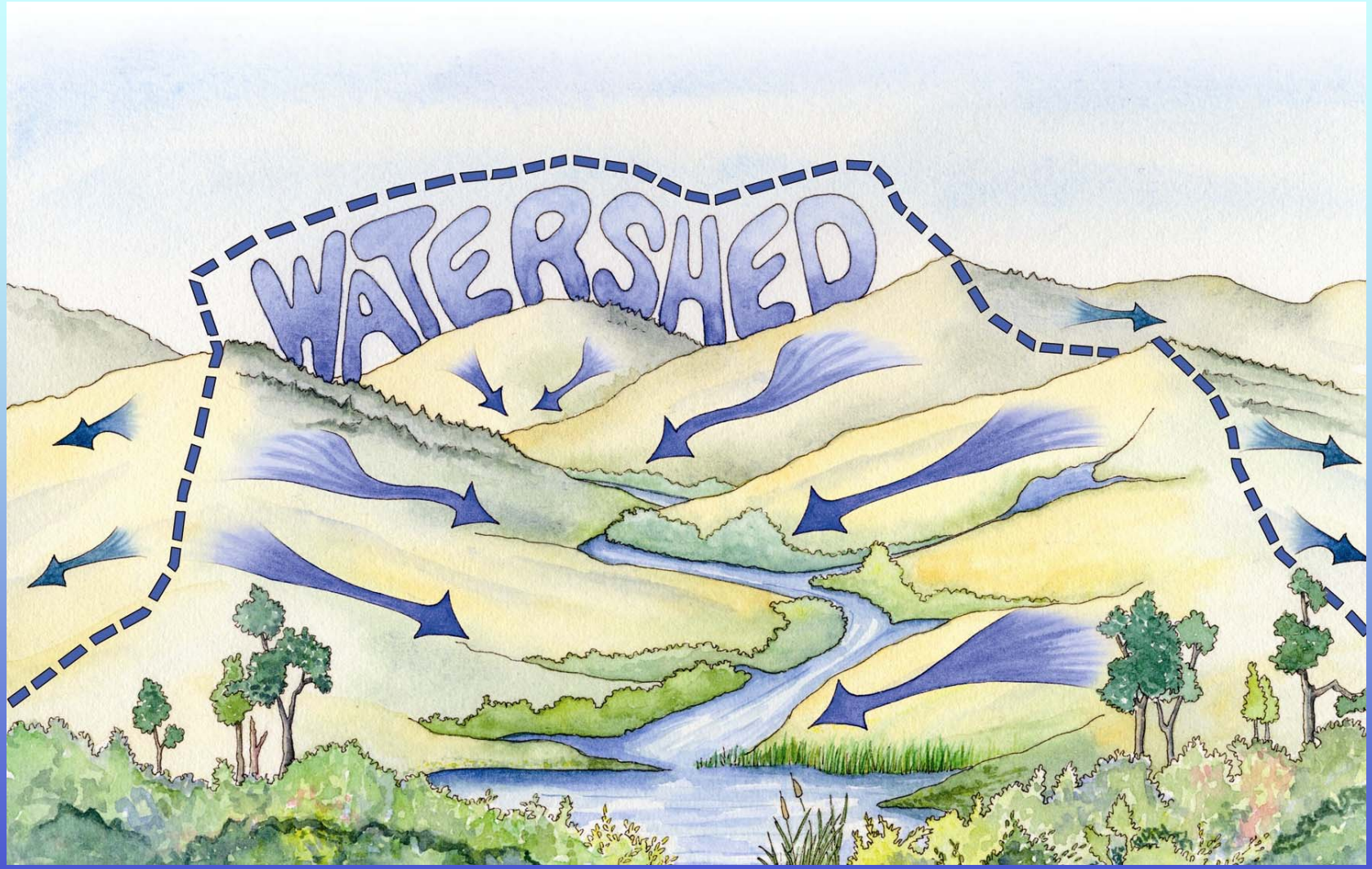
Wabamun Lake Watershed 101

Presented to the Wabamun Watershed Management Council
December 2011

What is a watershed?



The specific land area that drains water into a river system or other body of water.

The factors that affect watersheds can be intensive and extensive

Features in the Wabamun Lake watershed and surrounding area

Characteristics of Wabamun Lake

Surface Area (km^2)	
• **Basin (excluding lake)**	**259.0**
• **Lake**	**81.8**
Basin Area/Lake Area Ratio	**3.2**
Volume (m^3)	**513×10^6**
Maximum Water Depth (m)	**11**
Mean Water Depth (m)	**6.3**
Shoreline Length (km)	**57.3**
Mean Residence Time (yr)	**> 100**

Notes:
Basin characteristics from the *Atlas of Alberta Lakes* (Mitchell and Prepas 1990)

Land-use/Cover by Major Sub-basin

Subwatershed	Area (km2)	%Watershed	%Forested	%Agriculture/ Exposed Soil	%Urban	%Wetlands	%Grassland/ Shrubs
Primary Streams	**124.8**	**45.7**	**15.2**	**16.5**	**0.7**	**6.5**	**6.8**
Ascot_09	2.5	0.9	47.5	13.9	4.6	15.3	18.7
Coal_12	11.9	4.4	37.0	35.7	2.1	10.1	15.2
Fallis_13	5.4	2.0	16.8	44.2	5.2	7.3	26.5
Freeman_05	3.3	1.2	40.4	33.0	2.0	7.0	17.7
Rosewood_26-27	39.6	14.5	38.5	27.5	0.2	20.4	13.3
Seba_20	8.1	3.0	47.6	19.6	6.2	11.9	14.6
Seba_22-23	54.0	19.8	27.0	45.4	1.3	11.9	14.4
Secondary Streams	**25.0**	**9.2**	**3.4**	**2.4**	**0.4**	**1.0**	**2.0**
Diffuse Areas	**39.5**	**14.5**	**6.1**	**1.3**	**0.2**	**3.4**	**3.4**
Mine-affected & Industrial	**83.8**	**30.7**	**4.6**	**12.2**	**0.2**	**10.0**	**3.7**
Watershed Total	**273.2**	**100.1**	**29.2**	**32.4**	**1.6**	**20.9**	**15.8**

http://environment.gov.ab.ca/info/library/8340.pdf

An Overview of Recent Aquatic Studies

AENV Study Objectives

Surface water quality component to determine:

- If surface water quality has changed over time (1982-present);
- If surface water quality varies across the lake.

Sediment quality component to determine:

- Levels of metals and trace organics (PAHs) in sediments;
- Compare Wabamun sediment to other lakes.

Biological studies to determine:

- Evaluate the significance of water and sediment quality to aquatic biota (field surveys and laboratory toxicity testing).

Surface Water Quality: Ongoing Monitoring (1982-present)

Lake Wabamun is part of a long-term water quality monitoring program:

- Monthly sampling for water quality and plankton during open-water (May-Oct);
- Water quality sampling once during winter (Feb).

Water Quality Measurements

- pH, dissolved oxygen, conductivity, temperature
- Nutrients (phosphorus and nitrogen), amount of algae (chlorophyll-*a)*, major ions
- Metals (water and sediment)
- Pesticides

Nutrients and Chemistry

When nutrients = human & ecological trouble

- Lakes naturally range between oligotrophic (nutrient poor) and eutrophic (nutrient rich)
- Studies show human activities in Alberta lakes are negatively impacting water quality
- Problems: fish kills, ecosystem effects, toxicity of surface waters, aesthetic issues, ↓ property values

Increasing nutrients in water; increasing 'greeness' (chl-a)

-Nil aquatic veg.
-Nil algae

-High aquatic veg.
-Moderate algae

-High aquatic veg.
-High algae

-Mod. aquatic veg.
-Extreme algae

Nutrients: W5

- **What are they?: Molecules that can be used by living organisms for life processes.**
- **Why are they needed?: Nutrients are essential for life to aid in extracting energy or driving growth**
  - **In ↑ amounts: CHOPNS**
  - **In ↓ amounts: Fe, Cu, etc.**
- **Where are they from?: Soil, Rocks, Precip., rivers, runoff, air, dust, organisms, mud, sediments, artificial**
- **Who uses them?: Plants, algae, animals, fish, microbes, chemical reactions**
- **When are they used? Constantly used, recycled, transformed, transported, released**




Changing lakes & nutrients

nutrients, greeness

Aquatic veg. dominated
clear

Algae dominated
turbid

nutrients, greeness

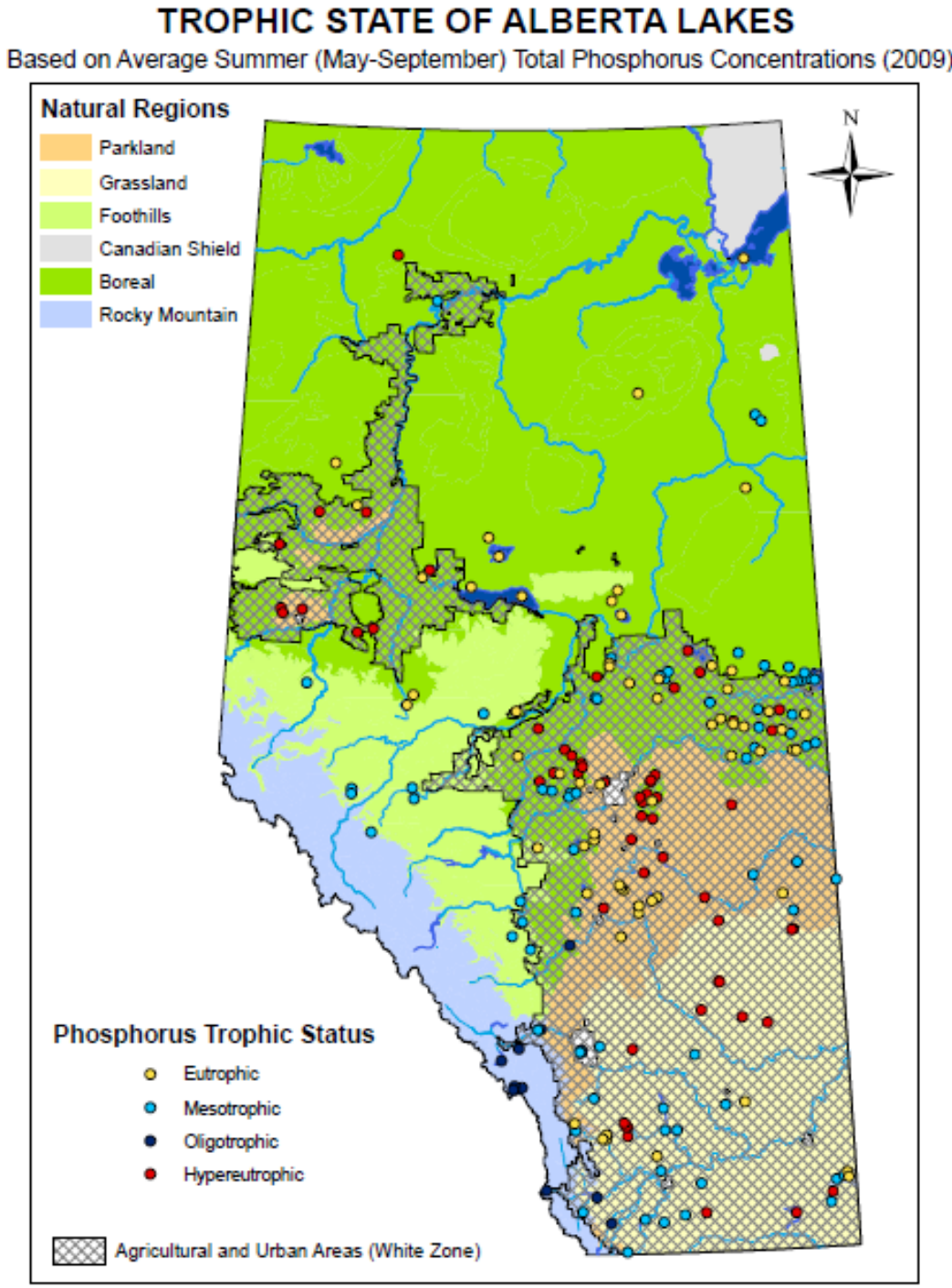
Alternative states: lakes can cycle between clear and turbid states

Causes of change: loss of veg. communities; increases of nutrients; physical conditions

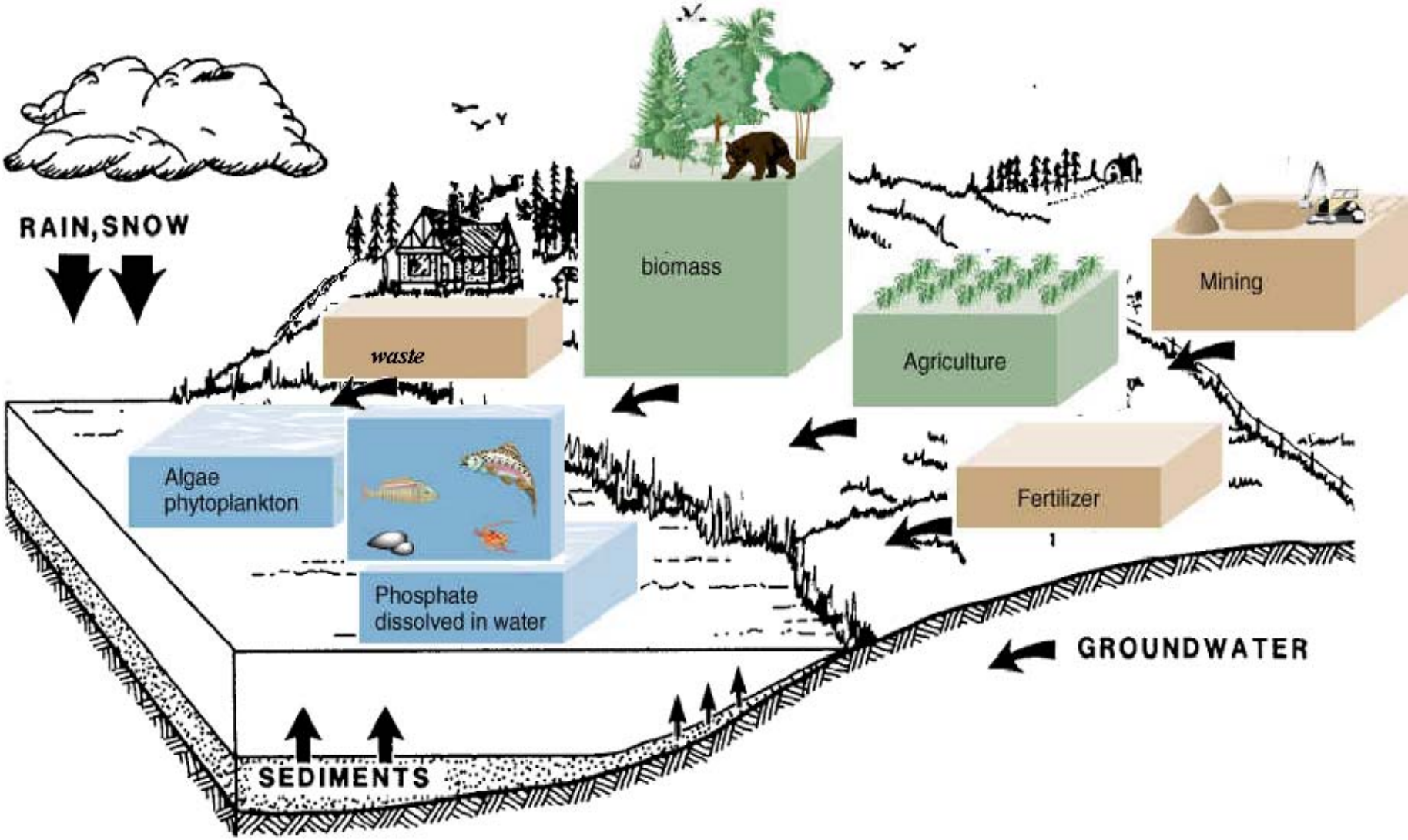
The majority of lakes in Alberta are highly productive

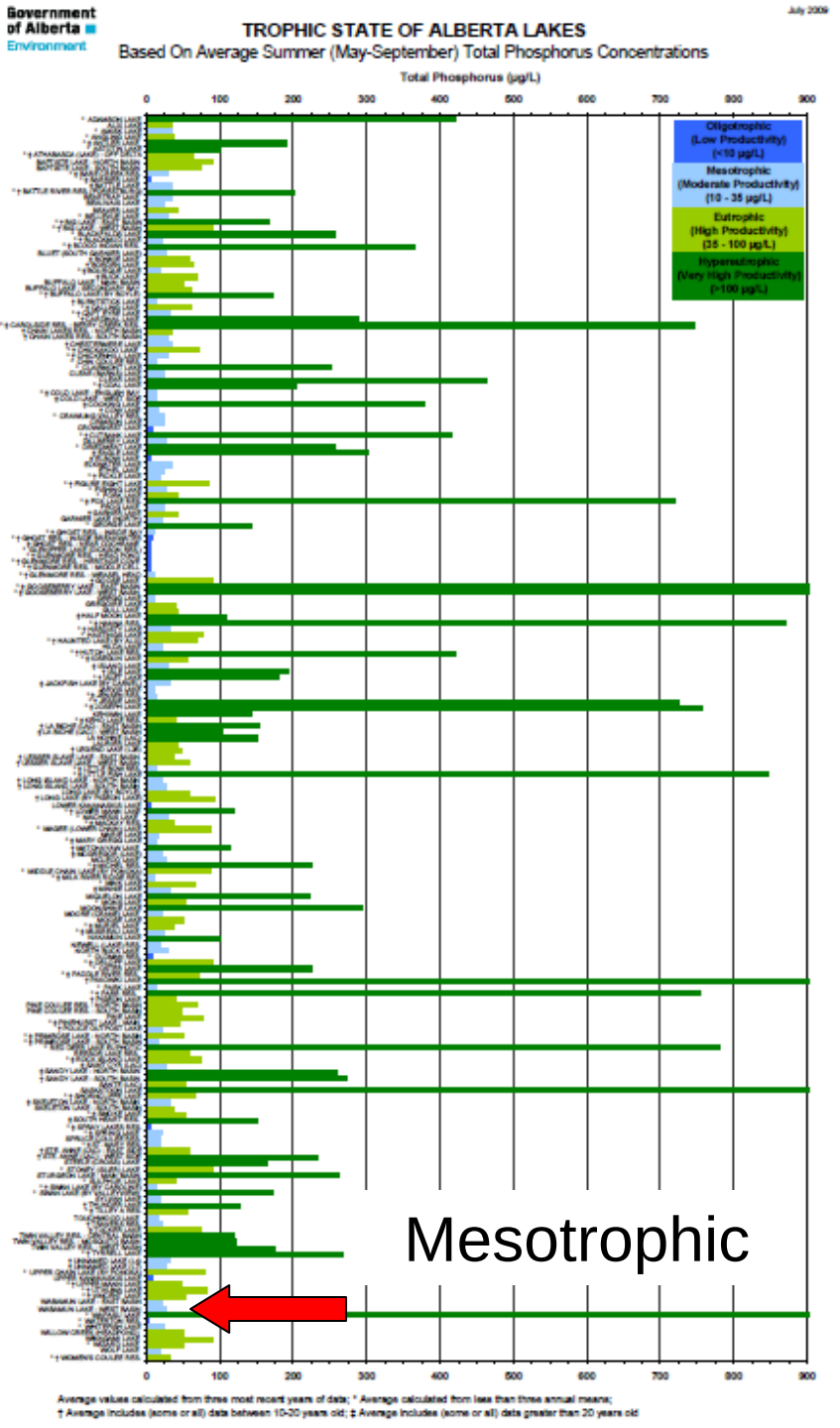
Causes of lake fertility is due in part to the geology, soil type, and disturbance

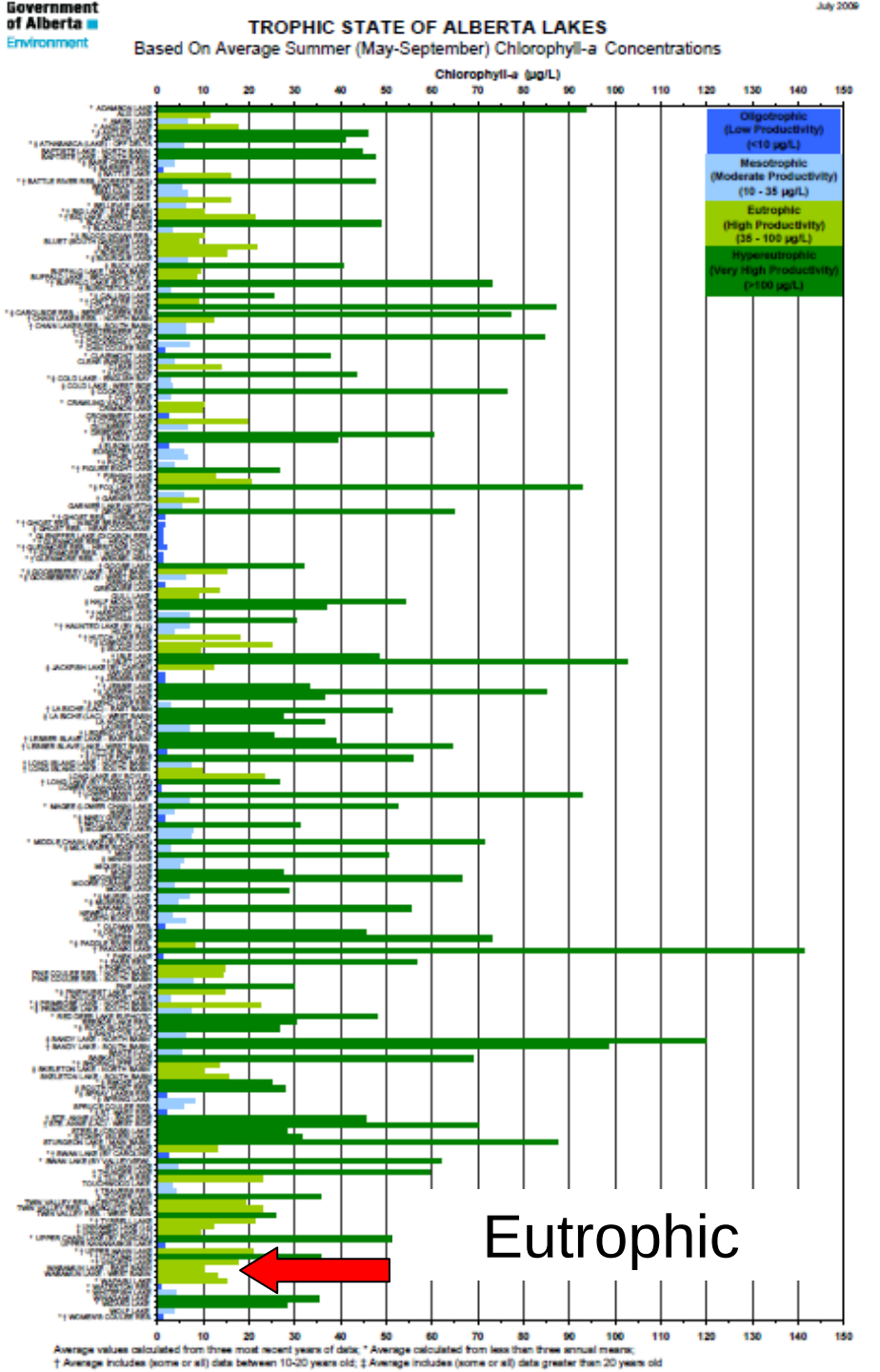
Wabamun is a moderately productive lake in terms of phosphorous concentration



Watershed + Nutrients Link




Government of Alberta
Environment
July 2009
TROPHIC STATE OF ALBERTA LAKES
Based On Average Summer (May-September) Total Phosphorus Concentrations
Total Phosphorus (µg/L)
0
100
200
300
400
500
600
700
800
900
Oligotrophic (Low Productivity) (<10 µg/L)
Mesotrophic (Moderate Productivity) (10 - 35 µg/L)
Eutrophic (High Productivity) (35 - 100 µg/L)
Hypereutrophic (Very High Productivity) (>100 µg/L)
Mesotrophic
Average values calculated from three most recent years of data; * Average calculated from less than three annual means;
† Average includes (some or all) data between 10-20 years old; ‡ Average includes (some or all) data greater than 20 years old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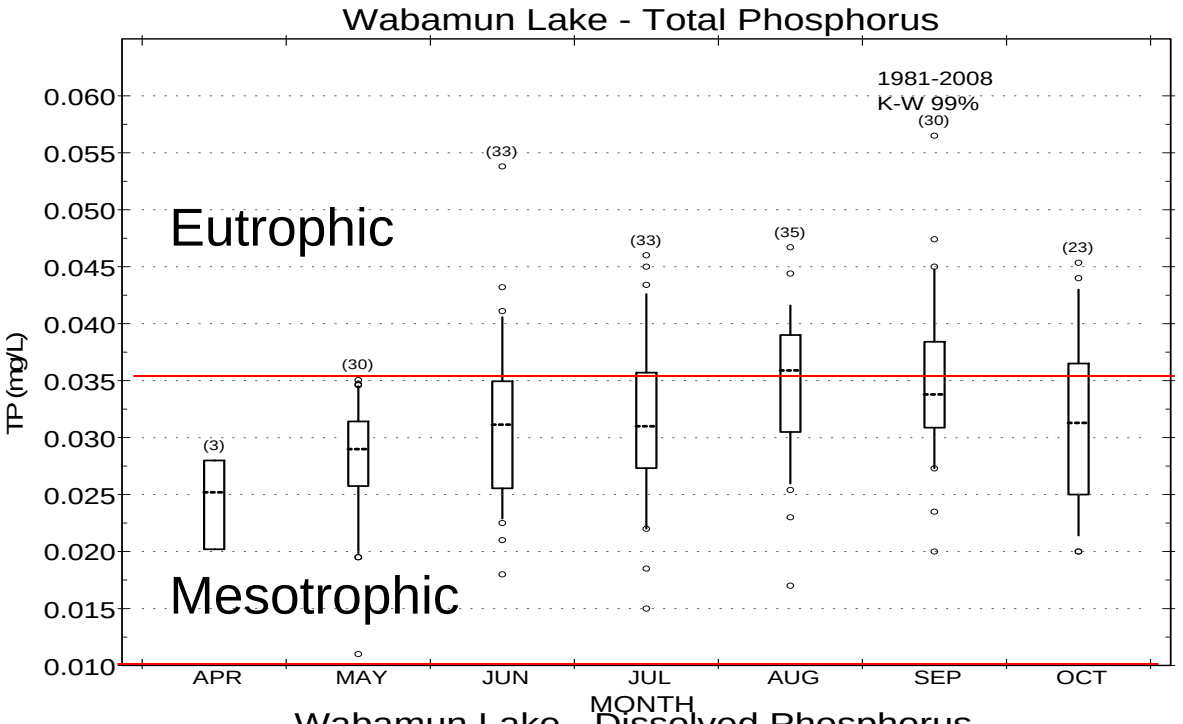
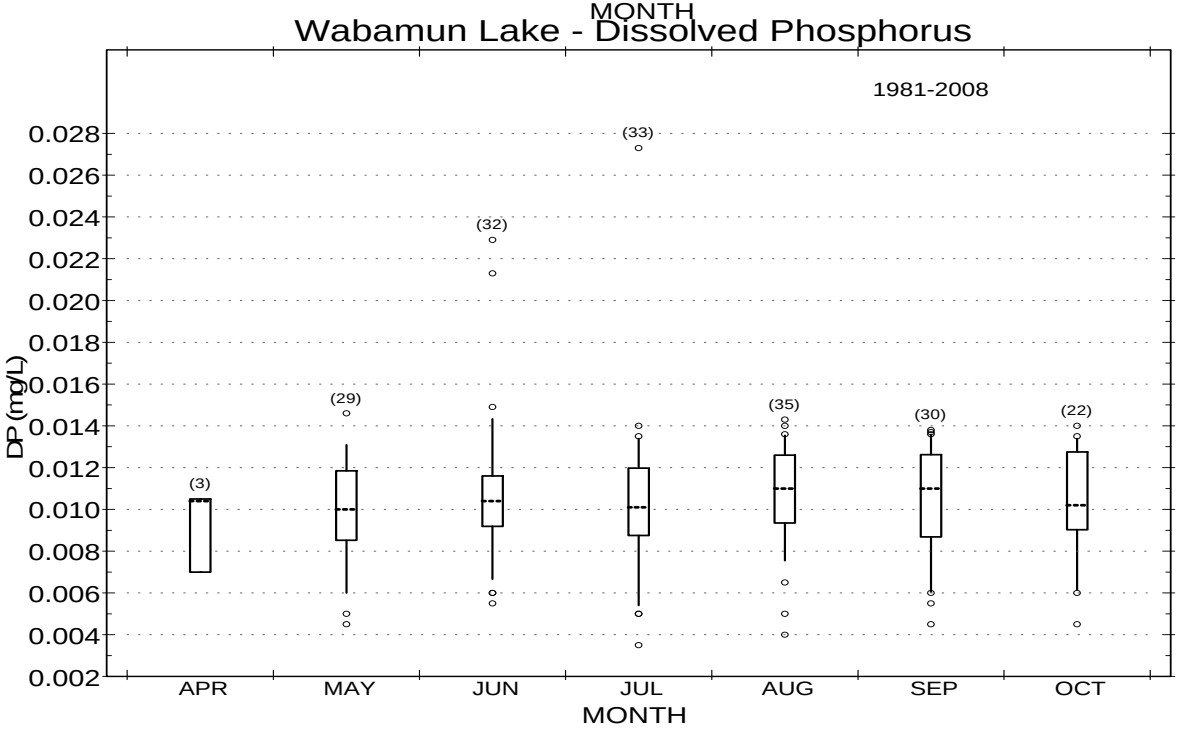
Water nutrient concentration changes seasonal and annually

This pattern is evident during the recent monitoring record

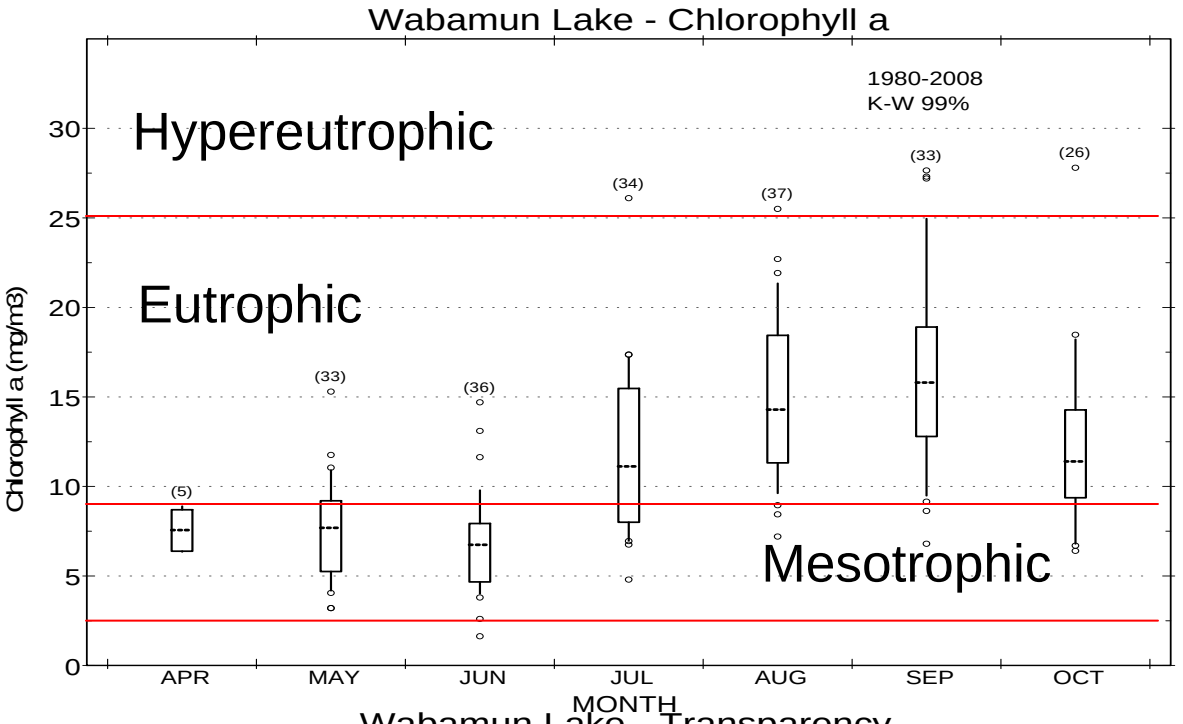


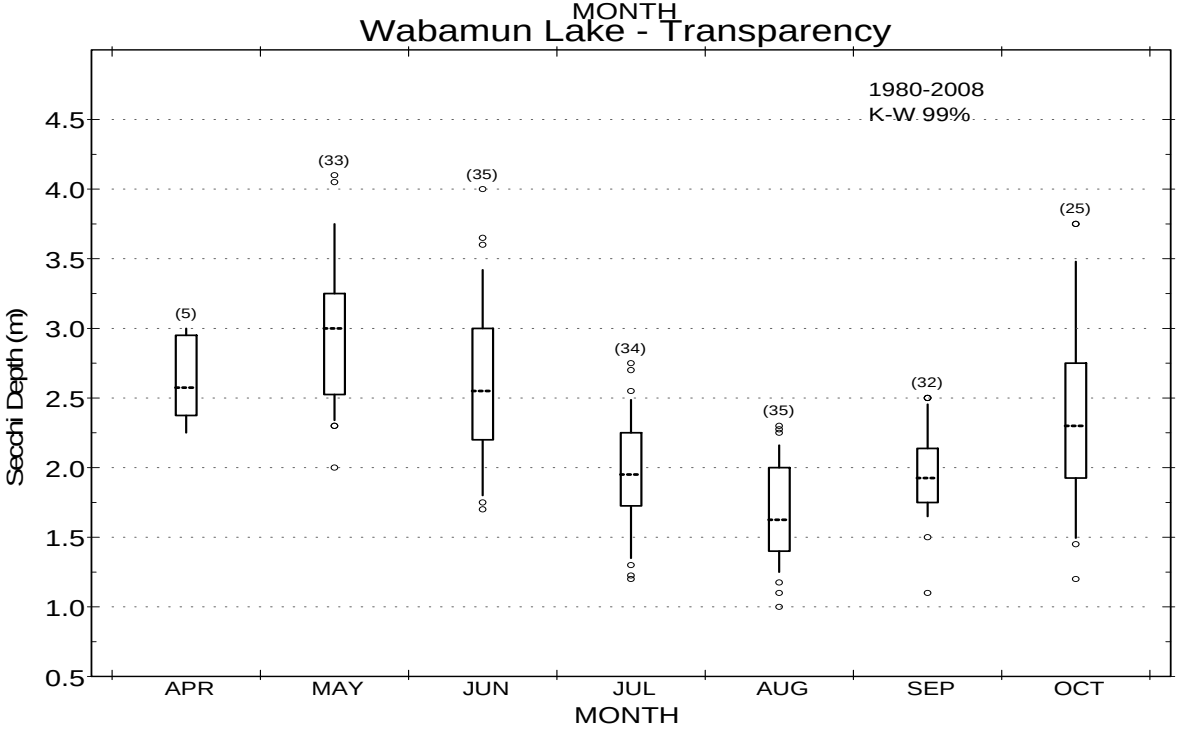


Preliminary data AEW report in prep

Biological communities respond to the availability of nutrients

Wabamun lake becomes more productive and less clear during the late open-water season

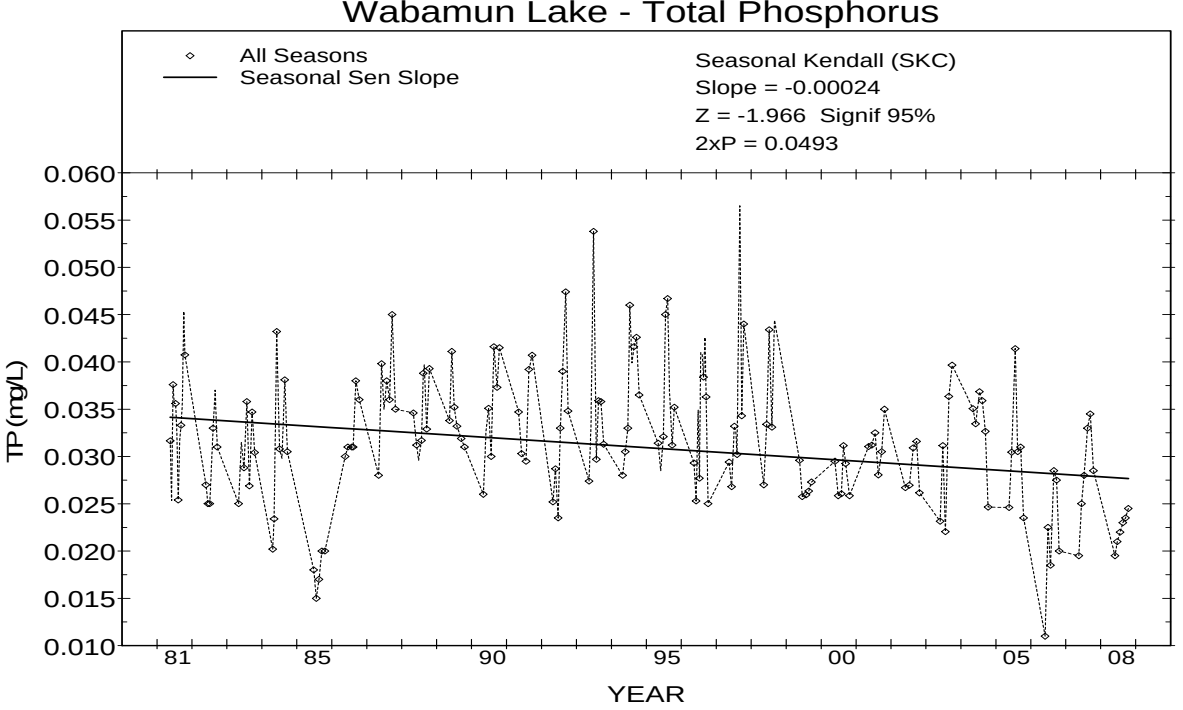


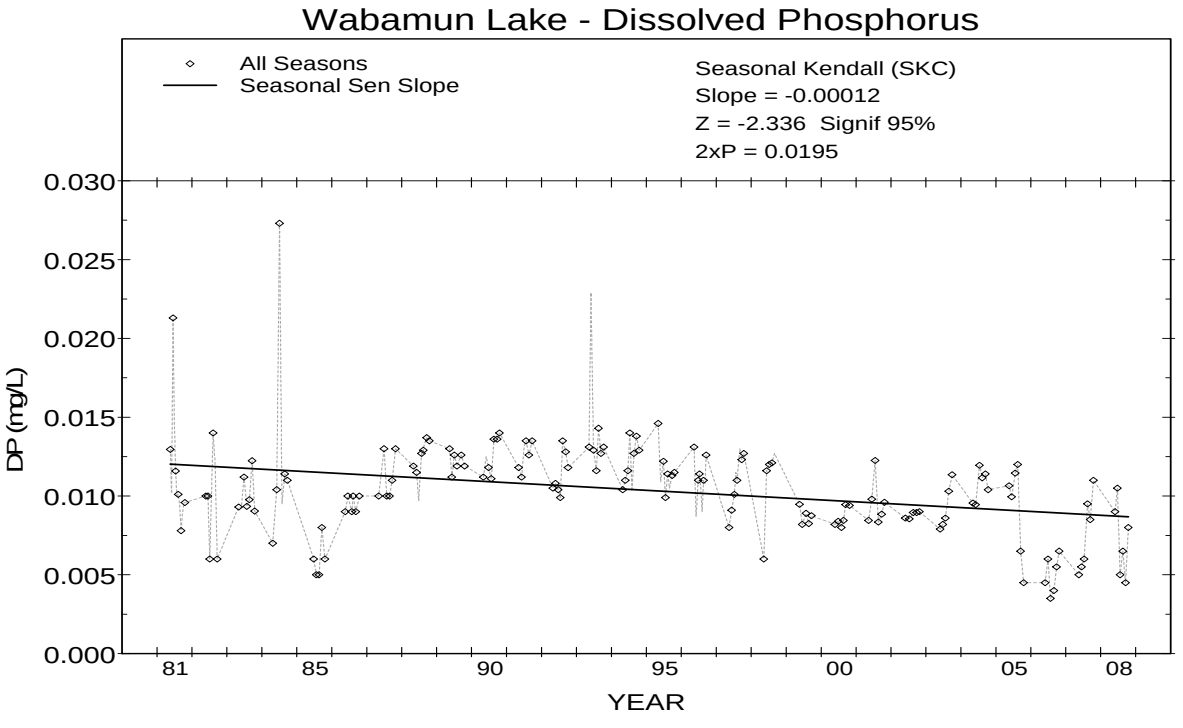


Nutrients that limit plant growth have decreased over the contemporary monitoring record (~30 years)

Water and sediment quality changes due to land-use alteration have already occurred

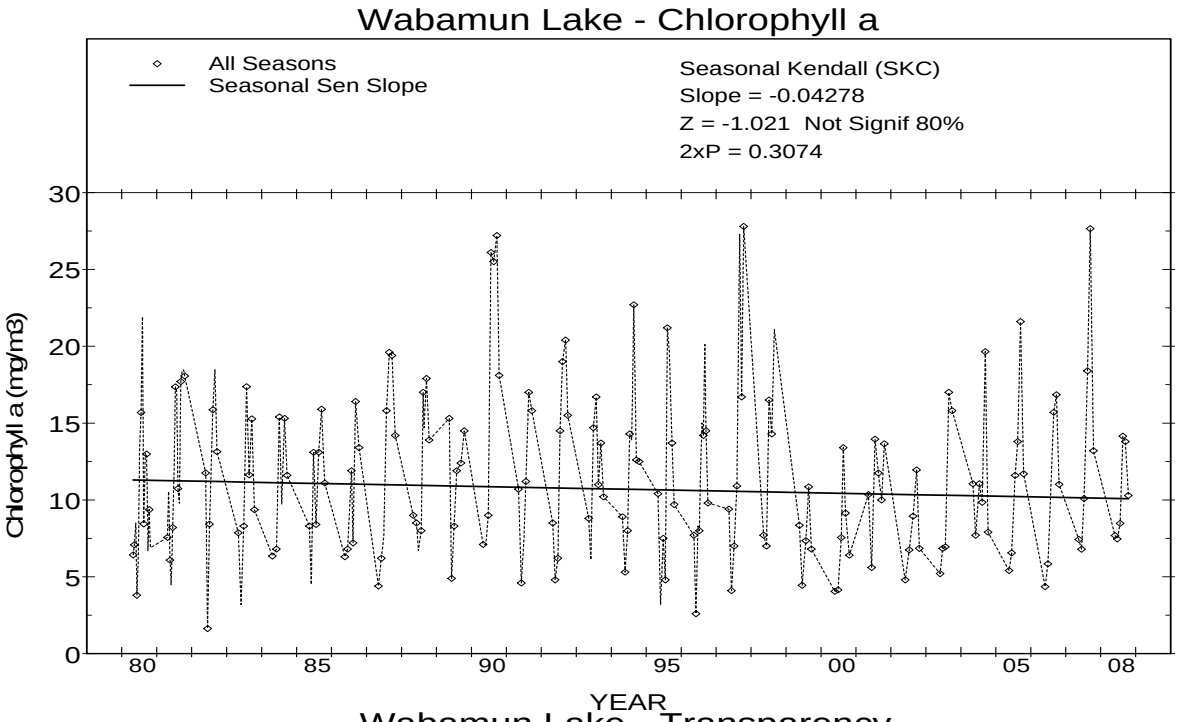
Historical reconstructions of lake water quality can provide new insight

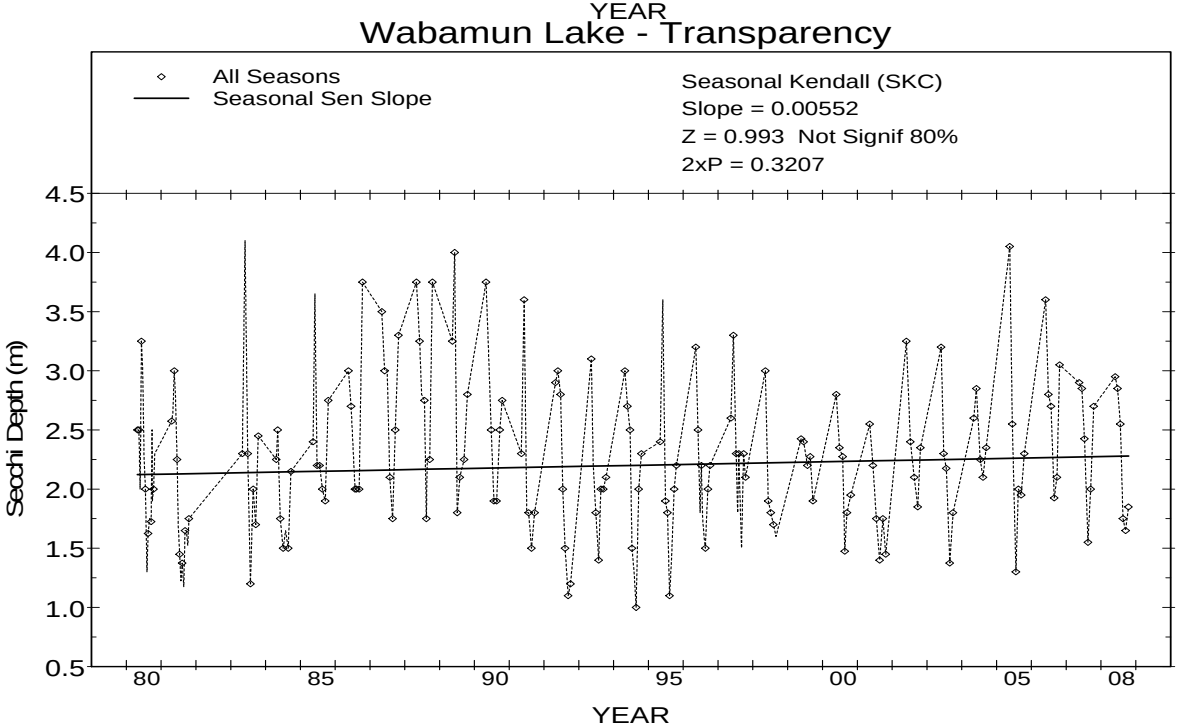




The relationship between algae growth and nutrients is not perfect

Reducing the nutrient loads to lakes from external sources may not contribute to immediate improvements in water quality

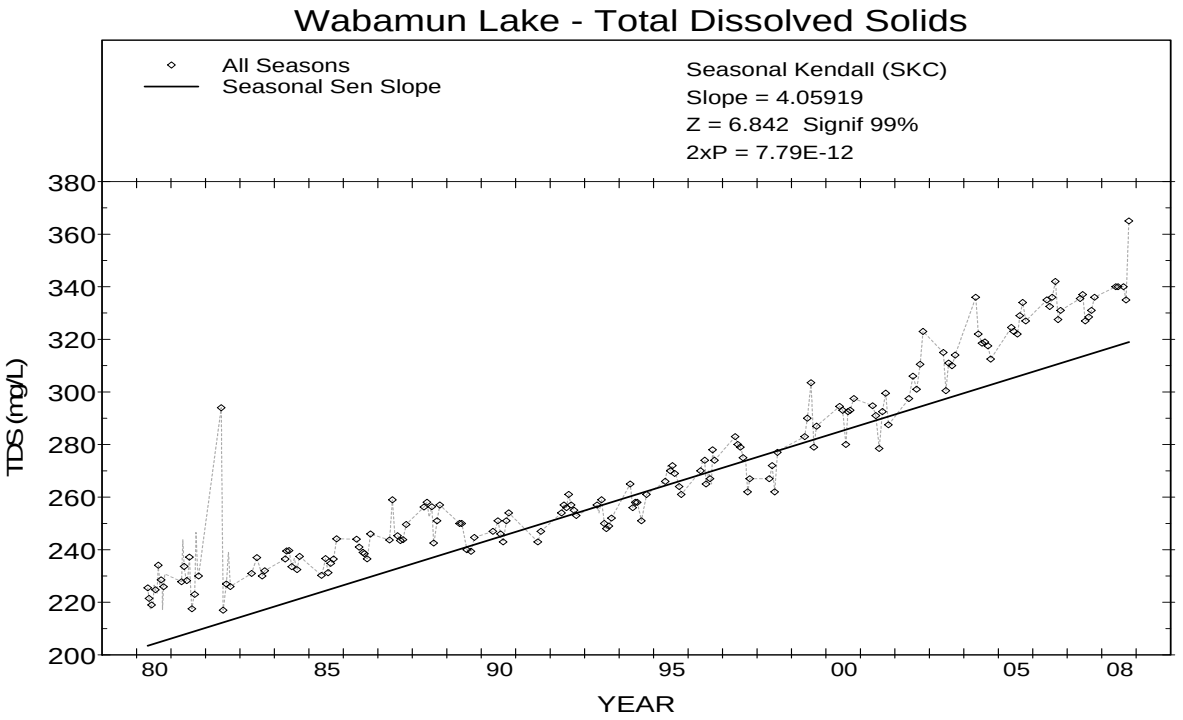


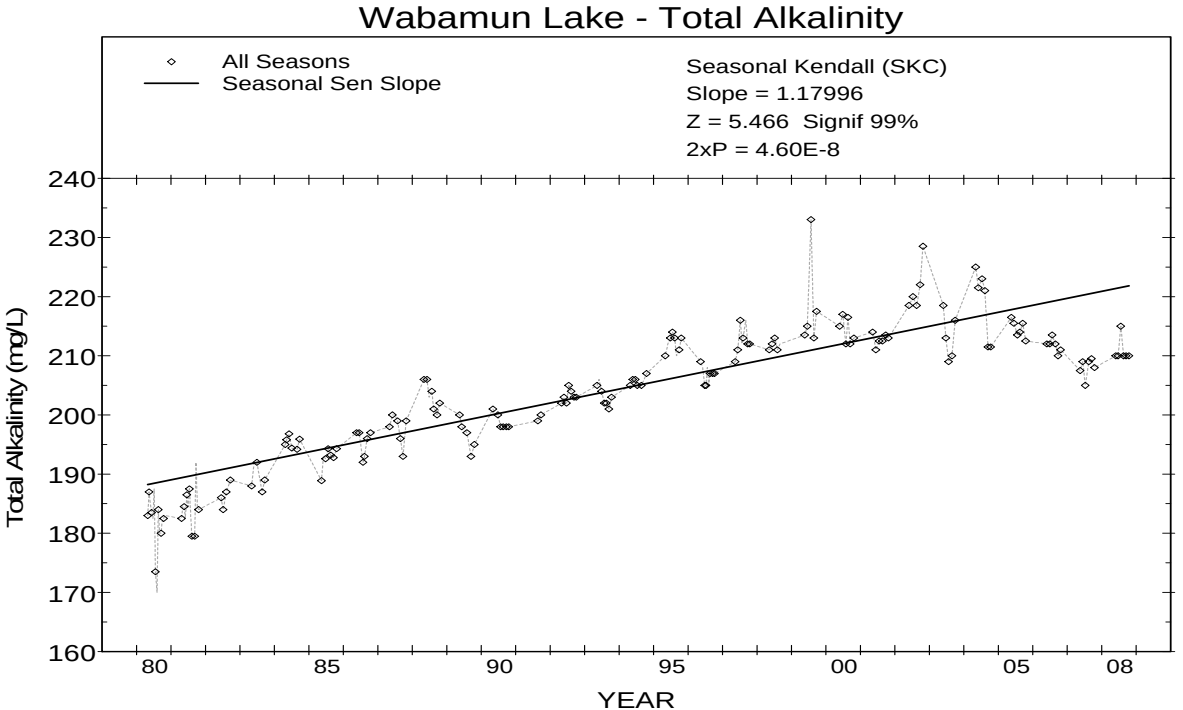


Preliminary data AEW report in prep

The ion load to Wabamun Lake has increased due to the construction of the WTP by TAU and drought

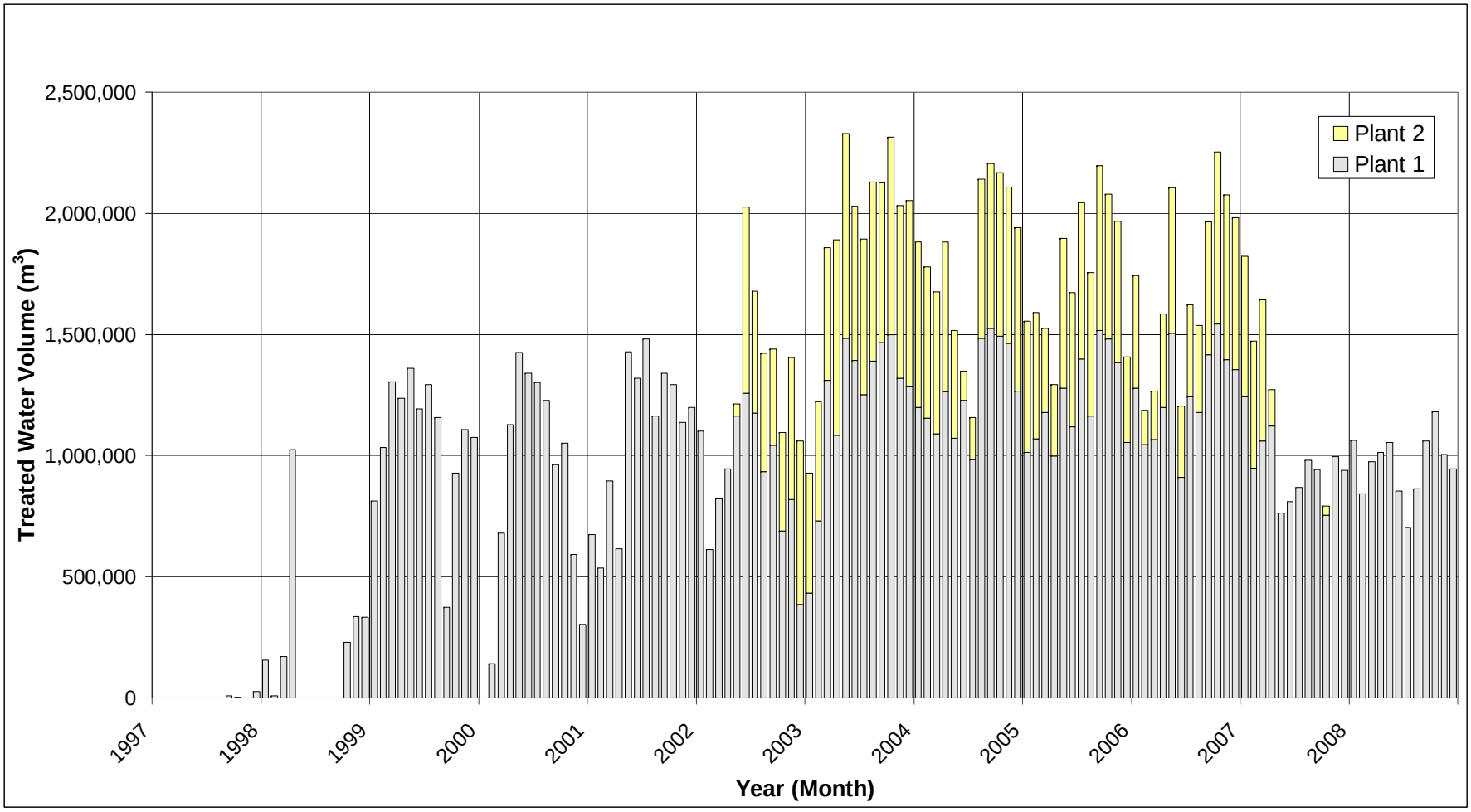
Increasing ion load from the WTP bind and precipitate otherwise bioavailable phosphorous “locking” it in the sediment



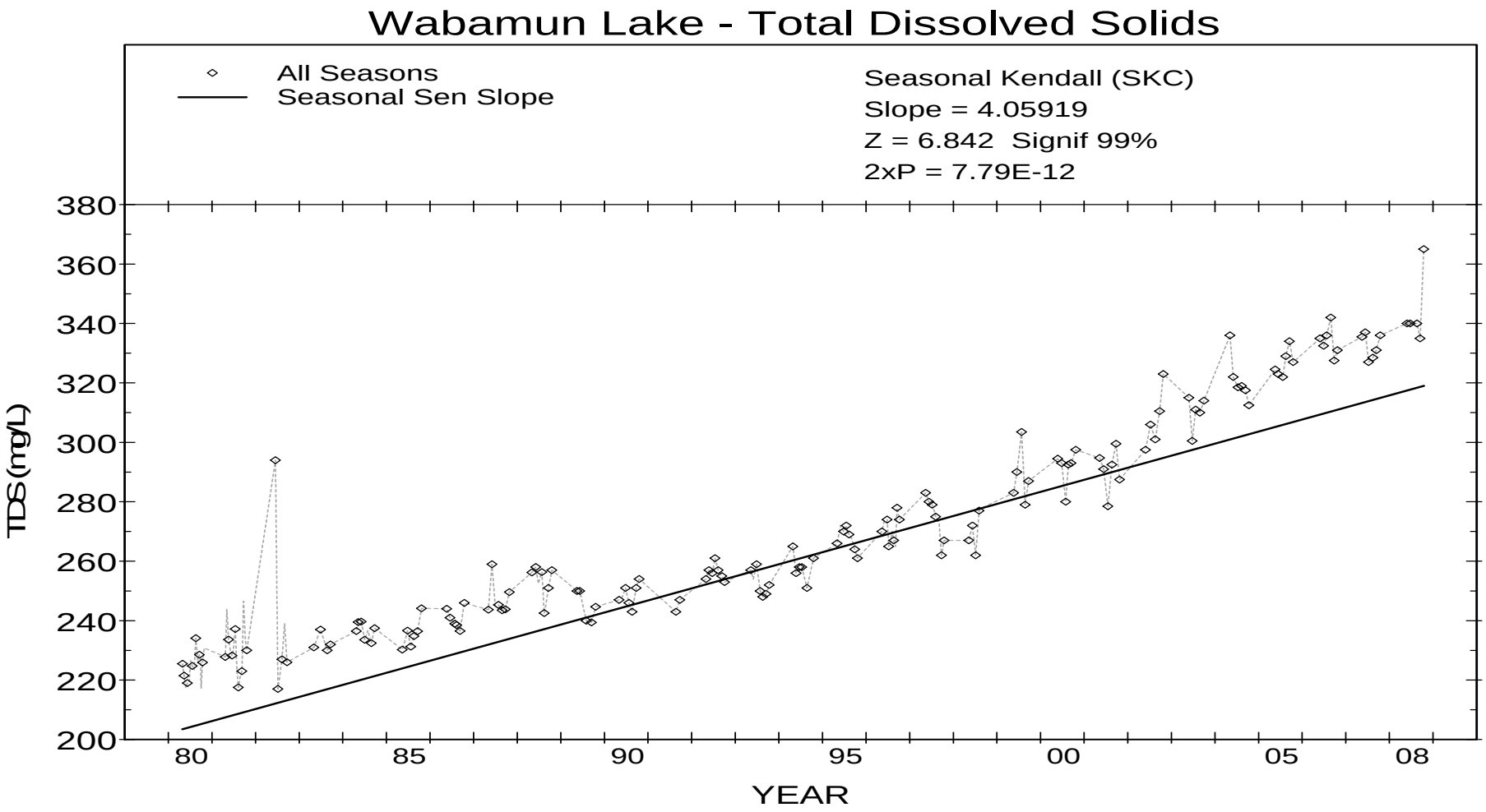


Preliminary data AEW report in prep

TransAlta Water Treatment Plant

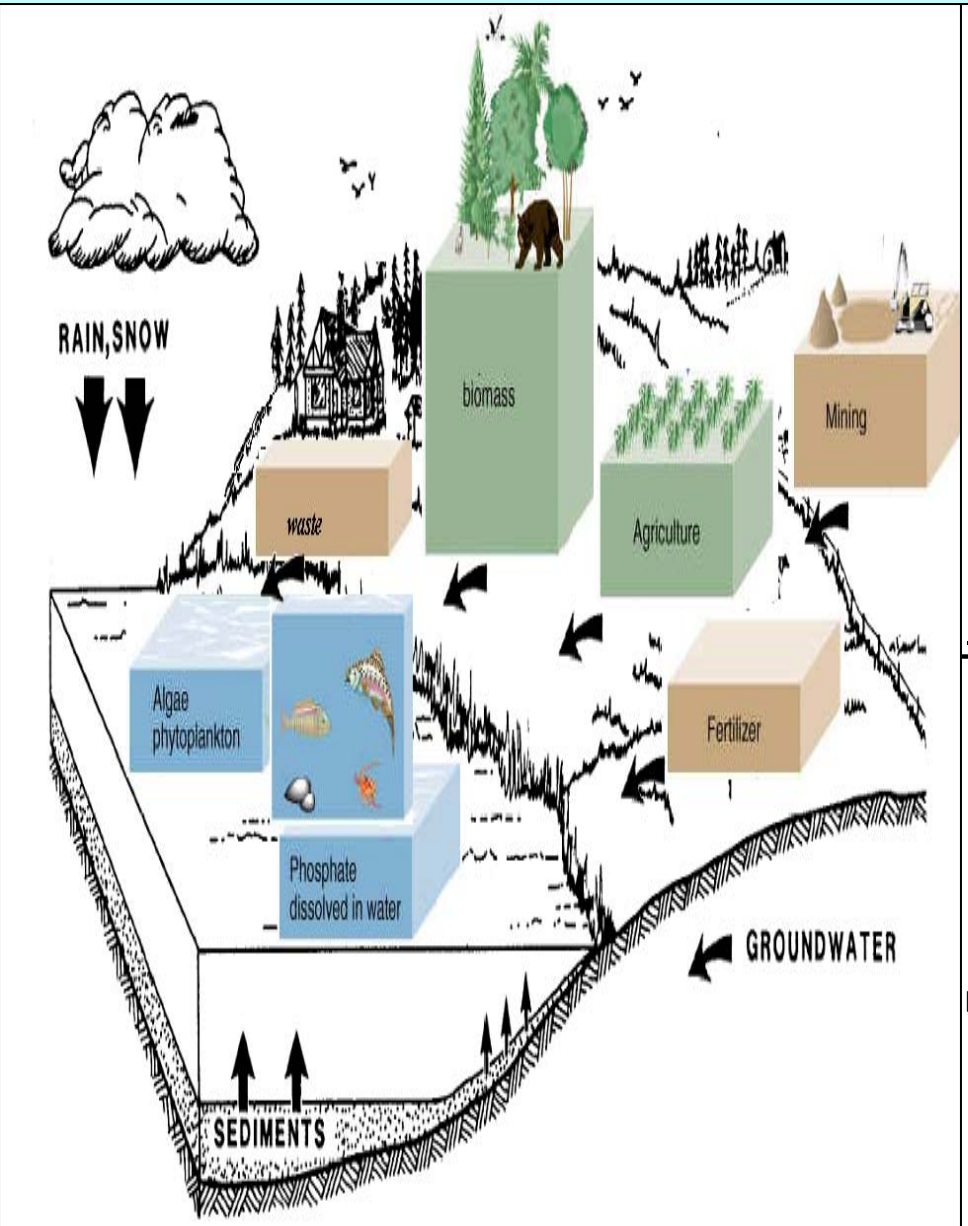


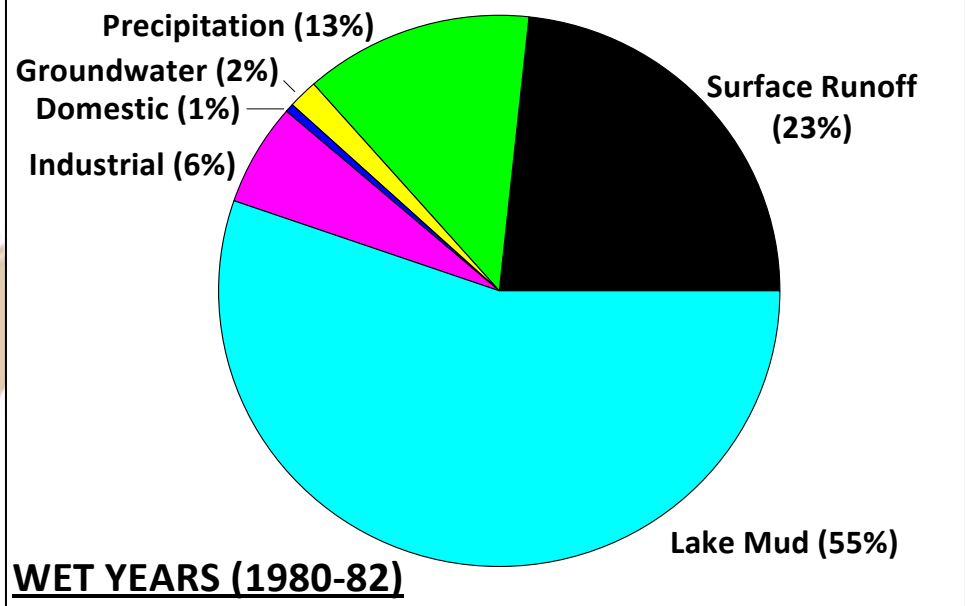
Operation of the TransAlta water plants to repay historical and current diversions from the watershed have contributed to surface water quality changes in Wabamun Lake



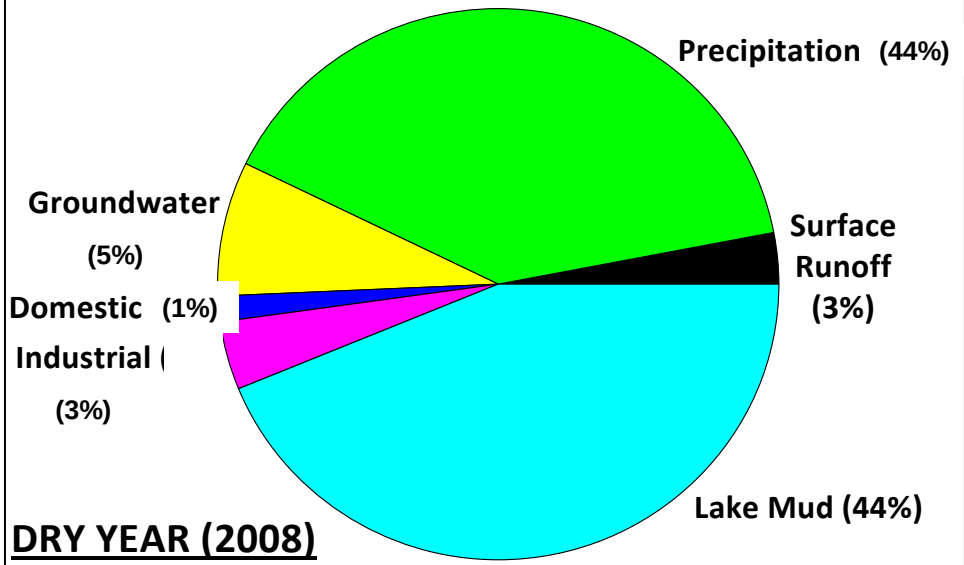
Total Dissolved Solids concentration is increasing due in part to the industrial diversions and lower flushing rate

Phosphorous Budget – Quality/Quantity





WET YEARS (1980-82)



DRY YEAR (2008)

Summary of Observations
Water Quality Trends

- Nutrient levels (phosphorus and nitrogen) have decreased or remain stable from 1982 to 2008
- Increasing dissolved solids is the result of treated water input and lower flushing
- Lake remains moderately productive
- Metals, including mercury, comply consistently with guidelines in water

Observations

Metals

- Metals sampled from 1999 to 2001
- All metals comply with Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME)
- No apparent changes over time

Observations

Plankton

- No overall change in plankton communities (number of species, biomass, numbers of phytoplankton/zooplankton) from the early-1990s to 2001

Sediment Metals

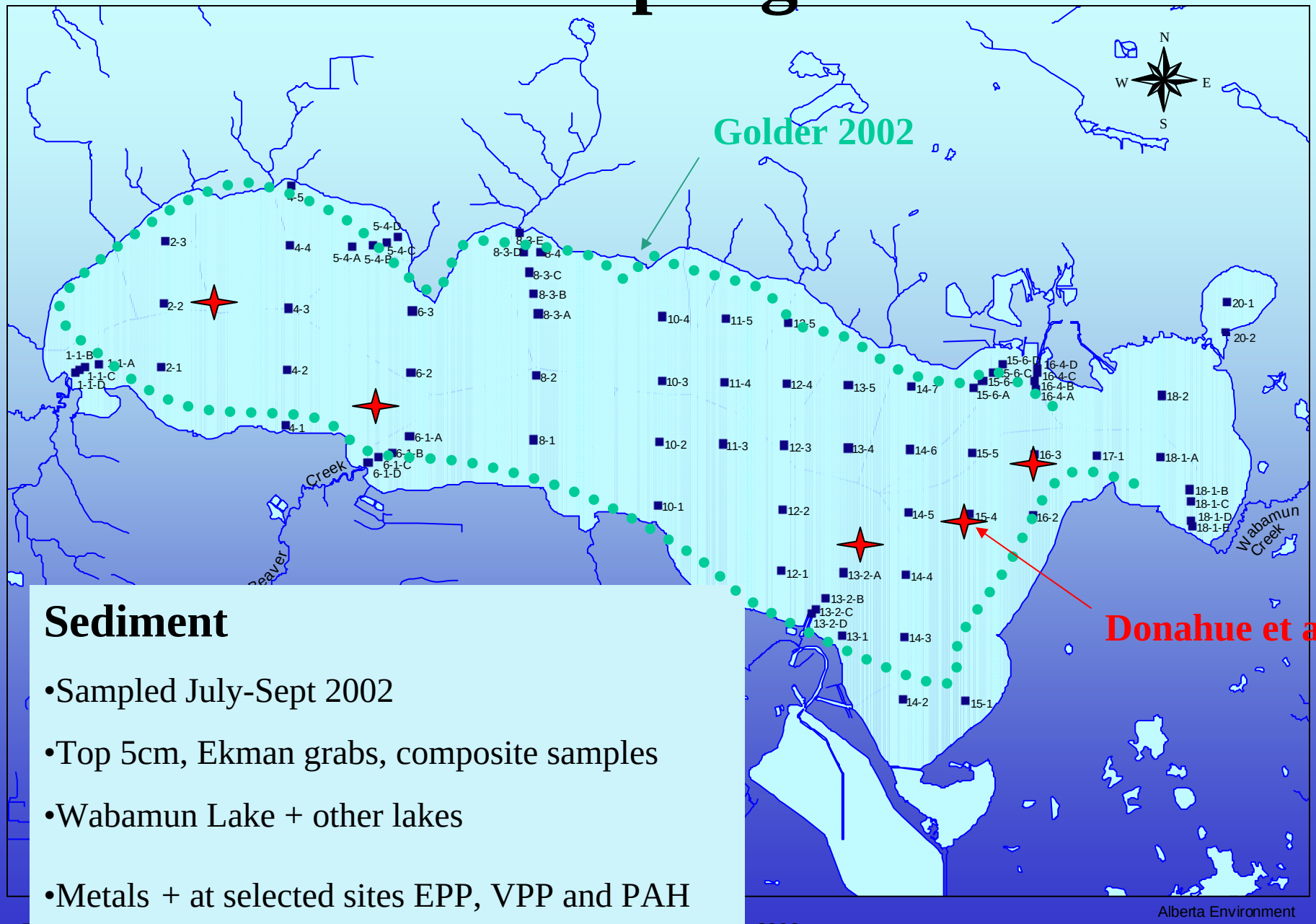
Sources of Metals

- Natural Sources
  - Metals are a natural component of the earth's crust. Wabamun located in an area of the Paskapoo know to have thick coal seams.
- Anthropogenic Sources
  - Disturbance of surficial geology (mining, agriculture, construction) would increase transport rates.
  - Coal mining, diversions from mines, ash lagoon.
  - Burning of fossil fuels, including burning of coal for power generation and vehicle emission.
  - Gravel washing (discontinued).

Sediment Study (2002)
Metals and Trace Organic Compounds

- **Purpose:**
  - Carry out a detailed study of Wabamun Lake sediments
  - Compare results to:
    - Sediment guidelines
    - Sediment quality of other Alberta lakes

Sediment Sampling Sites 2002

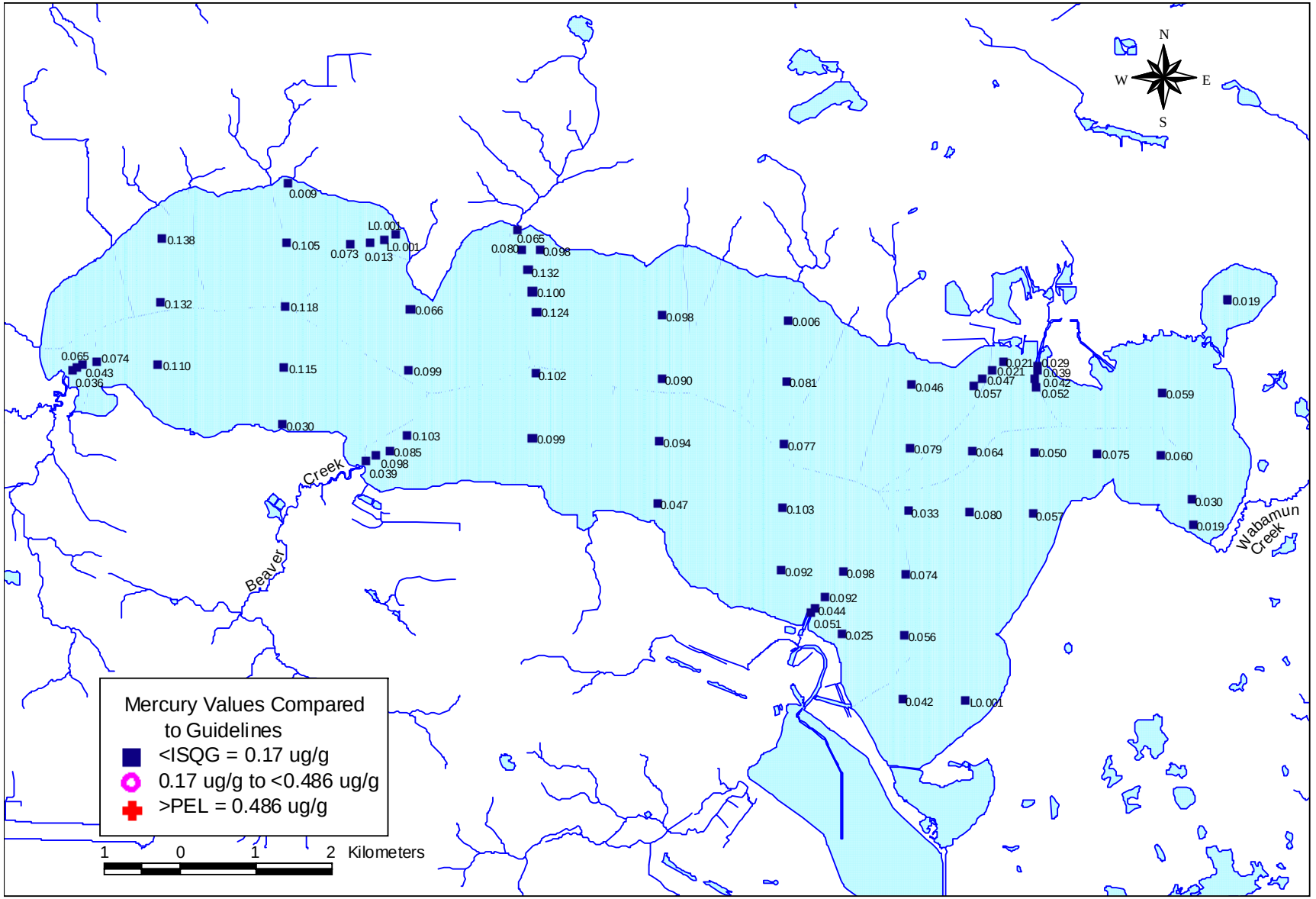


Sediment

- Sampled July-Sept 2002
- Top 5cm, Ekman grabs, composite samples
- Wabamun Lake + other lakes
- Metals + at selected sites EPP, VPP and PAH

Figure 1 Sediment sites sampled during the Wabamun Lake survey, summer, 2002

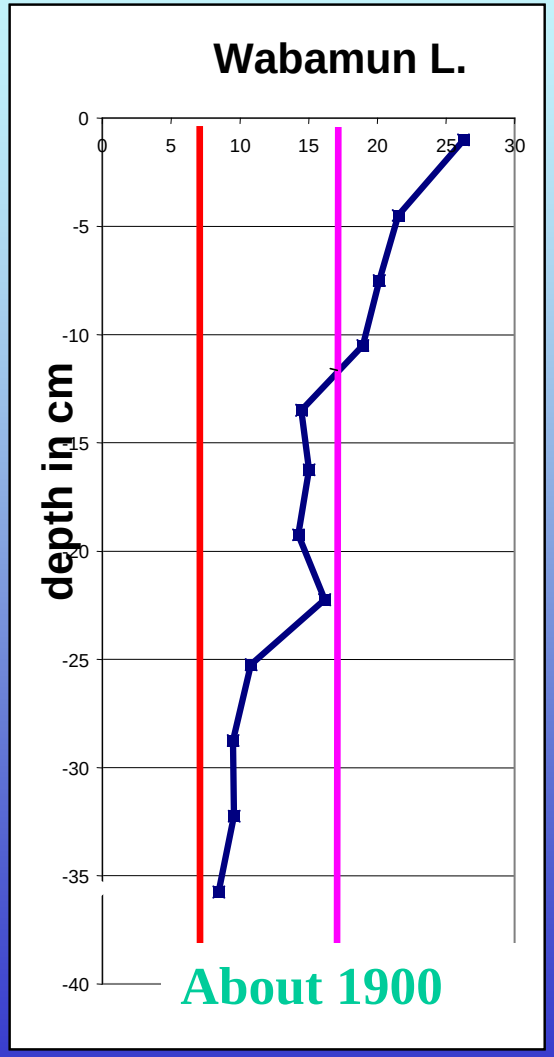
Mercury in Sediments

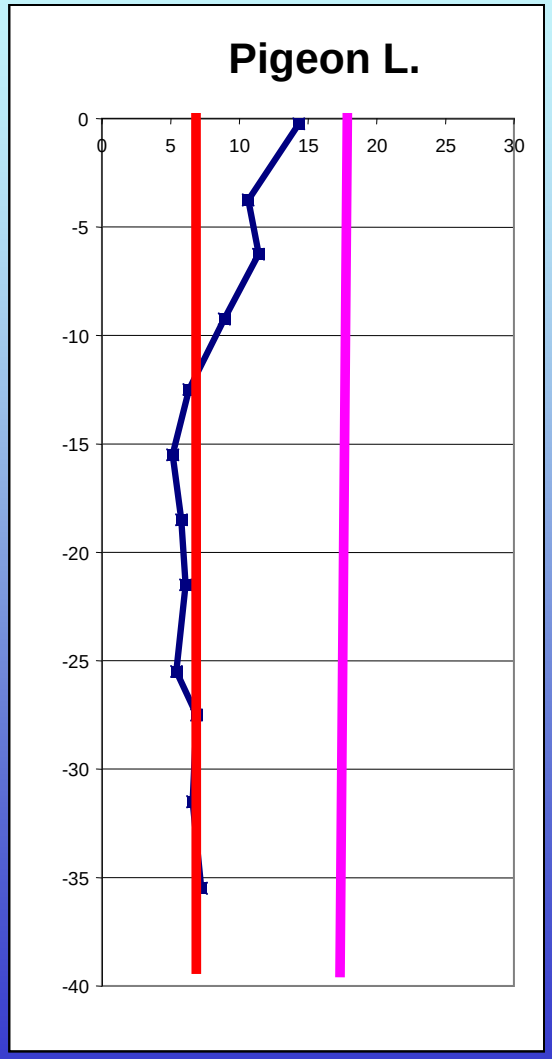


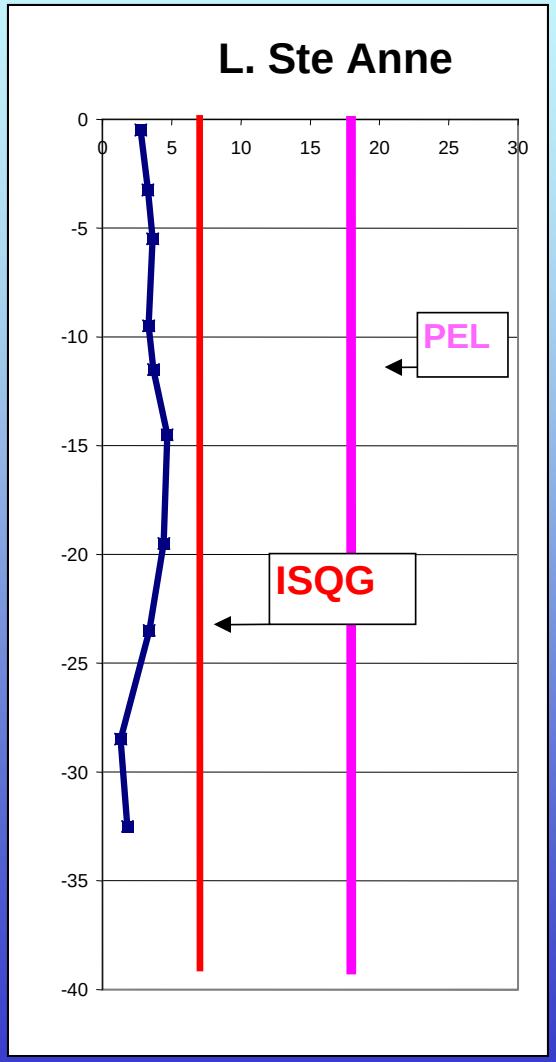
Alberta Environment

Figure 11 Concentration of total mercury in Wabamun Lake sediment samples, summer, 2002

Background + Human Effects
Arsenic in ug/g







From Donahue(2002)

Summary of Observations

Metals in Sediments

- Several metals exceed sediment guidelines in Wabamun and other lakes (arsenic, cadmium, chromium, copper, zinc)
- Several metals in Wabamun Lake occur at higher concentrations than in other lakes (mercury, cadmium, copper, zinc, antimony)
- Mercury within guidelines in all samples
- Some metals are comparable among all lakes (nickel, bismuth, silver, lithium, cobalt, strontium, thallium)

Sediment Organics

Sources of Polycyclic Aromatic Hydrocarbons

- Coal mining, coal burning
- Fossil fuel burning (boats, weed harvesters, highway traffic, railway traffic)
- Creosote treated wood structures (piers, pilings, CN railway, railroad ties)
- Coal seams in and near the lake
- Forest fires
- Relative importance of these sources is not presently known

Sediment Study (2002)
Trace Organics

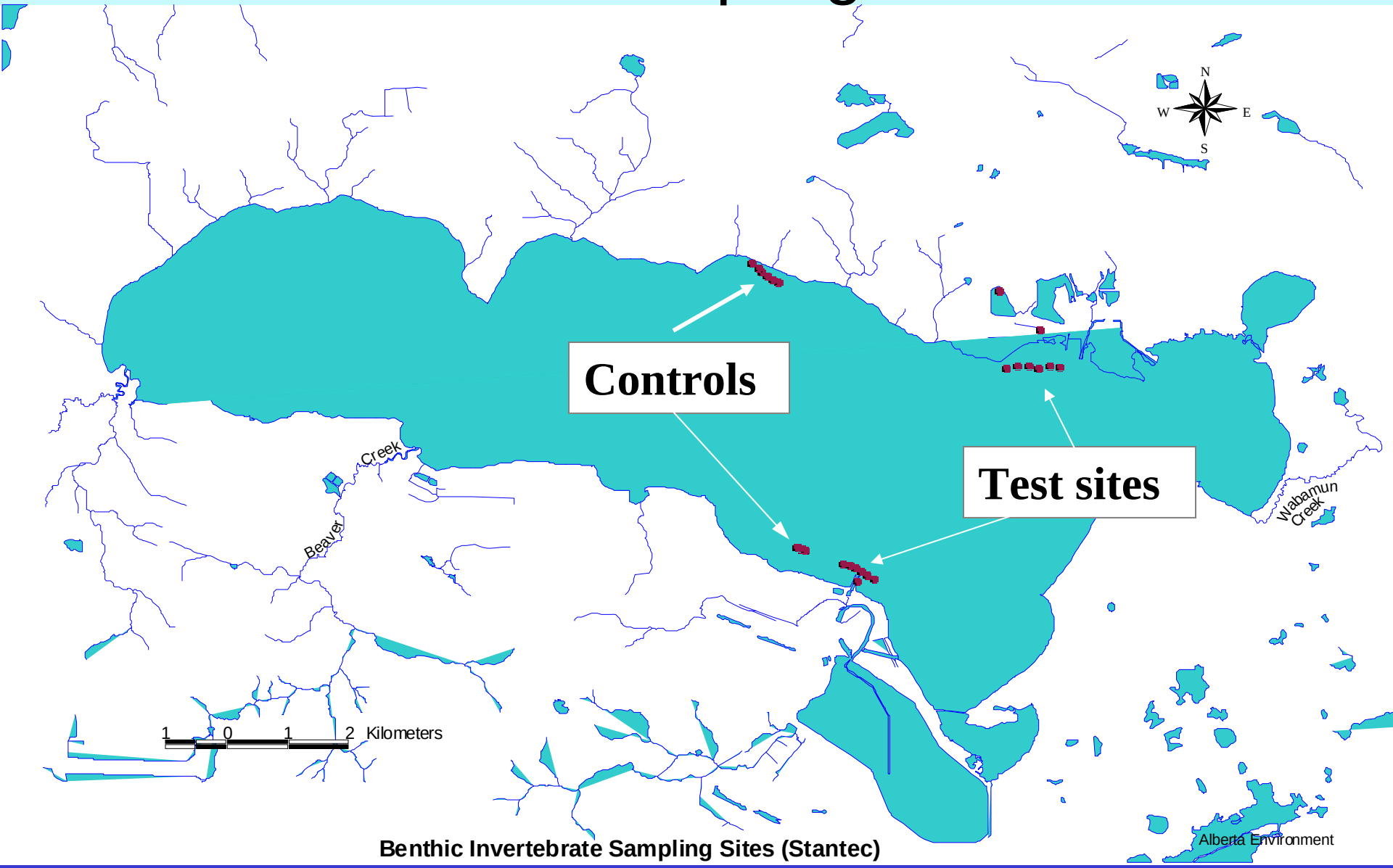
- Many different types of trace organics analyzed
- Polycyclic aromatic hydrocarbons (PAH) the main type detected in the sediments
- PAH are organic compounds with both natural and human origins

Summary of Observations
Polycyclic Aromatic Hydrocarbons

- Metals and polycyclic aromatic hydrocarbons (PAH) were detected in sediments from all study lakes
- Some concentrations in Wabamun Lake were higher and above guidelines
- Both natural and human sources are contributing to sediment loading
- Influence on aquatic life is being investigated

Invertebrate Sampling

Invertebrate Sampling Sites -2002



Summary of Observations
Benthic Invertebrates

- Wabamun Lake has an abundant and diverse benthic invertebrate community
- 128 different invertebrates were recorded
  - **Insects**: mayflies, caddis flies, midge, beetles, boatmen, moths & flies, dragon & damsel flies
  - **Crustaceans**: water fleas, copepods, seed shrimp, scuds
  - **Worms**: leaches, round worms, aquatic earthworms, flat worms
  - **Molluscs**: snails, clams
  - Others: hydras, water bears

Summary of Observation
Benthic Invertebrates

- Benthic invertebrate communities at test sites similar to background sites
- Some differences
  - Mild nutrient enrichment near ash lagoon (now decommissioned)
  - Possible responses to habitat differences near the Water Treatment Plant
- No indication of toxicity in the lake

Presentation Outline

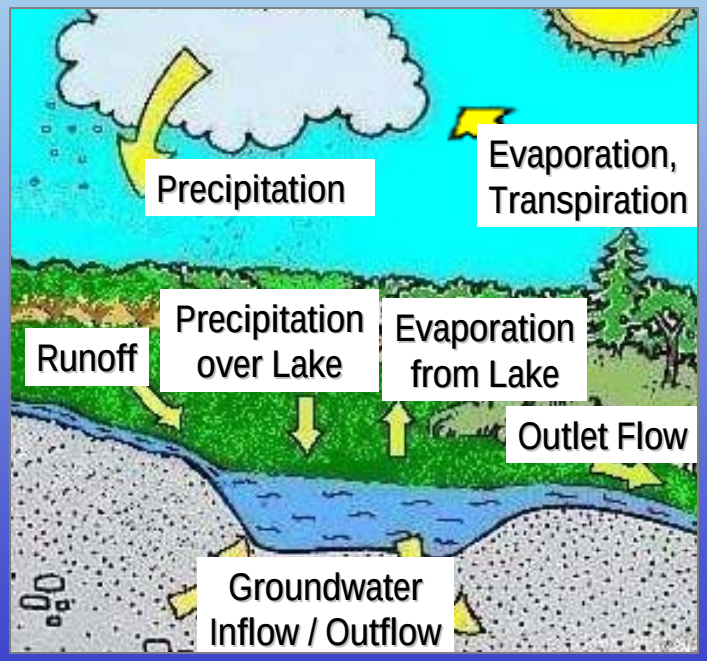
1) Background and Introduction
2) Aquatic monitoring
   - Water quality/quantity
   - Metals and organics
   - Sediment Toxicity
   -Invertebrate Sampling
3) Fisheries

Water Balance

Water Balance Fundamentals

- Water Balance Equation:

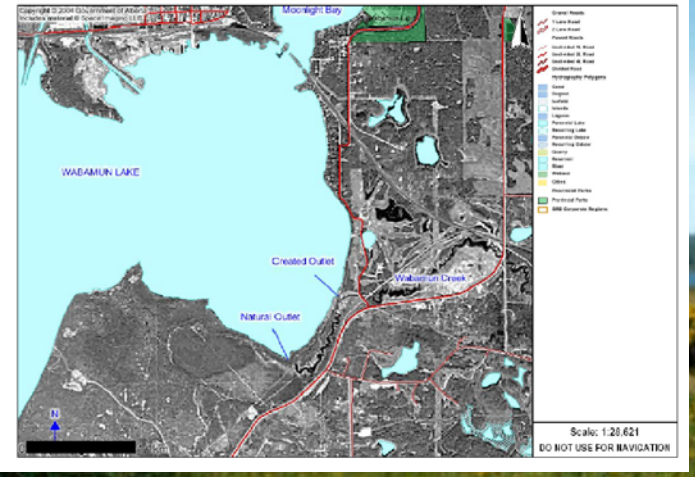
  Inflow +/- Change in Storage = Outflow



- Inflow: Direct Precipitation (rain, snow), Surface Runoff, Groundwater
- Outflow: Evaporation, Outlet Discharge, Groundwater
- Change In Storage: Lake Volume (as observed by lake levels)

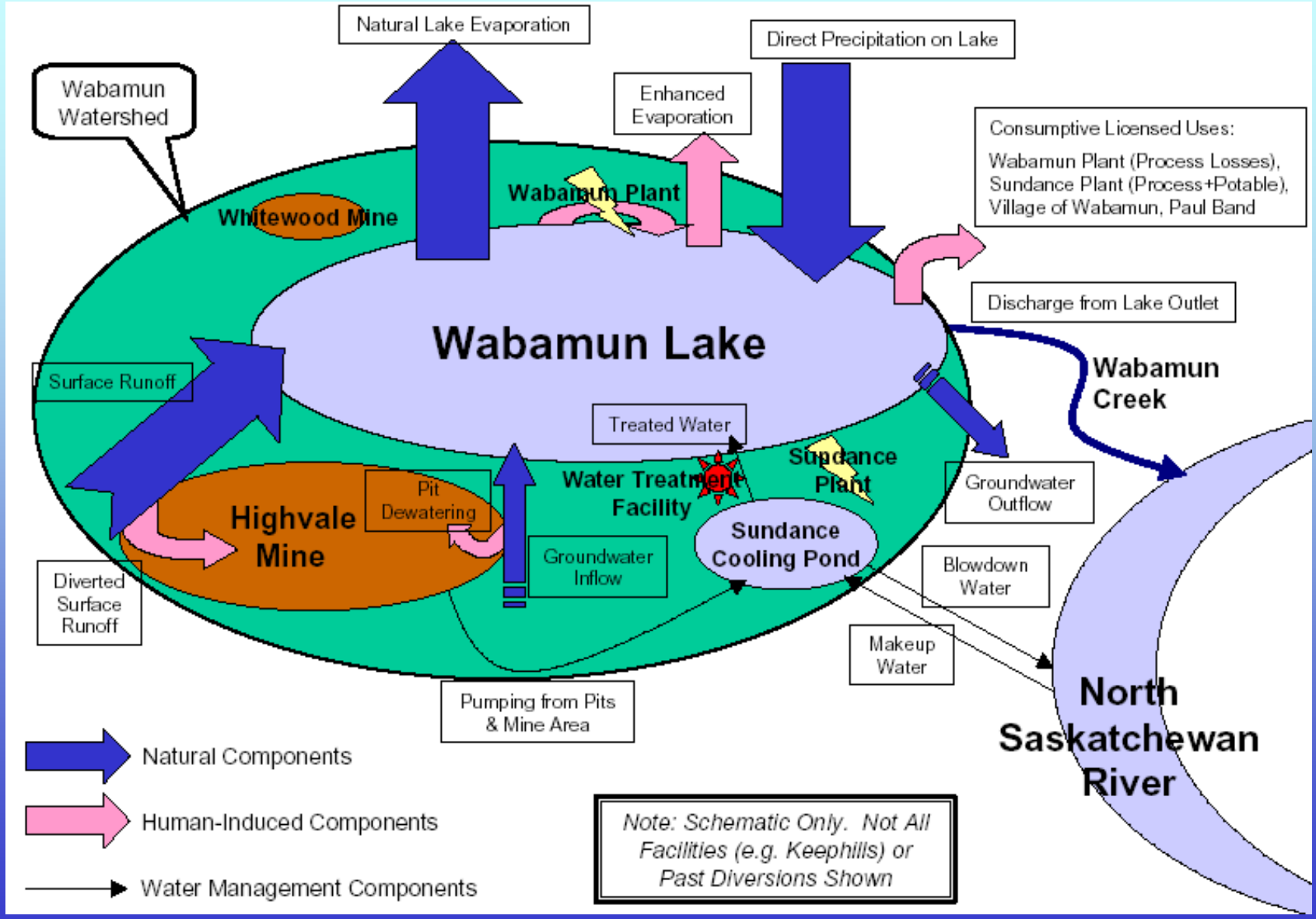
Outlet discharge

- Current structure at outlet consists of a broad crested concrete-capped weir (est.1998); previously earth-fill road at ~same elevation
- Outlet elevation set at 724.55 m
- Model calculates discharge based on a weir equation
- No actual spill to Wabamun Creek since 2008

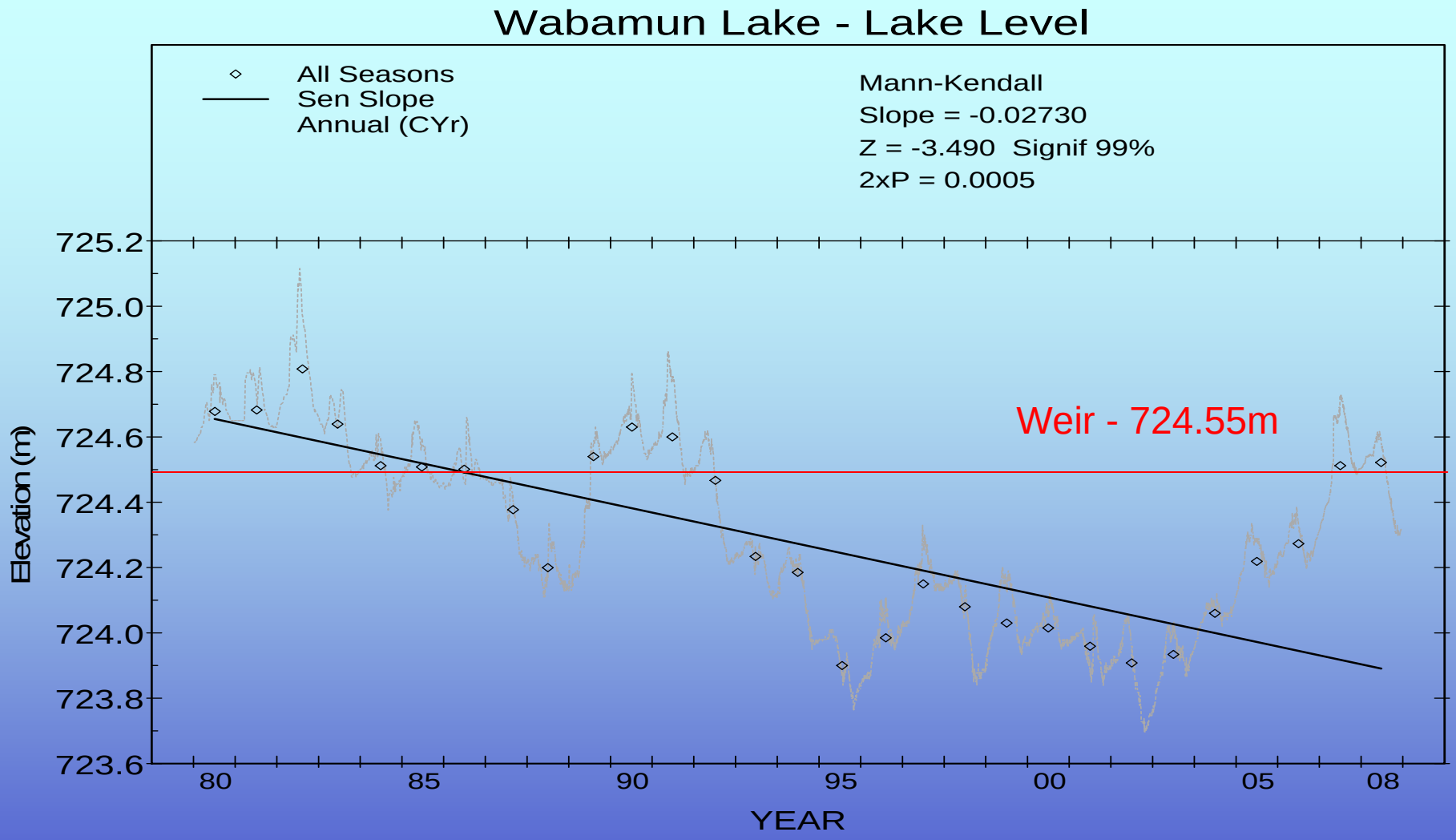


Current Weir Elevation - 724.55m ASL

Water Balance

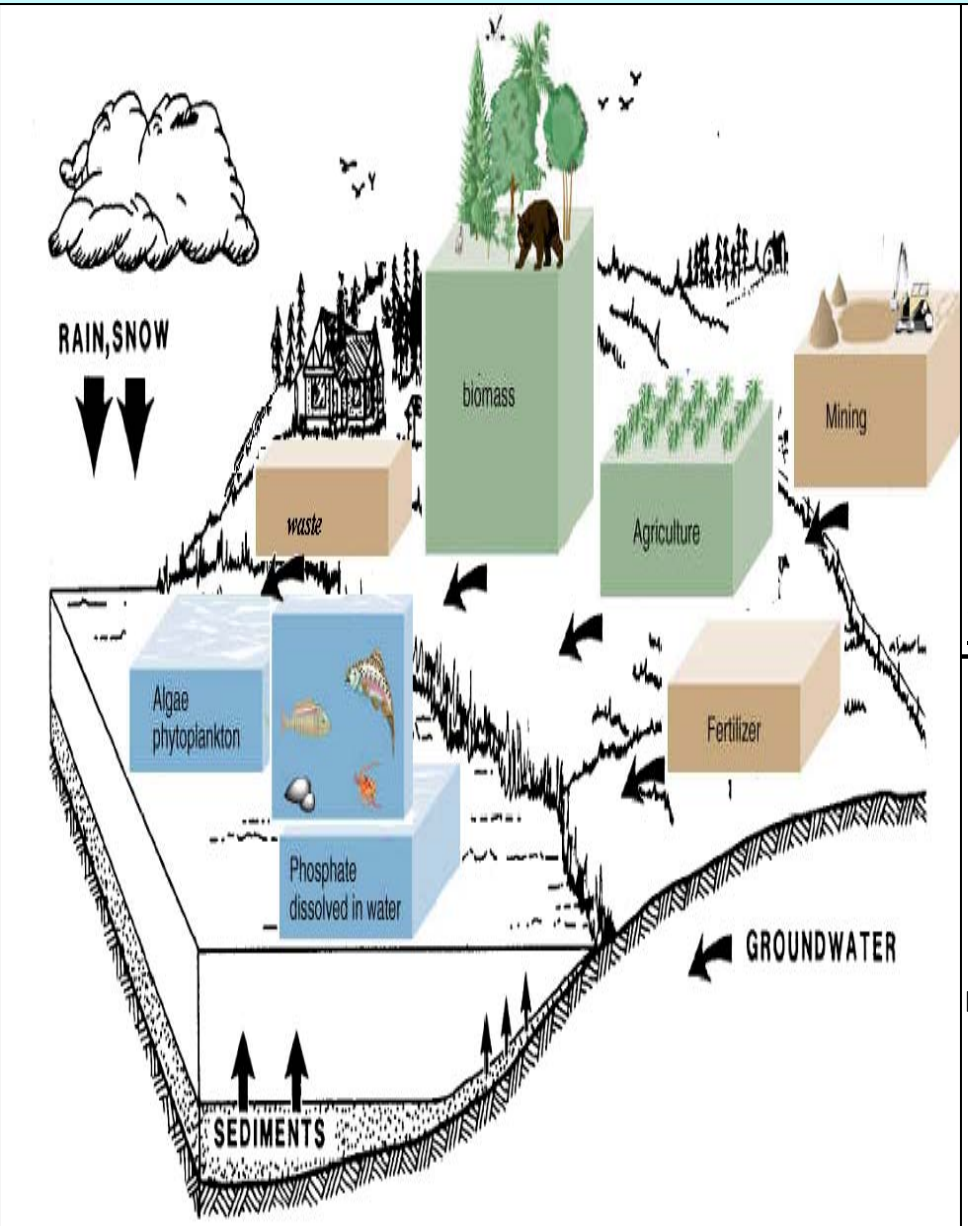


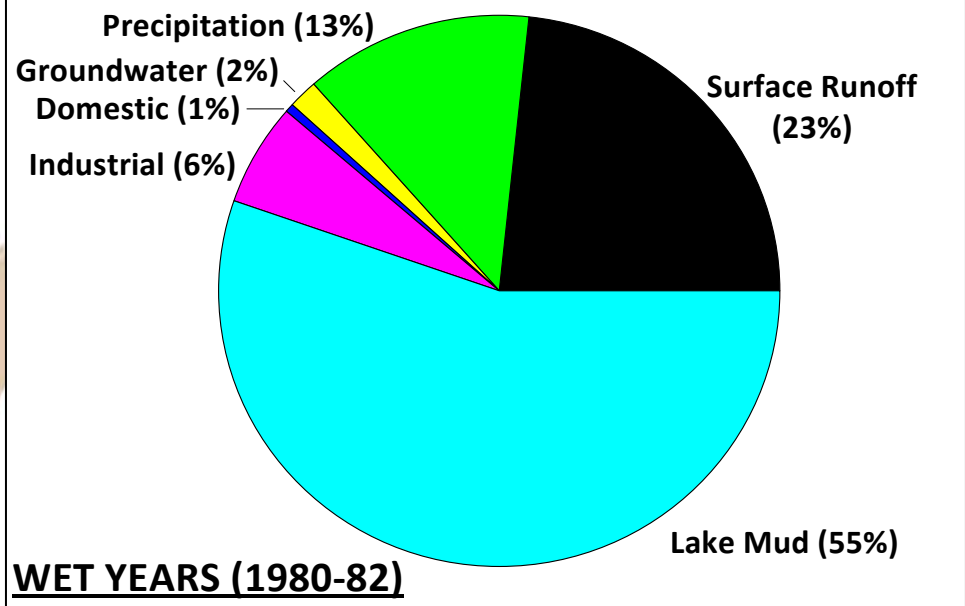
Wabamun Lake Water Balance 1982-2001 AENV 2002



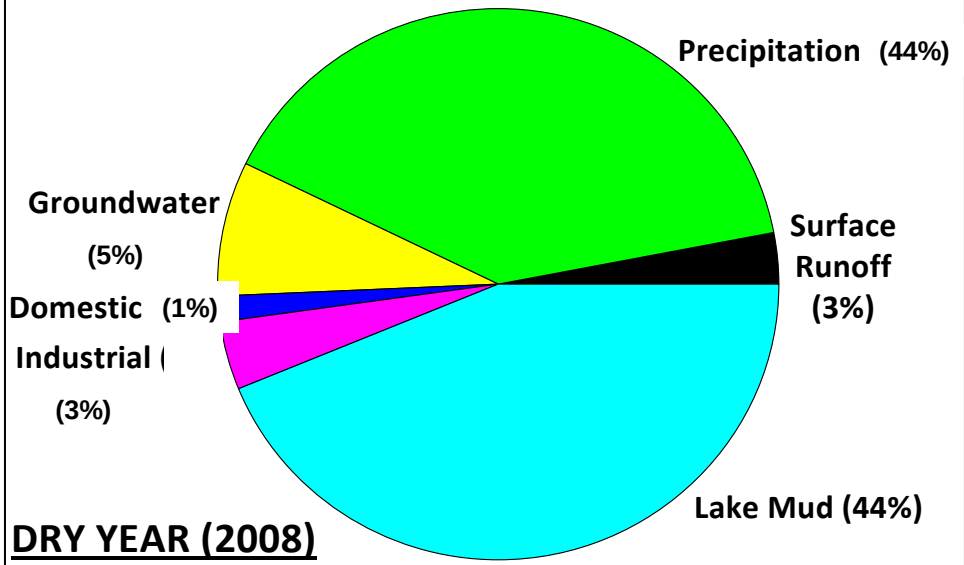
Lake elevation decreased from the 1980's to early 2000s; however, recovery has been evident since 2003.

Phosphorous Budget – Quality/Quantity





WET YEARS (1980-82)



DRY YEAR (2008)

Fisheries

Wabamun Fisheries

Lake Whitefish
Problem: Recruitment failures
Cause: Unknown, possibly low water
Action: Commercial fishery closed (2003 – present) to protect remaining adults, reduce industry effect

Northern Pike
Problem: Lack of older fish
Cause: Heavy mortality
Action: Reduce harvest (sport and commercial) and industry mortality

Walleye
Problem: Extirpated, stocking failed
Cause: Little suitable habitat
Action: restart stocking program (2011 and 2012)

Yellow Perch
Problem: Lack of older fish
Cause: Heavy natural mortality
Action: No action

Wabamun Fisheries

Fish Community
Problem: Natural lake diversity threatened by exotics from NSR
Cause: Water transfer
Action: Treatment plant

Overview of Wabamun Fisheries

Fish Contaminates /Kills
Problem: Hg, industrial activities, oil spill and harvest
Cause: Water transfer, industry
Action: TAU / SRD monitoring

What is causing heavy mortality?

Questions?