Nutrient Forum Meeting Packet

At the February 23, 2022 Forum, we will discuss Ecology's proposed Year 2 Optimization Scenarios that we will evaluate with the Salish Sea Model (SSM) in 2022-23. In preparation for this upcoming Forum, we invite you to read over this meeting packet to familiarize yourself with the proposed scenarios.

Table of Contents

We also encourage you to review the most recent results of our Salish Sea Modeling, published in 2021:

- Year 1 Optimization Scenarios Tech Memo[1] – our most recent SSM results from Ahmed et al (2021).
- Year 1 Optimization Scenarios results webmap[2] – this is a helpful resource to examine areas of improvement achieved and remaining areas of noncompliance with DO standards predicted under each Year 1 Optimization Scenario.

---

[1] A. Ahmed, J. Gala, T. Mohamedali, C. Figueroa-Kaminsky, and S. McCarthy. 2021. Memo to Water Quality Program: Technical Memorandum: Puget Sound Nutrient Source Reduction Project Phase II - Optimization Scenarios (Year 1). Washington Department of Ecology, Environmental Assessment Program. 9/9/2021.

[2] Year 1 Optimization Scenarios results webmap

1. Glossary of Key Terms

Basin: Group of inland waters and bays that share similar hydrodynamic characteristics and the watersheds that drain to them.

BNR#: Biological nitrogen removal (BNR) is a wastewater treatment method that uses microbes and increased retention time to achieve low concentrations of total nitrogen in wastewater effluent. BNR8, BNR5, and BNR3 refer to monthly average effluent TN concentrations of 8mg/L, 5mg/L, and 3mg/L, respectively.

Framework: Alternative ways to distribute TN mass loads from WWTPs and watersheds. There are WWTP frameworks and watershed frameworks.

Region: All basins combined in the Washington State Waters of the Salish Sea.

Scenario: For Year 2 modeling, a scenario is equal to the combination of one WWTP Framework and one Watershed Framework

Total Nitrogen (TN): Both dissolved organic and inorganic forms of nitrogen.

TN Load Target: The cumulative anthropogenic total nitrogen (TN) load attributed regionally to WWTP discharges and the anthropogenic fraction from all watershed inflows in the region or an individual basin. All total nitrogen (TN) mass load targets are expressed as the mass load per unit of time (i.e. kg/day or kg/year).

Target Range: The range of total anthropogenic load that the scenarios need to be within to be included in the Year 2 scenario list.

Watershed: Freshwater inputs in the Salish Sea Model. Each input represents the cumulative nutrient load from human and natural sources draining to that input. Watershed nutrient load reductions refer to the cumulative point and nonpoint nutrient sources within the watershed.

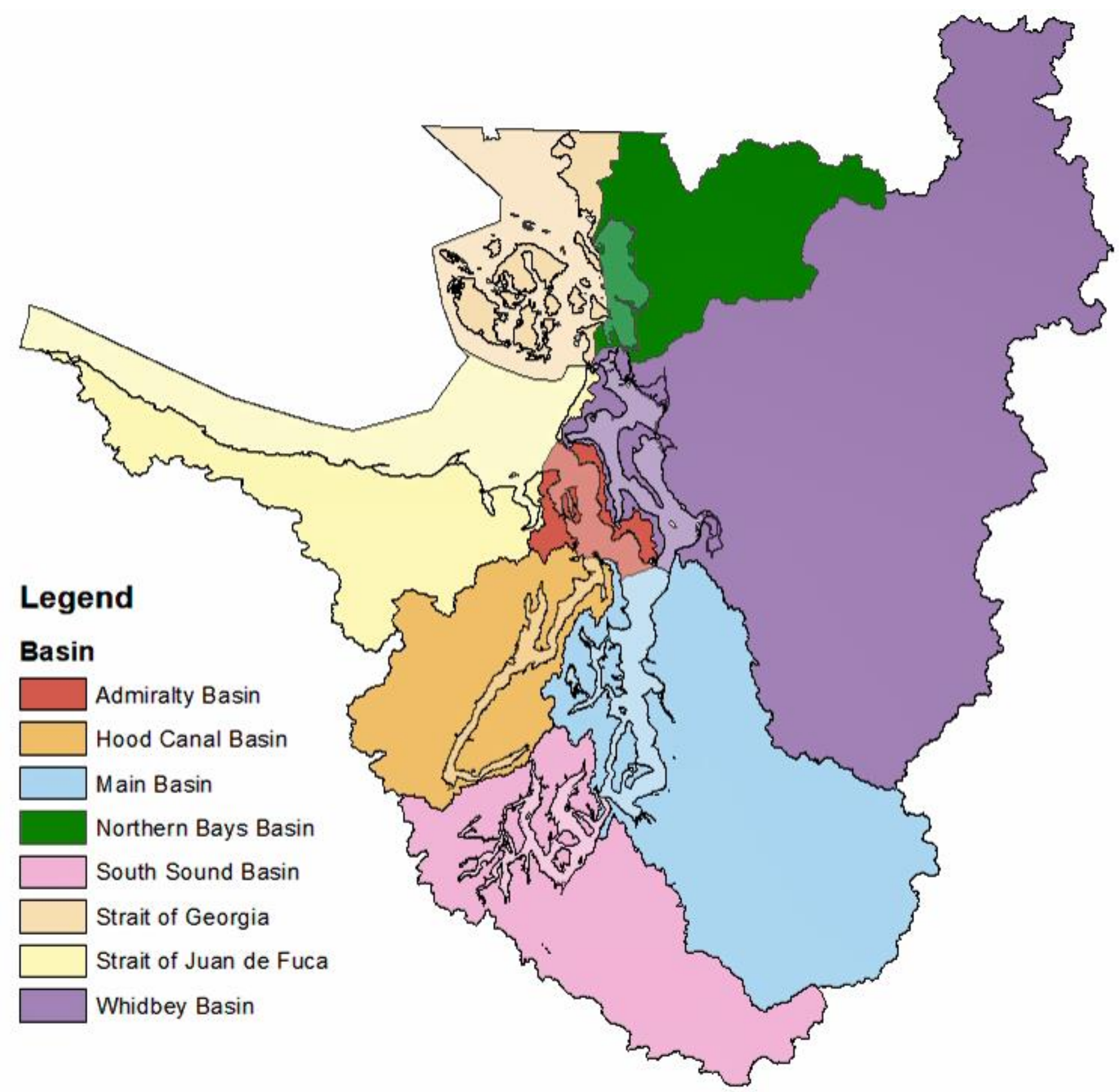

Figure 1: Map of the Washington Waters of the Salish Sea Region and Basins for the Year 2 scenarios

2. Overview: How we designed and use Year 2 Scenarios

Our Goal: find the nutrient reduction scenario (or set of scenarios) that results in the highest predicted compliance with Dissolved Oxygen (DO) standards in the Washington waters of the Salish Sea.

We expect to achieve more compliance with DO standards by being strategic about where and when reductions occur rather than continuing to ratchet down the total regional TN loads. Our proposed model scenarios represent different frameworks for reducing wastewater treatment plant (WWTP) discharges and human nutrient sources in watersheds. The frameworks vary total nitrogen (TN) and total organic carbon (TOC) loads to explore which nutrient load reduction targets lead to the most improvement. We combine a WWTP framework with a watershed framework to develop a nutrient reduction scenario to model. The 2024 Puget Sound Nutrient Reduction Plan (NRP) will include final nutrient reduction targets for WWTPs and watersheds based on these modeling results.

The scenarios we propose will answer three questions that will inform Ecology's decisions on nutrient reduction targets in the NRP:

1. Will DO compliance improve if we make bigger reductions near predicted-noncompliant areas?
2. How do smaller sources further away from noncompliant areas impact DO?
3. What are the DO improvements from different WWTP seasonal limits throughout the year?

Salish Sea Model results from our 2021 Optimization Scenario technical memo (Ahmed et al, 2021, Figures 21 and 22[3]) were used to identify the basins with watersheds and WWTPs that, respectively, had the biggest improvement both within their basin and on other basins. The proposed scenarios in this packet focus on redistributing bigger nutrient reductions from these basins with bigger impacts: Northern Bays, Whidbey Basin, Main Basin, and South Sound Basin. The regional TN load reductions will be similar to the levels tested in Ahmed et al (2021).

We also want to understand the DO impact of smaller basin loads that are further away from predicted-noncompliant areas, to inform whether reductions from these basins should be similar to bigger basins. These smaller basin loads are in the Strait of Juan de Fuca and Strait of Georgia, Hood Canal, and Admiralty Inlet basins (Figure 1). Modeling results show the effect of their nutrient loads on DO is less than compared to the other basins.

It is clear from our latest model results that annual TN reductions from WWTP discharges are needed. There are a couple different ways to distribute those loads seasonally throughout the year, and we want to know the DO improvement potential from those options. WWTP load reduction frameworks define these alternative load distributions.

Each proposed scenario consists of one WWTP load reduction framework and one watershed load reduction framework. Each combination of frameworks represents one possible alternative to reduce regional human sources of nutrients. We can compare scenario results to narrow in on one or more scenarios that meet our DO improvement goal.

Metrics for our DO improvement goal

We learned from the recent Optimization Scenario results (Ahmed et al, 2021, Figure 12[4]) runs that large nitrogen reductions from both WWTP and watershed human sources are necessary to meet DO standards throughout all of the marine waters of Puget Sound. Reducing existing TN loads from WWTPs and watersheds by 56% - 72%, resulted in improvement of 87.3% - 94.2% from the existing noncompliant area. The scenarios we propose will explore how DO standards compliance could be improved from the Scenario 5 results.

All scenarios will be tested against the following conditions:

1. Compliance with marine DO water quality standards.
2. Meeting the Budd Inlet DO TMDL bubble allocation for regional anthropogenic sources external to Budd Inlet.

Based on the design of the WWTP and Watershed frameworks, we expect the combined load reductions in our proposed scenarios to result in attainment of standards that are similar or better to the results from

---

[3] [Figures 21 and 22 (Ahmed et al, 2021)]()
[4] [Figure 12 (Ahmed et al, 2021)]()

Scenarios 5b-5d (the method to compare SSM results to DO standards is described in Year 1 Optimization Scenario Tech Memo, Appendix F[5]).

Budd Inlet DO TMDL bubble allocation

The draft Budd Inlet DO TMDL[6], being prepared for EPA review and approval in 2022, includes load and wasteload allocations within Budd Inlet, and a bubble allocation for the cumulative anthropogenic nitrogen and carbon loads external to Budd Inlet. The TMDL describes how DO standards can be attained in Budd Inlet by implementing the load and wasteload allocations it prescribes. When the bubble allocation for external anthropogenic nutrient sources to Budd Inlet is met, and the other Budd Inlet DO TMDL allocations are satisfied, the TMDL predicts dissolved oxygen will meet standards in Budd Inlet.

Choosing the Regional TN Load Target Range

The sum of one WWTP framework TN load paired with one watershed framework TN load is considered the regional TN load for that particular scenario combination. We only considered scenarios with regional TN loads within the ranges of TN loading defined by results from our Optimization Scenario modeling; specifically the regional TN loads from Scenarios 5b-e (Ahmed et al, 2021, Table 2[7]) . Our modeling team determined that Scenario 5a did not to meet the Budd Inlet TMDL bubble allocation for cumulative sources external to Budd Inlet, therefore it is not included in this range.

Scenario 5b-5e results from Ahmed et al (2021) were used as the upper and lower bounds of the regional load targets for the proposed Year 2 scenarios (Table 1).

Table 1: 2006 existing anthropogenic total nitrogen loads compared to anthropogenic loads from Scenarios 5b-e by basin.

	2006 EXISTING Anthropogenic TN load (kg/day)		2006 Scenario 5b Anthropogenic TN Load (kg/day)		2006 Scenario 5c Anthropogenic TN Load (kg/day)		2006 Scenario 5d Anthropogenic TN Load (kg/day)		2006 Scenario 5e Anthropogenic TN Load (kg/day)	
	Watersheds	WWTPs	Watersheds	WWTPs	Watersheds	WWTPs	Watersheds	WWTP	Watersheds	WWTPs
Regional TN Load Target (by major source category)	18,673	37,406	11,428	16,254	11,428	13,250	11,427	9,290	6,666	9,290
Total Regional TN Load Target	56,079		27,682		24,678		20,717		15,956	

Testing scenarios within this range

Model Year Choices

Residence time of marine waters in terminal inlets and bays is an important driver of DO. The length of residence time is spatially and inter-annually variable. Longer residence times more slowly flush out WWTP and watershed nutrient loads than short residence times, and there is a greater potential to deplete DO if anthropogenic nutrient loads are not flushed out to the Straits and Pacific Ocean relatively quickly; especially in terminal inlets and bays. Model Year 2006 represents a critical condition year with much longer than average residence time, and 2014 represents an average year in terms of its residence time.

Not all scenarios will be run for both years, but all scenarios that we consider for final TN load targets will be evaluated for both years. Total loads will be slightly different for each year because the loads are based on that year's flows, but the frameworks are applicable to both years.

[5] Year 1 Optimization Scenario Tech Memo, Appendix F
[6] Budd Inlet DO TMDL Webpage
[7] Table 2 (Ahmed et al, 2021)

3. WWTP Frameworks

Description

There are five different WWTP Frameworks we are proposing (Table 3). Each framework tests different levels of wastewater treatment that will add up to different total TN loads. These frameworks will help us test:

- The size the regional WWTP TN load can be and still meet our water quality goals.
- How different seasonal TN loads impact DO throughout the year.
- How much reduction is needed from WWTPs in basins with relatively small TN loads.

Typically, achieving TN concentrations below 8mg/L in treated effluent is difficult during cold weather months without maintaining warm water temperatures to support efficient microbiological denitrification[8,9]. To account for the optimal nitrogen removal performance achievable due to seasonal changes in temperatures, all WWTP frameworks follow a 3-season schema (Table 2) with different levels of TN reduction during each season that incorporate temperature constraints.

Table 2: WWTP Seasonal Periods used for all WWTP TN Reduction Frameworks.

Seasonal Periods
Cold Weather Months = Nov-Mar
Warm Weather Months = Apr-Jun; Oct
Hot Weather Months = Jul-Sep

Built-in Assumptions

Wastewater treatment plants are categorized according to their type:

- Combined stormwater and sewer system domestic WWTPs
- Separate storm/sewer system facilities
- Facility size classes from the Nutrient General Permit
- Federal or tribal-owned facilities
- Private facilities
- Industrial facilities

Each framework identifies a cumulative basin WWTP TN load and the average monthly BNR treatment levels each facility needs to operate at to meet their TN load target. BNR treatment levels are used to estimate loads. Our assumption for carbon reductions associated with each BNR treatment level is the same used for performance expectations in the Bounding Scenarios and Year 1 Optimization Scenarios modeling efforts. If an individual facility is already meeting a lower TN concentration than the framework level, the existing concentrations are used.

TN load estimates are based on 2006 and 2014 actual daily effluent flows multiplied by effluent TN concentrations, and effluent TN concentrations are represented by BNR levels in each WWTP framework. Each framework applies the BNR levels equally to facilities in each category, unless otherwise noted. The final Budd Inlet DO TMDL wasteload allocations will be used for those specific facilities covered under that TMDL.

Load reductions in the proposed frameworks focus on reductions from domestic wastewater treatment plants, but do not change industrial wastewater levels from their existing conditions. Total nitrogen concentrations from the handful of industrial wastewater facilities represented in the model are generally in the same TN load range as small domestic WWTPs and they generally discharge to the Strait of Juan de Fuca and Strait of Georgia. Future evaluation of industrial WWTP reductions will rely on new permit-required nitrogen and carbon monitoring data from these facilities.

---

[8] Komorowska-Kaufman, M., H. Majcherek, and E. Klaczynski. 2005. Factors affecting the biological nitrogen removal from wastewater. Process Biochemistry, Vol. 41, Issue 5. https://doi.org/10.1016/j.procbio.2005.11.001.

[9] Chen, X., X. Wei, Y. Yang, S. Wang, Q. Lu, Y. Wang, Q. Li, and S. Wang. 2021. Comparison of nitrogen removal efficiency and microbial characteristicis of modified two-stage A/O, A2/O and SBR processes. Environ Geochem Health 43, 4687-4699. https://doi.org/10.1007/s10653-021-00855-9.

Table 3: Summary of WWTP Frameworks including each basin's TN load representing the sum of the loads from all WWTPs directly discharging to marine waters in each basin.

Basin	Basin #	2006 Basin WWTP Avg. Daily TN Loads (kg/day)					
		Existing WWTP TN Load	Framework A	Framework B	Framework C	Framework D	Framework E
Bellingham, Samish, & Padilla Bays	1	1,043	500	504	441	441	603
Whidbey Basin	2	3,351	2,314	2,122	1,962	1,962	2,297
Main Basin	3	28,863	10,985	11,174	9,769	9,769	13,244
South Sound	4	3,503	1,930	1,923	1,811	1,811	1,811
Hood Canal	5	1	1	1	1	1	1
Admiralty	6	36	36	36	36	36	36
SJF - US	7	260	137	142	143	260	201
SOG - US	8	350	300	301	310	350	348
Regional WWTP TN Load		**37,406**	**16,203**	**16,203**	**14,473**	**14,636**	**18,541**
Total Percent Reduction		-	**56.6%**	**56.6%**	**61.2%**	**60.3%**	**50.4%**
Seasonal Biological Nitrogen Reduction Levels Tested		2006 Existing load from WWTP marine discharges	Cool= BNR8 Warm= BNR8 Hot= BNR5	Cool= Remainder Warm= BNR5 Hot= BNR3	Cool= BNR8 Warm= BNR5 Hot= BNR3	Uses estimated maximum TN reductions for basins 1-4 & **cap WWTP loads in basins 5-8 at existing**	Uses estimated maximum TN reductions for all basins but **Combined systems at existing levels during cool months**
What this tests		Existing load that must be reduced	Estimated minimum TN reduction with treatment	Estimated minimum that allows more load during cool months	Estimated maximum TN reduction	Improvement without WWTP reductions in basins 5-8	Existing impact from Combined Storm/Sewer WWTPs
Seasonality		-	Cool Months = Nov-Mar | Warm Months = Apr-Jun, Oct | Hot Months = Jul-Sep				

4. Watershed Frameworks

Description

We propose 8 different watershed reduction frameworks (Table 5). Each watershed framework represents the reduction of the cumulative anthropogenic nutrient loads within it. How each watershed reduction is achieved could be from a range of point or nonpoint source reductions (for example, municipal stormwater and wastewater discharges, agriculture, forestry, and atmospheric deposition), but individual source reductions are not being specified during this phase of the project. For this phase, we are concerned with the total anthropogenic load reduction from each watershed.

The proposed watershed frameworks will help us test:

- How much DO improves by reducing more nutrients from watersheds closer to predicted-noncompliant basins vs. evenly distributing reductions across all basins.
- The impact of two different regional watershed TN loads on DO.

Watersheds are categorized by both basin and the size of their average daily TN loads (Table 4). This allows us to set different percent reduction goals among these three size categories and according to the basin they discharge to. The regional watershed TN loads for Framework F (9,000 TN kg/day) is considered the minimum watershed TN load target, and Framework G (6,666 TN kg/day) is considered the maximum watershed TN load target. Framework H tests if DO compliance changes if watersheds with the smallest cumulative anthropogenic loads (the Straits, Hood Canal, and Admiralty Inlet) are capped at existing 2006 and 2014 levels.

Table 4: Watershed Load Size Categories.

Category	Watershed Average Daily TN Load (kg/day)
Small	0 – 200
Medium	201 – 1,000
Large	1,001 – 4,000

Built-in Assumptions

- Each framework emphasizes different percent reductions (from existing loads) for each watershed category in each basin.
- Watershed and Basin TN and total organic carbon loads are based on the same percent reductions from existing levels.
- Watershed load reductions are only applied to the estimated anthropogenic fraction (point and nonpoint sources) of the total watershed loads and the natural source fraction is assumed to remain constant.
- Watershed nutrient load reductions are applied at the same level all year long; there is no seasonal component to the target loads.
- Watersheds receiving load allocations under the Budd Inlet DO TMDL will be set to those levels for all of the frameworks.

Table 5: Summary of Watershed Anthropogenic TN Reduction Frameworks.

Basin	Basin #	2006 Basin Watershed Avg. Daily TN Loads (kg/day)								
		Existing Watershed TN Load	Framework F#			Framework G#			Framework H#	
			F1	F2	F3	G1	G2	G3	H1	H2
Bellingham, Samish, & Padilla Bays	1	4,190	1,919	2,059	2,040	1,421	1,454	1,481	1,421	1,421
Whidbey Basin	2	5,580	2,491	2,673	2,081	1,845	1,945	1,538	1,845	1,845
Main Basin	3	3,403	1,556	1,669	1,653	1,152	1,236	1,201	1,152	1,152
South Sound	4	4,028	2,110	1,606	2,243	1,563	1,190	1,629	1,563	1,563
Hood Canal	5	628	395	424	420	292	314	305	292	628*
Admiralty	6	152	96	103	102	71	95	92	71	152*
Strait of Juan de Fuca - US	7	254	159	171	169	118	158	154	254*	254*
Strait of Georgia - US	8	438	275	295	292	204	273	265	438*	438*
Regional Watershed TN Load		**18,673**	**9,000**			**6,666**			**7,036**	**7,453**
Total Percent Reduction		-	**51.8%**			**64.3%**			**62.3%**	**60.1%**
Framework Variations		2006 Existing load from anthropogenic (point and nonpoint sources) in watersheds	**F1**: Increased reductions in basins with biggest impact (1-4) **F2**: start with F1, with extra reduction in South Sound Basin **F3**: start with F1, with extra reduction in Whidbey Basin			**G1**: Increased reductions in basins with biggest impact (1-4) **G2**: start with G1, with extra reduction in South Sound Basin **G3**: start with G1, with extra reduction in Whidbey Basin			**H1**: Uses G1 for basins 1-6, but puts basins 7-8 at existing load **H2**: Uses G1 for basins 1-4 but puts basins 5-8 at existing load	
What this tests		Existing Load that must be reduced	Estimated minimum TN load reduction with spatial variation			Estimated maximum TN load reduction with spatial variation			DO sensitivity to loads in the Straits, Hood Canal, and Admiralty Inlet	

5. Draft Proposal for Year 2 Optimization Scenarios

The proposed list of scenarios is based on the combinations of paired WWTP and watershed TN reduction frameworks, and represents the prioritized scenarios that we can complete with our given modeling resources and timeline. Evaluating all of the proposed Year 2 scenarios (Table 6) will help us identify the scenario/s with the best-predicted DO compliance.

Table 6 includes the full list, and is summarized here as:

> **Steps 1-4)** designed to hone in on the combination of WWTP and watershed reductions that will achieve the most improvement of predicted DO noncompliant area, magnitude, and noncompliant days. The scenarios in these steps will be run for model year 2006.
>
> **Step 5)** leaves room for evaluating several frameworks for 2014 or additional framework combinations of interest.
>
> **Step 6)** will provide an anchor point for meeting DO standards in remaining noncompliant areas aside from Budd Inlet. This scenario will be run for model year 2006 and 2014.

Table 6: Draft proposal for Year 2 Optimization Scenarios.

Draft Year 2 Optimization Scenario List and Suggested Sequence	**Model Runs for Each Option**
Step 1: Find the best-predicted improvement from watersheds. Test all 6 Watershed Frameworks against each other by pairing each with the WWTP framework with the lowest regional load baseline (model year 2006) ○ WWTP Framework C + Watershed F1 (additional run with Watershed G1) ○ WWTP Framework C + Watershed F2 (additional run with Watershed G2) ○ WWTP Framework C + Watershed F3 (additional run with Watershed G3)	6
Step 2: Find the best-predicted improvement from WWTPs. Test 3 similar WWTP baselines against each other using the best performing watershed framework; one of the following will have already been run in Step 1 (model year 2006) ○ Best Watershed Framework + WWTP Framework A ○ Best Watershed Framework + WWTP Framework B ○ Best Watershed Framework + WWTP Framework C	2
Step 3: Test geospatial and combined system sensitivity frameworks for watersheds and WWTPs (model year 2006) ○ WWTP Framework D + Watershed Framework H1 ○ WWTP Framework D + Watershed Framework H2 ○ WWTP Framework E + Best Watershed Framework	3
Step 4: Test best WWTP/Watershed Framework combo for 2014	1
Step 5: Capacity to test other combinations. Final runs on any combinations of frameworks we haven't tested yet or run for model year 2006 or 2014 but want to test	0-8
Step 6: Increase Scenario 5e improvement. DO Standards attainment test with modified Scenario 5e framework (model years 2014 and 2006) designed to increase DO improvement compared to Scenario 5e predictions ○ Uses Watershed Framework G1 + Scenario 5e WWTP loads (BNR3-all annual)	2
Total Model Runs	**15-23**

The scenario in step 6 attempts to improve the remaining noncompliant areas from Scenario 5e, by redistributing the same regional watershed load to bigger reductions in basins with remaining noncompliance.

This final scenario uses the Watershed Framework G2 (with the estimated maximum TN reduction with extra reductions in the South Sound basin) paired with the original Scenario 5d WWTP load (based on achieving an extreme annual BNR level of 3mg/L for all WWTPs with marine discharges).

6. Additional Tables

The following tables provide additional detail to help Forum members understand Ecology's proposal and to prepare for a more detailed discussion. On April 30, 2019, the Puget Sound Nutrient Forum collected public feedback on the proposed draft Year 1 scenarios. Some of the feedback included ideas that were added to a "parking lot" of ideas for Year 2 scenarios. Ecology considered these ideas as the Year 2 draft scenario proposal was being developed (Table 7).

Table 7: Parking lot of Year 2 Scenario ideas from the April 2019 Nutrient Forum, and how Ecology considered them for the draft Year 2 scenario proposal.

Parking Lot Scenarios	How we consider this idea for the Year 2 list
1. Sub-basin evaluation of significance of sensitive watersheds in basins	Included this idea into watershed load categories and watershed frameworks.
2. Run less restrictive treatment level for winter months than 8mg/L	Included this idea into WWTP Frameworks B and E
3. Run climate change and future population growth together	Khangaonkar et al (2019)[10] used the SSM to evaluate Salish Sea Response to climate change, sea level rise, and future nutrient loads. That paper serves as an examination of the future response to these combined stressors, and findings point to increases in the area of annually recurring hypoxia.
4. Consider WWTP loads on a seasonal average loading performance level based on concentrations and annual limit based on total annual mass load	All WWTP Frameworks are expressed as loads that are calculated based on BNR treatment levels. Frameworks are expressed as loads, as will final anthropogenic source targets.
5. Develop attenuation/equivalency factors for human sources to inform a WQ trading framework	This task will need to be defined and conducted under the direction of specific water quality trading investigations.
6. Run final sets of reduction combinations based on what we learn about the most significant sources in Year 1 results	We are doing this by looking at the range of reductions and improvements from Scenario 5 runs and Scenario 1 and 2 results.
7. Analysis of SSM outputs could include examining the change in ocean-acidification parameters for key scenarios	At this time we only have the staff/work capacity to do the DO analysis.
8. Consider future changes in the ocean from climate change based on global model CC projections	See response to parking lot item 3.

[10] 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

Table 8: Ranked total TN loads for each paired framework combination proposed for Year 2. Scenarios that include Watershed-F# and Watershed-G# frameworks will have the same total load using any of the 3 framework variations. Scenario 5 loads from the Year 1 Optimization Scenarios technical memo (shaded rows) are included to show how the proposed scenarios fit within the range of regional TN loads that we are testing.

Scenarios	**Total Regional TN Load (kg/day)**	**Percent Reduction from Total**
Increase Scenario 5e DO improvement	15,959	72%
Scenario 5e	*15,959*	*72%*
Scenario 5d	*20,717*	*63%*
WWTP-C & Watershed-G#	21,139	62%
WWTP-D & Watershed-H1	21,672	61%
WWTP-D & Watershed-H2	22,089	61%
WWTP-A & Watershed-G#	22,869	59%
WWTP-B & Watershed-G#	22,869	59%
WWTP-C & Watershed-F#	23,473	58%
Scenario 5c	*24,678*	*56%*
WWTP-A & Watershed-F#	25,203	55%
WWTP-B & Watershed-F#	25,203	55%
WWTP-E & Watershed-G#	25,207	55%
WWTP-D & Watershed-F#	25,207	51%
Scenario 5b	*27,682*	*51%*

Table 9: Watershed Framework F# details. Basins with higher reductions outlined in red, extra reductions highlighted in yellow.

Basin	Basin #	Framework F# Basin Loads (units are Anthropogenic TN kg/day)											
		F1: more reductions in basins 1-4 and for largest watersheds				**F2:** more reductions in basins 1-4 with extra South Sound Basin load reductions				**F3:** more reductions basins 1-4 with extra Whidbey Basin load reductions			
		Percent Reduction from Existing			Total Basin Load	Percent Reduction from Existing			Total Basin Load	Percent Reduction from Existing			Total Basin Load
		Sm*	Md.*	Lg.*		Sm*	Md*	Lg*		Sm*	Md*	Lg*	
Bellingham, Padilla, & Samish Bays	1	-	47.6%	56.3%	1,919	-	43.8%	53.2%	2,059	-	44.3%	53.6%	2,040
Whidbey	2	47.6%	47.6%	56.3%	2,491	43.8%	43.8%	53.2%	2,673	55.5%	62.9%	62.9%	2,081
Main	3	47.6%	-	56.3%	1,556	43.8%	-	53.2%	1,669	44.3%	-	53.6%	1,653
South Sound	4	47.6%	47.6%	-	2,110	55.0%	62.5%	-	1,606	44.3%	44.3%	-	2,243
Hood Canal	5	37.1%	-	-	395	32.6%	-	-	424	33.2%	-	-	420
Admiralty	6	37.1%	-	-	96	32.6%	-	-	103	33.2%	-	-	102
SJF-US	7	37.1%	-	-	159	32.6%	-	-	171	33.2%	-	-	169
SOG-US	8	37.1%	-	-	275	32.6%	-	-	295	33.2%	-	-	292
Total Load					**9,000**				**9,000**				**9,000**

**Watershed Load Size Category*

Table 10: Watershed Framework G# details. Basins with higher reductions outlined in red, extra reductions highlighted in yellow.

Basin	Basin #	Framework G# (units are Anthropogenic TN kg/day)											
		G1: more reductions in basins 1-4 and for largest watersheds				**G2:** more reductions in basins 1-4 with extra South Sound Basin load reductions				**G3:** more reductions basins 1-4 with extra Whidbey Basin load reductions			
		Percent Reduction from Existing			Total Basin Load	Percent Reduction from Existing			Total Basin Load	Percent Reduction from Existing			Total Basin Load
		Sm*	Md*	Lg*		Sm*	Md*	Lg*		Sm*	Md*	Lg*	
Bellingham, Padilla, & Samish Bays	1	-	61.2%	67.7%	1,421	-	65.3%	65.3%	1,454	-	59.6%	66.3%	1,481
Whidbey	2	61.2%	61.2%	67.7%	1,845	58.7%	65.3%	65.3%	1,945	67.6%	67.6%	73.0%	1,538
Main	3	61.2%	-	67.7%	1,152	58.7%	-	65.3%	1,236	59.6%	-	66.3%	1,201
South Sound	4	61.2%	61.2%	-	1,563	66.7%	72.2%	-	1,190	59.6%	59.6%	-	1,629
Hood Canal	5	53.4%	-	-	292	50.0%	-	-	314	51.5%	-	-	305
Admiralty	6	53.4%	-	-	71	37.5%	-	-	95	39.3%	-	-	92
SJF-US	7	53.4%	-	-	118	37.5%	-	-	158	39.3%	-	-	154
SOG-US	8	53.4%	-	-	204	37.5%	-	-	273	39.3%	-	-	265
Total Load					**6,666**				**6,666**				**6,666**

**Watershed Load Size Category*

Table 11: Watershed Framework H# details. These frameworks include the estimated maximum TN reductions for the basins with the biggest DO impacts (basins 1-4), and cap the load targets for the other basins at existing levels indicating no further loading would be allowed.

Basin	Basin #	Watershed Framework H# (units are Anthropogenic TN kg/day)			
Bellingham, Padilla, & Samish Bays	1	**H1**: Framework G1 loads for basins 1-6; existing loads for basins 7-8	1,421	**H2**: Framework G1 loads for basins 1-4; existing loads for basins 5-8	1,421
Whidbey	2		1,845		1,845
Main	3		1,152		1,152
South Sound	4		1,563		1,563
Hood Canal	5		292		628*
Admiralty	6		71		152*
SJF-US	7		254*		254*
SOG-US	8		438*		438*
Total Load			**7,036**		**7,453**

Existing load for model year

Table 12: Marine WWTP Inputs, their recieving basin, and their Facility Group.

SSM ID	Facility Name	Basin	Basin Number	Facility Group	Facility Description
504	Fort Lewis	South Sound	4	Federal	Federally owned wastewater treatment facility
584	Whidbey Naval Station	SOG - US	8	Federal	Federally owned wastewater treatment facility
516	US Oil & Refining	Main Basin	3	Industrial	Industrial wastewater treatment facility
517	West Rock	Main Basin	3	Industrial	Industrial wastewater treatment facility
544	Kimberly Clark	Whidbey Basin	2	Industrial	Industrial wastewater treatment facility
564	Port Townsend Paper	Admiralty	6	Industrial	Industrial wastewater treatment facility
569	BP Cherry Point	SOG - US	8	Industrial	Industrial wastewater treatment facility
570	Conoco Phillips	SOG - US	8	Industrial	Industrial wastewater treatment facility
575	Intalco	SOG - US	8	Industrial	Industrial wastewater treatment facility
582	Shell Oil	Bham, Samish, Pad Bays	1	Industrial	Industrial wastewater treatment facility
583	Tesoro	Bham, Samish, Pad Bays	1	Industrial	Industrial wastewater treatment facility
587	Nippon Paper	SJF - US	7	Industrial	Industrial wastewater treatment facility
539	West Point	Main Basin	3	NPG, DOM-CS	Dominant domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
543	Everett Snohomish	Whidbey Basin	2	NPG, DOM-CS	Dominant domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
566	Bellingham	Bham, Samish, Pad Bays	1	NPG, DOM-CS	Dominant domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
503	Chambers Creek	South Sound	4	NPG, DOM-SS	Dominant domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
514	Tacoma Central	Main Basin	3	NPG, DOM-SS	Dominant domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
525	Brightwater	Main Basin	3	NPG, DOM-SS	Dominant domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
537	South King	Main Basin	3	NPG, DOM-SS	Dominant domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
506	LOTT	South Sound	4	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
519	Bremerton	Main Basin	3	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
550	Mt Vernon	Whidbey Basin	2	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
557	Snohomish	Whidbey Basin	2	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
565	Anacortes	SOG - US	8	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
588	Port Angeles	SJF - US	7	NPG, Mod-CS	Moderate domestic wastewater treatment facility class under the NGP with a combined sewage and stormwater system
515	Tacoma North	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
520	Central Kitsap	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
521	Port Orchard	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system

SSM ID	Facility Name	Basin	Basin Number	Facility Group	Facility Description
526	Edmonds	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
529	Lakota	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
530	Lynnwood	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
533	Midway	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
534	Miller Creek	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
535	Redondo	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
536	Salmon Creek	Main Basin	3	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
546	Lake Stevens 001	Whidbey Basin	2	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
547	Lake Stevens 002	Whidbey Basin	2	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
549	Marysville	Whidbey Basin	2	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
554	OF100	Whidbey Basin	2	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
567	Birch Bay	SOG - US	8	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
568	Blaine	SOG - US	8	NPG, Mod-SS	Moderate domestic wastewater treatment facility class under the NGP with a separate sewage and stormwater system
501	Boston Harbor	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
505	Hartstene	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
507	McNeil Is	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
508	Rustlewood	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
510	Shelton	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
511	Tamoshan	South Sound	4	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
518	Bainbridge Kitsap Co 7	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
523	Alderwood	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
524	Bainbridge Island City	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
527	Gig Harbor	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
528	Kitsap Co Kingston	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
531	Manchester	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
538	Vashon	Main Basin	3	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
541	Port Gamble	Hood Canal	5	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
542	Coupeville	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
545	La Conner	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP

SSM ID	Facility Name	Basin	Basin Number	Facility Group	Facility Description
548	Langley	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
551	Mukilteo	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
552	Oak Harbor Lagoon	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
553	Oak Harbor RBC	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
555	Penn Cove	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
556	Skagit County 2 Big Lake	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
558	Stanwood	Whidbey Basin	2	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
563	Port Townsend	Admiralty	6	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
571	Eastsound Orcas Village	SOG - US	8	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
572	Eastsound Water District	SOG - US	8	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
573	Fisherman Bay	SOG - US	8	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
574	Friday Harbor	SOG - US	8	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
576	Larrabee State Park	Bham, Samish, Pad Bays	1	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
585	Clallam Bay POTW	SJF - US	7	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
586	Clallam DOC	SJF - US	7	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
589	Sekiu	SJF - US	7	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
590	Sequim	SJF - US	7	NPG, SMA	Small domestic wastewater treatment facility class under the NGP
502	Carlyon	South Sound	4	Private	Private domestic wastewater treatment facility
509	Seashore Villa	South Sound	4	Private	Private domestic wastewater treatment facility
512	Taylor Bay	South Sound	4	Private	Private domestic wastewater treatment facility
532	Messenger House	Main Basin	3	Private	Private domestic wastewater treatment facility
540	Alderbrook	Hood Canal	5	Private	Private domestic wastewater treatment facility
561	Warm Beach Campground	Whidbey Basin	2	Private	Private domestic wastewater treatment facility
562	Port Ludlow	Admiralty	6	Private	Private domestic wastewater treatment facility
580	Roche Harbor	SOG - US	8	Private	Private domestic wastewater treatment facility
581	Rosario Utilities	SOG - US	8	Private	Private domestic wastewater treatment facility
513	Puyallup	Main Basin	3	Tribal	Tribally owned wastewater treatment facility

SSM ID	Facility Name	Basin	Basin Number	Facility Group	Facility Description
522	Suquamish	Main Basin	3	Tribal	Tribally owned wastewater treatment facility
559	Swinomish	Whidbey Basin	2	Tribal	Tribally owned wastewater treatment facility
560	Tulalip	Whidbey Basin	2	Tribal	Tribally owned wastewater treatment facility
577	Lummi Goose Pt	SOG - US	8	Tribal	Tribally owned wastewater treatment facility
578	Lummi Sandy Pt	SOG - US	8	Tribal	Tribally owned wastewater treatment facility
579	Makah	SOG - US	8	Tribal	Tribally owned wastewater treatment facility

Table 13: SSM watershed inputs by Basin and Watershed Load Group. Some inputs represent a single large watershed, and some inputs represent several adjacent small watersheds.

SSM ID	SSM Watershed Name	Basin	Basin Number	Watershed Load Group
421	Samish_Bell south	Bellingham, Samish, & Padilla Bays	1	B
423	Whatcom_Bell north	Bellingham, Samish, & Padilla Bays	1	B
419	Nooksack R	Bellingham, Samish, & Padilla Bays	1	C
414	Whidbey east	Whidbey Basin	2	A
411	Skagit R	Whidbey Basin	2	B
412	Snohomish R	Whidbey Basin	2	C
413	Stillaguamish R	Whidbey Basin	2	C
379	Bainbridge Island East	Main Basin	3	A
371	Bainbridge Island West	Main Basin	3	A
372	Blackjack Cr	Main Basin	3	A
380	Blake Island	Main Basin	3	A
381	Buenna	Main Basin	3	A
373	Chico Cr	Main Basin	3	A
383	Curley Cr	Main Basin	3	A
384	Des Moines Cr	Main Basin	3	A
374	Dyes Inlet	Main Basin	3	A
385	Ellisport	Main Basin	3	A
386	Federal Way	Main Basin	3	A

SSM ID	SSM Watershed Name	Basin	Basin Number	Watershed Load Group
387	Gig Harbor	Main Basin	3	A
375	Gorst Cr	Main Basin	3	A
382	Green Valley Cr	Main Basin	3	A
369	Hylebos Cr	Main Basin	3	A
388	Judd Cr	Main Basin	3	A
389	Kitsap NE	Main Basin	3	A
390	Lake Washington	Main Basin	3	A
376	Liberty Bay	Main Basin	3	A
391	Magnolia Bch	Main Basin	3	A
392	Maury Island	Main Basin	3	A
377	Miller Bay	Main Basin	3	A
393	Miller Cr	Main Basin	3	A
394	Olalla Cr	Main Basin	3	A
395	Saltwater St Pk	Main Basin	3	A
396	Shingle Mill Cr	Main Basin	3	A
397	South Snohomish	Main Basin	3	A
398	Tahlequah	Main Basin	3	A
399	University Place	Main Basin	3	A
378	Green R	Main Basin	3	C
370	Puyallup R	Main Basin	3	C
301	Agate East	South Sound Basin	4	A
302	Agate West	South Sound Basin	4	A
303	Anderson east	South Sound Basin	4	A
304	Anderson west	South Sound Basin	4	A
305	Artondale	South Sound Basin	4	A
306	Burley Cr	South Sound Basin	4	A
307	Butler Cr	South Sound Basin	4	A
308	Campbell Cr	South Sound Basin	4	A
310	Coulter Cr	South Sound Basin	4	A

SSM ID	SSM Watershed Name	Basin	Basin Number	Watershed Load Group
311	Cranberry Cr	South Sound Basin	4	A
312	Dana Passage North	South Sound Basin	4	A
313	Dana Passage South	South Sound Basin	4	A
314	Deer Cr	South Sound Basin	4	A
316	Dutcher Cove	South Sound Basin	4	A
317	Ellis_Mission Cr	South Sound Basin	4	A
318	Filucy Bay	South Sound Basin	4	A
319	Fox Island	South Sound Basin	4	A
320	Frye Cove	South Sound Basin	4	A
321	Gallagher Cove	South Sound Basin	4	A
322	Glen Cove	South Sound Basin	4	A
323	Goldsborough Cr	South Sound Basin	4	A
325	Grant East	South Sound Basin	4	A
326	Grant West	South Sound Basin	4	A
327	Green Cove	South Sound Basin	4	A
328	Gull Harbor	South Sound Basin	4	A
329	Hale Passage	South Sound Basin	4	A
330	Henderson Inlet	South Sound Basin	4	A
331	Herron	South Sound Basin	4	A
332	Hope Island	South Sound Basin	4	A
333	Jarrel Cove	South Sound Basin	4	A
334	Johns Cr	South Sound Basin	4	A
335	Kennedy_Schneider	South Sound Basin	4	A
336	Ketron	South Sound Basin	4	A
337	Ketron Island	South Sound Basin	4	A
338	Mable Taylor Cr	South Sound Basin	4	A
339	Mayo Cove	South Sound Basin	4	A
324	McCormick Cr	South Sound Basin	4	A
341	McLane Cove	South Sound Basin	4	A

SSM ID	SSM Watershed Name	Basin	Basin Number	Watershed Load Group
342	McLane Cr	South Sound Basin	4	A
343	McNeil Island	South Sound Basin	4	A
344	Mill Cr	South Sound Basin	4	A
345	Minter Cr	South Sound Basin	4	A
346	Moxlie Cr	South Sound Basin	4	A
348	Peale Passage	South Sound Basin	4	A
349	Perry Cr	South Sound Basin	4	A
350	Purdy Cr	South Sound Basin	4	A
351	Rocky Cr	South Sound Basin	4	A
352	Rosedale	South Sound Basin	4	A
353	Schneider Cr	South Sound Basin	4	A
355	Sherwood Cr	South Sound Basin	4	A
356	Skookum Cr	South Sound Basin	4	A
357	Snodgrass Cr	South Sound Basin	4	A
358	Squaxin Island East	South Sound Basin	4	A
359	Squaxin Island West	South Sound Basin	4	A
360	Sun Pt	South Sound Basin	4	A
361	Tolmie	South Sound Basin	4	A
362	Van Gelden	South Sound Basin	4	A
363	Vaughn	South Sound Basin	4	A
364	Whitman Cove	South Sound Basin	4	A
365	Wilson Pt	South Sound Basin	4	A
366	Woodard Cr	South Sound Basin	4	A
368	Young Cove	South Sound Basin	4	A
315	Capitol Lake	South Sound Basin	4	B
309	Chambers Cr	South Sound Basin	4	B
340	McAllister Cr	South Sound Basin	4	B
347	Nisqually R	South Sound Basin	4	B
354	Sequalitchew Cr	South Sound Basin	4	B

SSM ID	SSM Watershed Name	Basin	Basin Number	Watershed Load Group
367	Woodland Cr	South Sound Basin	4	B
442	Cushman No 2	Hood Canal	5	A
400	Dabob Bay	Hood Canal	5	A
401	Dosewallips R	Hood Canal	5	A
402	Duckabush R	Hood Canal	5	A
403	Hamma Hamma R	Hood Canal	5	A
404	Kitsap_Hood	Hood Canal	5	A
405	Lynch Cove	Hood Canal	5	A
406	NW Hood	Hood Canal	5	A
407	Port Gamble	Hood Canal	5	A
408	Quilcene	Hood Canal	5	A
409	Skokomish R	Hood Canal	5	A
410	Tahuya	Hood Canal	5	A
415	Port Townsend	Admiralty Inlet	6	A
416	Whidbey west	Admiralty Inlet	6	A
424	Clallam Bay	Strait of Juan de Fuca - US	7	A
425	Discovery Bay	Strait of Juan de Fuca - US	7	A
426	Dungeness R	Strait of Juan de Fuca - US	7	A
427	Elwha R	Strait of Juan de Fuca - US	7	A
428	North Olympic	Strait of Juan de Fuca - US	7	A
429	Port Angeles	Strait of Juan de Fuca - US	7	A
430	Sequim Bay	Strait of Juan de Fuca - US	7	A
417	Birch Bay	Strait of Georgia - US	8	A
418	Lopez Island	Strait of Georgia - US	8	A
420	Orcas Island	Strait of Georgia - US	8	A
422	San Juan Island	Strait of Georgia - US	8	A