We are interconnected, we are resilient

As air temperatures warm

forests change, fires increase

glaciers retreat, snowpack diminishes

sediment increases

rivers change, salmon respond

base sea level rises

estuaries and oceans change

forces combine, increasing flood risk

We are interconnected, we are resilient

In partnership with Skagit Climate Science Consortium, Skagit Land Trust, Skagit Watershed Council, and Swinomish Indian Tribal Community, MoNA welcomes you to explore and experience climate change and its impacts on Northwest coastal communities through ***Surge***, a week-long exhibition of art, science, and information.

Surge is a collection among scientists, educators, and artists to link changes and impacts such as rising sea levels and changing river flows with how these affect people and the ecosystem we live in and depend upon. This year's exhibit is fundamentally about interconnectedness. The exhibits involve forests and forest ecosystems, magnitude and movement of freshwater and sediment, coastal and estuarine areas, and invite curiosity about the interconnectedness of the physical (storm surge, sea level rise, flooding, salt) and living (plants, animals, human) worlds. ***Surge*** offers the opportunity for that curiosity to result in greater awareness that can lead to community efforts to inspire change.

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Climate Change Drivers → System Changes and Impacts → Human and Local Challenges

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As winter temperatures get warmer, the winter freezing level in the Skagit has risen (the elevation where the temperature is cold enough for most precipitation to fall as snow, not rain).

The winter of 2014-2015 had an average winter freezing level of 6,000 feet. That's 1,400 feet above the 1948-2015 average elevation and 400 feet higher than it had ever been since records began in 1948.

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Skagit Air Temperature Warms

Rising Winter Freezing Levels

Shrinking Glaciers

Changing Precipitation Patterns

Bigger and More Frequent Floods

More Rain and Less Snow

More Sediment in Rivers

Heavier Rain Events

Increased Skagit Flood Risk

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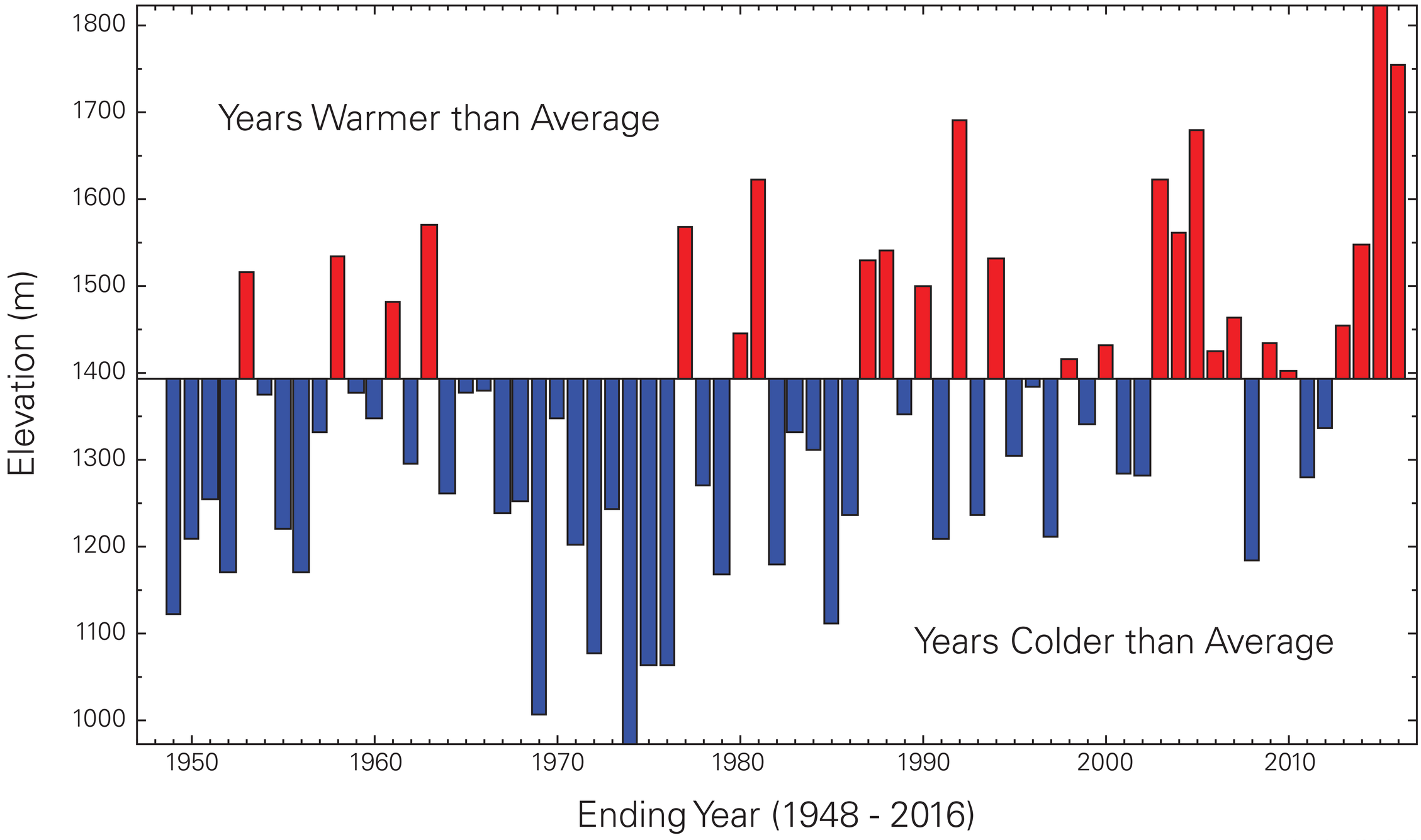
0°C Level at 48.51°N, 121.46°W — 7 Months Ending in April



Data provided by the Office of the Washington State Climatologist
www.climate.washington.edu

Last data: 2016-04-17
Means from 1981 - 2010
Western Regional Climate Center

Temperature Trends Since 1920

CANADA

WASHINGTON

OREGON

IDAHO

MONTANA

COLDER **WARMER**

2.0°C (3.6°F)

1.5°C (2.7°F)

1.0°C (1.8°F)

0.5°C (0.9°F)

Data provided by the Office of the Washington State Climatologist
www.climate.washington.edu

Menne et al. 2009: ftp://ftp.ncdc.noaa.gov/pub/data/ushcn/v2/monthly/menne-etal2009.pdf
USHCN version 2.5.0.20150123

Wildfires in the Skagit River Basin have historically been uncommon and relatively small. In a warmer climate, the number and size of forest fires are expected to increase, with the biggest effects observed in extreme drought years. West-side fires that occurred in the record drought year of 2015 provided a preview of a future with smokier skies.

The Goodell Fire burned over 7,000 acres near Newhalem in August 2015. Ignited by lightning, this fire crossed the North Cascades Highway, causing the temporary shutdown of Seattle City Light hydroelectric facilities and evacuation of the town of Diablo.


Seattle
City Light
31437

From 1959 to 2009, the Skagit lost about 12.3 square miles of glacial ice, representing a 19% loss in area and 800 billion gallons of water.

The loss of water is equivalent to about 100 years of Skagit County water supply at the current rate of consumption.

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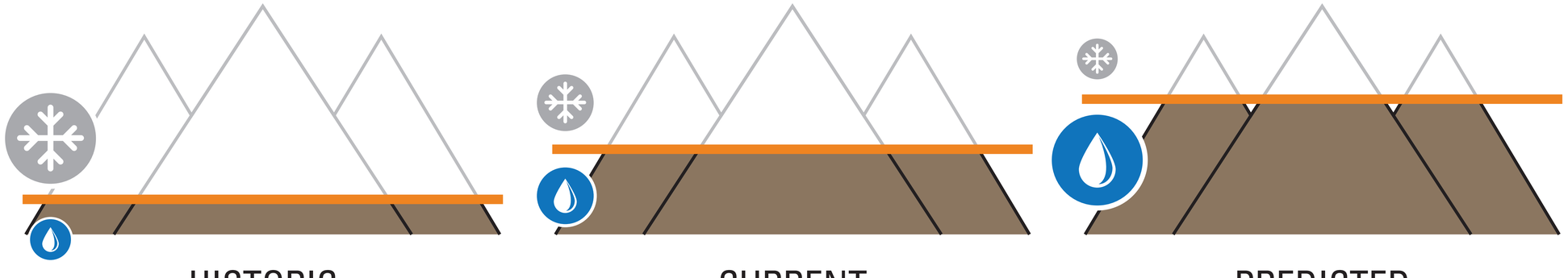
Rising Winter Freezing Levels



HISTORIC

CURRENT

PREDICTED

When precipitation falls as snow, it is stored as ice and snow that slowly melts, providing water to the Skagit River throughout the year, including late summer and drought periods.

FREEZING LEVEL

When precipitation falls as rain, water enters the Skagit River during fall and winter, contributing to flood risk. As freezing levels rise, the land area contributing to flooding increases.

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Time

Glacier Cumulative Mass Balance (Meter Water Equivalent)

10
5
0
-5
-10
-15
-20
-25
-30
-35

Gain of Ice

Loss of Ice

North Cascade Glaciers

- N.Klawatti
- Noisy
- Silver
- Sandalee
- S.Cascade

**Glacier-wide averages calculated using conventional glacier maps (1993/1995 & 2004/2006/2010).*
Annual balances calculated from direct method were adjusted to reflect differences with geodetic mass balance measurements.

1959 1961 1963 1965 1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005 2007 2009 2011 2013 2015

Water Year

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Since the late 1880s, an estimated 90 million cubic meters of sediment has accumulated in Skagit Bay. This is enough to bury the I-5 corridor between Canada and Oregon 15 feet deep or cover a football field 10 miles high.

The sediment has filled in the deeper parts of Skagit Bay an average of 49 feet and up to 90 feet in some places, and represents a tenfold increase in the rate of sedimentation that occurred prior to constructing levees.

Since 1975, an average of 3 to 5 feet of sediment has accumulated across most of the 30 reaches studied along the Skagit River between Sedro-Woolley and Fir Island. Up to 10 feet has accumulated in a few areas particularly near Mount Vernon.

This build-up of sediment in the river reduces the ability of the river channel to carry water (conveyance capacity) during a high flow and increases the possibility that floods will overtop the levees and cause flooding.

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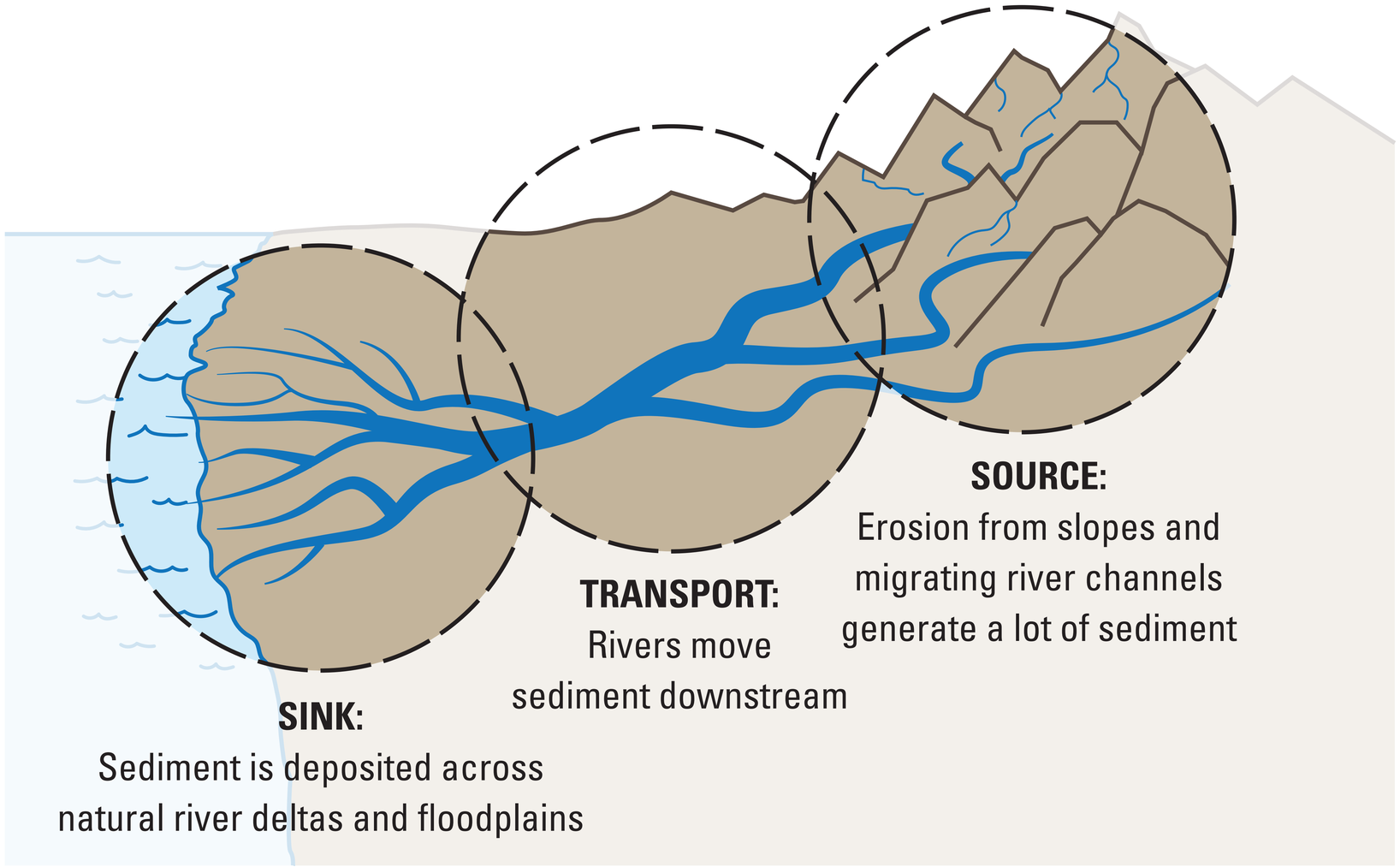
Flow of Sediment



Sediment is the sand, mud, and pebbles that were once solid rock.

Sediment flows in tributary streams and river channels of the Skagit, from the Cascade Mountains to Skagit Bay and Puget Sound.

Skagit Salmon and Their Relatives:
All Are Vulnerable to Climate Change

Pink salmon 

Chum salmon 

Chinook salmon 

Coho salmon 

Sockeye salmon 

Steelhead/
Rainbow trout 

Bull trout 

Cutthroat trout 

Mountain
Whitefish 

REFERENCES FOR FISH ILLUSTRATIONS: Pink, Chum, Sockeye, and Cutthroat: ***US fish and Wildlife Service***; Chinook, Coho, Steelhead, Bull trout: ***National Oceanic and Atmospheric Association***; Mountain whitefish: ***bigtrout.com***

Species have different ***life histories:*** they live in different habitats at different stages in their life (top right), and have differing life expectancy. Salmon spawn and then die, while trout and whitefish may spawn multiple times.

Because of their life history variation, salmon are vulnerable to climate change in different ways. Climate impacts are colored by life stage (top right color scale). Climate impacts for each species follow a different color scale (right).

These results are based on what climate impacts are expected by 2050, and vulnerabilities will increase if climate impacts worsen.

Life Stage	Spawning	Incubation	Freshwater Rearing	Estuary Rearing	Nearshore Rearing	Ocean Rearing

Year	Season	Pink	Chum	Chinook	Coho	Sockeye	Steelhead	Bull trout	Cutthroat	Whitefish
0	Summer									
	Fall									
	Winter									
	Spring									
1	Summer									
	Fall									
	Winter									
	Spring									
2	Summer									
	Fall									
	Winter									
	Spring									
3	Summer									
	Fall									
	Winter									
	Spring									
4	Summer									
	Fall									
	Winter									
	Spring									

The same species may exhibit more than one life history.

Salmon die after they spawn.

Vulnerability	Lowest				Highest

Climate Impact	Pink	Chum	Chinook	Coho	Sockeye	Steelhead	Bull trout	Cutthroat	Whitefish
↑ Spawning Temperature									
↑ Temperature During Incubation									
↑ Winter Flooding									
↑ Suspended Sediment in Winter									
↓ Summer River Flows									
↑ Summer River Temperature									
↑ Sea Level									
↓ Suspended Sediment in Spring									
↑ Summer Nearshore Temperature									
↓ Nearshore Dissolved Oxygen									
↑ Ocean Temperatures									

Species are vulnerable to climate impacts only in habitats they use.

12 inches of sea level rise

turns a 100-year storm

into a 10-year storm event

24 inches of sea level rise

turns a 100-year storm

into an annual event

This range of sea level

increase is projected for

Puget Sound by 2100

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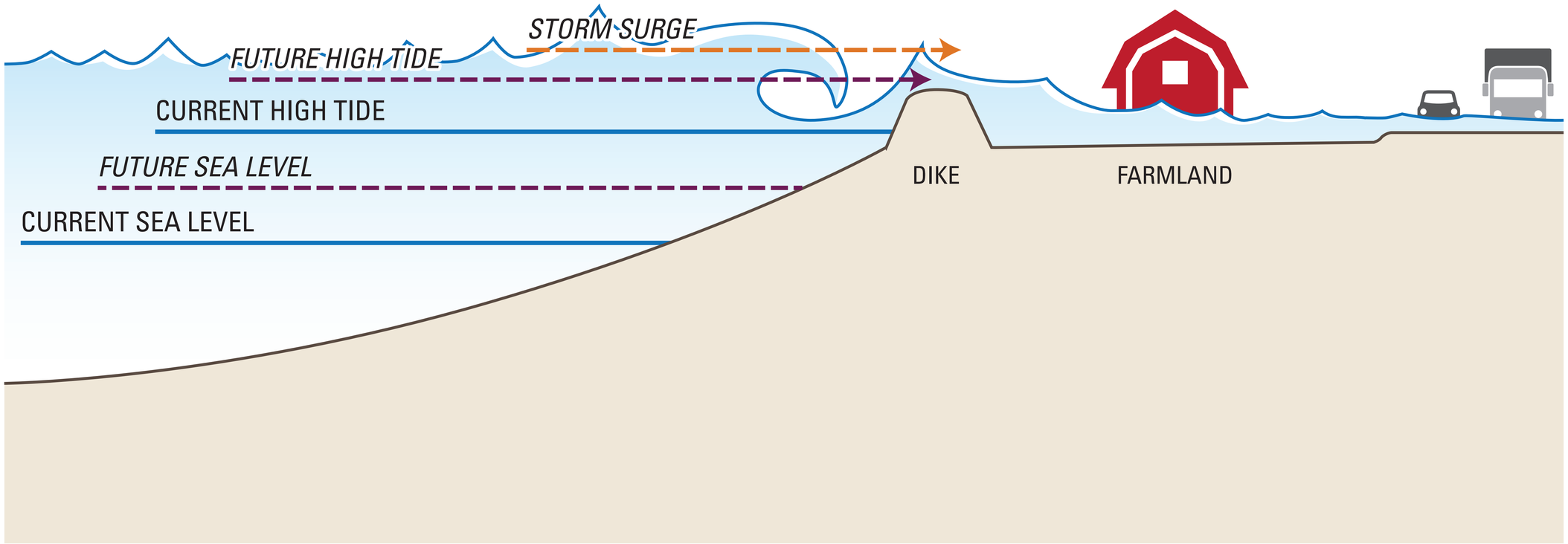
Rising Sea Levels & Storm Surge



NOTE: Sea, tide, and storm surge levels are for illustrative purposes only and do not depict actual or projected levels.

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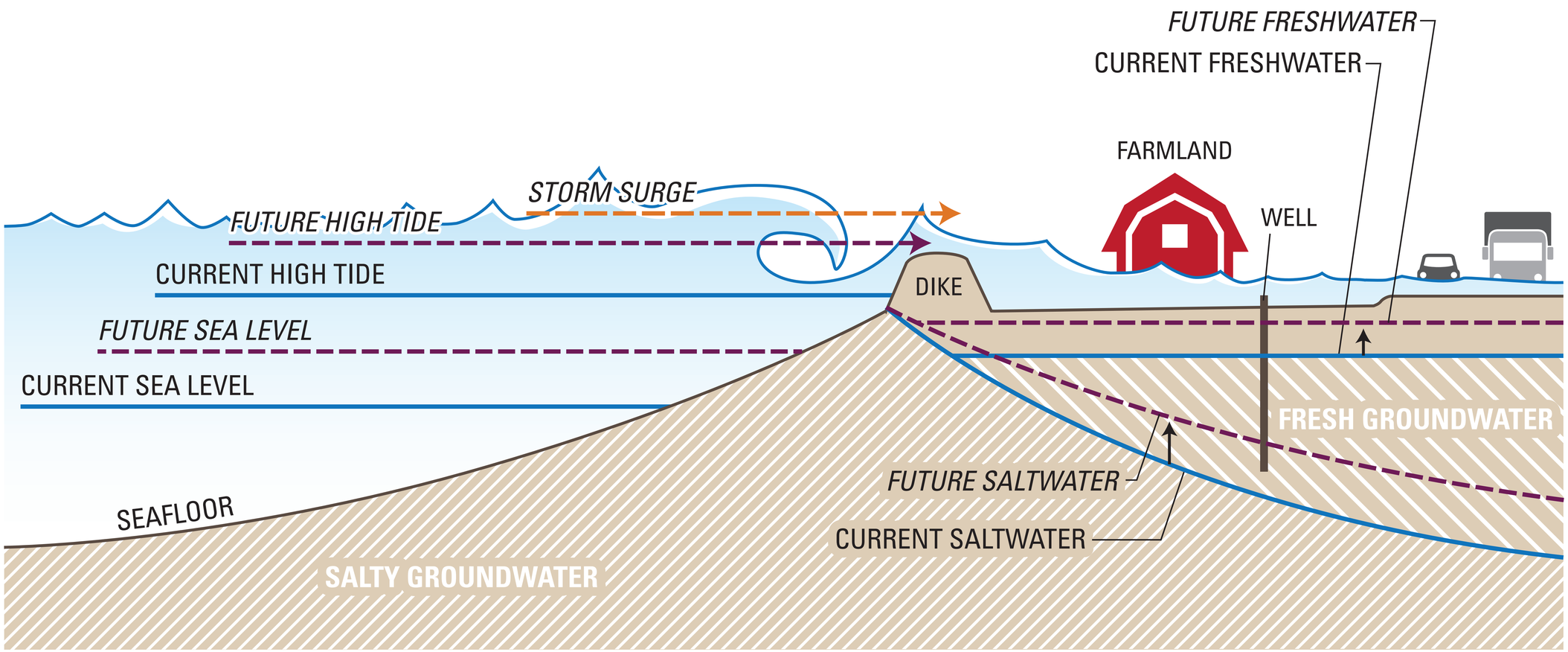
Rising Sea Levels, Groundwater & Storm Surge



NOTE: Sea, tide, and storm surge levels, depth of groundwater, and location of saltwater lens are for illustrative purposes only and do not depict actual or projected levels.

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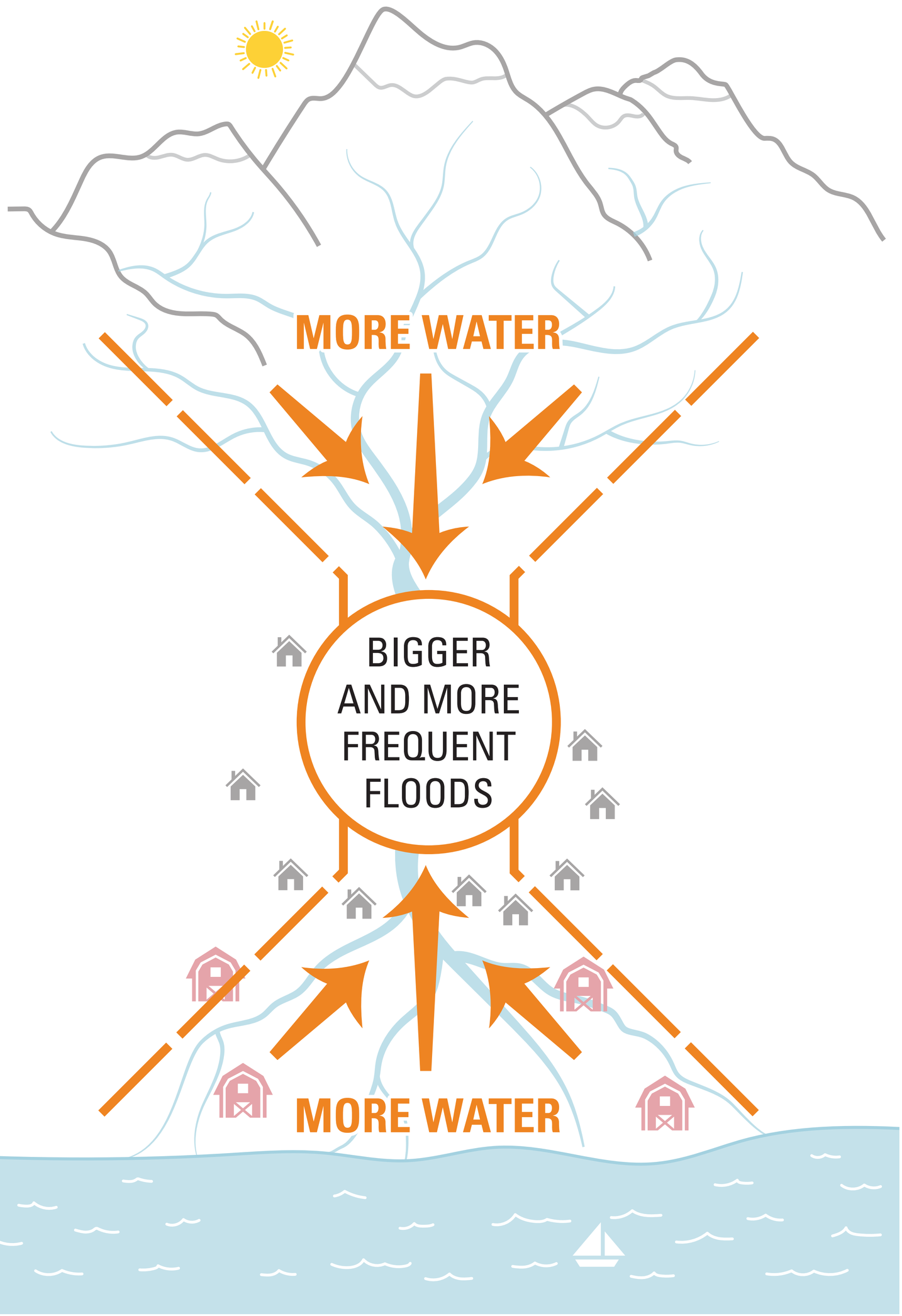
Climate Change: Combining Forces

Warming Temperatures

Rising Winter Freezing Levels

Shrinking Glaciers

Heavier Rain Events



Rising Sea Levels

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Adaptation:

Responding to shifts associated with climate variability and climate change by forming and taking deliberate actions leading to:

- A reduction in harm or risk, or
- The realization of benefits for people or ecosystems

Resiliency:

The ability to recover readily from adversity; buoyancy