Big Chetac Lake
Getting Rid of the Green
Phase 3

Nutrient Budget and Management
Data Analysis Report

Prepared for:
Big Chetac Chain Lake Association and Wisconsin Department of Natural Resources

Prepared by:

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Special Thanks to:

- Bernie Lenz (formerly of SEH)
- Craig Roesler, WDNR

*for assistance in writing this report

Big Chetac Chain Lake Association

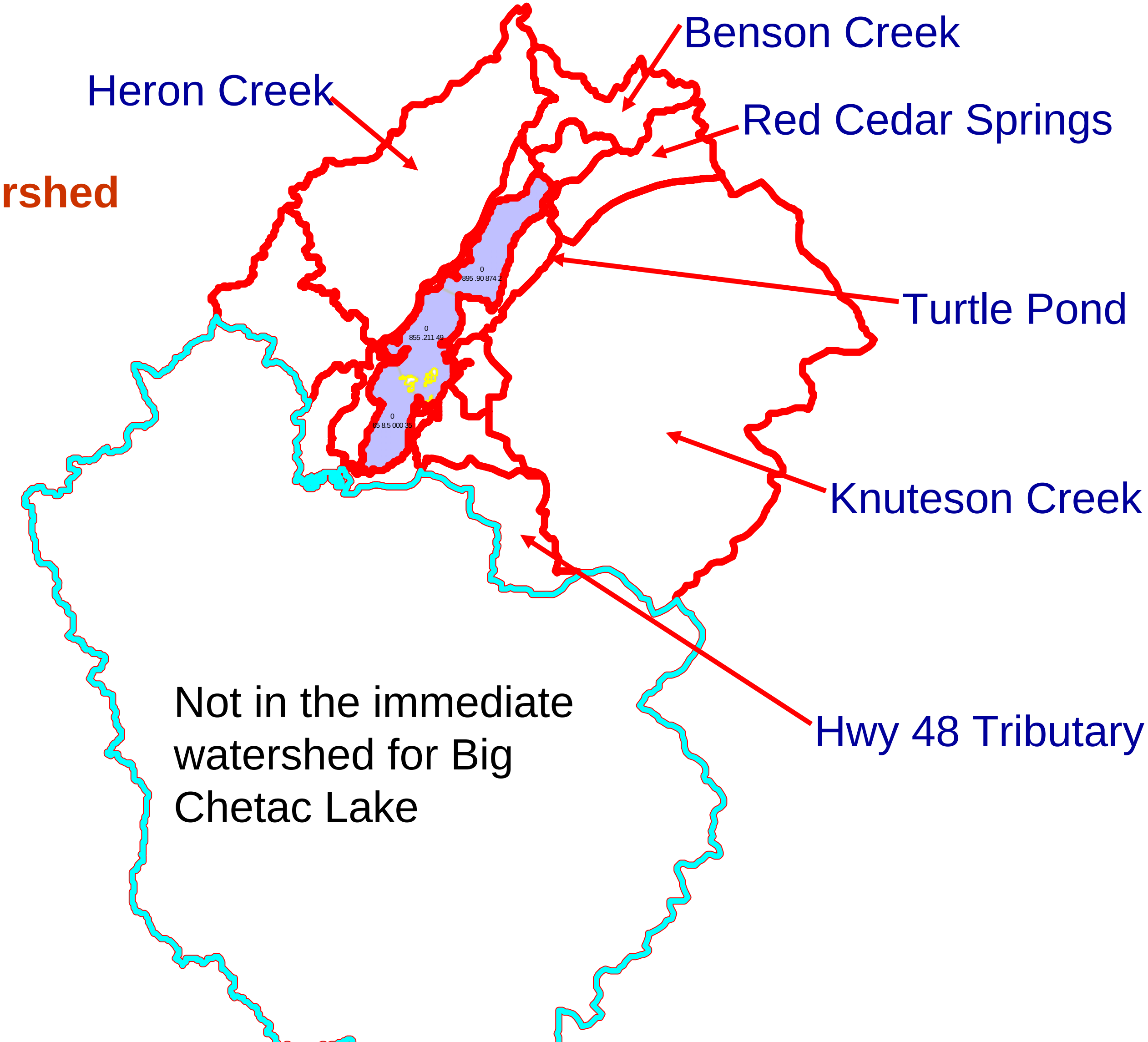
*for patience and understanding

General Lake Information

- Surface Area = 2,406 acres
  - this is about 25% larger than what is stated in the DNR Lake Book
- Maximum Depth – 28 ft
- Average Depth 14 ft
- Drainage Lake
- Watershed = approx. 34,541 acres
  - A little more than 14 to 1 watershed to lake ratio

Big Chetac Lake Watershed

Direct Drainage Watershed = 34,541 acres



General Impressions

- Lake is highly eutrophic (nutrient rich)
- Lake has lots of Curly-leaf pondweed, an invasive species
- Lake is well developed around the shoreline
- Lake use and enjoyment are impaired due to poor water quality and excessive weeds (at least with CLP)

Six Phase Lake Study to be completed: 2007-2009

- Phase One (2007)
  - Water quality, lake stage, and tributary sampling
    - **data collection for Phase Three analysis**
- Phase Two (2007)
  - Groundwater, internal loading, and CLP
    - **data collection for Phase Three**
- Phase Three (2008-09)
  - Nutrient and Water Budget Analysis
    - **today's discussion**
- Phase Four (2008-09
  - Historical Sediment Core Sampling and Analysis
- Phase Five (2008)
  - Full point-intercept plant survey
- Phase Six (2009)
  - Lake User Survey and Comprehensive Lake/Aquatic Plant Management Plan

Water Budget

- Lake Volume – **41,141,263 m^3** (33,354 acre-feet)
- Tributary and Watershed In-flow – **37,188 m^3/day**
- Outflow to Birch Lake and over the dam – **26,671 m^3/day**
- Precipitation, Evaporation, and Lake Storage also taken into account
  - Rainfall = 13.6”
  - Evaporation from Lake = 21.2”
  - Lake Storage = 1.1”
- Total Hydraulic Residence Time – **approx. 3 years**
  - Based on 2007 data from May through September
    - Dry year, except in late August and September

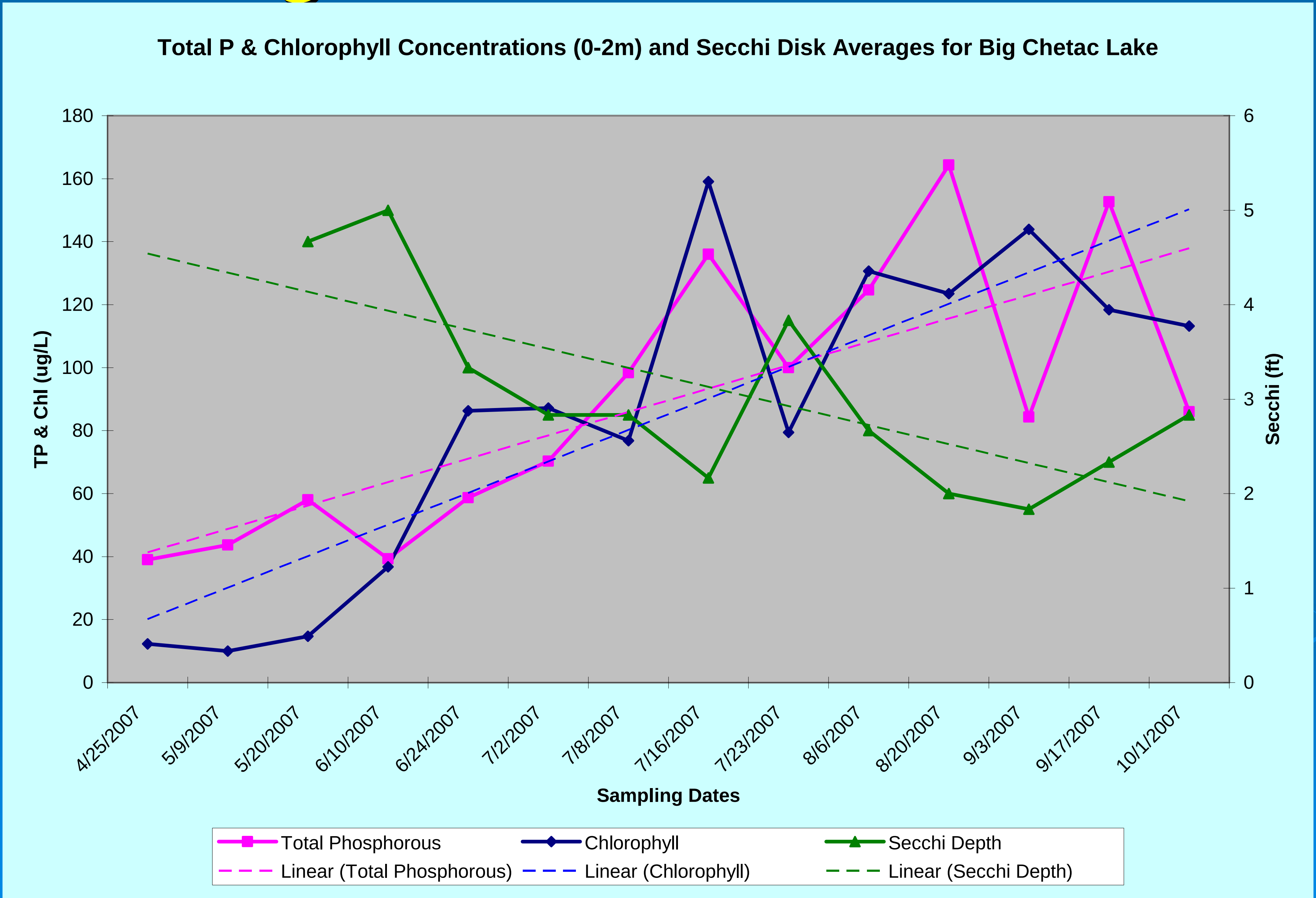
In-Lake Water Quality

- Three lake sites: North, Central, and South Basins
- 15 dates between May and September 2007
- Essentially every meter from surface to bottom
- Total Phosphorous, Total Nitrogen, Chlorophyll *a*, and water clarity (Secchi disk)
- Temperature, Dissolved Oxygen, and pH Profiles also collected

Goals of Lake Sampling

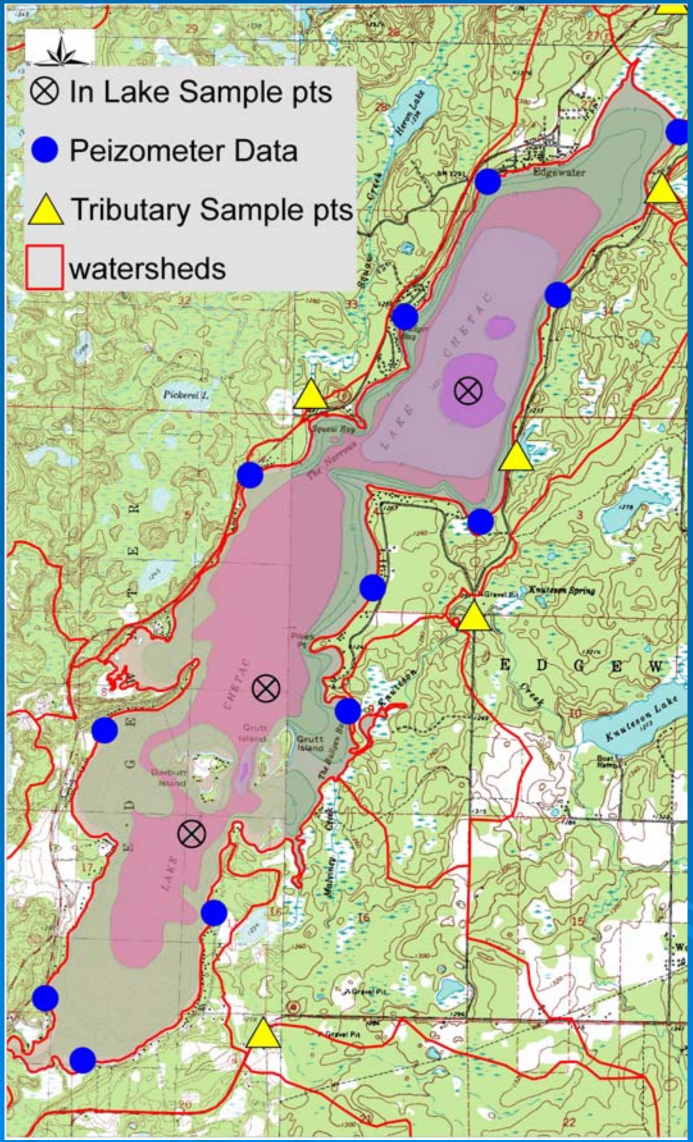
- Determine seasonal changes in phosphorus mass, algal abundance and pH
- Determine the total in-lake phosphorous mass for the year
- Determine if Big Chetac Lake was nitrogen or phosphorous limited.
- Determine the time period for which each basin became anoxic or oxygen depleted in the bottom waters

Big Chetac Lake trends

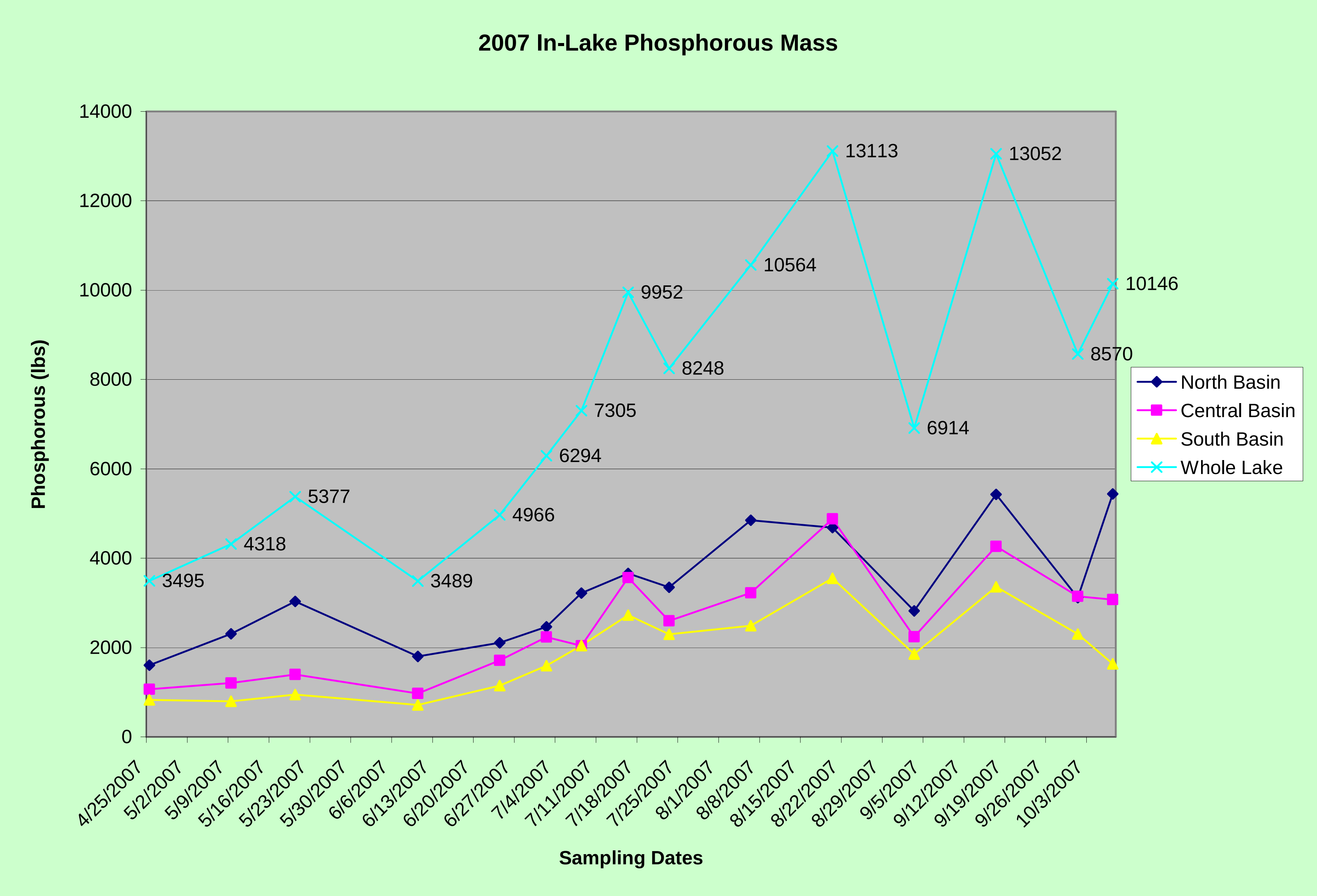


Total In-Lake Phosphorous Mass

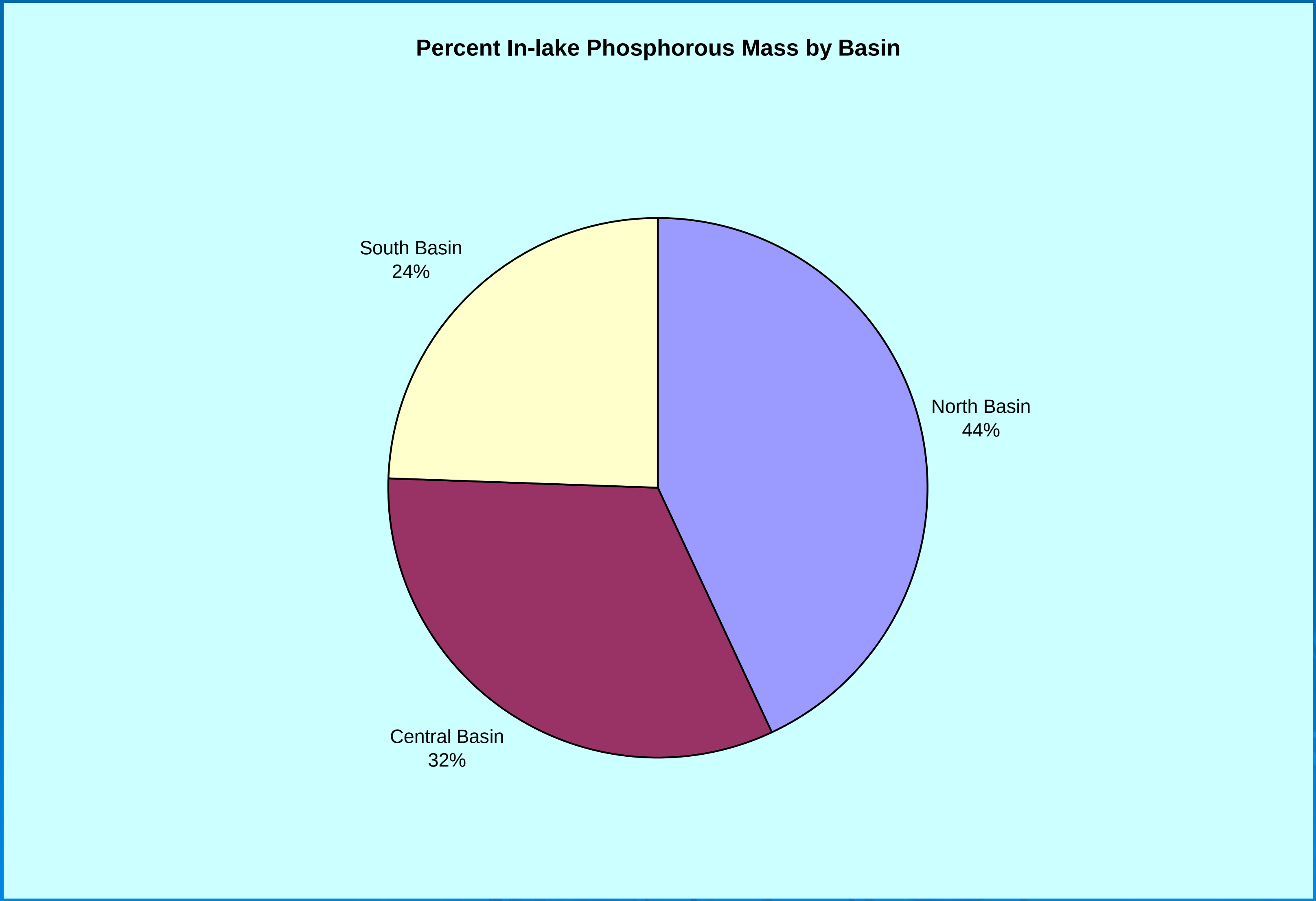
- **Phosphorous sampling at three basins, top to bottom, multiple times**
- **Calculate amount of phosphorous at each depth in each basin, each time**
- **Record the increases**
- **The difference between the minimum phosphorous mass and the maximum phosphorous mass during the year shows the lake's response to inputs of phosphorus**
- It doesn't matter how much phosphorous is coming into a lake, if – if the lake can handle it!



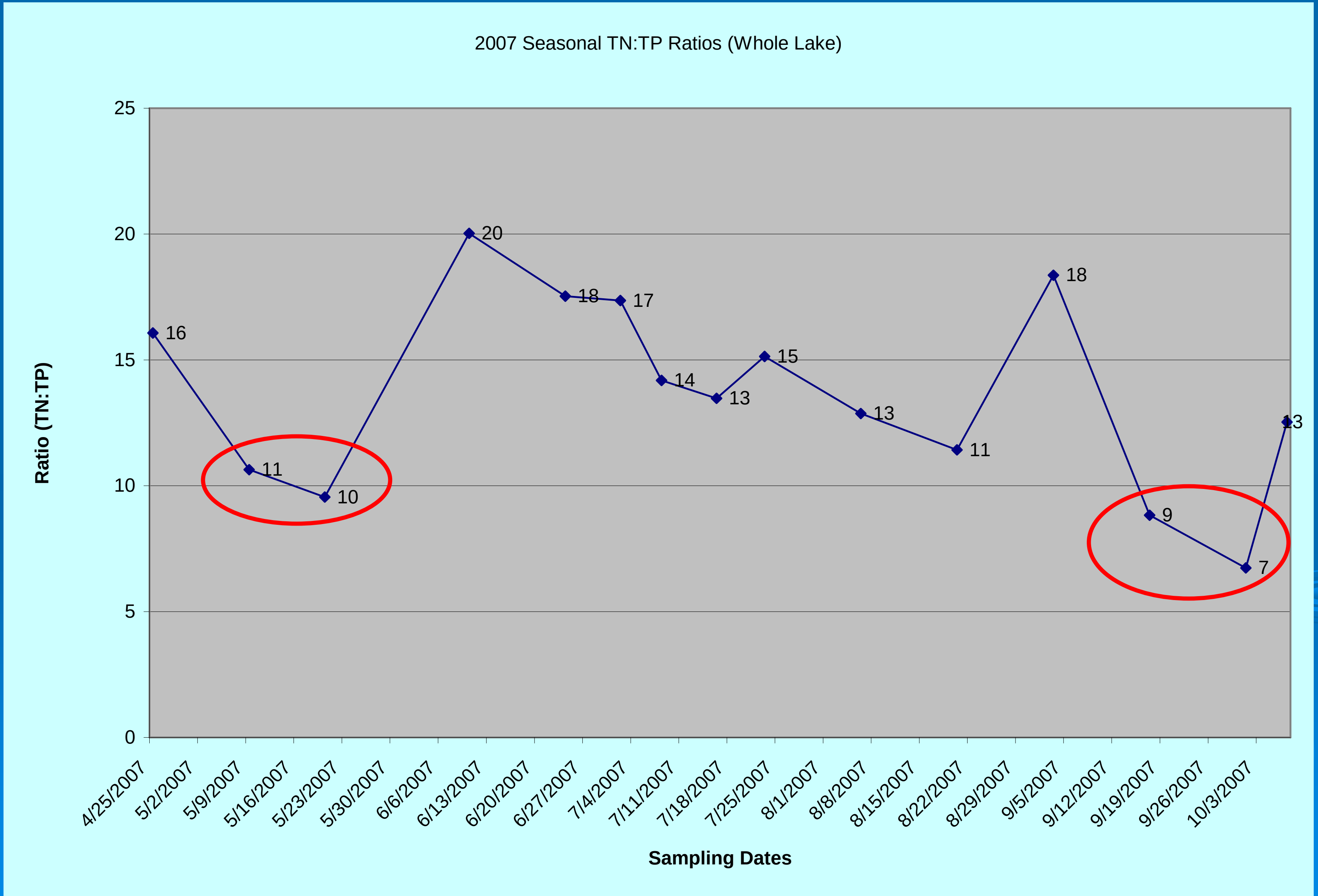
Big Chetac Can't Handle It!!



In-lake Mass per Basin



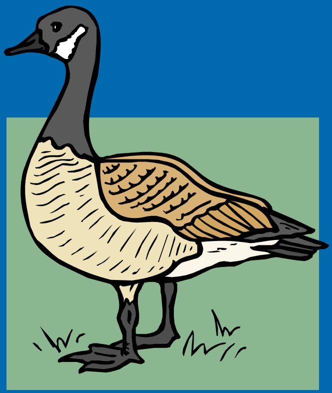
Nitrogen or Phosphorous Limited?

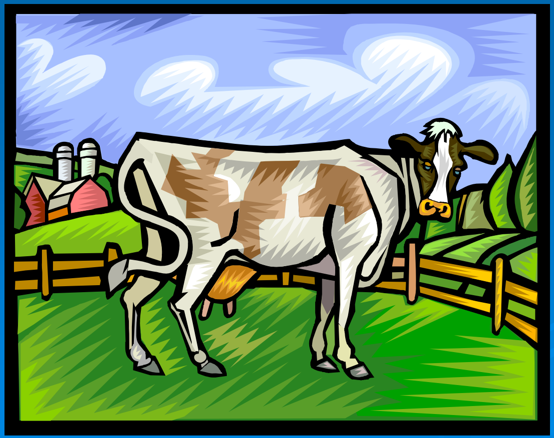


Total Mass of Phosphorous in Big Chetac Lake in 2007

- 9,624 lbs increase of phosphorous from May to September 2007
- Now, where did it come from ?

Other?





Sources and Sinks

- **Sources**
  - Sedimentation
  - Fertilizer
  - Agriculture
  - Urban or residential runoff
  - Decaying plant material
  - Fecal matter (birds, animals, people)
  - Waste treatment
- **Sinks**
  - Encumbered by the sediment in a lake
  - Plant uptake from the sediment
  - Algae uptake from the water
  - Outflow from a lake
  - Animals that are herbivores
  - Waste Treatment

Phosphorous Sources Looked at in this Study

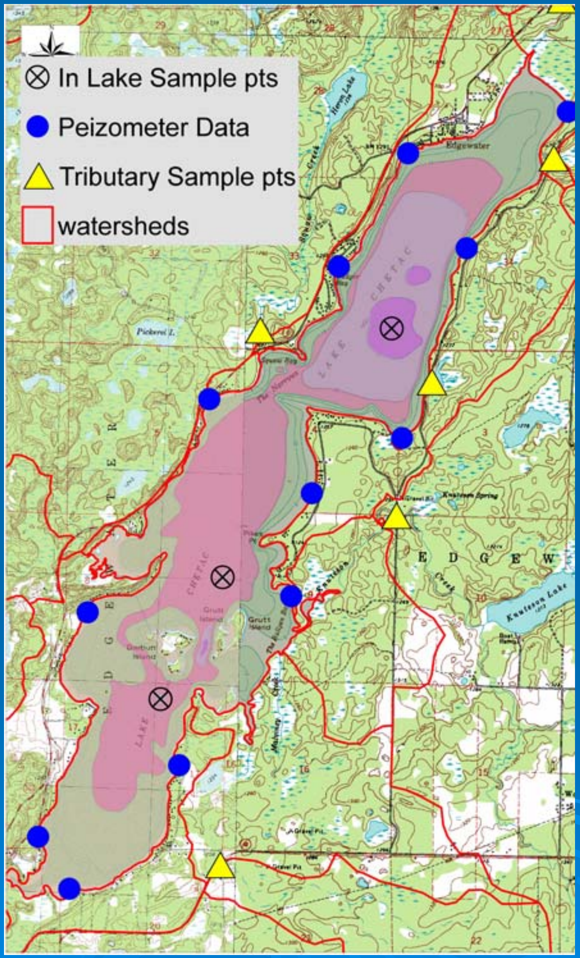
- Atmospheric Deposition
- Groundwater Flow
- Septic System
- Curly-leaf pondweed
- Internal Loading (recycling)
- Tributary Loading (larger watershed)
- Near Shore/Shoreline Contributions
- We didn’t look at goose poop! Sorry.

1. Atmospheric Deposition

- phosphorous found in the dust and other particulate matter that is blown over and settles into the lake
- cleansed from the air when it rains
- 506 lbs (4% of total P)
- **Natural Source**
- **Field cover crops, dampened roads, etc**

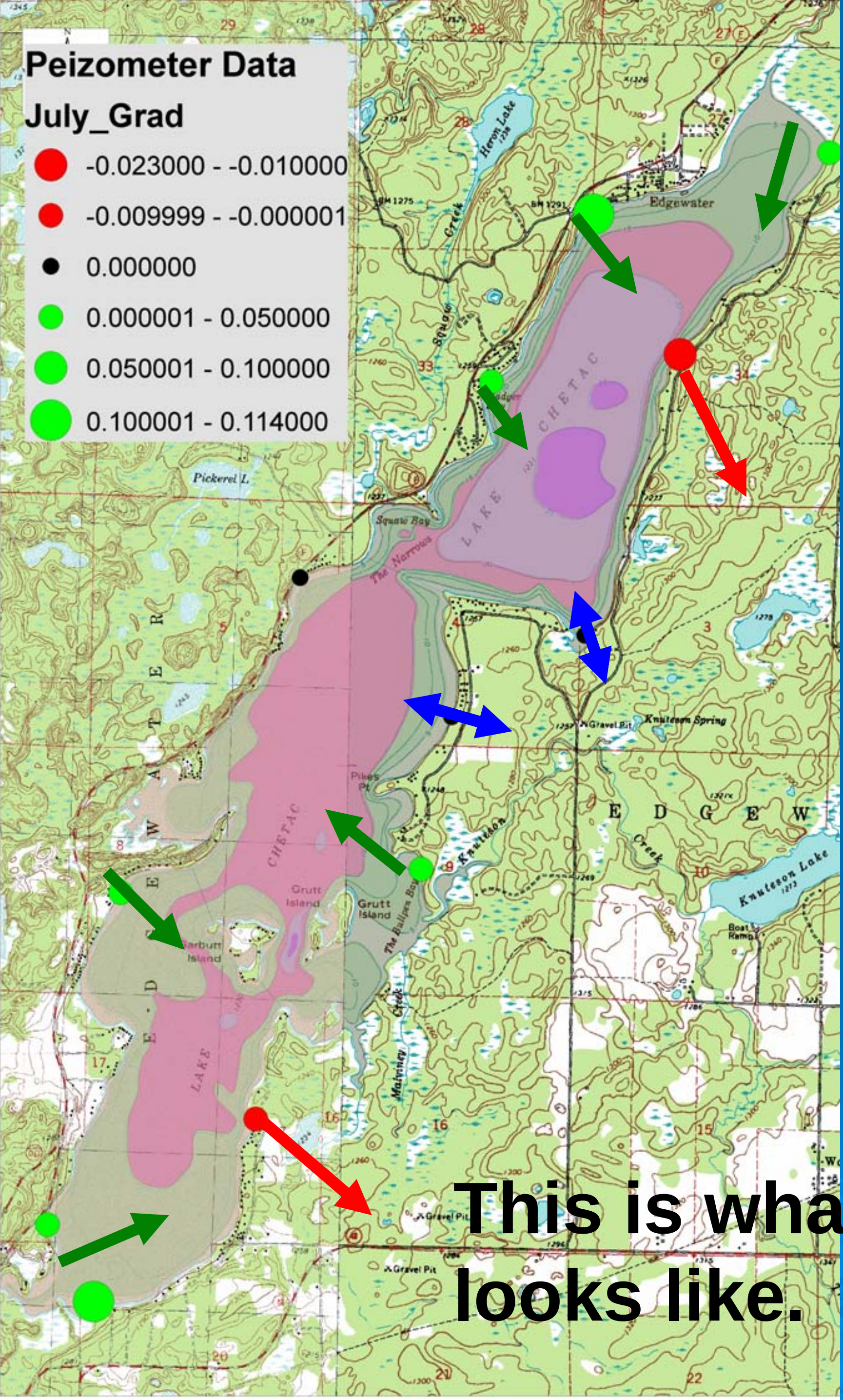
2. Groundwater Contributions

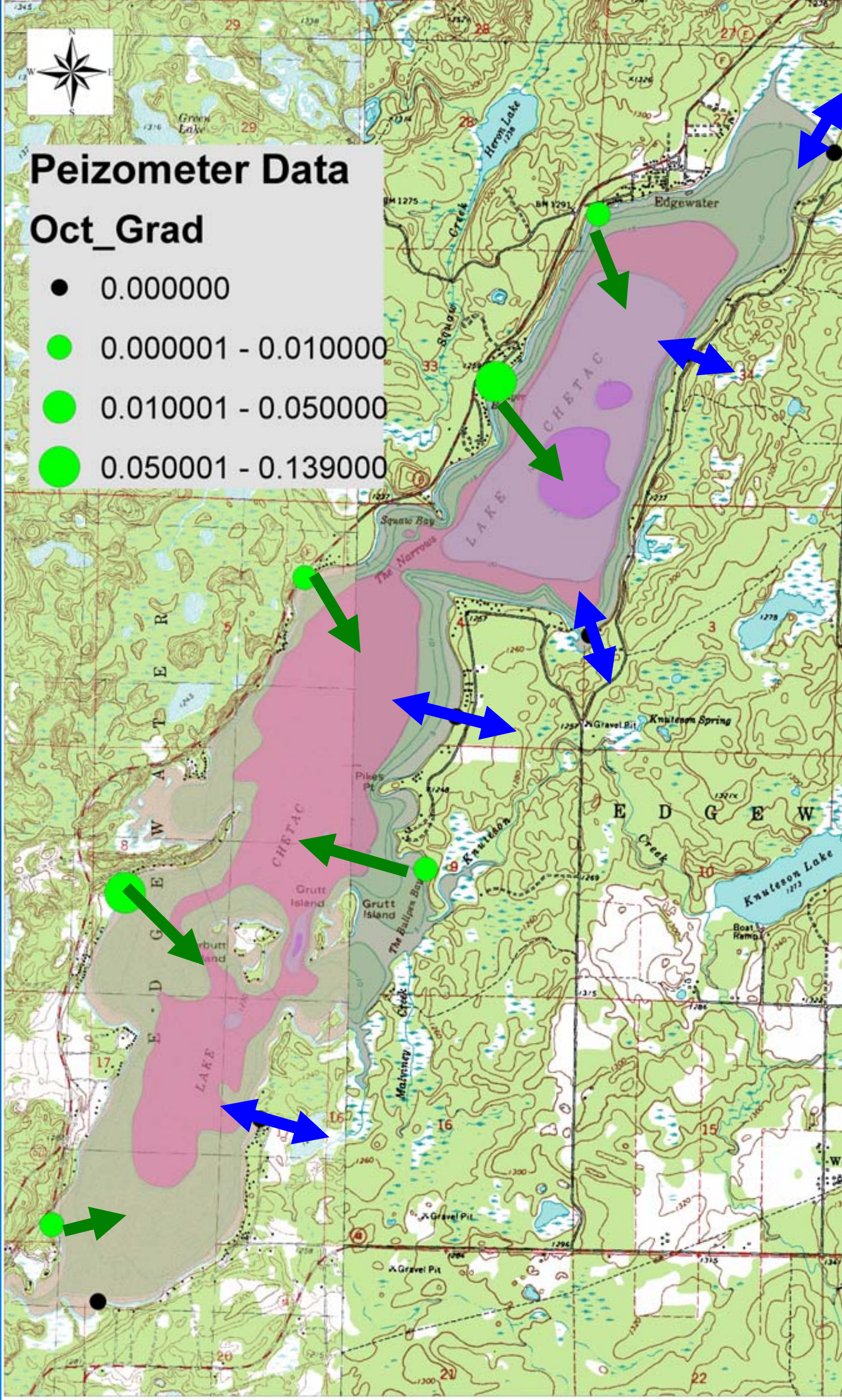
- Determined by measuring groundwater flow and TP concentrations in the water
- 12 peizometers installed around the lake.
- Hydraulic head measured in each to determine amount and direction of flow
- Water sampling from the peizometers to determine TP concentrations
- Natural Source
  - **Can be made worse when flowing through failing septic systems**



Groundwater Results

- flows into the lake primarily from the north and west
- flows out primarily to the south and east
- approximately 4,990,670 gallons of ground water flows into the lake per day
- 499 lbs of phosphorous or 4% of the total seasonal load



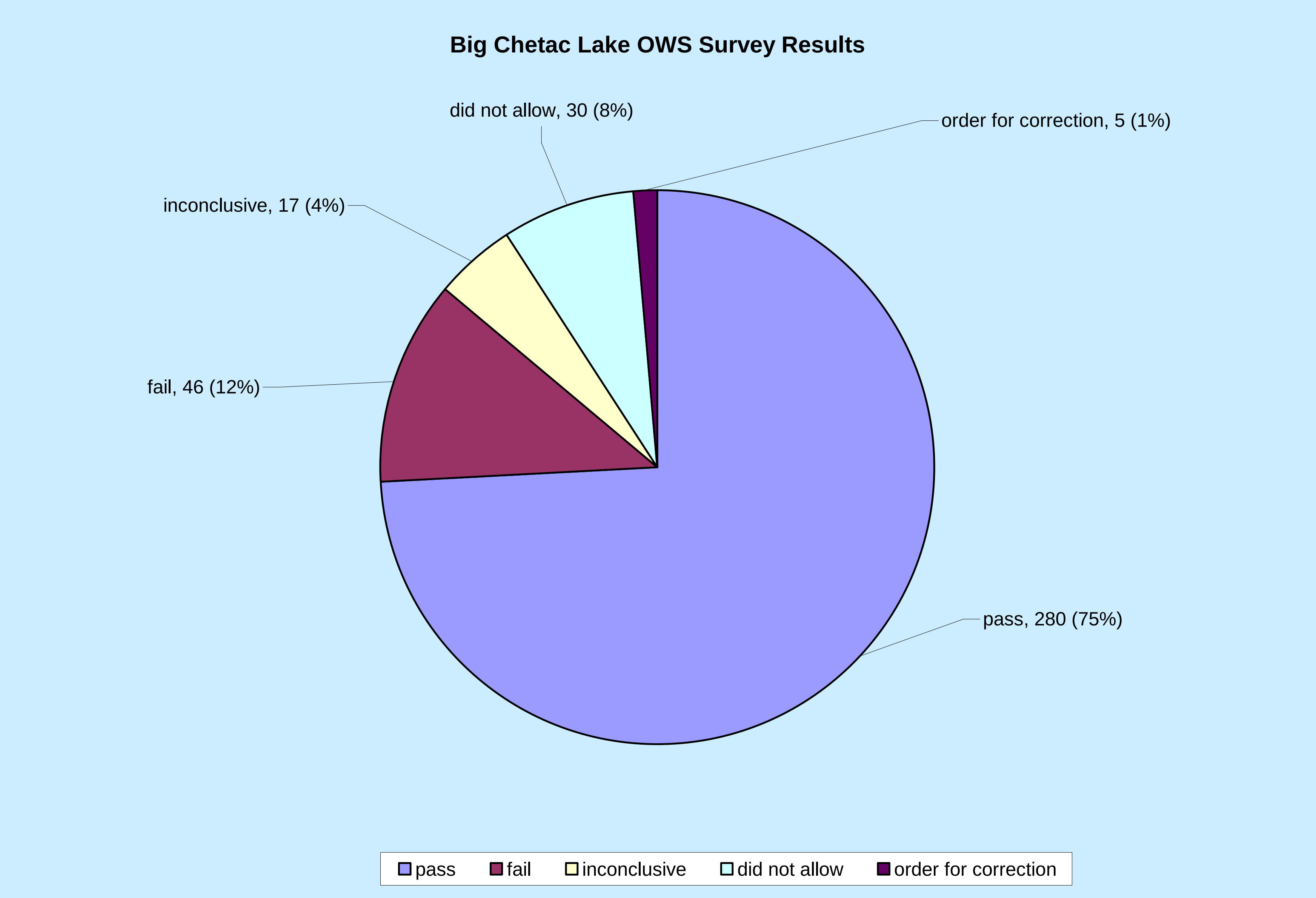


This is what it looks like.

3. Septic Systems

- Survey of almost all systems completed by Sawyer County, Summer 2008
  - Based on 62% agreement of the Lake Association
- Goals of the survey
  - To identify compliant, non-compliant, and failing systems
  - To issue “orders for correction” to the worst offenders
- Attempted to survey 378 systems
- Tied in with groundwater study

Results



Big Chetac Lake OWS Survey Results
did not allow, 30 (8%)
order for correction, 5 (1%)
inconclusive, 17 (4%)
fail, 46 (12%)
pass, 280 (75%)
pass
fail
inconclusive
did not allow
order for correction

Factors to consider when calculating Septic System Input

- Groundwater Flow
- Failing and Passing Systems
- Per capita years the system is in use (people years)
- Export coefficient based on average discharge of phosphorous from household septic and gray water
- Soil retention coefficient based on soil type and slope of shoreline

Septic Contribution Calculations

- Groundwater from east to west
- 292 passing systems
- 81 failing
  - 46 failing + (17 x 0.5) inconclusive + (30 x 0.9) did not allows = 81 failing
- House discharge coefficient of 0.5 kg/capita/year
  - Based on a phosphorous ban on laundry detergent
  - Could range from 0.3 to 0.8
- Soil retention coefficient of 0.9
  - Based on a scale from 0 (all phosphorous in the soil gets to the lake) to 1 (no phosphorous gets to the lake)
  - Sandy loam soil, good permeability, and good drainage around most of Big Chetac Lake

Calculations continued:

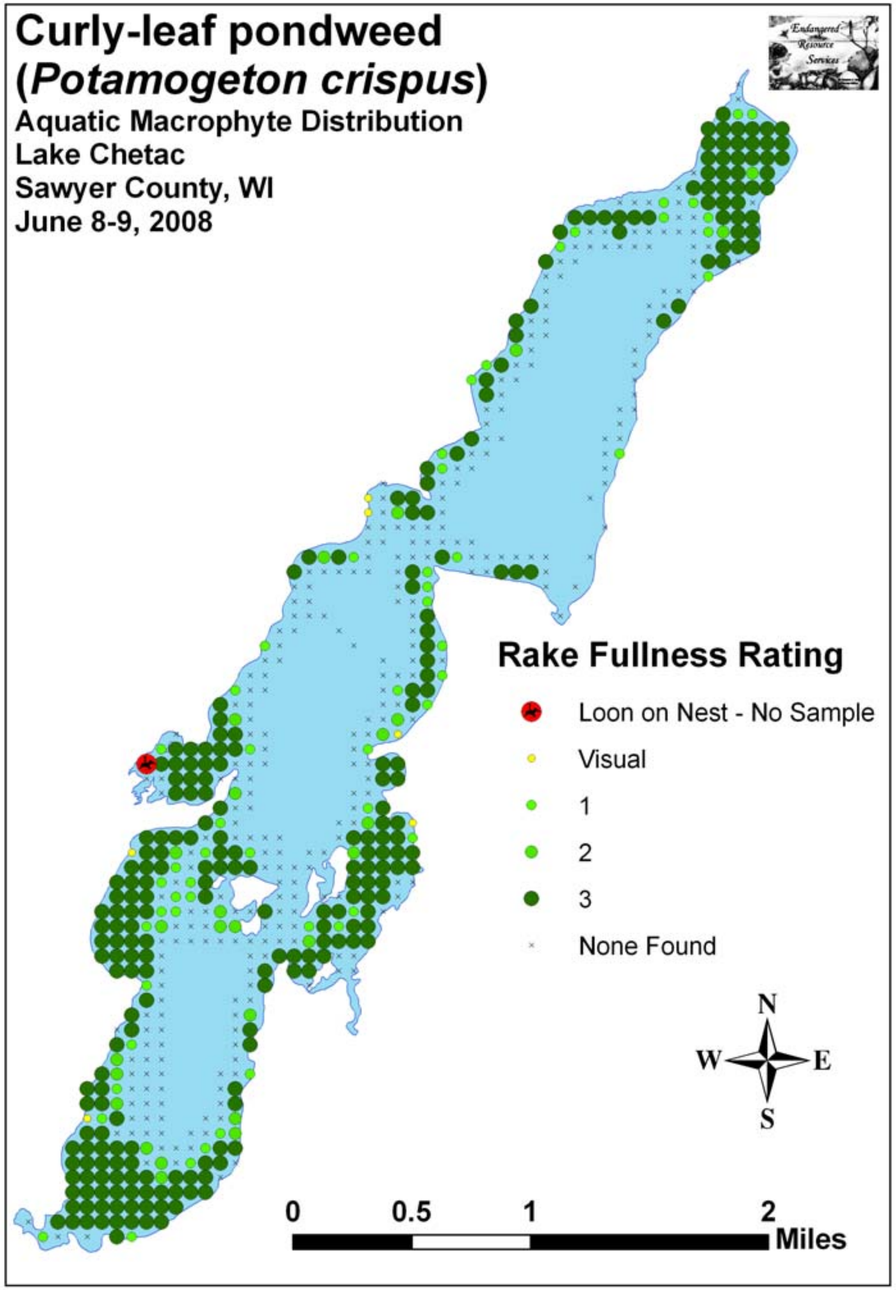
- Capita Years - determined by multiplying the number of people in a household by the total time they use the septic system
- Sawyer County Surveyed Septic Owners when they could, not a great response
  - **30% permanent, 1.92 people/house, 365 days of use (51% of total permanents surveyed)**
  - **70% seasonal, 2.67 people/house, 94.33 days of use (19% seasonals surveyed)**

Total Septic Contributions

- All septic systems regardless of groundwater flow
  - 373 Septic Systems included
  - 108.2 lbs of phosphorous
  - 1.2 % of total load
- All septic systems with groundwater flow considered
  - 108 Septic systems included
  - 32 lbs of phosphorous
  - < 1% of total load

4. Curly-leaf Pondweed

- 25-35% of the lake's surface area (depends on what surface area you use)
- 66% of littoral (plant growing) zone
- 621 acres in June of 2008
- Approx. 9,696 tons of CLP
  - Rice Lake has approximately 3000 tons, and harvests annually about 1000 tons.



How much phosphorous from CLP?

- Approximately **3,500 lbs (1.75 tons)** could be added seasonally if all phosphorous in the CLP went back into the lake
- Not all phosphorous taken up by CLP is released back into the lake (see next slide)
- A better, more conservative value might be **1,761 lbs or 15%** of the total load

How does a plant use up and return phosphorous in a lake?

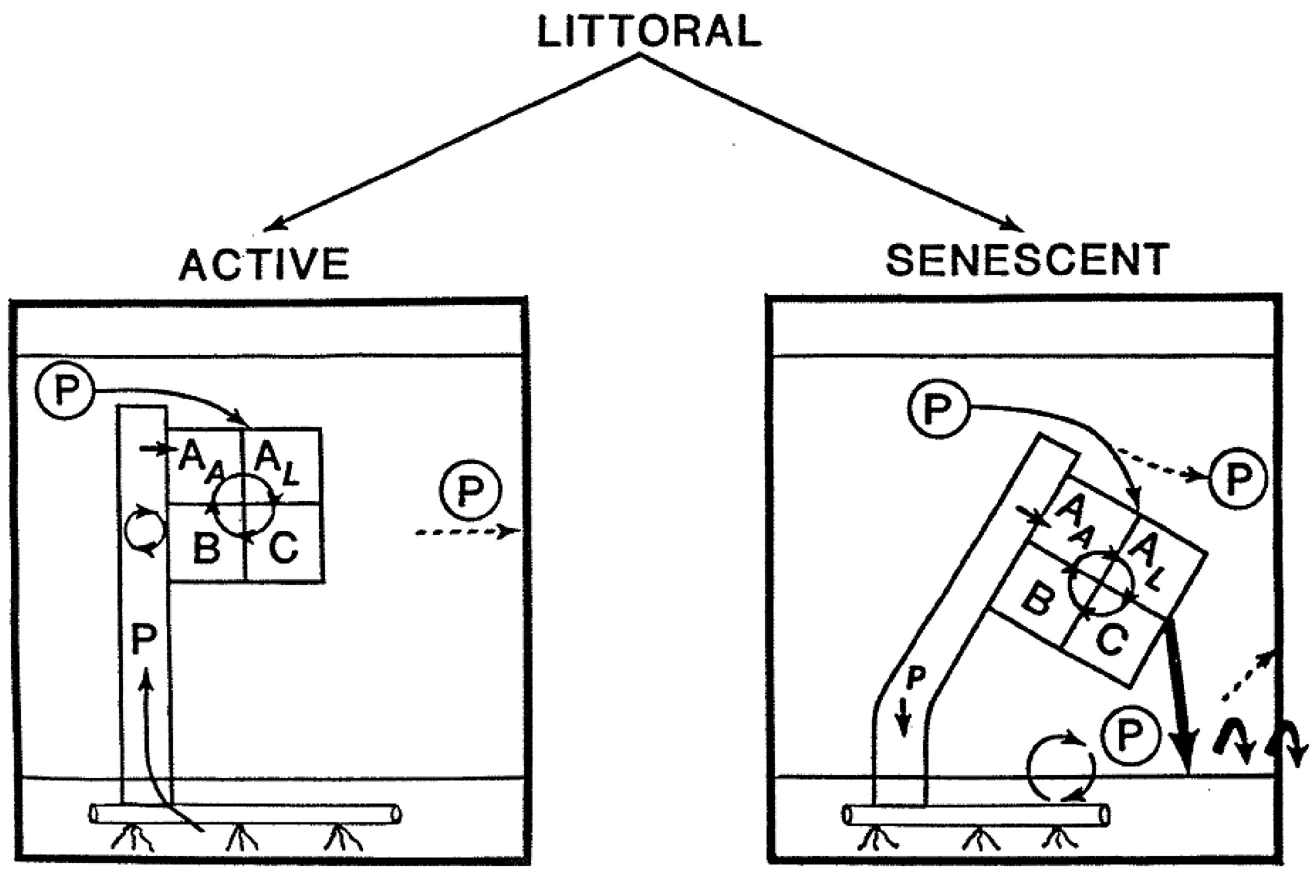


FIGURE 13-9 Fluxes of phosphorus (P) from the sediments to submersed littoral macrophytes and among the epiphytic microflora of the periphyton. A_A = adnate algae; A_L = loosely attached algae, B = bacteria; and C = inorganic or organic particulate detritus, such as calcium carbonate. (From Wetzel, 1990a.)

5. Sediment Phosphorous Release

(internal recycling or release of phosphorous)

- Need to know total time the lake becomes depleted of oxygen near the bottom
- Need to know seasonal pH levels in the lake
- Need to know release rates for phosphorous from the bottom sediments under different situations
- For Big Chetac we needed this information for each basin

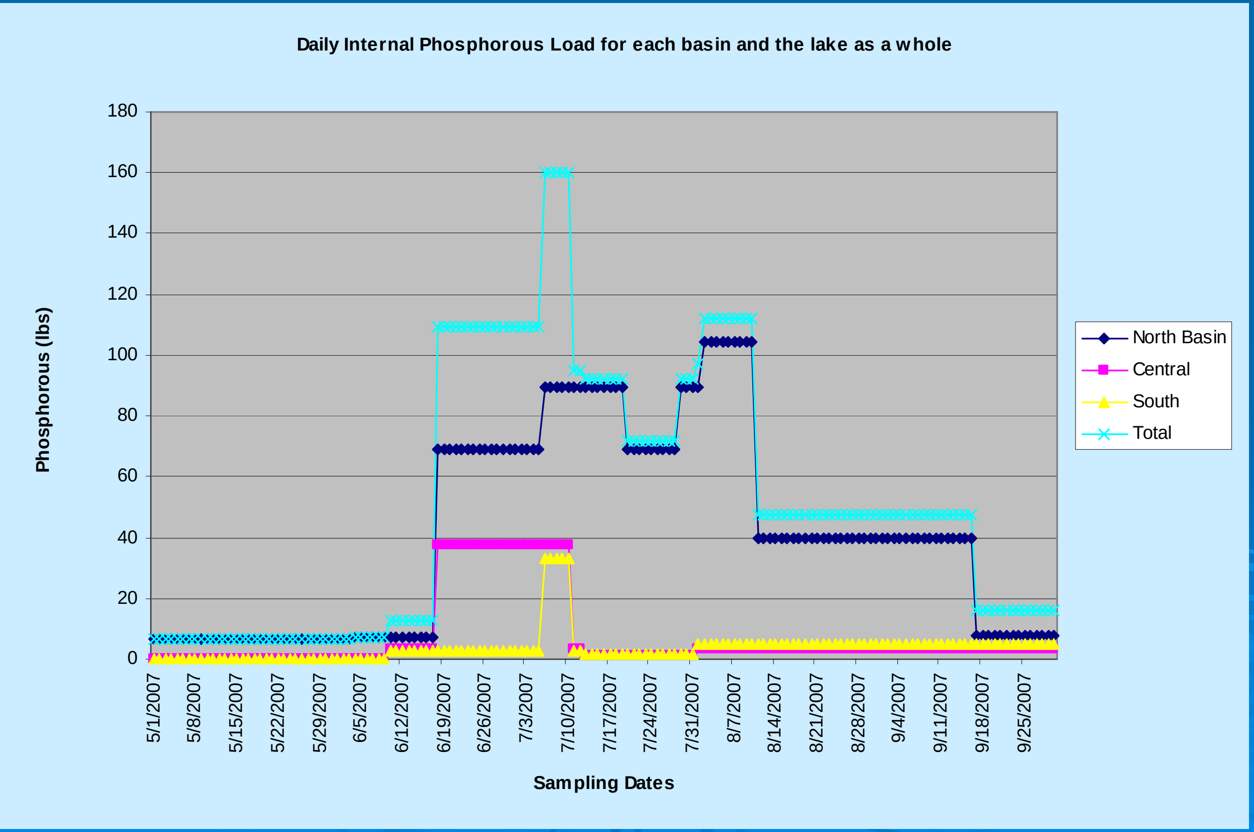
Dissolved Oxygen Concentrations

Dissolved Oxygen Depletion & high pH days in 2007

- North Basin
  - DO depletion
    - 90 days, beginning June 18th
  - High pH
    - Entire season, beginning June 4th
- Central Basin
  - DO depletion
    - 23 days, beginning June 18th
  - High pH
    - Entire season, beginning June 10th
- South Basin
  - DO depletion
    - 5 days, beginning July 5th
  - High pH
    - Entire season, beginning June 10th

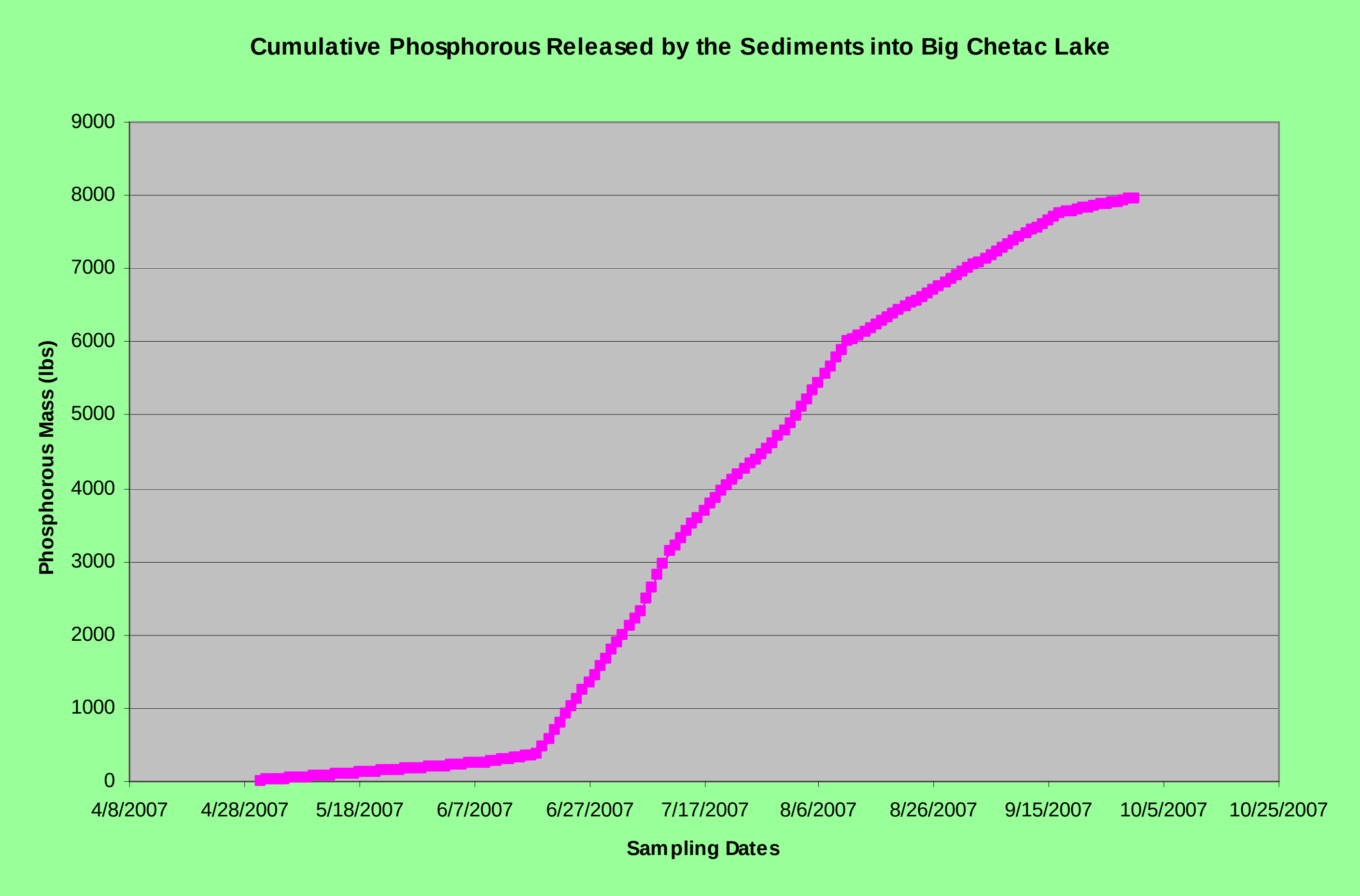
What does the previous slide mean?

- Lots of phosphorous coming from the bottom sediments, internal release, recycling back into the lake for use by algae!



How Much?

- 7,971 lbs of phosphorous being re-released into the lake from the sediments seasonally
- 69% of the total phosphorous loading

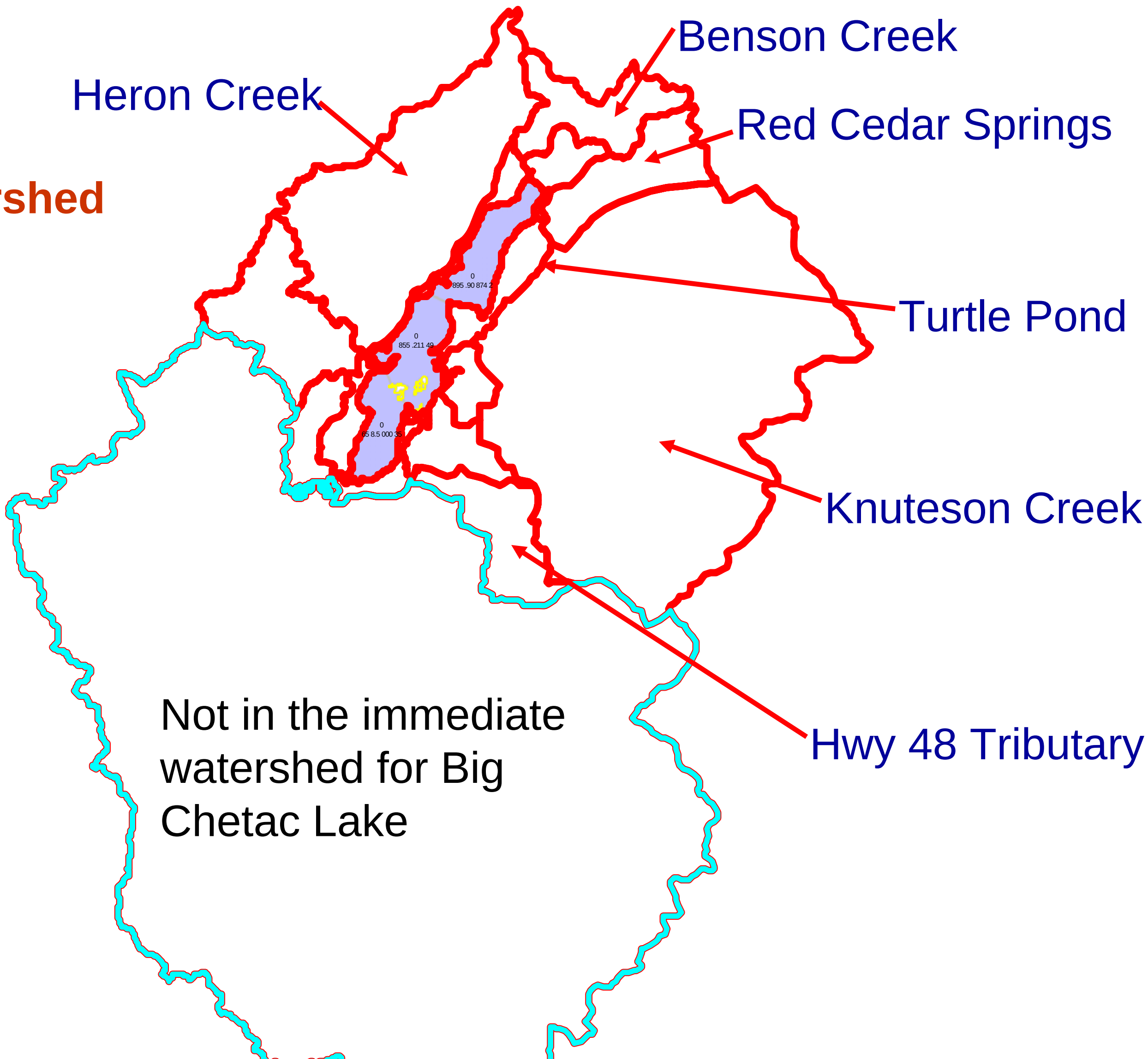


6. Tributary Loading

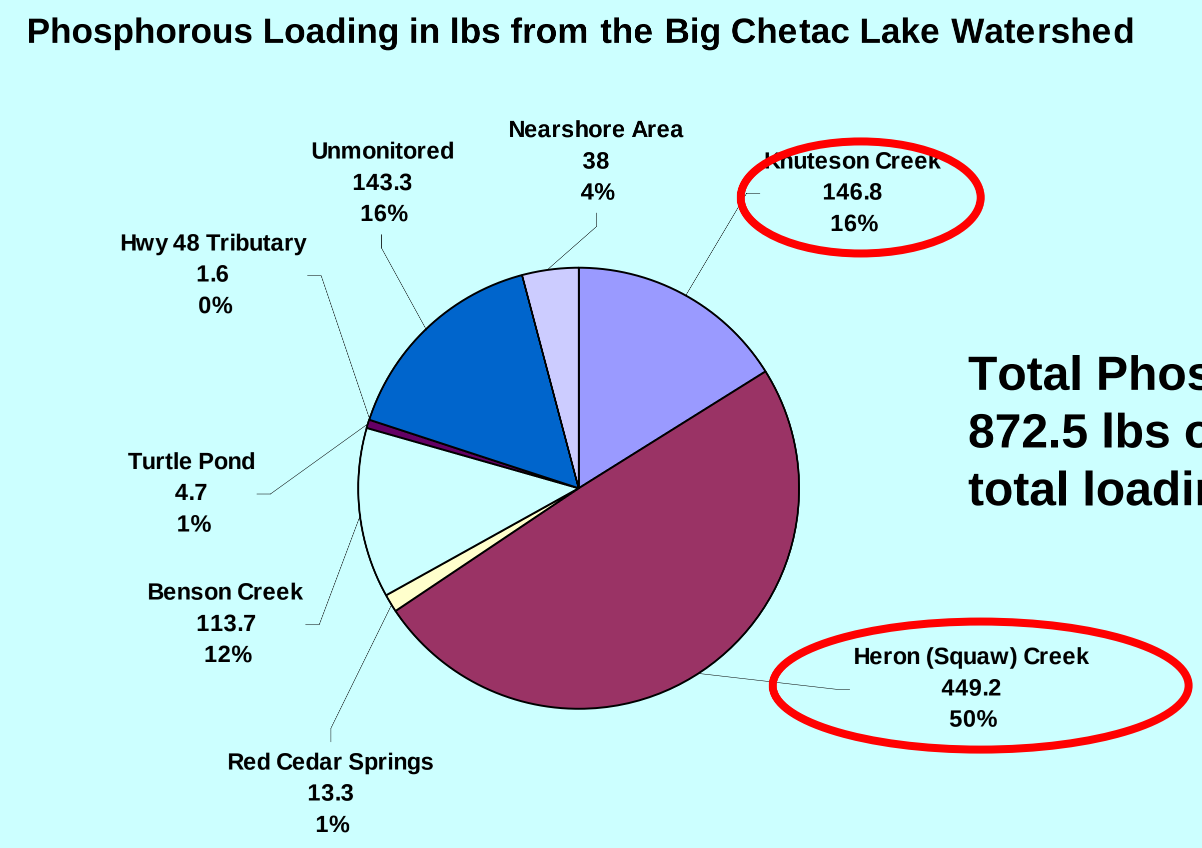
- 6 sources of tributary flow into the lake and the rest of the unmonitored watershed were evaluated
  - Nutrient sampling
  - Flow measurement
- Total Flow into Big Chetac = 15.2 cfs
- Total Phosphorous Loading = **872.5 lbs or 7%** of total loading

Big Chetac Lake Watershed

Direct Drainage Watershed = 34,541 acres

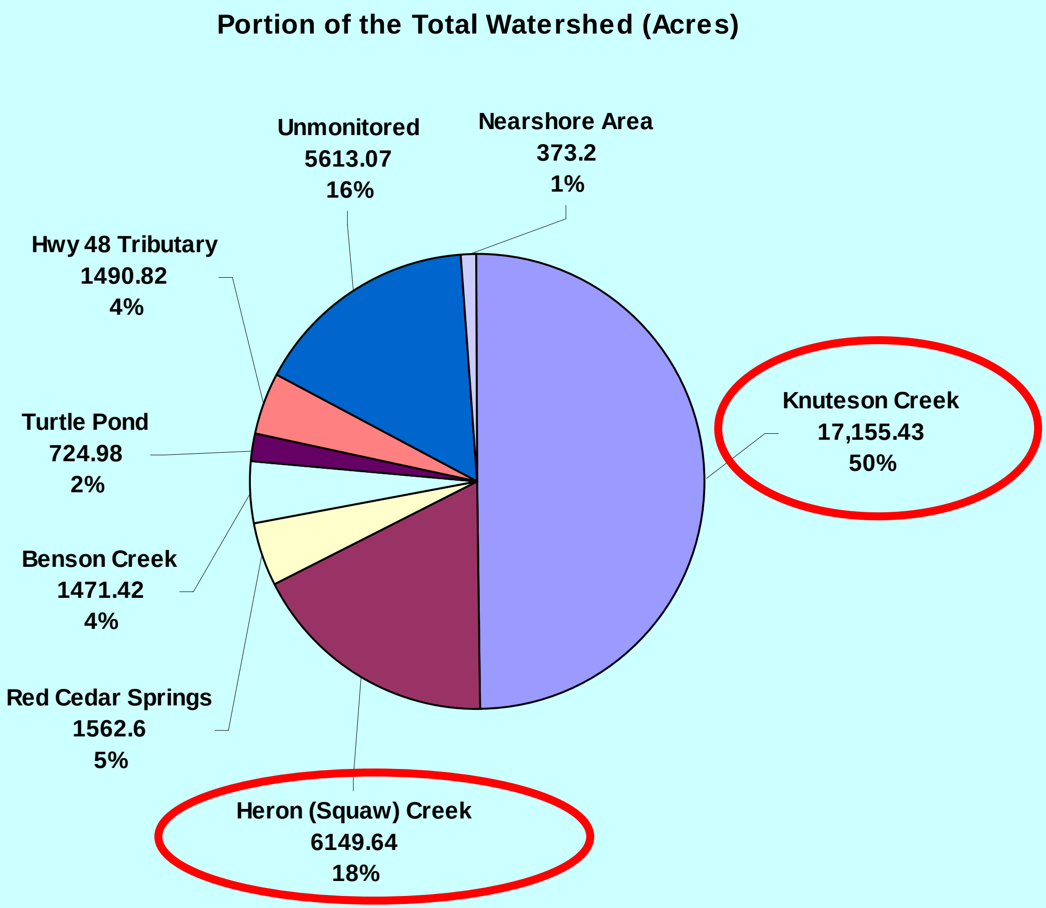


Tributary Loading – lbs of phosphorous from each sub-watershed



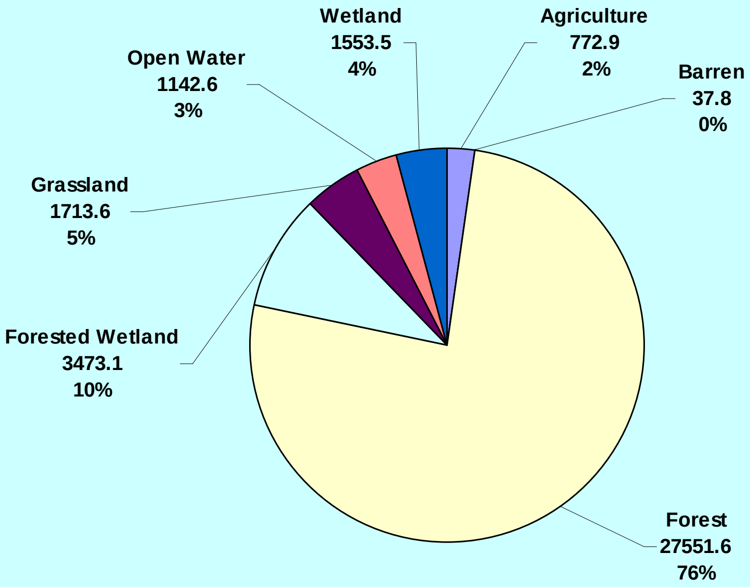
Total Phosphorous = 872.5 lbs or 7% of total loading

Sub-Watershed Areas



How about the larger Big Chetac Lake Watershed?

Total Ground Cover in Acres for the Big Chetac Lake Watershed



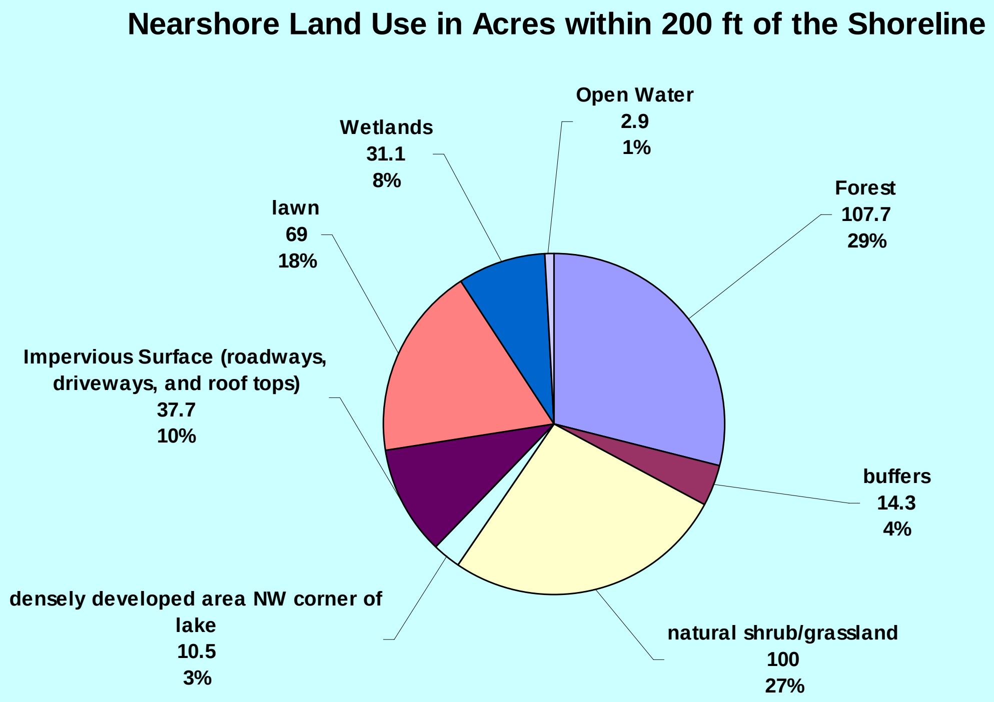
7. Near Shore Contributions

- An area within 200 ft of the shoreline
  - Contains most of the residential development
  - Roads & other impervious surfaces
- Land use determined by looking at high quality color aerial photos
- Runoff coefficients (3 levels) for each type of land cover/use used to calculate phosphorous loading from this area

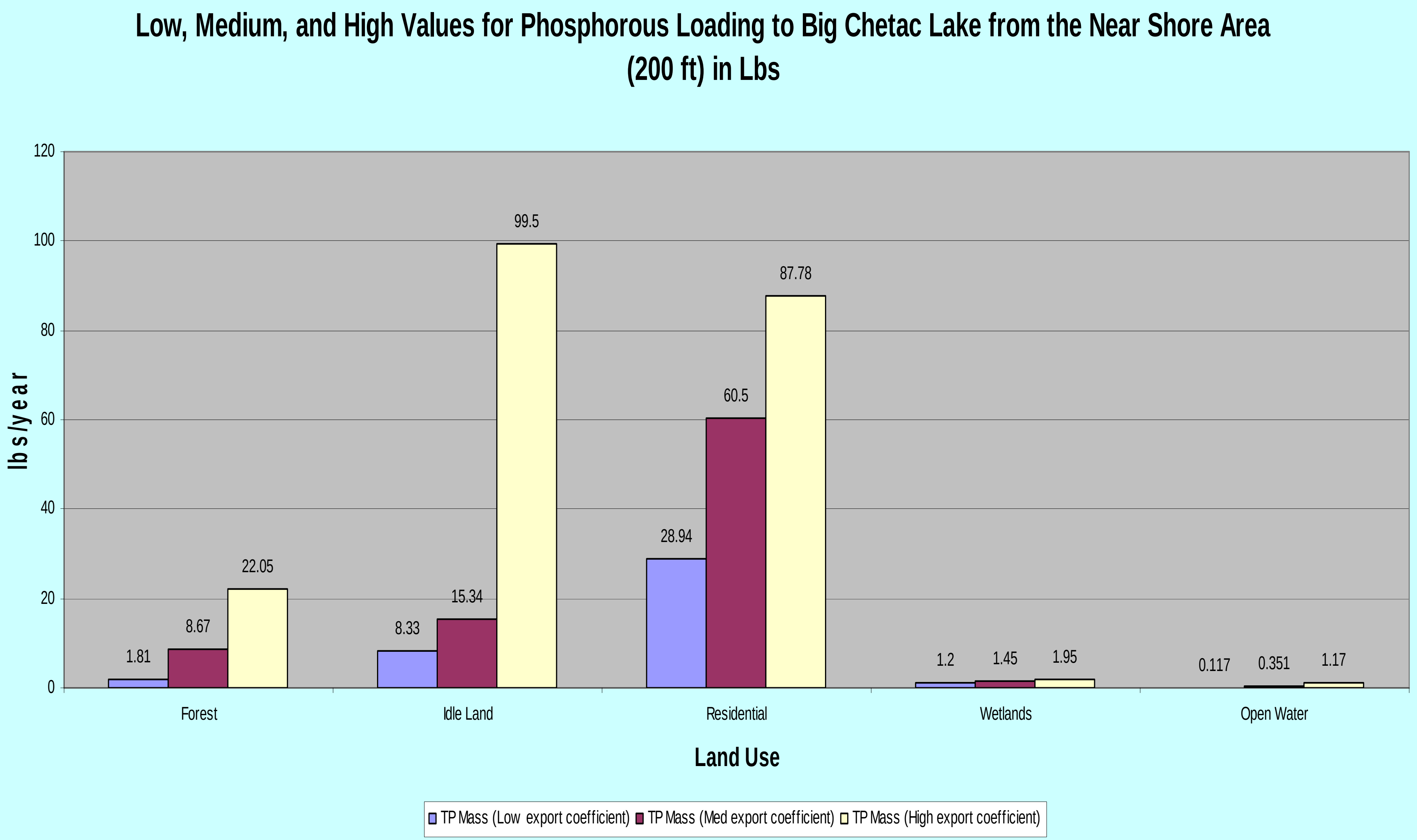
Type of Land Use within 200ft of shoreline

- Lawn
- Wetlands
- Open water
- Forest
- Buffer strips
- Impervious surfaces
- Higher density development
- Shrub/grassland

Total Land Use



Phosphorous Loading

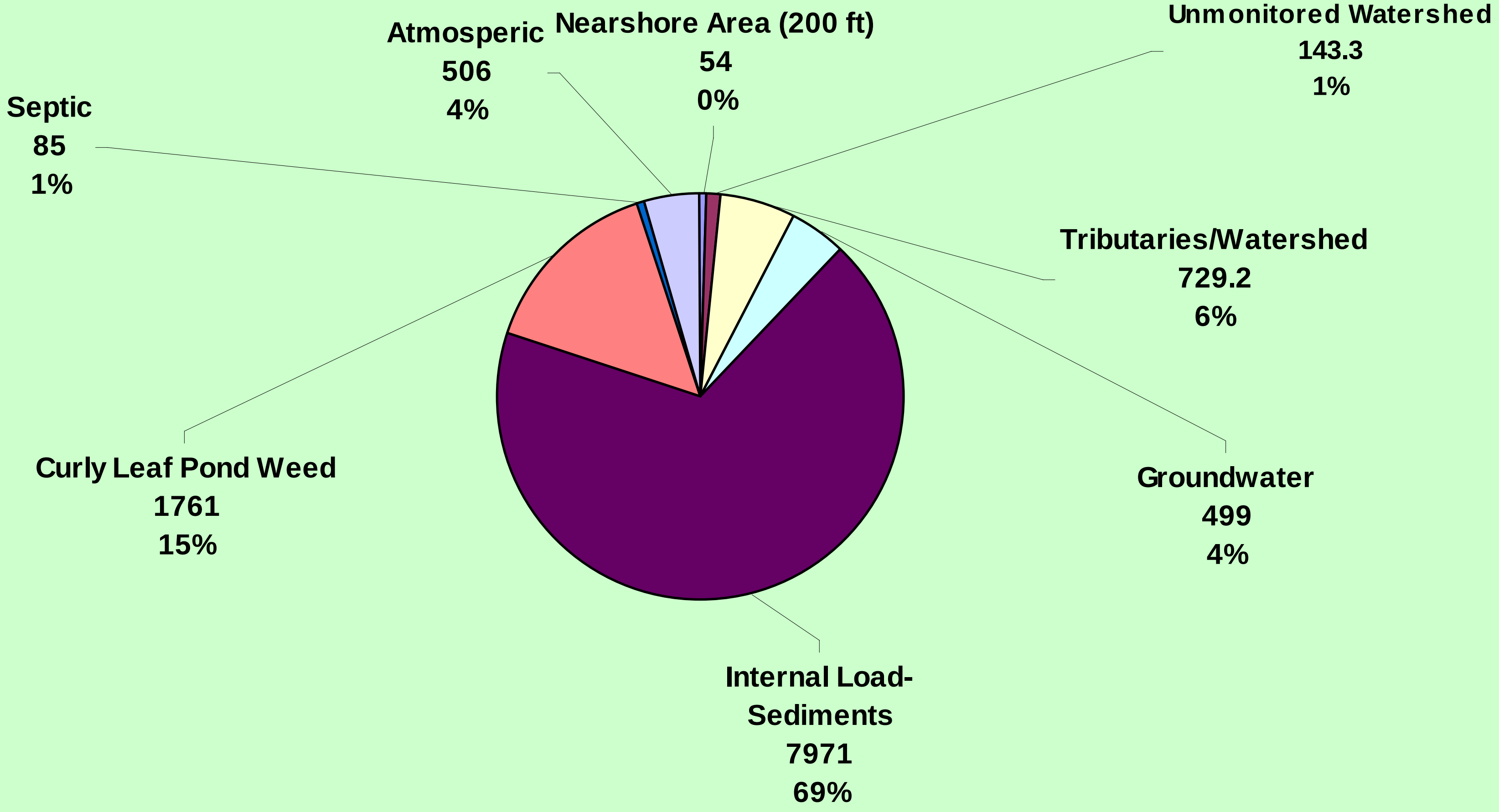


Nearshore Total Contribution

- 90 to 468 lbs of phosphorous annually depending on the whether the low, medium, or high coefficient is used
- Some of the nearshore contribution is already accounted for in groundwater and tributary calculations so the low value is used
- 90 lbs adjusted for the seasonal value form May through Sept = 54 lbs or <1%

Overall Picture

May through September 2007 Phosphorous Loading in lbs. to Big Chetac Lake



Summary

- Internal Loading is the biggest source of phosphorous to the lake at 69%
  - Nearly overwhelms all other contributions
- Curly-leaf pondweed is also a problem at 15% (conservative)
- Watershed, nearshore, and septic system improvements would benefit, but unless the two primary sources are brought under control their impact will be minimal.

Management recommendations will be forth coming with the completion of Phase Six of the Project in Fall of 2009

Any Questions?