

Goal 5 Plan and act toward zero waste in the region.

Low Consequence Risks

68. Raises the risk of coastal inundation, which could damage public- and private-sector infrastructure (homes, businesses, roads, etc.) and create waste that cannot be reused or recycled

| | |
|----------------|--------------------|
| Stressor | Sea-level Rise |
| Consequence | Low |
| Likelihood | Medium |
| Spatial Extent | Place |
| Horizon | More than 30 years |
| Confidence | Medium |

69. Raises the risk of floods and landslides, which could damage public- and private-sector infrastructure (homes, businesses, roads, etc.) and create waste that cannot be reused or recycled

| | |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| Stressor | Increasing Storminess |
| Consequence | Low Debris management from hazard events are costly, however they should not have a long term impact on achieving waste reduction goals. |
| Likelihood | Medium |
| Spatial Extent | Site |
| Horizon | More than 30 years |
| Confidence | Medium |

71. Increases solid waste volume

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|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stressor | Population Change |
| Consequence | Low Population growth will generate additional waste, however the rate of growth from additional climate change induced migration is unknown. The same waste reduction strategies should apply to all. |
| Likelihood | Low |
| Spatial Extent | Extensive |
| Horizon | More than 30 years |
| Confidence | Low |

72. Increases summer use of parks, which could raise waste volume and disposal costs

| | |
|----------------|--------------------------------------------------------------------------------------------------------------------|
| Stressor | Warmer Summer |
| Consequence | Low Existing waste disposal is not a major concern as is vandalism and theft of public park facilities. |
| Likelihood | Low There is no evidence to suggest climate change will alter people's behavior of disposing of waste at parks. |
| Spatial Extent | Site |
| Horizon | More than 30 years |
| Confidence | Low |

Goal 5 Plan and act toward zero waste in the region.

Low Consequence Risks

73. Increases winter use of parks, which could raise waste volume and disposal costs

Stressor **Warmer Winter**

Consequence **Low**

Seasonal park variation will unlikely impact maintenance and disposal costs

Likelihood **Low**

Spatial Extent **Extensive**

Horizon **More than 30 years**

Confidence **Low**

74. Raises the risk of wildfires, which could damage public- and private-sector infrastructure (homes, businesses, roads, etc.) and create waste that cannot be reused or recycled

Stressor **Increasing Drought**

Consequence **Low**

Likelihood **Low**

Spatial Extent **Site**

Horizon **More than 30 years**

Confidence **Medium**

Goal 6 Ensure that residents have the resources to meet their daily needs.

High Consequence Risks

75. Raises the risk of coastal inundation, which could damage public- and private-sector infrastructure (homes, businesses, roads, etc.)

Stressor Sea-level Rise

Consequence High

As sea-level rise predictions are high enough to inundate much of downtown Olympia by the end of the century, including the port and LOTT wastewater treatment, this risk has a very high consequence of affecting our ability to provide basic needs to residents within the project area.

Likelihood High

The below predictions by the City of Olympia shows the possible extent of affected areas, and for these reasons, there is a high likelihood this risk will occur and affect our region:

- With 1 foot of sea-level rise, Olympia could expect nuisance flooding 30 times annually, affecting approximately 261 structures and inundating up to 163 acres;
- With 2 feet of sea-level rise, Olympia could expect nuisance flooding 160 times annually; affecting approximately 328 structures and inundating up to 252 acres;
- With 4 feet of sea-level rise, Olympia could expect nuisance flooding 440 times annually or during more than half of its high-tide events, affecting approximately 402 structures and inundating up to 368 acres.

Spatial Extent Place

Coastal and near coastal areas will be affected throughout the project area.

Horizon More than 30 years

Confidence High

76. Raises the risk of coastal inundation, which could cut off key routes that provide residents access to vital goods and services

Stressor Sea-level Rise

Consequence High

As sea-level rise predictions are high enough to inundate much of downtown Olympia by the end of the century, including the port and LOTT wastewater treatment, this risk has a very high consequence of affecting our ability to provide basic needs to residents within the project area.

Likelihood High

All models predicts with fairly high certainty that we will experience significant sea-level rise by the end of the century, and there is a high amount of critical infrastructure that lies within the sea-level rise zone.

Spatial Extent Place

This will be limited to low-lying coastal areas, and potentially freshwater areas as coastlines move inland.

Horizon More than 30 years

Confidence High

Goal 6 Ensure that residents have the resources to meet their daily needs.

High Consequence Risks

77. Increases demand for water (drinking, irrigation, etc.)

Stressor Population Change

Consequence High

If population change is extreme enough to stress our water demand and distribution network, then it could have intense consequences for the region and basic needs of our residents.

Likelihood Low

As we are comparatively 'water rich' in this region, we could be a destination for climate refugees. However, it is unknown to what extent population change and migration will be due to climate change, and even more so, unsure how that will affect water resources.

Spatial Extent Extensive

This could affect all residents within the project area.

Horizon More than 30 years

Confidence Medium

This is a new area of study, so I am not very confident in our being able to predict how population change will affect our region, as it's difficult to take into account how we will change development and infrastructure over time to accommodate higher population density.

Medium Consequence Risks

78. Introduces or exacerbates disease vectors (carriers), which could harm human health (warmer, wetter winters also exacerbate exposure to pathogens and other health threats)

Stressor Warmer Summer

Consequence Medium

Warmer summers have the potential to foster the growth of many diseases that could have an extreme adverse effect on human health and vitality, as well as the health and vitality of our food sources.

Likelihood High

Climate change is projected to exacerbate or introduce a wide range of health threats, including infectious diseases from exposure to viruses and bacteria, which would affect human health outcomes in Thurston County and the broader Puget Sound region. Exposure pathways include food, water, air, soil, trees, insects and animals. Specific types of harmful algae, cyanobacteria, enteric bacteria & protozoan parasites, viruses, fungi, and bacteria all have the potential to increase in extent and frequency with warmer summers. (Source: TRPC, adapted from table in USGCRP, 2016)

Spatial Extent Extensive

This risk has the potential to affect the entire project area and greater region.

Horizon More than 30 years

Confidence Medium

Goal 6 Ensure that residents have the resources to meet their daily needs.

Medium Consequence Risks

79. Threatens the survival of salmon, which support cultural and economic practices and ecosystem services

Stressor Warmer Water

Consequence Medium

While it is very likely this risk will occur and salmon species will be very affected, there is medium confidence this will affect the health and vitality of residents in the project area. Some are sure to be affected, however it will not likely lead to mass loss of health and economic resources.

Likelihood High

The average annual temperature of most streams within the project area is projected to rise roughly 5°F for the 2040s and 2080s [Figures 29 & 30, on pgs. 41-42] per a moderate emissions scenario, according to U.S. Forest Service modeling. Theoretically, suitable conditions for salmonids and other aquatic species would shift upstream to higher elevations as air and water temperatures warm. Some fish may even shift their migration timing earlier as stream temperature and volume conditions change. This will likely have a larger effect on the ecosystem, as well as those who rely on salmon for subsistence living and economic vitality. Additionally, as stated above, this will have a great affect on the ecosystems.

Spatial Extent Extensive

This effects of this will be observed throughout the entire project area and greater region.

Horizon 10-30 years

Confidence High

80. Reduces aquifer recharge and could spur more groundwater pumping when surface water is scarce, which could lower well levels and raise the cost of pumping water from greater depths

Stressor Increasing Drought

Consequence Medium

Water availability, being on the most basic needs of residents in the area, is directly threatened by increasing drought. A future with warmer, drier summers could spur growing communities around the state to increase their groundwater withdrawals when surface water is limited (Pitz, 2016). This could exacerbate water quantity and affordability vulnerabilities.

Likelihood High

This will primarily effect those residents that rely on wells and groundwater recharge. Studies conducted in Everett, Tacoma and Seattle and noted in UW CIG's 2015 assessment find that the reliability of municipal water supplies — that is, the probability of meeting demand in a given year — is largely unaffected by projected changes precipitation (Mauger et al., 2015). The report did not reference any Thurston County communities, although we can infer similar results.

Spatial Extent Place

This is taking place in subsections of our project area.

Horizon 10-30 years

Confidence Medium

Goal 6 Ensure that residents have the resources to meet their daily needs.

Medium Consequence Risks

81. Makes it harder to balance competing demands for water (reduces energy, water and food security)

Stressor Increasing Drought

Consequence **Medium**

Drought would affect surface water (streams and reservoirs) and groundwater (large municipal and small private wells), ultimately affecting peoples' ability to meet their daily need of having clean water.

Likelihood **High**

Models project a more than 20 percent decline in summer precipitation by the 2050s and 2080s for the Puget Sound region, per the high and low scenarios. Changes in temperature are also expected to exacerbate periodic El Nino and La Nina cycles and the intensity of seasonal rainfall and drought events.

Spatial Extent **Extensive**

This will affect the entire project area, however, there will likely be larger adverse effects in the Nisqually watershed, where it is mixed snow-rain dominant.

Horizon **0-10 years**

Confidence **Medium**

82. Raises the risk of wildfires and elevated levels of PM10 from smoke

Stressor Increasing Drought

Consequence **Medium**

Increases in PM10 and other windblown dust particles due to wildfire could degrade air and water quality, directly impeding our ability to provide all residents with a healthy environment.

Likelihood **High**

The historical frequency of local wildfires suggests that such hazards have a "high" probability of occurrence, but about 97 percent of future fires will be small — five acres or less — concluded the Natural Hazards Mitigation Plan for the Thurston Region. The plan did not factor in climate change but cautioned that it may create more suitable conditions (e.g., warmer, drier summers) for bigger, more frequent wildfires.

Spatial Extent **Extensive**

Forests cover much of the project area and broader county. Wildfires occur in all parts of the project area and county — particularly the wildland-urban interface.

Horizon **More than 30 years**

Confidence **High**

83. Makes it harder for calcifying organisms to form shells, and ultimately harms commercial and recreational shellfisheries

Stressor Ocean Acidification

Consequence **Medium**

Ocean acidification is projected to increase the frequency, magnitude and duration of harmful pH conditions throughout Puget Sound (Mauger et al, 2016). This could have medium to high consequence for a specific population of people and their ability to meet their daily needs.

Likelihood **High**

This has a medium likelihood because lower ocean pH will affect development of shell forming organisms. This will have a significant effect on commercial and recreational shellfisheries.

Spatial Extent **Place**

Coastal and near coastal areas will be affected throughout the project area.

Horizon **10-30 years**

Confidence **High**

Goal 6 Ensure that residents have the resources to meet their daily needs.

Medium Consequence Risks

84. Raises the risk of floods and landslides, which could cut off access to goods and services

Stressor Increasing Storminess

Consequence **Medium**

There are many smaller, rural communities in Thurston county that are more intensely affected and cut off by floods and landslides. Additionally, within the urban centers, floods and landslides can shut down roads and access routes for fire and emergency services.

Likelihood **Medium**

There are already instances within the county where floods or landslides temporarily cut off residents' abilities to meet their daily needs. This would likely become worse with increased storminess. More than 65,000 acres and \$1.5 billion in buildings and contents are currently within Thurston County's flood hazard areas (TRPC, 2009).

Spatial Extent **Place**

Horizon **0-10 years**

Confidence **Medium**

85. Shifts life cycle of fish, fowl and animals, which could reduce populations that support subsistence and recreational hunting

Stressor **Warmer Winter**

Consequence **Medium**

The native tribes, as well as many locals, use fishing and hunting as a food source. If these wildlife populations are stressed by a change in the reproductive cycles within the food web due to warmer winters, people may not be able to rely on those food sources, and it may further stress local food distribution networks and potentially drive up prices.

Likelihood **Medium**

There is not a scientific consensus on how this will pan out, however, assuming this does happen, there is a medium likelihood that having fewer resources to fish and hunt would adversely affect the ability for people and families to meet their daily needs.

Spatial Extent **Extensive**

Warmer winters have the potential to affect reproductive cycles of wildlife across the region, and across different ecosystems.

Horizon **10-30 years**

Confidence **Low**

I was unable to find any scientific consensus to back this up.

86. Raises the risk of floods and landslides, which could damage homes and businesses and cause personal injury or death

Stressor **Increasing Storminess**

Consequence **Medium**

While the effects would be more localized than landslides and floods cutting off goods and services, this has the potential to be extremely detrimental to residents living in the areas that may not be maintainable in the future due to floods and landslides. Culverts, flood control systems, and bridges can be built, but they can only do so much. This could be mitigated by some sort of relocation program if residents actually get cut off, however, that is yet to be determined.

Likelihood **Medium**

It is fairly like this will happen at some location within the project area. How likely it is to affect this goal depends on how the community responds to the need to build flood and landslide controls, and/or work on a relocation effort if residents and communities look like they are going to be cut off permanently. More than 65,000 acres and \$1.5 billion in buildings and contents are currently within Thurston County's flood hazard areas (TRPC, 2009).

Spatial Extent **Place**

While it will most likely be just specific sites, there is the potential larger communities or subdivisions will be affected.

Horizon **10-30 years**

Confidence **Medium**

Goal 6 Ensure that residents have the resources to meet their daily needs.

Medium Consequence Risks

87. Puts more strain on services (social, emergency, etc.)

Stressor Increasing Storminess

Consequence **Medium**

If increased storminess leads to increased stress on emergency services, those services will not be as able to provide relief to those in need, which has a large consequence for making sure residents have their daily needs met.

Likelihood **Medium**

At the rate we are seeing increases in storminess, emergency services will likely be able to adapt and work to be more nimble in a changing environment.

Spatial Extent **Extensive**

This has the potential to be a region-wide issue.

Horizon **10-30 years**

Confidence **Medium**

88. Puts more strain on transportation (roads, transit, etc.)

Stressor **Population Change**

Consequence **Medium**

The potential consequence from increased population on our transportation network is high, being that a functional transportation network is essential for meeting the basic needs of our community.

Likelihood **Low**

The timeline at which population increase is happening will likely give transportation agencies and planners time to plan for increased population. This is a new field of scientific study, so there is not much research to determine when and how intense population change due to climate change may be in our area.

Spatial Extent **Extensive**

This could have region wide impacts

Horizon **More than 30 years**

Confidence **Low**

89. Puts more strain on schools (e.g., unplanned influx or loss of students)

Stressor **Population Change**

Consequence **Medium**

The potential consequence from increased population on schools is high, being that access to quality education is a cornerstone of a healthy community.

Likelihood **Low**

The timeline at which population increase is happening will likely give school districts time to plan for increased student enrollment. This is a new field of scientific study, so there is not much research to determine when and how intense population change due to climate change may be in our area.

Spatial Extent **Extensive**

People throughout the entire project area could be affected.

Horizon **More than 30 years**

Confidence **Low**

This is a new area of study, so I am not very confident in our being able to predict how population change will affect our region, as it's difficult to take into account how we will change development and infrastructure over time to accommodate higher population density.

Goal 6 Ensure that residents have the resources to meet their daily needs.

Medium Consequence Risks

90. Puts more strain on services (social, emergency, etc.)

Stressor Population Change

Consequence **Medium**

The potential consequence from increased population on services is high, being that access to quality social and emergency services are part of having a healthy and vibrant community.

Likelihood **Low**

The timeline at which population increase is happening will likely give social and emergency service providers time to plan for increased population. This is a new field of scientific study, so there is not much research to determine when and how intense population change due to climate change may be in our area.

Spatial Extent **Extensive**

This could affect all residents within the project area.

Horizon **More than 30 years**

Confidence **Low**

This is a new area of study, so I am not very confident in our being able to predict how population change will affect our region, as it's difficult to take into account how we will change development, services, and infrastructure over time to accommodate higher population density.

91. Increases summer peak energy demand for cooling residential and commercial buildings, which could place more demand on grid and reduce energy security

Stressor **Warmer Summer**

Consequence **Medium**

Increases in peak energy could potentially hinder our ability to ensure residents meet their daily needs. However, given the many different types of energy production in the region, we will likely be able to shift the balance of production to accommodate needs.

Likelihood **Low**

PSE's 2015 Integrated Resource Plan — which uses scenarios to evaluate energy supply and demand decisions over the ensuing 20 years — projects that PSE's base peak demand growth rate will average 1.6 percent annually (almost 1,000 additional megawatts, from 2015-2035) (Puget Sound Energy, 2015). The resource plan does not call for additional hydropower generation capacity.

Rather, the plan targets significant investments in energy efficiency, wind power generation and other measures to meet projected demand. This could mean higher reliance on fossil fuels, which may affect the consequence of other risks.

Spatial Extent **Extensive**

Accommodating peak energy demand is a region-wide issue.

Horizon **0-10 years**

Confidence **High**

Goal 6 Ensure that residents have the resources to meet their daily needs.

Low Consequence Risks

92. Increases extreme temperatures, which could cause hyperthermia — a major risk for people who are elderly, homeless or work outdoors

Stressor Warmer Summer

Consequence Low

As of now we have more mild temperature extremes than other parts of the region. However we are seeing trends that support hotter, more extreme summers, which has the potential to increase chances of hyperthermia and threaten the basic needs of those most vulnerable in our region: homeless, elderly, children, and outdoor workers.

Likelihood High

Populations especially vulnerable to extreme heat and other exposure pathways include people who work outdoors, people who are homeless, people with chronic disease (e.g., diabetes, asthma, obesity), people with mental illness, and people who are socially isolated and economically disadvantaged (Thurston County, 2010). If extreme summer temperatures continue to increase, these populations will be severely inhibited from meeting their daily needs.

Spatial Extent Place

While spatially, this may occur throughout the project area, it is likely to affect certain people disparately, such as the homeless or the elderly. For that reason, it's likely focused on hospitals, elderly care centers, urban centers, and other congregation places for these populations.

Horizon 0-10 years

Confidence Medium

93. Reduces snowpack that supports winter recreation activities

Stressor Warmer Winter

Consequence Low

Reduced snowpack could stop winter ski/snowboard resorts, and other winter resorts from operating throughout the winter, potentially forcing them to close. While closing some recreation areas may be problematic for individuals, the region as a whole will likely not feel a great effect from winter recreational activities and resorts closing.

Likelihood High

It is likely a reduced snowpack would severely lessen opportunities for winter recreation.

Spatial Extent Site

It would affect only certain sites in the region, such as winter recreational areas and ski/snowboard resorts.

Horizon 10-30 years

Confidence High

94. Raises the risk of wildfires, which could damage utility infrastructure

Stressor Increasing Drought

Consequence Low

Wildfires damaging utility infrastructure could directly impede our ability to accomplish the goal of residents meeting their daily needs and having resources at their disposal.

Likelihood Medium

The historical frequency of local wildfires suggests that such hazards have a “high” probability of occurrence, but about 97 percent of future fires will be small — five acres or less — concluded the Natural Hazards Mitigation Plan for the Thurston Region. The plan did not factor in climate change but cautioned that it may create more suitable conditions (e.g., warmer, drier summers) for bigger, more frequent wildfires. Higher frequency of wildfires, with potentially more and larger fires during the season, could inhibit the ability of utility companies to repair their infrastructure, resulting in longer downtimes for affected residents.

Spatial Extent Place

Forests cover much of the project area and broader county. Wildfires occur in all parts of the project area and county — particularly the wildland-urban interface.

Horizon More than 30 years

Confidence Medium

Goal 6 Ensure that residents have the resources to meet their daily needs.

Low Consequence Risks

95. Raises the risk of wildfires, which could close roads and cut off access to vital goods and services

Stressor Increasing Drought

Consequence Low

While wildfires have their own risk associated directly with them, the cutting off of resources directly inhibits accomplishing this goal, however, any 'cut off' from resources due to wildfire would likely be temporary.

Likelihood Medium

The historical frequency of local wildfires suggests that such hazards have a "high" probability of occurrence, but about 97 percent of future fires will be small — five acres or less — concluded the Natural Hazards Mitigation Plan for the Thurston Region. The plan did not factor in climate change but cautioned that it may create more suitable conditions (e.g., warmer, drier summers) for bigger, more frequent wildfires.

Spatial Extent Extensive

Forests cover much of the project area and broader county. Wildfires occur in all parts of the project area and county — particularly the wildland-urban interface.

Horizon 0-10 years

Confidence Medium

96. Parches farm fields and other open spaces, which could erode and release windblown dust (e.g., PM10) that degrades air quality

Stressor Increasing Drought

Consequence Low

Drought would affect ability to irrigate fields, both leading to decreases in crop yield, and increases in PM10 and other windblown dust particles which could degrade air quality, directly impeding our ability to provide all residents with a healthy environment.

Likelihood Medium

Spatial Extent Place

Horizon More than 30 years

Confidence Medium

97. Raises home cooling costs (e.g., buying, installing, and using air-conditioning), leaving less money to meet basic needs

Stressor Warmer Summer

Consequence Low

We have relatively low cost of electricity in the region, however for financially stressed families, any amount of increase in expenses could be problematic for fulfilling core needs.

Likelihood Medium

It is somewhat likely that utility costs will go up as the climate becomes more extreme, and there is a medium likelihood that the rise in utility costs will stress families to the extent that they cannot meet their basic needs. The more likely scenario is that this, combined with other costs associated with a changing climate, could affect a families' ability to meet their basic needs.

Spatial Extent Extensive

PSE serves 1.1 million customers across the region, and serves most customers within the project area.

Horizon 10-30 years

Confidence Medium

It's variable as to how sharply PSE's rates will increase, as it is a private company.

Goal 6 Ensure that residents have the resources to meet their daily needs.

Low Consequence Risks

98. Increases frequency, depth and duration of inundation of low coastal areas (e.g., downtown Olympia), which could reduce shoreline recreation opportunities

Stressor Sea-level Rise

Consequence **Low**

Shoreline recreation opportunities has little to do with meeting the daily needs of the community. Perhaps a small amount of people who are reliant on shoreline recreation for income / business will be affected, however, shorelines will still be there, they just may change. For that reason, I believe this risk has low consequence.

Likelihood **Low**

It is fairly likely that due to predicted sea-level rise, some shoreline recreational activities will be displaced.

Spatial Extent **Place**

This would only affect coastal areas.

Horizon **More than 30 years**

Confidence **Low**

99. Raises the risk of wildfires, which could result in personal injury or death

Stressor Increasing Drought

Consequence **Low**

Likelihood **Low**

Spatial Extent **Place**

Horizon **More than 30 years**

Confidence **Low**

100. Puts more strain on energy grid

Stressor Population Change

Consequence **Low**

We have a robust energy supply network, with many diverse sources of energy.

Likelihood **Low**

Because of the diversity of our energy sources, it is unlikely that population change over the course of decades will affect our ability to provide electricity to residents in the project area / region.

Spatial Extent **Extensive**

The entire project area / region would be affected.

Horizon **More than 30 years**

Confidence **Low**

Goal 7 Support local food systems to increase community resilience, health, and economic prosperity.

High Consequence Risks

101. Makes it harder to balance competing demands for water (reduces water available to junior water right holders, threatening the survival of livestock and crops for newer farmers)

Stressor Increasing Drought

Consequence High

Water could be limiting factor for new farms as groundwater extraction is more closely regulated

Likelihood High

Spatial Extent Extensive

Most of Thurston County's watersheds are likely over-appropriated.

Horizon 0-10 years

Confidence High

Recent court cases are driving an increasing scrutiny of water rights

102. Threatens the survival of salmon, which support cultural and economic practices and ecosystem services

Stressor Warmer Water

Consequence High

Salmonid species are very sensitive to temperature and are limited in how much they can shift migration patterns to adjust for changing habitat.

Likelihood High

Spatial Extent Extensive

Horizon 0-10 years

Confidence High

Rising temperatures and effect on salmonids have been studied extensively.

103. Makes it harder for calcifying organisms to form shells, and ultimately harms commercial and recreational fisheries

Stressor Ocean Acidification

Consequence High

Could undermine Washington's natural and commercial shellfisheries

Likelihood High

Spatial Extent Extensive

All marine areas

Horizon 0-10 years

Confidence High

Shellfish growers are already seeing impacts

Goal 7 Support local food systems to increase community resilience, health, and economic prosperity.

High Consequence Risks

104. Reduces food available for and survival of salmon and other marine life

Stressor Ocean Acidification

Consequence High

Would undermine survival of natural and commercial salmonids

Likelihood Medium

Spatial Extent Extensive

Would affect salmon populations throughout Puget Sound

Horizon 10-30 years

Confidence Low

Although acidification is happening, its direct effect on the food chain, as well as timing, is uncertain.

Medium Consequence Risks

105. Raises the risk of lower crop yield or failure

Stressor Increasing Drought

Consequence Medium

Farmers could shift to other less water-intensive crops

Likelihood Medium

Spatial Extent Extensive

Will affect all farmed areas of Thurston County

Horizon 10-30 years

Confidence Medium

Studies show projected declines related to lower irrigation levels

106. Increases range and survival of pests and diseases that affect crops

Stressor Warmer Winter

Consequence Medium

Depends on type of disease and whether alternative, resistant crops are available

Likelihood Medium

Spatial Extent Extensive

Effects are likely to be regional

Horizon 0-10 years

Confidence High

Expansion of range of some pests have already been observed.

Goal 7 Support local food systems to increase community resilience, health, and economic prosperity.

Medium Consequence Risks

107. Accelerates risk of food spoilage and increases need for better refrigeration, storage and distribution infrastructure

| | |
|----------------|---------------------------------------------------------------|
| Stressor | Warmer Summer |
| Consequence | Medium |
| Likelihood | Medium |
| Spatial Extent | Extensive Affects general infrastructure throughout region |
| Horizon | 10-30 years |
| Confidence | Low Sources are mostly theoretical/anecdotal |

Low Consequence Risks

108. Increases risk of flooding that could damage agricultural lands and assets (crops and livestock)

| | |
|----------------|--------------------------------------------------------------------------------------------------------------------------|
| Stressor | Increasing Storminess |
| Consequence | Low This is likely a manageable agricultural concern. |
| Likelihood | High |
| Spatial Extent | Place Farmland in floodplains — Nisqually Delta, along Deschutes River, etc. |
| Horizon | 0-10 years |
| Confidence | Medium Although the likelihood of flooding is high, it is not known how many assets may be at risk in the floodplain. |

109. Pushes saltwater farther into estuaries, which may inundate near-coastal farms and ranches

| | |
|----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stressor | Sea-level Rise |
| Consequence | Low Could use more information on how many acres of farmland falls into SLR projections; how much of that compares with county-wide acres of farmland? |
| Likelihood | High |
| Spatial Extent | Site Will affect only the limited number of farms affected by SLR — such as on Eld Inlet |
| Horizon | More than 30 years |
| Confidence | Medium Based on FEMA flood maps and IPCC projections of SLR, but timing of SLR and compounding role of subsidence introduces some uncertainty |

Goal 7 Support local food systems to increase community resilience, health, and economic prosperity.

Low Consequence Risks

110. Increases heat stress risk for dairy cows and other large livestock

Stressor **Warmer Summer**

Consequence **Low**

Likelihood **Medium**

Spatial Extent **Place**

Horizon **10-30 years**

Confidence **Medium**

111. Increases in atmospheric CO2 decreases the nutritional quality of forage and pasture lands for livestock and wild animals

Stressor **Warmer Summer**

Consequence **Low**

This is likely a manageable agricultural concern, if nitrogen levels are increased to match increasing yields

Likelihood **Medium**

Spatial Extent **Extensive**

This will likely affect all watersheds in the planning area and county

Horizon **More than 30 years**

Confidence **Medium**

Based on experiments, rather than in-field demonstration

112. Turns coastal marshes and forests into mudflats that alters nesting habitat

Stressor **Sea-level Rise**

Consequence **Low**

Animals may be able to shift to other available habitat

Likelihood **Medium**

Spatial Extent **Place**

Nisqually Delta and other shoreline areas

Horizon **More than 30 years**

Confidence **Medium**

Based on modeled changes

113. Increases pressure to develop rural areas, which could reduce, fragment and/or degrade agricultural lands

Stressor **Population Change**

Consequence **Low**

Existing regulations will limit extent of development in rural areas

Likelihood **Low**

Spatial Extent **Extensive**

Horizon **More than 30 years**

Confidence **Low**

Limited concrete data on how climate change will affect population shifts

Goal 8 Ensure that the region's water supply sustains people in perpetuity while protecting the environment.

High Consequence Risks

114. Makes coastal groundwater more vulnerable to saltwater intrusion and inundation

Stressor Sea-level Rise

Consequence **High**
Saltwater intrusion makes well water undrinkable.

Likelihood **High**
High likelihood for shallow, coastal wells.

Spatial Extent **Place**
Limited to coastal areas

Horizon **10-30 years**

Confidence **High**

115. Makes it harder to balance competing demands for water (all uses)

Stressor Increasing Drought

Consequence **High**
An adequate supply of water is critical to the survival of Thurston County residents, business and industry, and flora and fauna.

Likelihood **High**
The effects of warmer summers and drought on stream flow and temperature are already being observed. The Deschutes River, Henderson Inlet, Totten/Eld Inlets, and Upper Chehalis River violate water temperature standards. [Vulnerability Assessment pg. 43]

Spatial Extent **Extensive**
All of Thurston County

Horizon **10-30 years**

Confidence **Medium**
Our region is already experiencing warmer summers (Climate Change Science Summary pg. 12) and stream temperature violations have been observed [Vulnerability Assessment pg. 38].

116. Decreases precipitation volume and groundwater recharge, which could raise pollutant concentrations in shallow wells and surface waters

Stressor Increasing Drought

Consequence **High**
Increased concentration of pollutants to undrinkable levels reduces the quantity of water available for households, agriculture, and other uses.

Likelihood **Medium**
Thurston County residents rely on a mix of private wells and municipal water systems for drinking water. Concentrated contaminants is not considered a risk for municipal systems, most of which rely on deep well, but could be a concern for private water systems. (Vulnerability Assessment pg. 51)

Spatial Extent **Extensive**
Countywide

Horizon **10-30 years**

Confidence **Low**
U.S. Global Climate Change Research Program reports that there are few studies looking into the specific health consequences arising from contamination and depletion of groundwater (USGCRP, 2016 pg. 108)

Goal 8 Ensure that the region's water supply sustains people in perpetuity while protecting the environment.

High Consequence Risks

117. Makes it harder to balance competing demands for water (all uses)

Stressor Population Change

Consequence High

Increased population growth in Thurston will have a significant impact on groundwater, the source of most of Thurston County's drinking water.

Likelihood Low

Thurston County's population is expected to increase by over 40%; migration due to climate change could increase that number and the amount of drinking water needed to support the County's residents.

Spatial Extent Extensive

Countywide

Horizon 10-30 years

Confidence High

Medium Consequence Risks

118. Increases plant transpiration (root uptake and leaf release of water) during winter months, which could lower water table.

Stressor Warmer Winter

Consequence Medium

Lower water table could affect the ability for water consumers (households, farms, etc.) to pump water from wells. Lower water table would also affect stream levels.

Likelihood Low

Spatial Extent Extensive

Countywide

Horizon More than 30 years

Confidence Low

Unknown how much of an effect warmer winters will have on evapotranspiration and the water table. The effect could be counteracted by increasing drought which could stress vegetation and reduce transpiration.

Low Consequence Risks

119. Increases volume of urban runoff and flooding, which decrease groundwater recharge

Stressor Increasing Storminess

Consequence Low

Lower water table could affect the ability for water consumers (households, farms, etc.) to pump water from wells. Lower water table would also affect stream levels.

Likelihood Low

Increased runoff due to more intense storms is expected however the impacts on groundwater are less certain.

Spatial Extent Extensive

Countywide

Horizon 10-30 years

Confidence Low

Goal 9 Move toward a carbon-neutral community.

Medium Consequence Risks

120. Increases summer peak energy demand for cooling residential and commercial buildings, which — depending on the energy source — may increase carbon emissions

Stressor Warmer Summer

Consequence Medium

To achieve carbon neutrality, the region would need to zero-out its greenhouse gas emissions (e.g., via carbon offsets, carbon-free renewables, or energy conservation and efficiency measures) across several sectors (buildings, transportation, waste, water, etc.). Any emissions increase from buildings would make achieving this goal more difficult.

Likelihood Medium

According to one study, residential cooling demand is projected to increase to 4.8-9.1 percent of Washington's total energy demand for the 2080s, relative to 1970-1999, due to the combined effects of higher air temperature, population growth, and greater use of air conditioners. The likelihood that this would increase the region's carbon footprint, however, depends on our energy sources. Washington state's Renewable Portfolio Standard (RCW 19.285) requires large utilities to obtain 15 percent of their electricity from new renewable resources (e.g., carbon-free solar and wind) by 2020 and to undertake cost-effective energy conservation measures. Currently, hydropower accounts for 36 percent of the electricity PSE delivers to its customers; coal and natural gas account for 35 percent and 24 percent, respectively, while nuclear wind and other sources account for the rest of the utility's energy portfolio.

Spatial Extent Extensive

Horizon 0-10 years

Confidence Medium

121. Increases overall energy consumption (transportation, buildings, waste, etc.)

Stressor Population Change

Consequence Medium

Assuming more people move here and use more energy that is generated from fossil fuels, this risk would affect the region's ability to achieve this goal. Investments in renewable energy, as well as energy conservation and efficiency would impact the consequence of this risk.

Likelihood Low

It is impossible to predict how many people might move to, within or from Thurston County — or when — as a result of climate change. Further, it is impossible to predict how long climate migrants will stay here and how much energy they will consume. While not impossible, it is difficult to predict what energy sources the region will use in coming decades. Thus, the likelihood of this risk is low.

Spatial Extent Extensive

Horizon Unclear

Confidence Medium

Goal 9 Move toward a carbon-neutral community.

Low Consequence Risks

122. Raises the risk of wildfires, which could destroy forests that serve as a net carbon sink

Stressor Increasing Drought

Consequence Low

More frequent and intense wildfires would damage forests and release their stored carbon. This would be but one source of emissions, however, so this risk is of "medium" consequence to this goal of carbon neutrality.

Likelihood High

The historical frequency of local wildfires suggests that such hazards have a "high" probability of occurrence, but about 97 percent of future fires will be small — five acres or less — concluded the Natural Hazards Mitigation Plan for the Thurston Region. The plan did not factor in climate change but cautioned that it may create more suitable conditions (e.g., warmer, drier summers) for bigger, more frequent wildfires.

Spatial Extent Extensive

Forests cover much of the project area and broader county. Wildfires occur in all parts of the project area and county — particularly the wildland-urban interface.

Horizon 0-10 years

Confidence Medium

123. Causes erosion and loss of organic materials (e.g., plants) that build up in reservoirs (e.g., Alder Lake), decay and emit greenhouse gases (e.g., methane)

Stressor Increasing Storminess

Consequence Low

There are few reservoirs in Thurston County (Alder Lake, LaGrande Reservoir and Skookumchuck Lake), so this risk would be of "medium" consequence to the region's ability to achieve its carbon-neutrality goal.

Likelihood High

A new study in the journal BioScience finds that reservoirs emit more methane than natural lakes, ponds, rivers, or wetlands. Microbes break down organic materials — sometimes doing so in the absence of oxygen — a process that leads to methane as a byproduct.

Spatial Extent Place

Within the project area: LaGrande and Alder Lake reservoirs; outside the project area: Skookumchuck Lake

Horizon 0-10 years

Confidence Low

We are unaware of any studies that assess this risk locally.

124. Accelerates release of carbon stored in soils

Stressor Warmer Summer

Consequence Low

To achieve carbon neutrality, the region would need to zero-out its greenhouse gas emissions (e.g., via carbon offsets, carbon-free renewables, or energy conservation and efficiency measures) across several sectors (buildings, transportation, waste, water, etc.). Any emissions increase from soils would make achieving this goal more difficult.

Likelihood Medium

Research shows that warmer temperatures may accelerate the release of carbon (from ancient organic materials) stored in soils. A recent study by Oregon State University researchers, for example, finds that as warmer weather and more atmospheric CO₂ stimulate plants to grow faster, they produce more root compounds that help free up "stored" carbon that is bonded to minerals in the soil. A separate study in the journal Nature finds that other factors — including chemical composition and water content — also affect the release of carbon stored in soils.

Spatial Extent Extensive

Horizon 0-10 years

Confidence Low

There is evidence that the region's temperature is warming. However, it is unclear whether our region's soils are more or less vulnerable to the release of stored carbon.

Goal 9 Move toward a carbon-neutral community.

Low Consequence Risks

125. Lowers reservoir levels, which exposes organic materials and causes them to decay and emit greenhouse gases

Stressor **Increasing Drought**

Consequence **Low**

While the Alder and LaGrande dams do not provide power for Thurston County residents, the reservoirs behind the dams are located within Thurston County. Thus, greenhouse gas emissions from decomposing organic materials on the exposed lake beds would affect the Thurston Region's ability to achieve its carbon-neutrality goal. This would be one of but many sources of greenhouse gases in the county, however, so the risk is of "medium" consequence to the goal.

Likelihood **Medium**

Warmer temperatures cause more water evaporation in rivers and reservoirs. Precipitation and stream volume also affect reservoir levels. We are not aware of any research that projects how changes evaporation rates would affect Alder Lake's volume. A federal Bureau of Reclamation study offers a potential reference case: Modeling projected that a 5-degree temperature increase would increase Lake Roosevelt's (Columbia River Basin) net evaporation rate by 1.3 inches (5.4 percent) annually by 2080. Given the number of local variables (known and unknown) that affect lake volume, we rate this risk as having a "medium" likelihood of affecting this goal.

Spatial Extent **Site**

Alder Lake and LaGrande dams.

Horizon **0-10 years**

Confidence **Low**

126. Increases energy consumed to pump wastewater and stormwater

Stressor **Sea-level Rise**

Consequence **Low**

Given the many sources of energy consumption in the region, this risk is of "medium" consequence to the goal. This also assumes that some of the region's energy portfolio comes from fossil fuel sources (e.g., coal and natural gas) that emit greenhouse gases.

Likelihood **Medium**

Models project more frequent and intense precipitation events and several feet of sea-level rise over the 21st century. Such changes could require the region's municipalities to consume more energy to pump stormwater and wastewater so as to prevent flooding and backups.

Spatial Extent **Extensive**

Horizon **10-30 years**

Confidence **Medium**

Goal 9 Move toward a carbon-neutral community.

Low Consequence Risks

127. Decreases production of hydropower (more summer evaporation) and increases pressure to remove dams on Nisqually River

Stressor Warmer Summer

Consequence Low

The two hydropower dams at the Alder Lake complex (Alder Lake and LaGrande dams) generate electricity for Tacoma Power and its customers in Pierce County. Thus, changes in these dams' power output — and long-term viability — would not affect the Thurston County region's ability to achieve its carbon neutrality goal. ... Puget Sound Energy — which has about 120,000 electric customers in Thurston County — owns and operates two dams, on the snowmelt-fed Baker and Snoqualmie rivers; PSE also purchases additional power from Central Washington public utility districts with Columbia River dams.

Likelihood Low

Warmer temperatures cause more water evaporation in rivers and reservoirs. Precipitation and stream volume, however, also affect reservoir levels. The only hydropower dams within the project area are operated by Tacoma Power, so there is low likelihood this risk will affect this particular goal.

Spatial Extent Site

Alder Lake and LaGrande dams on the Nisqually River

Horizon More than 30 years

Confidence Medium

128. Decreases capacity to produce clean hydropower (less rainfall and water behind dams)

Stressor Increasing Drought

Consequence Low

The two hydropower dams at the Alder Lake complex generate electricity for Tacoma Power and its customers in Pierce County. Thus, changes in these dams' capacity to generate power would not affect the Thurston County region's ability to achieve its carbon neutrality goal.

Likelihood Low

Drought — a deficiency in precipitation over an extended period — would likely reduce local reservoir water levels and the capacity to generate hydropower at the Alder Lake and LaGrande dams. However, as noted previously, this dams provide power for residents beyond the region. Thus, this risk has a "low" likelihood of affecting the Thurston Region's ability to move toward carbon neutrality.

Spatial Extent Site

Alder Lake and LaGrande dams

Horizon 0-10 years

Confidence Medium

129. Necessitates moving water farther distances, which consumes more energy/causes more greenhouse gas emissions

Stressor Increasing Drought

Consequence Low

Transporting water farther distances would require more energy, which would affect the region's ability to achieve this goal. Given the many other sources of energy consumption, this risk is of "medium" consequence to the goal.

Likelihood Low

According to a recent Ecology Department study, scarcity of surface water could spur more consumption of groundwater. This could require pumping water from greater depths, which consumes more energy. Depending on the energy source, it could also cause more energy emissions.

Spatial Extent Extensive

Horizon 10-30 years

Confidence Medium

Goal 9 Move toward a carbon-neutral community.

Low Consequence Risks

130. Reduces extent and volume of snowpack and glaciers, exacerbating sediment runoff that builds up in Alder Lake and reduces the reservoir's capacity to generate hydropower

Stressor Warmer Winter

Consequence Low

The two hydropower dams at the Alder Lake complex generate electricity for Tacoma Power and its customers in Pierce County. Thus, changes in these dams' power output — and long-term viability — would not affect the Thurston County region's ability to achieve its carbon neutrality goal.

Likelihood Low

Climate models project major reductions in snowpack and glacier volume and extent over the 21st century, which would leave soil more vulnerable to runoff and accretion behind the Alder Lake dam. A USGS study found that the increasing volume of sediment decreased Alder Lake's storage capacity by 15 percent between 1945 (dam completion date) and 2011. These risks, while clear and measureable, are still unlikely to affect the Thurston Region's ability to achieve its carbon neutrality goal because the power generated at Alder Lake is for customers in Pierce County.

Spatial Extent Site

Alder Lake reservoir and dam

Horizon 0-10 years

Confidence High

Goal 10 Maintain air quality standards.

High Consequence Risks

131. Increases overall energy consumption (transportation, buildings, waste, etc.)

Stressor Population Change

Consequence High

Assuming more people move here and use more energy that is generated from fossil fuels, this risk would affect the region's ability to achieve this goal. Investments in renewable energy, as well as energy conservation and efficiency would impact the consequence of this risk.

Likelihood Low

It is impossible to predict how many people might move to, within or from Thurston County — or when — as a result of climate change. Further, it is impossible to predict how long climate migrants will stay here and how much energy they will consume. While not impossible, it is difficult to predict what energy sources the region will use in coming decades. Thus, the likelihood of this risk is low.

Spatial Extent Extensive

Horizon More than 30 years

Confidence Low

Medium Consequence Risks

132. Increases production of surface ozone (VOCs interacting with NOx) and accumulation of fine particulate matter (PM2.5)

Stressor Warmer Summer

Consequence Medium

The federal standard for Particulate Matter (PM) 2.5 is 12 micrograms per cubic meter of air, annual average. The federal standard for surface ozone is 0.075 parts per million, 8 hour average. The Thurston Region is currently below these thresholds. According to Olympic Region Clean Air Agency data: Our three-year average for 2012-2015 was 7.0 micrograms of PM2.5 per cubic meter of air; our three-year average for surface ozone was 0.058 ppm for the same period. Increases in PM2.5 and ozone as a result of warmer summers would be of "medium" consequence in meeting this goal.

Likelihood Medium

Modeling indicates that, with locally higher surface temperatures in polluted regions, regionally triggered feedbacks in chemistry and local emissions will, with "medium confidence," (IPCC, 2013) increase peak levels of surface ozone and PM2.5 (particulate matter smaller than 2.5 micrometers in diameter).

Spatial Extent Extensive

Horizon 0-10 years

Confidence Medium

133. Raises the risk of wildfires and elevated levels of PM10 from smoke

Stressor Increasing Drought

Consequence Medium

ORCAA currently measures the region's PM10 — the biggest source of which is wood smoke (household stoves and brush piles). An increase in this coarse particulate matter from wildfires would have a "medium" effect the Thurston Region's ability to remain in attainment for this air-quality standard.

Likelihood Medium

The historical frequency of local wildfires suggests that such hazards have a "high" probability of occurrence, but about 97 percent of future fires will be small — five acres or less — concluded the Natural Hazards Mitigation Plan for the Thurston Region. The plan did not factor in climate change but cautioned that it may create more suitable conditions (e.g., warmer, drier summers) for bigger, more frequent wildfires.

Spatial Extent Extensive

Horizon 0-10 years

Confidence Medium

Goal 10 Maintain air quality standards.

Low Consequence Risks

134. Increases summer peak energy demand for cooling residential and commercial buildings, which — depending on the energy source — could degrade air quality

Stressor Warmer Summer

Consequence Low

Buildings are currently one of the largest sources of energy consumption and emissions in Thurston County, according to the Thurston Climate Action Team. Any increase in building energy consumption — assuming the power is generated by some fossil fuels (e.g., coal or natural gas) — would affect our ability to achieve this goal.

Likelihood Medium

According to one study, residential cooling demand is projected to increase to 4.8-9.1 percent of Washington's total energy demand for the 2080s, relative to 1970-1999, due to the combined effects of higher air temperature, population growth, and greater use of air conditioners. The likelihood that this would degrade the region's air quality, however, depends on our energy sources. Washington state's Renewable Portfolio Standard (RCW 19.285) requires large utilities to obtain 15 percent of their electricity from new renewable resources (e.g., carbon-free solar and wind) by 2020 and to undertake cost-effective energy conservation measures. Currently, hydropower accounts for 36 percent of the electricity PSE delivers to its customers; coal and natural gas account for 35 percent and 24 percent, respectively, while nuclear wind and other sources account for the rest of the utility's energy portfolio.

Spatial Extent Extensive

Horizon 0-10 years

Confidence Medium

135. Parches farm fields and other open spaces, which could erode and release windblown dust (e.g., PM10) that degrades air quality

Stressor Increasing Drought

Consequence Low

ORCAA currently measures the region's PM10 — the biggest source of which is wood smoke. An increase in this coarse particulate matter in the form windblown dust would have a "medium" effect the Thurston Region's ability to remain in attainment for this air-quality standard.

Likelihood Medium

Models project a more than 20 percent decline in summer precipitation by the 2050s and 2080s for the Puget Sound region, per the high and low scenarios. Changes in temperature are also expected to exacerbate periodic El Nino and La Nina cycles and the intensity of seasonal rainfall and drought events. The "medium" likelihood works under the assumption that there would be more windblown dust with more drought events.

Spatial Extent Extensive

Horizon 10-30 years

Confidence Medium

Goal 10 Maintain air quality standards.

Low Consequence Risks

136. Increases use of polluting generators following storm-induced power outages

Stressor **Increasing Storminess**

Consequence **Low**

If people use generators following a major storm event, the use would be temporary and have a "low" consequence of on this goal.

Likelihood **Medium**

The Natural Hazards Plan for the Thurston Region finds that damaging rain already has a "high" (38 percent chance) annual chance of occurrence. Climate models project that the frequency and intensity of today's heaviest 24-hour rain events (top 1 percent) would increase this century. However, this risk assumes a particular human response — using polluting generators — to this hazard. Given uncertainty over this particular human response, we contend that this risk has a "medium" likelihood of occurring and affecting this goal.

Spatial Extent **Extensive**

Horizon **0-10 years**

Confidence **Low**

This assessment relies on major assumptions about a human response to a hazard, which models show might be more frequent and intense.

Goal 12 Make strategic decisions and investments to advance sustainability regionally.

Medium Consequence Risks

137. Makes it harder to balance competing demands for water (all uses)

Stressor **Increasing Drought**

Consequence **Medium**

Drought would affect surface water (streams and reservoirs) and groundwater (large municipal and small private wells).

Likelihood **High**

Models project a more than 20 percent decline in summer precipitation by the 2050s and 2080s for the Puget Sound region, per the high and low scenarios. Changes in temperature are also expected to exacerbate periodic El Nino and La Nina cycles and the intensity of seasonal rainfall and drought events. This could necessitate that we make strategic investments to advance sustainability in the region.

Spatial Extent **Extensive**

Water supply-and-demand vulnerability is projected to be lowest in rain-dominant watersheds (Deschutes and Kennedy-Goldsborough) where there are simple institutional arrangements and where demand rarely exceeds supply. Vulnerability would be greater in snow-influenced watersheds such as the Nisqually.

Horizon **10-30 years**

Confidence **High**

138. Necessitates retrofitting stormwater and wastewater infrastructure to mitigate flooding and backups that threaten water quality and human health and welfare

Stressor **Increasing Storminess**

Consequence **Medium**

The region's urbanized areas have billions of dollars worth of stormwater and wastewater infrastructure that was designed based on historic conditions. Retrofitting such infrastructure to accommodate bigger rain events would be extremely costly.

Likelihood **High**

The Natural Hazards Plan for the Thurston Region finds that damaging rain already has a "high" (38 percent chance) annual chance of occurrence. Climate models project that the frequency and intensity of today's heaviest 24-hour rain events (top 1 percent) would increase this century.

Spatial Extent **Place**

This risk would affect urbanized areas.

Horizon **0-10 years**

Confidence **High**

Intensity of such large rainfall events is project to increase 22 percent by the 2080s, and frequency would increase from two days per year to 7 days per year.