APPLICABILITY OF STREAM QUANTIFICATION TOOLS FOR ASSESSING COMPENSATORY MITIGATION CREDITS FROM RESTORATION

Brian Murphy, PhD, PH, PE
Principal, River Works, Ltd.
Denver, Colorado

John Schwartz, PhD, PE
University of Tennessee, Knoxville
Professor, Dept. of Civil & Environmental Engineering
Director, Tennessee Water Resources Research Center

<u>ASCE EWRI Task Committee</u>: Natalie Collar (CO), Daniel Johnson (SC), John Ramirez Avila (MS), Chris Crose (SC), Karina Bynum (TN), Tess Thompson (VA)

Baltimore, Maryland
August 22, 2023

Development of Current SQT Framework

2004. USEPA/USACOE document *Physical Stream Assessment* for CWA Section 404. by Somerville and Pruitt survey protocols used by practitioners dominated by Rosgen restoration methods.

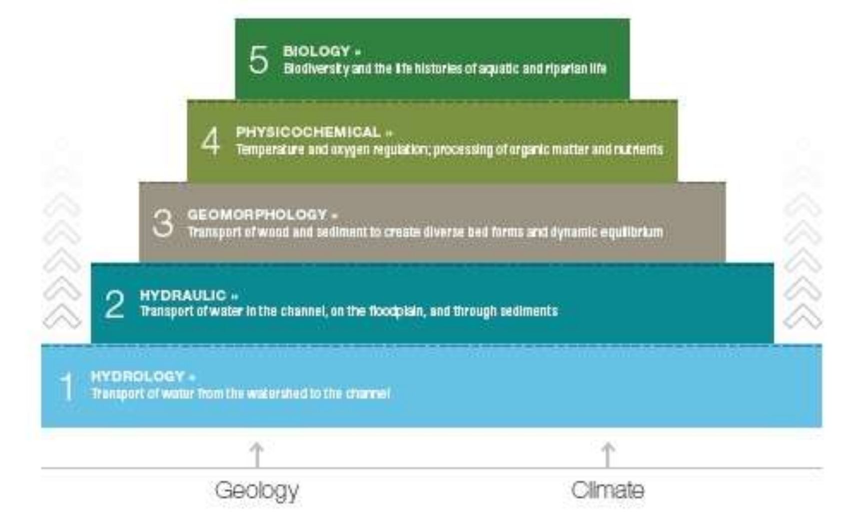
2006. USACOE ERDC TN-EMRRP SR-52 document on *Functional Objectives for Stream Restoration* by JC Fischenich published summarizing five primary functions, as follow (Table 1)….

Table 1. Summary of Primary Functions.

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

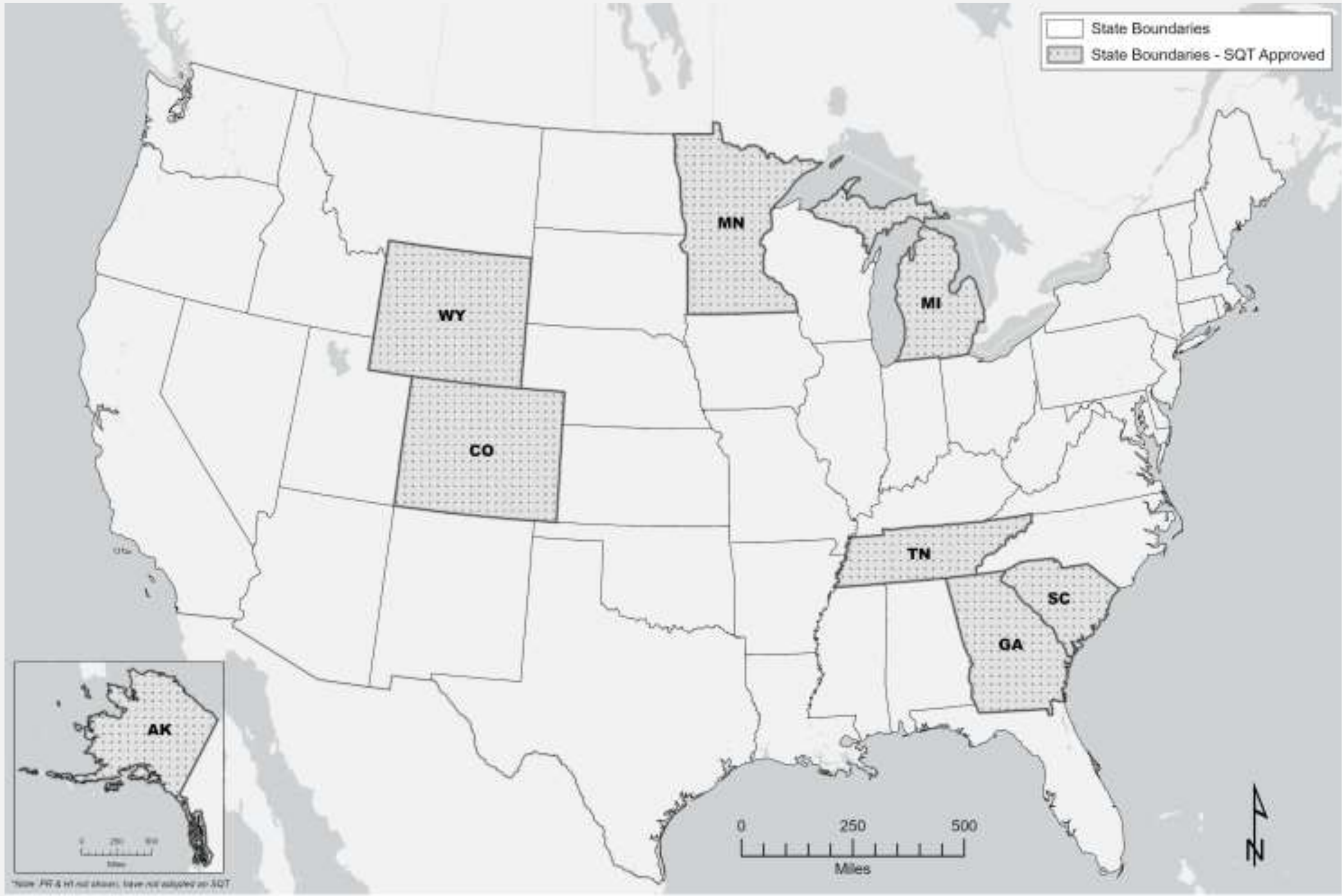
- System Dynamics
- Hydrologic Balance
- Sediment Processes & Character
- Biological Support
- Chemical Processes & Pathways

2012. USEPA/USFWS - EPA 843-K-12-006 *A Function-Based Framework for Stream Assessments and Restoration Projects* by Harman et al. published a pyramid-structured framework. Functional categories hierarchically and linearly organized for hydrology, hydraulics, geomorphology, physiochemical, and biology.



Current State SQTs:

Wyoming
Colorado
Georgia
Tennessee
Minnesota
Michigan
South Carolina
Alaska



Adoption of Stream Quantification Tools (SQT) by State
April 2023

FUNCTIONAL OBJECTIVES FOR STREAM RESTORATION

US Army Corps of Engineers

ERDC TN-EMRRP SR-52

September 2006

Five functional categories and 15 critical functions identified by U.S./International Committee.

- System Dynamics
- Hydrologic Balance
- Sediment Processes and Character
- Biological Support
- Chemical Processes and Pathways

Table 1. Summary of Primary Functions.

System Dynamics	Hydrologic Balance	Sediment Processes and Character	Biological Support	Chemical Processes and Pathways
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Functional Objectives for Stream Restoration

by J. Craig Fischenich[1]

September 2006

Complexity	Value as Planning Tool	Cost
Low Moderate High	Low Moderate High	Low Moderate High

OVERVIEW

The National Research Council (1996) defined restoration as "the return of the form and function of an ecosystem to its pre-disturbance condition…" This definition presents two challenges when working in today's environment.

First, the significant hydrological changes and infrastructure encroachments found in many watersheds often prevent the reestablishment of the stream form to a condition prior to disturbance. These streams have a new form consistent with the altered conditions, and may not be able to maintain functions associated with a pre-disturbance condition.

Second, while the general concept of "functions" can be grasped by most, the specific functions provided by streams and riparian corridors have yet to be defined in a manner that can serve as a basis for assessment, design, and management.

The recommendations presented in this document center on the recognition that the character of stream systems (and, thus, their value or potential to support certain uses) is a result of a set of dynamic and interrelated processes referred to as functions in this report. Fifteen critical functions were identified by a committee of U.S. and international scientists, engineers, and practitioners, and were synthesized into a framework for ecosystem evaluation.

Understanding the basic functions of streams and riparian corridors provides planners and designers with a concise and effective basis from which to evaluate proposed projects, and offers several powerful advantages over assessments that focus upon beneficial uses. Use of functions and processes can be elegantly incorporated within a systems approach, enhancing understanding, enabling predictions, and supporting management decisions.

This report presents the functional framework and discusses ways in which the framework can be applied to support the Corps' Ecosystem Restoration and Urban Flood Damage Reduction Programs.

Figure 1. Healthy streams and riparian zones support important functions, even if their form has been altered from historic conditions.

[1] USAE Research and Development Center, 3909 Halls Ferry Rd., Vicksburg, MS 39180

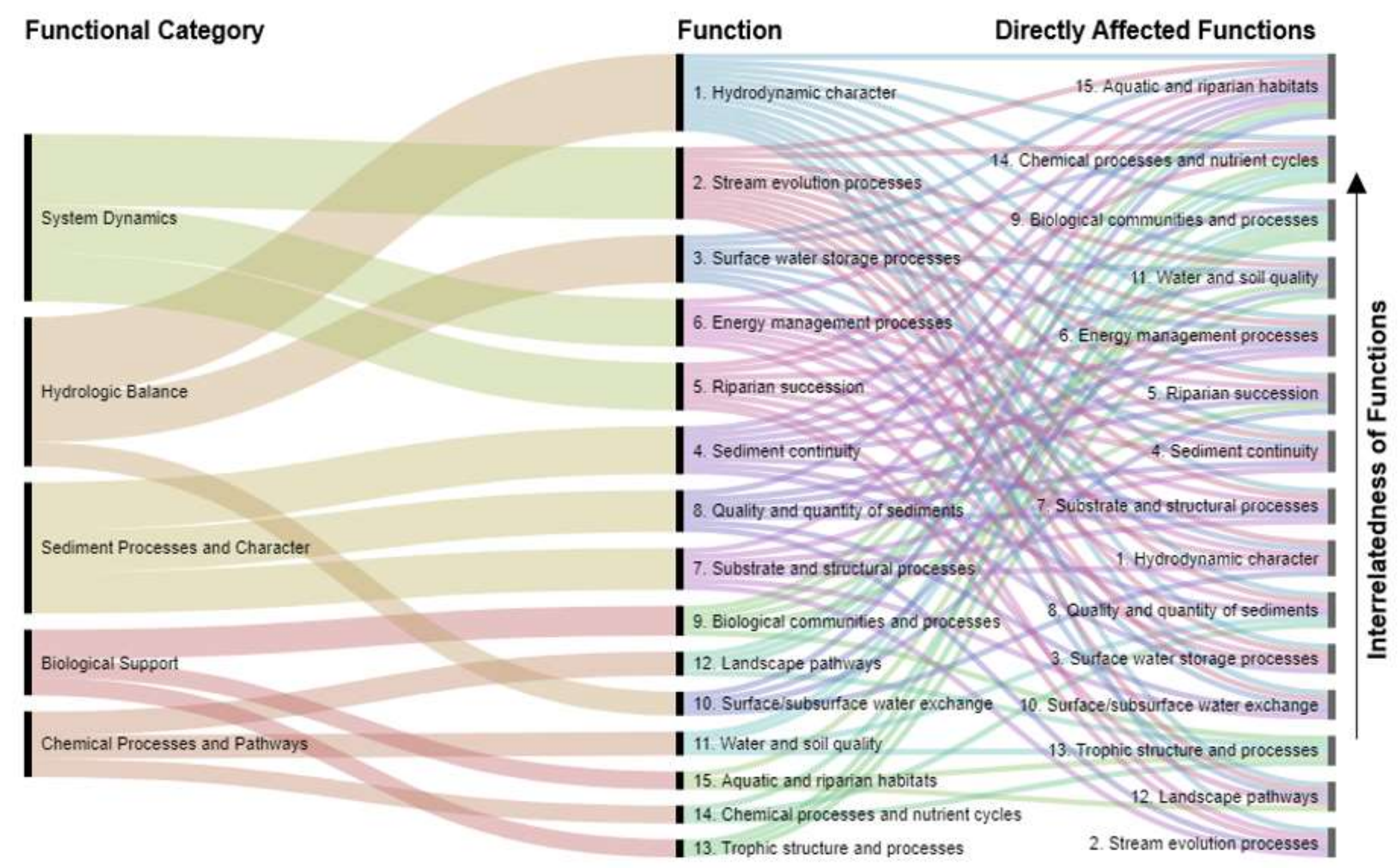
ERDC TN-EMRRP SR-52 1

FUNCTIONAL OBJECTIVES FOR STREAM RESTORATION

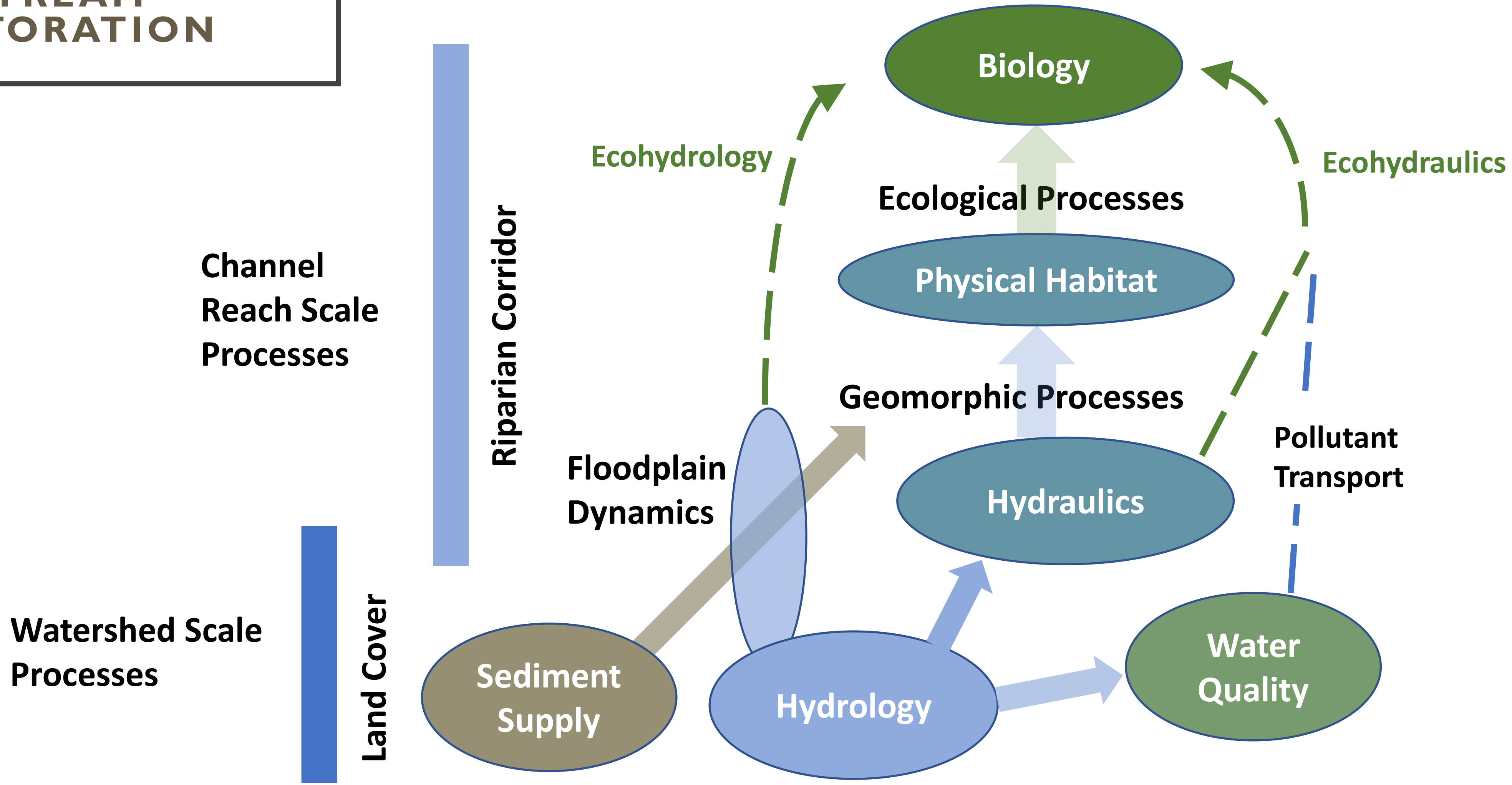
- System Dynamics
- Hydrologic Balance
- Sediment Processes and Character
- Biological Support
- Chemical Processes and Pathways

C. Fischenich, 2003

Interconnectedness among functional categories operating at different spatial and temporal scales



FUNCTIONAL FRAMEWORK FOR STREAM RESTORATION



Stream Assessments:

Over decades, many methods have been developed to assess stream functions based on quantifying physical, chemical, and biological processes that maintain stream ecosystems (404 regulations: 33 CFR 333.2).

The many stream assessments use a measurement method to quantify function-based parameters and their functional capacity to measure the degree to which an area of aquatic resource preforms a specific function (33 CFR 332.2). Parameters may be grouped into components of an assessment framework, functional categories to measure functional capacity.

Examples: Selected Stream Assessments

- USEPA EMAP Habitat Survey Protocols
- Oregon Stream Function Assessment Method
- USEPA Rapid Bioassessment Protocols
- CO River Health Assessment Framework
- River Condition Assessment Tool
- Stream Quality Index
- USFS Stream Inventory Protocols
- Others……

OREGON STREAM FUNCTIONAL ASSESSMENT

- Oregon Stream Functional Assessment Method (SFAM, Quantification Tool) –
- **Functional Groups:**
  - **Hydrology**
  - **Geomorphology**
  - **Biological**
  - **Water Quality**

Table 2.1 Stream Function Categorization, Definition, and Ecosystem Services Provided

FUNCTIONAL GROUP	SPECIFIC FUNCTIONS	DEFINITION AND SERVICES/VALUES PROVIDED
Hydrologic functions	Surface water storage (SWS)	Temporary storage of surface water in relatively static state, generally during high flow, as in floodplain inundation, backwater channels, wetland depressions. Providing regulating discharge, replenishes soil moisture, provides pathways for fish and invertebrate movement, low velocity habitat and refuge, and contact time for biogeochemical processes.
	Sub/surface transfer (SST)	Transfer of water between surface and subsurface environments, often through hyporheic zone. Provides aquifer recharge, base-flow, exchange of nutrients/chemicals through hyporheic, moderates flow, and maintains soil moisture.
	Flow variation (FV)	Daily, seasonal and inter-annual variation in flow. Provides variability in stream energy driving channel dynamics, provides environmental cues for life history transitions, redistributes sediment, provides habitat variability (temporal), provides sorting of sediment and differential deposition.
Geomorphic functions	Sediment continuity (SC)	The balance between transport and deposition of sediment such that there is no net erosion or deposition (aggradation or degradation) within the channel. Maintains channel character and associated habitat diversity, provides sediment source and storage for riparian and aquatic habitat succession, maintains channel equilibrium.
	Substrate mobility (SM)	Regular movement of channel bed substrate. Provides sorting of sediments, mobilizes/flushes fine sediment, creates and maintains hydraulic diversity, creates and maintains habitat.
Biological functions	Maintain biodiversity (MB)	Maintain the variety of species, life forms of a species, community compositions, and genetics. Biodiversity provides species and community resilience in the face of disturbance and disease, full spectrum trophic resources, balance of resource use (through interspecies competition).
	Create and maintain habitat (aquatic/riparian) (CMH)	Create and maintain the suite of physical, chemical, thermal and nutritional resources necessary to sustain organisms. Habitat sustains native organisms. Habitat includes in-channel habitat, as defined largely by depth, velocity, and substrate, and riparian habitat, as defined largely by vegetative structure.
	Sustain trophic structure (STS)	Production of food resources necessary to sustain all trophic levels including primary producers, consumers, prey species and predators. Trophic structure provides basic nutritional resources for aquatic resources, regulates the diversity of species and communities.
Water Quality functions	Nutrient cycling (NC)	Transfer and storage of nutrients from environment to organisms and back to environment. Provides basic resources for primary production, regulates excess nutrients, provides sink and source for nutrients.
	Chemical regulation (CR)	Moderation of chemicals in the water. Limits the concentration of beneficial and detrimental chemicals in the water.
	Thermal regulation (TR)	Moderation of water temperature. Limits the transfer and storage of thermal energy to and from streamflow and hyporheic zone.

OREGON STREAM FUNCTIONAL ASSESSMENT

- Oregon Stream Functional Assessment Method (SFAM, Quantification Tool)

Table 2.2 SFAM Function and Value Measures

Function Measures	
F1	Natural Cover
F2	Invasive Vegetation
F3	Native Woody Vegetation
F4	Large Trees
F5	Vegetated Riparian Corridor Width
F6	Fish Passage Barriers
F7	Floodplain Exclusion
F8	Bank Armoring
F9	Bank Erosion
F10	Overbank Flow
F11	Wetland Vegetation
F12	Side Channels
F13	Lateral Migration
F14	Wood
F15	Incision
F16	Embeddedness
F17	Channel Bed Variability

Value Measures	
V1	Rare Species Occurrence & Special Habitat Designations
V2	Water Quality Impairments
V3	Protected Areas
V4	Impervious Area
V5	Riparian Area
V6	Extent of Downstream Floodplain Infrastructure
V7	Zoning
V8	Frequency of Downstream Flooding
V9	Impoundments
V10	Fish Passage Barriers
V11	Water Source
V12	Surrounding Land Cover
V13	Riparian Continuity
V14	Watershed Position
V15	Flow Restoration Needs
V16	Unique Habitat Features

Metrics are scored 0.0 to 1.0 and quantified similarly to other SQTs

General Review of GA, CO/WY, SC, and TN

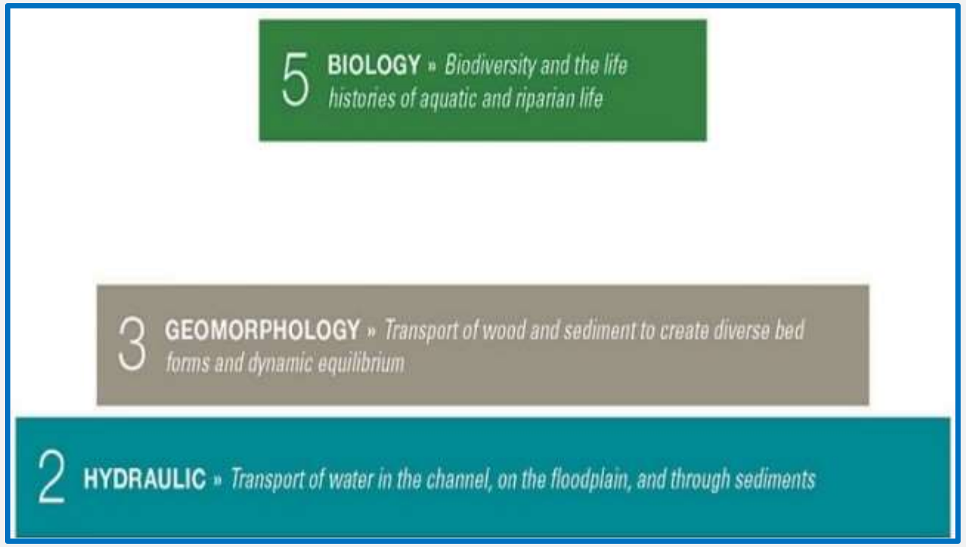
GEORGIA SQT

- Georgia Stream Quantification Tool
  - Slides from Eric Somerville, USEPA

Ecological Performance Standards

- Based on project objectives,
- Based on attributes that are <u>objective</u> and verifiable,
- Used to determine if the project is developing into the <u>desired resource type</u> & providing the <u>expected</u> <u>functions.</u>

Removed categories Hydrology and Physiochemical



GEORGIA SQT

- Georgia Stream Quantification Tool

Slide Justin Hammond, USACE

EXISTING CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	Function-Based Parameters	Measurement Method	Field Value	Index Value	Parameter	Category	Category	Overall	Overall
Hydraulics	Floodplain Connectivity	Bank Height Ratio	1.50	0.31	0.31	0.31	Functioning At Risk	0.20	Not Functioning
		Entrenchment Ratio	2.00	0.30					
Geomorphology	Riparian Vegetation	Left Buffer Width (ft)	0	0.00	0.00	0.29	Not Functioning		
		Right Buffer Width (ft)	0	0.00					
	Bed Form Characterization	Pool Spacing Ratio	2.00	0.75	0.58				
		Percent Riffle	30	0.82					
		LWD Index	25	0.16					
Biology	Macros	Genus Taxa Richness	10	0.00	0.00	0.00	Not Functioning		
		Proportion Genus-level EPT Richness	10.00						
		Proportion Genus-level Clinger Richness	10.00						
		Proportion Genus-level Shredder Richness	10.00						

PROPOSED CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	Function-Based Parameters	Measurement Method	Field Value	Index Value	Parameter	Category	Category	Overall	Overall
Hydraulics	Floodplain Connectivity	Bank Height Ratio	1.00	1.00	0.85	0.85	Functioning	0.94	Functioning
		Entrenchment Ratio	2.40	0.70					
Geomorphology	Riparian Vegetation	Left Buffer Width (ft)	200	1.00	1.00	0.99	Functioning		
		Right Buffer Width (ft)	200	1.00					
	Bed Form Characterization	Pool Spacing Ratio	4.00	0.95	0.98				
		Percent Riffle	40	1.00					
		LWD Index	200	1.00					
Biology	Macros	Genus Taxa Richness	50	0.98	0.98	0.98	Functioning		
		Proportion Genus-level EPT Richness	50.00						
		Proportion Genus-level Clinger Richness	30.00						
		Proportion Genus-level Shredder Richness	10.00						

Required

Required

Optional, based on anti-degradation policy

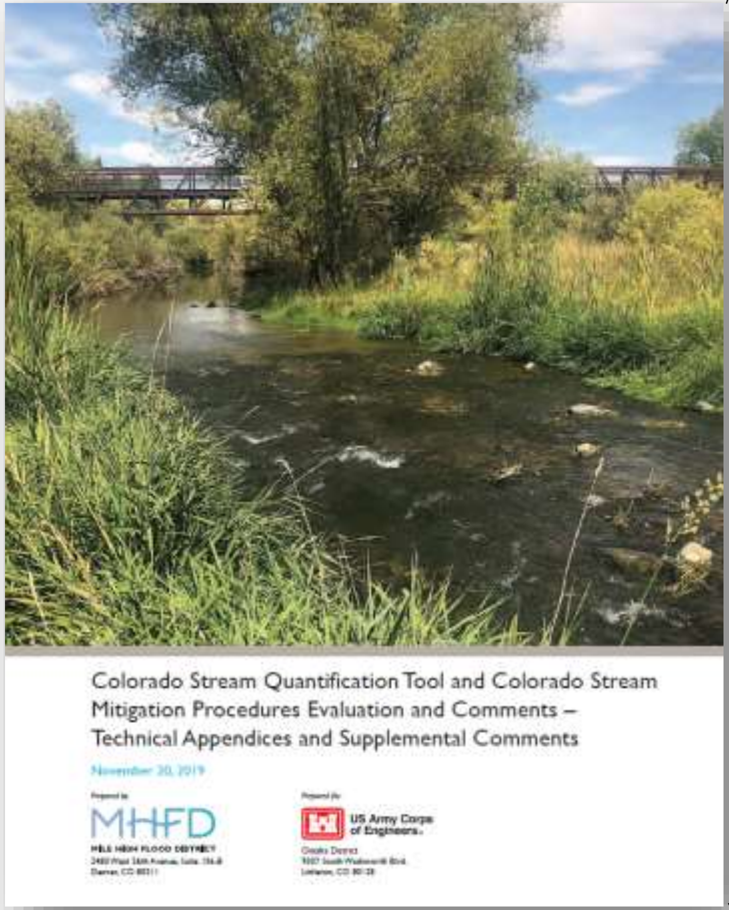
<u>Comment</u>: Need for regionalization, lack of funding (Parameters: LWDI, % riffle, pool-spacing)

A REVIEW: COLORADO STREAM QUANTIFICATION TOOL

Function-based Parameters: Reach Data Inputs

(14 parameters, 34 metrics)

Functional Category	Function-Based Parameter	Metric	Field Value
Reach Hydrology & Hydraulics	Reach Runoff	Land Use Coefficient	65
		Impervious Cover (%)	
		Concentrated Flow Points (#/1000 LF)	0
		Water Quality Capture Volume	
	Baseflow Dynamics	Average Velocity (fps)	4
		Average Depth (ft)	0.72
	Floodplain Connectivity	Return Interval (yr)	
		Bank Height Ratio	1
		Entrenchment Ratio	14
		Percent Side Channels (%)	25
Geomorphology	Large Woody Debris	LWD Index	250
		No. of LWD Pieces/ 100 meters	
	Lateral Migration	Greenline Stability Rating	
		Dominant BEHI/NBS	VL/M
		Percent Streambank Erosion (%)	7
		Percent Armoring (%)	10
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)	
	Bed Form Diversity	Pool Spacing Ratio	3.9
		Pool Depth Ratio	2
		Percent Riffle (%)	56
		Aggradation Ratio	1.2
	Plan Form	Sinuosity	1
	Riparian Vegetation	Riparian Width (%)	70
		Woody Vegetation Cover (%)	80
		Herbaceous Vegetation Cover (%)	
		Percent Native Cover (%)	80
Physicochemical	Temperature	Daily Maximum Temperature (°C)	20
		MWAT (°C)	
	Dissolved Oxygen	Dissolved Oxygen Concentration (mg/L)	7
	Nutrients	Chlorophyll a (mg/m2)	50
Biology	Macroinvertebrates	CO MMI	40
	Fish	Native Fish Species Richness (% of Expected)	65
		SGCN Absent Score	
		Wild Trout Biomass (% Change)	



…The Mile High Flood District (Flood District) agrees that a functions-based impact and mitigation approach is needed in Colorado and that a quantification tool is an objective means to that end.

The Flood District is concerned, though, that a state-wide quantification tool with a one-size-fits-all approach is challenging for practitioners to implement, may not accurately reflect lift and loss, and may result in inappropriate use as assessment and design tools.

To provide substantive, holistic, and comprehensive comments on their application state-wide and within its boundaries, the Flood District established a Flood District Task Force (Task Force) that undertook an evaluation of the COMP and CSQT.

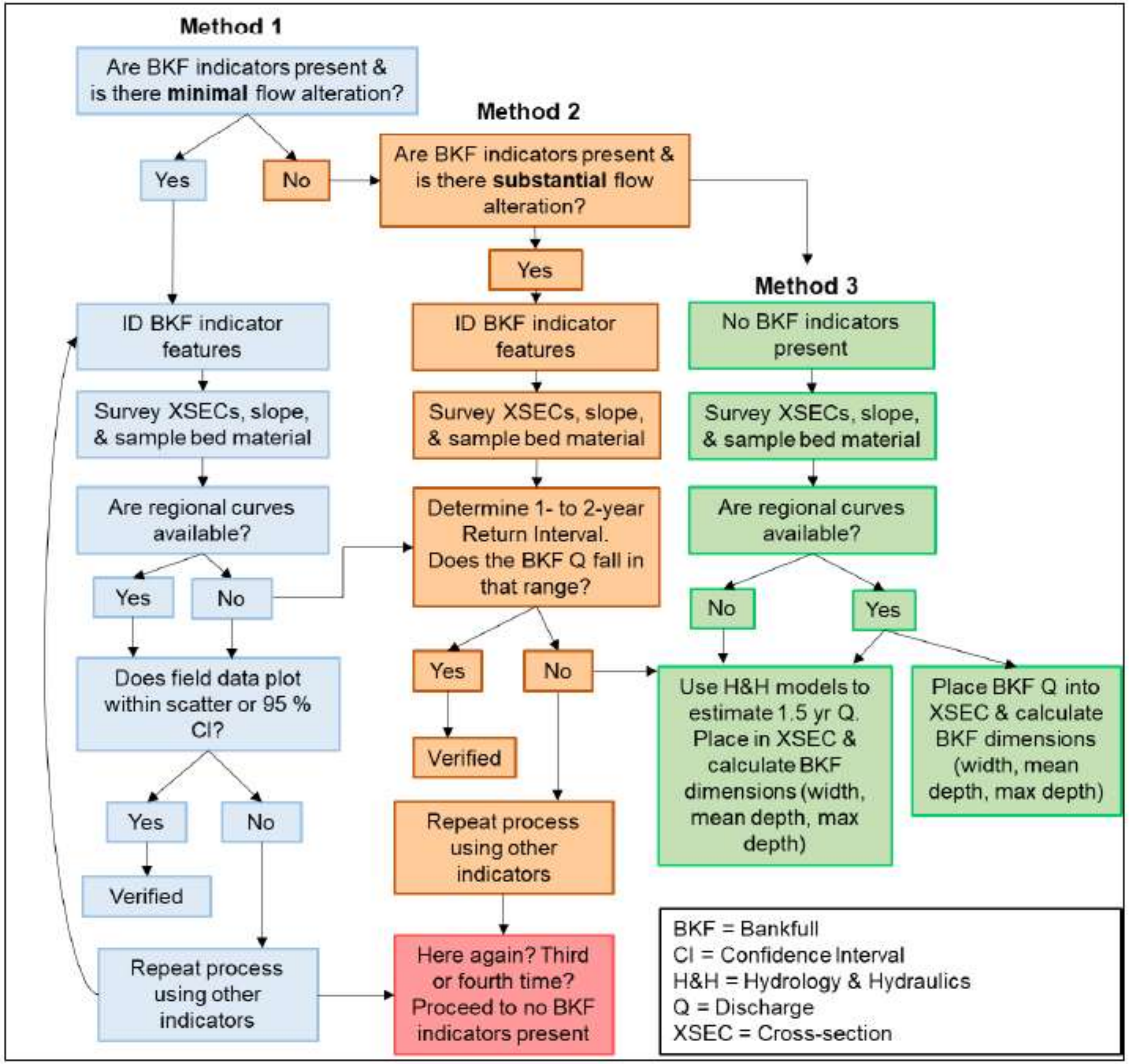
The Task Force focused its evaluation, comments, and recommendations on the following aspects of COMP and CSQT:

- Scientific Support of Functional Categories, Parameters, and Metrics
- CSQT Data Collection and Analysis Testing Protocol
- User Manual, Workbooks, and Field Forms

COLORADO SQT

WY/CO Revision V.2

Bankfull verification flow chart with three methods for bankfull verification.



SOUTH CAROLINA SQT

- SC Stream Quantification Tool

Slide David Wilson, USACE

Functional Category	Function-Based Parameters	Metric	EXISTING CONDITION ASSESSMENT			
			Field Value	Index Value	Parameter	Category
Hydrology	Reach Runoff	Land Use Coefficient				
		Concentrated Flow Points (#/1000 LF)				
Hydraulics	Floodplain Connectivity	Bank Height Ratio (ft/ft)				
		Entrenchment Ratio (ft/ft)				
	Flow Dynamics	Width/Depth Ratio State (O/E)				
Geomorphology	Large Woody Debris	LWD Index				
		LWD Piece Count (#/100m)				
	Lateral Migration	Erosion Rate (ft/yr)				
		Dominant BEHI/NBS				
		Percent Streambank Erosion (%)				
		Percent Streambank Armoring (%)				
	Riparian Vegetation	Buffer Width (ft)				
		Average DBH (in)				
		Tree Density (#/acre)				
		Native Shrub Density (#/acre)				
		Native Herbaceous Cover (%)				
		Monoculture Area (%)				
	Bed Form Diversity	Pool Spacing Ratio (ft/ft)				
		Pool Depth Ratio (ft/ft)				
		Percent Riffle (%)				
Physicochemical	Temperature	Summer Daily Maximum (°F)				
	Bacteria	E. Coli (MPN/100 ml)				
	Nitrogen	Total Nitrogen (mg/L)				
	Phosphorus	Total Phosphorus (mg/L)				
	Suspended Sediment	Total Suspended Solids (mg/L)				
		Turbidity (NTU)				
Biology	Macroinvertebrates	EPT Taxa Present				
	Fish	South Carolina Biotic Index				

- Credit Tool
- Full Regionalized SQT
- Complete Workbooks and Guides
- Corps Add-on Guidance includes:
  - Priority Categories
  - Protections of smaller order streams
  - incentives for watershed level protections

TENNESSEE STREAM QUANTIFICATION TOOL V.1

Category notes and roll-up issues

Function-based Parameters: Reach Data Inputs

Existing Condition Scores (ECS)

Score Range 0-1

Functional Categories

Hydrology (2)
Hydraulics (2)
Geomorphology (22)
Physiochemical (4)
Biology (6)

Note: * Bankfull-based NCD design parameters

EXISTING CONDITION ASSESSMENT					Roll Up Scoring				
Functional Category	Function-Based Parameters	Measurement Method	Field Value	Index Value	Parameter	Category	Category	ECS	ECS
Hydrology	Catchment Hydrology	Watershed Land Use Runoff Score				*			
	Reach Runoff	Stormwater Infiltration							
Hydraulics	Floodplain Connectivity *	Bank Height Ratio				*			
	*	Entrenchment Ratio							
Geomorphology	Large Woody Debris *	Large Woody Debris Index				*			
		# Pieces							
	Lateral Migration	Erosion Rate (ft/yr)							
	*	Dominant BEHI/NBS							
	*	Percent Streambank Erosion (%)							
		Percent Armoring (%)							
	Riparian Vegetation	Left - Average Diameter at Breast Height (DBH; in)							
		Right - Average DBH (in)							
		Left - Buffer Width (feet)							
		Right - Buffer Width (feet)							
		Left - Tree Density (#/acre)							
		Right - Tree Density (#/acre)							
		Left - Native Herbaceous Cover (%)							
		Right - Native Herbaceous Cover (%)							
		Left - Native Shrub Cover (%)							
		Right - Native Shrub Cover (%)							
	Bed Material Characterization	Size Class Pebble Count Analyzer (p-value)							
	Bed Form Diversity *	Pool Spacing Ratio							
	*	Pool Depth Ratio							
	*	Percent Riffle (%)							
	*	Aggradation Ratio							
	Plan Form	Sinuosity							
Physicochemical	Bacteria	E. Coli (Cfu/100 mL)				*			
	Organic Enrichment	Percent Nutrient Tolerant Macroinvertebrates (%)							
	Nitrogen	Nitrate-Nitrite (mg/L)							
	Phosphorus	Total Phosphorus (mg/L)							
Biology	Macroinvertebrates	Tennessee Macroinvertebrate Index				*			
		Percent Clingers (%)							
		Percent EPT - Cheumatopsyche (%)							
		Percent Oligochaeta and Chironomidae (%)							
	Fish	Native Fish Score Index							
		Catch per Unit Effort Score							

Two parameters, land use cannot be changed, stormwater not used. No roll-up (averaging)

Two parameters rely on bankfull determination. Sensitive to determination and difficult to obtain in urban streams. Roll-up by 2.

Twenty-two (22) parameters rolled-up (averaged) into category condition score. Geomorphic restoration relates to these parameters.

Four (4) parameters, mostly not used. If not used value = 0 and de-weights other category scores per the total score.

Six (6) parameters, mostly not used. If not used value = 0 and de-weights other category scores per the total score.

Selected Findings by the TC Working Group Members:

- Flexibility in assessment protocols; one SQT protocol cannot quantify all possible conditions and stream restoration strategies.
- **More complex than needed, make simpler and cost effective, and improve on assessing/scoring functional lift of physical, chemical, and biological attributes.**
- **Parameters dictate design methodology, in general, parameters used for single-threaded channel restoration using Natural Channel Design – limits credit generation for multi-threat channels, urban stream restoration, headwater streams, and unique conditions in different ecoregions.**
- **Reference (performance) curves not adequate across state ecoregions: regionalization.**
- **Existing condition scores for debiting (small reaches) ≠ crediting (large reaches).**
- Bankfull (BF) estimate, difficult to determine in highly alternated channels, i.e., urban watersheds and channelized streams. BF requires riffle structure and may be absent in some channel conditions. Non-stationary in urban streams.
- Physical habitat not assessed directly, but noted as a key category for function-based metrics to assess stream functional condition.

Some TC Concluding Remarks:

- **Reassessment of the Stream Assessment Framework for compensatory mitigation needs to focus on *ecosystem function* rather than metrics used in a geomorphic restoration design methodology. And include valley/ floodplain dynamics.**
- **SQT Metrics should be process-based so they are applicable across multiple ecoregions and watershed stressor conditions.**
- **Alternatives to bankfull methods are needed in defined conditions**
- **Physical Habitat and Riparian Corridor Quality should be functional categories to quantify ecosystem processes.**
- **Further Study – more science on quantifying ecological response from stream restoration to formalize an effective assessment framework for stream function and to provide greater certainty in mitigation crediting.**

TN SQT REVIEW :: WORKING GROUP

Original
Working Group Members:

PROFESSIONAL COMMUNITY

John S. Schwartz, University of Tennessee, Knoxville
David Blackwood, West Tennessee River Basin Authority
Matt Clabaugh, Barge Design Solutions, Inc.
Cat Hoy /Chris Fleming, BDY Environmental
Jed Grubbs, Cumberland River Compact
Casey Hertwig / Daniel Spradlin, CEC
Brady McPherson / Will Stanley, Stantec
Josh Sitz, KCI
Chris Todd, Envirogreen, Inc.
Angel Fowler, RES
Shawn Wurst, RES/TDOT

REGULTORY COMMUNITY

Jonathon Burr, TDEC
Jimmy Smith, TDEC
Adam Kelly, TDEC
Claire Wainwright, TDEC
Ryan Evans, ACOE Nashville District
Joshua Frost, ACOE Nashville District
Will Worrell, ACOE Nashville District
Damon McDermott, ACOE Memphis District

TN Department of Environment & Conservation

Review group initiated by **TDEC** after approximately one year of SQT being in effect and professional community has identified issues. Working Group formed in August 2020.

TN SQT REVIEW :: WORKING GROUP

Review Objectives:

1. Compile and summarize issues from working group members associated with the existing TN SQT individual metric scorings and the total existing condition scores (ECS) used for compensatory stream mitigation debits and credits.
2. Provide suggestions for a revised TN SQT that better measure stream functional attributes for a boarder range of stream types (East to West Tennessee).
3. Ensure that any revisions work for both debiting and crediting, and the basic currency does not change.

TN Healthy Watersheds Initiative Study: Restoration Potential from Urban Streams

Valley & Ridge Study Results: TN SQT Existing Condition Scores

ECS	Urban Impaired		Urban Restored		Ecoregion Reference	
	Baker Cr.	0.47	Williams Cr.	0.52	Mill Run	0.69
	Beaver Cr.	0.58	Beaver Cr.	0.59	Indian Cr.	0.70
	Friar Br.	0.58	Friar Br.	0.53	Dry Cr.	0.70
	Third Cr.	0.42	Third Cr.	0.56	Big War Cr.	0.75
Avg.	**0.53**		**0.55**		**0.71**	

Restored streams:
Post-period > 7 years

- **Ecoregion reference streams: Average ECS = 0.71 (functioning, *barely*)**
- Urban and urban restored streams similar in ECS :: Functioning-at-Risk
- Minimal functional lift between urban and urban restored streams; however urban restored streams were observed with greater biotic integrity (TMI & Fish IBI) scores than urban impaired.
- **Beaver Creek restored now with a TMI = 32 (supporting) from a pre-restoration TMI = 23-29; and an estimated pre-restoration SQT = 0.51 compared to a post-construction SQT = 0.59.**

Addressing the Roll-up Weighting of the Total Existing Condition Score

Existing Functional Categories

Hydrology (2)
Hydraulics (2)
Geomorphology (22)
Physiochemical (4)
Biology (6)

- Suggested to adjust the number of metrics per category
- Suggested that about 2-4 required metrics per category would reduce weighting issue.
- Allow various optional metrics per category for project site conditions when appropriate meeting objectives.
- A proposed arrangement of categories is as follow:
  - Hydrology
  - Hydraulics
  - Geomorphology: Channel Stability
  - Geomorphology: Physical Habitat
  - Geomorphology: Riparian Corridor
  - Water Quality/Biology *

* *Merging* Physiochemical and Biology Categories

TN SQT V.2 TEST

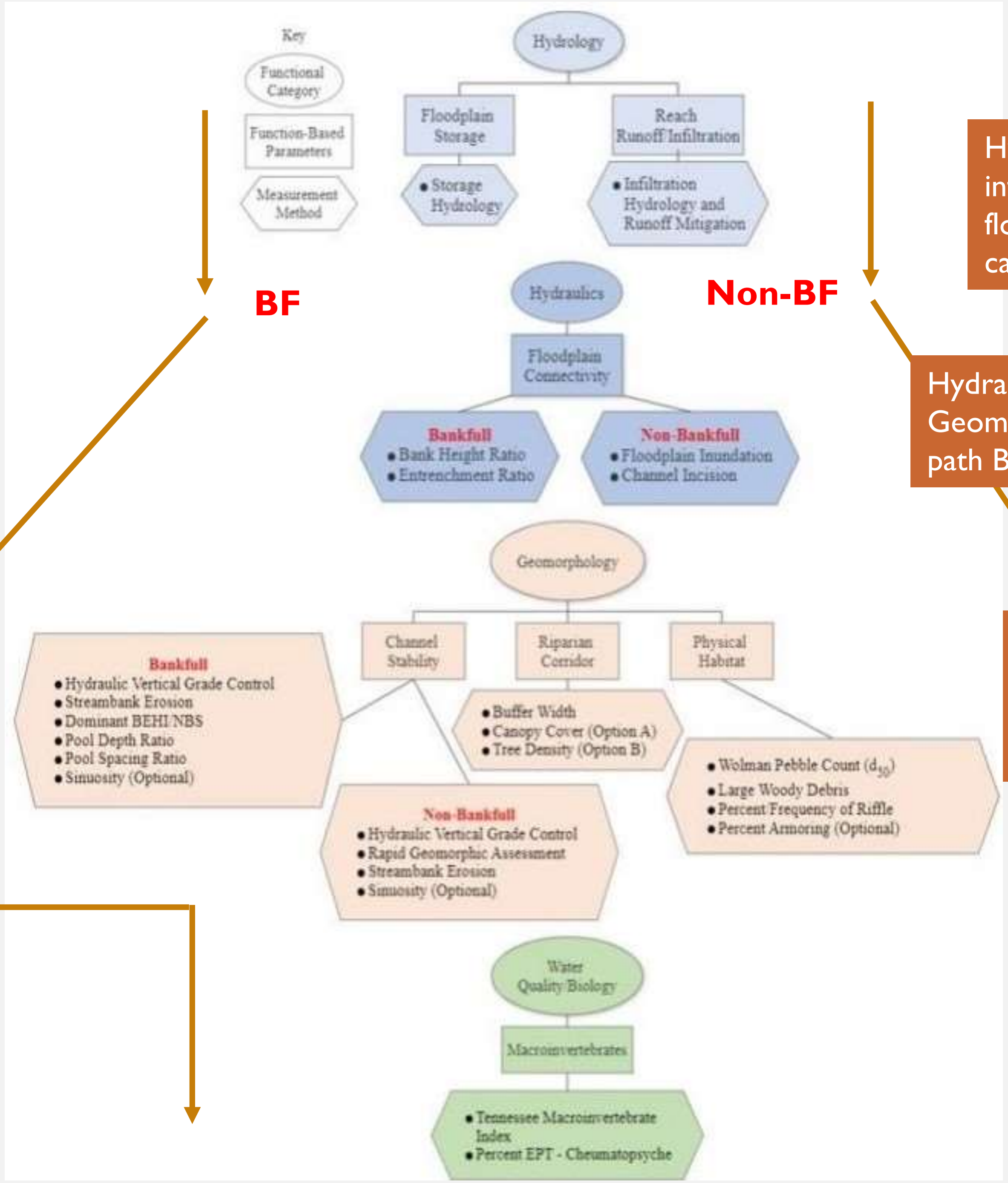
Function-based Parameters:

Proposed Revision

TN SQT Structural Assessment Scheme:

- Hydrology
- Hydraulics
- Geomorphology: Channel Stability
- Geomorphology: Physical Habitat
- Geomorphology: Riparian Corridor
- Water Quality/Biology

Whether BF or Non-BF paths, 2-3 required parameters per category with optional parameters.



Hydrology to include infiltration attribute per floodplain dynamics – can protect & restore

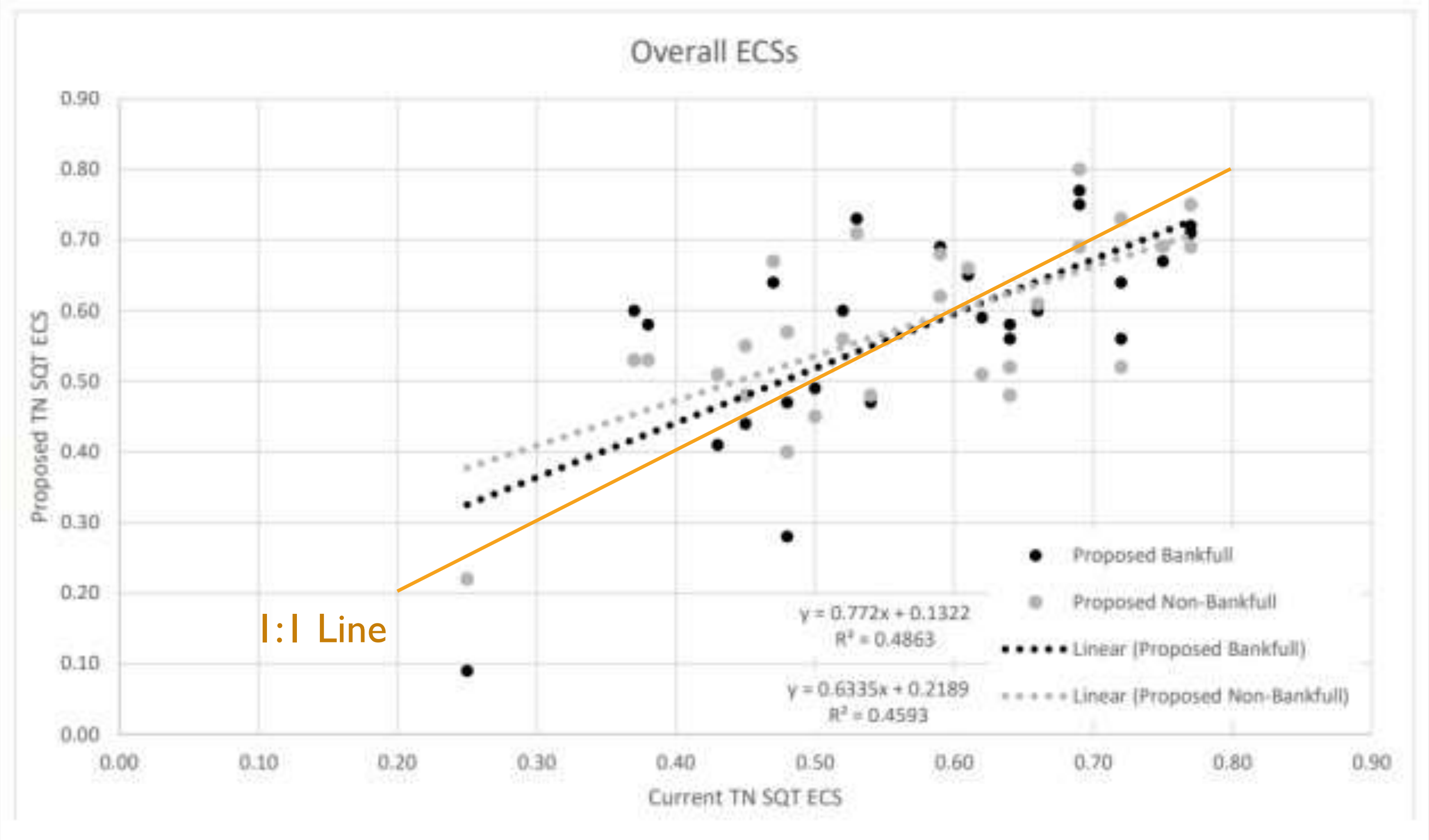
Hydraulics and Geomorphology: choose path BF or Non-BF

Geomorphology sub-categories: Channel; Stability, Riparian Corridor, and Physical Habitat

Physiochemical and Biology merged into single category

TN SQT REVIEW WORKING GROUP

Comparing Current Version with Proposed Revised Version



Results:

Data variable $R^2 = 0.46\text{-}0.47$ but significant trend ($p < 0.05$)

Suggests migration credit currency is not altered significantly overall.

Individual site existing condition scores (ECSs) will vary and partially dependent on BF estimates.

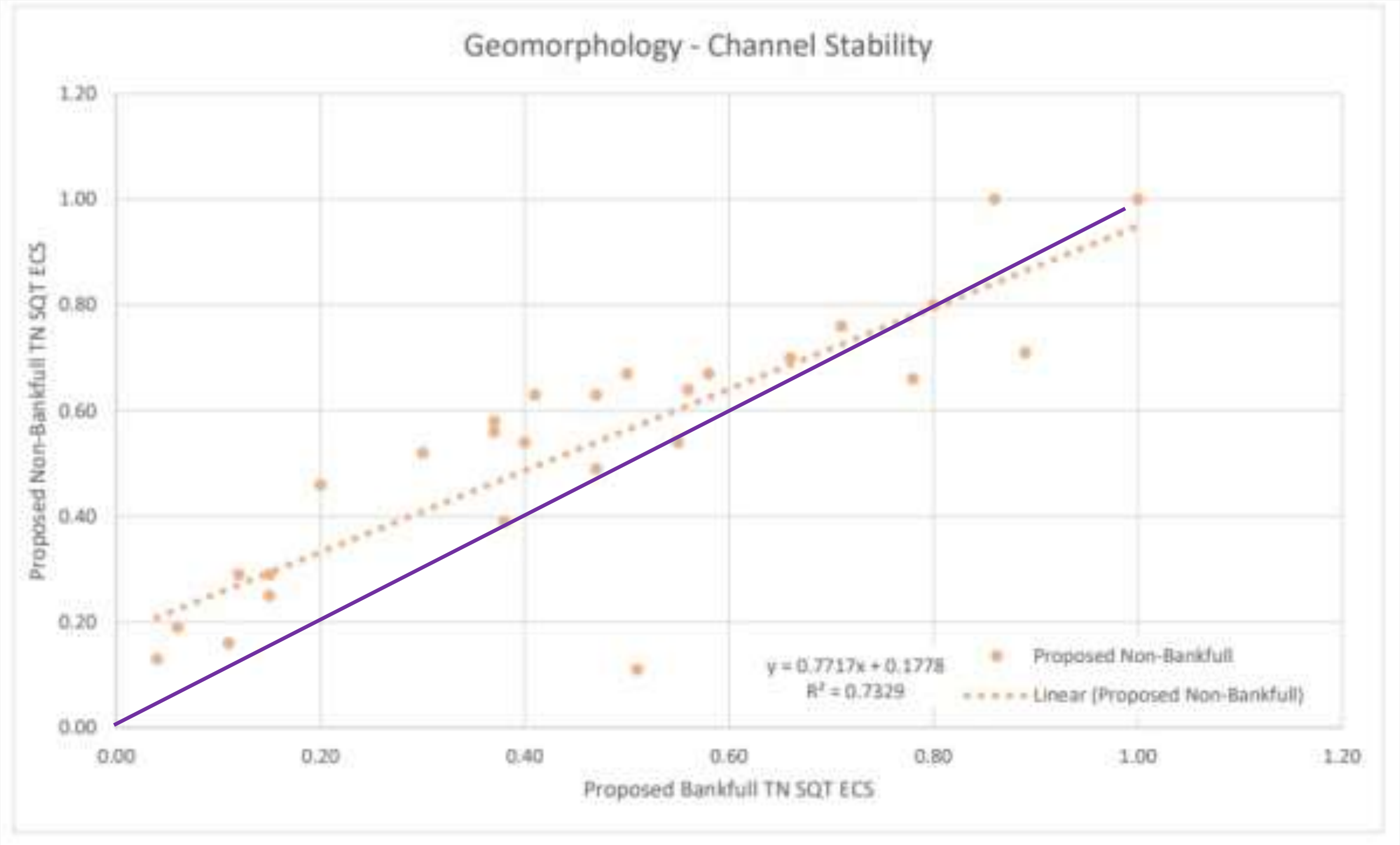
TN SQT REVIEW WORKING GROUP

Comparing Proposed Revised Version: Geomorphology Category Bankfull to Non-Bankfull

In General,

Non-bankfull scores slightly higher than bankfull scores.

Both correlated with $R^2 = 0.73$, and significant ($p < 0.05$).



TENNESSEE STREAM QUANTIFICATION TOOL V.2

Functional Category	Parameter	Metric	Selection Guide	Index Value	Parameter Score	Category Score
Hydrology	Catchment Hydrology	Watershed LUR score	always	0.067	0.067	0.2
	Reach Runoff	Stormwater Infiltration	always	0.067	0.067	
	Floodplain Storage	Infiltration Potential	always	0.067	0.067	
Hydraulics	Floodplain Connectivity	Bank-Height Ratio	bankfull available	0.1	0.2	0.2
		Entrenchment Ratio	bankfull available	0.1		
		Aggradation Ratio	bankfull available (optiona	(0.067)		
		Floodplain Inundation Freq	bankfull not available	0.1	0.2	
		Channel Incision (shear stress ratio)	bankfull not available	0.1		
Geomorphology I	Large Woody Debris	Large Woody Debris (LWD)	always	0.1	0.1	0.2
	Riparian Corridor	Buffer Width	always	0.025	0.1	
		Canopy Cover	always	0.025		
		% Invasive Woody Species	always	0.025		
		Average DBH	always	0.025		
Geomorphology II	Channel Stability	% Streambank Erosion	always	0.033	0.1	0.2
		% Streambank Armoring	always	0.033		
		Rapid Geomorphic Assessment	always	0.033		
	Physical Habitat	Wolman Pebble Count	always	0.025 (bf), 0.033 (nbf)	0.1	
		% Riffle	always	0.025 (bf), 0.033 (nbf)		
		Pool-Pool Spacing Ratio	always (alt NBF method)	0.025 (bf), 0.033 (nbf)		
		Pool Depth Ratio	bankfull available	0.025		
Biology / Water Quality	Biology	Tennessee Macroinvertebrate Index	always, unless TMI submetrics option chosen	0.2 or 0.1	0.2 or 0.1	0.2
		% Clingers	TMI submetrics option	0.2 or 0.1		
		% EPT - Chuematopsyche				
		% Oligo. & Chironom.				
	Water Quality	% Nutrient Tolerant macro	WQ option		0.1	
		Mean Nitrate-Nitrite				
		Mean Total Phosphorous				
		Geomean E. coli				

Bankfull or Non-Bankfull

Non-Bankfull Alternative

Public Comment Period on V.2, Comparison b/t V.1 & V.2, and Training Manual – September 2023

TENNESSEE STREAM QUANTIFICATION TOOL V.2

Functional Category	**Sub-Category / Parameter**	**Functional Attribute / Functional Statement**
Hydrology	- Catchment Hydrology - Reach Runoff / Stormwater Infiltration - **Floodplain Storage**	- Watershed scale runoff based on land cover/land use - Enhanced infiltration of surface runoff & WQ improvements - Promote infiltration on floodplains, side-channel/wetlands restoration; area-based
Hydraulics	Floodplain Connectivity - Bank Height Ratio - Entrenchment Ratio - **Floodplain Inundation** - **Channel Incision** - Aggregation Ratio	 - BF measures of floodplain inundation and channel incision. - NBF measures of floodplain inundation and channel incision. - Excessive sediment deposition, habitat quality (optional).

Public Comment Period on V.2, Comparison b/t V.1 & V.2, and Training Manual – September 2023

TENNESSEE STREAM QUANTIFICATION TOOL V.2

Functional Category	**Sub-Category / Parameter**	**Functional Attribute / Functional Statement**
Geomorphology I	- Large Woody Debris Riparian Corridor - Buffer Width - **Canopy Cover** - Average DBH - **% Invasive Woody Sp.**	- Provides channel structure associated with habitat quality - Provides channel structural stability and shape for water temperature - Limits vegetation diversity.
Geomorphology II	Channel Stability - **% Streambank Erosion** (modified) - **Rapid Geomorphic Assessment** - % Streambank Armoring	- Fluvial erosion; Channel stability per degree of channel adjustment both vertical and lateral erosion. - A measure of streambank habitat quality.

TENNESSEE STREAM QUANTIFICATION TOOL V.2

Functional Category	Sub-Category / Parameter	Functional Attribute / Functional Statement
Geomorphology II	Physical Habitat - Wolman Pebble Count - % Riffle - Pool Spacing Ratio - Pool Depth Ratio	- Sediment supply/transport and bed sediment for habitat quality - Mesohabitat quality for pool habitat units. Pool spacing has a non-bankfull methodology.
Biology / Water Quality	Biology - TMI - % Clingers, % EPT – Chuemato., % Oligo. & Chironom. Water Quality % Nutrient Tolerant MI, NO3-+NO2-, TP - *E. coli*	- A measure of biotic integrity and water quality impairment - A TMI indicator for excessive nutrients, and direct chemical measure. - A measure of fecal pollution.

Questions

Discussion

Baltimore, Maryland
August 22, 2023

TN SQT V.2: CHANNEL STABILITY

Geomorphology Category:

USDA Rapid Geomorphic Assessment

(USDA NSL, Simon, 1996, 1998, 2004)

Consists of nine sub-metrics
Each sub metric: 0 to 4
Total Score: 0 to 36

Stable TS = or < 11
Conditional Stable 11 to < 19
Unstable > 19

Many published works, and USDA data available in in most US ecoregions.

Braided

1. **Primary bed material**

Bedrock	Boulder/Cobble	Gravel	Sand	Silt Clay
0	1	2	3	4

2. **Bed/bank protection**

Yes	No	(with)	1 bank protected	2 banks
0	1		2	3

3. **Degree of incision (Relative elevation of "normal" low water; floodplain/terrace @ 100%)**

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	0

4. **Degree of constriction (Relative decrease in top-bank width from up to downstream)**

0-10%	11-25%	26-50%	51-75%	76-100%
0	1	2	3	4

5. **Stream bank erosion (Each bank)**

	None	Fluvial	Mass wasting (failures)
Left	0	1	2
Right	0	1	2

6. **Stream bank instability (Percent of each bank failing)**

	0-10%	11-25%	26-50%	51-75%	76-100%
Left	0	0.5	1	1.5	2
Right	0	0.5	1	1.5	2

7. **Established riparian woody-vegetative cover (Each bank)**

	0-10%	11-25%	26-50%	51-75%	76-100%
Left	2	1.5	1	0.5	0
Right	2	1.5	1	0.5	0

8. **Occurrence of bank accretion (Percent of each bank with fluvial deposition)**

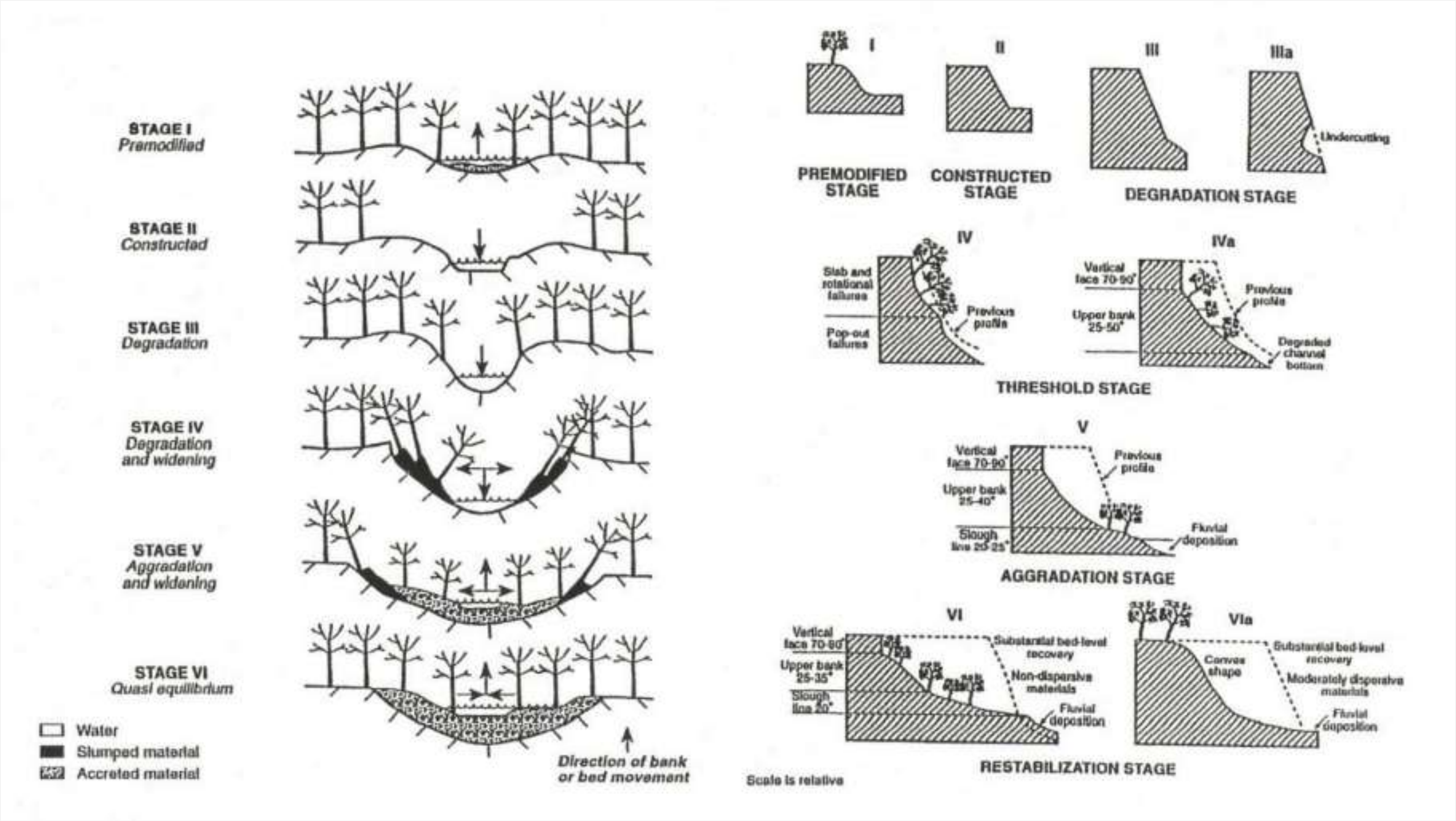
	0-10%	11-25%	26-50%	51-75%	76-100%
Left	2	1.5	1	0.5	0
Right	2	1.5	1	0.5	0

9. **Stage of channel evolution**

I	II	III	IV	V	VI
0	1	2	4	3	1.5

Geomorphology Category: USDA Rapid Geomorphic Assessment

- RGA based on the channel adjustment concepts applied in the Channel Evolution Model (Simon and Darby 1999)
- **CEM Stages 1-6**



Channel Evolution Model

(USDA NSL, Simon, 1998, 2004)

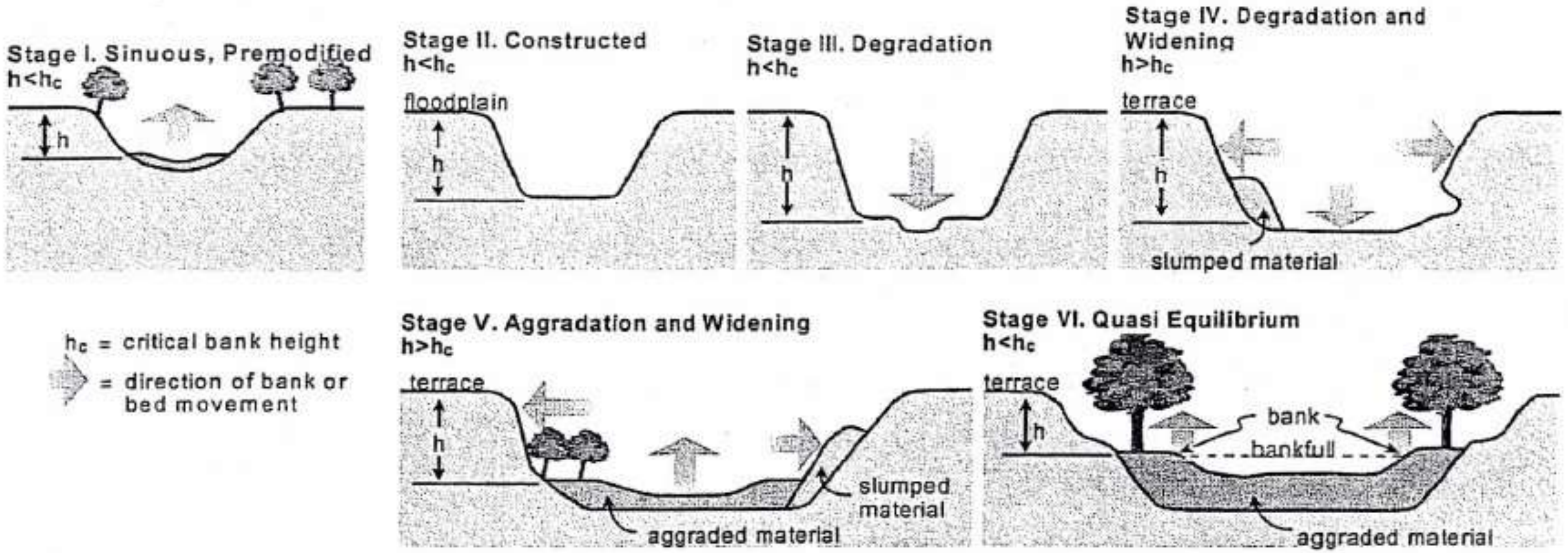


Figure B-1. Quick reference diagrams of Stages of Channel Evolution.

<u>USDA Scale 0 to 4</u>

0 most stable

4 most unstable

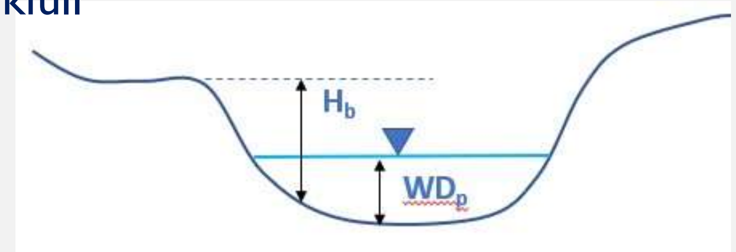
Stage of channel evolution

I	II	III	IV	V	VI
0	1	2	4	3	1.5

Suggested Equivalent CEM metric ESC

I	II	III	IV	V	VI
1.0	--	0.5	0.1	0.3	0.7

Channel Incision measured by WD_p/H_b ratio not using bankfull



Bankfull Indicators

Bankfull Discharge: Multiple hydrogeomorphic indictors

NRCS: Part 654 Nat'l Engr. Handbook (2007)

Table 5.1

Bankfull indicator	Reference
Minimum width-to-depth ratio	Wolman (1955) Pickup and Warner (1976)
Highest elevation of channel bars	Wolman and Leopold (1957)
Elevation of middle bench in rivers with several over-flow sections	Woodyer (1968)
Minimum width-to-depth ratio plus a discontinuity (vegetative and or physical) in the channel boundary	Wolman (1955)
Elevation of upper limit of sand-sized particles in boundary sediment	Leopold and Skibitzke (1967)
Elevation of low bench	Schumm (1960); Bray (1972)
Elevation of active flood plain	Wolman and Leopold (1957) Nixon (1959)
Lower limit of perennial vegetation	Schumm (1960)
Change in vegetation (herbs, grass, shrubs)	Leopold (1994)
A combination of: • elevation associated with the highest depositional features • break in bank slope • change in bank material • small benches and other inundation features • staining on rocks • exposed root hairs	Rosgen (1994)

Identifying Bankfull Indicators

TN SQT User's Manual

Tips for Identifying the Bankfull Feature:

1. Look for depositional features such as point bars. Bankfull is often the highest elevation or top of point bar.
2. Check the bank for a break between depositional processes and channel formation processes such as a slope break.
3. For incised channels with a developing floodplain, bankfull is typically the back of a sloping bench. The front of the bench is typically the inner berm.
4. Scour lines should only be used to reinforce indicators from depositional features.

Notes:

Scour line identification has been termed Active Channel Width

Use regional curves to check field measurements

Bankfull Indicators Limitations

Table 3. Summary of stream conditions that affect bankfull indices as Table 5-11 in the NRCS 2007 National Engineering Handbook, Part 654.

<u>Evaluate</u>

Urban Streams

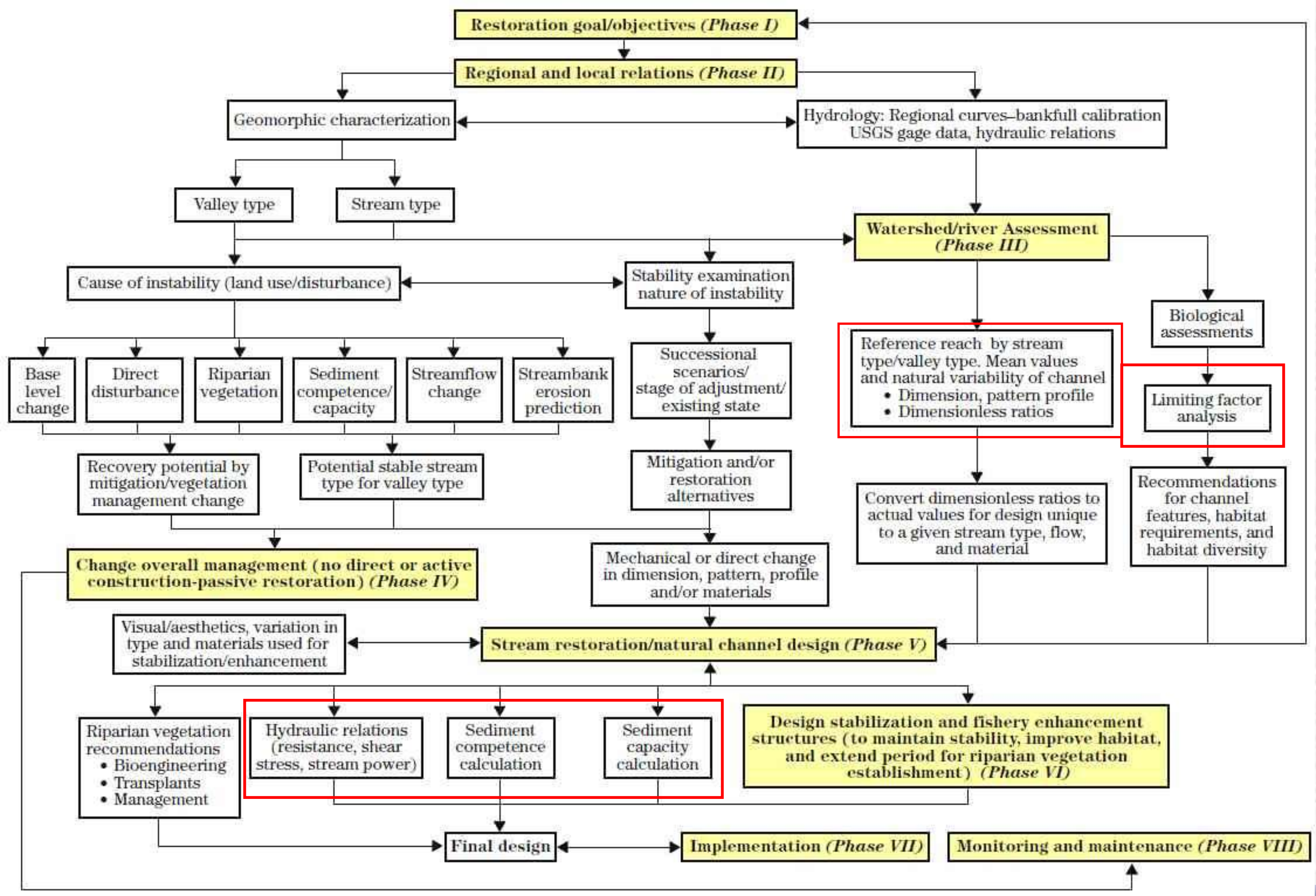
Bedrock Channels

Engineered Channels

Table 5–11 Summary of stream conditions that affect bankfull indices

Reach condition	Process	Effect on bankfull indices
Threshold	Sediment transport capacity of the reach exceeds the sediment supply, but the channel grade is stable	Bankfull indices may be relics of extreme flood events, and may indicate a bankfull flow that is too high
Degrading	The sediment transport capacity of the reach exceeds the sediment supply to the reach, and the channel grade is lowering	The former flood plain is in the process of becoming a terrace. As a result, bankfull indices may indicate a flow that is too high
Aggrading	The sediment transport capacity of the reach is less than the sediment supply	The existing flood plain or in channel deposits may indicate a flow that is too low
Recently experienced a large flow event	Erosion and/or deposition may have occurred on the bed and banks	Bankfull indices may be missing or may reflect the large flow event
Channelized	Sediment transport capacity may not be in balance with sediment supply. The channel may be aggrading or degrading. The reach may be functioning as a threshold channel	Bankfull indices may be relics of previous channel, artifacts of the construction effort, embryonic, or missing altogether

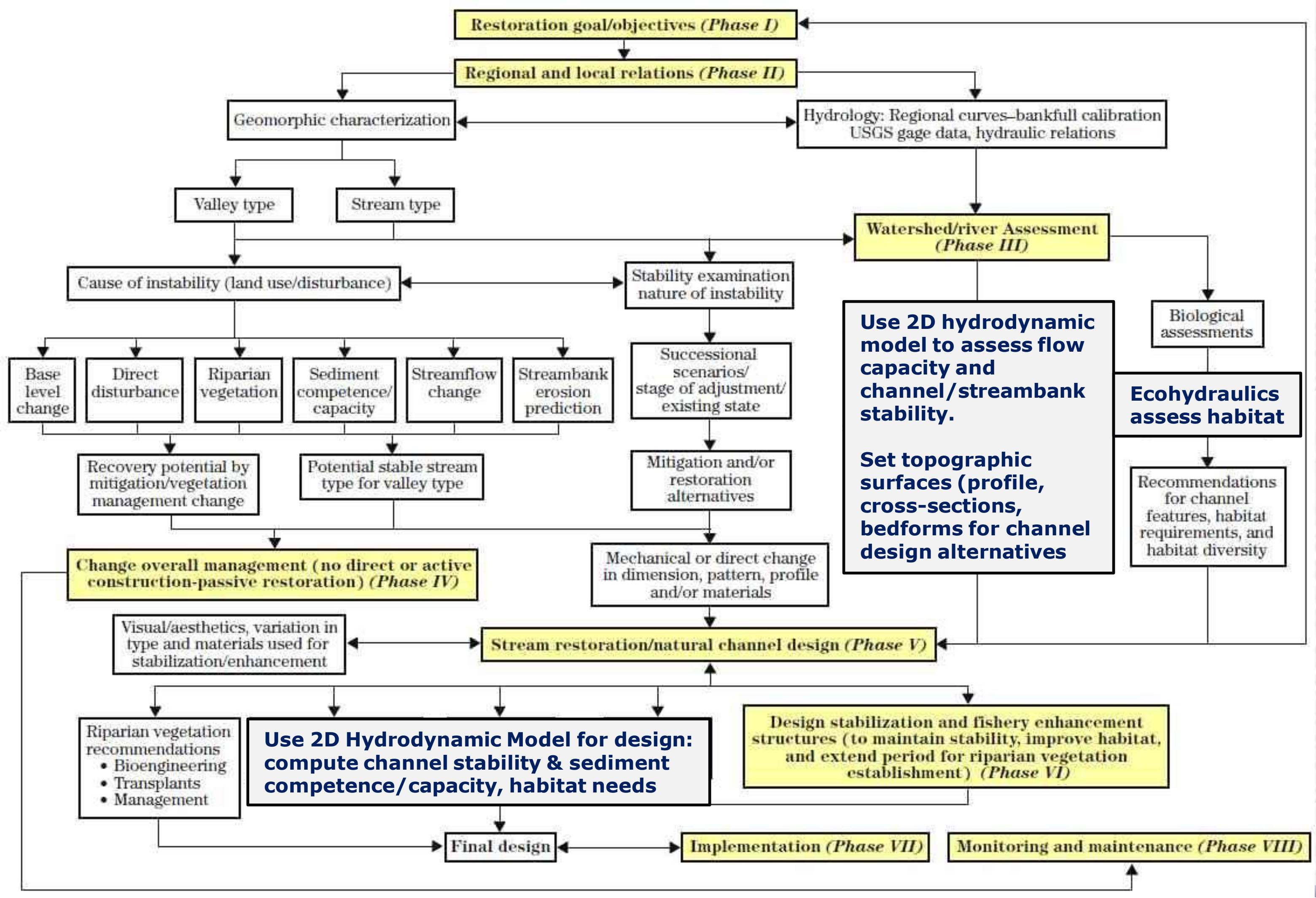
Natural Channel Design Approach



Can be replaced with Hydrodynamic Model

NRSC Part 654 NEH (2007), Ch. 11 Rosgen Geomorphic Channel Design

Natural Channel Design Approach



NRSC Part 654 NEH (2007), Ch. 11