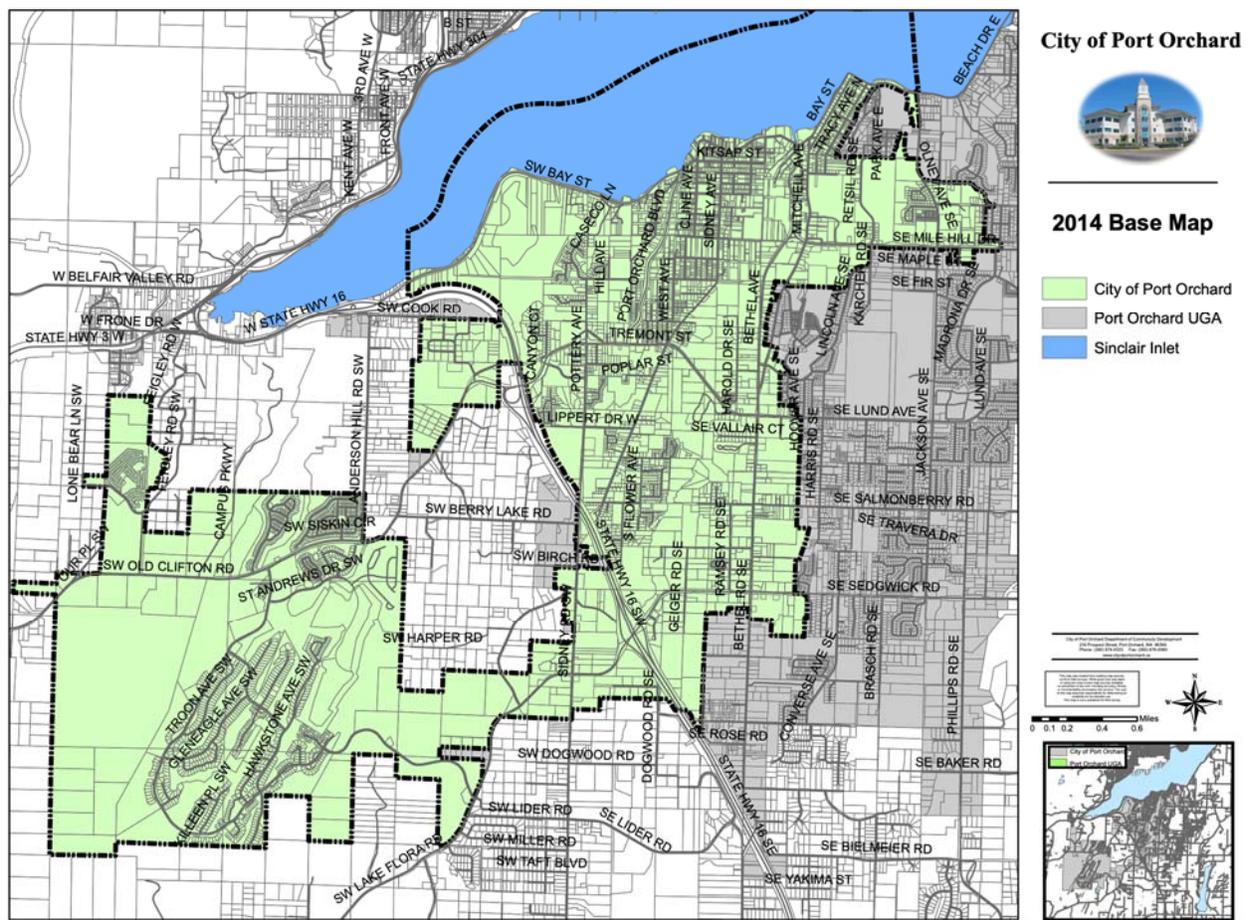


Appendix A. Port Orchard Climate Impacts

Introduction

This appendix highlights projected impacts of climate change for the City of Port Orchard. Port Orchard is a small but growing city in Kitsap County that is located near other major urban centers in the Puget Sound region. The small city has a strong community spirit and maritime history. This appendix is organized to mirror the organization of the main assessment report, with specific impacts to Port Orchard highlighted.

Figure A-1. Map of Port Orchard



Future Climate Change Projections

Sea Level Rise

Under the low-emissions scenario (RCP4.5), Port Orchard will as likely as not (50% likelihood) experience sea level rise of 0.4 feet by 2030, 0.8 feet by 2050, and 2.2 feet by 2100. Port Orchard is virtually certain (99% likelihood) to experience sea level rise of 0.05 feet by 2050 and 0.3 feet by 2100. Under the high-emissions scenario (RCP8.5), Port Orchard will as likely as not (50% likelihood) experience sea level rise of 0.35 feet by 2030, 0.75 feet by 2050, and 2.15 feet by 2100 and virtually certain (99% likelihood) to experience sea level rise of 0.1 feet by 2050 and 0.45 feet by 2100. These rising sea levels are expected to exacerbate the city’s existing challenges with saltwater in its downtown area, which the City is currently seeking to address through updates to its Shoreline Master Program and downtown area plan.

Table A-1. Probabilistic Sea Level Rise Projections for Port Orchard⁹¹⁴

Emissions Scenario	Likelihood	Location		Year (sea level rise, ft)			Location Notes
		Lat.	Long.	2030	2050	2100	
RCP4.5 Low Emissions Scenario	50%	47.6°N	122.7°W	0.4	0.8	2.2	West Port Orchard
	90%	47.6°N	122.7°W	0.2	0.4	1.3	West Port Orchard
	95%	47.6°N	122.7°W	0.2	0.3	1.1	West Port Orchard
	99%	47.6°N	122.7°W	0.1	0.2	0.6	West Port Orchard
	50%	47.6°N	122.6°W	0.3	0.7	1.7	Port Orchard and Bremerton
	90%	47.6°N	122.6°W	0.1	0.3	0.7	Port Orchard and Bremerton
	95%	47.6°N	122.6°W	0	0.2	0.5	Port Orchard and Bremerton
	99%	47.6°N	122.6°W	-0.1	-0.1	0	Port Orchard and Bremerton
	50%			0.35	0.75	1.95	Average sea level rise
	90%			0.15	0.35	1	Average sea level rise
	95%			0.1	0.25	0.8	Average sea level rise
	99%			0	0.05	0.3	Average sea level rise
RCP8.5 High Emissions Scenario	50%	47.6°N	122.7°W	0.4	0.8	2.2	West Port Orchard
	90%	47.6°N	122.7°W	0.2	0.4	1.3	West Port Orchard
	95%	47.6°N	122.7°W	0.2	0.3	1.1	West Port Orchard
	99%	47.6°N	122.7°W	0.1	0.2	0.6	West Port Orchard
	50%	47.6°N	122.6°W	0.3	0.7	2.1	Port Orchard and Bremerton
	90%	47.6°N	122.6°W	0.1	0.3	1.1	Port Orchard and Bremerton
	95%	47.6°N	122.6°W	0.1	0.2	0.8	Port Orchard and Bremerton
	99%	47.6°N	122.6°W	-0.1	0	0.3	Port Orchard and Bremerton
	50%			0.35	0.75	2.15	Average sea level rise
	90%			0.15	0.35	1.2	Average sea level rise
	95%			0.15	0.25	0.95	Average sea level rise
	99%			0	0.1	0.45	Average sea level rise

⁹¹⁴ See all Kitsap County sea level rise projections in [Appendix D. Sea Level Rise Projections, Likelihood Maps, and Graphs.](#)



Other Future Climate Projections

In addition to localized sea level rise projections, Port Orchard is likely to experience climate impacts comparable to other parts of the Puget Sound region. These impacts include:

- **Warmer surface and subsurface marine waters.** Regional models project a 2.2°F temperature increase by mid-century (2030-2059) under moderate emissions scenarios.
- **More acidic oceans and more intense and frequent low dissolved oxygen events** and dead zones.
- **Warmer air temperatures**, with expected warming of 4.9°F by end of century under RCP4.5 and 8.5°F by end of century under RCP8.5.
- An **increase in the number of extreme heat days** during the summer and **decrease in freeze-free days** during the winter.
- **Increased intensity of maximum 24-hour precipitation events.**
- **Changes in seasonal precipitation patterns**, with **increased winter precipitation** and **decreased summer precipitation.**

Climate Impacts

Public Health

Many of the public health impacts associated with future climate change in Port Orchard are likely to reflect countywide health impacts. Health impacts include:

- **More heat-related illnesses and deaths** from more frequent heat waves. This will particularly affect **outdoor laborers, elderly people, and youth.**
- **More acute and chronic respiratory illnesses** with air quality degradation from regional wildfires and longer pollen seasons.
- **More acute injuries directly associated with extreme events**, such as flooding, winter storms, and landslides. There may also be additional injuries or deaths associated with disruption of medical services and communication channels.
- **Increased prevalence of vector-borne diseases**, such as West Nile virus, Lyme diseases, paralytic shellfish poisoning, and *C. gattii*.
- **Increased food insecurity**, especially for those who are reliant on natural resources for jobs and wages.
- **Potential increases in mental health illnesses** (e.g., post-traumatic stress disorder, anxiety, depression). Children and people dependent on natural resources face a higher risk of mental health illnesses linked to climate change.
- Children, elderly people, Tribal and Indigenous peoples, outdoor laborers, homeless people, people with chronic illnesses, and low-income people will be **disproportionately at risk of climate-related health risks.**
- Long-term climate impacts will likely continue **stress the regional health and social safety net.**

Economy

Port Orchard's industries are diverse, and include retail trade, healthcare, educational services, manufacturing, construction, accommodation and food services, public administration, and construction. The most common occupations from Port Orchard residents include construction and extraction occupations, sales and related occupations, office and administrative support occupations, management occupations, and food preparation and service occupations.⁹¹⁵ People working in the natural resource economies, such as logging, mining, fishing, and agriculture, are likely to experience future impacts to business revenue. Outdoor laborers are likely to experience lost labor hours due to extreme heat and poor air quality during the summer. This is particularly salient for Port Orchard, which has a large workforce in construction. Lost labor hours from future climate change is the biggest economic damage from future climate change across the Pacific Northwest.

Climate change may also affect housing values and buildable land for Port Orchard, especially for many of its low-lying coastal residences. The average housing sales value for Port Orchard is \$291,390 (reported in 2019).⁹¹⁶ Future sea level rise, storm surges, and flooding events could lead to decreased values for these properties.

Cultural Resources

There are 21 nationally registered historic places and 201 archaeological sites in Kitsap County. In Kitsap County, places and districts listed in the National Register of Historic Places in Port Orchard include the Masonic Hall (also known as Sidney Museum, at 202 Sidney Avenue, shown in Figure A-2) and Hotel Sidney (also known as Navy View Apartments, at 700 Prospect Street). Both places are near the Port Orchard waterfront, which may face future damages from flooding, storm surges, and sea level rise. Maintenance costs and operations of these historical buildings may be affected due to future climate change. Similarly, recreational opportunities, parks, and monuments may face similar impacts.

Figure A-2. Historic Masonic Hall in Port Orchard⁹¹⁷ (photo from Kitsap County Historical Society & Museum)



⁹¹⁵ <https://datausa.io/profile/geo/port-orchard-wa>.

⁹¹⁶ Kitsap County Assessor Single Family Residence Sales History. 2020

⁹¹⁷ Kitsap County Historical Society & Museum. Kitsap County Register of Historic Places. <https://kitsapmuseum.org/research-archives/kitsap-county-register-of-historic-places/>.

Public Infrastructure

Climate impacts to public infrastructure in Port Orchard could include:

- **Potential disruption of transportation routes and damage to ferry terminals.** This may affect the Bremerton/Port Orchard ferry operations as well as Port Orchard's connection to other parts of Kitsap County and Puget Sound.
- Potential **overload and damage of stormwater and wastewater infrastructure** from flood inundation and/or saltwater intrusion.
- More **frequent flooding of low-lying coastal infrastructure**, including roads, structures, and public facilities.
 - Downtown Port Orchard, which is built largely on piers and on pilings, may experience a higher risk of impacts from flooding events and storms surges.
 - This could also disrupt access for Port Orchard residents. For example, State Route 3 through Gorst frequently floods during heavy rain events and storms.
- **Degradation of public infrastructure** from flooding, saltwater intrusion, and extreme heat.
- **Disruption of power and energy** to residents and businesses during extreme events.

Land Use and Development

Climate change is likely to affect future land use development. For example, the mixed-use development of Port Orchard's waterfront may be affected by future sea level rise, storm surges, and flooding. Future climate change may also affect buildable land, zoning, land cover types, and vegetation cover for Port Orchard. However, land use decisions can worsen or mitigate future climate change. For example, increasing green spaces can offset heat island effects and provide natural flood control.

Agriculture

Port Orchard has several working farms and nurseries. Any negative impact of climate change will have detrimental effects for agricultural economics and livelihoods. Future climate change impacts to crops, nurseries, and livestock include the following:

- Potential competing interests of future irrigation demand and limited summer water availability.
- Benefits to some crops that will thrive in warmer temperatures and increased carbon dioxide concentrations, which could extend growing seasons.
- Expansion of pest and disease ranges, which could lead to decreased agricultural productivity.
- More frequent flooding, which could lead to decreased yields.

Local Government Finance

Insurance premiums could increase in the future due to climate change. In particular, insurance costs for structures and buildings within the flood zone is likely to increase as the risk of damages from flooding will increase due to sea level rise and storm surges (Figure).

Although municipal bonds for Kitsap County and Puget Sound are relatively resilient compared to other urban areas in the U.S., municipal bonds for Kitsap County localities may also be adversely affected in the future, especially if future extreme weather events increase in frequency and intensity. Furthermore, tax revenue



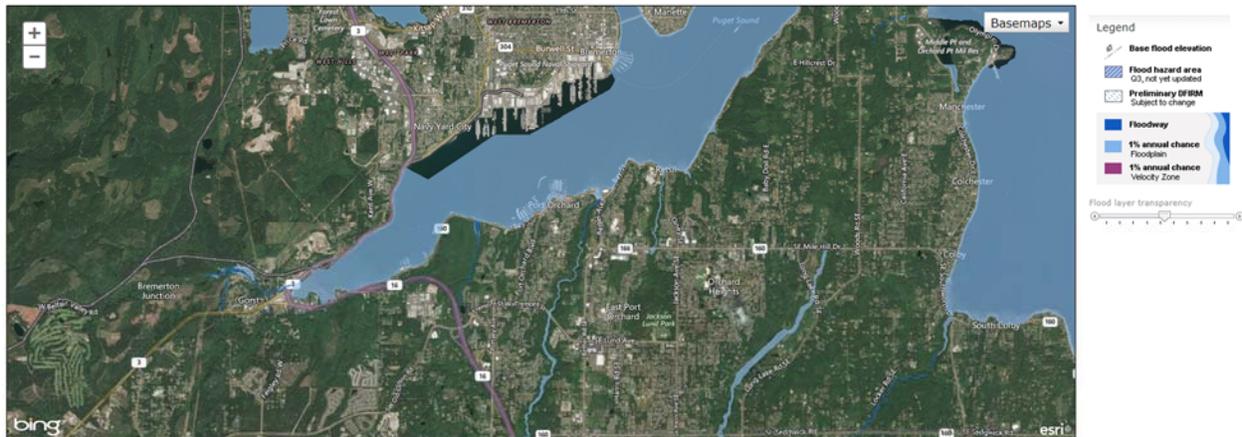
BREMERTON
WASHINGTON

Port
ORCHARD

may be affected from future climate change and regional growth trends, especially if developers and potential residents are deterred from investing in Port Orchard area properties due to perceived climate-related risks.

Figure A-3. FEMA Flood Insurance maps for the 1% annual chance floodplain for Port Orchard.

(Flood insurance rate maps outline flood hazards in a community and includes flood insurance risk zones, 1% and 0.2% annual chance floodplains.)



Geologic and Natural Hazards

There is a range of geologic and natural hazards that will increase due to future climate change. Landslide risk will likely increase due to heavier rain events, soil erosion and destabilization, and sediment transport patterns. There have been 3 LIDAR-defined landslides in Port Orchard, affecting about 0.54 square miles. An estimated 1,031 people, or about 9.4% of Port Orchard's population, live in landslide hazard areas. Additionally, about 11% of Port Orchard's building stock, or 739 structures, and 39 critical facilities are located within the landslide hazard area.⁹¹⁸

Furthermore, there is very high likelihood that coastal flooding from sea level rise and storm surges will increase in frequency and intensity. From FEMA and U.S. Census data, flood damages and insurance claims have totaled \$6.8 million for Port Orchard (dollar year not reported).⁹¹⁹ Future flooding will result in more damages, which will subsequently affect insurance rates and property values.

⁹¹⁸ Kitsap County Department of Emergency Management. 2015.

⁹¹⁹ FEMA. 2015. Risk Report: For Kitsap County, including the Cities of Bremerton, Bainbridge, Port Orchard, Poulsbo, the Port Gamble S'Klallam Indian Reservation, the Suquamish Tribe, and Unincorporated Kitsap County. https://fortress.wa.gov/ecy/gispublic/AppResources/SEA/RiskMAP/Kitsap/Kitsap_Project_Docs/Risk%20Report%20-%20Kitsap%20County%20-%20Final.pdf.

Hydrology and Hydrogeology

Port Orchard is likely to see similar climate impacts to hydrologic and hydrogeologic systems as Kitsap County. Key impacts could include:

- **Groundwater recharge** may be affected by hydrologic changes, including from increasing water temperatures, sea level rise, and declining summer flows.
- **Stream and riverine flooding** will become more frequent, which can have widespread health, infrastructure, and habitat impacts.
- **Regional hydropower production** will decrease in the summer months, which may create a mismatch in energy supply and demand with expected increases in energy demand during the summer due to cooling demands.
- **Summer water availability** may affect irrigation capacity for agriculture.

Habitat

Climate change will affect all types of habitat in Kitsap County. Key climate impacts include:

- **Terrestrial habitats**
 - Some impacts to vegetation distribution and composition, forest growth and productivity and wildfire regimes are expected to change in lower elevation areas in the Puget Sound region.
 - Prevalence of invasive species and pests will increase, altering habitat types and vegetation distribution.
- **Freshwater and aquatic habitats**
 - Regionally, warmer stream temperatures and lower spring and summer flows will affect cold-water fish species across multiple life-cycle stages.
 - Wetland habitats are likely to contract, threatening habitats for a variety of species and shelter for juvenile fish.
 - Climate impacts to aquatic benthic invertebrates, amphibians, and salmonids will have downstream ecosystem and food-web impacts.
- **Marine and coastal habitats**
 - Marine waters around Kitsap County will likely experience increased acidification, more frequent growth of harmful algal blooms (HABs), and more frequent low dissolved oxygen events and dead zones. These changes will have impacts to shellfish populations, reduce benthic invertebrate and crustaceans, and alter marine food webs.
- **Increased prevalence of invasive species and diseases** across all habitat types. Novel and new species and diseases could emerge in the future. Currently known invasive species and diseases known include the following:

○ Invasive tunicates	○ Parrotfeather
○ European green crabs	○ <i>Ichthyophonus hoferi</i>
○ New Zealand mud snail	○ Harmful algae
○ Varnish clams	○ <i>Alexandrium catanella</i>
○ Giant hogweed	○ Mountain pine beetle
○ Tansy ragwort	○ Spruce beetle
○ Purple loosestrife	○ Swiss needle cast
○ Hydrilla	

Fire

Kitsap County's wildland-urban interface (WUI) area has not been linked to future increased wildfire risk. However, warmer and drier conditions coupled with population growth and development will likely increase relative wildfire risk for Kitsap County. WUI expansion increases the risk of wildfires to rapidly spread across the wildland-to-urban landscape, potentially resulting in significant costs and damages to infrastructure and result in the loss of human life.^{920,921} The increased risk is often due to the land use changes associated with increasing population growth and development as well as higher probability of fires spreading across a landscape due to the additional fuel loads from residences.^{922,923} Although there has been no scientific studies in the Puget Sound area on WUI expansion and fire risk, regional and national trends are suggesting that there is an association between WUI growth and fire risk due to compounding impacts of climate change, development, and individual residents' choices.^{924,925} For example, **parts of Port Orchard has been defined as "at-risk" areas because it is considered to be part of the WUI, as defined by the Healthy Forest Restoration Act.**^{926,927} Expanding development and WUI areas are partially correlated to increasing fire suppression and response costs, suggesting that Kitsap County and its municipalities may carry additional cost burden of firefighting in the future.^{928,929}

Kitsap County already has a robust capacity to respond to fires. Kitsap County has multiple fire districts and staffed firefighters based out of 29 fire stations and multiple other volunteer firefighting units that covers most County area.⁹³⁰ South Kitsap Fire and Rescue provides services to the Port Orchard area.

⁹²⁰ Bar Massada *et al.* 2009. Wildfire risk in the wildland-urban interface: A simulation study in northwestern Wisconsin. *Forest Ecology and Management*. 258: 1990-1999.

⁹²¹ Bar Massada *et al.* 2014.

⁹²² Bar Massada *et al.* 2014.

⁹²³ Warziniack *et al.* 2019. Responding to Risky Neighbors: Testing for Spatial Spillover Effects for Defensible Space in a Fire-Prone WUI Community. *Environmental and Resource Economics*. 73: 1023-1047. Doi:10.1007/s10640-018-0286-0.

⁹²⁴ Liu *et al.* 2015. Climate change and wildfire risk in an expanding wildland-urban interface: a case study from the Colorado Front Range Corridor. *Landscape Ecology*. 30(10): 1943-1957. Doi: 10.1007/s10980-015-0222-4.

⁹²⁵ Morgan *et al.* 2019.

⁹²⁶ Silvis Lab. Wildland-urban interface (WUI) change 1990-2010. University of Wisconsin-Madison. Accessed 9 January 2020. <http://silvis.forest.wisc.edu/data/wui-change/>.

⁹²⁷ Bainbridge Island Fire Department. 2010.

⁹²⁸ Bainbridge Island Fire Department. 2010.

⁹²⁹ Gude *et al.* 2013. Evidence for the effect of homes on wildfire suppression costs. *International Journal of Wildland Fire*. 22: 537-548. <https://doi.org/10.1071/WF11095>.

⁹³⁰ Kitsap County Department of Information Services. Kitsap County Fire Districts and Stations. Geographic Information System (GIS) Division, Kitsap County Department of Information Services. www.kitsapgov.com/dis/Documents/fire_districts_stations.pdf.

