DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS

VERSION 6.0.5

TUTORIAL # 19

ABUTMENT SCOUR ANALYSIS

[HEC-18 PROCEDURE]

KVL Consultants, Inc.

ABUTMENT SCOUR ANALYSIS
[HEC-18 PROCEDURE]

TABLE OF CONTENTS

ABUTMENT SCOUR ANALYSIS
[HEC-18 PROCEDURE]

DATE UPDATED: APRIL 20, 2022
TUTORIAL TIME: 40 MINUTES

1.0 INTRODUCTION

Based on the ratio between the embankment projected length (L) and the floodplain width (B_f), abutment scour can be computed based on two conditions: **Live-Bed Condition** and **Clear-Water Condition**. If the ratio (L/B_f) is greater than or equal to 0.75, the live-bed condition equations will be used. Conversely, if the ratio (L/B_f) is less than 0.75, the clear-water condition equations will be used. It may be pointed out that the abutment scour already includes contraction scour. Abutment scour is a type of local scour and forms part of the total scour depth. When abutment scour is evaluated, no additional contraction scour should be added to the total scour depth.

This tutorial includes the two conditions of Abutment Scour identified as follows:

- **Condition A - Abutment Scour for Live-Bed Condition (Wingwall)**
- **Condition B - Abutment Scour for Clear-Water Condition (Spill-Through)**

2.0 ABUTMENT SCOUR FOR LIVE-BED CONDITION (WINGWALL)

If the L/B_f ratio is greater than or equal 0.75, the live-bed abutment scour equations should be used to evaluate the local scour from abutment structure. The procedure for evaluating Abutment Scour for live-bed conditions, also referred as **Condition A**, is from the HEC-18 Manual of the Federal Highway Administration (2012). The abutment scour in this condition could be evaluated in either of the two types: *Wingwall* or *Spill-Through*.

The following sets of data are used for evaluating the abutment scour under the live-bed condition.

❖ Embankment and Floodplain Data:

- Projected length of embankment, L (ft): *85.00*
- Width of floodplain, B_f (ft): *100.00*

❖ Hydraulic Data:

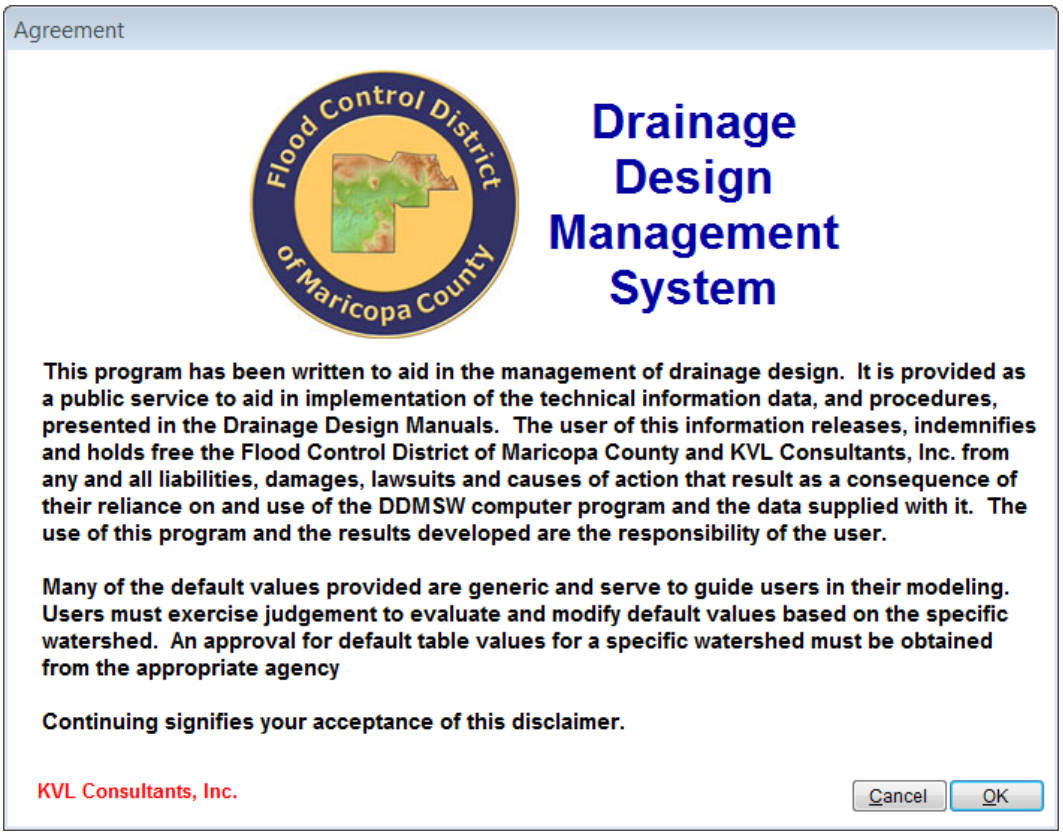
- Upstream flow depth, y_1 (ft): *10.00*
- Unit discharge at upstream floodplain, q_1 (ft^2/s): *57.00*
- Unit discharge at constricted opening, q_{2c} (ft^2/s): *78.60*
- Flow depth prior to scour, Y_o (ft): *9.50*

The analysis procedure for evaluating abutment scour for live-bed condition is summarized as follows:

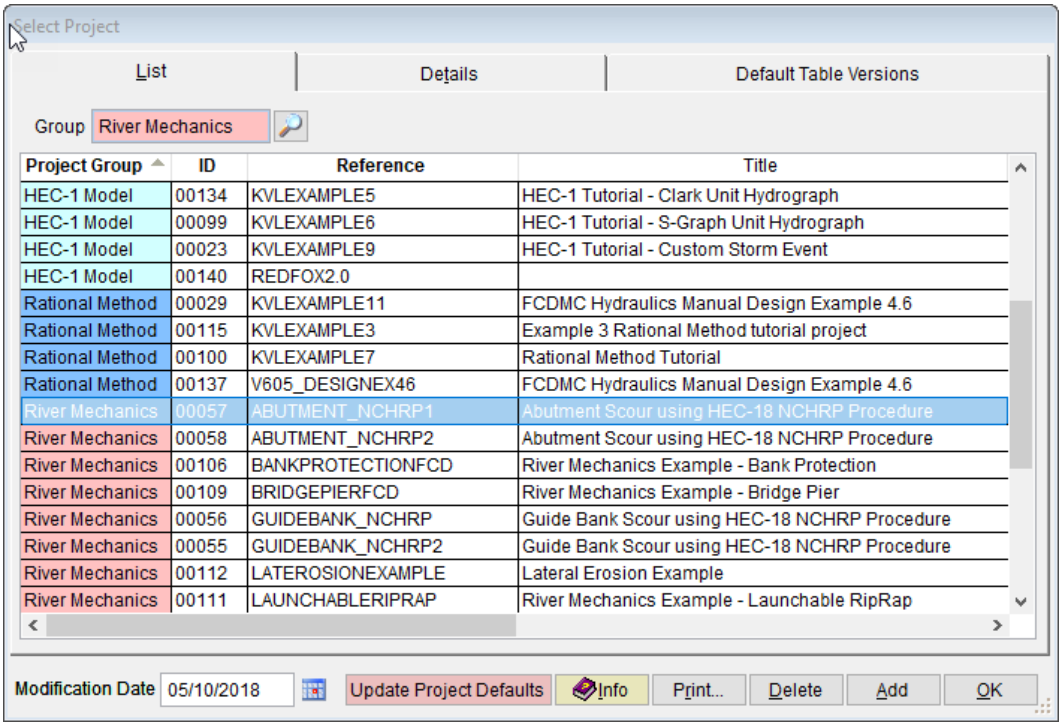
- ❖ Step 1: Establish a New River Mechanics Project and Defaults Set-up
- ❖ Step 2: Set up Abutment Scour Basic Data
- ❖ Step 3: Calculate Abutment Scour
- ❖ Step 4: Report and Document the results

2.1 Step 1 - Establish a New Project and Defaults Set-up

(a) Start **DDMSW**. Click the ***OK*** button to accept the software disclaimer as shown below.



After **DDMSW** is launched, the **SELECT PROJECT** form is automatically opened as shown in the following figure.



(b) Click the ***Add*** button on the **SELECT PROJECT** form to start a new project (**File ➔ New Project ➔ Add**).

(c) Check the ***River Mechanics*** checkbox, then click the ***OK*** button to exit the **NEW PROJECT OPTIONS** dialog box.

(d) On the **SELECT PROJECT** form, enter '*V605_ABUTMENT_NCHRP1'* into the ***Reference*** textbox. This is the name of the new project. Users can choose any name for the ***Reference*** textbox as long as it does not already exist in the current **DDMSW** project database.

(e) Type into the ***Title*** textbox a brief descriptive title for this project *(Optional) (e.g., 'Abutment Scour using HEC-18 NCHRP Procedure').*

(f) Type into the ***Location*** textbox the location of this project *(Optional) (e.g., 'Maricopa County, Arizona')*

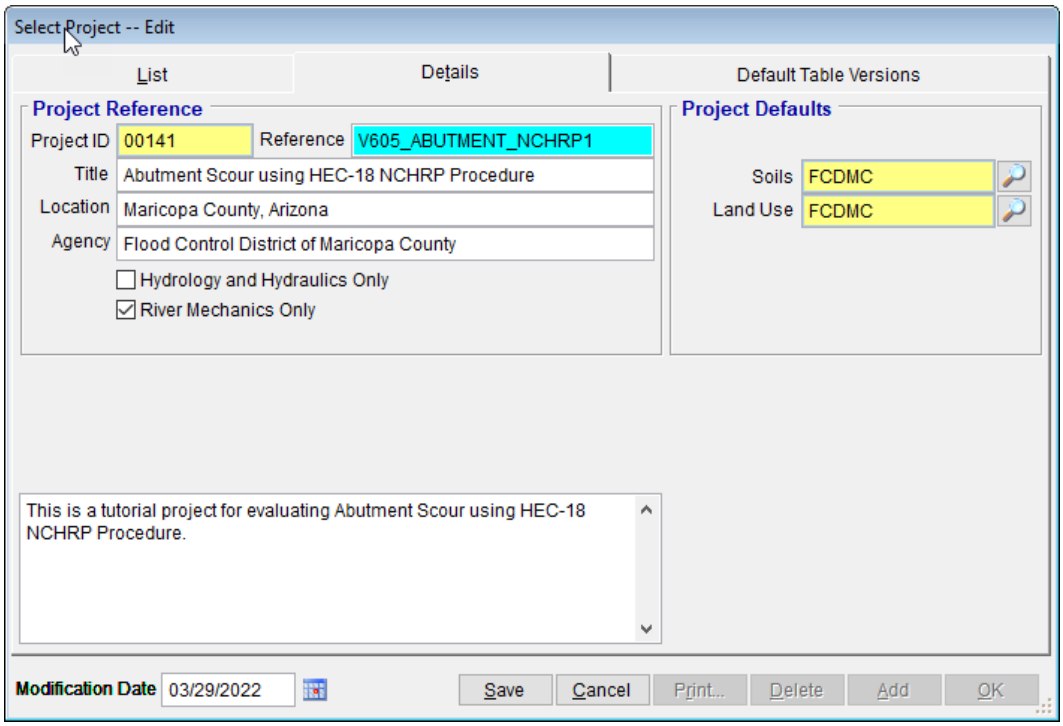
(g) Type into the ***Agency*** textbox the agency or company name *(Optional) (e.g., 'Flood Control District of Maricopa County').*

(h) Check ***River Mechanics Only*** checkbox.

(i) Type a detailed description of this project into the comment area under the ***Project Reference*** frame *(Optional) (e.g., 'This is a tutorial project for evaluating Abutment Scour using HEC-18 NCHRP Procedure').*

(j) Set the ***Modification Date*** to today's date by clicking on the Calendar icon.

(k) Click the ***Save*** button to save the entered data.

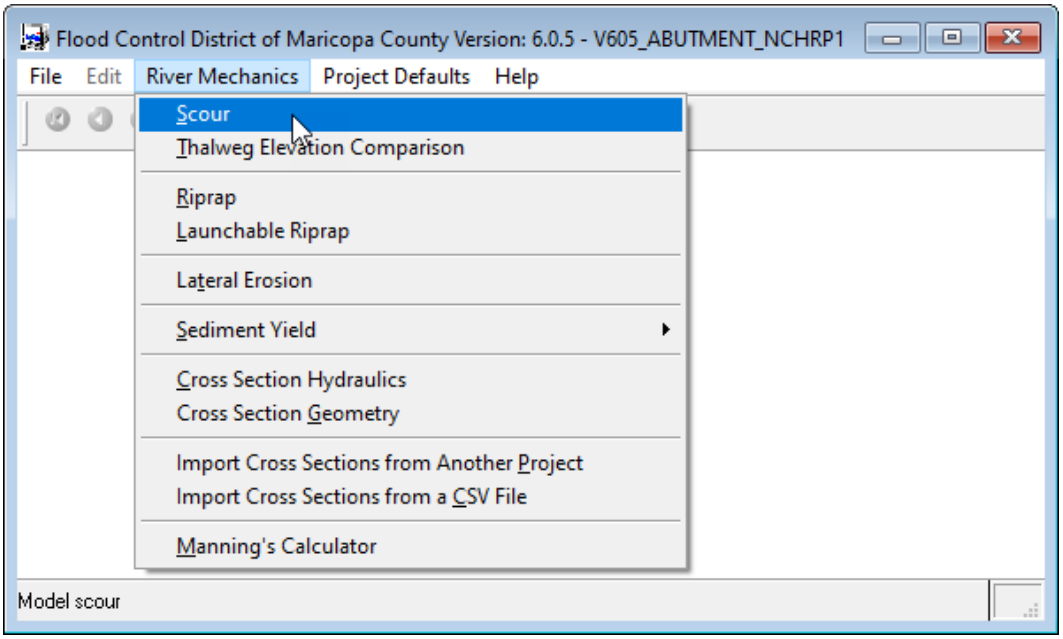


(l) Click the ***OK*** button on the **SELECT PROJECT** form to exit.

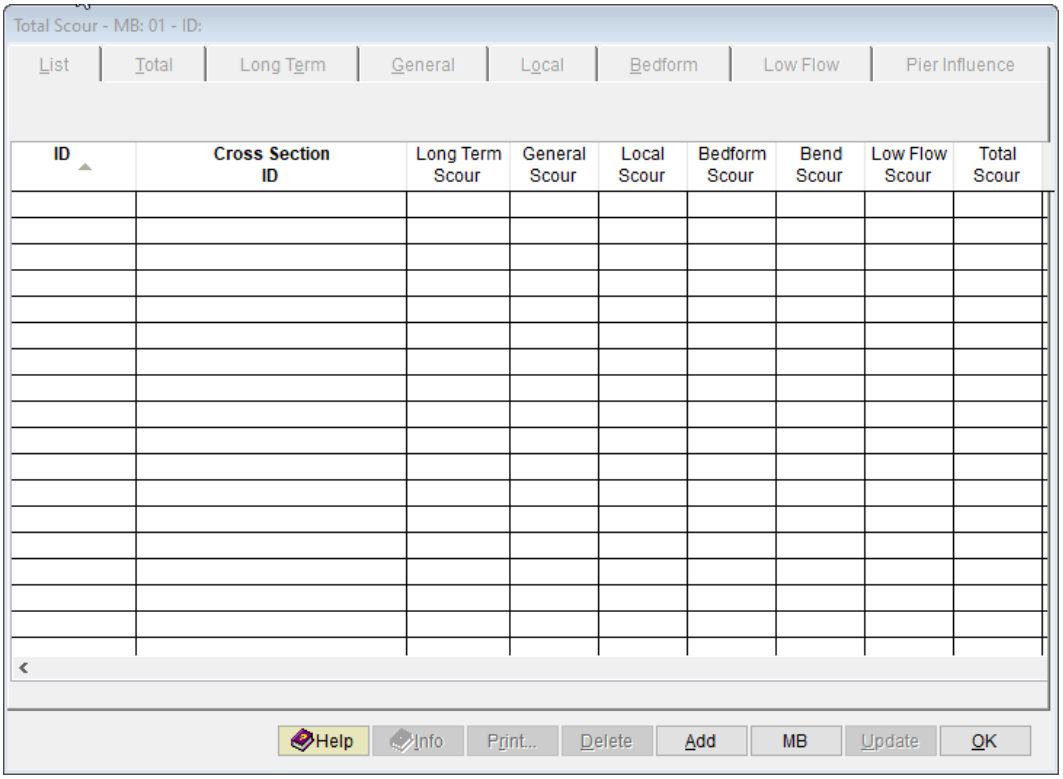
Note: The ***Project ID*** *00141* in the above figure is the unique database record identifier for the project, which is automatically generated by the program when a new project is created. Each time a new project is created, a ***Project ID*** is assigned by the program. The ***Project ID*** assigned to your project will not necessary be the same as the ***Project ID*** shown in the above figure

2.2 Step 2 - Set up Abutment Scour Basic Data

(a) From the menu bar of the main application window, click ***River Mechanics*** ➔ ***Scour,*** to open the **TOTAL SCOUR** form.

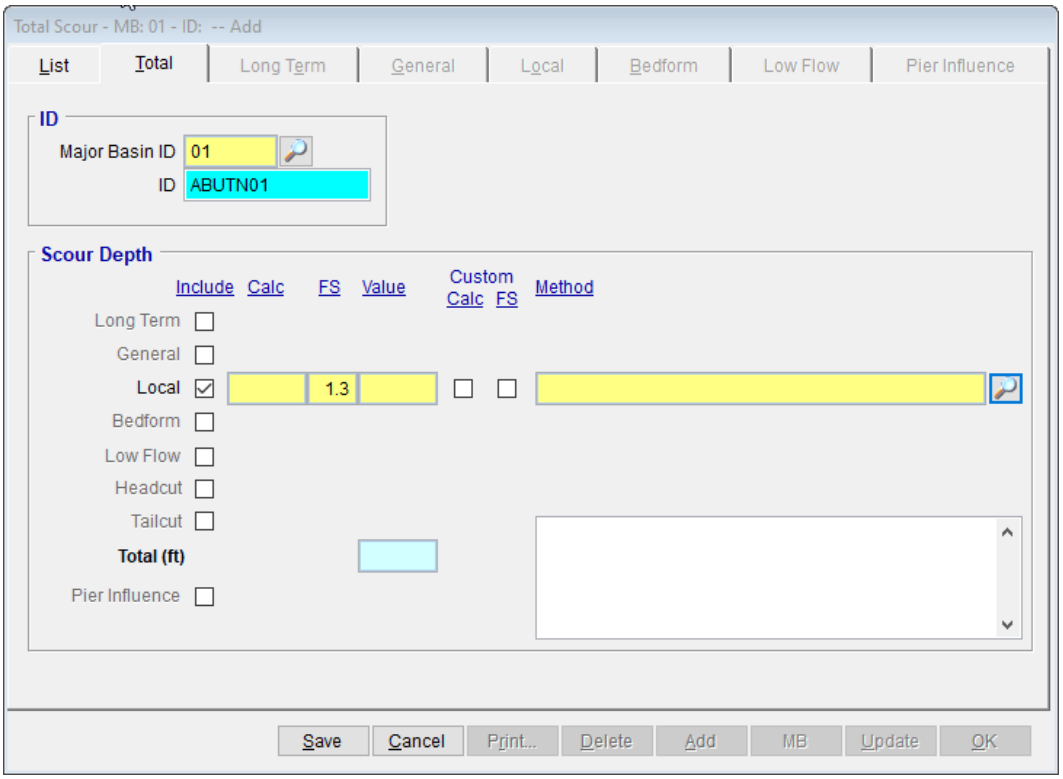


(b) On the **TOTAL SCOUR** form, click the ***Add*** button at the bottom of the form to activate the necessary data entry fields.



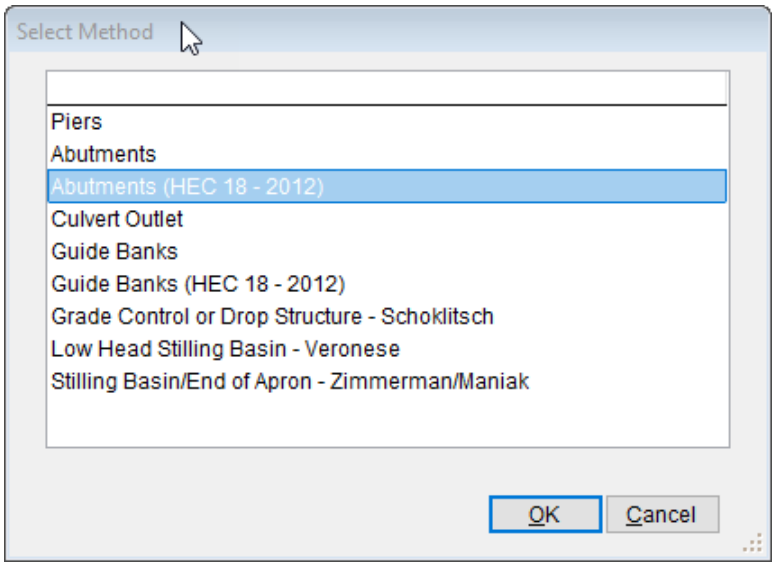
(c) Type "*ABUTNO1*" into the ***ID*** textbox (this ***ID*** is for Abutment No.1).

(d) Check the ***Local*** check box only.

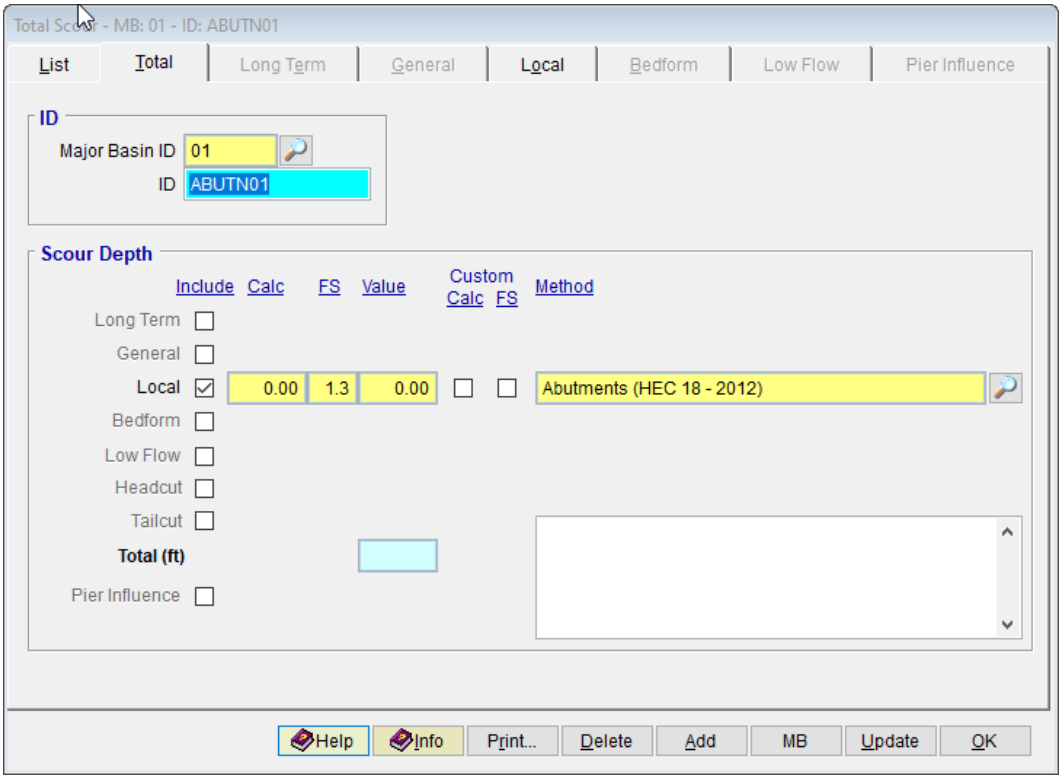


(e) Click the browse button  in the ***Method*** column across the ***Local*** checkbox to access and select specific local scour method for the project.

(f) Select "*Abutments (HEC 18 – 2012)*" from the **SELECT METHOD** dialog box, then click ***OK*** to exit.



(g) Click the ***Save*** button to save the entered data. The **TOTAL SCOUR** form should look like the figure provided below.



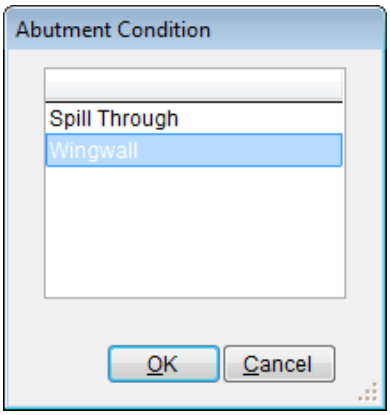
2. 3 Step 3 - Calculate the Abutment Scour

(a) On the **TOTAL SCOUR** form, select the ***Local*** tab

(b) Enter *"85"* into the ***Projected Length of Embankment, L* (ft)** textbox.

(c) Enter "*100"* into the ***Width of Floodplain, B_f (ft)*** textbox.

(d) Click the browse button beside the ***Abutment Condition for Amplification Factor*** to select the abutment type. Choose *"Wingwall"* and click ***OK*** to exit the **ABUTMENT CONDITION** window.



Note that the ***Abutment Scour Condition*** is automatically set to *A* since the evaluated L/B_f ratio is *0.85*, which is greater than the threshold value of *0.75*. This classifies the problem to be under **Condition A** or a **Live-Bed Condition.**

(e) Click the **Save** button to save the entered data.

(f) Enter "*10*" into the ***Upstream Flow Depth, y_1 (ft)*** textbox.

(g) Enter "*57*" into the ***Upstream Unit Discharge, q_1 (sq ft/sec)*** textbox.

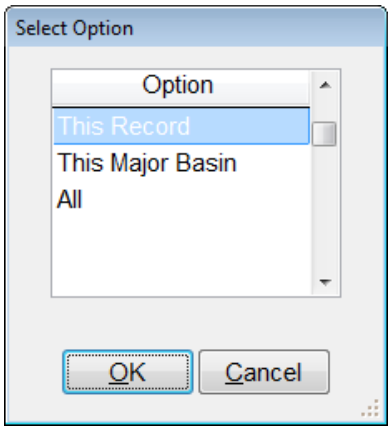
(h) Enter *"78.6"* into the ***Unit Discharge in the Constricted Opening, q_{2c} (sq ft/sec)*** textbox.

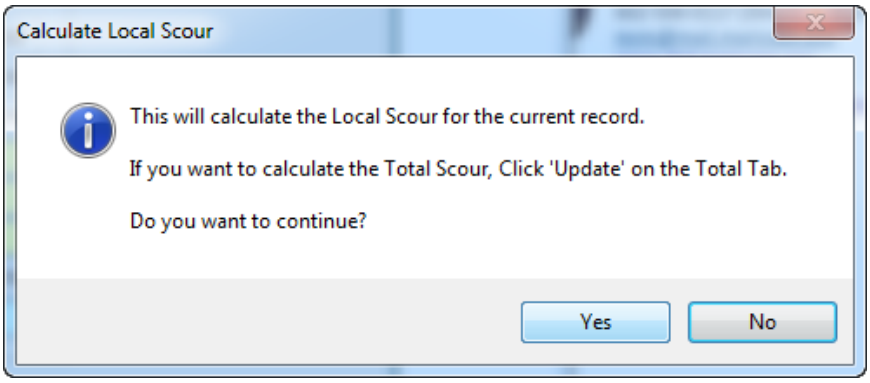
(i) Enter "*9.5*" into the ***Flow Depth Prior to Scour, Y_o (ft)*** textbox.

(j) Click the ***Save*** button to save the entered data.

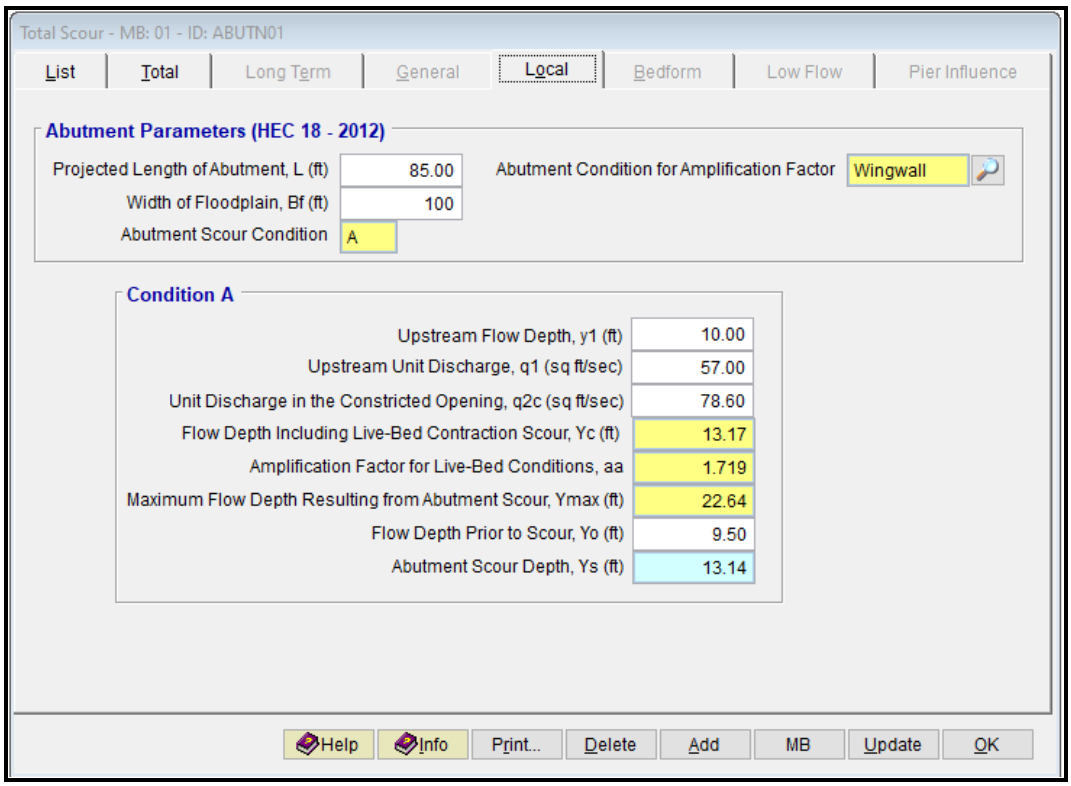
(k) Click the ***Update*** button to update past analysis results if they exist or to initiate the evaluation of the Abutment Scour for the **Live-Bed Condition.**

(l) Select "*This Record*" from the **SELECTION OPTION** dialog box, then click **OK** to exit**.** On the **CALCULATE LOCAL SCOUR** dialog box, click ***Yes*** to continue.





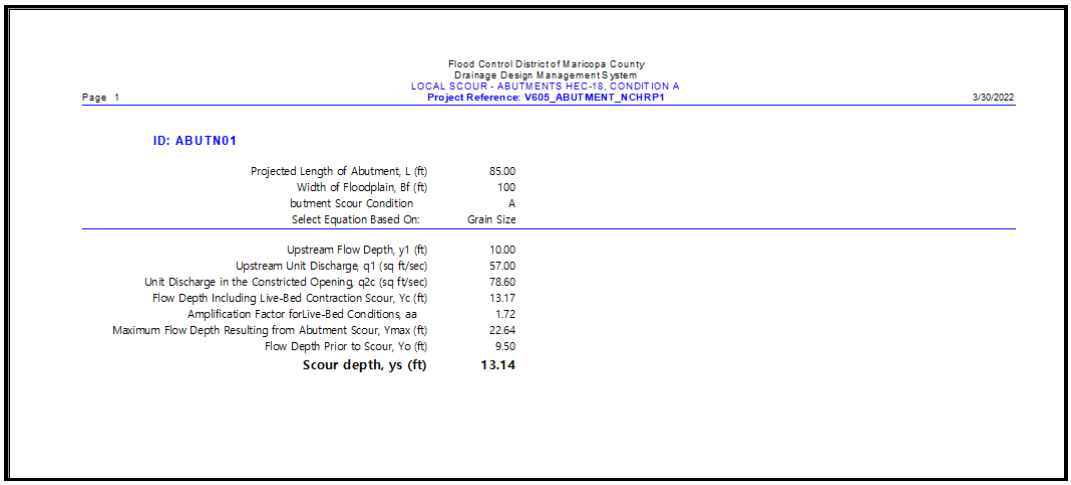
After the update the ***Local*** tab form should look like the figure provided below.



2. 4 Step 4 - Report and Document the Results

In this section, procedures will be given on how to view, print, and export the calculation results from the abutment scour analysis.

(a) To view the results on the screen, click the ***Print …*** button on the ***Local*** tab of **TOTAL SCOUR – MB: 01 – ID: ABUTNO1** form. A report will be generated as shown in the following figure.



Flood Control District of Maricopa County
Drainage Design Management System
LOCAL SCOUR - ABUTMENTS HEC-18, CONDITION A
Page 1 Project Reference: V605_ABUTMENT_NCHRP1 3/30/2022

ID: ABUTN01

Projected Length of Abutment, L (ft)	85.00
Width of Floodplain, Bf (ft)	100
butment Scour Condition	A
Select Equation Based On:	Grain Size
Upstream Flow Depth, y1 (ft)	10.00
Upstream Unit Discharge, q1 (sq ft/sec)	57.00
Unit Discharge in the Constricted Opening, q2c (sq ft/sec)	78.60
Flow Depth Including Live-Bed Contraction Scour, Yc (ft)	13.17
Amplification Factor forLive-Bed Conditions, aa	1.72
Maximum Flow Depth Resulting from Abutment Scour, Ymax (ft)	22.64
Flow Depth Prior to Scour, Yo (ft)	9.50
Scour depth, ys (ft)	**13.14**

(b) To print the results, click the printer symbol ( ).

(c) To export the results to PDF format or to other formats, click the export symbol ( )

This concludes the first tutorial for **Abutment Scour under Live-Bed Condition** (or **Condition A**).

3.0 ABUTMENT SCOUR FOR CLEAR-WATER CONDITION (SPILL-THROUGH)

If the L/B_f ratio is less than 0.75, the clear-water abutment scour equations should be used. The clear-water condition is also called **Condition B** in the HEC-18 Manual of the Federal Highway Administration (2012). Abutment scour can be computed for either of two options: *Wingwall* or *Spill-Through*.

The data sets provided below are for evaluating Abutment Scour (Spill-Through Option).

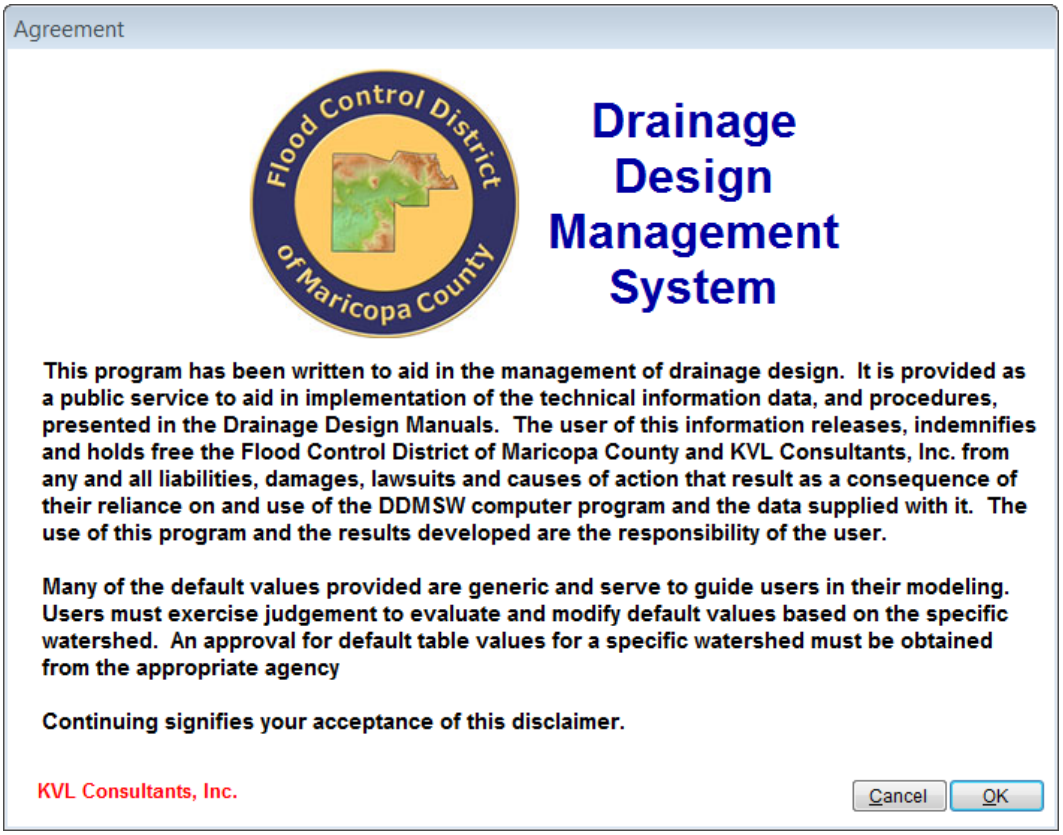
- Embankment and Floodplain Data:
  - Projected length of embankment, L (ft): *65.00*
  - Width of floodplain, B_f (ft): *100.00*
- Hydraulic and Sediment Data:
  - Unit discharge at upstream floodplain, q_f (ft^2/s): *5.70*
  - Unit discharge at constricted opening, q_{2f} (ft^2/s): *10.10*
  - Particle size with 50 percent finer, D_{50} (ft): *0.0010*
  - Manning's n of floodplain under the bridge: *0.025*
  - Critical shear stress for floodplain material: *0.04*
  - Flow depth prior to scour, Y_o (ft): *3.50*

The analysis procedure for evaluating Abutment Scour for clear-water condition is summarized as follows:

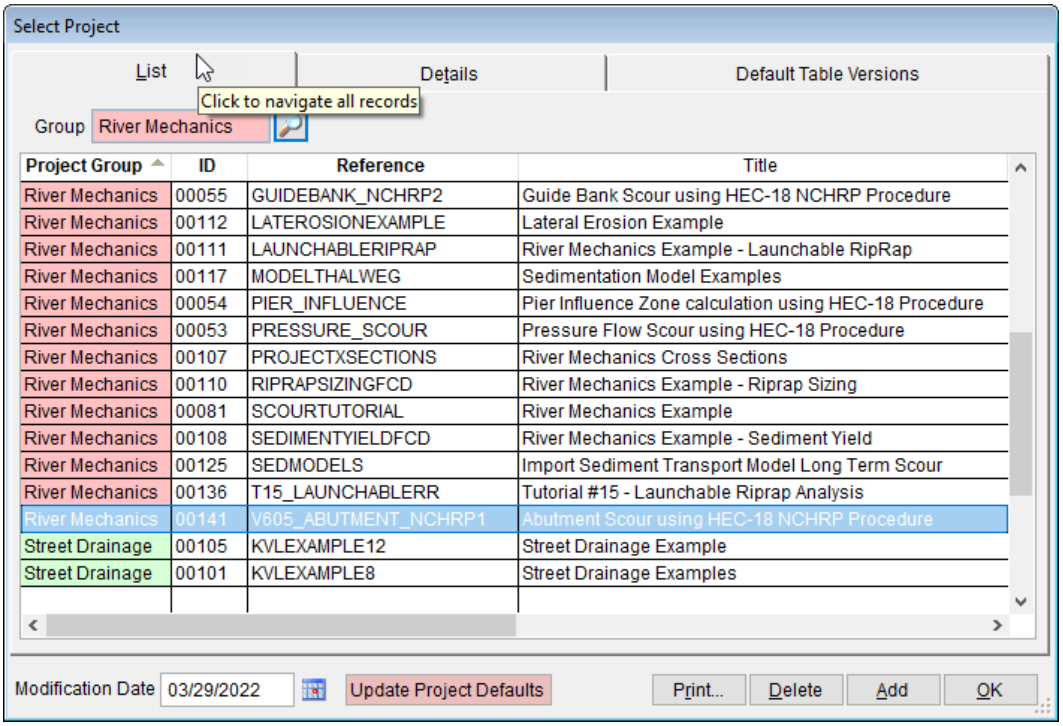
- Step 1: Establish a New River Mechanics Project and Defaults Set-up
- Step 2: Set up Abutment Scour Basic Data
- Step 3: Calculate Abutment Scour – Grain Size Equation
- Step 4: Calculate Abutment Scour – Shear Stress Equation
- Step 5: Report and Document the results

3.1 Step 1 - Establish a New Project and Defaults Set-up

(a) Start **DDMSW**. Click the ***OK*** button to accept the software disclaimer as shown below.



After **DDMSW** is launched, the **SELECT PROJECT** form is automatically opened as shown in the following figure.



(b) Click the ***Add*** button on the **SELECT PROJECT** form to start a new project. Alternatively, one can add/create a new project by executing ***File ➔ New Project ➔ Add***.

(c) Select the ***River Mechanics*** checkbox, then click the ***OK*** button to close the **NEW PROJECT OPTIONS** dialog box.

(d) On the **SELECT PROJECT** form, enter "V605*_ABUTMENT_NCHRP2*" into the ***Reference*** textbox. This is the name of the new project. Users can choose any name to be entered into the ***Reference*** textbox as long as it does not exist already in the current **DDMSW** project database.

(e) Type into the ***Title*** textbox a brief descriptive title for this project. *(Optional) (e.g., 'Abutment Scour using HEC-18 NCHRP Procedure')*

(f) Type into the ***Location*** textbox the location of this project. *(Optional) (e.g., 'Maricopa County, Arizona').*

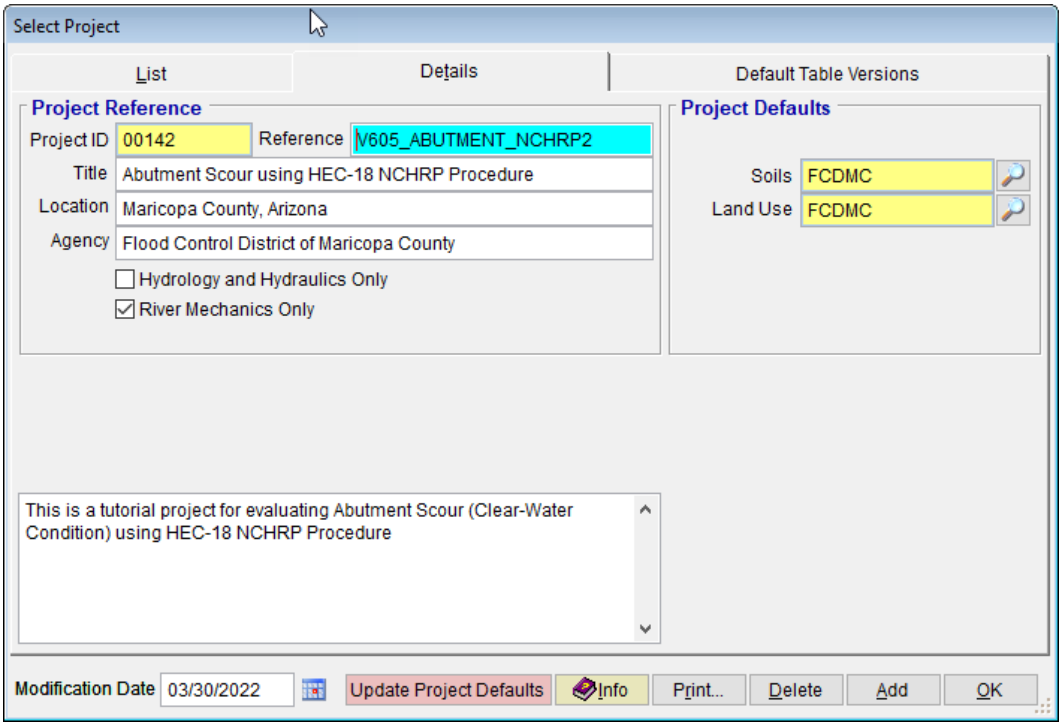
(g) Type into the ***Agency*** textbox the agency or company name**.** *(Optional) (e.g., 'Flood Control District of Maricopa County')*

(h) Check ***River Mechanics Only*** checkbox for this project.

(i) Type a detailed description of this project into the comment area under the ***Project Reference*** frame**.** *(Optional) (e.g., 'This is a tutorial project for evaluating Abutment Scour (Clear-Water Condition) using HEC-18 NCHRP Procedure')*

(j) Set the ***Modification Date*** using today's date by clicking on the Calendar icon.

(k) Click the ***Save*** button to save the entered data. The figure provided below shows what the form should look like.

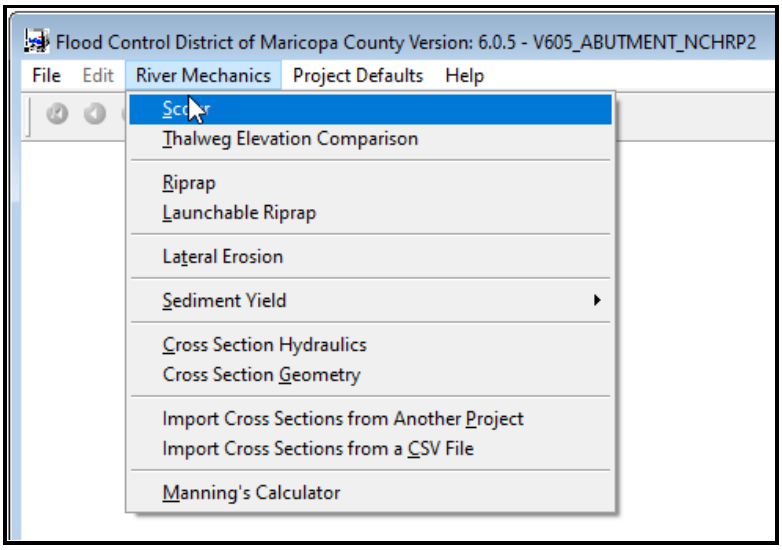


(l) Click the ***OK*** button to exit / close the **SELECT PROJECT** form.

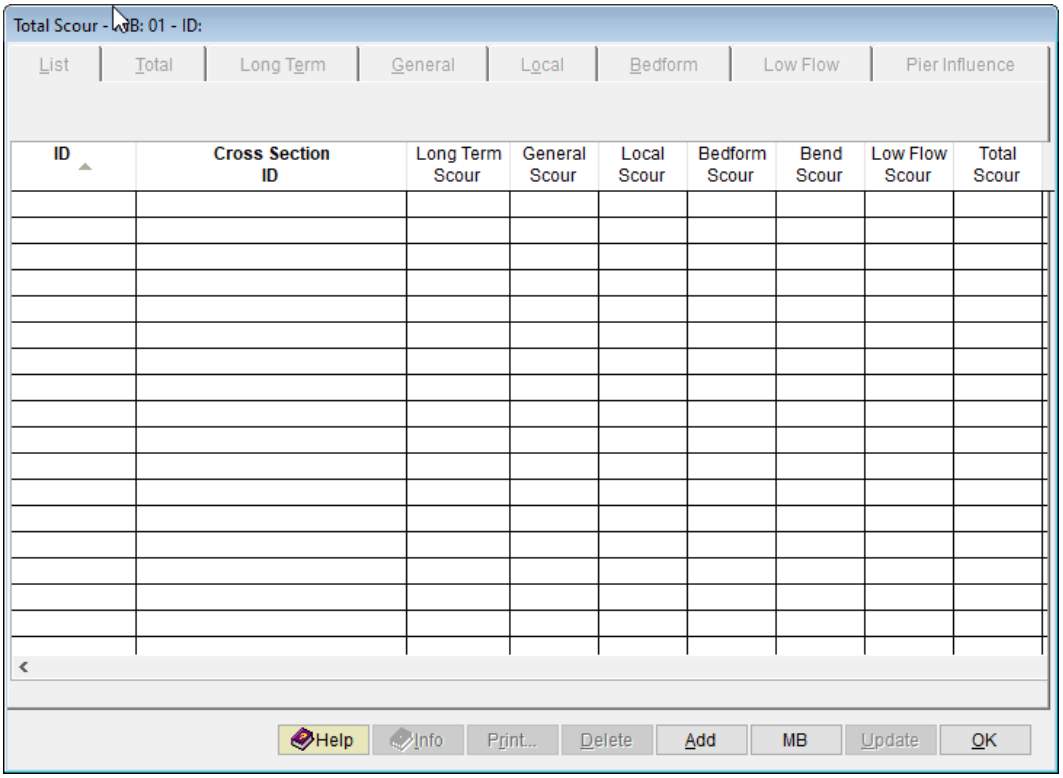
Note: The ***Project ID*** *"00142"* in the above figure is the unique database record identifier for the project, which is automatically generated by the program when a new project is created. Each time a new project is created, a ***Project ID*** is assigned by the program. The ***Project ID*** assigned to your project will not necessary be the same as the ***Project ID*** shown in the above figure.

3.2 Step 2 - Set up Abutment Scour Basic Data

(a) From the menu bar of the main application window, click ***River Mechanics*** ➔ ***Scour***, to open the **TOTAL SCOUR** form.



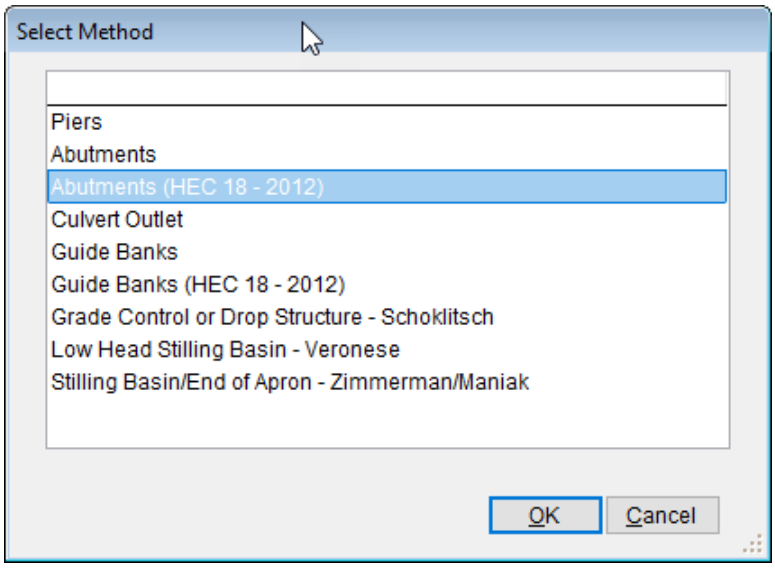
(b) On the **TOTAL SCOUR** form, click the ***Add*** button to activate the necessary data entry fields for the new project.



(c) Enter "*ABUTNO2*" into the ***ID*** textbox (this ***ID*** identifies that it is for Abutment No.2).

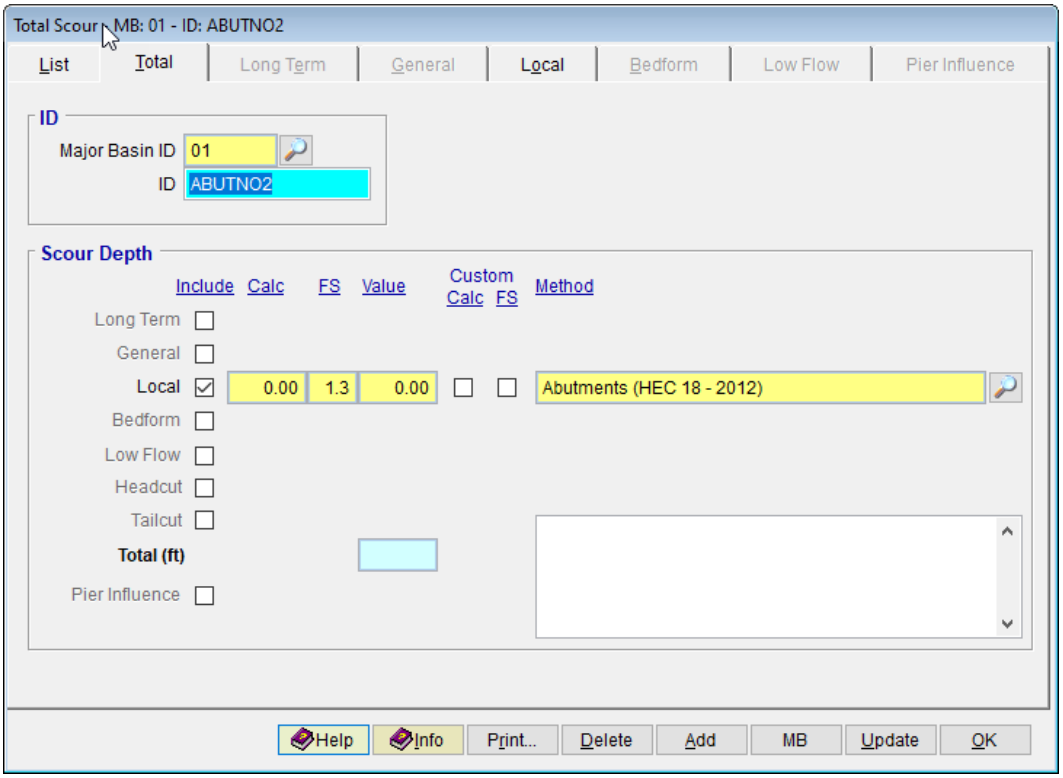
(d) Check the ***Local*** checkbox.

(e) Click the browse button under the ***Method*** column across the ***Local*** checkbox to open the local scour method select menu.



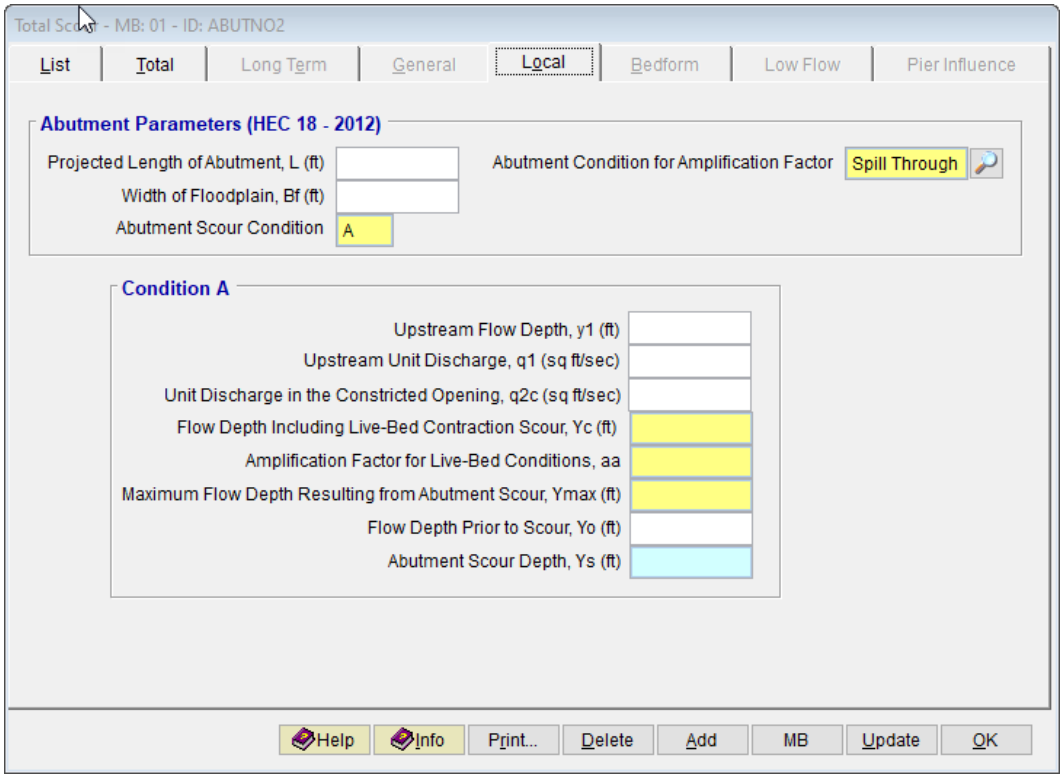
(f) Select the '*Abutments (HEC 18 – 2012)*' from the **SELECT METHOD** dialog box, then click ***OK*** to close.

(g) Back to the **TOTAL SCOUR – MB: 01 – ID: ABUTNO2** form, click the ***Save*** button to save the entered data.



3.3 Step 3 - Calculate the Abutment Scour – Grain Size Equation

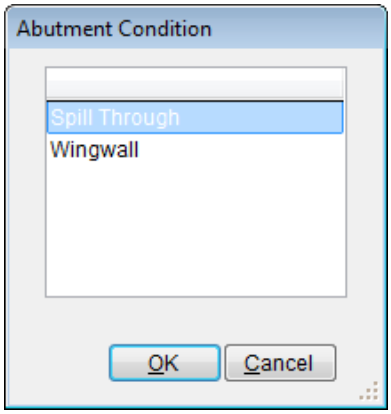
(a) Click the ***Local*** tab to open the form for entering relevant data for evaluating Abutment Scour depth.



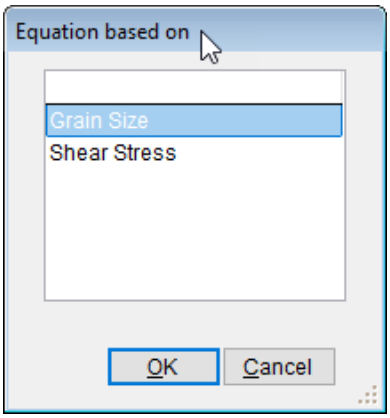
(b) Enter *"65"* into the ***Projected Length of Embankment, L (ft)*** textbox.

(c) Enter *"100"* into the **Width of Floodplain, B_f (ft)** textbox.

(d) Click the browse button beside the ***Abutment Condition for Amplification Factor*** textbox to select the Abutment type. Choose *"Spill Through"* and click ***OK*** to exit the **ABUTMENT CONDITION** dialog box.



(e) Click the browse button on the right side of the ***Select Equation Based On*** textbox to select which equation to use between *"Grain Size"* or *"Shear Stress"*. Choose *"Grain Size"*, then click ***OK*** to exit the **EQUATION BASED ON** dialog box.



(f) Back on the ***Local*** tab form, click the ***Save*** button to save the entered data.

(g) Enter "*5.7*" into the ***Upstream Unit Discharge, q_f (sq ft/sec)*** textbox.

(h) Enter "*10.1*" into the ***Unit Discharge in the Constricted Opening, q_{2f} (sq ft/sec)*** textbox.

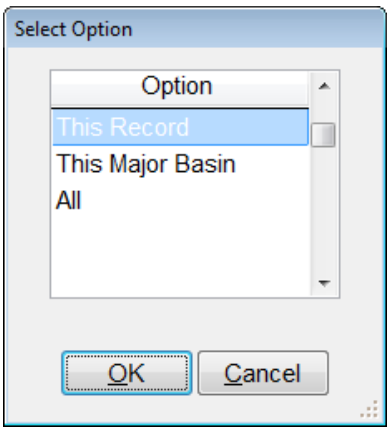
(i) Enter "*0.0010*" into the ***Particle Size with 50 Percent Finer, D_{50} (ft)*** textbox.

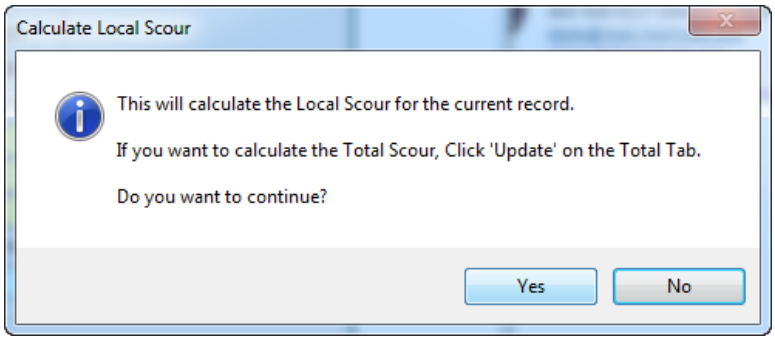
(j) Enter "3.5" into the ***Flow Depth Prior to Scour, Y_o (ft)*** textbox.

(k) Click the ***Save*** button to save the entered data.

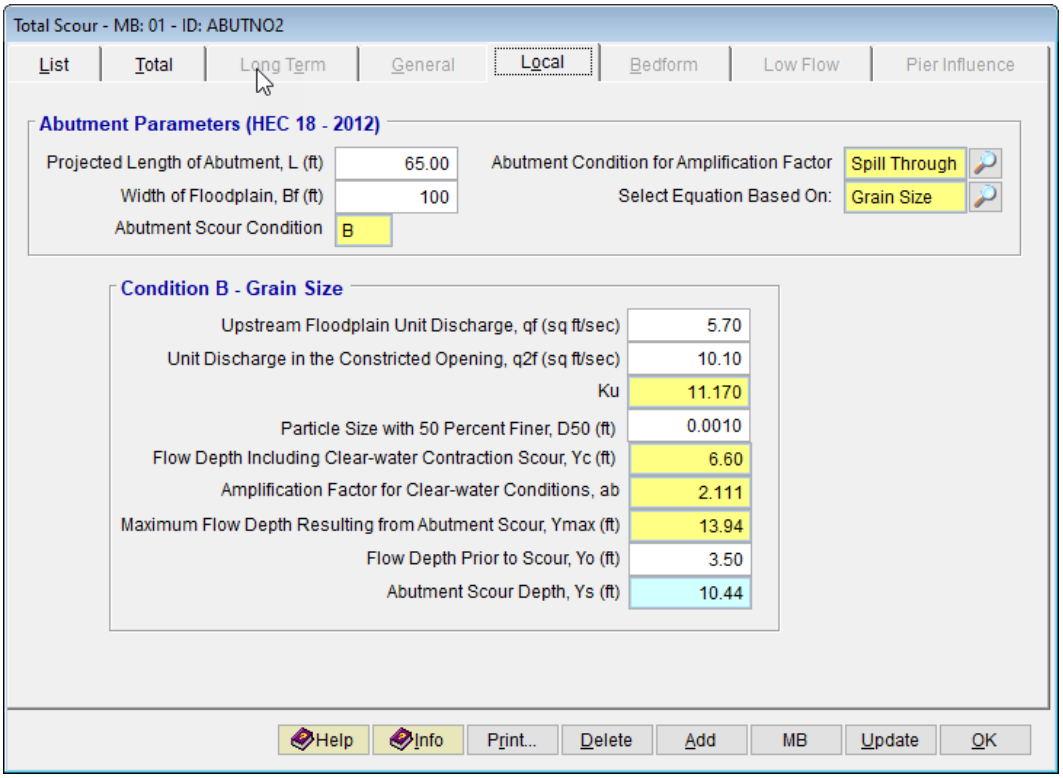
(l) Click the **Update** button to update the analysis.

(m) Select "*This Record*" from the **SELECTION OPTION** dialog box, then click ***Yes*** to continue.





After the update, the form should now look like the figure provided below.

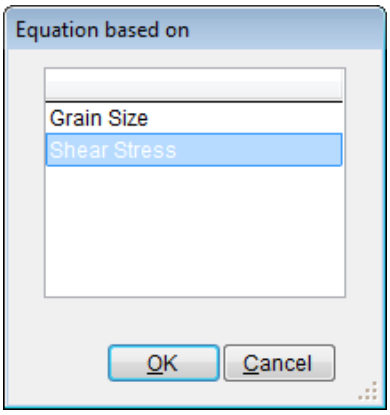


3.4 Step 4 - Calculate the Abutment Scour – Shear Stress Equation

An alternative option to evaluate the Abutment Scour is to use equations for the *"Shear Stress"* option.

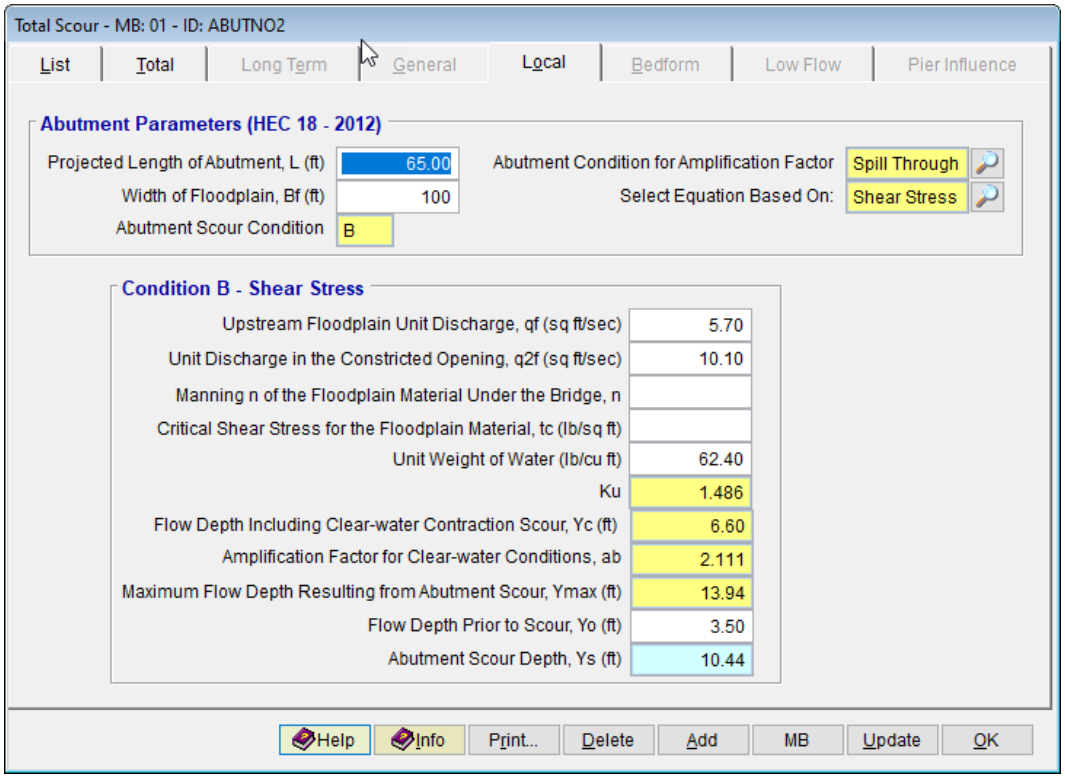
(a) On the same ***Local*** tab form, keep the same data that were employed for the *'Grain Size'* option.

(b) Click the browse button beside the ***Select Equation Based On*** textbox and select *"Shear Stress"*. Click ***OK*** to exit the **EQUATION BASED ON** dialog box.



(c) Click the ***Save*** button to accept the changes made on the data.

Note that the selection of *"Shear Stress"* for the ***Abutment Scour Condition B analysis*** has transformed the ***Local*** tab form as shown. Now the form has added three more input data fields. They are ***Manning's n of the Floodplain Material Under the Bridge***, ***Critical Shear Stress for the Floodplain Material, t_c (lb/sq ft)***, and ***Unit Weight of Water (lb/cu ft).***

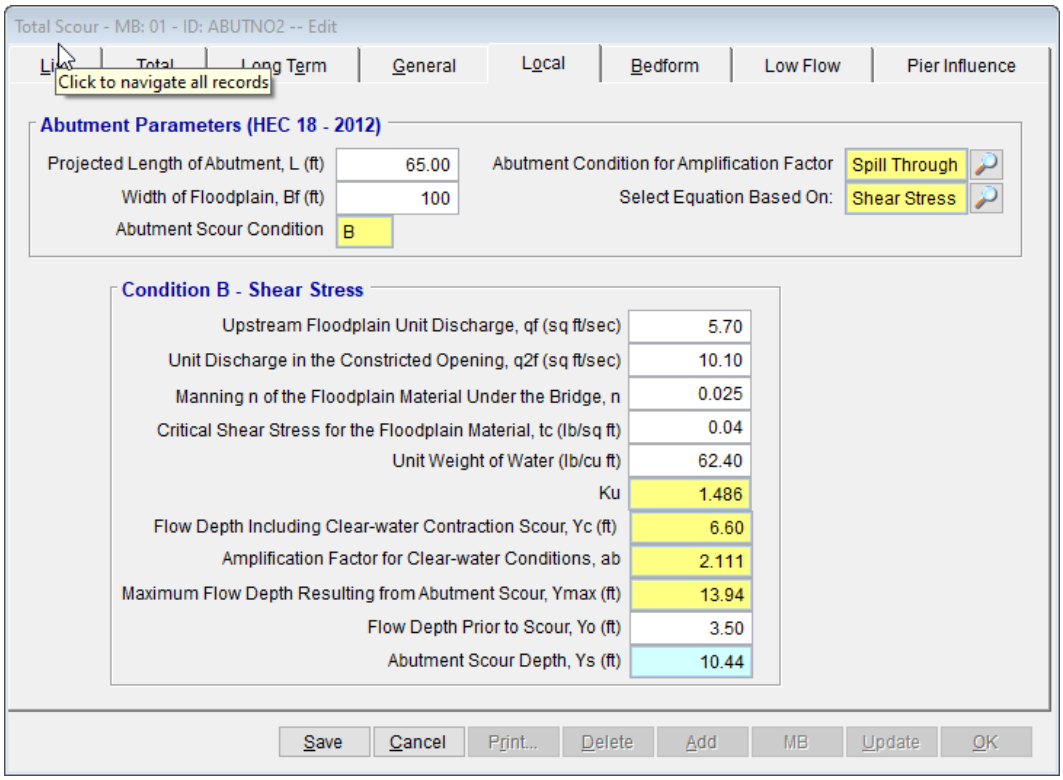


(d) Enter *"0.025"* into the ***Manning n of the Floodplain Material Under the Bridge, n*** textbox.

(e) Enter *"0.04"* into the ***Critical Shear Stress for the Floodplain Material, t_c (lb/sq ft)*** textbox.

(f) Enter *"62.4"* into the ***Unit Weight of Water (lb/cu ft)*** textbox.

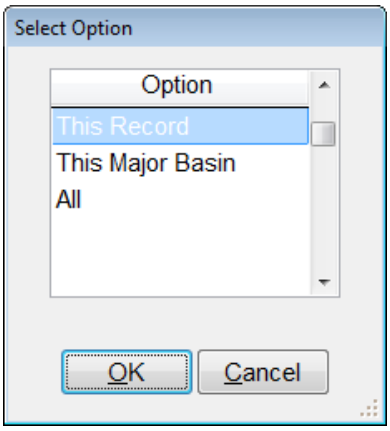
Keep the other input data to be the same as were used in the *"Grain Size"* option. The completed form should now look as the screenshot provided below:

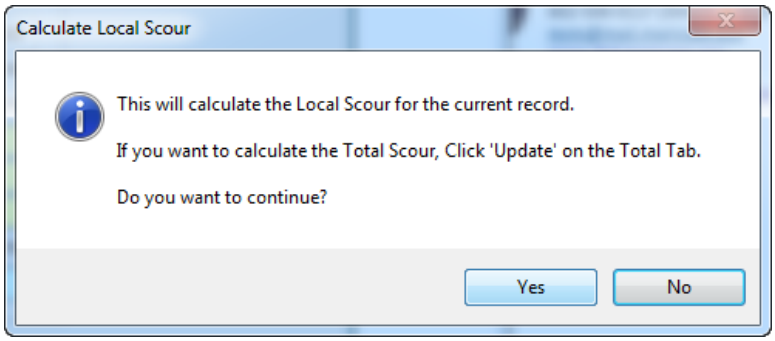


(g) Click the ***Save*** button to accept all the changes made on the form.

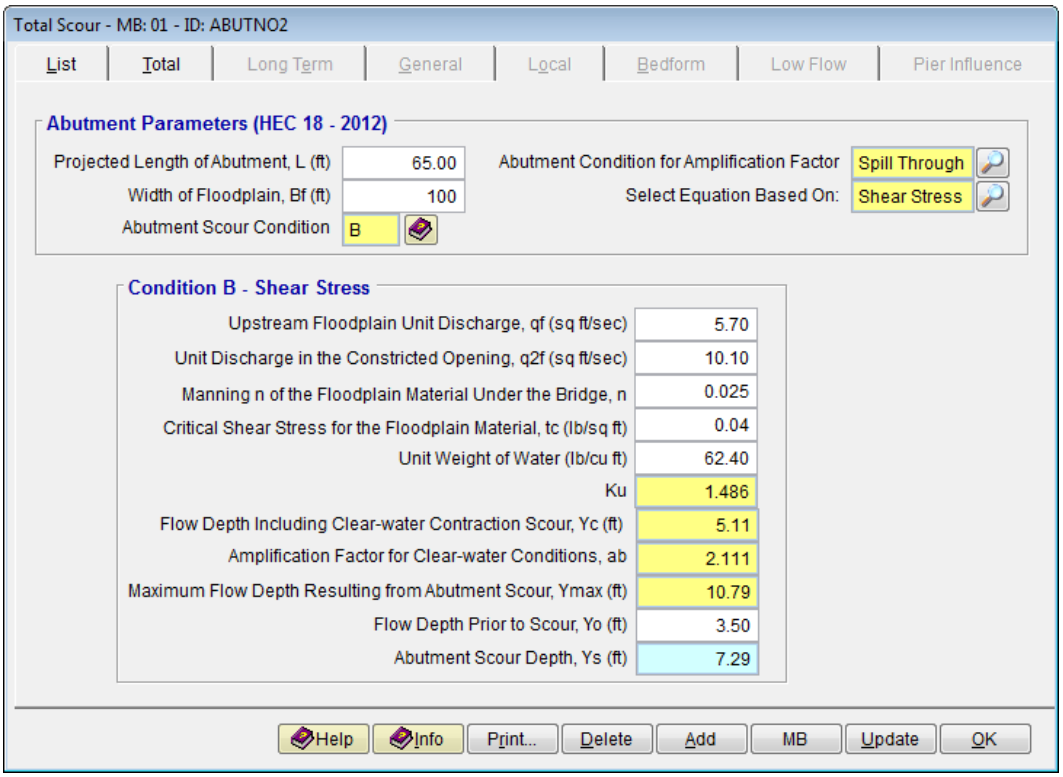
(h) Click the ***Update*** button to update the Abutment scour analysis results.

(i) Select "*This Record*" from the **SELECTION OPTION** dialog box, then click ***Yes*** to continue.





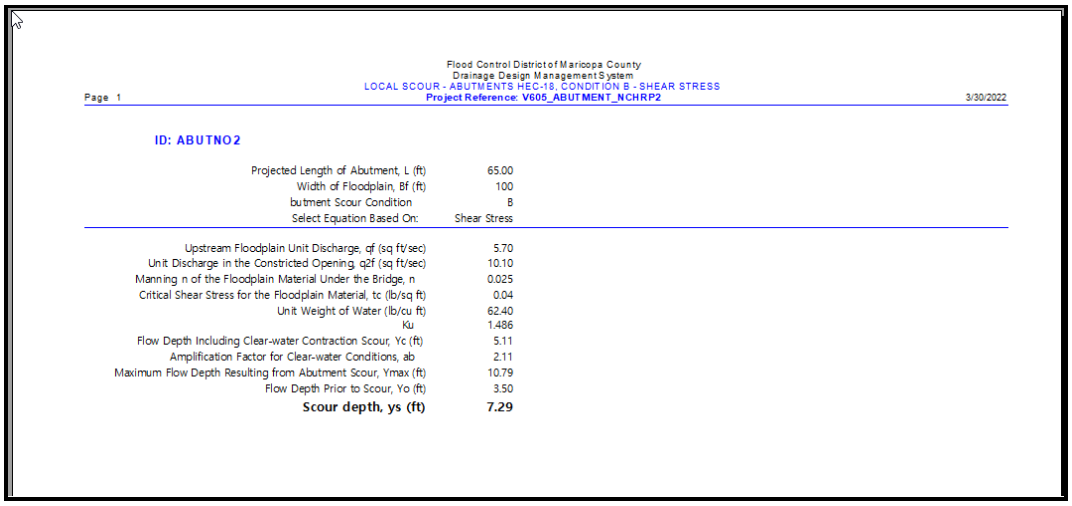
After the update, the evaluated Abutment Scour depth for the "Shear Stress" option (*i.e., 7.29*) appears to be less than the one evaluated for the "Grain Size" option (*i.e., 10.44*).



3.5 Step 5 - Report and Document the Results

This section includes procedures how to view, print, and export results from performing Abutment Scour analysis.

(a) To view the analysis results on the screen, click the ***Print …*** button on the ***Local*** Tab of the **TOTAL SCOUR – MB: 01 – ID: ABUTNO2** form. As a result, a report is generated as shown below:



Flood Control District of Maricopa County
Drainage Design Management System
LOCAL SCOUR - ABUTMENTS HEC-18, CONDITION B - SHEAR STRESS

Page 1 — Project Reference: V605_ABUTMENT_NCHRP2 — 3/30/2022

ID: ABUTNO2

Projected Length of Abutment, L (ft)	65.00
Width of Floodplain, Bf (ft)	100
butment Scour Condition	B
Select Equation Based On:	Shear Stress
Upstream Floodplain Unit Discharge, qf (sq ft/sec)	5.70
Unit Discharge in the Constricted Opening, q2f (sq ft/sec)	10.10
Manning n of the Floodplain Material Under the Bridge, n	0.025
Critical Shear Stress for the Floodplain Material, tc (lb/sq ft)	0.04
Unit Weight of Water (lb/cu ft)	62.40
Ku	1.486
Flow Depth Including Clear-water Contraction Scour, Yc (ft)	5.11
Amplification Factor for Clear-water Conditions, ab	2.11
Maximum Flow Depth Resulting from Abutment Scour, Ymax (ft)	10.79
Flow Depth Prior to Scour, Yo (ft)	3.50
Scour depth, ys (ft)	**7.29**

(b) To print the results, click the printer symbol ( ).

(c) To export the results to PDF format or to other formats, click the export symbol ( )

This concludes this second tutorial for **Abutment Scour under Clear-Water Condition** (**Condition B**).