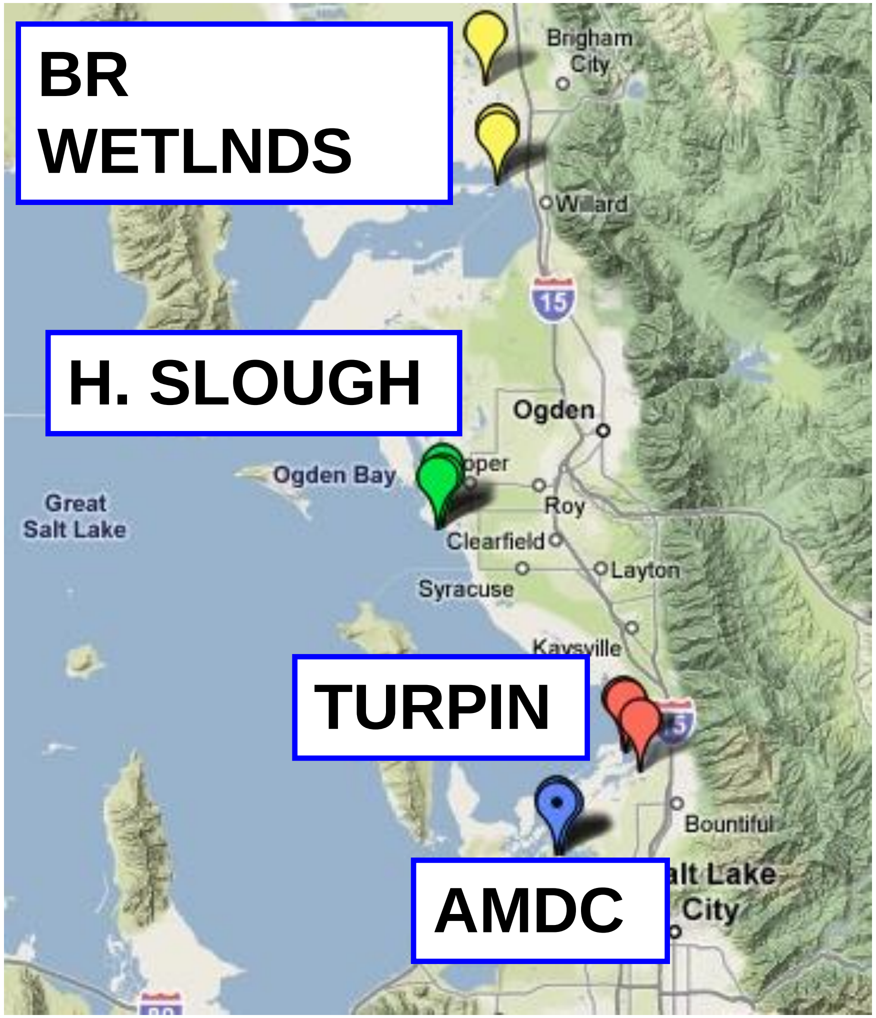
Diel fluctuations of mercury in Farmington Bay outfall:

Are we underestimating inputs to Great Salt Lake?

Utah Division of Forestry, Fire & State Lands

The University of Utah

TOPICS



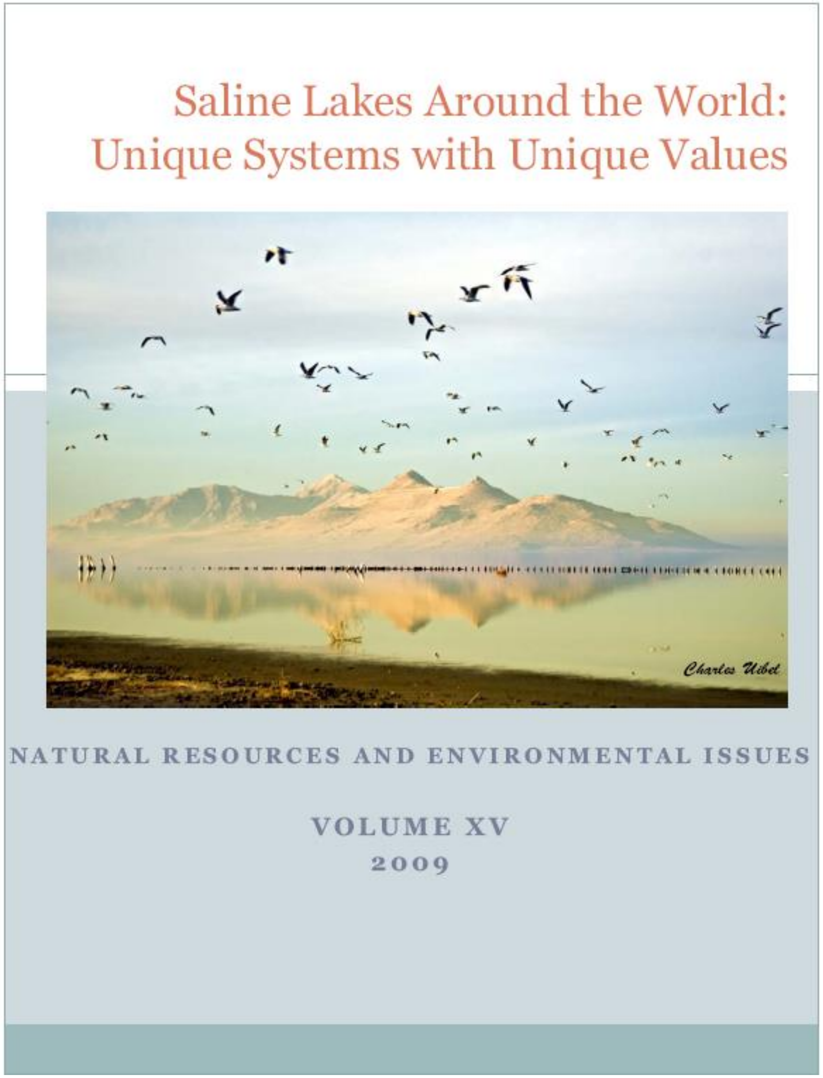
- Why do we care about a diel variation?
- Diel results from Howard Slough
- Geochemical and hydrologic conditions in Farmington Bay
- Farmington Bay diel
- NWIS mapper

Why do we care?

Lake managers can’t do much about controlling atmospheric sources of mercury, but can do something about managing Hg methylation

NEW Hg PUBLICATION

http://www.cnr.usu.edu/quinney/files/uploads/NREI2009online.pdf



Mercury Inputs to Great Salt Lake, Utah: Reconnaissance-Phase Results

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ABSTRACT

In response to increasing public concern regarding mercury (Hg) cycling in Great Salt Lake (GSL) ecosystem, a series of studies were initiated to differentiate between the mass of Hg from riverine versus atmospheric sources to GSL. Cumulative riverine Hg load to GSL during a 1 year time period (April 1, 2007 to March 31, 2008) was 6 kg, with almost 50% of the cumulative Hg load contributed by outflow from Farmington Bay. Comparison of cumulative annual atmospheric Hg deposition (32 kg) to annual riverine deposition (6 kg) indicates that atmospheric deposition is the dominant input source to GSL. A sediment core collected from the southern arm of GSL was used to reconstruct annual Hg deposition rates over the past ~ 100 years. Unlike most freshwater lakes, small changes in water level in GSL significantly changes the lake surface area available for direct deposition of atmospheric Hg. There is good agreement between lake elevation (and corresponding lake surface area) and Hg deposition rates estimated from the sediment core. Higher lake levels, combined with sediment focusing processes, result in an increase in Hg accumulation rates observed in the sediment core. These same combination of processes are responsible for the lower Hg accumulation rates observed in the sediment core during historic low stands of GSL.

INTRODUCTION

Great Salt Lake (GSL), in the western United States, is a terminal lake with a surface area that can exceed 5100 km^2 (Figure 1). The lake is bordered on the west by desert and on the east by the Wasatch Mountain Range. Completion of a railroad causeway in 1959 divided GSL into a North and South Arm (Figure 1) and significantly changed the water and salt balance (Loving et al. 2000). More than 95% of the freshwater surface inflows enter GSL south of the railroad causeway resulting in consistently higher salinities in lake water north of the railroad causeway. A similar rock-filled automobile causeway separates Farmington Bay from the main body of GSL (Figure 1).

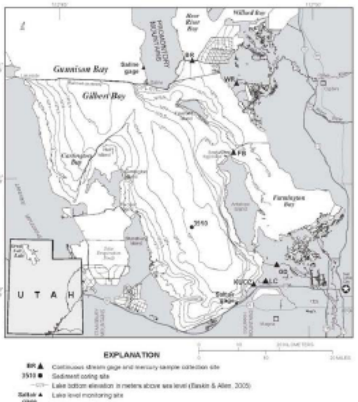
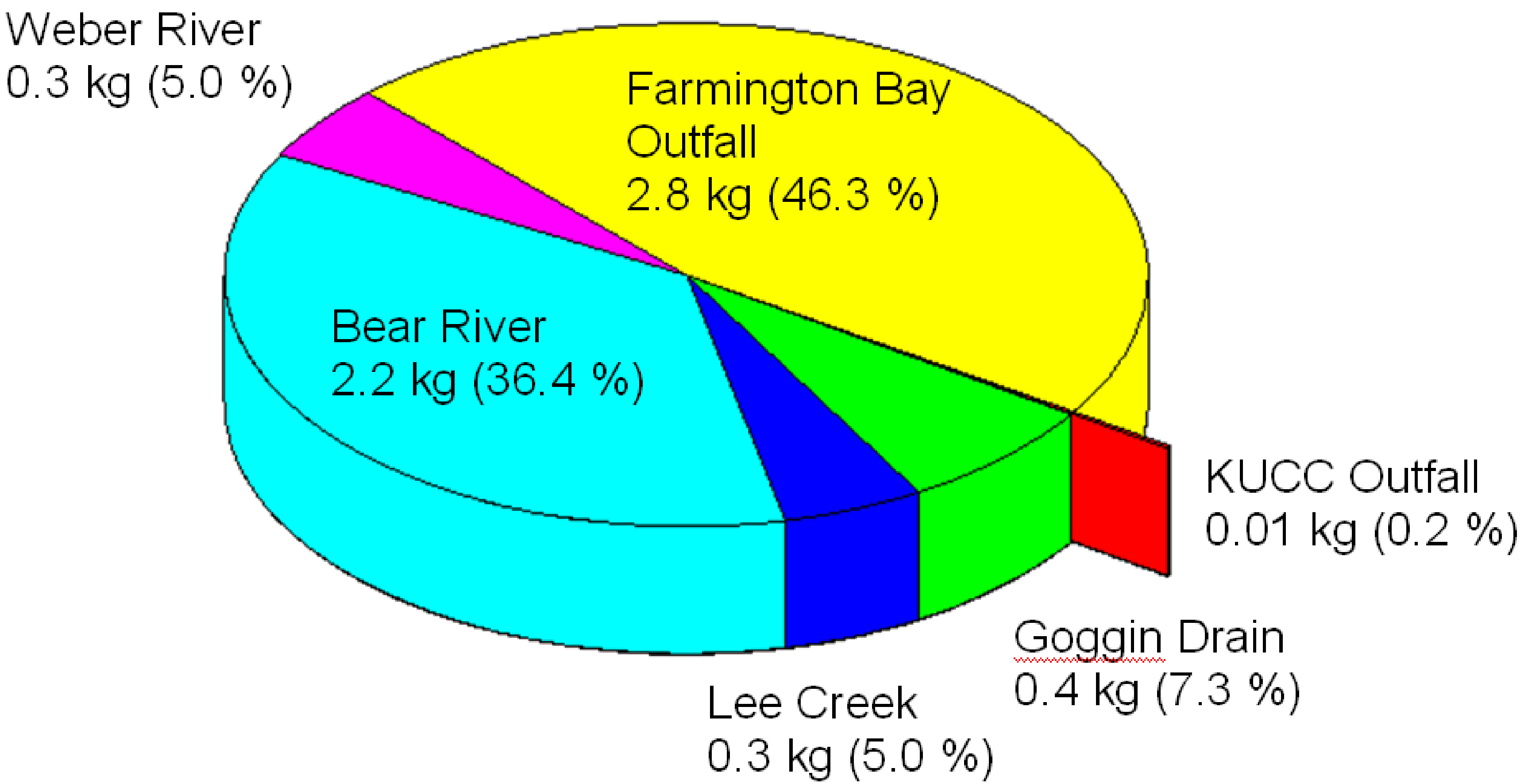


Figure 1–Location of stream gages, lake elevation monitoring sites, and sediment core site, Great Salt Lake, Utah.

The GSL ecosystem receives industrial, urban, mining and agricultural discharge from a 3.8 x 10^4 km^2 watershed with a population exceeding 1.7 million people. The open water and adjacent wetlands of the GSL ecosystem support millions of migratory waterfowl and shorebirds from throughout the Western Hemisphere (Aldrich & Paul 2002). In addition to supporting migratory dependent waterbirds, the brine shrimp population residing in GSL supports a shrimp industry with annual revenues as high as 60 million US dollars (Isaacson et al. 2002). Other industries supported by GSL include mineral production (halite, K salts, Mg metal, Cl_2, $MgCl_2$, and nutritional supplements) and recreation that includes waterfowl hunting (Anderson & Anderson 2002; Butts 2002; Isaacson et al. 2002; Tripp 2002).

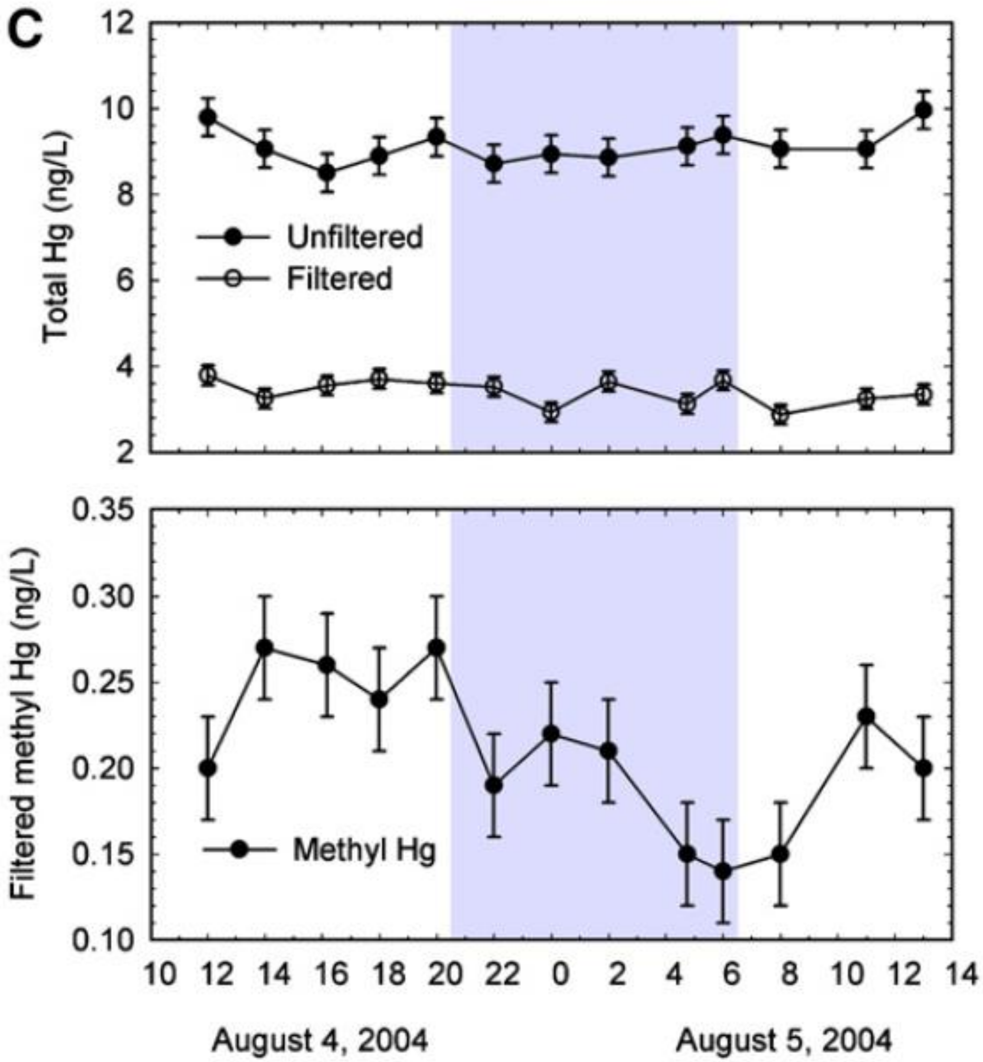
Despite the ecological and economic importance of GSL, little is known about the input and biogeochemical cycling of Hg in the lake and how increasing anthropogenic pressures may affect its cycling. Reconnaissance-phase sampling and analysis of water samples from GSL by the

ANNUAL RIVERINE Hg LOAD IS 6 KG



MADISON RIVER DIEL [Hg]

Nimick and others, 2007



Wetlands flow to FB

Google Earth image of Farmington Bay mud flats

WETLAND Hg ISSUES

Farmington Bay mud flats

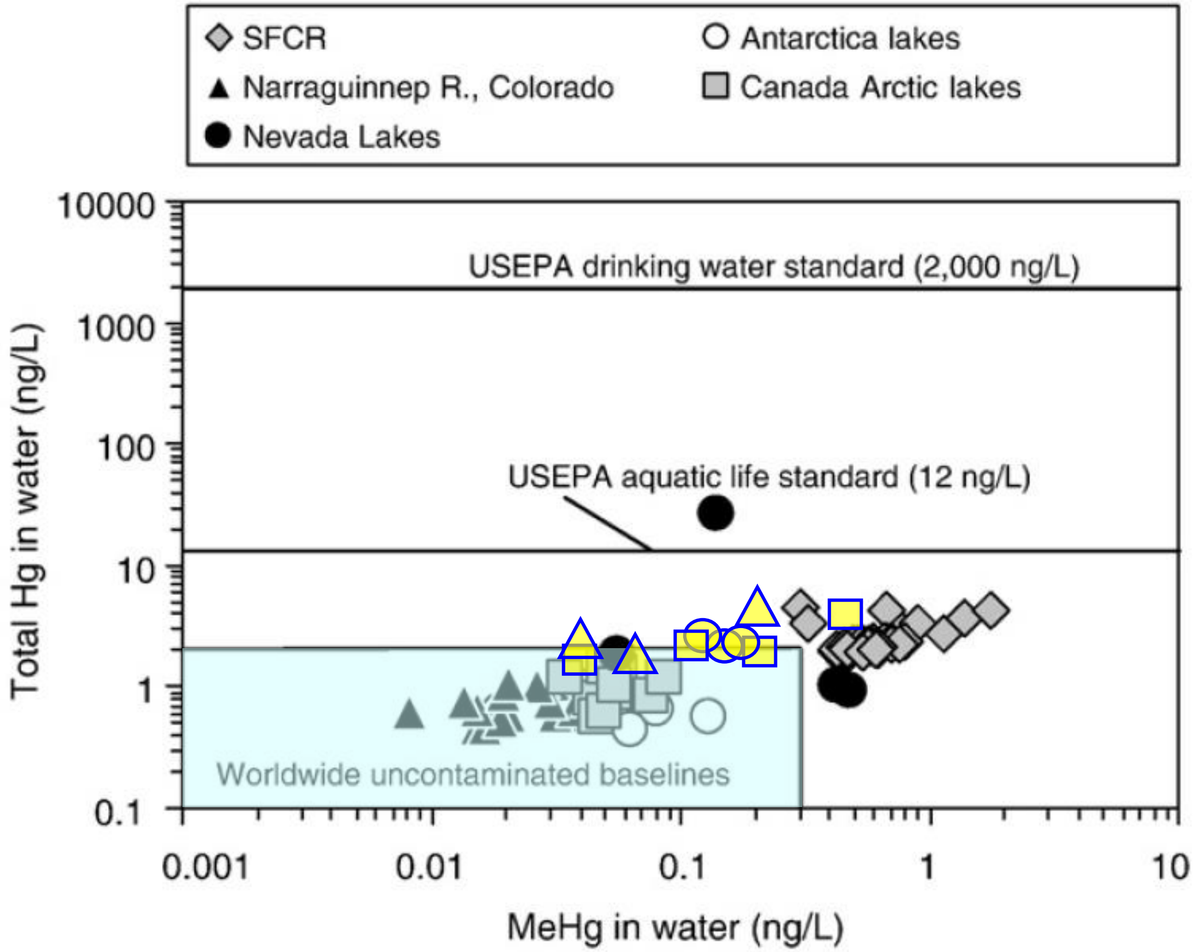
- Wet/dry cycles
- High DOC and SO_4
- Diel redox cycles
- Variable input sources
- High bird use

BEAR RIVER REFUGE CONTAMINATION

Gray and Hines, 2009, Chemical Geology

Explanation

- △ Inflow
- □ Wetland
- ○ Outflow

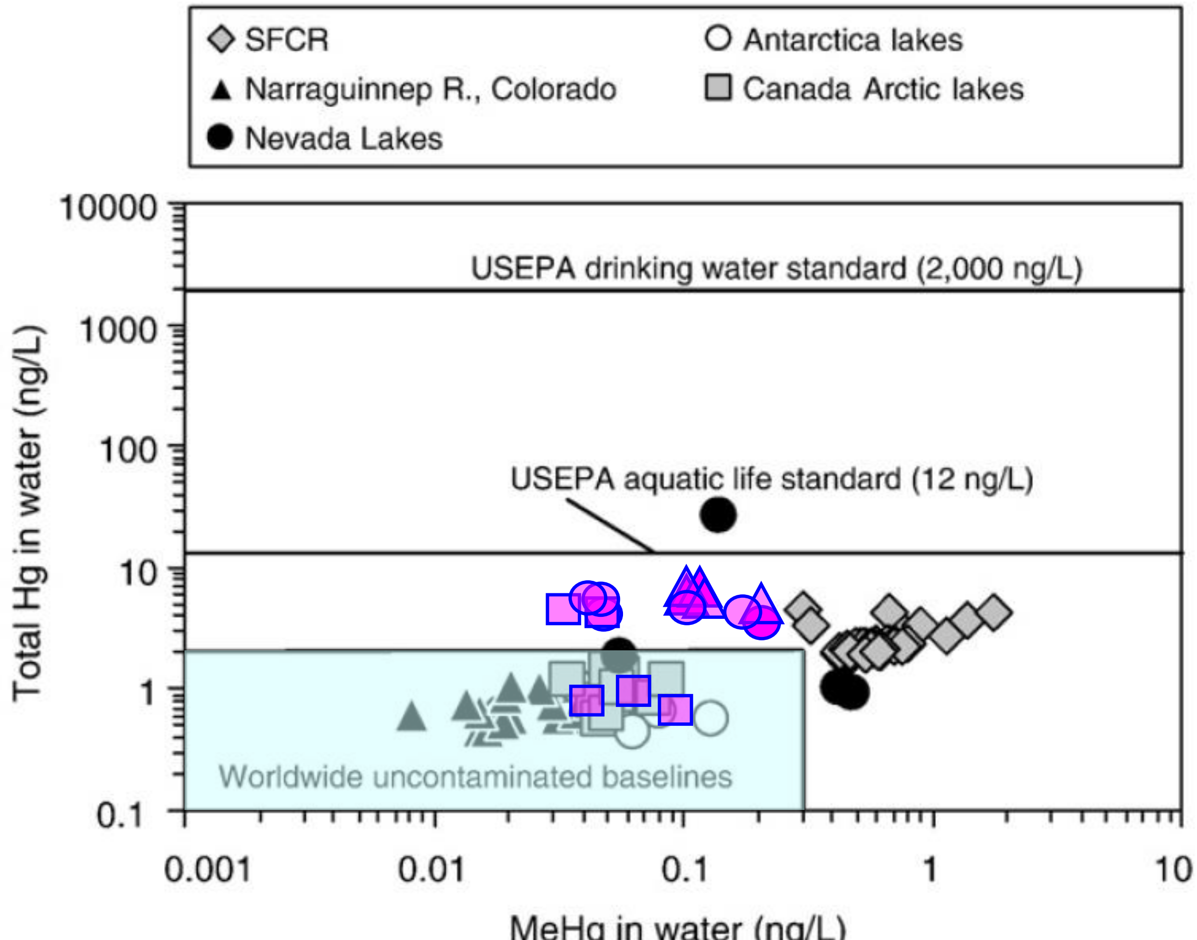


AMBASSADOR DUCK CLUB CONTAMINATION

Gray and Hines, 2009, Chemical Geology

Explanation

- Inflow
- Wetland
- Outflow

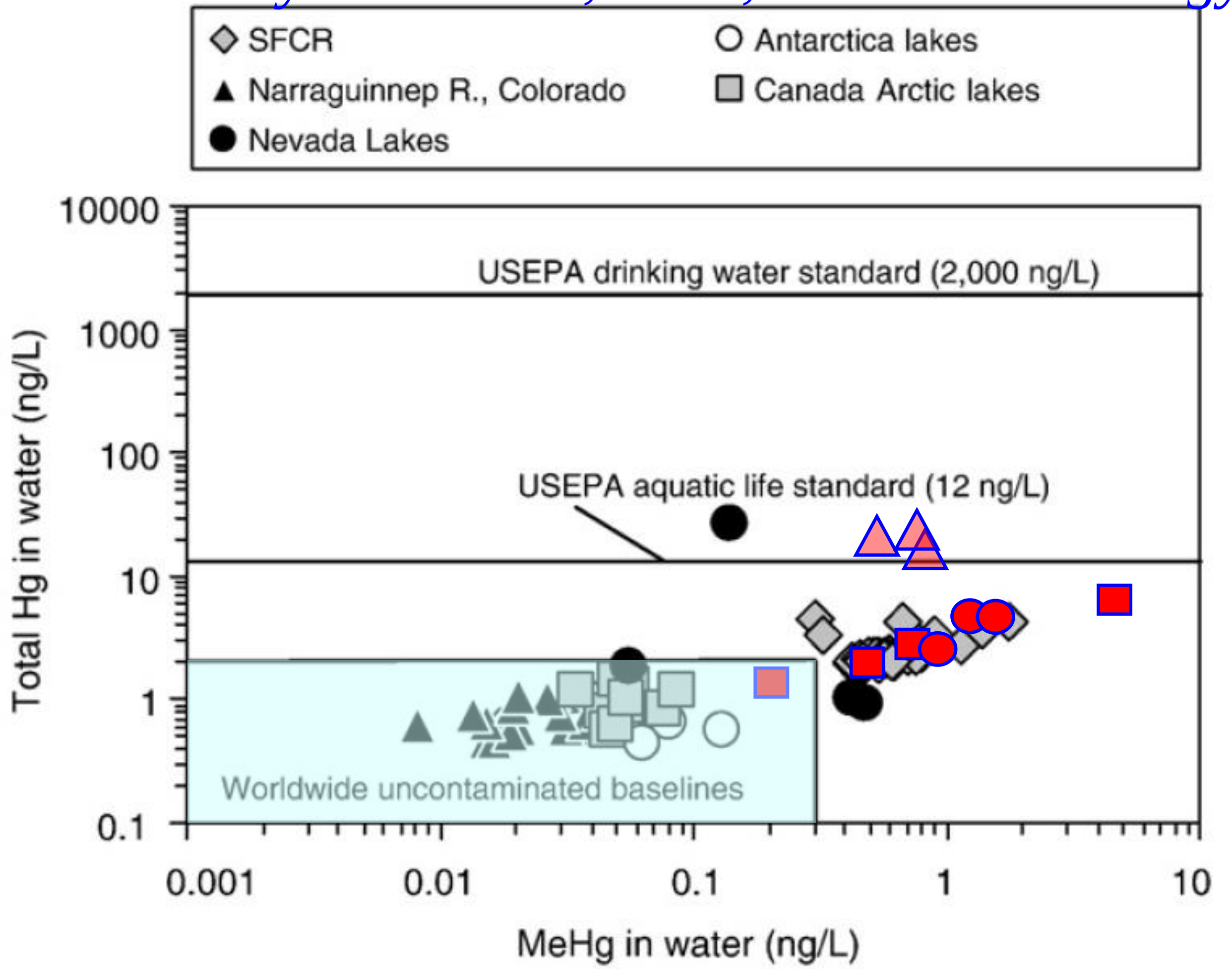


TURPIN UNIT CONTAMINATION

Gray and Hines, 2009, Chemical Geology

Explanation

- Inflow
- Wetland
- Outflow

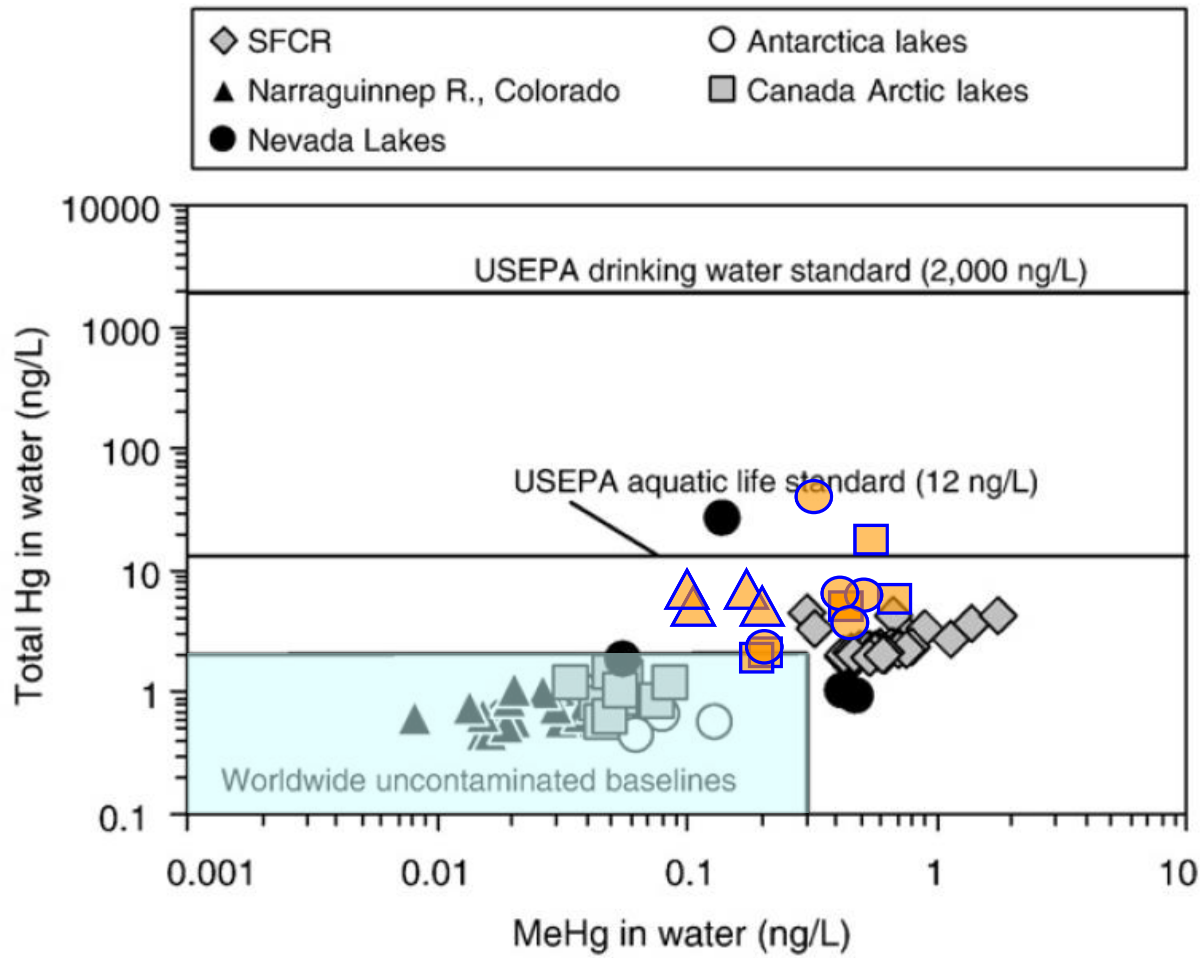


HOWARD SLOUGH CONTAMINATION

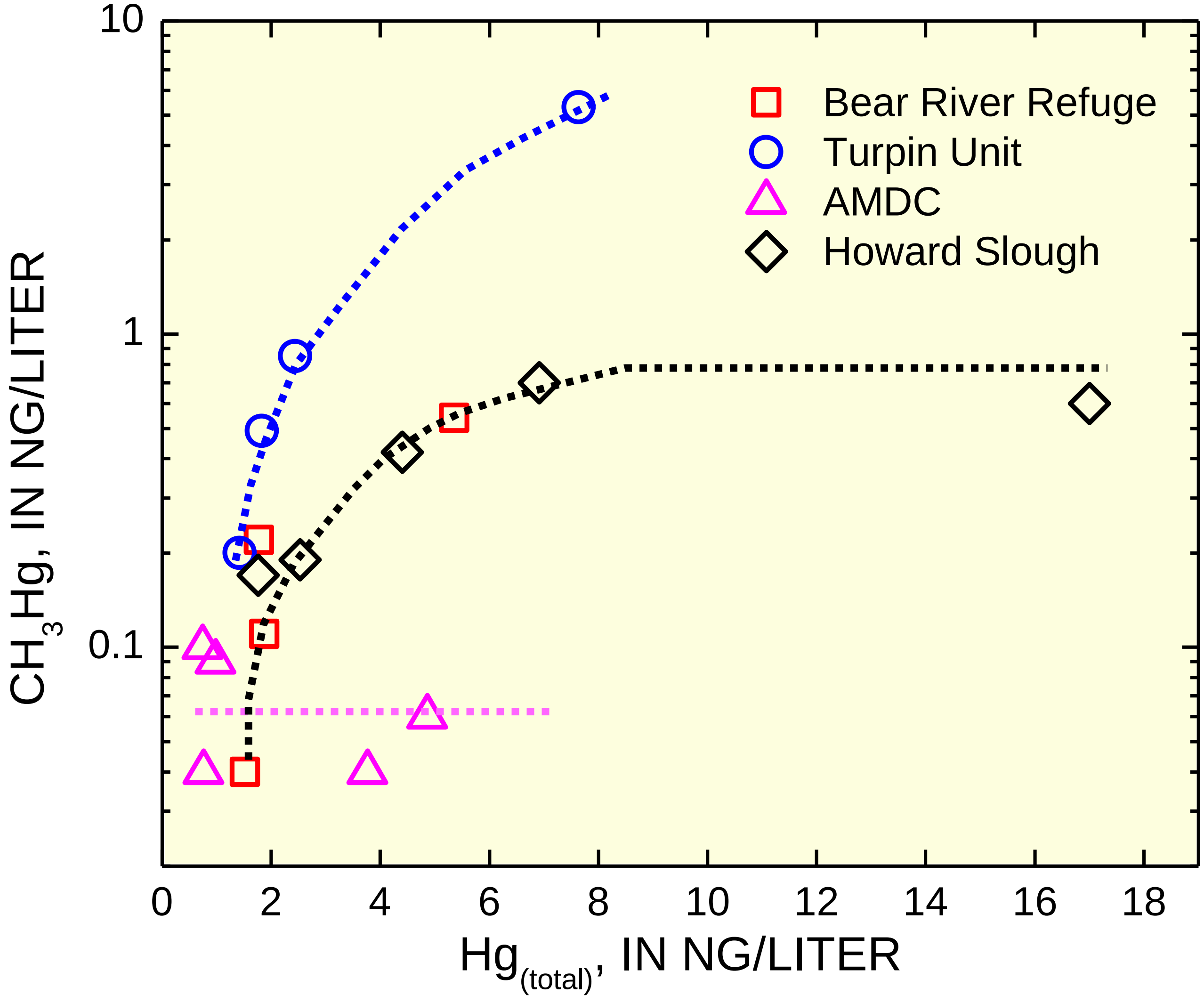
Gray and Hines, 2009, Chemical Geology

Explanation

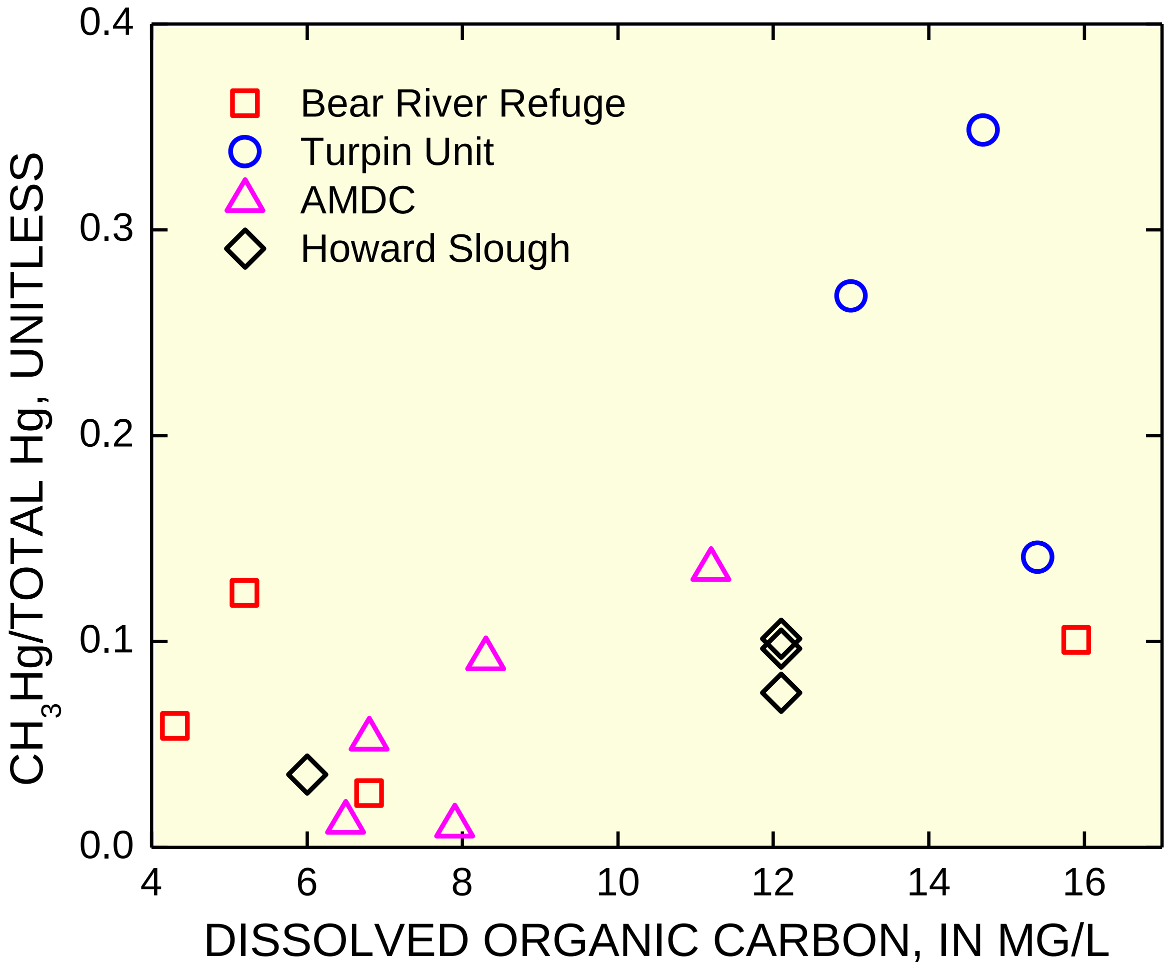
- Inflow
- Wetland
- Outflow



TURPIN UNIT ANOMALLY

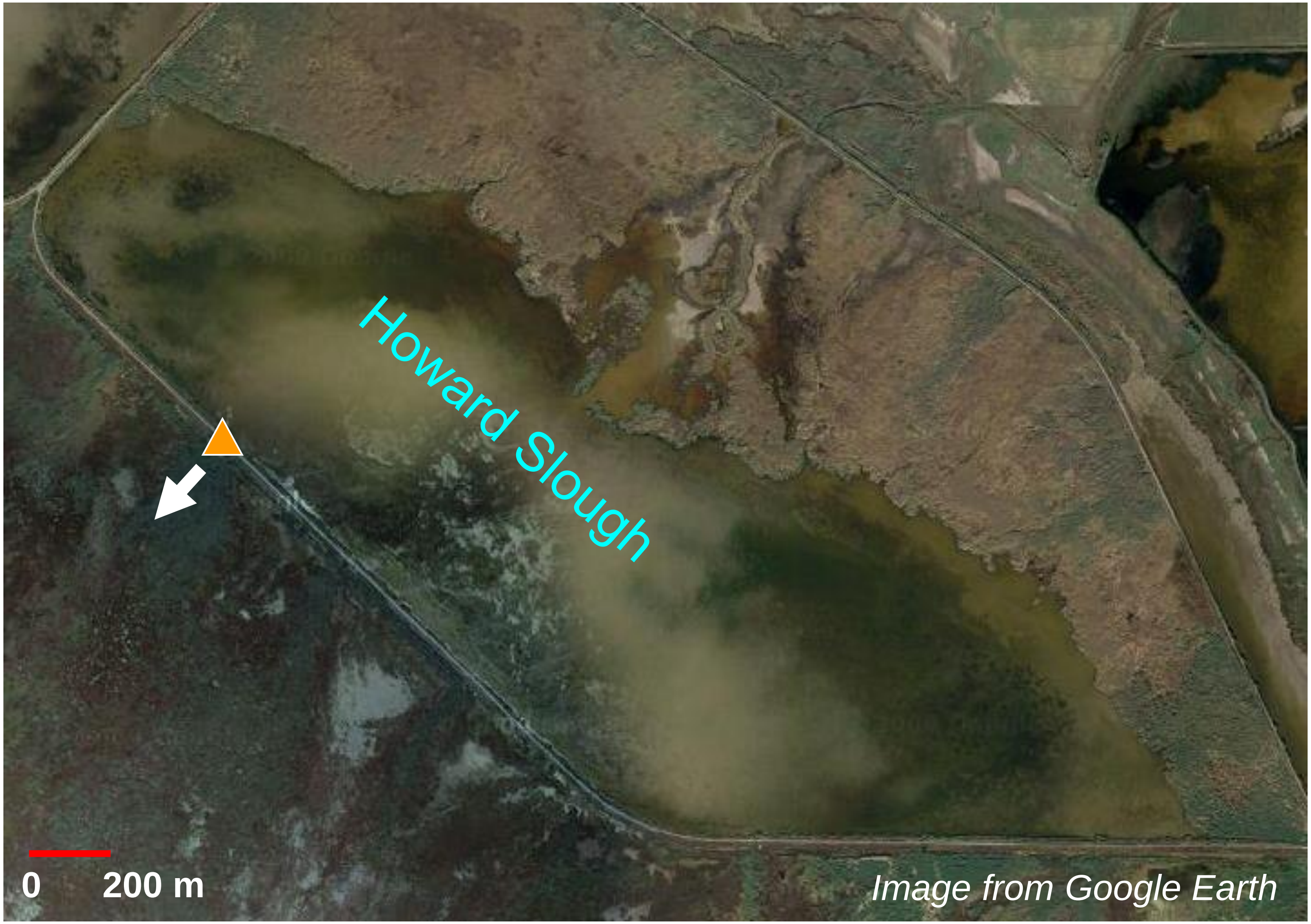


IS DOC IMPORTANT?

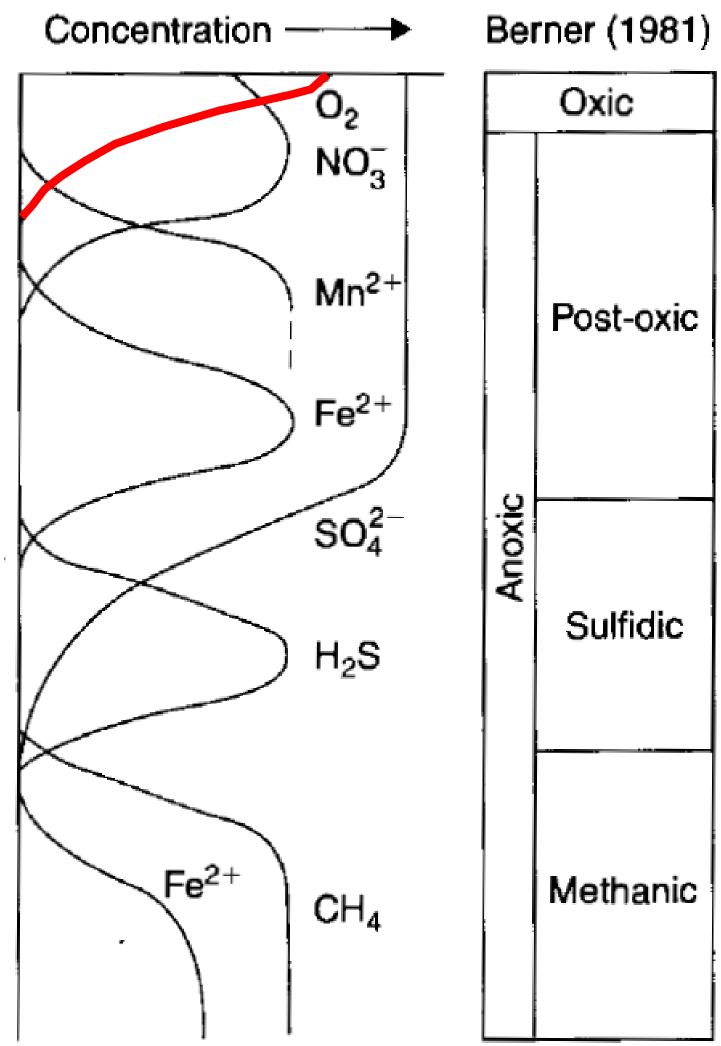


Howard Slough diel results

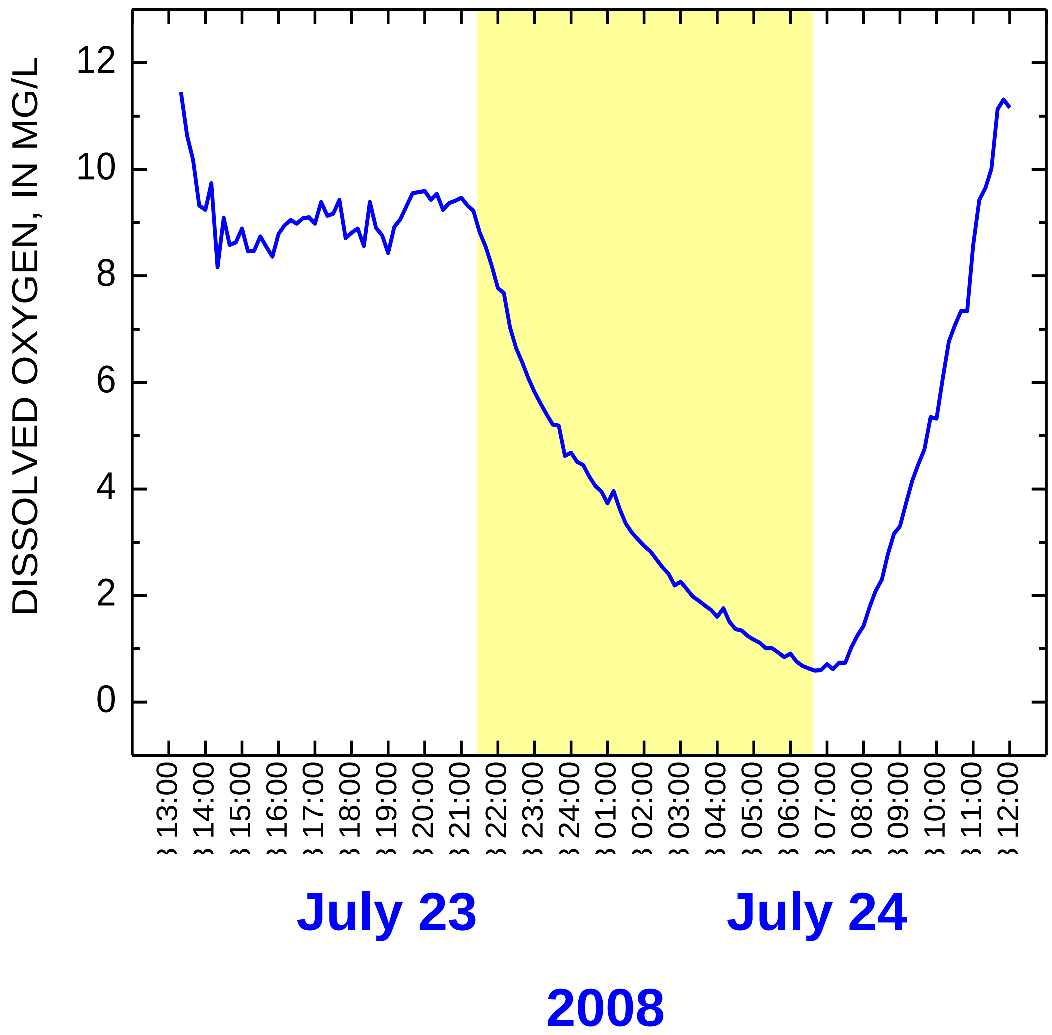
LOCATION



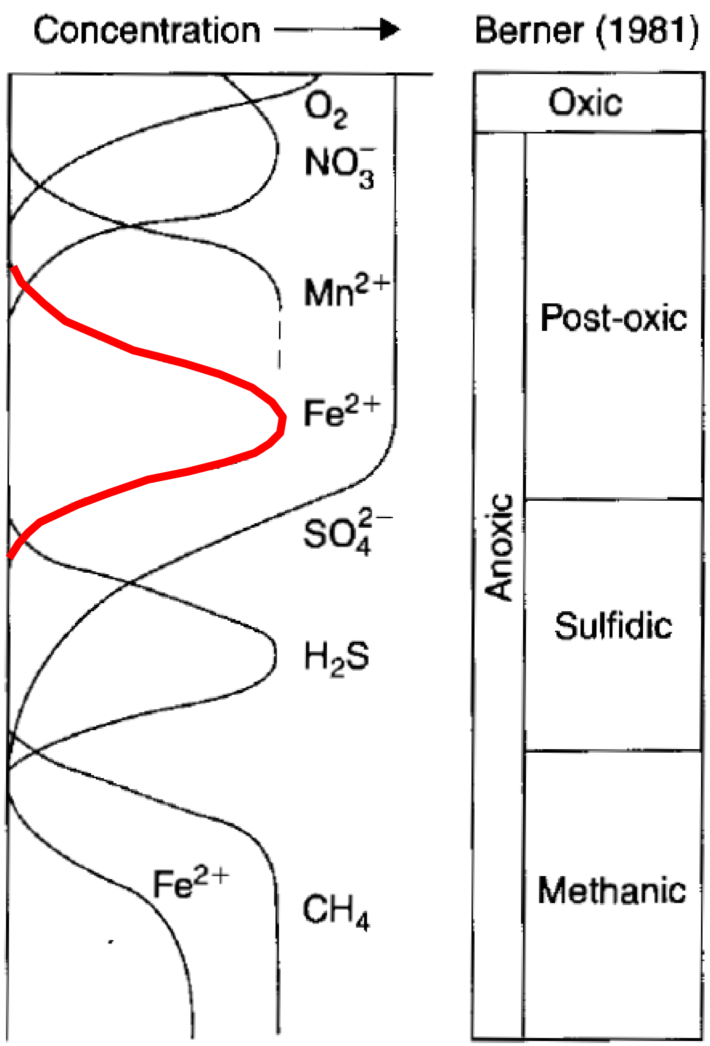
DIEL VARIATION IN DO

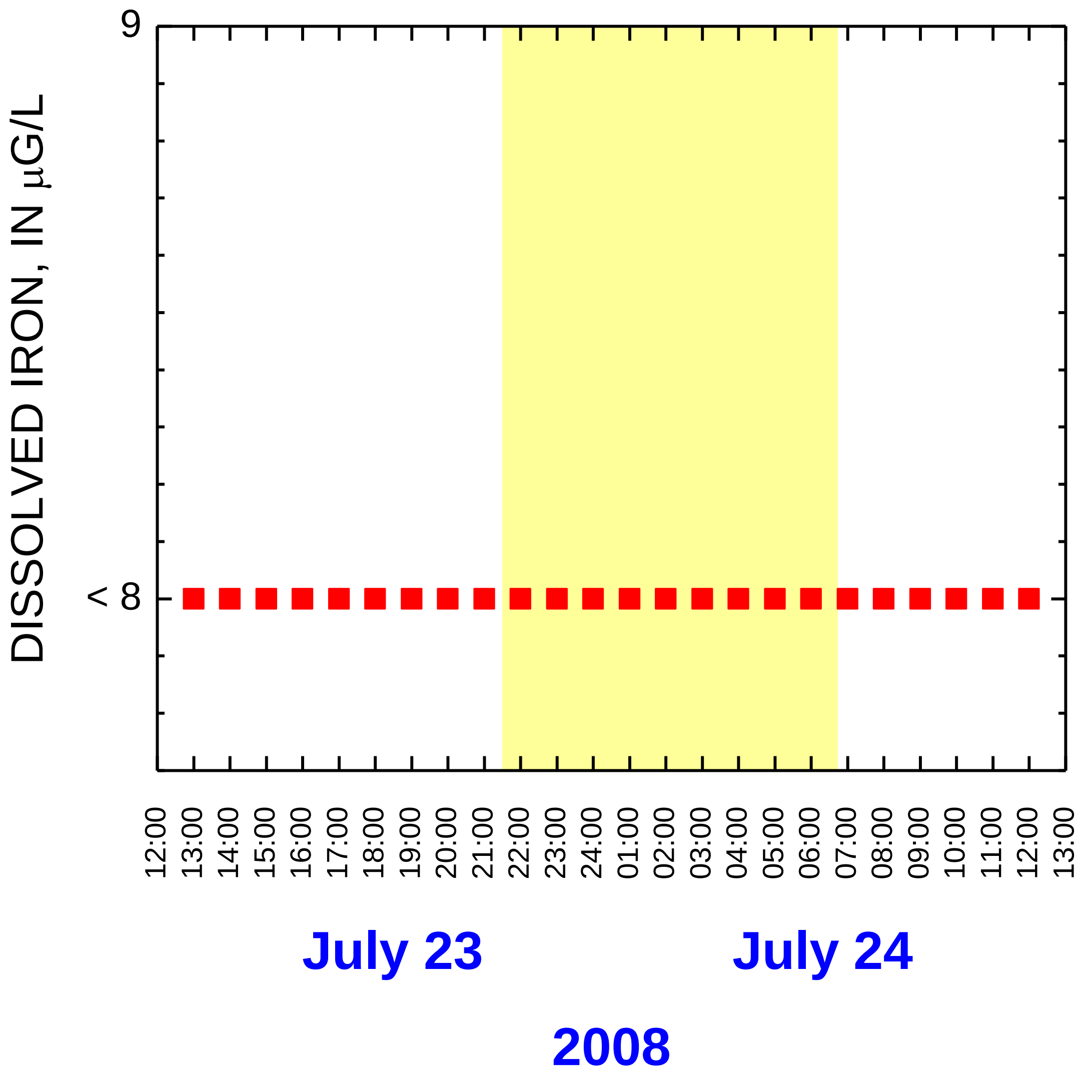


Howard Slough diel variation

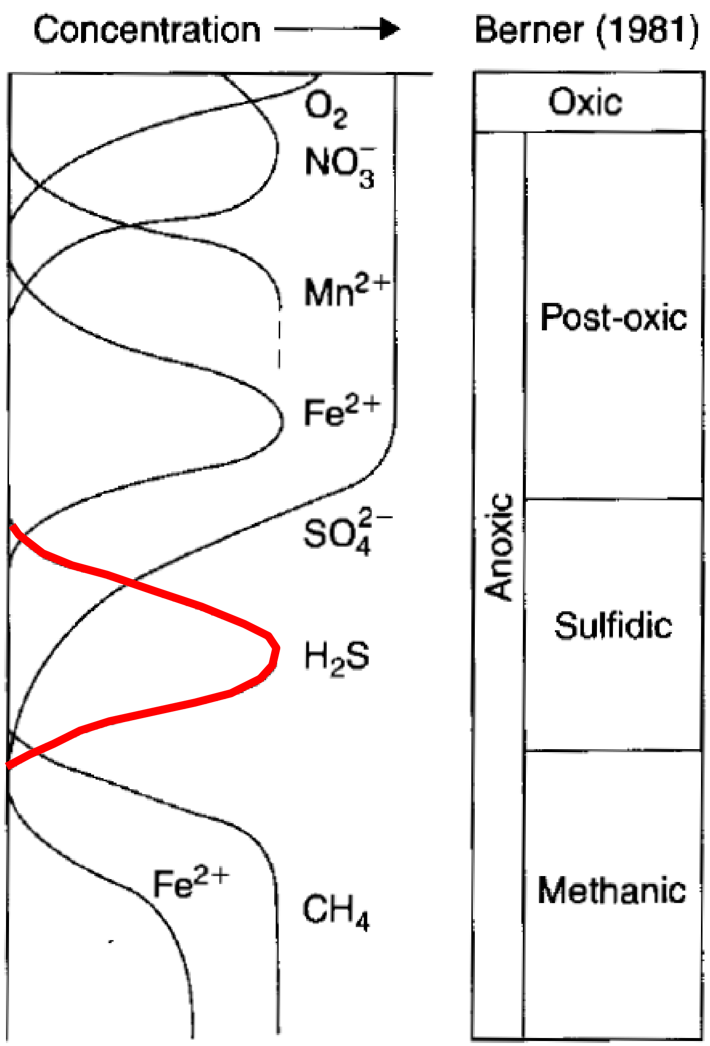


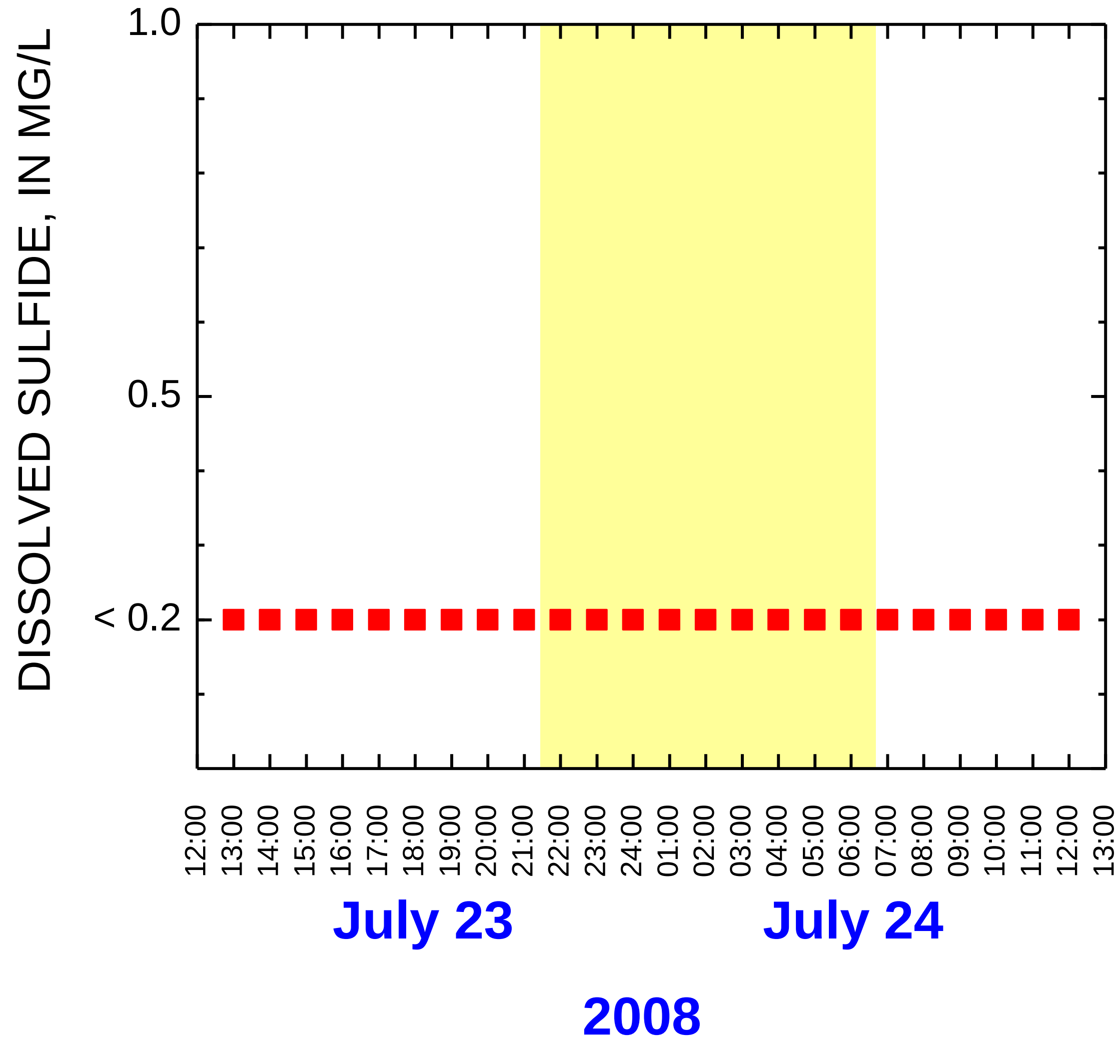
DIEL VARIATION IN Fe





DIEL VARIATION IN H_2S





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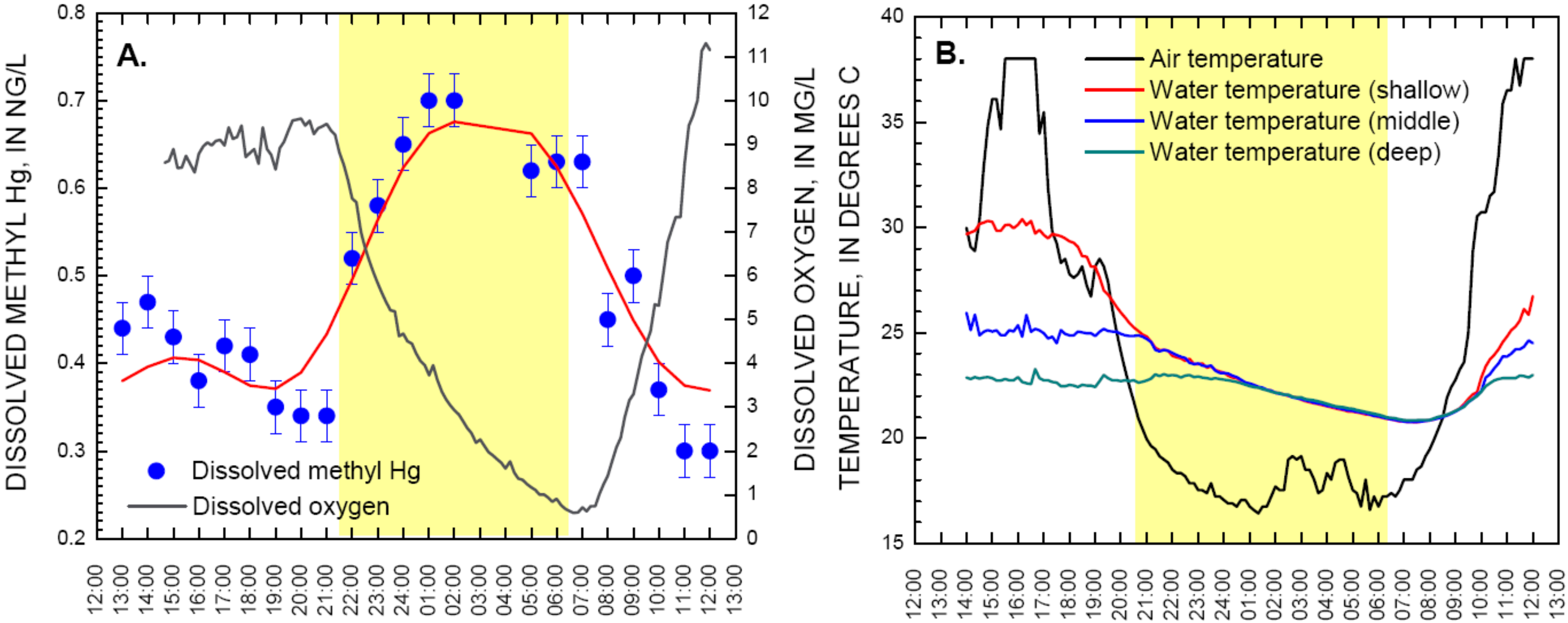
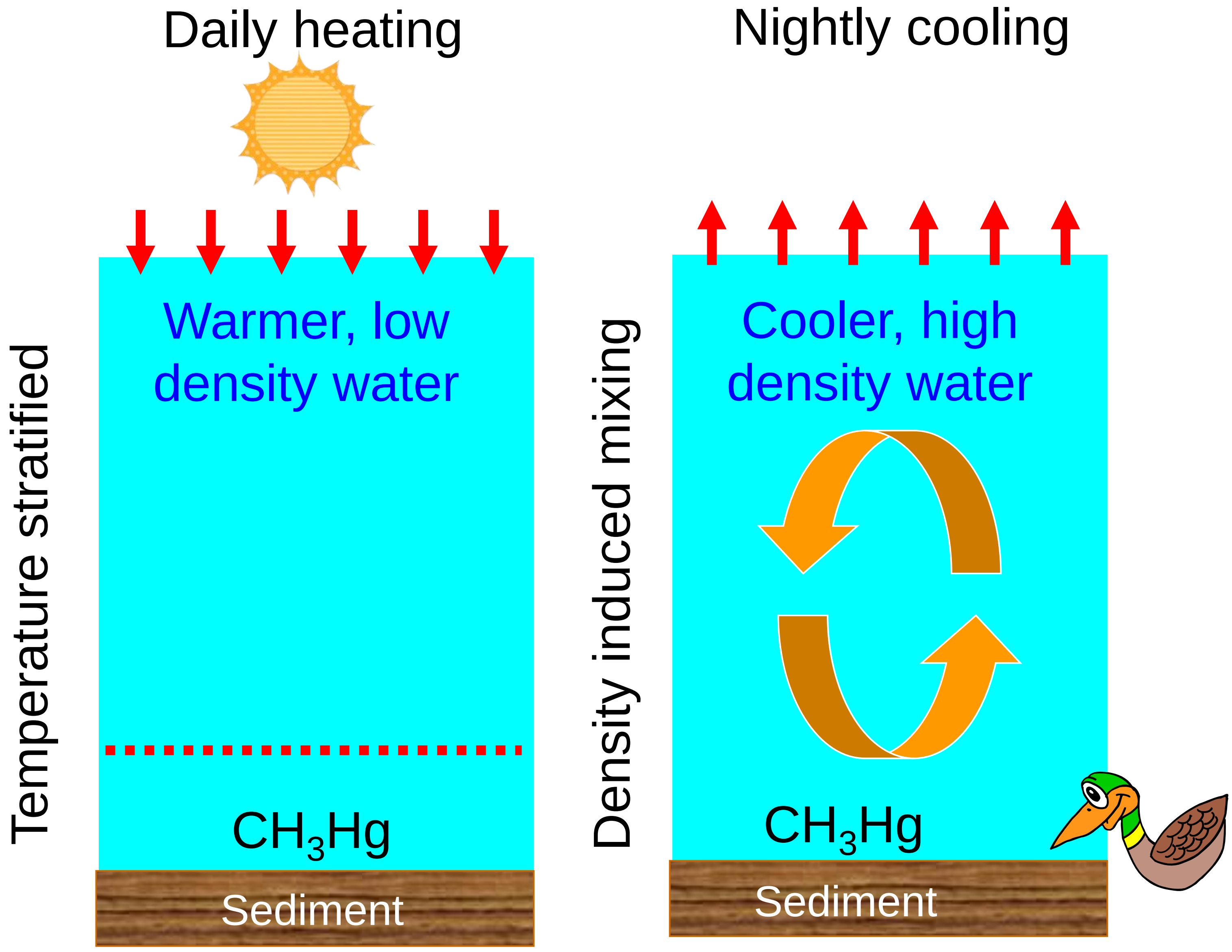
DIEL VARIATION IN METHYL Hg

Howard Slough wetland

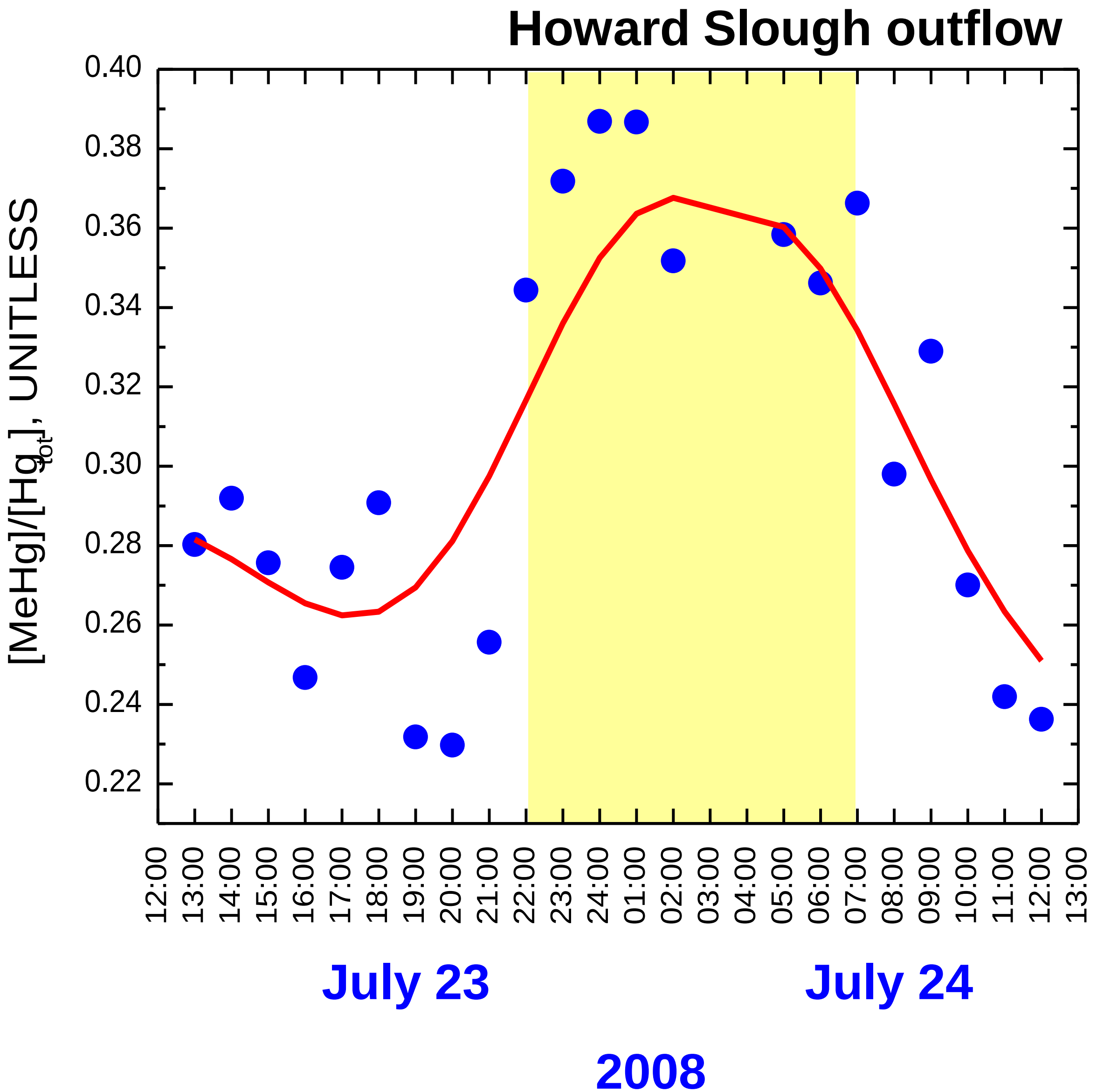
Highest methyl Hg in Madison River diel was 0.27 ng/L



WATER COLUMN MIXING



RATIO OF CH_3Hg TO Hg_{tot}



- **MeHg:HgT typically 0.10 (Ullrice et al., 2001)**
- **AMDC did not show a significant diel variation**

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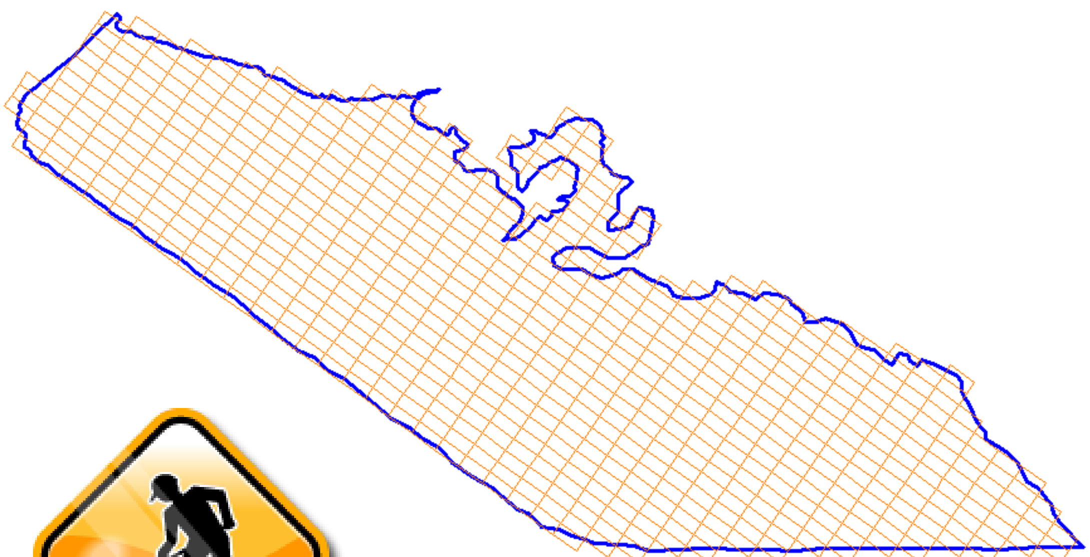
HYDRODYNAMIC MODELING

Model objective: *Simulate diel overturn of water column via daytime heating and nighttime cooling*

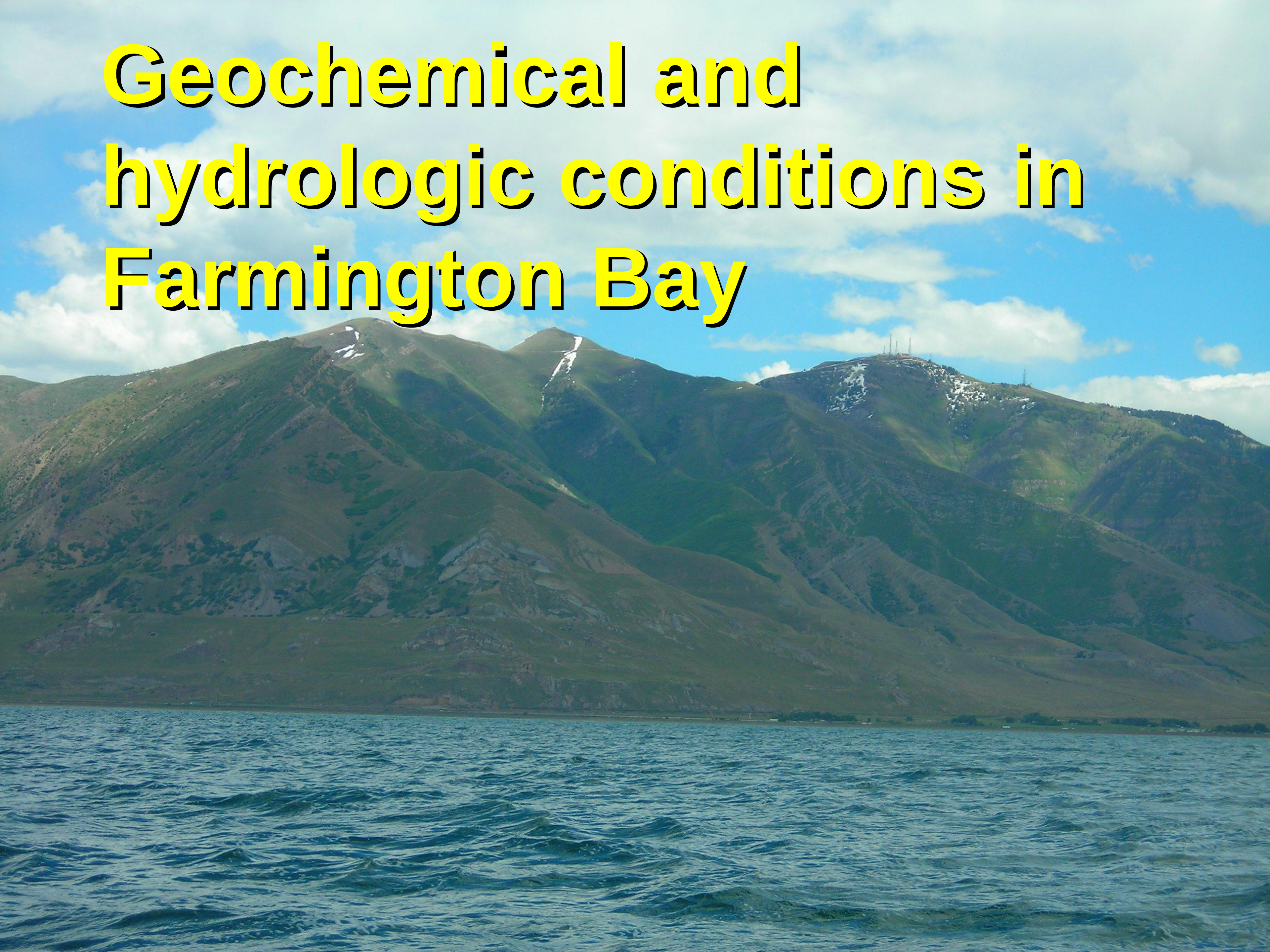
Howard Slough model grid



Boundary conditions

- **Inflows**
- **Outflows**
- **Meteorological data**
- **Salinity**
- **Water temperature**

Geochemical and hydrologic conditions in Farmington Bay



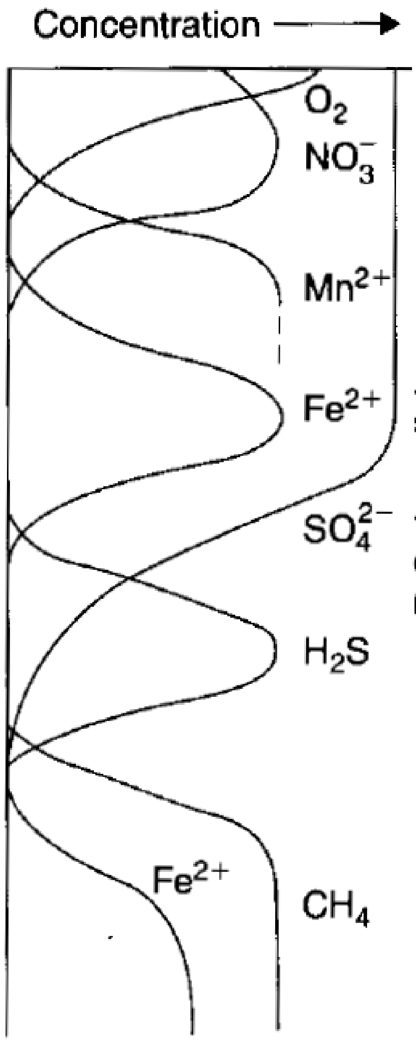
FARMINGTON BAY DIEL

FORESTRY, FIRE & STATE LANDS
REQUEST FOR PROPOSALS
Cover Sheet

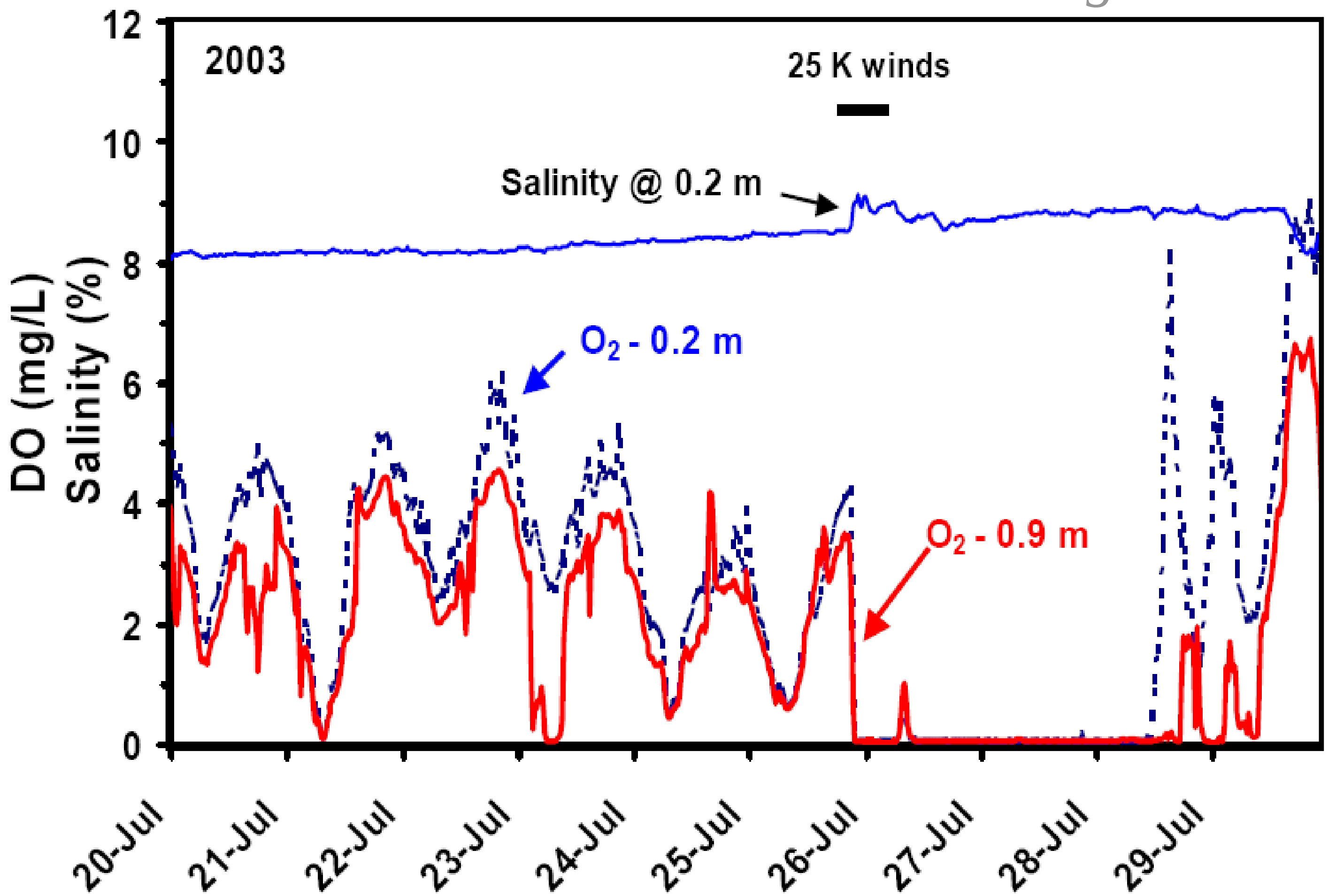
USGS science for a changing world

DAILY ANOXIA IN FB

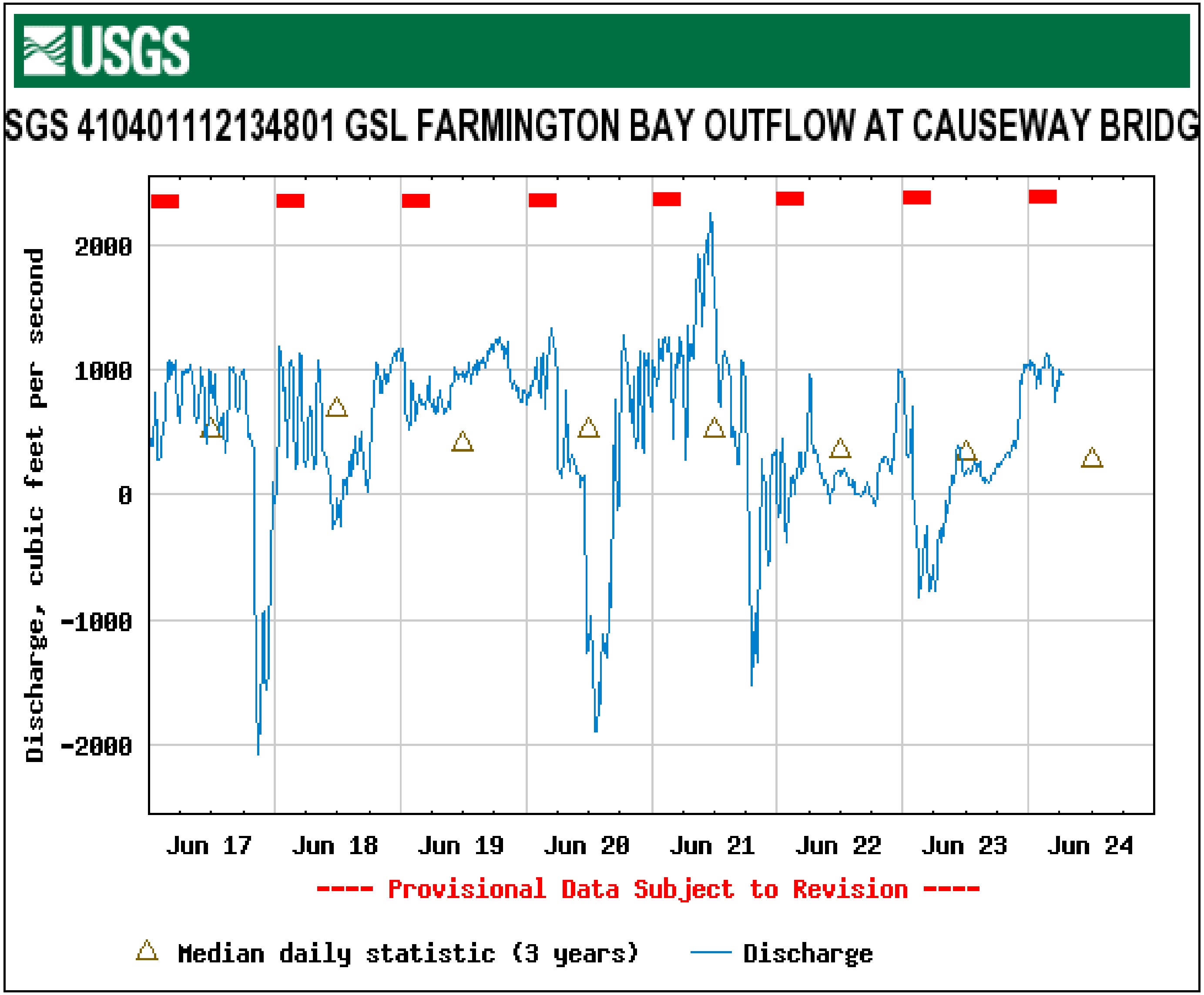
Anoxia likely driven by sulfide production in salt wedge



Wurtsbaugh 2006

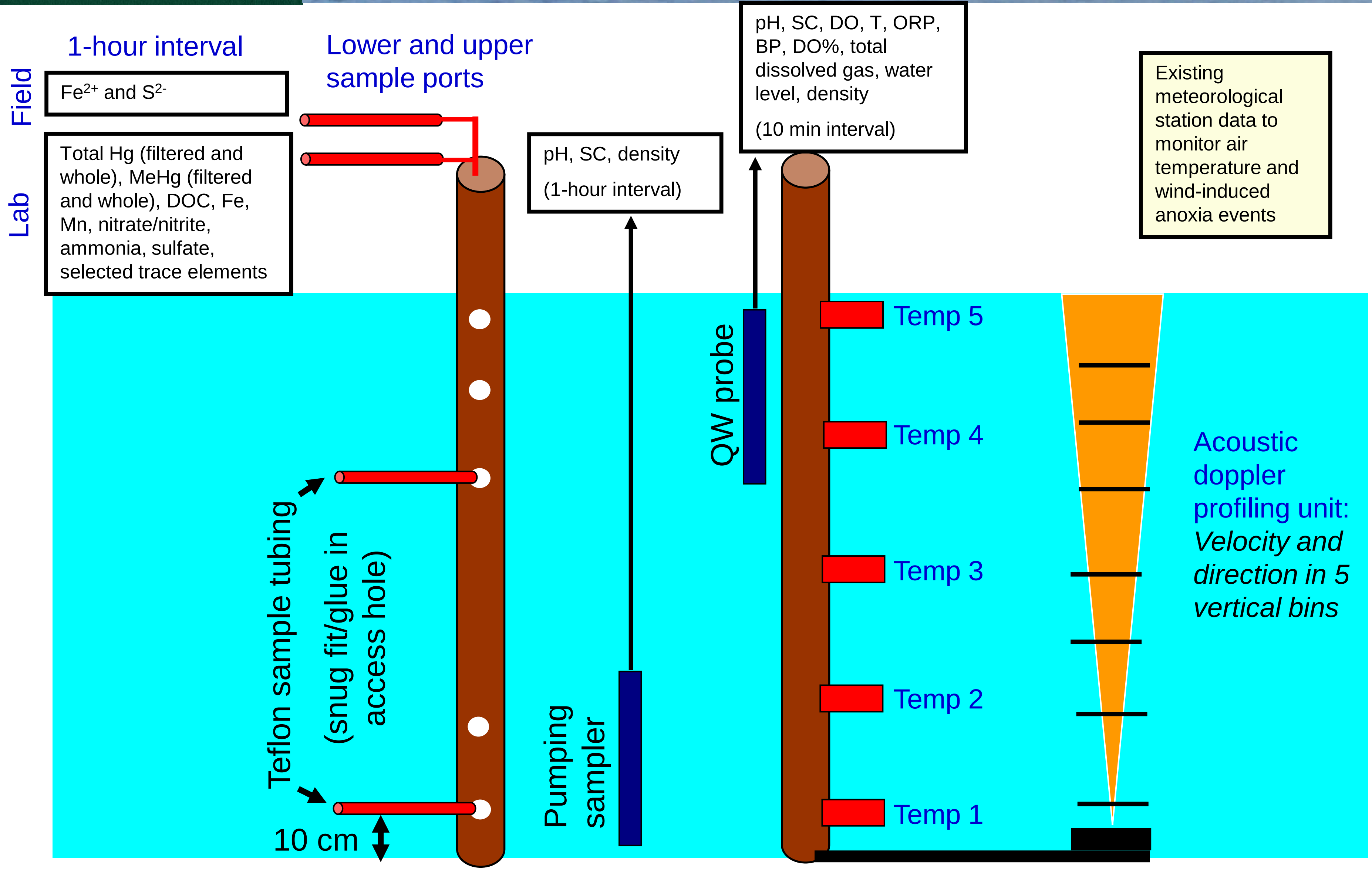


DAILY DISCHARGE VARIATION IN FARM. BAY



Midnight to 6 am (dark)

FB DIEL (JULY 14-15)



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MANAGEMENT IMPLICATIONS

Lake managers can't do much about controlling atmospheric sources of mercury, but can do something about managing Hg methylation

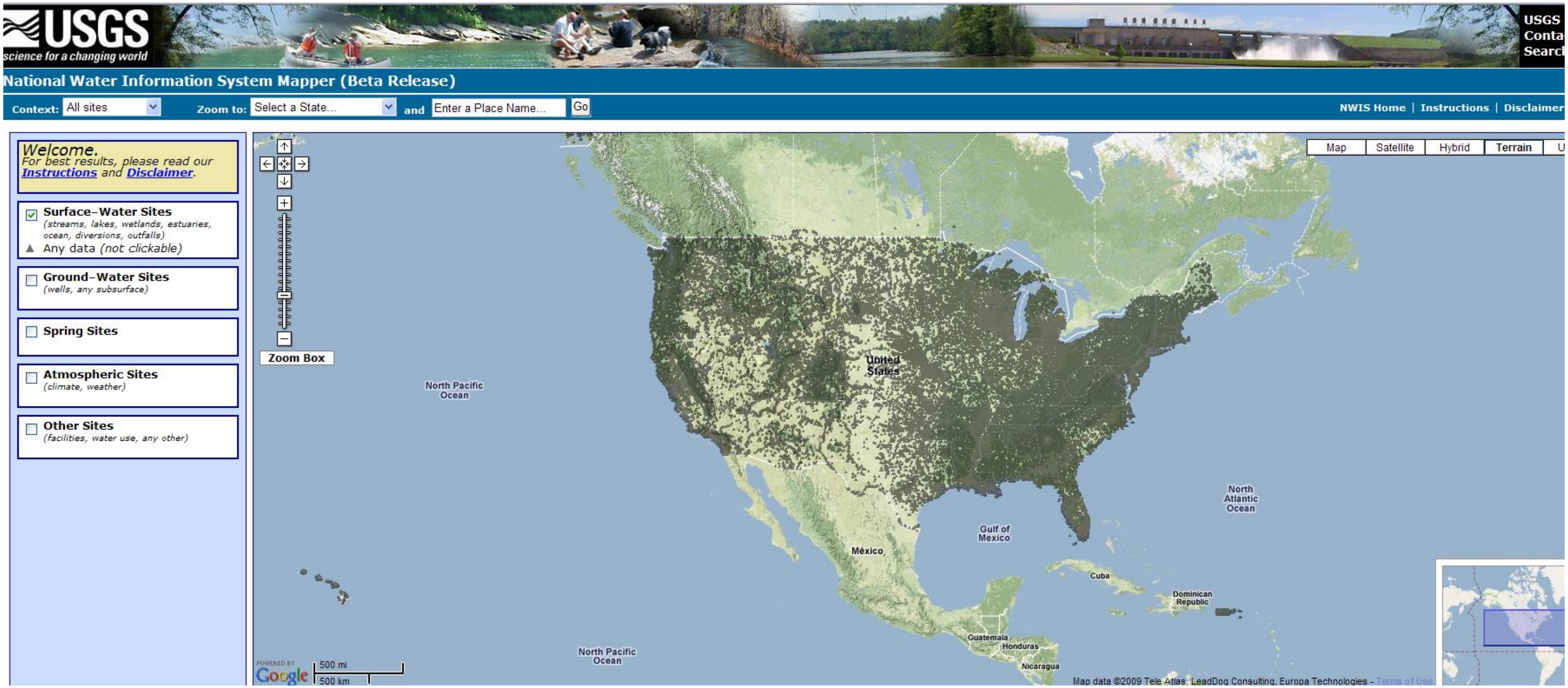
Outflow monitoring at Bear River wetlands

- **What if water with higher $Hg_{(total)}$ was applied to Bear River or AMDC wetlands?**
- **Will even more CH_3Hg be produced in the Turpin Unit with increased DOC or $Hg_{(total)}$**
- **How can we "force" other wetlands to behave like AMDC?**
- **Will the FB diel results provide more justification to "open up" Farmington Bay?**

DATA ARCHIVING

USGS National Water Information System

http://wdr.water.usgs.gov/nwisgmap/index.html



DATA ARCHIVING

Howard Slough sites

USGS 410803112092701 (B- 5- 3)26ddd Howard Slough Inlet

Available data for this site | SUMMARY OF ALL AVAILABLE DATA | GO

Lake Site

DESCRIPTION:
Latitude 41°08'02.6",   Longitude 112°09'26.9"   NAD83
Davis County, Utah, Hydrologic Unit 16020102
Datum of gage: 4,222 feet above sea level   NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Field/Lab water-quality samples	2008-05-28	2008-10-23	7

USGS 410732112092601 (B- 5- 3)35bdd Howard Slough (mid-pond)

Available data for this site | SUMMARY OF ALL AVAILABLE DATA | GO

Lake Site

DESCRIPTION:
Latitude 41°07'31.9",   Longitude 112°09'25.6"   NAD83
Davis County, Utah, Hydrologic Unit 16020102
Datum of gage: 4,210 feet above sea level   NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Field/Lab water-quality samples	2008-05-28	2008-10-23	35

USGS 410724112093901 (B- 5- 3)35cbc Howard Slough Outlet

Available data for this site | SUMMARY OF ALL AVAILABLE DATA | GO

Lake Site

DESCRIPTION:
Latitude 41°07'24.5",   Longitude 112°09'39.2"   NAD83
Davis County, Utah, Hydrologic Unit 16020102
Datum of gage: 4,206 feet above sea level   NGVD29.

AVAILABLE DATA:

Data Type	Begin Date	End Date	Count
Field/Lab water-quality samples	2008-05-28	2008-10-23	31

DATA ARCHIVING

Sample Datetime	Time datum	Time datum reliability code	Sample Medium Code	Agency Collecting Sample, Code	ITIS taxonomic code	Body part code	Temper-ature, water, deg C (00010)	Baro-metric pres-sure, mm Hg (00025)	Specif-ic conduc-tance, wat unf uS/cm 25 degC (00095)	Sam-pling depth, meters (00098)	Hydro-gen ion, water, unfltrd calcd, mg/L (00191)	Dis-solved oxygen, mg/L (00300)	Dis-solved oxygen, percent of sat-uration (00301)	pH, water, unfltrd field, std units (00400)	Organic carbon, water, fltrd, mg/L (00681)	Purpose site visit, code (50280)	Methyl-mercury water, unfltrd ng/L (50284)	Mercury water, unfltrd ng/L (50286)	Methyl-mercury biota tissue, dry wgt ng/g (63741)	Mercury biota, tissue, dry wgt ng/g (63745)
2008-05-28 12:00	MDT	K	WS	USGS-WRD			20.1	653	1120		M	10.4	134	8.6	12.1	1001	0.70	6.91		
2008-06-12 09:10	MDT	K	BA	USFWS	175089	59													243	248
2008-06-12 09:15	MDT	K	BA	USFWS	175089	59													498	563
2008-06-12 09:30	MDT	K	BA	USFWS	175089	59													2350	2740
2008-06-12 09:45	MDT	K	BA	USFWS	175089	59													2300	2180
2008-06-19 11:00	MDT	K	BA	USFWS	175089	59													523	596
2008-06-23 08:15	MDT	K	BA	USFWS	175089	59													583	656
2008-06-23 09:10	MDT	K	BA	USFWS	175089	59													236	286
2008-06-23 13:50	MDT	K	WS	USGS-WRD			22.6	655	865		M	13.5	183	9.7	12.1	1001	0.19	2.53		

Related Work

LDS Installation 8/2009

- Data Logger
- Single Cable T-Chain
- Meteorology (wind speed, direction, radiation, air temperature)
- Three SC Sensors
- pH sensor and 3 PAR sensors
- Real Time Data Transmission

Lake Victoria, Africa (from CWR)

UTAH DIVISION OF Wildlife Resources

LDS Site Placement