Environmental Flows
Principals, approaches, calculations

By

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Presentation Contents

- Definition of Environmental Flow
- Environmental Flows Methodologies
- Choosing the right method for EF
- Challenges for successful E-flows implementation

Definition of Environmental Flows

- Environmental Flows can be defined as "*the water regime provided within a river, wetland or coastal zone to maintain ecosystems and their benefits*"

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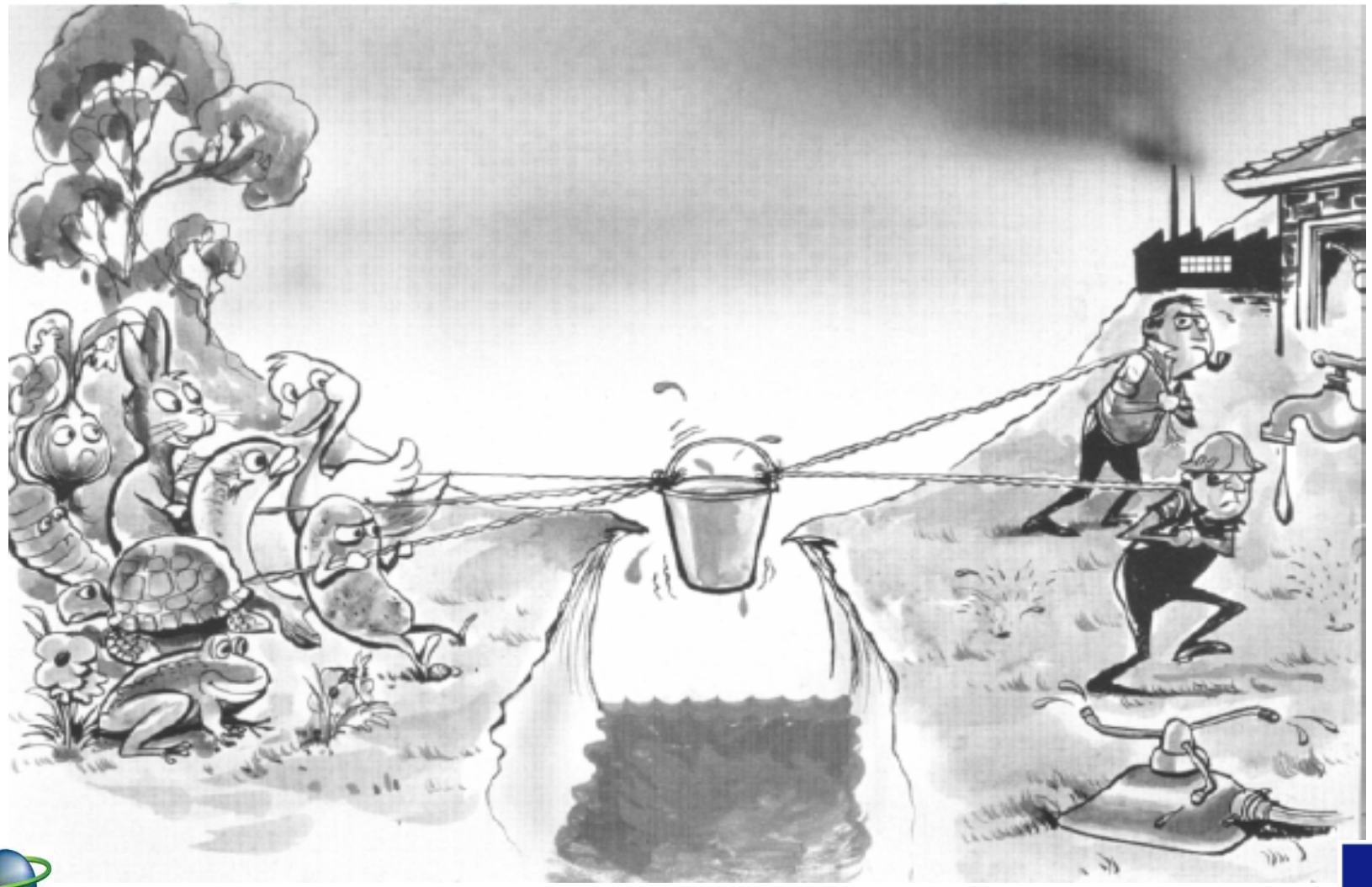
Environmental Flows preserve Other Species Rights



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Environmental Flow and Water Management

- Despite the growing recognition on environmental aspects
- Water requirements for development sectors have higher priority at political level than Environmental needs
- lack of understanding of the socio-economic cost and benefits associated with its implementation

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INTEGRATED WATER RESOURCES MANAGEMENT
COORDINATION FOR A SUSTAINABLE FUTURE

HYDRAULICS
Velocity, Depth, Substrate

ECOLOGY
Habitat types
Ecological processes
Indicator species

HYDROLOGY
Flows in m^3/sec

The Engineer **The Ecologist**

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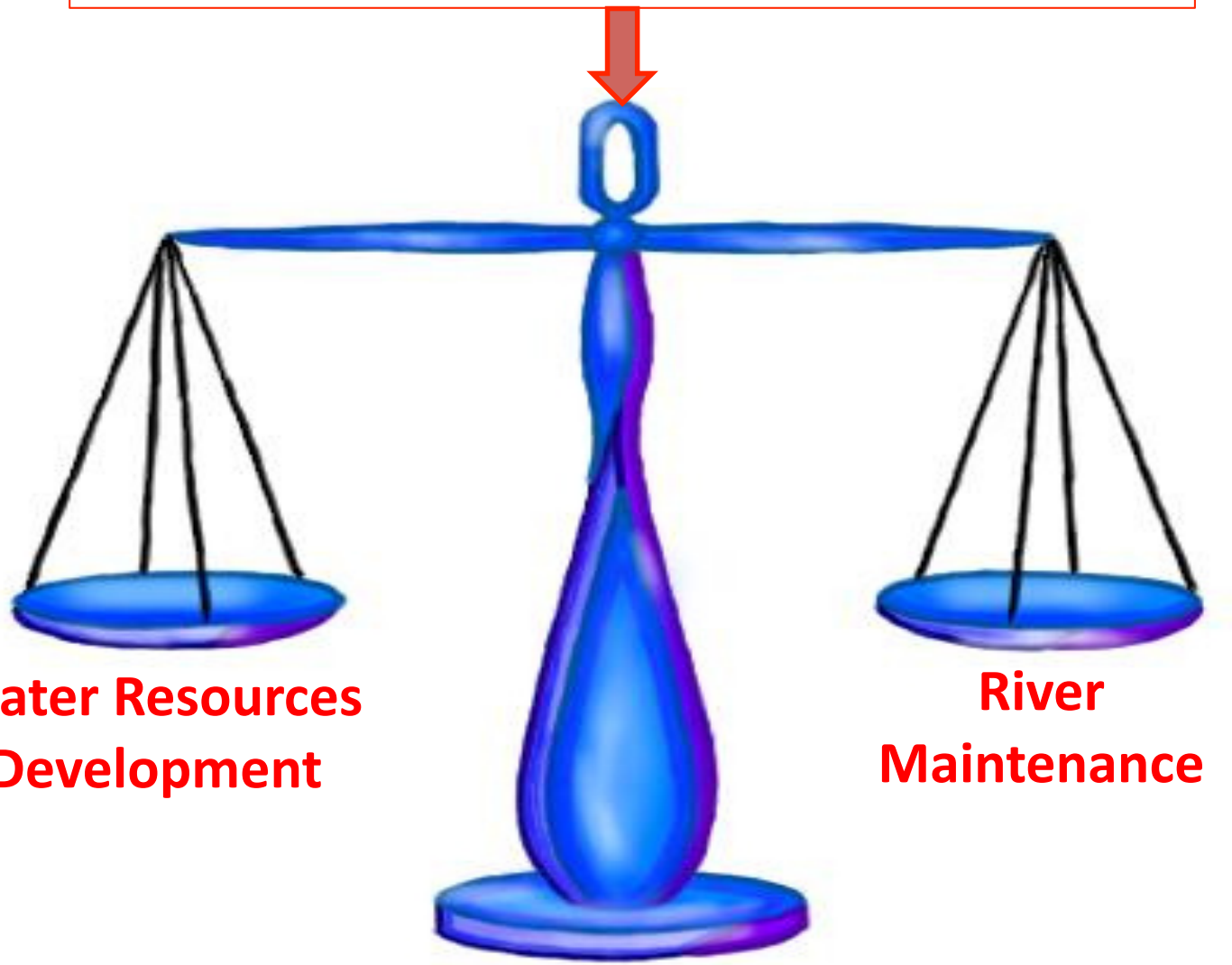
Environmental Flow

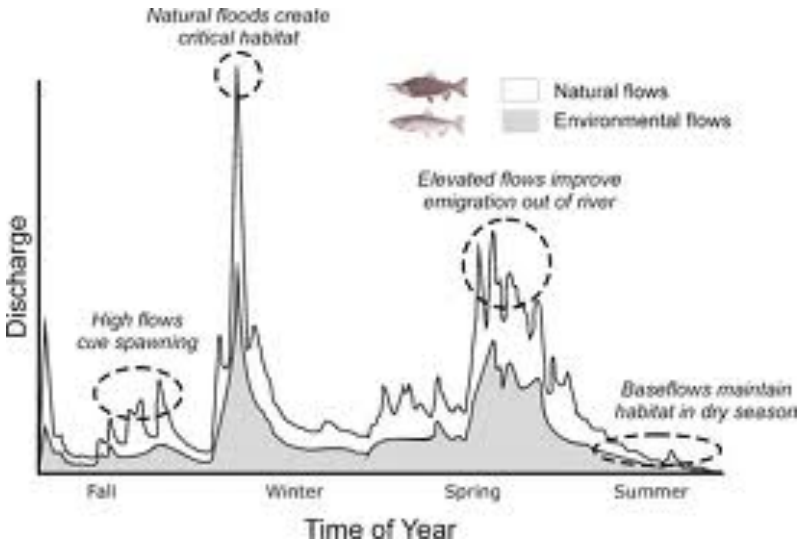


Water Resources Development

River Maintenance

Environmental Flows Adoption and Methods

- In 2003, a survey revealed the existence of 207 individual methodologies for EF Calculations
- They fall into four discrete groups:
  - Hydrological index methods,
  - Hydraulic rating methods,
  - Habitat simulation methods,
  - Holistic methodologies

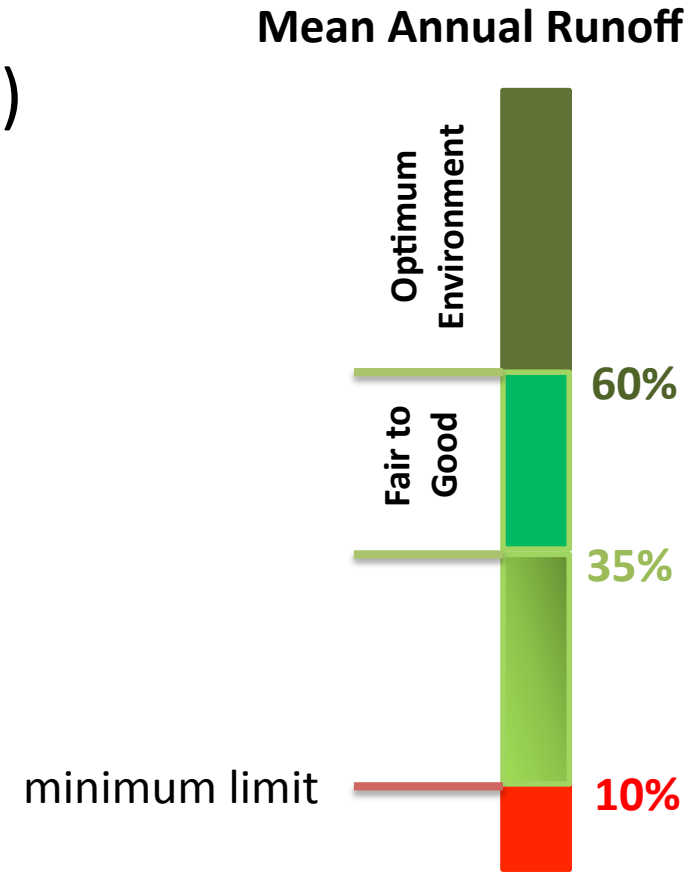


Categories of environmental flows methodologies and examples

1. Hydrologic
   - Tennant
   - Q_{90}
2. Hydraulic rating
   - Wetted perimeter method
3. Habitat simulation
   - IFIM
   - PHABSIM
4. Holistic methods
   - Building Blocks Methodology (BBM)

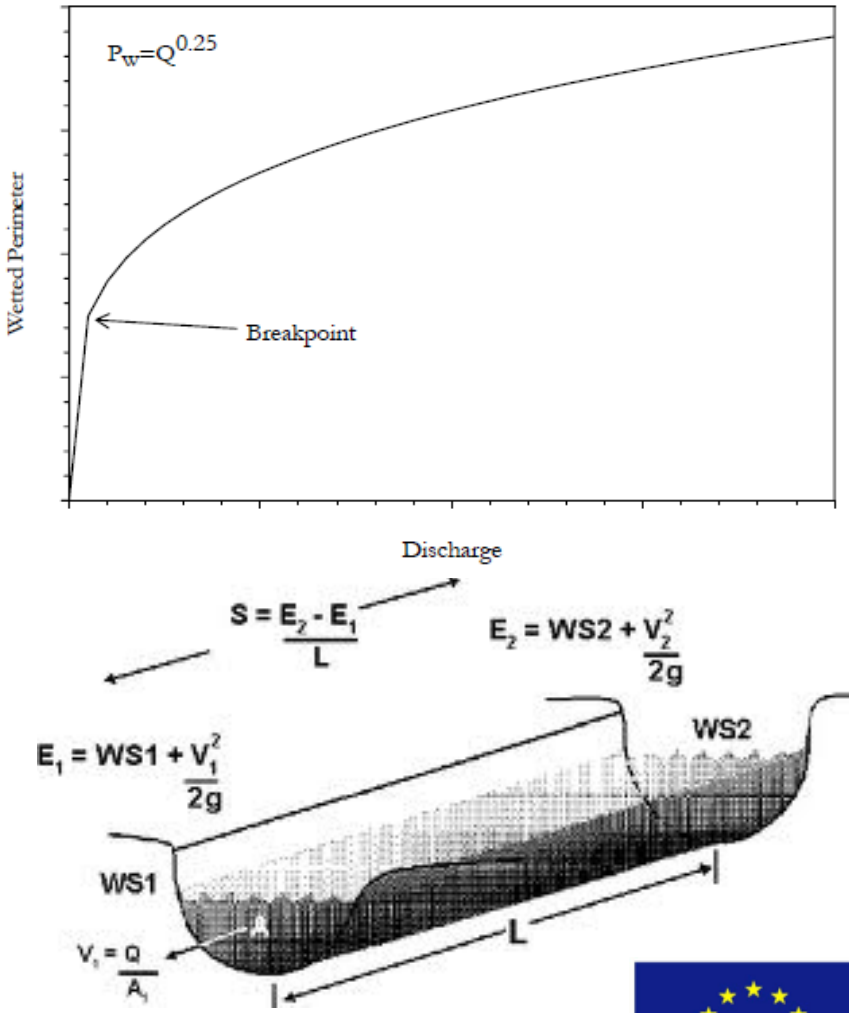
The Tennant Method

- Separate Mean Annual Runoff (MAR) into several ecologically relevant ranges
  - The minimum limit for environmental Flow is 10% of the annual MAR
  - The Fair to Good habitat conditions requires at least 35% of the MAR
  - Optimum Environment in the river requires > 60% of the MAR
  - Limitations of this method:
    - No flow variability considered
    - It is arbitrary



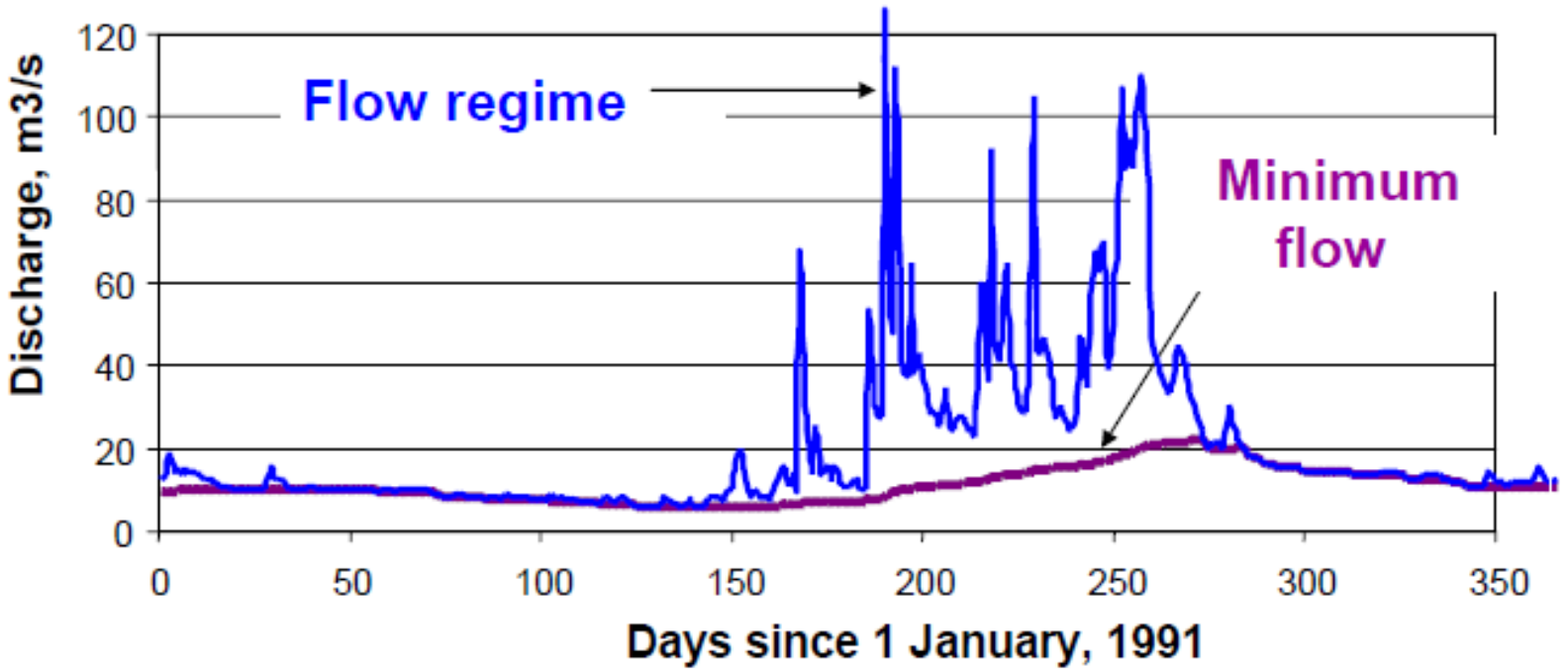
The Wetted Perimeter method

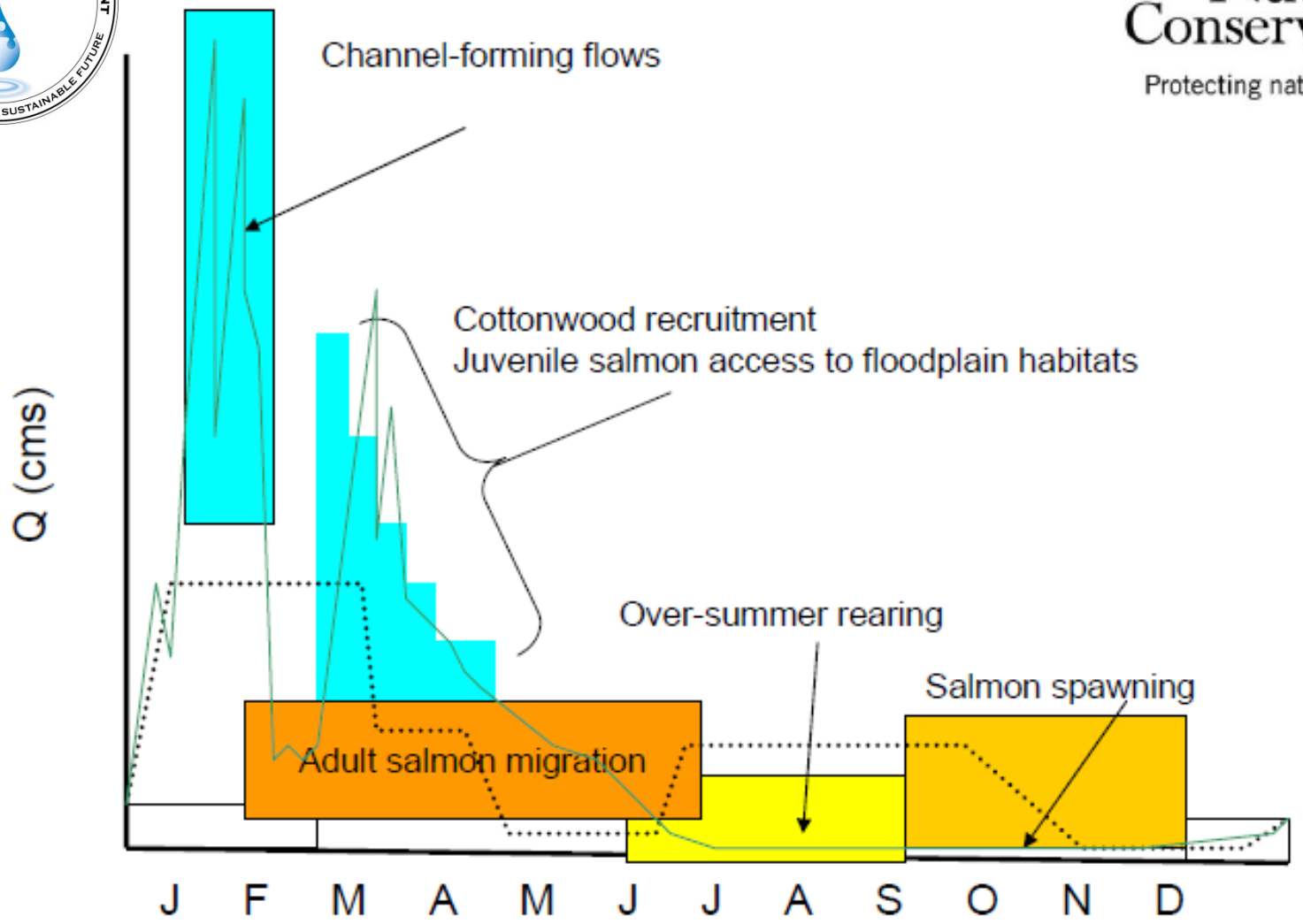
- Based on historical flow records and cross-section data
- They assume links between hydraulic conditions and habitat availability of target biota.
- Environmental flow is given either as a minimum flow, below which habitat is rapidly lost, or as the flow producing a fixed percentage reduction in habitat availability.
- The Wetted Perimeter Method is the most commonly applied hydraulic rating method
- It suggested that a 20% reduction in wetted perimeter at mean flow might be the maximum allowable degradation



Shift from minimum flow to flow regime:

* magnitude, frequency, duration, timing, rate of change
* flow components (low flows, freshes, floods)

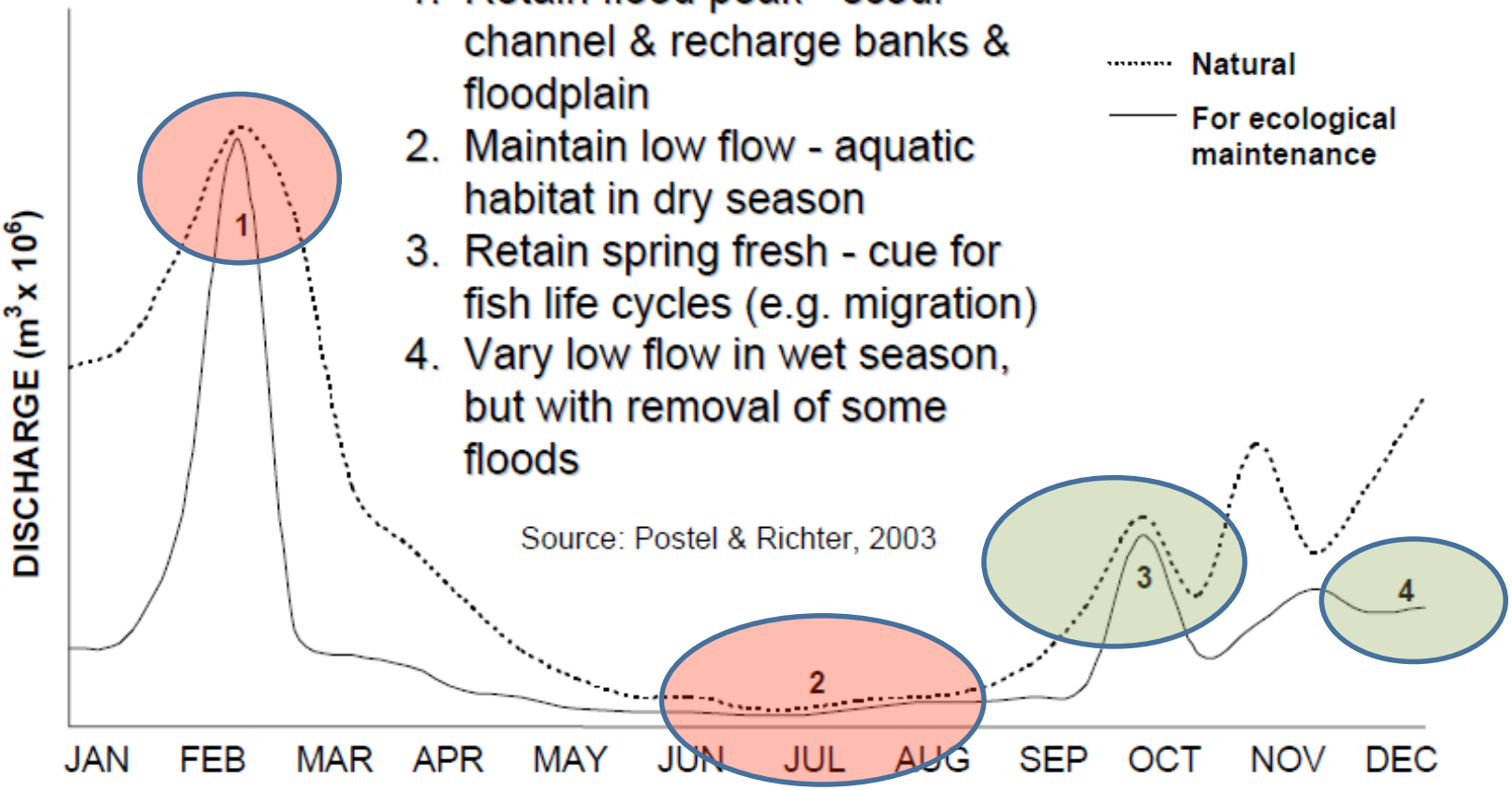




Determining flow needs for various ecosystem processes

Holistic Methodologies: natural flow paradigm

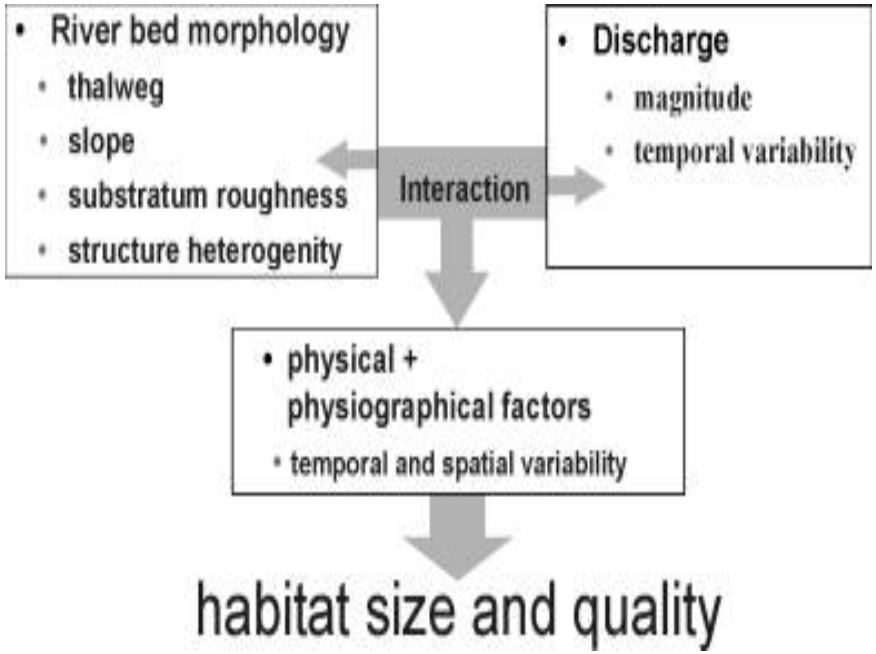
1. Retain flood peak - scour channel & recharge banks & floodplain
2. Maintain low flow - aquatic habitat in dry season
3. Retain spring fresh - cue for fish life cycles (e.g. migration)
4. Vary low flow in wet season, but with removal of some floods



Source: Postel & Richter, 2003

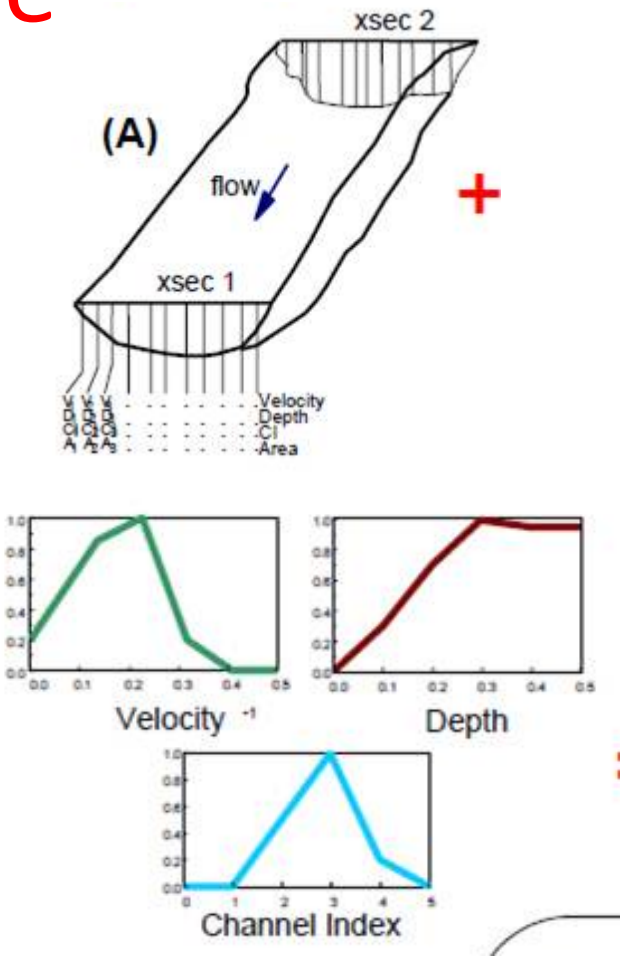
Methodology to Evaluate instream Flow Alteration

- The aim was to develop an index connected to instream flow to evaluate the performance of certain species
- Microhabitat methodology adopts a deterministic approach for simulating the fish response to a water diversion
- A microhabitat simulation using PHABSIM program was used to estimate EF



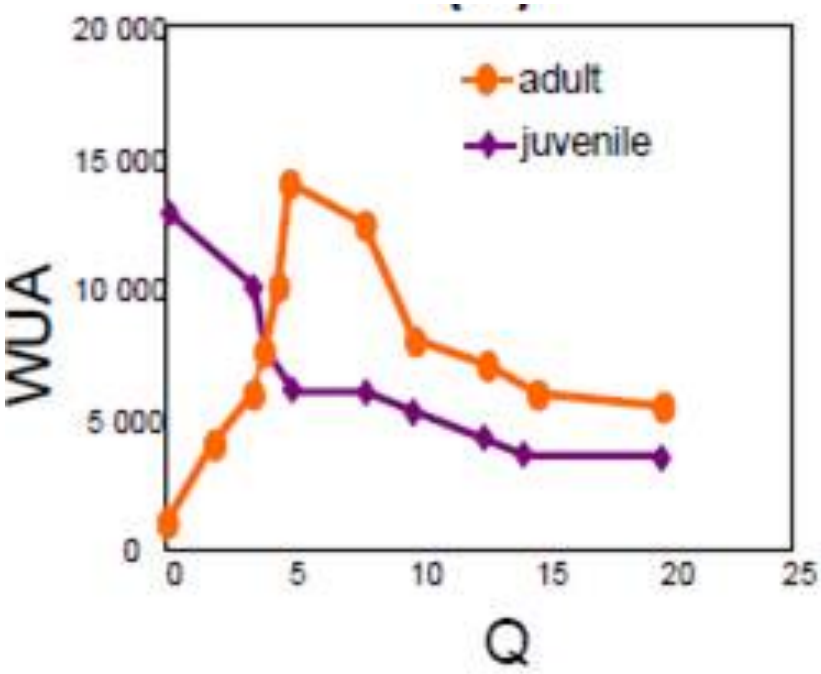
Methodology to Define physical habitat Response

- The simulation has two steps:
  - The Hydraulic simulation for microhabitat response to flow variation
  - The suitability of the new habitat conditions is computed by means of a set of suitability curves.



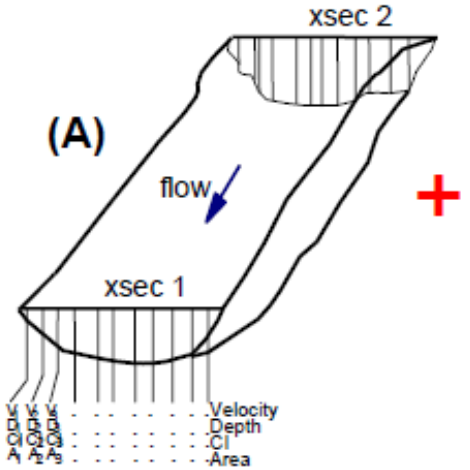
Habitat Response Index

- The result is an index, called Weighted Usable Area (WUA), with the dimension of an area (m2).
- It represents an area weighted for the fish preference.
- It is an index of the capacity of a stream reach to support the species and life stage being considered
- it is not a physical and measurable quantity, rather it must be considered to be an index.
- It transforms the hydrologic information into biological information



Habitat simulation methodologies

e.g. IFIM/PHABSIM



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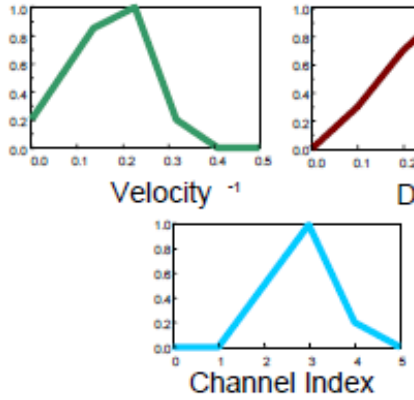
(B) Habitat suitability curves for target sp.



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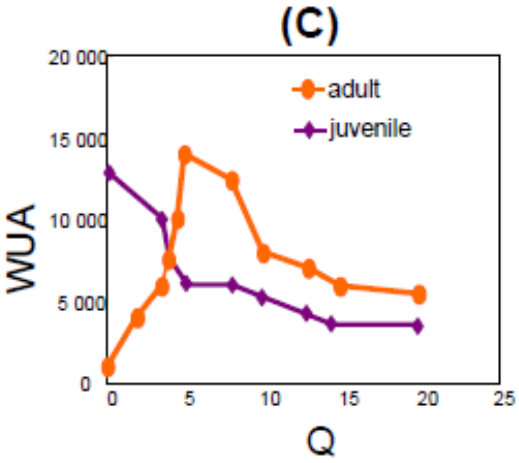
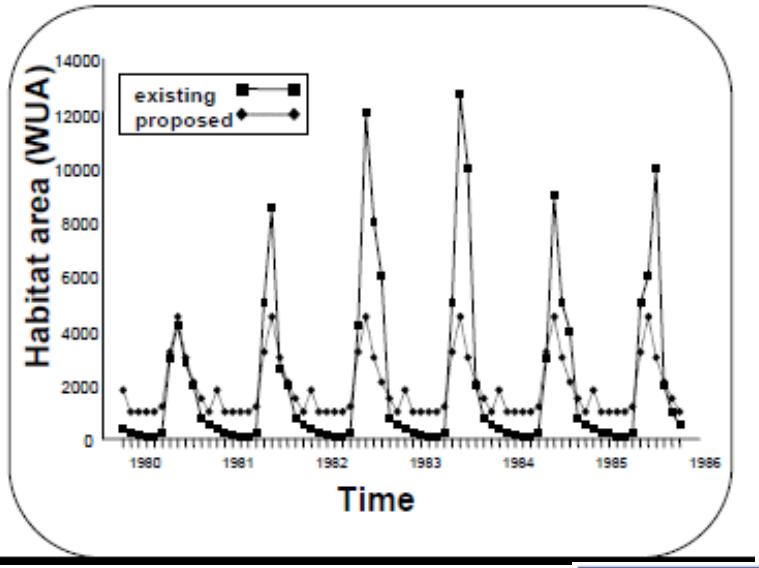
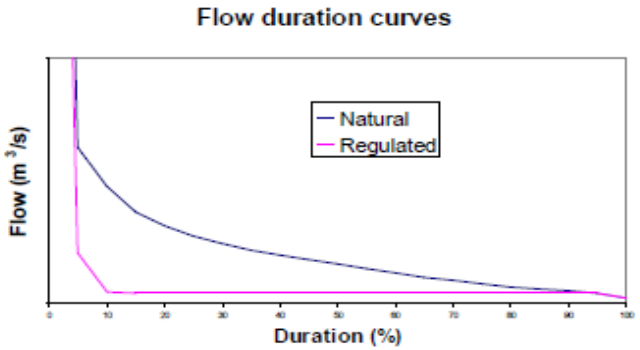
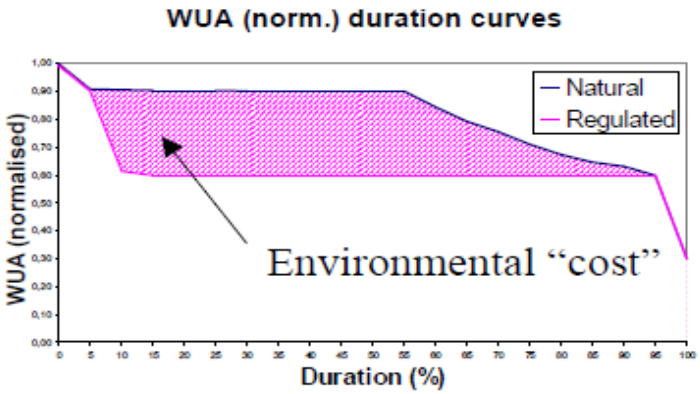




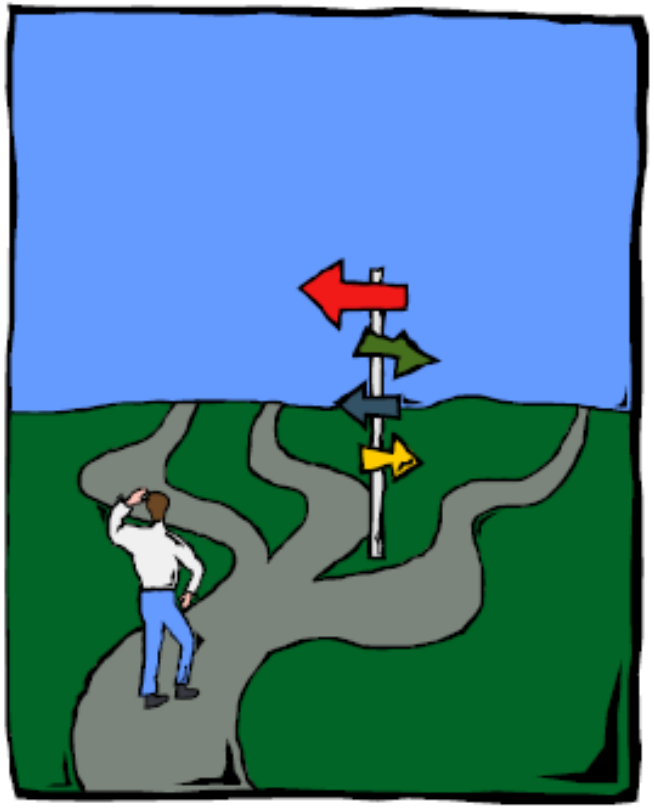
The estimation of the Environmental Cost

- Natural and regulated time series were considered
- Translation of the hydrologic forcing factors into a biological response using WUA versus flow curve
- The environmental cost of a water management policy is the distance between natural and regulated WUA duration curves
- The higher the value is, the worse the environmental impact results



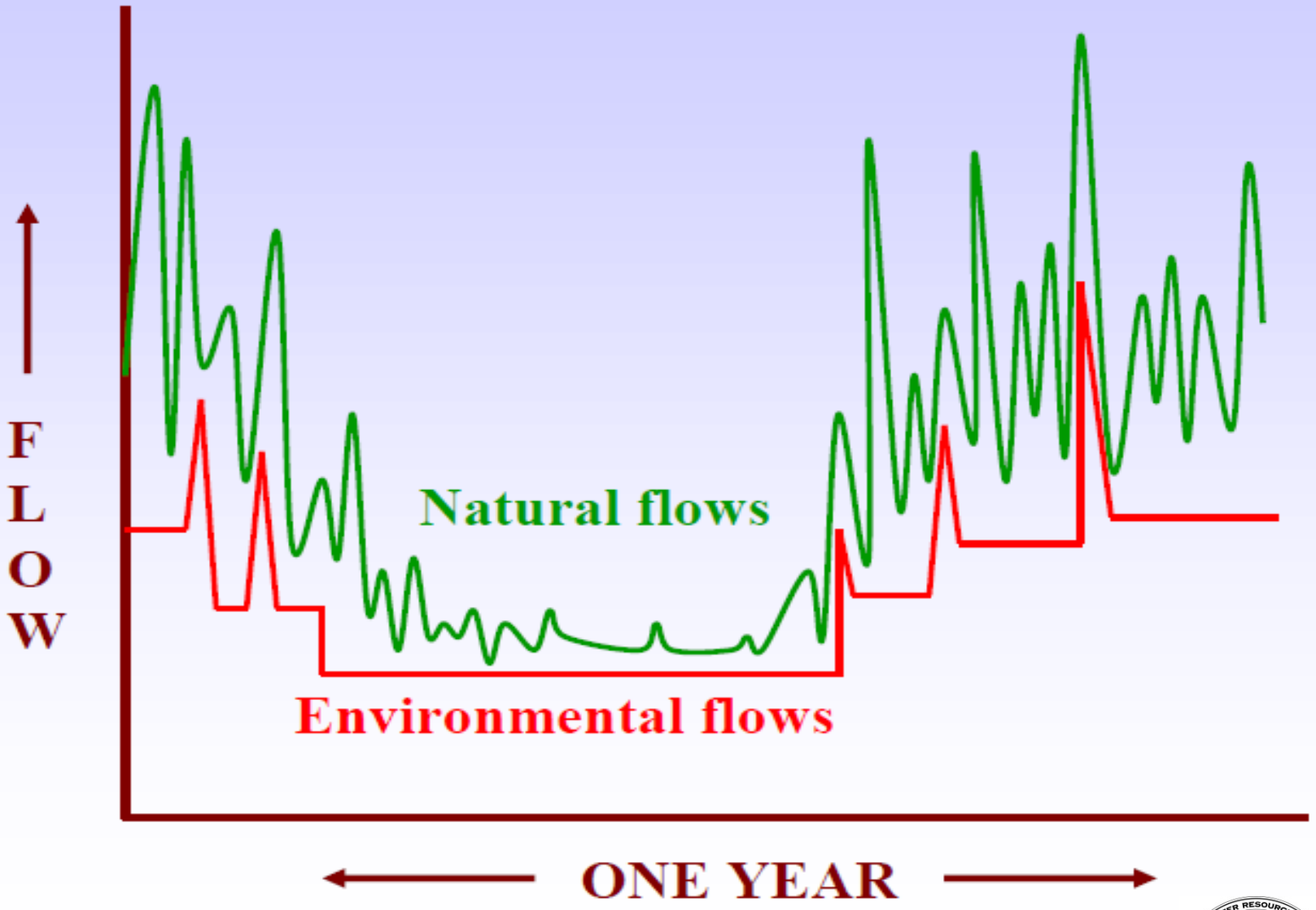


Choosing the right method



Environmental Flow varies based on area type and land use

RIVER FLOWING THROUGH A CONSERVATION AREA



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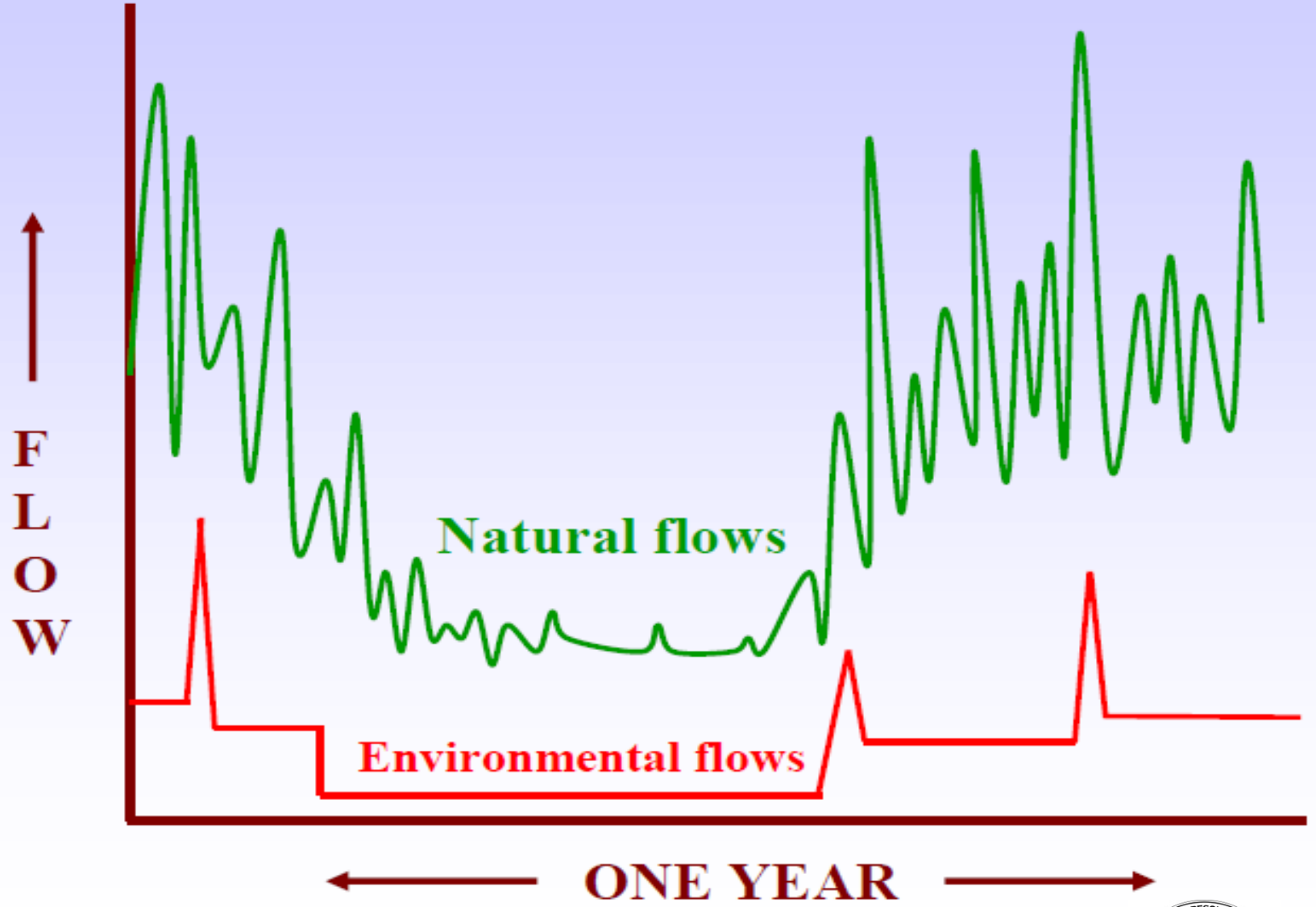
RIVER FLOWING THROUGH AN URBAN AREA



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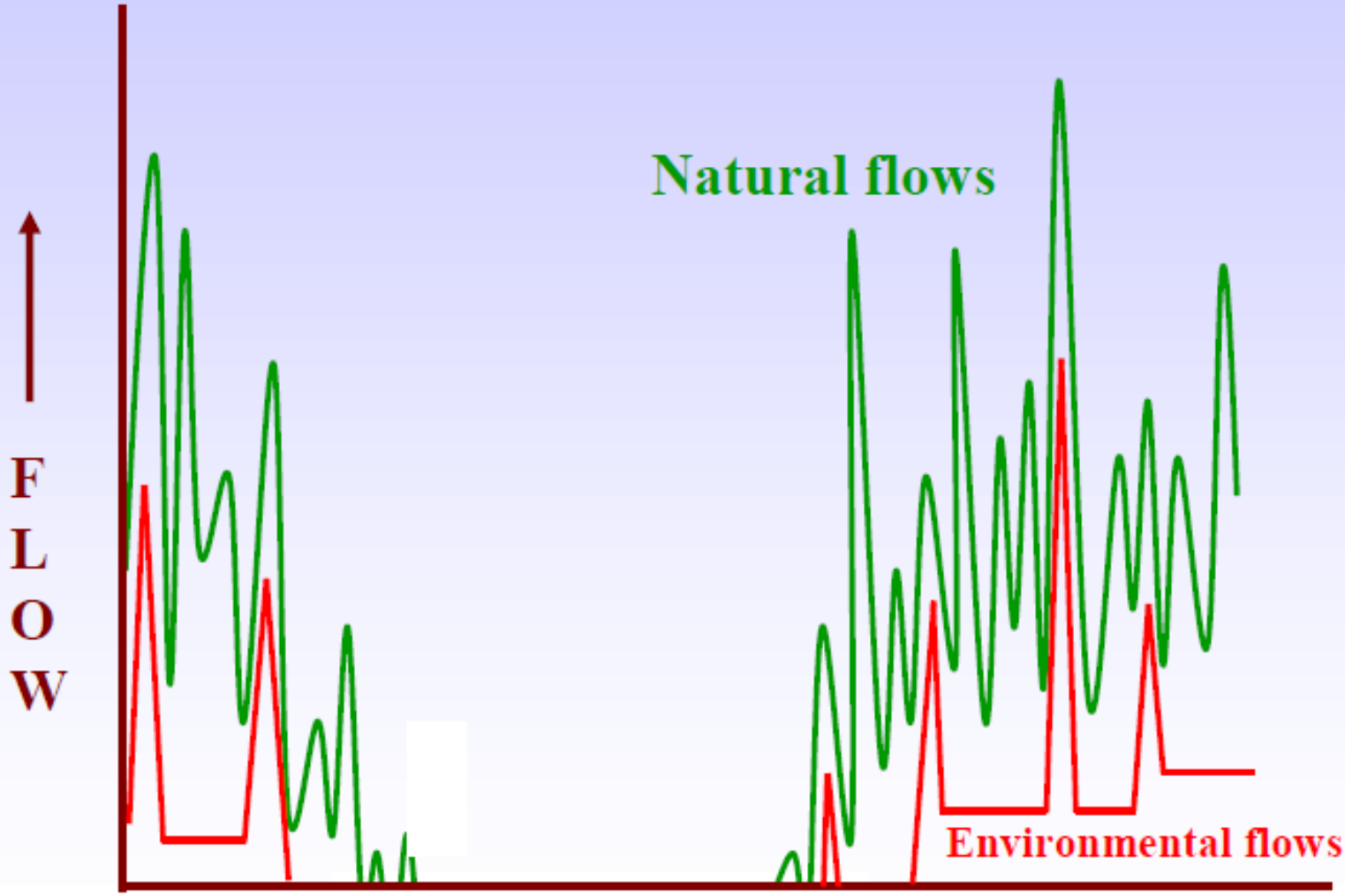
A TEMPORARY RIVER (NO FLOW IN THE DRY SEASON)



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Hydrological methodologies: strengths and deficiencies

- Simple, rapid, inexpensive desktop approaches
- Low data needs, primarily flow data
- Suitable for water resource planning purposes
- Potential for regionalization for different river ecotypes
- Simplistic, inflexible, low resolution output
- Direct ecological links absent or limited
- Dynamic nature of flow regime seldom addressed
- Suitable for low controversy situations

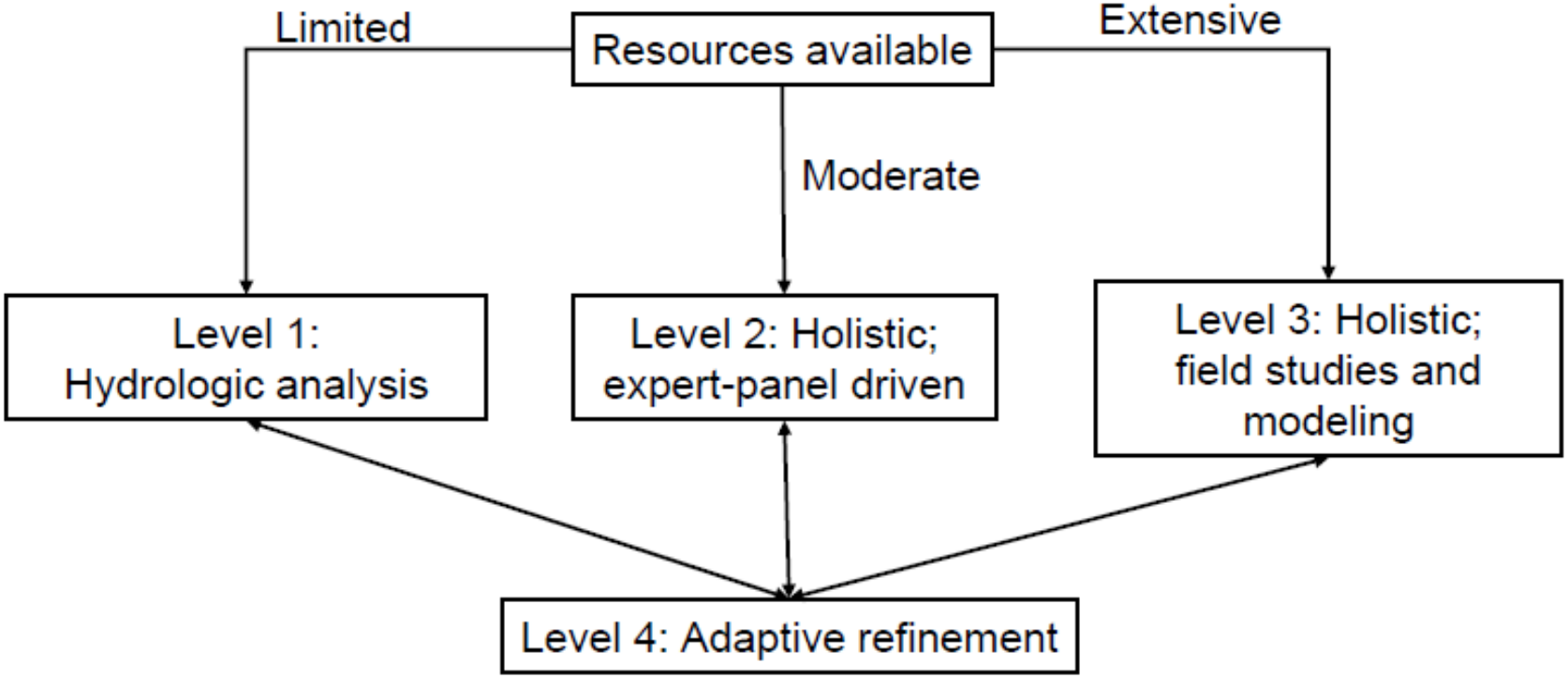
Habitat simulation methodologies strengths and deficiencies

- High resolution habitat-flow relationships for target species
- Generate alternative e-flow scenarios for different species
- Advanced technical support
- Focus on target species, not whole ecosystem
- Not applicable for some ecosystem components
- Limited links with characteristics of flow regime
- Output restricted to flow-hydraulic habitat relationships
- Resource intensive relative to output
- Poor links with biological responses to flow change

Holistic methodologies strengths and deficiencies

- Whole-ecosystem focus
- Generates alternative environmental flow scenarios for different ecological and social conditions
- Use of interdisciplinary expert judgment in structured, consistent process
- Usable in data rich and data poor contexts (use of available techniques and understanding)
- Explicit links with characteristics of flow regime and with biological and social responses to flow change
- Reliant on expert judgment
- Difficulties in reconciling opinions of different experts
- Moderate to high resource demands

Choosing the Right Method



Choosing the Right Method

Time		Funds
Months 1 - 5	Level 1: Hydrologic analysis	~ $10,000
Months 6 - 12	Level 2: Holistic; expert-panel driven	~ $100,000
Years 2 – 5 +	Level 3: Holistic; field studies and modeling	~ $1,000,000 +
	Level 4: Adaptive refinement	Requires sustainable budget

Challenges for Successful E-flows Implementation

- Development of **policy and legislation** on resource protection, which would legitimize sustainable use.
- Establishment of **national research programmes** to increase the knowledge base and identify links between ecosystems and flows.
- Use of the **best available knowledge** from focused short-term research to answer immediate management questions and move ahead despite limited knowledge.

Challenges for successful E-flows implementation

- Use of **structured, transparent processes for options assessment** and decision-making,
- **Learning by doing**, through the **monitoring** of the outcomes of the chosen option.
- Use of **strategic adaptive management** by adjusting management plans where indicated by monitoring results.

How can an E-Flows assessment be incorporated into river basin management planning?

- *Understanding stakeholder needs and increasing awareness*
- *Setting legislation, standards and guidelines*
- *Understanding river use and addressing tradeoffs*
- *Increasing inter-sectoral communication and coordination*
- *Setting goals and monitoring results*
- *Implementing research programmes*

Are there any regional conventions on environmental flows?

- **No**, there is no regional convention that deals specifically with environmental flows.
- **However** there are treaties, such as the Mekong River Agreement, which sets up the framework for cooperation between riparian States in all fields of the basin's sustainable development for the protection of ecosystems.
- Sub national agreements, such as the Murray Darling Basin Initiative in Australia

What is the best way forward with transboundary E-Flows Assessments?

- *Transboundary **commitment** and legislation*
- *Addressing **imbalances** and **responsibilities***
- *Develop **research** and **monitoring** Programs*

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