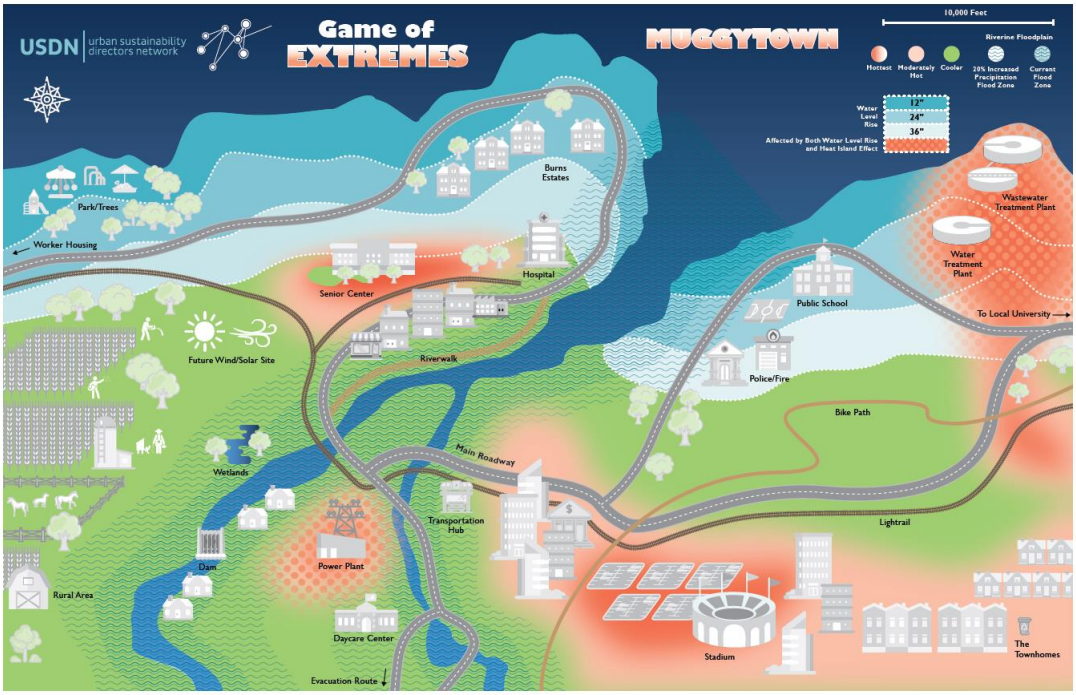
Game of Extremes
Participant Workbook



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1 Introduction

This workbook contains instructions and worksheets to support the "*Game of Extremes*", a hands-on, interactive game that allows workshop participants to immerse themselves in a fast-paced, fictional climate change assessment and adaptation plan[1].

Many state and local governments are already preparing for the impacts of climate change by conducting vulnerability and risk assessments to inform the development and implementation of adaptation strategies. *Adaptation* is the practice of planning for anticipated climate change and developing strategies to address potential impacts. While the *Game of Extremes* focuses specifically on flooding (coastal and riverine) and extreme heat (days above 95 degrees Fahrenheit[2]), the planning tools and framework presented can be adopted to address many other climate change hazards (e.g., drought, wildfires, etc.).

Figure 1 shows the overall process for incorporating climate change into municipal project planning. The exercises that are part of the *Game of Extremes* follow Steps 1-6: review climate science; inventory assets and operations; assess vulnerability; assess risk; plan adaptation; and implement adaptation measures. **Let's get started!**

Figure 1. Process for Incorporating Climate Change into Project Planning and Implementation

[1] The Game of Extremes is based on The Game of Floods created for the USDN in 2016. The Game of Floods was based on a planning tool originally developed for Marin County, California to assist stakeholders in better understanding and prioritizing adaptation strategies needed to respond to sea level rise and coastal flood hazards. This interactive tool was leveraged and expanded by Kris May and Rebecca Verity at AECOM to include vulnerability analysis with permission from Marin County. Additional refinements to focus the game on city stakeholders were made in support of the USDN toolkit development, also with permission from Marin County.

[2] Days above 95 degrees is commonly used as a proxy measure for extreme heat projections, whereas extreme heat warnings are normally based on a heat index that combines heat and humidity to determine an extreme for a given location.

2 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 climate 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, 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 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 water 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 degradation, damage, or destruction.

Climate Hazard The component of climate (e.g., water 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.

Exposure The exposure of an asset is the degree to which an asset is susceptible to hazards (i.e., depth of flooding due to water level rise, storm surge and wave run up).

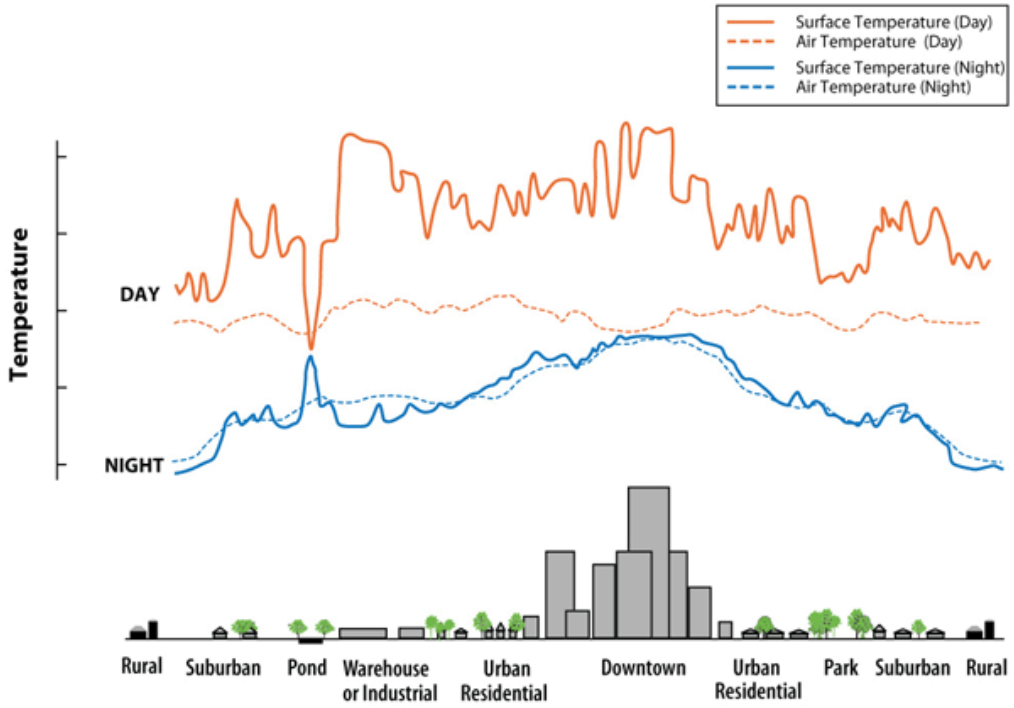
Extreme Heat	Temperatures that are much higher than the average for a particular time and place. For comparative studies, extreme heat days are often defined when the daily maximum temperature exceeds 95°F.
Flooding	The temporary or permanent inundation of a normally dry area as a result of abnormally high water levels. This training toolkit distinguishes between two types of flooding: (1) coastal and (2) riverine. *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.
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.
King Tide	The highest predicted high tide of the year at a coastal location. It is above the highest water level reached at high tide on an average day. King tides are also known as perigean spring tides (EPA).
Planning Horizon	The timeframe that should be considered when planning for and adapting to climate change (e.g., 2050, 2100, 2100+).
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.
Sensitivity	The degree to which assets, human beings, or the environment are 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.
Urban Heat Island	The accumulation of heat within urban areas caused by heat absorption and re-radiation of large impervious surfaces (e.g., roadways, sidewalks, buildings). Downtown building areas also reduce wind flow trapping heat. This causes the urban landscape to be hotter than the surrounding areas. Air temperatures in cities, particularly after sunset, can be as much as 22°F (12°C) warmer than the air in neighboring, less developed regions. Higher air pollution is also associated with UHIs, which can lead to smog and decreased air quality.
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.
Water Level Rise	This term is used in Game of Extremes as an alternative to the coastal-only “sea level rise”. It denotes an increase in local waterbody levels that could lead to permanent flooding of low-lying assets near the waterbody.

-Game Start-

3 Understand your City

Adaptation to water level rise, riverine flooding from increased precipitation and extreme heat 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 water level rise, change in precipitation patterns, or the number/magnitude of extreme heat days will occur at any given time in the future. Given these uncertainties, climate change planning must rely on the best available science. For the purposes of the game, you will be presented with a prepared climate scenario (as part of the next section).

For understanding the potential impacts of extreme heat, an understanding of the Urban Heat Island effect is also needed. The Urban Heat Island (UHI) effect is the accumulation of heat within urban areas caused by heat absorption and re-radiation of large impervious surfaces (e.g., roadways, sidewalks, buildings). Downtown building areas also reduce wind flow trapping heat. This causes the urban landscape to be hotter than the surrounding areas. Higher air pollution is also associated with UHIs, which can lead to smog and decreased air quality.



Temperature differentials showing the Urban Heat Island effect. (EPA)

Below are recommended resources for understanding your local climate:

Resource	Data	Website
US Climate Resilience Toolkit's Climate Explorer	Historical and projected county-level climate data	https://crt-climate-explorer.nemac.org/
National Climate Assessment	Historical and projected regional and sector-specific climate information and data	https://nca2014.globalchange.gov/
NOAA's National Centers for Environmental Information (NCEI)	Comprehensive oceanic, atmospheric, and geophysical data	https://www.ncdc.noaa.gov/
NOAA's NCEI State Climate Summaries	State-level information on historical and projected climate conditions	https://statesummaries.ncics.org/
NOAA Climate.gov	Climate maps and datasets that document various climate conditions	https://www.climate.gov/

GAME OF EXTREMES ACTIVITY [10-15 minutes]

- Review the *Game of Extremes* game board. Imagine that the board is a dense city with buildings, streets, critical assets and homes throughout. In particular, identify areas impacted by the urban heat island (UHI) effect and riverine or coastal flooding. Imagine that the colors on the board represent different baseline temperatures (red = +10°F; pink = +5°F; green / white = +0°F). Note that the dotted lines denote coastal flood zones, even when the color between dotted lines is a red or pink because of the overlap between flood and heat zones. Red / pink areas with dots represent areas affected by both the heat island effect and flood exposure.
- Review your role card. You are encouraged to play the game from the viewpoint of your role character.
- Very briefly introduce yourself (based on your role) to the rest of the players at your table.
- Familiarize yourself with the description of Muggytown below.

City Description:

Muggytown was originally settled by Native peoples, who were drawn to the rich and fertile soils and pushed out by colonization that started in the late 1700s. Given its proximity to the coast and, thus, easy access to export markets, the city's economy boomed in the early 1900's resulting in both additional farmland development as well as rapid urbanization. The city's economy still has a strong agriculture focus, but it has also expanded to include technology, tourism, and healthcare industries. The city's population is currently 422,000 and the demographic makeup is 50% White, 30% Black or African American, 14% Hispanic or Latino, 5% Asian or Asian American, and 1% Native American. 20% of Muggytown residents live below the poverty line and the city has a homeless population of roughly 4,000 people. A large percentage of the low-income population lives in or around the Townhomes public housing complex in the southeast area of the city.

Due to the rapid urbanization of Muggytown, the downtown area is made up of many impervious surfaces such as roadways, buildings, and parking lots. This has resulted in major urban heat island issues in the city. In the past decade, the city has experienced three heat waves lasting longer than three days which have claimed at least 10 lives. The area of the city around the river is a mix of farmland and industrial parks, both of which have experienced damaging precipitation-related flooding several times in the past decade. In addition, because of water level rise, the part of the city along the coast, with both transportation facilities and tourism infrastructure, is increasingly experiencing king tide flooding and will be susceptible to permanent inundation from water level rise.

4 Asset Inventory

The development of the asset inventory is a critical initial step in climate adaptation planning. Key assets are identified and catalogued. Information to be catalogued at this stage 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, heat wave)
- Upstream and downstream linkages (if applicable)
- Future planned upgrades or repairs (if any)

GAME OF EXTREMES ACTIVITY [40 minutes]

- As a group, your table should identify the 10 assets on the board you consider critical for the resilience of the city, including the functioning of the city and the needs of the residents, taking into account economic, social, and environmental concerns. These assets will be the focus of the adaptation plan developed later in the game.
    - Review the climate change scenario card your facilitator gives you that describes the timeframe and types of impacts Muggytown will experience.
    - Review the assets on the board and the related asset cards and advocate for the assets you think most important to prioritize. This is an opportunity for you to get into your role!
    - Complete the Asset Inventory section of the table below by listing the 10 assets selected by your team.

Asset Inventory, Vulnerability Assessment, and Risk Assessment Table

	Asset Inventory				Vulnerability Assessment									Risk Assessment	
	Asset	**Year Built**	**Condition (Poor, Moderate, Good)**	**Prior Damage History (Y/N)**	**WLR Exposure Score**	**Riverine Flood Exposure Score**	**Flood Sensitivity Score**	**Flood Adaptive Capacity Score**	**Heat Exposure Score**	**Heat Sensitivity Score**	**Heat Adaptive Capacity Score**	**Total Score (E+S+AC)**	**Ranking (1 to 10)**	**Potential Consequence of Flooding**	**Potential Consequence of Extreme Heat**
Ex	*Public School*	*2016*	*Good*	*N*	*2*	*0*	*1*	*2*	*1*	*1*	*2*	***9***		*School closure; Evacuation of vulnerable population; Perpetuation of mold problems and associated illness;*	*Power outage causing closure of facility; Lack of air conditioning with vulnerable population;*
1															
2															
3															
4															
5															
6															
7															
8															
9															
10															

5 Vulnerability and Risk

5.1 Assessing Vulnerability

The vulnerability assessment utilizes the results of the asset inventory, future climate scenario selection, inundation mapping, and heat island areas shown on the game board to assess vulnerability to flooding and extreme heat. Vulnerability is the degree to which an asset may be physically or functionally impacted by a climate hazard, and is made up of three components: ***exposure***, ***sensitivity***, and ***adaptive capacity***. *Exposure* is the degree to which an asset may physically interact with a climate hazard, *sensitivity* is the degree to which an asset (or the people who depend on it) is adversely affected by that climate hazard, and *adaptive capacity* is the ease with which an asset can be repaired, modified or relocated in the face of climate hazards.

At the completion of the vulnerability assessment, each vulnerable asset will have a rating (i.e., low, medium or high) for exposure, sensitivity, and adaptive capacity and an overall composite vulnerability score. Vulnerability ratings feed into the consequence assessment for identification of potential consequences should assets fail, and vulnerability and risk ratings ultimately inform prioritization of adaptation planning.

GAME OF EXTREMES ACTIVITY [30 minutes]

- Teams first create definitions for high, medium and low exposure, sensitivity and adaptive capacity. Teams are free to choose from the list of definitional criteria provided or create their own criteria.
- Then, using the definitions your team has created, evaluate the vulnerability of each asset and record results in the Vulnerability Assessment table above.
    - Each team should review the Asset Cards for the assets selected for the Asset Inventory, as these provide details on the assets' sensitivity and adaptive capacity. Players should also review the Game Board to determine the assets' exposure to water level rise, riverine flooding, and extreme heat, bearing in mind the heat island effect, although noting that every asset is affected by extreme heat and increases in average temperature.
    - The total vulnerability score column is calculated by adding the sensitivity, exposure, and adaptive capacity scores together. Use a 3 point scale to assign scores: Low (1 point), Medium (2 points), and High (3 points), for Exposure, and Sensitivity; and, Good (1 point), Medium (2 points) and Poor (3 points) for Adaptive Capacity.

Sample definitional criteria for Exposure, Sensitivity and Adaptive Capacity

Exposure Definition Criteria:

- In 12” water level rise zone
- In 24” water level rise zone
- In 36” water level rise zone
- 20% increase in precipitation intensity
- No change in precipitation intensity
- 29 additional days of extreme heat
- 55 additional days of extreme heat
- 68 additional days of extreme heat
- + 1 heat wave per year
- + 2 heat waves per year
- Location in reddest part of heat island
- Location in pink part of heat island
- Not located in heat island

Sensitivity Definition Criteria:

- Infrastructure over 30 years olds
- Infrastructure over 10 years old
- Infrastructure less than 10 years old
- Became completely unusable during recent heat or flood event
- Was only slightly affected by past heat or flood events
- Has never been affected by a past heat or flood event
- Impact negatively affected 100% of the population
- Impact negatively affected 50% of the population
- Impacts the city’s vulnerable populations

Adaptive Capacity Criteria:

- Easily repaired, relocated, or modified
- Inexpensive to repair, relocate, or modify
- Moderately difficult to repair, relocate, or modify
- Moderately difficult to repair, relocate, or modify
- Very difficult to repair, relocate or modify
- Very expensive to repair, relocate, or modify

Fill in the following lines with your team's definitions. One example is provided, and if your team gets stuck, your facilitator can help.

Exposure Rating Definition:

High (3):

- Located in reddest part of heat island; will experience 68 more days of extreme heat; will experience 2 more heat waves per year.
- Located in 12" water level rise zone.
- Located in the 20% increased precipitation intensity zone.

Medium (2):

Low (1):

Sensitivity Rating Definition:

High (3):

Medium (2):

Low (1):

Adaptive Capacity Rating Definition[3]:

Good (1):

Medium (2):

Poor (3):

Using these definitions, use the Asset Inventory, Vulnerability Assessment, and Risk Assessment Table to score the exposure, sensitivity and adaptive capacity of each of your assets.

[3] Adaptive Capacity ratings are the inverse of Exposure and Sensitivity ratings; if an asset has low adaptive capacity, it is more vulnerable and, therefore, has a higher vulnerability score.

5.2 Risk / Impacts

Risk is typically assessed by evaluating the probability (or *likelihood*) that climate impacts would occur and the *consequence* of these impacts. Since likelihood has often been accounted for through the selection of the climate scenarios for the assessment (the climate scenario card in this game) potential consequence is often the primary consideration. Consequence considers the magnitude of the impact that would occur under the selected climate change scenario. The questions below can be useful in framing the consequence of water level rise and extreme heat 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?
  - What is the length of disruption, i.e., hours, days, weeks? Does the disruption threaten 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)?
  - Will disruption at this asset have cumulative effects throughout an interconnected system (e.g. failure due to overheating of a signal box due for a light rail station will cause delays throughout the rail network)?
- **Cost**:
  - What is the cost to repair or replace the asset?
  - What are the economic (or health and safety) costs associated with the disruption?
  - Are there secondary impacts that need to be considered (i.e., potential impacts to costs associated with human health and safety, or costs to other sectors, such as the environment and public recreation)?
- **People:**
  - Are there any direct or indirect impacts to human health? (physiological, mental)
  - Are any populations more severely affected by this impact?

The intent of the consequence assessment is to develop a means to further prioritize assets for adaptation planning and implementation.

OPTIONAL GAME OF EXTREMES ACTIVITY [20 minutes]

- Complete the Optional Consequence Assessment section of the Asset Inventory, Vulnerability Assessment, and Risk Assessment Table by thinking about the potential consequence of impacts on the asset in question, and providing a description of damage, disruption, and overall relative cost (consider both direct and indirect consequences and short-term vs. long-term costs).

6 Developing Adaptation Strategies

During this phase, potential adaptation strategies are developed for assets, projects, or community features that are identified as vulnerable. Adaptation strategies are categorized as physical / structural, programs, or governance related such as changes to design guidelines, budget processes, planning, or programs. If a consequence assessment was also completed, the adaptation plan may further prioritize adaptation planning for assets, projects, or features whose vulnerability poses the highest consequences. Together, the vulnerability and consequence ratings can help develop a prioritized list of assets for adaptation strategy development and implementation.

In many instances, it is not feasible or cost effective to design and build for long-term potential water level rise, precipitation, or extreme heat scenarios of a highly uncertain nature, such as at the upper end estimates for the year 2100. In this case, a project could be designed and constructed to account for mid-century climate conditions (for example, 12 inches of water level rise or 29 more extreme heat days by 2050), while also designing the facility with the ability to adapt to more severe climate conditions over time. Therefore, adaptation plans will often include both near-term and long-term solutions.

GAME OF EXTREMES ACTIVITY [45 minutes]

- Complete the Adaptation Planning worksheet on the next page of this guide.
    - The facilitator will provide each team with a list of potential Adaptation Strategies and their associated costs as well as the table's budget card. The majority of the strategies include only one-time capital costs. However, the few strategies that have associated Operations & Maintenance costs, e.g., tree planting, also include those costs and are noted as such.
    - Review the completed Asset Inventory and Vulnerability Assessment and identify a range of short-term (to be implemented in the next 5 years) and long-term (to be completed 5 or more years in the future) adaptation strategies that can best help the selected assets adapt to the climate scenario, given the budget available.
    - Keep in mind your role's priorities and any barriers or opportunities related to the adaptation strategies you and your team may choose. Also, keep in mind the short- and long-term benefits of each action your team thinks through.
    - Think of innovative ways to achieve your adaptation and resilience goals within your budget constraints! Feel free to think outside the box and add adaptation strategies other than the ones listed in the sheet.

GAME OF EXTREMES

Adaptation Planning

Short-Term Adaptation Plan (within 5 years)

	Adaptation Strategy	Asset(s) Protected	Cost	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
		Total Cost		

Long-Term Adaptation Plan (beyond 5 years)

	Adaptation Strategy	Asset(s) Protected	Cost	
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
		Total Cost		

7 Implementing Adaptation Strategies (Optional)

During this section, your facilitator will lead you through a discussion of how city staff might implement some of the adaptation strategies selected in the preceding section.

OPTIONAL GAME OF EXTREMES ACTIVITY [30 minutes]

Complete the Optional Adaptation Implementation exercise by choosing one of the planning, budgeting or programs strategies from the previous section of the game, talk through the following questions:

- Which city agencies would lead the effort to implement the strategy?
- Who else would need to be involved or engaged (City departments, leadership, additional stakeholders, citizens, consultants, etc.)?
- What are the main barriers to implementing the strategy, e.g., funding, political will (or political opposition), lack of data, permitting, and how would you overcome these barriers?
- What additional climate change data is needed, if any, and where would it come from?
- What are the key opportunities for integrating climate adaptation considerations into standard city decision-making processes, e.g., budgeting, planning, program development, etc.?