Obstructions on the Path to Restoring Impaired Waters

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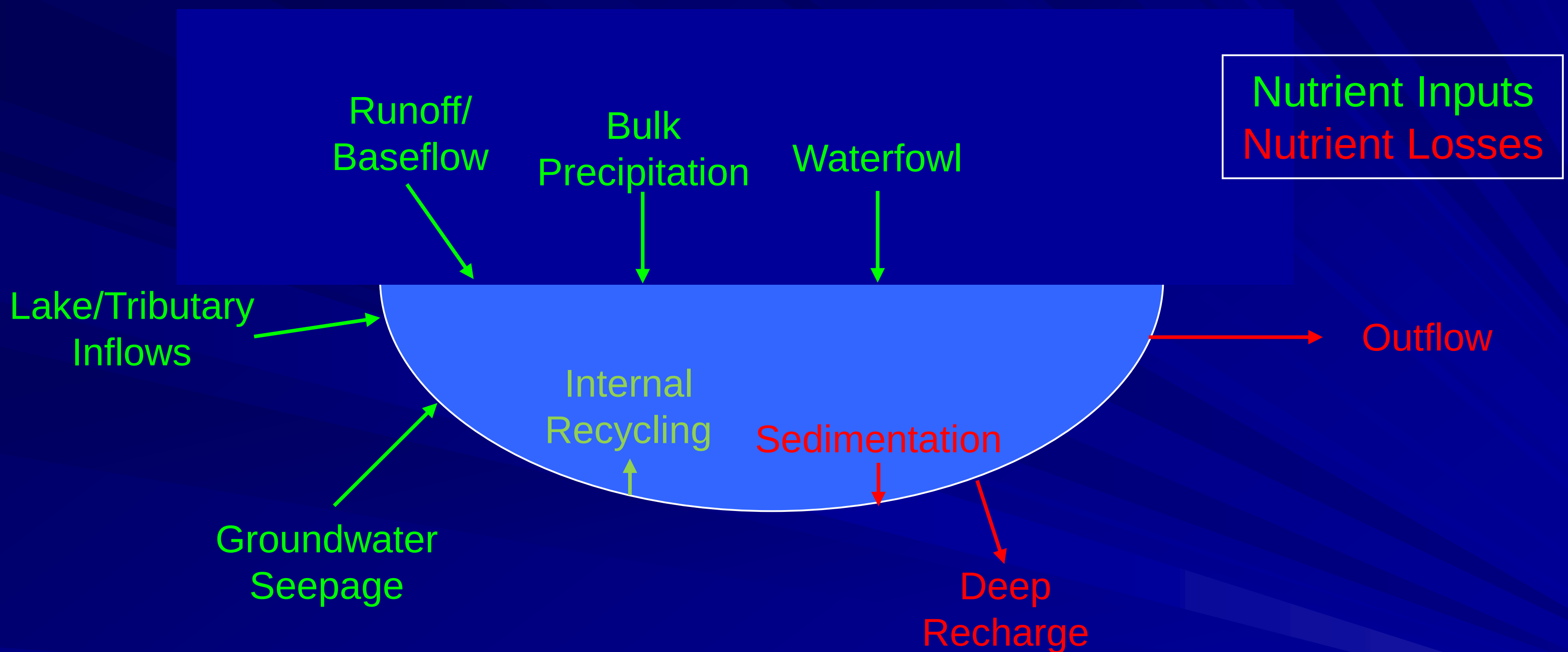
ERD
Water Quality Engineering

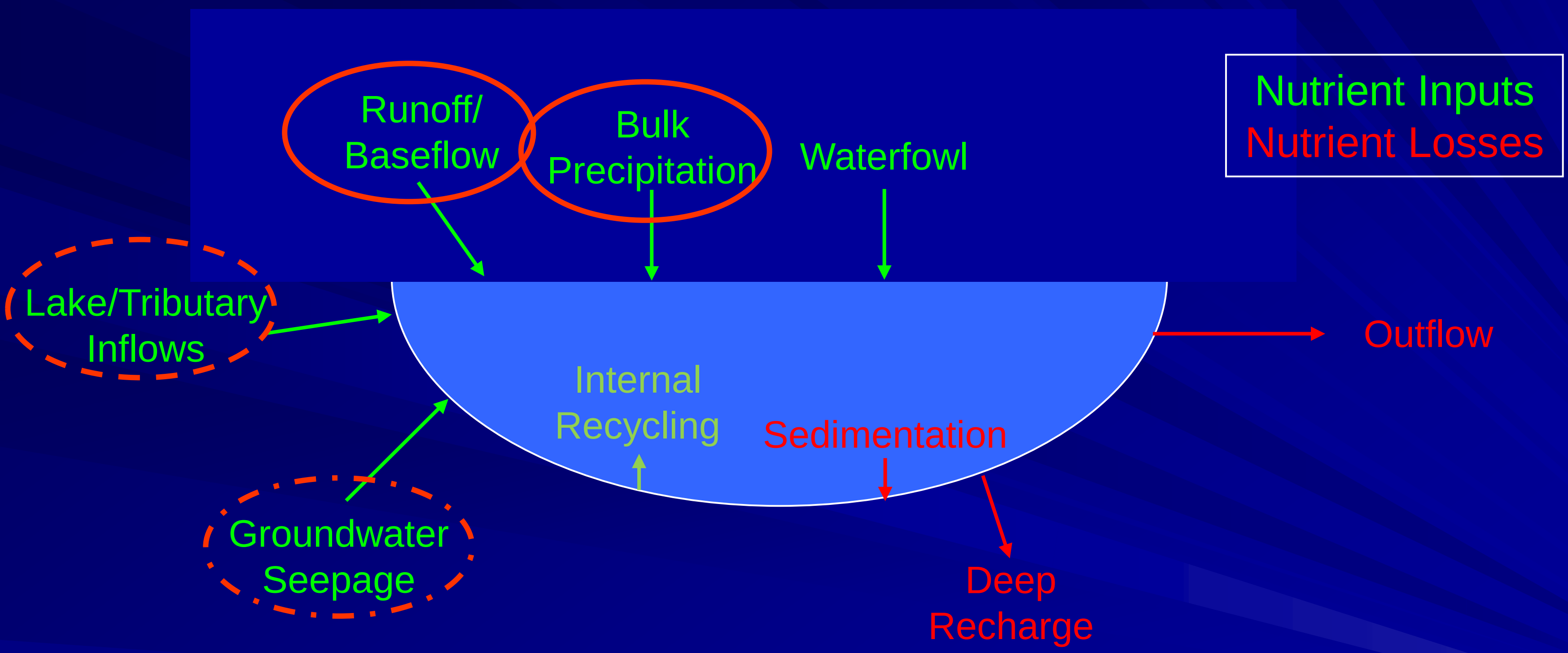
Typical Nutrient Inputs/Losses to Waterbodies



TMDL Process

- TMDLs
  - The TMDL allocates loadings to point sources and nonpoint sources “which include both anthropogenic and natural background sources of the pollutant”
  - Primary focus is on runoff
  - Implementation of the TMDL is supposed to restore water quality
- The approach assumes that runoff caused the impairment
  - Assumes that “impaired waters” will be restored through stormwater management
- The current TMDL process ignores many significant sources of nutrient loadings to waterbodies
  - Internal recycling
  - Groundwater seepage
  - Baseflow
- Over-emphasizes the significance of runoff loadings
  - Many models overestimate runoff loadings
  - Models are often calibrated by increasing runoff to account for missing components

Typical Nutrient Inputs Included in Florida TMDL Evaluations

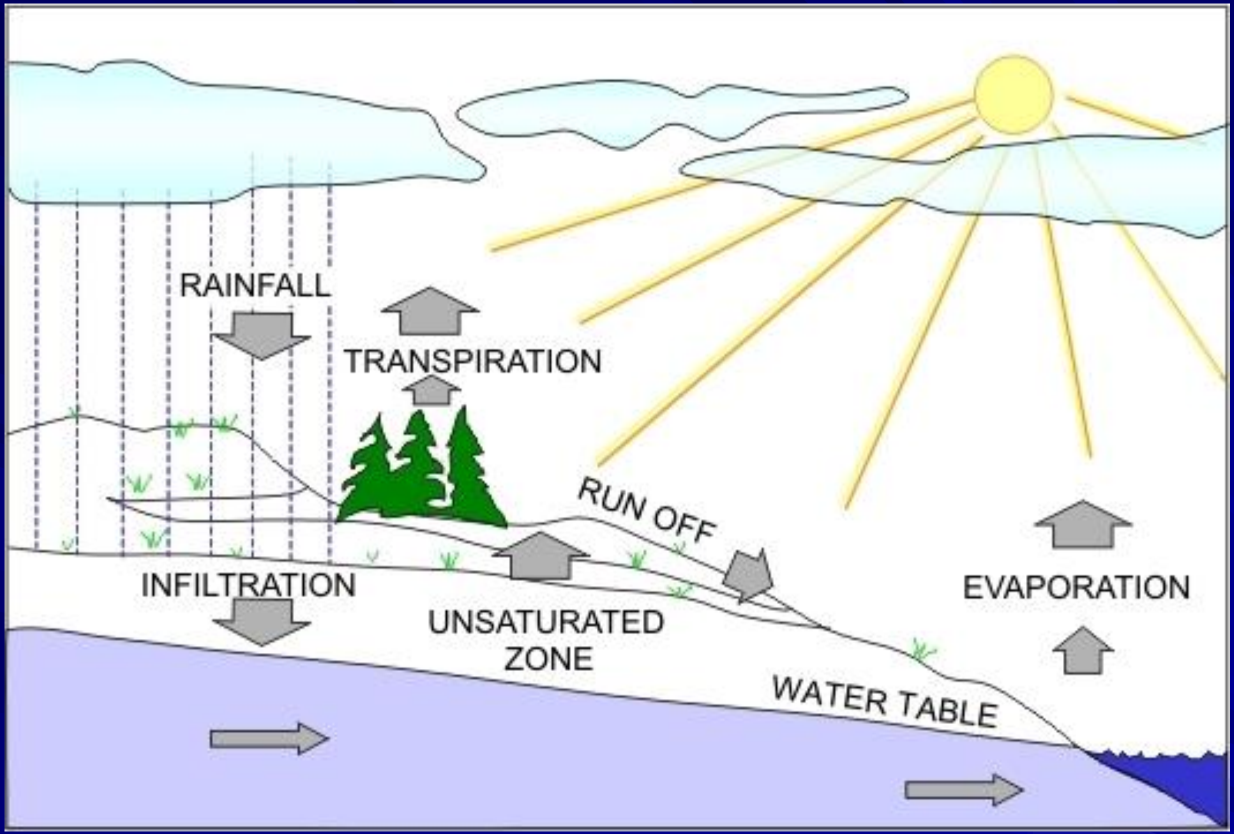


Deficiencies in TMDL Process

- Failure to include all sources
  - Groundwater seepage
  - Internal recycling
- Incorrect science
  - Nutrient limitation
  - Focus on runoff as causative agent
  - Calculation of loadings to downstream waterbodies
  - Assignment of credits
- Alternative to TMDL
- Regulatory obstacles
  - Inability to address internal loadings

1. Failure to Include All Sources

a. Groundwater Seepage

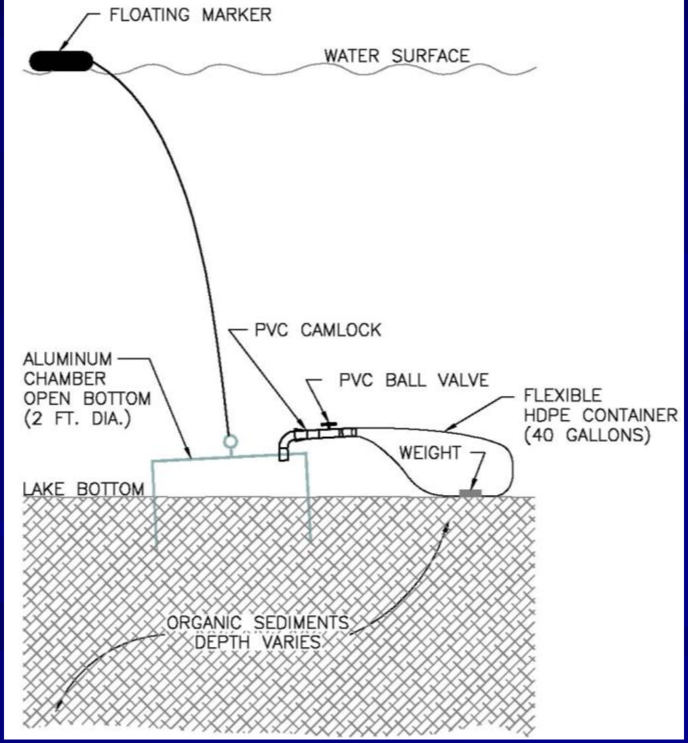


<u>Florida TMDL Process Assumptions</u>

- Seepage only considered if septic tanks are located within the basin
- Seepage impacts are limited to parcels within 600 ft of the receiving water

a. Groundwater Seepage – cont.

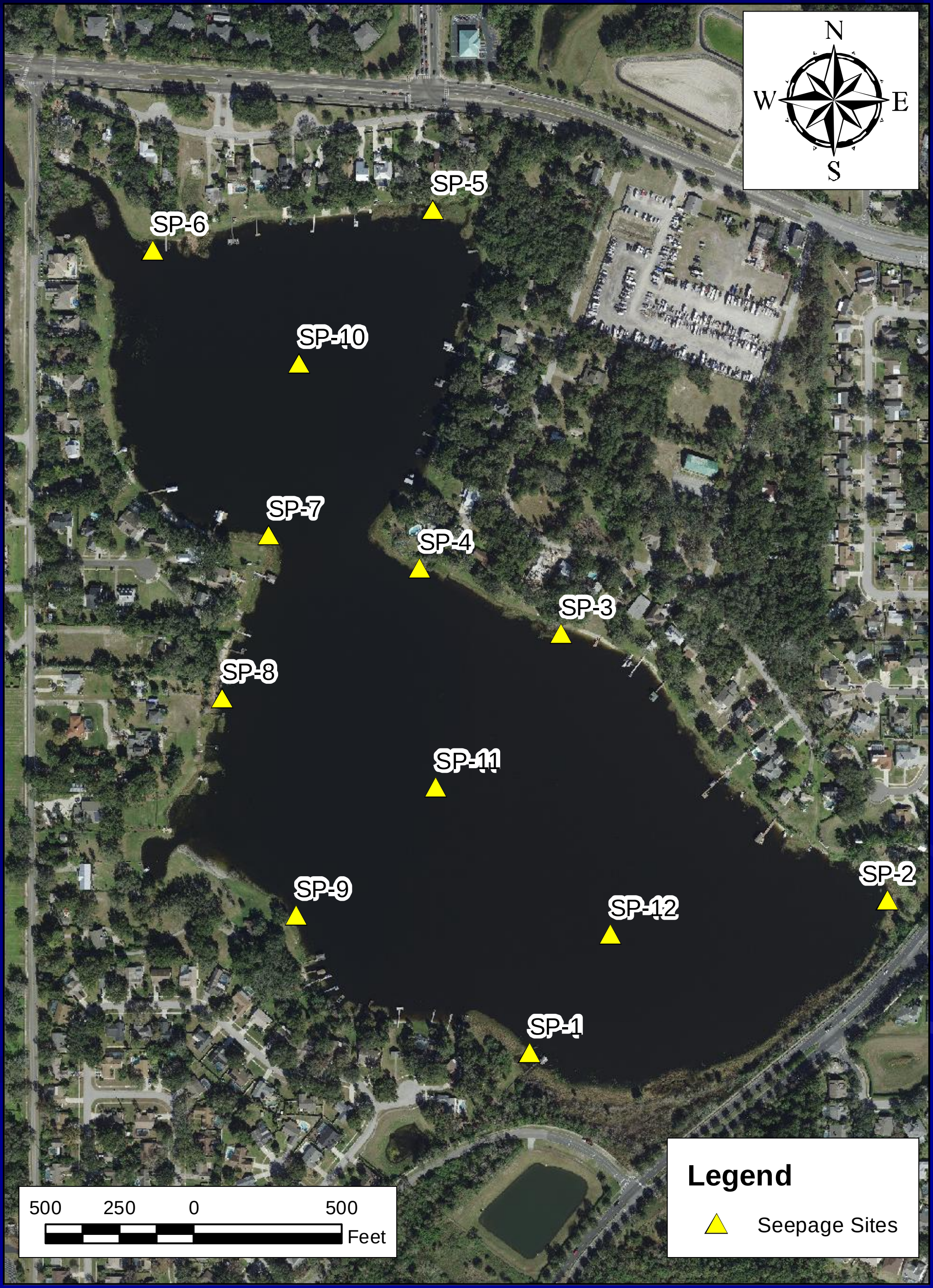
- Seepage inputs occur into every waterbody
  - Occurs whether septic tanks are present or not
  - Originates from the entire basin area
  - Internal recycling

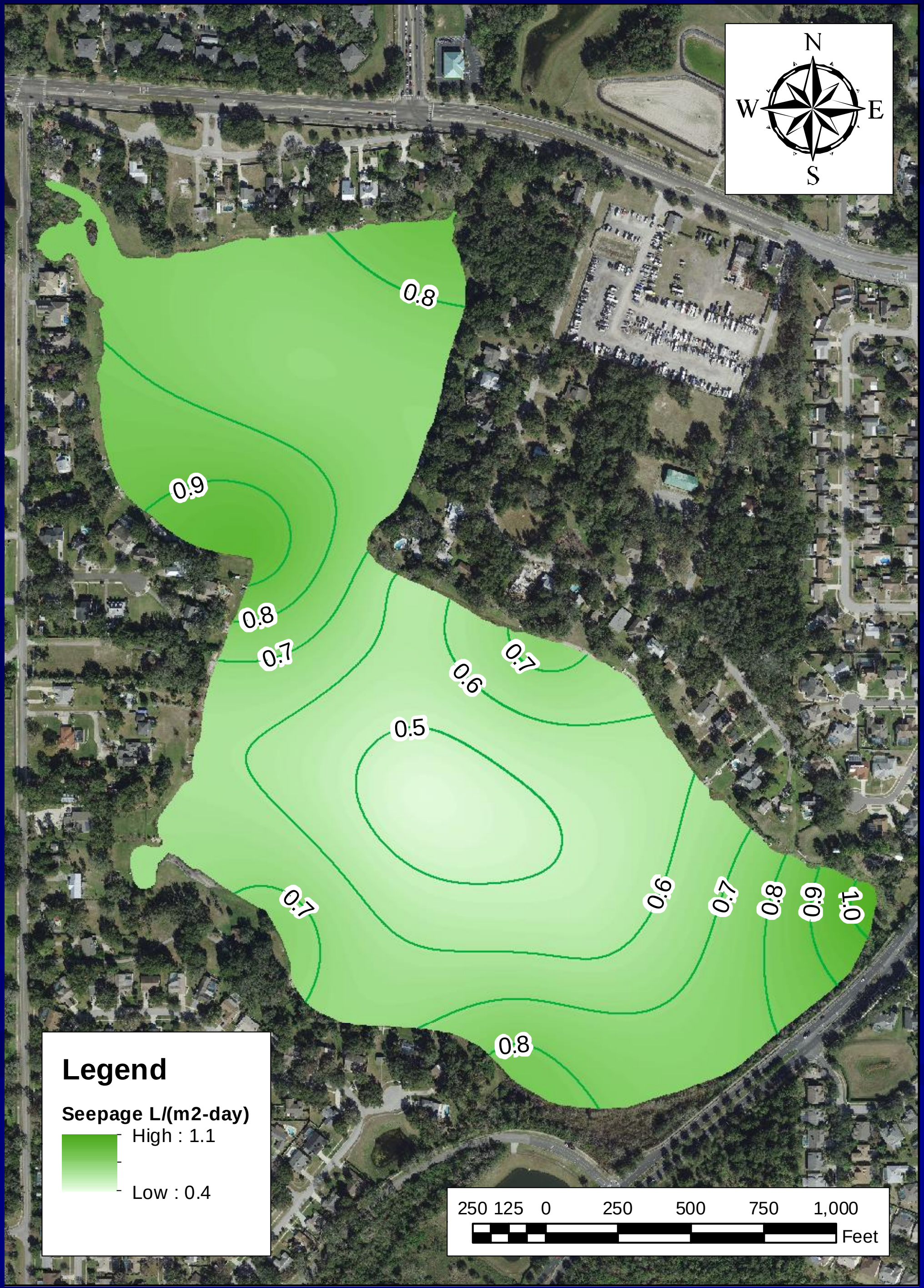


Seepage inflows measured by ERD

Parameter	Units	Mean Value	No. of Studies
TN Load - Sewered	g/m^2-yr	1.443	8
TN Load - Septic	g/m^2-yr	2.057	19
TP Load - Sewered	g/m^2-yr	0.082	8
TP Load - Septic	g/m^2-yr	0.194	19

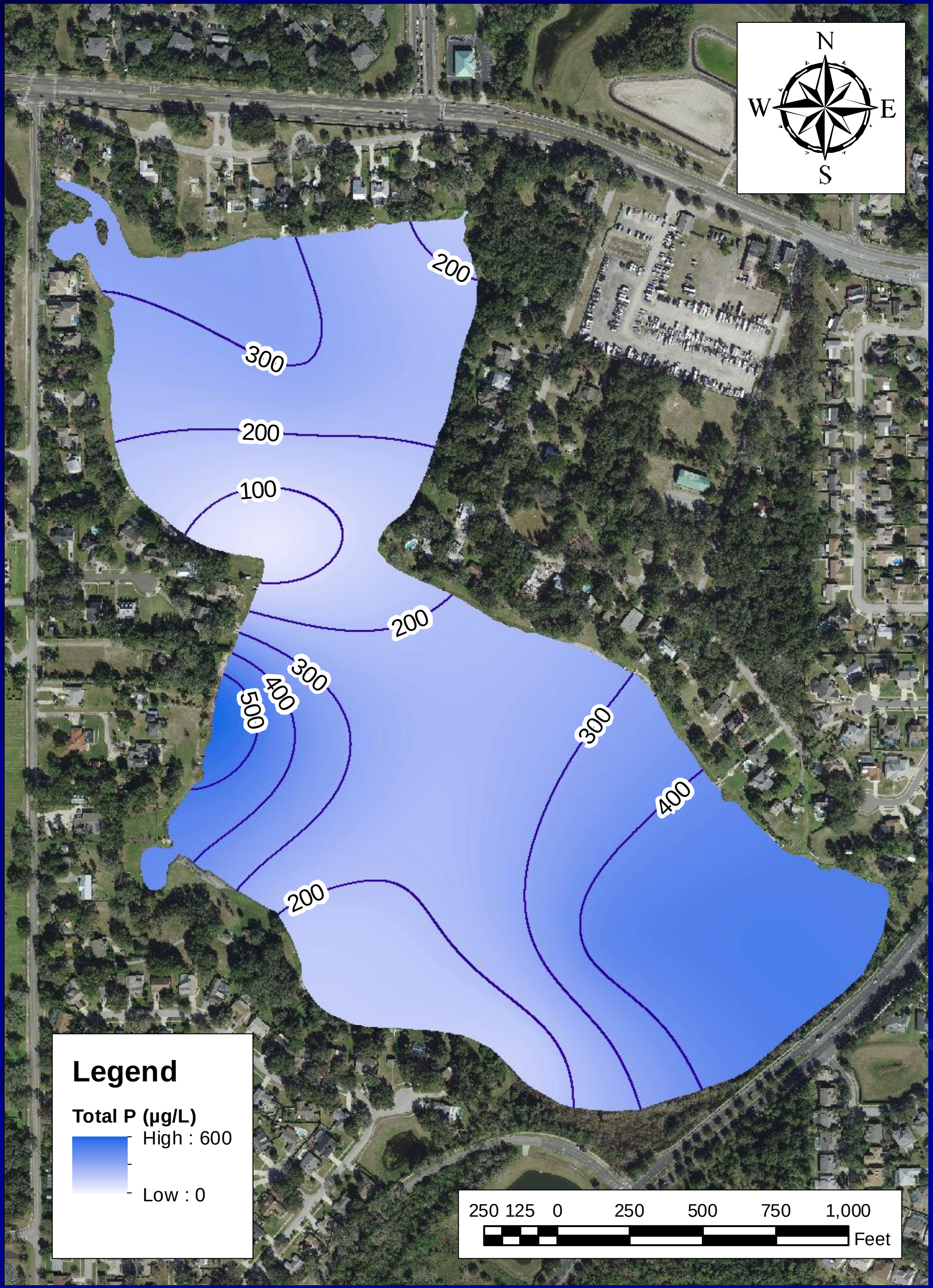
Seepage Monitoring Sites in Lake Rose





Mean Seepage Inflow Isopleths for Lake Rose from January-December 2019

Seepage Total Phosphorus Concentrations in Lake Rose from January-December 2019



b. Internal Recycling

- The largest source of sediments to most lakes is deposition of organic matter from biologically generated organic matter



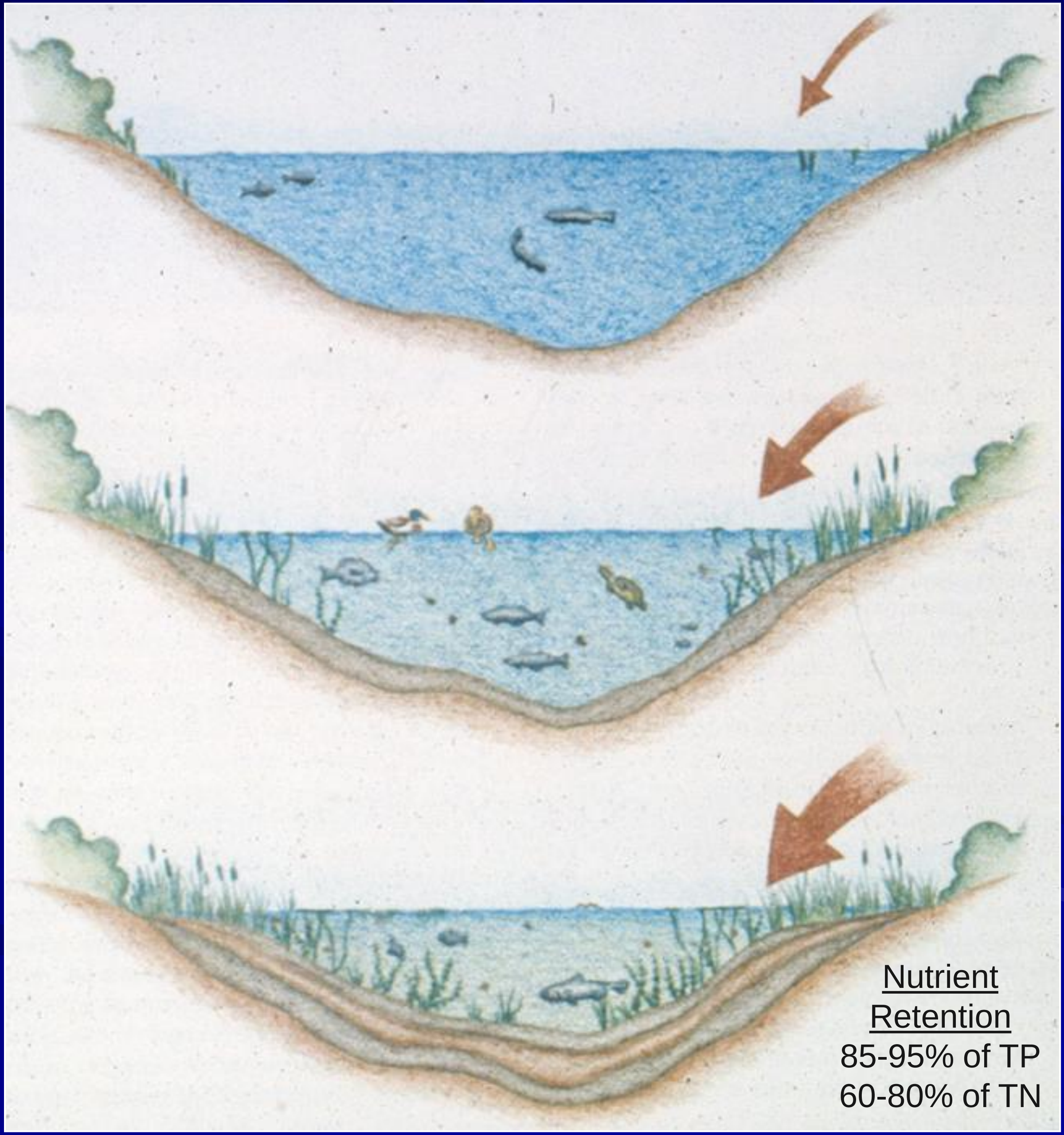
- Organic biological matter generates deposition of ~ 0.5 - 1 cm/year in highly productive urban lakes
- Easily decomposable organic matter decomposes quickly
- Organics difficult to break down accumulate and become organic muck
- Watershed management cannot eliminate internal loading

Solids Deposition and Lake Aging

Newly formed lake
- few nutrients
- low productivity
- little sediment

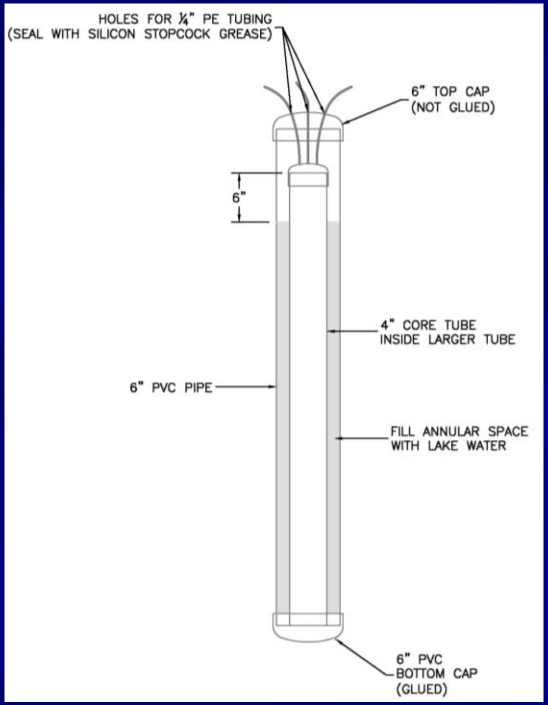
Middle aged lake
- increasing nutrients
- moderate prod.
- increasing sediment
- decreasing depth

Aging lake
- high nutrients
- high productivity
- deep sediments
- plant invasions



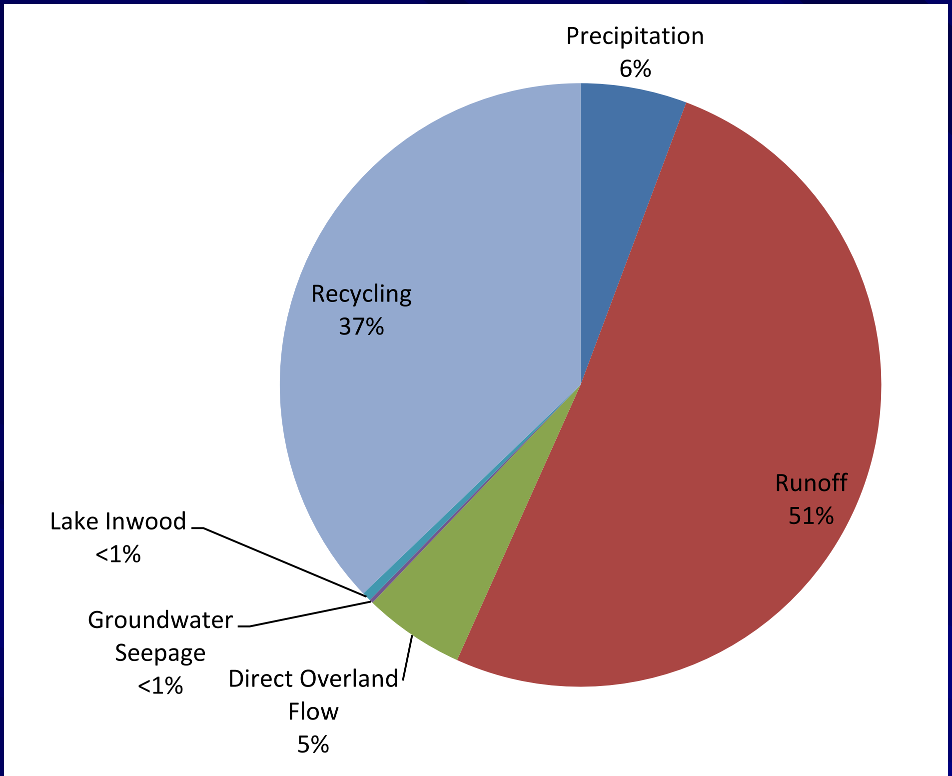
Quantifying Internal P Recycling

- Large diameter core samples collected at multiple sites
- Core samples incubated under aerobic and anaerobic conditions
- Samples collected every 2 days and analyzed for phosphorus and nitrogen



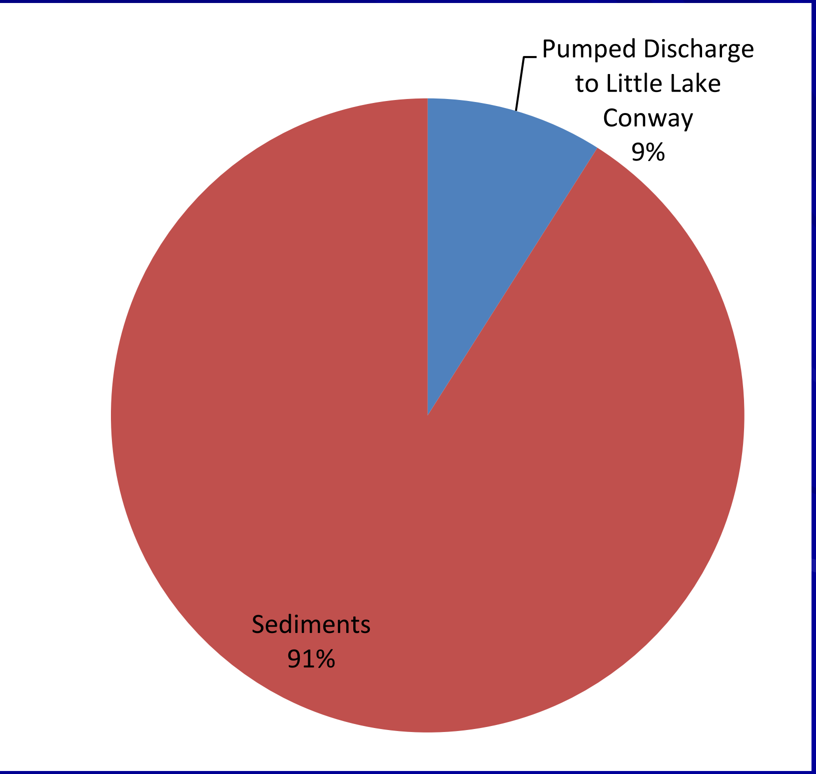
Lake Anderson

- 12.7-acre urban lake
- mean depth = 13 ft.
- mesotrophic/eutrophic



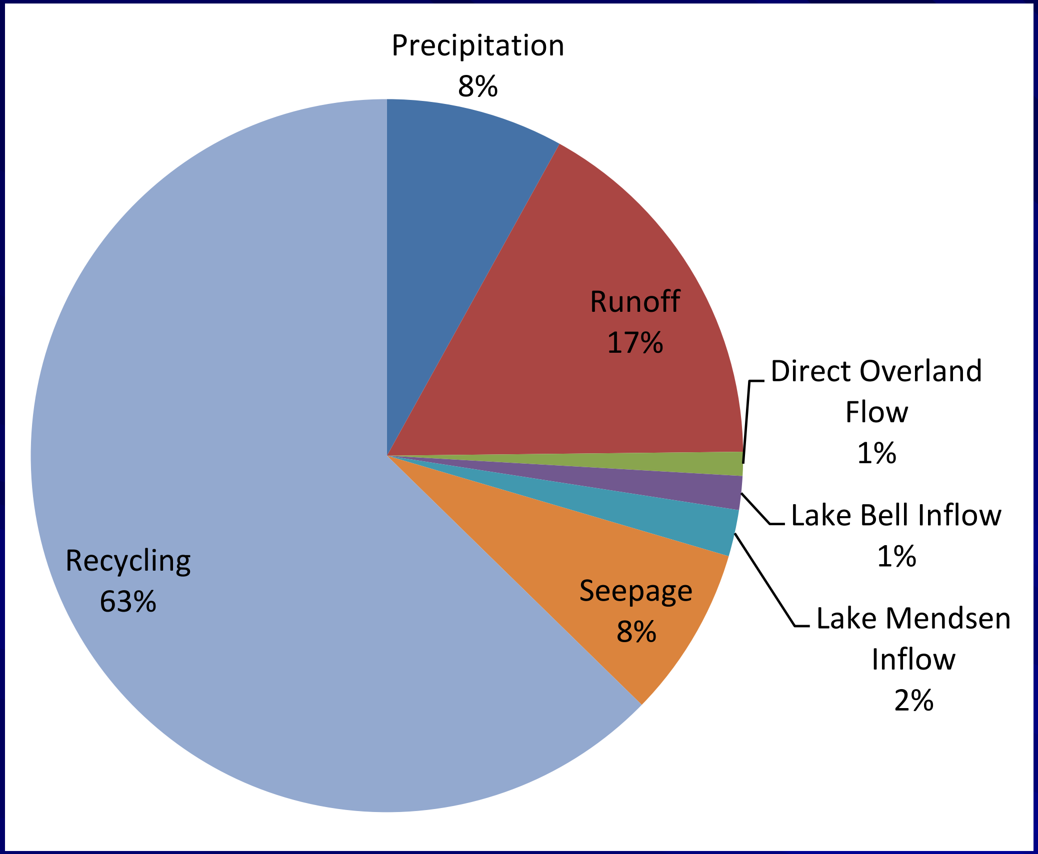
TP Inputs

TP Losses



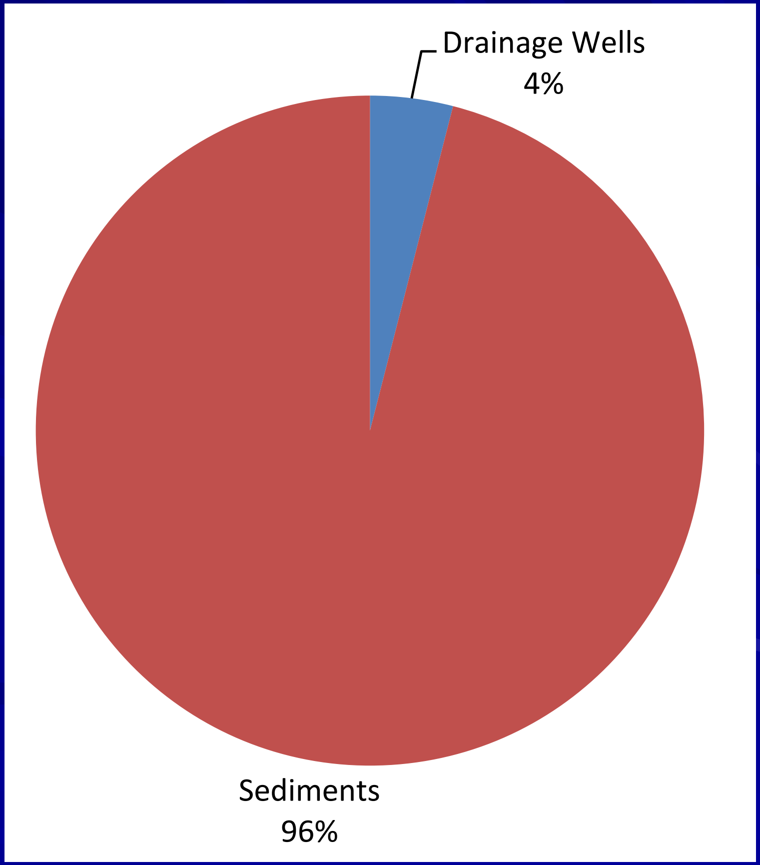
Lake Killarney

- 240-acre urban lake
- mean depth = 15 ft.
- mesotrophic/eutrophic
- significant BMPs installed

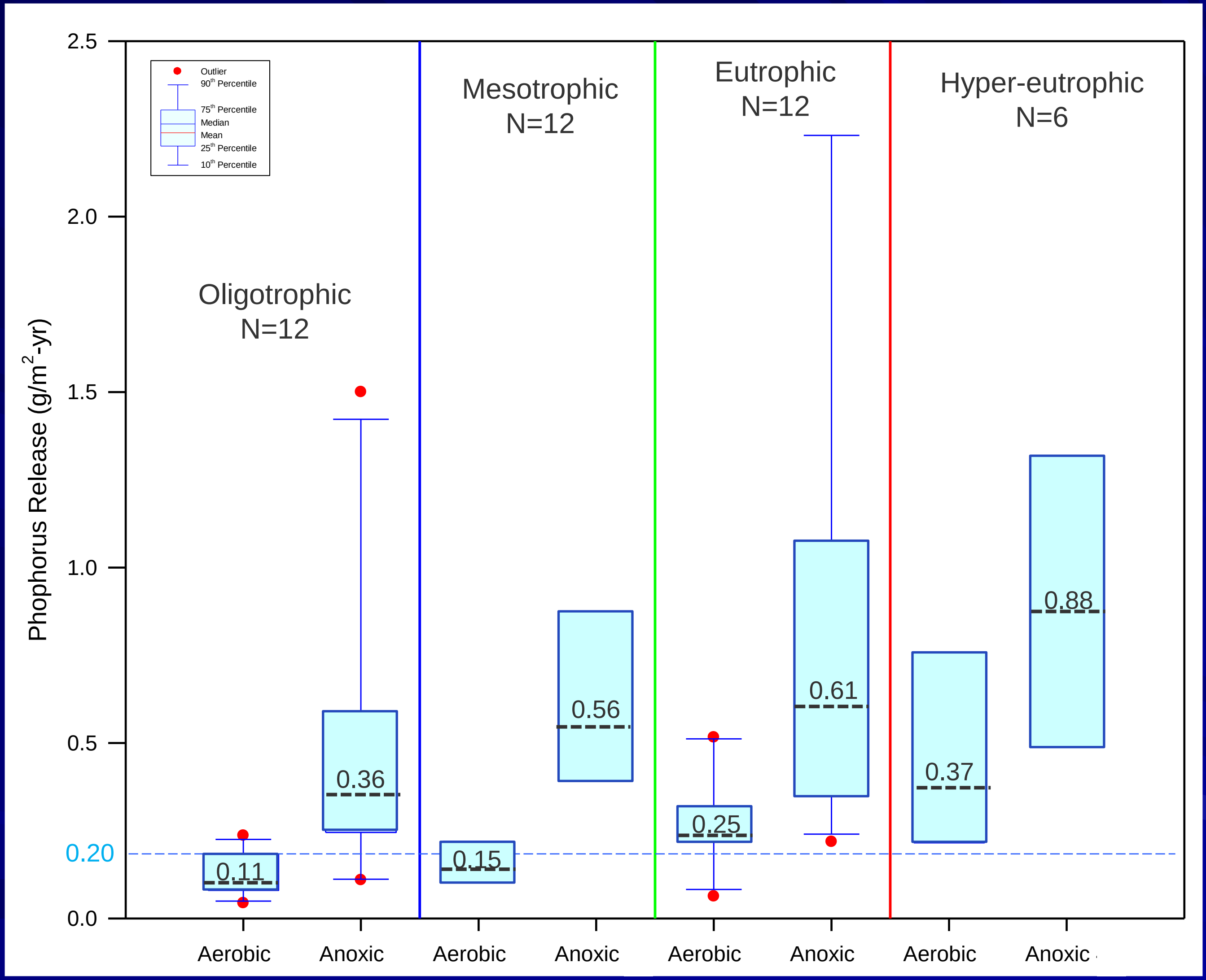


TP Inputs

TP Losses



TP Benthic Release by Trophic Status
(42 lakes)



- TP sediment release occurs in <u>all</u> lakes
- TP benthic release increases with trophic status

2. Incorrect Science

a. Nutrient Limitation

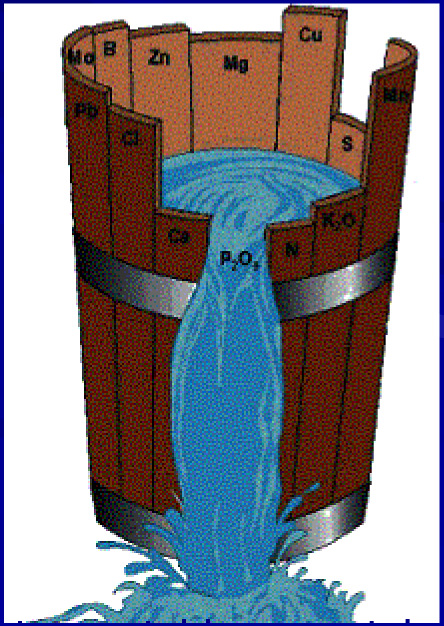
- A pioneer in agricultural chemistry, biochemistry and organic chemistry

- Invented fertilizer

- In 1840 he developed a theory, later referred to as Liebig's Law of the Minimum, that states that an organism will continue to grow until an element important for the development of the organism, becomes in short supply, and growth can no longer occur

- This element is then referred to as the "limiting nutrient"

Justis von Liebig
(1803-1873)

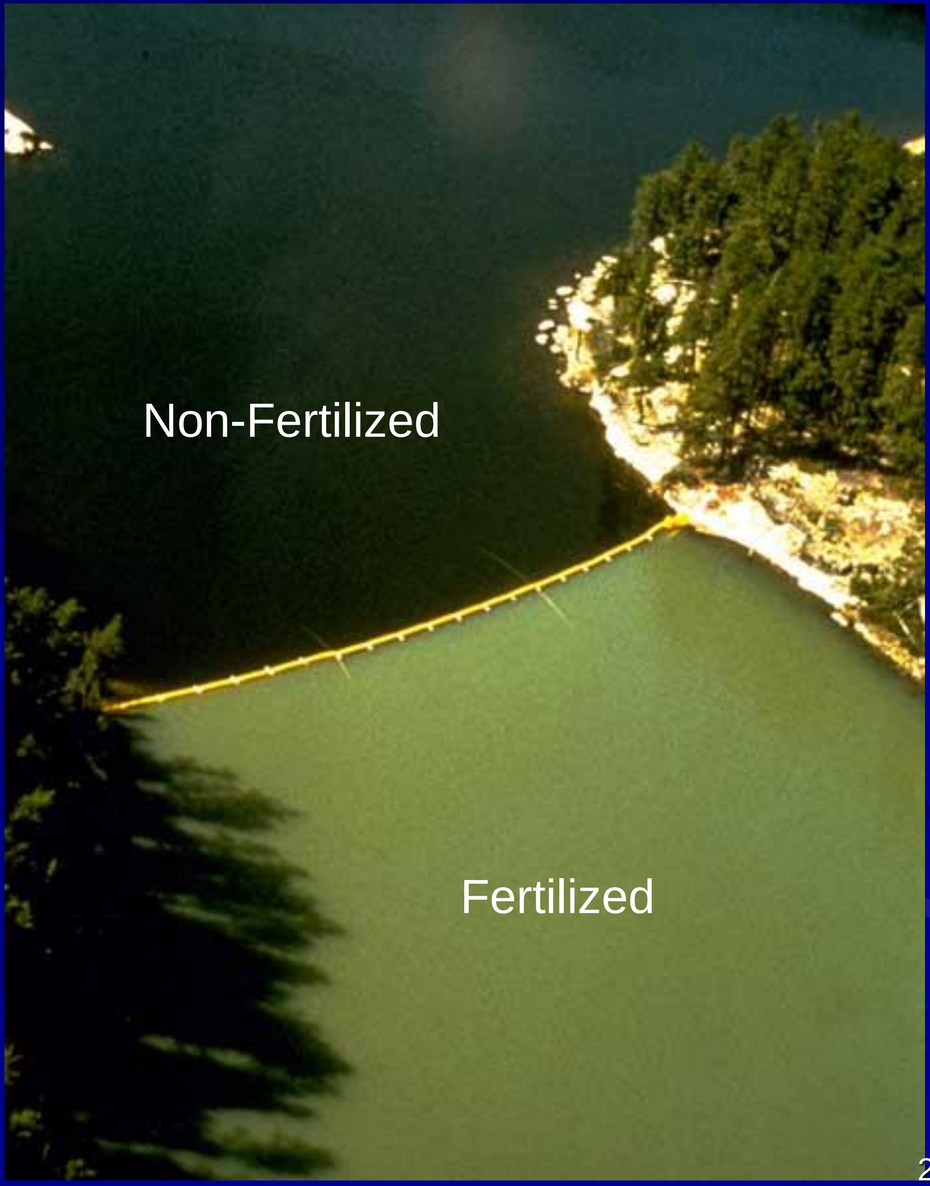


a. Nutrient Limitation – con’t.

During the 1970s, Schindler conducted whole lake enrichment and nutrient limitation studies in the experimental lake region of Canada

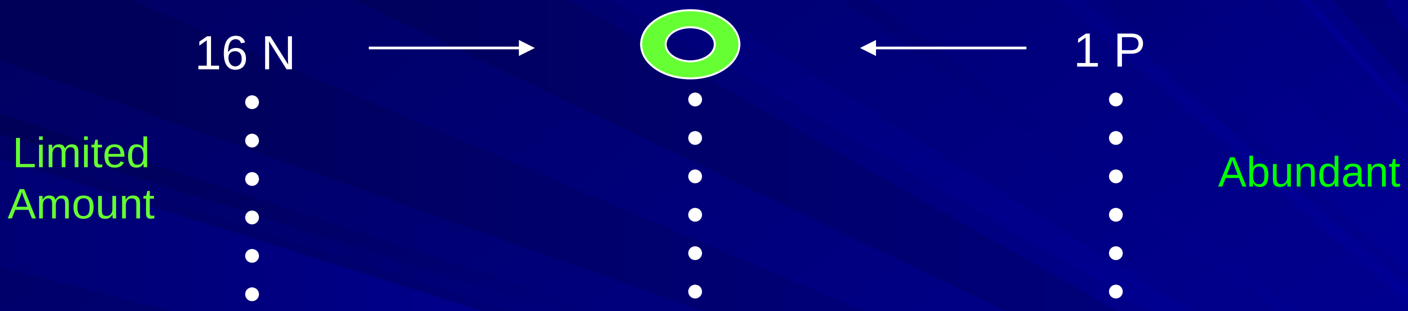
Artificially fertilized lakes with N and P and monitored results

Quantified impacts of nutrient loadings both visually and chemically



a. Nutrient Limitation – con't.

- Normal algal growth



  - Process repeated until water column concentrations become too low for uptake

- Algal growth with N fixation
  - N is constantly replenished
  - N never becomes limiting
  - Growth will continue until P is exhausted

Use of Nutrient Limitation in TMDLs

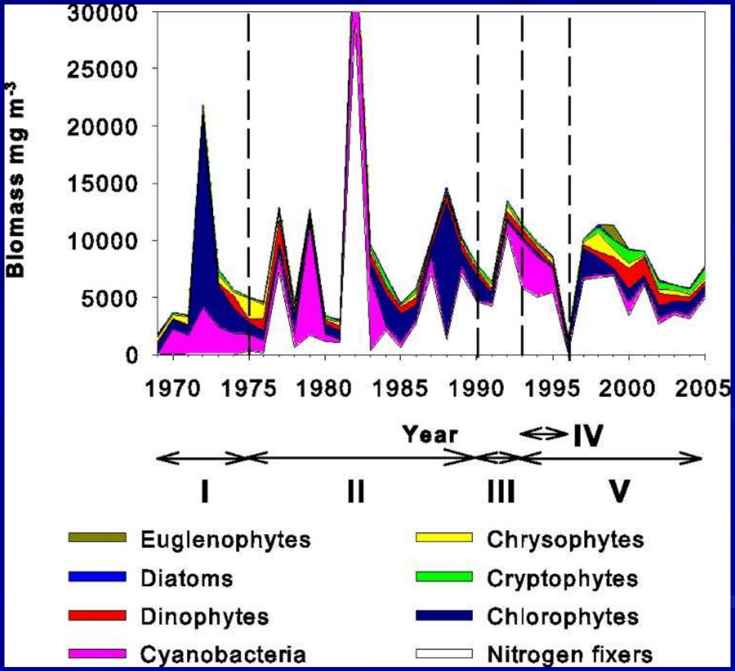
- FDEP uses nutrient limitation to determine which element needs to be reduced to restore water quality
- How does nutrient limitation relate to water quality restoration?
  - Nutrient limitation relates to factors necessary to <u>increase</u> algal growth
  - Water quality restoration involves <u>reducing</u> algal growth
  - Two very different objectives
- Eutrophic lakes cannot be restored by reducing nitrogen
  - No valid scientific account of a eutrophic lake <u>ever</u> being restored by controlling nitrogen
  - Nutrient ratios may have diagnostic value for the lake
  - Only P reduction can restore a eutrophic lake since any nitrogen deficiency can be easily satisfied by cyano-bacteria
- The N:P ratio cannot be used to determine the nutrient that must be reduced to restore water quality

Impacts of Nitrogen Reduction

- Schindler, et. al (2008) published a paper which summarized 37 years of whole lake experiments on Lake 227 in the Experimental Lakes Region (ELR) in Alberta titled:

  "Eutrophication of lakes cannot be controlled by reducing nitrogen input: Results of a 37-year whole-ecosystem experiment"

- Lake 227 was fertilized for 37 years with constant annual inputs of P and steadily reducing inputs of N
  - Test the hypothesis that controlling N can control algal growth
- Reducing nitrogen inputs favored N_2 fixing cyanobacteria as a response to N limitation
- N fixation was sufficient to maintain eutrophic conditions in spite of lack of external N loads
- N reductions without P reduction increased algal growth



Year	N (kg/yr)	P (kg/yr)	N:P
1969	249	20.7	12.1
1970-74	308	24.8	12.4
1975-82	110	23.6	4.7
1983	110	19.8	5.5
1984-89	110	23.6	4.7
1990-97	0	23.6	0
1998	0	31.9	0
1999-05	0	24.5	0

Concluded that to reduce eutrophication, the focus of must be on decreasing inputs of P

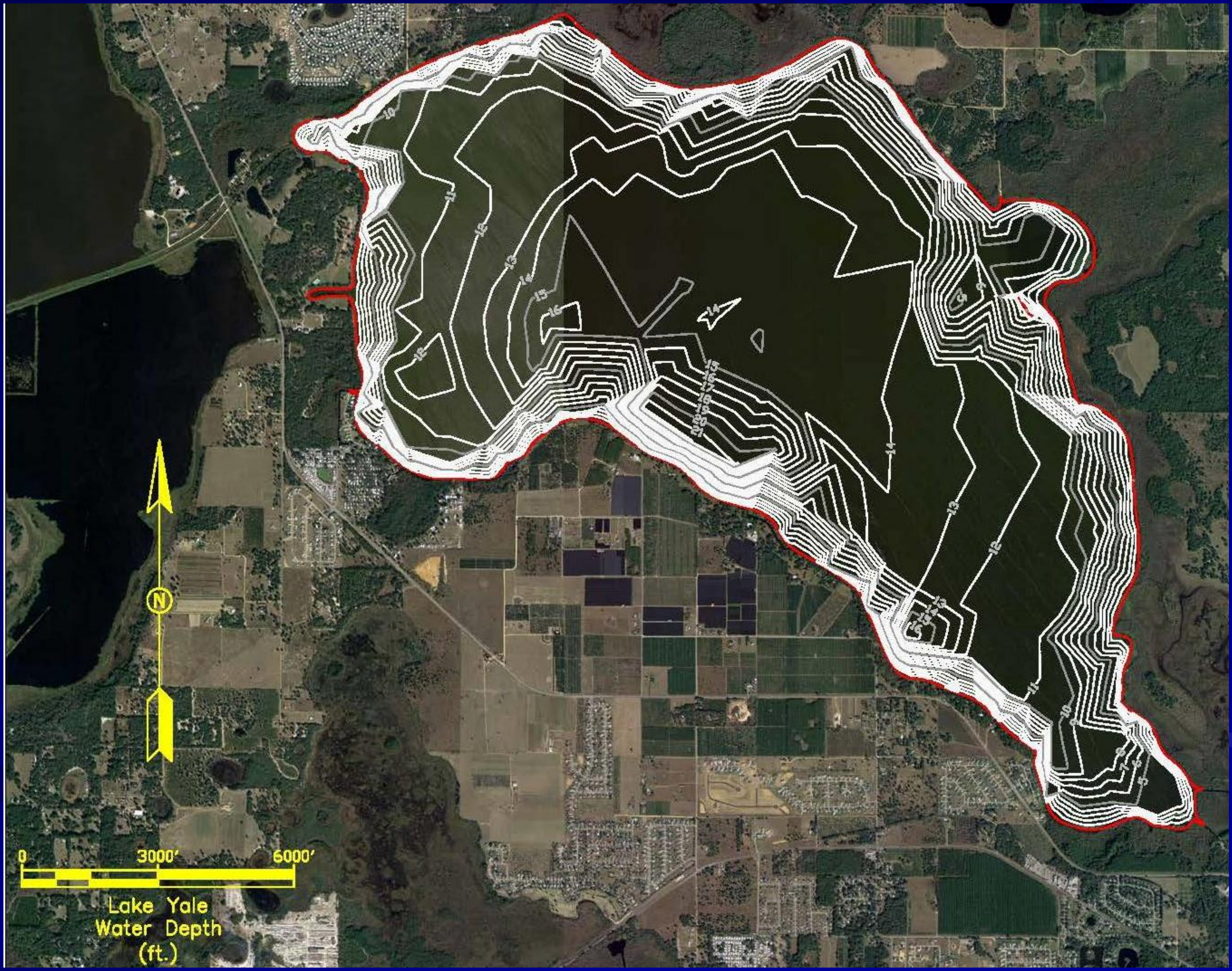
Restoration Strategies

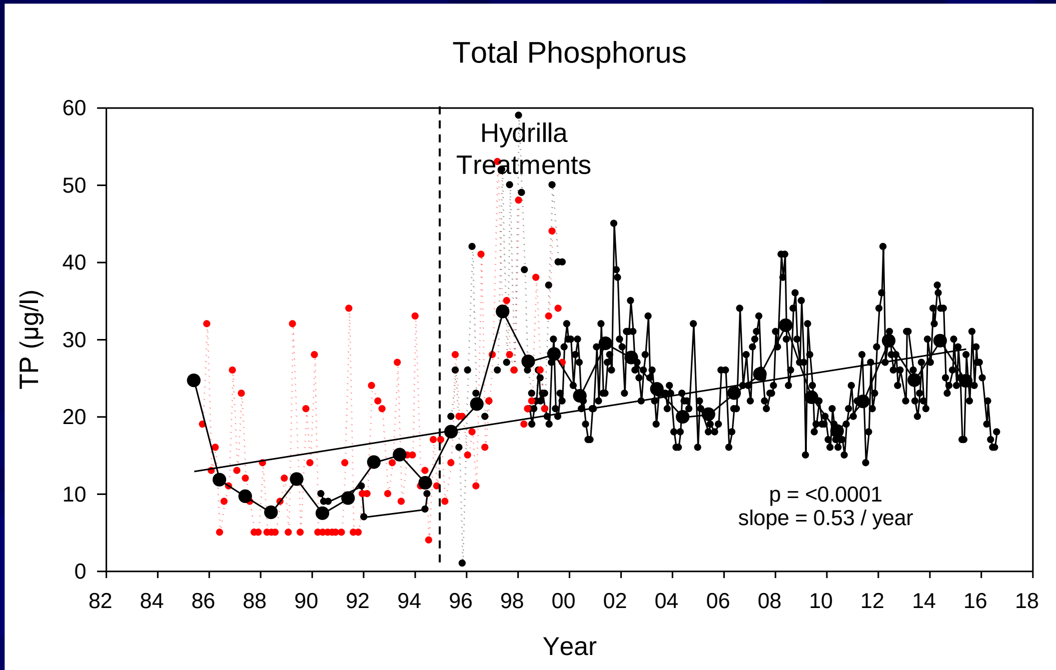
- Restoration strategy should maximize P removal
  - Most BMPs which remove P also remove N as well
  - P is easier and much less expensive to remove with more predictable outcomes than N

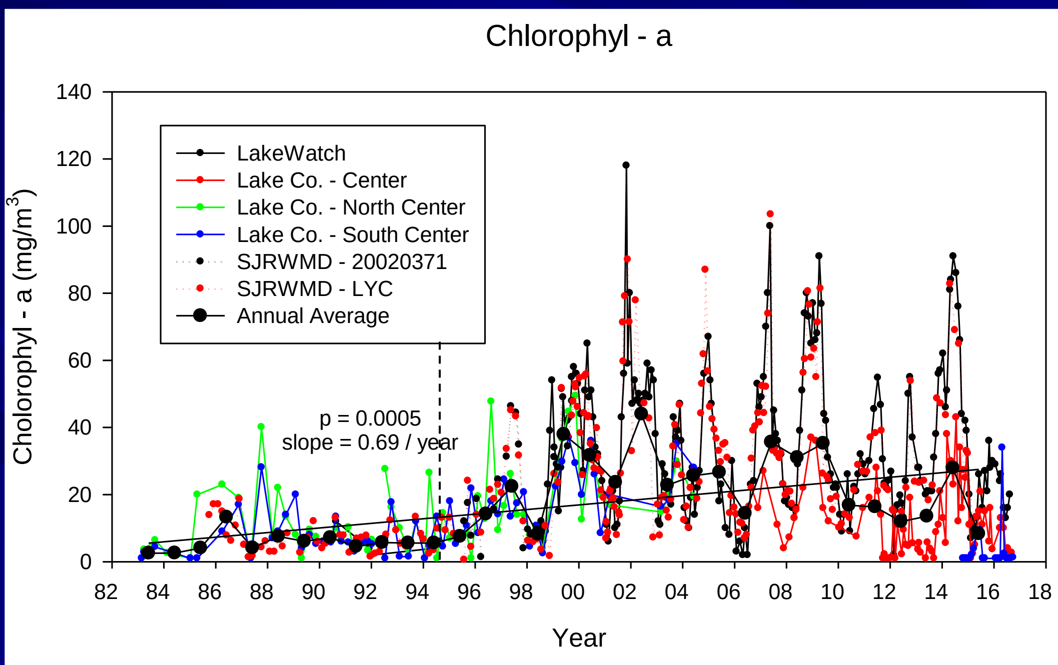
- P removal must be applied to all P sources, not just external sources
  - Internal recycling of P is significant in most eutrophic lakes and must be addressed as a nutrient source

b. Focus on Runoff as Causative Agent

Water Depth Contours for Lake Yale







Trends in Total Phosphorus and Chlorophyll-a in Lake Yale from 1982-2016

- statistically significant increases in both TP and Chlorophyll-a over time

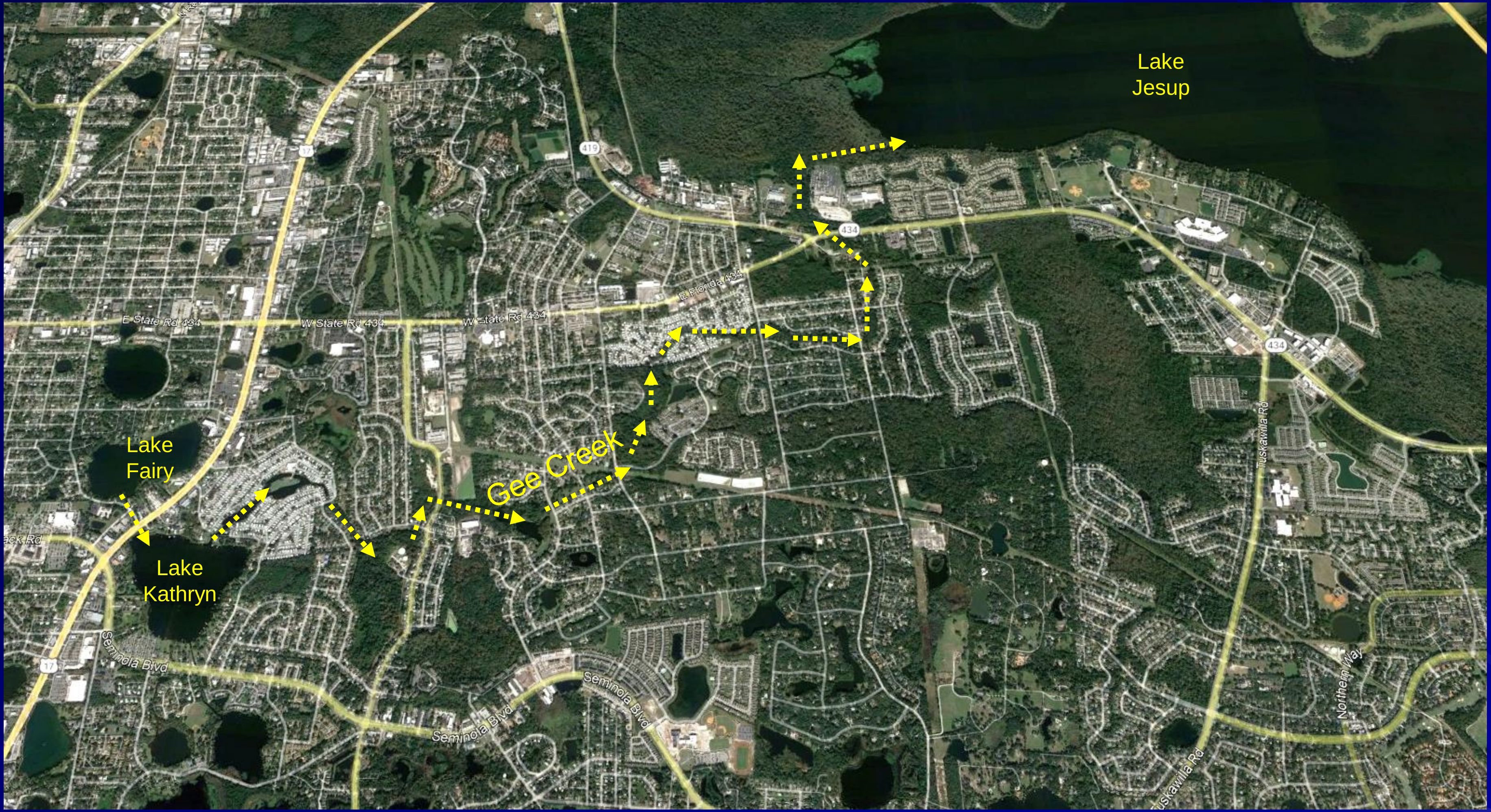
- impairment status caused by improper vegetation management, not runoff

Comparison of Estimated TMDL and ERD Calculated Loadings of Total Phosphorus to Lake Yale

Source	Annual Total Phosphorus Load (kg/yr)	
	TMDL	ERD
Bulk Precipitation	1432[1] (combined)	1249
Runoff + Overland Flow		509
Groundwater Seepage	Not Included	149
Internal Recycling	Not Included	7,981
TOTAL:	1,432	9,888

1. TMDL requires a 10% reduction in runoff TP = 143 kg/yr = 1.4% of annual ERD load

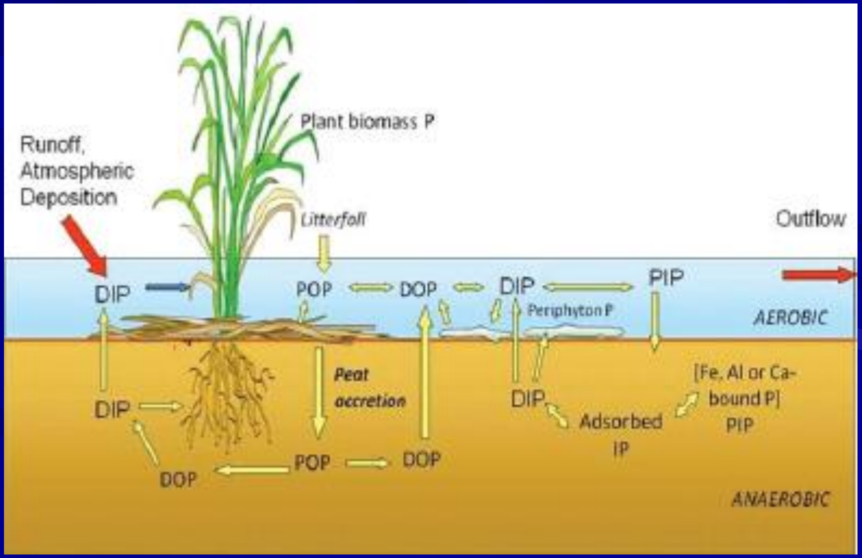
c. Calculation of Loadings to Downstream Waterbodies



- Currently, load reductions to upstream waterbodies are assumed to result in similar load reductions to the ultimate receiving water
  - A 25 kg reduction in TP loading to Lake Kathryn is assumed to be a 25 kg reduction to Lake Jesup

Shallow Hardwood Wetlands

- Shallow waterbody with nutrient rich, acidic, and typically anoxic soils
- Water quality of wetland discharges is based primarily on an equilibrium between the soils and the water column
  - First-order reaction rate based on concentration
  - Equilibrium reached in 3-4 days
  - High concentrations will be reduced
  - Low concentrations will be increased
  - Total P - ~ 0.1 mg/L (100 ppb)
  - Total N - ~ 1-2 mg/L (1,000 – 2,000 ppb)



Loadings Reaching Receiving Waters

Wet Detention

TP = 250 ug/L
TN = 1,500 ug/L

Removes solids and dissolved nutrients

Hardwood Wetland

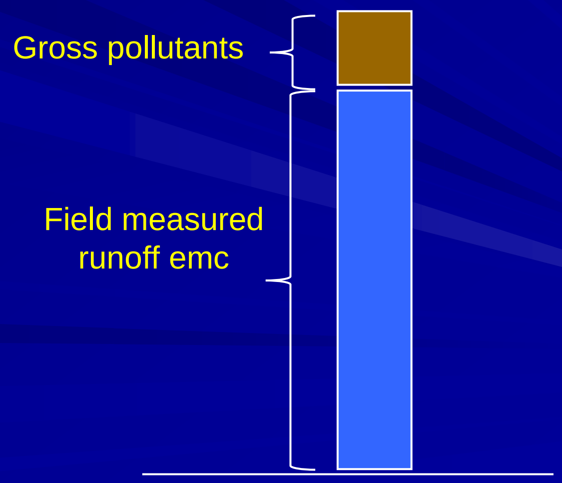
Little uptake by vegetation; water reaches equilibrium with soils

TP = 100 ug/L
TN = 1,000 – 2,000 ug/L

- Load reductions reaching the receiving waterbody will be reduced or may increase
  - A 25 kg reduction in TP loading to Lake Kathryn may result in only a minimal reduction to Lake Jesup, or perhaps an increase

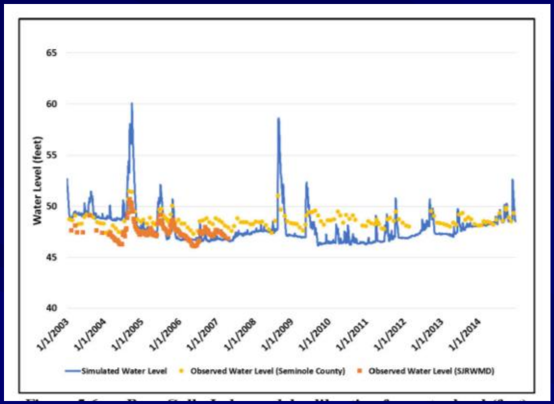
d. Assignment of Credits

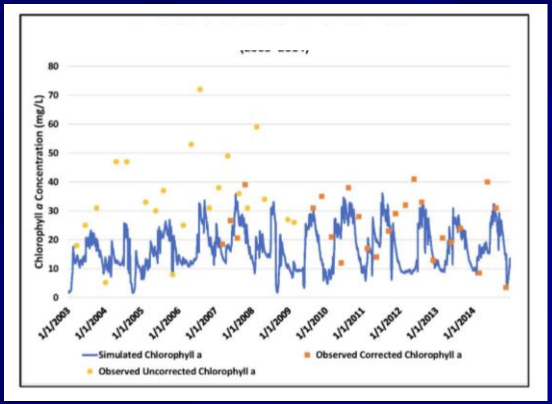
- Assignment of credits can be over generous
  - Educational credit of 5.5%
    - Common activities include billboards and educational pamphlets
    - Do these activities modify homeowner activities?
- Street sweeping
  - Auto-samplers do an extremely poor job of collecting representative sample of runoff solids
  - Manufacturers claim that water moves through the suction tubing at a rate of 2 fps - Minimum velocity required to transport most solids
  - Velocities through strainer holes are much lower
    - ~ 0.24 fps (12% of required velocity)
  - Impacts of these gross pollutants are not included in emc data
  - When TMDL credits are provided for gross pollutant devices, the loads are subtracted from loads which did not include them
  - In multi-lake systems the street solids will never reach the receiving water

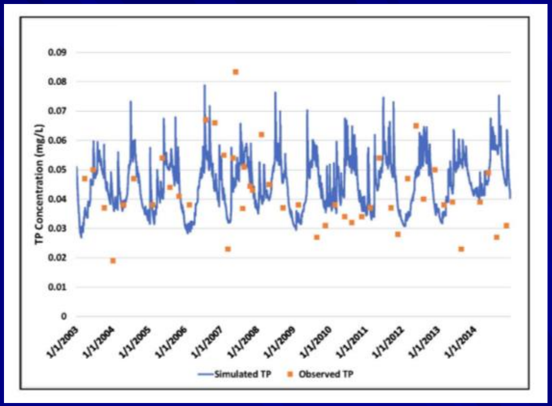


e. Basic Science

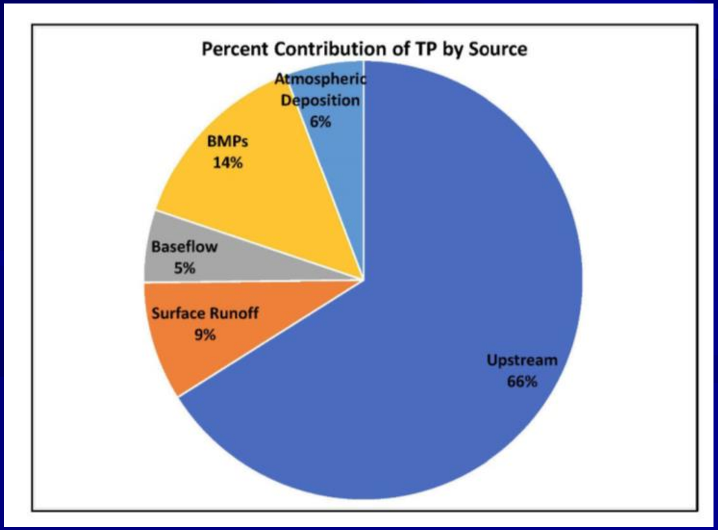
- Modeling issues







  – Each of these are considered to be a “good” fit



- Modeling was used to determine that the sediments removed 70 lbs of TP, rather than adding

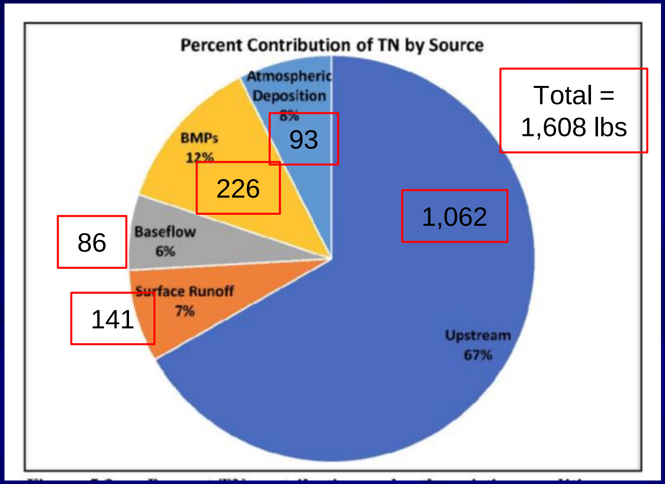
- All lakes have internal recycling

- Modeling is the least accurate method of estimating internal recycling

- A large source of TP loading has not been included

e. Basic Science – con't.

- Incomplete nutrient budgets



- Modeling was used to determine that TN load from internal recycling is 4,127 lbs

- Not included in nutrient budget

- Internal recycling is 3 times greater than all other sources combined

3. TMDL Alternative

Alternative to TMDL – con't.

- Current process involves TMDL development by FDEP
  - FDEP primarily addresses stormwater
  - Ignores or gives little attention to other inputs
  - FDEP dictates the sources to be addressed

- 4e designation
  - Impaired waters with ongoing or completed restoration activities
  - Waterbody is still included on the 303(d) list
  - Placement on the Verified List is postponed for one five-year assessment cycle to allow for implementation of the 4e plan and evaluation of progress toward restoration.
  - Must show measured water quality improvements through routine monitoring
  - TMDL is deferred until additional information is submitted to complete the pollutant reduction plan, or until additional water quality data are collected documenting that a waterbody is no longer impaired
  - Permittee controls the restoration activities

4e Designation

- Goal of 4e Designation
  - To implement appropriate restoration activities and, if necessary, additional study so that by the next assessment cycle either a 4b Reasonable Assurance Plan (RAP) can be approved or the waterbody attains water quality
  - If the waterbody is still identified as impaired by the next assessment cycle and a 4b (Reasonable Assurance Plan) has not been approved, then the waterbody would be placed on the Verified List

- Advantages
  - Plan development is locally controlled
  - An approved plan postpones the development of a TMDL and moves straight to restoration activities
  - Enables stakeholders to focus on implementing projects and fixing problems, not on the TMDL process itself
  - Basic document that describes basic goals, objectives, and activities

4e Designation Process

- Plan initiated
  - Shareholders contact FDEP concerning process
  - Provide basic information
- Develop restoration plan
  - Describe current conditions
  - Delineate watershed
  - Participating entities
  - Target water quality goals
  - Identify point and non-point source pollutants
  - Identify projects and funding sources
  - Develop success targets and monitoring
  - Timeframe
- Finalize Restoration Plan
  - Submit information to FDEP
- Finalize Assessment
  - Receive FDEP approval
- Implement Restoration Plan

4. Regulatory Obstacles

Alum Sediment Inactivation

Application Equipment

Lake Killarney During Application

- Alum sediment inactivation reduces TP load from internal recycling by 80%
- TP removal cost = $200/kg ($85/lb)
- Water quality goals can often be achieved through this alone

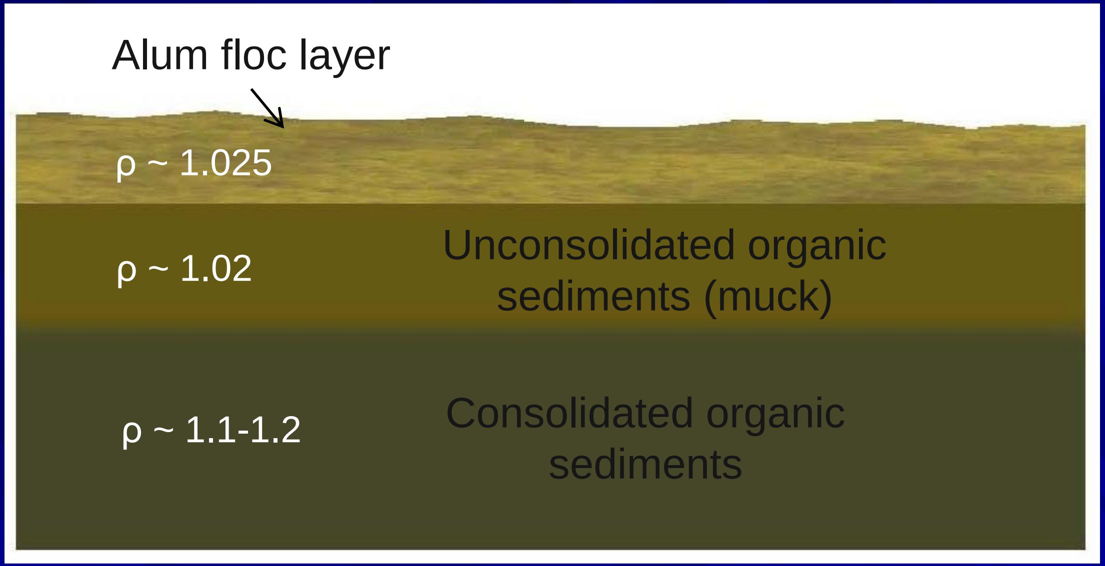
Historical Permitting Status

- During the 1980s, FDEP recognized the potential of alum for treating runoff and for sediment inactivation
  - Authorized multiple test projects for stormwater treatment and sediment inactivation
- Funded research projects to identify impacts to sediment chemistry and biota
  - Floc is inert and tightly binds constituents in sediments, reduces nutrient availability and makes sediments less toxic
  - Improves benthic diversity and density
- FDEP General Counsel issued an opinion in 1990s that:
  - Alum can be applied to Waters of the State
  - Due to beneficial impacts, no permit is required except for stormwater applications
  - More than 50 whole lake applications conducted in Florida under this opinion
    - 3.5 million gallons of alum
- In 2008, Gov. Scott gutted FDEP and the Water Management Districts
  - No longer any institutional knowledge of alum or permitting status

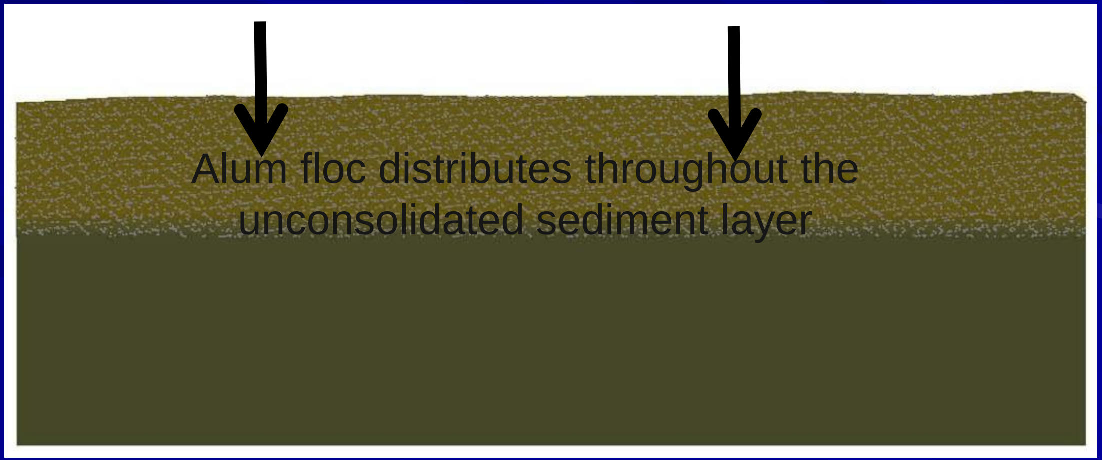
Alum Floc Settling in Lake Sediments

- Alum floc initially settles onto the top of the loose surficial layer
- Floc migrates downward over time into unconsolidated sediment layer
- Floc binds sediment P
- No visible floc layer

Floc initially settles onto the surface of the sediments



Floc migrates downward over time



Alum Floc Drying Process

Floc after initial water decanting

After 4-7 days

After 30 days

Once completely dried, the floc forms into a rock-hard material that will not re-dissolve

Chemical Characteristics of Dried Alum Residual

- Dried residual easily meets all applicable Clean Soil Criteria

- Passed all TCLP testing

Parameter	Units	Value	Clean Soil Criteria[2] (Chap. 62-777 FAC)
Aluminum	µg/g	51,096	72,000
Antimony	µg/g	< 6.3	26
Barium	µg/g	< 21	110
Beryllium	µg/g	< 0.53	120
Cadmium	µg/g	0.5	75
Calcium	µg/g	1,564	None
Chromium	µg/g	65.0	210
Copper	µg/g	31.6	110
Iron	µg/g	764	23,000
Lead	µg/g	0.7	400
Magnesium	µg/g	96.8	None
Manganese	µg/g	12.3	1,600
Mercury	µg/g	< 0.091	3.4
Nickel	µg/g	2.3	110
Zinc	µg/g	50.6	23,000
NO_x	µg/g	0.773	120,000
Total N	µg/g	2,054	None
SRP	µg/g	< 1	None
Total P	µg/g	166	None
pH	s.u.	6.17	None

FDEP Eco-Summary of Lake Holden

- During 2012, the FDEP Central District Office conducted 3 site visits to Lake Holden
  - January 19 – water chemistry, field measurements, and LCI sample
  - May 24 – water chemistry, field measurements, and LVI
  - October 2 – water chemistry, field parameters, and repeat LCI and LVI
- Conclusions
  - LVI score on May 24 corresponded with a Category II “Healthy” designation
    - “Lake Holden has a stable, healthy plant community, dominated by beneficial, submersed aquatic plants”
  - Reductions in the proportion of cyanobacteria
    - “Phytoplankton data indicate stability and balance in the algal community with low potential for armful (sic.) algal blooms”
  - LCI score was 59, corresponding to “very good” designation
  - Encountered benthic species which were indicators of good water quality
    - Mayflies and caddisflies were encountered – both are pollution sensitive
    - “Overall, the benthic community appears to be balanced and stable and has shown considerable improvement from past conditions.”

Current Conditions

- Over 50 alum sediment inactivation projects have been conducted in Florida
- FDEP has funded about half of the alum applications conducted by ERD through grants either directly or through WMDs
- FDEP gives generous TMDL credits for alum sediment inactivation
- Research conducted directly by FDEP on alum treated lakes raves about the improvements in benthic communities, water quality, and lack of HABs

Recent Developments

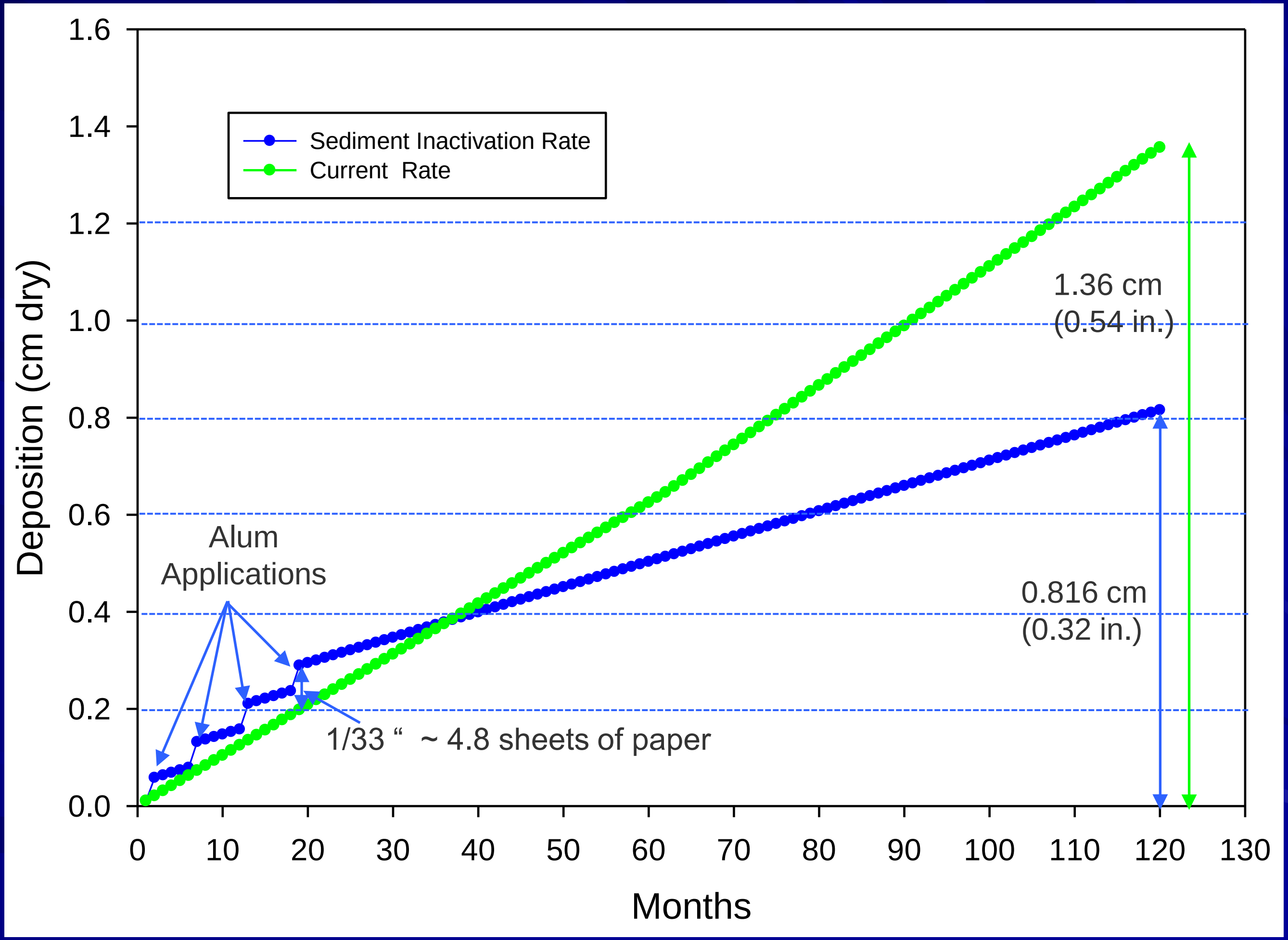
- On Dec. 22, 2020, the U.S. EPA transferred Section 404 authority to the Florida Department of Environmental Protection (FDEP)
- Staff became aware of the current alum sediment inactivation activities
  - Staff had no knowledge of this practice
  - Made an independent determination that alum additions could not be conducted in Florida
- After considerable backlash, FDEP staff indicated that alum can only be applied to waters which are not Sovereign Submerged Lands (SSL) due to concerns over “dredge and fill” issues
  - < 140 ac or part of a chain-of-lakes, or a formal HWL designation has been conducted
  - Permit is required
- Alum applications to Sovereign Submerged Lands are <u>not</u> “permissible or permittable”
  - SSL - > 140 ac or part of a chain-of-lakes, or a formal designation has been conducted

Solids Deposition in a Eutrophic Lake With and Without Alum Sediment Inactivation

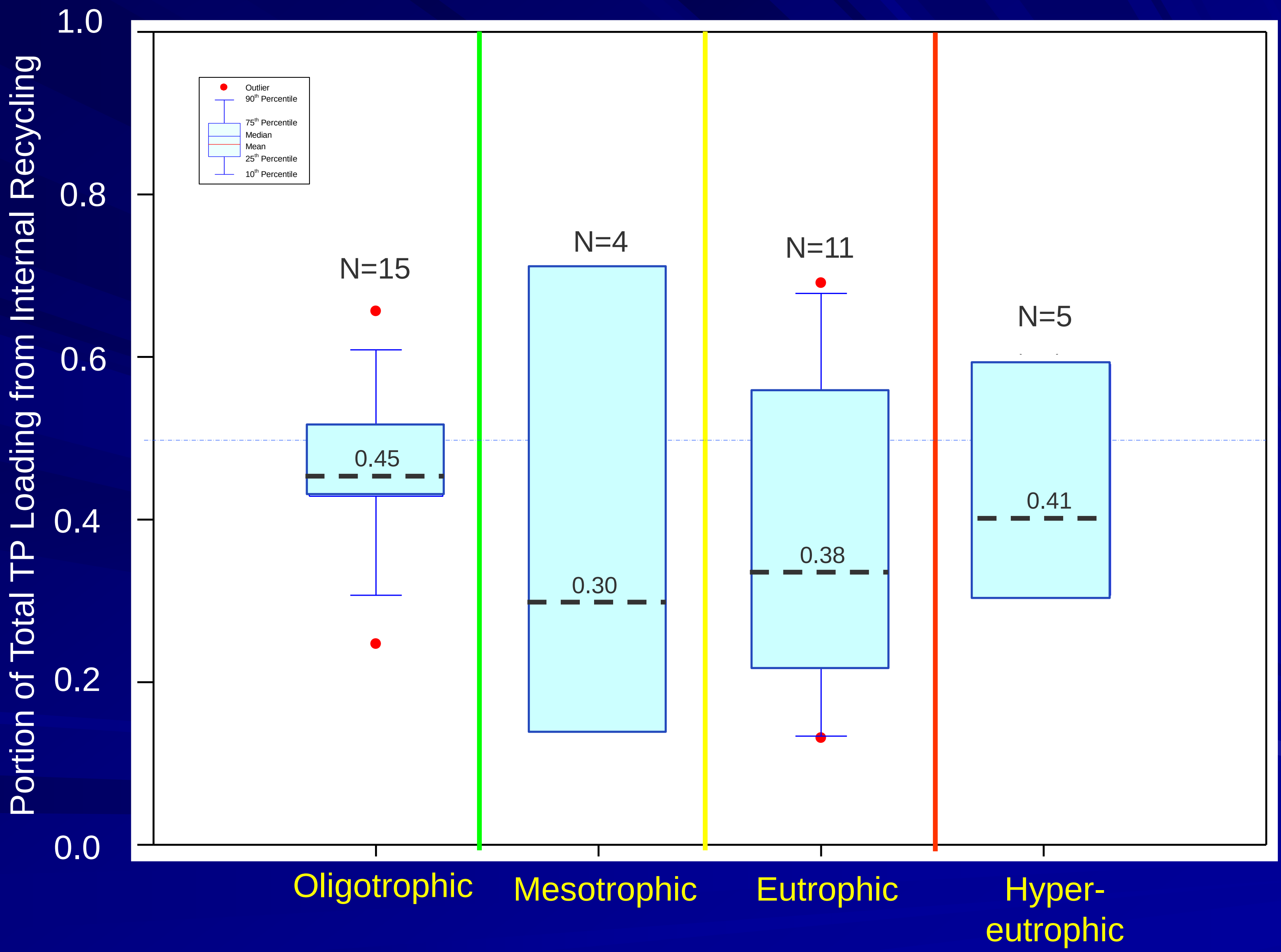
- Dry solids deposition of alum floc from a typical dose of 100 g Al/m^2 is 1/16 of an inch

- After about 36 months the whole lake deposition rate begins to decrease

- Lower lake deposition rate continues for the life of the application ~ 10yrs



Fraction of Total TP Loading Contributed by Recycling



Current FDEP Policies

- Vegetation management activity
- Deposits inches of dried solids on the lake bottom
- Solids ultimately decay and release nutrients back into the water column

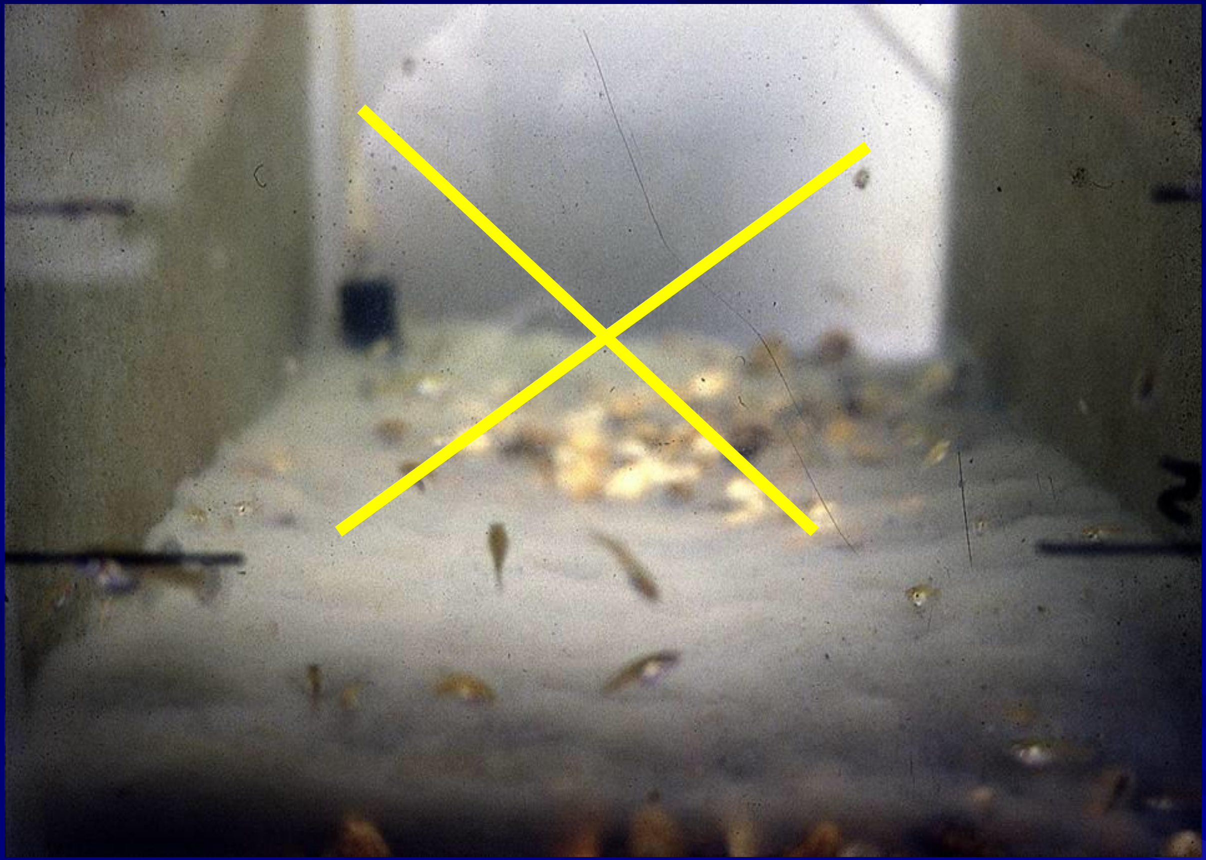
Current FDEP Policies

- FDEP approves this activity

Current FDEP Policies

- Alum sediment inactivation which adds 1/16 of an inch of dried solids and has well documented benefits

Current FDEP Policies



- FDEP does not approve of this activity because of concerns over “fill”

Summary

- Current TMDL techniques omit significant loading sources to waterbodies
  - Baseflow
  - Seepage
  - Internal recycling
- Omitted parameters are often significant loading sources
- Process over emphasizes significance of runoff loadings
  - Leads to expensive BMP projects with limited water quality improvements
- Limiting nutrient concept is incorrectly used
  - Eutrophic lakes can only be restored by removing P
  - P removal is less expensive and more reliable than N
- Incorrect and incomplete science
- Load reduction credits are generous
- Although water quality problems may have been created by runoff, restoration cannot be achieved by treating runoff alone

Summary – cont.

- All eutrophic lakes have significant internal recycling
  - In many lakes, internal recycling is more significant than runoff inflows
  - If water quality restoration is the primary objective, then treatment of stormwater may not provide the best improvement
  - Control of internal recycling is a highly reliable and low-cost method of reducing P loadings
    - Internal P inactivation - ~ $50/kg TP (20-year PW cost)
    - Stormwater BMPs - ~ $200-10,000+/kg TP (20-year PW cost)
  - Most successful lake management option available
  - Loss of sediment inactivation as a lake management tool prevents Impaired Waters from being restored
    - Under current conditions restoration of Impaired Waters is not possible
- Shareholders should consider implementation of a 4e Plan
  - Allows shareholders to direct the restoration process
- We deserve better

Questions?