curve may be used to determine project removal rates. The final removal rate is then applied to the entire drainage area to the dry channel RSC project.

Localities will need to check with their state stormwater agency on the specific data to report individual retrofit projects, and must meet the BMP reporting, tracking and verification procedures established by the Retrofit Expert Panel (WQGIT, 2012). In general, the following information will be reported:

a. Retrofit class (i.e., new retrofit facility)
b. Location coordinates
c. Year of installation (and ten year credit duration)
d. 12 digit watershed in which it is located
e. Total drainage area and impervious cover area treated
f. Runoff volume treated
g. Projected sediment, nitrogen, and phosphorus removal rates

Section 6: Credit Calculation Examples

The following examples are based on typical projects one might encounter in urban areas and have been created to show the proper application of the four protocols to determine the nutrient and sediment reductions associated with individual stream restoration projects. Depending on the project design, more than one protocol may apply to be used to determine the total load removed by the stream restoration project.

Section 6.1
Design Example for Protocol 1
Credit for Prevented Sediment during Storm Flow

Bay City, VA is planning on restoring 7,759 feet of Hickey Run[3]

Step 1. *Estimating stream sediment erosion rate*

Five reaches were subdivided into a total of 28 banks for BEHI and NBS assessment (Figure 1, Appendix B). The BEHI and NBS scores were taken for each bank and an estimated stream erosion rate was made using the curve developed by the USFWS. The bank height and length were used to convert the erosion rate from feet per year to pounds per year using Equation 1 from the description of Protocol 1 in Section 5. The data used in this calculation is provided in Appendix B.

The bank erosion estimates in feet per year were multiplied by the bulk density and the total eroding area (bank length in feet x bank height in feet) to convert the sediment loading to tons per year. The loading rates for each of the 5 reaches were totaled to give

[3] The data used for this example are taken from Hickey Run collected by the USFWS except for bulk density which was taken from Van Eps et al. (2004).

an estimated erosion rate for the entire 7,759 feet project length. The predicted erosion rate for the entire project length is 1,349 tons per year (348 pounds per linear foot per year).

Step 2. *Convert erosion rate to nutrient loading rates*

From Walter et al. (2007), the phosphorus and nitrogen concentrations measured in streambank sediments are:

- 1.05 pounds TP/ton sediment
- 2.28 pounds TN/ton sediment

A sediment delivery ratio of 0.175 is applied only to the sediment load to account for the loss that occurs because of depositional processes between the edge-of-field and edge-of-stream loads. This ratio is applied here for example purposes only and localities will not be required to make this calculation when submitting the load reduction attributed to stream restoration projects. The ratio is incorporated into the CBWM and is subject to change based on further refinements of the model. Refer to Appendix B for additional information about the sediment delivery ratio. Therefore, the total predicted sediment, phosphorus and nitrogen loading rates from the restoration area is:

Sediment =	236 tons per year
Total Phosphorus =	1,416 pounds per year
Total Nitrogen =	3,076 pounds per year

Step 3. *Estimate stream restoration efficiency*

Assume the efficiency of the restoration practice to be 50% (from Baltimore County DEP Spring Branch Study). Therefore, the sediment and nutrient credits are:

Sediment =	118 tons per year
Total Phosphorus =	708 pounds per year
Total Nitrogen =	1,538 pounds per year

Section 6.2
Design Example for Protocol 2
Credit for In-Stream and Riparian Nutrient Processing within the Hyporheic Zone during Base Flow

Bay City would like to also determine the nutrient reduction enhancement credits that would be earned if parts of the restoration design for Hickey Run resulted in improved connectivity of the stream channel to the floodplain as indicated by a post construction bank height ratio of 1.0. Note that the credits from this protocol should be added to the credits from Protocol 1. Also note that because floodplain connection to a functioning wetland is not possible, Protocol 2 is used to determine base flow load reduction and not Protocol 3.

Step 1. *Determine the total post construction stream length that has a bank height ratio of 1.0 or less.*

It was determined that the stream restoration could improve the floodplain connectivity by reducing the bank height ratio to 1.0 for 500 feet of stream channel. Only one side of the stream meets the reconnection criterion because of an adjoining road embankment on the other side. In the study by Striz and Mayer (2008), the groundwater flow is split into left and right bank compartments allowing the hyporheic box to be split into a left and a right bank compartment on either side of the stream thalweg divide. In step 2, only half of the stream width is used to size the hyporheic box dimensions.

Step 2. *Determine the dimensions of the hyporheic box.*

This is done by adding 5 feet to the width of the stream channel taken from the thalweg to the edge of the connected side of the stream at mean base flow depth. Multiply the result by the 5 foot depth of the hyporheic box. This is the cross sectional area of the hyporheic box. Multiply the cross sectional area by the length of the restored connected channel from Step 1. The post construction stream width from the 500 foot channel segment at base flow will be on average 14 feet. To determine the width of the hyporheic box, 5 feet is added to width of half of the total stream width (7 feet) for a total width of 12 feet. The depth of the box is 5 feet. The total volume of the hyporheic box is 500(12 × 5) = 30,000 cubic feet.

Step 3. *Multiply the hyporheic box mass by the unit denitrification rate*

This step requires the estimation of the bulk density of the soil within the hyporheic box. Assume that the bulk density of the soil under a stream is 125 pounds per cubic foot. The total mass of the soil is calculated in Equation 2 below.

$$\frac{(30{,}000\ ft^3)(125\ lb/ft^3)}{2{,}000} = 1{,}875\ tons \qquad \text{(Eq. 2)}$$

Where: 2,000 = conversion from pounds to tons

The hyporheic exchange rate is 1.95×10^{-4} lb/ton/day of soil (conversion from 97.6 μg TN/kg/day of soil); therefore, the estimated TN credit is:

$$(1.95\ x\ 10^{-4}\ \ lb/ton/day)(1{,}875\ tons) = 0.37\ \ lb/day\ or\ 135\ \ lb/yr \qquad \text{(Eq. 3)}$$