STREAM TIERED ASSESSMENT FRAMEWORK: MODEL

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EMRRP Webinar
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PRESENTATION OVERVIEW

- Introduction
- Tiered framework workflow
- Model for stream assessment
  - Goals
  - Methods
  - Findings
  - Structure
- Future research needs, summary, next steps

INTRODUCTION TO THE STREAM TIERED ASSESSMENT FRAMEWORK

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WHY ARE WE HERE: STREAM FUNCTIONS

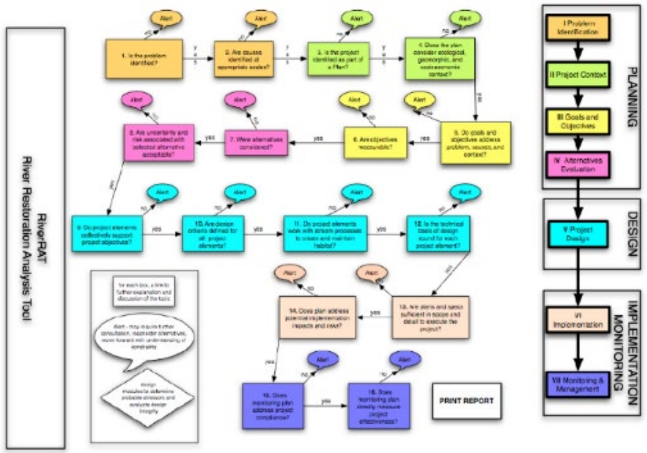
- Streams support biodiversity and regulate water quality
- Provide essential ecosystem services: flood control, nutrient cycling, food provision, recreation
- Stream assessments are vital for effective management, guiding management actions
- Our framework assesses these essential stream functions with a structured, tiered approach

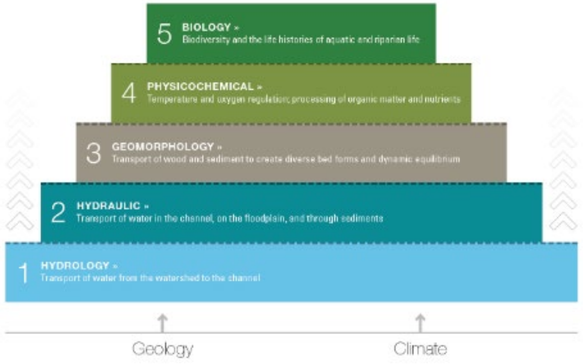
WHY ARE WE HERE: STREAM FUNCTIONS

- Anthropogenic disturbances (e.g., land use changes) affect ecosystem functions
- Assessments are needed for informed, sustainable management actions
- Existing assessments often focus on specific objectives and are limited in scope
- This creates a need for a more holistic framework

WHY ARE WE HERE: STREAM FUNCTIONS

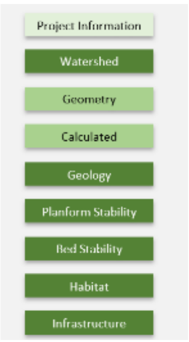
- Existing assessments and frameworks cumulatively cover diverse ranges of objectives, contexts, efforts
- Individual frameworks are limited and have loosely defined scope and objectives
- No framework offers a comprehensive or standardized approach to stream assessment
- Our goal: address this gap, allowing for more consistent evaluation





System Dynamics	Hydrologic Balance	Sediment Processes and Character	Biological Support	Chemical Processes and Pathways
Stream Evolution Processes	Surface Water Storage Processes	Sediment Continuity	Biological Communities and Processes	Water and Soil Quality
Energy Management	Surface / Subsurface Water Exchange	Substrate and Structural Processes	Necessary Habitats for all Life Cycles	Chemical Processes and Nutrient Cycles
Riparian Succession	Hydrodynamic Character	Quality and Quantity of Sediments	Trophic Structures and Processes	Landscape Pathways

Other assessments



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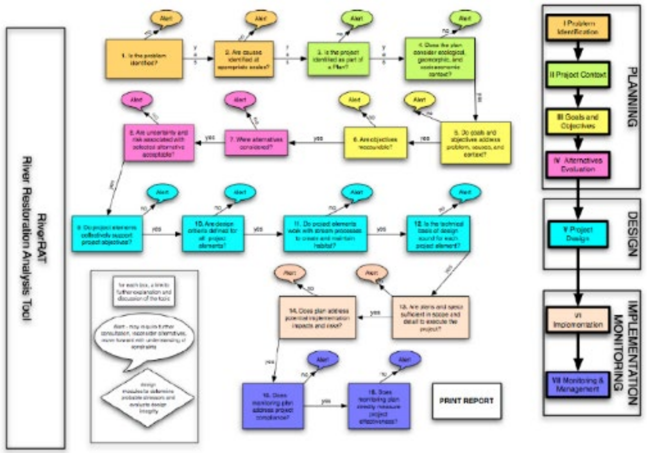

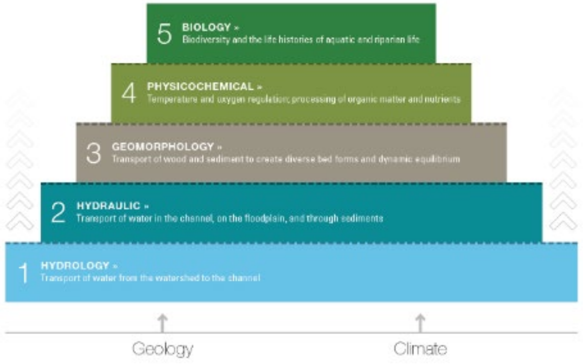

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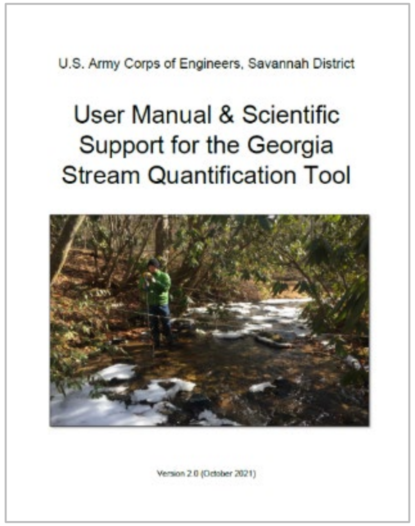
Riparian Succession	Hydrodynamic Character	Quality and Quantity of Sediments	Trophic Structures and Processes	Landscape Pathways

Other assessments

NEED FOR A STANDARDIZED ASSESSMENT APPROACH

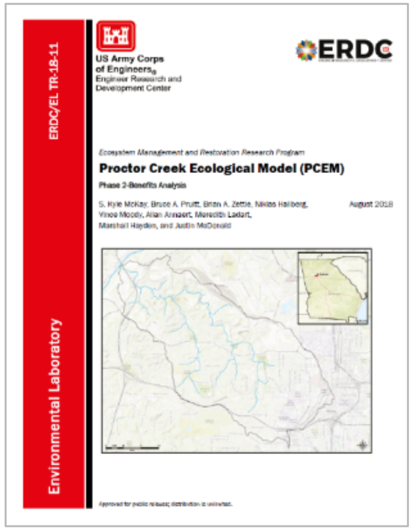
Utoy Creek, Atlanta, Georgia

Assessment Options


U.S. Army Corps of Engineers, Savannah District

User Manual & Scientific Support for the Georgia Stream Quantification Tool

Version 2.0 (October 2021)


ERDC/EL TR-18-11

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Ecosystem Management and Restoration Research Program

Proctor Creek Ecological Model (PCEM)

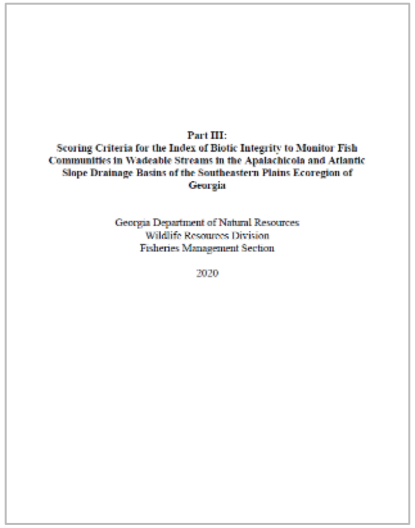
Phase 2-Benefits Analysis

S. Kyle McKay, Bruce A. Pruitt, Brian A. Zettle, Niklas Hallberg, Vince Moody, Allan Annaert, Meredith Ladart, Marshall Hayden, and Justin McDonald

August 2018

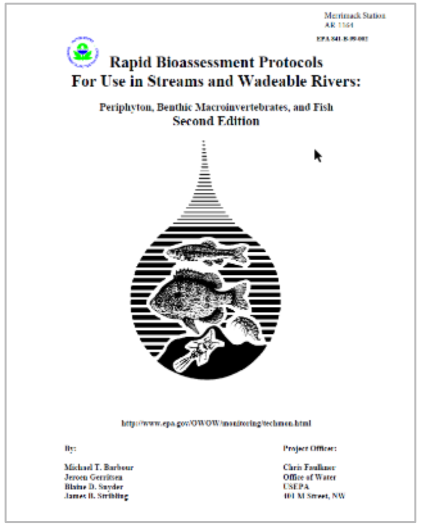
Environmental Laboratory

Approved for public release; distribution is unlimited.


Part III:
Scoring Criteria for the Index of Biotic Integrity to Monitor Fish Communities in Wadeable Streams in the Apalachicola and Atlantic Slope Drainage Basins of the Southeastern Plains Ecoregion of Georgia

Georgia Department of Natural Resources
Wildlife Resources Division
Fisheries Management Section

2020


Merrimack Station
AR 1164

Rapid Bioassessment Protocols For Use in Streams and Wadeable Rivers:

Periphyton, Benthic Macroinvertebrates, and Fish
Second Edition

http://www.epa.gov/OWOW/monitoring/techmon.html

By:
Michael T. Barbour
Jeroen Gerritsen
Blaine D. Snyder
James B. Stribling

Project Officer:
Chris Faulkner
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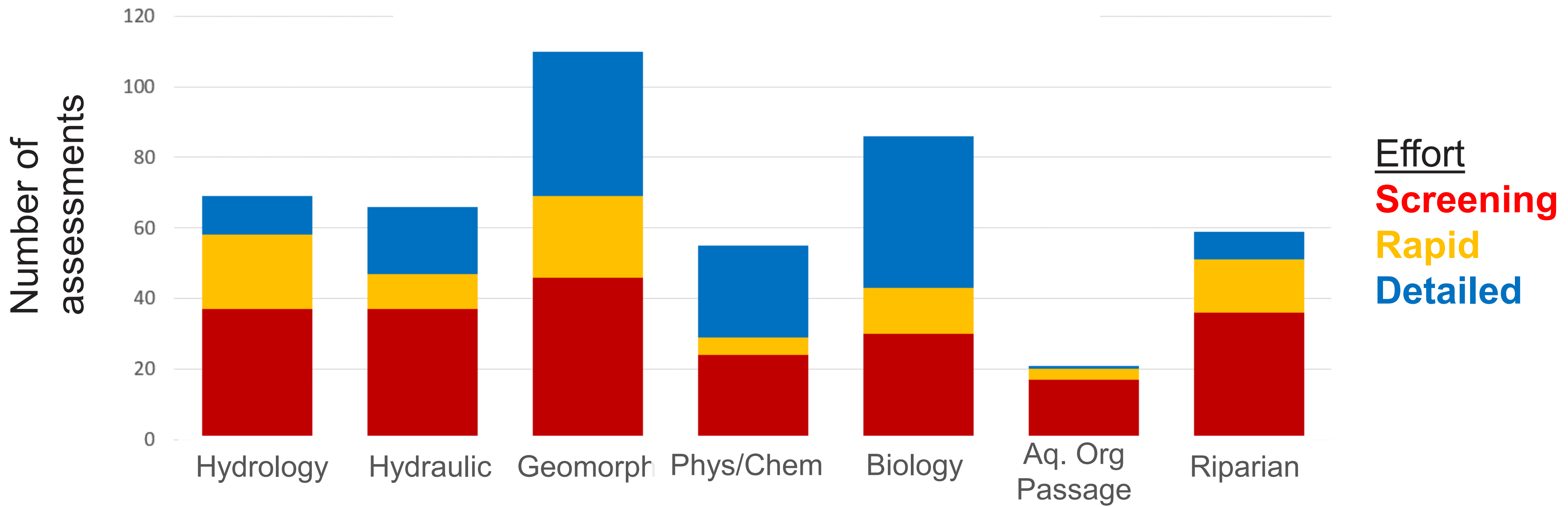
USEPA
401 M Street, NW

Assessment Wishlist:

1. Clear assessment selection guidance.
2. Comprehensive function evaluation.
3. Clarify any functional differences.
4. Address effort and confidence.
5. Facilitate comparison across different assessments.
6. Enhance flexibility and consistency.

CHALLENGES IN STREAM ASSESSMENTS

- **Hundreds** of assessment tools have been developed at local, state, and federal levels within both public and private sectors (Stepchinski et al., 2024)
  - Many assessments with many different focuses
  - No comprehensive function-based assessment
- How do you…
  - Find and select an assessment from the hundreds out there?
  - Compare results from different assessments?
  - Factor project considerations: details, effort, resources, and confidence into selection?



DIVIDE ASSESSMENTS BY LEVEL OF EFFORT

Screening Assessments

Rapid Assessments

Detailed Assessments

WORKFLOW

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Select Tier of Assessment

Consider project phase, goals, resources, desired effort and confidence

MODEL

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GOALS FOR THE MODEL

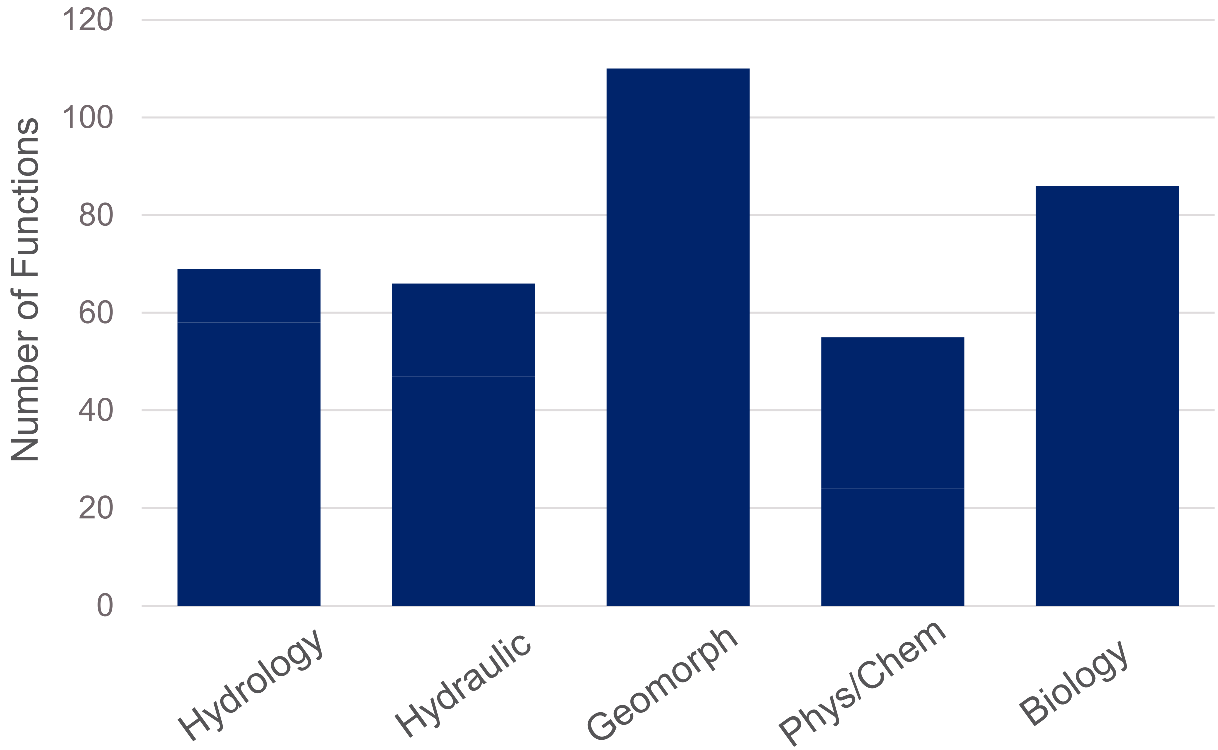
- A comprehensive, functions-based set of model variables that are applicable to a wide range of stream types and objectives
- Model structure that provides (1) clear communication of functions and (2) scoring system condition and rolling up scores
- Model can be used for any tier (level of effort) assessment

MODEL DEVELOPMENT PROCESS

- **Review of Conceptual Frameworks**
  - Common frameworks for assessing streams
  - Over 190 quantitative tools for restoration (Stepchinski et al. 2024)
- **Identification of Functional Outcomes**
  - Organize functions around:
    - Stream functions pyramid (Harman et al. 2012)
    - Goals of the Clean Water Act
  - Two main model categories:
    - Functions-based models: Evaluate ecological functions and processes
    - Physical habitat-based models: Focus on structural characteristics for habitats
- **Selecting Model Functions**
  - Identify similarities and differences for assessing functions between resources
  - Remove overlap and redundancies
  - Exclude overly general or specific functions for broader applicability

KEY FINDINGS

- **Lack of Consensus on Stream Functions**
  - No function is universally represented in assessments.
- **Geomorphic and biological assessment methods dominate**
  - Most assessments contain these, and many contain only these metrics.
  - Comparatively, water quality (phys/chem) are the least well represented
- **Limited Holistic Approaches**
  - Few assessments include more than four functional categories, indicating a lack of comprehensive views.



MODEL VARIABLES AND STRUCTURE

STREAM FUNCTIONS AND PROCESSES

- Qualitatively Comprehensive
- Methodologically Non-Prescriptive
- Flexible Metric Selection
- Non-Prescriptive Aggregation
- These are evaluated in our model

Function	Description
Catchment hydrology	Alters water quantity and quality via land uses.
Surface water storage	Attenuates upstream flows via natural and artificial features (e.g., wetlands).
Reach inflow	Addresses localized inputs from tributaries, ditches, and pipes.
Flow duration	Integrates the range of "typical" flows experienced by other processes.
Flow alteration	Examines the degree to which upstream infrastructure or land uses have fundamentally altered flow regimes (e.g., hydropeaking, dams, withdrawals).
Low flow dynamics	Ensures habitat availability and water quality during low water levels.
Baseflow dynamics	Indicates non-storm conditions experienced the majority of the time.
High flow dynamics	Influences erosion and channel maintenance during peak flows.
Floodplain connectivity	Enhances nutrient cycling and habitat availability via water exchange.
Hyporheic connectivity	Addresses surface-subsurface connections important for temperature regulation, nutrient dynamics, and food webs.
Channel evolution	Addresses legacy, ongoing, and anticipated change in channel form (i.e., dimension) and slope (i.e., profile) in response to flow and sediment inputs.
Lateral stability	Examines the role of bank processes and erosion in channel change.
Planform change	Observes patterns in sinuosity and curvature affecting habitat complexity.
Sediment continuity	Maintains channel morphology and habitats through sediment processes.
Large wood	Enhances habitat complexity and streambank stability.
Bed composition	Supports aquatic habitats through streambed material and bedform dynamics.
Light and thermal regime	Regulates water chemistry, drives carbon sources and dynamics, and governs the breadth of niche space available for organisms.
Carbon processing	Dictates availability of energy sources and supports food webs with ties to pH, production, respiration, and overall system metabolism.
Nutrient cycling	Drives productivity and quality of waters based on nitrogen & phosphorous.
Water and soil quality	Indicates the fate and transport of contaminants and other focal constituents.
Habitat provision	Supports diverse niches for a range of life stages of aquatic & riparian taxa.
Population support	Provides for reproduction, survival, and movement of key taxa.
Community dynamics	Facilitates balanced assemblages composed of native taxa with minimal invasive species dominance and representation of keystone species, ecological engineers, and other functionally important taxa.
Watershed connectivity	Facilitates colonization dynamics and capacity to recover after disturbance.

MODEL STRUCTURE

Model Layer	Purpose	Associated Documentation
Ecosystem Condition	Analytical layer for scoring indices and decision-making	Ecosystem Ecology (Odum), Clean Water Act (CWA 1971), Stream Functions (Fischenich 2006)
Categories	Organization of functions, Communication Tool	Stream Functions Pyramid (Harman et al., 2012)
Variables	Variables representing key stream functions and processes	Stream Functions (Fischenich 2006)

CATEGORIES LAYER

VARIABLES LAYER

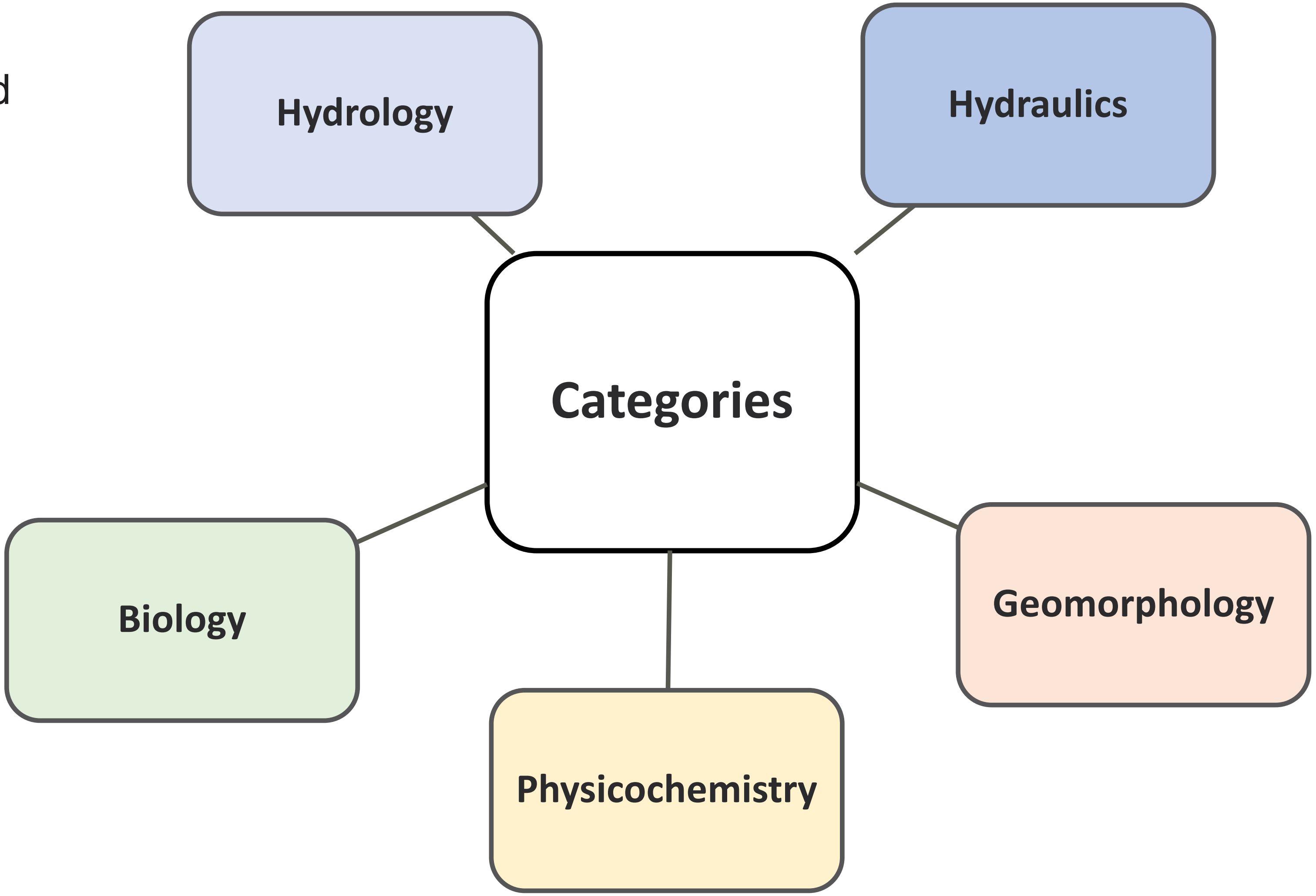
ECOSYSTEM CONDITION LAYER

Functional Category	Functional Variable	Score	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	Catchment hydrology		D	*i*	*i*
	Surface water storage		D	*i*	
	Reach inflow		D	*i*	
	Flow duration		D		*i*
	Flow alteration		D	*i*	*i*
Hydraulics	Low flow dynamics		D	*i*	*i*
	Baseflow dynamics		D	*i*	*i*
	High flow dynamics		D	D	
	Floodplain connectivity		*i*	D	D
	Hy		*i*	D	D
Geomorphology	Ch		D		
	Lat		D	*i*	
	Planform change		D		*i*
	Sediment continuity		D	D	*i*
	Large wood		*i*		D
	Bed composition		D		D
Physicochemistry	Light & thermal regime			D	*i*
	Carbon processing			*i*	D
	Nutrient cycling			D	*i*
	Water and soil quality			D	*i*
Biology	Habitat provision				D
	Population support			*i*	D
	Community dynamics			*i*	D
	Watershed connectivity		D		D
			Physical	Chemical	Biological
	Condition Sub-Index				
	Overall Ecosystem Condition Index				

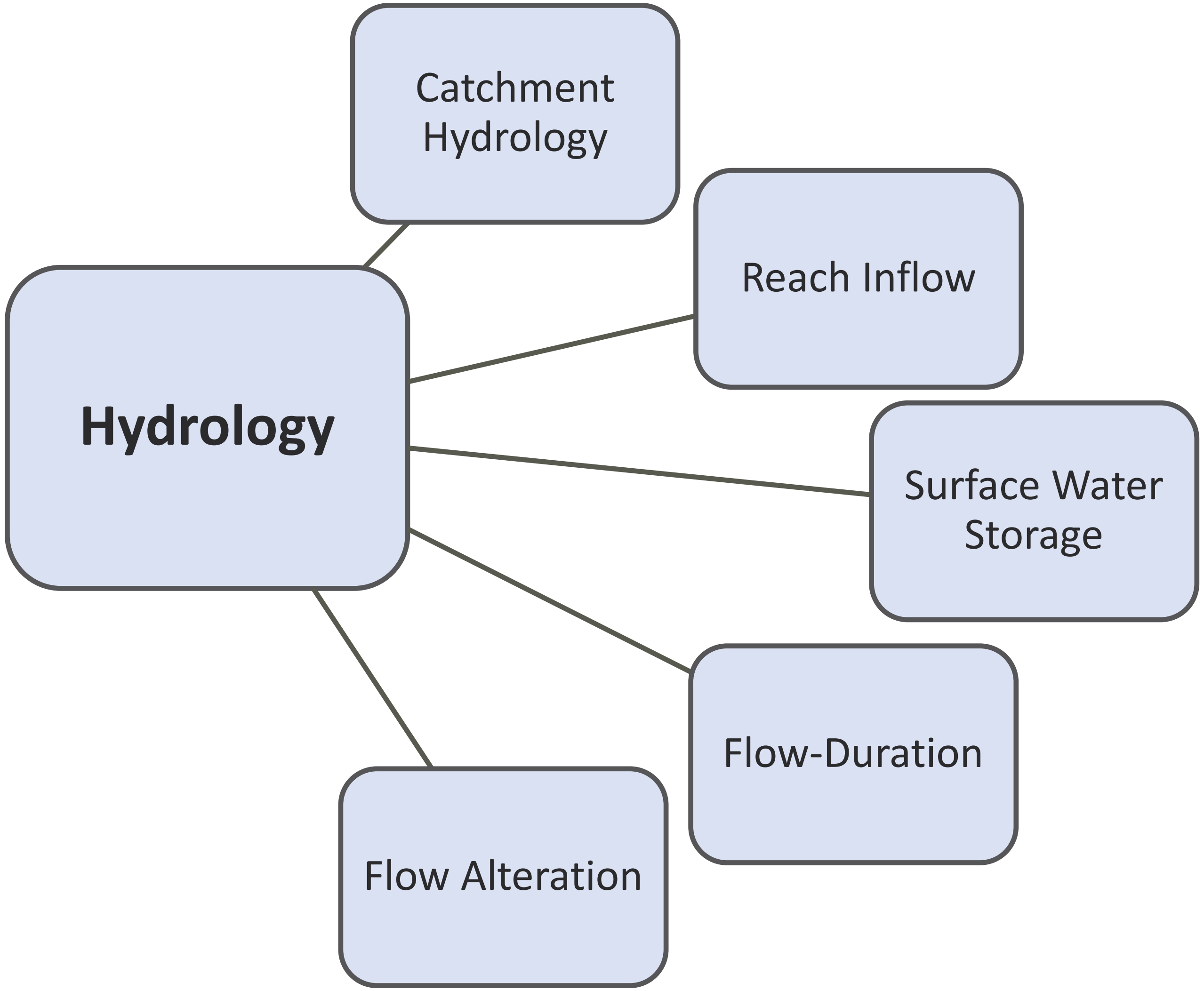
[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

MODEL CATEGORIES

- Track and organize stream functions and processes
- Communication Tool



MODEL VARIABLES



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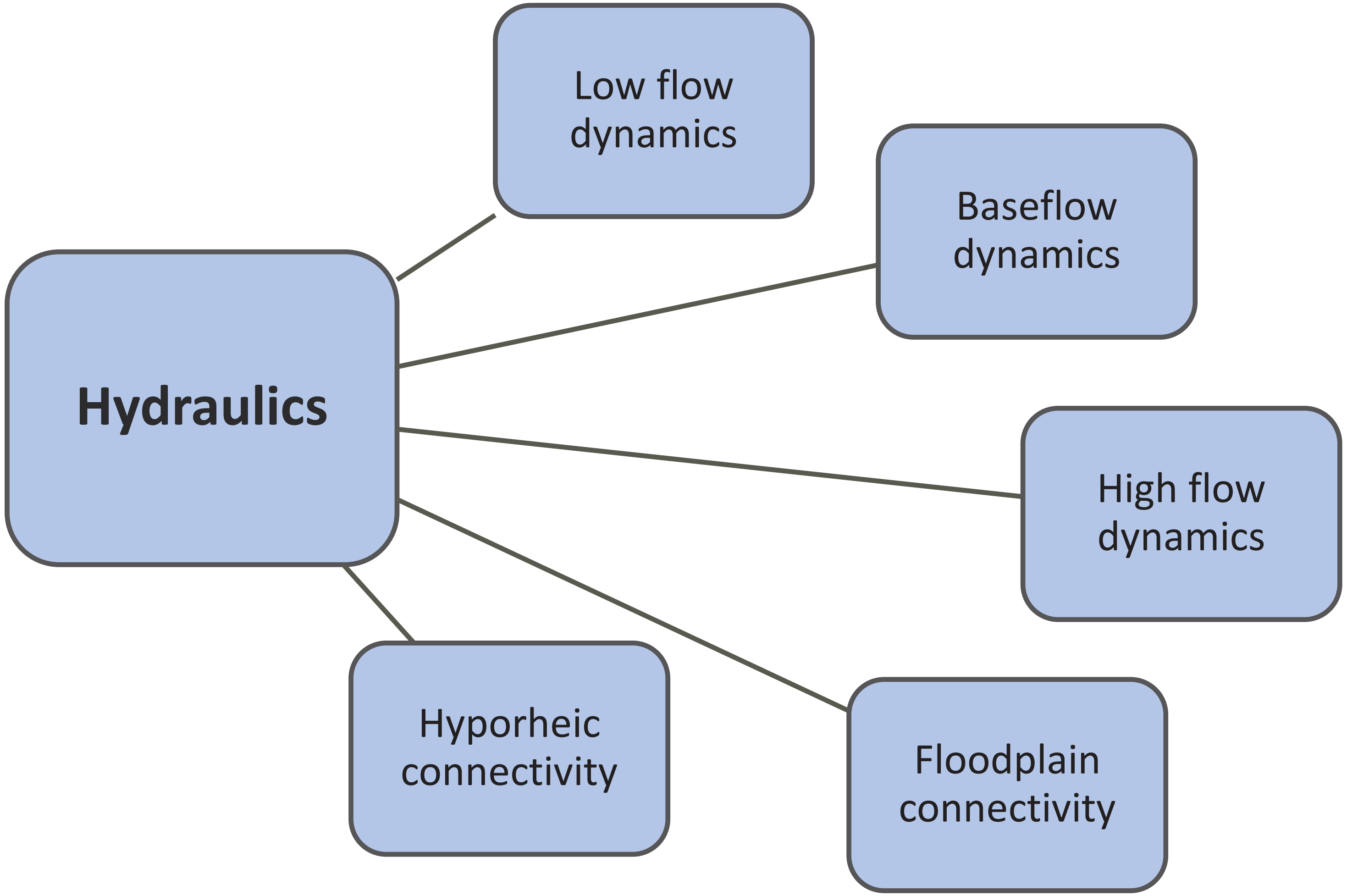

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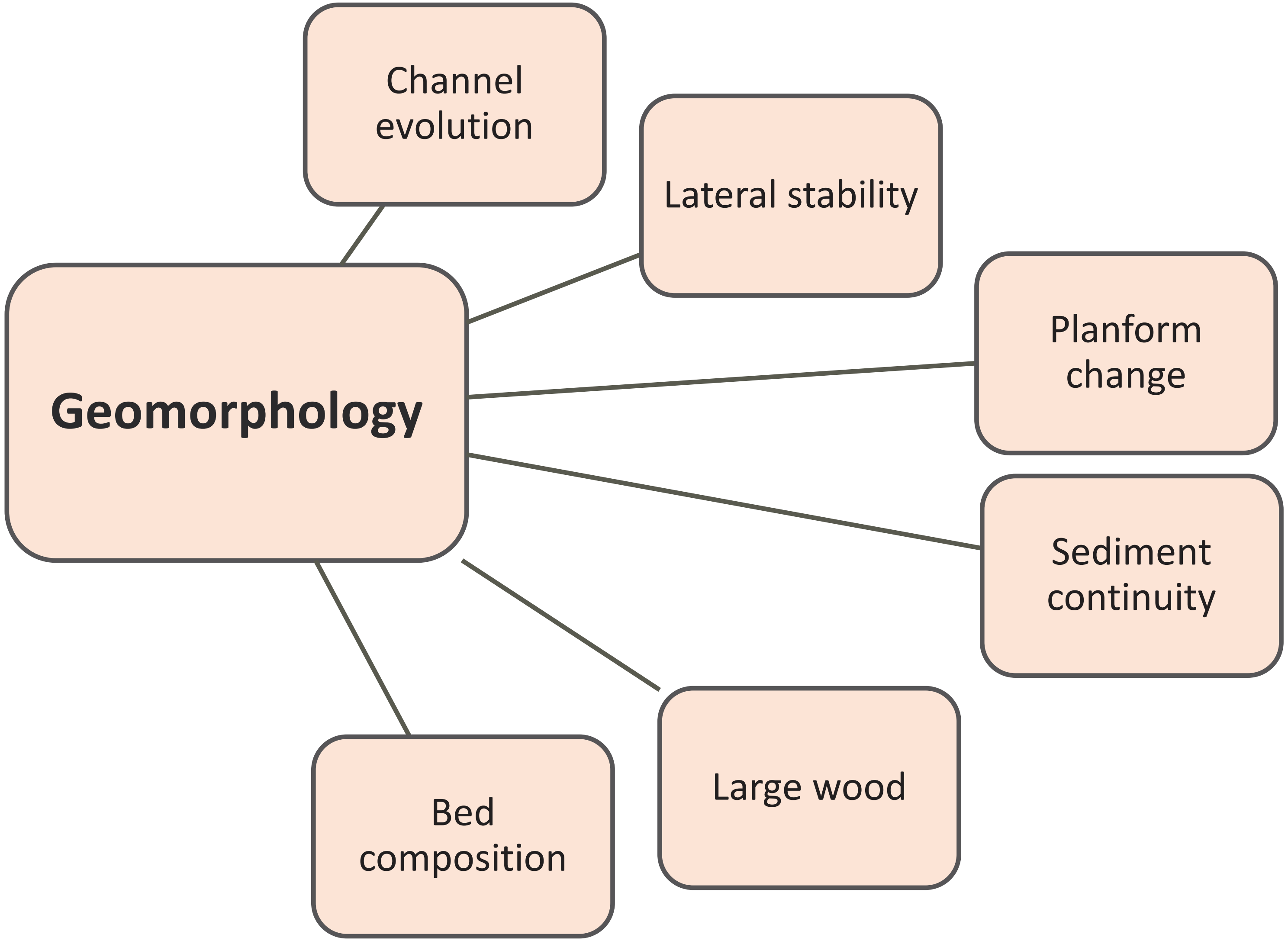

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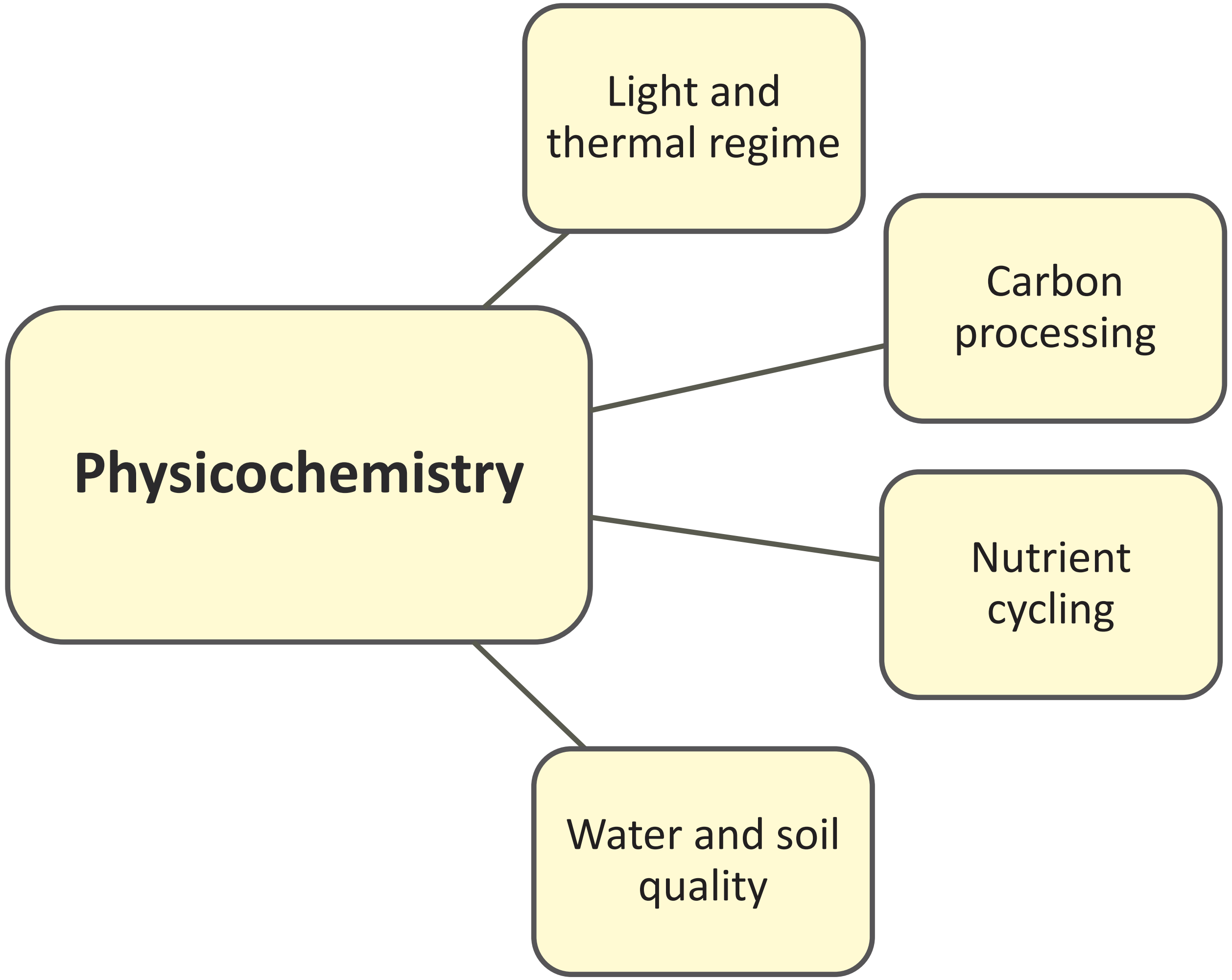
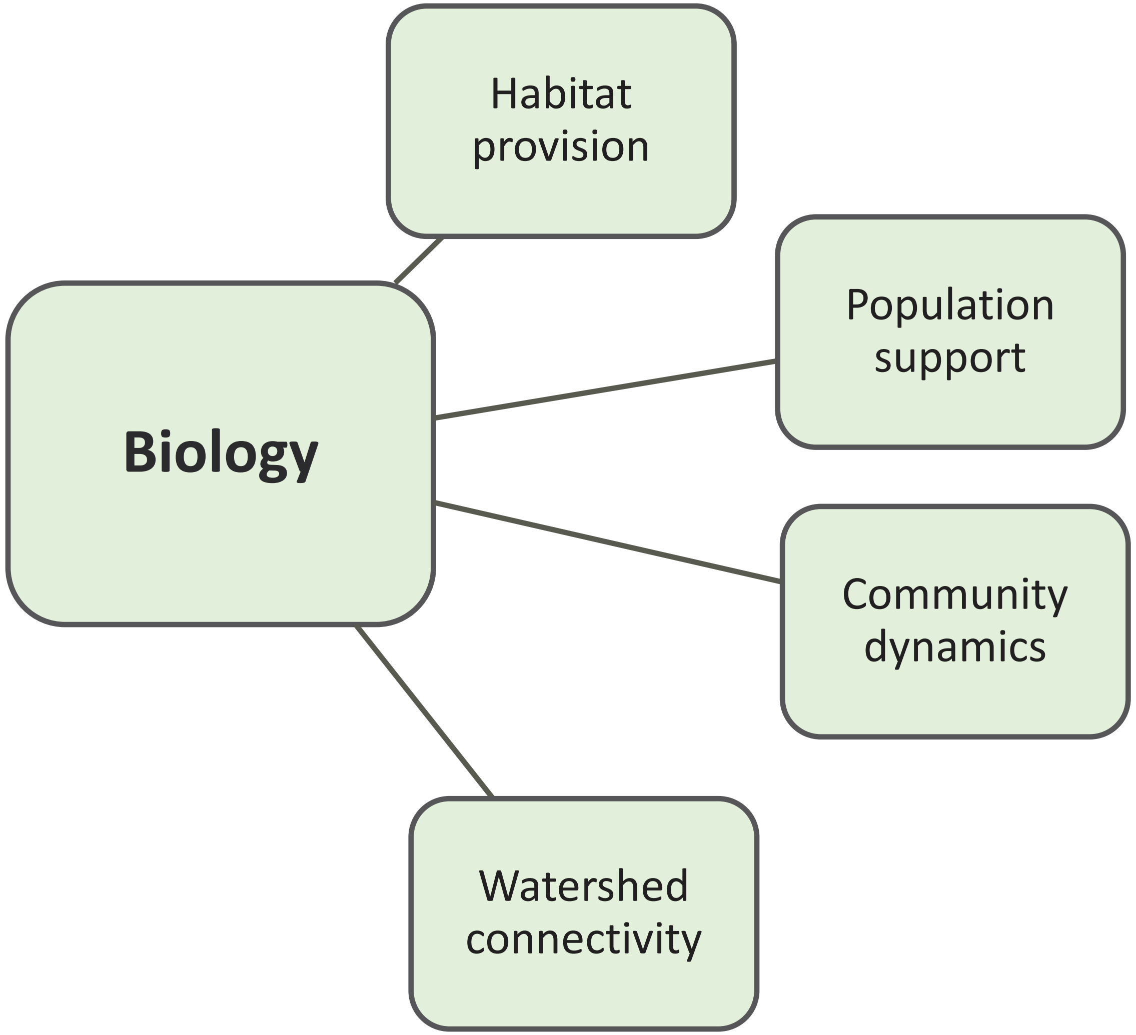


MODEL VARIABLES



DOWN-SELECTING VARIABLES

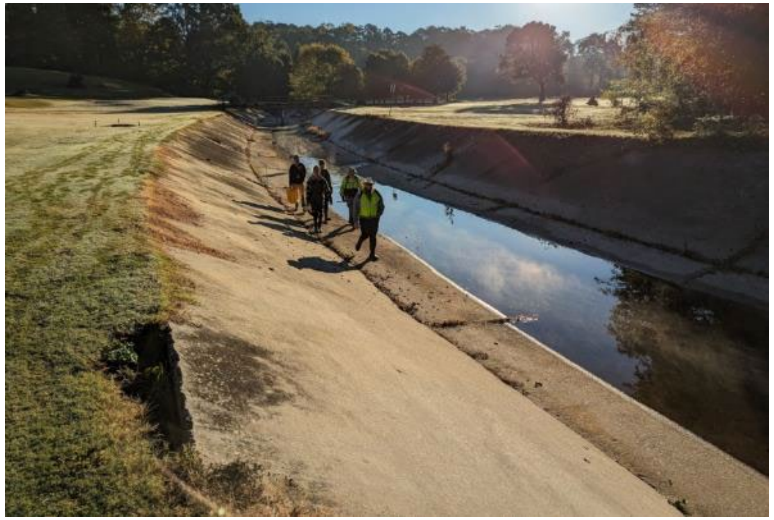
- **Variable Selection**
  - Use project objectives and site conditions
- **Recommendation**
  - Minimum of 10 variables (2 per category)
- **Benefits**
  - Ensures balanced representation across categories
  - Prevents single variable from skewing model outcomes

Functional Category	Functional Variable	Score
Hydrology	Catchment hydrology	
	Surface water storage	
	Reach inflow	
	Flow duration	
	Flow alteration	
Hydraulics	Low flow dynamics	
	Baseflow dynamics	
	High flow dynamics	
	Floodplain connectivity	
	Hyporheic connectivity	
Geomorphology	Channel evolution	
	Lateral stability	
	Planform change	
	Sediment continuity	
	Large wood	
	Bed composition	
Physicochemical	Light & thermal regime	
	Carbon processing	
	Nutrient cycling	
	Water and soil quality	
Biology	Habitat provision	
	Population support	
	Community dynamics	
	Watershed connectivity	
	Condition Sub-Index	
	Overall Ecosystem Condition Index	

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25

DOWN-SELECTING VARIABLES

Utoy Creek, Atlanta, Georgia



Functional Category	Functional Variable	Score (0-1.0)	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	~~Catchment hydrology~~		D	*i*	*i*
	~~Surface water storage~~		D	*i*	
	Reach inflow		D	*i*	
	Flow duration		D		*i*
	~~Flow alteration~~		D	*i*	*i*
Hydraulics	~~Low flow dynamics~~		D	*i*	*i*
	~~Baseflow dynamics~~		D	*i*	*i*
	High flow dynamics		D	D	
	Floodplain connectivity		*i*	D	D
	Hyporheic connectivity		*i*	D	D
Geomorphology	~~Channel evolution~~		D		
	~~Lateral stability~~		D	*i*	
	~~Planform change~~		D		*i*
	~~Sediment continuity~~		D	D	*i*
	Large wood		*i*		D
	Bed composition		D		D
Physicochemistry	Light & thermal regime			D	*i*
	Carbon processing			*i*	D
	~~Nutrient cycling~~			D	*i*
	~~Water and soil quality~~			D	*i*
Biology	Habitat provision				D
	Population support			*i*	D
	Community dynamics			*i*	D
	~~Watershed connectivity~~		D		D

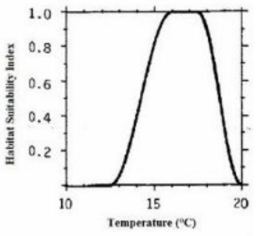
	Physical	Chemical	Biological
Condition Sub-Index			
Overall Ecosystem Condition Index			

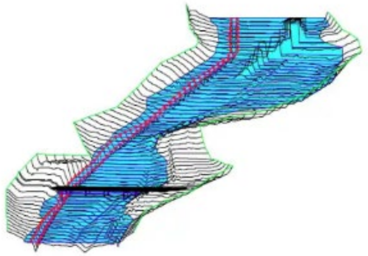
[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

HOW DO YOU EVALUATE THE VARIABLES?

- **Metrics, Methods, and Performance Criteria**
  - Metrics = Proxies for stream functions (i.e., variables)
  - Methods = Ways to measure metrics
  - Performance criteria = How to score the metric
  - Selected based on the Tier (level of effort)
- **Tier-Specific Toolboxes**
  - Helps identify suitable metrics, methods, and performance criteria from list of > 190 assessments
  - Tailored to level of effort and resources

PERFORM THE ASSESSMENT!





Aggregate scores

ECOSYSTEM CONDITIONS LAYER

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	Reach inflow		D	*i*	
	Flow duration		D		*i*
	Flow alteration		D	*i*	*i*
Hydraulics	Low flow dynamics		D	*i*	*i*
	Baseflow dynamics		D	*i*	*i*
	High flow dynamics		D	D	
	Floodplain connectivity		*i*	D	D
	Hyporheic connectivity		*i*	D	D
Geomorphology	Channel evolution		D		
	Lateral stability		D	*i*	
	Planform change		D		*i*
	Sediment continuity		D	D	*i*
	Large wood		*i*		D
	Bed composition		D		D
Physicochemistry	Light & thermal regime			D	*i*
	Carbon processing			*i*	D
	Nutrient cycling			D	*i*
	Water and soil quality			D	*i*
Biology	Habitat provision				D
	Population support			*i*	D
	Community dynamics			*i*	D
	Watershed connectivity		D		D
			Physical	Chemical	Biological
	Condition Sub-Index (0-1.0)				
	Overall Ecosystem Condition Index (0-1.0)				

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

SCORE AGGREGATION

Utoy Creek, Atlanta, Georgia

Functional Category	Functional Variable	Score (0-1.0)	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	~~Catchment hydrology~~		D	i	i
	~~Surface water storage~~			i	
	Reach inflow	0.40	D (0.40)	i (0.10)	
	Flow duration	0.20	D (0.20)		i (0.05)
	~~Flow alteration~~		D	i	i
Hydraulics	~~Low flow dynamics~~		D	i	i
	~~Baseflow dynamics~~		D	i	i
	High flow dynamics	0.40	D (0.40)	D (0.40)	
	Floodplain connectivity	0.27	i (0.07)	D (0.27)	D (0.27)
	Hyporheic connectivity	0.07	i (0.02)	D (0.07)	D (0.07)
Geomorphology	~~Channel evolution~~		D		
	~~Lateral stability~~		D	i	
	~~Planform change~~		D		i
	~~Sediment continuity~~		D	D	i
	Large wood	0.33	i (0.08)		D (0.33)
	Bed composition	0.27	D (0.27)		D (0.27)
Physicochemistry	Light & thermal regime	0.20		D (0.20)	i (0.05)
	Carbon processing	0.20		i (0.05)	D (0.20)
	~~Nutrient cycling~~			D	i
	~~Water and soil quality~~			D	i
Biology	Habitat provision	0.27			D (0.27)
	Population support	0.13		i (0.03)	D (0.13)
	Community dynamics	0.13			
	~~Watershed connectivity~~		D		D
			(1.44/4.75)	(1.15/5)	(1.77/8.5)
			Physical	Chemical	Biological
	Condition Sub-Index (0-1.0)		0.30	0.23	0.21
	Overall Ecosystem Condition Index (0-1.0)		0.25		

0.40 x 0.25 = 0.10

(4 x 1.0) + (3 x 0.25) = 4.75

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

DECISION MAKING

What do you use?

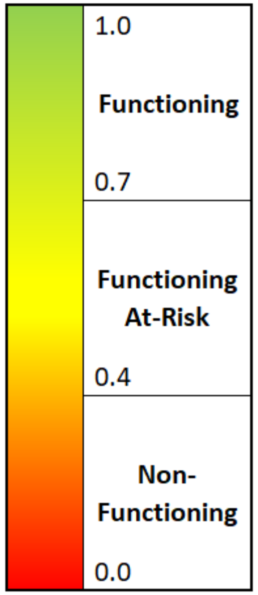
- Overall Ecosystem Condition Index
- Sub-indices: Physical, Chemical, Biological condition

Decisions will depend on project phase, objectives, and constraints

Possible use cases

- Restoration Planning Level Studies
- Refinement of existing regulatory tools
- As a design tool to support NBS

Functional Category	Functional Variable	Score (0-1.0)	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	~~Catchment hydrology~~		D	i	i
	~~Surface water storage~~		D	i	
	Reach inflow	0.40	D	i	
	Flow duration	0.20	D		i
	~~Flow alteration~~		D	i	i
Hydraulics	~~Low flow dynamics~~		D	i	i
	~~Baseflow dynamics~~		D	i	i
	High flow dynamics	0.40	D	D	
	Floodplain connectivity	0.27	i	D	D
	Hyporheic connectivity	0.07	i	D	D
Geomorphology	~~Channel evolution~~		D		
	~~Lateral stability~~		D		
	~~Planform change~~		D		
	~~Sediment continuity~~		D		
	Large wood	0.33	i		
	Bed composition	0.27	D		
Physicochemistry	Light & thermal regime	0.20			
	Carbon processing	0.20			
	~~Nutrient cycling~~				
	~~Water and soil quality~~				
Biology	Habitat provision	0.27			
	Population support	0.13			
	Community dynamics	0.13			
	~~Watershed connectivity~~		D		



	Physical	Chemical	Biological
Condition Sub-Index (0-1.0)	0.26	0.34	0.22
Overall Ecosystem Condition Index (0-1.0)	0.27		

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

SUMMARY, TAKEAWAYS, NEXT STEPS

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SUMMARY

How does this model meet assessment wishlist items?

- This standardized model can simplify assessment workflow
- Comprehensive function evaluation for a wide range of streams
- Flexibility in assessment methods used (Tiered Approach)
- This model structure is flexible yet consistent, so it can be applied and compared across different scales and projects (e.g. across a watershed or at a specific stream site)
- Potential use cases for refining existing regulatory tools and design support for NBS

NEXT STEPS…

- Develop a framework for sensitivity analysis on this adaptable model structure
- Applying, testing, and refining framework and model
- Manuscript preparation for peer-reviewed journal publication
- Presentation at American Geophysical Union conference & River Restoration Northwest conference

ACKNOWLEDGEMENTS

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- For information on EMRRP, please contact the program manager, Dr. Brook Herman (Brook.D.Herman@erdc.usace.army.mil), or consult https://emrrp.el.erdc.dren.mil/.

THANK YOU

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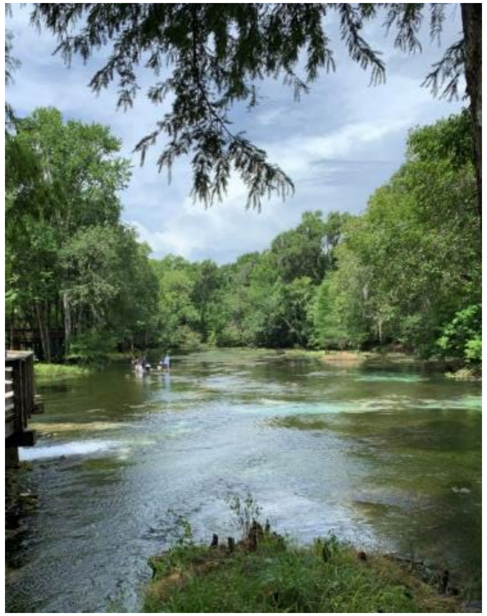
https://usace-wrises.github.io/RiverEngineeringResources/



EMRRP

https://emrrp.el.erdc.dren.mil/

DISCUSSION

1) Do the 24 proposed variables (functions) seem consistent across streams you have worked on?

Category	Function	Description
Hydrology	Catchment hydrology	Alters water quantity and quality via land uses.
	Surface water storage	Attenuates upstream flows via natural and artificial features (e.g., wetlands).
	Reach inflow	Addresses localized inputs from tributaries, ditches, and pipes.
	Flow duration	Integrates the range of “typical” flows experienced by other processes.
	Flow alteration	Examines the degree to which upstream infrastructure or land uses have fundamentally altered flow regimes (e.g., hydropeaking, dams, withdrawals).
Hydraulics	Low flow dynamics	Ensures habitat availability and water quality during low water levels.
	Baseflow dynamics	Indicates non-storm conditions experienced the majority of the time.
	High flow dynamics	Influences erosion and channel maintenance during peak flows.
	Floodplain connectivity	Enhances nutrient cycling and habitat availability via water exchange.
	Hyporheic connectivity	Addresses surface-subsurface connections important for temperature regulation, nutrient dynamics, and food webs.
Geomorphology	Channel evolution	Addresses legacy, ongoing, and anticipated change in channel form (i.e., dimension) and slope (i.e., profile) in response to flow and sediment inputs.
	Lateral stability	Examines the role of bank processes and erosion in channel change.
	Planform change	Observes patterns in sinuosity and curvature affecting habitat complexity.
	Sediment continuity	Maintains channel morphology and habitats through sediment processes.
	Large wood	Enhances habitat complexity and streambank stability.
	Bed composition	Supports aquatic habitats through streambed material and bedform dynamics.
Physicochemical	Light and thermal regime	Regulates water chemistry, drives carbon sources and dynamics, and governs the breadth of niche space available for organisms.
	Carbon processing	Dictates availability of energy sources and supports food webs with ties to pH, production, respiration, and overall system metabolism.
	Nutrient cycling	Drives productivity and quality of waters based on nitrogen & phosphorous.
	Water and soil quality	Indicates the fate and transport of contaminants and other focal constituents.
Biology	Habitat provision	Supports diverse niches for a range of life stages of aquatic & riparian taxa.
	Population support	Provides for reproduction, survival, and movement of key taxa.
	Community dynamics	Facilitates balanced assemblages composed of native taxa with minimal invasive species dominance and representation of keystone species, ecological engineers, and other functionally important taxa.
	Watershed connectivity	Facilitates colonization dynamics and capacity to recover after disturbance.

DISCUSSION

2. Is there a minimum number of variables that should be included in each sub-index (physical, chemical, biological)?

-E.g., 3 or more D or *i* per column?

3. Does a Clean Water Act framing resonate as an approach to aggregating indices?

-CWA aims to restore and maintain the chemical, physical, and biological integrity of the Nation's waters

Functional Category	Functional Variable	Score (0-1.0)	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	~~Catchment hydrology~~		D	*i*	*i*
	~~Surface water storage~~		D	*i*	
	Reach inflow	0.40	D (0.40)	*i* (0.10)	
	Flow duration	0.20	D (0.20)		*i* (0.05)
	~~Flow alteration~~		D	*i*	*i*
Hydraulics	~~Low flow dynamics~~		D	*i*	*i*
	~~Baseflow dynamics~~		D	*i*	*i*
	High flow dynamics	0.40	D (0.40)	D (0.40)	
	Floodplain connectivity	0.27	*i* (0.07)	D (0.27)	D (0.27)
	Hyporheic connectivity	0.07	*i* (0.02)	D (0.07)	D (0.07)
Geomorphology	~~Channel evolution~~		D		
	~~Lateral stability~~		D	*i*	
	~~Planform change~~		D		*i*
	~~Sediment continuity~~		D	D	*i*
	Large wood	0.33	*i* (0.08)		D (0.33)
	Bed composition	0.27	D (0.27)		D (0.27)
Physicochemistry	Light & thermal regime	0.20		D (0.20)	*i* (0.05)
	Carbon processing	0.20		*i* (0.05)	D (0.20)
	~~Nutrient cycling~~			D	*i*
	~~Water and soil quality~~			D	*i*
Biology	Habitat provision	0.27			D (0.27)
	Population support	0.13		*i* (0.03)	D (0.13)
	Community dynamics	0.13		*i* (0.03)	D (0.13)
	~~Watershed connectivity~~		D		D

	Physical	Chemical	Biological
	(1.44/4.75)	(1.15/5)	(1.77/8.5)
Condition Sub-Index (0-1.0)	0.30	0.23	0.21
Overall Ecosystem Condition Index (0-1.0)	0.25		

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)

DISCUSSION

4. Does a system, weighting direct and indirect outcomes, align or conflict with USACE modeling policy or practice? (vs. fixed values?)

Functional Category	Functional Variable	Score (0-1.0)	Physical Effect[1]	Chemical Effect[1]	Biological Effect[1]
Hydrology	~~Catchment hydrology~~		D	*i*	*i*
	~~Surface water storage~~		D	*i*	
	Reach inflow	0.40	D (0.40)	*i* (0.10)	
	Flow duration	0.20	D (0.20)		*i* (0.05)
	~~Flow alteration~~		D	*i*	*i*
Hydraulics	~~Low flow dynamics~~		D	*i*	*i*
	~~Baseflow dynamics~~		D	*i*	*i*
	High flow dynamics	0.40	D (0.40)	D (0.40)	
	Floodplain connectivity	0.27	*i* (0.07)	D (0.27)	D (0.27)
	Hyporheic connectivity	0.07	*i* (0.02)	D (0.07)	D (0.07)
Geomorphology	~~Channel evolution~~		D		
	~~Lateral stability~~		D	*i*	
	~~Planform change~~		D		*i*
	~~Sediment continuity~~		D	D	*i*
	Large wood	0.33	*i* (0.08)		D (0.33)
	Bed composition	0.27	D (0.27)		D (0.27)
Physicochemistry	Light & thermal regime	0.20		D (0.20)	*i* (0.05)
	Carbon processing	0.20		*i* (0.05)	D (0.20)
	~~Nutrient cycling~~			D	*i*
	~~Water and soil quality~~			D	*i*
Biology	Habitat provision	0.27			D (0.27)
	Population support	0.13		*i* (0.03)	D (0.13)
	Community dynamics	0.13		*i* (0.03)	D (0.13)
	~~Watershed connectivity~~		D		D
			(1.44/4.75)	(1.15/5)	(1.77/8.5)
			Physical	Chemical	Biological
	Condition Sub-Index (0-1.0)		0.30	0.23	0.21
	Overall Ecosystem Condition Index (0-1.0)		0.25		

[1]D=Direct effect on conditions (1.0 score weight), i = indirect effect on conditions (0.25 score weight)