City of Eugene Climate Vulnerability Pilot Review Process

August 2013 **Final Report**

Prepared for:
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Prepared by:
Oregon Partnership for Disaster Resilience
A Program of the
Community Service Center

UNIVERSITY OF OREGON

Community Planning Workshop

SPECIAL THANKS & ACKNOWLEDGEMENTS

This project, funded in part by the City of Eugene and part through a FEMA Hazard Mitigation Grant Program planning grant, involves the development and implementation of an integrated approach to evaluating natural hazard and climate change related vulnerabilities. The project would not have been possible without the vision and leadership of Matt McRae and Babe O'Sullivan at the City of Eugene and Ken Vogeney with the City of Springfield. Results of this project will inform the 2015 update to the Eugene/Springfield Natural Hazard Mitigation Plan in addition to other local planning activities. This project utilized additional support provided by the Community Planning Workshop (CPW) and the Oregon Partnership for Disaster Resilience (OPDR) at the University of Oregon's Community Service Center.

Project Steering Committee:

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- Babe O'Sullivan, City of Eugene
- Ken Vogeney, City of Springfield
- Felicity Fahy, Eugene Water and Electric Board
- Josh Foster, Oregon Climate Change Research Institute
- Steve Adams, Institute for Sustainable Communities
- Jeff Weber, Oregon Department of Land Conservation and Development
- Myrnie Daut, City of Eugene
- Stacy Burr, City of Eugene
- Dr. Patrick Luedtke, Lane County Public Health
- Forrest Chambers, City of Eugene

Project Manager:

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- Josh Bruce, Interim Director, Oregon Partnership for Disaster Resilience
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About the Community Service Center

The Community Service Center (CSC), a research center affiliated with the Department of Planning, Public Policy, and Management at the University of Oregon, is an interdisciplinary organization that assists Oregon communities by providing planning and technical assistance to help solve local issues and improve the quality of life for Oregon residents. The role of the CSC is to link the skills, expertise, and innovation of higher education with the transportation, economic development, and environmental needs of communities and regions in the State of Oregon, thereby providing service to Oregon and learning opportunities to the students involved.

About the Oregon Partnership for Disaster Resilience

The Oregon Partnership for Disaster Resilience (OPDR) is a coalition of public, private, and professional organizations working collectively toward the mission of creating a disaster-resilient and sustainable state. Developed and coordinated by the Community Service Center at the University of Oregon, the OPDR employs a service-learning model to increase community capacity and enhance disaster safety and resilience statewide.

Table of Contents

Volume I: Pilot Summary Process

Volume II: Annexes

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INTRODUCTION:

In 2010 Eugene finalized a Community Climate and Energy Action Plan (CEAP). The plan makes recommendations to reduce fossil fuel use and adapt to climate change. While the CEAP contains recommendations to adapt to climate change and rising fuel prices, the planning process did not have resources to adequately understand the adaptive capacity of community systems and services. Nor does it prioritize adaptation actions. The process outlined below continues where the Climate and Energy Plan left off – by carefully assessing the community vulnerability to climate change and energy scarcity.

This vulnerability assessment is outlined in the CEAP as recommendation 23.1 "Conduct a climate and energy vulnerability assessment that assesses the midterm, and longer-term climate and energy vulnerabilities of essential services – specifically energy, water, food, health, housing, and sanitation."

In addition to the vulnerability assessment outlined in the CEAP, the Eugene/Springfield Joint Natural Hazards Mitigation Plan also requires review, update and re-approval by 2015. The Cities of Eugene and Springfield viewed this project as an opportunity to combine the assessment of climate change and energy vulnerability assessment with an updated assessment of hazard risk and vulnerability. While many communities are beginning to undertake assessments of climate and energy impacts, this is one of few attempts to integrate those assessments with natural hazards. Notably, since initiation of the project, FEMA has released new natural hazard mitigation planning guidance that specifically encourages the integration of climate change risk.

To develop the assessment tool and assist with process facilitation, the City contracted with the Oregon Partnership for Disaster Resilience (OPDR) at the University of Oregon's Community Service Center to create a regional climate and vulnerability assessment that will:

- Identify the systems (e.g., food, sanitation, energy, water, transportation, etc.) and services (e.g., health, housing, social services, etc.) within the Eugene-Springfield metropolitan area that are likely to be impacted by climate change and rising and volatile energy prices
- Complete a literature review of existing assessment methods and tools
- Review and report projected local climate- and energy-related changes
- Assess vulnerability to changes, and adaptive capacity of systems and services
- Determine the systems and services most likely to be challenged under future scenarios
- Develop recommendations to help regional leaders prioritize funding and resources to increase community resilience

Vulnerability Assessment Background

Like communities around the world, the Eugene Springfield metro area has a unique set of vulnerabilities both to natural hazards and economic stresses. Local businesses, residents, and governments have tools to lessen the risk and respond to these vulnerabilities including building codes, emergency management plans, natural hazard mitigation plans, as well as municipal budget forecasting and savings and investments, among others. Projected *regional changes in climate* due to global climate change and *rising fuel prices* brought about by a peak in global petroleum production will heavily influence the community's vulnerabilities to natural hazards and economic stressors.

Purpose of Vulnerability Assessment

Determine the local systems and services most vulnerable to *natural hazard events*, *changes in climate* and *increasing energy prices.* This information will be used to aid in prioritizing funding to mitigate impacts, increase local resilience and adaptive capacity.

An integrated regional natural hazard, climate and energy vulnerability assessment will:

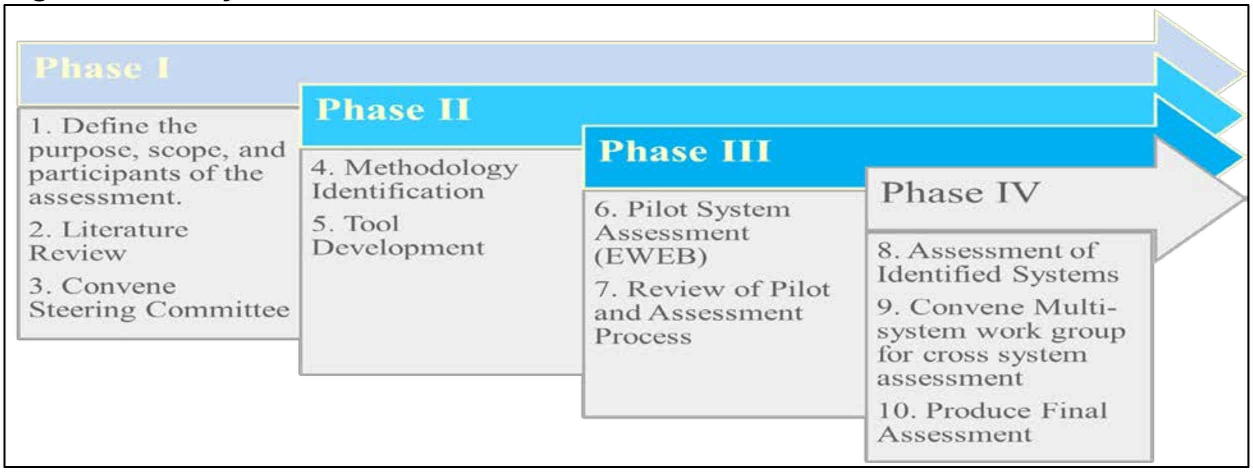
1. Identify the systems that are likely to be impacted by climate change and rising and volatile energy prices
2. Review and report projected local climate- and energy-related changes
3. Assess vulnerability to changes, and adaptive capacity of systems and services
4. Determine the systems and services most likely to be challenged under future scenarios.
5. Develop recommendations to help regional leaders prioritize funding and resources to increase community resilience.

PHASE I:
PROCESS OVERVIEW

This section provides a summary of the Hazards Vulnerability Assessment pilot process to date and a review of the lessons learned for the process. The summary presents our approach to Hazards Vulnerability with respect to the identified phases the process followed. The process is composed of four phases, of which this document focuses on Phases I through III.

Phase I takes into consideration steering committee identification and literature review. Phase II consists of OPDR's work on the literature review, methodology identification, tool development, and hazards and scenario selection. Phase III considers the pilot assessment of the Drinking Water system. Finally, a lessons learned section presents process observations with specific focus on several key categories including: what worked, what did not work, what we kept, and what we changed.

Figure 1.1. Project Phases



Source: Scope of Work, Eugene-Springfield Climate and Energy Vulnerability Assessment

Steering Committee

The project team from the Cities of Eugene and Springfield selected a steering group to help direct the vulnerability assessment effort and to provide oversight as the vulnerability assessment tool was developed and piloted. The steering committee is composed of people from a variety of organizations with different perspectives and various experiences with vulnerability assessments. The group includes Staff from the State Department of Land Conservation and Development, the Oregon Climate Change Research Institute at Oregon State University (OCCRI), the Institute for Sustainable Communities (ISC) - a national non-profit assisting communities with climate adaptation, Lane County Public Health, the Eugene Water and Electric Board (EWEB, a publically owned water and electricity utility), and Emergency management representatives from the Cities of Eugene and Springfield. Table 1.1 lists steering committee participants.

Table 1.1. Steering Committee Members

Name	Title	Organization
Matt McRae	Climate & Energy Analyst	City of Eugene
Babe O'Sullivan	Sustainability Liaison	City of Eugene
Ken Vogeney	City Engineer	City of Springfield
Felicity Fahy	Sustainability Coordinator	EWEB
Josh Foster	Faculty Research Assistant	OCCRI
Josh Bruce	Director	OPDR
Steve Adams	Senior Program Director	ISC
Jeff Weber	Coastal Conservation Coordinator	DLCD
Myrnie Daut	Risk Service Director	City of Eugene
Stacy Burr		City of Eugene
Dr. Patrick Luedtke	Director	Lane County Public Health
Forrest Chambers	Interim Emergency Manager	City of Eugene

Source: Climate Vulnerability Assessment Steering Committee Identification

PHASE I:
INFORMATION GATHERING

This section outlines the steps taken to initiate the project.

Literature Review

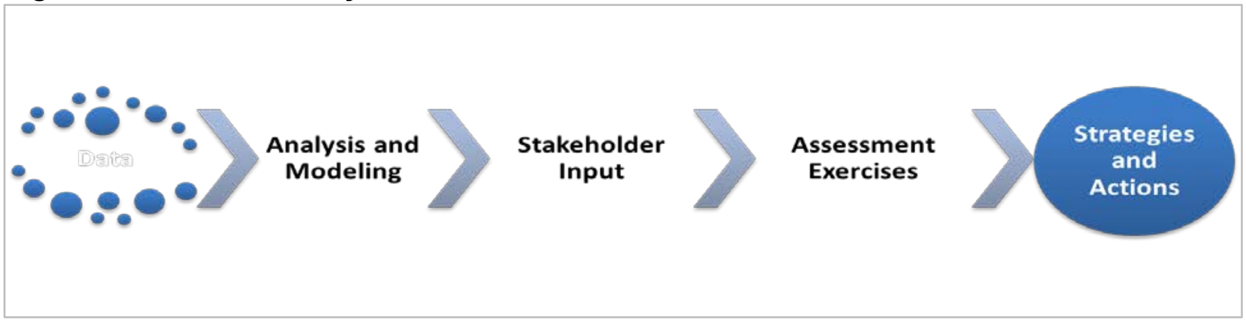
In this first phase, OPDR identified and reviewed twenty-four assessments and frameworks from North America, Europe, Asia and Australia. OPDR identified and summarized several assessment examples that could be applied to the project.

Our research identified several broad "categories" of climate vulnerability assessments for consideration:

- scenario analysis
- sensitivity assessment
- portfolio assessment
- threshold approach

Each vulnerability assessment type can be viewed in further detail in (Appendix A). In addition to the four assessments categories, four generalized steps were identified in the literature review. Figure 1.2 below illustrates the primary assessment stages common to most of the assessment tools we reviewed.

Figure 1.2. Vulnerability Assessment Phases



Source: Memorandum to the City of Eugene, Vulnerability Assessment: Methodology and Tool Refinement, Oregon Partnership for Disaster Resilience, 05 December 2012

Steering Committee Meeting #1 – Introduction to Project

OPDR formally initiated the project with a steering committee meeting on December 6, 2012. OPDR provided an overview of the project and description of project phases and the Steering Committee was asked to share their perceived "best outcomes" and "worst fears" for the project. The results are summarized below (see Table 1.2).

OPDR next presented the Steering Committee with a summary of the literature review including introduction to the four vulnerability assessment types. The consensus amongst the group was to move forward with further research and development of a combined scenario and threshold based assessment method. The emphasis on threshold assessments as the assessment type includes scenarios as an element. The initial timeframe for assessing the potential effects of climate change was set for years 2030 and 2060 respectively. This timing was based upon existing climate scenarios provided by state climatologists.

Table 1.2. Best Outcomes and Worst Fears Summary

Best Outcomes	Worst Fears

• Cost conscious process
• Focused plan looking at new horizon
• Targeted action items to improve resilience (specific)
• Measurable action items
• Good info for strategic planning
• Understandable by the public
• Defensible to elected officials
• Assessment based on real science (not pulling out ungrounded scenarios)
• Process that is replicable and iterative
• Inclusive process –
    o Process that builds capacity in our organizations to address the risks
    o More informed staff
• Maintained plan – regular refreshment of vulnerability assessment (active plan)
• Links in with other climate and energy planning efforts regionally and statewide
	• Duplicative
	• Not creative
	• "Spinning in the data"
	• Liability due to indefensible projections
	• Doesn't change (increase) the planning horizon – "still looking at our toes"
	• Vulnerability assessment becomes so detailed and expensive that it's not transferrable to other jurisdictions

Source: Introductory Climate Vulnerability Steering Committee Meeting, committee member input, 06 December 2012

PHASE II: METHODOLOGY AND TOOL DEVELOPMENT

Methodology Development

The OPDR team identified a climate vulnerability assessment created by the International Council on Local Environmental Initiatives (ICLEI) to use as a baseline. The ICLEI framework offers guidance on how to develop and support a team to conduct a resiliency study, details of how to conduct the study, and how to best use that study to develop meaningful goals and actions. In addition, OPDR focused on assessments conducted by the Cities of Flagstaff, AZ and Atlanta, GA, both of which used ICLEI's Guidebook for their assessments. Using the guidebook and the two city assessments as models, OPDR developed and refined a new climate vulnerability assessment tool applicable to Eugene/Springfield. This summary will focus on the details of the climate resiliency study, which involves a vulnerability assessment and risk assessment of different sectors and planning areas to identify priorities for action.

Climate Change vulnerability was only a part of the considerations for the assessment process. The project also includes natural hazards vulnerability. OPDR used established Oregon Emergency Management (OEM) risk assessment methodology and OPDR's relative risk assessment as the baselines for incorporating natural hazards vulnerability into the process.

Steering Committee Meeting #2 – Methodology Assessment

OPDR presented the Steering Committee with the ICLEI, OEM, and OPDR methodologies. The group approved the use of these methodologies as the baseline for developing our climate vulnerability assessment. OPDR introduced a scoring methodology to the committee, which produced a great amount of discussion and concern over scoring, to be discussed later.

Tool Development

Using the ICLEI model, the OPDR research and development team began the process of creating a vulnerability assessment tool that incorporated climate change and natural hazards across each identified system in the community. Research revealed that the incorporation of both vulnerability types for each system had not previously taken place comprehensively in the United States, or internationally. The following sections review the development of the major components of the assessment tool: adaptive capacity, risk, sensitivity, and scoring.

Adaptive Capacity

Adaptive Capacity is a natural, built, or human system's ability to accommodate a new or changing environment, exploit beneficial opportunities and/or moderate negative effects. Adaptive Capacity is assessed independently of hazard or climate change considerations. The adaptive capacity assessment takes a snapshot of current system components, business activities and operations.

The assessment aims to measure the adaptive capacity of a system in six major components:

1. Current and Future Demand + Supply – to determine how adaptive a system will be to future scenarios, develop a baseline of how the system operates and the extent of the current demands on the system.
2. Planning + Upgrades – a system with strategic and comprehensive planning processes, consistent maintenance schedules, technology adoption, and regular upgrades and retrofits will likely be more adaptive.
3. Limiting Factors + Needs – a system may be affected and/or limited by multiple factors outside the function and operation of the system, including, but are not limited to: politics, budgeting, energy costs, regulations, etc.
4. System Interdependencies – How will one system be directly or indirectly affected by changes in another system?
5. Capacity Opportunities – within the current operations and planning processes, have opportunities been identified by system managers?
6. Adaptation + Mitigation – if a given system currently integrates hazard and/or climate change mitigation/adaptation within the system's operations and planning, the system will be more adaptive.

The adaptive capacity assessment areas were developed and defined from a review of the ICLEI question types and categories. The six assessment categories were determined to be the most representative of any system's adaptive capacity.

Risk

The original vulnerability assessment tool included two separate assessment categories for measuring vulnerability: risk and sensitivity. Risk is the degree of impact of climate change conditions or hazards on a natural, built, or human system, weighed against the probability of impact from the same hazard. The risk methodology comes from OPDR's relative risk assessment tool that measures the risk within a given community as a whole. The relative risk assessment included five components:

1. Population Affected - percentage of the population that would be adversely affected by a given scenario.
2. Threat to Life – percentage of the population that would experience major injury or death if a given scenario were to occur.
3. Economic Disruption – determine the economic impact of a given scenario. Determination would include monetary value being lost and over what extent of time.
4. Ecological Disruption – natural systems that are adversely affected by a given scenario, which then directly or indirectly affects a system.

5. Social Disruption – social systems that will be adversely affected by a given scenario.

Relative Risk was not initially changed by the Steering Committee or OPDR team for the pilot process but left as is straight from the original methodology.

Sensitivity

Sensitivity is the degree to which a natural, built, or human system is affected (either adversely or beneficially) by direct or indirect exposures to climate change conditions or hazards. Sensitivity is considered in relation to a hazard or climate change impact. The sensitivity assessment was based on the ICLEI, Flagstaff and Atlanta assessments and included four components:

1. Primary Infrastructure – components absolutely necessary to operate or maintain a system at its most basic capacity.
2. Secondary Infrastructure – used to extend or improve a systems services and/or operations. Secondary infrastructure, in theory, is more easily replaceable than the primary infrastructure and failure would result in limited capacity loss, but not result in entire system failure.
3. Capacity – if affected by climate change or hazard, how long will a system continue to operate under adverse conditions?
4. Interdependencies – in the event of a natural disaster or climate stress, how do systems influence each other?

This reflects the risk and sensitivity sections of the assessment as they were used in the pilot assessment of drinking water. After the pilot, this portion of the assessment was refined.

Question Development and Scoring

OPDR developed questions based on examples from ICLEI, Atlanta, Flagstaff, OEM and OPDR. One of the challenges was ensuring each question is broad enough to be applicable across any system being assessed, while at the same time being specific enough and understandable by managers of individual systems.

Another challenge was finding the right balance of scored and narrative answers. The ICLEI model uses narrative questions and subjectively scored answers later. OEM and OPDR methodologies use a more quantitative method scoring 1 thru 5, using a percentage scale or “Very High” to “Very Low” scale. The OPDR team opted to include scores for most questions in order to facilitate the later assessment of each system. Space is provided for narrative responses to every question to capture nuanced explanations.

Scenarios and Natural Hazards

The tool assesses the vulnerability and adaptive capacity of community systems in response to a series of hazards. OPDR evaluated a wide range of natural, man-made and technical hazards for use in the tool. The tool is designed for use with any natural, man-made or technical hazard however, due to limited face time with managers of each system; the team quickly narrowed the list of potential hazards to:

- earthquake (catastrophic widespread hazard),
- flood (chronic and isolated hazard),
- wildfire (rare and isolated hazard), and
- a small number of climate- and energy-specific impacts.

Preliminary hazard scenarios proposed for use in the process can be reviewed Appendix B.

Steering Committee Meeting #3 – Tool development and assessment

The OPDR team gathered feedback about the tool as a whole, each assessment section, individual questions, and scoring. The Steering Committee tested the tool and offered suggestions including revisions of wording and methodology. At this stage, questions were refined, dropped, and added to the assessment.

Steering Committee members provided feedback including:

- Concern that scores would be used out of context by others outside the system
- Concern that system managers may become overly focused on scores
- Concern system managers may not feel free to reveal sensitive or proprietary information
- Scoring is needed to provide comparisons between systems and hazards
- Scoring provides some justification for conclusions

PHASE III: PILOT ASSESSMENT

The study team selected Drinking Water as the system to pilot test the assessment on. The process engaged water operations staff at Eugene Water and Electric Board (EWEB). EWEB is the sole provider of drinking water and electricity within Eugene. Due to scheduling challenges, other water utilities (including the Springfield Utility Board) were not included in the pilot phase. The Drinking Water system assessment took place over two two-hour meetings. The following EWEB employees participated in the assessment:

Table 3.1. EWEB Assessment Meeting Attendees

Name	Title
Felicity Fahy	EWEB Sustainability Coordinator
Bob Den Ouden	EWEB Business Support Analyst
Joe Moll	McKenzie River Trust (local land trust)
Amy Chinitz	Springfield Utility Board (SUB – observer)
Karl Morgenstern	EWEB Source Protection & Property Supervisor
Steve Ewing	EWEB Water Distribution Management Technician
Ray Leipold	EWEB Water Treatment and Supply Supervisor
Steve Fassio	EWEB Control Systems Administrator
Brad Taylor	EWEB Water Operations Manager
Kevin McCarthy	EWEB Operations Support Services Supervisor

Source: EWEB Adaptive Capacity Assessment Meeting, Sign-In Sheet, 18 March 2013

EWEB Meeting #1 – Adaptive Capacity Assessment

The project team sent assessment participants the scenarios and the vulnerability assessment tool a week before the meeting to familiarize them with the process. The meeting included a project overview, completion of the adaptive capacity assessment tool and a short summary discussion.

The project team and EWEB staff agreed that regardless of the assessment scores and output, there was significant value in the discussions the meeting generated. All of the departments within EWEB frequently discuss and plan for risk management; however the results of discussions and planning are not always shared as widely or as regularly as they could be. Having representatives from with various areas of expertise discussing facilitated cross-department communication.

EWEB Meeting #2 – Risk and Sensitivity Assessment

The second meeting assessed the risk and sensitivity of the EWEB drinking water system to earthquake, flood, wildfire, climate change, and volatile and rising fuel prices. EWEB water managers were given a description of the hazard scenario and provided maps of the areas that would be affected by a given hazard (flood, wildfire, liquefaction, etc.). The earthquake assessment took one hour and involved detailed conversation about the impact on the drinking water system. The group concluded that the earthquake scenario would result in major (likely catastrophic) impacts to the drinking water system. The flood assessment took approximately 20 minutes resulting in a determination that flood would have very little impact on EWEB drinking water operations. The wildfire assessment took approximately 20 minutes and resulted in a determination that wildfire would have moderate impact on EWEB drinking water operations. With the last 20 minutes the facilitator started a broader discussion on the impacts of climate change and fuel price fluctuations. The risk and sensitivity meeting did not run as smoothly as the adaptive capacity meeting, because:

- Questions were divided into risk and sensitivity and some questions were redundant
- Maps provided did not include specific location of EWEB systems, but were of the entire community limiting their usefulness to the process.
- Earthquake scenario was too catastrophic a scenario to start with, leading to long clarifying questions and detailed narratives. The group suggested starting with a lower impact hazard like flood

The project team also noted:

- Two hours is not enough time to assess all the hazards
- No time for process review and comments from the systems' experts at the end of the entire process

Steering Committee Meeting #4 – Drinking Water Pilot Review and Results

The results of the water system assessment were shared with Steering Committee. Based on the steering committee discussion, the project team refined several of the assessment questions (see below). The team also agreed to start the sensitivity and impacts assessment with a less catastrophic hazard instead of the Cascadia earthquake scenario. This will avoid overwhelming system manager with such a large event and potential multi-system failure(s). The group established a sub-committee to discuss further development of the scoring methodology.

Tool Refinement and Changes

The risk and sensitivity portions of the assessment were consolidated.
Two smaller sections were developed at the end of the assessment to determine how the system would be affected by a given hazard and how climate change and fuel prices might exacerbate or change the impacts of the hazard.

Scoring Sub-Committee Meeting #1 – Scoring Review and Refinement

To review the scoring methodology, OPDR convened a sub-committee from the larger Steering Committee group. The group included:

- Matt McRae, City of Eugene
- Felicity Fahy, EWEB
- Ken Vogeney, City of Springfield
- Josh Foster, OCCRI
- Josh Bruce, OPDR

The OPDR research team proposed to calculate average adaptive capacity, risk, and sensitivity scores based on the answers provided by EWEB staff. Specifically, the team proposed to total the question scores from each category and divide by the total number of questions. For example:

$$\frac{(\text{Question 1 score + Question 2 score +Question 3 score + …})}{\text{Total Number of Questions}}$$

OPDR proposed converting the adaptive capacity score to a weight factor. After the scores for risk and sensitivity had been added together to form an impact score, the overall impact score would be multiplied by the adaptive capacity weighted score. Below is the equation one using adaptive capacity:

(Vulnerability + Risk) x Adaptive Capacity = Sensitivity Score

The premise being that the more or less adaptive a system is the greater or lesser the impact hazards will have on a given system. The table below outlines the proposed adaptive capacity scores and weighting scale.

Table 3.2. Adaptive Capacity Value Scale

Number Value	Adaptive Capacity	Weighting Scale
1-1.99	Very Low	1.50
2-2.99	Low	1.25
3-3.99	Medium	1
4-4.99	High	0.50
5	Very High	0.25

Source: Discussion, Scoring Sub-Committee Meeting, 16 May 2013

The next two tables illustrate how the weighted score would theoretically work in the assessment tool, comparing Drinking Water to Health in an earthquake scenario. Keep in mind these do not reflect actual assessment scores.

Table 3.3. Sample Assessment Scores for Drinking Water System

Drinking Water						
Hazard	Adaptive Capacity (AC)	Risk	Sensitivity	Risk + Sensitivity	AC Weight Score	Impact Score
Earthquake	2.5 (low)	5	4	9	1.25	11.25

Health						
Hazard	Adaptive Capacity (AC)	Risk	Sensitivity	Risk + Sensitivity	AC Weight Score	Impact Score
Earthquake	4.5 (high)	5	4	9	0.50	4.5

Source: Discussion, Scoring Sub-Committee Meeting, 16 May 2013

The hypothetical scores above would indicate that the Drinking Water system has a low adaptive capacity and thus would experience a relatively larger impact in the event of an earthquake. In the other table, we see that although the Health System has the same risk and sensitivity to earthquake as the Drinking Water, Health has a higher adaptive capacity thus reducing its impact from an earthquake event.

After the EWEB assessment was completed, the research team developed two sets of scores. The first set of scores considered scoring the narratives, and the second set only scores those questions with scored answers. The narratives were scored through research team discussion and consensus on what narrative information was indicating about the system. The results of scoring are summarized below.

Table 3.4. EWEB Results – Adaptive Capacity

	Scores w/Narratives	Scores w/o Narratives
Total Points	64	23
Total Questions	23	7
Score	2.78 (Low)	3.28 (Medium)
Weight Factor	1.25	1

Source: EWEB Adaptive Capacity Assessment Meeting, 18 March 2013

EWEB Results – Risk and Sensitivity

Hazard	Risk	Sensitivity
Earthquake	3.8 (Med-High)	3.3 (Med)
Flood	N/A	1.7 (Low)
Wildfire	N/A	2.9 (Low-Med)
Climate Change	N/A	N/A
Fuel Prices	N/A	N/A

Source: EWEB Risk and Sensitivity Meeting, 2 April 2013

The scores reflect the concerns discovered and reviewed here earlier. Risk was not assessed after earthquake because of redundancy and not being applicable to the Drinking Water system.

The Scoring Sub-Committee did not ultimately make a decision on how scoring would take place, opting to wait to see the results from additional systems in order to make a more informed decision about scoring. The sub-committee did agree to add a set of questions to the end of each adaptive capacity section, which would gage the systems' experts' opinion on their system's adaptive capacity for a given section. The question is as follows:

- Based on the discussion in this section, how would you rank the system overall in respect to (Insert Adaptive Capacity Section Title)?
    1. Very Low
    2. Low
    3. Medium
    4. High
    5. Very High

The question should provide additional useful scores in the adaptive capacity assessments.

The Scoring Sub-Committee also agreed on a few scoring principles:

- To ensure accuracy, scoring should be done as soon as possible after the meeting with system managers
- At least two and preferably three people should jointly score each system – to avoid bias
- At least one person should participate in all or almost all of the scoring sessions – in order to provide consistency.
- Scoring teams should be made up of people who attended the meeting of the system they are scoring.

PHASE IV:
SYSTEMS' ASSESSMENTS

Phase IV is the assessment of all remaining systems. This section summarizes the Health sector assessment.

The OPDR research team developed a survey tool using Qualtrics, an on-line survey vendor. The Qualtrics tool allows the facilitators and note takers for each assessment to complete notes in an organized and consistent fashion. At the end of each meeting, all note-taker surveys are sent to the Qualtrics database which allows for easy compilation of notes, narratives, and scores. The Qualtrics tool allows for easy streamlining of the assessment and final analysis of any system being assessed.

Health Meeting #1 – Adaptive Capacity Assessment

The project team identified stakeholders for the Health assessment with the help Dr. Patrick Luedtke, the Director of Lane Public Health, and Steering Committee Member. Unlike the Drinking Water system, the Health system contains multiple sectors with multiple agencies. The table below lists those agencies that were represented for the Health Assessment meetings.

Table 4.1. Health Assessment Meeting Attendees

Name	Title	Organization
JoAnna Kamppi		
Rick Hammel		
Selene Jaramillo		Lane Co. public Health
Tracy DePew		Peace Health
Charley McGrady		
Tom Hambly		

Source: Health Adaptive Capacity Assessment Meeting, June 6, 2013

The above list does not represent the entire Health system. Representatives from the Pharmacy and Assisted-Living sectors were contacted but no representatives were made available for the assessment. The list of stakeholders and those not represented, however, does illustrate how broad and complex a single system can be. As the Drinking Water system is represented by a single organization, the Health system is composed of multiple organizations.

The adaptive capacity assessment went smoothly. It was quickly apparent that the stakeholders present for the Health system have a long history of cooperation and a comprehensive understanding of all sectors within the Health System.

Health Meeting #2 – Sensitivity & Impacts Assessment

For the second Health assessment meeting, the new Sensitivity & Impacts assessment was used for the first time. The earthquake scenario was the first hazard used to run through the assessment. The new assessment sections were understood and easily followed. The climate change and fuel price scenarios presented at the end were also easily understood and accepted by the stakeholders. The entire two hours allotted for the meeting was used to assess the earthquake scenario alone. The Health systems' stakeholders agreed to meet a third time to discuss flood, wildfire, and possibly heat. Heat was previously identified as a hazard of concern, especially in the future and climate change, for the Health system.

Health Meeting #3 – Sensitivity & Impacts Assessment (continued)

The third Health assessment meeting was allotted an hour and a half. It was determined that since we had already covered the Health system in great detail during the earthquake scenario, that flood and wildfire would be assessed with enough time to cover Heat and have an overall process discussion at the end of the assessment process. The flood scenario assessment took the entire time allotted.

As a result, it was determined by the OPDR research team and Health system experts' input that future assessments should run all the scenarios through each question at the same time. For the first two systems, we had run one hazard scenario through the entire system and then repeated the process with the next hazard scenario. In addition, it was determined that future assessments will take place over the course of two three-hour meetings. The first meeting will assess a system's adaptive capacity in the first two-hours, with a start into the Sensitivity & Impacts assessment using the last hour. The second meeting would finish the assessment of Sensitivity & Impacts, with the remaining time being devoted an overall discussion about the process and project with Systems' experts.

Pilot Process Conclusions

The vulnerability assessment process through creation and implementation was a time consuming process. After several rounds of discussion, assessments of systems, and refinement the vulnerability assessment tool has been well received and is fairly straight forward in process. The time consuming elements of the process involve systems identification, stakeholder participation, meetings, systems assessments, and scoring and analysis.

- Clearly defined terms, used appropriately and consistently throughout the process is key to maintaining system wide understanding and continuity
- Assessment takes a minimum of six-hours per system.
- Two-hours for adaptive capacity, three-hours for sensitivity & impacts, and one-hour for overall discussion and review
- A mix of appropriate organizations and stakeholders should be invited to the vulnerability assessment
- Finding six-hours, in any time blocks, of any system's stakeholder's time is difficult
- A single point of contact within a system who has connections within the entire system is key to inviting and including the appropriate stakeholders in the room
- Providing stakeholders with the vulnerability assessment tool, hazard scenarios, and any other pre-meeting material in advance will help prepare stakeholders and facilitate smoother vulnerability assessment meetings
- Maps with hazard information is helpful and useful for the vulnerability assessment, however, having maps from the system with primary and secondary infrastructure mapped will help immensely
- Narrative questions are more valuable and important than scoring the questions
- Having systems' experts in the same room discussing climate change and natural hazards, while identifying interdependencies and vulnerabilities is the most valuable process component to the entire project
- Hazard by hazard or all hazards run through at same time?
- Strive to have one or two people to participate in all or almost all of the assessment meetings to provide consistency.

Lessons Learned

What Worked

- Using ICLEI, Flagstaff, and Atlanta as a baseline for the creation of the methodology and vulnerability assessment tool
- Diverse Steering Committee guiding the development and process of the vulnerability assessment tool
- The terms and definitions used throughout the process
- The adaptive capacity assessment section has been well received by Steering Committee and systems' experts
- Having systems' experts in the same room discussing climate change and natural hazards, while identifying interdependencies and vulnerabilities is the most valuable process component to the entire project
- Including climate change and fuel price fluctuations as an exacerbating factor against a given scenario

What Did Not Work

- OPDR Relative Risk questions were only applicable to the community as a whole, but not to a given system
- A focus solely on narrative questions or scored questions is not recommended. Narrative questions do not provide easy justification for new projects or funding for systems' administrators. Scored questions do not allow for the detailed discussion and valuable information could be missed
- Hazard maps without system specific infrastructure mapped, is difficult for systems' experts to provide specific information on potential hazard impacts
- Including two separate time horizons for climate change does not provide any additional information, one single time horizon with the most reliable climate change predictions is better
- Viewing climate change or fuel price fluctuations as a separate hazard
- We had to reduce hazards from "all hazards" experienced in the Willamette valley to just a few (because of limited face time with system managers). We decided to use the following hazards:
  - Wildfire (infrequent, geographically isolated, affects some but not all)
  - Flood (chronic, geographically isolated, affects some but not all)
  - Earthquake (catastrophic scenario – affects all or almost all of the population)
- We specifically chose not to use:

- Landslide (not a major threat to a large population. Landslides in our area tend to be creeping not catastrophic)
    - Volcano (exceptionally infrequent hazard. Most mitigation actions are response-centered, not mitigation)
    - Dam safety (unlikely and wide ranging impacts depending on time of year and sequence of failures; aside from managing evacuations, mitigation actions are primarily at the site of the dams themselves)

- There are few material costs of conducting the assessment. The vast majority of resource is system manager time for meetings, time for logistics (setting meetings, meeting materials, etc.), and summarizing findings.

- Scoring methodology
    - Strive to have one or two people score all or almost all of the system narratives to provide consistency
    - Ensure two or three people are involved in translating narratives into scores for each system to reduce bias

- Meeting Management
    - Start with a scenario that's not earthquake
    - Don't make climate migration an assumed impact
    - The 5 hours for each assessment only gives us time to assess vulnerabilities – but still doesn't give us time to develop clear, refined actionable mitigation strategies

Memo

To: Babe O'Sullivan, Matt McCrae and the Eugene-Springfield Climate, Energy and Natural Hazards Vulnerability Assessment Steering Committee

From: Casey Hagerman, Jack Heide, Josh Bruce and Michael Howard, Oregon Partnership for Disaster Resilience (OPDR)

Date: December 5, 2012

Re: **Vulnerability Assessment: Methodology and Tool Refinement**

This memo summarizes a review of literature related to climate change vulnerability assessments across multiple sectors.

Background

The purpose of this phase of the project is to outline possible assessment methods and tools to use for the Eugene-Springfield Climate Change Vulnerability Assessment. The tools will be reviewed by the steering committee and refined for use in our pilot study.

Methodology

OPDR conducted the literature review of possible assessment tools using sources provided from Eugene-Springfield city representatives, the Department of Land Conservation and Development (DLCD), and through internet searches. In this first phase, OPDR identified and reviewed twenty-four assessments and frameworks from North America, Europe, Asia and Australia. OPDR identifies and summarizes several assessment examples that could be applied to this project in the Findings section below.

General Assessment Types

Our research identified several broad "categories" of climate vulnerability assessment. An Environmental Protection Agency (EPA) report reviewed climate change related vulnerability assessments conducted by water utilities across the United States. Vulnerability assessments were reviewed from two perspectives, top-down and bottom up. The EPA report identifies four types of Vulnerability Assessments tools:

1a. Scenario Analysis: Uses plausible Green House Gas (GHG) emissions projections, and works through Global Climate Change Models (GCMs) by downscaling regional climate models. Uses hydrology, demand, operational, and/or management models to measure the vulnerability of water utility systems. *Strength*s: Use of multiple variable scenarios. *Weakness*es: Expert level statistical and technical data.

1b. Sensitivity Analysis: Uses incremental climate change projections (precipitation and temperature) to bracket a possible range of hydrologic futures altered by climate change. *Strengths:* No GHG emission or GCMs required, or downscaling. *Weaknesses:* High data resource and computational needs.

1c. **Portfolio Assessment**: Measures a mixture of potential projects and/or systems against technical, environmental, and economic feasibility to meet future demands. *Strengths:* Measures many alternatives against multiple feasibilities to develop best outcomes. *Weaknesses:* Technical, computational model required.

1d. **Threshold Approach**: Identifies system components at risk to climate change and conducts a risk assessment of overall system. *Strengths:* Qualitative or semi-quantitative. *Weaknesses:* Technical expertise required.

General Assessment Process

The Vulnerability Assessment Tool will focus on analyzing system thresholds in relation to climate change uncertainties. Each step of this process represents tools used by a number of domestic and international climate change and resilience assessments. The depth and scope of each step depends on the capacity of the parties and stakeholders involved. One of the Steering Committee's primary responsibilities is to help refine the scope of each step in order to best proceed with the assessment process. The assessment process involves the following four generalized steps:

1. **Data Collection and Analysis**
   Collect existing and necessary baseline data: non-climate change predictions, regional climate change models, sector portfolios (existing systems, proposed projects, potential future projects). Data can be analyzed using sophisticated computer modeling, or standard quantitative analysis.
2. **Stakeholder Participation**
   The process requires bringing the appropriate and professional stakeholders to the table. Stakeholders should include: technical sector experts, project managers, policy makers, climate change experts, etc.
3. **Scenario Exercises**
   Using data and stakeholder input, testing sector systems against climate change scenarios will provide input for critical thresholds of concern, and suggest possible mitigation and adaptation strategies. Scenarios are pulled from existing climate change resources and/or created by collaborative processes.
4. **Develop Strategies and Actions**
   Individual and multi-sector needs and opportunities are identified and developed to ensure robust and resilient sector systems.

Findings

Below are summaries of the most applicable assessments we reviewed. Summaries include a basic description of the approach, strengths and weaknesses in the tools, and in which of the four steps it would be most helpful.

International Assessments

1. UK Government, climate change impact assessment: Lisa Horrocks, et al. *"Provisions of research to identify indicators for the Adaptation Sub-Committee"*. AEA Technology. July, 2011. Framework for measuring climate change impacts and adaptations. Focuses on visually mapping systems and multi-sector analysis. *Strengths:* Detailed methodology to assess Drivers, Impacts and Actions (Adaptations). Focus on critical infrastructure and energy. *Weaknesses:* Data-heavy and time consuming.

*Best used in steps 1 & 4.***2. Sweden nonprofit, basic resilience assessment**: Resilience Alliance, Mike Jones, "*A Practitioners Guideline For Learning About Resilience While Doing A Resilience Assessment*". October, 2012. Tool to assess sector's "thresholds of concern" and adaptive cycles. Recommends small-scale adaptations. *Strengths:* Contains good scenario questions. Emphasizes nested systems and cross-scale analysis. *Weaknesses:* Not climate change specific. Time consuming.

Best used in steps 2 & 3.

3. Indonesian Government, all-sector vulnerability assessment: Ministry of the Environment "*Risk and Adaptation Assessment to Climate Change in Lombok Island"*. August, 2010. http://www.paklim.org/wp-content/uploads/downloads/2011/05/Risk-and-Adaptation-Assessment-to-Climate-Change-in-Lombok-Island.pdf. Multi-sector analysis of regional system vulnerabilities. Looks at natural and social systems. *Strengths:* Uses a quantitative and qualitative approach. Analyzes water and agriculture systems. *Weaknesses:* No methodology for collaboration. Data heavy and wrong scale.

Best used in steps 1 & 4.

4. International Collaborative, vulnerability assessment best practices: Downing, Thomas, and Anand Patwardhan. **"***Assessing Vulnerability for Climate Adaptation"*. Publisher and date unknown. ftp://147.125.80.20/pub/for/references/DowningPATWARDHAN%20Assessing%20Vulnerability%20for%20Climate%20Adaptation.pdf. Technical paper recommending activities and techniques for differing levels of vulnerability analysis. Contains annexes with climate change-specific tools. *Strengths:* Analyzes future vulnerabilities and offers detailed assessment tools. *Weaknesses:* Catch all for tools, not a systematic methodology.

Best used in steps 3 & 4.

North American Assessments

1. Northeast U.S. Mega-region, social vulnerability index, "*Social Vulnerability to Climate Change":* A vulnerability assessment which focuses on various populations, within the Northeast, and their vulnerability to climate change measured against race, education, location, income, and access to resources. *Strengths:* clear methodology, maps most at risk populations. *Weaknesses:* statistical and GIS analysis required.

Best used in steps 1 & 4.

2. Multnomah County, public health vulnerability assessment, "*Public Health Impacts of Climate Change in Multnomah County"*: A climate adaptation plan used by Multnomah County and the City of Portland to determine the public health sector's vulnerability and resilience to climate change. Uses the CDC's Building Resilience Against Climate Effects (BRACE) framework as the assessment tool. *Strengths:* Established framework, limited climate change data, and qualitative. *Weaknesses:* Sector data and experts required.

Best used in steps 1, 2,& 4.

Next Steps

OPDR will be elaborating on each of these assessment tools at our meeting this Thursday, December 6, 2012. We will discuss pros and cons and show some examples. With feedback from the steering committee, we will further refine the methodology to use for the water system pilot of this climate, energy and natural hazards vulnerability assessment project.

Community Planning Workshop

PARTNERSHIP FOR DISASTER RESILIENCE
CSC.UOREGON.EDU/OPDR

March 14, 2013

To
From **OPDR Project Team**
SUBJECT **HAZARD AND CLIMATE SCENARIOS**

Purpose

The purpose of these scenarios is to inform the assessment of system specific vulnerabilities, risks and capability to adapt. Once complete, the assessments will inform climate and threat/hazard planning at both the system and jurisdictional level. For example, identified system vulnerabilities to the earthquake hazard may inform mitigation strategies in the Eugene/Springfield Natural Hazard Mitigation Plan. Please become familiar with these scenarios generally and be prepared to discuss potential impacts to the system you work with.

I. Hazard/Threat Scenarios

Earthquake:

A major Cascadia event (9+ on Richter scale) causes significant shaking and structural damage to multiple critical facilities across the Eugene/Springfield Metro area. The event results in more than 100 fatalities locally (the majority in a single building collapse) and many more injured. Base utility outages (electric, sewer, water) affect all parts of the city and aren't expected to recover for weeks; earthquake triggered landslides and soil liquefaction have damaged underground infrastructure throughout the metro region. The I-5 corridor is damaged with several bridges out both North and South limiting access to Salem and Portland; locally, bridge and roadway damage limits transportation access throughout the metro region. Given the extensive damage to communities throughout Oregon, Washington, northern California and British Columbia, basic materials, equipment and labor needed to commence infrastructure recovery are in short supply with priority being given to larger cities and metropolitan areas. Social and economic systems are severely impaired.

Flood:

Major flooding occurs along the McKenzie and Willamette Rivers over the course of a week. In some areas floodwaters greatly exceed the mapped 100-year flood zone. Evacuation orders are in place for multiple neighborhoods.

Wildfire:

In late September, several large wildfires are burning on a mix of public and private lands in the McKenzie and Willamette River watersheds west of Eugene-Springfield. In addition, a local wildfire is burning just south of the Eugene city limit within the UGB; the fire has burned several homes and is threatening two subdivisions in the south hills. Mandatory evacuation orders are in place for large portions of south Eugene; Springfield is on high alert. Smoke is impacting the entire metro area. The fires are precipitated by dry winter conditions the previous two years and above average summer temperatures. Extreme heat (100+) is occurring and forecast for the next seven to ten days impacting vulnerable populations and beginning to strain local medical services.

Landslide:

Several prolonged periods of intense rainfall falling on already saturated winter soils have caused multiple small landslides throughout the metro region in areas of steep slopes; primary impacts are to roadways. A larger, slow moving rotational slide is also impacting a residential area; the slide has destroyed or severely damaged several homes and is impacting a collector street. Several additional residences are threatened. Rapidly moving landslides have also occurred in adjacent counties resulting in several deaths.

Winter Storm:

A large winter storm is impacting the greater Willamette Valley, with temperatures below freezing and two to three feet of snow on the valley floor; larger quantities of snow have fallen at higher elevations. We are three days into the event with below freezing temperatures expected to persist for the next five to seven days. The storm has already caused severe damage to trees and above ground utilities, closures of key transportation corridors (including I-5), numerous residential water supply issues due to burst pipes, and disruptions to essential services and delivery of assistance. Vehicle access to the south hills is extremely limited with some areas of the city completely isolated; emergency crews cannot access many areas with standard equipment. With electricity out, the potential for residential fires are becoming a major concern. Schools are closed for an extended period and no commercial freight is moving into or out of the area.

Energy Failure:

A computer malfunction has caused a widespread power outage throughout the Pacific Northwest impacting roughly five-million customers. Power is not restored to the EWEB and EPUD service areas for roughly 36 hours.

Fuel Spill:

A semi-truck carrying 8,000 gallons of gasoline bound for McKenzie Bridge overturns just before Holden Creek Lane. The accident results in an explosion, fire and significant quantity of liquid fuel spilling into the McKenzie River. Highway 126 is closed for nine-hours.

Dam Failure:

Unusually heavy rainfall within Lane County results in the failure of several dams that result in heavy flooding, power failure, and large sections of the populations in danger. The flooding results in heavy debris flow and structural damages to bridges downstream. Downstream water levels reach 30’ in downtown.

Upper Willamette Valley Climate Change Scenarios

2030: expected climate impacts

- Average annual temperature increase by 2-4 F [1]
- Less precipitation in spring, summer and fall [1]
- Snowpacks decline by 60% [1]
- Storm events increase in intensity with more flooding [1]
- Increased summer water shortages [2]
- Reduced summertime hydroelectric power [1]
- Increase in extreme heat events [2]
- Increase in wildfire frequency and intensity [2]
- Shift in growing season duration and timing [1]

2060: expected climate impacts

- Average annual temperature increase by 6-8 F [1]
- Possible monsoon patterns in spring, with summer droughts [1]
- Snowpacks decline by 80% [1]
- Earlier stream flow peaks, but at lower levels [3]
- Reduction in of forest biomass [1]
- Increase risk of food contamination [1]
- Longer growing season[1]
- Increase in insects and plant pests [2]
- Commodity, food and materials prices doubled [4]
- Increased city population density [4]

Sources:

1. Preparing for climate change in the Upper Willamette River Basin, 2009. from Climate Leadership Initiative.

http://www.theresourceinnovationgroup.org/storage/willamette_report3.11FINAL.pdf

2. Likelihood of climate risks for Oregon, from 2010 Oregon Climate Adaptation Framework.

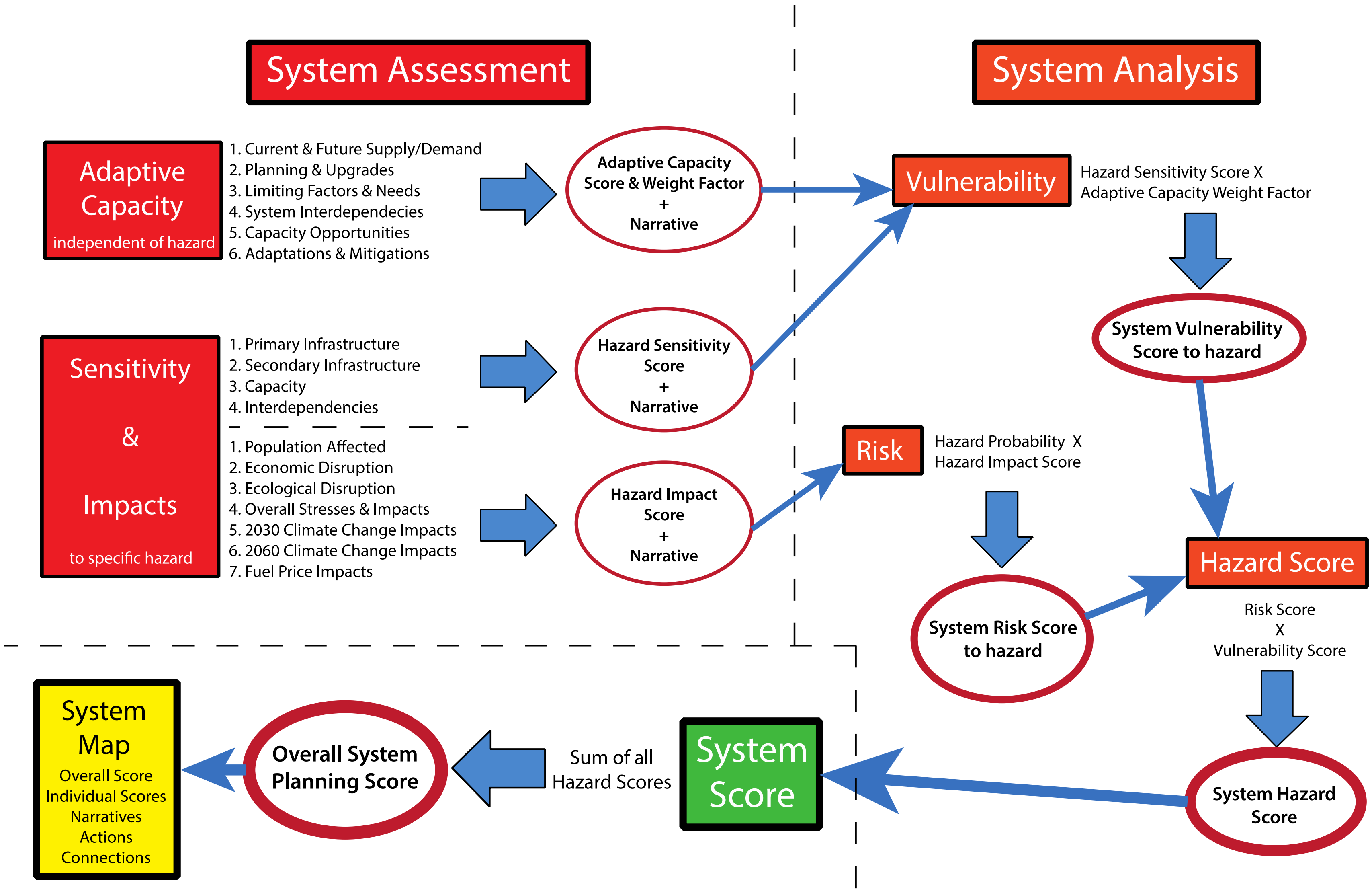
http://www.oregon.gov/LCD/docs/ClimateChange/Framework_Final.pdf

3. Impacts of natural climate vulnerability on Pacific Northwest Climate, Climate Impacts Group, University of Washington.

http://www.ef.org/westcoastclimate/D_PNW%20impacts.pdf

4. General forecast based on extrapolation of current trends

Appendix C: Assessment Tool Diagram



City of Eugene 2013 Hazard-Climate-Energy Vulnerability Assessment Tool

A city-systems approach to assessing hazard and climate change impacts

Prepared by Oregon Partnership for Disaster Resilience

In partnership with City of Eugene and City of Springfield, Oregon

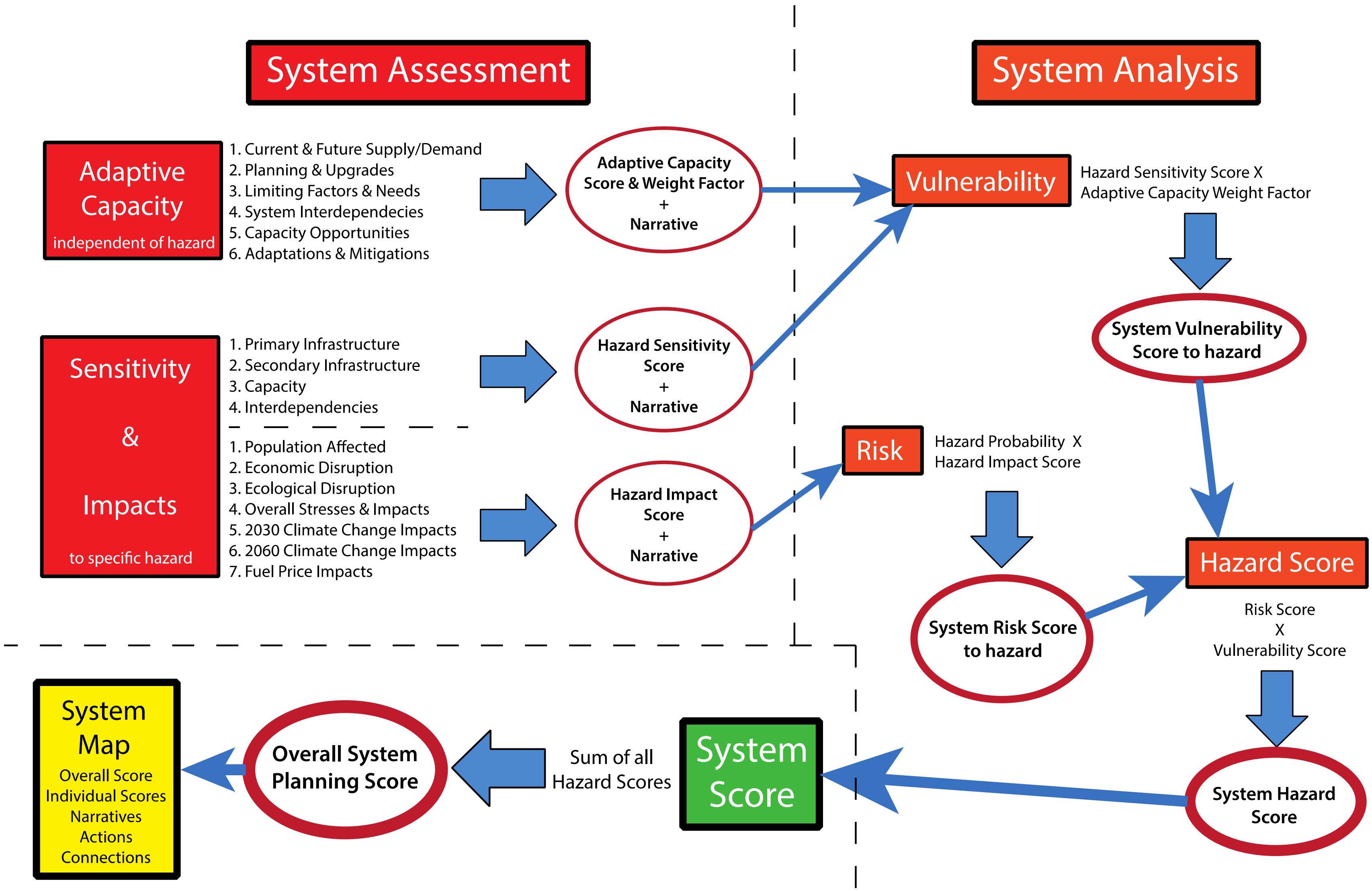
Introduction

The City of Eugene Hazard-Climate-Energy Vulnerability Assessment Tool ('the Tool'), is a new way of assessing city sectors such as water, energy, and food, for vulnerabilities not only from from natural hazards, but also climate change impacts, and energy and fuel price instability. The Tool seeks to assess an individual system's current adaptive capacity, sensitivity and risk to these potential impacts, and compare interdependencies between systems. This assessment and comparison will assist the City of Eugene in prioritizing mitigation and adaptation strategies and projects, as well as increase overall adaptive capacity across sectors.

This Tool was piloted and refined using input from the public and private sectors, and the results will be shared across sectors. This Tool uses both quantitative and narrative lines of questioning in order to encourage conversation amongst stakeholders, and to increase the overall shared learning between systems. The answers to the questions are scored and used to develop overall system vulnerability scores that can be cross-compared in a number of ways. This exercise is intended to be repeated every 5 years (?) in order to reassess advances in adaptive capacities, and the effectiveness of ongoing system planning, mitigations and adaptations.

The first step in the Tool is the system assessment. This step is composed of Part 1: Adaptive Capacity, and Part 2: Sensitivity and Impacts. The second step in the Tool is to analyze the answers to the questions in order to produce Vulnerability, Risk, and Hazard scores for the system. The third step involves developing an overall system planning score, which, along with the narratives, can be mapped along with other systems for cross-comparison. Figure 1 illustrates the process involved in the Tool.

Figure 1: Assessment Tool Diagram



Part 1: Adaptive Capacity Assessment

System Assessed:

Purpose

The purpose of this section is to assess your system's adaptive capacity. This assessment takes a snapshot of current system components, business activities and operations. The assessment is intended to provide a "base case" against which the system's adaptive capacity can be measured should a shock, emergency or long-term environmental change (e.g. natural, social, economic, etc.) occur.

Instructions to system managers:

In answering the following questions, please discuss your assumptions, how you arrived at answers, what narratives inform your answers, what cross-system conversations you may have, and what specific future scenarios you may entertain to arrive at your answers. If answers are related to system specific data please ensure the source of the data is included in your answer.

Please provide a description of the system, including its uses and users, its physical boundaries (for example, the water system will extend from the upper watershed to the wetlands), its legal and contractual obligations to provide service, its ownership, and its primary and secondary infrastructure components. This system description is intended to provide additional context for your answers. Some questions have ranked answers, while narrative questions do not. You will have the opportunity to score your system's adaptive capacity for each section as well as overall. For the Part 1 Adaptive Capacity questions, a low (1) factors into very low adaptive capacity, while a high score (5) factors into a highly adaptive system.

Adaptive Capacity

A natural, built, or human system's ability to accommodate a new or changing environment, exploit beneficial opportunities and/or moderate negative effects. Adaptive Capacity is assessed independently of hazard or climate change considerations.

1. Current and Future Demand + Supply

In order to determine how adaptive a system will be to future scenarios, a baseline of how the system operates and the current demands on the system will be necessary.

1.1. What is the average daily demand in respect to current capacity of the system?

1. Very High
2. High
3. Medium
4. Low
5. Very Low

1.2. What is the peak demand in respect to current capacity of the system?

1. Very High
2. High
3. Medium
4. Low
5. Very Low

1.3. Given projected demand, when would the current system reach 100% capacity?

1. < 5 years
2. 5-10 years
3. 10-25 years
4. 25-50 years
5. > 50 years

1.4. What are the supply or service issues you foresee in the long term (20-50 years)? Also, consider issues in the mid-term (5-20 years).

1.5. What are the known thresholds of failure on the system? Under what circumstances are these thresholds predicted to be reached?

1.6. Does your system experience seasonal lows and highs? Please list busiest and slowest times of the year of your system?

1.7. What question didn't we ask that we should have?

1.8. Based on the discussion in this section, how would you rank the system *overall* in respect to Current and Future Supply and Demand?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

2. Planning + Upgrades

A system with strategic and comprehensive planning processes, that uses consistent maintenance schedules, that uses the latest technology, and that plans upgrades and retrofits will likely be more adaptive.

2.1. Considering your system's sector worldwide, how rapidly does the sector undergo change (in technology, management practices, etc.)?

1. < 5 years
2. 5-10 years
3. 10-25 years
4. 25-50 years
5. > 50 years

2.2. How responsive is the local system to worldwide sector advances (in technology, etc.)?

1. >10 Years (The majority of system components are antiquated or based on technology no longer utilized.)
2. 5-10 Years
3. 3-5 Years
4. 1-3 Years
5. <1 Year (System employs the most advanced, cutting edge technology in the field.)

2.3. To what degree are the standards and expectations of the community being met by the current system?

2.4. To what extent is the system insured against catastrophic loss or failure? Also, explain how it is insured. What type?(self-insured negligence, impact, liability, federal)

2.5. Given a catastrophic failure of the system how much would it cost to replace the system now? Consider primary infrastructure.

2.6. How easy is it to replace parts and/or repair the system?

2.7. What question didn't we ask that we should have?

2.8. Based on the discussion in this section, how would you rank the system *overall* in respect to Planning and Upgrades?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

3. Limiting Factors + Needs

A system may be affected and/or limited by multiple factors outside the function and operation of the system. Limiting factors include, but are not limited to: politics, budgeting, energy costs, policies, laws, regulations, administrative and management, workforce availability and training, socio-economics, etc.

3.1. Describe the limiting factors of the system? (ex: politics, budgets, access to capital, regulations, energy costs, decision making apparatus, social systems, etc.)

3.2. Are there operational parameters or standards that, if not met, will directly or indirectly affect the system as a whole? (example: wastewater treatment must remove contaminants by X ppm, and if it does not do this, will it affect the service provided by the system?)

3.3. To what degree are system needs met? (System needs may include resource allocation, personnel, public/private assistance, etc. Please specify system needs).

3.4. What question didn't we ask that we should have?

3.5. Based on the discussion in this section, how would you rank the system *overall* in respect to Limiting Factors and Needs?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

4. System Interdependencies

It is important to understand if this system is directly and/or indirectly affected by other systems. In order to maintain a holistic approach to the community, it is important to understand which systems will be directly or indirectly affected by an adverse change in one system, and vice versa. In considering system interdependencies please list any systems that are fundamentally reliant on another system to operate. Also, note reliance on systems for only part of a given system's operations.

4.1. Which other systems or subsystems does this system fundamentally *rely on*? (Please check all that apply) Please explain how and why for each.

- ☐ Business/Industry
- ☐ Governance
- ☐ Nonprofits
- ☐ Communication
  - o Telephone
  - o Television
  - o Radio
- ☐ Drinking water
- ☐ Storm water
- ☐ Transportation
  - o Transit
  - o Freight
  - o Highway
  - o Non-motorized
- ☐ Housing
  - o Single-Family
  - o High-Density
  - o Temporary
- ☐ Energy
  - o Electricity
  - o Transmission/distribution
  - o Natural Gas
  - o Gas/Diesel
  - o Biofuels
- ☐ Food
  - o Agriculture
  - o Processing
  - o Distribution/Storage
  - o Wholesale/Retail
- ☐ Health
- ☐ Sanitary sewer
- ☐ Natural systems
  - o Watershed
  - o Forest
  - o Wetlands
  - o Parks and Open Space
- ☐ Public Safety
  - o Fire/EMS
  - o Police

4.2. How many other systems rely on *this* system to operate effectively? (Please check all that apply) Please explain how and why for each.

- ☐ Business/Industry
- ☐ Governance
- ☐ Nonprofits
- ☐ Communication
  - o Telephone
  - o Television
  - o Radio
- ☐ Drinking water
- ☐ Storm water
- ☐ Transportation
  - o Transit
  - o Freight
  - o Highway
  - o Non-motorized
- ☐ Housing
  - o Single-Family
  - o High-Density
  - o Temporary
- ☐ Energy
  - o Electricity
  - o Transmission/distribution
  - o Natural Gas
  - o Gas/Diesel
  - o Biofuels
- ☐ Food
  - o Agriculture
  - o Processing
  - o Distribution/Storage
  - o Wholesale/Retail
- ☐ Health
- ☐ Sanitary sewer
- ☐ Natural systems
  - o Watershed
  - o Forest
  - o Wetlands
  - o Parks and Open Space
- ☐ Public Safety
  - o Fire/EMS
  - o Police

4.3. What parts of the system have redundancies or backups (infrastructure, stockpiles, etc)? Please list.

4.4. What is the capacity of the redundant system? How long can it last, how many does it serve?

4.5. Are there interagency mutual aid agreements? If so, what do they entail?

4.6. What question didn't we ask that we should have?

4.7. Based on the discussion in this section, how would you rank the system *overall* in respect to System Interdependencies?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

5. Capacity Opportunities

Within the current operations and planning processes, potential opportunities may have already been identified by a given system's stakeholders.

5.1. What capacity building opportunities have already been identified by system management? (i.e. technological, organizational, personnel/training, regulatory) (List all)

5.2. What question didn't we ask that we should have?

5.3. Based on the discussion in this section, how would you rank the system *overall* in respect to Capacity Opportunities?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

6. Adaptation + Mitigation

If a given system currently integrates hazard and/or climate change mitigation/adaptation within the system's operations and planning, the system will be more adaptive.

6.1. Does the system currently employ a hazard/disaster plan/climate change adaptation plan? What are the important aspects?

6.2. Does the system employ ecological restoration as a mitigation strategy? What are they?

6.3. Does system offset carbon emissions in any way? By how much?

6.4. What question didn't we ask that we should have?

6.5. Based on the discussion in this section, how would you rank the system *overall* in respect to Adaptation and Mitigation?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

7. Other Information

7.1. Is there other information that we need?

7.2. What keeps you awake at night?

7.3. Based on the overall discussion and assessment of adaptive capacity, how would rate the overall adaptive capacity of your system?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

Part 2: Sensitivity and Impact Assessment

System Assessed:

Hazard Considered: [earthquake] [flood] [wildfire]

Instructions to system managers:

In discussing and answering the following questions, please document and record your assumptions, how you arrived at answers, narratives that inform answers, cross-system conversations you may have, and specific future scenarios you may entertain to arrive at answers. If answers are related to system specific data please ensure the source of the data is included in your answer.

A. Hazard Sensitivity

Hazard sensitivity is defined as the degree to which a natural, built, or human system is affected (either adversely or beneficially) by direct or indirect exposures to climate change conditions or hazards. Consider sensitivity in relation to the hazard or climate change impact(s) outlined in the scenario. Ranked answers will be averaged based on the number of questions answered. A low average ranking indicates low sensitivity; a high average ranking indicates high sensitivity. For the Part 2 Hazard Sensitivity and Impact questions, a low score (1) factors into a low sensitivity, and a high score (5) factors into a high sensitivity.

A1. Lead Off Questions

A1.1 How would you rank your system's overall sensitivity to this hazard? Why?

1. Extremely insensitive: A major hazard event will have no impacts to the system.
2. Mostly Insensitive: A major hazard event will have only minor impacts to the system.
3. Unknown sensitivity: A major hazard event will have unknown impacts to the system.
4. Somewhat sensitive: A major hazard event will have mostly minor, but maybe major impacts to the system.
5. Extremely sensitive: A minor hazard event will have major impacts to the system.

A1.2 Are there any other hazards not being assessed here that are a major concern for your system? (Drought, winter storm, terrorism, tsunami, etc.) Why?

A2. Primary Infrastructure

The infrastructure absolutely necessary to operate or maintain a system at its most basic capacity. Example: for drinking water system, primary infrastructure includes source intake, filtration and main distribution components.

A2.1 Please describe the components of your primary infrastructure and its basic capacity.

A2.2 What amount of the primary infrastructure is in the hazard-affected zone?

1. None
2. Very Little
3. Some
4. Quite a bit
5. All

A2.3 Considering all of the system components, including critical and essential components, what amount of the primary infrastructure would have to be impacted to trigger a catastrophic system failure?

1. Very High
2. High
3. Medium
4. Low
5. Very Low

A2.4 What question didn't we ask that we should have?

A3. Secondary Infrastructure

The infrastructure used to extend or improve a system's services and/or operations. The secondary infrastructure, in theory, is more easily replaceable than the primary infrastructure. Secondary infrastructure failure would result in minor to moderate capacity loss, but not result in entire system failure. Example: for drinking water system, secondary infrastructure includes secondary distribution components, meters, and hydrants.

A3.1 Please describe the components of your secondary infrastructure.

A3.2 How much of the secondary infrastructure and/or subsystems of the given system is in the hazard-affected area?

1. None
2. Very Little
3. Some
4. Quite a bit
5. All

A3.3 What percentage of the secondary infrastructure would have to fail in order to impact the primary infrastructure?

1. Very High
2. High
3. Medium
4. Low
5. Very Low

A3.4 What question didn't we ask that we should have?

A4. Capacity

If affected by climate change conditions or a hazard it will be important to know and understand how long a system (in its current state) could continue to operate under adverse conditions.

A4.1 On average, what percentage of the system would likely be disrupted if this hazard occurred?

1. <5%
2. 5% or 25%
3. 25% or 50%
4. 50% to 75%
5. 75% to 100%

A4.2 Will the hazard result in system demands that will likely exceed system supply and/or service delivery capacity? By how much?

1. No
2. Maybe
3. For a limited duration
4. Yes
5. Don't know

A4.3 How long can the current system operate if affected by this hazard? Consider question in relation to primary infrastructure.

1. Months or years
2. Weeks
3. Days
4. Hours
5. Minutes

A4.4 What question didn't we ask that we should have?

A5. System Interdependencies

As systems do not operate independently or in a vacuum, connections between systems are important aspects to identify potential pinch points, service delivery interruptions, or other aspects that affect system sensitivity.

A5.1 Which outside systems or sectors, if themselves affected by hazards or climate events, would affect your system's operations? How and to what degree?

- ☐ Business/Industry
- ☐ Governance
- ☐ Nonprofits
- ☐ Communication
  - o Telephone
  - o Television
  - o Radio
- ☐ Drinking water
- ☐ Storm water
- ☐ Transportation
  - o Transit
  - o Freight
  - o Highway
  - o Non-motorized
- ☐ Housing
  - o Single-Family
  - o High-Density
  - o Temporary
- ☐ Energy
  - o Electricity
  - o Transmission/distribution
  - o Natural Gas
  - o Gas/Diesel
  - o Biofuels
- ☐ Food
  - o Agriculture
  - o Processing
  - o Distribution/Storage
  - o Wholesale/Retail
- ☐ Health
- ☐ Sanitary sewer
- ☐ Natural systems
  - o Watershed
  - o Forest
  - o Wetlands
  - o Parks and Open Space
- ☐ Public Safety
  - o Fire/EMS
  - o Police

A5.2 Which outside systems or sectors are affected by your operations and adaptation activities? Describe those affects.

A5.3 What question didn't we ask that we should have?

B. Hazard Impacts

The degree of chronic stresses and major or catastrophic impacts from hazards on a natural, built, or human system.

B1. Lead Off Questions

B1.1 What are the expected chronic stresses to this system should this hazard occur?

B1.2 What are the expected major or catastrophic impacts to this system should this hazard occur?

B2. Population Affected

Percentage of the population that would be adversely affected by a given scenario. Does not refer to injury or death.

B2.1 What percentage of local population would be adversely affected if the hazard occurred today? (Does not refer to injuries or deaths)

1. Very Low
2. Low
3. Medium
4. High
5. Very High

B2.2 If this hazard occurs, what are the potential impacts to the workforce of your system. Or: Given a sudden 20% decrease in workforce, what are the stresses and impacts expected?

B3. Economic Disruption

Determine the economic impact of a given scenario. Determination would include monetary value being lost and over what extent of time.

B3.1 If this event occurred in your (region, county, city, facility) and had a direct impact on your system that interrupted service or supply, estimate the duration of interruption to major businesses and industry.

1. Hours
2. Days
3. Weeks
4. Months
5. 1 Year or longer

B3.2 If this event occurred in your (region, county, city, facility) and had a direct impact on your system, estimate the percentage of commercial business that would be interrupted.

1. < 10%
2. 10-30%
3. 30-50%
4. 50-75%
5. > 75%

B3.3 If your system is impacted by this hazard, what is the impact on service and/or supply revenue coming into your system?

B4. Ecological Disruption

Natural systems that are adversely affected by a given scenario, which then directly or indirectly affects a system. (Ex: hazmat release into watershed, which affects water quality

B4.1 To what extent is your system reliant on ecosystem services? Explain.

1. Very Low
2. Low
3. Moderate
4. High
5. Very High

B4.2 If the ecological system is impacted, what is the effect on your system?

B4.3 If your system is impacted, what is the effect on the ecological system?

B5. Overall Stresses and Impacts

B5.1 How would you rank this hazard's overall impact on your system?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

B5.2 Compared to other hazards, how would you rank this hazard's impacts as a matter of planning importance?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

B5.3 What question didn't we ask that we should have?

C. Climate Change Impacts

Climate change can create additional or compounding stresses and impacts for systems. A system that considers climate change as part of its planning can reduce its overall sensitivity/vulnerability and create a more adaptive system overall.

C1. 2050 Climate Change

Climate change scenarios for 2050 include:

- *average annual temperature increase by 2-4 degrees F*
- *Decrease in spring, summer and fall precipitation*
- *60% snowpack decline*
- *increase in extreme heat events*
- *increase in wildfire frequency and intensity*

C1.1 How would you rank your system's overall sensitivity to the climate scenario forecasts for 2050?

1. Very Low
2. Low
3. Medium
4. High
5. Very High

C1.2 Do any of the climate scenario factors exacerbate your sensitivity to this hazard? How?

1. No
2. Maybe
3. For a limited duration
4. Yes
5. Don't know

C1.3 Describe the predicted stresses and impacts to climate scenarios of 2050? Which factors will impact the system the most?

C1.4 What adaptations are your system considering or performing to address climate scenarios of 2050?

D. Fuel Price Impacts

The cost of petroleum affects many systems and should represent a major consideration for planning and operations. Please consider the following questions in respect to fossil fuels and products derived from fossil fuels that your system heavily relies on.

D1.1 How much is this system reliant on fossil fuels and products derived from fossil fuels? Please list.

1. Not at all reliant
2. Very little reliance
3. Somewhat reliant
4. Heavily reliant
5. Completely reliant

D1.2 What kind of effect has recent fuel price volatility had on this system's operations?

D1.3 What kind of impact would $10/gallon fuel have on this system's operations?

D1.4 What question didn't we ask that we should have?