

South Carolina Stream Quantification Tool

Version 1.0

Debit Calculator User Manual



US Army Corps
of Engineers®

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Version 1.0
Debit Calculator User Manual

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South Carolina Steering Committee

South Carolina Department of Natural Resources (Lead Agency)

- Greg Mixon
- Lorianne Riggan
- Stacie Crowe
- Susan Davis
- Tom Daniel

US Army Corps of Engineers, Charleston District

- Amanda Heath
- David Wilson
- Jonathan Swartz
- Laura Boos
- Kristin Andrade
- Adrianna Krzywicka
- Travis Hughes

US Environmental Protection Agency

- Kelly Laycock

South Carolina Department of Health and Environmental Control

- Blair Williams
- Charles Hightower
- Christopher Stout
- Heather Preston
- Logan Smith
- Michele Culbreath
- Sarah Reed
- William Wenerick

US Fish and Wildlife Service

- Christopher Hernandez
- Mark Caldwell
- Melanie Olds
- Thomas McCoy
- Morgan Wolf

National Marine Fisheries Service

- Cynthia Cooksey
- Pace Wilber

Natural Resources Conservation Service

- Sylvia Harris
- Sudie Thomas

US Forest Service

- James Whalen
- Jason Jennings

South Carolina Forestry Commission

- Holly Welch

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Version

SC Debit Calculator Version	Date finalized	Description
Version 1.0	December 2021	Original version

Acronyms

BEHI/NBS – Bank erosion hazard index/Near-bank stress

BHR – Bank height ratio

DNR – South Carolina Department of Natural Resources

ECS – Existing condition score

ER – Entrenchment ratio

FF – Functional feet/foot

Δ FF – Change in functional feet

$-\Delta$ FF – Functional loss

$+\Delta$ FF – Functional lift

FFS – Functional foot score

PCS – Proposed condition score

RPW/Non-RPW – Relatively permanent waters/Non-relatively permanent waters

SC – South Carolina

SFPF – Stream Functions Pyramid Framework

SQT – Stream Quantification Tool

USACE – United States Army Corps of Engineers

USEPA – United States Environmental Protection Agency

Glossary of Terms

Condition – The relative ability of an aquatic resource to support and maintain a community of organisms having a species composition, diversity, and functional organization comparable to reference aquatic resources in the region (USACE & USEPA, 2008).

Credit – A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the accrual or attainment of aquatic functions at a compensatory mitigation site. The measure of aquatic functions is based on the resources restored, established, enhanced, or preserved (USACE & USEPA, 2008).

Cumulative impact – Defined by the National Environmental Policy Act, it is the additive impact on the environment that results, regardless of the entity or multiple entities undertaking the impact, incrementally from the past, present, or reasonably foreseeable future (USACE, 2011).

Debit – A unit of measure (e.g., a functional or areal measure or other suitable metric) representing the loss of aquatic functions at an impact or project site. The measure of aquatic functions is based on the resources impacted by the authorized activity (USACE & USEPA, 2008).

Field value – A field measurement or calculation input into the SQT for a specific metric. Units vary based on the metric or measurement method used.

Functions – The physical, chemical, and biological processes that occur in ecosystems (USACE & USEPA, 2008).

Function-based parameter – A structural measure which characterizes a condition at a point in time, or a function (i.e., process, expressed as a rate) that describes and supports the functional statement of each functional category (Harman et al., 2012).

Functional category – The levels of the Stream Functions Pyramid: hydrology, hydraulics, geomorphology, physicochemical, and biology. Each category is defined by a functional statement (Harman et. al., 2012).

Functional change – Proposed functional foot score (Proposed FFS) minus existing functional foot score (Existing FFS).

Functional foot score (FFS) – The product of a condition score and quantity (stream length in feet).

- Existing FFS = Existing functional foot score. Calculated by measuring the existing stream length and multiplying it by the existing condition score (ECS).
- Proposed FFS = Proposed functional foot score. Calculated by measuring the proposed stream length and multiplying it by the proposed condition score (PCS).

Functional lift – A positive functional foot score or positive net change in functional feet (+ Δ FF).

Functional loss – A negative functional foot score or negative net change in functional feet (- Δ FF).

Impact duration – The length of time an adverse impact is expected to last; categorized as temporary, recurrent, or permanent (USACE, 2011).

Index value – Dimensionless value between 0.00 and 1.00 that express the relative condition of a metric field value compared with reference condition.

Metric – Specific tools, equations, assessment methods, etc., that are used to quantify a function-based parameter. (Also called measurement method in *A Function-Based Framework for Stream Assessment and Restoration Projects* [Harman et al., 2012]).

Mitigation Rule – The 2008 Federal Compensatory Mitigation Rule administered by the USACE and the USEPA (33 CFR Parts 325 and 332; 40 CFR Part 230).

Performance standards – Observable or measurable physical (including hydrological), chemical and/or biological attributes that are used to determine if a compensatory mitigation project meets its objectives (USACE & USEPA, 2008).

Priority category – This factor is used to determine the value of the aquatic resource in question in relation to the functions or services it is providing based on its position in the landscape relative to water quality and/or habitat connectivity, or based on its functions and services it provides related to rare, threatened, or endangered species (USACE, 2011).

Project area – The geographic extent of a project. A project area may include multiple project reaches where there are variations in stream physical characteristics and/or differences in impact activity.

Project reach – A homogeneous stream reach within the project area, i.e., a stream segment with similar valley morphology, stream type (Rosgen, 1996), stability condition, riparian vegetation type, and bed material composition. Multiple project reaches may exist in a project area where there are variations in stream physical characteristics and/or differences in impact activity.

Reference condition – A stream condition that is considered fully functioning for the parameter assessed, where functioning ranges from an unaltered/pristine to minimally disturbed condition. Reference condition is NOT the best available condition that can be achieved at a site. (Also known as reference standard in the SQT). Note that this definition differs from USACE & USEPA (2008) definition.

Reference curves – A relationship between observable or measurable metric field values and dimensionless index values. These curves are fitted to threshold values that represent the degree of departure from a reference condition for a given field value. These curves are used to calculate the index value for a given metric at a project area.

Representative sub-reach – A length of stream within a project reach that is selected for field data collection of function-based parameters and metrics. The representative sub-reach is typically 20 times the bankfull width or two meander wavelengths (Leopold, 1994).

Stream Functions Pyramid Framework (SFPF) – The Stream Functions Pyramid (Pyramid) is comprised of five functional categories based on the premise that lower-level functions (hydrology, hydraulics, geomorphology) support higher-level functions (physicochemical

and biology) and that they are all influenced by local geology and climate. The SFPP includes the organization of function-based parameters, metrics (or measurement methods), and reference standards (performance standards) to assess the functional categories of the Pyramid (Harman et al., 2012).

Stream type – This distinction is based on regulatory implementation of the Clean Water Act and the jurisdictional determination of the stream as either a: non-relatively permanent water (RPW) and non-navigable, a 1st or 2nd Strahler stream order perennial RPW and non-navigable, or all other streams greater than 2nd stream order and traditional navigable waters (USACE, 2011).

Permitted impacts – Activities that adversely affect waters of the United States and may require compensatory mitigation (USACE & USEPA, 2008).

Chapter 1. Introduction

The South Carolina (SC) Debit Calculator is an application of the Stream Quantification Tool (SQT) used to assess functional loss caused by permitted stream impacts. The purpose of this Debit Calculator User Manual is to introduce key concepts and provide instruction on how to use the SC Debit Calculator workbook for impacts under the purview of the US Army Corps of Engineers (USACE) Charleston District.

This manual is used in conjunction with the *South Carolina Stream Quantification Tool Data Collection and Analysis Manual* (Data Collection and Analysis Manual), which provides information on data collection for the SC SQT and Debit Calculator (see SC SQT Manual Directory below). The *SQT Spreadsheet User Manual* provides background on the SQT as well as rules and procedures for using the SQT workbook; the *SQT Spreadsheet User Manual* is not needed to use the Debit Calculator.

Version 1.0 of the SC SQT and Debit Calculator include global edits informed by SQT and Debit Calculator development in states across the United States, including North Carolina (Harman and Jones, 2017), Tennessee (TDEC, 2018), Wyoming (USACE, 2018a), Georgia (USACE, 2018b), Colorado (USACE, 2020), Minnesota (MNSQT SC, 2019), and Michigan (EGLE, 2020). Additionally, data collected in South Carolina¹ and in the southeast region were used to develop reference curves for select metrics.

SC SQT Manual Directory

1. **Debit Calculator Manual** – *Describes data collection method options along with rules and procedures for using the Debit Calculator Microsoft Excel workbook* (This document).
 - Appendix A – Practical Debit Calculator Examples
2. **Data Collection and Analysis Manual** – *Describes instructions to collect and analyze data for the SQT and/or Debit Calculator input.*
3. **SQT Spreadsheet User Manual** – *Describes rules and procedures for using the SQT Microsoft Excel workbook.*

1.1. Purpose of the Debit Calculator

The Debit Calculator is an application of the SQT. The Debit Calculator was developed to quantify functional loss associated with permitted impact activities, while the SQT was developed to assess and quantify both functional lift and loss associated with stream mitigation or impact activities. The Debit Calculator can be used to determine debits from reach-scale impacts typically encountered in the Clean Water Act (CWA) 404 program. The Debit Calculator implements the same quantification approach as the SQT to ensure parity between the functional change measured by the SQT and Debit Calculator tools. Specifically, the same

¹ <https://www.dnr.sc.gov/environmental/streamrestoration.html>

function-based parameters and metrics used to assess functional change with the SQT are also used to assess functional loss with the Debit Calculator.

A main goal of the SQT and Debit Calculator is to produce objective, verifiable, and repeatable results by consolidating well-defined, quantitative data collection procedures for stream condition and underlying processes. The SQT and the Debit Calculator were specifically developed to:

The same function-based parameters and metrics used to assess functional change with the SQT are also used to assess functional loss with the Debit Calculator.

1. Quantify the numerical differences between an existing (pre-activity) stream condition and the proposed (post-activity) stream condition. This numerical difference is known as functional lift or loss and can be related to a stream credit determination method as defined by the Mitigation Rule (USACE & USEPA, 2008).
2. Relate restoration and impact activities to changes in stream functions by primarily selecting function-based parameters and metrics that can be altered by reach-scale practices.
3. Create parity or equivalency between functional lift (credits) and loss (debits).

The purposes above translate into different uses for the SQT and Debit Calculator in South Carolina, including:

1. Site Selection – The tools can help with avoidance and minimization by determining which site and/or design will yield the least functional loss for a proposed impact activity.
2. Functional Lift or Loss – The tools can quantify functional change for a proposed or active project.
3. Calculation of Debits for Compensatory Mitigation Requirements for 404 Permits – The Debit Calculator was developed to incorporate the change in function (i.e., the proposed functional foot score minus the existing functional foot score). This can be used to assist in determining the appropriate number of debits which result from a proposed project, and which would need to be offset through purchase or other means of credit generation (i.e., permittee responsible mitigation).
4. Stream Relocations – The SQT can be applied to on-site relocations to help determine if the proposed mitigation activities will offset the proposed impacts. The Debit Calculator and SQT can be used together to determine whether proposed activities will offset proposed impacts when the impact and restoration occur on separate reaches within the project area.

1.1.1. PRIMARY DIFFERENCES BETWEEN THE SQT AND DEBIT CALCULATOR

To measure functional change, the SQT requires measurement of the existing (pre-activity) and proposed conditions (post-activity), as well as monitoring to verify the proposed condition. The primary challenge with measuring functional loss using the SQT is that the proposed condition is *not monitored*, which prevents verification of the proposed condition. The proposed condition

must be estimated through project design documents, modeling, literature reviews, and best professional judgement.

Thus, *the Debit Calculator was created to provide an alternative, rapid method to assess the proposed condition for permitted impacts.*

This rapid, proposed condition method uses impact severity tiers (Section 2.5) to determine the proposed condition.

Additionally, *the Debit Calculator was created to provide alternative options, varying in level of effort, to assess the existing condition for permitted impacts.*

The rapid existing condition method(s) applies standard scores to functional parameters in all functional categories.

The Debit Calculator was created to provide:

- An alternative, rapid method to assess the proposed condition for permitted impacts.
- Alternative options to assess the existing condition, varying in level of effort, for permitted impacts.

The primary differences between the SQT and Debit Calculator, with respect to the Debit Calculator, are:

1. Proposed condition is assessed using impact severity tiers.
2. All five functional categories must be scored.
3. There are assessment options for determining the existing condition score.
 - a. This provides rapid alternatives for assessment and ensures that the functional lift calculated by the SQT equals the functional loss calculated by the Debit Calculator.

1.2. SQT and Debit Calculator Key Concepts

The following concepts are critical in understanding the applicability and limitations of the SQT and Debit Calculator:

- The SQT and Debit Calculator provide quantification of functional loss from proposed impacts in terms of debits and quantification of functional lift from proposed restoration activities in terms of credits. They may be used to inform decisions about compensatory mitigation requirements, however the SQT and Debit Calculator do not determine whether a particular activity would require compensatory mitigation under current Corps Regulatory Authority.
- The parameters and metrics in the SQT and Debit Calculator were selected due to their sensitivity in responding to reach-scale changes associated with the types of activities commonly used in stream restoration and permitted impacts. These parameters are *not intended* to comprehensively characterize all structural measures or processes that occur within a stream.
- The SQT and Debit Calculator do not quantitatively score watershed condition. The SQT assesses watershed condition qualitatively and uses the information to inform restoration potential for a given site or watershed. Impact activities should consider watershed condition as part of avoidance and minimization of impacts.

- The SQT and Debit Calculator assess the reach corridor, including the stream channel, adjacent floodplain, riparian buffer extent, and the lateral drainage area. The SQT and Debit Calculator outputs reflect the condition of the riparian corridor even though the unit of measure is stream feet (linear feet).
- The SQT and Debit Calculator are designed to assess the same parameters and metrics pre-activity and post-activity to provide parity between methods used to quantify change in condition. *Unless the same parameters and metrics are used, it is not appropriate to compare scores across sites.*
- Reference curves relate point-in-time condition measurements to functional capacity on a scale of 0.00 to 1.00, where 0.00 represents no functional capacity and 1.00 represents pristine or unaltered condition. Reference curves standardize all metrics to an ecologically relevant scale.
- The overall existing and proposed condition scores range from 0.00 to 1.00, where each of the five functional categories contributes a maximum of 20% to the overall score. Overall condition scores in the SQT and Debit Calculator are additive. In the Debit Calculator, all five categories are assessed; whereas, in the SQT, users have the option to assess parameters in the hydrology, hydraulics, and geomorphology functional categories alone, or to also assess physicochemical and biology parameters.
- Functional feet are calculated by multiplying the quantity (stream length in linear feet) by the overall condition score. The unit of measure provides scale to the overall condition score, an otherwise unit-less measure. Scale is necessary for debit and credit quantity determinations.
- The primary output of the Debit Calculator is functional loss ($-\Delta FF$). However, the SC Debit Calculator outputs a total debit score as well, which applies adjustments to $-\Delta FF$ based on the following adjustment factors: cumulative impact, impact duration, priority category, and stream type (USACE, 2011).
- The overall output score is reflective of the stream and ecological characteristics of the specific reach being assessed. Therefore, the overall output is not a condition score for all fluvial systems. To help avoid out-of-kind mitigation, the overall score output by the SQT and Debit Calculator is related to stream size (Strahler stream order; Strahler, 1957) and flow type (perennial, intermittent, and ephemeral) to help match impacted stream systems to mitigation stream systems and thus avoid out-of-kind mitigation. For example, an overall score of 0.5 for an ephemeral stream is not functionally equivalent to a 0.5 score for a perennial stream. Additional matches can be made by comparing the input and stratification sections between two sites.

1.3. Downloading and Revising the SQT and Debit Calculator Package

The SC SQT package, including the Debit Calculator workbook and this user manual, can be downloaded from the SC Department of Natural Resources website². Feedback may be submitted at any time to environmental@dnr.sc.gov.

In addition to this user manual, the following spreadsheets and documents are available:

- SC SQT workbook – Microsoft Excel workbook described in the SC SQT Spreadsheet User Manual.
- SC SQT Spreadsheet User Manual – Describes the calculations performed by the SC SQT workbook and how to use the workbook for stream restoration projects.
- SC SQT Data Collection and Analysis Manual – Describes how to collect and process data and calculate input for the SC SQT.
- SC Debit Calculator workbook – Microsoft Excel workbook used to calculate debits.

Supporting information can be found at the Stream Mechanics webpage³, including other state SQTs, the Debit Tool White Paper, the Stream Functions Pyramid diagram, *A Function-Based Framework for Stream Assessment and Restoration Projects* (Harman et al., 2012), and new function-based parameters with metrics and reference standards (not included in Harman et al. [2012]). In addition, the Workshops tab on the Stream Mechanics site provides a list of courses providing further education on the Stream Functions Pyramid Framework, the SQT, and other courses related to stream assessment and restoration.

The SC SQT and Debit Calculator will be updated and revised periodically as additional data are gathered and reference curves and metrics are refined. Field data supporting refinement of reference curves and evaluation of metrics are appreciated. The SQT and Debit Calculator architectures are flexible and future versions of the tools can accommodate additional parameters and metrics. If a user is interested in proposing additional parameters or metrics for incorporation into the tool, they should email a written proposal for consideration to environmental@dnr.sc.gov. The written proposal should include a justification and rationale (e.g., data sources and/or literature references) and should follow the Streams Functions Pyramid Framework for identifying reference curves, threshold values, and index scores (see Section 1.4 below).

1.4. Background and Concepts

The SC Debit Calculator is a Microsoft Excel workbook used to quantify functional loss and inform debits. The Debit Calculator and SQT apply concepts from the Stream Functions Pyramid Framework (SFPF; Harman et al., 2012). The Debit Calculator and SQT use the same function-based parameters and metrics to assess up to five functional categories: hydrology, hydraulics, geomorphology, physicochemical, and biology (South Carolina Steering Committee, 2021a).

² <https://www.dnr.sc.gov/environmental/streamrestoration.html> or www.dnr.sc.gov/sqt

³ <https://stream-mechanics.com/>

The Stream Functions Pyramid (Figure 1) is based on the premise that lower-level functions support higher-level functions and that they are all influenced by local geology and climate. Each functional category is defined by a functional statement. For example, the functional statement for Level 1, Hydrology is “the transport of water from the watershed to the channel”, which supports all higher-level functions. The Stream Functions Pyramid *alone* depicts a hierarchy of stream functions but does not provide a specific mechanism for addressing functional capacity, establishing reference standards, or communicating functional change. Building off the Stream Functions Pyramid, the SFPF lays out a framework to quantify stream functions. The SQT and Debit Calculator utilize this structure and key components are described below:

- **Functional categories** describe levels 1 through 5 of the Stream Functions Pyramid: hydrology, hydraulics, geomorphology, physicochemical, and biology. Each functional category is defined by a functional statement.
- **Function-based parameters** describe and support the functional statements for each functional category. Parameters are “function-based” because they are described by metrics that quantitatively measure stream condition; the metrics themselves are not direct measures of stream function.
- **Metrics** (known as measurement methods in Harman et al. [2012]) are specific tools, equations, assessment methods, etc., that quantify the function-based parameter. There can be more than one metric for a single function-based parameter. Metrics selected for the SQT and Debit Calculator are structural or compositional attributes that indicate condition at a given point-in-time. Thus, metrics are surrogates for stream functions (USACE & USEPA, 2008). Metrics support the functional statement of the functional category in which it resides.
- **Reference curves** (known as performance standards in Harman et al. [2012]) relate point-in-time condition measurements to functional capacity on a scale of 0.00 to 1.00, where 0.00 represents no functional capacity and 1.00 represents pristine or culturally unaltered condition. Reference curves standardize all metrics to an ecologically relevant scale. See Section 3.5.1.4 for more information on reference curves.

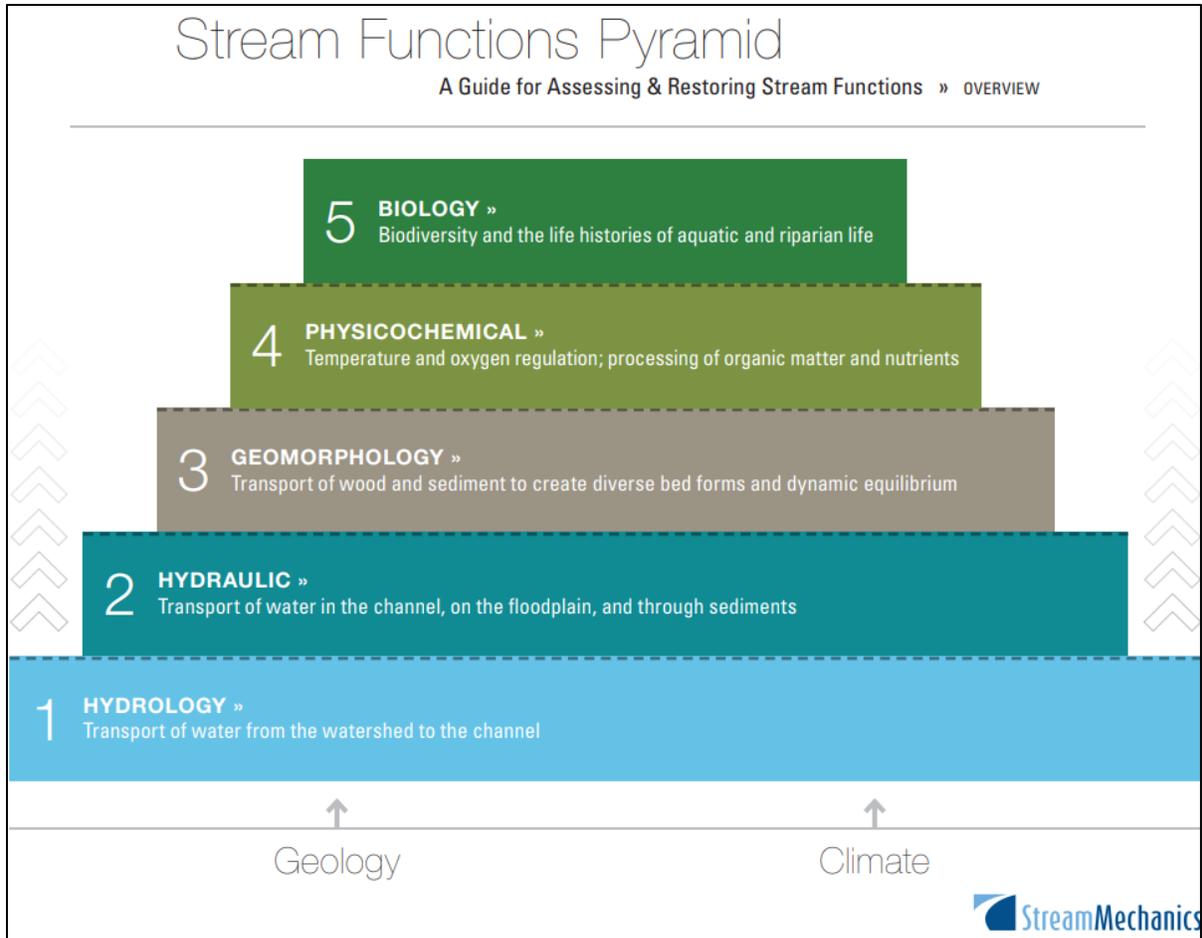


Figure 1. The Stream Functions Pyramid is based on the premise that lower-level functions support higher-level functions and that they are all influenced by local geology and climate.

Chapter 2. Getting Started

This chapter outlines how to implement the Debit Calculator and details concepts unique to the Debit Calculator.

2.1. Debit Calculator Process

The typical process for evaluating functional change imposed by stream impact projects with the Debit Calculator is outlined in Table 1.

Table 1. Typical stream impact evaluation process using the Debit Calculator

Phase and Task(s)	Associated Spreadsheet
Project and Reach Delineation (Section 2.2)	
Delineate the project area(s) and determine project reaches primarily based on impact activities.	Project Summary
Existing Conditions Assessment (Sections 2.3 and 2.4)	
Select the debit option to assess the existing condition. Different debit options can be selected for different project reaches. Directions are provided for each debit option below.	Functional Loss
➔ Debit Option 1	
Select Priority Category. No data collection required.	Project Summary
➔ Debit Options 2a, 2b, and 3	
Coordinate with regulating agencies to select parameters and metrics based on your reach-specific setting and proposed impacts.	Parameter and Metric Selection
Collect data to characterize the existing condition. The number of parameters measured depends on the debit option selected. For all debit options, existing condition standard scores will be assumed for parameters not measured.	Existing Condition
Proposed Conditions Assessment (Section 2.5)	
Coordinate with regulating agencies to select the appropriate impact severity tier for each project reach.	Functional Loss

2.2. Reach Delineation

The SQT is a reach corridor assessment methodology. Large impact projects may be subdivided into multiple reaches. Reach delineation is largely influenced by differences in morphology or condition and the degree of impact to function-based parameters associated with an impact activity. Guidance for reach delineation is provided in Section 3.1 of the Data Collection and Analysis Manual (South Carolina Steering Committee, 2021b).

For long reaches, certain parameters can be assessed within a representative sub-reach to avoid quantitative assessment of long stream lengths with similar physical conditions (Section 3.2, Data Collection and Analysis Manual, 2021b). The sub-reach must be 20 times the bankfull width or two meander wavelengths (Leopold, 1994), whichever is longer. Sub-reach delineation is applicable to debit options 2a, 2b, and 3, where applicants elect to measure some or all parameters in all five functional categories.

For short reaches, the entire reach length should be assessed. A common example is a short reach (e.g., 25 feet) between two culverts. In this example, the 25 feet of stream corridor between the two culverts is assessed. Some metrics in the SQT require a minimum sample size or reach length. Instruction is provided below for the LWD and bed form diversity parameters:

- Scale the LWDI field value or LWD piece count field value to 328 ft, the length of the LWD assessment reach. This is applicable to debit options 2a, 2b, and 3 where the LWD parameter is measured.
- Assess a stream length that is longer than the project reach to capture the necessary data to determine bed form diversity metrics. This is applicable to debit options 2b and 3 where the bed form diversity parameter is measured.

2.3. Existing Condition Assessment Options (Debit Options)

The SC Debit Calculator includes four debit options to assess the existing condition. The debit options and their recommended use are presented in Table 2. Debit option 1 requires the least effort because it requires no field or desktop assessment; instead, standard scores are assumed for parameters in all five functional categories. As the debit option number increases, the assessment requires more field data collection and analysis effort.

Table 2. Description of debit options and recommended use.

Debit Options	How to Determine the Existing Condition Score	Recommended Use
1	No assessment – Assume standard scores for parameters in all five functional categories.	Permit applicants who do not want to perform an assessment. Typically used if the existing condition is good.
2a	Partial Assessment – Estimate the existing condition score by assessing a <i>minimum</i> number of parameters (see Section 3.4.1 for list of parameters to measure).	Permit applicants who want to assess a minimum number of parameters. Typically used if the existing condition is degraded; select debit option 2a or 2b based on

Debit Options	How to Determine the Existing Condition Score	Recommended Use
	Parameters that are not assessed are assigned a standard score.	observed impairments and available resources.
2b	Partial Assessment – Estimate the existing condition score by assessing some, but not all, parameters (see Section 3.4.1 for list of parameters). Parameters that are not assessed will be assigned a standard score.	Permit applicants who want to assess more than the minimum (option 2a), but not all parameters (option 3). Typically used if the existing condition is degraded; select debit option 2a or 2b based on observed impairments and available resources.
3	Full Assessment – Perform existing condition assessment of all applicable parameters. Standard scores are not assumed.	Permit applicants who have the staff and expertise to perform assessments in all five functional categories. Typically used for larger projects, or when the existing channel and contributing watershed are degraded and a cost/benefit analysis proves this option is worthwhile.

2.4. Existing Condition Survey Assessment Methods

When users elect to partially or fully measure the existing condition (i.e., debit options 2a, 2b, or 3), users have the option to use rapid or detailed survey methods to quantify hydraulic and geomorphology metrics that require survey data.

- For the *rapid method*, parameters are quantitatively measured using tapes and stadia rods instead of standard surveying equipment like laser levels or a total station. Profiles cannot be plotted using this method.
- For the *detailed method*, a longitudinal profile is surveyed consisting of at least four profiles: thalweg, water surface, bankfull, and low bank. Standard survey methods can be used to collect these data using a survey-grade GPS, laser or standard level, total station, or similar equipment (Harrelson et al., 1994; Rosgen, 2014).

See Section 3.3 in the SC Data Collection and Analysis Manual (South Carolina Steering Committee, 2021b) for more information.

2.4.1. EXISTING CONDITION STANDARD SCORES

Debit options 1, 2a, and 2b assign standard scores to function-based parameters for the existing condition when the metric is NOT measured/assessed. The standard score is assigned (rather than measured) based on priority category. Priority category is a factor that recognizes the importance of aquatic resources that provide valuable functions and services on a watershed scale, that occupy important positions in the landscape, or that are considered important because of their rarity. Adverse impacts to primary priority areas should be avoided and minimized to the maximum extent practicable (USACE, 2011).

Priority categories are defined as follows and include any project that is within or immediately adjacent (USACE, 2011):

- **Primary Priority** areas include: waters in or adjacent to State Heritage Preserves or Wildlife Management Areas, National Wildlife Refuges, National or State Forests; National Park Service or State Park Lands, Federal Wild and Scenic Rivers; anadromous fish spawning habitat; Outstanding Resource Waters or Outstanding Natural Resource Waters; Essential Fish Habitat; state natural trout streams; waters with Federal/State listed Threatened and Endangered species; or waters that are federally designated critical habitat.
- **Secondary Priority** areas include: 303 (d) listed streams; waters with Federal At-Risk Species; waters with State Wildlife Action Plan conservation priority species; State Trout Put, Grow, and Take or Put and Take streams; stream and river reaches within 0.5 river miles upstream or downstream of a Primary Priority reach; or waters in State Scenic River Corridors.
- **Tertiary Priority** areas include: all other streams.

The Debit Calculator assigns standard scores as follows:

- Primary 1.00
- Secondary 0.80
- Tertiary 0.70

2.4.2. MINIMUM EXISTING CONDITION STANDARD SCORES

The SC Debit Calculator will implement a scoring override for streams that are assessed as having an overall existing condition score less than 0.30. In this scenario, a minimum existing condition score of 0.30 will be assigned. This override ensures that all stream impacts, regardless of the starting condition of the stream, will yield functional loss. This accounts for losses to stream functions that are not included in the SQT.

2.5. Proposed Condition Assessment and Impact Severity Tiers

The SC Debit Calculator assigns a proposed condition score using impact severity tiers for all debit options.

The impact severity tier is a categorical determination of adverse impacts to stream functions, ranging from no loss to total loss. Tier 0 represents no permanent loss of stream functions and Tier 6 represents complete loss of stream functions. Therefore, under a Tier 0 scenario, the applicant would not need to complete the Debit Calculator process.

Each tier is delineated by the severity and magnitude of impacts to stream functions, represented by function-based parameters. As tier number increases, the number of parameters affected and the severity of impacts increase. The impact severity tiers focus on impacts to parameters caused by the activities, rather than the activities themselves. Because the tiers focus on impacts to functions, specific activities may be appropriately assigned to multiple tiers depending on the magnitude of the impact and the particulars of a proposed project. For example, a small bank stabilization project may be a Tier 1 impact if only riparian vegetation and/or lateral migration parameters are impacted. However, if the bank stabilization was large

enough to impact physicochemical and/or biological functions, then the project would be a Tier 4 impact.

Impact severity tier category descriptions, and percent functional loss associated with each tier are presented in Table 3.

Table 3. Impact severity tier category descriptions, example activities, and percent functional loss associated with each tier.

Impact Severity Tier	Impacts to Function-Based Parameters	Functional Loss (%)
Tier 0	No permanent impacts to aquatic functions; impacts do not require compensatory mitigation.	0
Tier 1	Minor impacts, primarily to reach runoff, flow dynamics, riparian vegetation, lateral migration, and some physicochemical and/or biological functions.	10
Tier 2	Minor impacts to reach runoff. Minor to moderate impacts to bed form diversity, flow dynamics, and large woody debris. Typically accompanied by moderate to severe impacts to riparian vegetation and lateral migration. Minor impacts to some physicochemical and/or biological functions.	20
Tier 3	Moderate impacts to reach runoff, bed form diversity, and riparian vegetation. Severe impacts to floodplain connectivity. Moderate to severe impacts to flow dynamics and large woody debris. Minor to moderate impacts to some physicochemical and biology functions.	50
Tier 4	Moderate to severe impacts to most hydraulic and geomorphologic functions. Moderate impacts to physicochemical and biology functions.	70
Tier 5	Severe impacts to all aquatic functions except for hydrology.	80
Tier 6	Total and permanent loss of all aquatic functions.	100

2.5.1. DEVELOPMENT OF IMPACT SEVERITY TIERS AND FUNCTIONAL LOSS VALUES

The functional loss values (%) associated with each impact severity tier were developed by modeling impact activities common in South Carolina streams. The modeling exercise predicts the effect of impact activities on each function-based parameter included in the SQT and Debit Calculator to ultimately determine a range of functional loss for each impact severity tier. By relating the effect of impact activities on function-based parameters, the Debit Calculator shifts the focus from impact activities to stream function, where function-based parameters serve as surrogates for stream functions.

The modeling exercise was an iterative process that followed the steps outlined below:

1. Definitions for impact severity tiers were determined by the steering committee. The definitions outline which parameters are typically impacted and the degree to which each parameter is impacted (i.e., no functional loss, minor loss, moderate loss, severe loss, or complete loss).
 - a. Due to the interconnected nature of stream functions and regulatory minimum thresholds for impacts, impacts to physicochemical and biological functions were attributed to every impact severity tier.
 - b. No mitigation is required for a Tier 0 impact.
2. A data matrix was created to model the functional loss (%) associated with each parameter for each impact severity tier. Functional loss values (%), ranging on a scale of 0 to 100%, were applied as follows: 0% represented no functional loss, 25% represented minor loss, 50% represented moderate loss, 75% represented severe loss, and 100% represented complete loss. Generally, as the impact severity tier increases, the functional loss values (%) increase and the number of parameters impacted increases. Minimum and maximum scenarios were modeled for each tier. Using a range acknowledged the uncertainty in matching a given activity to the impact of a specific function. For each tier minimum and maximum scenarios, a total percent functional loss was calculated using the roll-up scoring method in the SQT (Section 3.5.1.4). Generally, the average of the minimum and maximum total percent functional loss for a given tier was the functional loss value (%) associated with that tier; the steering committee chose to round the total percent functional loss multipliers to the nearest ten.
 - a. For example, functional loss values (%) of 8% and 14% were determined for the Tier 1 minimum and maximum scenarios, respectively. The average of these values is 11% which was rounded to 10%, the nearest ten. Therefore, the functional loss (%) associated with Tier 1 impacts is 10%.
3. Common impact activities were obtained from the USACE Charleston District Compensatory Mitigation Guidelines (2010) and steering committee input. Example activities were ranked by scale of impact and assigned to an impact severity tier based on the definition for each tier (Table 3). Functional loss values (%) were assigned by parameter for each example activity using the values described in step 2. For each example activity, a total percent functional loss was calculated using the roll-up scoring method in the SQT (Section 3.5.1.4). Results were compared with the output matrix from step 2 to determine if the total functional loss values (%) for each tier were reasonable.
4. The output from step 3 was used to:
 - a. Improve data matrix outputs from step 2, i.e., the total functional loss values (%) for each tier.
 - b. Improve impact severity tier definitions.
 - c. Determine whether the number of tiers adequately capture the range of functional loss associated with common South Carolina stream impact activities.

Figure 2 depicts the iterative modeling results: the minimum and maximum functional loss values (%) associated with each functional category for each impact severity tier. Final functional loss values (%) are presented in Table 3. Additionally, the steering committee

determined that six tiers sufficiently expressed the range of functional loss associated with common South Carolina stream impact activities.

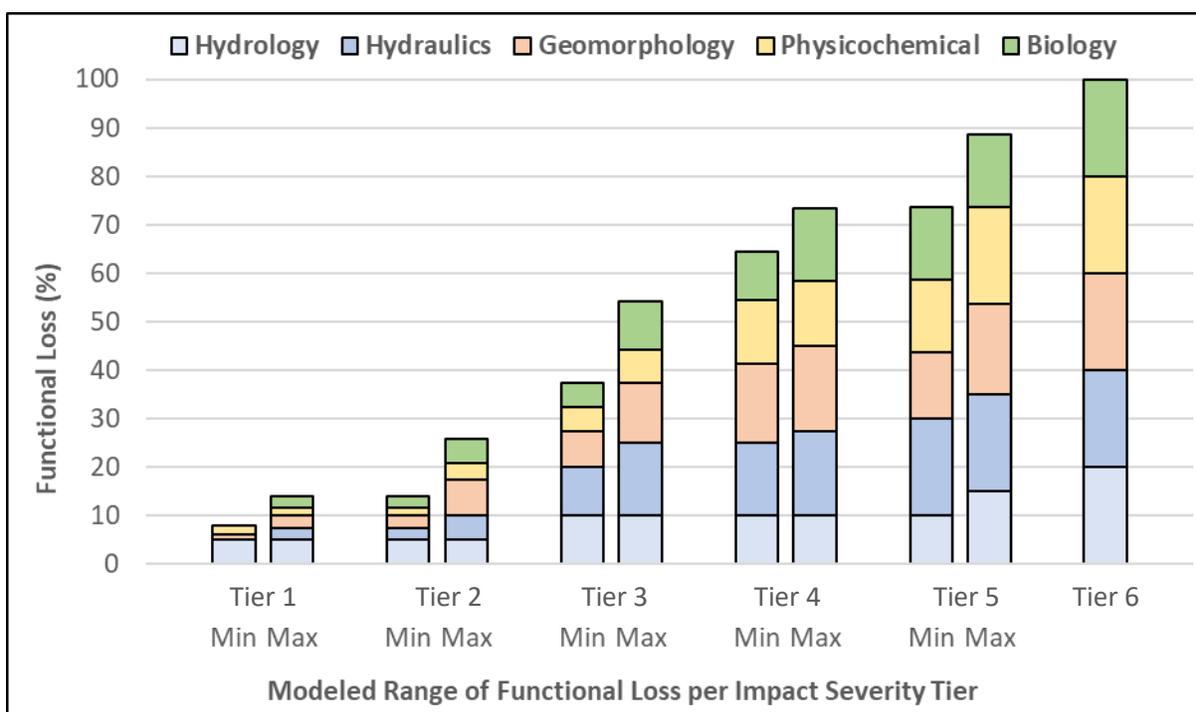


Figure 2. Modeled minimum and maximum functional loss values (%), displayed by functional category, for each impact severity tier.

2.5.2. SCORING IN THE SQT VERSUS DEBIT CALCULATOR

To measure functional change, the SQT and Debit Calculator require measurement of the existing (pre-activity) and proposed conditions (post-activity). When using the Debit Calculator, the existing condition is the condition pre-impact, and the proposed condition is the condition post-impact. The SQT and Debit Calculator outputs existing condition scores (ECSs) and proposed conditions scores (PCSs). In the Debit Calculator, the ECS is a standard score based on priority category (debit option 1) or the overall score output from the existing condition assessment (debit options 2a, 2b, and 3; Section 2.4.1). The PCS automatically calculates based on the selected impact severity tier (Section 2.5) and the ECS.

The SQT determines functional loss and functional lift in units of functional feet (FF). Functional foot scores (FFSs) are calculated using an existing condition score (ECS) and existing stream length or a proposed condition score (PCS) and a proposed stream length. Functional change (ΔFF) is calculated using the proposed FFS and the existing FFS as follows:

- *Existing FFS = Existing Condition Score * Existing Stream Length*
- *Proposed FFS = Proposed Condition Score * Proposed Stream Length*
- *$\Delta FF = Proposed FFS - Existing FFS$*

Functional loss is generated when the PCS is lower than the ECS, and the ΔFF yields a negative value ($-\Delta FF$). Functional lift is generated when the PCS is greater than the ECS, and the ΔFF yields a positive value ($+\Delta FF$). Debits are informed by functional loss ($-\Delta FF$) and credits are informed by functional lift ($+\Delta FF$).

In the Debit Calculator, the existing condition score is calculated using the same equations as in the SQT. However, the Debit Calculator provides existing condition assessment *options*, ranging in level of effort (Section 2.3). The PCS is calculated within the Functional Loss spreadsheet by applying a multiplier to the ECS, as follows:

- $Proposed\ Condition\ Score = Existing\ Condition\ Score * (100 - Functional\ Loss\ [\%])$

Percent functional loss ranges from 0 to 100% and is determined by the impact severity tier. Impact severity tiers are described in Section 2.5. The PCS is calculated as a function of the ECS. Therefore, the functional loss value (%) associated with an impact severity tier is subtracted from 100%. For example, consider an impact to a reach categorized as a Tier 4 impact, where the existing condition score is 0.80. Tier 4 impacts are associated with 70% functional loss (Table 3). Plugging in 0.80 as the ECS variable and 70% (expressed in decimals) as the functional loss variable in the above equation yields a PCS of 0.24 as follows:

- $Proposed\ Condition\ Score = Existing\ Condition\ Score * (100 - Functional\ Loss\ [\%])$
- $0.24 = 0.80 * (100 - 70\ [\% \text{ use decimals}])$

Once the PCS is calculated in the Debit Calculator, the Proposed FFS and Functional Change (ΔFF) are calculated using the equations above.

Chapter 3. South Carolina Debit Calculator Workbook

This chapter outlines content in the Debit Calculator workbook step-by-step. The SC Debit Calculator workbook includes four visible spreadsheets and two hidden spreadsheets. All equations are visible and there are no macros. All spreadsheets are locked to prevent editing in certain cells.

The spreadsheets include:

1. Project Summary
2. Functional Loss
3. Parameter and Metric Selection
4. Existing Conditions (applicable to debit options 2a, 2b, and 3)
5. Reference Standards (hidden) – This contains the linear equations for all the reference curves included in the SQT.
6. Pull Down Notes (hidden) – This spreadsheet contains all the inputs for drop-down menus throughout the workbook.

This chapter describes each of the visible spreadsheets in detail. Reference curves are described in Section 3.5.1.4 in this manual. See the SQT Spreadsheet User Manual for more information on scoring using reference curves.

3.1. Quick Reference Guide for Debit Option 1 Users

Pertinent sections in this chapter are outlined below for debit option 1 users for a quick reference.

Debit option 1: No assessment – Assume standard scores for all required parameters, and complete the following:

- Project Summary spreadsheet (Section 3.2.)
 - Reach Summary table (Section 3.2.1.2.)
 - Adverse Impact Adjustment Factors table (Section 3.2.1.3.)
- Functional Loss spreadsheet (Section 3.3.1.)
 - Functional Loss Summary table (Section 3.3.1.1.)

3.2. Project Summary Spreadsheet

The purpose of the Project Summary spreadsheet is to provide project information, identify and describe the reaches within a project area, and summarize the functional loss and total debits associated with the project. The Project Summary spreadsheet requires the user to provide general and detailed information regarding the proposed project.

3.2.1. COMPONENTS OF THE PROJECT SUMMARY SPREADSHEET

3.2.1.1. *Project Summary Spreadsheet*

Project Name – Provide the name of the project. For example, this could be a developing subdivision, a road project, or commercial and retail space.

Applicant – Identify the name of the person or entity legally responsible for the project.

Project ID / Permit Number(s) – Provide the unique project ID. Or, if applying for a regulatory permit, provide the permit number.

Date – Provide the date the Debit Calculator workbook was completed.

Project Description – Provide a description of the project including the purpose and any associated previous activity or permits.

Total Functional Loss (-ΔFF) – Automatically populates from the Functional Loss spreadsheet once all impacts have been summed.

Total Debits – Sums the results from the Adverse Impact Adjustment Factors table within the Project Summary spreadsheet.

3.2.1.2. *Reach Summary Table*

Figure 3 displays the Reach Summary table as shown on the Project Summary spreadsheet. Data inputs are detailed below.

Reach Summary					
Reach ID	Flow Type	Stream Order	Priority Category	Reach and Impact Description	Functional Loss (-ΔFF)
Reach 1	Perennial	2	Secondary	Rip-rap armoring and culvert installation	

Figure 3. Example Reach Summary table as shown on the Project Summary spreadsheet.

Reach ID – Identify each impact by stream and project reach. For example, STR-1 R-2 would be the second reach of the first stream impacted in the project. If there is only one reach along

the impacted stream, no reach identifier is needed. This information automatically populates the fields in the Functional Loss and Existing Conditions spreadsheets.

Flow Type – Drop down menu with option to select perennial, intermittent, or ephemeral.

Stream Order – Drop down menu with option to select 1, 2, 3, or 4+. Stream order, as defined by Strahler (1957), is a classification system based on stream/tributary relationships. Headwater streams are first order; the stream becomes second order downstream of the confluence of two first order streams; the stream becomes third order downstream of the confluence of two second order streams; and so on.

Priority Category – Drop down menu with option to select primary, secondary, or tertiary. Priority categories are described in Section 2.4.1. This information automatically populates fields in the Functional Loss spreadsheet.

Reach and Impact Description – Describe the proposed impact to the stream. For example, impacts such as 300 linear feet of 6' x 4' culvert, 600 linear feet of full bank hard armoring, or 250 linear feet of stream fill.

Functional Loss (- Δ FF) – Automatically populates the functional loss, or net change in functional feet per project reach from the Functional Loss spreadsheet.

Aerial Photograph of Project Reach – Provide an aerial photograph of the project reach. The photo could include labels indicating where work is proposed, the project easement, and any important features within the project site or catchment.

3.2.1.3. Adverse Impact Adjustment Factors Table

Figure 4 displays the Adverse Impact Adjustment Factors table as shown on the Project Summary spreadsheet. Table items are detailed below.

Adverse Impact Adjustment Factors							
Reach ID	Existing Stream Length (LF)	Stream Type	Stream Type R Factor	Impact Duration	Impact Duration R Factor	Sum of R Factors	Debits (FF)
Reach 1	200	1st and 2nd Order pRPWs	0.8			0.9	
						0.1	
						0.1	
						0.1	
						0.1	
						0.1	
						0.1	
						0.1	
						0.1	
						0.1	
Additional Existing Project Length (ft)			Cumulative Impact R Factor	<div style="border: 1px solid black; padding: 5px; background-color: #ffffcc;"> Note: Add additional length from any additional project workbook(s) if more than one workbook is used. </div>			
Total Existing Project Length (ft)	200		0.1				

Figure 4. Example Adverse Impact Adjustment Factors table as shown on the Project Summary spreadsheet.

Reach ID – Automatically populates from input in the Reach Summary table.

Existing Stream Length – Automatically populates from the Functional Loss spreadsheet.

Additional Existing Project Length – Input additional length from any additional project workbook(s) if more than one workbook is used.

Total Existing Project Length – Sums the total existing project length, including each reach’s existing stream length and any additional existing project length in other workbooks. This value is used to determine the Cumulative Impact R Factor, described below.

Stream Type – Automatically populates based on stream order input in the Reach Summary table. Flow types that are ephemeral or intermittent are assigned “Non-RPW” for non-relatively permanent waters, stream orders 1 and 2 that are also perennial are assigned “1st and 2nd order pRPWs” for perennial relatively permanent waters, and streams orders 3 and 4+ are assigned “All Other Streams” (USACE, 2011):

- **Non-Relatively Permanent Waters (Non-RPW)** are non-navigable tributaries that are not relatively permanent (i.e., the tributaries typically do not have continuous flow for at least 3 months of the year).
- **1st and 2nd Strahler Stream Order Perennial RPWs (pRPWs)** are non-navigable tributaries of traditional navigable waters that are relatively permanent where the tributaries typically have continuous flow at least seasonally (e.g., typically three months).
- **All Other Streams** include greater than 2nd order tributaries and traditional navigable waters.

Stream Type R Factor – Automatically populates the R factor (adjustment factor) based on stream type. **Stream type** categories are based on the suite of functions that they perform and are defined as follows per the Guidelines for Preparing a Compensatory Mitigation Plan (USACE, 2011):

- **Non-Relatively Permanent Waters:** The Debit Calculator automatically populates a value of 0.1 for non-RPWs.
- **1st and 2nd Strahler Stream Order Perennial RPWs:** The Debit Calculator automatically populates a value of 0.8 for 1st and 2nd Order perennial RPWs.
- **All Other Streams:** The Debit Calculator will automatically populate a value of 0.4 for all other streams.

Cumulative Impact – The impact on the environment, which results from the incremental impact of an action when added to other past, present, and reasonably foreseeable future actions regardless of what agency, or person undertakes such other actions, as defined by the National Environmental Policy Act. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time.

Cumulative Impact R Factor – Automatically populates the R Factor (adjustment factor) based on the cumulative impact based on the linear feet of stream impacted (Table 4).

Table 4. Adverse impact adjustment factor values for cumulative impact (linear feet) per the Guidelines for Preparing a Compensatory Mitigation Plan (USACE, 2011).

Cumulative Impact in Linear Feet	Cumulative Impact R Factor Value
50 feet or less	0.01
51 – 300	0.10
301 – 500	0.20
501 – 999	0.40
1000 – 6000	1.5
Greater than 6000 feet	3.0

Impact Duration – Drop down menu with the option to select temporary, recurrent, or permanent. **Impact duration** means the length of time the adverse impacts are expected to last per the Guidelines for Preparing a Compensatory Mitigation Plan (USACE, 2011):

- **Temporary** means impacts will occur for a period of one year or less and restoration of the aquatic system will occur following termination of the permitted activity.
- **Recurrent** refers to repeated impacts of short duration (such as on-channel 24-hour storm detention).
- **Permanent** means project impacts will occur for a period of greater than one year.

Impact Duration R Factor – Automatically populates the R Factor (adjustment factor) based on the impact duration. **Impact duration** categories are defined as follows per the Guidelines for Preparing a Compensatory Mitigation Plan (USACE, 2011):

- **Temporary:** The Debit Calculator automatically populates a value of 0.05 for temporary impacts.
- **Recurrent:** The Debit Calculator automatically populates a value of 0.1 for recurrent impacts.
- **Permanent:** The Debit Calculator automatically populates a value of 0.3 for permanent impacts.

Sum of R Factors – Automatically sums the R Factors (adjustment factors) associated with stream type, cumulative impact, and impact duration.

Debits – Automatically calculates the debits by multiplying functional loss (- Δ FF) with the Sum of R Factors associated with each respective reach.

3.3. Functional Loss Spreadsheet

The Functional Loss spreadsheet is the main sheet in the SC Debit Calculator workbook where users enter data to describe the existing stream reach and the impact activity. By selecting an impact severity tier, functional loss is quantified. Cells that allow input are shaded grey and most other cells are locked. Each component of the Functional Loss spreadsheet is discussed below.

Users enter data and make selections on this spreadsheet to quantify functional loss per project reach. Up to 10 reaches can be entered into one Debit Calculator workbook. The spreadsheet automatically sums the total functional loss on the Project Summary spreadsheet. If more than 10 reaches are located in a project area, the user must use an additional Debit Calculator workbook. The additional project lengths from any additional Debit Calculator workbooks must be entered into the Project Summary spreadsheet in the Additional Existing Project Length cell of the Adverse Impact Adjustment Factors table.

3.3.1. COMPONENTS OF THE FUNCTIONAL LOSS SPREADSHEET

3.3.1.1. **Functional Loss Summary Table**

Figure 5 depicts the Functional Loss Summary table where users enter data including the debit option, the impact severity tier, and the stream length for the existing and proposed conditions. Table items are detailed below.

FUNCTIONAL LOSS SUMMARY									
Reach ID	Priority Category	Debit Option	Existing Stream Length	Proposed Stream Length	Existing Condition Score (ECS)	Impact Severity Tier	Proposed Condition Score (PCS)	Functional Loss (-ΔFF)	Flow Type and Stream
Reach 1	Secondary	2a	200	200	0.66	Tier 2	0.53	-26	P2
0	0								
0	0								
0	0								
0	0								
0	0								
0	0								
0	0								
0	0								
0	0								
Functional Loss (-ΔFF)								-26	

Figure 5. Example Functional Loss Summary table from the Functional Loss spreadsheet.

Reach ID – Automatically populates from the Project Summary spreadsheet.

Priority Category – Automatically populates from the Project Summary spreadsheet.

Debit Options – Drop down menu with option to select one of the four debit options for determining the existing site conditions. These options (1, 2a, 2b, and 3) are described in Section 2.3. Please note, debit options can vary for each stream reach within the project area. Coordinate with any regulating agencies to select parameters and metrics based on your reach-specific setting and proposed impacts.

Existing Stream Length – Calculate the length of the stream that will be directly impacted by the permitted activity. Stream length should be measured along the centerline of the channel prior to impact, such as measuring the channel length of the stream before a culvert is installed.

Proposed Stream Length – Calculate the length of stream channel after the impact has occurred. For pipes, the proposed length is the length of the pipe at a minimum. If the stream will be straightened by the permitted activity, the proposed length will be less than the existing length. **Proposed stream lengths should not be longer than the impact length; the debit calculator will highlight the cell if the existing stream length is shorter than the proposed stream length.** Streams cannot be lengthened by pipes. Therefore, a 300-foot pipe along 275 feet of stream will only impact 275 linear feet of stream.

Existing Condition Score (ECS) – Represents pre-activity condition on a scale of 0.00 to 1.00. Standard ECS values automatically populate in this column once the debit option is selected (and after the priority category is selected on the Project Summary spreadsheet). For debit

options 2a, 2b, and 3 where the existing condition is partially or fully assessed, users can input data in the Existing Conditions spreadsheet to update the ECS score in the functional loss summary table.

Impact Severity Tier – Drop down menu to select an impact severity tier in order to calculate a proposed condition score. The impact severity tier is a categorical determination of the amount of adverse impact to stream functions, ranging from no loss to total loss from a proposed activity (Section 2.5).

Proposed Condition Score (PCS) – Automatically calculates using the selected impact severity tier and the ECS. Represents post-impact condition on a scale of 0.00 to 1.00. Section 2.5 describes how the PCS is calculated.

Functional Loss (- Δ FF) – Automatically calculates the change in functional feet associated with the ECS and PCS. Section 2.5 describes how Δ FF are calculated.

Flow Type and Stream Order – A label describing flow type and stream order (e.g., P2 for a perennial, second order stream) automatically populates based on stream order and flow type inputs on the Project Summary spreadsheet. Flow type and stream order (Strahler, 1957) provide context for the Δ FF value generated. This label helps match impacted stream systems to mitigation stream systems, thus, avoiding out-of-kind mitigation.

3.3.1.2. Debit Option Summary Table

This table outlines instructions to assess the ECS and PCS for each debit option. Debit options are described in Section 2.3.

3.3.1.3. Existing Condition Standard Scores Table

When debit option 1 is selected, this table summarizes the standard scores used for the existing condition based on the priority category (e.g., primary, secondary, or tertiary). The Existing Conditions spreadsheet also uses these values to score any parameters that are not assessed for debit options 2a and 2b.

3.3.1.4. Existing Condition Score Summary Table

When debit options 2a, 2b, or 3 are used, this table summarizes the overall ECSs from each condition assessment in the Existing Conditions spreadsheet. The values in this table are presented in the order they are entered into the Project Summary spreadsheet. Users should ensure they have entered the data for the correct reach in the Existing Conditions spreadsheet.

3.3.1.5. Impact Severity Tier Summary Table

This table summarizes functional loss (%) and description of impacts to function-based parameters associated with each impact severity tier. Impact severity tiers are described in Section 2.5.

3.4. Parameter and Metric Selection Spreadsheet

This spreadsheet applies to an applicant that elects to assess some or all of the existing condition by choosing debit options 2a, 2b, or 3. Recall that if an applicant elects to not measure a parameter, a standard score will be assumed for each parameter that is not measured based on priority category type. Thus, the Debit Calculator will quantify a condition score using all five functional categories regardless of the debit option selected.

For each debit option, this spreadsheet outlines which parameters and metrics are required or optional. The information in this spreadsheet is duplicated below to provide additional instructions for parameter and metric selection by debit option and applicability to the landscape.

3.4.1. DEBIT OPTIONS

Debit option 2a requires measurement of five parameters, listed below. The tool will assume values for bed form diversity, riparian vegetation, physicochemical, and biology parameters. The exception to the list below is if the parameter is not applicable (see Section 3.4.2).

- Reach Runoff
- Floodplain Connectivity
- Flow Dynamics
- Large Woody Debris
- Lateral Migration

Debit option 2b requires measurement of seven parameters, listed below. The tool will assume values for physicochemical and biology parameters. The exception to the list below is if the parameter is not applicable (see Section 3.4.2).

- Reach Runoff
- Floodplain Connectivity
- Flow Dynamics
- Large Woody Debris
- Lateral Migration
- Riparian Vegetation
- Bed Form Diversity

Debit option 3 requires measurement of all parameters within all five functional categories, listed below, with exceptions for the macroinvertebrate parameter.

- Floodplain Connectivity
- Flow Dynamics
- Large Woody Debris
- Lateral Migration
- Riparian Vegetation
- Bed Form Diversity
- Temperature
- Bacteria
- Nitrogen
- Phosphorus
- Macroinvertebrates (where an applicable reference curve exists)

3.4.2. PARAMETER AND METRIC APPLICABILITY

Even if a parameter is required by a debit option, it will only be measured if it is also applicable to the stream system at the project site. Information on parameter and metric selection based on applicability to the landscape, presented below, is organized by functional category and function-based parameter.

Hydrology

Reach runoff: This parameter is applicable to all stream systems. Land use coefficient and concentrated flow point metrics are applicable to all stream systems.

Hydraulics

Floodplain Connectivity: This parameter is applicable to all stream systems. Bank height ratio (BHR) is applicable to all stream systems. Entrenchment ratio (ER) is applicable to all single-thread perennial and intermittent stream systems.

Flow Dynamics: This parameter is applicable to all single-thread stream systems. Width/depth ratio state is applicable to all single-thread perennial and intermittent stream systems.

Geomorphology

Large Woody Debris (LWD): This parameter is applicable to all stream systems. Users have an option to evaluate either the large woody debris index (LWDI) or LWD piece count metric, but not both.

- *LWDI* characterizes the quantity and quality of large woody debris in the stream channel.
- *LWD piece count* (number per 100 meters) characterizes the quantity of large woody debris in the stream channel.

Lateral Migration: This parameter is applicable to all stream systems. Additionally, applicability varies based on metric:

- *Dominant bank erosion hazard index/near-bank stress (BEHI/NBS)* and *percent streambank erosion* metrics are evaluated together. Dominant BEHI/NBS and percent streambank erosion metrics are applicable to single-thread channels only.
- *Erosion rate* (feet per year) is measured in substitute of dominant BEHI/NBS and percent streambank erosion.
- *Percent streambank armoring (%)* is assessed when armoring techniques are present or proposed in the project reach.

Riparian Vegetation: This parameter is applicable to all stream systems. Buffer width (feet), average diameter at breast height (DBH), and tree density (number/acre) are applicable to all stream systems. In addition to those three metrics, users should measure the following metrics when applicable:

- *Native shrub density* (number/acre) is measured IF the riparian vegetation community consists of pastureland, cropland, or other land uses without existing trees that renders the canopy cover at <20%.
- *Native herbaceous cover* (%) is measured IF the area adjacent to the project reach is or should be a Piedmont prairie vegetation community.
- *Monoculture Area* (%) is measured IF silviculture operations are present or proposed within the project area.

Bed Form Diversity: This parameter is applicable to all single-thread perennial and intermittent stream systems; this parameter is specifically not applicable to multi-thread systems. Pool spacing ratio (feet per feet), pool depth ratio (feet per feet), and percent riffle (feet per feet) are applicable to all single-thread, perennial, or intermittent streams.

Physicochemical

Note: *Physicochemical and biology functional categories were not regionalized for the SC SQT version 1 and select parameters, metrics, and reference curves were carried over from the NC SQT (version 4, in progress).*

Temperature, Bacteria, Nitrogen, and Phosphorus: These parameters are applicable to all wadeable stream systems. A specific limitation for the temperature parameter is listed below:

- *Summer daily maximum* (° F) is only applicable to coldwater streams and is recommended for streams that are designated Trout (Natural; Put, Grow, and Take; and Put and Take) streams under S.C. Code of Regulation 61-69.

Biology

Macroinvertebrates: This parameter is applicable to perennial and intermittent stream systems.

- Note, the macroinvertebrate parameter was carried over from the NC SQT and requires future regionalization in South Carolina. Thus, not all regions in South Carolina have applicable reference curves for macroinvertebrates. If a project lies outside of the ecoregions and river basins shared with North Carolina, scoring is not available in the SQT and Debit Calculator version 1.

Fish: DNR is working to develop an index of biotic integrity (IBI) for fish. At this time, the NC IBI remains in the SQT and Debit Calculator version 1 solely as a placeholder for ease of insertion of the SC IBI when it is developed. The NC IBI is not available for use in the SC SQT or Debit Calculator and does not contribute to scoring in the Debit Calculator.

3.5. Existing Conditions Spreadsheet

The Existing Conditions spreadsheet is the calculator that quantifies the existing condition prior to a permitted impact for **debit options 2a, 2b, and 3**. Recall that standard scores are assumed for all parameters not measured for debit options 2a, 2b, and 3. Standard scores are based on priority category as described in Section 2.4.1.

Users enter existing condition data into this spreadsheet for each project reach assessed. Users should ensure they have entered the data for the correct reach in the Existing Conditions spreadsheet. There is space to input data for 10 reaches. If a project has more than 10 reaches, an additional Debit Calculator workbook will need to be used.

3.5.1. COMPONENTS OF THE EXISTING CONDITIONS SPREADSHEET

3.5.1.1. *Site Information and Reference Standard Stratification Table*

The Site Information and Reference Standard Stratification section is shown in Figure 6. Users input values into the gray cells and select inputs from the drop-down menus in the blue cells. White cells within this table are locked from editing and the input is provided by the user on the Project Summary and Functional Loss spreadsheets. **Instructions for collecting data for this table are provided in the Data Collection and Analysis Manual (South Carolina Steering Committee, 2021b)**, with the exception of latitude and longitude.

Many of the fields in this table are linked to the selection of parameters, metrics, and reference curves, known as *stratification*. Where reference curves for a metric are stratified, the index value calculation cells will use the input provided in this table to select the appropriate reference curves. Note that incorrect information in the Site Information and Reference Standard Stratification Table may result in applying reference curves that are not suitable for the project, affecting site scoring.

Site Information and Reference Standard Stratification							
Reach ID:	Reach 1	Ecoregion:	Blue Ridge Mountains	Buffer Valley Slope (%):	21 - 40 %	Upstream Latitude:	35.12
Priority Category:	Secondary	Existing Stream Type:	B	Dominant Buffer Land Use:	Commercial / Golf Course / Agriculture /	Upstream Longitude:	-82.63
Debit Option:	2b	Reference Stream Type:	B	Canopy Cover (%):	> 20 %	Downstream Latitude:	25.12
Stream Order:	2	Valley Type:	Confined Alluvial	Stream Temperature:	Coldwater	Downstream Longitude:	-82.62
Flow Type:	Perennial	River Basin:	Broad	Macroinvertebrate Sampling Method:			

Figure 6. Site Information and Reference Standard Stratification input fields.

3.5.1.2. *Existing Condition Assessment Table*

In the Existing Condition Assessment table, metrics are listed by functional category and then parameter (Figure 7). Under the Field Value column in the Existing Condition Assessment table, users input values into the gray cells and select inputs from the drop-down menus in the blue cells. Field values are a measurement or calculation input into the Debit Calculator for a specific metric. Units and scale vary by metric (see Table 5). The column to the right of the Field Value column is the Index Value column. Index values are dimensionless values between 0.00 and 1.00 that express the relative condition of a metric field value compared with reference condition (Section 3.5.1.4). Index values are automatically calculated when metric field values are entered (Figure 7).

Following the example presented in Figure 6, the applicant implemented debit option 2b for a “secondary” priority category reach. Therefore, the applicable parameters and metrics within the hydrology, hydraulics, and geomorphology categories were assessed (Figure 7). In this debit option 2b example, physicochemical and biology metrics were not measured; therefore, standard scores were assumed, which occurs at the parameter level (Figure 7). Prior to data entry, the existing conditions assessment table will depict a standard score of 0.80 for all parameter, category, and ECS scores. Standard ECS scores of 0.80 are assumed for “secondary” priority category reaches (see Section 2.4.1). If the priority category had been “primary” the existing condition assessment table would depict 1.00 for the parameter, category, and ECS scores. Similarly, if the priority category had been “tertiary” the existing condition assessment table would depict 0.70 for the parameter, category, and ECS scores.

EXISTING CONDITION ASSESSMENT					Roll-Up Scoring			
Functional Category	Function-Based Parameter	Metric	Field Value	Index Value	Parameter	Category	Category	ECS
Hydrology	Reach Runoff	Land Use Coefficient	60	0.78	0.74	0.74	Functioning	0.66
		Concentrated Flow Points (#/1000 LF)	2	0.70				
Hydraulics	Floodplain Connectivity	Bank Height Ratio (ft/ft)	2	0.00	0.35	0.49	Functioning At Risk	
		Entrenchment Ratio (ft/ft)	1.4	0.7				
	Flow Dynamics	Width/Depth Ratio State (O/E)	0.7	0.63				
Geomorphology	Large Woody Debris	LWD Index	265	0.52	0.52	0.45	Functioning At Risk	
		LWD Piece Count (#/100m)						
	Lateral Migration	Erosion Rate (ft/yr)			0.33			
		Dominant BEHI/NBS	M/M	0.50				
		Percent Streambank Erosion (%)	23	0.49				
		Percent Streambank Armoring (%)	35	0.00				
	Riparian Vegetation	Buffer Width (ft)	50	0.16	0.59			
		Average DBH (in)	8	0.86				
		Tree Density (#/acre)	100	0.74				
		Native Shrub Density (#/acre)						
		Native Herbaceous Cover (%)						
Monoculture Area (%)								
Bed Form Diversity	Invasive/Non-native Cover (%)	25						
	Pool Spacing Ratio (ft/ft)	6	0.23	0.35				
	Pool Depth Ratio (ft/ft)	2	0.30					
Percent Riffle (%)	80	0.51						
Physicochemical	Temperature	Summer Daily Maximum (°F)			0.80	0.80	Functioning	
	Bacteria	Fecal Coliform (Cfu/100 ml)			0.80			
	Nitrogen	Total Nitrogen (mg/L)			0.80			
	Phosphorus	Total Phosphorus (mg/L)			0.80			
Biology	Macroinvertebrates	EPT Taxa Present			0.80	0.80	Functioning	
	Fish	North Carolina Index of Biotic Integrity						

Figure 7. Existing condition results for a debit option 2b assessment of a “secondary” priority category reach. In this example, physicochemical and biology metrics were not measured; therefore, standard scores of 0.80 (“secondary” priority category) were assumed, which occurs at the parameter level (Parameter column under Roll-Up Scoring). Roll-Up Scoring results in an overall ECS score of 0.66.

3.5.1.3. Common Data Entry Errors and Tips

FALSE Return

When a field value is entered into the Existing Condition Assessment table, the neighboring index value cell checks the data in the Site Information and Reference Standard Stratification section and either returns an index value based on the appropriate reference curve or returns FALSE (Figure 8). A FALSE is returned when:

- Data are missing from the Site Information and Reference Standard Stratification Table on the Existing Conditions spreadsheet (Figure 6).
- or
- Reference curves do not exist for the selected input. For example, the summer daily maximum temperature metric only has reference standards for coldwater streams. If the project reach classifies as warmwater, then the field value will return FALSE.

Metric	Field Value	Index Value
Pool Spacing Ratio	3.4	FALSE
Pool Depth Ratio	1.8	FALSE
Percent Riffle (%)	40	0.00

Figure 8. Index value errors.

Erroneous Index Value

If the spreadsheet does not return an index value as expected, the user should check the Site Information and Reference Standard Stratification Table for that reach for data entry errors. Then, check the stratification information provided in Appendix A of the SC SQT Spreadsheet User Manual (South Carolina Steering Committee, 2021b) to see if there are reference curves applicable to the project location. Incorrect information in the Site Information and Reference Standard Stratification Table may result in applying reference curves that are not suitable for the project.

Expected Range of Metric Field Values

Table 5 provides the expected range of values for each metric. **Guidance on collecting and analyzing data to calculate field values for the condition assessments is provided in the Data Collection and Analysis Manual (South Carolina Steering Committee, 2021b).** Additionally, Appendix A in the SQT User Manual includes a list of all function-based parameters, metrics, reference curve thresholds, and applicable references for reference standards.

Table 5. Expected range of values for metric field values.

Metric	Field Value Range	Metric	Field Value Range
Land Use Coefficient	0.0 – 100.0	Native Shrub Density (#/Ac)	≥ 0

Metric	Field Value Range	Metric	Field Value Range
Concentrated Flow Points (#/1000 LF)	≥ 0.00	Native Herbaceous Cover (%)	0 – 100
Bank Height Ratio	≥ 1.00	Monoculture Area (%)	0 – 100
Entrenchment Ratio	≥ 1.00	Invasive/Non-native Cover (%) ¹	0 – 100
Width/Depth Ratio State	≥ 0	Pool Spacing Ratio	≥ 0.0
LWD Index	≥ 0	Pool Depth Ratio	≥ 1.00
LWD Piece Count (#/100m)	≥ 0	Percent Riffle (%)	≥ 0.0
Erosion Rate (ft/yr)	≥ 0	Summer Daily Maximum (°F)	≥ 0.0
Percent Streambank Erosion (%)	0 – 100	Fecal Coliform (CFU/100 ml)	≥ 0
Percent Streambank Armoring (%)	0 – 100	Total Nitrogen (mg/L)	≥ 0.00
Buffer Width (ft)	≥ 0	Total Phosphorus (mg/L)	≥ 0.000
Average DBH (in)	≥ 0.0	EPT Taxa Present	≥ 0
Tree Density (#/Ac)	≥ 0	North Carolina Index of Biotic Integrity	12 - 60

¹ This metric is for tracking purposes only. It is not used for scoring and is only included in the monitoring condition assessments.

3.5.1.4. Scoring the Existing Condition

Metrics in the SQT and Debit Calculator are linked to reference curves that relate measured field values to a function index scale ranging from 0.00 to 1.00. The function index scale rates field values relative to departure from the reference condition in the region. The function index value range is standardized across metrics by determining how field values relate to functional capacity (i.e., functioning, functioning-at-risk, and not-functioning conditions; Table 6). The Debit Calculator and SQT use the same reference curves to score metrics. Reference curves can be viewed in the SQT workbook.

Table 6. Functional capacity definitions used to define reference standards, copied from the SC SQT Spreadsheet User Manual (South Carolina Steering Committee, 2021b).

Functional Capacity	Definition	Index Score Range
Functioning (F)	A functioning value means that the metric is quantifying the functional capacity of one aspect of a function-based parameter in a way that fully supports aquatic ecosystem structure and function . The reference condition concept aligns with the definition for a reference condition for biological integrity (Stoddard et al., 2006). A score of 1.00 represents an unaltered or pristine condition (native or natural condition). The range of values (0.70-1.00) accounts for natural variability in high-quality reference datasets and the potential for these datasets to include minimally and least disturbed sites.	0.70 to 1.00
Functioning-at-risk (FAR)	A functioning-at-risk value means that the metric is quantifying one aspect of a function-based parameter in a way that may support aquatic ecosystem structure and function , but not at a reference condition. In many cases, this indicates the parameter is adjusting in response to changes in the reach or the catchment towards lower or higher function.	0.30 to <0.70
Not functioning (NF)	A not functioning value means that the metric is quantifying or describing one aspect of a function-based parameter in a way that does not support aquatic ecosystem structure and function . An index value less than 0.30 represents an impaired or severely altered condition relative to reference condition; an index value of 0.00 represents a condition that provides no functional capacity for that metric.	0.00 to <0.30

Roll-up Scoring

Scoring occurs automatically as field values are entered into the existing condition assessments. The SQT uses a roll-up scoring process as follows (see Figure 7):

- The reference curve outputs an index value ranging from 0.00 to 1.00 for a given metric based on the user input metric field value.
- Index values are averaged per parameter to calculate parameter scores. For metrics that are not assessed (i.e., a field value is not entered), the metric is removed from the scoring and no index value is provided. It is NOT counted as a zero for the parameter score calculation.

- Parameter scores are averaged per functional category to calculate functional category scores.
- Functional category scores are weighted evenly and summed to calculate an overall condition score.

Scoring Exceptions

There are three scoring exceptions in the SQT and Debit Calculator:

- **Width/Depth Ratio State (O/E):** The width/depth ratio state metric captures problems associated with aggradation (width/depth ratio is larger than reference value) and incision (width/depth ratio is less than reference value). A width/depth ratio that is smaller than the reference width/depth ratio is only a problem if the channel is incised, as indicated by the BHR. Thus, when a field value less than 1 is entered into the Debit Calculator for the width/depth ratio state metric, the index value calculation will check whether the BHR is greater than 1.2. If BHR is greater than 1.2, then the reference curve will be used to calculate the index value. If BHR is less than or equal to 1.2, then the reference curve is not used to compute the index value and instead, a 1.00 index value is assigned.
- **Percent Streambank Armoring:** The percent streambank armoring metric captures problems associated with hardened, streambank armoring techniques. If present or proposed armoring techniques exceed 50% of the project reach, then the lateral migration parameter will score a 0.00 and the other lateral migration metrics (BEHI/NBS and percent streambank erosion) do not need to be assessed. At this magnitude, the armoring is so pervasive that lateral migration processes would likely have no functional value.
- **North Carolina Index of Biotic Integrity for Fish:** Users are instructed to not use this metric in the SC SQT and Debit Calculator v1.0. This metric is a placeholder until the SC biotic index for fish is complete. The metric is excluded from the roll-up scoring process in the Debit Calculator so that a standard score for the existing condition is not assumed and included in scoring.

Chapter 4. References

- Harman, W.A. and C.J. Jones. 2017. North Carolina Stream Quantification Tool: Spreadsheet User Manual, NC SQT v3.0. Environmental Defense Fund, Raleigh, NC.
- Harman, W.A., Starr, R., Carter, M., Tweedy, K., Clemmons, M., Suggs, K., & Miller, C. 2012. A Function-Based Framework for Stream Assessment and Restoration Projects. US Environmental Protection Agency, Office of Wetlands, Oceans, and Watersheds, Washington, DC EPA 843-K-12-006.
- Harrelson, C.C., Rawlins, C.L. & Potyondy, J.P. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RMRS-GTR-245. US Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.
- Leopold L.B. 1994. A View of a River. Cambridge (MA): Harvard University Press, Harvard University.
- Michigan Department of Environment, Great Lakes, and Energy (EGLE). 2020. Michigan Stream Quantification Tool: Spreadsheet User Manual, MiSQT v1.0., EGLE, Lansing, MI.
- Minnesota Stream Quantification Tool Steering Committee (MNSQT SC). 2019. Minnesota Stream Quantification Tool and Debit Calculator (MNSQT) User Manual, Version 1.0. U.S. Environmental Protection Agency, Office of Wetlands, Oceans and Watersheds (Contract # EP-C-17-001), Washington, D.C.
- Rosgen, D.L. 1996. Applied River Morphology. Fort Collins (CO): Wildland Hydrology Books.
- Rosgen, D.L. 2014. River Stability Field Guide, Second Edition. Fort Collins (CO): Wildland Hydrology Books.
- South Carolina Steering Committee. 2021a. South Carolina Stream Quantification Tool: Spreadsheet User Manual, SC SQT v1.0. South Carolina Department of Natural Resources, Columbia, SC.
- South Carolina Steering Committee. 2021b. South Carolina Stream Quantification Tool: Data Collection and Analysis Manual, SC SQT v1.0. South Carolina Department of Natural Resources, Columbia, SC.
- Stoddard, J.L., Larsen, D.P., Hawkins, C.P., Johnson, R.K. & Norris, R.H. 2006. Setting Expectation for the Ecological Condition of Streams: The Concept of Reference Condition. *Ecological Applications*, 16(4): 1267-1276.
- Strahler, A.N. 1957. Quantitative Analysis of Watershed Geomorphology. *Transactions, American Geophysical Union*, 38: 913-920. <http://dx.doi.org/10.1029/TR038i006p00913>.
- Tennessee Department of Environment and Conservation (TDEC). 2018. Tennessee Stream Quantification Tool: Spreadsheet User Manual. TN SQT v1.0. Nashville (TN): Tennessee Department of Environment and Conservation.

https://www.tn.gov/content/dam/tn/environment/water/documents/ppo_water_arap-tn-sqt-spreadsheet-user-manual-DRAFT.PDF

- United States Army Corps of Engineers (USACE), Department of Defense, & United State Environmental Protection Agency (USEPA). 2008. Compensatory Mitigation for Losses of Aquatic Resources: Final Rule. 33 CFR Parts 325 and 332 & 40 CFR Part 230. [EPA–HQ–OW–2006–0020; FRL–8545–4].
- United States Army Corps of Engineers. 2010. Guidelines for Preparing a Compensatory Mitigation Plan. Charleston District, South Carolina.
- United States Army Corps of Engineers. 2018a. Wyoming Stream Quantification Tool (WSQT) User Manual and Spreadsheet. Version 1.0, Omaha District, Wyoming Regulatory Office, Cheyenne Wyoming.
- United States Army Corps of Engineers. 2018b. Georgia Interim Stream Quantification Tool and User Manual. In: 2018 Standard Operating Procedures for Compensatory Mitigation. Buford (GA): USACE Savannah District, Georgia Regulatory Branch.
- United States Army Corps of Engineers. 2020. Colorado Stream Quantification Tool (CSQT). User Manual and Spreadsheets. Version 1.0. U.S. Army Corps of Engineers, Albuquerque District, Pueblo Regulatory Office.

Appendix A. Practical Examples