



Environmental Flows: From Science to Policy

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The Nature Conservancy

The Nature
Conservancy 

SAVING THE LAST GREAT PLACES ON EARTH

Environmental Flow Prescriptions by River

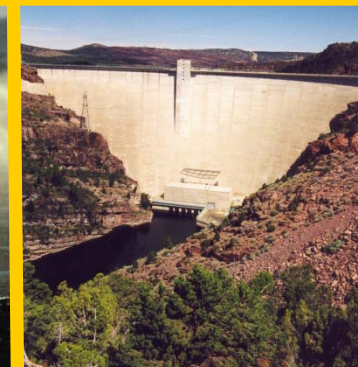


— Rivers for which environmental flows have been or are being prescribed



Criteria for a Regional Environmental Flow Method

- Addresses many rivers simultaneously
- Explicitly links flow and ecology
- Applies across a spectrum of:
 - ▲ Flow alteration types
 - ▲ Data availability and scientific capacity
 - ▲ Social and political contexts

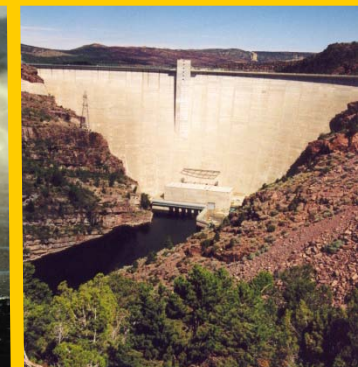


2006

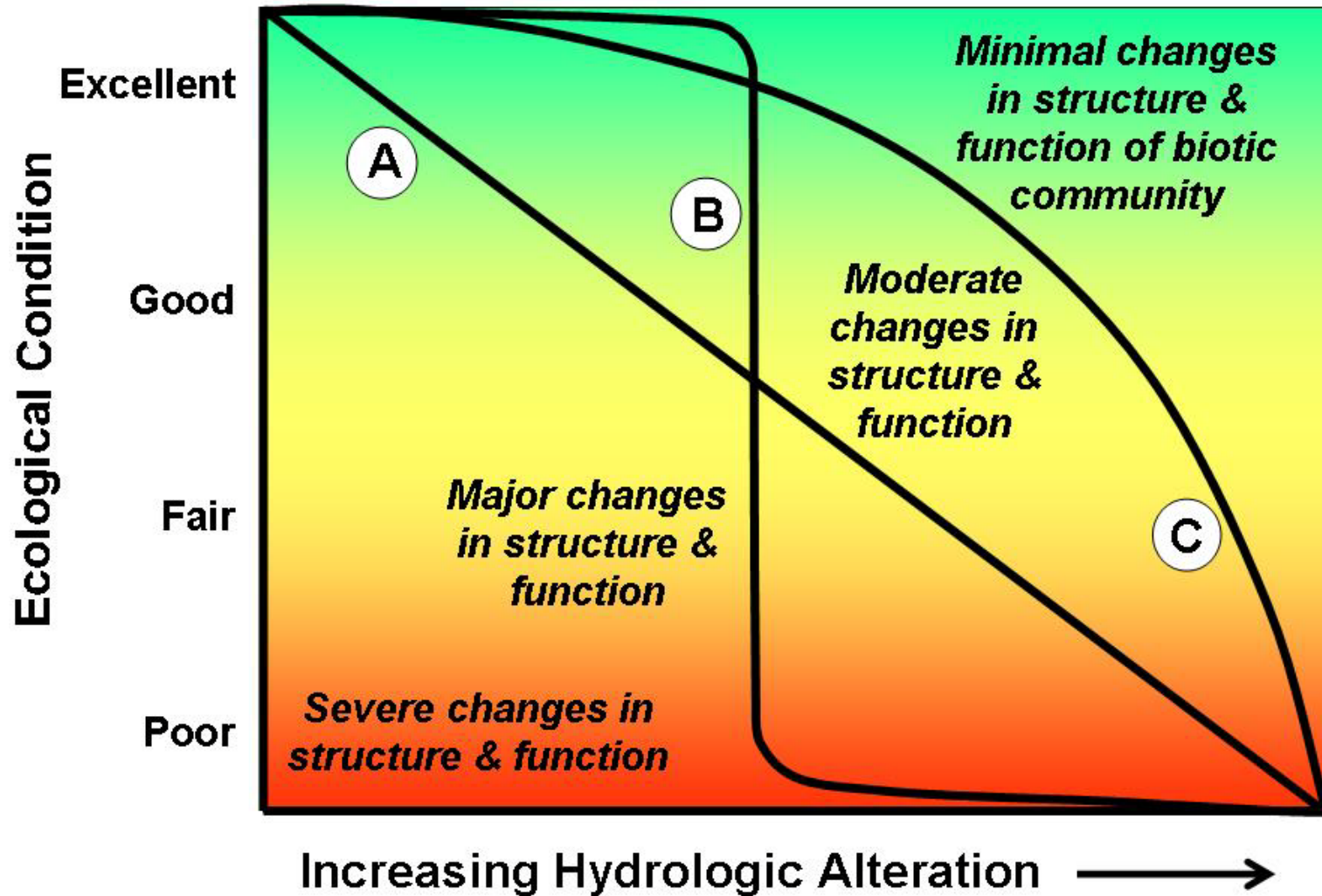
Arthington AH, Bunn SE, Poff NL, Naiman RJ.
The challenge of providing environmental flow
rules to sustain river ecosystems. *Ecological
Applications* 16(4):1311-1318

2008

Ecological Limits of Hydrologic Alteration (ELOHA)

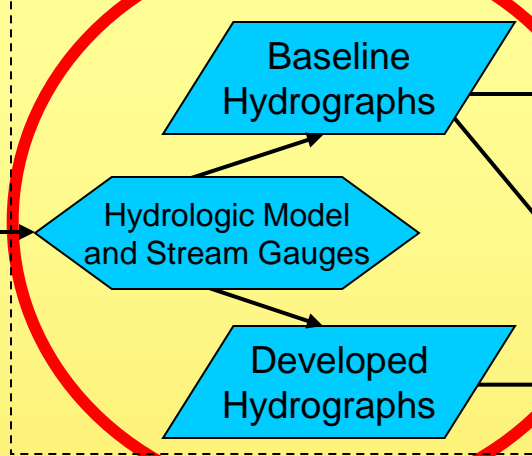


Flow Alteration - Ecological Response Curve

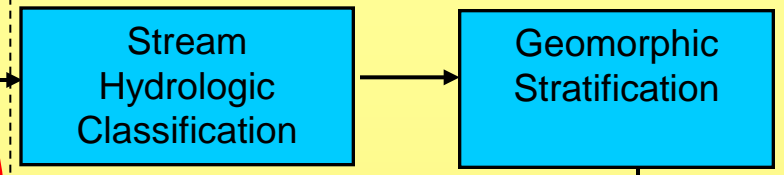


SCIENTIFIC PROCESS

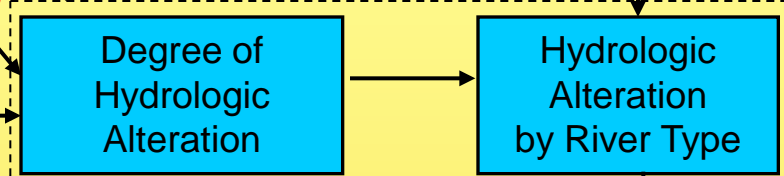
Step 1. Hydrologic Foundation



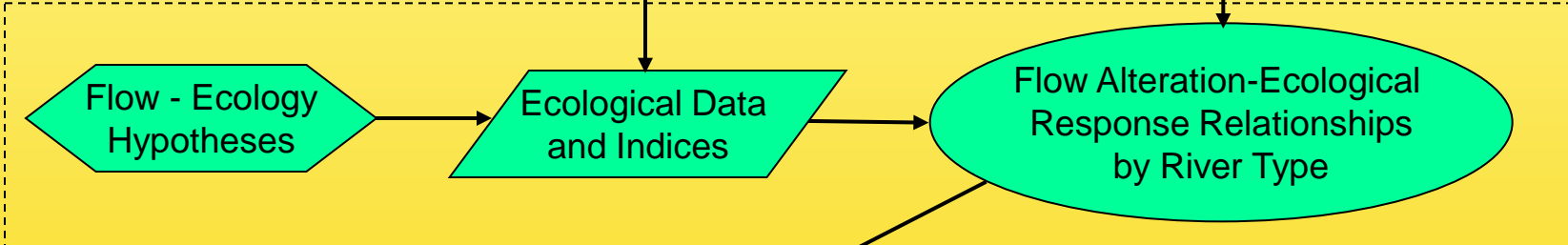
Step 2. Stream Classification



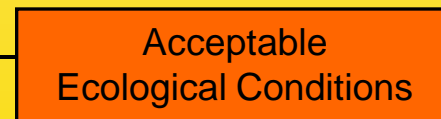
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships

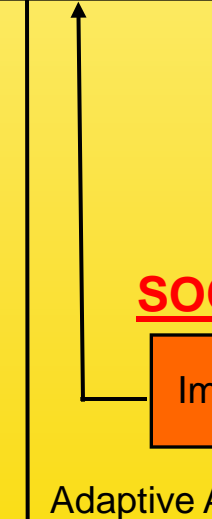
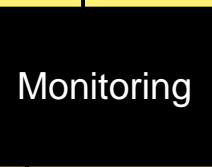


SOCIAL PROCESS

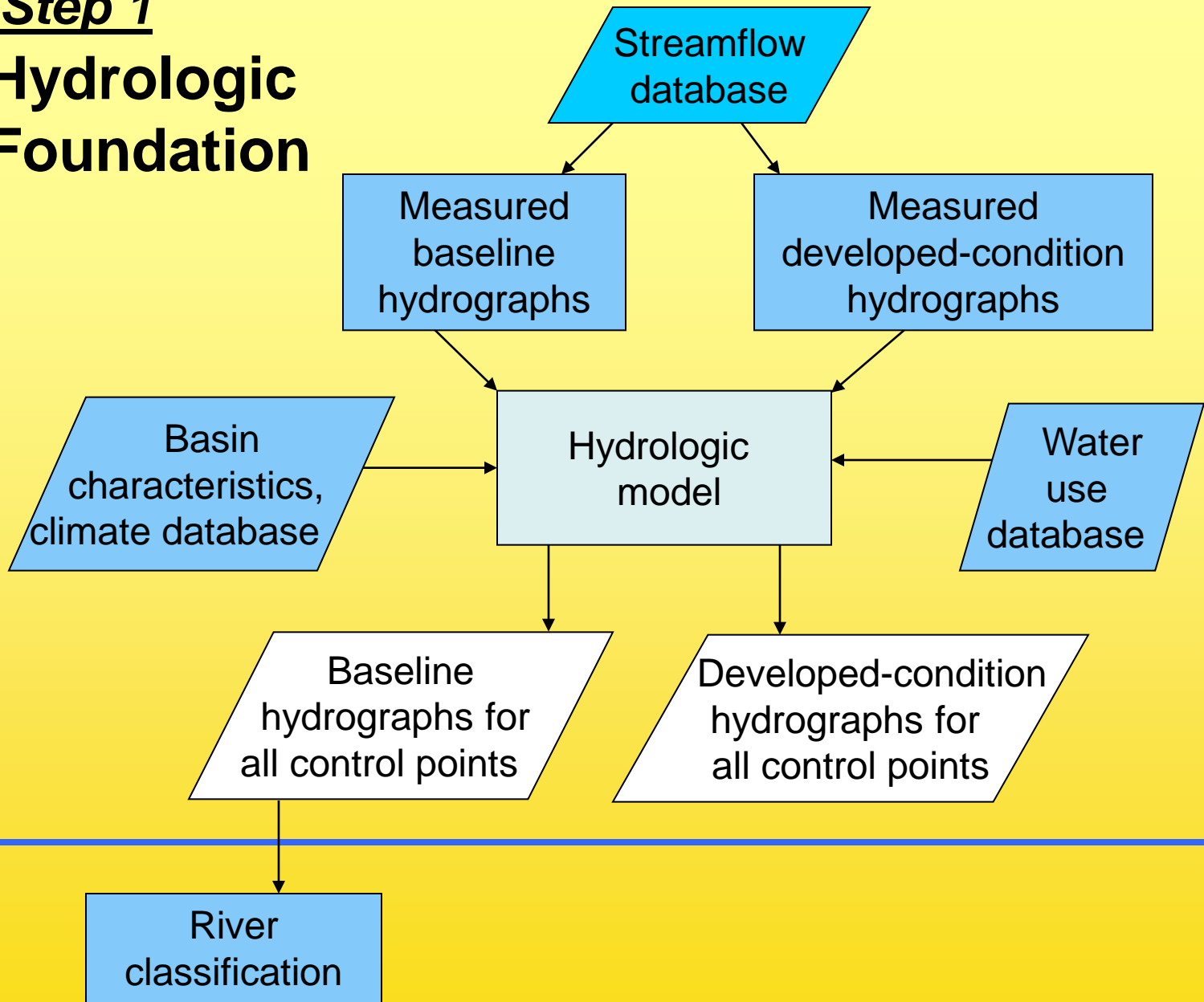


Adaptive Adjustments

Monitoring



Step 1
**Hydrologic
Foundation**



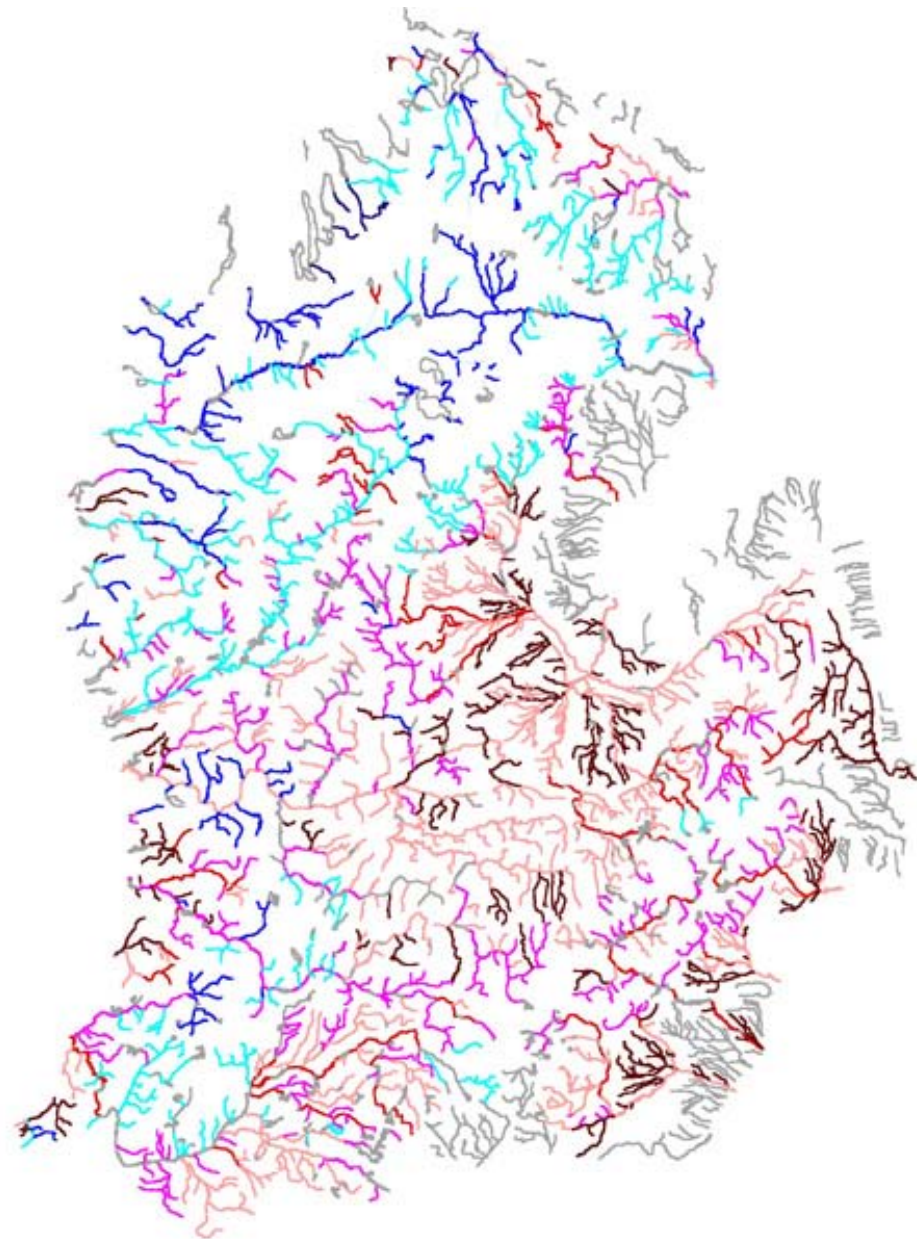
Step 2

River Classification

- *Hydrology-based*
- *Define flow-ecology response curves for types of rivers*

Michigan Flow Regimes

- Groundwater-driven, super high baseflow
- Groundwater-driven, high base, low peakflow
- Groundwater-driven, high base, mod peakflow
- Groundwater-driven, infl. by wetlands
- Runoff-driven, fair base and mod peakflow
- Runoff-driven, mod base and fair peakflow
- Runoff-driven, low base and high peakflow
- Runoff-driven, v. low base and v. high peakflow
- Runoff-driven, infl. by wetlands
- Lakes, ponds, etc.
- Missing data

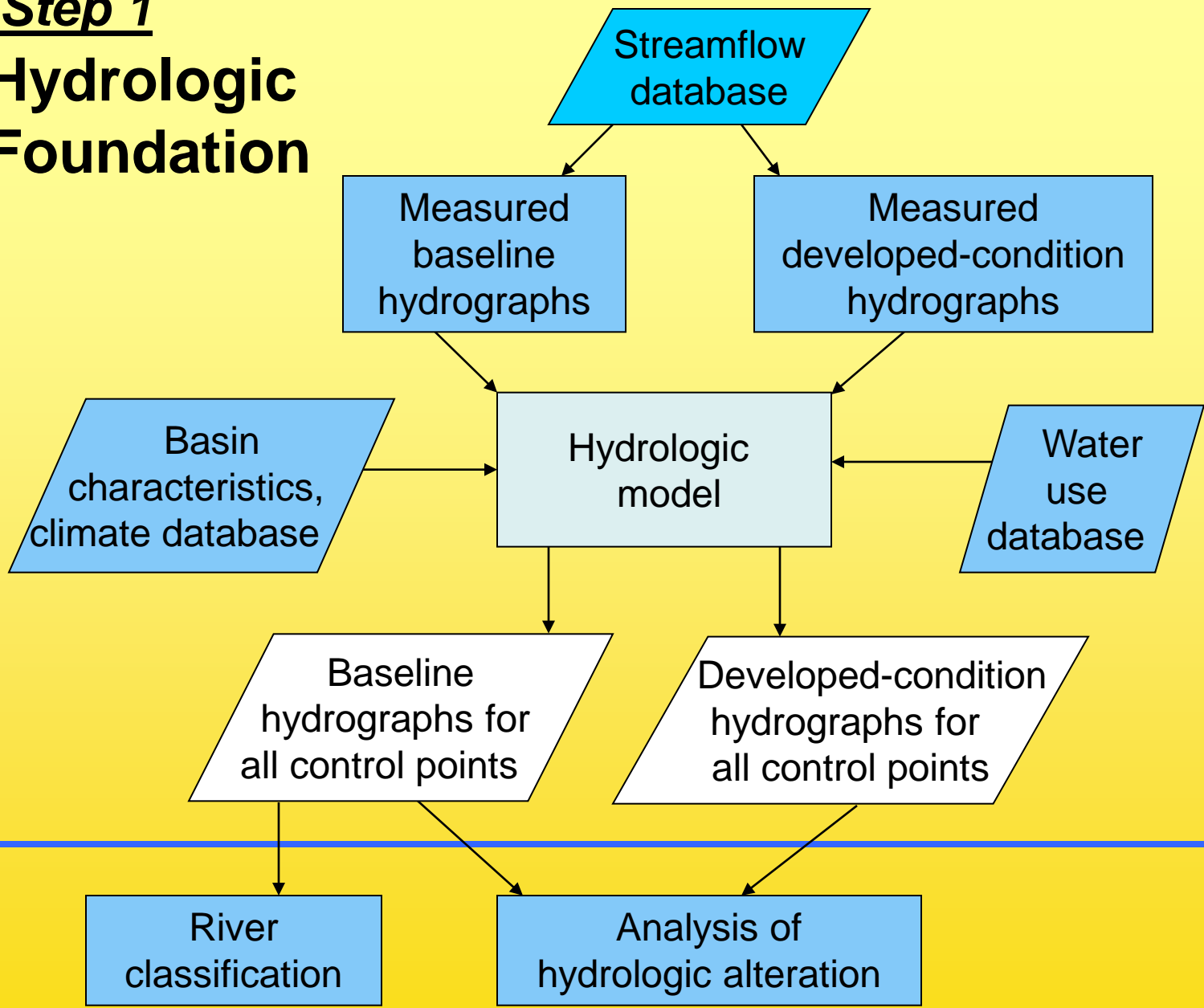


MICHIGAN, USA

Seelbach et al



Step 1 Hydrologic Foundation





Step 3

Compute Hydrologic Alteration

SELECTING HYDROLOGIC VARIABLES

Criteria

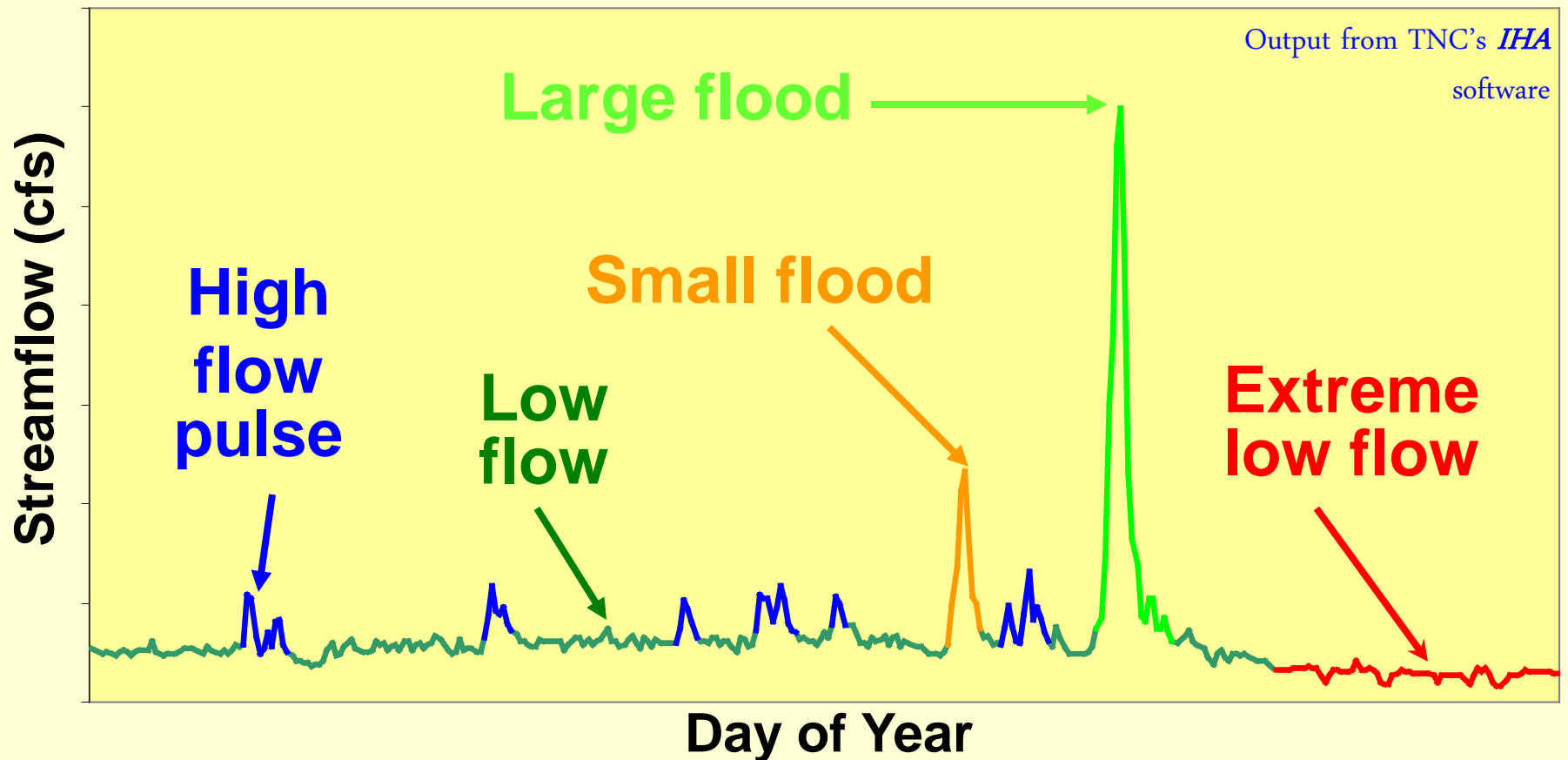
- Strongly linked to ecological condition
- Amenable for use as water management targets

Examples

- ▲ Timing of flood peaks
- ▲ Duration of zero-flow period
- ▲ Percent of August flow diverted

Compute Hydrologic Alteration

ENVIRONMENTAL FLOW COMPONENTS



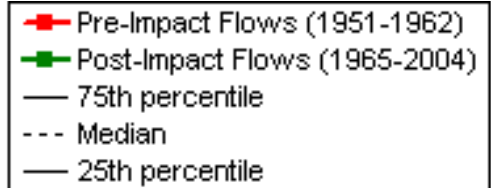
For each:

Magnitude, frequency, duration, timing, rate of change

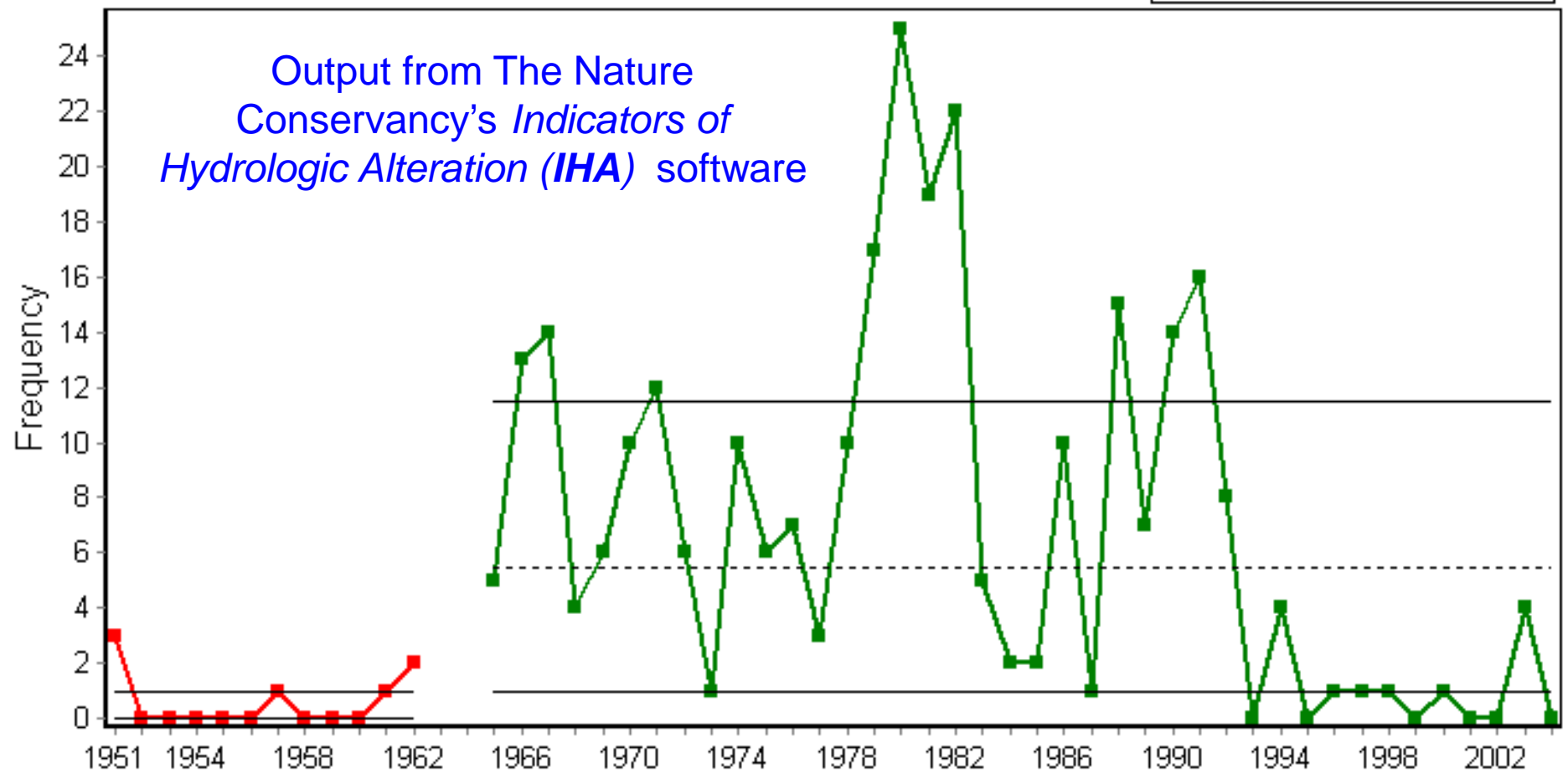
Step 3

Compute Hydrologic Alteration

Green River at Greendale, Utah
High Flow Pulses (Frequency)

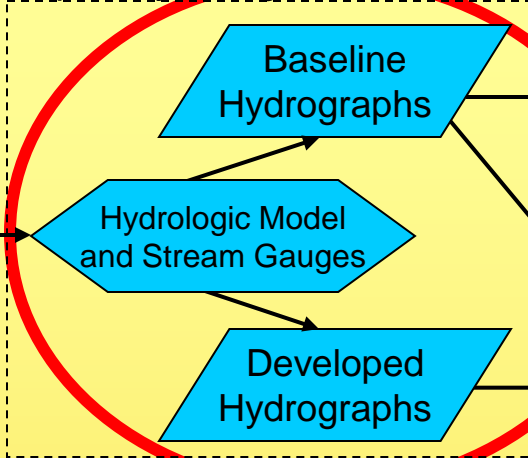


Output from The Nature Conservancy's *Indicators of Hydrologic Alteration (IHA)* software

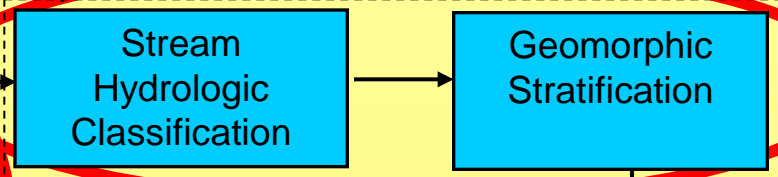


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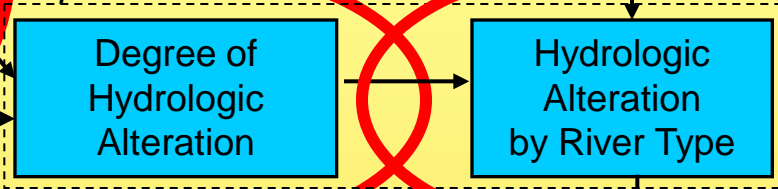
Step 1. Hydrologic Foundation



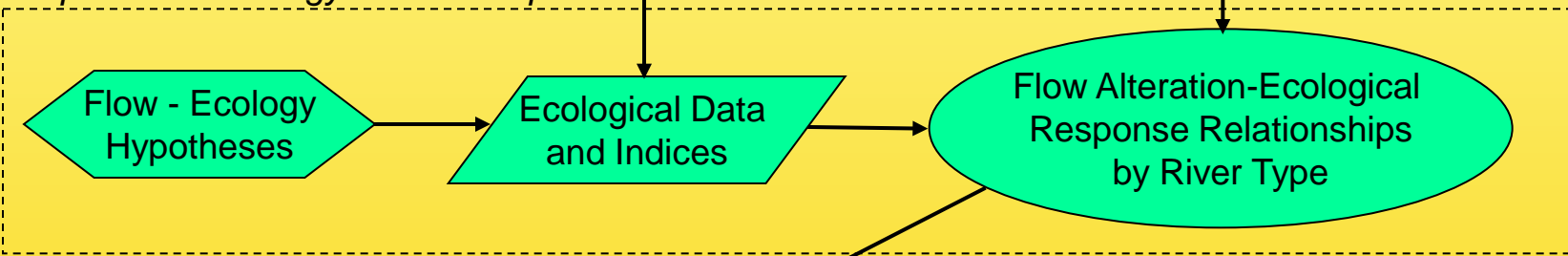
Step 2. Stream Classification



Step 3. Flow Alteration



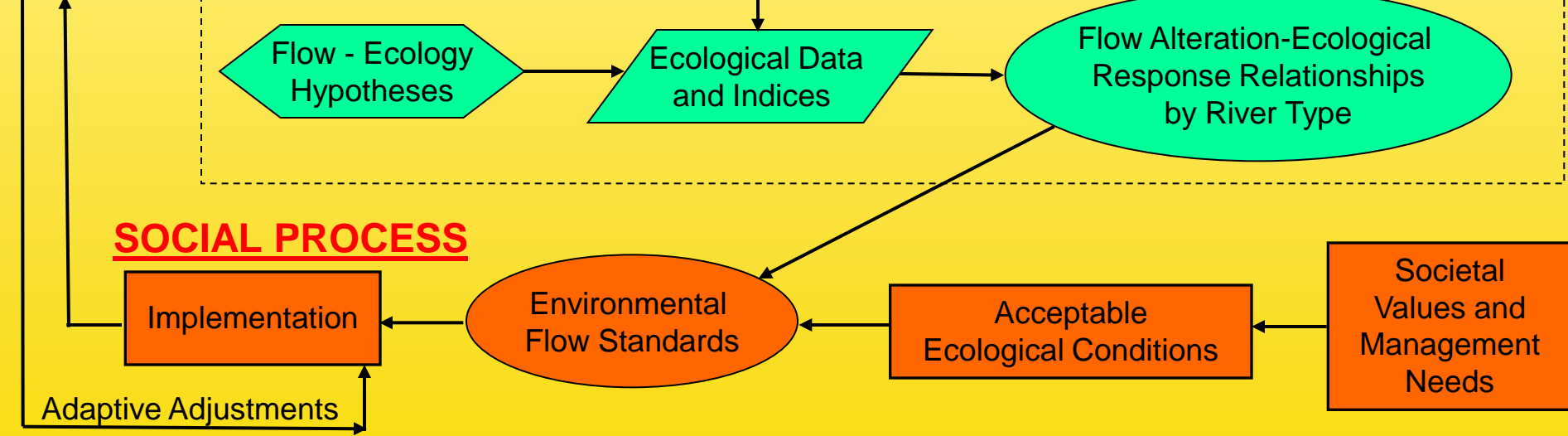
Step 4. Flow-Ecology Relationships

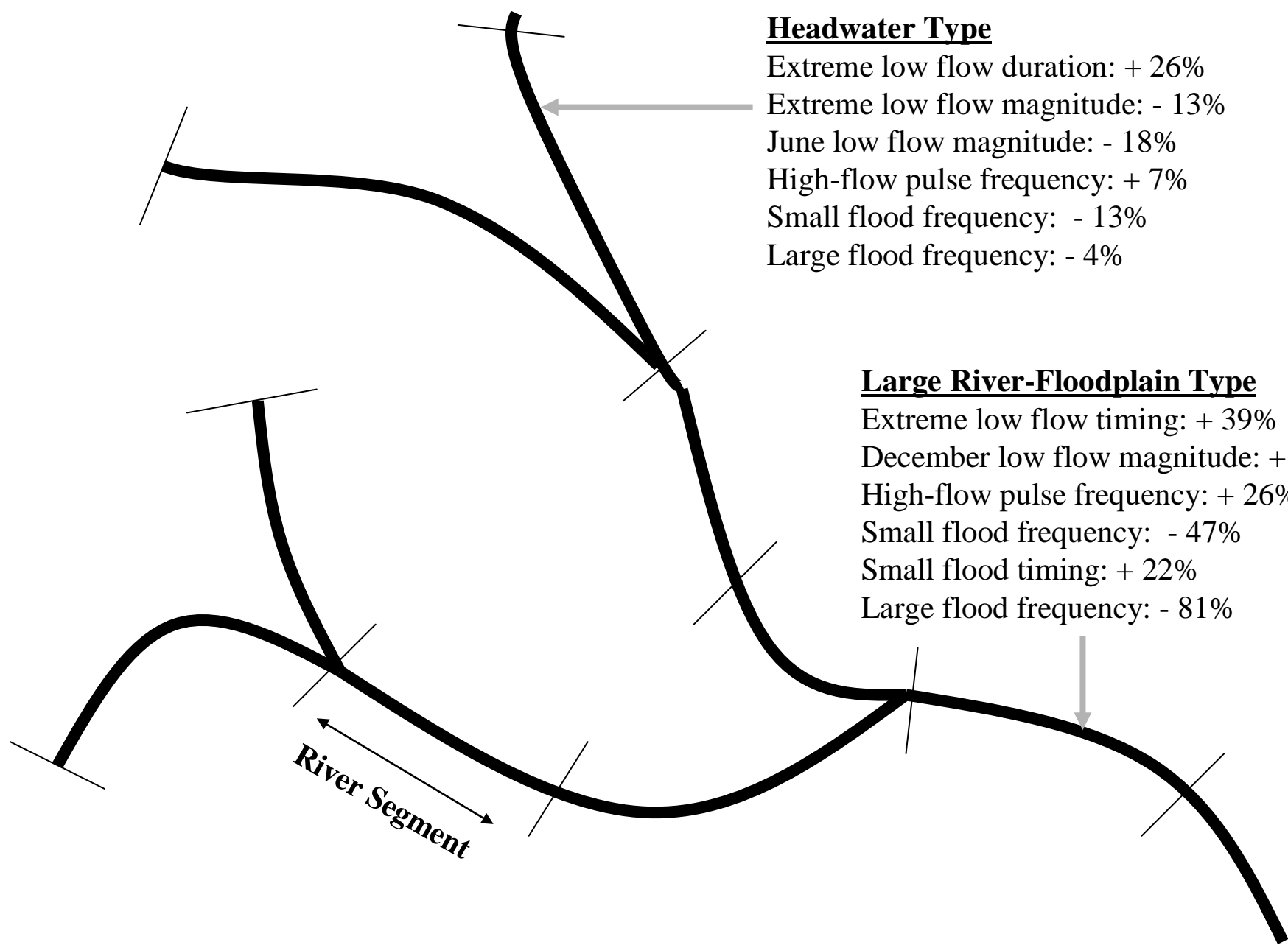


SOCIAL PROCESS



Adaptive Adjustments





Headwater Type

- Extreme low flow duration: + 26%
- Extreme low flow magnitude: - 13%
- June low flow magnitude: - 18%
- High-flow pulse frequency: + 7%
- Small flood frequency: - 13%
- Large flood frequency: - 4%

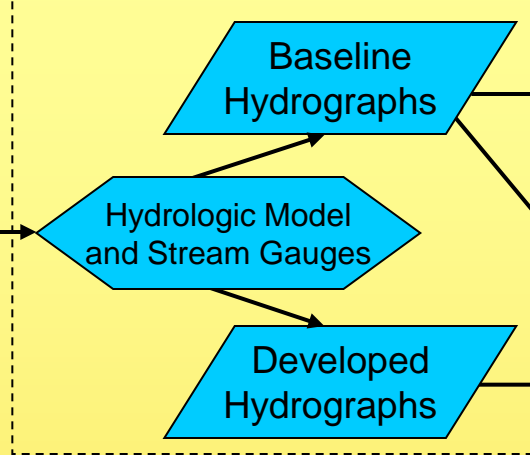
Large River-Floodplain Type

- Extreme low flow timing: + 39%
- December low flow magnitude: + 45%
- High-flow pulse frequency: + 26%
- Small flood frequency: - 47%
- Small flood timing: + 22%
- Large flood frequency: - 81%

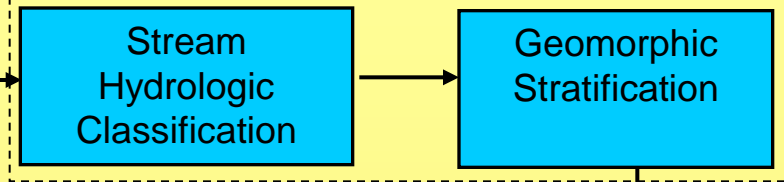
River Segment

SCIENTIFIC PROCESS

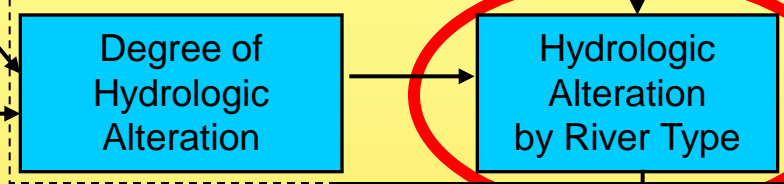
Step 1. Hydrologic Foundation



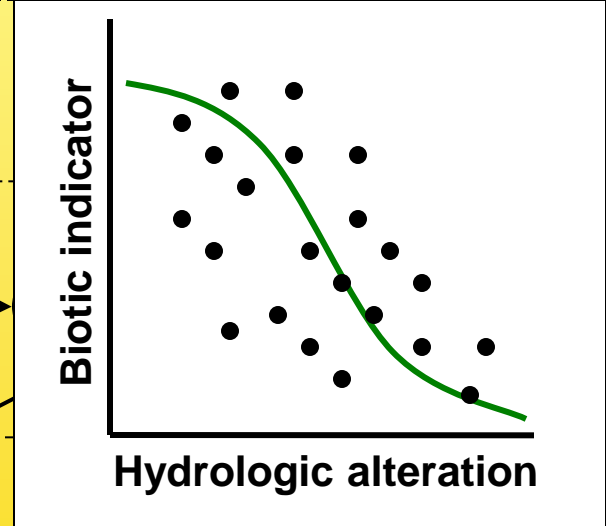
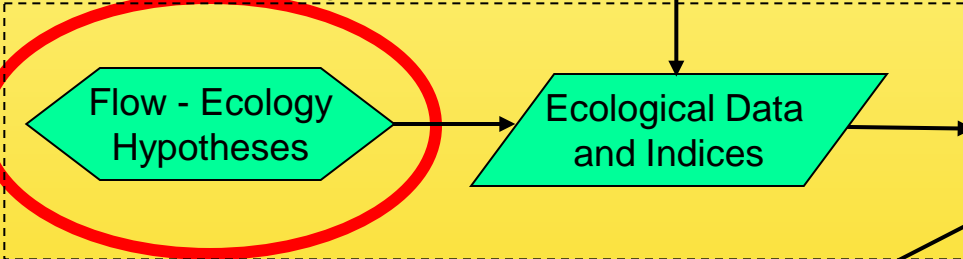
Step 2. Stream Classification



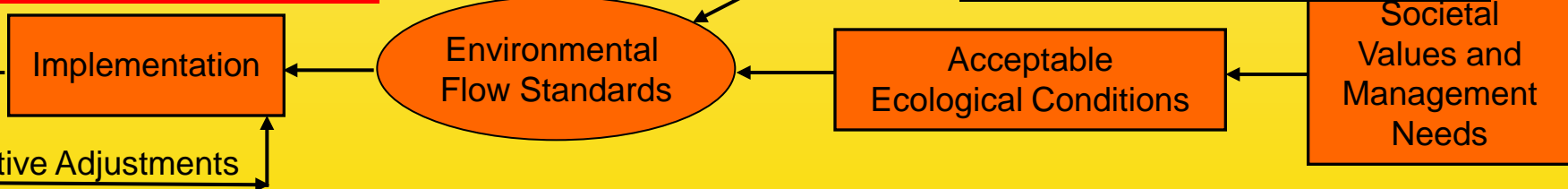
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships



SOCIAL PROCESS



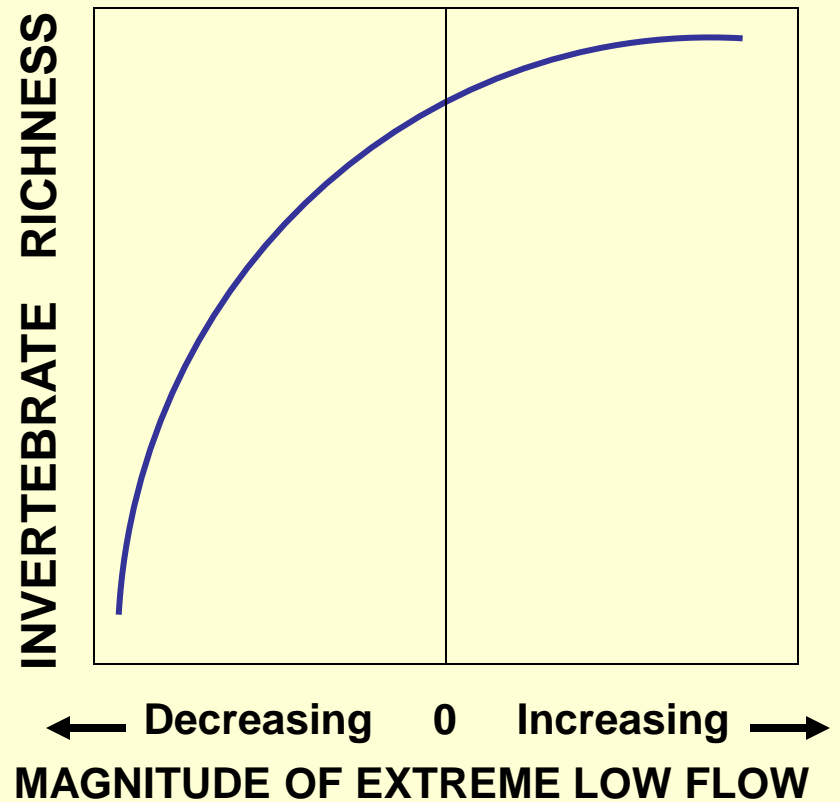
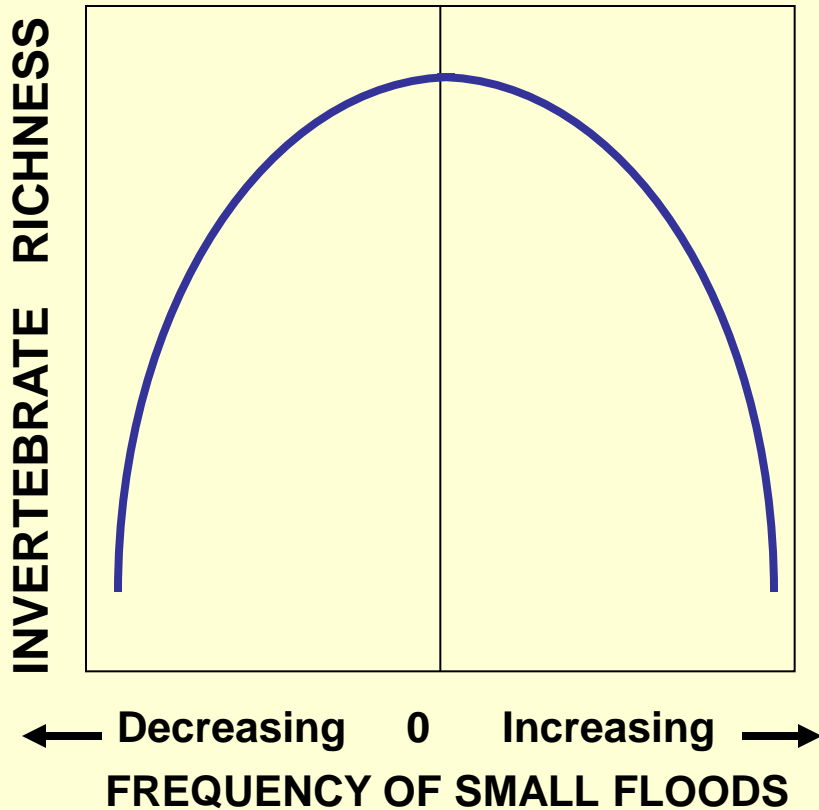
Monitoring

Adaptive Adjustments

Step 4

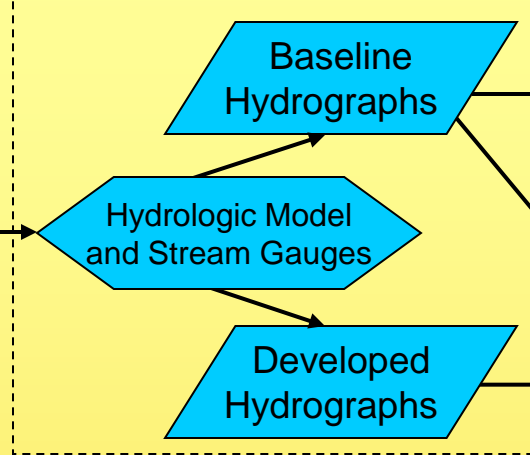
Flow Alteration- Ecological Response Relationships

FLOW-ECOLOGY HYPOTHESES

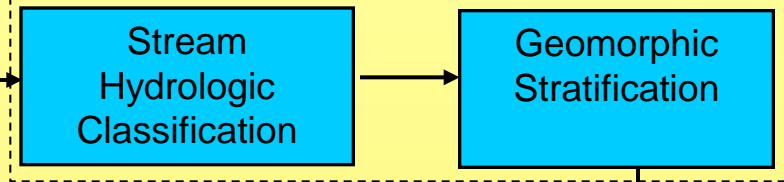


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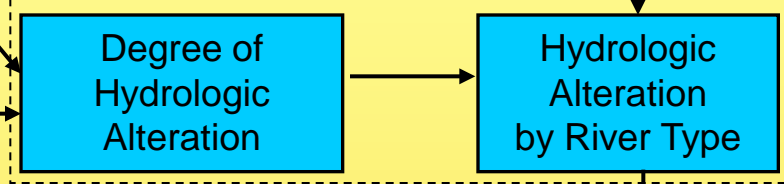
Step 1. Hydrologic Foundation



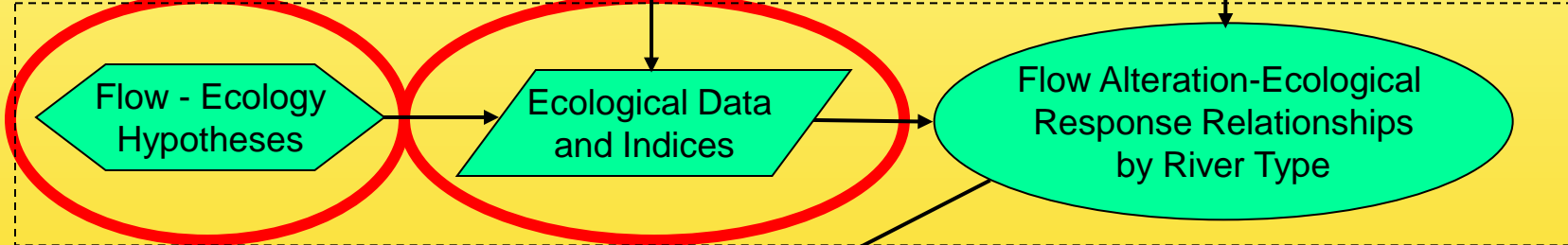
Step 2. Stream Classification



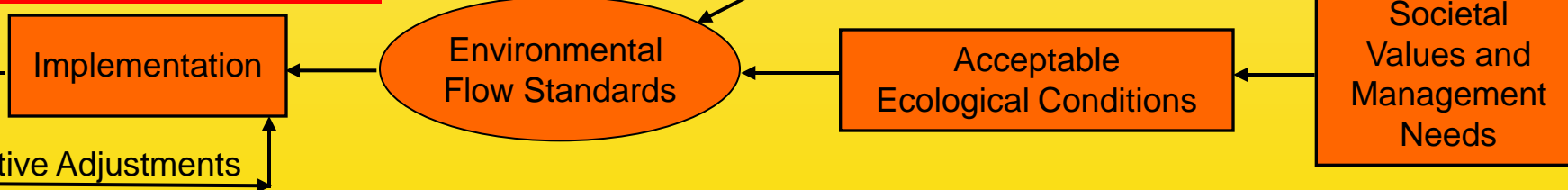
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships



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Monitoring

Adaptive Adjustments

Flow - Ecology Response Curves

ECOLOGICAL DATA COMPILATION

Criteria

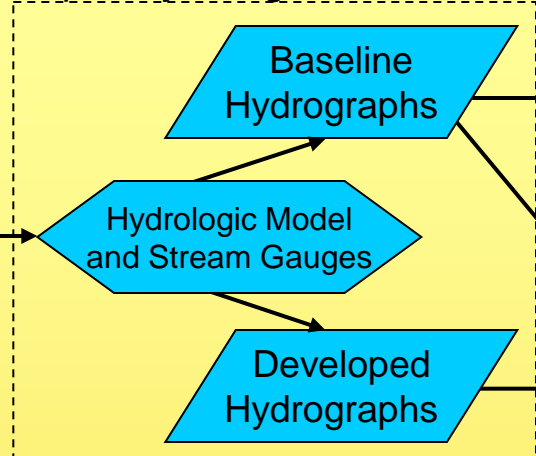
- Sensitive to existing or proposed flow alteration
- Can be validated with monitoring data
- Are valued by society

Examples

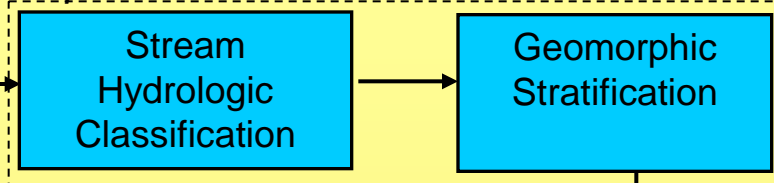
- ▲ Aquatic invertebrate species richness
- ▲ Riparian vegetation recruitment
- ▲ Larval fish abundance

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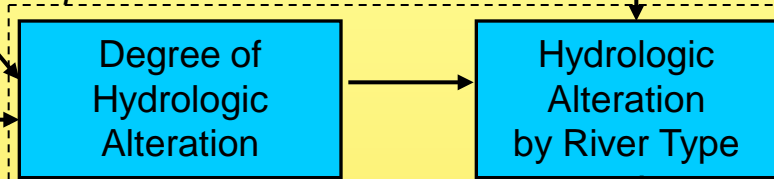
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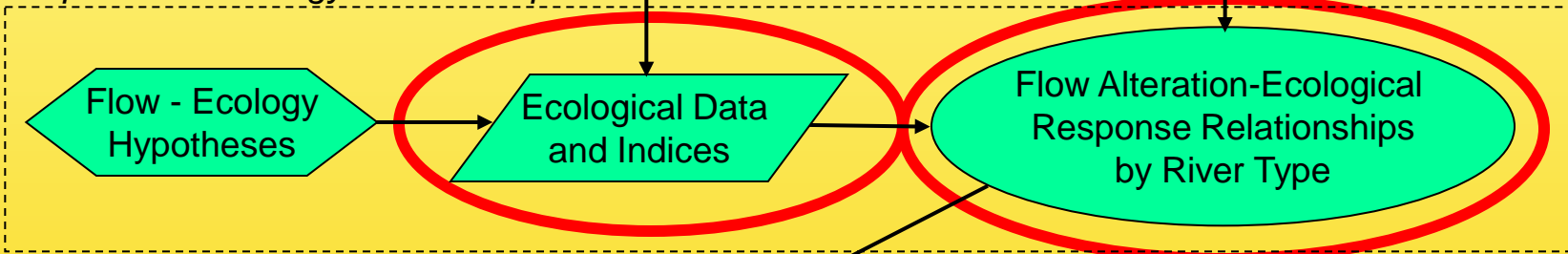
Step 2. Stream Classification



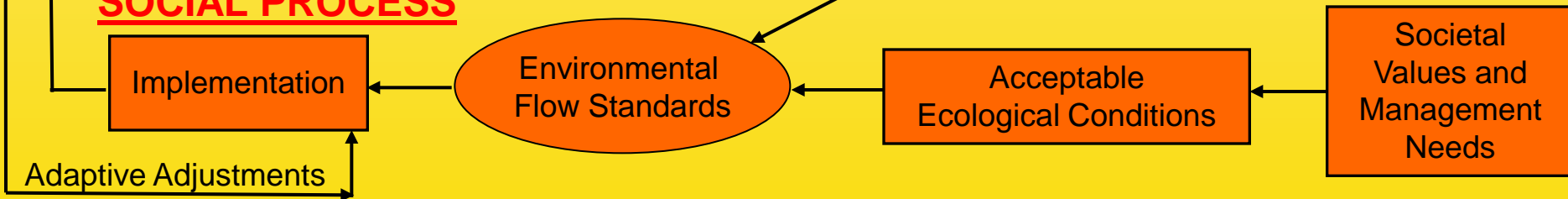
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships

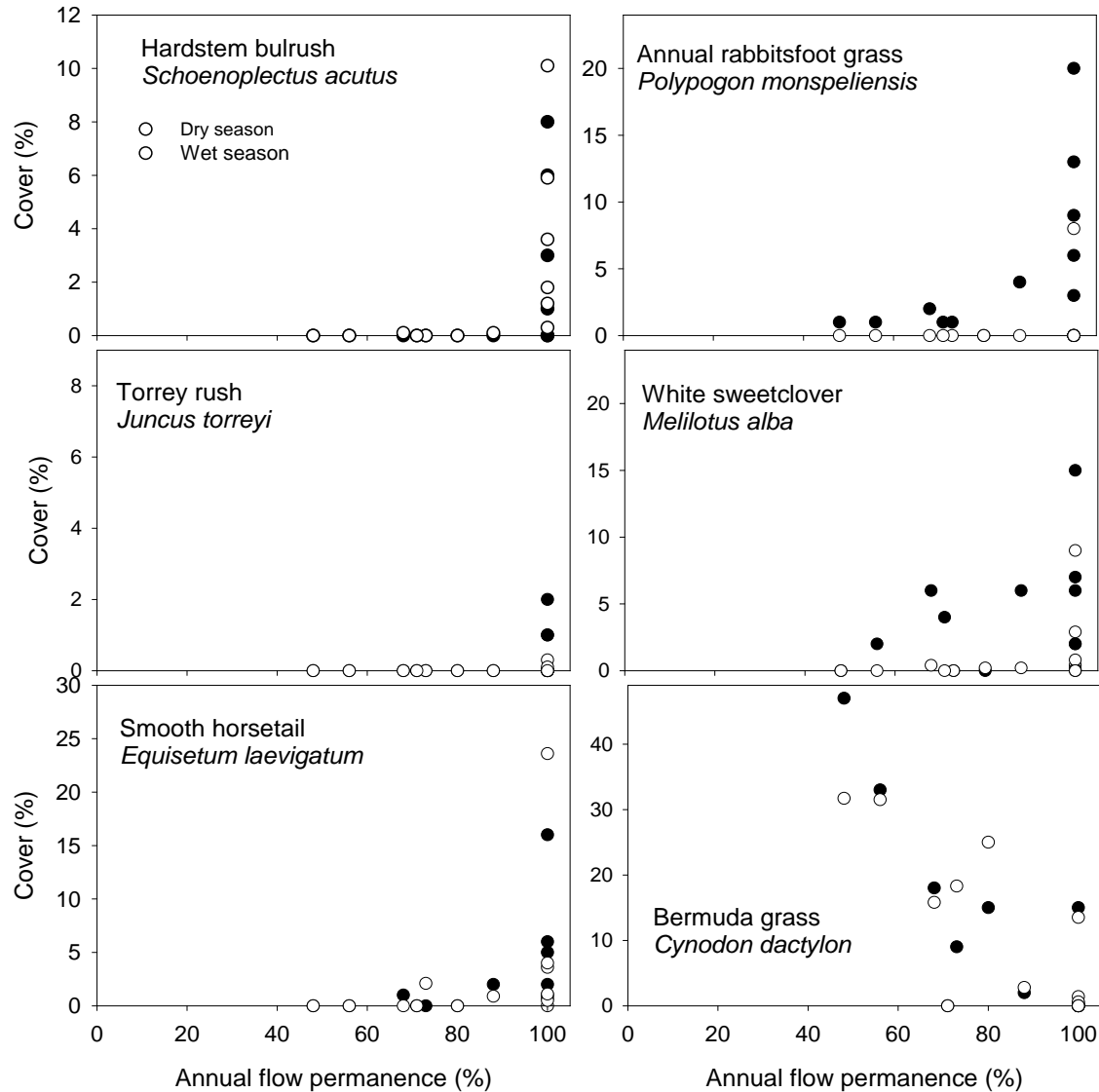


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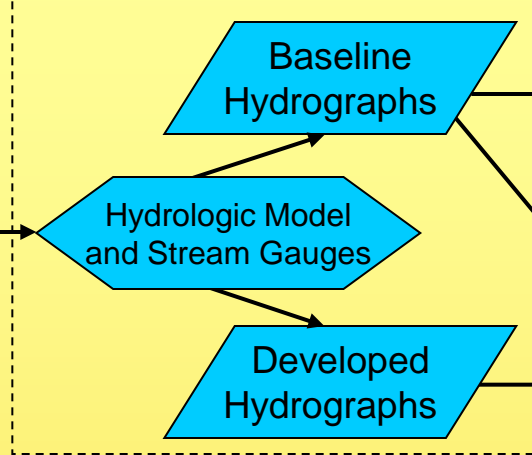
Flow - Ecology Response Curves

Species cover vs. flow permanence

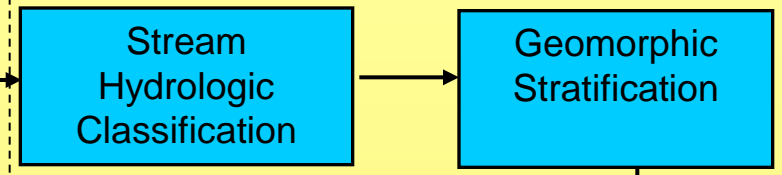


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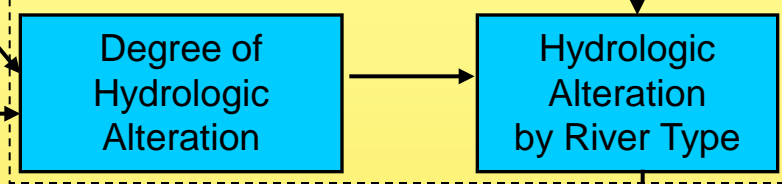
Step 1. Hydrologic Foundation



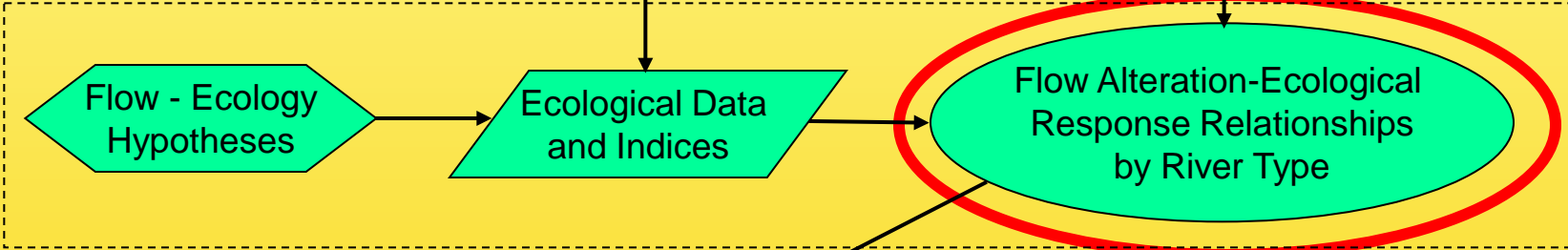
Step 2. Stream Classification



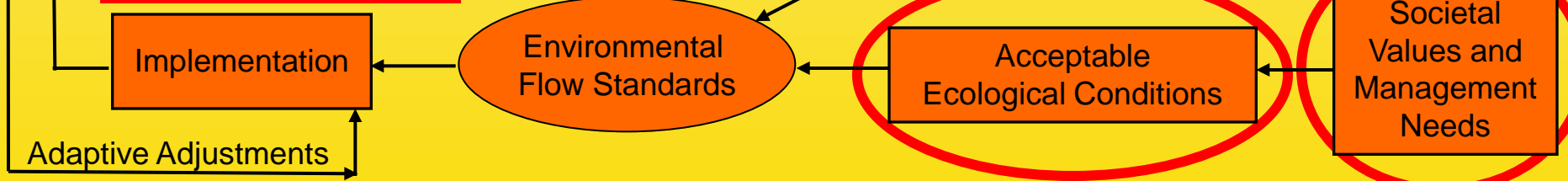
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships

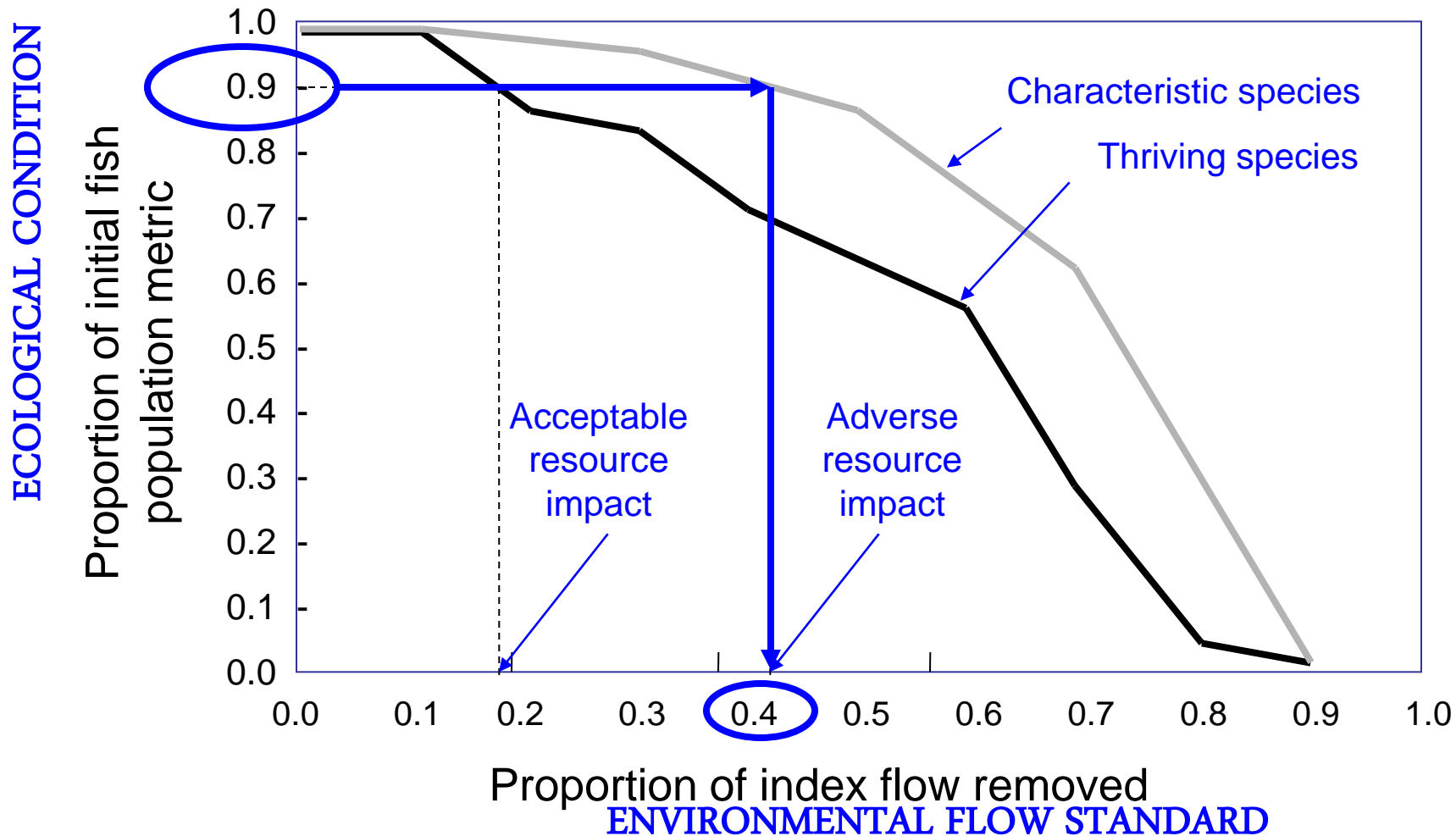


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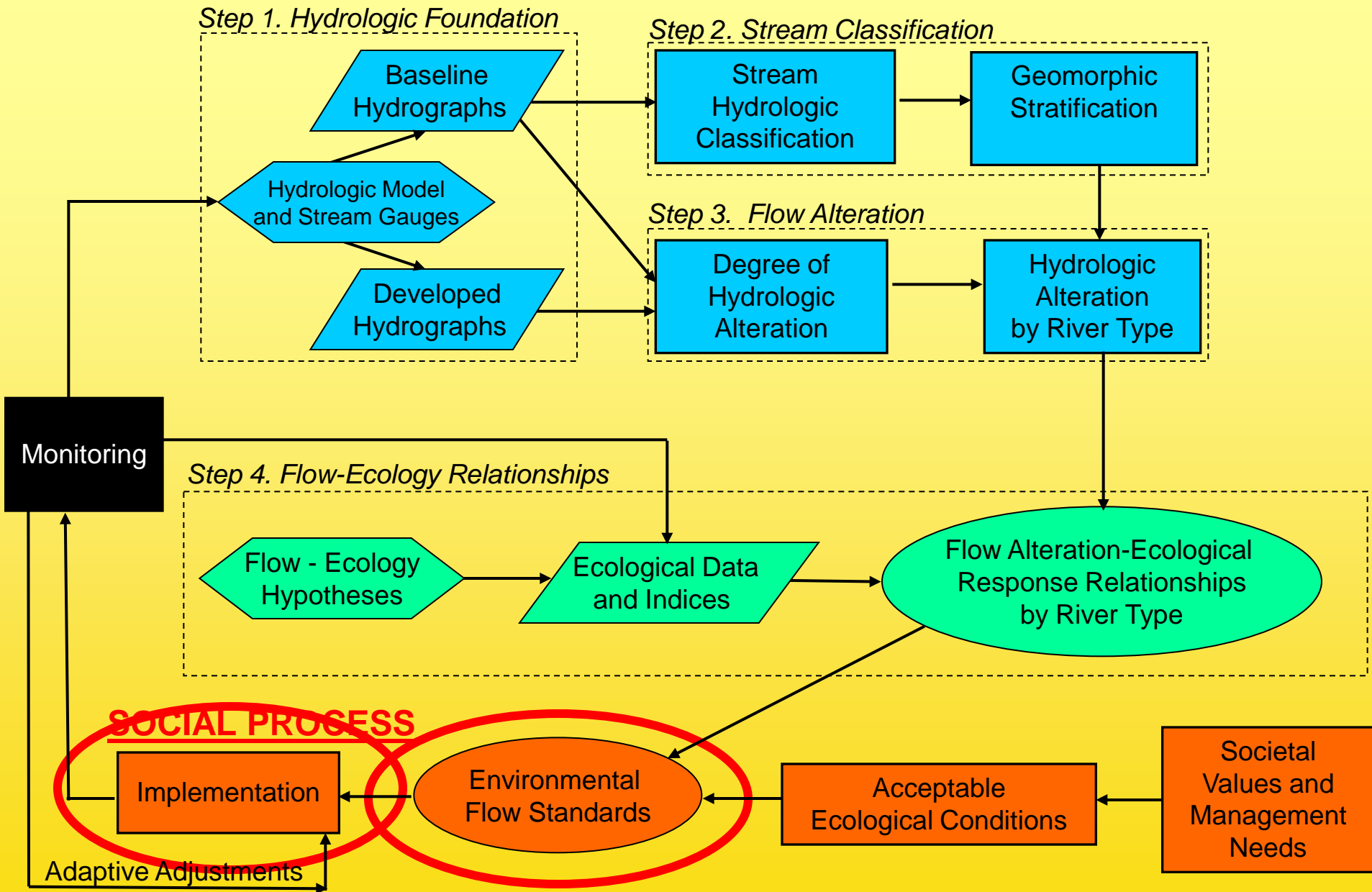


- Step 1.* Determine acceptable ecological conditions Define environmental
- Step 2.* flow targets

Michigan's Screening Tool for Ground-Water Withdrawals

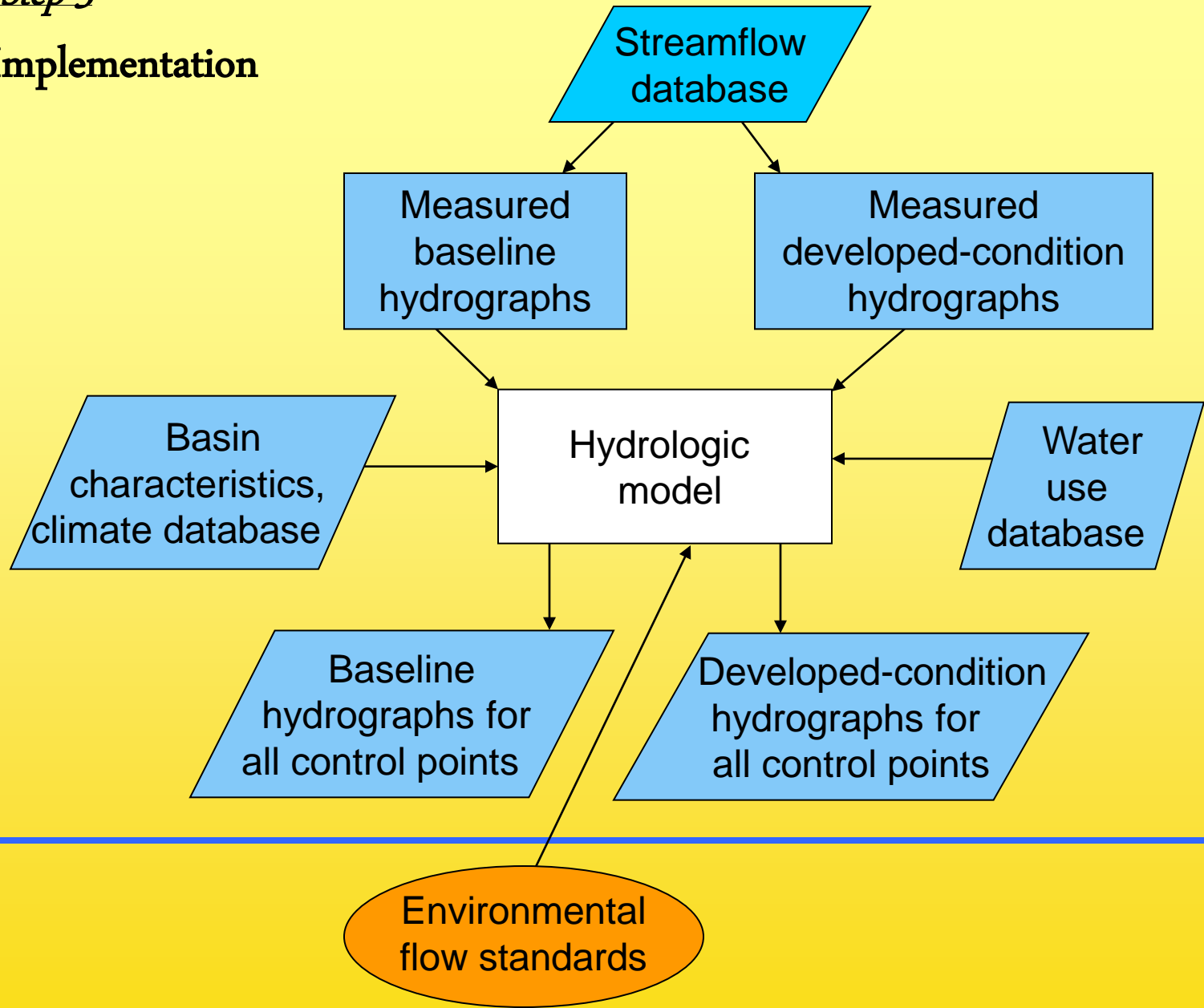


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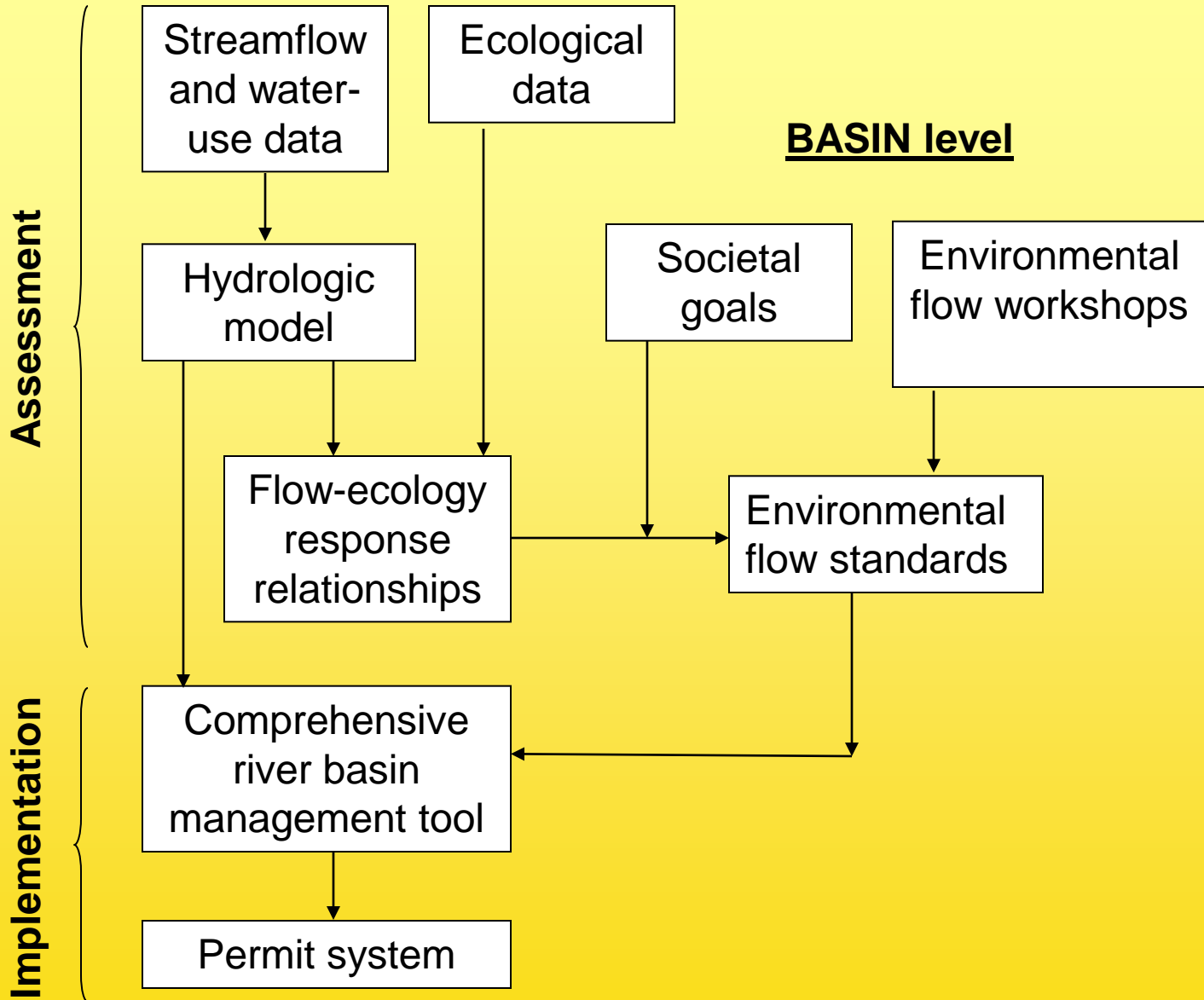
Step 3

Implementation



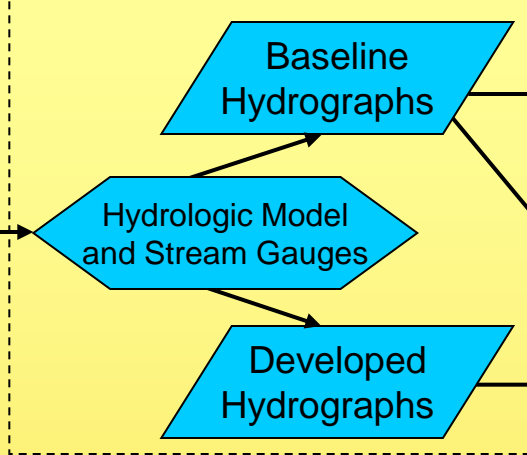
STATE level

BASIN level

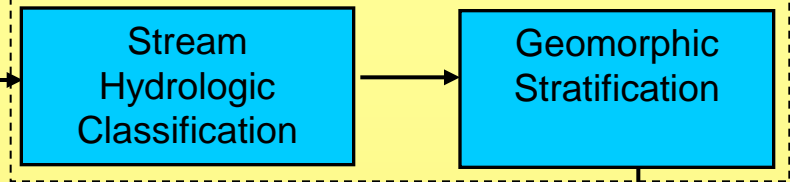


SCIENTIFIC PROCESS

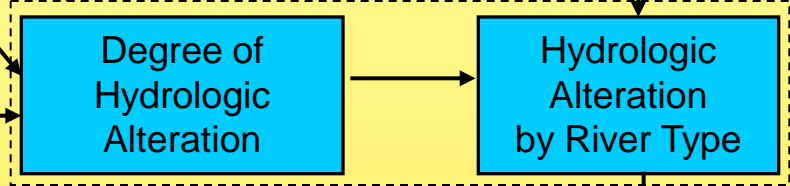
Step 1. Hydrologic Foundation



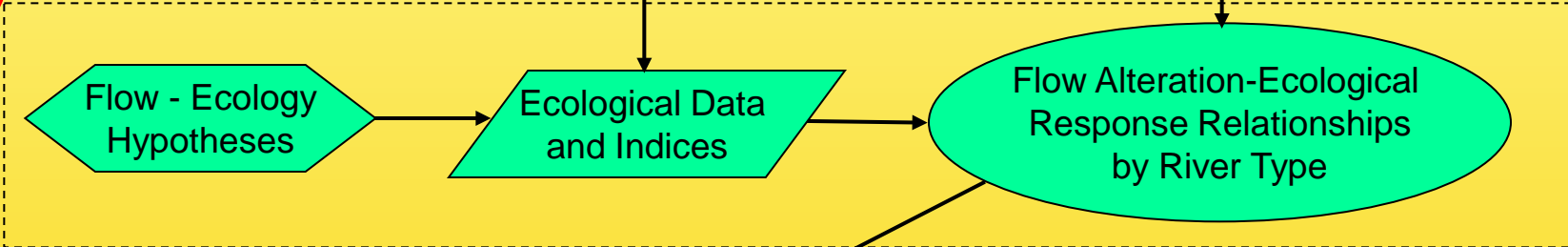
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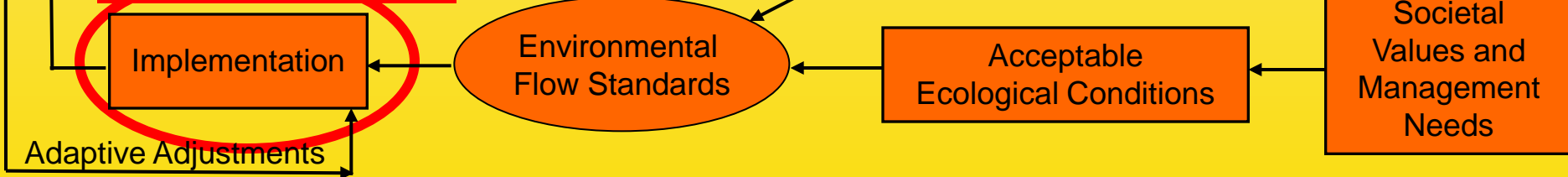
Step 3. Flow Alteration



Step 4. Flow-Ecology Relationships



SOCIAL PROCESS





For further information:

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[nature.org/ELOHA](https://www.nature.org/ELOHA)

The Nature
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SAVING THE LAST GREAT PLACES ON EARTH

Extra slides



Implementing Environmental Flow Targets

- Protection
 - ▲ Land-use decisions (growth management)
 - ▲ Comprehensive water management plan
 - ▲ Withdrawal permitting

- Restoration
 - ▲ Dam re-operation
 - ▲ Conjunctive ground- / surface-water use
 - ▲ Drought management planning
 - ▲ Demand management (conservation)
 - ▲ Water transactions
 - ▲ Moving diversion points

Step 3

Compute Hydrologic Alteration

Green River at Greendale, Utah Magnitude of Small Floods

