DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS

VERSION 5.6.0

TUTORIAL # 15
LAUNCHABLE RIPRAP DESIGN ANALYSIS

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LAUNCHABLE RIPRAP DESIGN ANALYSIS

DATE UPDATED: MAY 1, 2018

1.0 INTRODUCTION

Instead of extending the riprap protection to the maximum scour depth below the thalweg in the river, one can use the toe-protection approach (also called "launchable riprap"). This is done by placing the riprap materials at the toe of the channel bank, which will launch as the scour takes place. The following is the suggested procedure for toe protection design, which has been implemented in the existing version of DDMSW.

2.0 PROCEDURE

2.1 STEP 1 – DETERMINE THE SCOUR DEPTH

Compute the total scour depth (Z_T) for bank erosion protection for the design flow rate (the software will allow users to input the total scour depth (Z_T) in a text box or transfer the total scour depth result from the Total Scour analysis).

2.2 STEP 2 – DETERMINE THE RIPRAP SIZE

Compute the riprap median size D_{50} for bank erosion protection for the design flow rate (the software will allow users to input the D_{50} value in a text box or transfer the result from Riprap Sizing analysis).

2.3 STEP 3 – DETERMINE THE THICKNESS OF RIPRAP

Compute the riprap layer thickness, $T = 1.5D_{50}$.

2.4 STEP 4 – DETERMINE THE TOE-PROTECTION THICKNESS

Compute the toe protection thickness, H, which should fall between 2T and 3T.

$$2T < H \leq 3T \tag{1}$$

(DDMSW will calculate a value of H = 3T (default), but allow users to choose a value between 2T and 3T).

2.5 STEP 5 – DETERMINE THE VERTICAL LAUNCH DISTANCE

Compute the vertical launch distance (H_V), which is defined as the vertical distance between the bottom of the toe protection and total scour depth below the thalweg (see Figure 20). The software will let users input the vertical launch distance in a text box or compute it if the users supply channel thalweg elevation and top of toe protection elevation. If the users supply channel the thalweg elevation (EL_{TG}) and the top of toe protection elevation (EL_{TOP}), then $H_V = (EL_{TOP} - H) - (EL_{TG} - Z_T) = EL_{TOP} - H - EL_{TG} + Z_T$ where Z_T is the total scour depth.

2.6 STEP 6 – DETERMINE THE VOLUME INCREASE COEFFICIENT

The software will allow users to input a volume increase coefficient (C_{VI}) in percent in a text box or choose if it is a dry placement or underwater placement of riprap. If the users chooses the placement method, the software will internally compute the volume increase coefficient (C_{VI}) in percent based on TABLE 1 below (note the coefficient is also a function of the computed H_V value). The table is adapted from US Army Corps Engineering Manual 1110-2-1601 (1994): Hydraulics Design of Flood Control Channels.
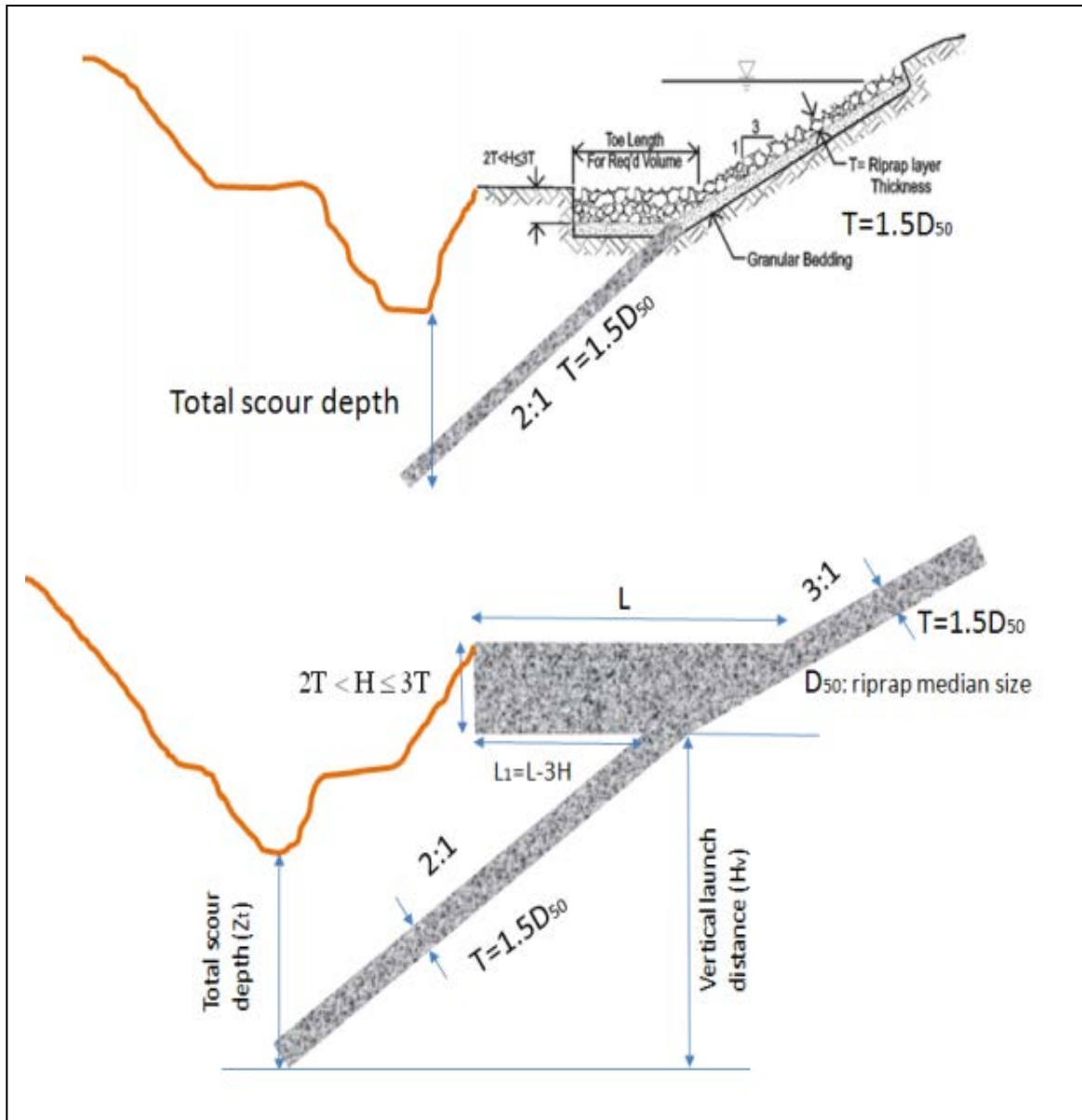
Channel Bank Toe-Protection ("Launchable Riprap")

TABLE 1 – Volume Increase Coefficient		
Vertical Launch Distance (H$_V$)	Volume Increase Coefficient in Percent (C$_{VI}$)	
	Dry Placement	Underwater Placement
< = 15.0 ft	25	50
> 15 ft	50	75

2.7   STEP 7 – DETERMINE THE TOE-LENGTH

Compute the required toe length L by

$$\mathbf{L = 1.5H} + \left(\mathbf{1} + \frac{C_{VI}}{\mathbf{100}}\right) * \mathbf{T} * \sqrt{\mathbf{5}} * \frac{H_V}{H} \qquad (2)$$

The derivation of above equation is as follows: The derivation is based on area instead of volume if we use 1 foot linear length of the channel along the flow direction. The required area can be computed as,

$$\left(\mathbf{1} + \frac{C_{VI}}{\mathbf{100}}\right) * T * \sqrt{5} * H_V \qquad (3)$$

Therefore,

$$H * (L - 3H) + \frac{1}{2}\mathbf{H} * \mathbf{3H} = \left(\mathbf{1} + \frac{C_{VI}}{\mathbf{100}}\right) * \mathbf{T} * \sqrt{\mathbf{5}} * \mathbf{H_V} \qquad (4)$$

Solving the above equation yields the equation for L in equation (2).

2.8   STEP 8 – SUMMARIZE THE FINAL DESIGN PARAMETERS

Now that the final design parameters for the toe-protection are found, summarize the design results.

3.0   EXAMPLE PROBLEM

3.1   PROBLEM STATEMENT AND DATA

Instead of using a traditional toe-down protection for the armored channel bank for a certain segment of the Salt River in Phoenix, Arizona, a "launchable riprap" toe-protection design is being considered for cost comparison. The launchable riprap will comprise of similar riprap materials and volume. Relevant data are provided as follows:

(a) Evaluated Total Scour Depth, ZT (ft) = 20.59 ft

(b) Riprap Size, D50 (ft) = 2.24 ft

(c) Top of Toe Protection Elevation (ft) = 100.0 ft

(d) Channel Thalweg Elevation (ft) = 95.0 ft

Important design requirements and specifications are provided below:

(a) Layer Thickness, T, is 1.5 D50

(b) Toe-Protection thickness, H, is 3T

(c) Dry placement

3.2 ANALYSIS RESULTS

Now that the final design parameters for the toe-protection are found, summarize the design results.

(a) Launch the DDMSW program

(b) Create a new project (File➜ New Project) to open the New Project Options dialog box.

(c) On the New project Options dialog box, select River Mechanics check box, and hit OK.

(d) On the Select Project form, enter the following:

- Reference: T15_LAUNCHABLERR *(Required)*
- Title: Tutorial #15 – Launchable Riprap Analysis *(Optional)*
- Location: Phoenix, Arizona *(Optional)*
- Agency: Flood Control District of Maricopa County *(Optional)*
- Comment Box: This project is developed to demonstrate the capability of DDMSW to perform launchable riprap design analysis. *(Optional)*
- Modification Date: Date Today *(Optional)*
- Project Defaults: *Accept the default settings*

(e) The completed form should look similar to the one provided below:

Select Project

List | Details

Project Reference

Project ID `00055` Reference `T15_LAUNCHABLERR`

Title `Tutorial #15 - Launchable Riprap Analysis`

Location `Phoenix, Arizona`

Agency `Flood Control District of Maricopa County`

☑ River Mechanics Only

Project Defaults

Soils `FCDMC`

Land Use `FCDMC`

This project is developed to demonstrate the capability of DDMSW to perform launchable riprap design analysis.

Modification Date `06/29/2016`

Info | Print... | Delete | Add | OK

(f) Click **OK** when ready. Click **OK** to accept the default data settings on the land use and soils.
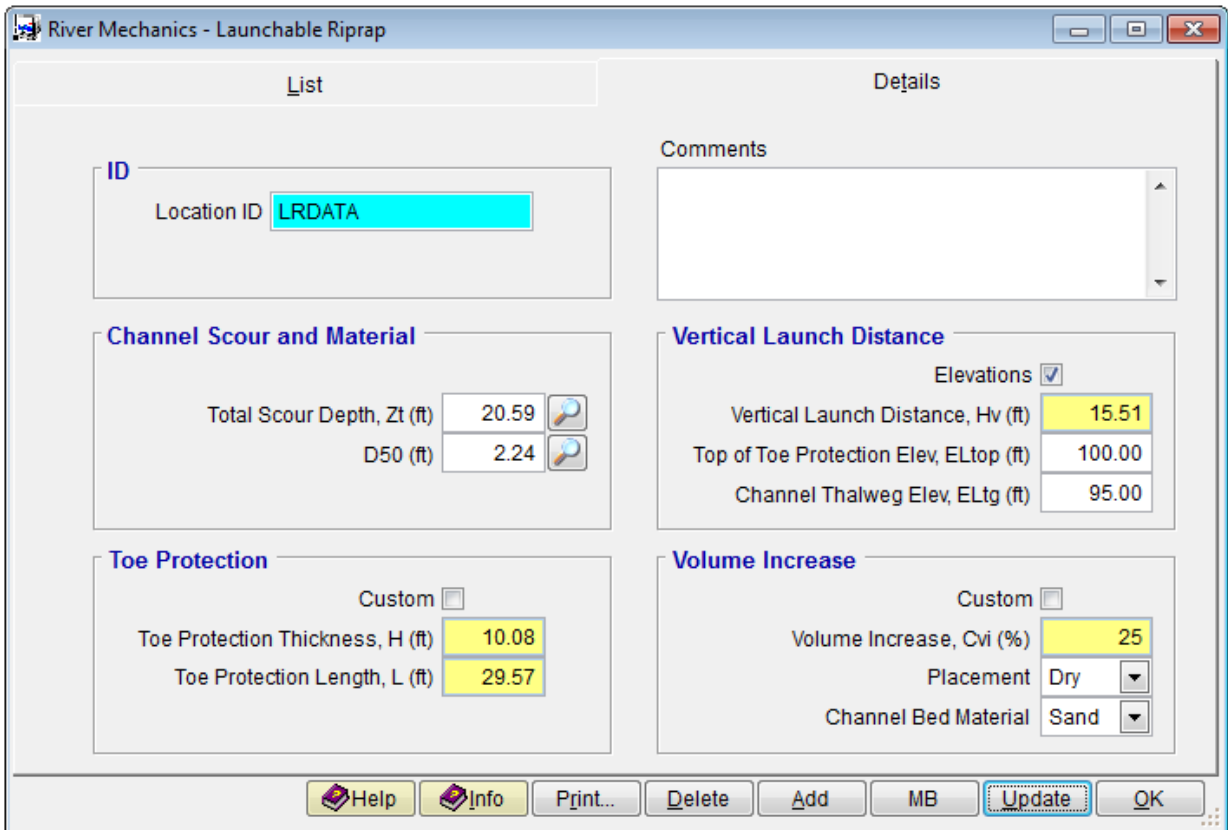
(g) Open the Launchable Riprap form (River mechanics ➔ Launchable Riprap).

(h) To start create a data set to analyze, click the **Add** button.

(i) On the Launchable Riprap form, enter the following data:

- **Location ID:** LRDATA1
- **Total Scour Depth, Z_T (ft):** 20.59
- **D_{50} (ft):** 2.24
- **Elevations (checkbox):** check
- **Top of Toed Protection Elev, ELtop (ft):** 100
- **Channel Thalweg Elev, ELtg (ft):** 95
- **Placement:** Dry
- **Channel Bed Material** Sand

(j) The result of the analysis is provided below:

This concludes this tutorial.