Appendix A:

Stream Debit Calculation Guide

This guide describes how to use the Debit Calculator workbook to estimate functional loss associated with impacts to stream systems. This guide provides step-by-step instructions on how project impacts and functional loss can be evaluated. See Chapter 1.2.c. of the Colorado Stream Quantification Tool and Debit Calculator (CSQT) User Manual (User Manual) for information on how the CSQT calculates functional loss.

For proposed stream impacts, data to inform proposed condition scores may not be available for various reasons. This guide lays out three options to calculate functional loss using the Debit Calculator workbook.

1. Selecting a Debit Option

The three debit options described in this section require varying levels of information and effort to calculate functional loss. To that end, not all Debit Calculator worksheets are required to complete a loss calculation. In general, debit option 1 requires the most information and effort, while debit option 3 requires the least. A summary of the worksheets required to implement each are illustrated in Table 1.

Table 1. Summary of Debit Options

Debit Option	Existing Condition Score (ECS)	Proposed Condition Score (PCS)
1	Assess existing condition using Quantification Tool worksheet	Estimate proposed condition using Quantification Tool worksheet
2	Assess existing condition using Quantification Tool worksheet	Use Debit Tool worksheet
3	Use Debit Tool worksheet	Use Debit Tool worksheet

1.1 Debit Option 1

Users that have detailed information to predict the proposed post-project condition may choose debit option 1 and use the Quantification Tool worksheet to calculate the existing and proposed condition using detailed project designs or modeling results. For this option, the user must be able to accurately predict the functional loss within the Reach Hydrology & Hydraulics and the Geomorphology categories using project design reports, drawings, field investigations, etc. For projects that impact physicochemical or biological functions, the user must also be able to reasonably predict how the project will affect physicochemical and biology parameters.

The following steps are necessary to complete debit option 1:

1. Determine the parameters and metrics that will be used to assess the reach (See parameter selection in User Manual Chapter 2).
2. Complete the Project Assessment worksheet (see User Manual Section 1.2.a).

3. Complete the Quantification Tool worksheet, including the Site Information and Reference Selection section, the Existing Condition Assessment section and the Proposed Condition Assessment section (see User Manual Section 1.2.c).

For the Proposed Condition Assessment, the user should rely on available data to estimate proposed condition field values. As with functional lift, the same parameters used to derive the existing condition score must also be used to determine the proposed post-impact condition score. Therefore, field values must be determined for all metrics used to assess the existing stream reach (Note: field value here refers to where data are entered into the worksheet and not the actual collection of field data to yield a field value). Proposed field values that describe the physical post-impact condition of the stream reach should be based on project design reports, drawings, field investigations, etc. If a project is considered as having a Tier 0-3 level of impact (Table 2), only Reach Hydrology & Hydraulics and Geomorphology metrics need to be evaluated within the CSQT. For Tier 4-5 impacts, physicochemical and biological parameters should also be evaluated or a default existing condition score should be applied in the Quantification Tool worksheet (see Section 1.3 below). The default existing condition score is 0.80, except in Outstanding Waters where the default score is 1.00.

Example: Determining Proposed (Post-Impact) Condition Score

For projects that result in relocating or straightening a channel, a practitioner could use construction documents to determine the cross-section and profile of the proposed channel. These data can be used to estimate the proposed floodplain connectivity field values. Bed form diversity metrics could also be estimated from the project design plans. The plans should indicate the extent of impervious surfaces to be added to the reach catchment and the number of concentrated flow points that would be added. This information can be translated into reach runoff field values.

Because channelization is a Tier 4 activity that could adversely affect physicochemical and biology parameters, these parameters would need to be assessed for the existing condition, and an estimate of their post-project condition would need to be provided in the tool.

Since both the existing and proposed condition are scored in the Quantification Tool worksheet for debit option 1, the functional loss (ΔFF) is calculated at the top of the sheet in the Functional Change Summary Table and is also reported in the Mitigation Summary Table (See User Manual Section 1.2.c). The functional category report card and the function-based parameter summary can also be used to communicate changes in functional capacity that are likely to result from the proposed impact.

1.2 Debit Option 2

This option relies on the user to perform an existing condition assessment of the project reach in the same way as Option 1, using the Quantification Tool worksheet. Then, the user will use the Debit Tool worksheet (Section 4.5) to estimate the proposed (post-impact) condition score and calculate functional loss. The Debit Tool worksheet provides estimates of proposed condition based upon the magnitude of impacts, referred to as the Impact Severity Tier (Table 16). This method is best suited for users who are able to evaluate the existing condition, but do not have accurate data and information to inform the proposed condition within the CSQT.

The following steps are required to complete debit option 2:

1. Determine the parameters and metrics that will be used to assess the reach (See Parameter Selection in Section 2.3). Users must consult with the Corps to determine the parameters necessary to evaluate impacts.
2. Complete the Project Assessment worksheet (see Section 1.2.a).
3. Complete the Site Information and Reference Selection and Existing Condition Assessment sections of the Quantification Tool worksheet (see Sections 1.2.c).
4. Complete the Debit Tool worksheet (Section 1.2.h).

The Debit Tool worksheet will automatically populate using existing condition scores entered in the Quantification Tool worksheet (see step 3 above). Instructions for completing step 4 and detail on how functional loss is calculated in the Debit Tool worksheet are provided below.

Note: If a project is considered as having a Tier 0-3 level of impact (Table 2), only Reach Hydrology & Hydraulics and Geomorphology metrics need to be evaluated within the Quantification Tool worksheet. For impacts within Impact Severity Tiers 4 and 5, if the existing condition for physicochemical and biological parameters is not evaluated, the Debit Tool will assume a default existing condition score (see Section 1.3 below). The default existing condition score is 0.80, except in Outstanding Waters where the default score is 1.00.

1.3 Debit Option 3

Debit option 3 is identical to debit option 2, except users would not perform an existing condition assessment. In this case, the tool assumes a default existing condition score (ECS) in the Debit Tool worksheet. The default existing condition score is 0.80, except in Outstanding Waters where the default score is 1.00. Just as with debit option 2, the Debit Tool worksheet is used to estimate the proposed (post-impact) condition score and calculate functional loss. This option is available for users who are unable to perform an assessment of the project reach prior to impact. This option is the fastest and easiest method for determining functional loss.

The following steps are needed to complete debit option 3:

1. Complete the Project Assessment worksheet (see User Manual Section 1.2.a.)
2. Complete the Debit Tool worksheet (User Manual Section 1.2.h.)

1.4 Using the Debit Tool Worksheet

The Debit Tool is a worksheet within the Debit Calculator workbook described in User Manual Section 1.2.h. To calculate functional loss using the debit tool, the following information should be entered into the Debit Tool worksheet:

Existing and Proposed Stream Lengths
Outstanding Water designation (Y/N)
Impact Severity Tier

Following entry of this information, the Debit Tool worksheet will automatically populate a proposed condition score and functional loss.

1.5 Development of Impact Severity Tier Equations

Determination of an impact severity tier is needed in order to calculate a proposed condition score using the Debit Tool workbook. The impact severity tier is a categorical determination of the adverse impact to stream functions, ranging from no loss to total loss. Tier 0 represents no permanent loss of stream function. Tiers 1 – 4 represent a range of impacts resulting from proposed activities; information to select between these tiers can come from project plans and documents, permit applications, discussions between the permit applicant and the Corps, etc. Tier 5 is exclusive to projects that completely fill the stream channel, and either pipe or relocate the original channel. Table 2 lists the impact severity tiers along with a description of impacts to key function-based parameters and example activities that may lead to those impacts. Note that some activities could be in multiple tiers depending on the magnitude of the impact and efforts taken to minimize impacts using bioengineering techniques or other low-impact practices.

Table 2. Impact Severity Tiers and Example Activities

Tier	Description (Impacts to function-based parameters)	Example Activities
0	No permanent impact on any of the key function-based parameters	Bio-engineering of streambanks
1	Impacts to riparian vegetation and/or lateral migration	Bank stabilization and utility crossings.
2	Impacts to riparian vegetation, lateral migration, and bed form diversity	Utility crossings, bridges, bottomless arch culverts
3	Impacts to riparian vegetation, lateral migration, bed form diversity, and floodplain connectivity	Bottomless arch culverts, channelization/grading projects
4	Impacts to riparian vegetation, lateral migration, bed form diversity, and floodplain connectivity. Potential impacts to temperature, processing of organic matter, and macroinvertebrate and fish communities	Channelization, bottomless arch culverts, weirs/impoundments
5	Loss of all aquatic functions	Pipes, relocation, fill of channels from mining or development

The Debit Tool workbook calculates the proposed condition score differently, depending on which impact severity tier is selected (Table 3). For example, impacts within Tiers 1 – 3 result in functional losses to Reach Hydrology & Hydraulics and Geomorphology functions, while Tier 5 impacts result in complete loss of all functions within the stream reach.

Table 3. Impact Severity Tiers and PCS Calculation

Impact Severity Tier	PCS Equation	Percent Loss
1	PCS = 0.83 * ECS	17%
2	PCS = 0.65 * ECS	35%
3	PCS = 0.37 * ECS	63%
4	PCS = 0.27 * ECS	73%
5	PCS = 0	100%

Tiers 1-4 – The existing condition score and the impact severity tier are used to calculate the proposed condition using the multipliers shown in Table 3. For example, a Tier 3 impact on a reach with an ECS of 0.52 would result in a proposed condition score of 0.31 (0.37 * 0.52 =0.31). This means that the proposed condition score is 37% of the existing condition score. The inverse is also true, meaning that there was a corresponding 63% loss of stream function.

Multipliers for each impact tier were developed from linear regression equations of modeled impact scenarios using a simplified version of the SQT; additional detail on how the multipliers were developed is provided in a white paper on the debit tool (Harman and Jones, 2017). The multipliers from Harman and Jones (2017) were modified for the CSQT to accommodate the evaluation of four functional categories instead of five (i.e., Hydrology and Hydraulics were combined into a single functional category for the CSQT, Reach Hydrology & Hydraulics). The percent loss associated with impact severity tiers 1 – 3 is calculated using an existing condition score based on an evaluation of functions within Reach Hydrology & Hydraulics and Geomorphology. In these tiers, there is no anticipated permanent functional loss to physicochemical or biology functions. As such, the equation is based on a maximum existing condition score of 0.60. For tier 4, there is potential permanent loss in physicochemical and biological functions and thus, this equation considers a maximum existing condition score of 1.00.

Tier 5 – Activities that completely fill the channel, removing all aquatic functions, are assigned to tier 5. The PCS is an automatic 0.00, meaning that all aquatic functions have been lost. Streams enclosed in pipes are included in this tier because it is assumed that no hydraulic, geomorphology, physicochemical, and biology functions are present in this reach. While hydrology is still present, it is simply being conveyed through the reach and not supporting any other functions.