Updated Budd Inlet model results accounting for external human sources of nutrients

Briefing for Deschutes Advisory Group
(6/27/13)

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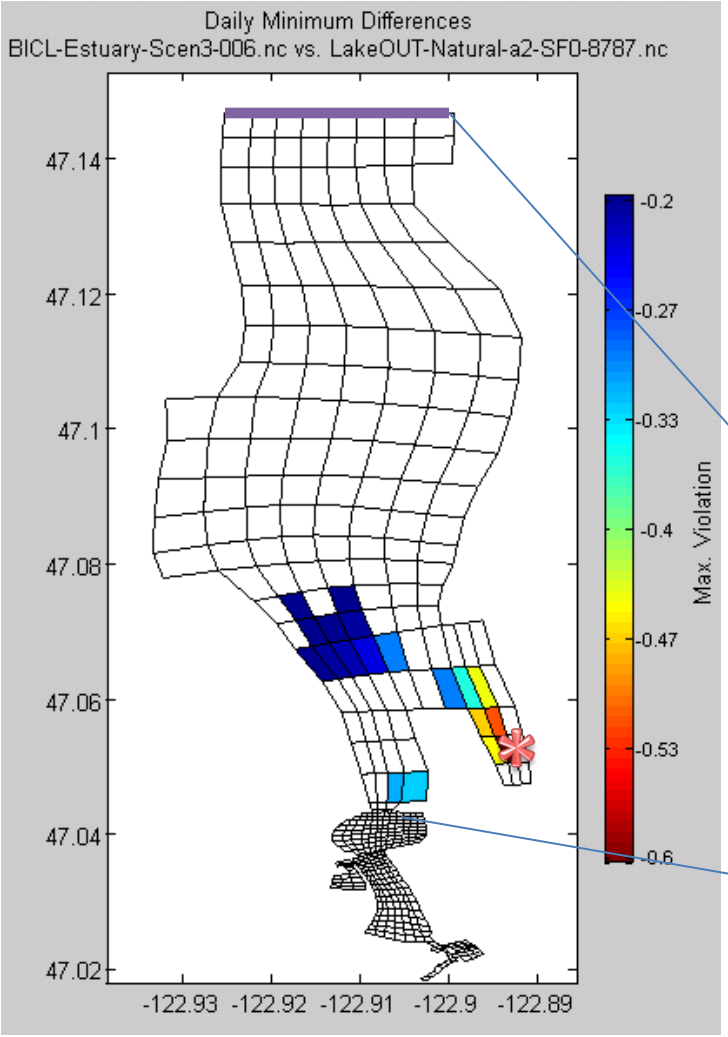
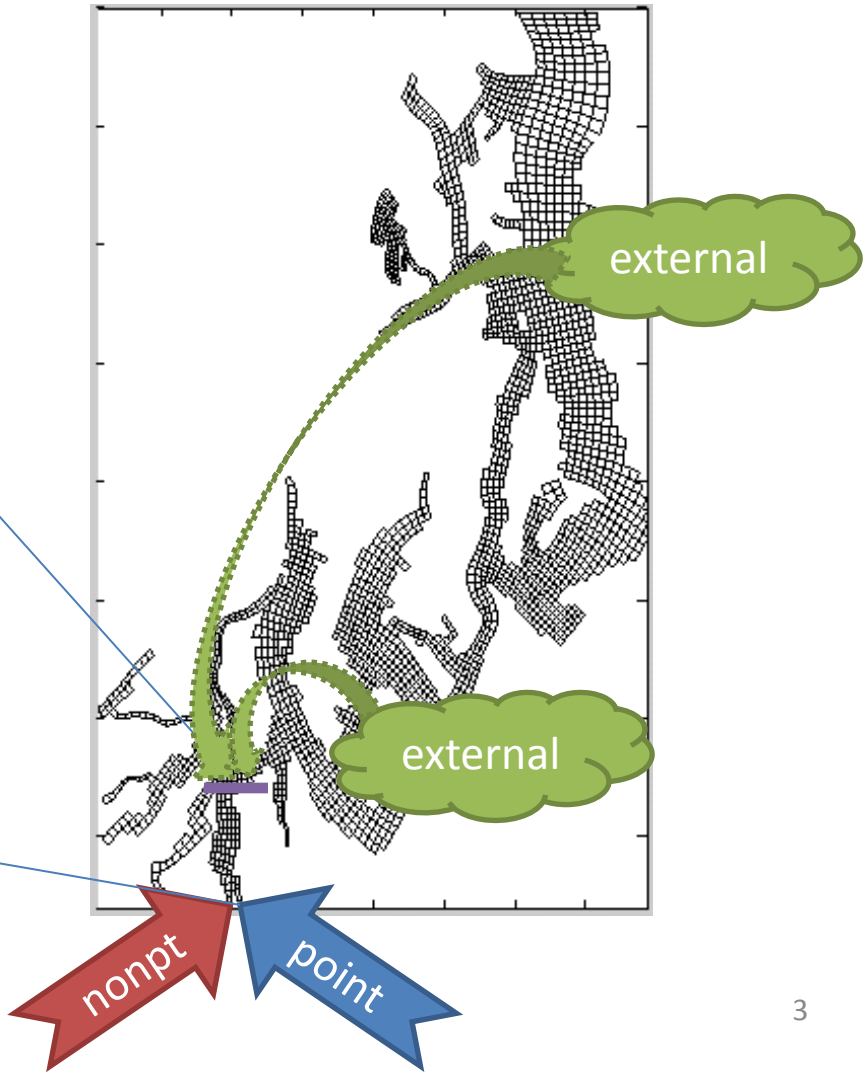
Overview

- Reminder: why did model need updating to account for external human sources?
- Budd Inlet results
  - Current impacts – *no major changes*
  - 2012 DAG scenarios – *no major changes*
  - Additional scenarios for Budd – *new info*
  - Sensitivity to Budd reflux – *new info*
- South Puget Sound modeling efforts
- Summary

Why did we use the nested models?

External sources add to oxygen deficit in Budd Inlet and must be considered in natural conditions (share in 0.2)





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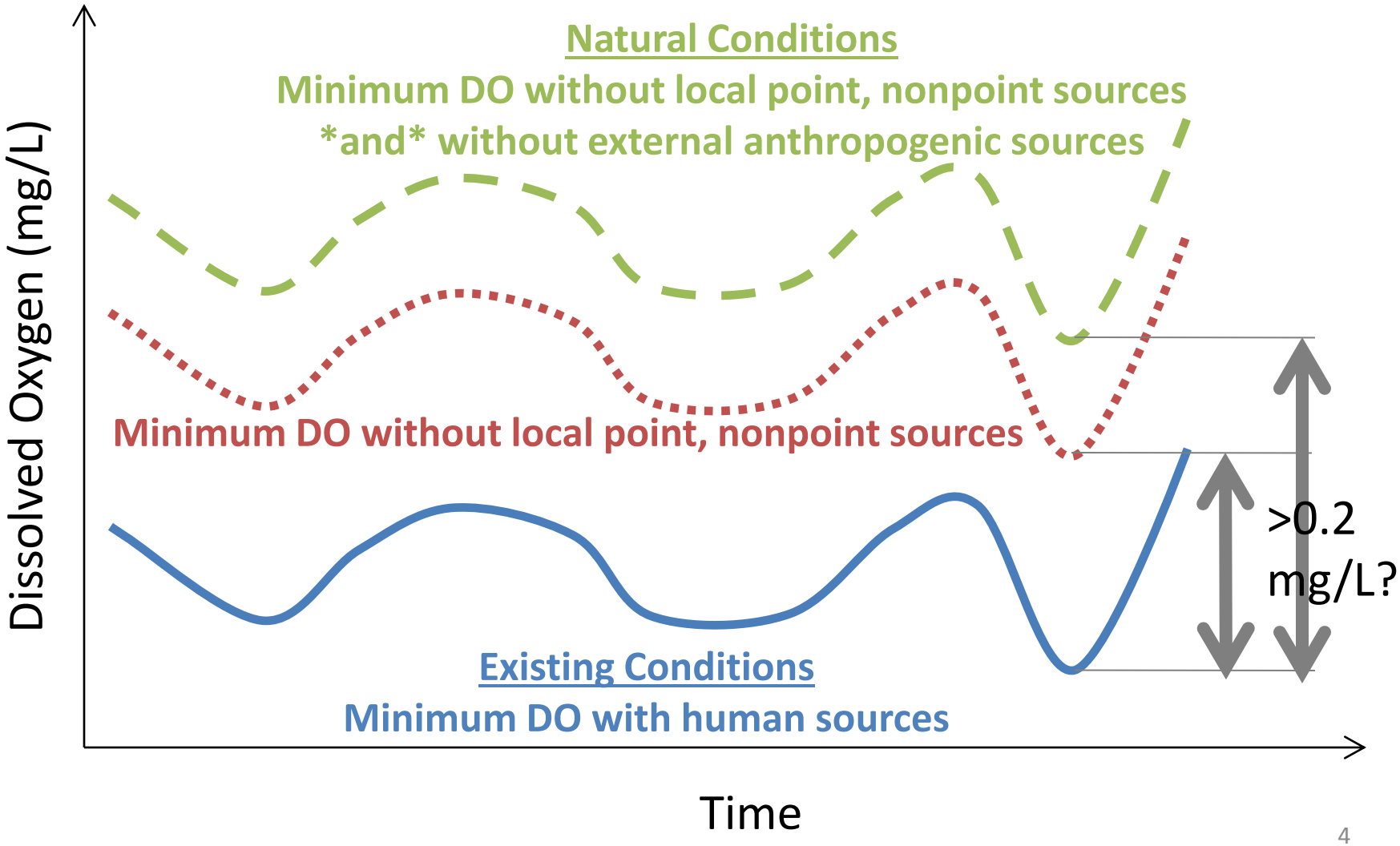
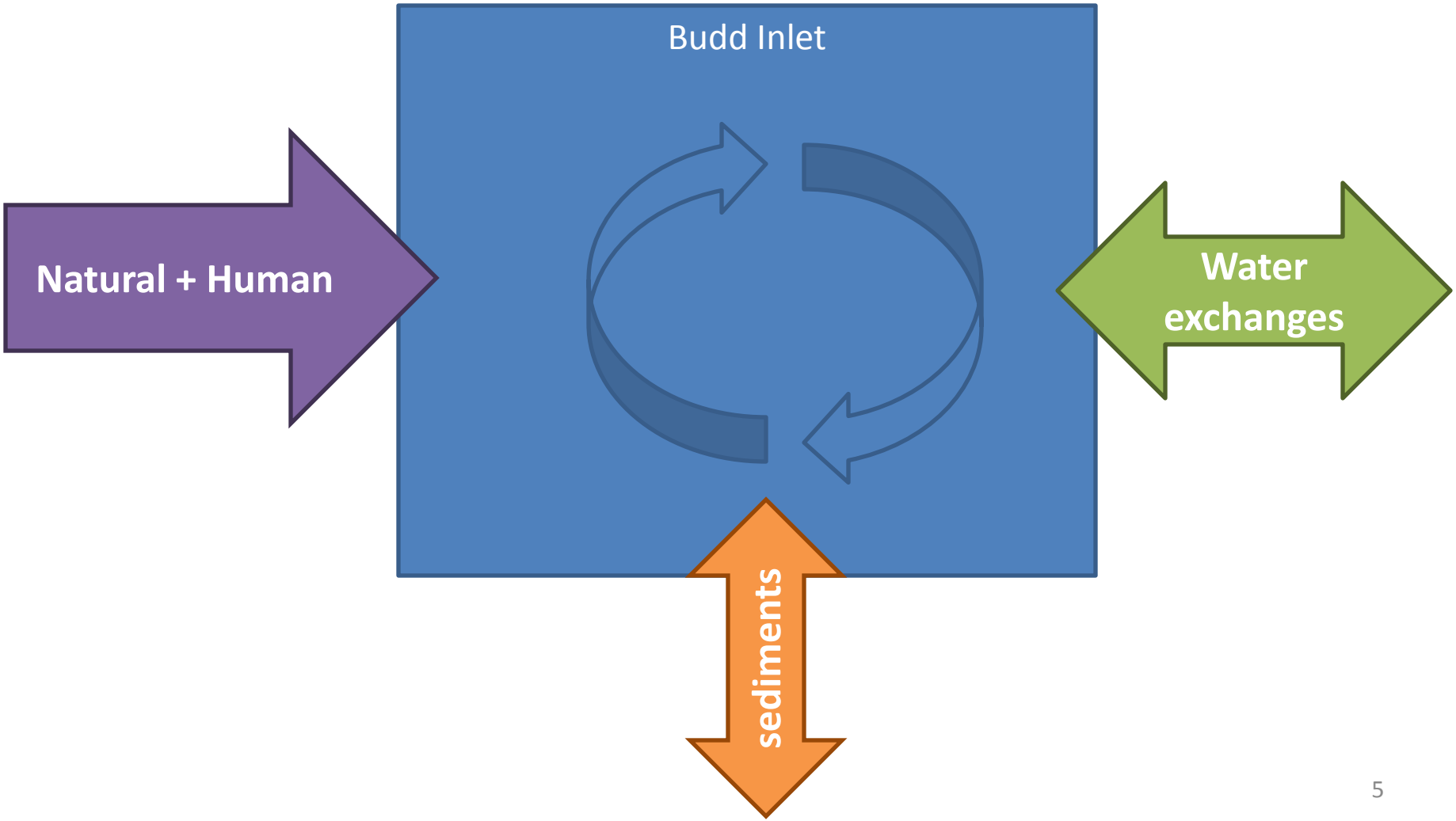


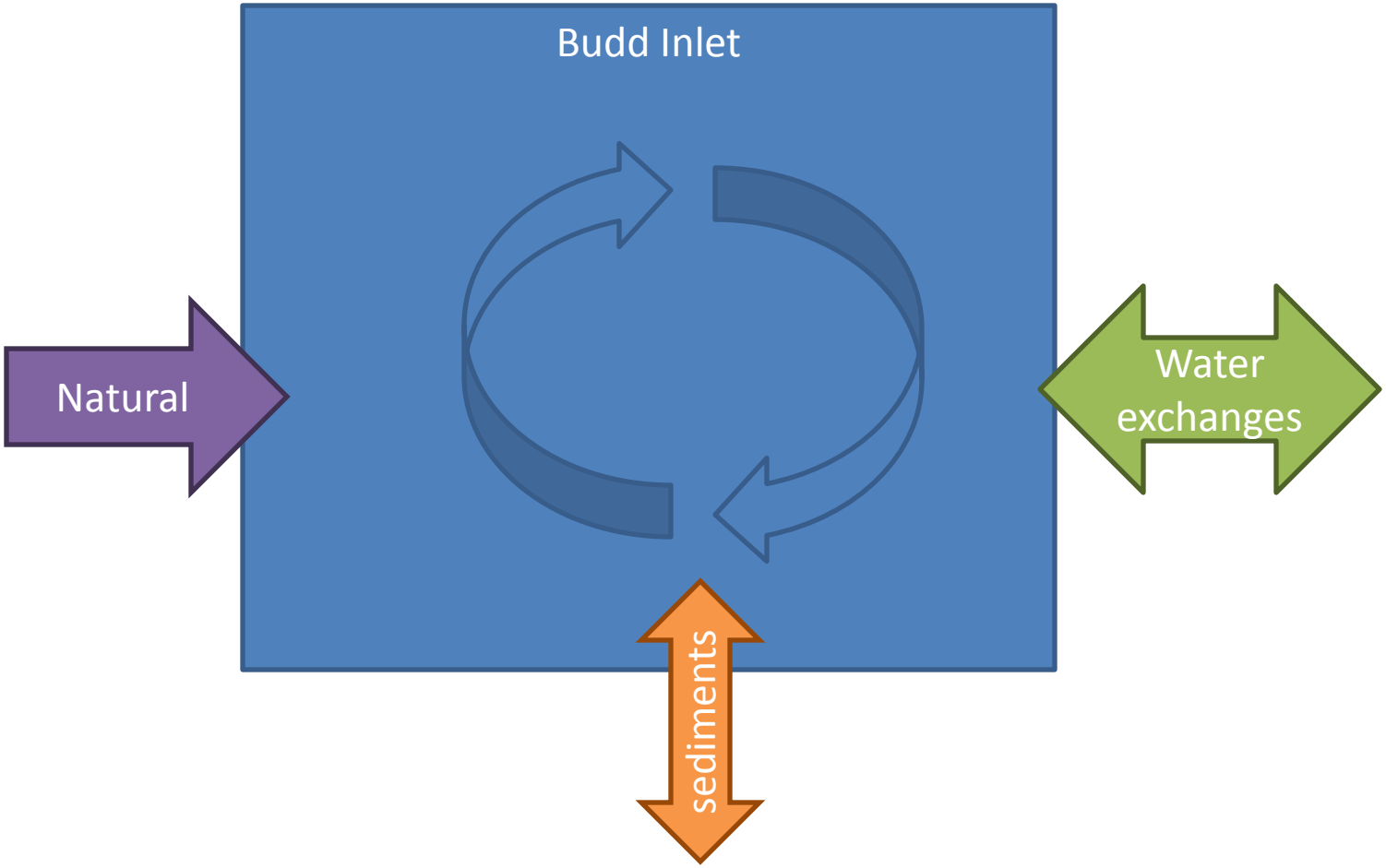
Why did we adjust boundary water quality and sediment fluxes?

Each source has two additional effects



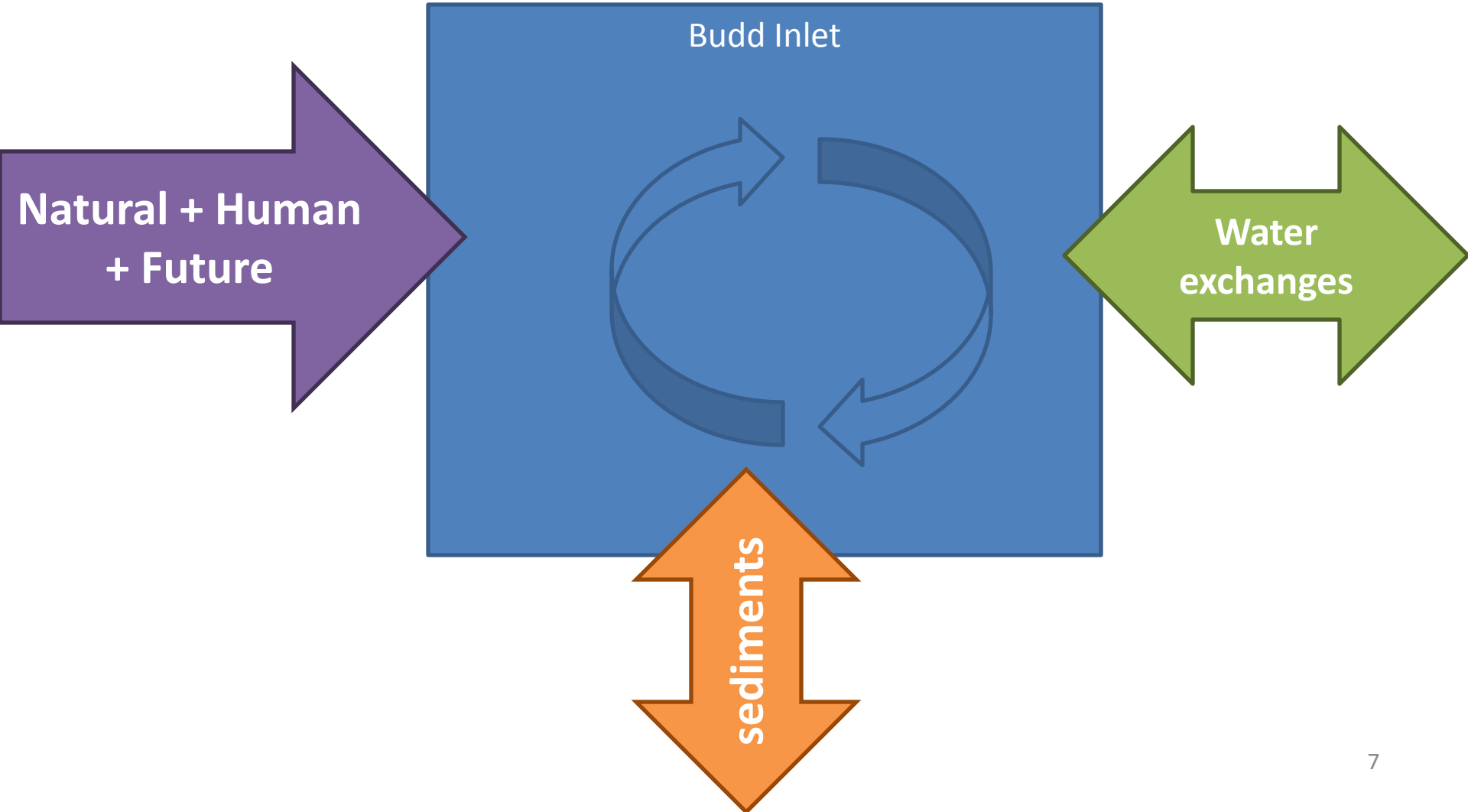
Why did we adjust boundary water quality and sediment fluxes?

Lower natural (or scenario) loading decreases sediment fluxes and water exchange concentrations



Why did we adjust boundary water quality and sediment fluxes?

Higher future loading increases sediment fluxes and water exchange concentrations

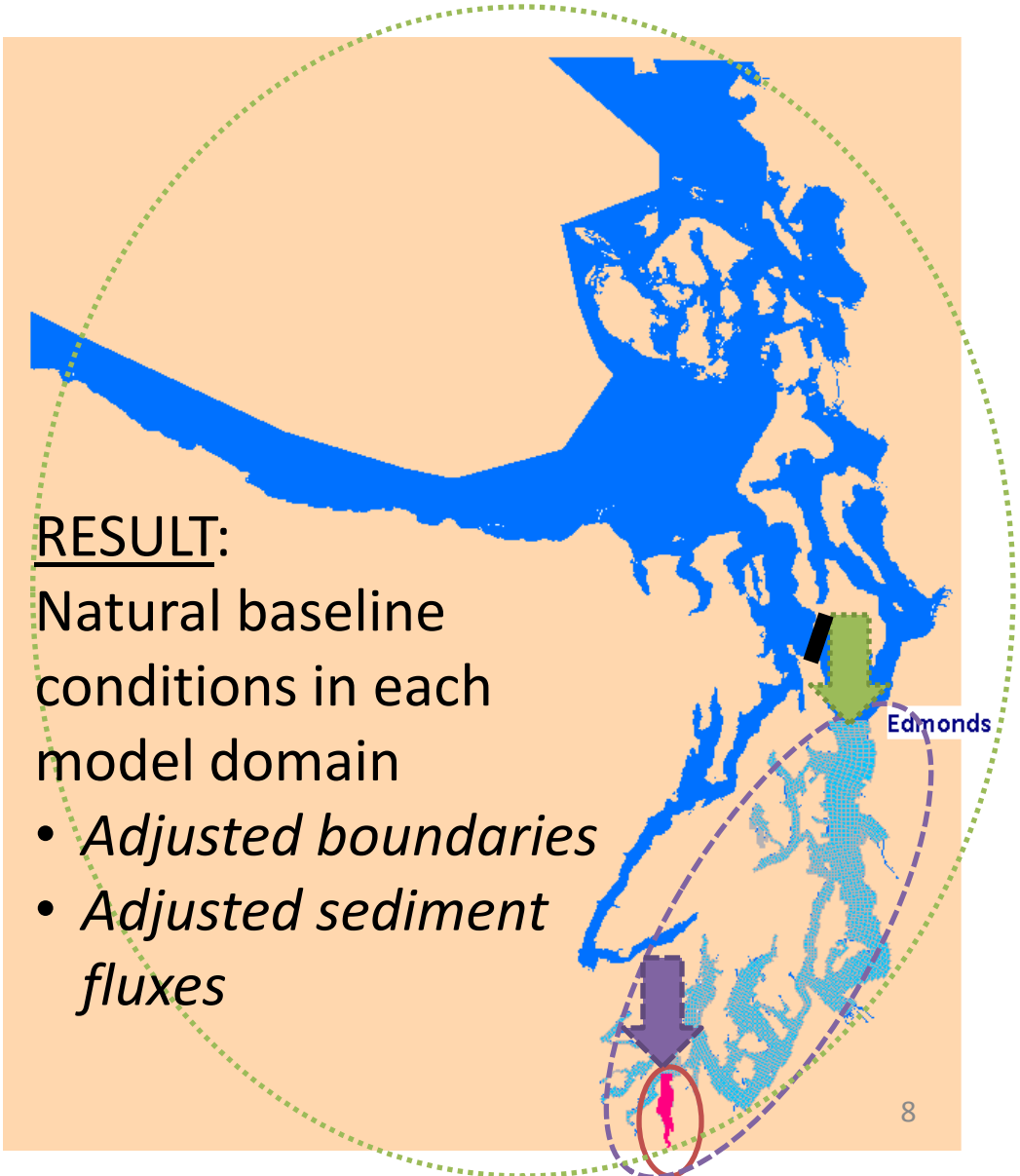


How did we use the nested models to adjust sediment fluxes and water concentrations?

1. Run PSGB model at natural conditions
   A. Adjust sediment fluxes under natural conditions
   B. Write out water quality at Edmonds boundary

2. Run SPS/CPS model at natural conditions with Edmonds adjusted
   A. Adjust sediment fluxes under natural conditions
   B. Write out water quality at Budd Inlet boundary

3. Run Budd model at natural conditions with boundary adjusted
   A. Adjust sediment fluxes under natural conditions
   B. Establish natural conditions in Budd Inlet



<u>RESULT</u>:
Natural baseline conditions in each model domain
- *Adjusted boundaries*
- *Adjusted sediment fluxes*

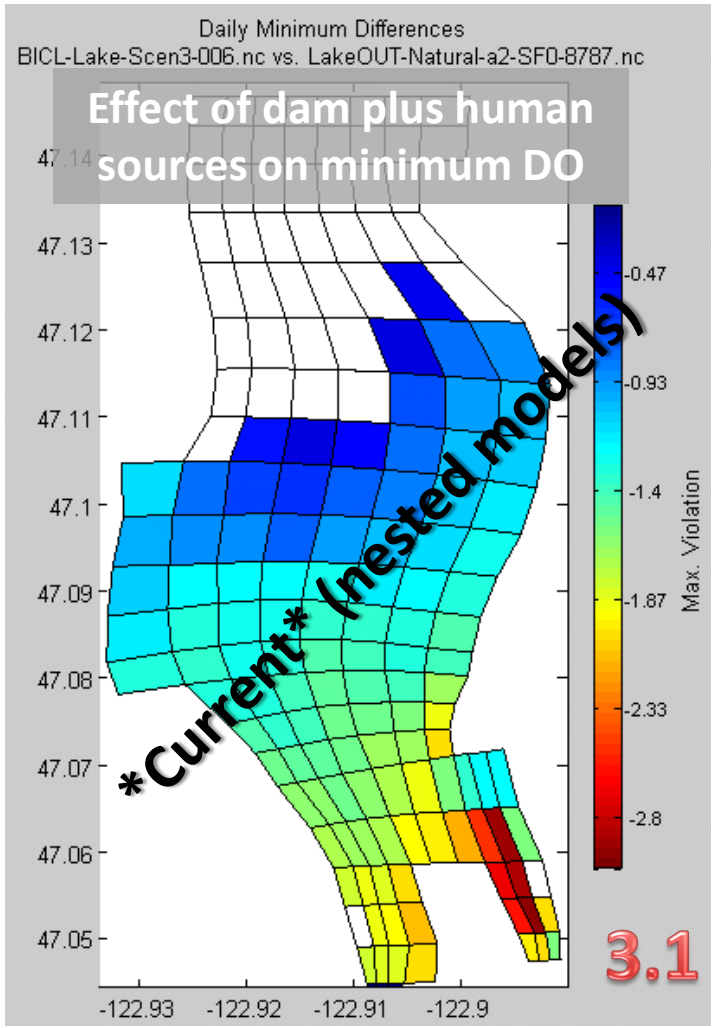
Budd Inlet results

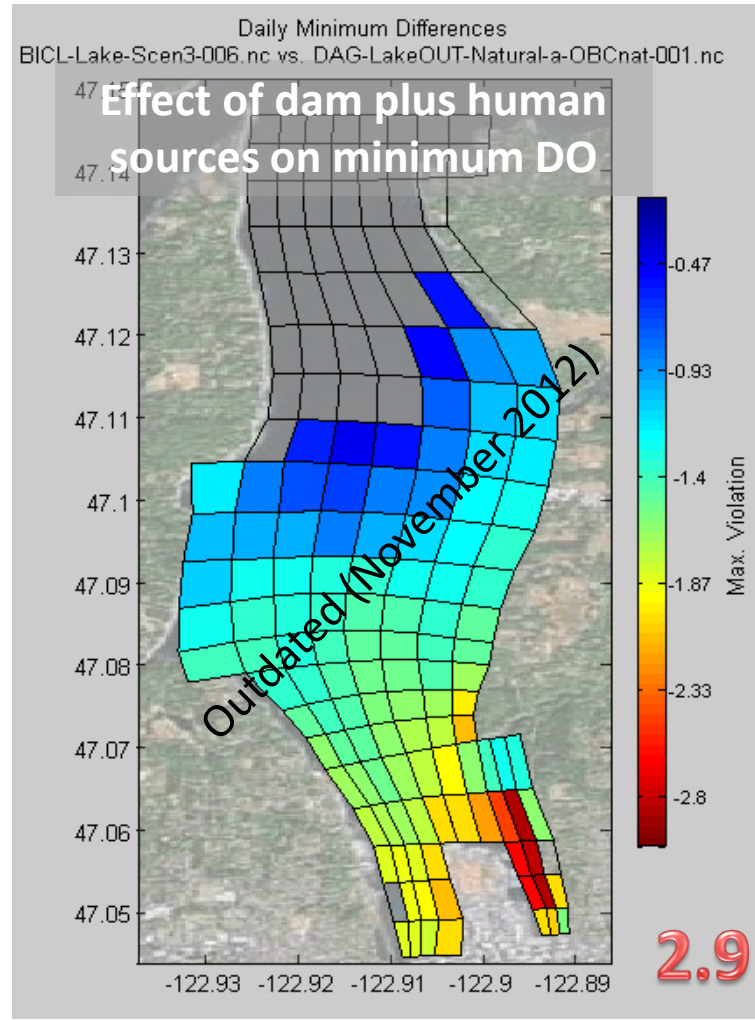
- Human sources violate water quality standards in southern Budd Inlet
  - Lake > external human > PS/NPS at East Bay cell
  - Lake ~ 2 mg/L
  - Local and external point and nonpoint 0.64 mg/L
- Similar WQ benefits from:
  - Reduce external human by 50% (+0.17 mg/L)
  - LOTT off Mar-Sep and reduce NPS by 50% (+0.13)
- Results not sensitive to reflux

Budd Inlet results – scenario overview

1. Current impacts of dam, point/nonpoint, local/external
2. Info previously shared with Deschutes Advisory Group (November 2012):
   - Dam alone
   - Local point + nonpoint sources (plus external human sources)
   - Advanced treatment at all 4 WWTPs
   - Move LOTT to Priest Point, Boston Harbor
   - Reduce nonpoint 10, 20, 50%
   - Reduce external sources affecting open boundary up to 50%
3. Additional Budd scenarios:
   - LOTT off (a) July – Sept and (b) Mar – Sept
   - With and without reducing local NPS by 20%, 50%

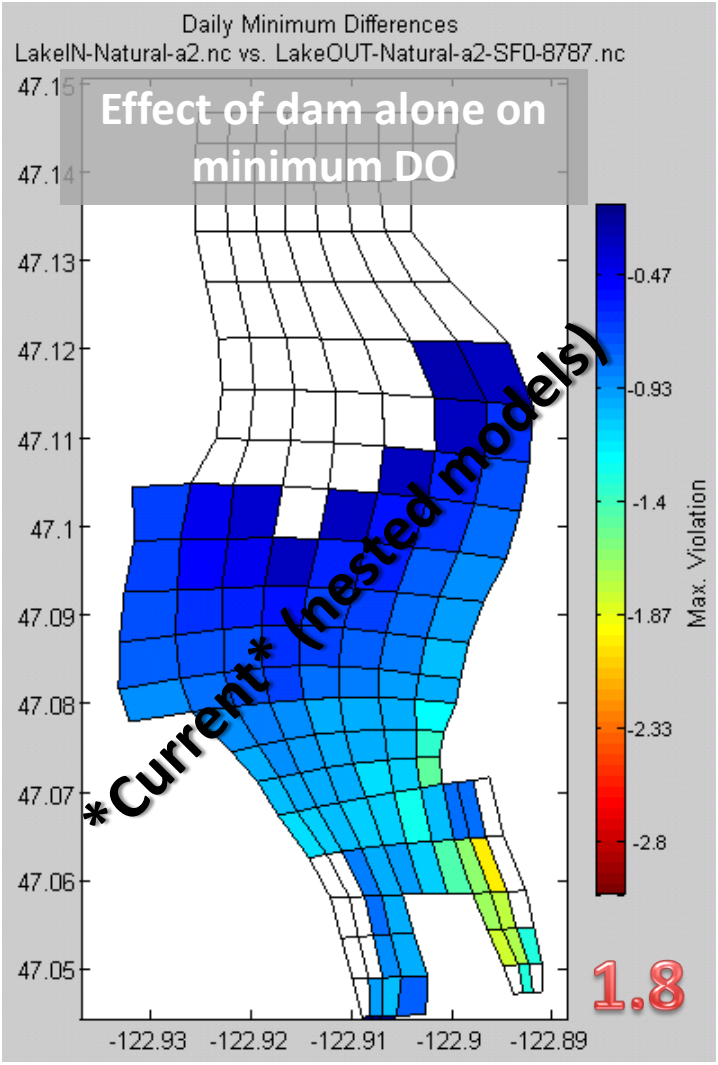
1A. Capitol Lake dam, local point, local nonpoint, and external human sources cause Budd Inlet DO violations

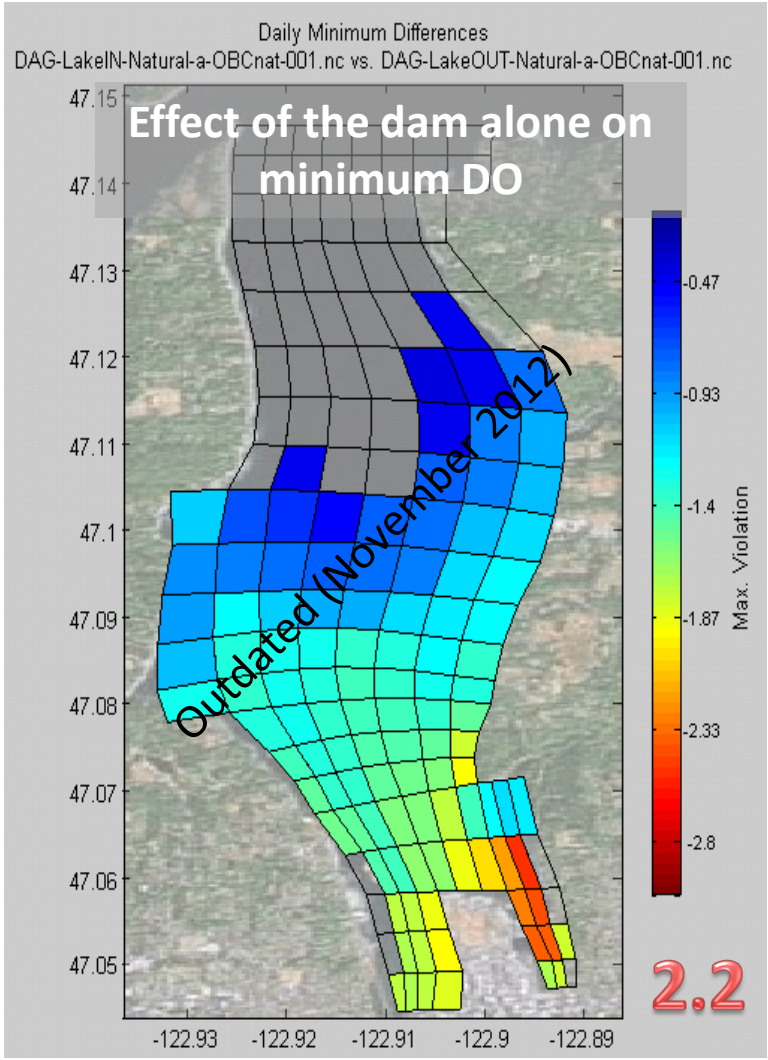




LakeIN_existing minus LakeOUT_Natural_a2

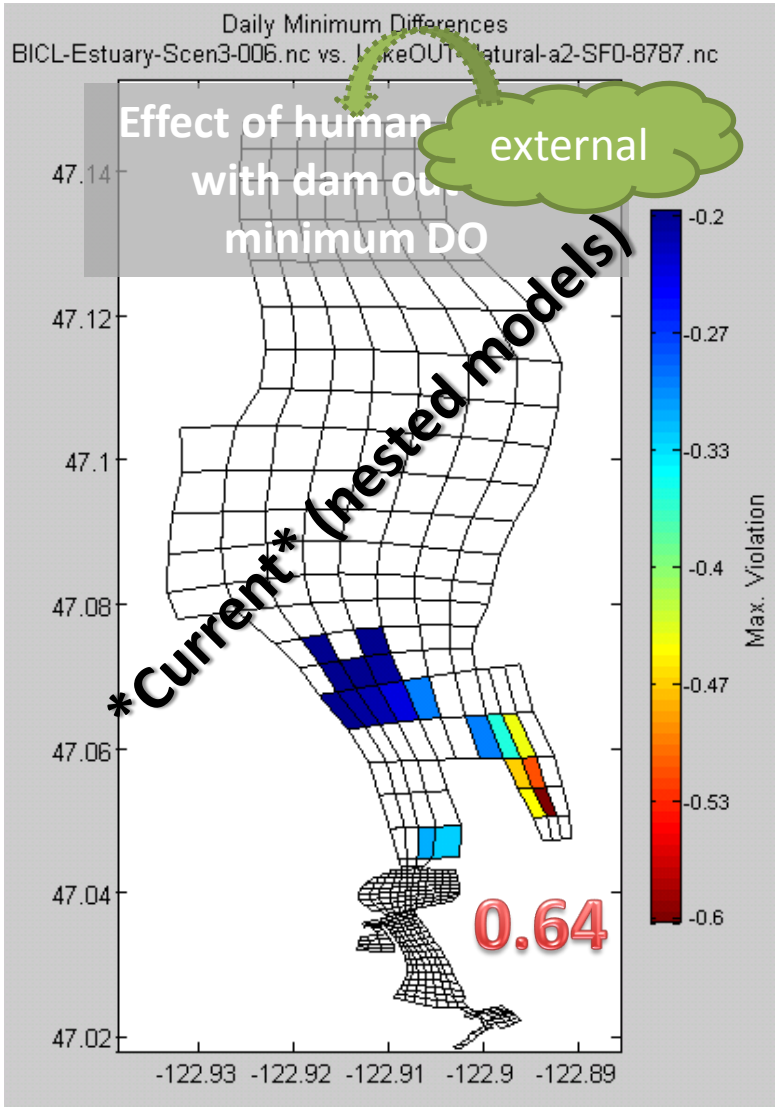
1B. Capitol Lake dam alone causes Budd Inlet DO violations

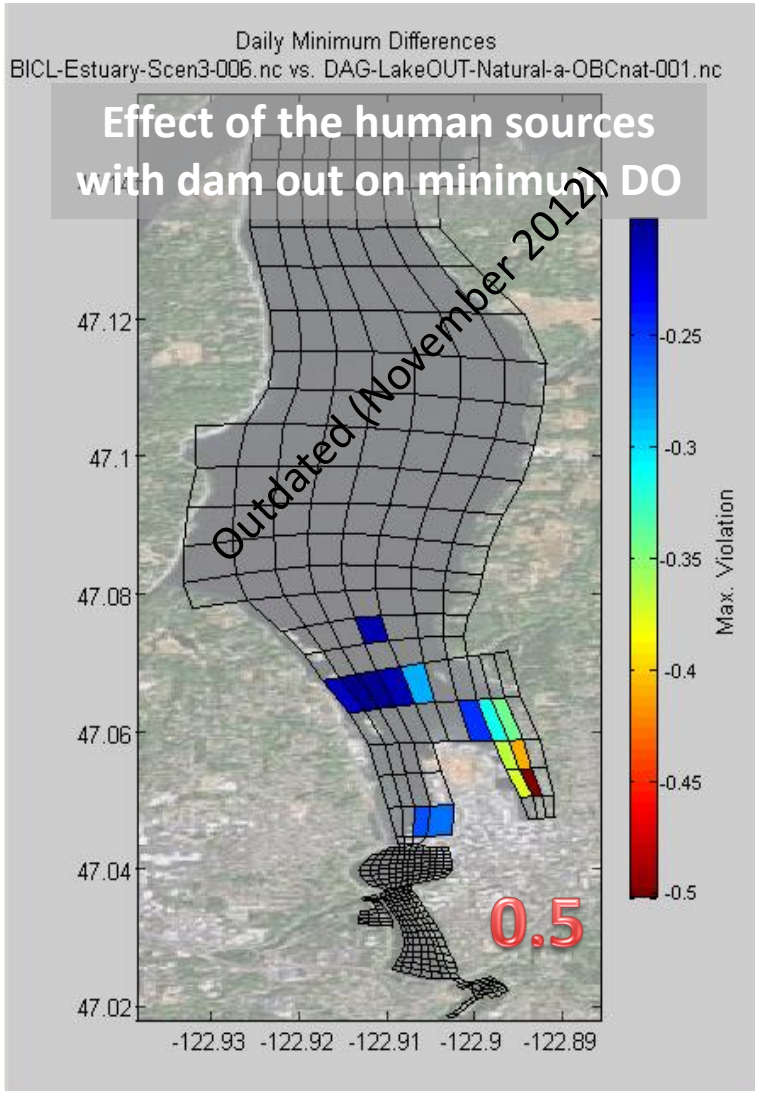




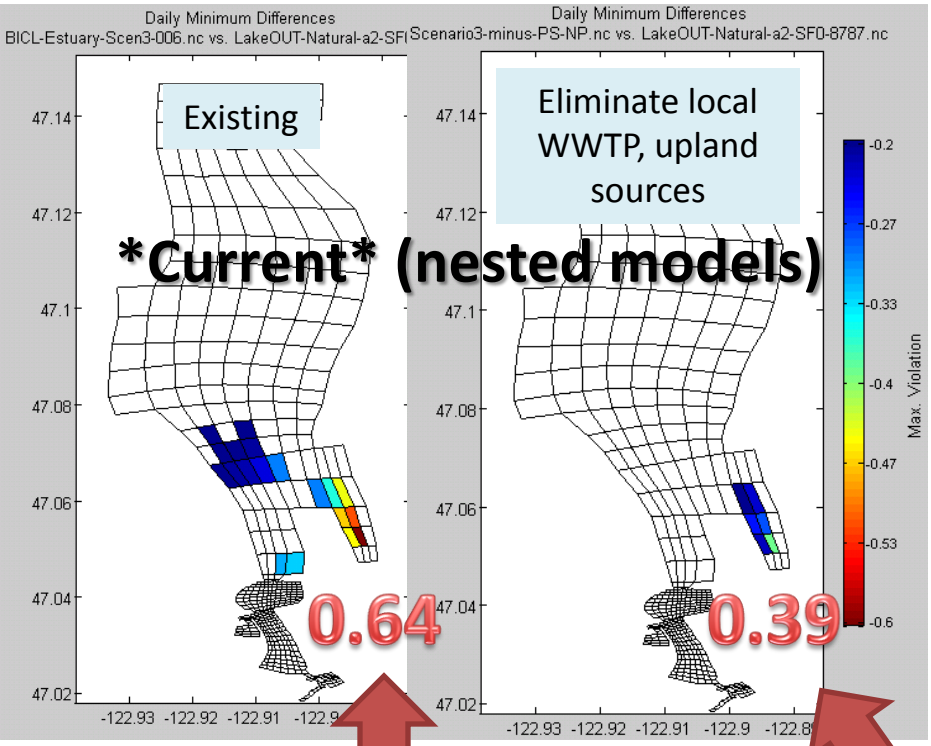
LakeIN_Natural minus LakeOUT_Natural

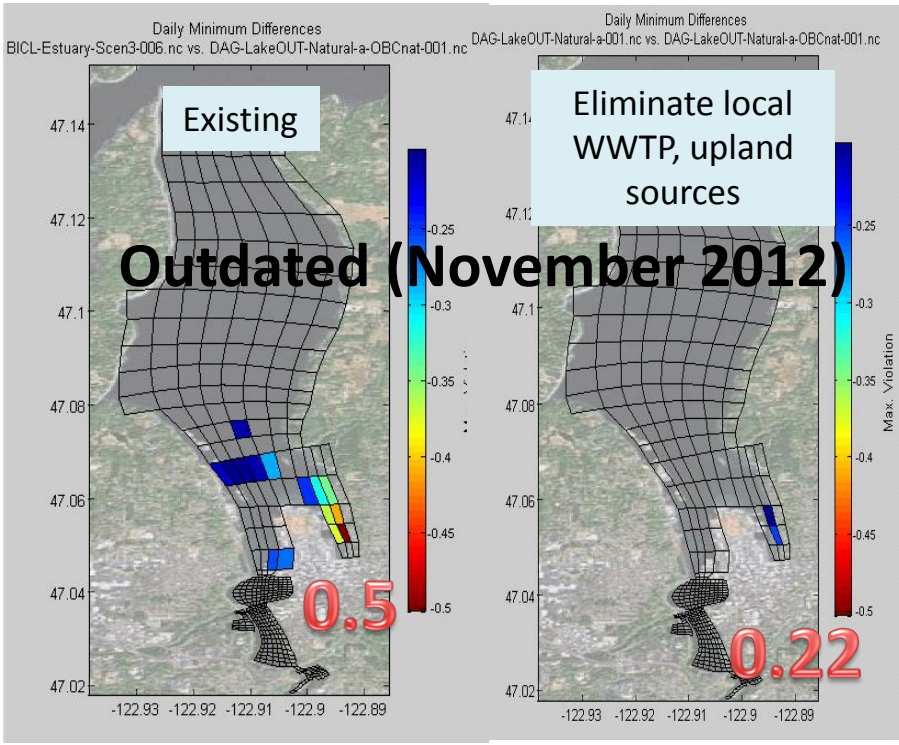
1C. Local point, local nonpoint, and external human sources cause Budd Inlet DO violations





1D. External human sources violate DO standards – Controlling local human sources would improve DO





Combined effect of external anthropogenic sources *plus* local point and nonpoint sources

Effect of external anthropogenic sources only

1. Current Budd Inlet impact updates

- Presence of dam has largest impact on DO
  - Natural conditions for remaining scenarios = dam out to isolate the effects of changes in nutrients
- Total DO depletion increased, including at critical East Bay cell from 0.5 to 0.64 mg/L
  - DO depletion due to external human sources increased
- Similar overall patterns as presented Nov 2012
- No changes in interpretation

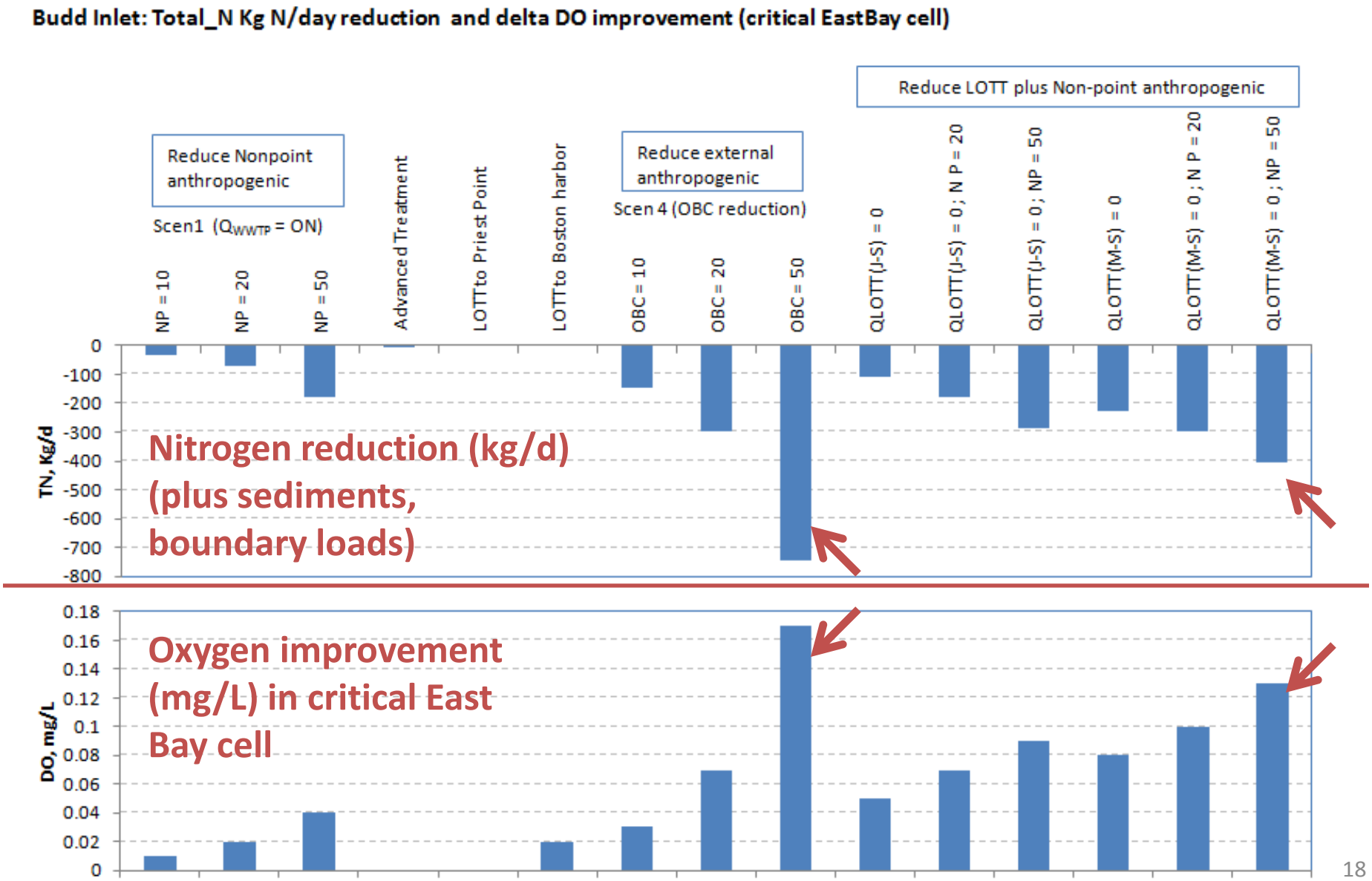
2. DAG scenarios

- Reduce local nonpoint by 10, 20, or 50%
- Add advanced treatment to three smaller wastewater treatment plants (LOTT as is)
- Shift LOTT outfall
  - To north of Priest Point Park
  - To Boston Harbor
- Reduce external sources at open boundary by 10, 20, or 50%

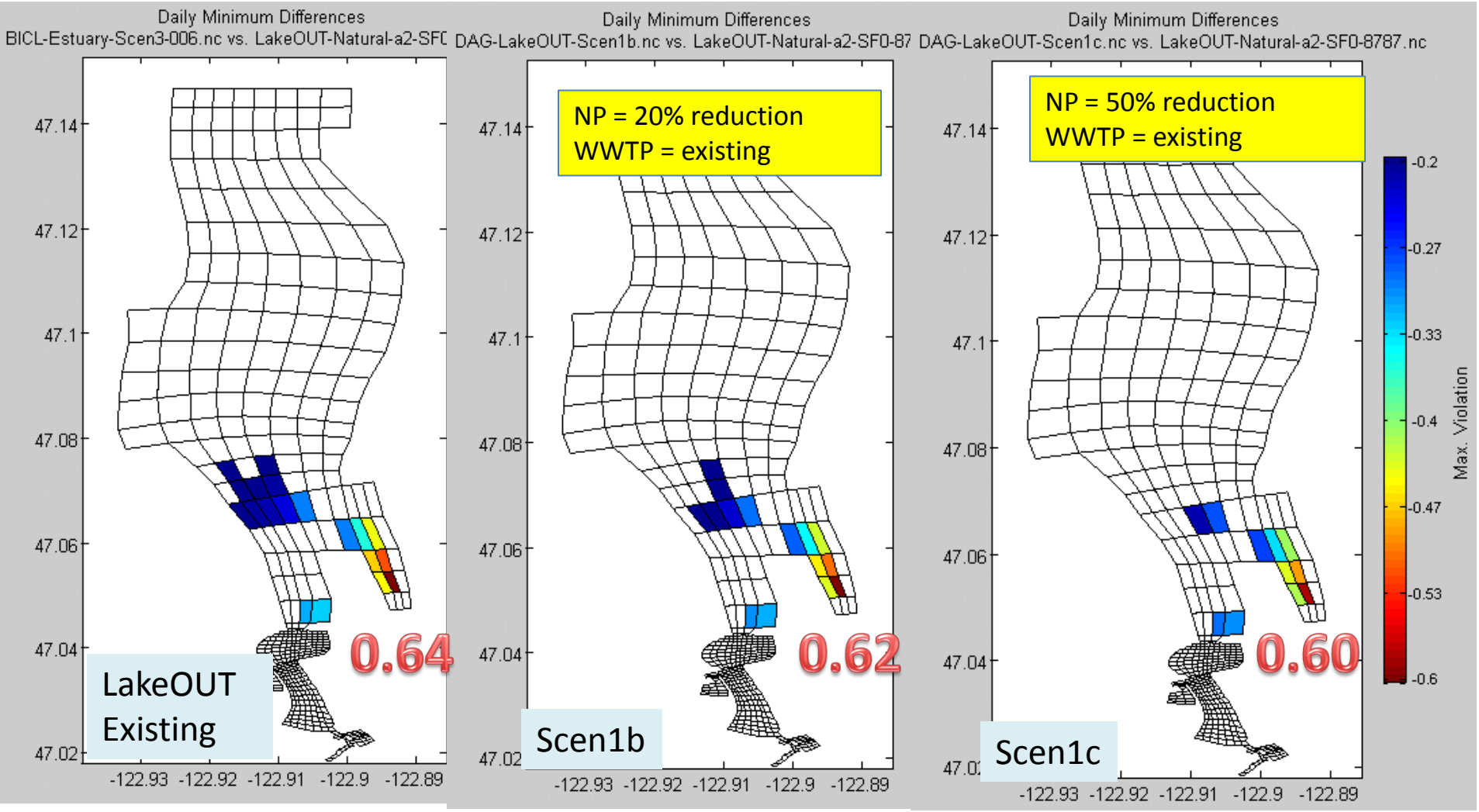
3. Additional scenarios – examples

- Exploratory
  - What range of benefits could be gained through different management actions?
  - No decision on whether these paths will be followed
- Reduce local nonpoint sources by (0, 20%) 50% <u>and</u>
  - LOTT discharges October to June only (off Jul-Sep)
  - LOTT discharges October to February only (off Mar-Sep)

2. DAG and 3. additional scenarios for Budd



2A. Decreasing local upland sources (nonpoint) makes small improvements

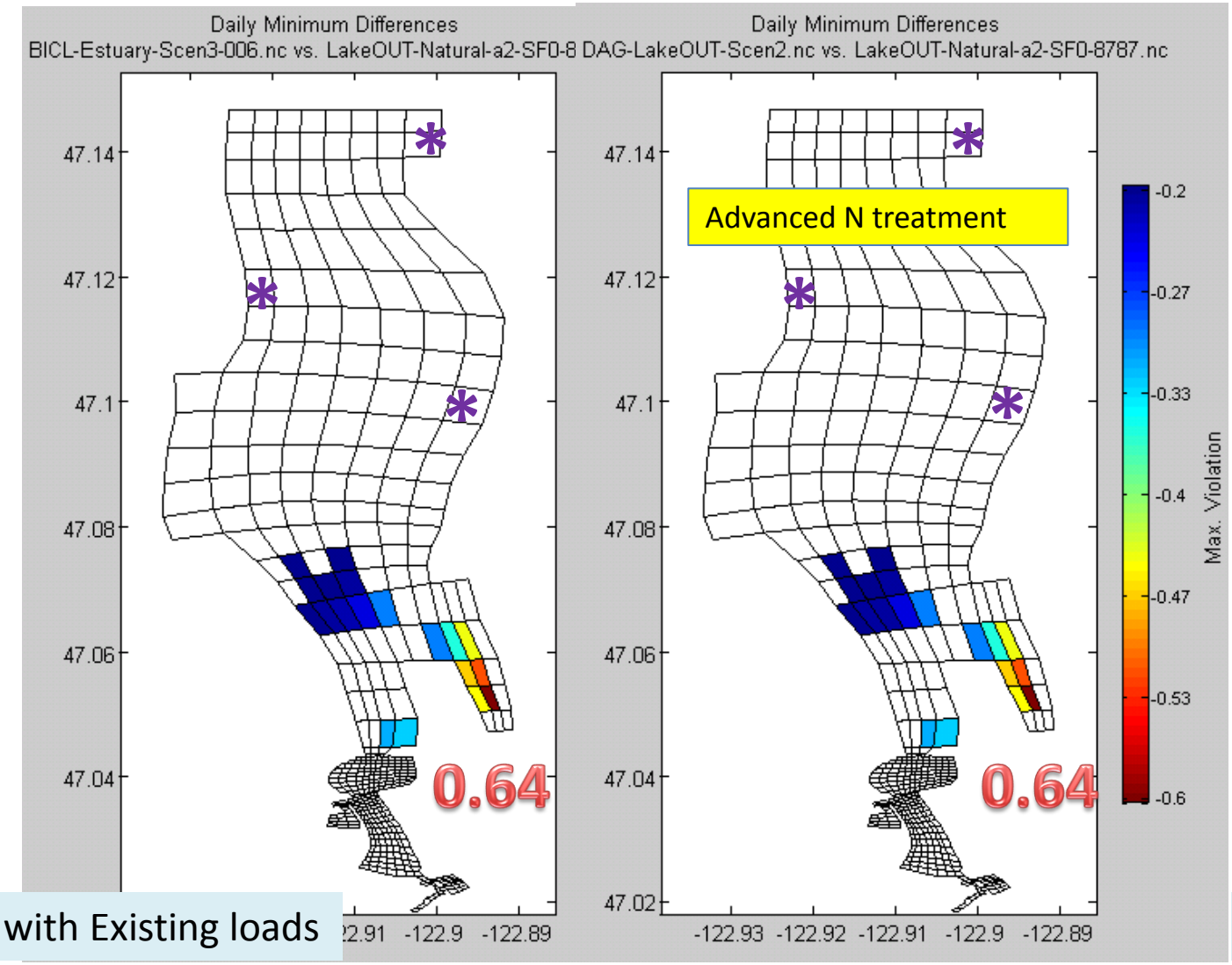


NP reduction = 59 Kg TN/d

NP reduction = 148 Kg TN/d

DO violations with anthropogenic NP reduction (% delta = exist – nat) and WWTP as is

2B. Adding advanced treatment at 3 small WWTPs does not change violations

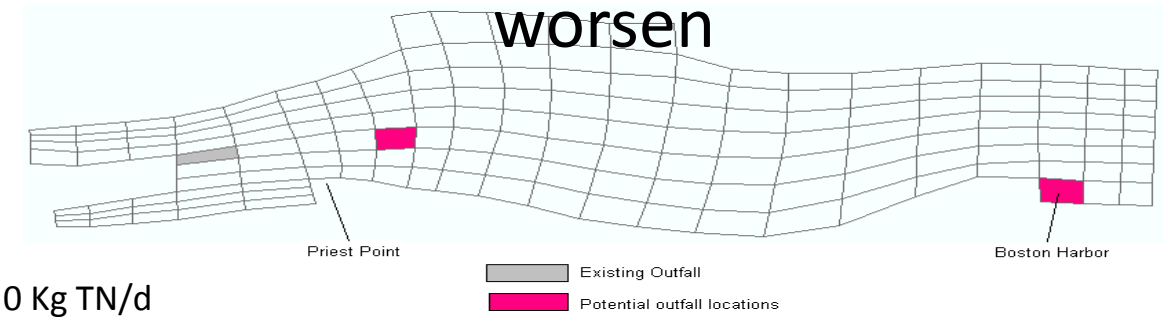


LakeOUT with Existing loads

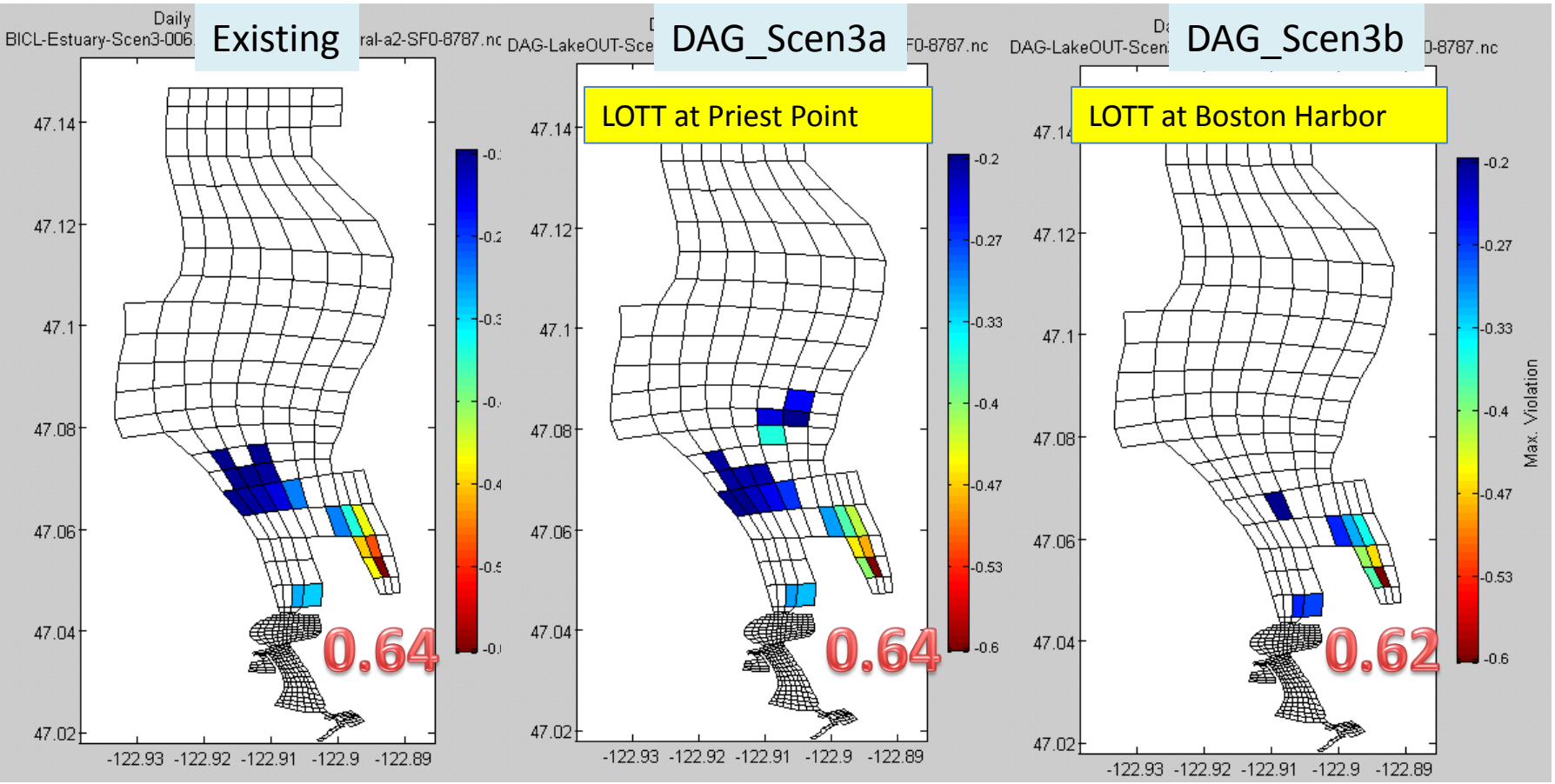
DAG_Scen2

Total TN reduction = 4 Kg TN/d

2C. Shifting LOTT outfall makes some improvements, some worsen

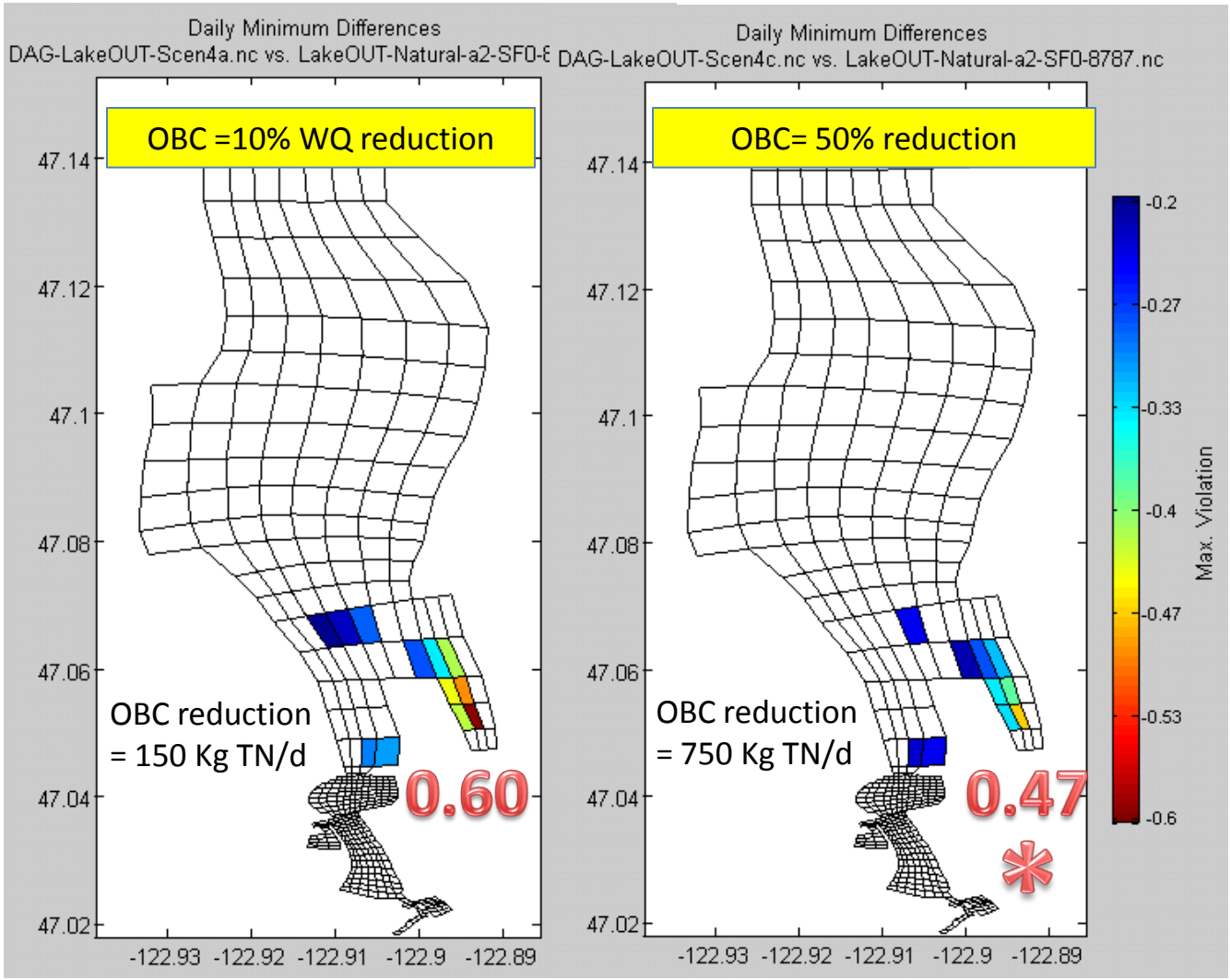


No load reduction = 0 Kg TN/d



Move LOTT outfall → North of Priest Point → Boston Harbor

2D. Eliminating 10-50% of the human sources at the open boundary decreases the DO deficit up to 0.17 mg/L



Scen4a

Scen4c

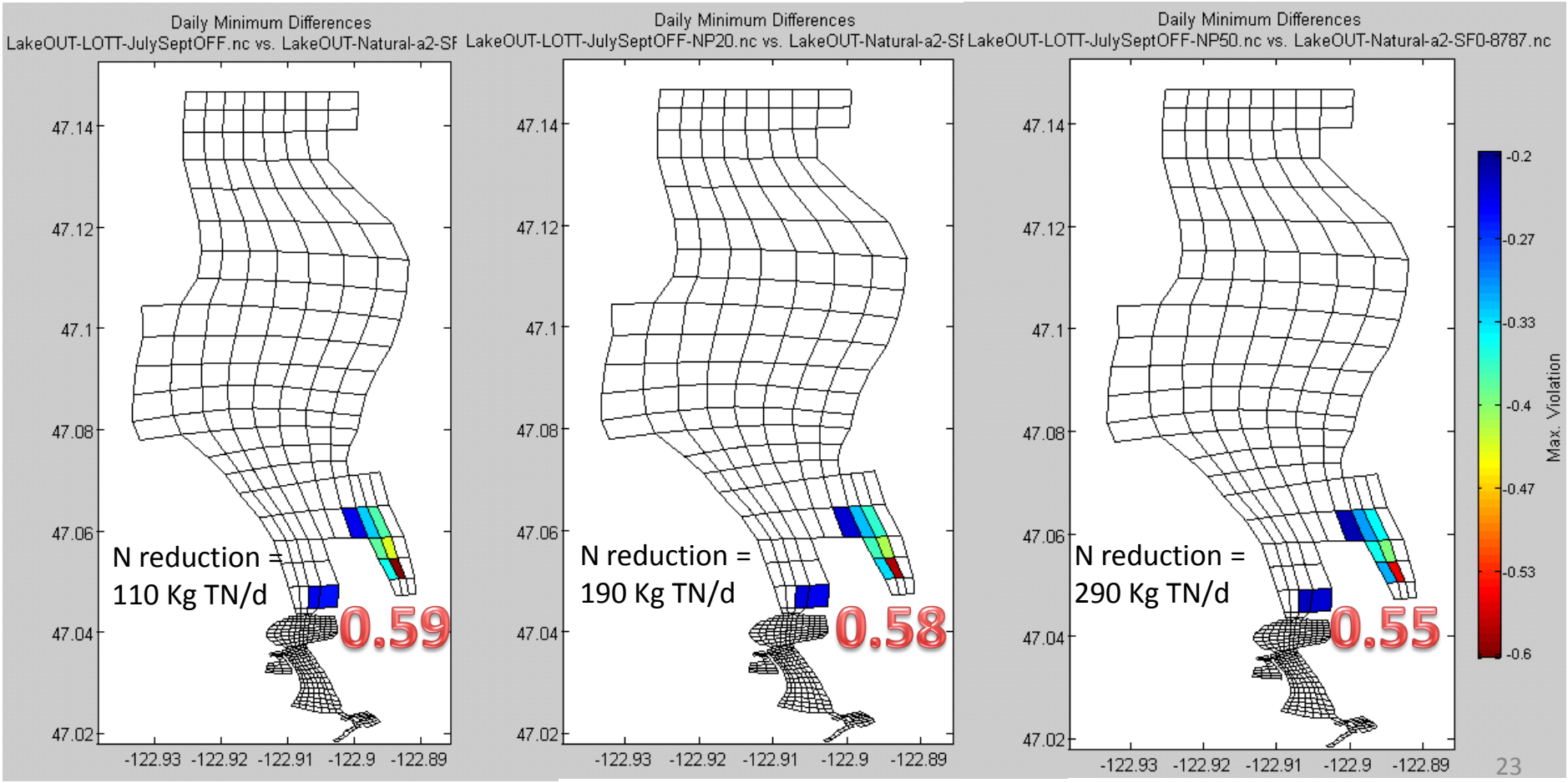
Unknown: which sources are responsible for open boundary concentrations?

3A. Decreasing local upland sources (0, 20, or 50%) and eliminating LOTT flows (Q_{LOTT} = 0) between July and September would decrease DO impact

Existing with Q_{LOTT} = 0 (July_Sept)

Existing with Q_{LOTT} = 0 (July_Sept)
NP_anthro = 20% reduction

Existing with Q_{LOTT} = 0 (July_Sept)
NP_anthro = 50% reduction

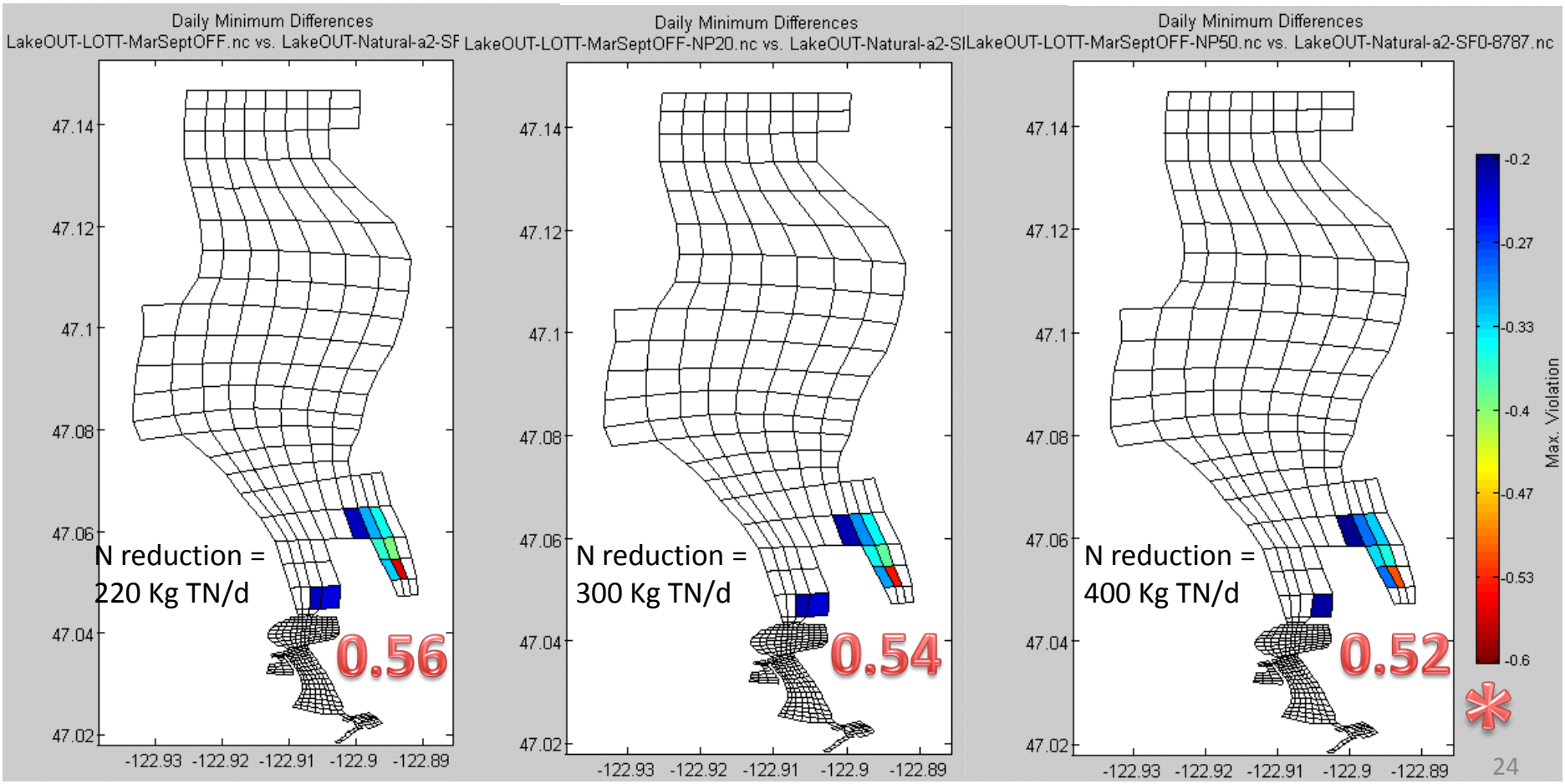


3B. Decreasing local upland sources (0, 20, or 50%) and eliminating LOTT flows (Q_{LOTT} = 0) between March and September would decrease DO impact

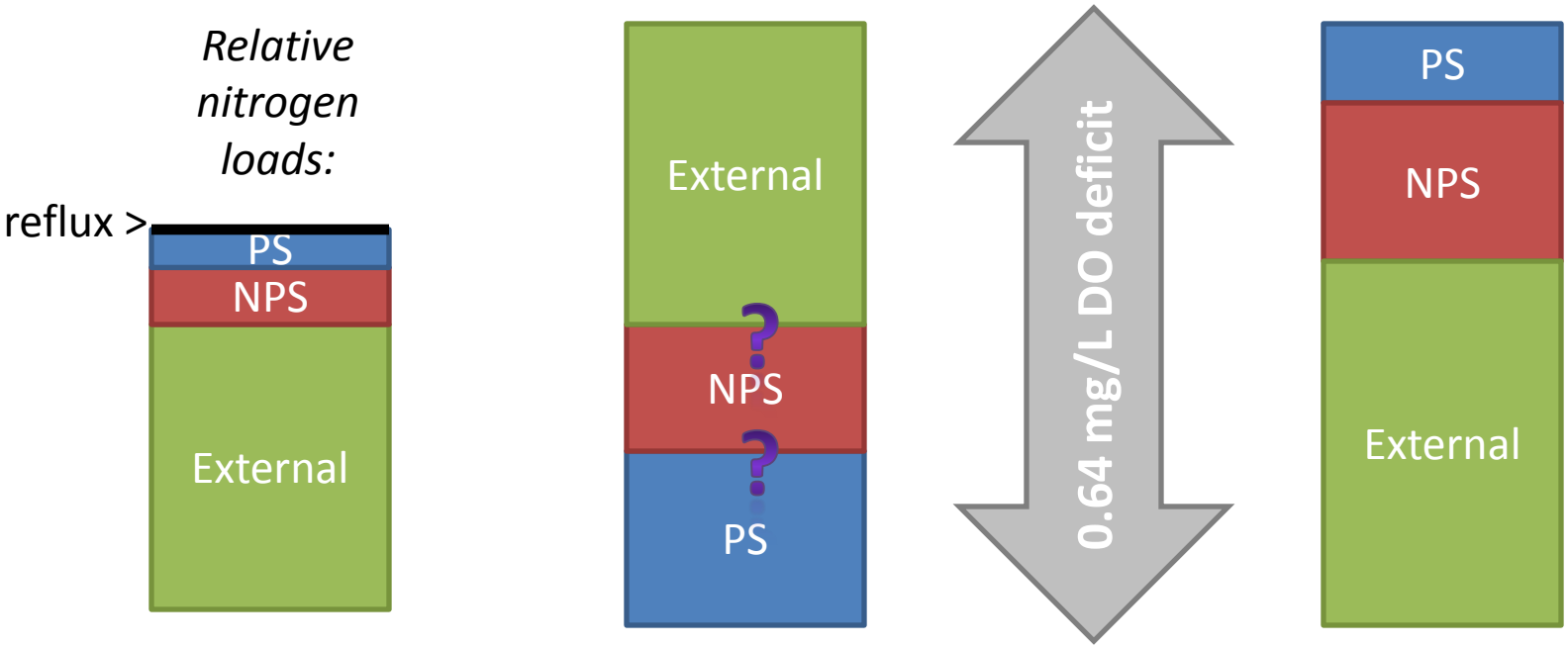
Existing with Q_{LOTT} = 0 (Mar_Sept)

Existing with Q_{LOTT} = 0 (Mar_Sept)
NP_anthro = 20% reduction

Existing with Q_{LOTT} = 0 (Mar_Sept)
NP_anthro = 50% reduction



Relative contribution of each source depends on the order of elimination

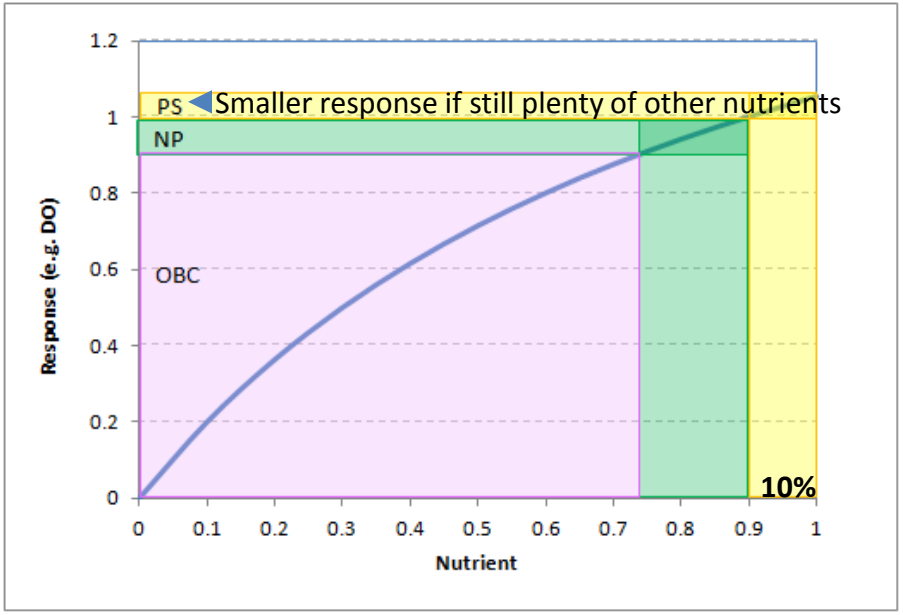


Relative contribution of each source depends on the order of elimination. Effects not linear.

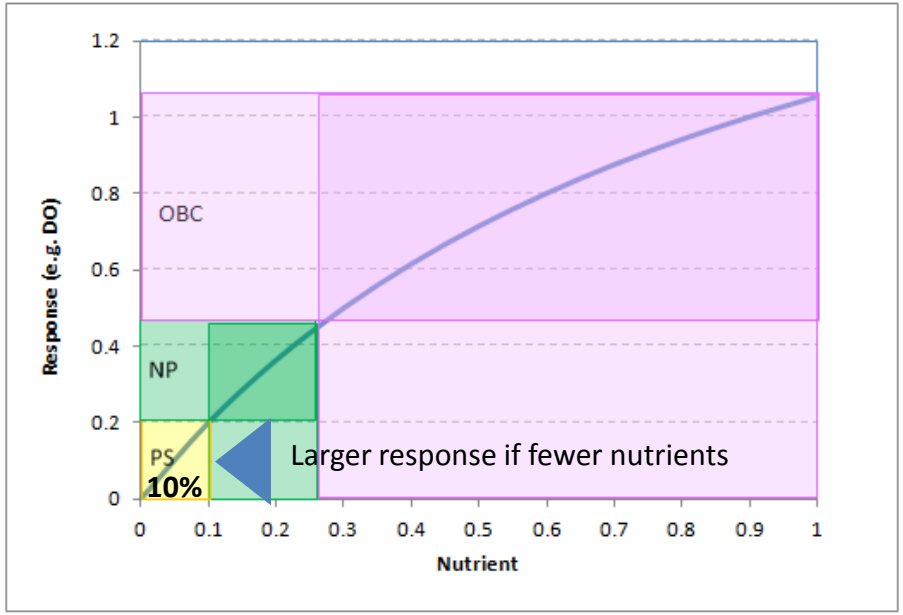
<u>New information</u>: linear is an ok first approximation, but the combined effects of multiple management actions must be verified with the model.

Nonlinear response to nutrient reduction

Reduce → 1. PS, then NP then OBC



Reduce → OBC, then NP then 3. PS



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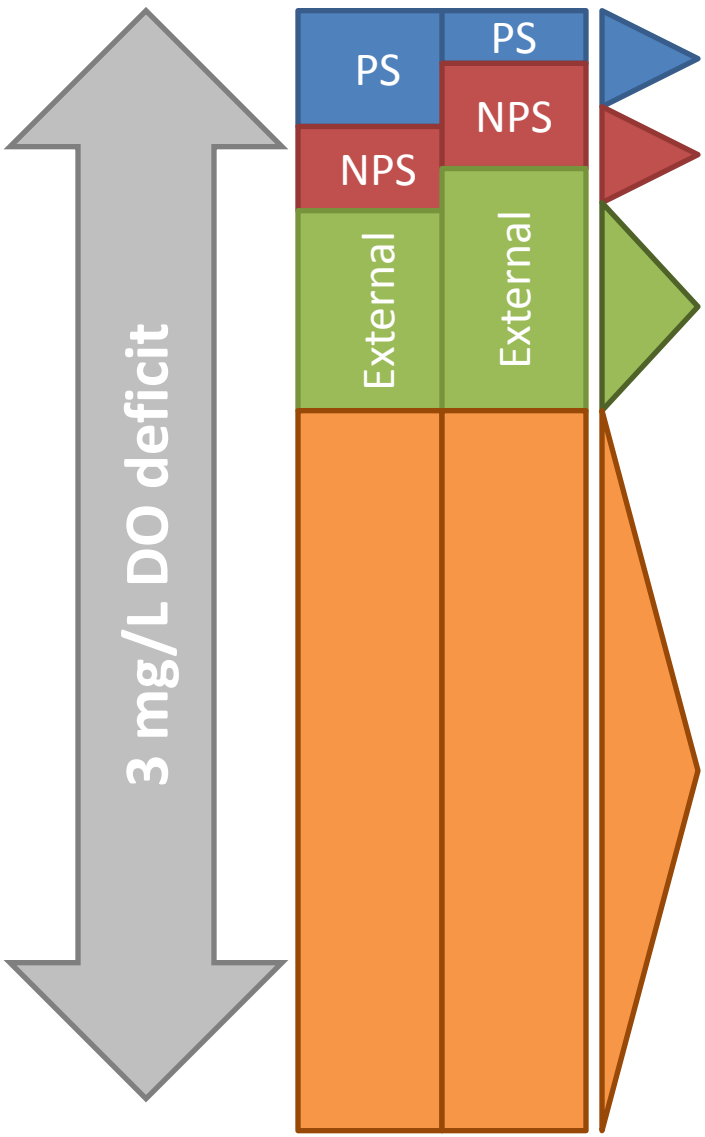
1. Budd Inlet model results for critical cell in East Bay – DO deficits from existing sources



~0.1 to 0.2 mg/L DO deficit from local Budd Inlet point sources

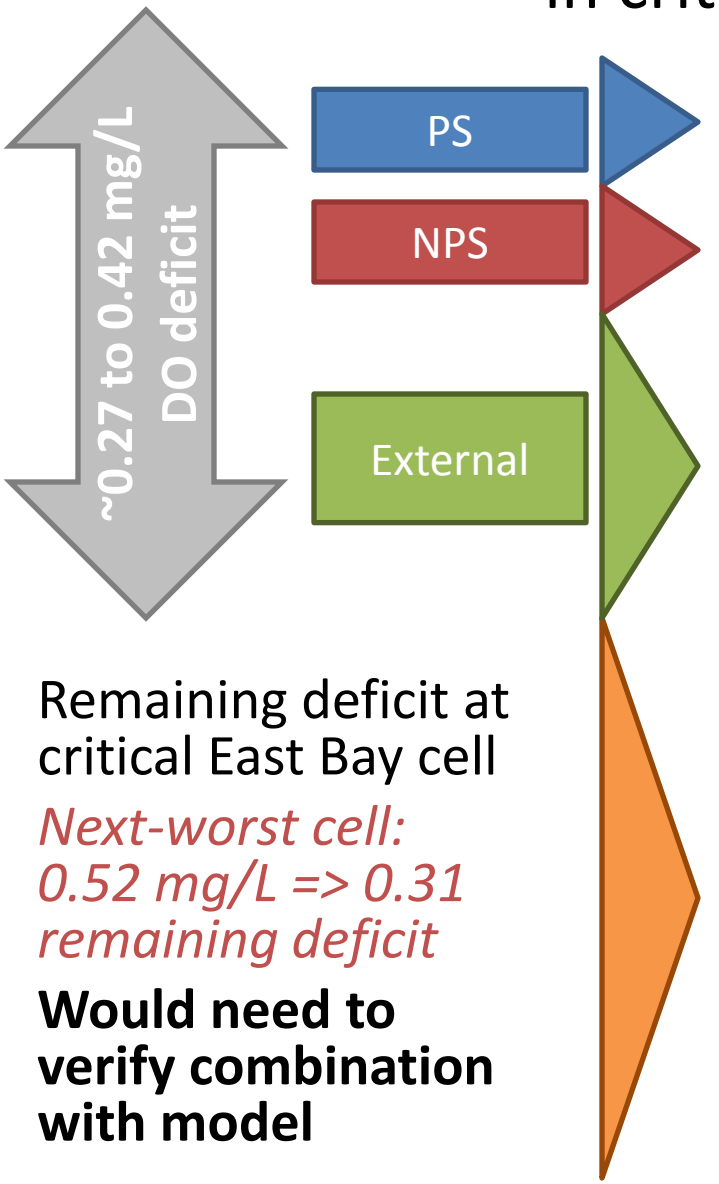
~0.1 to 0.2 mg/L DO deficit from local Budd Inlet non point sources

~0.3 to 0.4 mg/L DO deficit from external human sources (PS/NPS?)

~2 mg/L DO deficit from Capitol Lake dam

Nonlinear response of DO to reduced nitrogen loads, so not additive. Range of effects indicated with ~ symbol. More detail later.

2 and 3. Combining two scenarios decreases DO deficit in critical East Bay cell

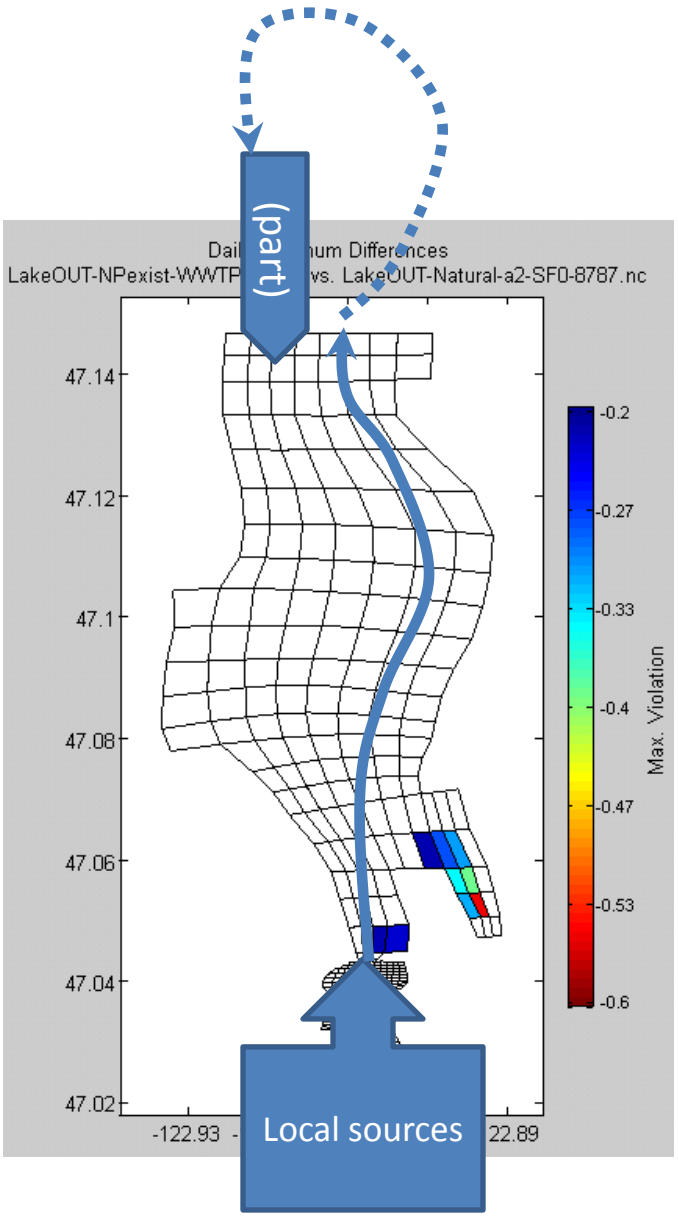


0.12 to 0.20 mg/L DO deficit from LOTT flows out (Mar-Sep) and reduce local Budd Inlet nonpoint sources 50% *

0.15 to 0.22 mg/L DO deficit from external human sources (PS/NPS?) *

0 mg/L DO deficit by removing Capitol Lake dam

- Remaining deficit at critical East Bay cell
- *Next-worst cell: 0.52 mg/L => 0.31 remaining deficit*
- **Would need to verify combination with model**

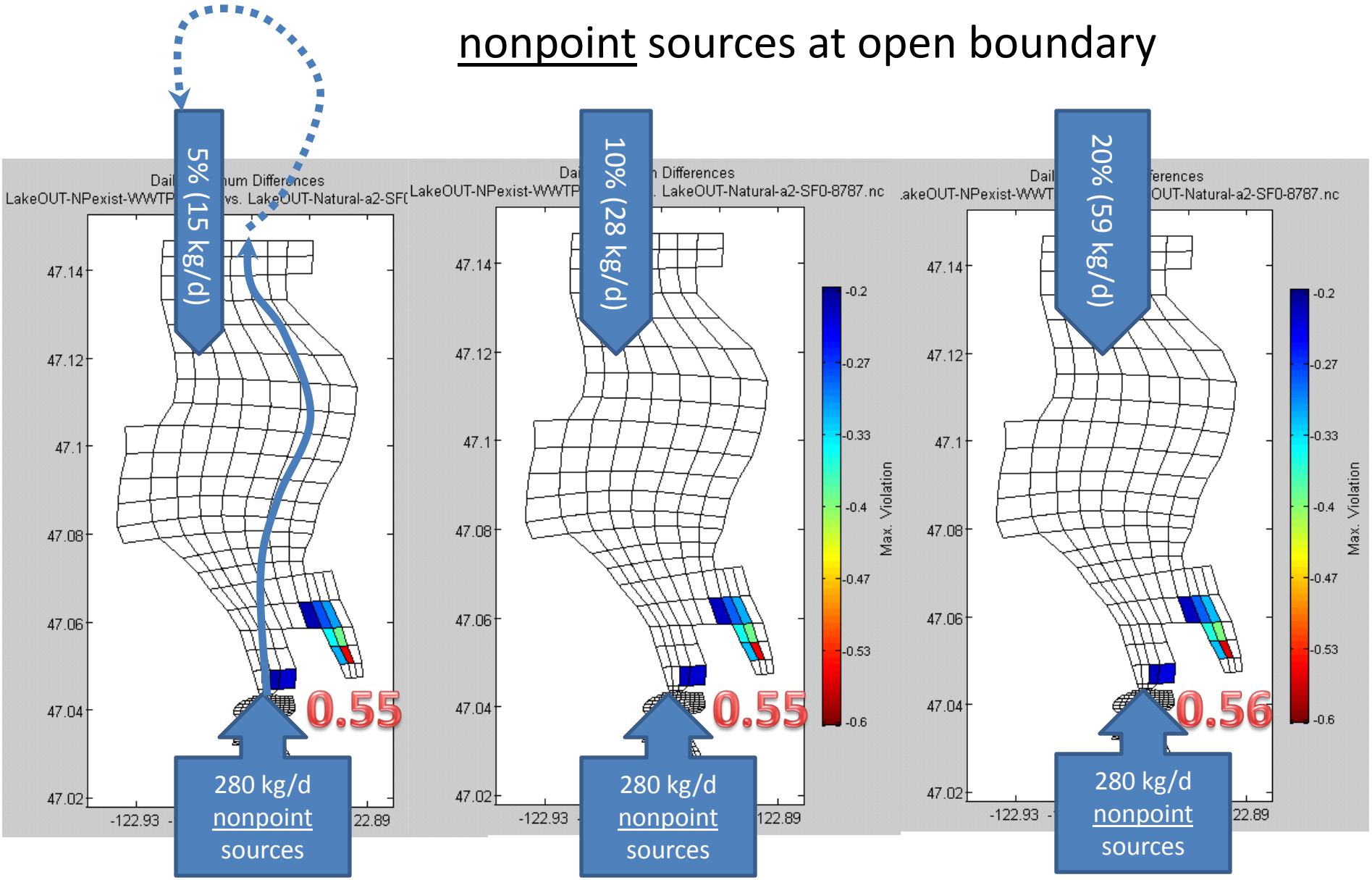


How sensitive are the results to reflux of local sources at open boundary?

Not very.

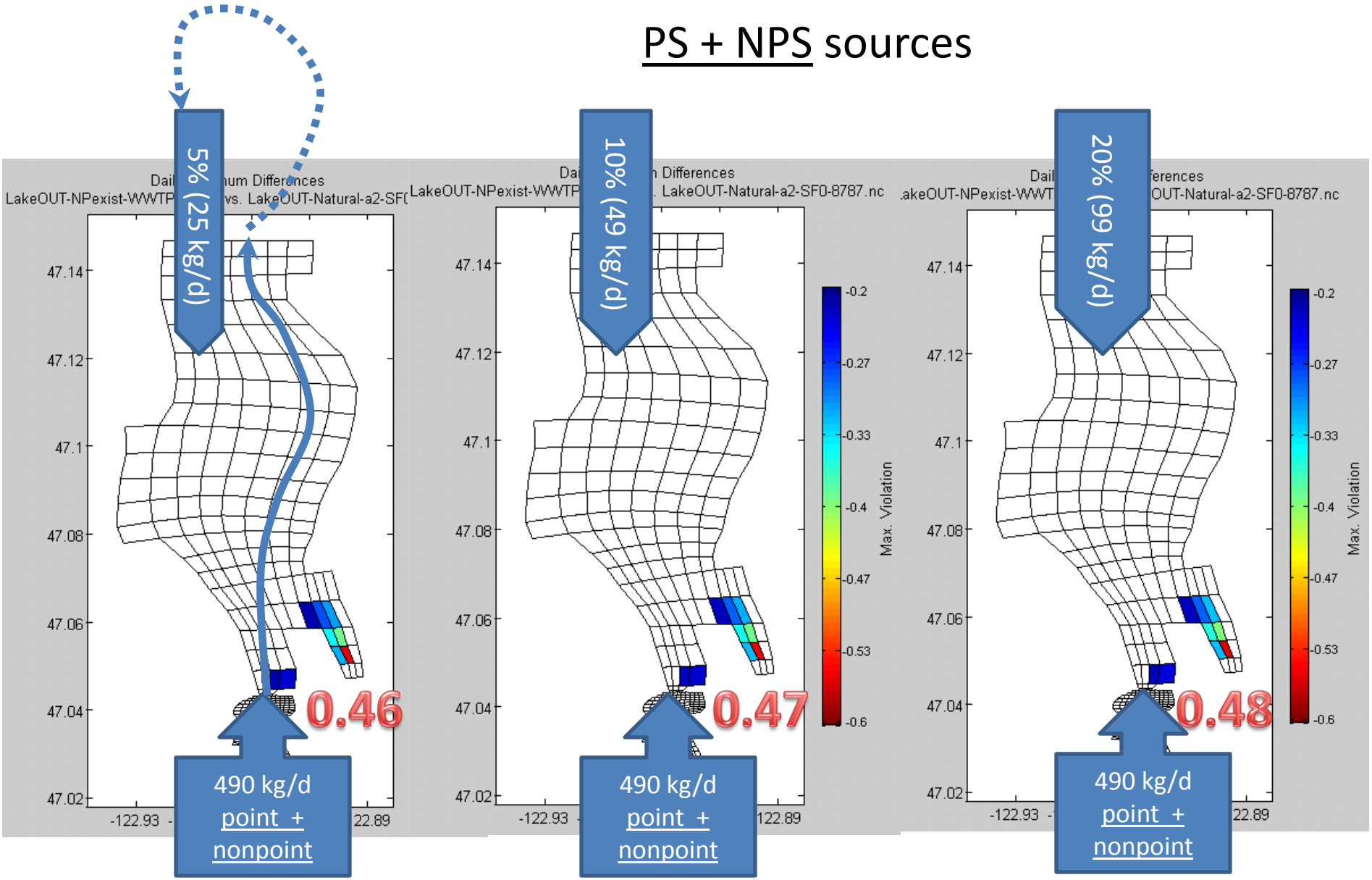
- Sensitivity analysis:
  - What if 5%, 10%, 20% of the local nutrients released to Budd Inlet came back in with a flood tide?

Budd DO deficit not sensitive to differences in reflux of <u>nonpoint</u> sources at open boundary



NP_existing (WWTP =0)_r5 NP_existing (WWTP =0)_r10 NP_existing (WWTP =0)_r20

Budd DO deficit not sensitive to differences in reflux of PS + NPS sources



NP_existing (WWTP =0)_r5

NP_existing (WWTP =0)_r10

NP_existing (WWTP =0)_r20

Budd Inlet results

- Human sources violate water quality standards in southern Budd Inlet
  - Lake > external human > PS/NPS at East Bay cell
  - Lake ~ 2 mg/L
  - Local and external point and nonpoint 0.64 mg/L
- Similar WQ benefits from:
  - Reduce external human by 50% (+0.17 mg/L)
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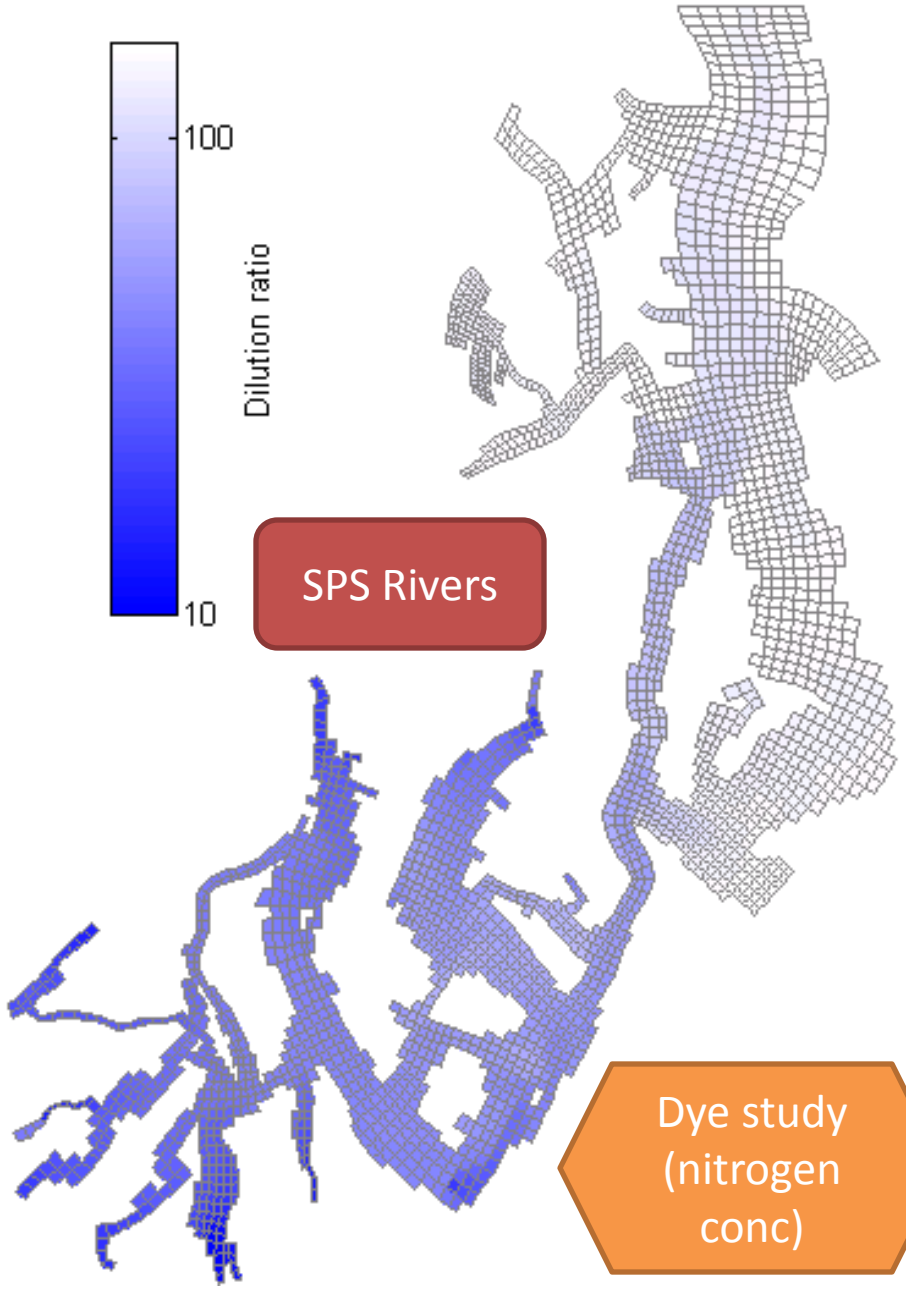
- Results not sensitive to reflux

Summary of results by scenario	Max violation in critical East Bay cell (mg/L)
Current impact of Capitol Lake dam alone	1.8
Current impact of external human sources plus local point and nonpoint sources	**0.64**
Current impact of external human sources alone (eliminate local point, nonpoint sources)	0.39
Reduce local upland (nonpoint?) by 50%	0.60 (0.04)
Add advanced treatment to 3 small plants	0.64 (0)
Shift LOTT outfall to Boston Harbor	0.62 (0.02)
Reduce external sources 50% at open bdry	0.47 (0.17)
Reduce nonpoint 50% and LOTT off Mar-Sep	0.52 (0.13)

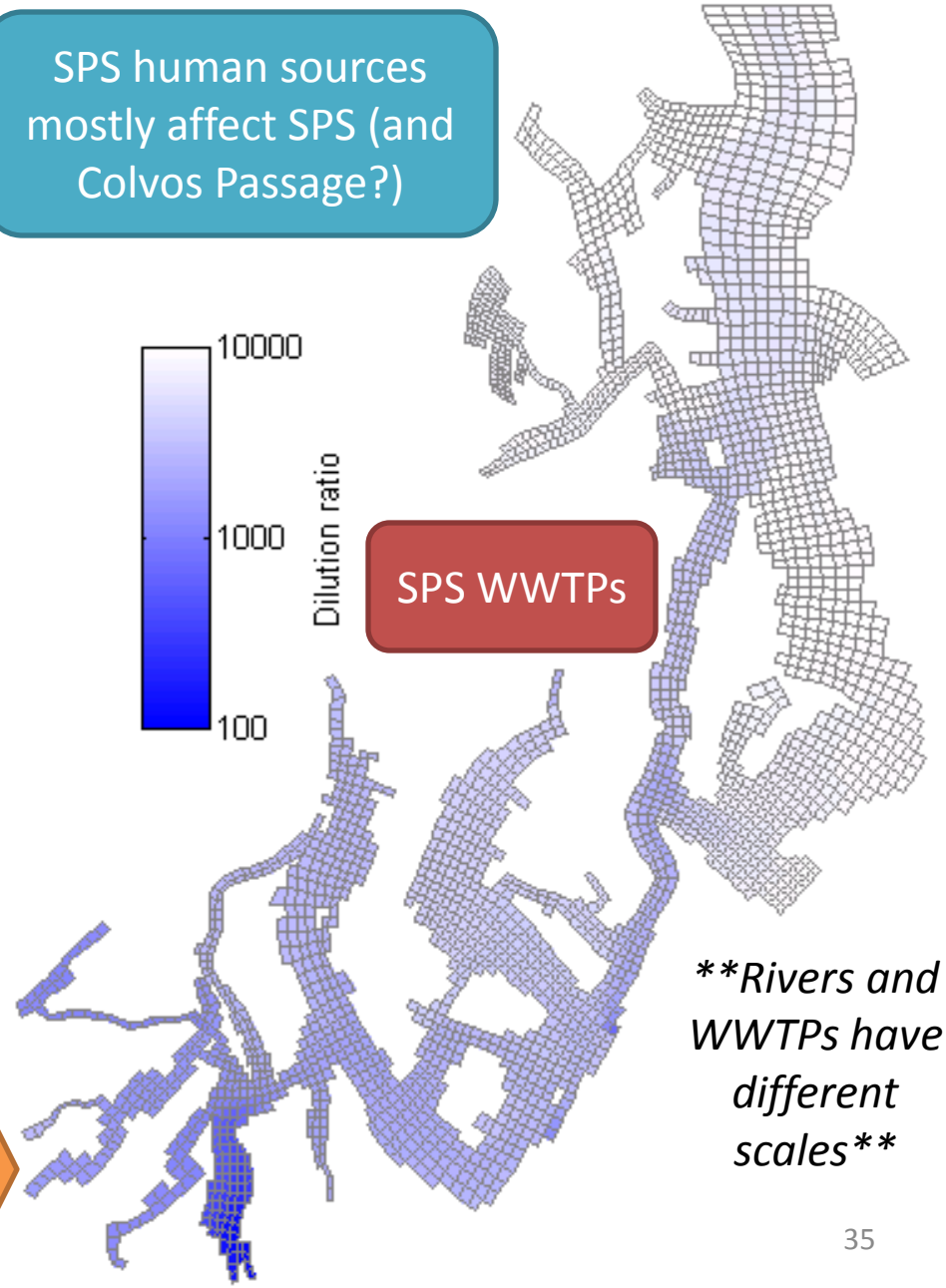
What about South Sound?

- *We're working on it…*
- October 2013 = external review draft report with water quality calibration and scenarios
- Same approach as for Budd:
  - Use larger model to get northern boundary conditions
  - Adjust sediment fluxes with scenarios

What have we learned from the circulation model?



SPS human sources mostly affect SPS (and Colvos Passage?)



Dye study (nitrogen conc)

Rivers and WWTPs have different scales

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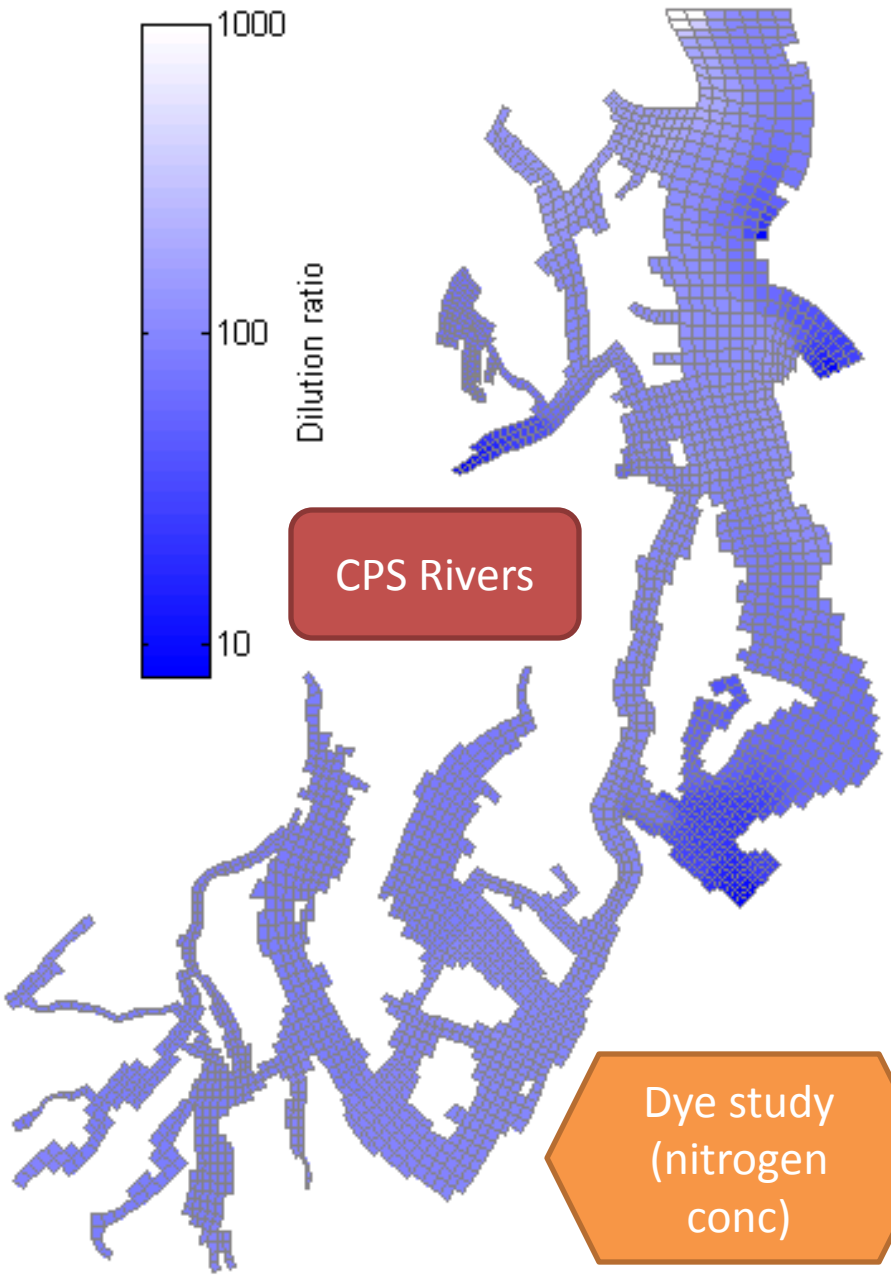
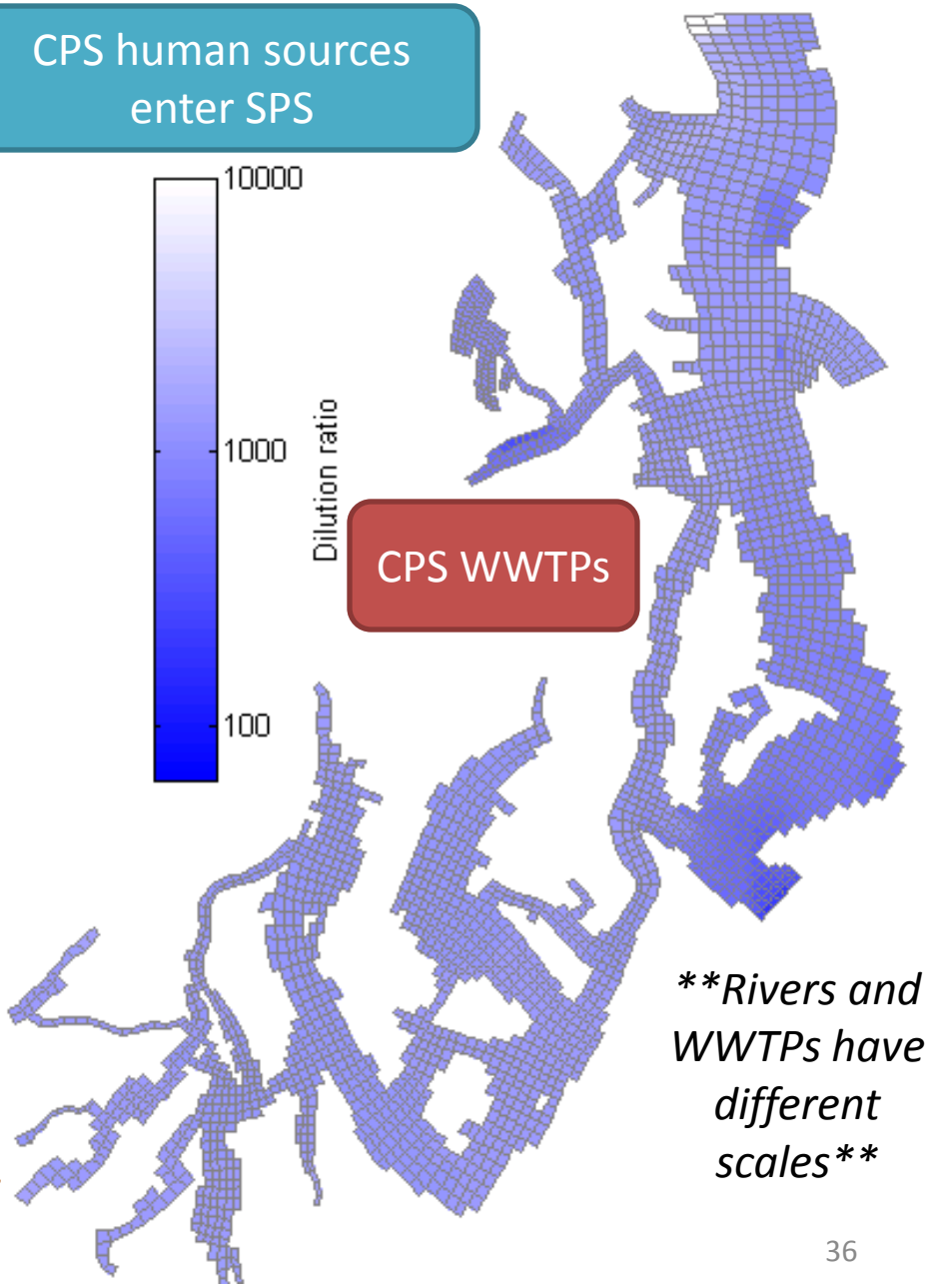


CPS Rivers

CPS human sources enter SPS



CPS WWTPs

Dye study (nitrogen conc)

Rivers and WWTPs have different scales

South Sound model runs – Phase 1 scenarios

#	Title	South Sound		Central Sound	
		PS	Upland	PS	Upland
1	Natural conditions	Off	Natural	Off	Natural
2	Current point and upland sources	On	Natural + human	On	Natural + human
3	No point but current upland sources	Off	Natural + human	Off	Natural + human
4	No upland but current point	On	Natural	On	Natural
5	Max permitted point plus current upland	Max	Natural + human	Max	Natural + human
6	Reduce point and upland human by 25, 50, and 75%	25, 50, 75%	Natural + 25, 50, 75% human	25, 50, 75%	Natural + 25, 50, 75% human
7	Point and upland sources in South Sound; only natural in Central Sound	On	Natural + human	Off	Natural