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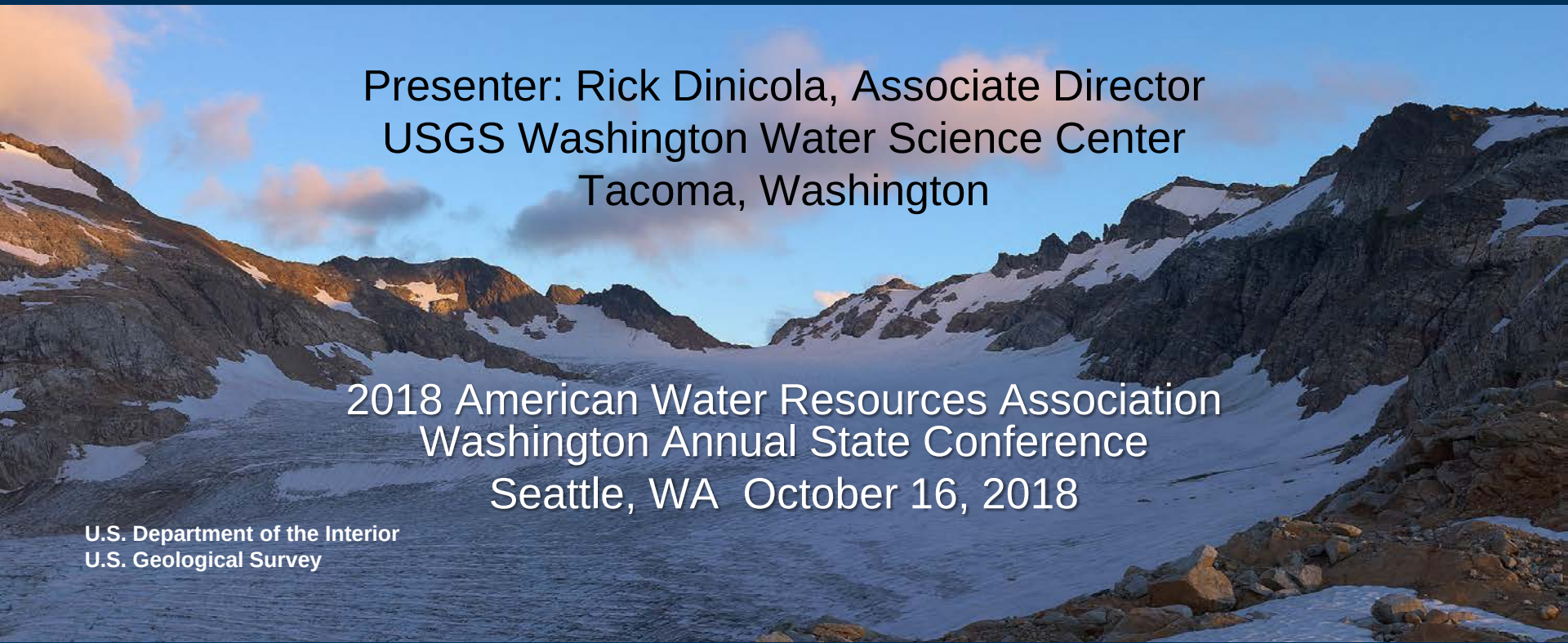
Anticipated Impacts of Climate Change on Western Washington Groundwater and Stream Baseflows



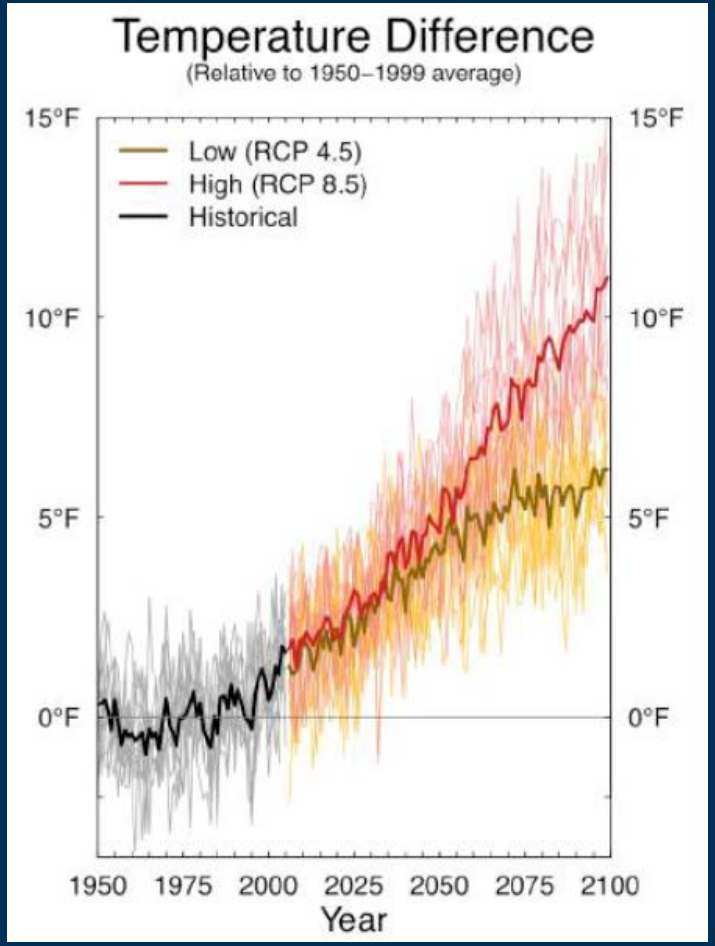
Presenter: Rick Dinicola, Associate Director
USGS Washington Water Science Center
Tacoma, Washington

2018 American Water Resources Association
Washington Annual State Conference
Seattle, WA October 16, 2018

U.S. Department of the Interior
U.S. Geological Survey

Today's presentation

- Informed conceptual model of potential climate change impacts to groundwater and baseflows in western WA
- Support for the conceptual model from recent applications of Puget Sound groundwater models
- Approach underway for evaluating impacts of climate change and population growth on groundwater and baseflows throughout the Puget Sound Aquifer System



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Abatzoglou and Brown, 2011

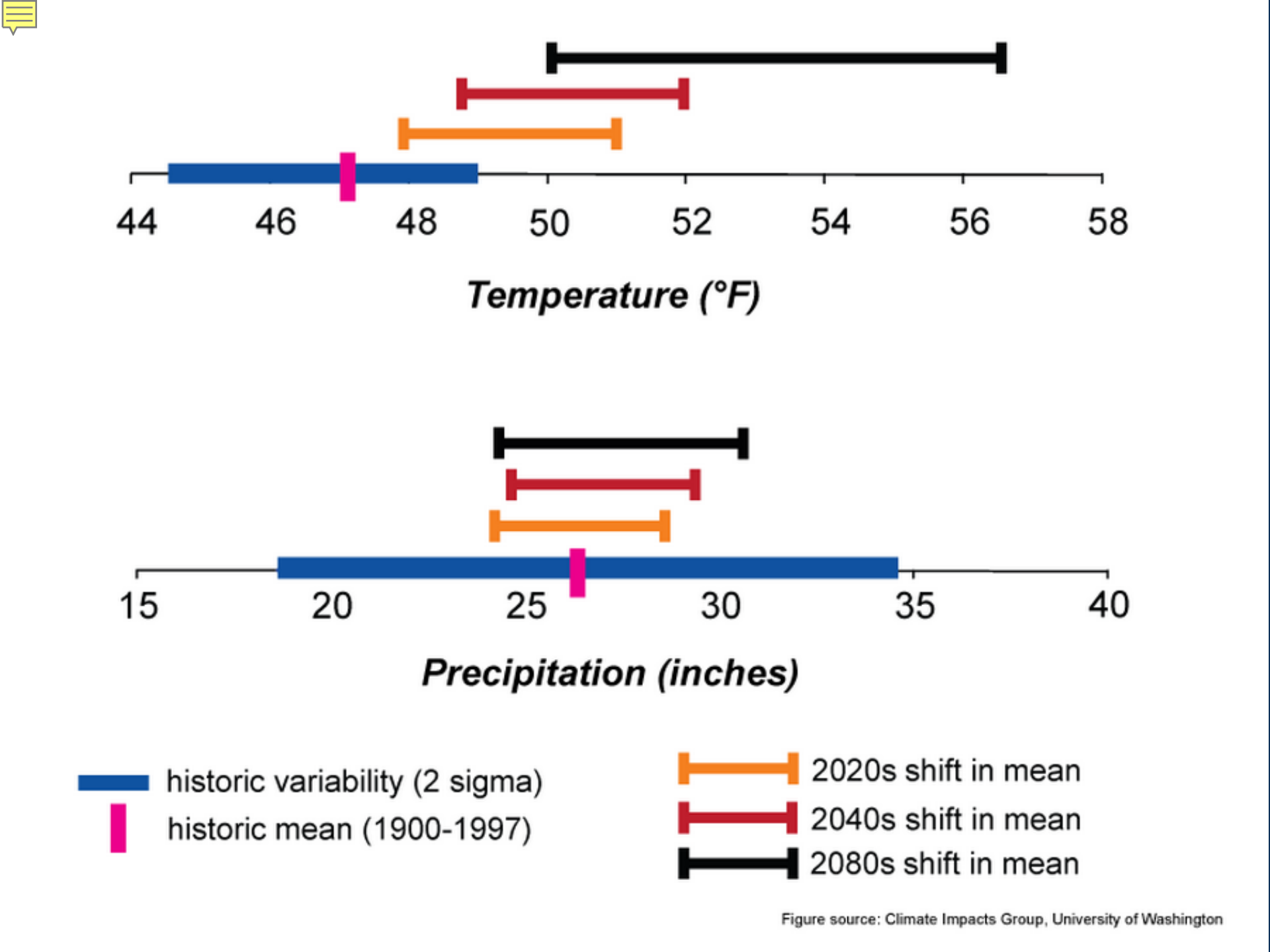
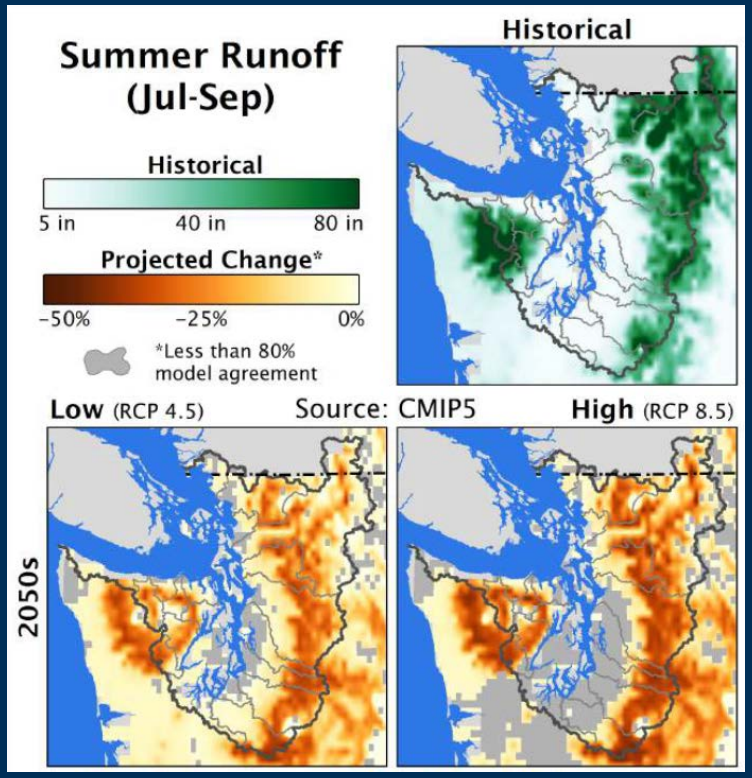


Figure source: Climate Impacts Group, University of Washington

Informed conceptual model of potential climate change impacts

Two primary elements of the conceptual model:

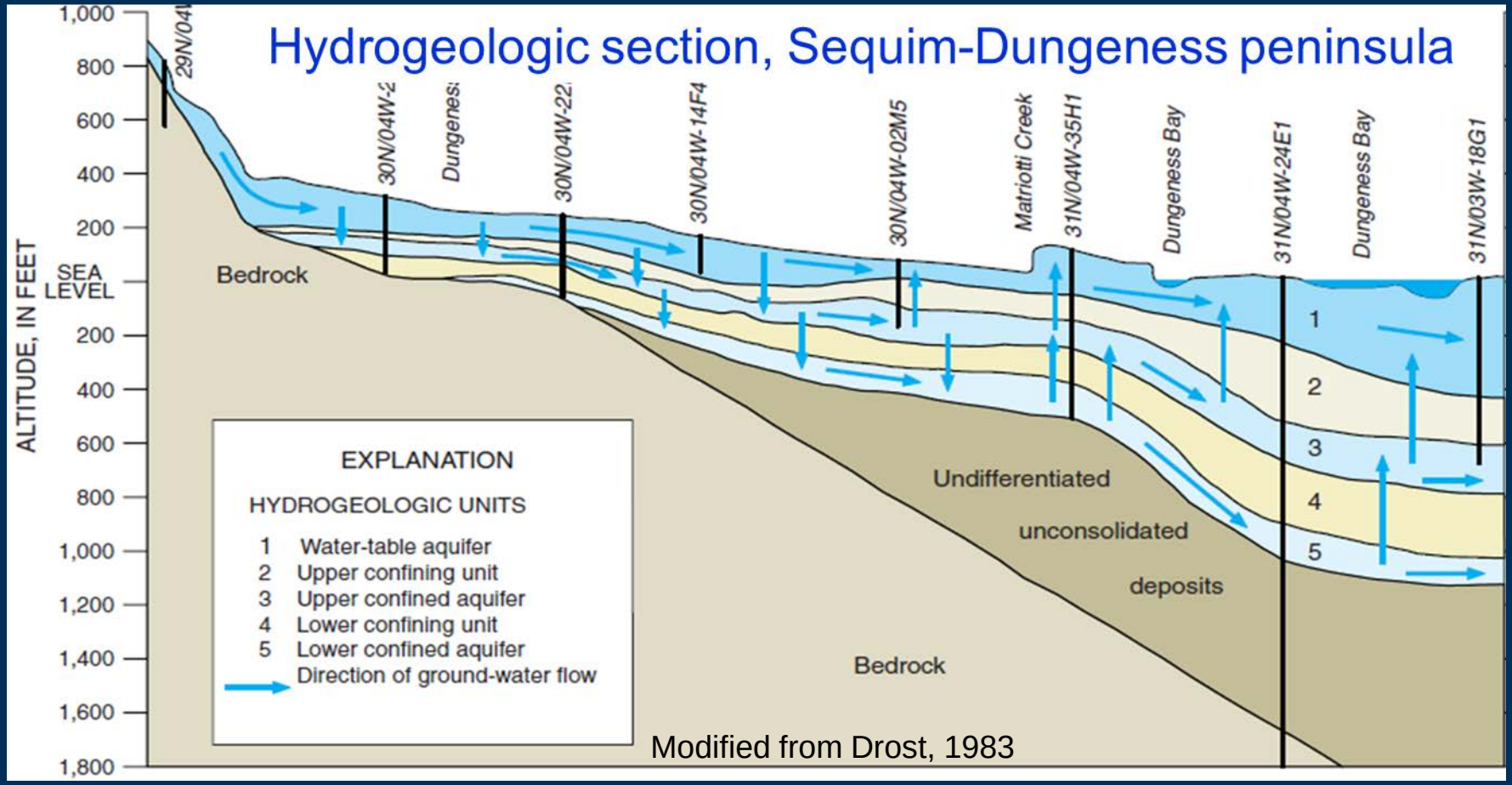
- Impacts on groundwater recharge and storage
- Impacts on groundwater/surface-water interactions and summer baseflows



Mote et. al. 2015

Climate change impacts on groundwater recharge and storage

- Direct impacts expected only in basins that rely on mountain front recharge or are semi-arid



Climate change impacts on groundwater recharge and storage (cont.)

- Direct impacts expected only in basins that rely on mountain front recharge or semi-arid areas with limited recharge
- As with annual precipitation, natural variability in recharge will remain large compared to long term trends expected from climate change

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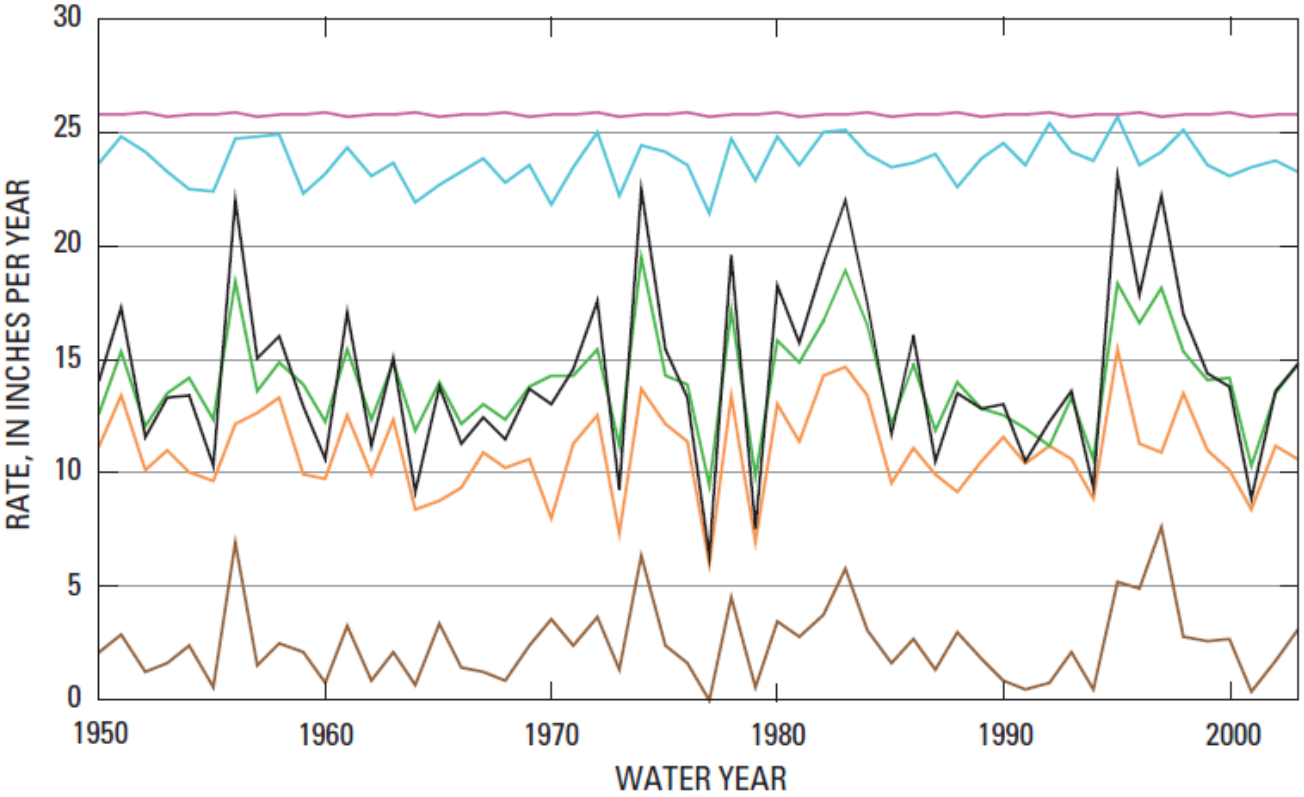
Variability in simulated water budget

Lower Naches River



EXPLANATION

- Precipitation
- Irrigation
- Predevelopment actual evapotranspiration
- Current actual evapotranspiration
- Predevelopment recharge
- Current recharge

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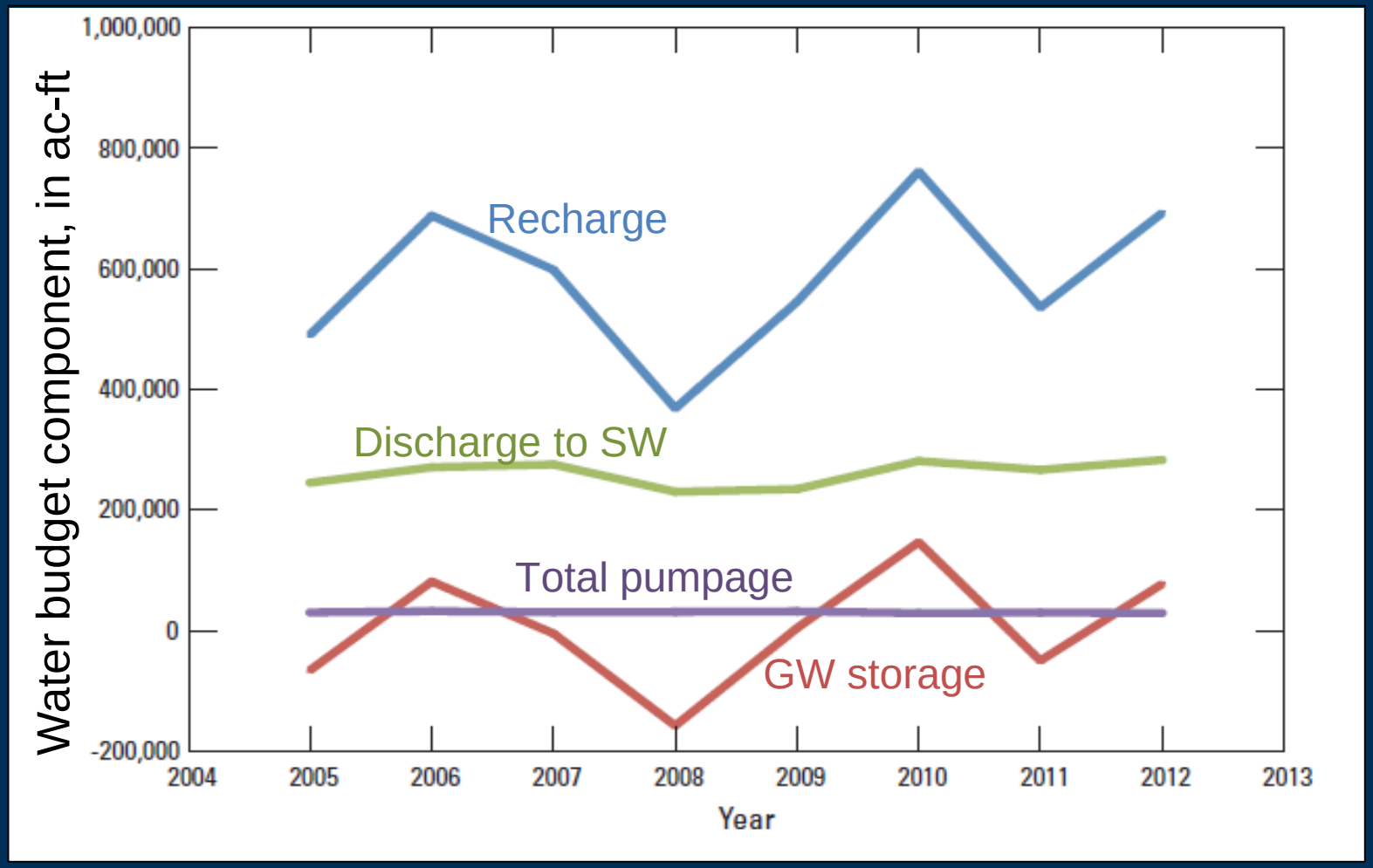
From Vaccaro and Olsen, 2007

Variability in simulated water budget
Kitsap Peninsula



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From Frans and Olsen, 2016

Impacts on groundwater/surface-water interactions and summer baseflows

- Wet winters will not guarantee high summer baseflows

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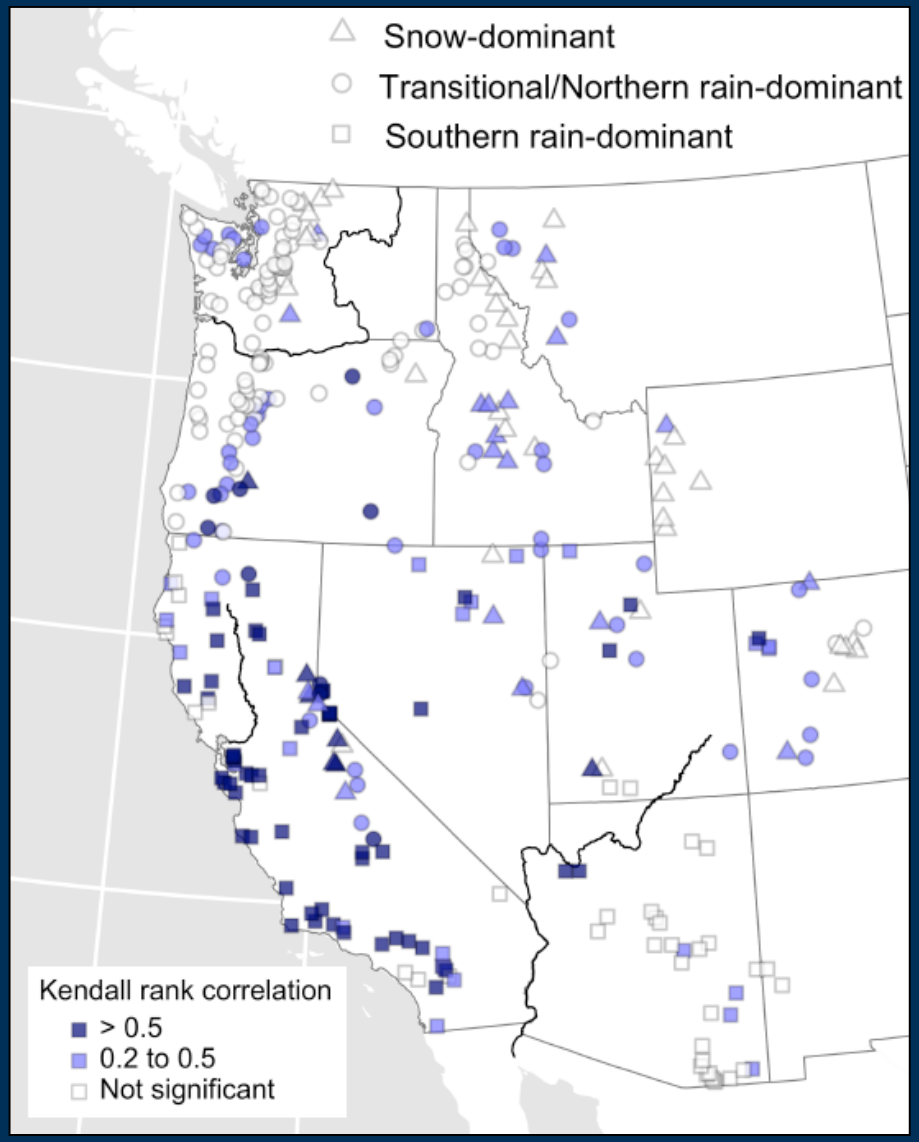
Wet winters will not guarantee high summer baseflows

- Jul-Sep streamflow is strongly correlated with Oct-Mar streamflow in areas receiving little spring or summer rain
- The correlation is weak for areas (like WA) that can receive substantial spring or summer rain



Journal of Hydrometeorology, Konrad, in press

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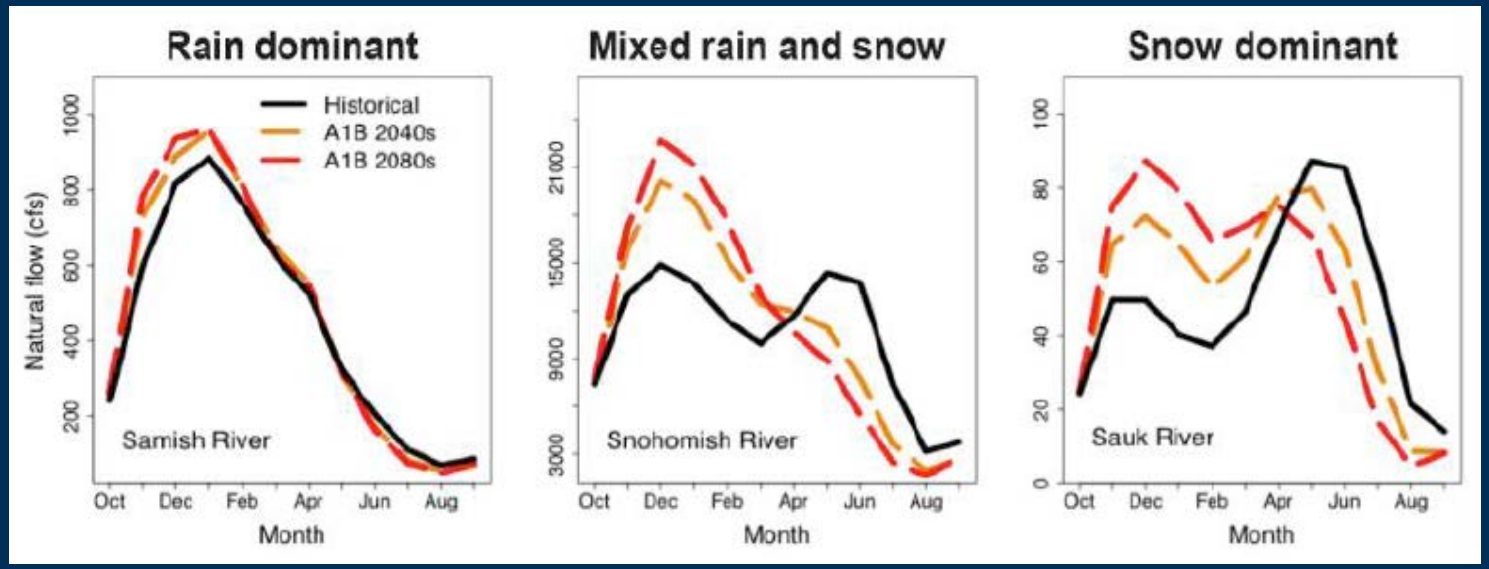
Impacts on groundwater/surface-water interactions and summer baseflows

- Wet winters do not guarantee high summer baseflows
- Impacts will differ for snow or rain dominated basins, and upland or lowland basins



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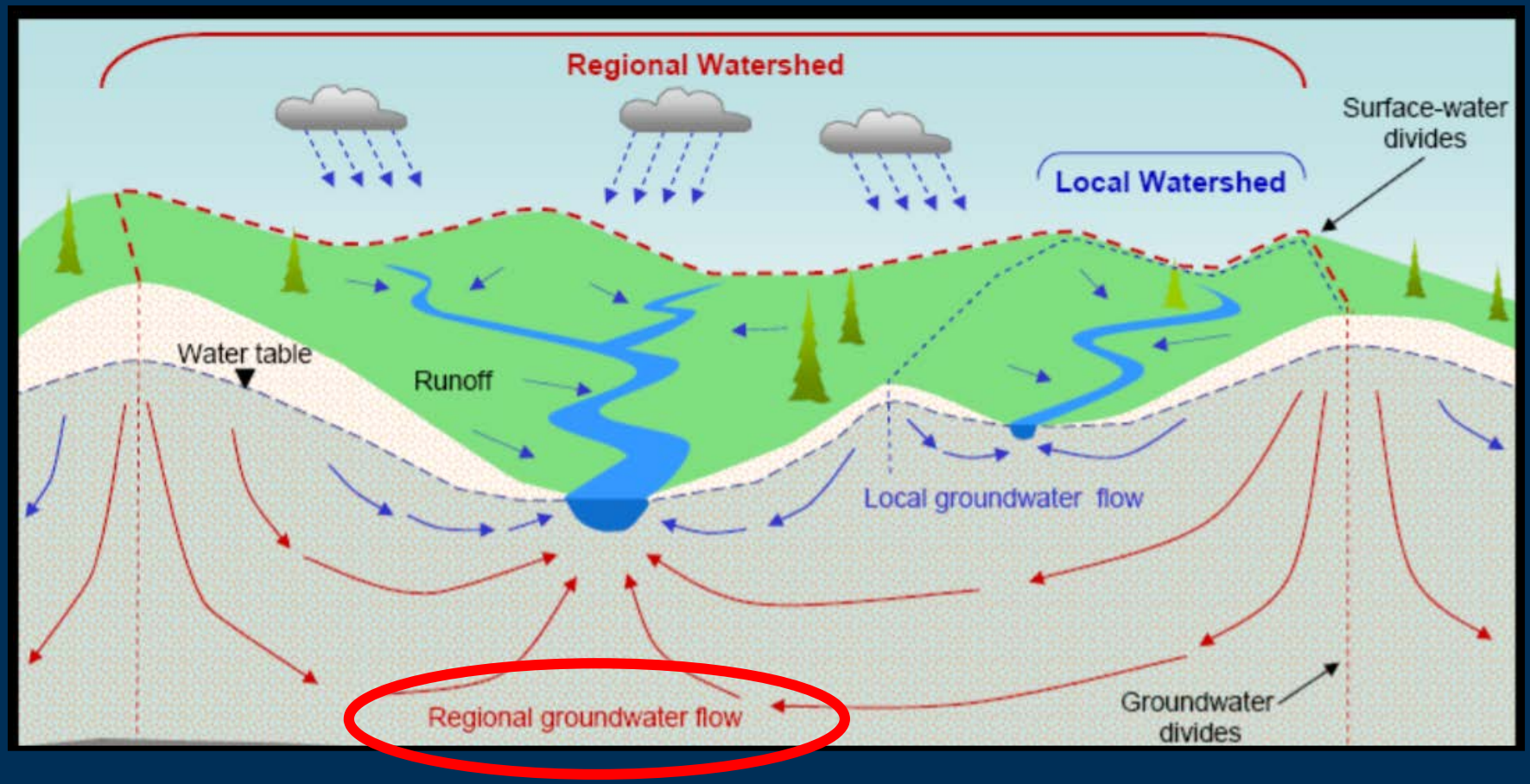
Summer baseflows in upland vs lowland basins



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Impacts on groundwater/surface-water interactions and summer baseflows

- Wet winters do not guarantee high summer baseflows
- Impacts will differ for snow or rain dominated basins, and upland or lowland basins
- Indirect impacts will be significant
  - Increased pumping to accommodate increased population and to mitigate drought
  - Less recharge due to more impervious surfaces
  - Increased evapotranspiration demand
  - Increased baseflow in urban areas with imported water

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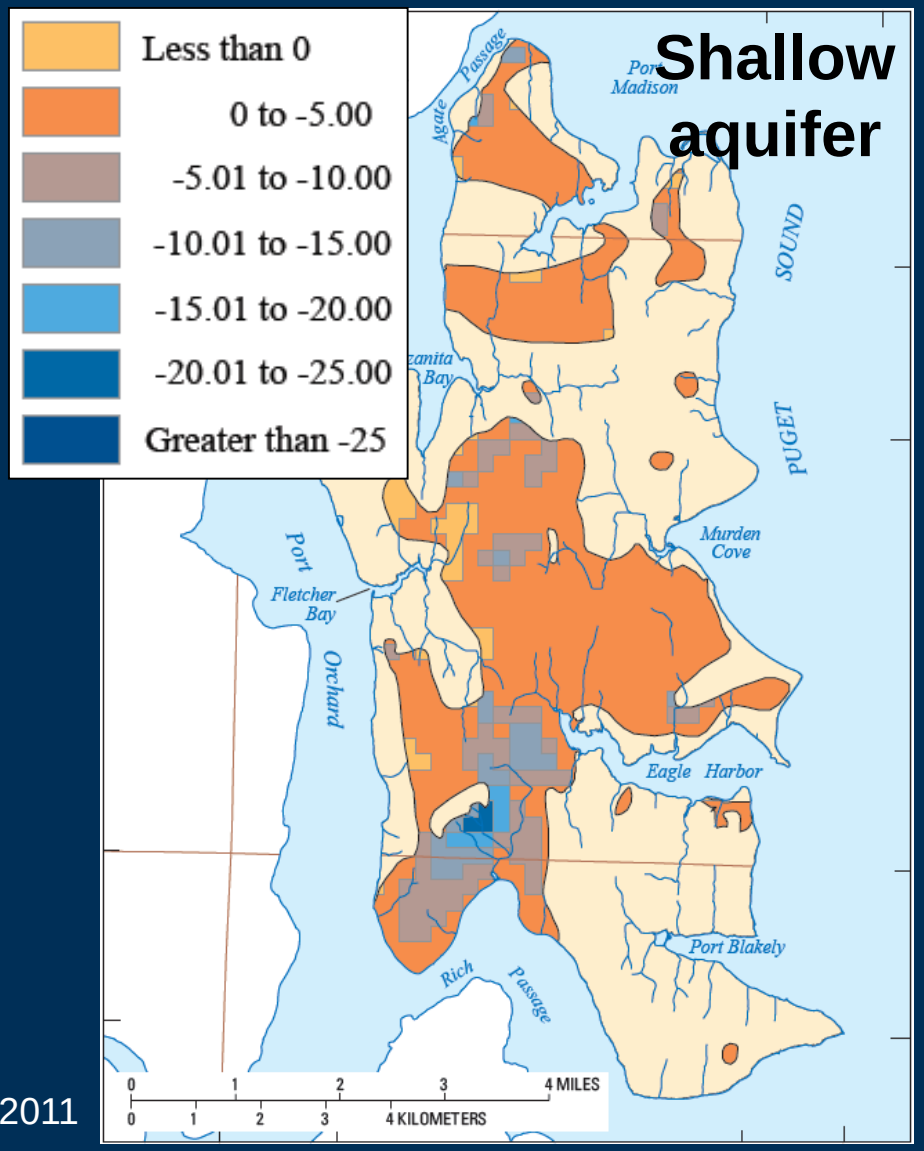
Indirect effects of expected change in recharge – Bainbridge Island

Simulated 37% increase in population and pumpage, and 4% increase in recharge (from climate change) 2008-2035

- Water-levels in shallow aquifer decreased slightly (mostly < 5-ft)
- Effects dominated by change in pumpage rather than the climate change induced slight increase in recharge



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Frans et al, 2011

Impacts on groundwater/surface-water interactions and summer baseflows

- Wet winters do not guarantee high summer baseflows
- Impacts will differ for snow or rain dominated basins, and upland or lowland basins
- Indirect impacts will be significant
- Changes in recharge would need to be much larger than expected to substantially impact most Puget Sound baseflows

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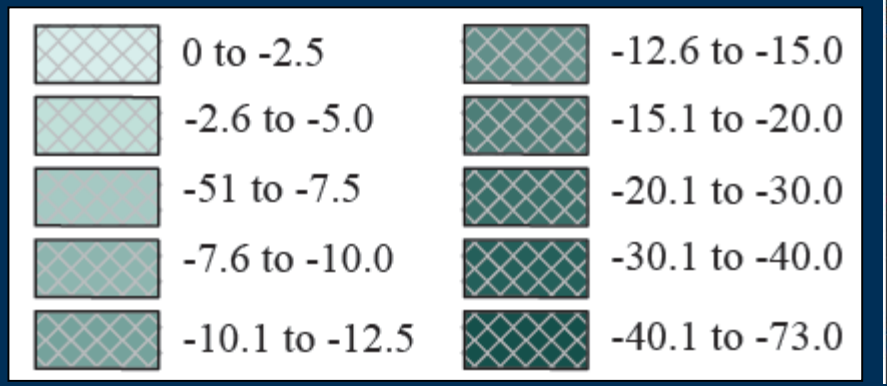
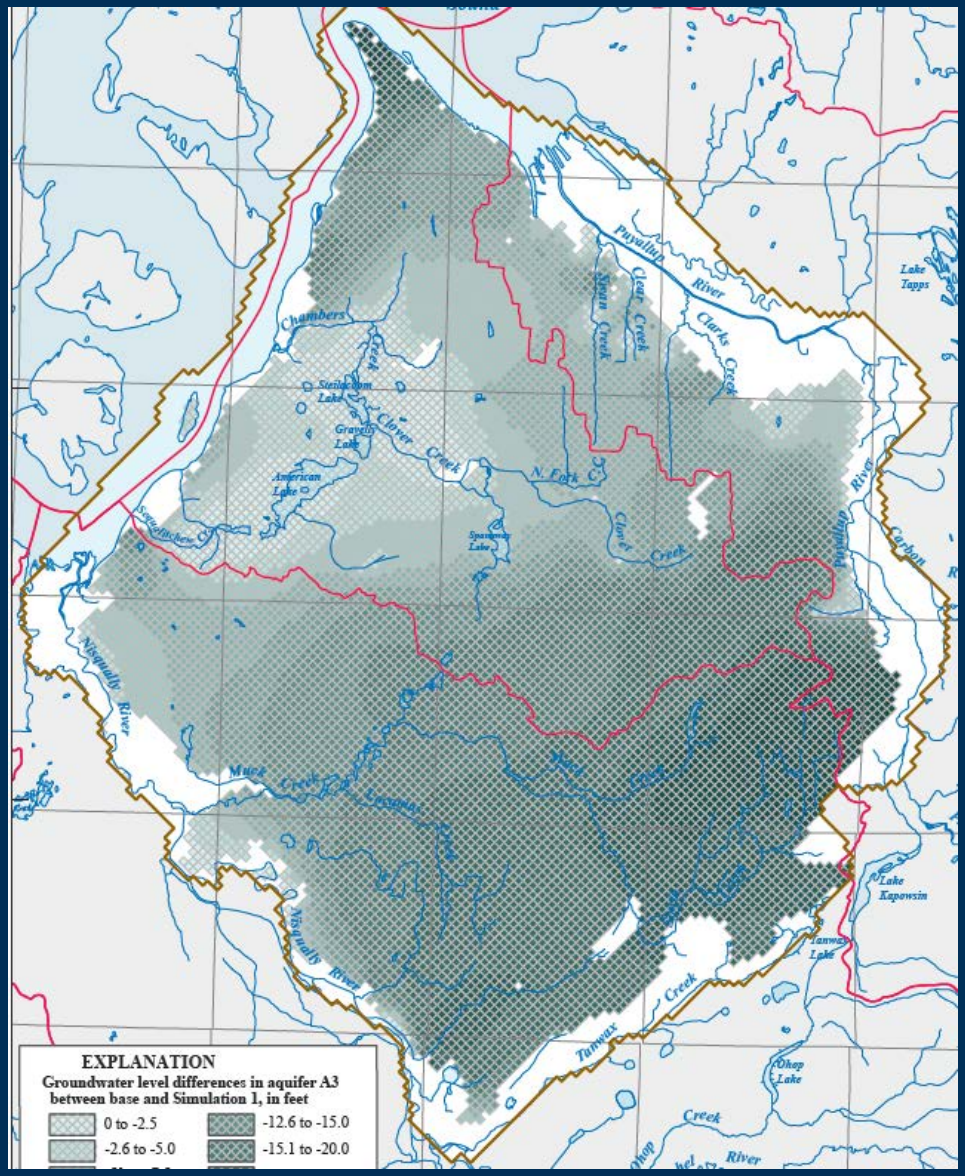
Substantial reduction in recharge

Chambers-Clover Basin

Simulated long-term 20% reduction in recharge

- Widespread declines in groundwater levels
- Reversal of GW-SW exchange from SW gaining 17,300-AF/yr to SW losing 23,000 AF/yr



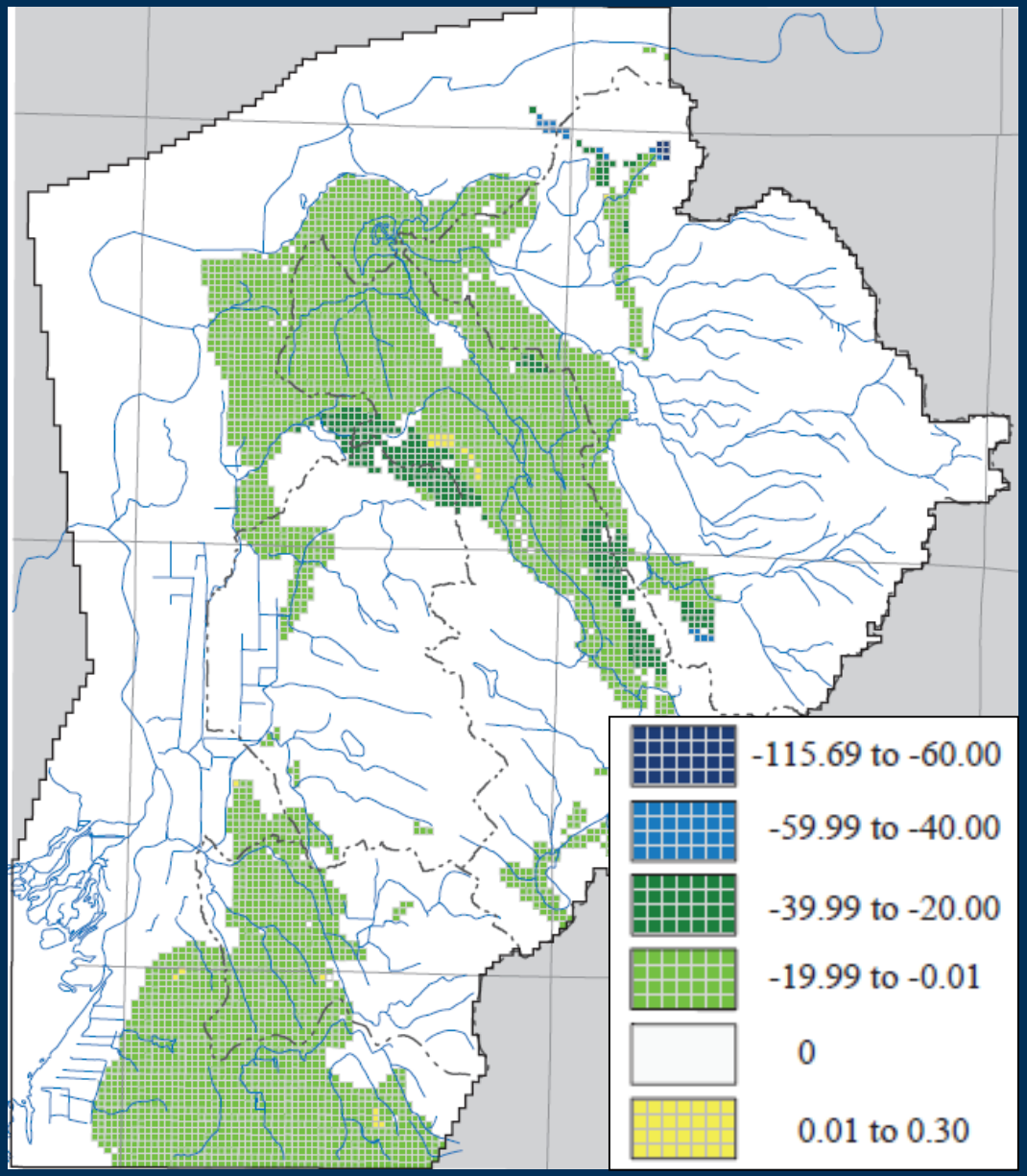


Substantial reduction in recharge

Lower Skagit trib. Basins

Simulated long-term 20% reduction in recharge

- Widespread declines in groundwater levels
- The reduction in recharge resulted in a nearly equal reduction in GW discharge to streams



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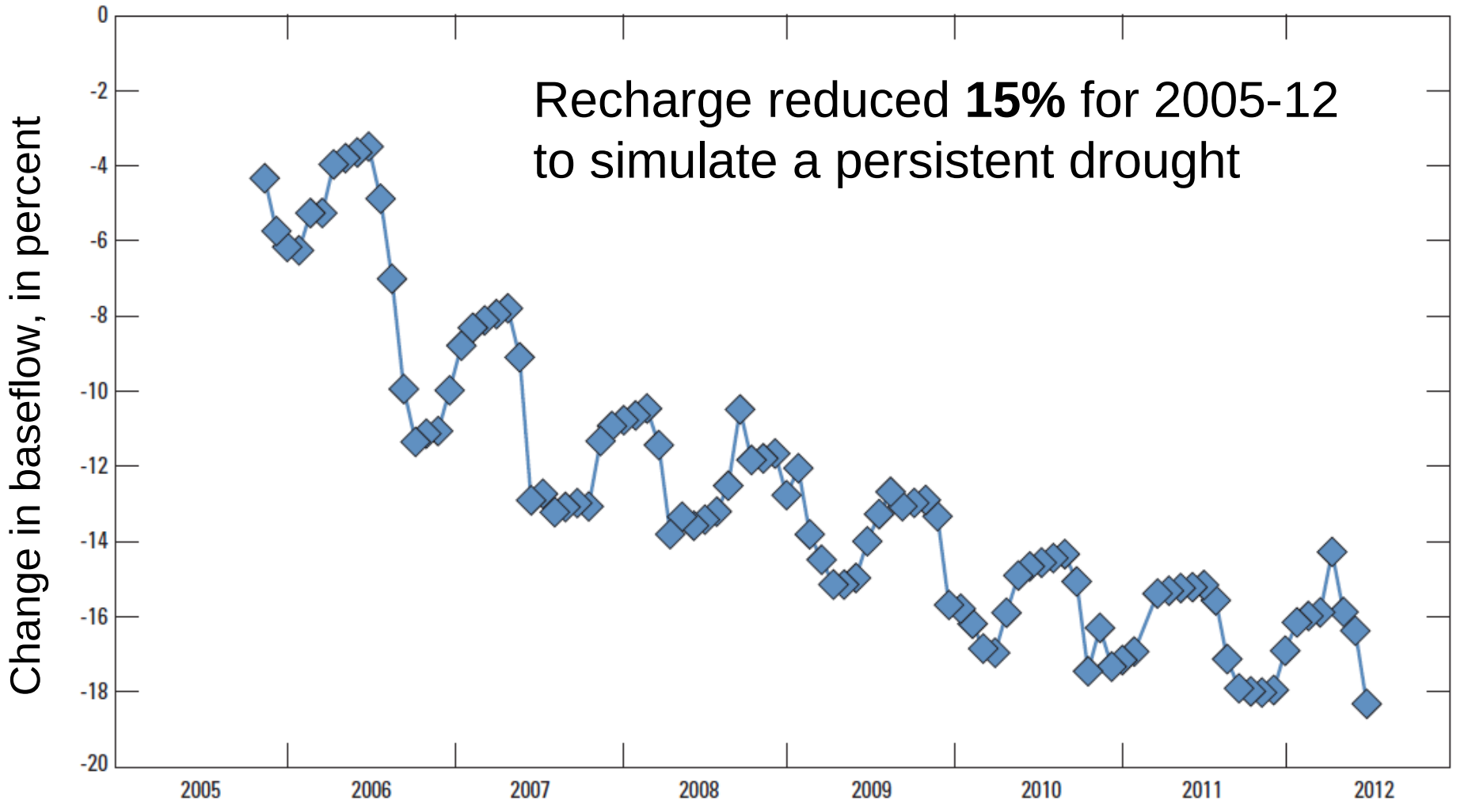
Substantial reduction in recharge

Kitsap Peninsula



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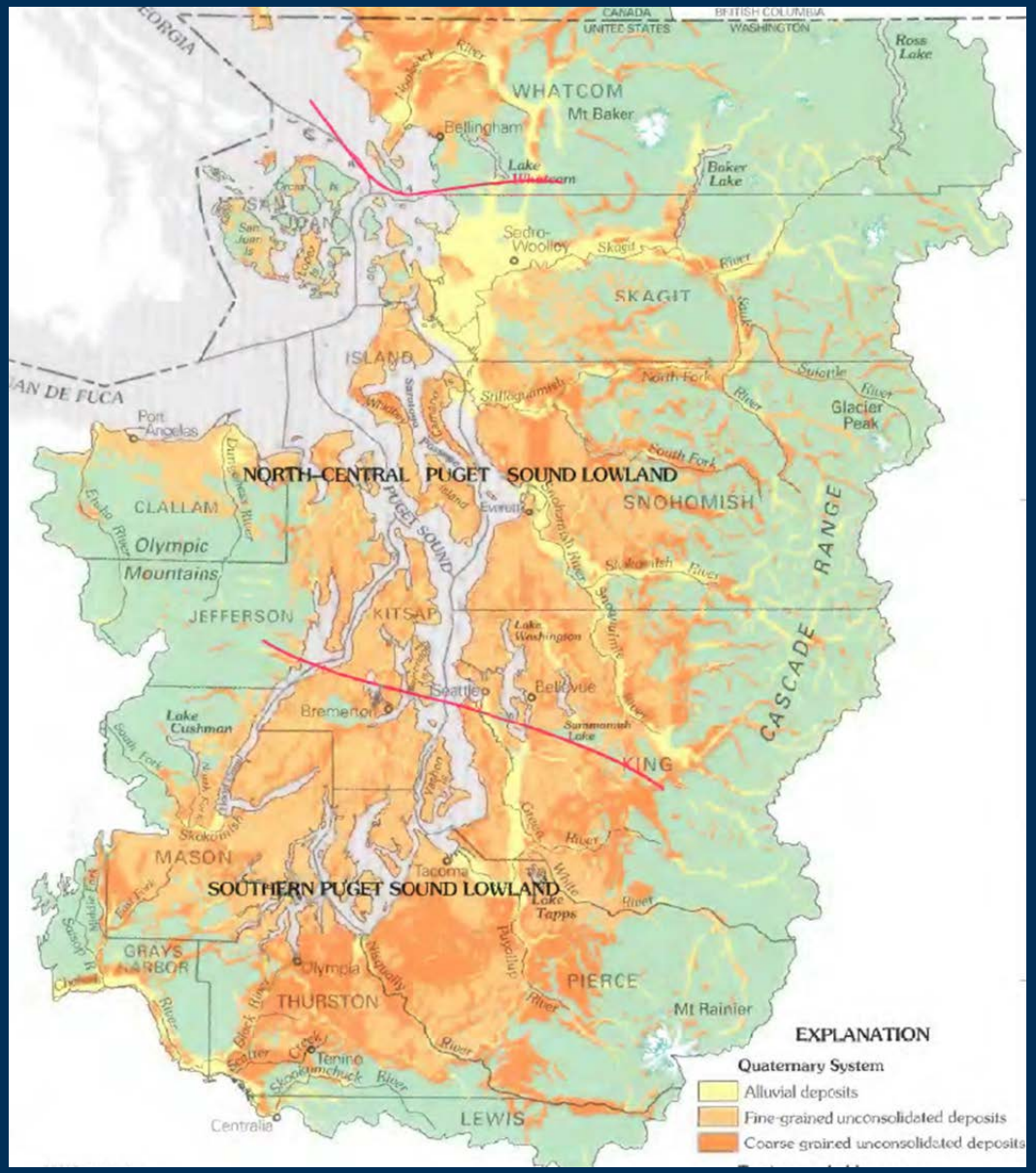
Groundwater budgets for Puget Sound Lowland basins

A Near-Term Action for the Puget Sound Partnership's 2018-2020 Action Agenda



Alluvial deposits

Fine-grained unconsolidated deposits

Coarse-grained unconsolidated deposits

Tertiary and older systems

Basement confining unit

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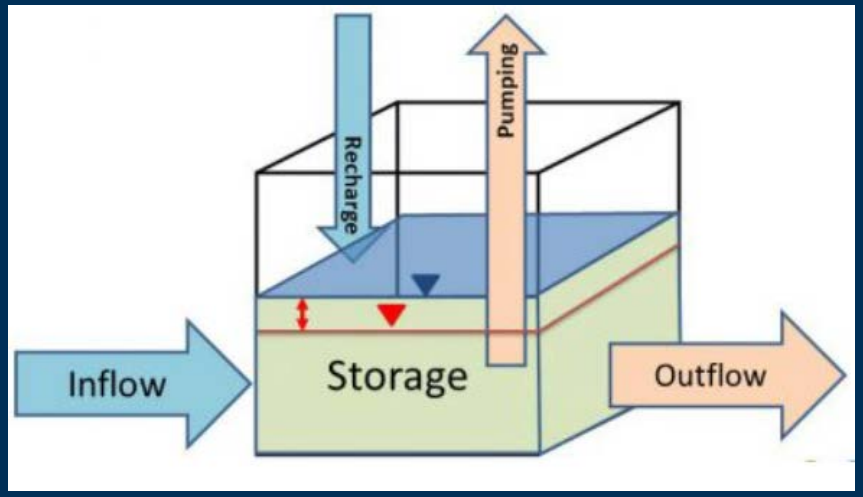
Groundwater budgets for Puget Sound Lowland basins - Objective

- Provide hydrogeologic and water-use information to water-resources stakeholders to foster development of water management and planning strategies that protect instream flows while ensuring water supplies for domestic, agricultural, and other out-of-stream uses.



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Groundwater budgets for Puget Sound lowland basins - Approach

- Compile monthly groundwater budgets and related hydrogeologic information for subbasins underlain by the ~7,200 sq-mi Puget Sound Regional Aquifer System
- Budgets compiled for approximately 36 lowland subbasins
  - Groundwater recharge using the Soil Water Balance model
  - Groundwater use (withdrawals and consumptive use)
  - Groundwater discharge to streams and rivers and directly to Puget Sound
  - Current surface-water withdrawals and streamflows to allow a holistic comparison of water demands, summer baseflows, and groundwater availability across the range of hydrogeologic settings of Puget Sound.

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Groundwater budgets for Puget Sound lowland basins - Approach (cont.)

- Groundwater budgets being compiled for 2015 conditions and ~2040 conditions with expected changes due to:
  - Changes in recharge due to climate change and increased impervious surfaces
  - Changes in groundwater use due to population growth
- Generate refined monthly groundwater budgets for selected subbasins where transient numerical groundwater models are available

Stay tuned for results in late 2019!

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Photo: Pugetsoundstreambenthos.org