Elements of a Comprehensive Puget Sound Nutrients Program

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A. Introduction

Continuing and projected human population growth and development in western Washington is generating a variety of water quality problems that threaten the health and aquatic productivity of Puget Sound, undercutting our efforts to recover salmon, the orca, and other aquatic life. These include the "conventional" pollutants like excess water temperatures in certain rivers and estuarine areas, low levels of dissolved oxygen in certain shallow embayments, and an array of "toxics" from runoff, spills and a variety of other sources. The Department of Ecology (DOE) has worked diligently over the last decade to examine whether excess nutrients are choking the system, and last fall proposed a new "general permit" to address an important component of the problem – increasing amounts of nutrients and other related pollutants from sewage treatment plants discharging directly into the Sound. DOE has invited public comments on its proposed permit, which as a general matter provides a good and creative framework from which to work. Below we offer both organizational and technical refinements to advance an approach that is designed to bolster the financial capability and a decision-making and science apparatus to do it effectively and efficiently. We also offer in part D a set of technical observations which dive deeper into the science and modeling issues which underscore the design and execution of an effective nutrients strategy. We see this as a generational opportunity to help rebuild the productivity of Puget Sound if we can get the details right. The most important ingredient for success will be the active leadership of both the regulatory community -- led by DOE and EPA -- and the water utilities which will shoulder a significant share of its funding and implementation.

B. Objectives

We write to recommend modernizing the conventional water quality regulatory machinery that builds upon the innovations which have occurred in several of the major estuaries around the coastal United States over the last two decades, including Chesapeake Bay, San Francisco Bay, the Gulf of Mexico and Massachusetts Bay. The approach embraces several objectives:

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1. Adopting a comprehensive approach that addresses the major sources of nutrients into the watershed, both from pipeline discharges[3] *and other sources*;
2. Embracing multiple geographic scales that gets at the big picture by designing local strategies tailored to the local ecology;
3. Designing a phased implementation approach that starts immediately on those actions which can be taken with current capabilities while planning and building the needed improvements which will take years;
4. Providing the financial capacity to do the job effectively and efficiently, funding the necessary planning, implementation, compliance and effectiveness monitoring and continuing to invest in new science to steer the effort; and
5. Embracing other necessary imperatives including the use of "green infrastructure" where possible, reducing greenhouse gas emissions and accounting for other climate change adaptations; reflecting social equity and fairness imperatives, and honoring Tribal Treaty rights and obligations.

C. Key Elements

Our approach recognizes that the challenges in tackling nutrients and DO problems successfully go far beyond the normal permit-by-permit, pipeline-by-pipeline approach, which is how the permitting machinery typically works. It presents a wonderful opportunity to strengthen the way that regional water quality improvements are planned, permitted, and implemented, and potentially tied into other riverine/estuarine habitat objectives that are vital to salmon recovery. Because Puget Sound is not nearly as impacted as the other major national estuaries, we've got time to develop a new framework for managing these challenges under the umbrella of a new general permit, which should include the following:

1. A new, invigorated collaboration for developing and implementing the strategy which includes the Department of Ecology, other government regulators, Tribal sovereigns, the local entities representing the major sources of nutrients, and other essential stakeholders. The recent engagements around nutrients have unfortunately been far too polarized, with the various "camps" seemingly talking past one another rather than addressing the significant unresolved issues. We need to change the dynamic and spend less time arguing positions and more time resolving issues successfully, steered by clear-eyed science about what we know and don't know about how things work. DOE has provided in its proposal a good platform from which to advance which opens the door to creative solutions, but we seem to be defaulting into hardened "positions" as we advance;

2. A new consortium of municipal sewage agencies to serve as the permit holder and shoulder the responsibility for coordinated planning, implementation, monitoring, information-sharing and adaptation on a collective basis;

3. An expert science institution to provide independent analysis, modeling, monitoring, information sharing, and performance tracking capabilities to verify if we are achieving the desired outcomes and enable us to adjust as needed;

[3] We encourage including under the general permit both pipeline discharges into marine waters and also discharges into the rivers upstream which flow into the Salish Sea.

4. Increased funding for modeling and monitoring provided by new nutrient discharge permit fees tied to nutrient loading levels and coupled with state matching grant support to help fund the institutional capacity to do the work and provide immediate and direct financial incentives to reduce loadings;

5. Consistent planning for potential nutrient discharge upgrades across large and small dischargers to ensure shared access to good information, local ownership and timely implementation; and

6. Updating science-based water quality goals that are based on now-outdated decades-old framing of oxygen standards to be reflective of the hypoxia area-time framework used by Long Island Sound, the Gulf of Mexico, and the Chesapeake Bay.

D. More Specific Comments on the Draft Nutrients General Permit

We include below more technical background and specifics for the general ideas expressed above.

1. **Puget Sound's eutrophication problem is slowly progressing.** Puget Sound's oxygen status has been measurably declining for more than 60 years. The declines have proceeded slowly, and the specific actions to most cost-effectively solve the problems are not yet clear. DOE and the region overall has time to get the science and policy right. In the interim, DOE's plans for freezing loads and encouraging optimization as an important first step are well-supported.

   DOE emphasizes the comparison to other estuaries around the US that have faced the same issue. While comparisons are difficult since different agencies use slightly different assumptions, a rough comparison of the nitrogen loading to the Sound to other major US estuaries[4] with active nutrient management programs suggests that Puget Sound has a number of qualities in its favor. These characteristics have mitigated the impact of its discharges and need to be better understood so as to gauge the effectiveness of any particular regulatory strategy. The ratio of Puget Sound's population to its water area suggests it is in slightly better shape than the other estuaries, and Puget Sound has two other advantages that allow the region and DOE time to respond:
   a. Its average depth is much deeper than the other urban coastal areas giving it a significantly reduced load of nitrogen per volume of water. Because the load is diluted

[4] This comparison builds on an approach by Kelly (2008) https://digitalcommons.unl.edu/cgi/viewcontent.cgi?article=1046&context=usepapapers and adds some data from Puget Sound (https://apps.ecology.wa.gov/publications/SummaryPages/1203049.html) and SF Bay (loadings only include POTW discharges, not rivers like the SSM). The Boston Harbor data are from before the Boston Harbor Project that moved the outfall offshore. The data should be considered illustrative of the overall points being made. They are very rough estimates with variability of at least 30-40% even including such parameters as area and volume. The comparison does point out the importance of understanding the zone of impact of deep discharges of nutrients and the exchange with surface waters that would allow light to reach enriched waters and grow phytoplankton.

over a much larger volume, the overall nitrogen concentration contributed by POTWs is reduced.

b. Puget Sound also differs significantly from these estuaries in that the import of nitrogen from deep offshore coastal waters dominates its nutrient loads.[5] As a result, reducing loadings from pipeline discharges across-the-board are less certain to achieve results than locally-tailored strategies.[6]

Estuary	Population	Area	Volume	Depth	Residence Time	Annual N load	Load per volume	Concentration
Units	Millions	sq.mi	Tr gal	(avg ft)	months	million lbs	uM/m3-yr	uM Nitrogen
N. Gulf of Mexico	18	7700	158	100	6	4004	217	108
Chesapeake	16	4480	18	21	7.6	250	156	99
Long Island Sound	15	1320	22	78	6	186	1770	37
SF Bay	8	550	3	14	0.8	40	317	21
Puget Sound	4	1020	44	450	2	104	49	12
old Boston Harbor	2.5	50	0.2	17	0.27	31	3927	87

2. **An integrated nutrient strategy needs to include all POTWs discharging into or upstream of Puget Sound, and needs to be based upon an overall nitrogen budget which encompasses all sources of nutrients -- both pipeline discharges and other "non-point" sources.** The proposed permit's focus on POTWs directly discharging into Puget Sound fails to recognize the importance of other "direct dischargers" of nitrogen upstream of Puget Sound. Moreover, an overall nitrogen budget for Puget Sound is crucial to making a convincing argument that the actions proposed by DOE will have measurable impacts and result in the intended outcomes..

   The draft permit indicates that the nutrient loads that POTWs are discharging into the rivers upstream are only 15-20% less than those being discharging directly into Puget Sound, yet riverine POTW discharges are not proposed to be covered by the general permit. DOE states that only deep water, POTW-derived, summertime nitrogen loads need consideration. Some of the assumptions about the interaction and seasonality of POTW and riverine discharges are illustrated by virtual dye models, but the assumptions would be much more compelling if they were documented by the Salish Sea Model (SSM) outputs for eutrophication. A detailed look at this issue by Banas et., 2015[7] concluded that biological parameters such as bacteria and nutrients have much less long-distance transport than standard salinity measures. Besides just tracking the movement of dye particles, the SSM should use its capacity to determine what the percentage contribution of distant sources to local sources for the areas of concern. Since the problems in the Sound are correlated with long residence times of 100-200 days, this assumption needs validation by a model—consider the counter example of the agricultural runoff to the Mississippi River causing the Gulf of Mexico dead zone.

[5] Mackas and Harrison (1997) estimate the nutrient loads exchanging through the Juan de Fuca and Admiralty Straits to be about 6-8 times greater than the wastewater load (https://apps.ecology.wa.gov/publications/documents/1103057.pdf).

[6] Even zeroing out all anthropogenic loads from the rivers and the POTWs is predicted by DOD to have a small cumulative effect on algal biomass (~5.4%) and Sediment Oxygen Demand (~17%) (https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2017JC013650).

[7] https://www.jstor.org/stable/44851502?seq=1

Finally, back to the big picture, much of the human-derived load input originates from Canada from their POTWs and Frasier River discharges. These are obviously not under DOE's jurisdiction, but they suggest that a parallel effort to secure a bilateral commitment from our northern neighbors to stabilize and reduce these loads will be important for success..

3. **Name a regional consortium as the permit lead.** The permit recognizes that regulating nutrients requires an estuary-wide approach. Rather than having 50+ individual agencies providing contrasting information using different assumptions, it should allow compliance through a new consortium of the POTWs, and commit to using more than half of the $9 million provided by the legislature to fund this organization's start-up. The consortium would be charged with providing annual reports that summarize agency data collection, integration of those data to become regional information, development of consistent agency optimization plans, tracking implementation and effectiveness of those optimization activities, and an evaluation of the costs of implementing further nutrient reduction.[8] Charging the consortium to develop the framework of optimization plans for its agencies would allow more rapid development of a consistent set of the most cost-efficient solutions possible. While optimization plans need to be tailored to individual facilities, there are a standard set of tools that agencies can use.

4. **Long-term wastewater planning is not effective dealing with single issues**. A strict limit on one item (3 ppm of total nitrogen) may not be effective for maximizing the productivity of Puget Sound. Other wastewater treatment issues--e.g. control of Combined Sewer Overflows or Sanitary System Overflows, maximizing the use of recycled water, maximizing freshwater stream flow, treating first-flush stormwater, minimizing toxics discharges-- may be more cost-effective. . A 3-ppm nitrogen goal is certainly not consistent with minimizing the carbon footprint.[9] The permit should encourage the integration of long-term nutrient reductions into overall, long-term wastewater plans for the wastewater utilities. These plans should be updated every permit cycle and reflected in each utility's individual capital plans. Finally, the permit should encourage these long-term plans to consider "green engineering" designs such as increased recycling, wetlands discharges, or sea level rise protections, etc. These "green" solutions would be things the wastewater utilities and the broader Puget Sound community would embrace. POTW capital plans are multi-decade commitments. A "trade" that allows flat nitrogen loads for XX years with implementation of a "green" engineering solution would encourage action.

5. **Charge the POTW consortium with developing a plan to reduce hypoxic zones in the Sound**. Besides nutrient loads, there are several other early actions that may be quicker to implement and more cost-effective (e.g., summertime nitrification; receiving water aeration; effluent aeration; effluent diversion for irrigation; integrating stormwater first flush treatment; wet

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[8] A pertinent example is the San Francisco Bay Area nutrient general permit (https://www.waterboards.ca.gov/sanfranciscobay/board_decisions/adopted_orders/2019/R2-2019-0017.pdf) which uses the Bay Area Clean Water Agency (BACWA), a joint powers agency that represents the 40+ wastewater agencies to compile monitoring data, funding for monitoring and modeling of the Bay for eutrophication, development of regional strategies for the area's POTWs to reach different nutrient load targets, and summarizing regional implementation of load reduction efforts.

[9] The higher carbon footprint required by a 3-ppm goal (due to the required addition of methanol or other carbon sources and much higher energy usage for pumping and aeration) was documented in DOE's November 13, 2020 forum.

weather controls for minimizing DO impacts). Some of these actions could be tested in the early stages of permit implementation.

6. **Use incentives to increase early adoption.** Given the newness of the nutrient general permit, the permit "sticks" for exceeding action limits should be delayed until the next cycle and replaced by "carrots" of assuring agencies that meet the action limits for these five years (or even better performance) shall have the same action levels in the next permit cycle. The major challenge in the SF Bay nutrient permit has been how to encourage early implementation. What we've found is that given the challenges of capital accumulation, spending, and permitting, the major thing the agencies need is time**.** Two permit terms would give them the planning certainty to incorporate into their capital planning. For example, the costs of "sidestream" treatment would be easier to absorb if they allowed compliance with the nutrient permit for 20 years.

7. **Consider nutrient fees**. Nutrient discharge fees have been used successfully in Long Island Sound and the North Sea to develop the most cost-effective solutions for nutrient removal. Both regions have found that ~$6 per pound of nitrogen becomes an efficient trace-off for maximizing nutrient reduction. Charging a nutrient discharge fee (similar to carbon pricing) is probably the most cost-efficient method for providing regional equity. Adopting a small fee (e.g. $.05-.10 per pound of nitrogen discharged) early would enable funding of the consortium's regional planning study, an independent model evaluation group, or cost-sharing for implementing any nitrogen optimization plans proposed by member POTWs. Such fees also provide a structure for additional Clean Water funding provided by the state by showing serious POTW agency intent.

8. **One Sound, One Science.**[10] The multi-billion capital costs that may result from the permit requires an open Puget Sound science community that works together to build a common body of scientific knowledge. Puget Sound has many different agencies providing information about the Sound that needs to be summarized regularly to ensure the regulatory and conservation agenda is driven by a process that tries to reach consensus on the science of the Sound. This open science community will have the capacity to adapt and inform future water, societal, and environmental decisions across multiple organizations and programs. "One Sound, One Science" will accelerate the discovery of facts and innovation within the open science community by exploring genuine differences in scientific opinion and addressing them in a transparent manner. Ver significant costs of managing nutrient discharges to the Sound will be (and should be) borne by public wastewater utilities, who will then pass those costs along to all of us. They deserve a role in the governance of how to ensure collaboration and communication among Sound scientists, agencies, and stakeholders that may have independent scientific missions to fulfill. An open science community that is well-connected with the policy and management community and other users of science has the capacity to inform decisions, adapt to change, and improve the existing science infrastructure.

   Of most importance to this "One Sound, One Science" principle is independent peer review of the Salish Sea Model (SSM), as undertaken for the Chesapeake Bay, Long Island Sound, Great Lakes, and Massachusetts Bay models. While the model results have passed a limited peer

[10] This concept appears in many regions of the country, The slogan is borrowed from the Sacramento delta.

review appropriate for scientific publication[11], its multi-billion dollar impact on the nutrient management strategy selection requires a more extensive review by an independent Model Evaluation Group (MEG). The review needs to extend to estimate the model's uncertainty in its prediction of management scenarios. As good as the model is, it is significantly limited by a paucity of data for biological transformation processes that are crucial to its conclusions -- as is very well recognized by its authors. It is quite simplistic in its handling of primary production, sediment diagenesis, zooplankton grazing, light penetration, and it uses settling velocities of carbon five times higher than normal to reproduce the hypoxic zone in Hood Canal and the southern Sound to match with one year of data. Eutrophication models are extraordinarily sensitive to light-limitation and grazing-limitation , which can overwhelm the benefits of nutrient control measures. The existing model outputs make it hard to evaluate this issue.

9. **Make DOE's DO Standard more relevant to estuarine eutrophication.** Before capital planning by the POTWs is finalized, DOE needs to develop a much more sophisticated approach to its DO standards to ensure that money spent on improving Puget Sound's productivity is more intelligently spent. The driver for reducing nitrogen loading is to comply with the state standard of preventing a decline of 0.2 ppm from baseline when water quality standards are violated. As a driver, this standard has two limitations: 1. It is not tied to a specific biological impact; and 2. It is beyond the predicted confidence level of even very sophisticated models. EPA's water quality standards are based on data from exposing organisms to different concentrations of parameters of concern, determining the actual level of impact, and incorporating a safety factor. Estuarine scientists in the Chesapeake, Long Island Sound, or Gulf of Mexico have developed a more advanced approach to consider the time and volume of water that is within certain ranges of percent saturation or absolute concentrations based on effects to local species. The general permit also presents hypoxic zones in the Sound, and it would be easy to adapt the new nutrient goals to address the size and timing of hypoxic zones. This characteristic is much more amenable to monitoring and modeling. Most scientists would argue that large scale estuarine DO models are hard-pressed to characterize DO to 0.5 ppm.[12] Often diurnal changes can vary DO by several parts per million and seasonal changes by twice that. The most obvious alternative to the DOE approach would be to use the same TMDL approach it uses for every other contaminant and use the SSM to calculate what nitrogen loads will allow Puget Sound to meet its DO standard. Such an approach would also give the POTW community clear guidance for their future capital plans.

[11] https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2017JC013650

[12] See DOE's model's Table 2 in https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2017JC013650)