

## Does Comfort Lake receive and accumulate a large load of sediment?

- **(1) What is sediment?**
    - *Which component are we concerned with?*
  - **(2) How much sediment does Comfort Lake accumulate?**
  - **(3) Is this large?**
    - *Relative to reference conditions and other sites*
- 
- *None of these questions is particularly simple or easy to answer.*
  - *All calculations can have considerable error.*
  - *Best approach is to try multiple independent calculations.*

## (1) What is sediment?

Lake sediment = particles that have settled, *or could settle*, to the bottom.

Driven mostly  
by landscape  
erosion

- ❖ Particles delivered to the lake by streams, overland runoff, and dustfall
  - Sand
  - TSS = Total Suspended Sediment
    - Organics: plant matter, eroded peat, algae from streams and upstream lakes
      - VSS = volatile suspended solids (~50%)
    - Inorganics: silts & clays from eroded soils
      - NVSS = non-volatile suspended solids (~50%)

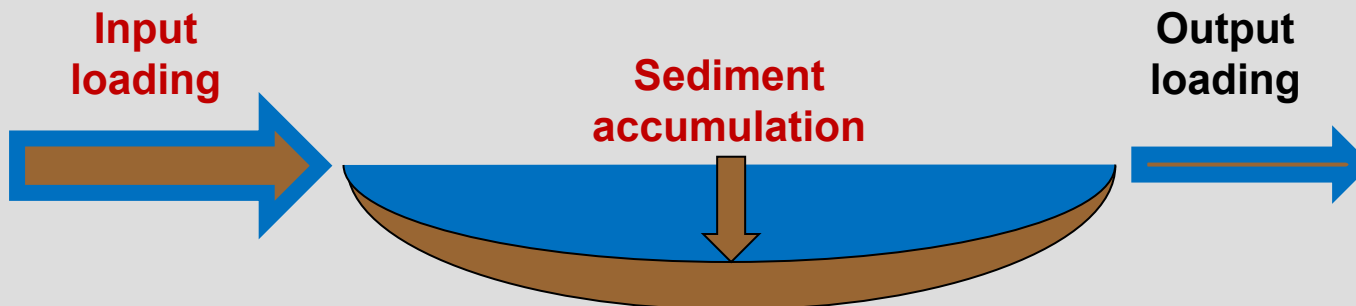
Driven mostly  
by nutrient  
delivery to lake

- ❖ Particles created in the lake
  - Organics = algae, macrophyte bits
  - Inorganics =
    - CaCO<sub>3</sub> (calcium carbonate)
    - Diatom frustules (cell walls; “biogenic silica”)
    - Metal oxides and salts

## Comfort Lake sediment components

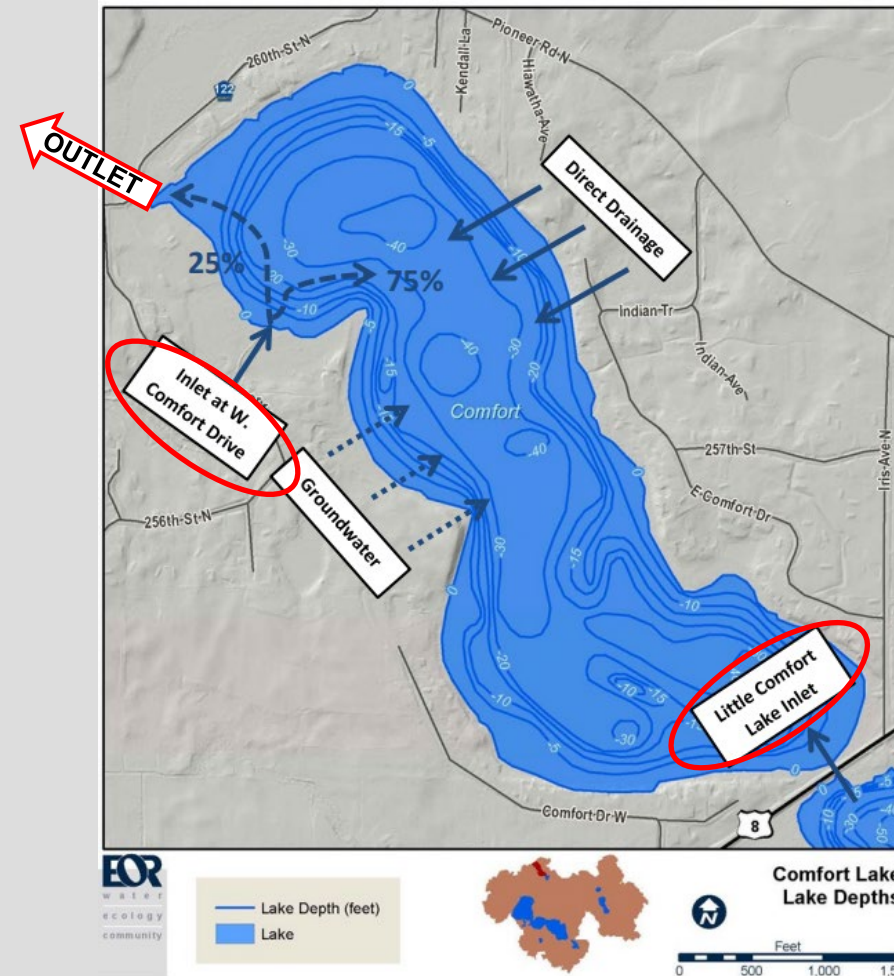
- ❖ Organics = 20-55%
  - Some washed in from stream inlet
  - Some (most?) from in-lake algal productivity
- ❖ Calcium carbonate = 20-30%
- ❖ Diatom frustules = 5-15%
  - Some from streams?
- ❖ Inorganics = 20-40%
  - Silts & clays from eroded soil

*How much **input loading** and **accumulation** of this component does Comfort Lake receive?*



## (2) How much sediment does Comfort Lake receive?

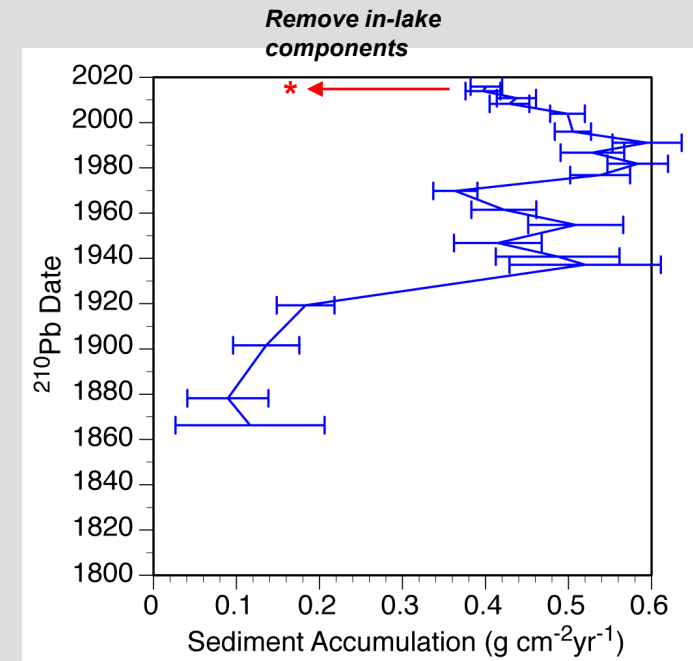
- ❖ What have we measured?
  - (2a) Sediment accumulation by Pb-210
  - (2b) Sediment budget from stream monitoring
    - Input – Output = Accumulation



## (2) How much sediment does Comfort Lake receive:

### (2a) Sediment accumulation as measured by Pb-210

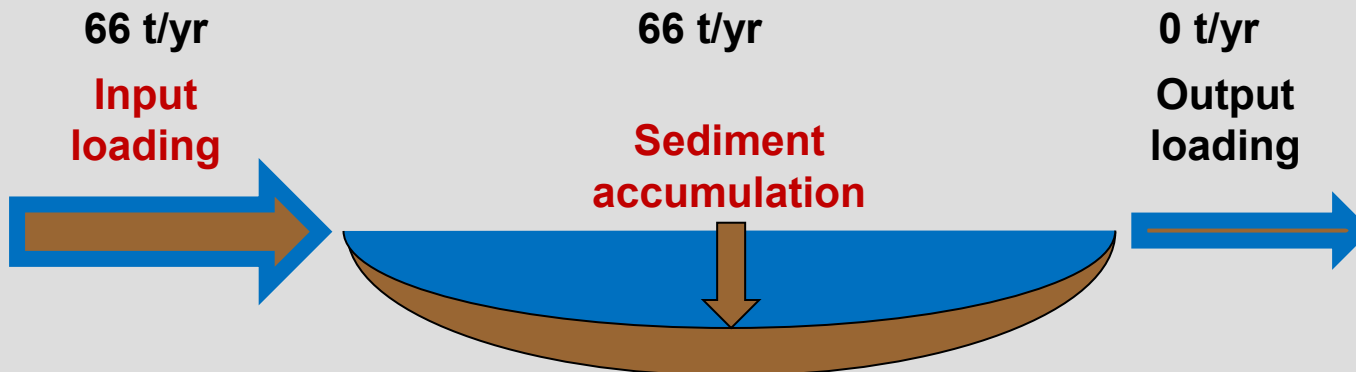
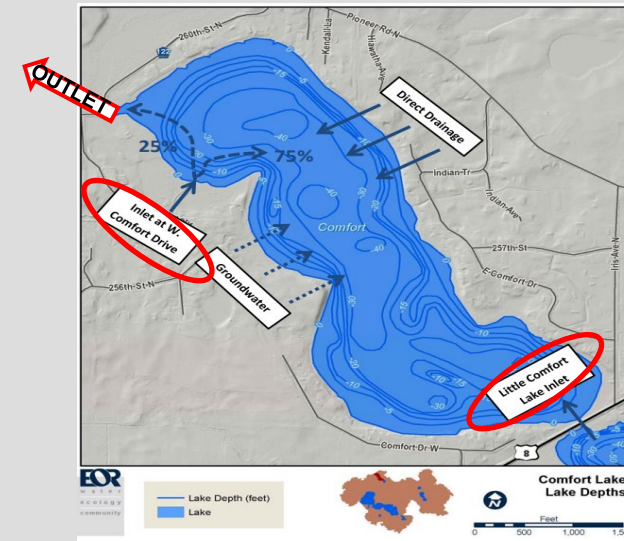
- **Sediment core collected from deep part of lake**
  - Pb-210 concentration and sediment content measured in sediment core
  - Gives sediment accumulation rate ( $\text{g}/\text{cm}^2/\text{yr}$ ) & focusing factor at core site
- **Results for Comfort Lake**
  - Current (top of core) accumulation of silts & clays =  $0.16 \text{ g}/\text{cm}^2/\text{yr}$  at core site
    - *Organics,  $\text{CaCO}_3$ , and bSi (diatoms) subtracted out from total*
  - Divide by focusing factor (2.89) to get  $0.055 \text{ g}/\text{cm}^2/\text{yr}$  over whole lake area
  - Times lake area (218 acres)
  - = **489 t/yr**
- **Limitations**
  - Not tested with multiple cores
  - Not compared to other methods...
    - *...which we'll test now*



## (2) How much sediment does Comfort Lake receive:

### (2b) Sediment accumulation as measured by stream monitoring

- **Load = suspended sediment concentration X stream flow**
  - Average of 2004-2020 values
  - Assumes NVSS = 50% of TSS
- **Input loads of NVSS = 66 t/yr**
  - From Little Comfort Lake = 27 t/yr
  - From Forest Lake via Sunrise River = 39 t/yr
- **Output loads of NVSS = 0**
  - It's all algae – no silts and clays
- **Sediment accumulation = 66 t/yr**
  - Much lower than the Pb-210 value of 489 t/yr



## (3) Is the sediment input and accumulation in Comfort Lake large?

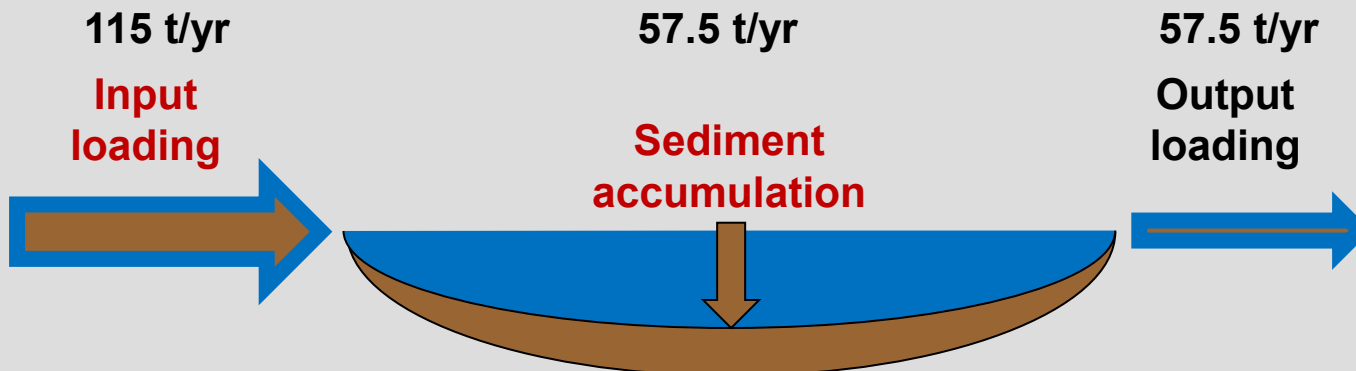
- ❖ **How does sediment in inlet streams and Comfort Lake compare to standards and other sites?**
  - *We tried to answer this question in (at least) four different ways.*



(3) *Is the sediment accumulation in Comfort Lake large:*

(3a) Input loading under reference (natural, pre-settlement) conditions

- Estimated reference NVSS from Robertson et al. 2006 statistical study of Great Lakes region
  - 7.1 mg/L NVSS in streams for our area
  - 0.05 t/ha/yr
- Input loads of NVSS = 115 t/yr
  - From direct basin around lake = 22 t/yr
  - From Little Comfort Lake = 30 t/yr
  - From Forest Lake via Sunrise River = 63 t/yr
- Output loads of NVSS = 57.5 t/yr (guessed 50% trapping)
- Sediment accumulation = **57.5 t/yr**



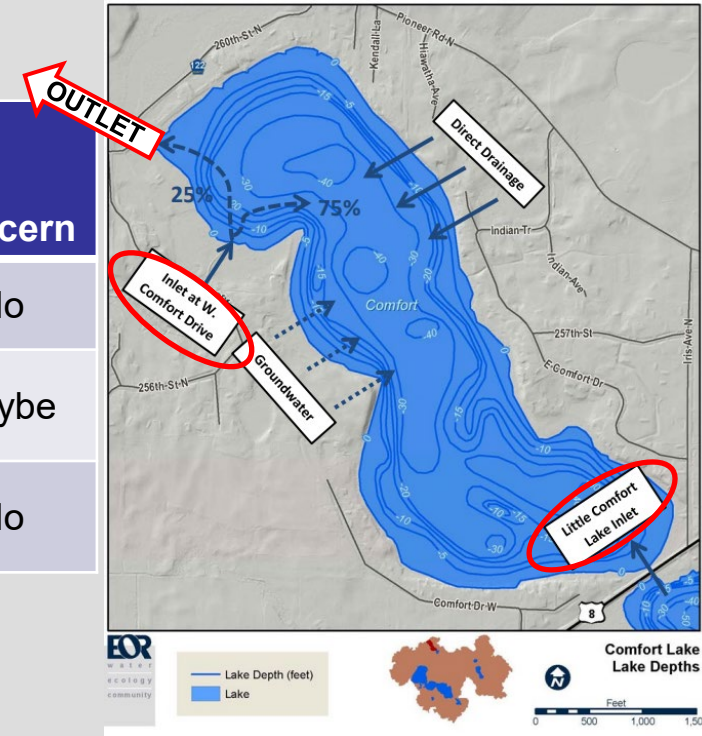


(3) Is the sediment accumulation in Comfort Lake large:

(3b) Are TSS concentrations in inlet streams large?

## Stream Concentrations (2011-2020)

Site	Number of NVSS Samples	Number of Exceedances	Percentage of Exceedances	Concern
Sunrise River	21	2	9.5%	No
Little Comfort Lake Inlet	21	5	24%	Maybe
Comfort Lake Outlet	17	0	0%	No

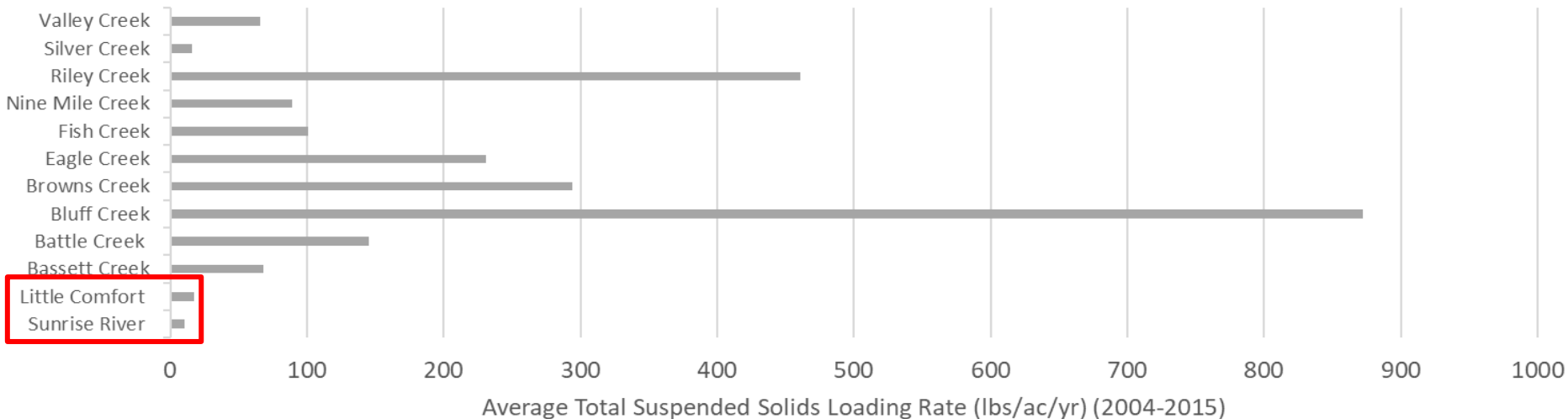
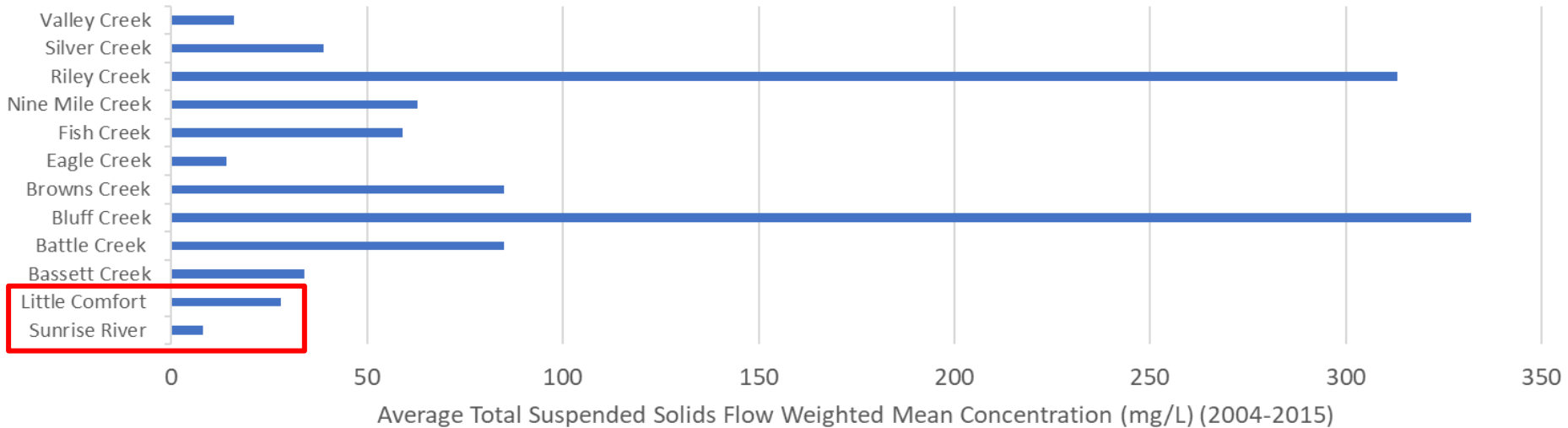


- TSS standard concentration: 30 mg/L
- Sampling Protocol

# 2022 Comfort Lake Sediment



## (3c) How do TSS concentrations and loading rates compare to other metro-area streams?

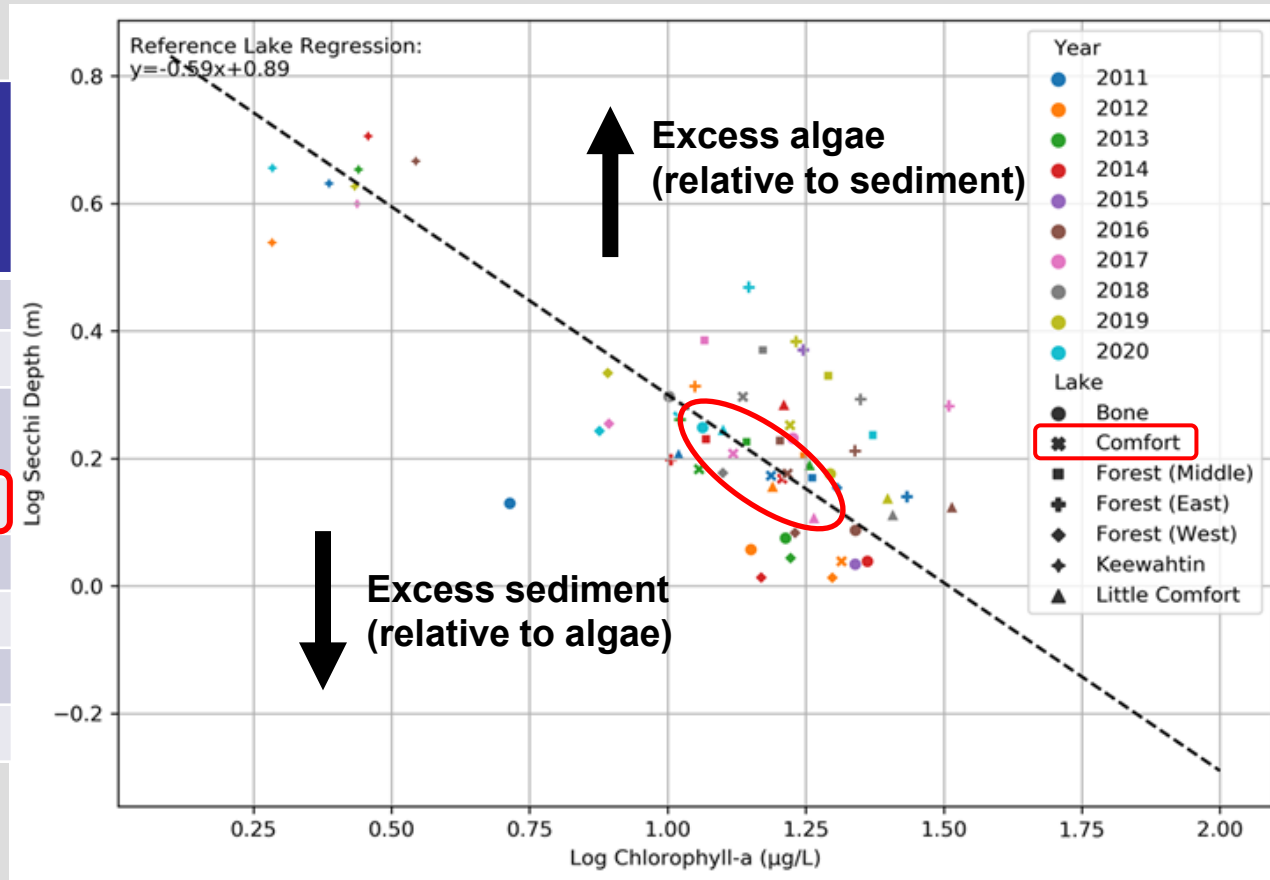


# 2022 Comfort Lake Sediment



## (3d) How does turbidity in Comfort Lake compare to other WD lakes?

Lake	Secchi Depth (ft) (2011-2020)	Distance to Reference Chl-a~Secchi Line
Keewahtin	15	0.08
Forest (East)	6.3	0.18
Forest (Middle)	6.1	0.11
<b>Comfort</b>	<b>5</b>	<b>0.05</b>
Little Comfort	4.8	0.07
Forest (West)	4.6	0.11
Bone	4.4	0.13
Moody	2.5	0.07



**Comfort Lake plots close to the regression line – so it does not have disproportionately more NVSS (silts and clays) relative to algae (or vice versa)**

## Summary

- ❖ (1) What sediment component are we interested in?
  - NVSS = non-volatile suspended solids = eroded soil silt & clay
- ❖ (2) What is NVSS accumulation in Comfort Lake?
  - (a) 489 t/yr from lake-sediment Pb-210 calculations
  - (b) 66 t/yr from stream monitoring calculations
- ❖ (3) Is this accumulation rate large?
  - (a) 57.5 t/yr under reference (natural) conditions
  - (b) TSS concentrations in inlet streams are not large. They mostly meet the standard (30 mg/L).
  - (c) TSS concentrations and loading rates are low compared to other metro-area streams.
  - (d) Turbidity in Comfort Lake is not driven by NVSS (silts and clays).

## Conclusions

- ❖ **The input loads and accumulation rates of NVSS in Comfort Lake do not appear to be large.**
  - *Monitored values are larger than the reference value, but overall near or better than current water-quality standards.*
- ❖ **The accumulation rate from the sediment Pb-210 study appears to be anomalously large.**
  - *However, the trends in the lake-sediment core samples are self-consistent and thus reliable.*
- ❖ **Reductions in TSS may be possible for Little Comfort Lake inlet**
  - *Additional monitoring between School Lake and Little Comfort Lake*
  - *Preliminary stream condition walk through during Little Comfort Lake model survey*

Minnesota  
designations:

