



DRAINAGE DESIGN MANAGEMENT SYSTEM FOR WINDOWS VERSION 5.6.0

TUTORIAL # 10 TOTAL SCOUR ANALYSIS FOR BANK PROTECTION



KVL Consultants, Inc.

TOTAL SCOUR ANALYSIS FOR BANK PROTECTION

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TOTAL SCOUR ANALYSIS FOR BANK PROTECTION

DATE UPDATED: APRIL 27, 2018

1.0 PROBLEM STATEMENT

To estimate the total scour depth for a channel bank protection at a mild or moderate bend (use “*Equilibrium Slope for Sediment-Laden Flow*” method for long-term scour, use “*Lacey*” method for general scour including bend) with the following given conditions:

❖ The Cross Section “*STUDYREACHCROSSSECTION*”

➤ Parameters for the Hydraulics and Geometry:

- **Design Flow Rate (cfs):** 3200
- **Dominant Flow Rate (cfs) :** 800
- **Channel Slope for Design flow (ft/ft):** 0.015
- **Channel Slope for Dominant Flow (ft/ft):** 0.015
- **Channel Manning’s n for Design Flow:** 0.035
- **LOB Manning’s n for Design Flow:** 0.035
- **ROB Manning’s n for Design Flow:** 0.035
- **Channel Manning’s n for Dominant Flow:** 0.030
- **LOB Manning’s n for Dominant Flow:** 0.030
- **ROB Manning’s n for Dominant Flow:** 0.030
- **The geometry (station and elevation) of this cross section:**

Station (X)	Elevation (Y)	Notes
100	100	
106	98	
156	98	<i>Left Bank Station</i>
166	95	
191	95	
201	98	<i>Right Bank Station</i>
251	98	
257	100	

- **D50 (mm) for Study Reach:** 1.50
- **D84 (mm) for Study Reach:** 10.00
- **D16 (mm) for Study Reach:** 0.50

- There is a grade control structure located at 800 feet downstream of the channel location for bank protection (cross section “*STUDYREACHCROSSSECTION*”)
- **Distance to Pivot Point (ft):** 800

❖ The Cross Section “*SUPPLYREACHCROSSSECTION*”

➤ Parameters for the Hydraulics and Geometry:

- **Design Flow Rate (cfs):** 3200
- **Dominant Flow Rate (cfs):** 800
- **Channel Slope for Design Flow (ft/ft):** 0.01
- **Channel Slope for Dominant Flow (ft/ft):** 0.01
- **Channel Manning’s n for Design Flow:** 0.035
- **LOB Manning’s n for Design Flow:** 0.035
- **ROB Manning’s n for Design Flow:** 0.035
- **Channel Manning’s n for Dominant Flow:** 0.030
- **LOB Manning’s n for Dominant Flow:** 0.030
- **ROB Manning’s n for Dominant Flow:** 0.030
- **The geometry (station and elevation) of this cross section:**

Station (X)	Elevation (Y)	Notes
100	100	
106	98	
181	98	<i>Left Bank Station</i>
191	95	
216	95	
226	98	<i>Right Bank Station</i>
301	98	
307	100	

- **D50 (mm) for Supply Reach:** 2.00
- **D84 (mm) for Supply Reach:** 12.00
- **D16 (mm) for Supply Reach:** 1.00

2.0 STEP-BY-STEP PROCEDURES

Step 1: Establish a New Project and Default Set-up

Step 2: Prepare the Cross Section Hydraulics

Step 3: Compute Total Scour

Step 3.1: Set up Total Scour Basic Data

Step 3.2: Calculate the Long Term Scour

Step 3.3: Calculate the General Scour

Step 3.4: Calculate the Bedform Scour

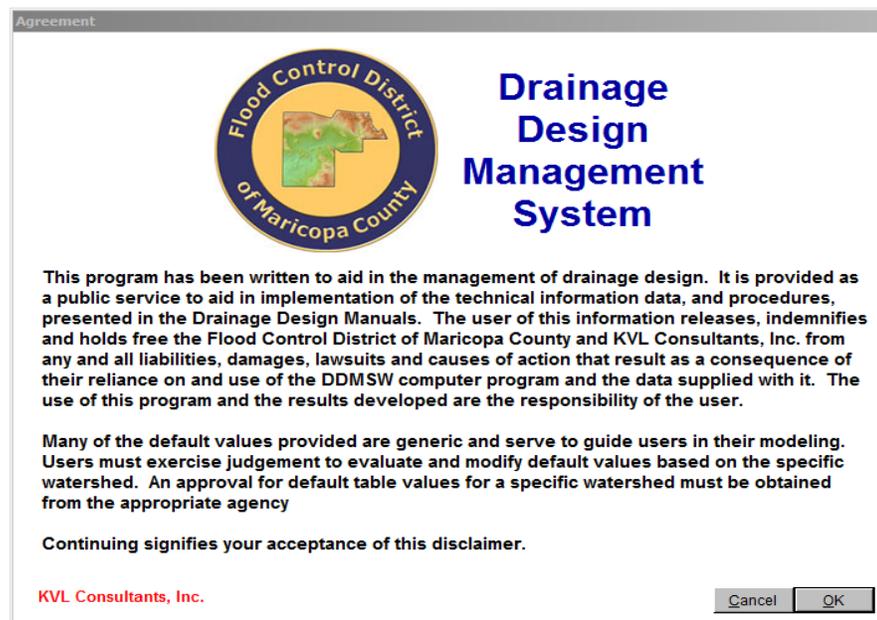
Step 3.5: Calculate the Low Flow Scour

Step 3.6: Calculate the Total Scour

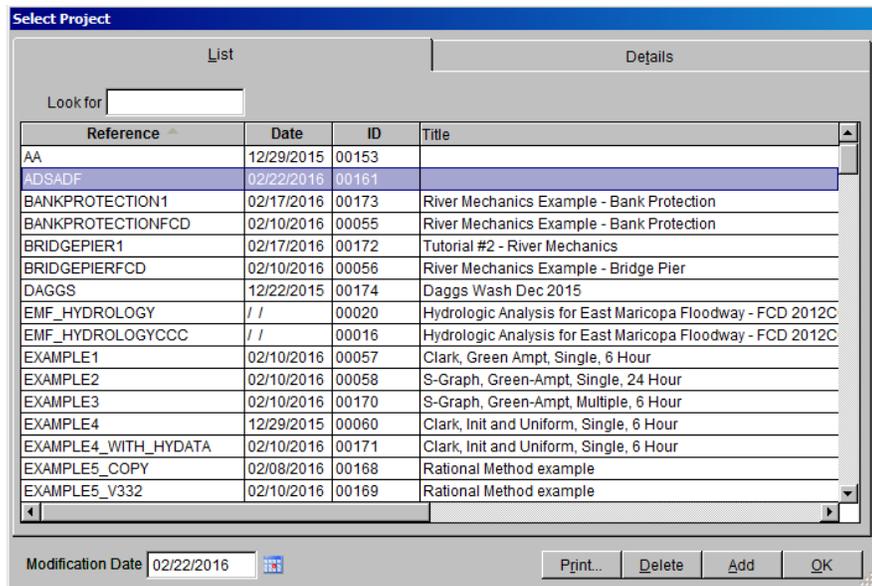
Step 4: Report and Documentation of Results

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

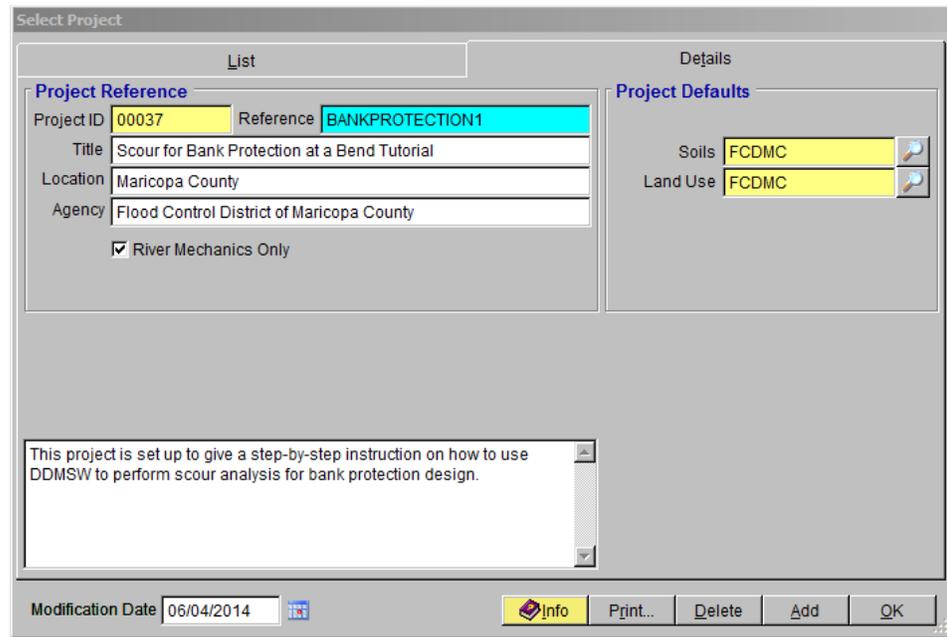
- (a) Click the **DDMSW** icon on the Desktop or Program menu to launch the **DDMSW**. Click OK to accept the software disclaimer as is shown in the following figure.



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



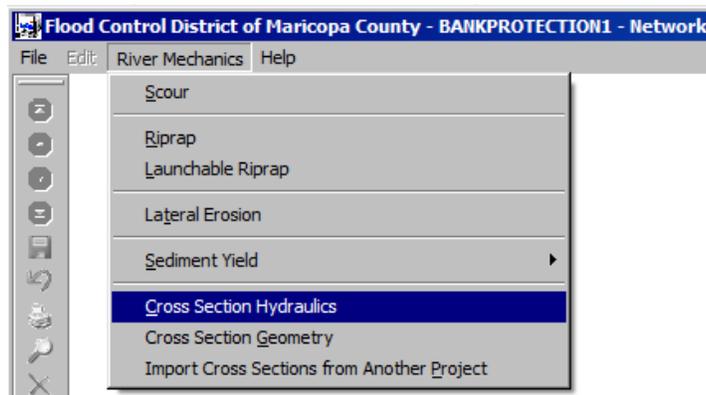
- (b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (Or **File** → **New Project** → **Add**).
- (c) On the **NEW PROJECT OPTIONS** form, select **River Mechanics** checkbox and click the **OK** button to close the form.
- (d) Type in “**BANKPROTECTION1**” into the **Reference** textbox. This is the name of this newly created project. The users can choose the name as long as it does not exist in the **DDMSW** database.
- (e) Type into the **Title** textbox a brief descriptive title of 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 to close the window, the following figure shows what the window looks like.
- (m) Click the **OK** button on the pop-up message box.



Note: the **Project ID** “00037” in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

2.2 Step 2 - Prepare the Cross Section Hydraulics

- (a) From the menu bar of the main application window, click River Mechanics → Cross Section Hydraulics to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window.



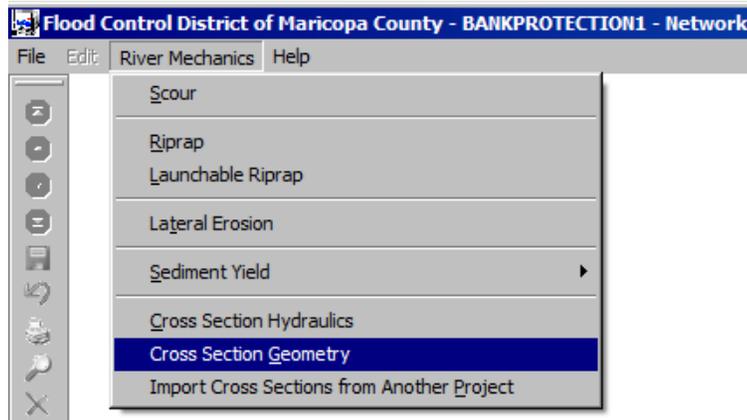
- (b) Click the **Add** button on the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** window to activate all the necessary data entry fields.

- (c) Select the "Calculate Data" for the **Source** ("Enter Data" can also be selected for the **Source** if the hydraulic results for a cross-section are available.)
- (d) Type "STUDYREACHCROSSSECTION" into the **Cross Section ID** textbox
- (e) By default, both the **Design** and **Dominant** textboxes in the **Entire Cross Section** frame are checked. If not, please check these two checkboxes.
- (f) Type in "3200" and "800" into the **Flow Rate (cfs)** textboxes for **Design** and **Dominant**, respectively
- (g) Type in "0.015" and "0.015" into the **Slope (ft/ft)** textboxes for **Design** and **Dominant**, respectively
- (h) Type in "0.035" and "0.030" into the **Manning's n Channel** textboxes for **Design** and **Dominant**, respectively. Use the same values ("0.035" and "0.030") for the **Manning's n LOB** and **Manning's n ROB** textboxes.
- (i) Check the **Total Scour** box. This should display the **Main Channel (Bedform Scour)** frame. Make sure both **Design** and **Dominant** are checked. The form should look as below.

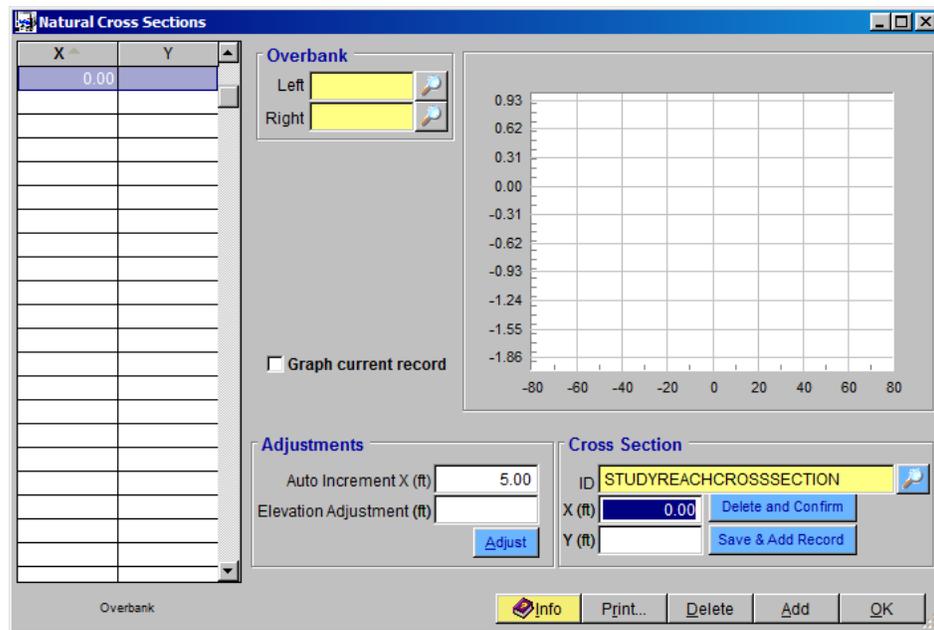
Parameter	Design	Dominant
Source	Calculate Data	Calculate Data
Flow Rate (cfs)	3200	800
Slope (ft/ft)	0.015000	0.015000
Manning's n Channel	0.035	0.030
Manning's n LOB	0.035	0.030
Manning's n ROB	0.035	0.030
Wetted Area (sq ft)		
Wetted Perimeter (ft)		
Average Width (ft)		
Top Width (ft)		
Hydraulic Depth (ft)		
Normal or Max Depth (ft)		
Velocity (ft/sec)		
Main Channel (Bedform Scour)		
Same as Entire Cross Section	Design <input checked="" type="checkbox"/>	Dominant <input checked="" type="checkbox"/>
Hydraulic Depth (ft)		
Velocity (ft/sec)		
Froude Number		

- (j) After the data entry, click the **Save** button. The form should look like the following figure.

- (k) Click the **OK** button to close the window.
- (l) From the menu bar of the main application window, click **River Mechanics** → **Cross Section Geometry** to open the **RIVER MECHANICS – CROSS SECTION GEOMETRY** form.



- (m) Click the “Magnifying Glass” on the right side of the **ID** textbox in the **Cross Section** frame to open the **SELECT CROSS SECTION ID** form. Highlight **Cross Section ID “STUDYREACHCROSSSECTION”** and click **OK** to close the form.

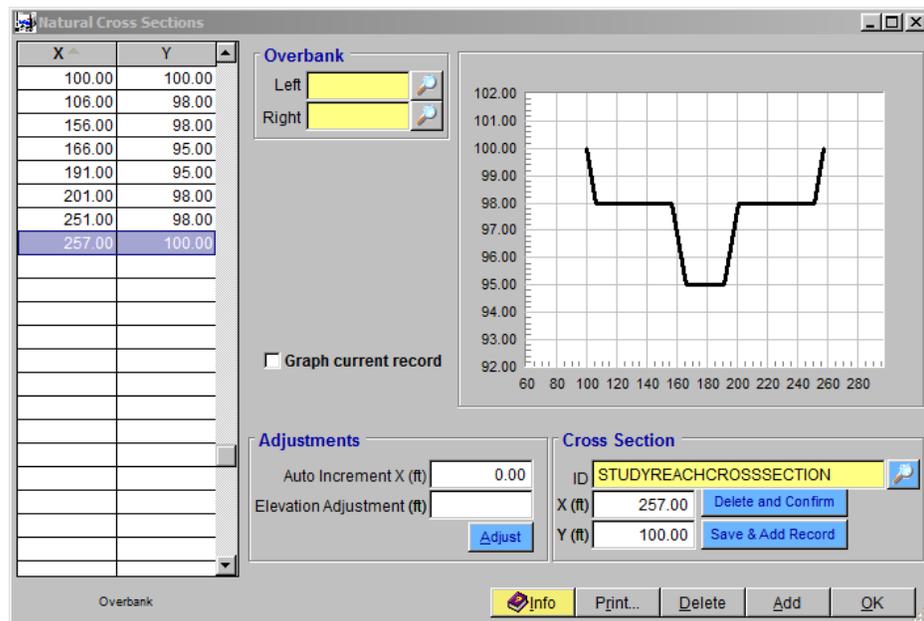


- (n) Click the **Add** button on the **NATURAL CROSS SECTIONS** form and type “100” and “100” into the **X (ft)** and **Y (ft)** textboxes, respectively. Click the **Save & Add Record** button.

(o) Repeat the above step (n) for the rest of pairs of **X** and **Y** values provided below.

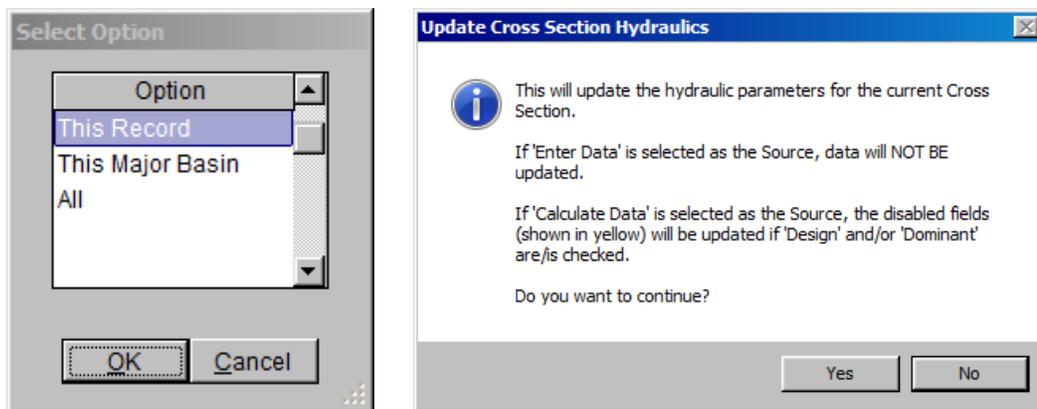
Station (X)	Elevation (Y)	Notes
106	98	
156	98	Left Bank Station
166	95	
191	95	
201	98	Right Bank Station
251	98	
257	100	

After all the **X** and **Y** values are entered, the **NATURAL CROSS SECTIONS** form should look like the following figure.

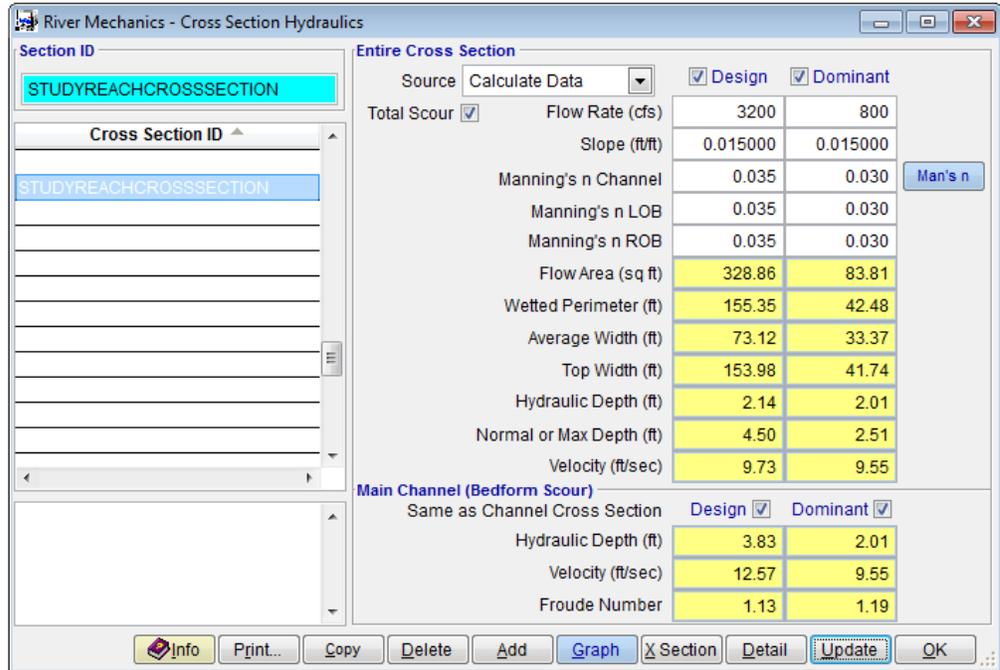


Cross-section data can be imported into **DDMSW**. However, the XY data must be prepared based on **DDMSW** XY data format before the cross-section is imported. To know the **DDMSW** XY data format, export the data of an existing cross-section (**File** → **Export Data** → select "Crosssections" under "Hydraulics" **Section** on the **SELECT A TABLE TO EXPORT** form. Click the **Export** button and on the **SELECT FIELDS TO EXPORT** form, select "XLS" as the **Export Type**. Click **Save** to save the setting, and click **Export**. On the **SAVE As** form, navigate to where you want to save the exported file and click the **Save** button. Finally, click **OK**. Once the file is created, the format can be examined. The format could be used as template for creating importable *.XLS files to DDMSW).

- (p) To define the Left Bank Station, select “156.00” on the XY grid table and click the “Magnifying Glass” on the right side of the **Left Overbank** textbox.
- (q) To define the Right Bank Station, select “201.00” on the XY grid table and click the “Magnifying Glass” on the right side of the **Right Overbank** textbox.
- (r) Click **OK** to close the **NATURAL CROSS SECTIONS** form.
- (s) Go back to the main application window, and click **River Mechanics** → **Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** form. Click the **Update** button to update the hydraulic parameter listed on the form by performing a hydraulic analysis using the geometric data provided. The textboxes with yellow highlights will be populated with results from the analysis.
- (t) Highlight “*This Record*” and click the **OK** button to close the **SELECT OPTION** form. Click **Yes** on the **UPDATE CROSS SECTION HYDRAULICS** form to continue.

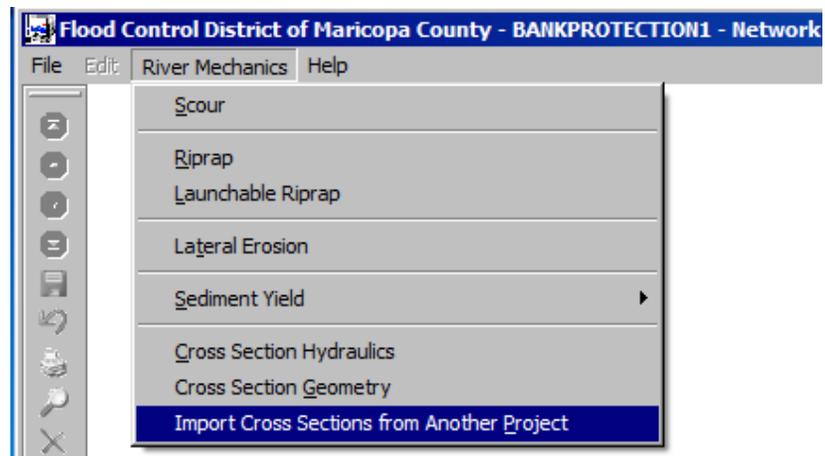


After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** form should look like the following figure.



To create the supply reach cross section data for the project, the user can manually enter the dataset using the same procedure [i.e., Step 2, from (a) to (t)]. In this tutorial, since the data have already been created in another project, the “SUPPLYREACHCROSSSECTION” dataset will be imported.

- (u) To import the “SUPPLYREACHCROSSSECTION” dataset, open the **IMPORT CROSS SECTIONS FROM ANOTHER PROJECT** form (**River Mechanics** → **Import Cross Sections from Another Project**).



- (v) On the **IMPORT CROSS SECTIONS FROM ANOTHER PROJECT** form, use the data provided below. Click **Import** to import the cross section data into the project. Select **Yes** to continue, and hit **OK** to close the form.

- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *SUPPLYREACHCROSSECTION*

(w) To check if the cross section data has been successfully imported, open the **NATURAL CROSS SECTIONS** form (**River Mechanics** → **Cross Section Geometry**).

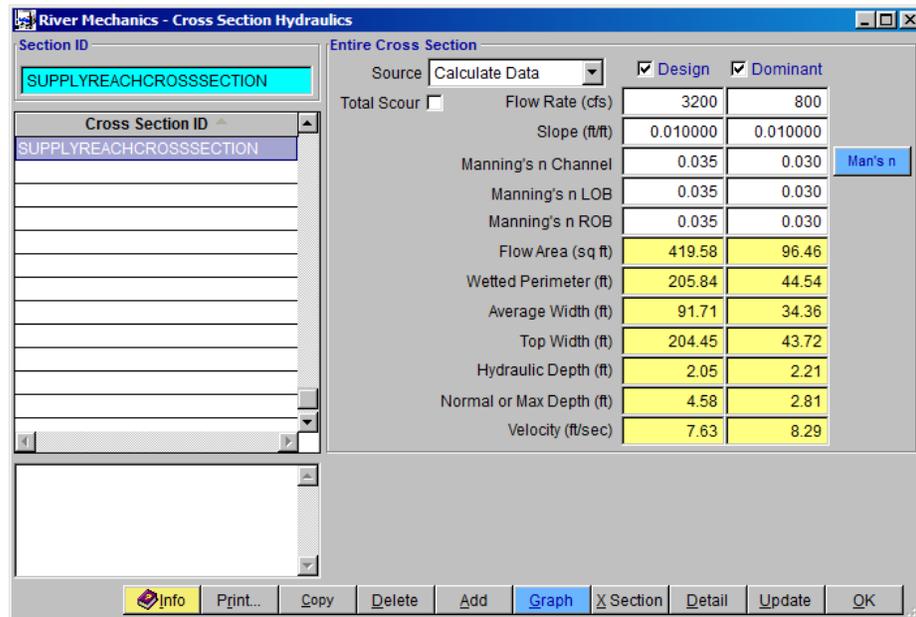
Compare the geometric data of the “*SUPPLYREACHCROSSECTION*” on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. “*SUPPLYREACHCROSSECTION*” can be selected by clicking on the magnifying icon next to **Cross Section ID** text box. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

Station (X)	Elevation (Y)	Notes
100	100	

Station (X)	Elevation (Y)	Notes
106	98	
181	98	Left Bank Station
191	95	
216	95	
226	98	Right Bank Station
301	98	
307	100	

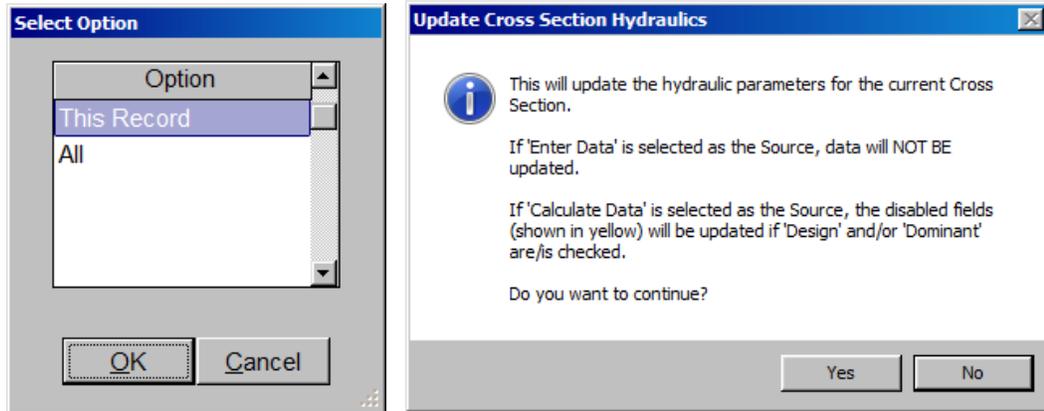
(x) To check if the imported data has all the correct **Flow Rates (cfs)**, **Slopes (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** data, open the **Cross SECTION HYDRAULICS** form (**River mechanics** → **Cross Section Hydraulics**). To compare, make sure that the **Section ID** is set to "SUPPLYREACHCROSSSECTION". Make any changes necessary to match the form below.

- **Cross Section ID:** SUPPLYREACHCROSSSECTION
- **Design Flow Rate (cfs):** 3200
- **Dominant Flow Rate (cfs):** 800
- **Design Slope (ft/ft):** 0.010
- **Dominant Slope (ft/ft):** 0.010
- **Design Manning's n (Channel, LOB, and ROB):** 0.035
- **Dominant Manning's n (Channel, LOB, and ROB):** 0.030



(y) If everything checks out, click the **Update** button to update the hydraulic analysis results.

- (z) On the **SELECT OPTION** form, select *“This Record”* and click **OK**. Hit **Yes** to continue.



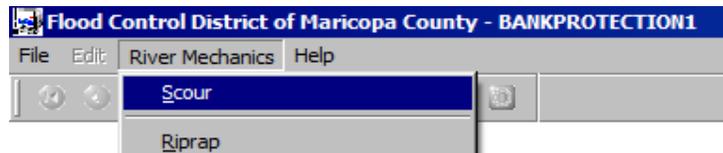
- (aa) Click **OK** to close the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** form.

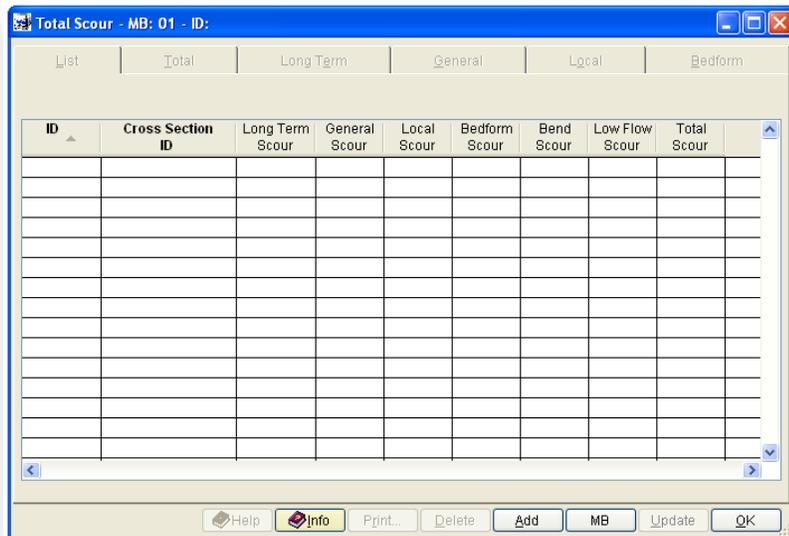
Creating the two cross sections and evaluating their respective hydraulics in **Step 2** are essential steps before proceeding to **Step 3** of this tutorial.

2.3 Step 3 - Compute Total Scour

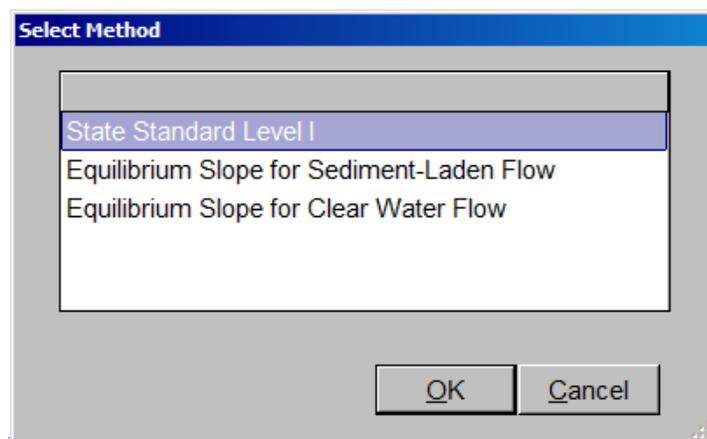
2.3.1 Set up Total Scour Basic Data

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

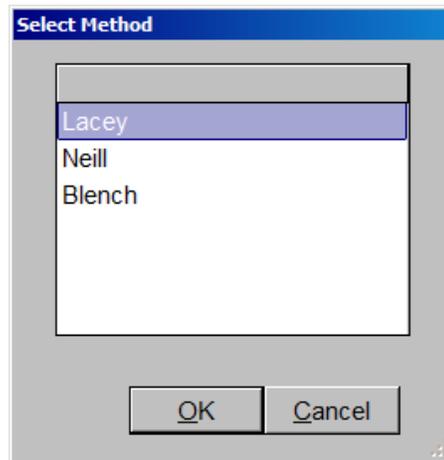




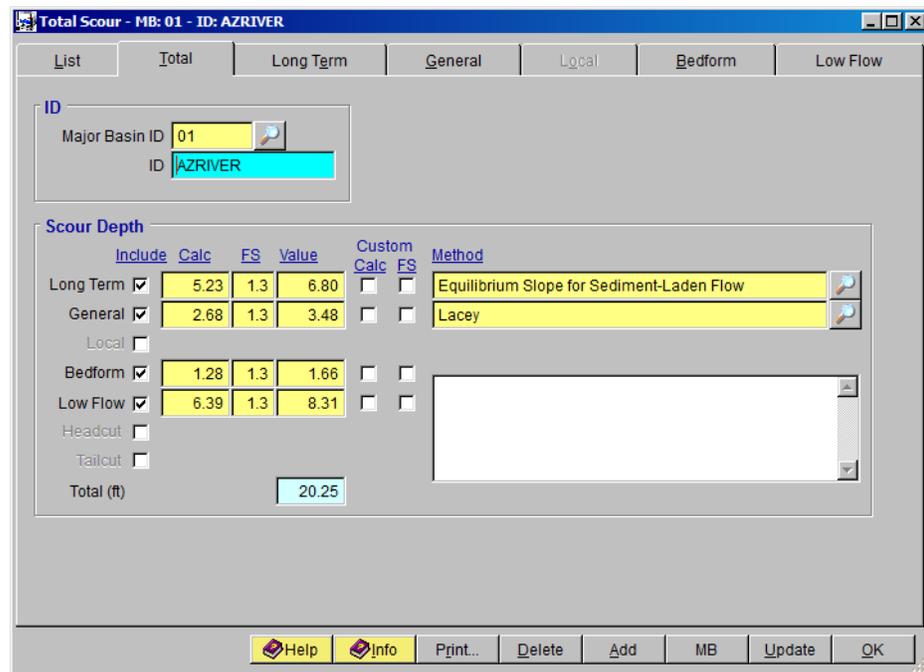
- (b) Click the **Add** button on the **TOTAL SCOUR** form to activate the data entry fields.
- (c) Type “AZRIVER” into the **ID** textbox.
- (d) Check the checkboxes for **Long Term**, **General**, **Bedform**, and **Low Flow** (Note: Do not check **Local**)
- (e) Click the browse button  in the **Method** column across **Long Term** checkbox on the **Total** tab to launch **SELECT METHOD** window and to select the method to use for Long-term scour analysis.
- (f) On the **SELECT METHOD** form, select the “*Equilibrium Slope for Sediment-Laden Flow*”, and click **OK** to close the **SELECT METHOD** form.



- (g) Click the browse button  in the method column across **General** check box on the **Total** tab to launch **SELECT METHOD** form.
- (h) Select “*Lacey*” method from the **SELECT METHOD** form to identify the method to use for General scour analysis. Click **OK** to close the **SELECT METHOD** form.



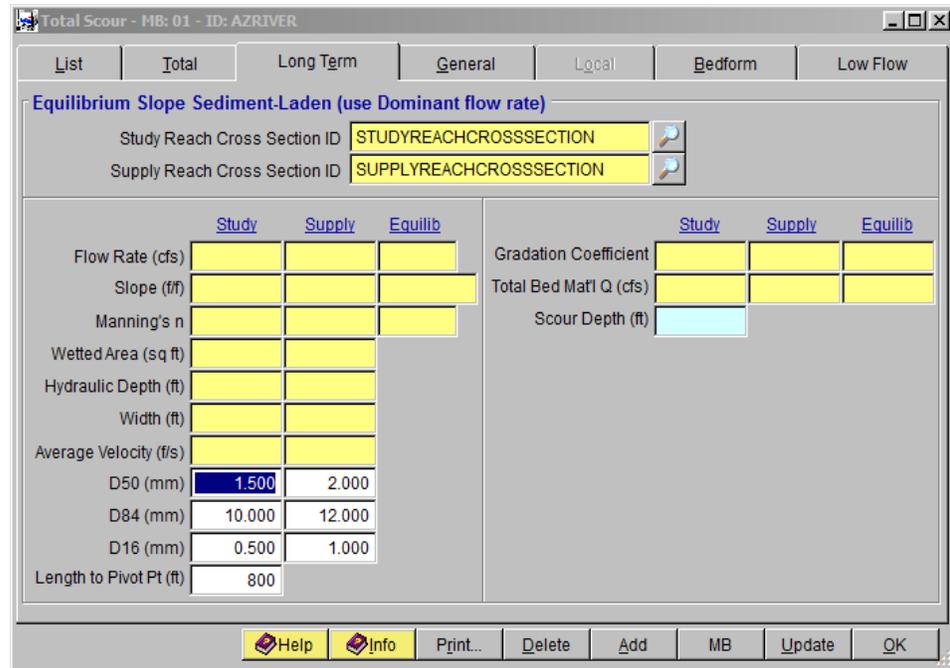
- (i) Click the **Save** button to save the entered data. The **TOTAL SCOUR** form should look like the following figure.



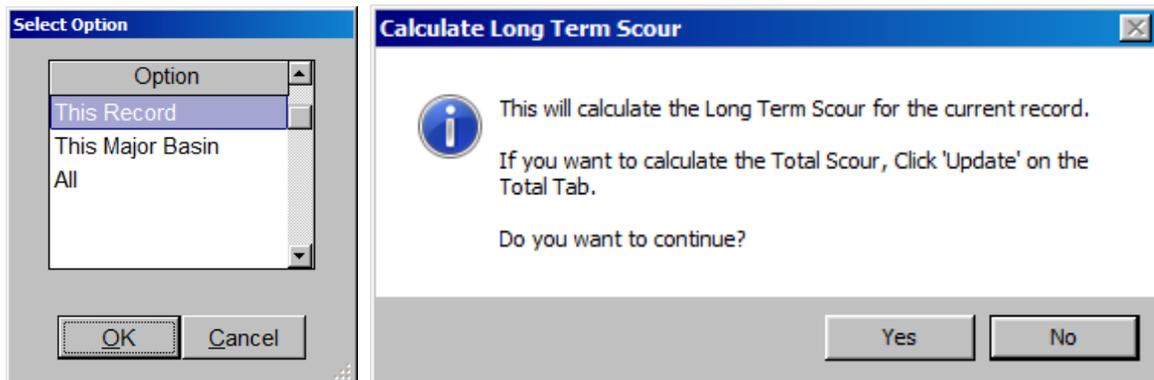
2.3.2 Calculate the Long Term Scour

- (a) Select the **Long Term** tab as shown in the following figure.

- (b) Click browse button  beside the **Study Reach Cross Section ID** to select the cross section ID *"STUDYREACHCROSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** form.
- (c) Click browse button  beside the **Supply Reach Cross Section ID** to select the cross section ID *"SUPPLYREACHCROSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** form.
- (d) Enter the **D50 (mm)** values *"1.5"* and *"2.0"* for **Study** and **Supply**, respectively.
- (e) Enter the **D84 (mm)** values *"10"* and *"12"* for **Study** and **Supply**, respectively.
- (f) Enter the **D16 (mm)** values *"0.5"* and *"1.0"* for **Study** and **Supply**, respectively.
- (g) Enter *"800"* into **Length to Pivot Pt (ft)** textbox
- (h) Click the **Save** button to save the entered data. (The form should look like the following figure).



- (i) Click the **Update** button to start the computation; select *"This Record"* from the **SELECTION OPTION** window, and click **Yes** to continue.



After the update, the final result of the long term scour calculation is shown in the following figure.

Total Scour - MB: 01 - ID: AZRIVER

List | Total | **Long Term** | General | Local | Bedform | Low Flow | Pier Influence

Equilibrium Slope Sediment-Laden (use Dominant flow rate)

Study Reach Cross Section ID: STUDYREACHCROSSSECTION

Supply Reach Cross Section ID: SUPPLYREACHCROSSSECTION

	Supply	Study	Equilib		Supply	Study	Equilib
Flow Rate (cfs)	800	800	800	Gradation Coefficient	4.00	4.83	4.83
Slope (ft/ft)	0.010000	0.015000	0.00863390	Total Bed Mat'l Q (cfs)	3.98	9.47	3.98
Manning's n	0.030	0.030	0.030	Scour Depth (ft)	5.09		
Wetted Area (sq ft)	96.46	83.81	101.52				
Hydraulic Depth (ft)	2.21	2.01	2.28				
Normal or Max Depth (ft)	2.81	2.51	2.92				
Average Width (ft)	34.36	33.37	33.37				
Average Velocity (ft/s)	8.29	9.55	7.88				
D50 (mm)	2.000	1.500					
D84 (mm)	12.000	10.000					
D16 (mm)	1.000	0.500					
Length to Pivot Pt (ft)		800					

Help | Info | Print... | Delete | Add | MB | Update | OK

2.3.3 Calculate the General Scour

- Click the **General** tab to evaluate the General scour.
- Click browse  button beside the **Cross Section ID** to select the cross section ID "STUDYREACHCROSSSECTION", and click **OK** to close the **SELECT CROSS SECTION ID** window.
- Enter "1.5" into the **D50 (mm)** textbox.
- Click the browse  button beside the **Bend Factor, Z** textbox to open the **SELECT FACTOR** window and select "Moderate Bend".

Select Factor

Straight Reach

Moderate Bend

Severe Bend

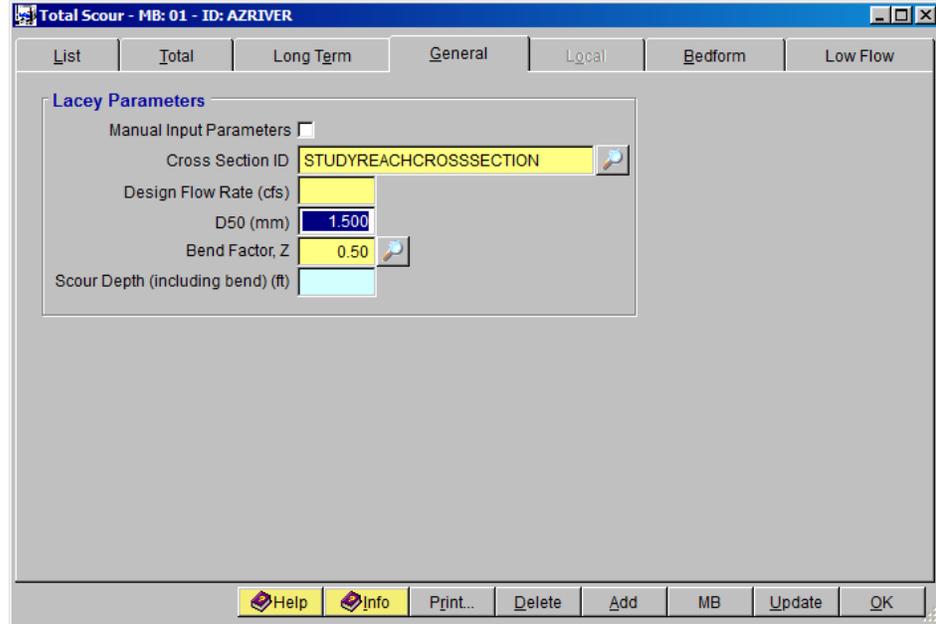
Right Angle Bend

Vertical Rock Bank or Wall

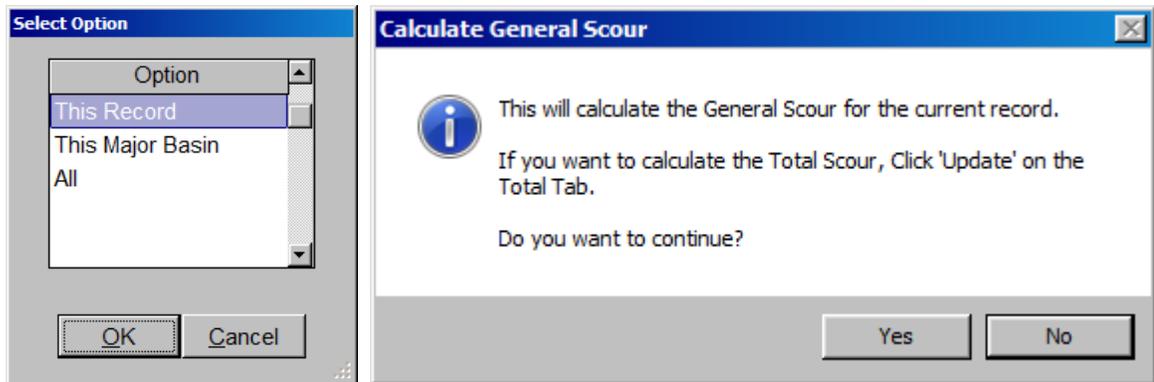
OK | Cancel

- Click the **Save** button to save the entered data.

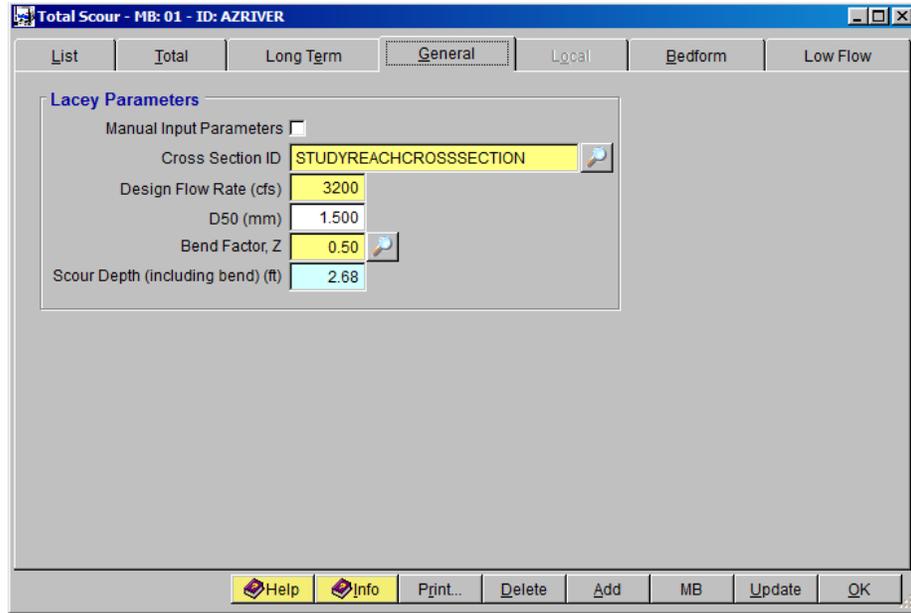
The following figure shows what the window looks like after the data entry.



- (f) Click the **Update** button and select "This Record" from the **SELECTION OPTION** window. Click **Yes** on the **CALCULATE GENERAL SCOUR** form to proceed.



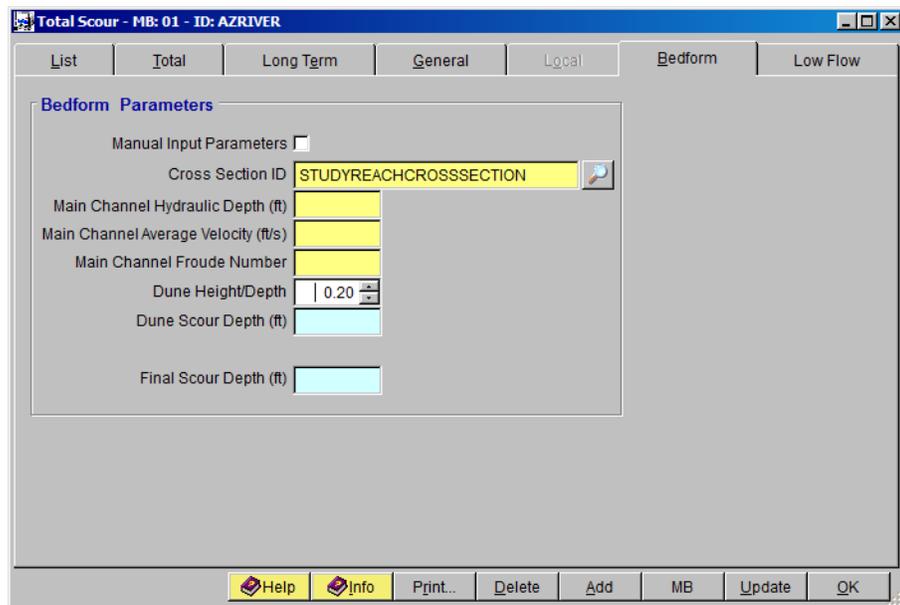
After the update, the final result of the general term scour calculation is shown in the following figure.



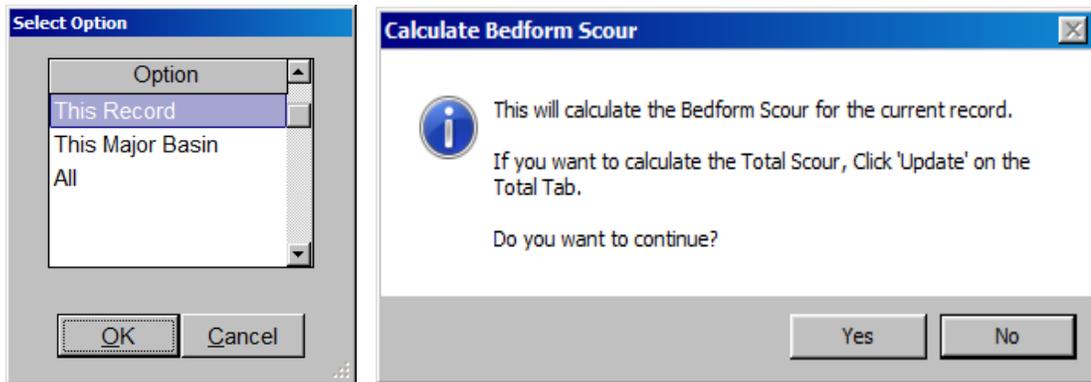
2.3.4 Calculate the Bedform Scour

In this section, a procedure on how to calculate the bedform scour will be provided.

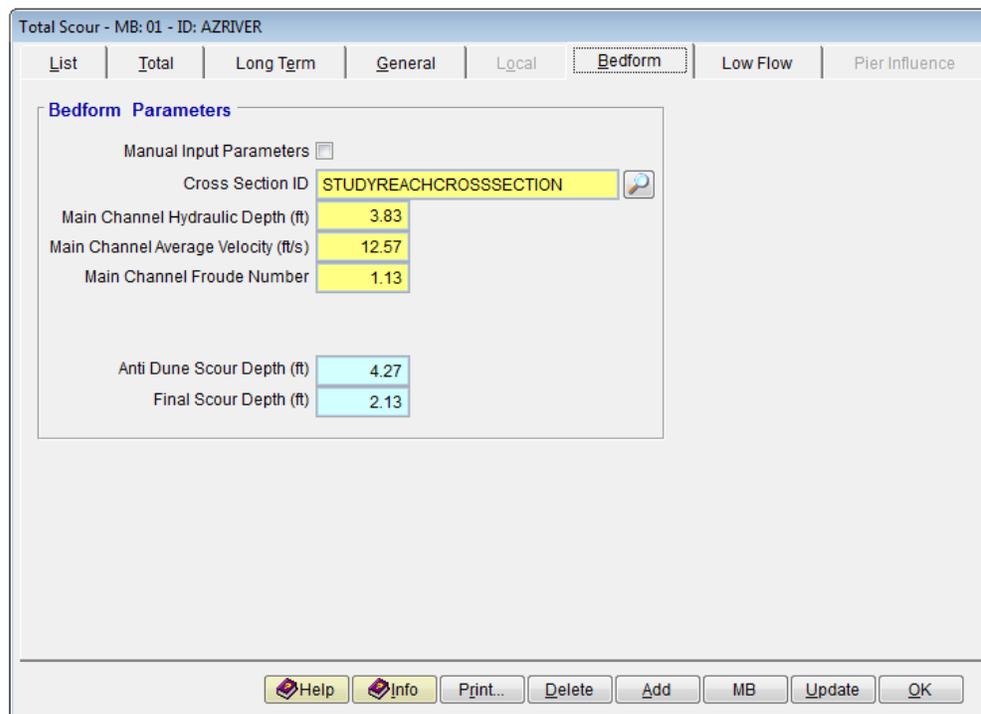
On the **TOTAL SCOUR** form, select the **Bedform** tab. The following figure shows what the window looks like before data entry.



- (a) Click browse  button beside the **Cross Section ID** to select the cross section ID *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.
- (b) Set the **Dune Height/Depth** value to *"0.20"*.
- (c) Click the **Save** button to save the data just entered.
- (d) Click the **Update** button and select *"This Record"* from the **SELECTION OPTION** window. Click **Yes** to continue.



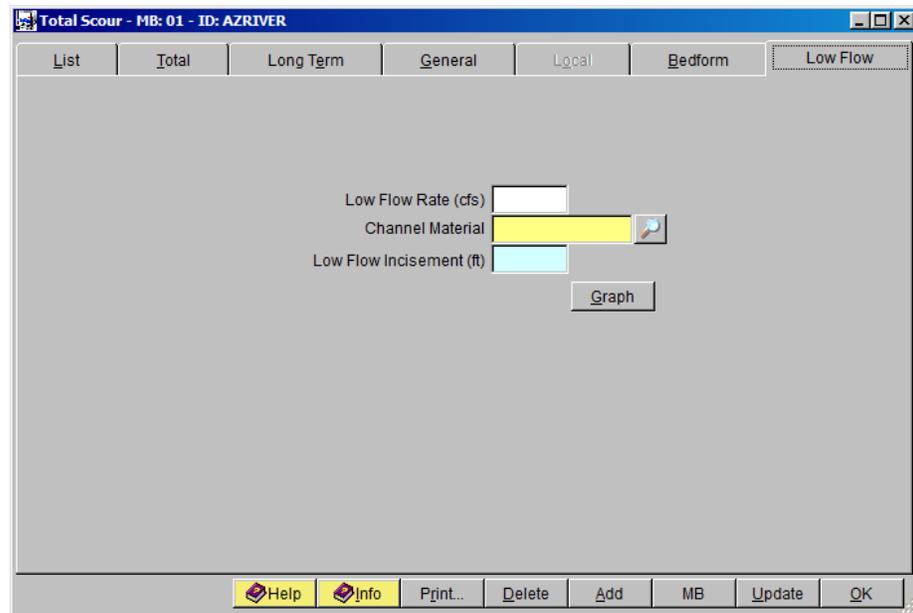
After the update, the final result of the bedform scour calculation is shown in the following figure.



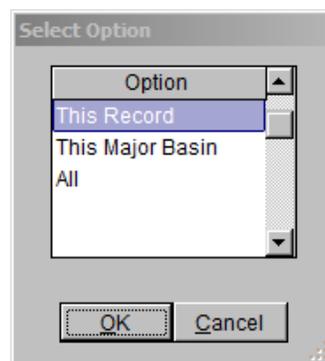
2.3.5 Calculate the Low Flow Scour

In this section, a procedure on how to calculate the low-flow scour will be provided.

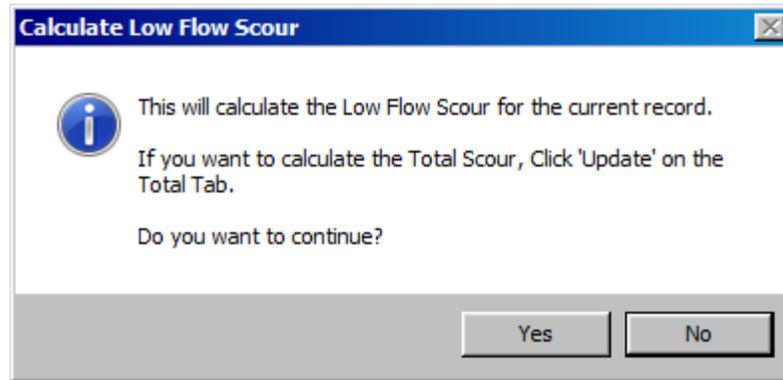
On the **TOTAL SCOUR** form, select the **Low Flow** tab. The following figure shows what the window looks like before data entry.



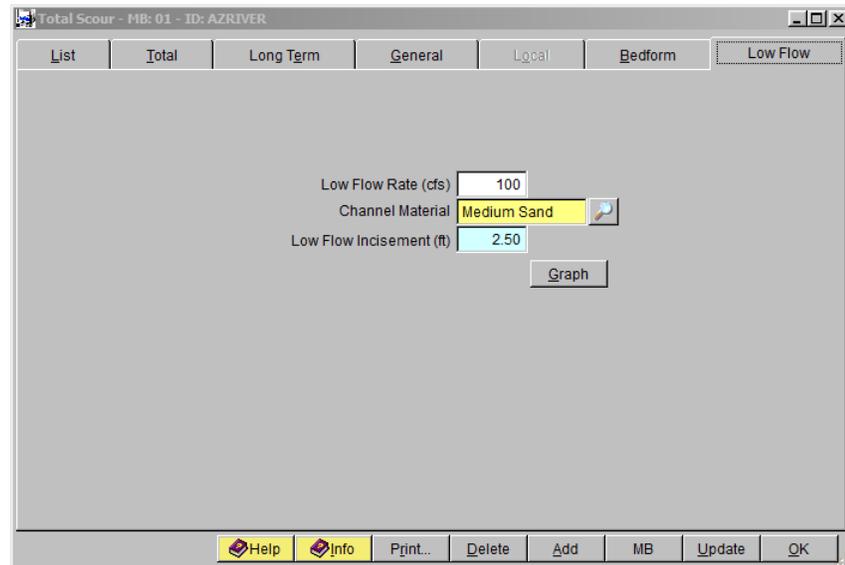
- Enter "100" into the **Low Flow Rate (cfs)** textbox.
- Click browse  button beside the **Channel Material** to select the channel material data. Choose "Medium Sand" and click **OK** to exit the **SELECT CHANNEL MATERIAL** form.
- Click the **Save** button to save the data just entered.
- Click the **Update** button and select "This Record" from the **SELECT OPTION** form. Click **OK**.



(e) On the **CALCULATE LOW FLOW SCOUR** form, click **Yes** to continue.



After the update, the final result of the low flow scour calculation is shown in the following figure.



2.3.6 Calculate the Total Scour

On the **TOTAL SCOUR** form, select the **Total** tab. The following figure shows what the form looks like.

Total Scour - MB: 01 - ID: AZRIVER

List Total Long Term General Local Bedform Low Flow Pier Influence

ID

Major Basin ID 01

ID AZRIVER

Scour Depth

	Include	Calc	FS	Value	Custom Calc	FS	Method
Long Term	<input checked="" type="checkbox"/>	5.09	1.3	6.62	<input type="checkbox"/>	<input type="checkbox"/>	Equilibrium Slope for Sediment-Laden Flow
General	<input checked="" type="checkbox"/>	2.68	1.3	3.48	<input type="checkbox"/>	<input type="checkbox"/>	Lacey
Local	<input type="checkbox"/>						
Bedform	<input checked="" type="checkbox"/>	2.13	1.3	2.77	<input type="checkbox"/>	<input type="checkbox"/>	
Low Flow	<input checked="" type="checkbox"/>	2.50	1.3	3.25	<input type="checkbox"/>	<input type="checkbox"/>	
Headcut	<input type="checkbox"/>						
Tailcut	<input type="checkbox"/>						
Total (ft)				16.12			
Pier Influence	<input type="checkbox"/>						

Help Info Print... Delete Add MB Update OK

As shown, the analysis results for the total scour which is the combination of the individual scour components previously analyzed are displayed.

2.4 Step 4 - Report and Documentation of Results

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

The total scour is the sum of the long term scour, general scour, local scour, bedform scour and low flow scour. In this tutorial, only the following four scours are covered, that is, the long term scour, general scour, bedform scour and low flow scour.

Make sure all the four scours listed above are checked in the **Total** tab and all the listed scours are updated.

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

Major Basin: 01
 ID: AZRIVER

Cross Section ID: STUDYREACHCROSSSECTION

Type	Calc (ft)	FS	Value (ft)	Method
Long Term	5.09	1.30	6.62	Equilibrium Slope for Sediment-Laden Flow
General	2.88	1.30	3.48	Lacey
Local		1.30		
Bedform	2.13	1.30	2.77	Comments
Low Flow	2.50	1.30	3.25	
Pressure Flow	0.00	1.30	0.00	
Headcut	-	1.30	-	
Tailcut	-	1.30	-	
Total			16.12	

- (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 ().
- (d) The individual scour components results and cross section hydraulics results can also be viewed, printed, and exported by clicking the **Print...** button under individual component scour menus and **Cross Section Hydraulics** menu.

This concludes this tutorial for scour evaluation for bank protection involving mild bends.