Bounding Scenarios: A first step in testing nutrient reduction scenarios using the Salish Sea model

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Puget Sound Nutrient Forum

What are the bounding scenarios?

The Salish Sea model is a robust and complex computer model used to simulate the physical, chemical, and biological properties of the Salish Sea and Puget Sound. It is the primary tool Ecology uses to test nutrient reduction scenarios in order to identify a suite of potential human nutrient reductions that help meet marine water quality standards for dissolved oxygen (DO) in Puget Sound.

As a first step to understand the impact of nutrient contributions on marine water quality in Puget Sound, we are evaluating the significance of large categories of human nutrient sources by establishing the range of potential improvements that could be achieved if those sources were modified. We are calling these bounding scenarios.

The bounding scenario results are a starting place for discussions about designing more refined nutrient reduction strategies during the optimization scenario phase. These scenarios compare existing conditions for two hydrodynamically different years to determine the depletion in DO due to human sources, and predict the amount of water quality improvement from reducing large categories of nutrient sources. We are using the latest version of the model that includes an expanded model domain, refined watershed delineations, and improved sediment and water chemistry to give us the improved model performance over previous versions.

Participants in the Puget Sound Nutrient Forum and the Marine WQ Implementation Strategy process will discuss the bounding scenario results and use them to develop new questions and more specific scenarios for the model to answer during the optimization phase.

What information do we hope to learn from the bounding scenarios?

The bounding scenarios are primarily designed to understand the significance of land-based loadings (rather than oceanic or atmospheric) and how Puget Sound water quality might improve if there are nutrient reductions from large categories of sources. There are two major categories of land-based sources: marine point sources and watersheds.

The marine point source category includes wastewater treatment plants and industrial facilities discharging either in close proximity to, or directly into, estuarine waters.

The watershed category includes nutrient loadings at the mouths of rivers and streams flowing into the Salish Sea. Nutrient loads from each watershed entering the Salish Sea represents the sum of point (wastewater, stormwater, and other permitted dischargers) and nonpoint sources, as well as natural sources. Since the Salish Sea Model does not extend beyond river mouths, Ecology is also exploring approaches to better understand sources and model nutrient reductions *within* watersheds

with the goal of estimating achievable reductions to overall downstream loads. The bounding scenarios do not include this type of analysis but we hope to improve that by the final optimization scenario.

We also want to know if it is possible to meet DO criteria in Puget Sound if we can achieve technology-based nutrient reductions from all marine. This is an important first step to understand whether or not these human source reductions will enable us to reach the water quality targets. We will then be able to make more informed decisions about what new combinations of reductions should be evaluated in the next round of modeling.

What assumptions make up the Bounding Scenarios?

Table 1 lists the key questions that each scenario seeks to answer and the assumptions for each scenario. Some scenarios predict the water quality improvement achieved from biological nutrient removal (BNR) technology that can be added to existing secondary treatment; our definition of BNR for the purposes of these scenarios includes the following assumptions:

- Total dissolved inorganic nitrogen (DIN) effluent limit of 8 mg/L (Nitrate/nitrate limit of 7.75 mg/L and ammonia limit of 0.25 mg/L) ; unless lower levels are achieved by existing performance
- Biological Oxygen Demand (BOD5) effluent limit of 8 mg/L
- BNR levels applied to the seasonal period of April – October

Table 1: Bounding scenario general assumptions and input parameters.

Bounding Scenario (BS) to manage Sources	Model Year Climate and Hydrology	Marine Source Flows	Watershed Source Flows	Source N removal target	Source C removal target
(BS-1) What is the relative difference between marine and watershed sources to Puget Sound?					
BS-1a. All *marine sources* at BNR levels	2006, 2008	Actual	Estimated actual	BNR levels achieved	BNR levels achieved
BS-1b. All *watersheds* at reference condition and no change to existing marine sources	2006, 2008	Actual	Estimated actual	Estimated Reference condition	Estimated Reference condition
(BS-2) What would be the effect if we focus on only the biggest marine sources to Puget Sound operating at biological nutrient removal (BNR) technology levels?					
BS-2a. Marine WWTPs > 1,000 kg DIN/day at BNR and others at actual	2006, 2008	Actual	Estimated actual	BNR levels achieved	BNR levels achieved
BS-2b. Marine WWTPs >8,000 kg DIN/day at BNR and others at actual	2006, 2008	Actual	Estimated actual	BNR levels achieved	BNR levels achieved

Bounding Scenarios Analysis Report

Ecology identified the initial suite of bounding scenarios and is conducting model simulations. An interim bounding scenarios analysis report will summarize the model results. We expect to publish the report in the fall of 2018.

In addition to the bounding scenario results, the report will include results for model runs of existing and reference conditions for 2006 and 2008, and a series of sensitivity analyses of the parameterization of the model. The sensitivity analyses were developed in response to earlier questions about the model performance based on assumptions for some parameters and rates (for example, carbon speciation in wastewater effluent, aeration coefficients, settling rates, and others).

We plan to hold two Nutrient Forum meetings that will go into further details about the bounding scenarios. The first, planned for September 20, will provide details on how the bounding scenarios were selected and then the second, planned for later in the fall (after the interim report is available), will go through the bounding scenarios results so there can be a robust discussion about Ecology's initial findings.

Where can I get more Information?

Ecology's website on reducing nutrient in Puget Sound has access to resources and documents related to this project. https://ecology.wa.gov/Water-Shorelines/Puget-Sound/Helping-Puget-Sound/Reducing-Puget-Sound-nutrients

The Quality Assurance Project Plan for the Salish Sea modeling effort: McCarthy, S. et al. 2018. Quality Assurance Project Plan: Salish Sea Model Applications. WA Department of Ecology, Publication #18-03-111. https://fortress.wa.gov/ecy/publications/SummaryPages/1803111.html

For description of how reference condition loadings are calculated see: Mohamedali et al. 2011, WA ECY publication 11-03-057 and Pelletier, et. al. 2017 Appendix B-1, WA ECY publication 17-03-009.

Watershed reference concentration estimates are partly based on EPA's reference condition guidance: Nutrient Criteria Technical Guidance Manual: Rivers and Streams (PDF) Chapter 7, Pages 94-97 (EPA-822-B-00-002)