University of New Hampshire

GREEN MOUNTAIN CONSERVATION GROUP

NEW HAMPSHIRE WATER RESOURCES RESEARCH CENTER
NH WRRC

OSSIPEE WATERSHED: TEN YEARS OF WATER MONITORING

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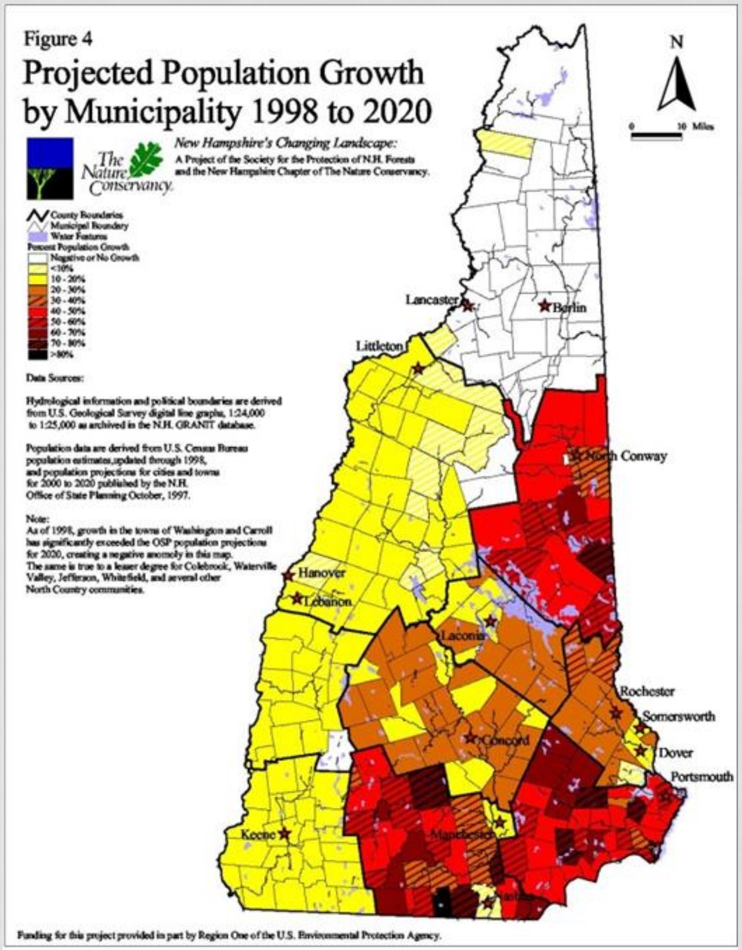
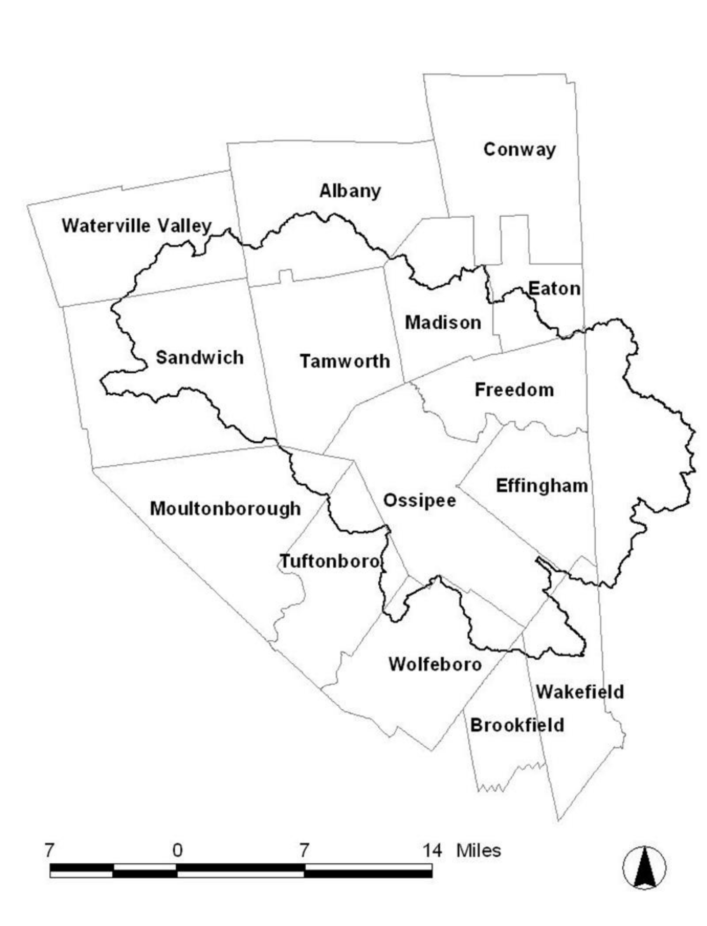
GROWING POPULATIONS: POTENTIAL THREAT TO WATER RESOURCES

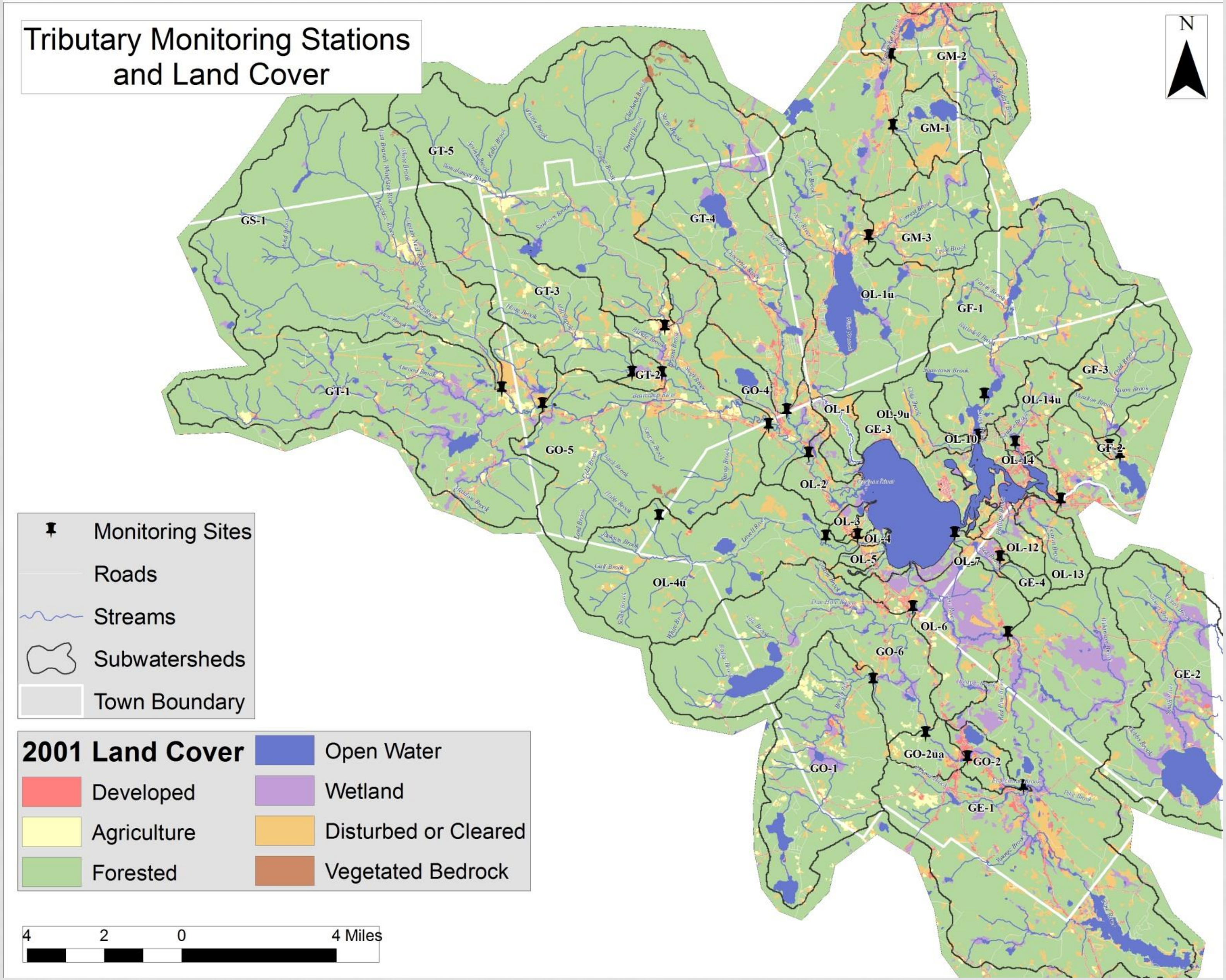


- NH is the fastest growing state in New England
  - Twice as fast as any other New England state
- Potential inputs
  - Nitrogen
    - Septic systems, animal waste
    - Fertilizer
    - Atmospheric deposition
  - Phosphorus
    - Septic systems
    - Fertilizers and detergents
    - Erosion/sediment
  - Sodium and Chloride
    - Road salt

OVERVIEW OF WATERSHED

- Subwatershed of the Saco River Basin
- Drains into the Saco River, through Maine and into the Atlantic Ocean
- Located in 14 towns





Tributary Monitoring Stations and Land Cover
N
GM-2
GM-1
GT-5
GS-1
GT-4
GM-3
OL-1u
GT-3
GF-1
GT-1
GT-2
GO-4
GF-3
OL-1
OL-9u
OL-14u
GE-3
OL-10
GO-5
OL-14
GF-2
OL-2
OL-3
OL-4
OL-5
OL-7
OL-12
OL-13
GE-4
OL-4u
OL-6
GO-6
GE-2
GO-2ua
GO-2
GO-1
GE-1
Monitoring Sites
Roads
Streams
Subwatersheds
Town Boundary
2001 Land Cover
Developed
Agriculture
Forested
Open Water
Wetland
Disturbed or Cleared
Vegetated Bedrock
4
2
0
4 Miles

SITE CATEGORIES ACCORDING TO SAMPLING REGIME

- Summer
  - 10 sites, 1-4 years
  - 8 sites, 5-9 years
- Apr-Oct
  - 8 sites, 1-4 years
  - 5 sites, 7-8 years
  - 5 sites, 10 years
- Year round
  - 7 sites, 8-10 years, year round since 2004 (April-Oct prior to 2004)
  - 2 sites, 7 years, year round since 2009 (summer only prior to 2009)

Site Name

Site Group		Frequency
5-9 yrs Summer	OL-10	19
	OL-13	34
	OL-1u	29
	OL-2	23
	OL-4u	25
	OL-5ua	18
	OL-7	60
	OL-9u	27
		235
7-8 yrs April-Oct	GF-2	79
	GM-2	86
	GM-3	100
	GO-4	76
	GT-5	85
		426
10 yrs April-Oct	GE-1	122
	GE-2	120
	GF-1	108
	GO-1	122
	GT-1	123
		595
8-10 yrs, year round 2004	GE-3	137
	GF-3	137
	GM-1	158
	GO-2	148
	GO-5	123
	GS-1	149
	GT-4	132
		984
7 yrs, year round 2009	OL-12u	69
	OL-14u	61
		130

SUMMER 5-9 YEARS

- OL-1u: West Branch River, Freedom
- OL-10: Hutchins Pond Outflow
  - Interest in understanding potential impacts from the wetland, horse farm, campground, and ski area
- OL-13: Leavitt Brook, Effingham
- OL-2: Bearcamp River
- OL-4u: Lovell River, Ossipee
- OL-5ua: Weetamoe Brook, Ossipee
- OL-7: Red Brook
  - Crosses RT 25
- OL-9u: Cold Brook, Freedom

APR-OCT 7-8 YEARS

- GF-2: Cold River, Freedom
  - Located in downtown Freedom where the river flows under the Maple Street Bridge; road runoff
- GM-2: Pequawket Brook, Madison
  - Downstream of a large gravel operation
- GM-3: Forrest Brook, Madison
  - Located in the center of Madison near two drinking water protection zones
- GO-4: Bearcamp River, West Ossipee
  - UNH property
- GT-5: Swift River, Tamworth
  - In the center of the Tamworth Village, downstream from new development

APR-OCT 10 YEARS

- GE-1: Pine River, Effingham
  - Downstream of two gravel pits and a designated drinking water zone
- GE-2: South River, Parsonfield, ME
  - Located downstream of the town's transfer station and capped landfill; potential road run-off as well
- GF-1: Danforth Brook, Freedom
  - Determine impact of road runoff as the brook flows under Ossipee Lake Road.
- GO-1: Beech River, Ossipee
  - Upstream of a mill, dump, and old tannery
- GT-1: Bearcamp River, Tamworth
  - Located downstream of the town's drinking water supply zone

LONG-TERM SITES 8-10 YEARS YEAR ROUND SINCE 2004

- GE-3: Ossipee River, Effingham Falls
  - Chosen to determine quality of water leaving Ossipee Lake
- GF-3: Cold River, Freedom
  - Concern over potential malfunctioning septic systems in Freedom Village
- GO-5: Bearcamp River, West Ossipee
  - Flows under the Whittier Covered Bridge
- GT-4: Chocorua River, Tamworth
  - Serves to monitor impacts along a 7 mile stretch of the busiest, most diversely utilized highway in the area. Drains RT 16
- GM-1: Banfield Brook, Madison
  - Determine the impact of road run-off, erosion, and timber cutting
- GO-2: Frenchman Brook, Ossipee
  - Downstream of the site where the brook passes under RT 16, potential for road runoff impact. History of dumping upstream
- GS-1: Cold River, Sandwich
  - Gravel pit located upstream of site. Site is located upstream of Tamworth's drinking wellhead zone

7 YEARS, YEAR ROUND SINCE 2009

- OL-12u: Phillips Brook, Effingham
  - Influenced by episodic flooding and draining due to upstream and downstream beaver activity. Concern for road salt as well
- OL-14u: Square Brook, Freedom
  - Site located close to Ossipee Lake Road; influence of road salt

PARAMETERS

- Out in the field
  - Temperature
  - Dissolved Oxygen
  - pH
  - Specific Conductivity
  - Turbidity

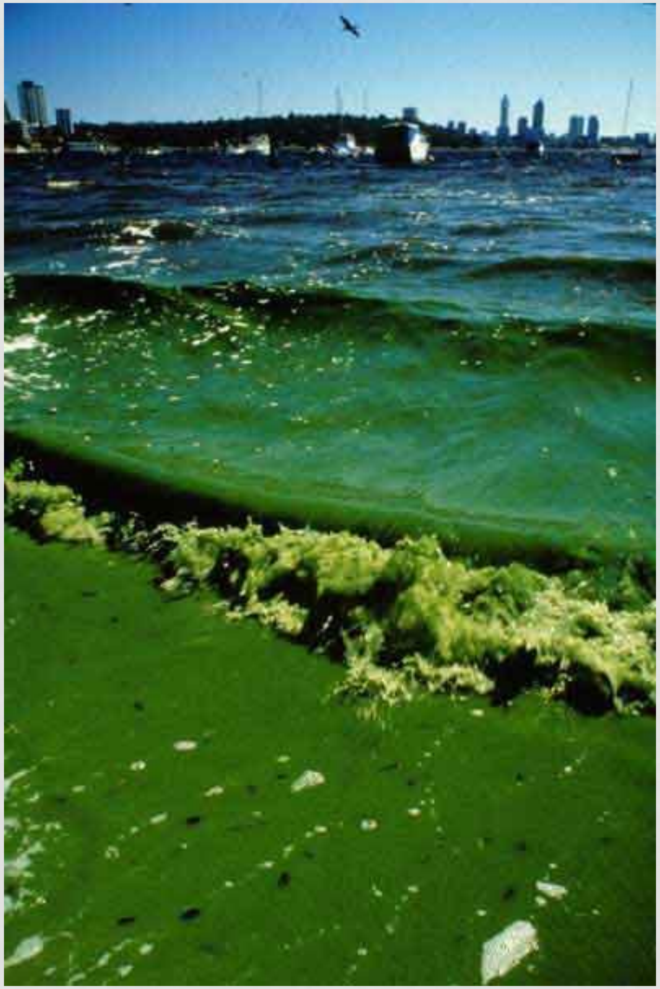
- In the lab
  - Dissolved Organic Carbon (DOC)
  - Dissolved Inorganic Nitrogen (DIN)
    - Nitrate (NO_3)
    - Ammonium (NH_4)
  - Dissolved Organic Nitrogen (DON)
  - Total Dissolved Nitrogen (TDN)
  - Total Phosphorus
  - Soluble Reactive Phosphorus (PO_4)
  - Chloride (Cl)
  - Sulfate (SO_4)
  - Sodium (Na)
  - Potassium (K)
  - Magnesium (Mg)
  - Calcium (Ca)
  - Silica (Silicon Dioxide SiO_2)

IMPORTANCE OF TEMPERATURE AND DISSOLVED OXYGEN

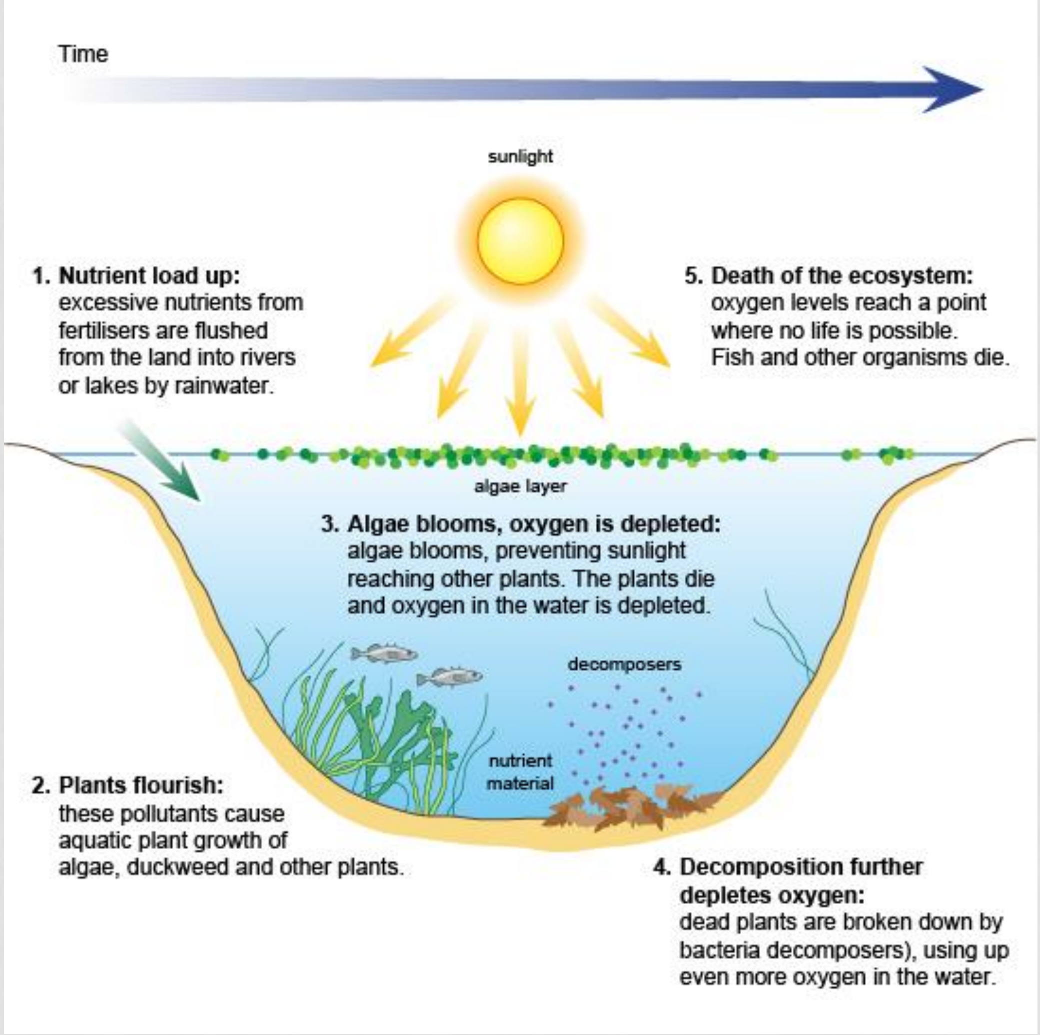
- Temperature
  - Changes can negatively impact aquatic organisms
  - Directly affects amount of DO water can hold
  - Increases caused by industrial discharge, impervious surface runoff, cutting of riparian vegetation, dams, and soil erosion
- Dissolved Oxygen
  - Sources include inputs from the atmosphere, photosynthesis, and swift-moving water
  - Essential to metabolic processes
  - Decomposition of organic matter consumes oxygen.
  - Readings below 5 mg/L are considered critical

IMPORTANCE OF NUTRIENTS

- Nutrients
  - Essential for growth, but toxic in large amounts
    - Overproduction, eutrophication, toxic algal blooms, fish kills
  - Phosphorus—often a limiting nutrient, present in low concentrations
    - No numeric standard, but anything above 50 ug/L indicates disturbance
  - Nitrogen—also a limiting nutrient
    - Elevated levels of nitrate (NO_3) can lead to death of aquatic organisms
    - EPA Maximum Contaminant Level (MCL) is 10 mg N/L in public water supplies
      - Blue baby syndrome
    - Associated with stomach cancer at concentrations of 4 mg N/L



EUTROPHICATION



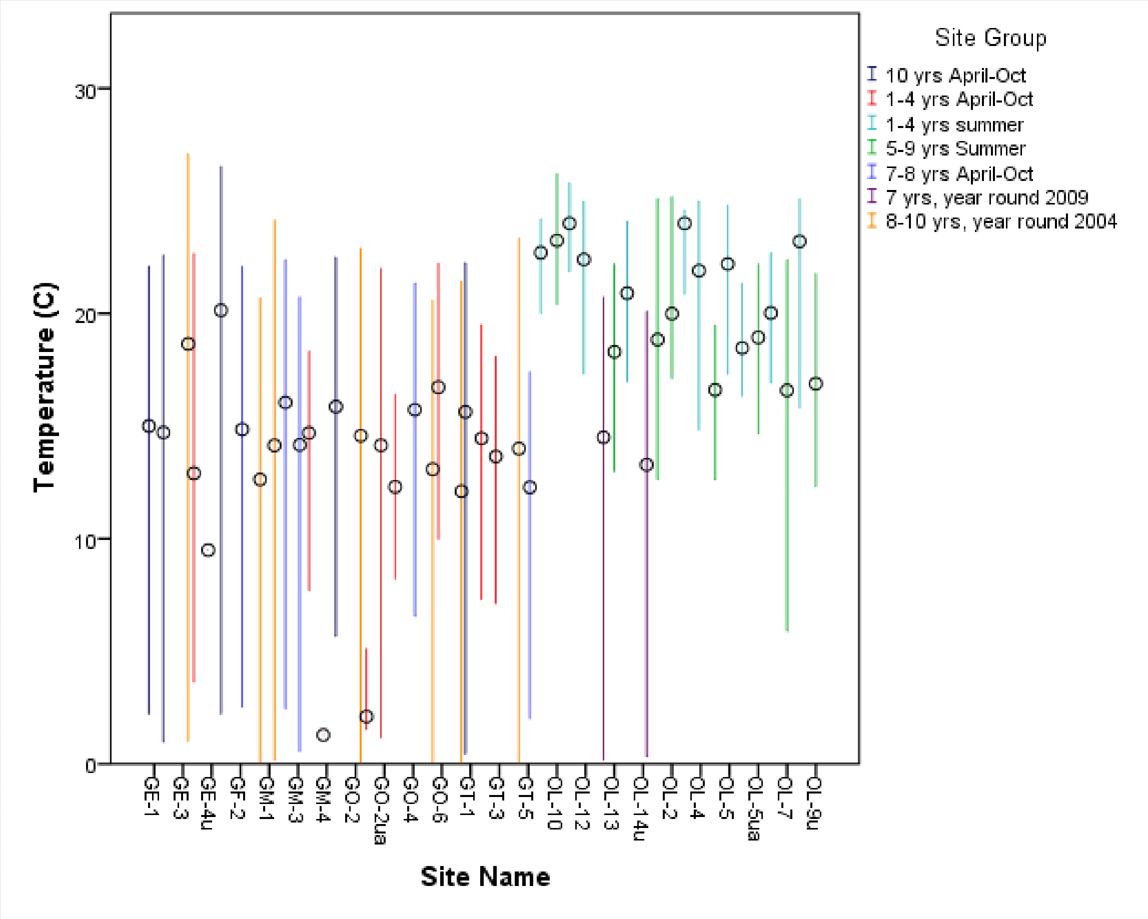
http://www.bbc.co.uk/schools/gcsebitesize/science/edexcel/problems_in_environment/pollutionrev4.shtml

IMPORTANCE OF DOC, SILICA, AND CHLORIDE

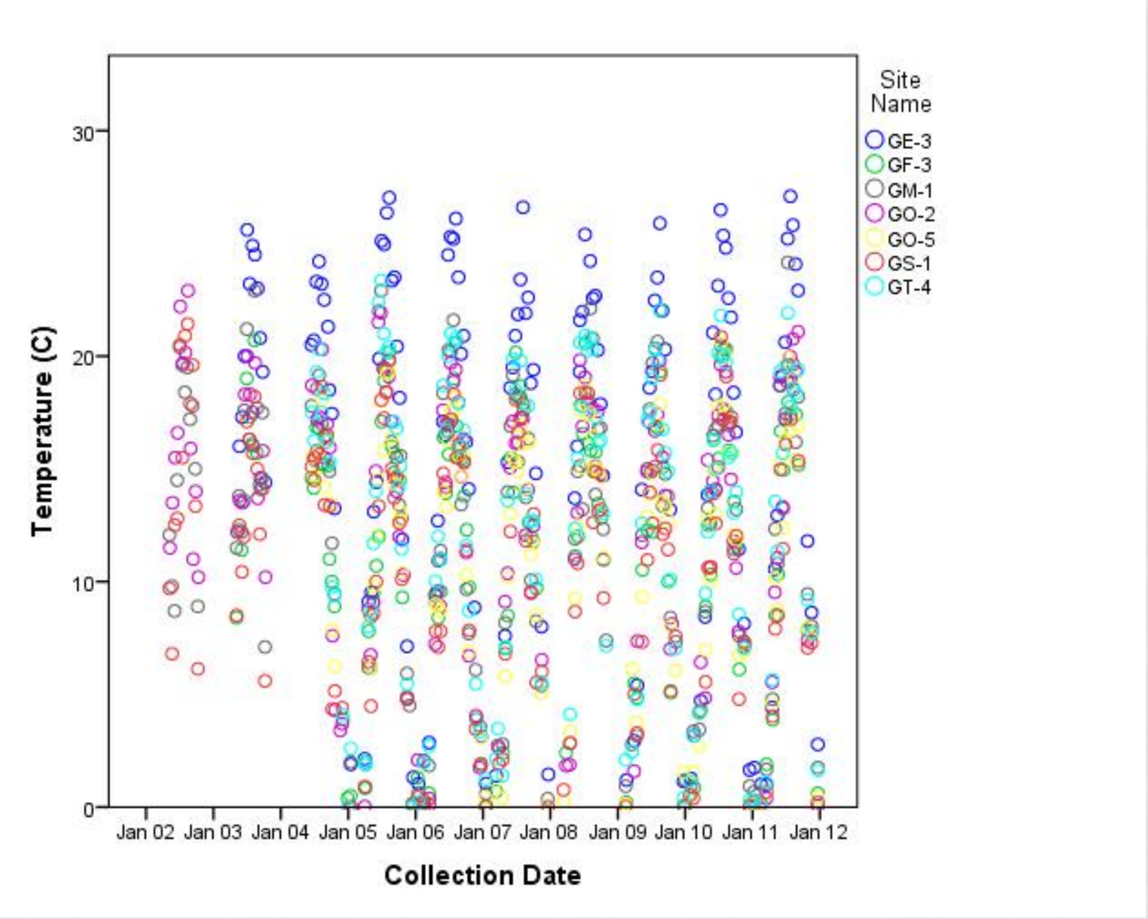
- Dissolved Organic Carbon (DOC)
  - Concentration indicates impact of terrestrial inputs on aquatic environment
  - Wetlands tend to increase amount present
- Silica (SiO_2)
  - Common in most rock-forming minerals
  - Presence in water result of weathering
  - Ground water has higher concentrations than surface water
  - Essential to diatom growth
- Chloride
  - Affected by geology
    - Marine clays and sediments
  - Human activities
    - Road salt, crop irrigation
    - Drinking water limit is 250 mg/L. Typical NH levels are less than 30 mg/L
  - Excessive amounts could negatively impact vegetation and be toxic to aquatic species
    - Acute: 860 mg Cl/L
    - Chronic: 230 mg Cl/L

FIELD PARAMETERS

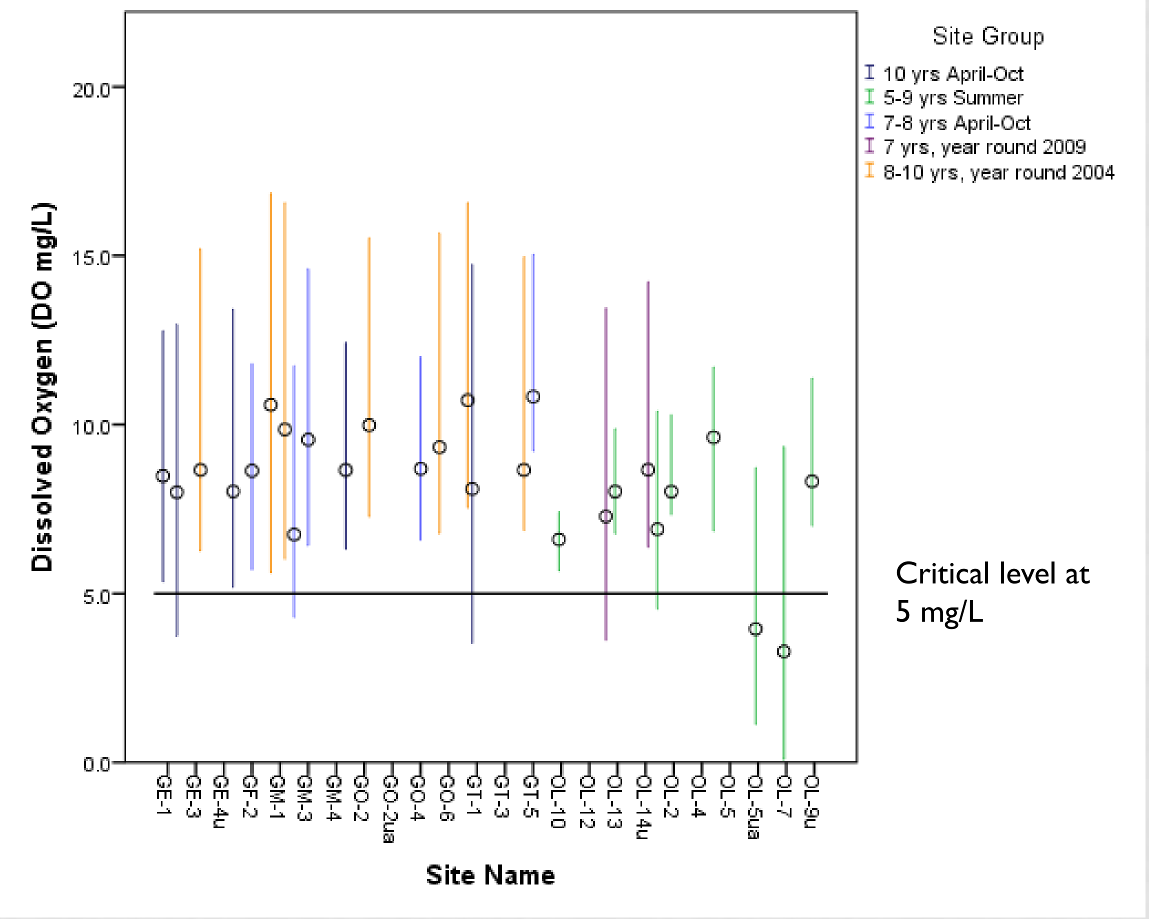
TEMP VARIABILITY



LONG-TERM: TEMPERATURE

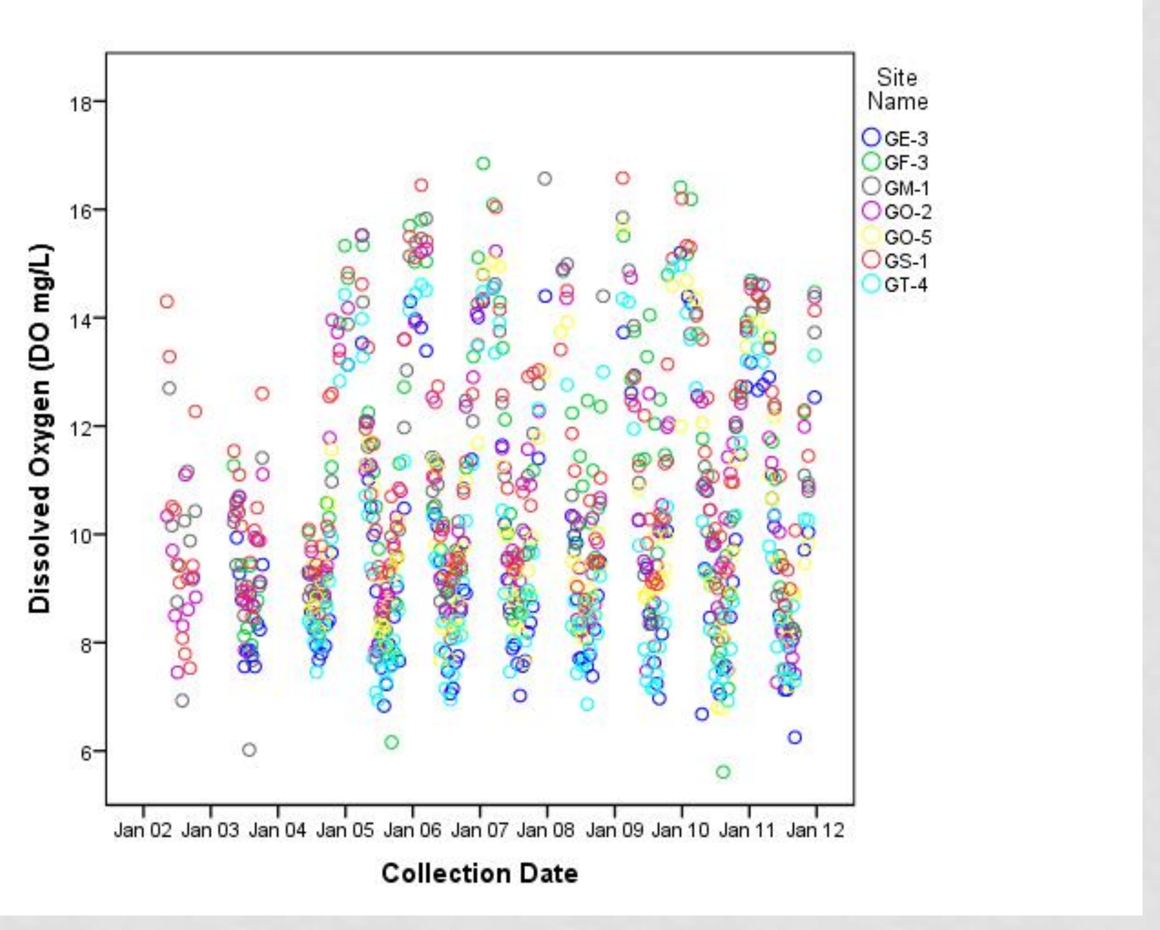


DO VARIABILITY



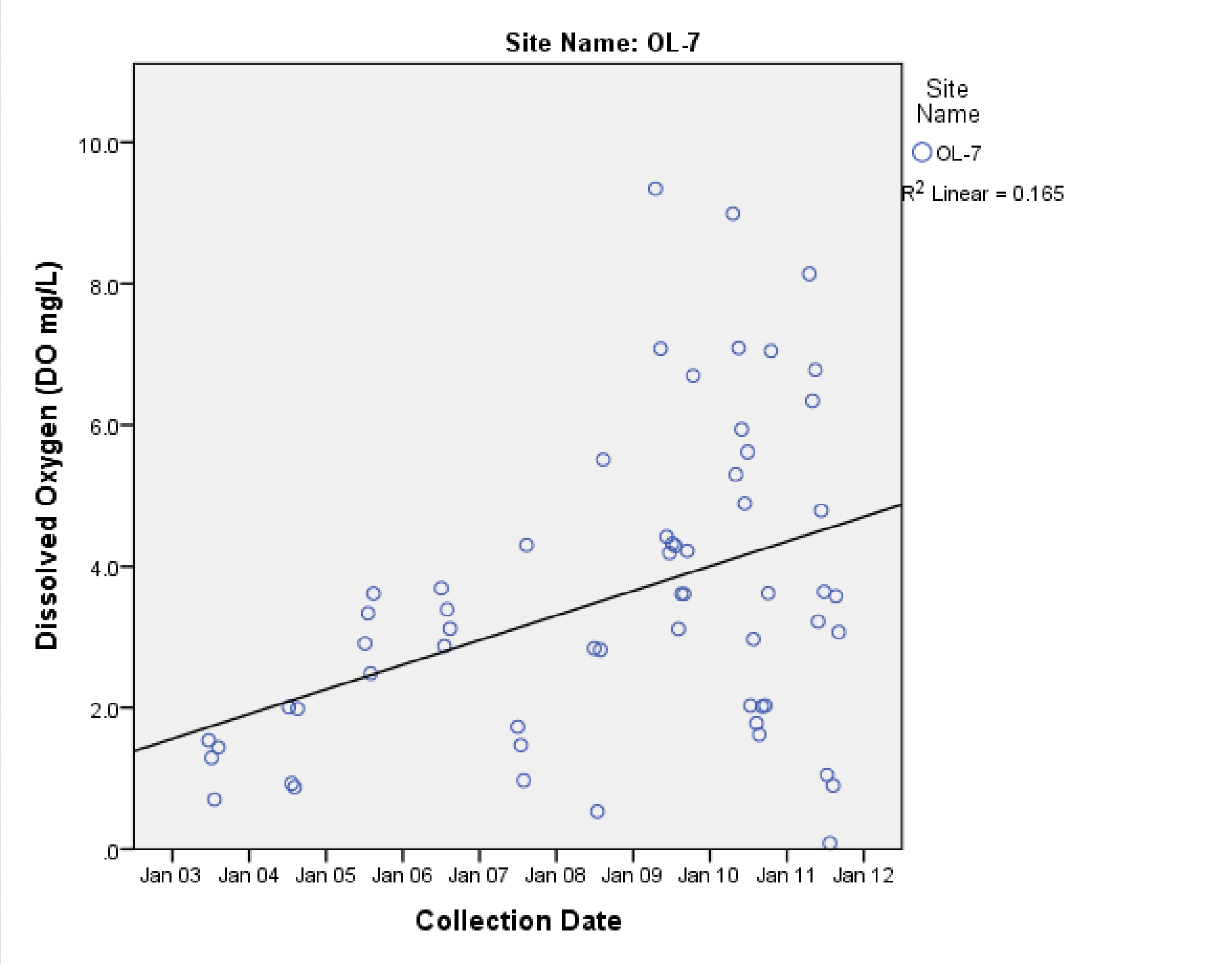
Critical level at 5 mg/L

LONG-TERM: DO



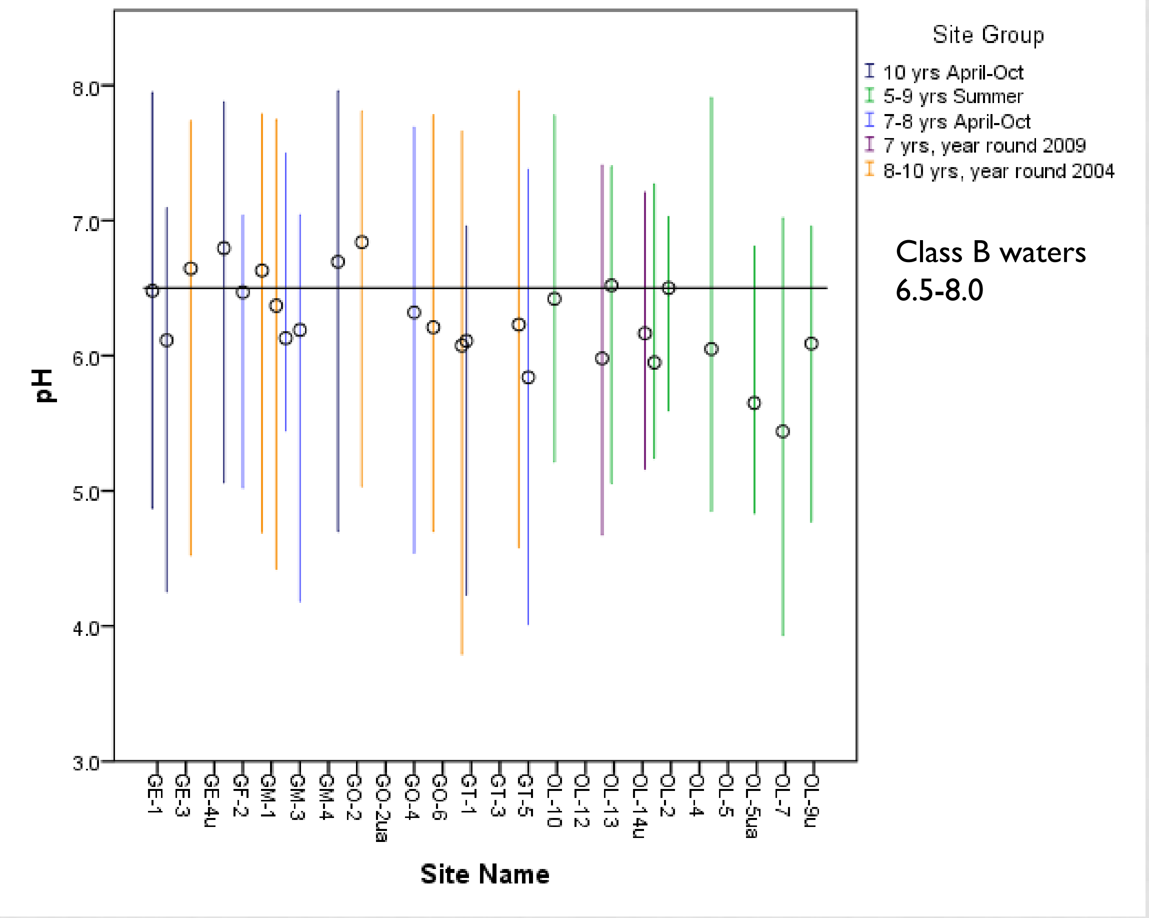
Dissolved Oxygen (DO mg/L)
18
16
14
12
10
8
6
Jan 02
Jan 03
Jan 04
Jan 05
Jan 06
Jan 07
Jan 08
Jan 09
Jan 10
Jan 11
Jan 12
Collection Date
Site Name
GE-3
GF-3
GM-1
GO-2
GO-5
GS-1
GT-4

OL-7: DO INCREASING



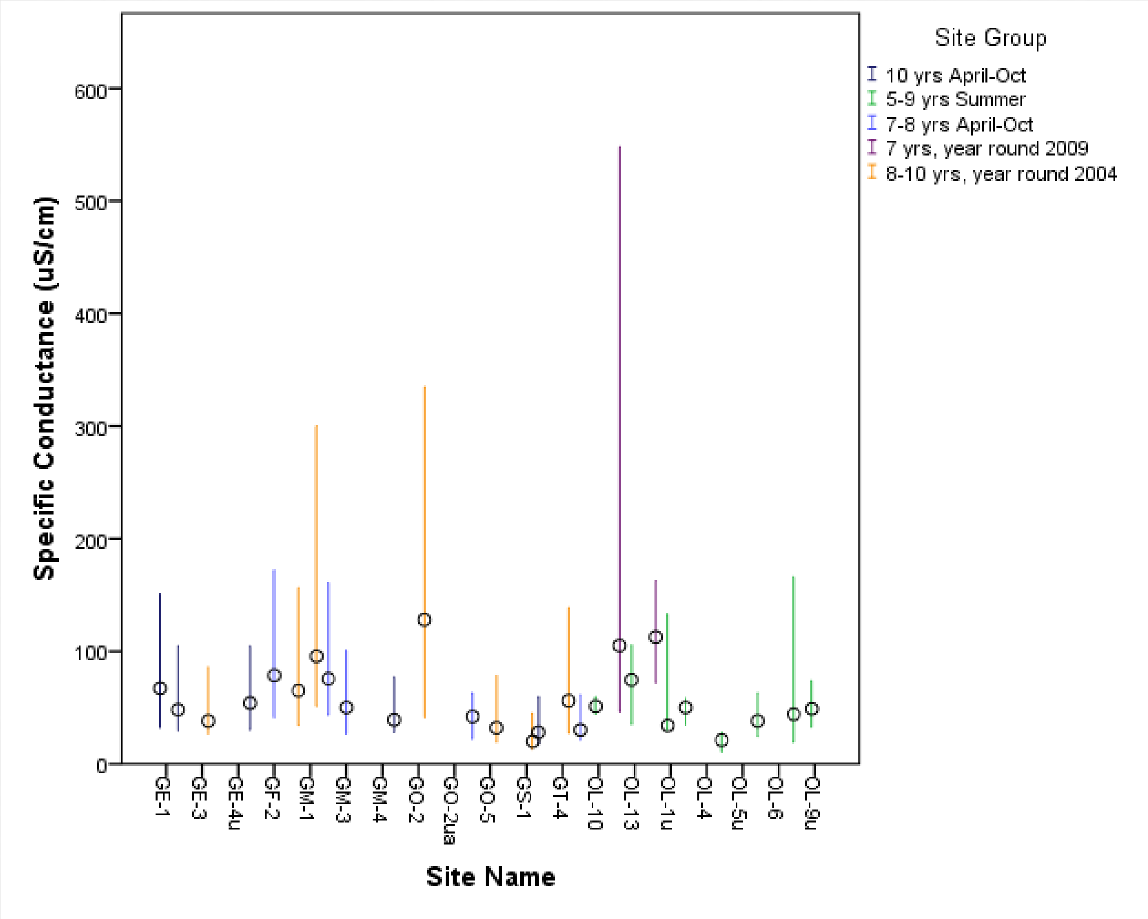
Upward trends suggest that DO levels for OL-7 could be increasing over time. Recently, sampling occurring in cooler months (Apr and Oct) and early/late summer.

PH VARIABILITY

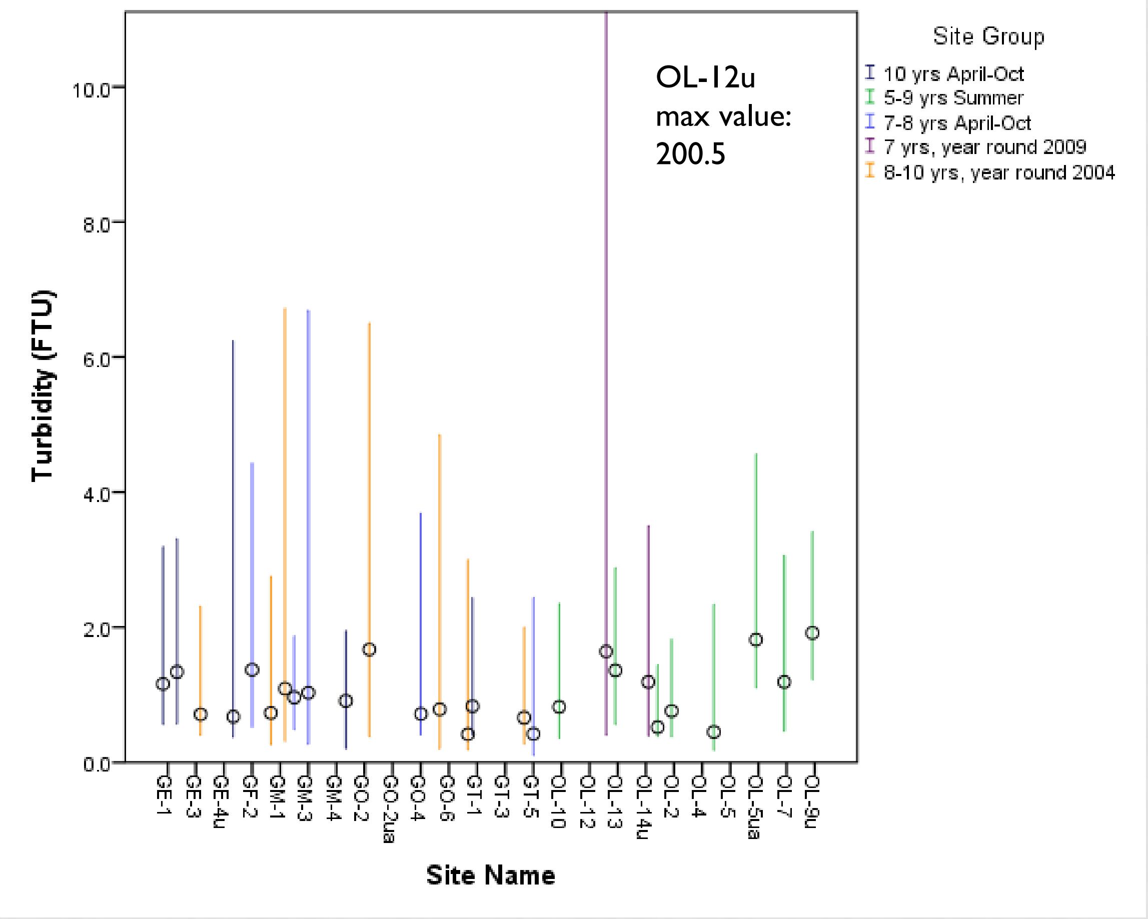


Class B waters
6.5-8.0

SPECIFIC CONDUCTANCE VARIABILITY

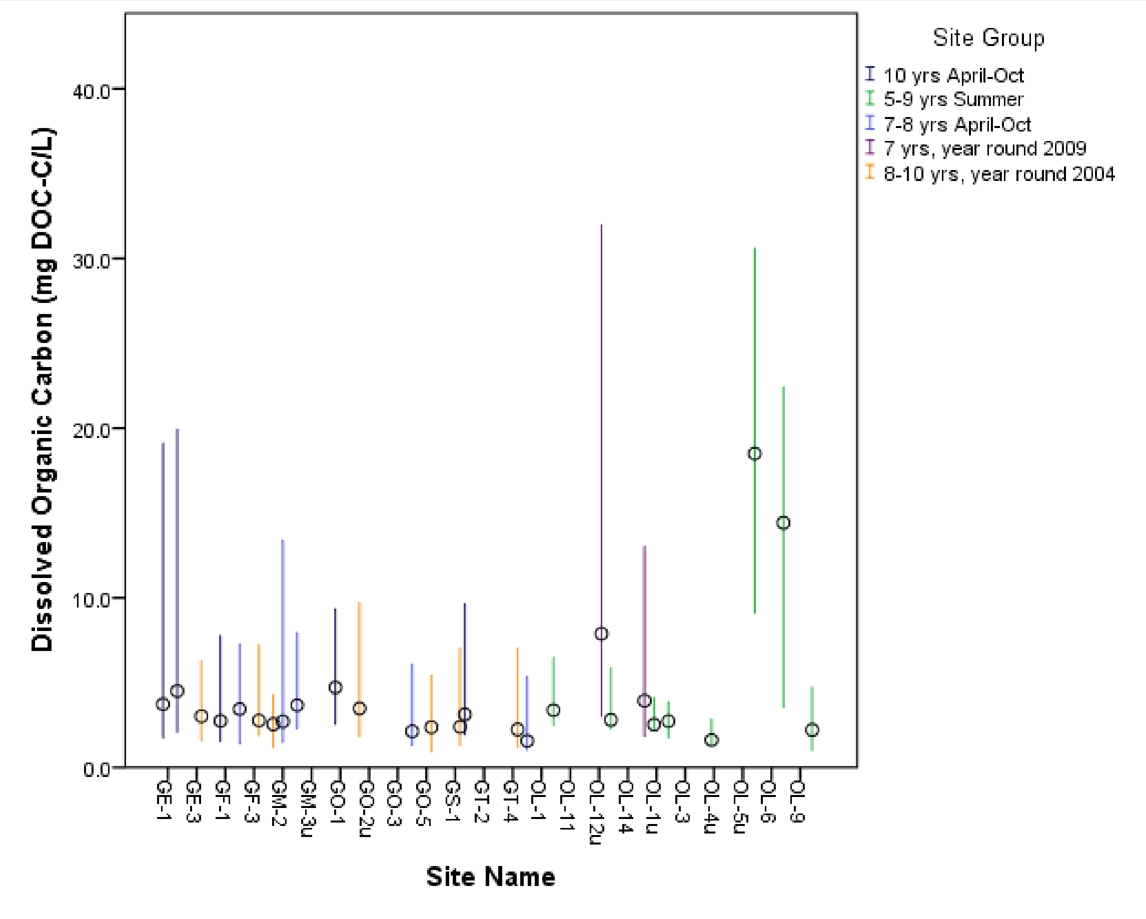


TURBIDITY VARIABILITY

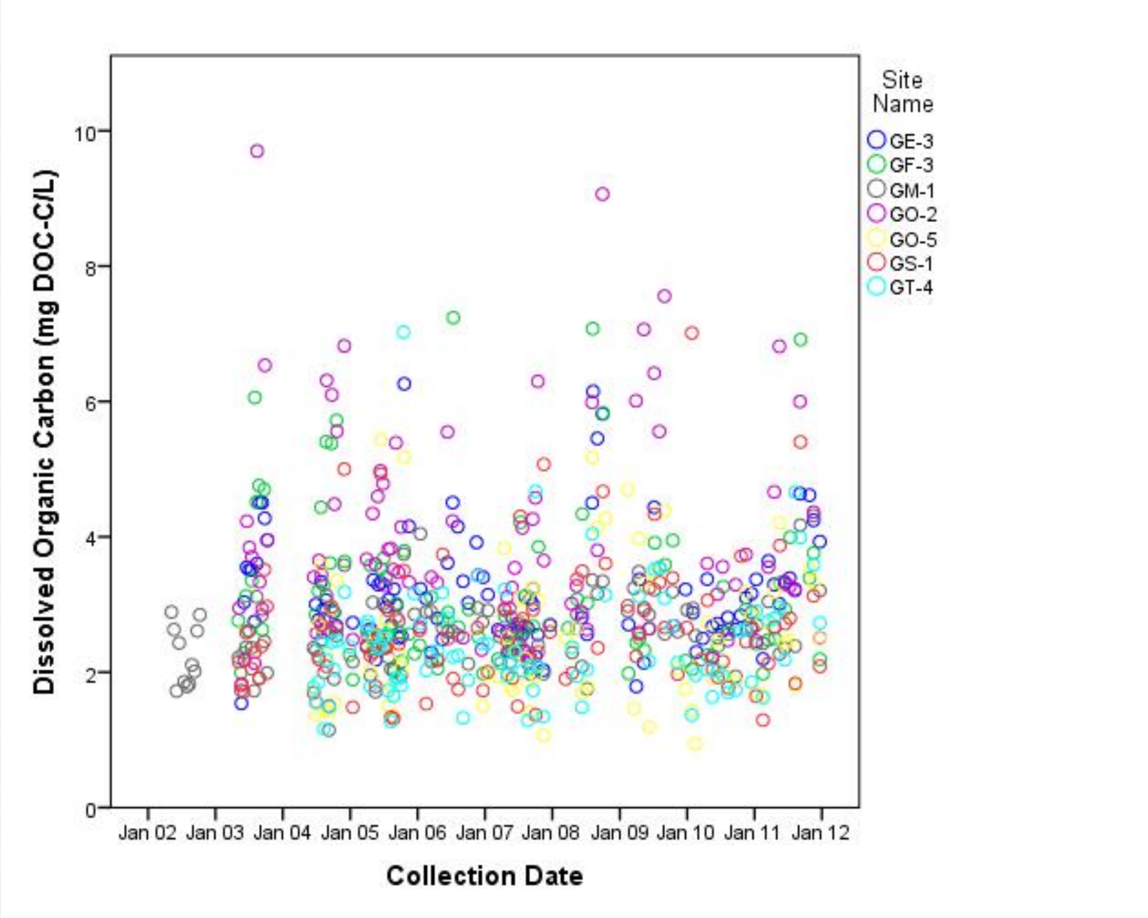


LAB PARAMETERS

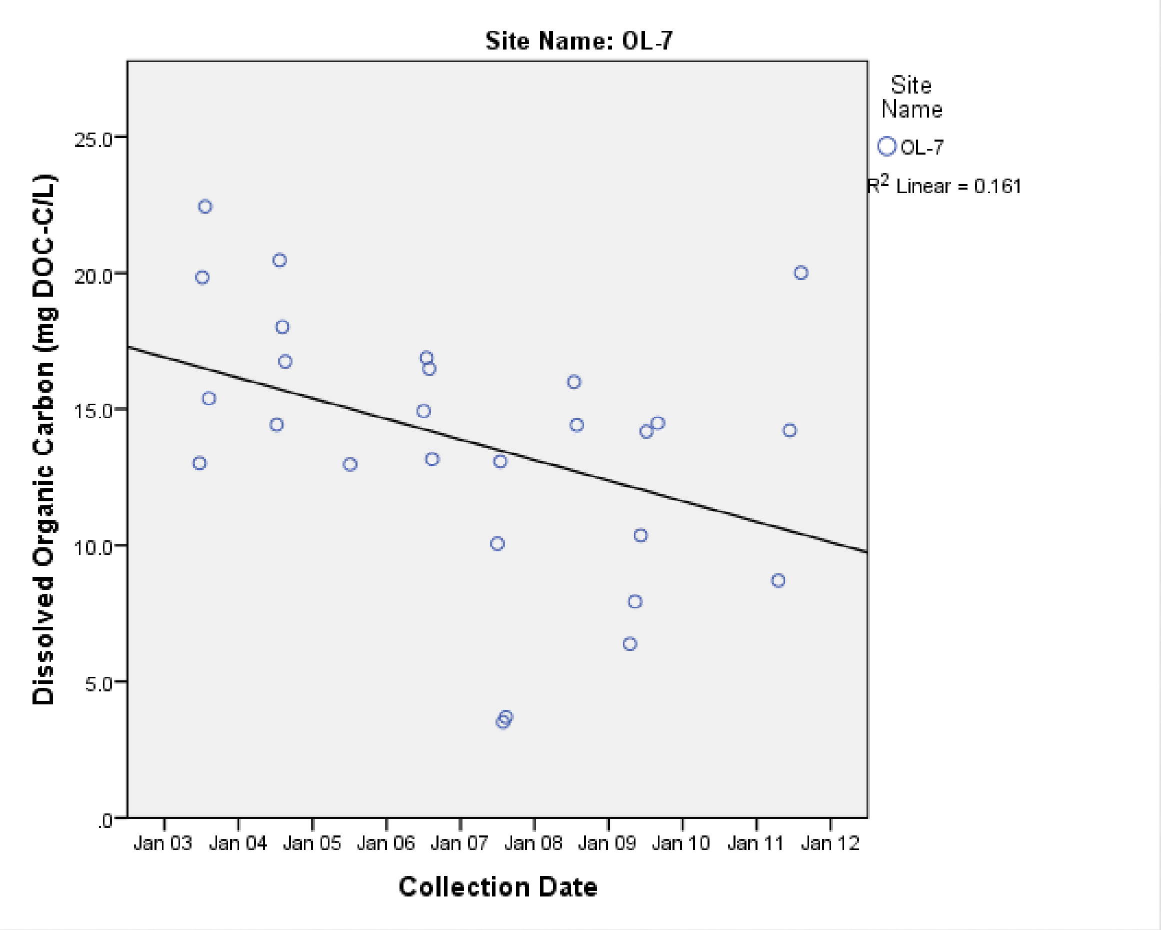
DOC VARIABILITY



LONG-TERM: DOC

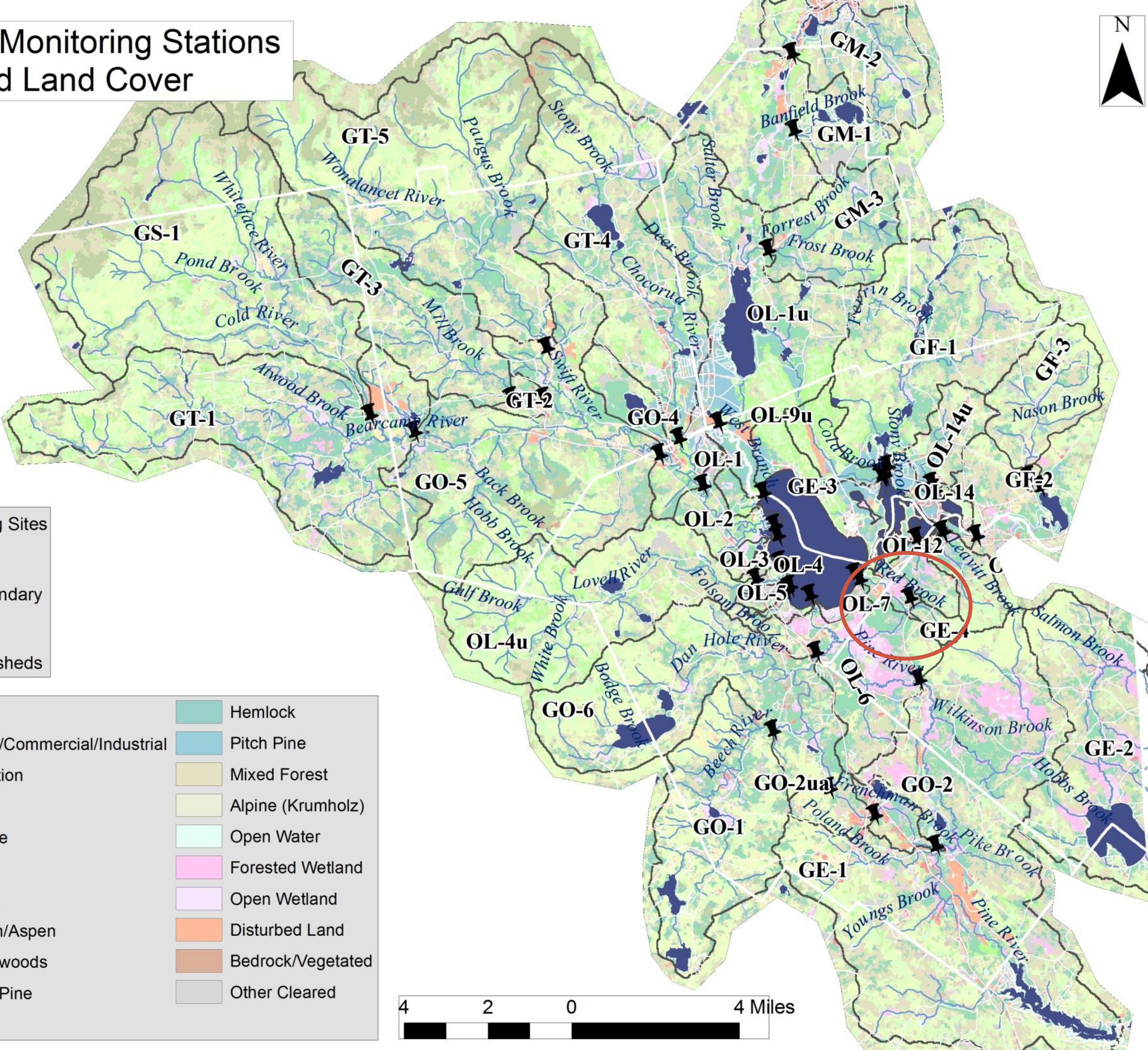


OL-7: DOC DECREASING



Concentration of DOC is decreasing, indicating that wetland contribution could be decreasing and causing an increase in DO levels.

Tributary Monitoring Stations and Land Cover

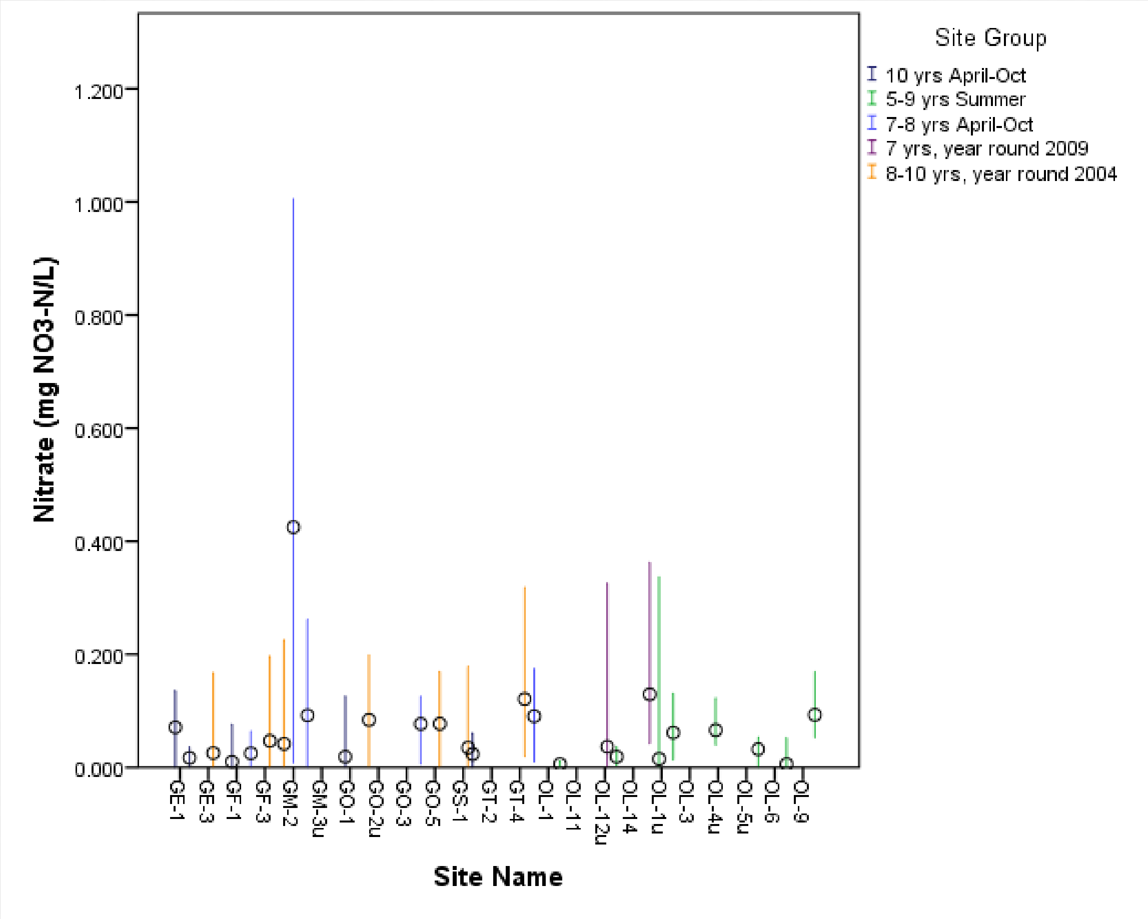


Monitoring Sites
Roads
Town Boundary
Streams
Subwatersheds

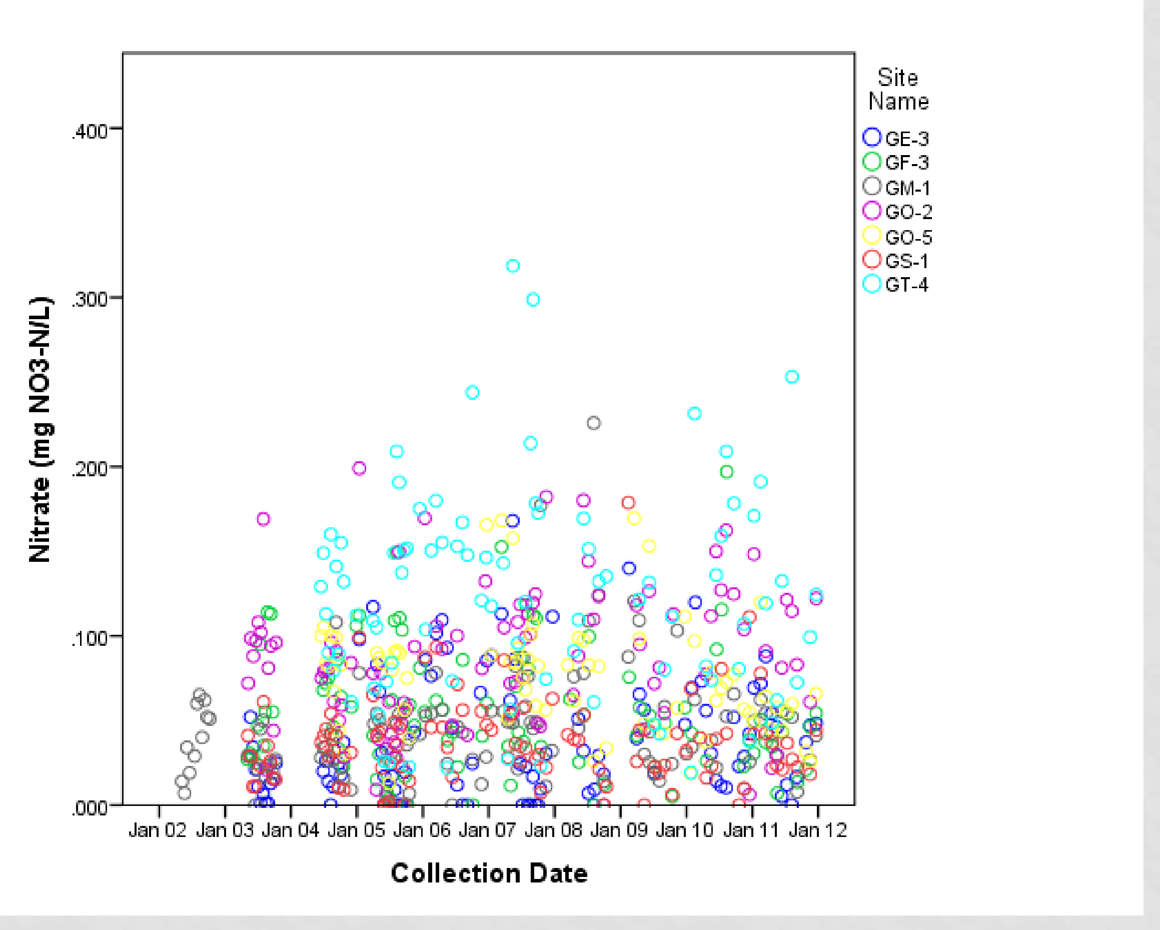
Land Cover

Residential/Commercial/Industrial	Hemlock
Transportation	Pitch Pine
Row Crops	Mixed Forest
Hay/Pasture	Alpine (Krumholz)
Orchards	Open Water
Beech/Oak	Forested Wetland
Paper Birch/Aspen	Open Wetland
Other Hardwoods	Disturbed Land
White/Red Pine	Bedrock/Vegetated
Spruce/Fir	Other Cleared

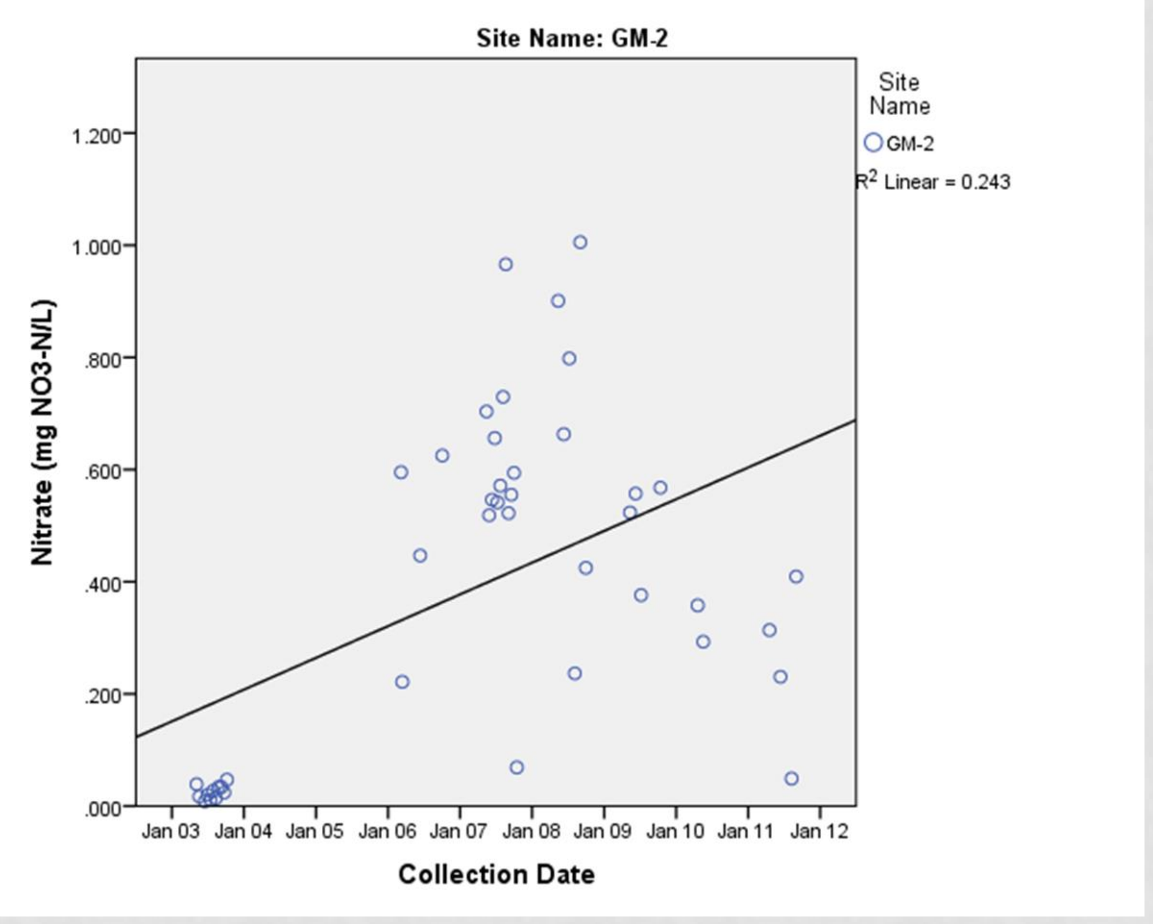
NITRATE VARIABILITY



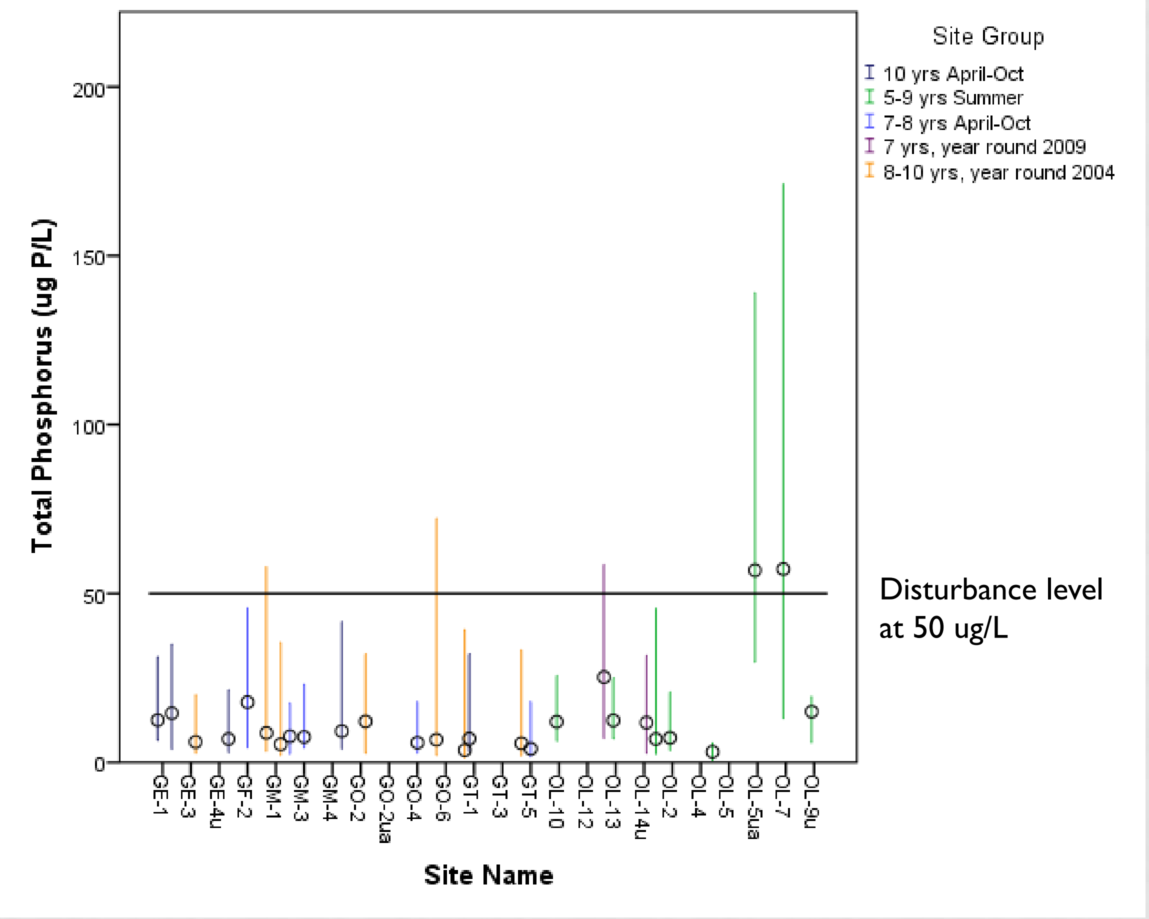
LONG-TERM: NITRATE



GM-2: NITRATE INCREASING

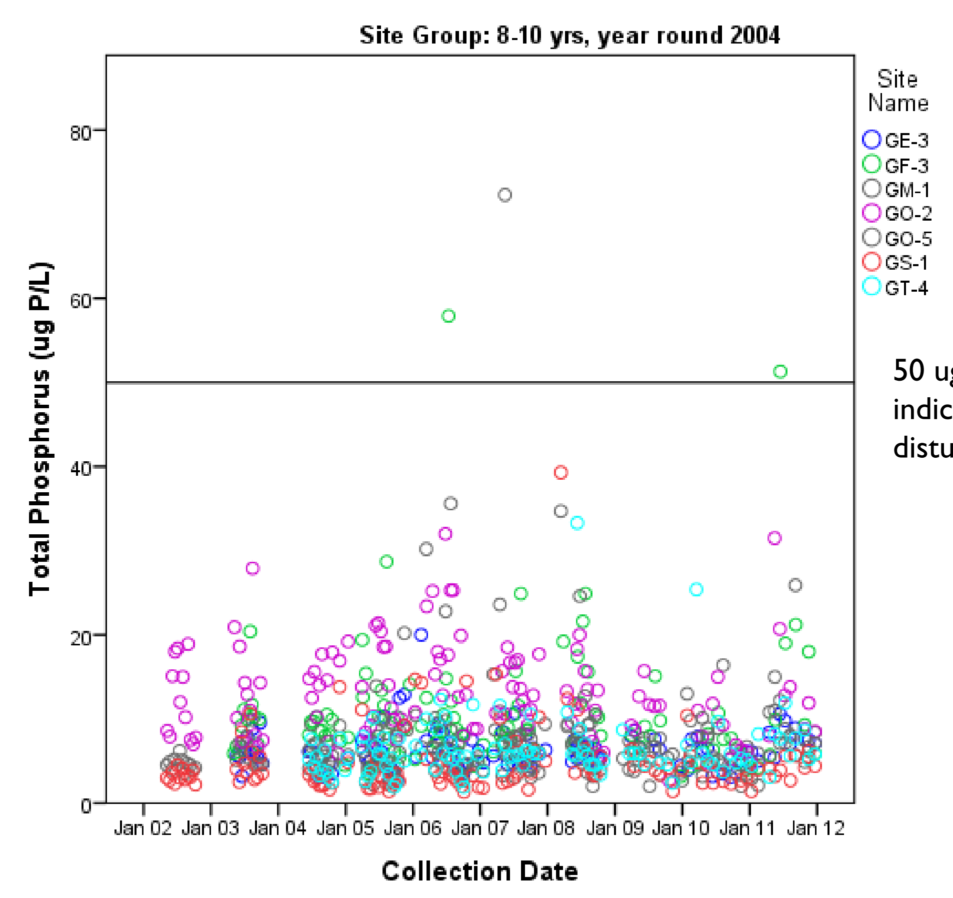


TOTAL PHOSPHORUS VARIABILITY



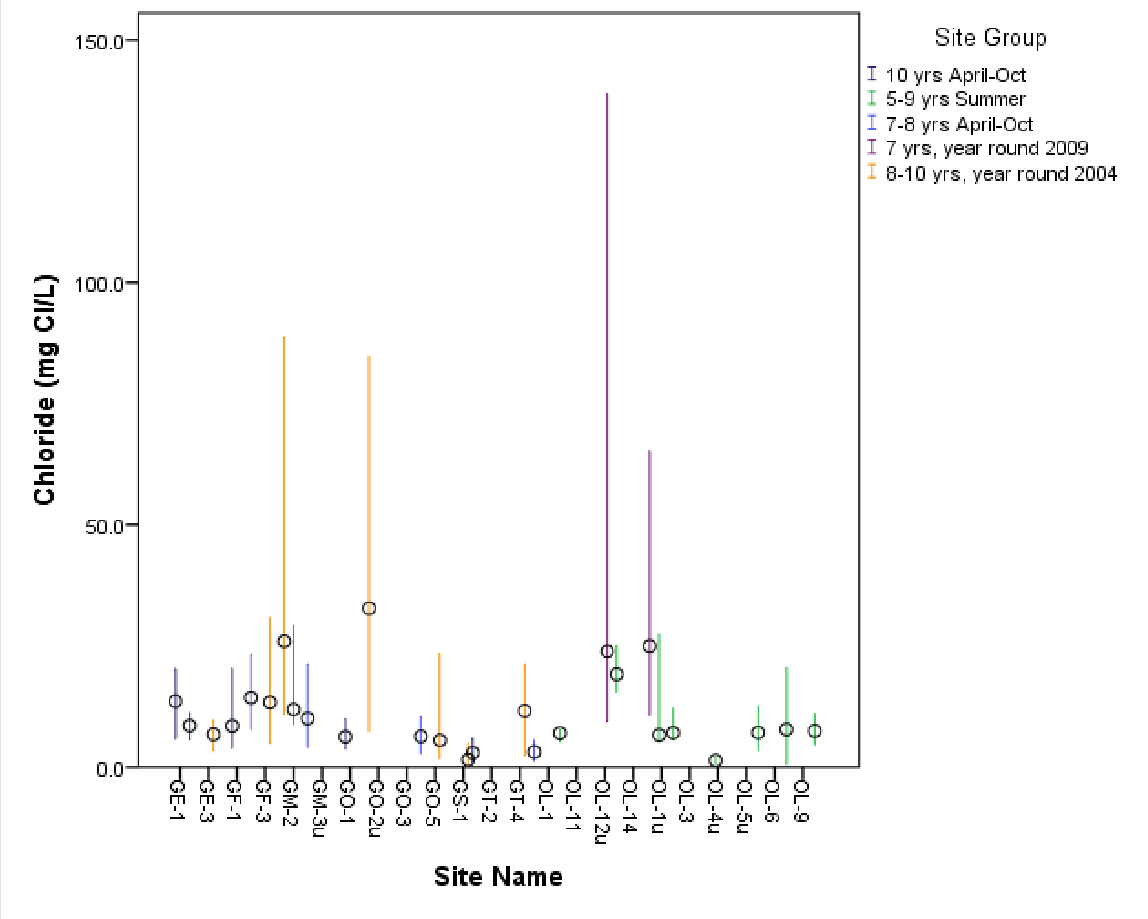
Disturbance level at 50 ug/L

LONG-TERM: TOTAL PHOSPHORUS

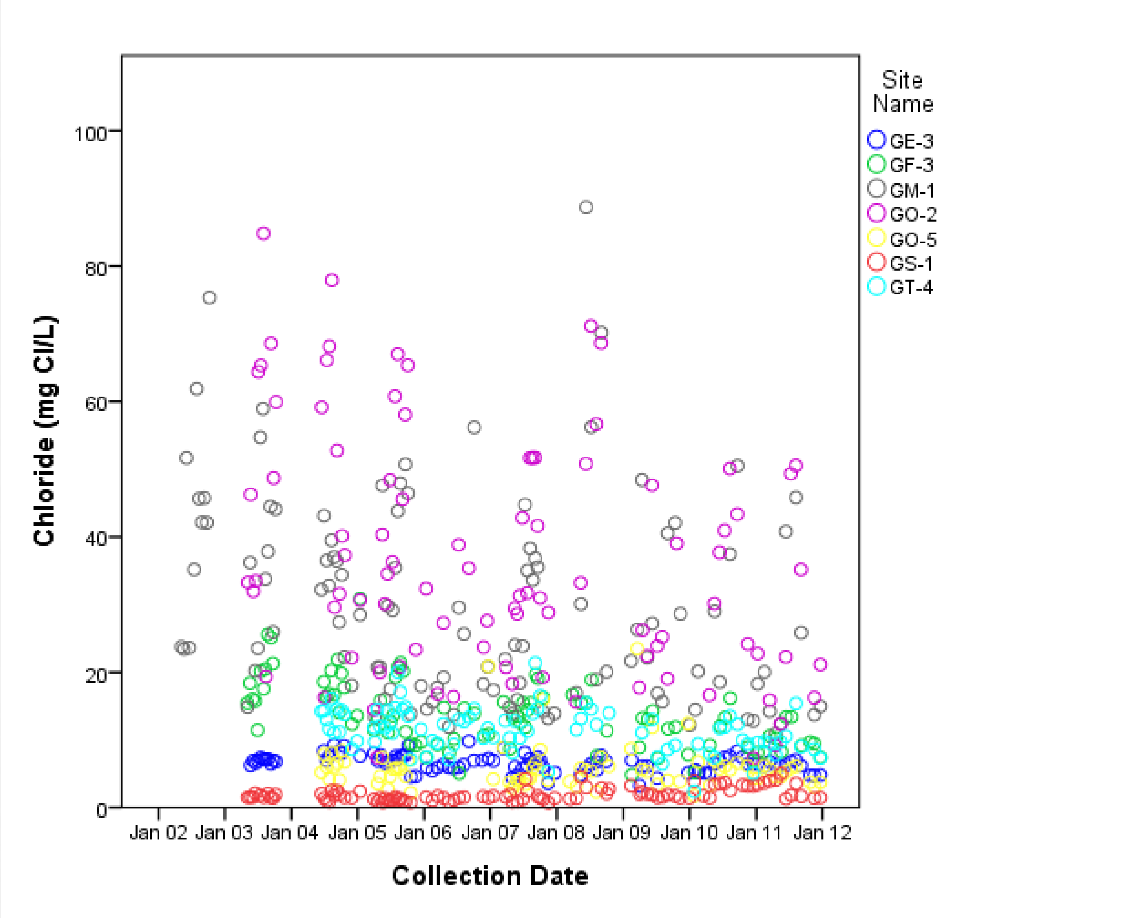


50 ug P/L indicates disturbance

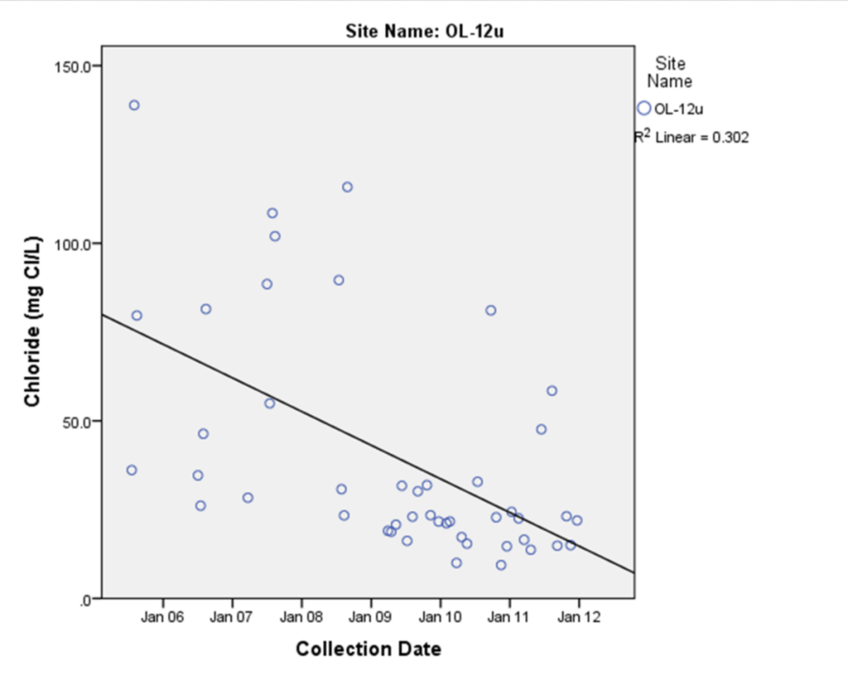
CHLORIDE VARIABILITY

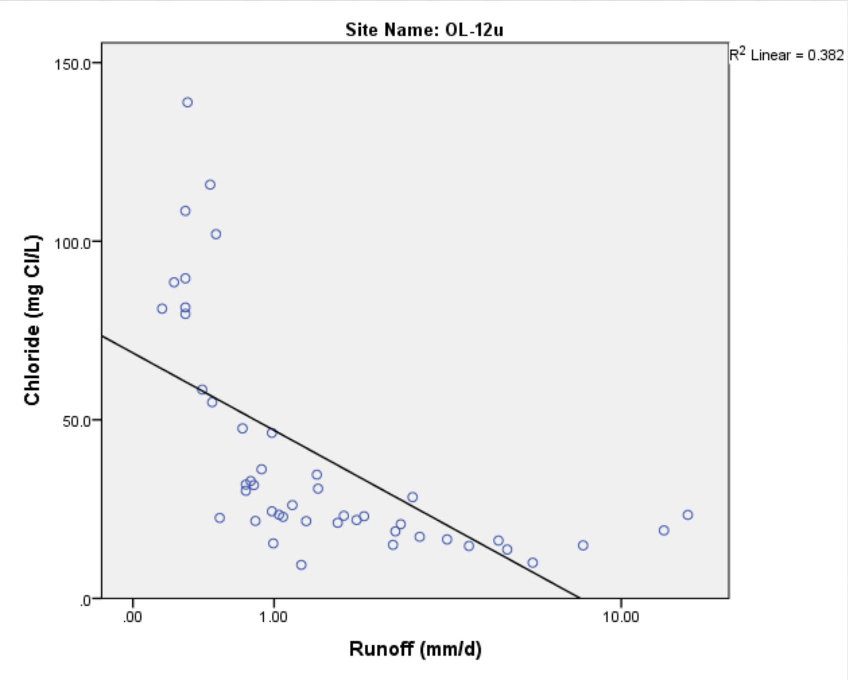


LONG-TERM: CHLORIDE

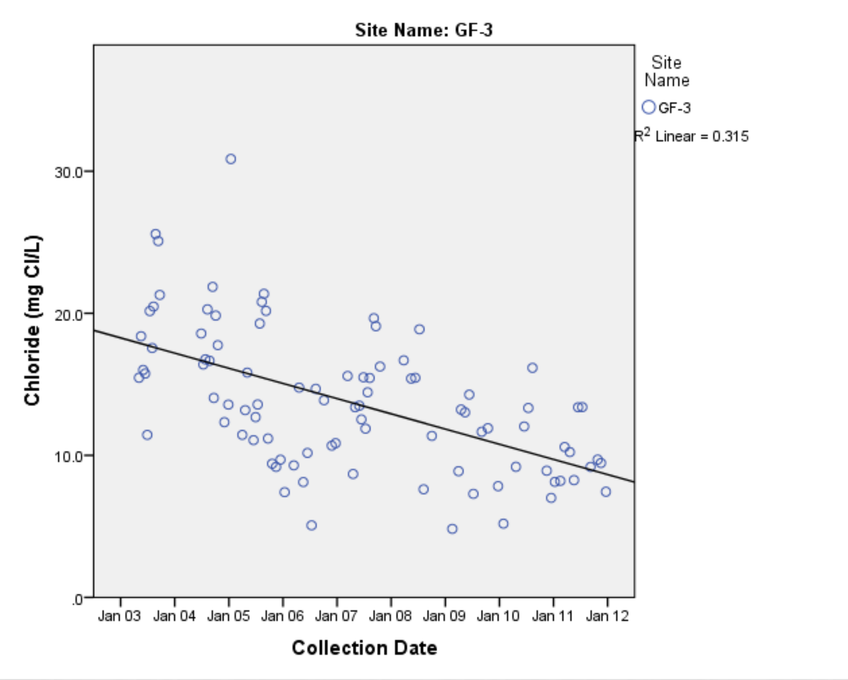


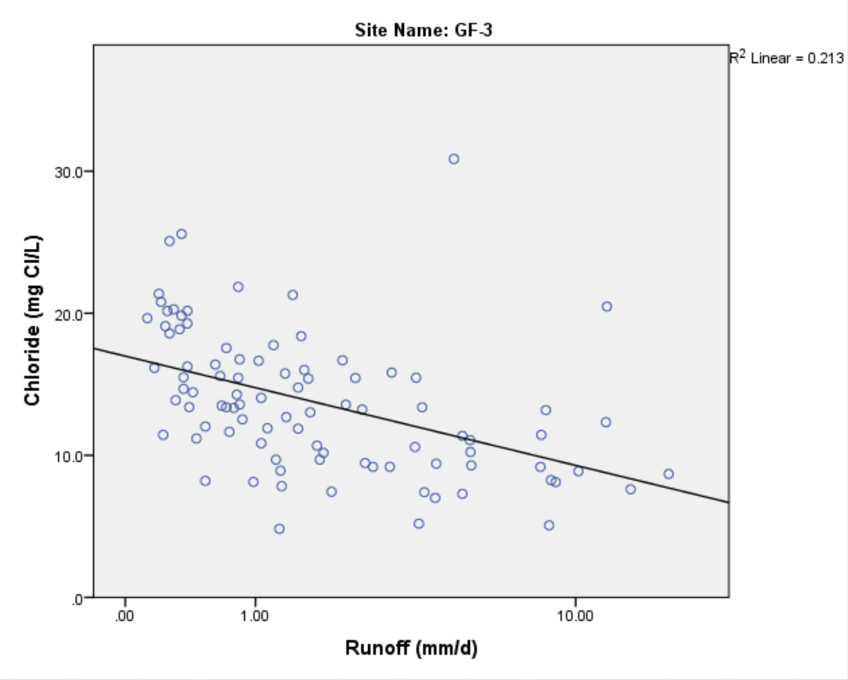
OL-12U (7YRS, YEAR ROUND SINCE 2009): CHLORIDE DECREASING



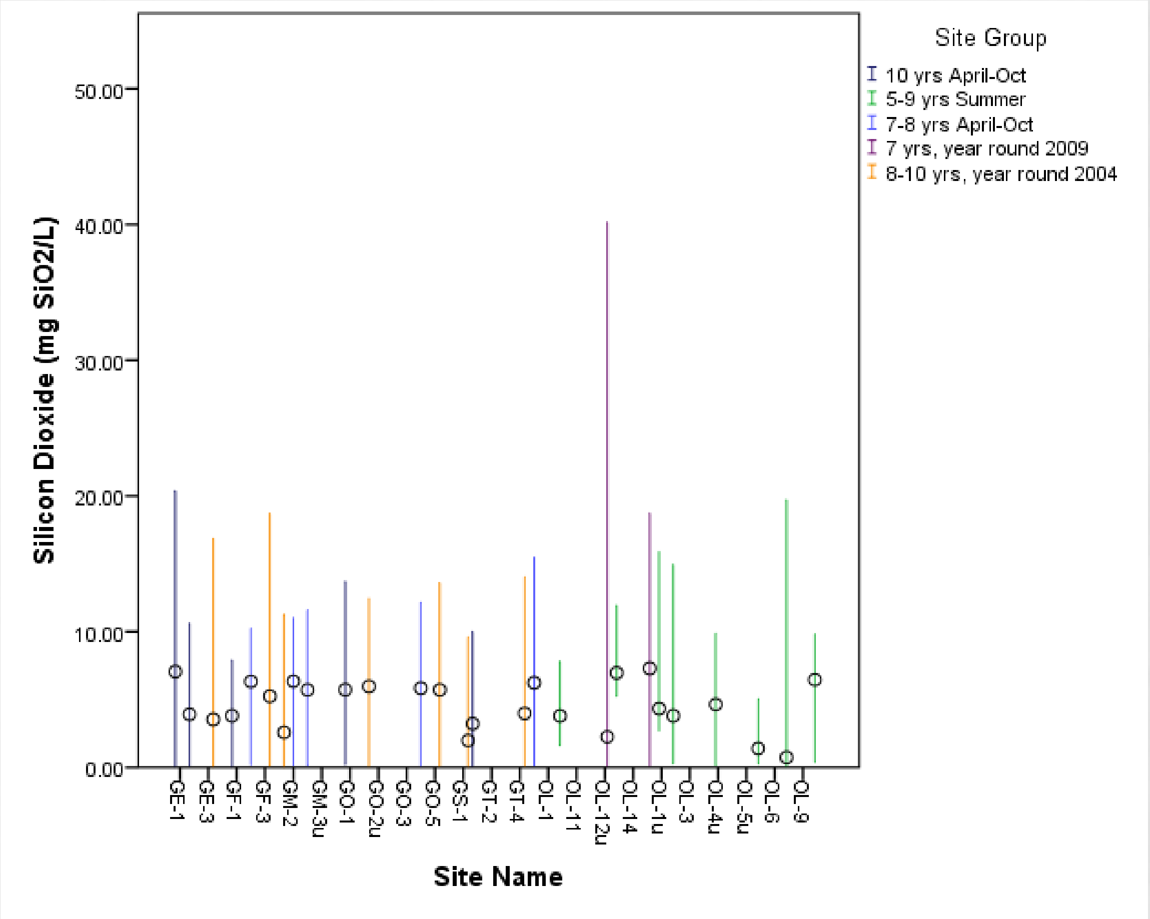


GF-3: CHLORIDE DECREASING

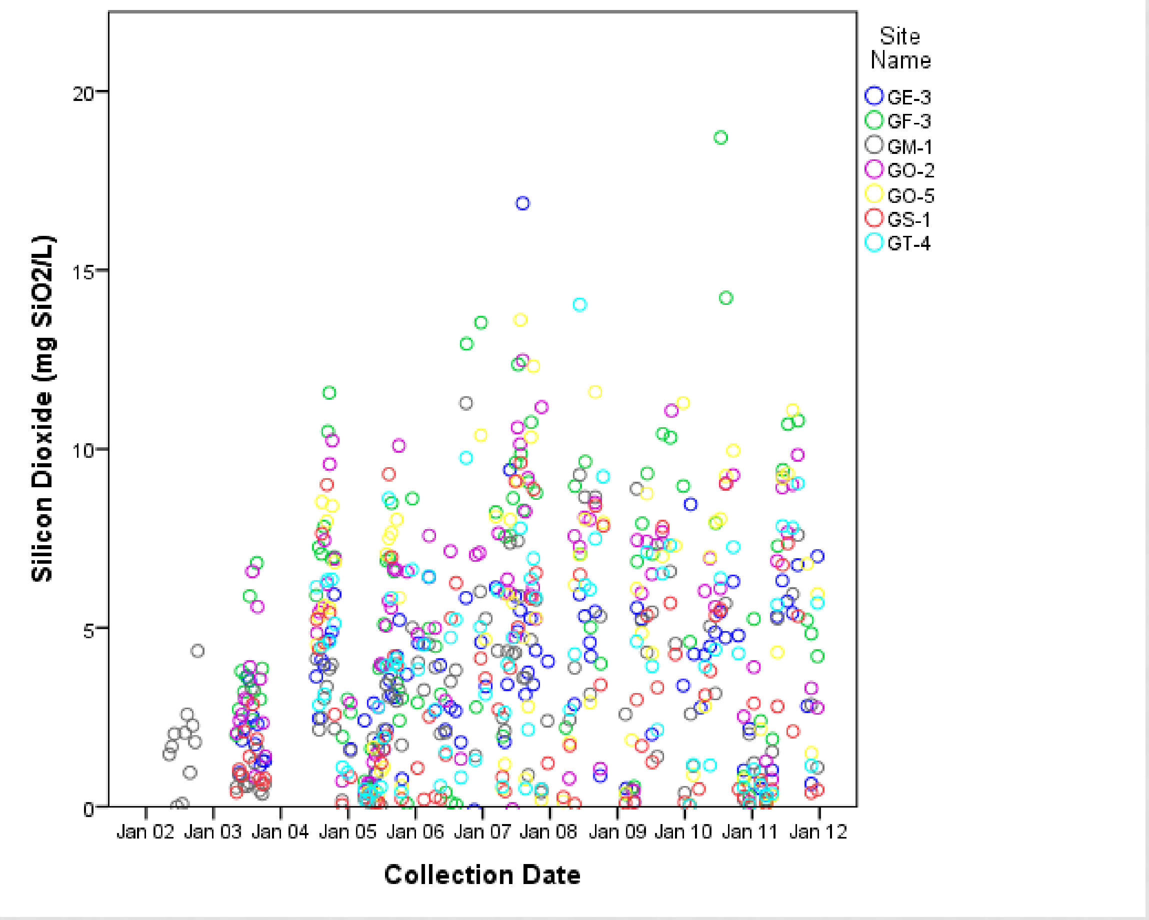




SILICA VARIABILITY

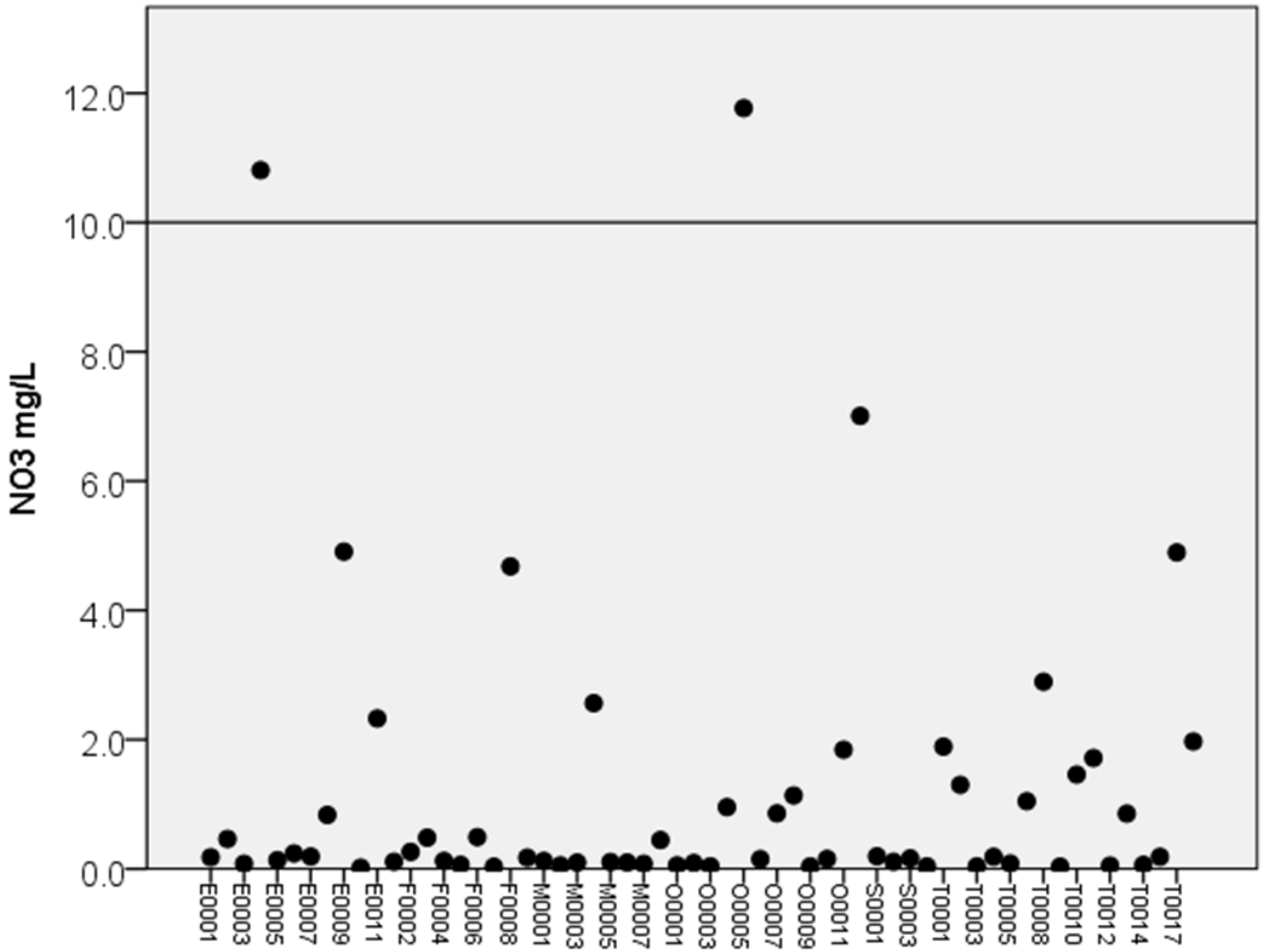


LONG-TERM: SILICA



GROUNDWATER MONITORING 2009

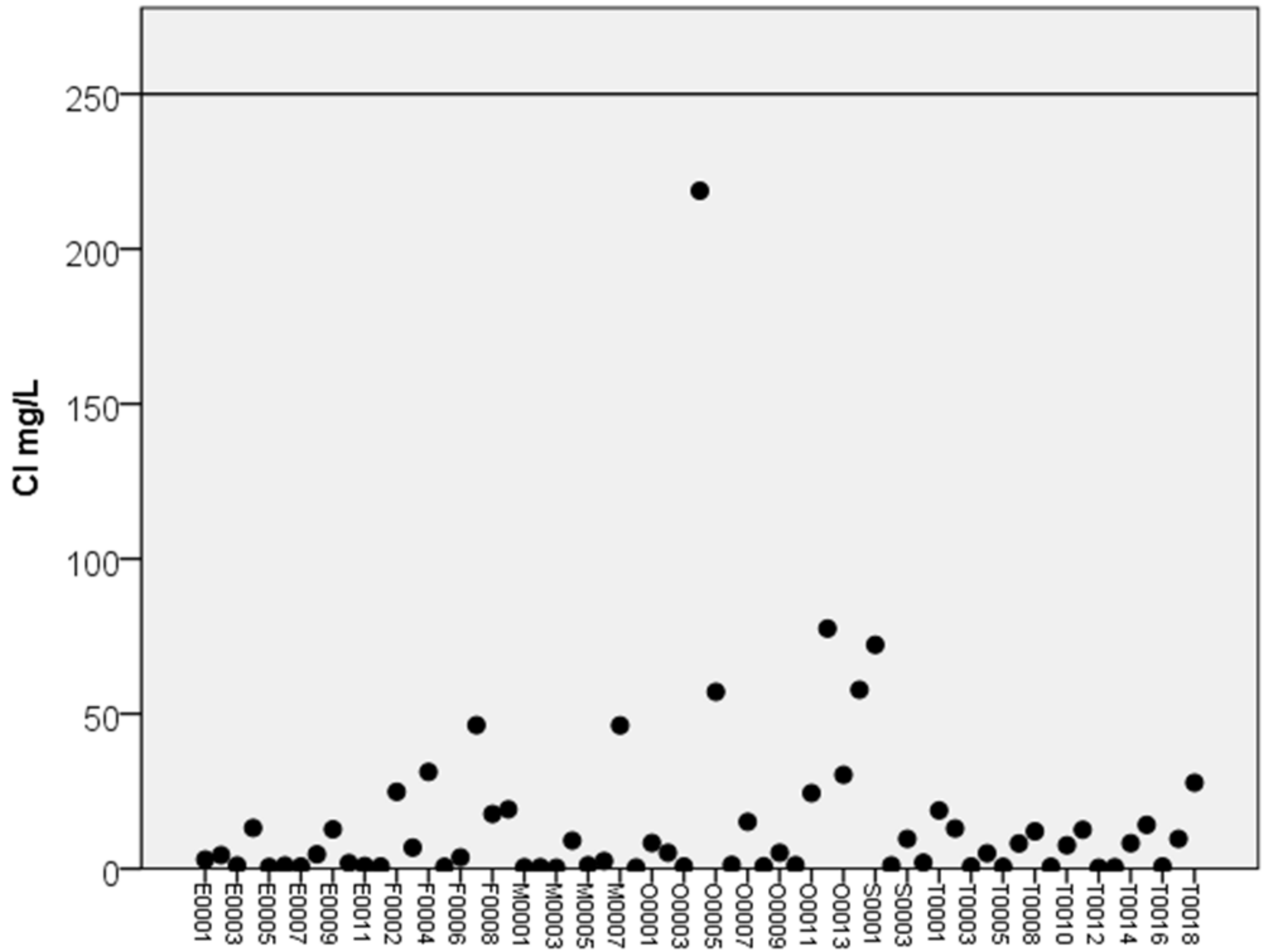
NITRATE IN GROUNDWATER



Max in ground water
= 11.8 mg/L

Max in surface water
= 1.0 mg/L

CHLORIDE IN GROUNDWATER

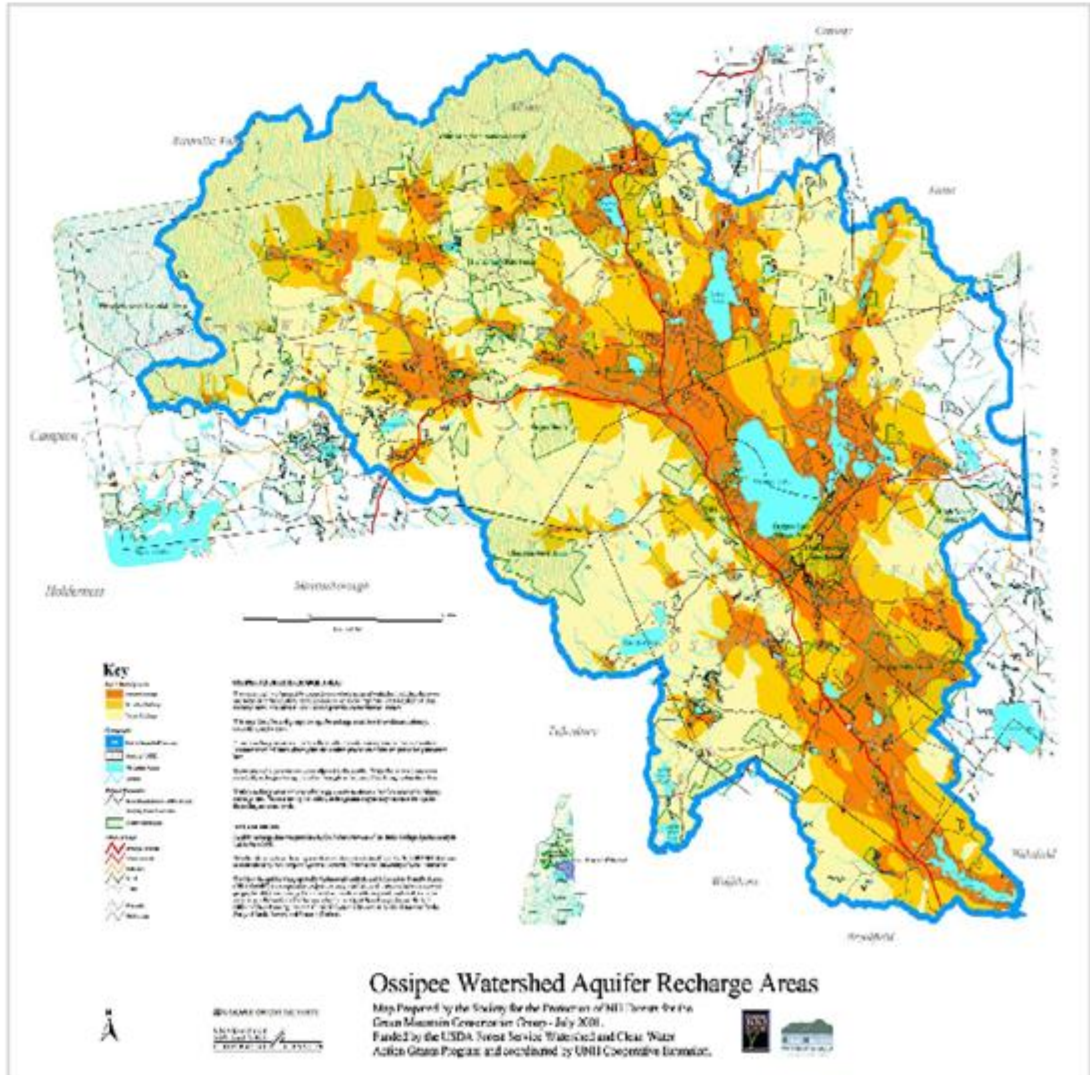


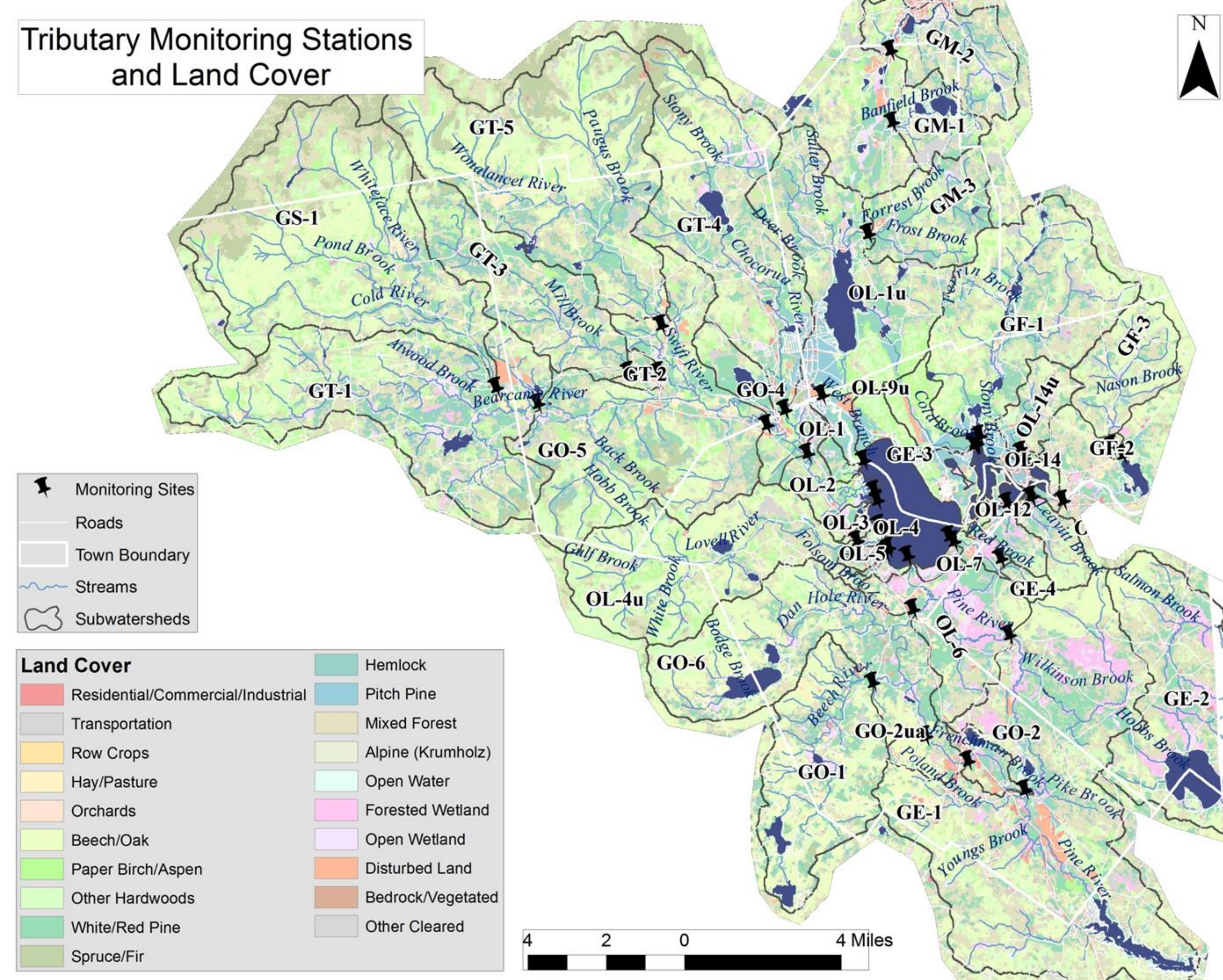
Max in ground water = 219 mg/L

Max in surface water = 139 mg/L

STRATIFIED DRIFT AQUIFER

- Made up of layers of sand and gravel deposited by glaciers
- More vulnerable to contamination
- Recharge with rainwater quickly
  - Allow pollution to flow more rapidly into it
- Groundwater easily passes through it
- Supplies majority of residents and businesses located in the watershed with drinking water





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N
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Residential/Commercial/Industrial
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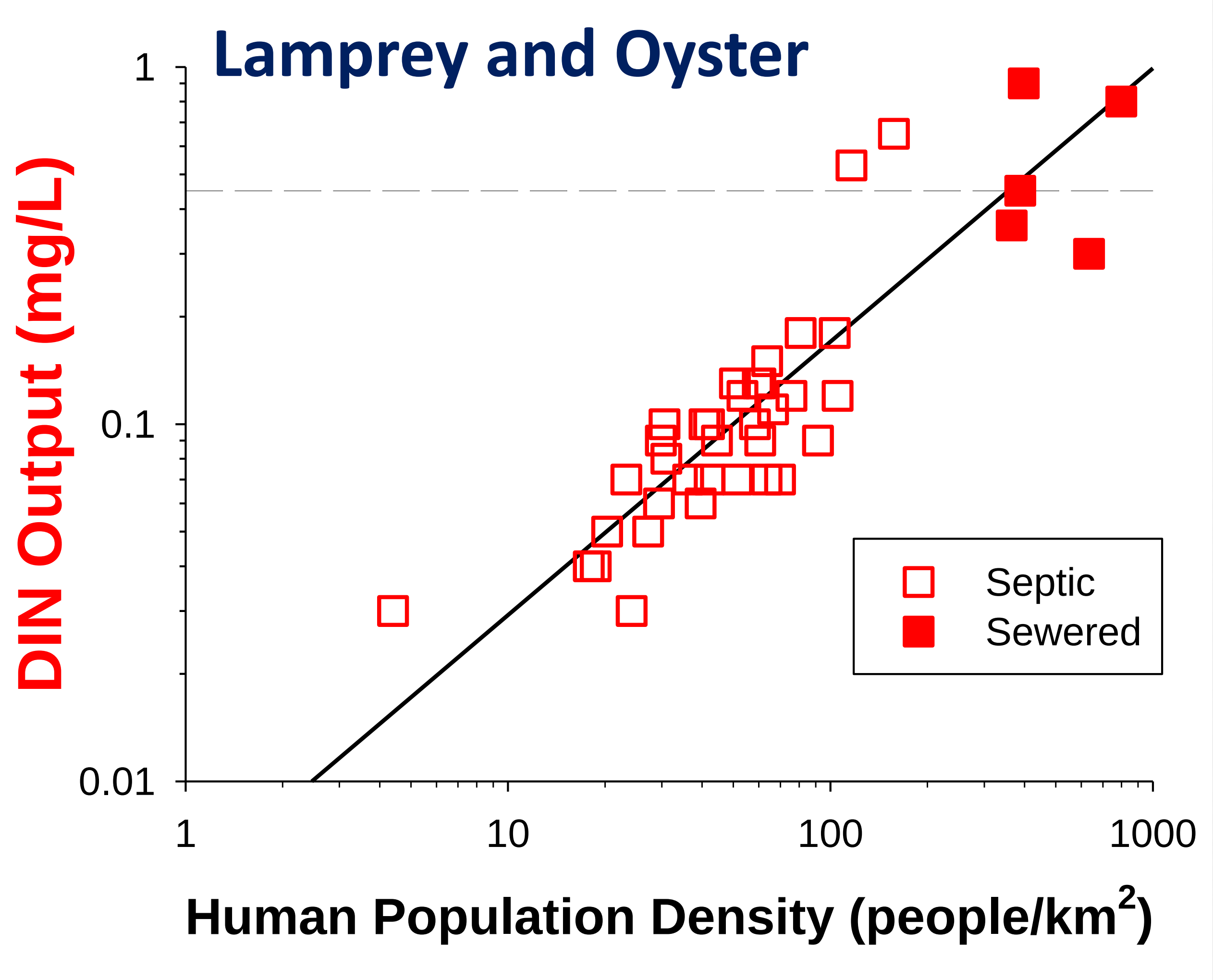
Row Crops
Hay/Pasture
Orchards
Beech/Oak
Paper Birch/Aspen
Other Hardwoods
White/Red Pine
Spruce/Fir
Hemlock
Pitch Pine
Mixed Forest
Alpine (Krumholz)
Open Water
Forested Wetland
Open Wetland
Disturbed Land
Bedrock/Vegetated
Other Cleared
4 2 0 4 Miles
GM-2
Banfield Brook
GM-1
GM-3
Forrest Brook
Frost Brook
GT-5
Wonalancet River
Paugus Brook
Stony Brook
Salter Brook
GS-1
Whiteface River
Pond Brook
Cold River
GT-3
Mill Brook
GT-4
Deer Brook
Chocorua River
OL-1u
Ferrin Brook
GF-1
GF-3
Nason Brook
Swift River
GT-2
GT-1
Atwood Brook
Bearcamp River
GO-4
OL-9u
West Branch
Cold Brook
Stony Brook
OL-14u
GO-5
OL-1
GE-3
OL-14
GF-2
Back Brook
Hobb Brook
OL-2
OL-12
Leavitt Brook
OL-3
OL-4
Red Brook
OL-5
OL-7
Lovell River
Folsom Brook
Gulf Brook
White Brook
GE-4
Salmon Brook
OL-4u
Dan Hole River
Pine River
OL-6
Bodge Brook
GO-6
Wilkinson Brook
Beech River
GE-2
GO-2ua
GO-2
Frenchman Brook
Hobbs Brook
GO-1
Poland Brook
Pike Brook
GE-1
Youngs Brook
Pine River

CONCLUSIONS AND ADVICE

- Overall surface water quality parameters are in healthy ranges.
  - Ground water has much higher levels of Cl and NO_3 than surface water.
- Develop watershed management plan to maintain water quality
- 10 years serves as a good baseline; still a relatively short time frame.
- Climatic events and influence of flow to further explain changes over time.
- Conduct sub-watershed level land use analysis to explain variation among sites and assess sampling program
  - Population density
  - Land use NLCD 2006 (includes % impervious)
- Consider adding to long-term year round sampling
    - OL-7 for critical DO concentrations (maybe more samples from upstream site GE-4 as well) – but if naturally occurring long-term monitoring may not be necessary
    - GM-2 for Nitrate

LANDSCAPE MODEL FOR SOUTHEAST NH WATERSHEDS



ANNUAL NITRATE AND HUMAN POPULATION DENSITY IN THE LAMPREY