Hutchinson
Environmental Sciences Ltd.

DEVELOPMENT AND APPLICATION OF A LAKE WATER QUALITY MODEL FOR THE CITY OF GREATER SUDBURY

Sudbury Lakes Advisory Panel Meeting
February 16, 2012

Purpose of Meeting

- Explain the Lake Water Quality Model Project
- We are at early stages of model development and calibration
- There will be another meeting

Purpose of Project

- The CGS is currently reviewing its Official Plan and is seeking scientific input in the development of land-use policies relating to shoreline development.
  - Guidance from
    - Provincial Policy Statement
    - MOE “LakeCap” Policy
    - District of Muskoka Lake System Health Program

Scope of Project – Technical

- Development and calibration of a watershed-based total phosphorus model for approximately 58 lakes in Greater Sudbury.
  - For whole lakes and embayments within lakes with rationale
- Development of model refinements to address uncertainties in:
  - estimates of human phosphorus inputs, dissolved organic carbon dynamics, shallow lakes, and lakes that become anoxic.
- Identification and modeling of lakes with significant internal phosphorus loads.
- Assessment of responsiveness of individual lakes to phosphorus inputs
  - sensitivity to phosphorus inputs and mobility of phosphorus from septic systems.

Scope of Project – Planning

- Recommendations on which lakes could or could not support additional development
- Recommendations for water quality monitoring.
- Recommendations of planning approaches and development guidelines for shoreline development

  water quality, lake trout habitat, shoreline availability and suitability, and regulatory agency guidelines.

Why Manage Lakes ?

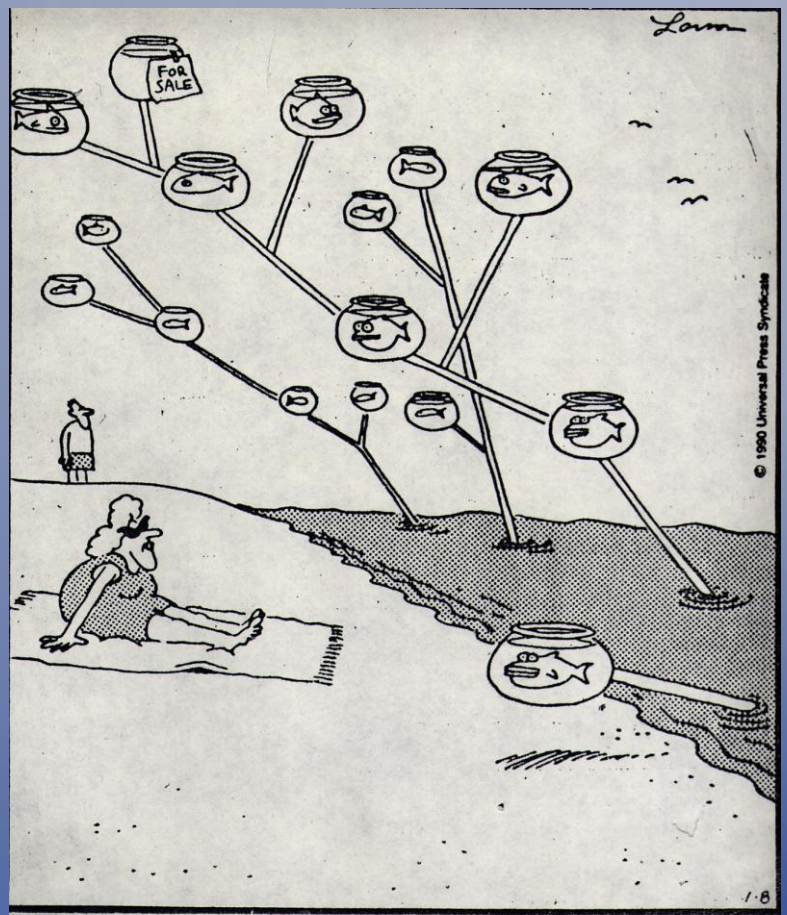
Why Plan for Lake Development ?

Water quality stability , to prevent observable changes by lake users and detrimental effects of lake use on aquatic life;

Social Stability to maintain pleasant recreational opportunities; and

Economic and planning stability, to preserve property values, regulatory environment and employment opportunities

Why Set Development Capacities ?



Encroachment of the fish developers.

In Ontario
Lake Management = Development Capacity

We protect water quality in recreational and urban lakes by:

Quantifying human sources of nutrients
Setting acceptable levels of nutrients (water quality objectives)
Setting “development capacities” to limit human nutrient impacts.

Background
Ontario's "Lakeshore Capacity Study - 1986

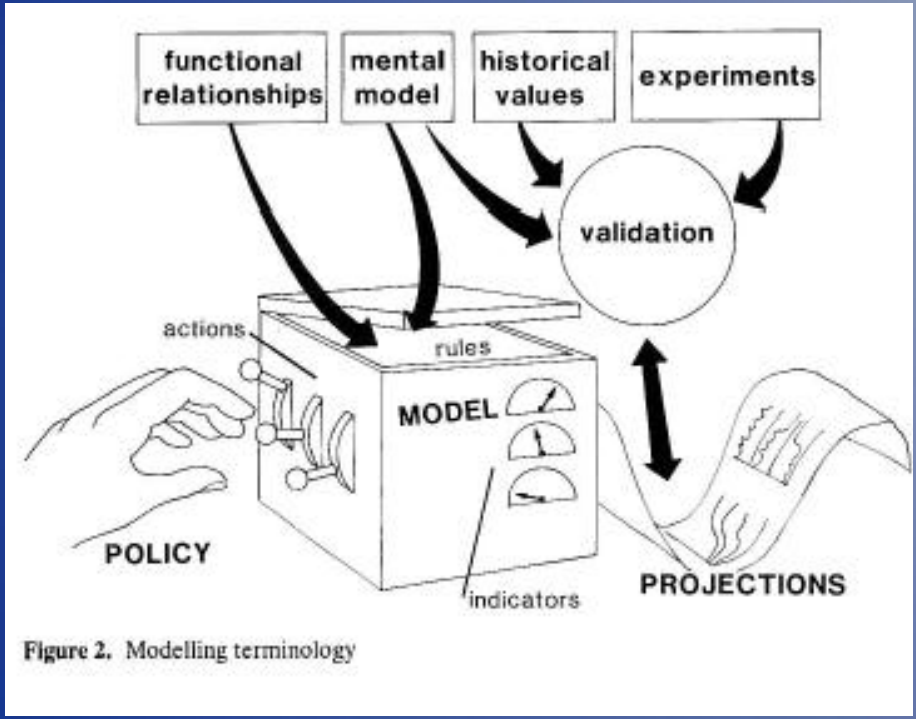
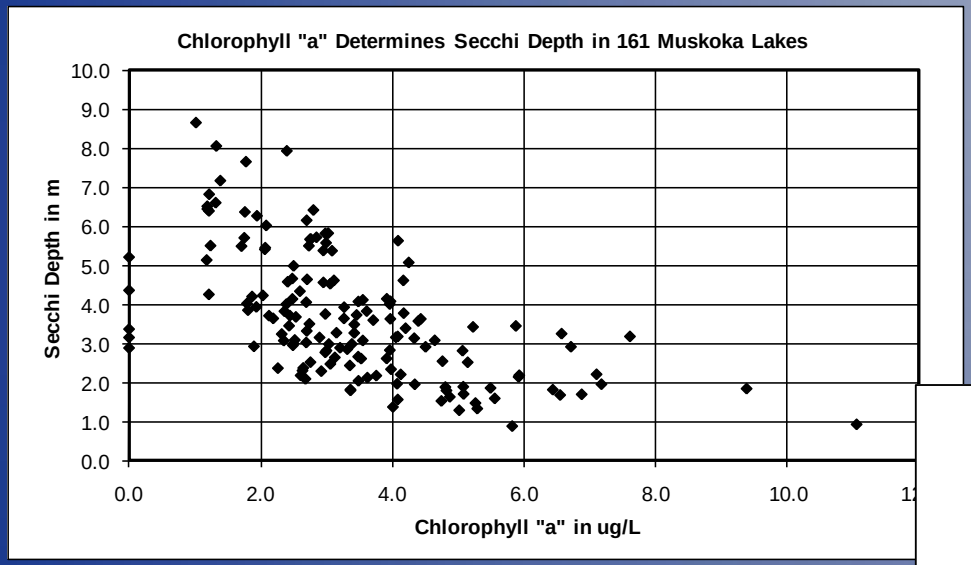


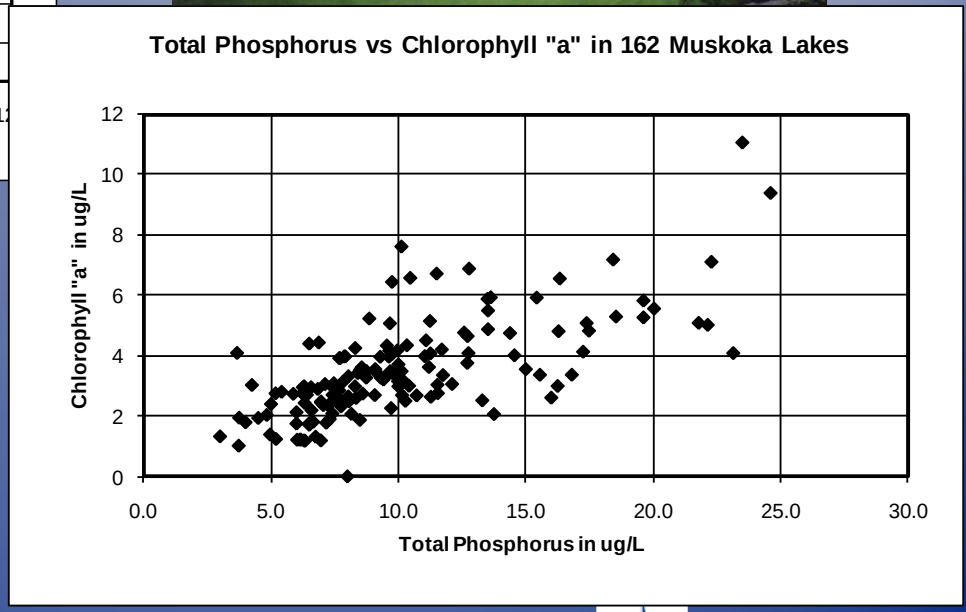
Figure 2. Modelling terminology

- **Ontario Lakeshore Capacity Simulation Model**
- a "black box" model of acceptable limits to development on recreational lakes
- Microbiology, Land Use, Fisheries, Wildlife, **Trophic Status** and Integration components
- Only the trophic status model was implemented by MOE
- Formal adoption in 2010.

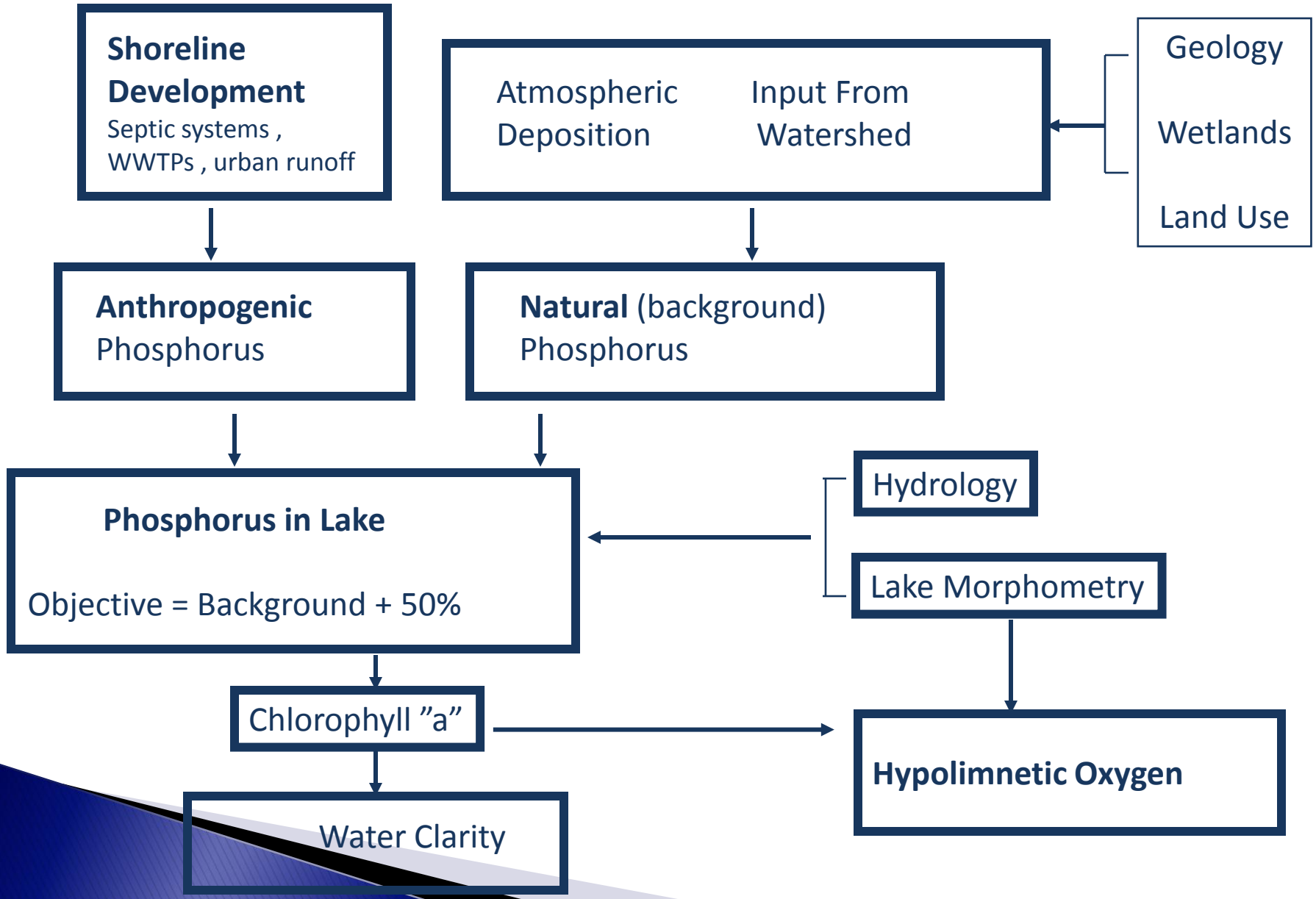
Ontario's "Lakeshore Capacity Trophic Status Model"

- Models "recreational" water quality (total phosphorus) to protect water clarity (visual aesthetics) and algal blooms

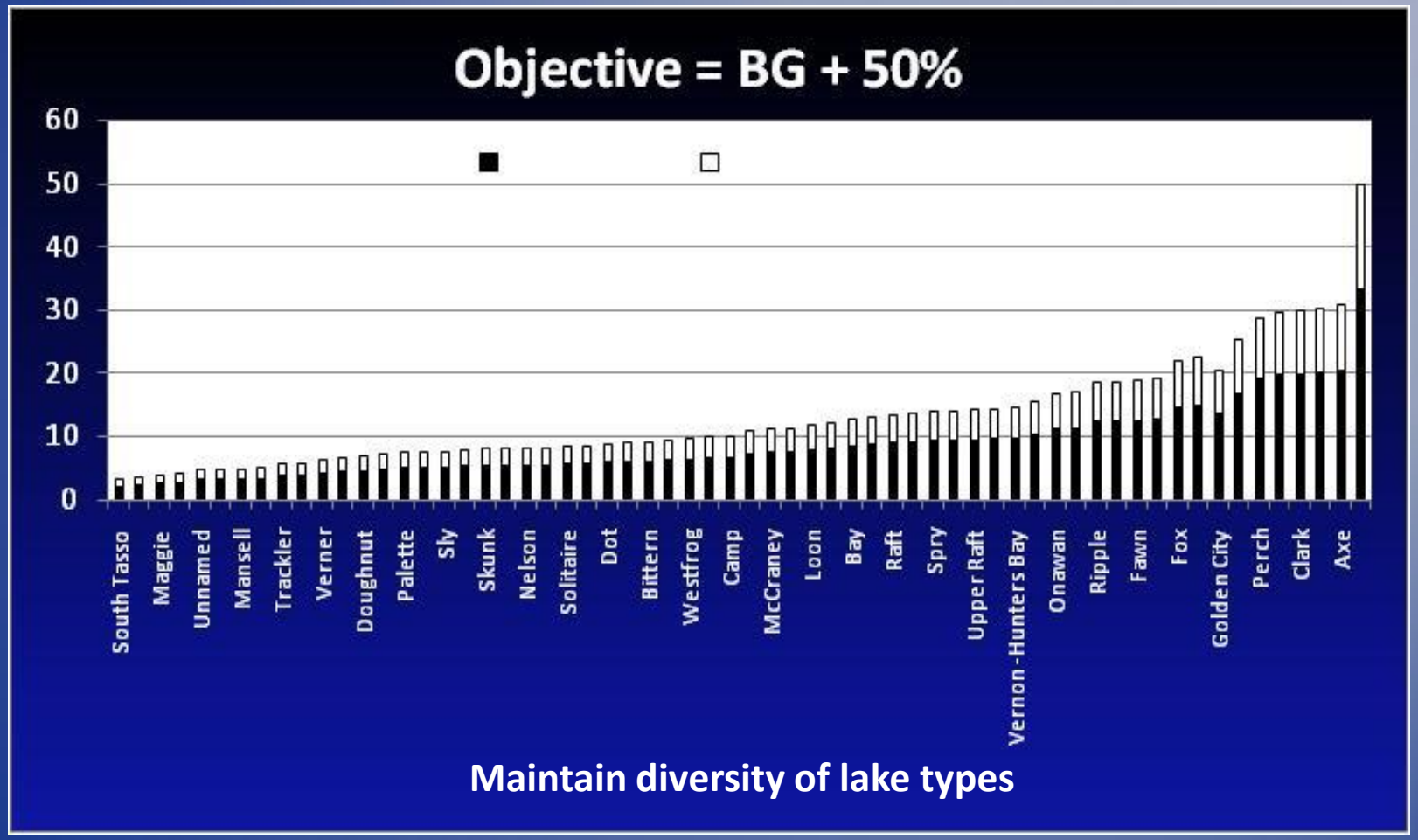




Ontario's "Lakeshore Capacity" Trophic Status Model



Translate Natural Phosphorus Concentration to a Water Quality Objective or Target



Hutchinson, N.J., B.P. Neary and P.J. Dillon. 1991. Validation and use of Ontario's Trophic Status Model for establishing lake development guidelines. Lake and Reserv. Manage.7(1):13-23.

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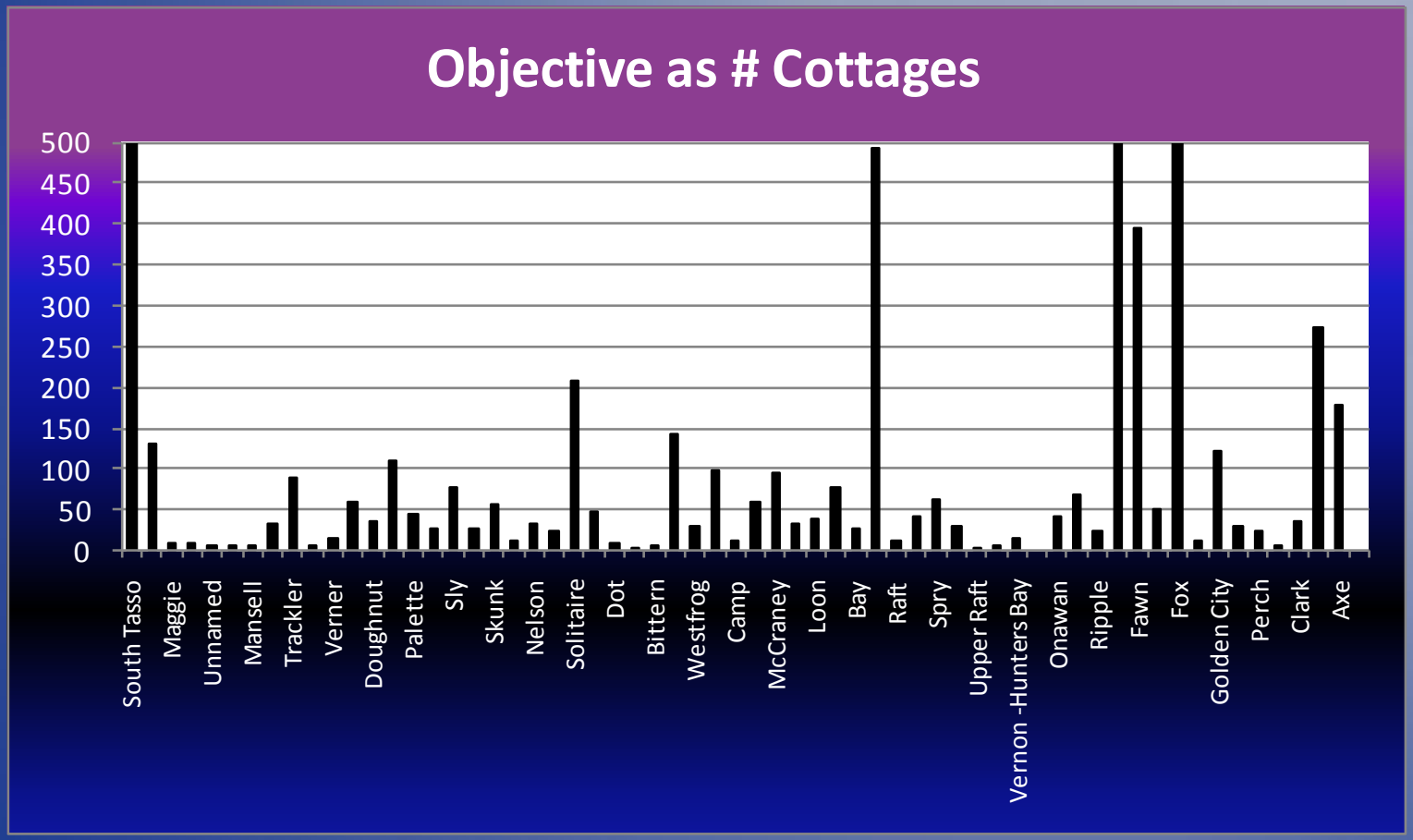
Translate Target Concentration of BG + 50% to "Development Capacity"



Implications

124 cottages is "acceptable"

125 cottages is "over capacity"

Does the model/approach support this precision ?

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Ontario's "Lakecap" Approach

Manage phosphorus loading by

-Modeling lake response to development
-Setting nutrient limits based on septic system loading
-Enforcing development capacities in the Official Plan
    -a regulated limit to the number of shoreline septic systems

"Planning by Plumbing "

Ontario's "Lakecap" Approach

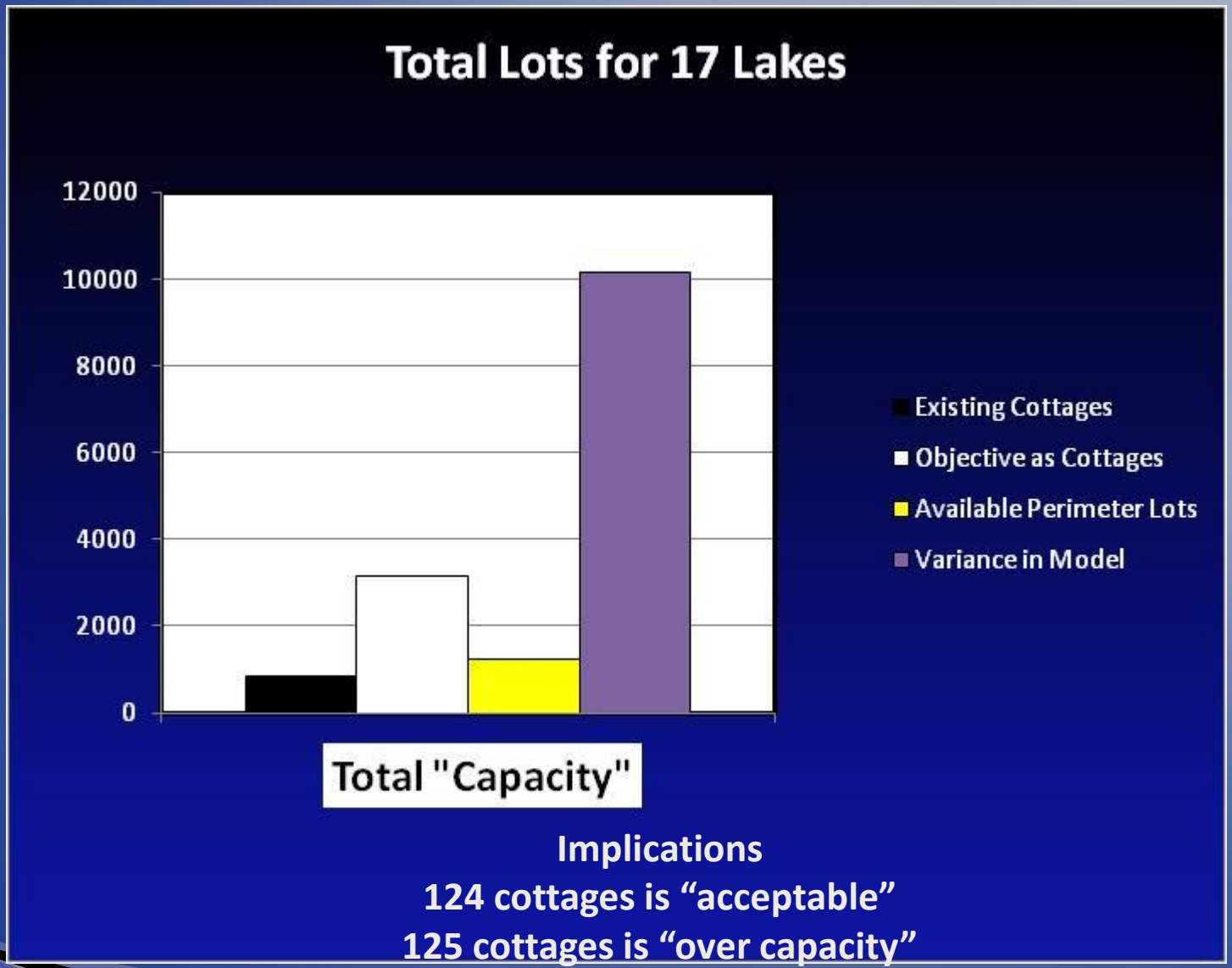
The model is complex – requires whole watershed orientation

- **watershed model must extend beyond City of Greater Sudbury boundary**
- **344 lakes > 10 ha.**

The model is "state of the art" but contains variables and uncertainty

- **usage of shoreline residences**
- **how many lots are there ?**
- **local coefficients for atmosphere and land use**
- **modelling 344 individual lakes with mean values for in-lake processes**
- **How much phosphorus moves from the septic system to the lake ?**
  - **MOE Assumption – 100%**
  - **PreCambrian Shield Research – <5%**

Water Quality is not the only “Capacity Factor”



Implications

124 cottages is “acceptable”

125 cottages is “over capacity”

Does the model/approach support this precision ?

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Problem "Lakeshore Capacity" assumes a finite limit

Assumes a "line in the sand"
Ontario uses BG+50% as "capacity"
Add cottages to modeled BG + 50 %

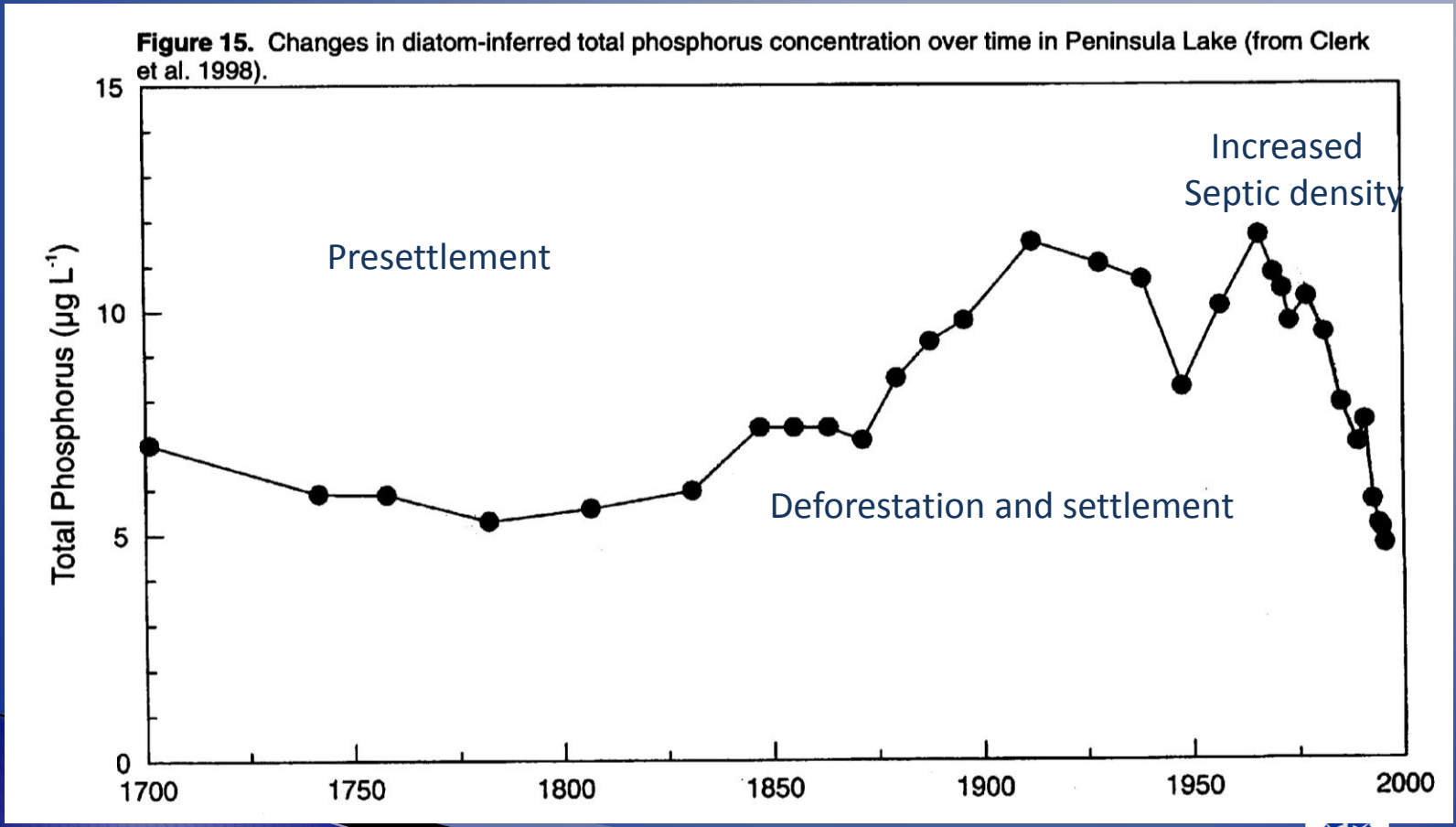
- "pollute up to" limit
- no recognition of management or stewardship

Reality is a "broad ribbon in the sand"
Consider
BG + 50% is a trigger for management not an absolute threshold or capacity

Environment Canada uses BG + 50% as a trigger for detailed investigation

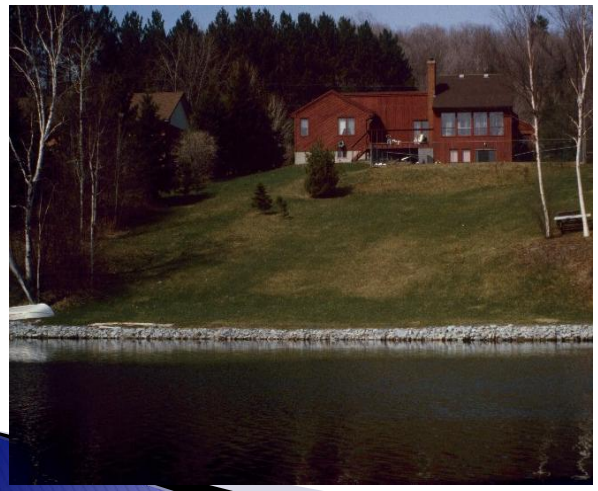
Problem – Context of Lakeshore Capacity

Peninsula Lake – Huntsville ON.
- 283 cottages, 189 upstream cottages
- no signal from shoreline development in lake sediments



So What ?

- Ask the right questions
- Lakeshore Capacity Asks
  - How much phosphorus is acceptable ?
  - How green can my lake become ?
  - How many users are acceptable ?
- Is growth the question ?
  - Or is better management of growth the question?



These lakes have lots of “capacity”

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Recognize What the Model and Lakecap Do Not Do

- Stop development
  - OMB decisions
- Stop removal of shoreline vegetation
- Protect Wetlands
- Require new development to be set back from the shoreline
- Encourage lake stewardship and Best Management Practices

Then What ?

- Recognize that development alters trophic status
- Recognize that variance >> specific capacity estimates
- Acknowledge where assumptions are not supported
- Manage nature of development vs “capacity”

Recognize What the Model and Lakecap Do

- Indicate the level of sensitivity of a lake to nutrient enrichment
- Indicate state of phosphorus concentration
- Guide development policy
  - Management requirements (development controls) scaled to sensitivity score
- Indicate when a lake has more phosphorus than is healthy
- Be the basis for planning and stewardship programs

Evolution
Muskoka Lake System Health Program

Focus on recreational water quality

- Phosphorus, chlorophyll “a”, water clarity

Managed through Official Plan policies

- First Canadian Municipality to place water quality protection in its Official Plan – early 1980s
- Extensive revision in 2005 – review in 2011

Technical Aspects

- Whole watershed Dillon-Rigler mass balance phosphorus model
  - Proximity to MOE Dorset Environmental Science Centre
- Pre-2005 – “Capacity” as allowable development intensity – absolute number of lots
- Post 2005 – Moved to ”Sensitivity Based Planning Controls”
- Explain how we got there
  - Major educational experience in municipal planning for a limnologist

Lake Nutrient Sensitivity = Responsiveness + Mobility

Responsiveness – Does lake respond if you add phosphorus?

Add standard areal load (1 cottage / 1.62 ha)
Model lake response

Responsiveness	
High	>80%
Medium	40-80%
Low	<40%

Mobility - Is phosphorus moving from septic systems to the lake ?

Compare modeled [TP] to measured [TP]
Does lake response suggest anthropogenic response ?

Mobility	
High	Low
>80%	<80%

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Lake Classification

How Sensitive is a Lake to Development?

		Mobility	
		High	Low
Responsiveness	High	High Sensitivity	Moderate Sensitivity
	Low	Moderate Sensitivity	Low Sensitivity

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Planning Context

- Purpose
  - Provide clear policy direction for environmentally sound development around our lakes and rivers
- Objectives
  - Reduce the impact of existing development
  - Minimize the impact of new development
  - Achieve a net reduction in phosphorus as redevelopment proceeds

Planning Context

- Translate Sensitivity to Lake Management Activities through OP Policies

		Mobility	
		High	Low
Responsiveness	High	High Sensitivity	Moderate Sensitivity
	Low	Moderate Sensitivity	Low Sensitivity

Planning Guidance

	Sensitivity		
Management Techniques	High	Medium	Low
Vegetated Buffers	X	X	X
Shoreline Naturalization	X	X	X
Soil Protection	X	X	X
On-Site SW Control	X	X	
Limit Impervious Surfaces	X	X	
Enhanced Septic Setback	XX	X	X
Septic Abatement Technologies	X		
Full Servicing	X		
Site Specific Soils Investigation	X		
Enhanced Lot Sizes	X		
Limit Lot Creation	X		
Compliance Monitoring/Securities	X		
Monitoring Intensity	Annual	Annual	BiAnnual

Conclusions – Guiding Principles for Sudbury Lakes Study

Trophic status models are useful to scale / estimate lake response to development

Modeled phosphorus concentrations have many variance elements

Modeled phosphorus estimates do not support fine estimates of development capacity

Conclusions – Guiding Principles for Sudbury Lakes Study

Therefore

Use trophic status model to scale lake sensitivity

Sensitivity =

- Will lake respond if phosphorus is added ?
- Does measured data suggest lake has responded to human impacts ?

Scale lot-specific management to lake sensitivity

Add assessment and development controls to Official Plan

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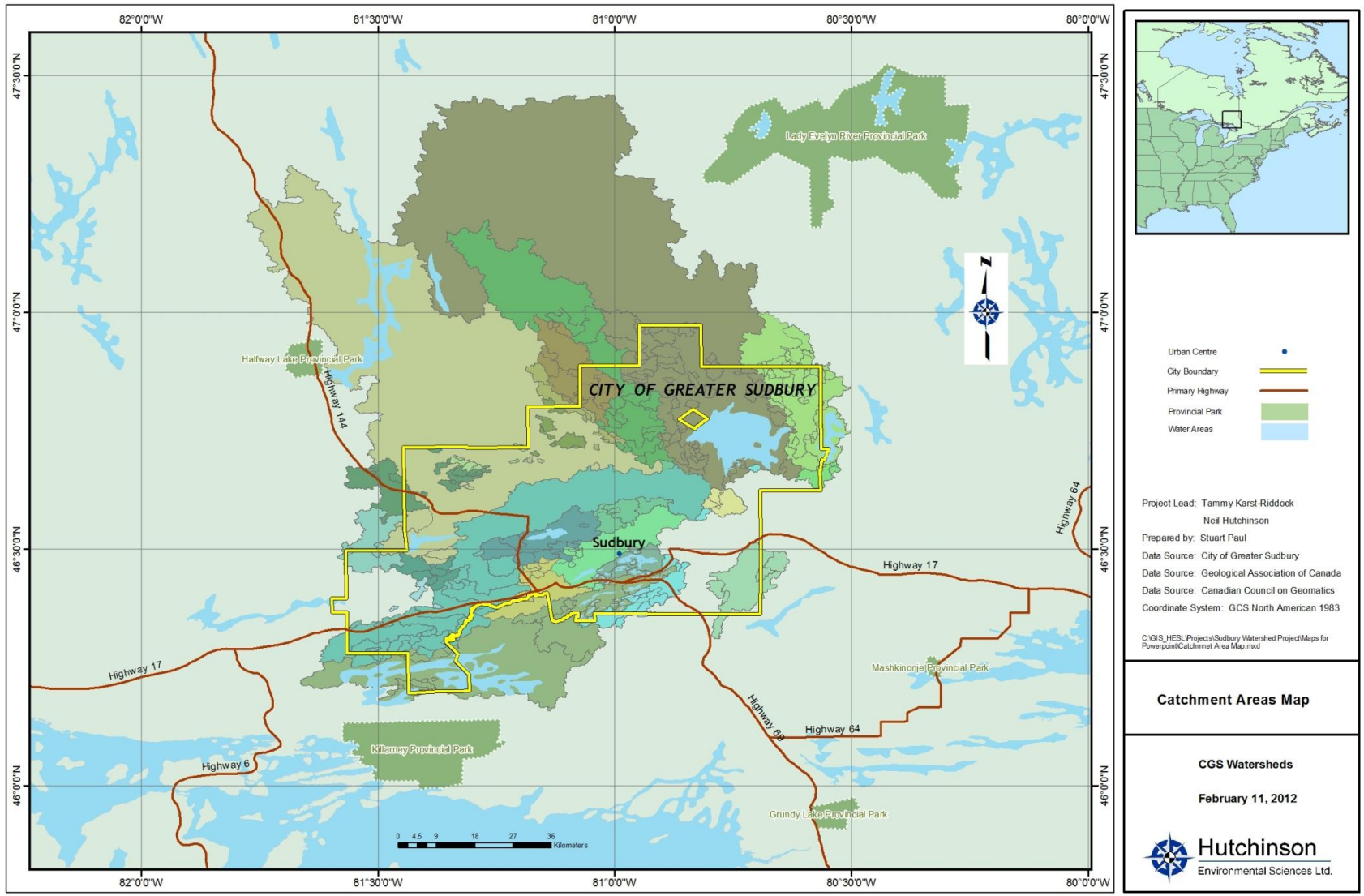
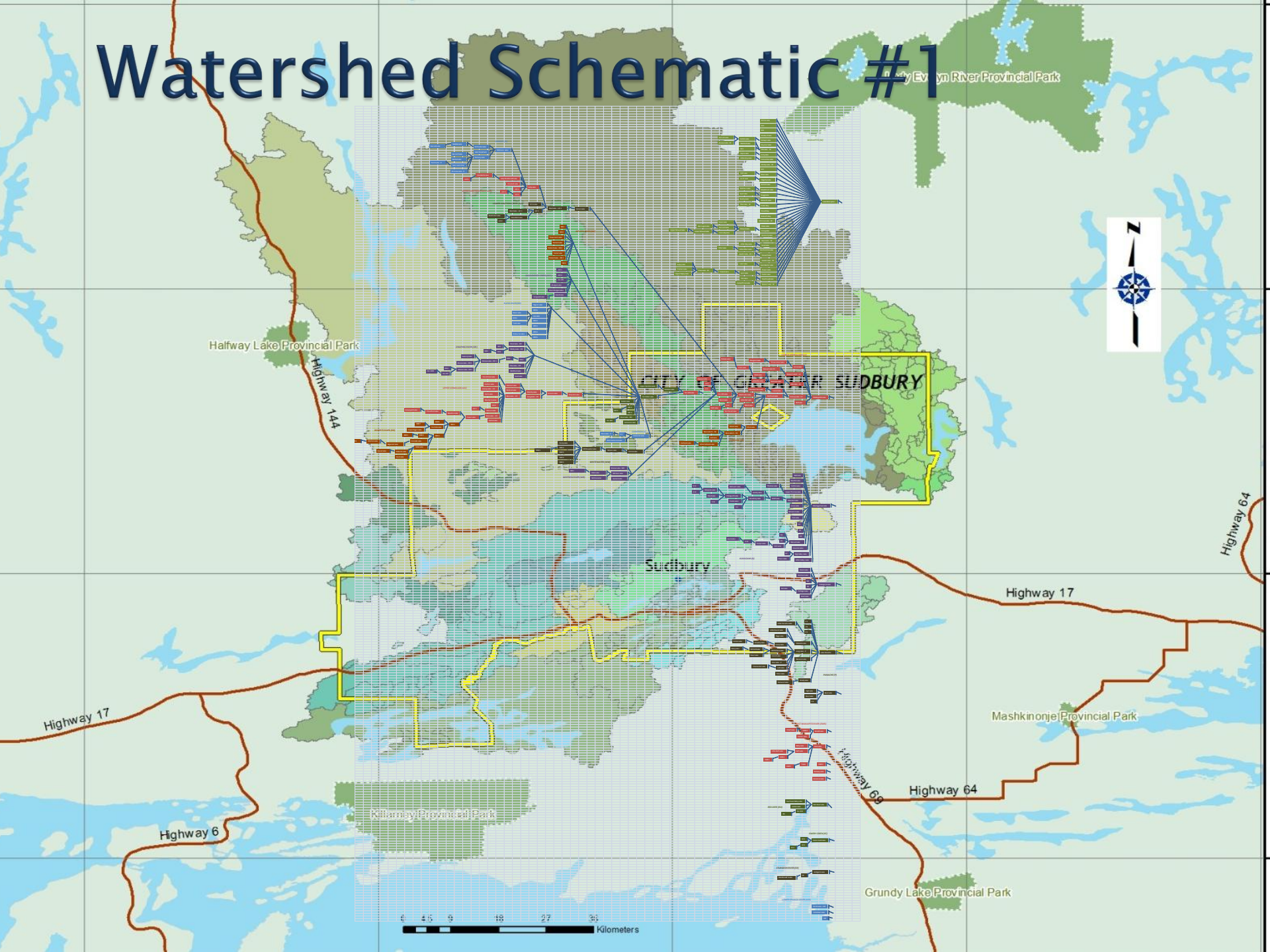
Status of Sudbury Lakes Study

- Watershed GIS Mapping
- Water Quality Data
- Timelines

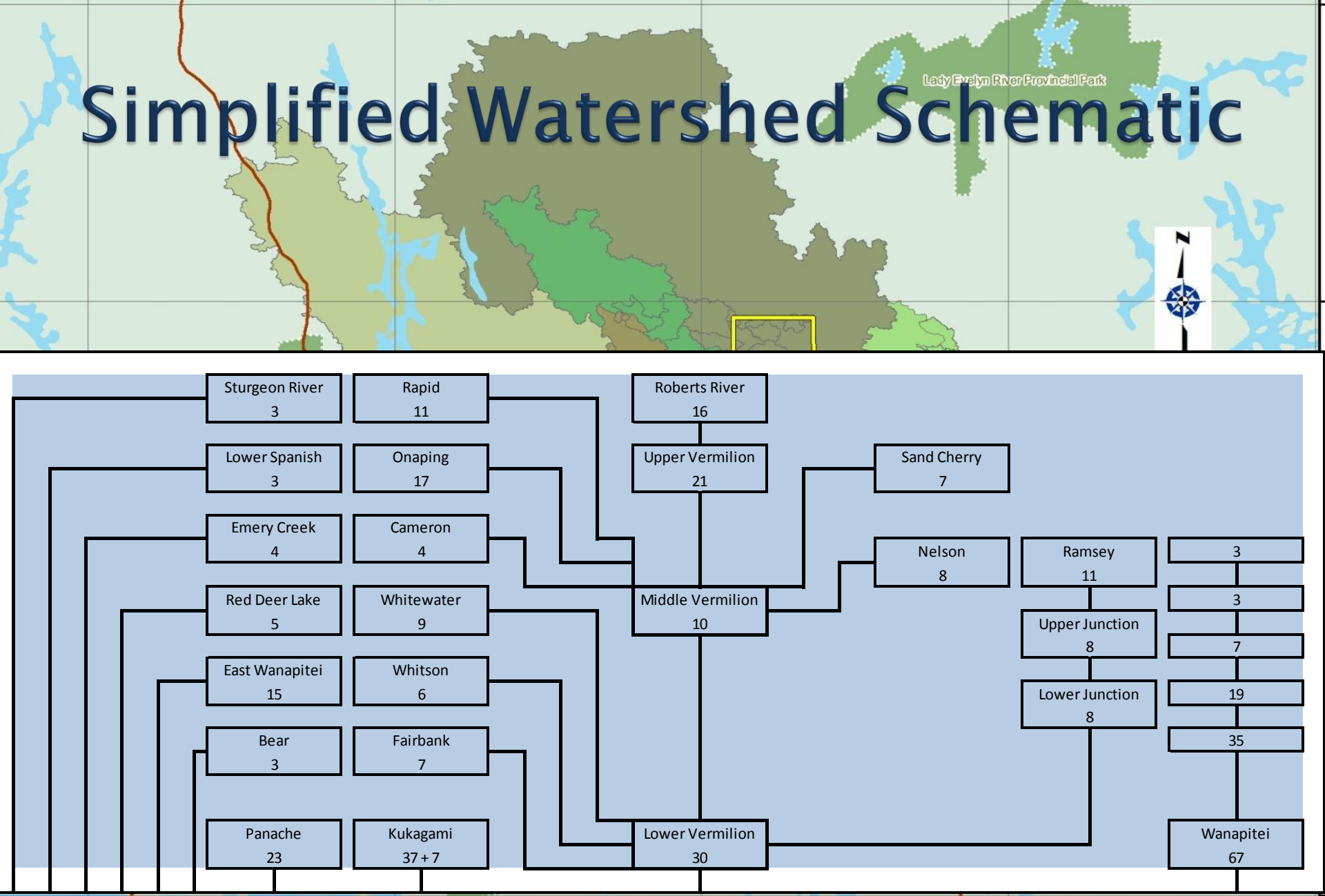
Study Area
(721,258 km², 344 lakes >10 ha)



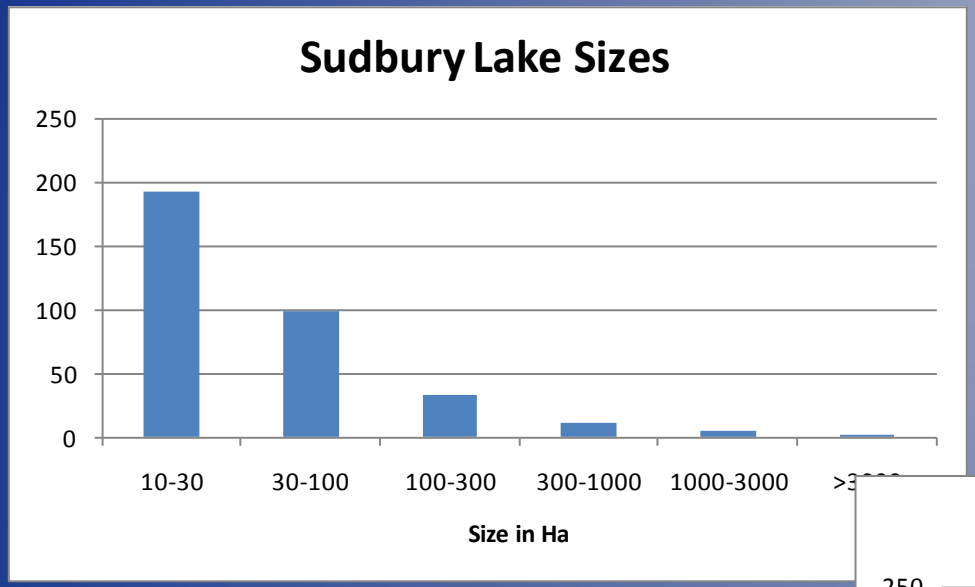
Watershed Schematic #1

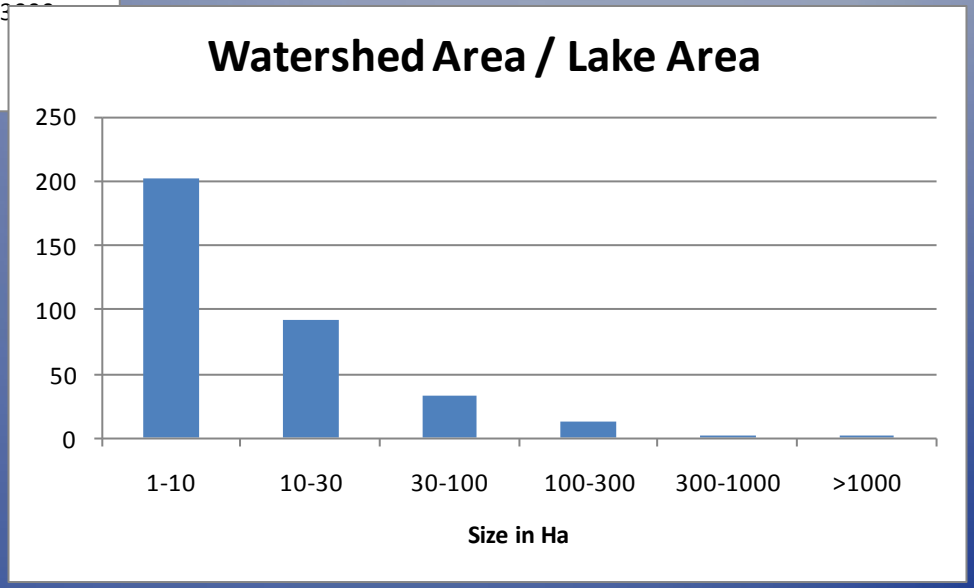


Simplified Watershed Schematic



Sizes and Watershed Ratios





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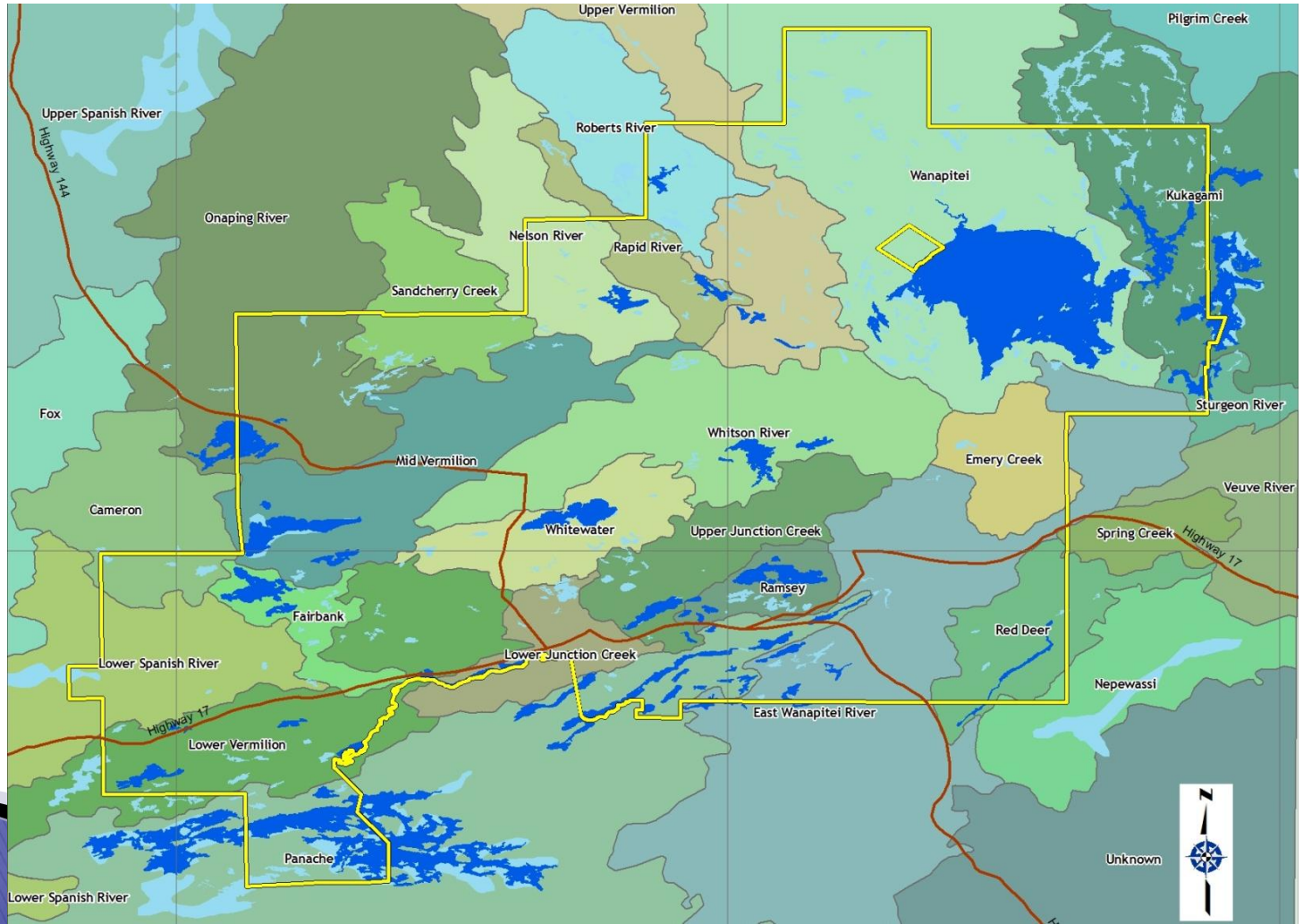
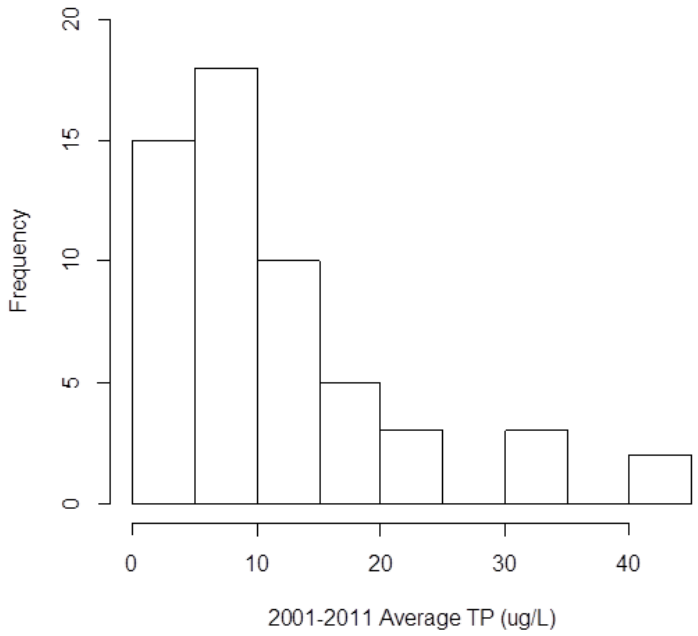
Total Phosphorus Monitoring in Sudbury Lakes

- CGS has monitored spring TP in 66 lakes since 2001
- Long term (≥ 5 years) data exist for 42 lakes, 58 lakes have 3 years

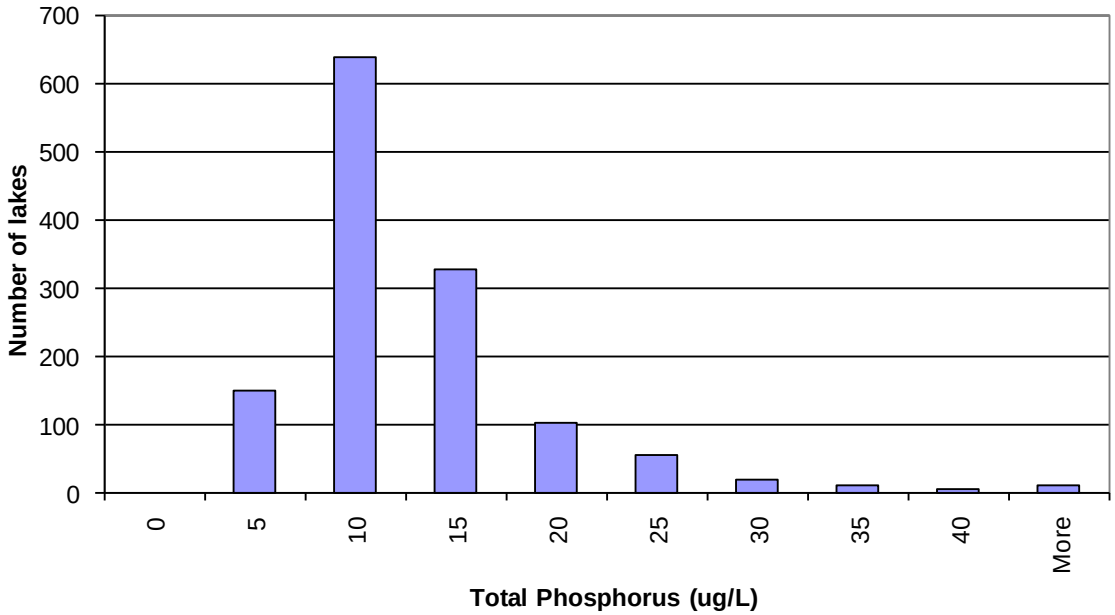


Total Phosphorus Concentrations in

66 Sudbury Lakes



1311 Ontario Lakes



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Timeline

Year	Task	Description	Due Date
2011	Project Initiation		01-Nov-11
	Task 1/2	Project Initiation + Presentation #1	Week of 7-Nov-11
	Task 3	Data Compilation and Review	25-Nov-11
	Task 4	Water Quality Data Analysis and Review	3-Dec-11
	Task 5	Initial Model Formulation	23-Dec-11
2012	Task 6	Gap Analyis and Recommendations	20-Jan-12
	Task 7	Model Refinement	31-Aug-12
	Task 8	Thresholds and Sensitivity Analysis	7-Sep-12
	Task 9	Planning Policy and Recommendations	14-Sep-12
	Task 10	Draft Report	28-Sep-12
	Task 11	Presentation #2	October 2012
	Task 12	MOE Review	October 2012
	Task 12	Final Report	9-Nov-2012

Questions?