DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS

VERSION 5.6.0

Tutorial # 19
Abutment Scour Analysis
HEC-18 (NCHRP) Procedure

KVL Consultants, Inc.

ABUTMENT SCOUR ANALYSIS (HEC-18 PROCEDURE)

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1.0 PROBLEM STATEMENT

Based on the ratio between the embankment projected length (L) and 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. 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 and the abutment scour is considered as a local scour component as part of the total scour depth. No additional contraction scour should be added to the total scour depth.

2.0 ABUTMENT SCOUR FOR LIVE-BED CONDITION (WINGWALL)

If the ratio (L/B_f) is greater than or equal 0.75, the live-bed abutment scour equations should be used to compute the local scour component due to abutment. The live-bed condition is also referred as Condition (a) in HEC-18 manual (Federal Highway Administration, 2012). The abutment scour can be computed for either wingwall abutment or spillthrough abutment.

The following parameters considers wingwall abutment with live-bed condition. To estimate the abutment scour using HEC-18 (NCHRP) procedure use the following given conditions:

❖   Parameters for abutment scour conditions:

- **Projected length of embankment (ft):**   *85.00*

- **Width of floodplain (ft):**   *100.00*

❖   Parameters for ***live-bed condition with wingwall abutment***:

- **Upstream flow depth (ft)**:   *10.00*

- **Unit discharge at upstream floodplain (ft^2/s)**:   *57.00*

- **Unit discharge at constricted opening (ft^2/s)**:   *78.60*

- **Flow depth prior to scour (ft)**:   *9.50*

2.1   Step-by-Step Procedures

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

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

(a)   Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW.** Click the **OK** button to accept the software disclaimer as shown in the following figure.
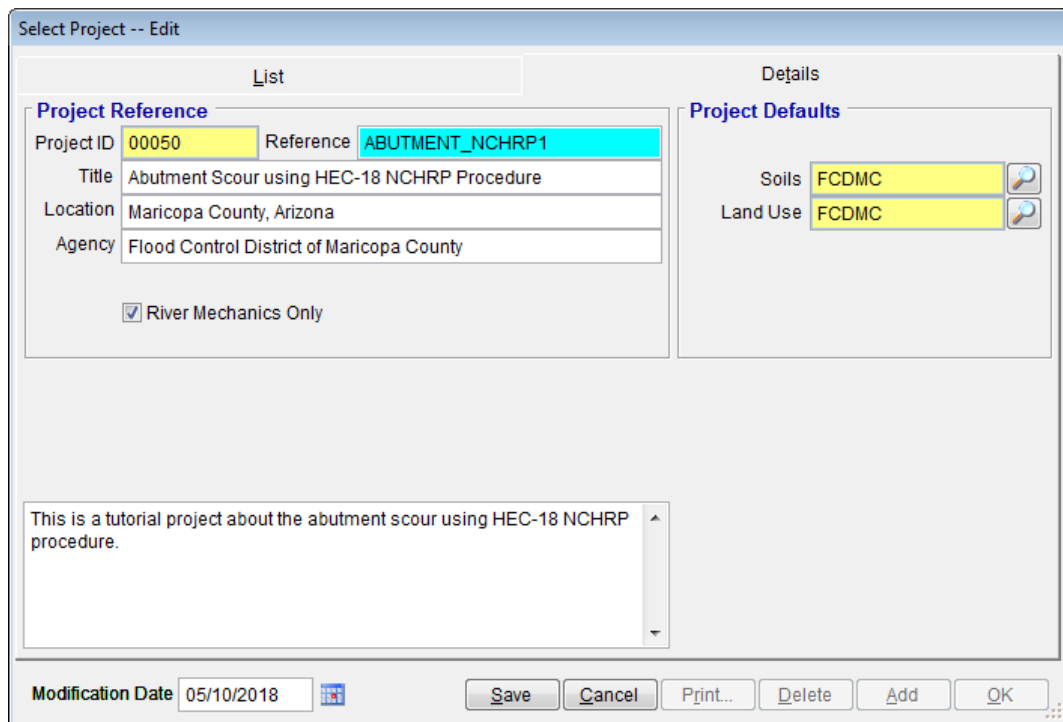

After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened as shown in the following figure.
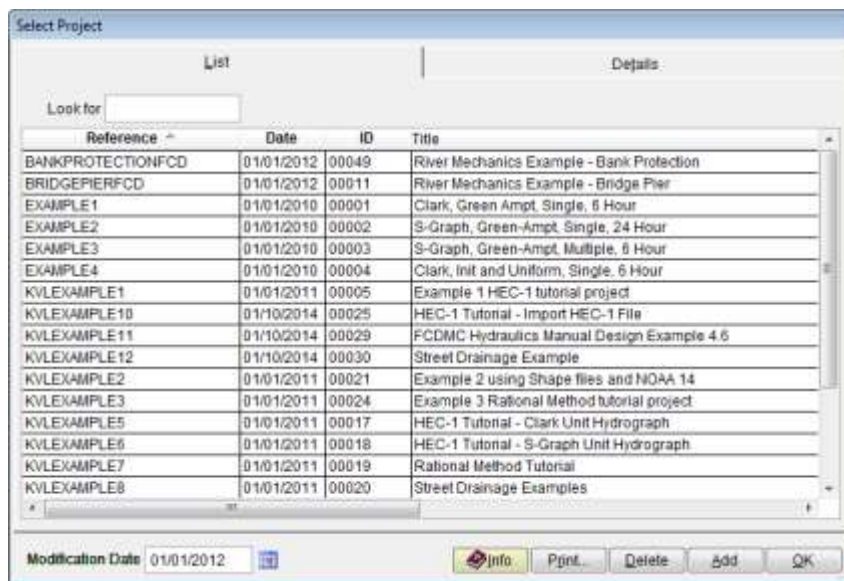
(b)   Click the **Add** button on the **SELECT PROJECT** window to start a new project (Or **File** ➔ **New Project** ➔ **Add**).
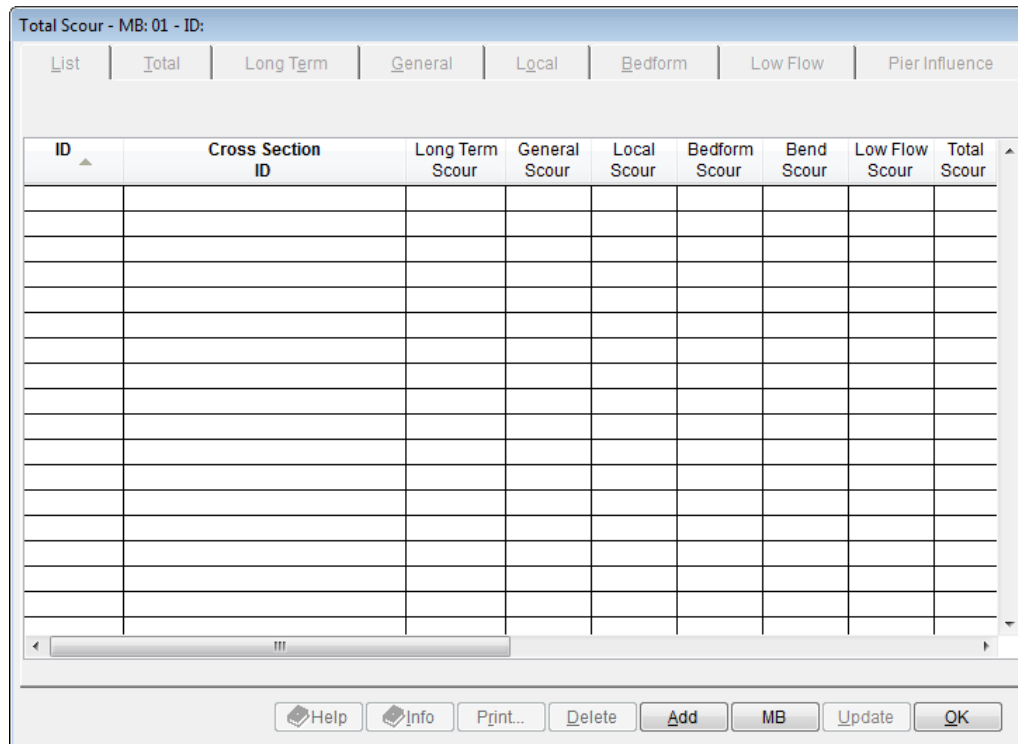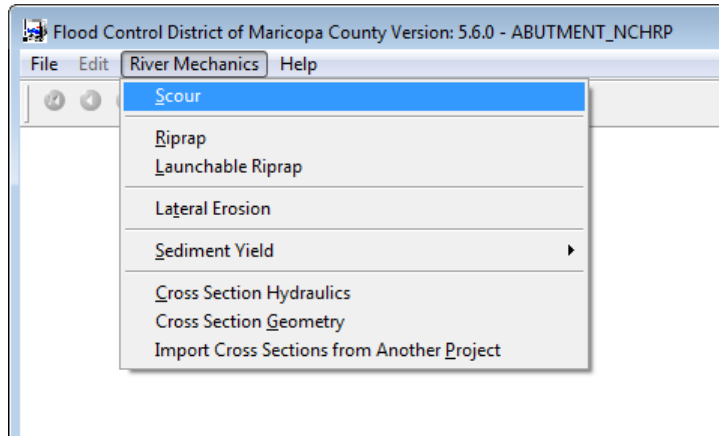
(c)   Select **River Mechanics** checkbox and click the **OK** button on the **NEW PROJECT OPTIONS** form.

(d)   Type "*ABUTMENT_NCHRP1*" into the **Reference** textbox. This is the name of this newly created project. Users can choose any name for the Reference textbox as long as it does not exist in the current **DDMSW** project database.

(e)   Type into the **Title** textbox a brief descriptive title for this project. *(Optional)*

(f)   Type into the **Location** textbox the location of this project. *(Optional)*

(g)   Type into the **Agency** textbox the agency or company name**.** *(Optional)*

(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)*

(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.

(l)   Click the **OK** button on the **SELECT PROJECT** window, and click the **OK** button on the pop-up message box. The following figure shows what the window looks like.


Note: the **Project ID** "*00050*" 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. When users create a new project, the **Project ID** of the new project will not be the same as the **Project ID** shown in the above figure.

2.1.2 Step 2 - Set up Abutment Scour Basic Data

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

(b) Click the **Add** button to activate the necessary data entry fields.

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

(d) Check the checkboxes **Local** only.

(e) Click the browse button in the **Method** column across **Local** check box to launch local scour method select menu.
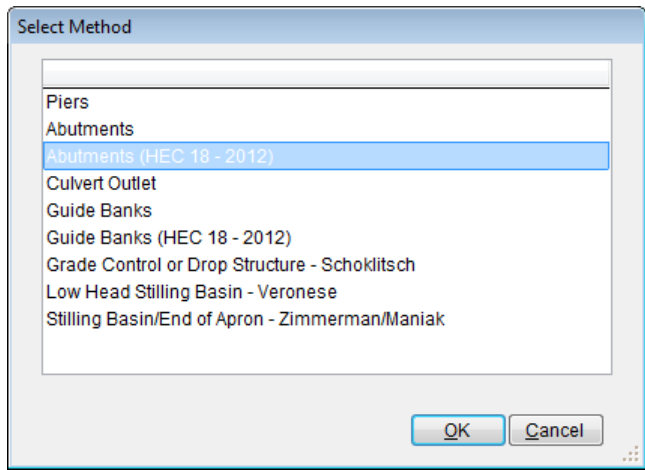
Select the "*Abutments (HEC 18 – 2012)*" from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window

(f)   Click the **Save** button to save the entered data. The **TOTAL SCOUR – MB: 01 – ID: ABUTNO1** window shows up like following figure.
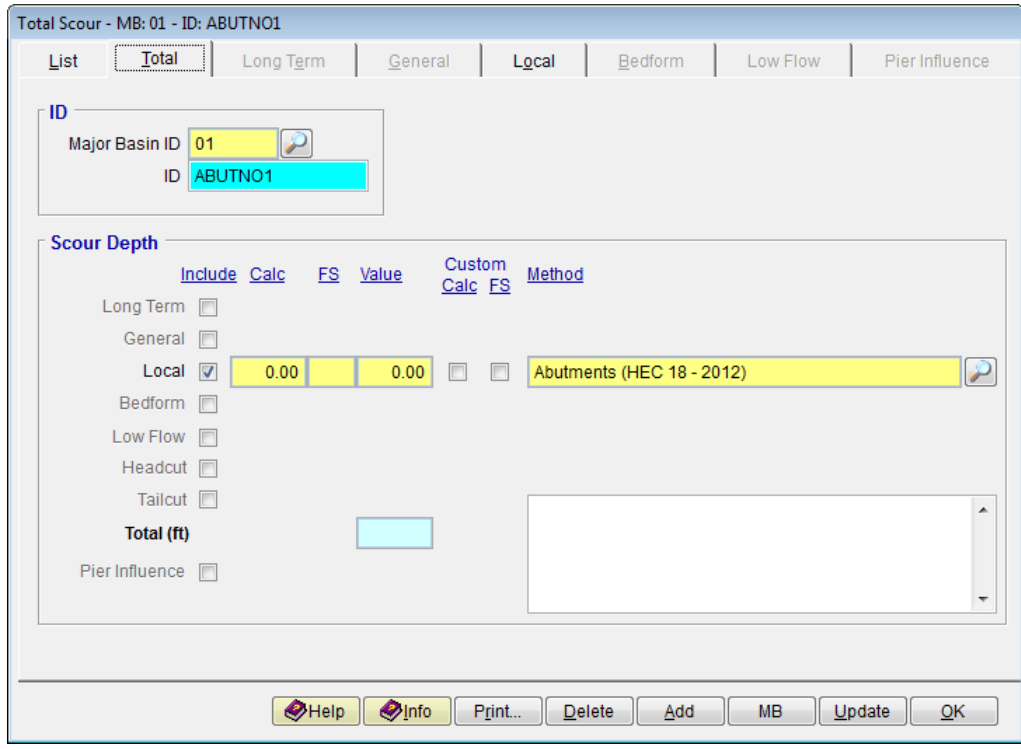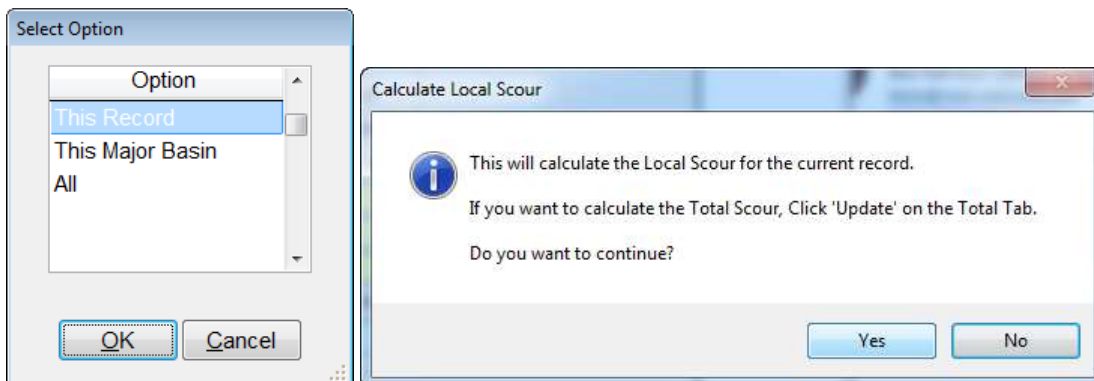
2.1.3 Step 3 - Calculate the Abutment Scour
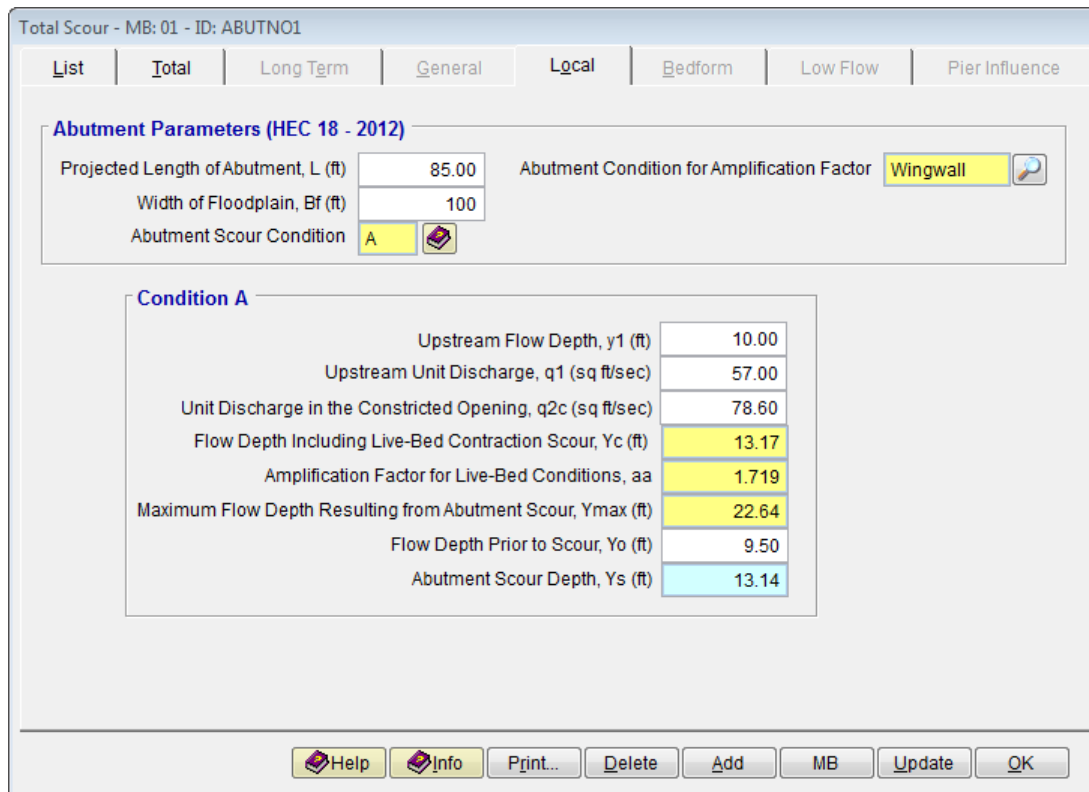
(a)   Click the **Local** tab

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

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

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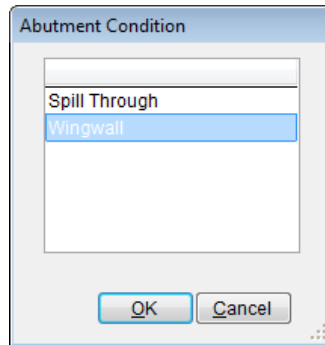
(e)   Click the **Save** button to save the entered data.

(f)   Enter "10" into the **Upstream Flow Depth, y1 (ft)** textbox.

(g)   Enter "57" into the **Upstream Unit Discharge, q1 (sq ft/sec)** textbox.

(h)   Enter "78.6" into the **Unit Discharge in the Constricted Opening, q2c (sq ft/sec)** textbox.

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

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

(k)   Click the **Update** button to update the data.

(l)   Select "This Record" from the **SELECTION OPTION** window, and click **Yes** from the confirmation message to proceed.

After the update the window looks like what is shown in the following figure

2.1.4 Step 4 - Report and Document the Results

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

(a)   To view the results on the screen, click the **Print …** button on the Local Tab of **TOTAL SCOUR – MB: 01 – ID: ABUTNO1** window, a report will be generated as is shown in the following figure.
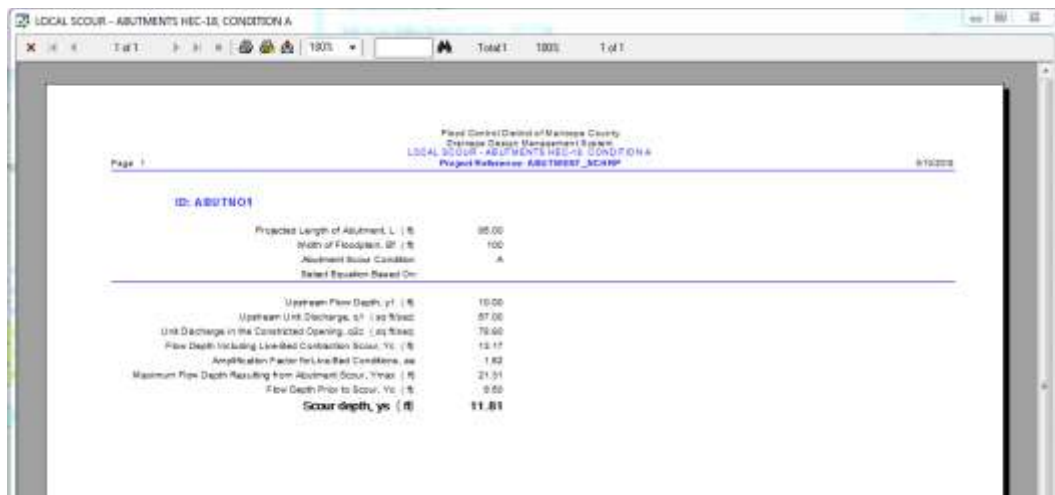
(b)   To print out the results on a printer, click the printer symbol (🖨).

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

This concludes tutorial for Abutment Scour Live-bed Condition evaluation.

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

If the ratio (L/B_f) is less than 0.75, the clear-water abutment scour equations should be used to compute the local scour component due to abutment. The clear-water condition is also referred as Condition (b) in HEC-18 manual (Federal Highway Administration, 2012). The abutment scour can be computed for either wingwall abutment or spillthrough abutment.

The following parameters considers spill through abutment with clear-water condition. To estimate the abutment scour using HEC-18 (NCHRP) procedure use the following given conditions:

❖   Parameters for abutment scour conditions:

- **Projected length of embankment (ft):**   *65.00*

- **Width of floodplain (ft):**   *100.00*

❖   Parameters for *clear-water condition with spill through abutment*:

- **Unit discharge at upstream floodplain (ft²/s):**   *5.70*

- **Unit discharge at constricted opening (ft²/s):**   *10.10*

- **Particle size with 50 percent finer (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 (ft)**:   *3.50*

3.1   Step-by-Step Procedures

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

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

(a)   Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW.**
Click the **OK** button to accept the software disclaimer as shown in the following
figure.

After the **DDMSW** is launched, the **SELECT PROJECT** window is automatically opened
as shown in the following figure.
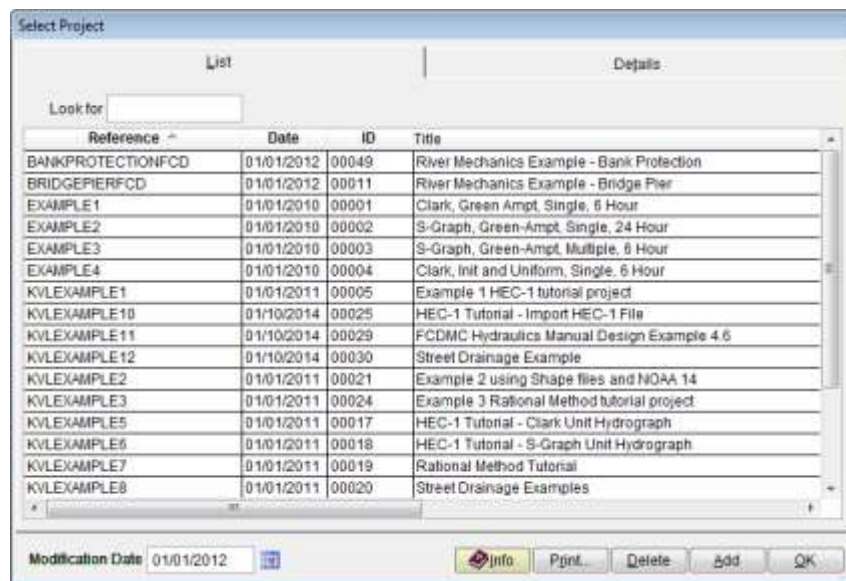
(b)   Click the **Add** button on the **SELECT PROJECT** window to start a new project (Or **File
➔ New Project ➔ Add**).

(c)   Select **River Mechanics** checkbox and click the **OK** button on the **NEW PROJECT OPTIONS** form.

(d)   Type "*ABUTMENT_NCHRP2*" into the **Reference** textbox. This is the name of this newly created project. Users can choose any name for the Reference textbox as long as it does not exist in the current **DDMSW** project database.

(e)   Type into the **Title** textbox a brief descriptive title for this project. *(Optional)*

(f)   Type into the **Location** textbox the location of this project. *(Optional)*

(g)   Type into the **Agency** textbox the agency or company name**.** *(Optional)*

(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)*

(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.

(l)   Click the **OK** button on the **SELECT PROJECT** window, and click the **OK** button on the pop-up message box. The following figure shows what the window looks like.

Note: the **Project ID** "*00050*" 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. When users create a new project, the **Project ID** of the new project will not be the same as the **Project ID** shown in the above figure.

3.1.2 Step 2 - Set up Abutment Scour Basic Data

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

(b)   Click the **Add** button to activate the necessary data entry fields.

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

(d)   Check the checkboxes **Local** only.

(e)   Click the browse button 🔍 in the **Method** column across **Local** check box to launch local scour method select menu.

Select the "*Abutments (HEC 18 – 2012)*" from the **Select Method** window, and click **OK** to close the **Select Method** window.

(f)   Click the **Save** button to save the entered data. The **Total Scour – MB: 01 – ID: ABUTNO1** window shows up like following figure.

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

(a)   Click the **Local** tab

(b)   Enter "6*5"* into the **Projected Length of Abutment, L (ft)** textbox.

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

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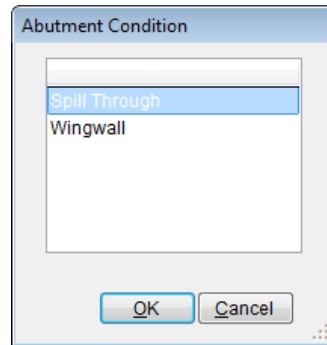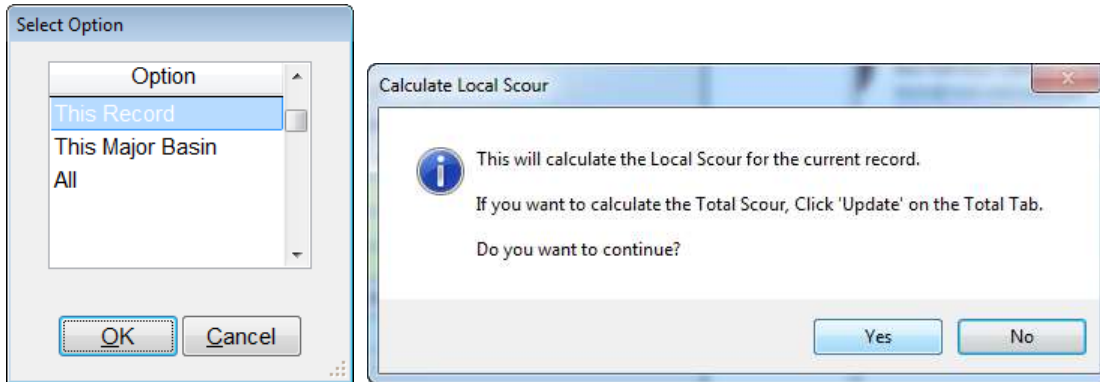

(e)   Click browse button beside the **Select Equation Based On** to select the basis for abutment equation. Choose *"Grain Size"* and click **OK** to exit the **Equation Based On** window.
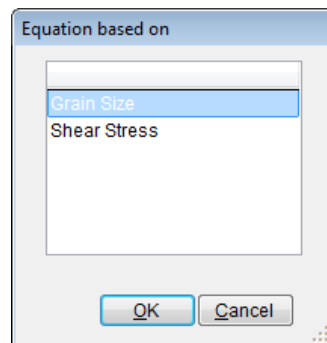

(f)   Click the **Save** button to save the entered data.

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

(h)   Enter "*10.1"* into the **Unit Discharge in the Constricted Opening, q2c (sq ft/sec)** textbox.

(i)   Enter "*0.0010"* into the **Particle Size with 50 Percent Finer, D50 (ft)** textbox.

(j)   Enter "3.*5"* into the **Flow Depth Prior to Scour, Yo (ft)** textbox.

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

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

(m)   Select "*This Record*" from the **SELECTION OPTION** window, and click **Yes** from the confirmation message to proceed.


After the update the window looks like what is shown in the following figure.
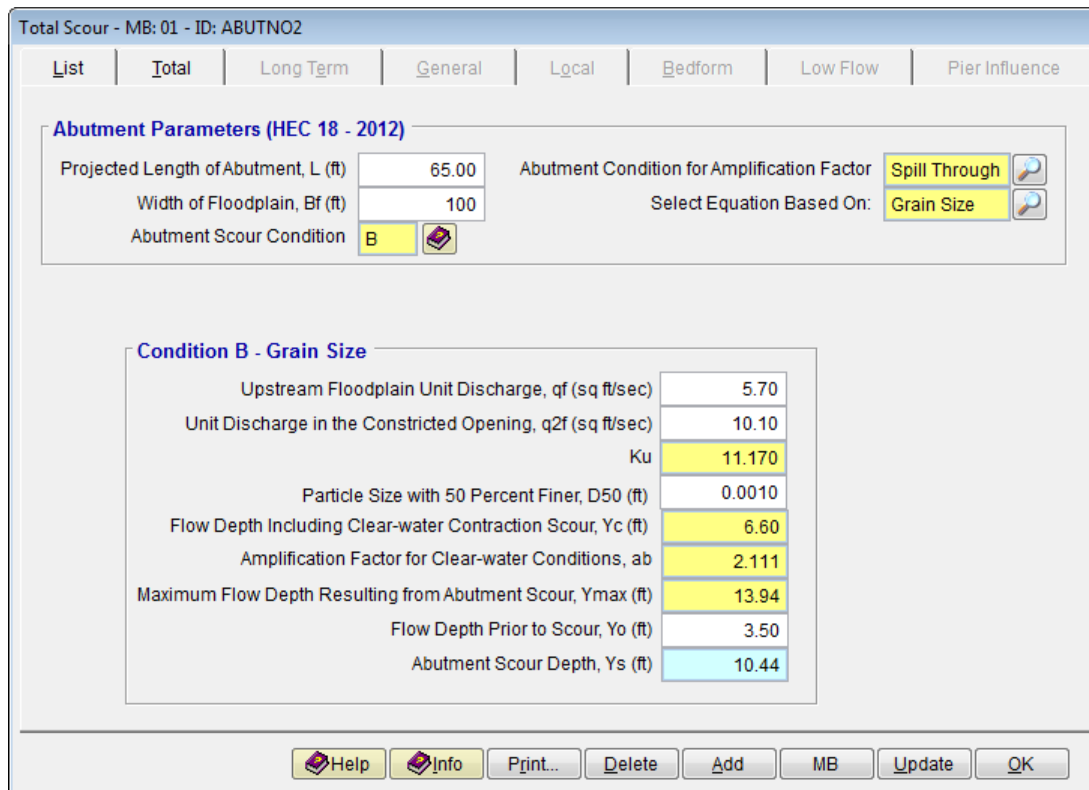
3.1.4 Step 4 - Calculate the Abutment Scour – Shear Stress Equation

(a)   Click the **Local** tab

(b)   Enter "6*5"* into the **Projected Length of Abutment, L (ft)** textbox.

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

(d) Click browse 🔍 button beside the **Abutment Condition for Amplification Factor** to select the abutment type data. Choose *"Spill Through"* and click **OK** to exit the **Abutment Condition** window.

Abutment Condition

Spill Through
Wingwall

OK   Cancel
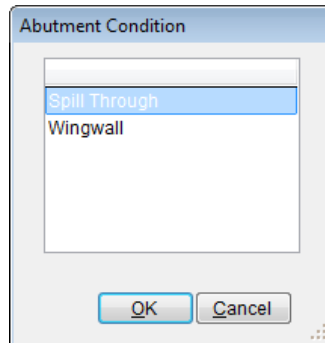
(e) Click browse 🔍 button beside the **Select Equation Based On** to select the basis for abutment equation. Choose *"Shear Stress"* and click **OK** to exit the **Equation Based On** window.
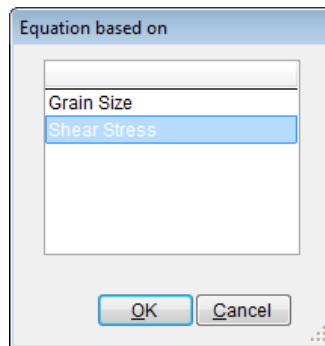
Equation based on

Grain Size
Shear Stress

OK   Cancel

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

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

(h) Enter *"10.1"* into the **Unit Discharge in the Constricted Opening, q2c (sq ft/sec)** textbox.

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

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

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

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

(m) Click the **Update** button to update the data.

(n) Select *"This Record"* from the **Selection Option** window, and click **Yes** from the confirmation message to proceed.

After the update the window looks like what is shown in the following figure.
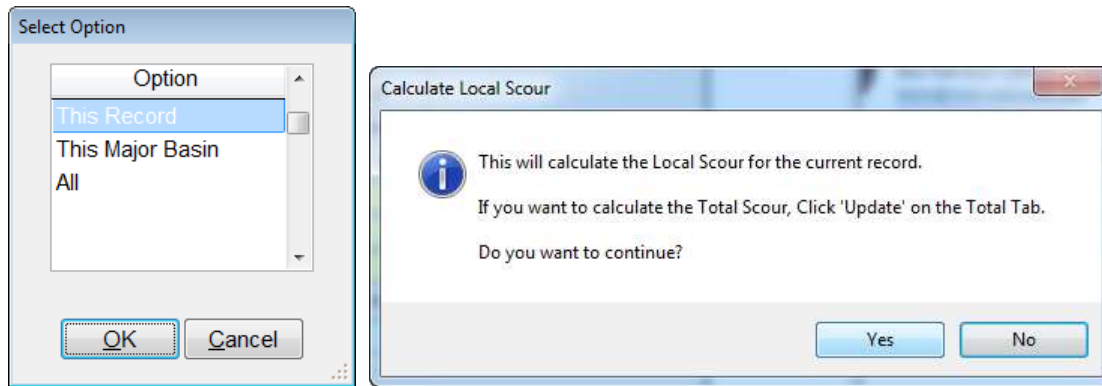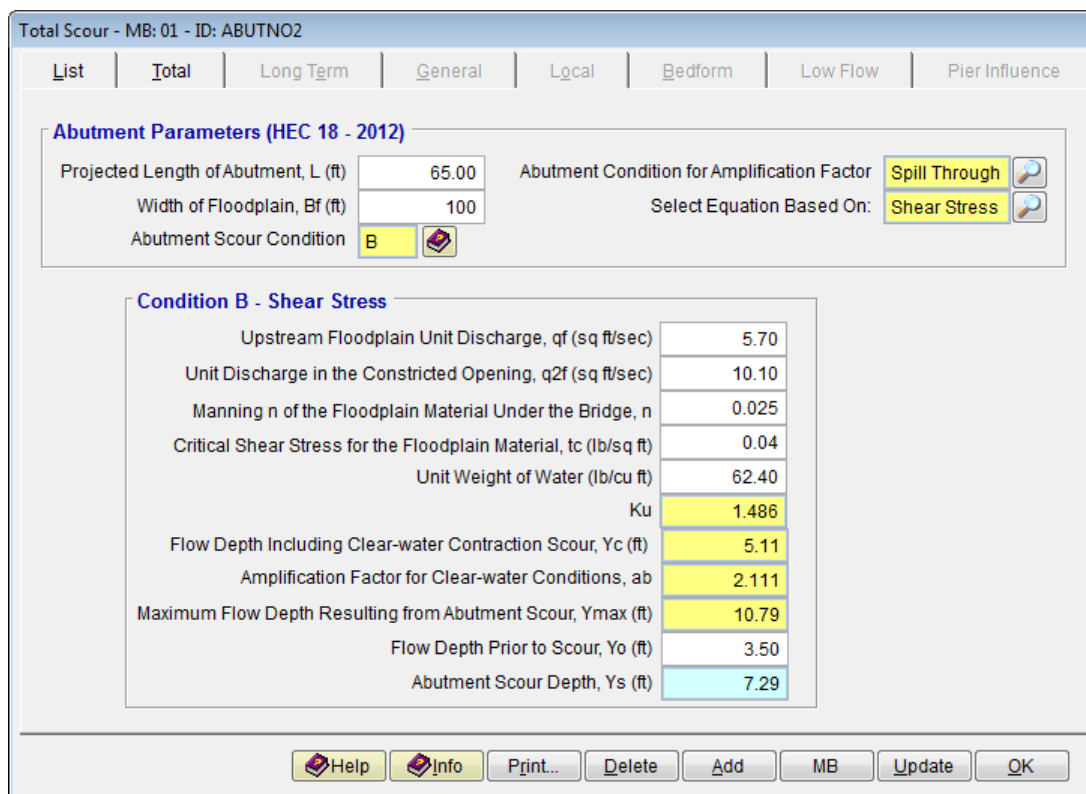

3.1.5 Step 5 - Report and Document the Results

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

(a)   To view the results on the screen, click the **Print …** button on the Local Tab of **TOTAL SCOUR – MB: 01 – ID: ABUTNO2** window, a report will be generated as is shown in the following figure.

Flood Control District of Maricopa County
Drainage Design Management System
LOCAL SCOUR - ABUTMENTS HEC-18, CONDITION B - SHEAR STRESS
Page 1   Project Reference: ABUT_2   5/14/2016

ID: ABUTN02

Projected Length of Abutment, L (ft)	85.00
Width of Floodplain, Bf (ft)	100
Abutment Scour Condition	B
Select Equation Based On:	Shear Stress

Upstream Floodplain Unit Discharge, qf (sq ft/sec)	6.70
Unit Discharge in the Constricted Opening, q2f (sq ft/sec)	10.10
Manning n of the Floodplain Material Under the Bridge, n	0.026
Critical Shear Stress for the Floodplain Material, tc (lb/sq ft)	0.04
nit 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 out the results on a printer, click the printer symbol (🖨).

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

This concludes this tutorial for Abutment Scour clear-water Condition evaluation.