WATER AND WASTEWATER ENGINEERING IN 21st CENTURY
Challenges and Opportunities
美國水環境工程回顧與挑戰

劉成均（美國夏威夷大學土木與環境工程系教授）
Clark C.K. Liu, Ph.D., P.E.
Professor of Civil & Environmental Engineering
University of Hawaii at Manoa, Honolulu, HI 96822 USA

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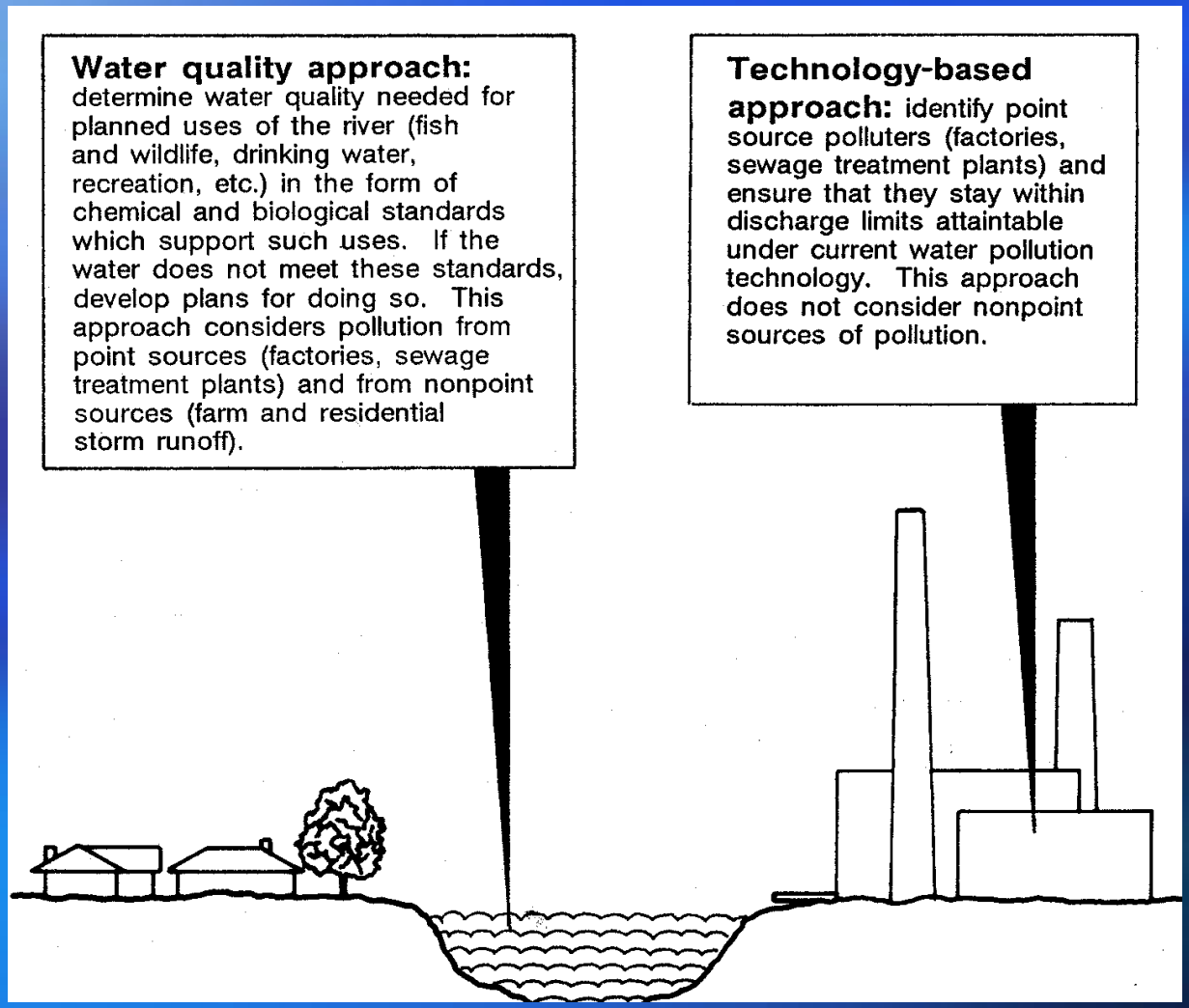
I. Progress of Environmental Engineering
（近三十年水環境工程之進程）

The objective of the Federal 1972 Clean Water Act:

"… to restore and maintain the chemical, physical, and biological integrity of the Nation's water."

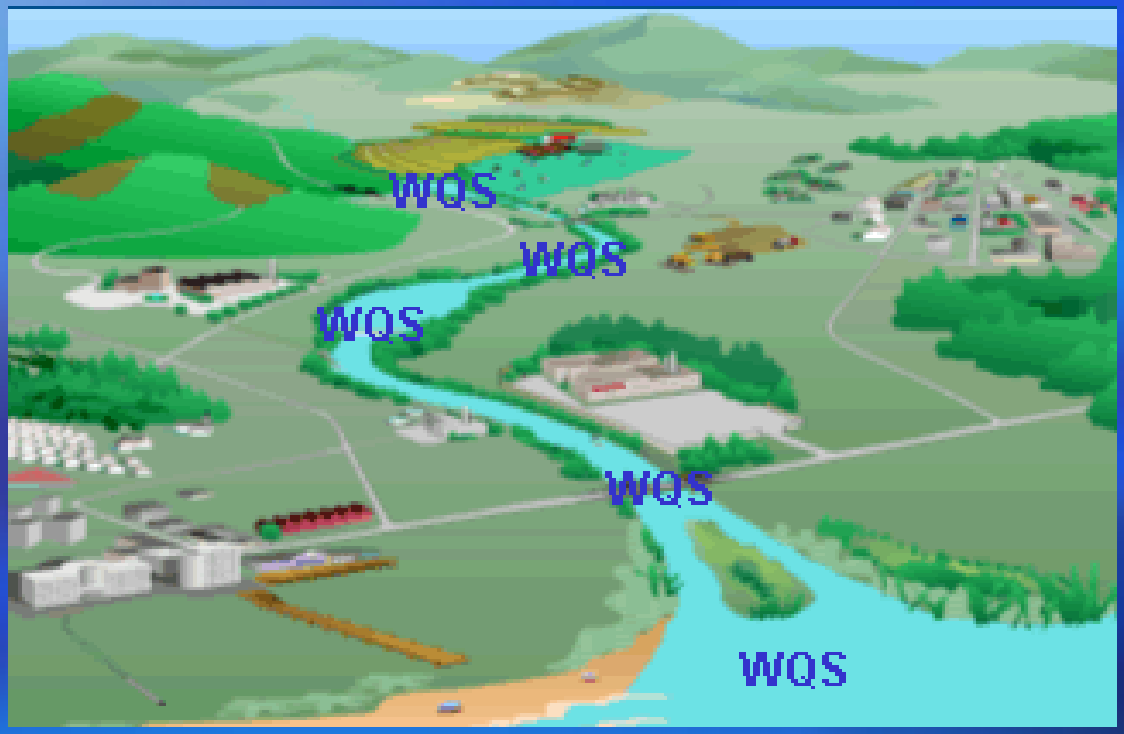
1. Water Quality Modeling and Treatment Technologies（水質模擬及處理技術）

The Clean Water Act of 1972 follows both water quality and technology-based approaches

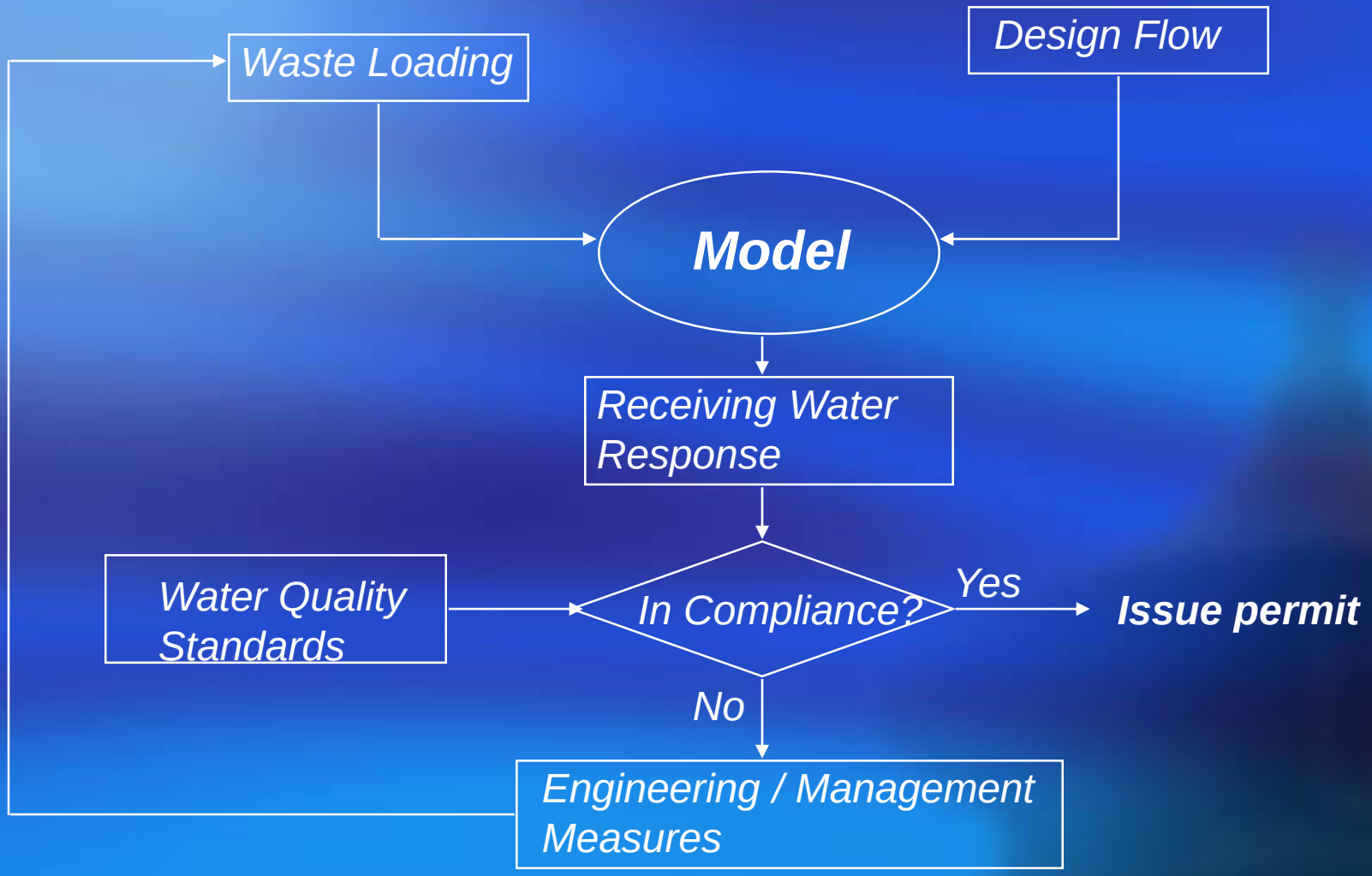


Water Quality Approach: (1) Best Use of a Water Body

Water Quality Approach: (2) Water Quality Standards



Water Quality Approach: (3) Effluent Permit



US Clean Water Act:
A Partial Success Story
美國淨水法實施以來已完成及未竟的工作

- **Every city and village has constructed wastewater treatment facilities at secondary or advanced level.**
- **States report over 40 percent of assessed waters are still too polluted for fishing or swimming even after years of water pollution control efforts**
- **States have identified about 21,000 polluted river segments, lakes, and estuaries**
  - **Over 300,000 river & shore miles & 5 million lake acres**
  - **Excess sediments, nutrients, and harmful microorganisms are leading reasons**

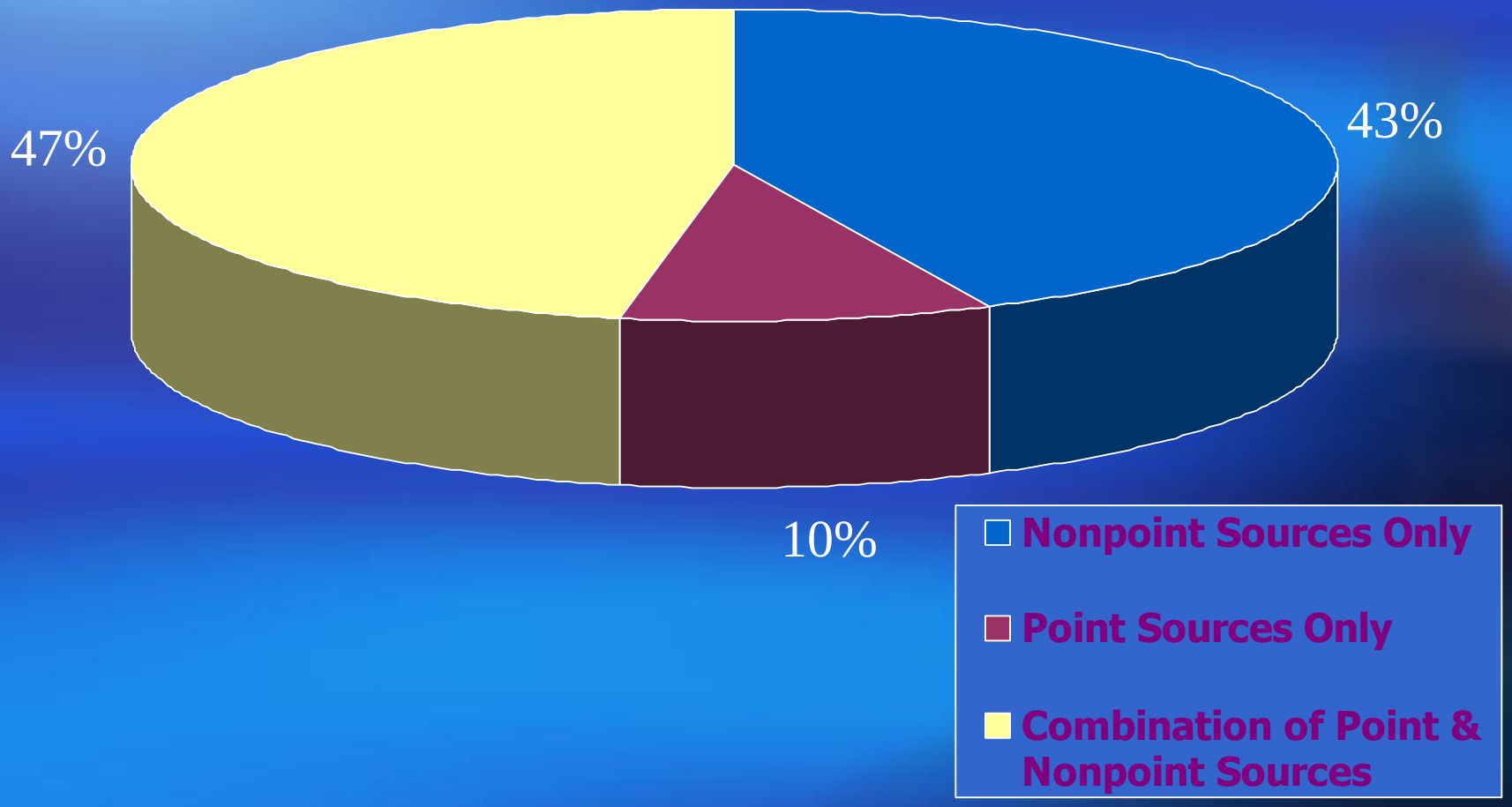
Top Reasons for Water Quality Standards Contravention

LAKES	ESTUARIES	STREAMRIVERS
NUTRIENTS	PATHOGENS	SEDIMENTS
SEDIMENTS	FCA[2]	METALS
DISSOLVED OXYGEN	METALS	PATHOGENS
pH	DISSOLVED OXYGEN	NUTRIENTS

Lake Eutrophication

Wiahiwa Reservoir, Oahu, Hawaii

Sources of Impairment by Category from the 1998 Water Quality Survey



Nonpoint Source Pollution Control:

Strategies to Attain and/or Maintain Water Quality Standards

- 303(d) Total Maximum Daily Loads (TMDLs)
- Sec. 320 - National Estuary Program
  - Comprehensive Conservation & Management Plans (CCMPs)
- Other holistic watershed-based strategies

1. Advancement of Treatment Technology: Biological Treatment

（生物處理技術的開發）

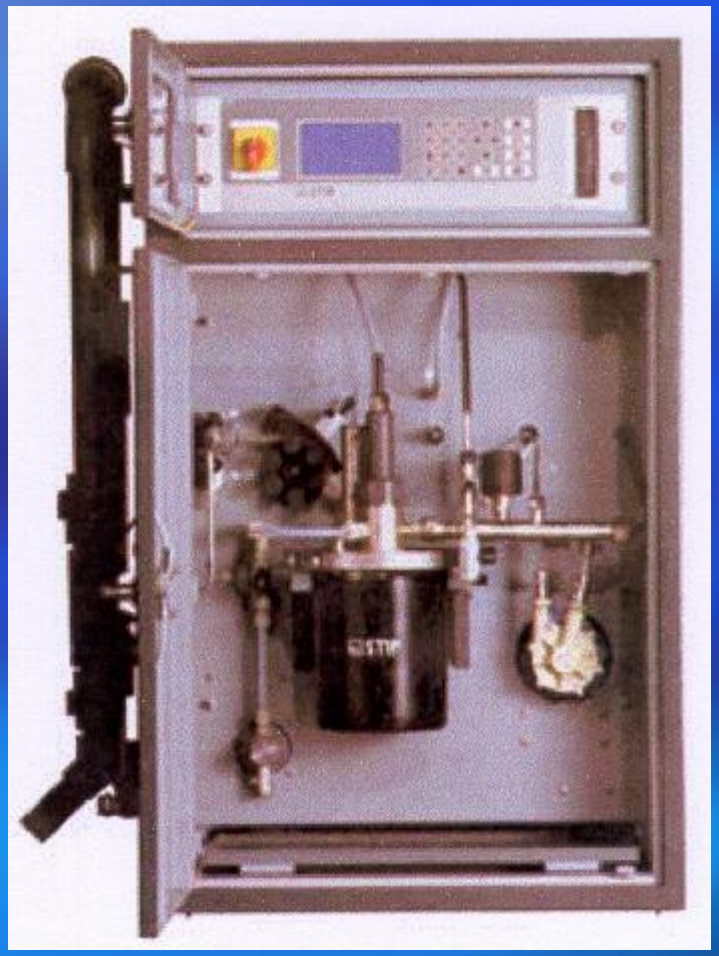
Activated Sludge Treatment Facility at E. Oahu, Hawaii

Advancement of Treatment Processes: Physical Chemical Treatment （物化處理技術的開發）

Pressure Driven Membrane

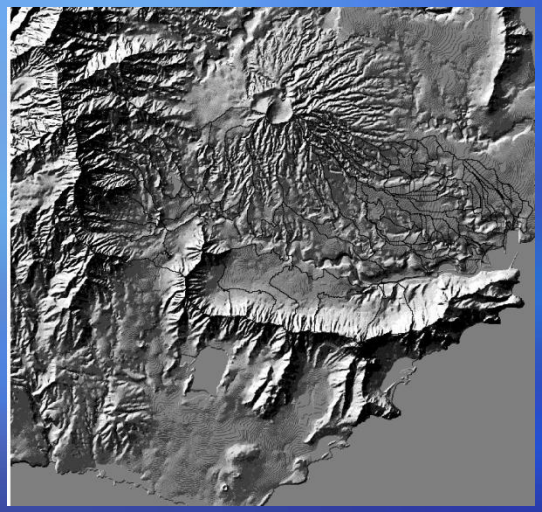
2. Environmental Monitoring and Assessment （環境監測及評估）

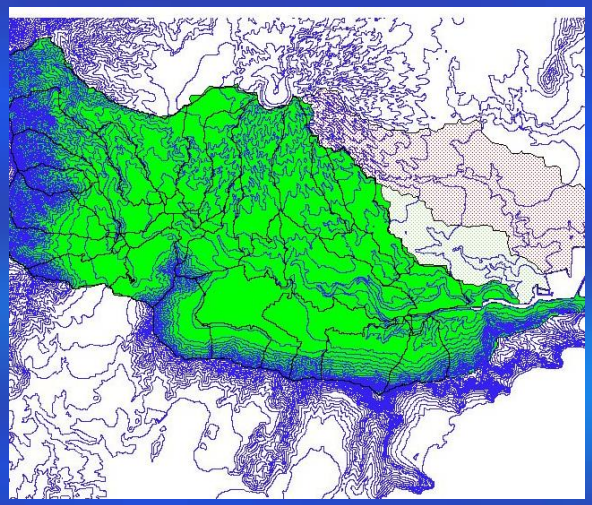
BIOX 1010 BOD Analyzer



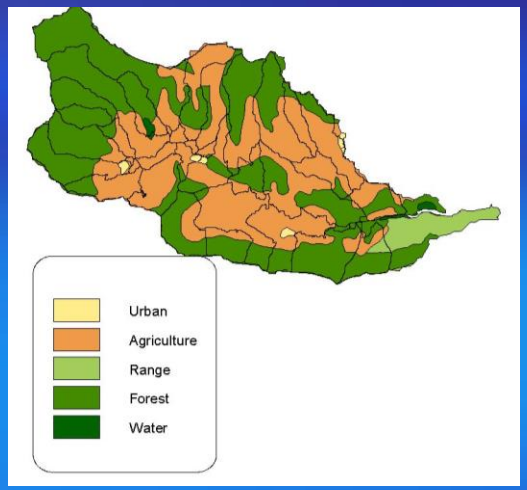
GIS and Water Quality Assessment
（地理資訊系統及水質評估）

Nawiliwili Basin, Kauai, Hawaii

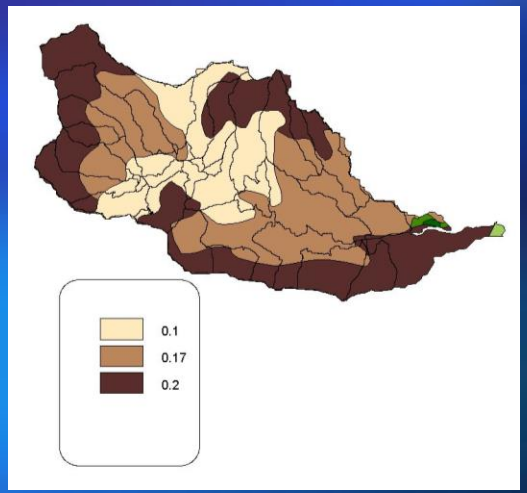




(a) Typography



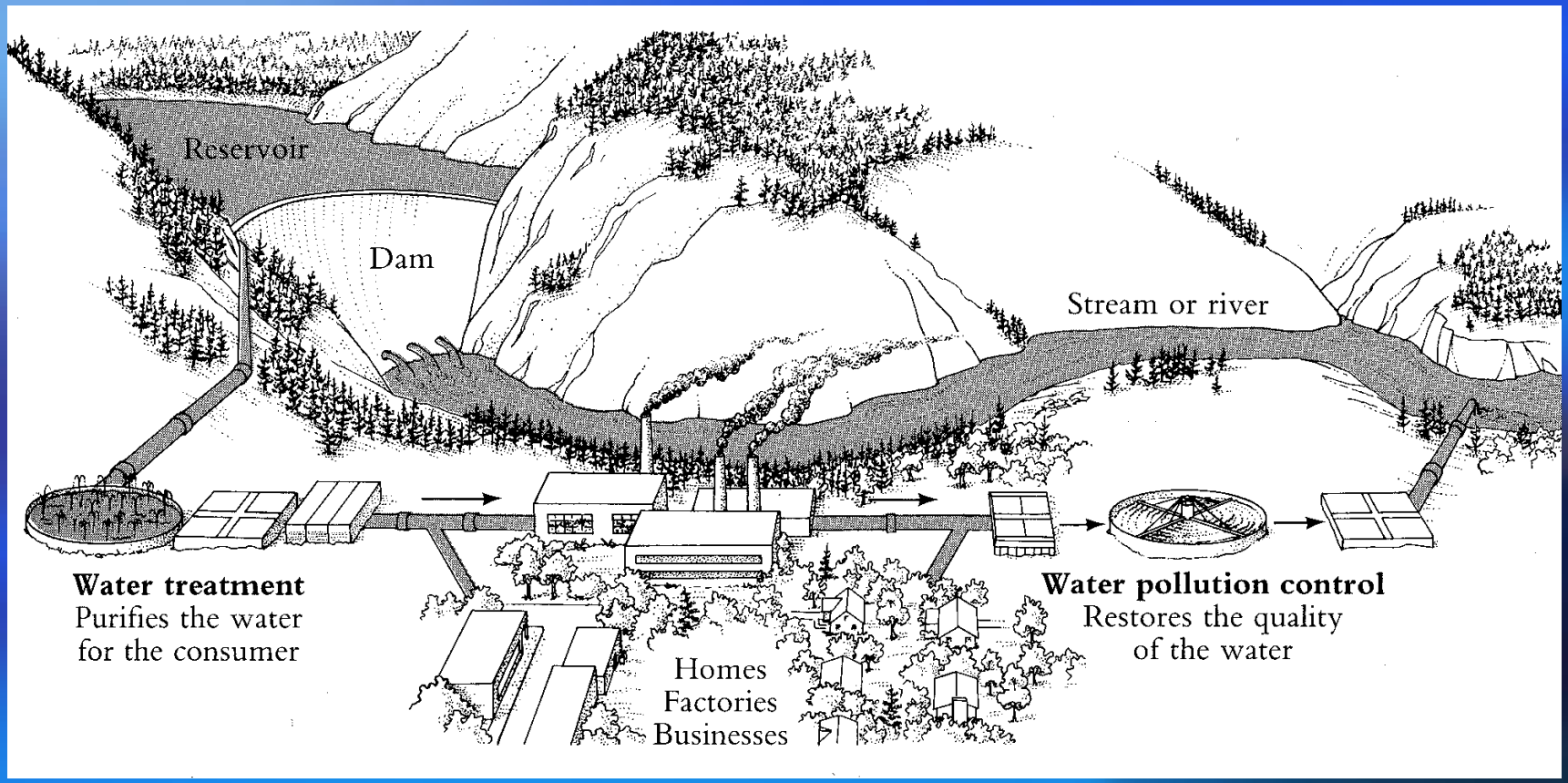
(b) Land use



(c) Soil erodibility

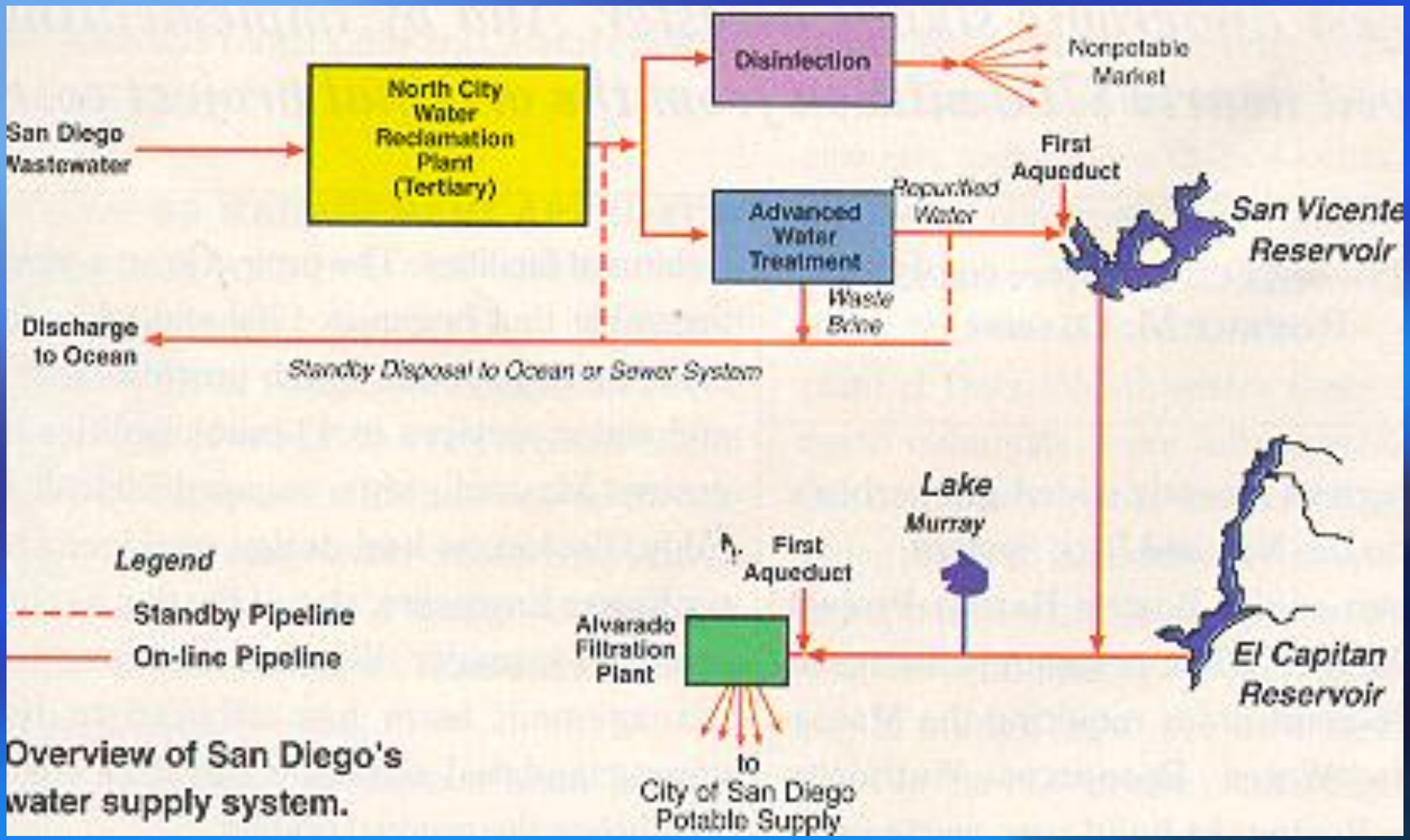
3. Wastewater Re-use（廢水再利用）

Traditional Environmental Engineering Systems（傳統方法）



Reference:
Liu, C.C.K. (2002). Wastewater Reuse, In: *the McGraw-Hill 2002 Yearbook of Science & Technology*, Published by the McGraw-Hill Book Co., pp. 406-409.

Modern Water and Wastewater Engineering Systems with Wastewater Reuse（當代水環境工程之廢水再利用方法）



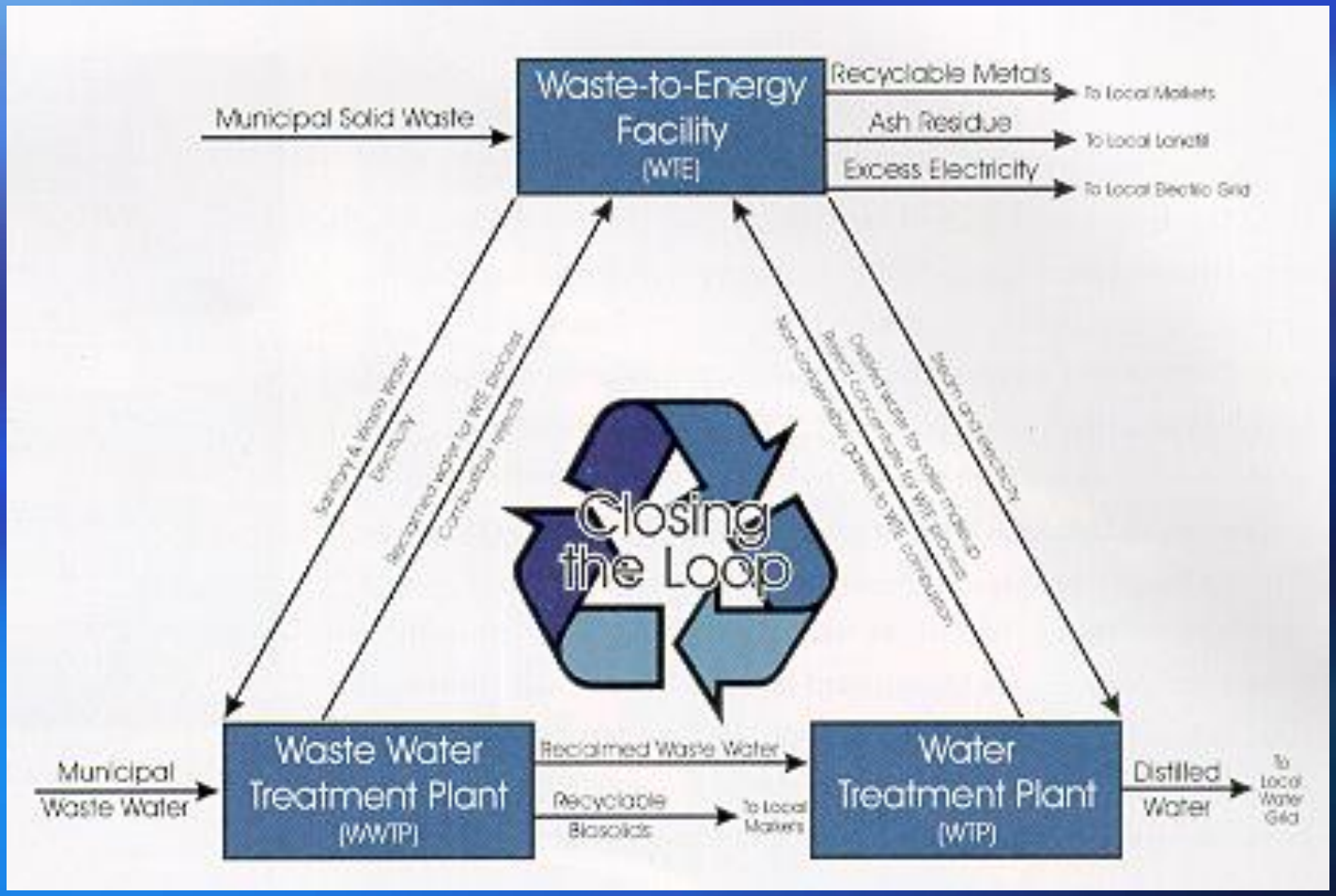
Overview of San Diego's water supply system.

Reference:
Richardson, T. and Trussel, R. Taking the Plunge, Civil Engineering ASCE, Vol.67, No.7, pp.42-45, 1997

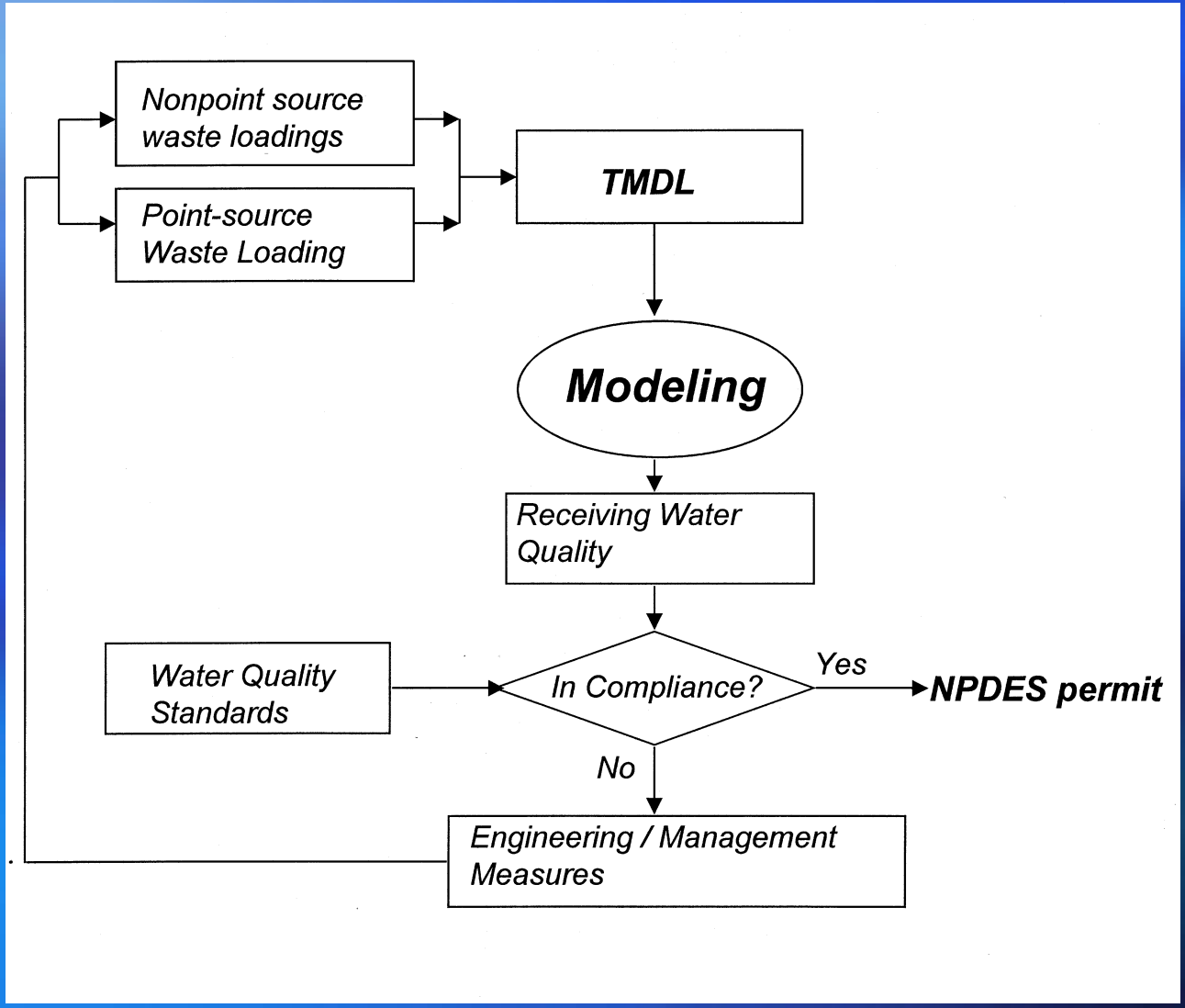
II. Key Research Areas of Environmental Engineering in 21th Century

（ 21世紀水環境工程重要研究領域）

1. Integrating Treatment Technology（整合性的處理技術）



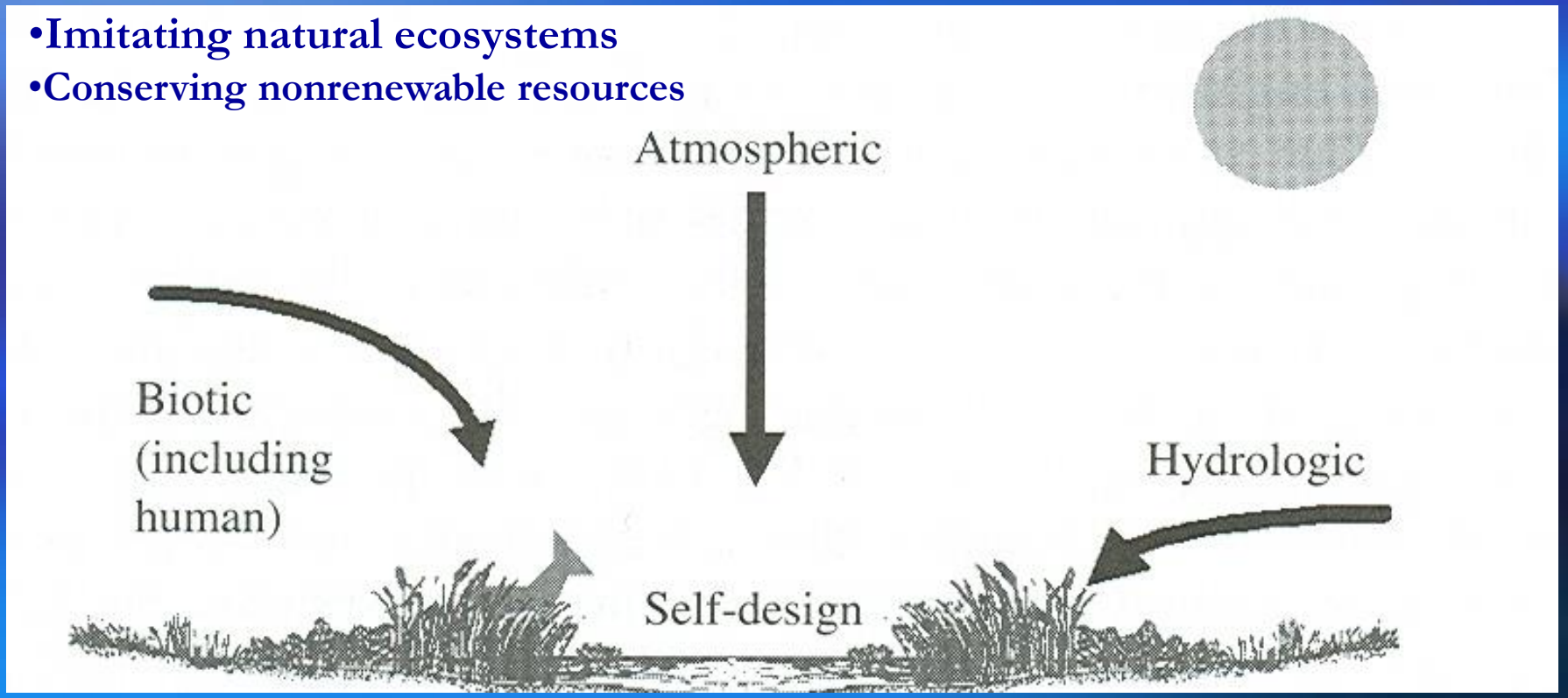
2. Non-point Source Pollution Control （非點源污染控制）



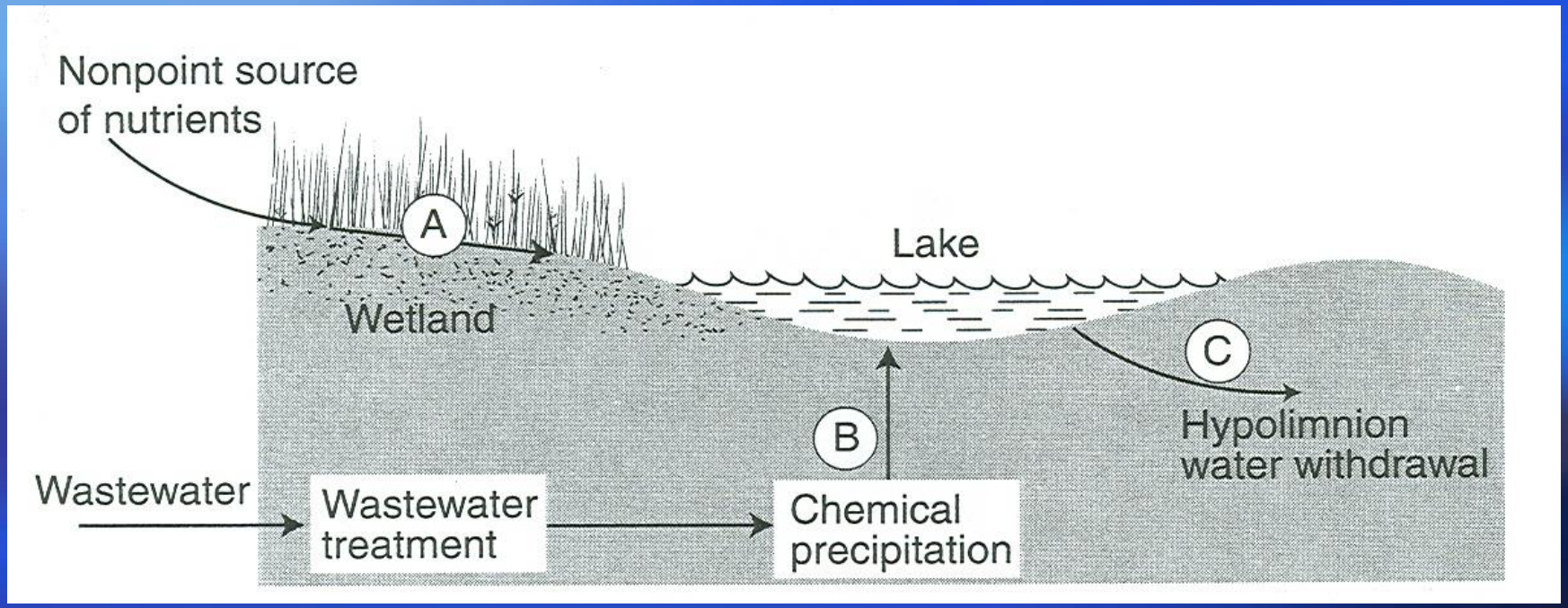
Application of Ecological Engineering
生態工程的應用

Ecological engineering utilizes the Self-Designing Capacity of Ecosystems

- Imitating natural ecosystems
- Conserving nonrenewable resources



Application of Ecological Engineering for Lake and Reservoir Restoration
生態工程在湖泊及水庫復育上之應用

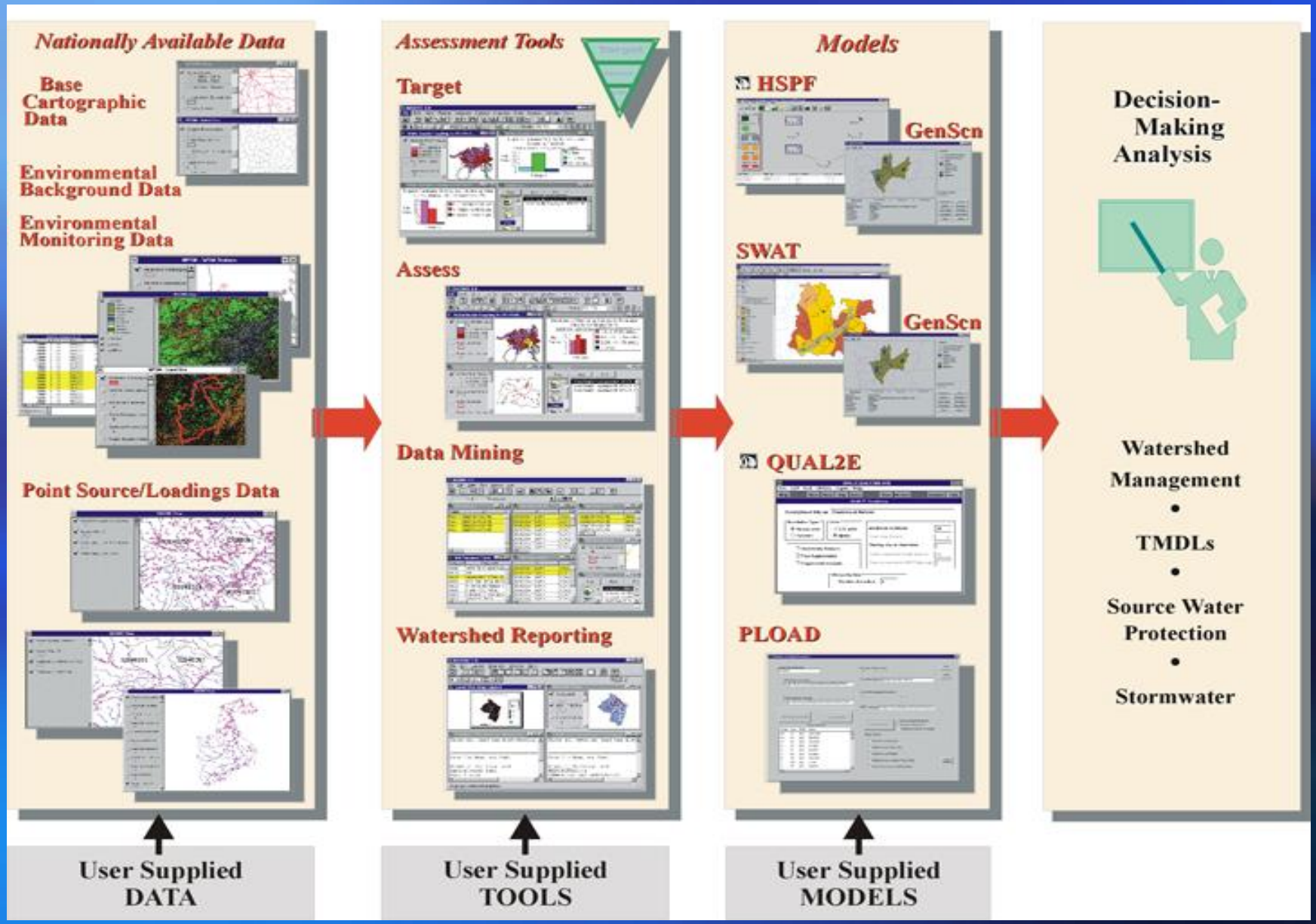


A Ecological Engineering

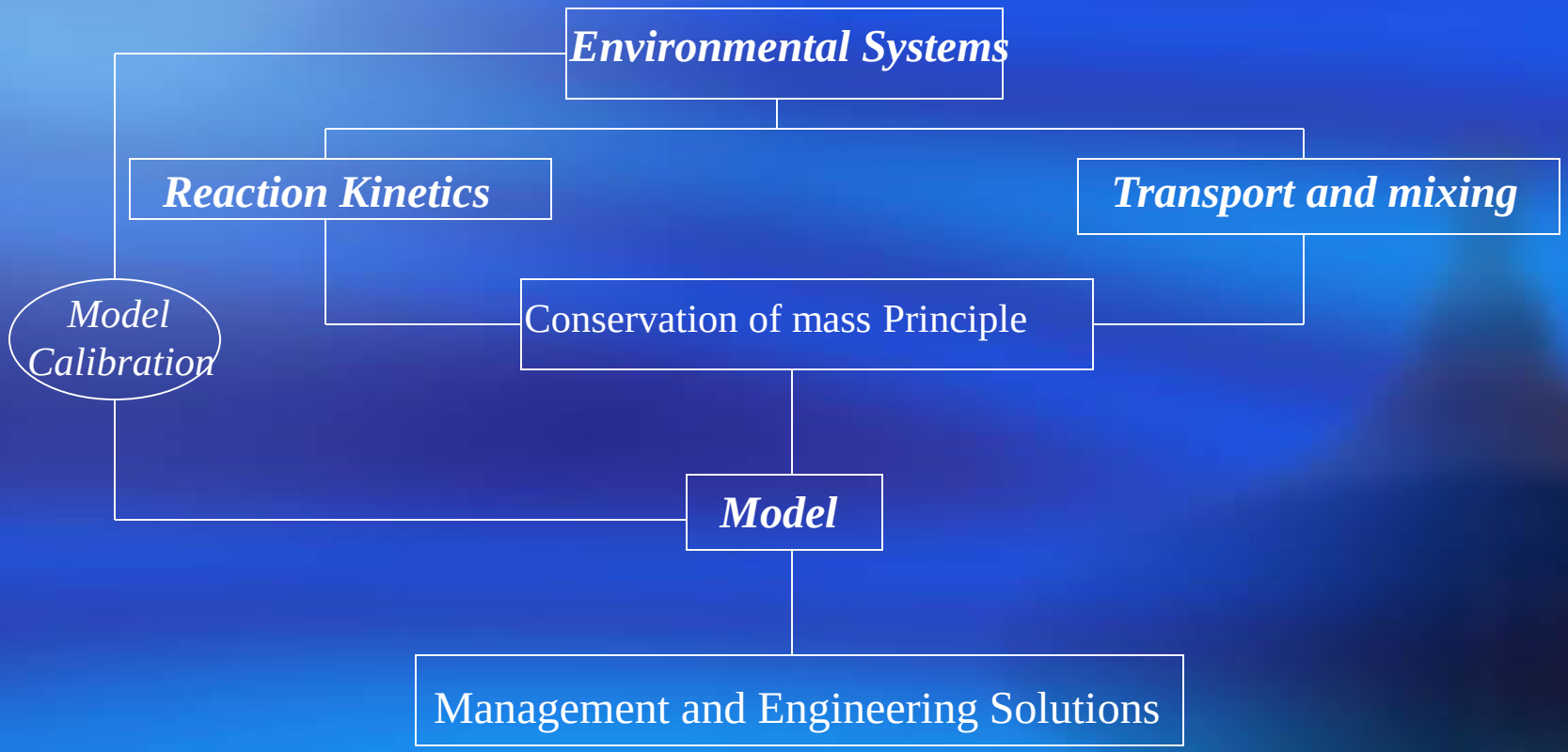
B and C Conventional Environmental Engineering

A New Approach to Watershed Modeling (集水區模擬之新方法）

(US EPA BASINS Model)



3. Contaminant Fate and Transport
（污染物在環境之傳輸）



Research on Reaction Kinetics（反應動力學研究）

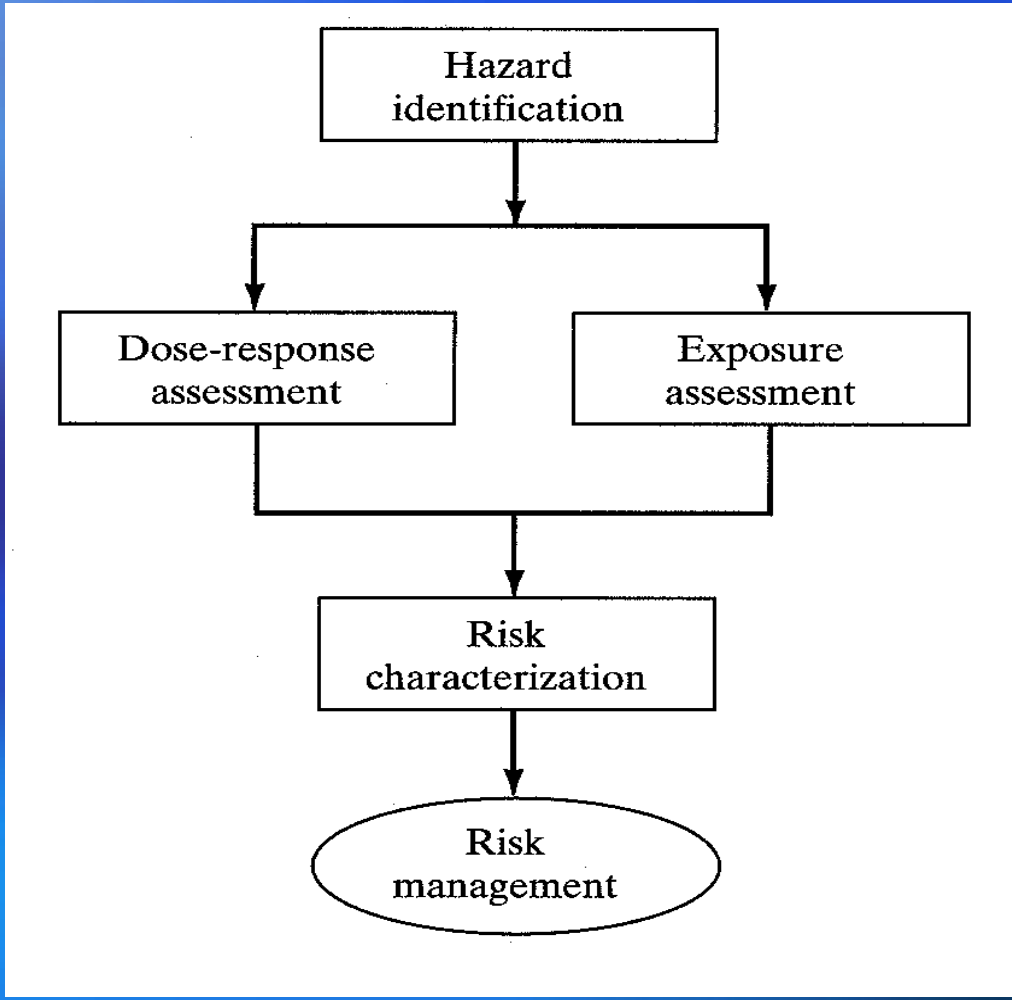
- Environmental processes at molecular scale
- Molecular biology of biodegradation
- Micro-sensors
- Interface transfer
- Transport and transformation processes in Membrane Bioreactors

Research on Environmental Fluid Mechanics
（環境流體力學研究）

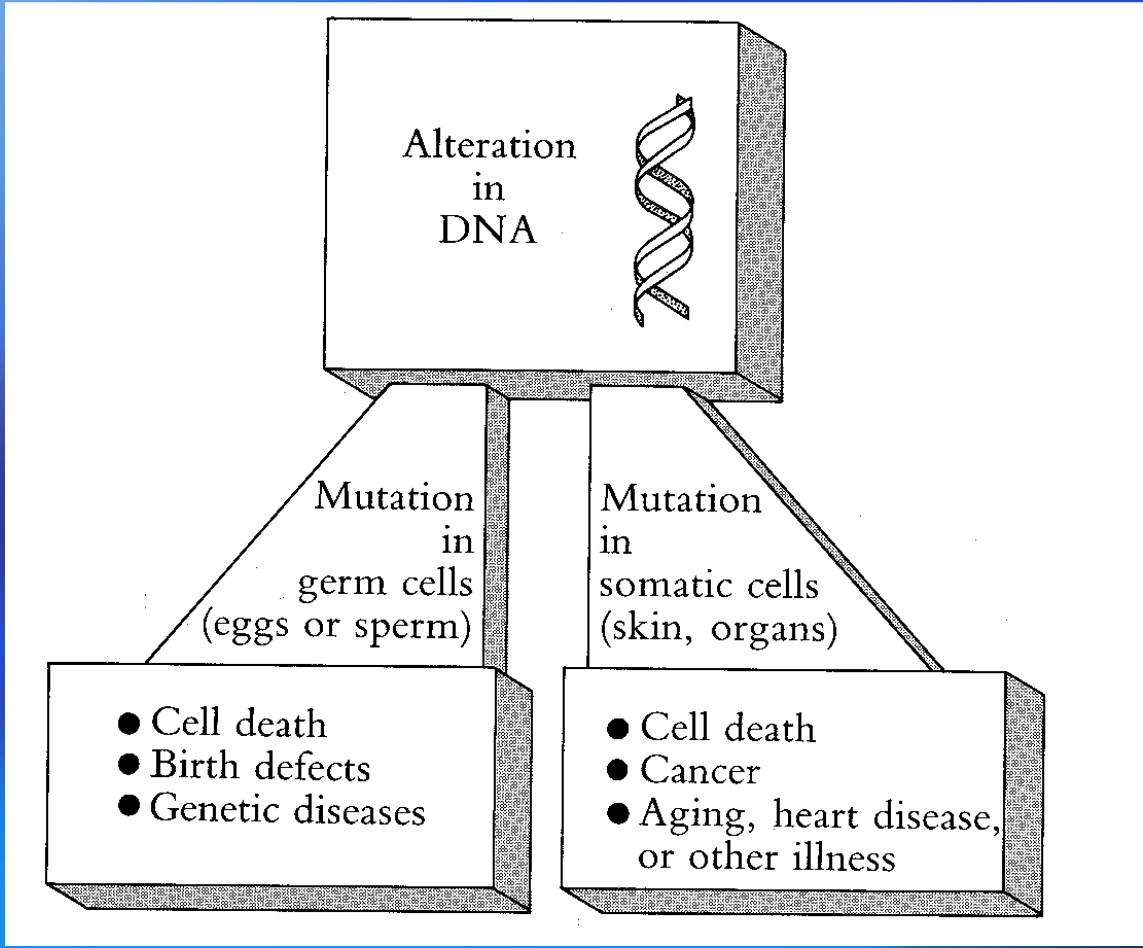
- Turbulent mixing in the environment
- Multi-phase flow and transport
- Computational Environmental Fluid Mechanics

Reference:
Cheng, A.H., Liu, C.C.K., Shen, H., Teng, M., and Wang, H.W. (2002). Fluid mechanics – An essential part of an environmental Engineering curriculum, *ASCE Journal of Professional Issues in Engineering Education and Practice*, *American Society of Civil Engineers,* Vol.128, No. 4, pp. 201-205.

4. Integrated Risk Assessment
（整合性風險評估）



Dose-Response Assessment: New Methods to determine Potency of Carcinogens（毒性物質反應劑量評估：鑑定致癌潛勢新方法）



Reference:
US EPA,Technology Transfer Report, EPA-625/9-79-003, Short-Term Tests for Carcinogens, Mutagens and other Genotoxic Agents..

New Methods for the Environment Assessment（環境問題之評估方法）

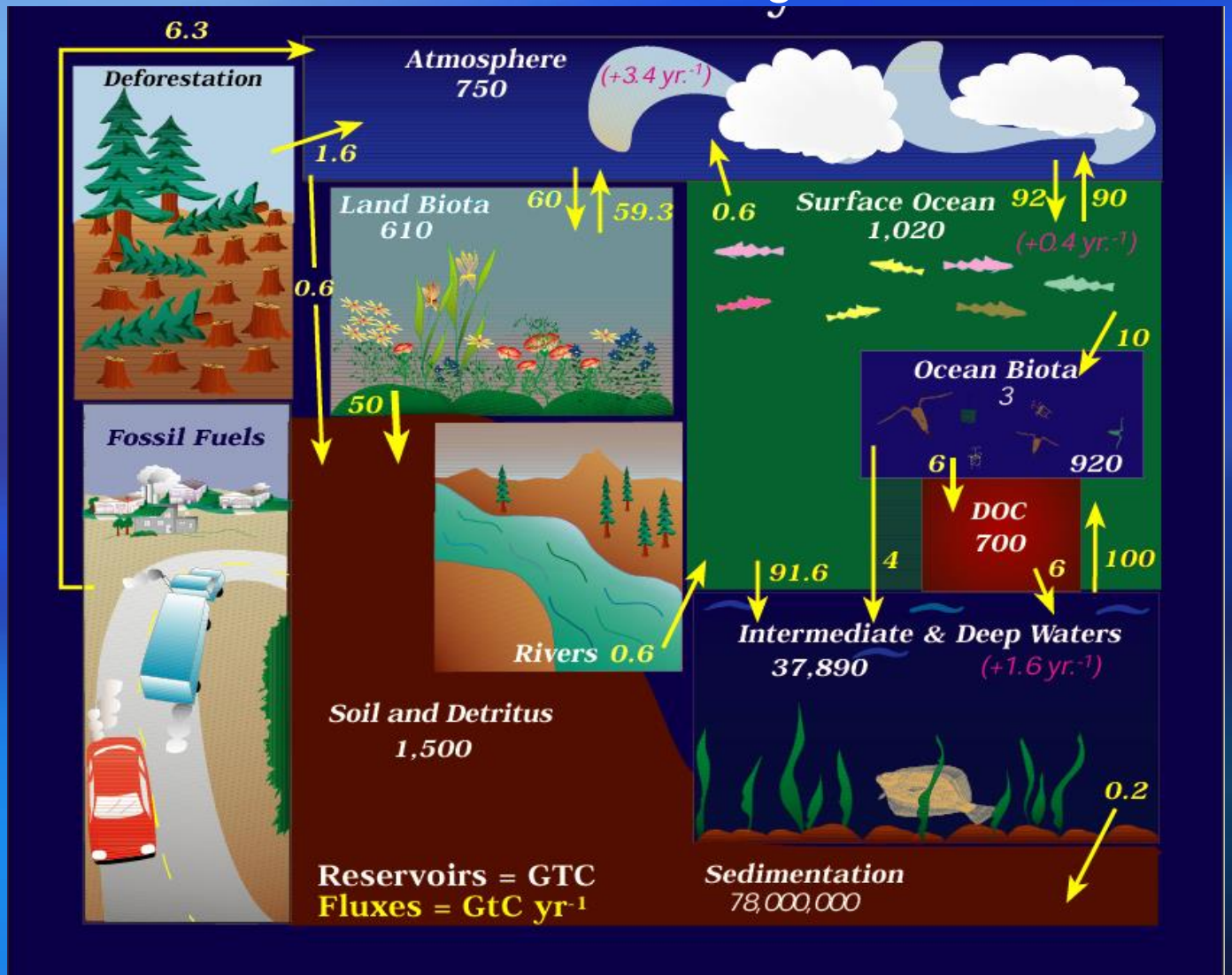
- Sensors and probes
- Profilers and arrays
- Remote sensing techniques
- Cyber-infrastructure

5. Emerging High Technology in Environmental Engineering
（應用於環境工程之高科技技術）

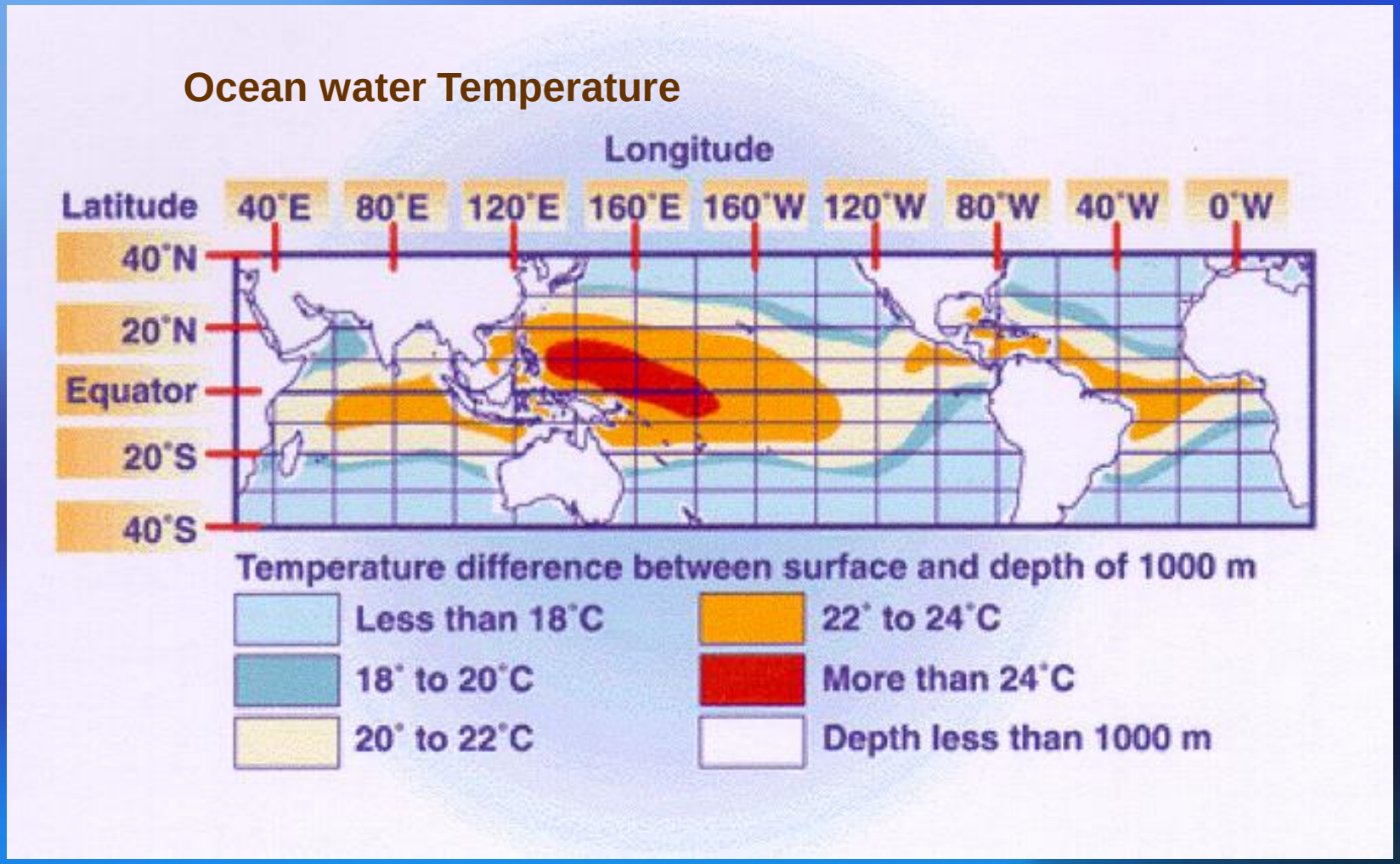
- Biotechnology in Water/Wastewater Treatment
- Membrane Technology
- Internet and Data sharing
- Internet and Environmental System
- Stochastic Modeling

6. Complex Environmental Systems and Global Environmental Problems（多元性環境系統及全球環境問題）

CO_2 Accumulation and Global Warming

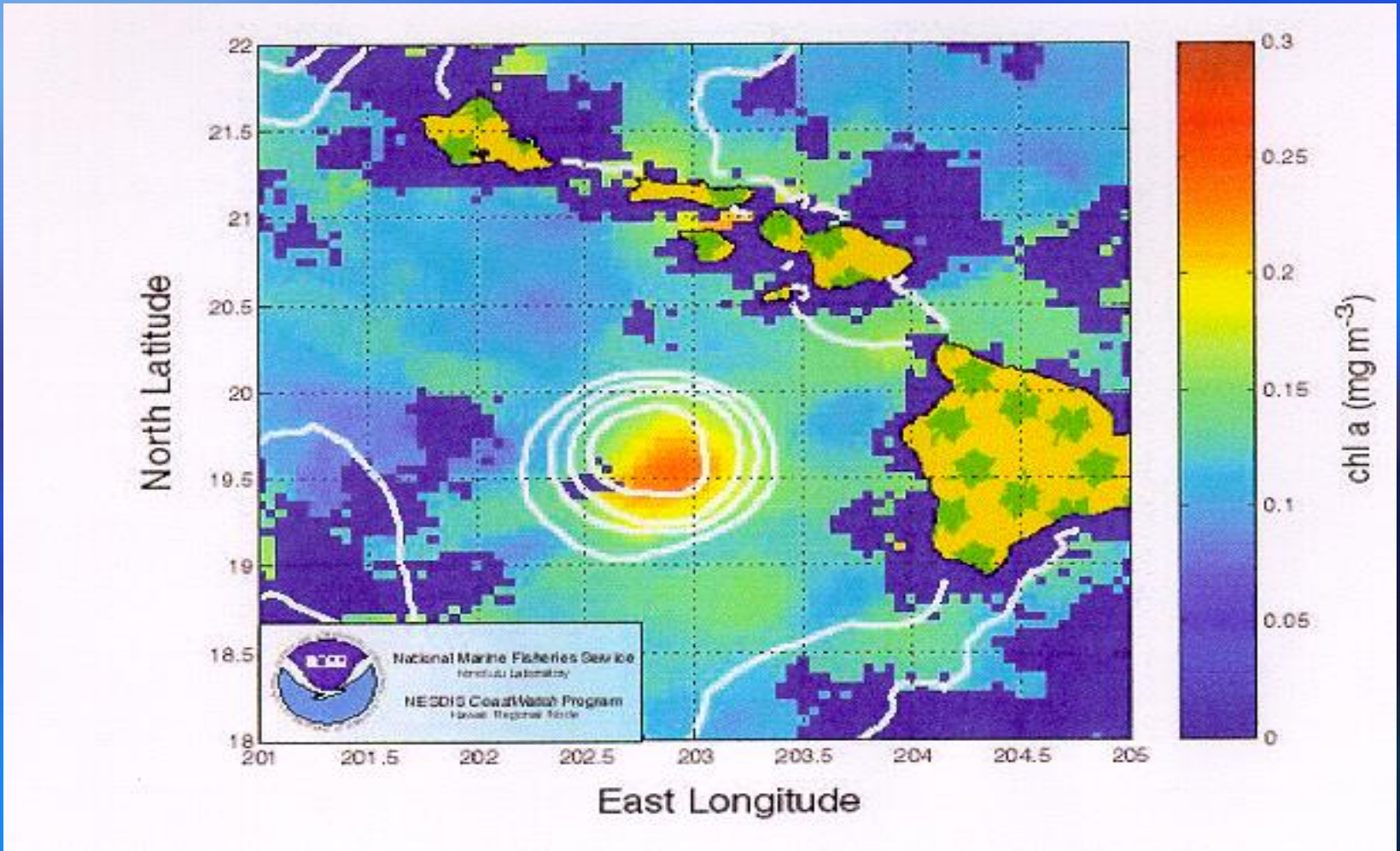


A Potential Blue Ocean Solution to a Green-House Problem
（用人工湧昇流水解決溫室效應問題）



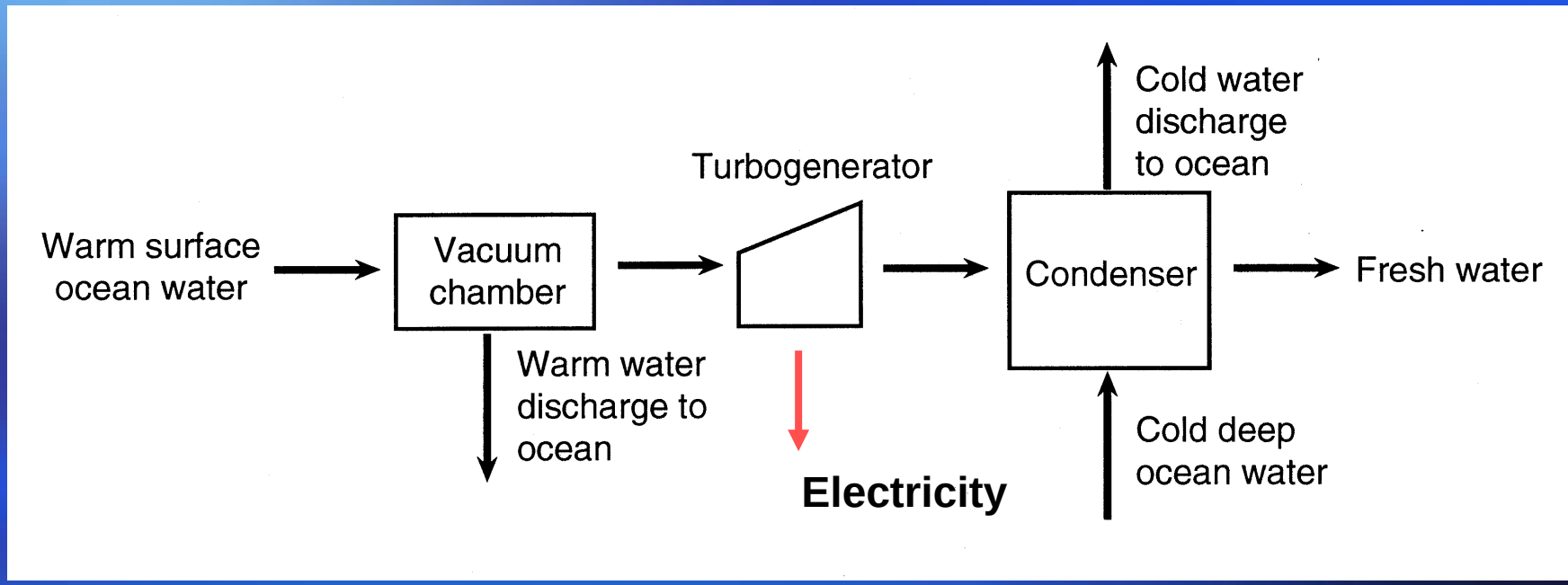
Reference:
Liu, C.C.K. (1999). Research on Artificial Upwelling and Mixing at the University of Hawaii at Manoa, *IOA Newsletter, International OTEC/DOWA Association* Vol.10, No.4, pp.1-8.

Natural Upwelling and Enhanced Primary Productivity（天然湧昇流增加海水初步生產力）

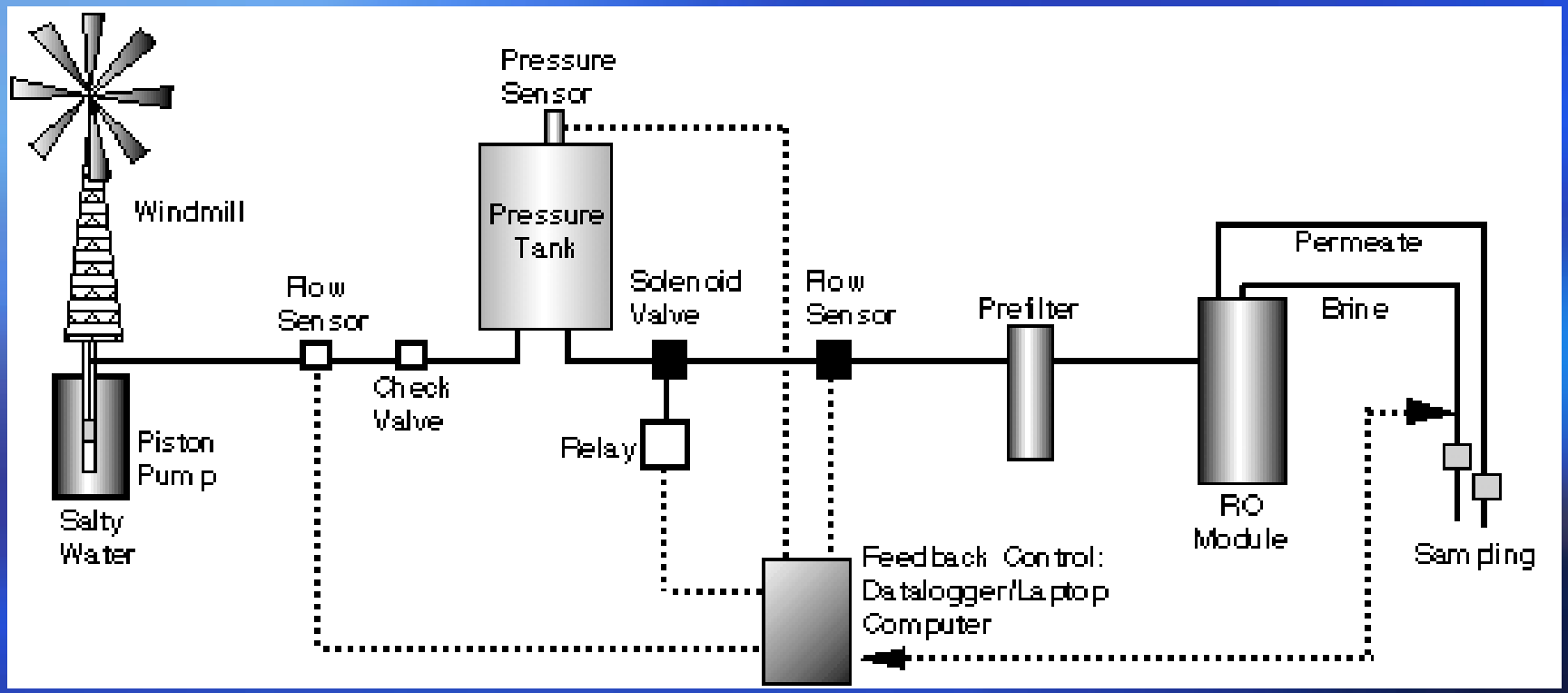


7. Concerted Resources/ Energy Development（資源及能源之配合開發）

An Open-Cycle OTEC Desalination System



Wind Driven RO desalination Developments （風力RO海水淡化）

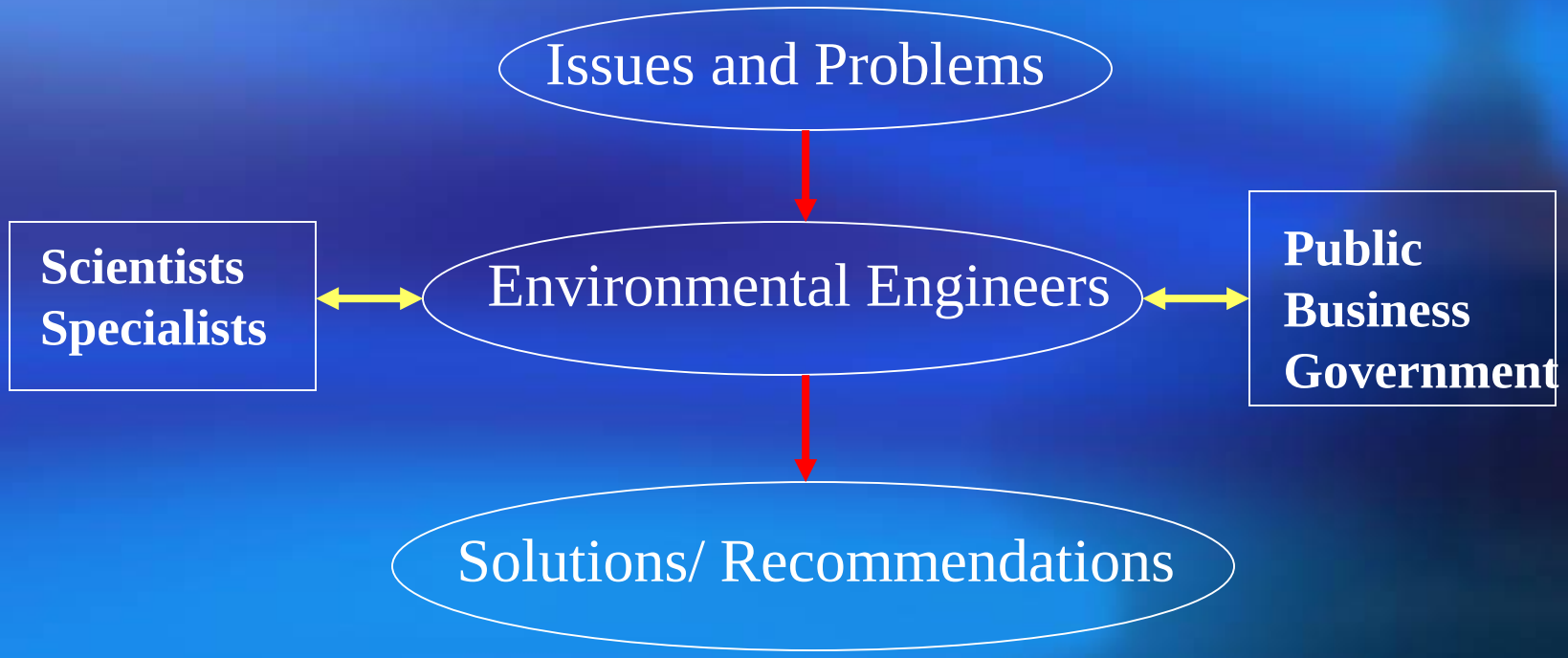


Reference:
Liu, C.C.K. Park, J. W., Migita, J. and Qing, G. (2002). Experiments of a prototype wind-driven reverse osmosis desalination system with feedback control, *Journal of Desalination*, Vol. 150, No. 3, pp. 277-287.

Field Experimental Site of wind driven reverse osmosis Processes
Coconut Island, Oahu, Hawaii（風力海水淡化試驗場，夏威夷）

III. Environmental Engineering Education and Practice （環境工程教育及實務）

A. Interdisciplinary Approach (跨科系的研究教學)



An Expanding Curriculum of Environmental Engineering（環境工程課程）:

- Water and wastewater treatment
- air pollution control
- water and air resource management
- industrial and hazardous waste management
- solid waste management
- contaminated site investigation and remediation
- pollution prevention
- environmental chemistry
- aquatic ecology
- environmental toxicology
- public health engineering
- environmental policy management

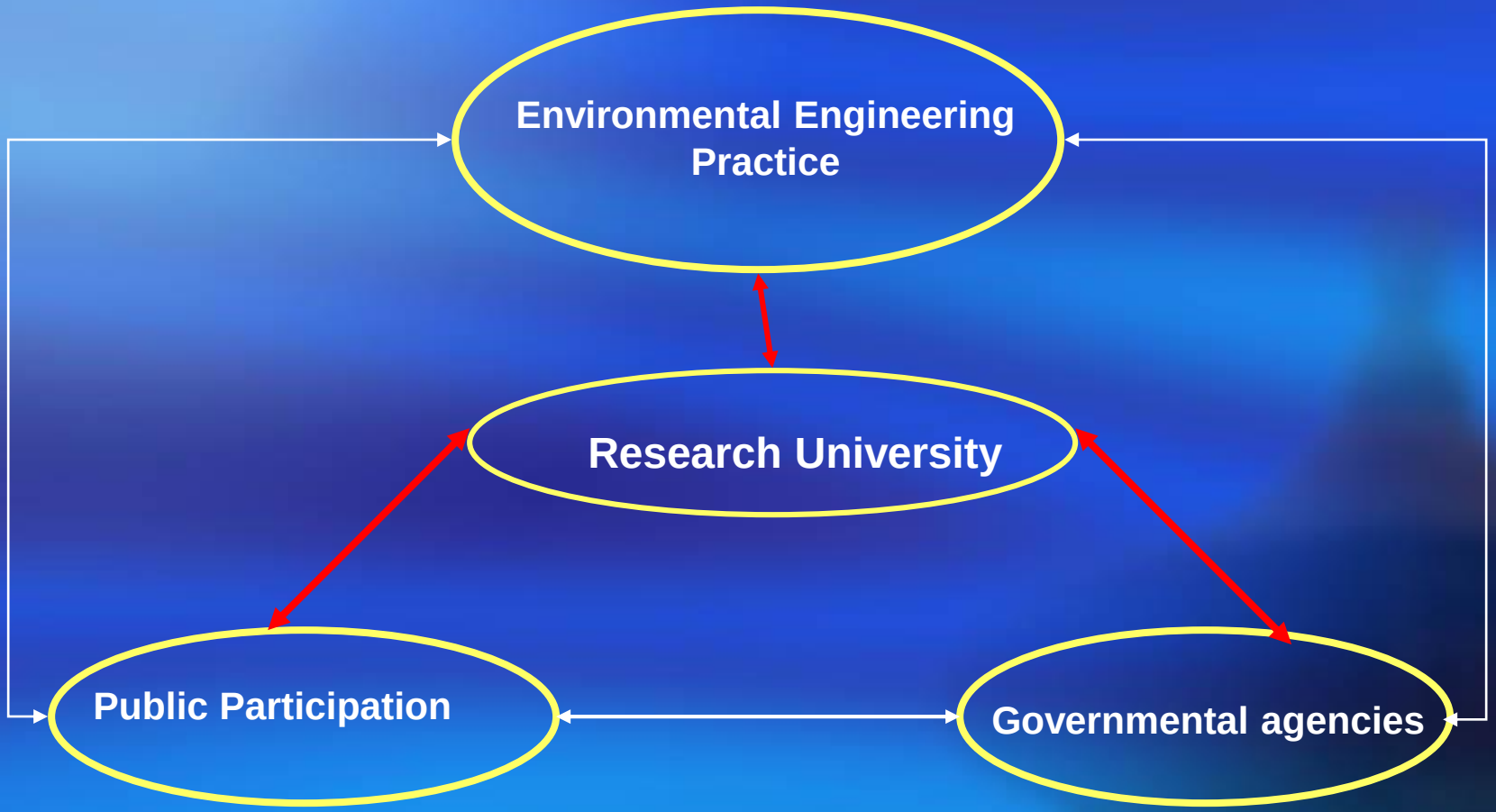
My vision of an environmental engineering education in the 21th century（21世紀環境工程教育之前瞻）

(1) To train our future environmental engineers with knowledge and skills to identify and solve environmental problems.

(2) To introduce our future environmental engineers to other relevant fields of physical and social sciences such that they can work together with other professionals to achieve a sustainable society.

(3) To make the future environmental engineering profession a life-long learning and exploration process.

B. Coordinated efforts for Environmental Conservation (環境保護工作上之協調)



Concluding Remarks（小結）

1. Human health and environmental well-being can be protected and improved by a balanced development of energy and resources.
2. Environmental engineering will play a key role in achieving this goal.
3. In order to face the challenge, Environmental Engineering must be re-defined and modernized .