Climate Preparedness Training Toolkit Template

October 2016

Table of Contents

1 Introduction 3
2 Climate Impacts 4
2.1 Understanding the range of impacts 4
2.2 Example 5
2.3 Exercise 6
3 Climate Science 8
3.1 Selecting an Appropriate Planning Horizon 8
3.2 Example 8
3.3 Exercise 10
4 Asset Inventory 11
4.1 Exercise 11
5 Risk Assessment 12
5.1 Likelihood and Consequence 12
5.2 Exercise 15
6 Developing Adaptation Solutions 19
6.1 Exercise 20
7 Key Terms and Definitions 21

1 Introduction

This workbook is a companion document to the Urban Sustainability Directors Network Climate Preparedness Training Toolkit Template. This workbook contains instructions and worksheets to support the Exercise Track of the training toolkit.

Many state and local governments are already preparing for the impacts of climate change by conducting vulnerability and risk assessments to inform the development of adaptation strategies. Adaptation is the practice of planning for anticipated climate change and developing strategies to address potential impacts. When coupled with the presentation slides, this workbook will lead participants through a series of exercises related to incorporating climate change into project planning and design. While the training toolkit focuses specifically on flooding (coastal, riverine, and urban), the planning tools and framework presented can be adopted to address many other climate change hazards (e.g., extreme heat, drought, etc.).

Figure 1 shows the overall process for incorporating climate change into municipal project planning. The exercises that are part of this workbook follow Steps 1-5: review climate science; inventory assets and operations; assess vulnerability; assess risk; and plan adaptation. **Let's get started!**

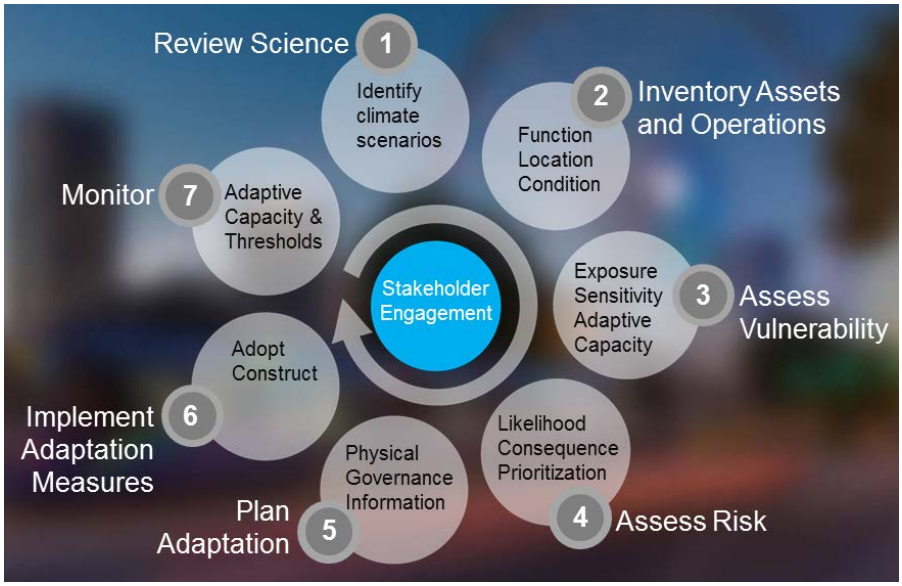


Figure 1. Process for Incorporating Climate Change into Project Planning

2 Climate Impacts

2.1 Understanding the range of impacts

The potential impacts felt from flooding – either temporary from periodic flooding from storms or extreme tides or permanent from sea level rise – are wide ranging and could include:

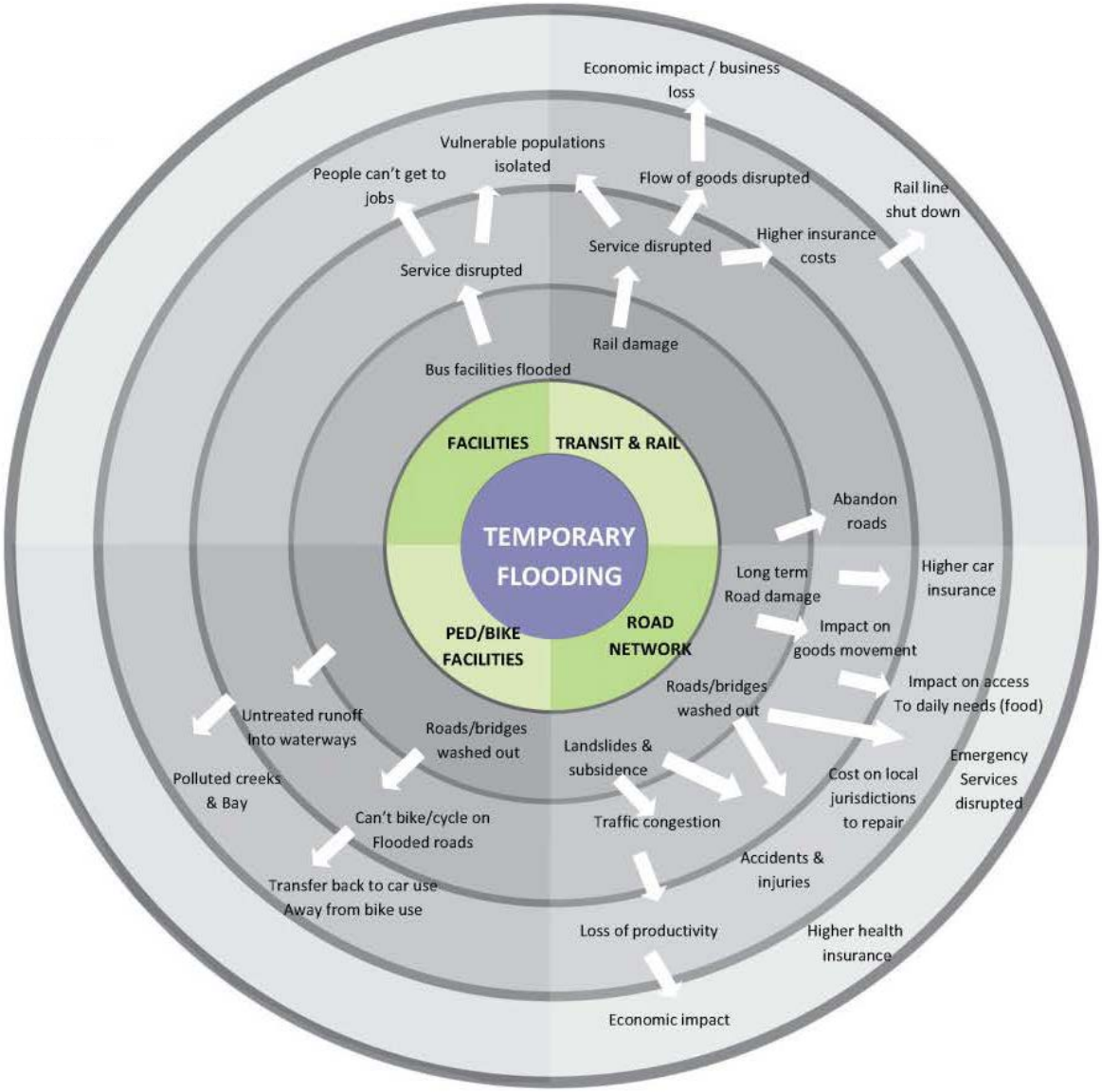
- **Buildings and Property:** Water damage, reduced capacity
- **Supply chain:** Disruption to transport network
- **Health and Safety:** Loss of power for light, pumping, communication, air conditioning; Water quality, vector- borne diseases
- **Environmental:** Erosion, habitat impacts
- **Operations and finance:** Economic impacts to business

There can be many 'cascading impacts' or knock-on effects that come about due to a coastal, riverine or urban flooding event on different government departments, many of which are interconnected. It is useful to map out these cascading impacts in multidisciplinary groups to see where working together could help address these impacts more efficiently.

2.2 Example

The following image shows the results from a 'cascading impacts' exercise. The group in this example was given the hazard of a temporary flooding event to review on different types of transportation facilities. They identified:

- The cascading impacts that affecting each asset type particular asset type
- The physical, social and economic impacts that overlap between different services / departments

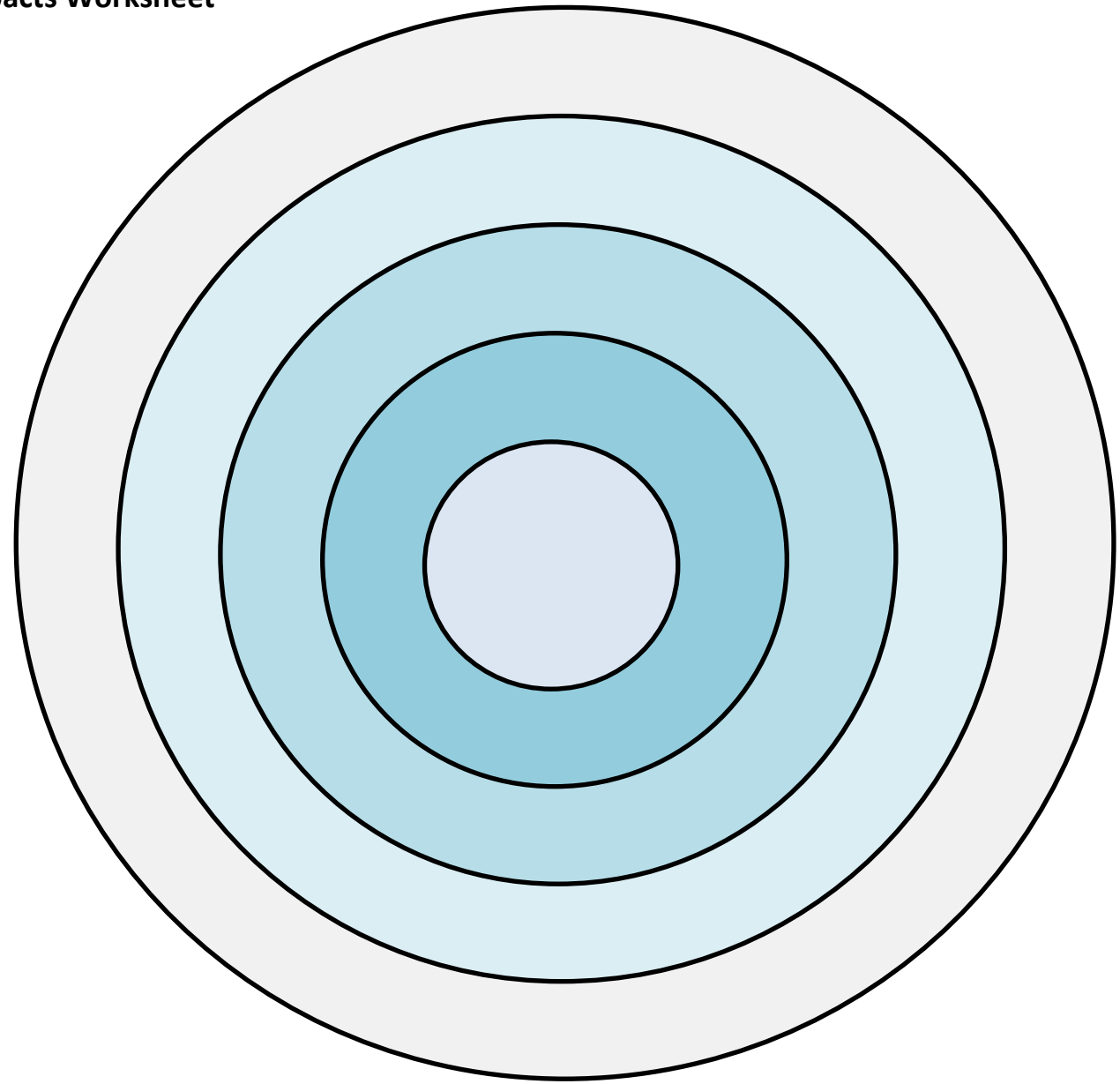


2.3 Exercise

Either using the worksheet on the next page, if working on your own, or on a larger sheet that will be provided by your training leader if working in a group, select a climate hazard that you wish to examine (such as sea level rise; urban flooding, riverine flooding) and a sector (such as buildings; transportation; power) or a neighborhood within your city. Write the hazard (and sector) in the central circle and carry out the following steps:

- Identify the cascading impacts that will affect your job / service / particular asset type
- Identify physical, social and economic impacts that overlap between different services / departments
- Consider the stakeholders / collaborations needed to address the impacts

Cascading Impacts Worksheet



3 Climate Science

3.1 Selecting an Appropriate Planning Horizon

Adaptation to sea level rise and changing precipitation patterns begins with an understanding of the current state-of-the-science. Climate science is continually being updated, revised, and strengthened. Although there is no doubt that climate change has occurred and will continue to occur, it is difficult to predict with certainty what amount of sea level rise or change in precipitation patterns will occur at any given time in the future. Given these uncertainties, climate change planning must rely on the best available science.

During project planning, the selection of an appropriate project planning horizon often influences the selection of climate change projections. There are two primary factors that influence project planning horizon selection:

- **Starting year** – when will the asset or facility be in use and fully-functional? Does the asset or facility exist today and, if yes, when was it constructed? If the asset or facility is to be newly constructed, when will construction be complete?
- **Lifespan (functional working life)** – how long will the asset or facility be in use at the given location (including regular repair and maintenance)?

Project planners should consider these factors as they select the appropriate planning horizon for evaluating climate vulnerabilities and risks and plan to accommodate or adapt to future climate conditions if they occur.

3.2 Example

Two new structures are in the planning process for a facility. Structure 1 exists today. It was originally constructed in 1960s and is in need of substantial rehabilitation and retrofitting. Structure 2 is new. Construction is anticipated to start in 2017, with a completion date of 2019. The facility is in an area for which a new Specific Plan is being developed. The Specific Plan will take about 2 years to complete and is for the time period 2018-2030.

Structure 1 (Rehab and Retrofit)

Starting Year:	1960
Functional Lifespan:	90 years (with rehabilitation, the structure is anticipated to remain in use until the year 2050, and then the structure is likely to be replaced)
Planning Horizon:	2050

Structure 2 (New Construction)

Starting Year: 2019

Functional Lifespan: 100 years (the structure is anticipated to have a functional working life of at least 100 years, assuming regular maintenance)

Planning Horizon: 2119 (2100 at a minimum)

Specific Plan

Starting Year: 2016

Plan Lifespan: 12 years (the plan is for 2018-2030)

Planning Horizon: To answer this question, it is necessary to understand the type of land use decisions that the Specific Plan covers. If the document is planning for new development that might have a lifespan of much longer than that, the appropriate planning horizon for land use decisions could be out to 2100.

3.3 Exercise

In a group, or on your own, choose a representative facility in your city, and consider what sources of information you would rely on when beginning a climate change vulnerability assessment. What timeframe are you most likely to consider (e.g., 30-year design life, 75-year functional lifespan, or 2100+ planning horizon). What agency or organization would you rely on for the current state-of-the science? Would you complete your assessment internal to your department, or would you collaborate with others?

Facility or Asset: _____

Year Built: _____

Lifespan: _____

Planning Horizon: _____

Climate Stressor(s) [sea level rise/riverine flooding/urban flooding]:

_____

_____

_____

Data Source(s): _____

_____

_____

_____

Collaborator(s):_____

_____

_____

4 Asset Inventory

The development of the asset and operations inventory is a required initial step in climate adaptation planning. Key assets and operations are identified and catalogued. Information to be catalogued may include:

- Year constructed / age
- Location
- Elevation (lowest adjacent grade and elevation of electrical components)
- Condition
- Materials
- Redundancy
- Maintenance history
- Prior damage or repair history related to climate variables (e.g., flooding)
- Upstream and downstream linkages (if applicable)
- Future planned upgrades or repairs (if any)

4.1 Exercise

In a group, or on your own, choose a representative facility in your city, and think about which assets might be the most sensitive to flooding, whether from sea level rise / storm surge or riverine /urban flooding and record them below. What is it about these assets that make them sensitive? Can you think of any relevant asset information that is not recorded above that would be helpful in assessing vulnerability?

Asset type	**Factors that make the asset sensitive**

5 Risk Assessment

5.1 Likelihood and Consequence

Risk is typically evaluated by comparing the probability that impacts would occur (or *likelihood*) to the *consequence* of these impacts. Likelihood of impact is rated using a relative rating system that ranges from rare events to events that are nearly certain to occur. Similarly, consequence is rated using a relative rating system that ranges from insignificant to catastrophic impacts. It is up to the professional conducting the risk assessment to decide how to categorize and score likelihood and consequence. However, likelihood can be difficult to quantify when considering sea level rise related impacts, as most current scientific studies cannot calculate the probability of a sea level rise projection occurring in any given year or at any particular level. Therefore, when assessing risks associated with sea level rise, potential consequence is often the primary consideration.

Consequence considers the magnitude of the impact that would occur under the selected sea level rise and storm surge scenarios. Information about the asset, such as its age, condition, and materials are often informative when considering the consequences. The questions below can be useful in framing the consequence of flooding related impacts.

- **Damage**:
  - What is the level of damage to the asset?
  - Can the asset be repaired, or would the asset require complete replacement?
- **Disruption**:
  - Is there a disruption in service?
  - If yes, what is the length of that disruption, i.e., hours, days, weeks? Does the disruption threatening public health and safety?
  - Will disruption at this asset have cumulative effects throughout an interconnected system (e.g. failure of a pump station will cause wastewater backups upstream)?
- **Cost**:
  - What is the cost to repair or replace the asset?
  - What are the economic (or health and safety) costs associated with the disruption in service?
  - Are there secondary impacts that need to be considered (i.e., potential impacts to human health and safety, or costs to other sectors, such as the environment and public recreation)?

The intent of the consequence assessment is to develop a means to prioritize assets for adaptation planning and implementation. The best questions for framing consequence may vary depending upon asset function or the type of service the asset provides (i.e., essential infrastructure, flood protection, health and safety, public access).

One method is to assign ratings from 1 to 5 for likelihood and consequence and use a matrix scoring system. A risk assessment helps differentiate the consequence of impacts to different assets that may be exposed to the same climate hazard.

The tables below provide some example ratings for Likelihood and Consequence, and how they combine to provide a risk rating.

Likelihood

Qualitative Measures of Likelihood

Likelihood	Descriptor	Recurrent Risks	Single Events
5	Almost Certain	Several times per year	More likely than not – greater than 50%
4	Likely	Once per year	As likely as not – 50/50
3	Possible	Once per 5 years	Less likely than not but still possible – less than 50% but still quite high
2	Unlikely	Once per 20 years	Unlikely but not negligible – low but greater than zero
1	Rare	Once per 100 years	Negligible – Probability very small

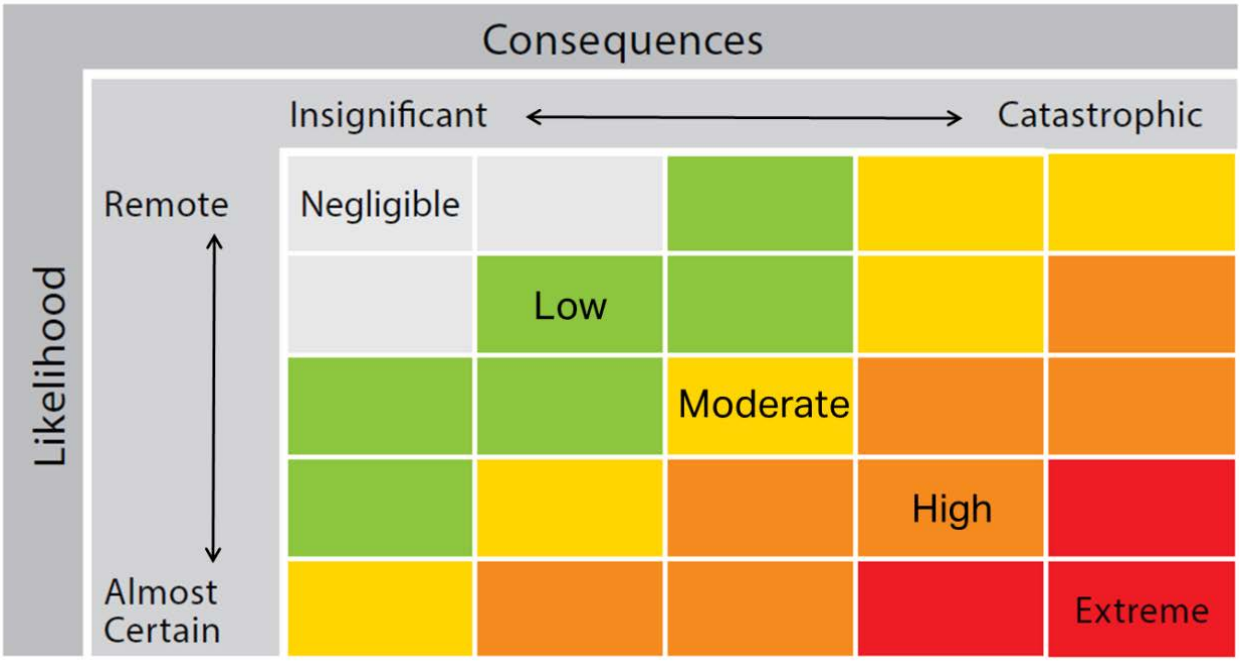
Consequence

Qualitative Measures of Consequence

Consequence	Descriptor	People	Infrastructure and Services
5	Catastrophic	Multiple deaths and severe injuries	Loss of asset or critical service failure for extended period of time (>6 months)
4	Major	Multiple deaths or severe injuries	Loss of asset function or major service failure for up to 1 month
3	Moderate	Severe injuries	Moderate loss of asset function or moderate service failure for up to 1 week
2	Minor	Major injury	Moderate service failure for up to 3 days
1	Insignificant	Minor injury or near miss	Minor service interruption for <1 day

Risk Matrix

Risk Scoring Matrix



5.2 Exercise

The small city of Sevenoaks, population 250,000, is located on the edge of the Atlantic Ocean in a Northeastern State. The stormwater system in Sevenoaks is a combined system, with a number of pumps, maintenance holes, and outfalls that are located in the City's mapped sea level rise hazard zone. Sevenoaks' road network is made up of paved local and arterial roads. There are no bridges in the town, although there are culverts (2 to 6 feet in diameter) throughout the town which convey small streams under roadways. Within the next few decades, the Northeastern States are likely to experience changes in current flood hazards as a result of climate change. These flood hazards include rising sea levels, increasing heavy precipitation storms, and rapid snowmelt during warmer winter and spring seasons. The table below summarizes the expected changes in these flood hazards by 2050, and the anticipated impacts that can occur in the Northeastern States and Sevenoaks.

Event	Time Horizon: 2050s (changes with reference to Year 2000)	Anticipated Impacts
Sea level rise	8" (low); 11-24" (med); 30" (high)	Permanent inundation of current shorelines and some inland areas. Increased temporary flooding and erosion during storm surge events. Increasing damage to coastal infrastructure.
Extreme Precipitation	↑ 0 to +10% change average rainfall, ↑ intensity of extreme rainfall events (>3 inches/day), but possibly less frequent occurrences.	Increased number of drought periods between severe rainfalls. More intense downpours exceeding capacity of stormwater conveyance system.
Rapid Snowmelt	↑ timing of peak streamflow (~10 days earlier), ↑ frequency of higher streamflow events (5 year peak flow now every 2 years)	Accelerated snowmelt from warmer winter and spring temperatures can affect timing of stream flooding, and increased ice jams damaging infrastructure. Increased peak streamflow resulting in overbank flooding.

The infrastructure systems under study are:

A. Stormwater system including pump stations, maintenance holes, control structure, and outfalls.
   Q. What are the consequences of flooding to the functioning of this system and the neighborhoods in which the system components are located?

B. Road network which is comprised of local and arterial asphalt paved roads. Road network has no bridges, but there are culverts to permit small streams to cross roads. Streams have occasionally overflowed onto roadway due to heavy rain events.
   Q. What are the climate change related consequences to roadway pavement, foundations and culverts?

Either working on your own or with your group, pick one type of infrastructure asset (A. stormwater system, B. local road network) to carry out a risk assessment. Refer to likelihood (L), consequence (C) and risk (R) score reference tables for a description of scores. *Note that the likelihood of future climate events has already been scored for you.*

Fill out the consequence (C) for the interaction between the three events and the infrastructure asset you have chosen. Provide justification as to the consequence score. Calculate risk score by multiplying likelihood x consequence (L x C), and determine whether assets fall under low, medium, high or extreme risk. As a group, decide who will present risk assessment results. Present the extreme to low risks.

Infrastructure A

Stormwater/Wastewater System

Instructions: Complete consequence (C) and risk scores (L x C). Provide justification for consequence scoring.

Future Weather Event (2050 Time Horizon)

Stormwater/Wastewater Elements		Sea Level Rise of 21 inches above average daily high tide			Rainfall event exceeding 3 inches / day, leading to localized street and stream flooding			Rapid Snowmelt (50% increase in spring season peak flow)		
		L	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**
Stormwater/ Wastewater System	Pump Stations and Treatment Facilities	5			4			4		
	Storm Drains and Conveyance Pipes	5			4			4		
	Outfalls	5			4			4		

Note: L=likelihood, C=consequence, and R=risk

Provide details on consequence scores:

Sea level rise of 21 inches by 2050, leading to permanent inundation or temporary flooding from exacerbated storm surge events

Rainfall event exceeding 3 inches/day, leading to street flooding and increased stream flows

Rapid snowmelt resulting in 50% increase in spring season peak flows and/or potential ice jams

Infrastructure B

Local and Arterial Road Network

Instructions: Complete consequence (C) and risk scores (L x C). Provide justification for consequence scoring.

Future Weather Event (2050 Time Horizon)

Infrastructure Elements		Sea Level Rise of 21 in above average daily high tide			Rainfall event exceeding 3 inches / day, leading to localized street and stream flooding			Rapid Snowmelt (50% increase in spring season peak flow)		
		L	**C**	**R**	**L**	**C**	**R**	**L**	**C**	**R**
Local road network and infrastructure	Road pavement	5			4			4		
	Road foundations	5			4			4		
	Culverts and crossings	5			4			4		

Note: L=likelihood, C=consequence, and R=risk

Provide details on consequence scores:

Sea level rise of 21 inches by 2050, leading to permanent inundation or temporary flooding from exacerbated storm surge events

Rainfall event exceeding 3 inches/day, leading to street flooding and increased stream flows

Rapid snowmelt resulting in 50% increase in spring season peak flows and/or potential ice jams

6 Developing Adaptation Solutions

During this phase of the adaptation planning process, potential adaptation strategies are developed for assets, projects, or community features that are identified as vulnerable. If a risk assessment was also completed, the adaptation plan may prioritize adaptation planning for assets, projects, or features whose vulnerability poses high risks. Together, the vulnerability and risk ratings can help develop a prioritized list of assets for adaptation strategy development and implementation.

The adaptation plan should clearly lay out the triggers or time horizons for implementation of the identified adaptation strategies, and the plan should include a means to monitor and respond to changes in the science, climate conditions, or the condition of the asset. This approach can reduce the near-term cost of project implementation, while providing for future flexibility and adaptation potential. The adaptation plan should include funding mechanisms necessary for implementation of future adaptation strategies.

In evaluating the adaptive capacity of a project, these questions are often asked: Does the project, project footprint, or adaptation feature(s) have the ability to be modified or changed to accommodate future higher sea level rise or a larger riverine flood plain as new data and science emerges? In other words, can project resilience be secured for some logical period of time (e.g., through 2050) and *also* accommodate further adaptation measures based on new developments and science in subsequent years? And what are those triggers or time horizons for implementation of adaptation measures (which make the project resilient now) and adaptive management approaches (which allow response to future trends with further measures)?

6.1 Exercise

The final exercise is a Climate Resilience Project Review to be done in a group. The aim of this exercise is to review a project that is under early stages of development in your city and to consider what adaptation strategies might be appropriate, taking advantage of the cross-department, multi-sector staff you have in the room. Your trainer will have chosen a project and will provide materials that will help you understand the project such as a location map or aerial, preliminary concept designs, potential flood zones, etc. and any other useful project details. You will be provided with a large print out of a plan or aerial to annotate. Think about what adaptation strategies could be integrated into the project so make it more resilient to potential future flooding.

Consider:

- Which climate change stressors affect the project?
- What constraints does the site have?
- What adaptation strategies might be possible?
- What are the opportunities for social, equity, economic, and environmental benefits to the City?
- What are the short, medium and long term benefits?
- Are there any potentially risks or negative consequences?
- How can the project highlight interdependencies between systems or sectors?
- What stakeholders should be involved in the project?
- In summary how could it contribute overall to the resilience of City?

7 Key Terms and Definitions

The following key terms are used throughout the training workshop and within this workbook.

Adaptation The practice of planning for anticipated climate change and developing strategies to address potential impacts.

Adaptive Capacity An asset's inherent ability to adjust to sea level rise impacts without the need for significant intervention or modification, and/or existing flexibility or redundancy within a system that allows for continued functionality when a system is under stress.

Asset Property, often a facility or structure (or a component of the facility or structure) regarded as having value. In this context, an asset is typically a physical component of an interrelated system that is essential to enable, sustain or enhance societal living conditions, such roads, bridges, tunnels, sewers, pump stations, etc. Natural resources, including open space, parks, and habitat, are also assets which may be considered in adaptation planning.

Climate Climate is often defined as the "average weather," or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities (such as temperature, air pressure, humidity, precipitation, and wind) over a period of time ranging from months to thousands of years. The traditionally accepted time period is 3 decades, as defined by the World Meteorological Organization (WMO). Climate in a wider sense is the state, including a statistical description, of the climate system.

Climate Change Climate change refers to any significant change in the measures of climate lasting for an extended period of time. In other words, climate change includes major changes in temperature, precipitation, wind patterns, or sea level rise, among others, that occurs over several decades or longer.

Climate Impact The physical manifestation of a short- or long-term climate stressor, such as flooding, degradation, damage, or destruction.

Climate Hazard The component of climate (e.g., sea level rise, storm surge, precipitation, temperature) or event (e.g., extreme storm) that causes short- or long-term stress or impact to an asset, system, or community over time. Also referred to as a climate *stressor*.

Consequence Something that happens to an asset or facility as a result of a particular climate impact or a combination of climate stressors. In a practical sense, consequence often considers damage, disruption, and/or costs to repair or replace. Also includes indirect consequences, such as impacts to supply chain or economic losses due to loss of function of an asset.

Design Life	The period of time designated by engineers during which the asset or facility is expected to perform within its specified design parameters.
Exposure	The exposure of an asset is the degree to which an asset is susceptible to hazards (i.e., depth of flooding due to sea level rise, storm surge and wave run up).
Flooding	The temporary inundation of a normally dry area as a result of abnormally high water levels. This training toolkit distinguishes between three types of flooding: (1) coastal, (2) riverine, and (3) urban. *Coastal* flooding is caused by the combination of high tides and waves. *Riverine* flooding is caused by prolonged or intense precipitation within a watershed that causes a river or creek to overtop its banks and inundate its floodplain. *Urban* flooding is caused by intense precipitation in developed areas that overwhelms the stormwater collection system. One type of flooding may be exacerbated by another – for example, urban flooding may be worsened during high tides due to back-up of the stormwater system.
Functional Lifespan	The actual period of time the asset or facility will be in use at the given location (including regular repair and maintenance). The functional lifespan is typically longer than the engineering design life.
Planning Horizon	The timeframe that should be considered when planning for and adapting to climate change (e.g., 2050, 2100, 2100+)
Sensitivity	The degree to which an asset is, or could be, affected (i.e., temporary flooding causes minimal impact, or results in complete loss of asset or shut-down of operation) by a climate stressor, if exposed to that stressor.
Risk	The potential chance of damage, disruption, injury or loss as a result of exposure to a climate hazard or stressor. Risk is often considered a combination of the cost of the impact or stressor and the likelihood that the impact will occur.
Vulnerability	The degree to which an asset may be physically or functionally impacted by a climate hazard. Vulnerability is a combination of exposure, sensitivity, and adaptive capacity.