Managing Groundwater Withdrawals to Sustain Aquatic Ecosystems

Kristen Blann, Eloise Kendy, and Phil Gerla
The Nature Conservancy

Objective: Ecological criteria are needed to effectively manage stream and river flow. Groundwater hydrology is essential in developing the flow – ecology relationships and implementing flow standards.

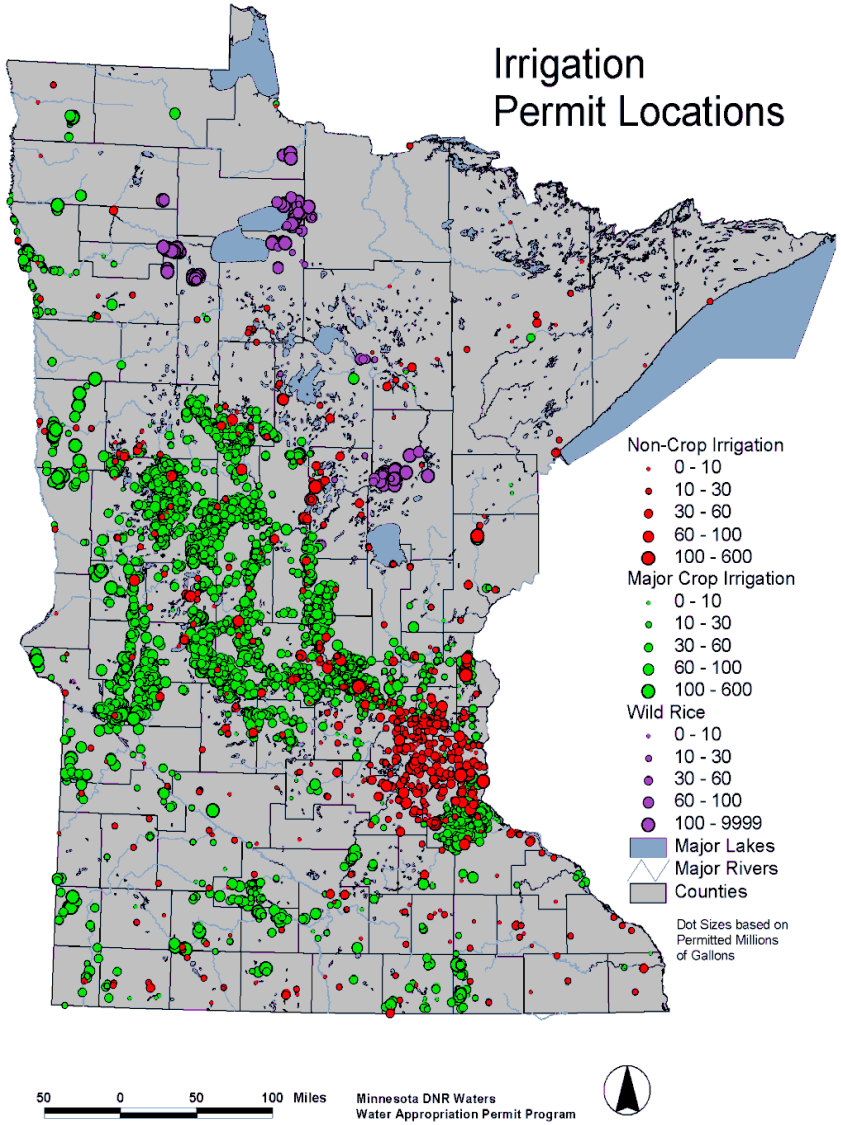
1. Need for Managing Flow

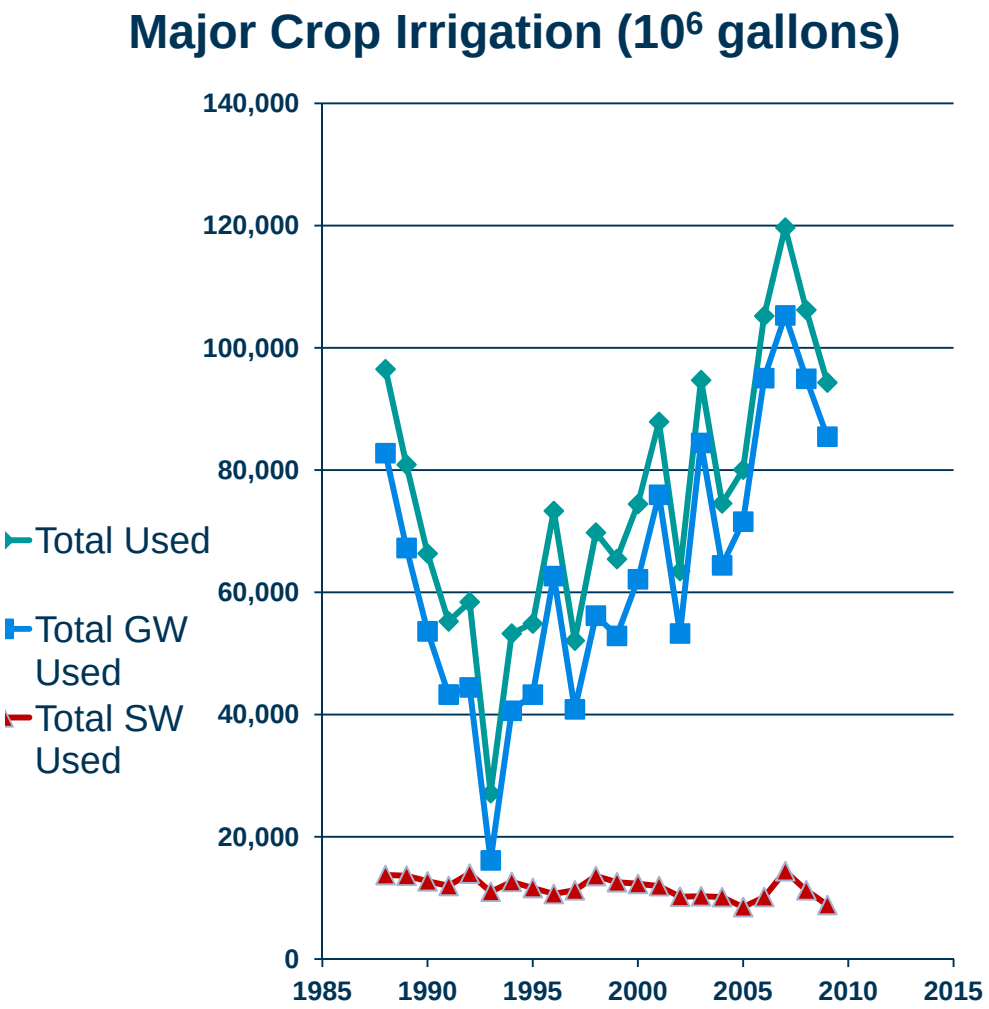
2. Methods Underlying Policy and Planning

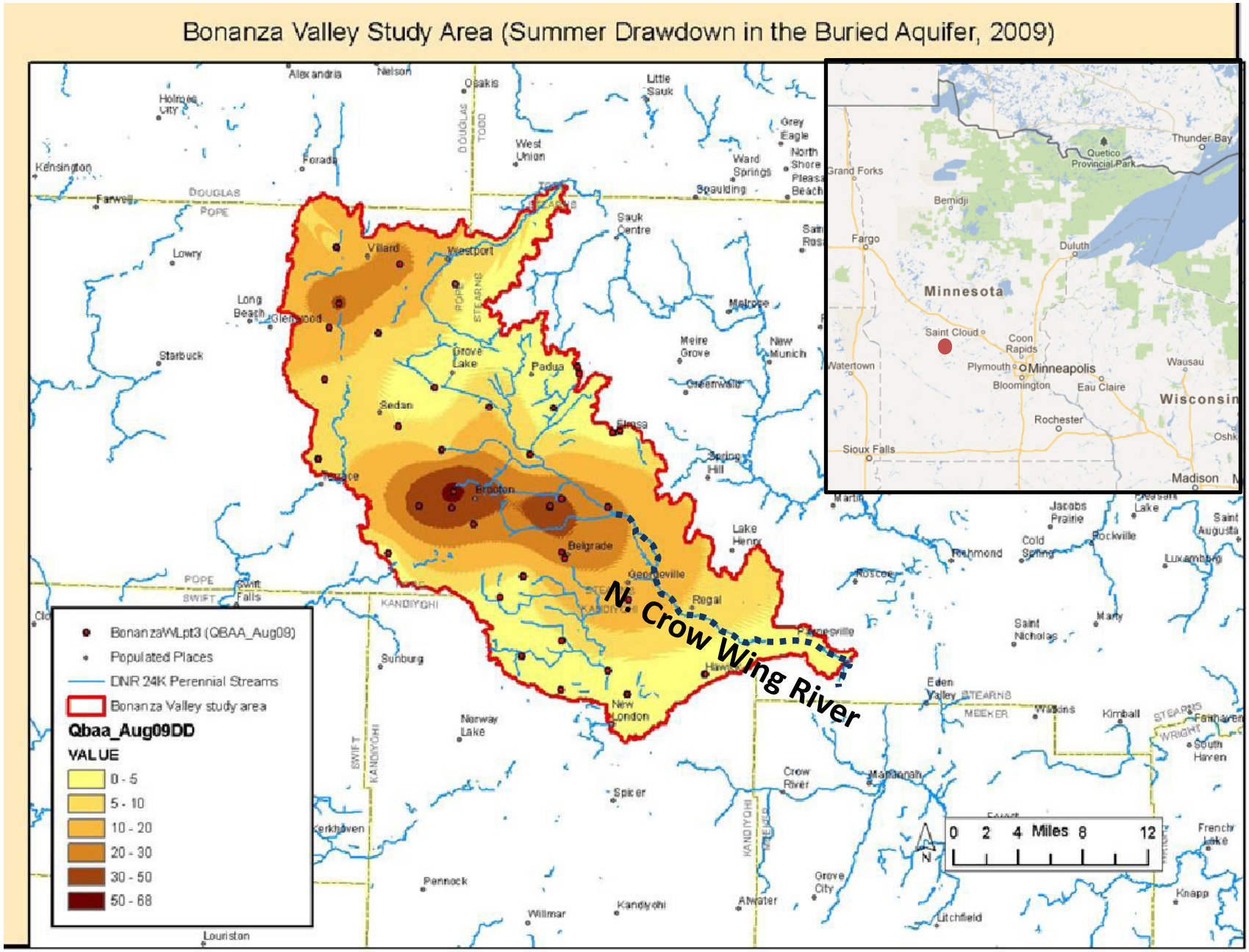
3. Examples of Implementation

4. Making the Connection to Groundwater

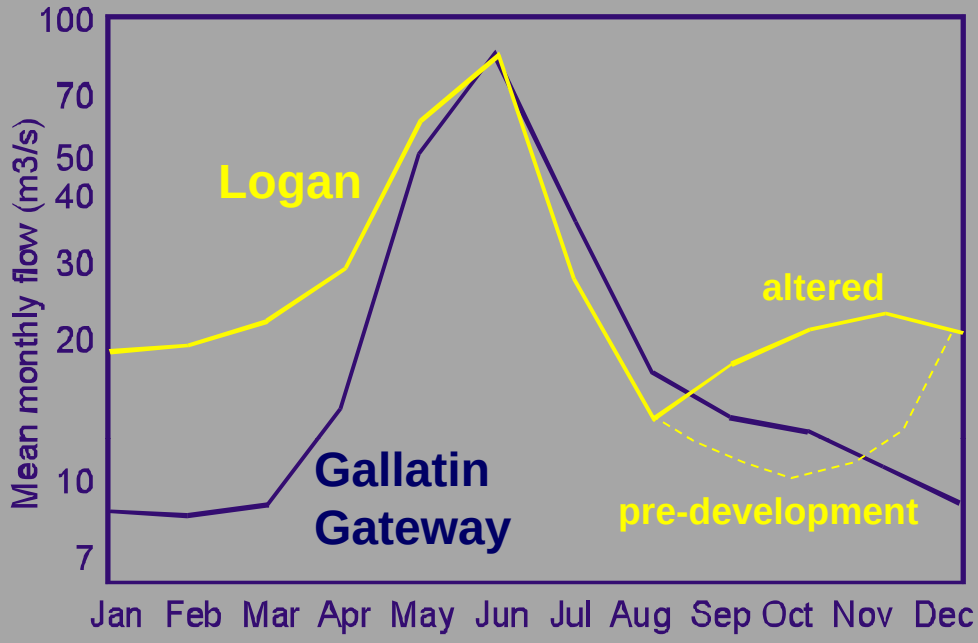
Water Use Increases in Minnesota

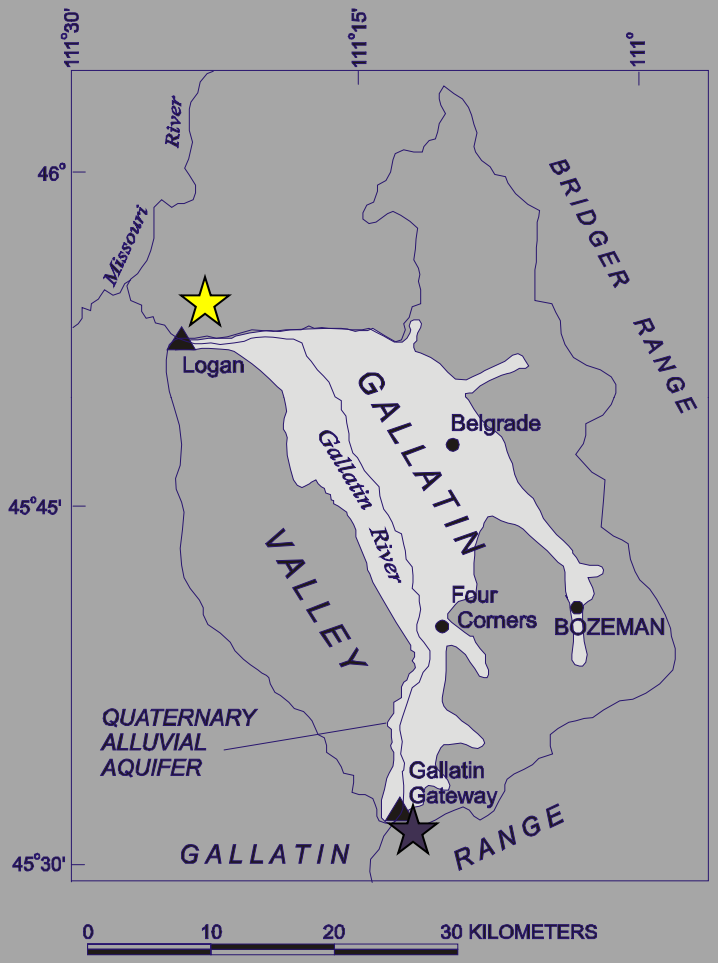






From E. Drivas and J. Leete, Minnesota DNR



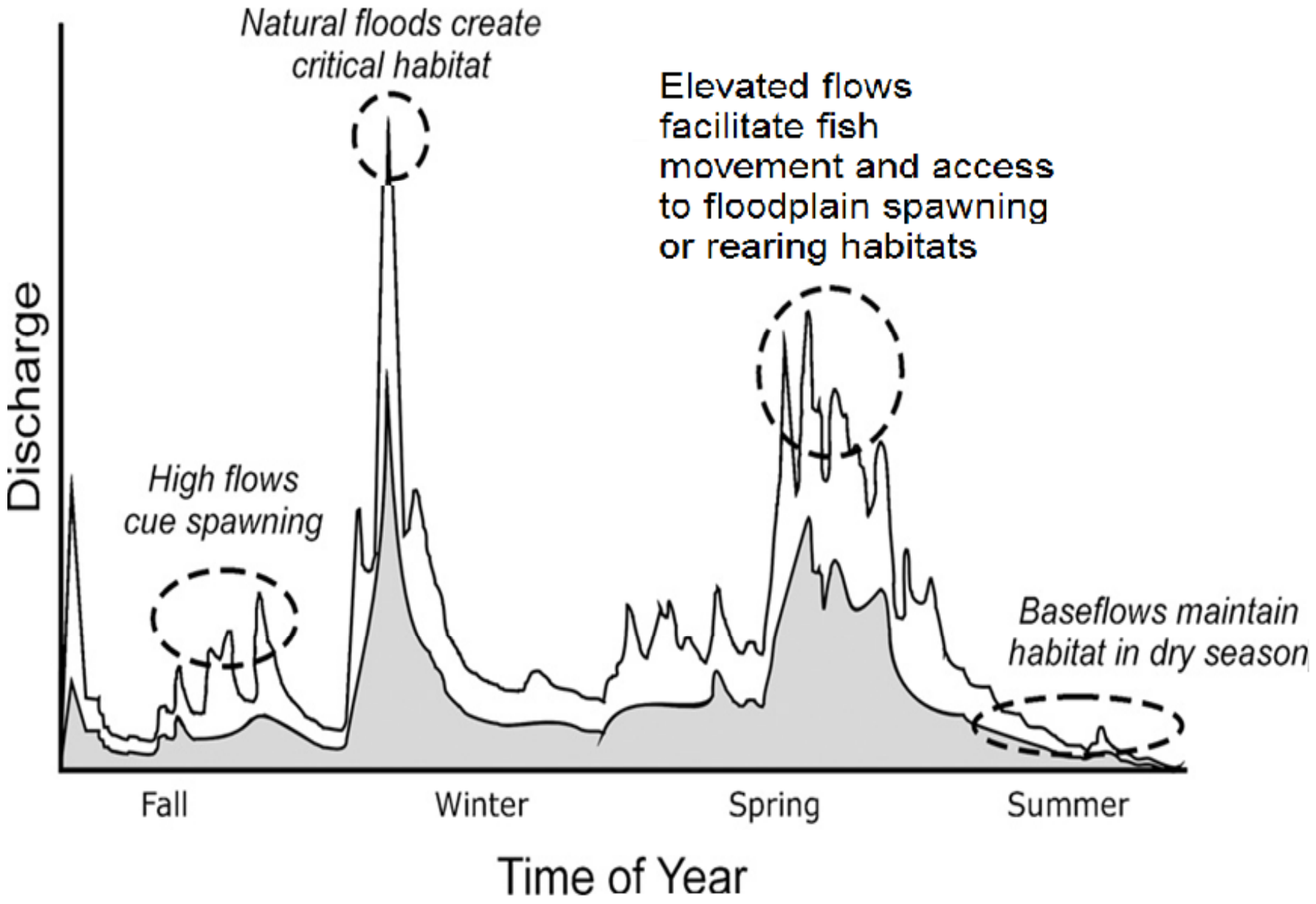


Average monthly flow of the Gallatin River, Montana

Kendy and Bredehoeft 2006

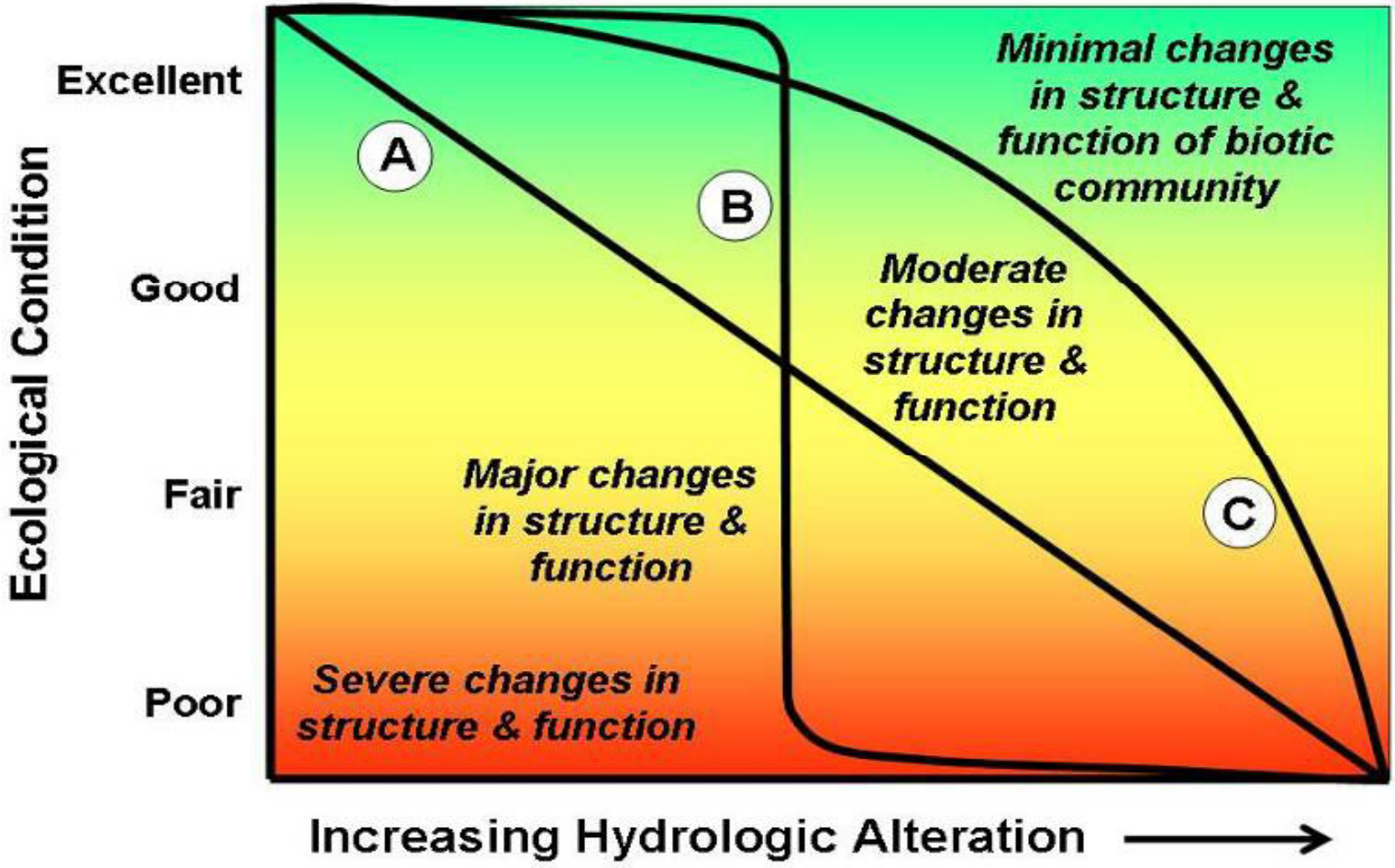
altered flow affects ecology

Ecological Consequences of Altered Flow



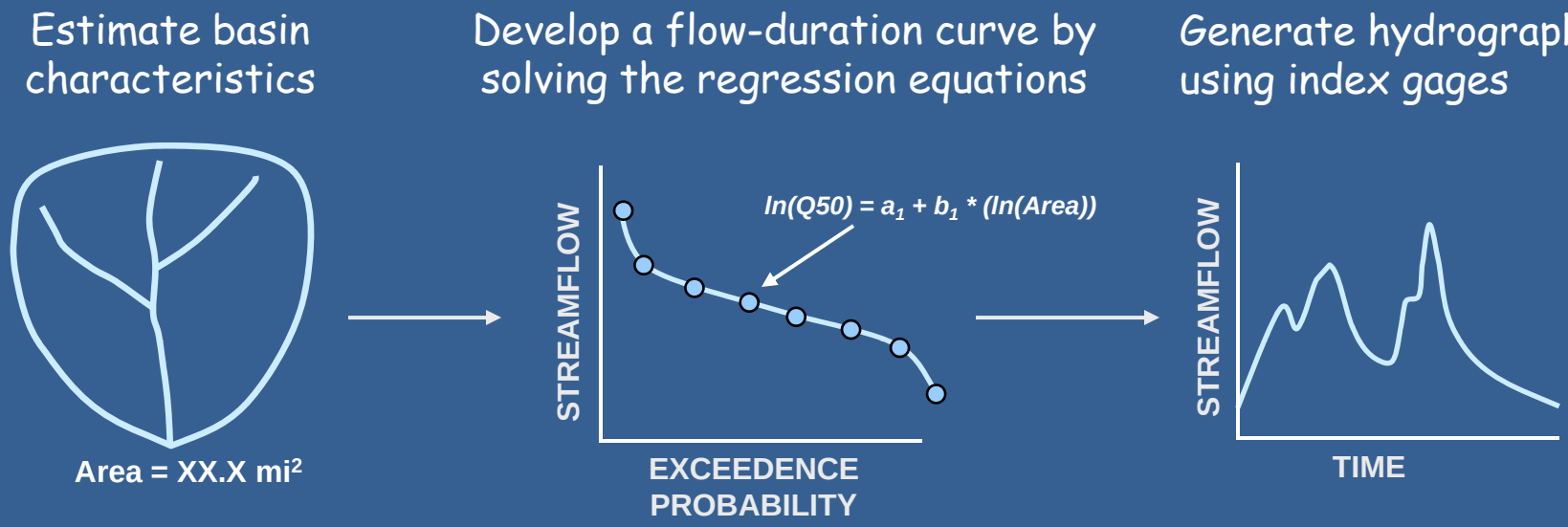
Flow-Ecology Relationship - Concept

A unique curve for classes of streams and river reaches …. essential for optimal permitting



from Kendy et al. 2012. A Practical Guide to Environmental Flows for Policy and Planning

Sustainable Yield Estimate Approach



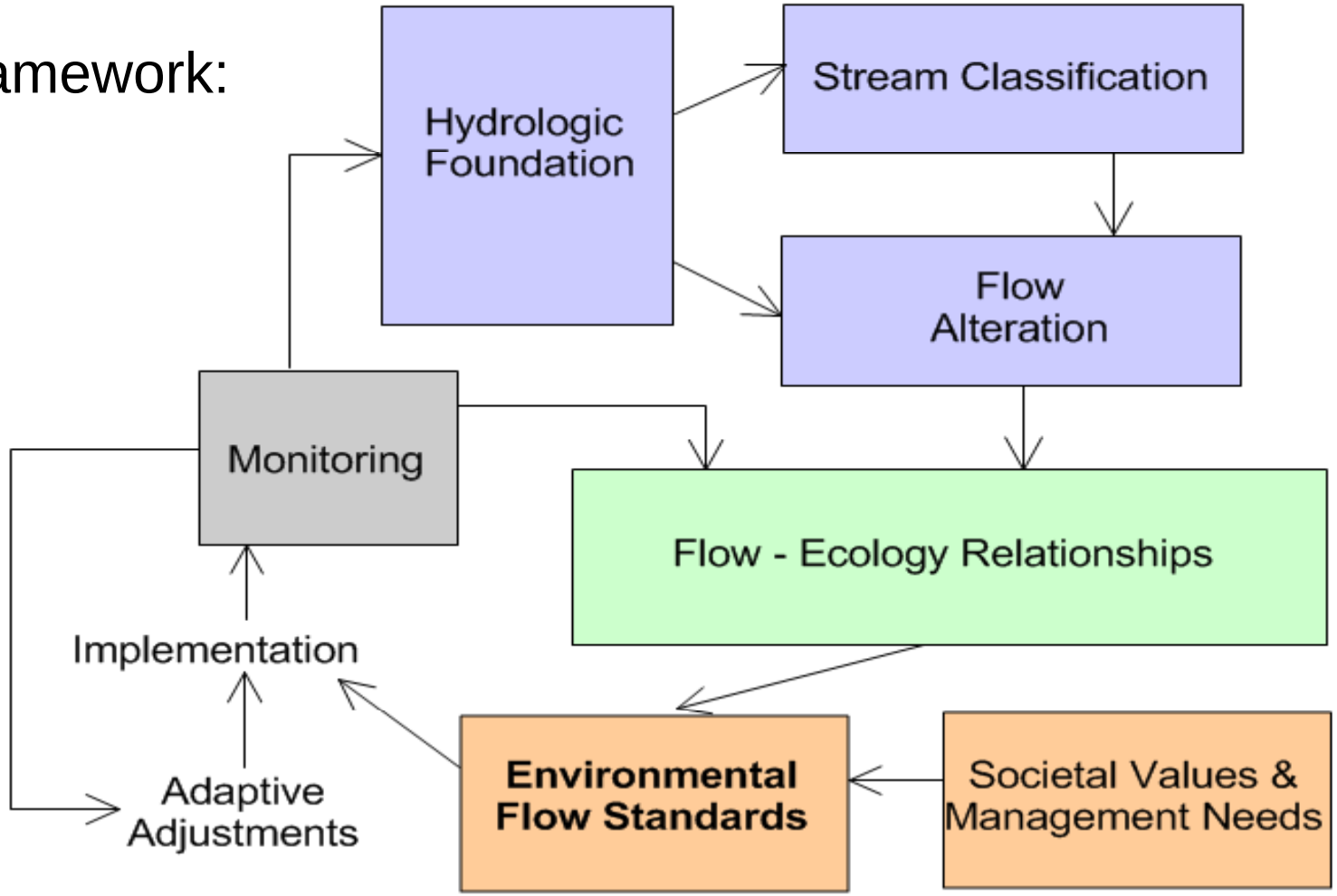
Groundwater is implicit in the regression equations

Generated hydrographs are applied to biological data

Sources: U.S. Geological Survey --- Archfield and others, 2010.; Ries and Friesz (1999); Fennessey (1994)

ELOHA – Ecological Limits of Hydrological Alteration

Framework:



adapted after Poff et al. 2010

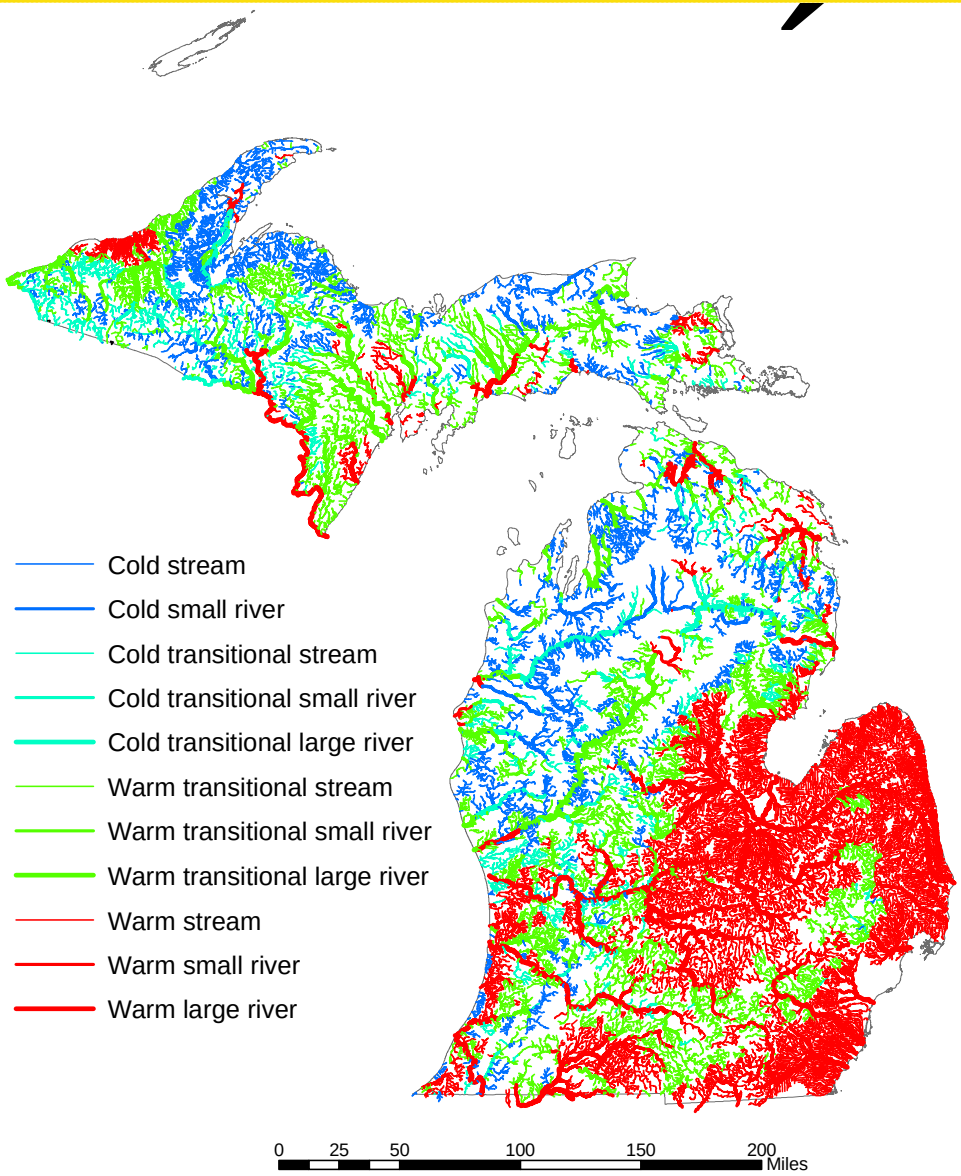
Michigan --- components

1. **HYDROLOGIC FOUNDATION**: August median flow; streamflow depletion model - GW pumping with delay (STRMDEPL).
2. **CLASSIFICATION:** Size and thermal class.
3. **GOAL CONDITION: "**Avoid Adverse Resource Impact" defined by broad stakeholder group.
4. **FLOW ECOLOGY** Fish community-flow models based on occurrence and abundance database (Zorn et al. 2008).
5. **APPLICATION**: On-line water withdrawal screening tool that checks for an adverse impact standard (fishes).

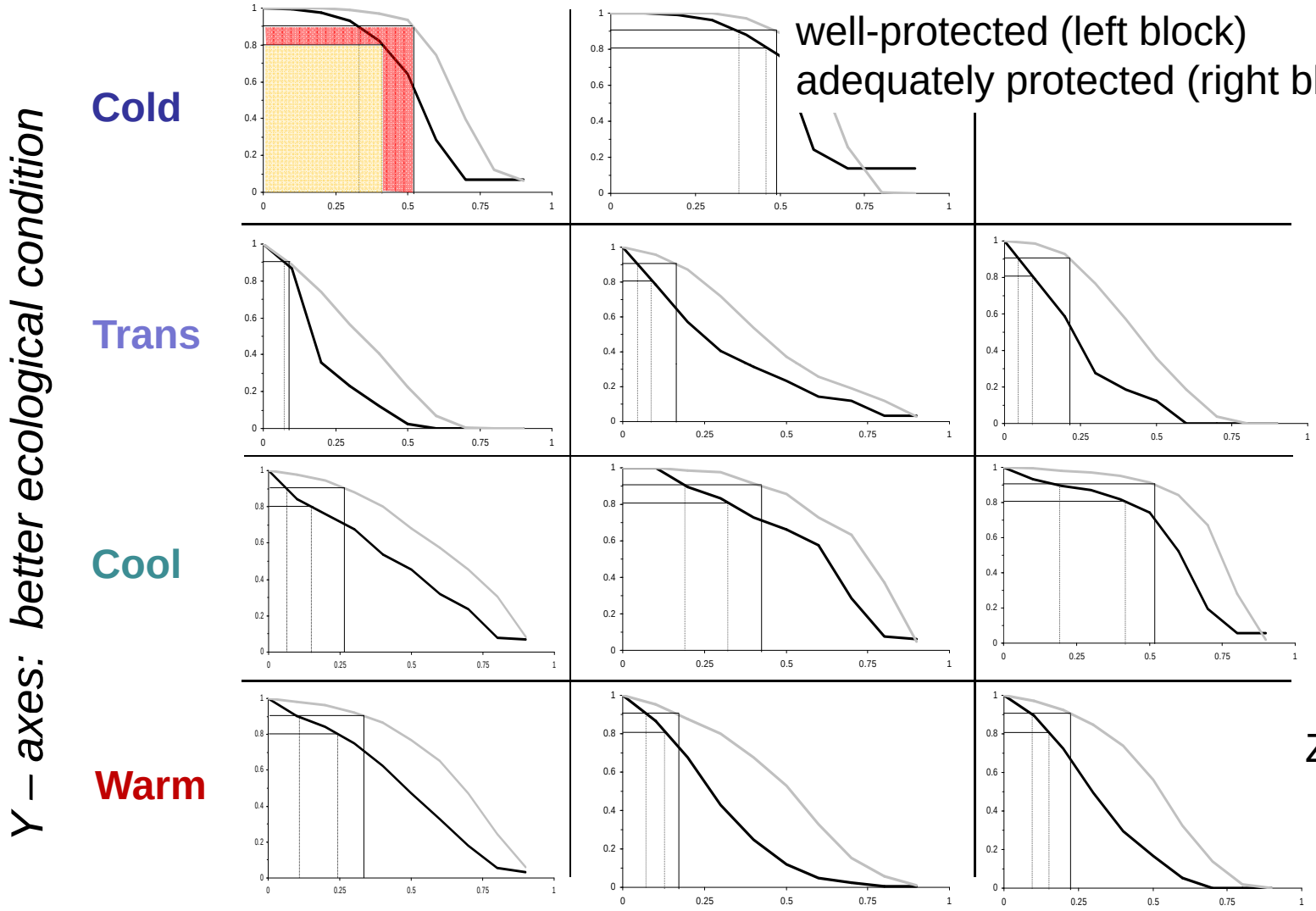
Michigan --- stream classification

-- hydrology
-- geomorphology
-- water temperature
-- ecoregion / habitat

Seelbach et al. 2006



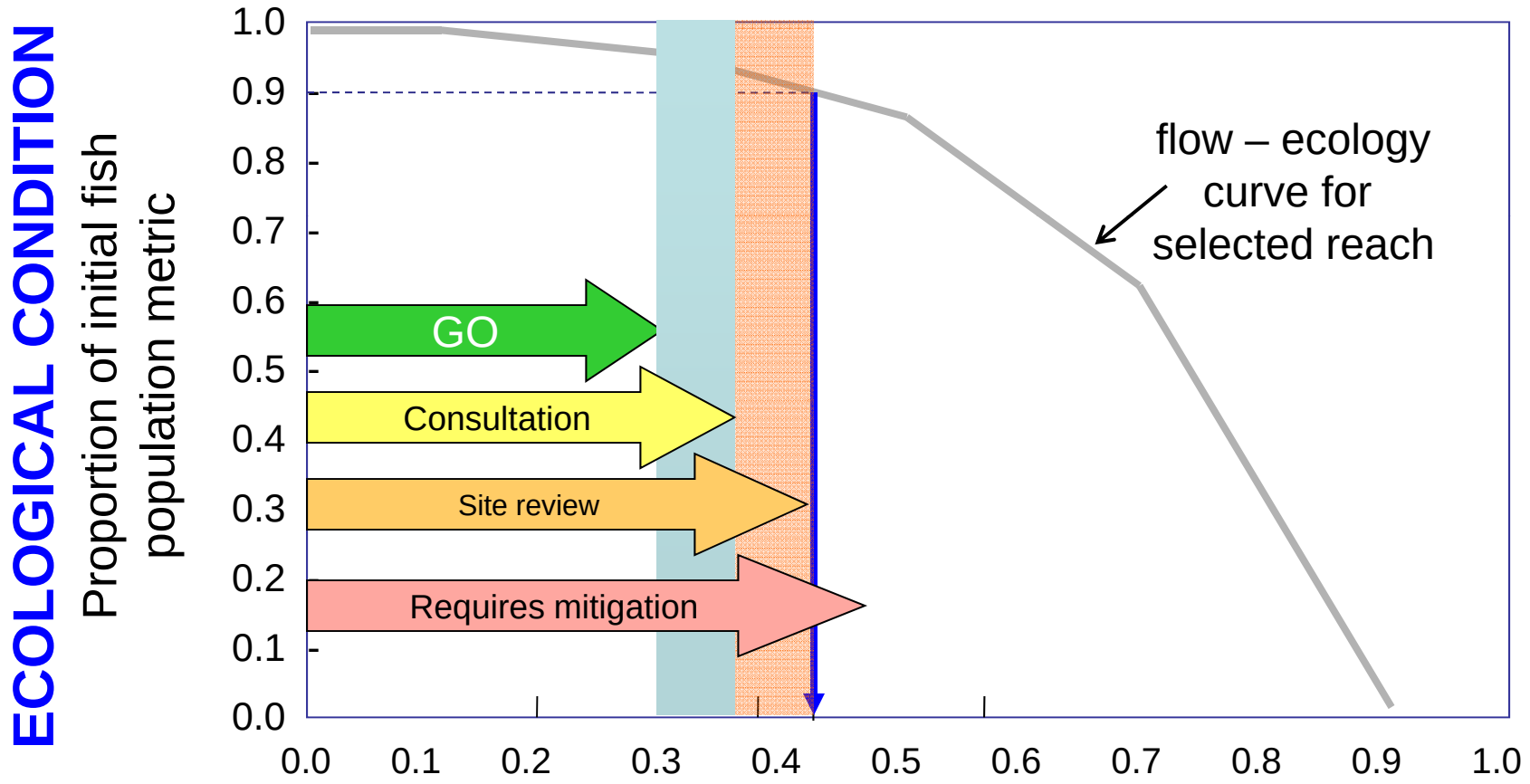
Michigan: Flow-Ecology Response Curves



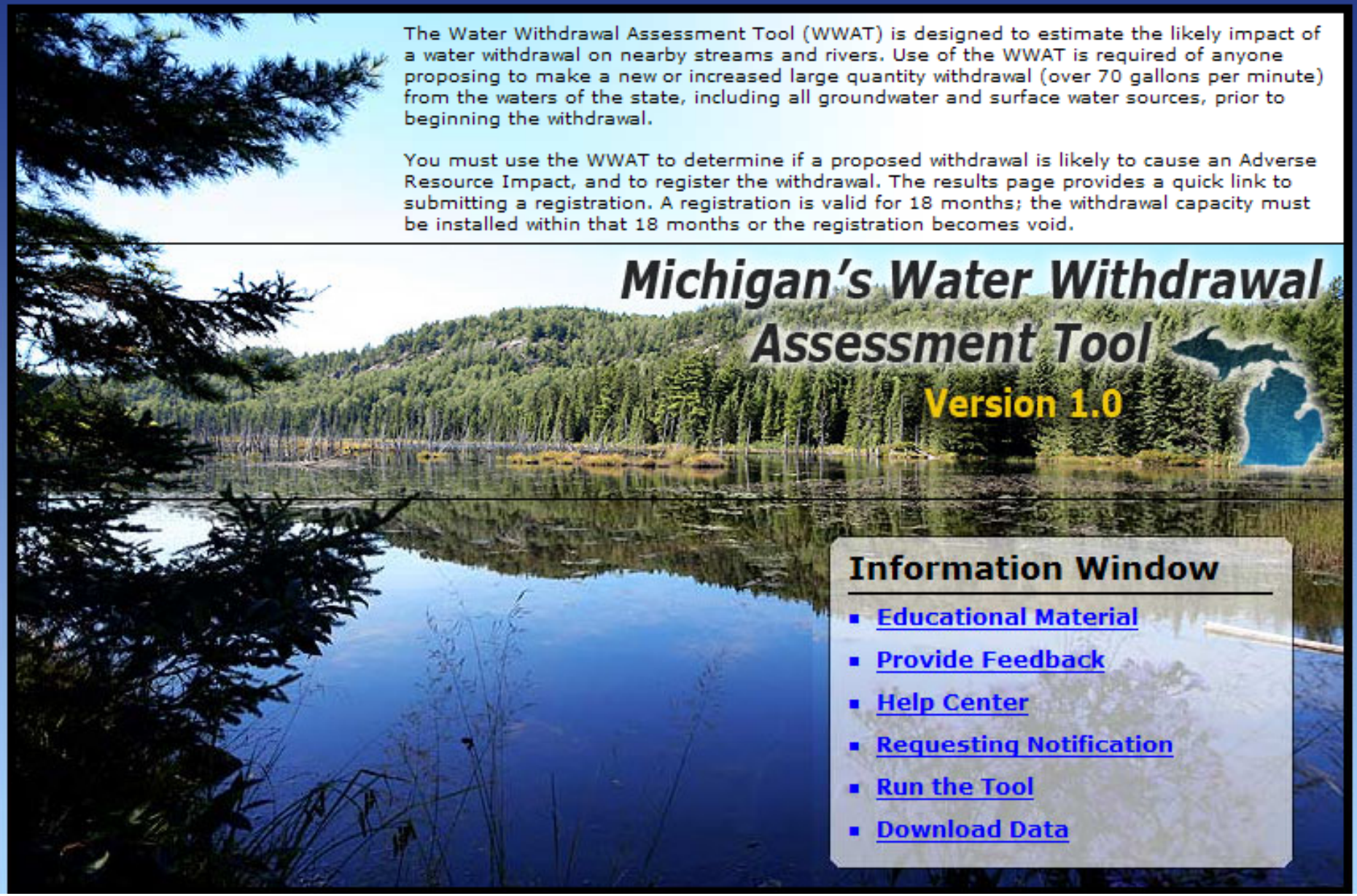
Zorn et al., 2008

Michigan: Example Flow-Ecology Relationship

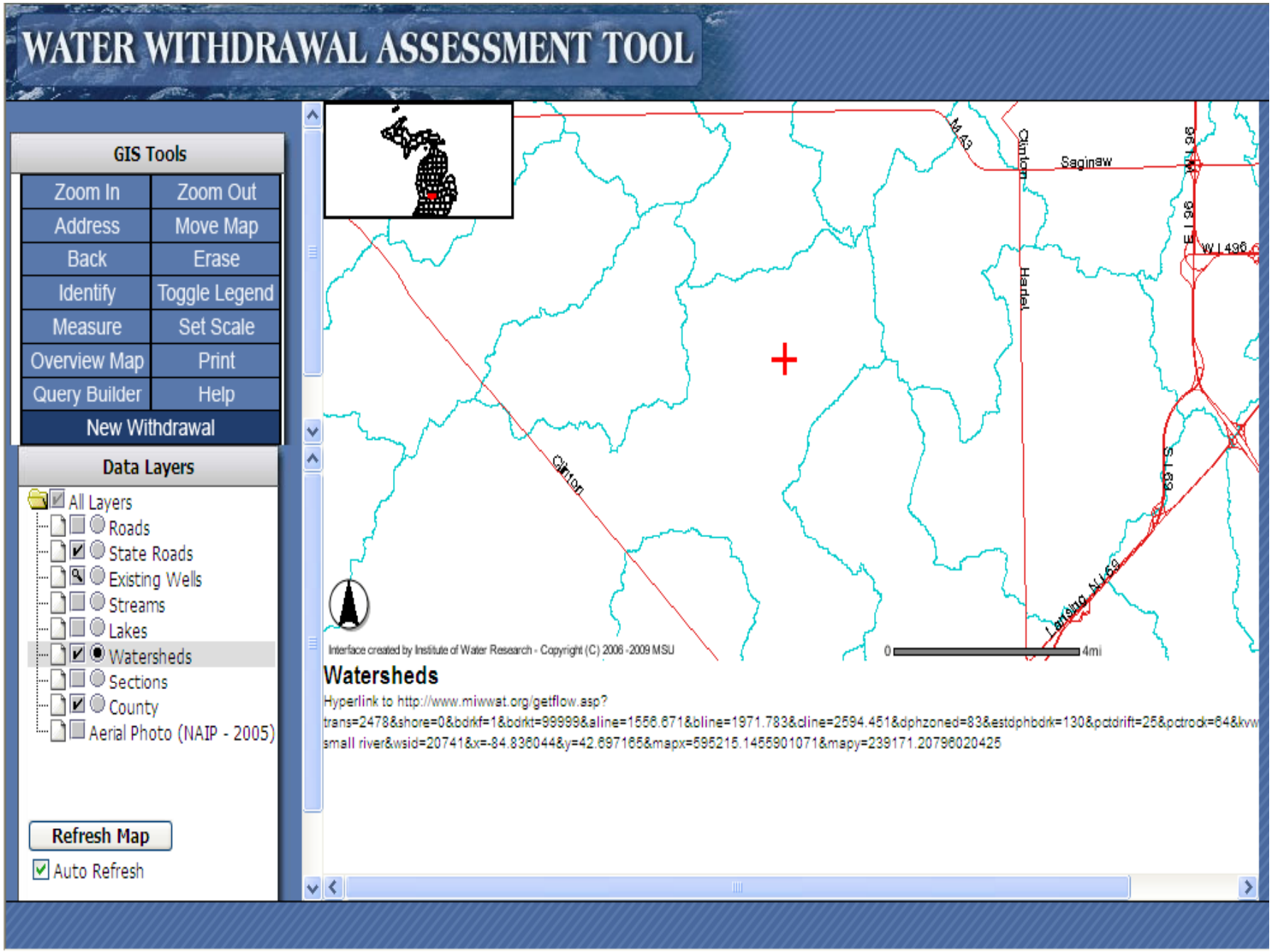
Limits: 10% change in the fish metric and 44% flow depletion



…water withdrawal management



WATER WITHDRAWAL ASSESSMENT TOOL

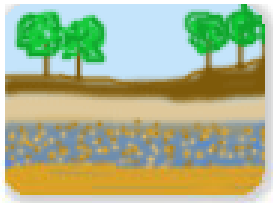


ENTER WITHDRAWAL INFORMATION

Pumping Source and Frequency

Withdrawal Source:

○ Surface Water (from stream)



◉ Ground Water

○ Shallow Pond

Pumping Frequency: ◉ Continuous ○ Intermittent

Pumping Parameters

Pumping Capacity (GPM): 70

Coordinates (X,Y): -84.84137 , 42.683384

Well Depth (FT): 25-50 ft

Aquifer Type: ○ Bedrock ◉ Glacial

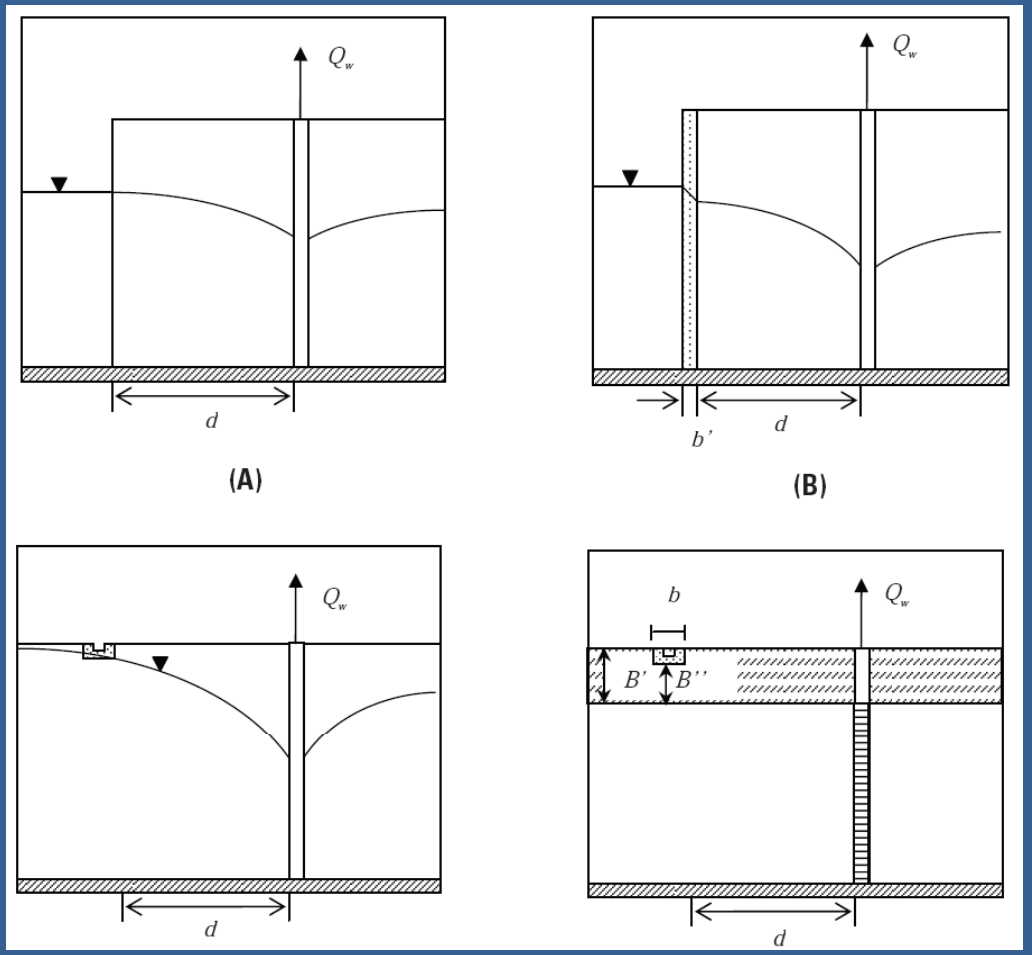
Current Stats at Location

- Depth to Bedrock (FT): 130
- Average Well Depth (FT): 83
- Percent Wells in Glacial: 25
- Percent Wells in Bedrock: 64

Send to Model

Michigan: Application of STRMDEPL

* Analytical
* Accounts for Pumping Delay
* Streambed Resistance
* Partial Penetration
* Leaky Confining Unit

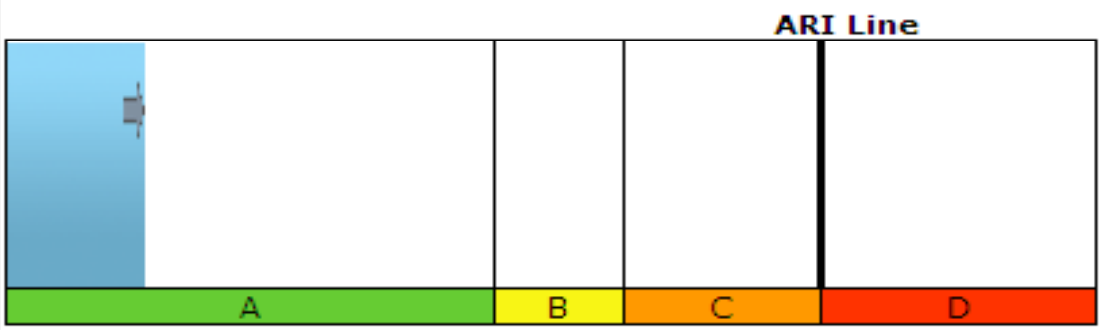


(Hunt, 1999 and 2003; Barlow, 2000; Reeves, 2008)

Water Withdrawal Screening Results

WARNING: For evaluation purpose only.

Adverse Resource Impact (ARI) Graph



The ARI graph above illustrates the estimated removal of water from a nearby stream and its potential for causing an adverse resource impact (ARI).

The proposed withdrawal has passed in Zone A.

Screening Results - PASSED

STREAM CLASSIFICATION: Cool small river

TEST VERSION RESULTS:
The proposed withdrawal would pass the screening process. The projected impact of the withdrawal lies within 'Zone A' and is not likely to cause an adverse resource impact.

REGISTRATION:
A Large quantity withdrawal (LQW) with a capacity of 70 gpm or greater must be registered with the Michigan Department of Environmental Quality or with the Michigan Department of Agriculture if the LQW is for

Actions:

Help

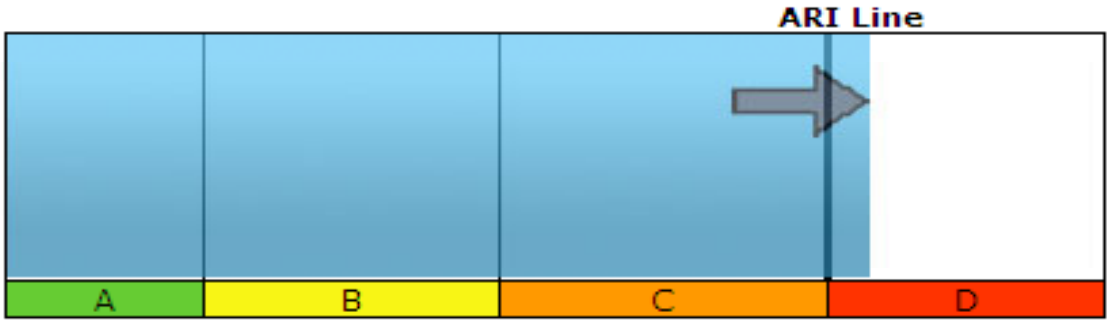
Rerun

Register Now

Feedback

Print Report

Adverse Resource Impact (ARI) Graph



The ARI graph above illustrates the estimated removal of water from a nearby stream and its potential for causing an adverse resource impact (ARI).

The proposed withdrawal is in Zone D, and is likely to have an adverse resource impact.

Screening Results - SITE SPECFIC REVIEW IS REQUIRED.

STREAM CLASSIFICATION: Cool stream

TEST VERSION RESULTS: The projected impact of the withdrawal lies within 'Zone D' and would likely cause an adverse resource impact. The withdrawal cannot be initiated without a site-specific review conducted by the Michigan Department of Environmental Quality. To pursue approval for the withdrawal as proposed, submit a request for a site-specific review through the button at the right.

MODIFYING A PROPOSED WITHDRAWAL:
Changing certain characteristics of the proposed withdrawal may decrease the flow taken from nearby river systems, thereby lessening the likelihood of an adverse resource impact. The following withdrawal characteristics may be altered in the screening process to reduce the potential impact to nearby river systems:

- Reduce the pumping frequency
- Reduce the pumping capacity
- Increase the well depth
- Relocate the withdrawal farther from nearby river systems

Actions:

Help

Rerun

Site Specific Review

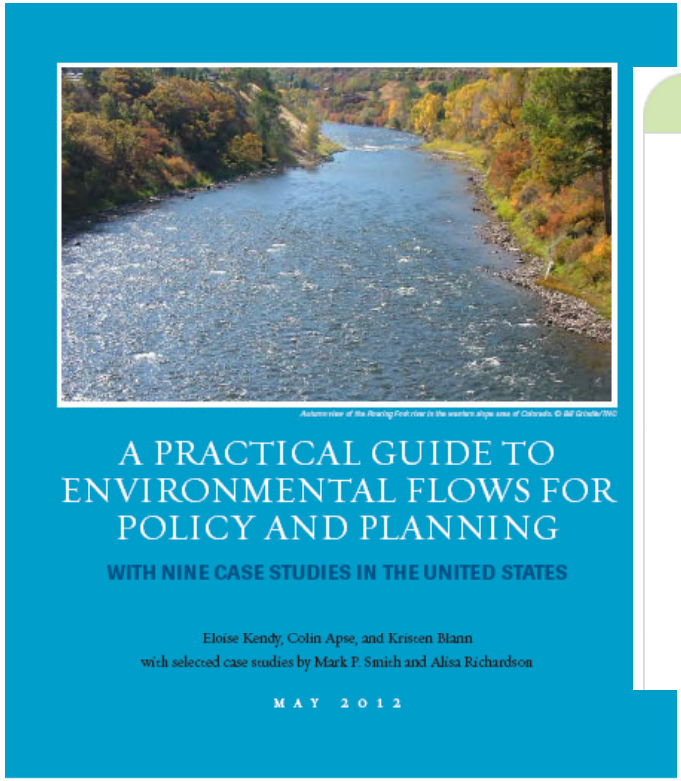
Feedback

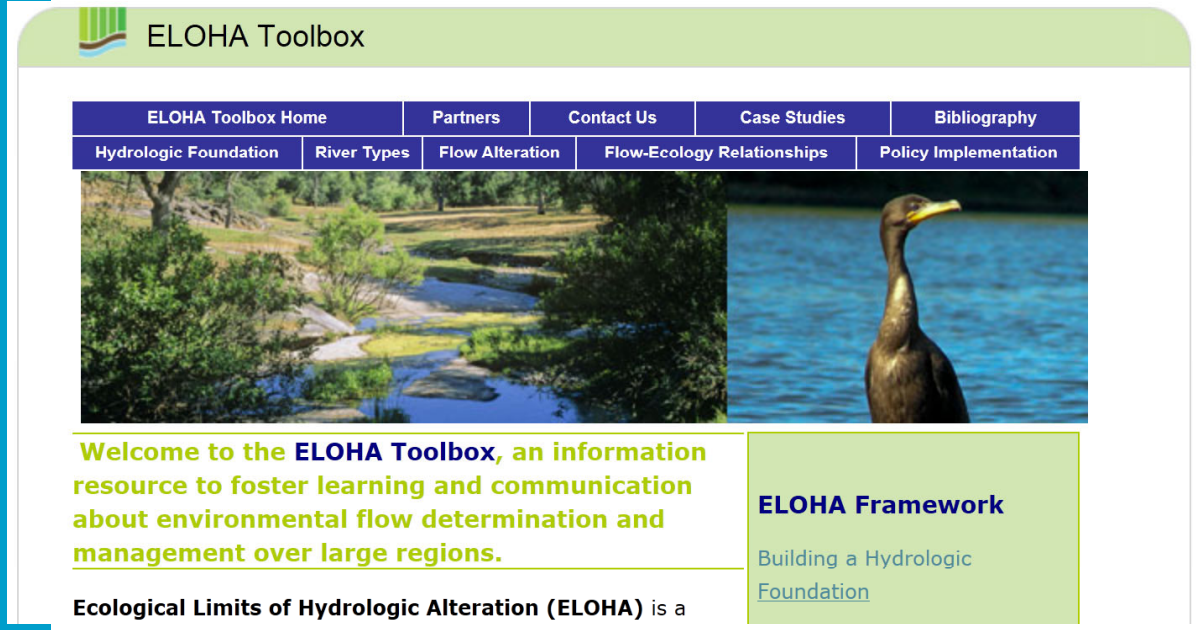
Print Report

Exit

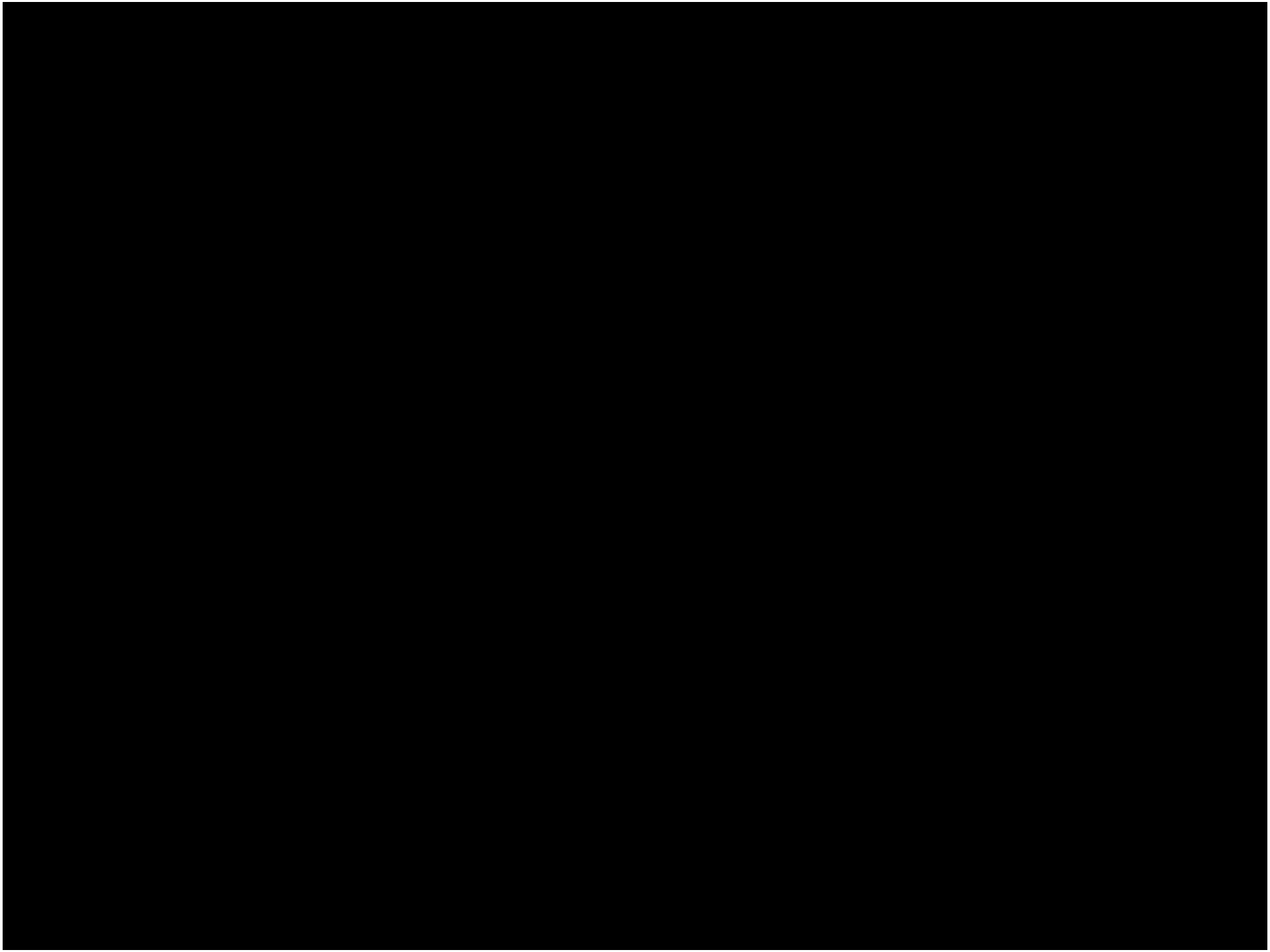
Summary

1. States and river authorities can optimize groundwater withdrawal permitting
2. ELOHA provides a framework for assessing and implementing environmental flows
3. Groundwater comes into the framework through:
    a. Estimating stream flows at ungauged sites
    b. Predicting stream flow depletion
4. Large-scale, regional watershed-based models and integrated water budgets can help address these needs





http://conserveonline.org/workspaces/eloha



Hydrological Basis

Biological data often do not have corresponding flow data

Generally, only certain classes of surface-water data will be available -

Records limited to altered conditions *– restoration targets?*

Monthly (not daily) flow series *– short duration events?*

Flow statistics based on regression *– careful calibration*

Longer-period daily data *– limited spatial distribution*

Accurate, spatially defined water-use data are essential