Puget Sound Nutrient Forum
July 17, 2019 10am-11:30am

Webex: Please register here.

At the July 17 Nutrient Forum, we will present the final modeling scenarios to be tested by the Salish Sea Model in 2019-2020. At the April 30 Nutrient Forum, we presented draft scenarios to the Forum and collected your feedback and proposed changes to the draft scenarios. We considered this feedback and worked with the Puget Sound Nutrient Source Reduction Project Steering Committee and Salish Sea Modeling Team to revise and finalize the modeling scenarios.

Included in this packet:

Final List of Salish Sea Modeling Scenarios 2019-2020

This list includes the five scenarios we plan to model in Year 1 with a table of the associated runs for each scenario. Please refer to glossary in this packet if you are unfamiliar with the modeling terms used.

Scenario 1: Watershed Significance by Basin

Objective: Understand the relative significance of existing watershed nutrient loads, grouped by Puget Sound basin, compared to reference dissolved oxygen (DO) conditions.

Scenario Runs:

- Keep marine point sources to existing levels.
- Evaluate impacts of watersheds by keeping watershed loading into one basin at reference loads and set watershed loadings into other basins to existing conditions. Repeat for each basin.
- Calculate anthropogenic impact of watersheds with the 2006 and 2014 reference condition.

Scenario 1 Runs: Watershed by basin	Input Year	Marine point sources	Watershed Sources
1. South Sound at reference	2006	Existing conditions	All other basins at existing conditions
2. Main Basin at reference	2006	Existing conditions	All other basins at existing conditions
3. Whidbey Basin at reference	2006	Existing conditions	All other basins at existing conditions
4. Hood Canal at reference	2006	Existing conditions	All other basins at existing conditions
5. Admiralty Inlet/Strait of Juan de Fuca at reference	2006	Existing conditions	All other basins at existing conditions
6. Padilla/Samish/Bellingham Bay/Strait of Georgia at reference	2006	Existing conditions	All other basins at existing conditions
7. South Sound at reference	2014	Existing conditions	All other basins at existing conditions
8. Main Basin at reference	2014	Existing conditions	All other basins at existing conditions
9. Whidbey Basin at reference	2014	Existing conditions	All other basins at existing conditions
10. Hood Canal at reference	2014	Existing conditions	All other basins at existing conditions

11. Admiralty Inlet/Strait of Juan de Fuca at reference	2014	Existing conditions	All other basins at existing conditions
12. Padilla/Samish/Bellingham Bay/Strait of Georgia at reference	2014	Existing conditions	All other basins at existing conditions

Scenario 2: Marine Point Source Reductions by Basin

Objective: Understand the relative significance of marine point sources, grouped by Puget Sound Basin, compared to reference DO conditions.

Scenario Runs:

- Set watershed sources to existing conditions.
- Set marine point sources discharging into one basin at reference conditions and set marine point sources discharging into all other basins to existing conditions. Repeat for each basin.
- Calculate anthropogenic impact with the 2006 reference condition.

Scenario 2 Runs: Marine point sources by basin	Input Year	Marine point sources	Watershed sources
1. South Sound at reference	2006	All other basins at existing conditions	Existing conditions
2. Main Basin at reference	2006	All other basins at existing conditions	Existing conditions
3. Whidbey Basin at reference	2006	All other basins at existing conditions	Existing conditions
4. Hood Canal at reference	2006	All other basins at existing conditions	Existing conditions
5. Admiralty Inlet/Strait of Juan de Fuca at reference	2006	All other basins at existing conditions	Existing conditions
6. Padilla/Samish/Bellingham Bay/Strait of Georgia at reference	2006	All other basins at existing conditions	Existing conditions

Scenario 3: Annual vs. Seasonal Marine Point Source Nutrient Load Reductions

Objective: Understand wastewater seasonal nutrient load reductions compared to reductions in annual loading and the resulting improvement to water quality.

Scenario Runs:

- Set marine point sources to assumed specific level of dissolved inorganic nitrogen (DIN) reduction (and commensurate dissolved organic carbon (DOC) reduction) with operational levels year-round.
- Compare to bounding scenario runs (seasonal treatment levels of 8mg/L)

Scenario 3 Runs: Annual vs. Seasonal loading	Input Year	Marine point sources	Watershed sources
1. Annual marine point source reductions	2006	All marine point sources at advanced treatment level	Existing conditions

*This run will be compared to the seasonal marine point source reductions run that was already modeled in the Bounding Scenarios Report. In the Bounding Scenarios Report, we modeled all marine point sources at advanced treatment levels from April-October.

Scenario 4: Future Population Growth

Objectives: Understand the impacts of population growth on future DO levels.

Scenario Runs:

- Set a baseline condition scenario with marine and watershed sources at reference levels of DIN.

Population growth runs:

- Use existing ocean boundary and climate conditions and marine wastewater effluent flows with population growth at 2040 levels under the 'low' population growth projections from Office of Financial Management (OFM).
- Use existing ocean boundary and climate conditions and marine wastewater effluent flows with population growth at 2040 levels under the 'high' population growth projections from Office of Financial Management (OFM).

Scenario 4 Runs: Future population growth & climate change	Boundary condition Year	Marine point sources	Watershed sources	Population Estimate
1. Future population growth (low estimate)	2014	Future flow, existing water quality conditions	Existing conditions	OFM 2040 Low population estimate
2. Future population growth (high estimate)	2014	Future flow, existing water quality conditions	Existing conditions	OFM 2040 High population estimate

Scenario 5: Everybody, Everywhere

Objective: Understand the total nutrient reductions needed to meet DO standards in Puget Sound through testing the improvement from a range of nutrients reductions at marine point sources and watershed sources.

Scenario 5 will be a series of runs, with differing combination of nutrients reductions at marine point sources and watershed sources. The exact inputs for these runs will be determined based on the results of Scenarios 1 and 2. The goal of this set of runs is to determine combinations of reductions that meet DO standards. Scenario 5 is different than others because it will be an adaptive process of ratcheting up or down nutrient reductions at different sources. Each run will be informed by the previous runs.

Scenario Runs:

- Set marine point sources at advanced nutrient removal levels.
- Set watershed sources at total anthropogenic DIN load reductions.
- Adapt marine point source and watershed sources inputs

Scenario 5 Runs: Everybody, everywhere	**Input Year**	**Marine point sources**	**Watershed sources**
1. Combined reductions of watersheds and marine point sources	2006	Initial input TBD: All WWTPs at advanced treatment level	Initial input TBD: Watershed inputs at reasonable reduction %
2-10. We expect to test 10 runs of different combinations of nutrient reductions	2006	TBD- adaptations of WWTPs at advanced treatment levels	TBD- adaptations of watershed inputs at reduction %

Responses to Forum Feedback

Below is a matrix of the Forum's proposed changes to the draft modeling scenarios presented at the April 30 Nutrient Forum. We have included the reasoning as to why we did or did not incorporate the change into the final set of scenarios.

Scenario 1: Watershed Significance by Puget Sound Basin

Objective: Understand the relative significance of existing watershed nutrient loads, grouped by Puget Sound basin, compared to reference dissolved oxygen (DO) conditions.

Proposed changes to scenario

Proposed Change	Details	Y or N	Reason
Change to Inputs	Run the inverse of proposed scenario: • Set focus basin at reference conditions • Set other basins at existing conditions.	Yes	We have decided to make this change to the draft scenario because we agree this will best address the non-linearity of how nutrient reductions may impact DO levels.
Geographic Framework	Separate Whidbey Basin so that Snohomish and Skagit river inputs are separated	No	We agree that separating Whidbey Basin will be useful in understanding watershed loadings. However, the number of additional scenarios exceeds our work capacity for Year-1. We will include it in our "Parking Lot" of runs to revisit for Year-2 modeling.
	Separate Sinclair Inlet from Main Basins	No	We agree that separating Sinclair and Dyes Inlets from the Main Basin can help us understand any near-field vs. far-field nutrient impacts within Main Basin. However, the number of additional scenarios exceeds our work capacity for Year-1. We will include this run in our "Parking Lot" of runs to revisit for Year-2 modeling.
	Separate discharges from Strait of Juan de Fuca with Admiralty Inlet Basin	No	If the budget and schedule allows within Year-1, we will add these additional runs. Otherwise, we will include this run in our "Parking Lot" of runs to revisit for Year-2 modeling.
Watershed input	Run this as a nutrient reduction scenario by running	No	As we understand the comment, this would require modeling watersheds to understand the nutrient reductions in

	watersheds with discharges that are meeting DO standards		freshwater to meet DO criteria there if there is currently an impairment. At this time we don't have a regional model that would allow us to determine freshwater nutrient reductions necessary for identified impaired freshwater. Watershed loads are represented in the model with the different nutrient species that interact with the marine water biogeochemistry that results in changes to dissolved oxygen. Watershed inflows are not assigned a DO value for the input. However, Scenario 5 will begin to address the impacts of nutrient reduction within watersheds on Puget Sound DO levels.
Additional Boundaries	Include population growth and climate change boundaries in this scenario.	No	We will not include these inputs in Scenario 1 due to our sequencing. We will use Scenario 4 to understand population growth. We will model climate change projections in Year 2. We may include these as inputs in more scenarios in Year-2 modeling.

Scenario 2: Marine Point Source Significance by Puget Sound Basin

Objective: Understand the relative significance of marine point sources, grouped by Puget Sound Basin, compared to reference DO conditions.

Proposed changes to scenario

Proposed Change	Details	Y or N	Reason
Change to Inputs	Run the inverse of proposed scenario: • Set focus basin for marine point source discharges to reference conditions • Set other basins at existing conditions.	Yes	We have decided to make this change to the draft scenario because we agree this will best address the non-linearity of how nutrient reductions may impact DO levels.
Geographic Framework	Separate Whidbey Basin so that Snohomish and Skagit river inputs are separated	No	We agree that separating Whidbey Basin will be useful in understanding watershed loadings. However, the number of additional scenarios exceeds our work capacity for Year-

			1. We will include it in our "Parking Lot" of runs to revisit for Year-2 modeling.
	Separate Sinclair Inlet from Main Basins	No	We agree that separating Sinclair Inlet will help us better understand near vs. far-field impacts of nutrient loading into the Main Basin. However, the number of additional scenarios exceeds our work capacity for Year-1. We will include it in our "Parking Lot" of runs to revisit for Year-2 modeling.
	Separate discharges from Strait of Juan de Fuca with Admiralty Inlet Basin	No	If the budget and schedule allows within Year-1, we will add these additional runs. Otherwise, we will include this run in our "Parking Lot" of runs to revisit for Year-2 modeling.
Marine point source nutrient levels	Run scenario at reduction levels by basin so that we continue to model impacts of advanced wastewater treatment	No	This is a potential scenario for the future and we have put this in our "Parking lot" to reconsider for Year-2 modeling.
Suggested other approach	Turn all small treatment plants on at once and turn off big treatment plants.	No	The Bounding Scenarios report gave us a good enough look at differing impacts between small and large treatment plants so we feel this run is not as valuable as the others.
Additional runs	Suggestion to model both this scenario and the inverse of this scenario to understand the full impacts of nutrient loading to Puget Sound AND the impact of reductions to Puget Sound.	No	We are unable to run both the draft scenario and inverse within our scheduling, but we have included this additional scenario in our "Parking lot" for Year-2.

Scenario 3: Annual vs. Seasonal Marine Source Nutrient Load Reductions

Objective: Understand wastewater seasonal nutrient load reductions compared to reductions in annual loading and the resulting improvement to water quality.

Proposed changes to scenario

Proposed Change	Details	Y or N	Reason
Watershed inputs	Consider putting watersheds at reference conditions vs. putting them at existing conditions	No	This will be too many input changes for the scenario.
Marine Point Source Treatment levels	For annual treatment input, run winter season at lower treatment level (ex:16 mg/L) and spring time at lesser concentration (8mg/L or less)	No	We typically only want to change one variable at a time in each run and this proposal changes both timing and treatment efficiency variables, and would confound comparison to the seasonal reductions from the bounding scenarios. However, this run may be useful in the future as we refine our understanding of impacts of different treatment levels. We will keep this scenario in the "Parking Lot" to be considered in Year 2 modeling.
	Choose treatment levels in lbs./year instead of concentrations since permits are issued with lbs./year limit.	Yes	This is not a change to the scenario, but we can start to report model and report results with a loading measurement that better aligns with permitting limits and loading capacities.
	Consider Total nitrogen (TN) vs. Total inorganic nitrogen (TIN) in annual vs. seasonal loadings.	No	We used dissolved inorganic nitrogen (DIN) as our loading parameter for nitrogen. DIN includes nitrate, nitrite, and ammonia and DIN loadings should not differ much from TN. However, algae can only use dissolved forms of nitrogen and any organic nitrogen must be converted to DIN before it is used.

Suggested other approach	Conduct cost-benefit analysis in place of running model scenario to better understand if seasonal or annual advanced treatment is more economically reasonable	No	This model run may help us understand the benefits of seasonal vs. annual treatment. Conducting a cost-benefit analysis is also quite expensive. We are considering how to incorporate cost-effectiveness analyses as we move forward with our nutrient management plan.

Scenario 4: Future Population Growth and Climate Change

Objectives: Understand the impacts of population growth on future DO levels.

Proposed changes to scenarios

Proposed Change	Details	Y or N	Reason
Future population projection year	Change the future population projection input year to 2050 or 2060, depending on how good we feel about the data input. Should be mindful of the capital-planning horizon.	No	A 2040 population growth projection from OFM will have less uncertainty than further out population projections. We also use 2040 to match the timeline for regional growth planning. We may consider other available future population estimates in future modeling.
Marine Point Source Treatment levels	Business as usual scenario: Change the marine point sources to existing conditions instead of reference conditions. This would show us what would happen if we do not intervene.	Yes	We want to understand the impact of additional nutrient loads from marine sources with future population at the current levels of treatment. The assumption we need to make is for running current monthly average nitrogen and carbon concentrations but at future influent flows due to population increase. We can only do this with marine sources until we have a watershed model.
Suggested other approach	Separate population growth and climate change inputs as individual scenarios The future population growth should be analyzed as a separate scenario as it would provide the most useful and comparable information to the other	Yes	We will run future population growth and climate change separately. In Year 1, we will run future population growth runs. We will delay climate change scenario runs to Year 2 modeling.

	scenarios of understanding the effects of loads on future changes in location, magnitude, and duration of DO responses		
Sequencing	Understanding the effects of climate change to DO response will be much more useful when refined scenarios are developed in Year-2 or beyond.	Yes	We will delay the climate change runs in Scenario 4 until Year 2 of modeling. This may also allow for us to improve our climate change inputs.
	Move this scenario to Year-2 modeling schedule due to uncertainty of many model inputs.	No	We mostly likely will not have improved future growth or climate change inputs by Year-2.
Climate Change input	Climate change inputs should use high projections, no reason to consider lower levels of climate change because these won't happen.	Yes, in Year 2.	We would like to understand the worst-case scenarios of climate change, and understanding the answers provided by the other scenarios is a higher priority for us in Year-1. We will delay climate change runs until Year 2 to use this time to use best climate change input data. A recent study using the SSM (Khangaonkar et al, 2019[1]) will help inform our next steps
Change from scenario to boundary conditions	Population growth and climate change are boundary conditions, not scenarios. These should be inputs in each scenario.	No	This suggestion is just a matter of semantics. This scenario is about the impact of future populations and climate so those inputs are the variables and we compare that to existing conditions to see how much worse water quality will get.

[1] Khangaonkar, T., Nugraha, A., Xu, W., & Balaguru, K. (2019). Salish Sea response to global climate change, sea level rise, and future nutrient loads. Journal of Geophysical Research: Oceans, 124. https://doi.org/10.1029/2018JC014670

Scenario 5: Everybody, Everywhere

Objective: Understand the total nutrient reductions needed to meet DO standards in Puget Sound through testing the improvement from a range of nutrients reductions at marine point sources and watershed sources.

Proposed changes to scenarios from Forum

No specific proposed changes, but we did receive questions on how we will decide inputs and how this scenario will be used.

Questions about inputs	Details	Reasons
Watershed sources	What is a reasonable reduction nutrient reduction for watershed sources?	We will determine the watershed source inputs after we have modeled Scenario 1. Scenario 1 will give us a better idea of how different geographic areas impact DO levels in Puget Sound. We can use this information to inform combinations of nutrient reductions that will meet DO standards in Puget Sound.
Marine point sources	How we will determine what level of advanced treatment to set the marine point sources?	This scenario will be an adaptive process and we expect to test ~10 different runs. Each run will be a different combination of nutrient reductions at marine point sources and watershed source. We may test multiple levels of advanced wastewater treatment and groupings of marine point sources.

Parking Lot of Modeling Scenarios for Year 2

The below scenarios were proposed by the Puget Sound Nutrient Forum. Due to limited resources and time, we are unable to model these scenarios in Year 1. We will revisit these proposed scenarios when we plan our Year 2 modeling.

Proposed changes to be reconsidered for Year-2:

- Sub-basin evaluation of significance of sensitive watersheds in basins including: Skagit and Snohomish in Whidbey Basin, tributaries to Sinclair-Dyes Inlet and Liberty Bay in the Main Basin, the Nooksack River in the Bellingham/Padilla/Samish Bays Basin, and key watershed inflows to the South Sound Basin.
- As a refinement run for Scenario 3: For marine source inputs, run "winter" season (Oct-Mar) at less restrictive treatment level (ex: monthly average DIN concentrations at 16 mg/L, exact levels to be determined) and Apr-Sep months at concentration more restrictive treatment level (e.g. monthly average DIN concentrations at 8mg/L or less, exact levels to be determined). Alternatively, could consider mass load differences between seasonal treatment.
- Alternate option for Scenario 4: Since we will run climate change and future population growth as separate runs, we will revisit and model the two inputs together.
- Consider marine source input loads on a seasonal average loading performance level based on concentrations and an annual limit based on total annual mass load.
- Develop attenuation/equivalency factors for human sources that can inform a WQ trading framework.
- Run final sets of marine and watershed source reductions based on what we learn about the most significant sources in Year-1.
- Analysis of SSM outputs could include examining the change in ocean-acidification parameters for key scenarios.
- Consider changes future changes in the ocean from climate change based on global model that includes ocean predictions at the SSM ocean boundary.

Glossary of terms

Advanced wastewater treatment

Advanced treatment is a general term for a wastewater treatment process that removes nitrogen before it is discharged into a water of the state. The treatment process removes nitrogen sequentially by nitrification under aerobic conditions and denitrification under anoxic conditions.

Existing conditions

Existing conditions are model outputs based on actual discharge conditions for a particular year (i.e. 2006, 2008, or 2014) and used to compare against reference conditions for that same year.

Marine point source

Point sources that discharge directly to marine waters of the Salish Sea and used as explicit model inputs including: municipal wastewater treatment plants (WWTP) and industrial facilities.

Anthropogenic dissolved oxygen (DO) depletion

DO depletion is the reduction of DO concentrations compared to an estimated reference condition that is due to human sources. It is calculated as the difference from reference conditions and existing conditions at each model grid cell including all water column layers.

Model run

A model run refers to a specific set of inputs tested by the Salish Sea Model. Some scenarios require multiple runs. Each model run changes at least one input (in some cases multiple inputs will be changed) to test the water quality response to that change, while other inputs stay the same.

Nonpoint source

Pollution that enters waters of the state from any dispersed land-based or water-based activities, including but not limited to atmospheric deposition, surface-water runoff from agricultural lands, urban areas, or forest lands, subsurface or underground sources, or discharges from boats or marine vessels not otherwise regulated under the NPDES program.

Nutrient load

Nutrient (nitrogen and carbon) loads quantify the amount of a nutrient entering Puget Sound in a given time period, where load = concentration x flow (e.g., lbs/day).

Reference conditions

Reference conditions are characterized by: existing ocean boundary and hydrologic conditions, and setting marine and watershed source inputs to estimated natural conditions. The reference condition helps calculate anthropogenic (human caused) DO depletion by providing a comparison to existing condition runs that use the same ocean boundary and hydrologic conditions but include human sources in marine and watershed inputs.

Scenario

A scenario refers to one model run or a set of model runs that when evaluated with the Salish Sea model informs the answers to a specific nutrient management question.

Watershed

A drainage area or basin in which all land and water areas drain or flow toward a central collector such as a stream, river, or lake at a lower elevation.

Watershed source

Specifically refers to the watershed input to the Salish Sea model. Watershed sources include both non-marine point and nonpoint nutrient sources and natural sources.

Puget Sound Basin Map: