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Salish Sea Ecosystem Conference

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Apr 4th, 1:45 PM - 2:00 PM

# River and wastewater effluent nutrient inputs into the Salish Sea model

Teizeen Mohamedali
*Washington State Dept. of Ecology, United States*, tmoh461@ecy.wa.gov

Anise Ahmed
*Washington State Dept. of Ecology, United States*, anise.ahmed@ecy.wa.gov

Sheelagh McCarthy
*Washington State Dept. of Ecology, United States*, shem461@ECY.WA.GOV

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# River & Wastewater nutrient loading into the Salish Sea Model

## Salish Sea Ecosystem Conference

April 4-6, 2018

Teizeen Mohamedali
Anise Ahmed
Sheelagh McCarthy

DEPARTMENT OF ECOLOGY
State of Washington

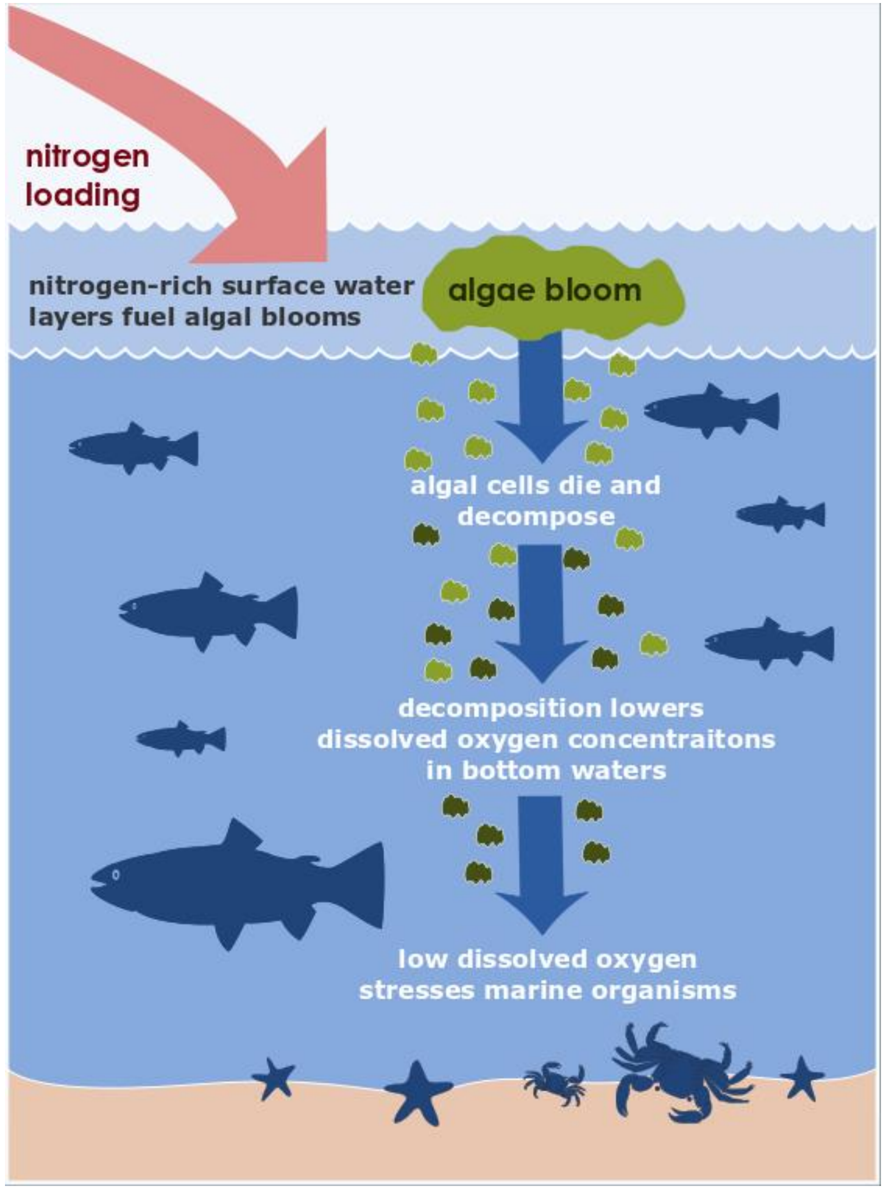
# Acknowledgements

- Past contributors:
  - Mindy Roberts
  - Brandon Sackmann
  - Chuck Springer
- Steve Hood and John Gala: for help with R scripting
- Funding in part from the EPA National Estuary Program grant
- The rest of the Salish Sea Modeling team at Ecology and PNNL

**Data sources:**

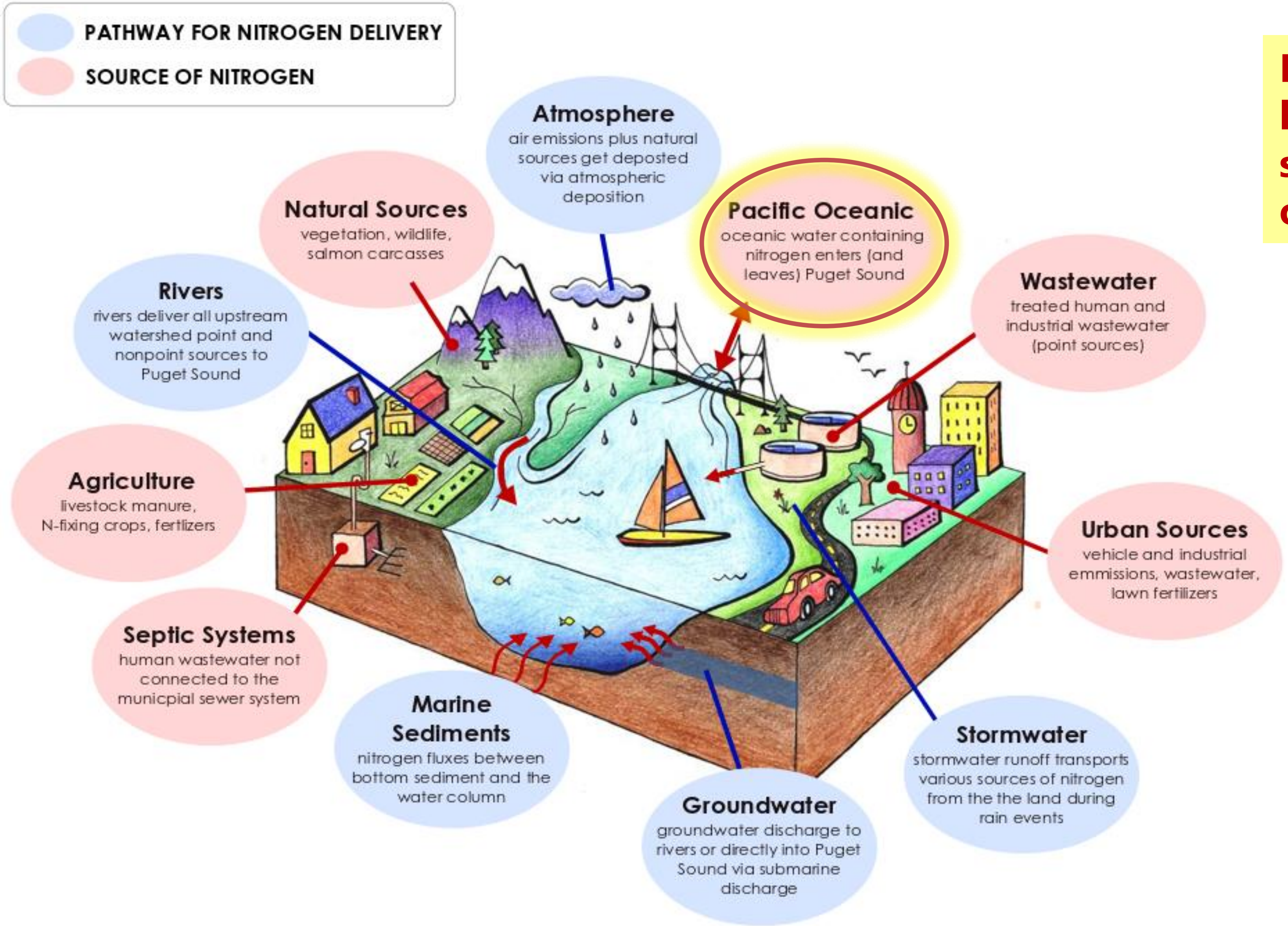
- Ecology Freshwater Monitoring Unit
- South Puget Sound Dissolved Oxygen Study data
- USGS streamflow and water quality data
- King County water quality data
- Kitsap County streamflow data
- USACE for Lake Washington/Ship Canal data
- Tacoma Power/Utilities
- Wastewater treatment facilities – effluent monitoring data
- Environment Canada

# Why estimate nutrient loading?



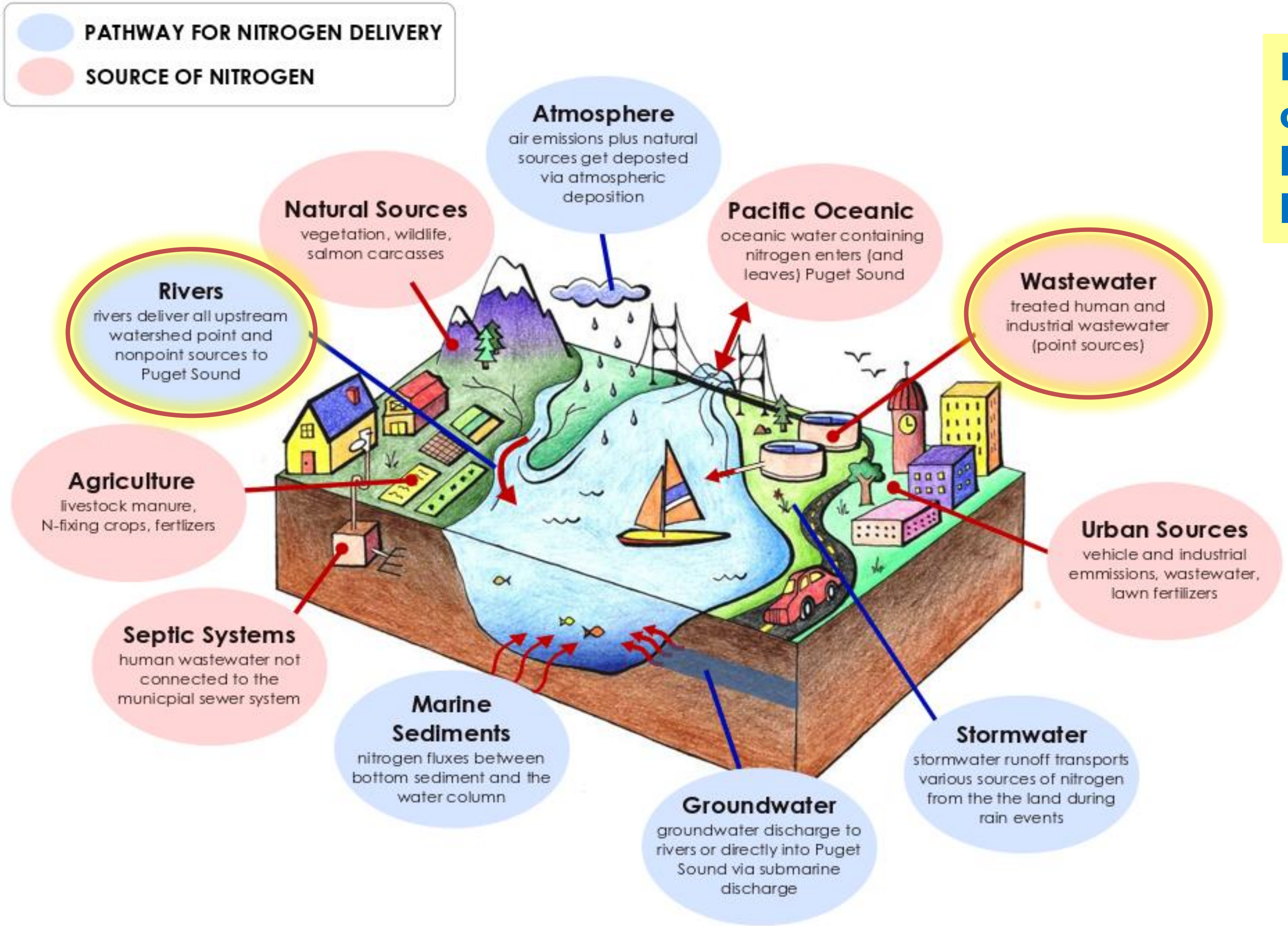

- Excess nutrients contribute to eutrophication, low oxygen levels and acidification
- Need estimates to establish boundary conditions for the **Salish Sea Model**
- Ability to quantify different sources, magnitude and timing of delivery to Salish Sea is informative
- Allows us to perturb conditions and change nutrient loading for model scenarios to evaluate effect on water quality

# Nutrient Sources & Pathways




**Pacific Ocean contributes the largest nitrogen load to the sound – driven by larger oceanic and global processes**

# Nutrient Sources & Pathways



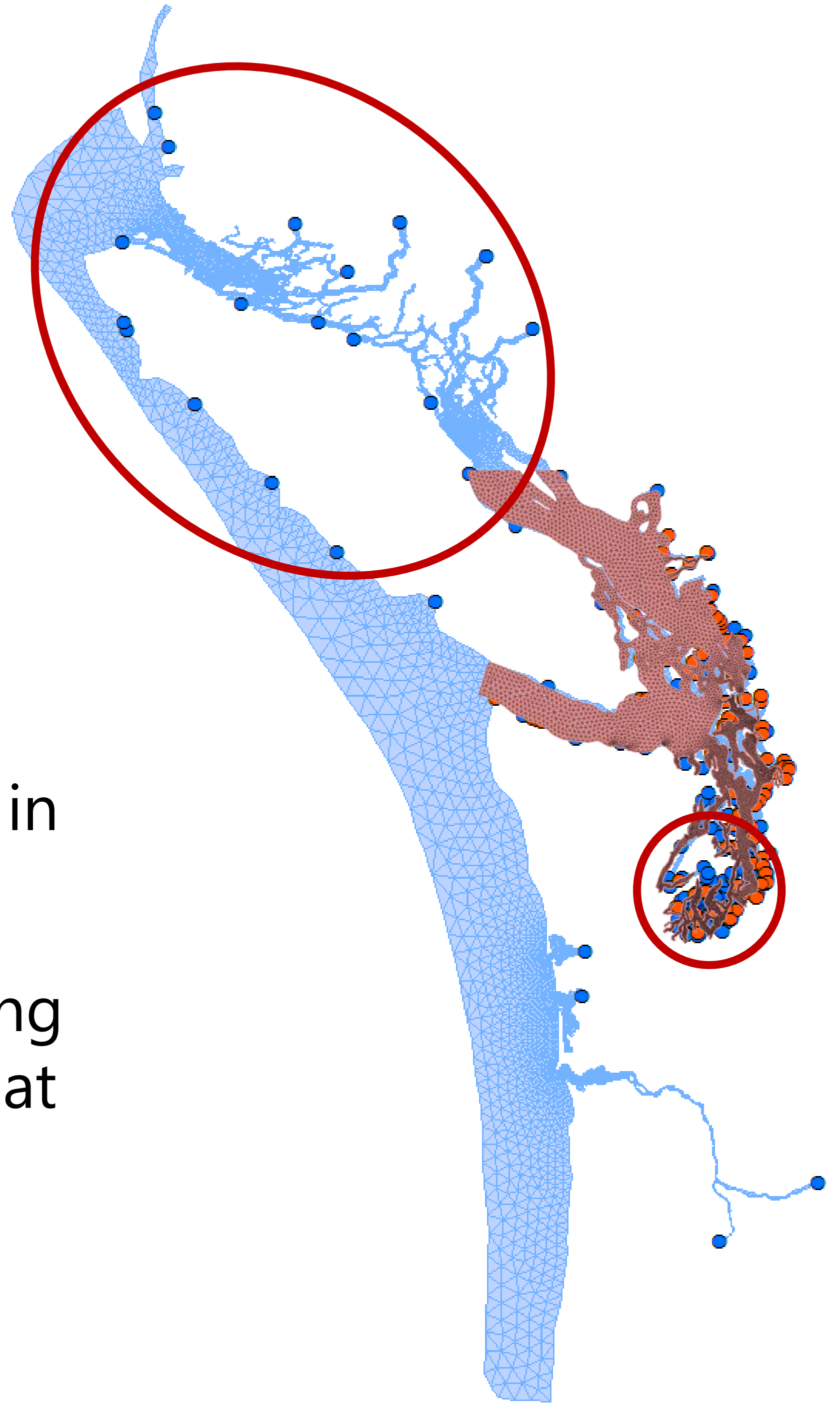

**Focus of this presentation is on rivers and wastewater loads – can influence through local management actions**

Focus on dissolved inorganic nitrogen (DIN), but we have estimates of:

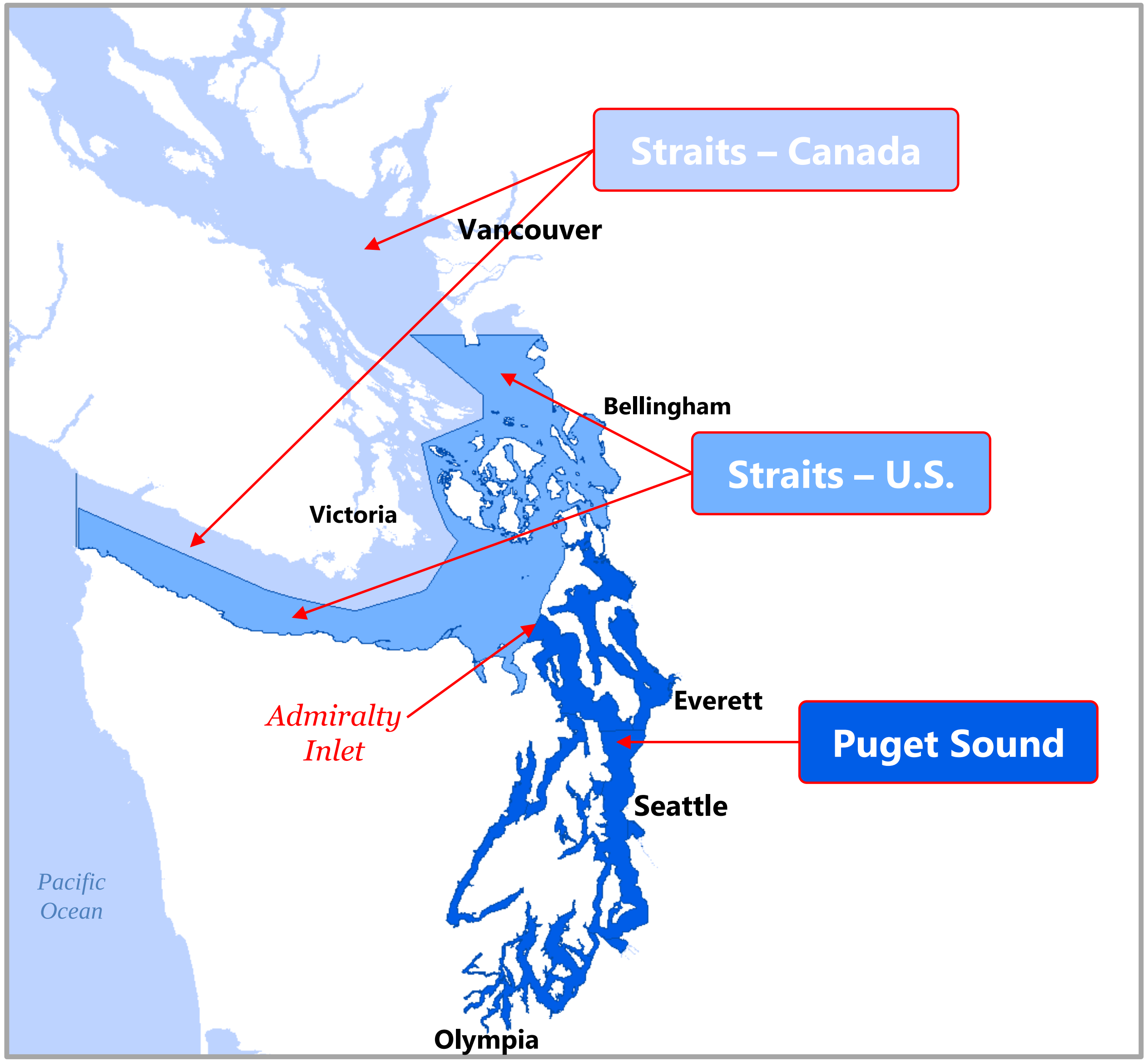
- organic and inorganic nitrogen
- organic and inorganic carbon
- organic and inorganic phosphorus

# Recent updates

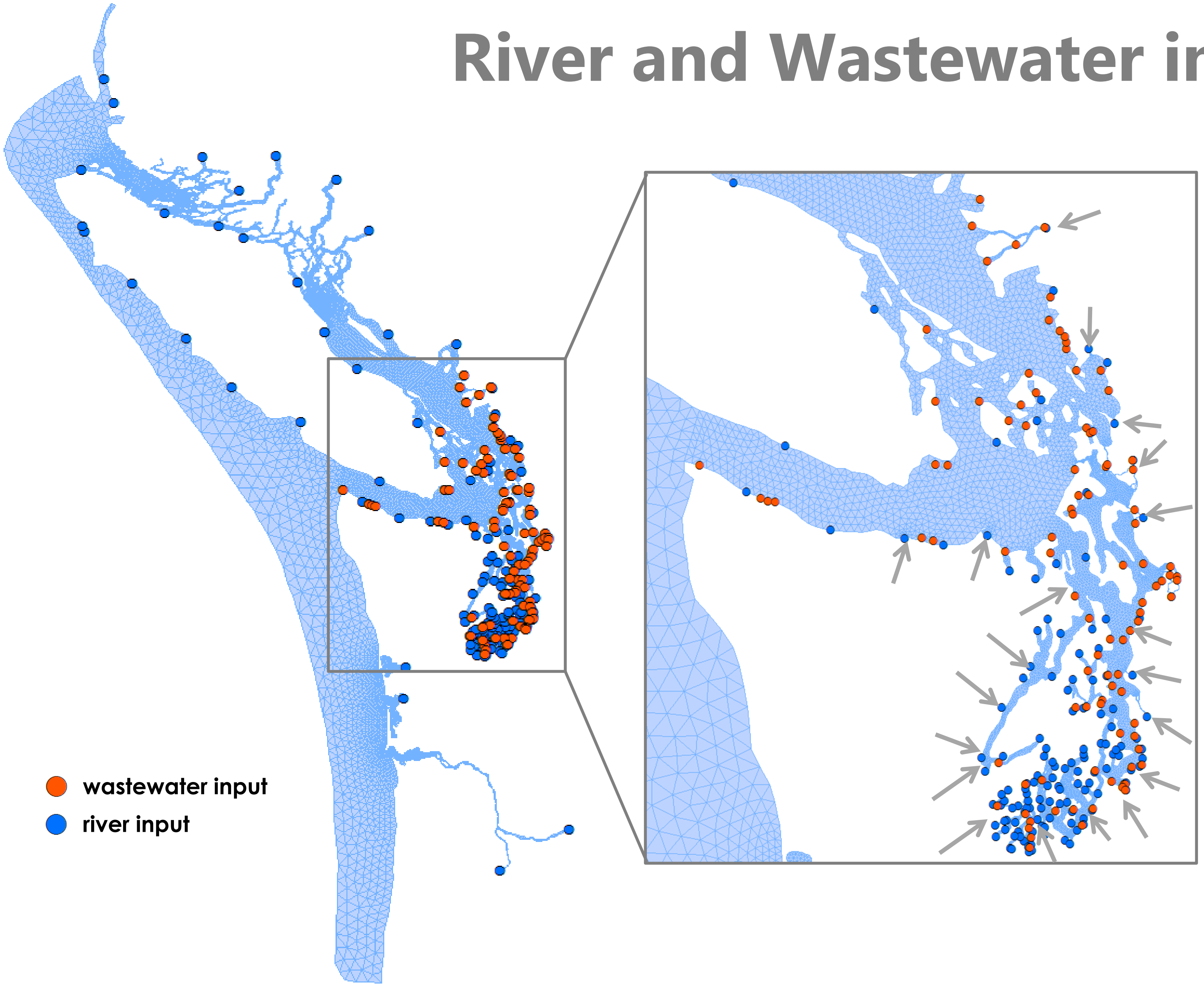
- Original time series from 1999-2008, extended through mid-2017
- Expansion of model grid → needed freshwater inflows into the northern boundary (British Columbia)
- Spatial refinement of freshwater loading estimates in South & Central Puget Sound
- Updated WWTP data based on discharge monitoring reports, where available, particularly for facilities that have been upgraded since 2008



# Geographic areas



# River and Wastewater inputs



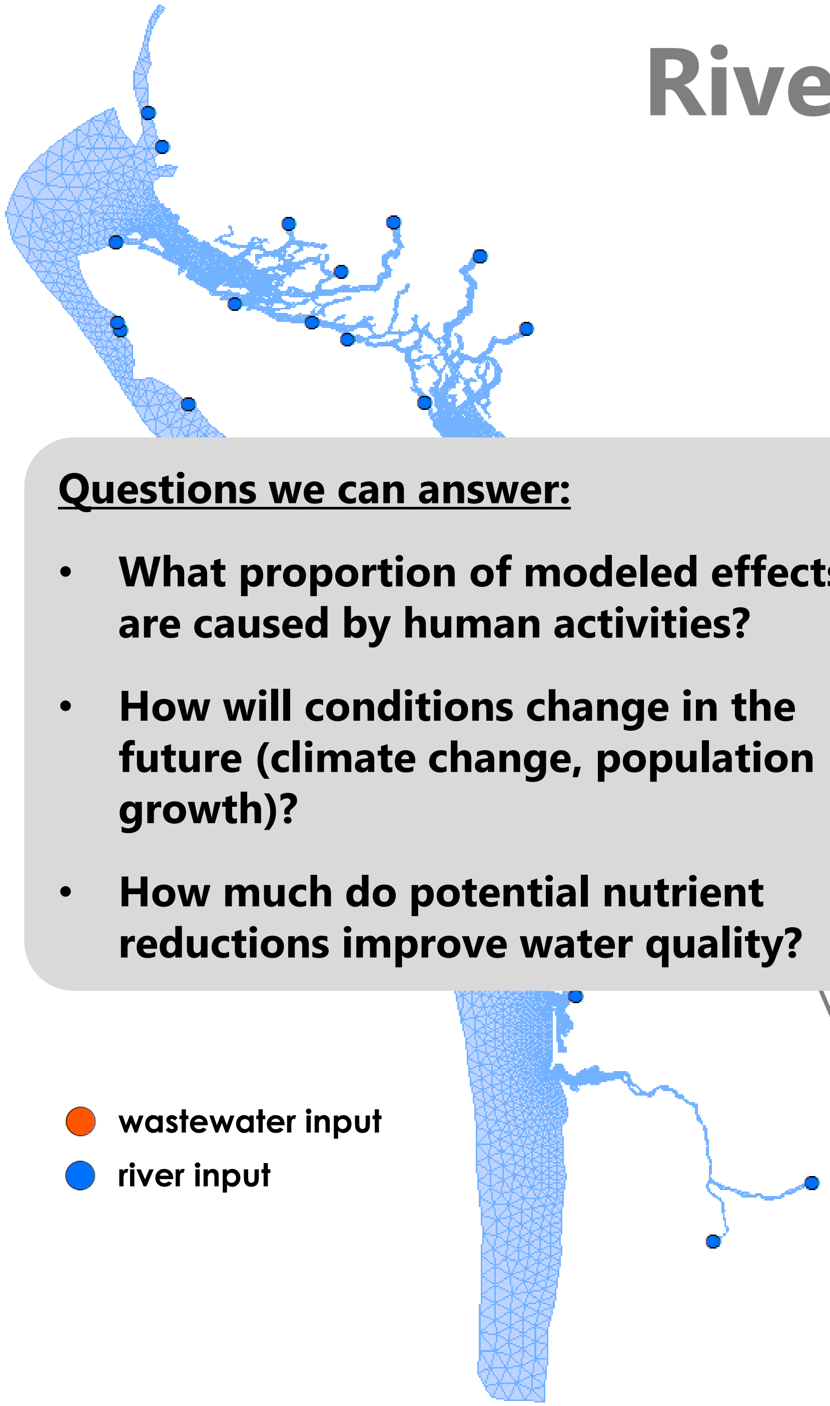

## 161 river and streams

- Rivers and streams entering Puget Sound, the Straits and the Pacific Ocean
- Higher spatial resolution in South & Central Puget Sound

## 99 point sources

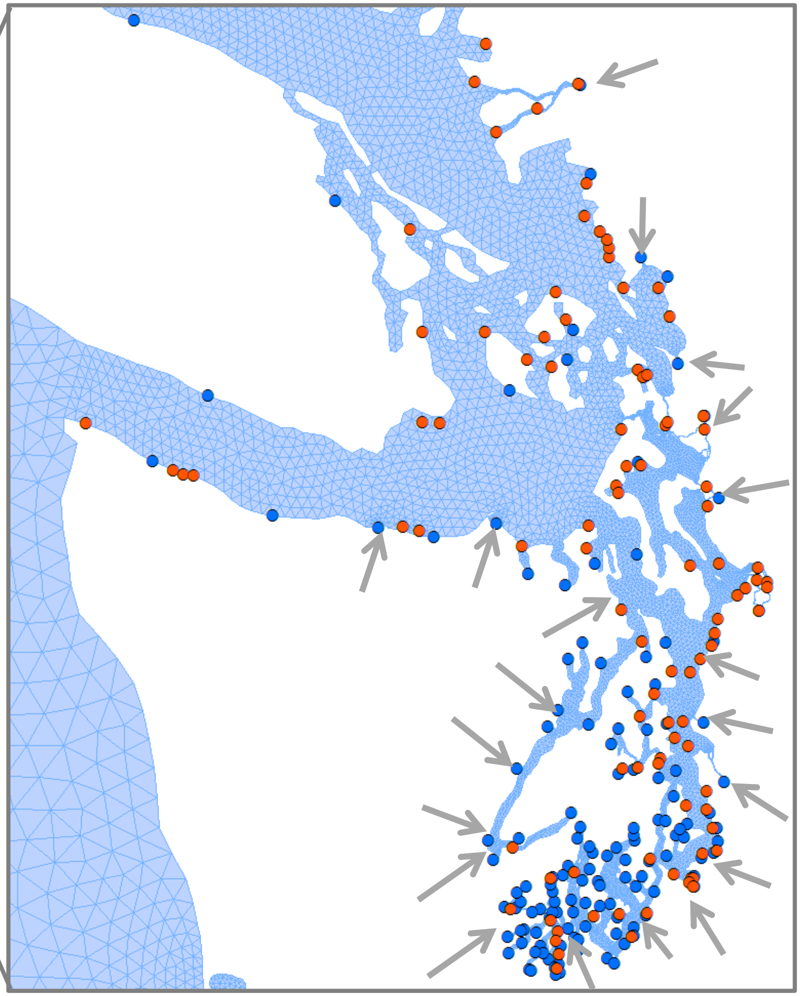
- All facilities with marine outfalls
- 78 U.S. WWTPs
- 9 Canadian WWTPs
- 10 industrial facilities

# River and Wastewater inputs




**Questions we can answer:**

- **What proportion of modeled effects are caused by human activities?**
- **How will conditions change in the future (climate change, population growth)?**
- **How much do potential nutrient reductions improve water quality?**



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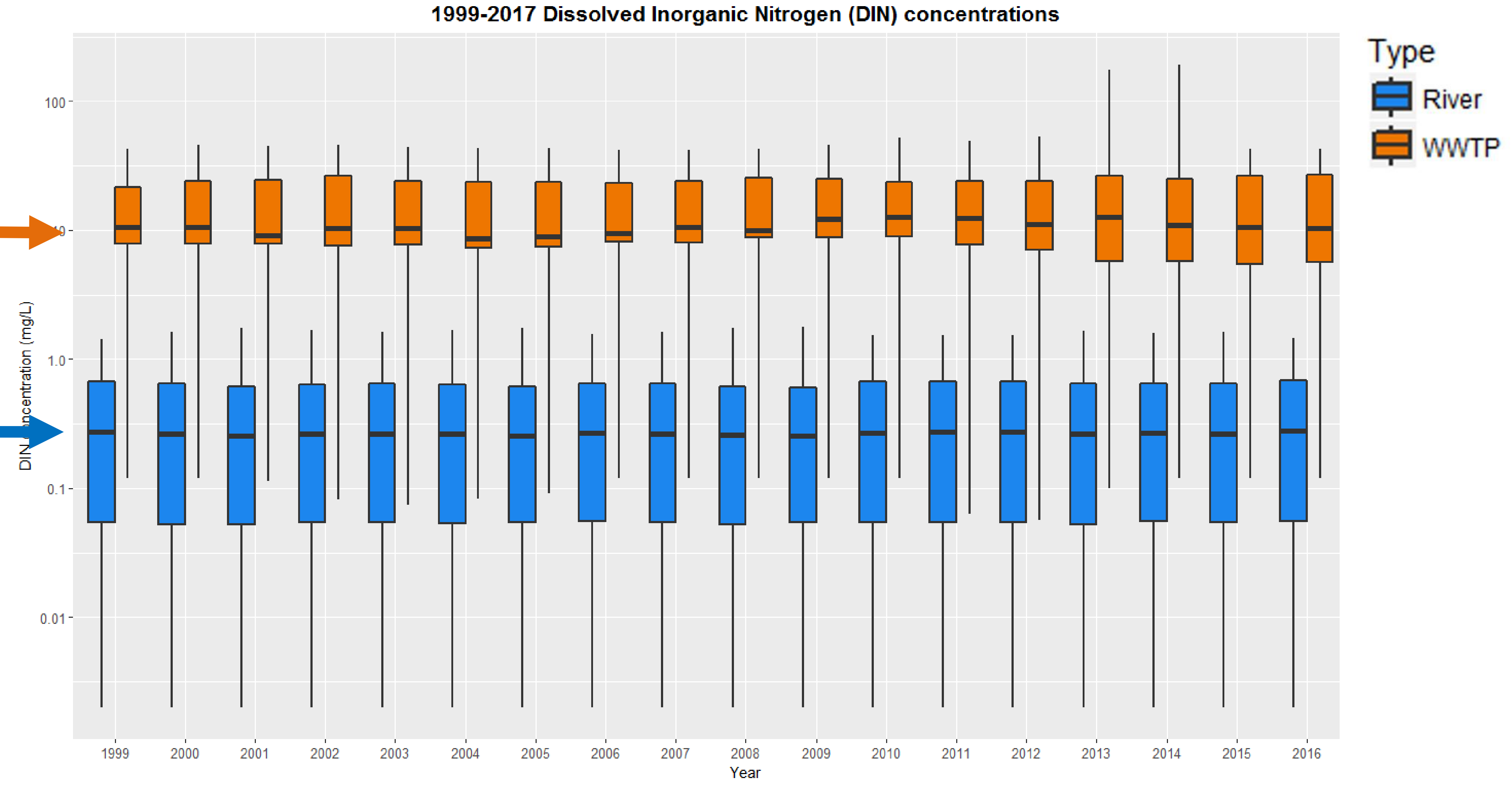
# River & Wastewater DIN concentrations

Wastewater median concentrations:
**>10 mg/L**

River median concentrations:
**<0.5 mg/L**



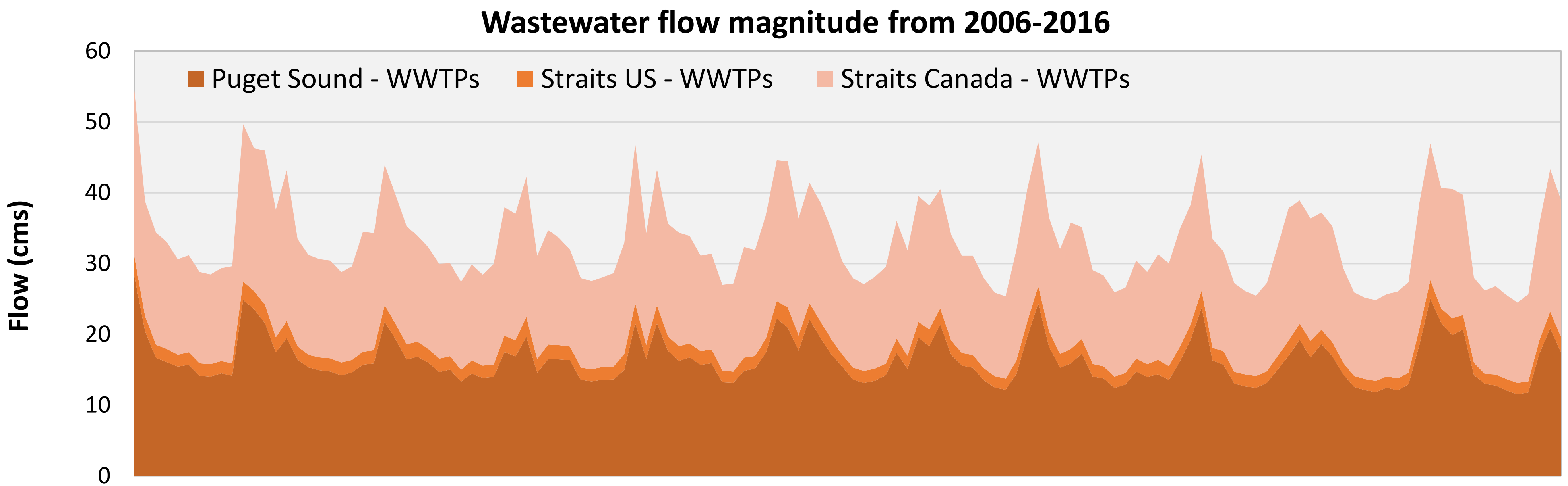
# Flows

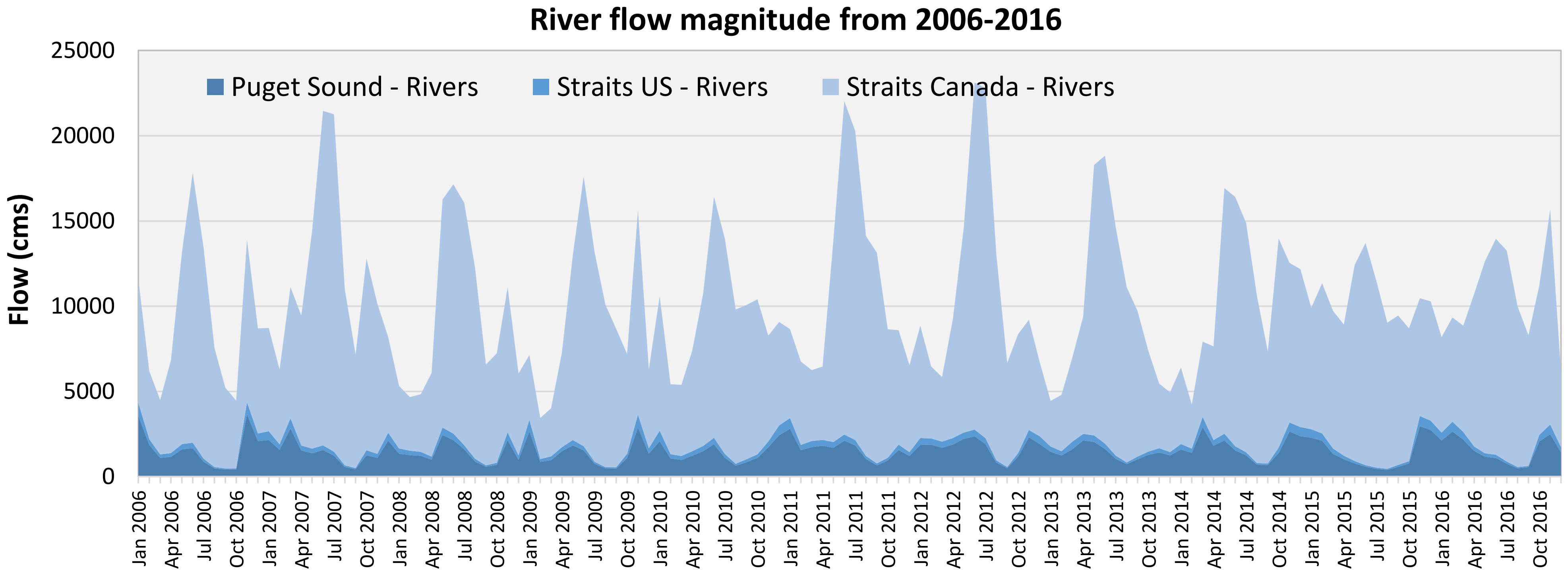
<u>**Wastewater:**</u>

- Sound: 16 cms (575 cfs)
- Straits: 17 cms (700 cfs)

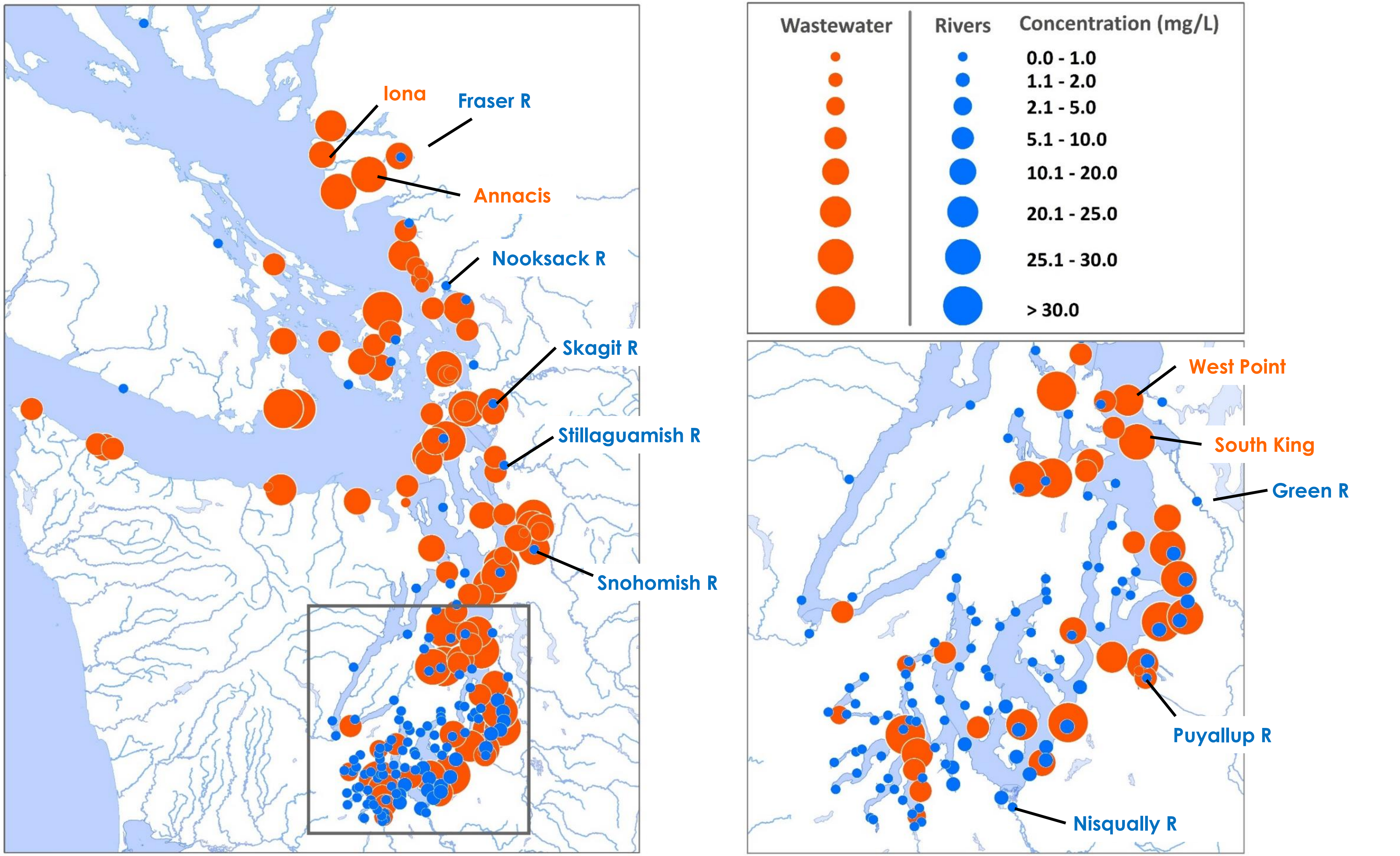
<u>**Rivers:**</u>

- Sound: 1,490 cms (52,620 cfs)
- Straits: 8,890 cms (313,950 cfs)

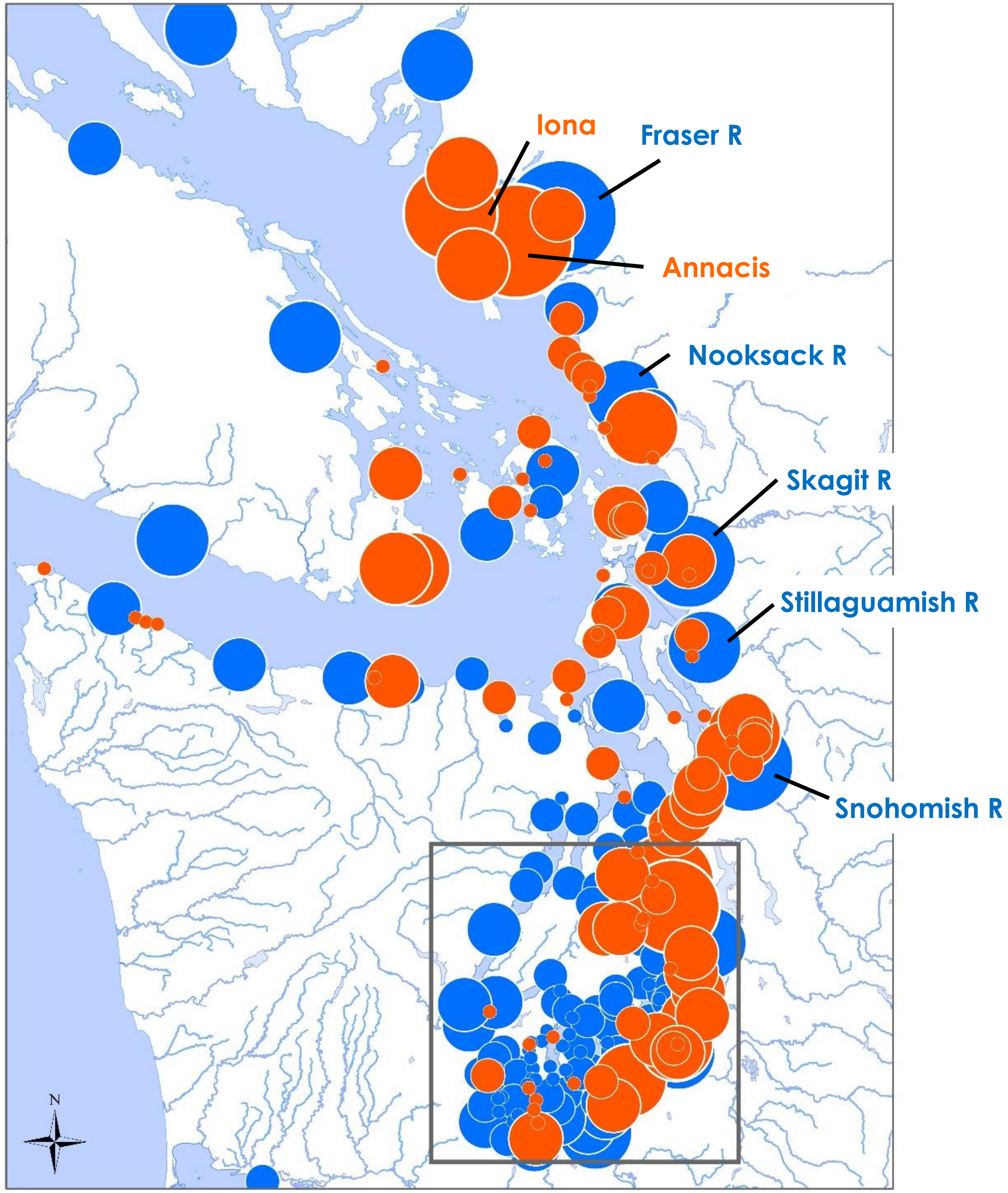


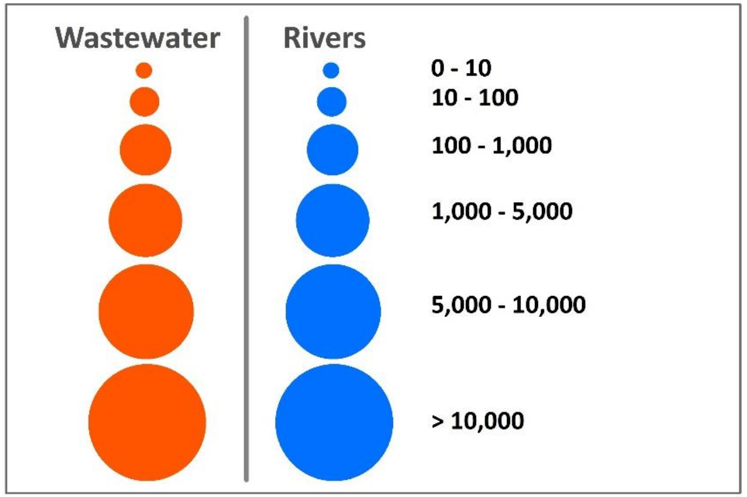



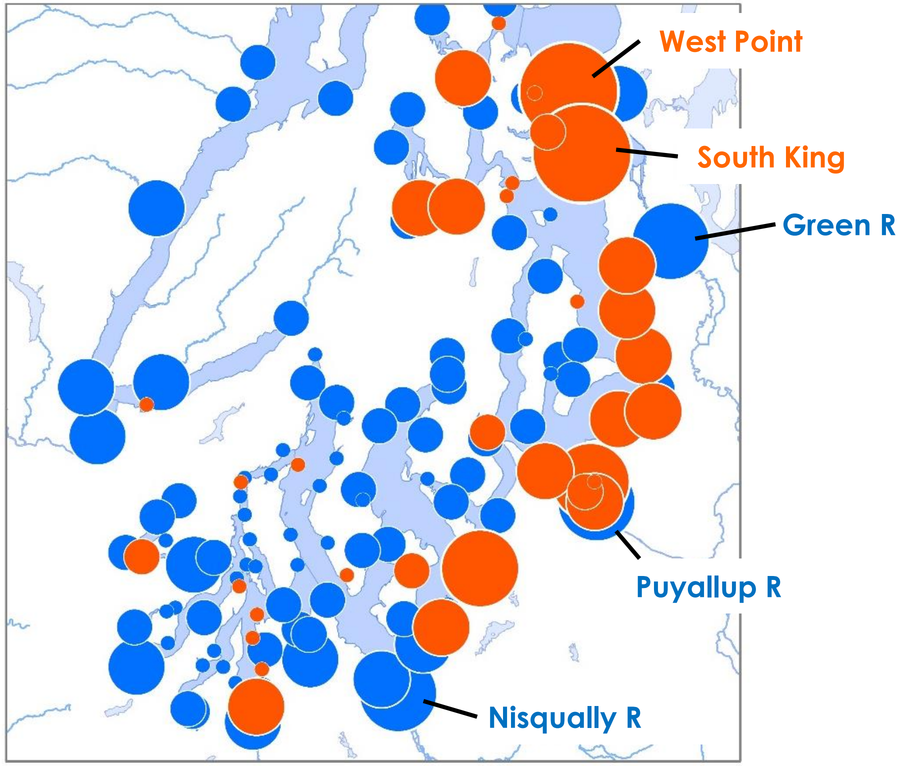
# Dissolved Inorganic Nitrogen (DIN) concentrations in mg/L: 1999-2017 annual averages



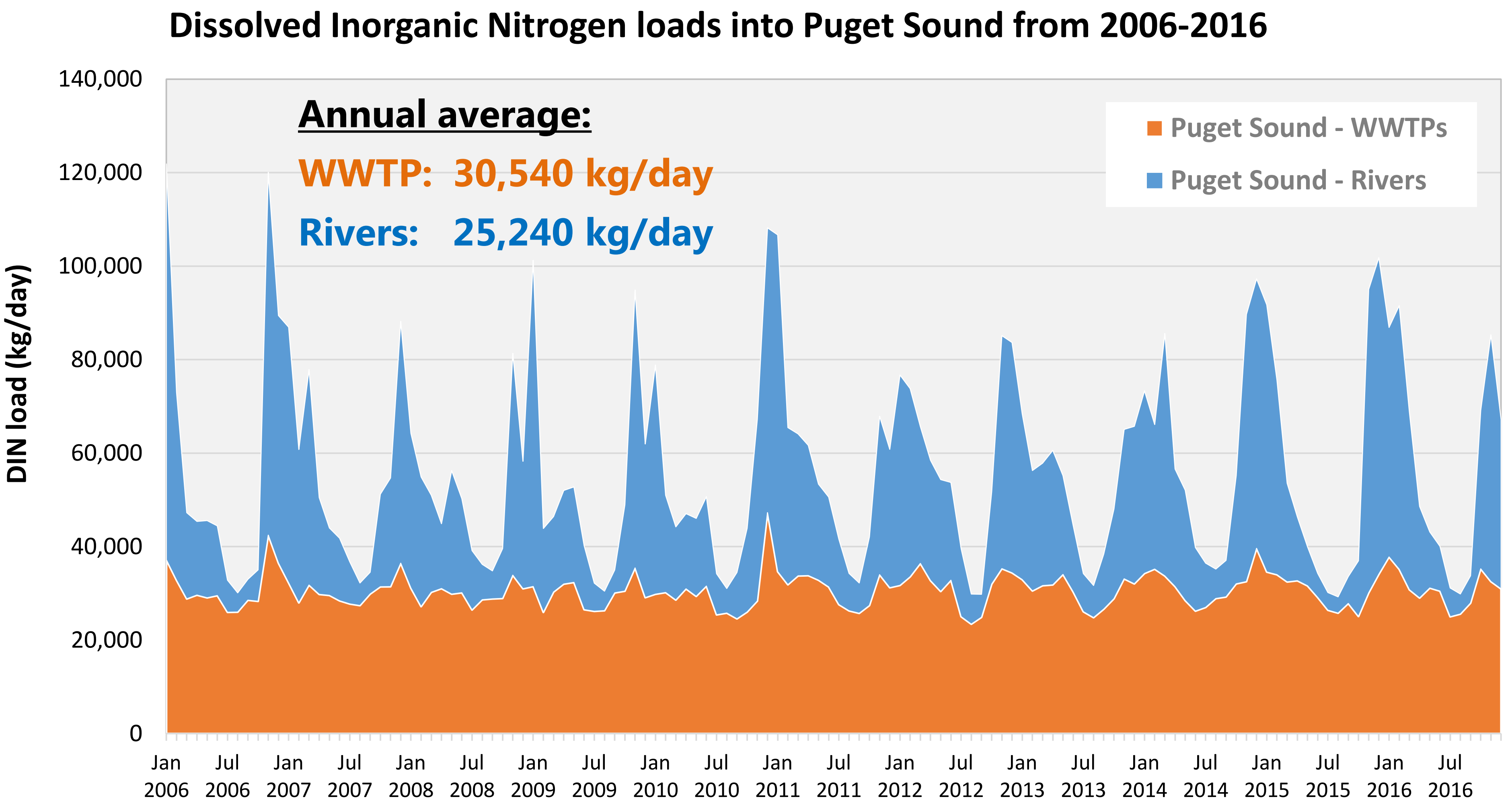
# Dissolved Inorganic Nitrogen (DIN) loads in kg/day: 1999-2017 annual averages

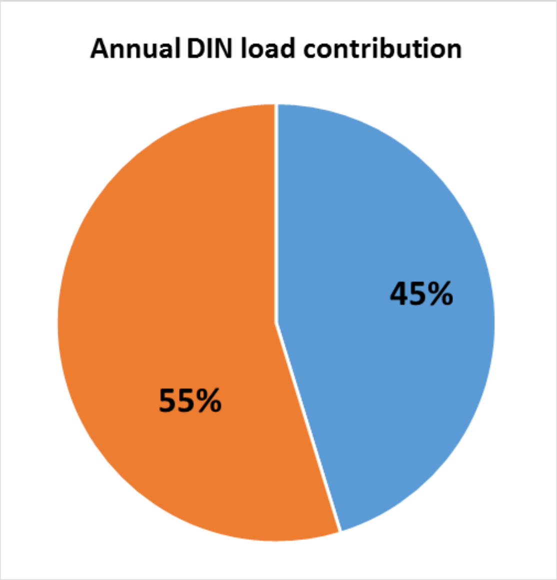


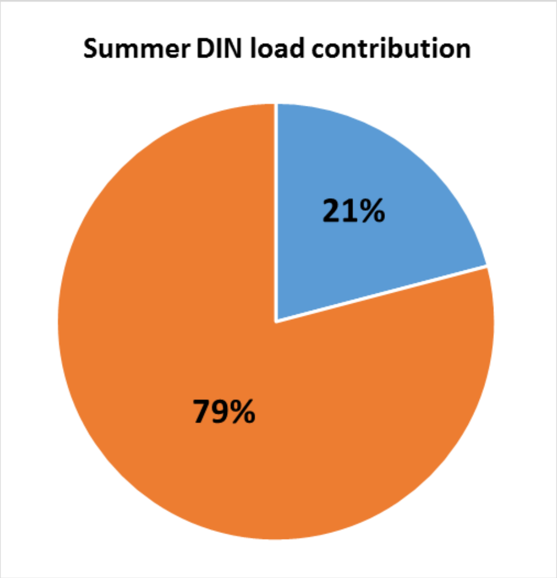



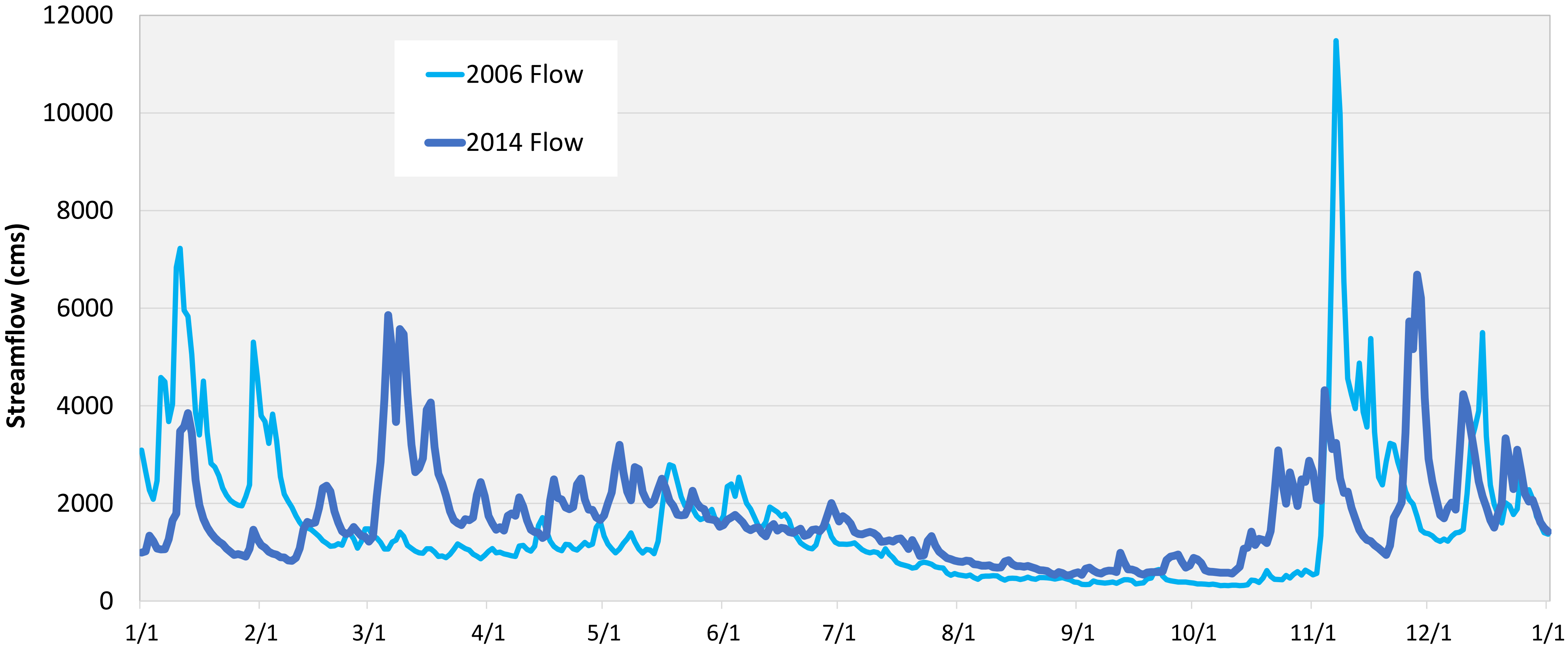
# Seasonal differences



# 2006 vs. 2014 river flows into Puget Sound



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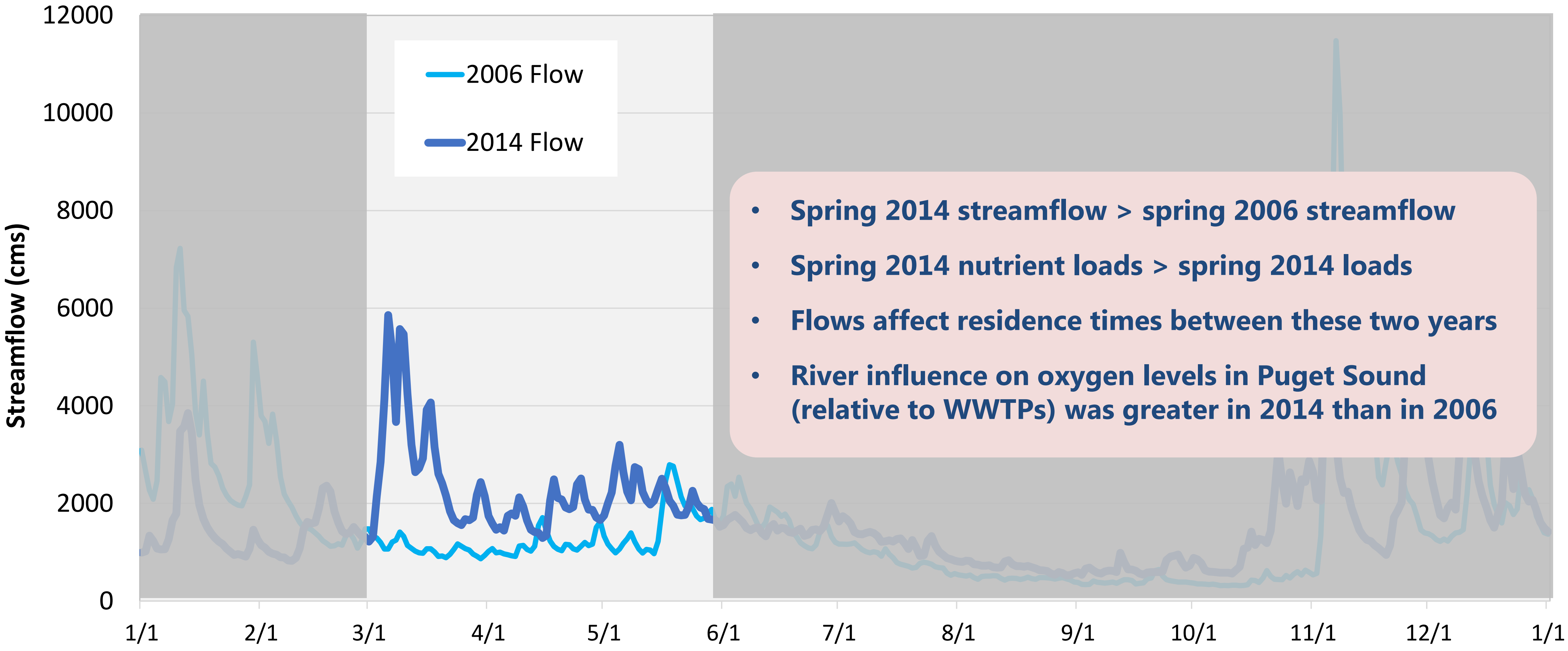
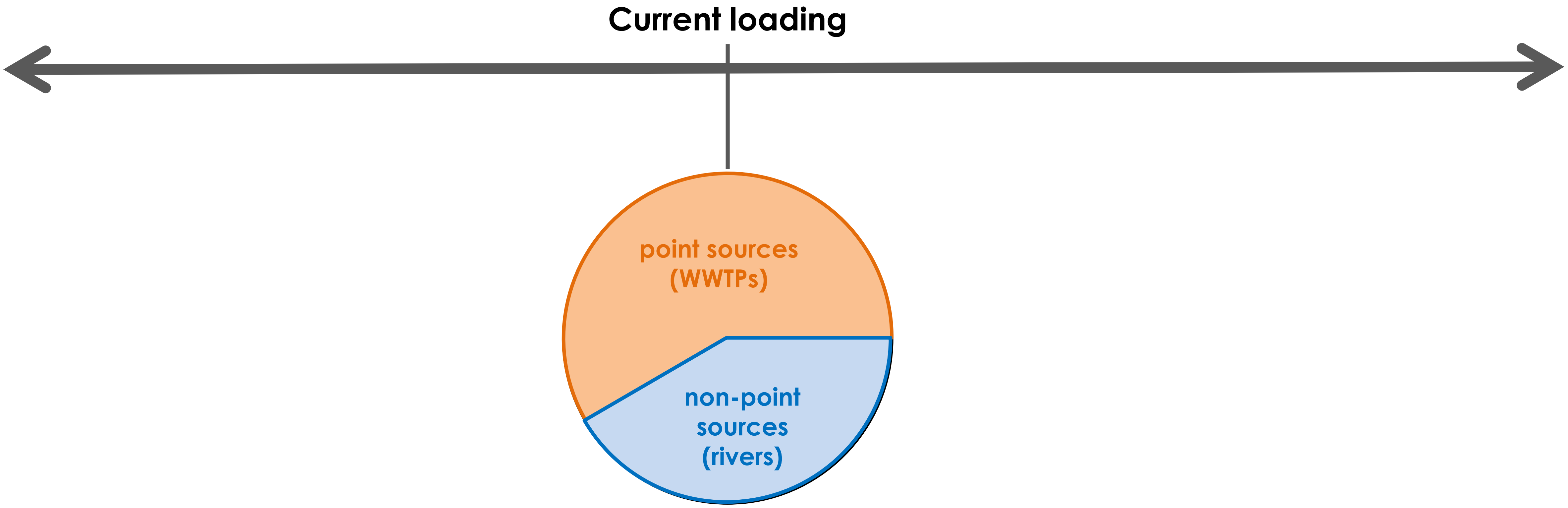



- **Spring 2014 streamflow > spring 2006 streamflow**
- **Spring 2014 nutrient loads > spring 2014 loads**
- **Flows affect residence times between these two years**
- **River influence on oxygen levels in Puget Sound (relative to WWTPs) was greater in 2014 than in 2006**

# Reference Conditions



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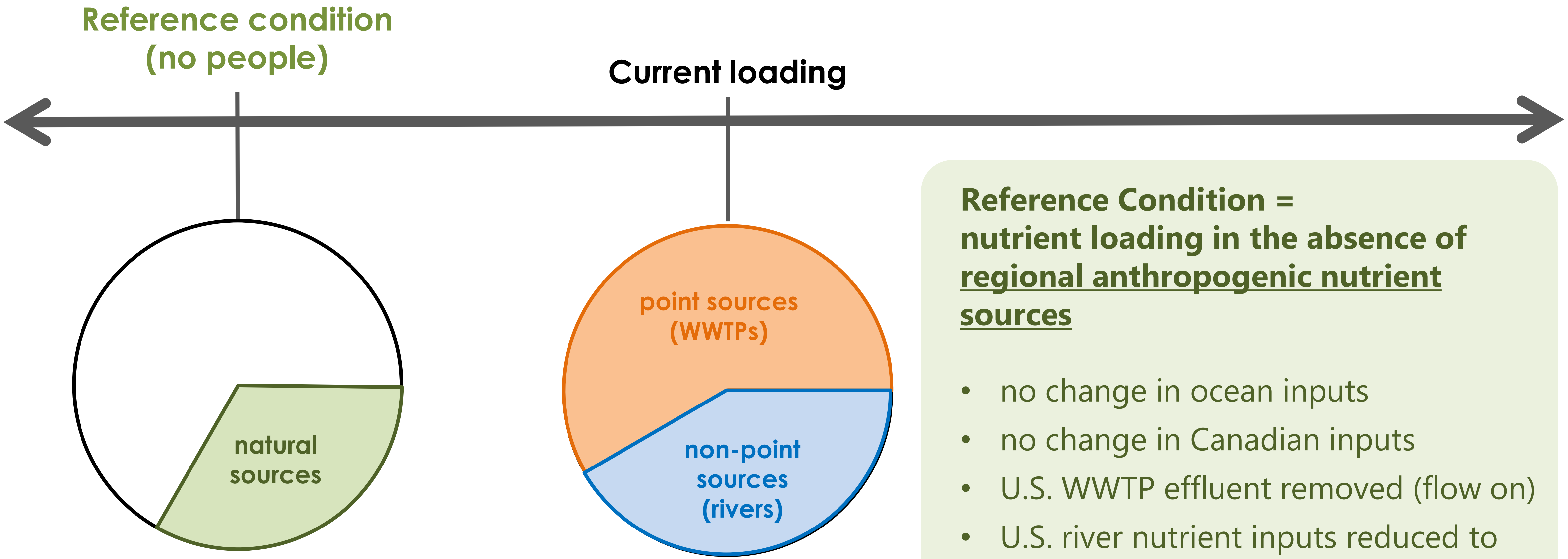
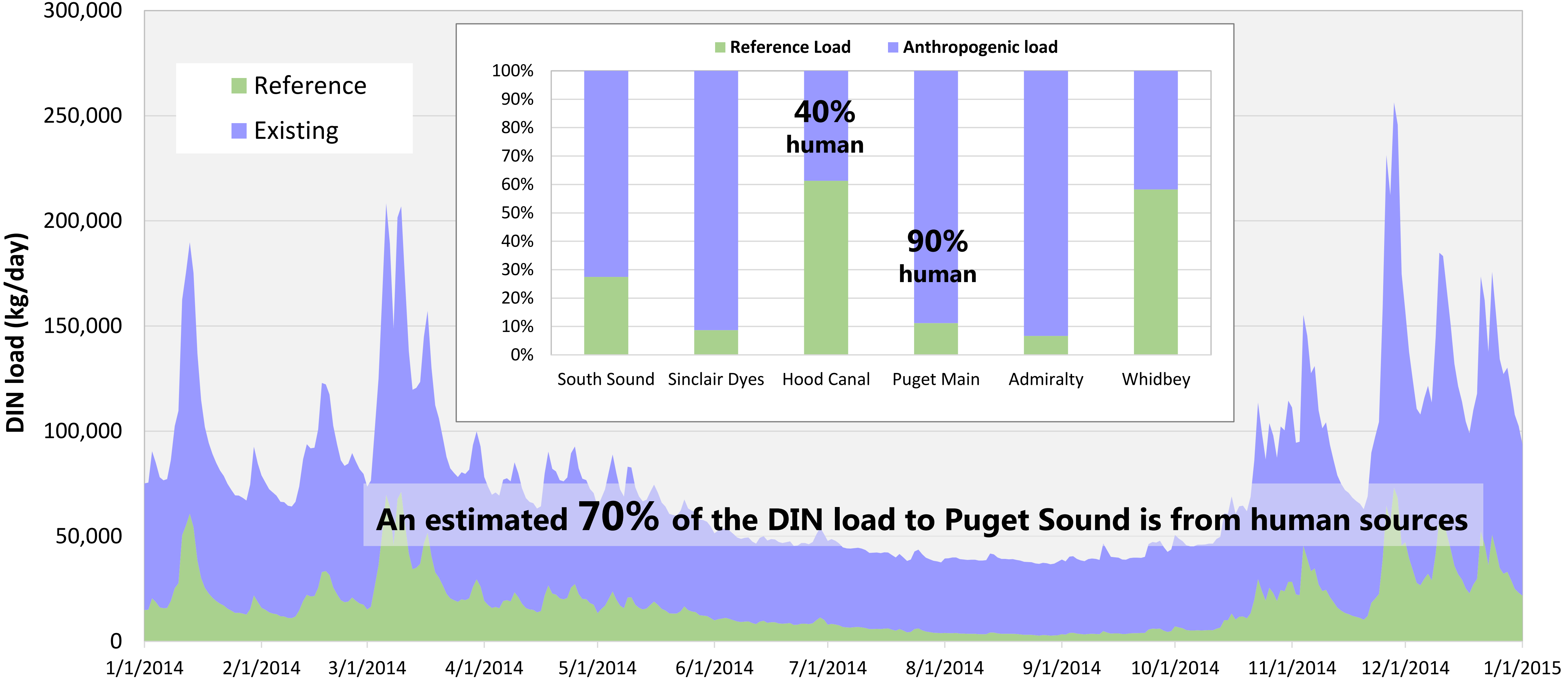



Published in Mohamedali et. al. (2011), updated in Pelletier et. al. (2017, Appendix B), estimates may be refined further in 2017-2018

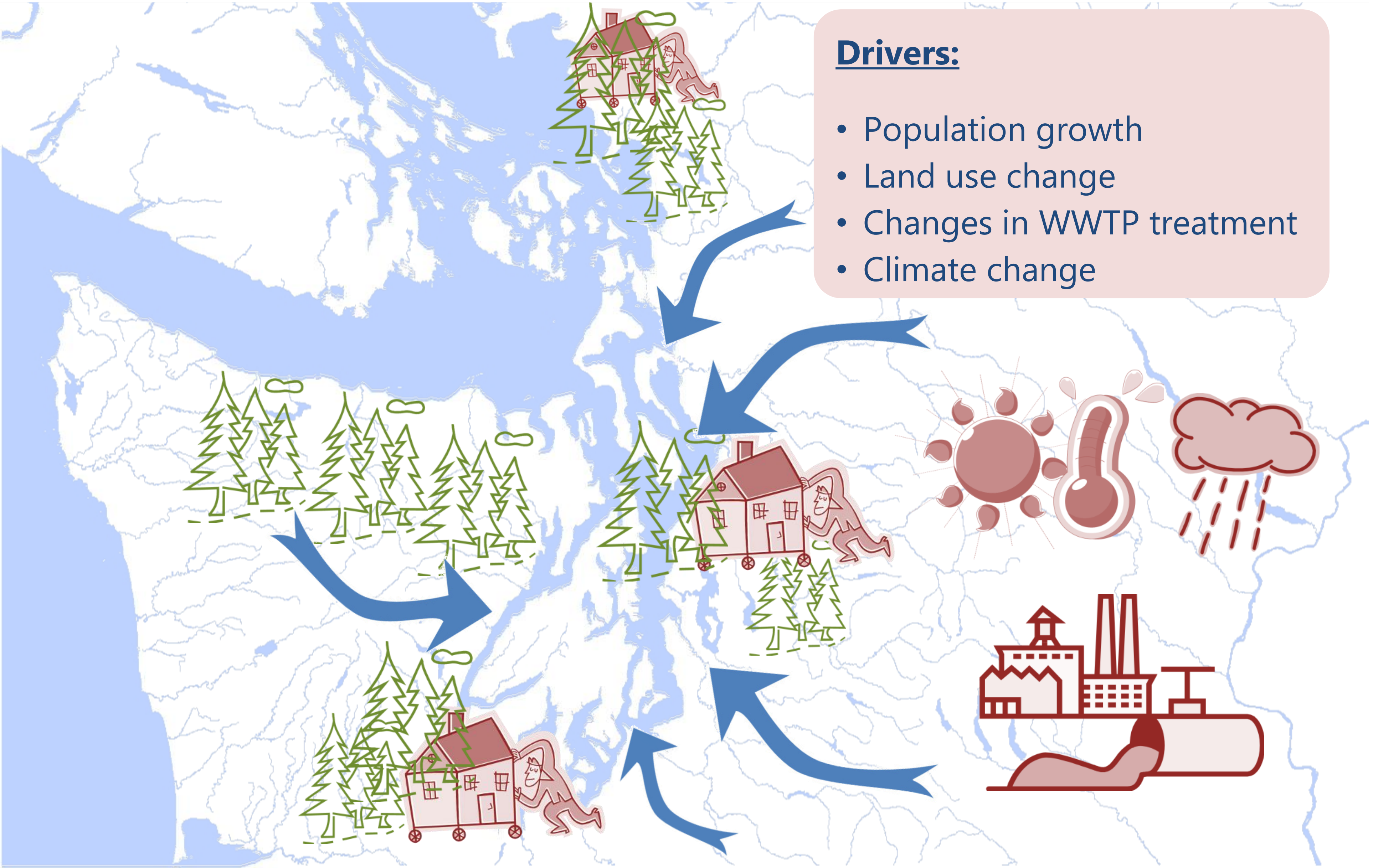
**Reference Condition = nutrient loading in the absence of <u>regional anthropogenic nutrient sources</u>**

- no change in ocean inputs
- no change in Canadian inputs
- U.S. WWTP effluent removed (flow on)
- U.S. river nutrient inputs reduced to estimate reference concentrations (no change in flow)

# Human vs. reference DIN loads in Puget Sound



# Future nutrient loading



**Drivers:**

- Population growth
- Land use change
- Changes in WWTP treatment
- Climate change

# Questions?

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## Next Steps

- **Continuous monitoring at select rivers -** to improve temporal resolution of nutrient inputs – our current statistical method may be underestimating river loading during rain events
- **Salish Sea Model runs to evaluate high-level impacts/influences of management actions** e.g. if the largest WWTPs had Biological Nutrient Removal technologies
- **Climate change and population growth scenarios** - refinement of previous estimates
- **Puget Sound Nutrient Reduction Project** – project that will be guided using the Salish Sea Model
- **Continuous technical improvement as time and resources allow**

## For more information:

**Salish Sea Model:** https://ecology.wa.gov/Research-Data/Data-resources/Models-spreadsheets/Modeling-the-environment/Salish-Sea-modeling (includes links to all model related publications)

**Reducing nutrients in Puget Sound:** https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients

**Nitrogen in Puget Sound - A Story Map:** https://waecy.maps.arcgis.com/apps/MapSeries/index.html?appid=907dd54271f44aa0b1f08efd7efc4e30

**Contacts:**
Teizeen Mohamedali: teizeen.mohamedali@ecy.wa.gov
Cristiana Figueroa-Kaminsky: c.figueroa-kaminsky@ecy.wa.gov