagre, 2007; Pederson et al., 2010). Years of drought and the spread of mountain pine beetle are also contributing to tree mortality, further exacerbating the problem of higher-fuel loads (Pederson et al., 2010). According to the SWCC, hotter summer temperatures and reduced moisture "have led to larger, more frequent, and more severe wildfires since the mid-1980s," and fire seasons now last "11 weeks longer each year compared with the 1970s" (Westerling et al., 2006). These dynamics are likely to be further exacerbated under future climate change (SWCC, 2010b).

The fire seasons of 2000, 2001, 2003, and 2007 had particularly significant impacts on the communities of Seeley Lake, Condon, and Lincoln. Wildfire response costs were substantial, and tourism- and recreational-supported businesses suffered (Maradeo et al., 2013).

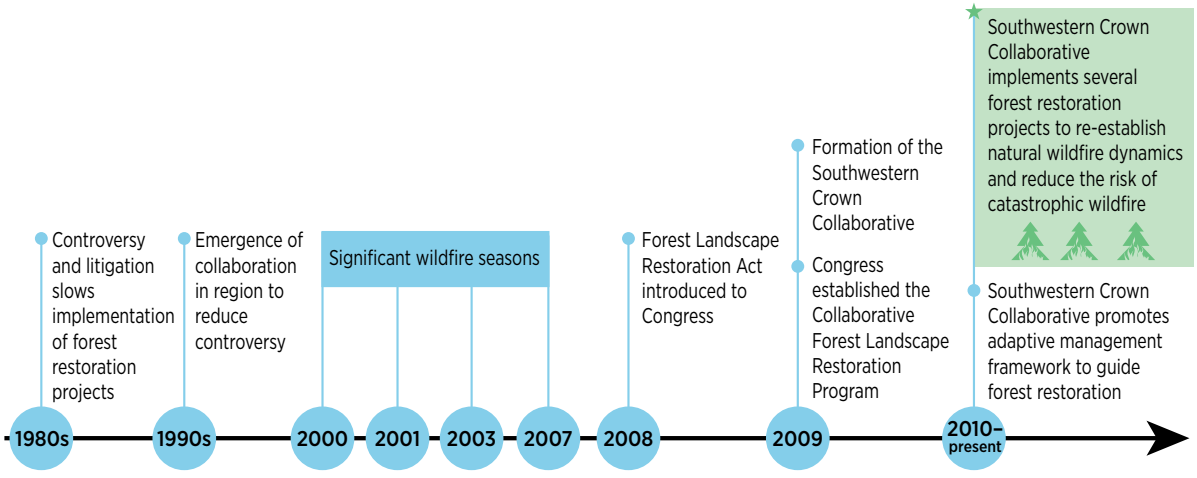


Exhibit 3. Southwestern Crown timeline of factors leading to community action.

In addition, travel was restricted along the main highway, air quality declined, and local citizens became concerned about their safety (SWCC, 2010a; Maradeo et al., 2013). During the 2007 Jocko Lakes Fire, community residents and businesses were evacuated for up to two weeks (Maradeo et al., 2013). The increasing frequency and severity of wildfires, along with their potential economic and safety impacts, created a desire in the community to act to reduce its wildfire-related risks (Austin, 2015).

The Southwestern Crown Community Forms a Collaborative to Access Federal Funding

The Forest Landscape Restoration Act was introduced to Congress as a way to support integrated, collaborative forest restoration at large scales. The Act, which established the Collaborative Forest Landscape Restoration Program (CFLRP), received bipartisan support. In 2009, Congress passed Title IV of the Omnibus Public Land Management Act, which provided funding for the CFLRP to "encourage the collaborative, science-based ecosystem restoration of priority forest landscapes" (Section 4001). The CFLRP was shaped by the increasing emphasis across the nation on community engagement in forest policy and management, and a key focus of the program is addressing escalating costs of fighting more frequent and intense wildfires (Schultz et al., 2012).The program addresses this issue by supporting projects that help reduce fuel loads and reestablishing natural fire regimes (SWCC, 2010a).

> **"As wildfire activity and suppression costs have grown dramatically, and as the effects of global warming are posing an ever-greater threat to forest and watershed health, and as the economy struggles, the time is right for this approach [the CFLRP]."**
>
> SENATOR BINGAMAN (D-NM);
> US Senate Committee on Energy and Natural Resources 2008, p. 1 (as quoted in Schultz et al., 2012)

According to Debbie Austin, former Lolo National Forest supervisor, the Southwestern Crown recognized the CFLRP as a resource that could help reduce the risk of wildfire in its community (Austin, 2015). Southwestern Crown's previous efforts at collaborative forest management were harnessed to take advantage of this new funding opportunity. Local and regional nonprofit organizations organized a "sharing meeting," which aimed to bring all the Southwestern Crown small, rural communities and national forests (i.e., the Lolo National Forest, the Flathead National Forest, and Lincoln National Forest) together. The meeting successfully established the SWCC, which then submitted a proposal for funding from the CFLRP. The SWCC bid was successful and secured funding in the first round of the program in 2010. In its bid, the SWCC identified 10 years of restoration projects to complete on 199,140 acres of USFS land with goals "to restore forest and aquatic ecosystem function, to improve landscape-level biodiversity, resiliency, and adaptability, to enhance recreational experiences, and to reduce risks for those living in the WUI" (SWCC, 2010a, p. 2). The SWCC's forest work explicitly aims to reduce risks of wildfire under climate change (SWCC, 2010a). The CFLRP will provide the Southwestern Crown region up to $4 million annually for forest restoration activities for 10 years (2010 through 2019). The CFLRP provides authority to fund 50 percent of the cost of implementing and monitoring ecological restoration treatments; however, the community must leverage these resources with local and private resources to match the funding (Title IV, 2009).

There was little opposition to forming the SWCC and applying to the CFLRP for restoration funding; however, the SWCC faces several challenges in implementing fuel-reduction projects under the CFLRP, as described in Exhibit 4.

The SWCC Prioritizes Monitoring and Adaptive Management to Reduce Catastrophic Wildfire Risks

The CFLRP promotes an adaptive management framework, which uses monitoring results to inform future management practices. The SWCC decided early on that monitoring the effects of forest treatments was a high priority (SWCC, 2012). The SWCC spends 10 percent of

EXHIBIT 4. PROJECT RESISTANCE

The SWCC adopted MFRC's 13 principles to plan and implement forest restoration projects (Exhibit 2), and it thus expected its collaborative approach would reduce controversy and litigation. The Colt Summit restoration project—a project focused on fuels reduction, vegetation and watershed restoration, and management for wildlife habitat—was a test case for SWCC's ability to move forward without legal challenges. Early on, several nonprofit organizations[a] raised concerns that the USFS failed to perform a full environmental impact statement to evaluate the effects of the project on wildlife and, therefore, did not meet the requirements of the National Environmental Policy Act (NEPA). WildWest Institute, a nonprofit organization who filed an amicus brief on behalf of the Plaintiffs, expressed concerns that that Colt Summit, which was planned before the SWCC was formed, was not adequately vetted by the SWCC or properly reviewed by the public as required by NEPA (WildWest Institute, 2012). These concerns resulted in the litigation of the project and, ultimately, delayed implementation. Several other regional environmental groups[b] felt that the project was adequately vetted with both the SWCC and the general public and appropriately underwent the NEPA processes; these groups filed an amicus brief on behalf of the USFS to support this project over the course of the litigation (The Wilderness Society et al., 2012).

Although the SWCC is awaiting a final decision by the courts on the Colt Summit project, the SWCC has been able to move the project forward by selecting a contractor for the work (Chaney, 2014). For some, however, the slow implementation of restoration projects, such as the halting of Colt Summit for four years, calls into question whether the SWCC is effectively reducing wildfire risk on the ground (Koehler, 2015).

a. These nonprofit organizations include Friends of the Wild Swan, Alliance for the Wild Rockies, Montana Ecosystem Defense Council, and Native Ecosystems Council.

b. These environmental groups include The Wilderness Society, Montana Wilderness Association, Montana Wood Products Association, Dale Bosworth, Abagail Kimbell, National Wildlife Federation, Seeley Lake Rural Fire District, Swan Ecosystem Center, American Forests, Pyramid Mountain Lumber, Clearwater Resource Council, Orville Daniels, and 15 other individuals and organizations.

its budget on monitoring (SWCC, 2012); more than any other CFLRP program (Parker, 2015). In addition, the SWCC holds annual adaptation management workshops, described below, to revise project goals and objectives to ensure that restoration is reducing the risk of catastrophic wildfires.

The adaptive management framework adopted by the SWCC includes four types of monitoring: surveillance, implementation, effectiveness, and ecological effects monitoring (SWCC, 2012; Hutto and Belote, 2013). As shown in Exhibit 5, the model starts by indicating the current condition of the resources and, through surveillance monitoring, the SWCC determines if there have been changes in conditions of the resources (Hutto and Belote, 2013). The three other monitoring types are linked with management activities and answer specific questions about the effects of the treatment. The box in Exhibit 5 lists the SWCC annual adaptive management meeting topics, and the questions answered at the meeting, as well as the actions taken based on the meeting (see arrows; Hutto and Belote, 2013).

Melanie Parker, former Executive Director of Northwest Connections, indicated that the annual adaptive management workshops are critical to the success of the

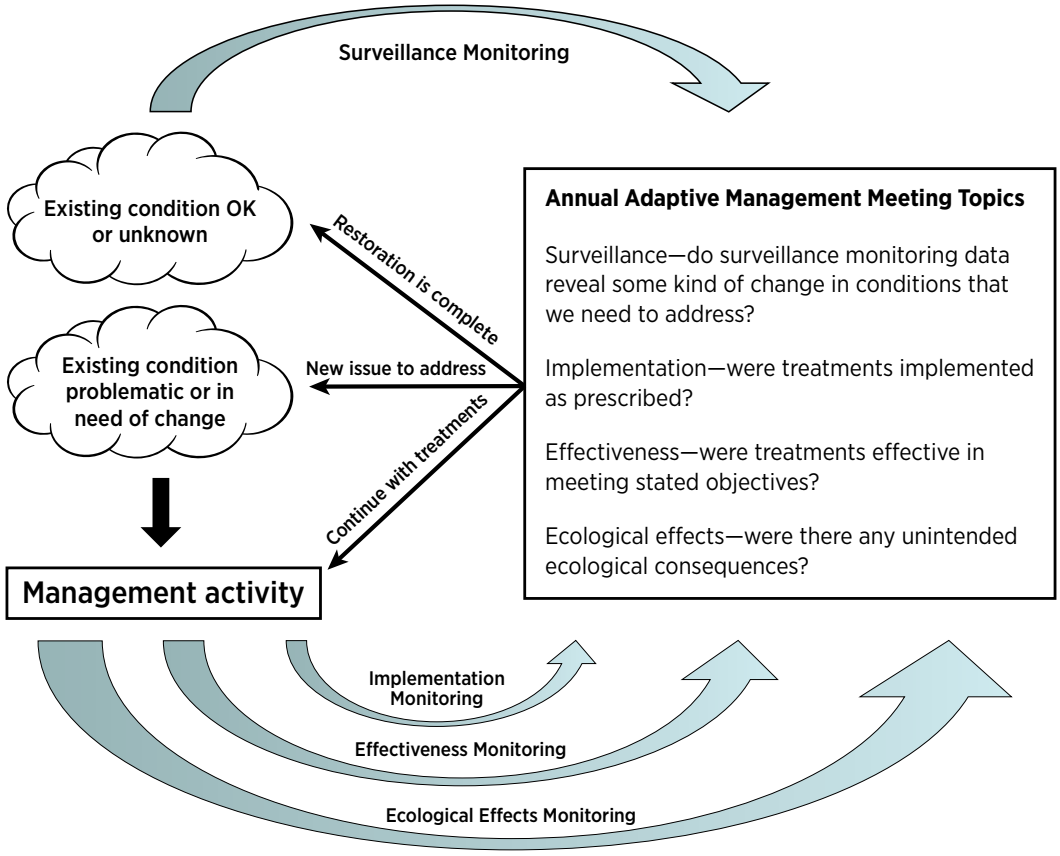


Exhibit 5. Types of monitoring within an adaptive management framework.
Source: Hutto and Belote, 2013.

SWCC (Parker, 2015). These workshops bring together the community and decision-makers for two days to ask the "so what" questions: Are the monitoring data revealing a change in conditions that needs to be addressed?; Were treatments effective in meeting objectives?; Were there any unintended consequences from the treatments? (Hutto and Belote, 2013; Parker, 2015). The workshops also provide an opportunity to discuss restoration trends—to look backward as well as forward—in order to "revise goals and objectives, adjust conceptual models and predictions about the systems in which management actions occur, or even to reassess the way in which a problem is framed" (SWCC, 2012, p. 13).

Accomplishments of Implementing Forest Restoration Projects in the Southwestern Crown

From 2010 to 2013, the SWCC supported forest-restoration efforts focused on reducing wildfire risk on 9,782 acres, with a goal of reducing wildfire risk on 27,000 acres of high-risk lands by 2019 (SWCC, 2013a). One of SWCC's fuel-reduction projects, the Meadow Smith restoration project, was highlighted as particularly successful in the CFLRP's annual report, (SWCC, 2013b). This restoration project, which included timber harvests in 2010 and 2011 and fuel treatments in 2012, allowed fire

managers to successfully contain and treat the July 2012 lightning-induced Condon Mountain fire (SWCC, 2013b). Fire Manager Brent Olson said, "The treatment was very effective as we had burning embers land into the [treatment area]. We didn't have any real spotting in that area because of the fuel treatment" (SWCC, 2013b, p. 7). The 2013 report concludes that without the Meadow Smith restoration project, the area "would have had a very different fate—high [tree] mortality" (SWCC, 2013b, p. 7).[10]

During interviews, Debbie Austin, Chelsea McIver, and Gary Burnett, the Executive Director of Blackfoot Challenge and Cochair of the SWCC, indicated that implementing the CFLRP in the Southwestern Crown is a "step in the right direction" because the community is better at collaboration and has met restoration and job targets; however, these interviewees also stress that "there is still more to do" (Austin, 2015; Burnett, 2015; McIver, 2015[a, b]). For example, Debbie Austin suggested that a streamlined approach for moving projects from conception to implementation should be developed for projects where the USFS and the public are working together. Chelsea McIver, focusing on the SWCC's goal of supporting rural, local economies indicated that SWCC restoration funding is creating benefits for local contractors and subcontractors, but further work is needed to make sure the opportunities are reaching the communities located closest to the resource and those that are most vulnerable—economically and socially (see Exhibit 6). Gary Burnett indicated that he will consider the Southwestern Crown CFLRP a success if the SWCC continues to exist and implement restoration projects after the CFLRP funding ends (Burnett, 2015).

Matthew Koehler indicated that although the SWCC is making progress towards its 10-year forest restoration goals, the SWCC is behind on its road decommissioning and some other watershed restoration goals (Koehler, 2015). For example, between 2010 and 2014, the SWCC completed 58 miles of road decommissioning work (or 15 percent of its 10-year goal; SWCC, 2015b). Currently, the SWCC expects that it will meet its goals by 2019 (SWCC, 2015b).

Anne Carlson emphasized the importance of the collaborative, holistic, integrated nature of the CFLRP and the SWCC's restoration projects as opposed to a singular focus on altering wildfire dynamics. The purpose of the CFLRP "is to encourage the collaborative, science-based ecosystem restoration of priority forest landscapes…" (Title IV, 2009). According to Dr. Carlson, this structure is "a critically important component to effective climate adaptation efforts" (Carlson, 2015).

Moving Forward

The Southwestern Crown CFLRP is a 10-year program (2010–2019) with 5 years of post-CFLRP monitoring (Title IV, 2009). Over the next two years (2015–2016), the SWCC is focused on conducting a Restoration Initiative for the Blackfoot and Swan (RIBS). The RIBS will identify specific acres across the Southwestern Crown where they can implement future restoration efforts that will "reduce the risks of uncharacteristic wildfire and conserve terrestrial and aquatic biodiversity across the SWCC landscape, taking into account potential influence of climate change" (USFS, 2014, p. 1). The RIBS project will then be used to determine future restoration efforts for the Southwestern Crown CFLRP (2017–2019). At the end of the CFLRP funding, the SWCC expects to continue its restoration work in the Southwestern Crown, although specific-funding sources have not been identified. According to Debbie Austin, SWCC partners are committed to continuing: "There's already a lot of talk about continuing. The group is committed to the place" and several projects are through the planning phase and are now ready to implement (Austin, 2015).

10. For additional information on the SWCC fuels reduction projects, see the SWCC projects webpage — http://www.swcrown.org/projects/ — and interactive map — http://www.swcrown.org/interactivemap/index.html.

EXHIBIT 6. SUPPORTING THE LOCAL ECONOMY THROUGH RESTORATION WORK

The federal government is a major land owner in the western part of Montana and the Southwestern Crown. Restoration and maintenance projects designed to reestablish natural fire dynamics and reduce vulnerability to catastrophic wildfires can provide economic benefits to local and regional communities; the SWCC works to support rural, local economies and engage community members in its restoration work. To date, however, results are mixed.

A 2013 local contractor participation assessment found that restoration funding provides some benefits to local communities through the utilization of local contractors and subcontractors; however, the extent of the benefits depends on a number of factors: the capacity of contractors in an area, the setting aside of contracts for economically- and socially-disadvantaged businesses, the value of the contract, and the type of work being conducted. Businesses located in the rural communities in the Southwestern Crown generally receive less than 3 percent of USFS restoration investments in the region (McIver, 2013; 2015a). However, businesses located in the surrounding five counties, which contain the Southwestern Crown boundary, receive roughly 60 percent of total restoration investments (McIver, 2013; 2015a). There are success stories of local contractors benefiting from SWCC restoration funding. For example, the long-term nature of the restoration funding (10-years) convinced some local contractors to make investments in training and equipment that can ensure long-term government contracts, creating a more sustainable business model. One former logger, whose business had suffered with the fall in timber prices, decided to receive training for stream restoration; he is now a successful stream restoration contractor for the federal government (Parker, 2015).

Lower income and isolated communities have been identified as particularly vulnerable to the impacts of climate change. Therefore, efforts to create more ecologically resilient forests as well as economically and socially resilient communities are an important strategy for many local forest communities. Federal policies require that small, disadvantaged businesses receive a fair share of federal procurement opportunities. However, the majority of the contracts set aside for minority-owned or other small, socially- or economically-disadvantaged businesses have gone to out-of-state or out-of-region businesses, which represents a significant lost opportunity for building wealth in lower income rural and tribal communities (McIver, 2015b). That said, two tribally-owned enterprises associated with the Confederated Salish and Kootenai Tribes are actively involved in conducting restoration work in the Southwestern Crown (McIver, 2015b). In addition, two workshops have been held to inform local contractors about the opportunities being created through the CFLRP and resources available to help them navigate the process of bidding on federal projects (McIver, 2015b).

In the Southwestern Crown, maintaining or increasing local businesses capacity and skills is vital to the success of the SWCC forest restoration projects. This investment in human, social and natural capital will help create more resilient forests and communities better able to deal with the effects of climate change (McIver, 2015b).

Acknowledgements[11]

We would like to thank the following people for participating in interviews as part of this case study:

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- **Dr. Anne Carlson,** The Wilderness Society
- **Mr. Matthew Koehler,** WildWest Institute
- **Ms. Chelsea McIver,** Bureau of Business and Economic Research, University of Montana
- **Ms. Melanie Parker,** Northwest Connections.

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- Montana Department of Natural Resource Conservation
- Blackfoot Challenge
- Clearwater Resource Council
- Pyramid Mountain Lumber
- University of Montana
- Missoula Country Rural Initiatives
- Northwest Connections
- The Nature Conservancy
- National Wildlife Federation
- Swan Ecosystem Center
- Trust for Public Lands
- Forest Business Network
- The Wilderness Society.

Bibliography

Austin, D. 2015. Interview with Debbie Austin, previous District Ranger, Lolo National Forest, Seeley Lake Ranger District, United States Forest Service (now retired). January 28.

Burnett, G. 2015. Interview with Gary Burnett, Executive Director, Blackfoot Challenge. January 12.

Carlson, A. 2015. Interview with Anne Carlson, Climate Associate, The Wilderness Society. January 23, 2015.

Chaney, R. 2014. Court ruling let 1 Seeley-Swan logging project go forward, halt 1 other. Missoulian. September 27. Available: http://missoulian.com/news/state-and-regional/court-rulings-let-seeley-swan-logging-project-go-forward-halt/article_ed4f551e-45e7-11e4-ac61-73024e14dbe1.html. Accessed March 27, 2015.

Fagre, D. 2007. Ecosystem responses to global climate change. In Sustaining Rocky Mountain Landscapes: Science, Policy, and Management for the Crown of the Continent Ecosystem, T. Prato and D. Fagre (eds.). Resources for the Future Press, Washington, DC.

Gorte, R. 2013. The Rising Cost of Wildfire Protection. A Research Paper by Headwaters Economics. June. Available: http://headwaterseconomics.org/wphw/wp-content/uploads/fire-costs-background-report.pdf. Accessed February 6, 2015.

Hutto, R.L. and R.T. Belote. 2013. Distinguishing four types of monitoring based on the questions they address. Forest Ecology and Management 289:183–189.

Koehler, M. 2015. Interview with Matthew Koehler, Executive Director, WildWest Institute. January 12.

Larson, A.J., R.T Belote, M.A. Williamson, and G.H. Aplet. 2013. Making monitoring count: Project design for active adaptive management. Journal of Forestry 111(5):1–9.

11. Please note that the primary case study researcher is related to an interviewee; the project team does not feel that there is a conflict of interest.

Maradeo, F., T. Quadros, R. Marshall, M. Arno, N. Fortunate, A. Branine, C. Calnan, C. Super, D. Poukish, D. Roberson, T. Love. P. Shelmerdine, R. White, R. Kehr, B. Gillespie, J. Ingebretson, A. Huntsberger, J. Haufler, C. Mehl, S. Yeats, C. Moon, and J. Normark. 2013. Seeley-Swan Fire Plan: 2013 Revision. A Component of the Missoula County Wildfire Protection Plan. Available: https://www.crcmt.org/uploads/Fire_2013SSFP.pdf. Accessed February 3, 2015.

McIver, C. 2013. An Assessment of Local Contractor Participation in the Southwestern Crown of the Continent CFLRP Project. Bureau of Business and Economic Research, University of Montana. June.

McIver, C. 2015a. Capturing the Benefits of Restoration: Local Business Utilization and Opportunities for Growth in Northwestern Montana. Forestry Thesis.

McIver, C. 2015b. Interview with Chelsea McIver, Research Associate, Bureau of Business and Economic Research, University of Montana. January 29.

Mehl, C., J. Haufler, S. Yeats, and B. Rieman. 2012. Southwestern Crown of the Continent Landscape Assessment. Ecosystem Management Research Institute. Available: http://www.emri.org/PDF%20Docs/Adobe%20files/SW%20Crown%20Landscape%20Assessment.pdf. Accessed February 3, 2015.

MFRC. 2007. Restoration Principles. Montana Forest Restoration Committee. Available: http://www.montanarestoration.org/principles-menu. Accessed January 31, 2015.

Parker, M. 2015. Interview with Melanie Parker, Executive Director, Northwest Connections. January 12.

Pederson, G.T., L.J. Graumlich, D.B. Fagre, T. Kipfer, and C.M. Muhlfeld. 2010. A century of climate and ecosystem change in Western Montana: What do temperature trends portend? Climatic Change 98:133–154.

Politico. 2012. 2012 Presidential Election. Available: http://www.politico.com/2012-election/results/map/#/President/2012/. Accessed February 4, 2013.

Red Lodge Clearinghouse. 2010. Swan Citizens Ad Hoc Committee and Swan Ecosystem Center. Posted January 24. Available: http://www.rlch.org/stories/swan-citizens-ad-hoc-committee-and-swan-ecosystem-center. Accessed January 31, 2015.

Schultz, C.A., T. Jedd, and R.D. Beam. 2012. The Collaborative Forest Landscape Restoration Program: A history and overview of the first projects. Journal of Forestry 110(7):381–391.

SWCC. 2010a. Southwestern Crown of the Continent Collaborative CFLRP Proposal. Southwestern Crown Collaborative. Available: http://www.fs.fed.us/restoration/documents/cflrp/2010Proposals/Region1/SWCrown/Southern_Crown_2010_CFLRP_Proposal_FINAL.pdf. Accessed January 23, 2015.

SWCC. 2010b. Southwestern Crown of the Continent Landscape Restoration Strategy. Southwestern Crown Collaborative. May 12. Available: http://www.fs.fed.us/restoration/documents/cflrp/2010Proposals/Region1/SWCrown/May_SW_Crown_Landscape_Strategy_FINAL.pdf. Accessed January 23, 2015.

SWCC. 2012. Long-Term Monitoring Plan: US National Forest Collaborative Forest Landscape Restoration Program. Southwestern Crown Collaborative. Available: http://www.swcrown.org/wp-content/uploads/2011/08/SWCC-Long-term-Monitoring-Plan-121720141.pdf. Accessed January 23, 2015.

SWCC. 2013a. 2013 Annual Update. Southwestern Crown Collaborative. December. Available: http://www.swcrown.org/wp-content/uploads/2012/02/2013-SWCC-Annual-Update.pdf. Accessed February 7, 2015.

SWCC. 2013b. CFLRP Annual Report: 2013. Southwestern Crown Collaborative. Available: http://www.swcrown.org/wp-content/uploads/2012/02/FY2013_CFLRP_AnnualReport_SWCC.pdf. Accessed February 7, 2015.

SWCC. 2015a. Southwestern Crown Collaborative. Available: http://www.swcrown.org/the-southwestern-crown/. Accessed January 31, 2015.

SWCC. 2015b. 2014 SWCC CFLRP Annual Report. Available: http://www.swcrown.org/wp-content/uploads/2012/02/CORRECTED-SWCC-CFLR_Annual_Report_V.2015-3-12.pdf. Accessed August 26, 2015.

Tabor, G. 2014. Interview with Gary Tabor, Executive Director, The Center For Large Landscape Restoration. February 21.

Tabor, G, A. Carlson, and T. Belote. 2014. Challenges and Opportunities for Large Landscape-Scale Management in a Shifting Climate: The Importance of Nested Adaptation Responses Across Geospatial and Temporal Scales. In Forest Conservation and Management in the Anthropocene: Adaptation of Science, Policy, and Practices. USDA Forest Service RMRS: 205–227. July.

The Wilderness Society, Montana Wilderness Association, Montana Wood Products Association, Dale Bosworth, Abagail Kimbell, National Wildlife Federation, Seeley Lake Rural Fire District, Swan Ecosystem Center, American Forests, Pyramid Mountain Lumber, Clearwater Resource Council, Orville Daniels, and 15 other individuals and organizations. 2012. Amicus Brief In Support of Defendants. In the United States District Court for the District of Montana Missoula Division. Matthew O. Clifford, Oakland, CA. February 27.

Title IV. 2009. Omnibus Public Land Management Act of 2009. Title IV—Forest Landscape Restoration. Available: http://www.fs.fed.us/restoration/documents/cflrp/titleIV.pdf. Accessed January 31, 2015.

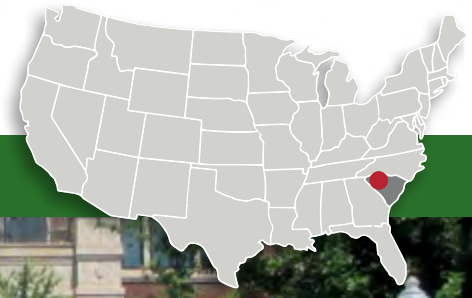
U.S. Census Bureau. 2013a. B19013: Median Household Income in the Past 12 Months (in 2013 inflation-adjusted dollars). 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

U.S. Census Bureau. 2013b. DP05: Demographic and Housing Estimates. 2009–2013 American Community Survey. U.S. Census Bureau's American Community Survey Office, American FactFinder.

USFS. 2014. Restoration Initiative for the Blackfoot and Swan—Project Initiation Letter. October 7. Available: http://www.swcrown.org/wp-content/uploads/2015/02/Signed-PIL-for-RIBS.pdf. Accessed April 2, 2015.

Westerling, A.L., H.G. Hidalgo, D.R. Cayan, and T.W. Swetnam. 2006. Warming and earlier spring increase Western U.S. Forest wildfire activity. Science 313:940–943.

WildWest Institute. 2012. Amicus Brief In Support of Plaintiffs. In the United States District Court for the District of Montana Missoula Division. Karr Law Firm, PLLC, Missoula, MT. February 27.



Spartanburg, South Carolina

Mainstreaming Climate Change into Programs, Management Actions, and Culture

SPARTANBURG, SOUTH CAROLINA

AUTHORS: Heather Hosterman, Karen Carney, and Jason Vogel

In this case study, you will learn about:

- How Spartanburg Water is mainstreaming climate change into utility existing programs and activities
- Leveraging extreme events to motivate action
- The important role of staff in catalyzing action on climate change and integrating climate change into programs and activities

Case Study Summary

Spartanburg Water is a public water and wastewater utility that is composed of two entities—Spartanburg Water System and Spartanburg Sanitary Sewer District Commission—under one name (Spartanburg Water, 2015a). The public water and wastewater utility is located in northeastern South Carolina and serves approximately 180,000 residents in communities across Spartanburg County, as well as parts of Greenville, Union, and Cherokee counties (Spartanburg Water, 2015b). A history of droughts and extreme rainfall conditions affected Spartanburg Water's operations, including water supply and water quality. These impacts, combined with increased recognition about climate change, led Spartanburg Water to begin to integrate climate change into the utility's operations and culture.

Spartanburg Water is undertaking a broad suite of actions to incorporate climate change planning into its programs, management actions, and culture. In this case study, we describe the key factors that shaped Spartanburg Water's thinking on climate change and provide examples of actions they are taking to reduce vulnerability to droughts and flooding. Interviewees feel that Spartanburg Water's work will reduce vulnerability by integrating climate change into programs and actions, and by increasing the capacity of staff to understand and respond to climate variability and impacts from climate change. However, Spartanburg Water is in the early stages of climate change integration, and it will take more time to know the full impact of Spartanburg Water's actions.

The Broader Context of Incorporating Climate Change into Programs, Management Actions, and Culture

Spartanburg Water has been engaged in water and sewer management for decades. Over the years, the utility developed several systems for dealing with a wide range of climate variability and natural hazards, such as gauging sites to monitor and manage water releases from reservoirs and ongoing watershed testing and monitoring. In addition, the utility has adapted to a shift in the community's economy from a focus on textiles to manufacturing. Spartanburg Water works with manufacturing businesses to develop innovative water and waste water solutions for companies, such as water recycling, which can save the company money by reducing water use and encourage them to relocate to or remain in Spartanburg.

Over the last five years, Spartanburg Water began to recognize the need to adapt its water and waste water management systems to take climate variability and impacts from climate change into consideration. The utility recognizes that in order to maintain its mission—to provide quality water and wastewater services to our region in a reliable manner (Spartanburg Water, 2015b)—it is critical to increase its resiliency to various changing circumstances, including changing climate and economic conditions (West, 2015). To ensure Spartanburg Water can meet its mission, the utility is integrating climate change planning into their business practices. Recently, Spartanburg Water incorporated climate considerations into its 2014 Strategic Plan. Under its goal of pursuing excellence in its products and services, Spartanburg Water laid out a strategy to reduce its carbon and water footprint by reducing paper consumption, and finalizing a discharge project and evaluating pumping strategies that can reduce energy consumption (Spartanburg Water, 2014). The utility is working to reduce greenhouse gas emissions from its fleet and is emphasizing carbon reductions in facility upgrades, including a recent upgrade to a water treatment plant.

Today, Spartanburg Water is undertaking a series of initiatives to ensure that climate change is factored into its programs, management actions, and culture. This case study profiles some of this work at Spartanburg Water, highlighting techniques used by the utility to ensure that climate change is integrated into its operations and decision-making processes.

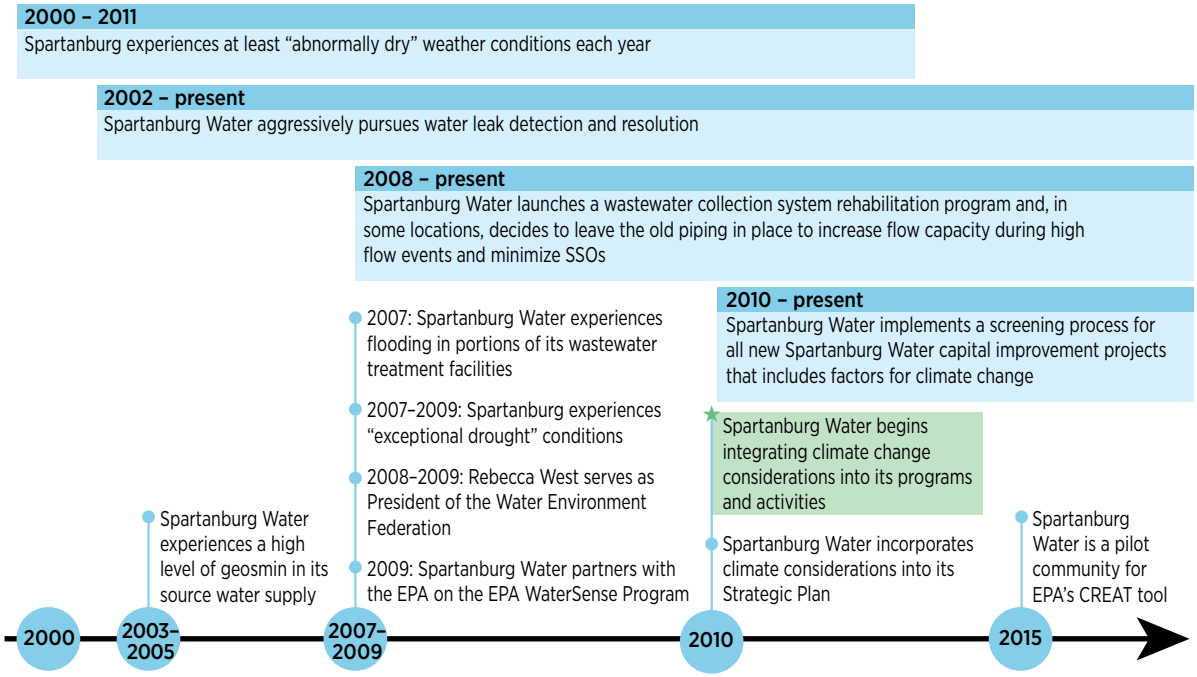


Exhibit 1. Spartanburg Water timeline of factors leading to utility action.

Why and How Spartanburg Water Incorporates Climate Change into its Programs and Activities

As we describe below, several factors led Spartanburg Water to advance its thinking on climate change and incorporate climate change into its existing programs and activities. Exhibit 1 shows the timeline of factors and actions undertaken by the utility.

Drought and Inland Flooding Motivates Spartanburg Water to Reduce Its Vulnerability to These Key Natural Hazards

Spartanburg Water is vulnerable to a wide range of natural and human-caused hazards (City of Spartanburg, 2011); however, the utility is primarily affected by droughts and inland flooding. This section describes the utility's experience with droughts and floods and the actions taken to date to reduce vulnerability to these natural hazards.

Droughts

Drought is identified as the highest natural hazard risk in Spartanburg County's Hazard Mitigation Plan (City of Spartanburg, 2011). From 2000 through 2011, Spartanburg County experienced at least "abnormally dry" conditions each year. From October 2007 through December 2009, the county experienced "exceptional drought," its most severe drought condition ranking (City of Spartanburg, 2011).[12] In 2008 alone, Spartanburg County had 39 weeks of "exceptional drought" conditions (City of Spartanburg, 2011), and reservoirs dropped to historic low levels during this time (Tuck, 2015). Spartanburg believes it is probable they will be exposed to long-lasting future drought events (City of Spartanburg, 2011), and Spartanburg Water expects future regional droughts to increase in frequency and severity, with greater variability in precipitation (U.S. EPA, 2011).

Future droughts that increase in frequency and severity can affect wastewater system operations, including

12. Dry; D1 is Moderate Drought; D2 is Severe Drought; D3 is Extreme Drought; and D4 is Exceptional Drought.

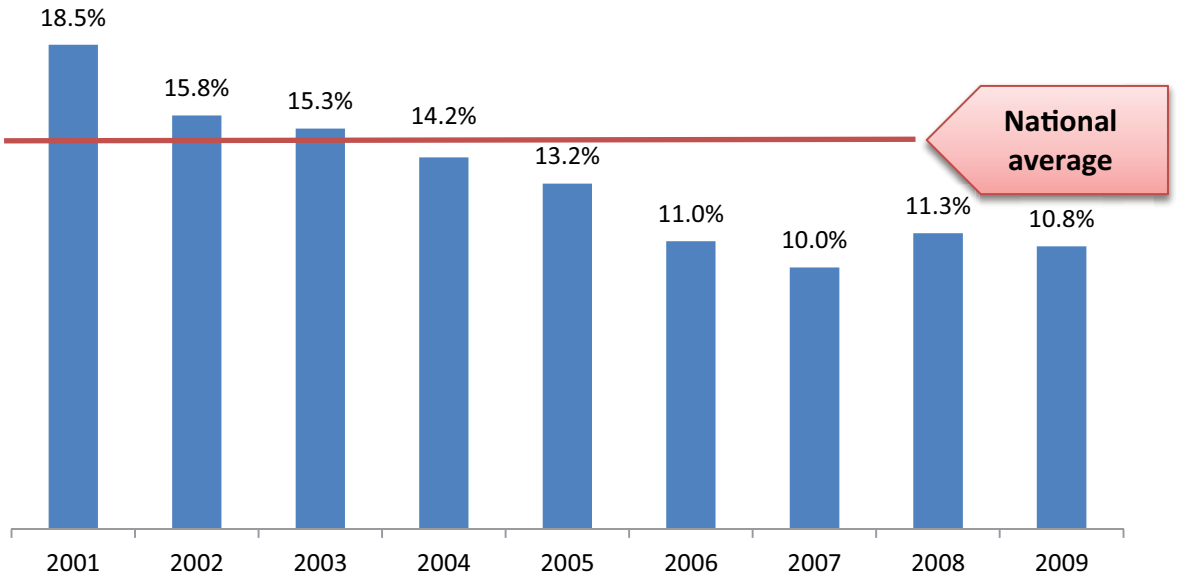


Exhibit 2. Spartanburg Water's conservation efforts reduced its unaccounted-for water to below the national average.

Source: Spartanburg Water, Undated.

changes in water quality in outflow streams. Spartanburg Water discharges wastewater effluent from treatment plants into relatively small streams, and the wastewater discharges can be the majority of the streamflow during drought conditions (U.S. EPA, 2011; West, 2015). In general, water quality in these small streams can decline under drought conditions because pollutants become more concentrated as less water is available to assimilate the pollutants. These conditions can restrict the amount of wastewater the utility can discharge, as its permit requires that in-stream water quality be maintained at specified levels to ensure the protection of human health and local fish populations (U.S. EPA, 2011). As future predictions of longer-lasting and intense droughts are a part of Spartanburg's climate reality, Spartanburg Water has analyzed scenarios where lower stream flows and poorer water quality may impact the discharge permits of its most strategic wastewater facility (West, 2015). Spartanburg Water is fortunate that its largest wastewater facility discharges to the Pacolet River, which is influenced by required water releases from Spartanburg Water's reservoirs upstream of this wastewater discharge (West, 2015). As a result, Spartanburg Water can plan for future extreme drought conditions because it understands how controlled releases from its reservoir will support the wastewater discharges from its treatment plants to help dilute pollutants and ameliorate water quality issues (U.S. EPA, 2011; West, 2015).

Spartanburg Water is also focused on saving water in its day-to-day operations, because drought can limit water quantity available to the utility. For example, the utility is aggressively pursuing the detection and resolution of water leaks in its system. The utility surveys its system for every five years using an electronic leak detection system. It also uses automated paging systems and other technologies to alert the utility about needed repairs. This helps ensure that small leaks do not escalate into expensive and wasteful breaks. Spartanburg Water also helps customers identify leaks in their homes and businesses through the installation of automatic meter reading (AMR) technology on meters in areas with old infrastructure. As a result of these actions, Spartanburg Water reduced unaccounted-for water from 18 percent in 2001 to approximately 11 percent in 2009 (Exhibit 2; Spartanburg Water, Undated).

Inland Flooding

According to Spartanburg County's Hazard Mitigation Plan, flooding events represent a moderate risk to the county (City of Spartanburg, 2011). Between 1950 and 2011, Spartanburg County experienced 65 flooding events, with property damage exceeding $24 million (2011 dollars; City of Spartanburg, 2011). During high rain events, Spartanburg can experience four times normal flows in some parts of its wastewater collection system (West, 2015), which can lead to higher flood risks to the community and damage key components of Spartanburg Water's facilities. Specifically, during intense rain and flooding events, wastewater pump stations can become flooded and portions of wastewater treatment facilities, because they are often located close to streams and in lower elevations, can also become flooded. In May 2007, Spartanburg Water experienced flooding in portions of its wastewater treatment facilities (West, 2015). In addition, during flooding events, erosion can expose water and wastewater lines that then fail or break because they are no longer structurally supported or because fast floating debris collides with them. Spartanburg Water regularly experiences breaks in its water and wastewater lines (West, 2015). To better manage impacts from infiltration and inflow during future flood events, Spartanburg Water is upgrading pipes in its wastewater collection system and, in some areas, leaving the old piping in place rather than closing it off (West, 2015). During high periods of infiltration and inflow, overflow can travel from the newer pipes to the old pipes, providing additional flow capacity. This gives the utility greater flexibility in managing wastewater during storms, and reduces the risks of sanitary sewer overflows (SSOs) and flooding for the utility and its customers. This increased flexibility is also highly relevant under future climate change, where intense precipitation events may become more frequent and intense (U.S. EPA, 2011; West, 2015).

Droughts and Flooding Combined

While droughts and floods can pose independent problems for Spartanburg Water, their combination can also exacerbate water taste and odor problems (West, 2015). High water temperatures, turbidity, and nutrient enrichment can increase levels of geosmin, a naturally occurring compound produced by soil bacteria and blue-green algae, which affects water taste and odor (Journey and Arrington, 2009). Spartanburg Water experienced a high level of geosmin from 2003 to 2005, when the region experienced tropical storms followed by drought (U.S. EPA, 2011). Because droughts and flooding are expected to increase in frequency and severity, the utility also expects that climate change will exacerbate geosmin water quality problems. Geosmin events have important financial implications: Rebecca West estimated that it can cost around $10,000–$20,000 per week to treat water and maintain customer service levels during a geosmin event (West, 2015). Spartanburg Water has established a monitoring system to predict when geosmin events might occur; however, additional management interventions may be required as climate change affects geosmin events.

Climate Change Awareness Raised among Spartanburg Water's Staff

Spartanburg Water encourages staff to participate in learning events, such as conferences, committees, and pilot programs. These learning events helped raise staff's awareness of climate change, as well as other related subjects. In particular, the utility's engineering and technical group—led by Rebecca West, Spartanburg Water's Chief Operating Officer—engaged in these learning events. This experience became the catalyst for the utility to recognize climate change as an issue and begin to incorporate climate change considerations into its programs and activities (West, 2015).

Participation in Conferences and Committees

Spartanburg Water encourages staff engagement in water conferences and committees, utility councils, and professional delegations. Through these experiences, utility staff members learn about the current research on climate change projections and how these projections might affect water utilities. These experiences also provide staff with an opportunity to network with other utilities "impacted by extreme events and learn about how they deal with the impacts" (West, 2015). For example, after Hurricane Katrina, Ms. West talked with affected water utilities to learn about the challenges they faced during and after the hurricane and how they

overcame these challenges or what lessons they learned from these challenges. Through this process, she learned that several utilities were struggling to repay loans on facilities that were completely destroyed by the hurricane. Based on this knowledge, she implemented a screening process for all new Spartanburg Water capital improvement projects that forced the utility to consider if "Spartanburg Water can pay for the project in 15 to 20 years, instead of the typical 30 year timeframe for utility investment projects" (West, 2015).[13] According to West (2015), this small action begins to prepare the utility financially for future extreme events and supports its resiliency to future climate change impacts.

> **Participation in committees and conferences is "one of the things that helps the light bulb go off."**
>
> REBECCA WEST

Spartanburg Water staff members who attend water conferences or networking events are asked to report back on information and lessons learned to share findings with other staff; this disseminates the information, including climate change information, to a broader range of staff (West, 2015).

CREAT Vulnerability Pilot Tool

Spartanburg Water began working with the EPA on its Climate Resilience Evaluation & Awareness Tool (CREAT) in 2010 and was a pilot community in 2015 (West, 2015). The CREAT tool allows utilities to evaluate the potential impacts of climate change on its water and wastewater services and to evaluate adaptation options to address these impacts using both traditional risk assessment and scenario-based decision making. Spartanburg Water decided that it was important to engage with CREAT because it witnessed how other utilities across the United States and "close to home" were severely impacted by climate vulnerability such as the effect of Hurricane Katrina on New Orleans, the effect of severe flooding on Nashville; and the effect of the extended droughts of 2002 and 2007–2009 on the Southeastern U.S. As Spartanburg Water better understood its potential "climate future," as identified by the scenarios in CREAT, it began to plan for the potential impacts from future climate change (West, 2015). This planning was holistic in nature and was incorporated in Spartanburg Water's Strategic Plan, Capital Plan, Financial Plan, and design aspects for its facilities and collection and distribution system (West, 2015). As climate change became incorporated in the key planning programs for the utility, it influenced how staff began to engage in planning and now it is another lens through which future projects are evaluated and developed (West, 2015). For example, in 2013, Spartanburg Water developed a Watershed Model of two of its most strategic watershed basins. The Watershed Model allows the utility to collect and analyze water flow and water quality information to determine what future potential impacts may be realized for its wastewater facility discharge permits (West, 2015). This model was developed as a planning tool for future wastewater facility upgrades and to help predict what impacts to water quality are being realized in these watersheds due to climate change and development (West, 2015).

Spartanburg Water Ensures Public Support through Outreach and Tailored Communication

Spartanburg Water invests time and effort into public education and outreach events. General information about watershed management and the urban water cycle is shared through Spartanburg Water recreational and community events. These include Paddlefest, an annual July event that incorporates water resource education with water games, and school educational classes, such as pontoon classrooms where students help with reservoir water sampling on pontoon boats (West, 2015).

During droughts, public outreach is an essential component of the utility's water conservation program. Spartanburg Water partnered with EPA WaterSense, a program that provides information on products and services to consumers to make smart water choices that save money and reduce water use without compromising performance, to customize WaterSense publications

13. This screening process that ensures all new capital improvement projects under consideration meet the utility's mission and integrate climate change also considers: if the project currently meets defined service levels and if the project will help Spartanburg Water be more resilient to climate impacts (West, 2015).

for utility customers. Publications include basic information on household water usage, the best time of day to undertake water-intensive activities, and how to improve water efficiency by replacing bathroom sink faucets and toilets and by implementing advanced irrigation technologies. In addition, Spartanburg Water's education and outreach program also targets different economic sectors in the community, particularly the emerging manufacturing industry.

According to Rebecca West, Spartanburg Water makes a conscious effort to tailor its communication to its audience. When communicating with the public, Spartanburg Water does not use climate change language. Rebecca West found that talking about immediate and future impacts from droughts and flooding is a more effective way of discussing climate change with the public rather than using the term "climate change" which can alienate some individuals.

Accomplishments of Incorporating Climate Change into Programs and Activities

Spartanburg Water's efforts to integrate climate variability and change into its existing programs and activities are nascent. As these efforts are expanded, Spartanburg Water hopes to further reduce vulnerability to drought and inland flooding events. When asked if the work to date has helped Spartanburg Water reduce its vulnerability to climate change, Rebecca West indicated that Spartanburg Water now understands the capabilities of its water and wastewater treatment facilities and has a process for assessing the performance of these facilities and adapting to changing circumstances as necessary (West, 2015). She added that "the Spartanburg region experienced several storms in recent years and during these events, Spartanburg Water was never out of service." Ken Tuck indicated that "Spartanburg Water is a model for other utilities."

> **"When I'm speaking to the … public, I talk about storm events and droughts. If I call it 'climate change,' ears turn off. It's still very visceral, so we've learned to talk around it."**
>
> REBECCA WEST

Spartanburg Water uses key performance indicators (KPIs) to quantify the performance of its work (Tuck, 2015; West, 2015). These include indicators that address components of vulnerability, including indicators for asset management (e.g., the performance of facilities and interruption of service), indicators for financials (e.g., debt ratio), and indictors for significant events (e.g., the number of contamination and rainfall events; West, 2015). The utility has considered bundling several KPIs to develop and track a "vulnerability" indicator, but has not yet developed such an indicator (West, 2015).

Moving Forward

Spartanburg Water will continue to integrate climate variability and change into its programs and activities as well as its culture. For example, the utility will continue to upgrade pipes in its wastewater collection system, increasing resiliency and redundancy by interconnecting the old piping with new pipes for extreme rain events. Spartanburg Water will also begin this process for its water and wastewater treatment system. In addition to engaging in innovative approaches and continuing its

use of advanced technology, Spartanburg Water is also committed to building a culture of resilience through developing policies that prepare for the future and making wise investments that increase resilience.

Acknowledgements

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- **Mr. Ken Tuck,** Spartanburg Water.

Bibliography

City of Spartanburg. 2011. Spartanburg County Hazard Mitigation Plan Update. Prepared by Atkins North America, Inc.

Journey, C.A. and J.M. Arrington. 2009. Taste and Odor Occurrence in Lake William C. Bowen and Municipal Reservoir #1, Spartanburg County, South Carolina. United States Geological Survey, United States Department of the Interior. Prepared in Cooperation with Spartanburg Water. Fact Sheet 2009-3043. June 2009.

Spartanburg Water. 2014. Strategic Plan 2014.

Spartanburg Water. 2015a. History of Spartanburg Water, Spartanburg Water. Accessed May 27, 2015. Available at http://www.spartanburgwater.org/history-of-spartanburg-water.

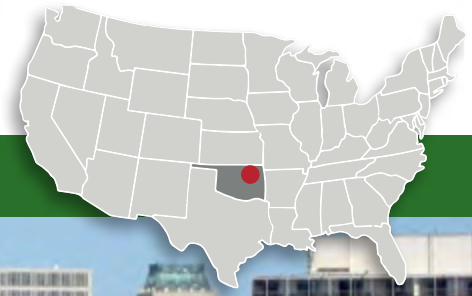
Spartanburg Water. 2015b. About Spartanburg Water, Spartanburg Water. Accessed May 27, 2015. Available at http://www.spartanburgwater.org/about-spartanburg-water.

Spartanburg Water. Undated. Spartanburg Water Works to Save Water! Brochure.

Tuck, K. 2015. Interview with Ken Tuck, Director of Water Treatment, Spartanburg Water. April 8, 2015.

U.S. EPA. 2011. Climate change vulnerability assessments: four case studies of water utility practices. Global Change Research Program, National Center for Environmental Assessment, U.S. Environmental Protection Agency, Washington, DC; EPA/600/R-10/077F.

West, R. 2015. Interview with Rebecca West, Chief Operating Officer, Spartanburg Water. April 8, 2015.



Tulsa, Oklahoma

Acquisition and Relocation

TULSA, OKLAHOMA

AUTHORS: Heather Hosterman and Jason Vogel

In this case study, you will learn about:

- Reducing vulnerability through an acquisition and relocation program
- Leveraging of extreme events to build motivation for action
- Importance of building partnerships and identifying champions to generate buy-in
- Value of pre-planning efforts to develop public information and strategies

Case Study Summary

The City of Tulsa is located along the Arkansas River in northeastern Oklahoma. After years of experiencing losses from flooding, the City of Tulsa began to advance comprehensive floodplain management along tributary streams.[14] One of the city's floodplain management programs is its acquisition and relocation program. This program consists of acquiring repeatedly flooded properties, removing or relocating buildings on those properties, and converting properties for public use, like parks. Since the 1970s, the City of Tulsa has acquired over 1,000 repeatedly flooded properties (Patton, 2009). Since the program's inception, the city has experienced several flooding events without any major flooding in program areas.[15] Although the City of Tulsa historically did not consider climate change, the community is now considering more frequent and severe future hazard events as it moves forward.

The Broader Context of Vulnerability Reduction from Inland Flooding in Tulsa, OK

Historically, the City of Tulsa experienced frequent and often devastating flooding events. Major flooding disasters produced some management changes. For example, after the 1923 flood, Tulsa preserved 2,800 acres of open-space in the Bird Creek floodplain; after the 1943 flood, the U.S. Army Corps of Engineers (Corps) developed the Arkansas River levee system to protect Tulsa's oil refineries; and after the 1957 and 1959 floods, the Corps built the Keystone Dam upstream of Tulsa on the Arkansas River (Patton, 2009). Flooding events in the 1970s and 1980s motivated community members to begin to think holistically about flood management instead of implementing intermittent actions. A community group, described in greater detail below, advocated for a comprehensive flood management system that included extensive flood maps, acquisition and removal of repetitively flooded property, ending new development in flood-prone areas, installing remedial works that hold and convey stormwater, and establishing a stormwater utility fee on water bills to create a funding stream for the maintenance and management of the flood control regulations. This case study focuses on the City of Tulsa's acquisition and relocation program for repeatedly flooded properties. However, the success of the acquisition and relocation program is contingent on the full suite of flood control regulations. As such, this case study touches on several aspects of Tulsa's comprehensive floodplain management system. In addition, we provide additional information about the history of flooding in Tulsa and the critical role of the community in implementing the suite of flood control regulations.

Why and How the City of Tulsa Acquired and Removed Repeatedly Flooded Properties

Several factors led to the City of Tulsa's acquisition program, including a history of flooding that built motivation for action, the community mobilizing to take action, the creation of regulatory flood maps to target acquisition, and marketing the acquisition program. These factors are described below individually, however the timing of these factors often overlapped. This case study focuses on key events from the 1970s through the 1980s. Exhibit 1 shows the timeline of these factors and the acquisition and removal of repeatedly flooded properties.

History of Flooding Builds Motivation for Action in Tulsa

Situated along the Arkansas River, the City of Tulsa was regularly flooded by catastrophic rainfall events (Exhibit 1). As the city urbanized in the 1950s and 1960s, buildings were constructed on flood-prone land. In particular, the Mingo Creek watershed underwent rapid development during this time (City of Tulsa, Undated). Flooding events of the 1970s and 1980s caused significant damage in the City of Tulsa, and motivated the community to begin to think holistically about flood control measures (Patton, 1993). Much of the flood damage during this time occurred in the Mingo Creek watershed, which "drains about one-third of the city but has accounted for about two-thirds of the city's flood damages" (Patton, 1993, p. 2).

14. This case study focuses on the City of Tulsa's comprehensive flood management program along tributary streams. This program has not yet focused on improving the local management program for the Arkansas River.

15. The City of Tulsa has not had a 100-year or 1 percent flooding rainfall event since 1984. The Tulsa metro area has experienced 1 percent rainfall intensities several times; however, due to the short duration of these rainfall events, they have not been classified as a 1 percent flooding event.

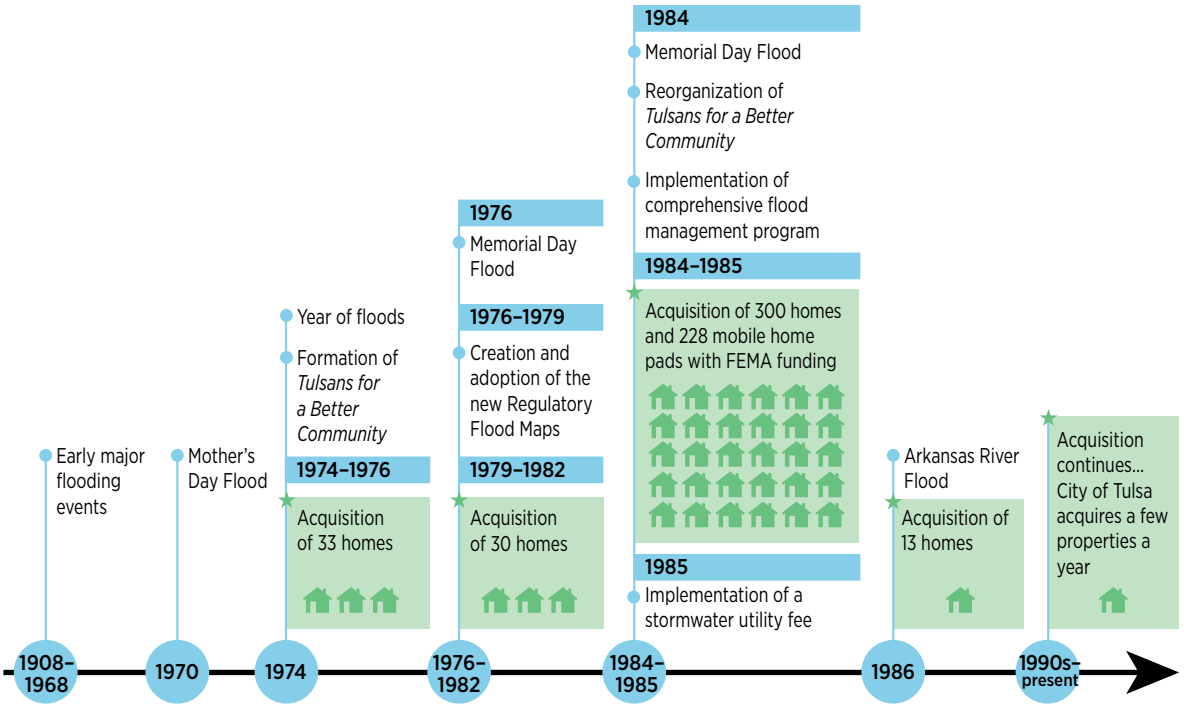


Exhibit 1. Tulsa timeline of flooding and actions taken.

The 1974 Year of Floods and the 1976 Memorial Day Flood were instrumental in mobilizing the community to action and beginning to motivate the City of Tulsa to move beyond redevelopment of affected areas to enact flood regulations (Patton, 2014). Through the course of these flooding events, 3 people were killed, 120 people were injured, and significant damage to homes and buildings occurred (City of Tulsa, Undated; Patton, 1993, 2009).

The 1984 Memorial Day Flood was the city's worst flooding event: 14 people were killed, 288 people were injured, and 6,800 homes were damaged (Flanagan & Associates, 2009; Patton, 2009). This flood became a catalytic event in advancing a comprehensive flood management program along the tributary streams that included the acquisition of repeatedly flooded properties (Patton, 2014). Without Tulsa's history of flooding, implementing comprehensive flood regulations along the tributary streams, including the acquisition program, would have been very difficult if not impossible (Flanagan, 2014).

Community Mobilizes to Take Action

After the June 1974 flood, Carol Williams, a Mingo Creek flood victim, convened a neighborhood meeting in her flooded living room with other Mingo Creek citizens who suffered from repeated flooding (Patton, 2009). This neighborhood group, called Tulsans for a Better Community, quickly became an effective advocacy group for flood control (Patton, 2009). The group promoted four key messages (Patton, 2009):

- Stop building in the floodplain
- Clear out flood-prone buildings
- Install channels and detention ponds
- Involve citizens at every point.

> **"I don't think you can overemphasize…the impact of [the 1984 Memorial Day] flood. …everyone remembers that flood."**
>
> GRAHAM BRANNIN, CITY OF TULSA

Tulsans for a Better Community drew support from across the city, including from Ann Patton, who was at the time a reporter for the *Tulsa World* newspaper; Ron Flanagan, a planning consultant; and J.D. Metcalfe, a respected businessman in Tulsa and later a city commissioner.[16] These community members, in addition to several other key players, became the champions of the comprehensive flood management program along tributary streams. Following the 1974 and 1976 flooding events, Tulsans for a Better Community advanced several flood control measures: the City of Tulsa acquired 63 repeatedly flooded properties, including 33 properties following the 1974 Year of Floods and 30 properties following the 1976 Memorial Day Flood (City of Tulsa, Undated; Patton, 1993, 2009).

According to Ron Flanagan and Ann Patton, *Tulsans for a Better Community* faced significant opposition from pro-development interests, particularly the Home Builders Association, who viewed flood-control measures as anti-development (Patton, 2009, 2014; Flanagan, 2014). In 1978, pro-development interests were successful in electing a pro-development commission, including Senator Inhofe as mayor of the City of Tulsa (Flanagan, 2014). This commission relaxed regulations in the late 1970s and early 1980s (Patton, 2009). However, a change in political power in 1984 which brought in newly elected officials sympathetic to flood victims, and the occurrence of the 1984 Memorial Day Flood, which was Tulsa's worst flooding event to date, suppressed the opposition (Patton, 2014).

After the 1984 Memorial Day Flood, Tulsans for a Better Community quickly re-organized and began to take action (Patton, 2009). The community was successful in using the 1984 Memorial Day Flood to advance a comprehensive flood management program along tributary streams because of: (1) the established partnerships among grassroots citizens, technical experts, and public sector officials; and (2) the community's previous work in developing and advocating for sophisticated solutions to flood mitigation (Patton, 2014). Once the flood occurred, the community was able to "seize [the] moment and execute bold plans" (Patton, 2009, p. 89).

City of Tulsa Creates Regulatory Flood Maps to Target Acquisition

After the 1974 and 1976 flooding events, the City of Tulsa recognized that the National Flood Insurance Program's (NFIP's) minimum floodplain standard was insufficient (City of Tulsa, Undated), and instead developed more extensive maps that: (1) consider forecasts of fully urbanized watershed development conditions; (2) extend the regulations watershed-wide, which widens and lengthens the regulatory flood maps along tributary streams; and (3) use stormwater detention ponds to detain stormwater and slowly release it downstream (Patton et al., 2010). The City of Tulsa Regulatory Floodplain Maps exceed U.S. Federal Emergency Management Agency (FEMA) minimum regulations. These maps provide public information about flood hazard areas, help the city to regulate development permits and freeboard requirements, and have been used by the city to identify and target properties for acquisition and clearance. The city targeted acquisition of areas that were most exposed to flood damages and incurred repetitive losses and flood insurance claims.

City of Tulsa Markets the Acquisition Program

To move the acquisition program from conception to implementation, the City of Tulsa needed to ensure homeowner participation and persuade FEMA to fund the program.

City of Tulsa Structures the Program to Incentivize Participation and Ensure Sustainability

According to Tim Lovell, Ron Flanagan, and Bill Robison, the acquisition program is voluntary. The City of Tulsa made the program attractive by paying homeowners the

16. Many people were pivotal in championing this program. We call out only three project champions in this case study because several interviewees mentioned them by name.

pre-flood market value of homes, allowing residents to live 30 days rent-free in their homes, paying relocation costs, and providing a $1,000 stipend if the homeowner moved outside of a floodplain. According to interviewees, most homeowners supported the program because of the city's sincerity in the purchase of repeatedly flooded properties.

The city recognized the need to make acquired properties multi-use so that public and private interests would remain committed to maintaining acquired properties and to not developing these properties in the future (Flanagan, 2014). Acquired properties throughout the City of Tulsa include walking and bicycling trails, picnicking facilities, and parks and greenways. It is worth noting that some of this acquired land now faces considerable development pressure and the land can technically be developed by the city or by others if sold by the city.

A stable, long-term funding source was essential to ensure the sustainability of the City of Tulsa's comprehensive flood management program along tributary streams, including the acquisition program (Patton, 2014; Robison, 2014). Within two years of the 1984 Memorial Day Flood, the City of Tulsa instituted a stormwater utility fee on water bills. This fund currently charges residents $5.92 per month and commercial, multi-family, or industrial facilities $5.92 per month per Equivalency Service Unit[17] (Robison, 2014). These funds provide approximately $24 million annually to the City of Tulsa; this funding is used for planning processes, acquisition of repeatedly flooded properties, maintenance of existing facilities, small drainage projects, and as a match for federal grants (Flanagan, 2014; Robison, 2014).

City of Tulsa and FEMA Develop a Unique and Innovative Method to Fund the Program

The City of Tulsa worked closely with The Federal Emergency Management Agency (FEMA) to develop a unique funding approach to an acquisition program. To help convince FEMA of the value of this program, the community used a benefit-cost analysis—on some occasions, FEMA paid out over $100,000 to repair a repetitive loss property valued at approximately $30,000 (Robison, 2014). The City and FEMA shared the cost of the acquisitions such that the City ended up paying somewhere between 33 percent and 50 percent of the project costs. (Patton, 1993). The City and FEMA worked together to ensure that project benefits exceed the cost of acquisition, demolition, and restoration of a structure.

Accomplishments of the Acquisition Program

Since the 1970s, the City of Tulsa has acquired over 1,000 repeatedly flooded properties (Patton, 2009). This program, in combination with other flood management regulations, has effectively reduced flood damage during high precipitation events. Since the program's inception, the city has experienced several 10- to 20-year flooding events without any major flooding in program areas; the city has not experienced a 100-year (i.e., a flood with a 1 percent probability of occurrence in any given year, also known as a "1 percent flooding event") in the Tulsa metro area since the 1984 Memorial Day Flood (see footnote 15), which would fully test the hazard mitigation program. Although the City of Tulsa has not experienced a 1 percent flooding event in the last 30 years, the city expects that its comprehensive flood management program, along tributary streams, would reduce the extent of damages caused by a 1 percent flooding event and likely reduce damages caused by a 500-year (i.e., a 0.2 percent flooding event; Robison, 2014). During the May 2015 flooding events, surrounding communities who have not adopted Tulsa's stringent flooding standards experienced significant flooding damages, whereas Tulsa experienced minor flooding (Flanagan, 2014). Interviewees generally feel that the city has successfully mitigated flooding.

The individuals we interviewed discussed several other indicators of the program's success:

- FEMA's NFIP Community Rating System (CRS) rates the City of Tulsa as a Class 2 Community, which provides Tulsans with some of the lowest flood insurance rates in the United States (Flanagan & Associates, 2009).
- In 1998, FEMA selected the City of Tulsa for a three-year Project Impact grant, which aimed to create public-private community partnerships for multi-hazard mitigation. The grant program included flooding,

17. An Equivalency Service Unit is the projected annual cost of maintaining 2,650 square feet of impervious property area (City of Tulsa, Undated).

as well as other extreme hazard events, such as extreme temperatures, tornadoes, and terrorism. The Project Impact grant resulted in the creation of Tulsa Partners, Inc., a nonprofit that fosters public/private partnerships to continue to advance multi-hazard mitigation and build a disaster-resistant, sustainable community (Lovell, 2014).

- The City of Tulsa is one of the 10 charter cities in the Natural Hazard Mitigation Association's Resilient Neighborhood Network (RNN). The RNN "link[s] together and build[s] cooperative grassroots communities learning and working to become safer, disaster-resilient, and sustainable" (Natural Hazard Mitigation Association, 2012, p. 1).
- The City of Tulsa was recently selected to join the Rockefeller Foundation's 100 Resilient Cities initiative, which is an outgrowth of the work described in this case study and will involve building off of existing and new partnerships to make the City of Tulsa more resilient (100 Resilient Cities, 2014).

According to interviewees, the City of Tulsa is a model for other communities trying to reduce vulnerability to inland flooding. Since the 1970s, many communities have used acquisition and removal or relocation of repeatedly flooded properties and the stormwater utility fee program as tools to reduce vulnerability to inland flooding. For example, following the Great Flood of 1993, the towns of Valmeyer (Illinois), Pattonsburg (Missouri), and Rhineland (Missouri) relocated their towns out of the floodplain (Stafford, 1998).

Moving Forward

As indicated above, the City of Tulsa has not experienced a large flooding event since the 1984 Memorial Day Flood. Interviewees indicated that because of this, many people are beginning to disregard flooding as a potential hazard. In addition, there is renewed interest in redeveloping open spaces and parks that have been dedicated to flood mitigation (Flanagan, 2014). In May 2015, flooding in Oklahoma resulted in only minor street flooding in Tulsa and significant flooding for neighboring communities who have not implemented stringent flood control regulations. Interviewees indicated that the lack of major flooding in the City of Tulsa confirmed some elected officials' feelings that Tulsa solved their flooding problems; as such, elected officials are now focused on other priorities, including streets, water, sewer, police and fire protection.

Interviewees believe that public information and education is now the key to ensuring that the public and private sectors are prepared for future extreme weather events, especially as the frequency and severity of future hazard events increases with climate change. As Ann Patton indicates, "the work is never done, the battle for wise floodplain management is never over, we must continue…" (Patton, 2014). Tulsa Partners is involved in several public information and education efforts; three of these efforts are described in more detail below.

City of Tulsa Program for Public Information

To increase public education on multi-hazard preparedness, Tulsa Partners, Inc. is working with the City of Tulsa's stormwater experts to create an outreach strategy that ensures that members of the public have the information and tools they need to reduce vulnerability to future extreme events. The outreach strategy is documented in the City of Tulsa Program for Public Information (PPI), which was adopted by the City Council and Mayor in December 2014, and is updated annually. The PPI stresses the importance of making sure Tulsans are not "lulled into a false sense of security that could make them vulnerable to unexpected tragedy" (City of Tulsa, 2014, p. 3). Having a PPI also allows the City of Tulsa to receive bonus points for outreach projects and public information activities eligible for credit under the FEMA NFIP/CRS (NFIP/CRS, 2014).

According to the PPI, the City of Tulsa is vulnerable to flooding and dam or levee failure events (City of Tulsa, 2014). The PPI requires that the City of Tulsa identify and track outreach projects on key messages such as, "Know your risk of flooding," and "What are your options if you live in a repetitive loss property?" (City of Tulsa, 2014, p. 13). Under this program, the city must track the number of times these key messages are disseminated, as well as which target areas or audiences are using various

outreach projects. It also requires outcome-based measurements that are to be tracked over time to show the effectiveness of the messaging. Target areas and audiences tracked include: areas subject to flooding by levee failure, areas subject to repetitive loss properties, areas within City Regulatory and Special Flood Hazard Areas, and vulnerable populations. For the PPI, the definition for vulnerable populations is consistent with the 2014 City of Tulsa Multihazard Mitigation Plan, and includes the elderly; people in poverty; people who speak a language other than English; people with mobility, hearing, visual or other physical disabilities; people with developmental or other cognitive disabilities; people with no access to private transportation; people with medical needs or medical/life support devices; and people with pets (City of Tulsa, 2014, p. 5). Exhibit 2 describes one project associated with the PPI that focuses on vulnerable populations. The PPI is overseen by a committee under the auspices of the City of Tulsa Stormwater Drainage and Hazard Mitigation Advisory Board.

EXHIBIT 2. REDUCING VULNERABILITY UNDER THE CITY OF TULSA PROGRAM FOR PUBLIC INFORMATION

Tulsa Partners is working on a project in conjunction with the Oklahoma Silver Jackets, the City of Tulsa, and Tulsa County to better understand how perceptions of flood risk affect personal preparedness efforts, as well as general understanding of flood risk, in two separate vulnerable areas located behind local levees. The residents of these areas are vulnerable both because of their high-risk of flood events as well as the high rates of poverty and residential turnover. With more extreme weather patterns occurring more frequently, these areas could be particularly hard-hit. This project, which is a part of a larger citywide PPI, is the first in a series of public information and education efforts that will serve to mitigate the larger danger of a flood event.

Source: Tulsa Partners.

According to Tim Lovell, the eventual goal is to expand the PPI to include other hazards identified in the City of Tulsa Multi-Hazard Mitigation Plan, such as such a wind and hail, because they may increase with climate change (Lovell, 2014). This is consistent with FEMA requirements to "...include a summary of the probabilities of future hazard events as well as changing future conditions" in future Multihazard Mitigation Plans (FEMA, 2015).

Tulsa Partners' Language & Culture Bank

The Language & Culture Bank is a communications and outreach effort that provides a vehicle for people with cross-cultural communication skills to assist community agencies in providing information to vulnerable populations that may not be able to obtain the information because of language or cultural barriers.[18]

Tulsa Partners' A Day Without Business

Tulsa Partners works with businesses to develop business continuity plans that ensure continued operations of a business when affected by adverse events, such as flooding. As part of this effort, Tulsa Partners holds the recurring "A Day Without Business" symposium after high-profile events, such as following Hurricane Katrina, to increase business preparedness for extreme events. These symposia and other workshops are overseen by Tulsa Partners' Disaster Resistant Business Council.

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- **Mr. Ron Flanagan,** Flanagan & Associates, LLC
- **Mr. Bill Robison,** City of Tulsa
- **Mr. Graham Brannin,** City of Tulsa.

18. For more information about Tulsa Partners Language & Culture Bank, see http://tulsapartners.org/tpi/tulsa-language-culture-bank/.

Bibliography

100 Resilient Cities. 2014. Tulsa's Resilience Challenge. Rockefeller Foundation. Available: http://www.100resilientcities.org/cities/entry/tulsa. Accessed December 29, 2014.

ACS. 2012. American Community Survey. American FactFinder. Available: http://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml. Accessed August 19, 2013.

Brannin, G. 2014. Interview with Graham Brannin, Planning and Intergovernmental Administrator, City of Tulsa. October 15.

City of Tulsa. 2014. City of Tulsa Program for Public Information. R.D. Flanagan & Associates and Tulsa Partners. December 2014.

City of Tulsa. Undated. Flood Control and Drainage. Available: https://www.cityoftulsa.org/city-services/flood-control/flooding-history.aspx. Accessed November 5, 2014.

FEMA. 2015. Hazard Mitigation Planning Frequently Asked Questions. Federal Emergency Management Agency. Available at https://www.fema.gov/hazard-mitigation-planning-frequently-asked-questions. Accessed August 21, 2015.

Flanagan & Associates. 2009. Multi-Hazard Mitigation Plan—2009 Update. City of Tulsa.

Flanagan, R. 2014. Interview with Ron Flanagan, Principal at Flanagan & Associates, LLC. October 15.

Flesher, J. 2014. City Planners avoid politics of 'climate change' label, saying they just want to 'get ready.' Associated Press. September 10.

Liu L., Y. Hong, J. Hocker, M. Shafer, L. Carter, J. Gourley, C. Bednarczyk, B. Yong, and P. Adhikari. 2012. Analyzing projected changes and trends of temperature and precipitation in the southern USA from 16 downscaled global climate models. Theoretical and Applied Climatology 109(3–4):345–360.

Lovell, T. 2014. Interview with Tim Lovell, Executive Director at Tulsa Partners, Inc. October 15.

Natural Hazard Mitigation Association. 2012. Resilient Neighbors Network, Framework Plan. Plan prepared by Resilient Neighbors Network Steering Committee and Natural Hazard Mitigation Association. Plan supported by Emergency Management Agency, the Federal Insurance and Mitigation Administration, and Natural Hazard Mitigation Association's Blue Ribbon Advisory Team. December 31.

NFIP/CRS. 2014. Developing a Program for Public Information for Credit under the Community Rating System of the National Flood Insurance Program. National Flood Insurance Program/Community Rating System. Available at http://crsresources.org/files/300/developing_a_ppi_for_credit_under_the_crs_2014.pdf. Accessed September 10, 2015.

NOAA. 2015. Tulsa, Oklahoma Total Monthly and Yearly Rainfall. National Weather Service Weather Forecast Office, National Oceanic and Atmospheric Administration. Updated: July 15, 2015. Available at http://www.srh.noaa.gov/tsa/?n=climo_tulyearrain. Accessed July 21, 2015.

Patton, A. 1993. From Harm's Way. Flood Hazard Mitigation in Tulsa, Oklahoma. December.

Patton, A. 2009. A Tulsa story: Learning to live in harmony with nature. In Global Warming, Natural Hazards, and Emergency Management, J.A. Bullock, G.D. Haddow, and K.S. Haddow (eds.). CRC Press, Boca Raton, FL.

Patton, A. 2014. Interview with Ann Patton, Professional Writer and Consultant. November 14.

Patton, A., J.K. Meshek, R. Flanagan, S. Hillman, M.L. Buchert, J. Page, D. Reynolds, and C. Williams. 2010. From Rooftop to River: Tulsa's Approach to Floodplain and Stormwater Management. City of Tulsa Stormwater Drainage Advisory Board and Public Works Department. Financial assistance provided by the Federal Emergency Management Agency, Oklahoma Department of Emergency Preparedness.

Qiao, L., Y. Hong, R. McPherson, M. Shafer, D. Gade, D. Williams, S. Chen, and D. Lilly. 2014. Climate Change and Hydrological Response in the Trans-State Oologah Lake Watershed—Evaluating Dynamically Downscaled NARCCAP and Statistically Downscaled CMIP3 Simulations with VIC Model. Water Resources Management 28(10):3291–3305.

Robison, B. 2014. Interview with Bill Robison, Lead Engineer, Stormwater Project Coordination, City of Tulsa. October 15.

Stafford, M. 1998. Uprooted town moves to higher ground after Midwest deluge of '93. Disaster: Government offered Pattonsburg, Mo., and other communities millions to move out of harm's way rather than remain in flood plain. Los Angeles Times. Associated Press. July 12. Available: http://articles.latimes.com/1998/jul/12/news/mn-2946. Accessed December 11, 2014.

Appendix A.
Key Definitions

Definitions for key terms we use in this report include:

Adaptation action — a policy, project, or program designed to reduce sensitivity or exposure to a climate vulnerability or to enhance adaptive capacity.

Adaptation professionals — the community of professionals from a variety of disciplines that focus on the issue of adapting to climate change

Adaptive capacity — "[t]he ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences" (IPCC, 2007, p. 869). While this definition of adaptive capacity is widely accepted, the literature is replete with additional perspectives about adaptive capacity that add value to any discussion of the concept. For example, the "assets"-based approach to adaptive capacity describes adaptive capacity as the availability of economic, technological, informational, natural, built, and social capital to adjust to or take advantage of climate impacts; this is highly relevant to many adaptation actions profiled in this report. However, it is also helpful to distinguish the need for developing "generic adaptive capacity" to address basic community development needs versus "specific adaptive capacity" to address clearly identified and delimited climate vulnerabilities (Eakin et al., 2014).

Climate adaptation — responses to climate variability, extreme events, and climate change.

Climate change — changes in climate variables and patterns of weather over time because of a warming of the Earth's atmosphere.

Climate impact — the effect experienced by a human or natural system as a result of climate variability, extreme events, or climate change, such as droughts, flooding, or sea level rise.

Community — a group of people living together in a common geographic area, typically under a municipal jurisdiction such as a city or county, but sometimes defined by a watershed or other geographic characteristic.

Community-based adaptation — the enterprise of reducing vulnerability to climate impacts at the community level.

Community-based champion — A person who catalyzes action to address current and future climate vulnerabilities. Typically a grass-roots organizer or a sustainability officer, city planner, emergency manager, elected official, or other public official involved in the day-to-day management of municipal affairs.

Exposure — people or assets in places that could be adversely affected by climate impacts.

Resilience — For this project, we avoid the term "resilience" even though it is broadly used in the climate adaptation field. This is because we view resilience narrowly as an element of adaptive capacity, or the ability to adjust to climate change. In other words, we subsume resilience under vulnerability for purposes of this project.

Sensitivity — "the degree to which a system is affected, either adversely or beneficially, by climate variability or change" (IPCC, 2007, p. 881). Sensitivity concerns what happens to a system once it is exposed to a climate impact.

Vulnerability — "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity" (IPCC, 2007, p. 883).

References

Eakin, H.C., M.C. Lemos, and D.R. Nelson. 2014. Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change* 27:1–8.

IPCC. 2007. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden, and C.E. Hanson (eds.). Cambridge University Press, Cambridge, UK.

Appendix B. Methods

This project was a two-year research effort conducted by Abt Associates[19] and funded by The Kresge Foundation. The goal was to conduct an empirical assessment of community-based adaptation through a project with methodological breadth and depth. To achieve this goal, we surveyed the field of climate adaptation through a review of selected technical and professional literature that aimed to evaluate the state of the practice. We supplemented this effort with interviews of 50 thought leaders from a variety of fields relevant to climate adaptation. This allowed us to understand where adaptation professionals felt the state of the practice was at. We then engaged in primary research: we conducted case studies of specific adaptation actions implemented in 17 United States communities. Our case study research incorporated site visits, archival reviews, and interviews in all 17 communities. A nine-person project team at Abt Associates conducted the research; three technical advisors and a 16-member project advisory committee provided critical input for this report.

Below, we discuss the six basic streams of research and analytical activity that we conducted to develop this report. Some of these activities took place in parallel, and all research activities were part of a reflexive, process-based approach to allow insights from any one analytical activity to inform and refine other analytical activities. For more detail on the assumptions and normative perspectives that framed this project, please see Chapter 1: Introduction. The activity streams discussed below sometimes occurred concurrently or iteratively. Their order is not meant to imply linearity or chronology in our research process.

Activity Stream 1: Understand Community-Based Adaptation State-of-the-Practice

To ensure that our work built on the ongoing progress in the field of community-based adaptation, we began by compiling a baseline of important community-based adaptation activities and issues. This was based primarily on a targeted literature review and a series of thought-leader interviews.

Our literature review focused on several notable efforts undertaken recently to assess the state-of-the-practice of climate adaptation, including National Research Council, 2010; Bierbaum et al., 2012; Carmin et al., 2012; Hansen et al., 2013; Thayer et al., 2013; and Melillo et al., 2014.

We also conducted 50 hour-long thought-leader interviews in early 2014 (see Appendix C for a list). The interviews were semi-structured and relied heavily on open-ended questions (see Appendix D), which typically elicited lengthy responses and in many cases resulted in highly productive conversations. After completing the interviews, we synthesized the responses related to: (1) community-based adaptation motivation, planning, and action; (2) barriers to adaptation; and (3) community engagement. See Appendix E for a summary of insights from thought leader interviews.

Activity Stream 2: Develop an Analytical Framework

Under this stream of activity, we constructed an overarching analytical framework to guide observations and to integrate insights and other findings from our compilation of research inputs. This aspect of our research and analytical approach was designed to be reflexive; that is, we recognized and intended that it would evolve over the course of the project.

19. The Kresge Foundation provided a grant for this project to Stratus Consulting Inc., which merged with Abt Associates during the project.

We developed an initial project framework to help the research team share a common conceptual orientation and to provide structure to initial research steps. This framework consisted of a set of key categories, including motivations for pursuing adaptation interventions, planning processes that support those interventions, and implementation activities. We used the framework to develop a semi-structured interview protocol for the thought-leader interviews in Activity Stream 1 and to develop the research protocol for case study development in Activity Stream 4.

The analytical framework evolved over the course of the project, in keeping with our reflexive research approach. Each manifestation of a framework for the project was informed by the evidence gathered up to that point; we made modifications to facilitate progress on the research project. For example, based on insights from the thought leader interviews, we revised the framework for case study selection; based on insights from case study selection, we revised the framework for case study research; and based on insights from the first pilot case studies, we revised the framework for later case studies.

Activity Stream 3: Obtain External Expert Guidance

To ensure that project outputs would be useful for community-based champions, salient for adaptation professionals, and grounded in the latest knowledge in the field, we sought a team of external experts in climate adaptation and related fields to provide input throughout the project and to critique each activity stream. We did this by engaging a project advisory committee (PAC) and using specialized technical advisors.

The PAC included nationally recognized experts from various fields related to community-based adaptation, including climate adaptation, natural hazards mitigation, planning, environmental justice, natural resource management, insurance, and community engagement and communications. The PAC was asked to contribute to and critique the project research approach, to provide guidance and feedback on case study selection, to review and critique project inputs and findings, and to assist in engaging audiences and communicating project outcomes. We met in person with the PAC three times over the course of the project to elicit and gather feedback, and held several webinar briefings to gather additional feedback. Our technical advisors provided review and technical advice on all project components and activity streams, including the project framework, the case study community selection process, our research methodology, early-stage case study outlines, draft case studies, project findings, our communications strategy, and the analysis and final report. Although the PAC and technical advisors provided ongoing advice throughout the project, including project design, conduct, and completion, the final responsibility for this project report, its conclusions, and its recommendations rest solely with the Abt Associates project team.

Activity Stream 4: Conduct Case Studies

To further ensure that project observations and findings were relevant and applicable to community-based champions, we developed case studies of vulnerability-reducing actions across a range of communities in the United States. We considered more than 110 potential community-based adaptation actions for full case study development, virtually all of which were identified through the thought-leader interviews. We used a range of criteria to winnow this list down to the 17 case studies included in this report (beginning on page 48). We sought to include a diversity of actions and approaches for reducing vulnerability to different types of climate impacts in communities that varied in geography, size,

Appendix B. (continued) Methods

socioeconomics, and political orientation. We aimed to explore the greatest number of cases studies possible in the greatest possible depth we could achieve, given available time and resources.

To ensure consistency in the collection of our case-based information, we developed a research protocol to help researchers systematically examine common enabling and limiting factors that can shape adaptation action. For each case study, a member of the research team conducted background research, project site visits, in-person interviews, and follow-up interviews via email or telephone. In this activity stream, we minimized researcher judgment as much as possible and attempted to reduce researcher bias through multiple rounds of internal research team, TA, and PAC reviews. The case studies were developed to capture the interviewees' perception of essential factors that shaped the development, implementation, and evaluation of the action.

Activity Stream 5: Compare Case Studies

We used information and observations gleaned from the first four activity streams to assess what was achieved at the community level, both in specific communities, as well as in aggregate across our portfolio of case studies. We also assessed how communities accomplished those achievements. We then engaged in multiple independent analytical activities to build on this record to assist and enable community-based champions, engage in an empirical assessment, and provide conclusions and tactical recommendations to assist adaptation professionals and community-based champions of climate adaptation. These activities included developing and testing qualitative cross-case narratives, surveying case study researchers for cross-case insights, and extensive analysis and review by the project team, our technical advisors, and the PAC. Ultimately, we developed Chapter 2: Case Studies and Cross-Case Findings based on this cross-case analysis. Our conclusions and recommendations emerge from this cross-case analysis as well as our selected literature review and thought leader interviews.

Activity Stream 6: Share Project Findings

We aimed to develop and communicate useful project outputs to community-based champions who could benefit from learning about good practices; we also wished to help advance the state-of-the-practice of climate adaptation. To support widespread dissemination of findings from this project, we are undertaking complementary communication efforts to reach our intended audiences. The key project outputs are this final report, the 17 case studies, and a companion project website. Additionally, we are focused on developing numerous webinars, professional conference presentations, and publications.

References

Bierbaum, R., J.B. Smith, A. Lee, M. Blair, L. Carter. F.S. Chapin III, P. Flemming, S. Ruffo, M. Stults, S. McNeely, E. Wasley, and L. Verduzco. 2012. A Comprehensive Review of Climate Adaptation in the United States: More than Before, but Less than is Needed. *Mitigation and Adaptation Strategies for Global Change.* Available: http://link.springer.com/article/10.1007%2Fs11027-012-9423-1#page-2.

Carmin, J., N. Nadkarni, and C. Rhie. 2012. Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey. Massachusetts Institute of Technology, Cambridge.

Hansen, L., R.M. Gregg, V. Arroyo, S. Ellsworth, L. Jackson, and A. Snover. 2013. The State of Adaptation in the United States: An Overview. A Report for the John D. and Catherine T. MacArthur Foundation. EcoAdapt.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

National Research Council. 2010. *Adapting to the Impacts of Climate Change.* The National Academies Press, Washington, DC.

Thayer, J., M. Rider, and D. Lerch. 2013. Resilient Against What?: How Leading U.S. Municipalities are Understanding and Acting on Resilience. Post Carbon Institute. October 16. Available: http://www.postcarbon.org/publications/resilient-against-what/. Accessed August 27, 2015.

Appendix C.
List of Thought-Leader Interviews

Exhibit C.1. List of interviewees, in alphabetical order

Name If applicable, includes names of other participants	**Organization**	**Expert area**
Adams, Steve	Institute for Sustainable Communities	Adaptation
Aggarwala, Rohit	Bloomberg and Columbia University; formerly Head of the New York City Office of Long Term Planning and Sustainability	Sustainability
Arroyo, Vicki and Jessica Grannis	Georgetown Climate Center	Law, adaptation
Becker, Bill	Soldier's Grove, DOE; formally worked with FEMA during Clinton Admin on Project Impact	Natural hazards mitigation
Berginnis, Chad	Association of State Floodplain Managers	Natural hazard mitigation, particularly flooding
Brunner, Ron	Department of Political Science, University of Colorado Boulder	Political science, adaptation
Chapin, Terry	University of Alaska	Native villages
Dillingham, Tim	American Littoral Society	Coastal restoration
Fitzgerald, Garret	Urban Sustainability Directors Network	Community networking
Fleming, Paul	Seattle Public Utilities	Water, community government, adaptation
Hector, Galbraith	National Wildlife Federation	Natural systems
Gillian, Nancy and Gwen Griffith	Model Forest Policy Program	Adaptation planning in rural/small localities
Graham, Tonya and Marni Koopman	GEOS Institute	Community-based adaptation
Grimm, Kristin	Spitfire Strategies	Communication
Haddow, George	Bullock & Haddow, LLC; formerly White House Liaison and Deputy Chief of Staff to FEMA under Clinton	Natural hazard mitigation
Hansen, Lara	EcoAdapt	Adaptation
Horton, Radley	Northeast Climate Science Center, Columbia University	Climate modeling
Johnson, Zoe	State of Maryland	Adaptation, state and local
Klima, Kelly	Carnegie Mellon University	Hazards mitigation
Kovacs, Paul	Property and Casualty Insurance Compensation Corporation	Adaptation, Canada
Laska, Shirley	University of New Orleans	Environmental justice

Exhibit C.1. List of interviewees, in alphabetical order

Name If applicable, includes names of other participants	**Organization**	**Expert area**
Lovell, Tim	Tulsa Partners	Natural hazard mitigation
McKenzie-Mohr, Doug	McKensie-Mohr & Associates, Inc.	Community-based social marketing
Meis, Kate	Local Government Commission	Mitigation and adaptation
Morello-Frosh, Rachel	University of California, Berkeley, Department of Environmental Science, Policy & Management	Environmental justice, public health
Moser, Susanne	Susanne Moser Research & Consulting	Adaptation
Murley, Jim	South Florida Regional Planning Council	Adaptation
Orr, David	Oberlin College, The Oberlin Project	Sustainability
Pastor, Manual	University of Southern California	Environmental justice
Patterson, Jacqui	NAACP	Environmental justice
Peterson, Sascha	ASAP; Adaptation International	Adaptation
Pike, Cara	Climate Access	Communication
Reeve, Kara	National Wildlife Federation	Community adaptation, natural systems
Rochman, Julie	Institute of Business and Home Safety	Insurance, natural hazard mitigation
Schwab, Jim	Manager of Hazards Planning Research Center at American Planning Association	Planning; natural hazard planning
Shepard, Peggy	WeAct	Environmental Justice
Simmons, Jill	City of Seattle	Sustainability
Steelman, Toddi	University of Saskatchewan	Community-based planning
Stein, Bruce	National Wildlife Federation	Community adaptation, natural systems
Stults, Missy	University of Michigan	Adaptation
Tabor, Gary	Center for Large Landscape Conservation	Natural systems
Thomas, Edward	President of the Natural Hazards Mitigation Association	Natural hazards mitigation
Venkataraman, Bina	Senior Advisor for Climate Change Innovation, Executive Office of the President	Adaptation
Winkelman, Steve	Center for Clean Air Policy	Adaptation

ASAP: American Society of Adaptation Professionals; DOE: U.S. Department of Energy; FEMA: Federal Emergency Management Agency; NAACP: National Association for the Advancement of Colored People.

Appendix D.
Thought-Leader Questionnaire

Introduction

Thank you for taking some time to talk with me today. I want this be more of a conversation, so please feel free to interrupt me at any time with questions or thoughts.

I am part of a team at Stratus Consulting (Abt Associates); in partnership with The Kresge Foundation, we are conducting an assessment of community-based adaptation in the United States. The primary goal of this project is to understand how communities are adapting to climate variability and change. In particular, we hope to understand how **communities** take **action** to **reduce their vulnerabilities**.

One of our first steps is to reach out to leaders in the adaptation field and in other project-related fields to ensure that we develop a solid empirical foundation for the project. You are one of these leaders and we appreciate you taking the time to contribute to this project.

Finally, I will be taking notes during the interview, so please bear with me if I have to pause after you finish speaking to get everything written down.

1. **To begin, can you please briefly describe your experience with adaptation at a community level?** [***Try to limit answer to 5 minutes.*** *If prompting is needed, experience can include observing or assessing communities taking action, and could include community-based action not specifically considered "adaptation."*]

Effectiveness

Many communities in the United States are beginning to adapt to climate impacts. The next few questions are about the effectiveness of such community efforts.

2. **In your experience, what gets communities motivated to adapt to climate impacts or reduce vulnerability?** [*Internal list only—Do not read list. If necessary, use as a prompt.*]

   - ☐ **Initiated mitigation/sustainability plan**
   - ☐ **Agency lead**
   - ☐ **Champion**
   - ☐ **Experienced extreme event(s)**
   - ☐ **Following lead of other communities**
   - ☐ **Other:** _____
   - ☐ **Other:** _____

3. **Do you think there is a difference between communities that get started by responding to an extreme weather event (or events) compared to those that proactively plan for climate adaptation?**

4. **What has been useful in moving communities towards implementing adaptation actions?**
   [*Prompts, if needed: How did you get started? Think of it in the context of a specific community.*]

[*Transition to* ***ACTION***]:

Now I'd like to move on from understanding what motivated communities and focus our attention on how communities take **action**.

5. **How have communities identified and selected adaptation actions that will reduce their vulnerability to climate?**

6. **How have communities engaged constituencies to gain support for actions to reduce vulnerability?**
   a. **Who are the primary community audiences being engaged?**
   b. **What are the primary communication or engagement methods or tools that are used?**

Barriers

Many communities in the United States have run into challenges or barriers to reducing their vulnerabilities. The next few questions focus on these barriers.

7. **What do you see as the main barriers for communities in adapting to climate impacts?**
   [*Internal list only—Do not read list. If necessary, use as a prompt.*]

- ☐ **Lack of funding**
- ☐ **Politics and/or political environment**
- ☐ **Lack of support from higher levels of government**
- ☐ **Lack of community support**
- ☐ **Lack of a champion**
- ☐ **Lack of knowledge/information** [*can either be climate data or how to adapt*]
- ☐ **Sense that planning is enough**
- ☐ **Negative reactions to the concept of climate change**
- ☐ **Other:** _____
- ☐ **Other:** _____
- ☐ **Other:** _____

[*Potential follow-up question*]:

I'd like to get your feedback on community challenges that have been identified by others. How important do you see [***insert barrier—ask about politics in particular if not mentioned earlier***] as a barrier to community adaptation?
[*Opportunity to pull from above list if you judge it appropriate for this specific interviewee.*]

Appendix D. (continued) Thought-Leader Questionnaire

8. **Do you think communities can begin the adaptation process without explicitly talking about climate change?**

9. **Do you know of communities that have overcome these barriers in the path to adaptation? If so, how?**

- ☐ **Lack of funding**
- ☐ **Politics and/or political environment**
- ☐ **Lack of support from higher levels of government**
- ☐ **Lack of community support**
- ☐ **Lack of a champion**
- ☐ **Lack of knowledge/information** [*can either be climate data or how to adapt*]
- ☐ **Sense that planning is enough**
- ☐ **Negative reactions to the concept of climate change**
- ☐ **Other:** _____
- ☐ **Other:** _____
- ☐ **Other:** _____

Conclusion

I have a few concluding questions.

10. **A key goal of our study is to share our findings with community adaptation leaders and organizations.**
    a. **Can you recommend effective approaches for disseminating this information to the right people?**
    b. **Are there any ways that you could help us with the information dissemination process** [*if prompting is needed, networks that they belong to, courses they teach, conferences or workshops they present at*]**?**

11. **Do you know of others who have experience that would benefit this project and who we should contact?**

12. **Are there specific communities that we should investigate more closely?**

13. **Finally, is there anything that you would like to add? Anything that I should have asked you but didn't?**

I appreciate your time today — thank you!

Appendix E.
Summary of Insights from Thought-Leader Interviews

The Abt Associates Project Team[20] conducted 50 interviews with thought leaders from diverse disciplines —adaptation, community-based decision making, natural hazards mitigation, environmental justice, law, insurance, and sustainability (see Appendix A for a complete list of interviewees, their affiliations, and expertise areas). Interviews took place from February 13, 2014, to April 28, 2014. Each interview lasted approximately one hour. The semi-structured interviews posed open-ended questions, which typically elicited lengthy responses and productive conversations between the interviewer and the interviewee. Each interviewer worked from a standard series of questions in a semi-structured interview template (see Appendix B for our list of questions).

This appendix provides a brief summary of interviewees' insights about community-based adaptation, which we organized into three major categories:

1. Community-based adaptation processes, specifically issues of motivation, planning, and action
2. Barriers to adaptation
3. Thoughts regarding community engagement.

At least one thought leader mentioned each point below, and many of these insights emerged from several of the interviews. We report insights into adaptation at the community level, as well as thought leaders' recommendations for future action. Although some thought leaders' perspectives align on several adaptation issues, some of the views expressed below may not be consensus views among the thought leaders.

Community-Based Adaptation Processes

This section summarizes key interview themes on community-based adaptation within three major areas: motivation, planning, and action.

Motivation

The interviews revealed more than 30 factors that prompted communities to begin an adaptation process or reduce their vulnerabilities. The following motivating categories emerged from four or more interviews, and are in order of frequency of mention:

- **Extreme events.** Recent large events or recurring events were the most frequently cited motivating factor for communities to begin adaptation.
- **Strong leadership.** Leadership from a champion, such as an elected official, an agency staff member, or other actively engaged community member, can be critical to raising awareness and motivating a community towards adaptation planning and action.
- **Peer action.** Seeing what other communities are doing can help start the adaptation process. It can also build healthy competition among communities to be a leader in climate adaptation.
- **Insurance.** Communities may undertake adaptation activities to regain insurance for homes and businesses after an extreme event or to benefit from a more favorable insurance rate.
- **Regulatory drivers.** Government requirements, mandates, or enforcement actions can help raise awareness about climate change and motivate communities to adapt.
- **Funding.** Communities may begin the adaptation process because funding is available from local, state, or federal governments; foundations; or nonprofit organizations.
- **Mitigation or sustainability efforts.** A number of thought leaders indicated that there is a shift in focus from greenhouse gas mitigation to adaptation. In addition, some said that sustainability and mitigation plans are increasingly incorporating adaptation and climate risks.

20. Members of the project team who conducted interviews included Jason Vogel, Megan O'Grady, Alexis St. Juliana, Heather Hosterman, and Joel Smith.

Appendix E. (continued)
Summary of Insights from Thought-Leader Interviews

Planning

Although we did not explicitly ask about adaptation planning, several thought leaders indicated that their adaptation activity is concentrated on analysis and planning. Some interviewees suggested that an adaptation plan, alone, can help decrease community vulnerability. Others suggested that the pathway from planning to taking action is a significant obstacle for many communities.

Action

We asked thought leaders how communities identify, select, and implement adaptation actions to reduce climate vulnerability. A few themes emerged from this discussion, including:

- **Using existing processes, regulations, and mechanisms to implement adaptation actions.** Communities can integrate adaptation actions into existing processes, regulations, and mechanisms. For instance, hazard plans can include elements of climate adaptation by planning for future events and hazards.
- **Focusing on actions that have multiple benefits.** Communities are more willing to undertake actions that have multiple benefits. For example, emergency or hazard mitigation planning can include planning for a wide range of hazards over a specific time horizon.
- **Small actions.** Engage community members "where they are" on the issues that matter to them and in a way that resonates with their priorities. For example, communities could be engaged on a small action that reduces impacts they are currently experiencing, such as a small action to develop an erosion control project.
- **Tools.** Tools can help communities move beyond planning.
- **Engaging dedicated technical staff.** Dedicated technical staff can help to usher adaptation through to its completion.
- **Allowing for a necessary time lag between planning and implementation.** Communities do not go straight from planning to implementation; there is a time lag. They may need to wait for an update to another plan, for example.
- **Lack of action.** Several thought leaders indicated that few examples of adaptation action exist in the United States.

Barriers

We asked thought leaders about the barriers that communities face in reducing their vulnerabilities and how communities have overcome these barriers on the path to adaptation. Thought leaders mentioned the following barriers, in order of frequency of mention:

- **Lack of funding.** Many interviewees said that communities lack the funding to develop adaptation plans or implement adaptation actions. In particular, high price tags for adaptation or adaptation planning can scare people away, especially when the community has limited funds for meeting many important community purposes.
- **Lack of knowledge and information.** Uncertainty, including lack of general and localized climate data and uncertainty about climate projections or climate impacts, can inhibit communities or community leaders from taking action.
- **Politics or the political environment.** These can be a barrier to adaptation. For example, a short election cycle can limit the political will to tackle long-term adaptation issues. The idea of climate change can itself be a hot-button issue that detracts from the goal of reducing vulnerability.
- **Lack of resources, staff, and capacity.** In some cases, communities may not have staff with the necessary knowledge to conduct vulnerability assessments,

develop adaptation plans, or implement adaptation plans. Lack of other resources can also pose problems.

- **Lack of authority.** Governments must have sufficient authority to implement adaptations. Coordinating multiple communities without such authority can be a challenge.
- **Legal barriers.** Adaptation policies must be in compliance with federal and state law and regulations.
- **More pressing day-to-day needs.** Communities have short-term priorities that often take precedence over adaptation.
- **Lost property tax revenue.** Limiting development, such as along valuable coastal areas, can result in lost property tax revenue.
- **Unrealistic optimism, amnesia about past events, or denial.** In some cases, communities feel a sense of optimism that they will face few challenges from climate change. In other cases, communities may feel that they will not experience extreme events again.
- **Sentimentality.** Communities may resist change because they feel they might lose their history or unique characteristics.
- **Lack of understanding of adaptation options.** Many communities do not know what the adaptation options are; they need help understanding the options and selecting the right one.
- **Organizational, cultural, or institutional inertia.** One of the challenges for adaptation, in particular, is for government entities to work across agencies. Some communities lack a history of collaboration among departments or agencies.
- **Misunderstanding of data.** Many communities feel they need site-specific data to make decisions or move forward. However, climate models are not yet sophisticated enough to provide the information communities *think* they need.
- **Fear.** If not communicated properly, adaptation can lead to perceptions that things are being "taken away" from individuals or the community.
- **Lack of urgency.** Climate change might feel like a problem that is far in the future. This can make adaptation planning and implementation a low priority in some communities.

Community Engagement

Several of the interview questions focused on issues surrounding community engagement, including whom to engage, how to engage them, and what messages to use. Below, we outline some of the key community engagement themes that emerged.

Whom to Engage

Interviewees focused on two dominant messages about whom to engage: that the messenger matters, and that the engagement process should target the community's needs. Information about climate change adaptation needs to come from a trusted source. Several thought leaders said that community engagement should be broad and inclusive, engaging all interested community members and stakeholder groups early on and throughout the adaptation process. Others felt it was more important to focus on engaging key constituencies, such as government agencies or key community groups.

How to Engage

Several thought leaders shared thoughts and experience on how to engage a community, including:

- **Leading with a "climate change" message is not necessary.** You can often address the issue of climate change adaptation from a starting point that the community feels is more relevant.

Appendix E. (continued) Summary of Insights from Thought-Leader Interviews

- **Work incrementally.** In some communities, it makes sense to start small and gain support along the way.
- **Community engagement is complex.** Community engagement can be more complex and time consuming than communities realize. Communities should be sure to have an effective communications strategy in place.
- **Take advantage of opportunities.** Promoting an adaptation action immediately after a severe event is an example of taking advantage of a community engagement opportunity.
- **Take a whole-community approach.** Adaptation should be not be considered in a vacuum. Develop a comprehensive approach that addresses current issues in addition to climate change.
- **Peer action.** Seeing what other communities are doing, with good results, can be an important motivator to start or continue the adaptation process.
- **Prepare advanced messaging.** Communities need to have their messaging prepared in advance of extreme events. There is a narrow window to act following an event.
- **Understand "where the community is" and meet them there.** This may mean focusing on an issue seemingly distant from climate adaptation—such as building a robust economy or preserving local environmental resources—and then shifting toward adaptation and vulnerability reduction.

What Message to Use

Finally, thought leaders emphasized that the message is important: *make climate change adaptation relevant at the community level.* Appeal to what matters to people and what affects them every day. If the community believes that climate change impacts will occur 50 or 100 years from now, it will be difficult to move the adaptation process forward.

- **Use positive messages.** A message about climate change vulnerabilities may not effectively motivate adaptation.
- **Emphasize economic resilience.** Framing adaptation in terms of avoided financial costs in the future, or conducting a cost-benefit analysis can be an effective communication tool.
- **Understand what information is currently being used.** Information and data can be tailored to meet the needs of local engineers or managers. Local planners and engineers are already using climate data to make decisions.
- **Use existing information.** Sometimes adaptation professionals complain that communities do not have sufficient climate data. In reality, sufficient data exist, but we need to do a better job targeting climate information to community information needs.
- **Improve knowledge of available resources.** Some interviewees said that existing tools and resources are sufficient, but communities need to know where to look.
- **Focus on strategies that have multiple benefits.** Communities are more likely to support strategies that produce multiple community benefits.

Miscellaneous

Other key thoughts and feedback we heard from the interviewees included:

- Communities may not actually use the tools developed by governments and academics
- Citizens tend not to read reports and may be more responsive to other media for communication

Appendix F.
References

Executive Summary

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

Chapter 1: Introduction

Adger, W.N., N.W. Arnell, and E.L. Tompkins. 2005. Successful adaptation to climate change across scales. *Global Environmental Change-Human and Policy Dimensions* 15:77–86.

Bierbaum, R., J.B. Smith, A. Lee, M. Blair, L. Carter. F.S. Chapin III, P. Flemming, S. Ruffo, M. Stults, S. McNeely, E. Wasley, and L. Verduzco. 2013. A Comprehensive Review of Climate Adaptation in the United States: More than Before, but Less than is Needed. *Mitigation and Adaptation Strategies for Global Change*. Available: http://link.springer.com/article/10.1007%2Fs11027-012-9423-1#page-2.

Brunner R.D. and A.H. Lynch. 2010. Adaptive Governance and Climate Change. American Meteorological Society, Boston.

Carmin, J., N. Nadkarni, and C. Rhie. 2012. Progress and Challenges in Urban Climate Adaptation Planning: Results of a Global Survey. Massachusetts Institute of Technology, Cambridge.

Dow, K., Haywood, B. K., Kettle, N. P., & Lackstrom, K. (2013). The role of ad hoc networks in supporting climate change adaptation: A case study from the Southeastern United States. *Regional Environmental Change*, *13*(6), 1235–1244. doi:10.1007/s10113-013-0440-8

Ekstrom, J. A., & Moser, S. C. (2014). Identifying and overcoming barriers in urban climate adaptation: Case study findings from the San Francisco Bay Area, California, USA. *Urban Climate*, *9*, 54–74. doi:10.1016/j.uclim.2014.06.002

Finzi Hart, J.A., P.M. Grifman, S.C. Moser, A. Abeles, M.R. Meyers, S.C. Schlosser, and J.A. Ekstrom. 2012. *Rising to the Challenge: Results of the 2011 California Coastal Adaptation Needs Assessment.* USCSG-TR-01-2012. USC Sea Grant, Los Angeles, CA. Available: https://woods.stanford.edu/sites/default/files/files/CACoastalAssessmentResults.pdf. Accessed August 27, 2015.

Hansen, L., R.M. Gregg, V. Arroyo, S. Ellsworth, L. Jackson, and A. Snover. 2013. The State of Adaptation in the United States: An Overview. A Report for the John D. and Catherine T. MacArthur Foundation. EcoAdapt.

Higbee, M. 2014. Integrating Hazard Mitigation and Climate Adaptation Planning: Case Studies and Lessons Learned. For the 2015 San Diego County Multi-Jurisdictional Hazard Mitigation Plan Updated. ICLEI-Local Governments for Sustainability USA. February. Available: http://icleiusa.org/wp-content/uploads/2015/08/Integrating-Hazard-Mitigation-and-Climate-Adaptation-Planning.pdf. Accessed August 27, 2015.

Hughes, S. (2015). A meta-analysis of urban climate change adaptation planning in the US. *Urban Climate*, *14*, 17–29. doi:10.1016/j.uclim.2015.06.003

Intergovernmental Panel on Climate Change, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F., D. Qin, G.-K. Plattner, M. Tignor, S.K. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P.M. Midgley (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1535 pp.

Appendix F. (continued) References

Intergovernmental Panel on Climate Change, 2014: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A:Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Kauneckis, D. and O. Cuffe. 2011. State and Local Government Perspectives on Climate Change Priorities: Results from a Survey in the State of Nevada. Department of Political Science, University of Nevada, Reno.

MDB. 2012. Joint MDB Report on Adaptation Finance 2011. A Report by a Group of Multilateral Development Banks comprising the African Development Bank, the Asian Development Bank, the European Bank for Reconstruction and Development, the European Investment Bank, the Inter-American Development Bank, the World Bank, and the International Finance Corporation. December.

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. doi:10.1016/j.landurbplan.2015.11.011

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

Moser, S.C. and M.T. Boykoff (eds.). 2013. *Successful Adaptation to Climate Change: Linking Science and Policy in a Rapidly Changing World.* Routledge, New York.

National Research Council. 2010. *Adapting to the Impacts of Climate Change*. America's Climate Choices: Panel on Adapting to the Impacts of Climate Change. National Research Council. The National Academies Press, Washington, DC. Available: http://www.nap.edu/catalog/12783/adapting-to-the-impacts-of-climate-change.

Rapson, R. 2013. The 'Fierce Urgency of Now': Getting the Climate Question Right. April 9 address at the University of Michigan Law School's Environmental Law and Policy Program Lecture Series. April 9. Available: http://kresge.org/about-us/presidents-corner/fierce-urgency-now-getting-climate-question-right. Accessed August 27, 2015.

Ray, A. and J. Grannis. 2015. From Planning to Action: Implementation of State Climate Change Adaptation Plans. *Michigan Journal of Sustainability* Volume 3, Spring. Available: http://dx.doi.org/10.3998/mjs.12333712.0003.001. Accessed August 27, 2015.

Rosenzweig, C., Solecki, W., Hammer, S. a, & Mehrotra, S. (2010). Cities lead the way in climate-change action. *Nature*, *467*(7318), 909–911. doi:10.1038/467909a

Shi, L., E. Chu, and J. Debats. 2015. Explaining progress in climate adaptation planning across 156 U.S. municipalities. *Journal of the American Planning Association*. doi:10.1080/01944363.2015.1074526

Smit, B., I. Burton, R.J.T. Klein, and J. Wandel. 2000. An anatomy of adaptation to climate change and variability. *Climatic Change* 45:223–251.

Srivastava, R., & Laurian, L. (2006). Natural hazard mitigation in local comprehensive plans: The case of flood, wildfire and drought planning in Arizona. *Disaster Prevention and Management*, *15*(3), 461–483. doi:10.1108/09653560610669936

Thayer, J., M. Rider, and D. Lerch. 2013. Resilient Against What?: How Leading U.S. Municipalities are Understanding and Acting on Resilience. Post Carbon Institute. October 16. Available: http://www.postcarbon.org/publications/resilient-against-what/. Accessed August 27, 2015.

UNFCCC. 2014. Adaptation. United Nations Framework Convention on Climate Change. Available: http://unfccc.int/adaptation/items/4159.php. Accessed August 27, 2015.

Chapter 2: Case Studies and Cross-Case Findings

Eakin, H.C., M.C. Lemos, and D.R. Nelson. 2014. Differentiating capacities as a means to sustainable climate change adaptation. *Global Environmental Change* 27:1–8.

Patton, A. 2009. A Tulsa story: Learning to live in harmony with nature. In *Global Warming, Natural Hazards, and Emergency Management,* J.A. Bullock, G.D. Haddow, and K.S. Haddow (eds.). CRC Press, Boca Raton, FL.

Chapter 3: Conclusions and Recommendations

Adger, W. N., Brown, K., Nelson, D. R., Berkes, F., Eakin, H., Folke, C., Galvin, K., Gunderson, L., Goulden, M., O'Brien, K., Ruitenbeek, J., Thompkins, E.L. 2011. Resilience implications of policy responses to climate change. *Climatic Change*, *2*, 757–766. doi:10.1002/wcc.133

Adger, W.N., Dessai, S., Marisa, G., Hulme, M., Lorenzoni, I., Nelson, D.R., et al., 2009. Are there social limits to adaptation to climate change? Climatic Change 93, 335–354.

Barnett, J., & O'Neill, S. 2010. Maladaptation. *Global Environmental Change*, *20*(2), 211–213. doi:10.1016/j.gloenvcha.2009.11.004

Berrang-Ford, L., Ford, J. D., & Paterson, J. 2011. Are we adapting to climate change? *Global Environmental Change*, *21*(1), 25–33. doi:10.1016/j.gloenvcha.2010.09.012

Bierbaum, R., J.B. Smith, A. Lee, M. Blair, L. Carter. F.S. Chapin III, P. Flemming, S. Ruffo, M. Stults, S. McNeely, E. Wasley, and L. Verduzco. 2013. A Comprehensive Review of Climate Adaptation in the United States: More than Before, but Less than is Needed. Mitigation and Adaptation Strategies for Global Change. Available: http://link.springer.com/article/10.1007%2Fs11027-012-9423-1#page-2.

Bours, D., Mcginn, C., & Pringle, P. 2014. Monitoring & evaluation for climate change adaptation and resilience : A synthesis of tools , frameworks and approaches, (May).

Brody, S, Himanshu, G, Lindquist E, and Vedlitz, A. 2010. Examining climate change mitigation and adaptation behaviors among public sector organizations in the United States. Local Environment 15(6): 591-603.

Carlson, K., & McCormick, S. 2015. American adaptation: Social factors affecting new developments to address climate change. *Global Environmental Change*, *35*, 360–367. doi:10.1016/j.gloenvcha.2015.09.015

Carmin, J., Anguelovski, I., & Roberts, D. 2012. Urban Climate Adaptation in the Global South: Planning in an Emerging Policy Domain. *Journal of Planning Education and Research*, *32*(1), 18–32. doi:10.1177/0739456X11430951

Ekstrom, J. A., & Moser, S. C. 2014. Identifying and overcoming barriers in urban climate adaptation: Case study findings from the San Francisco Bay Area, California, USA. *Urban Climate*, *9*, 54–74. doi:10.1016/j.uclim.2014.06.002

Appendix F. (continued) References

Eisenack, K., Moser, S. C., Hoffmann, E., Klein, R. J. T., Oberlack, C., Pechan, A., Rotter, M., Termeer, C. J. A. M. 2014. Explaining and overcoming barriers to climate change adaptation. *Nature Climate Change*, *4*(10), 867–872. doi:10.1038/nclimate2350

Few, R, Brown K, and Tompkins E. 2006. Public Participation and Climate Change Adaptation. Working Paper 95. Norwich, UK: Tyndall Center for Climate Change Research.

Government Accountability Office. 2009. Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions. GAO-10-113. Government Printing Office: Washington, D.C. October 7. Available: http://www.gao.gov/products/GAO-10-113.

Hallegatte, S. 2009. Strategies to adapt to an uncertain climate change. *Global Environmental Change*, *19*(2), 240–247. doi:10.1016/j.gloenvcha.2008.12.003

Haywood, B. K., Brennan, A., Dow, K., Kettle, N. P., & Lackstrom, K. 2014. Negotiating a Mainstreaming Spectrum: Climate Change Response and Communication in the Carolinas. *Journal of Environmental Policy & Planning*, *16*(1), 75–94. doi:10.1080/1523908X.2013.817948

Hughes, S. 2015. A meta-analysis of urban climate change adaptation planning in the US. *Urban Climate*, *14*, 17–29. doi:10.1016/j.uclim.2015.06.003

Intergovernmental Panel on Climate Change. 2012. *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*. (C. B. Field, V. Barros, T. F. Stocker, Q. Dahe, D. J. Dokken, K. L. Ebi, ... P. . Midgley, Eds.). Cambridge, UK and New York, NY, USA: Cambridge University Press. doi:10.1017/CBO9781139177245

Kates, R. W., Travis, W. R., & Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(19), 7156–61. doi:10.1073/pnas.1115521109

Kingdon, J.W. 1995. *Agendas, Alternatives, and Public Policies*. New York: Addison-Wesley Educational Publishers Inc.

Melillo, J.M., T.C. Richmond, and G.W. Yohe (eds.). 2014. *Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program. doi:10.7930/J0Z31WJ2.

Morello-Frosch, Rachel, Manuel Pastor, James Sadd, and Seth B. Shonkoff. 2009. The Climate Gap: Inequalities in How Climate Change Hurts Americans & How to Close the Gap. Los Angeles: Program for Environmental and Regional Equity, University of Southern California.

Moser, S.C. and M.T. Boykoff (eds.). 2013. *Successful Adaptation to Climate Change: Linking Science and Policy in a Rapidly Changing World.* Routledge, New York.

Moser, S. C. and J. A. Ekstrom. 2010. A framework to diagnose barriers to climate change adaptation, *PNAS*, 107 (51): 22026-22031, DOI:10.1073/pnas.1007887107

National Research Council. 2010. *Adapting to the Impacts of Climate Change*. America's Climate Choices: Panel on Adapting to the Impacts of Climate Change. National Research Council. The National Academies Press, Washington, DC. Available: http://www.nap.edu/catalog/12783/adapting-to-the-impacts-of-climate-change.

Park, Angela. 2009. Everybody's Movement: Environmental Justice and Climate Change. Washington, DC: Environmental Support Center. http://envsc.onenw.org/esc-publications/ copy_of_ESC%20everybody%20s%20movement.pdf

Quay, R. 2010. Anticipatory Governance. *Journal of the American Planning Association*, *76*(4), 496–511. doi:10.1080/01944363.2010.508428

Schrock, G., Bassett, E. M., & Green, J. 2015. Pursuing Equity and Justice in a Changing Climate: Assessing Equity in Local Climate and Sustainability Plans in U.S. Cities. *Journal of Planning Education and Research*, (October 2014). doi:10.1177/0739456X15580022

Smit, B. and Wandel, J. 2006. Adaptation, adaptive capacity and vulnerability. Global Environmental Change. 16(3), 282-292. Doi:10.1016/j.gloenvcha.2006.03.008

Smith, J.B., Schneider, S.H., Oppenheimer, M., Yohe, G.W., Hare, W., Mastrandrea, M.D., Patwardhan, A., Burton, I., Corfee-Morlot, J., Magadza, C.H.D., Füssel, H., Pittock, A.B., Rahman, A., Suarez, A., van Ypersele, J. 2009. Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern". Proc. Natl. Acad. Sci. U.S.A. 106, 4133–4137

Solecki, W., Leichenko, R., & O'Brien, K. 2011. Climate change adaptation strategies and disaster risk reduction in cities: connections, contentions, and synergies. *Current Opinion in Environmental Sustainability*, *3*(3), 135–141. doi:10.1016/j.cosust.2011.03.001

Tompkins, E. L., Adger, W. N., Boyd, E., Nicholson-cole, S., Weatherhead, K., & Arnell, N. 2010. Observed adaptation to climate change: UK evidence of transition to a well-adapting society. *Global Environmental Change*, *20*(4), 627–635. doi:10.1016/j.gloenvcha.2010.05.001

Viguié, V. and S. Hallegatte. 2012. Trade-offs and synergies in urban climate policies. Nat. Clim. Change 2 (5), 334–337. doi:10.1038/nclimate1434


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