March 27, 2014

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Shelton, WA 98584

Mr. Andrew Kolosseus
Washington Department of Ecology
PO Box 47775
Olympia, WA 98504-7775

RECEIVED
MAR 31 2014
WA State Department
of Ecology (SWRO)

Dear Andrew:

Here, at last, is my analysis of the TMDL Report's assessments of the Lake and Estuary alternatives for Washington's Capitol City.

I find that, given the data in the Report and the methods used to assess the alternatives, a case for eliminating the Lake is not supportable. Perhaps additional studies and/or data of which I am not aware may change this tentative assessment; time will tell.

As is true of all analyses of complex studies, it is possible that some of my inferences and conclusions are mistaken. But, given a number of significant gaps in the TMDL text, I do believe that most knowledgeable marine ecologists reading it would arrive at the same conclusions.

I would like to emphasize that this report is not adversarial. Everyone involved with deciding the outcome of the Capitol Lake or Estuary choice has in common a desire to make the best-informed decision possible for the future environmental health, public enjoyment, and economic and cultural benefits of our state. I hope that this report can inform and advance the understanding the public and of all others who will participate in that decision.

Sincerely yours,

David H. Milne

David H. Milne

Capitol Lake: Protector of Water Quality in Budd Inlet.

RECEIVED
MAR 31 2014
WA State Department
of Ecology (SWRO)

David H. Milne
March 17, 2014.

Executive Summary.

This report was prompted by claims that Capitol Lake has a negative impact on Budd Inlet's water quality and that a reconstructed estuary at the head of the Inlet would be environmentally preferable. My findings contradict such claims.

I find that the Lake does not have negative effects on Budd Inlet and that the Lake improves the water quality of the Inlet.

The evidence I analyzed is in a Dept. of Ecology document, the "TMDL Tech Report (2012)" listed in the References. DOE compiled this evidence by using a computer simulation to compare two sets of scenarios, one with a Lake and one with a reconstructed estuary at the head of the Inlet. My analysis is divided into 9 sections. The conclusion of each section (except the Introduction) is as follows:

2) The computer calculations presented are only tangentially relevant to a Lake/Estuary comparison and are presented in formats that are very prone to misinterpretation.

3) All violations of water quality *standards* reported by the computer are mathematically microscopic and ecologically inconsequential.

4) The TMDL computer simulation data show no water quality *problems* occurring anywhere at any time throughout Budd Inlet.

5) Data that probably show a beneficial effect of Capitol Lake on all of Budd Inlet have been mistakenly presented as showing a negative effect.

6) Water exiting Capitol Lake does not go into areas that experience water quality *standards* violations (East Bay, eg); it flows straight toward the mouth of the Inlet.

7) Capitol Lake prevents some 27 metric tons of nitrate nitrogen from entering Budd Inlet every summer – a huge beneficial impact equivalent to the action of two LOTT plants.

8) There are many likely sources of East Bay's water quality standards violations in and near that Bay. The Lake is not one of them.

9) It seems likely that the "baseline" for simulations of the Lake's effects was wrongly calculated. If so, "Lake Scenario" simulation outcomes are not to be trusted.

I conclude that Capitol Lake is the Deschutes River Watershed's biggest and best asset for preventing and reducing water quality degradation in Budd Inlet.

Capitol Lake: Protector of Water Quality in Budd Inlet.

David H. Milne
March 17, 2014.

This report addresses the influence of Capitol Lake on the water quality of Budd Inlet.

> **My findings indicate that the Lake does not have the negative effects on Budd Inlet that are often said to exist and that in fact the Lake almost certainly improves the water quality of that Inlet.**

This report is intended to inform the community discussion of the relative merits of retaining Capitol Lake in its present location or replacing it with a reconstructed estuary. It is not an advocacy paper, nor is it intended to be adversarial to any persons or group now grappling with this important community issue.

I was drawn into this study by the appearance last summer (2013) of letters to the Olympian (some by people I know and respect) conveying views of the Lake's effects on Budd Inlet that I knew to be erroneous. I wondered where their information was coming from, and with help from friends and colleagues tracked it to a primary source. I began a study of that source (the "TMDL Report") in November, 2013.

The TMDL Report presents the results of computer simulations that examined, first, water quality conditions in Budd Inlet with Capitol Lake in place, then second, conditions with the Lake replaced by a reconstructed estuary. Those simulations and their results are described in the sections of this report that follow. The computer model that performed those simulations is an immensely powerful diagnostic tool for analyzing a vast number of water quality conditions in huge bodies of water over the course of a year. Its forte' is to spotlight areas in local waters that are most vulnerable to degradation by changes in human activities and/or certain natural conditions. That is what it is designed to do, and it does that with phenomenal power and accuracy.

The vast store of information that the computer's calculations create can be used for many other kinds of insights about Budd Inlet, including answers to questions I raise in this report. However, if it is not actually programmed by its users to show those other data, it doesn't show them. It was not so programmed for the Lake/Estuary comparisons. Instead, it showed the kinds of data that it is designed to display. *Misinterpretation of those data in this case is, I believe, a key reason why the TMDL Report is mistakenly said to show a negative impact by Capitol Lake on Budd Inlet.*

I hope that the report that follows can be of value to various experts who have read the TMDL Report. To that end, I've provided as much technical detail as I think necessary to show that the data presented there demonstrate no real problems caused by the Lake and indeed that the data demonstrate a positive Lake effect on the Inlet's water quality.

I also hope to inform non-technical readers who are interested in the Lake/Estuary discussion. For their benefit, I include in each section of the report an underlined "take-home" statement; one that says what that section is intended to show. But I have also attempted to express the technical detail in ways that enable all readers to grasp it, whether or not they have read the TMDL Report.

For all readers, I've tried to keep the text straightforward, *as brief as possible*, and "on target." Details that are helpful or interesting but not essential are mentioned in the end-notes to each section. To avoid ponderous language, I use the following abbreviations:

TMDL Report	= "Total Maximum Daily Load Report" by Roberts and other authors (2012), shown in the References section at the end of this report;
L/E Chapter	= "Lake/Estuary Chapter" = the chapter in the TMDL Report (pp. 187 – 212) that presents the Lake/Estuary simulation findings;
BI Model	= the "Budd Inlet Model," the computer model used to perform the Lake/Estuary calculations for Budd Inlet;
S/CPS DO Model	= the "South & Central Puget Sound Dissolved Oxygen Model," a different computer model that uses the same methods of calculation as does the BI Model but which was used to simulate all of Puget Sound from Edmonds to Olympia;
SPS DO Draft	= "South Puget Sound Dissolved Oxygen Study Draft," an unpublished report made available in Draft form in November, 2013, for public comment. The SPS DO Draft describes the S/CPS DO Model simulation work. The Draft is listed under Ahmed and others, 2013, in the References section at the end of this report;
WQ Standards	= "Water Quality" *Standards*; I use this phrase to ensure that the data reported by the BI Model will not be mistaken for Water Quality *Problems* – an entirely different phenomenon.

I bring to this study a detailed "hands-on" knowledge of our local inlets, gained via decades of classroom and field work in marine sciences as an Evergreen State College faculty member. In conducting this research I studied many print resources in addition to the TMDL Report, all of them listed in the References section at the end. Many colleagues and friends in the shellfish industry, at Evergreen, in the "Capitol Lake Improvement and Protection Association," and elsewhere have been helpful with answers to my questions and suggestions for further research. As with all analyses of data, there is always a chance that I am mistaken and that some other interpretation of the same data may be closer to "the truth." For that reason I use the usual tentative language of science; "almost certainly," "probably," "appears to be" and the like where appropriate – not phrases like "is definitely," "causes," "undoubtedly," etc. This is not to be construed as

doubt on my part that the interpretations I offer are correct. I believe them to be correct and would not put them in writing with my name on it, if I thought otherwise.

Section 2. The Budd Inlet Model and Its Simulation Results.

For modeling purposes, the surface of Budd Inlet is divided up into 168 grid squares (see Fig. 1)[1]. The water beneath each square is divided up into some 19 layers spanning the depths from surface to bottom. (Some cells in some of these layers may have no water in them during low tides.) During each simulation, the computer starts on January 15 and proceeds to September 15, examining every last cell of this giant 3-d grid, calculating the dissolved oxygen (DO) in each cell and comparing it with a simple pre-assigned water quality standard (for example, 5.0 mg DO/L throughout East and West Bays) or a more complicated standard in some places.[2] If the calculated DO drops below the standard by

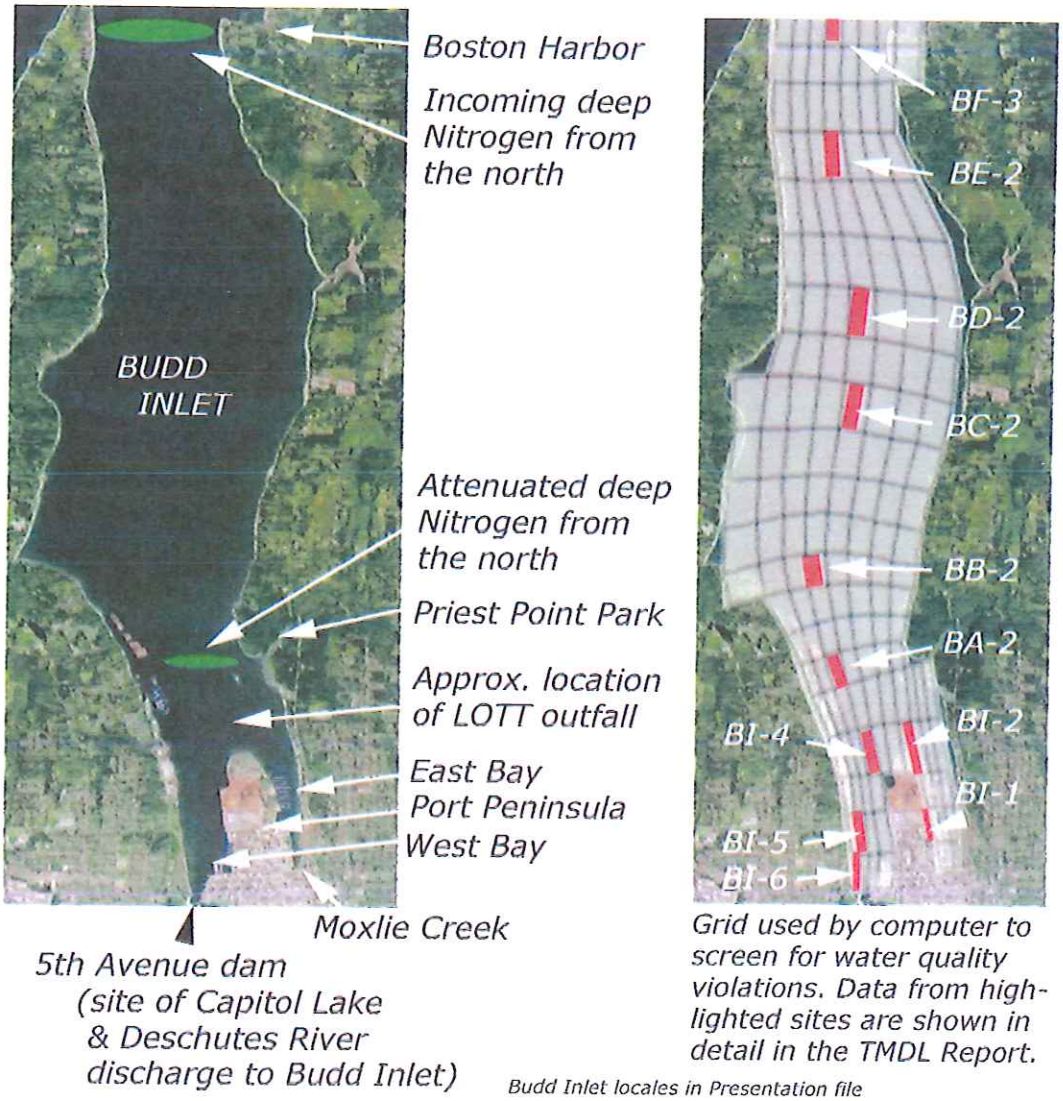


Figure 1. Left. Budd Inlet with sites and phenomena mentioned in this report. Right. Grid used by the BI Model to screen Budd Inlet for violations of water quality standards. Some detailed data are available in the TMDL Report at the grid locations identified. Sources: Photo from Google Earth with labels added (photo date May 2013); Grid from TMDL Appendix G page G-21 with highlights added.

0.20 mg DO/L or more, at just one depth on just one occasion, the surface grid square is "flagged."

The flag can never be taken away, even if virtually all other DO's at all other depths beneath that surface square are far above the standard for the entire computer "year". If violations of the same magnitude occur beneath that square many times during the "year," or at many different depths at the same time, the surface "flag" remains the same. The only change that can occur after the surface is flagged is in its color, if a later violation is more serious than the earlier one. An illustration of this flagging process is shown in Figure 2.

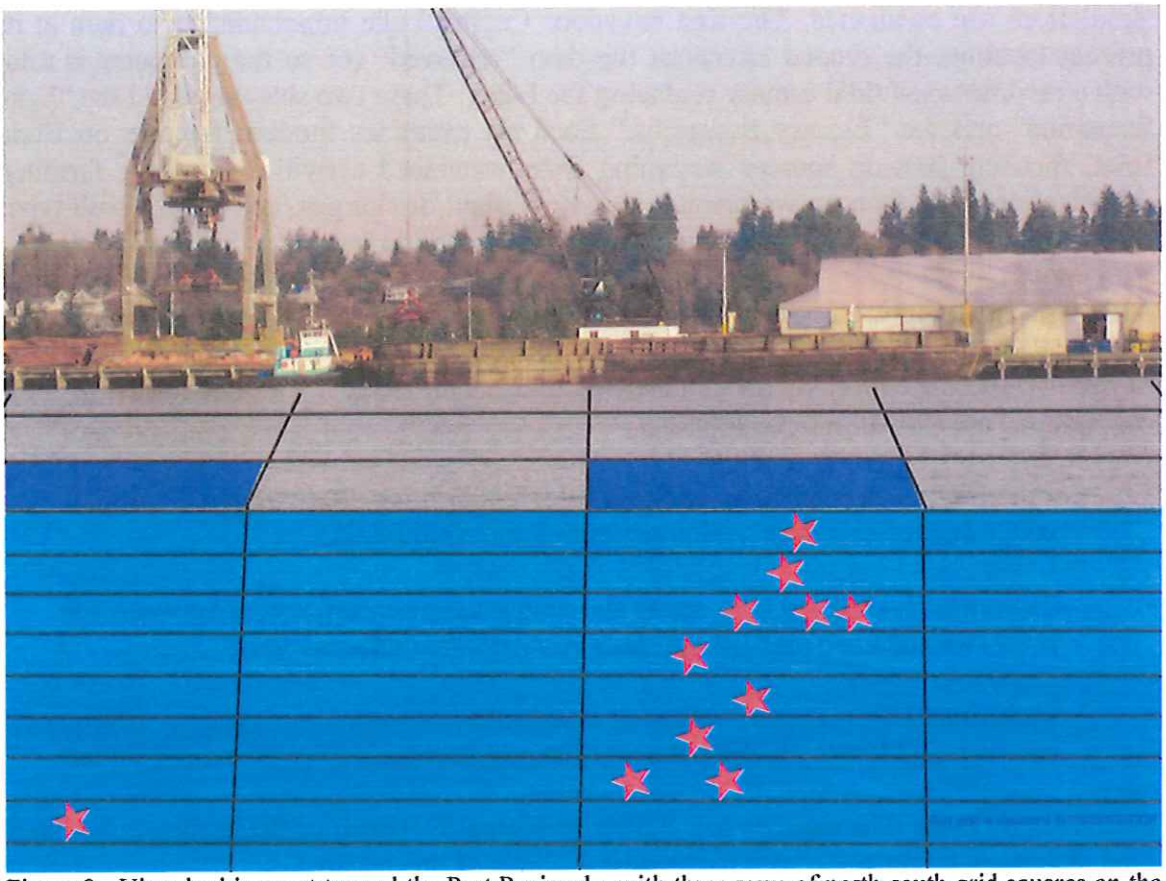


Figure 2. View looking east toward the Port Peninsula, with three rows of north-south grid squares on the surface and 9 depth layers seen in cross section below the surface squares. Say the WQ standard here is 5.0 mg DO/L in all grid cells, from surface to bottom. Suppose the calculated dissolved oxygen level drops to 4.80 mg DO/L in the 8th depth layer at left, just once during the entire computer "year." The surface square is flagged. Suppose multiple occurrences, all of calculated 4.80 mg DO/L levels, occur at different depths and times during the year in the water column to the right. The flag is not changed. However if a calculated violation lower than the worst earlier one occurs (say, 4.25 mg DO/L) the flag's color is changed to show the lowest DO ever seen at that place during that computer "year." *The flag color by itself gives no indication of how deep, or how often, or on what date(s) the violation(s) occurred, only the "worst case" level found during the simulation.* [For reference, grid site BI-5 in Figure 1 is in mid-channel just out of this picture to the right (south), grid site BI-4 is near the far shore just out of the picture to the left (north).]

Since the computer calculates DO's for every cell under every grid square in the entire Inlet, moving its "clock" forward by 6-minute time steps (the "iteration interval" of the model[3]) through every day between January 15 and September 15, it is clear that every surface square that escapes being flagged has survived a fantastically rigorous assessment of its vulnerability to water quality degradation. It is also true that a square flagged just once for one six-minute violation is displayed identically [has the same "mug shot"] at the end of the simulation, with [as] a square flagged thousands of times for the same-level violation.

Data Produced by the Budd Inlet Model.

For comparison of the Lake's and Estuary's impacts on Budd Inlet, two sets of model simulations are conducted. The first envisions Capitol Lake impounded by a dam at its present location, the second envisions the dam "removed" (or so the computer is told) with a reconstructed tidal estuary replacing the Lake. These two sets are called the "Lake Scenarios" and the "Estuary Scenarios." Each set examines modern impacts on Budd Inlet, focusing first on sources stemming from watershed activities (logging, farming, urbanization, etc), then on wastewater treatment plant discharges, and finally both types of sources operating at the same time, to analyze the total impacts.

Although the computer generates and stores many kinds of data during each simulation, the Lake/Estuary Chapter of the TMDL Report mainly focuses on its calculated dissolved oxygen (DO) concentrations for evidence of impacts on Budd Inlet. The results of these calculations are shown in three formats:

1) Format 1. Aerial views of Budd Inlet highlighting areas "flagged" for DO water quality standards violations during the simulations;

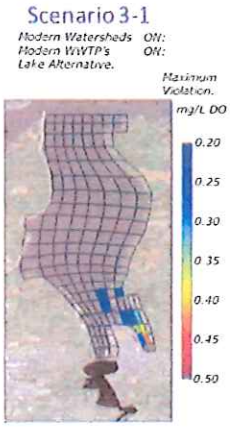
2) Format 2. Detailed time series showing maximum differences between DO levels for the Lake and Estuary Scenarios at a few selected sites;

3) Format 3. In one case, a view of Budd Inlet showing the maximum differences between DO levels for the Lake and Estuary Scenarios over the whole Inlet.

Examples of these data formats are shown in Figure 3. (Each of these figures is examined at a much larger scale later in the next sections of this report.)

In producing these findings, the computer is doing exactly what is has been programmed to do and presenting its findings in exactly the formats that best display its discoveries. However these findings are mostly irrelevant to the Lake/Estuary discussion and their presentation in these Formats is very prone to mistaken interpretation.

The findings shown in each of these data formats are analyzed in the next sections of this report.



Format 1. View showing sites flagged for water quality violations (and sites not flagged).

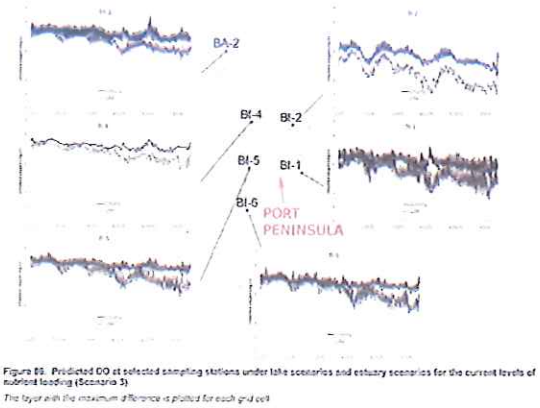


Figure 86. Predicted DO at selected sampling stations under lake scenarios and estuary scenarios for the current levels of nutrient loading (Scenario 3)

The layer with the maximum difference is plotted for each grid cell

Format 2. Graphs showing changes and differences in DO levels from March to September at sites in or near West Bay and East Bay, comparing Lake & Estuary Scenarios.

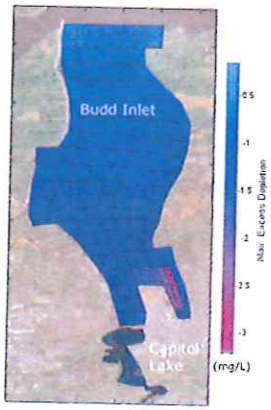


Figure 87. Predicted maximum difference in DO between lake and estuary [alternatives] for the [modern] levels of nutrient loading

Format 3. View showing maximum DO differences over all of Budd Inlet between Lake and Estuary Scenarios.

Figure 3. Methods of data presentation used in the Lake/Estuary Chapter, TMDL Report. All Formats show simulation results for 1997. Sources: TMDL's Figures 90c, 86, and 87 (L to R, pp. 206, 199, 200 in the L/E Chapter, slightly modified for illustration here).

Notes – Section 2.

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[1] 168 grid squares as shown in Figure 84, TMDL Report.

[2] The numerical water quality standards are as follows; 7.0 mg DO/L or more, "extraordinary" water, 6.0-7.0 "excellent," 5.0-6.0 "good," 4.0-5.0 "fair."

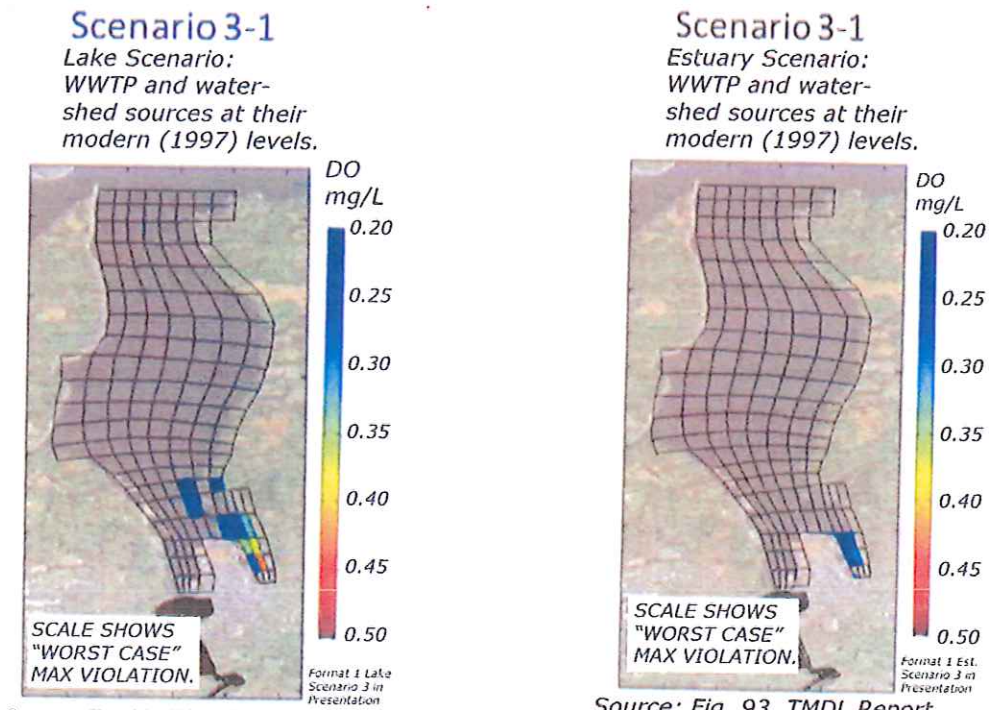
A "moving target" standard is used in areas where the water's DO level goes below the pre-assigned numerical standard, even in the Inlet's pre-modern "natural" condition. In such cases, the standard is whatever the natural level of DO would be at that season, depth, and place or the assigned numerical standard, whichever is lowest. Regardless, in all cases the computer compares the DO levels it calculates with some standard. The DO in the water must drop below the standard by at least 0.20 mg DO/L in order for the computer to "flag" that site.

The TMDL Report hints that the pre-assigned standard 5.0 mg DO/L is used everywhere in East and West Bays. The SPS DO Draft Model uses 5.0 for that region, 6.0 for most of Budd Inlet, and a "moving target" standard for the water around Priest Point Park. Figure 24 at the end of this report shows the Budd Inlet standards used by the S/CPS DO model.

[3] Page 187, TMDL Report.

Section 3. Analysis of Format 1 Data and Presentations.

Figure 4 shows the results of two simulations, one with the Lake at the head of Budd Inlet and the other with an estuary taking the place of the Lake. Each of these shows the areas flagged for Water Quality Standards violations during their respective runs. In the Lake scenario, there are 10 flagged grid squares, all in or near East Bay or near the site of the LOTT outfall. The four squares flagged in the Estuary Scenario are all in East Bay.



Source: Fig. 90, TMDL Report. Source: Fig. 93, TMDL Report.

Figure 4. Grid squares flagged for Water Quality Standards violations in simulations with the Lake present and with the Lake replaced by an estuary. (Labels of the original Figures in the TMDL Report have been reformatted here for ease of reading. In the TMDL Report, the original Figure captions read "Predicted maximum violation of the DO water quality standard under the lake [estuary] scenarios.")

Three important features of all such data portrayals are as follows;

1) For both scenarios, the vast majority of the grid squares throughout Budd Inlet are not flagged. That is, despite the rigor of the computer's search for Water Quality Standards violations in every last cell, it found none in almost every case – nothing even so tiny as 0.2 mg/L.

2) One would expect that, if Capitol Lake were somehow degrading water quality in Budd Inlet, the lake's major effect would occur in West Bay, which receives the full first blast of water from the Lake. No effect is seen there in the Lake Scenario. Instead, all adverse indications are elsewhere.

3) Almost all of the violations in both Scenarios (9 of the total 14) are microscopically small and ecologically insignificant. All squares flagged dark blue show that *the worst predicted violation of the entire computer "year"* was only 0.2 mg/L – the smallest violation that the computer is set to detect. The worst of *all* flagged violations (Lake Scenario, East Bay) was somewhat less than 0.5 mg/L.

How small a change in DO is 0.2 mg DO/L? Natural water is hugely variable in the amount of oxygen it contains, from top to bottom, hour to hour, day to day. Figure 5 shows 0.2 mg/L in the context of changes in the amounts of dissolved oxygen in the bottom and surface waters in East Bay at grid square BI-1 from dates in April to September 1997, when the BI computer model was calibrated. The graphs show the computer's calculated values of DO, circles show measured values actually observed. In that variable system, 0.2 mg DO/L is a change so microscopic that it would be difficult to find in any real body of water.[1]

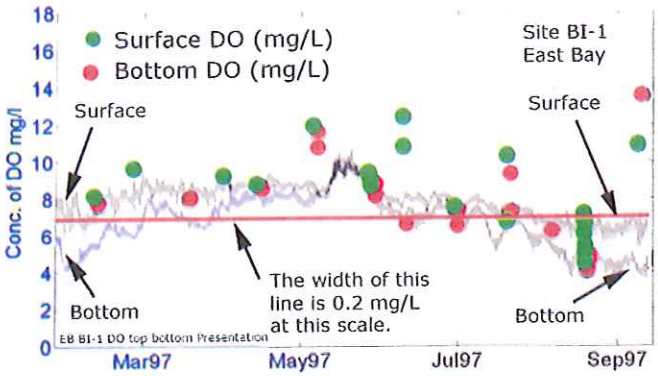


Figure 5. Predicted (graphs) and observed (circles) values of dissolved oxygen at the surface and bottom of East Bay, grid site BI-1, during the marine growing season of 1997. A line whose width is 0.2 mg/L is shown. A DO decrease of this size is the smallest "violation" flagged by the computer. Source: composite of TMDL Appendix G2 figures BI-1 KB and KT, pp G2-13 & 15.

This is a prime example of the model's ability to direct our attention to grid squares that are most vulnerable to water quality degradation even before changes there become measurable or noticeable. It is *not* showing us a "water quality problem."

How long do the small violations shown in Figure 4 persist? The TMDL Report uses other Format 1 Figures to attempt to answer this question (Figures 91 and 93, TMDL). Unfortunately, the scale on these Figures is ambiguous and doesn't permit interpretation with certainty.[2]

Almost all scenario simulations show the Lake outcome with more flagged grid squares than the Estuary outcome. There are several possible reasons for this (addressed in Sections 8 and 9 below). One is that the Lake does indeed create more vulnerable (flagged) areas than does the Estuary. Another arises from the fact that switching the simulated south end of Puget Sound between Lake and Estuary conditions requires introducing structural model changes having little or nothing to do with water body properties. Those changes, not inherent properties of the lake or estuary, could be the reason for many differences in the outcomes. (Specifically, there is a difference in the physical widths of the discharges to West Bay in the two scenarios.) Finally, there may be a fundamental error in the way in which the baseline for the Lake simulations – "Lake Scenario 1" – was constructed. That possibility is discussed in Section 9.

In conclusion, the Format 1 data presentation invites the interpretation that the areas flagged have "water quality problems." For the reasons given above, that would be a mistaken conclusion. A definition of "water quality problem" that has ecological significance and another way of looking at the "interpretation mistake" is seen by analyzing data presented in Formats 2 and 3, in the sections that follow.

Notes -- Section 3.

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[1] A change of 0.2 mg/L is the amount by which the meter on a DO-measuring device fluctuates with every passing second as the water in contact with the probe goes streaming by – that is, it is at the level of measurement "noise" in the natural system.

[2] The scale is labeled "days/layers" with values ranging from zero to 90. If this is a "worst case" portrayal, as is true of virtually every other Format 1 Figure, then a violation of 0.2 mg/L in the bottom depth layer occurring all day every day for 90 days would be rated "90" – but so would a violation of 0.2 mg/L occurring for just 10 seconds in each of 10 depth layers once every day for 9 days – a total of just 15 minutes' miniscule violations. A few sentences that describe "duration" of the violations (p. 205, TMDL) do not resolve this ambiguity.

Section 4. Analysis of Format 2 Data and Presentations.

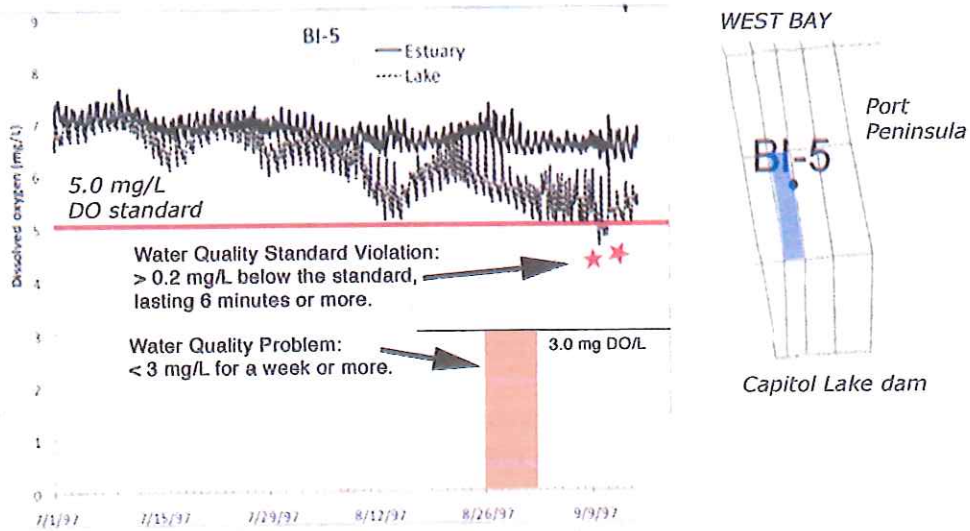
Figure 6 shows one of six similar graphs portrayed in Figure 86 of the TMDL Report. (All six are shown in miniature in Figure 3, Section 1 above.) This example of data in Format 2 shows how dissolved oxygen at site BI-5 in West Bay changes with time during part of the computer "year". The time span actually shown (July 1 – September 15) is about half of the marine growing season in Budd Inlet, when longer days make possible explosions of phytoplankton growth in the water. The upper graph curve shows the dissolved oxygen level at some depth every day from July 1 to September 15 for the Estuary scenario, the lower curve shows the DO level every day at the same depth for the Lake scenario.

With a few features added to the TMDL graph by me, Figure 6 shows the following;

1) A "water quality *standards* violation" is not the same thing as a "water quality *problem*;"

2) The TMDL graphs comparing Lake and Estuary show only two or three small *WQ standard violations* for the Lake Scenario occurring at some unspecified depth(s) on only a few days during the 77-day interval[1];

3) The DO concentrations shown in Format 2 are always much higher than the concentrations at which real water quality problems begin.



Comparison: Water Quality Standard Violation vs. Water Quality Problem.

Excerpted from Fig. 86 p 199 TMDL with the vertical axis extended to zero mg/L DO. The 5.0 mg/L standard line and a figure defining "water quality problem" have been added.

no prob4 3.0 WQ BI-5 in Lake/Estuary File

Figure 6. Calculated daily differences in DO levels between the Lake and Estuary Scenarios at grid square BI-5, July 1–September 15 1997, shown in Format 2. The difference on each day is the vertical distance between the two curves on that day.

In Figure 6, the curves show the calculated DO concentrations at some depth for the Lake and Estuary scenarios, each day. What depth? At whatever depth the difference is greatest on each day at site BI-5. The depths are probably not the same from day to day; we are not told in the TMDL Report exactly which depths they are. The only thing we can be sure of is that the differences shown by the graphs are the biggest differences of all; nowhere in the water column, each day, is there a bigger difference between "Lake" and "Estuary" DO's than the ones shown.

A Water Quality (WQ) *problem* occurs when DO concentrations in the water drop to a low value that causes aerobic organisms – crabs, fish, clams etc.– to experience respiratory distress. Estuarine organisms are "accustomed" (= "adapted") to such conditions and if the low DO concentration persists for only a day or so they can "hang in there" and resume normal life when the DO level increases again. If the water remains low in DO for a few days, mobile organisms may begin to move about and may escape to higher-DO water.[2]

The level to which DO must fall to begin to stress organisms depends upon many factors – water temperature, presence of toxins (say, metals), time of year, whether or not local organisms are adapted to occasional low DO in their usual circumstances – but the critical concentration is usually near 3 mg DO/L. At 2 mg/L, stress on the organisms starts to become acute. If those conditions persist for a week, then a true low-oxygen crisis bears down on the community and some organisms may die.[3]

A week-long period with a DO-level of 3 mg/L has been added to Figure 6. The Lake and Estuary DO levels are always 1.5-2.0 mg/L higher than that threshold, in this and every other Format-2 graph in the TMDL Report. Nowhere do the curves even remotely approach a level and duration at which a true water quality problem would be created.[4]

One's first impression from Figure 4 (Format 1 data, previous section) is that the computer has shown *water quality problems* in East Bay. This is an intuitive misinterpretation of what the computer is telling us. The figures show us *water quality standard violations* that resulted in calculated DO's in those areas ranging from 4.8 mg/L (most cases) to 4.5 mg/L (lowest value) by the end of the growing season. Those colored squares draw attention to those places as *areas vulnerable to WQ degradation* – not areas experiencing ecological Water Quality problems.

In reality, parts of East and West Bays do indeed experience true, severe seasonal water quality problems. Figure 7 shows the results of measurements of DO made from a dock on the east shore of West Bay opposite grid square BI-5, obtained by a colleague and me on September 14, 2013.[5] Unlike the TMDL data presentations, this one shows the DO data in a conventional format in which one can see what's happening at all depths – interpreted as follows.

On September 14 2013 at the dock mentioned, dissolved oxygen was highest at the surface (nearly 6.0 mg/L) but decreased with depth, then increased, then decreased all the way to the bottom 4.5 meters below. DO dropped below the critical 3 mg/L threshold

about 2 meters below the surface, then to 2 mg/L and lower about 3.5 m below the surface. If the water deeper than 2 meters were to remain at 3 mg/L or lower for the next week – or if it had already been at 3 mg/L or lower during the week previous to Sept. 14 – then that dock site and the deep water organisms living there would experience a true life-threatening water quality problem.

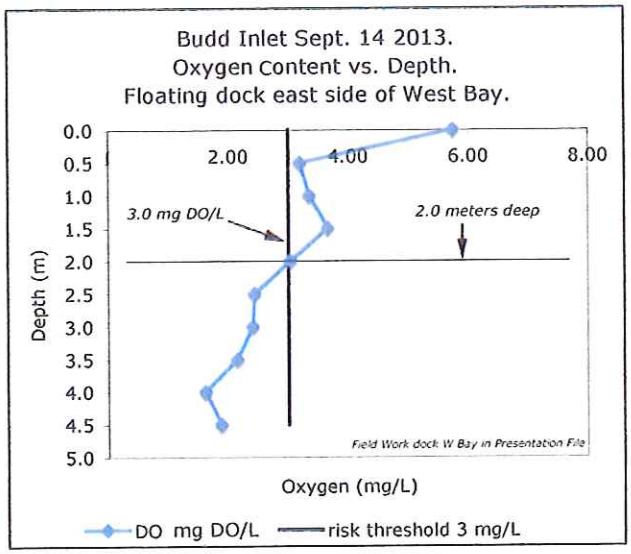


Figure 7. Decrease in dissolved oxygen with depth at a site in West Bay, showing a potential water quality problem below 2 meters deep. Observed Sept. 14, 2013.

There are big differences in calculated DO levels between the "Lake" and "Estuary" situations as shown in Format 2 in Figure 6. In this case, *really* big differences in DO's, not just miniscule 0.2 mg/L differences.

Why?

The explanation is probably that Capitol Lake exerts a powerful beneficial effect on Budd Inlet's water quality. This likelihood is analyzed in detail in the discussion of Format 3 (Section 5, below).

Notes -- Section 4.

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[1] The author is surprised that area BI-5 is not flagged (in Figure 4 Lake Scenario and in other Format 1 Lake figures) for the small violations shown in this graph. Perhaps the violations are less than 0.2 mg/L?

[2] Mobile organisms "may" escape – they are often unable to tell whether they are moving into a zone of lower or higher DO and may make things worse for themselves.

[3] Organisms living in water that is naturally reduced to low oxygen levels for long intervals are often, themselves, adapted to surviving long stressful exposures. Their presence can indicate that long-lasting low-DO periods occur in those waters even under natural conditions. Recalling from my memory only, there is at least one such organism in Puget Sound. As I recall, a tiny clam *Axinopsida sericata* is one such animal. As I recall, it is found in the deep water of the Bend of Hood Canal -- but not in West Bay, Olympia. (I made sporadic efforts to find it in Olympia Harbor, without success, about 2000 – 2003.) If someone can confirm or amend this I'd appreciate it!

[4] It is surprising that none of the computer simulations reported in the TMDL Report predict the real water quality problems that occur from time to time in East and West Bays. More is said of this later in this report. [Specifically, to catch events that don't occur every year, simulations need to be done for more than one year.]

[5] This Figure is called a "vertical profile" of dissolved oxygen in water. It is in a conventional format that is used and understood by aquatic researchers everywhere.

Section 5. Analysis of Format 3 Data and Presentations.

At first glance, Figure 87 of the L/E Chapter seems to present powerful evidence that Capitol Lake has a negative effect on water quality throughout all of Budd Inlet (Figure 8). It shows the computer's calculation that, at some (unspecified) depth under every grid square, the Inlet would have less dissolved oxygen under the Lake Scenario than if an Estuary were to replace the Lake. The differences are significant – mostly about 1 mg/L but approaching 3 mg/L in the most extreme cases. As in the other Formats portraying the computer's findings, the "worst case" is shown here for each grid square. The depths at which these big differences occur are not shown and are probably not the same everywhere, nor are the dates, but we can be sure that there are no bigger differences at any other depths at any other times under each grid square.

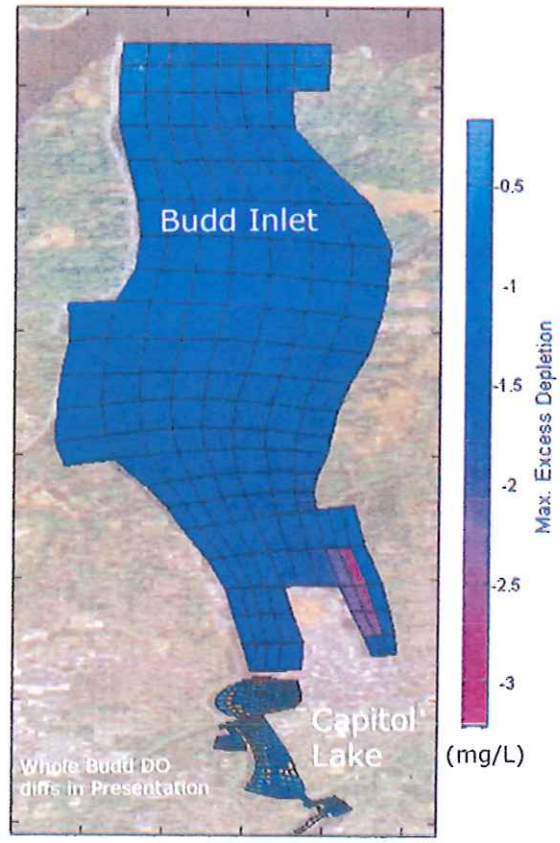

Figure 87. Predicted maximum difference in DO between lake and estuary scenarios for the [modern] levels of nutrient loading.

Figure 8. Budd Inlet with reduced O2 levels shown in all grid squares, all lower in the Lake Scenario than in the Estuary Scenario. Source: Fig. 87 in TMDL report with some label clarification.

This finding almost certainly results from a beneficial effect on Budd Inlet by Capitol Lake that the computer is not set to recognize. Understanding it begins with a look at how water moves in Budd Inlet. The explanation is detailed and it may be helpful to see where it is going before starting on it.

In a nutshell, the Deschutes River water is high in nutrient content; the water discharged by Capitol Lake has low nutrient levels. High nutrient water discharged into Budd Inlet in the Estuary Scenario would fuel explosive growth of phytoplankton with huge additions of dissolved oxygen to the water – all of this near the surface. The excess oxygen would escape into the air, clouds of phytoplankton would settle into deep water and decompose, lowering oxygen levels near the bottom. The net effect on the ecosystem of the "nutrient party" at the surface would be to lower the DO level near the bottom – the "hangover," so to speak -- with consequent stress on the organisms there. A low-nutrient discharge from Capitol Lake would suppress this effect, resulting in less oxygen at the surface (where it is almost always abundant) but more at the bottom (where it is almost always scarce).

The computer knows nothing of all this. It is set to look for the biggest differences it can find between DO levels in the Lake and Estuary Scenarios, and finds them – right at the

surface, I expect, where the extra oxygen helps nothing. The deteriorating DO situation at the bottom caused by this extra surface oxygen production is overlooked.

To illustrate, consider the following.

Figure 9 shows the major internal pattern of water movement throughout the Inlet. The example is in West Bay, but this pattern of movement (known as "estuarine circulation"[1]) prevails throughout all of Budd Inlet and indeed throughout almost all of the Salish Sea and Puget Sound, from Neah Bay through the Strait of Juan de Fuca to Olympia.

A huge non-stop flow of low-salinity water moves slowly outward at the surface toward the Pacific Ocean and is balanced by an inward flow of high-salinity water of nearly equal size moving along the bottom. (In West Bay, the lower-salinity surface flow is about 20 times the size of the Deschutes River.) Both surface and bottom flows are driven by the incoming fresh river water at the head of the estuary. Tidal changes are not responsible for these flows, which would occur even if there were no tides at all.

The bottom water entering Puget Sound from the Pacific Ocean is typically low in dissolved oxygen and high in nutrient nitrogen content. As it moves toward the heads of estuaries, some of this bottom water is dragged upward and into the outgoing surface flow, feeding nutrients to the surface water. The landward and upward movements of nutrients in this way are colossal. They dwarf the amounts of concern to us that arise from human activities. For example, local deliveries of nitrogen nutrients to Budd Inlet are on the order of 572 kg N/day (representative summer LOTT + Deschutes River discharge values).[2] The flow of nutrients from natural- + human-sources to the north into the mouth of Budd Inlet along the bottom carries about 8348 kg N/day (see Figure 1)[3]. By the time this huge bottom flow reaches waters off Priest Point Park, most of its nitrogen load has risen to the surface, leaving "only" about 1670 kg N/day to continue its southward journey, mostly into West Bay.[4]

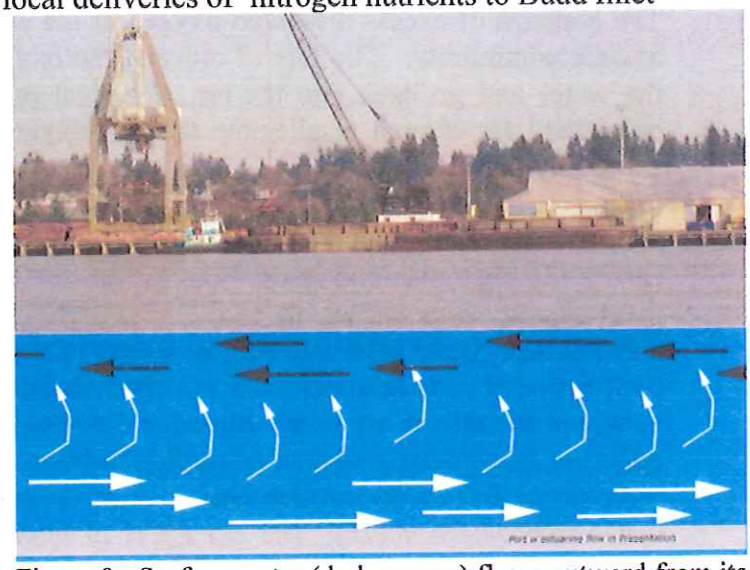

Figure 9. Surface water (dark arrows) flows outward from its river source to the ocean; deep water (light arrows) flows inward from the ocean to the head of the estuary. Water from the deep flow gradually mixes upward into the surface flow and exits the estuary – a pattern known as "estuarine circulation."

This massive inward and upward movement of nutrients is the reason why estuaries are such biologically productive waters.

As the nutrients rise to the surface, they are used by single-celled plants (phytoplankton) that grow, multiply, photosynthesize and release oxygen into the water. The constant rise of nutrients from the dark deep waters below into the lighted surface waters replenishes the nutrients that have been used up and sustains the exuberant growth of the phytoplankton. Any nutrients added by human activities amplify this process. The numbers given above – about 1670 kg N delivered daily to East and West Bays from the bottom with another ~ 572 kg N/L added daily by Budd Inlet natural and anthropogenic sources (if no Lake were present) – suggest that the local sources might raise the total daily nutrient load to 2242 kg N/day, of which the Budd Inlet sources would be responsible for some 25% of the total.

One result of this "nutrient forcing" is a huge production of oxygen in the upper waters of the Inlet. The nutrients – primarily nitrate (NO_3^-) and nitrite (NO_2^-) – are the "fertilizers" that enable explosive population growth of single-celled plants, which produce and release vast amounts of oxygen.

Exuberant phytoplankton growth at the surface has a "dark side," however. The plant cells and/or their remains eventually end up in deep water, either by sinking or by being carried downward by the small herbivores (zooplankton) that eat and assimilate them. Plant matter that reaches the bottom in one form or another decomposes. The bacteria that decompose it consume oxygen – *lots* of oxygen. The result is that the exuberant oxygen production at the surface comes at a price – a decrease in dissolved oxygen levels at the bottom – somewhere, sometime.

The bonanza of excess dissolved oxygen at the surface does little to help the rest of the aquatic community. The fate of most of the oxygen produced there is to diffuse out of the water and go back into the air. Physical processes are usually not able to mix it downward far enough to alleviate the low-oxygen conditions existing in deeper water, especially during summers.

Where is the "somewhere else" that pays the price? The seaward drift of surface water carries the phytoplankton in the Inlet toward the north. The organic matter produced by them usually sinks farther out in the inlet than where it was produced, most of it (probably) outside Budd Inlet into deeper waters of the South Sound. Some of the lower DO (and recycled nutrients) released out there is carried back into Budd Inlet in the deep flow, but the effects are much diluted and dispersed when returning from far away. *The effect on Budd Inlet's oxygen of adding nutrients to the water is likely to be a marked increase in DO at the surface and a small or moderate decrease in DO in the deeper water somewhere nearby. The net effect of high nutrient input on the whole system's water quality is negative; excess DO at or near the surface is a sign of water quality imbalance, not ecosystem health.* That is the symptom that the BI Model was not set to recognize.

Figure 10 shows a "vertical profile" of the distribution of water temperature, salinity and dissolved oxygen obtained by University of Washington researchers in August, 1958.[5] The location is "Buoy 12" in West Bay, west of the Port docks. The graphs show that the

water temperature at the surface is about 20 degrees C and drops to about 15 deg C near the bottom in the pattern shown. Water salinity shows a mirror image of the same pattern, increasing from about 26 ppt at the surface to about 30 ppt near the bottom. Dissolved oxygen is at about 12 mg/L near the surface, declining in deeper water in a similar pattern.

Interpretation is as follows. The surface layer is fresher and warmer than the bottom layer. (Recall that this site is right in the main flow of water out of Capitol Lake, which is causing this pattern.) All curves "break" (change direction) at about two meters depth. That is a likely indication that the outward surface flow shown in Figure 9 takes place in the upper two meters of water and that the deep inward flow is below that depth.

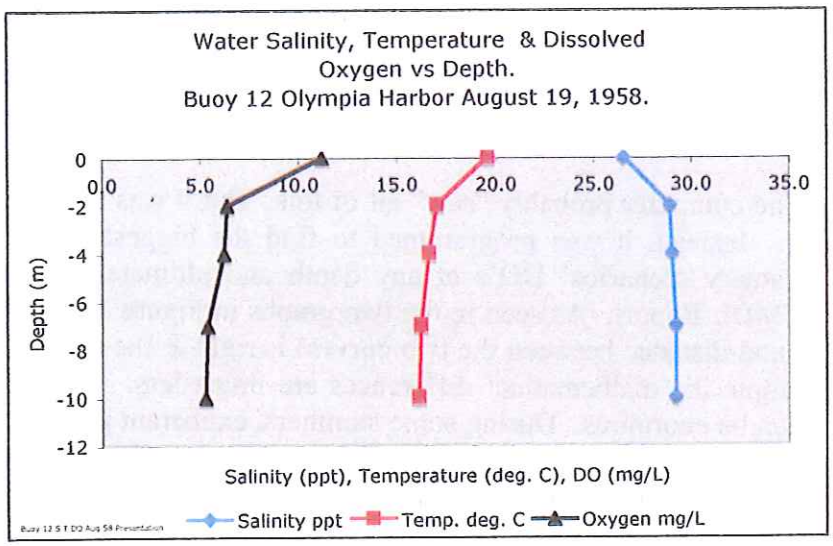

Figure 10. Vertical distribution of West Bay water temperature, salinity, and dissolved oxygen at Buoy 12 in Olympia (WA) Harbor. August 19, 1958.

Figure 11 shows two vertical profiles of dissolved oxygen at the Buoy 12 site, one of them the same curve shown in Figure 10 (August 1958), the other from August of 1957. The 1957 curve is amended here for illustrative purposes. The WQ DO standard at this site, 5.0 mg/L at all depths, is shown as a vertical line, indicating that neither curve would have resulted in a "flag" at that site in the Format #1 presentation shown in

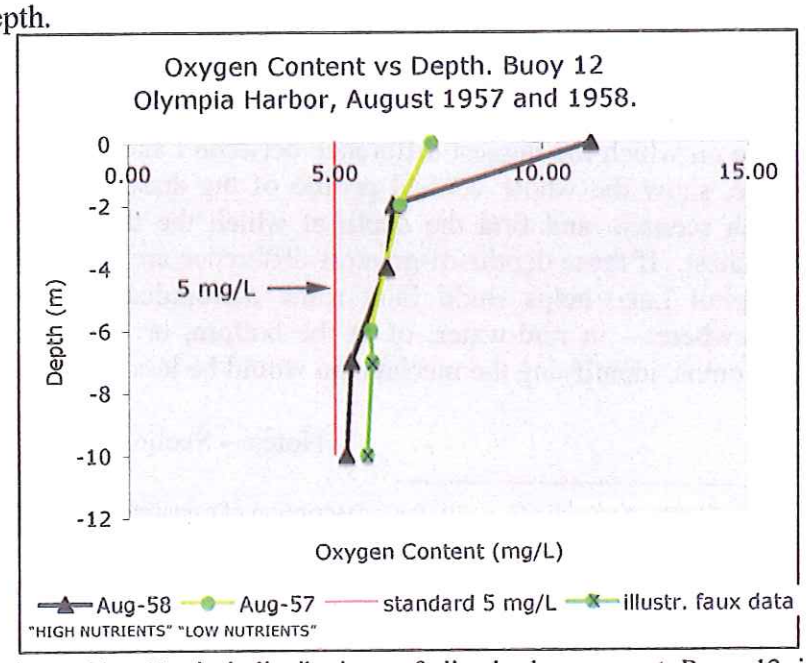

Figure 11. Vertical distributions of dissolved oxygen at Buoy 12 in Olympia (WA) Harbor. August 2 1957, and August 19 1958, with 5 mg/L DO level indicated. Deepest two 1957 values are calculated for illustrative purposes, not observed data. See Text.

Figure 4 above.

In 1957 the UW researchers obtained DO measurements at only three depths; surface, 2 meters, and 7 meters. I have extended the 1957 curve to 10 meters depth by adding two artificial "values" at 8 meters and 10 meters. The artificial values were calculated by adding 0.5 mg/L to the 1958 observed values at those depths. The result is a pair of vertical profiles containing (mostly) real data that mimic what we would see in a high-nutrient and a low-nutrient situation. Specifically, a low nutrient situation would result in a profile like that for 1957; a high nutrient situation would result in a profile like that for 1958.

The computer probably "saw" all of this. But it was not programmed to call attention to it. Instead, it was programmed to find the biggest difference between the Lake and Estuary scenarios' DO's at any depth and ultimately report that in Figure 87 of the TMDL Report. As seen in the two graphs in Figure 11, the biggest difference (ie, horizontal distance between the two curves) is right at the surface. At other depths in this example the mathematical differences are much less. However the ecological difference can be enormous. During some summers, exuberant phytoplankton growth in nearby Eld Inlet creates such clouds of sinking decomposing phytoplankton that almost all oxygen at the bottom is used up and oysters and other shellfish die. [Pers. Comm. Dan Cheney].

Instead of showing a problem, the Format 3 display almost certainly shows that the Lake is protecting West Bay from eutrophication by flooding the surface with low-nutrient water whereas an estuary of the Deschutes River would drive the ecosystem toward oxygen depletion in the bottom waters.

There is an easy way to show whether or not this hypothesis is correct. That is, for each of the labeled grid sites shown in Figure 1, search the stored simulation data to find the date on which the biggest difference between Lake and Estuary DO's occurred. For that date, show the whole vertical profile of the dissolved oxygen content of the water for each scenario and find the depth at which the difference between the two profiles is greatest. If those depths-of-greatest-difference are at or near the surface, then it's settled; Capitol Lake helps Budd Inlet resist eutrophication. If the greatest differences are elsewhere -- in mid-water, or at the bottom, or scattered at random among the water columns, identifying the mechanism would be less straightforward.

Notes -- Section 5.

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[1] See TMDL Appendix G, p. 49, for a description of estuarine circulation.

[2] 572 kg N/day from Tables 35 & 36, TMDL, Scenario 3. Of this daily load, 327 kg N/day are from "natural" watershed sources, 92 kg/day are from the summer LOTT discharge, and 153 kg/day are added by human activities to all watersheds around Budd Inlet; however the vast majority of watershed nitrogen is carried in the Deschutes River and Percival Creek.

572 kg/day is the amount that would go into Budd Inlet daily if the Lake were not there. The Lake reduces the Deschutes and Percival nitrogen discharges by 40% or (usually) much more.

[3] See Table 35 "Open Boundary" TMDL L/E Chapter p. 202, and TMDL Appendix G p. 49.

[4] I have calculated 1670 kg N/day from the following data on page 49 Appendix D. The bottom flow entering Budd Inlet from the north is about 500 cubic meters of water per second. By the time it reaches Priest Point, that flow is said to be 100 m^3/sec. Thus 80% of the water carrying 80% of the nitrogen load that entered Budd Inlet has risen to the surface by the time the bottom current reaches Priest Point, as shown in Figure 9. The 20% of bottom nitrogen remaining is (0.2)x(8348) = 1670 kg N/day reaching Priest Point. ... "mostly into West Bay ..." The bottom inflow is driven by the surface outflow, almost all of which is due to the Deschutes River at West Bay.

[5] Source: Collias, E. E., J. Dermody and C. A. Barnes. Physical and Chemical Data for Southern Puget Sound. August 1957 – October 1958. University of Washington Technical Report No. 67. UW Press, 1962.

Section 6. Most Capitol Lake Water Doesn't Move Eastward to East Bay – It Flows Northward.

In order for water released at the dam to have an effect (negative or positive) in or near East Bay – where the WQ Standard violations (Figure 4 above) and the largest DO differences between the "Lake" and "Estuary" Scenarios always occur, the water must turn eastward as it flows out of West Bay, pass the end of the Port Peninsula and go to the entrance of East Bay. Data in TMDL Appendix G suggest that this doesn't happen. In July 1997 at least, surface water exiting West Bay proceeded straight northward hugging the west shore as shown by computer model calculations and field observations. If that is usually the case, Capitol Lake can't possibly cause problems in East Bay; the sources of those problems must lie in or near East Bay itself.

Figure 12 shows the salinity at the surface of West Bay in grid square BI-5 (west of the Port docks, see Figure 1 above) from a date in April to about September 15, 1997, as calculated by the computer. The calculated salinities (dark lines) vary daily between values lower than about 12 parts per thousand (ppt) to about 25 ppt. The erratic up- and down swings are caused by tidal changes that flood the site with saltier water when the tide is rising and allow fresher water from the direction of the dam to flow through it when the tide is ebbing.

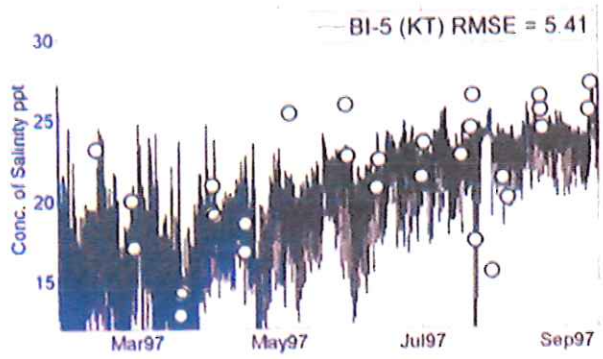


Figure 12. Calculated (graph) and observed (circles) values of surface salinity in grid square BI-5, West Bay, April–September 1997. Source: Figure G33 TMDL Appendix G p. 47.

Between July 22 and August 7 1997, Capitol Lake was completely drained. The effect of this can be seen in this graph. The computer's calculated surface salinity plunged from a high of about 24 ppt to a value lower than 12 ppt, literally overnight. For the next few days following the release, calculated surface salinities returned to a high level and remained there, then resumed their typical up and down fluctuations for the rest of the computer's "season." Field measurements (circles on the graph) confirmed that surface salinity dropped dramatically here during this episode.

The data of Figure 12 with the comparable graphs of surface salinity for other sites are shown in Figure 13. In that Figure, abruptly dropping surface salinities are seen in both the computer calculations and in the field measurements for sites in West Bay (BI-6, -5, -4), and at site BA-2 north of West Bay. The comparable data for the entrance and interior of East Bay (BI-2 and 1, respectively) show only a feeble indication of this event, at best. At the site farthest out in the Inlet in this Figure (BB-2), there was no sign of a salinity decrease either in the calculated predictions or in measurements. (For reference, BA-2 and BI-2 are respectively about 10,000 and 7000 feet distant by water from the dam.)[1]

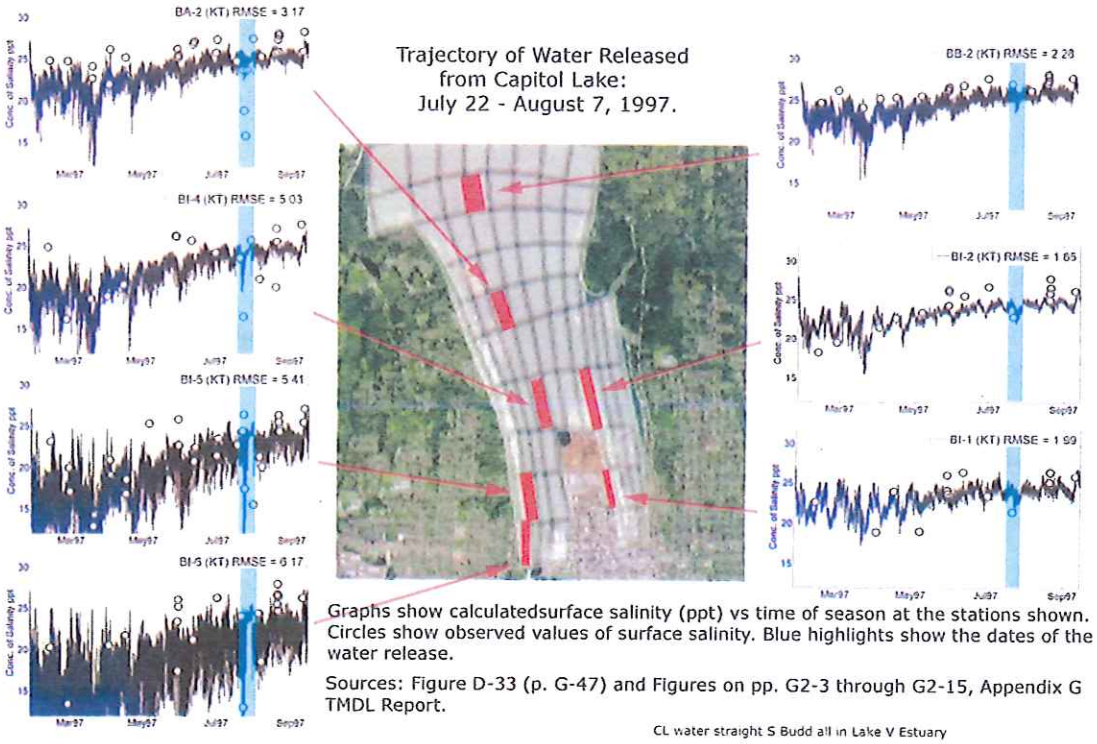


Figure 13. Surface salinities at sites in southern Budd Inlet showing movement of a fresh water release from Capitol Lake July 22–August 7, 1997. Sites along the west shore (left) show a strong abrupt depression of surface salinity on the dates of the release (highlighted). Sites near East Bay (BI-1 & 2) and mid channel north of Priest Point Park (BB-2) show no signal or at most a weak suggestion of this event.

"Strong flow north, feeble flow east;" this same pattern is seen in other data calculated by the computer, specifically its estimates of "Carbon Biological Oxygen Demand" (CBOD) at the same sites.[2]

Figure 14 shows the CBOD graphs calculated for the sites shown in Figure 13. In a nut-shell, they show the same pattern as do the surface salinity graphs, with some expectation of a small CBOD spike at the entrance of East Bay (BI-2), perhaps a hint of a weak spike north of Priest Point Park (BB-2) and none in the interior of East Bay (BI-1).

Unlike measuring salinity, measurement of CBOD is a laborious process. No observed values are shown in the source Figures in the Appendices and perhaps none are available for comparison with the graphs. But the graphs make it clear from the way in which the Budd Inlet Model handles both salinity and CBOD that the Model does not move water from the entrance of West Bay into that of East Bay.

There are other considerations. The surface outflow from West Bay is partially blocked from access to East Bay by a weak "curtain" of rising fresh water from the 1000-foot LOTT outfall extending northward from the Port Peninsula between grid squares BI-4 and BI-2. The feeble northward surface flows from Moxlie and Mission Creeks

(respectively at the head and mouth of East Bay) further impede any movement of West Bay surface water toward and into East Bay. Capitol Lake water doesn't go there. By direct transfer at least, the Lake is not responsible for any of East Bay's water quality problems or water quality standards violations.

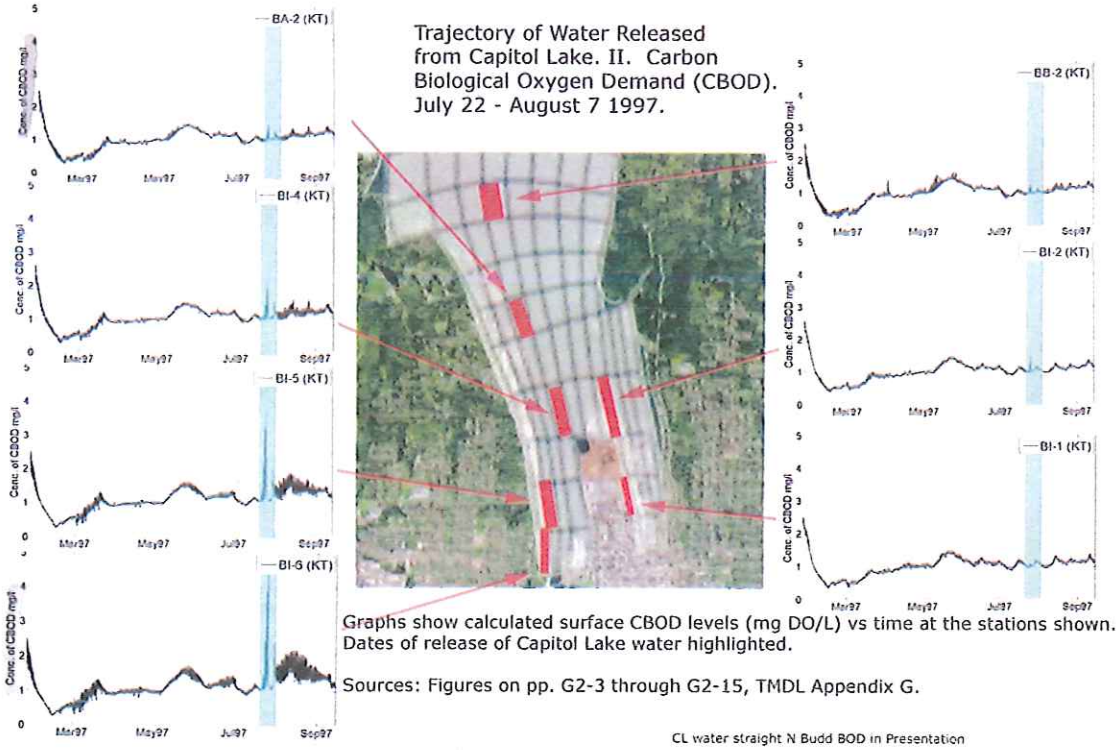


Figure 14. Surface values of Biological Oxygen Demand at sites in southern Budd Inlet showing movement of a water release from Capitol Lake July 22–August 7, 1997. Sites along the west shore (left) show strong-to-weak "spikes" in CBOD on the dates of the release (highlighted). The entrance to East Bay (BI-1) shows a weak spike in BOD, as may a mid channel site north of Priest Point Park (BB-2). The site in East Bay (BI-1) shows no signal of this event.

Notes -- Section 6.

[1] Distances dam to sites; measured on Google Earth aerial photo of southern Budd Inlet.

[2] In addition to fresh water, draining the lake added an uncharacteristic rush of organic matter – fragments of plants, organic carbon particles and the like – to West Bay. This material, beginning to decay there, uses up oxygen as bacteria consume it. The amount of oxygen that this extra material will use up is its "BOD". This is measured in mg DO/L.

Section 7. Does the Model Reproduce Capitol Lake's Nutrient Capture Property?

The Deschutes River is loaded with nutrient nitrogen. As described below, Capitol Lake removes between 40% and 90% of the river's nitrogen during the marine growing season before releasing the water to Budd Inlet. The operation of this gigantic "water purification effect" by Capitol Lake is the single most important difference between the Lake and Estuary Scenarios with regard to water quality in Budd Inlet. Unfortunately, there is no definite statement in the TMDL Report that the Budd Inlet Model included that effect. The following describes the Lake's capture of nutrient nitrogen and looks at evidence that the Model actually simulated this phenomenon.

The main source of fresh water entering Budd Inlet in either Lake or Estuary scenario is the Deschutes River. At present the river's water enters Capitol Lake at the Lake's South Basin, flows northward through an extensive "filter" of large plants ("macrophytes") in the Middle Basin, then exits from the North Basin into Budd Inlet at the Fifth Avenue dam (Figure 15). A second freshwater source entering the lake is Percival Creek, which enters the north end of the Middle Basin from the west.

Figure 16 shows the volume of flow of the Deschutes River in 2008, measured just upstream from the point where it enters Capitol Lake at the South Basin.[1] The flow of Percival Creek is not included in this inflow measurement. (The Creek's volume input is about 10% that of the Deschutes River.) Figure 16 also shows the volume of flow out of Capitol Lake into Budd Inlet during spring and summer, measured at the dam. This flow includes the water from both the creek and the river.[2]

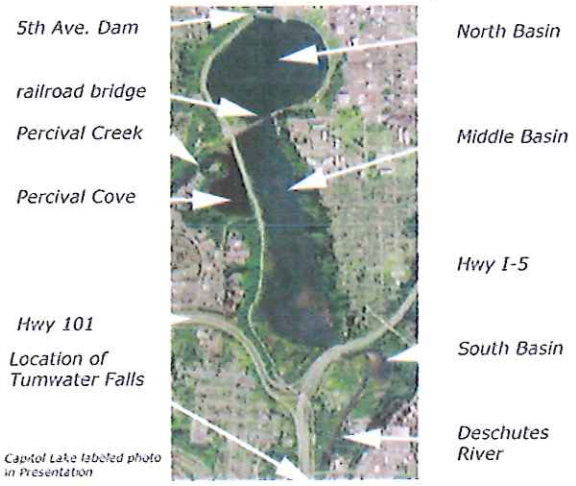


Figure 15. Capitol Lake and local landmarks. Tumwater Falls is just outside this image to the south. Budd Inlet is just to the north of the 5th Avenue dam.

Both the river and the creek have high nutrient nitrogen contents. Nitrogen is the "fertilizer" that plants can use and that can cause water quality problems if it becomes too abundant.[3]

Figures 16 - 19 (next page) give a nutshell presentation of the nitrogen-cleanup action of Capitol Lake. Figure 16 shows monthly Deschutes River flows measured upstream from the Lake (inflow) and total flows at the dam (outflow) as mentioned. Figure 17 shows the nitrogen concentrations in those respective waters. Multiplying each monthly N concentration by the monthly volume of flow gives Figure 18 showing the actual amounts of nitrogen (in thousands of kg/month) entering and leaving the Lake each month.[4] Figures 17 and 18 both show the dramatic reduction of nutrient nitrogen by the Lake before the water reaches the dam. Finally, Figure 19 shows the quantities of

nitrogen nutrients kept out of Budd Inlet by the Lake during each month of that summer. (These numbers are the differences between the "incoming" and "outgoing" values in Figure 18.)

One thousand kilograms is a metric ton (= "tonne" = 2,200 lb). Thus, in June 2008, Capitol Lake prevented 4.20 metric tons of nitrogen (in the form of nitrate and nitrite) from entering Budd Inlet (Figure 19). As a way of visualizing this, imagine yourself on the 5th Ave. Bridge on June 1 this summer. Piled around you are 1,850 50-lb bags of fertilizer whose N content is 10% nitrate.

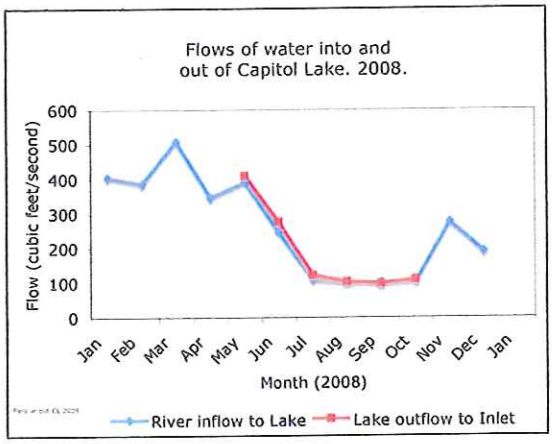


Figure 16. Volumes of water discharged by the Deschutes River to Capitol Lake and by the Lake to Budd Inlet each month (inflow) and summer months (outflow). 2008.

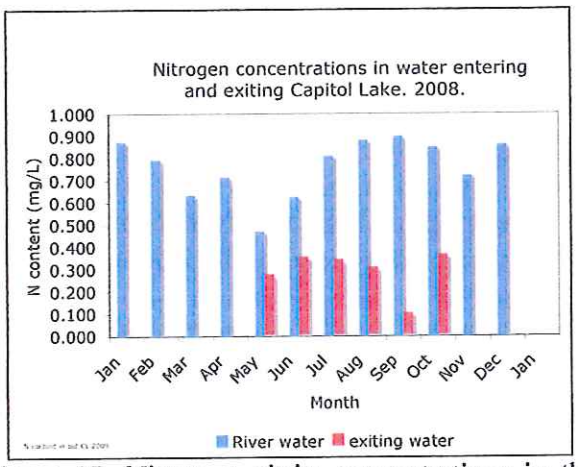


Figure 17. Nitrate + nitrite concentrations in the waters entering (year long) and exiting Capitol Lake (summer months) each month. 2008.

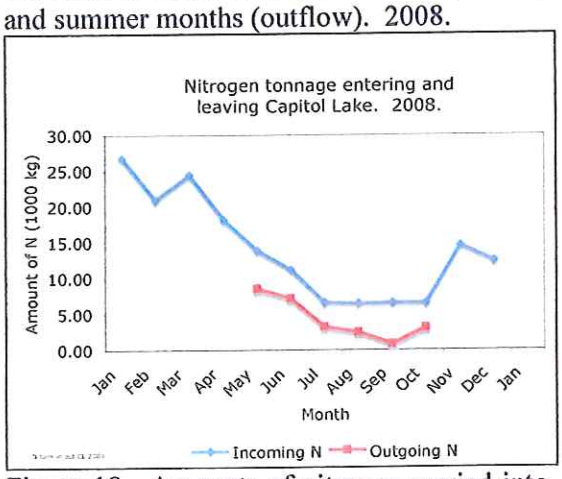


Figure 18. Amounts of nitrogen carried into Capitol Lake each month and carried out during months of the marine growing season. 2008.

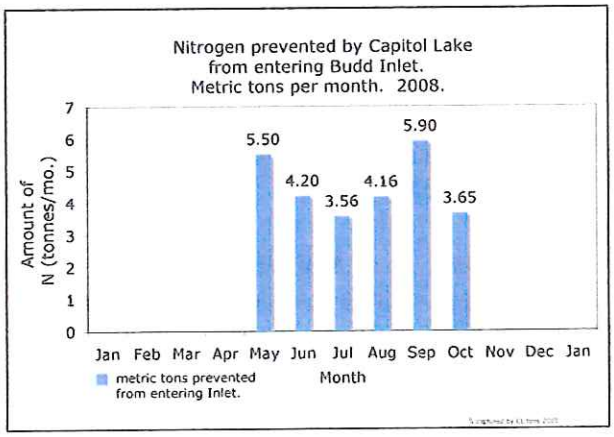


Figure 19. Metric tons of N nutrients prevented from entering Budd Inlet by Capitol Lake during the marine growing season, 2008. [These numbers are underestimates of the Lake's powerful effect; see Footnote 4.]

Starting on June 1, pour 60 bags of fertilizer into the water going over the dam into Budd Inlet every day for the entire month, to get an idea of how much nitrogen Capitol Lake keeps out of the Inlet during a month in the marine growing season.

The Lake reduces the tonnage of nitrogen nutrients entering Budd Inlet every month of the growing season.[5] That has been known since at least 1978, when the CH2M-Hill consulting firm reported this phenomenon to Washington's Department of Ecology. The Lake performs a free "ecosystem service" that is about the equivalent of passing the Deschutes River through two consecutive wastewater treatment plants, each with the nitrogen-removal capacity of our community's LOTT plant.[6]

Without the Lake, all of the Deschutes River's nitrate would go directly into Puget Sound.

Did the BI Model Simulate The Lake's N-Reduction Accurately?

Did the Budd Inlet model successfully simulate the reduction of nitrogen nutrients going into the Inlet from the Lake?

Nowhere does the L/E Chapter in the TMDL Report mention this, and queries to the report writers by some interested parties have gone unanswered.[7] I infer that the model does accurately simulate the Lake's N reduction, based upon data reported in the TMDL Appendices.

The model used for Capitol Lake's connection with Budd Inlet appears to be a combination of four models that team up to simulate the Lake system. These are (roughly) 1) a water movement ("Transport") calculator, 2) a model ("WQCBM") that mostly calculates water chemistry and water quality changes, 3) a model ("GAM") that calculates phytoplankton growth and its effects, all linked to a fourth model ("WQADD") that simulates the growth of macrophyte plants.[8] For some unexplained reason, the Lake is divided up for simulation into some 281grid squares, more than those for all of the much larger Budd Inlet (assigned 168 squares). About 10 depth layers are used, despite the Lake's shallow depths (average about 9 feet) and homogenous water columns.[9]

The Lake model was calibrated by adjusting its parameters to make its output best fit observed data taken in 2004.

Figure 20 shows how the model's calculations matched DO levels observed at the Lake's surface during the calibration period. The computer's calculations tracked observed trends with reasonable fidelity. During that time DO remained at high concentrations seldom seen in salt water, all summer long.[10]

The models were also used to predict dissolved inorganic nitrogen (DIN) levels in Capitol Lake during the calibration runs. Figure 21 shows its calculations for water at three sites – CL1, CL3 and CL4 – from May through September at the north ends of the South, Middle, and North Basins, respectively.

The graphs in Figure 21 show the model's prediction that DIN levels at all three sites will be about as high as is typical for Deschutes River water in early May. In this it is far off target for the Middle and North Basins, where the measured values (which show the Lake's N-removal process already in action at this early date) are less than half of the calculated predictions. By August the computer accurately reproduces what the Lake is actually doing, predicting DIN's near or at zero during mid-summer and matching the measured values.

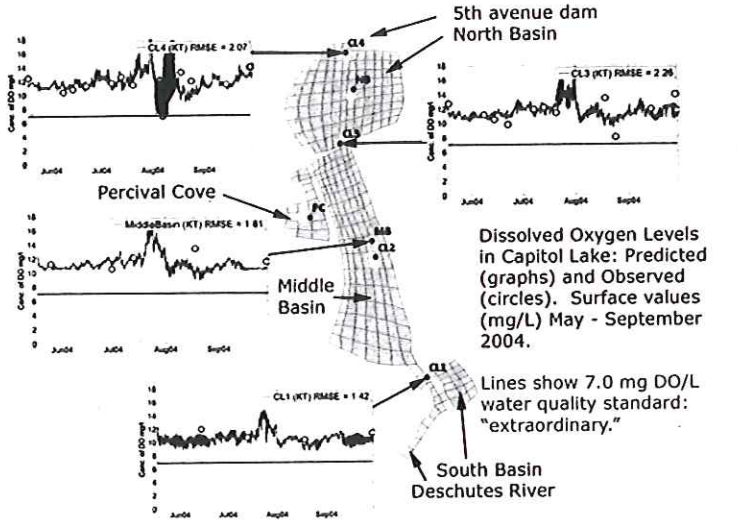


Figure 20. Grid used by Capitol Lake model, with summer dissolved oxygen levels at the surface calculated for four sample sites. Circles show surface values observed during that time. Figure 85, TMDL Report, with illustrative labels added.

My inference from these data is that, if this performance by the model as calibrated was achieved in the simulation runs, then the model accurately mimicked Capitol Lake's reduction of DIN in the discharge water.

What about the opposite case? Did the computer use elevated DIN levels characteristic of the Deschutes River in its Estuary Scenarios? No explicit mention is made of this in the TMDL Report.

We do have one strong indication that the Estuary Scenarios used nitrogen nutrient inputs that are higher than those used in the Lake Scenarios.
That is, the data in Figure 8 (analyzed earlier) could hardly have been obtained by this particular Model were it not comparing a low DIN Lake Scenario with a high DIN Estuary Scenario.

Capitol Lake's nitrogen removal capability is the Deschutes River Watershed's biggest water quality asset – something strangely missing from the TMDL Report. The data in Figure 19 (and the CH2M-Hill Report) should be foremost elements in any discussion of the Lake/ Estuary alternatives for the head of Budd Inlet.

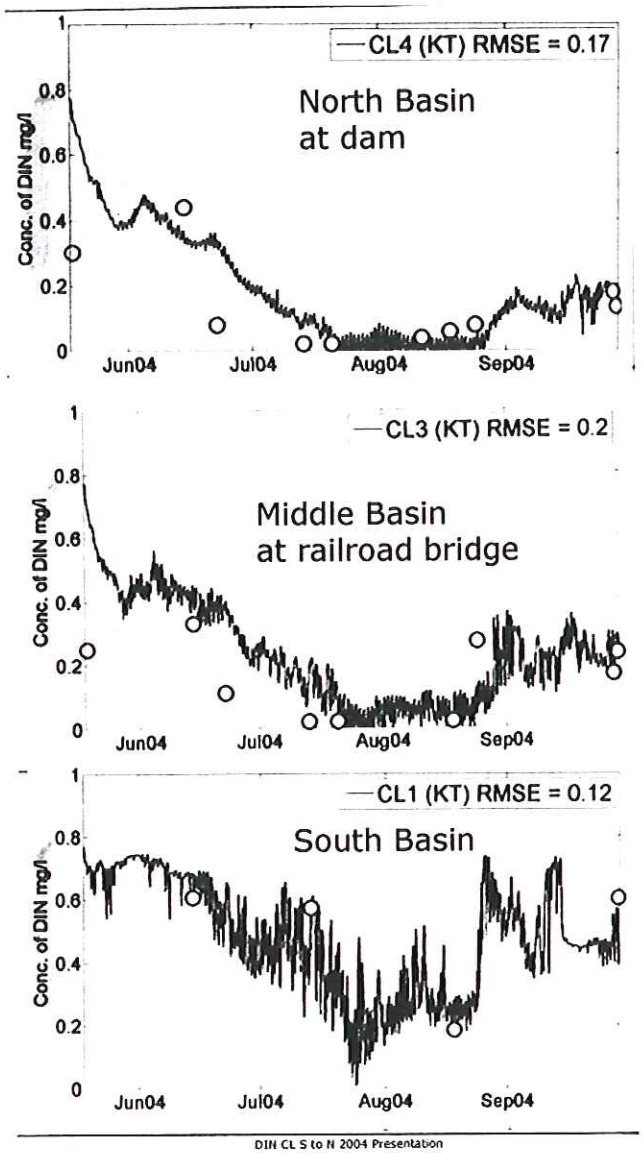


Figure 21. Comparison of the Lake Model's predictions (graphs) with measured values (circles) of dissolved inorganic nitrogen (DIN) at three Capitol Lake sites. May–September 2004.

Notes -- Section 7.

[1] The data used for this example were provided by John DeMeyer. He obtained them from two online sources provided by DOE. The Lake inflows and nitrogen concentrations can be seen at <_____>. The outflows and their nitrogen concentrations were posted on line in response to a request by JD but were removed after two weeks. He and I have not been able to relocate their source.

The data recorded by JD span 2004-2009. Inflow data are provided for every year. Outflow data were for the whole year 2004 and for the summer months only in 2005-2009, as seen in Figures 17 and 18 above.

I have used these "JD" data for this example for two reasons. 1) the nutrient levels reported are near those of the present time. 2) The outflow data were measured right at the dam. The earlier data reported by

CH2M-Hill (1978) show exactly the same pattern of nitrogen removal by the Lake and could have been used in place of the JD data. Advantages would be the certainty of the data source and a level of detail that allows us to identify the Middle Basin as the main site of nitrogen capture. Disadvantages would be that the CH2M-Hill data are decades old, we would need to infer that the nutrient concentration of the outflow is the same as that of the North Basin, and would need to infer that the outflow equals the inflow -- reasonable inferences, but not quite the same thing as certainty. In any event, the CH2M-Hill data show exactly the same pattern of seasonal nitrogen removal as do the JD data.

[2] The "JD" data for 2008 included inflow from the Deschutes River for every month except September. (That datum is missing.) I have interpolated between the August (97 cfs) and October (102 cfs) inflows to estimate the September inflow at 100 cfs. That is the only datum that I have had to estimate for this data set. An alternative would be to assume the September inflow was the same as the September outflow (94 cfs). The two figures are so similar that I have used the interpolation for September inflow.

[3] The Deschutes River comes close to being the largest contributor of nitrogen nutrients to all of South Puget Sound during the summer months. Of 56 South Sound large and small watersheds measured in 2006-07, the Deschutes River had higher nitrogen nutrient concentrations (about 0.8 mg NO_3+NO_2 per Liter) in its waters than all but 10 tiny inconsequential streams. On the same scale, the much larger Nisqually River was almost the lowest on the list (50th out of 56th at about 0.3 mg/L; see Figure F-2 p. 124, Mohamedali & other authors 2011). When the flow volumes of the waterways are considered, the discharges of the Nisqually and Deschutes Rivers are at the top of the list with nitrogen discharges at 1011 and 729 kg N/day (respectively Nisqually and Deschutes Rivers, 2007 annual monthly averages) and 199 and 198 kg N/day (respectively Nisqually and Deschutes Rivers, September 2007 averages). No other creeks are close to these numbers; the next largest September nitrogen discharge of 26 waterways listed by Mohamedali & others 2011, Table 7 p. 28, is from Chambers Creek at 112 kg N/day).

[4] The amount of nutrients entering the Lake omits the Percival Creek contribution. Including this omission would make the total "inflow" higher in nutrients, the "outflow" volumes and nitrogen concentrations the same, and therefore the removal ability of Capitol Lake even more impressive than the tonnages shown in these data.

[5] This is a true statement about dissolved nutrient nitrogen, but also only a partial representation of what is probably the whole nitrogen-budget situation. After the growing season, the lake plants die back and some of their foliage, stems, etc. begin to break loose and go over the dam. As these plant parts decay in salt water, the nitrogen they took up during the growing season is released. By this time phytoplankton growth has slowed dramatically and most of the released nutrients leave Budd Inlet, ultimately to reach the Pacific Ocean. The net effect of the Lake is to capture and hold a lot of nitrogen during the growing season, then gradually release much of it in the form of dead plant biomass to the Inlet after the growing season. (This is my expectation; I know of no studies that show this for Capitol Lake. Some such study is needed and would help determine an optimal lake vegetation harvest for maximizing year-round nitrogen removal by the Lake.)

[6] ... "Two LOTT plants = one Capitol Lake ..." 1) From the JD data for September 2007; River inflow = 76 cfs with N concentration in inflow = 1.050 mg/L; outflow at dam = 79 cfs with N concentration in outflow = 0.282 mg/L; the Lake received 195.3 kg N/day incoming nitrogen and reduced it to 54.5 kg N/day outgoing before discharging it to Budd Inlet. 2) From Table 9 p. 36 Mohamedali & other authors 2011, the LOTT plant discharged 142 kg N/day as an annual monthly average in 2007 and lowered that to 76 kg N/day during September 2007 by "turning on" its nitrogen recovery apparatus. About 53% of the incoming nitrogen to the plant is still present in the outflow. 3) To reduce the ~195 kg/day incoming from the Deschutes River to the level discharged by Capitol Lake (~55 kg/day), the first LOTT plant treating the whole Deschutes River would reduce its nitrogen input to 53% of 195 or about 103. The second LOTT plant would reduce that level to 53% of 103 or about 55 kg N/day.

[7] John DeMeyer and Bob Holman have inquired about whether the low N discharge of the Lake has been recognized and/or successfully replicated by the modelers.

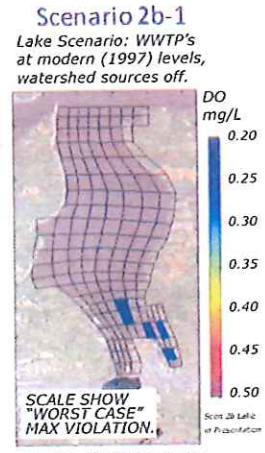
[8] See pp. 187-189, TMDL Report. One infers from this reading that this combination of models is also the one that is used to simulate Budd Inlet with, of course, modifications to accommodate presence or absence of tides, salinity, and other properties of fresh- or saltwater systems.

[9] My count of 168 grid squares used to simulate Budd Inlet is from Figure 84, TMDL Report. Figure 85 of the Capitol Lake grid shows 281 grid squares. Slightly different grid square numbers are occasionally mentioned in the TMDL Report (for example, 159 for Budd Inlet on p. ___), however the exact number doesn't matter. On page 18, TMDL Appendix H, statements are made to the effect that the shallow depth of the Lake and absence of stratification of its waters (that is, the water is homogeneous from surface to bottom) are such that simulation by layers is hardly necessary; the whole water column is the unit of interest.

[10] Fresh water is inherently capable of holding more dissolved oxygen than salt water. At Tumwater Falls, the churning river water takes up oxygen from the atmosphere and is "100% saturated" when it enters the Lake just downstream. When the river is colder than the Lake, its entry flow can be expected to creep along the bottom – thus, by contrast with the situation in estuaries, delivering high-oxygen water to the bottom. This process usually keeps the DO of the bottom water near or at the same levels as prevail near the surface.

Section 8. Why do WQ standards violations keep showing up in East Bay?

Figure 22 shows a scenario pattern that occurs throughout the TMDL L/E Chapter. As in all other scenario findings presented in Format 1, the "violations" blamed on Capitol Lake are in East Bay or near its entrance. Might factors other than Capitol Lake be responsible for this pattern of "violations?" The answer is "yes," as explored in the following.



Source: Fig. 90 TMDL Report

Figure 22. Lake scenario with watershed sources at "natural" levels and Waste Water Treatment Plants discharging at modern (1997) levels.

East Bay is far enough and physically isolated enough from the Lake water entering Budd Inlet at the dam that it may respond more dramatically to local inputs at the head of that bay than to the big inputs farther away. The small seldom-mentioned Moxlie Creek enters East Bay from a culvert. Its water typically has a high nitrogen concentration (about 60% of the median level in the Deschutes River in 2006-2007).[1] This tiny creek dumped the equivalent of five or six 50-lb bags of fertilizer (of 10% nitrate content) into East Bay every day during September, 2007.[2] Because the Creek's flow is so small, it is unlikely that it sets up a meaningful estuarine circulation pattern like that which dominates West Bay. The mouth of East Bay is weakly blocked by a small fresh water outflow from Mission Creek (itself high in nitrogen nutrients) and a diffuse curtain of fresh water from the LOTT outfall between East and West Bays. All of this adds up to a semi-isolated, nutrient-stoked pocket of water whose main exchange with the rest of the Inlet is a non-directional back-and-forth tidal sloshing.[3] It is possible and even likely that the effects of this small creek dominate the computer's nearby grid squares more than do large inputs originating at the distant 5th Avenue dam.

It would be easy to find out. Simply set Moxlie Creek's nitrogen content at zero (not its "natural" level) and run a simulation again. (Evidently the Budd Inlet model is incapable of making such a simulation, but the Whole-Sound C/SPS DO Model can do it.[4])

Notes -- Section 8.

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[1] Median N concentrations of 56 rivers, creeks and streams (including Moxlie Creek) are shown for 2006-2007 in Figure F2 p. 124 (Mohamedali & other authors, 2011).

[2] Table 7 (Mohamedali & other authors, 2011 p. 28) reports Moxlie Creek's daily discharge for September 2007 as 55 kg N/day.

[3] Further factors that isolate East Bay are the obstruction of surface flow by a dock that blocks about half of its entrance and the prevention of oxygen exchange with the air by boat hulls that cover 8-15% of the inlet. These factors are not included in the model but may contribute to the vulnerability of the Bay to real-life WQ standards violations.

[4] A. Kolosseus, pers. Comm.. March 5, 2014.

Section 9. Was the Budd Inlet Model used "The Wrong Way?"

Deep in the heart of this whole vast complex simulation business is a critical first step that starts the procedure and governs the way in which all subsequent WQ standards violations are assigned. This section describes that first step, as best as possible from the sketchy information available. It appears that it was applied "The Right Way" for the Estuary Scenarios, but "The Wrong Way" for the Lake Scenarios.

The starting steps require that "Scenario 1" be created -- one version for the set of Estuary simulations and a second version for the set of Lake simulations. Scenario 1 is a preliminary run of the computer simulation for the water bodies in their "natural" pre-modern conditions with no inputs from WWTP's and no inputs of silt, nutrients, etc. from watersheds affected by such activities as logging, agriculture, and urban development.[1]

When the Scenario 1 run is made with "natural" (pre-modern) conditions, every cell under every grid square is "watched" by the computer to see if the natural water ever, even just once for just six minutes throughout the entire computer "year" (January 15 – September 15), violates the modern 20th century water quality standards that have been assigned to those water bodies. At the end of the run, some squares are flagged for violations and all of the rest are unflagged.[2] *The calculations from all later simulations exploring this or that impact caused by modern human activities are compared with this Scenario 1 "grid map," cell by cell, moment by moment, area by area, all "year" long to determine where violations caused by those activities occur.*

To illustrate, Figure 23 shows a "Scenario 1 grid map" for Budd Inlet with Capitol Lake in place as calculated by the Model for all of Puget Sound (the C/SPS DO Model). It shows that with Budd Inlet and an imaginary Capitol Lake at a time when no modern human activities impacted the water quality, 20th century "standards" (= 6 mg DO /L outer Budd Inlet, 5 mg/L inner Inlet) would have been "violated" in the grey zone on the map and the respective standards would never have been violated in the red and green zones.

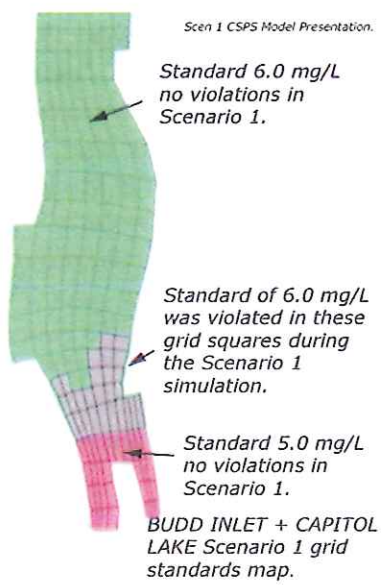


Figure 23. Scenario 1 grid map for Budd Inlet created by the C/SPS DO Model research team. I have added the red and green colors and labels. Source: Compiled from parts of Figure 45 SPSS Draft, p. 87.

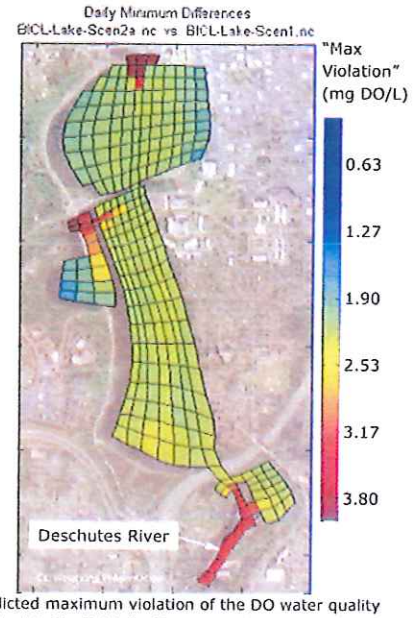
In all subsequent simulations with Capitol Lake in place – "Lake Scenarios" that is – some with modern watershed impacts, some with WWTP impacts, some with both, DO's in cells in the green (or red) zones must fall below 6.0 (or 5.0) mg DO/L to flag a violation. In the grey

zone, DO's must fall below either the natural DO level or the standard (in this case 6 mg/L), whichever is the lowest at that moment, to flag a violation.[3]

It appears that the Scenario 1 grid map was done "The Right Way" for the Estuary simulations. [*However, see End Note 4 below.*] That is, an estuary was envisioned "attached" to the south end of Budd Inlet, the estuary + Budd Inlet system were given pre-modern ("natural") levels of nutrient inputs, and then a "year"-long simulation was run comparing the "natural" water with 20th century water quality standards. From this comparison, an Estuary Scenario 1 grid map appears to have been created. <u>All later estuary simulations using modern levels of nutrient inputs were then compared with that grid map to identify areas in modern-day violation.</u>

The "Lake + Budd Inlet" Scenario 1 grid map was devised in a fundamentally different way. No modern numeric DO standards were assigned to the Lake. A Lake + Budd Inlet simulation using "natural" levels of nutrient inputs and other properties should have been compared with 20th century WQ standards to create a Lake Scenario 1 "standards grid map" for finding violations in later simulations using modern nutrient input levels.[4] *Evidently there are no numerical standards for fresh water lakes; the "standard" in this case is the "moving target" of whatever the DO was in the "natural" water body less 0.20 mg DO/L*

Figure 24 shows what happens when "modern" Capitol Lake is compared with "natural" Capitol Lake by this criterion. That comparison shows modern Capitol Lake in massive violation of water quality standards in every grid square. The reason is that in "modern" times, the Deschutes River is thought to be 3°C warmer than in its "natural" condition, reducing the water's ability to hold oxygen even when saturated by passage over the falls. A warmer modern River and Lake guarantees that "violations" will be "found" everywhere, less so in the Lake (where plant photosynthesis makes up some of the difference) than in the free-flowing river.



"Predicted maximum violation of the DO water quality standard in Capitol Lake from nonpoint sources (Scenario 2a-1)." *The layer with the maximum violation is plotted for each grid cell.* Source: Fig. 92, TMDL Report.

Figure 24. Purported violations of (never specified) water quality standards in Capitol Lake compared with some (never-specified) "Lake Scenario 1" with Deschutes River and Percival Creek nutrient inputs at modern levels.[5] Source: TMDL Fig. 92 p. 208.

The bottom line is that the procedure used flags the 1997 lake water for "violations" everywhere, despite the fact that it has modern DO's higher than 7.0 mg DO/L – often higher than 10 -- throughout the year, often from top to bottom (see Figure 20 above). The TMDL Report rationalizes that, no matter what the high level of DO in Capitol Lake may be under modern conditions, any decline of 0.2 mg/L or more below the "natural" conditions qualifies as a "violation." (p. 203, TMDL). What would be

"extraordinary" water quality in Budd Inlet is therefore shown as a "violation of water quality standards" in Capitol Lake.

For salt water, 20th century numeric standards are assigned at the outset and the water in its pre-modern "natural" (Scenario 1) state is compared with those standards throughout a computer "year." As shown by Figure 23, the DO in every cell under most of the grid squares in "natural" Budd Inlet never violated the modern standards, even for 10 minutes of the "year." Nothing is said in the TMDL Report about the standard that the Estuary (Scenario 1) water was compared with, but the impression gained is that, like East and West Bays in Figure 23, whatever the chosen standard was, it was never violated. The "playing field wasn't level;" the salt water in the basin, undoubtedly with lower DO's than the fresh water in the basin, was given a much less stringent standard to measure up to than was the fresh water.

The biggest gap in the TMDL Report L/E Chapter is its omission of descriptions of the Lake Scenario 1 and the standards applied to it, and the same information for the Estuary Scenario 1. If there is a future edition of that Report, this major deficiency needs to be remedied.

When Budd Inlet was simulated as part of the large Central/South Sound study, the model used (C/SPS DO Model) definitely included the fact that Capitol Lake reduces the nitrogen nutrient load that would otherwise be discharged to Puget Sound by the Deschutes River. Since that model has fewer grid squares than does the Budd Inlet Model, it also simulated the discharge of the Capitol Lake outflow to the whole south end of West Bay. (In the Budd Inlet Model Scenarios, the Estuary discharges to the whole south end of West Bay whereas the Lake discharges to just one grid square – a structural model artifact that could account for differences in Lake/ Estuary outcomes.) In this case the modelers probably used the same data from "natural" pre-modern times for the river and lake as were used by the Budd Inlet modelers.

When this large-scale Sound-wide simulation engine was run with these differences from the Budd Inlet Model simulations ...

... it showed no net difference between the Lake and Estuary outcomes.

As did the BI Model, the C/SPS DO Model mapped out regions of mostly feeble WQ standards violations. With the Lake present (the only case that this model is set to simulate) these violations are, as usual, mostly in or outside the mouth of East Bay (Figure 25, left). An "Estuary" case borrowed from the TMDL research is compared with it (Figure 25 right). The Estuary case shows the usual East Bay flagged violations, tiny WQ standards violations extending to the west shore of Budd Inlet, and a few more seriously affected cells right in West bay itself. [6]

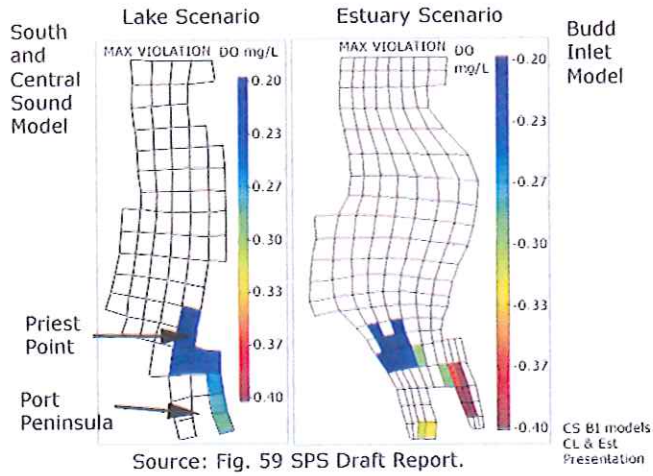


Figure 25. Output of the S/CS DO Model with Capitol Lake included (left) and the BI Model with Capitol Lake replaced by an estuary (right), for Budd Inlet.

As pointed out in Sections 2, 3, and 4 above, it is a mistake to use flagged patches of miniscule WQ standards violations as a way of blaming Capitol Lake for problems in Budd Inlet. It is also a mistake to assume that every flagged patch is traceable back to the Lake and not, say, to a local source like Moxlie Creek or to a model artifact like the difference in grid squares receiving discharges between the Lake and Estuary simulations. The C/SPS DO Model seems to have shown us that standards violations are still to be found when sought by a more powerful, versatile model, but that they do not seem to be much different between Lake and Estuary scenarios.

Notes -- Section 9.

[1] The amounts of nutrients discharged to Puget Sound by rivers and creeks in former pre-industrial times are not zero. Estimating those amounts is a real challenge to modelers, ecologists, and others interested in understanding the natural landscape of the past. Usually there are few early era measurements to rely on, but from studies of modern creeks in "untouched" landscapes (and other research) values can be estimated with a fair level of confidence. These values are used in the Scenario 1 simulations.

[2] It is surprising how often "natural" conditions violate modern 20th-century WQ Standards assignments. In a C/SPS DO Model simulation of all of Puget Sound from Edmonds to Olympia as it probably existed in its natural state, fully 93% of the main body of Puget Sound violated the modern standards (see Figure 45 p. 87 SPS DO Draft.) This massive violation was made nearly inevitable by assigning a very high 20th century standard (7.0 mg DO/L) to most of Puget Sound from surface to bottom, despite that fact that the bottom water entering from the Pacific Ocean contains much less oxygen than this concentration most of the year. (Barnes & other authors, 1964.)

[3] This is the "moving target" mentioned in Section 1.

[4] *Starting on page 32, the parts of this section that are written in italics were substituted for my original text as a result of new information provided by the TMDL modelers on March 20. The respondents (see*

"Ahmed and other authors, 2014" in the References section) explained the method by which they found water quality standards violations in Capitol Lake. (This clarified the interpretation of Figure 24, which, absent an explanation in the TMDL Report, I had inferred had been obtained by comparing the Lake with salt water.) It appears that a credible "Right Way" Capitol Lake Scenario 1 was constructed, but the Lake was then compared with a much different set of water quality standards than the ones used for the Estuary Scenario 1 waters.

Some doubt remains. Many of the same modelers ran the C/SPS DO model with a "Right Way" Capitol Lake Scenario 1. But the same modelers make this statement: "The Budd Inlet project has determined that the natural condition against which scenarios are compared is without the Capitol Lake dam." (p. 104 C/SPS DO Draft) – seemingly implying that both Lake and Estuary must use the Estuary Scenario 1. That is the only sentence of explanation available in the C/SPS Draft and the TMDL Report.

[6] The "Estuary Scenario" figure borrowed by the C/SPS researchers and shown in Figure 25 right above is most similar to a "Scenario 4" estuary figure on page 93, TMDL Report. "Scenario 4" is run with the LOTT plant discharging at the maximum level permitted (about four times its present-day discharge) and the Deschutes River at its modern level of nutrient discharge. The "Lake Scenario" figure calculated by the C/SPS researchers (Figure 25 left above) most closely resembles the "Scenario 4" lake figure on page 206, TMDL Report.

Section 10. REFERENCES.

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"SPS DO Draft." See Ahmed and others (2013) above.

"TMDL Report". See Roberts and others (2012), above.

TMDL Appendices. Same as Roberts and others (2012) above. Appendices A & B (Glossary and Acronyms/Abbreviations) included with the TMDL Report. Appendices C – M available on line only at the site shown for Roberts et al (2012).

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Conclusions and Recommendations.

As best I (the author) can tell from the TMDL Report findings, there is no indication that Capitol Lake has any negative effect on Budd Inlet's water quality. Indeed, it appears that the Lake's discharge water suppresses eutrophication of Budd Inlet – a major beneficial water quality impact.

The simulations described in the TMDL Report were directed at producing "patterns" – not at finding "underlying mechanisms" by which water from the Lake or Estuary might influence Budd Inlet. The patterns of water quality standards violations shown in Formats 1, 2, and 3 contain useful information but are easily misinterpreted and do not lend themselves to understanding the dynamics of the Inlet, Lake, or Estuary.

Where do we go from here? I recommend the following.

1) Describe in detail the "natural" Estuary Scenario 1 and Lake Scenario 1. *Give the numerical values* of all 20th-century water quality standards against which the "natural" water in each grid cell is initially compared when the respective Scenario 1's are tested against modern water quality standards; outer Budd Inlet, inner Budd Inlet, in the Estuary, and in the Lake. Show via a grid map (like Figure 45 in the South Puget Sound Dissolved Oxygen Study, copied in Figure 26 here) all grid cells in which the water of Inlet, Lake, and Estuary in its "natural" (= pre-modern) condition does or does not violate the standards.

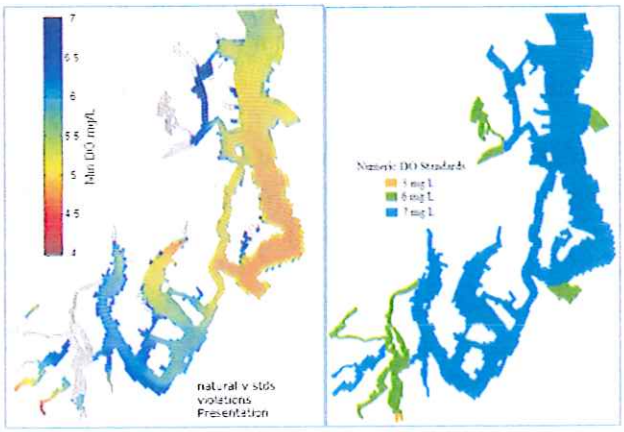

Figure 45. Grid cells with minimum DO below the numeric standard under natural conditions. Cells in white are above the numeric standards under natural conditions.

Figure 26. Water quality standards violations in Scenario 1 for Puget Sound (left) compared with 20th century water quality standards (right). This is Figure 45 of the C/SPS DO Draft Report; comparable maps should be shown for Budd Inlet, both for the Lake and for the Estuary Scenario 1's.

[*The results of this exercise will take the form of a map of Inlet + Estuary with the standards shown on the whole map, a map of Inlet + Lake with the standards shown on the whole map, and final separate grid maps for Inlet + Lake and Inlet + Estuary showing areas where the natural waters violate modern standards and areas where they do not (as in Figure 26). This exercise should show us whether the Lake /Estuary comparisons in the TMDL Report were made with a flawed Lake Scenario 1 formulation.*]

2) Determine whether it is plausible that Capitol Lake influences East Bay by running a season-long simulation with a "dye tracer" released at the 5th Avenue dam/estuary mouth, to see where the discharge water actually goes after it enters West Bay.

[*Data in the TMDL Appendix indicate that in July 1997, at least, water from the dam does not approach East Bay in any significant amounts. A season-long simulation can tell us whether that is also the case during the rest of the marine growing season.*]

3) Test the possibility that the patterns seen in and near East Bay are influenced by local sources such as Moxlie Creek and/or the LOTT outfall – not Capitol Lake or the Estuary by running the simulation with Moxlie Creek's nitrogen content set at zero with all other Lake and Estuary values set at their modern (watershed + WWTP) levels.

[*Not recommended here but perhaps consider for future simulations; include in the model the effects on DO of the raft of boats and docks blocking about half of the Bay's entrance (and covering about 10% of its surface area) on surface outflow and uptake of oxygen from the air in East Bay.*]

4) Obtain from stored data the dates upon which the "worst case DO differences" shown in TMDL Figure 87 (p. 200) occurred and the depths at which they occurred, and show the vertical profiles of DO concentrations in each depth layer under the labeled grid squares BI-1, -2, -4, -5, -6, BA-2, BB-2, BC-2, BD-2, BE-2, BF-3 (Appendix G p. 17).

[*If the vertical profiles show the Estuary creating more oxygen at or near the surface – in the "euphotic zone" – than does the Lake, then the Figure shows a beneficial impact of the Lake on Budd Inlet.*]

5) Clarify the interpretation of Figures showing the duration of WQ standards violations (Figures 91 and 94, TMDL pp. 207 & 210), particularly the interpretation of the scale "days/layers."

6) If it is deemed useful to continue using the existing model for the Lake/Estuary pattern comparisons (or if it is the easiest next step), run the Estuary simulations again for several additional years; a wet year, a dry year, and 2004, and compare the outcomes with the patterns of "Estuary" WQ standards violations obtained for 1997.

[*In general, a single simulation of a complex system influenced by phenomena that change yearly in ways that are partially random (as, weather patterns) or in ways that are completely predictable (as, tide patterns) is not enough for confidence that the system is well understood. Running it again for a recent "wet" year and a recent "dry" year would sharpen our focus on whether the results using data for 1997 are typical. Because the Budd Inlet model was calibrated with 1997 data, whereas the Lake and Estuary models were calibrated with 2004 data, a 2004 simulation ought to be included in any extra runs of the model. The 1997 model run for the Estuary scenarios was probably done "The Right Way;" comparing those runs with data from other years would probably be trustworthy.*]

7) If feasible, "broaden" the Capitol Lake outfall so that the discharge enters all four grid squares at the south end of West Bay (as in the Estuary Scenarios) and try future Lake

Scenarios with that condition. If feasible, model the Lake and Estuary with grids whose squares are the same size as those used for Budd Inlet.

[*This addresses the possibility that artifacts of the model, rather than real-life differences between the Lake and Estuary systems, may play a role in the patterns of WQ standards violations shown in the L/E Chapter. The estuary is modeled with a 500-foot outflow (from the lower West Hill roundabout to Bayview Market) essentially emptying into the whole south end of West Bay*[1]*, whereas the narrow Lake outflow is confined to just one or two grid squares there. The Lake and Estuary models also use more grid squares for those small bodies of water than does the model for all of Budd Inlet. These differences between* <u>*models*</u> *could influence the final simulation results as much as (or more than) the differences between Lake and Estuary* <u>*systems*</u>.][2]

8) Make a data CD showing Salinities, Temperatures, and DO's in each depth layer for each month (April – September) for the grid squares mentioned in (4) above available to parties who request it.

10) For future simulations, avoid Format I presentations of data. Show depths and dates of WQ standards violations and the durations of violations in consecutive minutes, days, weeks, or months in conventional formats.

11) If there is to be a future edition of the TMDL Report, include text and figures explaining the removal of nutrients from Deschutes River water by Capitol Lake.

Notes -- Recommendations.

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[1] 500-foot opening; see p. 197, TMDL Report

[2] The modelers themselves note that the South and Central Sound Model's fewer, larger grid squares won't "find" as many "violations" as can a model with more numerous, smaller squares. P. 104, South Puget Sound Dissolved Oxygen Study Draft.

From: Wagner, Lydia (ECY)
Sent: Thursday, July 03, 2014 4:25 PM
To: David Milne
Cc: Kolosseus, Andrew (ECY); Doenges, Rich (ECY); Roberts, Mindy (ECY)
Subject: Report Response

Dear Dr. Milne,

Thank you for sharing your analysis of the June 2012 report on the Deschutes River, Capitol Lake, and Budd Inlet study. I also appreciate you and Ginny Sterns meeting with Andrew Kolosseus and myself on March 6 to discuss your comments. Our colleagues from the Environmental Assessment Program have addressed your conclusions in the attached memo.

As you know, Ecology staff is concentrating on preparing the final report for the freshwater portions of the Deschutes River above the falls, Percival Creek and its tributaries, and Black Lake Ditch and its tributaries. Ecology will address the marine portions of the watershed in the next phase scheduled to begin in 2015. At that time Ecology will resume discussions on the marine-related issues, including Capitol Lake. Your comments, and all other comments received by Ecology, will inform our next steps. If you want to discuss your findings with the advisory group, this will be the appropriate time, and I will work with you on scheduling.

While we are focusing our work on the freshwater portions of the watershed above Capitol Lake, we wanted to share Ecology's responses to your March 2014 report. Our response focuses on the summary statements contained in the Executive Summary. We are available to discuss our responses in person if you are interested in another meeting. You may also be interested in questions and answers on the Deschutes TMDL website available at http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/qa.html.

Again, thank you for your comments on the study. We encourage you to continue to track ongoing efforts on this project and in the Deschutes watershed. Ecology continues to maintain a public process on this project through the Deschutes TMDL Advisory Group and our website (http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/advgrp.html).

If you have any questions, please contact me, the Water Cleanup Plan Coordinator (TMDL Lead) for this project, at 360-407-6329 or Lydia.Wagner@ecy.wa.gov.

Sincerely,

Lydia

Lydia C. Wagner | Water Cleanup Plan (TMDL) Coordinator | Lydia.Wagner@ecy.wa.gov
WA Department of Ecology | Direct 360.407.6329 | Main 360.407.6000 | Fax 360.407.6305
PO Box 47775 | Olympia, WA 98504-7775 | Street: 300 Desmond Dr. SE | Lacey, WA 98503-1274
http://www.ecy.wa.gov/programs/wq/wqhome.html

DEPARTMENT OF ECOLOGY
Environmental Assessment Program

July 2, 2014

TO: Rich Doenges, Water Quality, SWRO
Andrew Kolosseus, Water Quality, SWRO
Lydia Wagner, Water Quality, SWRO

FROM: MR by KE Mindy Roberts, Modeling & Information Unit, Statewide Coordination Section, Environmental Assessment Program
GP Greg Pelletier, MISU, SCS, EAP
Anise Ahmed, MISU, SCS, EAP

THROUGH: KE Karol Erickson, Unit Supervisor, MISU, SCS, EAP
WK Will Kendra, Section Manager, SCS, EAP

SUBJECT: Response to Memorandum from David Milne Dated March 17, 2014

We reviewed the Executive Summary and 39-page report and found multiple errors in interpretation and omissions described below. This memorandum corrects the executive summary statements in ***bold italics,*** and supplements the questions and answers available at http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/qa.html. There are additional errors in the analysis that are not directly addressed here.

These responses supplement our two responses to similar comments previously submitted. In November 2013, David Milne submitted 20 comments through the South Puget Sound Dissolved Oxygen Study, some relating to the June 2012 report on the Deschutes River, Capitol Lake, and Budd Inlet study (https://fortress.wa.gov/ecy/publications/SummaryPages/1203008.html). Responses were included in the South Puget Sound Dissolved Oxygen Study's response to comments. In December 2013, David Milne submitted four questions and comments related to the June 2012 Deschutes River, Capitol Lake, and Budd Inlet study. Several overlapped with comments submitted on the South Sound study. We responded to the December 2013 questions in a memo forwarded to David Milne by Lydia Wagner.

[1] I find that the Lake does not have negative effects on Budd Inlet and that the Lake improves the water quality of the Inlet.
Overall, the Capitol Lake dam has a quantifiable, detrimental impact on Budd Inlet dissolved oxygen concentrations. The negative impact results from the combined effects of circulation in southern Budd Inlet, carbon loading from Capitol Lake, and nitrogen loading from Capitol Lake.

The presence of the dam, independent of any human contribution of nutrients, increases the amount of time that water stays in Budd Inlet (https://fortress.wa.gov/ecy/publications/SummaryPages/1403021.html).

The dam releases water from the Deschutes River and Percival Creek as a pulsed flow. Water stays in southern Budd Inlet longer than it does compared with continuous flows from the Deschutes River and Percival Creek without the dam in place. The increase in residence time of the water contributes to lower dissolved oxygen levels in southern Budd Inlet than would occur without the dam in place.

Capitol Lake receives inputs from the Deschutes River and Percival Creek. This results in extensive algae blooms in the lake. Plant growth in Capitol Lake discharges more organic carbon to Budd Inlet than would occur if the Deschutes River and Percival Creek flowed into Budd Inlet directly. As the organic carbon decays, oxygen is used up in the process. This causes lower oxygen levels than would occur without the dam in place.

Capitol Lake does decrease the amount of nitrogen released to Budd Inlet. This has been known since 2004, when the Washington State Department of Ecology (Ecology) developed quarterly reports with interim monitoring data (http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/technical.html). The computer model of Capitol Lake correctly predicts that the water leaving Capitol Lake has much lower nitrogen concentrations than the water entering through the Deschutes River during the growing season. Originally, Ecology hypothesized that this could decrease dissolved oxygen impacts in Budd Inlet, but other factors affect oxygen. The combined effects of the dam (decreased circulation in southern Budd Inlet, higher residence time, higher carbon loading, and lower nitrogen loading) cause greater impacts on dissolved oxygen in Budd Inlet than would occur without the dam in place.

(2) The computer calculations presented are only tangentially relevant to a Lake/Estuary comparison and are presented in formats that are very prone to misinterpretation.
The computer modeling approach was designed specifically to evaluate the relative impact of the lake and estuary alternatives. Ecology worked closely with the Department of General Administration and the Capitol Lake Adaptive Management Plan (CLAMP) Steering Committee to ensure that the modeling conducted as part of Ecology's Total Maximum Daily Load study could be used by CLAMP during the Estuary Feasibility Studies. Ecology's modeling was identified as an in-kind contribution to the General Administration studies.

Computer models are essential tools to determine whether water quality standards are met. The modeling analysis conducted by Ecology was designed to evaluate the contribution of all human influences, including management of the Capitol Lake dam, on potential violations of the water quality standards.

The technical study (https://fortress.wa.gov/ecy/publications/summarypages/1203008.html), published in June 2012, presents the information needed to compare with the water quality standards. The report findings were presented at numerous meetings of the Deschutes Advisory

Group, and the report was subject to extensive peer review, including advisory group members and a paid independent review.

(3) All violations of water quality standards reported by the computer are mathematically microscopic and ecologically inconsequential.

This statement is mainly a critique that the water quality standard for dissolved oxygen in Budd Inlet is too stringent. When dissolved oxygen concentrations are naturally low, the dissolved oxygen standards developed by Ecology under the Clean Water Act require no more than a 0.2 mg/L decrease from natural conditions due to the combined effects of all human activities. In Budd Inlet, wastewater discharges alone cause 0.1 to 0.2 mg/L impacts, nonpoint sources alone cause 0.1 to 0.2 mg/L impacts, and sources outside of Budd Inlet cause 0.3 to 0.4 mg/L impacts. However, the presence of the Capitol Lake dam causes the greatest single impact on Budd Inlet dissolved oxygen, deteriorating oxygen concentrations 1 to 2 mg/L, up to ten times as much as is allowed by the water quality standards. For additional information, see https://fortress.wa.gov/ecy/publications/SummaryPages/1403021.html. These changes in dissolved oxygen concentrations are neither microscopic nor ecologically inconsequential.

(4) The TMDL computer simulation data show no water quality problems occurring anywhere at any time throughout Budd Inlet.

This statement is mainly a critique that the water quality standards are too stringent. Computer modeling of dissolved oxygen in Budd Inlet indicates widespread violations of the dissolved oxygen standards. The Capitol Lake dam has the single greatest impact on Budd Inlet dissolved oxygen, and ten times the impact of the LOTT wastewater discharge.

Dr. Milne proposes substituting a threshold dissolved oxygen concentration of 3 mg/L to determine whether a water quality problem occurs instead of using the state's water quality standards found in WAC 173-201A. He suggests that as long as dissolved oxygen is generally above 3 mg/L, there is no water quality problem.

Severe and widespread effects would likely occur below concentrations of 2 to 3 mg/L. However, the scientific consensus also shows that significant biological effects can occur at higher dissolved oxygen levels (for example, http://www.pnas.org/content/105/40/15452.full). TMDLs and the water quality standards are intended to provide a margin of safety to prevent water quality conditions causing severe effects.

(5) Data that probably show a beneficial effect of Capitol Lake on all of Budd Inlet have been mistakenly presented as showing a negative effect.

Dr. Milne assumes that the greatest differences in dissolved oxygen were predicted to be near the surface. However, the greatest differences in dissolved oxygen were predicted to be near the bottom. (The last paragraph of his analysis states that if the greatest differences in dissolved oxygen were predicted to be near the bottom instead of near the surface, then the argument in support of comment #5 is not applicable.)

In 2004, Ecology presented interim data in quarterly reports that show lower nitrogen concentrations leaving the lake than entering the lake (http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/technical.html). These were discussed at

numerous meetings of the Deschutes Advisory Group. Subsequent computer modeling indicates that while nitrogen is taken up by plants and sediments within the lake during the growing season, the lake produces much higher loading of carbon to Budd Inlet than would occur with an estuary in place. In addition, the Capitol Lake dam alters the circulation in Budd Inlet. The combined effect is that the lake has a strong detrimental impact on Budd Inlet dissolved oxygen, especially near the bottom where the dissolved oxygen is lowest. For more information, see https://fortress.wa.gov/ecy/publications/SummaryPages/1403021.html.

(6) Water exiting Capitol Lake does not go into areas that experience water quality standards violations (East Bay, eg); it flows straight toward the mouth of the Inlet.
This is not correct. We have conducted tracer studies of water leaving Capitol Lake. While much of it flows north past Priest Point Park, some is entrained in an eddy in East Bay. The dam increases the amount of time water remains in East Bay, worsening water quality.

(7) Capitol Lake prevents some 27 metric tons of nitrate nitrogen from entering Budd Inlet every summer—a huge beneficial impact equivalent to the action of two LOTT plants.
While Capitol Lake reduces nitrogen loads to Budd Inlet, it cannot be compared pound-for-pound with the LOTT discharge. Water from Capitol Lake also brings substantially more oxygen-demanding carbon into Budd Inlet than would occur under an estuary alternative. The dam also alters circulation. Capitol Lake dam causes ten times the impact on dissolved oxygen concentrations as the LOTT wastewater discharge.

(8) There are many likely sources of East Bay's water quality standards violations in and near that Bay. The Lake is not one of them.
The Capitol Lake dam exerts the biggest impact on East Bay. East Bay dissolved oxygen concentrations are also influenced by wastewater discharges such as the LOTT outfall and pollution sources in the Deschutes River, Percival Creek, and Indian/Moxlie Creek watersheds. However, the dam has over ten times the impact of any of these sources.

(9) It seems likely that the "baseline" for simulations of the Lake's effects was wrongly calculated. If so, "Lake Scenario" simulation outcomes are not to be trusted.
The baseline was not wrongly calculated. There are numerous errors in this section of the analysis. For example, the analysis states that the South and Central Puget Sound model shows that standards violations are "not … much different between Lake and Estuary scenarios." However, the South and Central Puget Sound model was not applied to the estuary alternative. For more information, see Question #8:
http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/qa.html.

Cc: Robert F. Cusimano

From: Scott Steltzner [mailto:ssteltzner@squaxin.us]
Sent: Tuesday, July 29, 2014 5:55 PM
To: Wagner, Lydia (ECY)
Subject: Review Dr. Milne's paper

Hi Lydia,

Attached is an independent review of Dr. Milne's paper Capitol Lake: Protector of Water Quality in Budd Inlet. Please feel free to share with whoever think would benifit from reading it.

Scott Steltzner
Fisheries Biologist
Squaxin Island Tribe
Natural Resources Department

3110 SE Old Olympic Hwy
Shelton, WA 98584

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The Squaxin Island Tribe Natural Resources Department was made aware of a paper written by Dr. David Milne entitled *Capitol Lake: Protector of Water Quality in Budd Inlet* after references to the report were made at several public meetings. The Tribe requested and was given a copy of the paper along with a document entitled *Peer Reviews of Dave Milne's Report*. The Tribe has long advocated for the removal of the 5th Avenue dam and restoration of the Deschutes estuary. This conclusion was based upon available science which clearly showed that full estuary restoration would be beneficial for the habitat and species of the Deschutes River system and Budd Inlet.

The executive summary to the report includes two statements from Dr. Milne:

1. "I find that the Lake does not have negative effects on Budd Inlet and that the Lake improves the water quality of the Inlet."
2. "I conclude that Capitol Lake is the Deschutes River Watershed's biggest and best asset for preventing and reducing water quality degradation in Budd Inlet."

A cursory reading of Dr. Milne's report showed that he had reviewed and analyzed work done by the Washington Department of Ecology for the ongoing Deschutes River, Capitol Lake and Budd Inlet Total Maximum Daily Load (TMDL) study. To our knowledge Dr. Milne's report represents the first time that actual scientific analysis was used that called into question the decision to remove the 5th avenue dam and restore the Deschutes estuary. Squaxin Island Tribal staff attempted to review Dr. Milne's paper but found what we considered fatal flaws where changes in circulation patterns and carbon loading were ignored. This called into question the analysis in the rest of the paper. However, our reviewers acknowledged that they are not experts in these issues.

The Ecology staff working on the TMDL includes Dr. Mindy Roberts, Dr. Anise Ahmed and Greg Pelletier, each of whom has over 20 years' experience conducting these type of investigations and who are considered national experts in this field. If Dr. Milne's analysis was correct Ecology staff had completely botched their own analysis and misinterpreted the model results and that these errors had been missed during several levels of review.

A document claiming to be a "Peer Review" was included with Dr. Milne's paper. It was less than two pages long and simply consisted of copies of emails from four individuals stating that the paper had been reviewed. Most responses consisted of one or two sentences and none found any issues with the paper. Tribal staff asked for the actual review papers, not the emails, and were told that the two page document was the "peer review". The review of Dr. Milne's paper was conducted by what appears to be four current and past faculty members of Evergreen State College. Curriculum vitae or statements of experience were not included as would be expected in an open review. Based upon information available through Evergreen the credentials of the reviewers appear to be:

Dr. Gerardo Chin-Leo, Ph.D. - oceanography and marine biology

Dr. Erik Thuesen, Ph.D. – marine biology

Oscar H. Soule, PhD – ecology

Kaye V Ladd, PhD - inorganic chemistry

Other than Dr. Chin-Leo with his background in oceanography, the review group appears to have different backgrounds then would be expected for a review of a TMDL and its related modeling. This

would not necessarily disqualify these outside reviewers; however, Tribal staff found it odd that reviewers whose expertise is for the most part outside of the subject area and who found no issues at all with a paper that essentially seeks to overturn the work of highly qualified personal provided no meaningful review comments.

To put Dr. Milne's report through a meaningful, third party peer review by someone highly qualified in the field we asked Dr. Jonathan Frodge to review the paper. Dr. Frodge is a stormwater scientist for the City of Seattle and board member and past president of the Washington Lakes Protection Association. Dr. Frodge agreed and his review of Dr. Milne's paper and the 2012 TMDL Technical Report along with his Curriculum Vitae are attached.

In response to Dr. Milne's declarations that "*I find that the Lake does not have negative effects on Budd Inlet and that the Lake improves the water quality of the Inlet*", and that "*Capitol Lake is the Deschutes River Watershed's biggest and best asset for preventing and reducing water quality degradation in Budd Inlet*" Dr. Frodge has replied "While this report raises some valid points, I do not agree with either of the above statements."

Review Comments of Jonathan D. Frodge Ph.D. on: *David H. Milne, Capitol Lake: Protector of Water Quality in Budd Inlet, March 17, 2014* relating to *Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Technical Report; Water Quality Study Findings, June 20012.*

I have been asked by Scott Steltzner, a fisheries biologist with the Squaxin Island Indian Tribe to review and comment on the *Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Technical Report* and the response report *Capitol Lake: Protector of Water Quality in Budd Inlet* by Dr. David H Milne. I have not previously been a participant in the discussions on the Deschutes River, Capitol Lake or Budd Inlet, other than general conversations, primarily at meetings of the *Washington Lakes Protection Association*, of which I am a past-President. I have a Ph.D. in limnology and over 30 years' experience working on lake, river and marine issues in Washington. I have attached my Vitae to the end of this document.

The goals stated for of the *Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Technical Report (TMDL)*, were to develop the loading capacity for these parameters in portions of the watershed and recommend loading reductions targets to meet water quality standards. These specific constituents are addressed in the TMDL because these are the monitored parameters that exceed the WAC 173-201A criteria and have been added to the State 303(d) listing. An expanded discussion from an ecosystem approach not limited to just the 303(d) listed parameters may have been beneficial in pre-emptively addressing the issues raised in Dr. Milne's report.

While the ecological impacts of invasive species are briefly mentioned in the TMDL, specifically for aquatic macrophytes, an evaluation of the impact invasive species has on the study area or State of Washington is not specifically addressed. This limitation of the TMDL is an unfortunate omission, and while it may not have direct bearing on the analyses for the parameters presented in the TMDL or Milne's response, this ecological problem should be addressed in any TMDL for these waterbodies.

Currently, Capitol Lake supports extensive growth of Eurasian water milfoil (*Myriophyllum spicatum*) and New Zealand Mud Snails (*Potamopyrgus antipodarum*). Eurasian milfoil has for years been a statewide problem, however the invasion New Zealand Mud Snails in Capitol Lake is recent (2009), and is very probably responsible for the spread of this snail into King County in Thornton and Kelsey creeks. This statewide environmental risk should be included in any evaluation of options for the Deschutes River, Budd Inlet, Capitol Lake and the waters of the State of Washington. The presence of this pioneering invasive population presents a predicted stress to aquatic organisms and communities of organisms which interfere in the health, survival, success or natural structure of native populations, and this issue should be considered when evaluating options for either keeping the lake or removing the dam and re-establishing an estuary.

An additional omission from both of these reports is a discussion of the loss of estuaries in Puget Sound and the impact this loss has on ESA listed chinook populations and connectedly the impact on the ESA listed Puget Sound Orca populations. According to Ecology, only 52 percent of the

original estuary and mudflat habitat remain in Washington. This anthropomorphic alteration of habitat needs to be considered in any decision or actions in regard to the Deschutes River, Capitol Lake, Budd Inlet and Puget Sound.

In order to comment on Dr. Milne's report I needed to read and reference the 2012 TMDL Technical Report. The primary assertion of Milne's report is, "*I find that the Lake does not have negative effects on Budd Inlet and that the Lake improves the water quality of the Inlet*", and that "*Capitol Lake is the Deschutes River Watershed's biggest and best asset for preventing and reducing water quality degradation in Budd Inlet*". While this report raises some valid points, I do not agree with either of the above statements. I will comment following the format in Milne's report.

> '2) *The computer calculations presented are only tangentially relevant to a Lake/Estuary comparison and are presented in formats that are prone to misinterpretation.*'

I agree with Milne that the TMDL Report could have done a better job at describing the river/lake/estuary interactions and options comparison, and like most reports on modeling results this TMDL was apparently difficult to write and more difficult to read and interpret, increasing the probability of misinterpretation. However, I believe the data and analyses provided in the TMDL and the attached Appendices are sufficient to make informed judgments on the options analyses and support the conclusions of the TMDL Technical Report. The TMDL focused on the 303(d) parameters while the major points of the Milne report focus on nitrate nitrogen and DO (see discussion below). Specifically, a more complete discussion of the nitrogen cycle as occurs in the river/lake/estuary, and not just DIN (dissolved inorganic nitrogen) may have clarified many of the issues posited in Milne's report.

> 3) *All violations of water quality standards reported by the computer are mathematically microscopic and ecologically inconsequential*.'

I think Milne is confusing model results with the actual standard. For all lakes, and for reservoirs with a mean annual retention time of greater than 15 days, human actions considered cumulatively may not decrease the 1-day minimum oxygen concentration more than 0.2 mg/l below estimated natural conditions. The impact as presented in the TMDL is that water body does not meet its assigned criteria due to human structural changes, and these human caused changes are what violates the State criteria and present the ecological risk. If Milne believes this is 'mathematically microscopic and ecologically inconsequential' he should work to change the State criteria.

It is unclear if the Milne report questions the relevancy of a 0.2 mg/l change, or if the absolute amount is not presumed to be quantitatively accurate. His contention that a 0.2 mg/L change is 'measurement noise' as attributed (pg.10) was correct several years ago but is no longer valid as most of the new DO probes are rated for an accuracy of +/-0.2 mg/L. It is confusing to refer to quantitative changes as 'microscopic', and nowhere is data presented to substantiate the statement that the modeled changes are 'ecologically insignificant'.

I do partially agree with the observation on pg. 11 that '3) the DO concentrations shown in Format 2 are always much higher than the concentrations at which real water quality problems begin'. However, in this case his 'much higher' is the same amount he previously referred to as

'mathematically microscopic and ecologically inconsequential' when describing the Capitol Lake inferred Budd Inlet model results. Additionally these graphs show a more pronounced change in DO the closer the grid cell is to the outlet of the reservoir.

As I understand the purpose of the State's anti-degradation policy is to identify a potential human caused change prior to the negative impacts occurring (defined in the WAC as a human influenced change of >0.2 mg/l), not to wait until the impacts are obvious and the degradation a fact not a prediction. These graphs of the model output specifically address this issue and provide strong support that the lake causes a human induced degradation. How much and how ecologically significant is not specifically addressed but have no bearing on exceedances of the criteria.

4) *The TMDL computer simulations data show no water quality problems occurring anywhere at any time throughout Budd Inlet.*

The argument presented in the Milne report supports the model output that the lake scenario has lower DO than a restored estuary would. The contention Milne presents is the lowered DO modeled with the lake scenario (i.e. human caused changes) are inconsequential, which I do not think is supported by my reading of the anti-degradation criteria in the *WAC 173-201A*. The argument in this section is based on the assumption that human induced reduced DO based on the presence of the reservoir is inconsequential unless and until serious and obvious water quality problems occur.

5) *Data that probably show a beneficial effect of Capitol Lake on all of Budd Inlet have been mistakenly presented as showing a negative effect*.

This is a personal conjecture of his that in my opinion is not supported by the data and model results presented in the TMDL and accompanying appendices.

6) *Water exiting Capitol Lake does not go into areas that experience water quality standards violations (East Bay, eg); it flows straight toward the mouth of the inlet.*

This is not my area of expertise and I do not have site specific information on the local flow patterns.

7) *Capitol Lake prevents some 27 metric tons of nitrate nitrogen from entering Budd Inlet every summer – a huge beneficial impact equivalent to the action of two LOTT plants.*

I find this statement simplistic, misleading and inaccurate. This appears to be based on an assumption that all of the summer change in nitrate/nitrite nitrogen concentration is a result of rapid burial in the sediments of Capitol Lake, and not from seasonal uptake by phytoplankton and conversion nitrate/nitrate that occurs every growing season in almost every temperate lake. Additionally, since the decrease in nitrate nitrogen during the growing season is primarily due to growth and uptake by planktonic algae and not burial, this statement would require that there be zero loss of algae from the lake to Budd Inlet, this scenario is not supported by the data. There will

be some burial of nitrogen in detrital algae cells in Capitol Lake, but even this nitrogen will be partially re-mobilized into the water column as ammonia.

I cannot determine if Milne's statement is specifically addressing only nitrate nitrogen and only during the 'summer growing season' and further making an inference that this addresses the entire nitrogen cycle and all species of nitrogen and marine nitrogen nutrient dynamics, or if he believes that only nitrate nitrogen needs to be of concern when evaluating the water quality impacts to Budd Inlet. Neither would be accurate. Milne does state that Capitol Lake removes between 40-90% of the river's nitrogen during the marine growing season before releasing the water to Budd Inlets, not differentiating nitrate from other forms of nitrogen. I disagree with his removal estimate which is apparently based on an assumption that nitrogen is all and only DIN -dissolved inorganic nitrogen which is incorrect.

On page 40 Milne states, 'The lake model includes macrophytes, which are the plants mainly responsible for extracting nitrogen from the water.' This is also incorrect, milfoil which dominates Capitol Lake gets nearly all nitrogen and phosphorus from the sediments and not water column. Milfoil does extract CO_2 and about half of available bicarbonate from the water column, but not nitrogen or phosphorus. Water column changes in nitrogen concentrations will be primarily phytoplankton mediated.

Most of the discussion in the TMDL and Milne's response to it centers on dissolved inorganic nitrogen (DIN) although Milne's statement is strictly about nitrate nitrogen. DIN is a regulated parameter based on wastewater treatment criteria and is defined as the sum of the concentrations of nitrate and ammonia, both parameters of concern when evaluating the efficiency of sewage treatment plant effluent, but only a subset of the nitrogen species of limnological importance. Comparing Capitol Lake to the LOTT WWTP where much of the nitrogen is removed via anaerobic denitrofication and bubbled into the atmosphere would only be accurate if the lake were anoxic (zero DO) for much of the summer. This does not happen and is not supported by the data.

Neither the Milne report nor the TMDL adequately discuss the timing and seasonal dynamics of the nitrogen cycle and role the different waterbodies have on the species of nitrogen dominant in a particular waterbody at a particular time. The additional species and dynamics of the various nitrogen forms and cycling of the various form of nitrogen are currently part of the water quality models and are listed as parameters of the TMDL models (Appendix G). An additional section added to the TMDL report on these nitrogen species and cycling should be provided, specifically a comparison of the TN inputs from the Deschutes River and outputs from Capitol Lake to Budd Inlet. Total nitrogen (TN) may be a better parameter to use when evaluating the relative impact of the lake or estuary scenario on the limiting nutrient in Budd Inlet.

I agree with Milne's contention that the TMDL Report does not adequately describe the water quality impacts of the Capitol Lake on the water quality of Budd Inlet, specifically nitrogen. My assumption is the authors of the TMDL focused on the 303(d) listed parameters for which the TMDL is required, and not on the general water quality impacts of the reservoir on Budd Inlet. The TMDL is organized by water body; Deschutes River, Capitol Lake, Budd Inlet, and the flow of one water body into the next and the chemical and ecological changes that occur and are relevant are very difficult to follow in the current report. As stated previously, an expanded discussion from an

ecosystem approach, and specifically the nitrogen cycle, not limited to only the 303(d) listed parameters may have been beneficial in pre-emptively addressing the issues raised in Dr. Milne's report and providing better understanding of the implications of the TMDL findings.

I agree that the TMDL model is considered to be suitable for the main purpose of this project to predict the response of critical bottom DO concentrations in inner Budd Inlet to variations in nutrient loading and concentration. While potentially 'mission creep', many estuarine models calculate estimates of total nitrogen and total phosphorus load, load status, and total suspended solids load. Total nitrogen is the sum of the nitrogen present in all nitrogen-containing components in the water column: large and small phytoplankton and zooplankton, suspended benthos, dissolved inorganic nitrogen (nitrate and ammonia), dissolved organic nitrogen, labile detritus (at the Redfield ratio which is already calculated in the TMDL report) and refractory detritus.

> 8) '*There are many likely sources of East Bay's water quality standards violations in and near the Bay. The lake is not one of them.'*

As in any urban setting, first sentence is probably correct. The second sentence, the lake is not one of them' (as discussed above) is not supported by any analyses or data presented in Milne's report and is substantially supported by the data and computer simulations presented in the TMDL Report.

> 9) *It seems likely that the "baseline" for simulations of the Lake's effects was wrongly calculated. If so, "Lake Scenario" simulation outcomes are not to be trusted."*

The TMDL Report presents data and model output that support the conclusions presented in the TMDL and that the lake effect baseline was not 'wrongly' calculated. Dr. Milne does not present specific data to support his belief in the likelihood of wrong calculations or his mistrust of the outcomes.

Curriculum Vitae

Jonathan D. Frodge
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EDUCATION

Ph. D. in Fisheries, Water Quality, and Aquatic Ecology. 1990.
The Limnology of Dense Beds of Aquatic Macrophytes, Before and After Stocking Sterile Grass Carp. University of Washington, Seattle, WA. 110 pp.

M.S. Wastewater Utilization and Natural Resources. 1985
Studies of Daphnia magna in a Large Sewage Oxidation Pond.
Humboldt State University, Arcata, CA. 97pp.

B.A. Environmental Biology. 1977 University of Colorado, Boulder, CO

WORK EXPERIENCE

Stormwater Scientist Seattle Public Utilities **10/2009 to present**

Coordinate data quality and management for water quality monitoring programs, develop Data Quality Objectives and Quality Assurance Plans for urban stormwater programs and combined sewer overflow post construction monitoring. Cooperatively developed Puget Sound regional monitoring program for streams status and trends, marine nearshore and pollution source identification for inclusion in NPDES Stormwater Permit. Conduct bacterial source identification studies. Provide expertise in drinking water protection monitoring. Develop and implement invasive species response protocols. Provide water quality, experimental design, data management, bacterial pollution investigation and regional water resource monitoring expertise to Utility. Develop ArcGIS 10.1 based public access and legacy pollution site investigation programs. Participate on graduate student committees.

- regional monitoring program development
- DQO and QAPP for CSO post-construction monitoring
- data quality, data management, data analysis
- limnology of lakes, streams and marine nearshore
- experimental design, statistical analysis, model application
- water quality scientific expertise and training
- oral and written presentation of research

Sr Linmologist/ Water Quality Planner III, Head of Freshwater Program
King County Department of Natural Resources **1/1991 to 10/2009**

Designed, coordinated, and managed the limnological monitoring, assessment, and protection programs for lakes Washington, Sammamish and Union, and their influent streams. Managed a group of seven scientists to protect and enhance the freshwaters of King County. Designed and implemented multi-year integrated watershed modeling and monitoring program. Designed and implemented regional swimming beach monitoring program. Developed WRIA 8 Chinook Recovery Plan for ESA listed Chinook. Participate on graduate student committees.

- limnology of lakes, streams, watershed analysis
- data quality, data management, data analysis
- regional program design and implementation and budgeting
- experimental design, statistical analysis,
- model selection and review
- technical resource,
- oral and written presentation of research
- print, radio and TV media resource

Staff Biologist University of Washington **4/85 - 12/90**

- water quality, aquatic ecology, and fisheries
- field leader of the Statewide Triploid Grass Carp Feasibility Study
- experimental design and implementation
- statistical analysis of chemical water quality and fisheries data
- oral and written presentation of research
- budgets, grants, and contracts
- coordinated research and logistics for ten lake projects in Washington and Oregon

Arcata Committee on the Environment City of Arcata, CA **7/83 - 4/85**

- graduate student representative focused on stream and salmon restoration
- conducted feasibility and Environmental Impact Studies
- urban stream, estuary, and marsh restoration,
- park planning and education

Aquaculture - Wastewater Technician City of Arcata, CA **5/83 - 4/85**

- managed and coordinated activities at the experimental salmonid wastewater reuse facility operated by the City of Arcata wastewater treatment facility
- weekend operator of Arcata Wastewater Treatment Facility

Assistant Fish Hatchery Manager Humboldt State University **10/82 - 7/83**

- raised salmonids for research
- conducted hatchery tours for the public

College Biology Instructor Sam Houston State University, TX **9/81 - 6/82**

- taught introductory biology and laboratory courses in undergraduate biology
- substituted for professor in human biology

INTERNATIONAL EXPERIENCE

Korean Environmental Institute International Environmental Assessment Forum , 'EA for Governing Waterfront Renewal' **10/ 2011**

- invited expert to discuss 'Policies, Opportunities, and Challenges of Riverside Planning' as part of the Korean Ministry of Environment's sustainable development efforts associated with the 'Four Rivers' project.
- conducted graduate seminar at Chungnam National University on water quality, stormwater pollution, and Green Stormwater Infrastructure (GSI).

U.S. / U.S.S.R. Investigation of Northern Lake Baikal **8/90 - 9/90**

- invited expert with Earth Island Institute on a multinational committee investigating the environmental, fisheries and water quality problems in northern Lake Baikal Siberia, USSR (Russia).
- developed draft plan for submittal to UN World Heritage Program.

Peace Corps Volunteer Ghana West Africa **9/77 - 9/80**

- taught science education at Enchi Teacher Training College,
- developed small scale chicken- fertilizer-aquaculture project,
- constructed elementary school

VOLUNTEER ACTIVITIES

President of the Washington Lakes Protection Association
1995-1997, 2007-2008
President of a statewide volunteer lake protection association affiliated with the North American lake Management Society. Helped to draft, provide testimony

and pass statewide legislation for the reduction of phosphorus in turf fertilizer Washington HB1489. Member of the Board of Directors

Region X Director
North American Lake Management Society **2000-2003**
Member of Board of Directors on an international scientific lake society

Board, Save Lake Sammamish **2009-present**
Board member and scientific expert for volunteer environmental organization focused on watershed and lake protection

Technical Committee, Puget Soundkeeper Alliance **7/2011-present**
Provide technical resource expertise on NPDES, CSO marine nearshore, and regional water quality. Participate in fundraising activities.

President, Roosevelt High School PTSA **2005-2007**
Conducted board meetings, communicated with school and parents, and delegated assignments for PTSA of largest public high school in Seattle.

SPECIAL TRAINING

- SCUBA, Life Saving, CPR, First Aid certified
- Experimental Design and Statistical Analysis
- Management for Scientists
- King County Management Training
- Pesticide and Industrial Chemical Risk Analysis and Hazard Assessment modeling
- Stormwater Chemistry
- WASP4, HSPF, Plumes CE-QUAL 3D model training
- GIS (ARC/INFO, ARCVIEW, ArcHydro, ArcGIS 10.1 Advanced, ERDAS)
- Public Outreach and Public Speaking
- maintenance and calibration of water quality sampling and analysis equipment
- competent in Microsoft products, multiple database programs, SPSS, graphic software,
- CEQUAL W2 modeling, CEQUAL 3D ICM modeling training
- WASP4 Pesticide and Industrial Chemical Risk Analysis and Hazard Assessment modeling
- Taste and Odor Evaluation Panel for Seattle Drinking Water

AWARDS

Rotary International Scholarship	1984
Wilbert M. Chapman Memorial Scholarship	1987
Jack D. Geil Memorial Scholarship	1988
Stewardship Award Pipers Creek Watershed	2007

PEER REVIEWED ARTICLES

Frodge, J. D., D. A. Marino, G. L. Thomas, and G. B. Pauley. 1995. Mortality of largemouth bass (*Micropterus salmoides*) and steelhead trout (*Oncorhynchus mykiss*) in densely vegetated littoral areas tested using in situ bioassay. Lake and Reserv. Manage. 11(2): 343-358.

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Perkins, W. W., E. B. Welch, J. D. Frodge, and T. Hubbard. 1997. A zero degree of freedom total phosphorus model; 2. Application to Lake Sammamish, Washington. Lake and Reserv. Manage. 13(2): 131-141.

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Thomas, G. L., S. L. Thiesfeld, S. A. Bonar, J. D. Frodge, and G. B. Pauley. 1989. Short-term effects of triploid grass carp (Ctenopharyngodon idella) on the plant community, fish assemblage, and water quality of Devils Lake Oregon. Technical Report. Washington Cooperative Fish and Wildlife Research Unit. 109 pp.

Thomas, G. L., S. A. Bonar, D. A. Beauchamp, J. D. Frodge, G. B. Pauley, T. B. Stables and S. L. Thiesfeld. 1990. Feasibility of aquatic plant control in Lake Lawrence, Thurston County, Washington using triploid grass carp (Ctenopharyngodon idella Val.). Technical Report. Washington Cooperative Fish and Wildlife Research Unit. 117 pp.

Thurman, D. A., Cowell, A., Taira, R., and Frodge ,J. 2004. Designing a collaborative problem solving environment for integrated water resource modeling. PNNL-SA-41096. G Whelan; WIT Press, Boston, MA, United States(US).

Thurman, D. A., Peterson T, and Frodge ,J. 2002. Defining requirements for an integrated water resource modeling system. Proceedings of the 6th World Multiconference on Systemics, Cybernetics, and Informatics, XVIII(474-479; International Institute of Informatics and Systemics,Orlando.

References

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August 20, 2014

To: Bob Wubbena, Jack Havens, and Denis Curtis
Re: Author's Response to the Review of the Report "Capitol Lake: Protector of Water Quality in Budd Inlet" by Dr. Jonathan Frodge.

Dear Bob, Jack, and Denis:

In accordance with your request, I have studied the review of my Report (henceforth "the Milne Report") by Dr. Jonathan Frodge, conducted by him on behalf of the Squaxin nation. I find nothing in Dr. Frodge's review to prompt me to modify any of the opinions and interpretations that I presented in that Report.

I must say that I had trouble following Dr. Frodge's analysis, which seems to contain many assumptions and misunderstandings of what the TMDL and Milne Reports actually present. In the following, I address his statements roughly in the order in which he makes them and also by topic, as best as possible consistent with reasonable readability and organization.

1) Irrelevant Introductory Statements.

Although the Milne Report addresses only the TMDL Report's seeming identification of negative effects of Capitol Lake on Budd Inlet's dissolved oxygen, Dr. Frodge begins with a discussion of other topics, namely fecal coliform bacteria, dissolved oxygen, pH, water temperature and fine sediment loading that the TMDL team is concerned with because the present levels of these properties (presumably in the Deschutes River) "exceed WAC 173-201A criteria." He continues this digression by invoking invasive species, even suggesting (without citing evidence) that the New Zealand Mud Snails now present in tributaries of Lake Washington arrived there from the population occurring in Capitol Lake. "Both Reports" are faulted for omitting discussion of "loss of estuaries in Puget Sound" and the impacts of these losses on Chinook and even Orca populations. The topics of this broad-brush approach, which occupies about 25% of his review, are outside the scope of the Milne Report and (I believe) that of the TMDL Report writers, as well.

2) Comments on Nitrogen Entrapment by the Lake and the Nitrogen Cycle.

On page 3 of his review, Dr. Frodge begins a series of mistaken assumptions and presents his own assessment of the nitrogen budget of Capitol Lake. He assumes that I attribute the disappearance of 27 tons of nitrate nitrogen in the Lake (which he describes as "simplistic, misleading and inaccurate[i]) to "burial in the sediments." I said nothing remotely resembling this claim. I made it clear that I attribute the Lake's uptake of that nitrogen to the growth of macrophytic plants. Dr. Frodge then mistakenly attributes the view "zero alga loss from the lake to Budd Inlet" to me, and goes on to repeatedly assert that N uptake in the Lake is entirely by planktonic algae. While that is often typical of lakes with extensive deep open water, it is unlikely for a shallow lake harboring macrophytes that grow to the surface almost everywhere.

It is difficult to reconstruct the macrophyte data from the TMDL Report and its Appendices. The model team concentrated heavily on the easily modeled phytoplankton but said little about the (to them) unfamiliar world of freshwater plants. To the extent that the Appendices provide data that permit calculation (Fig. H11 and chlorophyll + carbon data in graphs), the organic carbon and nitrogen in macrophytes outweighs that of the phytoplankton by some 50-60 times in the Lake basins. Certainly N and C are taken up by phytoplankton and go over the dam in that form – but I anticipate that much, much more of both elements remains behind in the Lake in the form of plants, at least during the months when they are actively growing.

As part of this discussion, Dr. Frodge offers the suggestion that the submerged Lake plant "Milfoil" extracts nutrients from the sediments via its root system but not from the water itself. In my admittedly long-past experience with these species as aquarium plants, I recall that they seldom remained rooted for long – being easily dislodged by the fish – and invariably ended up floating at the surface where they continued to grow. That growth was fueled by nutrients in the water – not the sediments. Whereas many macrophytes have the ability to extract nutrients from the sediments via their roots, I believe that most or all of them can also take up nutrients directly from the water.

Dr. Frodge comments on my focus on the Nitrogen (N) content of nitrite and nitrate ions, correctly pointing out that consideration of total dissolved inorganic N (these two plus ammonium) and organic dissolved N would be preferable. However, I was constrained to analyze the N forms presented in the data accessible to me. Data from an ephemeral DOE website forwarded to me by Mr. John DeMeyer refers to N in the form of nitrate + nitrite; that presented in the CH2M-Hill consultants' report refers to the nitrate form of N.

My Report's conclusions would not be affected had I included the ammonium and organic forms of N. Both are typically much scarcer in natural waters than nitrite + nitrate-N (each on the order of 5% - 10% as abundant as nitrate/nitrite). Where ammonium and/or organic nitrogen are shown separately (as in the TMDL Appendices and the CH2M-Hill Report), graphs charting the changes with time and position of these materials are usually not significantly different from graphs of the changes in nitrate and nitrite except for their much smaller scales.

It is of course difficult to compare the LOTT plant with Capitol Lake as regards N uptake. LOTT deals with a much smaller inflow of water and is primarilv concerned with ammonium rather than nitrate and nitrite. In terms of the tonnage of nutrient N removed from the water entering each system, the Lake and LOTT are comparable. The fact that these two systems dispose of their incoming N in different ways is immaterial.

3) The Small Magnitude of 0.20 mg/L; What It Can and Can't Tell Us.

The figure 0.20 mg of dissolved oxygen per liter of seawater is central to the Budd Inlet Model's designation of water quality violations in Budd Inlet. In every instance in which a violation is designated, the calculated value of DO in the water at that time, place, and depth is at least 0.20 mg/L lower than some water quality standard. That water quality standard is always 6 mg/L in most of central and outer Budd Inlet and 5.0 mg/L in most

of the inner Inlet, but it is sometimes a variable value in an area mostly around Priest Point.

There are four problems with using such a small DO decline as the measurement that defines a violation of a water quality standard. They are:

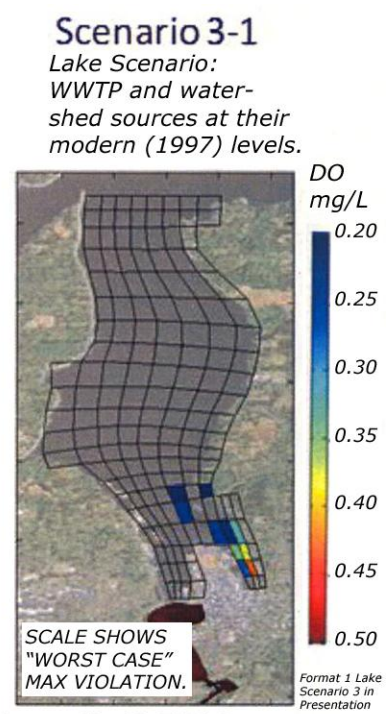
1) In cases where the numeric standard is variable, the standard itself is also unknown to us. It is a calculated (estimated) number.

2) The inherent inhomogeneity of DO levels in marine water is much greater than the 0.20 mg/L decline that the model defines as a violation;

3) Even if the model could show us a 0.20 mg/L momentary or long-term drop in the oxygen content of water in Budd Inlet, that decline would seldom, given the average oxygen concentrations in the Inlet, stress or jeopardize marine life;

4) It appears that the model is not really able to reliably detect and identify mathematically microscopic declines in DO of this tiny magnitude.

For this discussion, I include Figure 90 from the TMDL Report as a visual example. That Figure shows the *worst case* impact of the presence of Capitol Lake and/or the dam on the modern (1997) water quality of Budd Inlet. All squares shown in the Figure were "searched" by the computer for an entire "computer year" (January 15 – September 15). Colored squares show where the model calculated water quality violations. (The blue squares show the smallest violations that the model is set to detect (0.2 mg/L), the value that we are examining here.) In the uncolored squares, the model found no violations at all.



Source: Fig. 90, TMDL Report.

Figure 90 (TMDL Report). The locations and severities of WQ standards violations detected by the Budd Inlet Model in a simulation with Capitol Lake in place. Captions are as modified by the author for this illustration.

Dr. Frodge suggests that the small size of the violation criterion – a drop of 0.2 mg DO/L below a standard – may be the true source of my concern and that I should "work to change the State criteria." Small as that figure is, I have confidence that whoever devises such standards produces numbers that we can and should accept and respect, including this one. My concerns are about the way in which it is used, in the TMDL context.

1) In many cases the DO standard with which the 0.20 mg/L criterion is compared may be the oxygen concentration of Budd Inlet water as it is estimated

to have once existed some 100-odd years ago (the "natural" pre-modern condition of the water). The blue "violation flags" touching the Priest Point shore and occurring to the west in Figure 90 occur in one such area.

Dr. Frodge appears to believe that a microscopic decline of 0.2 mg/L (or a bigger one) needs to last for a full day in order for the model to flag such an area as "in violation." That is mistaken. The actual criterion, as can only be ascertained by examining the South Sound DO Report in conjunction with the TMDL Report, is that the "violation" persist for as little as six minutes during the entire model "year" (January 15 – September 15)[ii].

Thus, a single instance of a calculated level of dissolved oxygen just 0.20 mg/L lower than a standard level *calculated to have existed some 100 years ago*, occurring just once and lasting for just six minutes at just one of some 10-15 depths, can be enough to result in a violation posted on the Budd Inlet chart as shown in the colored squares in the Figure.

That is a fantastically ephemeral and speculative basis for assigning "water quality violation" designations to parts of Budd Inlet and a reason for regarding those designations with a degree of caution.

2) A modern DO meter, if used correctly on a homogeneous body of water, is capable of detecting changes in the dissolved oxygen level of 0.01 mg/L (much better than the 0.20 mg/L value asserted by Dr. Frodge). In tidal salt water, a DO meter's readout flickers between values that differ by 0.2 mg/L *or more* from second to second. The fluctuating readout is caused by the inherent inhomogeneity of the water passing the measurement probe. That is the situation at every depth. When examining all depths (as the model does), the inhomogeneity is even greater. As I illustrated in Figure 5 of the Milne Report, searching for an ephemeral or even permanent 0.20 mg/L decline in waters that usually differ by 1, 2, 3 or more mg/L between surface and bottom at any given time (and by as much as 1.0 mg/L every 24 hours and 0.2 mg/L from second to second at the same depth) must necessarily result in findings that are tentative at best. Thousands – millions? – of field measurements would be needed to statistically detect such a small change in the midst of that highly variable backdrop. It is by comparison with the natural inhomogeneity of the water that I characterize 0.20 mg/L as a "mathematically microscopic" decline in dissolved oxygen concentrations.

3) Although the standard with which a 0.20 mg/L decline is compared can be a calculated value from Budd Inlet's natural past, more often it is a rigid unchangeable number; 6.0 mg/L in the central and outer inlet, 5.0 mg/L in the innermost reaches beginning with the tier of squares touching the Port Peninsula and extending through East and West Bays. Where "violations" are shown in Figure 90, they are at most declines of 0.5 mg/L below the standard. The data selected by the TMDL writers for display in Figure 90 and other such Figures are the *worst case* violations calculated for an entire "computer year." Since the numeric standard is 5.0 mg/L in the affected area – East Bay and environs – such calculated "violations" never decrease the DO level below 4.5 mg/L even at the worst of times. The 4.5 mg/L level is comfortably above the 3.0 mg/L threshold regarded by many aquatic ecologists as that at which respiratory stress begins to affect aerobic marine organisms.[iii]

Where the TMDL Report shows actual DO levels in the water at various sites (as in TMDL Figure 88), DO's in the "Lake Scenario" seldom fall below 4.0 mg/L and recover within a few days on occasions when they do so. Never do we see a decline below 3.0 mg/L lasting a week or more – the definition of an ecological "water quality problem" that I presented and illustrated in the Milne Report. This absence of water quality "problems" (not the same thing as water quality "standard violations") prompts my view that the standards violations reported are "ecologically inconsequential.[iv]"

4) After the Milne Report was released, I realized that the Budd Inlet Model has a property that appears to make it incapable of reliably identifying water quality standard violations smaller than about 2.0 mg/L – ten times larger than the smallest "violations" that the model is set to report. This new development is mentioned at the end of this paper.

Although the following does not hinge upon the numeric value "0.20 mg/L," it bears upon the interpretation of Figures and Graphs in the TMDL Report that shape our view of the effect of Capitol Lake on Budd Inlet. Dr. Frodge makes reference to the State's anti-degradation policy as aimed at preventing future degradation, not waiting for it to happen. He appears to believe, as do many others, that the TMDL Report's findings project some future degradation yet to come. In fact, the TMDL findings show "violations" (not "degradations") that have already happened. The modern water quality of Budd Inlet already reflects any new effects that the dam and Lake might have created after their construction. Violations flagged as in Figure 90 show the "price" we have already paid, once and for all, by having the Lake and dam in place, not some future change to beware of.

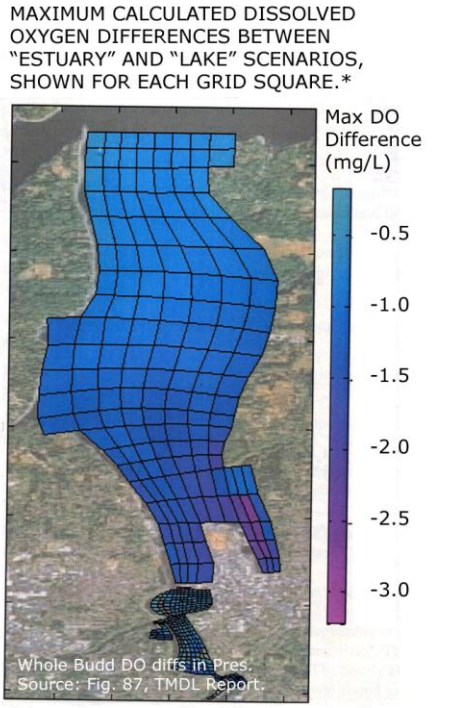
That "price" is not high. As many readers of the TMDL Report seem to have done, Dr. Frodge may have focused on the ten "violation" flags shown for the Lake Scenario in Figure 90 above and concluded (or assumed) that the Lake's presence diminishes the dissolved oxygen content of Budd Inlet as a whole. Overlooked is all of the rest of Budd Inlet, some 149 uncolored grid squares in Figure 90 in which the computer's exhaustive search failed to find even one short- or long-lived "mathematically microscopic" or larger water quality standard violation at any depth. Contrary to the popular view, that Figure shows that Capitol Lake has little or no impact at all on the dissolved oxygen *standards*, and by inference, on the DO *levels* in Budd Inlet.

4) So Does Capitol Lake Reduce The Dissolved Oxygen Content of Budd Inlet?

Dr. Frodge mistakenly states that the Milne Report "supports the model output that the lake scenario has lower DO than a restored estuary would." I said no such thing.

TMDL Figure 87 (reproduced here), unlike TMDL Figure 90 shown above, compares DO levels from both the Lake and the Estuary Scenarios directly with each other, rather than with water quality standards. This Figure is probably responsible for the widespread mistaken impression that Budd Inlet would have more oxygen in it with an estuary rather than with Capitol Lake at its head.

As with all other TMDL maps and even some time series graphs, Figure 87 shows the situation at just one depth in each grid square. The Figure shows the DO difference at the one and only depth under each colored square that possessed the biggest difference between Lake and Estuary DO, just once during the computer year. The actual depth of that biggest difference is never specified, nor is the date; dates and depths are not necessarily the same from square to square. The color gives the magnitude of each "biggest difference."



* In each square, the DO at one depth on one date would be higher with the Estuary in place than with the Lake in place.

TMDL Figure 87. The caption and labeling have been modified by the author for greater clarity.

I stated that this mode of portrayal of such unconventional data is probably the reason why readers end up believing that the Inlet would have more dissolved oxygen in it if the lake were replaced by an estuary.

I repeat my interpretation that Figure 87 shows an expected result of nutrient overloading in the estuary scenario, namely that the extra oxygen shown is mostly (or entirely) at or near the surface as is universal in eutrophication situations. Always as a negative ancillary effect in such situations, somewhere and sometime at the bottom DO levels go lower as a consequence of sinking and decay of the extra organic matter produced at the surface. It is true that the Inlet's surface waters would have more oxygen if Budd Inlet became loaded with nutrients – but the inevitable oxygen decrease at the bottom would be far more stressful to marine life than the exuberant excess at the surface would be helpful.

As I remarked in the Milne Report, this interpretation could be tested by comparing the model's calculated DO's at the bottom in the Estuary and Lake scenarios to see whether levels remain higher in the Lake case. To date, no one has done so.[v]

5) Where Do We Go From Here?

I believe that the above paragraphs address every point raised by Dr. Frodge. Because his points were scattered throughout his analysis, a reader of his paper and this one may have to search both to locate the correspondences of arguments. Some of his points are tangential or mistaken, or are based upon misinterpretations. They reflect an unfamiliarity with both the TMDL Report and the Milne Report that may be inevitable for any busy professional reviewer with limited time for study of both Reports in depth.

In conclusion, his review has not prompted me to alter any of the views and interpretations that I presented in the Milne Report in any major or minor way.

The TMDL Report's Chapter 11 is now behind us. Developments by the modeling team and from my own continued study have brought new and promising ideas to the fore. These were presented in the symposium of July 17 before the AHSS and are now well known to all parties.

From my point of view, the following post-Milne-Report insights strengthen my conviction that use of the Budd Inlet Model can and should proceed, but with renewed caution.

First, it became evident to me that the Model may have a "margin of error" that is larger than the small sizes of the smallest WQ violations that it is being used to detect. In order to optimize the "fit" of its predicted DO levels to the whole suite of observed data available for calibration, the modelers best-fitted its calculations to the data by minimizing the "root mean square error" (RMSE) statistical parameter for many (all?) grid squares where observed data were available. The practical result: we can be "confident" (never certain) that the DO levels that the computer calculates are usually within +/- 2 or so mg/L of the "true" but unknown levels in the water. That figure, tentatively, is the "margin of error." This idea was posited for the first time in the July 17 symposium, and all of us – the modelers Mssrs. Anise Mohamedali and Greg Pelletier and I -- were in tentative agreement that, at that time, that seemed to be an accurate interpretation of the RMSE.

Further study may refine this idea. But at the moment, it appears that a violation as small as 0.2 mg/L (one tenth the size of the margin of error) can't be reliably identified by the model. It is as though the model resembles a low-power microscope that can only recognize large objects, but it is being used to "see" (by calculation) small objects (violations) that require a high-power microscope -- which the model is not.

Second, Figure 87 above shows DO differences between the Lake and Estuary scenarios that extend all the way to the entrance of Budd Inlet at Boston Harbor. Exuberant growth of the phytoplankton with its high oxygen production in the surface water drifts outward into South Puget Sound and probably exerts the effect of depleting oxygen in the deeper water beyond. The drift of that deep water is back into Budd Inlet. Those events take place outside the domain of the model and their effects are lost to the simulation. The model can't "know" what Budd Inlet has done to the deep water flowing back in at the entrance or include those effects in its simulation. The only fix for this "black hole" at

the edge of the computer's vision of Budd Inlet is for programmers to extend the model's domain (or, perhaps easier, use the larger South Sound model to assess the situation in Budd Inlet).

While seeking examples of how the missing "deep return water" might have affected the simulation outcomes, I examined Budd Inlet dissolved oxygen data for 1997 as presented in the BISS report. I discovered 15 instances of bottom waters so low in oxygen that they should have been flagged by the Budd Inlet Model. In eight cases, the declines in levels below the standards were quite large -- greater than 1.0 mg/L. None of these occurrences were flagged. Perhaps this lapse was attributable to the model's inability to "see" changes in deep water created by Budd Inlet beyond the model domain, perhaps not. In any event, the reasons for their occurrence should be sought and identified.

In recent months, the TMDL team has explored alternative hypotheses for explaining the disappearance of nutrient nitrogen from Capitol Lake every summer. The team proposed a valid and important new idea with potential for advancing all of our understanding of the relationships between the Lake and Budd Inlet. That is, that the Lake's plants do indeed take nitrogen nutrients out of the Deschutes River's water, but they convert it to biomass that immediately escapes to Budd Inlet during the growing season. That biomass – represented by organic carbon in the model – consumes oxygen as it decays, with said decay taking place in the salt water, not the lake.

This proposition addresses a phenomenon that surely plays a role in the overall ecology of Budd Inlet. That is, the Lake vegetation that takes up nitrogen must release it in some form, sooner or later. My expectation has been that it is "later," after the growing season, in the form of decaying senescent plants, organic particles, and dissolved organic molecules resulting from decay. The new hypothesis is that said release occurs "sooner," during the growing season. If so, the decaying organic matter released from the Lake would lower oxygen concentrations at the bottom of Budd Inlet at a critical time, during the summer. If this proves to be the case, the oxygen level at the bottom of Budd Inlet and adjacent waters would go as low under the Lake scenario as I would expect it to be under the Estuary scenario.

This important alternative hypothesis needs study. Finding answers here will improve the modeling effort and our understanding of the systems' dynamics. The fact remains that, even should we find that the organic carbon created by the Lake plants really does escape immediately to Budd Inlet, that would not necessarily be a reason for getting rid of the Lake. It would simply emphasize the importance of vegetation harvesting as a part of routine Lake maintenance, removing the excess biomass with its contained carbon and nitrogen from the water and stimulating renewed plant growth and nutrient uptake.

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[i] On July 17, 2014, two of the TMDL modelers cited the 27-ton figure in their presentation and remarked that they accepted it as accurate (in their words, "do not dispute it.").

[ii] I have stated my understanding that a decline of DO below a standard for as little as six minutes is the criterion used to trigger a permanent "violation" flag for each area in which this occurs, as I have described here, with no comment to the contrary from the TMDL writers.

[iii] The threshold of respiratory stress varies depending upon the type of organism (fish, crabs, clams, etc), water temperature, and other factors. For some species and situations, the level can be as high as 4.0 mg/L, in other cases it can be lower than 3. Almost universally, all organisms suffer life-threatening respiratory distress if the level declines to 2.0 mg/L. A review at www.pnas.org/cgi/do1/10.1073/pnas.0803833105 provides a detailed discussion of hypoxia thresholds.

[iv] I do not seek to deny or minimize the potential for real water quality problems in Budd Inlet. The Budd Inlet Scientific Study (BISS) data show declines in DO to levels between 3.0 and 4.0 mg/L near the bottom on several occasions during 1996-97, as do data collected by LOTT in 2009-2011. These occurrences were in East and West Bay and waters as far north as Priest Point Park.

[v] This absence of response may be due to the difficulty of recovering data from a model run after the run is completed. The model is immensely complex and (I guess) erases most of the data after each iteration to make room for the flood of numbers produced by the next iteration, saving only data that it has been programmed to store – in this case, the biggest difference between Lake- and Estuary DO at whatever depth that occurs.

Capitol Lake/Budd Inlet Technical Discussion

November 3, 2014
1:30 – 3:30 p.m.
300 Desmond Dr. SE, Lacey

AGENDA

Moderator: Lydia Wagner, Ecology

- Welcome, Introductions, & Ground Rules — All
- Discussion — All
- Summary & Closing Comments — Lydia Wagner, Ecology

Purpose: This is a discussion for the scientists, modelers, and reviewers of the technical studies conducted related to Capitol Lake and Budd Inlet. The goal is to identify specific areas of agreement and disagreement on the study conclusions.

Participants: Representatives from Ecology's Environmental Assessment Program (EAP), the Capitol Lake and Improvement Protection Association (CLIPA), and the Deschutes Estuary Restoration Team (DERT).

Discussion topics:

- Fate of nitrogen in Capitol Lake; nutrients, oxygen, and phytoplankton; lessons learned from South Sound Dissolved Oxygen Study
- Model results, design, and limitations

Format:

- Participants have the opportunity to present their key issues and ask questions about the technical work.
- Ecology digitally records the entire discussion.
- The discussion is moderated to ensure everyone has a chance to speak and that we keep to the allotted time.

Follow up:

- Within several working days, Ecology provides a brief summary of the topics discussed. It will include key issues brought forward and identify areas of agreement and disagreement.
- Ecology posts the agenda, summary, and audio recording on the Deschutes TMDL website.
- Further discussions related to Capitol Lake/Budd inlet will occur with the Deschutes TMDL Advisory Group in 2015 during work on the Capitol Lake/Budd Inlet TMDL.

Draft Science Summary Statements – November 3, 2014

1. Evaluating oxygen depletion requires the combined effects of physics, chemistry, and biology.

2. Capitol Lake produces the largest detrimental impact on dissolved oxygen compared with any other human activity, including local wastewater discharges, local nonpoint sources, and external anthropogenic sources.

3. The Capitol Lake dam increases the residence time of East Bay, which degrades dissolved oxygen by itself, independent of carbon or nitrogen loading.

4. Capitol Lake transforms nitrate to organic nitrogen and discharges to Budd Inlet. The lake is shallow, so has little retention.

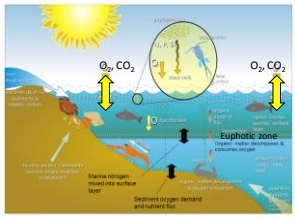
5. Capitol Lake also converts C from air into organic carbon, much more delivery of TOC to Budd Inlet. This causes oxygen to decline in Budd Inlet. More organic carbon gets produced in the lake than if it were to be an estuary.

6. Capitol Lake is a eutrophic lake, based on phosphorus levels.

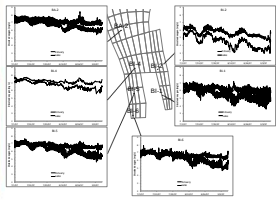
Materials for Budd Inlet and Capitol Lake science meeting November 3, 2014

Anise Ahmed
Greg Pelletier
Mindy Roberts

Evaluating oxygen depletion requires the combined effects of physics, chemistry, and biology

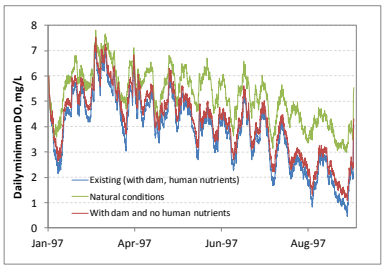


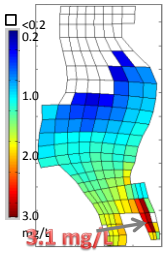
Source: Cope and Roberts (2013); Adapted from Downing JA, et al. Gulf of Mexico hypoxia: land and sea interactions. Task force report no. 134. Ames, IA:Council for Agricultural Science and Technology, 1999



Source: Roberts et al. (2012) – Predicted dissolved oxygen with and without the dam in place

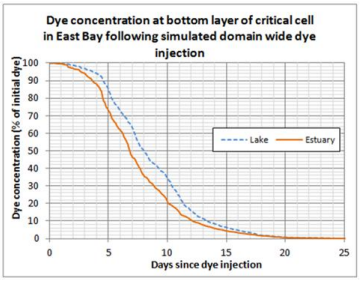
Capitol Lake produces the largest detrimental impact on dissolved oxygen compared with any other human activity, including local wastewater discharges, local nonpoint sources, and external anthropogenic sources

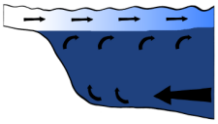




Source: Ahmed (2012)

The Capitol Lake dam increases the residence time of East Bay, which degrades dissolved oxygen by itself, independent of carbon or nitrogen loading

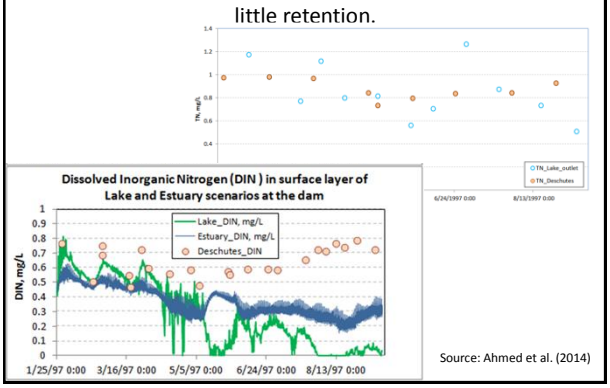




Yes, Capitol Lake dam increases the residence time in East Bay

Source: Ahmed et al. (2014)

Capitol Lake transforms nitrate to organic nitrogen and discharges to Budd Inlet. The lake is shallow, so has little retention.



Source: Ahmed et al. (2014)

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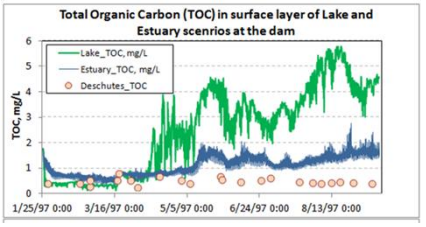
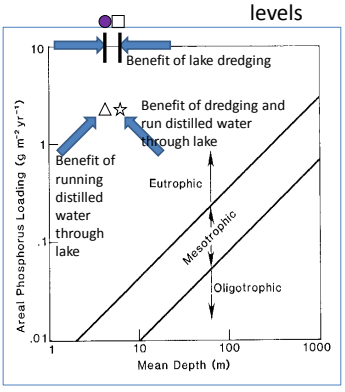


Source: Ahmed et al. (2014)

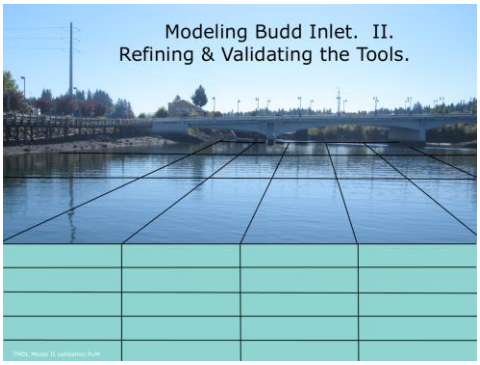
Capitol Lake is a eutrophic lake, based on phosphorus levels



Source: Vollenweider (1968), adapted in Roberts (2009)

Sources

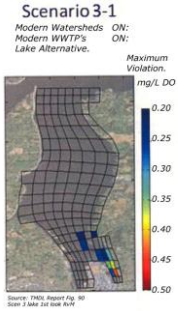
- Ahmed, A., G. Pelletier, and M. Roberts. 2014. POSTER: Anthropogenic Dissolved Oxygen Impacts in Budd Inlet: Comparing Influences from a Lake or Estuary. Washington State Department of Ecology Publication No. 14-03-021.
- Ahmed, A. 2012. Deschutes Advisory Group presentation on November 15.
- Cope, B. and M. Roberts. 2013. Review and Synthesis of Available Information to Estimate Human Impacts to Dissolved Oxygen in Hood Canal. Washington State Department of Ecology Publication No. 13-03-016.
- Roberts, M., A. Ahmed, G. Pelletier, and D. Osterberg. 2012. Deschutes River, Capitol Lake, and Budd Inlet Temperature, Fecal Coliform Bacteria, Dissolved Oxygen, pH, and Fine Sediment Total Maximum Daily Load Technical Report: Water Quality Study Findings . Washington State Department of Ecology Publication No. 12-03-008.
- Roberts, M. 2009. Letter to Nathaniel Jones, General Administration on Potential Water Quality Conditions Associated with a Dredged Lake Alternative. February 23. http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/galetter.pdf.
- Vollenweider, R.A. 1968. The Scientific Basis of Lake and Stream Eutrophication, with particular Reference to Phosphorus and Nitrogen as Eutrophication Factors. Technical Report DAS/DSI/68.27. Organization for Economic Cooperation and Development, Paris, France.



FIRST GLANCE: MAXIMUM CALCULATED WATER QUALITY VIOATIONS IN MODERN BUDD INLET.

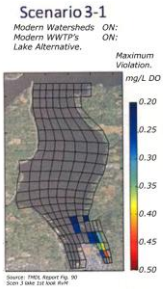
Colors show maximum calculated water quality violations under present conditions, Jan. 15 - Sep 15, 1997.

- Violations are shown where we'd expect them -- near/in East Bay/LOTT outfall.
- No violations are shown where we'd also expect them -- in West Bay.
- Some 90+ % of Budd Inlet shows no violations at all, despite a rigorous computer search.



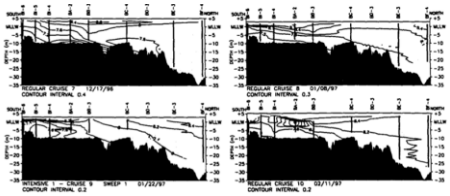
SECOND GLANCE: MAXIMUM CALCULATED WATER QUALITY VIOLATIONS IN MODERN BUDD INLET.

1) All violations shown are small -- 0.2 - 0.5 mg/L;
2) We don't know the depths at which these violations occurred;
3) We don't know the dates on which these violations occurred;
4) These are the worst of all violations detected by the model between Jan. 15 & Sep. 15, 1997.



Did The Model Succeed at Identifying Real WQ Standards Violations?

Dissolved Oxygen Data from Budd Inlet.
(From the Budd Inlet Scientific Study, 1998.)



Four profiles along the west shore of Budd Inlet, from Cooper Point (right, each profile) to Fifth Avenue dam (left). Isolines show DO concentrations at depth.

Dec. 17 '96 (UL), Jan. 8 '97 (UR),
Jan. 22 '97 (LL), Feb. 11 '97 (LR).

Dissolved Oxygen profile of Sept. 10, 1997, with backdrop west shore of Budd Inlet.

Dissolved Oxygen profile along west shore from Cooper Point (right) to end West Bay. Sept. 10, 1997. Contour Interval 2.0 mg/L. Source: Budd Inlet Scientific Study Appendix E-5.

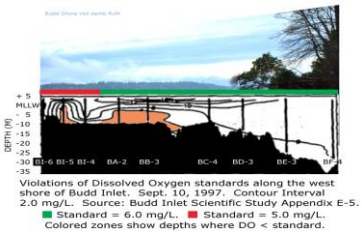
Example of template used for identifying WQ standards violations.

Dissolved Oxygen Standards used by the Budd Inlet Model.

Green -- 6.0 mg/L "Excellent"
Red -- 5.0 mg/L "Good"
Outlined area is the "Scenario 1 Zone" where the standard may vary.

If the computer finds that the DO of the water at any depth, any location, any time (between Jan. 15 and Sept. 15 1997) drops 0.2 mg/L below the standard shown, that location is flagged for further study.

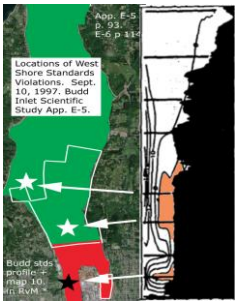
DO Standards Violations Along West Shore. September 10, 1997.



Bottom water DO at Station BI-5 (orange color, left) was below 4 mg/L on September 10 '97. Bottom water DO at BA-2 & BB-3 (orange, center) was below 6 mg/L at this time. (The standards violated are shown as a red and green color band at the surface.)

Surface Locations in Violation of DO Standards along West Profile. Sept. 10, 1997.

White stars show violations of less than 1.0 mg/L … here, DO levels of 5+ mg/L in an area where the standard is 6.0 mg/L. Black star shows violation greater than 1.0 mg/L … here a level less than 4 where the standard is 5.0 mg/L.



Locations of All Violations of DO Standards along all ☐Profiles on Sept. 10, 1997.

Locations of DO standards violations along the West Shore (previous slide) and all other affected stations in Budd Inlet.

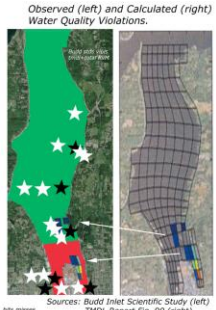
White star:
violation < 1.0 mg/L
Black star:
violation > 1.0 mg/L.

All Observed DO Standards Violations. Budd Inlet, August 6 - September 10, 1997.

Left to right: Aug. 6, Aug. 20-21, Sept. 10, Total. Total (19) is for Jan 22 - Sept. 10 1997. (No violations occurred prior to August 6.) Thirteen were less than 1 mg/L, 6 were greater than 1 mg/L.

The Budd Inlet Model Overlooked 19 Real-Life Water Quality Standards Violations.

Observed (left) and Calculated (right) Water Quality Violations.



Sources: Budd Inlet Scientific Study (left) TMDL Report Fig. 90 (right).

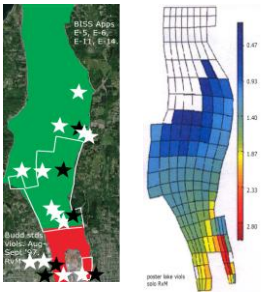
hits misses tmdl RvM

As reported in TMDL Figure 90, the model overlooked all 19 observed violations.

The locations of calculated violations (right figure) are also shown in the left figure for comparison. The locations are exact. The left figure has (hidden) the same grid as is in the right figure.

For all other locations in the right figure, the model may or may not be correct in (a) identifying violations and/or (b) no violations, since it is able to check dates and places in between the times & locations of the observed DO's.

A Recent Model Run Seems Closer to Reality.



A run of the Budd Inlet Model reported by a recent DOE poster shows Budd Inlet blanketed with violations that include all of the real-life violations existing in the BISS data. The poster result shows severe violations occurring where the real data showed none (example, BI-2 at the entrance to East Bay), however the model may have found violations that occurred between the sample dates used by the oceanographers.

As usual, the right figure shows the worst violation of the computer year, at one unspecified depth under each grid square. It is not really possible to use this comparison to validate or invalidate model projections.

More oxygen in Budd Inlet if the dam is removed?

The color of each grid square shows the maximum increase in dissolved oxygen that would occur there if Capitol Lake were replaced by an estuary.

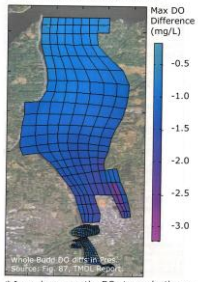
Each colored square refers to …

1) just one depth (not specified, not always the same depth for all squares);

2) just one date (not specified, not always the same date for all squares);

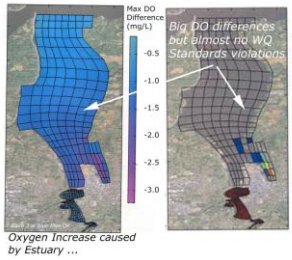
3) duration of perhaps as little as six minutes (not specified, not always the same duration for all squares).

MAXIMUM CALCULATED DISSOLVED OXYGEN DIFFERENCES BETWEEN "ESTUARY" AND "LAKE" SCENARIOS, SHOWN FOR EACH GRID SQUARE.*



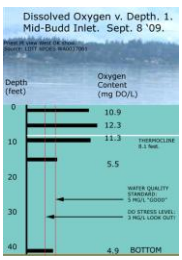
* In each square, the DO at one depth on one date would be higher with the Estuary in place than with the Lake in place.

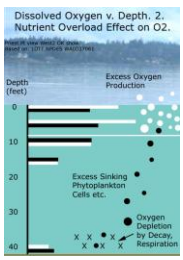
The Lake doesn't create less dissolved oxygen in Budd Inlet … the Estuary creates *more* …



If the Lake were lowering dissolved O_2 throughout Budd Inlet, we would see water quality violations everywhere. Instead, the Estuary is raising dissolved O_2 everywhere - at some unspecified depth, on some unspecified date. *What's going on here?*

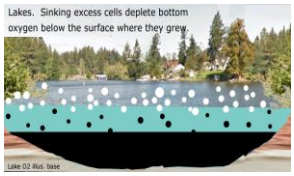
What Fig. 87 (TMDL) probably shows …

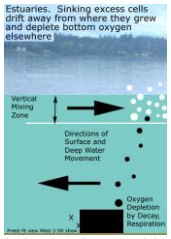




Left. Observed (& typical) O_2 distribution with depth, mid-Budd Inlet.
Right. Effect of nutrient overload at surface is (often) much more O_2 at the surface, small reductions at the bottom.

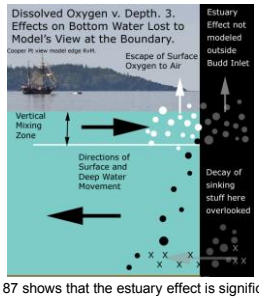
EUTROPHICATION 101. Benthic Oxygen Depletion.





Water movement governs where benthic oxygen depletion resulting from eutrophication will take place. In lakes, there is no "escape" of sinking decaying material from the surface. In estuaries, surface production drifts seaward while the resultant sinking decaying cells drift landward.

Eutrophication at the "Edge of the Universe" …



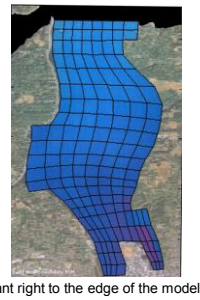


Fig. 87 shows that the estuary effect is significant right to the edge of the model's domain (right figure). The effects beyond the boundary on the incoming deep water can't be simulated. *This may be a significant source of error*.

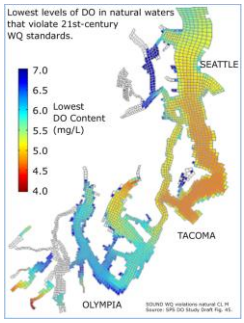
… For Accurate Simulations of Estuary Scenarios …

1) Extend the Budd Inlet Model out into South Sound far enough to encompass the Estuary effect, or …

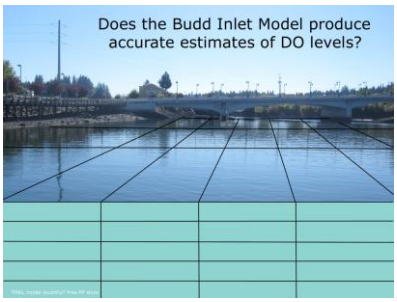
2) Use the South Sound Model whose boundary extends beyond Seattle to Edmonds.*

Other advantages of using the SS Model include an ability to assess the effects of not-so-remote nutrient sources on Budd Inlet (eg from the large Chambers Bay and Fort Lewis WWTP's) and a subtle expansion of our viewpoints to our actions in Budd Inlet affect waters in the rest of South Sound beyond Boston Harbor.

* recommended …



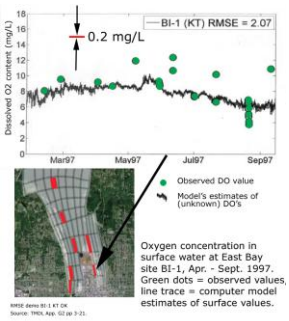
For confidence in the Model's projections, we need to know that its estimates of DO levels in Budd Inlet are accurate.



Can the Budd Inlet Model Reliably Detect DO Changes of Only 0.2 mg/L?

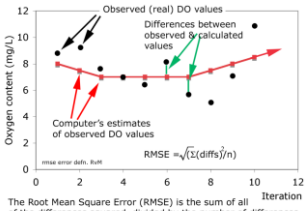
The graph (right) shows the dissolved oxygen concentration in surface water at site BI-1 in East Bay during spring & summer, 1997. The observed data (green dots) were used (in part) to calibrate the model.

The graph shows the best fit of the model's predictions to the data. The next slides focus on the "RMSE" statistic shown at the upper right.



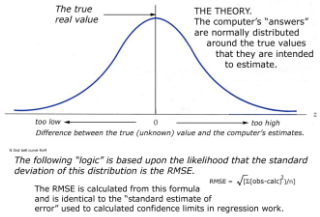
Getting Close to the Right Answer … The RMSE is the key.

The RMSE is a measure of how close estimates come to the real (often unknown) values of some phenomenon -- in this case, to dissolved oxygen levels in the water. The model has been adjusted to make the RMSE as small as possible.



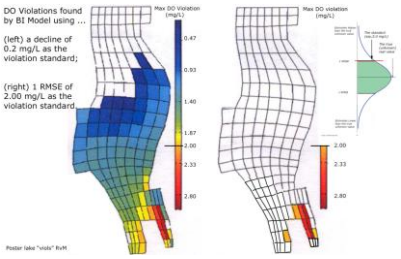
The Root Mean Square Error (RMSE) is the sum of all of the differences squared, divided by the number of differences, then "unsquared" by taking its square root.

IF THE ANWERS TO THE QUESTIONS ARE "YES," PROCEED …



1) Are the differences between the estimates and the real DO values normally distributed?
2) Does the mean of that [normal] distribution = 0?
3) *Does the standard deviation of that distribution = the RMSE??*

Solo Estimates have a wide margin of error …



WQ violations in Budd Inlet if the model flags … 1) everything 0.2 mg/L or more below the standard (left) and 2) everything that is 1.0 RMSE or more below the standard (right). The latter uses RMSE = 2.0 mg/L (East Bay surface value). The model would need to calculate a value 3.0 mg/L or less to flag a square … but you would be "84% confident" that the violation is real.

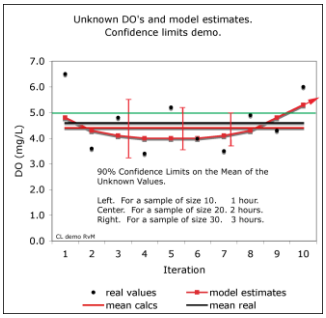
Confidence Limits. Means Are The Answer …

What if the upper confidence limit (UCL) of a sample of size n were used as the criterion for flagging violations?

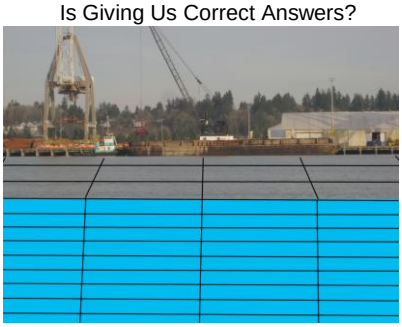
In this example, 90% CL's are calculated from the RMSE*. If 10 or 20 estimates are made and averaged, the UCL falls above the standard. If 30 estimates are averaged, the UCL falls at/below the standard and we are "90% confident" that the violation is real -- not just a random artifact of sampling.

The price you pay is, fewer violations "found." The payoff is, when you find one you can be very confident that it is real.

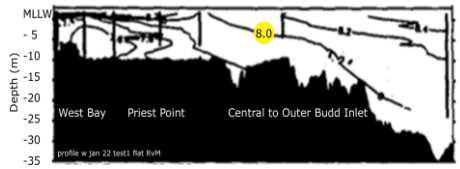
In this example RMSE = 2.0 (East Bay value), CL's are from
CL = +/- $z_{.05}$*rmse/√(n)



The Key Question …
How Can We Be Sure That The Model Is Giving Us Correct Answers?



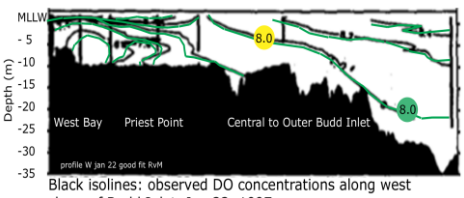
Testing the Model. 1. The Real-Life Dissolved Oxygen Distribution to be Replicated.



Dissolved Oxygen profile along west shore from Cooper Point (right) to end of West Bay (left). 8.0 mg/L isoline highlighted. Contour Interval 0.2 mg/L. Jan 22, 1997. Source: Budd Inlet Scientific Study.

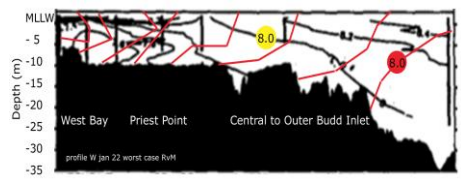
The model is capable of producing data that can be presented in this format. To test the model's accuracy for this example, use it to estimate DO levels on January 22, 1997, and compare with this figure.

Testing the Model. 1a. Example of a Close Fit of Model Output to the Observed DO Distribution.



Black isolines: observed DO concentrations along west shore of Budd Inlet, Jan 22. 1997.
Colored isolines; possible outcome of a model test in which the calculations fit the observed values closely.

Testing the Model. 1b. Example of a Poor Fit of Model Output to the Observed Distribution .



If the model can't replicate the observed distribution of dissolved oxygen in Budd Inlet …
THEN IT SHOULDN'T BE USED FOR IDENTIFYING WATER QUALITY STANDARDS VIOLATIONS.

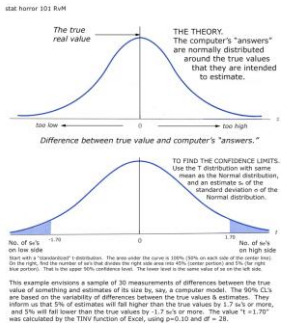
The End …

… and the beginning of the next phase.

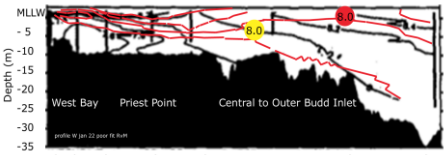
See handout for recommendations based on this presentation!

Dave Milne
Nov. 3, 2014

How it's done … quick, let's get out of here! Next slide please!

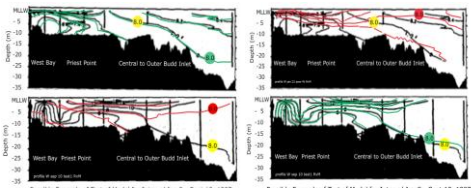


Testing the Model. 2b. Example of a Loose Fit between Model Output and the Observed DO Distribution.



Black isolines: observed DO concentrations along west shore of Budd Inlet, Jan 22. 1997.
Colored isolines: possible outcome of a model test in which the calculations do not fit the observed values closely.
(Red isolines are from the Jan. 8, 1997, observed values.)

Testing the Model. 3. Possible Outcomes.



Possible Example of Test of Model for Interval Jan 8 - Sept 10, 1997.
1. Close fit to observed DO isolines at start, drift from the observed pattern by the end of the simulation.

Possible Example of Test of Model for Interval Jan 8 - Sept 10, 1997.
2. Poor fit to observed DO isolines at start, with better fits developing as the simulation proceeds.

Black figures show observed DO isolines on Jan 8 (upper) and Sept. 10 (lower). Colored lines show examples of comparisons of a model's calculated values with observed values. Green = good fit, red = poor fit.
Left. Possibility 1. The fit gets worse toward the end of the simulation.
Right. Possibility 2. The fit becomes better toward the end of the simulation.

Recommendations for further refinement of the Budd Inlet simulations.

Recommendation	Rationale
1) Simulate the inlet between dates March 15 and October 15.	Some WQ standards violations occur after Sept. 15, the present cut-off date of the simulation. There are none before March 15.
2) Change the present unconventional practice of reporting model outputs (as a single unspecified depth on a single unspecified date showing the maximum level of WQ standards violation for the duration of the simulation) to showing a vertical profile of DO on the date(s) of the violations. If impractical for all violation locations, at least do so for violations at stations reported in the BISS data.	It is presently impossible to compare the model outputs with observed data. The present mode of reporting precludes conventional interpretation by aquatic ecologists.
3) Always report the 90% confidence limits on estimates of the size of WQ stds violations.	Estimates of unknown values of DO's in nature may or may not be far off the mark. Confidence limits put such estimates in perspective.
4) Use as the criterion for identifying WQ stds violations whether or not the upper confidence limit (not the estimate itself) falls below the WQ standard.	If the upper confidence limit falls below the standard, we may be very sure that there really is a violation. *Especially* if it is an UCL of a mean of several estimates.
5) For validation of whichever model is used, calculate dissolved oxygen vertical profiles for all the BISS stations, on the same dates as the BISS stations were observed and at the same times of day.	These stations, dates, and times are available in the BISS data spreadsheet. This makes a crucial model validation test possible. This calculation is critical to determining whether the model replicates the structure of Budd Inlet water or not.
6) Find a way to extend the Budd Inlet model's "view" into the water beyond Boston Harbor, or use the larger South Sound model for the simulations.	It appears that significant Estuary Scenario effects occur right up to the edge of the Budd Inlet model's domain. For accurate simulations of Estuary Scenarios, it is essential that the water beyond Boston Harbor be brought into the simulation.
7) Articulate the perceived problems to be fixed when modifying the model, and what constitutes "success."	[I am thinking of the poster. Maybe this has already been done, I lost my copy! If so, good work.]
8) It would be helpful if model output maps show the calculated DO's of water in the bottom layer over the whole of Budd Inlet at representative dates.	The bottom layer is almost always the place where DO goes lowest. This would provide valuable overviews of the situation at the bottom.

Squaxin Island Tribe
Natural Resources Department

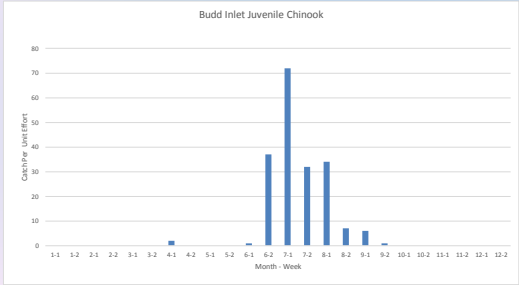
Project Review

- CLAMP
  - WDOE
  - WDFW
  - WDNR
  - Squaxin Island Tribe
- WRIA 13 Technical Team
- South Puget Sound Technical Team
- PSNERP

Current Conditions

- Invasive Species
- Circulation
- Excessive Algae
- Water Quality Problems
- Poor Fish Survival

Beach Seine Captures in Lower Budd Inlet Over a Calendar Year



Poor Water Quality

- State/EPA listings- impaired

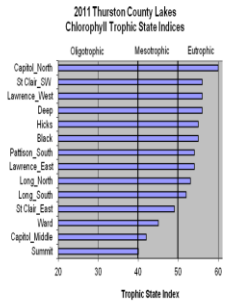
  Lake
  - Phosphorus
  - Bacteria
  - Invasive exotic species

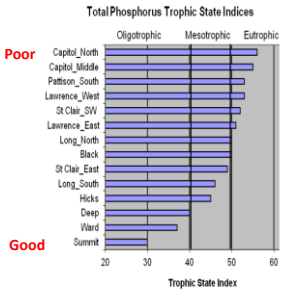
  Inlet
  - Dissolved oxygen
  - Temperature
  - Ammonia-N
  - Bacteria

Thurston County Water Quality

- Capitol Lake = Poor
- "Poor" - High nutrient and chlorophyll *a* concentrations, and low water clarity; Classified as Eutrophic; Uses impaired during most of the summer season by excess algae and/or naquatic macrophyte (plant) growth.

Thurston County Lake Quality





Thurston County Lake Quality

Summit	Excellent
Deep	Good
Hicks	Good
Ward	Good
Black	Fair
Lawrence	Fair
Long	Fair
Pattison	Fair
St. Clair	Fair
Capitol	Poor

Peer Review

Ecology/EPA

1. Cadmus Group and Dr. Scott Wells

2. Dr. Wells

Capitol Lake: Protector of Water Quality in Budd Inlet

– Staff from Evergreen State College

Peer Review

1. Dr. Chin-Leo
   Academic- oceanography, marine biology
   Work- bacteria, plankton
2. Dr. Thuesen
   Academic- biology
   Work- zooplankton, jellyfish, geoduck
3. Dr. Soule
   Academic- ecology?
   Work- desert ecology
4. Dr. Ladd
   Academic- inorganic chemistry
   Work- chemistry, tunicates

Capitol Lake/Budd Inlet Technical Discussion

November 3, 2014

The purpose of this summary is to document the meeting and accompany the items posted on the Deschutes TMDL website.

Participants

Anise Ahmed, Ecology, Environmental Assessment Program
Jonathan Frodge, Washington State Lake Protection Association
Bob Holman, Capitol Lake Improvement and Protection Association
David Milne, Professor, Evergreen State College (Retired)
Sue Patnude, Deschutes Estuary Restoration Team
Greg Pelletier, Ecology, Environmental Assessment Program
Mindy Roberts, Ecology, Environmental Assessment Program
Scott Steltzner, Squaxin Island Tribe, Natural Resources Department
Lydia Wagner, Ecology, Moderator
Bob Wubbena, Capitol Lake Improvement and Protection Association

We discussed the agenda and ground rules. The moderator recommended the order of presentations as 1) Ecology staff, 2) David Milne, and 3) Scott Steltzner/Jonathan Frodge. Each group would have 20 dedicated minutes for a presentation or dissemination of information, followed by a 10 minute discussion. After completing all three presentations we would have a final 20 minute group discussion. There was no change to the agenda or order of presenters. The meeting started at 1:40 p.m. and concluded at 3:40 p.m.

Agenda

- Introduction/Ground Rules - Lydia Wagner
- Ecology science statements - Mindy Roberts, Greg Pelletier, Anise Ahmed (20 mins)
    - Discussion (10 minutes)
- Modeling Budd Inlet - David Milne (20 minutes)
    - Discussion (10 minutes)
- Squaxin Island Tribe perspective - Scott Steltzner; Science review – Jonathan Frodge (20 minutes)
    - Discussion (10 minutes)
- General Discussion (20 minutes) – All
- Summary/Closing Comments – Lydia Wagner

Further discussions on the technical issues related to Budd Inlet and Capitol Lake will occur with the Deschutes TMDL Advisory Group in 2015.

Ecology is posting the following items on the Deschutes TMDL website, http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/index.html, under "Related Information", http://www.ecy.wa.gov/programs/wq/tmdl/deschutes/related.html.

- Agenda
- Draft Science Summary Statements *(Ecology – Anise Ahmed, Greg Pelletier, Mindy Roberts)*
- "Materials for Budd Inlet and Capitol Lake science meeting" - presentation slides *(Ecology – Anise Ahmed, Greg Pelletier, Mindy Roberts)*
- "Modeling Budd Inlet. II. Sharpening & Validating the Tools" – presentation slides *(David Milne)*
- "Recommendations for further refinement of the Budd Inlet simulations" *(David Milne)*
- "Squaxin Island Tribe, Natural Resources Department, Project Review" – presentation slides *(Squaxin Island Tribe, Scott Steltzner)*
- Capitol Lake/Budd Inlet Technical Discussion Summary *(Ecology – Lydia Wagner, Moderator)*
- Audio file of entire meeting *(Recorded by Ecology – Lydia Wagner, Moderator)*

Acronyms used in presentations

BI: Budd Inlet
CL: Confidence limit
CLAMP: Capitol Lake Adaptive Management Plan
CLIPA: Capitol Lake Improvement and Protection Association
DERT: Deschutes Estuary Restoration Team
DO: Dissolved oxygen
DOE: Department of Ecology
EAP: Environmental Assessment Program (Ecology)
EPA: U.S. Environmental Protection Agency
LL: Lower left
LOTT: Lacey, Olympia, Tumwater, Thurston County
LR: Lower right
PSNERP: Puget Sound Nearshore Ecosystem Restoration Project
QAPP: Quality Assurance Project Plan
RMSE: Root mean square error
SIT: Squaxin Island Tribe
TMDL: Total maximum daily load
UCL: Upper confidence limit
UL: Upper left
UR: Upper right
WDFW: Washington State Department of Fish and Wildlife
WDNR: Washington State Department of Natural Resources
WDOE: Washington State Department of Ecology
WQ: Water quality
WRIA: Water Resource Inventory Area
WWTP: Wastewater treatment plant

-----Original Message-----
From: Robert Wubbena [mailto:rwubbena@gmail.com]
Sent: Saturday, November 15, 2014 4:30 PM
To: Wagner, Lydia (ECY); Bellon, Maia (ECY); Liu, Chris (DES); Chris Sanders
Cc: Allen Miller; Bob Holman; Bob VanSchoorl; Brenda Hood; Dan Cheney; Dave Milne; Denis Curry; Don Melnick; Gary Larson; Ginny Stern; Jack Havens; Jewel Goddard; Jim Lengenfelder; John DeMeyer; Les Eldridge; Mary Thompson; Nancy Ronning; Robert Wubbena; Ron Rants; Doenges, Rich (ECY); Toteff, Sally (ECY); Martin, Carrie R. (DES)
Subject: Letter To Ecology--Scientist to Scientist--Nov 3 Questions

Lydia, attached is our CLIPA response to the six questions that Mindy handed to us at the end of the meeting on November 3 meeting. As we indicated at that time, we need to review the questions and provide a more inclusive and written response. The attached letter provides that response and our additional reflections on the November 3 meeting.

We noted that you have posted the tape of the meeting along with the handouts at the meeting, along with the six draft questions. Please now post our response to those six questions so that our CLIPA response is properly noted for others to review.

We have met with the State Capitol Committee and continue to meet with the individual members of the SCC to encourage them to proceed with the decision process on the future of Capitol Lake. We will be happy to meet with Ecology Staff at any time to address the technical issues that we have identified. Our understanding of the Ecology model, its limits and input boundaries, is now quite thorough. We will continue to provide comments at the various TMDL meetings and ensure that all views are presented. However, it is time to advance the decision process that has been delay since the formation of the CLAMP process.

CLIPA has prepared a draft plan for the Deschutes River Urban Watershed Plan that extends from Pioneer Park to Priest Point Park.
We would encourage you and Ecology to incorporate this new discussion in the TMDL meetings. This Plan seeks to involve all issues important to the future of the Urban waterfront and the quality of water for all uses.

Thank you for your assistance in keeping all of the various viewpoint posted and available for the large community to read and provide comments.

--
Bob Wubbena
2201 Bayside PL NE
Olympia WA 98506
360-280-9100
rwubbena@gmail.com

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CLIPA
Capitol Lake Improvement and Protection Association
"Save the Lake - Preserve the Past, Improve the Future"

Lydia Wagner
Dept. of Ecology
RE: Ecology's Requested Response to Nov 3 Meetings Questions

Dear Lydia,

First thank you for arranging the first opportunity for our CLIPA representative and expert Dr Dave Milne to meet with Ecology Modeling Staff Mindy Roberts, Greg Pelletier, and Anise Ahmed and others. This was CLIPA'S first opportunity to have an in-depth give-and-take discussion with Mindy Roberts and her staff to better understand the boundaries/limitations and design of the Ecology water quality model on lower Budd Inlet.

At the end of the meeting, Mindy Roberts provided each of us with six "Draft Science Summary Statements—November 3, 2014" and asked us to respond to the listed statements. We indicated that our response could not be a short statement, but rather we would need to review them, put them in the context of the expanded information provided at that November 3 meeting, and then reply in writing. We wanted to ensure that our message could be documented and posted on the Ecology Website to share with others. This letter provides our response.

WATER QUALITY MODEL. THE BOUNDARIES MODELED, AND THE LIMITS OF USEFULNESS OF ECOLOGY'S MODEL FOR A COMMUNITY DECISION ON THE FUTURE MANAGEMENT AND CHANGES TO CAPITOL LAKE AND THE DESCHUTES URBAN WATERSHED.

INITIAL REFLECTIONS ON THE ECOLOGY MODEL'S USEFULNESS.

The Budd Inlet Model limits its inputs to factors that do not include all of the major conditions that impact water quality. It does not consider cost/ benefit relationships of the alternative strategies; it does not include a thorough consideration of Community Priorities;

It is based on a supposed "natural" condition (estuary) not representative of the existing (lake) situation for "lake scenarios" necessary for assessing alternative future improvements to water quality.

Even if the model is considered to be validated within the limits of what Ecology used to model projected dissolved oxygen benefits, those projected benefits will cost more than $258 million in initial costs to remove the Tide Gate and clean up the accumulated sediment, while at the same time the resulting project will destroy many of the other Community amenities of Capitol Lake, including the historic 1911 design of the State Capitol Campus; it will result in a lost marine boating channel; and there is no identified

CLIPA Capitol Lake Improvement and Protection Association
606 Columbia Street NW #100-C www.SaveCapitolLake.org
Olympia, Washington 98501 Friends@SaveCapitolLake.org
CLIPA is a non-profit, 501(c)(3) organization

method or community support to finance the $258 million in upfront cost. The following are additional comments that support our conclusions.

- A MODEL IS A TOOL, NOT A DECISION FINALIZER. CLIPA believes that any computer based model is a tool meant to be used for consideration of future decisions – not to proscribe them. The limitations of the tool are defined by various boundary constraints, the input information, and the level of accuracy to which the model can realistically identify the existing and changing environmental conditions that the tool is designed to simulate.

- ECOLOGY'S WATER QUALITY MODEL RESULTS ARE CONSTRAINED BY ITS BOUNDARY LIMITS AND INTERNAL SET POINTS. We understand from the Nov 3 meeting that Ecology's model attempts to simulate changes in oxygen levels in lower Budd Inlet under a variety of future conditions. The model seeks to predict changes in other water quality parameters as well, and then seeks to compare its findings under a 'Natural Condition" to those of a "Current Condition" (with the Tide Gate installed). Ecology also attempts to allocate portions of these causes of environmental change to various anthropogenic- and non-anthropogenic sources and natural watershed contributions to current conditions. Ecology specifically addressed the LOTT discharge, and then associated all other impacts to the Capitol Lake/Tide Gate design. We are not told how Moxlie Creek , the storm water sources discharging below Tumwater Falls, the position of the LOTT outfall, 30 years of neglected (= not dredged) sediment and other "fixable" sources are distinguished from the effect of the dam in Ecology's designation of Capitol Lake as the largest human contributor to oxygen depletion in Budd Inlet.

- NATURAL BEFORE DEVELOPMENT VS STAFF/ATTORNEY OPINION VS CURRENT REALITY. Ecology modelers that said the model's "natural baseline" is based on the advice of one of their attorneys. They concluded that their analysis of water quality conditions in Puget Sound should be compared with "Natural Conditions—before human impacts" – that is, an estuary -- and should not include a parallel baseline condition (a lake) that would enable determination of effects of improvements by simple maintenance. At the Nov 3 meeting, Mindy Roberts mentioned that DOE is actually not using the true "Natural Condition---i.e. a 2000 foot opening at the Fourth Ave Bridge, the absence of the Railroad bridge/berm across the Capitol Lake basin, or Budd Bay Harbor full of sediment (absent pre-harbor dredging which began at the turn of the Century) and subsequent flood stage adjustments to sediment routing of low flow conditions below the Tumwater Falls. Ecology instead has fabricated a set of limits for the model that has no baseline reference to any true Natural or Existing conditions.

- REGULATORY STANDARDS---LAKE Vs RIVER, IMPOUNDMENT STANDARDS. When asked why Ecology is modeling the potential "water quality violations of the Clean Water Act as if Capitol Lake is a Lake rather than as an impounded River per State definition, they said their attorney mandated that they use a lake definition. It is difficult for CLIPA to accept that an attorney general would intervene in a scientific investigation in such a specific way.

- SOURCES OF HUMAN OXYGEN-IMPACTING CONTAMINANTS IN LOWER BUDD INLET. When asked how Ecology integrated into the model their own field data that shows over 80% of the Budd Bay Inlet nitrogen loading comes from Northern Puget Sound (some 40 times that added by the Deschutes River Watershed), they said the model was "adjusted to do so." The contaminant load from the North includes significant input from human sources and, being fixable, could be considered as an option in the Capitol Lake Management Plan. Nevertheless, Ecology finds that a Tide Gate removal project (calculated by CLIPA to cost $258 million) would

be beneficial even though the huge contaminant loading in Budd Inlet that comes from the North would not be reduced by this expenditure.

- CAPITOL LAKE AS AN EXISTING LOW COST, POSITIVE IMPACT ON BUDD INLET WATER QUALITY. When asked how Ecology factored in the benefits of a potential "plant harvesting system in Capitol Lake" to remove the "natural plant accumulated contaminant load from the Deschutes Watershed" as a practical solution to the long term water quality improvements for lower Budd Bay, they said it was not cost effective. We have not seen any documents that support that finding. (Note: a routine lake dredging program would include a plant harvest program at little additional cost and could be implemented within a year or two.)

- DO SOLIDS/SEDIMENTS FACTOR INTO ECOLOGY'S LONG TERM WATER QUALITY IMPROVEMENT MODEL? The meeting time was too short to ask this question, but it is a major significant part of both water quality considerations and management of the Deschutes Urban Watershed, including lower Budd Inlet. In the absence of information on how sediment impacts the physical flow patterns, and how turbidity/sediment/solids are factored into the water quality objectives for the lower Budd Inlet, the model is limited in value to the community decision process. Management of solids and sediments is a primary achievable practice that impacts the entire watershed and the alternative plans and costs.

- RIVER AND INLET HYDRAULICS BEFORE THE ISTHMUS/DAM AND HOW EXISTING HARBOR RESPONDS AND IMPACTS WATER QUALITY THROUGHOUT LOWER PUGET SOUND. Ecology said that Capitol Lake-increases the "residency time of the water in East Bay and is the cause of the poor water quality in there. High concentrations of bacterial contaminants and nitrogen coming from the urban watershed of Moxlie Creek and the shallow waters near Swan Town were not isolated as possible significant contributors to water quality there. Until that is done, we cannot be sure that Capitol Lake has any effect on East Bay. We are unsure of how much residency time in Capitol Lake itself has been modeled, since the Lake is now essentially full of sediment and its residency time is now very reduced. Ecology does not credit Capitol Lake for Flood Management benefits because of its limited capacity to impound water as a River Impoundment/Flood Control system (flood risk reduction is provided primarily by managing tidal, flood flow and tide gate mechanical flow/timed releases). These are effects and benefits that must be discussed openly.

- LIMITED MODEL INPUT, LIMITS MODEL OUTPUT. Ecology limited our discussion on Nov 3 to only those questions related to the design of the model, and not how the model might be used by the State Capitol Committee (SCC) and the Community in making a major decision on the future management of Capitol Lake. Therefore, when Ecology documents suggest that the removal of the Capitol Lake Tide Gates "might improve the water quality in Budd Inlet as it relates to oxygen depletion", such statements must be footnoted with the above 8 items and related questions. The fact that the Ecology based conclusion does not incorporate the many State Environmental Protection Act (SEPA) or the National Environmental Protection Act (NEPA) required factors on which a final environmental permitting decision must be made, *the model's findings must be considered advisory* and not all inclusive in the environmental permitting process. The Ecology conclusions related to their model are just that, an Ecology staff conclusion that their model, as designed, suggests that "Capitol Lake is the largest (accumulation of upstream/and physical factors) contributor of human factors that impacts oxygen levels in Budd Bay of the projected sources from the Deschutes Watershed (not including the human sources incoming from the North".

COMMENTS BY OTHERS AT NOVEMBER 3 MEETING.

- CLIPA representatives (Wubbena and Holman) emphasized that CLIPA's objectives were consistent with some of Ecology's stated TMDL objectives in that we both want to improve and manage water quality in the Deschutes River Watershed, including Budd Bay to the Priest Point Park area. However the program must be inclusive of all of the Urban Watershed needs and part of a long term management plan.

- CLIPA's expert, Dr Dave Milne, referenced his previous Peer Review and written response documents that are posted on the Ecology Website, and then presented an update on his documented statements about the validity of the Ecology model. (See attached Power Point presentation and the recording of the meeting.)

- Squaxin Tribe representative Scott Steltzner' clarified that the Squaxin Nation is not a part of the Pro Estuary group, but rather they are focusing on water quality issues impacting Puget Sound and healthy salmon runs. His power point was not limited to Capitol Lake or Budd Inlet, but he spoke more generally of the tribes interests. It was unclear how their support for a $20m fish hatchery above the Tumwater Falls is coordinated with the future management options for Capitol Lake. He also spoke to his understanding of the limited qualifications of four of the Evergreen Professors that "endorsed Dr Milne's Peer Review and response documents, and then introduced Dr Frodge as the tribe's "invited expert to comment".

- Dr Frodge spoke in general statements, gave some opinions on the Lake plant issue and its relationship to the oxygen discussion, but added no new information except for some comparable findings from Lake Washington and other Washington lakes. He did not offer additional specific information on the Ecology model or the local conditions.

CLIPA'S RESPONSE TO ECOLOGY'S "DRAFT SCIENCE SUMMARY STATEMENTS (agree, disagree, other) as requested by Ecology.

- ECOLOGY' STATEMENT-Evaluating oxygen depletion requires the combined effects of physics, chemistry, and biology.

CLIPA would add "time" as part of this list. We agree with this statement and would caution that the evaluation is shaped, limited, or even invalidated if the input data are incorrect or incomplete. (See above comments.)

- ECOLOGY'S STATEMENT-Capitol Lake produces the largest detrimental impact on dissolved oxygen compared with any other human activity, including local wastewater discharges, local non-point sources and external anthropogenic sources.

CLIPA disagrees. We suggest that this statement is premature and that any such claim must be supported by a clear published demonstration that the model is actually capable of accurate, consistent replication of real water quality conditions known to exist in Budd Inlet. That demonstration – a "validation of the model" – has not been provided. (See above comments.) Capitol Lake is an accumulator of many human and natural watershed impacts that are manifested in different forms and in different ways ---flood stage, low flow conditions from an impounded river that has a widely varying flow rate, watershed discharge violations that are slowly being addressed by Ecology and local governments. Ecology is using a model that has a fabricated and misleading "natural baseline". The nexus of measuring the model results is Budd Bay. The effects of the 80% loading including Northern human contributions, Moxlie Creek

contributions, and varied sediment and plant life conditions in Capitol Lake add complexity to the real world situation that does not appear to have been isolated and identified by the Model. The limit placed on the model "by an attorney's opinion" puts the "Ecology Science Summary Statement" into a questionable category of being correct. The Model, with its many limitations, omissions, and dubious "mandated" baseline conditions may suggest what Ecology strongly concludes, but CLIPA believes it does not. The many shortcomings of the Model severely limit the value of the Model Output as informative to making any regulatory or community decisions.

- ECOLOGY--The Capitol Lake dam increases the residence time of East Bay, which degrades dissolved oxygen by itself, independent of carbon or nitrogen loading.

CLIPA does not agree. There are many other factors that might (and probably do) cause the DO anomalies in East Bay as previously explained to Ecology by Dr Milne. Other observers (Holcomb, Wubbena) hold that this conclusion by Ecology can be better explained by the hydraulic modeling of the Deschutes River low flow to flood stage conditions under the alternative "filled conditions that have been in varying stages since the last dredge in 1985". Timing of flood stage and tidal influences, along with Dr Milne's view of shallow-water biological activity do not support the Ecology conclusion as it relates to the complete story. We do not know if Ecology's "natural conditions" include legitimate open flow condition vs. the existing land mass, tide gate, and the sediment shaping flows in lower Budd Inlet. The Ecology reported "residence time effect" in East Bay must be isolated from Moxlie Creek's contribution to oxygen depletion, which must be compared with the potential contribution from the "Deschutes River contribution and the 80% contaminant load from the humans to the North, before the DOE statement can be considered valid.

- ECOLOGY'S STATEMENT-Capitol Lake transforms nitrate to organic nitrogen and discharges to Budd Inlet. The lake is shallow, so has little retention.

CLIPA agrees to the basic statement. The important question in this situation is whether the transformed nitrogen goes to Budd Inlet immediately or after the growing season. As Dr Milne has presented in his written analysis, the seasonal changes in water quality are associated with the form of chemistry in the natural biological process, flow, time and what assumptions the model places on the limits of measurement. Is it a lake or is it an impounded river? On the statement that the lake "is shallow, so has little retention", we are unsure of which statement Ecology believes is correct. See previous statement about residence time and other CLIPA comments. We assume that since Ecology prepared these six statements that they believe that the six statements are valid, internally consistent and are used to shape the Ecology Water Quality Model. Is this correct?

- ECOLOGY'S STATEMENT-Capitol Lake also converts C (carbon) from air into organic carbon, (sic) much more delivery of TOC to Budd Inlet. This causes oxygen to decline in Budd Inlet. More organic carbon gets produced in the lake than if it were to be an estuary.

CLIPA agrees with the statement if you track the carbon in its various forms under either scenario—lake or no lake. However the amount of carbon formed and changed is essentially the same under either the lake or no-lake scenarios. It simply appears at different times and locations. We expect that, under an ecologically realistic lake scenario, the net result will be that the lake can be used as a low cost natural treatment process that will benefit the long term water quality conditions in Budd Inlet. (See Dr Milne's Peer Reviews and his Power Point presentation from the AHSS (July) meeting.

- ECOLOGY'S STATEMENT-Capitol Lake is a eutrophic lake, based on phosphorus levels.

CLIPA agrees. However, eutrophic conditions in a lake or impoundment often occurs naturally and do not necessarily denote a negative situation. A eutrophic plant-filled water body can be managed to operate as a natural nutrient removal system. We agree that phosphorus levels are higher than if watershed management practices were improved and that as a result, the current level of phosphorus coming into the impoundment (lake) from the watershed contributes to a localized eutrophic condition in portions of the impoundment----in between the flood stage run offs from the watershed. When properly maintained and managed, the impoundment phosphorus levels can be managed. Compared to the true lake conditions in the other water bodies in Thurston County, this is a temporary problem waiting for the SCC to implement a properly designed Capitol Lake Management Program.

SUMMARY OF CLIPA'S RESPONSE TO ECOLOGY'S MODEL/COMMENTS

In summary, we appreciate the help from the Ecology staff to arrange for this exchange of information and clarification of the Ecology Model design. The limits of the Ecology Budd Bay/Capitol Lake model are now better known and documented for discussion with the State Capitol Committee and Community decision makers as they develop a long term management plan for the Deschutes Urban Watershed. CLIPA will continue to participate in public meetings arranged by Ecology to discuss the TMDL studies related to the Deschutes River, and will continue to provide written input from a Community's perspective and our understanding of how the entire Deschutes Watershed functions under current conditions.

We look forward to Ecology's role as an objective consultant in assisting the SCC, CLIPA and the Community in better defining all of the conditions that are important in preparing an effective Deschutes Urban Watershed Management Plan. A good plan should address most of the objects of the TMDL objectives, while being fully responsive, in addition, to the needs of all present and future users of the Deschutes Urban Watershed.

Sincerely

Capitol Lake Improvement and Protections Association
Co-Chairs, Jack Havens, Denis Curry, Bob Wubbena

cc:
State Capitol Committee, Gov Inslee, Lt Gov Owen, Sec of State Wyman, Commissioner of Lands Goldmark
Squaxin Tribal Council
Ecology, Director Maia Bellon
DES, Director Chris Liu
WDFW, Dep Director Joe Stohr
County Commissioners
City of Olympia, Mayor Bauxbaum
City of Tumwater, Mayor Kmet
Ruckelshaus Center, Chris Page
CLIPA Board of Directors
Deschutes River TMDL Participants