

# Good Practice Handbook: EFlows assessments for Hydropower Projects

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GOOD PRACTICE HANDBOOK  
Environmental Flows for  
Hydropower Projects  
Guidance for the Private Sector in Emerging Markets

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# Aims of Handbook

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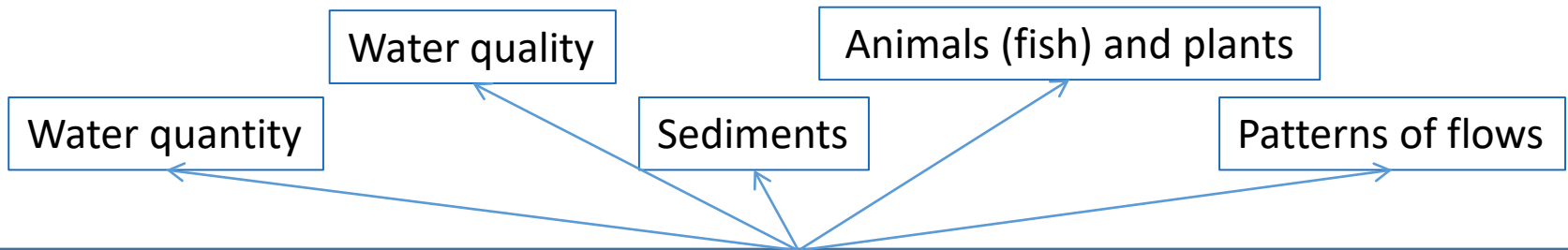
To promote consistent approach to EFlows assessments in WBG-funded HPPs.

- guide the selection of appropriate level of effort/resolution in the EFlows Assessment to do this (Decision Tree)
- guide standardisation of the quality, content and effectiveness of EFlows Assessments
- indicate how to align the EFlows work with impact assessment tools such as ESIAs, CIA, SEAs

The Handbook does not provide instructions on how to:

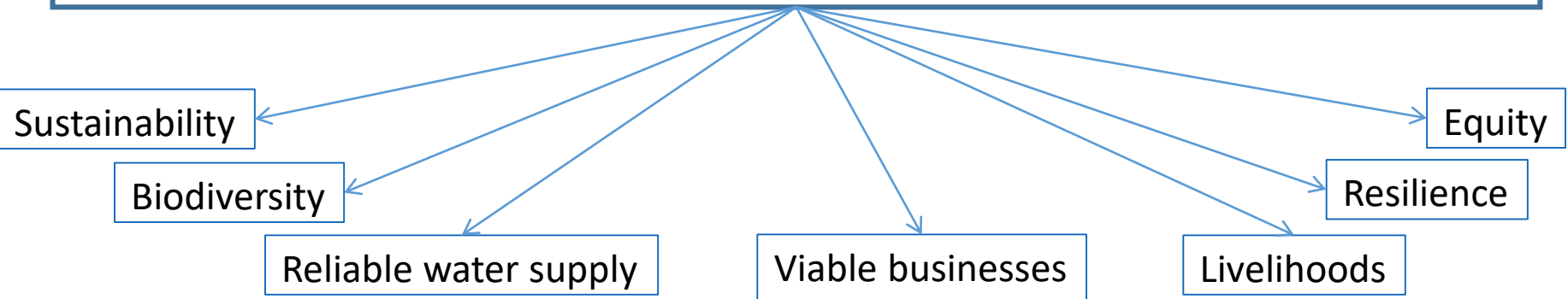
- carry out an EFlows assessment
- select stakeholders
- negotiate and make decisions on EFlows allocations
- implement EFlows

# What are EFlows?



The quantity, timing and quality of the flow of *water, sediment and biota* necessary to sustain freshwater and estuarine ecosystems, and the human livelihoods and well-being that depend on these ecosystems

Amended from Brisbane Declaration (2007)



*Protecting the systems that support us*

# EFlows and WBG safeguards

Policy Safeguards	Environmental Safeguards	Consequences for	EFLWS ASSESSMENTS
<b>OP 4.01</b> Environmental Assessment	<b>ESS1 / PS1</b> Assessment and Management of Environmental and Social Risks and Impacts	<ul style="list-style-type: none"><li>• aquatic ecosystems and ecosystem services</li><li>• flooding risk</li><li>• competing downstream water uses (e.g. irrigation)</li></ul>	
<b>OP 4.07</b> Water Resources Management	<b>ESS3 / PS3</b> Resource Efficiency and Pollution Prevention	<ul style="list-style-type: none"><li>• water quality (pollutants; temperature change)</li><li>• sedimentation / nutrient loads</li><li>• carbon emission</li></ul>	
<b>OP 4.37</b> Dam Safety	<b>ESS4 / PS4</b> Community health, Safety and Security	<ul style="list-style-type: none"><li>• river navigation / transport</li><li>• water-borne disease</li><li>• dam safety and flooding risk</li><li>• risks from releases</li></ul>	
<b>OP 4.12</b> Involuntary Resettlement	<b>ESS5 / PS5</b> Land Acquisition & Involuntary Resettlement	<ul style="list-style-type: none"><li>• bank erosion / sedimentation</li><li>• river structures</li><li>• crops and livelihoods (fishing)</li></ul>	
<b>OP 4.04</b> Natural Habitats	<b>ESS6 / PS6</b> Biodiversity Conservation and Sustainable Management of Living Natural Resources	<ul style="list-style-type: none"><li>• biodiversity</li><li>• ecosystem services</li><li>• river connectivity</li><li>• nutrient recycling</li></ul>	
<b>OP 4.36</b> Forests			
<b>OP 4.10</b> Indigenous People	<b>ESS7</b> Historically Underserved Traditional Local Communities / <b>PS7</b> Indigenous Peoples	<ul style="list-style-type: none"><li>• natural resources</li><li>• livelihoods (e.g. fishing, hunting)</li><li>• spiritual / cultural resources / practices</li></ul>	
<b>OP 4.11</b> Physical Cultural Resources	<b>ESS8 / PS8</b> Cultural Heritage	<ul style="list-style-type: none"><li>• cultural heritage resources</li><li>• cultural practices and ceremonies</li></ul>	
<b>OP 4.36</b> Forests			
	<b>ESS9</b> Financial Intermediaries	<ul style="list-style-type: none"><li>• compliance with ESS by FIs</li></ul>	
<b>OP 4.01</b> Environmental Assessment	<b>ESS10</b> Stakeholder Engagement and Information Disclosure	<ul style="list-style-type: none"><li>• river health / biodiversity</li><li>• river-based livelihood dependencies</li><li>• operational scenarios</li></ul>	
<b>OP 4.04</b> Natural Habitats			
<b>OP 7.50</b> International Waterways		<ul style="list-style-type: none"><li>• all of the above</li></ul>	

# EFlows, rivers and people

## Onset and duration of seasons:

- link with climatic factors
- cues fruiting and flowering
- cues migration/breeding
- support life-history patterns

## Dry-wet transitions:

- distribute sediments and nutrients flushed from the watershed
- distribute seeds
- support migration of adults and larvae

## Floods:

- dictate channel form
- flush and deposit sediment and debris
- promotes habitat diversity
- support floodplains
- distribute seeds
- facilitate connectivity
- control terrestrial encroachment

## Dry periods

- promote in-channel growth
- support larval stages
- maintain intra-annual variability

## Intra- and inter-annual variability:

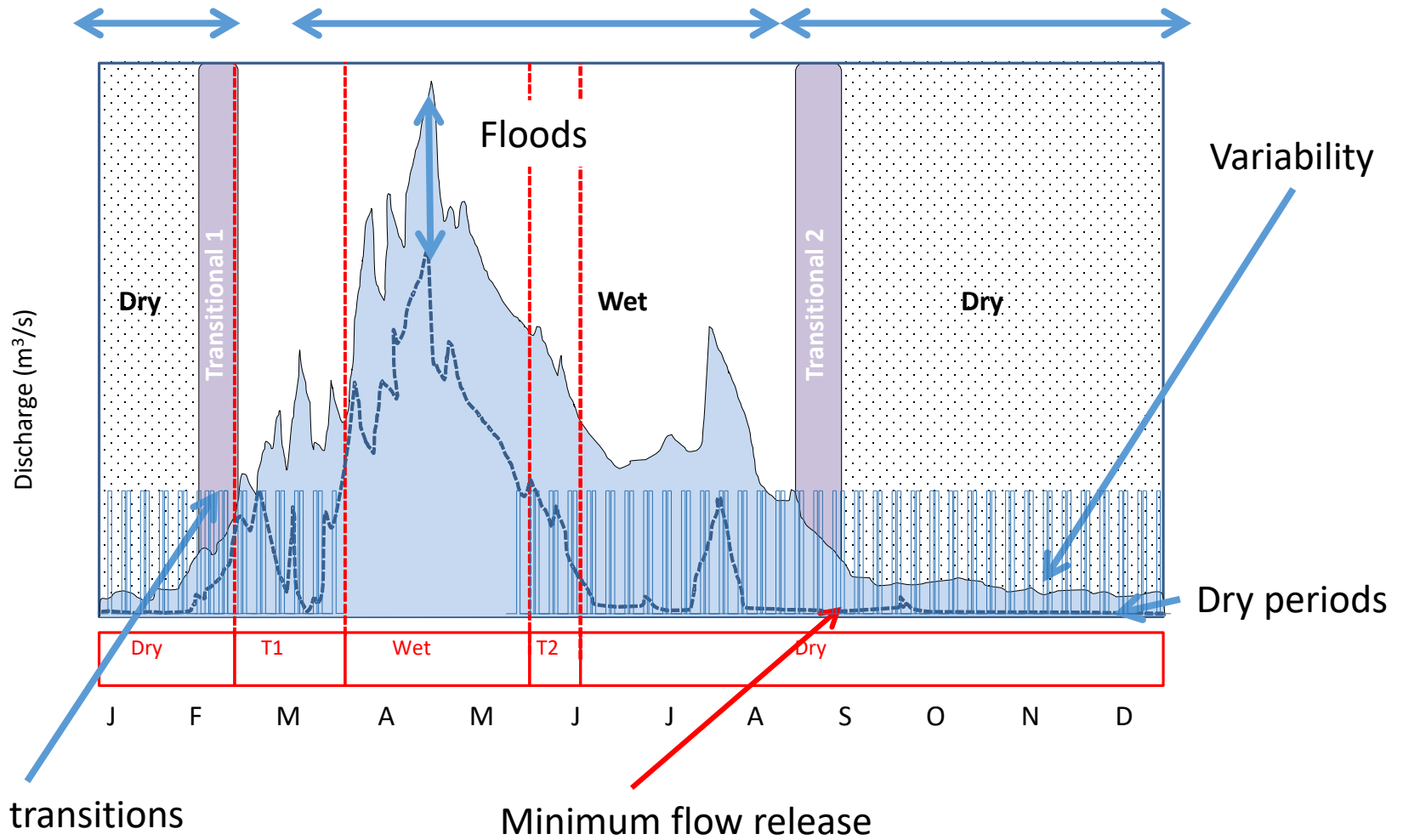
- promotes diversity
- discourages invasions

Disch

Months of a year



## Onset and duration of seasons



# EFlows and hydropower

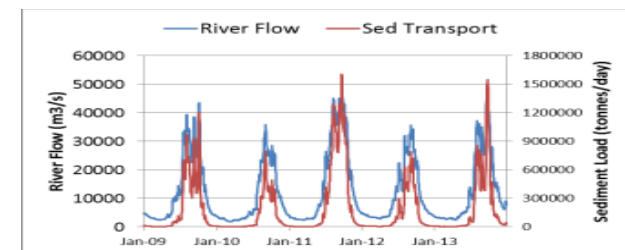
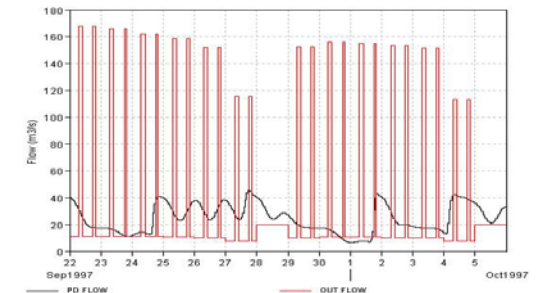
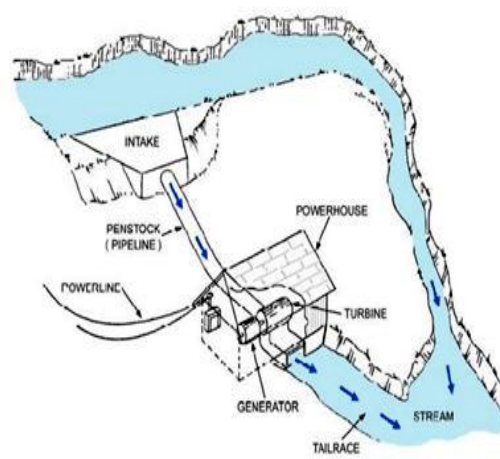
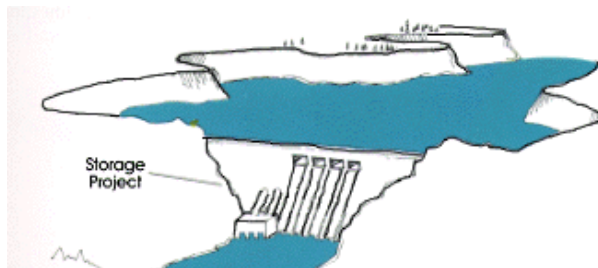
Handbook recognises 'EFlows' impacts of HPPs as:

- Dewatering of a reach
- Changes in pattern of flows of water *and sediment*
  - Diverted reach
  - Downstream of powerhouse/tailrace
    - Storage
    - Power production
- Lost of connectivity (flow of biota):
  - Longitudinal – barrier effect of the dam wall and the reservoir
  - Lateral – reduced flooding of floodplains



# Factors influencing potential impact

- Location
- Design
- Operation (water and sediments)



# ‘Run-of-river’ hydropower

Used to describe a considerable range of designs:

- HPPs with no storage
- HPPs with limited storage and no peaking-power releases
- HPPs with moderate storage and peaking-power releases
- HPPs that rely on large upstream storage facilities
- HPPs where the flow of a river is diverted from the host river to another river

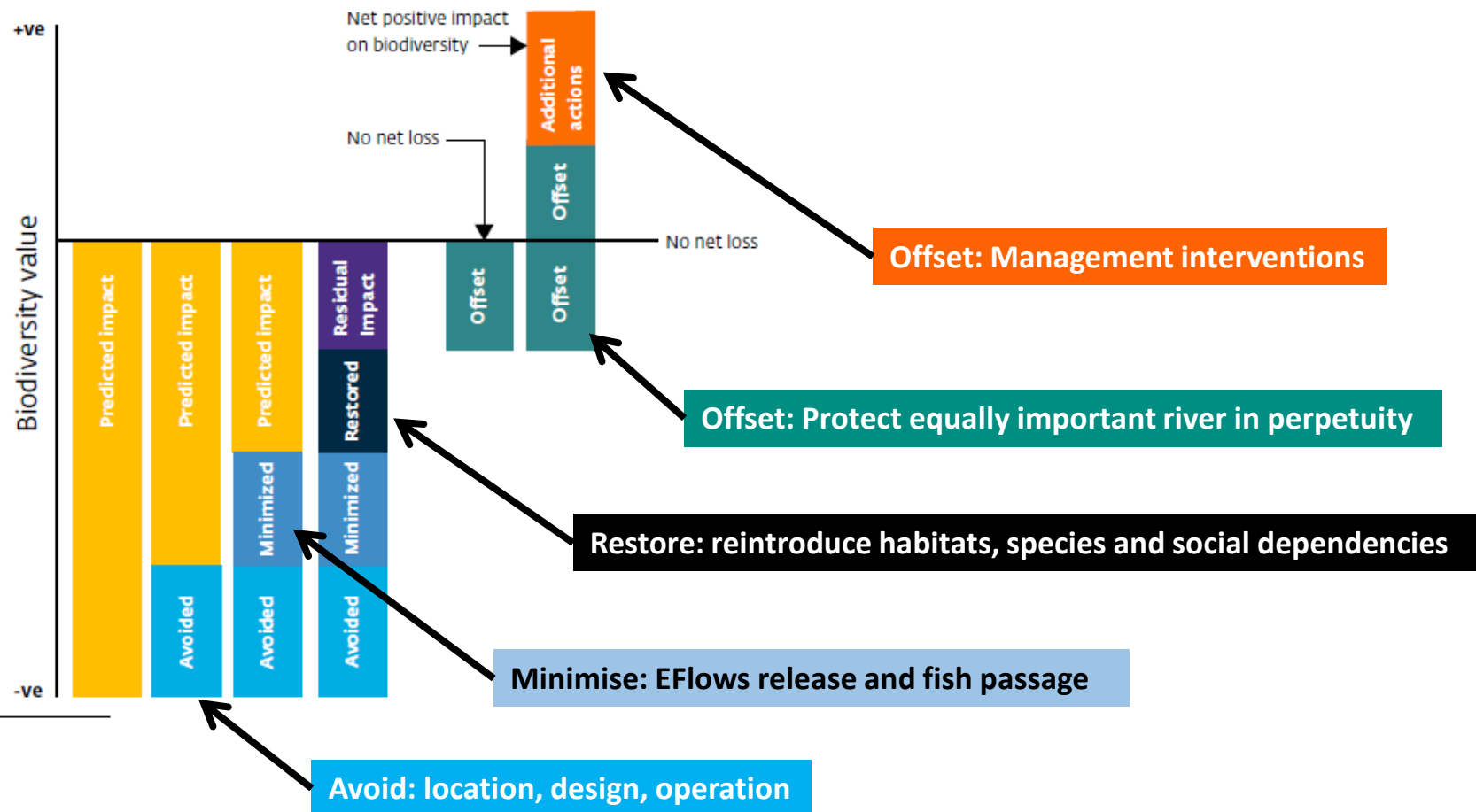
Of limited value from an EFlows perspective

Handbook refers to “true run-of-river” or “low impact and design” HPPs:

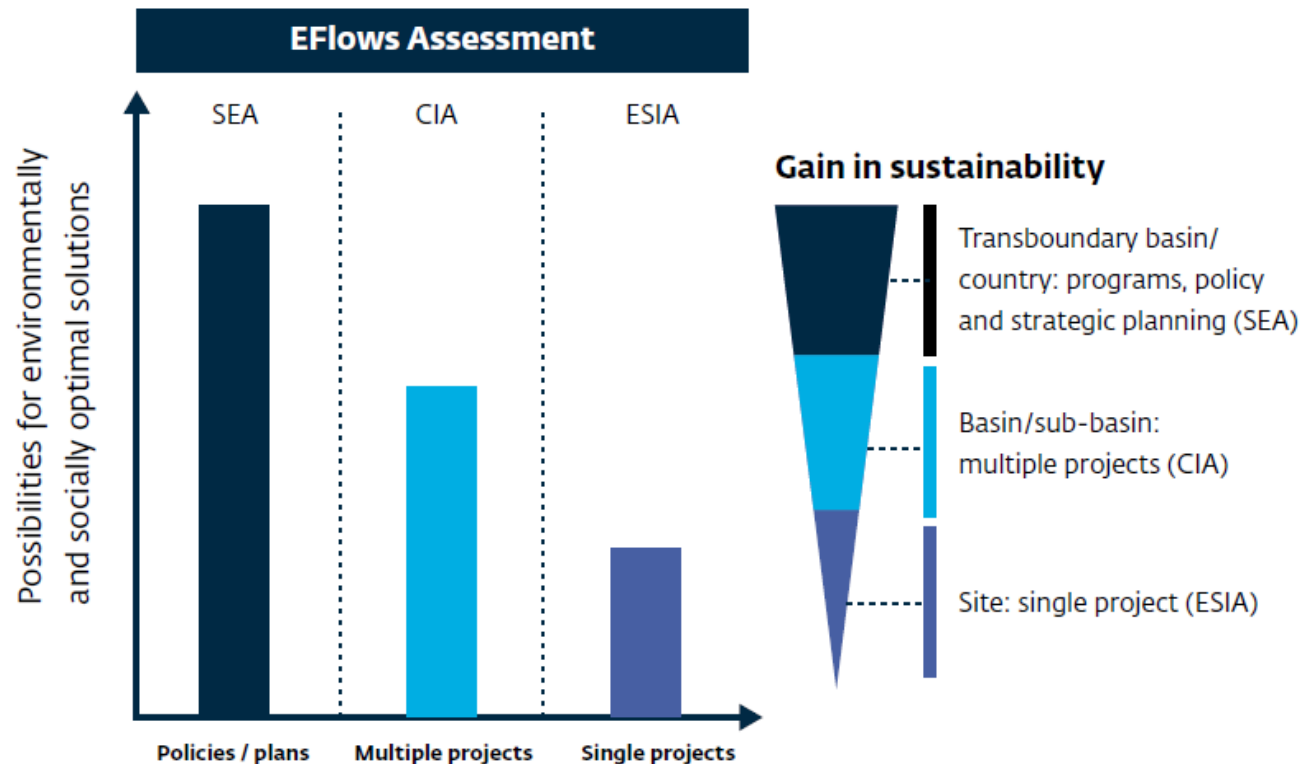
*“Hydropower plants that release downstream into the same river,  
with a short or no diversion,  
have  $\leq$  48-hour dry-season storage and  
do not make peaking-power releases”*

# EFlows and the mitigation hierarchy

“Projects should seek to minimise impacts while optimising energy generation”



# Basin-level versus project-level assessments



There is no right or wrong time or scale to do an EFlows assessment or to make provision for EFlows

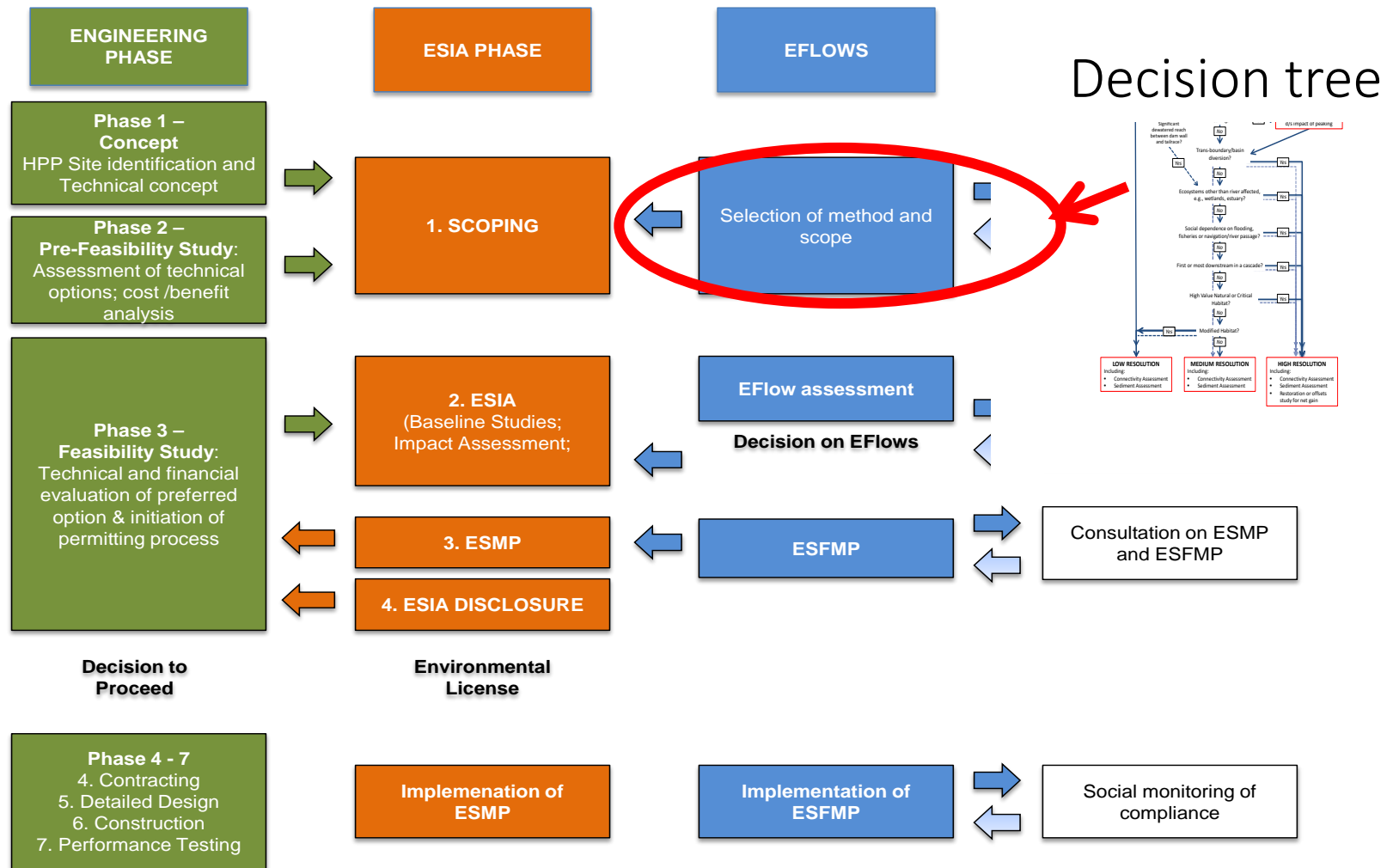
# Basin-level (SEAs & CIAs)

- Long been an understanding in the WBG that basin planning offers more options for sustainability:
  - Less uncertainty.
  - Meaningful biodiversity protection
  - Less controversy
  - More streamlined project-level review
  - Less expenditure on assessing impacts
  - Fewer operational constraints
  - Economically favourable outcomes
  - Positive public recognition
- EFlows assessments are required to guide detailed water-resource planning, including location, design and operating rules for dams at the basin level.

# ESIAs

In the absence of basin-wide studies, the EFlows assessment for a specific HPP should be done in parallel with or under the umbrella of the ESIA.

*Include in RFPs.*



# Assessment methods

EFlows assessment methods have been developing for more than 30 years, and provide a wide array of options

## Tennant Method

Objective	Recommended percentage of AAF <sup>1</sup>	
	October - March	April - September
Flashy or maximum flows	200%	200%
Fair or degrading	10%	30%
Poor or minimum	10%	10%
Severe degradation	10% - zero flow	10% - zero flow

**Hydrological - prescriptive**

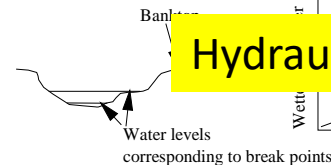
Prescriptive – recommend a flow

- no information on what will happen if you *don't* meet EFlows requirements

Interactive – provide implications of different flows

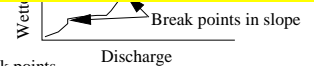
- information of allow trade-offs

(a)

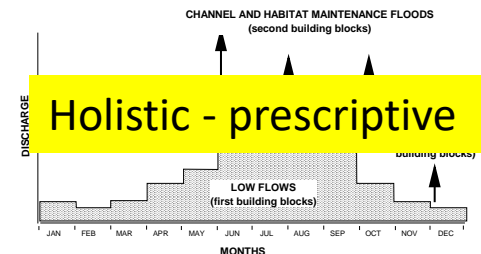


(b)

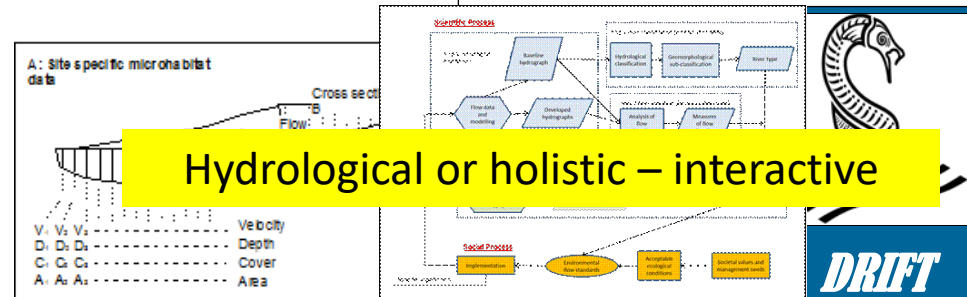
**Hydraulic - prescriptive**



**Holistic - prescriptive**



LOW\_MEDIUM\_HIGH



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# Low resolution

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- Usually desktop
- Based on data extrapolated from areas where more detailed studies have been undertaken
- Hydrological or hydraulic indices used as EFlows
- Typically prescriptive
- No consideration of sediment flows
- No detail on the responses of habitat or species
- Useful parts of scoping exercises to encourage basin-wide thinking and guide the selection of strategic priorities



# Medium and high resolution

Medium- and high-resolution methods are similar to one another:

- Collect and use data from the study river
- Focus on relationships between flows and river life
- Can address climate change impacts

They are distinguished from one another by:

- Spatial scope
- Number of components (water quality, plants, fish, birds, etc.)
- Level of effort in collecting and analysing local information

Usually incorporate:

- Survival of individual species
- Migration and barriers
- Impacts of sediment reduction
- Effects of peaking-power releases
- Other, such as management interventions

Method	Categorisation	Level of resolution
The Tennant Method	Hydrological	Very low
New England Aquatic Base-Flow (ABF)		Very low
IHA/RVA		Low
The Desktop Model		Low
Wetted perimeter method	Hydraulic rating	Low
Instream Flow Incremental Methodology (IFIM)	Habitat simulation	Medium or high
CASiMir		Medium or high
System for Environmental Flow Analysis (SEFA)		Medium or high
The Building Block Methodology	Holistic	Medium or high
The Benchmarking Methodology		Medium or high
Eco Modeller		Medium or high
ELOHA		Medium
DRIFT		Medium or high
Murray-Darling Adjustment Ecological Elements		Medium or high

Q&A Break

# What resolution?

As potential impacts increase in magnitude and complexity:

- Need greater understanding of implications and options
- Need for greater detail in assessments.

*For instance, if potential impacts include:*

- *Changes to timing and duration of seasons*
- *Peaking flow releases*
- *Changes to frequency and duration of flooding of floodplains*
- *Changes to sediment supply and sediment transport capacity*
- *Barrier to upstream and downstream movement of biota*

*It does not make sense to set a minimum flow without proper investigation.*

Other issues affecting resolution:

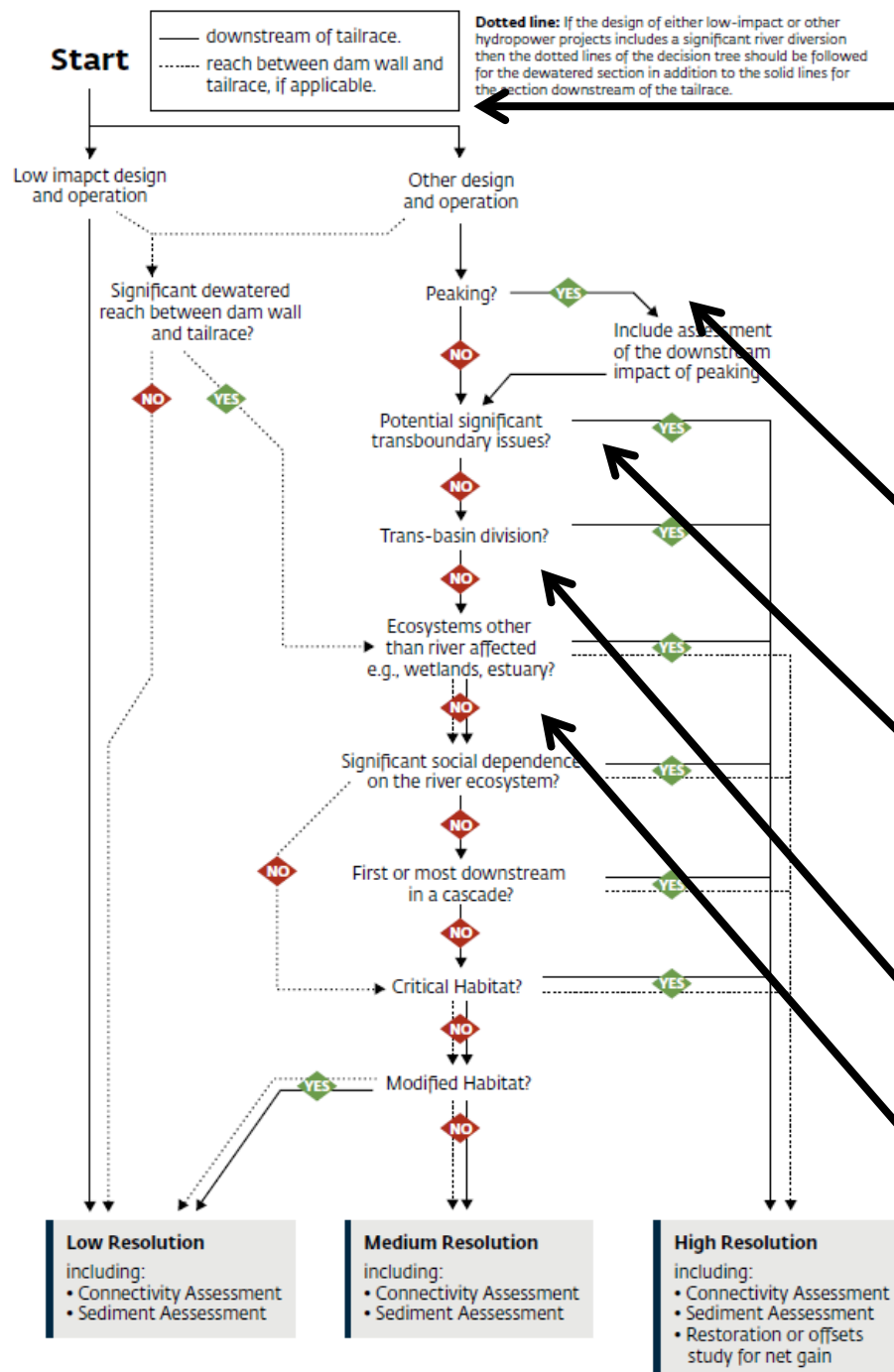
- Existing impacts as a result of other developments
- Position in a cascade/political boundaries
- Type of ecosystem affected
- Degree of social dependency

# What resolution ?

## Selection criteria

1. Storage volume (ability to control flows)
2. Peaking vs baseload operation
3. Transboundary/basin diversion
4. Ecosystems other than rivers, e.g., estuary
5. Social dependence on fish/river passage/other
6. 1<sup>st</sup> or most downstream in a cascade
7. High value Natural or Critical Habitat (IFC/WB definitions)
8. Modified habitat

# What resolution ?



**Choose an appropriate starting point:**  
Identification of the HPP in terms of its storage capacity, and whether or not the design includes a significant river diversion.

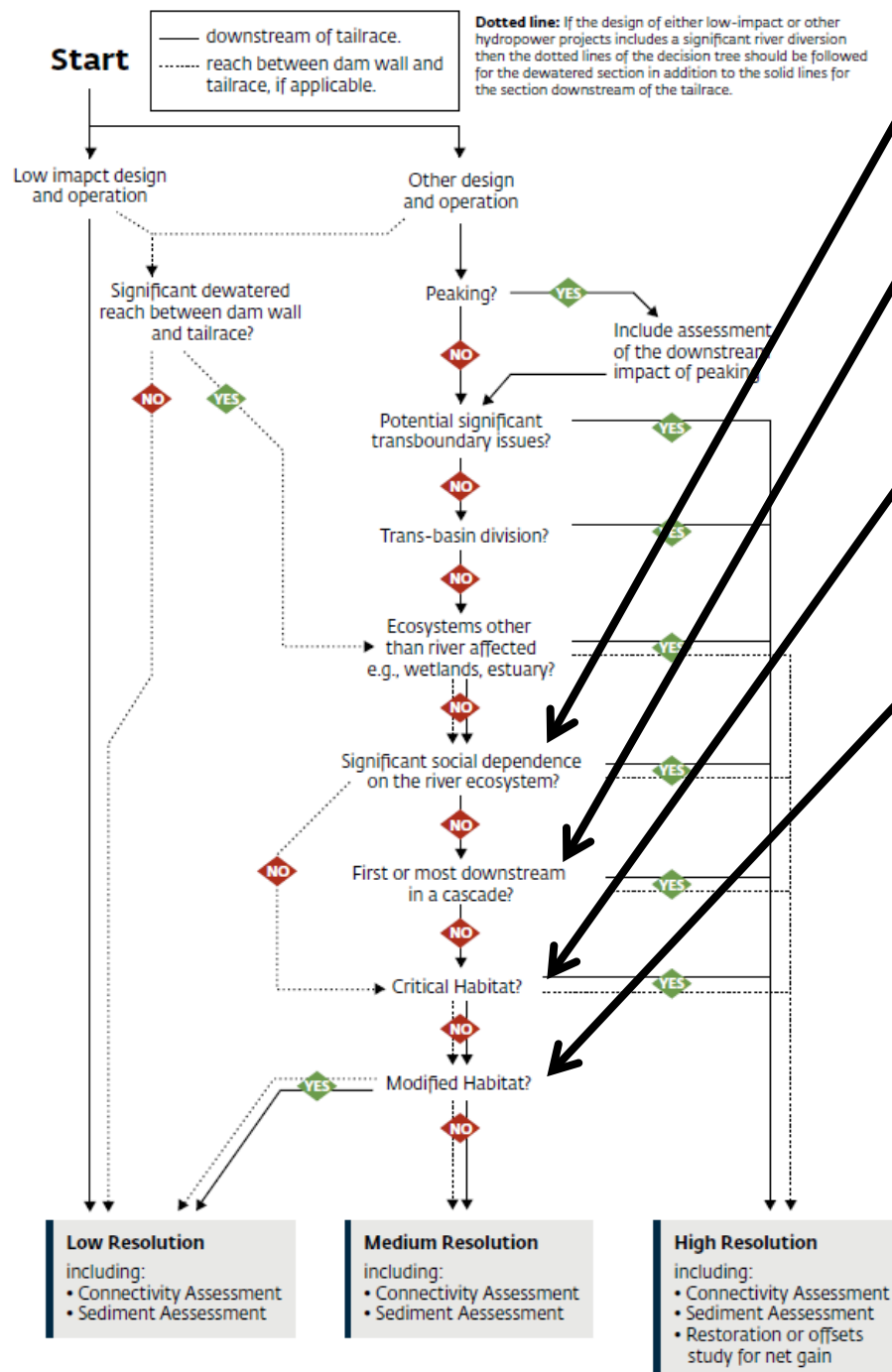
**Peaking versus baseload generation:**  
Peaking power generation requires EFlows methods with analysis of hourly flows.

**Transboundary issues:** If the dam affects a downstream country/ies then all affected countries should receive sufficient detail of likely impacts for negotiations and decision.

**Trans-basin diversion:** Are two rivers affected?

**Other affected ecosystems:** Are there significant downstream lakes, wetlands, swamps or estuaries that would be affected?

# What resolution ?



**Social dependence:** Are there river users dependent on ecosystem services provided by the river?

**Location in cascade:** Is the proposed dam the first or most downstream one in a cascade?

**Critical habitat** or similar terms formally defined in WBG policy – raises risk profile of a project.

**Modified habitat** formally defined in WBG policy – reduces risk profile.

**Sediment assessment:** Sediments trapped by a hydropower dam can significantly alter downstream channel morphology and habitats and increase bank erosion.

**Connectivity assessment:** The movement of biota and other material along the river and how this would be affected by the dam.

In general, the decision tree will recommend:

**Low-resolution** methods for HPPs that will not affect natural and critical habitats; for true run-of-river projects; or for baseload plants that have no substantial influence on the flow regime.

**Medium-resolution** methods for HPPs that that will not affect critical habitats; have low social dependence; or are near other existing HPPs (e.g., cascade of dams) as long as they are not the first or most downstream one.

**High-resolution holistic** methods for HPPs that will affect critical habitats;  
OR ecosystems other than rivers;  
OR high social dependence;  
OR transboundary  
OR has a trans-basin diversion.



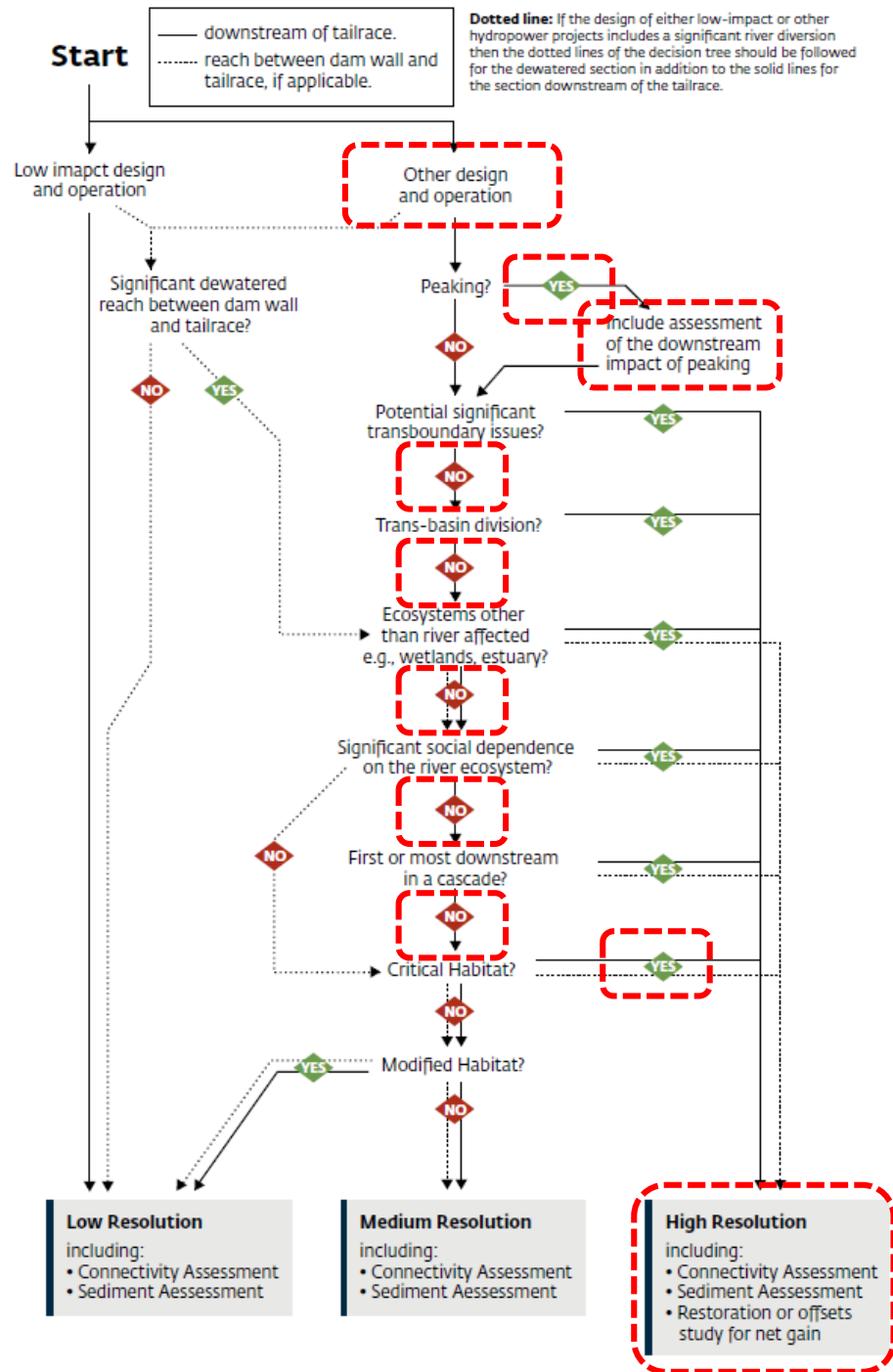
Examples

# Poonch River Mahaseer National Park

Golden Mahaseer



# Gulpur HPP – retrospective



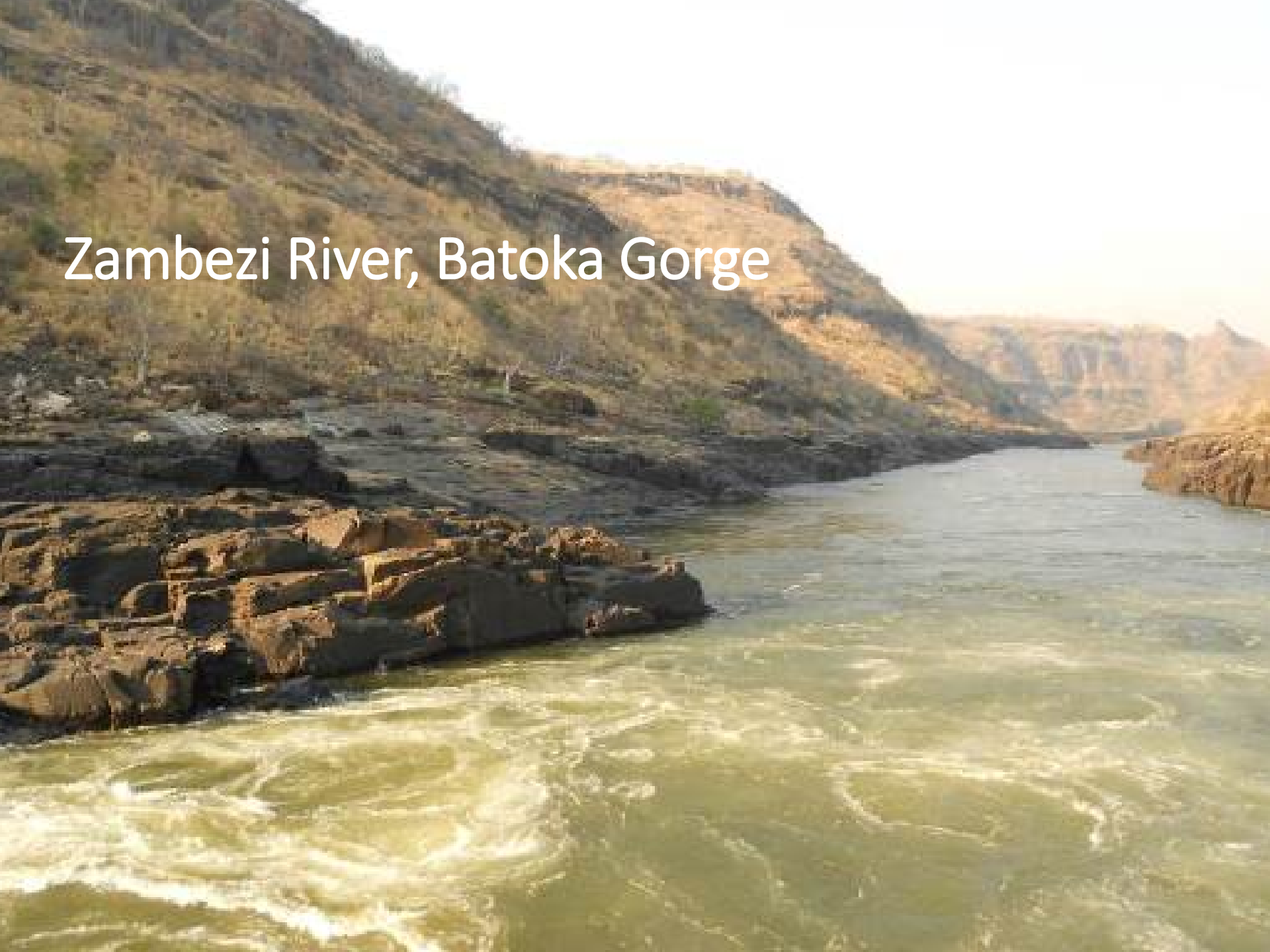
# Poonch: Scope and costs (2014/15)

- Four sites, one upstream, one between the dam wall and the tailrace and two in the river downstream of the tailrace and Mangla Dam.
- The EFlows scenarios incorporated considerations of:
  - changes to pattern and volume of downstream flows
  - the downstream effects of sediment trapping and/or flushing
  - changes in connectivity assessment for key migratory fish
  - options for turbine selection
  - options for management protection (i.e., offsets).
- The team = 4 international consultants and a team of local specialists.
- Cost: ± US\$ 350 000.00

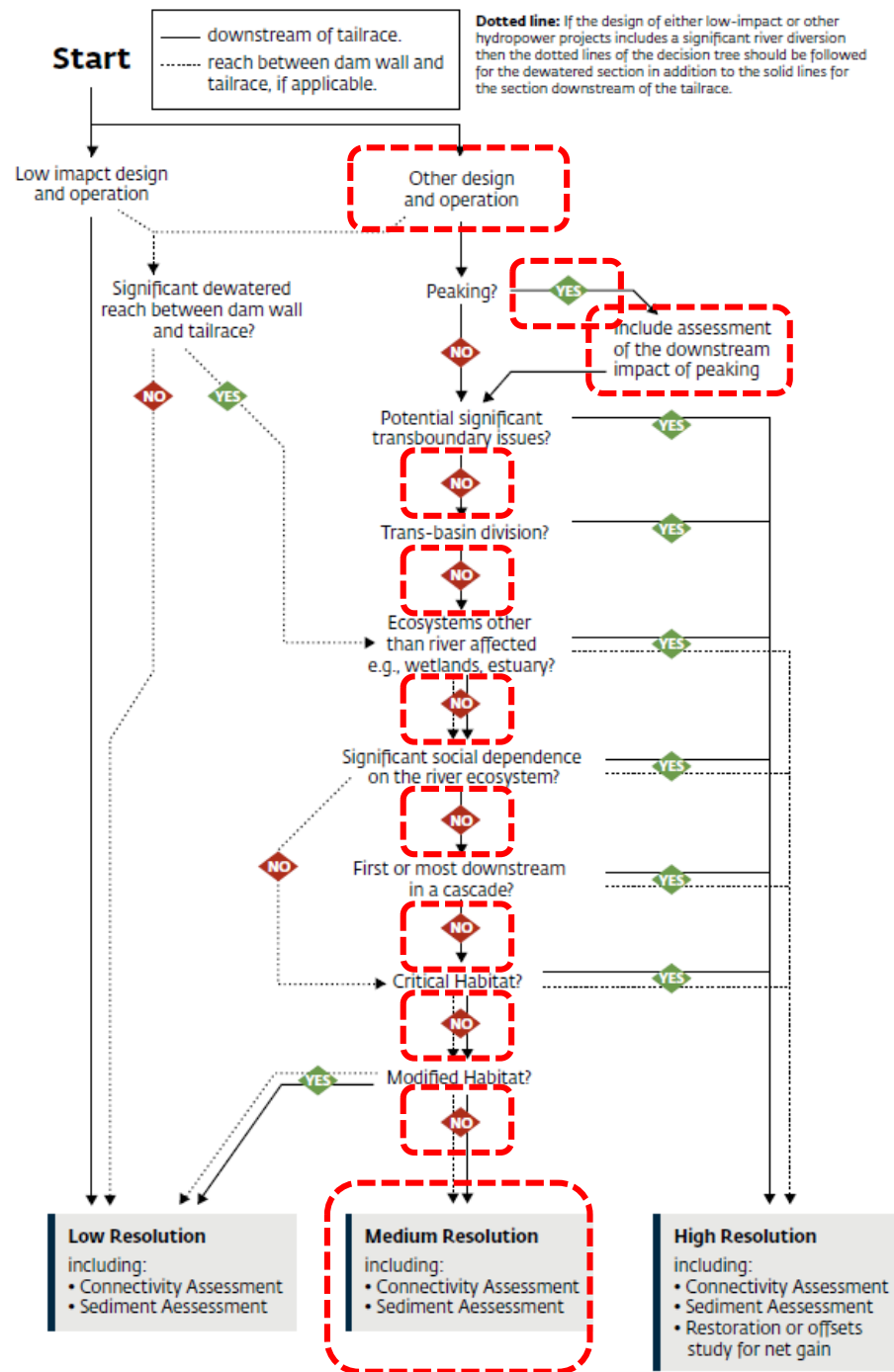
The EFlows assessment influenced the planned turbine design, weir location and operational regime of the HPP. Management measures to enhance the protection status of the park and its fish to achieve a biodiversity net gain outcome were developed with conservation management stakeholders and communities.



# Zambezi River, Batoka Gorge



# Batoka HPP – retrospective



# Batoka: Scope and costs (2014)

- Two sites downstream of the tailrace to Kariba Dam.
- The EFlows scenarios incorporated considerations of:
  - changes to pattern and volume of downstream flows
  - the downstream effects of sediment trapping and/or flushing
  - changes in connectivity assessment for key migratory fish (Victoria Falls)
- The team = 6 consultants:
  - EF specialist
  - Hydraulics
  - Geomorphology
  - Vegetation
  - Inverts
  - Fish
- Cost: ± US\$ 110 000.00 *inclusive of disbursements.*

*“The use of the holistic environmental flow modelling was instrumental in proving our ability to achieve net gain to the lenders as well as local authorities, and in making the project an example of creating a win-win situation for the economic development and environment.*

*The financial costs of the study and subsequent negotiations were negligible relative to other development costs; the costs of the protection measures were incorporated into the power purchase agreements, and; the redesign of the diversion tunnel resulted in a considerable reduction in construction costs.”*

CEO Mira Power – Gulpur HPP



# — Other features of the Handbook

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- **Data requirements** for EFlows Assessments of each level for hydropower projects, on issues such as socio-economics, hydrology, hydraulics, water quality, fish and more ...
- The **relative costs** of each level of EFlows Assessment, in terms of the number of specialists, work trips, people days, and more ...
- Generic **Terms of Reference** for project and basin Low-, Medium- and High-resolution EFlows Assessments, in terms of:
  - Engagement of stakeholders
  - Selection of scenarios
  - Preparation of hydrological data
  - Screening for offsets
  - Collection of field data
  - Preparation of the Environmental Management Plan
  - And more ...
- Annotated Table of Contents for an **EFlows Management Plan**
- **Logframe** for integration of EFlows into hydropower projects and planning
- A basic **10-point checklist** for reviewing an EFlows Assessment

# Recommended approach



Understand the context of river functioning and the provision of ecosystem values and services into which EFlows will be introduced



Understand the potential downstream impacts associated with hydropower development and how these can be mitigated



Understand the kinds of information provided by EFlows Assessments



Apply a context-appropriate EFlows Assessment Method



Conduct a comprehensive and appropriate stakeholder engagement program leading to a decision on EFlows and other mitigation measures based on the outcome of the assessment



Compile an EFlows Management Plan



GOOD PRACTICE HANDBOOK

# Environmental Flows for Hydropower Projects

Guidance for the Private Sector in Emerging Markets



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