Our Gem:
Water Quality in Coeur d'Alene Lake

Part I. Managing Nutrients to Control Metals and Support Beneficial Use

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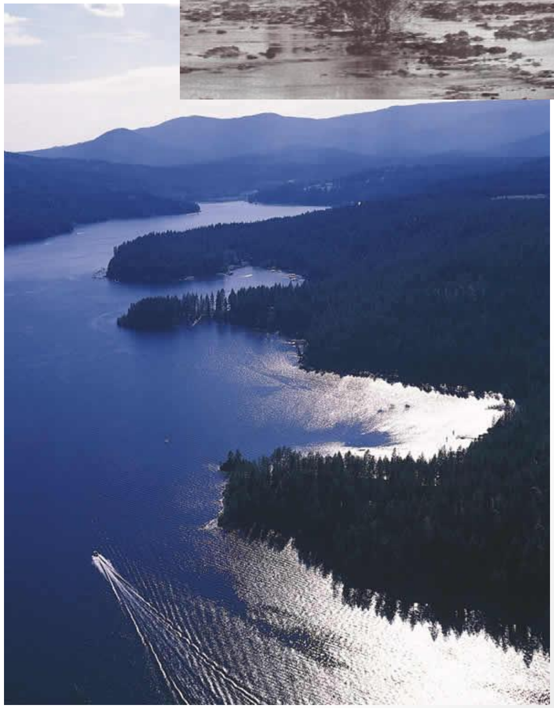
Lake Management Program Overview

- Historical mining practices contributed over 75 million metric tons of lead, zinc, cadmium, and arsenic contaminated sediments to Cd'A Lake
  - Runoff from Cd'A River continues to transport this sediment to the lake
- Lake Management Program developed and implemented as an alternative to U.S. EPA action under CERCLA



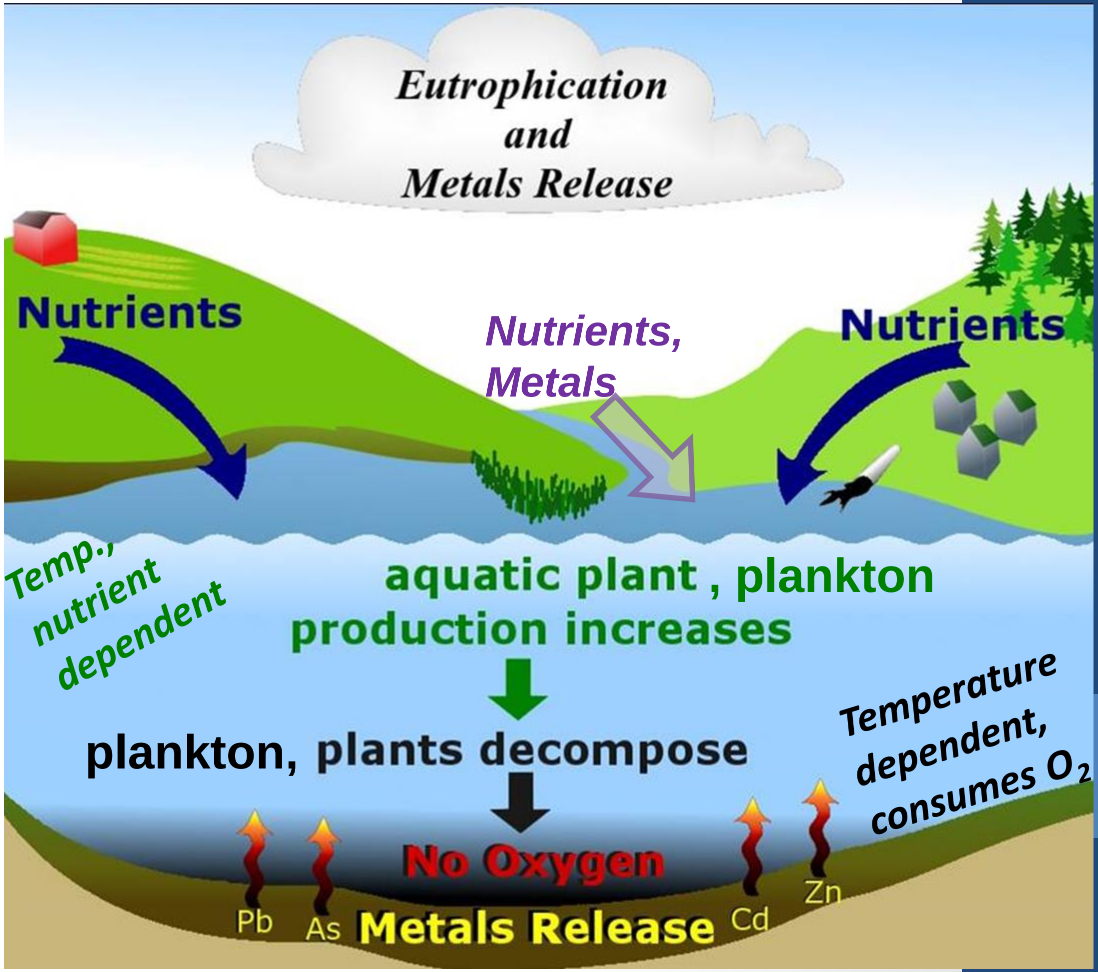
- **Program Objective**

  "To protect and improve lake water quality by *limiting basin-wide nutrient inputs* that impair lake water quality conditions, which in turn *influence the solubility of mining-related metals contamination* contained in lake sediments."

- Approach involves *science*, *monitoring*, *nutrient reduction projects*, *education*, *outreach*, *regional collaboration*

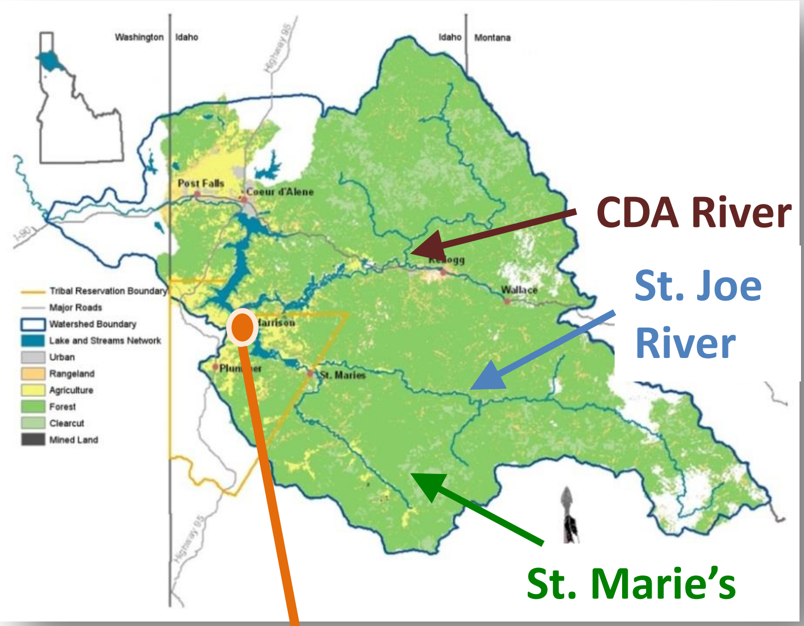
Nutrients, Metals, and Lake Metabolism

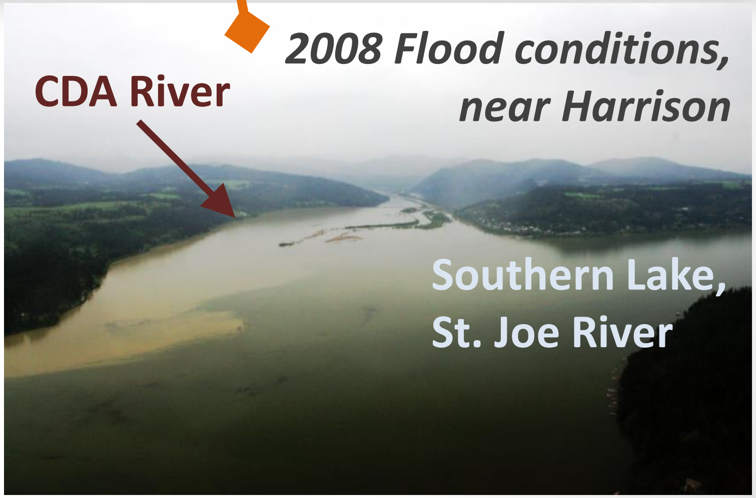
- Coeur d'Alene Lake has a complex metabolic system
- Metabolism revolves around nutrients, carbon, oxygen
- Lake metabolism impacts metal cycling
  - Uptake into plankton, biota
  - Cycling between lake "areas"
  - Deposition to sediments
  - Release from sediments
- Metals and metabolism constrain aquatic life
  - **Lower O_2**: increase levels of dissolved metals, harm fish
  - **Higher metals**: reduces overall lake productivity
  - *Higher O_2 and lower metals improves lake health*



Cd’A Lake’s Metabolism is Strongly Influenced by Three Rivers

- Most metals and nutrients enter the lake via St. Joe, St. Marie’s and Cd’A rivers
  - Lake functions as a sink for metals and nutrients
  - Buffers nutrient and metal input to the Spokane River
  - Extent of retention within the lake varies with:
    - ***time*** (seasonal, inter-annual)
    - ***chemical constituent***
- Smaller inputs from
  - Atmospheric deposition
  - Smaller creeks, streams
  - Near-shore development
  - Transport from sediments to overlying water *(benthic flux)*

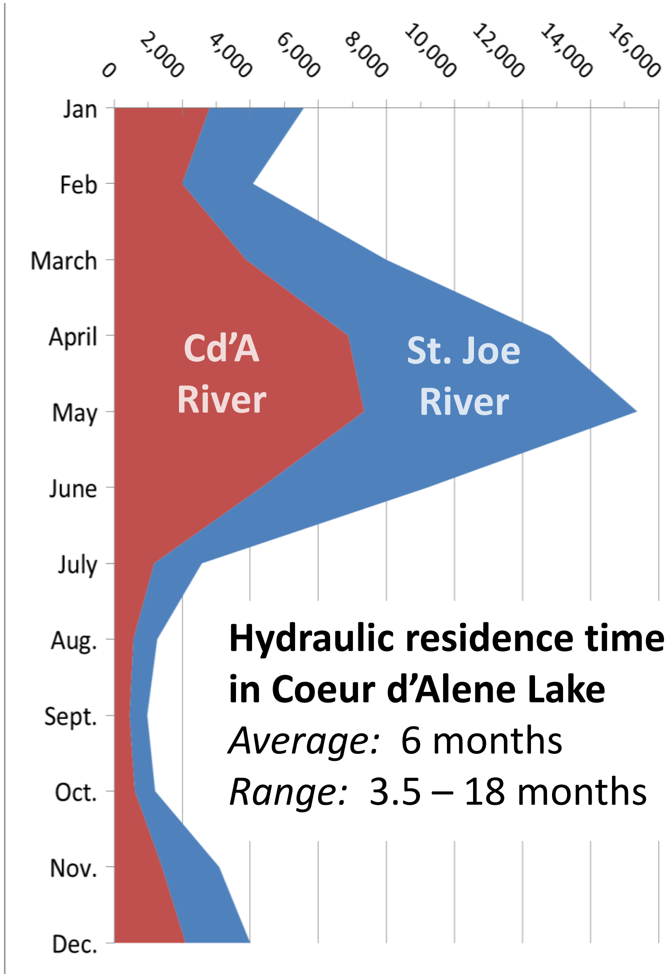




Variable River Flow and Loading

- Graphic is of **average** monthly flow on Cd'A and St. Joe Rivers
- Large variance in average monthly flow rates over the course of a year.
- Highest average flow ~April - May
- During run-off periods (Feb – June), flow levels can vary dramatically from year to year

Average Monthly River Discharge (cubic feet / sec)



Hydraulic residence time in Coeur d'Alene Lake
Average: 6 months
Range: 3.5 – 18 months

Variable River Flow and Loading

Four Trends in Nutrient, Metal Loading

Constituent	Time Period	Average Load In (tons/yr)	Average Load Out (tons/yr)	Average % retained
Total Phosphorous ~40-60%	1975	198	--	--
	CY 1991	103	53	49%
	CY 1992	43	28	35%
	WY 2004-06	117	45	62%
	WY 2009-13	--	--	--
Total Nitrogen ~10-20%	1975	3,748	--	--
	CY 1991	2,325	1,929	17%
	CY 1992	1,050	854	19%
	WY 2004-06	468	406	13%
	WY 2009-13	--	--	--
Total Lead ~85-95%	CY 1991	575	75	87%
	CY 1992	89	15	83%
	WY 2004-06	139	6.3	95%
	WY 2009-13	*400*	*18*	*95%*
Total Zinc ~25-45%	CY 1991	1,097	714	35%
	CY 1992	532	357	33%
	WY 2004-06	519	288	45%
	WY 2009-13	*460*	*350*	*25%*
Total Cadmium ~40-60%	CY 1991	9.8	6.3	36%
	CY 1992	4.6	2.8	39%
	WY 2004-06	3.2	1.2	62%
	WY 2009-13	--	--	--

From 1970's – 1990's, N & P loading appears to have ***decreased*** by 40% -- 60%

Between any two consecutive years, loading for a given constituent can vary by a factor of 2 – 6

Multi-year trends in loading can go in different directions *(e.g, ~2005 -- ~2011 Zn decreases, Lead increases)*

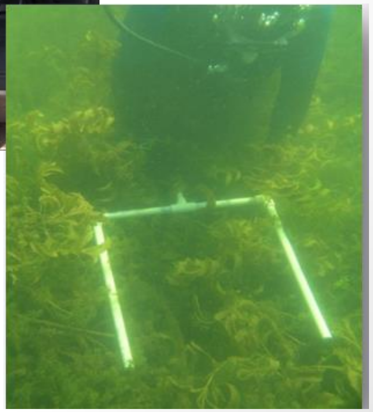
Lake's ability to retain constituents is generally consistent across years *(does vary by constituent)*

Percentages are proportion of inflows retained in Cd'A Lake, mass is US short tons

Science: Objectives of Lake Monitoring

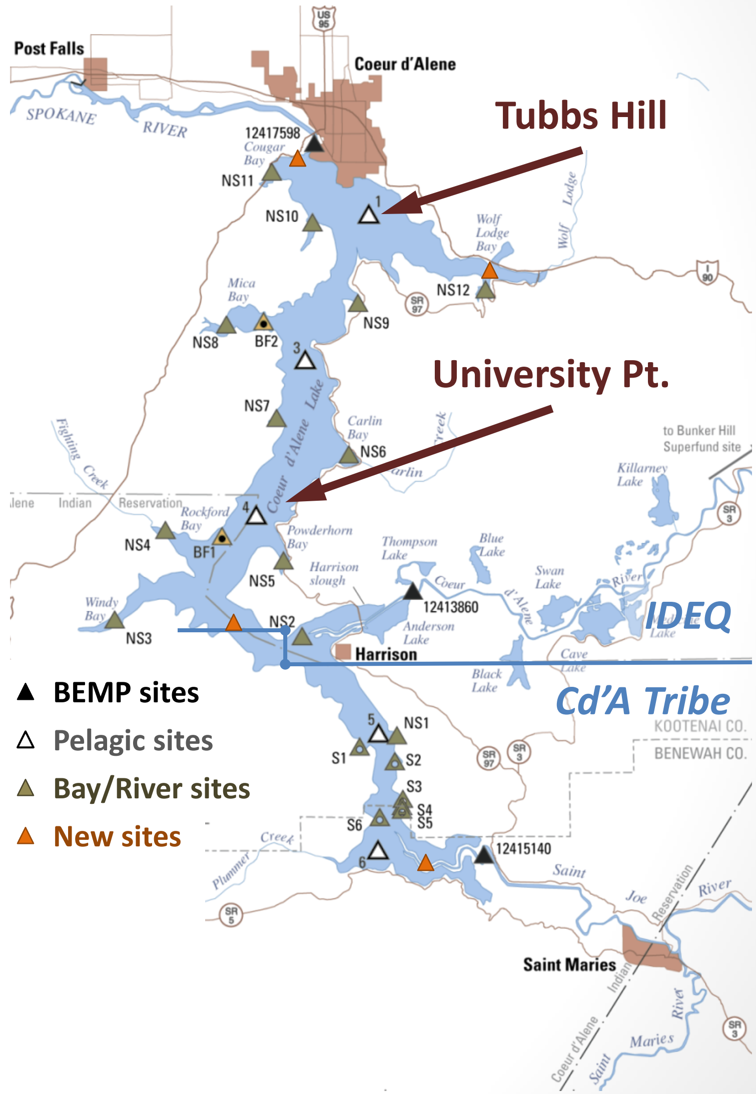
- **Science Program Objectives**
  - Assess lake health relative to:
    - *historic trends*
    - *regional benchmarks*
  - Identify “good” and “bad” trends
  - Diagnose causes of trends, and impacts to the lake community
  - Evaluate management options
  - Provide high quality, actionable information to public stakeholders
- **What criteria do we evaluate?**
  - *Lake Health*: water quality criteria, food web structure and dynamics, incidence of harmful algae blooms and invasive species
  - *Causative factors*: metals, nutrients, pH, temperature, O_2, chemical and biological indicators, weather, lake physics, land use patterns

Note: *also monitor nutrient loading in regional watershed*



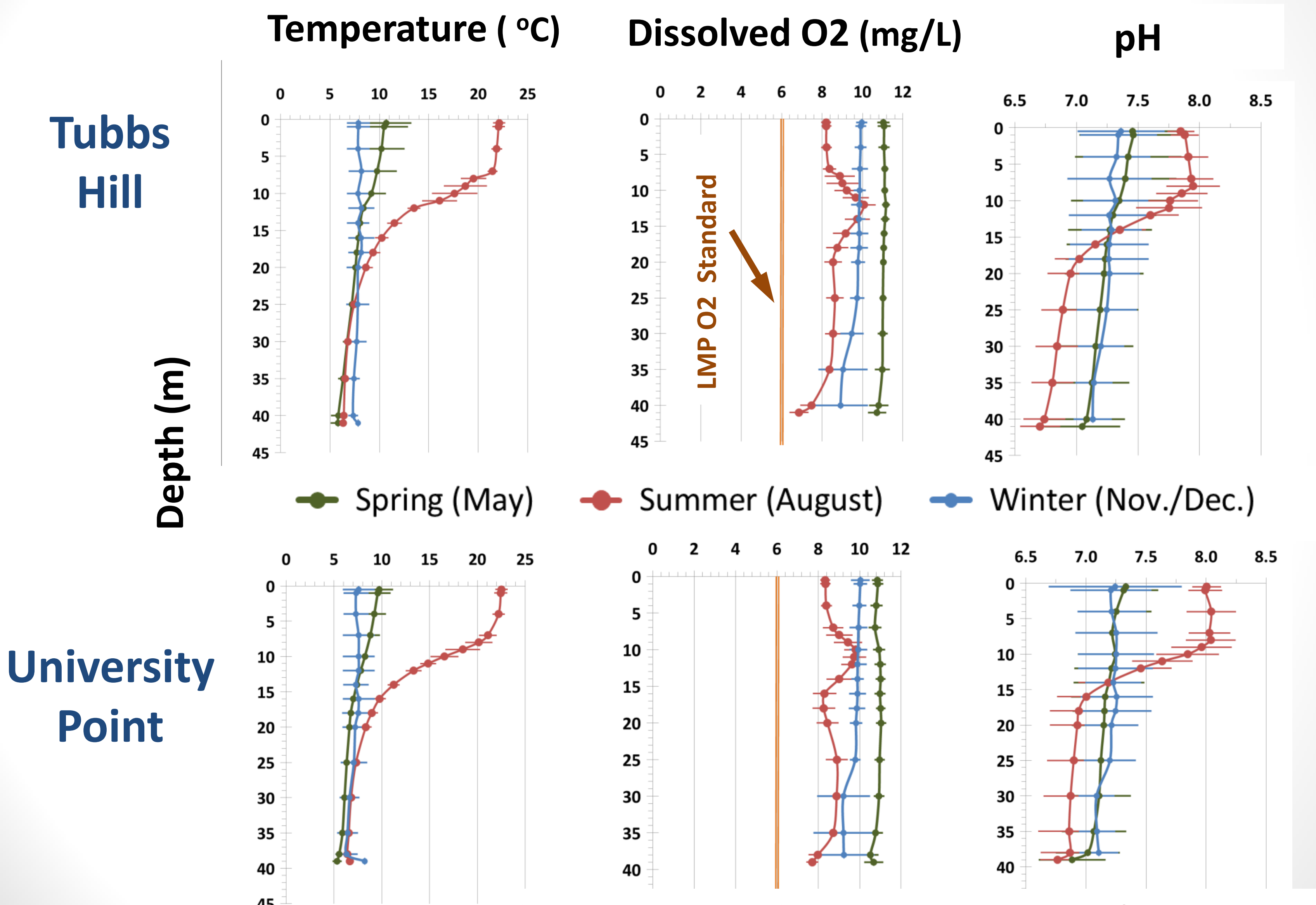
Monitoring: Cd'A Lake Sampling Sites

- Monitoring Sites
  - 8 Pelagic sites (3 rotational)
  - All bays in northern lake (rotational, not all shown)
  - Anoxic "hole" near Cougar Bay
  - ~8 times/yr, multiple depths
- Monitoring Parameters
  - *General*: O_2, pH, Temperature, Chl-a, turbidity, conductivity
  - *Nutrients*: Total, Dissolved Nitrogen and Phosphorous
  - *Metals*: Total, Dissolved As, Cd, Fe, Pb, Mn, Zn (also Ca, Mg)
  - *Biologic*: plankton, bacteria, and benthic vegetation
  - Other parameters as needed



Cd'A Lake Sampling Sites -- Photos

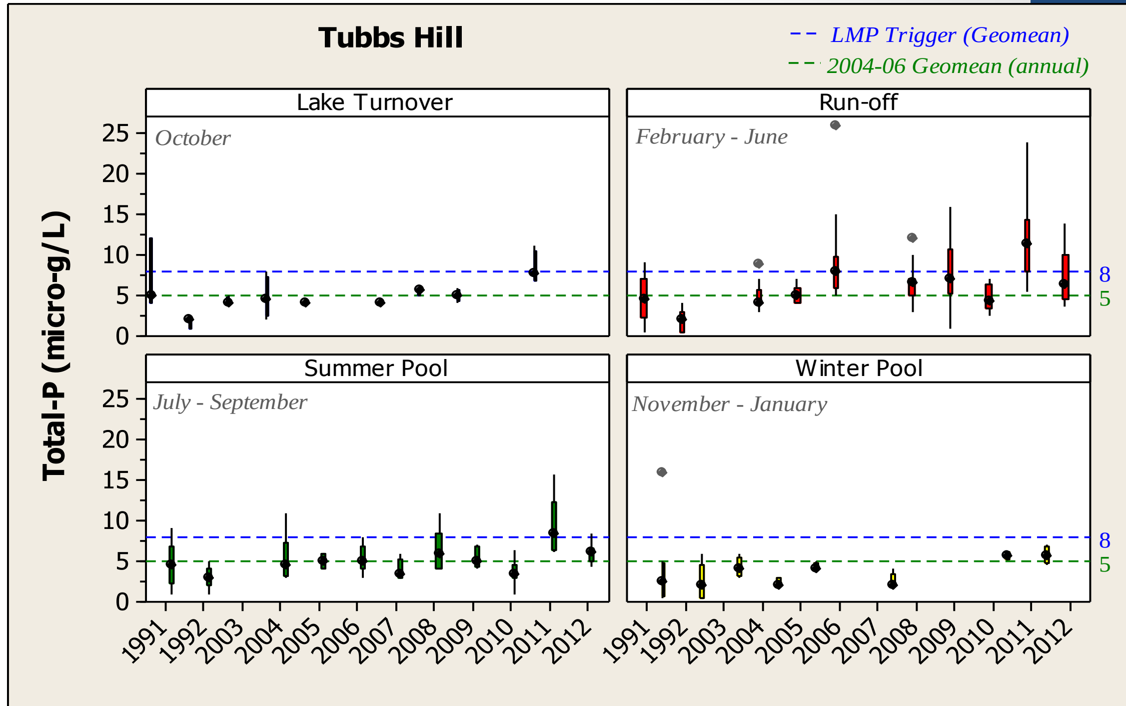
Monitoring: General Chemistry, Physics

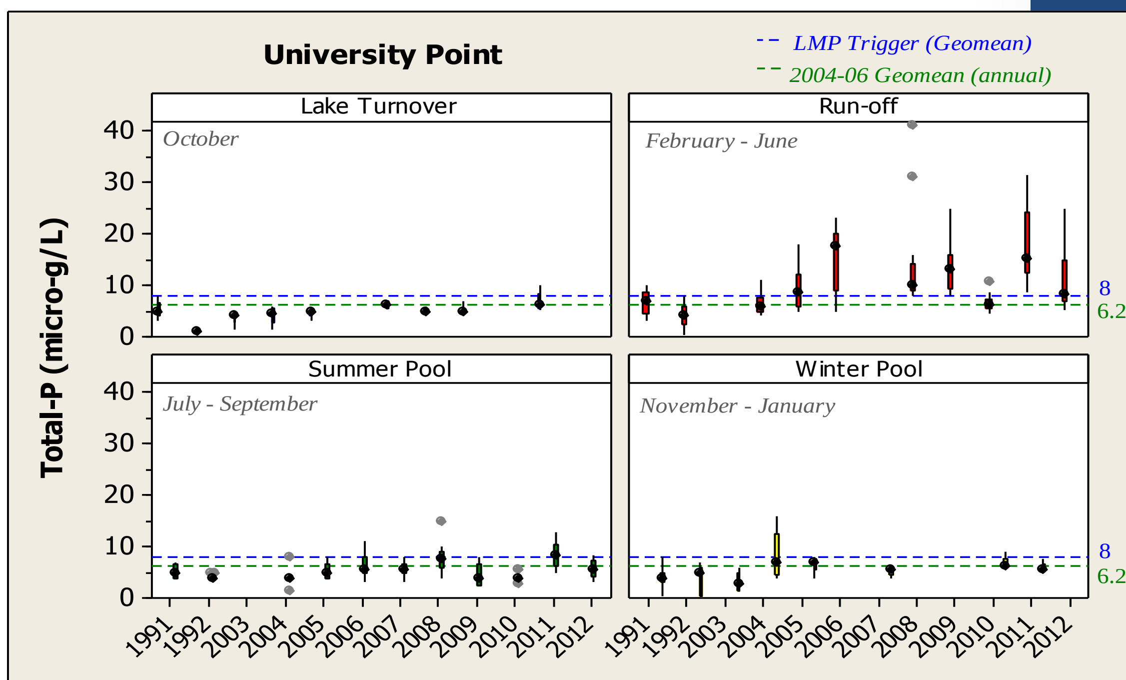


Plotted Values are the Average and 95% C.I. for 2007 - 2013

Total Phosphorous

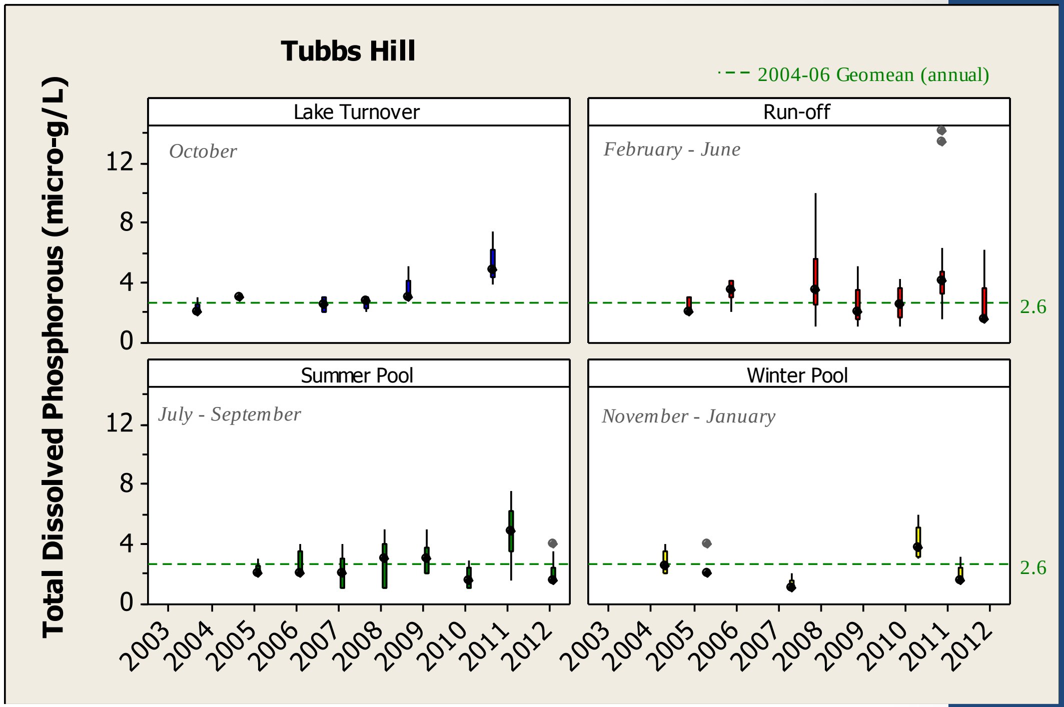
- Data are for *1991 – 2012*
- Total-P levels highly variable
  - Year to year, seasonally, place to place
- General Trends
  - Highest in spring run-off, and closer to rivers
  - Levels drop by summer, remain low thru winter
  - Trend of *increasing* total-P during spring run-off
  - Annual Mean ~ 6 – 9 ppb
  - Annual Max ~10 – 25 ppb

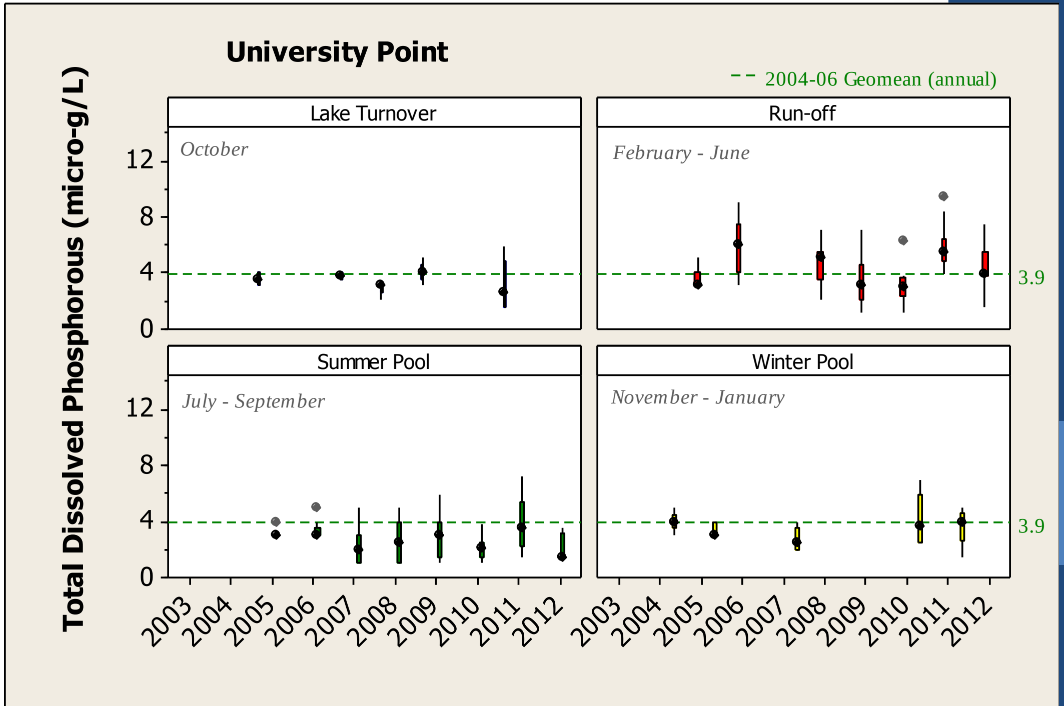




Total Dissolved Phosphorous

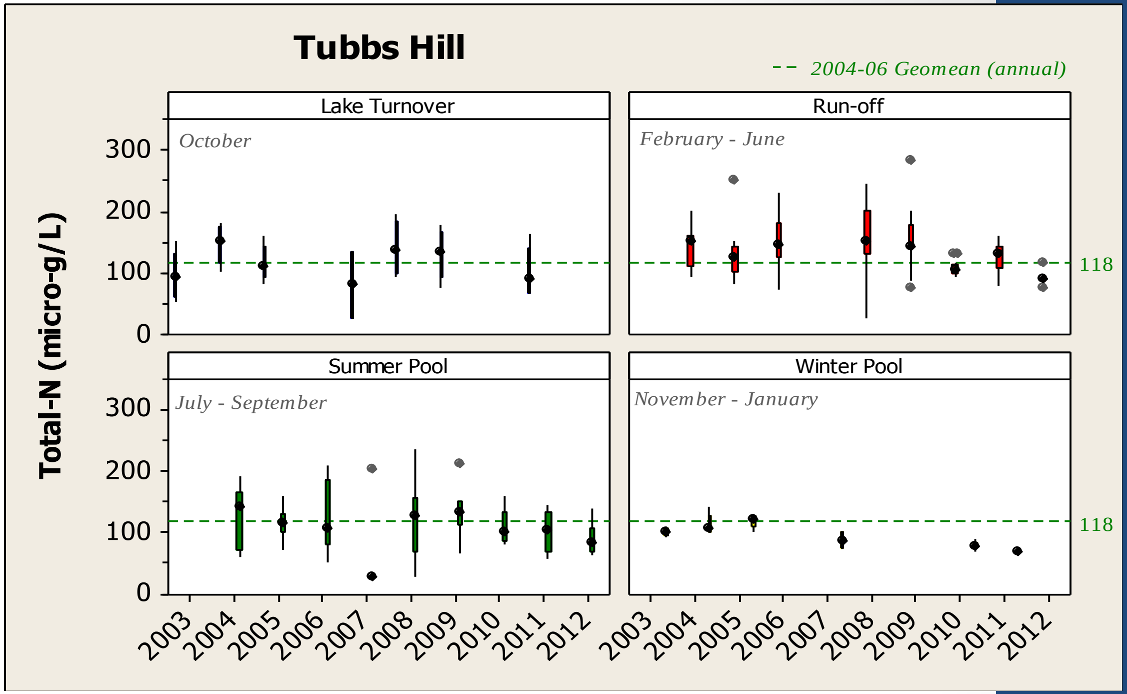
- Data are for *2004 – 2012*
- Total Dissolved-P less variable
  - ~50% of Total-P
  - Soluble Reactive Phosphorous (strongly reactive subset of TDP) below detection limits
- General Trends
  - Highest in spring run-off, and closer to rivers
  - Levels drop somewhat by summer, low thru winter
  - *No inter-annual trend* in TDP
  - Annual Mean ~ 3 – 5 ppb
  - Annual Max ~6 – 8 ppb

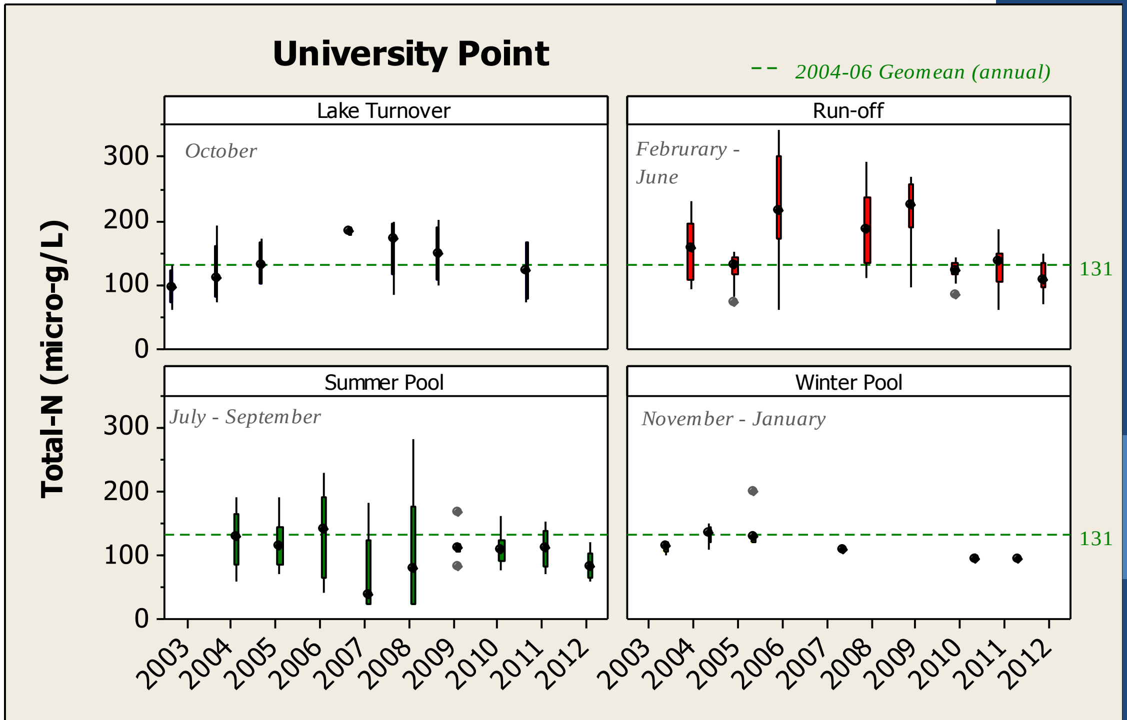




Total Nitrogen

- Data are for *2003 – 2012*
- Some variability in Total-N
  - ~Consistent year-to-year
  - Some seasonal fluctuations
- General Trends
  - Highest in spring, declines thru summer, lowest in winter
  - Trend of *decreasing* total-N
  - Before 2009:
    - Mean ~100 – 150 ppb
    - Max ~200 – 300 ppb
  - After 2009:
    - Mean ~85 – 115 ppb
    - Max ~140 – 160 ppb

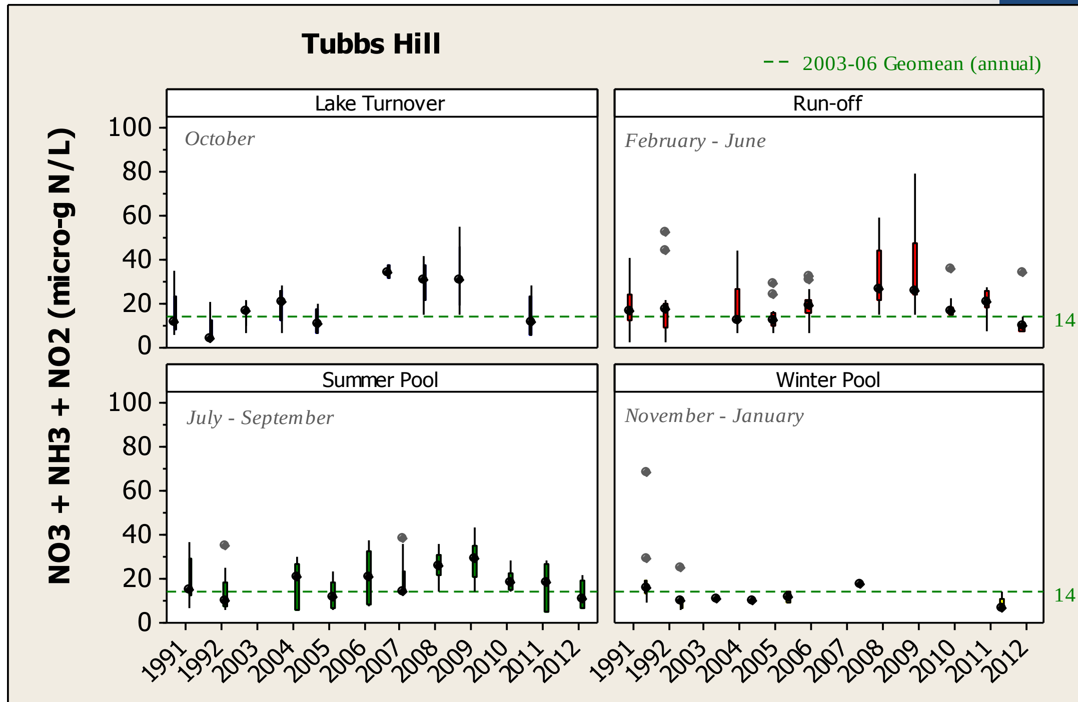


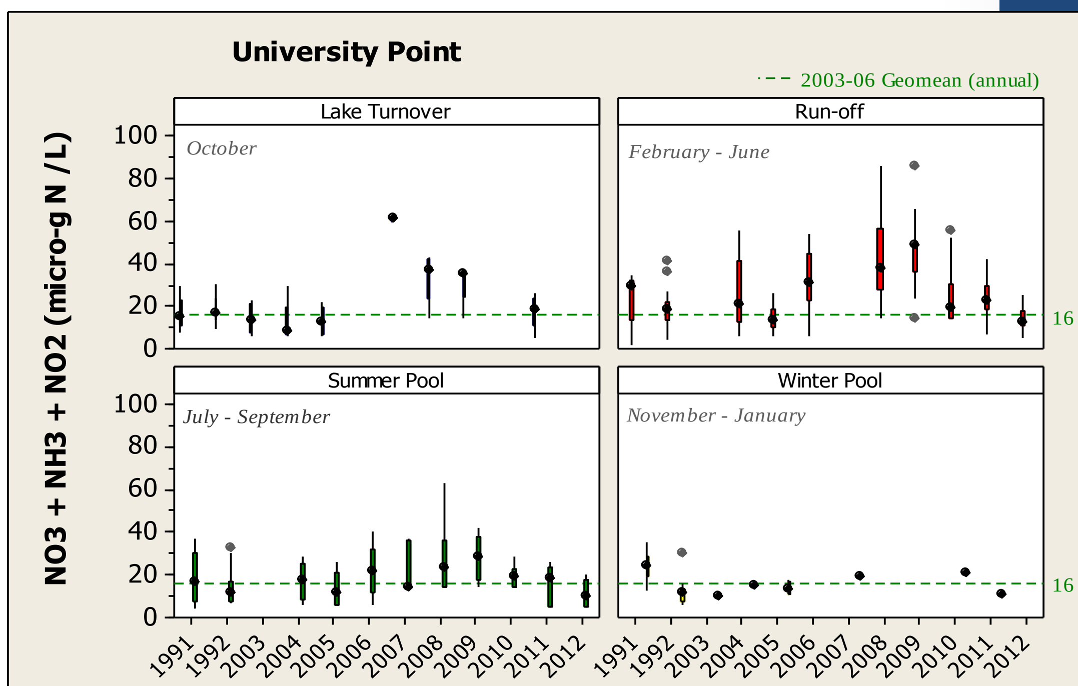


Nitrogen Ions

($NH_3 + NO_3 + NO_2$)

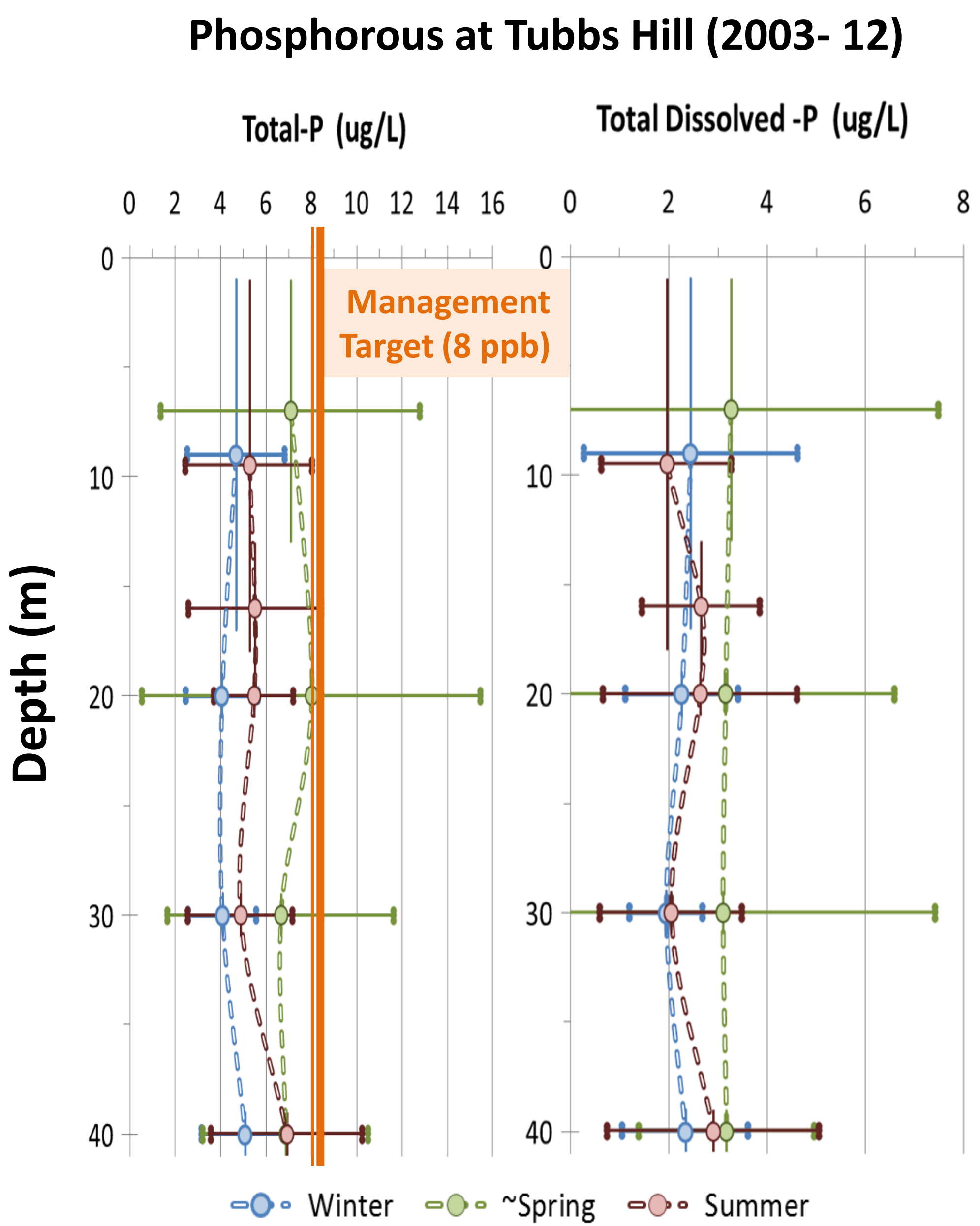
- Data are for *1991 – 2012*
- Mostly NO_3^-, ~20% of Total-N
- Time trends similar to Total-N
- General Trends
  - Highest in spring, declines thru summer, lowest in winter
  - Trend of *decreasing* N-ions
  - Before 2009:
    - Mean ~20 – 30 ppb
    - Max ~50 – 80 ppb
  - After 2009:
    - Mean ~10 – 15 ppb
    - Max ~30 – 50 ppb





Science: So, What Does This All Mean?

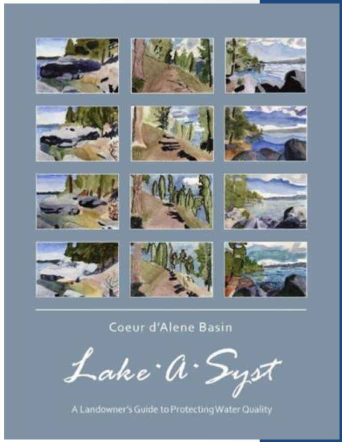
- **Nutrient levels are variable.**
  - Seasonal *(highest in **Spring**)*
  - Inter-annual *(high/low flow years)*
  - ***Plan around dynamic background inputs to the Spokane River***
- **Lake functions as a "buffer system" for the Spokane River**
  - Lake processes capture nutrients within sediments and biota
  - Metal contamination inhibits the lake's biologic systems
- **Limited capacity to absorb nutrients**
  - ***Physical***: residence time, land-use in watershed
  - ***Biogeochemical:*** lake ecosystem, sediment chemistry, contaminants
  - ***System appears to be improving***



Implementation: What are we "Doing"?

- Helping build a regional collaborative
- Public Education – at all levels
  - ***K-12***: Classrooms, teacher education, regional fairs, boy scouts, girl scouts
  - ***University***: interns, collaborative R&D
  - ***Adult***: distribute educational materials
- Engaging and informing partners
  - ***Agencies***: federal, state, local
  - ***Interest Groups***: property owners, environmental, economic, outdoor
- Facilitating restoration and "riparian improvement" projects
  - *Bank Stabilization*
  - *Storm water management*

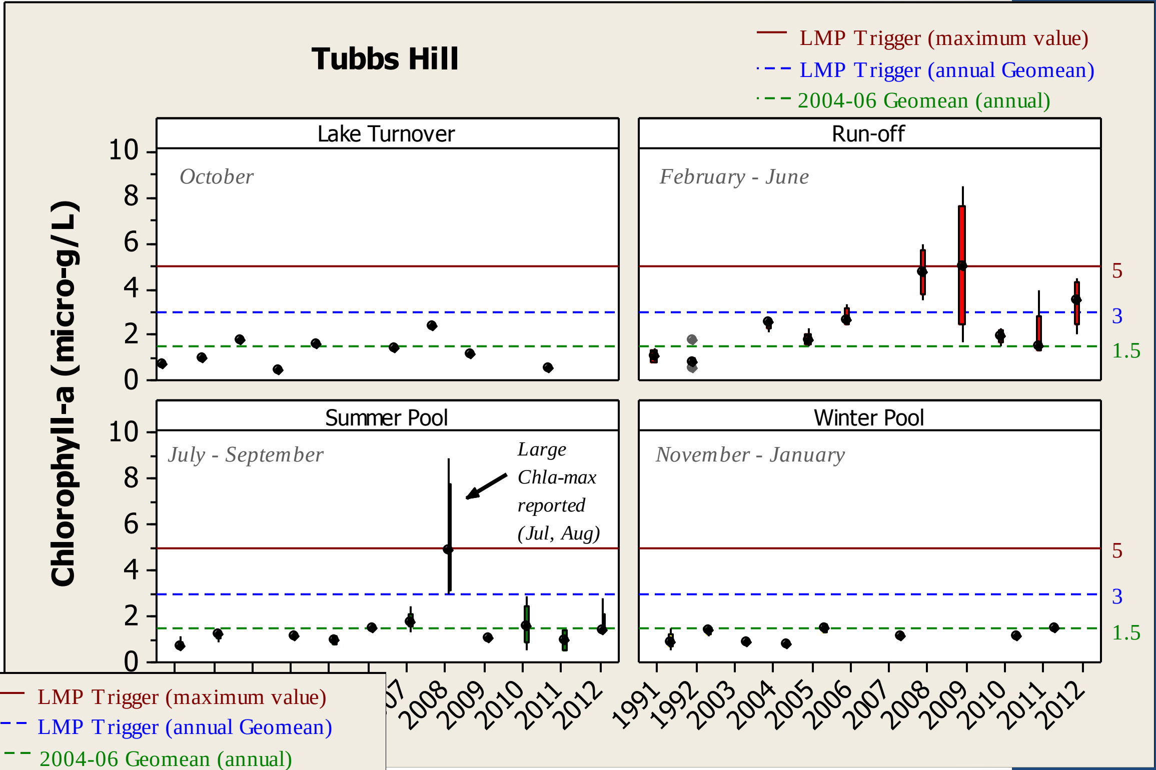
Our Gem
Coeur d'Alene Lake Collaborative

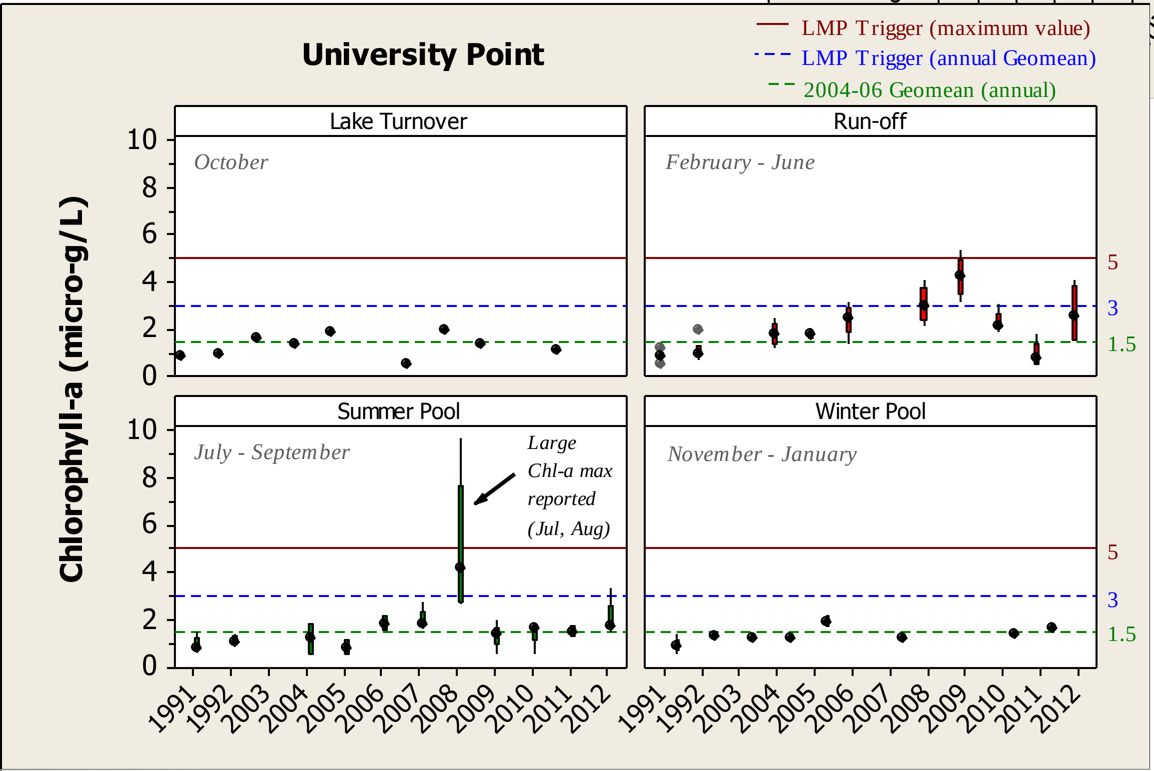


Restoration Partnership


Our Team
Glen Petit
Bob Witherow
Jamie Brunner
Laura Laumatia
Dale Chess
ID 1922 AT
Craig Cooper
EVINRUDE

Chlorophyll



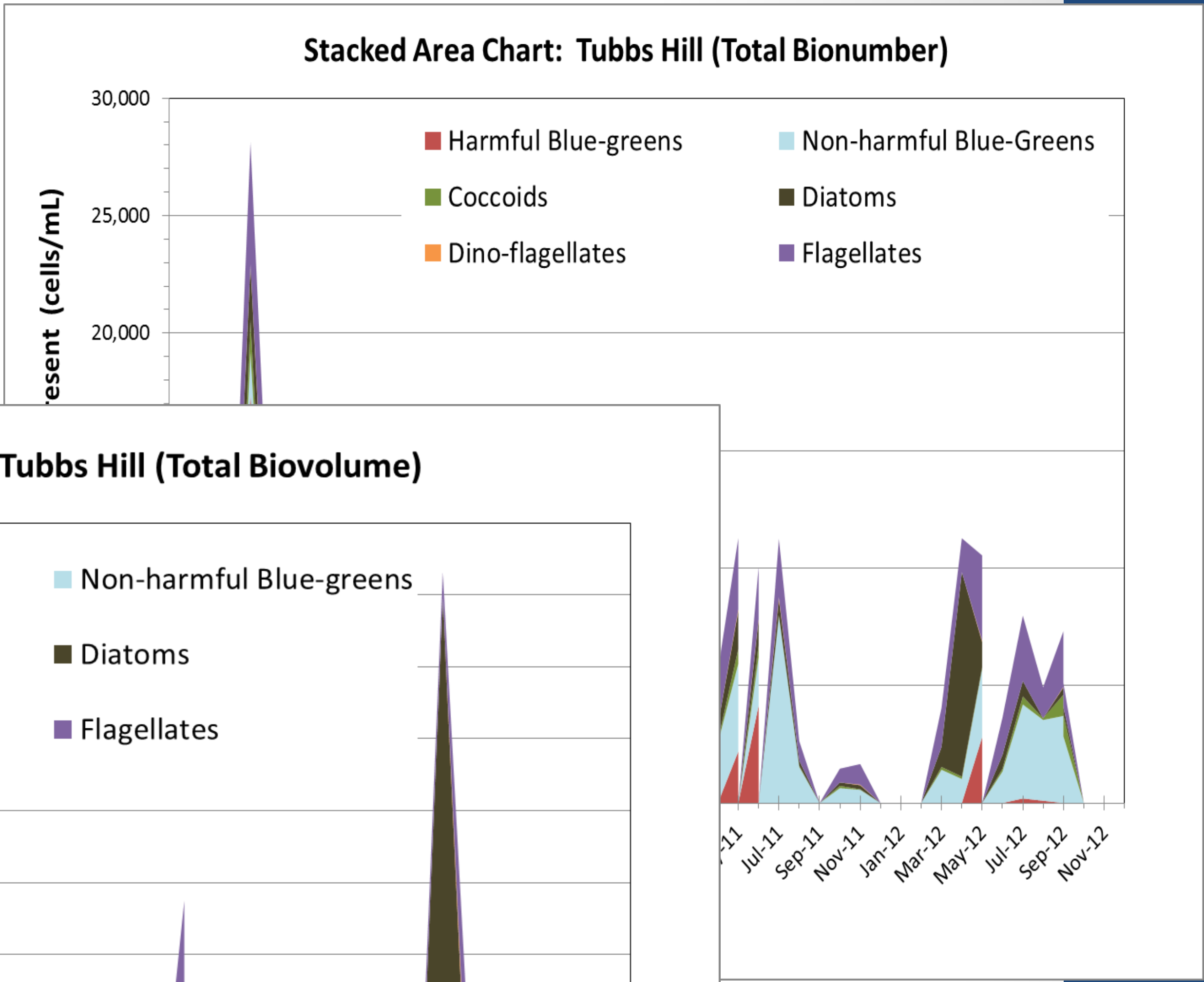


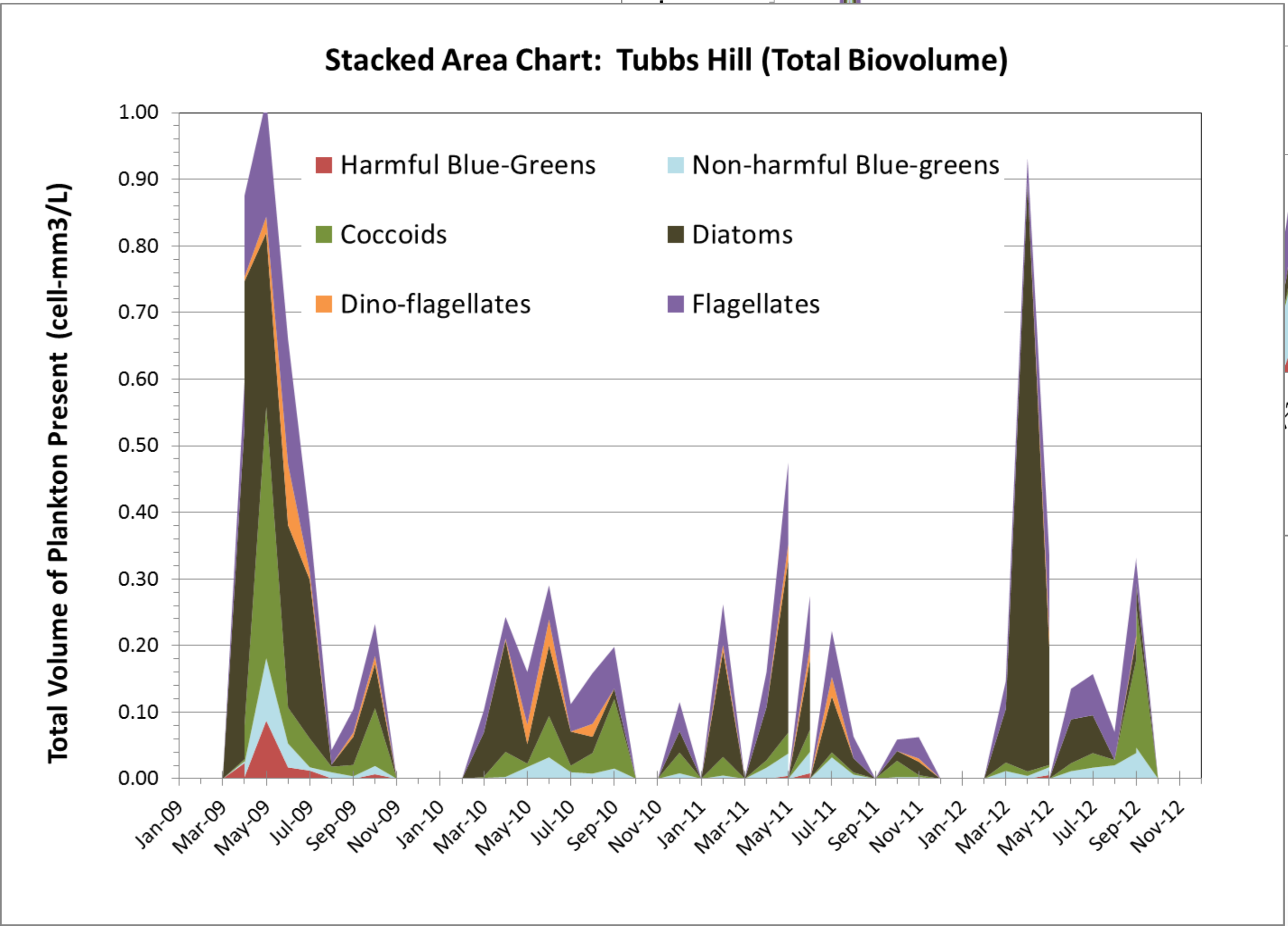
Secchi Disc Depth (clarity)

Secchi Disc July – Oct. (Tubbs Hill)	Total Samples Collected	Geometric mean (m)	Mean (m)	95% C.I.
1991	5	8.2	8.3	1.8
1992	5	8.4	8.5	2.3
2003	2	--	8.7	--
2004	3	8.8	8.8	--
2005	3	9.4	9.4	--
2006	2	--	9.9	--
2007	4	10.5	10.5	2.0
		9.3	9.4	--
		9.5	9.6	--
		9.9	10.1	--
		9.9	10.2	--
		8.9	9.1	--

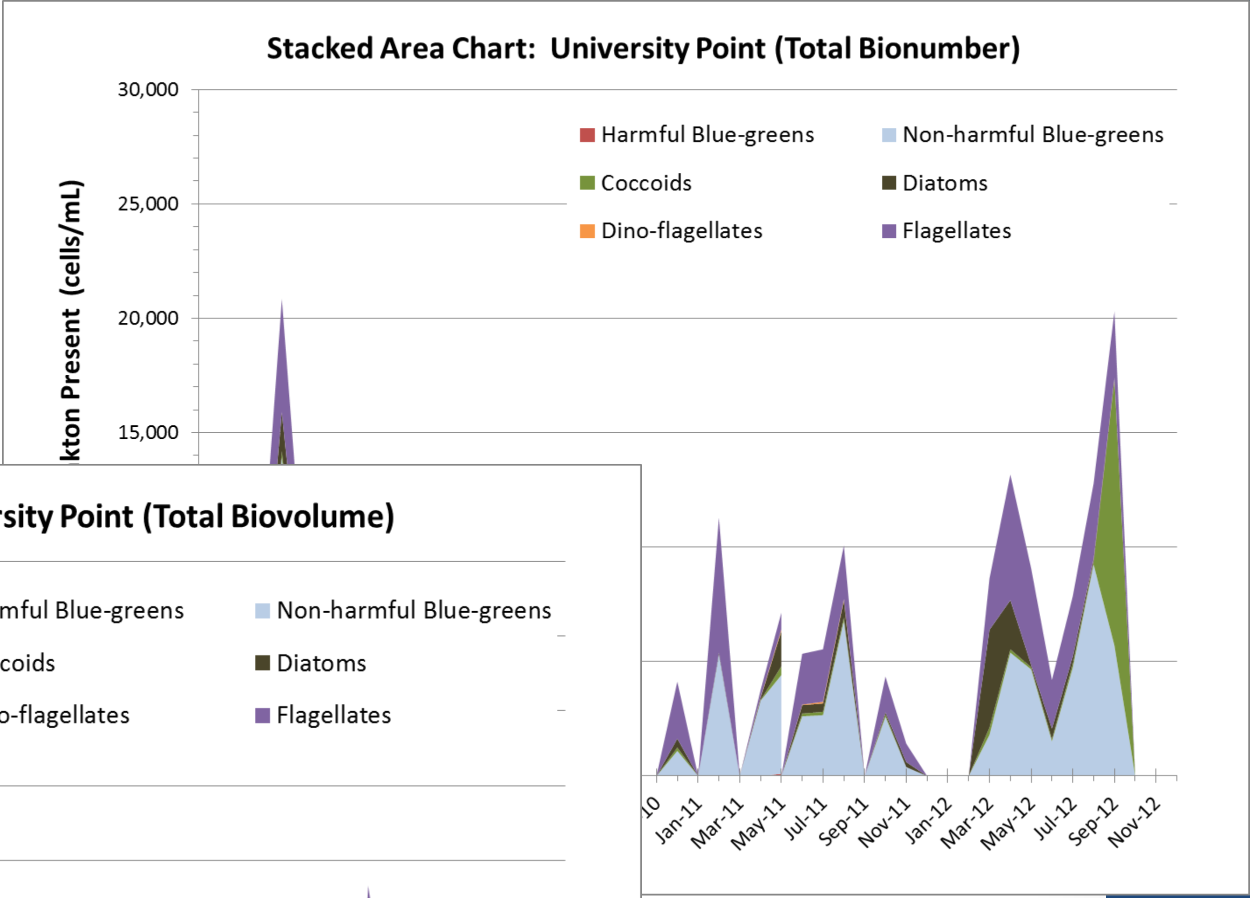
Secchi Disc July – Oct. (Univ. Point)	Total Samples Collected	Geometric mean (m)	Mean (m)	95% C.I.
1991	5	7.6	7.8	2.3
1992	5	7.8	7.8	0.6
2003	1	--	8.5	--
2004	3	7.5	7.5	--
2005	3	10.1	10.2	--
2006	2	--	8.5	--
2007	4	9.3	9.4	3.3
2008	3	7.5	7.6	--
2009	3	10.0	10.1	--
2010	3	8.6	8.8	--
2011	3	8.3	8.8	--
2012	3	8.4	8.5	--

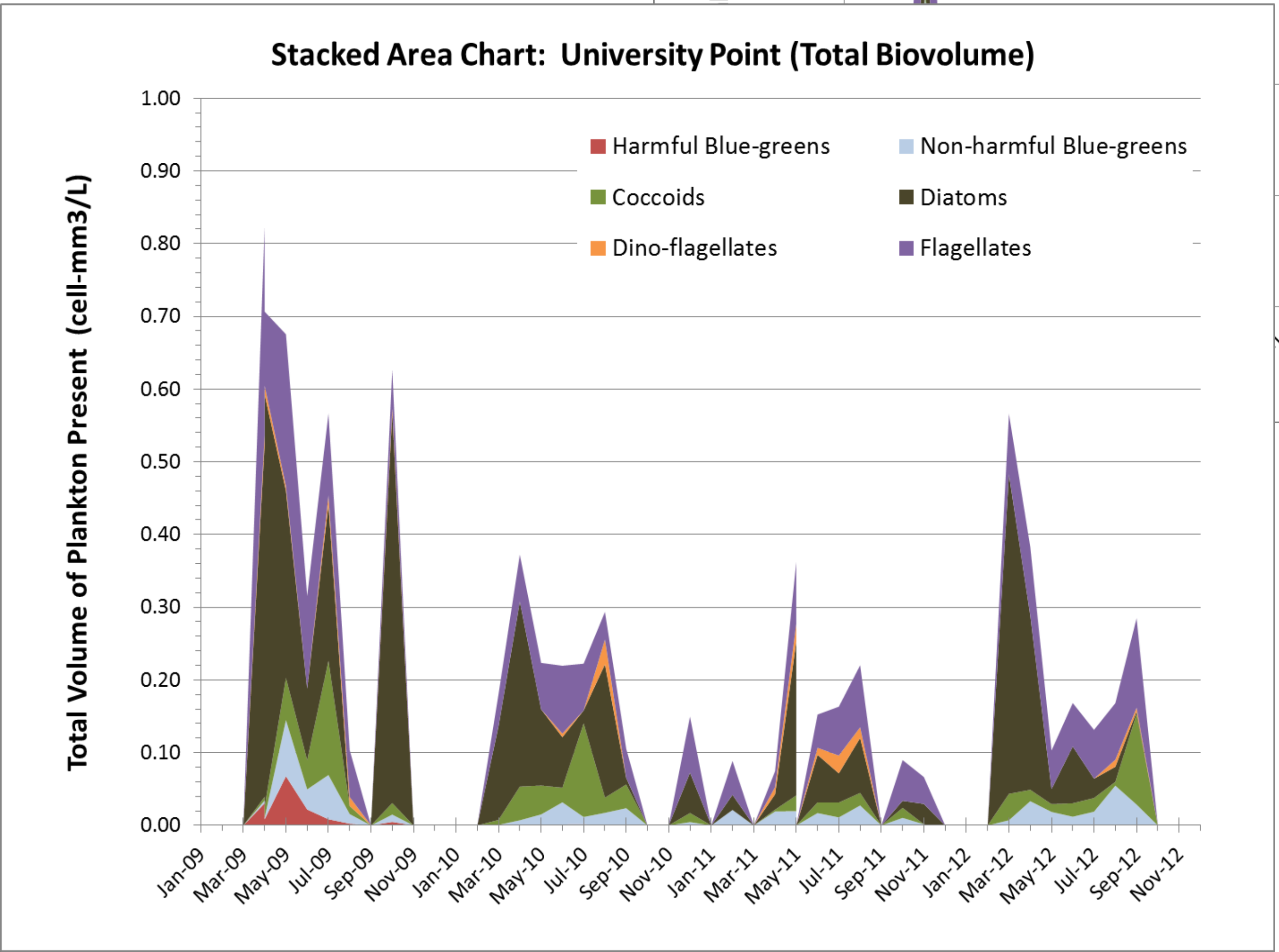
Phytoplankton Tubbs Hill



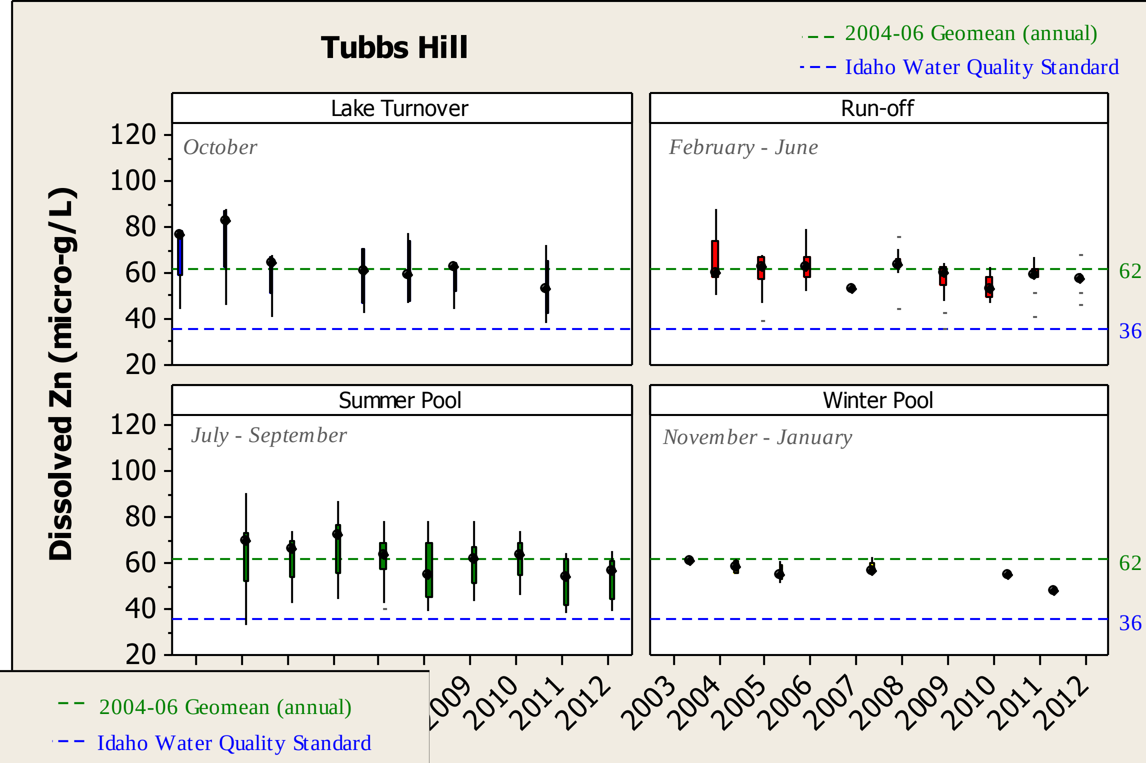


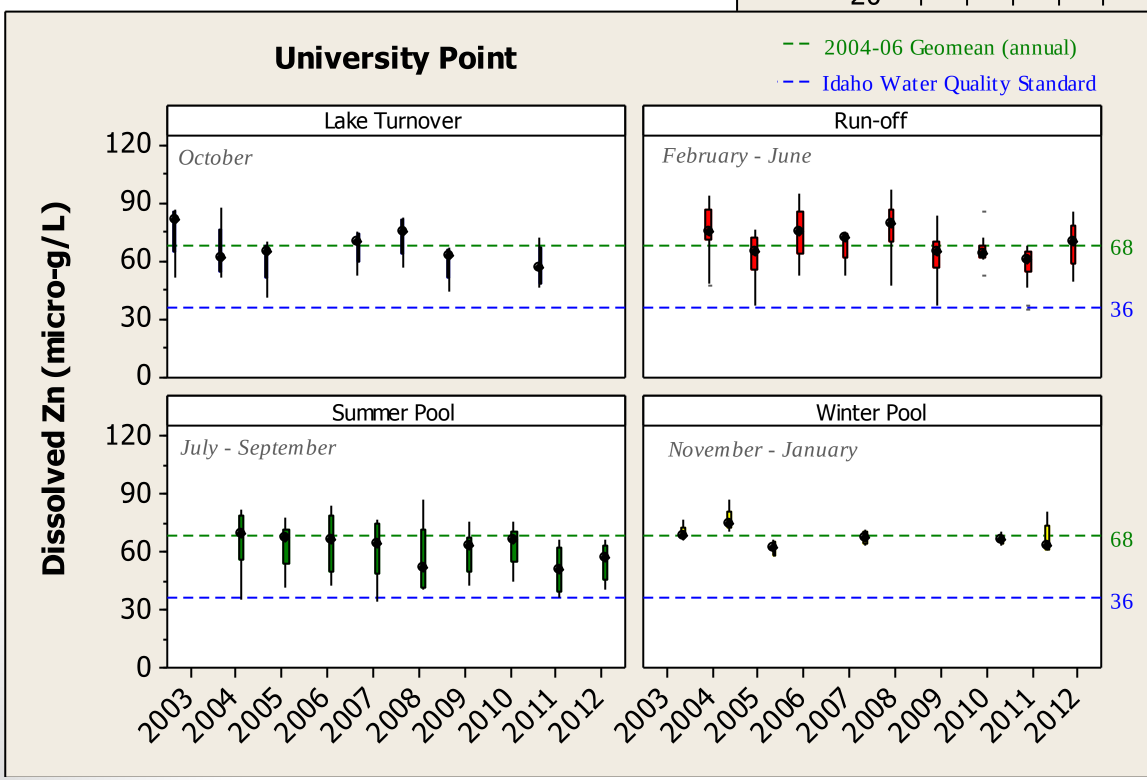
Phytoplankton University Pt.



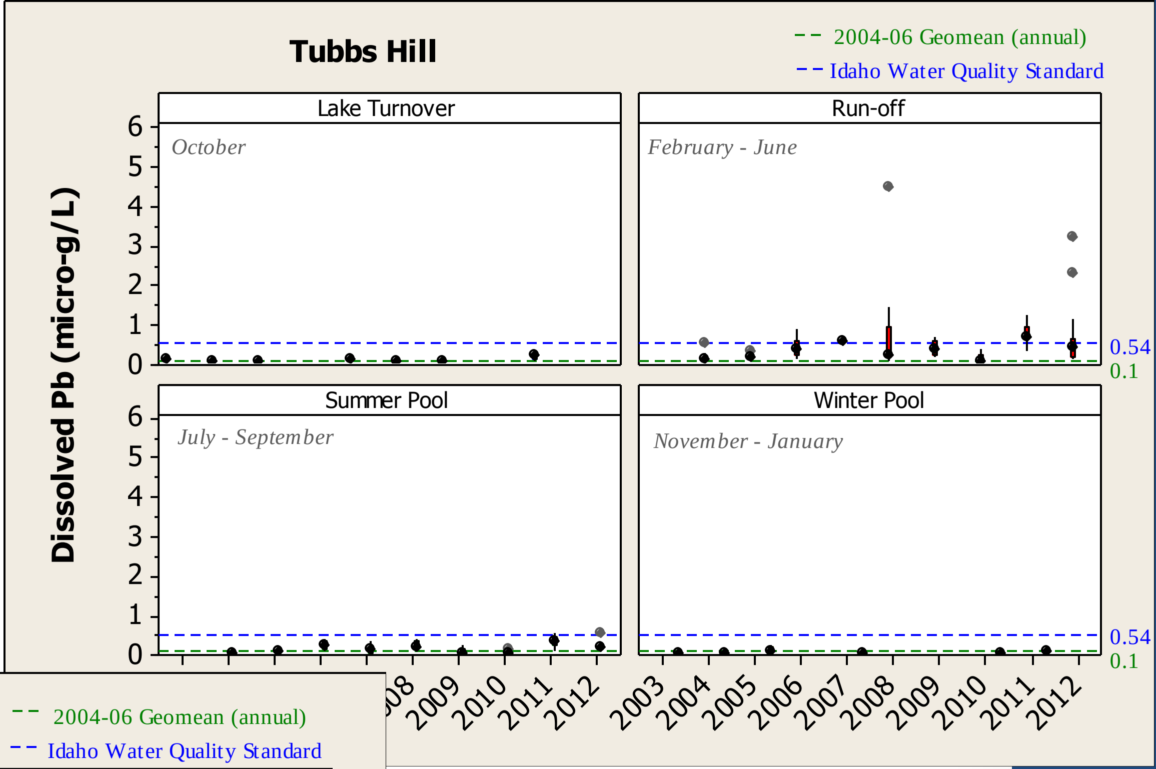


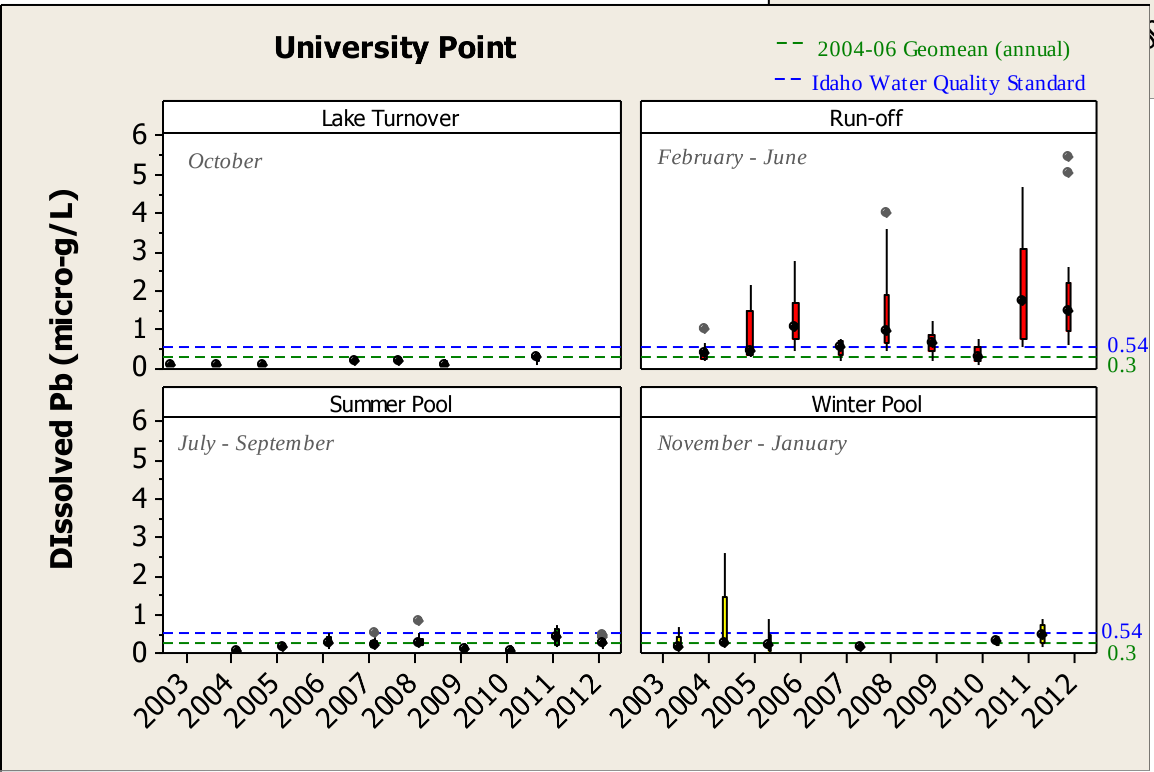
Dissolved Zinc





Dissolved Lead





Dissolved Cadmium