Colorado Stream Quantification Tool and Debit Calculator

Review Checklist

September 2021

Prepared For: **Army Corps of Engineers**

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Contents

Appendices

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1. Introduction

The Colorado Stream Quantification Tool (CSQT) is a function-based stream assessment tool developed through a collaborative partnership between federal and state agencies in Colorado. The CSQT evaluates the change in functional capacity (i.e., departure from reference conditions) for Clean Water Act Section 404 (CWA) compensatory mitigation projects and permitted impacts using the CSQT workbook and the Debit Calculator (DC) workbook, respectively. CSQT version 1.0 was released for use in all regions of Colorado in July 2020. The U.S. Army Corps of Engineers (USACE) Albuquerque and Omaha Districts contracted with Stream Mechanics and Ecosystem Planning and Restoration to produce the Colorado Stream Quantification Tool and Debit Calculator Review Checklist (Checklist; PDF provided in Appendix 1). The purpose of the Checklist and this document is to provide practitioners and regulators with a rapid method to determine:

1. Whether sufficient data are provided;
2. Whether the practitioner followed the methods outlined in the CSQT User Manual (USACE 2020a) to collect data and calculate field values; and
3. Whether the field values are reasonable.

The Checklist provides a method to ensure accuracy in the CSQT stream assessment. The Checklist does not review the project design.

The Checklist is comprised of four worksheets, and directions for each worksheet are presented as follows:

1. Introduction worksheet (this chapter).
2. Package Completeness (PC) worksheet is described in Chapter 2.
3. Existing (Pre-Project) Assessment (EA) and Proposed (Post-Project) Assessment (PA) worksheets are described in Chapter 3.

The Checklist and this document provide direction on priority areas to review, identification of errors or inaccuracies, and additional information and tips to assist the regulator in determining the accuracy and completeness of a CSQT or Debit Calculator submittal package.

To avoid redundancy, the document will refer to the CSQT User Manual where possible (UM; USACE 2020a).

General Checklist Overview

Depending on the type of submittal, the contents of the Checklist will vary based on data that is entered in the **Introduction** worksheet. Specifically, VBA macros are used to determine which worksheets are hidden or visible (Table 1) and to hide specific items/rows within visible worksheets. For example, the **Existing** and **Proposed Assessment** worksheets and certain questions within **Package Completeness** worksheet are not applicable to a Debit Calculator submittal where no assessment was performed (e.g., Debit Option 3 for all reaches); these checklist items will be hidden when Debit Option 3 is selected on the Introduction worksheet. Hidden worksheets and rows can be unhidden by the reviewer if needed. For these features to work, the user must enable macros for the workbook. The Checklist is fully functional without macros enabled, and the reviewer can determine which questions are applicable to the project being reviewed.

Depending on the type of submittal, reviewers may also have to complete Checklist items in the **Existing Assessment (EA)** and/or **Proposed Assessment (PA)** worksheets (Table 1).

Table 1. Checklist worksheets applicable for different submittals

For **CSQT workbook** submittals that are **calculating lift/loss** using the existing and proposed condition assessments on the Quantification Tool worksheet, the reviewer completes: ➢ PC worksheet (see Chapter 2 for instruction) ➢ EA worksheet (Chapter 3) ➢ PA worksheet (Chapter 3)	For **CSQT workbook** submittals for **monitoring** reports, the reviewer completes: ➢ PC worksheet (Chapter 2) ➢ PA worksheet (Chapter 3)
For **Debit Calculator** submittals that use **Debit Option 3 for all reaches** in the project, the reviewer completes: ➢ PC worksheet (Chapter 2) If any reaches in the project area use **Debit Option 2,** the reviewer completes**:** ➢ PC worksheet (Chapter 2) ➢ EA worksheet (Chapter 3)	For **Debit Calculator** submittals where **any reach utilizes Debit Option 1**, the reviewer completes: ➢ PC worksheet (Chapter 2) ➢ EA worksheet (Chapter 3) ➢ PA worksheet (Chapter 3)

The **Package Completeness (PC)** worksheet described in Chapter 2 will be used for all submittals. Some questions in the Package Completeness checklist are labeled as **CSQT, DC,** or **Monitoring** to indicate whether they apply to the **CSQT workbook (CSQT)**, **Debit Calculator workbook (DC)**, or CSQT workbook submittals that include post-project monitoring, respectively. Questions without these labels are applicable to all three of these submittals.

Some questions in the **Proposed Assessment (PA)** worksheets are labeled **Monitoring** or **Proposed** to indicate whether they apply to CSQT workbook submittals that include post-project monitoring or the proposed but not yet constructed condition.

For ease of reference when using this document alongside the Checklist, questions are presented in groupings of five.

Getting Started

In the following chapters of this document, questions are labeled according to the worksheet they appear on (i.e., PC, EA, PA). Within this document and in the Checklist, questions are labeled according to type of submittal (i.e., CSQT, DC, Monitoring) followed by the question number. For example:

- PC-7-CSQT: This label indicates question number 7 in the Package Completeness worksheet for submittals **using the CSQT for lift or loss**.
- PC-7-DC: This label indicates question number 7 in the Package Completeness worksheet for submittals **using the Debit Calculator**.
- PC-7-Monitoring: This label indicates question number 7 in the Package Completeness worksheet applicable to **post-project monitoring** in a CSQT workbook submittal.
- EA-7: This label indicates question number 7 in the Existing Assessment worksheet. Existing (pre-project) assessments are applicable to submittals using the **CSQT** workbook or for reaches using Debit Options 1 or 2 in the **Debit Calculator** workbook.
- PA-13-Monitoring: This label indicates question number 13 in the Proposed Assessment worksheet applicable to post-project monitoring in a CSQT workbook submittal.

Each worksheet is comprised of a series of questions, or items, that generally refer to the submittal content. There are five columns for each question (Figure 1), including User Manual Section, Practitioner Submittal Page #, Submitted, Acceptable, and Comments. The 'User Manual Section' column is provided for reference only and lists where in the UM the review item content is referenced. The 'Practitioner Submittal Page #' column will indicate where in the submittal the corresponding information is found. The reviewer answers 'yes', 'no', or 'partially' for Submitted and Acceptable and, if needed, provides a reason/explanation in the Comments. Any 'no' or 'partially' responses are flags to the practitioner to update the submittal. Some items might not be applicable to a specific project or reach.

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
2	Is there a description and visual depiction of the reaches and reach breaks within the Project Area?	Sections 1.2.1 & 2.1.1				

Figure 1. Example checklist question from worksheet

Introduction Worksheet

Within the Introduction worksheet complete the Submittal Information (Figures 2 and 3) and then complete the Parameter and Metric Selection of the worksheet as described below.

Step 1: Enter the **Reviewer Name**, **Project Name**, **Sponsor**, **Date**, and **Applicant Submittal**.

Step 2: Select either CSQT or Debit Calculator for the **Workbook(s) Submitted**. This selection will change some text and options on the **Introduction worksheet** and items within the **PC worksheet**.

Submittal Information		
Reviewer Name:	C. Jones	Person filling out this checklist.
Project Name:	Example Project	
Sponsor:	ABC Consulting	
Date:	9/16/2021	
Applicant Submittal:	ABC Mitigation Bank DRAFT Mitigation Plan	E.g., Prospectus, mitigation plan, monitoring plan
Workbook(s) Submitted:	CSQT	Fill out separate checklists for projects that use both workbooks, CSQT and Debit Calculator.
***Applicable Workbooks:**	CSQT v1_Reach 1; CSQTv1_Reach 3; CSQT v1_UT3	List the workbook file names that are reviewed using this checklist.
Monitoring Submittal (Y/N):	N	Reviewer will complete both the Existing Assessment and Proposed Assessment checklists.
Existing Condition Survey Method:	Detailed	Existing Assessment represents the pre-project conditions. This is N/A to Debit Option 3 and monitoring condition assessments in the CSQT.
Proposed Condition Survey Method:	Detailed	Proposed Assessment represents the post-project conditions (proposed, as-built, monitored). This is N/A to Debit Options 2 and 3.

Figure 2. Introduction worksheet submittal information – CSQT Example

Step 3: List the titles of the **Workbook(s) Submitted** that are being reviewed. The Checklist can be used to review individual reaches or multiple reaches within a single project if mitigation or impact activities are relatively similar across reaches. Multiple Checklists may be needed depending on project complexity.

Step 4 *for reviews of CSQT workbook(s)*: indicate whether the CSQT submittal is for post-project **Monitoring: Yes (Y) or No (N)** (Figure 2).

OR

Step 4 *for reviews of Debit Calculator workbook(s)*: the reviewer should identify the **most complicated Debit Option** being reviewed using the Checklist: **Debit Option 1, 2, or 3**. Debit Option 1 being the most complicated and Debit Option 3 being the least complicated (Figure 3).

Submittal Information		
Reviewer Name:	C. Jones	Person filling out this checklist.
Project Name:	Example Project	
Sponsor:	ABC Consulting	
Date:	9/16/2021	
Applicant Submittal:	Impact Report	E.g., Prospectus, mitigation plan, monitoring plan
Workbook(s) Submitted:	Debit Calculator	Fill out separate checklists for projects that use both workbooks, CSQT and Debit Calculator.
***Applicable Workbooks:**	CSQT Debit Calc v1_Reach 1; CSQT Debit Calc v1_Reach 3; CSQT Debit Calc v1_UT3	List the workbook file names that are reviewed using this checklist.
Select the most complicated debit option used:	2	Reviewer will complete the Existing Assessment checklist.
Existing Condition Survey Method:	Rapid	Existing Assessment represents the pre-project conditions. This is N/A to Debit Option 3 and monitoring condition assessments in the CSQT.
N/A		Proposed Assessment represents the post-project conditions (proposed, as-built, monitored). This is N/A to Debit Options 2 and 3.

Figure 3. Introduction worksheet submittal information - Debit Example

Step 5 *for CSQT and Debit Options 1 and 2 reviews*: enter the **Existing** (pre-project) **Condition Survey method** and **Proposed** (post-project) **Condition Survey Method**, separately as applicable. Survey data were collected using either **Detailed or Rapid** methods. Questions EA-7 and PA-7 vary depending on the survey methods used, refer to Chapter 3. *No survey data are collected for reaches using Debit Option 3.*

Step 6: Complete the **Parameter and Metric Selection** portion of the **Introduction** worksheet according to the Parameter Selection Checklist (required form from UM Appendix B)[1]. Selections made in this section are used for hiding specific items in the worksheets using the toggle buttons (Figure 4) located on the PC, EA, and PA worksheets.

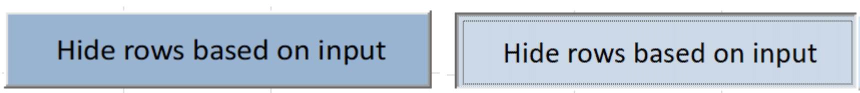


Figure 4. Toggle button that hides rows on the PC, EA, and PA worksheets. When pressed the button appears as shown on the right and rows are hidden. Otherwise, the button appears as shown on the left and rows are not hidden.

Once this section is completed the toggle buttons in the Checklist worksheets will hide/un-hide rows based on the parameters and metrics being reviewed. When no data entry is provided in this section of the **Introduction** worksheet, the toggle buttons will hide checklist items that are associated with optional parameters and metrics. These include items specifically related to the following:

- PC-18 items related to baseflow dynamics parameter; LWDI metric; aggradation ratio metric; and physicochemical, biology, and flow alteration module metrics.
- EA-10, EA-14 to EA-17
- PA-10, PA-14 to PA-17

Before changing any inputs in this section, make sure the toggle buttons on the other worksheets are NOT pressed (Figure 4, left image).

[1] Refer to PC-9 in Chapter 2 for more information.

2. Package Completeness Worksheet

The Package Completeness (PC) worksheet assists the reviewer with checking the completeness of a practitioner's submittal. This worksheet helps the reviewer determine whether sufficient information was submitted to verify the CSQT or Debit Calculator results. A toggle button located on this worksheet will hide items that are not applicable based on input provided on the Introduction worksheet, refer to Chapter 1.

For **CSQT workbook** submittals, items in this worksheet review the completeness of information within the CSQT Project Assessment worksheet, Catchment Assessment worksheet, Quantification Tool worksheet, and Monitoring Data worksheet (when applicable), as well as the required field forms. Note that the Monitoring Data worksheet does not need to be completed unless the CSQT submittal is for post-project monitoring.

For **Debit Calculator workbook** submittals, this checklist reviews the completeness of information within the Project Assessment worksheet, Debit Calculator worksheet, Existing Conditions worksheet (when applicable), and Proposed Conditions worksheet (when applicable), as well as the required field forms for Debit Options 1 and 2. No field forms are required for reaches assessed using Debit Option 3.

In general, submittals should include the required forms (outlined below), location information for where measurements were taken, and figures depicting data collected (e.g., survey data plotted as cross-sections and longitudinal profiles, time series plots of temperature and dissolved oxygen concentration [DO]). Photos are recommended for some metrics. The required forms are included in Appendix B of the UM and Example 1 illustrates the forms required in a CSQT submittal for a large project.

Required forms that may apply to multiple reaches:

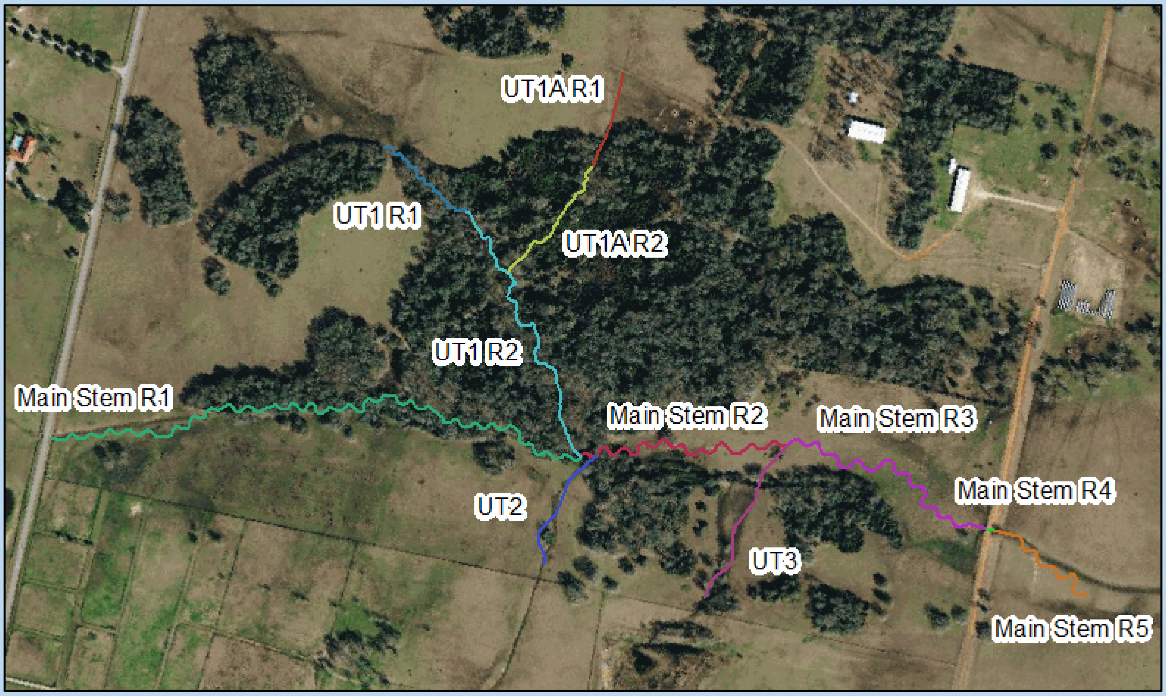
- Catchment Assessment (worksheet in CSQT workbook)
- Bankfull Verification Documentation
- Parameter Selection Checklist

Required forms **for each reach**:

- Project Reach Form
- Field Value Documentation Forms[2] for <u>Existing and Proposed</u> Conditions
- Riparian Extent Form
- Riparian Vegetation Form(s)

[2]The Field Value Documentation form is divided between three separate worksheets in the Excel version of Appendix B of the UM: (1) hydrology & hydraulics; (2) geomorphology; and (3) physicochemical & biology.

Example 1: Number and type of required forms for sample project



Based on the map, this project has 11 project reaches on 5 streams (main stem and 4 unnamed tributaries [UT]). The project submittal should include the following type and number of forms:

1) Catchment Assessment (worksheet in CSQT workbook): 5; one for the main stem and one for each of the UTs
2) Bankfull Verification form: 1 for entire project, unless flow alteration is suspected on the main stem; in that case, 2 forms would be likely be provided (see Section 2.6 of UM)
3) Parameter Selection Checklist form: 1 for entire project, unless parameter and metric selection differs among reaches
4) Project Reach Form: 11
5) Field Value Documentation forms: Existing (11) and Proposed (11); 22 in total
6) Riparian Extent forms: 11
7) Riparian Vegetation forms: Variable. Each form contains data for four plots and every reach will need at least 6 plots.

PC Checklist Items 1 through 5

PC-1: Were data collection and analyses completed by those with sufficient experience?

Teams collecting and analyzing data should have combined experience and expertise in botany, aquatic ecology, hydrology, and geomorphology, as well as in applying the assessment methods used to calculate metrics. Throughout Chapter 2 of the UM, experience requirements are listed for each metric. Some metrics, namely those associated with physicochemical and biology functional categories and the flow alteration module, require additional expertise.

Reviewer Action: Review the submittal to ensure team members and their respective expertise are identified. There is not space in the CSQT or Debit Calculator workbook to record this information. The submittal can be in the form of a memorandum submitted to USACE prior to data collection that outlines parameter and metric selection, data collection methods, and experience of field team members.

PC-2: Is there a description and visual depiction of the reaches and reach breaks within the Project Area?

Assessments within the CSQT and Debit Calculator assess the stream reach corridor, where reaches are delineated based on relatively homogeneous condition and character (UM Section 2.1). A submittal should identify the number of reaches, their location relative to one another (see Example 3 in the UM), and the reasoning behind the reach delineations, including the differences and similarities between reaches within a project area.

Reviewer Action: In the CSQT workbook, review the **Reach Description** section in the **Project Assessment** worksheet (Section 1.2.1). A CSQT workbook submittal should include a map or drawing that identifies the overall project area, the location of any reach breaks within the project area, and the unique name of each reach. Typical reach break criteria are found in UM Section 2.1.1.

Reviewer Action: In the Debit Calculator workbook, review the **Latitude and Longitude** on the **Project Assessment** worksheet. In this workbook there is not a section within the Project Assessment worksheet to include a picture of reaches and reach breaks. Large projects may have multiple reaches that are not proximal, and a single figure may not be practicable. Within the Debit Calculator workbook, latitude and longitude are required for each reach to ensure reaches can be spatially located. Within the submittal package, maps should also be provided for additional location information.

For large mitigation or impact projects where multiple reaches have the same Site Information and Reference Stratification and exhibit similar conditions (see Quantification Tool worksheet in the CSQT or Existing Conditions worksheet in the Debit Calculator), it may be acceptable to consolidate reach assessments of existing conditions. *This can only be done in coordination with USACE*. For example, consider a project with more than 20 reaches where rapid measurements of the existing conditions were taken in every reach at a preliminary phase of the project. Rapid measurement showed that multiple reaches had very similar existing conditions and had the same stratification for all measured metrics (e.g., similar slope for percent riffle scoring). USACE may find it reasonable to allow detailed data collected on a single reach to represent the existing condition for multiple reaches. In this case, the reviewer should ensure that *measurements representing multiple reaches were in fact collected from a single reach*, e.g., if large woody debris (LWD) was measured in Reach 2, all data collected should also be from Reach 2. This is only applicable to the existing condition. Post-project conditions should be monitored in every reach, although after the first 3-5 years of monitoring, a similar consolidating procedure may be possible. Project closeout conditions should be measured in every reach to verify the proposed changes have been achieved.

PC-3: Is every reach within the Project Area represented in a workbook?

Reviewer Action: Ensure that reaches identified in question 2 are accounted for in the submittal workbook(s). In the Introduction worksheet of the Checklist, list the file names of all workbooks to review with this copy of the Checklist. Typical reach break criteria are found in UM Section 2.1.1. Reach IDs are provided in the **Project Assessment** worksheet of both the CSQT and Debit Calculator workbooks (UM Section 1.2.1).

For a CSQT submittal, separate CSQT workbooks are needed for every reach in a project area and the number of workbooks should match the number of reaches depicted on the map described in question 2.

For a Debit Calculator submittal, each workbook can contain up to 10 reaches. If a project contains more than 10 reaches, then multiple workbooks would be required.

PC-4-CSQT: Are the process drivers, reference stream type, and sinuosity values on the Project Assessment worksheet applicable to the reach?

Reviewer Action: Review the **Process Drivers** section (UM Section 2.2.1) of the **Project Assessment** worksheet in the CSQT to ensure it is complete and consistent with the landscape, climate, and described conditions (including field values) at the site. Note that it may be useful to revisit this section after reviewing the condition assessments. For instance, if the LWD parameter is evaluated for a reach, the selected biology process driver should not be 'no large wood'. Note that sediment transport capability (under geology) and valley type (under geology) are used for stratification in the **Quantification Tool** worksheet.

Reviewer Action: Review the **Reference Stream Type** section (UM Section 2.2) of the **Project Assessment** worksheet in the CSQT to ensure it is complete and consistent. Tables 2 and 3 are provided to assist with review.

Table 2. Relationship between valley type and reference stream type

Valley Type	Typical Reference Stream Types
Unconfined Alluvial Valley	C, E, D_A
Confined Alluvial Valley	Bc, C
Colluvial Valley	A, B, Bc

Table 3. Relationship between sediment regime and reference stream type

Sediment Regime	Typical Reference Stream Types
Source	A, B
Transport	B, C, E
Response	C, D_A

Sinuosity values can be used to check the accuracy and appropriateness of existing and proposed stream length values, e.g., to ensure existing values are not underestimated or that proposed values are not overly sinuous for the valley setting and posing a risk of project failure. High sinuosity in natural settings is a function of low to moderate stream power, moderate to high biotic interaction, and moderate erosion resistance. An approximate guide for evaluating sinuosity values in single-thread reaches is provided in Table 4; sinuosity values are not applicable to reaches where the reference stream type is a multi-thread channel. Note that sinuosity can be difficult to measure at a project reach scale, particularly for short reaches, and it may be appropriate for sinuosity measurements to span multiple reaches or extend outside the project area.

Table 4. Approximate guide to evaluate sinuosity values based on reference stream type

Reference Stream Type	Likely Range of Sinuosity
B	1.0 – 1.3
C	1.2 – 1.5
E	1.3 – 1.8

Reviewer Action: In the CSQT workbook, review the sinuosity values in the **Reach Description** section of the **Project Assessment** worksheet to ensure values are consistent with the references stream type, and that valley length is consistent for existing and proposed conditions. The following equations can be used to verify whether the existing and proposed valley lengths are equal based on information provided in the submittal.

- Existing reach length / Existing sinuosity = Valley length
- Proposed reach length / Proposed sinuosity = Valley length
- Unless the valley length has changed, Existing reach length / Existing sinuosity = Proposed reach length / Proposed sinuosity

Valley length should not change between the existing and proposed conditions. Valley length, stream length, and sinuosity values for the existing condition are recorded on the **Project Reach** form (UM Appendix B, Section II.E. of the form).

Valley length should NOT be measured inside the channel. Valley length should be a straight line down the valley unless the valley itself turns. Errors in valley length measurements can lead to erroneous sinuosity measurements. Incised meanders can create confusion in sinuosity measurements, particularly in a degraded setting where severe incision into highly erodible alluvium has led to a heavily entrenched stream. For example, in a heavily entrenched system, if valley length is measured within the incised area instead of along the straight-line valley length (UM Section 2.2.2), the result will be a low existing sinuosity even though the true sinuosity using the straight-line valley length is much higher. In general, the valley length used to calculate sinuosity should be the same for the existing and proposed conditions.

PC-4-DC: Is information complete for every stream reach on the Project Assessment worksheet? This includes flow permanence, stream order, impact description, outstanding water classification, and location information.

Reviewer Action: In the Debit Calculator workbook, review the Project Assessment worksheet to ensure completeness of reach information, including reach location(s), reach characteristics, and description of the impact activity (UM Section 1.2.1 and UM Section 1.2.8). The explanatory text should include a description of anticipated impacts to aquatic ecosystem functions and parameters within each project reach. Ensure that reaches are correctly classified as Outstanding Waters, which are designated by Colorado Department of Public Health and Environment (CDPHE); maps can be found on the CDPHE website or in the Colorado Natural Heritage Program Watershed Planning Toolbox (UM Section 2.4).

PC-4-Monitoring: Review the inputs on the Project Assessment and Quantification Tool worksheets. Have any responses or values changed from the previous submittal?

Reviewer Action: In the CSQT workbook, review both the **Project Assessment** and **Quantification Tool** worksheets for consistency with previously submitted CSQT workbooks for that project reach (UM Section 1.2). Transcription errors or data incorrectly submitted for a reach can occur (e.g., Reach 1 data submitted for Reach 2). Checking previously submitted CSQT workbooks for consistency with the monitoring submittal CSQT workbook is a quick way to spot errors. Where discrepancies do exist, check for an applicant-provided explanation for the change in values or other rationale.

PC-5: Are the existing and proposed project reach stream lengths accurate?

Reviewer Action: Verify whether values provided in the CSQT or Debit Calculator workbook match the stream length values on the **Project Reach** form and values reported in associated documents such as the permit application, mitigation plan, construction plan set, etc.

In the CSQT workbook, stream length is entered into the **Site Information and Reference Selection** section of the **Quantification Tool** worksheet (UM Section 2.4). For a CSQT workbook submittal, the proposed stream length is likely to match or exceed the existing stream length.

In the Debit Calculator workbook, stream length is entered in the **Functional Loss Summary** section of the **Debit Calculator** worksheet (UM Section 1.2.8). For a Debit Calculator workbook submittal, the proposed stream length cannot exceed the existing stream length; the Debit Calculator will highlight the cell in red if the proposed stream length is longer than the existing stream length.

PC Checklist Items 6 through 10*

*Note: Checklist items PC-6, PC-7, and PC-8 are not relevant to CSQT submittals for post-project monitoring and the rows will be hidden.

PC-6-CSQT: Does the Catchment Assessment worksheet identify applicable reaches and are all reaches accounted for?

Reviewer Action: In the CSQT workbook, ensure all identified project reaches are listed on a **Catchment Assessment** worksheet and review Catchment Assessment worksheet(s) for completeness (UM Section 2.3). In the case where one Catchment Assessment worksheet is used for multiple reaches, the Catchment Assessment worksheet must only be completed in one CSQT workbook; a list of applicable reaches should be provided at the top of the Catchment Assessment worksheet.

PC-6-DC: Did the practitioner include the Permit Number and project description?

Reviewer Action: In the Debit Calculator workbook, review the **Project Assessment** worksheet to ensure permit number and project description are complete. If the project is assigned a project ID or permit number by USACE, it must be provided on the Project Assessment worksheet. For projects that have not yet been assigned an ID or permit number, this field can be left blank (UM Section 1.2.8). The project description should include information about the project purpose and the proposed activities causing the impacts.

PC-7-CSQT: Is the restoration potential description informed by the catchment assessment results, presence of human-induced reach-scale constraints, and reach corridor assessment results?

Restoration potential is the highest level of restoration that can be achieved given constraints, both on- and off-site (UM Section 3.2.1). To inform restoration potential, the **Catchment Assessment** worksheet in the CSQT workbook includes eleven categories of processes and stressors that exist outside of the project reach and may limit functional lift. It does not address stressors occurring within the project area that can be addressed as part of restoration activities.

Reviewer Action: In the CSQT workbook, review the **Restoration Potential** selection and **Restoration Approach Question 2** on the **Project Assessment** worksheet, and the **Catchment Assessment** worksheet for completeness. Restoration potential will likely be partial for most projects. If a full restoration potential is proposed, ensure the submittal includes: 1) assessment of existing physicochemical and biology functions using appropriate metrics; and 2) monitoring of proposed conditions using these same metrics.

PC-7-DC: Is a Debit Option selected for each reach?

Reviewer Action: In the Debit Calculator workbook, review the Debit Option column in the **Functional Loss Summary** table on the **Debit Calculator** worksheet to ensure a Debit Option is selected for each reach. The Debit Calculator includes three options for practitioners to calculate debits (Table 5 and UM Section 1.2.8). The level of effort for the practitioner and the reviewer varies for each Debit Option, with Debit Option 3 being the least effort and Debit Option 1 being the most effort.

Table 5. Debit Options summary

Debit Option	Existing Condition Score	Proposed Condition Score
1	Assess existing condition using Existing Conditions worksheet.	Estimate proposed condition using Proposed Conditions worksheet.
2	Assess existing condition using Existing Conditions worksheet.	Estimate proposed condition based on impact severity tier.
3	Use Existing Conditions worksheet - use standard score for all functional categories.	Estimate proposed condition based on impact severity tier.

PC-8-CSQT: Does the project have function-based goals and measurable objectives that align with the restoration potential?

Reviewer Action: In the CSQT workbook, review **Restoration Approach Question 3** on the **Project Assessment** worksheet. Goals and objectives should be reach-specific and not exceed the restoration potential (UM Section 3.2.2). For instance, a goal to restore the native fish community to a reference condition would not be appropriate if the reach only has partial restoration potential (see question PC-7-CSQT). Multiple goals and objectives may be similar between project reaches within a project area and it is reasonable for the Project Assessment worksheet to refer to further explanation within the mitigation plan or other submittal if the space provided in the worksheet is limiting. However, it is important that goals and objectives are considered for every reach and reflect any differences that were used to delineate project reaches, if applicable.

For stream restoration projects, goals and objectives specify what the practitioner will do to address functional impairment (UM Section 3.2.2). When the CSQT is used as part of an individual permit to show no loss of aquatic resource functions (no debits), an implicit goal is to avoid further functional impairment.

PC-8-DC: For each reach, is an impact severity tier selected and is it appropriate for the described impact activity?

Reviewer Action: In the Debit Calculator workbook, review the impact severity tier column in the **Functional Loss Summary** table in the **Debit Calculator** worksheet to ensure it is complete for each reach and appropriate given the information submitted by the applicant. Information to support tier selection may include project plans and documents, permit applications, and discussions between the permit applicant and the USACE. Note: the impact severity tier is needed for all Debit Options.

Determination of an impact severity tier is needed to inform the proposed condition score (PCS; UM Section 1.2.8). The impact severity tier is a categorical determination of the amount of adverse impact to stream functions, ranging from no loss (Tier 0) to total loss (Tier 5), from a proposed activity. Tier 4 and tier 5 impacts account for losses to physicochemical and biology stream functions while lower impact severity tiers do not.

It is important to consider the scale of any proposed activity to determine whether the activity is likely to impact higher-level functions. For example, bank stabilization using rip rap or other hard armoring techniques is provided as an example activity for a Tier 1 impact (UM Table 4). However, stabilizing banks at a great extent, such as 2,000 linear feet, may cause impacts akin to channelization, a Tier 3 impact. At this scale, hard armoring may cause severe impacts to hydraulic and geomorphic functions with possible impacts to physicochemical and biology functions.

The Project Completeness review is complete for any reaches assessed using Debit Option 3. Continue to the following section for all other assessments.

PC-9: Is every reach represented on a Parameter Selection Checklist and are the selected parameters and metrics appropriate for the reach?

The **Parameter Selection Checklist** is a required form in UM Appendix B.

Reviewer Action: Review the **Parameter Selection Checklist** to ensure appropriate metrics have been selected for the project using UM Section 2.5. One form may be used for all project reaches unless parameter and metric selection differs among reaches. If multiple forms are provided, ensure each project reach has an associated form.

Certain parameters must be evaluated at every reach, regardless of valley morphology or flow permanence; these include reach runoff, floodplain connectivity, lateral migration, and riparian vegetation. Bed form diversity should also be measured in every single-thread perennial and intermittent project reach. Further guidance is provided in UM Section 2.5.

The CSQT does not assume that improving physical condition will result in improved chemical and biological conditions. Projects with a partial restoration potential will likely not be able to overcome watershed stressors to fully restore chemical and/or biological conditions; however, many reach scale practices can contribute to cumulative, watershed-scale benefits for chemical and biological functioning and project proponents may opt to collect physicochemical and biological metrics associated with quantifiable objectives. Where full restoration potential is anticipated for the reach, physicochemical and biology parameters and metrics should always be assessed and monitored after restoration (see PC-7-CSQT).

PC-10: Is location information provided for all measurements and samples within each project reach for all relevant assessments (existing, proposed, monitoring)?

Reviewer Action: Review submittal for completeness of field measurement locations. UM Chapter 2 provides instructions for data collection for each metric; field data collection methods are provided in UM Appendix A. Location information must be presented at a useful scale using a site sketch, map, aerial images, plan set, or by providing the latitude and longitude of measurement locations. Photos are recommended for the existing condition and monitoring assessments, but not for proposed condition assessments.

Maps or drawings should include the location of data collection sites for:

- Representative sub-reaches
- Representative riffle cross-section(s) (photos recommended)
- Concentrated flow points (photos recommended)
- Riffle features, geomorphic pools, and significant pools (photos recommended)
- Banks assessed for lateral migration (photos recommended)
- Riparian vegetation plots (photos recommended)

Location information for surveyed data are also required. The following locations can be provided on maps or drawings OR as a station along the representative sub-reach (e.g., on the Rapid Survey Form within UM Appendix A):

- Head of every riffle and pool feature (geomorphic and significant)
- Middle of the riffle where the bankfull maximum depths, low bank heights, flood-prone width(s), mean depth(s), and bankfull width(s) are measured
- Deepest location of all geomorphic and significant pools

The location of the following should also be identified if the relevant metric is selected:

- Additional cross-sections as needed based on parameter and metric selection (i.e., baseflow dynamics, aggradation ratio for bed form diversity) (photos recommended)
- All side channels within reach (% side channels; photos recommended)
- 100m LWD assessment reach (LWD metrics)
- Length/extent of armoring within reach (% armoring; photos recommended)
- Gage locations (temperature, DO, and flow alteration)
- Sampling locations (chlorophyll α (mg/m2), CO MMI, and fish metrics)
- Reference/control reach (wild trout biomass metric)

PC Checklist Items 11 through 15

PC-11: Is there a completed Project Reach form for each reach? Project Reach forms include data/values for stream reach length, sinuosity, bankfull identification, concentrated flow points, and, when applicable, armoring and side channels.

The **Project Reach** form is a required form provided in UM Appendix B.

Reviewer Action: Review the **Project Reach** form(s) to ensure all sections have been completed for each project reach. Data collection and analysis instructions are provided in UM Chapter 2. Note: field measurements for side channels and percent armoring sections only need to be completed if Percent Side Channels and Percent Armoring were selected on the **Parameter Selection Checklist** (UM Appendix B).

PC-12: Does every reach have Field Value Documentation forms for all relevant assessments (existing, proposed, monitoring)? And are the forms completed for all parameters and metrics checked on the Parameter Selection Checklist?

The **Field Value Documentation** forms (UM Appendix B) are split into three separate worksheets: (1) hydrology & hydraulics; (2) geomorphology; and (3) physicochemical & biology metrics. Field Value Documentation forms are required for all field values input into a condition assessment.

Reviewer Action: Ensure the correct number of **Field Value Documentation** forms have been provided:

- For CSQT and Debit Calculator workbook – Debit Option 1 submittals, separate Field Value Documentation forms should be provided for both existing and proposed condition assessments in each project reach.
- For Debit Calculator workbook – Debit Option 2 submittals, separate Field Value Documentation forms should be provided for existing condition assessments in each project reach.
- For CSQT monitoring submittals, separate Field Value Documentation forms should be provided for each post-project condition assessment in each project reach.

Review each Field Value Documentation form to ensure it is complete for each metric selected by the practitioner on the **Parameter Selection Checklist** (UM Appendix B). If a metric field value is not anticipated to change between the existing and proposed conditions, the Field Value Documentation form for proposed conditions can simply state that the value is unchanged (values do not need to be duplicated; Figure 5); any additional discussion can be included in the notes section in the Field Value Documentation form to provide clarity.

For monitoring submittals, all metrics may not be assessed every monitoring year (UM Section 3.4). For any metrics not measured in a particular monitoring year, the previously measured value should carry over on the Field Value Documentation form. The Field Value

Documentation forms should clearly indicate which values have been measured in the current monitoring year and which have been held constant.

Land Use Coefficient - Existing		
Lateral Drainage Area (total; Acres)	76.8	Measured from USGS StreamStats basin delineations for the upstream and downstream project extent.
Forested or scrub-shrub (Acres)	33.5	Land uses were delineated using aerial imagery from 2015 and field verified that aerial conditions were consistent with available imagery.
Herbaceous (Acres)	43.3	Same as above.
Open Water (Acres)	0	
Open Space (Acres)	0	
Impervious Surfaces (Acres)	0	
Pasture (Acres)	0	
Cropland (Acres)	0	
FIELD VALUE - Land Use Coefficient (%)	**59**	Calculated
Land Use Coefficient - Proposed		
Lateral Drainage Area (total; Acres)		
Forested or scrub-shrub (Acres)		
Herbaceous (Acres)		
Open Water (Acres)		
Open Space (Acres)		
Impervious Surfaces (Acres)		
Pasture (Acres)		
Cropland (Acres)		
FIELD VALUE - Land Use Coefficient (%)		Restoration activities will plant within existing scrub-shrub land uses and no land use change is proposed from existing condition.

Figure 5. Land use coefficient field value documentation example

PC-13-CSQT & DC: Are responses provided for all applicable fields in the Site Information and Reference Selection section?

The **Site Information and Reference Selection** section in the **Quantification Tool** worksheet (CSQT workbook) and the **Existing Condition** worksheet (Debit Calculator workbook) include fields that: 1) provide information only (e.g., project name, reach ID); 2) provide context for parameter selection, change in functional feet, or bankfull verification (e.g., drainage area, flow permanence); and 3) apply the correct reference curves for some metrics (stratification).

Reviewer Action: Review the **Parameter Selection Checklist** (UM Appendix B) to ensure that the relevant fields in the Site Information and Reference Selection section in the submitted workbook(s) are completed for selected metrics (UM Section 2.4). Incorrect information in this section of the worksheet can lead to FALSE values for scoring index values or application of the wrong reference curves. Depending on parameter and metric selection, a user does not need to fill out every field. Table 6 summarizes the Site Information fields that enable metric stratification, and lists the metrics associated with each stratifying field.

PC-13-Monitoring: Have any responses in the Site Information and Reference Selection section changed from the previous submittal?

Reviewer Action: When reviewing monitoring submittals, refer to previously submitted CSQT workbooks to check for consistency in the Site Information and Reference Selection section (UM Section 2.4). Errors with CSQT submittals are often related to transcription mistakes or mixing up data from multiple reaches. If the data do not appear to be submitted erroneously, request that the applicant provide an explanation for the change in values.

Table 6. CSQT parameters and metrics stratified by fields in the Site Information and Reference Selection section

Site Information and Reference Selection Field*	Metric(s) Stratified per Site Information and Reference Selection Field
Ecoregion	- Woody Vegetation Cover
Biotype	- Chlorophyll α - Colorado Multi-metric Index (CO MMI) (macroinvertebrates metric)
Proposed Bankfull Width	- Baseflow Depth - Bankfull width is also used to calculate pool spacing ratio
Stream Slope	- Percent Riffle
River Basin	- Number of Native Fish Species
Stream Temperature	- Daily Maximum & Maximum Weekly Average Temperature (MWAT) (temperature metrics) - Baseflow Depth
Reference Vegetation Cover	- Woody Cover - Herbaceous Cover
Stream Productivity Class	- Wild Trout Biomass
Valley Type	- Percent Side Channels - Riparian Extent
Reference Stream Type	- Entrenchment Ratio - Pool Spacing Ratio
Sediment Regime	- Bank Height Ratio

* Note that the Site Information and Reference Selection section in the Debit Calculator workbook has a different layout and order than the CSQT workbook.

PC-14: Have field values been entered for all selected parameters and metrics in all relevant assessments (existing, proposed, monitoring)? And are field values associated with the correct Reach ID?

Reviewer Action: Cross-check the **Parameter Selection Checklist** (UM Appendix B) with the **Existing and Proposed Condition Assessment** sections of relevant worksheets (i.e., **Quantification Tool** and **Monitoring Data** worksheets in the CSQT workbook or **Existing Condition** and **Proposed Condition** worksheets in the Debit Calculator workbook). Ensure field values have been entered into all relevant condition assessments (e.g., existing, proposed, as-built, monitoring, etc.), in all relevant worksheets, and for all selected metrics. Example 2 highlights example mistakes to be check for during a review.

For the CSQT and Debit Option 1 - Debit Calculator submittals, the same parameters and metrics should be assessed for the existing condition, proposed condition, and for all monitoring events, including the as-built condition (UM Section 1.2.3). For example, if the Greenline Stability Rating was used to assess the existing lateral migration condition, it must also be used to assess the proposed condition and every monitoring assessment (CSQT only); it cannot be replaced with other lateral migration metrics or dropped entirely.

For monitoring submittals, all metrics may not be assessed every monitoring year (UM Section 3.4). For any metrics not measured in that monitoring year, the previously measured value should be entered for that event (e.g., existing condition or as-built condition) and a new field value entered the year it is measured. In these instances, the reviewer should cross-check with the Field Value Documentation forms which should clearly indicate which values have been measured in the current monitoring year and which have been held constant.

Reviewer Action: Ensure reach ID information is consistent across all worksheets and forms. For the Debit Calculator, there is space to enter data for 10 project reaches in the **Existing Condition** and **Proposed Condition** worksheets. The Reach ID(s) that were entered in the Project Assessment worksheet automatically populate in the Site Information and Reference Selection sections of the Existing Condition and Proposed Condition worksheets.

PC-15: Is every reach represented on a Bankfull Verification form?

Reviewer Action: Review the **Bankfull Verification** form(s) (UM Appendix B; UM Section 2.6) for completeness and ensure each project reach is represented on a form. One or more forms may be needed for a project.

Note that bankfull verification is performed as part of the existing condition assessment only; no Bankfull Verification forms should be submitted for proposed or monitoring assessments. However, the Bankfull Verification form from the existing condition assessment is needed to review the proposed or monitoring assessment calculations.

Example 2: Checking field values

For projects with multiple reaches, comparing the Site Information and Reference Selection section and the field values for all reaches serves as a robust quality check. The reviewer can catch errors or anomalies during this comparison, as demonstrated below (e.g., information that does not match up with the reach description).

Project Name:	Example		Example		
Reach ID:	Reach 1		Reach 2		
Restoration Potential:	Partial		Partial		
Project Reach Stream Length - Existing (ft):	1000		800		
Project Reach Stream Length - Proposed (ft):	1300		800		
Metric	**Existing Field Value**	**Proposed Field Value**	**Existing Field Value**	**Proposed Field Value**	
Land Use Coefficient	59	59	57	57	
Concentrated Flow Points (#/1000 LF)	1.25	0	2.2	0	
Bank Height Ratio	1.3	1	1.4	1	
Entrenchment Ratio	8	9	4	8	
Percent Side Channels (%)	0	0	0		**(1)**
LWD Index	179	400	0	180	
No. of LWD Pieces/ 100 meters	0	8			**(2)**
Greenline Stability Rating					
Dominant BEHI/NBS	H/H	L/H	H/H	L/H	
Percent Streambank Erosion (%)	8.7	5	50	5	
Percent Armoring (%)			0	0	**(3)**
Pool Spacing Ratio	0	5	0	5	
Pool Depth Ratio	1.7	2	1	2	
Percent Riffle (%)	71	60	100	60	
Aggradation Ratio					
Riparian Extent (%)	77	77	65	65	
Woody Vegetation Cover (%)					**(4)**
Herbaceous Vegetation Cover (%)					
Percent Native Cover (%)	97	97	84	84	

Errors identified above are shown highlighted in yellow and explained here:

1) Metric is assessed for Reach 2 existing condition but not the proposed condition.
2) Only one of the LWD metrics should be used, not both. The LWD index was used, so No of LWD pieces per 100m should not be scored.
3) Percent Armoring metric is only used when armoring is present or proposed.
4) Woody or herbaceous cover needs to be assessed.

PC Checklist Items 16 through 18

PC-16: Does every reach have a Riparian Extent form for all relevant assessments (existing, proposed, and monitoring) that includes an aerial or topographic image depicting observed and expected riparian areas?

Reviewer Action: Review the **Riparian Extent** form for each reach (UM Appendix B). The form should include an aerial or topographic image with the observed and expected riparian extent delineated and labeled. Riparian extent is the percentage of the historic or expected riparian area that currently contains riparian vegetation and is free from utility-related, urban, or otherwise soil disturbing land uses (UM Section 2.8.4). Whenever possible, the expected riparian area should be determined using aerial imagery and other spatial data to identify hydrologic, topographic, and geomorphic indicators of expected riparian extent, which should then be validated in the field.

PC-17: Were the correct number of Riparian Vegetation forms provided? Photos of every vegetation plot are recommended.

All riparian vegetation metrics are assessed at plots located at equally spaced intervals along the assessment sub-reach. For instruction on how to calculate the recommended number of sampling plots per sub-reach, refer to the UM Appendix A, Section 7. For convenience, Table 7 includes the recommended sub-plots per length of stream sub-reach.

Reviewer Action: Review the **Riparian Vegetation** forms for each project reach to ensure they include the appropriate number of plots. **Riparian Vegetation** forms should be provided for existing and post-project monitoring condition assessments but should not be used to estimate proposed condition field values.

Table 7: Recommended number of sampling plots per sub-reach

Sub-Reach Length	Number of Plots per Side	Number of Plots per Sub-Reach
300-400 ft	3 plots	6 plots
400-600 ft	4 plots	8 plots
600-900 ft	6 plots	12 plots
900-1300 ft	8 plots	16 plots

PC-18: Are sufficient data provided to verify all field values? In addition to the required forms listed above, the following items are needed:

The required forms in UM Appendix B are listed in the previous checklist items and cover many of the parameters and metrics in the condition assessments. This section includes parameter or metric specific information that is needed as part of a submittal but is not explicitly listed in the previous checklist items. This includes maps, field forms, other supporting data, and figures depicting data collected (e.g., survey data plotted as cross-sections and longitudinal profiles, time series plots of temperature and DO).

The contents of this list will vary based on the input provided on the Introduction worksheet of the Checklist.

Reviewer Action: Ensure all items in the Checklist that are applicable to the parameters and metrics selected are provided in the submittal. A few specific notes are provided below.

- *Photos:* Site photos are recommended to document existing and post-project monitoring conditions. Note that photos are not relevant for a proposed condition assessment. Photos are recommended to document concentrated flow points, side channels, and areas of armoring. As noted in within this item and in item PC-17, photos are also recommended to document typical in-channel and floodplain conditions; each bank assessed for lateral migration and each riparian vegetation plot. Location information for photos should be provided. Photos should be clearly labeled to indicate the reach and feature depicted (i.e., typical riffle found in Reach 1).
- *Physicochemical, biology, or flow alteration module metrics:* Inclusion of these metrics may require additional upfront planning for data collection and processing. Review submittal to ensure information is provided in a mitigation or monitoring plan that outlines study design, monitoring schedule, and a discussion of natural and anthropogenic sources of stressors. Additionally, the submittal must include an outline or plan to quantify uncertainty and determine the final proposed condition value at project closeout/end of monitoring.

3. Existing Assessment and Proposed Assessment Worksheets

The Checklist workbook includes two worksheets to assess the information provided for the existing (pre-project) condition and the proposed (post-project) condition: Existing Assessment (EA) and Proposed Assessment (PA), respectively. The checklist items in these worksheets review whether the practitioner followed the methods outlined in the UM and whether the field values provided in the existing, proposed, or monitoring condition assessments are reasonable.

- The EA and PA worksheets are both applicable to reaches assessed using the Debit Calculator workbook - Debit Option 1 and the CSQT workbook.
- A Debit Calculator workbook - Debit Option 2 submittal uses the EA worksheet only.
- A monitoring submittal uses the PA worksheet only.

A toggle button located on this worksheet will hide items that are not applicable based on input provided on the Introduction worksheet, refer to Chapter 1. Some questions in the PA worksheet relate specifically to field data collection that is not applicable to a proposed condition that has not yet been constructed. These questions (PA-12, PA-14 to PA-17) are only applicable to CSQT submittals for post-project monitoring. Additionally, the contents of question 7 (EA-7 and PA-7) in these worksheets will vary based on the survey method selection.

EA and PA Checklist Items 1 through 5

EA-1 & PA-1: Are the location and number of measurements for each metric consistent with the UM?

Reviewer Action: Review the **Field Value Documentation** forms, maps, drawings, or photos to verify that practitioners have collected the correct number of measurements from the locations specified in the User Manual for each metric. Guidance on the number of required cross-sections for a reach is provided in Example 3.

UM Chapter 2 provides instructions for data collection for each metric; field data collection methods are provided in UM Appendix A. Appendix 5 of this document provides tips for condition assessment field values for the basic suite of metrics (i.e., reach runoff, floodplain connectivity, large woody debris, lateral migration, bed form diversity, and riparian vegetation), including checking measurement locations.

Example 3: How many cross-sections are required?
Every reach will have at least one riffle cross-section and additional cross-sections may be necessary or required based on reach conditions and parameter selection. Two examples are presented here.

EXAMPLE A: Project reach targeted for enhancement only surveyed a single cross-section that was used for bankfull verification and determined the existing stream type. The valley topography was consistent throughout the reach and the entrenchment ratio measured at the representative cross-section was used as the field value for the entrenchment ratio metric.

EXAMPLE B: For a project reach exhibiting signs of aggradation where a stable riffle was not available within the project reach, three cross-sections were surveyed:

(1) Representative riffle upstream of the project reach for bankfull verification. The upstream reach was stable, not aggrading or degrading. This cross-section also provided the reference width/depth (W/D) for the aggradation ratio metric.
(2) A riffle was surveyed within the representative sub-reach that provided the existing stream type and entrenchment ratio field value. The valley width between natural terraces is consistent and low bank values were collected as part of the longitudinal profile. Bank Height Ratio (BHR) values were < 2.0, so additional cross-sections of bankfull bench width were not needed.
(3) Bankfull widths were measured at each riffle within the representative sub-reach to determine which was the widest and the widest riffle was surveyed to calculate the W/D as the numerator for aggradation ratio metric.

EA-2 & PA-2: Are the following items identified according to the definitions in the UM: Concentrated flow points, side channels, LWD, armoring, expected riparian area, observed riparian area, percent native cover?

To ensure proper scoring of existing, proposed, or monitored conditions it is important that applicants properly identify and follow measurement methods outlined in the UM. For instance, based on the UM definition, outfalls from stormwater BMPs would not be considered a concentrated flow point, but anthropogenic erosional features (e.g., ditches) would (UM Section 2.7.1). Similarly, to be counted in the SQT, side channels must be connected to the main channel at one or both ends (UM Section 2.7.3).

Reviewer Action: Review maps, photographs, and other relevant information in the submittal to ensure all relevant features, including concentrated flow points (UM Section 2.7.1), side channels (UM Section 2.7.3), large woody debris (UM Section 2.8.1), armored banks (UM Section 2.8.2), expected and observed riparian areas (UM Section 2.8.4), and native plant species (UM Section 2.8.4) were correctly identified based on the definitions and methods in the UM.

EA-3 & PA-3: Are the field values in the Field Value Documentation forms for concentrated flow points, percent side channels, percent armoring, and LWD reasonable based on the data provided?

Reviewer Action: Review the data provided for the listed metrics. Data will be provided on the proposed construction plan set, **Project Reach** form, in field notes, or as photos (UM Sections 2.7.1, 2.7.3, 2.8.1, & 2.8.2). Appendix 5 of this document includes general tips for each of these metrics in addition to tips for reviewing calculations and proposed condition values.

EA-4 & PA-4: Is there a representative riffle cross-section adequate for bankfull verification that labels or presents bankfull area, width, mean depth, flood-prone width, water surface elevation, W/D, and ER?

Reviewer Action: A survey of a representative riffle is required for all assessments (existing, proposed, and monitored) and every project reach (UM Section 2.6 & Appendix A Section 3). Review survey results to ensure data are plotted with labels and dimensions for bankfull, bankfull width, bankfull mean depth, flood-prone width, water surface elevation, width/depth and entrenchment ratio. See Figures 6 and 7 for examples of cross-sections plotted using detailed survey and rapid survey methods, respectively. For proposed condition assessments, a cross-sectional diagram should be included, and will likely be based on typical cross-section(s) within the construction plan set.

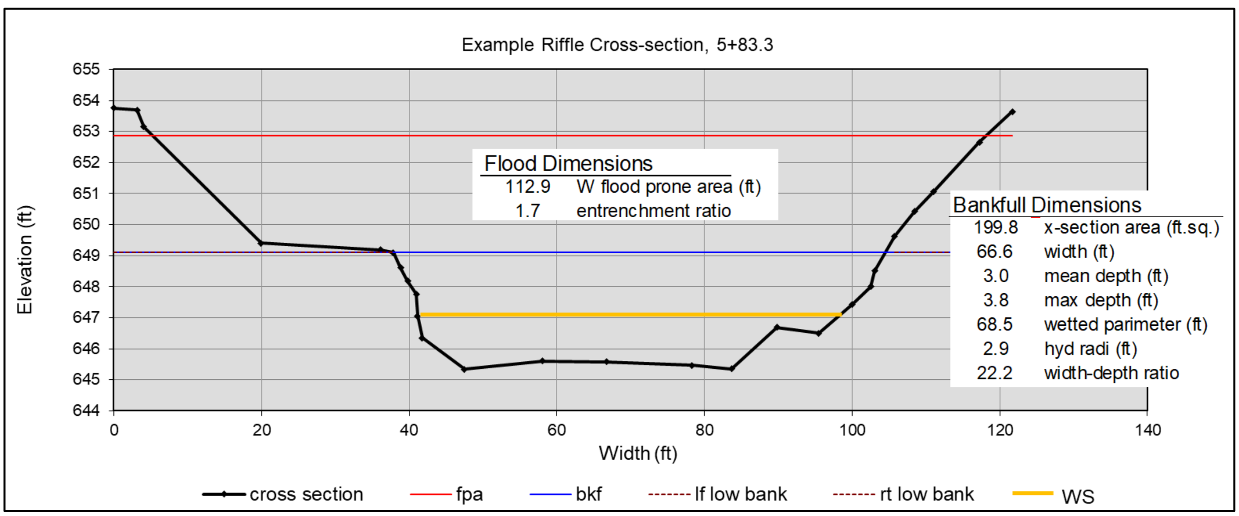


Figure 6. Detailed representative riffle cross-section used for bankfull verification and reach classification.

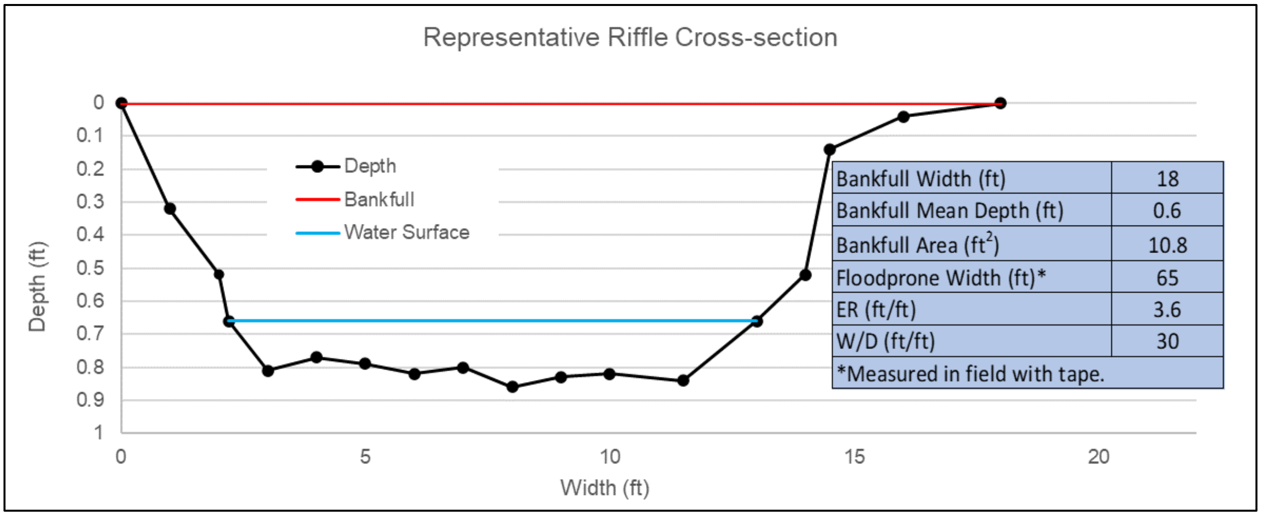


Figure 7. Example of a representative riffle cross-section surveyed using rapid methods.

EA-5: Did the bankfull verification process follow one of the three methods in the flow chart and is the bankfull determination reasonable based on the data provided?

Correctly identifying bankfull stage and dimensions is crucial, and this should be done using multiple lines of evidence. Bankfull identification and verification methods are provided in UM Section 2.6. The bankfull verification flow chart (refer to UM Figure 21) outlines three methods to verify bankfull stage. All methods begin with a search for bankfull indicators within the project reach and a geomorphic survey (refer to UM Appendix A). Bankfull stage and dimensions are needed to calculate field values for several metrics, including bank height ratio, entrenchment ratio, LWD Index, dominant BEHI/NBS, pool spacing ratio, pool depth ratio, and aggradation ratio. Additionally, the CSQT uses bankfull dimensions in the definition of side channels; in identifying the length of the representative sub-reach; and potentially in delineating the expected riparian area.

Reviewer Action: Bankfull identification and verification methods should be documented and explained using the required **Bankfull Verification** form provided in Appendix B of the UM. Bankfull identification and verification are performed as part of the existing condition assessment and do not need to be repeated during monitoring. Appendix 4 of this document provides examples of the bankfull verification process.

Often only one bankfull verification is needed for an entire project area. However, if flow alteration affects the main stem but does not affect tributaries or other resources, it is appropriate to have separate or multiple bankfull verification efforts within the project area.

PA-5: Was verified bankfull applied correctly to ratio metrics across condition assessments (proposed and monitoring)?

Reviewer Action: Review the proposed assessment and the **Bankfull Verification** form from the existing condition assessment to ensure that the proposed bankfull dimensions are consistent with the verified bankfull feature in the existing condition assessment.

> Bankfull dimensions can change between the existing and proposed conditions but bankfull discharge typically does not.

Ratio metrics include bank height ratio, entrenchment ratio, pool spacing ratio, pool depth ratio, and aggradation ratio (UM Sections 2.7.3 and 2.8.3). In calculating aggradation ratio, the observed W/D will be calculated from a surveyed cross-section and the bankfull feature will be consistent for each monitoring event. For the other ratio metrics listed, bankfull dimensions are used to normalize measurements of bank height, flood-prone width, pool spacing, and pool depth so that metrics can be scored across all stream sizes and types. Consistent with guidance provided in the Compensatory Mitigation Requirements for performance standards (USACE 2012), the design bankfull dimensions will be held constant throughout monitoring. Direction, with a focus on monitoring, is provided below for each ratio metric.

Bank height ratio - use the design bankfull maximum depth from the typical riffle cross-section applicable to the representative sub-reach as the denominator for every riffle within the sub-reach.

Entrenchment ratio - use the design bankfull width from the typical riffle cross-section for every riffle where the entrenchment ratio is measured throughout monitoring. The proposed/design bankfull width may be recorded in the Site Information and Reference Stratification section of the workbook (refer to Table 6 on page 21 of this document).

Pool spacing ratio - use the same bankfull width as entrenchment ratio to normalize all pool spacing measurements.

Pool depth ratio - use the design bankfull mean depth from the typical riffle cross-section applicable to the representative sub-reach as the denominator for every pool within the sub-reach.

EA and PA Checklist Items 6 through 10

EA-6 & PA-6: Does the representative sub-reach meet minimum length requirements, and does it start and end at the head of the same type of feature?

Reviewer Action: Ensure the representative sub-reach(es) are consistent with UM Section 2.1.2. The length of representative sub-reaches should be either 20 times the bankfull width or the length of two meander wavelengths (additional detail in UM Appendix A Section 5). When a project reach is shorter than this, geomorphic survey data should be collected from the entire project reach. Figure 8 shows an example of a representative sub-reach that extends for two meander wavelengths from upstream to downstream.

Review the start and end points of the representative sub-reach(es) to ensure they begin and end at the head (beginning) of the same type of bedform feature. Typically, a sampling reach begins and ends at the head of a riffle feature, although it can begin and end at the head of the same type of feature (e.g., pool, run, or glide). This is important for measuring the slope and percent riffle metric as there should be an equal number of riffle and pool features.

For proposed condition assessments, the design plan set likely shows the longitudinal profile for the entire project reach. Location information should be provided for any measurements used to calculate the proposed field values. On the **Field Value Documentation** form(s), practitioners should indicate whether field values reflect measurements from throughout the entire project reach or from a representative sub-reach.

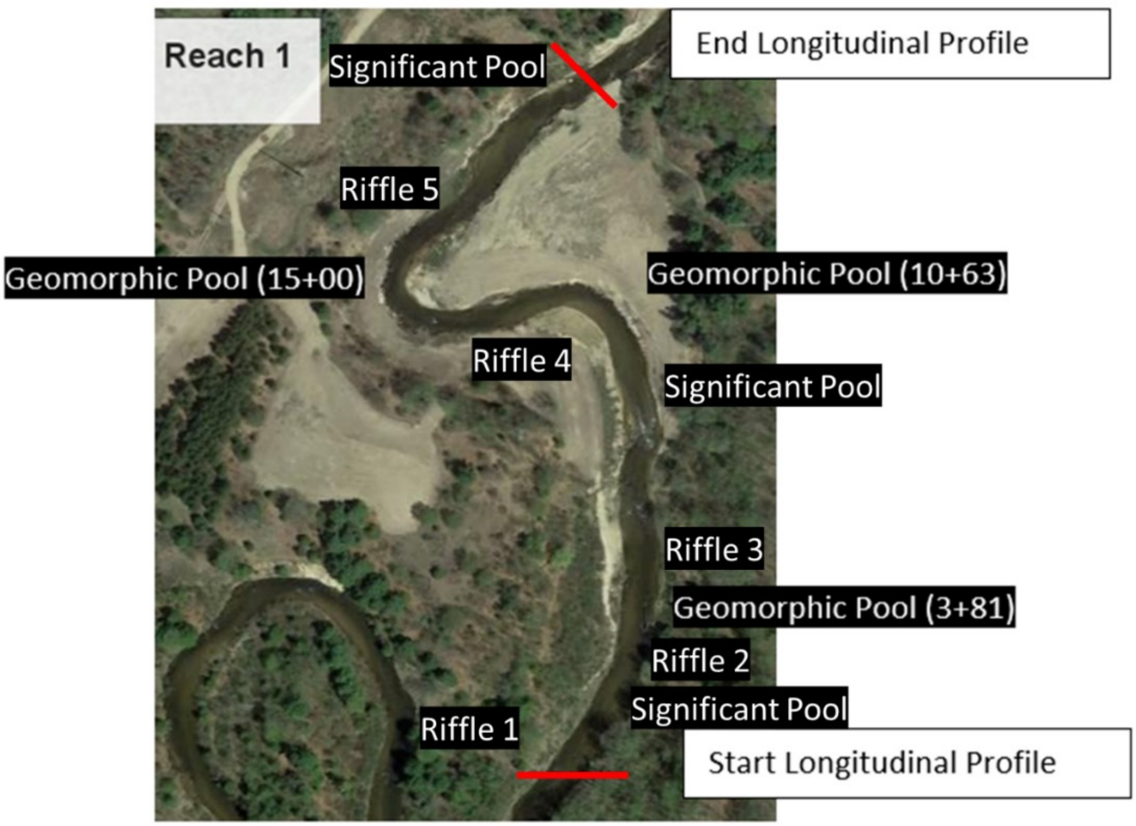


Figure 8. Example aerial image showing extent of representative sub-reach and bed form identification. The start of the longitudinal profile is the upstream extent of the survey.

EA-7 & PA-7 *where Detailed Survey methods were used:* Does the Longitudinal Profile of the representative sub-reach include the thalweg, water surface, bankfull, low bank, water surface elevation slope, bankfull slope, head of riffle and pool features, and labels for pool types?

The question shown in the Checklist will vary depending on whether survey data were collected using detailed survey methods (UM Appendix A Section 4) or rapid survey methods (UM Appendix A Section 5), as selected on the Introduction worksheet.

Reviewer Action: Review the detailed survey data collection consisting of surveyed elevations from a longitudinal profile within the representative sub-reach and riffle cross-section(s) (see UM Appendix A, Section 4). Survey data should be plotted on a longitudinal profile figure, with labeled items collected systematically throughout the representative sub-reach (Figure 9), as opposed to isolated/infrequent shots. It is critical that the longitudinal profile is provided at a scale where calculations can be verified. Practitioners should provide raw or processed survey data used to create the longitudinal profile (e.g., RIVERMorph export or Reference Reach Spreadsheet).

Low bank elevations should be measured either throughout each riffle feature, or at a minimum, in the middle of each riffle feature to calculate the bank height ratio field value. If low bank height is not provided on the profile, then cross-sections are needed at every riffle in the representative sub-reach. Where baseflow dynamics are selected (i.e., average velocity and depth metrics), verify that the survey data includes a minimum of three riffle cross-sections to determine the wetted area at baseflow.

Note that for a proposed condition assessment, water surface elevation and water surface slope are not required. For the existing condition and any monitored condition, water surface elevations and water surface slope are required.

An example detailed survey submittal is provided in Appendix 2 of this document. Appendix 2 of this document includes a longitudinal profile figure and data form; a representative cross-section figure and data form; and the Field Value Documentation forms for floodplain connectivity and bed form diversity metrics. Appendix 3 of this document provides example field value calculations for the metric field values provided in Appendix 2.

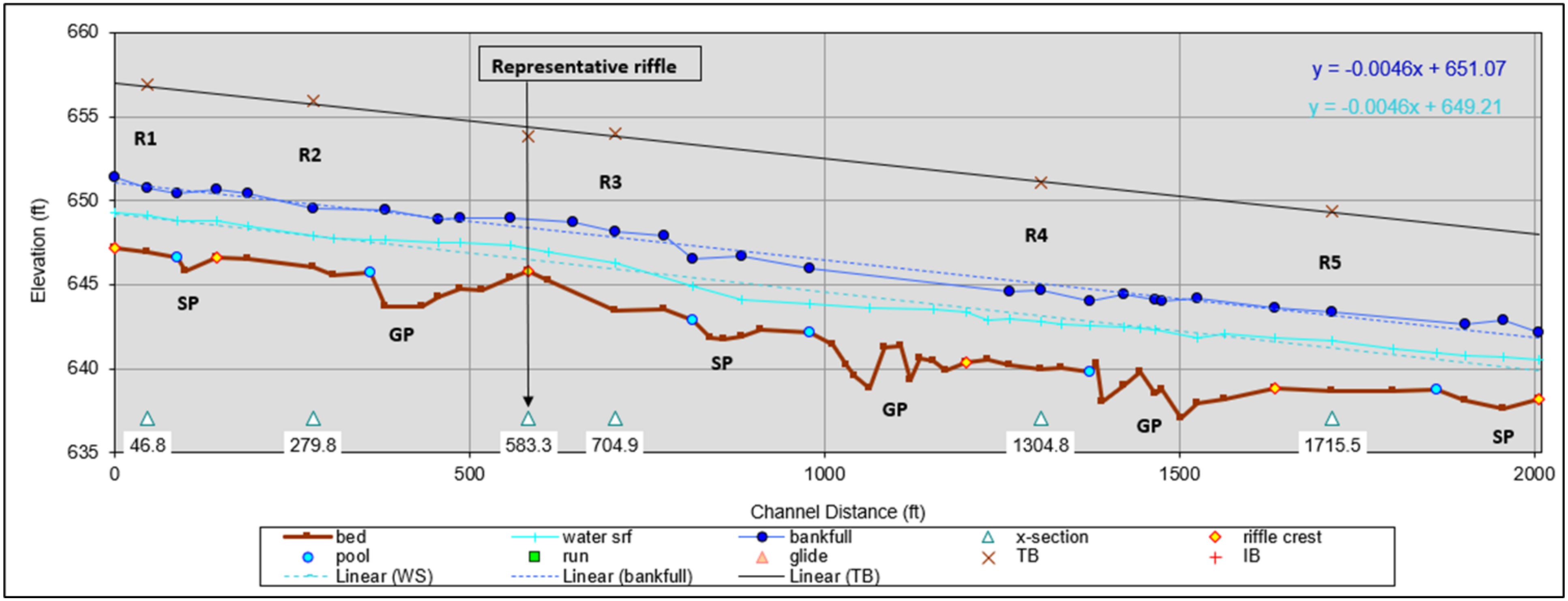


Figure 9. Example longitudinal profile using data collected using detailed survey methods. GP = Geomorphic Pool, SP = Significant Pool, R = Riffle.

EA-7 & PA-7 *where Rapid Survey methods were used:* Are the following values provided: riffle lengths; pool lengths and types; low bank features; maximum pool and riffle depths; station of maximum pool depth; flood-prone width(s); riffle mean depth(s); and bankfull width(s)?

Rapid survey data collection consists of measurements taken within the representative sub-reach and riffle cross-section(s) (see UM Appendix A, Section 5). Rapid survey methods have a lower accuracy than detailed methods and values should be rounded according to the accuracy of the field survey equipment (typically a whole foot or tenth of a foot). UM Appendix A, Section 12 includes an **Rapid Survey Form** to assist with rapid survey data collection. Example tables of collected data using this field form are provided (Figures 10 and 11).

Reviewer Action: Review the rapid survey data. Where baseflow dynamics metrics are selected (i.e., average velocity and depth), verify that the survey data includes a minimum of three riffle cross-sections to determine the wetted area at baseflow.

	R1	R2	R3	R4	R5
Begin Station	0	143	583	1201	1635
End Station	88	361	815	1373	1863
Low Bank Height (ft)	3.8	5.2	4.8	6.8	5.8
BKF Max Depth (ft)	4	3.7	4.4	5.1	4.5
BKF Mean Depth (ft)			3		
BKF Width (ft)			66.6		
Flood Prone Width (ft)			113		

Figure 10. Example riffle data collected using rapid survey methods. This is the same reach shown in Figure 9.

	P1	P2	P3	P4	P5	P6
Geomorphic Pool?		G		G	G	
Station	100	382	859	1063	1502	1956
Pool Depth (ft) Measured from BKF	4.8	5.6	5.3	7.4	7.1	4.5

Figure 11. Example pool data collected using rapid survey methods. G = Geomorphic Pool; this is the same reach shown in Figure 9.

EA-8 & PA-8: Does the identification of bed features match the definition in the user manual? This includes riffles, geomorphic pools, and significant pools.

Riffles are defined in the glossary of the UM as shallow, steep-gradient channel segments typically located between pools. Riffles can also be defined as the portion of the profile that is not occupied by a geomorphic or significant pool (see EA-7, PA-7, and UM Appendix A, Section 4).

The typical methods/characteristics used to identify riffles include water surface slope (steeper gradient compared to pool features), bed sorting (riffles have coarser bed material in gravel bed streams), and plan form (riffles are typically located in crossover features of the plan form of meandering channels).

Reviewer Action: Review the riffles depicted and/or described for all condition assessments. The following can be used to support proper identification of riffles:

- In step-pool systems, riffles are the cascade sections of steep mountain streams. Steps between geomorphic pools in these systems will also count towards riffle lengths. Steeper systems tend to have distinct water surface slope changes that will indicate riffle and pool features.
- In meandering systems, riffles represent the section between lateral-scour pools (known as the crossover), which can be identified from the plan form.
- In gravel bed or coarser bed streams, riffle features will generally align with the crossover. However, the riffle start/end stations may correspond to bed material sorting or water surface slope if either of these are measurable or apparent. Otherwise, riffle features will be derived solely on plan form as described in the next bullet.
- In low-gradient sand-bed streams that lack a standard riffle-pool morphology, the riffle feature is defined solely by plan form. The start/end stations of riffle features will correspond with the points of curvature and tangency for the radius of curvature. Note that any significant pools within the crossover would create two riffles within a single crossover: one riffle upstream of the significant pool and one riffle downstream.
- If the stream has been straightened and there is no crossover, then there are no geomorphic pools. Riffles will be any section between significant pools. If no pools meet the definition of significant, then the reach is 100% riffle.

Information on pool identification is provided in Section 4 of Appendix A of the UM. Review the location information provided for geomorphic and significant pools to ensure they are labeled and identified appropriately.

> The pool spacing ratio metric is calculated using geomorphic pools only. Pool depth ratios are calculated for all geomorphic and significant pools.

For proposed condition assessments, the design plan set likely shows a longitudinal profile for the entire project reach. Proposed condition field values should be calculated from bed features and pool types within the representative sub-reach portion of the longitudinal profile. This allows changes to be tracked from the proposed condition throughout monitoring.

EA-9 & PA-9: Are the survey measurements in the Field Value Documentation forms reasonable based on the geomorphic survey data provided? Survey data are used for BHR, ER, W/D, PSR, PDR, and percent riffle. [PSR = pool spacing ratio; PDR = pool depth ratio]

Reviewer Action: Compare the rapid or detailed survey data with the input on the **Field Value Documentation** forms for data collection or analysis errors. Appendix 5 of this document includes general tips for each of these metrics in addition to tips for reviewing calculations and proposed condition field values.

Aggradation ratio is calculated using the widest width/depth (W/D) observed in the representative sub-reach. Verify that multiple riffle cross-sections with aggradation features were measured to ensure that the widest value for the sub-reach is obtained. Given the reliance on cross-section data to calculate the aggradation ratio, reviewers should refer to the submitted survey data to check for consistency of methods. See UM Sections 2.7.2, 2.7.3, and 2.8.3 for more information.

EA-10 & PA-10: If the baseflow dynamics parameter is assessed, is the baseflow discharge that determines wetted dimensions the same for all 3 cross-sections? Based on the data provided, are the field values for this parameter reasonable?

Baseflow dynamics metrics are informed by survey data collected from a minimum of three riffle cross-sections, with flow measurements to inform existing condition metric calculations (see methods in UM Section 2.7.2).

Reviewer Action: Cross-section figures should include labels for wetted area, bankfull dimensions, and bankfull discharge. Compare the survey data provided with the values recorded on the **Field Value Documentation** form. Where baseflow dimensions will change but baseflow discharge will not, the same baseflow discharge value should be used for all cross-sections and all condition assessments: existing, proposed, and monitoring. Projects that propose to alter baseflow discharge should analyze and explain any expected baseflow discharge variation due to climate and project-related activities.

When evaluating proposed condition field values, examine whether the proposed activities are intended to slow velocity and depth by narrowing channels or removing inner berm features.

EA and PA Checklist Items 11 through 15

EA-11: For O/E metrics, is the expected value reasonable: Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics?

For metrics that use a reference (or expected) condition to calculate the field value, the expected condition should align with a functioning condition. A functioning condition fully supports aquatic ecosystem structure and function, reflecting an unaltered or pristine condition. Refer to Table 1 in Section 1.2 of the UM.

Reviewer Action: Review each expected value for Observed/Expected (O/E) metrics following the guidance presented below.

Expected riparian area: Review the map of the expected riparian area boundary to ensure it has been drawn consistently with the methods outlined in the User Manual (UM Section 2.8.4). Ensure the boundary appears reasonable based on aerial imagery and other site information provided.

Aggradation ratio: The reference W/D is derived from the representative riffle cross-section, a riffle cross-section adjacent to the project reach, or through the design process (UM Section 2.8.3).

Native fish species richness: Expected values are generated from the species assemblage list (UM Appendix C and Section 2.10.2), relevant site information and following consultation with a Colorado Parks & Wildlife (CPW) area fish biologist. Reviewers should evaluate information in the submittal, including site characteristics, UM Appendix C, and any discussion or notes from the practitioner's consultation with a CPW area fish biologist to verify the expected value.

Flow alteration: Expected values for flow alteration reflect the stream flows that would result from natural hydrologic processes such as rainfall-runoff and snowmelt without anthropogenic influence, and should be calculated by using historic flow data, where available, or by using modeling software such as StateMod. Review the data, historic or modeled, and other information provided in the submittal, to verify the expected value (See UM Section 2.11).

PA-11: For O/E metrics, is the expected value the same value used for the existing condition assessment? Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics.

Reviewer Action: Review the relevant O/E metrics and ensure field values for the proposed, as-built, and monitoring assessments were calculated using the same expected values verified in EA-11. For the expected riparian area, the area and the mapped physical location should remain constant between all condition assessments.

EA-12 & PA-12-Monitoring: Are the vegetation plots within the expected riparian extent?

This question is not applicable to proposed conditions and the row will be hidden.

Reviewer Action: Cross-check the riparian extent maps with the riparian plot locations to ensure plots are located within the expected riparian area, and that plots were not inappropriately relocated to avoid modified areas within the expected riparian area. Vegetation plots may extend beyond the current, observed riparian extent but should not extend beyond the expected riparian area. Where the expected riparian area extends further than observed, plots may extend into developed or modified upland areas. Plots can be reshaped if needed; detailed instructions for reshaping riparian vegetation plots are provided in Section 7 of Appendix A.

EA-13 & PA-13-Monitoring: Are the field values for riparian vegetation metrics reasonable based on the data provided?

Reviewer Action: Check the **Riparian Vegetation** forms (UM Appendix B) for accuracy, appropriate species identification, and reference community type. **Riparian Extent** forms (UM Appendix B) should also be checked to ensure the observed extent has been drawn consistently with the methods outlined in the User Manual (UM Section 2.8.4) and appears reasonable based on aerial imagery and other site information provided. The observed riparian extent boundary should always be the same or within the expected extent. Photos and aerial imagery are useful for verifying vegetation field values.

PA-13-Proposed: Are the field values for riparian vegetation metrics reasonable based on the monitoring timeline and proposed planting?

Proposed field values for riparian vegetation metrics will vary based upon planting schedule, channel work (e.g., reducing incision can increase the riparian extent percentage), and the monitoring period. For example, a site with a 10-year monitoring period would be expected to achieve a higher proposed condition score compared to that same site with only a 5-year monitoring period.

Reviewer Action: For woody and/or herbaceous vegetation cover percentages, be wary of high index values that may not be reasonable to achieve during the project timeline. Weigh all proposed field values against what is possible during the monitoring period and closeout. For percent native cover, a field value of 100% is unlikely in all but the most pristine locations, and reviewers should consider the presence of invasive species at, adjacent to, and nearby the project reach. For riparian extent, the observed riparian area should always be the same or within the expected extent. For projects that propose restoring all or portions of the riparian area, consider whether the proposed project can reasonably address the factors that limited the existing, observed riparian area.

EA-14 & PA-14-Monitoring: For metrics requiring the installation of data loggers or a flow gage (e.g., temperature metrics, dissolved oxygen concentration, baseflow dynamics metrics) - Is there an explanation for any data gaps?

This question is not applicable to proposed conditions and the row will be hidden.

As noted in the Package Completeness portion of the Checklist, clearly labeled plots of the recorded data along with the deployment and interval settings must be documented on the **Field Value Documentation** forms.

Reviewer Action: During review, consider whether data gaps would preclude use of the data to inform field value calculations. Any data gaps or anomalies during the sampling period must be explained (e.g., equipment malfunction).

EA-15 & PA-15-Monitoring: Does the data collection meet the season/timing requirements?

This question is not applicable to proposed conditions and the row will be hidden.

Data collection efforts for riparian vegetation metrics, temperature metrics, DO, Chlorophyll α, CO MMI, and fish metrics have seasonal, timing, and sampling frequency requirements (Table 8).

Table 8. Summary of metrics with constraints on data collection season, timing, and sampling frequency. See also Table A.2 Sampling Restrictions in UM Appendix A.

Assessment Metric		Sampling Period	Time of Day	No. of Sampling Events
Riparian Vegetation metrics		Growing season	NA	1
Temperature metrics		July and August (62 days minimum)	NA	N/A
DO		7 consecutive days in July or August	Early morning	N/A
Chlorophyll α		Mid-summer to early fall	NA	1
CO MMI	Biotype 1 & 2	Late June to early November	NA	1
	Biotype 3	May 1 to November 30	NA	1
Fish metrics	Method Option 1	Minimum of 60 days apart between sampling	NA	2 within the same year
	Method Option 2	Same season between years	NA	2 in consecutive years

Reviewer Action: Review the submitted **Riparian Vegetation** forms, **Field Value Documentation** forms (UM Appendix B), other data forms or field notes (e.g., optional **Physicochemical and Biology Form** provided in Appendix A) to ensure data were collected following the requirements presented in Table 8.

EA and PA Checklist Items 16 through 19

EA-16 & PA-16-Monitoring: If fish sampling is occurring, has a Colorado Parks & Wildlife (CPW) scientific collection permit been obtained?

This question is not applicable to proposed conditions and the row will be hidden.

A CPW scientific collection permit is required to collect fish samples (UM Section 2.10.2). Practitioners should not collect any data without obtaining the appropriate permit.

Reviewer Action: Ensure a copy of the CPW permit is included in the submittal.

EA-17 & PA-17-Monitoring: For the Wild Trout Biomass metric, is the control reach an appropriate reference for the project reach?

This question is not applicable to proposed conditions and the row will be hidden.

Fish sampling from a nearby control reach is required to account for natural variability in fish populations. Criteria for identifying an appropriate control reach are provided in the Wild Trout Biomass definition (UM Section 2.10.2).

Reviewer Action: Review control reach information in the submittal to ensure it is an appropriate reference reach for the project.

EA-18 & PA-18: Are the values in the Field Value Documentation forms consistent with the data provided and do the field values on the forms match the field values in the condition assessment?

Reviewer Action: Many mistakes in SQT submittals are data transcription and conversion errors. Double-check field values to ensure functional lift and loss calculations are accurate. Appendix 5 of this document provides guidance for common mistakes and calculation errors.

EA-19: Are the existing condition field values reasonable given the data provided, reference curves, goals, objectives, and constraints?

This question is applicable to CSQT submittals proposing functional lift. Portions of this question are applicable to submittals measuring loss using Debit Options 1 or 2, but those submittals would not include goals or objectives. For projects proposing functional lift, the goals and objectives of the project are often reflected in the existing condition parameter scores. For example, projects that aim to increase aquatic connectivity for native species are not likely to have a functioning score for the fish parameter for the existing condition.

Reviewer Action: To evaluate whether the existing condition field values are reasonable, review the stressors noted in the **Catchment Assessment**; reach-specific constraints; and the site conditions observed in photos or in the field. In the CSQT, reference curves relate field values for each metric to functional capacity of reference aquatic resources (UM Chapter 2, Section 1.2, and the Scientific Support for the CSQT [USACE, 2020b]). Consider the existing condition index scores for each metric, parameter, category, and overall score in the context of available site information and photos. Determine whether the index scores in the **Summary** tables in the **Quantification Tool** worksheet (CSQT workbook) or the **Debit Calculator** worksheet (Debit Calculator workbook) reasonably reflect the existing condition data, site information and reference selection, site photos, known constraints, and other available information.

PA-19-Proposed: Are the proposed condition field values reasonable given the data provided, reference curves, design approach, monitoring timeline, goals, objectives, and constraints?

Reviewer Action: To evaluate whether the proposed condition field values are reasonable, review the stressors noted in the **Catchment Assessment**; reach-specific constraints, goals, and objectives; restoration potential; existing site conditions; design approach and monitoring timeline (UM Chapter 2). The proposed condition represents an estimate of conditions at project closeout. As such, the length of any monitoring period will affect the reasonableness of achieving proposed condition field values at project closeout.

Consider the proposed condition index scores for each metric, parameter, category, and overall score in the context of available project information, including design plans and project goals and objectives. Determine whether the index scores in the **Summary** tables in the **Quantification Tool** worksheet (CSQT workbook) or the **Debit Calculator** worksheet (Debit Calculator workbook) reasonably reflect the actions proposed for the site (e.g., structures, grading, armoring, etc.). For Debit Calculator - Debit Option 1 submittals, determine whether the summary values are reasonable given the impacts described in the **Project Assessment** worksheet. For CSQT workbook submittals, determine whether summary values reasonably reflect the stated goals and objectives identified in **Restoration Approach Question 3** in the **Project Assessment** worksheet. When the CSQT is used as part of an individual permit to demonstrate no loss of aquatic resource functions (no debits), an implicit goal is to avoid further functional impairment.

Consider how different design approaches (e.g., Stage 0, beaver dam analogs, or natural channel design) may impact field values. For example, a project that is implementing natural channel design is likely to have a proposed bank height ratio of 1 or 1.1, while a restoration project that proposes Stage 0 may have a proposed bank height ratio that is less than 1. For impact sites using Debit Option 1, the proposed bank height ratio is not likely to be 1 unless they are maintaining connection to an existing floodplain or excavating a bankfull bench sufficiently wide for the reference stream type. Appendix 5 of this document includes some additional guidance, tips for evaluating field values and identifying calculation errors.

PA-19-Monitoring: Is the project on track to achieve the proposed condition field values?

Review and compare all field values, index values, and information provided in the **Quantification Tool** and **Monitoring Data** worksheets (CSQT workbook). Functional change is estimated in the proposed condition assessment and then verified through measurement of post-project conditions (UM Chapter 2 and Section 3.4). Post-construction monitoring ensures that the project has met, or is on track to achieve, the proposed conditions. For third party mitigation, functional lift expected for the project is detailed in the mitigation plan. For projects that utilized the CSQT to demonstrate avoidance and minimization, the proposed conditions anticipate a project that does not result in functional loss of measured functions. Once post-project and monitoring data have been collected, those data and CSQT outputs can be used to review regulatory decisions related to performance standards, credit releases, adaptive management, special permit conditions, or project closeout.

4. References

U.S. Army Corps of Engineers (USACE). 2020a. Colorado Stream Quantification Tool (CSQT) User Manual and Spreadsheets. Version 1.0. U.S. Army Corps of Engineers, Albuquerque District, Pueblo Regulatory Office.

USACE. 2020b. Scientific Support for the Colorado Stream Quantification Tool. Version 1.0. U.S. Army Corps of Engineers, Albuquerque District, Pueblo Regulatory Office.

U.S. Army Corps of Engineers (August 2012). *Attachment 12505.1 Table of Uniform Performance Standards for Compensatory Mitigation Requirements* 12505.1-SPD Table of Uniform Performance Standards.pdf (army.mil)

Appendix 1: Review Checklists (PDF Copy)

This appendix provides three copies of the Checklist:

- CSQT Submittal using detailed survey methods, all parameters and metrics included. Introduction, PC, EA, and PA - 14 pages.
- CSQT Monitoring submittal using rapid survey methods, all parameters and metrics included. Introduction, PC, and PA - 10 pages.
- DC Debit Option 2 submittal using rapid survey methods, only required/minimum parameters and metrics included. Introduction, PC, and EA - 9 pages.

CSQT and Debit Calculator Review Checklist
INTRODUCTION

Submittal Information

Reviewer Name:		Person filling out this checklist.
Project Name:		
Sponsor:		
Date:		
Applicant Submittal:		E.g., Prospectus, mitigation plan, monitoring plan
Workbook(s) Submitted:	CSQT	Fill out separate checklists for projects that use both workbooks, CSQT and Debit Calculator.
***Applicable Workbooks:**		List the workbook file names that are reviewed using this checklist.
Monitoring Submittal (Y/N):	N	Reviewer will complete both the Existing Assessment and Proposed Assessment checklists.
Existing Condition Survey Method:	Detailed	Existing Assessment represents the pre-project conditions. This is N/A to Debit Option 3 and monitoring condition assessments in the CSQT.
Proposed Condition Survey Method:	Detailed	Proposed Assessment represents the post-project conditions (proposed, as-built, monitored). This is N/A to Debit Options 2 and 3.

* This checklist can be used for each reach within a project area, it could also be used to review an entire submittal. This will depend on the reviewer and the complexity of the project.

CSQT and Debit Calculator Review Checklist
INTRODUCTION
Parameter and Metric Selection*

*Before changing any inputs make sure rows are not hidden on the other worksheets.

Single-thread (Y/N):		The entrenchment ratio metric for floodplain connectivity and all the metrics used to quantify the bed form diversity parameter are not applicable to multi-thread channels.
Lateral Migration Assessment Method:		Select Greenline Stability Rating or Dominant BEHI/NBS.
Is there or should there be a natural supply of large woody debris (Y/N):		
Is man-made armoring present or proposed (Y/N):		Use the armoring metric for lateral migration when man-made armoring is present or proposed.
Is there or should there be <20% absolute woody vegetation cover (Y/N):		Measure the riparian extent, woody vegetation cover, and native cover metrics for the riparian vegetation parameter.
Is the stream bedrock-dominated (Y/N):		
Is this a perennial stream where hydraulic conditions during summer/fall baseflow periods should support trout assemblages (Y/N):		
Are physicochemical or biology functions measured (Y/N):		
For single-thread streams in alluvial valleys, are there or should there be side channels (Y/N):		
Is the stream a transport reach where riffles are exhibiting signs of aggradation, or there is a risk of aggradation due to sediment supply (Y/N):		

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-1	Were data collection and analyses completed by those with sufficient experience?	Chapter 2				
PC-2	Is there a description and visual depiction of the reaches and reach breaks within the Project Area?	Sections 1.2.1 & 2.1.1				
PC-3	Is every reach within the Project Area represented in a workbook?	Sections 1.2.1 & 2.1.1				
PC-4	CSQT: Are the process drivers, reference stream type, and sinuosity values on the Project Assessment worksheet applicable to the reach?	Section 2.2				
PC-5	Are the existing and proposed project reach stream lengths accurate?	Section 2.4				
PC-6	CSQT: Does the Catchment Assessment worksheet identify applicable reaches and are all reaches accounted for?	Section 2.3				
PC-7	CSQT: Is the restoration potential description informed by the catchment assessment results, presence of human-induced reach-scale constraints, and reach corridor assessment results?	Section 3.2.1				
PC-8	CSQT: Does the project have function-based goals and measurable objectives that align with the restoration potential?	Section 3.2.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-9	Is every reach represented on a **Parameter Selection Checklist** and are selected parameters and metrics appropriate for the reach?	Section 2.5 & Appendix B				
PC-10	Is location information provided for all measurements and samples within each project reach for all relevant assessments (existing, proposed, monitoring)?	Chapter 2 & Appendix A				
PC-11	Is there a completed **Project Reach form** for each reach? Project Reach forms include data/values for stream reach length, sinuosity, bankfull identification, concentrated flow points, and, when applicable, armoring and side channels.	Chapter 2 & Appendix B				
PC-12	Does every reach have **Field Value Documentation forms** for all relevant assessments (existing, proposed, monitoring)? And are the forms completed for all parameters and metrics checked on the Parameter Selection Checklist?	Appendix B & Section 3.4				
PC-13	CSQT & DC: Are responses provided for all applicable fields in the Site Information and Reference Selection section?	Section 2.4				
PC-14	Have field values been entered for all selected parameters and metrics in all relevant assessments (existing, proposed, monitoring)? And are field values associated with the correct Reach ID?	Section 1.2.3 & Section 3.4				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-15	Is every reach represented on a **Bankfull Verification form**?	Section 2.6 & Appendix B				
PC-16	Does every reach have a **Riparian Extent form** for all relevant assessments (existing, proposed, monitoring) that includes an aerial or topographic image depicting observed and expected riparian areas?	Section 2.8.4 & Appendix B				
PC-17	Were the correct number of **Riparian Vegetation forms** provided? Photos of every vegetation plot are recommended.	Section 7 in Appendix A & Appendix B				
PC-18	Are sufficient data provided to verify all field values? In addition to required forms listed above, the following items are needed:					
	Photos are recommended to document site conditions. This includes photos documenting any concentrated flow points, side channels, and areas of armoring.	N/A				
	<u>For detailed survey field methods:</u> 1) **Longitudinal Profile form** or field data, 2) **Standard Cross-Section form** or field data, 3) Longitudinal profile figure, 4) Cross-section figure(s), 5) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 4 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
For rapid survey field methods: 1) **Rapid Survey form** or field data, 2) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 5 in Appendix A				
For physicochemical, biology, or flow alteration module metrics Implementing these metrics requires additional rationale documenting upfront planning (e.g., memo or mitigation plan) for data collection and processing that includes consideration of natural and anthropogenic sources of stressors, and quantifying uncertainty.	Sections 2.9, 2.10, & 2.11				
Land Use Coefficient metric: 1) Aerial image depicting topography and lateral drainage area (LDA) delineation. 2) Aerial image depicting land uses in the LDA.	Section 2.7.1				
Average Velocity & Average Depth metrics: 1) Three riffle cross-section figures with wetted dimensions and baseflow discharge identified. 2) Time-series plot of data recorded.	Section 2.7.2				
LWD Index metric: **LWDI field form**	Section 2.8.1				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
Lateral Migration metrics: 1) **Lateral Migration form**, **GSR form** or field data. 2) Map of ratings (either GSR or BEHI/NBS) along representative sub-reach. 3) Photos of each assessed bank, or representative banks, recommended.	Section 2.8.2				
Aggradation Ratio 1) Widest riffle cross-section figure(s) from detailed survey or data from rapid method. 2) If the reference W/D is from a cross-section, then the cross-section must be provided.	Section 2.8.3				
Daily Maximum Temperature and MWAT: Time-series plot of data recorded.	Section 2.9.1				
Dissolved Oxygen Concentration: Time-series plot of data recorded.	Section 2.9.2				
Chlorophyll α: **Physicochemical and Biology form**	Section 2.9.3				
CO MMI: **Physicochemical and Biology form**	Section 2.10.1				
Native Fish Species Richness and SGCN Absent Score: **Physicochemical and Biology form**	Section 2.10.2				
Wild Trout Biomass: **Physicochemical and Biology form** with location of reference control site identified.	Section 2.10.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-1	Are the location and number of measurements for each metric consistent with the UM?	Chapter 2 & Appendix A				
EA-2	Are the following items identified according to the definitions in the UM: Concentrated flow points, side channels, LWD, armoring, expected riparian area, observed riparian area, percent native cover?	Sections 2.7.1, 2.7.3, 2.8.1, 2.8.2, & 2.8.4				
EA-3	Are the field values in the **Field Value Documentation** forms for concentrated flow points, percent side channels, percent armoring, and LWD reasonable based on the data provided?	Sections 2.7.1, 2.7.3, 2.8.1, & 2.8.2				
EA-4	Is there a representative riffle cross-section adequate for bankfull verification that labels or presents bankfull area, width, mean depth, flood-prone width, water surface elevation, W/D, and ER?	Section 2.6 & Section 3 of Appendix A				
EA-5	Did the bankfull verification process follow one of three methods in the flow chart and is the bankfull determination reasonable based on the data provided?	Section 2.6				
EA-6	Does the representative sub-reach meet minimum length requirements and does it start and end at the head of the same type of feature?	Section 2.1.2 & Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-7	Does the Longitudinal Profile of the representative sub-reach include the thalweg, water surface, bankfull, low bank, water surface elevation slope, bankfull slope, head of riffle and pool features, and labels for pool types?	Section 4 in Appendix A				
EA-8	Does the identification of bed features match the definitions in the user manual? This includes riffles, geomorphic pools, and significant pools.	Section 4 in Appendix A				
EA-9	Are the survey measurements in the **Field Value Documentation** forms reasonable based on the geomorphic survey data provided? Survey data are used for BHR, ER, W/D, PSR, PDR, and percent riffle.	Sections 2.7.3, & 2.8.3 and Sections 4 & 5 of Appendix A				
EA-10	If the baseflow dynamics parameter is assessed, is the baseflow discharge that determines wetted dimensions the same for all 3 cross-sections? Based on the data provided, are the field values for this parameter reasonable?	Section 2.7.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-11	For O/E metrics, is the expected value reasonable: Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics?	Sections 1.2 (Table 1), 2.8.3, 2.8.4, 2.10.2, 2.11, & Appendix C				
EA-12	Are the vegetation plots within the expected riparian extent?	Section 7 in Appendix A				
EA-13	Are the field values for riparian vegetation metrics reasonable based on the data provided?	Section 2.8.4				
EA-14	For metrics requiring the installation of data loggers or a flow gage (e.g., temperature metrics, dissolved oxygen concentration, baseflow dynamics metrics) - Is there an explanation for any data gaps?	Sections 2.7.2, 2.9 & 2.11				
EA-15	Does the data collection meet the season/timing requirements?	Table A.2 in Appendix A				
EA-16	If fish sampling is occurring, has a Colorado Parks & Wildlife (CPW) scientific collection permit been obtained?	Section 2.10.2				
EA-17	For the Wild Trout Biomass metric, is the control reach an appropriate reference for the project reach?	Section 2.10.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-18	Are the values in the **Field Value Documentation** forms consistent with the data provided and do the field values on the forms match the field values in the Condition Assessment?	Chapter 2 & Appendix B				
EA-19	Are the existing condition field values reasonable given the data provided, reference curves, goals, objectives, and constraints?	Chapter 2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-1	Are the location and number of measurements for each metric consistent with the UM?	Chapter 2 & Appendix A				
PA-2	Are the following items identified according to the definitions in the UM: Concentrated flow points, side channels, LWD, armoring, expected riparian area, observed riparian area, percent native cover?	Sections 2.7.1, 2.7.3, 2.8.1, 2.8.2, & 2.8.4				
PA-3	Are the field values in the **Field Value Documentation** forms for concentrated flow points, percent side channels, percent armoring, and LWD reasonable based on the data provided?	Sections 2.7.1, 2.7.3, 2.8.1, & 2.8.2				
PA-4	Is there a representative riffle cross-section adequate for bankfull verification that labels or presents bankfull area, width, mean depth, flood-prone width, water surface elevation, W/D, and ER?	Section 2.6 & Section 3 of Appendix A				
PA-5	Was verified bankfull applied correctly to ratio metrics across condition assessments?	Sections 2.7.3 & 2.8.3				
PA-6	Does the representative sub-reach meet minimum length requirements and does it start and end at the head of the same type of feature?	Section 2.1.2 & Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-7	Does the Longitudinal Profile of the representative sub-reach include the thalweg, water surface, bankfull, low bank, water surface elevation slope, bankfull slope, head of riffle and pool features, and labels for pool types?	Section 4 in Appendix A				
PA-8	Does the identification of bed features match the definitions in the user manual? This includes riffles, geomorphic pools, and significant pools.	Section 4 in Appendix A				
PA-9	Are the survey measurements in the **Field Value Documentation** forms reasonable based on the geomorphic survey data provided? Survey data are used for BHR, ER, W/D, PSR, PDR, and percent riffle.	Sections 2.7.2, 2.7.3, & 2.8.3 and Sections 4 & 5 of Appendix A				
PA-10	If the baseflow dynamics parameter is assessed, is the baseflow discharge that determines wetted dimensions the same for all 3 cross-sections? Based on the data provided, are the field values for this parameter reasonable?	Section 2.7.2				
PA-11	For O/E metrics, is the expected value the same value used for the existing condition assessment? Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics.	Sections 2.8.3, 2.8.4, 2.10.2, & 2.11				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-13	Proposed: Are the field values for riparian vegetation metrics reasonable based on the monitoring timeline and proposed planting?	Section 2.8.4				
PA-18	Are the values in the **Field Value Documentation** forms consistent with the data provided and do the field values on the forms match the field values in the Condition Assessment?	Chapter 2 & Appendix B				
PA-19	Proposed: Are the proposed condition field values reasonable given the data provided, reference curves, design approach, monitoring timeline, goals, objectives, and constraints?	Chapter 2				

CSQT and Debit Calculator Review Checklist
INTRODUCTION

Submittal Information

Reviewer Name:		Person filling out this checklist.
Project Name:		
Sponsor:		
Date:		
Applicant Submittal:		E.g., Prospectus, mitigation plan, monitoring plan
Workbook(s) Submitted:	CSQT	Fill out separate checklists for projects that use both workbooks, CSQT and Debit Calculator.
***Applicable Workbooks:**		List the workbook file names that are reviewed using this checklist.
Monitoring Submittal (Y/N):	Y	Reviewer will complete the Proposed Assessment checklist for post-project monitored conditions.
N/A		Existing Assessment represents the pre-project conditions. This is N/A to Debit Option 3 and monitoring condition assessments in the CSQT.
Monitoring Survey Method:	Rapid	Proposed Assessment represents the post-project conditions (proposed, as-built, monitored). This is N/A to Debit Options 2 and 3.

* This checklist can be used for each reach within a project area, it could also be used to review an entire submittal. This will depend on the reviewer and the complexity of the project.

CSQT and Debit Calculator Review Checklist
INTRODUCTION
Parameter and Metric Selection*

*Before changing any inputs make sure rows are not hidden on the other worksheets.

Single-thread (Y/N):		The entrenchment ratio metric for floodplain connectivity and all the metrics used to quantify the bed form diversity parameter are not applicable to multi-thread channels.
Lateral Migration Assessment Method:		Select Greenline Stability Rating or Dominant BEHI/NBS.
Is there or should there be a natural supply of large woody debris (Y/N):		
Is man-made armoring present or proposed (Y/N):		Use the armoring metric for lateral migration when man-made armoring is present or proposed.
Is there or should there be <20% absolute woody vegetation cover (Y/N):		Measure the riparian extent, woody vegetation cover, and native cover metrics for the riparian vegetation parameter.
Is the stream bedrock-dominated (Y/N):		
Is this a perennial stream where hydraulic conditions during summer/fall baseflow periods should support trout assemblages (Y/N):		
Are physicochemical or biology functions measured (Y/N):		
For single-thread streams in alluvial valleys, are there or should there be side channels (Y/N):		
Is the stream a transport reach where riffles are exhibiting signs of aggradation, or there is a risk of aggradation due to sediment supply (Y/N):		

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-1	Were data collection and analyses completed by those with sufficient experience?	Chapter 2				
PC-2	Is there a description and visual depiction of the reaches and reach breaks within the Project Area?	Sections 1.2.1 & 2.1.1				
PC-3	Is every reach within the Project Area represented in a workbook?	Sections 1.2.1 & 2.1.1				
PC-4	Monitoring: Review the inputs on the Project Assessment and Quantification Tool worksheets. Have any responses or values changed from the previous submittal?	Section 1.2				
PC-5	Are the existing and proposed project reach stream lengths accurate?	Section 2.4				
PC-9	Is every reach represented on a **Parameter Selection Checklist** and are selected parameters and metrics appropriate for the reach?	Section 2.5 & Appendix B				
PC-10	Is location information provided for all measurements and samples within each project reach for all relevant assessments (existing, proposed, monitoring)?	Chapter 2 & Appendix A				
PC-11	Is there a completed **Project Reach form** for each reach? Project Reach forms include data/values for stream reach length, sinuosity, bankfull identification, concentrated flow points, and, when applicable, armoring and side channels.	Chapter 2 & Appendix B				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-12	Does every reach have **Field Value Documentation forms** for all relevant assessments (existing, proposed, monitoring)? And are the forms completed for all parameters and metrics checked on the Parameter Selection Checklist?	Appendix B & Section 3.4				
PC-13	Monitoring: Have any responses in the Site Information and Reference Selection section changed from the previous submittal?	Section 2.4				
PC-14	Have field values been entered for all selected parameters and metrics in all relevant assessments (existing, proposed, monitoring)? And are field values associated with the correct Reach ID?	Section 1.2.3 & Section 3.4				
PC-15	Is every reach represented on a **Bankfull Verification form**?	Section 2.6 & Appendix B				
PC-16	Does every reach have a **Riparian Extent form** for all relevant assessments (existing, proposed, monitoring) that includes an aerial or topographic image depicting observed and expected riparian areas?	Section 2.8.4 & Appendix B				
PC-17	Were the correct number of **Riparian Vegetation forms** provided? Photos of every vegetation plot are recommended.	Section 7 in Appendix A & Appendix B				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-18	Are sufficient data provided to verify all field values? In addition to required forms listed above, the following items are needed:					
	Photos are recommended to document site conditions. This includes photos documenting any concentrated flow points, side channels, and areas of armoring.	N/A				
	<u>For detailed survey field methods:</u> 1) **Longitudinal Profile form** or field data, 2) **Standard Cross-Section form** or field data, 3) Longitudinal profile figure, 4) Cross-section figure(s), 5) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 4 in Appendix A				
	<u>For rapid survey field methods:</u> 1) **Rapid Survey form** or field data, 2) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
For physicochemical, biology, or flow alteration module metrics Implementing these metrics requires additional rationale documenting upfront planning (e.g., memo or mitigation plan) for data collection and processing that includes consideration of natural and anthropogenic sources of stressors, and quantifying uncertainty.	Sections 2.9, 2.10, & 2.11				
Land Use Coefficient metric: 1) Aerial image depicting topography and lateral drainage area (LDA) delineation. 2) Aerial image depicting land uses in the LDA.	Section 2.7.1				
Average Velocity & Average Depth metrics: 1) Three riffle cross-section figures with wetted dimensions and baseflow discharge identified. 2) Time-series plot of data recorded.	Section 2.7.2				
LWD Index metric: **LWDI field form**	Section 2.8.1				
Lateral Migration metrics: 1) **Lateral Migration form**, **GSR form** or field data. 2) Map of ratings (either GSR or BEHI/NBS) along representative sub-reach. 3) Photos of each assessed bank, or representative banks, recommended.	Section 2.8.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
Aggradation Ratio 1) Widest riffle cross-section figure(s) from detailed survey or data from rapid method. 2) If the reference W/D is from a cross-section, then the cross-section must be provided.	Section 2.8.3				
Daily Maximum Temperature and MWAT: Time-series plot of data recorded.	Section 2.9.1				
Dissolved Oxygen Concentration: Time-series plot of data recorded.	Section 2.9.2				
Chlorophyll α: **Physicochemical and Biology form**	Section 2.9.3				
CO MMI: **Physicochemical and Biology form**	Section 2.10.1				
Native Fish Species Richness and SGCN Absent Score: **Physicochemical and Biology form**	Section 2.10.2				
Wild Trout Biomass: **Physicochemical and Biology form** with location of reference control site identified.	Section 2.10.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-1	Are the location and number of measurements for each metric consistent with the UM?	Chapter 2 & Appendix A				
PA-2	Are the following items identified according to the definitions in the UM: Concentrated flow points, side channels, LWD, armoring, expected riparian area, observed riparian area, percent native cover?	Sections 2.7.1, 2.7.3, 2.8.1, 2.8.2, & 2.8.4				
PA-3	Are the field values in the **Field Value Documentation** forms for concentrated flow points, percent side channels, percent armoring, and LWD reasonable based on the data provided?	Sections 2.7.1, 2.7.3, 2.8.1, & 2.8.2				
PA-4	Is there a representative riffle cross-section adequate for bankfull verification that labels or presents bankfull area, width, mean depth, flood-prone width, water surface elevation, W/D, and ER?	Section 2.6 & Section 3 of Appendix A				
PA-5	Was verified bankfull applied correctly to ratio metrics across condition assessments?	Sections 2.7.3 & 2.8.3				
PA-6	Does the representative sub-reach meet minimum length requirements and does it start and end at the head of the same type of feature?	Section 2.1.2 & Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-7	Are the following measurements provided: riffle lengths; pool lengths and types; low bank heights; maximum pool and riffle depths; station of maximum pool depth; flood-prone width(s); riffle mean depth(s); and bankfull width(s)?	Section 5 in Appendix A				
PA-8	Does the identification of bed features match the definitions in the user manual? This includes riffles, geomorphic pools, and significant pools.	Section 4 in Appendix A				
PA-9	Are the survey measurements in the **Field Value Documentation** forms reasonable based on the geomorphic survey data provided? Survey data are used for BHR, ER, W/D, PSR, PDR, and percent riffle.	Sections 2.7.2, 2.7.3, & 2.8.3 and Sections 4 & 5 of Appendix A				
PA-10	If the baseflow dynamics parameter is assessed, is the baseflow discharge that determines wetted dimensions the same for all 3 cross-sections? Based on the data provided, are the field values for this parameter reasonable?	Section 2.7.2				
PA-11	For O/E metrics, is the expected value the same value used for the existing condition assessment? Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics.	Sections 2.8.3, 2.8.4, 2.10.2, & 2.11				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PROPOSED (Post-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PA-12	Monitoring: Are the vegetation plots within the expected riparian extent?	Section 7 in Appendix A				
PA-13	Monitoring: Are the field values for riparian vegetation metrics reasonable based on the data provided?	Section 2.8.4				
PA-14	Monitoring: For metrics requiring the installation of data loggers or a flow gage (e.g., temperature metrics, dissolved oxygen concentration, baseflow dynamics metrics) - Is there an explanation for any data gaps?	Sections 2.7.2, 2.9 & 2.11				
PA-15	Monitoring: Does the data collection meet the season/timing requirements?	Table A.2 in Appendix A				
PA-16	Monitoring: If fish sampling is occurring, has a Colorado Parks & Wildlife (CPW) scientific collection permit been obtained?	Section 2.10.2				
PA-17	Monitoring: For the Wild Trout Biomass metric, is the control reach an appropriate reference for the project reach?	Section 2.10.2				
PA-18	Are the values in the **Field Value Documentation** forms consistent with the data provided and do the field values on the forms match the field values in the Condition Assessment?	Chapter 2 & Appendix B				
PA-19	Monitoring: Is the project on track to achieve the proposed condition field values?	Chapter 2				

CSQT and Debit Calculator Review Checklist
INTRODUCTION

Submittal Information

Reviewer Name:		Person filling out this checklist.
Project Name:		
Sponsor:		
Date:		
Applicant Submittal:		E.g., Prospectus, mitigation plan, monitoring plan
Workbook(s) Submitted:	Debit Calculator	Fill out separate checklists for projects that use both workbooks, CSQT and Debit Calculator.
***Applicable Workbooks:**		List the workbook file names that are reviewed using this checklist.
Select the most complicated debit option used:	2	Reviewer will complete the Existing Assessment checklist.
Existing Condition Survey Method:	Rapid	Existing Assessment represents the pre-project conditions. This is N/A to Debit Option 3 and monitoring condition assessments in the CSQT.
N/A		Proposed Assessment represents the post-project conditions (proposed, as-built, monitored). This is N/A to Debit Options 2 and 3.

* This checklist can be used for each reach within a project area, it could also be used to review an entire submittal. This will depend on the reviewer and the complexity of the project.

CSQT and Debit Calculator Review Checklist
INTRODUCTION
Parameter and Metric Selection*

*Before <u>changing</u> any inputs make sure rows are not hidden on the other worksheets.

Single-thread (Y/N):		The entrenchment ratio metric for floodplain connectivity and all the metrics used to quantify the bed form diversity parameter are not applicable to multi-thread channels.
Lateral Migration Assessment Method:		Select Greenline Stability Rating or Dominant BEHI/NBS.
Is there or should there be a natural supply of large woody debris (Y/N):		
Is man-made armoring present or proposed (Y/N):		Use the armoring metric for lateral migration when man-made armoring is present or proposed.
Is there or should there be <20% absolute woody vegetation cover (Y/N):		Measure the riparian extent, woody vegetation cover, and native cover metrics for the riparian vegetation parameter.
Is the stream bedrock-dominated (Y/N):		
Is this a perennial stream where hydraulic conditions during summer/fall baseflow periods should support trout assemblages (Y/N):		
Are physicochemical or biology functions measured (Y/N):		
For single-thread streams in alluvial valleys, are there or should there be side channels (Y/N):		
Is the stream a transport reach where riffles are exhibiting signs of aggradation, or there is a risk of aggradation due to sediment supply (Y/N):		

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist

PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-1	Were data collection and analyses completed by those with sufficient experience?	Chapter 2				
PC-2	Is there a description and visual depiction of the reaches and reach breaks within the Project Area?	Sections 1.2.1 & 2.1.1				
PC-3	Is every reach within the Project Area represented in a workbook?	Sections 1.2.1 & 2.1.1				
PC-4	DC: Is information complete for every stream reach on the Project Assessment worksheet? This includes flow permanence, stream order, impact description, outstanding water classification, and location information.	Sections 1.2.1, 1.2.8, & 2.4				
PC-5	Are the existing and proposed project reach stream lengths accurate?	Section 1.2.8				
PC-6	DC: Did the practitioner include the Permit Number and project description?	Section 1.2.8				
PC-7	DC: Is a Debit Option selected for each reach?	Section 1.2.8				
PC-8	DC: For each reach, is an impact severity tier selected and is it appropriate for the described impact activity?	Section 1.2.8				
PC-9	Is every reach represented on a **Parameter Selection Checklist** and are selected parameters and metrics appropriate for the reach?	Section 2.5 & Appendix B				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-10	Is location information provided for all measurements and samples within each project reach for all relevant assessments (existing, proposed, monitoring)?	Chapter 2 & Appendix A				
PC-11	Is there a completed **Project Reach form** for each reach? Project Reach forms include data/values for stream reach length, sinuosity, bankfull identification, concentrated flow points, and, when applicable, armoring and side channels.	Chapter 2 & Appendix B				
PC-12	Does every reach have **Field Value Documentation forms** for all relevant assessments (existing, proposed, monitoring)? And are the forms completed for all parameters and metrics checked on the Parameter Selection Checklist?	Appendix B & Section 3.4				
PC-13	CSQT & DC: Are responses provided for all applicable fields in the Site Information and Reference Selection section?	Section 2.4				
PC-14	Have field values been entered for all selected parameters and metrics in all relevant assessments (existing, proposed, monitoring)? And are field values associated with the correct Reach ID?	Section 1.2.3 & Section 3.4				
PC-15	Is every reach represented on a **Bankfull Verification form**?	Section 2.6 & Appendix B				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
PC-16	Does every reach have a **Riparian Extent form** for all relevant assessments (existing, proposed, monitoring) that includes an aerial or topographic image depicting observed and expected riparian areas?	Section 2.8.4 & Appendix B				
PC-17	Were the correct number of **Riparian Vegetation forms** provided? Photos of every vegetation plot are recommended.	Section 7 in Appendix A & Appendix B				
PC-18	Are sufficient data provided to verify all field values? In addition to required forms listed above, the following items are needed:					
	Photos are recommended to document site conditions. This includes photos documenting any concentrated flow points, side channels, and areas of armoring.	N/A				
	For detailed survey field methods: 1) **Longitudinal Profile form** or field data, 2) **Standard Cross-Section form** or field data, 3) Longitudinal profile figure, 4) Cross-section figure(s), 5) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 4 in Appendix A				
	For rapid survey field methods: 1) **Rapid Survey form** or field data, 2) Photos recommended to document conditions along representative sub-reach, and for each cross section and riffle.	Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
PACKAGE COMPLETENESS

Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
Land Use Coefficient metric: 1) Aerial image depicting topography and lateral drainage area (LDA) delineation. 2) Aerial image depicting land uses in the LDA.	Section 2.7.1				
Lateral Migration metrics: 1) **Lateral Migration form**, **GSR form** or field data. 2) Map of ratings (either GSR or BEHI/NBS) along representative sub-reach. 3) Photos of each assessed bank, or representative banks, recommended.	Section 2.8.2				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-1	Are the location and number of measurements for each metric consistent with the UM?	Chapter 2 & Appendix A				
EA-2	Are the following items identified according to the definitions in the UM: Concentrated flow points, side channels, LWD, armoring, expected riparian area, observed riparian area, percent native cover?	Sections 2.7.1, 2.7.3, 2.8.1, 2.8.2, & 2.8.4				
EA-3	Are the field values in the **Field Value Documentation** forms for concentrated flow points, percent side channels, percent armoring, and LWD reasonable based on the data provided?	Sections 2.7.1, 2.7.3, 2.8.1, & 2.8.2				
EA-4	Is there a representative riffle cross-section adequate for bankfull verification that labels or presents bankfull area, width, mean depth, flood-prone width, water surface elevation, W/D, and ER?	Section 2.6 & Section 3 of Appendix A				
EA-5	Did the bankfull verification process follow one of three methods in the flow chart and is the bankfull determination reasonable based on the data provided?	Section 2.6				
EA-6	Does the representative sub-reach meet minimum length requirements and does it start and end at the head of the same type of feature?	Section 2.1.2 & Section 5 in Appendix A				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-7	Are the following measurements provided: riffle lengths; pool lengths and types; low bank heights; maximum pool and riffle depths; station of maximum pool depth; flood-prone width(s); riffle mean depth(s); and bankfull width(s)?	Section 5 in Appendix A				
EA-8	Does the identification of bed features match the definitions in the user manual? This includes riffles, geomorphic pools, and significant pools.	Section 4 in Appendix A				
EA-9	Are the survey measurements in the **Field Value Documentation** forms reasonable based on the geomorphic survey data provided? Survey data are used for BHR, ER, W/D, PSR, PDR, and percent riffle.	Sections 2.7.3, & 2.8.3 and Sections 4 & 5 of Appendix A				
EA-11	For O/E metrics, is the expected value reasonable: Expected riparian area, aggradation ratio, native fish species richness, and flow alteration metrics?	Sections 1.2 (Table 1), 2.8.3, 2.8.4, 2.10.2, 2.11, & Appendix C				
EA-12	Are the vegetation plots within the expected riparian extent?	Section 7 in Appendix A				
EA-13	Are the field values for riparian vegetation metrics reasonable based on the data provided?	Section 2.8.4				

Reviewer:
Date:

CSQT and Debit Calculator Review Checklist
EXISTING (Pre-Project) ASSESSMENT

	Item	User Manual Section	Practitioner Submittal Page #	Submitted (Y/N/P)	Acceptable (Y/N/P)	Comments
EA-18	Are the values in the **Field Value Documentation** forms consistent with the data provided and do the field values on the forms match the field values in the Condition Assessment?	Chapter 2 & Appendix B				
EA-19	Are the existing condition field values reasonable given the data provided, reference curves, goals, objectives, and constraints?	Chapter 2				

Appendix 2: Detailed Survey Example Submittal

This appendix provides an example submittal package when a detailed survey of existing conditions is performed on a reach. When a detailed survey is completed, the following should always be included in the submittal:

- Location information for all survey measurements within the project reach (Figure 1),
- Longitudinal Profile Form or field data* (Figure 2),
- Standard Cross-Section Form or field data* (Figure 3),
- Longitudinal profile figure (Figure 4),
- Cross-section figure(s) (Figure 5), and
- Photos (recommended) to document conditions along representative sub-reach, and for each cross section and riffle.

**A submittal may include either the completed Longitudinal Profile and Standard Cross Section Forms from UM Appendix A, field notes or a copy of the data processing file used to generate figures (e.g., a Mecklenburg spreadsheet).*

This appendix includes Field Value Documentation form examples for metric field values derived using the survey data. This appendix does not include all required items for an SQT submittal, for example the Bankfull Verification Documentation, Project Reach forms, and Field Value Documentation Form for all required metrics are not included.

Data were collected using Single base Real Time Kinematic GNSS survey on July 10, 2020. The vertical accuracy of the data is ±0.07 feet and the horizontal accuracy of the data are ±0.05 feet. Note the accuracy of measurements determines the appropriate number of significant digits for a field value.

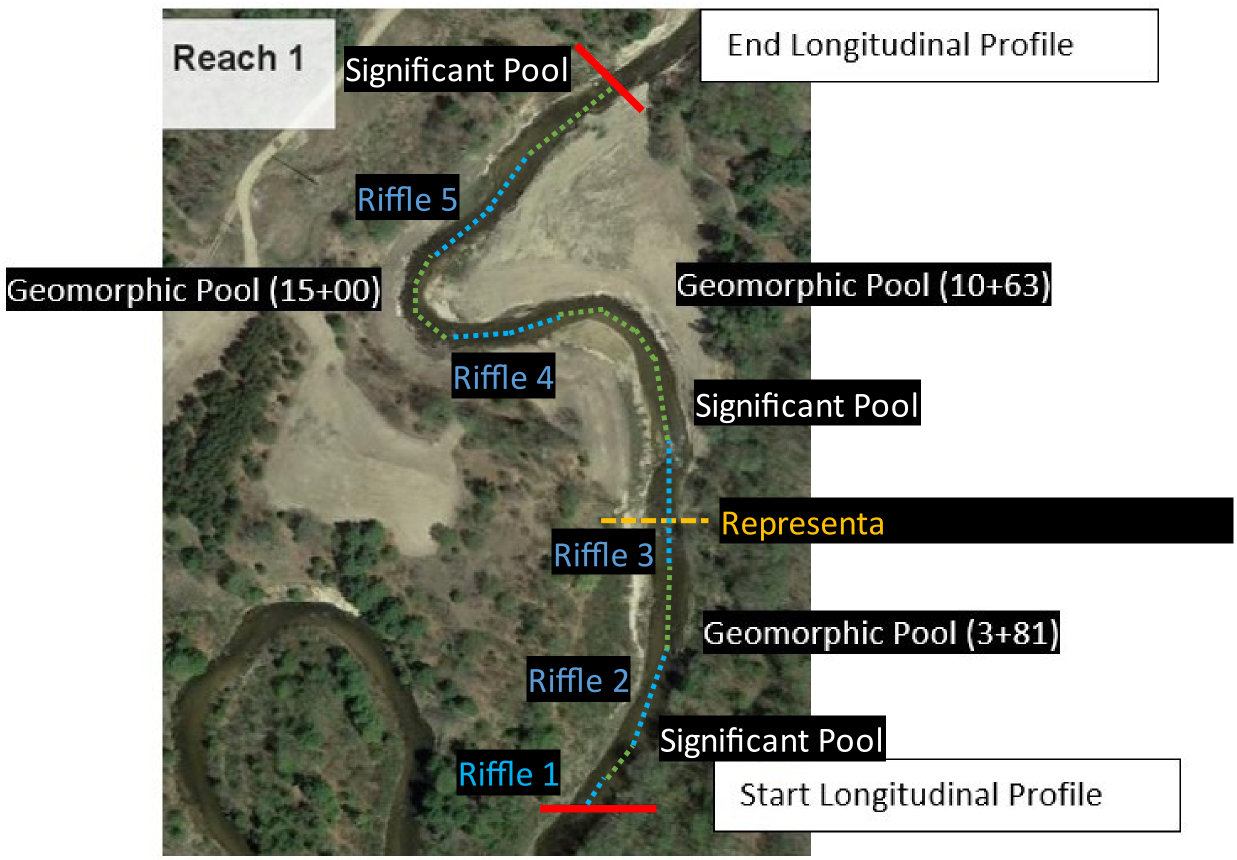


Figure 1. Location figure for example project showing location of the survey extents, bed features, and pool types. The start of the longitudinal profile is the upstream extent of the survey.

notes	cross section ID	bed feature	station	ELEV centerline	ELEV thalweg	surface water	ELEV bankfull	ELEV TB
20001		R	0.0	647.165	647.165	649.31	651.434	
20005	1		46.8	646.94	646.94	649.134	650.748	656.9
20008 - SP		P	88.1	647.232	646.602	648.769	650.435	
20012			100.3	646.966	645.779			
20016		R	143.4	646.676	646.609	648.764	650.656	
20020			189.1	646.511	646.511	648.491	650.417	
20023	1		279.8	646.049	646.049	647.882	649.523	655.9
20026			308.1	645.585	645.585	647.72		
20030 - GP		P	360.8	645.691	645.691	647.662		
20034			381.6	645.554	643.73	647.666	649.487	
20039			433.9	643.723	643.723			
20040			456.9	644.265	644.265	647.515	648.859	
20043			487.0	644.726	644.726	647.521	648.995	
20046			518.4	644.701	644.701			
20047			558.1	645.403	645.403	647.314	648.928	
20050	3	R	583.3	645.786	645.786			653.8
20051		Rapid	612.5	645.238	645.238	646.921		
20053			645.7				648.7	
20054	1		704.9	643.449	643.449	646.31	648.195	654
20058		Step	774.9	643.514	643.514		647.906	
20062 - SP		P	815.2	642.851	642.851	644.878	646.553	
20066			839.4	641.825	641.825			
20067			859.2	641.765	641.765			
20068			883.9	641.944	641.944	644.139	646.692	
20072			909.8	642.328	642.328			
20073 - GP		P	979.5	642.438	642.192	643.822	645.947	
20079			1013.0	642.015	641.456			
20082			1031.5	641.983	640.229			
20084			1042.6	641.893	639.551			
20086			1063.1	641.596	638.815	643.596		
20092			1084.9	641.513	641.301			
20094			1108.7	641.336				
20095			1121.0	641.732	639.325			
20097			1134.4	640.601				
20099			1154.1	640.44		643.552		
20105			1171.3	640.475	639.886			
20107		R	1200.6	641.137	640.365	643.387		
20112			1229.6	640.977	640.517	642.892		
20116			1261.9	640.229	640.229	642.96	644.587	
20120	1		1304.8	639.933	639.933	642.832	644.658	651.1
20124			1333.5	640.041	640.041	642.68		
20127 - GP		P	1373.3	639.844	639.844	642.561	644.055	
20132			1383.3	640.274				
20134			1391.3	639.19	638.052			
20136			1421.7	639.428	639.018	642.514	644.393	
20140			1445.9	640.068	639.801	642.429		
20143			1466.2	641	638.49	642.314	644.084	
20148			1476.3	641.114	638.751		644.041	
20151			1501.9	639.693	637.065			
20153			1524.8	638.784	637.967	641.853	644.192	
20158			1563.7	638.847	638.205	642.111		
20162		R	1635.1	638.825	638.825	641.829	643.646	
20167	1		1715.5	638.713	638.713	641.712	643.361	649.4
20171			1801.7	639.55	638.689	641.186		
20177 - SP		P	1863.1	638.768	638.768	640.938		
20181			1903.4	638.082	638.082	640.822	642.657	
20185			1956.3	637.64	637.64	640.687	642.862	
20188		R	2007.0	638.216	638.216	640.54	642.166	

Figure 2. Example field data from longitudinal profile included in the Mecklenburg spreadsheet. Note identification of riffles (R), geomorphic pool (GP), significant pool (SP), and the elevation of the low bank features (identified as top of bank (TB)) at the approximate mid-point of riffles. Field data may alternatively be provided on a Longitudinal Profile form.

Distance (ft)	Elevation (ft)	Omit Bkf	Notes
0.00	653.755	☐	XS1LPINGN
3.13	653.698	☐	LTERR
4.05	653.148	☐	GND
19.97	649.408	☐	GND
36.18	649.186	☐	GND
37.87	649.099	☐	BKF
38.83	648.601	☐	GND
39.79	648.177	☐	X1GND
40.95	647.757	☐	X1GND
41.15	647.06	☐	X1LEW
41.79	646.341	☐	X1EOCH
47.48	645.338	☐	X1CH
58.05	645.598	☐	X1CH
66.73	645.582	☐	X1CH
78.31	645.467	☐	X1CH
83.68	645.353	☐	X1CH
89.82	646.689	☐	X1CH
95.48	646.5	☐	X1CH
100.05	647.427	☐	X1REW
102.55	648	☐	X1GND
103.05	648.507	☐	X1GND
105.78	649.63	☐	X1GND
108.49	650.424	☐	X1GND
111.01	651.057	☐	X1GND
117.27	652.658	☐	X1GND
121.69	653.637	☐	X1RPINGND

Figure 3. Example field data from the representative cross-section included in the Mecklenburg spreadsheet. Note identification of terraces (TERR), cross-section Pins, ground (GN or GND), channel (CH), bankfull features (BKF), edge of channel (EOCH), and the edge of water (aka water surface elevation) (LEW and REW). Field data may alternatively be provided on a Standard Cross-Section form.

Longitudinal Profile for Example Project, Reach 1.

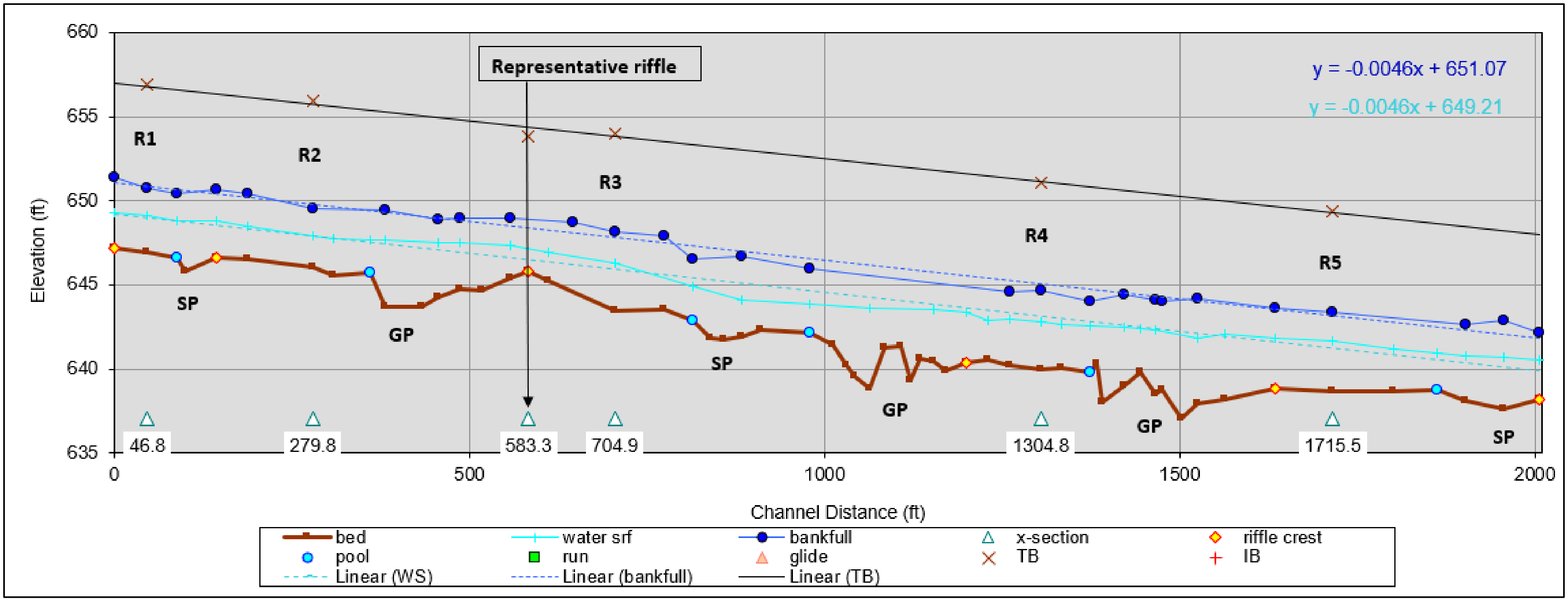
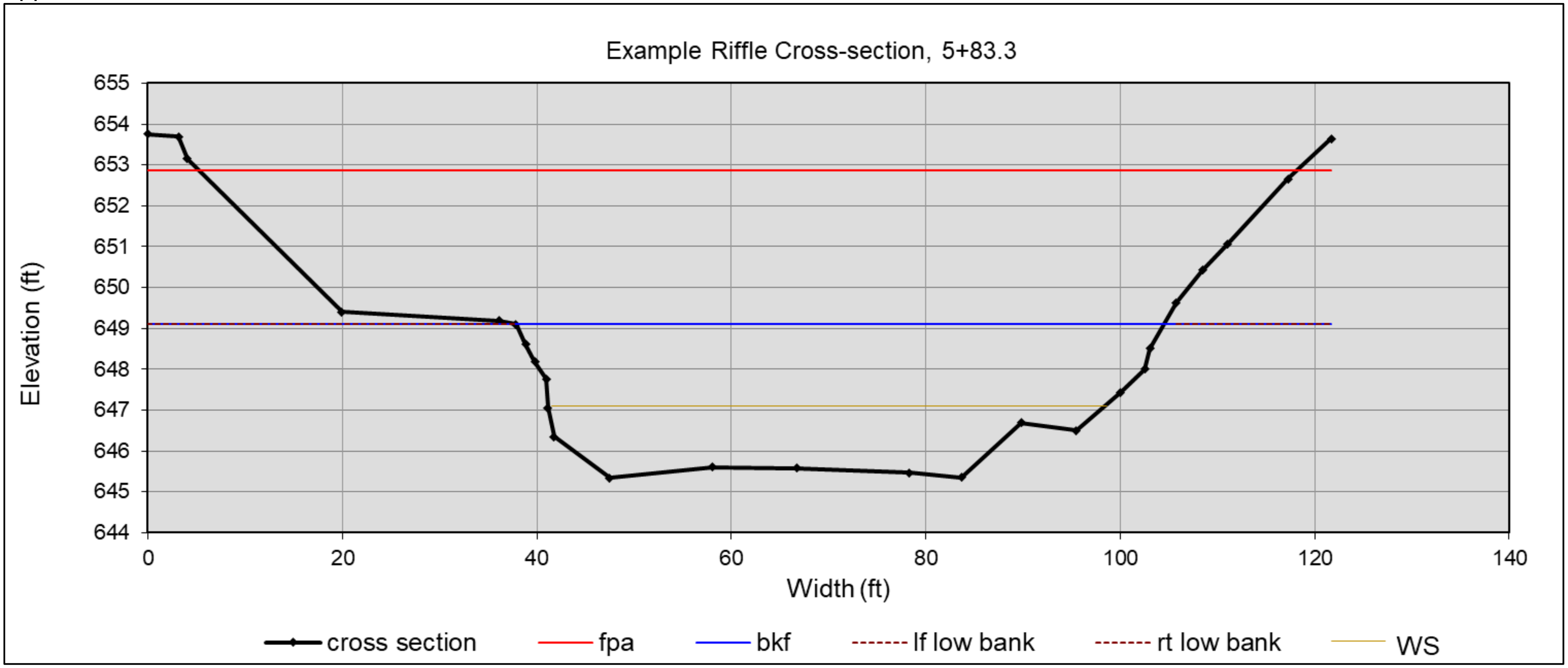


Figure 4. Example longitudinal profile labeling each riffle (e.g., R1), geomorphic pool (GP), significant pool (SP), and the elevation of the low bank features (identified as top of bank (TB) in legend) at the approximate mid-point of riffles.



Bankfull Dimensions	
199.8	x-section area (ft.sq.)
66.6	width (ft)
3.0	mean depth (ft)
3.8	max depth (ft)
68.5	wetted parimeter (ft)
2.9	hyd radi (ft)
22.2	width-depth ratio

Flood Dimensions	
112.9	W flood prone area (ft)
1.7	entrenchment ratio
---	low bank height (ft)
---	low bank height ratio

Figure 5. Representative riffle cross-section used for bankfull verification, stream classification, and to calculate the entrenchment ratio field value. It also provides the denominator for the pool spacing ratio (bankfull width) and the pool spacing ratio (riffle mean depth). This cross-section was not used to calculate the weighted BHR as it is not located near the center of riffle 3 (R3 in Figure 2) but the flood-prone width of 112.9 feet indicates that the bankfull bench is not wide enough for the low bank height to be equal to the bankfull height. The low bank elevation for this cross-section is 653.8 feet.

Field Value Documentation

Entry to the Field Value Documentation Form for field values derived from the longitudinal profile (Figure 4) and cross-section (Figure 5) for the example reach are provided in Table 1 (Reach hydrology and hydraulics) and Table 2 (Geomorphology). The calculations used to create these values are provided in Appendix 3.

Table 1. Field Value Documentation Form data entry for Floodplain Connectivity parameter.

Floodplain Connectivity		
Riffle lengths - Riffle 1	88.1	Detailed survey methods were used. Refer to longitudinal profile (Figure 1). Lengths were rounded to 0.1 feet.
Riffle lengths - Riffle 2	217.4	
Riffle lengths - Riffle 3	231.9	
Riffle lengths - Riffle 4	172.7	
Riffle lengths - Riffle 5	228	
Bank Height Ratio		
BHR - Riffle 1	2.5	Detailed survey methods were used. Refer to longitudinal profile (Figure 1). Low bank feature was a consistent terrace throughout the reach. Bankfull was calculated from the trendline on Figure 1.
BHR - Riffle 2	2.6	
BHR - Riffle 3	2.4	
BHR - Riffle 4	2.2	
BHR - Riffle 5	2.4	
FIELD VALUE - Weighted Bank	2.4	Calculated
Entrenchment Ratio		
ER - Riffle 3	1.7	Non-weighted; Topographic data indicate that flood-prone width is relatively uniform for the reach. Value from the representative riffle cross-section (Figure 2).
FIELD VALUE - Weighted Entrenchment Ratio (ft/ft)	1.7	Calculated

Table 2. Field Value Documentation Form data entry for Bed Form Diversity parameter.

Bed Form Diversity		
Pool Spacing Ratio		
Median of Pool Spacings	560	Three geomorphic pools associated with meander bends are shown in Figure 1. This leads to two pool spacing measurements for the sub-reach.
Number of Geomorphic Pools	3	
Bankfull Riffle Width (ft)	66.6	Value from the representative riffle cross-section (Figure 2).
FIELD VALUE - Pool Spacing Ratio	**8.4**	Calculated
Pool Depth Ratio		
Average of measured pool depth	5.8	Six pools, 3 geomorphic and 3 significant, are shown in Figure 1.
Number of pools measured	6	
Mean Riffle Depth	3.0	Value from the representative riffle cross-section (Figure 2).
FIELD VALUE - Pool Depth Ratio	**2.0**	Calculated
Percent Riffle (%)		
Reach Length	2200	Refer to reach break delineations.
Bankfull Riffle Width	66.6	Value from the representative riffle cross section (Figure 2). 20 * 66.6 = 1332 FT
Representative Sub-Reach Length	2007	Pulls from project reach form.
Total Riffle Length in Representative Sub-Reach	938.1	Detailed survey methods were used. Refer to longitudinal profile (Figure 1). Lengths were rounded to 0.1 feet.
FIELD VALUE - Percent Riffle (%)	**47%**	Calculated

Appendix 3: Example Field Value Calculations from Survey Data

Function-based Assessment Calculations

This appendix provides example calculations to determine metric field values from detailed survey data. This appendix builds upon the example reach in Appendix 2. Calculations are provided for the following metrics derived from existing conditions survey data.

- Floodplain Connectivity Parameter
  - Bank Height Ratio (BHR)
  - Entrenchment Ratio (ER)
- Bed Form Diversity Parameter
  - Pool Spacing Ratio
  - Pool Depth Ratio
  - Percent Riffle

Note: Appendix 1 is an example of an existing condition assessment where ratios are calculated using the representative riffle surveyed within the project reach (Appendix 2, Figure 5). For monitoring assessments, the denominator for these ratios would be equal to riffle bankfull dimensions proposed in the design (e.g., from typical cross-section dimensions in the construction plan set).

Floodplain Connectivity

Bank Height Ratio (BHR)

BHR is calculated from the survey data presented in the longitudinal profile (Appendix 2, Figure 4). The thalweg and low bank elevations are shown on the longitudinal profile (Table 1). The bankfull elevation used to calculate bankfull maximum depth is calculated using the trendline for bankfull indicators throughout the representative sub-reach (Table 1). Calculated values for BHR and the weighted bank height ratio field value are shown in Table 2.

Example BHR calculation For Riffle 2 (R2):

$$\text{BHR} = \frac{\text{Top of Low Bank (LB) elevation} - \text{Thalweg (TW) elevation}}{\text{Bankfull (BKF) elevation regression} - \text{TW elevation}} = \frac{\text{Low Bank Height}}{\text{Bankfull Riffle Max Depth}}$$

$$\text{BHR at R2} = \frac{(655.9-646.1)}{(649.8-646.1)} = \frac{(9.8)}{(3.7)} = 2.6$$

Table 1. Bank Height Ratio stations and elevations from the longitudinal profile.

Riffle ID	Station		Station of BHR Measurement	Elevation		
	Start	End		TW	LB	BKF*
R1	0	88.1	46.8	646.9	656.9	650.9
R2	143.4	360.8	279.8	646.1	655.9	649.8
R3	583.3	815.2	704.9	643.5	654.0	647.8
R4	1200.6	1373.3	1304.8	639.9	651.1	645.1
R5	1635.1	1863.1	1715.5	638.7	649.4	643.2

**Bankfull (BKF) is calculated using the trendline equation shown on the longitudinal profile.*

Table 2. Bank Height Ratio calculations.

Riffle ID	Length	Bankfull Max Depth (BKF – TW)	Low Bank Height (LB – TW)	BHR	BHR * Riffle Length
R1	88.1	4.0	10.0	10.0/4.0 = 2.5	220.3
R2	217.4	3.7	9.8	2.6	565.2
R3	231.9	4.3	10.5	2.4	556.6
R4	172.7	5.2	11.2	2.2	379.9
R5	228.0	4.5	10.7	2.4	547.2
SUM	**938.1**	-	-	-	**2269.2**
BHR Field Value = 2269.2/938.1 = 2.4					

Entrenchment Ratio (ER)

ER is calculated from survey data collected from each riffle within the representative sub-reach and then weighted by riffle length. In this example topographic data indicate that flood-prone width is relatively uniform throughout the project reach. Therefore, one measurement of flood-prone width is sufficient to represent the reach (see UM Section 2.7.3).

Example ER calculation for the representative cross-section shown in Appendix 2 Figure 3:

$$\text{ER} = \frac{\text{Flood-prone Width}}{\text{Bankfull Width of riffle cross-section}}$$

$$\text{ER} = \frac{(112.9)}{(66.6)} = 1.7$$

Bed Form Diversity

Pool Spacing Ratio

Pool spacing is the length between the maximum depths of each geomorphic pool. Pool spacing ratio is calculated from the survey data presented in the longitudinal profile (Appendix 2, Figure 4). There are three geomorphic pools (GP) within the reach and labeled in the longitudinal profile. This metric requires stations for the deepest location of each geomorphic pool (Table 3). The bankfull width of the representative riffle (Appendix 2, Figure 5) is 66.6 feet.

Table 3. Pool Spacing Ratio calculations.

Pool ID	Station	Spacing (ft)	Pool Spacing Ratio
GP	381.6	-	-
GP	1063.1	1063.1-381.6 = 681.5	10.2
GP	1501.9	438.8	6.6
		Median	**8.4**

Example for pool spacing 1:

$$\text{Pool Spacing Ratio} = \frac{\text{Distance between max depth of sequential geomorphic pool}}{\text{Bankfull Width of representative riffle cross-section}}$$

$$\text{Pool Spacing Ratio} = \frac{681.5}{66.6} = 10.2$$

Pool Depth Ratio

Pool Depth Ratio is measured at the maximum depth location for all significant and geomorphic pools. Pool Depth Ratio is calculated from the survey data presented in the longitudinal profile (Appendix 2, Figure 4). Calculated values for pool depth ratio and the field value are shown in Table 4. The thalweg elevations are shown on the longitudinal profile. The bankfull elevations are calculated using the trendline for bankfull indicators throughout the representative sub-reach. The bankfull mean depth of the representative riffle (Appendix 2, Figure 5) is 3.0 feet.

Table 4. Pool Depth Ratio calculations.

Pool Type	Max Pool Depth Station	Thalweg Elevation	Bankfull Elevation Regression	Pool Depth	Pool Depth Ratio
SP	100.3	645.8	650.6	4.8	1.6
GP	381.6	643.7	649.3	5.6	1.9
SP	859.2	641.8	647.1	5.3	1.8
GP	1063.1	638.8	646.2	7.4	2.5
GP	1501.9	637.1	644.2	7.1	2.4
SP	1956.3	637.6	642.1	4.4	1.5
				Average *(Field Value)*	**2.0**

Example for the first significant pool (SP at 100.3):

$$\text{Pool Depth Ratio} = \frac{\text{Max pool depth}}{\text{Bankfull Mean Depth from representative riffle cross−section}}$$

$$\text{Pool Depth Ratio} = \frac{(650.6-645.8)}{3.0} = \frac{4.8}{3.0} = 1.6$$

Percent Riffle

Percent Riffle is the total length of riffle and run bed features divided by the total length of representative sub-reach. Percent Riffle is calculated from the survey data presented in the longitudinal profile (Appendix 2, Figure 4). The representative riffle is 66.6 feet wide, which means the representative sub-reach must be at least 20 times that length (1332 feet) or two meander wavelengths, whichever is longer. Two meander wavelengths were surveyed for the longitudinal profile shown in Appendix 2, Figure 2 and the length is 2007 feet, which is longer than 20 times the bankfull riffle width. As shown in Appendix 2, Figure 4 the surveyed reach length begins and ends at the head of a riffle feature.

As shown in Table 2, the total length of riffles within the surveyed reach is 938.1 feet. The sub-reach length is 2007 feet.

Example percent riffle calculations:

$$\text{Percent Riffle} = 100 * \frac{\text{Total riffle length within sub−reach}}{\text{Total sub−reach length}} = 100 * \frac{938.1}{2007.0} = 47\%$$

Appendix 4: Bankfull Verification Examples

The bankfull verification process is described in Section 2.6 of the CSQT User Manual (UM; USACE 2020). This appendix provides examples for the bankfull verification methods from the UM and are shown here in Figure 1. Bankfull identification (described in Appendix A of the UM) should be performed by professionals with a background in geomorphology and the necessary experience to accurately complete the methods described in the UM. Bankfull discharge modeling and return interval calculations should be performed by engineers or hydrologists with experience with hydrologic and hydraulic modeling in Colorado, including the modeling of water diversions and withdrawals.

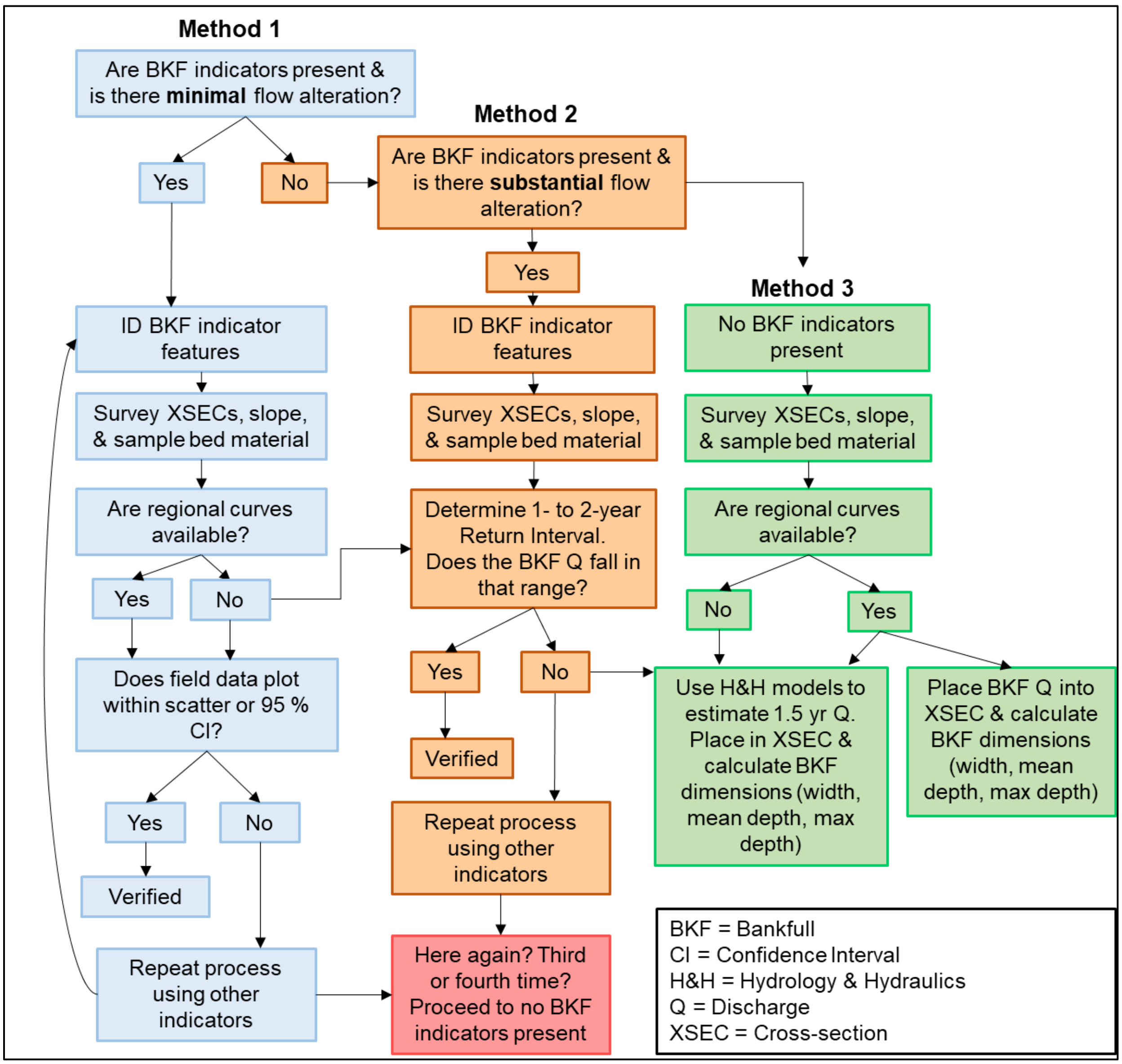


Figure 1. Bankfull verification flow chart duplicated from the CSQT User Manual.

Practitioners and regulators should always start with the field identification of geomorphic features: inner berm, bankfull, and the terrace. Bankfull indicators should be sought for all sites following the instructions provided in UM Appendix A, Section 3. These instructions include quality control and descriptions of primary and secondary field indicators. If these features are identified, they should be tested and verified with Methods 1 and 2. This is often an iterative process. If geomorphic features are not present due to urban or other impacts, then Method 3 can be used. Use of Method 3 as shown in Figure 1 requires sufficient explanation and rationale demonstrating no field indicators were present or those identified were insufficient.

The general process of bankfull identification and verification is provided below using an example.

1. Identify bankfull indicators at the site.

Following the checklist format from UM Appendix A, Section 3, field indicators of bankfull throughout the reach are recorded. Field notes for the difference between water surface elevation and suspected bankfull indicators are recorded on the required Project Reach Form (Figure 2). The difference between water surface and bankfull should be similar among all measurements. Note, the difference between water surface and other geomorphic features, such as the inner berm or terrace, might differ from that of the bankfull feature. For example, it is common for the difference between water surface and the inner berm to be half of the difference between water surface and bankfull. The difference between water surface and a terrace will be greater than the difference between water surface and bankfull.

II.	**Reach Walk**							
A.	Difference between bankfull (BKF) stage and water surface (WS) (ft)	1.1	1.2	1.0	1.1	1.1	1.2	
	Difference between BKF stage and WS (ft) *Average or consensus value from reach walk.*		1.1					

Figure 2. Project Reach Form difference between bankfull and water surface example.

Where detailed survey methods were implemented, the difference between water surface and bankfull should be consistent between the surveyed cross-sections and the longitudinal profile. This can be visually observed by comparing the slope of the best-fit-line through bankfull indicators in the longitudinal profile and compare that slope to the water surface slope for the reach. These two lines should be parallel, as shown in the longitudinal profile (e.g., Figure 4, Appendix 2 of this document).

For this example, an incised channel is being used; a photo of the channel and geomorphic indicators is provided in Figure 3. There are three geomorphic indicators present at this site: inner berm, bankfull, and terrace. The back of a floodplain bench is identified as being the most likely bankfull feature. The inner berm is the front of the bench, and the terrace is the top of bank. Note, all three features could be tested against the regional curve; however, since the back of the bench in a small, incised channel is often the bankfull feature, it is tested first. The difference between water surface and the potential bankfull feature was measured at several places along the reach. The measured values and the average were recorded in Figure 2.

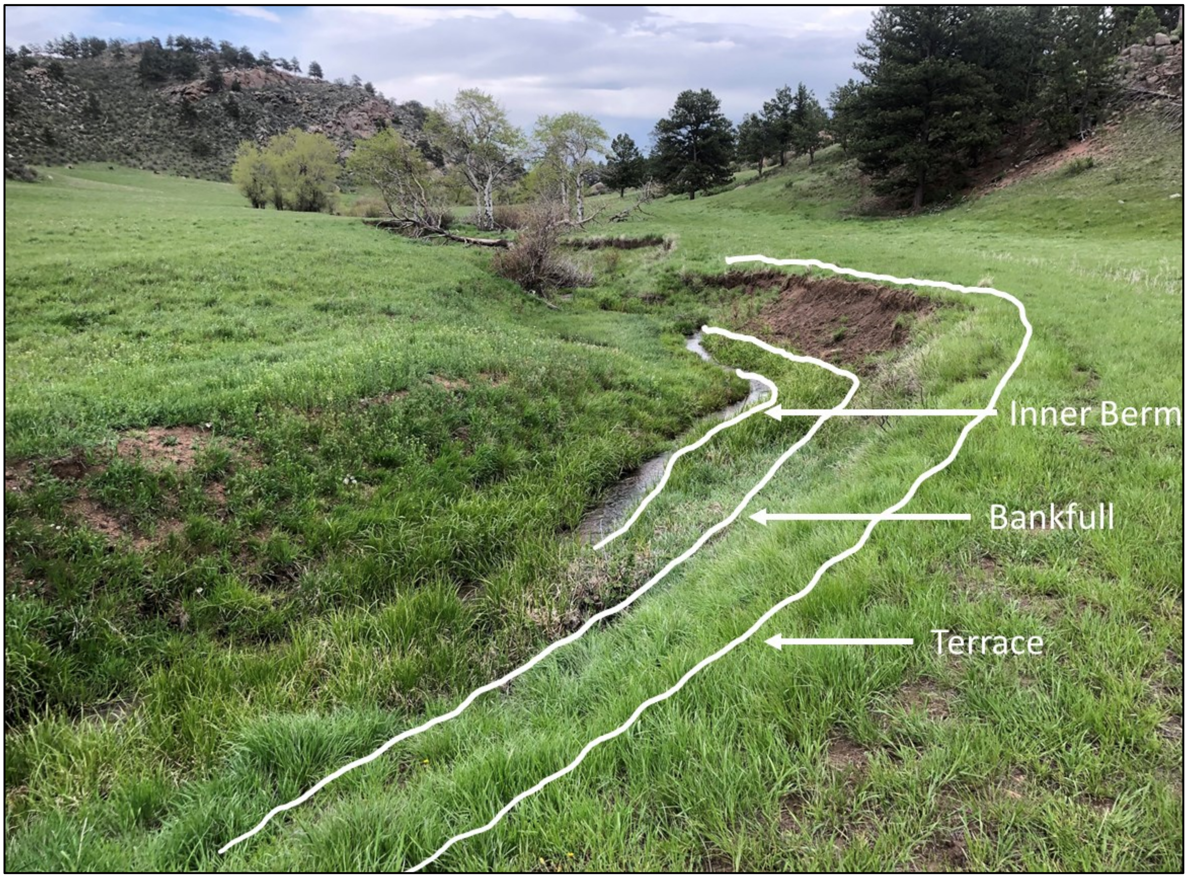


Figure 3. Bankfull identification example showing inner berm, bankfull, and terrace geomorphic features.

Differences between water surface and both inner berm and terrace elevations were also recorded in case they were needed for bankfull verification. The inner berm averaged 0.5 feet above water surface elevation on the day of the survey and the terrace was 4.0 feet above water surface elevation. The next steps include:

2. Survey riffle cross-sections and slope, and sample bed material.
3. Process cross-section data.

A rapid survey was performed for a riffle cross-section with a strong bankfull indicator.[1] The cross-sectional area, width, and mean depth associated with each of the features identified

[1] Rapid survey instructions are provided in UM Appendix A.

(suspected bankfull, inner berm, and terrace) were calculated. The slope for the reach was measured across a riffle-pool sequence as 1.8% and the D84 was 90mm. This information was used to make the following calculations:

Inner Berm Area = 3 ft^2

Bankfull Area = 10 ft^2

Terrace Area = 80 ft^2

Bankfull Discharge = 40 cfs

This information can now be used with a bankfull regional curve (Method 1 in Figure 1) and/or flood frequency analysis (Method 2 in Figure 1) to verify the bankfull feature.

Method 1

Method 1 from the flow chart uses bankfull regional curves, preferably watershed-specific regional curves, to verify the field-identified feature. Regional curves are relationships derived from sites with well-formed bankfull features that relate bankfull dimensions (most often bankfull cross-sectional area at a riffle) to drainage area. A watershed-specific regional curve is preferrable for validating field indicators because it ensures that the sites used to develop the regional curve are under the same climatic, geologic, and anthropogenic influences as the project. Watershed-specific regional curves require field identification of bankfull at sites in the same watershed as the project, preferably sites with similar drainage area and then within ±1 log scale of the project drainage area. For example, a project with a drainage area of around 7 sq. mi., surveys of bankfull should occur at sites ranging from about 1 to 100 square miles.

Using Method 1, the data from the example project were overlayed onto a watershed-specific curve shown in Figure 4. The graph shows the inner berm feature, bankfull, and terrace cross-sectional areas overlayed onto the regional curve data. The dashed lines represent the range of scatter and were added by hand as an aid in visualizing the upper and lower range of scatter. Some regional curves are published with 95% confidence limits or intervals. If the regional curve includes statistically produced confidence limits, they should be used rather than a hand drawn line. The overlay shows that the inner berm plots well below, and the terrace plots well above the range of scatter. The cross-sectional area for the bankfull feature falls within the range of scatter and is therefore confirmed as the bankfull feature. An example bankfull verification form is provided at the end of this appendix.

Published regional curves are shown in Table 1, note that Blackburn-Lynch (2017) provides additional equations for hydrologic landscape units. Refer to the source material to determine applicable range of drainage area, standard error, or range of scatter associated with calculated values.

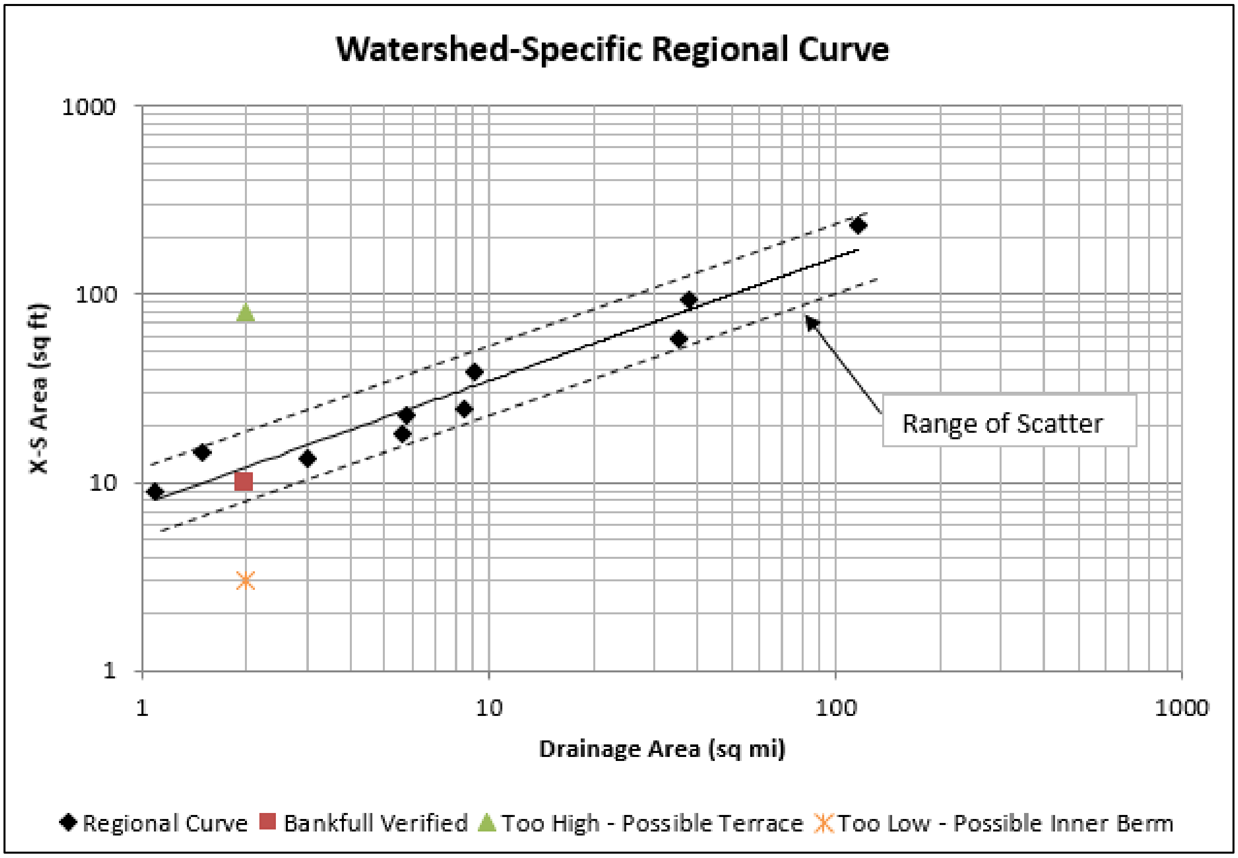


Figure 4. Example watershed-specific regional curve showing features surveyed at a project site that corresponded to inner berm (below the range of scatter), bankfull (verified), and a terrace (above the range of scatter).

Table 1. Published Regional Curves applicable to various areas of Colorado.

$$A_{BKF} = a(Drainage\ Area)^b$$

Physiographic Province	Units	a	b	R2	Reference
Great Plains	Metric	0.36	0.54	0.63	Blackburn-Lynch (2017)
Middle Rocky Mountains	Metric	0.69	0.50	0.57	Blackburn-Lynch (2017)
Southern Rocky Mountains	Metric	0.41	0.50	0.63	Blackburn-Lynch (2017)
Wyoming Basin	Metric	0.06	0.84	0.83	Blackburn-Lynch (2017)
Rocky Mountain Hydrologic Region in Wyoming	S.I.	8.6	0.62	0.85	Foster (2012)

Method 2

If a regional curve for the cross-sectional area is not available and cannot be developed, then a flood frequency analysis can be used to check the field-derived bankfull value. This method can also be used to further verify the bankfull determination made in Method 1. Note, Method 1 should not be skipped; Method 2 follows Method 1 per the flow chart.

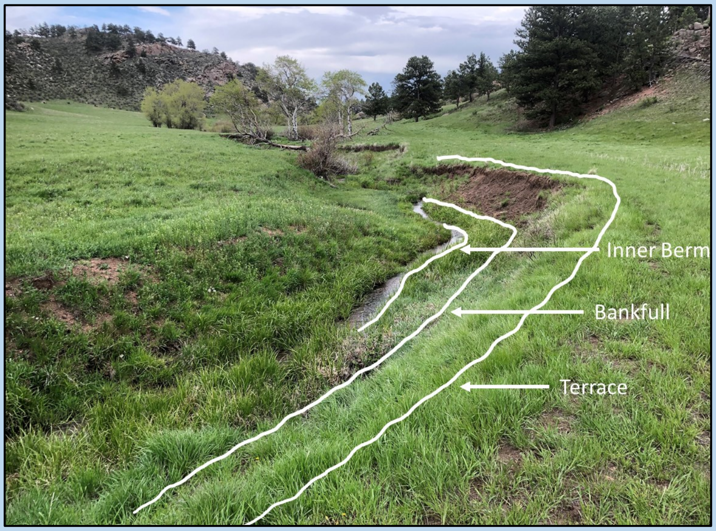
Flood frequency analysis is based on discharge rather than area and it is important to remember that unless velocity is measured in the field (average velocity for a cross-section using a flow meter) then the calculated discharge value for a cross-section is a coarse estimate.

In the absence of a regional curve, the USGS published regression equations, and statistical hydrologic models implemented in an application called StreamStats can be used for bankfull verification. StreamStats is the most likely source of flood frequency data.[2] The practitioner should determine whether values from StreamStats are reasonable for the site. Generally, the extent of flow alteration for the project area may mean different methods for estimating return interval discharge are needed (e.g., hydrologic process modeling). This section provides two examples to show how Method 2 can be used with the data provided by StreamStats.

- Example A uses the data from the example above to further verify the bankfull determination.
- Example B uses a new example, where a bankfull regional curve was not available to make the verification.

[2] https://streamstats.usgs.gov

Example A: Further verification



Cross-sectional area (A) = 10 ft^2

Slope (S) = 1.8%

Riffle D84 = 90mm used to estimate roughness value "n"

$$Q = \frac{1.49}{n} A R^{2/3} S^{1/2} = 40 \text{ CFS}$$

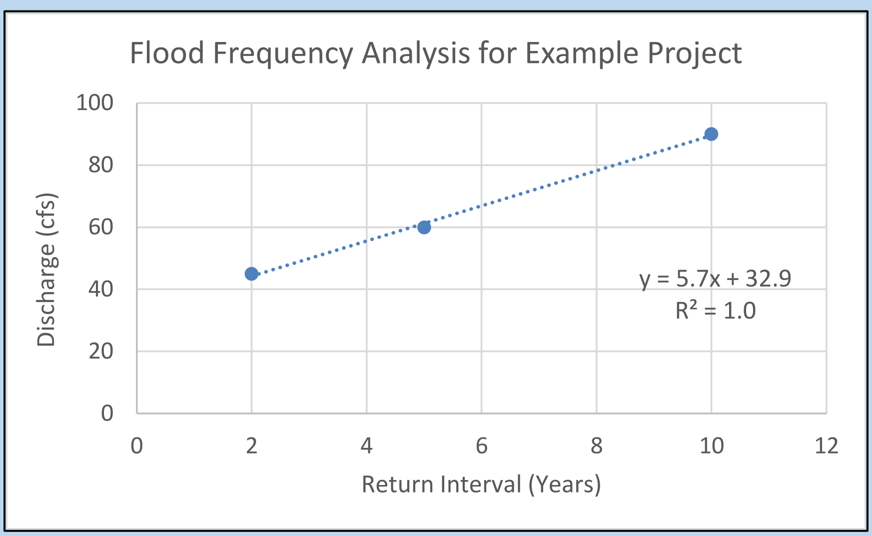
Where R is the hydraulic radius calculated from the cross-section data.

StreamStats was used to calculate discharge values for the 2-, 5-, and 10-year return intervals. StreamStats calculates higher return intervals, but these are not needed (or preferred) for this analysis. Relationships are not linear and thus, including higher return interval events will affect the interpolation of the 1.5-year return interval.

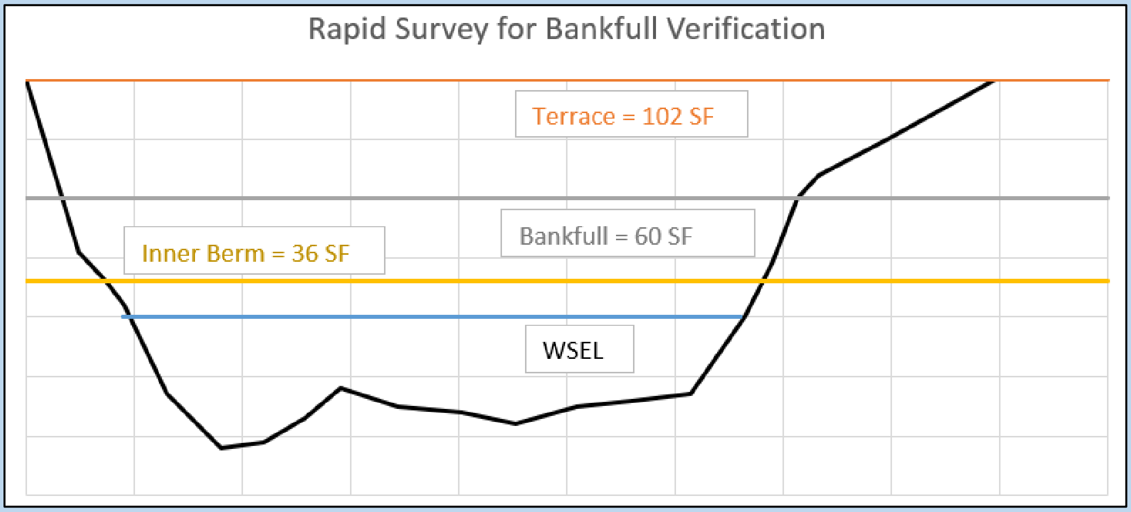
The StreamStats data were used to create the graph below. A linear regression line and equation were created from the data. The equation was then used to estimate the 1.5-year return interval discharge, as shown in equation (1).

(1) Discharge (cfs) = 5.7 (RI) + 32.9, *where: RI equals the 1.5-year return interval*.
= 5.7(1.5) + 32.9 = 41 cfs

This value is very close to the 40 cfs estimated from the field data and further verifies that the back of the floodplain bench represents the bankfull feature.

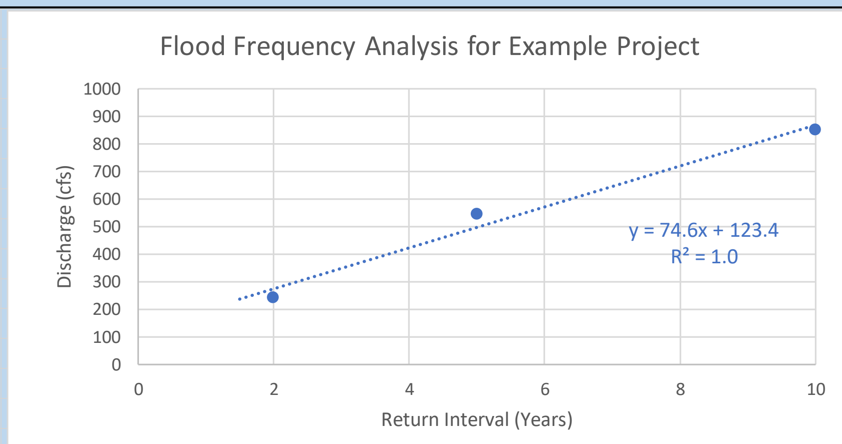


Example B: Regional curve is not available



For this site, bankfull indicators were identified throughout the reach, the bankfull stage was associated with a bankfull cross-sectional area of 60 ft^2, which was used to calculate a bankfull discharge of 180 cfs. There were no regional curve data for the site, so a flood frequency analysis was performed to verify bankfull. Values from StreamStats and the USGS references for the flood frequency prediction equations are shown below. The 1.5-year return interval discharge is calculated as 235 cfs which is close to the 180 cfs estimated from the field data. This analysis verifies the bankfull feature that corresponds to 60 ft^2 cross-sectional area at the cross-section above.

RI	AEP	Q (cfs)
2	50	243
5	20	544
10	10	852
25	4	1380
50	2	1910
100	1	2580
200	0.5	3350
500	0.2	4550



Capesius, J.P., and Stephens, V. C.,2009, Regional Regression Equations for Estimation of Natural Streamflow Statistics in Colorado: U. S. Geological Survey Scientific Investigations Report 2009-5136, 32 p.
Kohn, M.S., Stevens, M.R., Harden, T.M., Godaire, J.E., Klinger, R.E., and Mommandi, A.,2016, Paleoflood investigations to improve peak-streamflow regional-regression equations for natural streamflow in eastern Colorado, 2015: U.S. Geological Survey Scientific Investigations Report 2016–5099, 58 p.

Method 3

Method 3 should only be used after following the flow chart through Methods 1 and 2. Bankfull indicators should be sought for all sites following the instructions provided in UM Appendix A, Section 3. Use of Method 3 requires sufficient explanation and rationale demonstrating no field indicators were present or those identified were unable to be verified (e.g., Figure 5). Without field indicators of the discharge that forms, maintains, and shapes channel dimensions, bankfull can be determined using Method 3, which relies solely on desktop methods. A bankfull discharge value is calculated and applied to a surveyed cross-section (Figure 6).

Figure 5. Urban channel devoid of bankfull indicators.

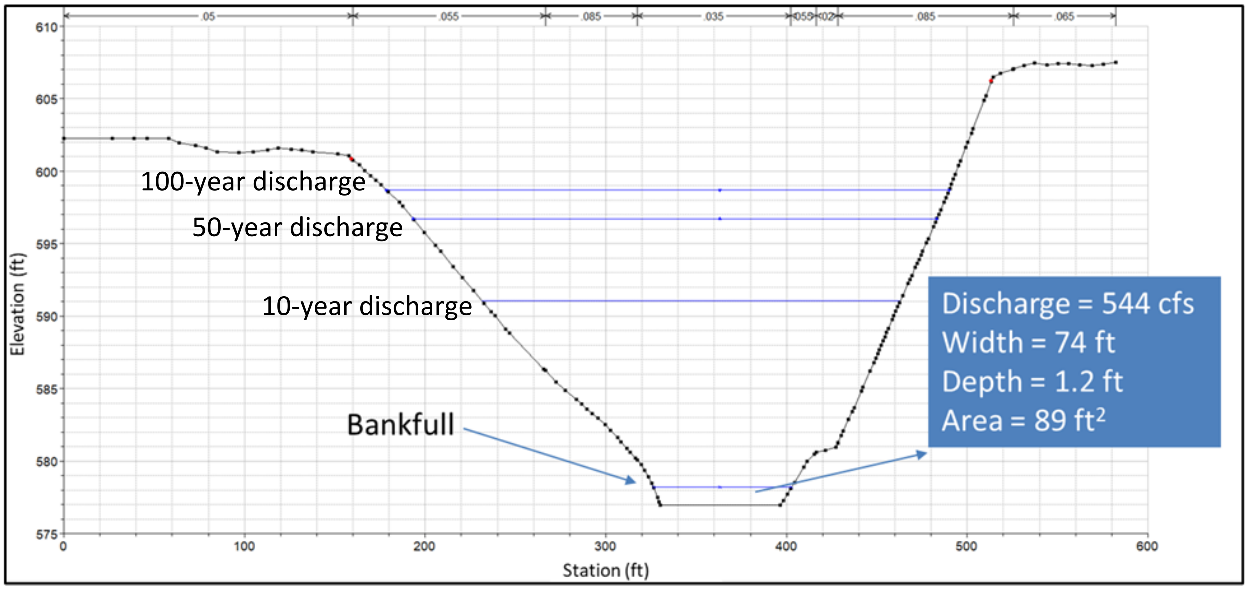


Figure 6. Bankfull discharge and other return interval flows shown on a cross-section using HEC-RAS.

Where regional curve data are available and applicable to the project area or project reach, the regional curve is used to calculate a discharge value. The discharge is then input into a hydraulic model, e.g., a single-section analyzer or HEC-RAS, to determine the corresponding dimensions (bankfull area, width, and mean depth). Figure 6 shows the example output from a HEC-RAS model with bankfull dimensions and calculated discharge. The bankfull, 10-year, 50-year, and 100-year discharges were input into HEC-RAS. The output is the cross-section showing the stage of bankfull and each return interval flow.

Where regional curves are not available, the practitioner may rely on hydrologic modeling to estimate the 1.5-year discharge (bankfull). Revisiting the discharge values reported by Stream Stats (Example B on page 8) and considering standard error (Figure 7), the bankfull discharge at the site may range from 100 to 300 cfs. This discharge is then placed in the cross-section using the same method as described in the paragraph above. This method results in a high level of uncertainty around the bankfull value. While this may be acceptable **for impact activities**, additional analyses and a discussion of risk will be needed when this method is used for restoration designs.

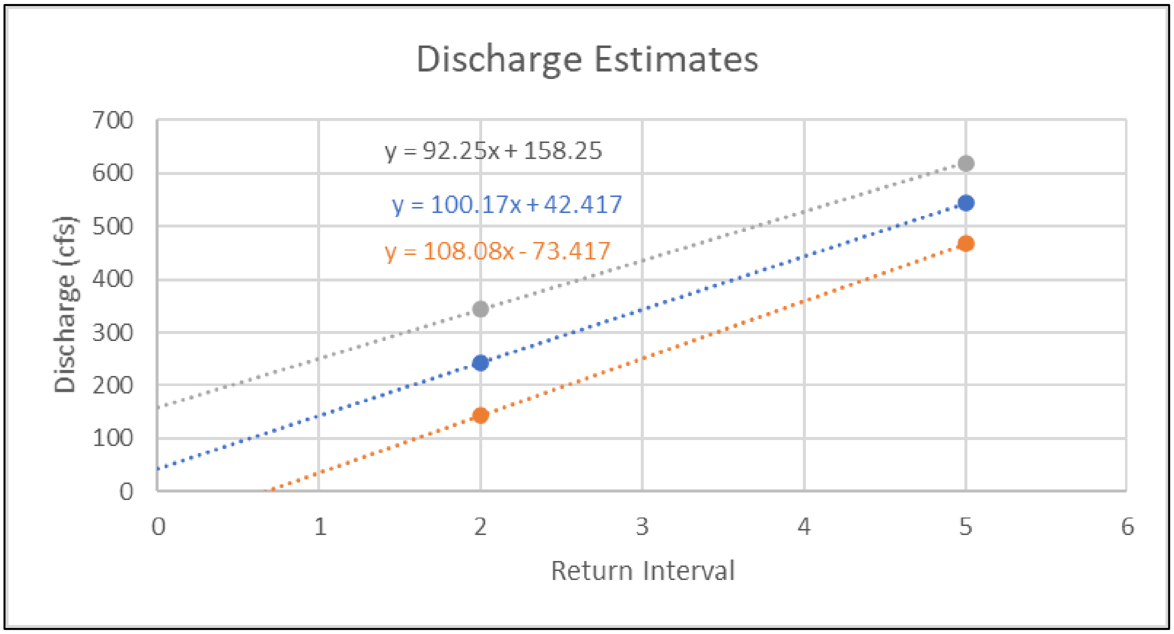


Figure 7. Example extrapolation using 2- and 5-year known discharges to estimate bankfull discharge. Standard error is depicted by the top (gray) and bottom (orange) linear relationships. References for the flood frequency analysis and standard error are provided in Example B, page 8.

Method 3 as preparation for a site visit

Method 3 provides a desktop method that can be used before going in the field to get an idea of where to look for bankfull at a project site. It is highly recommended to determine approximate expected bankfull dimensions before going into the field. Alternatively, the Torizzo and Pitlick (2004) equations (provided below) can be used to quickly estimate width and depth from estimated bankfull discharge.

$$Width = 3.25\ Q^{0.56}$$

$$Mean\ Depth = 0.31\ Q^{0.26}$$

Note, mean depth is not the same as the maximum depth measured to the thalweg elevation. It can be coarsely measured in the field between bankfull and the bottom edge of channel (the break in slope between the channel bottom and start of the streambank).

References

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Foster, K. 2012. Bankfull-Channel Geometry and Discharge Curves for the Rocky Mountains Hydrologic Region in Wyoming. Scientific Investigations Report 2012-5178, U.S. Geological Survey.

Torizzo M, Pitlick J. 2004. Magnitude-frequency of bed load transport in mountain streams in Colorado. Journal of Hydrology. 290(1-2):137-151.

U.S. Army Corps of Engineers (USACE). 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 5: Tips for Checking Condition Assessment Field Values

Note: This Appendix addresses some commonly applied SQT metrics, not all metrics are included here.

Parameter	Metric	Where is it measured?	Calculation Check*	Proposed Condition?	Tips
Reach Runoff	Land Use Coefficient	Lateral drainage area (LDA)	The total drainage area to the downstream end of the project area is equal to the upstream catchment for each stream + LDA for each project reach. There is no overlap in LDAs between reaches.	Does the LDA change as a result of the project? Changing land uses results in lift/loss.	To get repeatable/verifiable results, a polygon shapefile of the LDA(s) should be dissected for the different land uses (e.g., run a union on the LDAs and a land use layer, zonal statistics on NLCD, or divide the LDA polygon by hand looking at an aerial).
Reach Runoff	Concentrated Flow Points (#/1000 LF)	Entire project reach	The concentrated flow point (CFP) measurement is normalized by 1000 linear feet of stream, and is NOT equal to the number of CFPs in the reach.	Does the project introduce new CFPs or install a Best Management Practice to remove CFP(s)? Combining CFPs does not count as lift.	CFPs have a specific definition, refer to the UM.
Floodplain Connectivity	Bank Height Ratio (BHR)	Near the middle of every riffle in representative sub-reach (typically includes at least 4 riffles in 2 meander wavelengths).	The BHR length-weighted average uses the lengths of riffles only, and should not be divided by the sub-reach length. There are bankfull bench width rules provided in the UM for incised channels that need to be checked. For monitoring, hold the denominator constant for all BHR calculations.	For designs of transport channels using natural channel design, the proposed field value could be near 1. BHR near 1, not equal to 1, will account for adjustments during monitoring.	Measurements near the center of the riffle avoid preferential measurement where the bank is lowest (monitoring) or where the bank is highest (existing condition). Is the BHR from the representative riffle consistent with the range of values measured at the middle of riffles?
Floodplain Connectivity	Entrenchment Ratio (ER)	Single measurement representative of reach/ sub-reach conditions may be sufficient.	Flood-prone width is measured perpendicular to the valley. For cross-section measurements, check the planform riffle angle. For monitoring, hold the denominator constant for all ER calculations.	Designs that reduce incision will likely increase ER. Earthwork can excavate a floodplain at a lower elevation than the historic floodplain/terrace.	Avoid preferential measurement of the best location (widest floodplain and narrow riffle for monitoring) or worst location (narrowest floodplain and wide riffle for existing condition).
Floodplain Connectivity	Percent Side Channels (%)	Entire project reach	It's a percent of the entire reach length; value can be >100.	Does the project introduce new side channels or remove/disconnect existing side channels?	Side channels have a specific definition, refer to the UM.

* Note that the accuracy of measurements will determine the appropriate number of significant digits for a field value. Keep this in mind when calculating and reviewing field values for all metrics.

Appendix 5: Tips for Checking Condition Assessment Field Values

Parameter	Metric	Where is it measured?	Calculation Check*	Proposed Condition?	Tips
Large Woody Debris (LWD)	LWD Index	100m segment of the project reach with the most wood	Check that the same number of pieces and dams are assessed for all variables. In the final index calculation the dam score is multiplied by 5.	Consider what amount of LWD is practicable at monitoring closeout. Too much wood without established riparian vegetation community could lead to unintended bank erosion. Index scores of 1.00 are unlikely.	LWD has a specific definition, refer to the UM. Harman et al. (2017) has example scoring for some typical structures used in restoration.**
	No. of LWD Pieces/ 100 meters		This field value is a count of the number of LWD pieces found in the assessment segment. If the project reach is shorter than 100m, then the number of pieces within the reach will need to be normalized.		LWD has a specific definition, refer to the UM.
Lateral Migration	Greenline Stability Rating (GSR)	Representative sub-reach; dependent on field method selected	The GSR is calculated by multiplying the percent community composition types by the respective stability class rating. The resulting values are summed, and this summed value is entered into the SQT. An example calculation is provided in Appendix C of Winward (2000).**	Consider what kind of riparian vegetation cover is possible to achieve by monitoring closeout. Index scores of 1.00 are unlikely.	Stability class ranking 1 describes community types least capable of buffering hydraulic forces while ranking 10 describes the community types with the highest buffering capabilities. The greenline is typically at or near bankfull stage. User can select from two field methods, see UM for references.
	Dominant BEHI/NBS	Representative sub-reach	Dominant rating for the ASSESSED banks. Field value is the rating that describes the largest portion of the assessed banks.	Anticipate the dominant BEHI/NBS for actively eroding streambanks. BEHI should take into account vegetation characteristics at project closeout. For meandering channels, the NBS is likely to be Moderate (M) or higher (H, VH, EX).	Do not assess the whole representative sub-reach unless all banks are actively eroding. Only the outside of meander bends and actively eroding banks are assessed.
	Percent Streambank Erosion (%)		Percent of total bank length in representative sub-reach that is actively eroding. Total bank length is twice the sub-reach length.	0% bank erosion is highly unlikely, unless the stream banks along the reach are completely armored.	Metric field value is calculated using BEHI/NBS data. Actively eroding has a specific definition, refer to UM.
	Percent Armoring (%)	Entire project reach	Percent of total bank length in project reach that is actively eroding. Total bank length is twice the project reach length.	Does the project install new armoring or remove existing armoring?	Armoring has a specific definition, refer to the UM.

** References are provided in Chapter 4 of the main document.

* Note that the accuracy of measurements will determine the appropriate number of significant digits for a field value. Keep this in mind when calculating and reviewing field values for all metrics.

Appendix 5: Tips for Checking Condition Assessment Field Values

Parameter	Metric	Where is it measured?	Calculation Check*	Proposed Condition?	Tips
Bed Form Diversity	Pool Spacing Ratio (PSR)	Representative sub-reach	Median of spacings between GEOMORPHIC pools only. Channelized streams and short reaches with no geomorphic pools have a field value of 0.0. For monitoring, hold the denominator constant for all PSR calculations.	Determine the representative sub-reach location within the reach and anticipate potential adjustments during construction and monitoring.	Pools have specific definitions, refer to the UM. If a sub-reach only has one geomorphic pool but there are geomorphic pools immediately upstream and/or downstream of the sub-reach, those pools should be used to calculate the PSR.
	Pool Depth Ratio (PDR)		Average of depths from all pools (Geomorphic AND significant). Where there are no pools, use a field value of 0.0. For monitoring, hold the denominator constant for all PDR calculations.	Consider depth to confining layer(s) and whether pools can be maintained through monitoring (e.g., a significant sediment supply may lead to pools filling in post-construction).	Pools have specific definitions, refer to the UM.
	Percent Riffle (%)		Riffle length includes runs. Field value is equal to [100 - %pools] (significant and geomorphic).	Determine the representative sub-reach location within the reach and anticipate potential adjustments during construction and monitoring.	Riffles and pools have specific definitions, refer to the UM. Sand bed channels will measure riffle length using just the planform of the channel.
	Aggradation Ratio	Numerator is the surveyed Width/Depth ratio (W/D) at the widest riffle in the representative sub-reach.	The field value is an observed/expected and the denominator (expected or reference W/D) has to be the same for all condition assessments (existing, proposed, and monitoring). Depth in the W/D is the mean depth, not the maximum depth.	The proposed field value will likely be near 1. Using a value near 1 but not equal to 1 will account for adjustments during monitoring.	W/D has a lot to do with hydraulic forces at a cross-section and the practitioner gets to choose the reference W/D based on design. Sediment transport competency equations may be used to determine reference W/D.

* Note that the accuracy of measurements will determine the appropriate number of significant digits for a field value. Keep this in mind when calculating and reviewing field values for all metrics.

Appendix 5: Tips for Checking Condition Assessment Field Values

Parameter	Metric	Where is it measured?	Calculation Check*	Proposed Condition?	Tips
Riparian Vegetation	Riparian Extent (%)	Representative sub-reach	This value is a percent and thus will not be >100%. When expected riparian extent is calculated using the meander width ratio (MWR) method, the proposed bankfull width should be used. The expected riparian area and physical location/mapped extent are the same for all condition assessments (existing, proposed, and monitoring).	Planting zones will generally correspond with observed riparian area. Reducing incision can increase the extent of the observed riparian community.	In general, the observed riparian area should not extend beyond the expected riparian area. For example, if proposed floodplain benching/excavation would extend beyond the otherwise expected area, i.e., excavation of a historical terrace, this area should be included when delineating expected riparian extent.
	Woody Vegetation Cover (%)		Absolute cover is collected by species and could be >100%. Make sure there are no typos in recording values from the field sheets.	Consider what kind of cover is possible to achieve by monitoring closeout. Index scores of 1.00 are unlikely.	Data collection for all three strata are needed for all sites, not just when woody vegetation is selected as the reference community type.
	Herbaceous Vegetation Cover (%)		Same guidance as provided for Woody Cover AND There should be 2 herbaceous cover plots nested within each plot; the field value is the average of averages. Calculate the average of the two locations to determine the herbaceous cover for each plot.		Data collection for all three strata are needed for all sites, not just when herbaceous vegetation is selected as the reference community type.
	Percent Native Cover (%)		Field value is the relative percent of cover within each plot that is native and is strictly ≤ 100%.	A field value of 100% native cover is likely unrealistic if there is an invasive species present, nearby (especially upstream) or highly likely to migrate to the project site post-construction.	Woody and herbaceous cover need to be collected for all sites regardless of reference vegetation cover in order to calculate this metric.

* Note that the accuracy of measurements will determine the appropriate number of significant digits for a field value. Keep this in mind when calculating and reviewing field values for all metrics.