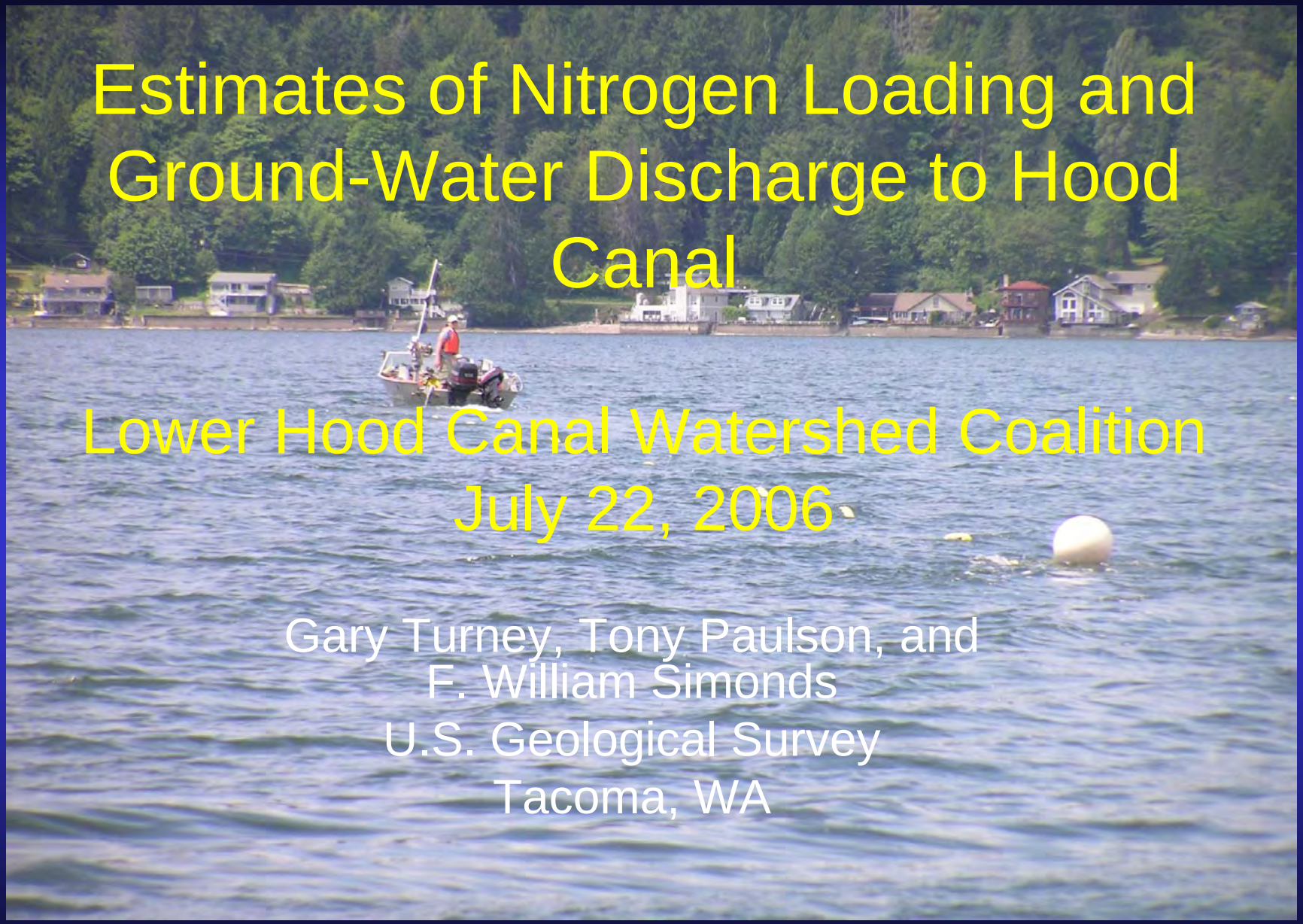

Estimates of Nitrogen Loading and Ground-Water Discharge to Hood Canal

Lower Hood Canal Watershed Coalition
July 22, 2006

Gary Turney, Tony Paulson, and
F. William Simonds
U.S. Geological Survey
Tacoma, WA

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Overall USGS Activities

1. Make initial estimates of nitrogen loading using available data and information.
2. Conduct specific studies to better quantify loading from selected sources. One of these is ground water.
3. Improve the initial load estimates using the results of the studies, and provide these data to UW as input to their model

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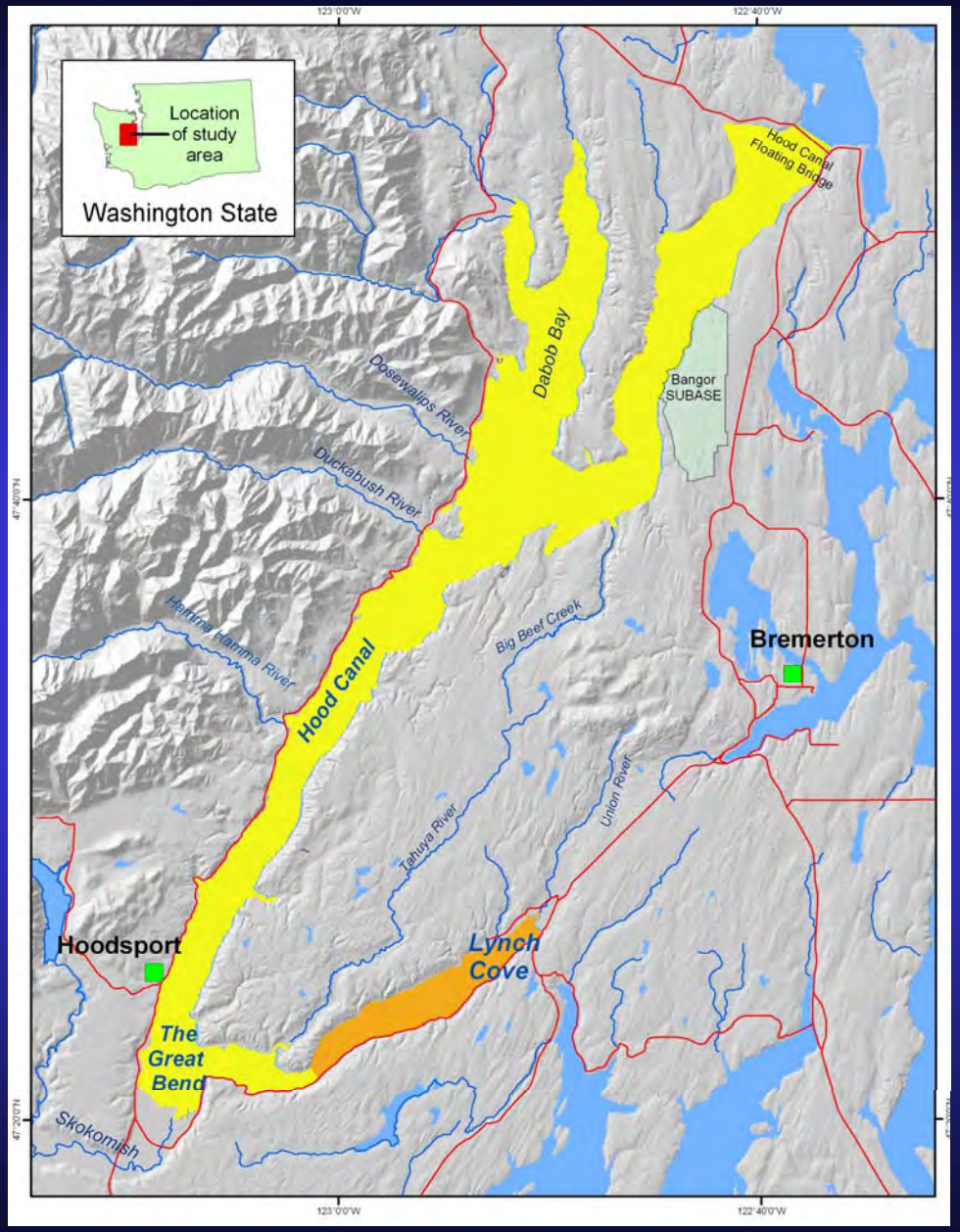
Nitrogen loading estimates were made for all of Hood Canal, and for just the Lynch Cove-Great Bend area.

Only existing data and data from the literature were used.



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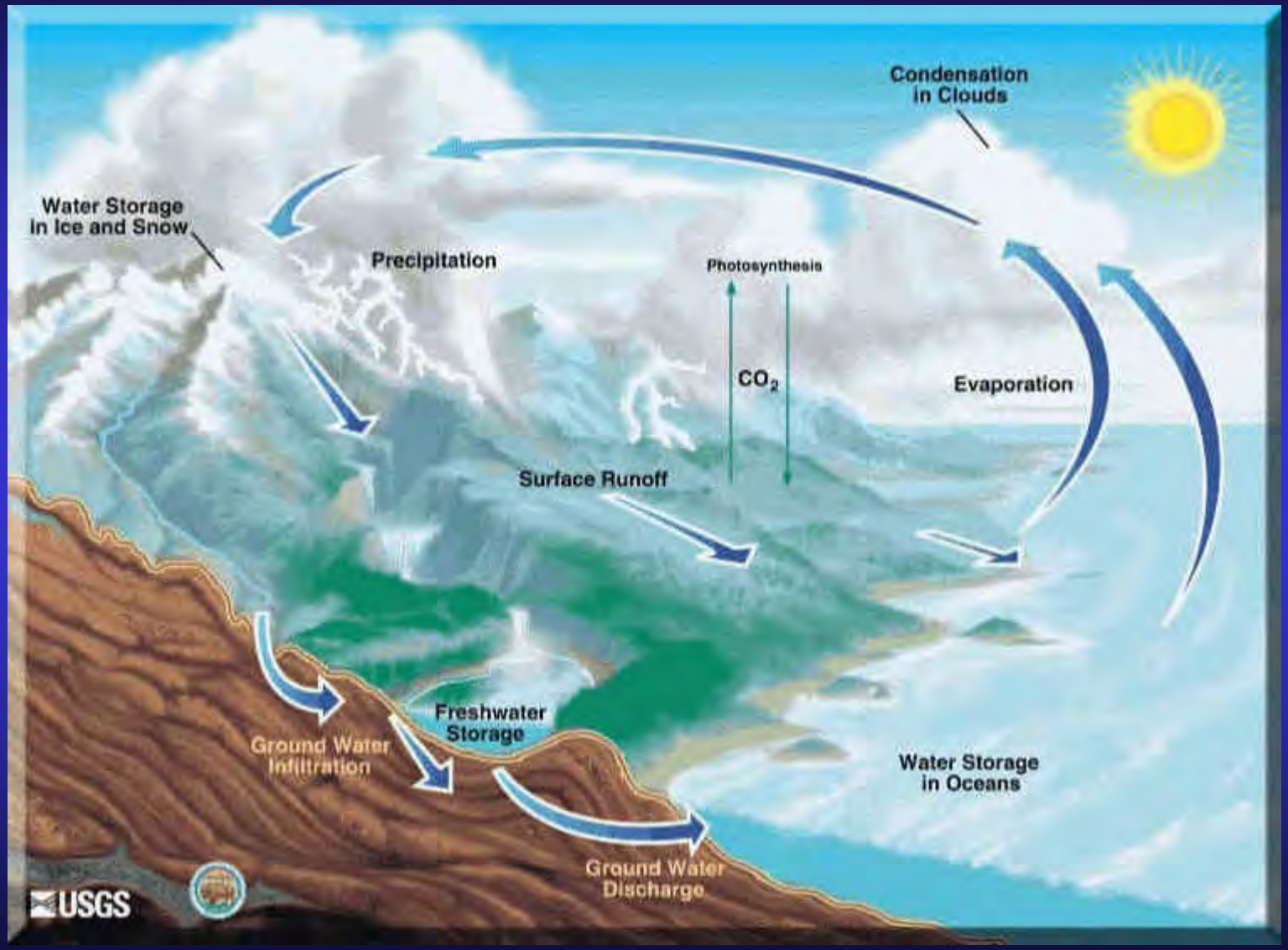
The Hydrologic Cycle



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Inputs of Nitrogen into Hood Canal from Freshwater

(metric tons per year)

1.	Surface water	493 ± 170
2.	Regional Ground Water	138 ± 77
3.	Near-Shore Septic Systems	26 ± 15
4.	Atmospheric	30 ± 11
5.	Other sources	1
	Total	688 ± 273 (415 to 961)

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Estimates Account for all Major Sources of Nitrogen

- Agricultural activities
- On-site sewage systems
- Storm water runoff
- Lawn fertilizer
- Changes in forestry (alder vs. conifer)
- Etc.

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Comparison with PSAT Estimates of Nitrogen Loading to Hood Canal
(metric tons per year)

USGS estimate - 415 to 961

PSAT estimate - Human sewage, agriculture manure, storm water runoff, and forestry - 64 to 280

Atmospheric loading to land - 192 to 351

Adjusted PSAT estimate - 256 to 631

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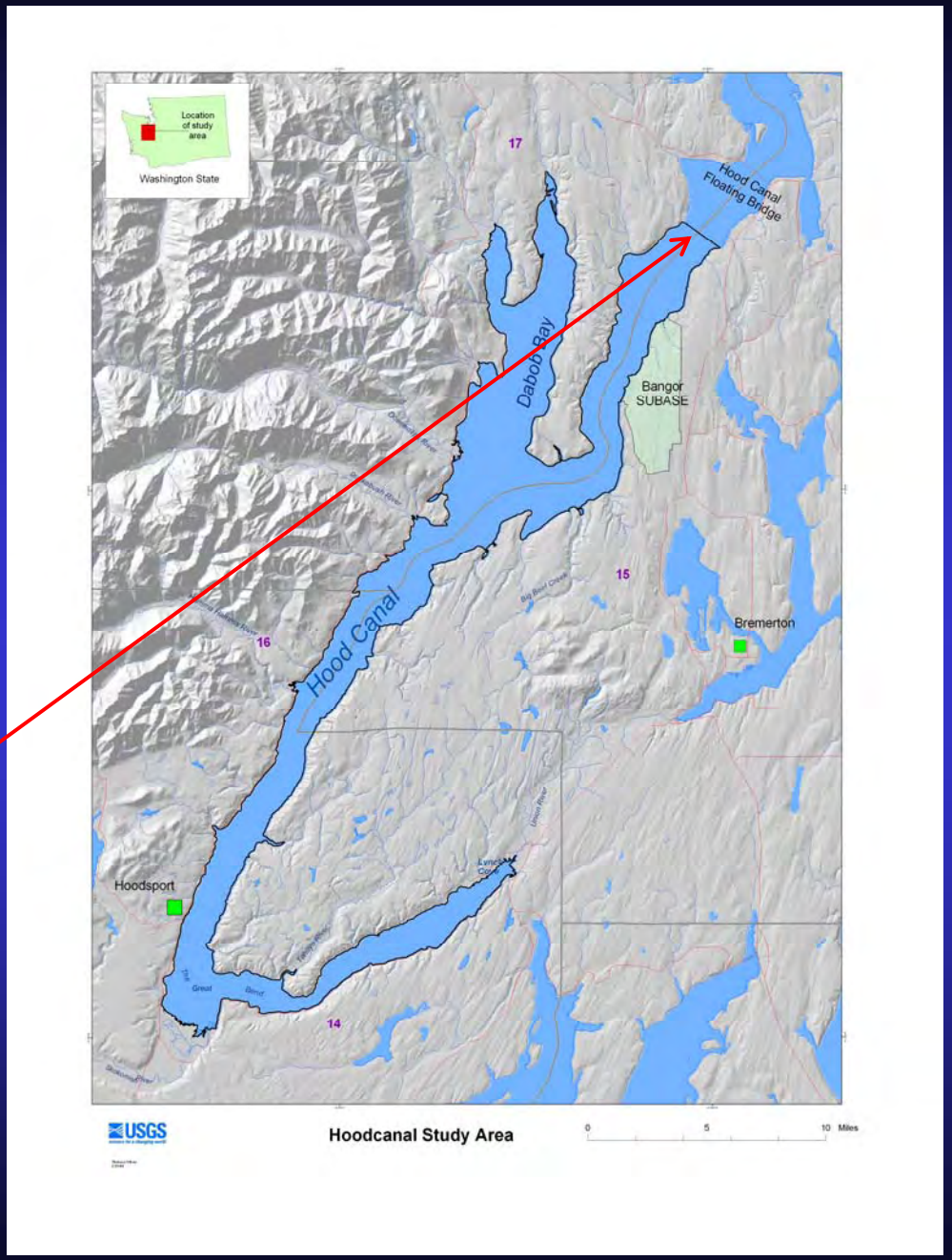
But marine water is also a source of nitrogen.

The boundary for the calculation of marine inputs of nitrogen is near the South Point-Lofall sill.



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Inputs of Nitrogen into Hood Canal from Marine Water

(metric tons per year)

Marine inputs	8,700 - 32,000
Total freshwater inputs	415 - 961

However, what's important is how this nitrogen moves through Hood Canal!

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Inputs of Nitrogen into Lynch Cove

(metric tons N per month, measured during September and October 2004)

1.	Surface water	0.9 ± 0.3
2.	Regional Ground Water	1.7 ± 0.7
3.	Near-Shore Septic Systems	0.84 ± 0.35
4.	Atmospheric	0.14 ± 0.075
	Marine	132 ± 84

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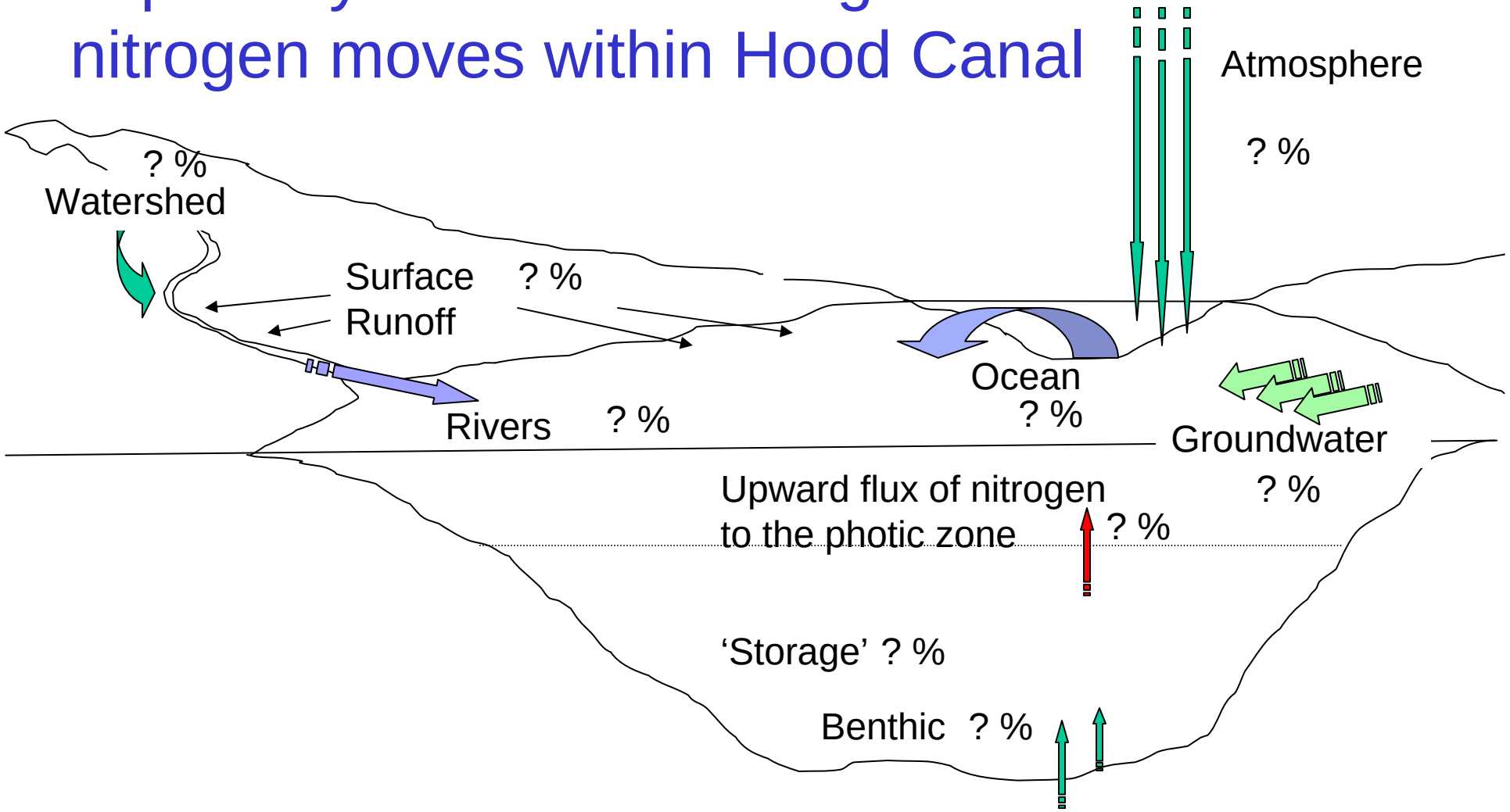
There are still many uncertainties, especially in understanding how nitrogen moves within Hood Canal



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Important Questions

- Can we further refine the estimated and measured inputs of nitrogen?
- How do these inputs vary seasonally?
- How does nitrogen move within Hood Canal, especially between the lower (marine) layer and the upper (photic) layer?
- How does nitrogen affect oxygen concentrations?

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Measuring Nitrogen Loading from Ground Water

Measuring Ground Water Discharge

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Measuring water levels:

In shallow, small diameter wells

using a manometer board

or by direct measurements

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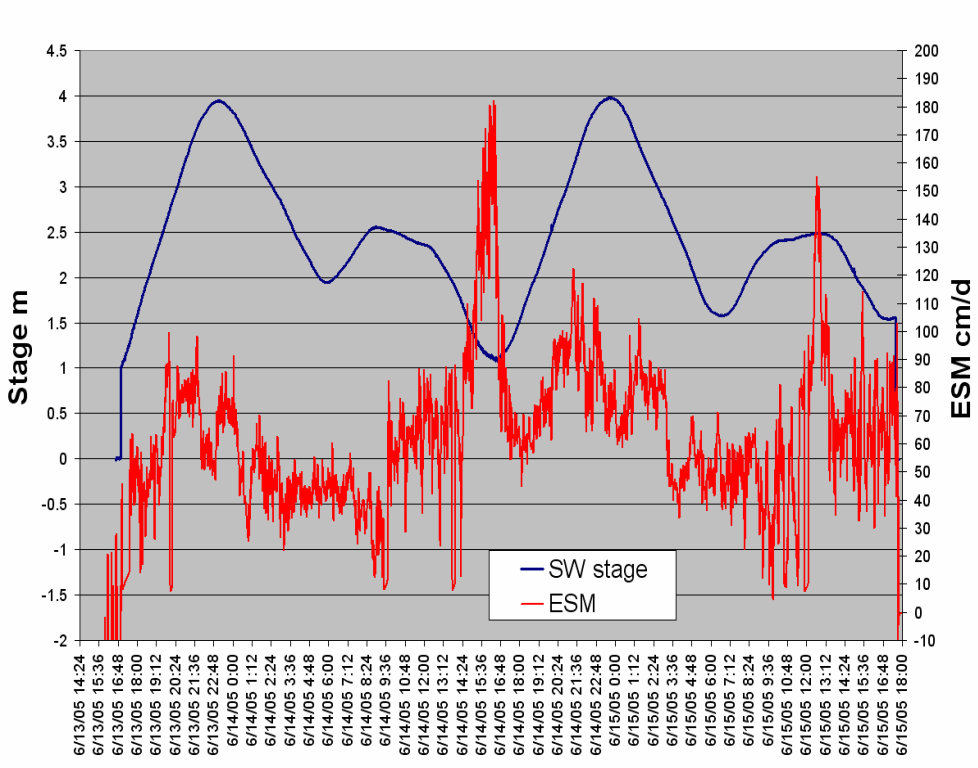
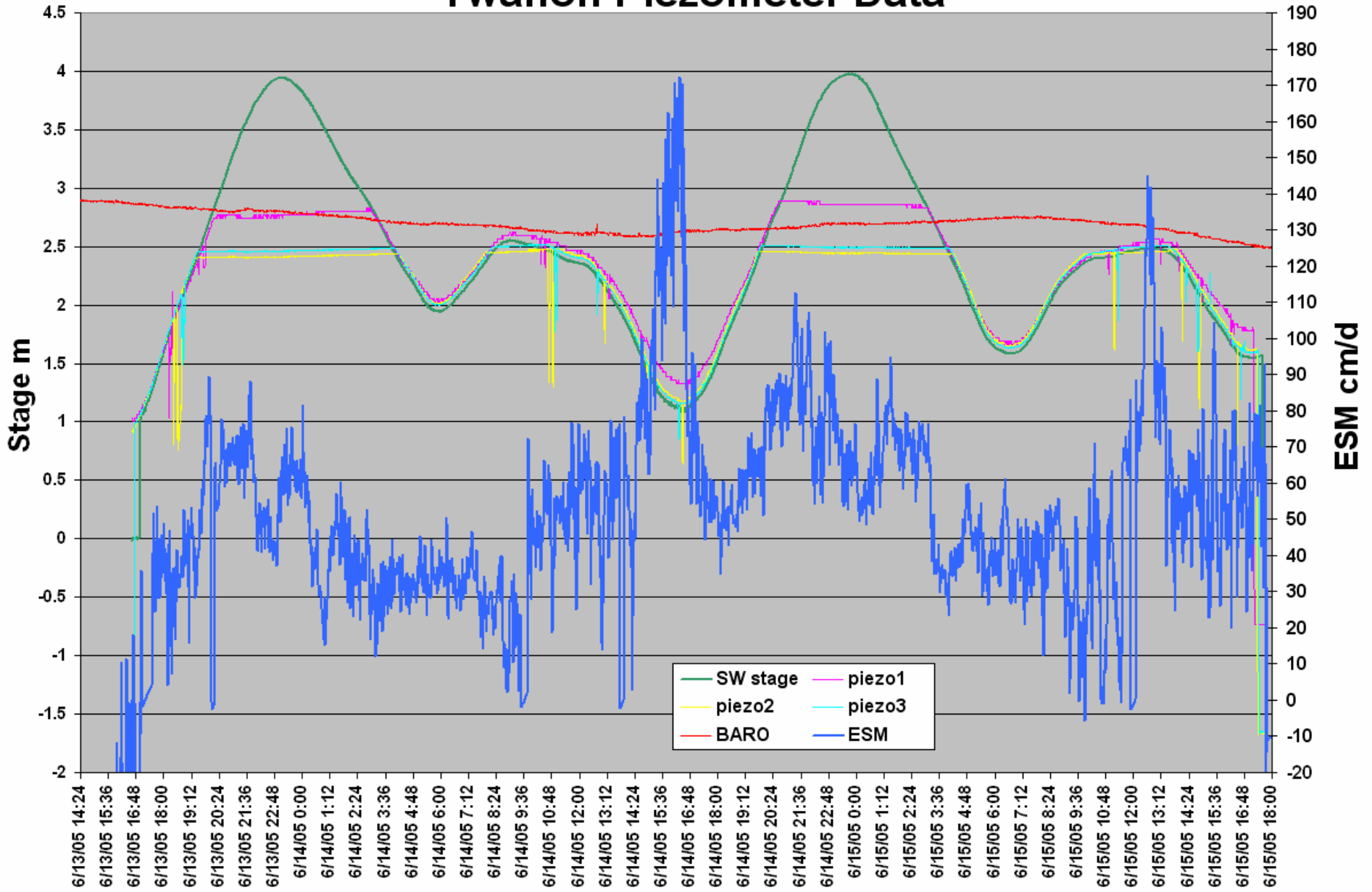
Measuring seepage using an Electromagnetic Seepage Meter (ESM)

Measures flow through an electromagnetic coil

Records continuous data



Twanoh Piezometer Data



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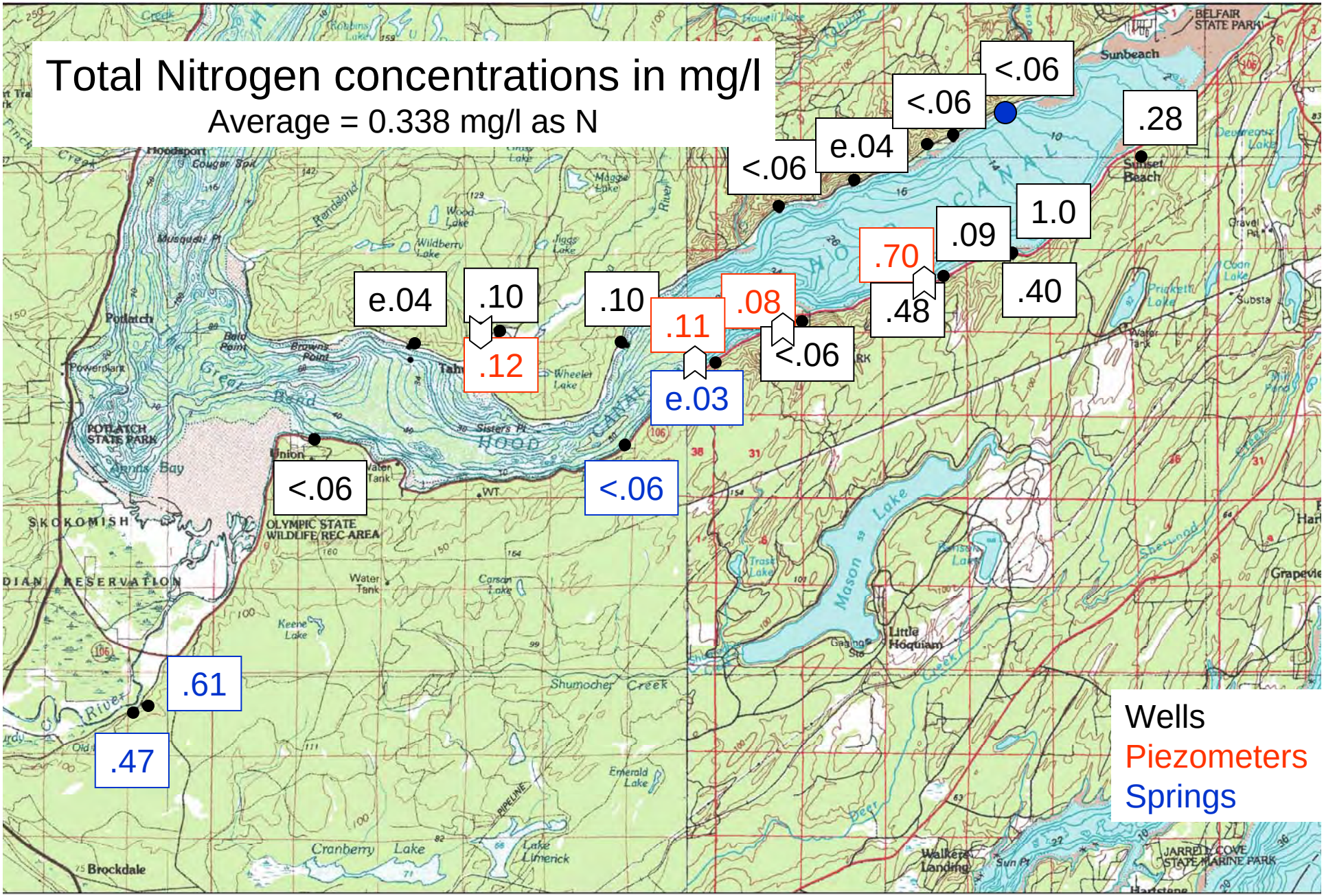
Nitrate Concentrations in Ground Water

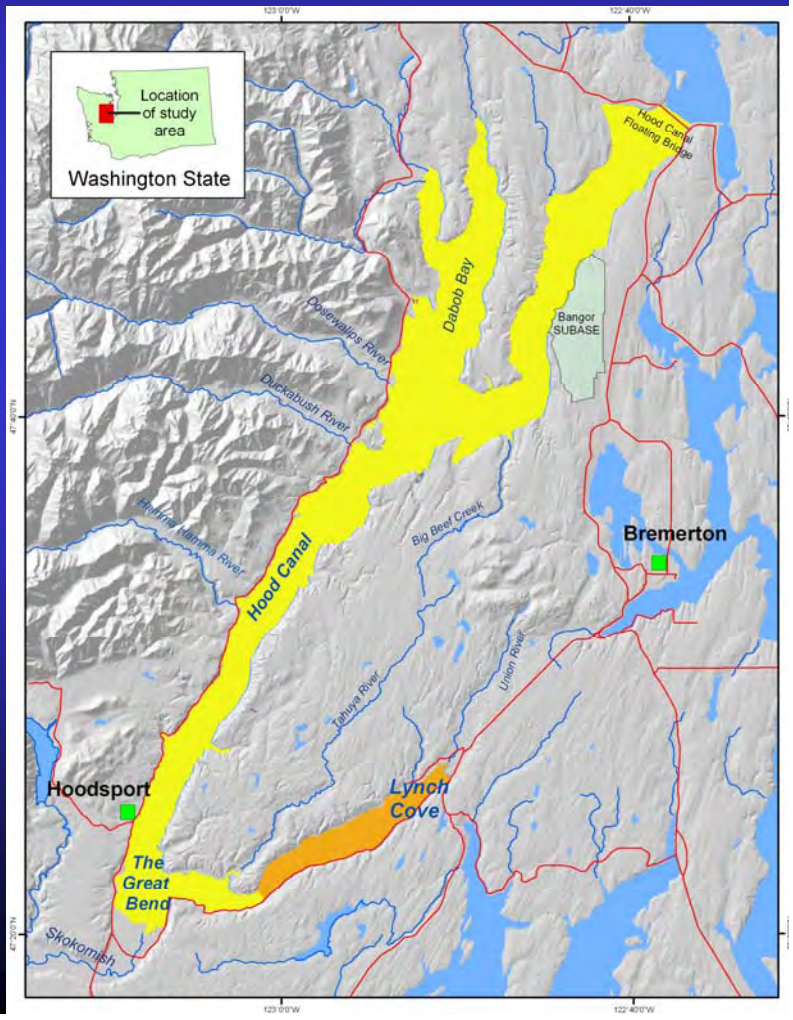


Estimating Nitrogen Loading to Lynch Cove from Ground Water

Load = Seepage x Concentration x Area

Nitrogen load from
1) Seepage measurements
(this method):
35.4 metric tons per year

2) Mass balance estimates
(previous method):
30.5 metric tons per year



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Other Methods of Estimating Nitrogen Loading from Ground Water

We have two independent estimates:

1) Mass balance approach (Paulson and others)
2) Physical seepage measurements

We are working on two more independent estimates:

3) Using Radon as a tracer
4) Using Radium isotopes as a tracer

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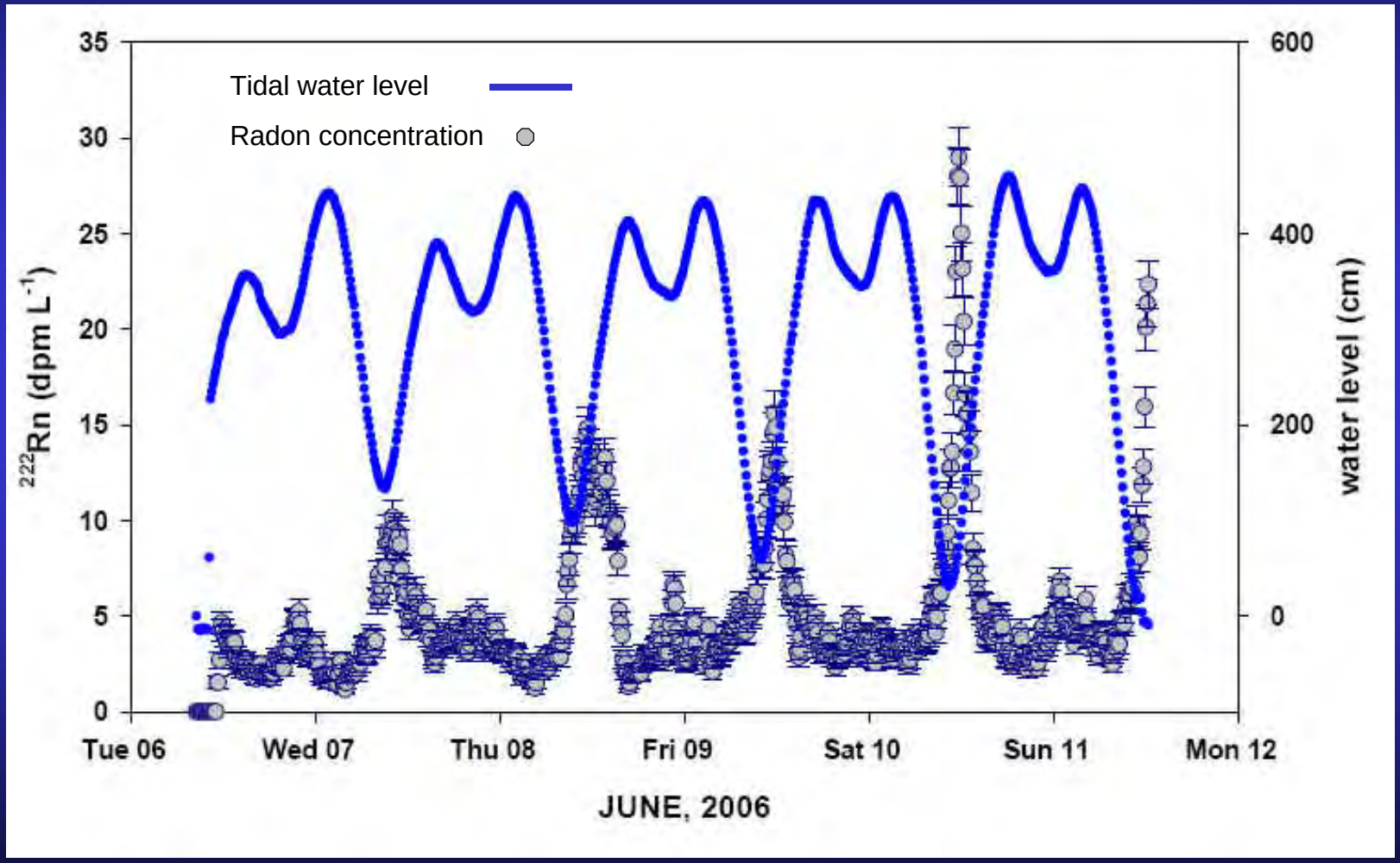
Estimating Nitrogen Loading from Ground Water Using Radon



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Preliminary data, subject to revision

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