CE102: Environmental Studies

By

Dr. Subrata Hait, Dept. of CEE

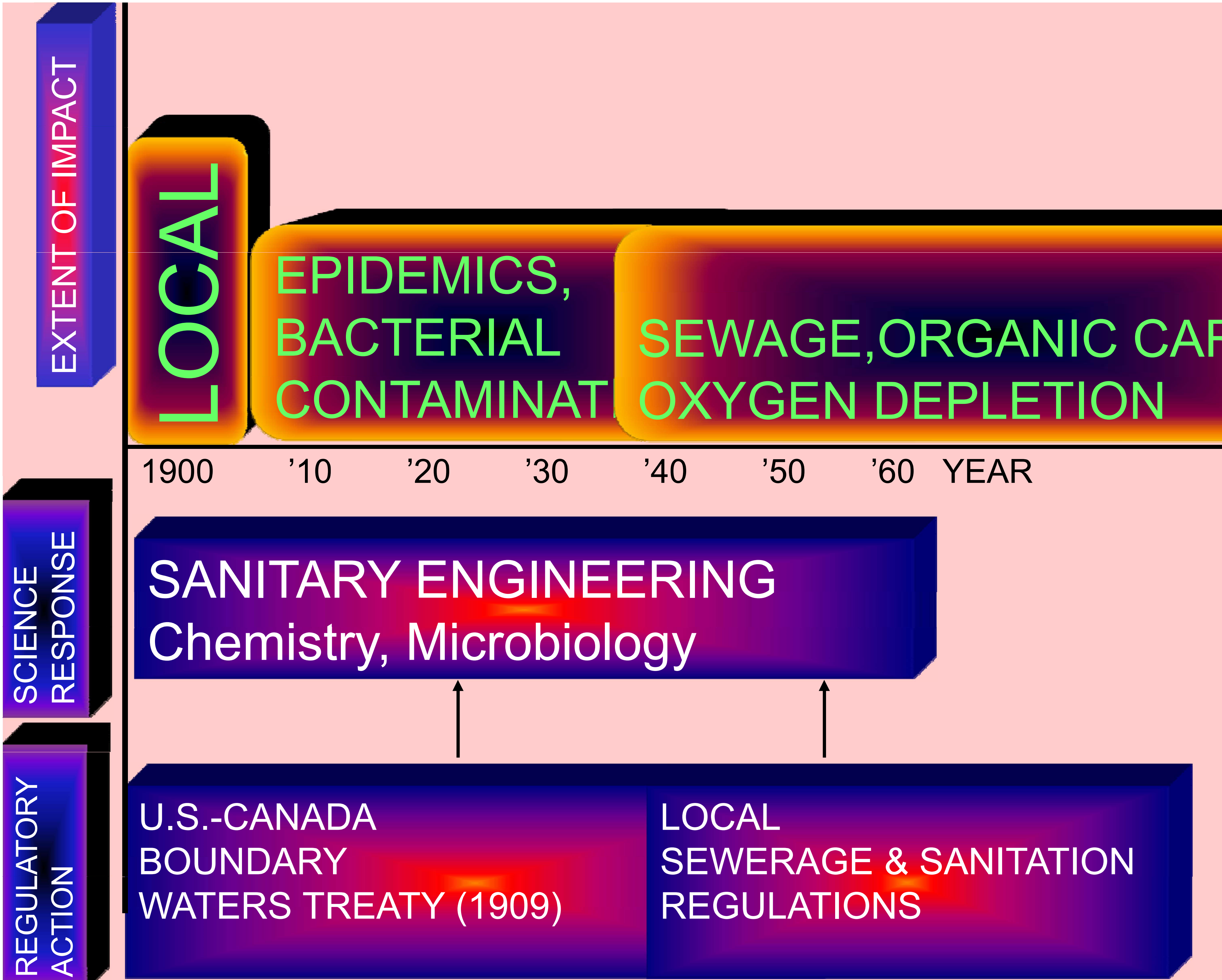
Explosion of Environmental Issues

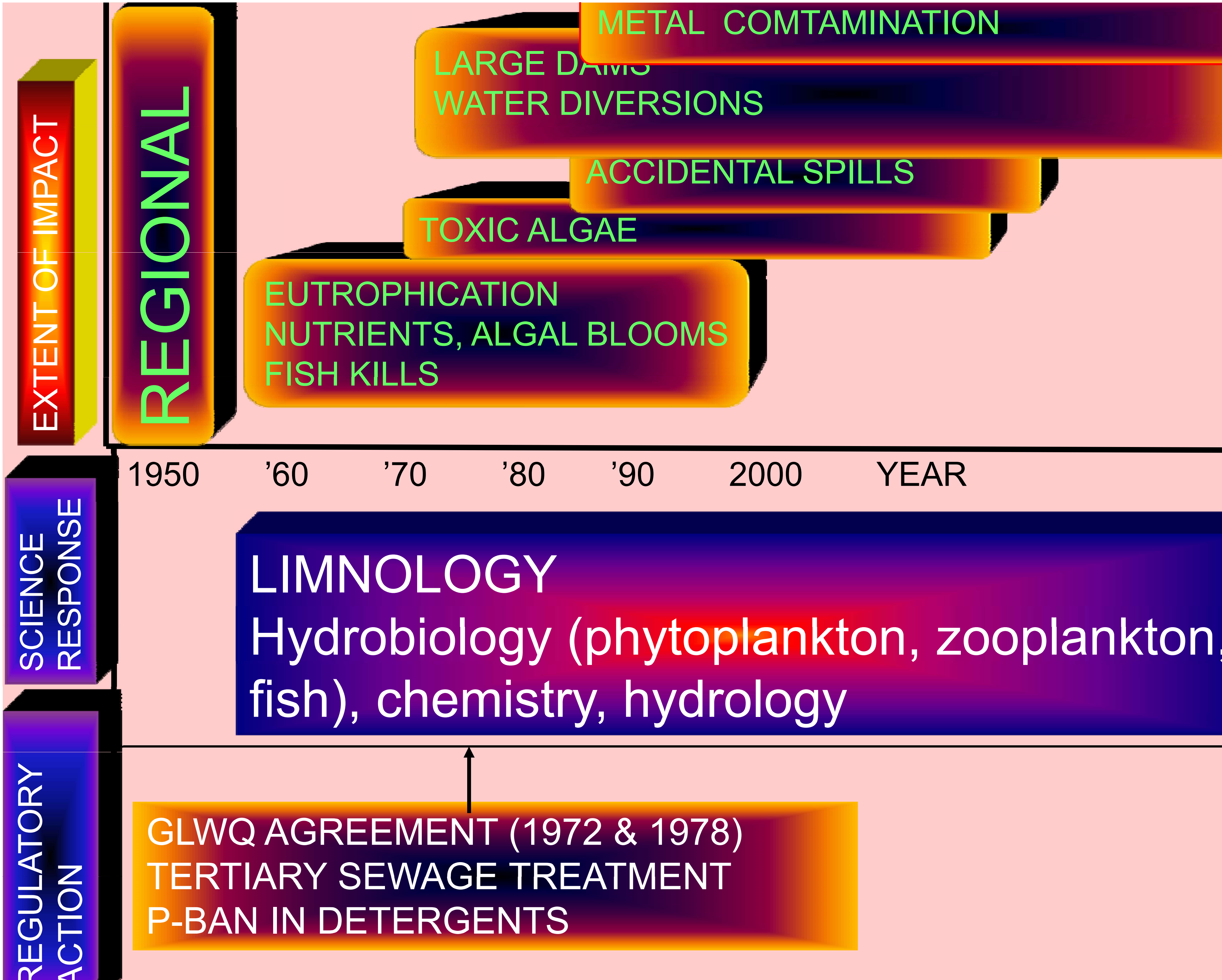
- From Few to Many, From Local to Global
- Science Response
- Response of Regulatory Agencies

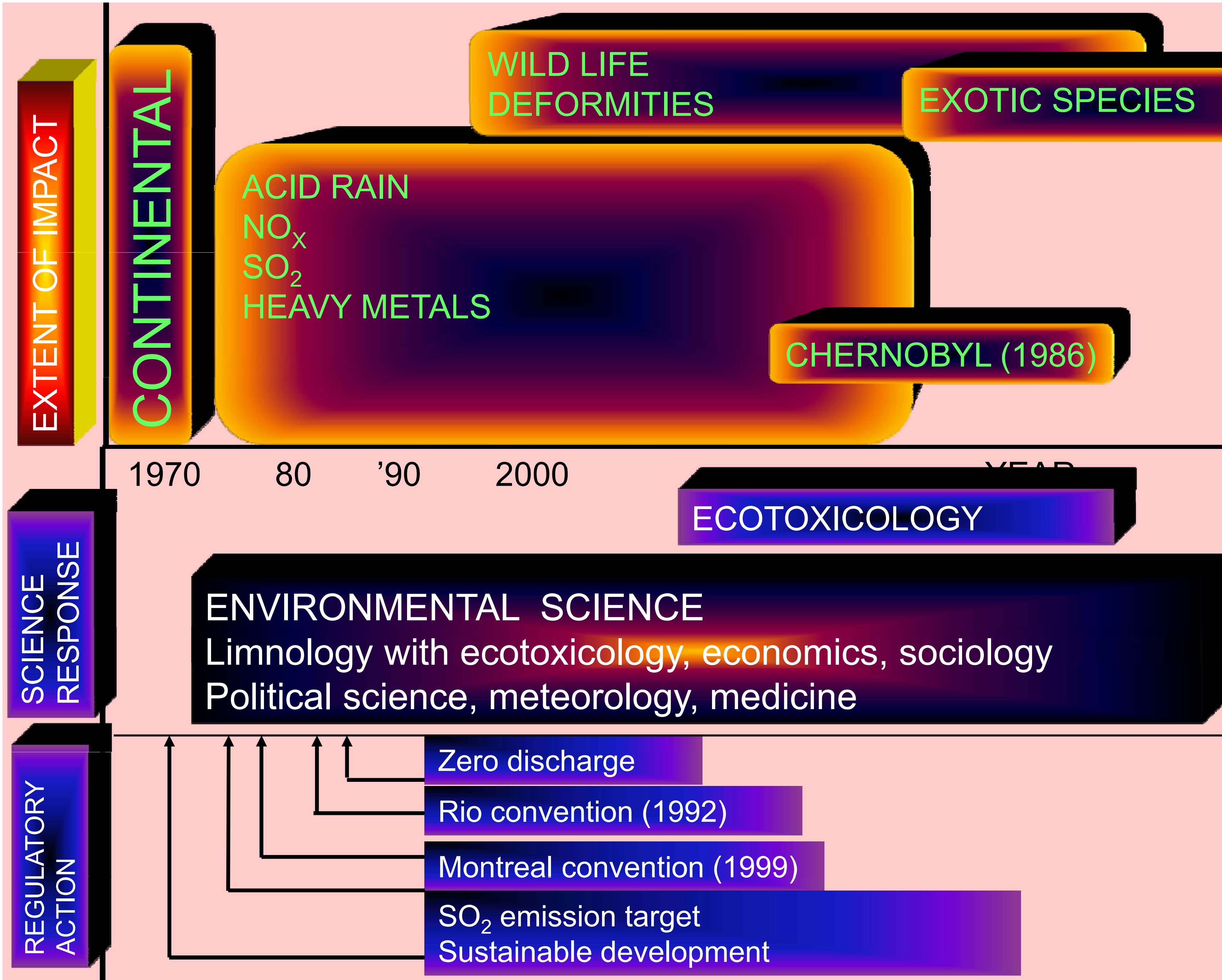
Explosion of Environmental Issues

Spatial Scales

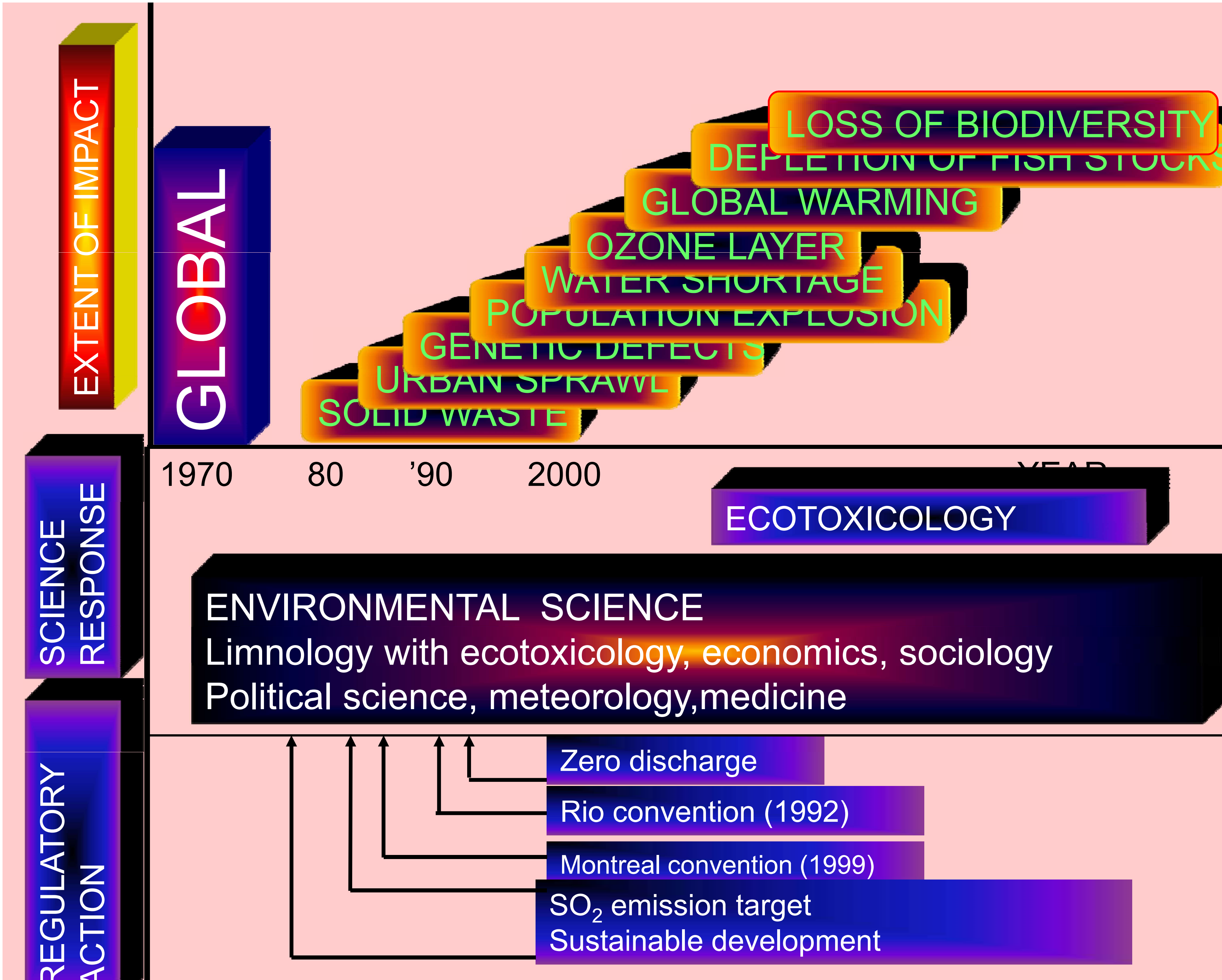
- Micro-scale (10 to 100 m) and Middle-scale (100 to 500 m
- Neighborhood scale (500 m to 4 km)
- Urban scale (4 to 100 km to 1,000 km)
- Continental scale (1,000 to 10,000 km)
- Global scale (> 10,000 km)


EXTENT OF IMPACT
LOCAL
EPIDEMICS,
BACTERIAL
CONTAMINATI
SEWAGE,ORGANIC CAR
OXYGEN DEPLETION
1900
’10
’20
’30
’40
’50
’60
YEAR
SCIENCE
RESPONSE
SANITARY ENGINEERING
Chemistry, Microbiology
REGULATORY
ACTION
U.S.-CANADA
BOUNDARY
WATERS TREATY (1909)
LOCAL
SEWERAGE & SANITATION
REGULATIONS

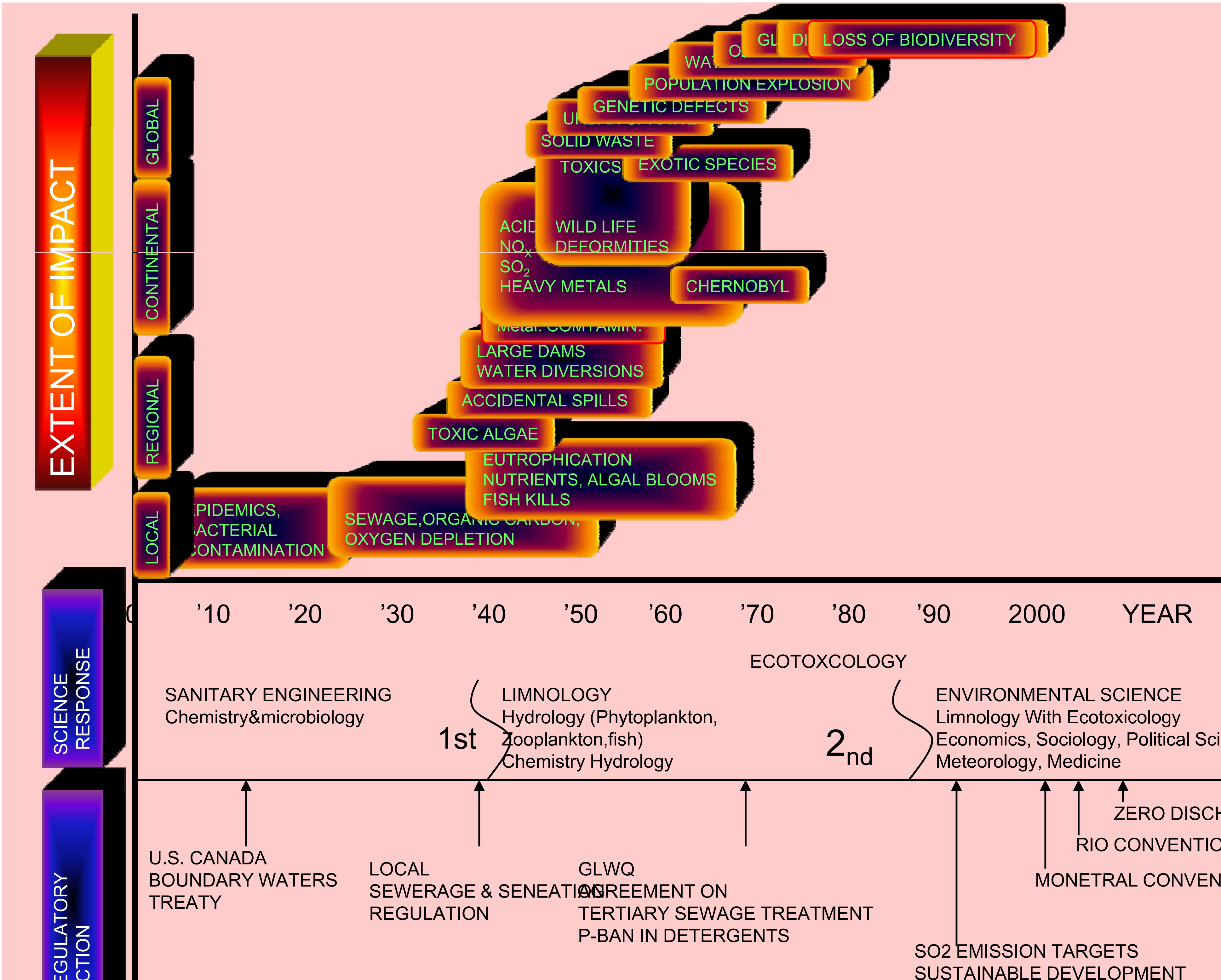

EXTENT OF IMPACT
REGIONAL
METAL COMTAMINATION
LARGE DAMS
WATER DIVERSIONS
ACCIDENTAL SPILLS
TOXIC ALGAE
EUTROPHICATION
NUTRIENTS, ALGAL BLOOMS
FISH KILLS
1950
'60
'70
'80
'90
2000
YEAR
SCIENCE RESPONSE
LIMNOLOGY
Hydrobiology (phytoplankton, zooplankton,
fish), chemistry, hydrology
REGULATORY ACTION
GLWQ AGREEMENT (1972 & 1978)
TERTIARY SEWAGE TREATMENT
P-BAN IN DETERGENTS

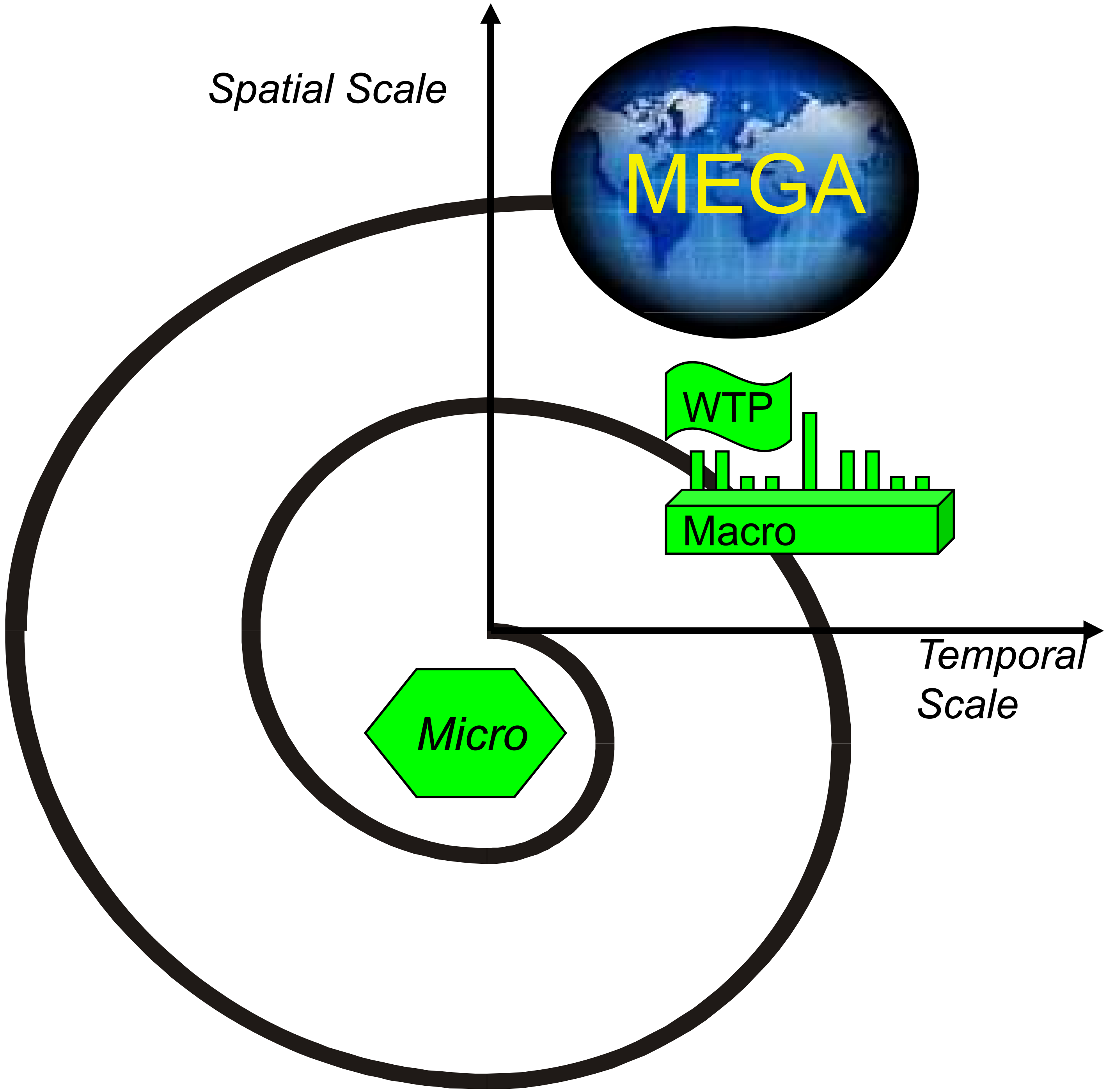


EXTENT OF IMPACT
CONTINENTAL
WILD LIFE
DEFORMITIES
EXOTIC SPECIES
ACID RAIN
NO_X
SO_2
HEAVY METALS
CHERNOBYL (1986)
1970
80
'90
2000
SCIENCE RESPONSE
ECOTOXICOLOGY
ENVIRONMENTAL SCIENCE
Limnology with ecotoxicology, economics, sociology
Political science, meteorology, medicine
REGULATORY ACTION
Zero discharge
Rio convention (1992)
Montreal convention (1999)
SO_2 emission target
Sustainable development



EXTENT OF IMPACT
GLOBAL
LOSS OF BIODIVERSITY
GLOBAL WARMING
OZONE LAYER
POPULATION EXPLOSION
1970
80
'90
2000
SCIENCE RESPONSE
ECOTOXICOLOGY
ENVIRONMENTAL SCIENCE
Limnology with ecotoxicology, economics, sociology
Political science, meteorology,medicine
REGULATORY ACTION
Zero discharge
Rio convention (1992)
Montreal convention (1999)
SO2 emission target
Sustainable development

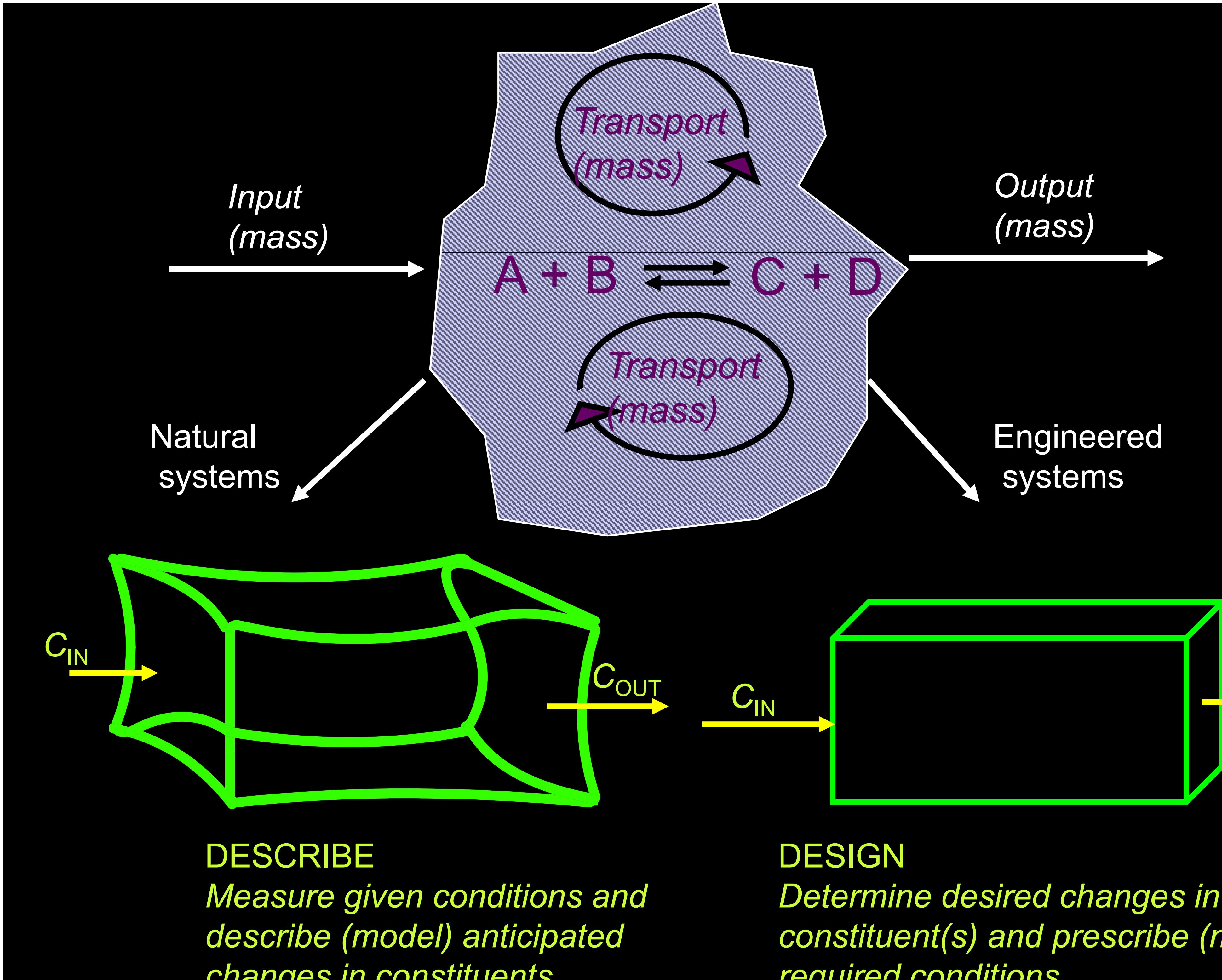

EXTENT OF IMPACT
GLOBAL
CONTINENTAL
REGIONAL
LOCAL
LOSS OF BIODIVERSITY
POPULATION EXPLOSION
GENETIC DEFECTS
SOLID WASTE
TOXICS
EXOTIC SPECIES
WILD LIFE
DEFORMITIES
NO$_X$
SO$_2$
HEAVY METALS
CHERNOBYL
LARGE DAMS
WATER DIVERSIONS
ACCIDENTAL SPILLS
TOXIC ALGAE
EUTROPHICATION
NUTRIENTS, ALGAL BLOOMS
FISH KILLS
SEWAGE,ORGA
OXYGEN DEPLETION
ACTERIAL
CONTAMINATION
SCIENCE RESPONSE
'10 '20 '30 '40 '50 '60 '70 '80 '90 2000 YEAR
ECOTOXCOLOGY
SANITARY ENGINEERING
Chemistry&microbiology
1st
LIMNOLOGY
Hydrology (Phytoplankton,
Zooplankton,fish)
Chemistry Hydrology
2nd
ENVIRONMENTAL SCIENCE
Limnology With Ecotoxicology
Economics, Sociology, Political Sci
Meteorology, Medicine
U.S. CANADA
BOUNDARY WATERS
TREATY
LOCAL
SEWERAGE & SENEATION
REGULATION
GLWQ
AGREEMENT ON
TERTIARY SEWAGE TREATMENT
P-BAN IN DETERGENTS
SO2 EMISSION TARGETS
SUSTAINABLE DEVELOPMENT
MONETRAL CONVEN
RIO CONVENTIO
ZERO DISCH



The environment is in fact a continuum of systems involving similar proc
over a remarkable range of temporal and spatial scales

Environmental Systems

- Natural
  - We are concerned with understanding a describing changes
- Engineered
  - We are concerned with the selection of conditio required to effectively accomplish speci changes


Input
(mass)
Output
(mass)
Transport
(mass)
A + B ⇄ C + D
Transport
(mass)
Natural
systems
Engineered
systems
C_{IN}
C_{OUT}
C_{IN}
DESCRIBE
Measure given conditions and
describe (model) anticipated
changes in constituents
DESIGN
Determine desired changes in
constituent(s) and prescribe (
required conditions

Natural & Engineered Environmental Systems

- While the objectives, information requirements a expected results for natural and engineered systems usually quite different, the underlying processes a principles of change are essentially the same. Similar the methods by which the processes are analyzed a described should be fundamentally the same.
- Successful approaches to system characterizatio process analyses, and quantification of components a constituent changes must in every instance, be based the same principles and precepts of process dynamics

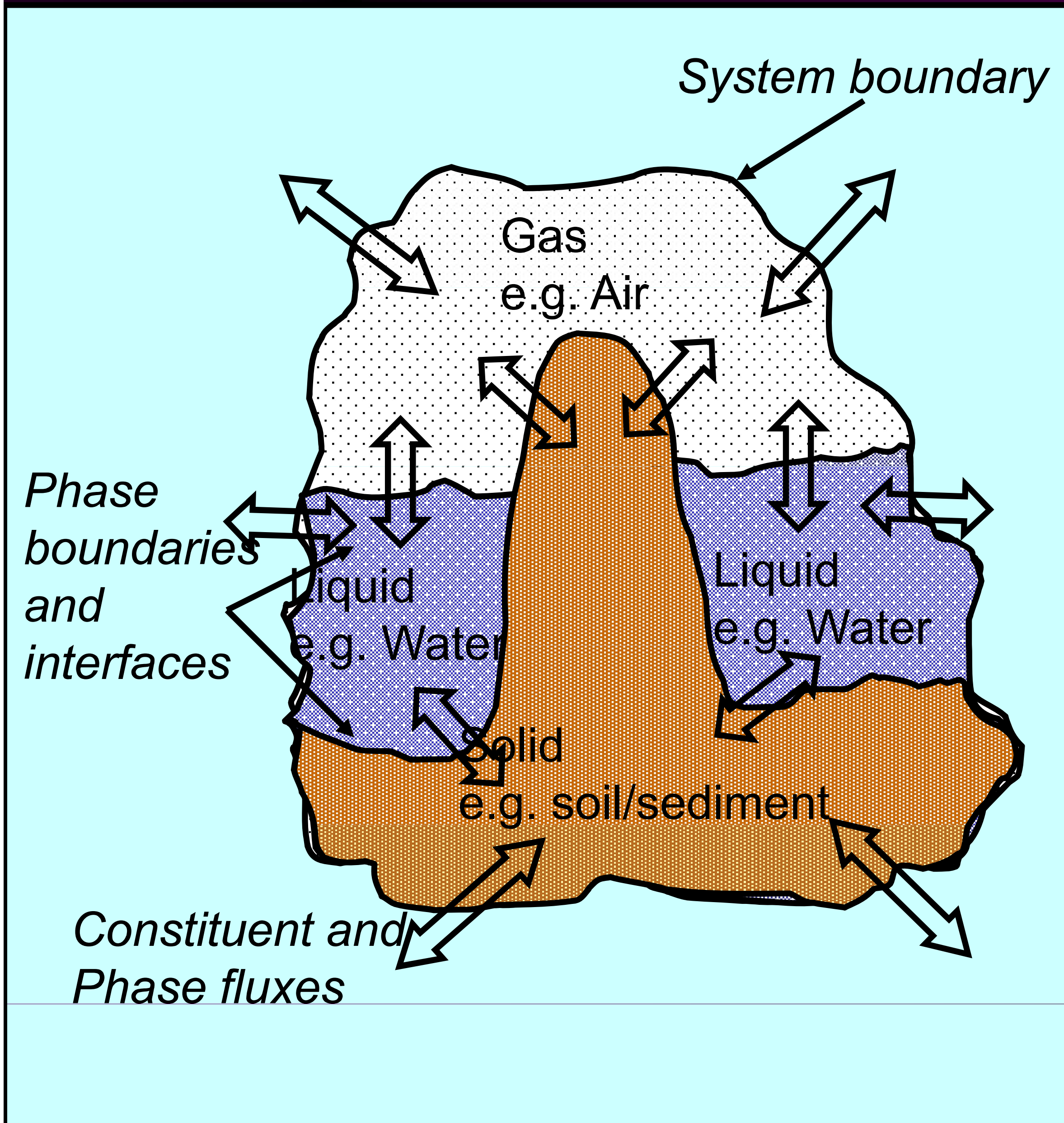
Character and Scale – Natural & Engineer
Environmental Systems

- At the most elementary level we distinguish t character of a system on the basis of its scale.

- By character we mean the properties of a syste and the nature of changes that occur within it.

- By scale we mean the size (spatial scale) of t system and the time (temporal scale) th together determine the boundaries within a over which the changes of interest occur

Generalized Multiphase System of Gaseous, Liquid and Solid Phases



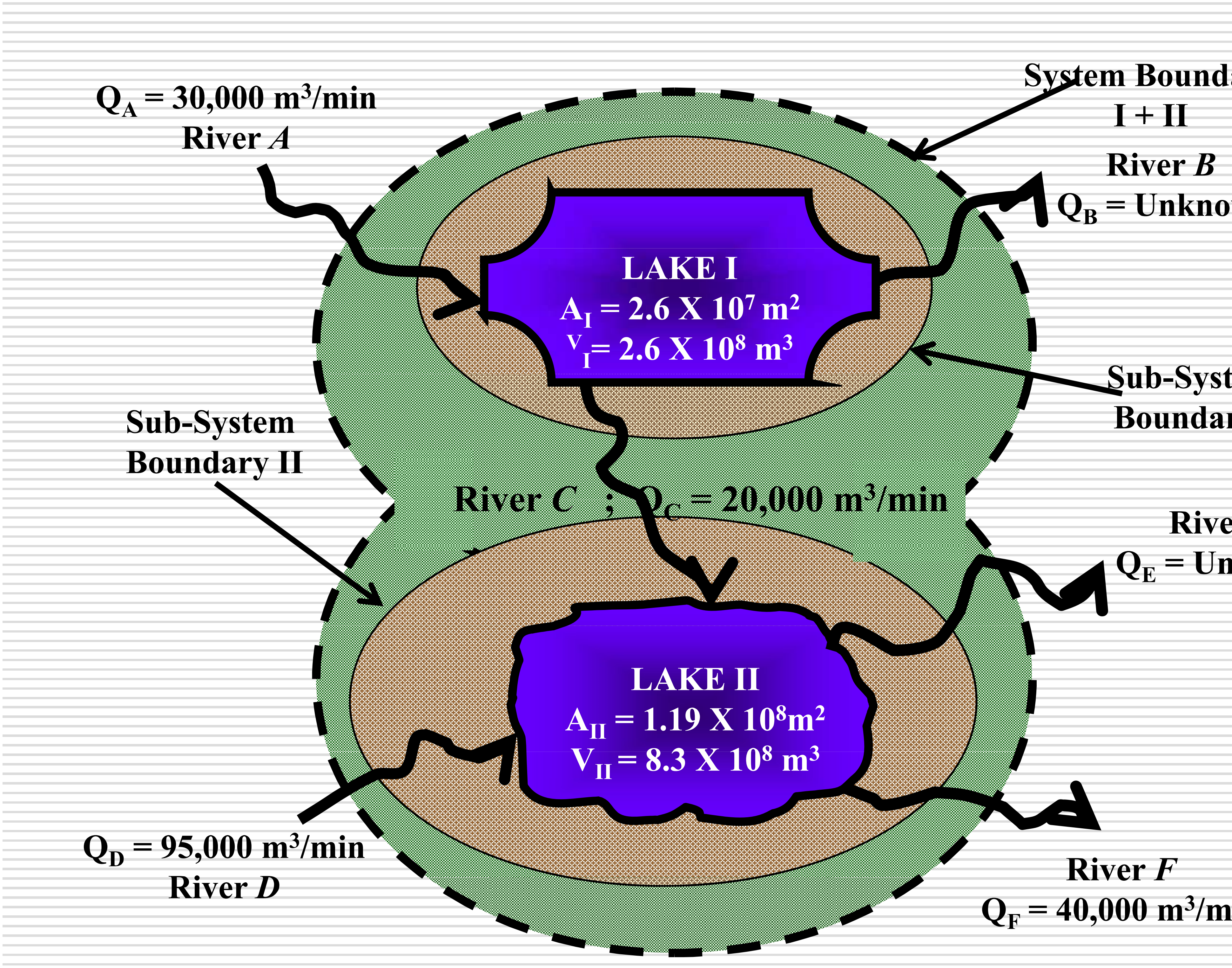
It is important to r
however, that
composition of each p
depicted in the **Fi**
changes as a result of p
and constituent r
reductions and additions
may occur not only
reactions among constitu
within the boundaries
phase, but also by mover
of mass across its p
boundaries
accumulations or deple
within interfaces at t
phase boundaries.

Environmental Systems –Analysis Approach

- All systems are comprised by subsystems; mega-scale syste by macro-scale systems, and macro-scale systems by micro-sc systems. This is why many processes can be influenced at macroscopic scale by similar microscopic mass trans phenomenon.
- The most fundamental analysis of any system has its orig ultimately at the molecular level, and must provide that there i continuity of principles derived from this scale to the full scale the system.

Environmental System Characterization

- We will begin to develop rigorous mass and material bal based approached to system characterization and modeling
- These approaches can be extended to analysis and desig systems involving increasingly more complex transport transformation phenomena
- Before embarking on this, let us first consider a relatively sir environmental system and several sets of different circumsta that lend themselves to intuitive and common sense approac material balance based "modeling"
- In this we will learn some basic ground rules. Mostly invo *Intuition and Common Sense*



Q_A = 30,000 m^3/min
River *A*
System Bound
I + II
River *B*
Q_B = Unkno
LAKE I
A_I = 2.6 X 10^7 m^2
V_I = 2.6 X 10^8 m^3
Sub-Syst
Bounda
Sub-System
Boundary II
River *C* ; Q_C = 20,000 m^3/min
Rive
Q_E = Un
LAKE II
A_{II} = 1.19 X 10^{8}m^2
V_{II} = 8.3 X 10^8 m^3
Q_D = 95,000 m^3/min
River *D*
River *F*
Q_F = 40,000 m^3/m

Objective:
Find Q_B and Q_E

- Volumes of lakes are constant
  - i) **Define boundary : → system boundary Lake I + Lake II**
  - ii) **Mass balance of water**

    $Q_A + Q_D = Q_B + Q_E + Q_F$ ---

    steady state condition → temporarily stable condition

  Otherwise

    $(Q_A + Q_D) - (Q_B + Q_E + Q_F) = d/dt\,(V_I + V_{II})$ ---

  - iii) **Redefine boundaries:**

    Lake I – subsystem → $Q_B = Q_A - Q_C = 10{,}000\ m^3/min$

    Lake II – subsystem → $Q_E = Q_C + Q_D - Q_F = 75{,}000\ m^3/min$

    What allows us to write above equation is that mass concentrat water in water is constant and equal to its density ρ_ω

    $Q_A\,\rho_\omega - Q_B\,\rho_\omega - Q_c\,\rho_\omega = 0$

  Assumption → System involved incurred no change in its properties

- Let us complicate by acknowledging that evaporation ma be important/significant (r = 0.5 cm/d → $cm^3/cm^2/d$)

- **New sink term**

→ $Q_A \rho_\omega - Q_B \rho_\omega - Q_c \rho_\omega - E_{V,I} \rho_\omega = 0$ ----

$(EV,I\ \rho\omega = 0.5 / 100 \times 1440\ m/min \times 2.6 \times 10^7\ m^2 = 90\ m^3/min)$

→ $Q_C \rho_\omega + Q_D \rho_\omega - Q_E \rho_\omega - Q_F \rho_\omega - EV,II\ \rho_\omega = 0$

$(EV,II\ \rho_\omega = 0.5 / 100 \times 1440 \times 1.19 \times 10^8 = 413\ m^3/min)$

$Q_B = 9910\ m^3/min$

$Q_E = 74,600\ m^3/min$

- Constituent mass balance
- Boundary same as before
- Chloride → no transformation → conservative
- Cl^- is not evaporated
- $C_A\,(Cl^-) = 40$ mg/L; $C_D\,(Cl^-) = 60$ mg/L

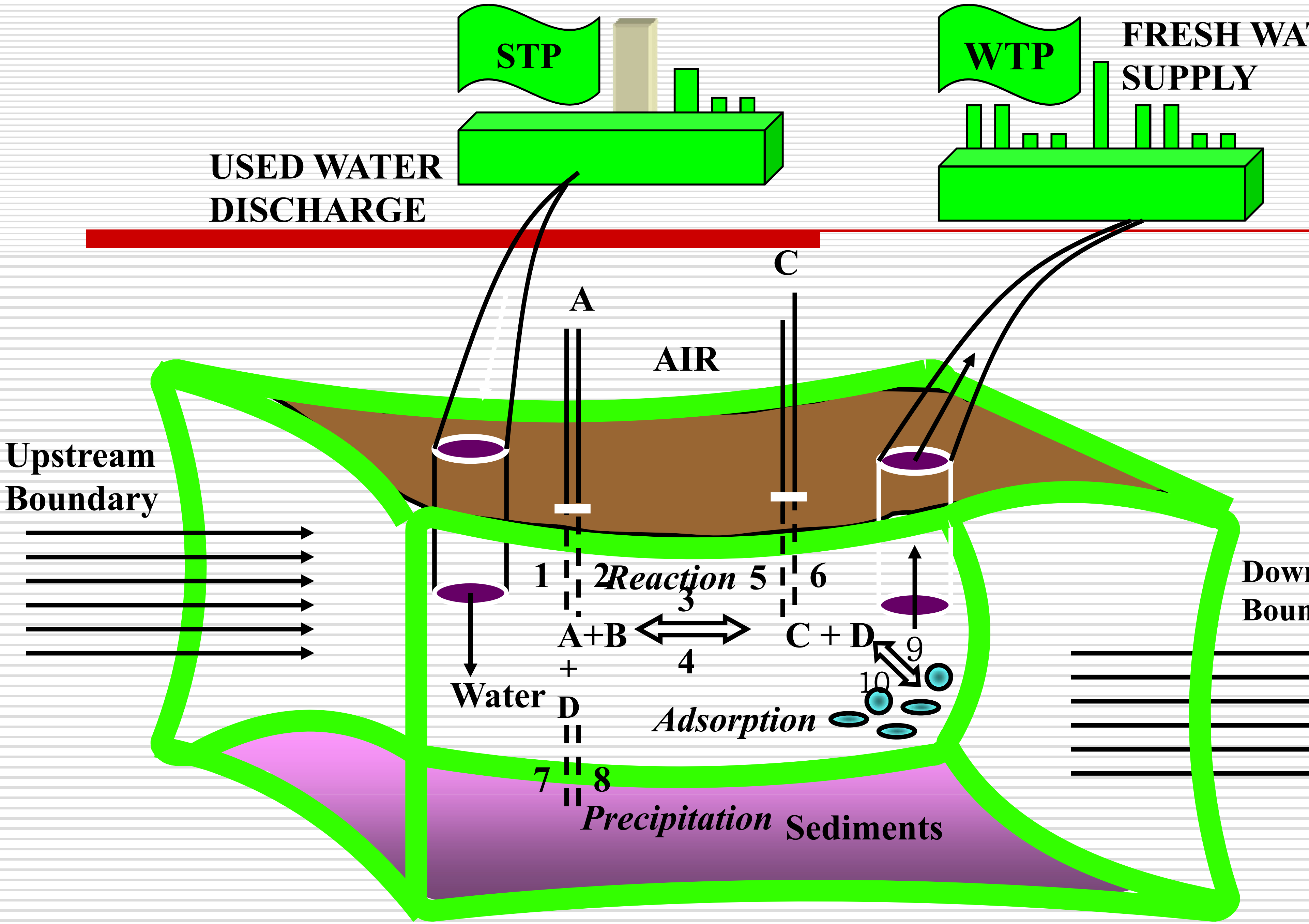
→ Assumption $C_B\,(Cl^-) = C_C\,(Cl^-)$ (complete mixing)

$$C_B(Cl) = C_C(Cl) = \frac{30{,}000\,X\,40}{9{,}910 + 20{,}000} = 40.1\,mg/L$$

$$C_E(Cl) = C_F(Cl) = \frac{(20{,}000\ \mathrm{X}\ 40.1) + (95{,}000\ \mathrm{X}\ 60)}{74{,}587 + 40{,}000} = 56.7\,mg/L$$

In reviewing the constructs of these intuitive “models”, note and contemplate these several important points:

1. Proper selection of boundaries can simplify solutions by reducing the number of unknowns
2. A separate and perhaps somewhat different material balance equation must be written for each component of interest
3. All transport and transformation processes should be first identified in physical context and then translated into equations
4. Any and all assumptions you are making should be identified, stated explicitly and analyzed for merit, and
5. Balanced equations should be developed in terms of general variables first, checked for dimensional consistency, and then quantified with numerical parameter values having appropriate units.



A Natural Environmental Macroscale System