Implementation of Integrated Water Management Plans for Sustainability

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Outline

I. Introduction

- I-1. Climate Change Impacts on Water Quality
- I-2. Adaptation policy
- I-3. Adaption Strategies
- I-4. National Sustainable Development Guideline

II. Integrated Watershed Management Plans

- II-1. Water Quality and Esthetic
- II-2. Conservation Approaches and Tools
- II-3. Water Front
- II-4. Administration Efficiency and Effectiveness
- II-5. Public Participation

III. Security and Sustainability of Water Supply System

- III-1. Optimization of Water Treatment Plant
- III-2. Implementation of Water-Reuse Policy in Ecological Industrial Park

IV. Conclusions and Recommendations

I. INTRODUCTION:

I-1. Climate Change Impacts on Water Quality

- **Reduction of oxygen content**
- **Alteration to habitats and distribution of aquatic organisms**
- **Bacteriological conditions and incidence of pathogens**
- **Alterations to thermal stratification and mixing of water in lakes (Dokulil et al., 2006)**
- **Change of nutrient cycling in aquatic systems and algal blooms.**
- **Increase of nitrogen mineralization and nitrification processes in the soils (Whitehead et al., 2002; 2006)**

I-2. Adaptation Policies

- The first priority for adaptation should be to reduce the vulnerability of people and societies to shift in hydro-meteorological trends, and extreme events.
- The second priority should be to protect and restore ecosystems that provide critical land and water resources and services.
- The third priority should be to close the gap between water supply and demand.

Reference: Climate Change and Water Adaption Issue, European Environment Agency technical report, 2007

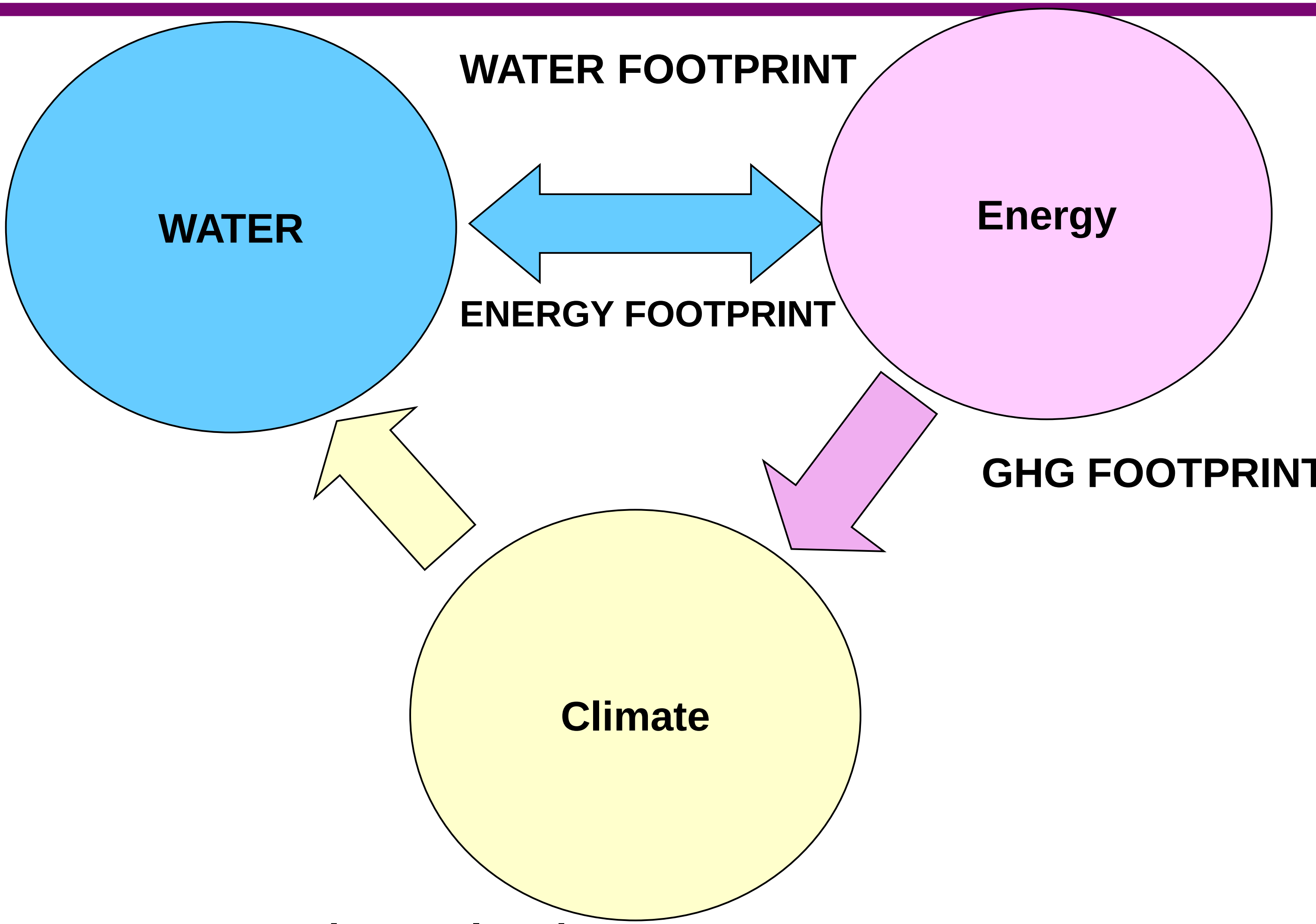
4

I-3. Adaption Strategies

- Increase reservoir capacity
- Increase transfers of water
- Implement water efficiency schemes
- Scale-up programmes of coastal protection
- Upgrade wastewater and storm-water systems
- Build resilient housing
- Modify transport infrastructures
- Install or adopt crop irrigation measures
- Make room for rivers
- Create wildlife corridors

Reference: Willows and Connell, 2003

Water → Energy → GHG footprints

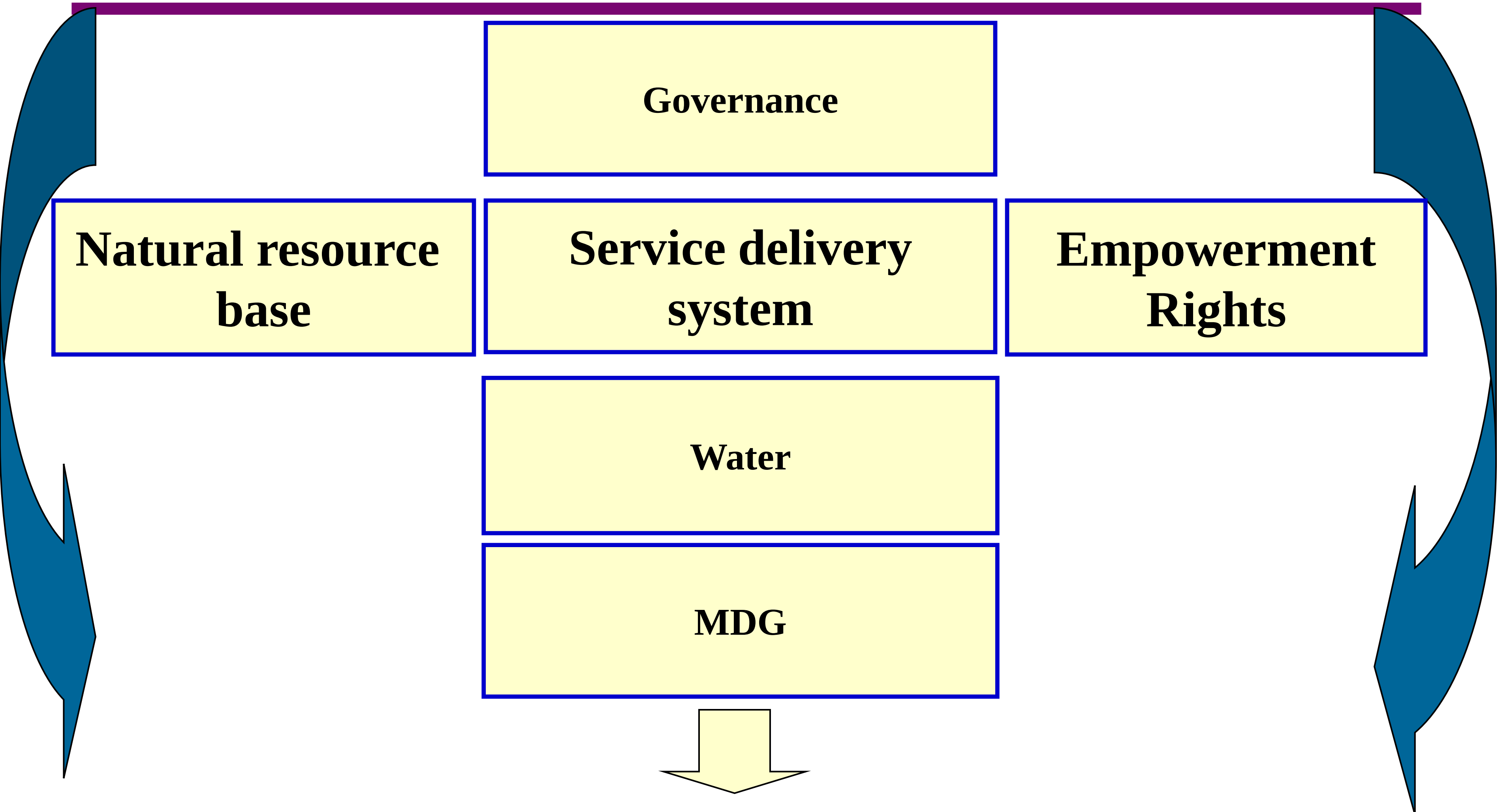


An inter-related system!

Reference: Clausen and Ipsen, 2008

6

The governance-water- climate link



Good water governance critical to Millennium Development Goals (MDG) achievement and adaptation to climate change

Reference: Clausen and Ipsen, 2008

7

Energy and water development are inter-related

<u>Water for energy</u>

Energy and power production requires water:

- **Thermoelectric cooling**
- **Hydropower**
- Minerals extraction and mining
- Fuel production (fossil, non-fossil)
- **<u>Bio-fuels</u>** **<u>(-fuelling food crisis!)</u>**

<u>Energy for water</u>

Water production, processing, distribution, and end-use requires energy:

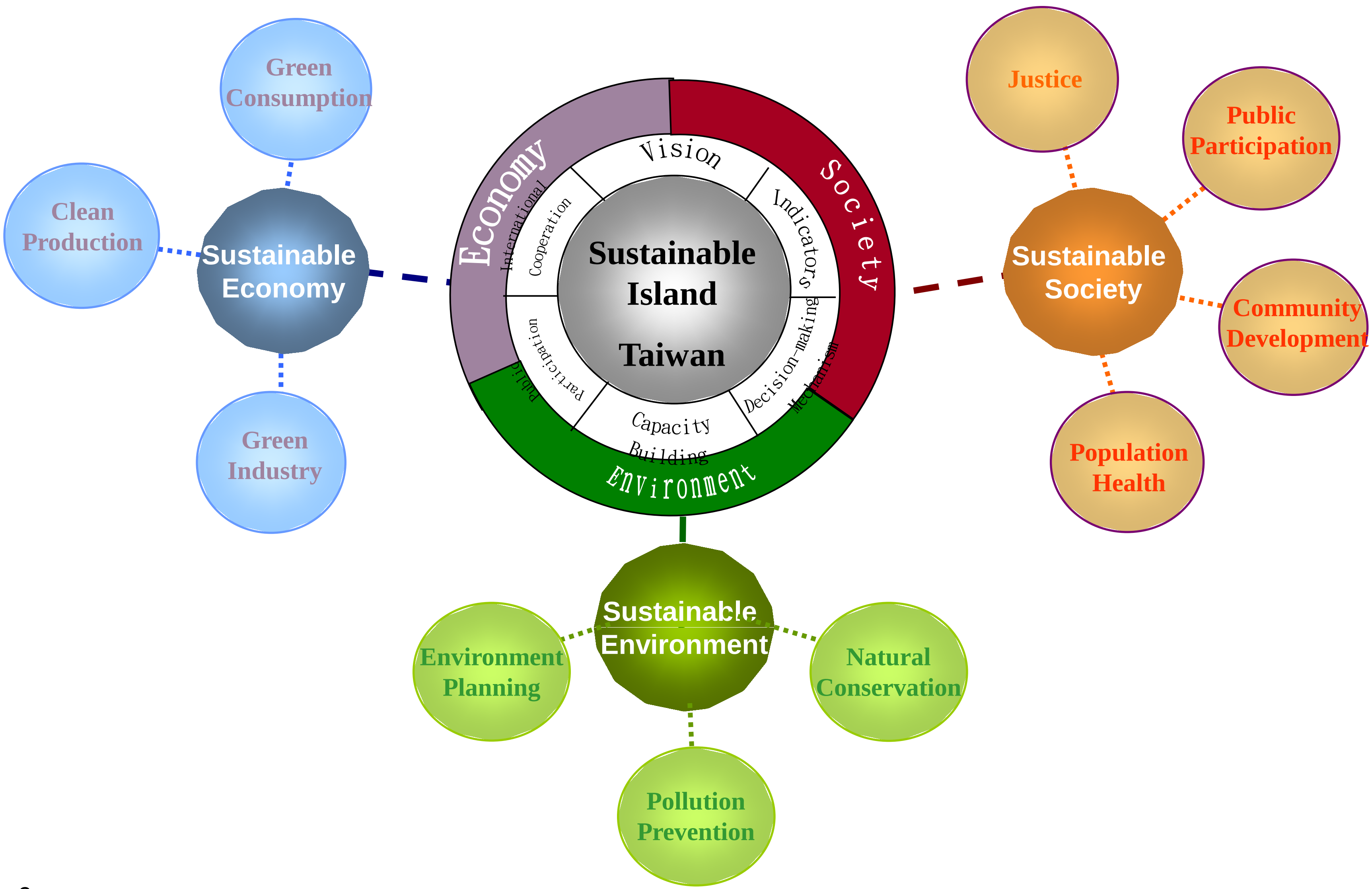
- **<u>Pumping</u>**
- Transport
- Treatment
- Raw water (GW,SW)
- **Desalination**

Water footprints for energy development

Energy footprints for water development

Reference: Clausen and Ipsen, 2008

I-4 National Sustainable Development Guideline



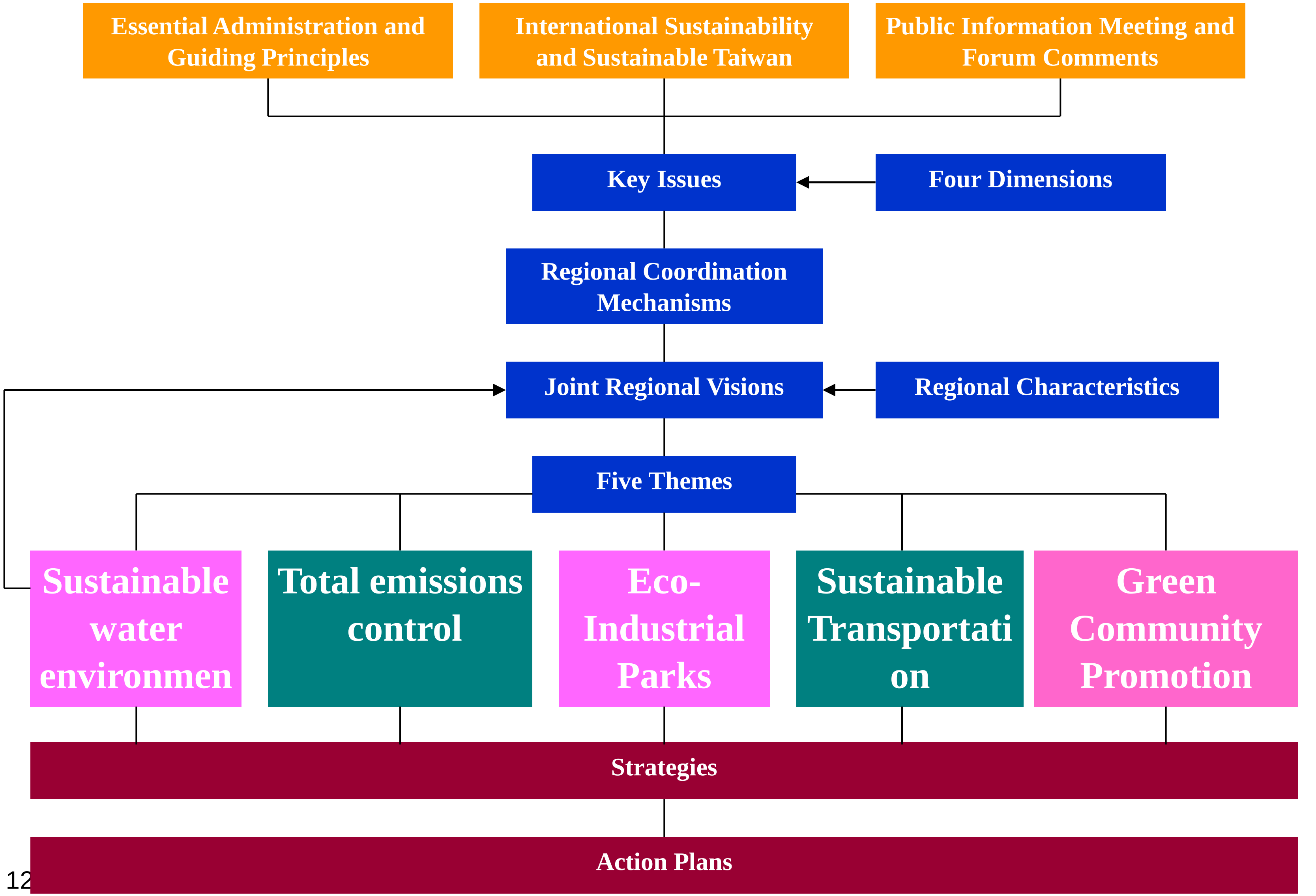
Sustainable Environment Guidelines

- Pollution prevention and treatment policy emphasizes effectiveness
- Nature conservation policy focuses on pre-emptive measures.
- Environmental planning policy stresses the sustainable use of resources

Local Agenda 21: Environmental Action Plan Towards Sustainability

11

Local Agenda 21: Environmental Action Plan Towards Sustainability



12

II. Integrated Watershed Management

- Promote national soil conservation plan, establish impact response plan in water resource, agriculture, public health, and infrastructure.
- Establish a sustainable reservoir management plan.
- Development of integrated and multimedia watershed management plans for the potential hazard and intensively used watersheds.
- Adopt low carbon generation land use model

Implementation of Integrated Watershed Management Plan (IWMP)

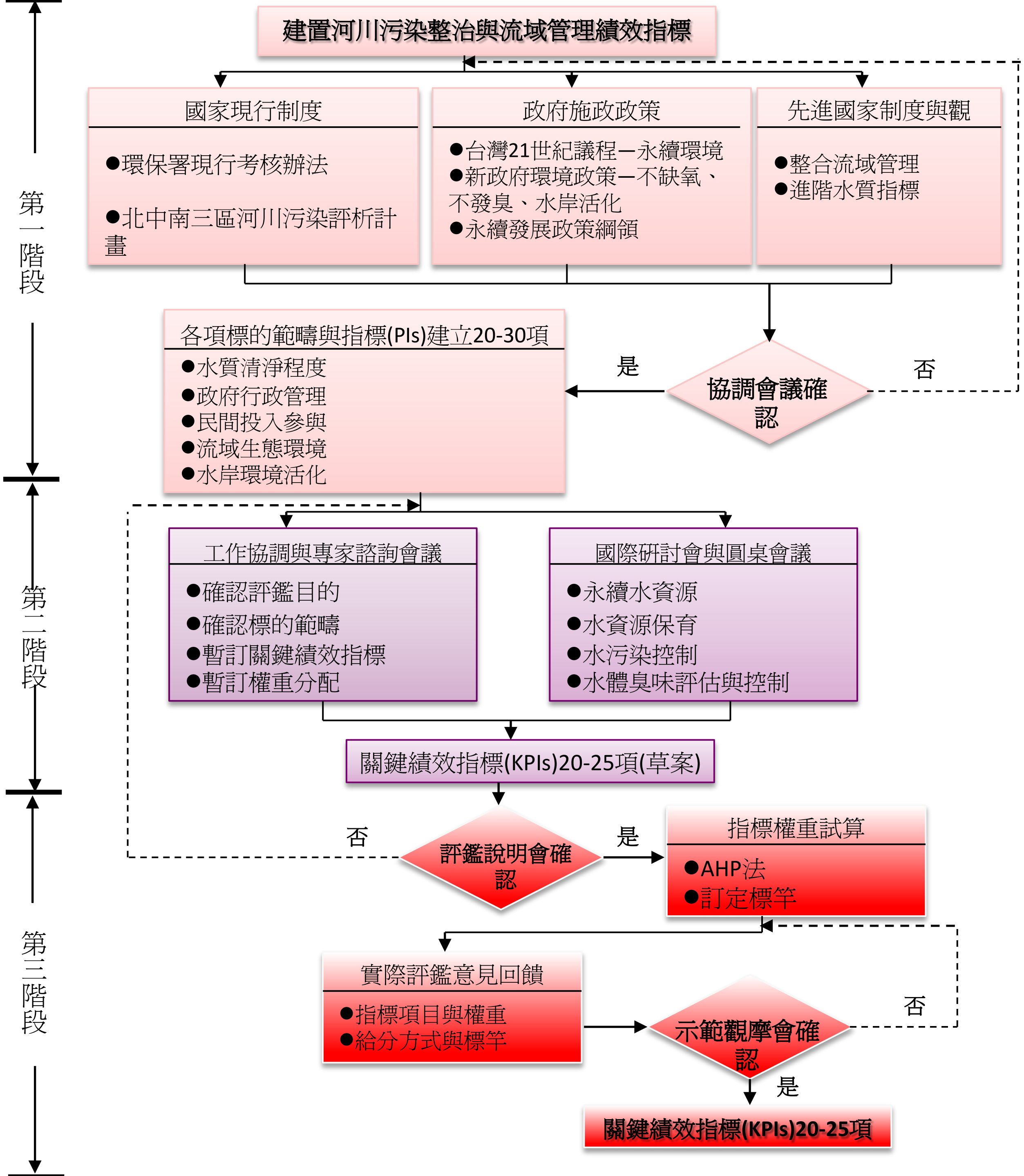
- **The IWMP across political and administrative boundaries by bringing together all interests upstream and downstream.**
- **The IWMP considers not only technical, but also socio-economic and ecological aspects.**
- **The IWMP focuses on complex decision-making that involves multi-disciplinary teams.**
- **The IWMP addresses specific social and economic needs in addition to the protection to natural resource and ecological health.**

- **KPIs for IWMP should be politically accountable, socially acceptable, technically executable, and economically affordable.**

建置河川整治成效評量指標方法

- 指標選擇須滿足下列標準 Richard (1999)
  - 關聯性(Relevance)：確認該指標對未來發展具關鍵影響
  - 可行性(Practicability) : 有實際、可靠及可利用之量測或監測方法
  - 合適性(Appropriateness) : 指標可反映出真實之影響，且和長期目標相符
- 指標之三項通用條件 (Prahbu, 2002)
  - 選擇指標須與評估或監測目標相關
  - 指標應傳遞生態與社會趨勢，其訊息可作為政策或管理反應依據
  - 應充分了解指標非線性特性及補償作用

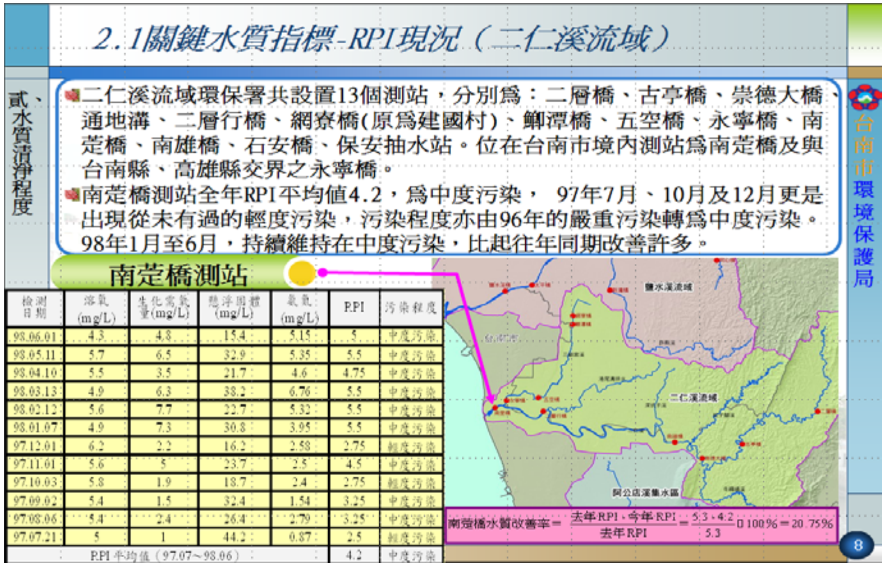
願景策略綱領與指標之關聯性


建置河川污染整治與流域管理績效指標
第一階段
國家現行制度
●環保署現行考核辦法
●北中南三區河川污染評析計畫
政府施政政策
●台灣21世紀議程—永續環境
●新政府環境政策—不缺氧、不發臭、水岸活化
●永續發展政策綱領
先進國家制度與觀
●整合流域管理
●進階水質指標
協調會議確認
是
否
各項標的範疇與指標(PIs)建立20-30項
●水質清淨程度
●政府行政管理
●民間投入參與
●流域生態環境
●水岸環境活化
第二階段
工作協調與專家諮詢會議
●確認評鑑目的
●確認標的範疇
●暫訂關鍵績效指標
●暫訂權重分配
國際研討會與圓桌會議
●永續水資源
●水資源保育
●水污染控制
●水體臭味評估與控制
關鍵績效指標(KPIs)20-25項(草案)
第三階段
評鑑說明會確認
否
是
指標權重試算
●AHP法
●訂定標竿
實際評鑑意見回饋
●指標項目與權重
●給分方式與標竿
示範觀摩會確認
否
是
關鍵績效指標(KPIs)20-25項

指標訂定方法流程

II-1. Water Quality and Esthetic (25%)

1. **Criteria contaminants**
2. **Eutrophication**
3. **Hazardous contaminants**
4. **Amenity**
   - □ **Clearness and sanitary**
   - □ **Smell and odor**



2.1關鍵水質指標-RPI現況（二仁溪流域）

貳、水質清淨程度

二仁溪流域環保署共設置13個測站，分別為：二層橋、古亭橋、崇德大橋、通地溝、二層行橋、網寮橋(原為建國村)、鯽潭橋、五空橋、永寧橋、南萣橋、南雄橋、石安橋、保安抽水站。位在台南市境內測站為南萣橋及與台南縣、高雄縣交界之永寧橋。

南萣橋測站全年RPI平均值4.2，為中度污染， 97年7月、10月及12月更是出現從未有過的輕度污染，污染程度亦由96年的嚴重污染轉為中度污染。98年1月至6月，持續維持在中度污染，比起往年同期改善許多。

南萣橋測站

檢測日期	溶氧 (mg/L)	生化需氧量(mg/L)	懸浮固體 (mg/L)	氨氮 (mg/L)	RPI	污染程度
98.06.01	4.3	4.8	15.4	5.15	5	中度污染
98.05.11	5.7	6.5	32.9	5.35	5.5	中度污染
98.04.10	5.5	3.5	21.7	4.6	4.75	中度污染
98.03.13	4.9	6.3	38.2	6.76	5.5	中度污染
98.02.12	5.6	7.7	22.7	5.32	5.5	中度污染
98.01.07	4.9	7.3	30.8	3.95	5.5	中度污染
97.12.01	6.2	2.2	16.2	2.58	2.75	輕度污染
97.11.01	5.6	5	23.7	2.5	4.5	中度污染
97.10.03	5.8	1.9	18.7	2.4	2.75	輕度污染
97.09.02	5.4	1.5	32.4	1.54	3.25	中度污染
97.08.06	5.4	2.4	26.4	2.79	3.25	中度污染
97.07.21	5	1	44.2	0.87	2.5	輕度污染
RPI 平均值（97.07~98.06）					4.2	中度污染

南萣橋水質改善率＝ (去年RPI－今年RPI) / 去年RPI ＝ (5.3－4.2) / 5.3 ×100%＝20.75%

II-1.1. 淡水河—河川污染指標(RPI)

- RPI年平均值最大僅相差0.27，**無明顯差異**，約在中度污染以下。
- **2010年與2011年的1月至10月RPI月平均值有相似的趨勢**
  - 1月至5月的RPI月平均值有增加的趨勢，5月至6月有減少的趨勢
  - 6月至8月則是有增加的趨勢，而8月至12月則又有減少的趨勢。
- 淡水河近年水質**RPI年平均值變動很小**，但

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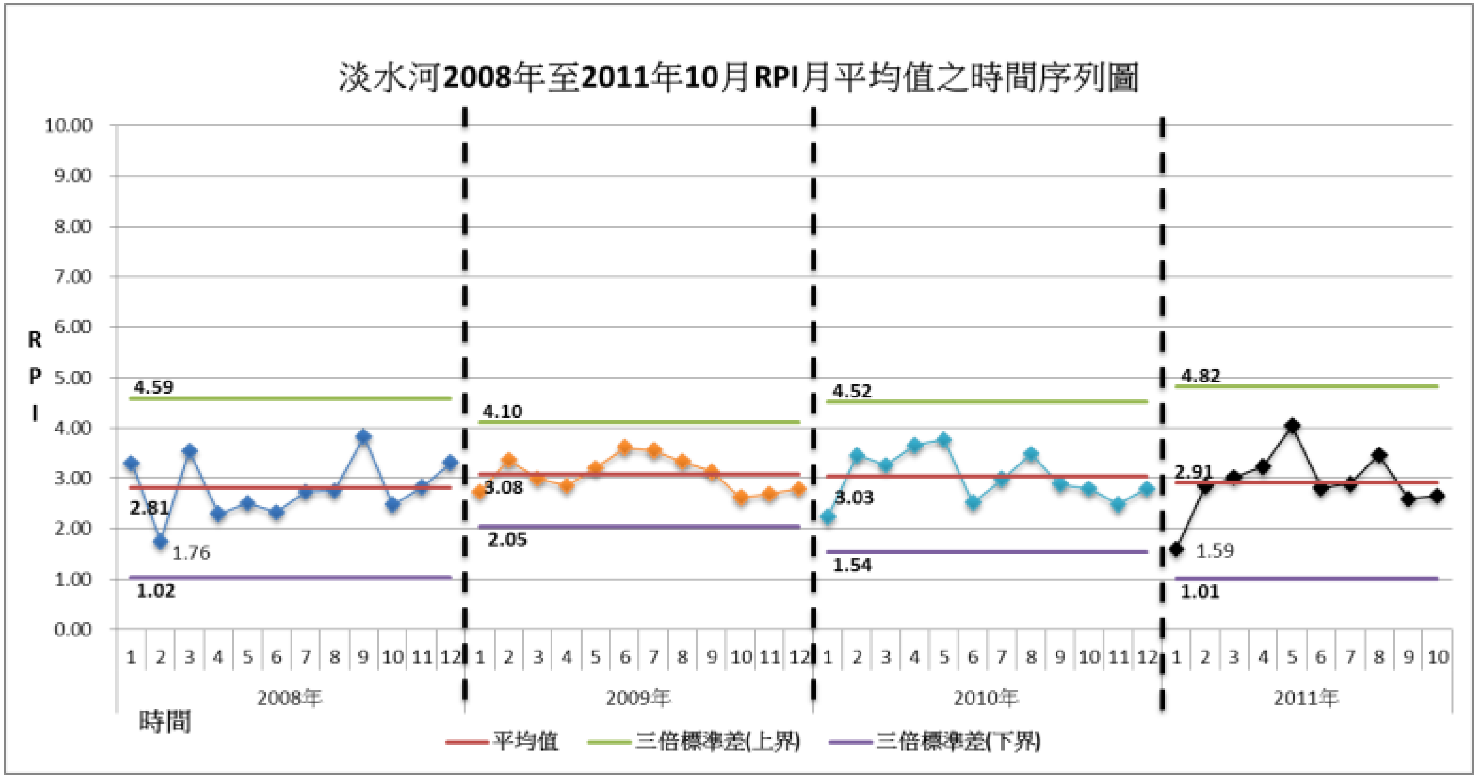
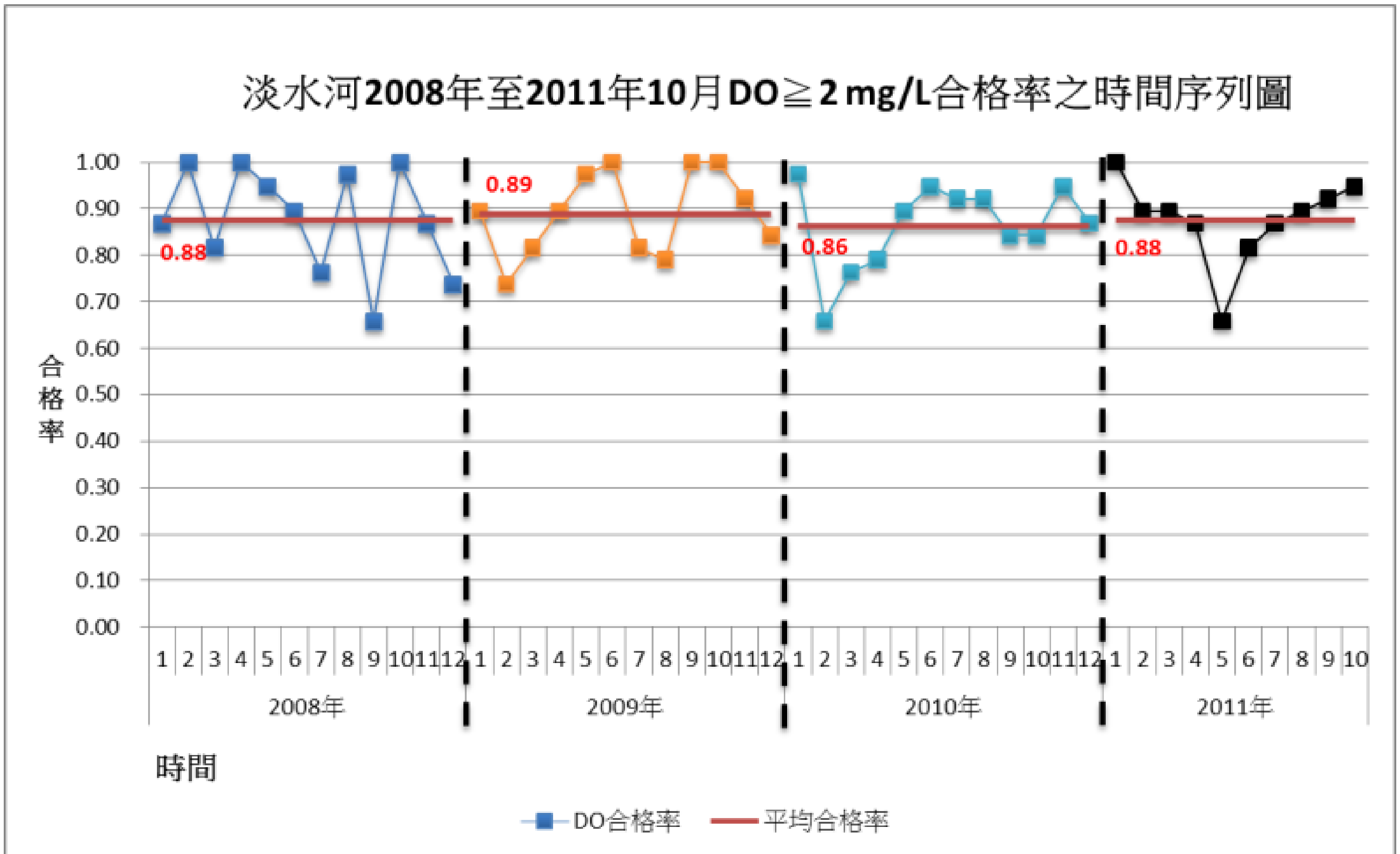


淡水河—DO ≧2 mg/L合格率

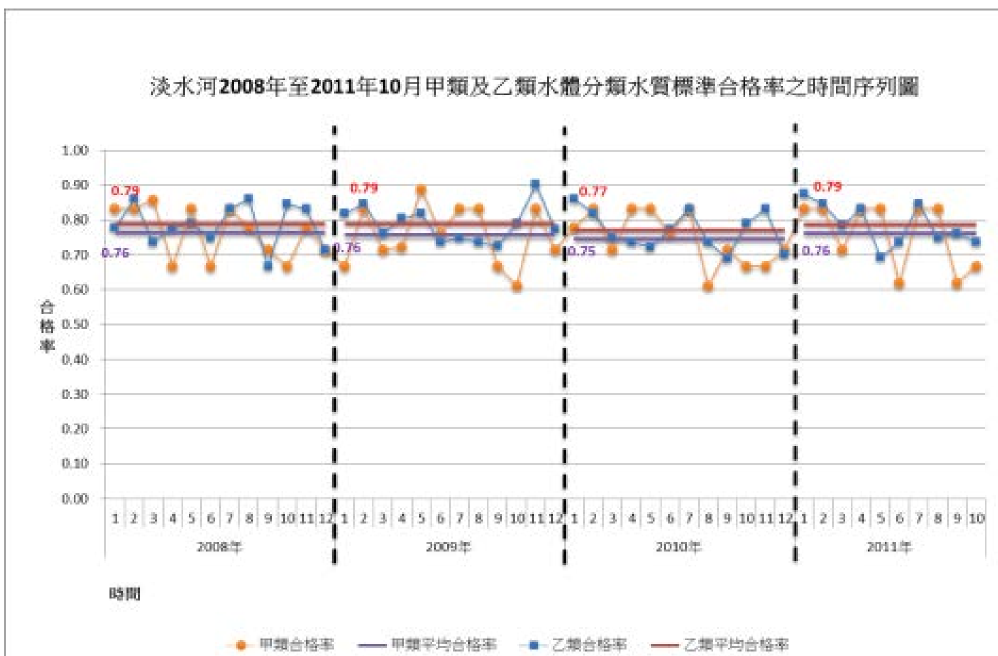
- 年合格率最大為89%(2009年)、最小為86%(2010年)，**無明顯差異**。
- **2009年及2010有相似的趨勢**
  - 2月的合格率都是該年度合格率最低的月份
  - 2月至6月的合格率有增加的趨勢。

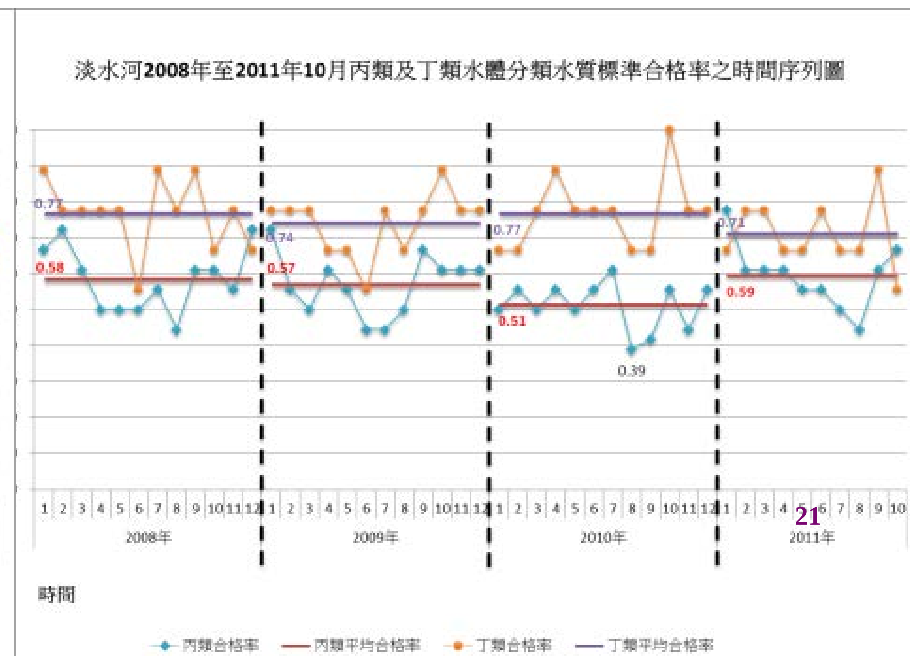


淡水河—水體分類水質標準合格率

- 2008年至2011年的全流域年度合格率無明顯差異
  - 2008年為73.1%、2009年為72.5%、2010年為72%、2011年為72.4%

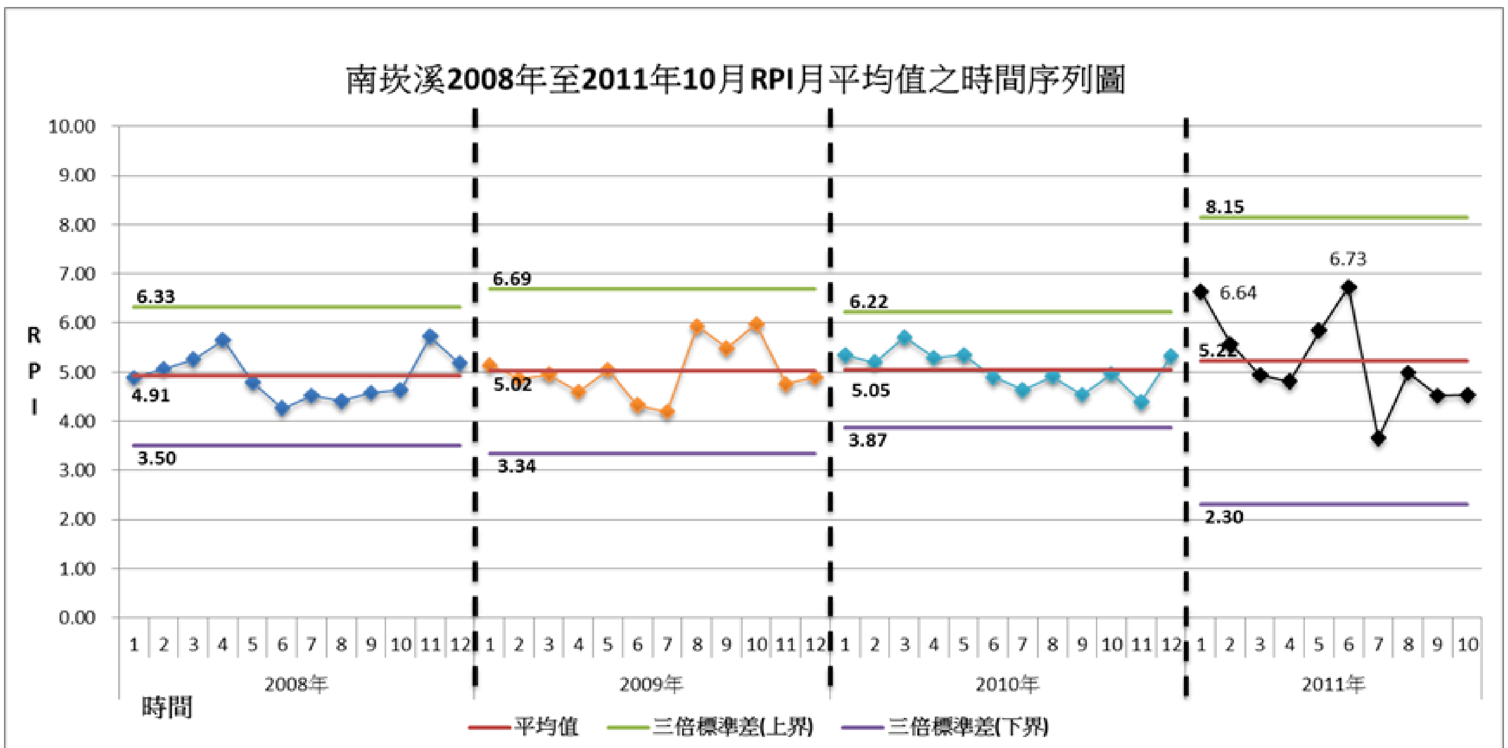
- 2008年至2011年的各類水體各自的年度合格率亦無明顯差異。
  - 甲類水體年合格率最大差距於僅有1.7%，乙類水體的最大差距為1.8%、丙類水體的最大差距為3.9%、丁類水體的最大差距則是為6.9%。





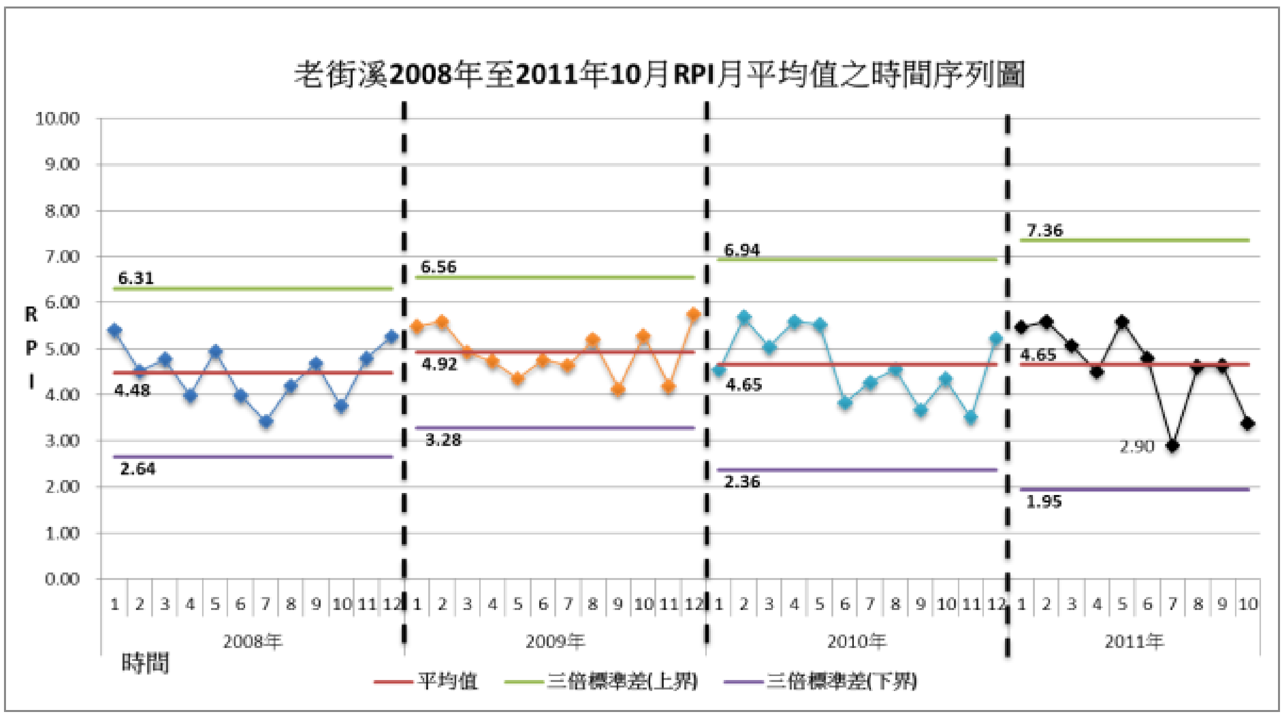
南崁溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.31，**無明顯差異**，近四年皆屬於中度污染。
- **2008年至2010年RPI月平均值有相似的趨勢**
  - 1月到6月水質有改善的趨勢
  - 7月到12月又變為惡化的趨勢。
- 南崁溪前三年水質**RPI年平均值變動很小**，　　　　　　　　。
- 2011年1月至10月的月平均值**比較容易出現變動很大的情形**。



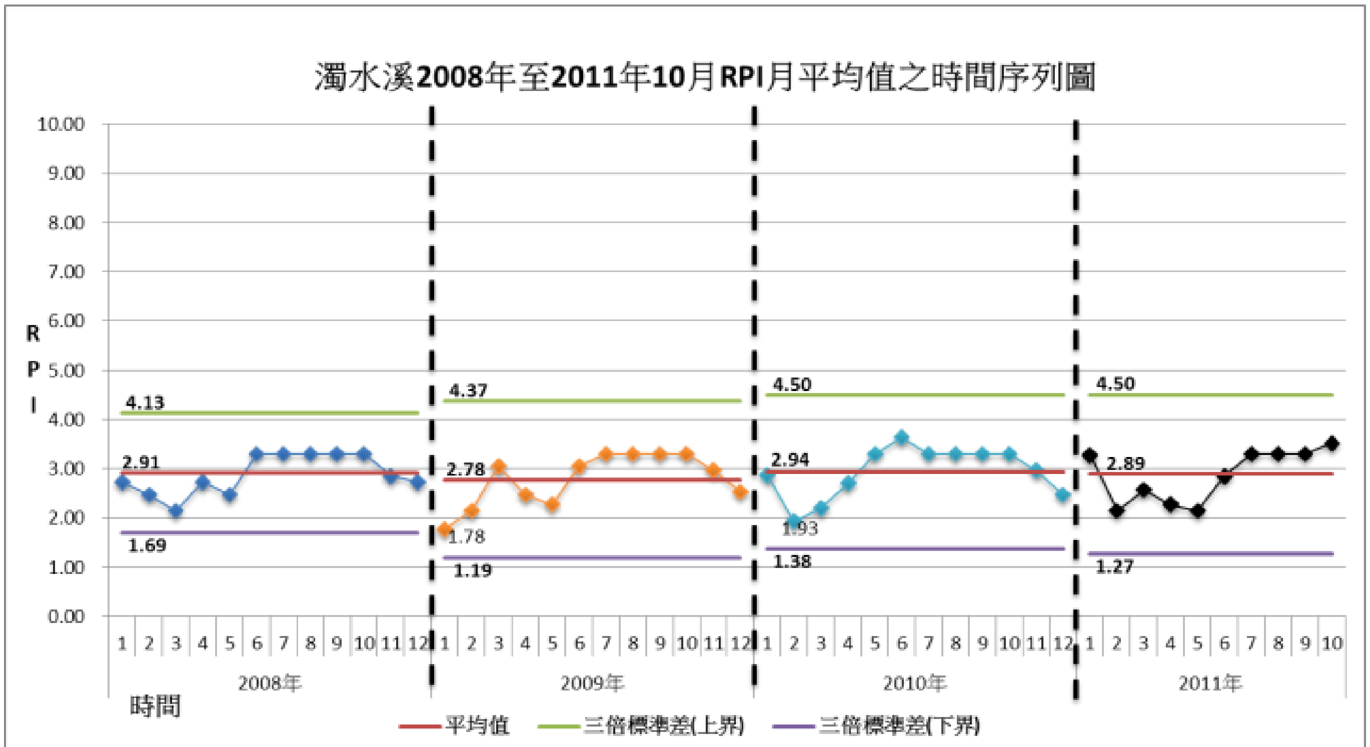
老街溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.44，**無明顯差異**，近四年皆屬於中度污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 1月到7月水質有改善的趨勢
  - 8月到12月又變為惡化的趨勢。
- 水質狀態較不穩定
  - 月平均值約在2.9至5.74之間
  -



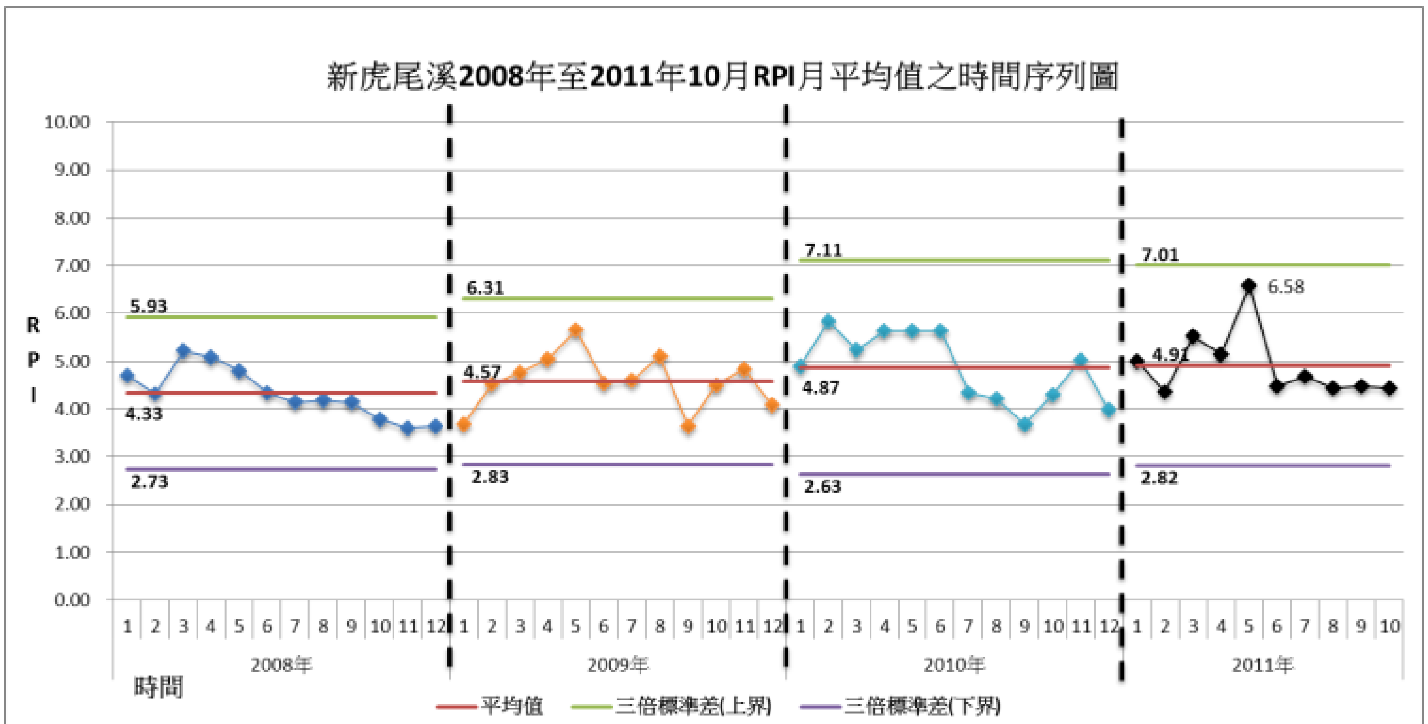
濁水溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.16，**無明顯差異**，近四年皆屬於輕度污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 6月至10月RPI有增加的趨勢
- **這四年的6月至10月RPI皆大於3**
  - 達到嚴重污染的標準



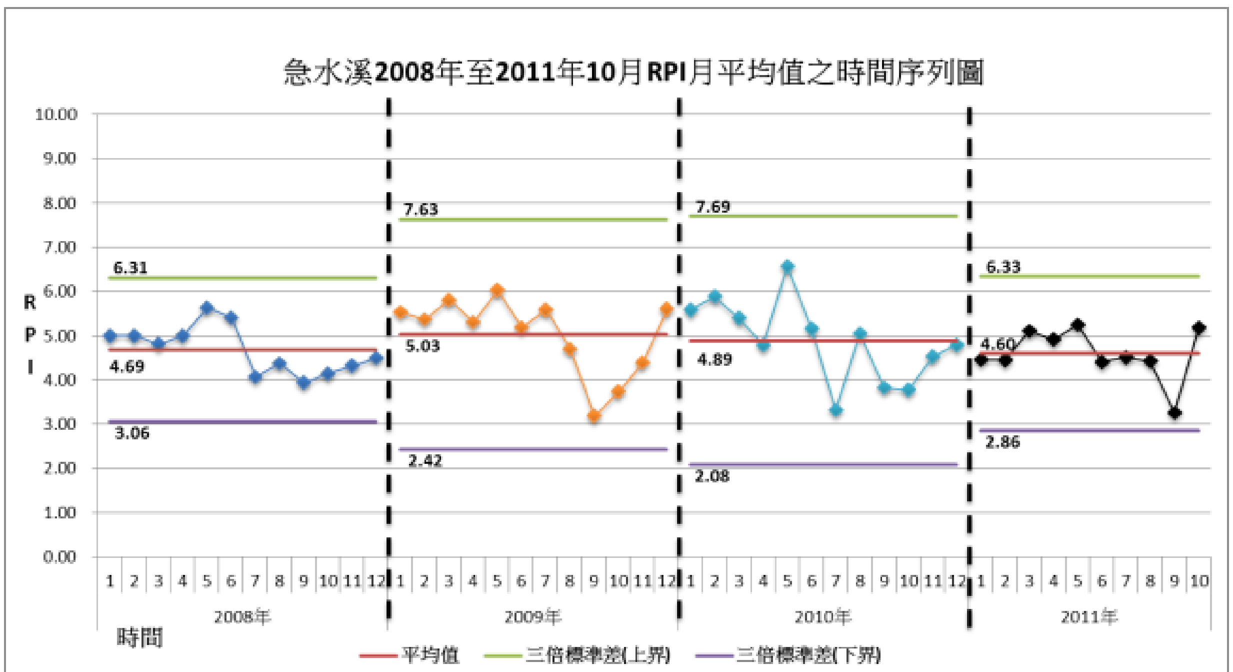
新虎尾溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.58，有些許差異，近四年皆屬於中度污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 5月至9月有下降的趨勢
  - 9月至12月則是有增加的趨勢
-
  - SS近四年年平均直接超過100 mg/L，都是屬於嚴重污染。
  - NH_3-N近四年年平均值有明顯增加的趨勢，2011年年平均值為嚴重污染。



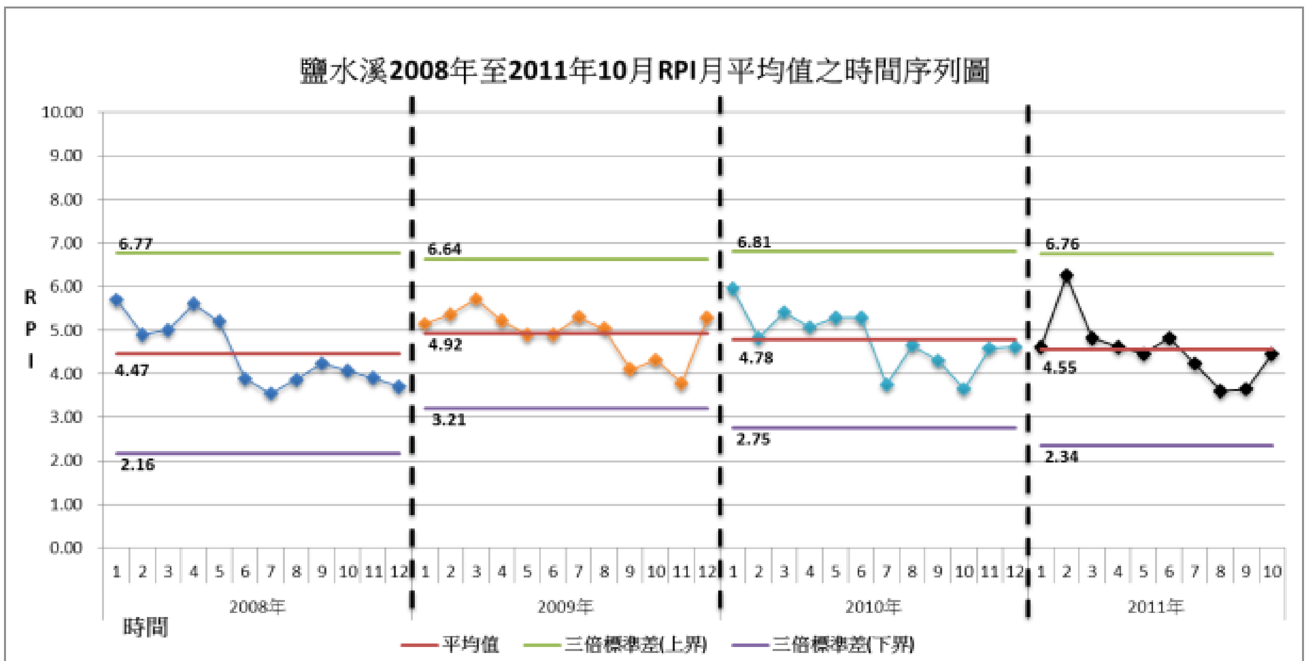
急水溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.34，無明顯差異，近四年皆屬於中度污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 1月至5月的RPI月平均值有增加的趨勢
  - 5月至9月則有減少的趨勢
  - 而9月至12月則是有增加的趨勢。
- **NH_3-N為最主要受污染的水質參數**
  - 近四年年平均值都超過3 mg/L
  - 月平均值變動很大，最大的月平均值是10.98 mg/L，最小則是0.4 mg/L。



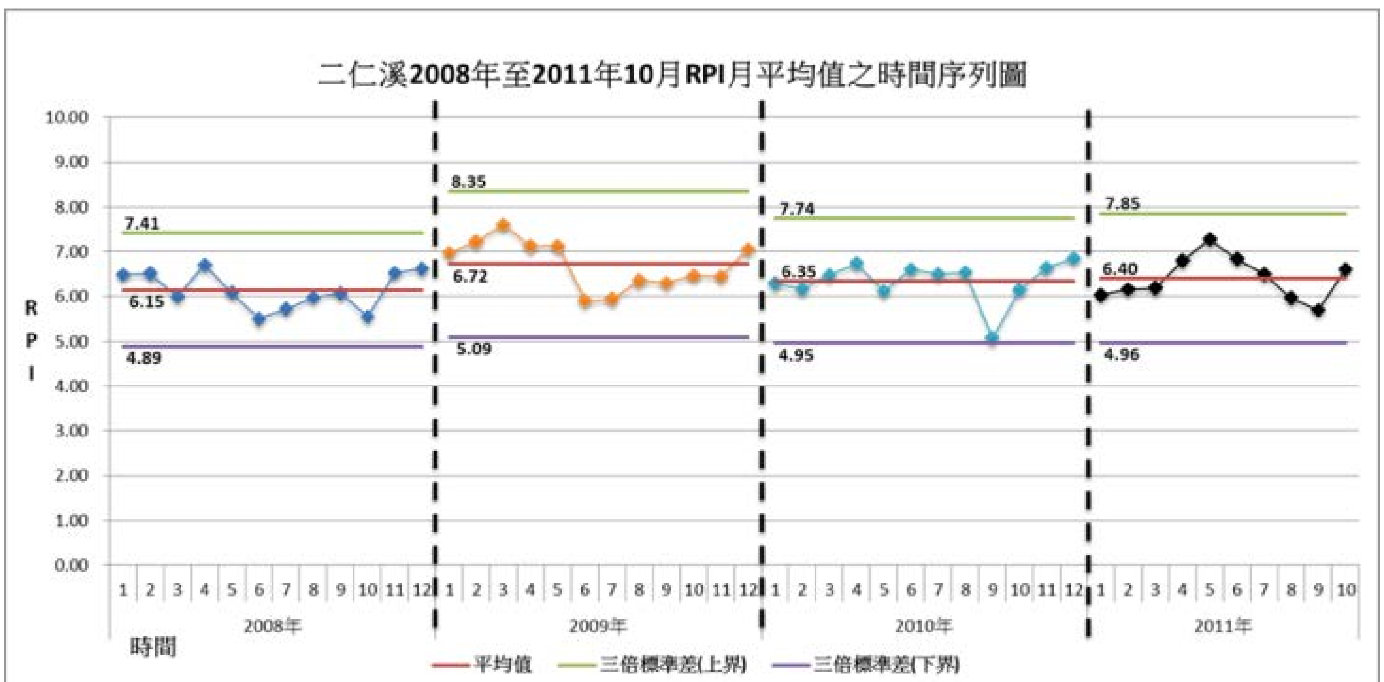
鹽水溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.45，無明顯差異，近四年皆屬於中度污染。
- **2008年至2010年RPI月平均值有相似的趨勢**
  - 1月的RPI月平均值皆高於年平均值
  - 之後開始有減少的趨勢
  - 各年的秋季(9-11月)水質都是比較好的。
- **NH_3-N為最主要受污染的水質參數**
  - 近四年年平均值都超過5 mg/L
  - 月平均值變動很大，最大的月平均值是11.67 mg/L，最小則是0.48 mg/L。



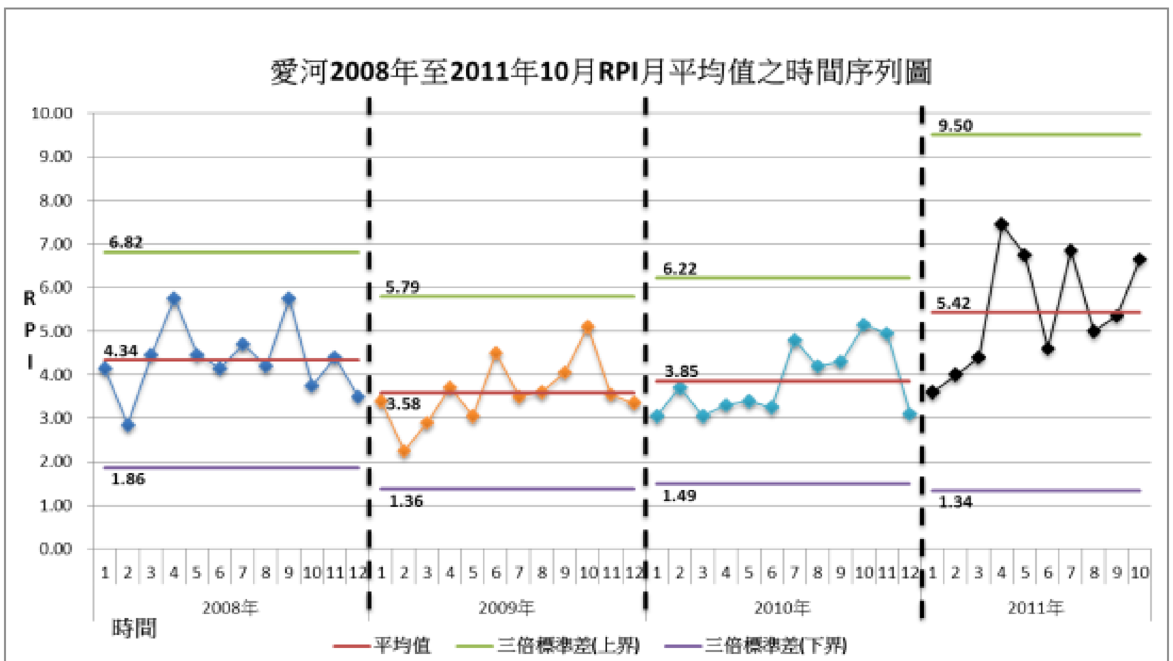
二仁溪—河川污染指標(RPI)

- RPI年平均值最大僅相差0.56，有些許差異，近四年皆屬於嚴重污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 1月至4月RPI月平均值有增加的趨勢
  - 4月至9月RPI月平均值則是有減少的趨勢。
- **BOD及NH_3-N為最主要受污染的水質參數，兩者都屬於嚴重污染**
  - BOD近四年年平均值都超過15 mg/L，2009年的月平均值變動較大。
  - NH3-N近四年年平均值都超過13 mg/L。



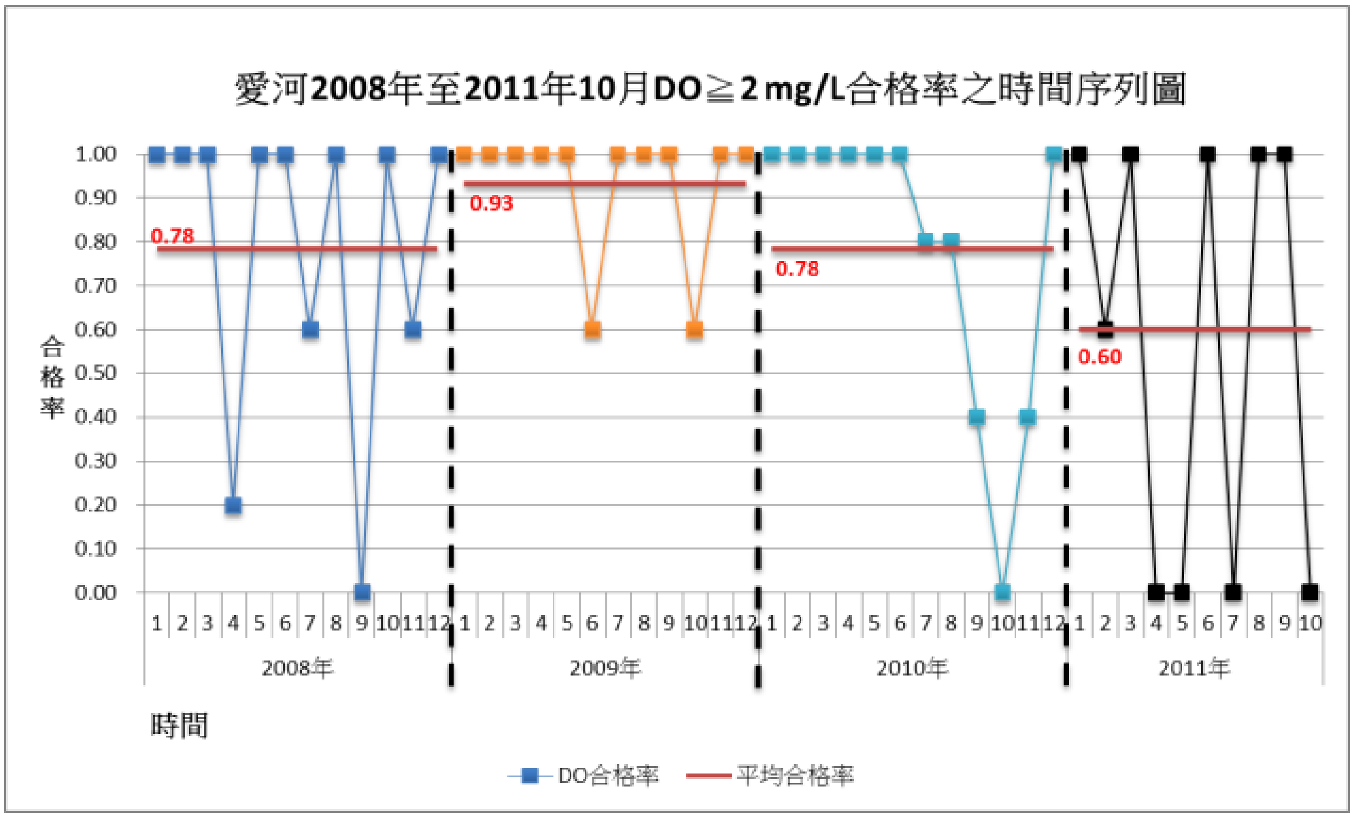
愛河—河川污染指標(RPI)

- RPI年平均值最大相差1.84，有明顯的差異，近四年皆屬於中度污染。
- **2008年至2011年10月RPI月平均值有相似的趨勢**
  - 2月的RPI月平均值屬於相對低點
  - 之後的RPI月平均值有增加的趨勢
  - 9、10月又到達相對高點。
- **NH_3-N為最主要受污染的水質參數，兩者都屬於嚴重污染**
  - 2008年至2010年都屬於中度污染
  - 但2011卻屬於嚴重污染，而且濃度平均增加了2.82 mg/L。



愛河—DO ≧2 mg/L合格率

- 年合格率最大為93%(2009年)、最小為60%(2011年) ，**有明顯的差異**。
- **愛河的月合格率變動較為劇烈**
  - 因為愛河河川長度較短，河水停留時間較短，**測站間的距離也比較近**
  - 當上游測站的溶氧值因外在因素導致其降至2 mg/L以下時，中下游測站容易受其影響導致其溶氧值也在2.0 mg/L，所以月合格率的變動也比較大。



愛河—水體分類水質標準合格率

- 愛河原性質屬於區域排水系統，所以在制定水體分類時考量愛河的性質並沒有劃定水體分類。

- 若依照2008年至2011年10月各年水質參數的年平均值而言，愛河水質比較符合丁類水體的標準。

九大重點河川近4年水質現況

- NH_3-N依舊是受污染最嚴重的水質參數。
- BOD的平均值只剩二仁溪屬於嚴重污染。
- 除了淡水河及濁水溪是屬於輕度污染，其餘河川皆在中度污染以上，應加強整治力度。

河川	4年RPI平均	DO (mg/L)	BOD (mg/L)	SS (mg/L)	NH_3-N (mg/L)	主要受污染參數 (中度污染以上)
淡水河	2.96	6.55	3.28	20.97	1.67	NH_3-N
南崁溪	5.04	6.54	8.72	35.68	11.69	BOD、NH_3-N
老街溪	4.68	6.57	11.07	23.72	5.80	BOD、NH_3-N
濁水溪	2.88	8.62	1.25	3714.06	0.11	SS
新虎尾溪	4.66	6.04	3.93	341.22	2.35	SS、NH_3-N
急水溪	4.81	3.90	5.65	57.67	3.79	DO、BOD、SS、NH_3-N
鹽水溪	4.69	5.26	9.00	64.92	6.84	BOD、SS、NH_3-N
二仁溪	6.40	3.25	18.34	144.96	19.83	DO、BOD、SS、NH_3-N
愛河	4.28	4.02	5.76	10.84	2.35	DO、BOD、NH_3-N

II-1.2. Control of Odor

- **Analytical Methods including chemical and olfactory analysis**
  - **the "flavor profile analysis method, FPA"**
    - **Classification and strength of the odorous substance**
  - **GC/MSD and sensory-GC.**
    - **Confirmation for the odorous substance**
  - **Forced-Choice Ascending Concentration Series Method of Limits, FCM**
    - **threshold**

Common Odorants in Water

Compound	Abbr	Formula	MW	Odor description	FCM Odor threshold
2-methylisoborneol	2-MIB	$C_{11}H_{20}O$	168	Musty	28.8 ng/L
trans-1,10-dimethyl-trans-9-decalol	Geosmin	$C_{12}H_{22}O$	182	Earthy	10 ng/L
2,2,6-trimethyl-1-cyclohexene-1-carboxaldehyde	β-cyclocitral	$C_{10}H_{16}O$	152	Grass/hay /woody	590 ng/L
4-(2,6,6-trimethyl-1-cyclohexen-1-yl)-3(E)-buten-2-one	β-ionone	$C_{13}H_{20}O$	192	Aromatic	4.3 ng/L
1-methyl-4-prop-1-en-2-yl-cyclohexene	d-limonene	$C_{10}H_{16}$	136	Lemon/ Sweet	1.4 µg/L
Indole	Indole	C_8H_7N	117	Facal	13.9 ng/L
3-methyl indole	Skatole	C_9H_9N	131	Facal	4.85 ng/L
Dimethyl sulfide	DMS	$(CH_3)_2S$	62.1	Decayed cabbage/ canned corn	42.1 ng/L
Dimethyl disulfide	DMDS	$(CH3)_2S_2$	94.2	Rotten cabbage	640 ng/L
Dimethyl trisulfide	DMTS	$(CH3)_2S_3$	126.2	Garlicky/ oniony	1.7 ng/L
Carbon disulfide	CS_2	CS_2	76.1	Food waste	66 ug/L
1,3,4,6,7,8-hexahydro-4,6,6,7,8,8-hexamethylcyclopenta-(g)-2-benzopyrane	HHCB	$C_{18}H_{26}O$	258.4	Fragrant	18.6ng/L
Ammonia	Ammon	NH_3	17	Ammonia	84.8 ug/L

Algae Related Compounds

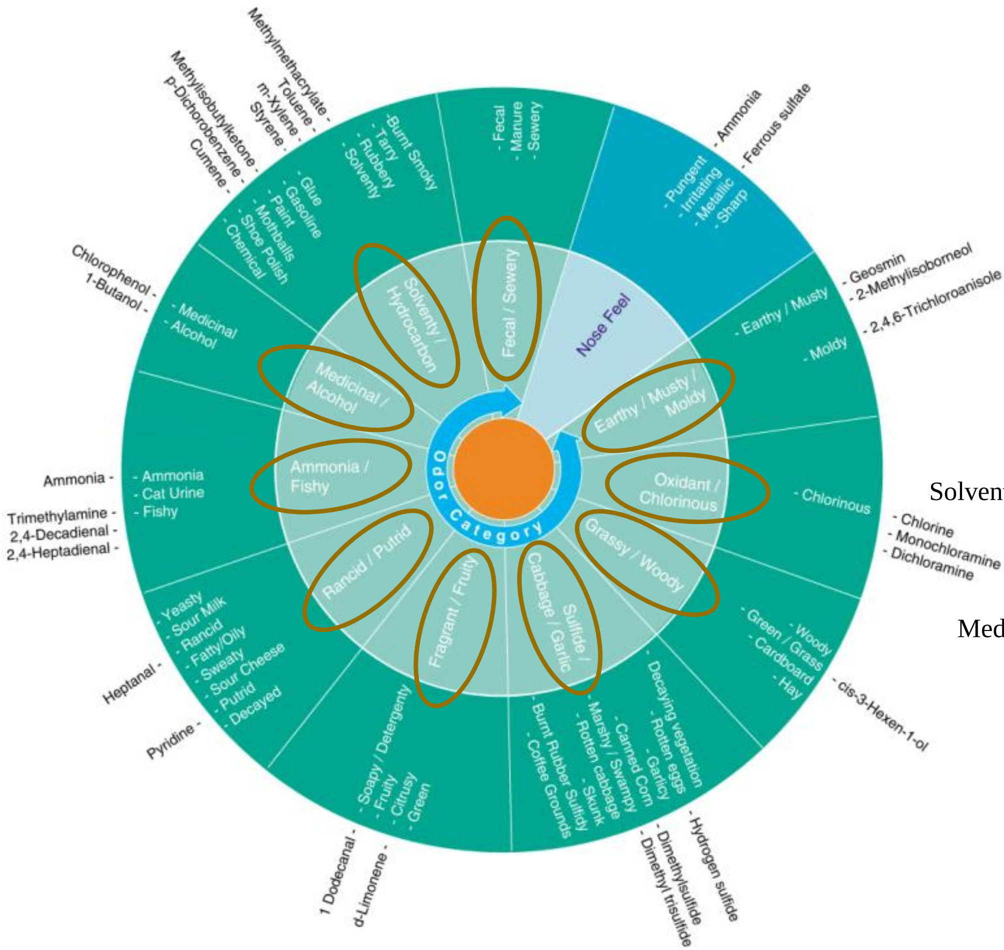
Fecal Compounds

Sulfur Related Compounds

a fragrant additive in consumer products

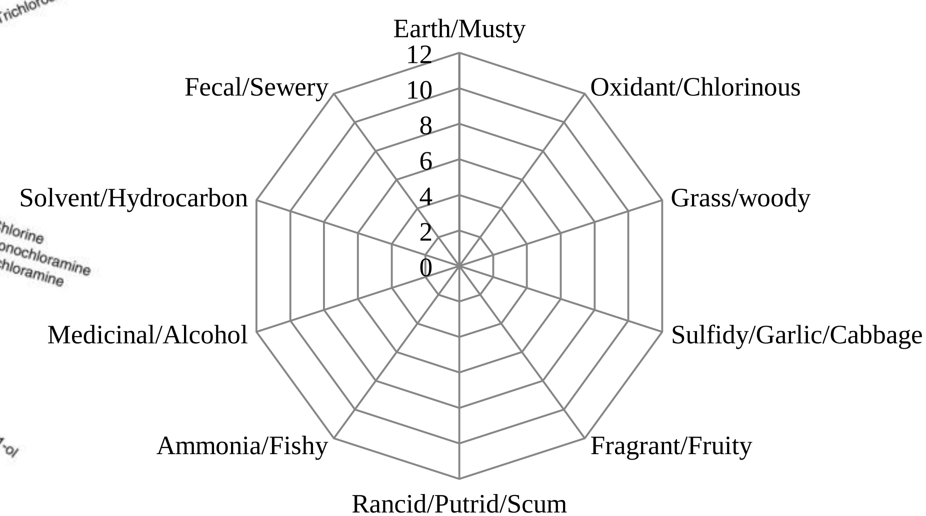
Odor Wheel for Wastewater

(Based on FPA)



(Burlingame et al., 2004)

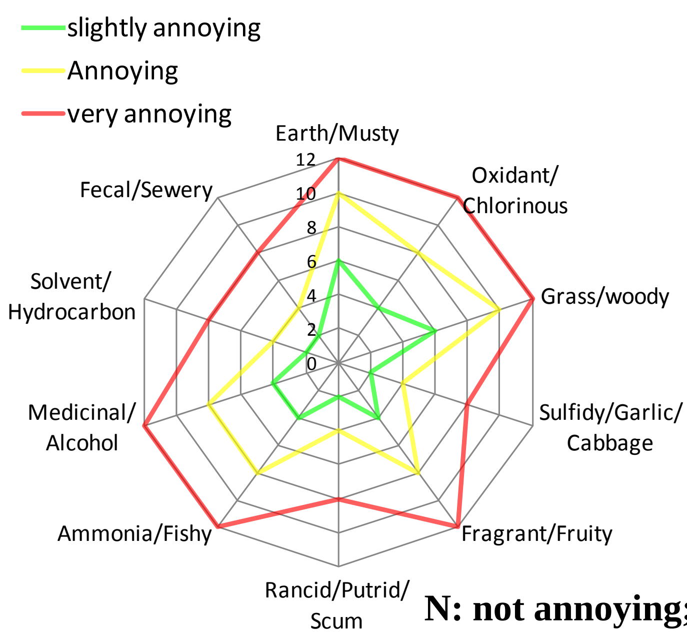
Visualized by
Radar Map

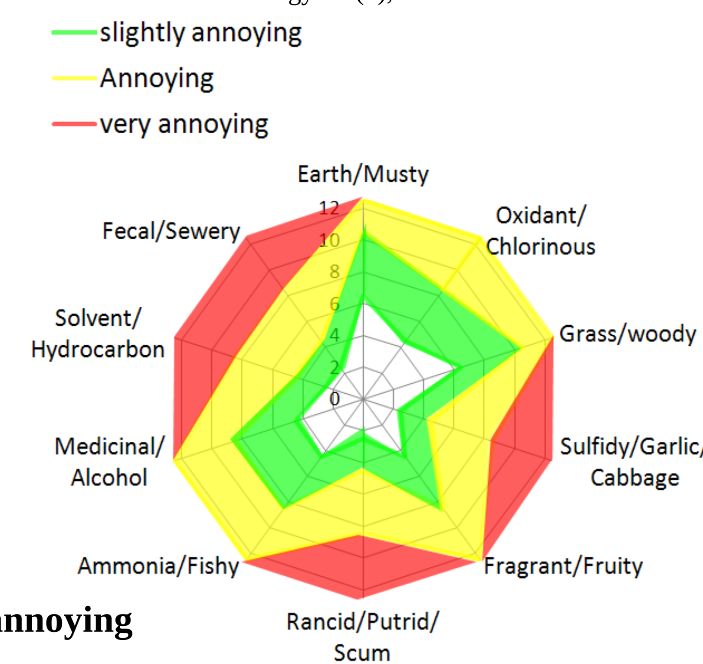


Transfer FPA to Annoyance Factor

	very weak 2	weak 4	weak-moderate 6	moderate 8	moderate-strong 10	strong 12
Earth/Musty			sa	sa	a	a
Oxidant/Chlorinous		sa	sa	a	a	va
Grass/woody			sa	sa	a	a
Sulfidy/Garlic/Cabbage	sa	a	a	va	va	va
Fragrant/Fruity		sa	sa	a	a	va
Rancid/Putrid/Scum	sa	a	a	va	va	va
Ammonia/Fishy		sa	sa	a	a	va
Medicinal/Alcohol		sa	sa	a	a	va
Solvent/Hydrocarbon	sa	a	a	va	va	va
Fecal/Sewery	sa	a	a	va	va	va

Burlingame (2009): Water Science & Technology 59(3), 595-602.





N: not annoying; SA:slight annoying

A:Annoying; VA:very annoying

Model Development for Odor Prediction in River

- Since there is no odorous parameter system in the WASP, it needs to modify the framework for the simulation of odorous substances. In this study, the ammonia-nitrogen system was modified for this purpose because of its simplicity in terms of reaction and parameter.
- The transport mechanisms of odorous substance in waterbody include sedimentation, decomposition and evaporation following first-order degeneration coefficient.

$$V_w \frac{dC_{od}}{dt} = QC_{in} - v_s A_w C_{od} - k_d V_w C_{od} - v_v V_w C_{od} - QC_{out}$$

where：

C_{od} = **Odor concentration [M/L^3]**

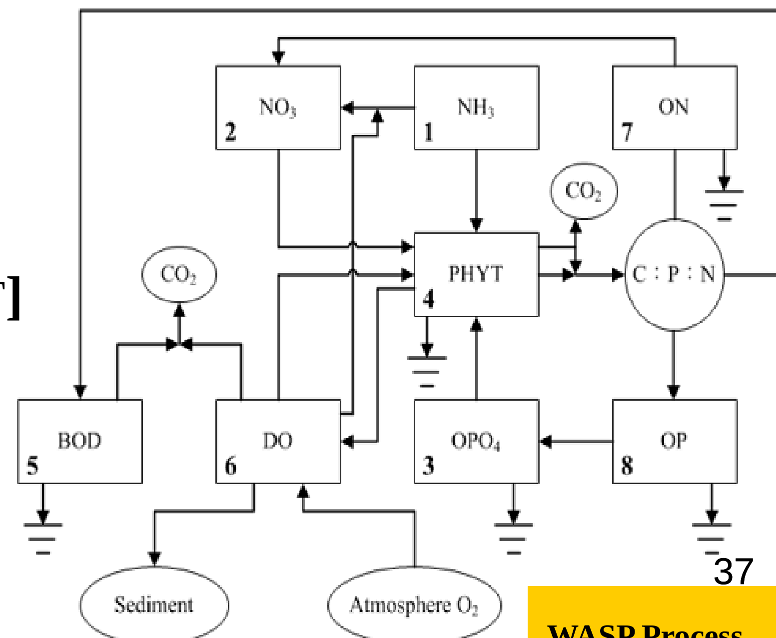
v_s = **Settling velocity [L/T]**

k_d = First-order degeneration coefficient [1/T**]**

v_v = Volatility coefficient **[L/T]**

V_w = **Volume[L^3]**

A_w = **Area [L^2]**



WASP Process

37

Figure: Validation of NH_3-N Prediction in Salt Crede by the Developed Model (July 6,2010)

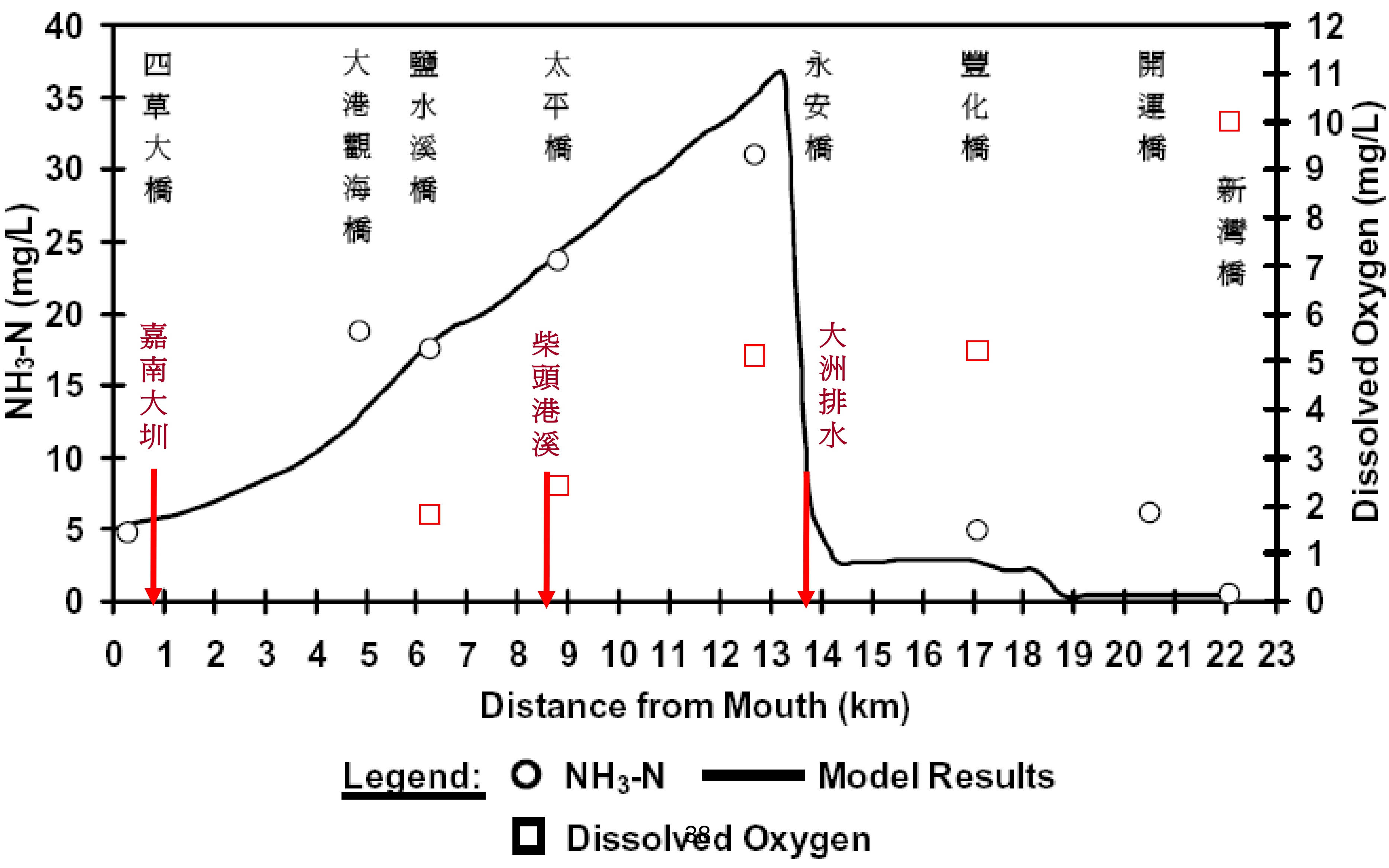


Figure: Validation of MIB Prediction in Salt Crede by the Developed Model (July 6,2010)

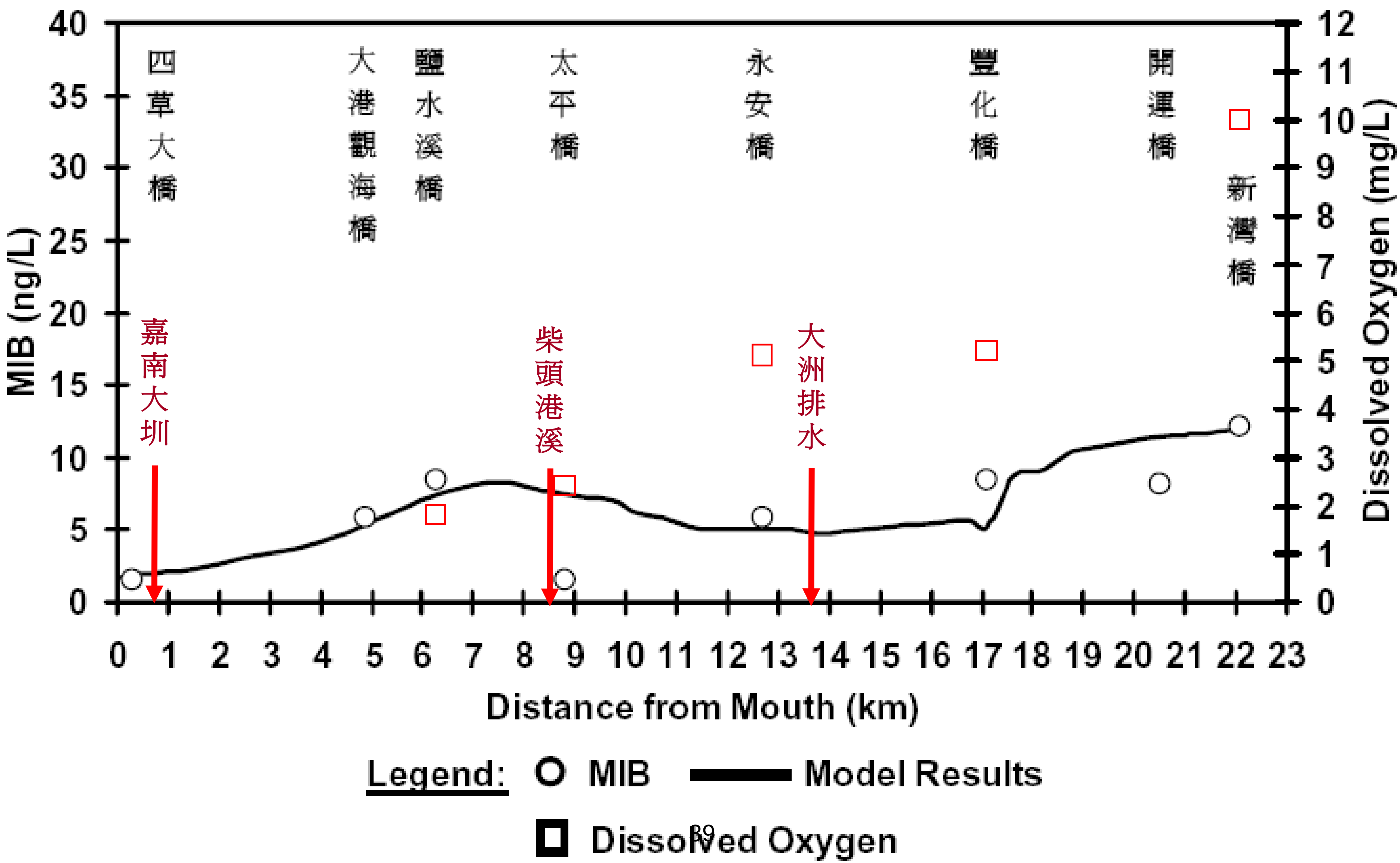
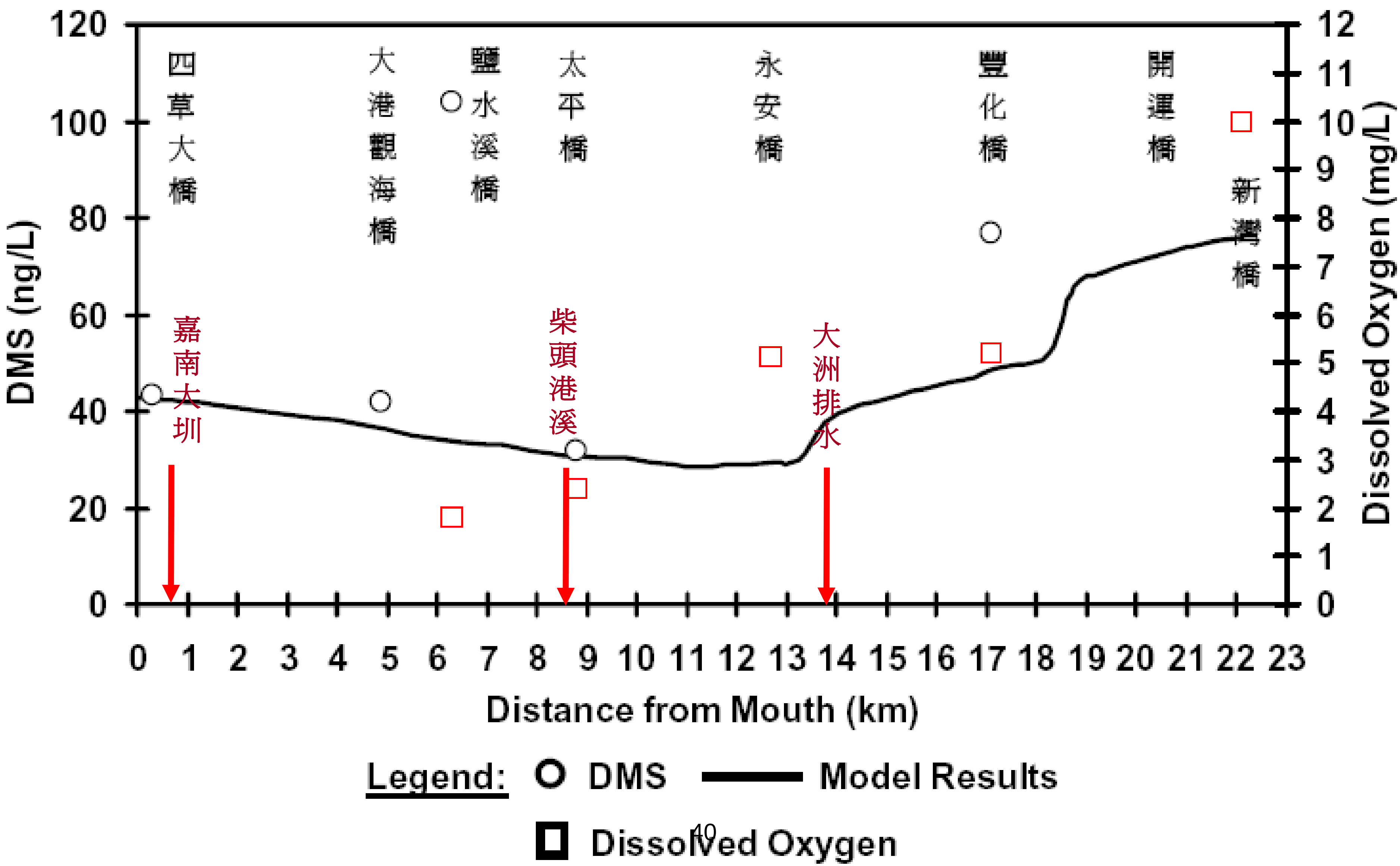


Figure: Validation of DMS Prediction in Salt Crede by the Developed Model (July 6,2010)



Odor Intensity vs. Water Quality

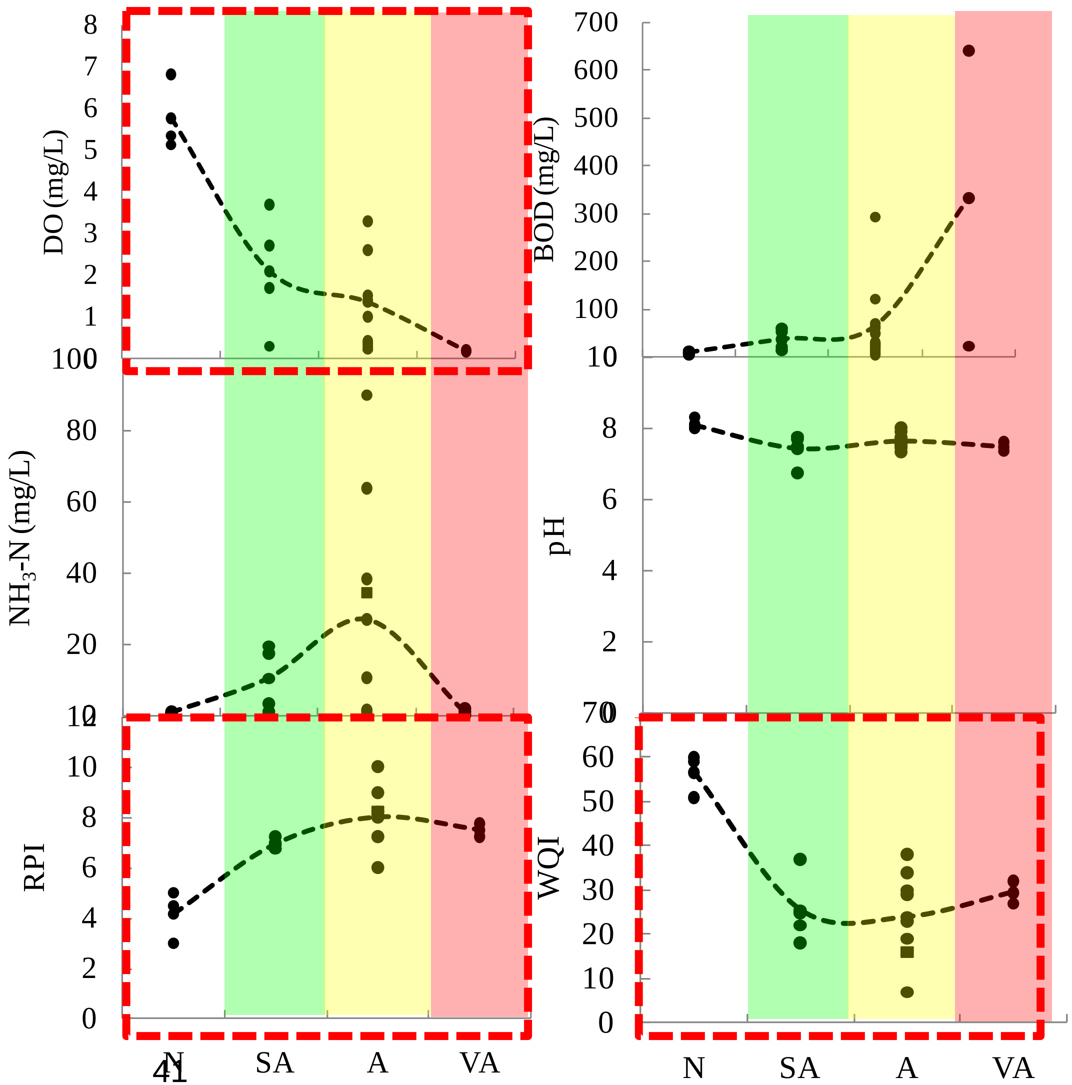
- **Classified by annoyance factors**
- **(>) Slight annoying**
  - DO < ~ 2
  - RPI > ~ 7
  - WQI< ~ 30

N: not annoying

SA: slight annoying

A: annoying

VA: very annoying

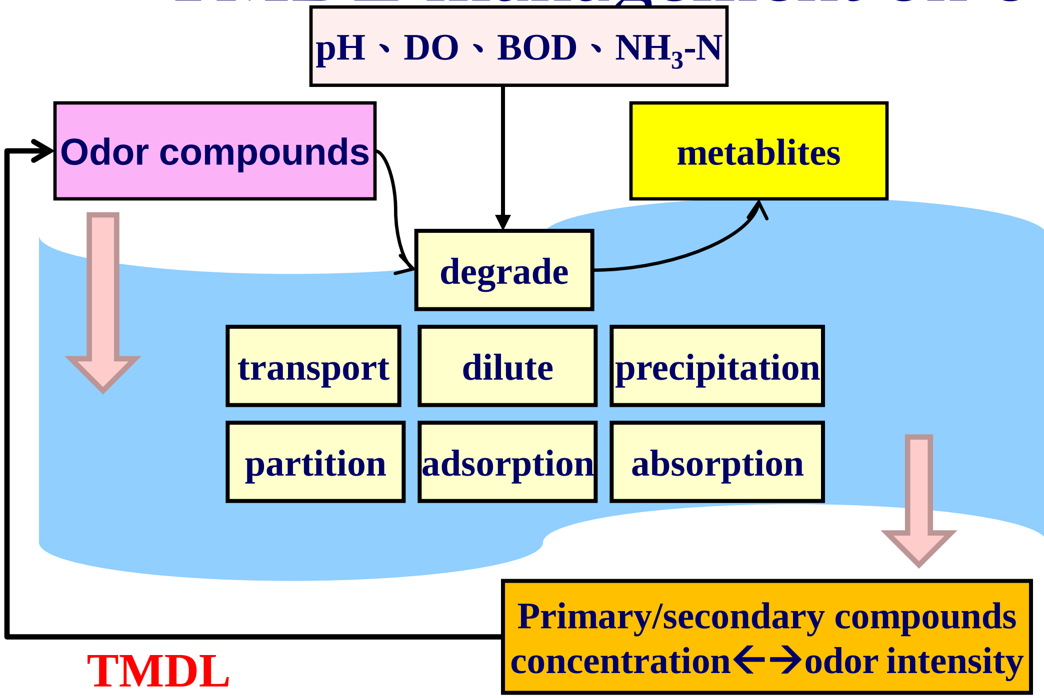


Summary

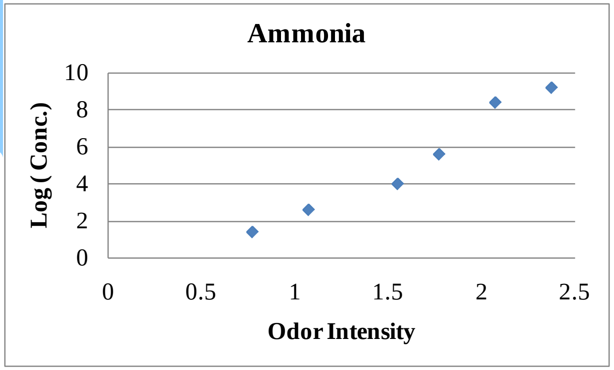
- **FPA intensity has been successfully transferred to annoyance factor for the assessment of river odor**
  - The most common odorants in the two rivers are DMS and CS_2
  - HHCB is a potential indicator of water pollution from domestic wastewater
  - Indole and skatole are good indicators of fecal pollution (from livestock wastewater)
- **Fecal odors are common annoying odor observed in the pollution associated with livestock wastewater**
- **Ammonia/Fishy and Fecal/Sewage are the two annoying odor groups often observed in the river water associated with sewage wastewater**
  - As DO $< \sim 2$, RPI $> \sim 7$, and WQI $< \sim 30$, the rivers may have

Future research Works

- Build up the gap between FPA results and resident and/or non-resident feeling
- TMDL management on odor control



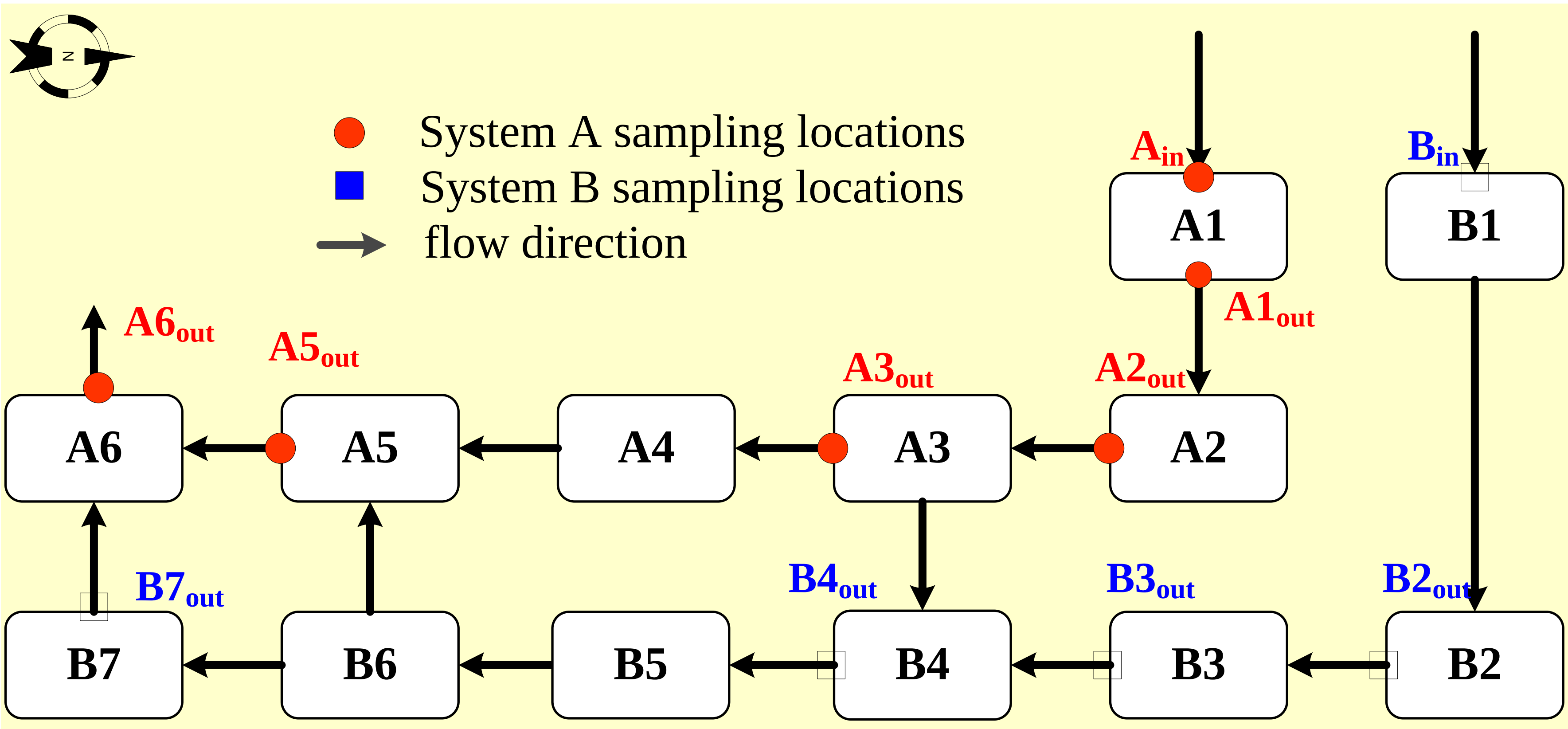
Weber-Fechner Law

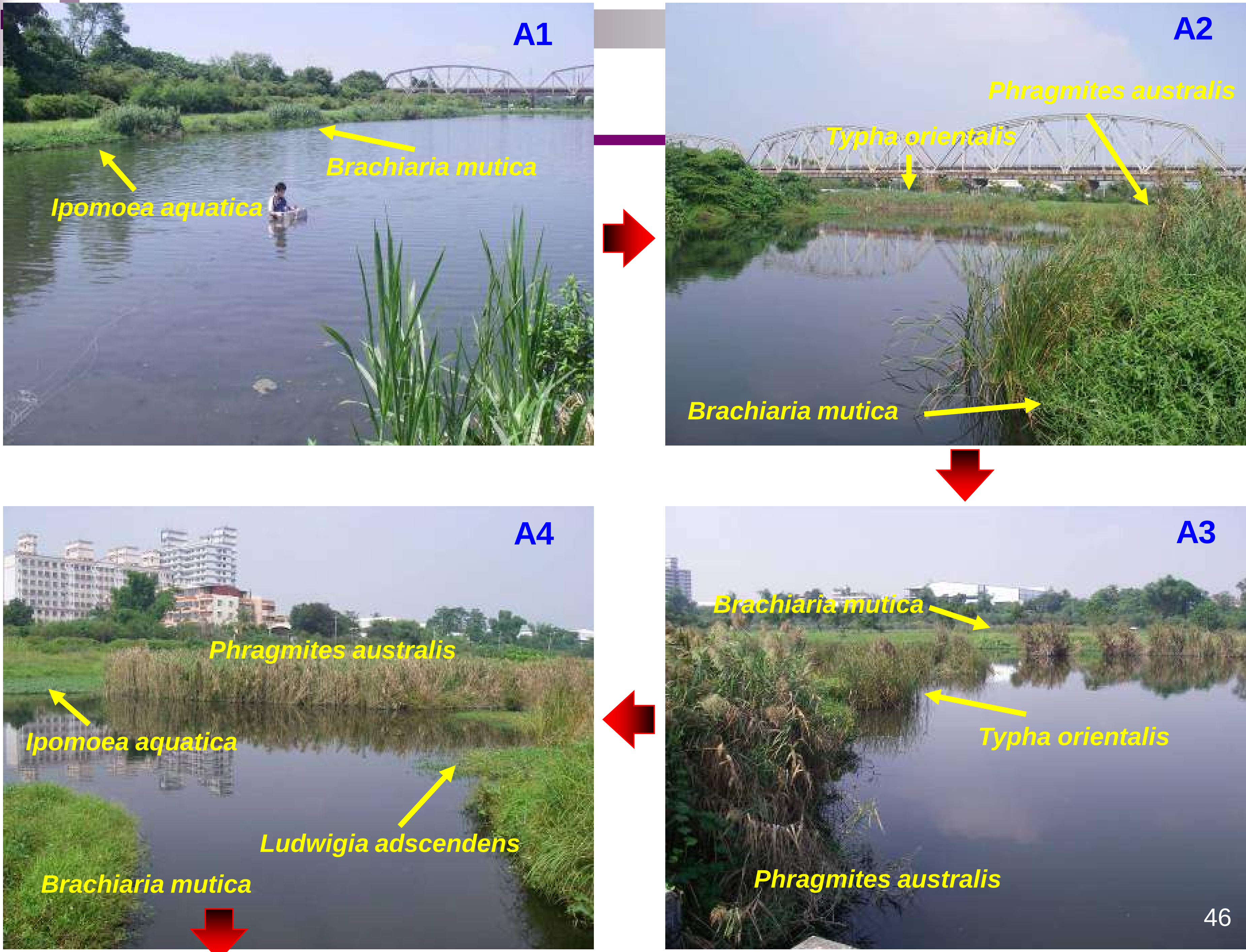


II-2. Conservation approaches and tools (15%)

1. Habitat and biodiversity conservation
2. River corridor protection
3. Land protection programs and land use ordinances

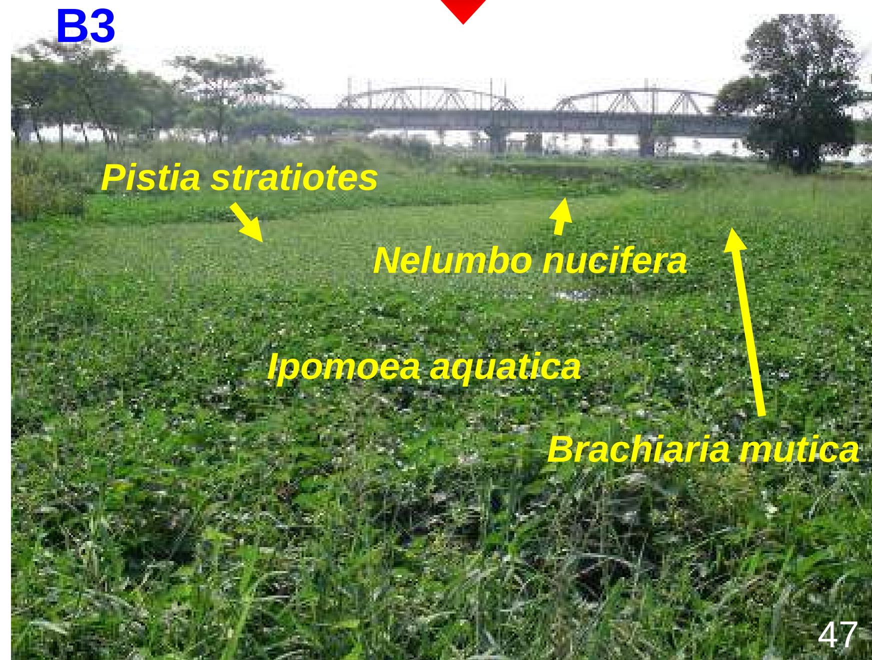
Sampling Locations Kaoping River Constructive Wetland




A1
Ipomoea aquatica
Brachiaria mutica
A2
Phragmites australis
Typha orientalis
Brachiaria mutica
A3
Brachiaria mutica
Typha orientalis
Phragmites australis
A4
Phragmites australis
Ipomoea aquatica
Ludwigia adscendens
Brachiaria mutica


B1
influent
Ipomoea aquatica


B2
Brachiaria mutica
Ipomoea aquatica
Pistia stratiotes
Nelumbo nucifera


B3
Pistia stratiotes
Nelumbo nucifera
Ipomoea aquatica
Brachiaria mutica


B4
Brachiaria mutica
Leersia hexandra

Achievements and Correction Plans

- The overall removal efficiencies are 99% for TC, 50% for BOD, and more than 30% for nutrients (e.g., total nitrogen, total phosphorus).
- The wetland system has a significant effect on water quality improvement and is capable of removing most of the pollutants from the local drainage system.
- The wetland sediment contained high concentrations of nutrients and metals.
- Pretreatment system is required to minimize the metal accumulation in the sediment.




Carbon Sequestered and Foliar Dust Retention by Woody Plants of the Greenbelt Along National Highway NO.1

Species	Carbon storage (t)	Carbon storage per plant (kg)	Dust accumulation of 20 leaves (mg)	Estimated foliar dust accumulation on leaves from each tree (g)
S. macrophylla	2.46	23.80	833.3	63.6
T. boivinil	0.75	15.52	25.0	26.5
P. indicus	0.10	2.69	21.6	8.8
B. papyrifera	0.27	7.30	14.2	4.5
A. confusa	3.67	104.86	26.9	564.9
M. pinnata	0.67	21.09	59.4	15.7
B. javanica	5.59	174.69	99.4	87.9
C. fitula	1.31	43.67	408.8	41.6
C. speciosa	1.35	67.75	112.3	129.6
T, chrysantha	0.02	1.00	202.1	30.2

Source: Yi-Chung Wang, Annals of Applied Biology 244 -251, 2011.


水黃皮
Pongamia Pinnata (L.) Pierre ex Merr


Erythrina corallodendron L.
珊瑚刺桐


山芙蓉
Hibiscus taiwanensis S.Y. Hu


Callistemon rigidus R. Br.
紅瓶刷子樹

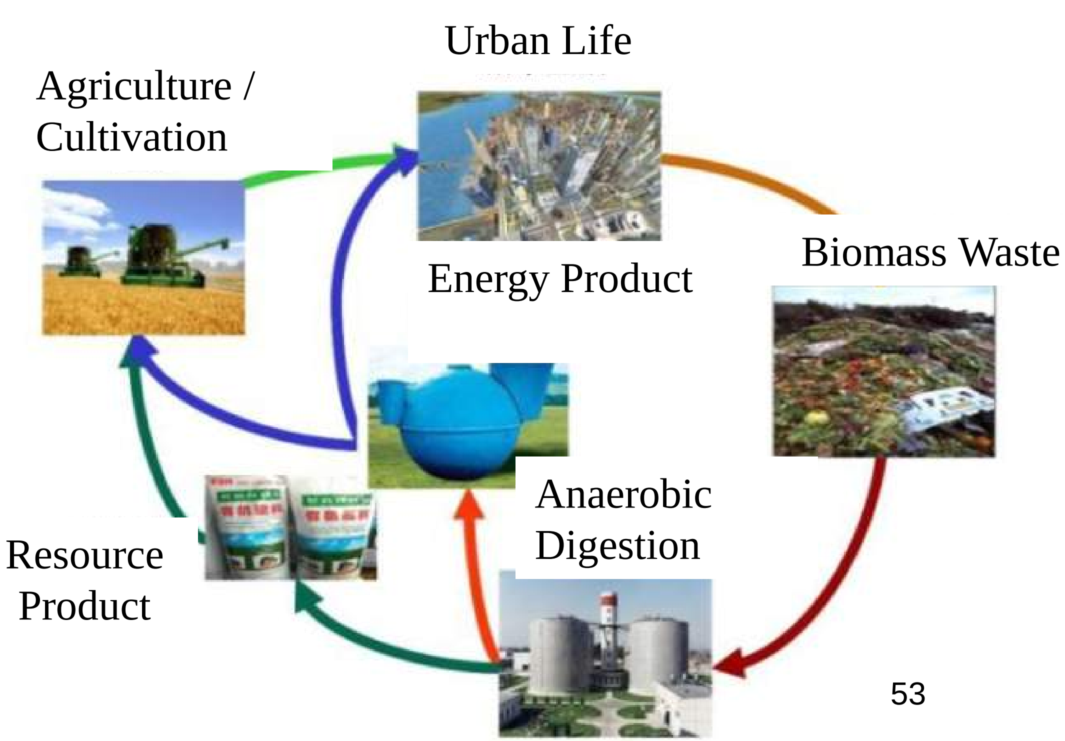
Carbon Sequestration by Wood Plants

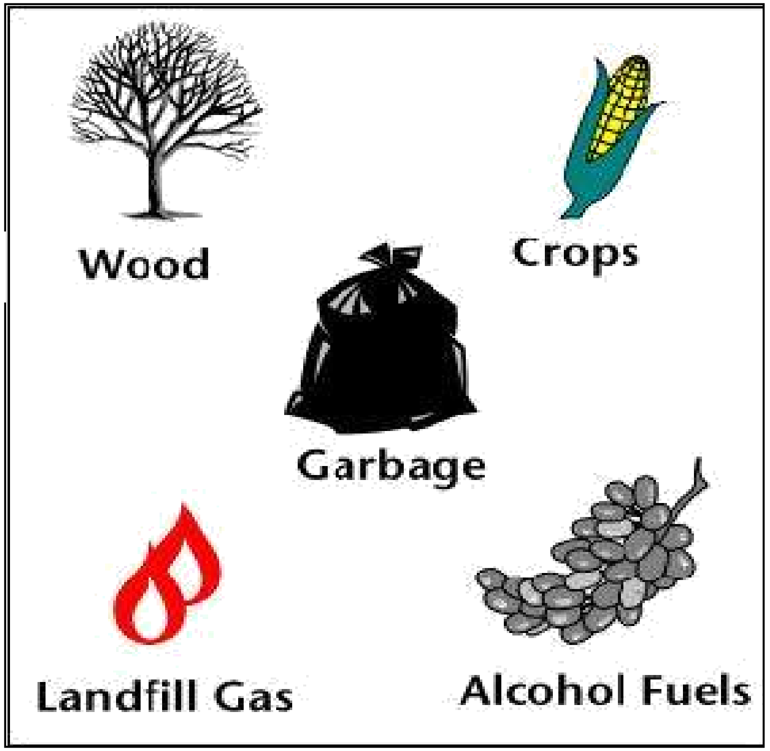
Species	V_{tree} (m^3)			C_{tree} (ton)		
	Mean	Min	Max	Mean	Min	Max
茄苳 *(Bischofia javanica Blume)*	0.066	0.001	0.911	0.026	0.000	0.354
黑板樹 *(Alstonia scholaris (L.) R. Br.)*	0.308	0.004	1.789	0.120	0.002	0.696
苦楝 *(Melia azedarach L.)*	0.117	0.001	2.307	0.046	0.000	0.897
大葉山欖 *(Palaquium formosanum Hayata)*	0.055	0.000	0.227	0.022	0.000	0.088
垂榕 *(Ficus benjamina)*	0.129	0.024	0.705	0.050	0.009	0.274
光蠟樹 *(Fraxinus formosana Hayata)*	0.052	0.000	0.309	0.020	0.000	0.120
Average	0.079			0.030		

Source: Yi-Chung Wang, Annals of Applied Biology 244 -251, 2011.

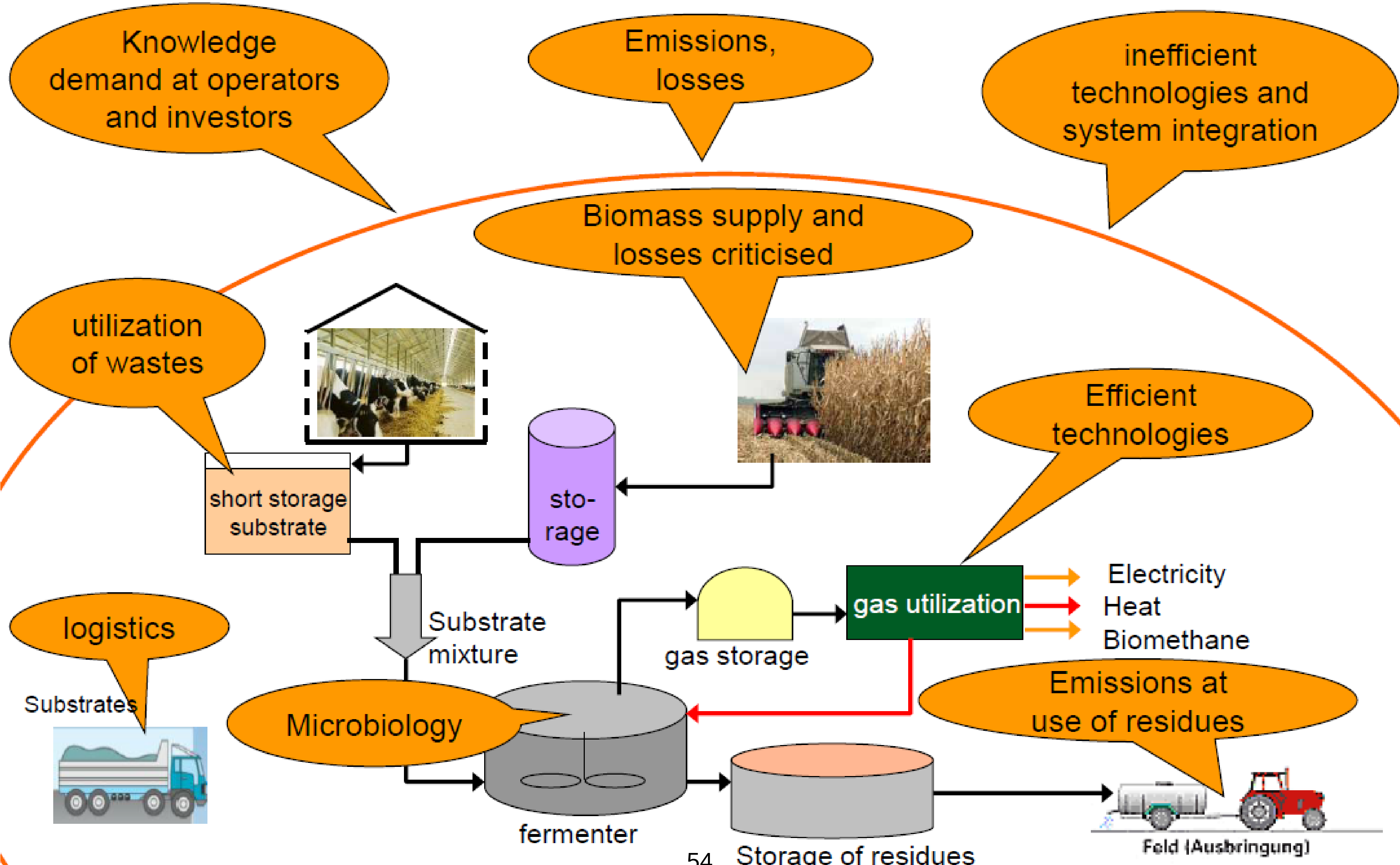
Biomass Energy Utilization

1) Forestry wastes (matchwood, etc.),
2) Agriculture wastes (pod, cob, bagasse, and rice straw),
3) Domestic wastes (garbage, kitchen waste),
4) Animal husbandry wastes (carcass),
5) Industrial organic wastes (waste plastics, rubbers, and paper).





Biogas: Research Fields

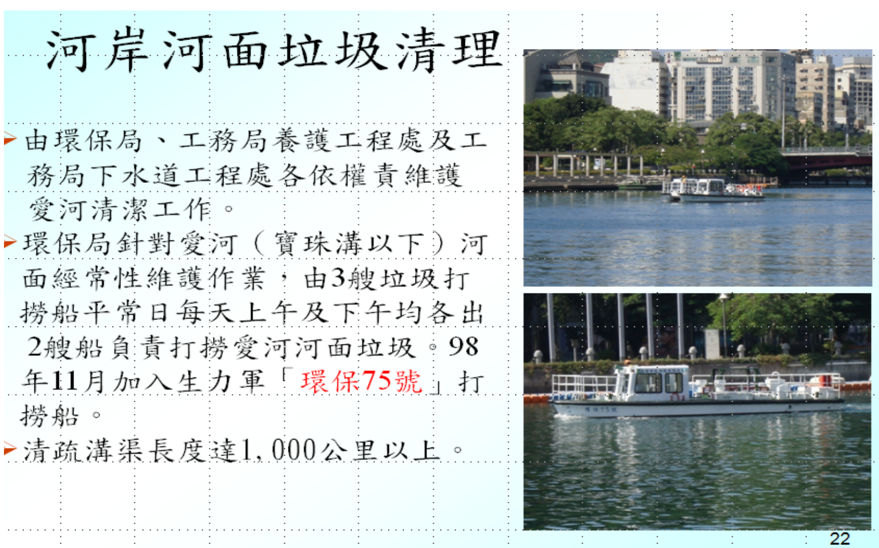


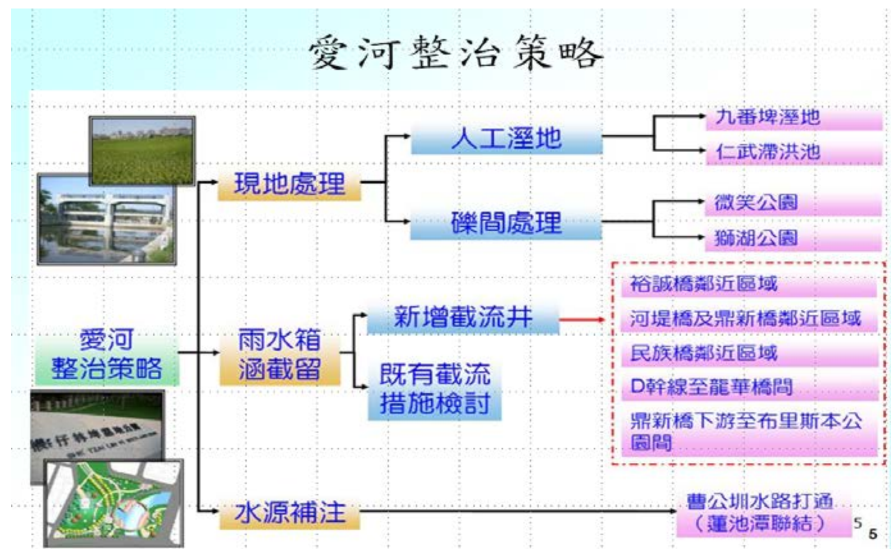
II-3. Water front (15%)

1. Green infrastructures
2. Ecological engineering practice
3. Access to recreation
4. Landscape conservation

II-4 Administration Efficiency and Effectiveness (25%)

1. Strategic and business plan
2. Point-source control
3. Non-point-source control
4. Cost-effectiveness analysis





Total Maximum Daily Loads

- The main strategy to execute TMDL is to assess the carrying capacity of the objective water body. After assessment, all point-source-pollution discharges in the designated area can be allocated through discharge permission.

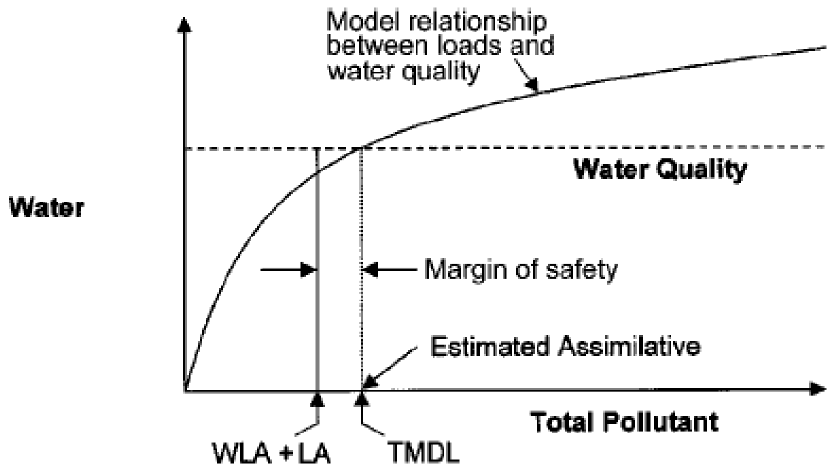
  TMDL=WLA+LA+MOS

  where

  WLA: point-source pollution

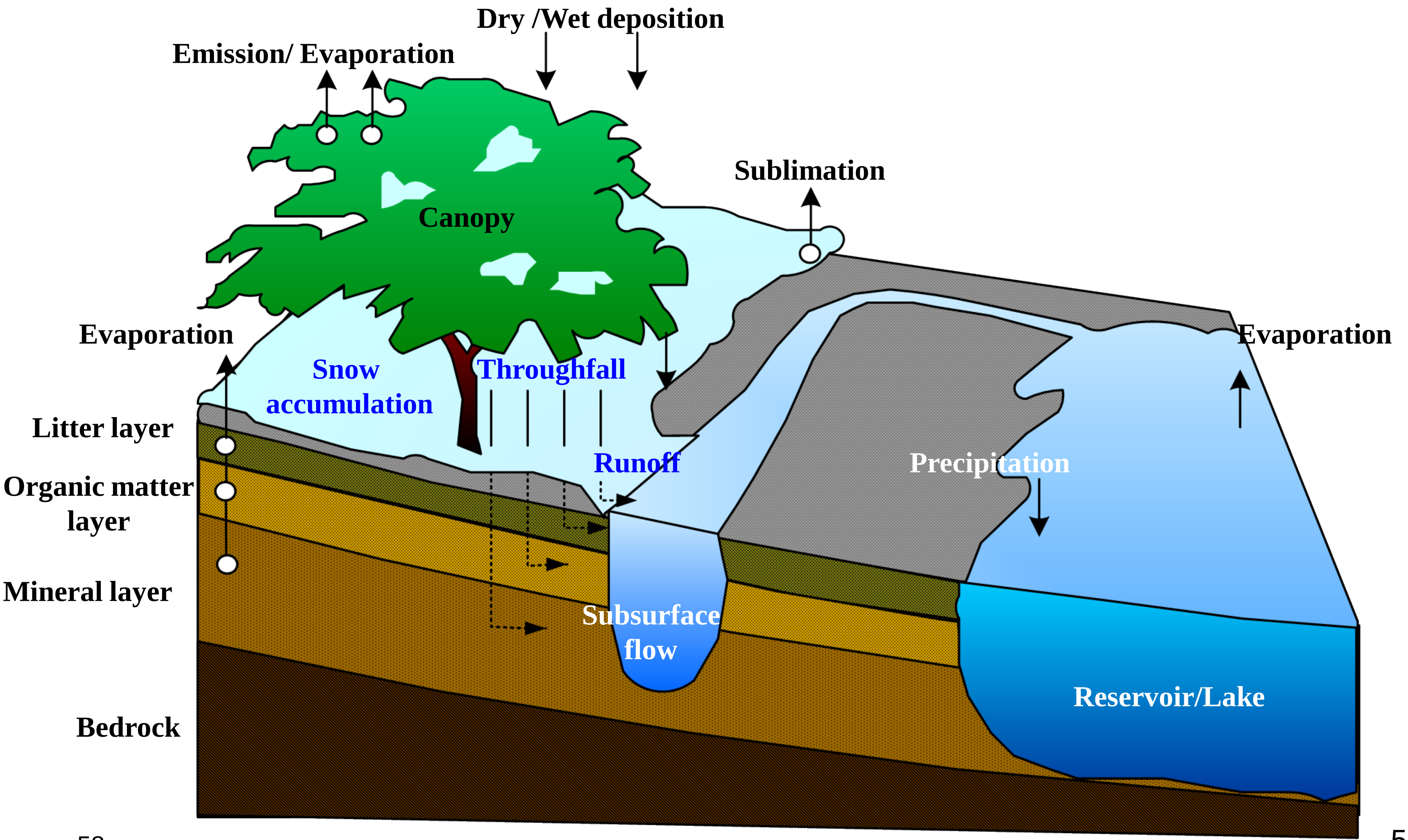
  LA: non-point-source pollution

  MOS：Margin of Safety



- Objective river
  - **Kaoping River:** Major river in southern Taiwan; seriously struck during Typhoon Morakot disaster in 2009.

IWMM Model - Hydrological/Chemical Process



Water Quality Analysis Simulation Program (WASP7)

- Simulation objectives
  - BOD, NH_3-N, DO, SS
- Input variables
  - Hydrodynamics
    - Velocity, flow rate, and depth
  - Water quality
    - Boundary conditions, point and non-point sources
- Key parameters
  - BOD deoxygenation rate
  - Nitrification rate
  - Reaeration coefficient
  - Sediment oxygen demand

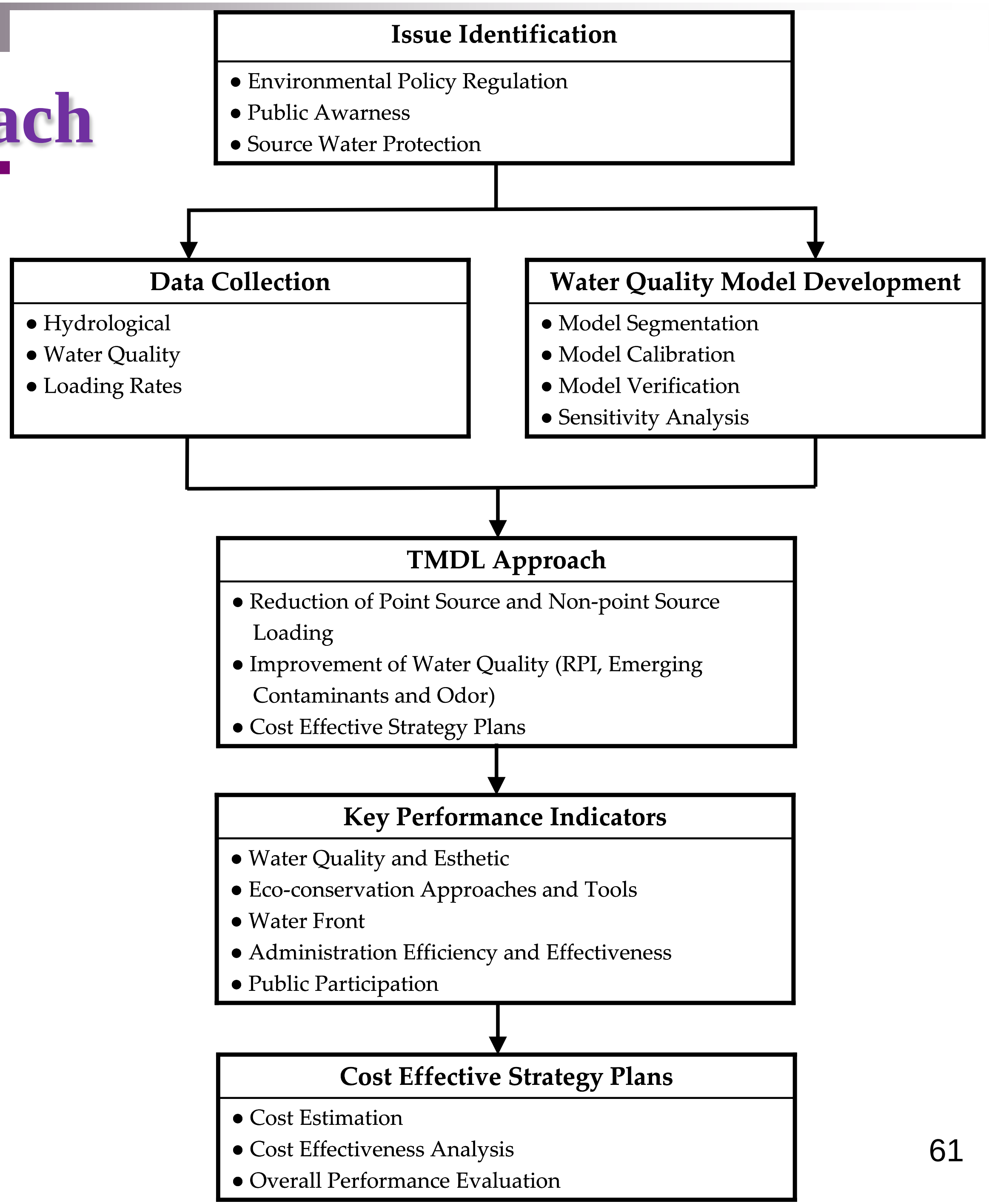
River Pollution Index (RPI) by TEPA

Table 1. The River Pollution Index classify the degree of pollution by TEPA

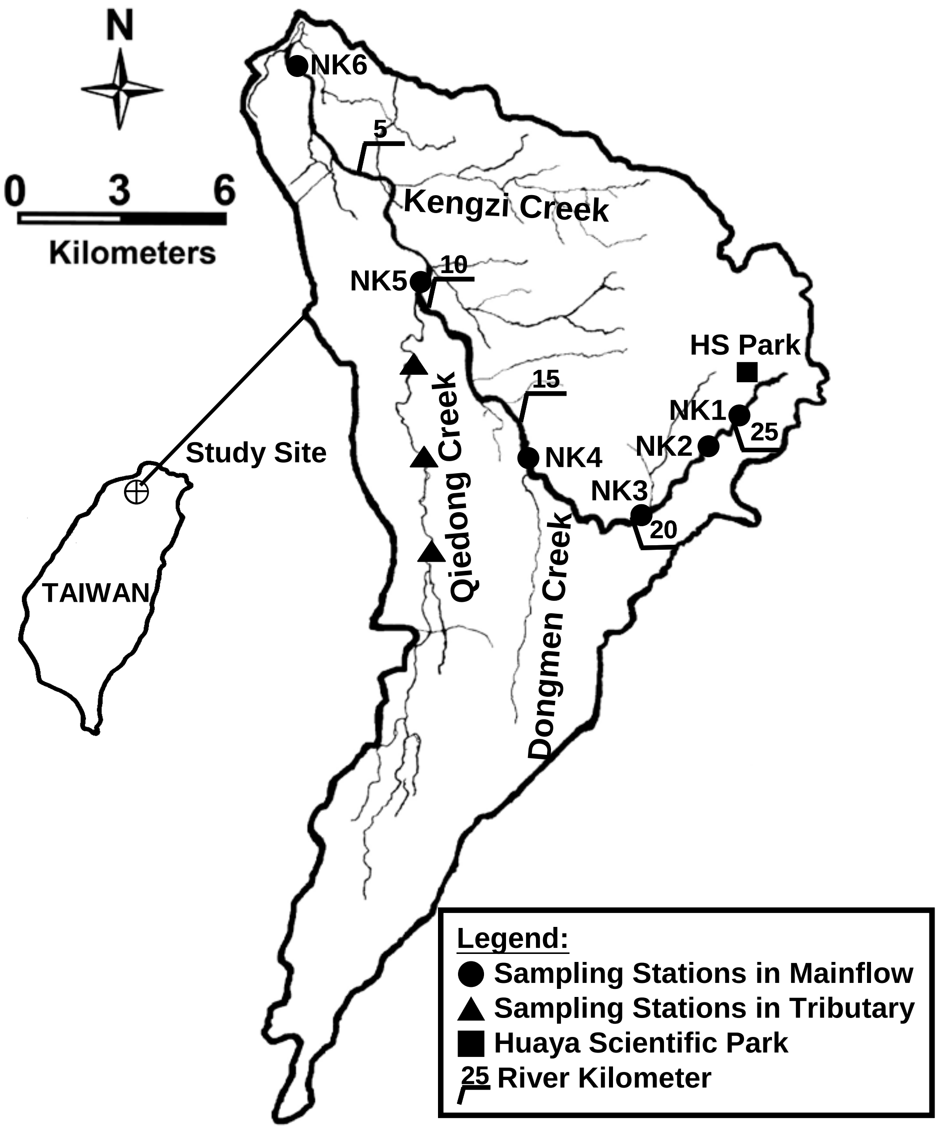
Parameter	Uncontaminated	Light pollution	Medium pollution	Serious pollution
Dissolved oxygen (mg/L)	> 6.5	4.6 – 6.6	2.0 – 4.5	< 2.0
BOD_5 (mg/L)	< 3.0	3.0 – 4.9	5.0 – 15	> 15
Suspended solids (mg/L)	< 20	20 – 49	50 – 100	> 100
Ammonia (mg/L)	< 0.5	0.5 – 0.99	1.0 – 3.0	> 3.0
Integral	< 2.0	2.0 – 3.0	3.1 – 6.0	> 6.0

Systematic approach

development of a river basin management by using TMDL

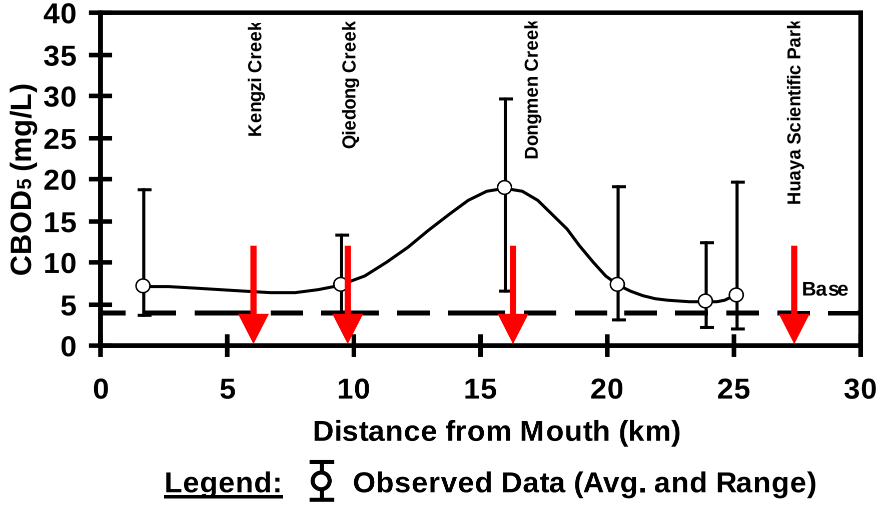


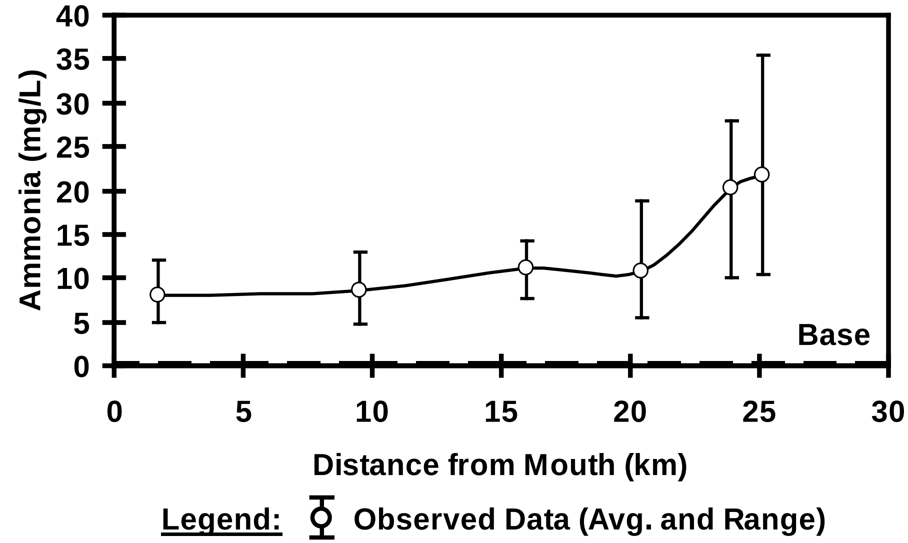
Location and Sampling Points (Nankan River)

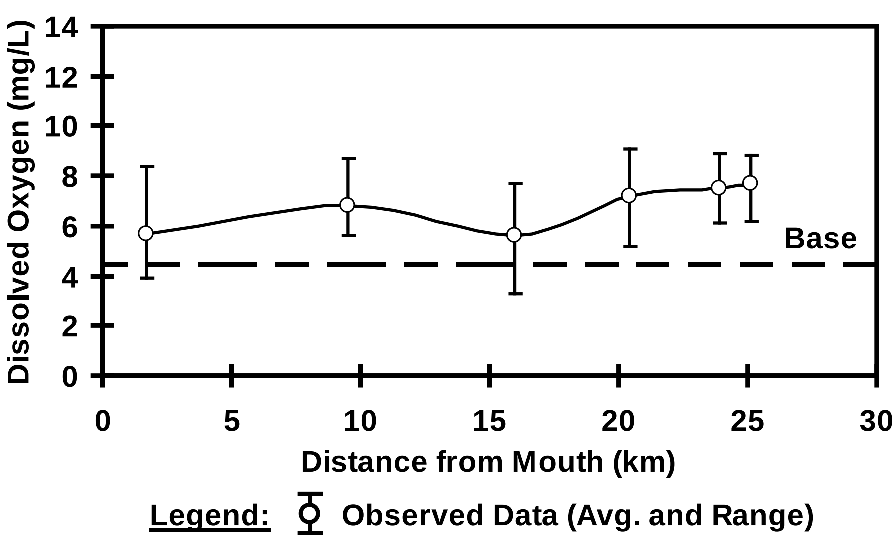


Location of Nankan River and its sampling points

CBOD$_5$, ammonia, and DO concentrations

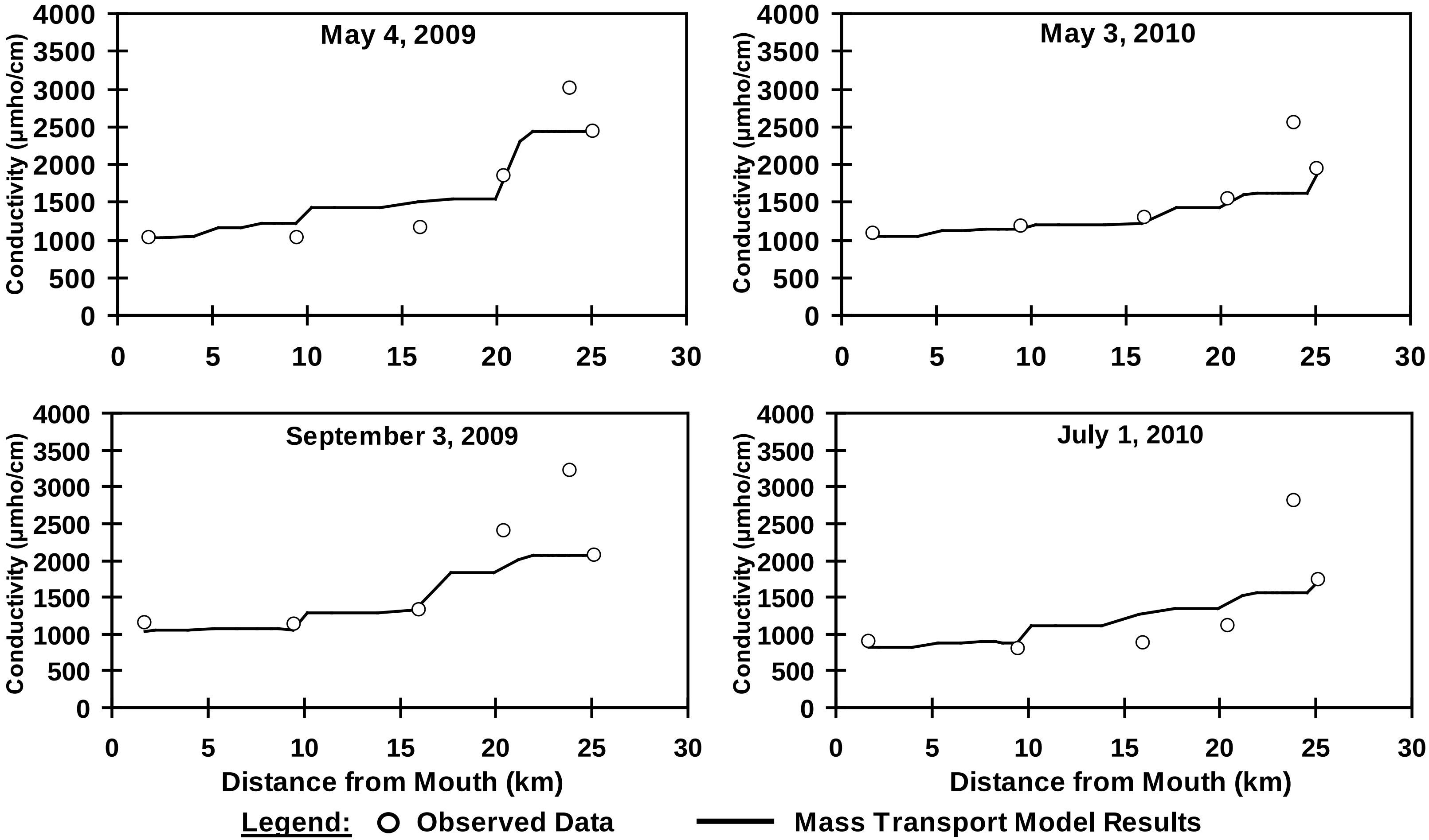






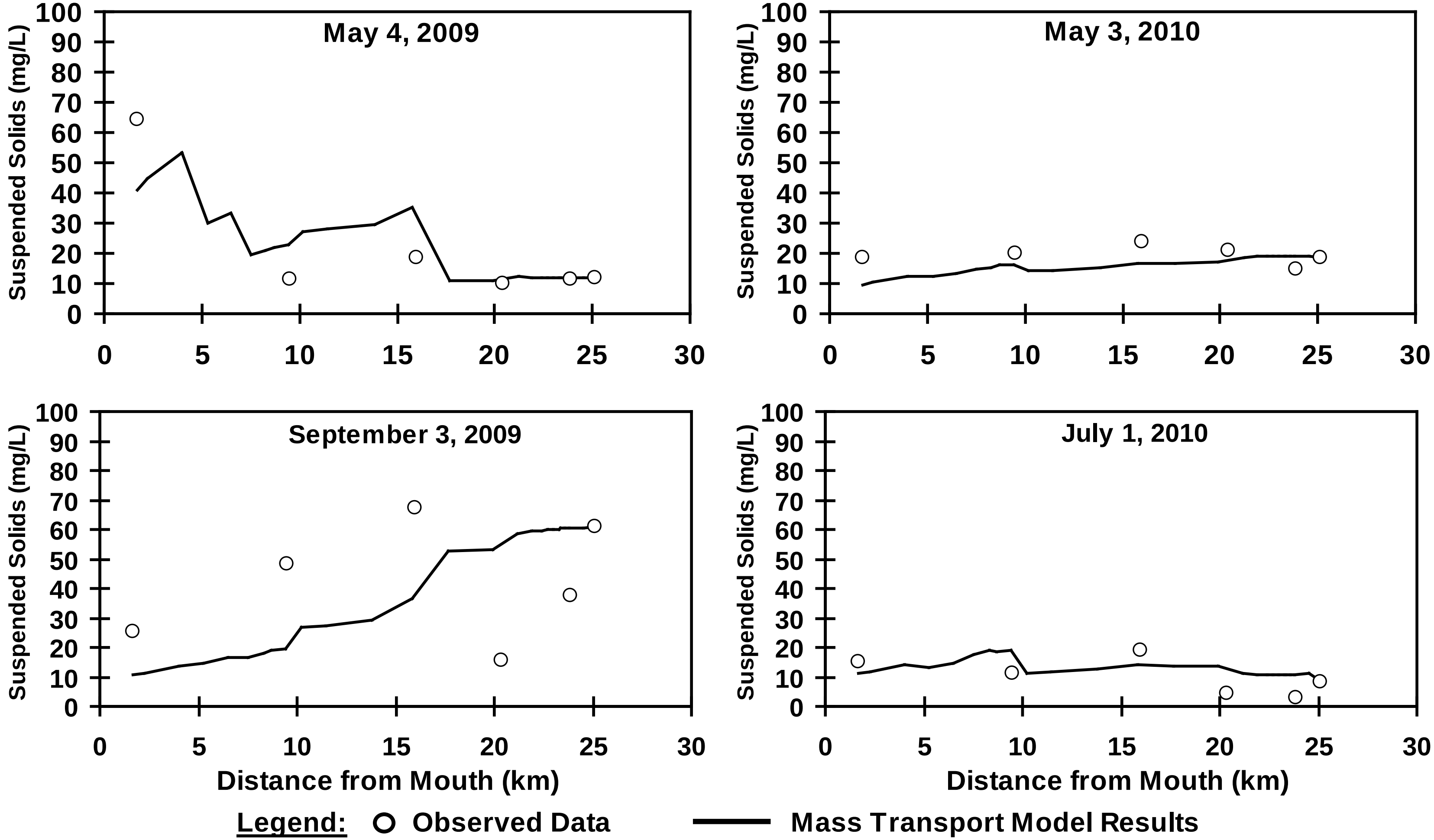
Measured CBOD$_5$, ammonia, and DO concentrations at Nankan River during January, 2008 to December, 2010

Specific Conductivity



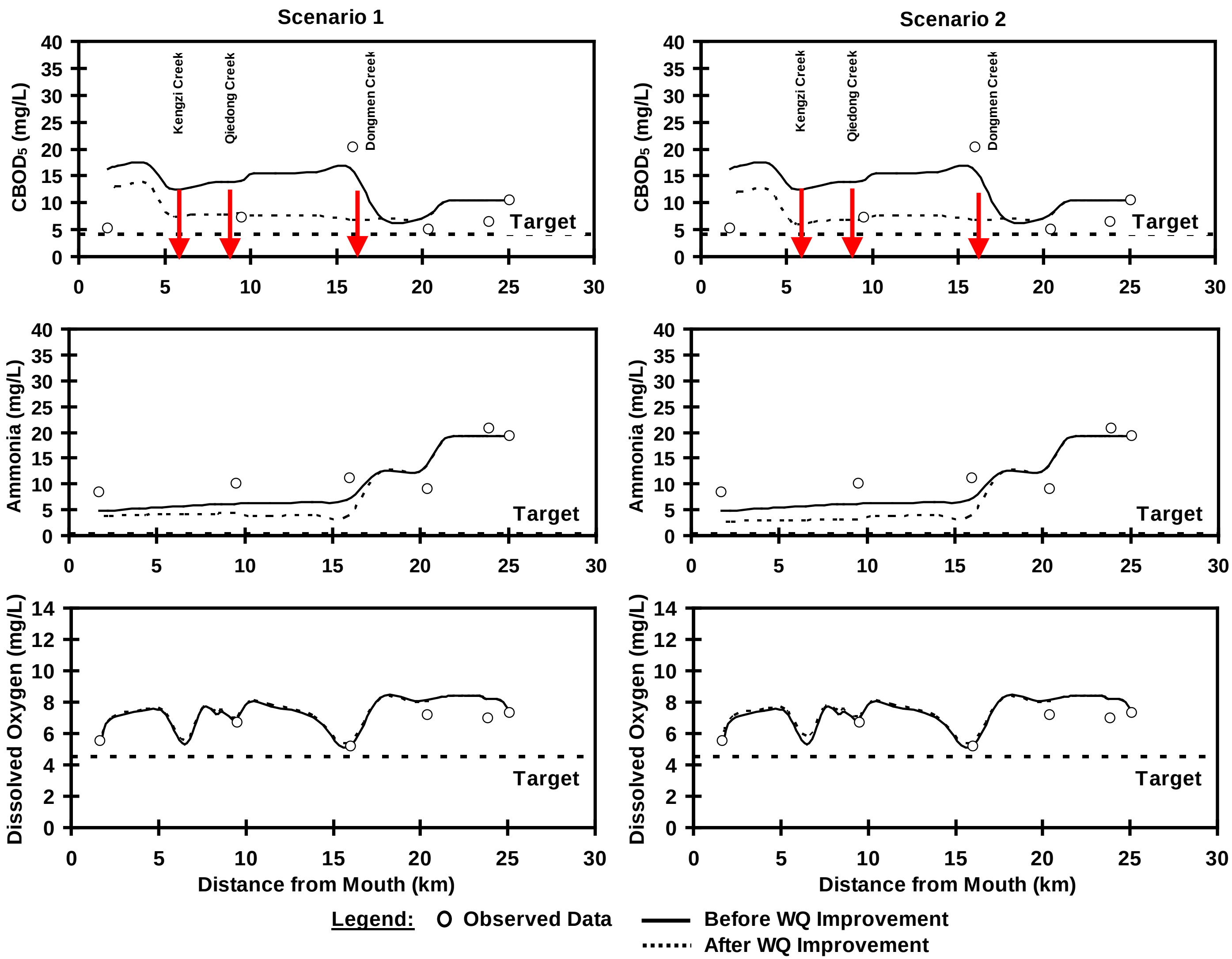
Steady-state mass transport model results versus data for the Nankan River in May 4, 2009, September 3, 2009, May 3, 2010, and July 1, 2010. (a) specific conductivity,

Suspended Solids (SS)



Steady-state mass transport model results versus data for the Nankan River in May 4, 2009, September 3, 2009, May 3, 2010, and July 1, 2010. (b) suspended solids

Improvement of assimilative capacity



Two scenarios for improving assimilative capacity of $CBOD_5$, ammonia, and DO concentration in the Nankan River

TMDL Scenarios (Nankan River)

Three Sets Evaluation of TMDL Scenarios for the Nankan River

Items	High	Medium	Low
	Scenario I	Scenario II	Scenario III
Loading Reduction			
• Point Source (BOD_5)	/day	/day	/day
• Point Source (NH_3-N)	/day	/day	/day
• Non-Point Source	–	–	–
Water Quality Improvement			
• RPI	3.1 – 4.0	4.1 – 5.0	5.1 – 6.0
• Odor	no DMS and DMTS	no skatole	no Indole
• CECs	–	–	–
Benefit/cost ratio (BOD_5)	2.21	1.55	1.10

Wastewater Alternatives Critical Conditions (Nankan River)

Two Sets Evaluation of Wastewater Alternatives Critical Conditions for the Nankan River

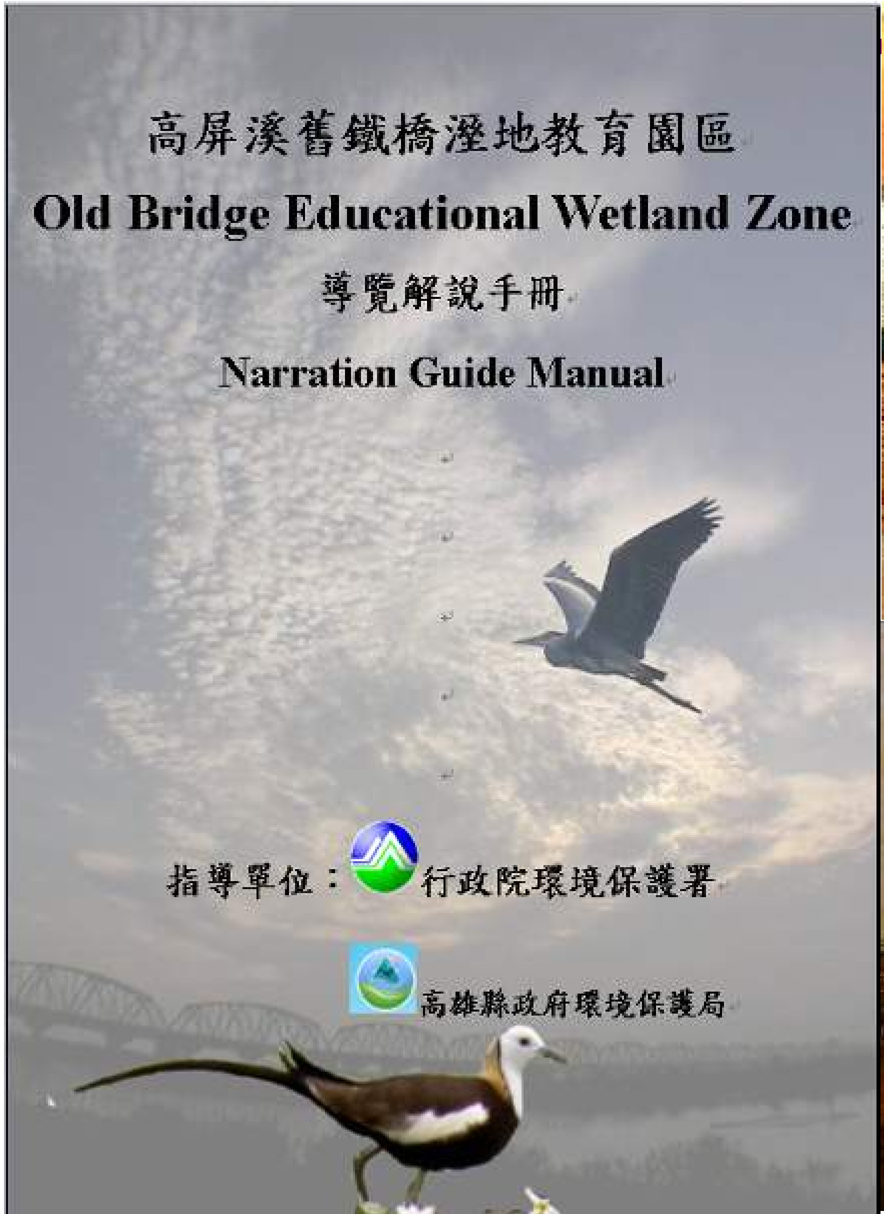
Item	Reduction loading rates of Alternative 1		
	Dongmen Creek	Qiedong Creek	Kengzi Creek
BOD_5 (kg/day)	707	0	0
Ammonia (kg/day)	256	0	0

Item	Reduction loading rates of Alternative 2		
	Dongmen Creek	Qiedong Creek	Kengzi Creek
BOD_5 (kg/day)	707	406	221
Ammonia (kg/day)	256	464	169

II-5. Public participation (20%)

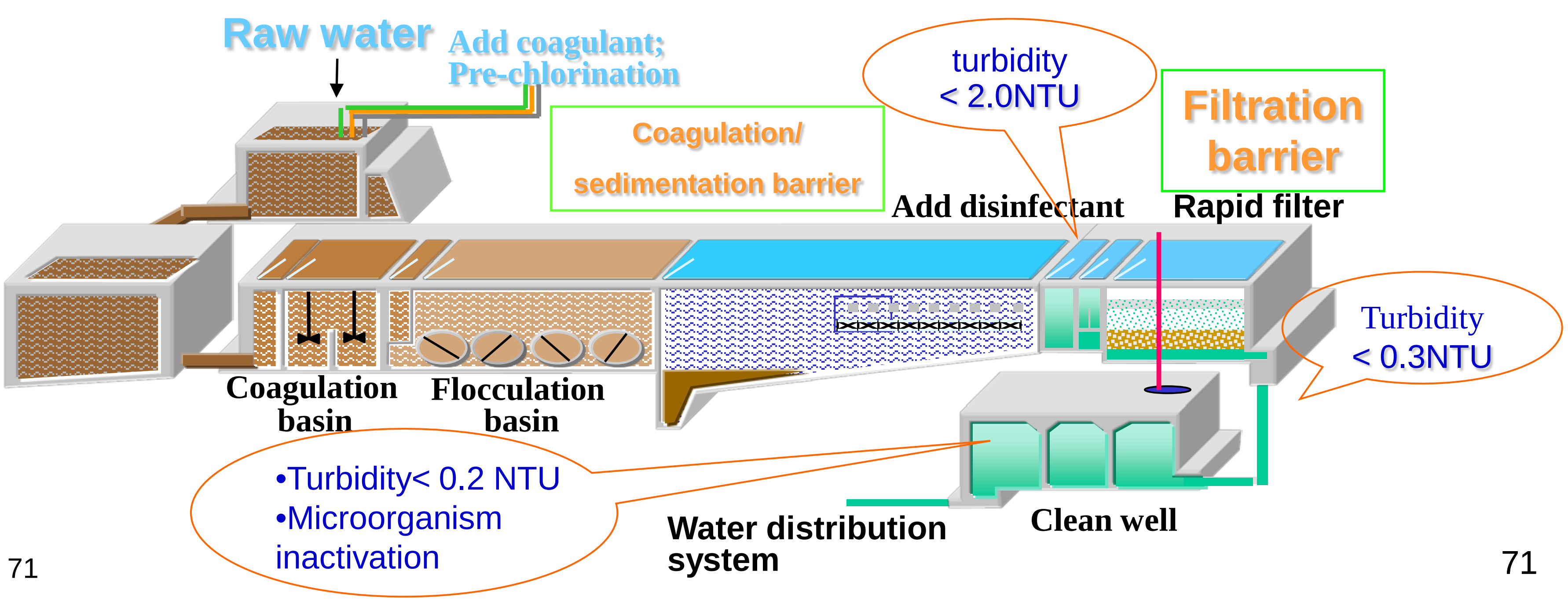
1. Stakeholder involvement
2. River patrol and audit
3. Public education
4. Outreach

Development of Education Program



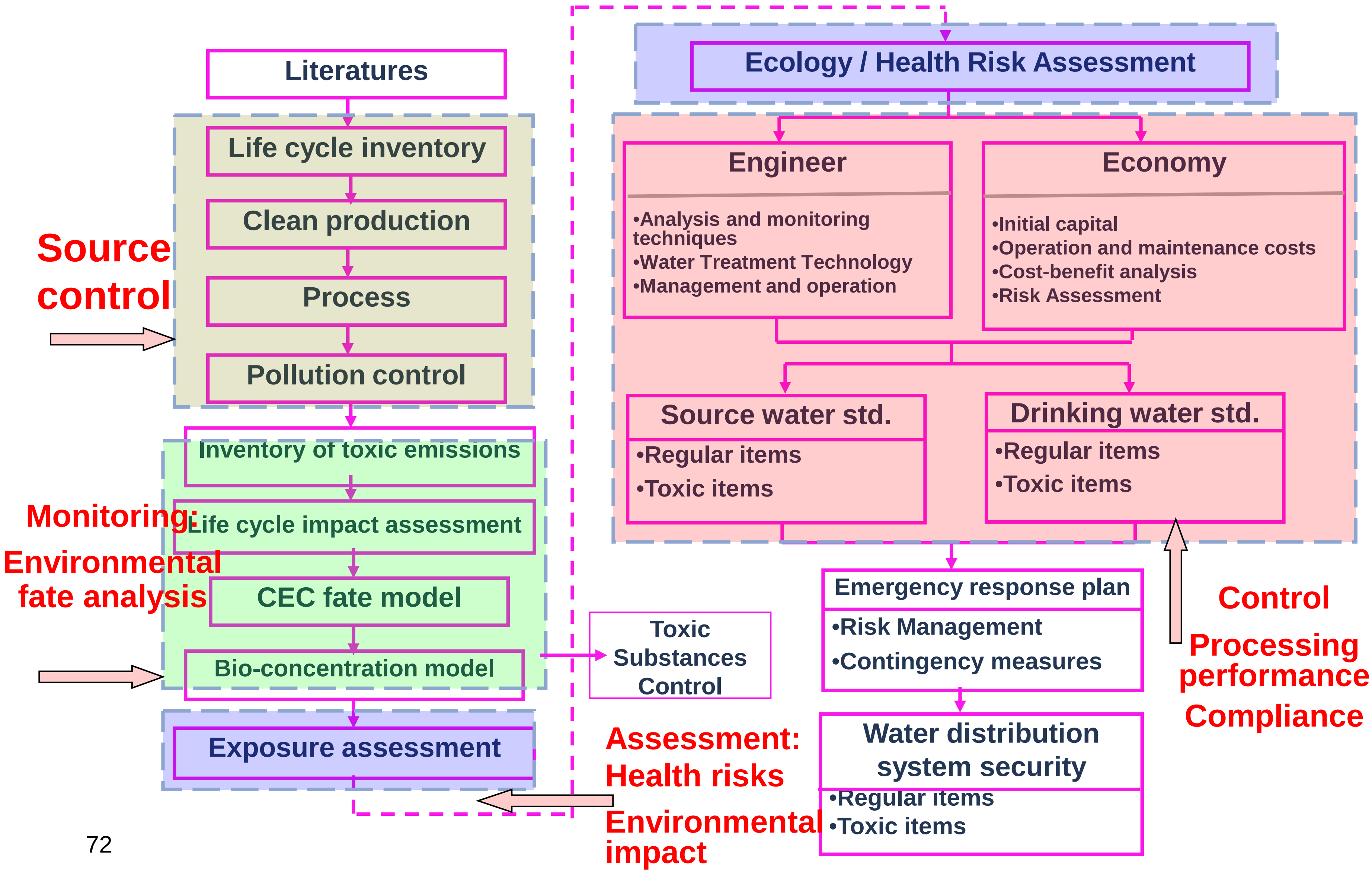
III. SECURITY AND SUSTAINABILITY OF WATER SUPPLY SYSTEM

IWA established the Bonn Charter which provides a framework for drinking water safety and has an emphasis on water resource management, from source development, through water treatment, to distribution and ultimately to the consumption stage .



71

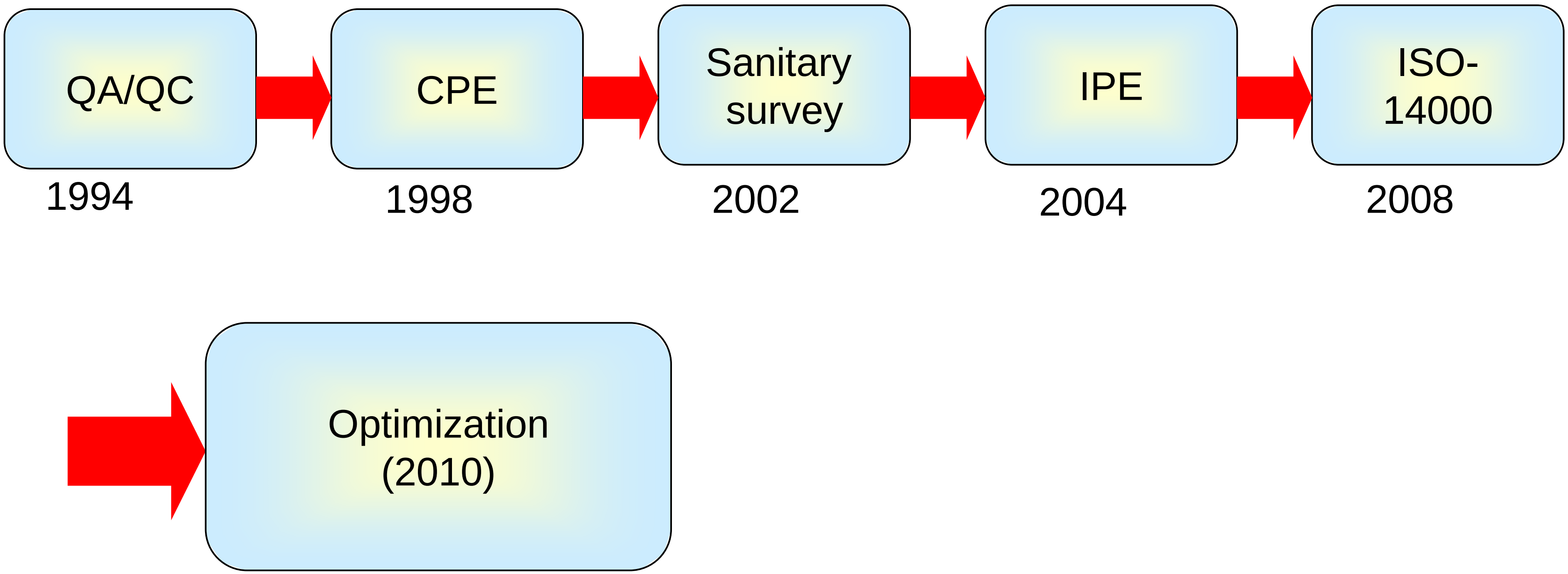
Strategic Control of CECs



III-1. Optimization of WTP

- Develop adequate and representative indicators for performance evaluation;
- Utilize the information technology to effectively execute the multi-barrier approach for protecting water quality;
- Up-grade the efficiencies of chemical coagulation, sedimentation, rapid filtration and chlorination processes ;
- Introduce the ICA (Instrumentation, Control and Automation) and MIS (Management Information System) techniques for optimum control;
- Install the advanced water treatment processes including ozonation, activated carbon and membrane.

Optimization of WTP—the Road Map



74

Scientific Questions

Source

How can source waters be assessed and managed?

Treatment

How effective are candidate treatment technologies?

Distribution

How can risks associated with changes in water quality in the distribution system be reduced?

Exposure

What is the exposure of the population to contaminants in drinking water?

Comprehensive Assessment for Safe Drinking Water

Collecting basic information
Typical characteristics of sources water
Related information
Basic information of treatment plant

Formation & Control of DBPs (Project I)

Investigating distribution of DBPs
Typical precursors of DBPs
DBPs formed from chlorination of precursors
DBPs from treatment plant

DBPs formation model
Water quality and environmental conditions
Water purification processes & DBPs yield

Assess Distribution of DBPs (Project II & III)

Formation control of DBPs
Water quality and environmental conditions
Formation control & operational parameters

Reduce Exposure Risk of DBPs (Project III)

Regulation & Criteria
SOPs of purification processes
Water quality criteria of source & drinking water

Comprehensive Research Strategy for Total Exposure Assessment and Risk Management

Source → Treatment /Formation → Distribution /Formation → Exposure → Dose → Response

Exposure Assessment

Hazard ID/Dose Response Assessment

Local Exposure Data ?

Risk Characterization

Risk Management

Additional Research

Determination of Optimum Dose by Response Surface Model

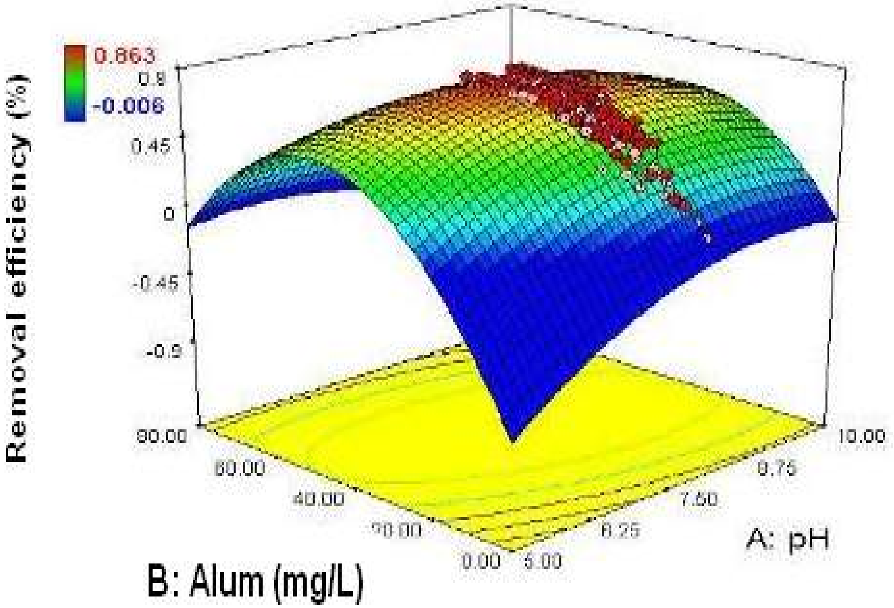
- **Jar test**
  - **Low turbidity, < 30 NTU**

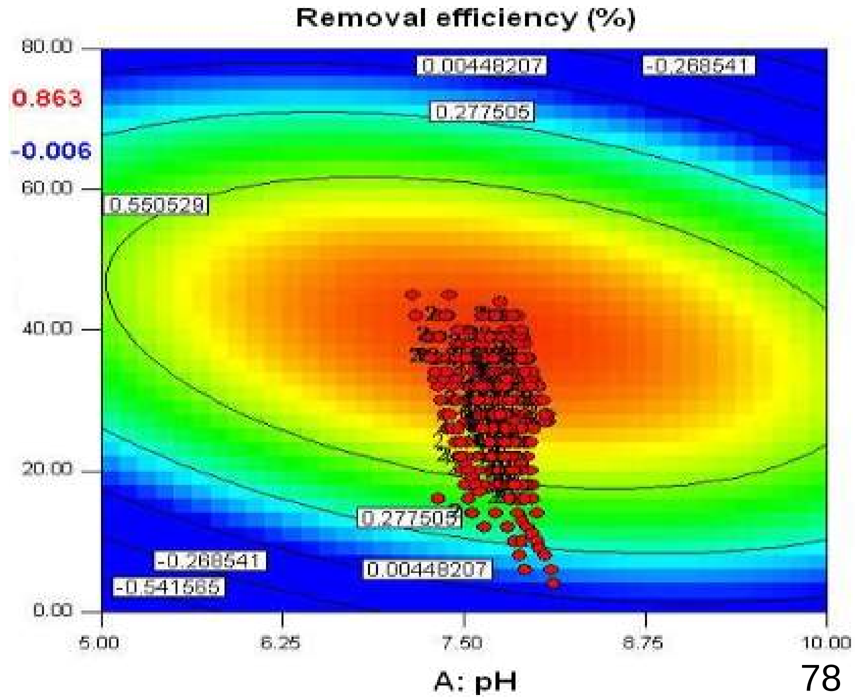
    (1) Model development

    Y=-3.75+0.8A+0.07B-0.003B-0.04A^2

    (2) Optimum dose

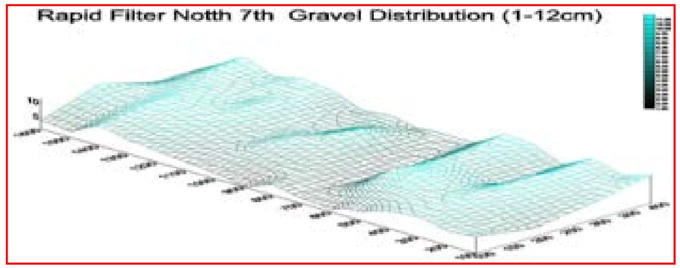
    Alum = 40 mg/L, pH = 7.7 and the removal efficiency = 82.4%

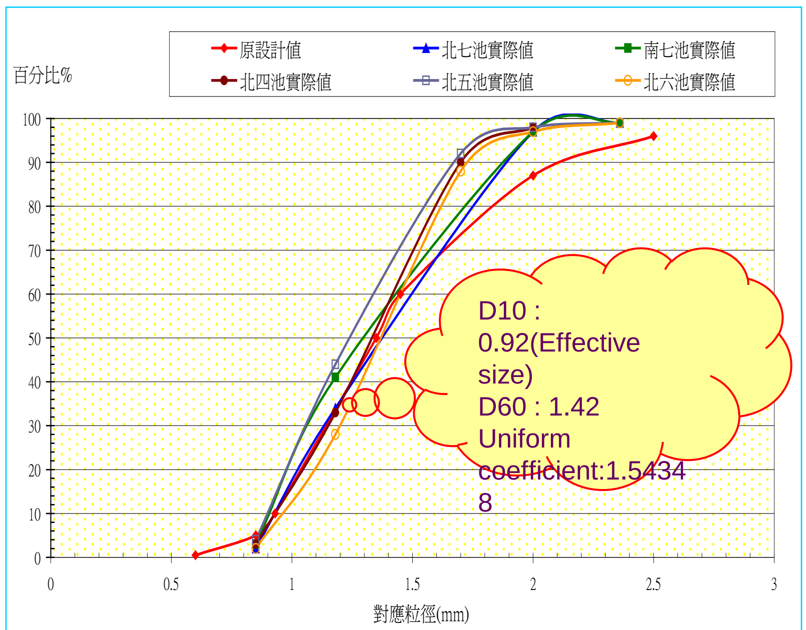




Maintenance Program:

Rapid Filtration Inspection

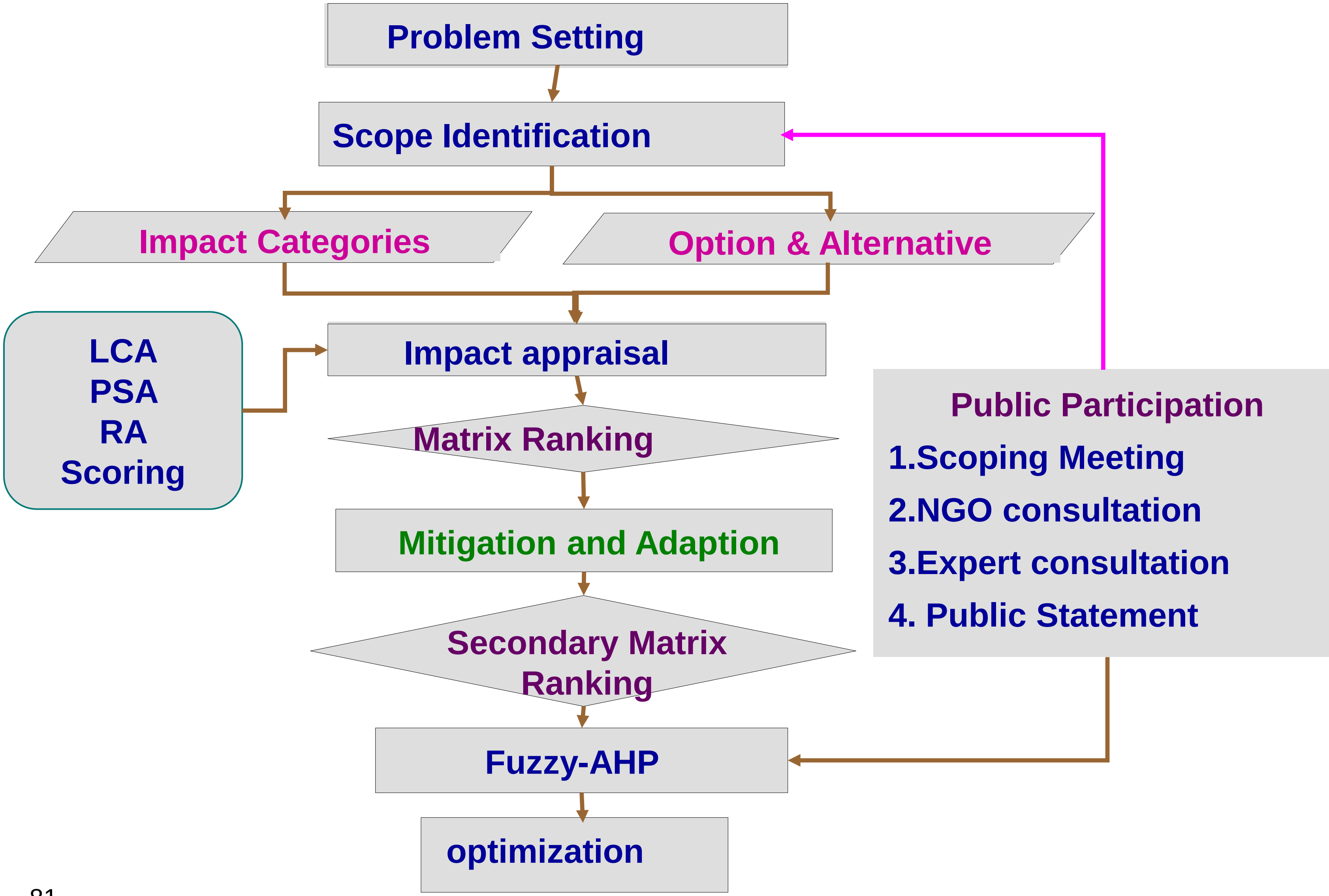




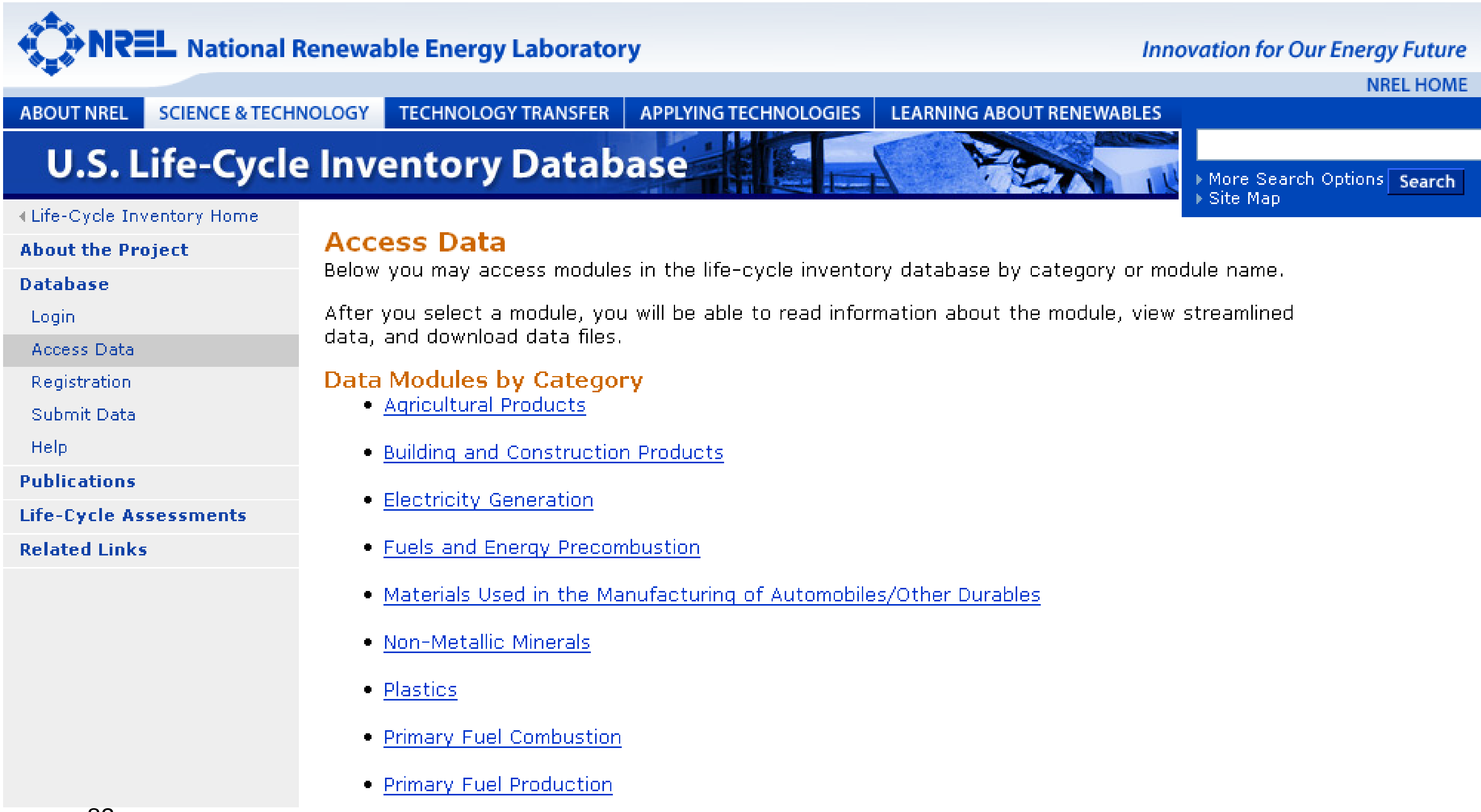
Energy Saving

- Incorporate the concept of "carbon neutralization"..
- Develop energy saving service technology and manufacturing capacity.
- Promote the energy saving policy and improve the energy saving efficiency.

Life Cycle Assessment for Optimization



NREL U.S. Life-Cycle Inventory Database



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U.S. Life-Cycle Inventory Database

More Search Options
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Search

- Life-Cycle Inventory Home
- About the Project
- Database
  - Login
  - Access Data
  - Registration
  - Submit Data
  - Help
- Publications
- Life-Cycle Assessments
- Related Links

Access Data

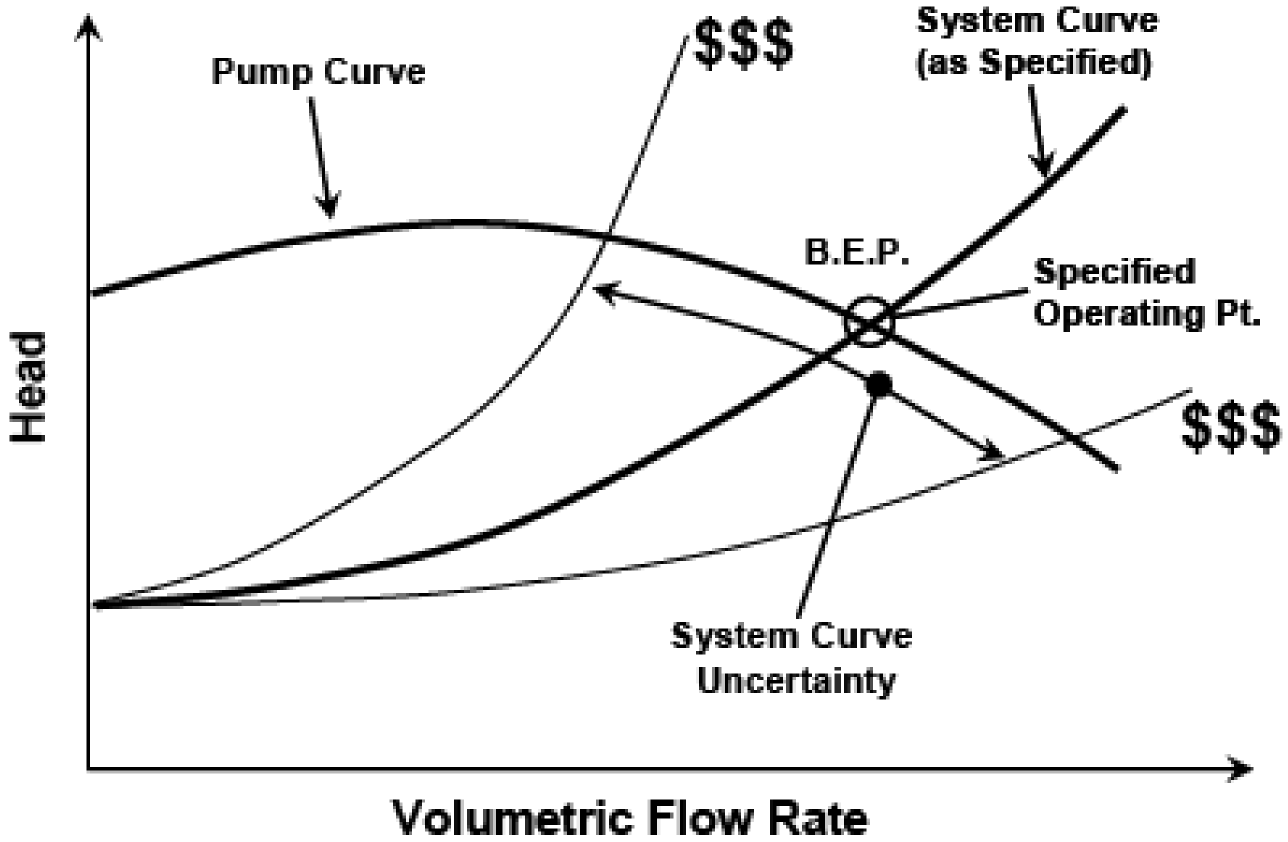
Below you may access modules in the life-cycle inventory database by category or module name.

After you select a module, you will be able to read information about the module, view streamlined data, and download data files.

Data Modules by Category

- Agricultural Products
- Building and Construction Products
- Electricity Generation
- Fuels and Energy Precombustion
- Materials Used in the Manufacturing of Automobiles/Other Durables
- Non-Metallic Minerals
- Plastics
- Primary Fuel Combustion
- Primary Fuel Production

Energy Saving



Motor system and the best efficiency point (BEP)

Energy Saving

Plan (Objectives) → **Do (Action plans)** → **Check (Performance Evaluation)** → **Act (Correction Plans)**

Flow rate (*10^4 CMD)	No. of filter	Water saving per year(M^3)	Energy saving per year (kWH)
70~80	24	—	—
60~70	22	365000	26900
50~60	20	730000	53800
40~50	18	1095000	80700

III-2 Implementation of Water-Reuse Policy in Ecological Industrial Park

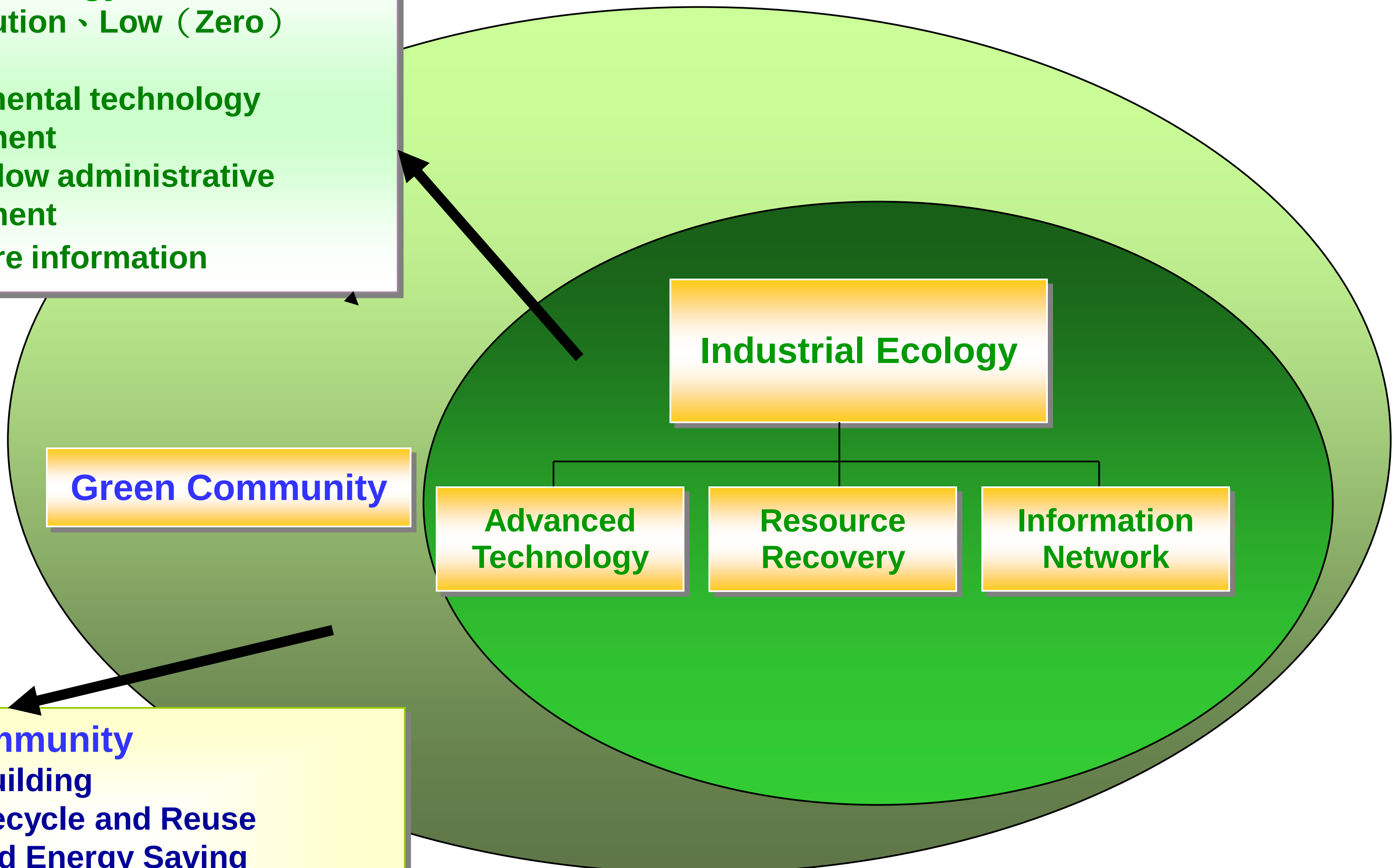
- Develop an integrated-water-management legislative framework that encourages and facilitates water recycling.
- Upgrade the existing wastewater treatment plants to achieve their practical and safe application.
- Regulate the toxic chemical substances to reduce the risk potency for water recycling.
- Adapt environmental auditing programs to ensure water recycling being undertaken safely and sustainable.

85

Development of Eco-Industrial Park

Industrial Ecology

- Low pollution、Low（Zero）emission
- Environmental technology development
- One-window administrative management
- Disclosure information



Green Community

- Green Building
- Waste Recycle and Reuse
- Water and Energy Saving
- Environmental Education
- Environmental Monitoring

IV. Conclusions and Recommendations

Adaptation to Climate Change: Water Resources and Energy

- Plan for alternative water sources (i.e., treated wastewater or desalinated seawater)
- Improve water use efficiency
- Revise water allocation
- Increase energy efficiency to offset increases in energy consumption
- Protect facilities against extreme weather events

IV. Conclusions and Recommendations

- **Natural ecological index:**

  ① Water : Water quality, Diversity of waters, and Continuity of river corridor

  ② Soil : Stability of riverbank, Diversity of settlement, and Stability of riverbed

  ③ Forest : Vegetation on the water-soil interface and Continuity of water-soil interface

  ④ Animal : Biodiversity

- **Human ecological index**

  ①People : Effect of human interference

IV. Conclusions and Recommendations

KPIs for IWMP should be politically accountable, socially acceptable, technically executable, and economically affordable.

- Water Quality and Esthetic
- Eco-conservation Approaches and Tools
- Access to Water Front
- Administration Efficiency and Effectiveness
- Public Participation

IV. Conclusions and Recommendations

Eco-conservation approaches and tools include:

(1) Implement Eco-protection policy

- Management of Natural Eco-conservation Area
- Wild Animal Conservation
- Integrated Water Management Plans (IWMP)

(2) Restore the habitat

- Ecological Corridor Protection
- Habitat and Biodiversity Conservation
- Eco-tech Engineering (Installations of Natural and Artificial Wetlands)

(3) Establish Eco-database

- Eco-Survey
- Eco-benefit Assessment
- Monitoring and Assessment Plans (Cost-effectiveness Analysis)

IV. Conclusions and Recommendations

Establish KPIs for Eco-benefit Assessment:

- Habitat and biodiversity
- Eco-benefit
- Pollution reduction
- Water quality improvement
- Flooding retention
- Environmental landscape
- Green tour
- Eco-education
- Social-economic benefit
- Carbon sink (neutral)
- Biomass energy utilization

Integrated Watershed Management plan

- Construction of the GIS net working and real time water quality monitoring system to effectively manage the watershed.
- Application of natural treatment systems (e.g., land treatment, constructed wetland, porous media infiltration) for domestic sewage.
- Development of security and sustainability of water supply system programs by Life cycle assessment
- Development of EIP (Eco-Industrial Park) for promotion of water-reuse policy.

92

Thank you for your attention