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# Climate Vulnerability Assessment & Resiliency Strategy

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## Introduction

### Background & Objectives

The City of Bozeman, along with other municipalities across the United States, is acting to establish local resilience initiatives to prepare for the effects of climate change and other hazards. Anticipating future changes and the need to adapt to the risks associated with changing local climate conditions, the City conducted a climate vulnerability assessment of municipal facilities to build resilience in delivering its services. The City established the following objectives to guide development of the Vulnerability Assessment and Resiliency Strategy:

1. Enhance City preparedness to respond to new climate conditions and the hazards that are being predicted for the community's future.
2. Understand climate-related vulnerabilities and impacts to municipal operations and services.
3. Prioritize needs and opportunities in a coordinated cross-departmental action plan to address the most vulnerable municipal operations and services.
4. Educate City staff to build a common understanding of resilience within the organization.

Building on proactive efforts to pursue resilience, the City followed a systematic process to assess and evaluate vulnerabilities and develop adaptation strategies (Figure 1). This Vulnerability Assessment and Resiliency Strategy (plan) identifies key actions to reduce climate-induced vulnerabilities for the City of Bozeman. Building a resilient community is a continuous process of compiling many efforts, steps, and projects. This plan serves as a pre-cursor to the City's upcoming Community Climate Action and Resiliency Plan.

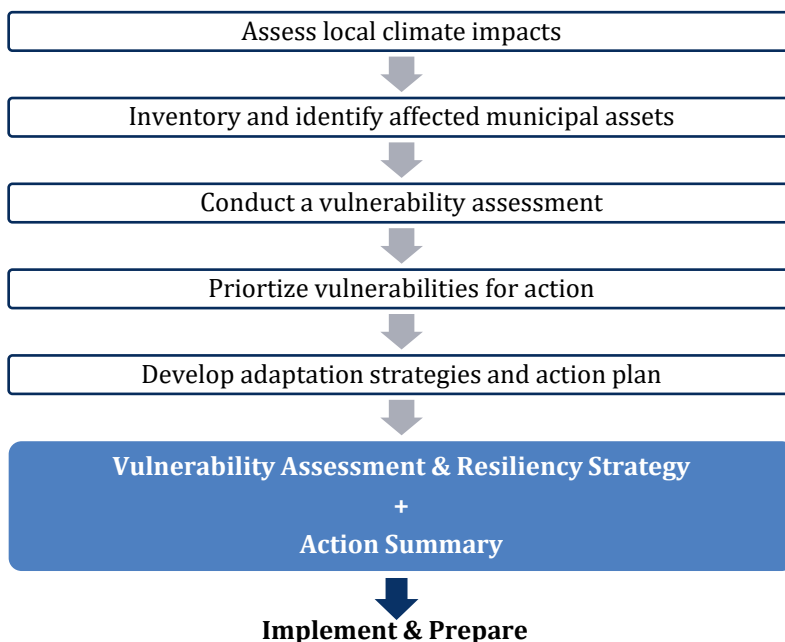


Figure 1. Vulnerability Assessment and Resiliency Strategy Process

### City Resilience Efforts

The City has already taken steps to increase resilience through policy mechanisms and planning efforts to-date:

- City of Bozeman Municipal Climate Action Plan (2008) outlined a strategy to create an adaptation plan.
- Bozeman Community Climate Action Plan (2011) resulted in increased energy efficiency and more distributed renewable energy community-wide.
- City of Bozeman Strategic Plan (2018) included actions to perform a community risk assessment and address climate change adaptation and mitigation.
- City of Bozeman was accepted into the National League of Cities' Sustainable Cities Institute Leadership in Community Resilience program with a 2018 cohort of 7 other cities across the United States to generate new insights related to the challenges and opportunities of local resilience initiatives.
- Future Shocks and City Resilience workshop, held in February 2018 and led by Arizona State University, introduced systems thinking for City staff to build sustainability and resilience skills.
- A Regional Resilience Summit was held in Bozeman in August 2018 for the Montana Department of Commerce's Montana Ready Communities Initiative to help develop a statewide Resilience Framework.

## Resilience Vision, Terms & Definitions

To support a common understanding of resiliency within the City organization, the City developed a resilience vision statement through a facilitated workshop process and in reference to established topical terms and definitions.

### Vision

The City of Bozeman will actively prepare for risks posed by a changing climate to build a future where:

- Values are institutionalized to support proactive, pragmatic, strategic, and integrated decision making.
- Risks are lowered for key City services, critical infrastructure, the economy, and the natural environment.
- The City supports the community and region through partnerships, education, and engagement.



### Terms and Definitions

<b>Resilience</b>	The ability to prepare and plan for, absorb, respond to, recover from, and more successfully adapt to adverse events (The National Academies, 2012).
<b>Climate Resilience</b>	The ability and extent to which systems can prepare and plan for, absorb, respond to, recover from, and adapt to the effects of climate-related shocks and chronic stressors (The National Academies, 2012).
<b>Hazard</b>	An act or phenomenon with the potential to harm the things of value (e.g., people or property) (Cutter, 2001).
<b>Vulnerability</b>	The degree to which a system is susceptible to or unable to cope with a climate hazard.
<b>Risk</b>	The estimated impact that a hazard would have on people, services, facilities, and structures in a community (National Disaster Preparedness Training Center, 2018).
<b>Sensitivity</b>	The degree to which a system is affected (adversely or beneficially) to the hazard.
<b>Adaptive Capacity</b>	The degree to which a system can currently cope and accommodate change caused by exposure to a climate hazard within existing resources and constraints.
<b>Climate Adaptation</b>	Actions that help cope with the effects of climate change.
<b>Climate Mitigation</b>	Human intervention to reduce the human impact on the climate system.
<b>Climate Change</b>	Long-lasting changes in average weather conditions encompassing both increases and decreases in temperature as well as shifts in precipitation, severe weather events, and other features of the climate system.
<b>Shock</b>	A sudden acute event that refers to a high-impact, short-term event that may significantly affect basic services, public safety, or the environment (e.g., earthquakes, flood, disease outbreak, terrorism).
<b>Stressor</b>	A chronic stress that refers to an ongoing environmental, social, and/or economic issue that weakens a system (e.g., high unemployment, climate change, poverty).

## Local Climate Impacts & Planning Landscape

### Local Climate Impacts

Over the past decade, the City of Bozeman has changed rapidly due to a growing population and bustling economy leading to increased urbanization and stress on the area's natural resources. Another major factor that has the potential to continue to significantly shape the community's future is climate change. Evidence of climate change is well documented throughout the United States (Climate Change Impacts in the United States: The Third National Climate Assessment, 2014) and Rocky Mountain West region. The potential climate impacts for Montana (Whitlock, Cross, Maxwell, Silverman & Wade, 2017), and Bozeman, specifically, are significant.

Nationally, the base level of disaster losses is slowly growing and becoming costlier. Since the early 1950s with the establishment of the Stafford Act, state and local governments are increasingly requesting assistance from the federal government to address disasters, suggesting that the ability to deal with disasters is not something local governments and communities can do alone. For example, 2017 was declared the most expensive year on record for weather and climate-related disasters in American history, topping \$306 billion (NOAA National Centers for Environmental Information, 2018). Many factors contribute to these national trends, like aging infrastructure, climate change, development in disaster prone areas, and rising costs.

In response, the public and private sectors are taking common sense and cost-effective steps to reduce risks and their associated economic impacts. Telecom AT&T made the decision to use thirty-year climate models to inform infrastructure decisions following a string of high-cost disasters. From 2016 to 2018, the company spent \$874 million on natural disasters, including \$626 million in 2017 alone (Flavelle, 2019). Moreover, Moody's Investor Services, Inc. has declared that state and local bondholders must account for climate change impacts or face downgrades (Moody's Investor Services, 2017). The goal is for bondholders facing the threat of a rating downgrade and more expensive debt to implement adaptation and resilience projects to offset the effects of climate change. It is estimated that planning for resilience during normal times will yield \$6 in economic benefits for every \$1 spent (Multihazard Mitigation Council, 2017).

To identify potential risks of a changing climate for Bozeman, an analysis of available statewide and national assessments was combined with local considerations, including Bozeman's Drought Management Plan. According to the 2017 Montana Climate Assessment, climate change in Montana is predicted to lead to temperature variability, shifts in precipitation and varying risk of certain severe weather events, as well as changes to other features of the climate system (Whitlock et al., 2017). Table 1 and Table 2 summarize the Montana Climate Assessment's future projections impacting Bozeman under two Representative Concentration Pathways (RCP) or emissions scenarios, RCP 4.5 and RCP 8.5, respectively.

Under the stabilization scenario, RCP 4.5, greenhouse gas emissions peak around 2040 and then begin to decline through the century as atmospheric carbon dioxide ( $CO_2$ ) concentration begins to level off. Under the business-as-usual scenario, RCP 8.5, greenhouse gas emissions increase through the century and warming continues to rise. The Montana Climate Assessment examined 20 global climate models and calculated the strength of consensus for each climate variable's direction of change (either increasing or decreasing). This is reported as the percentage of model agreement. Additional information on the climate modeling approach can be found in the [Montana Climate Assessment](#).



*Figure 2. Montana Countryside*

Table 1. Under the stabilization emissions scenario (RCP 4.5), the difference, or change, projected from historical conditions (1971-2000) to mid-century (2040-2069) and end-of-century (2070-2099) thirty-year averages for Southwest Montana.

	<b>RCP 4.5 (2040-2069)</b>	<b>RCP 4.5 (2070-2099)</b>	<b>Model Agreement</b>
<b>Average annual temperature</b>	+4.5°F	+5.6°F	100%
<b>Average daily summer maximum temperature</b>	+4.5°F	+6.5 °F	100%
<b>Average number of days above 90° F</b>	+25 days	+29 days	100%
<b>Average number of freeze free days above 32° F</b>	+30 days	+41 days	100%
<b>Average annual precipitation<sup>1</sup></b>	+0.9 inch/year	+1.1 inch/year	85% <sup>2</sup> /90% <sup>3</sup>
<b>Change in summer precipitation</b>	-0.1 inch/month	-0.1 inch/month	65%

Table 2. Under the business-as-usual emissions scenario (RCP 8.5), the difference, or change, projected from historical conditions (1971-2000) to mid-century (2040-2069) and end-of-century (2070-2099) thirty-year averages for Southwest Montana.

	<b>RCP 8.5 (2040-2069)</b>	<b>RCP 8.5 (2070-2099)</b>	<b>Model Agreement</b>
<b>Average annual temperature</b>	+6.0°F	+9.8°F	100%
<b>Average daily summer maximum temperature</b>	+6.0°F	+11.8°F	100%
<b>Average number of days above 90° F</b>	+33 days	+54 days	100%
<b>Average number of freeze free days above 32° F</b>	+41 days	+70 days	100%
<b>Average annual precipitation<sup>4</sup></b>	+1.2 inch/year	+1.7 inch/year	85% <sup>5</sup> /100% <sup>6</sup>
<b>Change in summer precipitation</b>	-0.1 inch/month	-0.1 inch/month	65%

As characterized in the modeled scenarios, average and annual seasonal temperatures in Montana have been increasing since the mid-20<sup>th</sup> century and are predicted to continue to increase through the century. Likewise, in the modeled scenarios, the timing of precipitation (e.g., winter versus spring and summer) and the form in which it will occur (e.g., rain versus snow) is anticipated to shift. This combination of increasingly warmer days with variable precipitation results in interrelated, indirect local climate impacts. For example, decreased snowpack may lead to more severe droughts in the summer and a susceptibility to wildfire risk in the watershed. This type of direct impact will have a broad range of additional, indirect effects on the local and regional economic and social systems. The heightened susceptibility to wildfire could reduce the amount and quality of water available along with damaging ecosystems and infrastructure, limiting city-wide services available to address the impacts. Therefore, the local outdoor and tourist economy could be compromised along with considerations to public health. Another indirect consequence of climate change is human migration caused by sea level rise and other extreme weather shocks and stressors. Sea-level rise in coastal communities in the United States is predicted to increase net-migration to Gallatin County up to an estimated 50,000 people by the end of the century, exacerbating Bozeman’s existing challenge of rapid population growth (Hauer, 2017).

<sup>1</sup> Interannual variability projected to range from -0.5 inch/year to +1.5 inch/year (≤80% model agreement).

<sup>2</sup> 85% model agreement for RCP 4.5 (2040-2069).

<sup>3</sup> 90% model agreement for RCP 4.5 (2070-2099).







<sup>4</sup> Interannual variability projected to range from -0.4 inch/year to +1.9 inch/year (≥80% model agreement).

<sup>5</sup> 85% model agreement for RCP 8.5 (2040-2069).

<sup>6</sup> 100% model agreement for RCP 8.5 (2070-2099).

Based on the assessment of local climate impacts and their direct and indirect effects, the following climate hazards (Table 3) were analyzed for this plan.

Table 3. Climate Hazards

 <b>Extreme Heat</b>	Stressor	More frequent and intense
 <b>Floods</b>	Acute shock	More severe
 <b>Drought</b>	Stressor	More frequent and intense
 <b>Reduced Mountain Snowpack</b>	Stressor	Decline in volume
 <b>Wildfire</b>	Acute shock	More extensive, frequent, and intense
 <b>Winter Storms</b>	Acute shock	More severe

## Planning Landscape

Climate resilience planning is not a standalone effort. The objective is to integrate climate resilience within existing and upcoming planning efforts to support mutual co-benefits and cross-coordination of initiatives and implementation actions. Exemplifying this ethic, the City has prioritized water supply, conservation, and drought management planning since adopting the 2012 Integrated Water Resources Plan. The 2017 Drought Management Plan includes a vulnerability assessment and defines drought response actions based on 4 stages of drought. The two documents provide a complete policy framework for the City to actively manage water use in a changing climate. Strategy 4: Climate Resilience Planning & Integration reinforces the City’s commitment to continue to advocate for integration of climate resilience within local policy and planning efforts.

Figure 3 details a review of local and regional planning efforts across climate hazards to identify shared values and potential points of further integration for the City of Bozeman and the community. Each plan was qualitatively assessed based on the following:

1. The extent to which it discusses the given climate hazard.
2. The climate hazard’s direct impact on the plan scope and content.
3. There remains an opportunity for improved integration of climate resilience in future policy and planning efforts, in reference to the climate hazard under consideration.

As indicated in Figure 3, the corresponding colors and definitions describe the climate resilience and integration rankings:

- - Yes, the climate hazard is adequately addressed and integrated within the policy and planning effort.
- - Somewhat, the climate hazard is peripherally addressed and there remains an opportunity for further integration in future policy and planning efforts.
- - No, the climate hazard is not explicitly addressed and there remains an opportunity for further integration in future policy and planning efforts.



	Extreme Heat	Floods	Drought	Reduced Mountain Snowpack	Wildfire	Winter Storms
Bozeman Municipal Climate Action Plan (2008)	●	●	●	●	●	●
Bozeman Community Climate Action Plan (2011)	●	●	●	●	●	●
City of Bozeman Drought Management Plan (2017)	●	●	●	●	●	●
Bozeman Community Plan (2009)	●	●	●	●	●	●
Bozeman Strategic Plan (2018)	●	●	●	●	●	●
Economic Development Strategy (2016)	●	●	●	●	●	●
Integrated Water Resources Plan (2013)	●	●	●	●	●	●
Bozeman Parks, Recreation, Open Space and Trails Plan (2007)	●	●	●	●	●	●
Urban Forest Management Plan (2016)	●	●	●	●	●	●
Bozeman Storm Water Facilities Plan (2008)	●	●	●	●	●	●
Bozeman Wastewater Collection Facilities Update (2015)	●	●	●	●	●	●
Montana State Water Plan (2015)	●	●	●	●	●	●

Figure 3. Climate Resilience Planning and Integration

## Vulnerability Assessment Results

There are a variety of frameworks and approaches available in practice to help guide communities in the process of building resilience. Leading frameworks referenced for this plan, and specifically in the vulnerability assessment, included the National Institute of Standards and Technology (NIST) Community Resilience Planning Guide for Buildings and Infrastructure Systems, the City Resilience Index developed by the Rockefeller Foundation, and the Federal Emergency Management Agency (FEMA) Community Resilience: Building Resilience from the Inside Out (AWR-228).

While exact terminology may vary across the landscape of resiliency frameworks and approaches, vulnerability is generally considered as a function of the sensitivity to a given climate hazard and the adaptive capacity of the asset (e.g., building or facility) (National Disaster Preparedness Training Center, 2018). A vulnerability assessment is an important step in climate adaptation planning and is the process of defining, identifying, classifying, and prioritizing systems that are susceptible to or unable to cope with the impacts of a changing climate. The outcomes of the vulnerability assessment lay the foundation for adaptation strategies. The City used the following formula to quantify vulnerability in analysis:

### Important Terms & Definitions

**Sensitivity:** The degree to which a building or facility is affected (adversely or beneficially) by exposure to a climate hazard.

**Adaptive Capacity:** The degree to which a building or facility can currently cope with and accommodate change caused by an exposure to a climate hazard within existing resources and constraints.

**Vulnerability:** The degree to which a building or facility is susceptible to or unable to cope with a climate hazard.

$$\text{Vulnerability} = \text{Sensitivity} + \text{Adaptive Capacity}$$

In total, 24 municipal buildings and facilities were considered in the vulnerability assessment and are organized into three primary building functions:



### Critical City Facilities

Critical City facilities generally provide or support operations and services for common public benefit. The following are considered critical City facilities:

- Bozeman City Hall
- Shops Complex
- Bozeman Public Safety Center (02/2021 completion)
- Law and Justice Center
- Cemetery Building
- Alfred Stiff Professional Building
- Bozeman Fire Dept. Station #1
- Bozeman Fire Dept. Station #2
- Bozeman Fire Dept. Station #3
- Gallatin County Coordination Center
- Vehicle Maintenance Building
- Laurel Glen Shops
- Logan Landfill
- Story Mill Landfill/Convenience Site/Household Hazardous Waste (HHW)
- Parking Garage



### Community Centers

Community centers are meeting places for social, educational, or recreational activities for all in the community. The following are considered community centers:

- Beall Recreation Center
- Bozeman Senior Center
- Lindley Center
- Bozeman Public Library
- Story Mill Community Center
- Swim Center
- Story Mansion



### Critical Infrastructure

Critical infrastructure delivers resources that make the community livable and underlies economic function. Critical infrastructure is key to protecting the life, health, and safety of the community and must remain operational. The following are considered critical infrastructure:

- Water Reclamation Facility
- Water Treatment Plant

Additional elements of the City of Bozeman’s infrastructure system were considered in analysis (e.g., lift and pump stations, watershed infrastructure, water storage, communications, transportation network, and grid energy) and determined beyond the scope of the vulnerability assessment for this plan. There weren’t relevant and uniform evaluation criteria for the broad diversity of systems; therefore, each system warrants a more focused study and evaluation of metrics to assess their vulnerabilities. The implementation strategy, Strategy 7: Ongoing Climate Monitoring & Risk Assessment, and associated action, OCMRA 2: Support evidence-based, ongoing assessments of the organization’s vulnerability and risk to changes in local climate, was identified as the recommended next step to further leverage the methodology outlined in this plan as the foundation for future analysis.

City sustainability staff conducted departmental interviews to gather information on the sensitivity and level of existing adaptive management capabilities within buildings, infrastructure, and operations to reduce the impact of climate-induced hazards as well as ideas for improving adaptive capacity moving forward. In addition to conducting departmental interviews, the City developed a qualitative analysis method to determine the sensitivity for municipal buildings and facilities. The method leveraged available data sources and standards, like the Occupancy Vulnerability Assessment Profile, as well as previous efforts within the organization, like the Fire Department Structures Inventory. A summary of the metrics informing the sensitivity analysis is provided in Appendix B. Sensitivity Metrics Summary. A summary of the adaptive capacity methodology and ranking is provided in Appendix C. Adaptive Capacity Summary. Sensitivity and adaptive capacity are ranked on a scale of low, medium, or high. These rankings inform the estimated overall level of vulnerability for each building or facility.

The following summarizes the potential vulnerabilities categorized according to building function – critical City facilities, community centers, and critical infrastructure – and potential climate impact – extreme heat, flood, drought, reduced mountain snowpack, wildfire, and winter storm. The resulting vulnerability assessment ranking for a given municipal building and facility was used to inform the City’s priority vulnerabilities and framework for identifying and prioritizing resiliency strategies.

### City Staff Engagement

Interviews conducted: **22**

Workshops: **5**

Participating staff: **36**

Divisions involved:

<i>Facilities</i>	<i>Water Reclamation</i>
<i>Human Resources</i>	<i>Fire</i>
<i>Finance</i>	<i>Police</i>
<i>Parking</i>	<i>Water and Sewer</i>
<i>Administration</i>	<i>Solid Waste</i>
<i>IT</i>	<i>Parks</i>
<i>Water Treatment</i>	<i>Recreation</i>
<i>Engineering</i>	<i>Forestry</i>
<i>Stormwater</i>	<i>Streets</i>
<i>GIS</i>	<i>Water Conservation</i>
<i>Planning/Building</i>	



Figure 4. Climate Resiliency Planning Workshop with Mayor Andrus

## Summary of Potential Vulnerabilities by Building Function



### Critical City Facilities

Of the buildings categorized as critical City facilities, seven have a high vulnerability to at least one climate hazard:

- Shops Complex
- Law & Justice Center
- Bozeman Fire Department Station #1
- Bozeman City Hall
- Alfred Stiff Professional Building
- Parking Garage
- Story Mill Landfill/Convenience Site/HHW

The primary climate hazards of concern for critical City facilities are extreme heat, drought, reduced mountain snowpack, winter storms, flood, and wildfire. Vulnerabilities attributable to the buildings and facilities are related to a combination of the following factors:

- Location and access in relation to a hazard event
- Limited climate control or operational plan for heat and cold
- Hampered ability to maintain municipal operations and services
- Necessity for a given building or facility to return to its functionality level during and after a hazard event quickly to initiate municipal and community recovery activities
- Compromised health and safety of City staff and workers



### Community Centers

Of the buildings and facilities categorized as community centers, five have a high vulnerability to at least one climate hazard:

- Story Mill Community Center
- Bozeman Senior Center
- Lindley Center
- Beall Recreation Center
- Swim Center

The primary climate hazards of concern for community centers are extreme heat, drought, reduced mountain snowpack, winter storms, and wildfire. Vulnerabilities attributable to the buildings and facilities are related to a combination of the following factors:

- Location and access in relation to a hazard event
- Limited climate control or operational plan for heat and cold
- Public access and serving diverse and vulnerable populations (e.g., children, elderly, or others with special needs)
- Compromised ability to make operational adjustments to reduce dependencies on water
- Daily occupant load
- Limited ability to mitigate hazard impacts and effects

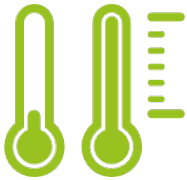


### Critical Infrastructure

Of the buildings and facilities categorized as critical infrastructure, the Water Treatment Plant operations have a high to medium vulnerability to drought, reduced mountain snowpack, and wildfire. Vulnerabilities are attributable to the following factors:

- Dependence upon snowpack for water supply
- Hindered ability to complete large-scale forest restoration work in the municipal watershed
- Limited water storage availability
- Necessity of cross-jurisdictional coordination
- Population growth and high summertime demand for water
- Location and access of treatment operations

## Summary of Potential Vulnerabilities by Hazard



### Extreme Heat

Over the century, annual and seasonal temperature averages and the number of days with extreme heat are projected to increase in Bozeman. Therefore, the City of Bozeman will need to adapt to

hotter average and peak temperatures throughout the course of the year. Extreme heat may lead to impacts on the health and well-being of the community regarding heat stress, discomfort due to building conditioning loads and operating conditions (energy demand), and air quality (urban heat island effects).

The most vulnerable buildings to extreme heat are primarily community centers serving diverse and vulnerable populations along with facilities lacking climate control for workers and/or no operational plan for increased extreme heat:

- Law & Justice Center
- Shops Complex
- Bozeman Senior Center
- Lindley Center
- Story Mill Community Center

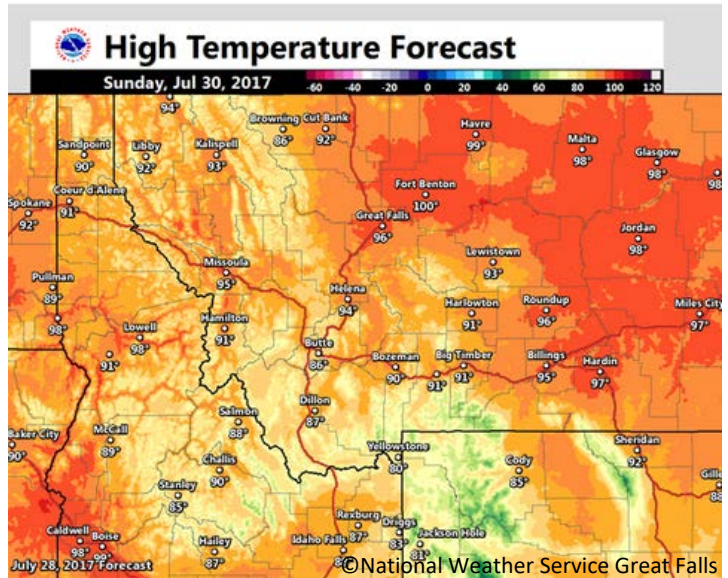


Figure 5. High Temperature Forecast in Montana (2017)



### Floods

The underlying causes of future flood risk for Bozeman are difficult to assess due to the interplay of anticipated climate impacts and human-related intervention. However, a number of anticipated climate change impacts may intensify the extent and damage from flood events. For example, more frequent precipitation events paired with the inability to store the increased volumes of water puts the community at-risk for flooding-related issues.

The most vulnerable buildings to flooding include those located in the floodplain:

- Bozeman City Hall
- Bozeman Fire Department Station #1
- Story Mill Community Center



Figure 6. Urban Flooding of Kagy Blvd. and Farmers Canal on College St.



### Drought & Reduced Mountain Snowpack

Bozeman is in a snowmelt-dominated watershed and mountain snowpack is the primary water source for the community. As snowpack is particularly sensitive to warming trends, a decline in snowpack volume with shifts toward earlier snowmelt will impact management and allocation of local water resources, especially considering Bozeman’s limited water storage. Interrelated to reduced mountain snowpack is drought. Drought is the persistent lack of precipitation that leads to dry conditions and reduced water resources. While drought is a natural part of Bozeman’s climate that will continue, the intensity, duration, and frequency are all factors affected by climate change.

Frequent and intense periods of drought will impact the City of Bozeman’s ability to accommodate growth, meet the needs of water users, and provide essential municipal operations and services.

The most vulnerable buildings to drought and reduced mountain snowpack include critical infrastructure serving a large proportion of the public and a community center that may be unable to continue to support activities given anticipated water stress:

- Water Treatment Plant operations
- Swim Center



*Figure 7. City of Bozeman Water Wise Demonstration Gardens and Permeable Pavers*



**Wildfire**

The mountainous and forested area surrounding Bozeman is susceptible to the direct effects of climate change, such as heat stress, reduced growth and productivity, and water stress. These impacts result in increased fire risk, charred ground, and thick smoke. Wildfire in the Sourdough and Hyalite watershed have the potential to negatively impact water quality due to erosion that can increase turbidity, sedimentation, and metal concentrations. Direct damage to equipment, specifically the Hyalite Reservoir and its intake, is also a concern related to wildfire. Furthermore, wildfire in the municipal watershed may char soils and remove vegetation, increasing the risk of flash floods and landslides. Wildfire smoke can cause unhealthy air conditions for the general population, especially young people, the elderly, and those with respiratory problems.

In this analysis, vulnerabilities were determined based on the critical function of the building, occupant load, contingency systems and plans in place (e.g., fire suppression system), Wildland Urban Interface (WUI) classification and access, and effects of smoke and air quality on occupants. It includes a limited assessment of the building or facility materials.

The most vulnerable buildings to wildfire include those with operations located in the WUI Intermix. Other buildings identified for smoke risk have high occupancy rates, diverse or vulnerable populations, and a limited ability to mitigate.

**Wildfire hazard:**

- Water Treatment Plant operations
- Story Mill Landfill/Convenience Site/HHW
- Lindley Center

**Smoke hazard:**

- Shops Complex
- Alfred Stiff Professional Building
- Bozeman City Hall
- Law & Justice Center
- Story Mill Community Center
- Senior Center
- Bozeman Public Library



*Figure 8. Roaring Lion Fire near Hamilton, MT (2016)*

### Bozeman Water Treatment Plant

In response to wildfire concerns, in 2014, the City of Bozeman completed construction of 22 Million Gallon per Day Water Treatment Plant that is designed to operate under conditions with elevated sedimentation. The plant is equipped with preliminary treatment, two sets of 300-micron strainers and a membrane filtration system to readily handle peak turbidities up to 1000 Nephelometric Turbidity Units (NTU). Plant operators have the operational flexibility and planning contingencies in place to handle even higher influent turbidities during runoff events. In addition, continued work to advance forest restoration measures in the watersheds will help minimize the risk and severity of wildfire, particularly around the water intakes. A new 5.3 Million Gallon water storage tank will increase the City’s treated water storage capabilities in the event the plant is forced to shut down after a runoff event. These efforts aim to minimize any disruption of water service for Bozeman residents and emergency responders.



Figure 9. City of Bozeman Water Treatment Plant



#### Winter Storms

Climate change has the potential to influence more frequent and severe winter storms. The City of Bozeman needs to adapt to these extreme winter storm events through building design, operational adjustments, and redundant backup equipment.

The buildings and facilities most vulnerable to extreme winter storms include those with priorities for clearing snow and re-establishing access, those that may experience compromised building integrity from additional snow load, and those that have building functions and equipment that could be impacted by corresponding cold temperatures:

- Parking Garage
- Beall Rec Center
- Swim Center
- Bozeman Senior Center
- Bozeman Fire Department Station #1



Figure 10. March 4, 2019 set a record low temperature of -39F in Bozeman



## Resiliency Implementation Roadmap


Adaptation strategies identified in this plan aim to reduce vulnerabilities for the City of Bozeman. Strategies are statements of intent and desired progress that support the overall resilience vision. Strategies detailed in this plan are the following:

1. Infrastructure and Capital Planning
2. Hazard Event Protocols and Training
3. Public Policies and Programs
4. Climate Resilience Planning and Integration
5. Inter-agency Community Partnerships
6. Awareness and Education
7. Ongoing Climate Monitoring and Risk Assessment

Each strategy has corresponding and specific actions that address the key vulnerabilities of municipal facilities and operations to build resilience in delivering the City’s municipal services. The strategies and actions included should not be viewed as comprehensive, nor as actions to replace existing programs and efforts. The strategies represent timely and strategic opportunities to enhance Bozeman’s climate resilience within a broad organizational framework and complement existing efforts and plans. Strategies and action details in this plan follow a similar formula, as illustrated below.

### Strategy Title


*Summary description of what the strategy entails.*

Action Title		
<b>Who</b>	Department	Responsible departments
	Partners	Supporting group(s) and organization(s)
<b>Primary Hazards</b>	Hazards addressed by action: 	
<b>Priority Assets</b>	Buildings or facilities impacted by action.	


## Resiliency Strategies Summary

### Strategy 1: Infrastructure & Capital Planning


*Plan for critical facility infrastructure hardening and capital projects that limit damage to property, protect human health, and improve operational performance during and after hazard events.*

ICP 1: Continue to build out back-up power, mobile back-up power, fuel storage, and communications redundancies for buildings and infrastructure.		
<b>Who</b>	Departments	IT, Facilities, Fire, Police
	Partners	Gallatin County Emergency Management
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Bozeman City Hall</li> <li>• Professional Building</li> <li>• Shops Complex</li> <li>• Bozeman Public Safety Center</li> <li>• Bozeman Public Library</li> <li>• Story Mill Community Center</li> </ul>	


**ICP 2: Increase air filtration capabilities in critical facilities to cope with wildfire smoke.**

<b>Who</b>	Department	Facilities
	Partners	City County Board of Health
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Alfred Stiff Professional Building</li> <li>• Bozeman City Hall</li> <li>• Bozeman Public Library</li> <li>• Bozeman Public Safety Center</li> <li>• Bozeman Senior Center</li> <li>• Shops Complex</li> <li>• Story Mill Community Center</li> </ul>	


**ICP 3: Provide covered parking for first responder vehicles and critical snow removal equipment to ensure reliable service and improve response time during extreme weather events.**

<b>Who</b>	Departments	Public Works, Fire, Police
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Shops Complex</li> <li>• Bozeman Public Safety Center</li> </ul>	


**ICP 4: Evaluate the need for heat, air conditioning, or passive cooling within City facilities to protect the health and safety of employees and users.**

<b>Who</b>	Departments	Facilities, IT, Parks & Recreation
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Shops Complex</li> <li>• Lindley Center</li> <li>• Story Mill Community Center</li> </ul>	


**ICP 5: Pursue automated dam controls at Middle Creek Dam to improve operational flexibility and enhance our ability to respond to wildfire or flood events.**

<b>Who</b>	Departments	Public Works (Water Treatment Plant, Engineering), IT
	Partners	<ul style="list-style-type: none"> <li>• Middle Creek Water Users' Association</li> <li>• Montana Department of Natural Resources and Conservation</li> <li>• State Water Projects Bureau</li> </ul>
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Water Treatment Plant</li> <li>• Related watershed infrastructure</li> </ul>	

ICP 6: Continue assessing the feasibility of watershed or aquifer groundwater storage and recovery projects, including strategic water reserves.

<b>Who</b>	Department	Public Works (Water Treatment Plant, Engineering)
	Partner	Montana Department of Natural Resources and Conservation
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Water Treatment Plant</li> <li>• Related watershed infrastructure</li> </ul>	

ICP 7: Continue to pursue science-based forest restoration measures to protect the municipal watershed.

<b>Who</b>	Department	Public Works (Water Treatment Plant, Engineering)
	Partner	US Forest Service
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Water Treatment Plant</li> <li>• Related watershed infrastructure</li> </ul>	

ICP 8: Create a demonstration project at a critical facility that showcases structural and operational resiliency, renewable energy plus storage, energy and water efficient building design, and best practices in stormwater management.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Facilities</li> <li>• Fire</li> <li>• Police</li> <li>• Stormwater</li> <li>• Water Conservation</li> </ul>
	Partner	NorthWestern Energy
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Bozeman Public Safety Center</li> <li>• Community Centers</li> </ul>	

Strategy 2: Hazard Event Protocols & Training

Continue developing operational protocols and training for hazard events.

HEPT 1: Coordinate an internal emergency communications plan with staff preparedness binders for reference, including contacts and relevant emergency shelter information.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Facilities</li> <li>• Public Works</li> <li>• Communications</li> <li>• Fire</li> <li>• Police</li> </ul>
	Partner	Gallatin County Emergency Management
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

**HEPT 2: Support cross training for City employees on emergency communications protocol and plan.**

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Facilities</li> <li>• Public Works</li> <li>• Communications</li> <li>• Fire</li> <li>• Police</li> <li>• Finance</li> <li>• Water Conservation</li> </ul>
	Partner	Gallatin County Emergency Management
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

**HEPT 3: Develop an operational and cancellation protocol for patrons of City Parks & Recreation programs for extreme heat, cold, and wildfire smoke.**

<b>Who</b>	Departments	Facilities, Parks and Recreation
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Story Mill Community Center</li> <li>• Beall Park</li> <li>• Bogert Park</li> <li>• Swim Center</li> </ul>	

**Strategy 3: Public Policies & Programs**

*Pursue policies and standards that build individual, organizational, and community resiliency.*


**PPP 1: Develop an internal Administrative Order to formalize the City’s organizational commitment to prepare and plan for, absorb, respond to, and adapt to climate hazards.**

<b>Who</b>	Department	City Administration
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	


**PPP 2: Continue to enhance and expand water conservation services, water use assessments, and efficiency rebate programs, including custom commercial rebates.**

<b>Who</b>	Department	Public Works (Water Conservation)
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	


PPP 3: Develop and implement code revisions to incorporate mandatory water conservation measures for new development in coordination with all other relevant City plans and standards

<b>Who</b>	Department	<ul style="list-style-type: none"> <li>Public Works (Water Conservation, Engineering)</li> <li>Community Development</li> <li>Legal</li> <li>Parks &amp; Recreation</li> </ul>
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	


PPP 4: Maintain a current tiered water pricing structure that increases with water usage.

<b>Who</b>	Department	Public Works (Water Conservation), Finance
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

PPP 5: Update stormwater engineering standards to include industry best practice requirements that extend asset life cycles, facilitate regulatory compliance, improve urban flood resiliency, and protect local water quality.

<b>Who</b>	Departments	Public Works (Stormwater, Engineering), Community Development
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

PPP 6: Regulate city maintained stormwater facilities to ensure their proper flood control and runoff treatment functions.

<b>Who</b>	Departments	Public Works (Stormwater, Engineering), Community Development
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

PPP 7: Integrate resiliency planning and climate change hazard considerations in City facility and infrastructure siting, orientation, design, construction, and operations.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>City Administration</li> <li>Facilities</li> <li>Strategic Services</li> <li>Public Works</li> <li>Community Development</li> <li>Parks &amp; Recreation</li> </ul>
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

PPP 8: Incorporate efficient and renewable energy processes, technologies, and energy storage in existing and future City operations for energy load reduction and peak load management.

<b>Who</b>	Departments	City Administration, Facilities, Strategic Services
	Partner	NorthWestern Energy
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

PPP 9: Evaluate ice rink management in City parks based on water, climate, and patron user data.

<b>Who</b>	Departments	Parks & Recreation, Public Works (Water Conservation)
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Bogert Park</li> <li>• Beall Park</li> <li>• Southside Park</li> </ul>	

#### Strategy 4: Climate Resilience Planning & Integration

*Integrate climate resilience within existing and upcoming City policy and planning efforts to support mutual co-benefits and cross-coordination of initiatives and implementation actions.*

CRPI 1: Incorporate resiliency and climate change hazards into economic development master planning efforts.

<b>Who</b>	Department	Economic Development
	Partner	Montana Outdoor Industry Association
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

CRPI 2: Integrate resiliency goals into long-term capital improvement plans, including infrastructure and facility projects.

<b>Who</b>	Departments	All
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	All	

CRPI 3: Incorporate anticipated climate hazards into emergency response and hazard mitigation.

<b>Who</b>	Departments	Fire, Police
	Partner	Gallatin County Emergency Management
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

CRPI 4: Identify opportunities to prepare and plan for, and adapt to climate change hazards through the Community Plan and regional planning efforts.

<b>Who</b>	Departments	Community Development, Public Works
	Partners	Gallatin County Planning Coordination Committee
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

Strategy 5: Inter-agency Community Partnerships

Build, sustain, and leverage partnerships with local and regional stakeholders to ensure collective investment, efficient action, and shared responsibility in the building of local resiliency.

IaCP 1: Grow existing partnerships with local and regional stakeholders to ensure collective investment, efficient action, and shared responsibility in building local resiliency.		
<b>Who</b>	Departments	All
	Partners	<ul style="list-style-type: none"> <li>• Bozeman School District</li> <li>• Gallatin County</li> <li>• Montana State University (Extension, Institute on Ecosystems, etc.)</li> <li>• NorthWestern Energy</li> <li>• U.S. Forest Service</li> <li>• Gallatin Local Water Quality District</li> <li>• Gallatin River Task Force</li> <li>• Gallatin Valley Land Trust</li> <li>• Montana Department of Environmental Quality</li> <li>• Montana Department of Natural Resources and Conservation</li> <li>• City-County Board of Health</li> <li>• Human Resources Development Council</li> <li>• Southwest Montana Community Organizations Active in Disasters</li> <li>• Southwest Montana Building Industry Association</li> </ul>
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

IaCP 2: Promote interagency and regional watershed management activities to address climate impacts on water resources and coordinate on water storage, supply, and wetlands.		
<b>Who</b>	Department	Public Works – Water Treatment Plant, Water Conservation, Engineering
	Partners	<ul style="list-style-type: none"> <li>• Gallatin County</li> <li>• Montana Department of Natural Resources and Conservation</li> <li>• Association of Gallatin Agricultural Irrigators</li> <li>• Montana Fish, Wildlife and Parks</li> <li>• Middle Creek Water Users Association</li> </ul>
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Water Treatment Plant</li> <li>• Related watershed infrastructure</li> </ul>	

IaCP 3: Assess climate equity using data and mapping to better understand how local climate impacts intersect with community demographics; address as needed.		
<b>Who</b>	Departments	Community Development, Strategic Services
	Partners	Montana Institute on Ecosystems, Human Resource Development Council
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

laCP 4: Continue to coordinate with social services and health agencies that assist with vulnerable residents, including transient populations.

<b>Who</b>	Departments	City Administration, Neighborhoods, Police
	Partners	<ul style="list-style-type: none"> <li>• Human Resources Development Council</li> <li>• City-County Board of Health</li> <li>• United Way</li> <li>• Greater Gallatin Homeless Action Coalition</li> <li>• Department of Health and Human Services</li> <li>• Gallatin County</li> </ul>
<b>Primary Hazards</b>		
<b>Priority Assets</b>	<ul style="list-style-type: none"> <li>• Community Centers</li> </ul>	

Strategy 6: Awareness & Education

*Prioritize proactive education within City operations to build individual, organizational, and community resiliency to weather impacts and climate-related hazards.*

AE 1: Develop a public education and awareness campaign exemplifying the City’s proactive efforts and leadership in resilience, as well as advancing the resiliency conversation with the community at large.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Communications</li> <li>• Neighborhoods</li> <li>• Public Works (Water Treatment Plant, Water Conservation, Stormwater, Engineering)</li> <li>• Strategic Services</li> </ul>
	Partners	TBD
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

AE 2: Distribute severe weather education and preparedness information to the public.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Communications</li> <li>• Neighborhoods</li> <li>• Gallatin County Emergency Management</li> <li>• Public Works (Water Conservation)</li> <li>• Parks &amp; Recreation</li> </ul>
	Partner	Montana State University
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

AE 3: Develop an internal working group for City staff to contribute best management practices that promote sustainability and resiliency.

<b>Who</b>	Department	Strategic Services (lead)
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	



AE 4: Identify partnership opportunities to reach Montana State University and the community on the importance of being prepared.

<b>Who</b>	Departments	<ul style="list-style-type: none"> <li>• Fire</li> <li>• Communications</li> <li>• Neighborhoods</li> <li>• Public Works (Water Conservation)</li> </ul>
	Partners	<ul style="list-style-type: none"> <li>• Gallatin County Emergency Management</li> <li>• Montana State University (Housing and Residence Life)</li> <li>• Bozeman School District</li> </ul>
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

Strategy 7: Ongoing Climate Monitoring & Risk Assessment

Adapt City operations to weather by conducting evidence-based assessment of the City’s vulnerability and risk to climate variability.

OCMRA 1: Support area streamflow, ditch, stormwater, snowpack, and ground water monitoring efforts.

<b>Who</b>	Department	Public Works (Water Treatment Plant, Engineering, Water Conservation)
	Partner	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

OCMRA 2: Support evidence-based, ongoing assessments of the organization’s vulnerability and risk to changes in local climate.

<b>Who</b>	Department	Strategic Services
	Partners	N/A
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

OCMRA 3: Expand current and past climate assessments to include large infrastructure and natural systems.

<b>Who</b>	Departments	Public Works, Strategic Services
	Partner	EPA
<b>Primary Hazards</b>		
<b>Priority Assets</b>	N/A	

Conclusion

Preparing for the continued and exacerbated effects of climate change, the City of Bozeman is taking a leading role to reduce key vulnerabilities of municipal facilities and build resilience in delivering its services. Building a resilient City is a continuous process of many collaborative and mutually-supportive efforts, steps, and projects. Through the intentional plan development process and vulnerability assessment, the City has identified seven key resilience strategies with associated adaptation actions, summarized below. These strategies and actions collectively accomplish the objectives outlined to guide the development of this plan and serve as a foundation to the City’s Community Climate Action and Resiliency Plan in 2019.

### Strategy 1: Infrastructure & Capital Planning

**ICP1:** Continue to build out back-up power, mobile back-up power, fuel storage, and communications redundancies for buildings and infrastructure.

**ICP 2:** Increase air filtration capabilities in critical facilities to cope with wildfire smoke.

**ICP 3:** Provide covered parking for first responder vehicles and critical snow removal equipment to ensure reliable service and improve response time during extreme weather events.

**ICP 4:** Evaluate the need for heat, air conditioning, or passive cooling within City facilities to protect the health and safety of employees and users.

**ICP 5:** Pursue automated dam controls at Middle Creek Dam to improve operational flexibility and enhance our ability to respond to wildfire or flood events.

**ICP 6:** Continue assessing the feasibility of watershed or aquifer groundwater storage and recovery projects, including strategic water reserves.

**ICP 7:** Continue to pursue science-based forest restoration measures to protect the municipal watershed.

**ICP 8:** Create a demonstration project at a critical facility that showcases structural and operational resilience, renewable energy plus storage, energy and water efficient design, and best practices in stormwater management.

### Strategy 2: Hazard Event Protocols & Training

**HEPT 1:** Coordinate an internal emergency communications plan with staff preparedness binders for reference, including contact and relevant emergency shelter information.

**HEPT 2:** Support cross training for City employees on emergency communications protocol and plan.

**HEPT 3:** Develop an operational and cancellation protocol for patrons of City Parks & Recreation programs for extreme heat, cold, and wildfire smoke.

### Strategy 3: Public Policies & Programs

**PPP 1:** Develop an internal Administrative Order to formalize the City's organizational commitment to prepare and plan for, absorb, respond to, and adapt to climate hazards.

**PPP 2:** Continue to enhance and expand water conservation services, water use assessments, and efficiency rebate programs, including custom commercial rebates.

**PPP 3:** Develop and implement code revisions to incorporate mandatory water conservation measures for new development in coordination with all other relevant City plans and standards.

**PPP 4:** Maintain current tiered water pricing structure that increases with water usage.

**PPP 5:** Update stormwater engineering standards to include industry best practice requirements that extend asset life cycles, facilitate regulatory compliance, improve urban flood resiliency, and protect local water quality.

**PPP 6:** Regulate city maintained stormwater facilities to ensure their proper flood control and runoff treatment functions.

**PPP 7:** Integrate resiliency planning and climate change hazard considerations in City facility and infrastructure siting, orientation, design, construction, and operations.

**PPP 8:** Incorporate efficient and renewable energy processes, technologies, and energy storage in existing and future City operations for energy load reduction and peak load management.

**PPP 9:** Evaluate ice rink management in City parks based on water, climate, and patron user data.

#### Strategy 4: Climate Resilience Planning & Integration

**CRPI 1:** Incorporate resiliency and climate change hazards into economic development master planning efforts.

**CRPI 2:** Integrate resiliency goals into long-term capital improvement plans, including infrastructure and facility projects.

**CRPI 3:** Incorporate anticipated climate hazards into emergency response and hazard mitigation.

**CRPI 4:** Identify opportunities to prepare and plan for, and adapt to climate change hazards through the Community Plan and regional planning efforts.

#### Strategy 5: Inter-agency Community Partnerships

**IaCP 1:** Grow existing partnerships with local and regional stakeholders to ensure collective investment, efficient action, and shared responsibility in building local resiliency.

**IaCP 2:** Promote interagency and regional watershed management activities to address climate impacts on water resources and coordinate on water storage, supply, and wetlands.

**IaCP 3:** Assess climate equity using data and mapping to better understand how local climate impacts intersect with community demographics; address as needed.

**IaCP 4:** Continue to coordinate with social services and health agencies that assist with vulnerable residents, including transient populations.

#### Strategy 6: Awareness & Education

**AE 1:** Develop a public education and awareness campaign exemplifying the City's proactive efforts and leadership in resilience, as well as advancing the resiliency conversation with the community at large.

**AE 2:** Distribute severe weather education and preparedness information to the public.

**AE 3:** Develop an internal working group for City staff to contribute best management practices that promote sustainability and resiliency.

**AE 4:** Identify partnership opportunities to reach Montana State University and the community on the importance of being prepared.

#### Strategy 7: Ongoing Climate Monitoring & Risk Assessment

**OCMRA 1:** Support area streamflow, ditch, stormwater, snowpack, and ground water monitoring efforts.

**OCMRA 2:** Support evidence-based, ongoing assessments of the organization's vulnerability and risk to changes in local climate.

**OCMRA 3:** Expand current and past climate assessments to include large infrastructure and natural systems.

## Appendix A. Interview Guide

### Objectives

- Gather operational information to assess the adaptive capacity of facilities and infrastructure
- Capture preliminary suggestions for adaptive management strategies (as preview to Resilience Summit)
- Increase understanding and alignment with departmental priorities - build momentum and reinforce related efforts, win-wins

### Approach

One-hour interviews in small groups or one-on-one conversations led by either Natalie or Heather, with Judy and/or Ellie supporting the first couple to test methodology (if needed).

### Agenda

Time (mins)	Agenda Item
5	Background and Interview Format
5	Introductions
35	Sensitivity and Adaptive Capacity of Facilities and Infrastructure
10	Strategies to Increase Adaptive Capacity
5	Recap and Next Steps

### Interview Format

- Background and Interview Format (5 mins)
  - Project background
  - Objectives of the interview
  - How results will be incorporated and when (i.e., next steps)
  - Housekeeping - hand-outs, advance materials prep, notetaking logistics
  - Clarifying questions on process
- Introductions (5 mins)
  - Understand the interviewee's job/role in the department; how long they've been in the department; other relevant background/experience they bring to the discussion
- Sensitivity and Adaptive Capacity of Facilities and Infrastructure (see Departmental Interviews hand-out) (35 mins)
  - Review list of climate stressors and hazard events covered by the project
  - Review list of buildings and infrastructure and confirm which apply to this department
  - Review definition and examples of sensitivity and adaptive capacity; definitions of high-med-low
    - Low - little to nothing can do to affect outcomes with current resources
    - Med - operational adjustments available to lessen impact but still be adversely affected
    - High - enough operational flexibility to withstand event without overly adverse impacts
  - **DISCUSSION #1** - document past adaptive management techniques
    - How have the list of buildings and infrastructure systems operated under adverse conditions in the past?
    - What types of operational adjustments were made to manage through hazard events?
  - **DISCUSSION #2** - considering future events for each of the climate-induced hazards, can you operate during <insert hazard>? What are your limitations operating under or during this hazard under the short and long term?
  - **DISCUSSION #3** - what best practices or operational improvements have been put into place following past events that would improve future performance under similar adverse conditions?
  - **DISCUSSION #4** - overall assessment of adaptive capacity.

*Interviewer Tip:*

Discussion #1 and #2 can start in broad terms, but ideally would start to address at the building level to inform populating the table at the building level

During discussion, invariably participants will share new suggestions and needs. Add those to a “parking lot” for the next agenda item.

- Fill out spreadsheet of high-med-low by building and system given definitions
- Strategies to Increase Adaptive Capacity (10 mins)
  - Review types of strategies that would increase adaptive capacity (i.e., reduce vulnerability) of facilities and infrastructure systems: capital improvements, adding equipment/systems for increased redundancies, operational changes, organizational structures/ roles/ accountability/ communications or policies
  - Review table of facilities and exposures
  - **DISCUSSION #5** - what's currently in the Capital Improvements Plan, departmental plan, or general wish list items that would have the added benefit (win-win) of also increasing resilience? (i.e., what items can this project reinforce and put momentum behind for quick wins or increased political will for bigger efforts?)
  - **DISCUSSION #6** - what new ideas have this conversation sparked to increase resilience? What are you seeing in your peer/trade association trends - benchmark cities, systems out there to aspire to, etc.
- Recap and Next Steps (5 mins)

## Appendix B. Sensitivity Metrics Summary

This table summarizes the components informing the aggregated sensitivity ranking for each climate hazard in the vulnerability assessment. The green highlighted boxes indicate that the component was used in the aggregated sensitivity ranking for that given hazard. For example, occupant load, goal to recovery, and demographics were the components considered for the extreme heat sensitivity ranking.

	Occupant Load	Goal to Recovery	Floodplain	Basement	Wildland Urban Interface	Emergency Power	Demographics
Extreme Heat							
Flood							
Drought							
Reduced Snowpack							
Wildfire							
Winter Storms							

The following are the definitions for each component of sensitivity and their equivalent quantitative and qualitative rank value:

### **Occupant Load** (City of Bozeman Fire Department Structures Inventory)

*What is the average number of occupants expected within a building or facility?*

- Low (0) – An average of 0 to 50 occupants are expected with the building or facility.
- Med (1) – An average of 50 to 100 occupants are expected with the building or facility.
- High (2) – An average of over 100 occupants are expected with the building or facility.

### **Goal to Recovery** (National Institute of Standards and Technology)

*What is the desired amount of time for a given building to return to its functionality level during and after a hazard event?*

- Low (0) – Resume normal operating capacity and level of functionality within long term (4+ months).
- Med (1) – Resume normal operating capacity and level of functionality within intermediate term (1-12 weeks).
- High (2) – Resume normal operating capacity and level of functionality within short term (0-3 days).

### **Floodplain** (FEMA)

*Is the building or facility located in the floodplain?*

- Low (0) – The building or facility is not located in the floodplain.
- Med (1) – The building or facility is in the 500-year floodplain.
- High (2) – The building or facility is in the 100-year floodplain.

### **Basement** (City of Bozeman Fire Department Structures Inventory)

*Does the building or facility have a basement?*

- Yes (1) – The building or facility does have a basement.
- No (0) – The building or facility does not have a basement.

### **Wildland Urban Interface** (Gallatin County Draft Community Wildfire Protection Plan)

*Is the building or facility located in the Wildland Urban Interface?*

- Med (0) – WUI Interface - < 50% cover of wildland vegetation within 40-acre radius
- High (2) – WUI Intermix – ≥ 50% cover of wildland vegetation within 40-acre radius

**Emergency Power** (City of Bozeman Fire Department Structures Inventory)

*Is there emergency power available at the building or facility?*

- Yes (0) – The building or facility does have backup emergency power.
- No (1) – The building or facility does not have backup emergency power.

**Demographics**

*Who regularly interacts with the building or facility?*

- Low (0) – The building or facility is restricted public access; occupants primarily self-sufficient adults.
- Med (1) – The building or facility is public access; occupants represent mix of the general public.
- High (2) – The building or facility is public access; occupants may be predominantly children, the elderly, or others with special needs.

## Appendix C. Adaptive Capacity Summary

The table below is populated with a high-med-low ranking rationale for each hazard type by building system given the following definitions:

- Low Adaptive Capacity – There is minimal ability to affect outcomes to a given hazard with current resources available.
- Medium Adaptive Capacity – Operational adjustments are available to lessen the impact to a given hazard, but the building and operations will still adversely be affected.
- High Adaptive Capacity – There is enough operational flexibility to withstand the given hazard without overly adverse impacts.

Hazard	High	Medium	Low
Extreme Heat	Indoor workers or public in climate-controlled environment	Indoor/outdoor workers, limited climate control or operational plan for heat	Indoor/outdoor workers or vulnerable members of the public; no climate control; no operational plan for heat
Drought	Operation not critically dependent upon water	Larger water uses, but operation can make adjustments to reduce dependencies on water	Operation can't function without water; limited contingencies
Flood	Operation not likely impacted or well-prepared	Operation potentially compromised but contingencies and redundancies in place	Operation likely compromised; potential damage to facility
Reduced Snowpack	Operation not impacted or numerous contingency water sources in place	Water supply contingency in place	Compromises ability to deliver water to residents
Winter Storms	Building well prepared for snow or operations not affected	Outdoor equipment storage compromises critical response time or challenges operation	Challenges operation; may cause damage to facility
Wildfire	Less susceptible building materials, contingency plans in place, defensible space, park irrigation available, fire suppression systems in place	Occupants likely impacted by smoke and limited ability to mitigate; facility materials may be prone to fire; defensible space may be lacking	Location/access challenging in fire; consequences potentially high; no direct steps to mitigate risk



## Appendix D. Vulnerability Assessment Summary

The Vulnerability Assessment table, below, pulls from the sensitivity and adaptive capacity rankings. There are nine potential rankings, for a given building or facility, **where the first indicator is sensitivity and the second is adaptive capacity**. The nine potential rankings are simplified into high-medium-low vulnerability, defined as the following:

- **Low Vulnerability (indicated by green)** - The building is able to adequately cope with the effects associated with the given hazard type (rankings included: Low-Medium; Low-High; Medium-High).
- **Medium Vulnerability (indicated by yellow)**- The building is susceptible to but has some capacity to cope with the given hazard type (rankings included: Low-Low; Medium-Medium; High-High).
- **High Vulnerability (indicated by red)** - The building is unable to cope with the given hazard type (rankings included: Medium-Low; High-Low; High-Medium).

Building/Facility	Extreme Heat	Drought	Flood	Reduced Snowpack	Winter Storms	Wildfire
Shops Complex	High - Medium	High - High	Low - High	High - High	Medium - Medium	High - Medium
Bozeman Public Safety Center (Proposed)	High - High	High - High	Medium - Medium	High - High	Medium - High	High - High
Law & Justice Center	High - Medium	High - High	High - High	High - High	Medium - Medium	High - Medium
Cemetery Building	Low - Medium	Low - Medium	Low - High	Low - Medium	Low - Medium	Low - Medium
Alfred Stiff Professional Bldg.	High - High	High - High	Medium - Medium	High - High	Medium - High	High - Medium
Bozeman Fire Department Station #1	Medium - Medium	Medium - Medium	High - Low	Medium - Medium	Medium - Low	Medium - Medium
Bozeman City Hall	High - High	High - High	High - Low	High - High	Medium - High	High - Medium
Gallatin County Coordination Center	Medium - High	Medium - High	High - High	Medium - High	Medium - High	Medium - Medium
Bozeman Fire Department Station #3	Medium - High	Medium - Medium	High - High	Medium - Medium	Medium - High	Medium - Medium
Bozeman Fire Department Station #2	Medium - High	Low - Medium	Low - High	Low - Medium	Medium - High	Low - Medium
Logan Landfill	Medium - High	Low - High	Low - Low	Low - High	Medium - High	Low - Medium
Story Mill Landfill/Convenience Site/HHW	Low - High	Low - High	Low - Low	Low - High	Medium - Medium	High - Low
Vehicle Maintenance Building	Low - High	Low - High	Low - High	Low - High	Medium - Medium	Low - Medium
Parking Garage	Low - High	Low - High	Low - Medium	Low - High	Medium - Low	Low - High
Laurel Glen Shops	Low - Medium	Low - High	Low - High	Low - High	Low - High	Low - High
Beall Rec Center	Medium - High	Medium - High	Low - Medium	Medium - High	Medium - Low	Medium - Medium
Bozeman Senior Center	High - Medium	High - High	Low - High	High - High	High - Medium	High - Medium
Lindley Center	Medium - Low	Medium - High	Low - High	Medium - High	Medium - Medium	High - Low
Bozeman Public Library	Medium - High	Medium - High	Low - Medium	Medium - High	Medium - High	Medium - Medium
Story Mill Community Center	High - Low	High - High	High - Medium	High - High	Medium - Medium	High - Medium
Swim Center	Medium - Medium	Medium - Low	Low - High	Medium - Low	Medium - Low	Medium - Medium
Story Mansion	Medium - Medium	Medium - High	Low - High	Medium - High	Medium - Medium	Medium - Medium
Water Reclamation Facility (WRF)	Low - High	Low - High	Low - High	Low - High	Medium - High	Low - High
Water Treatment Plant (WTP)	Low - High	Medium - Low	Low - High	Medium - Low	Medium - High	High - Medium

The table below summarizes the vulnerability rankings, detailed in the previous table, of each building or facility organized into a simplified low-medium-high format:

		<b>Extreme Heat</b>	<b>Drought</b>	<b>Flood</b>	<b>Snowpack</b>	<b>Winter Storms</b>	<b>Wildfire</b>
<b>Vulnerability Ranking</b>	<b>High</b>	Shops Complex Law & Justice Center Bozeman Senior Center Lindley Center Story Mill Community Center	Swim Center Water Treatment Plant (WTP)	Bozeman Fire Dept. Station #1 Bozeman City Hall Story Mill Community Center	Swim Center Water Treatment Plant (WTP)	Bozeman Fire Dept. Station #1 Parking Garage Beall Rec Center Bozeman Senior Center Swim Center	Shops Complex Law & Justice Center Alfred Stiff Professional Bldg. Bozeman City Hall Story Mill Landfill/ Convenience Site/ HHW Bozeman Senior Center Lindley Center Story Mill Community Center Water Treatment Plant (WTP)
	<b>Medium</b>	Bozeman Public Safety Center Alfred Stiff Professional Bldg. Bozeman Fire Dept. Station #1 Bozeman City Hall Swim Center Story Mansion	Shops Complex Bozeman Public Safety Center Law & Justice Center Alfred Stiff Professional Bldg. Bozeman Fire Dept. Station #1 Bozeman City Hall Bozeman Fire Dept. Station #3 Bozeman Senior Center Story Mill Comm. Center	Bozeman Public Safety Center Law & Justice Center Alfred Stiff Professional Bldg. Gallatin County Coordination Center Bozeman Fire Dept. Station #3 Logan Landfill Story Mill Landfill/ Convenience Site/ HHW	Shops Complex Bozeman Public Safety Center Law & Justice Center Alfred Stiff Professional Bldg. Bozeman Fire Dept. Station #1 Bozeman City Hall Bozeman Fire Dept. Station #3 Bozeman Senior Center Story Mill Comm. Center	Shops Complex Law & Justice Center Story Mill Landfill/ Convenience Site/ HHW Vehicle Maintenance Building Lindley Center Story Mill Community Center Story Mansion	Bozeman Public Safety Center Bozeman Fire Dept. Station #1 Gallatin County Coordination Center Bozeman Fire Dept. Station #3 Beall Rec Center Bozeman Public Library Swim Center Story Mansion
	<b>Low</b>	Cemetery Building Gallatin County Coordination Center Bozeman Fire Dept. Station #3 Bozeman Fire Dept. Station #2 Logan Landfill Story Mill Landfill/ Convenience Site/ HHW Vehicle Maintenance Building Parking Garage Laurel Glen Shops Beall Rec Center Lindley Center Bozeman Public Library Bozeman Public Library Water Reclamation Facility (WRF) Water Treatment Plant (WTP)	Cemetery Building Gallatin County Coordination Center Bozeman Fire Dept. Station #2 Logan Landfill Story Mill Landfill/ Convenience Site/ HHW Vehicle Maintenance Building Parking Garage Laurel Glen Shops Beall Rec Center Lindley Center Bozeman Public Library Story Mansion Water Reclamation Facility (WRF)	Shops Complex Cemetery Building Bozeman Fire Dept. Station #2 Vehicle Maintenance Building Parking Garage Laurel Glen Shops Beall Rec Center Bozeman Senior Center Lindley Center Bozeman Public Library Swim Center Story Mansion Water Reclamation Facility (WRF) Water Treatment Plant (WTP)	Cemetery Building Gallatin County Coordination Center Bozeman Fire Dept. Station #2 Logan Landfill Story Mill Landfill/ Convenience Site/ HHW Vehicle Maintenance Building Parking Garage Laurel Glen Shops Beall Rec Center Lindley Center Bozeman Public Library Story Mansion Water Reclamation Facility (WRF)	Bozeman Public Safety Center Cemetery Building Alfred Stiff Professional Bldg. Bozeman City Hall Gallatin County Coordination Center Bozeman Fire Dept. Station #3 Bozeman Fire Dept. Station #2 Logan Landfill Laurel Glen Shops Bozeman Public Library Water Reclamation Facility (WRF) Water Treatment Plant (WTP)	Cemetery Building Bozeman Fire Dept. Station #2 Logan Landfill Vehicle Maintenance Building Parking Garage Laurel Glen Shops Water Reclamation Facility (WRF)

## Appendix E. References

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- (2014). *Climate Change Impacts in the United States: The Third National Climate Assessment*. Washington DC: U.S. Global Change Research Program. Retrieved from National Climate Assessment: <https://nca2014.globalchange.gov/>
- Cutter, S. L. (2001). *American Hazardscapes: The Regionalization of Hazards and Disasters*. Washington, D.C.: Joseph Henry Press.
- Flavelle, C. (2019, March 27). *AT&T, Beset by Disaster Costs, Turns to 30-Year Climate Modeling*. Retrieved from Bloomberg: <https://www.bloomberg.com/amp/news/articles/2019-03-27/at-t-beset-by-disaster-costs-turns-to-30-year-climate-modeling>
- Hauer, M. E. (2017). Migration inducted by sea-level rise could reshape the US population landscape. *Nature Climate Change*, 321-325.
- Moody's Investor Services. (2017, November 28). *Moody's: Climate change is forecast to heighten US exposure to economic loss planning short- and long-term credit pressure on US states and local governments*. Retrieved from Moody's: [https://www.moody.com/research/Moodys-Climate-change-is-forecast-to-heighten-US-exposure-to--PR\\_376056](https://www.moody.com/research/Moodys-Climate-change-is-forecast-to-heighten-US-exposure-to--PR_376056)
- Multihazard Mitigation Council. (2017). *National Hazard Mitigation Saves 2017 Interim Report: An Independent Study - Summary of Findings*. Washington: National Institute of Building Sciences.
- National Disaster Preparedness Training Center. (2018). AWR-228 Community Resilience: Building Resilience from the Inside Out Version 3.0. Denver, CO. Retrieved from <https://www.ndpc.us/Catalog/NDPTC/AWR-228>
- National Institute of Standards and Technology. (n.d.). Community Resilience Planning Guide for Buildings and Infrastructure. *Special Publication 1190*.
- NOAA National Centers for Environmental Information. (2018). *U.S. Billion-Dollar Weather and Climate Disasters (2018)*. Retrieved from <https://www.ncdc.noaa.gov/billions/>
- The National Academies. (2012). *Disaster Resilience: A National Imperative*. Washington, D.C.: The National Academies Press.
- Whitlock C, Cross W, Maxwell B, Silverman N, Wade AA. (2017). *2017 Montana Climate Assessment*. Bozeman and Missoula MT: Montana State University and University of Montana, Montana Institute on Ecosystems.