Chelan County Climate Resilience Strategy

In early 2019, Chelan County began engagement with local and state partners aiming to build resilience to the impacts of climate change in the county. A core planning and funding group has been leading this effort, and is comprised of Chelan County Natural Resources, Chelan County Public Utility District, Washington State Department of Natural Resources, and the University of Washington Climate Impacts Group.

The purpose of this document is to achieve two key benefits of county-wide climate resilience planning which were identified through community workshops:

1. Improved communication and coordination, and
2. The opportunity to advance projects of mutual benefit.

We need your feedback!

Please review this document, and take a short survey on what you think works, what resonates with you, and importantly, what is missing that needs to be addressed:

https://www.surveymonkey.com/r/chelan_climate

This document is divided into four sections based on climate change impacts: Wildfire, Snowpack & Instream Flow, Floods, and Water Supply. If you would like to provide feedback or ideas to be addressed in the final strategy document, use the link in the upper right-hand portion of this page.

Resilience Strategies and Where to Find Them

Wildfire Resilience Strategies: *Page 9*

- Build awareness and preparedness of Chelan County Communities
- Coordinate and improve of emergency preparedness systems, particularly early detection
- Develop Fire Safe Places in Fire Prone Areas with Wildland Urban Interface Policies and Codes
- Create Fire Adapted Communities
- Protect critical facilities (also see flooding)
- Coordinate ecological recovery programs for areas subject to fire
- Monitor exotic and invasive species on resource and natural lands and prioritize protection and enhancement of such areas
- Continue to build partnerships across agencies to monitor and respond to climate changes and vulnerabilities in forested and shrub-steppe lands

Snowpack & Instream Flow Resilience Strategies: *Page 15*

- Encourage watershed-scale community building to adapt to changing instream flow and snowpack within the watershed.
- Promote and encourage water efficiency and conservation
- Reduce impacts of climate change to aquatic systems through stream-habitat improvement and connectivity

Flooding Resilience Strategies: *Page 20*

- Improve flood warning and information dissemination
- Evaluate and improve stormwater management and infrastructure for high-intensity rainfall events
- Protect and upgrading or relocation of vulnerable critical facilities locations vulnerable to flooding
- Revise transportation infrastructure
- Replant bare, disturbed, and recently burned areas to increase infiltration and slow movement of water

Water Supply Resilience Strategies: *Page 25*

- Develop rural water management through water budgets, exempt well tracking, voluntary metering, and water banks, or other measures
- Promote increased water storage solutions that help agricultural producers adapt to changing conditions and decrease production losses due to lack of water availability
- Drought planning to increase water conservation, and build awareness around individual risk from drought

Chelan County Climate Resilience Strategy

DRAFT August 5, 2020

Executive Summary (to be written after feedback is received)

Introduction

Climate change is expected to have wide-ranging impacts on life in Chelan County. In recent decades Washington State, including Chelan County, has experienced significant droughts, declining snowpack, and several extreme wildfire seasons. These events and conditions are expected to become more common as the climate continues to warm. In early 2019, Chelan County began engagement with local and state partners aiming to build resilience to the impacts of climate change in the county.

This document is a result of multiple community workshops and community engagement throughout 2019 and 2020, and seeks to build a foundation for future climate resilience and adaptation work in Chelan County.

PURPOSE

What does building climate resilience mean? The Washington State Department of Natural Resources' (DNR) Plan for Climate Resilience defines resilience as: **"Being prepared for, and adapting to, current and future climate-related changes."** In alignment with DNR's definition, this document attempts to answer these key driving questions:

- Where are we heading based on current trends and projections?
- What does that mean for commerce, communities, residents of Chelan County as well as visitors?
- What are steps Chelan County and the greater community can take to build climate resilience?

In answering these questions, the purpose of this document is to achieve two key benefits of county-wide climate resilience planning which were identified through community workshops: 1) improved communication and coordination, and 2) the opportunity to advance projects of mutual benefit.

This document is divided into four sections based on climate change impacts: Wildfire, Snowpack & Instream Flow, Floods, and Water Supply. For the given topic, each section presents an overview of observed and current trends, future projections, impacts, current initiatives, and resilience strategies. The description of impacts in each of the four sections are based on impacts described in the reports listed in the section "How Our Partners are Preparing for These Changes" with additional input on local impacts from the planning team and community engagement. Resilience strategies are drawn from stakeholder

discussions of priorities and gaps as well as a review of current initiatives and potential strengthening of activities in Chelan County.

REGIONAL CLIMATE CHANGE OVERVIEW

There are multiple climate change impacts expected across Washington State and the Pacific Northwest, most of which will have specific consequences for Chelan County. Two of the main concerns related to climate change are rising temperatures and increased seasonal variability in precipitation.

Temperature

The Pacific Northwest and Washington State have experienced long-term increases in air temperature. The average year in the Northwest is +1.54°F warmer than during the first half of the 20th century, and the coldest day of the year between 1986 and 2016 was +4.78°F warmer than the coldest day historically between1901and1960.[1]

Temperatures are expected to continue rising, with average annual temperature in Chelan County projected to increase between +4.6° F and +5.9° F by the 2050s[2] and between +5.8° F and +9.7° F by the 2080s under a low and high greenhouse gas scenario, relative to historical conditions.[3] Warming is projected to occur across all seasons, with more warming during summer months. Models project that extreme heat events will become more frequent and extreme cold events will become less frequent.

Natural climatic variability will continue to play an important role in the region's climate, amplifying or dampening the long-term trends driven by climate change. However, it should be noted that the magnitude of the projected change in temperature is large when compared to the natural climatic variability observed in the 20th century.

Greenhouse gas scenarios are plausible "what if" scenarios of future greenhouse gas concentrations in the atmosphere based on emissions and sequestration. The scenarios are used in climate models to make projections of how much and how fast the climate changes. Higher scenarios result in more warming at a faster rate, although warming associate with the scenarios is similar until mid-century.

We cannot say which scenario is most likely, so it is important to consider the range. In this document the low scenario refers to Representative Concentration Pathway (RCP) 4.5, the moderate scenario refers to Special Report on Emissions Scenarios (SRES) A1B, and the high scenario refers to RCP 8.5. The scenarios referenced in this document are those used in the studies that generated the data; not all studies include all scenarios.

For more information see Mauger et al. 2015. State of Knowledge: Climate Change in Puget Sound. https://cig.uw.edu/resources/special-reports/ps-sok/

Precipitation

Year-to-year variability in precipitation in Washington state is large in comparison to any long-term trend, and natural variability has a significant influence on regional precipitation, which results in oscillations of wet and dry years. Total annual precipitation is projected to increase slightly but will continue to be influenced by year-to-year variability. Projections for seasonal precipitation are mixed,

[1]USGCRP, 2017: Climate Science Special Report: Fourth National Climate Assessment, Volume I [Wuebbles, D.J., D.W. Fahey, K.A. Hibbard, D.J. Dokken, B.C. Stewart, and T.K. Maycock (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 470 pp., doi: 10.7930/J0J964J6.
[2] Climate model projections are presented as 30-year averages centered on the given decade, e.g. the 2050s is the 30-year period from 2040 to 2069.
[3] Projected changes in the climate described in this document are relative to the average of the historical period from 1971 to 2000 unless otherwise specified.

with most models projecting drier summers by the 2050s (-6% to -8% for a low and high greenhouse gas scenario, respectively). As well, most models project increases in winter, spring, and fall precipitation.

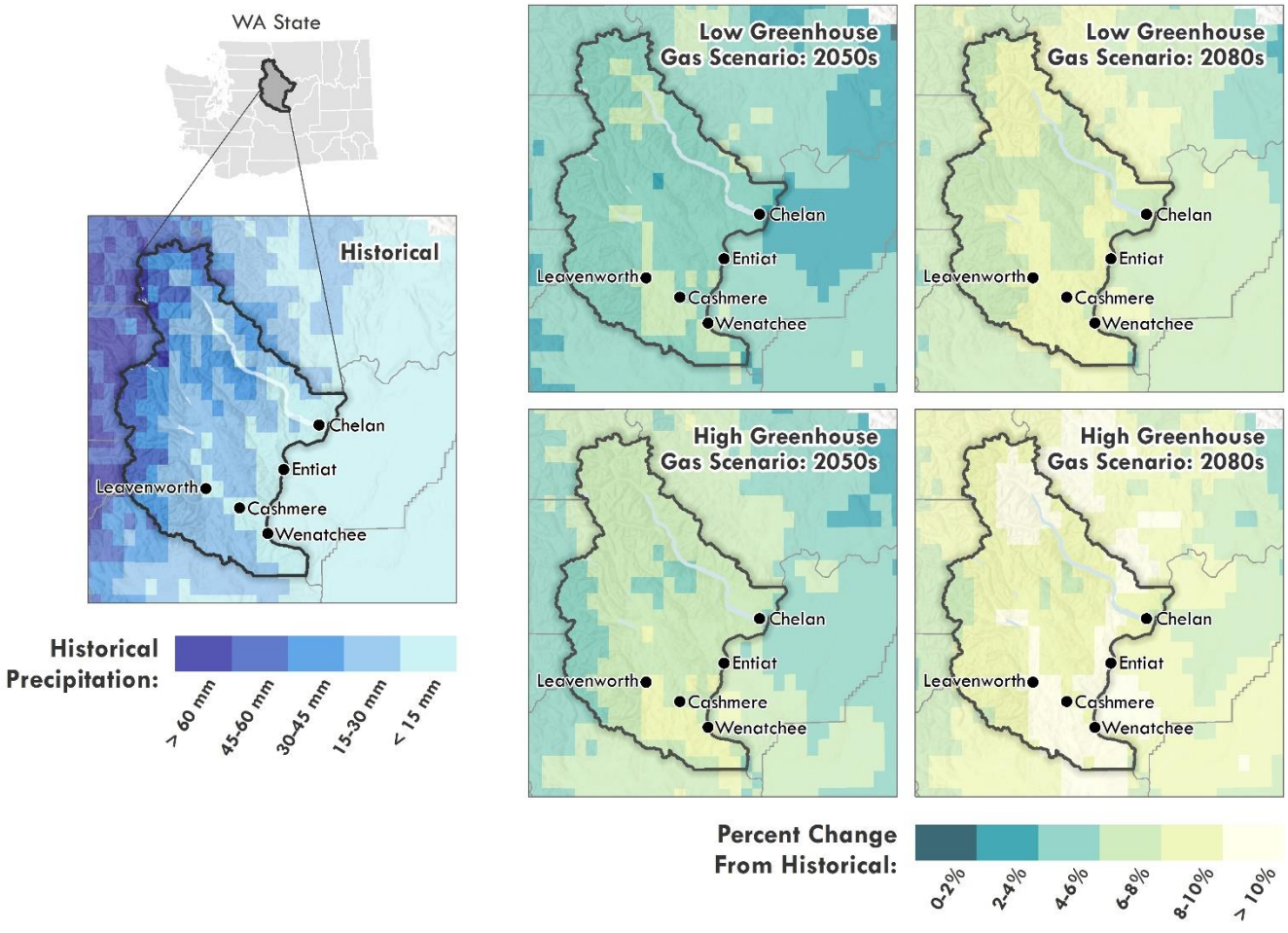
Furthermore, extreme short-term precipitation events are projected to become more frequent and more intense. Across Washington state, the number of days with more than one inch of rain is projected to increase by +13% for the 2050s under a high greenhouse gas scenario[4].

Exhibit 1. Projected Average Annual Air Temperature, Chelan County

(exhibit to be prepared)

Source: Integrated Scenarios, 2015 ; BERK, 2020

Exhibit 2. Total Annual Precipitation, Chelan County



Source: Integrated Scenarios, 2015; BERK, 2020

The change in temperature and precipitation will affect availability of water for fish, farming, and potable use, fire and flood hazard prevalence, winter and summer recreation and tourism, and more as described later in this strategy.

[4] Kunkel, K. E. et al., 2013: *Part 6. Climate of the Northwest U.S.*, NOAA Technical Report NESDIS 142-6.

HOW OUR PARTNERS ARE PREPARING FOR THESE CHANGES

Building climate resilience depends not only on actions within and by Chelan County, but on the variety of agencies and landowners who have jurisdiction and ownership within the county. This section highlights the regional and statewide organizations who are developing plans, strategies, and efforts responding to climate change. Chelan County and partners can leverage these initiatives to build local resilience efforts.

- **National Park Service and US Forest Service (NPS and USFS)**: North Cascadia Adaptation Partnership and joint climate change vulnerability assessments on NPS and USFS land in and around Chelan County. See http://adaptationpartners.org/ncap/.
- **Washington State Department of Natural Resources (DNR)** – Recently released Plan for Climate Resilience in February 2020, a detailed agency-wide climate resilience effort. This DNR plan also articulates a series of statewide systems-level needs and opportunities supporting and facilitating community-level resilience planning and implementation. See https://www.dnr.wa.gov/climate-change.
- **Washington State Department of Fish and Wildlife (WDFW)** – Climate-resilient floodplain restoration and guidelines for incorporating climate change into culvert design and water crossing structures.
- **Washington State Parks (WSP)** – Statewide Parks climate vulnerability assessment and adaptation plan. See https://parks.state.wa.us/DocumentCenter/View/11074/01-WA-Parks-Vulnerability-PDF.
- **Washington State Department of Transportation (WSDOT)** – Incorporating climate smart design into roadways and culvert design, building resilient transportation systems, and undergoing climate impacts vulnerability assessment of WSDOT infrastructure and roadways. See https://www.wsdot.wa.gov/construction-planning/environment/sustainable/climate-change.
- **Confederated Tribes of the Colville Reservation** – Natural resources vulnerability assessment completed to understand impacts of climate change on priority plants and animals within the Colville Tribes Traditional Territory, including on-reservation land as well as Okanogan Highlands and other off-reservation land. See https://www.colvilletribes.com/climate-change.
- **University of Washington Climate Impacts Group (UW CIG)** – Driving the science of climate impacts, and assisting with technical implementation of climate resilience planning region-wide, UW CIG is a critical participant to all of the climate vulnerability and resilience planning listed above, as well as this strategy document. See https://cig.uw.edu/.

Wildfire

OBSERVED / CURRENT

Eastern Washington and Chelan County have experienced several large wildfires in recent years. In 2015 the state saw its worst wildfire season in recent history with over 1 million acres burned, followed by another million acres burned in 2017. These recent wildfire seasons are not unprecedented in terms of the amount of acreage that burned historically in eastern Washington prior to fire exclusion with settlement, but they are uncharacteristic in terms of the amount of acreage burned at high severity.[5]

These wildfire seasons are also unprecedented in terms of their impacts to the livelihoods and resources of the communities in which the wildfires burned. Although it is difficult to characterize trends in wildfire at the small scale of Chelan County, several trends of increasing wildfire activity across the western U.S. are relevant to eastern Washington and Chelan County:

- The area burned by wildfire in the western US has increased 12-fold from 1973 to 2012.[6]
- The number of large wildfires (> 100 acres) in the western US has increased by about seven fires per year from 1984 to 2011.[7] This trend in large wildfires is critical because the largest wildfires burn 99% of the area burned each year.
- Wildfire season length, defined as the time between the first reported wildfire discovery date and the last wildfire control date, has increased across the western U.S. For forested areas, the average length of the fire season has increased by 84 days for 2003 to 2012 compared to the 1973 to 1982 average.[8]

These trends of increasing wildfire activity are due to a combination of factors including population growth and development in the wildland-urban interface, a legacy of forest management, and warmer and drier summers that lead to drier fuels (i.e. live and dead vegetation). Increasing temperatures and water balance deficit (atmospheric demand for water) due to climate change account for about half of the observed increase in fuel dryness since the 1970s.[9]

PROJECTIONS

Wildfire activity is projected to increase across eastern Washington as temperatures continue to increase. The area burned by wildfire in forested areas of eastern Washington is projected to double by the 2020s and increase *4-fold* by the 2040s, relative to the 1980-2006 average, for a moderate greenhouse gas scenario.[10] Projected increases in area burned are less for non-forested ecosystems in eastern Washington, but these areas are still projected to see twice as much area burned by the 2040s.

It is important to note that these projections are for increases in area burned on average -- predicting fire in any given year or how big any particular wildfire season will be is not possible, despite the clear trend towards increasing area burned.

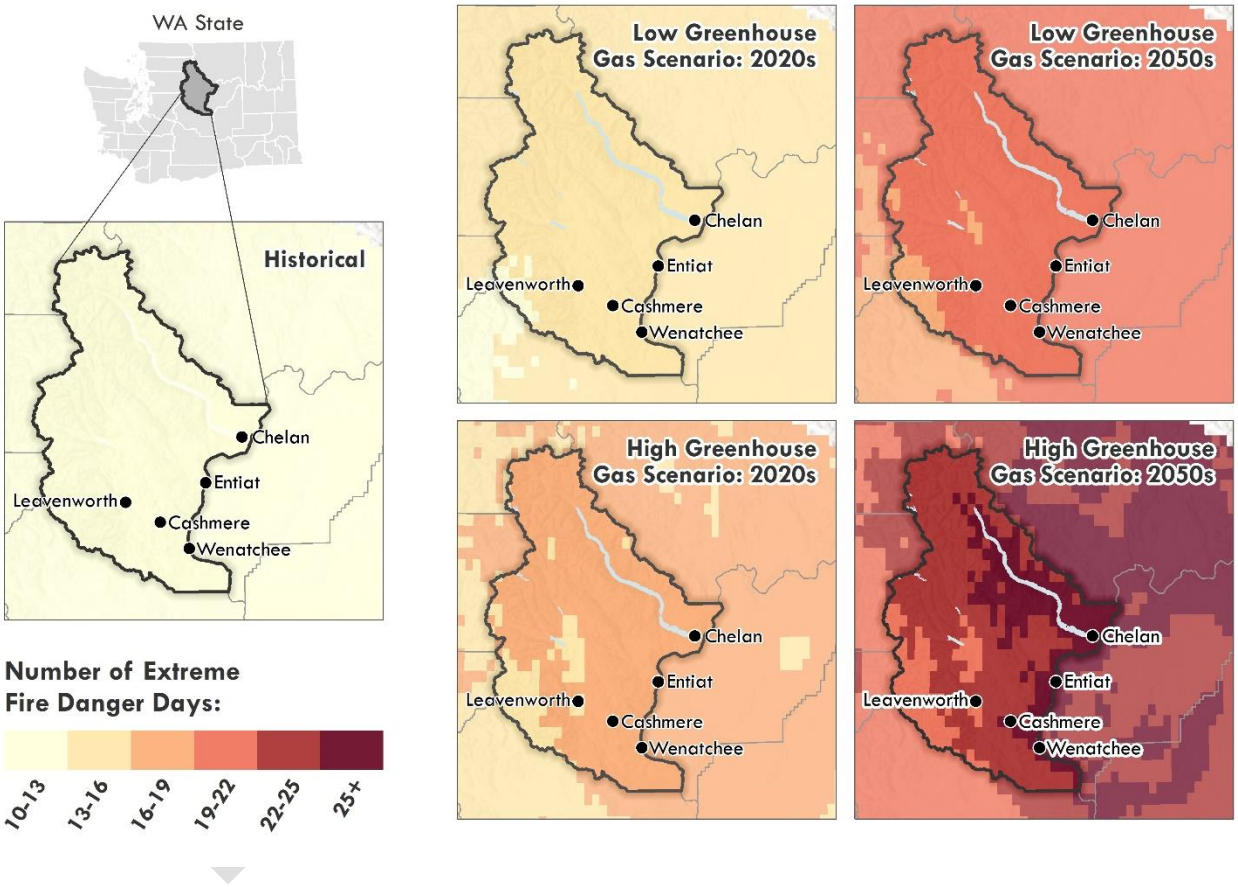
[5] Haugo, et al. 2019. The missing fire: quantifying human exclusion of wildfire in Pacific Northwest forests, USA.
[6] Westerling 2016. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring.
[7] Dennison et al. 2014. Large wildfire trends in the western United States, 1984-2011
[8] Westerling 2016. Increasing western US forest wildfire activity: sensitivity to changes in the timing of spring
[9] Abatzoglou and Williams 2016. Impact of anthropogenic climate change on wildfire across western US forests
[10] Littell et al. 2010. Forest ecosystems, disturbance, and climatic change in Washington State, USA. Medium warming scenario is CMIP 3 emissions scenario A1B.

Increasing area burned is due to higher temperatures and drier summers that will dry fuels and enable wildfires to spread. Fuel moisture in summer is an indicator of the climatic potential for wildfire. When fuel moisture is low there is significant potential for wildfires.

Summer (June - August) 100-hr fuel moisture[11] is projected to decrease across eastern Washington, particularly at higher elevations.[12] By the 2050s, average 100-hr fuel moisture in summer in Chelan County is expected to decrease by -6% for a low greenhouse gas scenario and-8% for a high greenhouse gas scenario.

Warmer and drier conditions are projected to increase the number of days with fire danger. By the 2050s, days with extreme fire danger[13] are expected to increase by +9 days for a moderate greenhouse gas scenario and +13 days for a high greenhouse gas scenario. Increases in extreme fire danger days are expected throughout the wildfire season and will be most noticeable early and late in the season.

Exhibit 3. Extreme Fire Danger Days, Chelan County



Source: Climate Toolbox, 2020; BERK, 2020

[11] Fuel moisture means the amount of water in vegetation available to a fire, and is shown as a percent of the dry weight of that specific fuel. (NOAA, 2020)
[12] The Climate Toolbox: Climate Mapper https://climatetoolbox.org/tool/Climate-Mapper
[13] Extreme fire danger days are defined as the days when 100-hr fuel moisture is below the historical (1971 - 2000 average).

IMPACTS

Greater area burned and more frequent large and severe wildfires in the region, if not mitigated, could have consequences for the livelihoods and resources valued by the residents of Chelan County.

- **Health and Well-Being:** A longer wildfire season and more frequent wildfires will increase the risk to communities, in terms of lives and property. Communities could experience more evacuations and economic impacts associated with loss of property. More wildfire could also increase the cost of homeowner's insurance or lead to areas where homeowners are no longer able to qualify for wildfire insurance coverage.

  Wildfire smoke creates hazardous air quality, especially for vulnerable populations including the young, elderly, and those with underlying respiratory conditions. Recent evidence suggests that for people with COVID-19, exposure to wildfire smoke may worsen symptoms or delay recovery, and for those without COVID-19, smoke may decrease the body's ability to fight off COVID-19.[14]

  After the fire burns, impacts to communities can continue with natural hazards including erosion, mudslides, and larger floods in watersheds with burned vegetation.

- **Agriculture:** Wildfires cause property damage to agriculture resources directly, or indirectly through smoke damage and loss of access to agriculture lands.

- **Fish and Wildlife:** More high-severity fires can reduce habitat for wildlife species that depend on old forests. Conversely more fire may increase habitat for species that use young, open forests. Wildfires can reduce aquatic habitat quality by increasing sedimentation and water temperatures due to increased erosion and a lack of shade when tree canopy is removed.

- **Forest Health:** On the one hand, more fire is needed in forest ecosystems in eastern Washington to maintain healthy forests.[15] However, when fires burn with uncharacteristically high severity, they may not lead to improved forest health. High-severity fires can increase the spread of invasive species. In dry areas where forest growth is already marginal, severe fires may lead to conversion from forest to non-forest ecosystems because tree species are unable to establish after fire.

- **Recreation:** Wildfires reduce access to recreation areas such as parks and national forests due to road or trail closures. Smoke from wildfires can reduce accessibility to all outdoor recreation, particularly for sensitive populations. More tree death due to drought or wildfire creates hazard trees that pose a risk to outdoor recreationalists and lead to closures of campgrounds, trails, and other recreation areas.

- **Infrastructure:** Wildfires directly damage property and infrastructure in the communities of Chelan County.

- **Energy and Communications:** Wildfires damage electricity distribution and transmission infrastructure, as well as communications infrastructure which can lead to interrupted electricity and communications services for residents. Increased tree death may also lead to higher costs of maintaining related facilities and for managing vegetation proactively.

[14] https://www.washington.edu/news/2020/07/29/expert-faq-wildfires-in-the-pacific-northwest-during-the-covid-19-pandemic/
[15] Washington State Department of Natural Resources. 2017. 20-Year Forest Health Strategic Plan. Washington State Department of Natural Resources.

- **Business:** More wildfire could damage businesses directly and reduce access for residents and tourists, adversely affecting livelihoods throughout the county. Wildfire smoke is hazardous to outdoor workers in the forestry, recreation, and agriculture sectors.

CURRENT INITIATIVES

Below is a selection of initiatives and projects underway which are contributing to building resilience to a changing wildfire season and more wildfires:

- **Chelan County Multi-Jurisdictional Natural Hazard Mitigation Plan** – Completed in May 2020, this plan specifically addresses wildfire as a key natural hazard to plan for in Chelan County, offering a comprehensive look at the effects of wildfire on the Chelan County communities.
- **Chelan County Community Wildfire Protection Plan** – Updated and adopted in 2018, this is a multi-jurisdictional effort directly working towards wildfire protection. Specific goals include improving response capabilities, creating fire-resilient landscapes, and promoting fire adapted communities. These goals are consistent with the direction established in the Washington State Wildland Fire Protection 10-Year Strategic Plan.
- **Chelan County Public Utility District Fire Hardening** – Multiple initiatives including hardening transmission infrastructure against fire risk (e.g., replacing wood with steel structures), clearing vegetation from high risk transmission infrastructure, and painting poles with fire retardant paint.
- **Cascadia Conservation District Wildfire Preparedness & Firewise** – Education and outreach materials focused on wildfire prevention and what to do when wildfire occurs. In coordination with the National Fire Protection Association (NFPA), Cascadia offers wildfire risk assessments, wildfire preparedness tips, wildfire toolkits, Firewise landscape guides (i.e., fire-resistant vegetation), and other materials to help build homeowner and community resilience to wildfire.
- **Landowner Assistance** – Financial assistance and cost sharing is available to landowners to help reduce fuels. There are programs administered through multiple organizations including Washington DNR's Landowner Assistance Program and Cascadia Conservation District.
- **Fire Districts** – Fire Districts in Chelan County offer outreach and education, support community wildfire preparedness, and can provide on-site wood chipping or fuel wood removal from properties, reducing the risk of wildfire spread (e.g., Fire District 1, Lake Wenatchee Fire and Rescue, and others).
- **Wildland Urban Interface Codes –** Chelan County and the cities of Chelan and Wenatchee have adopted Wildland-Urban Interface standards. Chelan County regulates roofing materials, and the cities regulate roofing, siding, landscaping, access, and other provisions.
- **20-Year Forest Health Strategic Plan for Eastern Washington** – Partners in the county are implementing multiple activities and initiatives linked to the 20-Year Forest Health Strategic Plan for Eastern Washington including landscape evaluations for forest health planning areas, forest health treatments by forest collaboratives, and landowner assistance.

KEY CLIMATE RESILIENCE GOALS

The strategies presented in the section below are in alignment with goals already adopted as part of Chelan County's wildfire response policy. The Chelan County Community Wildfire Protection Plan uses the seven goals below to frame wildfire protection within the County:

- **Improve Response Capabilities** of local fire protection services and other emergency responders to protect people and property through training, equipment needs and by increasing collaboration and coordination among public agencies, non-profit organizations, business, and industry.
- **Create Fire Resilient Landscapes** by preserving, rehabilitating, and enhancing natural systems to serve natural hazard mitigation functions.
- **Promote Fire Adapted Communities** through public education and outreach informing residents what they can do before, during and after a wildland fire and by providing tools and funding resources to assist in implementing pre and post disaster mitigation activities.
- **Protect Economy** by developing mechanisms that ensure that commerce, trade, and essential business activities remain viable in the event of a wildland fire
- **Develop a Short- and Long-Term Wildfire Recovery Plan** which addresses the natural, social, and economic challenges associated with recovering from natural disasters.
- **Utilize Existing Plans and Guidelines** when developing and implementing mitigation strategies by referring to the National Cohesive Strategy, CPAW Report and the Washington DNR 20-Year Forest Health Strategic Plan.

Resilience Strategy Table Legend

Status

- Early/Limited
- Moderate/Partial
- Mature/Robust

Resources Needed

- $: < $100,000
- $$: $100,000 - $500,000
- $$$: > $500,000 +

RESILIENCE STRATEGIES

Exhibit 4. Wildfire Climate Resilience Strategies

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
Build awareness and preparedness of Chelan County Communities	▪ Moderate/Partial	▪ Chelan County Fire Marshall ▪ Cities ▪ Fire Districts	▪ $: Coordinator
Coordinate and improve of emergency preparedness systems, particularly early detection[16]	Unknown	▪ Chelan County Fire Marshall ▪ Fire Districts	▪ $: Coordinator

[16] This appears to be a proposal for Zone F Entiat in the Chelan County Community Wildfire Protection Plan 2018 Update. Here it is meant to be broader in application across county.

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
Develop Fire Safe Places in Fire Prone Areas with Wildland Urban Interface Policies and Codes[17]	▪ Moderate/Partial Varying levels of land use policies and development regulation oversight in rural and urban areas	▪ Chelan County Community Development Department ▪ Individual city planning and building departments	▪ $$$: Incentives, especially for upgrading existing structures for greater fire resilience ▪ $: Staff
Create Fire Adapted Communities	▪ Moderate/Partial Chelan County Community Wildfire Protection Plan details a series of mitigation actions, and contains extensive wildfire hazard mapping Participation in Firewise communities	▪ Chelan County (with many local and regional partners) ▪ Fire Departments ▪ Individual landowners	▪ $$$: Funding to implement mitigation goals ▪ $: Education and outreach surrounding resources available to individual landowners for building local fire resilience (e.g. fuel reduction)
Protect critical facilities (also see flooding)	▪ Early/Limited Mapping of critical facilities has been prepared	▪ Chelan County ▪ Cities ▪ Chelan PUD ▪ School Districts ▪ Fire Districts ▪ Telecommunication Providers	▪ $$$: Funding to implement improvements
Coordinate ecological recovery programs for areas subject to fire	▪ Early/Limited Conservation practices funded in some burned areas (e.g. NRCS)	▪ USFS ▪ WDNR ▪ WDFW ▪ Conservation District ▪ Chelan County Natural Resources Department	▪ $$$: Planning and Reserve funding
Monitor exotic and invasive species on resource and natural lands and prioritize protection and enhancement of such areas	▪ Moderate/Partial	▪ USFS ▪ WDNR ▪ WDFW ▪ Conservation District	▪ $$: Funding to implement improvements

[17] This is proposed as a business incentive for offering discounted materials in Zone G Fire Adapted Communities near Lake Wenatchee in the Chelan County Community Wildfire Protection Plan 2018 Update. Here it is meant to be broader in application across county.

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
		▪ Chelan County Natural Resources Department	
Continue to build partnerships across agencies to monitor and respond to climate changes and vulnerabilities in forested and shrub-steppe lands	▪ Early/Limited	▪ USFS ▪ Bureau of Reclamation ▪ NRCS ▪ WDNR ▪ WDFW ▪ Conservation District ▪ Chelan County Natural Resources Department	▪ $: Staff resources to develop and maintain partnerships

Snowpack & Instream Flow

OBSERVED / CURRENT

Washington's snowpack and glaciers are in decline due to rising temperatures across the state. These changes will have consequences for the region's water resources.

While snowpack varies year-to-year, spring snowpack in the Washington Cascades declined by about -30%, on average, between 1955 and 2016.[18] This decline in snowpack is primarily driven by warming air temperatures, but also reflects natural climatic variability.

Glaciers in the North Cascades are also losing mass. Between 1900 and 2009, glacier area in the North Cascades decreased approximately -56% (+/-3%).[19] This decline in glacial area was not steady across the observed period. The decline was rapid in the first half of the 20th century, and remained relatively stable before declining again beginning in the 1990s.[20] In the Stehekin River watershed between 1993 and 2009, an average of ~11% of total summer runoff originated from meltwater contributions from the three glaciers within the watershed.[21]

PROJECTIONS

Snowpack is projected to further decline with warming in the future. In Chelan County, average spring snowpack is projected to decline between -26.9% and -33.5% by the 2050s and between -36.2% and -53.5% by the 2080s under a low and high greenhouse gas scenario, respectively.

18 Mote et al. 2018. Dramatic declines in snowpack in the western US. *Nature Climate and Atmospheric Sciences.*

19 Dick, K. Glacier Change in the North Cascades, Washington: 1900-2009. *Dissertations and Theses* (2013) doi:10.15760/etd.1062.

20 Granshaw, F. D. & Fountain, A. G. Glacier change (1958–1998) in the North Cascades National Park Complex, Washington, USA. *Journal of Glaciology* **52**, 251–256 (2006).

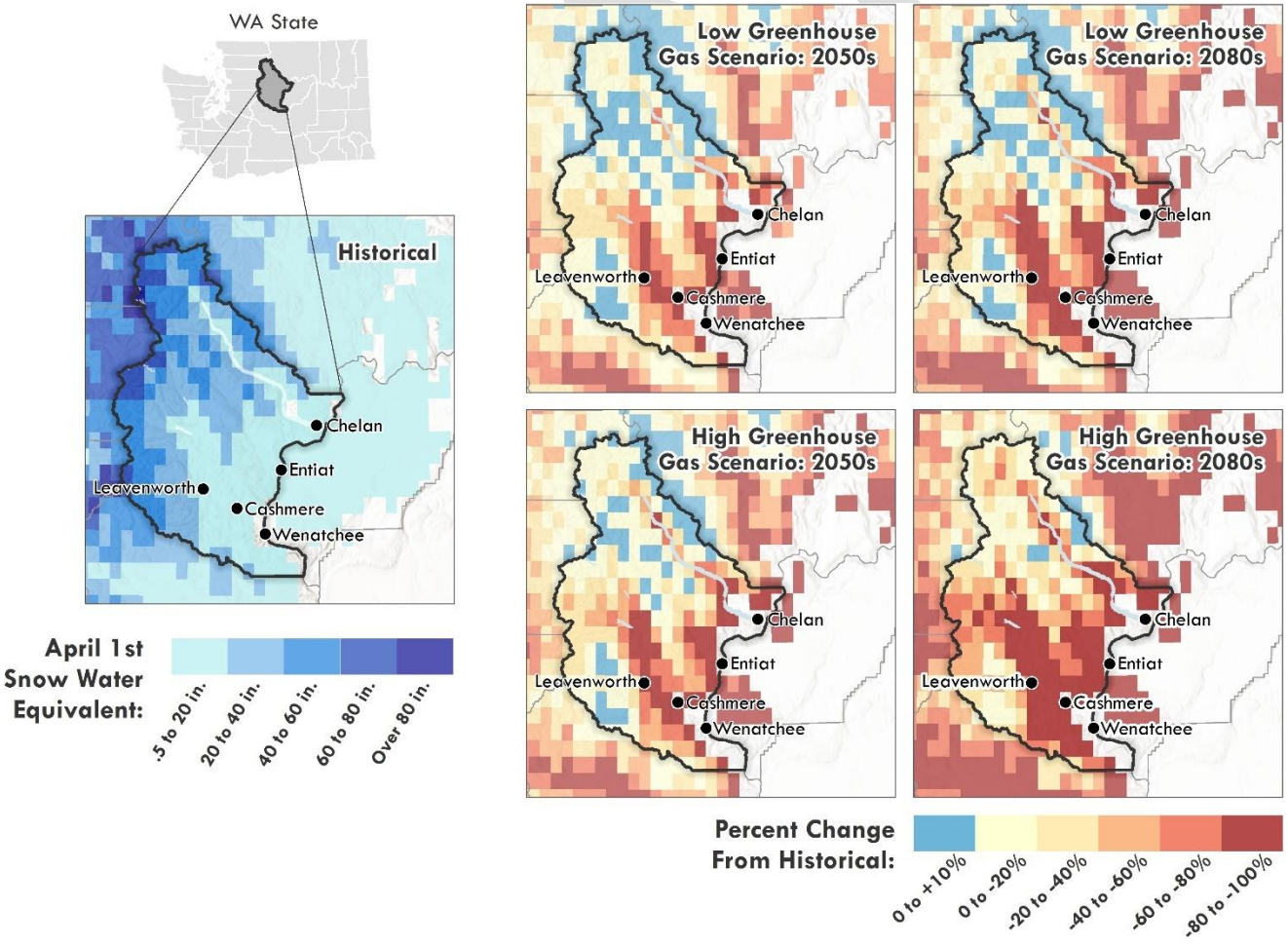
21 Riedel, J., and M. A. Larrabee. 2011. North Cascades National Park Complex glacier mass balance monitoring annual report, Water year 2009: North Coast and Cascades Network. Natural Resource Technical Report NPS/NCCN/NRTR—2011/483. National Park Service, Fort Collins, Colorado.

Average summer streamflow is also projected to decline. Summer streamflows are projected to be lower and warmer due to increasing summer air temperature, drier summers, and reductions in snowpack and glacial mass.

Streamflows are typically lowest and present the greatest challenges for competing in stream and out of stream uses in August. Total runoff in August, which includes any surface water flows in addition to subsurface runoff in shallow groundwater, is projected to decline between -20.4 % and -26.1% by the 2050s and between -27.2% and -36.1% by the 2080s, under a low and high greenhouse gas scenario, respectively. In the Entiat River (near the City of Entiat) average summer streamflow (June - August) is projected to decline by -38% by the 2040s and -54% by the 2080s under a moderate greenhouse gas scenario, relative to 1916-2006. Low summer streamflow conditions are projected to become more acute in the Entiat River due to the combined effects of less summer precipitation and warmer summer air temperatures.

Declining snowpack, glacier loss, and a shift towards earlier snowmelt will also contribute to lower summer streamflows in watersheds that historically accumulated snowmelt. The 7Q10 streamflow (the lowest 7-day average streamflow with a 10-year return interval) is projected to decline in the Entiat River. For a moderate greenhouse gas scenario, 7Q10 flows are projected to decline -3% by the 2040s and -7% by the 2080s, relative to 1916-2006.

Exhibit 5. April 1st Snow Water Equivalent, Chelan County



Source: Integrated Scenarios, 2015; BERK, 2020

Exhibit 6. Climate Indicator Mapping – Total Runoff (August, Chelan County)

(exhibit to be prepared)

Source: Integrated Scenarios, 2015; BERK, 2020

IMPACTS

What is the impact of changing snowpack and instream flows on:

- **Health and Well-Being**: Declining snowpack, and a transition to winter precipitation falling as rain instead of snow, could result in more road washouts and downed trees in winter. This could increase road closures and reduce access for residents.
- **Agriculture**: See Water Supply section.
- **Fish and Wildlife**: Projected declines in snowpack and summer streamflows are expected to affect fish health and hatchery operations. Additionally, projected increases in stream temperatures will likely facilitate the range expansion of invasive fish species that were previously unable to inhabit higher elevation stream reaches due to cold water temperatures. Conifer species are projected to encroach into subalpine meadow habitat in the Cascade mountains reducing the abundance of this habitat for wildlife.
- **Forest Health**: Many invasive species have life-history characteristics that will be favored as temperatures increase and natural disturbance events become more frequent or severe. Invasive species often are excellent dispersers, facilitating their spread to new areas that were previously uninhabitable due to climatic barriers. For example, invasive species may expand their range as snowlines retreat, establishing in higher elevation areas that were previously too cold.
- **Recreation**: Declining summer streamflow may negatively affect recreational activities or guiding services that are dependent on water features (e.g., river rafting, whitewater kayaking, and fishing). Declines in snowpack, and associated projected declines in snow duration, may negatively impact businesses dependent on outdoor winter recreation including groomed and maintained ski areas.
- **Infrastructure:** Changes in winter precipitation and intense precipitation events could alter road maintenance and passability (snow and ice removal, standing water), and alter bridge and culvert design.
- **Energy**: Changes in precipitation, reduced snowpack, and changes in the timing of snowmelt may alter seasonal patterns of energy generation.
- **Business**: Extreme weather events could disrupt business operations, such as supply chains.

CURRENT INITIATIVES

- **Icicle Work Group** – A joint effort between Chelan County and the Washington State Department of Ecology, this group seeks to find collaborative solutions for water management within the Icicle Creek Watershed. They are developing a water resource management strategy comprised of projects that, among other goals, protects streamflow that provides healthy habitat, meets water quality objectives, and is resilient to climate change. Asking the question, how do we hold back water in

absence of snowpack to benefit instream flow and water supply?

- **City of Leavenworth Water Improvement Project** – The City received grant funding to install widespread advanced metering infrastructure, so customers can remotely detect leaks and monitor water usage in real time. One goal of this project is to reduce water demand as snowpack and streamflow changes.
- **WDFW Culvert Sizing Guidance** – The Washington Department of Fish and Wildlife is working with UW CIG to develop climate resilient culverts, which will help guide installation of new culverts and bridges in Chelan County (and statewide) in order to accommodate changing instream flow.
- **Mission Ridge Ongoing Snowpack Monitoring and Snow Creation** – As a recreation-based business based on snowpack, Mission Ridge is preparing for long-term changes by keeping a close eye on year-to-year snowpack. While some recent years have had record snowfall, inconsistency is the consistency here, and they are seeing high variability in snowpack between seasons. They also make their own snow. With an 18 million-gallon reservoir at the top of the mountain which uses pumped stream water, and two dozen 'snow guns' that create snow, they are able to adapt to the changing environmental pressures.
- **Stemilt-Squilchuck Water Storage** – This effort explores using water storage as instream flow shifts to capture water when it is more available.
- **Watershed Plans** – Watershed plans are approved for Lake Chelan, Entiat, Wenatchee and Stemilt-Squilchuck with water quality and quantity and fish and wildlife habitat measures. Implementation strategies include streamflow monitoring and community water metering.

KEY CLIMATE RESILIENCE GOALS

Using the Icicle Creek Work Group Vision & Guiding Principles as a framework for thinking about building resilience to changing snowpack and instream flow, the strategies in this section build upon policy and efforts already adopted throughout the county. Some key takeaways from the Icicle Creek Work Group as presented here:

- **Vision:** The Icicle Creek Work Group seeks to find collaborative solutions for water management within the Icicle Creek drainage to provide a suite of balanced benefits for existing and new domestic and agricultural uses, non-consumptive uses, fish, wildlife, and habitat while protecting treaty and non-treaty fishing interests.
- **Guiding Principles:**
  - Streamflow that: a. Provides passage, b. Provides healthy habitat, c. Serves channel formation function, d. Meets aesthetic and water quality objectives, e. Is resilient to climate change.
  - Sustainable hatchery that: a. Provides healthy fish in adequate numbers, b. Is resource efficient, c. Significantly reduces phosphorus loading, d. Has appropriately screened diversion(s), e. Does not impede fish passage
  - Tribal Treaty and federally-protected fishing/harvest rights are met at all times.
  - Provide additional water to meet municipal and domestic demand.

- Improved agricultural reliability that: a. Is operational, b. Is flexible, c. Decreases risk of drought impacts, d. Is economically sustainable.
- Improves ecosystem health including protection and enhancement of aquatic and terrestrial habitat.

RESILIENCE STRATEGIES

Exhibit 7. Snowpack and Instream Flow Strategies

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
Encourage watershed-scale community building to adapt to changing instream flow and snowpack within the watershed. For example: ▪ Irrigation efficiencies and returning diverted water back into streams during critical flow periods. ▪ Forestry practices and riparian enhancement that improve water-holding capacity and reduce stream temperatures. ▪ Critical areas restoration to maintain or reduce stream temperatures, and restore flow patterns. ▪ Management of invasive or non-native aquatic species that thrive in warmer waters.	▪ Early/Limited Limited watershed-scale community building implementation in Icicle Creek Watershed – extend to other priority areas of Chelan County.	▪ Chelan County ▪ Chelan PUD ▪ UWCIG ▪ WDNR	▪ $$$: Funding to develop climate resilience strategies that leverage watershed plans
Promote and encourage water efficiency and conservation	▪ Moderate/Partial Ongoing	▪ Chelan County Natural Resources Department ▪ Chelan PUD ▪ Conservation District ▪ Irrigation Districts ▪ Municipal Service Providers ▪ Agricultural Producers	▪ $$$: Funding for infrastructure improvements ▪ $$: Funding for agricultural conservation practices
Reduce impacts of climate change to aquatic systems through stream-habitat	▪ Moderate/Partial In progress implementation of watershed plans	▪ Chelan County Natural Resources Department ▪ Chelan PUD	▪ $$$:Funding to implement watershed and habitat plans

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
improvement and connectivity		▪ Conservation District ▪ WDNR ▪ WDFW	

Flooding

OBSERVED / CURRENT

In eastern Washington, floods often occur in the foothills of the Cascade Range as the snowpack rapidly melts out in late spring and early summer. In some areas of eastern Washington, flooding also occurs during winter when above average winter temperatures cause heavy winter precipitation to fall as rain, as well as melting existing snowpack.[22] Small watersheds in eastern Washington may also experience smaller scale flash floods during summer thunderstorms or cloudburst events.

The convergence of Icicle Creek and the Wenatchee River in Leavenworth, the reach of the Wenatchee River between Cashmere and Wenatchee, and the Wenatchee River headwaters are areas particularly vulnerable to flooding in Chelan County.[23]

PROJECTIONS

Climate change will increase both the frequency and magnitude of flood events in and around Chelan County. A shift from snow to rain at mid- to high-elevations, increasing cool season precipitation, greater sediment transport, and heavier extreme precipitation events are the primary drivers of these projected changes. As temperatures continue to increase, a greater fraction of winter precipitation will fall as rain rather than snow, increasing winter runoff and streamflow volumes. In Chelan County, total cool season (October to March) runoff is projected to increase between +27% and +39% by the 2050s and between +43% and +74% by the 2080s for a low and high greenhouse gas scenario, respectively.

At the Entiat River near the City of Entiat, natural streamflow volume associated with the 100-yr flood event is projected to increase +41% by the 2040s and +88% by the 2080s under a moderate greenhouse gas scenario, relative to the 1916-2006 average[24].

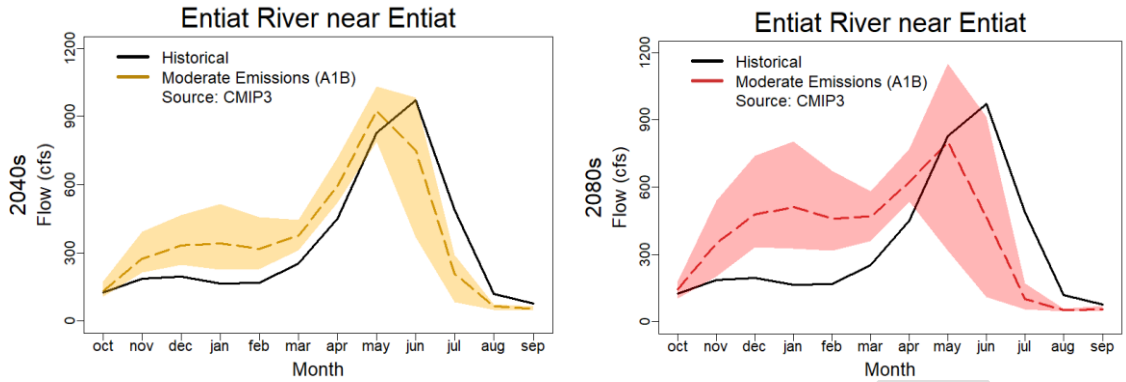
Exhibit 8**Error! Reference source not found.** shows hydrographs of the average monthly streamflow at the Entiat River near Entiat for (left) the 2040s and (right) the 2080s under a moderate greenhouse gas scenario. The black line on each graph represents the average monthly historical streamflow (1916-2006) at this location.

[22]What causes floods in Washington State? Fact Sheet 228-96. By: David L. Kresch and Karen Dinicola. https://doi.org/10.3133/fs22896

[23]Chelan County Flood Control Zone District. 2017. Chelan County Comprehensive Flood Hazard Management Plan. Chelan County Flood Control Zone District, Public Works Department. Wenatchee, Washington.

[24] Hamlet, A.F. et al., 2013. An overview of the Columbia Basin Climate Change Scenarios Project: Approach, methods, and summary of key results.

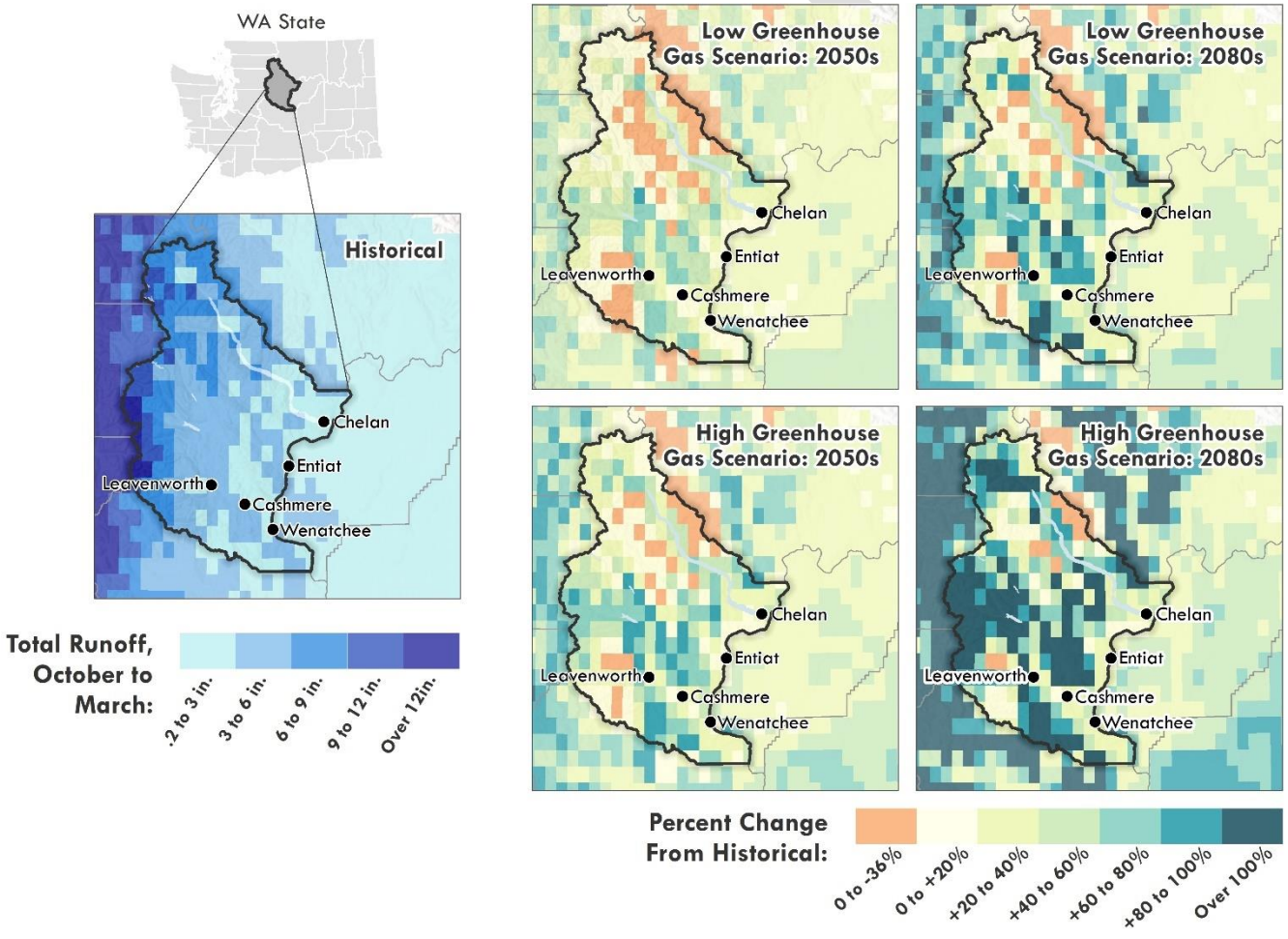
Exhibit 8. Average Monthly Streamflow of Entiat River



Source: Hamlet et al., 2013

Monthly hydrographs illustrate projected changes in streamflow of the Entiat River, which include higher winter streamflow, earlier peak streamflow, and declining summer streamflow. The projected increases in winter streamflow and associated projected increases in winter flood potential are driven by more winter precipitation and a greater fraction of winter precipitation falling as rain instead of snow.

Exhibit 9. Total Runoff, 6-month October-March Chelan County



Source: Integrated Scenarios, 2015; BERK, 2020

IMPACTS

What is the impact of a change in flooding on:

- **Health and Well-Being**: More frequent or larger flood events increase risks to Chelan County communities and infrastructure located in areas susceptible to flooding. Examples of vulnerable infrastructure include homes, businesses, roadways, health services, and septic systems. Projected increases in the frequency and magnitude of floods could reduce the effectiveness of existing flood protection infrastructure.
- **Agriculture**: Projected increases in winter streamflows will increase the flood risk for agricultural lands. Some vegetable crops may be particularly vulnerable to floods if they are still in the ground in fall (when flooding can begin) or if they need to be planted in the spring, before flood waters recede. Floods may also damage livestock facilities and equipment.
- **Fish and Wildlife**: Projected increases in flooding will likely result in elevated salmon egg and fry mortality via exacerbated streambed scour and egg suffocation. Larger and higher velocity streamflows in winter can kill juvenile fish or wash them out of rearing habitat early, likely to result in increased predation downstream.
- **Recreation**: Increased flooding may limit or block access to recreational areas. Flooding can lead to trail washouts, damage recreational infrastructure and facilities, and may necessitate relocation of campgrounds in areas continually closed due to flooding. [25]
- **Infrastructure:** Increased flooding may result in landslides, damaging road and utility infrastructure, and requiring additional emergency staff and resources to mitigate.
- **Energy**: Higher winter streamflow volumes and more frequent flooding can increase the need to spill at hydroelectric projects, decreasing potential hydropower generation.
- **Business**: Increased flooding can interrupt business operations by impacting distribution networks, reducing business travel or tourism, and damaging business assets and inventory.

CURRENT INITIATIVES

- **Chelan County Comprehensive Flood Management Plan** – this plan provides mitigation measures and actions around a wide range of alternatives, all aimed at protecting life and property within Chelan County. While limited in budget, it does address climate change specifically. Some objectives that build climate resilience are minimizing new development in high-risk areas, working cooperatively with public agencies and stakeholders, and considering flood hazard management policies that promote resiliency and sustainable operations of critical facilities.
- **Culvert Sizing Guidance** – Both WDFW and UW CIG are working on climate change adapted culvert design. In addition to its relationship with accommodating changing instream flow, the new culvert sizing guidance aims to better accommodate flood events which may be more extreme as a

[25] Whitely Binder et al., 2017. Preparing Washington State Parks for Climate Impacts: A Climate Change Vulnerability Assessment for Washington State Parks. A collaboration of the Washington State Parks and Recreation Commission and the University of Washington Climate Impacts Group. Seattle, WA. https://doi.org/10.7915/CIG6B27QV

result of climate change impacts.

- **City of Cashmere Levee Management Plan** – There are three major levees that protect Cashmere from major flood events. This is a joint project between Chelan County and Cashmere, this plan provides a maintenance, vegetation management, and capital improvement plan that balances the need of flood risk reduction with aquatic species living in the Wenatchee River.
- **WDFW Emergency Hydraulic Project Approval (HPA) Permitting** – this is an effort by WDFW to streamline the emergency HPA permitting process, which are needed for all building or other work related activities that divert or change the flow of water. In cases where flooding is happening or water diversion is quickly needed, WDFW can issue a verbal approval of a project.
- **WSDOT Climate Impacts Assessment** – this statewide project assesses critical transportation routes and infrastructure within Chelan County in terms of vulnerability to climate impacts.

KEY CLIMATE RESILIENCE GOALS

Similar to the Wildfire section, the resilience strategies below are rooted in the guiding goals adopted in the Chelan County Comprehensive Flood Management Plan (October 2017):

- **Protect life**
- **Protect property**
  - New development in floodplains shall be constructed so that they can withstand the 100-year flood w/o sustaining significant damage
- **Maintain sustainable operation of identified critical facilities**
  - Consider flood hazard management policies that promote resilience and sustainable operations of critical facilities
  - Avoid construction of critical facilities in floodplains.
  - Consider and account for the potential impacts of climate change over the life of the facility
- **Increase the awareness of flood risk and ways to mitigate its impacts**
  - Improve early warning emergency response systems and plans, including implementing widespread river/stream level monitoring
  - Inform the public on the risk exposure to flood hazards and increase individual capability to prepare, response, recover, and mitigate the impacts of flood events.
- **Strive to protect or restore the natural and beneficial functions of floodplains**
- **Encourage the development and implementation of long-term, cost effective flood mitigation projects and programs.**

RESILIENCE STRATEGIES

Exhibit 10. Flood Climate Resilience Strategies

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
Improve flood warning and information dissemination	▪ Early/Limited Multi-jurisdiction coordination underway and continued dialogue needed	▪ Chelan County Flood Control District ▪ Chelan PUD ▪ USACE ▪ USFS ▪ Washington Dept. of Ecology ▪ WDFW ▪ Irrigation and Reclamation Districts	▪ $$: Expanded regional funding among partners ▪ $$$: Local and countywide grant funding
Evaluate and improve stormwater management and infrastructure for high-intensity rainfall events	▪ Moderate/Partial Variable based on stormwater management plans	▪ Chelan County Public Works Departments ▪ Cities' Public Works Departments ▪ Chelan PUD ▪ WSDOT ▪ WDFW	▪ $$$: Funding to implement improvements ▪ $: Staff
Protect and upgrading or relocation of vulnerable critical facilities locations vulnerable to flooding[26]	▪ Early/Limited Mapping has been prepared.	▪ Chelan County ▪ Cities ▪ Chelan PUD ▪ School Districts ▪ Fire Districts ▪ Telecommunication Providers	▪ $$$: Funding to implement improvements
Revise transportation infrastructure: ▪ Improve transportation infrastructure where needed, e.g. enlarging road crossings. ▪ Remove or redesign roads that disrupt	▪ Early/Limited WSDOT Climate Smart Design initiated	▪ Chelan County Public Works ▪ Cities Public Works ▪ WSDOT	▪ $$$: Funding to implement improvements

[26] An objective in Chelan County Multi-Jurisdiction Natural Hazard Mitigation Plan.

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
floodplain function or intercept precipitation and ground water and accelerate its movement into stream systems.			
Replant bare, disturbed, and recently burned areas to increase infiltration and slow movement of water	▪ Moderate/Partial Watershed plans and riparian plantings in selected areas Conservation practices funded in some burned areas (e.g. NRCS)	▪ Chelan County Natural Resources Department ▪ Conservation District ▪ USFS ▪ WDFW ▪ WDNR	▪ $$: Reserve funding

Water Supply

OBSERVED / CURRENT

Significant changes in annual streamflow have not been observed in eastern Washington rivers including Stehekin River and the Wenatchee River in Chelan County. However, substantial declines in streamflow have been observed in the driest years. Between 1948 and 2006, streamflow declined in dry years by about -22% and -38% in these Chelan County rivers. This suggests that since mid-century, dry years have been getting drier.[27]

Spring peak streamflow is shifting earlier in the year in response to declines in snowpack. Between 1948 and 2002, the timing of peak spring streamflow advanced 16 days in response to warming temperatures and associated declines in snowpack.[28] Located at mid-elevation in the Cascades, the Wenatchee watershed is particularly sensitive to warming as a small amount of warming can cause significantly more winter precipitation to fall as rain instead of snow.

PROJECTIONS

Although total annual precipitation is not projected to change substantially, only a marginal increase in average precipitation is projected, the critical change to water supply will be a shift in the timing of natural water availability throughout the year.[29] If unmitigated, this shift in the timing of water availability may create challenges for adequate water supply when water demand is highest.

Water Supply

Higher winter temperatures are projected to increase the fraction of winter precipitation that falls as rain rather than snow, decreasing snowpack and shifting snowmelt earlier in spring (See Snowpack and

[27] Luce, C. H. & Holden, Z. A. Declining annual streamflow distributions in the Pacific Northwest United States, 1948–2006. *Geophys. Res. Lett.* **36**, L16401 (2009).
[28] Stewart, I. T., Cayan, D. R. & Dettinger, M. D. Changes toward Earlier Streamflow Timing across Western North America. *J. Climate* **18**, 1136–1155 (2005).
[29] Snover et al. 2013. Climate Change Impacts and Adaptation in Washington State: Technical Summaries for Decision Makers.

Instream Flows & Floods sections). Due to these changes in the climate, winter water supply is projected to increase and summer water supply is projected to decrease.

Unregulated surface water supply in the Columbia River Basin for November through May is projected to *increase* by +31% (+/- 9%) by the 2030s (relative to the 1981-2011 average).[30] Conversely, unregulated surface water supply for June through October is projected to decrease by -10% (+/- 8%) for the same timeframe due to earlier spring runoff and drier summers.

The change in seasonal water supply for any watershed within the Columbia Basin will vary. Watersheds where streamflow is driven primarily by snowmelt are expected to experience the largest change in streamflow timing and seasonal supply.

In Chelan County specifically, total runoff during the cool season (October to March) is expected to increase between +27% and +39% for the 2050s and +43% and +74% by the 2080s for a low and high greenhouse gas scenario, respectively. In contrast, total runoff during the warm season (April through September) is expected to decrease between -8% and -11% for the 2050s and -12% and -22% by the 2080s for a low and high greenhouse gas scenario, respectively.

Water Demand

For Chelan County, maximum air temperatures in summer (June - August) are projected to increase between +6.3° F and +8.1°F by the 2050s, and between +7.5°F and +12.8°F under a low and high greenhouse gas scenario. Some climate projections also show decreases in summer precipitation. However, summer precipitation in this region is already very low and it is difficult to project changes in summer precipitation because much of it comes in convective storms, which are difficult for climate models to simulate. Higher temperatures may lead to increasing agricultural and municipal water demand in the long-term.

In the near-term (through the 2030s) agricultural water demand for the Columbia River Basin, which makes up about 80% of the water demand in the region, is forecasted to decrease slightly. This decrease is primarily due to warmer and wetter conditions in spring that lead to an earlier and shorter irrigation season, as well as changes in the crop mix towards crops that require less water. As temperatures continue to increase, this decline in agricultural water demand may not continue as the gains made by shifting to lower-water-use crops diminish.

For the Washington portion of the Columbia River Basin specifically, water demand for irrigation is forecasted to decrease by -7% (+/- 1%) through the 2030s relative to the 1981 2011 average.[31] However, demand for surface water specifically may increase during this period to compensate for declining groundwater supply, which is currently meeting a portion of the irrigation demand. Other changes in agricultural production in response to warmer temperatures and a longer growing season may increase irrigation demand in other ways that lead to an overall increase in water demand.

Communities and resources most vulnerable to the altered timing of water supply and demand will be those that depend on groundwater or surface water from mid-elevation watersheds, which are most susceptible to the effects of warmer temperatures on snowpack and streamflows.

[30] Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001

[31] Columbia River Basin Long-term Water Supply and Demand Forecast. 2016. Publication No. 16-12-001

Exhibit 11. Climate Indicator Mapping – Total Runoff (6-month April-September, Chelan County)

(exhibit to be prepared)

Source: Integrated Scenarios, 2015; BERK, 2020

IMPACTS

- **Health and Well-Being:** Extreme rain or snow melt events could result in an increased risk of waterborne diseases in drinking water due to pathogens in the runoff around drinking water wells or flooding of wells.[32]
- **Agriculture:** Changes in the availability of summer water supply and timing of the irrigation season will lead to changes in the types of crops that are grown in the region. In the near-term, increases in total surface water supply and changes in the crop mix appear to mitigate any increases in irrigation demand due to warmer temperatures. The longer term availability of water for irrigation is less certain and will depend on changes in crop production, irrigated land, and groundwater supply.
- **Fish and Wildlife:** Decreasing surface water availability in summer and increasing water demand for agriculture and municipal use are expected to lower instream flows in summer. Currently in drought years, instream flow targets are often not met and the expected changes in summer water supply and demand could increase the challenge of meeting these targets. Lower summer water availability, combined with warmer stream temperatures is expected to decrease habitat quality for cold-water fish and affect fish health and hatchery operations.
- **Forest Health:** Warmer summer temperatures and greater evaporation are expected to increase drought stress and vegetation mortality in natural ecosystems including forests. This impact confounds existing forest health problems due to past fire exclusion and a transition towards forests with greater tree density and fewer drought-tolerant species.
- **Recreation:** Less snowpack and early snowmelt will shorten the winter recreation season on average. More years with low snowpack and early snowmelt could create an economic burden for winter recreation businesses and those that depend on the industry for their livelihoods.

  Changes to inflows to Lake Chelan could result in changes to reservoir elevations that could be cause for concern even within the operating range. For lakes not regulated by dams, lower lake elevations in summer could reduce recreational opportunities and water quality.

  Poor forest health can lead to more hazard trees that require closing or reducing access to recreation sites, increase maintenance costs, and pose a safety hazard to recreationalists and outdoor workers.
- **Infrastructure:** Increased drought risk could alter drinking water supplies for public, private, and independent water systems, and potentially increase reliance on groundwater.[33]

[32] See Washington Department of Health, Drinking Water – Climate Change: https://www.doh.wa.gov/CommunityandEnvironment/ClimateandHealth/DrinkingWater.

[33] See Washington Department of Ecology, Impacts of climate change on water resources: https://ecology.wa.gov/Air-Climate/Climate-change/Climate-change-the-environment/Water-supply-impacts#:

- **Energy:** Demand for hydropower energy is expected to increase across the Columbia River Basin primarily driven by population growth, which could lead to an increase in demand for instream flows for hydropower generation. Conversely, changes in load shape during winter (i.e., reduction in typical winter peaking) could reduce operational pinch points and make additional power available.[34]
- **Business:** Warmer temperatures and associated increases in water demand for irrigating turf could increase costs for businesses and state and local parks.

CURRENT INITIATIVES

- **Icicle Work Group** – As mentioned above, this is joint effort between Chelan County and the Washington State Department of Ecology, in addition to what is listed in the Snowpack and Instream Flow section, the work group is also addressing water storage and supply. They are considering high-elevation small scale storage, groundwater recharge (flooding), and run-of-river dams to create hydroelectricity to reduce the costs of pumping.
- **City of Leavenworth Water Improvement Project** – See Snowpack and Instream Flow.
- **Chumstick and Mission Creek Alluvial Storage** – This is a series of projects to increase stream complexity in key watershed areas to slow flow and increase infiltration. The project is underway with county funding, and monitoring is in place to evaluate the goal of water conservation through stream restoration.
- **Chelan Natural Resources Department Wenatchee Basin Modeling** – This alluvial water system model was implemented to determine the amount and severity of stream incision across the watershed, and to model the potential benefit that could accrue to water supply from reducing stream incision.
- **Chelan County Voluntary Stewardship Program** – Agriculture producers in Chelan County can participate in an alternative approach to address critical area protection and promote viable agriculture. The producers have implemented a number of conservation practices including irrigation efficiencies, opting for less water intensive irrigation, and upgrading/maintaining systems to minimize water waste.

KEY CLIMATE RESILIENCE GOALS

The strategies for building a climate resilient water supply are in alignment with Water Supply Policy 3.1 of the Chelan County Comprehensive Plan (2017): "Support data collection for water quality and quantity which can be used to evaluate land uses and development. Including but not limited to:

- Support the implementation of watershed plans to address water quantity and quality including instream flows. Continue to plan reserves for future population growth and track exempt well use.
- Improve County tracking and coordination efforts with public water providers.

[34] https://www.chelanpud.org/docs/default-source/commission/climate-change.pdf

- Evaluate the existing exempt well and reserve tracking system for expansion Countywide.
- Consider varying regulations for each WIRA or sub-basin based on water quantity and quality concerns.
- For areas where physical availability is potentially limiting, support studies on safe sustaining yield of water in relation to planned growth.
- Support mitigation measures including infrastructure projects.
- Support analysis of water bank options, or other alternatives, where instream flow reserves are exhausted, or where there are concerns over legal or physical availability.
- Support development of outreach/educational materials to residents, interest groups and developers.
- Amend the County Comprehensive Plan to reflect new data and revise land uses as appropriate.
- Water source priorities are as follows, in order of priority: 1. Connection to an existing public water system where available; 2. Where a public water system is not available, implementation of a new public water system consistent with DOH and CDHD requirements; and 3. Individual well outside the service of a public water system."

RESILIENCE STRATEGIES

Exhibit 12. Water Supply Climate Resilience Strategies

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
Develop rural water management through water budgets, exempt well tracking, voluntary metering, and water banks, or other measures	▪ Moderate/Partial Partial tracking in various basins (e.g. WRIA 45 and 46); partial establishment of reserve quantities; no water banks.	▪ Chelan County ▪ Chelan PUD ▪ Irrigation Districts	▪ $$$: Funding to implement watershed plans, well tracking program, and water bank
Promote increased water storage solutions that help agricultural producers adapt to changing conditions and decrease production losses due to lack of water availability	▪ Moderate/Partial Watershed Plans, ongoing	▪ Chelan County ▪ Chelan PUD ▪ Irrigation Districts	▪ $$$: Funding to implement watershed plans
Drought planning to increase water conservation, and build awareness around individual risk from drought	▪ Moderate/Partial Multi-Jurisdiction Natural Hazard Mitigation Plan addresses Awareness and information by special districts;	▪ Chelan County ▪ Cascadia Conservation District ▪ Chelan PUD	▪ $: Coordinator/staff

STRATEGY	STATUS	LEADS AND PARTNERS	RESOURCES NEEDED
		▪ Municipal Water Providers ▪ Irrigation Districts	

Cross-Sector Strategies

Following are climate resiliency strategies that cut across the subjects addressed in this Climate Resilience Strategy. These strategies would address multiple hazards or expected climate conditions:

- Assess the capacity of health systems to respond to emerging health and safety threats and to integrate climate preparedness into their hazard response plans and daily operations.
- Develop priorities to proactively implement climate change adaptation measures for the most vulnerable populations.
- Identify locations where changes in surface and groundwater flow due to climate change (e.g. larger floods, erosion, fire) could result in new or greater releases of toxic substances to the environment.
- Seek funding for holistic measures to protect and restore fish and wildlife habitats and ecosystem function to support resilience.
- Partner with agricultural producers to encourage sustainable farming practices that are aligned with future climate conditions to address adequate water supply and conservation, opportunities for voluntary ecological enhancements in climate vulnerable areas, and other strategies.
- Improve and promote the range of weather-independent and all-season tourism and recreation opportunities.
- Keep outreach and education around climate resilience multi-lingual to ensure engagement to all members of the community.

Near-Term Implementation Steps

(to be developed with stakeholder input at follow up meeting)