UNIVERSITY of GUELPH

ENGINEERING

Eflows: Underexplored Dimensions

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ENVIRONMENTAL FLOWS

- Non-stationarity
- Positioning Eflows
- Social dimensions
- Mechanistic flow-ecology
- Non-flow factors
- Other ecosystems
- Groundwater
- High flows
- Cold climate
- Risk - based

"Environmental flows describe the quantity, timing and quality of water flows required to sustain freshwater and estuarine ecosystems and the human livelihoods and well-being that depend upon these ecosystems."

(Brisbane Declaration, 2007)

Need to recognize that it is a changing world: climate, landscapes and social values.

DIFFERENT CONTEXTS

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➢*Environmental flow assessments take place in many different management contexts, at various spatial scales, within different biophysical systems, and in contrasting socioeconomic contexts and political settings. These settings and circumstances have a strong bearing on the methods most suited to achieving desired ecological outcomes. As many reviews of methods have noted, there is no single best approach to determining an environmental flow regime.*

Arthington, 2013

SOCIO–POLITICAL / SCIENCE INTERFACE

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- Policy makers in leading jurisdictions recognize that different objectives are appropriate for different rivers
- Deciding on the desired condition is a sociopolitical challenge
- The scientific challenges are to:
  - provide information to support the objective setting;
  - determine the water (and other) needs to achieve particular objectives;
  - and development management strategies to meet needs

COMMUNICATION / MESSAGES

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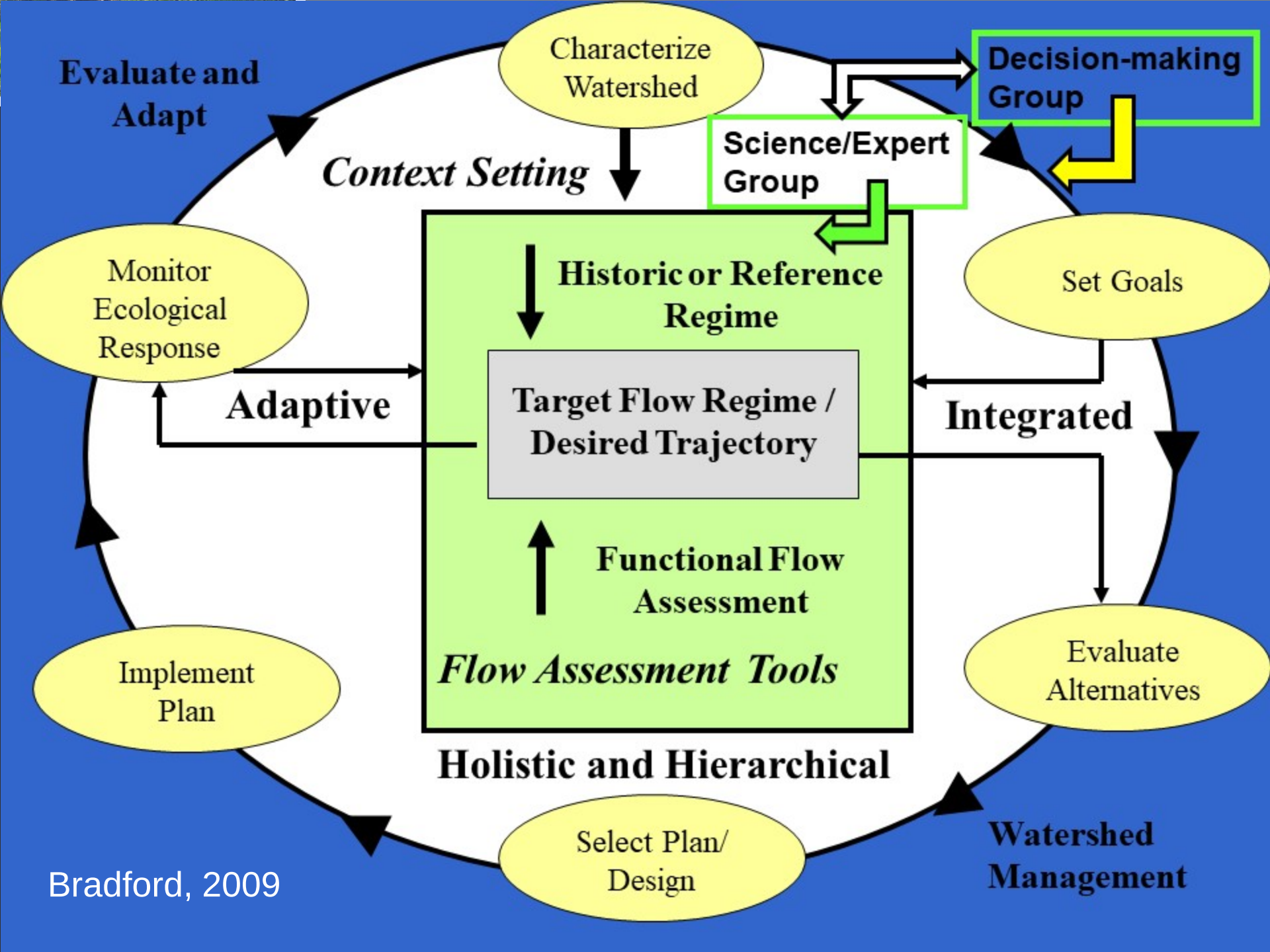
- The same (or similar) analyses can support users with different needs (i.e. real time operations vs short-term management such as low water response vs long-term water resources management and planning).
- Seasonally variable baseflows are a critical part of the target regime developed - a minimum flow limit is not a “target”
- Use language that targets what other groups understand – meet them on their own terms
- Can be considered within other existing frameworks, rather than yet another type of assessment that needs to be done.



Bradford, 2009

HOLISTIC EFLOW APPROACHES

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- Most methods now take a holistic systems approach to consider the hydrologic regime required for a wide range of functions and species
- Frameworks that integrate social dimensions are increasingly being recognized as important to the success of Eflow assessments
- Water needs for “cultural” objectives that better appreciate the complexity of human relationships with water (Jackson, 2017)

ENVIRONMENTAL FLOW APPROACHES

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- Eflows may be based on:
  - Limiting alterations from a reference regime;
  - Building up a regime based on water requirements of specific functions and species; OR
  - **Both** (recognizing strengths and limitations of each)
- Non-stationarity in climate and in ecological features means that reliance on “historic” reference regimes may not achieve desired outcomes
- Need to get onto restoration trajectory

FLOW - ECOLOGY RELATIONSHIPS

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- Understanding of flow-ecology relationships is needed regardless of the approach
- Ideally, process-based (mechanistic) understanding leading to development of dynamic ecosystem models
- Data and knowledge gaps will remain into the foreseeable future – conceptual frameworks (and structured expert judgment processes) can be used

MULTIPLE STRESSORS

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- We also know that there are other important factors – thermal regime (e.g. Olden and Naiman, 2010), sediment regime (e.g. Wohl et al., 2015), …
- Very important to understand where flow interventions are likely to achieve desired outcomes or where other restoration actions are needed

CONCEPTUAL FRAMEWORKS

Scale	Biotic and Human Needs (Functions)	Variables that limit function(s)	Flow-related processes governing variable	Non-flow related processes affecting variable	Flow regime (temporal aspects)
	Step 1	Step 2	Step 3	Step 4	Step 5

Zaghal, 2010

See Beaton and Bradford, 2013 for example application

Can consider range of scales and processes operating across scales which may define critical cause-response linkages

Consider flow response guilds
(e.g. Merritt et al. 2010 – riparian vegetation)

ECOLOGICAL WATER NEEDS

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- Starting to be extended from river flows to the “ecological water requirement” of other ecosystems like wetlands
- Increasing attention being given to the needs of groundwater dependent ecosystems
  - But how to express needs – flows, levels, gradients??

GROUNDWATER

- Groundwater dependent ecosystems may depend on the surface expression of groundwater OR the subsurface presence of groundwater (Eamus *et al.*, 2006)

Photo: Bradford

- Even where groundwater contributes a relatively small proportion of water inputs:
  - Timing of contribution may be critical
  - May be a critical source of chemical constituents

GROUNDWATER

- Consider vernal pool where hydroperiod (temporal pattern of surface inundation) important to amphibians

Jefferson Salamander Recovery Team. 2009.

- May be flow-through, with little net volumetric contribution from groundwater
- But, difficult to replicate water quality (and timing of drydown) without subsurface exchanges

GROUNDWATER

Near surface presence of groundwater can:

- influence surface runoff processes (saturated overland flow) and upland-wetland linkages
- influence distribution of inflows throughout a wetland

URBAN HYDROLOGIC ALTERATIONS

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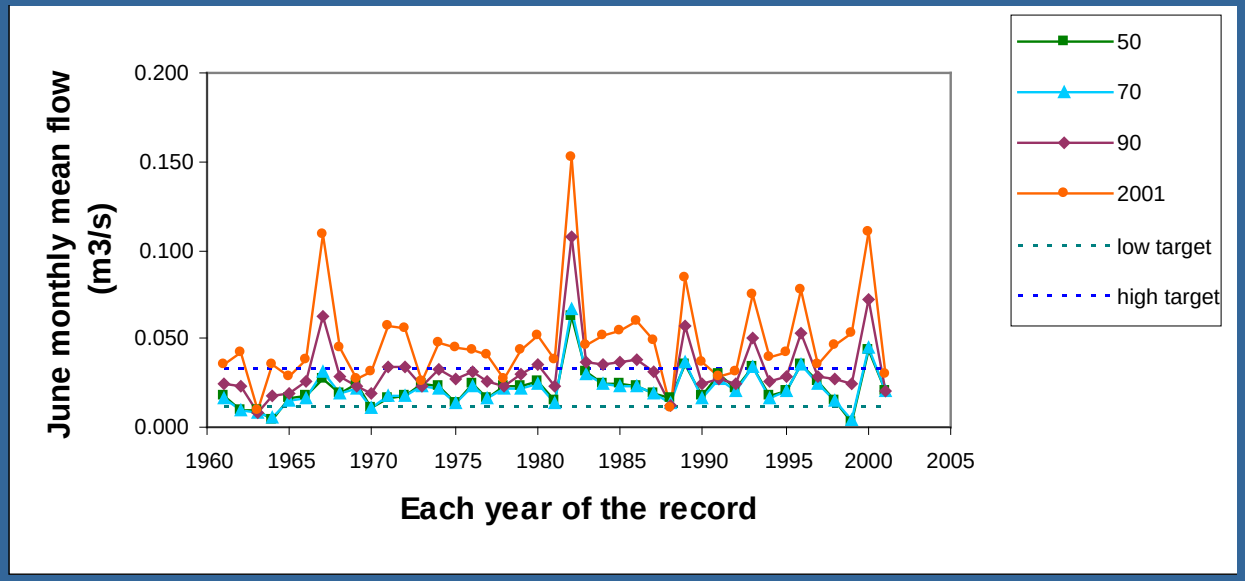
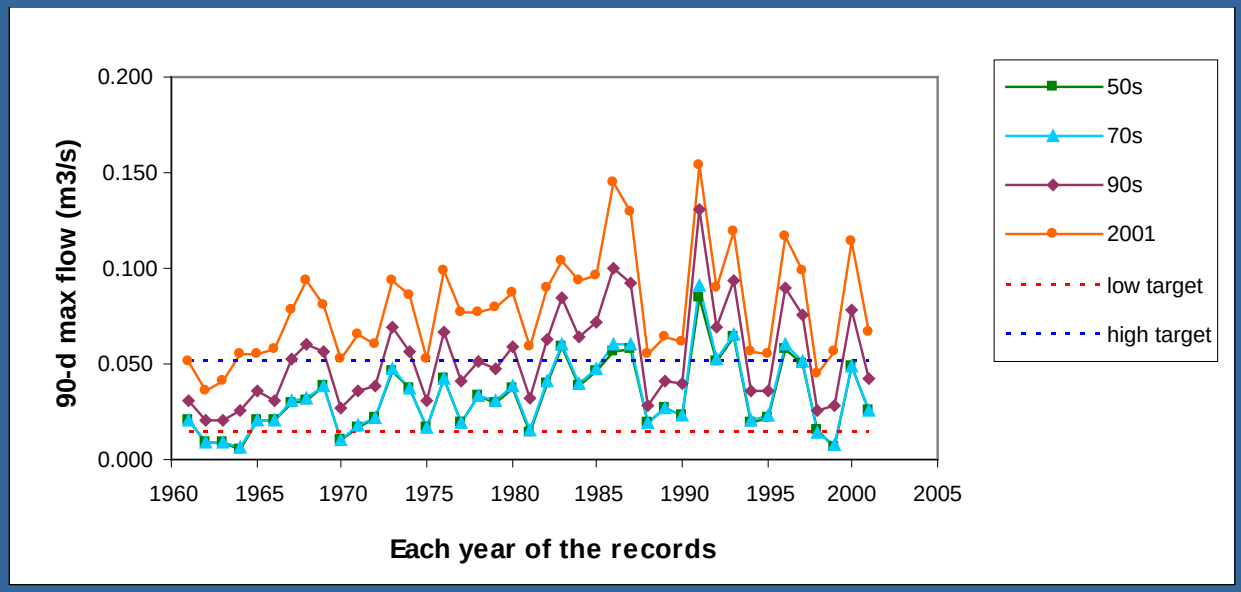
- Urbanization results in altered flow volume, pattern and quality
- Described as a new “class” of Eflow problem because it requires reduction of a large excess volume of water to maintain the ecological integrity of rivers (Walsh and others, 2012)
- Increasing flows evident from Indicators of Hydrologic Alterations

URBAN HYDROLOGIC ALTERATIONS





Bradford et al. 2007

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- Even baseflows may increase BUT geomorphic responses (e.g. loss of longitudinal connectivity) may result in poorer conditions under low flows
- Low impact development infiltration approaches are important to match pre-development infiltration volumes
- Less evapotranspiration still translates into excess runoff volume but this presents an opportunity for rainwater harvesting / use

COLD CLIMATE

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- The now well recognized suite of “Indicators of Hydrologic Alteration” (Richter et al. 1996) doesn’t capture ecologically-relevant hydrological characteristics unique to rivers in cold climates
- Peters and others (2014) recommend augmenting the established metrics with indicators such as:
  - Annual ice on/off dates
  - Ice-cover duration
  - Spring freshet initiation
  - Peak water level during ice break up

UNCERTAINTY

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- Long-term flow gauge data is scattered; even less data is available for non-flow variables
- Much remains to be learned about flow – ecology relationships
- Tools (e.g. models) have limitations
- Uncertainty should be acknowledged but it is not unique to complex ecological systems
- Risk-based approaches make sense to prioritize use of scarce resources

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