Surface Water Quality Monitoring: Program Design for Data Analysis

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Water Quality Assessment Operation

- **Survey**

- **Monitoring**

- **Surveillance**

WQ Assessment Operation

- ## Survey

  A finite duration, intensive program

  to measure, evaluate and report the quality of the aquatic environment

  for a specific purpose

- ## Monitoring

  Long-term standardized system

  of measurements, observations, evaluations and reporting of the aquatic environment
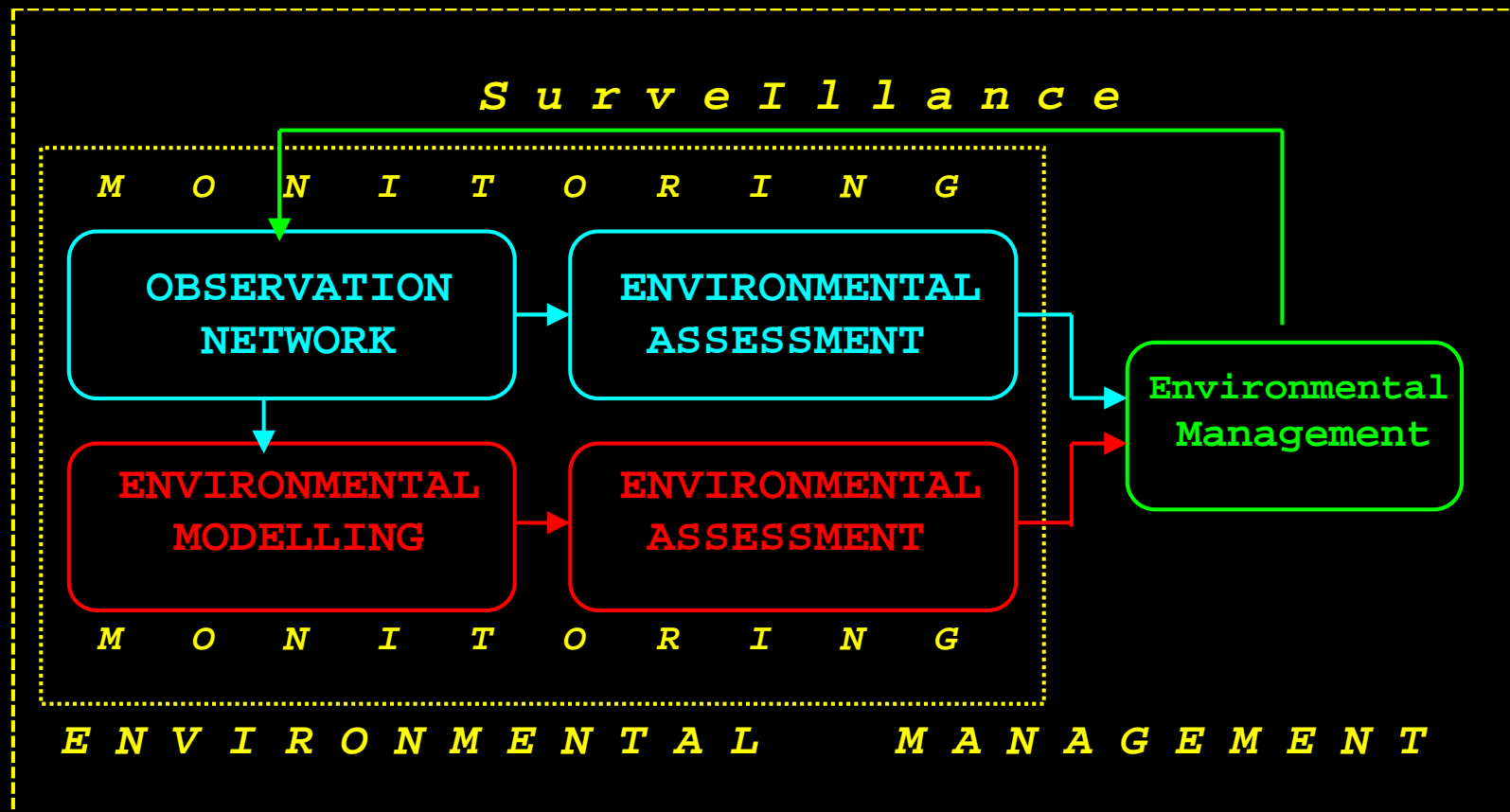
  to define status and trends

- ## Surveillance

  Continuous, specific system

  of measurements, observations and reporting

  for water quality management and operational activities

# Monitoring Operation and Surveillance

WQ Assessments Programs

- Simple monitoring
  - limited number of samples
  - simple analysis of observations
- Intermediate-level monitoring
  - specific lab facilities
  - computer processing and interpretation
- Advanced level monitoring
  - sophisticated techniques
  - highly trained personal
  - advanced data analysis and interpretation

Inadequate Assessments Programs

- The objectives of the assessment were not properly defined

- The program was developed with insufficient knowledge of the water body

- There was inadequate planning of sampling frequency and analysis

- Database were poorly developed

- Data were improperly interpreted and reported

Impact from Inadequate Sampling Frequency
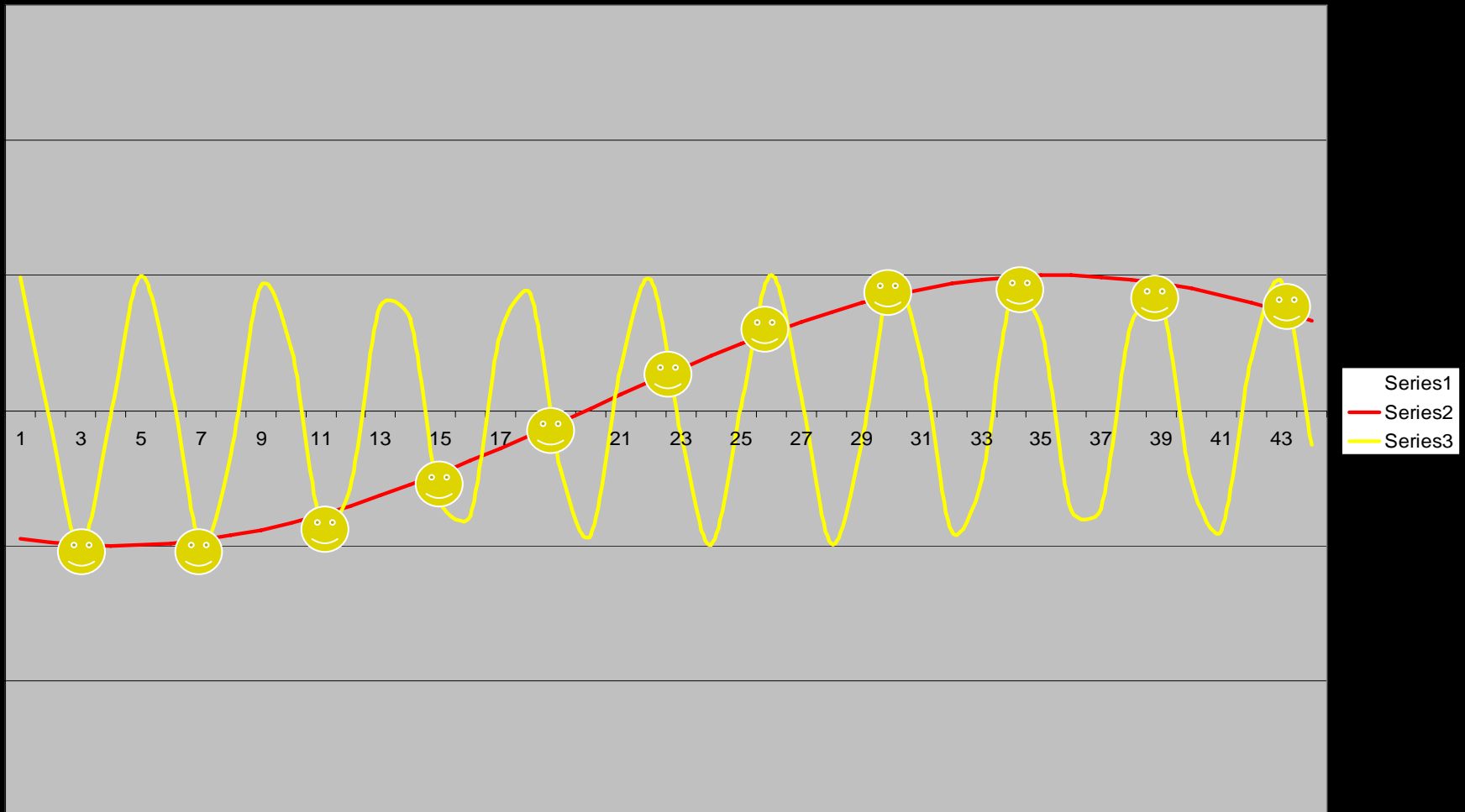
Observation Network

- Source of uncertainties and data misinterpretation
- Multidimensional nature:
  - Concentration / value = f (x, y, z, t)
  - Representative Parameters
  - Parameters to support analysis
- Network parameters:
  - Temporal – Frequency
  - Spatial – Discreteness
  - List of parameters

Spatial Discreteness
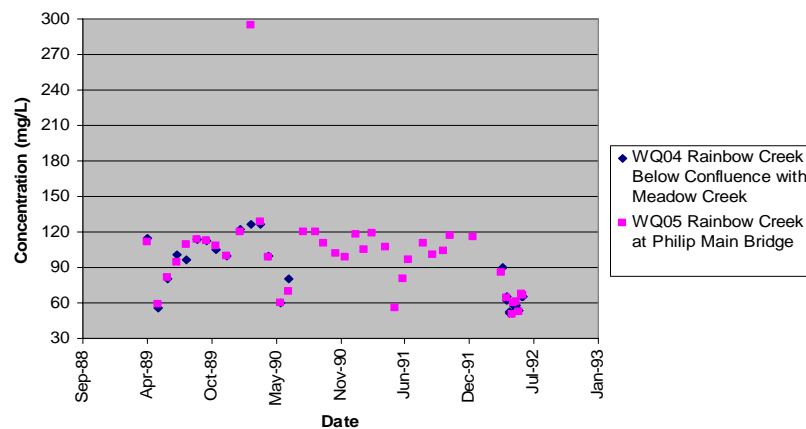
Rivers

- Upstream vs. Midstream and Downstream
- Fall vs. Spring
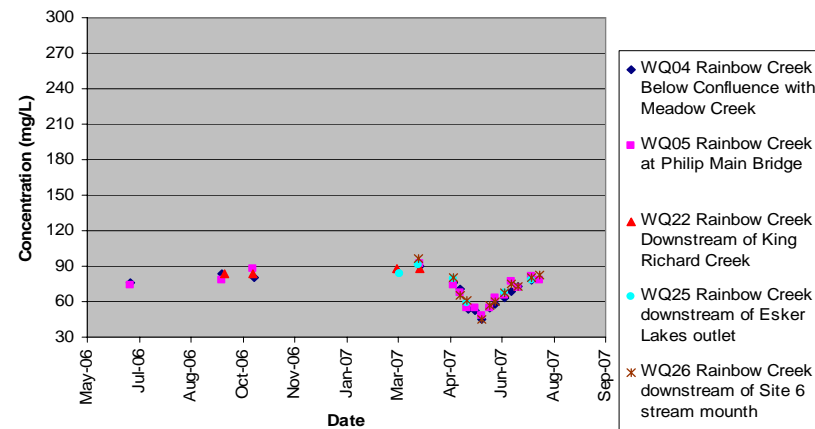 - Surface-groundwater interactions

Lakes

- Hydrodynamics / mixing
- Effects of seasonality
  - Composite samples vs. lake homogeneity
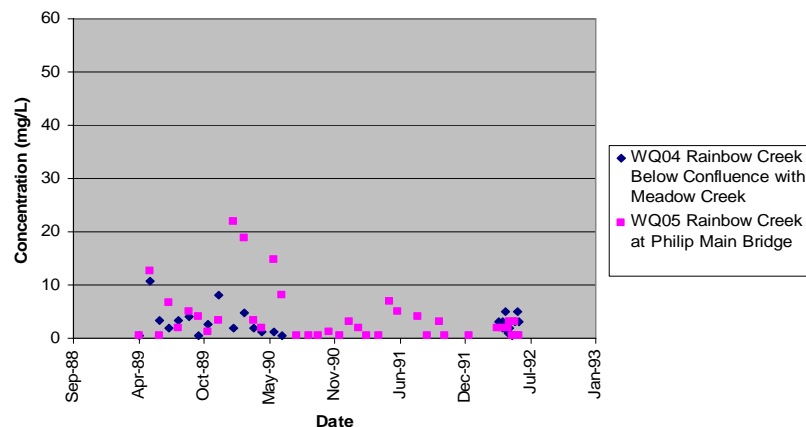
Water Quality Time Series Comparison

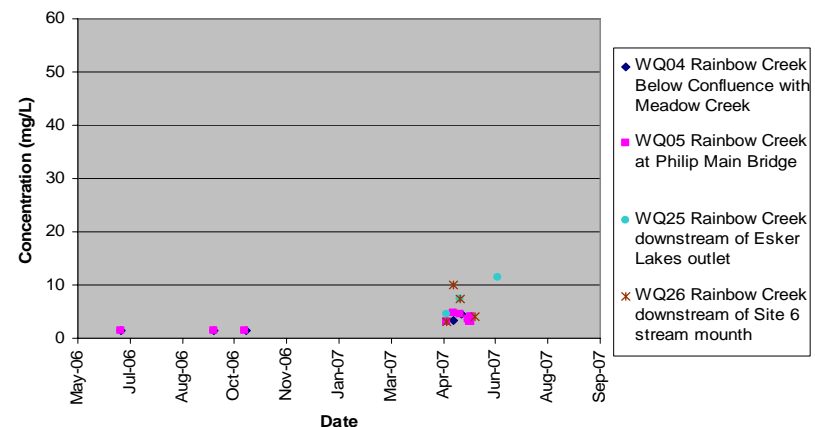Midstream Rainbow Creek (Total Dissolved Solids)
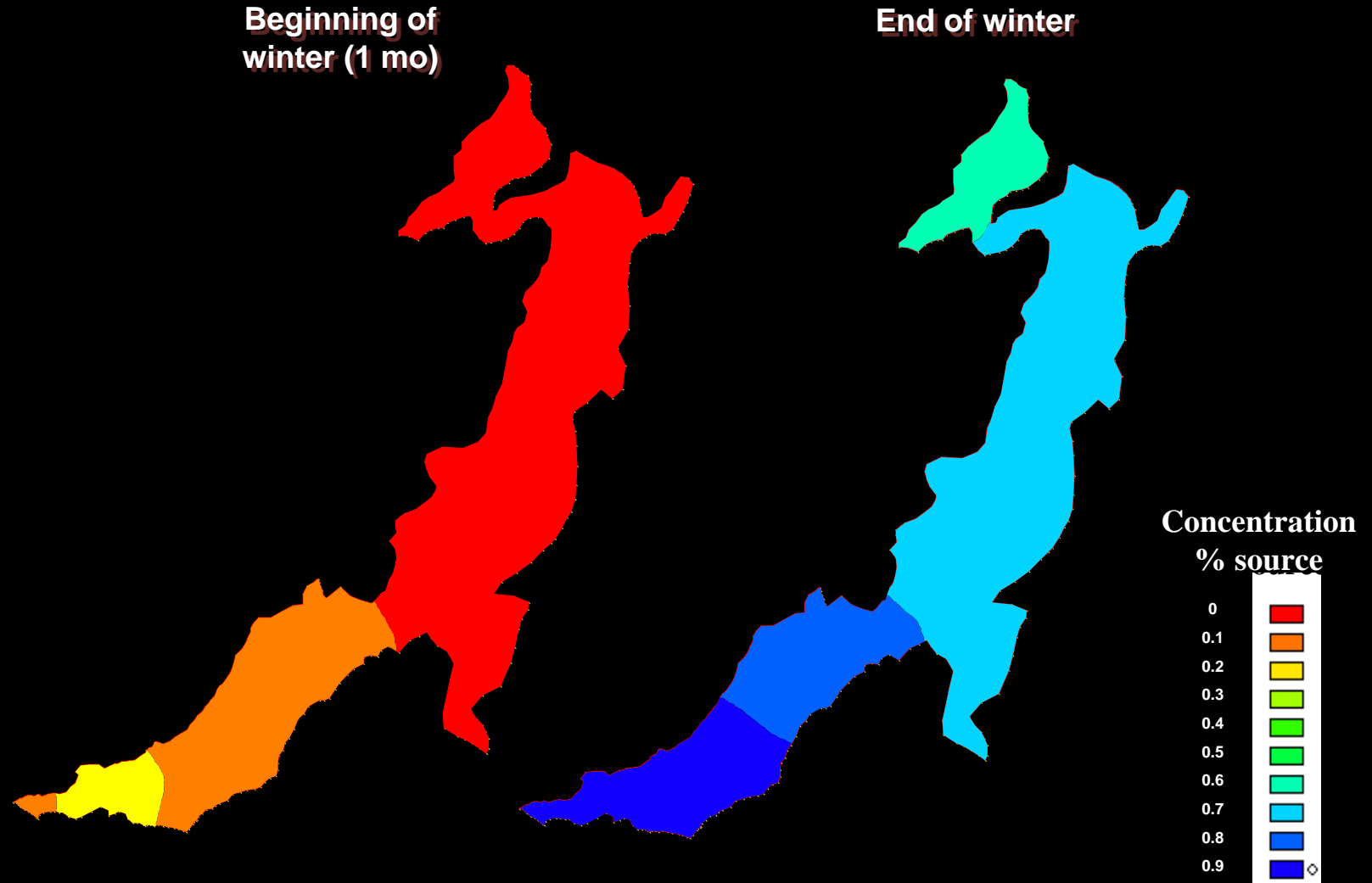

Midstream Rainbow Creek (Total Dissolved Solids)

Midstream Rainbow Creek (Total Suspended Solids)

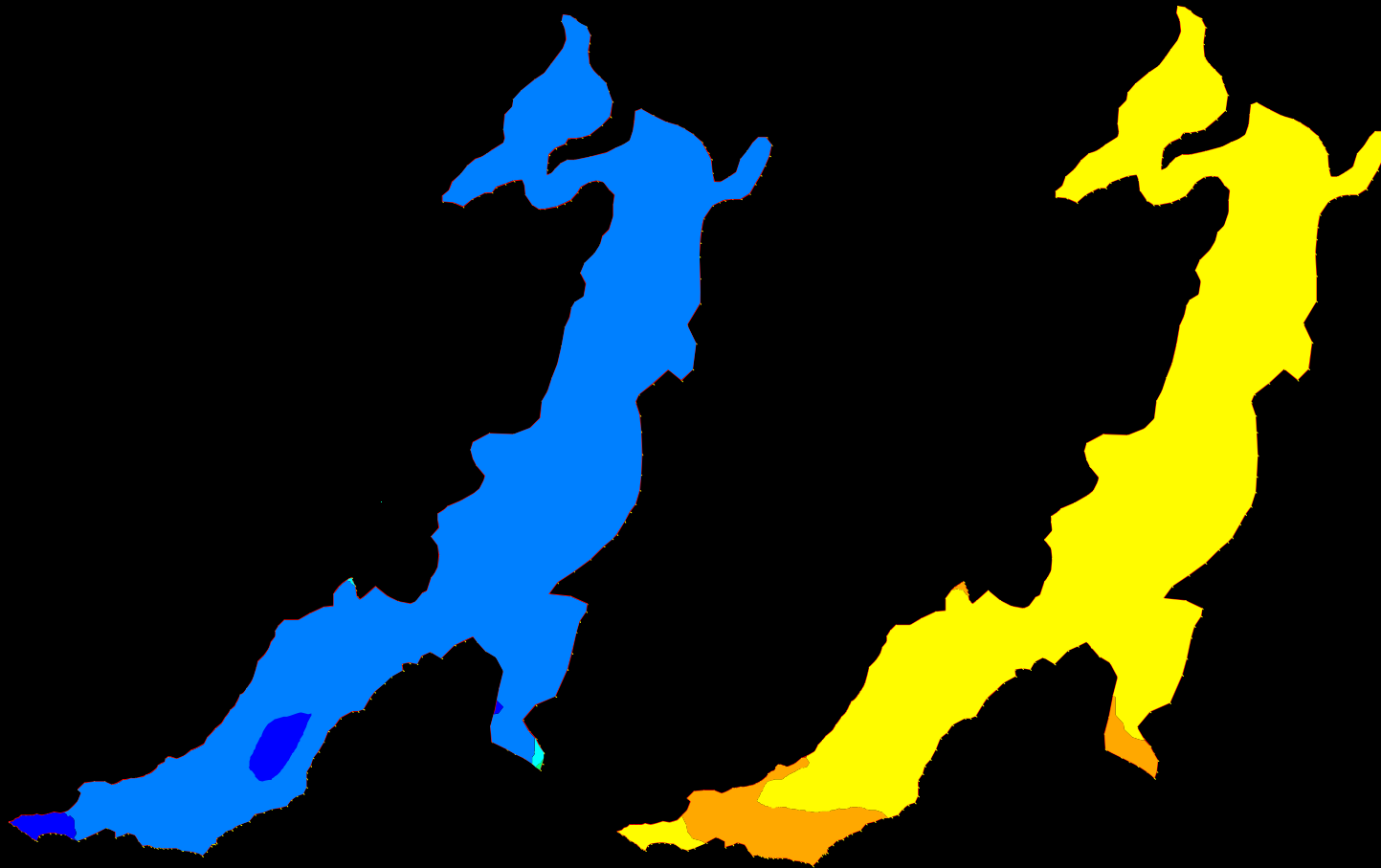Midstream Rainbow Creek (Total Suspended Solids)
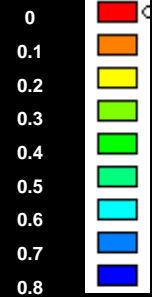
Lakes Heterogeneity - Winter

Beginning of winter (1 mo)

End of winter

Concentration % source

0	
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	
0.9	

amec

Lakes Heterogeneity - Summer

Beginning of summer

End of summer

Concentration % source

0	
0.1	
0.2	
0.3	
0.4	
0.5	
0.6	
0.7	
0.8	

Applications:

- Water Quality Management – Surveillance

- Water Quality Trends – Planning

Water Supply System Example
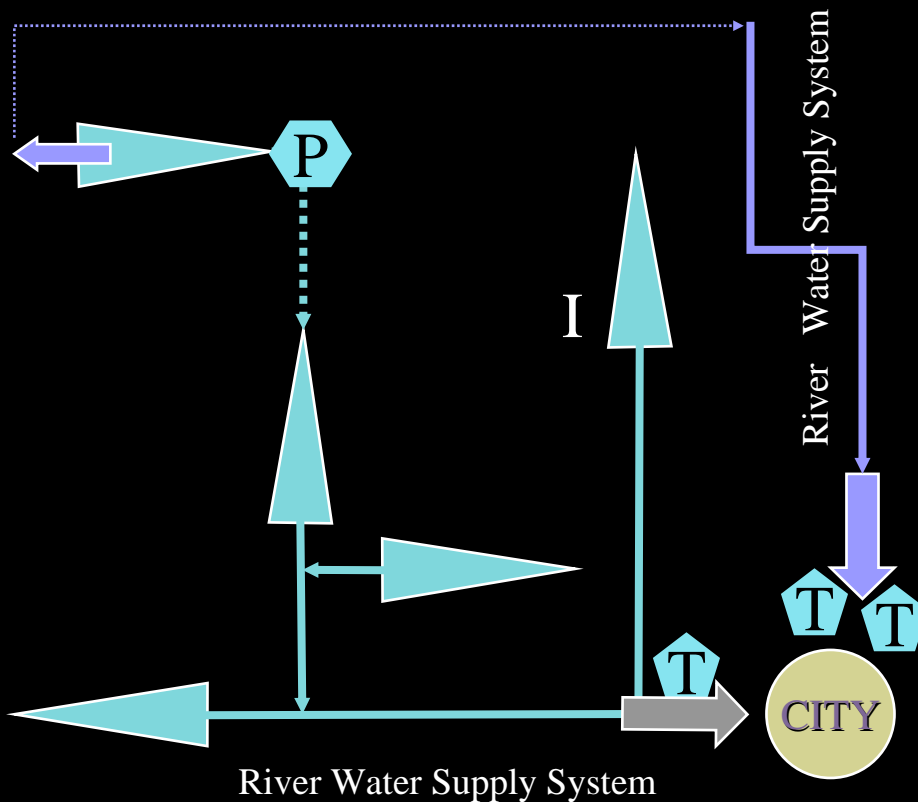
Includes:

- rivers, ────────
- reservoirs, ◀─────
- canals ▪▪▪▪▪▪▪▪▪▪▪
- pumping stations **P**
- water treatment plants **T**

Problems:

- organic and nutrient pollution
- algae blooming in reservoirs
- bacteria contamination
- pesticides and heavy metals
- high natural water colour

River Water Supply System

Water Quality Management
Selective Withdrawal

Summer

Autumn

Winter

Q
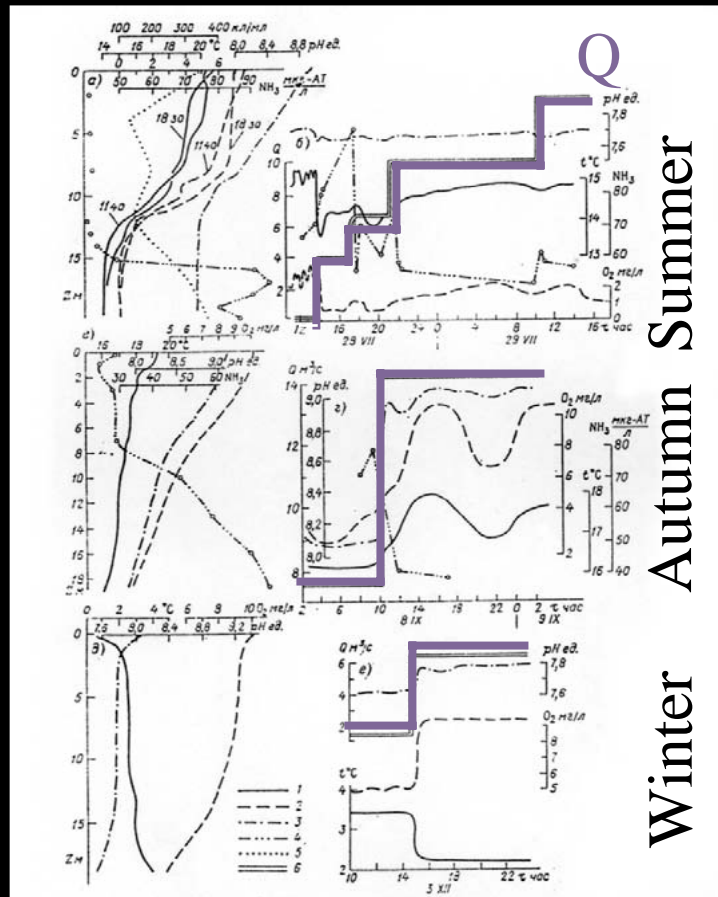
$$\delta = 1.77 \left(\frac{q^2}{g * E} \right)^{1/4}$$

Discharge Q m^3/sec	Stability 10^{-6} cm^{-1}	Withdrawal Layer, m
4	1.0	2.8
4	0.1	5.0
4	0.01	8.9
7	1.0	3.7
7	0.1	6.7
7	0.01	11.8
14	1.0	5.3
14	0.1	9.4
14	0.01	16.7

Watershed Water Quality Management

Total Pollutant Annual Loading

$$L_P = \Sigma (EC_{PU} \times A_U)$$

Water Quality Indicator (δL_p)

$$\delta L_p = (L_{pi} - L_{pi+1}) / L_{pi}$$

L_P Total Pollutant Annual Load (kg/yr)

EC_{PU} Export Coefficient (kg/ha/yr), by land use activity

A_U Area of land use type (ha)
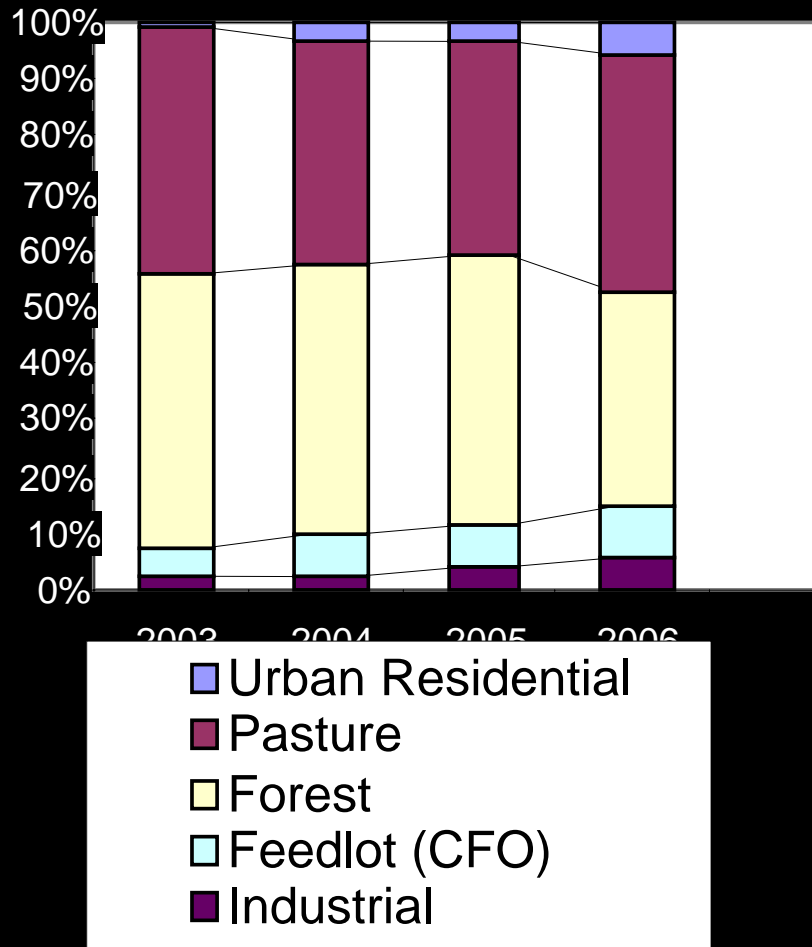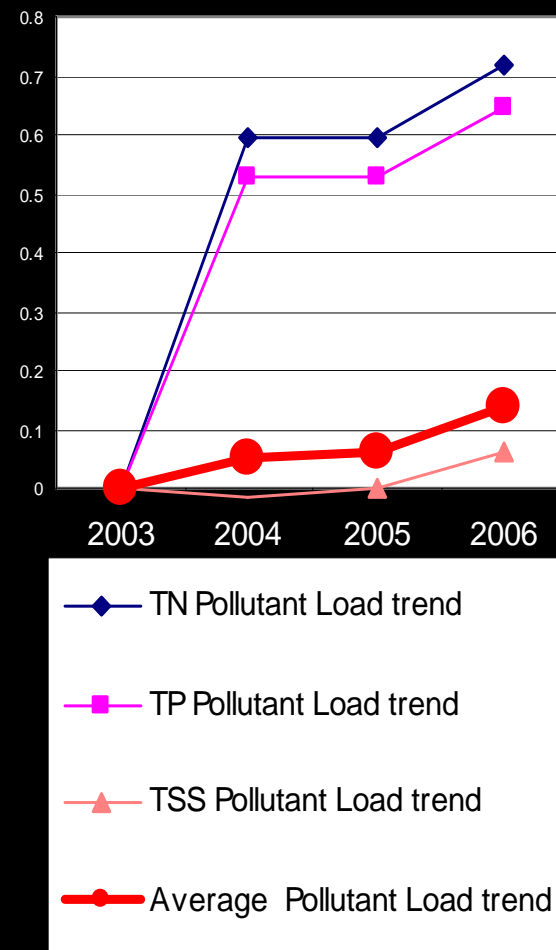
L_{pi} TPAL for the 1st year

L_{pi+1} TPAL for the next year (or years)

Potential Land Use Changes (Example)

Trend in Total Pollutant Annual Loadings

(Water Quality Indicator)

Water Supply System Structure

- Water system includes ponds, reservoirs, and river / creeks

  - pollution sources: point sources, surface runoff, air emissions

- Surface water supply

  - drinking water (reservoirs)

- Recreation (ponds and reservoirs)

  - swimming, water sports activity, fishing

Water Quality Survey Program

- **Extensive Survey Program**
  - water sampling
  - bottom sediments collection
  - snow collection (before spring snowmelt)
- **Survey Network with focus on:**
  - spatial heterogeneity of water quality in reservoirs
  - temporal variability in existing databases
  - heavy metals in water and sediments
  - watersheds pollution from deposition to snow

Water Quality Monitoring Design

- Evaluation of spatio-temporal heterogeneity in water quality
  - multivariate statistical analysis (cluster and regression analysis)
  - time-series analysis (temporal variations)
  - historical analysis of pollution loads from bottom sediments cores
- Recommendations for
  - improvement of WQ monitoring networks
  - concurrent water intakes

Monitor to Support Aquatic Health