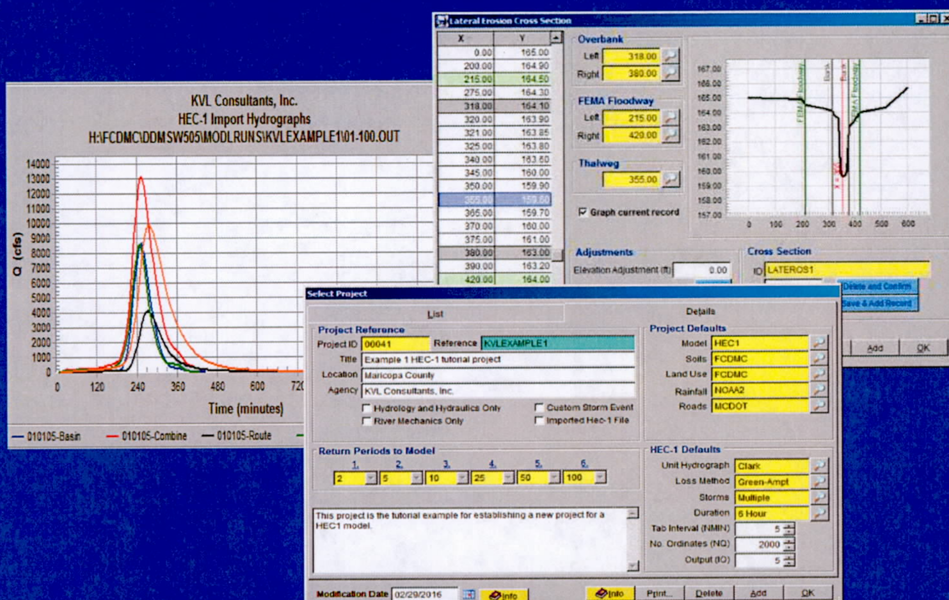
The Flood Control District of Maricopa County

DDMSW Training Workshops

RIVER MECHANICS / STORM DRAINAGE HYDRAULICS

March 10, 2016



Maricopa County Department of Transportation (MCDOT)

Computer Training Room

2919 W Durango St, Phoenix, Arizona 85009

Presented by:

Kenneth Lewis, P.E.

KVL Consultants, Inc.

DDMSW Training Workshop

River Mechanics and Storm Drainage Hydraulics

Training Dates: March 10, 2016 (Thursday)
March 15, 2016 (Tuesday)

Location: Flood Control District of Maricopa County
2801 West Durango Street
Phoenix, Arizona 85009

Instructor: Kenneth V. Lewis, P.E.
DDMSW Developer

This training class is designed for hydraulic and hydrologic engineers interested in learning DDMSW, an application program that implements the District's Design Methodologies and Standards.

Agenda

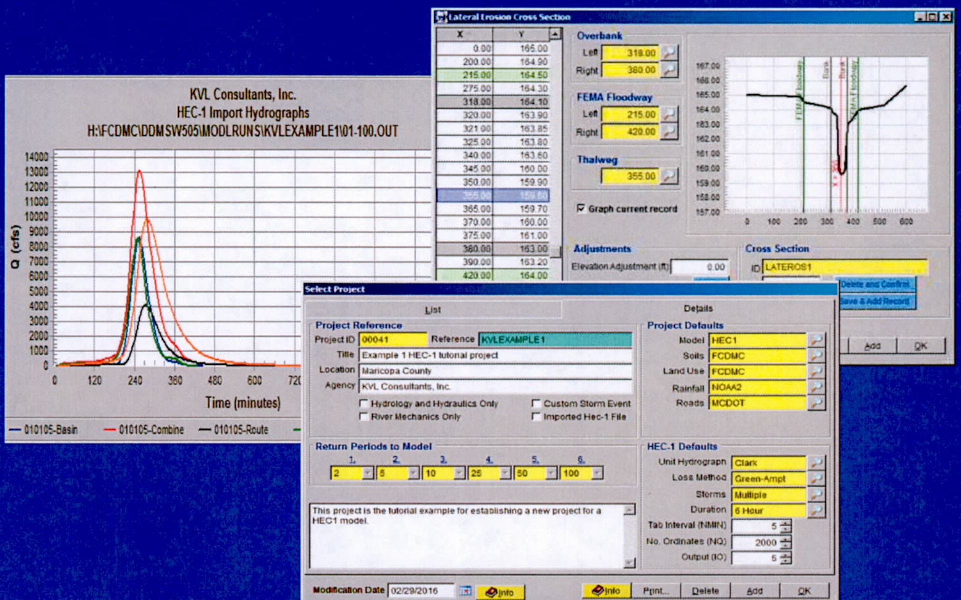
8:30 – 9:00	**Training Overview**
	System Overview, Program Installation, General Features, Files, Tools, Administration, Help, Register Controls
9:00 – 10:00	**River Mechanics Overview**
10:00 – 10:15	**Morning Break**
10:15 – 11:00	**River Mechanics Examples**
	Scour, Sediment Yield, Riprap Sizing, Launchable Riprap, Lateral Erosion
11:00 –12:00	**Tutorial #1 – Scour Analysis**
12:00 – 1:00	**Lunch Break**
1:00 – 2:00	**Tutorial #2 – Sediment Yield Analysis**
2:00 – 2:30	**Tutorial #3 – Riprap Sizing**
2:30 – 2:45	**Afternoon Break**
2:45 – 4:30	**Storm Drainage Hydraulics Examples**
	Conveyance Facilities, Street Drainage, StormPro Backwater Module

The Flood Control District of Maricopa County

DDMSW Training Workshops

RIVER MECHANICS

March 10, 2016



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DDMSW 5.1
Training Workshops
RIVER MECHANICS

Engineering Application Development and River Mechanics Branch
Engineering Division
Flood Control District of Maricopa County

March 10, 2016

This document contains step-by-step tutorials for the River Mechanics module of DDMSW. The five tutorials for the River Mechanics cover the computations of total scour for bank protection at a bend, total scour for bridge pier, sediment yield analysis for a watershed, riprap sizing for bank protection at a straight channel, and lateral erosion.

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B. Step-by-Step Procedures II-55

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II River Mechanics

2.1 Calculate Total Scour for Bank Protection at a Bend

A. 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*	*Left Bank Station*
166	*95*	
191	*95*	
201	*98*	*Right Bank Station*
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*	*Left Bank Station*
191	*95*	
216	*95*	
226	*98*	*Right Bank Station*
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*

B. 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

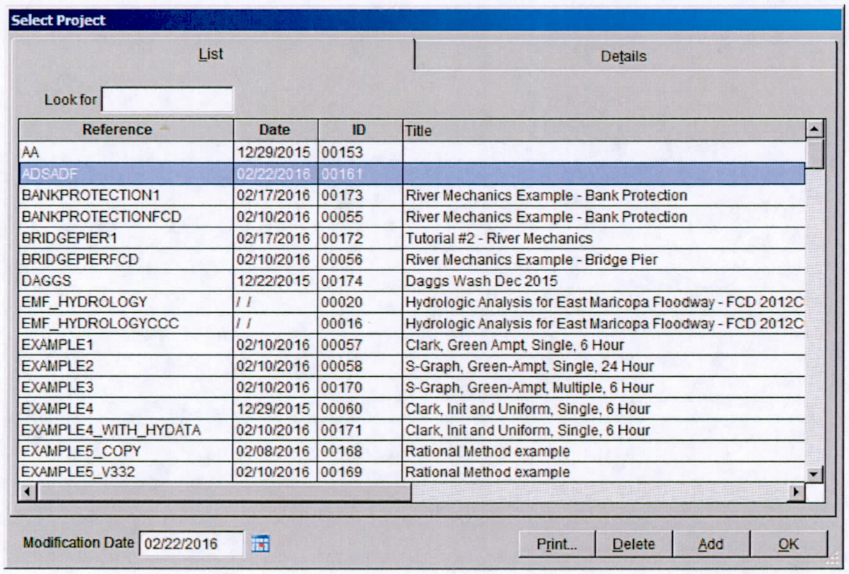
Step 3.6: Calculate the Total Scour

Step 4: Report and Documentation of Results

B.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.

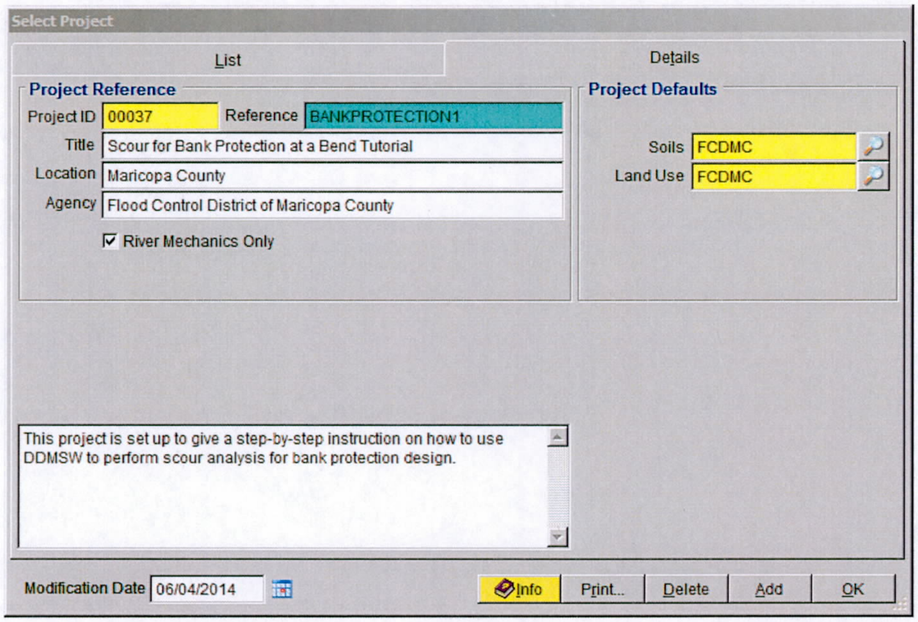
(i) Type a detailed description of this project into the comment area under the **Project Reference** frame ***(Optional).***

(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.

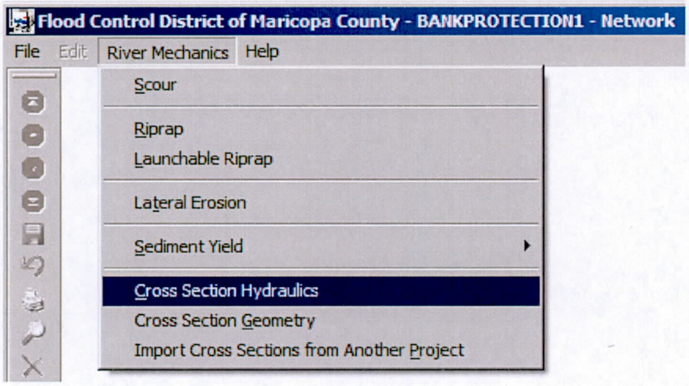
(m) Click the **OK** button on the pop-up message box.



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.

B.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.

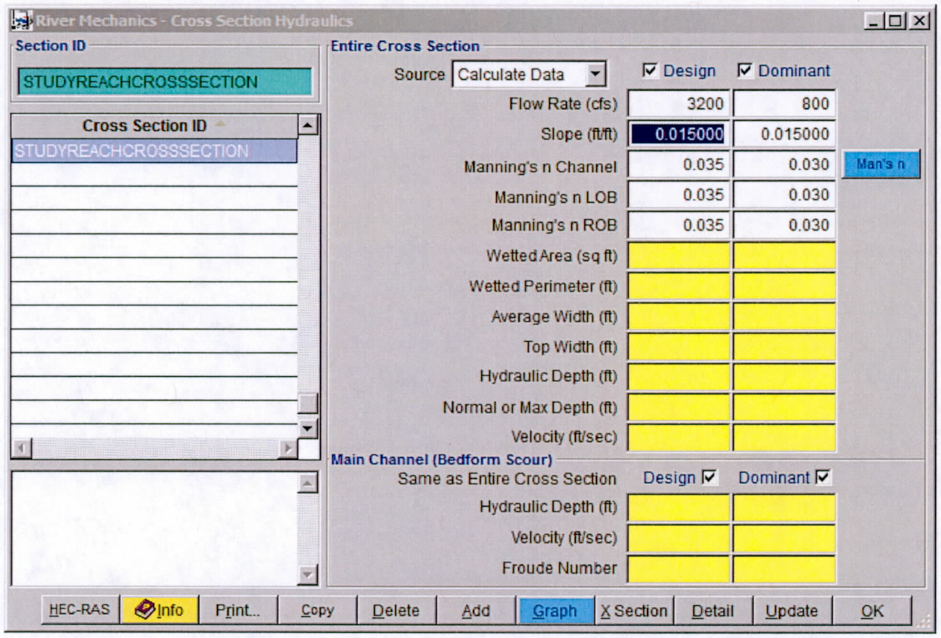
(f) Type in *"3200"* and *"800"* into the **Flow Rate (cfs)** textboxes for **Design** and **Dominant**, respectively

(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.

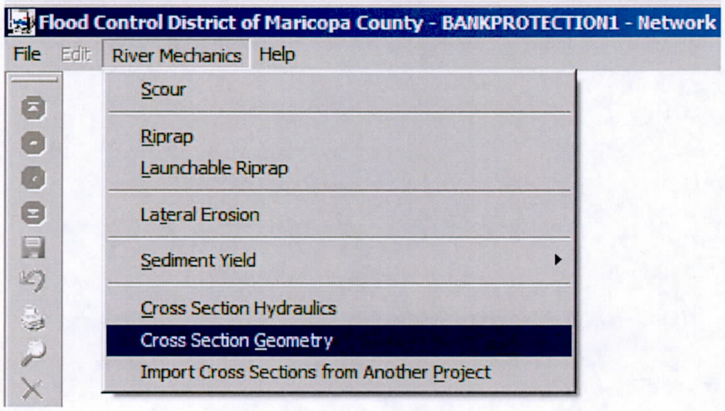
(i) Check **Same as Channel Cross Section** checkboxes for both **Design** and **Dominant** in the **Main Channel (Bedform Scour)** frame (Note: These boxes are checked if the bedform scour computation is based on the Channel cross-section hydraulics).

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

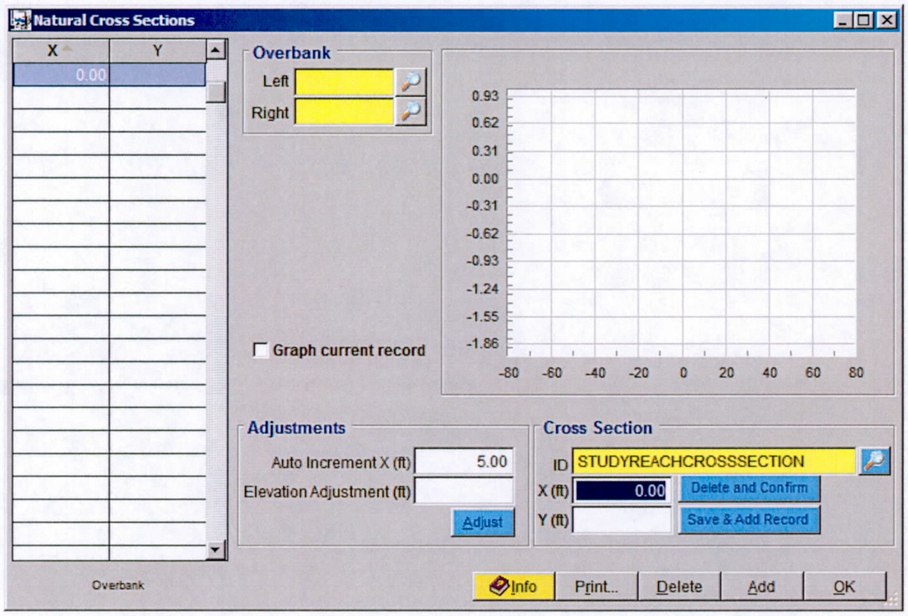


(k) Click the **OK** button to close the window.

(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.

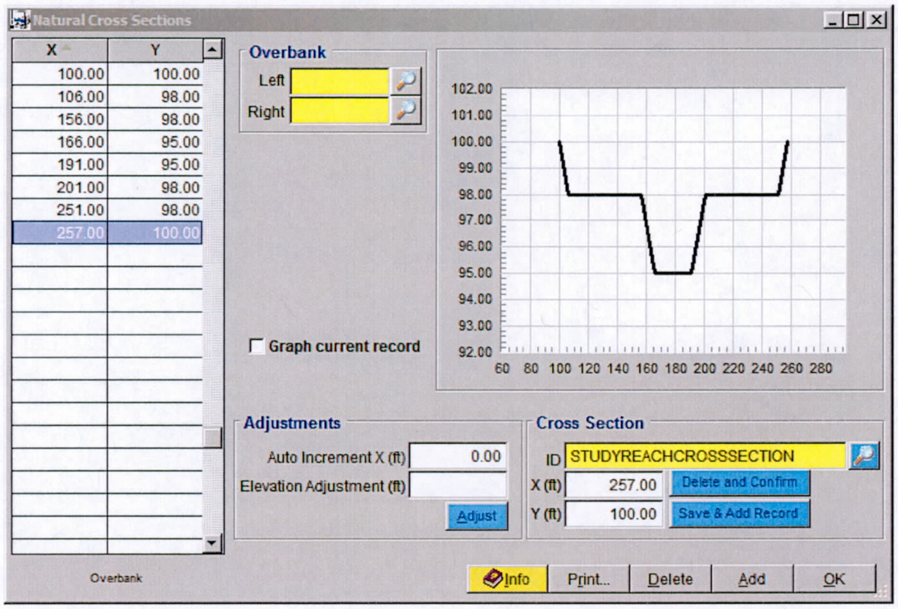


(n) Click the **Add** button on the **NATURAL CROSS SECTIONS** form and type *"100"* and *"100"* into the **X (ft)** and **Y (ft)** textboxes, respectively. Click the **Save & Add Record** button.

(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).

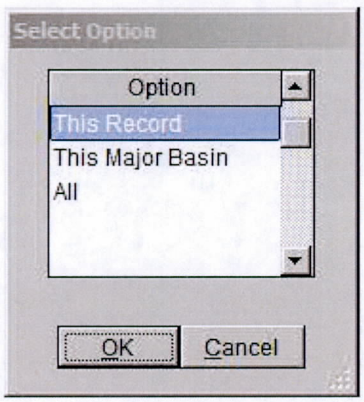
(p) To define the Left Bank Station, select *"156.00"* on the XY grid table and click the "Magnifying Glass" on the right side of the **Left Overbank** textbox.

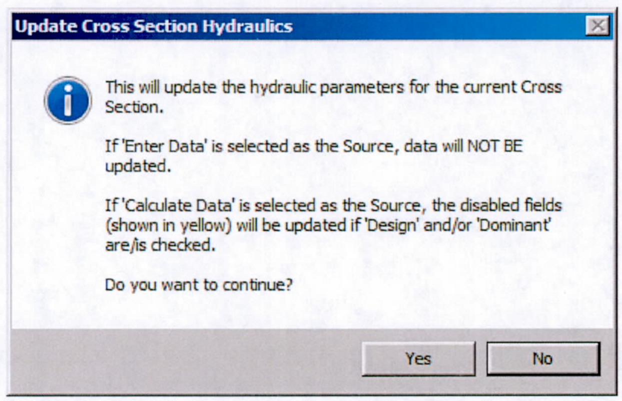
(q) To define the Right Bank Station, select *"201.00"* on the XY grid table and click the "Magnifying Glass" on the right side of the **Right Overbank** textbox.

(r) Click **OK** to close the **NATURAL CROSS SECTIONS** form.

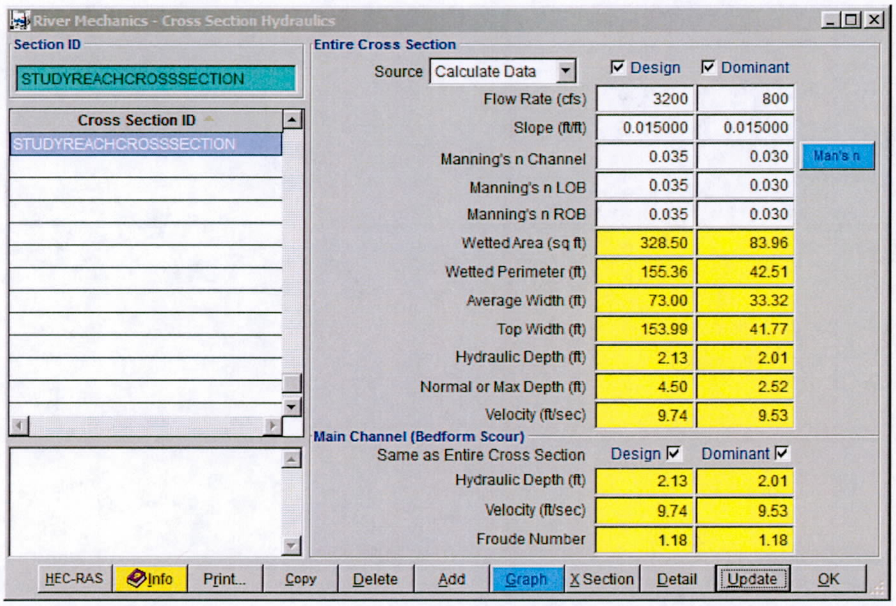
(s) Go back to the main application window, and click **River Mechanics ➔ Cross Section Hydraulics** from the menu bar to open the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** form. Click the **Update** button to update the hydraulic parameter listed on the form by performing a hydraulic analysis using 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.



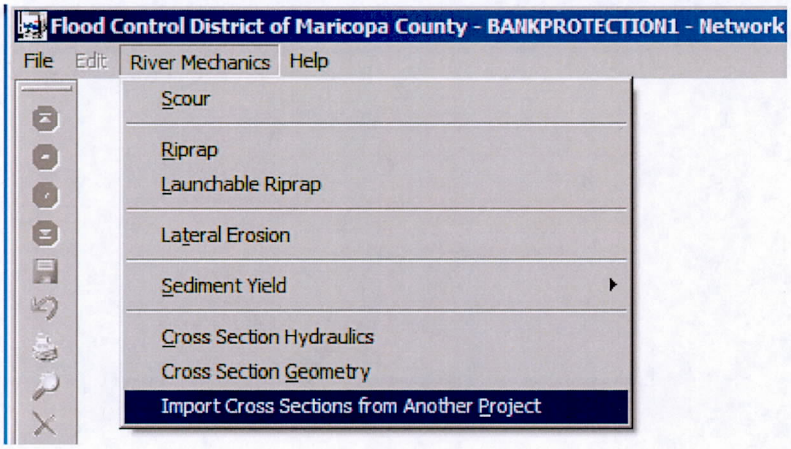


After the update, the **RIVER MECHANICS – CROSS SECTION HYDRAULICS** form should look like the following figure.



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.

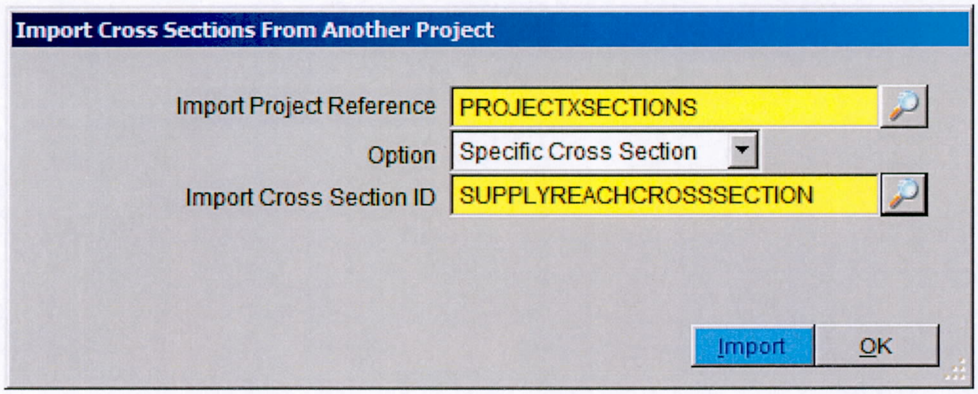
(u) To import the *"SUPPLYREACHCROSSSECTION"* dataset, open the IMPORT CROSS SECTIONS FROM ANOTHER PROJECT form (**River Mechanics ➔ Import Cross Sections from Another Project**).



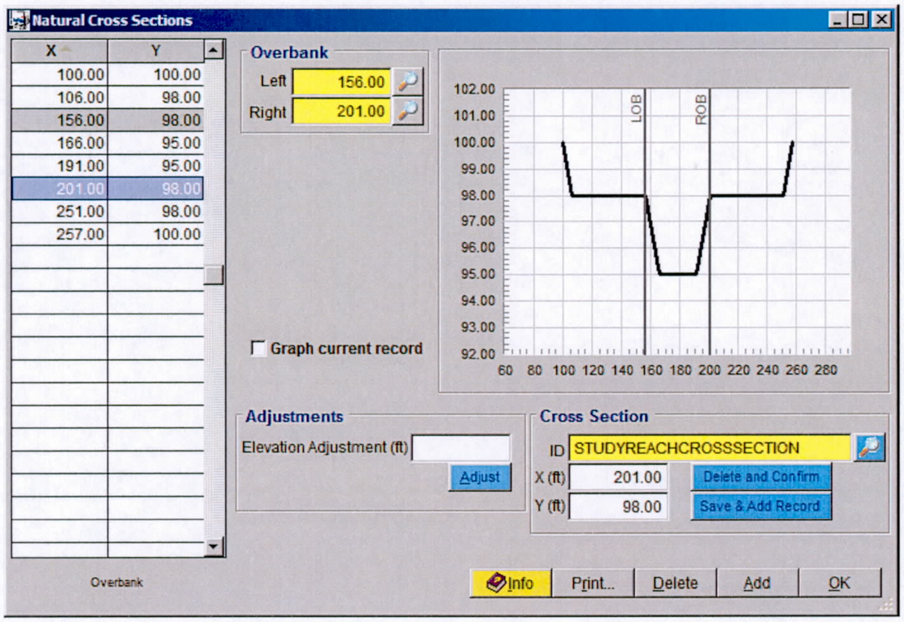
(v) On the IMPORT CROSS SECTIONS FROM ANOTHER PROJECT form, use the data provided below. Click **Import** to import the cross section data into the project. Select **Yes** to continue, and hit **OK** to close the form.

- **Import Project Reference:** *PROJECTXSECTIONS*

- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *SUPPLYREACHCROSSSECTION*



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



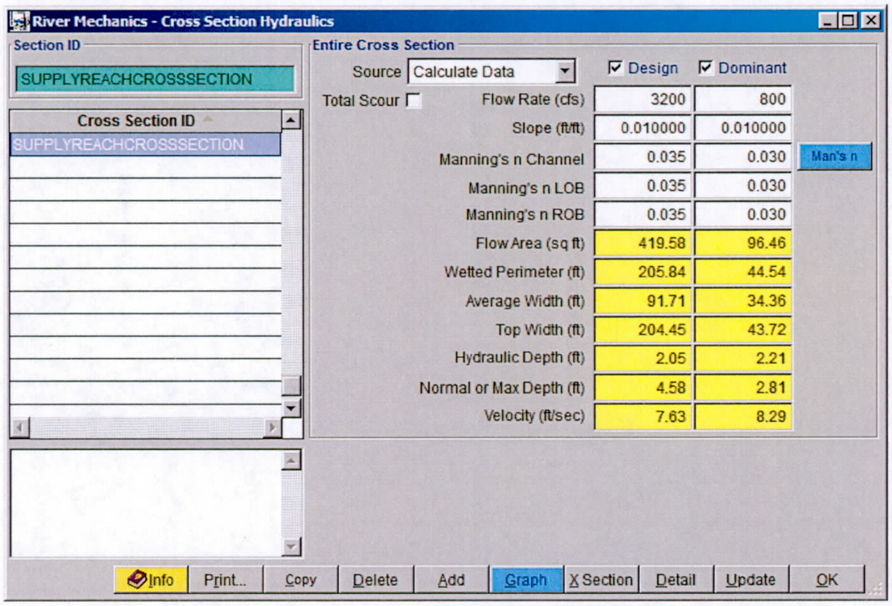
Compare the geometric data of the *"SUPPLYREACHCROSSSECTION"* on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. *"SUPPLYREACHCROSSSECTION"* can be selected by clicking on the magnifying icon next to **Cross Section ID** text box. Make necessary data edits or adjustments 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*	

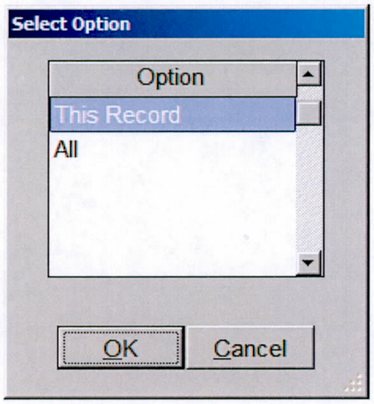
(x) To check if the imported data has all the correct **Flow Rates (cfs)**, **Slopes (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** data, open the CROSS SECTION HYDRAULICS form (**River mechanics ➔ Cross Section Hydraulics**). To compare, make sure that the **Section ID** is set to *"SUPPLYREACHCROSSSECTION"*.

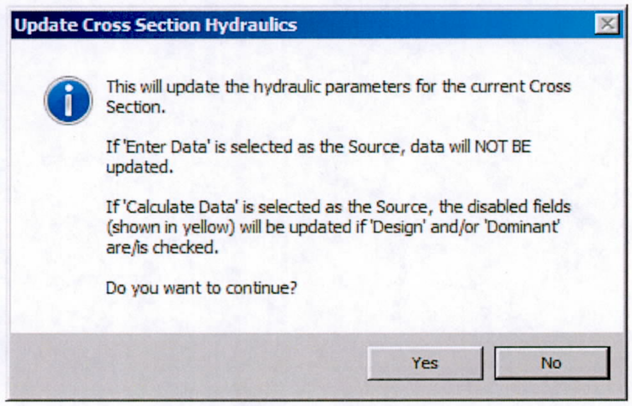
- **Cross Section ID:** *SUPPLYREACHCROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rate (cfs):** *800*
- **Design Slope (ft/ft):** *0.010*
- **Dominant Slope (ft/ft):** *0.010*
- **Design Manning's n (Channel, LOB, and ROB):** *0.035*
- **Dominant Manning's n (Channel, LOB, and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





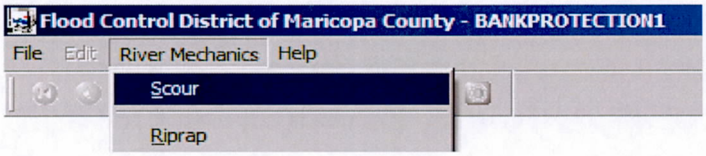
(aa) Click **OK** to close the **River Mechanics – Cross Section Hydraulics** form.

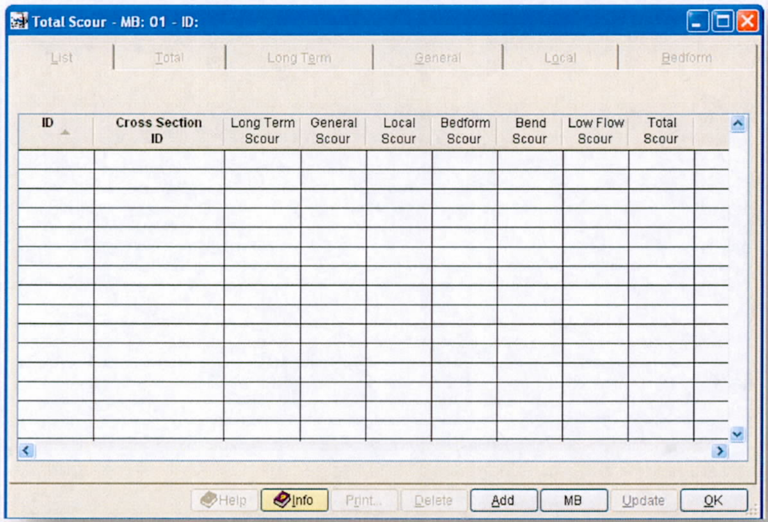
Creating the two cross sections and evaluating their respective hydraulics in **Step 2** are essential steps before proceeding to **Step 3** of this tutorial.

B.3 Step 3 - Compute Total Scour

B.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.





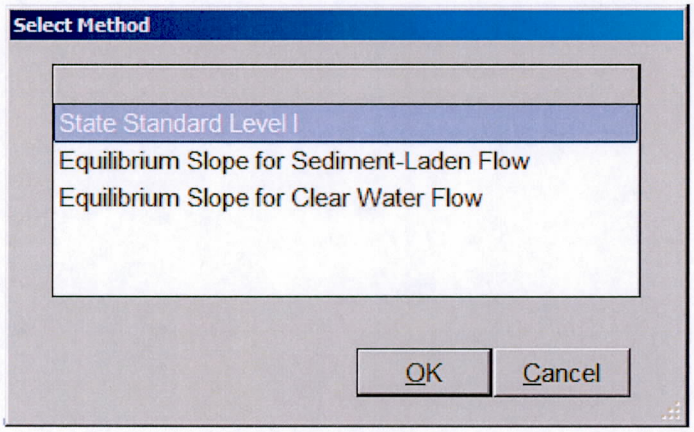
(b) Click the **Add** button on the **Total Scour** form to activate the data entry fields.

(c) Type *"AZRIVER"* into the **ID** textbox.

(d) Check the checkboxes for **Long Term, General, Bedform,** and **Low Flow** (Note: Do not check **Local**)

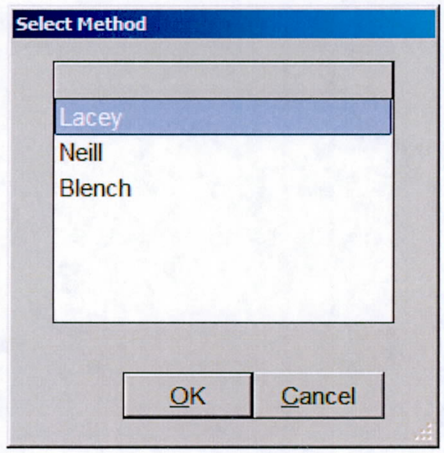
(e) Click the browse button in the **Method** column across **Long Term** checkbox on the **Total** tab to launch **Select Method** window and to select the method to use for Long-term scour analysis.

(f) On the **Select Method** form, select the *"Equilibrium Slope for Sediment-Laden Flow"*, and click **OK** to close the **Select Method** form.

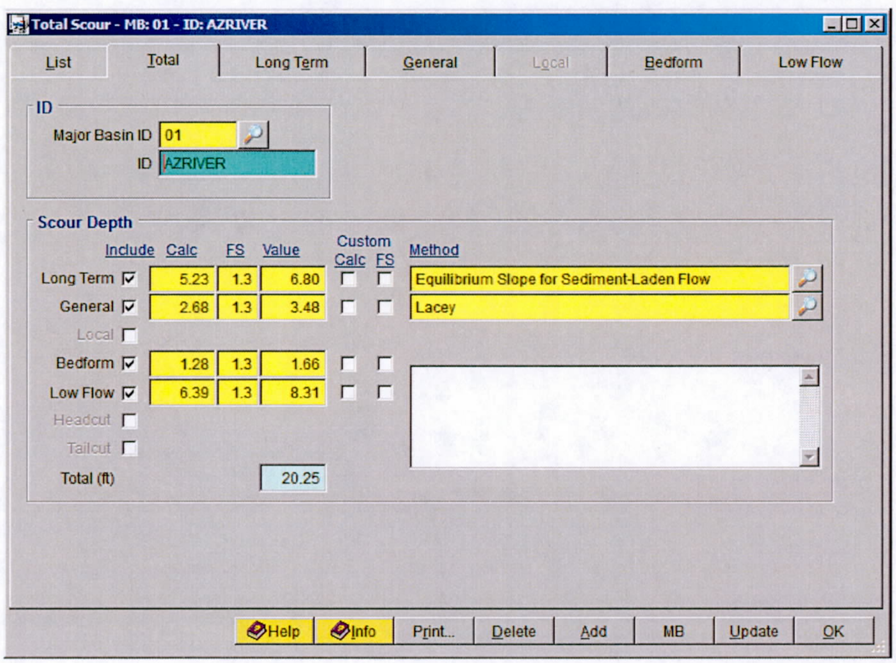


(g) Click the browse button in the method column across **General** check box on the **Total** tab to launch **Select Method** form.

(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.

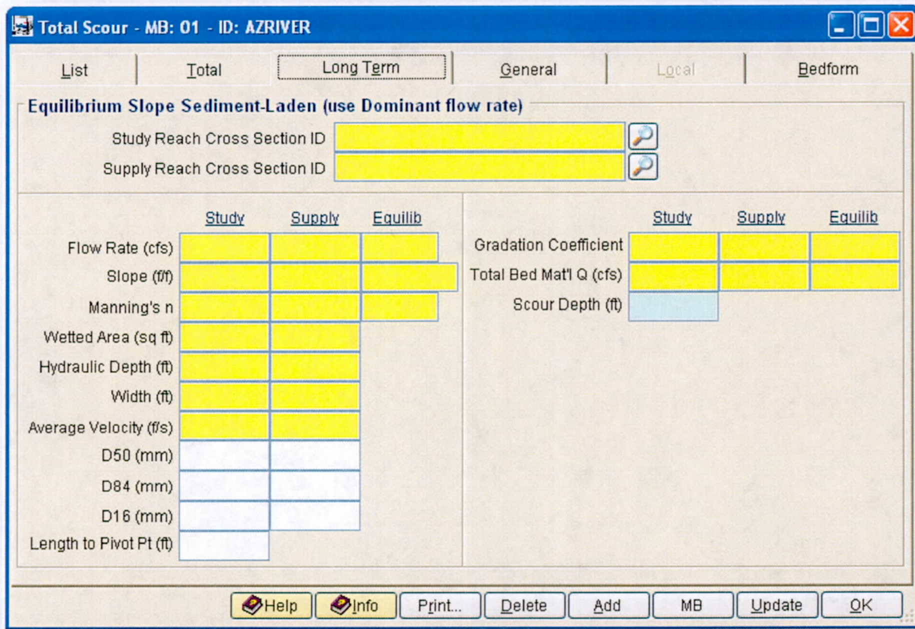


(i) Click the **Save** button to save the entered data. The **Total Scour** form should look like the following figure.



B.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 *"STUDYREACHCROSSSECTION"*, 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** *"SUPPLYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** form.

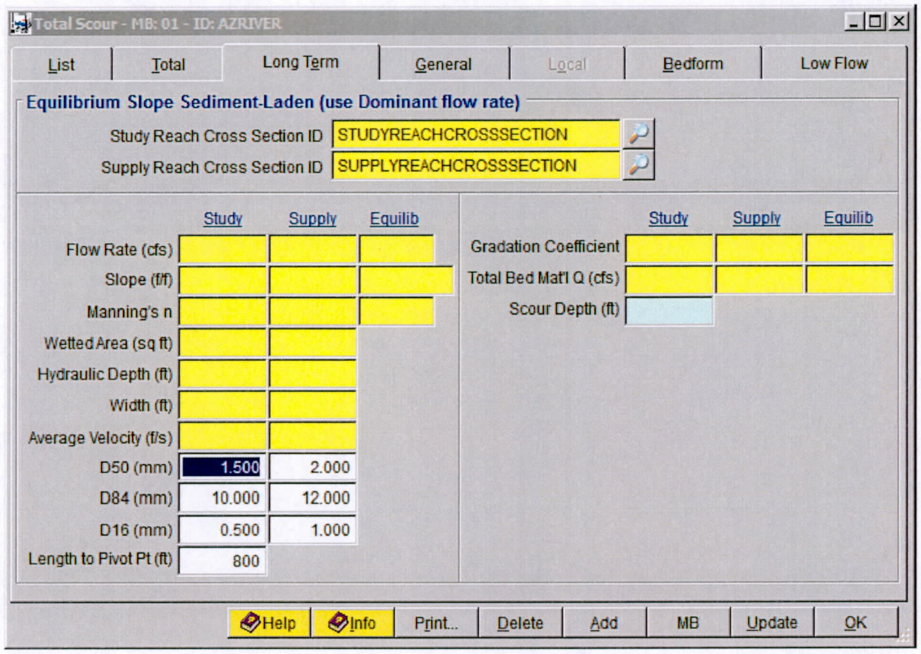
(d) Enter the **D50 (mm)** values *"1.5"* and *"2.0"* for **Study** and **Supply**, respectively.

(e) Enter the **D84 (mm)** values *"10"* and *"12"* for **Study** and **Supply**, respectively.

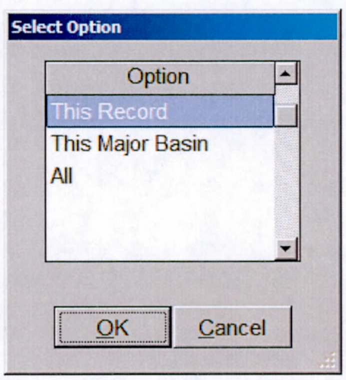
(f) Enter the **D16 (mm)** values *"0.5"* and *"1.0"* for **Study** and **Supply**, respectively.

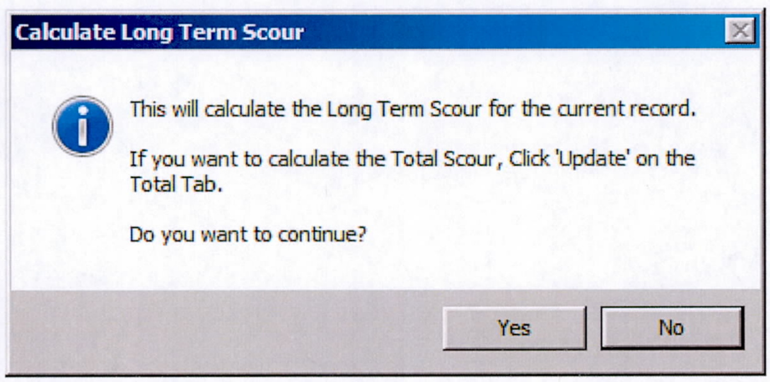
(g) Enter *"800"* into **Length to Pivot Pt (ft)** textbox

(h) Click the **Save** button to save the entered data. (The form should look like the following figure).

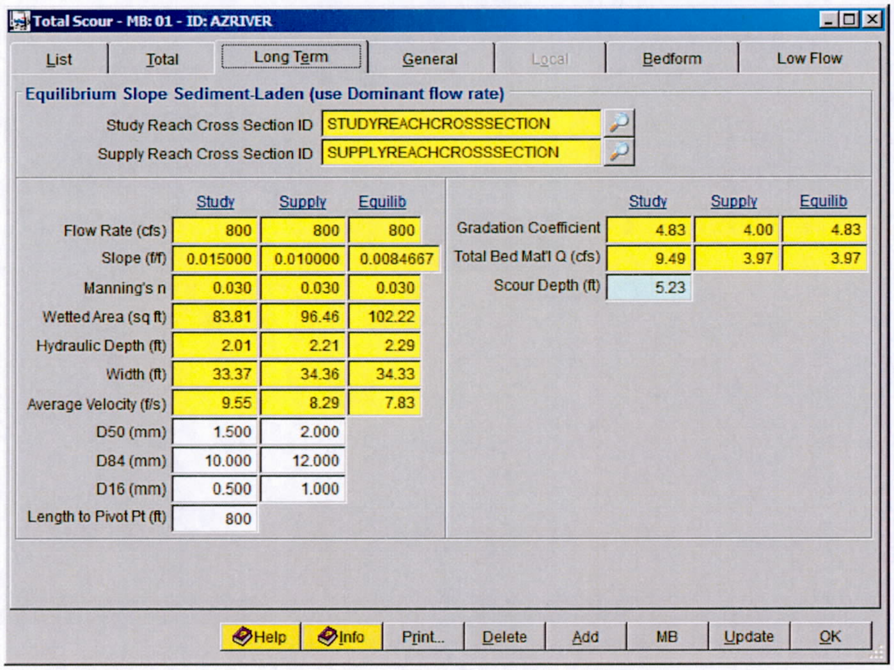


(i) Click the **Update** button to start the computation; select *"This Record"* from the **SELECTION OPTION** window, and click **Yes** to continue.





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



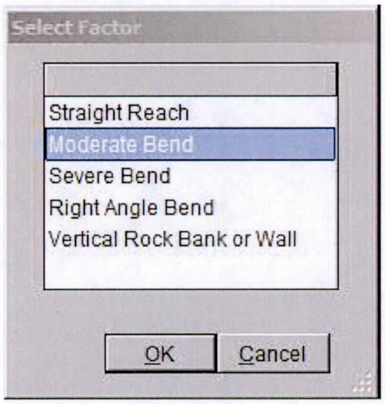
B.3.3 Calculate the General Scour

(a) Click the **General** tab to evaluate the General scour.

(b) 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.

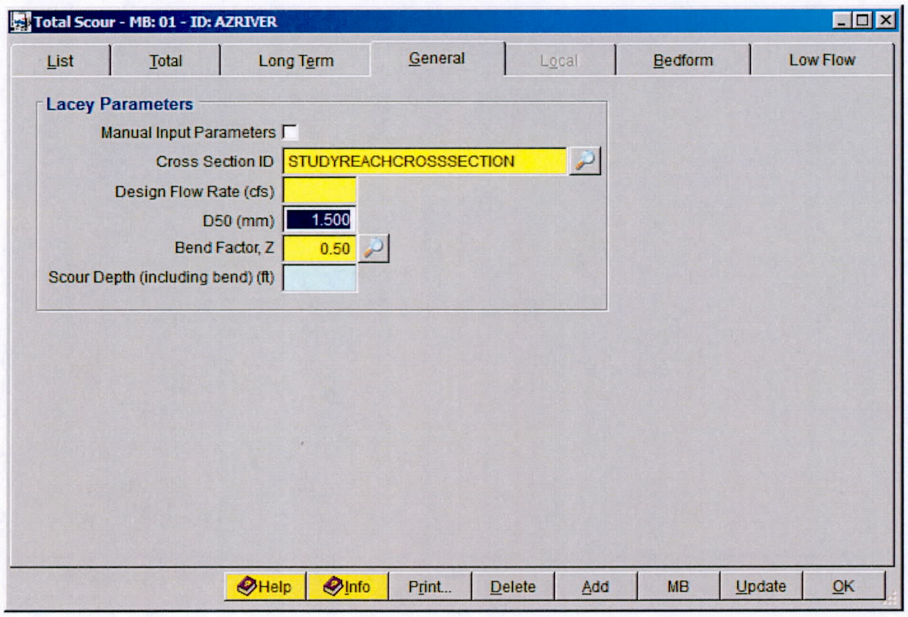
(c) Enter *"1.5"* into the **D50 (mm)** textbox.

(d) Click the browse button beside the **Bend Factor, Z** textbox to open the **SELECT FACTOR** window and select *"Moderate Bend"*.

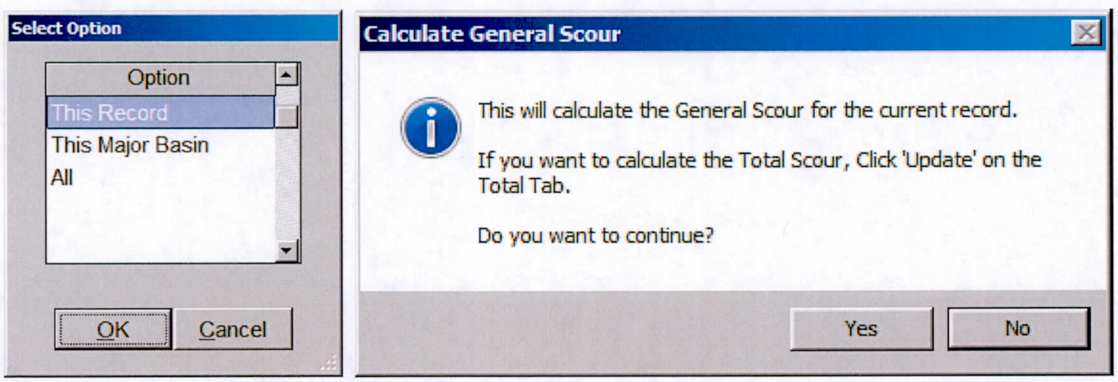


(e) Click the **Save** button to save the entered data.

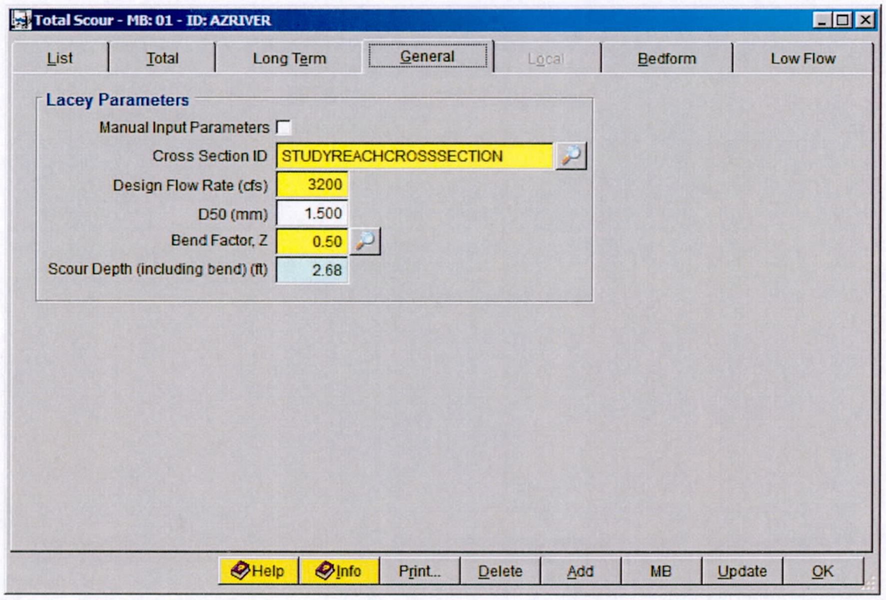
The following figure shows what the window looks like after the data entry.



(f) Click the **Update** button and select *"This Record"* from the **Selection Option** window. Click **Yes** on the **Calculate General Scour** form to proceed.



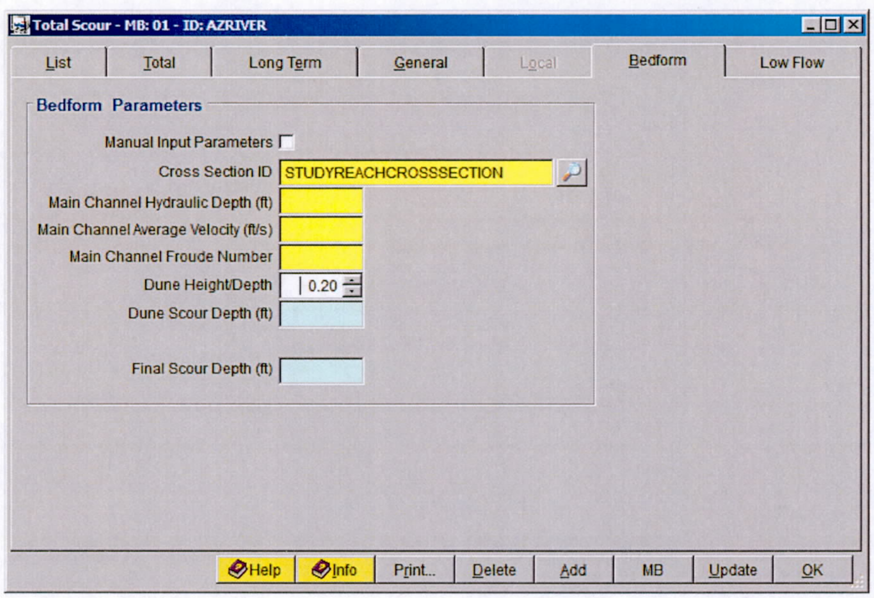
After the update, the final result of the general term scour calculation is shown in the following figure.



B.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.

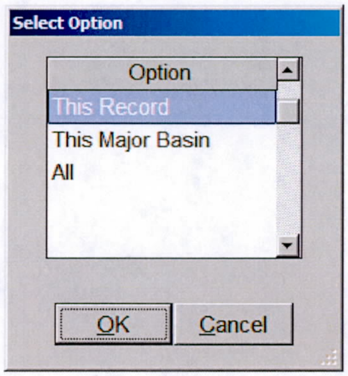


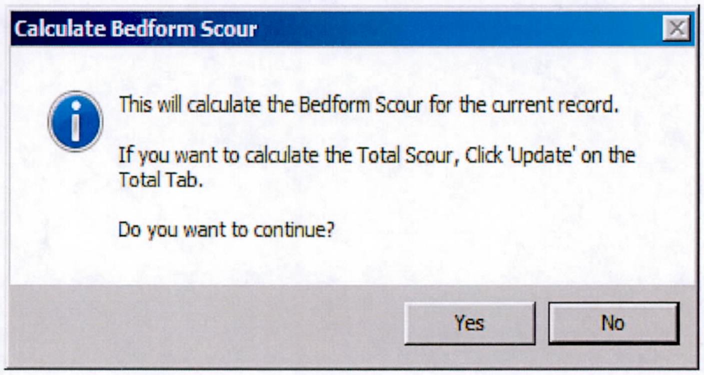
(a) Click browse button beside the **Cross Section ID** to select the cross section **ID** *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **Select Cross Section ID** window.

(b) Set the **Dune Height/Depth** value to *"0.20"*.

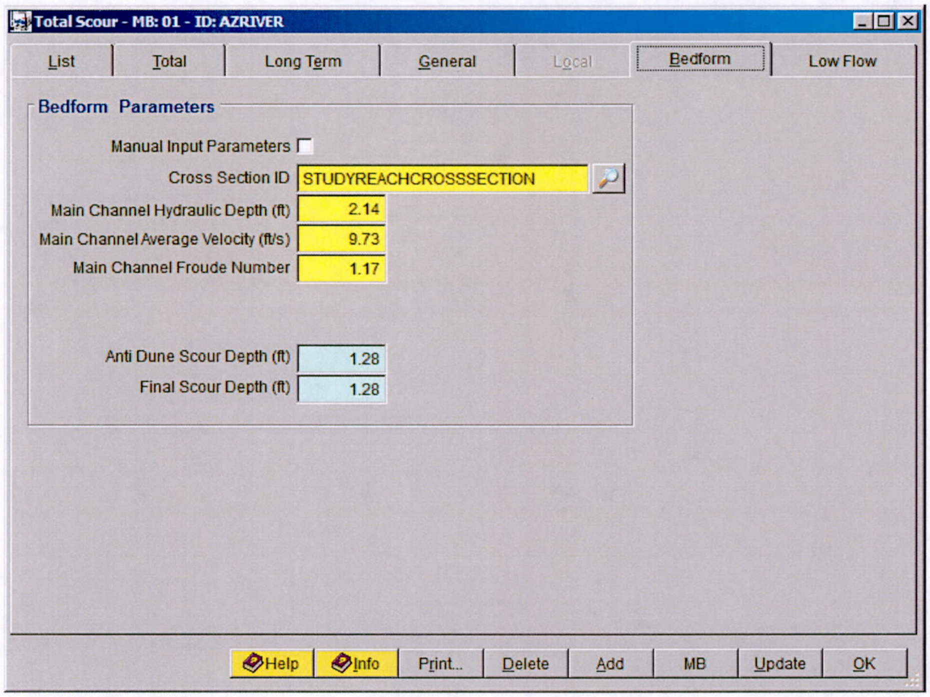
(c) Click the **Save** button to save the data just entered.

(d) Click the **Update** button and select *"This Record"* from the **Selection Option** window. Click **Yes** to continue.





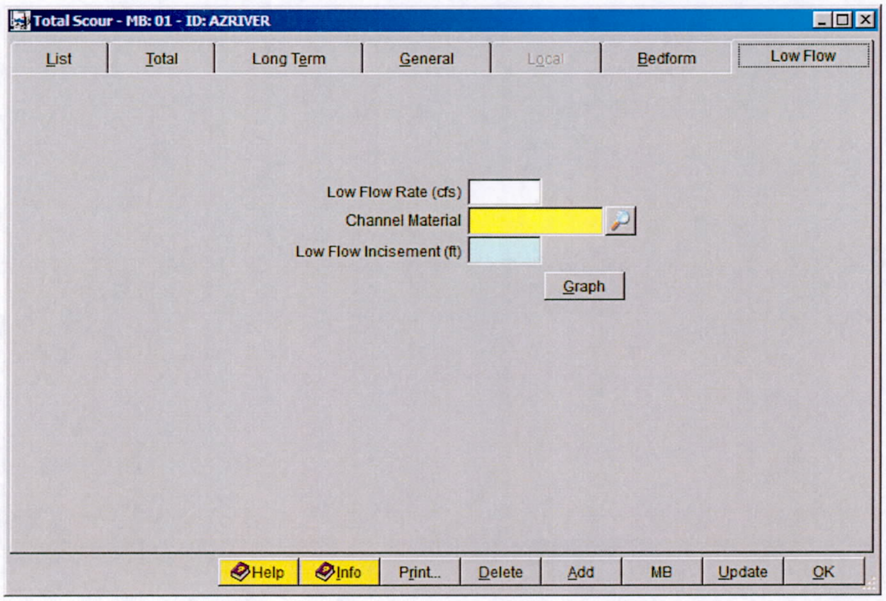
After the update, the final result of the bedform scour calculation is shown in the following figure.



B.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.

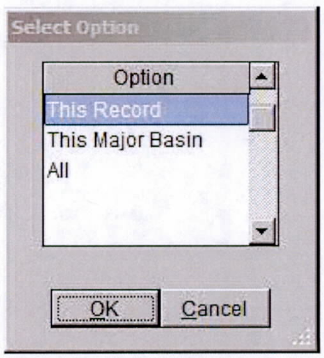


(a) Enter *"100"* into the **Low Flow Rate (cfs)** textbox.

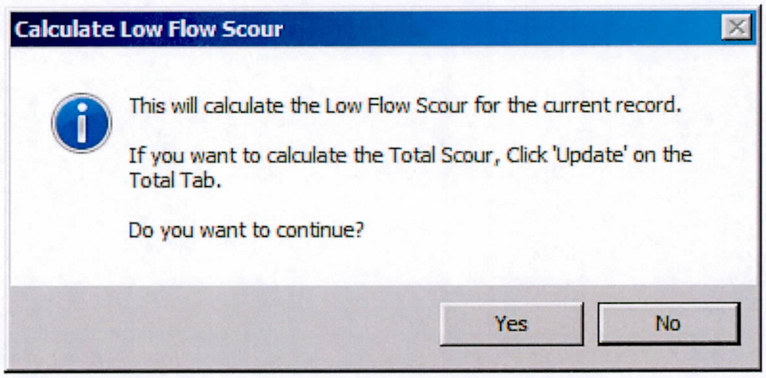
(b) Click browse button beside the **Channel Material** to select the channel material data. Choose *"Medium Sand"* and click **OK** to exit the **Select Channel Material** form.

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

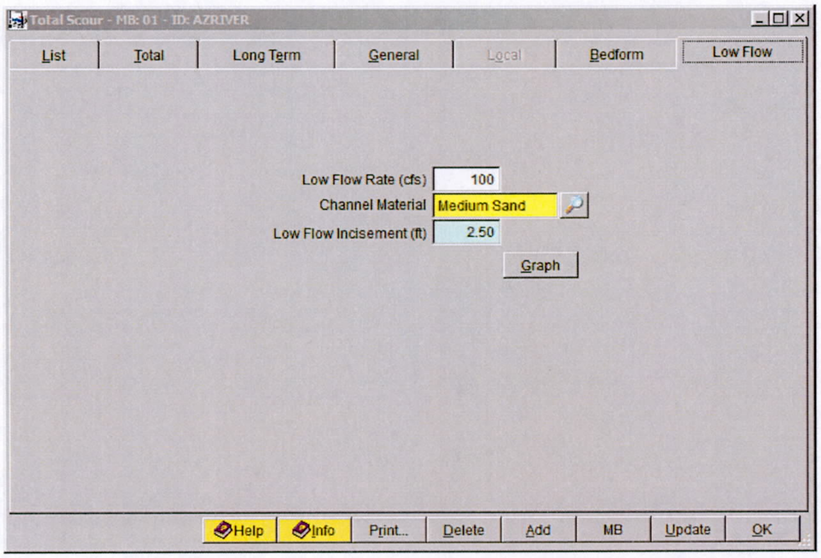
(d) Click the **Update** button and select *"This Record"* from the **Select Option** form. Click **OK**.



(e) On the **Calculate Low Flow Scour** form, click **Yes** to continue.

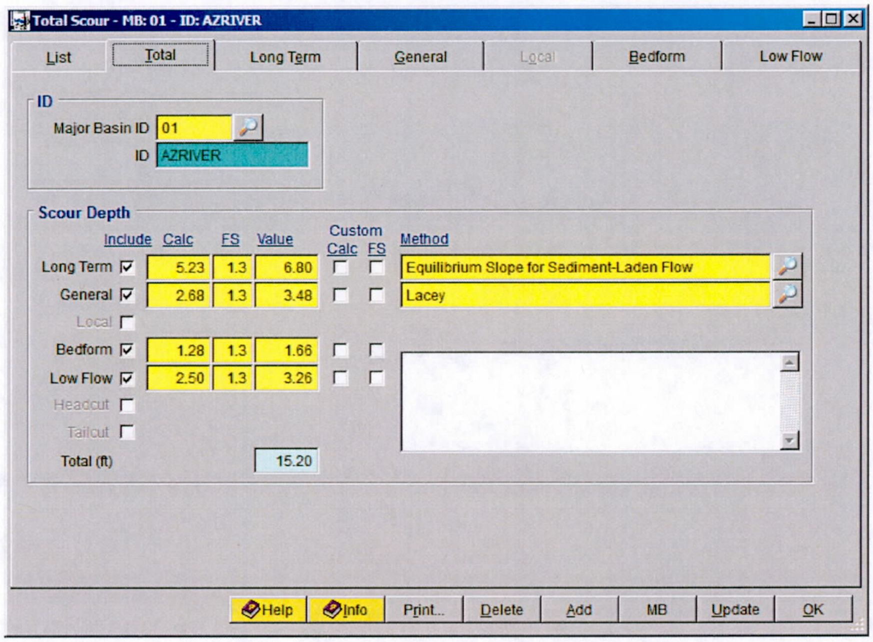


After the update, the final result of the low flow scour calculation is shown in the following figure.



B.3.6 Calculate the Total Scour

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



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

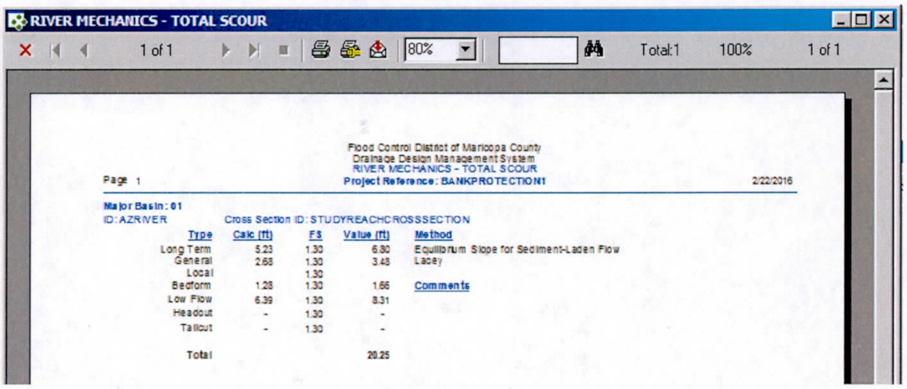
B.4 Step 4 - Report and Documentation of Results

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.



(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.

2.2 Calculate Total Scour for Bridge Pier

A. Problem Statement

To estimate the total scour depth for a bridge pier (use *"Equilibrium Slope for Sediment-Laden Flow"* method for long-term scour, use *"Neil"* method for general scour including a moderate bend, and use the local scour at the piers) with the following given conditions:

❖ The Cross Section *"BRIDGECROSSSECTION"*

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (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 geometric data (station and elevation) of the cross section:**

Station (X)	Elevation (Y)	Notes
100	*100*	
106	*98*	
131	*98*	*Left Bank Station*
141	*95*	
166	*95*	
176	*98*	*Right Bank Station*
201	*98*	
207	*100*	

❖ The Cross Section *"STUDYREACHCROSSSECTION"*

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (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*
- **Length to Pivot Point (ft):** *800*
- **The geometric data (station and elevation) of the cross section:**

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

❖ The Cross Section "*SUPPLYREACHCROSSSECTION*"

➢ Parameters for Hydraulics and Geometry:

- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rates (cfs):** *800*
- **Channel Slope** for **Design Flow (ft/ft):** *0.010*
- **Channel Slope** for **Dominant Flow (ft/ft):** *0.010*
- **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 geometric data (station and elevation) of the cross section:**

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*	

❖ Parameters for the ***Long Term*** *Scour* :

- **D50 (mm)** for Study Reach: *1.50*
- **D84 (mm)** for Study Reach: *10.00*
- **D16 (mm)** for Study Reach: *0.50*
- **D50 (mm)** for Supply Reach: *1.50*
- **D84 (mm)** for Supply Reach: *12.00*
- **D16 (mm)** for Supply Reach: *1.00*

❖ Parameters for the **General** Scour:

- **Exponent m:** *Coarse Gravel (0.85)*
- **Bend Factor, z:** *Moderate Bend (0.60)*
- **D50 (mm):** *1.50*
- **Bend Angle (Degrees):** *45.00*

❖ Parameters for the **Low Flow** Scour:

- **Low Flow Rate (cfs):** *100.00*
- **Channel Material** *Medium Sand*

❖ Parameters for the **Local** Scour:

- **Pier Width, a (ft):** *2.50*
- **Pier Length, L (ft):** *60.00*
- **Angle of Attack (Degrees):** *30.00*
- **D50 (mm):** *1.50*
- **D95 (mm):** *20.00*
- **Nose Shape Factor, K1:** *1.0 (Round Nose)*
- **Bed Condition Factor, K3:** *1.2 (Medium Dune)*

B. Step-by-Step Procedures

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

Step 2: Prepare the Cross Section Hydraulics

Step 3: Import Cross Section and Hydraulic Data

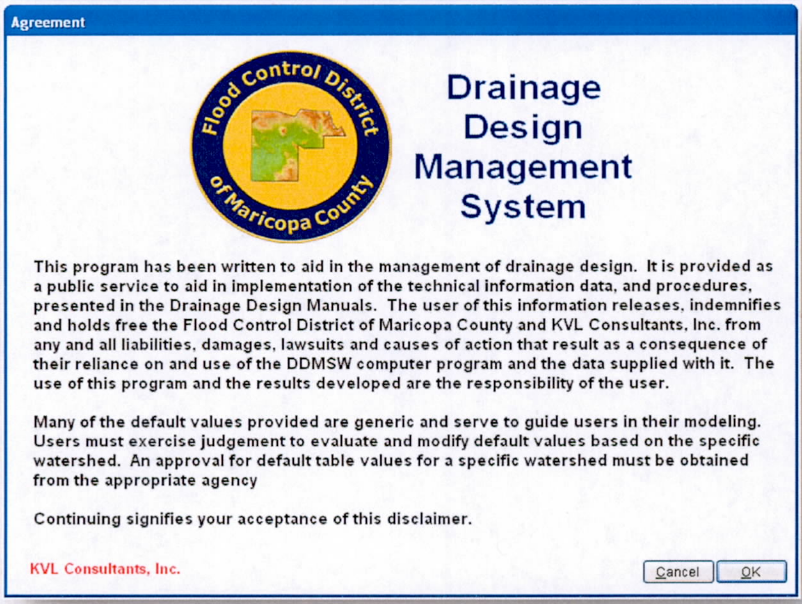
Step 4: Calculate Total Scour at Bridge Piers

- Step 4.1: Set up Total Scour Basic Data
- Step 4.2: Calculate the Long Term Scour
- Step 4.3: Calculate the General Scour
- Step 4.4: Calculate the Local Scour
- Step 4.5: Calculate the Low Flow Scour
- Step 4.6: Calculate the Total Scour

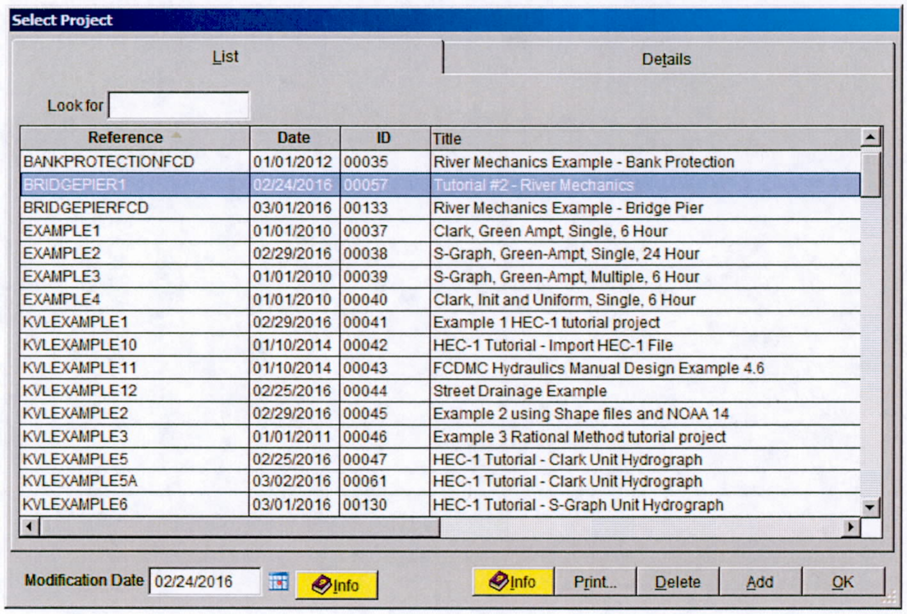
Step 5: Report and Document the Results

B.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 "*BRIDGEPIER1*" 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)***

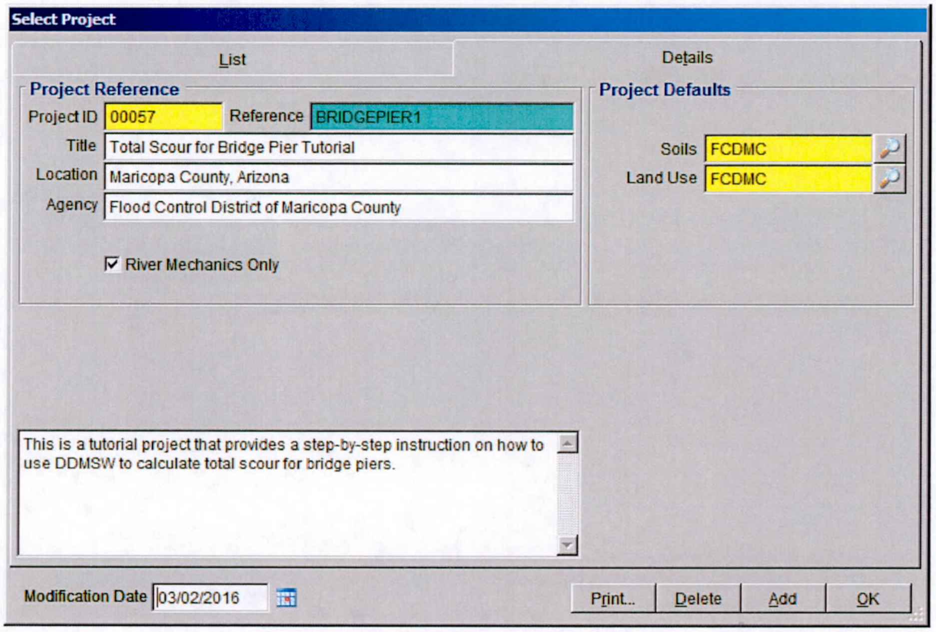
(h) Check **River Mechanics Only** checkbox for this project.

(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** *"00057"* 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.

B.2 Step 2 - Prepare the Cross Section Hydraulics

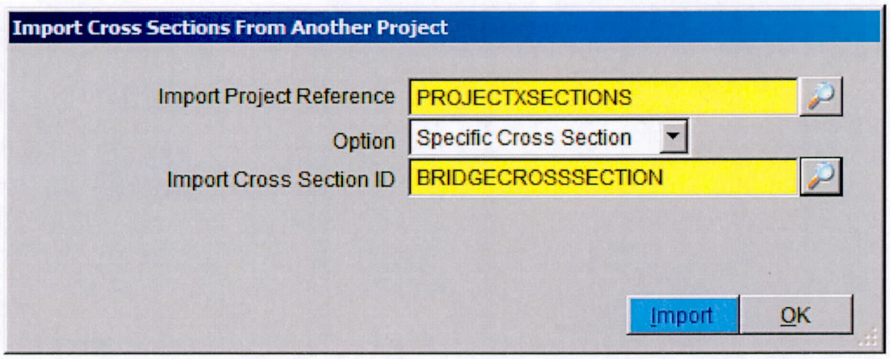
All the three (3) cross section data that will be used for this tutorial will be imported from another project. These cross section data are:

- Bridge Cross Section Data *"BRIDGECROSSSECTION"*
- Study Reach Cross Section Data *"STUDYREACHROSSSECTION"*
- Supply Reach Cross Section Data *"SUPPLYREACHCROSSSECTION"*

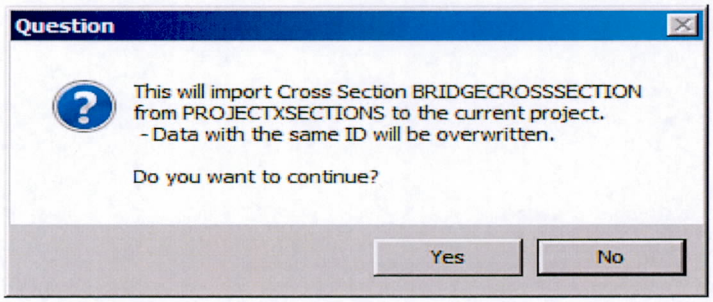
B.2.1 Import the Bridge Cross Section Data

(a) To import the first cross section data (Bridge Cross Section Data), open the IMPORT CROSS SECTIONS FROM ANOTHER PROJECT form (**River Mechanics → Import Cross Sections from Another Project**). Use the following data on the form.

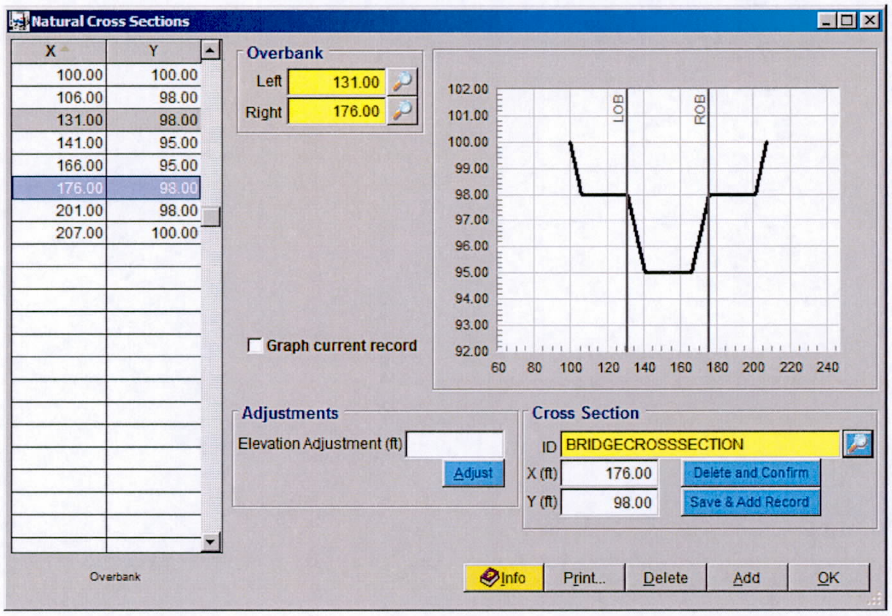
- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *BRIDGECROSSSECTION*



(b) Once the specified data have been selected, click the **Import** button. Select **Yes** to proceed, and hit **OK** to close the **Import Cross Section from Another Project** form.



(c) To check if the bridge cross section data has been successfully imported, open the **Natural Cross Sections** form (**River Mechanics ➔ Cross Section Geometry**). For the **Cross Section ID**, select *"BRIDGECROSSSECTION"* by clicking the Selector button at the right side of the **ID** textbox.

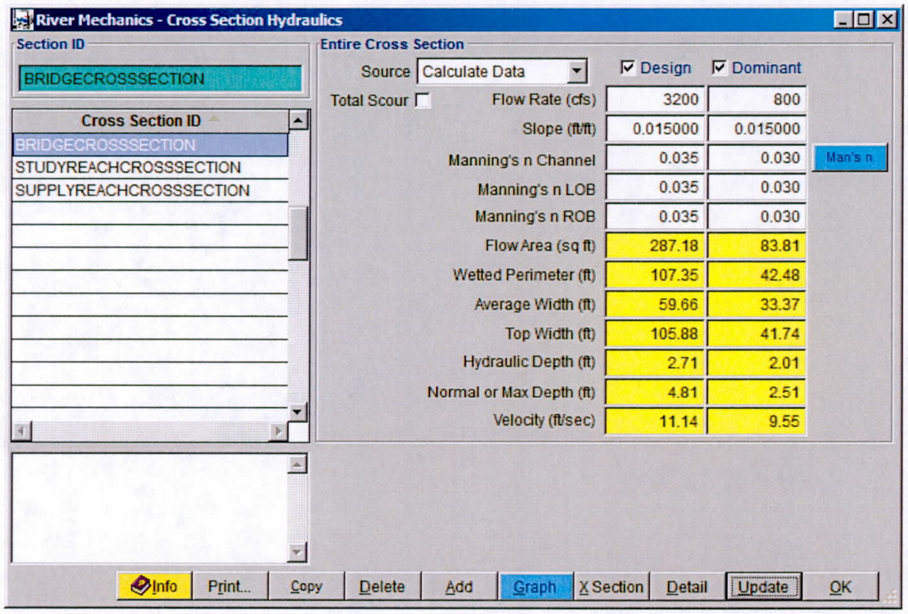


Compare the geometric data on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

Station (X)	Elevation (Y)	Notes
100	*100*	
106	*98*	
131	*98*	*Left Bank Station*
141	*95*	
166	*95*	
176	*98*	*Right Bank Station*
201	*98*	
207	*100*	

(d) To check if the imported hydraulic 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**). Make sure that the **Cross Section ID** is set to *"BRIDGECROSSSECTION"* and compare the data on the form and the following data:

- **Cross Section ID:** *BRIDGECROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rate (cfs):** *800*
- **Design Slope (ft/ft):** *0.015*
- **Dominant Slope (ft/ft):** *0.015*
- **Design Manning's n (Channel, LOB, and ROB):** *0.035*
- **Dominant Manning's n (Channel, LOB, and ROB):** *0.030*



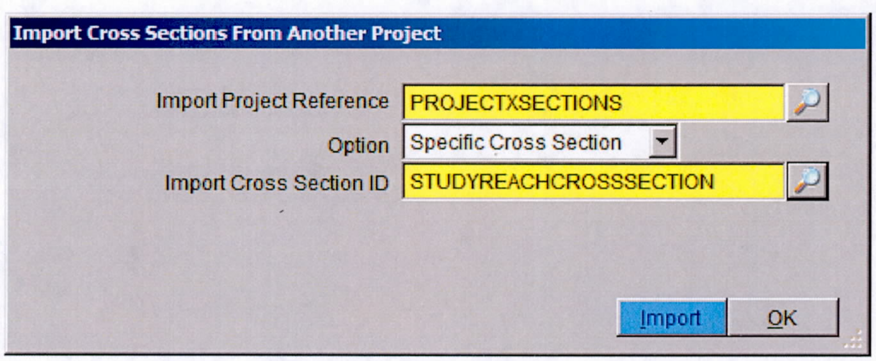
(e) If everything checks out, click the **Update** button to update the hydraulic analysis results. On the **Select Option** form, select *"This Record"* and click **OK**. Hit **Yes** to continue.

(f) Click **OK** to close the **River Mechanics – Cross Section Hydraulics** form.

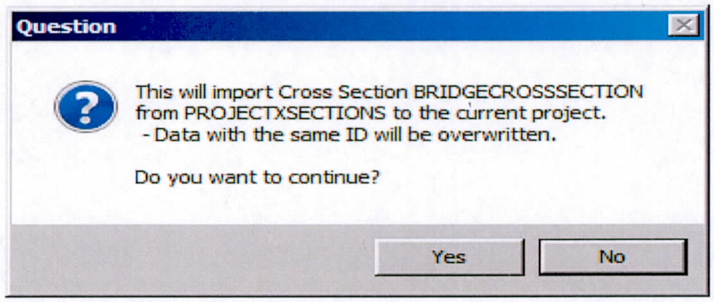
B.2.2 Import the Study Reach Cross Section Data

(a) To import the second cross section data (Study Reach Cross Section Data), open the **Import Cross Sections from Another Project** form (**River Mechanics ➔ Import Cross Sections from Another Project**). Use the following data on the form.

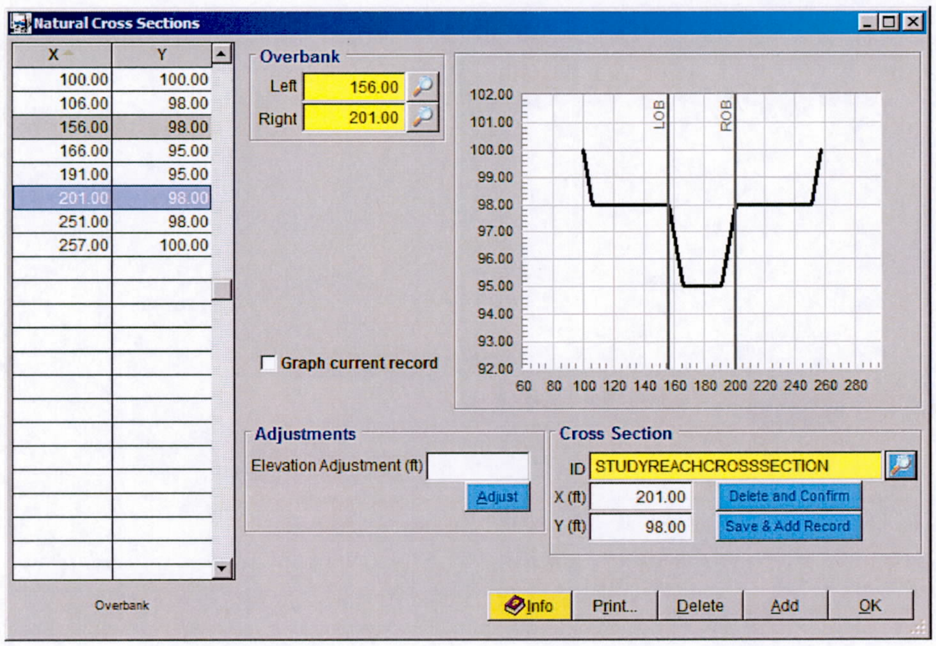
- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *STUDYREACHCROSSSECTION*



(b) Once the specified data have been selected, click the **Import** button. Select **Yes** to continue, and hit **OK** to close the **IMPORT CROSS SECTION FROM ANOTHER PROJECT** form.



(c) To check if the study reach cross section data has been successfully imported, open the **NATURAL CROSS SECTIONS** form (**River Mechanics → Cross Section Geometry**). For the **Cross Section ID**, select *"STUDYREACHROSSSECTION"* by clicking the Selector button at the right side of the **ID** textbox.



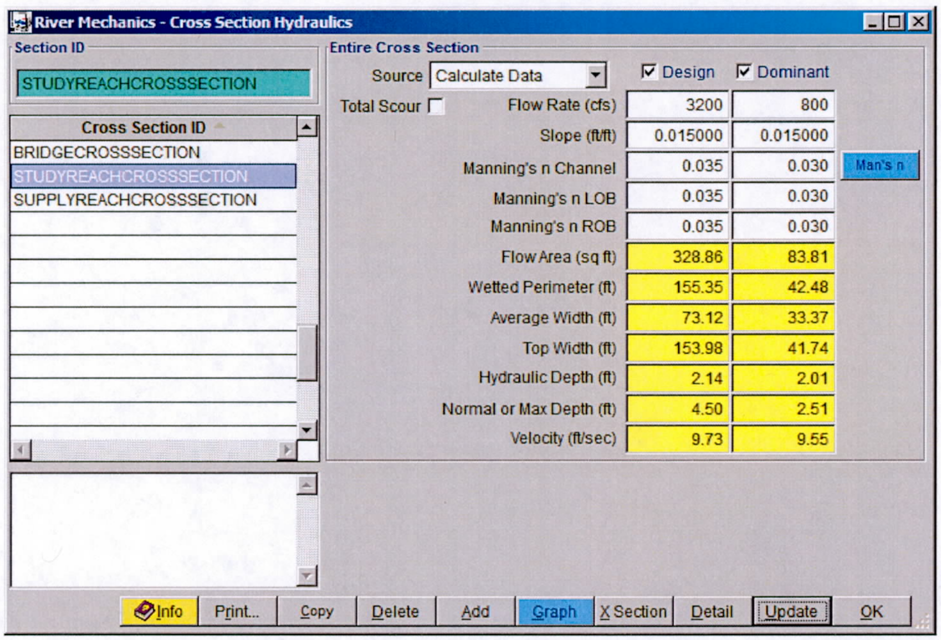
Compare the geometric data on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

Station (X)	Elevation (Y)	Notes
100	*100*	
106	*98*	

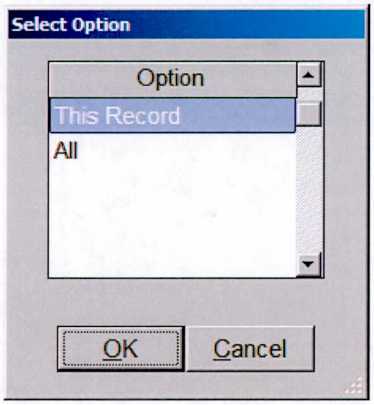
Station (X)	Elevation (Y)	Notes
156	*98*	*Left Bank Station*
166	*95*	
191	*95*	
201	*98*	*Right Bank Station*
251	*98*	
257	*100*	

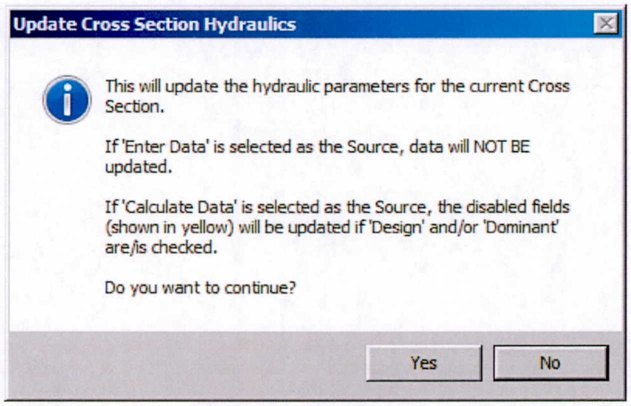
(d) To check if the imported hydraulic data has all the correct **Flow Rates (cfs)**, **Slopes (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** data, open the **CROSS SECTION HYDRAULICS** form (**River mechanics → Cross Section Hydraulics**). Make sure that the **Cross Section ID** is set to *"STUDYREACHCROSSSECTION"* and compare the data on the form and the following data:

- **Cross Section ID:** *STUDYREACHCROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rate (cfs):** *800*
- **Design Slope (ft/ft):** *0.015*
- **Dominant Slope (ft/ft):** *0.015*
- **Design Manning's n (Channel, LOB, and ROB):** *0.035*
- **Dominant Manning's n (Channel, LOB, and ROB):** *0.030*



(e) If everything checks out, click the **Update** button to update the hydraulic analysis results. On the **Select Option** form, select *"This Record"* and click **OK**. Hit **Yes** to continue.

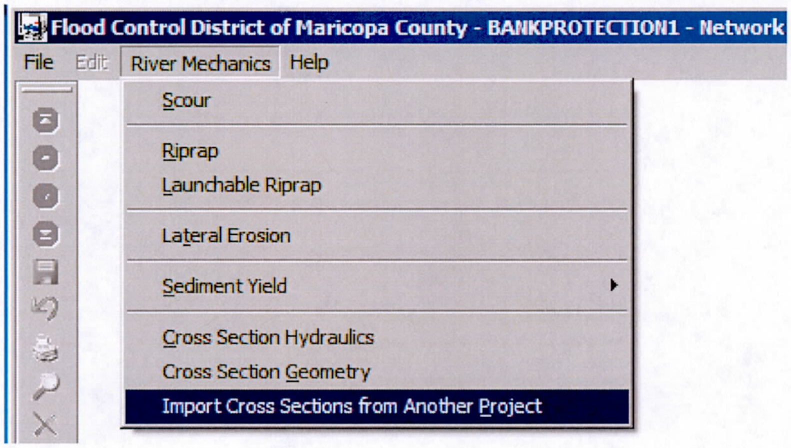




(f) Click **OK** to close the **River Mechanics – Cross Section Hydraulics** form.

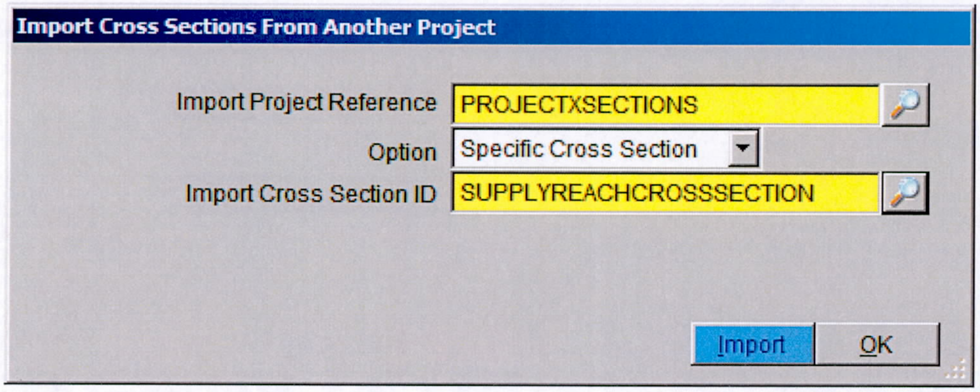
B.2.3 Import the Supply Reach Cross Section Data

(a) To import the *"SUPPLYREACHCROSSSECTION"* dataset, open the **Import Cross Sections from Another Project** form (**River mechanics → Import Cross Sections from Another Project**).

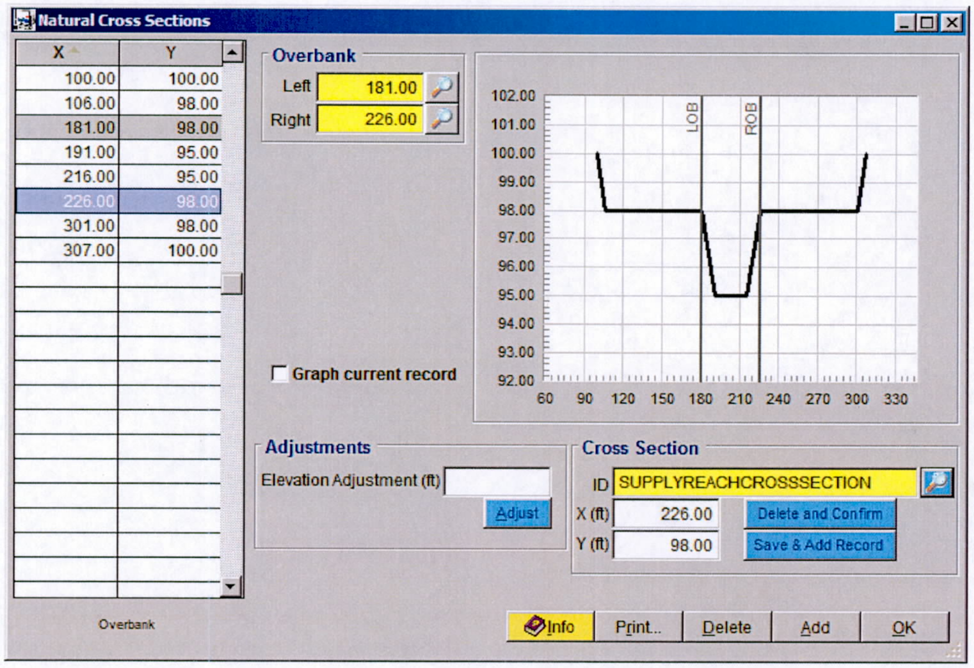


(b) On the **Import Cross Sections from Another Project** form, use the data provided below. Click **Import** to import the cross section data into the project. Select **Yes** to continue, and hit **OK** to close the form.

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



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



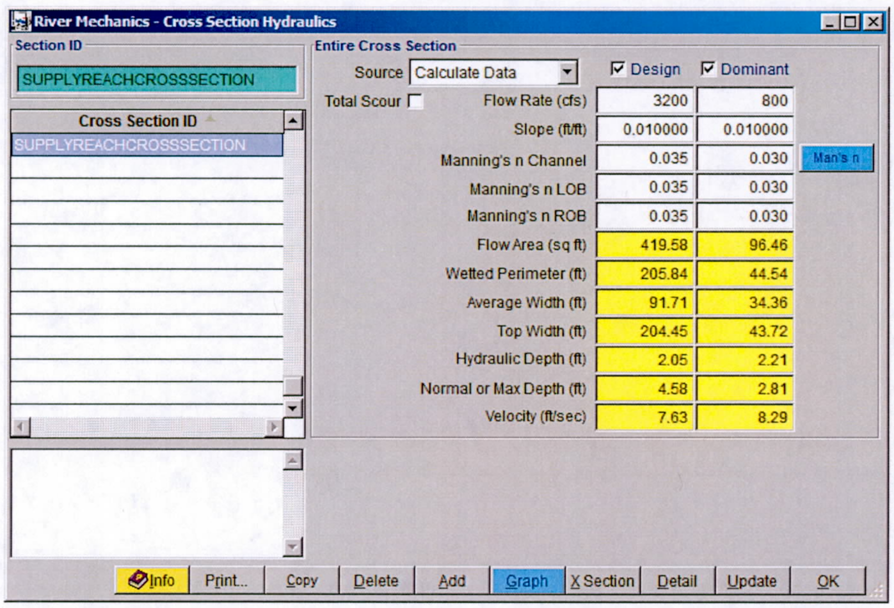
Compare the geometric data on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

Station (X)	Elevation (Y)	Notes
100	*100*	
106	*98*	
181	*98*	*Left Bank Station*
191	*95*	
216	*95*	

Station (X)	Elevation (Y)	Notes
226	*98*	*Right Bank Station*
301	*98*	
307	*100*	

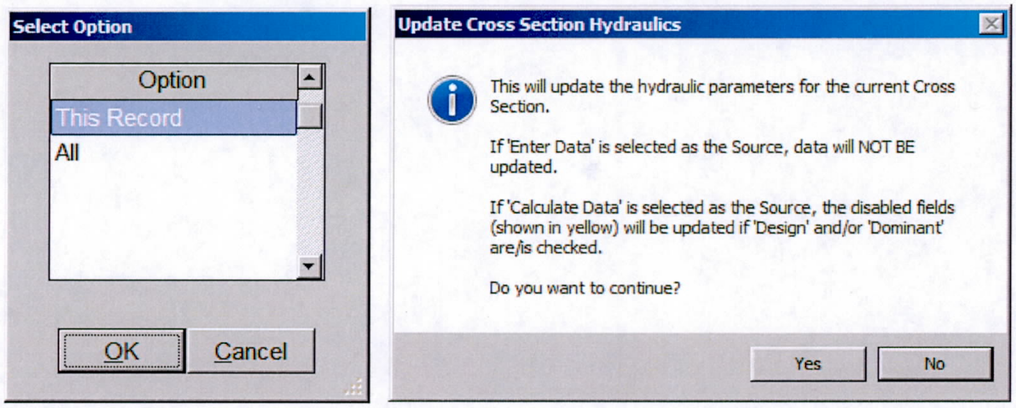
(d) To check if the imported data has all the correct **Flow Rates (cfs)**, **Slopes (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** data, open the **Cross Section Hydraulics** form (**River mechanics ➔ Cross Section Hydraulics**). To compare, make sure that the **Cross Section ID** is set to *"SUPPLYREACHCROSSSECTION"*.

- **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*



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

(f) On the **Select Option** form, select *"This Record"* and click **OK**. Hit **Yes** to continue.



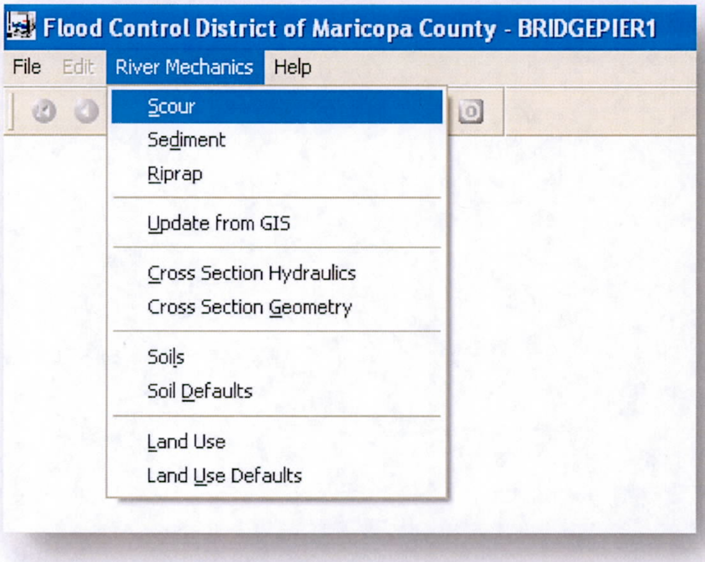
(g) Click OK to close the **River Mechanics – Cross Section Hydraulics** form.

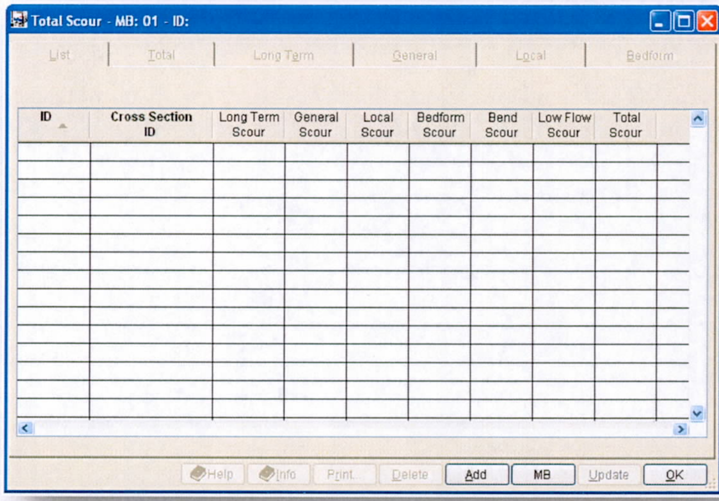
Creating the three cross sections and evaluating their respective hydraulics in **Step 2** are essential steps before proceeding to **Step 3** of this tutorial.

B.3 Step 3 - Calculate Total Scour

B.3.1 Set up Total Scour Basic Data

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



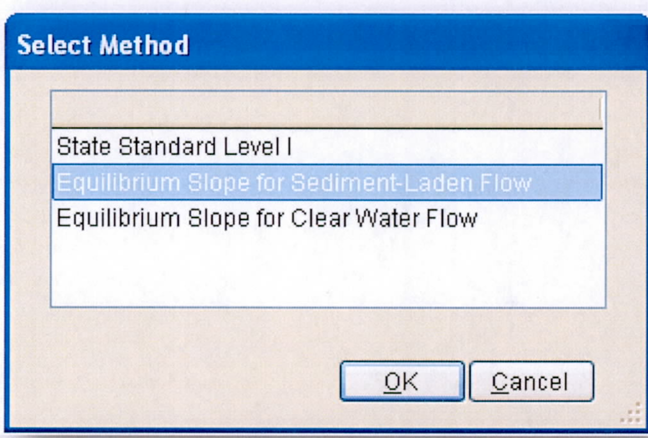


(b) Click the **Add** button to activate the necessary data entry fields.

(c) Type *"PIERNO1"* into the **ID** textbox (this **ID** indicates that it is for Pier No.1).

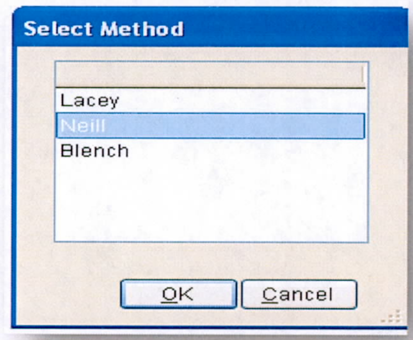
(d) Check the checkboxes **Long Term**, **General**, **Local**, and **Low Flow** (**Bed Form** is not computed because it will be part of pier local scour computation where the K3 factor, the *Bed Condition Factor*, will be used).

(e) Click the browse button in the **Method** column across **Long Term** check box to launch long term scour method select menu.



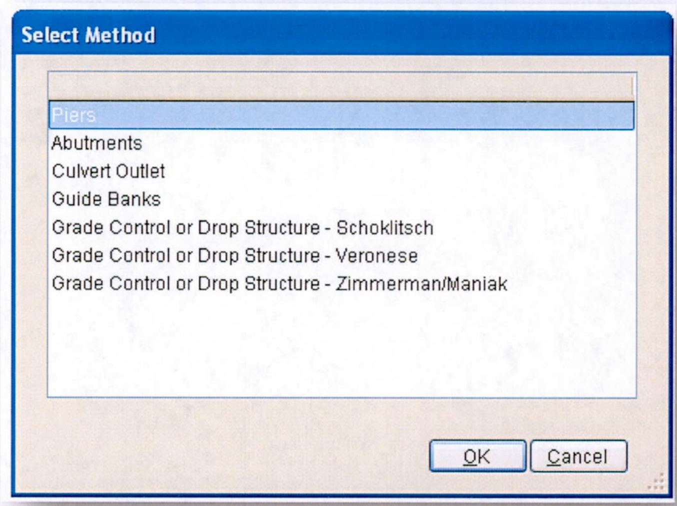
Select the *"Equilibrium Slope for Sediment-Laden Flow"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(f) Click the browse button in the **Method** column across **General** check box to launch general scour method select menu.



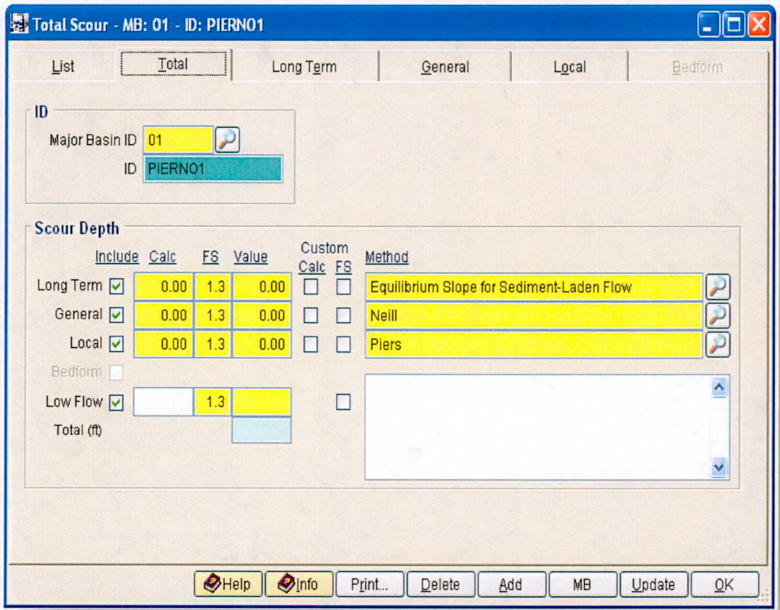
(g) Select the *"Neil"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

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



(i) Select the *"Piers"* from the **SELECT METHOD** window, and click **OK** to close the **SELECT METHOD** window.

(j) Click the **Save** button to save the entered data. The **TOTAL SCOUR – MB: 01 – ID: PIERNO1** window shows up like following figure.



B.3.2 Calculate the Long Term Scour

(a) Click the **Long Term** tab.

(b) Click browse  button beside the **Study Reach Cross Section ID** to select the cross section **ID** *"STUDYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

(c) Click browse  button beside the **Supply Reach Cross Section ID** to select the cross section **ID** *"SUPPLYREACHCROSSSECTION"*, and click **OK** to close the **SELECT CROSS SECTION ID** window.

(d) Enter the **D50 (mm)** values *"1.5"* and *"1.5"* for **Study** and **Supply**, respectively.

(e) Enter the **D84 (mm)** values *"10"* and *"12"* for **Study** and **Supply**, respectively.

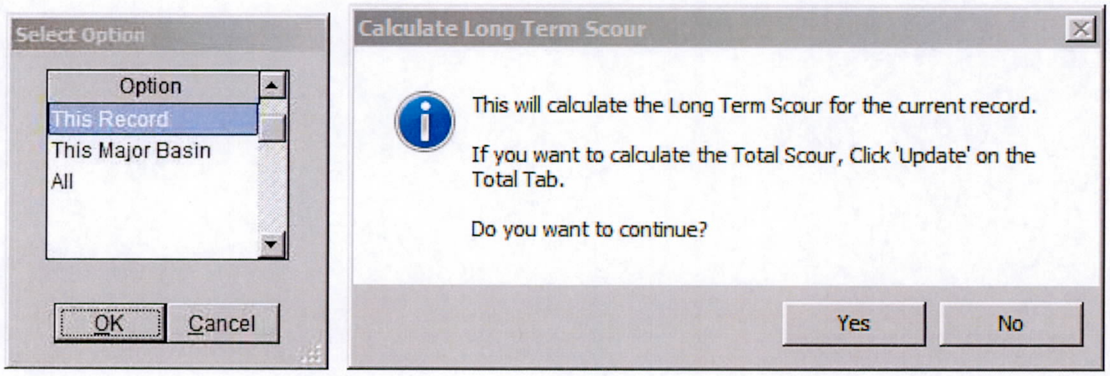
(f) Enter the **D16 (mm)** values *"0.5"* and *"1.0"* for **Study** and **Supply**, respectively.

(g) Enter *"800"* into **Length to Pivot Pt (ft)**.

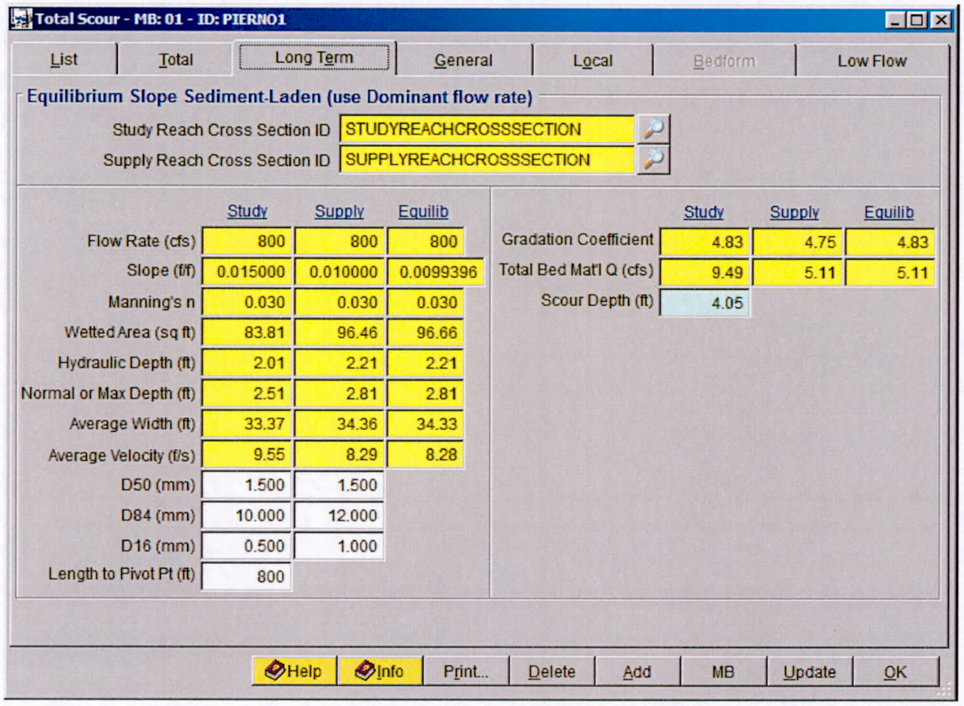
(h) Click the **Save** button to save the entered data.

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

(j) Select *"This Record"* from the **Selection Option** window, and click the **Yes** button on the **Calculate Long Term Scour** dialog box to proceed.



After the update, the result of the long term scour calculation shows in the following figure.



B.3.3 Calculate the General Scour

(a) Click the **General** tab.

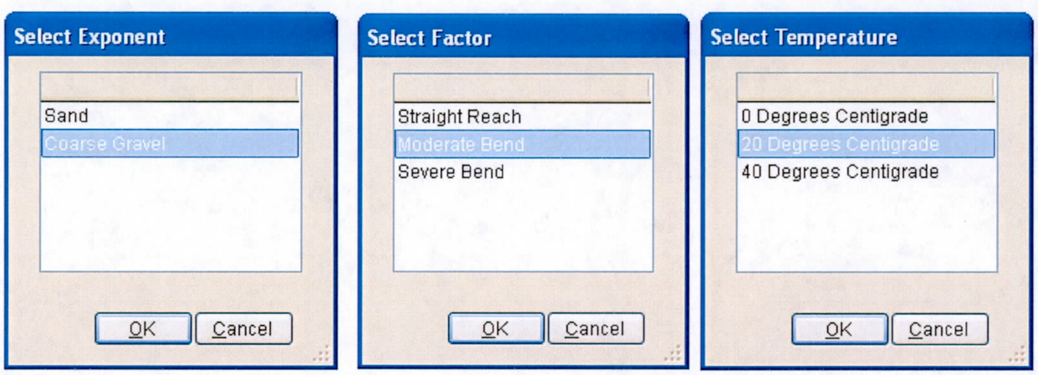
(b) Click the browse button beside the **Bridge Section ID** textbox to open the **Select Cross Section ID** window. Select the *"BRIDGECROSSSECTION"* and click **OK** to close the window.

(c) Click the browse button beside the **Upstream Section ID** textbox to open the **Select Cross Section ID** window. Select the *"STUDYREACHCROSSSECTION"* and click **OK** to close the window (<u>Note</u>: Upstream section is for the area upstream of the bridge contraction. It can be generally represented by the study reach cross-section. The supply reach cross-section is not used as the upstream section because it is upstream of the study reach and is generally far away upstream from the bridge).

(d) Click the browse button beside the **Exponent m** textbox to open the **Select Exponent** window. Select the *"Coarse Gravel"*, and click **OK** to close the window.

(e) Click the browse button beside the **Bend Factor, Z** textbox to open the **Select Factor** window. Select the *"Moderate Bend"* bend factor and click **OK** to close the window.

(f) Click the browse button beside the **Water Temp (C)** textbox to open the **Select Temperature** window. Select the *"20 Degrees Centigrade"* and click **OK** to close the window.



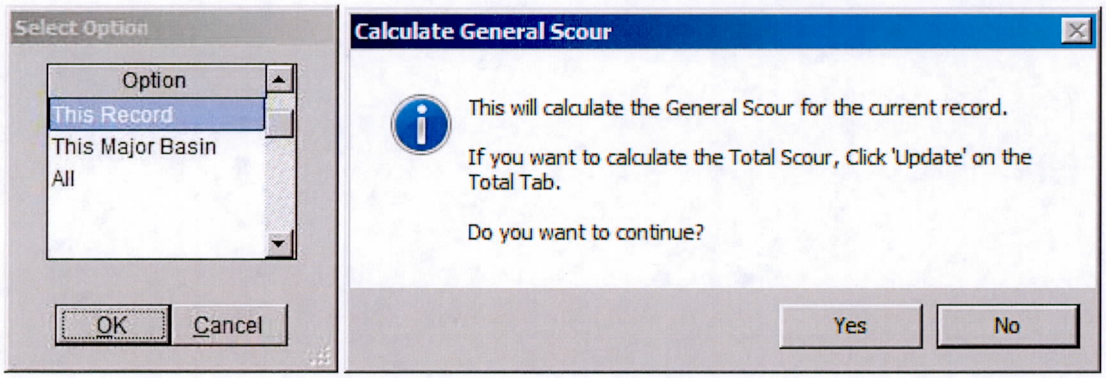
(g) **D50 (mm)**: Use the default value of *"1.5"* in the textbox (the default value is from the D50 value entered in study reach under Long Term scour menu for **Supply**). Or enter a value directly in this box. (<u>Note</u>: if a different value is entered here, the D50 value in Long Term for **Supply** will be changed).

(h) Enter *"45"* into the **Bend Angle (Degrees)** textbox

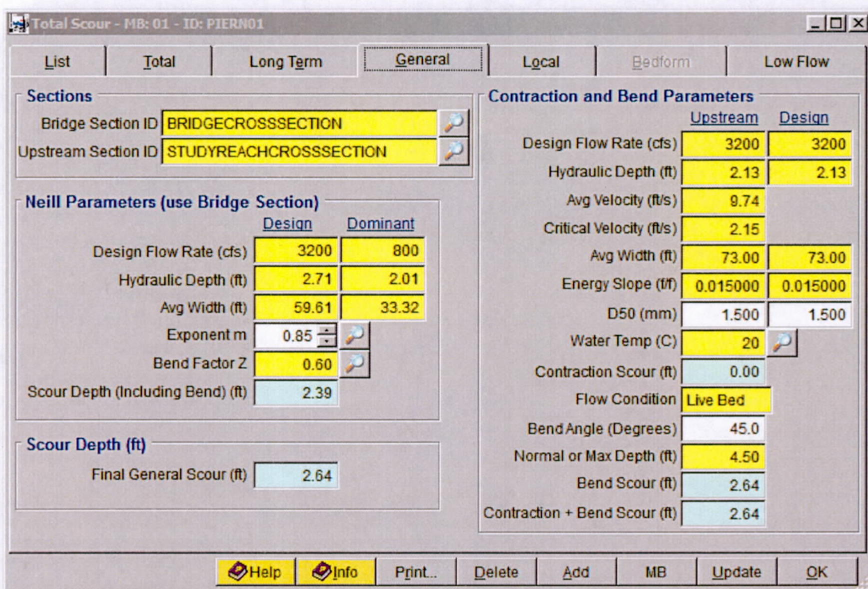
(i) Click the **Save** button to save the entered data.

(j) Click the **Update** button on the **General** tab to update the data.

(k) Select *"This Record"* from the **Selection Option** window, and click the **Yes** button on the **Calculate General Scour** dialog box to proceed.



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



B.3.4 Calculate the Local Scour

(a) Click the **Local** tab.

(b) Click the browse button beside the **Bridge Section ID** textbox to open the **Select Cross Section ID** widow. Select the *"BRIDGECROSSSECTION"* and click the **OK** button to close the window.

(c) Enter *"2.5"* into the **Pier Width, (ft)** textbox.

(d) Enter *"60"* into the **Pier Length, L (ft)** textbox.

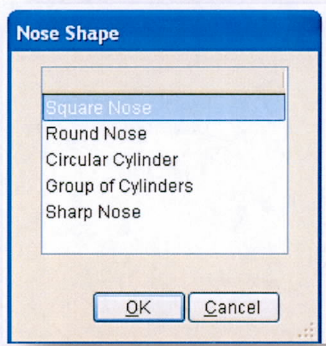
(e) Enter *"30"* into the **Angle of Attack (Degree)** textbox.

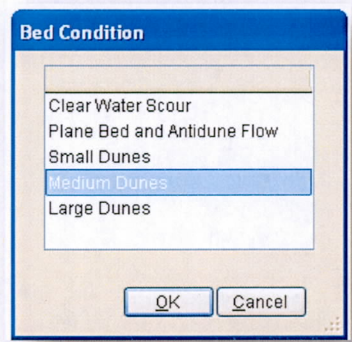
(f) Enter *"1.5"* into the **D50 (mm)** textbox.

(g) Enter *"20.0"* into the **D95 (mm)** textbox.

(h) Click the browse button beside the **Nose Shape Factor, K1** textbox to open the **NOSE SHAPE** window. Select *"Round Nose"* item, and click **OK** button to close it.

(i) Click the browse button beside the **Bed Condition Factor, K3** textbox to open the **BED CONDITION** window. Select *"Medium Dunes"* item and click **OK** button to close the window.



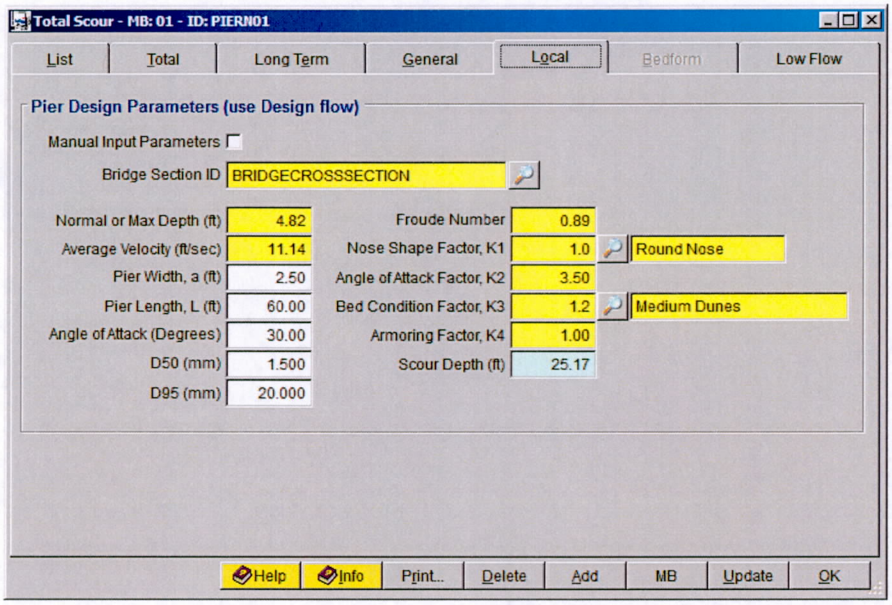


(j) Click the **Save** button to save the entered data.

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

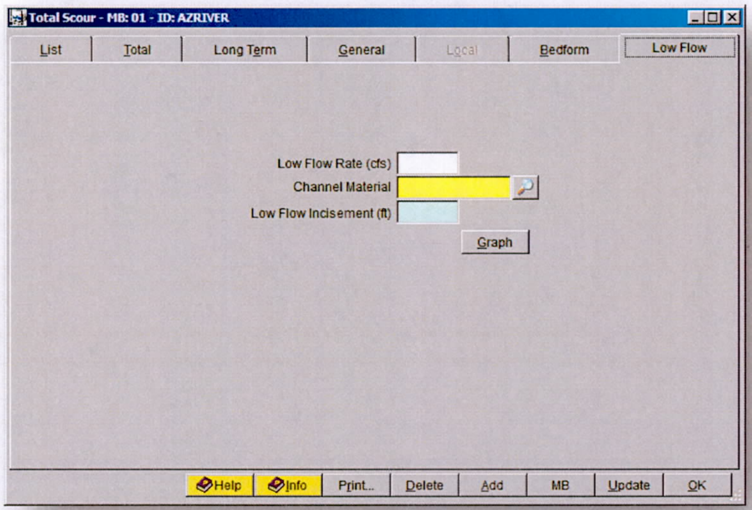
(l) Select *"This Record"* from the **SELECTION OPTION** window, and click **Yes** from the confirmation message to proceed.

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



B.3.5 Calculate the Low Flow Scour

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

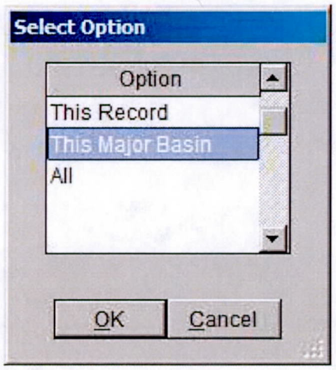


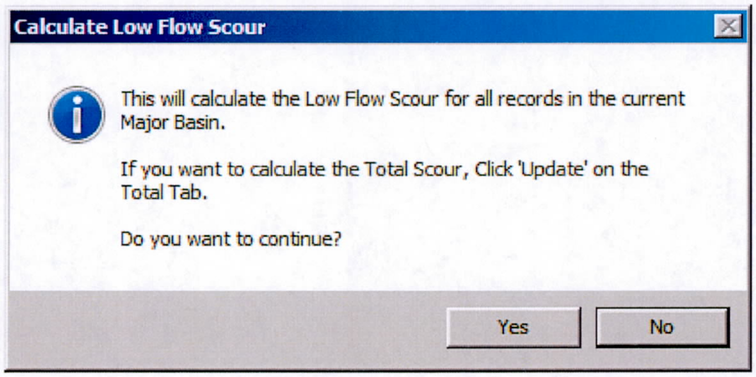
(a) Enter *"100"* into the **Low Flow Rate (cfs)** textbox.

(b) 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** window.

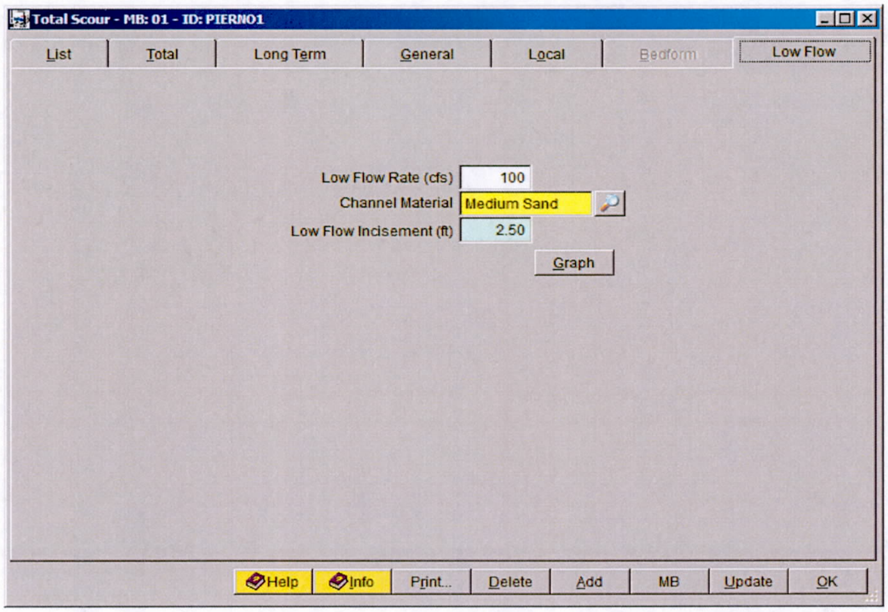
(c) Click the **Save** button to save the data just entered.

(d) Click the **Update** button and select *"This Major Basin"* from the **SELECTION OPTION** window. Click **Yes** to continue.





After the update the final result of the low flow scour calculation result shows in the following figure

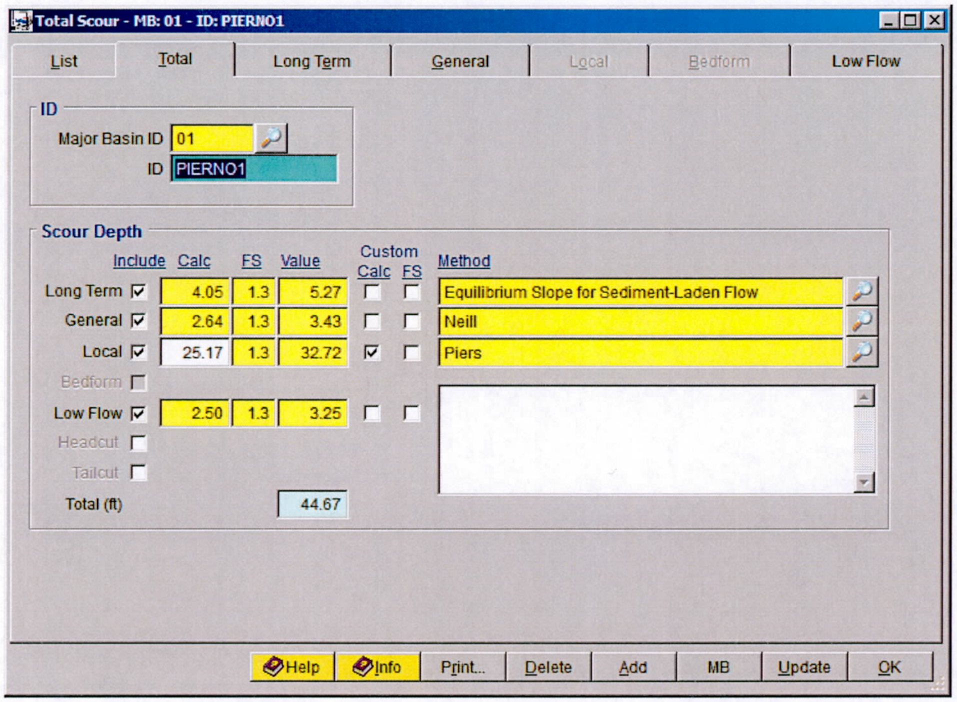


B.3.6 Calculate the Total Scour

(a) Click the **Update** button to compute the total scour and individual scour components.

(b) Select *"This Record"* from the **SELECTION OPTION** window to proceed.

After the update the window, the total scour results and individual scour components are displayed as shown in the following figure.

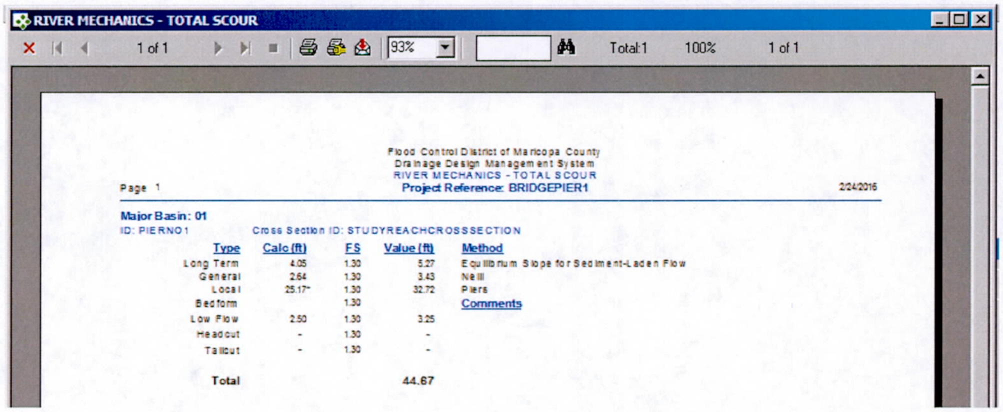


B.4 Step 4 - Report and Document the Results

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

The total scour is the sum of the long term scour, general scour, local scour, bedform scour and low flow scour. In this tutorial, these scour components are covered.

(a) To view the results on the screen, click the **Print ...** button on the **TOTAL SCOUR – MB: 01 – ID: PIERNO1** window, a report will be generated as is shown in the following figure.



RIVER MECHANICS - TOTAL SCOUR

1 of 1 | 93% | Total:1 | 100% | 1 of 1

Flood Control District of Maricopa County
Drainage Design Management System
RIVER MECHANICS - TOTAL SCOUR
Page 1 | Project Reference: BRIDGEPIER1 | 2/24/2016

Major Basin: 01
ID: PIERNO1 | Cross Section ID: STUDYREACHCROSSSECTION

Type	Calc (ft)	FS	Value (ft)	Method
Long Term	4.05	1.30	5.27	Equilibrium Slope for Sediment-Laden Flow
General	2.64	1.30	3.43	Neill
Local	25.17*	1.30	32.72	Piers
Bedform		1.30		Comments
Low Flow	2.50	1.30	3.25	
Headcut	-	1.30	-	
Tailcut	-	1.30	-	
Total			44.67	

(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 bridge pier scour evaluation.

2.3 Calculate Sediment Yield for a Watershed

A. Problem Statement

To estimate the sediment yield for a watershed, including wash load and bed load, with the following given design parameters:

- The Cross Section *"STUDYLOCATIONCROSSSECTION"*
  - Parameters for Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Dominant Flow Rates (cfs):** *800*
    - **Channel Slope** for **Design Flow (ft/ft):** *0.015*
    - **Channel Slope** for **Dominant Flow (ft/ft):** *0.015*
    - **Manning's n (Channel, LOB, ROB)** for **Design Flow:** *0.035*
    - **Manning's n (Channel, LOB, ROB)** for **Dominant Flow:** *0.030*
    - **The geometric data (station and elevation) of the cross section:**

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

  - Parameters for **Sediment Yield**:

Return period	Q (cfs)	Volume (ac-ft)
2 year	*277*	*12.00*
5 year	*486*	*18.00*
10 year	*645*	*23.00*
25 year	*869*	*30.00*
50 year	*1046*	*36.00*
100 year	*1231*	*42.00*
Design	*1231*	*42.00*

- Parameters for **Wash Load**:

  - **Sediment Area (sq mi):** *0.3508*
  - **D10 (mm)** for channel bed material soil sample: *0.500*
  - **Slope Length (ft):** *400*
  - **Slope (%):** *2.50*

- Parameters for **Bed Load**:

  - **D16 (mm)**: *0.800*
  - **D50 (mm)**: *1.500*
  - **D84 (mm)**: *10.00*

- Parameters for **Soils**:

Sediment Area ID	Soil ID	Area
• *SED1*	*6453*	*0.0508*
• *SED1*	*64590*	*0.0447*
• *SED1*	*64591*	*0.2548*
• *SED1*	*64598*	*0.0004*

- Parameters for **Land Uses**:

Sediment Area ID	Land Use Code	Area
• *SED1*	*120*	*0.0022*
• *SED1*	*150*	*0.1647*
• *SED1*	*160*	*0.0620*
• *SED1*	*180*	*0.0296*
• *SED1*	*230*	*0.0314*
• *SED1*	*410*	*0.0609*

B. Step-by-Step Procedures

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

Step 2: Prepare the Cross Section and Hydraulic Data

Step 3: Import Cross Section and Hydraulic Data

Step 4: Prepare Sediment and Relevant Data

Step 4.1: Set up Sediment Yield Basic Data

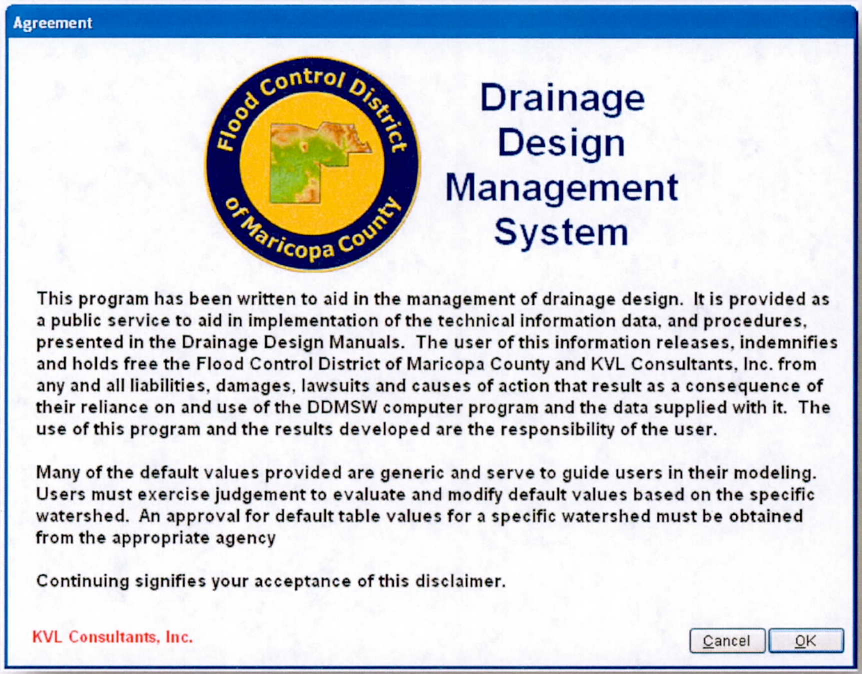
Step 4.2: Prepare Land Use and Soil Data

Step 5: Calculate the Sediment Yield

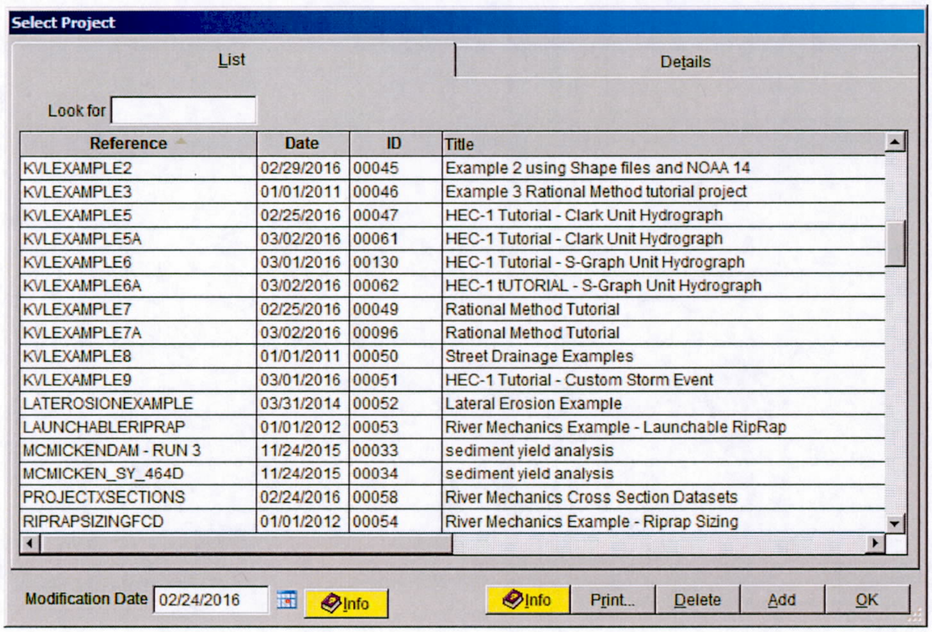
Step 6: Report the Results

B.1 Step 1 - Establish a New Project and Default 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 (A new project can also be started by clicking **File ➔ New Project** under the menu bar).

(c) On the **New Project Options** form, select **River Mechanics** checkbox and click the **OK** button to close the form.

(d) Type *"SEDIMENTYIELD1"* 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)***

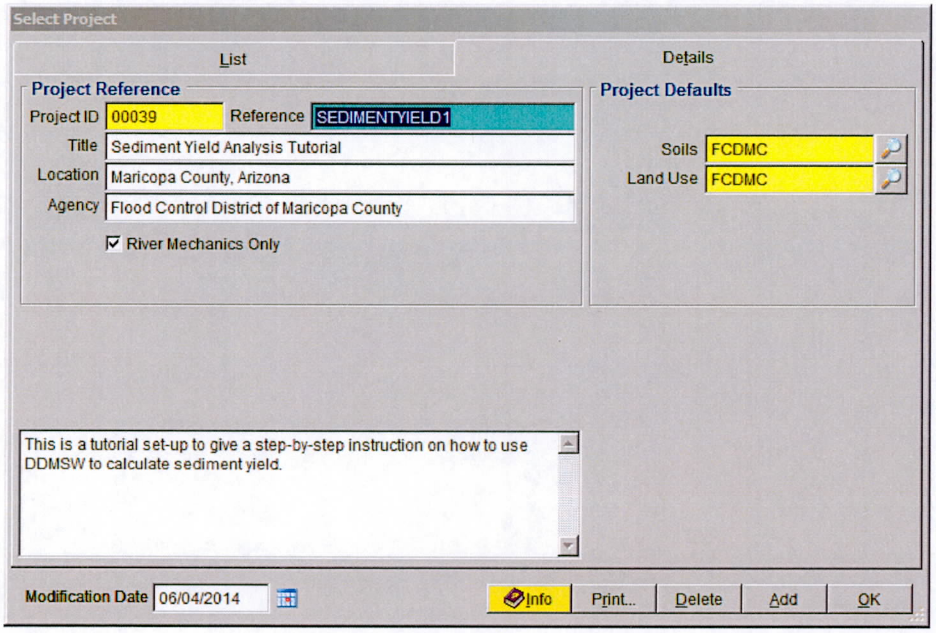
(g) Type into the **Agency** textbox the agency or company name. ***(Optional)***

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

(k) Click **OK** button on the **Select Project** window, and click **OK** button on the pop-up message box for landuse, soils data, etc. The following figure shows what the window looks like.



Note: the **Project ID** *00039* 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.

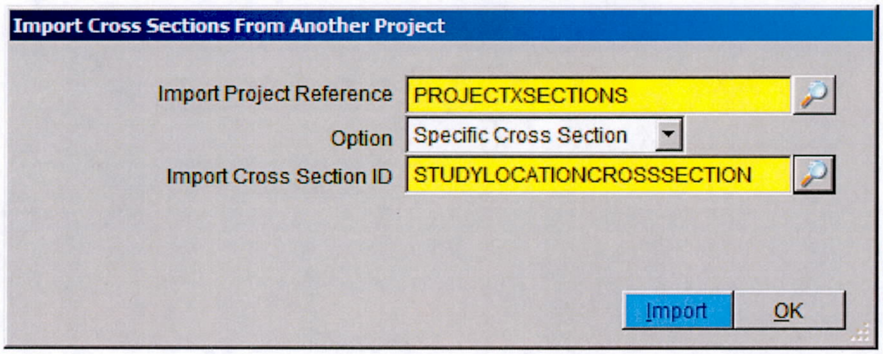
B.2 Step 2 - Prepare the Cross Section and Hydraulic Data

Only one (1) cross section data, the *"STUDYLOCATIONROSSSECTION"*, will be used for this tutorial. This cross section data will be imported from another project.

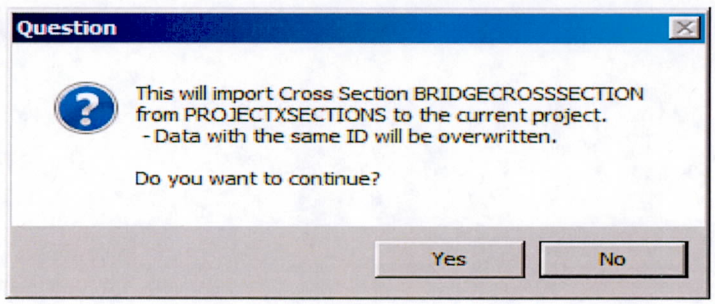
B.2.1 Import the Study Location Cross Section Data

(a) To import the first cross section data (Study Location Cross Section Data), open the **Import Cross Sections from Another Project** form (**River Mechanics ➔ Import Cross Sections from Another Project**). Use the following data on the form.

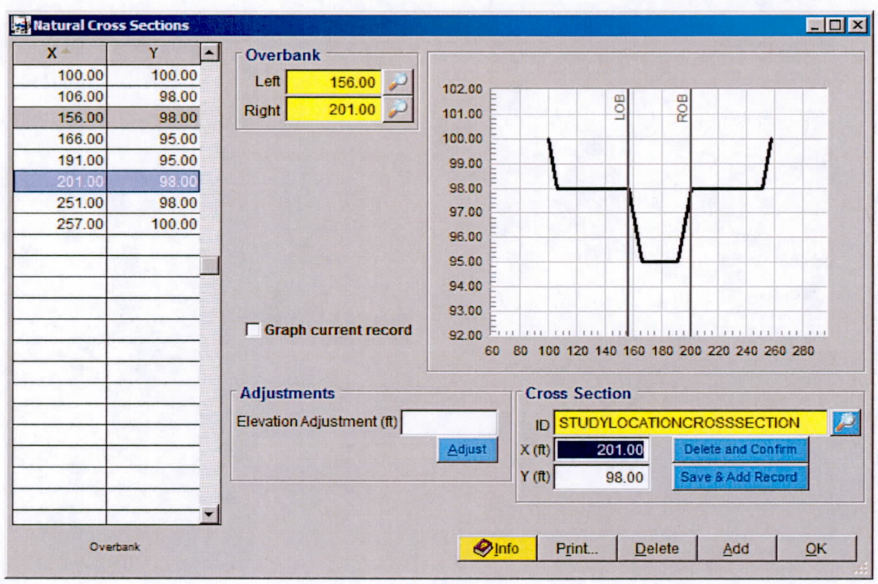
- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *STUDYLOCATIONCROSSSECTION*



(b) Once the specified data have been selected, click the **Import** button. Select **Yes** to proceed, and hit **OK** to close the **Import Cross Section from Another Project** form.



(c) To check if the bridge cross section data has been successfully imported, open the **Natural Cross Sections** form (**River Mechanics ➔ Cross Section Geometry**). For the **Cross Section ID**, select *"STUDYLOCATIONCROSSSECTION"* by clicking the Selector button at the right side of the **ID** textbox.

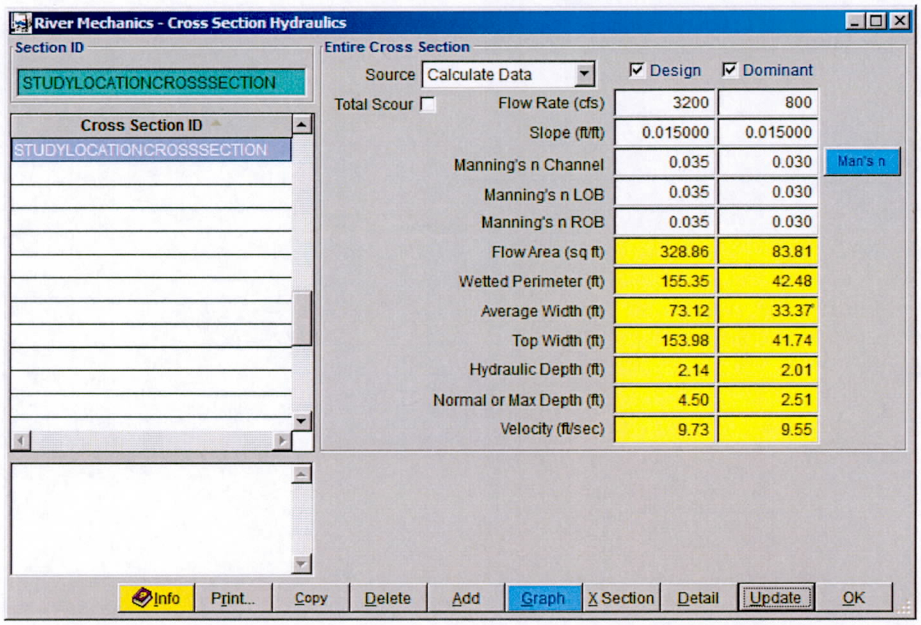


Compare the geometric data on the **Natural Cross Sections** form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

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

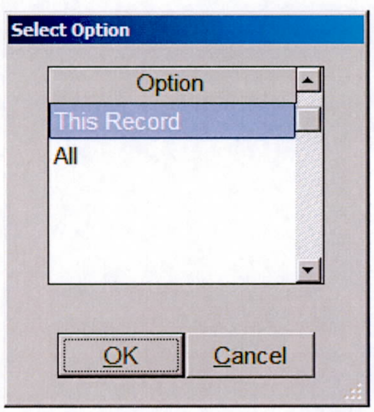
(d) To check if the imported hydraulic data has all the correct **Flow Rates (cfs)**, **Slopes (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** data, open the **Cross Section Hydraulics** form (**River mechanics ➔ Cross Section Hydraulics**). Make sure that the **Cross Section ID** is set to *"STUDYLOCATIONCROSSSECTION"* and compare the data on the form and the following data:

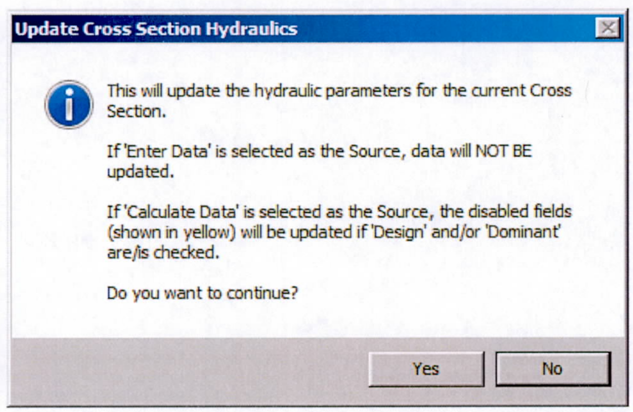
- **Cross Section ID:** *STUDYLOCATIONCROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Dominant Flow Rate (cfs):** *800*
- **Design Slope (ft/ft):** *0.015*
- **Dominant Slope (ft/ft):** *0.015*
- **Design Manning's n (Channel, LOB, and ROB):** *0.035*
- **Dominant Manning's n (Channel, LOB, and ROB):** *0.030*



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

(f) On the Select Option form, select *"This Record"* and click **OK**. Hit **Yes** to continue.



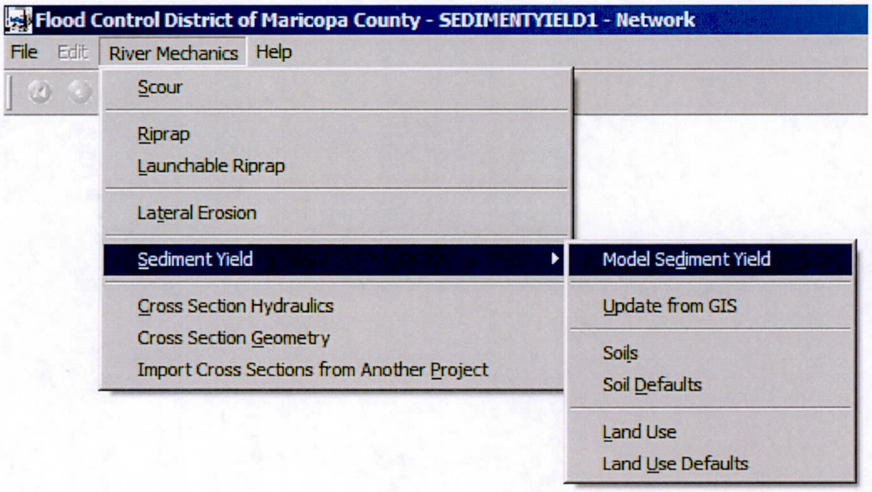


(g) Click **OK** to close the River Mechanics – Cross Section Hydraulics form.

B.3 Step 3 - Prepare Sediment and Relevant Data

B.3.1 Set up Sediment Yield Basic Data

(a) From the menu bar of main application window, click **River Mechanics → Sediment Yield → Model Sediment Yield** to open the River Mechanics – Sediment yield - **MB: 01** window.



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

(c) Type *"DAM1"* into the **ID** textbox, a unique **ID** for the location on the water course.

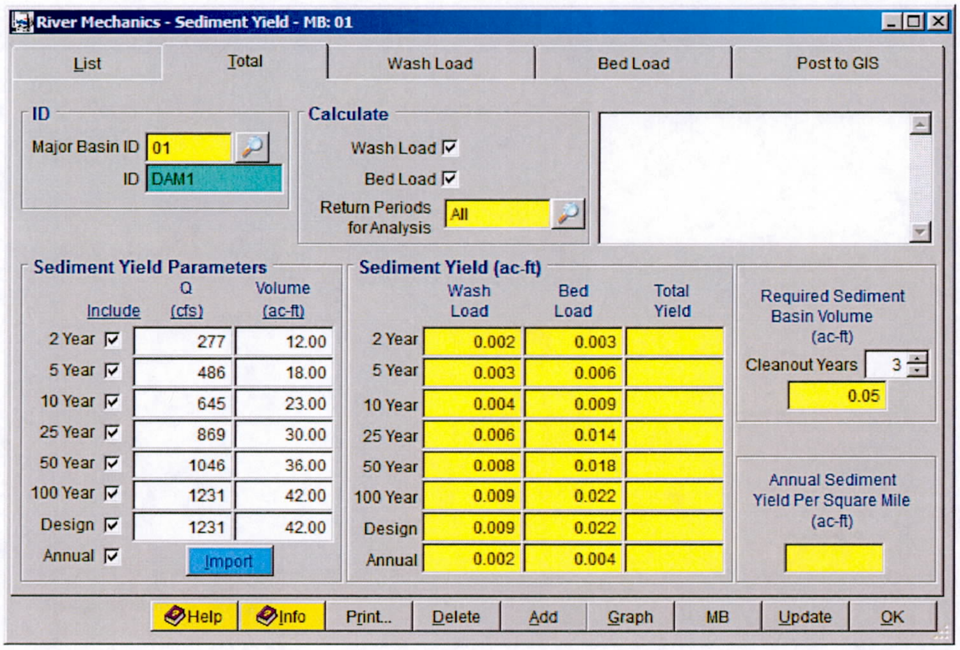
(d) Check the **Wash Load** and **Bed Load** checkboxes in the **Calculate** frame.

(e) Click the browse button beside the **Return Periods for Analysis** textbox in the **Calculate** frame to select *"All"* for the return periods.

(f) Check all the checkboxes in the **Sediment Yield Parameters** frame to activate all the discharges and volumes textboxes. Enter the following discharge and volume values for the sediment yield parameters

Return Period	Q (cfs)	Volume (ac-ft)
2 year	*277*	*12.00*
5 year	*486*	*18.00*
10 year	*645*	*23.00*
25 year	*869*	*30.00*
50 year	*1046*	*36.00*
100 year	*1231*	*42.00*
Design	*1231*	*42.00*

(g) Click the **Save** button to save the entered data. After the data entry, the window should look like the following figure.



(h) Click the **Wash Load** tab.

(i) Enter *"SED1"* into the **Sediment Area ID** textbox (**Sediment Area ID** is the unique ID for the drainage area that contributes sediment to the study location. This ID is used when land use and soil data are used to compute the wash load).

(j) Enter *"0.3508"* in the **Area (sq mi)** textbox.

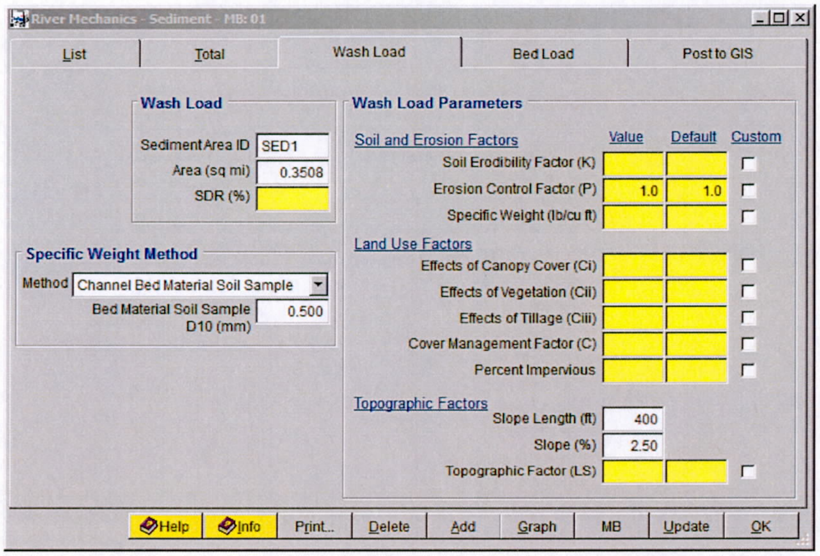
(k) Select *"Channel Bed Material Soil Sample"* as the **Specific Weight Method**.

(l) Enter *"0.50"* into the **Bed Material Soil Sample D10 (mm)** textbox.

(m) Enter *"400"* into the **Slope Length (ft)** textbox in the **Wash Load Parameters** frame.

(n) Enter *"2.50"* into the **Slope (%)** textbox in the Wash Load Parameters frame.

(o) Click the **Save** button to save data entry. The **RIVER MECHANICS – SEDIMENT YIELD** form should look like the following figure.

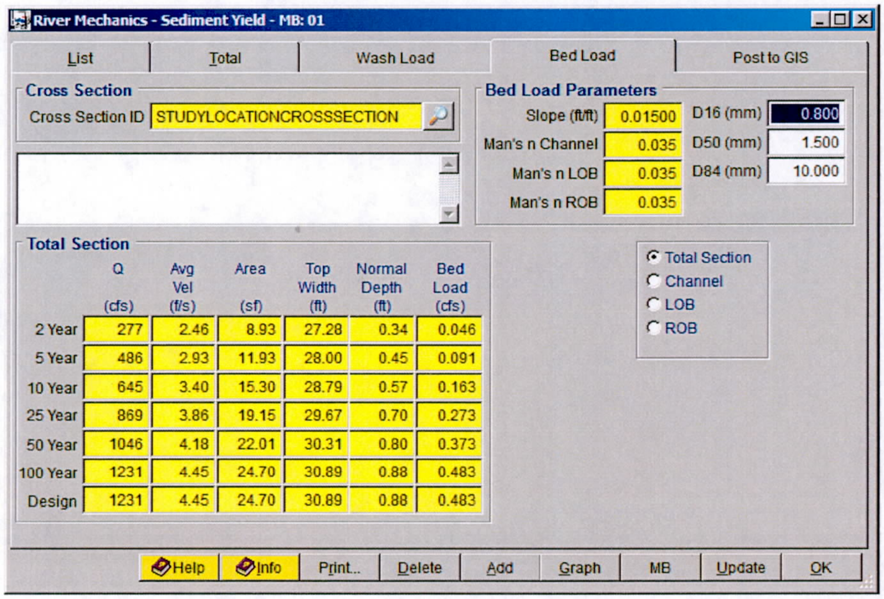


(p) Click the **Bed Load** tab and click browse button beside the **Cross Section ID** textbox in the **Cross Section** frame to select "*STUDYLOCATIONCROSSSECTION*" as the cross section **ID**. Click **OK** to exit the **SELECT CROSS SECTION ID** form.

(q) On the **Bed Load Parameters** frame in the **Bed Load** tab, enter the following data:

- **D16 (mm):** *0.80*
- **D50 (mm):** *1.50*
- **D84 (mm):** *10.00*

(r) Click the **Save** button to save the data entry. The **RIVER MECHANICS – SEDIMENT YIELD form** should look like the following figure.



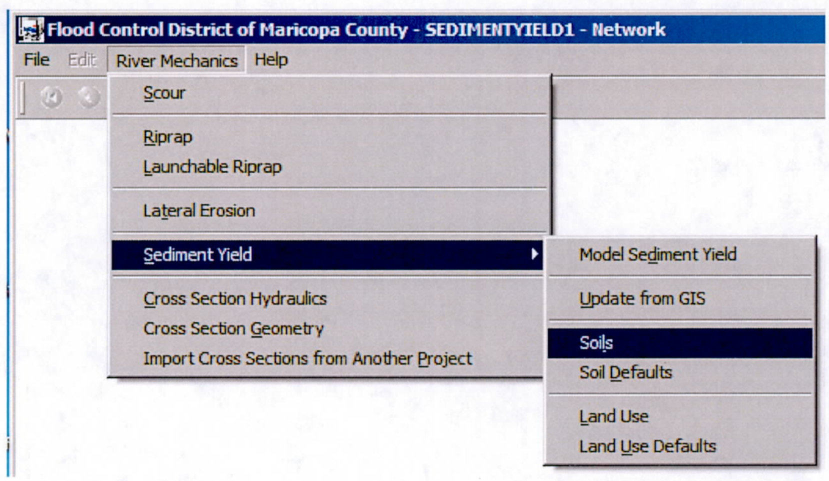
(s) Click **OK** to close the window.

B.3.2 Prepare Land Use and Soil Data

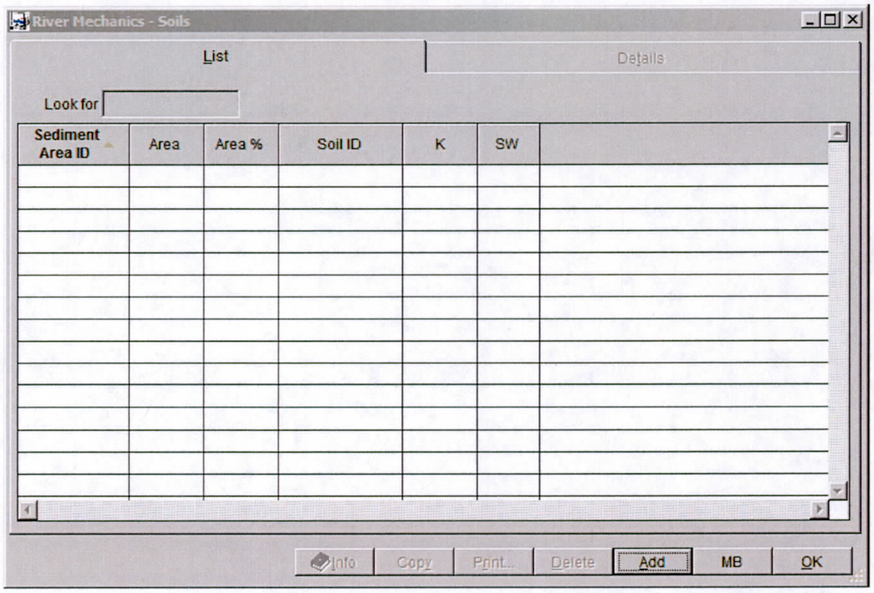
In this section, procedures will be provided on how to prepare the landuse and soil data for the project area.

B.3.2.1 How to Prepare Soil Data

(a) Click **River Mechanics ➔ Sediment Yield ➔ Soils** from the menu bar on the main application window as is shown in the following figure and a blank **River Mechanics – Soils** window opens.



(b) Click the **Add** button on the **River Mechanics – Soils** window to activate the data entry.

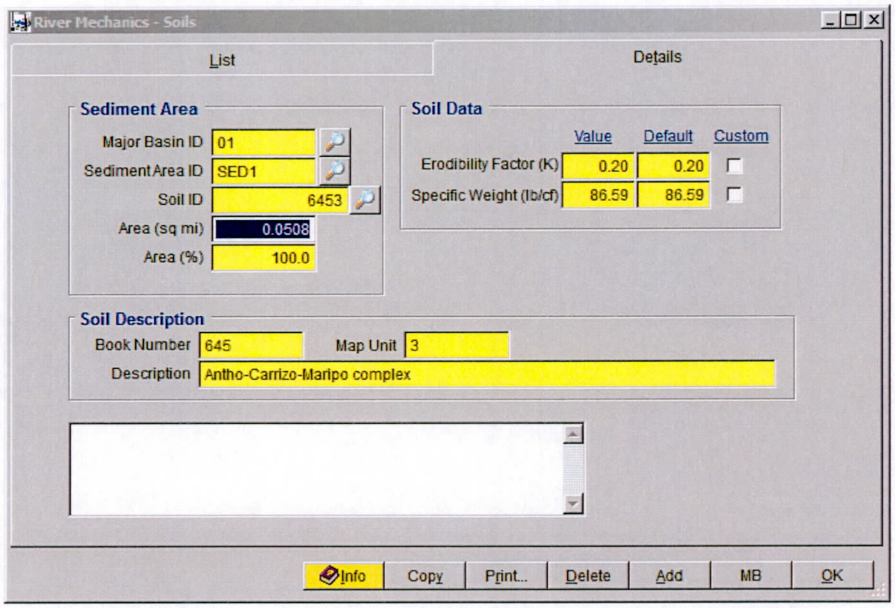


(c) On the **Details** tab of the **River Mechanics – Soils** window, click the browse button beside the **Sediment Area ID** textbox in the **Sediment Area** frame. On the **Select ID** window, highlight *"SED1"* and click **OK** to close the window.

(d) Click the browse button beside the **Soil ID** textbox in the **Sediment Area** frame. On the **Select ID** window, highlight **Soil ID** *"6453"* and click **OK** to close the window.

(e) Enter *"0.0508"* into the **Area (sq mi)** textbox in the **Sediment Area** frame.

(f) Click the **Save** button to save the data just entered. The window should look like the following figure.



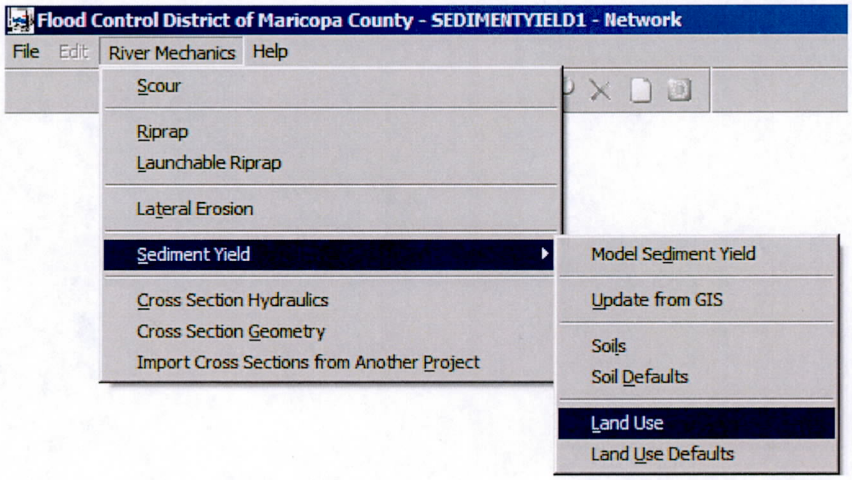
Repeat the above five steps to enter the rest of the soils data for this sediment area.

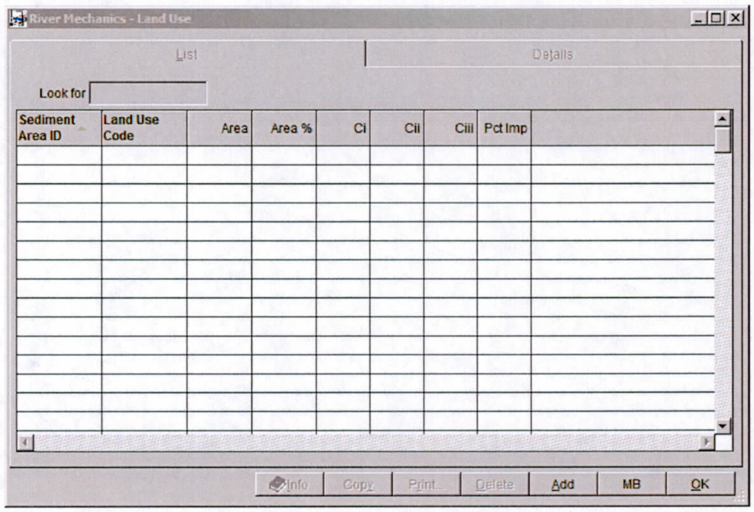
Sediment Area ID	Soil ID	Area (sq mi)
SED1	*64590*	*0.0447*
SED1	*64591*	*0.2548*
SED1	*64598*	*0.0004*

(g) After the data entry, click **OK** to close the window.

B.3.2.2 How to Prepare Land Use Data

(a) Click **River Mechanics ➔ Sediment ➔ Land Use** from the menu bar on the main application window as is shown in the following figure and the blank **RIVER MECHANICS – LAND USE** window opens.





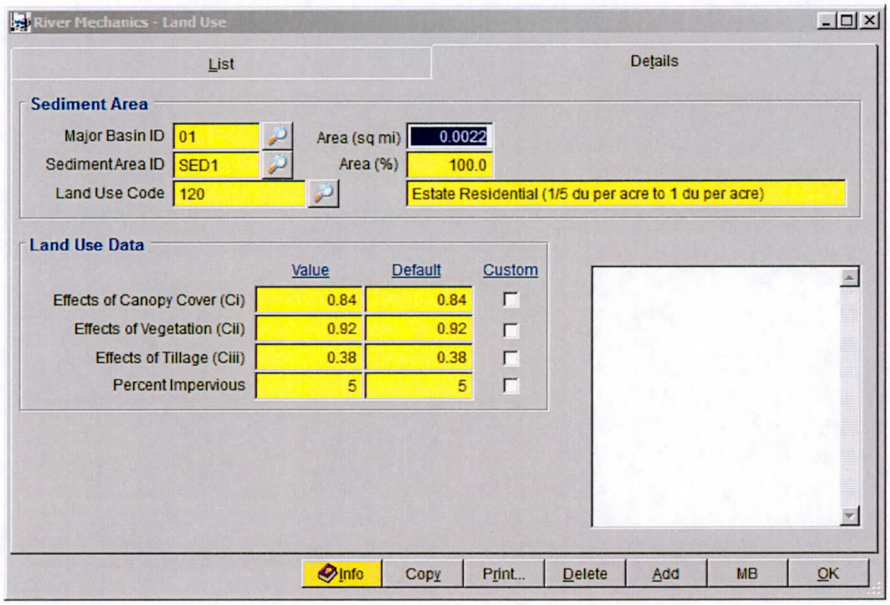
(b) Click the **Add** button to activate the data entry.

(c) Click the browse button beside the **Sediment Area ID** textbox in the **Sediment Area** frame to open the **Select ID** window. Highlight *"SED1"* and click **OK** to select and close the window.

(d) Click the browse button beside the **Land Use Code** textbox in the **Sediment Area** frame to open the **Select ID** window. Highlight code *"120"* and click **OK** to select and close the window.

(e) Enter *"0.0022"* into the **Area (sq mi)** textbox in the **Sediment Area** frame of the **River Mechanics – Land Use** window.

(f) Click the **Save** button. The window should look like the following figure.



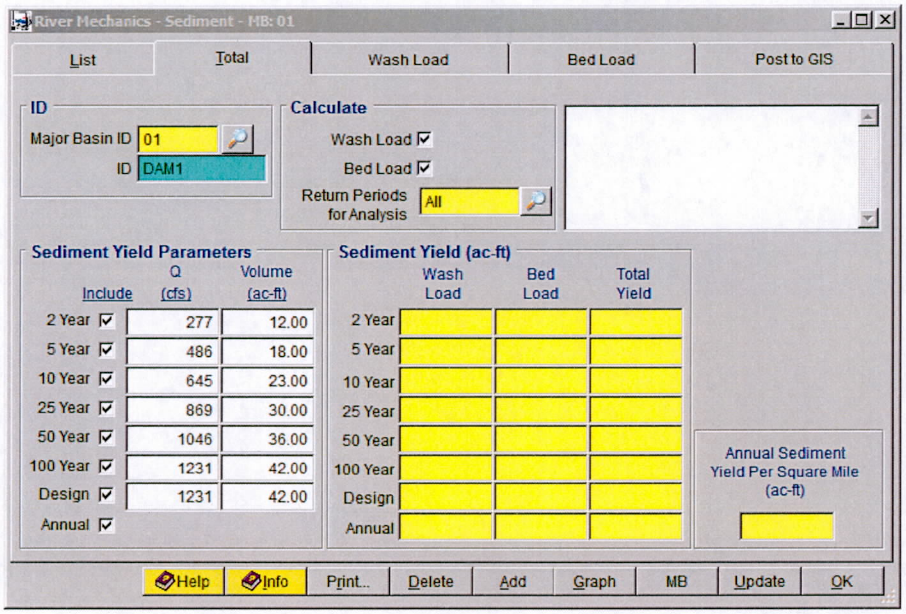
(g) Repeat the above five steps to enter the rest of the land use data for this sediment area.

Sediment Area ID	Land Use Code	Area (sq mi)
SED1	*150*	*0.1647*
SED1	*160*	*0.0620*
SED1	*180*	*0.0296*
SED1	*230*	*0.0314*
SED1	*410*	*0.0609*

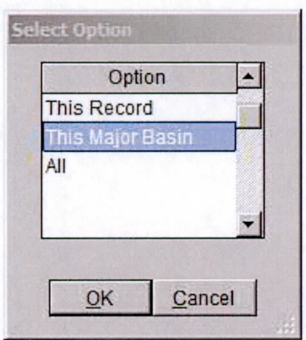
(h) After the data entry, click **OK** to close the window.

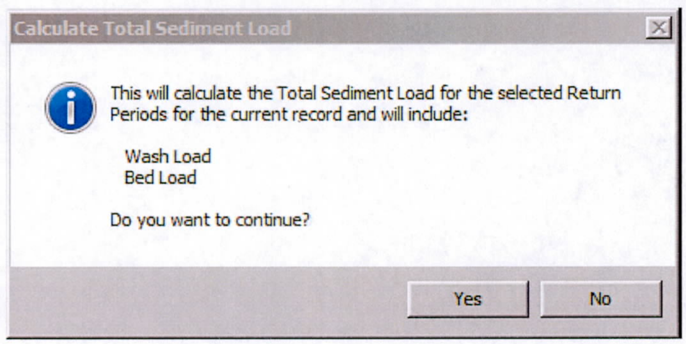
B.4 Step 4 - Calculate the Sediment Yield

In this section, a step-by-step instruction will be provided how to calculate the sediment yield. Open the **RIVER MECHANICS – SEDIMENT YIELD** form from the menu bar (**River Mechanics ➔ Sediment Yield ➔ Model Sediment Yield** and click the **Total** tab.



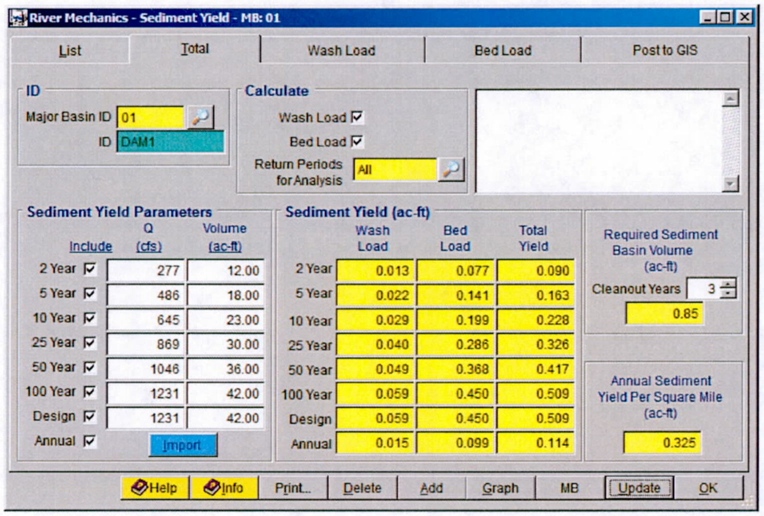
(a) Click the **Update** button on the **River Mechanics – Sediment Yield** form to compute the sediment yield. A new window **Select Option** opens, select *"This Major Basin"*, and click **OK** to close it.

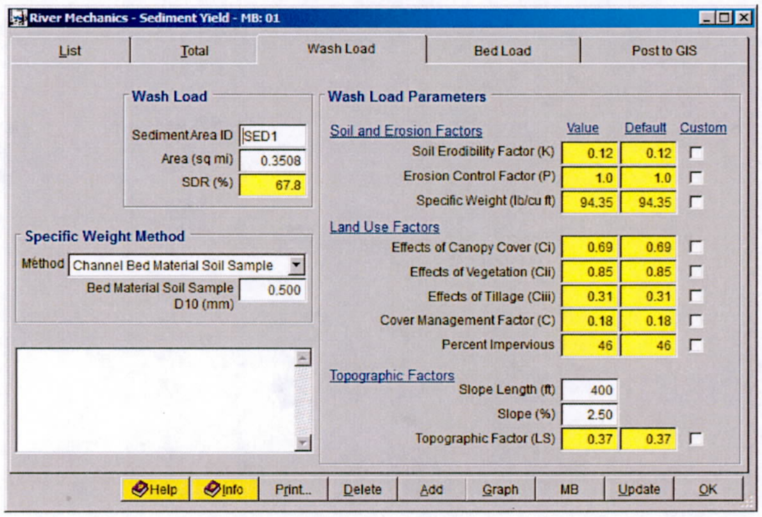


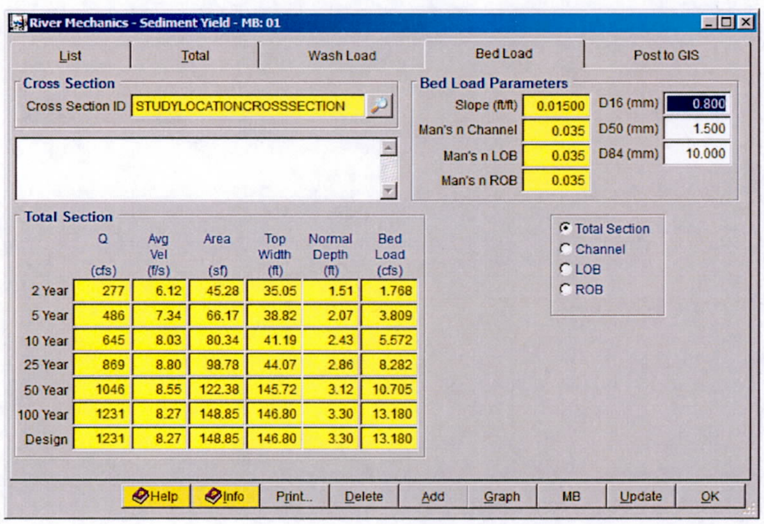


(b) On the **Calculate Total Sediment Load** dialog box, click **Yes** to continue.

The following three figures show the results in the **Total**, **Wash Load** and **Bed Load** tabs when the *"Channel Bed Material Soil Sample"* method is used in **Wash Load**.


River Mechanics - Sediment Yield - MB: 01
List
Total
Wash Load
Bed Load
Post to GIS
ID
Major Basin ID 01
ID DAM1
Calculate
Wash Load
Bed Load
Return Periods for Analysis All
Sediment Yield Parameters
Include
Q (cfs)
Volume (ac-ft)
2 Year 277 12.00
5 Year 486 18.00
10 Year 645 23.00
25 Year 869 30.00
50 Year 1046 36.00
100 Year 1231 42.00
Design 1231 42.00
Annual
Import
Sediment Yield (ac-ft)
Wash Load
Bed Load
Total Yield
2 Year 0.013 0.077 0.090
5 Year 0.022 0.141 0.163
10 Year 0.029 0.199 0.228
25 Year 0.040 0.286 0.326
50 Year 0.049 0.368 0.417
100 Year 0.059 0.450 0.509
Design 0.059 0.450 0.509
Annual 0.015 0.099 0.114
Required Sediment Basin Volume (ac-ft)
Cleanout Years 3
0.85
Annual Sediment Yield Per Square Mile (ac-ft)
0.325
Help
Info
Print...
Delete
Add
Graph
MB
Update
OK

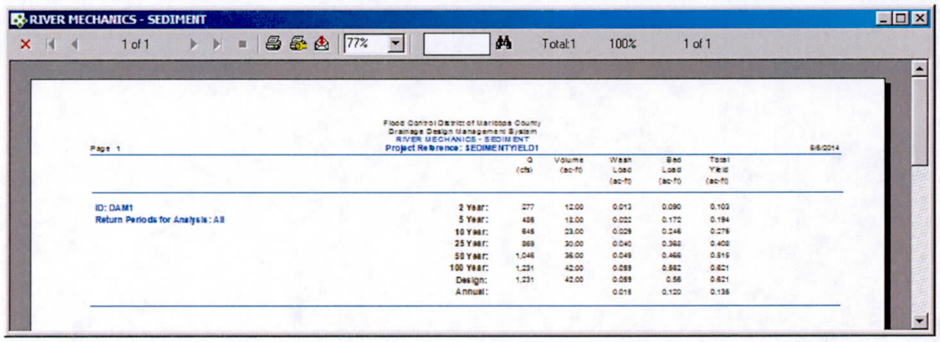

River Mechanics - Sediment Yield - MB: 01
List
Total
Wash Load
Bed Load
Post to GIS
Wash Load
Sediment Area ID SED1
Area (sq mi) 0.3508
SDR (%) 67.8
Specific Weight Method
Method Channel Bed Material Soil Sample
Bed Material Soil Sample D10 (mm) 0.500
Wash Load Parameters
Soil and Erosion Factors
Value
Default
Custom
Soil Erodibility Factor (K) 0.12 0.12
Erosion Control Factor (P) 1.0 1.0
Specific Weight (lb/cu ft) 94.35 94.35
Land Use Factors
Effects of Canopy Cover (Ci) 0.69 0.69
Effects of Vegetation (Cii) 0.85 0.85
Effects of Tillage (Ciii) 0.31 0.31
Cover Management Factor (C) 0.18 0.18
Percent Impervious 46 46
Topographic Factors
Slope Length (ft) 400
Slope (%) 2.50
Topographic Factor (LS) 0.37 0.37
Help
Info
Print...
Delete
Add
Graph
MB
Update
OK


River Mechanics - Sediment Yield - MB: 01
List
Total
Wash Load
Bed Load
Post to GIS
Cross Section
Cross Section ID STUDYLOCATIONCROSSSECTION
Bed Load Parameters
Slope (ft/ft) 0.01500
Man's n Channel 0.035
Man's n LOB 0.035
Man's n ROB 0.035
D16 (mm) 0.800
D50 (mm) 1.500
D84 (mm) 10.000
Total Section
Q (cfs)
Avg Vel (f/s)
Area (sf)
Top Width (ft)
Normal Depth (ft)
Bed Load (cfs)
2 Year 277 6.12 45.28 35.05 1.51 1.768
5 Year 486 7.34 66.17 38.82 2.07 3.809
10 Year 645 8.03 80.34 41.19 2.43 5.572
25 Year 869 8.80 98.78 44.07 2.86 8.282
50 Year 1046 8.55 122.38 145.72 3.12 10.705
100 Year 1231 8.27 148.85 146.80 3.30 13.180
Design 1231 8.27 148.85 146.80 3.30 13.180
Total Section
Channel
LOB
ROB
Help
Info
Print...
Delete
Add
Graph
MB
Update
OK

B.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 sediment yield.

(a) Report the results for Total Sediment Yield: Click the **Print ...** button on the **Total** tab of the **RIVER MECHANICS – SEDIMENT – MB: 01** window to generate a report like the following figure.



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

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

(d) More detailed information for wash load, bed load, and **Cross Section Hydraulics** can also be viewed, printed, and exported by clicking the **Print...** button under **Wash Load, Bed Load** and **Cross Section Hydraulics** menu.

This concludes this tutorial for sediment yield analysis.

2.4 Calculate Riprap Size for Bank Protection

A. Problem Statement

To estimate the riprap sizing for bank protection using "*Channel Banks on Curved Reach*" type with the following given design parameters:

- The Cross Section "*STUDYLOCATIONCROSSSECTION*"
  - Parameters for Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Channel Slope (ft/ft):** *0.015*
    - **Design Manning's n (Channel, LOB, ROB):** *0.035*
  - The geometric data (station and elevation) of the cross section:

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

  - Parameters for Channel Banks:
    - **Bank Slope Angle (Degrees):** *45.00*
    - **Specific Weight for Stone (lb/cu ft):** *150.00*
    - **Specific Weight for Water (lb/cu ft):** *62.40*

B. Step-by-Step Procedures

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

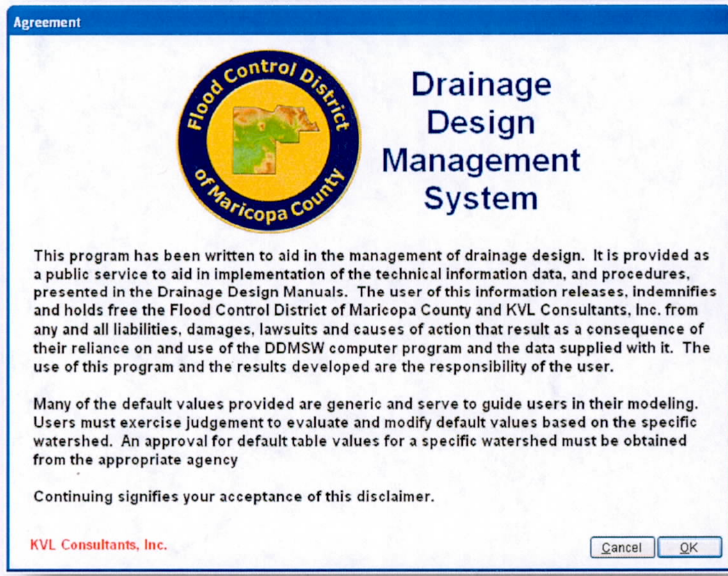
Step 2: Prepare the Cross Section Geometry

Step 3: Calculate Riprap Sizing

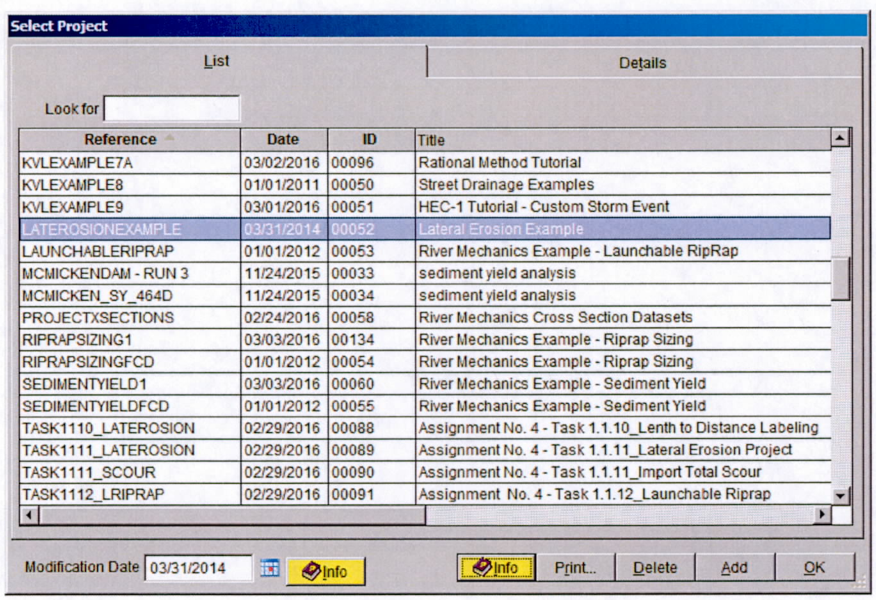
Step 4: Report and Document the Results

B.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 you can start a new project by **File ➔ New Project ➔ Add**).

(c) Select **River Mechanics** checkbox and click the **OK** button on the **New Project Options** form.

(d) Type *"RIPRAPSIZING1"* 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 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)***

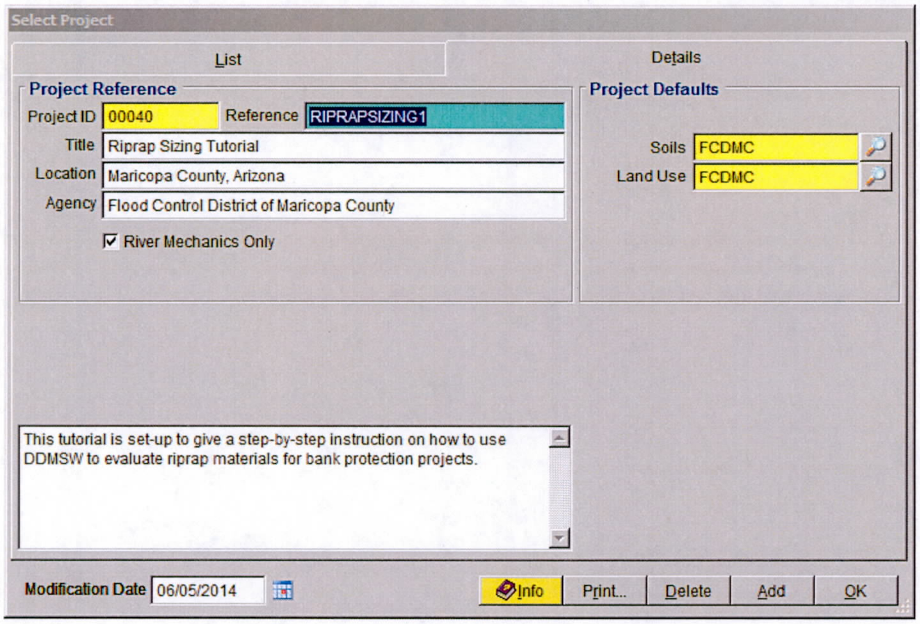
(h) Check **River Mechanics Only** checkbox for this project.

(i) Type a detailed description of this project into the comment area under the **Project Reference** frame. ***(Optional)***

(j) On the **Modification Date**, use the current date.

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

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



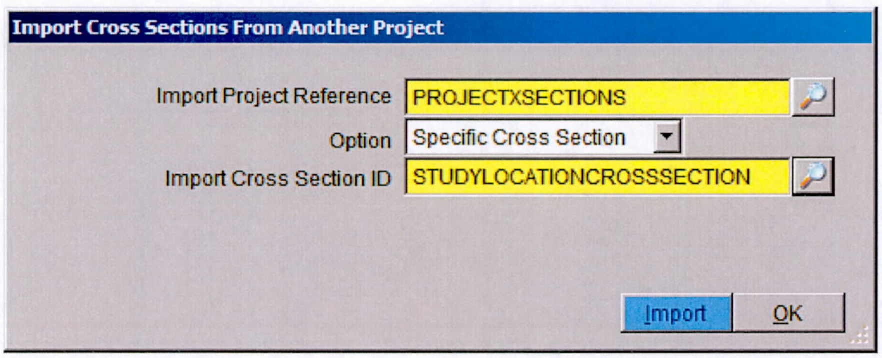
<u>**Note:**</u> the **Project ID** *00040* in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

B.2 Step 2 - Prepare the Cross Section and Hydraulic Data

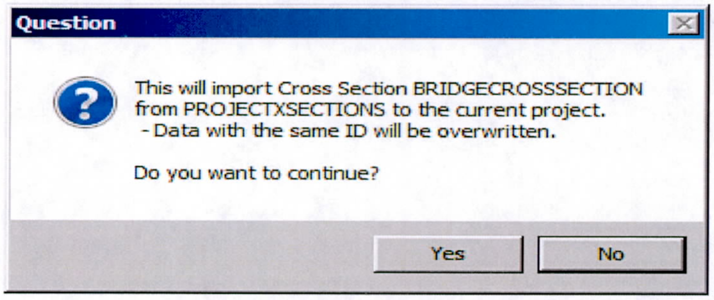
Only one (1) cross section data, the "*STUDYLOCATIONROSSSECTION*", will be used for this tutorial. This cross section data will be imported from another project.

(a) To import the first cross section data (Study Location Cross Section Data), open the **IMPORT CROSS SECTIONS FROM ANOTHER PROJECT** form (**River Mechanics ➔ Import Cross Sections from Another Project**). Use the following data on the form.

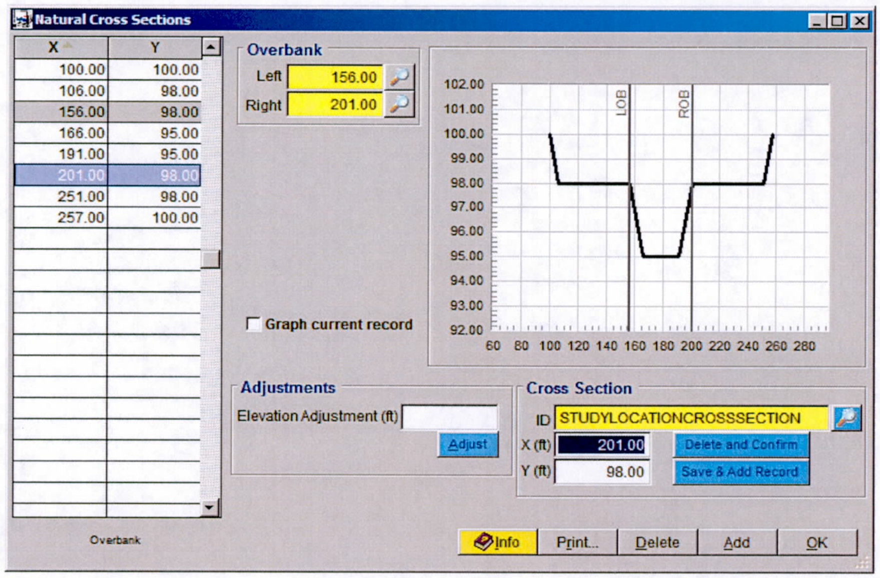
- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross section*
- **Import Cross Section ID:** *STUDYLOCATIONCROSSSECTION*



(b) Once the specified data have been selected, click the **Import** button. Select **Yes** to proceed, and hit **OK** to close the **IMPORT CROSS SECTION FROM ANOTHER PROJECT** form.



(c) To check if the bridge cross section data has been successfully imported, open the **NATURAL CROSS SECTIONS** form (**River Mechanics → Cross Section Geometry**). For the **Cross Section ID**, select *"STUDYLOCATIONCROSSSECTION"* by clicking the Selector button at the right side of the **ID** textbox.

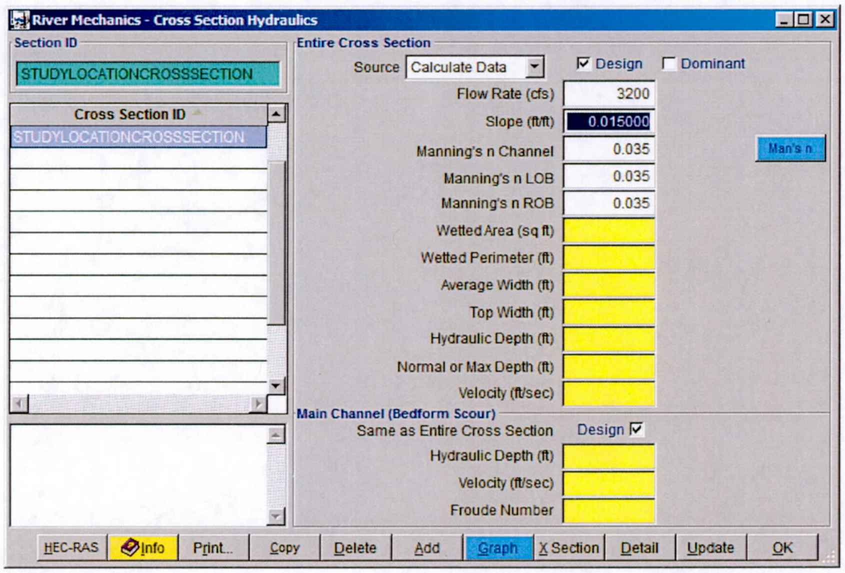


Compare the geometric data on the **NATURAL CROSS SECTIONS** form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

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

Station (X)	Elevation (Y)	Notes
257	*100*	

(d) To check if the imported hydraulic 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**). Make sure that the **Cross Section ID** is set to *"STUDYLOCATIONCROSSSECTION"* and only the "Design" checkbox is checked. Please note the dominant flow event will not be used in the Riprap Sizing analysis.

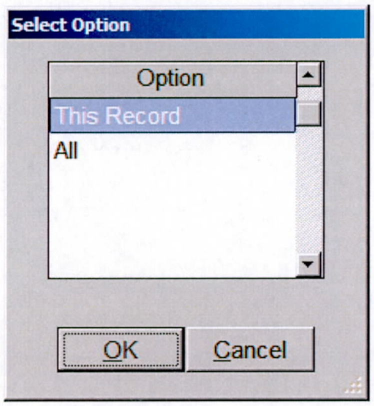


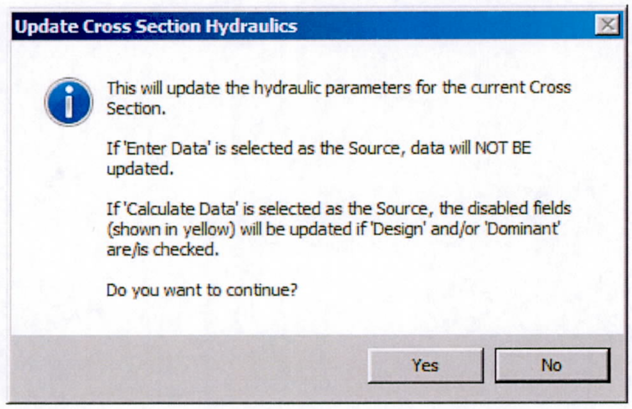
Compare the imported data on the form against the actual data as follows:

- **Cross Section ID:** *STUDYLOCATIONCROSSSECTION*
- **Design Flow Rate (cfs):** *3200*
- **Design Slope (ft/ft):** *0.015*
- **Design Manning's n (Channel, LOB, and ROB):** *0.035*

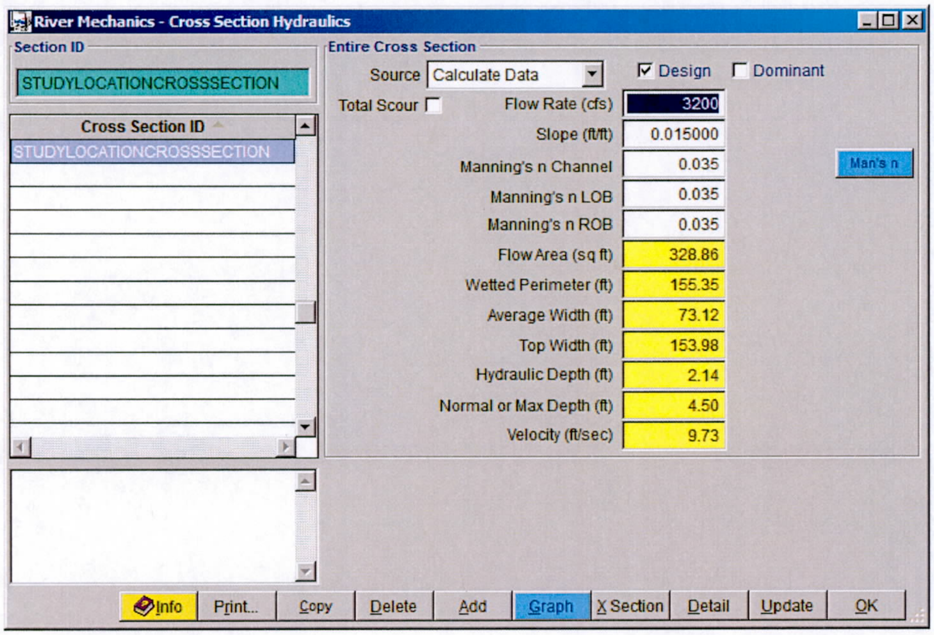
(e) If everything checks out, click the **Update** button to update the hydraulic analysis results.

(f) On the **SELECT OPTION** form, select *"This Record"* and click **OK**. Hit **Yes** to continue.





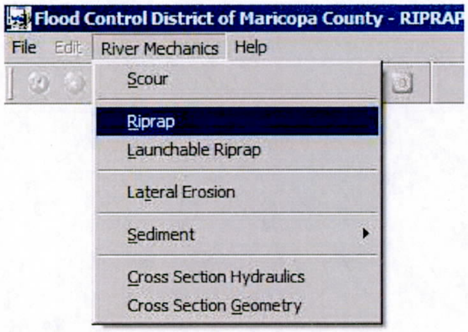
After the update, the **River Mechanics – Cross Section Hydraulics** window looks like the following figure.

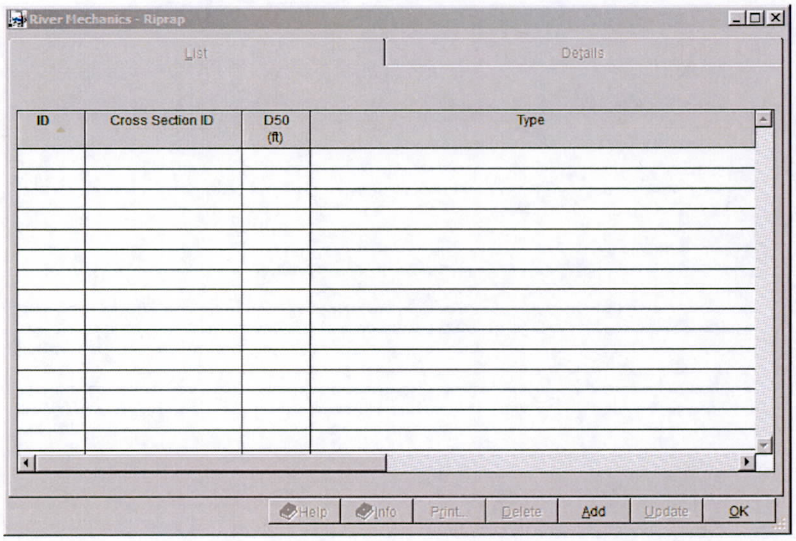


(g) Click **OK** to close the **River Mechanics – Cross Section Hydraulics** form.

B.3 Step 3 - Calculate Riprap Size

(a) From the menu bar of main application window, click **River Mechanics ➔Riprap** to open the **River Mechanics - Riprap** window.





(b) Click **Add** button on the **River Mechanics - Riprap** window.

(c) Enter *"CHNL1"* into the **Location ID** textbox

(d) Browse for *"Channel Banks on Curved Reach"* in the **Type** textbox

(e) Click **OK** on the **Select Type** dialog box.

(f) Check **Use Cross Section ID** check box

(g) Browse for *"STUDYREACHCROSSSECTION"* in the **Section ID** textbox.

(h) Click **OK** on the **Select Cross Section ID** dialog box.

(i) Enter *"3"* into the **Bank Slope (H:V)** textbox

(j) Enter *"150.00"* into the **Specific Weight Stone (lb/cu ft)** textbox

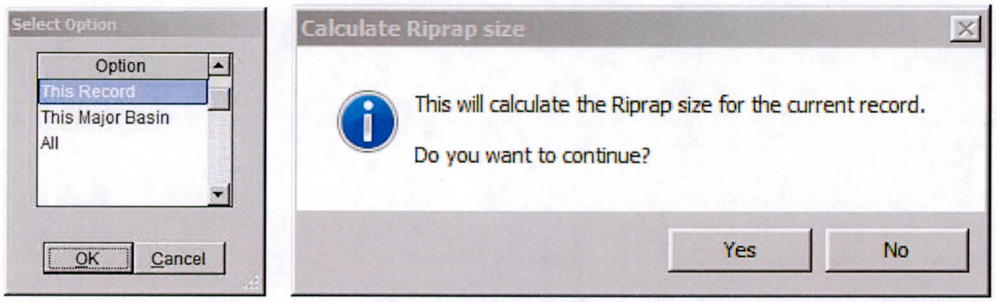
(k) Enter *"62.40"* into the **Specific Weight Water (lb/cu ft)** textbox

(l) Select *"Angular"* from the drop down for Riprap **Type** in the **Safety Factor** frame.

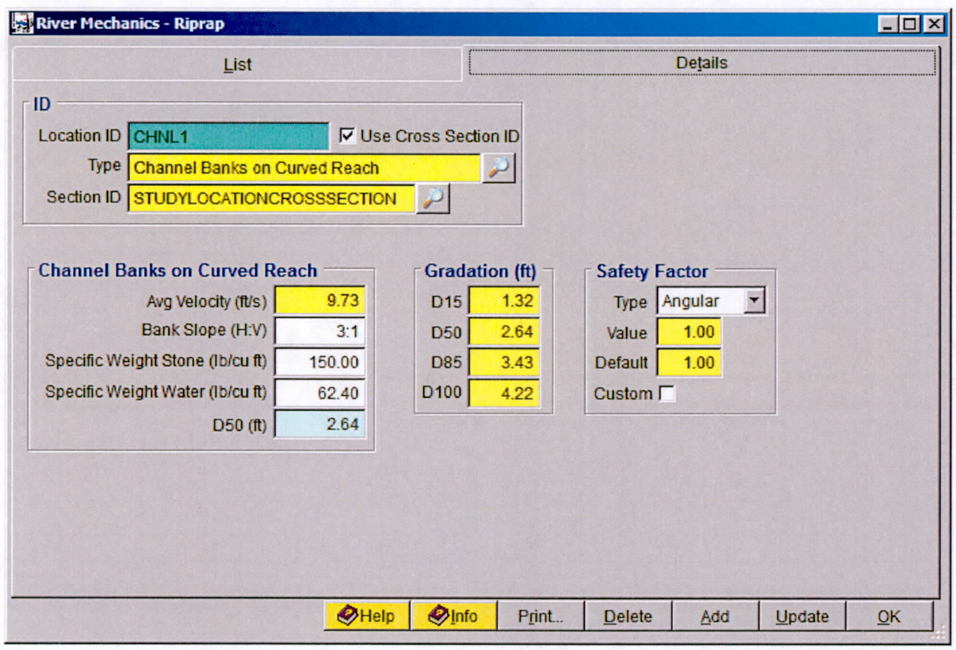
(m) Click the **Save** button.

(n) Click **Update** button to compute riprap median size **D50 (ft)**.

(o) Highlight *"This Record"* in the **Selection Option** window and click **OK**. Click **Yes** when the **Calculate Riprap Size** dialog box opens.



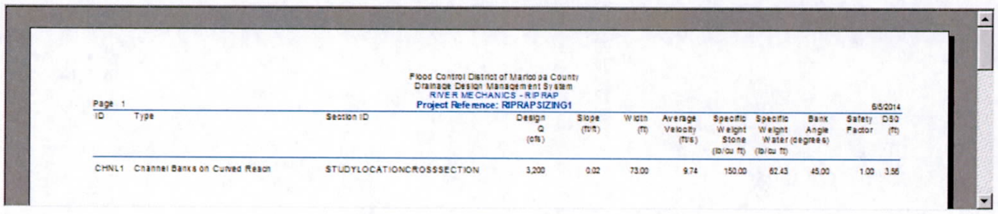
After the update process is finished, the window looks like what is shown in the following figure. Click **OK** to close the window.



B.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 riprap sizing.

(a) Click the **Print ...** button on the **River Mechanics – Riprap** window. A report will be generated as is shown in the following figure.


Flood Control District of Maricopa County
Drainage Design Management System
RIVER MECHANICS - RIPRAP
Project Reference: RIPRAPSIZING1

Page 1 6/5/2014

ID	Type	Section ID	Design Q (cfs)	Slope (ft/ft)	Width (ft)	Average Velocity (ft/s)	Specific Weight Stone (lb/cu ft)	Specific Weight Water (lb/cu ft)	Bank Angle (degrees)	Safety Factor	D50 (ft)
CHNL1	Channel Banks on Curved Reach	STUDYLOCATIONCROSSSECTION	3,200	0.02	73.00	9.74	150.00	62.43	45.00	1.00	3.56

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

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

(d) More detailed information for cross section hydraulics can also be viewed, printed, and exported by clicking the **Print...** button under **Cross Section Hydraulics** menu.

This concludes this tutorial for sediment yield analysis.

2.5 Lateral Erosion Analysis

A. Problem Statement

To estimate the lateral erosion corridor for a watercourse as a basis to protect the public from potential flood encroachments caused by unmitigated lateral bank migration.

The following data are provided for this tutorial:

- The Cross Section *"LATEROSXSECTION"*
  - Parameters for Hydraulics and Geometry:
    - **Design Flow Rate (cfs):** *3200*
    - **Channel Slope (ft/ft):** *0.015*
    - **Design Manning's n for Main Channel:** *0.035*
    - **Design Manning's n for LOB:** *0.045*
    - **Design Manning's n for ROB:** *0.050*
  - The geometric data (station and elevation) of the cross section:

Station (X)	Elevation (Y)	Notes
0	*165.0*	
200	*164.9*	
215	*164.5*	*FEMA Floodway Left Station*
275	*164.3*	
318	*164.1*	*Left Bank Station*
320	*163.9*	
321	*163.85*	
325	*163.8*	
340	*163.6*	
345	*160.0*	
350	*159.9*	
355	*159.6*	*Thalweg Station*
365	*159.7*	
370	*160.0*	
375	*161.0*	
380	*163.0*	*Right Bank Station*
390	*163.2*	

Station (X)	Elevation (Y)	Notes
420	*164.0*	*FEMA Floodway Right Station*
515	*164.3*	
600	*164.6*	
900	*165.0*	

➢ Data for Alternative Analyses

(a) Alternative Scenario #1: No Data Available

- **Channel Depth, D (ft):** *4.5*

(b) Alternative Scenario #2: Scour Data Available

- **Channel Depth, D (ft):** *4.5*
- **Scour Depth, Zt (ft):** *12.0*

(c) Alternative Scenario #3: Scour and Historical Data are Available

- **Channel Depth, D (ft):** *4.5*
- **Scour Depth, Zt (ft):** *12.0*
- **Left Historical Lateral Erosion Distance, Lh (ft)** *85.0*
- **Right Historical Lateral Erosion Distance, Rh (ft)** *85.0*

(d) Alternative Scenario #4: Scour, Historical Data and Cross Section Data are Available

- **Cross Section ID:** *LATEROSXSECTION*
- **Scour Depth, Zt (ft):** *12.0*
- **Left Historical Lateral Erosion Distance, Lh (ft)** *85.0*
- **Right Historical Lateral Erosion Distance, Rh (ft)** *85.0*
- **FEMA Floodway Left Station** *215.0*
- **FEMA Floodway Right Station** *420.0*
- **Thalweg Station** *355.0*

B. Step-by-Step Procedures

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

Step 2: Prepare the Cross Section Geometry

Step 3: Import Cross Section and Hydraulic Data

Step 4: Calculate Lateral Erosion Distance

4.1 Scenario #1 – No Data Available

4.2 Scenario #2 – Scour Data Available

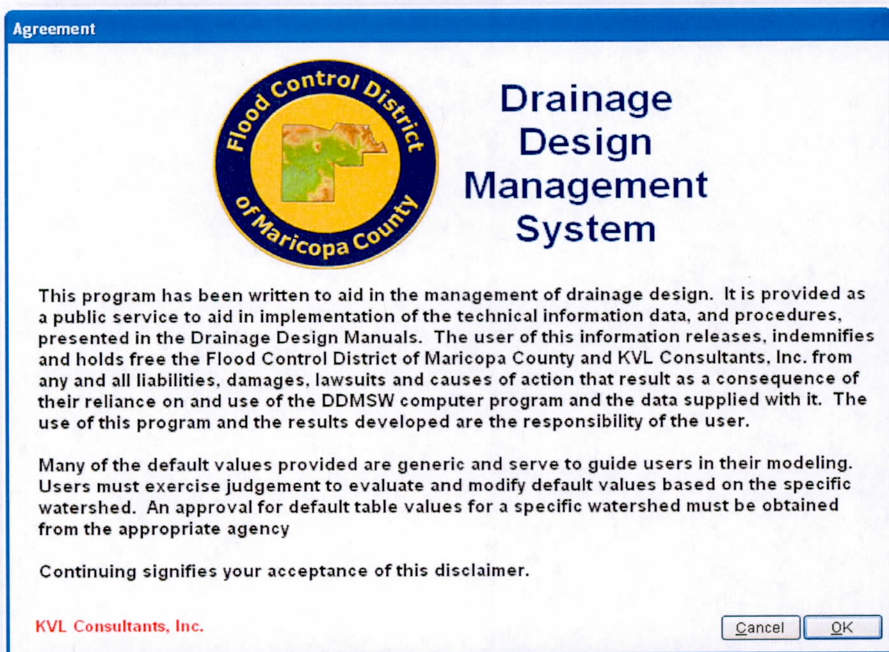
4.3 Scenario #3 – Scour and Historical Data Available

4.3 Scenario #4 – Scour, Historical and Cross Section Data Available

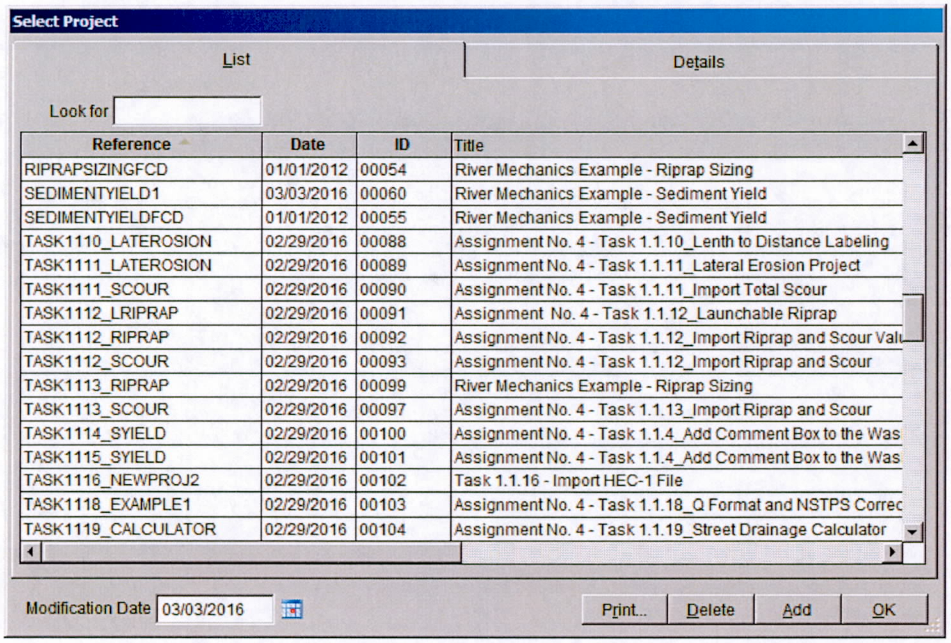
Step 5: Report and Document the Results

B.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.



Reference	Date	ID	Title
RIPRAPSIZINGFCD	01/01/2012	00054	River Mechanics Example - Riprap Sizing
SEDIMENTYIELD1	03/03/2016	00060	River Mechanics Example - Sediment Yield
SEDIMENTYIELDFCD	01/01/2012	00055	River Mechanics Example - Sediment Yield
TASK1110_LATEROSION	02/29/2016	00088	Assignment No. 4 - Task 1.1.10_Lenth to Distance Labeling
TASK1111_LATEROSION	02/29/2016	00089	Assignment No. 4 - Task 1.1.11_Lateral Erosion Project
TASK1111_SCOUR	02/29/2016	00090	Assignment No. 4 - Task 1.1.11_Import Total Scour
TASK1112_LRIPRAP	02/29/2016	00091	Assignment No. 4 - Task 1.1.12_Launchable Riprap
TASK1112_RIPRAP	02/29/2016	00092	Assignment No. 4 - Task 1.1.12_Import Riprap and Scour Valu
TASK1112_SCOUR	02/29/2016	00093	Assignment No. 4 - Task 1.1.12_Import Riprap and Scour
TASK1113_RIPRAP	02/29/2016	00099	River Mechanics Example - Riprap Sizing
TASK1113_SCOUR	02/29/2016	00097	Assignment No. 4 - Task 1.1.13_Import Riprap and Scour
TASK1114_SYIELD	02/29/2016	00100	Assignment No. 4 - Task 1.1.4_Add Comment Box to the Was
TASK1115_SYIELD	02/29/2016	00101	Assignment No. 4 - Task 1.1.4_Add Comment Box to the Was
TASK1116_NEWPROJ2	02/29/2016	00102	Task 1.1.16 - Import HEC-1 File
TASK1118_EXAMPLE1	02/29/2016	00103	Assignment No. 4 - Task 1.1.18_Q Format and NSTPS Correc
TASK1119_CALCULATOR	02/29/2016	00104	Assignment No. 4 - Task 1.1.19_Street Drainage Calculator

(b) Click the **Add** button on the **SELECT PROJECT** window to start a new project (or you can start a new project by **File → New Project**).

(c) On the **NEW PROJECT OPTIONS** form, select **River Mechanics** checkbox and click the **OK** button to close the form.

(d) Type *"LATEROSION1"* 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)***

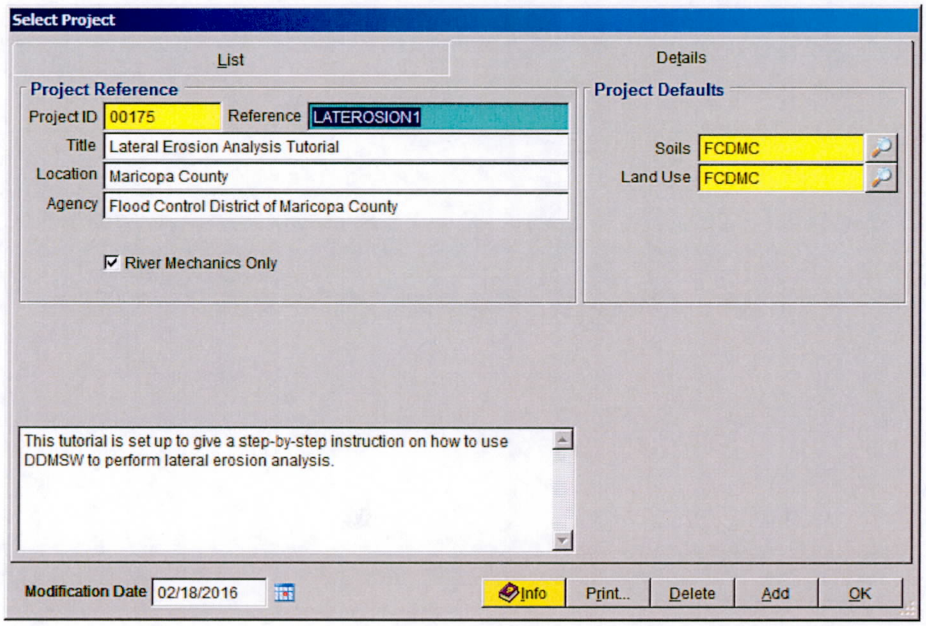
(g) Type into the **Agency** textbox the agency or company name. ***(Optional)***

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

(i) Type a detailed description of this project into the **Comment Box** under the **Project Reference** frame. ***(Optional)***

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

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

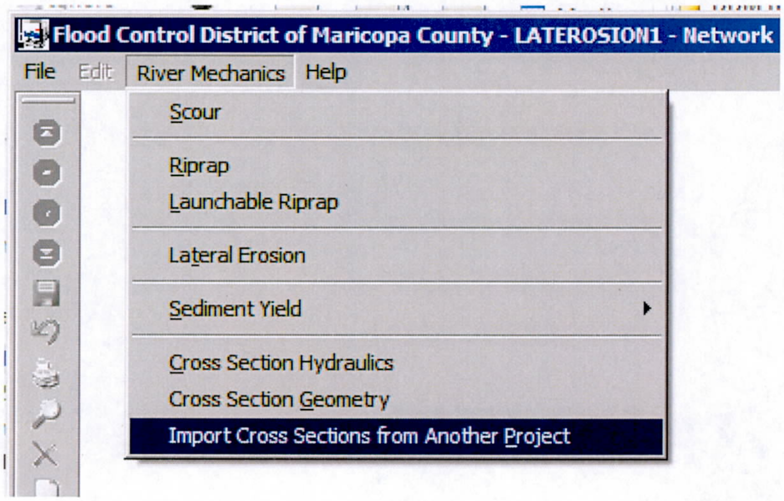


Note: the **Project ID** *00175* in the above figure is the database records unique read-only identifier of the project, which is automatically generated by the program when a new project is created. When the users create a new project, the **Project ID** of this new project will not be the same as the **Project ID** shown in the above figure.

B.2 Step 2 – Prepare the Cross Section and Hydraulics Data

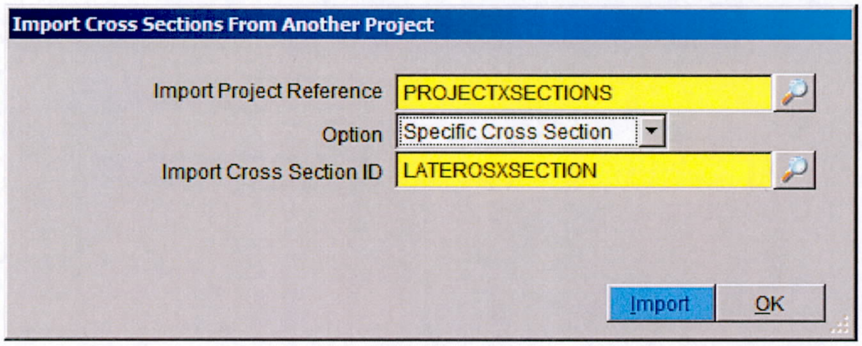
To develop the cross section and hydraulic data to be used for this project, the *"LATEROSXSECTION"* dataset will be used which will be imported from another project.

(a) From the menu bar of main application window, click **River Mechanics → Import Cross Sections from Another Project** to open the **IMPORT CROSS SECTIONS FROM ANOTHER PROJECT** form.

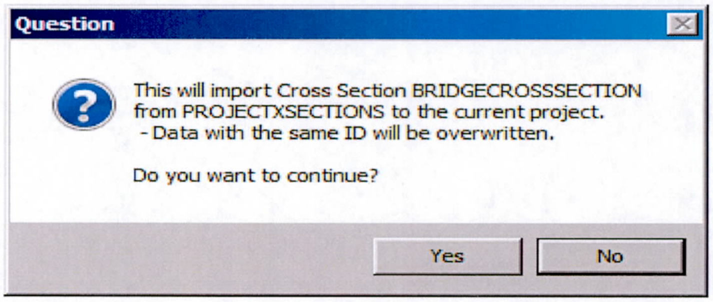


(b) On the **IMPORT CROSS SECTIONS FROM ANOTHER PROJECT** form, select the following settings:

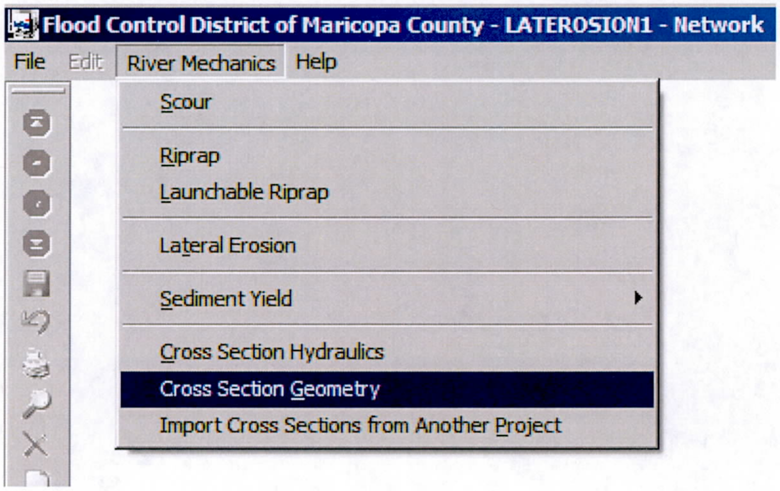
- **Import Project Reference:** *PROJECTXSECTIONS*
- **Option:** *Specific Cross Section*
- **Import Cross Section ID:** *LATEROSXSECTION*



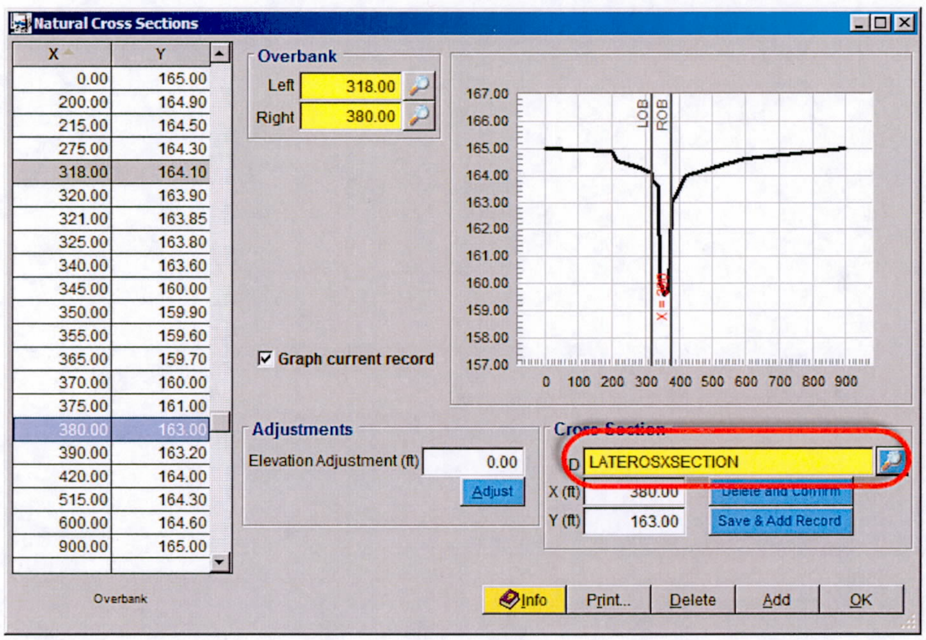
(c) Once the specified data have been selected, click the **Import** button. Select **Yes** to proceed, and hit **OK** to close the **IMPORT CROSS SECTION FROM ANOTHER PROJECT** form.



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



(e) On the form, select *"LATEROSXSECTION"* for the **Cross Section ID** by clicking the Selector button at the right side of the **ID** textbox.

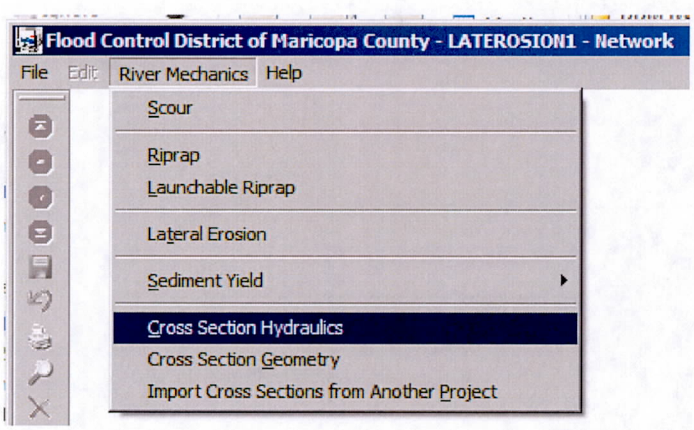


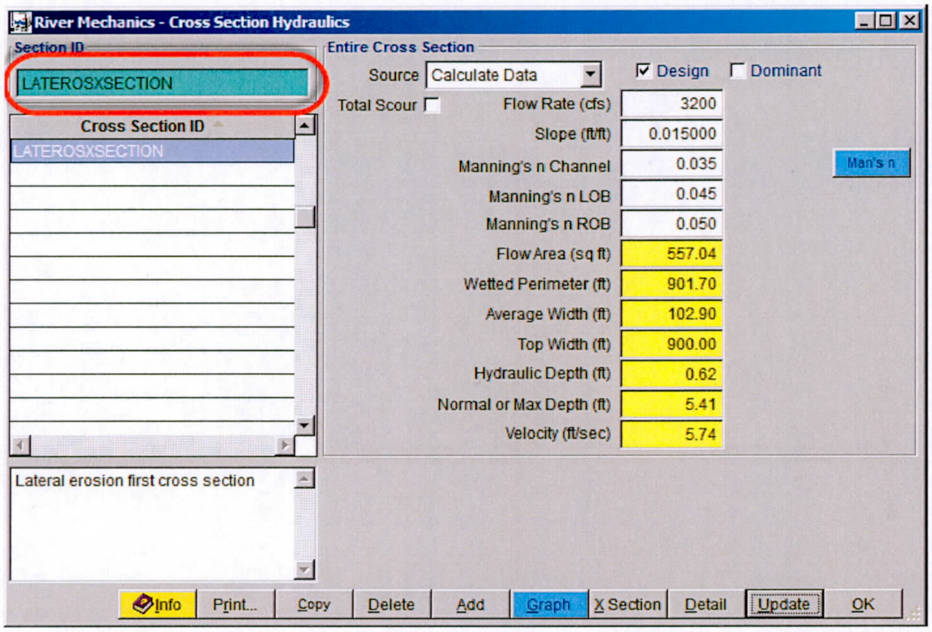
Compare the geometric data on the NATURAL CROSS SECTIONS form against the tabulated data listed below. Make necessary data edits or adjustments on the form, if necessary. Click **OK** to close the form.

Station (X)	Elevation (Y)	Notes
0	*165.0*	
200	*164.9*	
215	*164.5*	*FEMA Floodway Left Station*
275	*164.3*	
318	*164.1*	*Left Bank Station*
320	*163.9*	
321	*163.85*	
325	*163.8*	
340	*163.6*	
345	*160.0*	
350	*159.9*	
355	*159.6*	*Thalweg Station*
365	*159.7*	
370	*160.0*	
375	*161.0*	
380	*163.0*	*Right Bank Station*
390	*163.2*	
420	*164.0*	*FEMA Floodway Right Station*
515	*164.3*	
600	*164.6*	
900	*165.0*	

(f) Edit the cross section geometry, if necessary, and click ***Save*** to save all changes and revisions. Click ***OK*** to close and exit the **NATURAL CROSS SECTION** form.

(g) To view the cross-section hydraulic data for this cross-section, open the **CROSS SECTION HYDRAULICS** form (**River Mechanics ➔ Cross Section Hydraulics**) and on the form select *"LATEROSXSECTION"* from the **Cross Section ID** listing.





(h) On the **Cross Section Hydraulics** form, ensure that the **Source** is set to "*Calculate Data*". Check to ensure that the imported data values for **Flow Rate (cfs)**, **Slope (ft/ft)**, and **Manning's n (Channel, LOB, and ROB)** are the project values specified for this project, otherwise, edit and modify them.

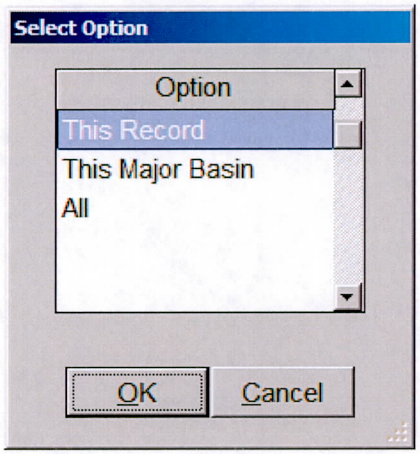
The project data are provided below:

- **Design Flow Rate (cfs):** *3200*
- **Channel Slope (ft/ft):** *0.015*
- **Design Manning's n for Main Channel:** *0.035*
- **Design Manning's n for LOB:** *0.045*
- **Design Manning's n for ROB:** *0.050*

(i) Click ***Save*** to save the edits, if you have made any.

(j) To recalculate or update the hydraulic analysis on this form, click **Update**.

(k) Select *"This Record"* from the **Select Option** form. Click ***OK*** to close the form.



(l) Click ***Yes*** on the UPDATE CROSS SECTION HYDRAULICS form to continue.

(m) Click **OK** to close the form.

B.3 Step 3 - Calculate Lateral Erosion Distance

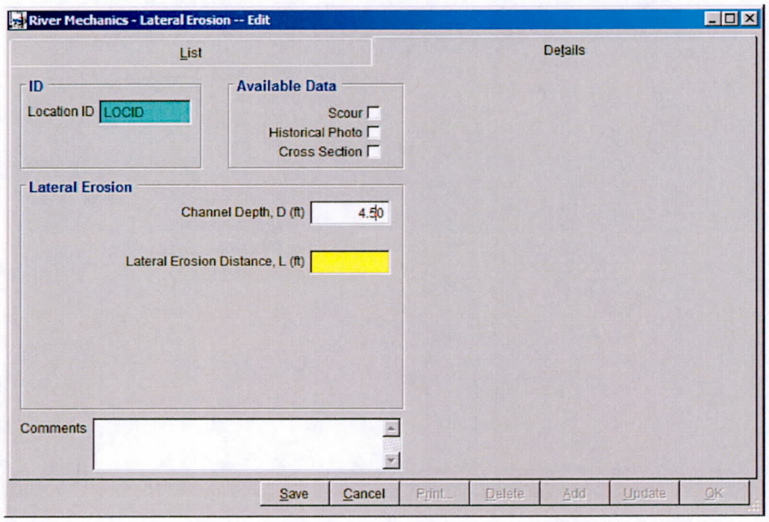
Four (4) analysis scenarios will be presented in this tutorial. These different scenarios are dependent on availability of data for analysis. These scenarios include: (a) no data; (b) with scour data; (c) with scour and historical data; and (d) with scour, historical, and cross section data.

B.3.1 Scenario #1 - No Data

(a) On the RIVER MECHANICS – LATERAL EROSION form (**River Mechanics → Lateral Erosion → Details** tab), make sure that all the check boxes in the **Available Data** frame are unchecked.

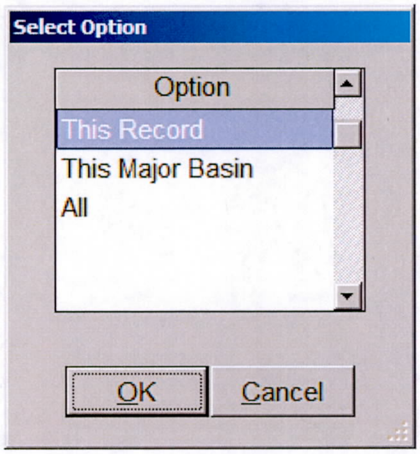
(b) Click **Add** to enter a new data and type in *"LOCID"* on the **Location ID** textbox.

(c) Type in *"4.5"* into the **Channel Depth, D (ft)** textbox. This information is assumed to be the field estimate made on the channel depth.



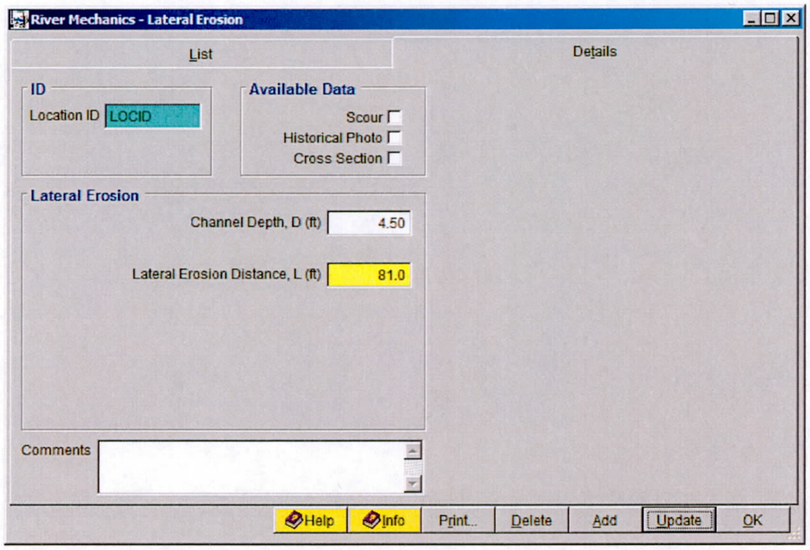
(d) Click ***Save*** to save the data entered.

(e) To calculate the **Lateral Erosion Distance, L (ft)**, click the ***Update*** button and select *"This Record"* from the **SELECT OPTION** form. Click ***OK*** to close the form.



(f) Click ***Yes*** when the **CALCULATE LATERAL EROSION** form opens.

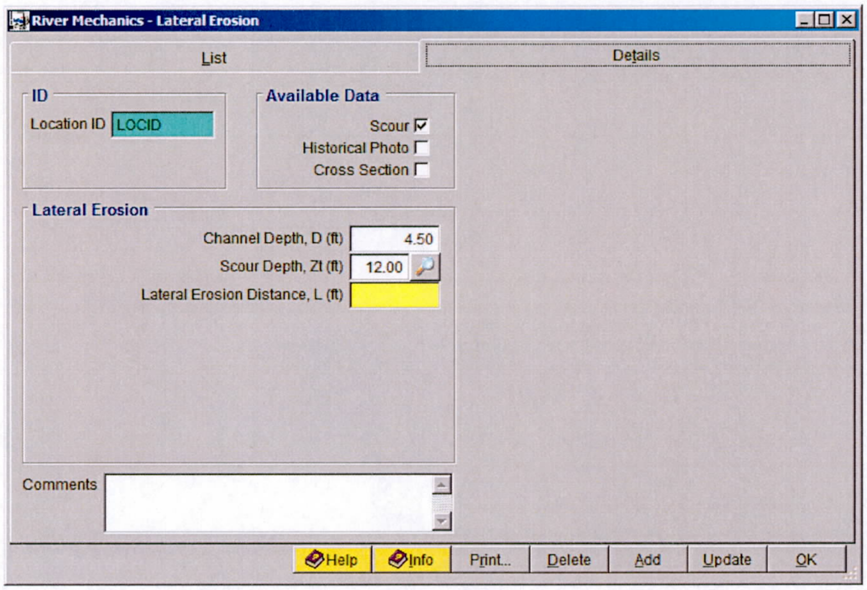
The following screen capture below shows the results of the analysis. The only data used was a field estimate of the **Channel Depth, D (ft)** at the location of interest.



B.3.2 Scenario #2 – Scour Data Available

(a) On the **River Mechanics – Lateral Erosion** form (**River Mechanics → Lateral Erosion**), check the **Scour** checkbox and leave the other two checkboxes unchecked.

(b) Type in *"12.00"* into the **Scour Depth, Zt (ft)** textbox, while keeping the value of the **Channel Depth, D (ft)** at *"4.50"*. Click **Save.**



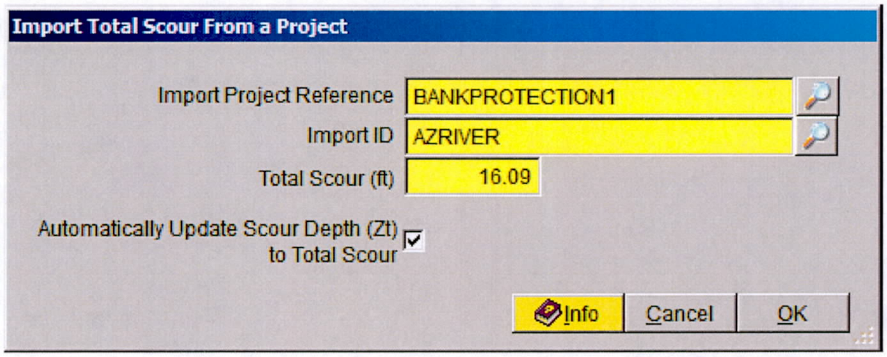
(c) To calculate the **Lateral Erosion Distance, L (ft)** for the manually entered data, click the ***Update*** button and select *"This Record"* from the **Select**

Option form. Click **Yes** to continue. Note that the estimated **Lateral Erosion Distance, L (ft)** is ***99 ft***.

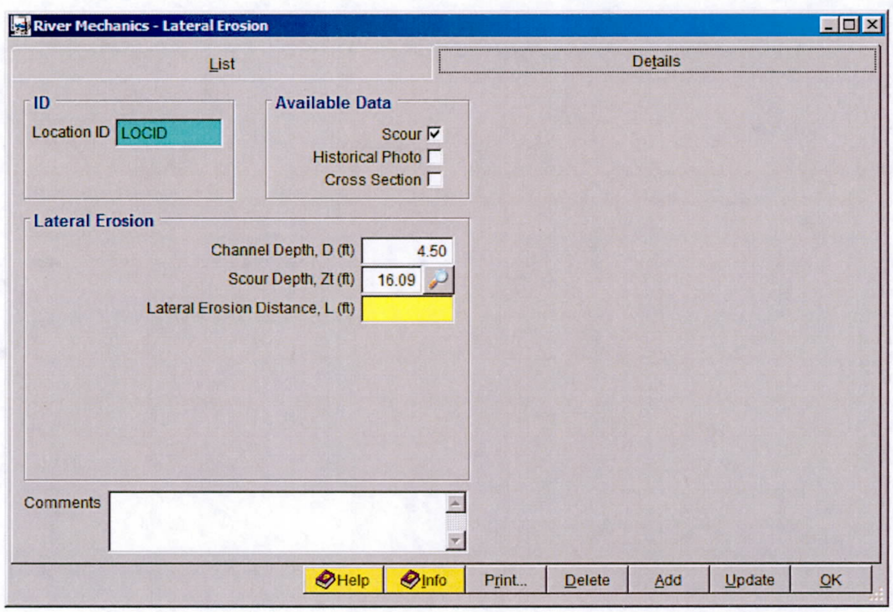
(d) As an alternative to the manual entries made, **DDMSW** has the capability to import the value from a scour analysis project. To use this import feature, click the magnifying glass across the **Scour Depth, Zt (ft)** textbox.

(e) On the **Import Total Scour From A Project** form, use the following data:

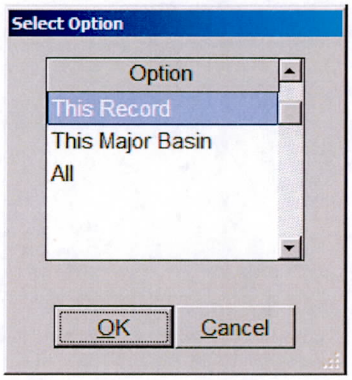
- **Import Project Reference**: *BANKPROTECTION1*
- **Import ID:** *AZRIVER*
- **Automatically Update Scour Depth (Zt) to Total scour Checkbox** *Check*



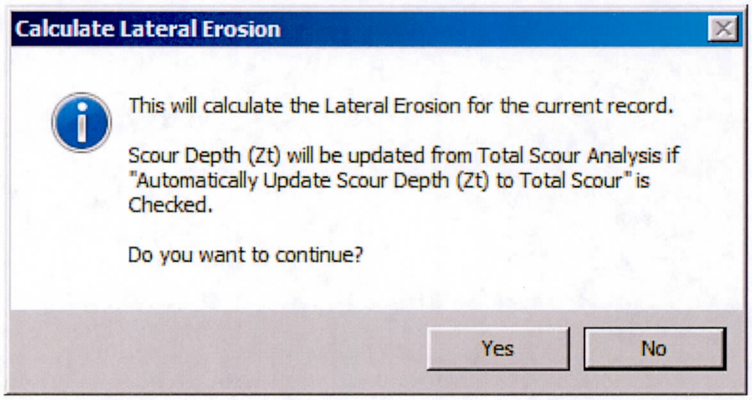
Click ***OK*** to close the form. [Note that the **Scour Depth, Zt (ft)** value has changed from *"12.00"* to *"16.09"*].



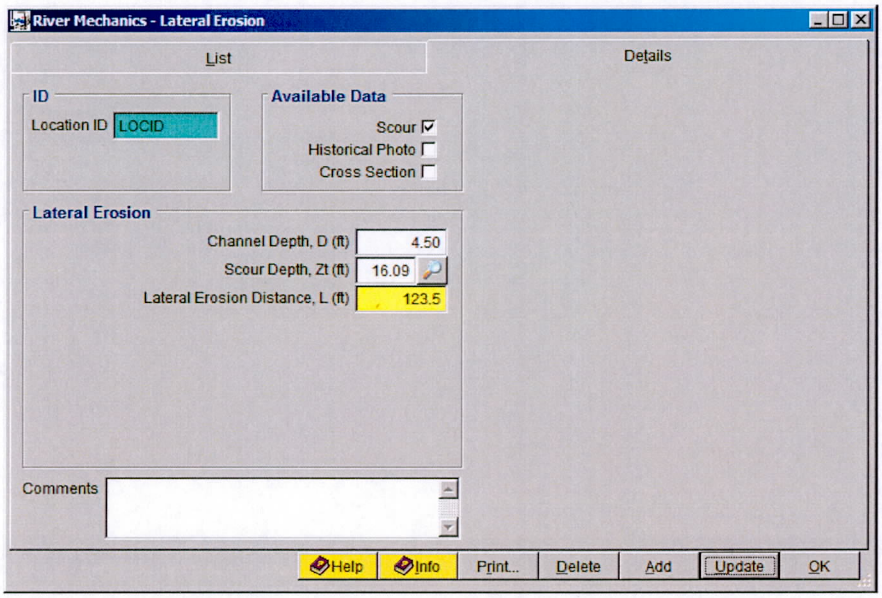
(f) To calculate the **Lateral Erosion Distance, L (ft)**, click the ***Update*** button and select *"This Record"* from the **SELECT OPTION** form. Click ***OK*** to close the form.



(g) Click ***Yes*** when the **CALCULATE LATERAL EROSION** form opens.

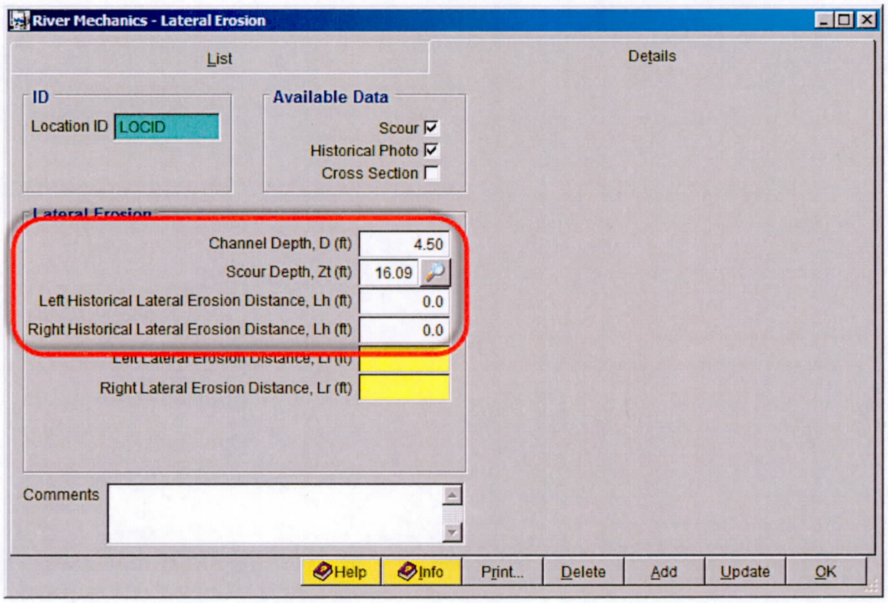


The screen capture below shows the results of the lateral erosion analysis where scour data is available, in addition to the field estimate of **Channel Depth, D (ft)** at *"4.50"* ft.



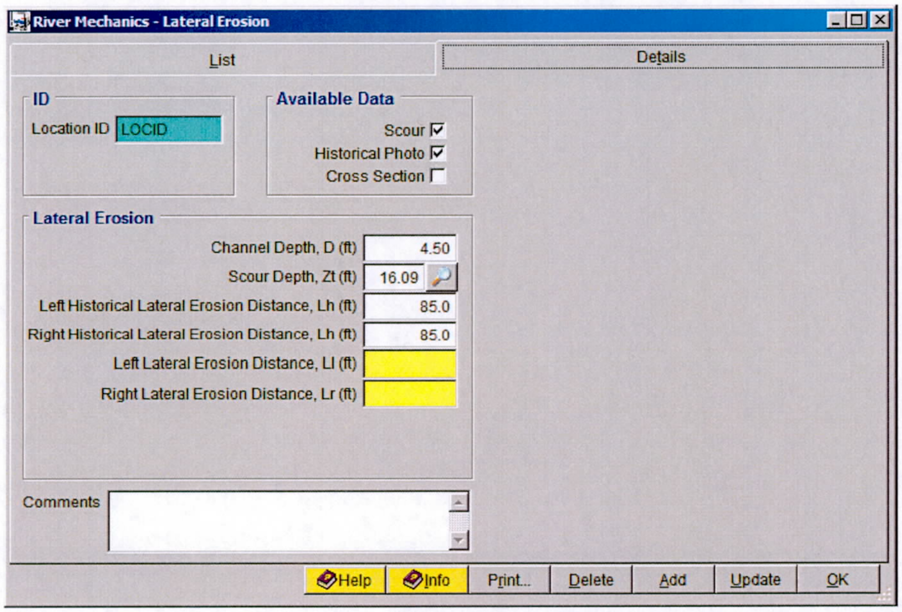
B.3.3 Scenario #3 – Scour and Historical Data Available

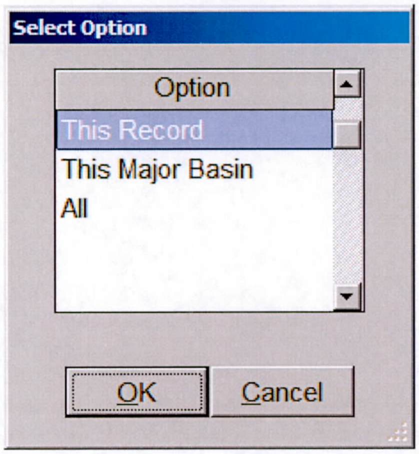
(a) On the **River Mechanics – Lateral Erosion** form (**River Mechanics → Lateral Erosion**), make sure that the **Scour** and **Historical Photo** checkboxes are checked. Leave the **Cross Section** checkbox unchecked.



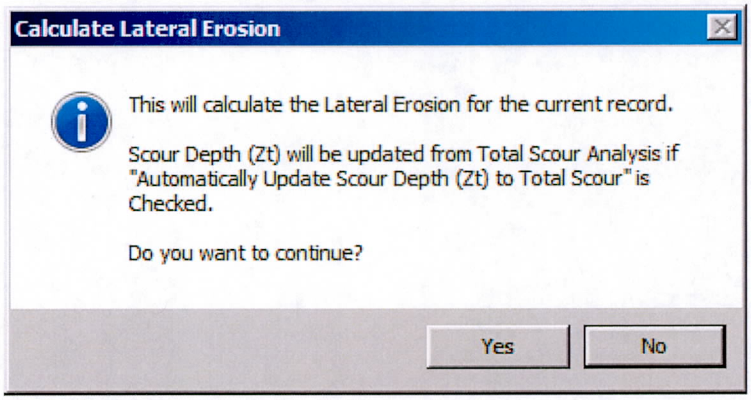
(b) Type in *"85.0"* into the **Left Historical Lateral Erosion Distance, Lh (ft)** and the **Right Historical Lateral Erosion distance, Lh (ft)** textboxes. Leave the **Channel Depth, D (ft)** value at *"4.50"* and the **Scour Depth, Zt (ft)** at "16.09" unchanged. Click ***Save*** to save the data.

(c) To calculate the **Lateral Erosion Distance, L (ft)**, click the ***Update*** button and select *"This Record"* from the **Select Option** form. Click ***OK*** to close the form.

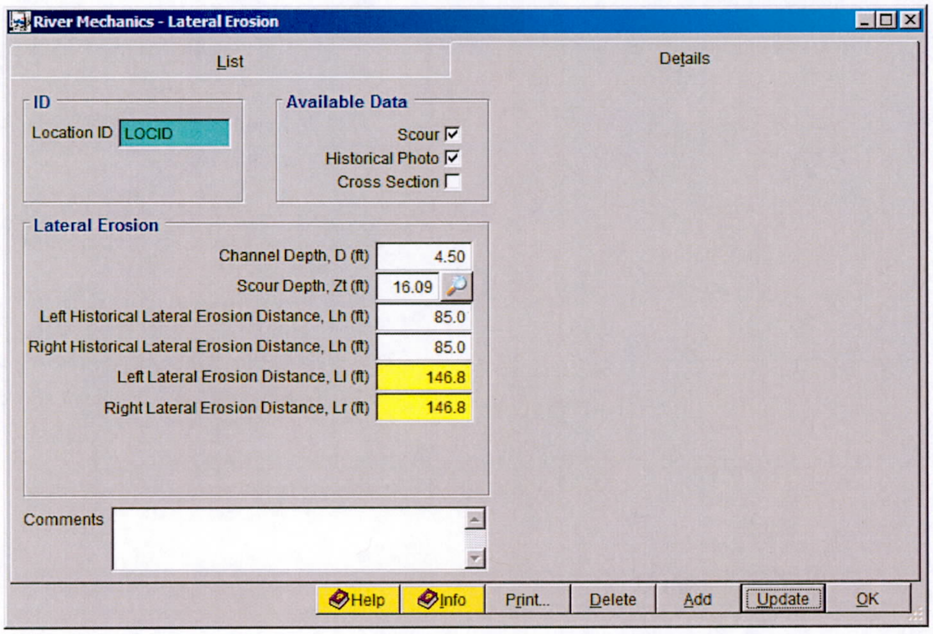




(d) Click ***Yes*** when the **Calculate Lateral Erosion** form opens.

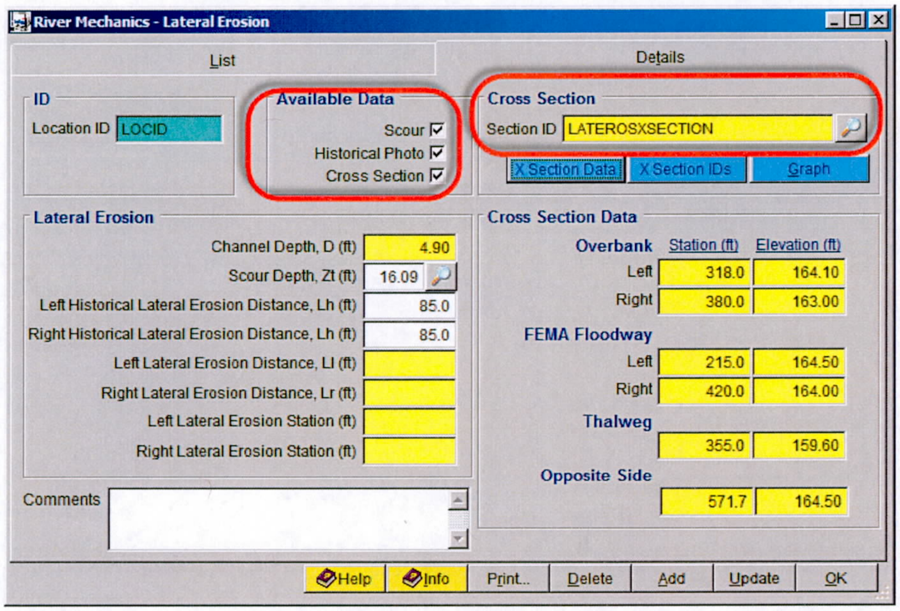


The screen capture below shows the results of the lateral erosion analysis where scour and historical data are available, in addition to the field estimate of **Channel Depth, D (ft)** at *"4.50"* ft.

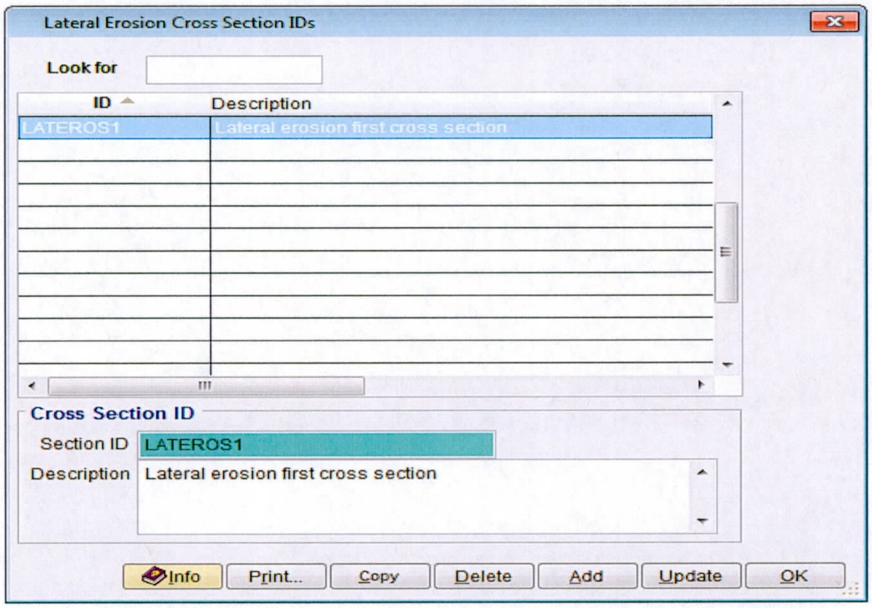


B.3.4 Scenario #4 – Scour, Historical and Cross Section Data Available

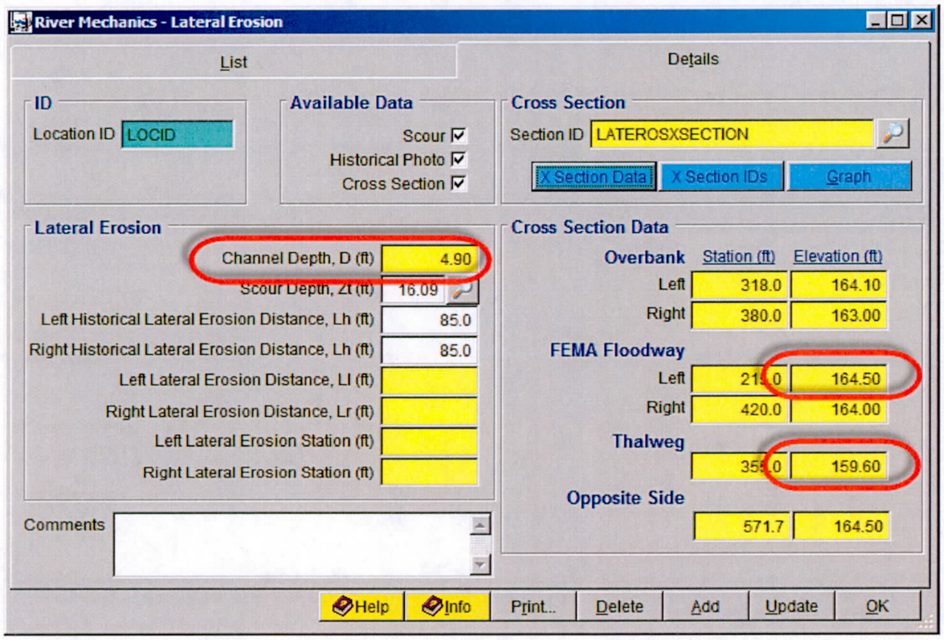
(a) On the RIVER MECHANICS – LATERAL EROSION form (**River Mechanics → Lateral Erosion**), make sure that all the checkboxes (i.e., **Scour, Historical Photo,** and **Cross Section)** are checked.



(b) To access the Cross Section Data for this project, click the **Selector** button (Magnifying glass) to the right of the **Section ID** textbox. On the **SELECT CROSS SECTION ID** form, select the *"LATEROSXSECTION"* from the list.

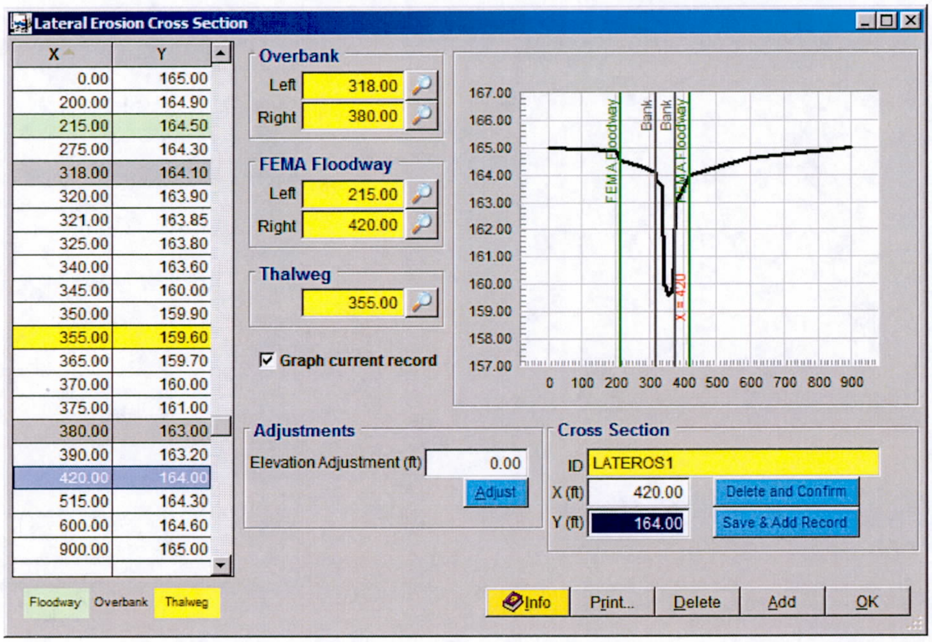


(c) Click ***OK*** to close the **SELECT CROSS SECTION ID** form.



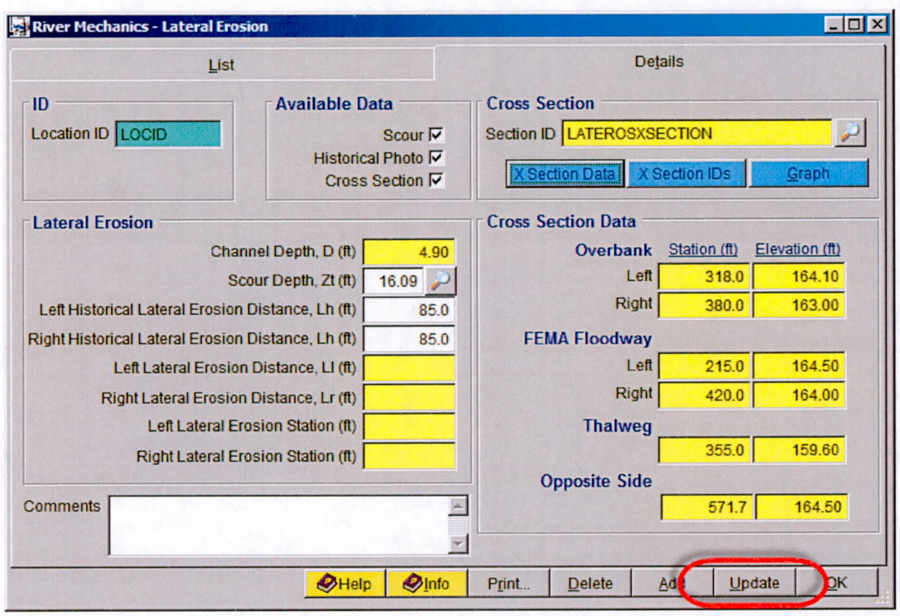
Note that by using the Cross Section Data, the **"Channel Depth, D (ft)"** textbox becomes "inactive" and a new value of the Channel Depth had replaced the manual data entered. This new value of the Channel Depth is the difference between the **FEMA Floodway Elevation** and the **Thalweg Elevation** (i.e., *164.50 -159.60 = 4.90 ft*).

(d) On the **River Mechanics – Lateral Erosion** form, click on the **X Section Data** button to view the **Lateral Erosion Cross Section** form that shows the cross section data and plot identifying the location of the banks and the FEMA Floodway limits.

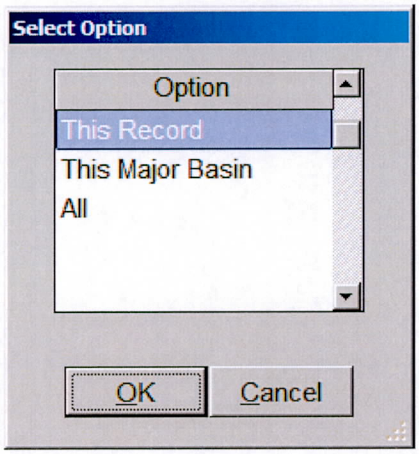


(e) Click ***OK*** to close the **Lateral Erosion Cross Section** form.

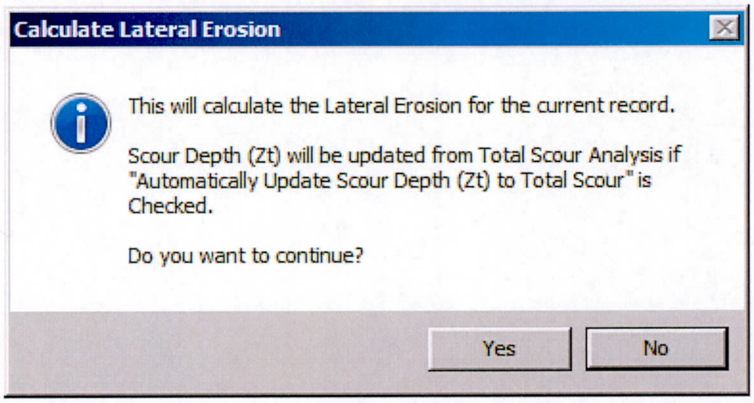
(f) To calculate the **Left Lateral Erosion Distance Ll (ft)**, and the **Right Lateral Erosion Distance, Lr (ft)**, click the ***Update*** button.



(g) When the **Select Option** form appears, highlight *"This Record"* and click ***OK*** to close the form.

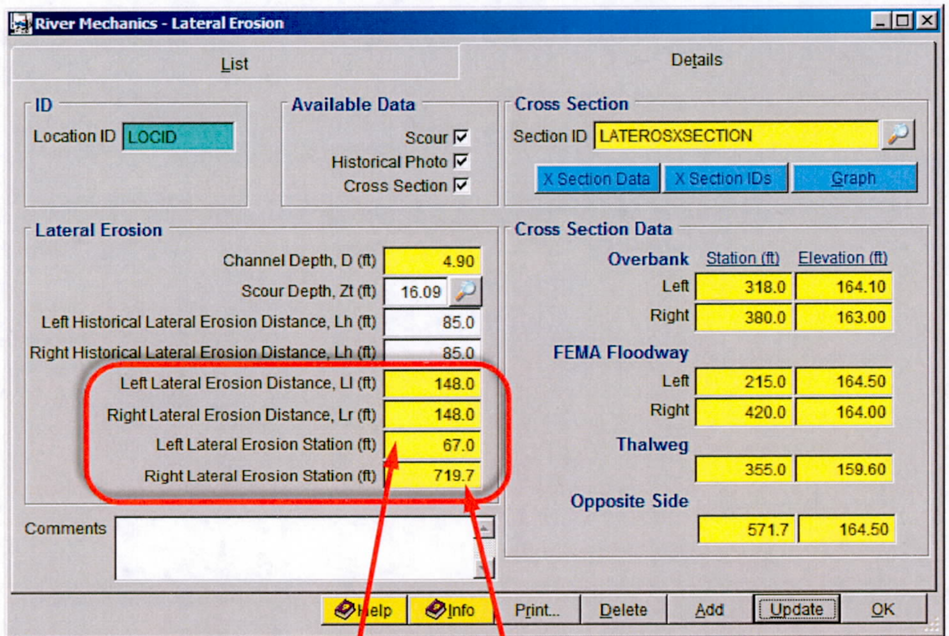


(h) Click ***Yes*** when the **CALCULATE LATERAL EROSION** form opens.

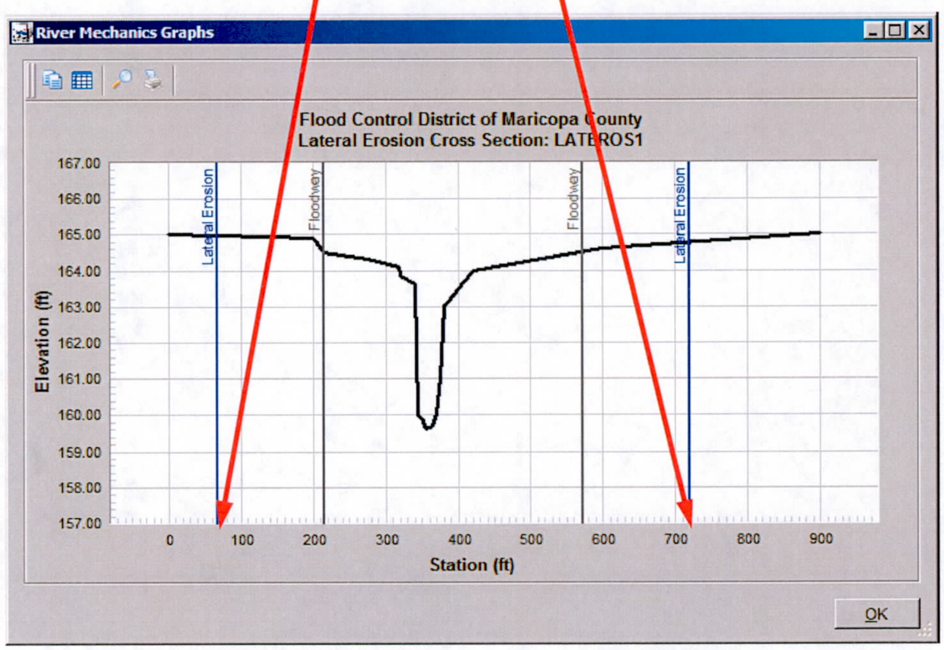


The screen capture provided below shows the results of the lateral erosion analysis where scour depth, historical data, and cross-section data are available. The summary of the results are:

- **Left Lateral Erosion Distance, Ll (ft):** **148.0**
- **Right Lateral Erosion Distance, Lr (ft):** **148.0**
- **Left lateral Erosion Station (ft):** **67.0**
- **Right Lateral Erosion Station (ft):** **719.7**



(i) To view the plot of the Lateral Erosion analysis results, click the **Graph** button. As shown on the results plot, the extent of lateral erosion on the left bank is at Station 67.0 ft and the lateral erosion on the right bank is at Station 719.7 ft. To exit the **River Mechanics Graphs** form, click the OK button.



B.4 Step 4 - Report / Document the Results

In this step, the instruction will be given on how to view, print, and export the calculation results of the lateral erosion analysis.

(a) To view the Lateral Erosion report, click the **Print ...** button on the **River Mechanics – Lateral Erosion** form.

Flood Control District of Maricopa County
Drainage Design Management System
RIVER MECHANICS - LATERAL EROSION
Project Reference: LATEROSION1

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ID	Cross Section ID	Channel Depth (ft)	Scour Depth (ft)	Historical Lateral Erosion Length		Lateral Erosion Length		Lateral Erosion Station	
				Left (ft)	Right (ft)	Left (ft)	Right (ft)	Left (ft)	Right (ft)
LOCID	LATEROS1	4,90	16,09	85,0	85,0	148,0	148,0	67,0	719,7

(b) To print the report, click the printer symbol ( ) at the top of the form.

(c) To export the report to a PDF file or other file formats, click the export symbol ( ) at the top of the form.

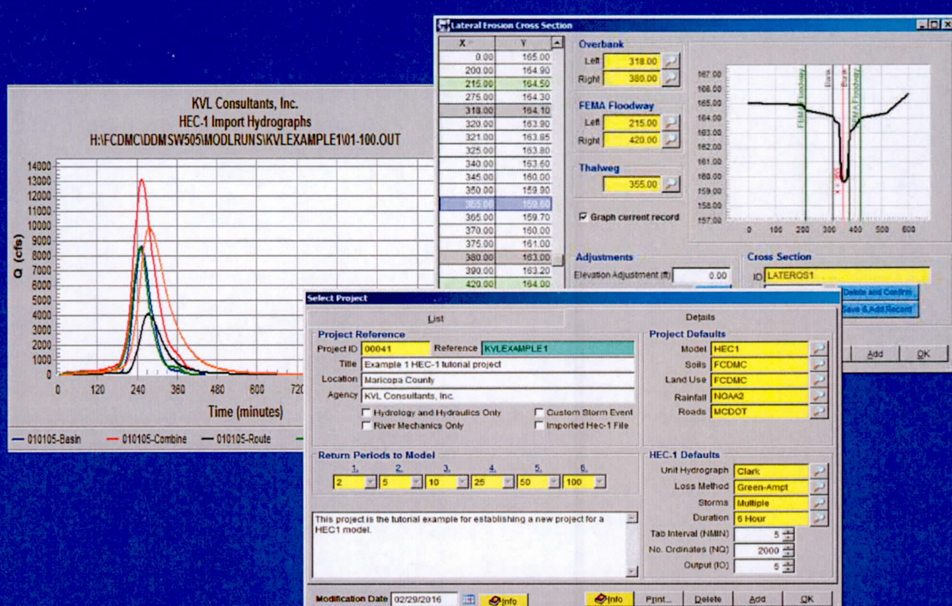
This concludes the tutorial for the Lateral erosion Analysis.

The Flood Control District of Maricopa County

DDMSW Training Workshops

STORM DRAINAGE HYDRAULICS

March 10, 2016



Maricopa County Department of Transportation (MCDOT)
Computer Training Room
2919 W Durango St, Phoenix, Arizona 85009

Presented by:
Kenneth Lewis, P.E.
KVL Consultants, Inc.

DDMSW 5.1
Training Workshops

STORM DRAINAGE HYDRAULICS

Engineering Application Development and River Mechanics Branch
Engineering Division
Flood Control District of Maricopa County

March 10, 2016

This document contains step-by-step tutorials for the Storm Drainage Hydraulics module of DDMSW. The two tutorials for the Storm Drainage Hydraulics cover the computations of street surface drainage and storm drainage system for hydraulic grade line analysis.

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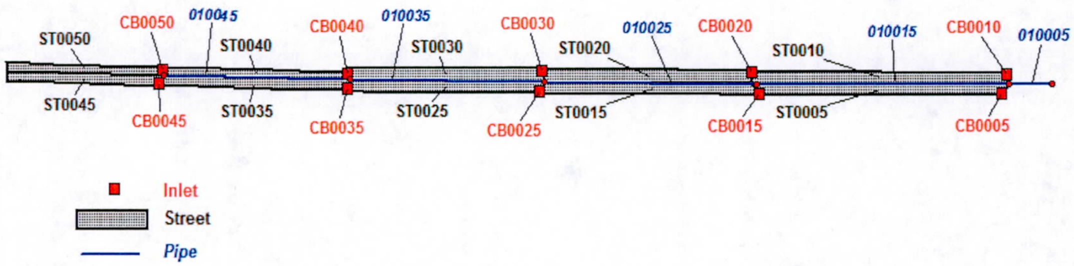
III Storm Drainage Hydraulics

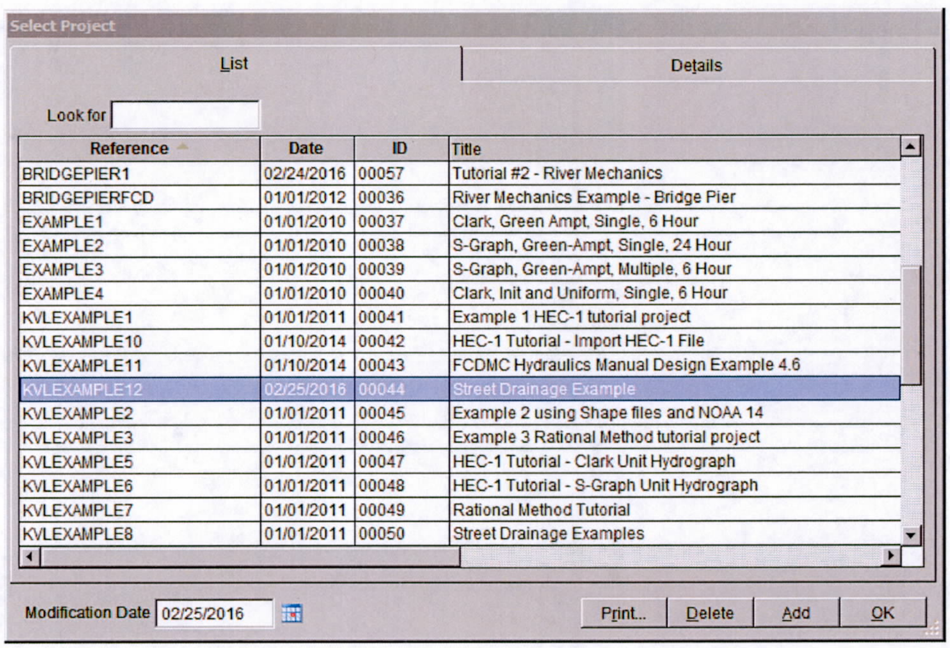
3.1 Street Drainage Example

This tutorial provides a Street Drainage working example using **DDMSW** (**KVLExample12**). The layout of the system is shown below.



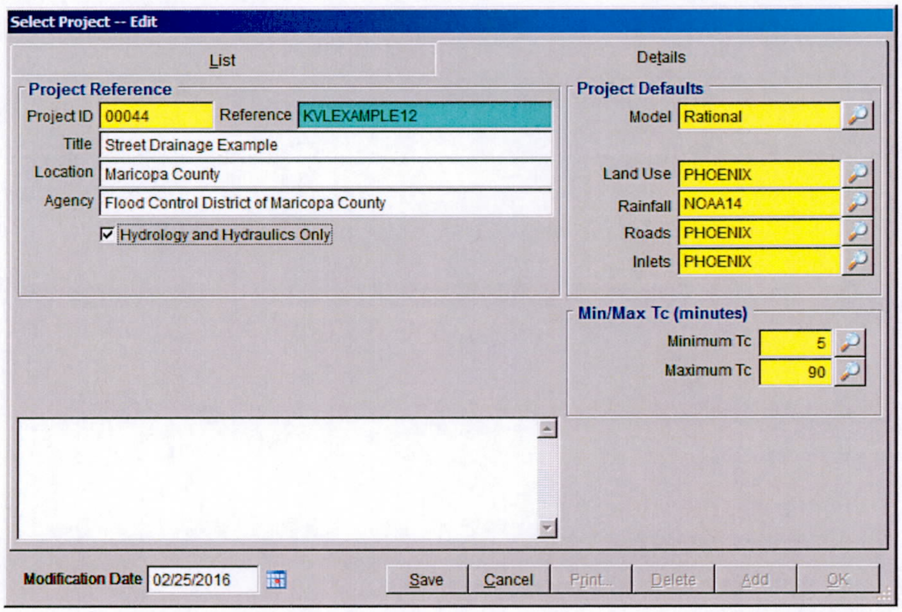
(A) Step 1 – Set Project Defaults (File ➔ Select Project)

For this example, select the data (**KVLExample12**) as shown on the following screen.



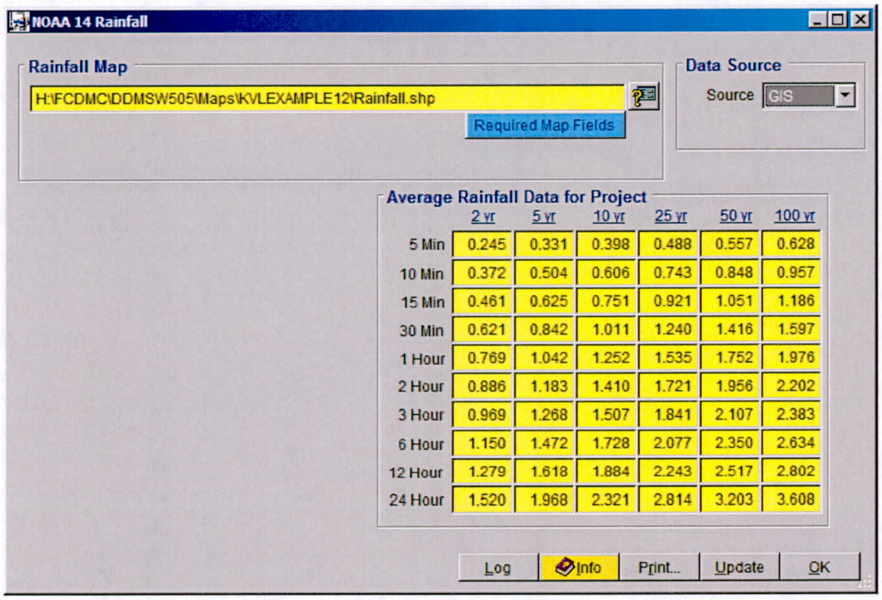
Reference	Date	ID	Title
BRIDGEPIER1	02/24/2016	00057	Tutorial #2 - River Mechanics
BRIDGEPIERFCD	01/01/2012	00036	River Mechanics Example - Bridge Pier
EXAMPLE1	01/01/2010	00037	Clark, Green Ampt, Single, 6 Hour
EXAMPLE2	01/01/2010	00038	S-Graph, Green-Ampt, Single, 24 Hour
EXAMPLE3	01/01/2010	00039	S-Graph, Green-Ampt, Multiple, 6 Hour
EXAMPLE4	01/01/2010	00040	Clark, Init and Uniform, Single, 6 Hour
KVLEXAMPLE1	01/01/2011	00041	Example 1 HEC-1 tutorial project
KVLEXAMPLE10	01/10/2014	00042	HEC-1 Tutorial - Import HEC-1 File
KVLEXAMPLE11	01/10/2014	00043	FCDMC Hydraulics Manual Design Example 4.6
KVLEXAMPLE12	02/25/2016	00044	Street Drainage Example
KVLEXAMPLE2	01/01/2011	00045	Example 2 using Shape files and NOAA 14
KVLEXAMPLE3	01/01/2011	00046	Example 3 Rational Method tutorial project
KVLEXAMPLE5	01/01/2011	00047	HEC-1 Tutorial - Clark Unit Hydrograph
KVLEXAMPLE6	01/01/2011	00048	HEC-1 Tutorial - S-Graph Unit Hydrograph
KVLEXAMPLE7	01/01/2011	00049	Rational Method Tutorial
KVLEXAMPLE8	01/01/2011	00050	Street Drainage Examples

On the same form (**Select Project**) select the **Details** tab.



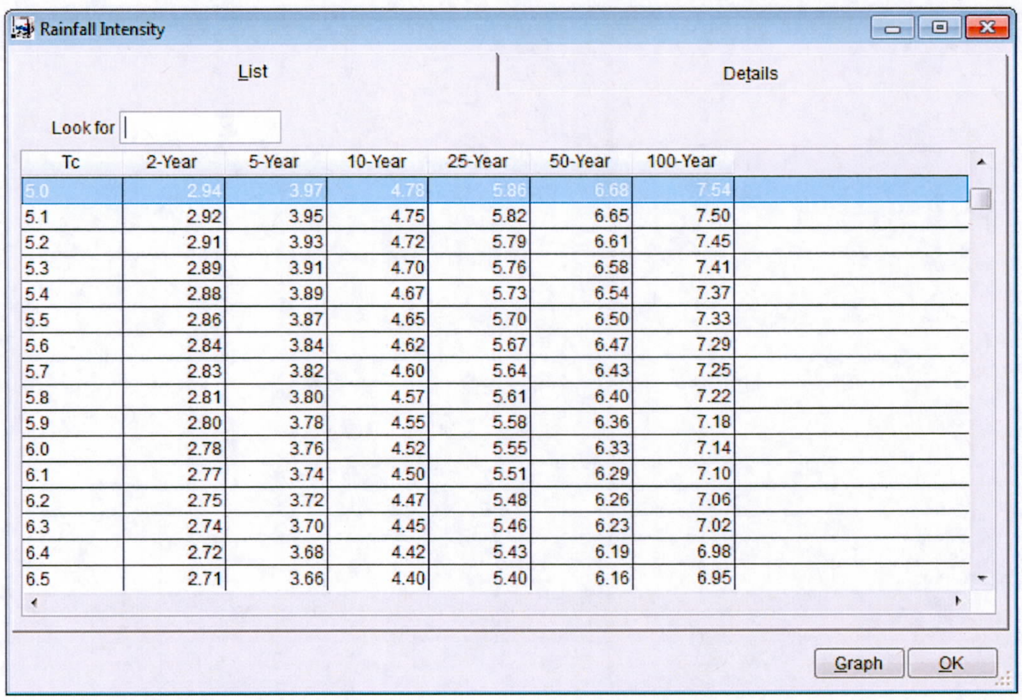
(B) Step 2 - Develop the Rainfall Data (Hydrology → Rainfall)

For this example, NOAA14 Rainfall shall be used and be developed using GIS. The GIS Shape file *("Rainfall.shp")* is included in the **KVLExample12** subfolder in the **Maps** folder (**C:\FCDMC\DDMSW505\Maps\KVLExample12**). Your path to this file may be different to that shown in this example. Enter the data as shown on the following screen and then click **Save**. Click **Update** to develop the rainfall data. Click **Yes** to continue and to exit the **Update NOAA14 Rainfall Using GIS** window. Click **OK** to exit the **NOAA 14 Rainfall** window.

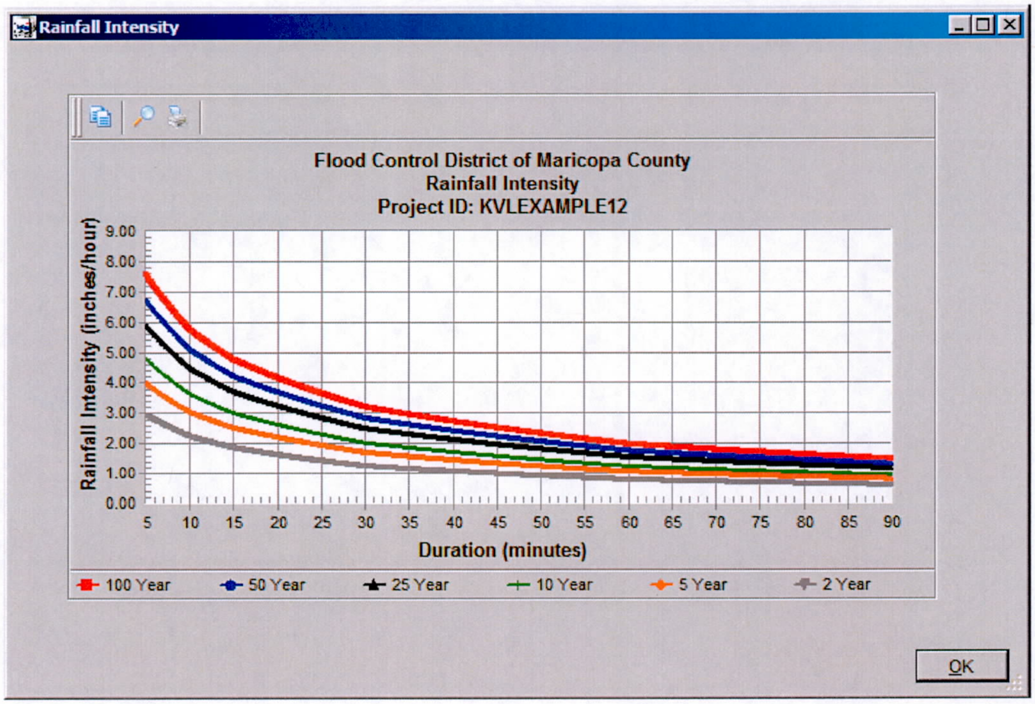


	2 yr	5 yr	10 yr	25 yr	50 yr	100 yr
5 Min	0.245	0.331	0.398	0.488	0.557	0.628
10 Min	0.372	0.504	0.606	0.743	0.848	0.957
15 Min	0.461	0.625	0.751	0.921	1.051	1.186
30 Min	0.621	0.842	1.011	1.240	1.416	1.597
1 Hour	0.769	1.042	1.252	1.535	1.752	1.976
2 Hour	0.886	1.183	1.410	1.721	1.956	2.202
3 Hour	0.969	1.268	1.507	1.841	2.107	2.383
6 Hour	1.150	1.472	1.728	2.077	2.350	2.634
12 Hour	1.279	1.618	1.884	2.243	2.517	2.802
24 Hour	1.520	1.968	2.321	2.814	3.203	3.608

To see a graph of the IDF (rainfall intensity-duration-frequency) curves, go to (**Hydrology ➔Rational Method ➔Rainfall Intensity**) and click **Graph.**

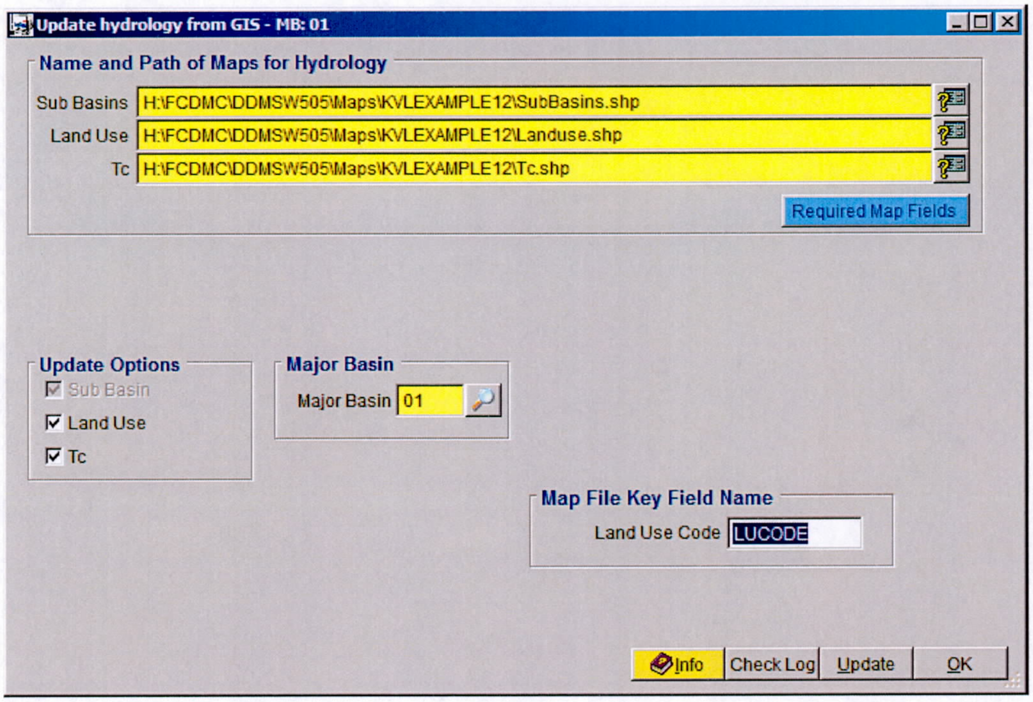


Tc	2-Year	5-Year	10-Year	25-Year	50-Year	100-Year
5.0	2.94	3.97	4.78	5.86	6.68	7.54
5.1	2.92	3.95	4.75	5.82	6.65	7.50
5.2	2.91	3.93	4.72	5.79	6.61	7.45
5.3	2.89	3.91	4.70	5.76	6.58	7.41
5.4	2.88	3.89	4.67	5.73	6.54	7.37
5.5	2.86	3.87	4.65	5.70	6.50	7.33
5.6	2.84	3.84	4.62	5.67	6.47	7.29
5.7	2.83	3.82	4.60	5.64	6.43	7.25
5.8	2.81	3.80	4.57	5.61	6.40	7.22
5.9	2.80	3.78	4.55	5.58	6.36	7.18
6.0	2.78	3.76	4.52	5.55	6.33	7.14
6.1	2.77	3.74	4.50	5.51	6.29	7.10
6.2	2.75	3.72	4.47	5.48	6.26	7.06
6.3	2.74	3.70	4.45	5.46	6.23	7.02
6.4	2.72	3.68	4.42	5.43	6.19	6.98
6.5	2.71	3.66	4.40	5.40	6.16	6.95

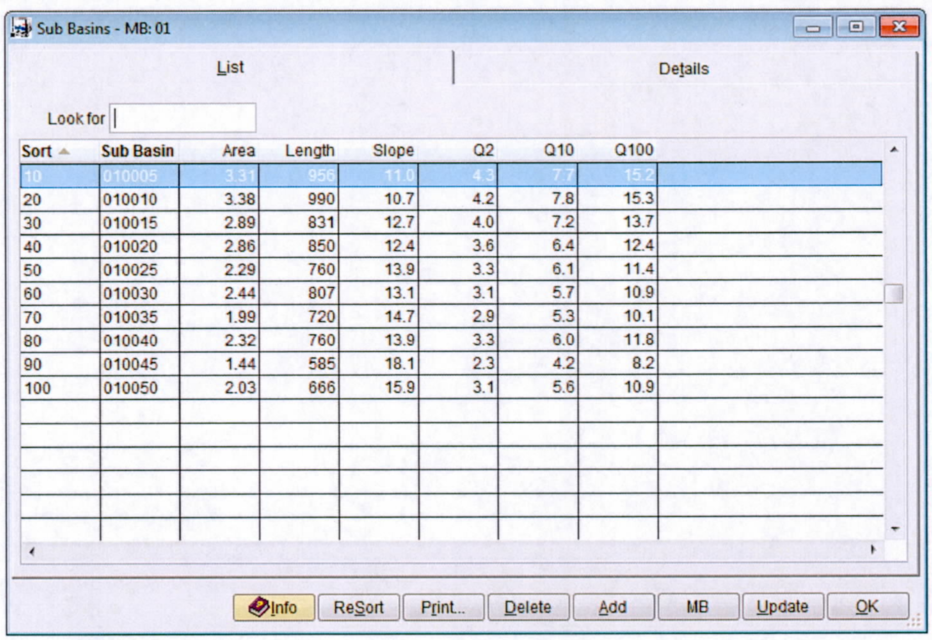


(C) Step 3 - Develop Sub Basin Data (Using GIS) (Maps ➔ Update Hydrology)

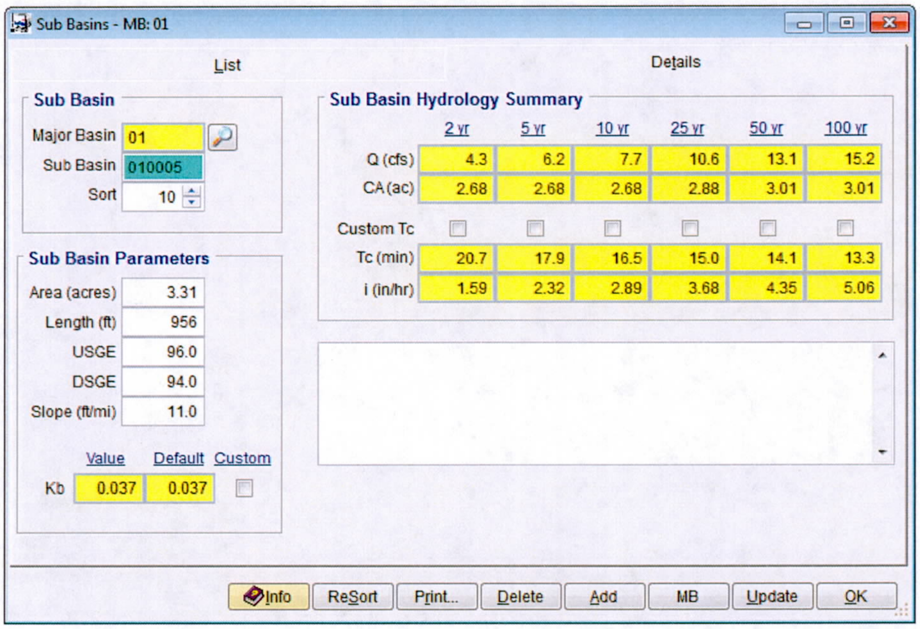
The Sub Basin and Land Use data will be developed using GIS. The shape files include SubBasins *("SubBasins.shp")*, Landuse *("Landuse.shp")* and Tc *("Tc.shp")* which are all located in the **KVLExample12** folder (**C:\FCDMC\DDMSW505\Maps\KVLExample12**). Open the **UPDATE HYDROLOGY FROM GIS** form (**Maps ➔ Update Hydrology**) to select the shapefiles. Again, your path to these files may be different. Enter the data shown below and click **Save.** Click **Update** to recalculate the sub basin parameters in the model.



After update, close the form by clicking **OK**. Check to see if all the Sub Basin parameters have been evaluated on the **Sub Basins** form (**Hydrology ➔ Sub Basins**).

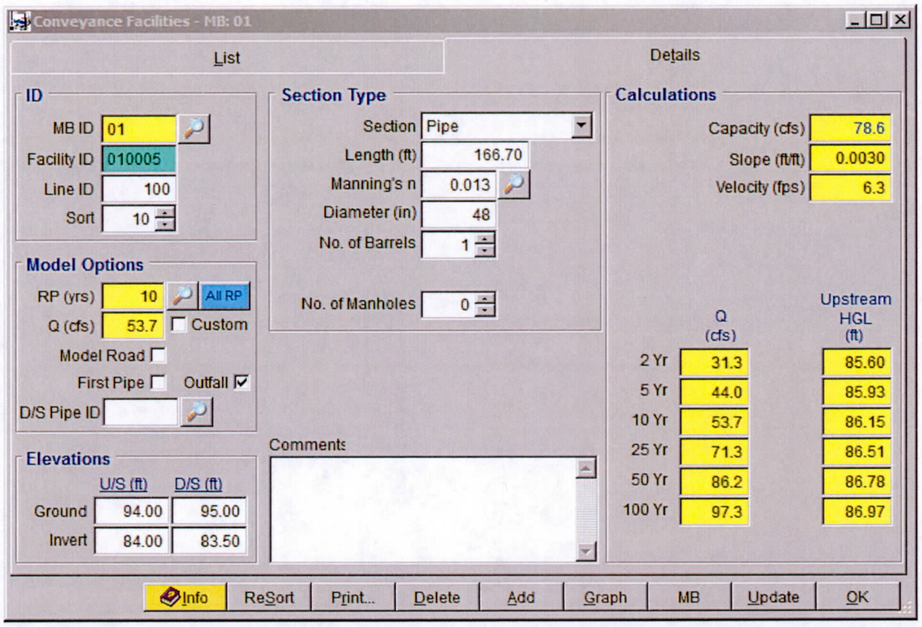


On the **Sub Basins** form, select the **Details** tab.



(D) Step 4 - Update Conveyance Facilities Data (Hydraulics➔ Conveyance Facilities)

For this example, the **STORMPRO** backwater model will be used to develop the hydraulic grade line (HGL). Therefore, it is necessary to sort the conveyance facilities in the correct order and establish the **Line ID** for each Conveyance Facility. This is done by clicking the **ReSort** button at the bottom of the form. With respect to the Figure (i.e., configuration of the drainage system) shown on the first page, all Conveyance Facilities will be **Line** *"100"*.

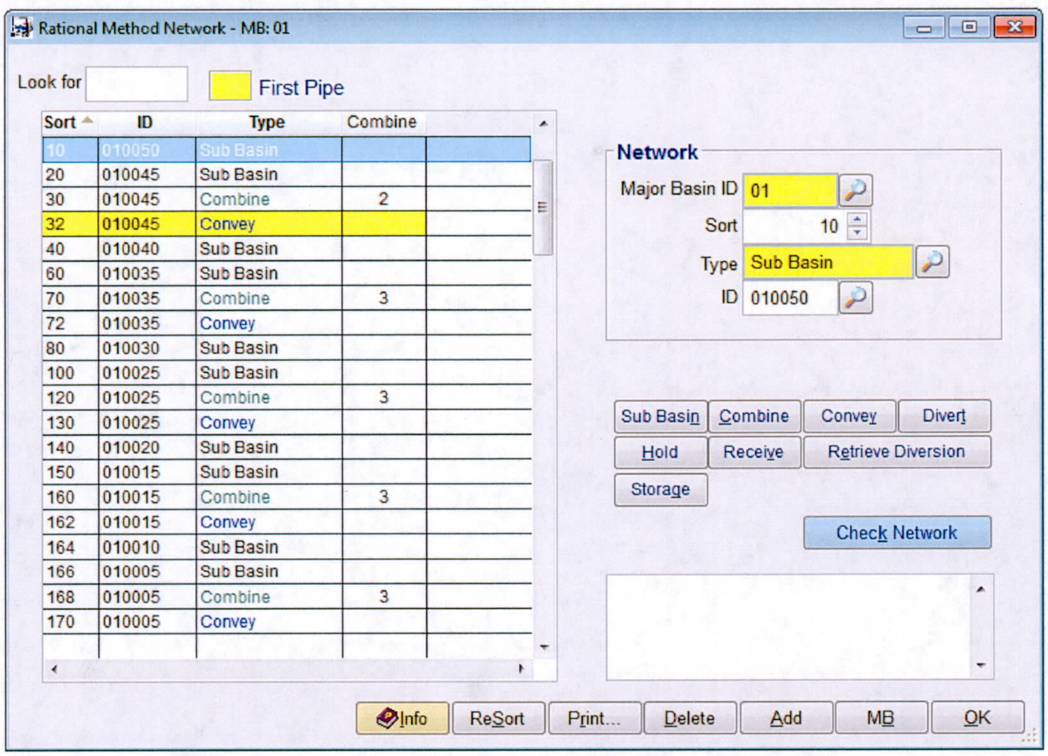


The following table presents the input data for all Conveyance Facilities. Common to all are the following: All *"Pipe"* **Section**; **Manning's n** is *"0.013"*; **No of Barrels** is *"1"*.

ID			Model Options					Elevations				Section		
Facility ID	Line ID	Sort	RP	Model Road	First Pipe	Outfall	DS Pipe ID	USGE	DSGE	USIE	DSIE	Length	Dia	Manholes
010005	100	10	10			X		94.00	95.00	84.00	83.50	166.70	48	
010015	100	20	10					95.00	94.00	85.00	84.00	100.00	48	1
010025	100	30	10					96.00	95.00	86.50	85.50	829.30	42	1
010035	100	40	10					97.00	96.00	88.00	87.00	761.10	36	1
010045	100	50	10		X			98.00	97.00	89.50	88.50	727.10	30	1

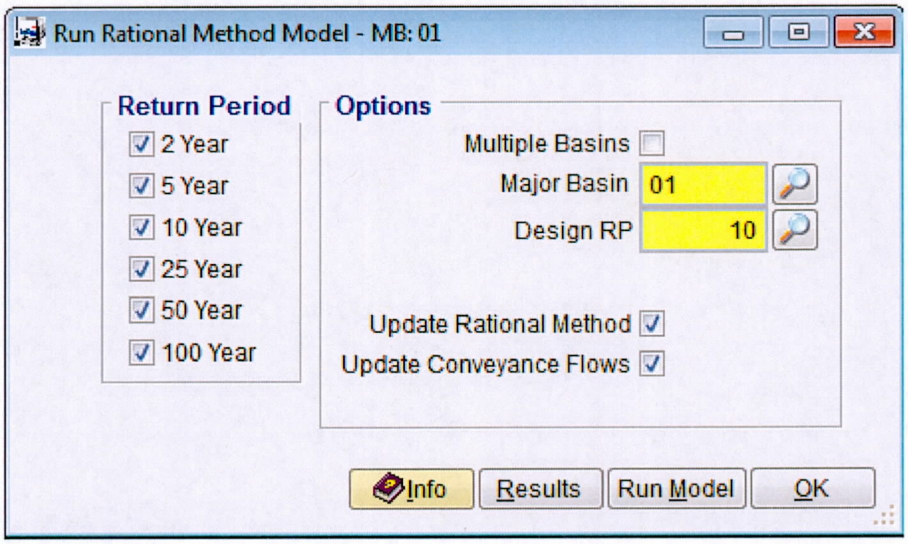
(E) Step 5 - Develop Rational Method Network (Hydrology➔Rational Method ➔Network)

Enter the data as shown below:



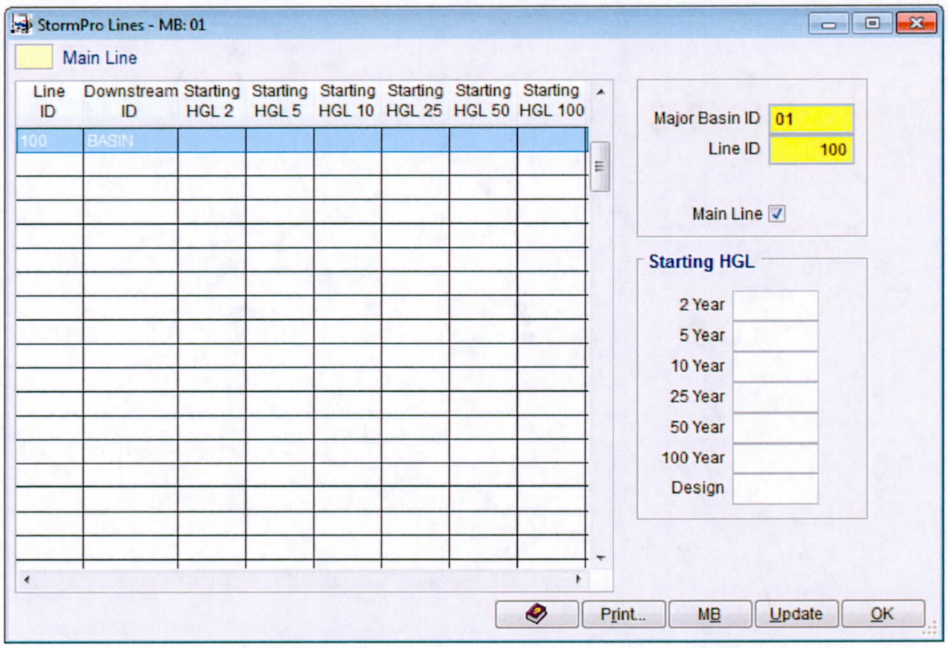
(F) Step 6 - Run Rational Method Model (Hydrology ➔ Rational Method ➔ Model)

Enter the data as shown below and then click **Run Model**.



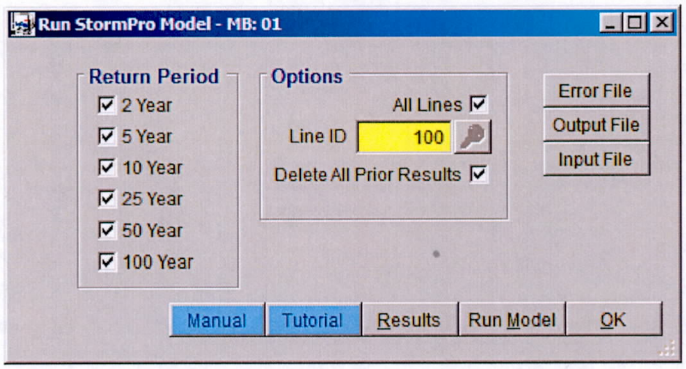
(G) Step 7 - Update StormPro Lines (Hydraulics ➔ StormPro Backwater ➔ Lines)

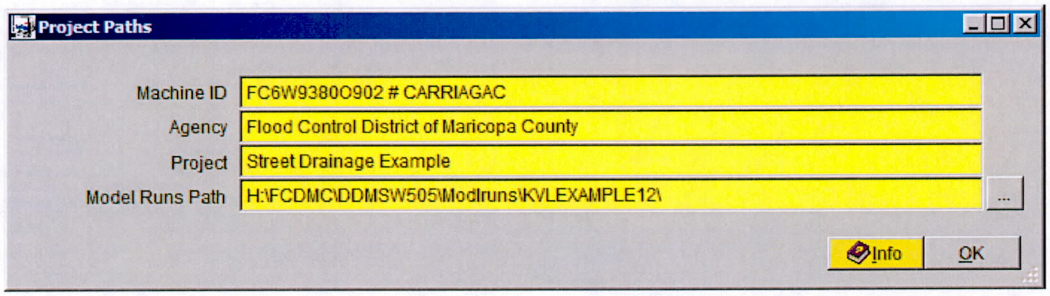
It is necessary to establish the starting water surface elevation for **Line ID** *"100"*. If left blank, the value will default to (D+Dc)/2, where D is the depth of the facility, and Dc is the critical flow depth. For **Line ID** *"100"*, check that it is a **Main Line**.

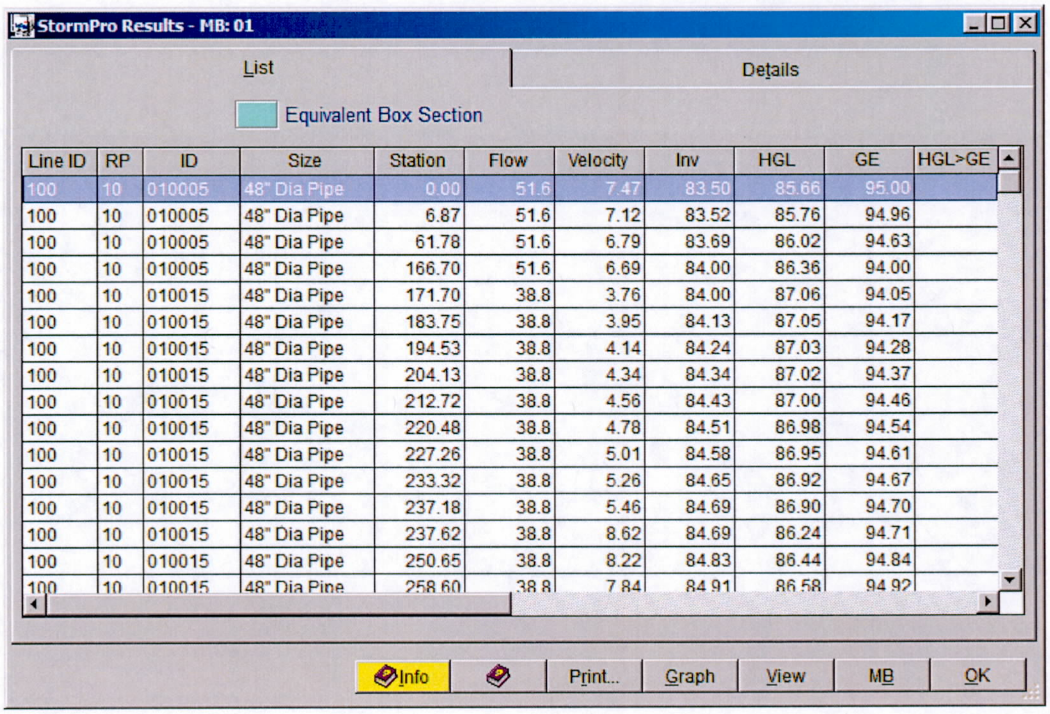


(H) Step 8 - Run StormPro Model (Hydraulics ➔ StormPro Backwater ➔ Model)

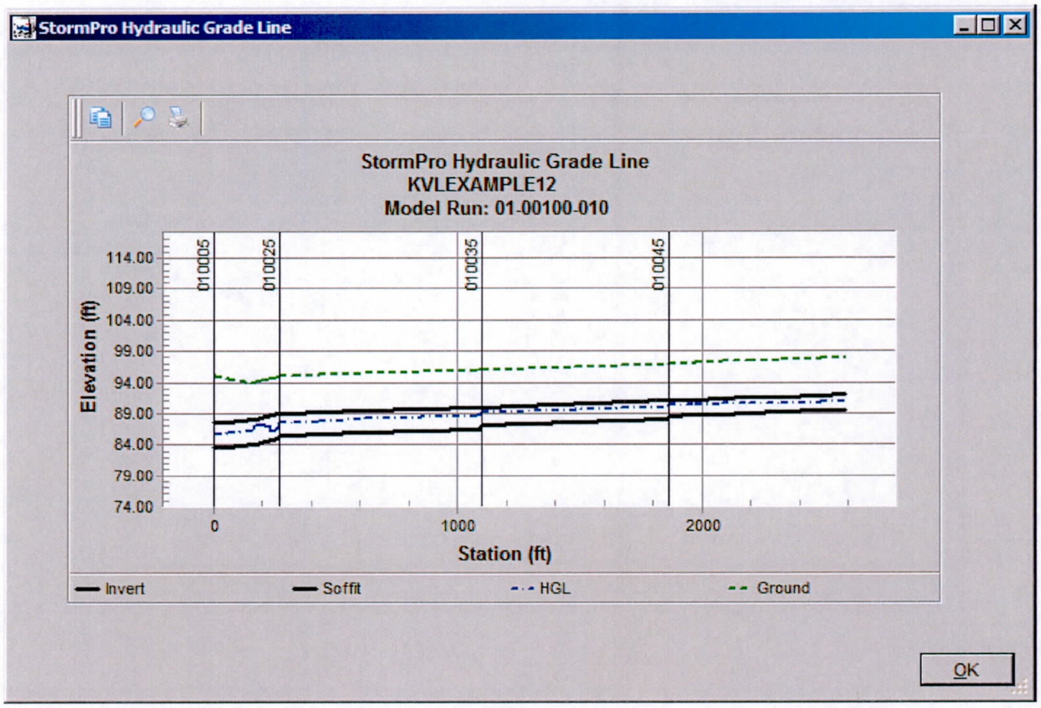
Select all **Return Periods**, check **All Lines** checkbox and check **Delete All Prior Results**. Please note that it is necessary to establish a folder for the model results. The results can be viewed by clicking **Results** and can be graphed by clicking **Graph** on the **STORMPRO RESULTS** window.





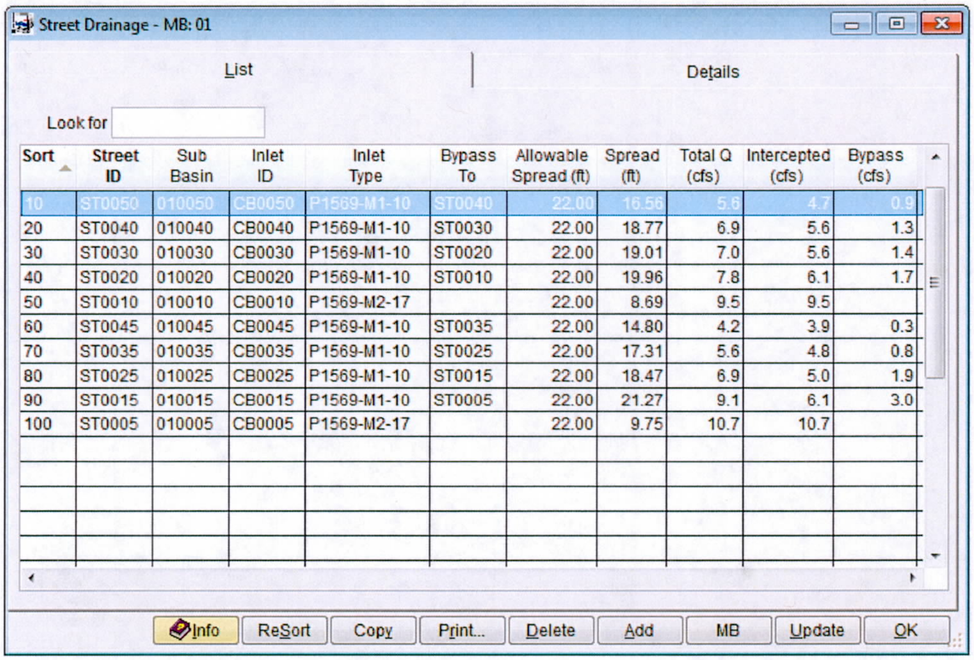


Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
100	10	010005	48" Dia Pipe	0.00	51.6	7.47	83.50	85.66	95.00	
100	10	010005	48" Dia Pipe	6.87	51.6	7.12	83.52	85.76	94.96	
100	10	010005	48" Dia Pipe	61.78	51.6	6.79	83.69	86.02	94.63	
100	10	010005	48" Dia Pipe	166.70	51.6	6.69	84.00	86.36	94.00	
100	10	010015	48" Dia Pipe	171.70	38.8	3.76	84.00	87.06	94.05	
100	10	010015	48" Dia Pipe	183.75	38.8	3.95	84.13	87.05	94.17	
100	10	010015	48" Dia Pipe	194.53	38.8	4.14	84.24	87.03	94.28	
100	10	010015	48" Dia Pipe	204.13	38.8	4.34	84.34	87.02	94.37	
100	10	010015	48" Dia Pipe	212.72	38.8	4.56	84.43	87.00	94.46	
100	10	010015	48" Dia Pipe	220.48	38.8	4.78	84.51	86.98	94.54	
100	10	010015	48" Dia Pipe	227.26	38.8	5.01	84.58	86.95	94.61	
100	10	010015	48" Dia Pipe	233.32	38.8	5.26	84.65	86.92	94.67	
100	10	010015	48" Dia Pipe	237.18	38.8	5.46	84.69	86.90	94.70	
100	10	010015	48" Dia Pipe	237.62	38.8	8.62	84.69	86.24	94.71	
100	10	010015	48" Dia Pipe	250.65	38.8	8.22	84.83	86.44	94.84	
100	10	010015	48" Dia Pipe	258.60	38.8	7.84	84.91	86.58	94.92	

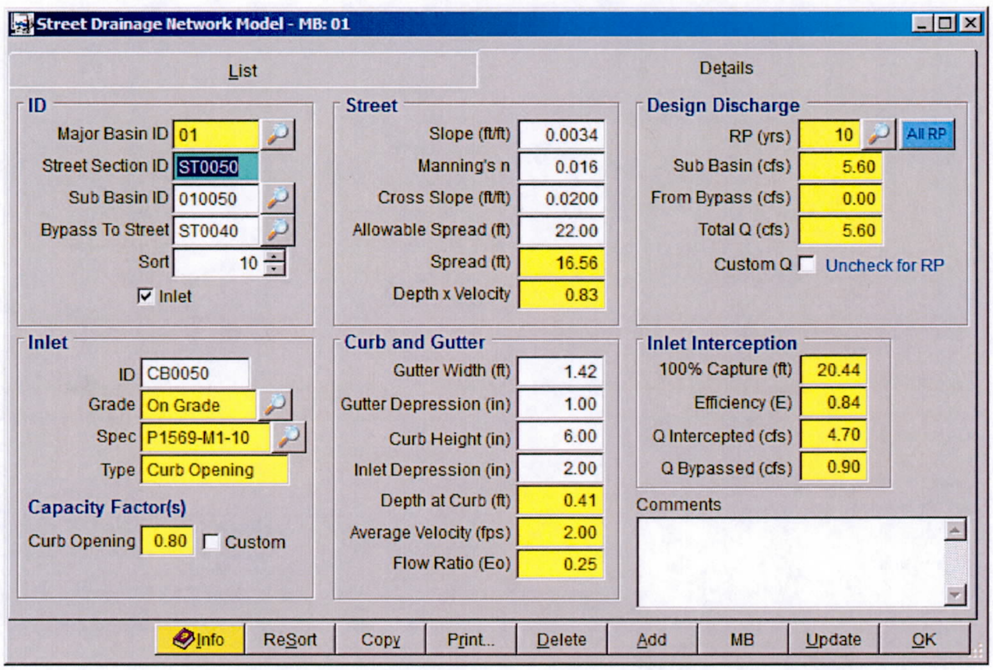


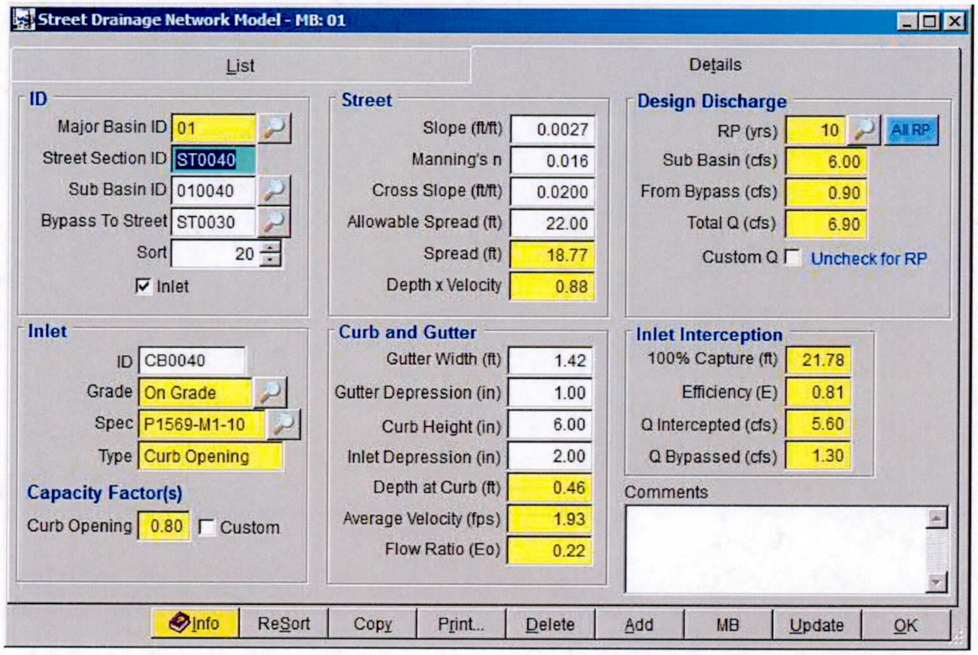
(I) Step 9 – Analyze Street Drainage Hydraulics (Hydraulics→Street Drainage→Network Model)

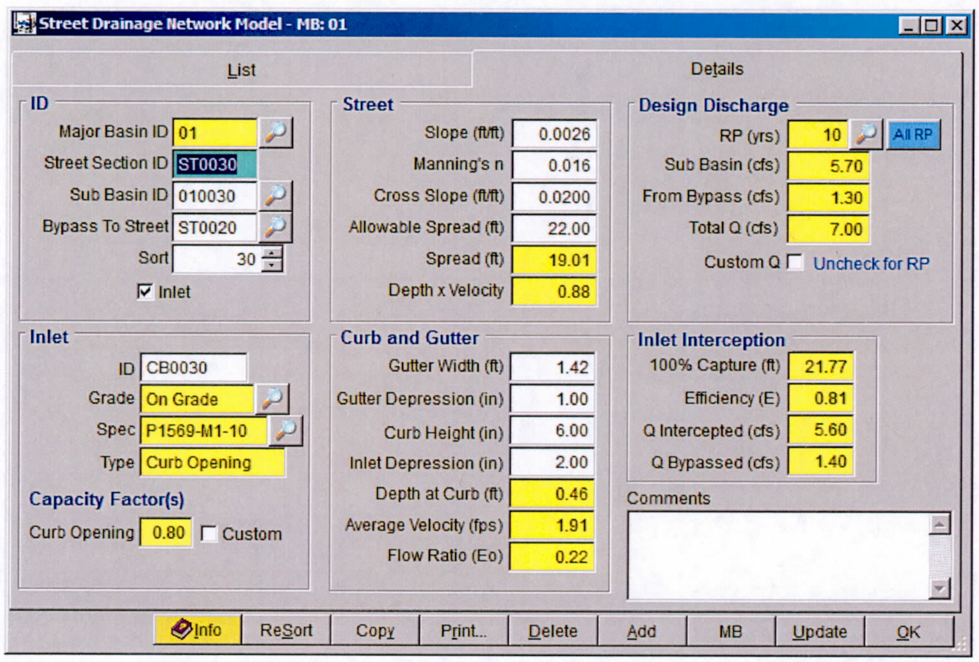
There are 10 street sections that need to be modeled as shown on the Figure in the first page of this tutorial. A summary of the data is shown below and details for each section are shown on the figures that follow. **It is important that the records are sorted in the order they need to be modeled.** After entering all the data, click **Update** to run the Model.

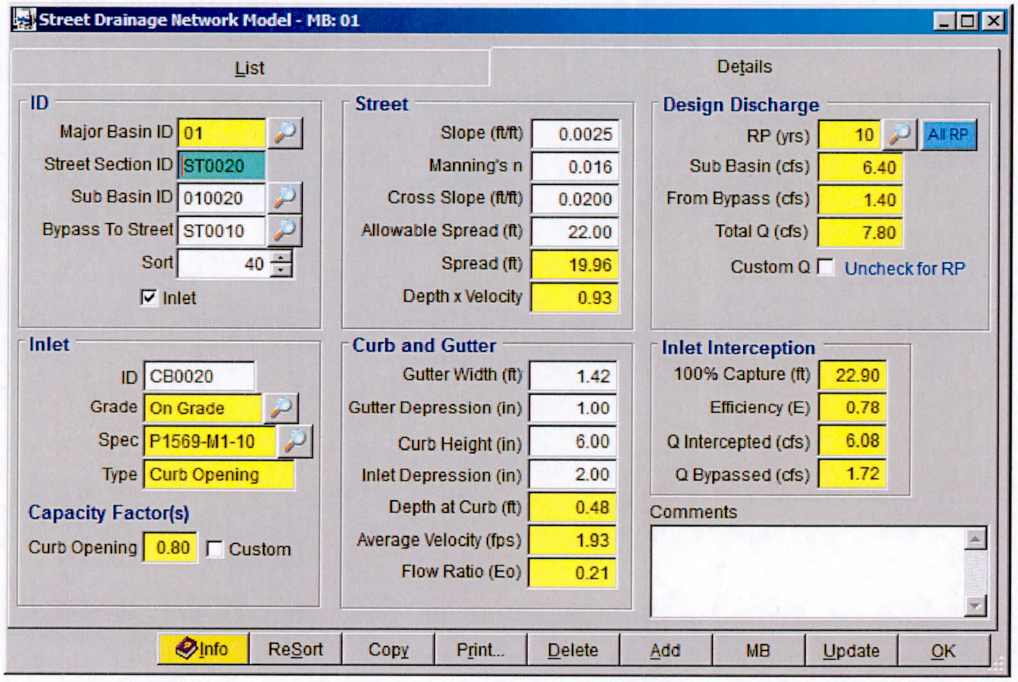


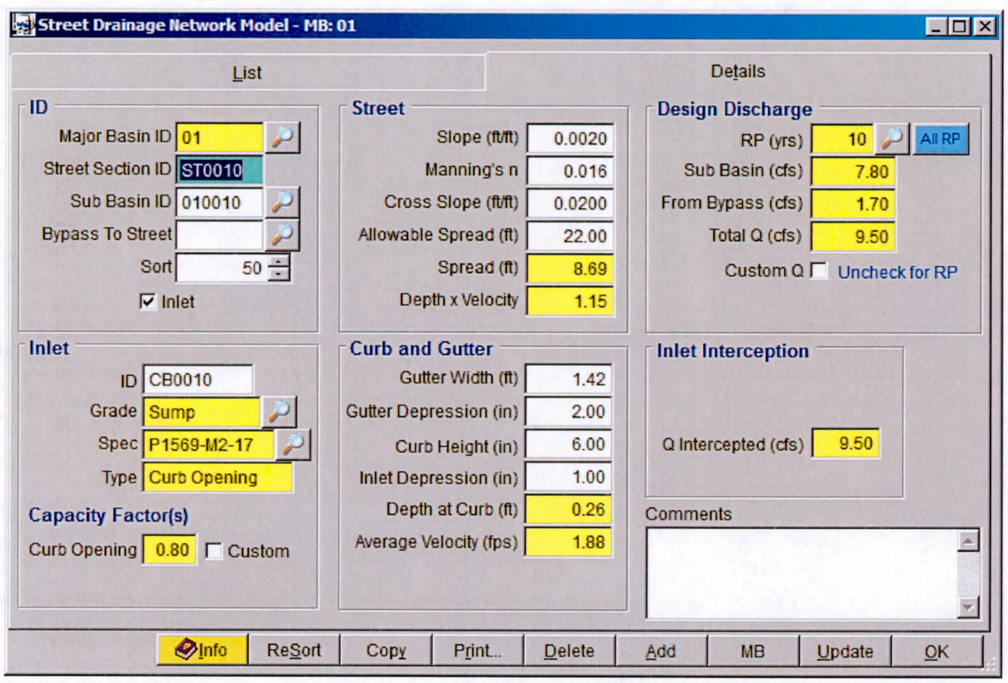
Sort	Street ID	Sub Basin	Inlet ID	Inlet Type	Bypass To	Allowable Spread (ft)	Spread (ft)	Total Q (cfs)	Intercepted (cfs)	Bypass (cfs)
10	ST0050	010050	CB0050	P1569-M1-10	ST0040	22.00	16.56	5.6	4.7	0.9
20	ST0040	010040	CB0040	P1569-M1-10	ST0030	22.00	18.77	6.9	5.6	1.3
30	ST0030	010030	CB0030	P1569-M1-10	ST0020	22.00	19.01	7.0	5.6	1.4
40	ST0020	010020	CB0020	P1569-M1-10	ST0010	22.00	19.96	7.8	6.1	1.7
50	ST0010	010010	CB0010	P1569-M2-17		22.00	8.69	9.5	9.5	
60	ST0045	010045	CB0045	P1569-M1-10	ST0035	22.00	14.80	4.2	3.9	0.3
70	ST0035	010035	CB0035	P1569-M1-10	ST0025	22.00	17.31	5.6	4.8	0.8
80	ST0025	010025	CB0025	P1569-M1-10	ST0015	22.00	18.47	6.9	5.0	1.9
90	ST0015	010015	CB0015	P1569-M1-10	ST0005	22.00	21.27	9.1	6.1	3.0
100	ST0005	010005	CB0005	P1569-M2-17		22.00	9.75	10.7	10.7	

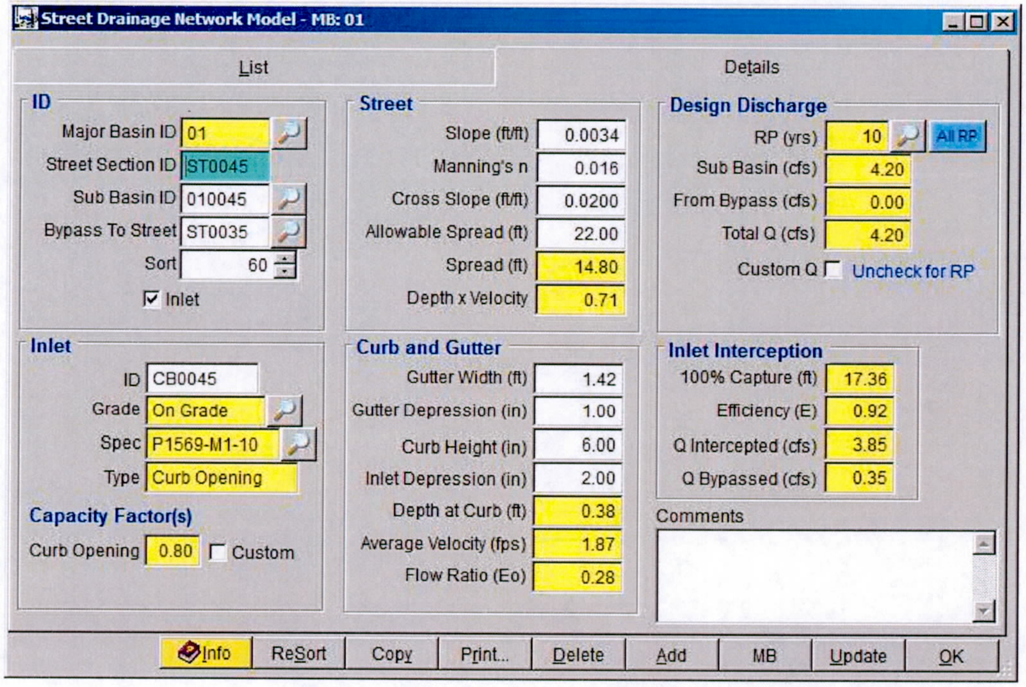


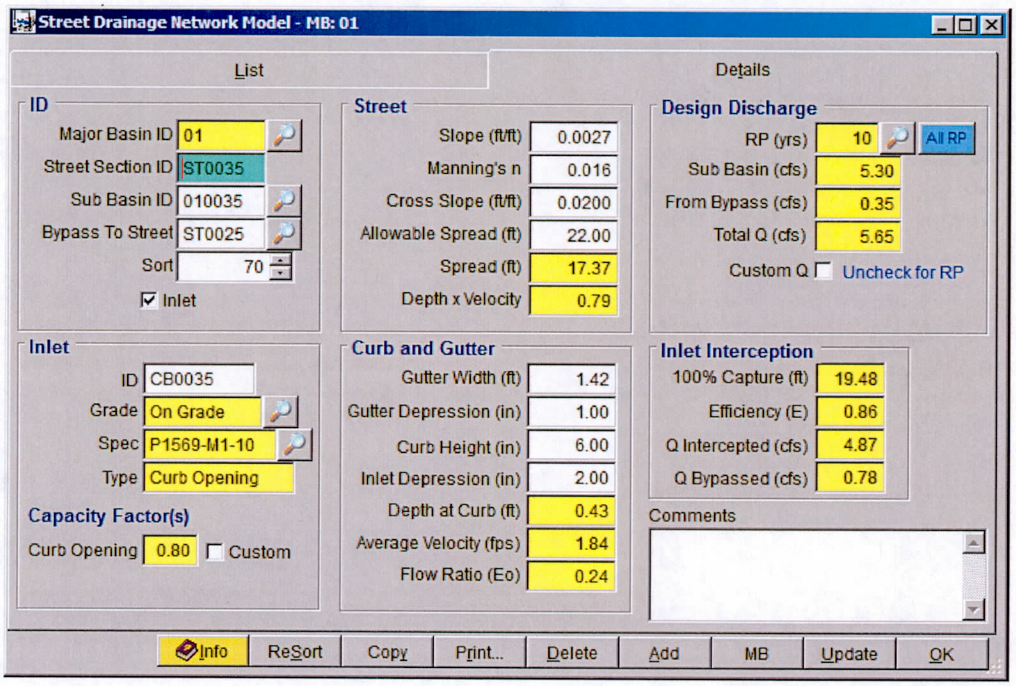

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0040
Sub Basin ID 010040
Bypass To Street ST0030
Sort 20
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 18.77
Depth x Velocity 0.88
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.00
From Bypass (cfs) 0.90
Total Q (cfs) 6.90
Custom Q
Uncheck for RP
Inlet
ID CB0040
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Curb Height (in) 6.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.46
Average Velocity (fps) 1.93
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 21.78
Efficiency (E) 0.81
Q Intercepted (cfs) 5.60
Q Bypassed (cfs) 1.30
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

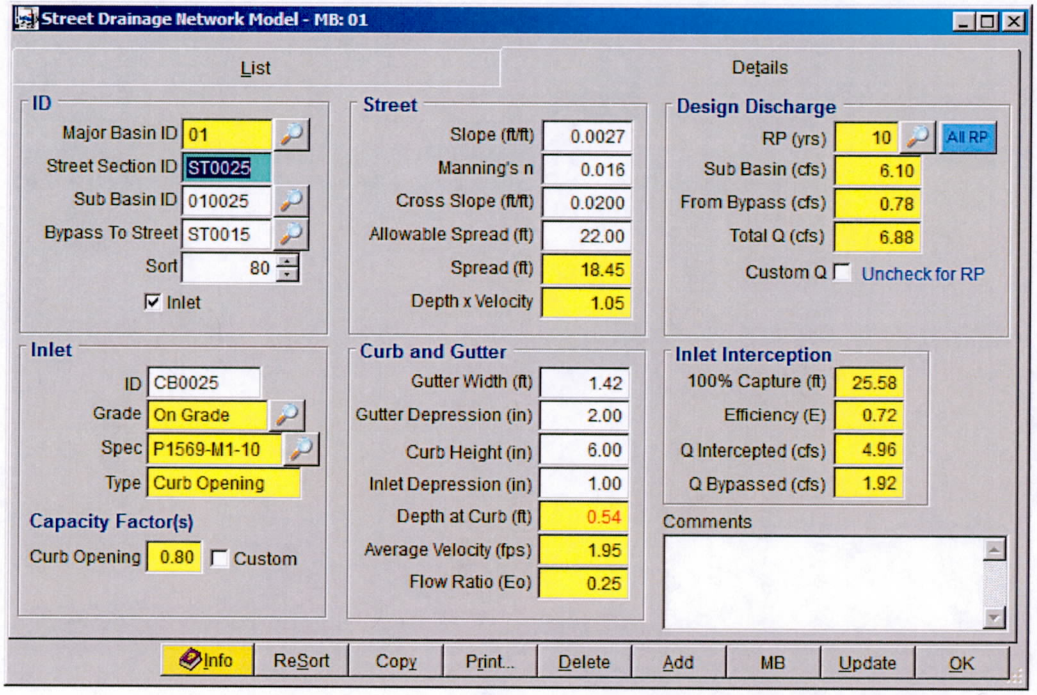

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0030
Sub Basin ID 010030
Bypass To Street ST0020
Sort 30
Inlet
Street
Slope (ft/ft) 0.0026
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 19.01
Depth x Velocity 0.88
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 5.70
From Bypass (cfs) 1.30
Total Q (cfs) 7.00
Custom Q
Uncheck for RP
Inlet
ID CB0030
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Curb Height (in) 6.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.46
Average Velocity (fps) 1.91
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 21.77
Efficiency (E) 0.81
Q Intercepted (cfs) 5.60
Q Bypassed (cfs) 1.40
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

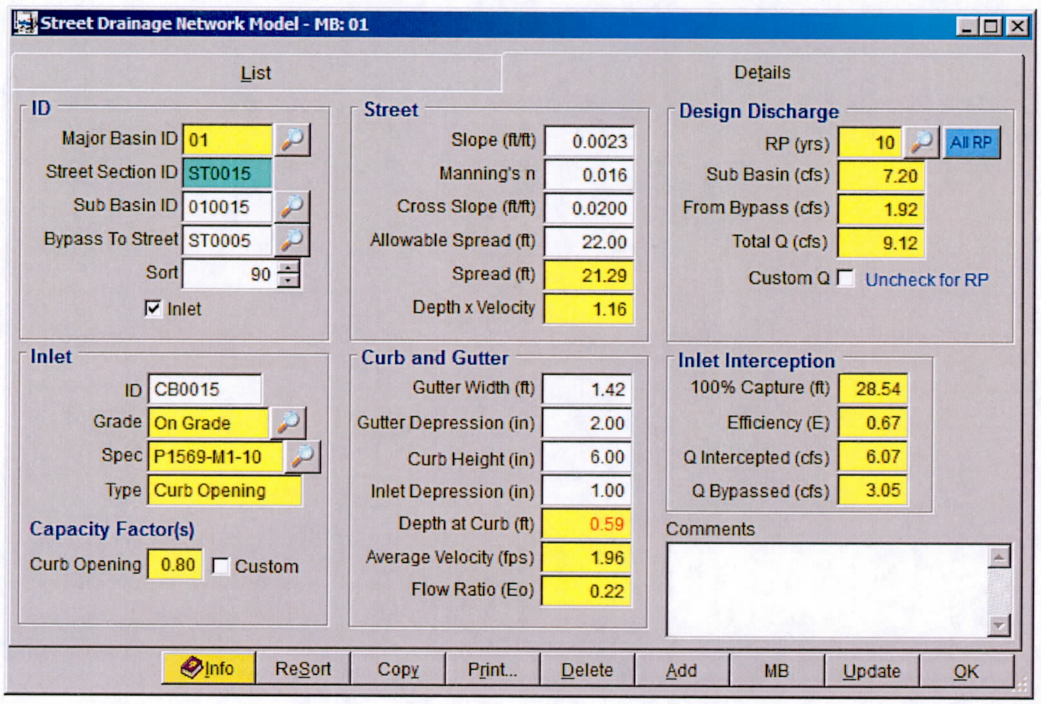

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0020
Sub Basin ID 010020
Bypass To Street ST0010
Sort 40
Inlet
Street
Slope (ft/ft) 0.0025
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 19.96
Depth x Velocity 0.93
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.40
From Bypass (cfs) 1.40
Total Q (cfs) 7.80
Custom Q
Uncheck for RP
Inlet
ID CB0020
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Curb Height (in) 6.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.48
Average Velocity (fps) 1.93
Flow Ratio (Eo) 0.21
Inlet Interception
100% Capture (ft) 22.90
Efficiency (E) 0.78
Q Intercepted (cfs) 6.08
Q Bypassed (cfs) 1.72
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

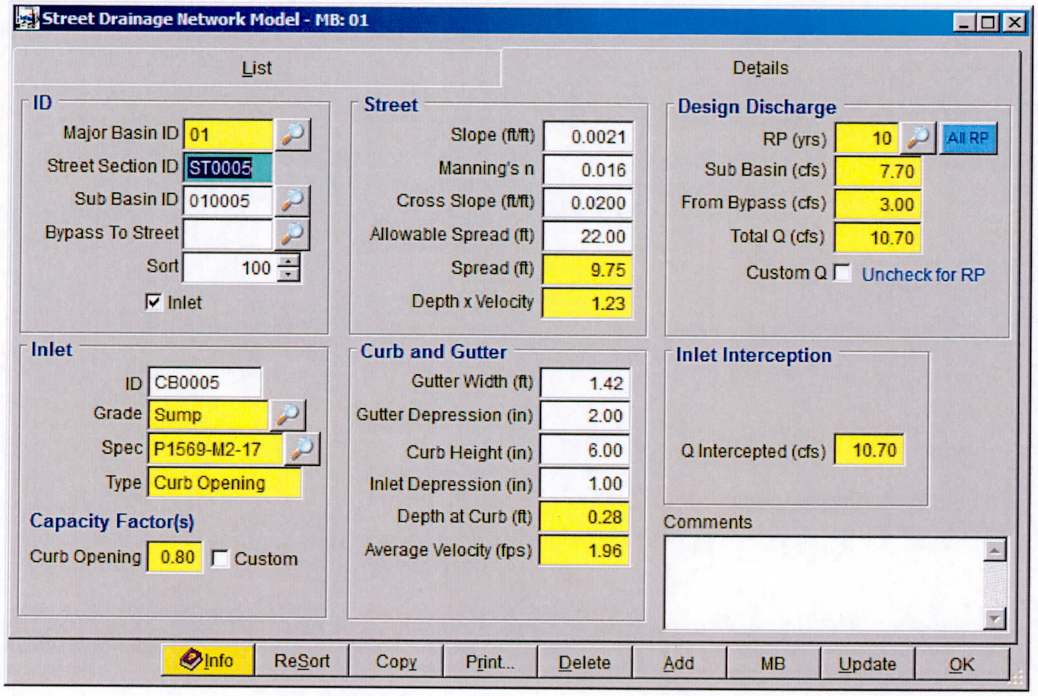

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0010
Sub Basin ID 010010
Bypass To Street
Sort 50
Inlet
Street
Slope (ft/ft) 0.0020
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 8.69
Depth x Velocity 1.15
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 7.80
From Bypass (cfs) 1.70
Total Q (cfs) 9.50
Custom Q
Uncheck for RP
Inlet
ID CB0010
Grade Sump
Spec P1569-M2-17
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Curb Height (in) 6.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.26
Average Velocity (fps) 1.88
Inlet Interception
Q Intercepted (cfs) 9.50
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0045
Sub Basin ID 010045
Bypass To Street ST0035
Sort 60
Inlet
Street
Slope (ft/ft) 0.0034
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 14.80
Depth x Velocity 0.71
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 4.20
From Bypass (cfs) 0.00
Total Q (cfs) 4.20
Custom Q
Uncheck for RP
Inlet
ID CB0045
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Curb Height (in) 6.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.38
Average Velocity (fps) 1.87
Flow Ratio (Eo) 0.28
Inlet Interception
100% Capture (ft) 17.36
Efficiency (E) 0.92
Q Intercepted (cfs) 3.85
Q Bypassed (cfs) 0.35
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0035
Sub Basin ID 010035
Bypass To Street ST0025
Sort 70
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 17.37
Depth x Velocity 0.79
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 5.30
From Bypass (cfs) 0.35
Total Q (cfs) 5.65
Custom Q
Uncheck for RP
Inlet
ID CB0035
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 1.00
Curb Height (in) 6.00
Inlet Depression (in) 2.00
Depth at Curb (ft) 0.43
Average Velocity (fps) 1.84
Flow Ratio (Eo) 0.24
Inlet Interception
100% Capture (ft) 19.48
Efficiency (E) 0.86
Q Intercepted (cfs) 4.87
Q Bypassed (cfs) 0.78
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0025
Sub Basin ID 010025
Bypass To Street ST0015
Sort 80
Inlet
Street
Slope (ft/ft) 0.0027
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 18.45
Depth x Velocity 1.05
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 6.10
From Bypass (cfs) 0.78
Total Q (cfs) 6.88
Custom Q
Uncheck for RP
Inlet
ID CB0025
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Curb Height (in) 6.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.54
Average Velocity (fps) 1.95
Flow Ratio (Eo) 0.25
Inlet Interception
100% Capture (ft) 25.58
Efficiency (E) 0.72
Q Intercepted (cfs) 4.96
Q Bypassed (cfs) 1.92
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK


Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0015
Sub Basin ID 010015
Bypass To Street ST0005
Sort 90
Inlet
Street
Slope (ft/ft) 0.0023
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 21.29
Depth x Velocity 1.16
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 7.20
From Bypass (cfs) 1.92
Total Q (cfs) 9.12
Custom Q
Uncheck for RP
Inlet
ID CB0015
Grade On Grade
Spec P1569-M1-10
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Curb Height (in) 6.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.59
Average Velocity (fps) 1.96
Flow Ratio (Eo) 0.22
Inlet Interception
100% Capture (ft) 28.54
Efficiency (E) 0.67
Q Intercepted (cfs) 6.07
Q Bypassed (cfs) 3.05
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

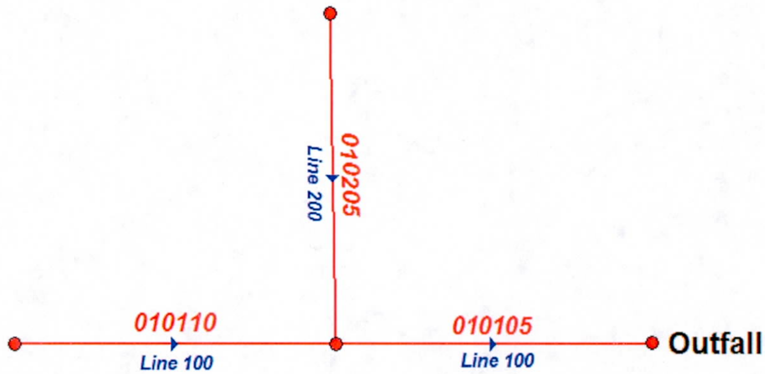

Street Drainage Network Model - MB: 01
List
Details
ID
Major Basin ID 01
Street Section ID ST0005
Sub Basin ID 010005
Bypass To Street
Sort 100
Inlet
Street
Slope (ft/ft) 0.0021
Manning's n 0.016
Cross Slope (ft/ft) 0.0200
Allowable Spread (ft) 22.00
Spread (ft) 9.75
Depth x Velocity 1.23
Design Discharge
RP (yrs) 10
All RP
Sub Basin (cfs) 7.70
From Bypass (cfs) 3.00
Total Q (cfs) 10.70
Custom Q
Uncheck for RP
Inlet
ID CB0005
Grade Sump
Spec P1569-M2-17
Type Curb Opening
Capacity Factor(s)
Curb Opening 0.80
Custom
Curb and Gutter
Gutter Width (ft) 1.42
Gutter Depression (in) 2.00
Curb Height (in) 6.00
Inlet Depression (in) 1.00
Depth at Curb (ft) 0.28
Average Velocity (fps) 1.96
Inlet Interception
Q Intercepted (cfs) 10.70
Comments
Info
ReSort
Copy
Print...
Delete
Add
MB
Update
OK

3.2 STORMPRO Backwater Model Tutorial

This tutorial provides a working example for the use of the **STORMPRO** Backwater Model. For this example, **KVLEXAMPLE7** will be used. Before developing the backwater model, it is necessary to develop the hydrology using the Rational Method and enter the data for all conveyance facilities. The detailed procedure for the Rational Method and Conveyance Facilities for this tutorial is provided in **TUTORIALS FOR DDMSW HYDROLOGY MODELING – TUTORIAL 3 RATIONAL METHOD MODELING.** This tutorial starts after the **RATIONAL METHOD MODELING TUTORIAL** has been completed.

The specific requirements for running **STORMPRO** using the pipe network shown below include:

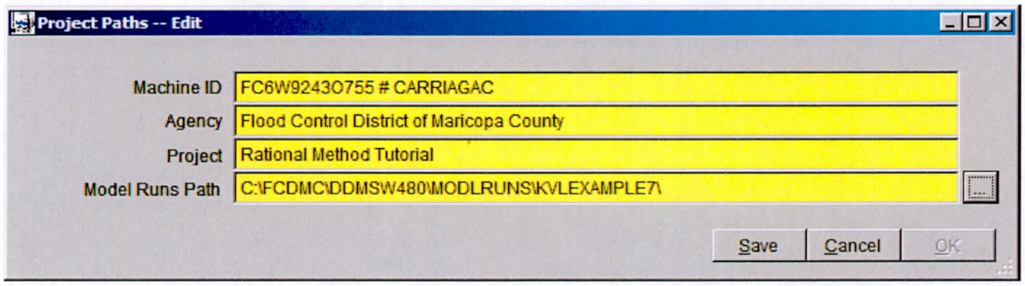
1. Establishing a folder for the model runs
2. Modifying the Conveyance Facilities
3. Establish the details for the Line IDs
4. Run Model



KvlExample7 Pipe Network

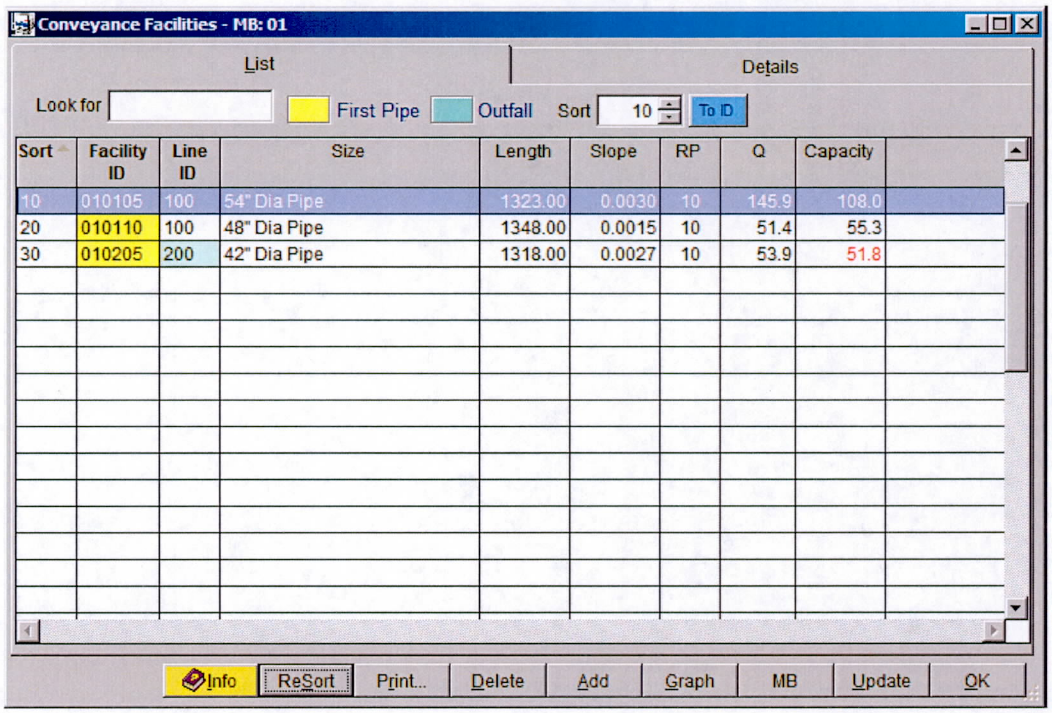
(A) Step 1 - Establish a Folder for Model Runs (File ➔ Project Paths)

For this example, a new folder (**H:\FCDMC\DDMSW505\Modlruns\kvlExample7**) was created.



(B) Step 2 - Modify Conveyance Facilities (Hydraulics ➔ Conveyance Facilities)

In addition to the data previously entered (in the **RATIONAL METHOD MODELING TUTORIAL**) for the **Conveyance Facilities**, the following data needs to be entered on the **CONVEYANCE FACILITIES** form on the **List** tab:



Line ID: STORMPRO models each line separately starting with the lowest **Line ID.** It is important to enter the **Line ID**'s in the order that the model should run. This is to establish the starting water surface elevation for Lines entering another Line. In the above network, all conveyance facilities in the **Main Line** (that goes to an Outfall) are labeled **Line ID** *"100"*. The upstream Line in this example is labeled **Line ID** *"200"*.

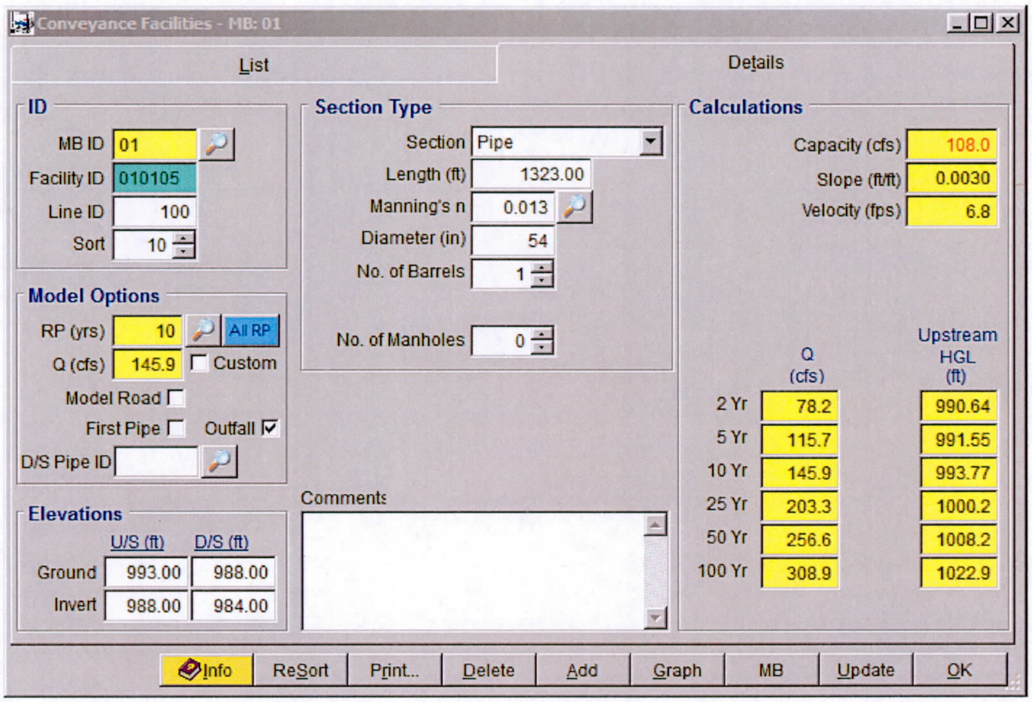
Sort: For **StormPro** to run correctly, the **Facility ID**'s must be sorted in the order from Downstream to Upstream. Use the **Sort** field to force the correct order. **This is critical.**

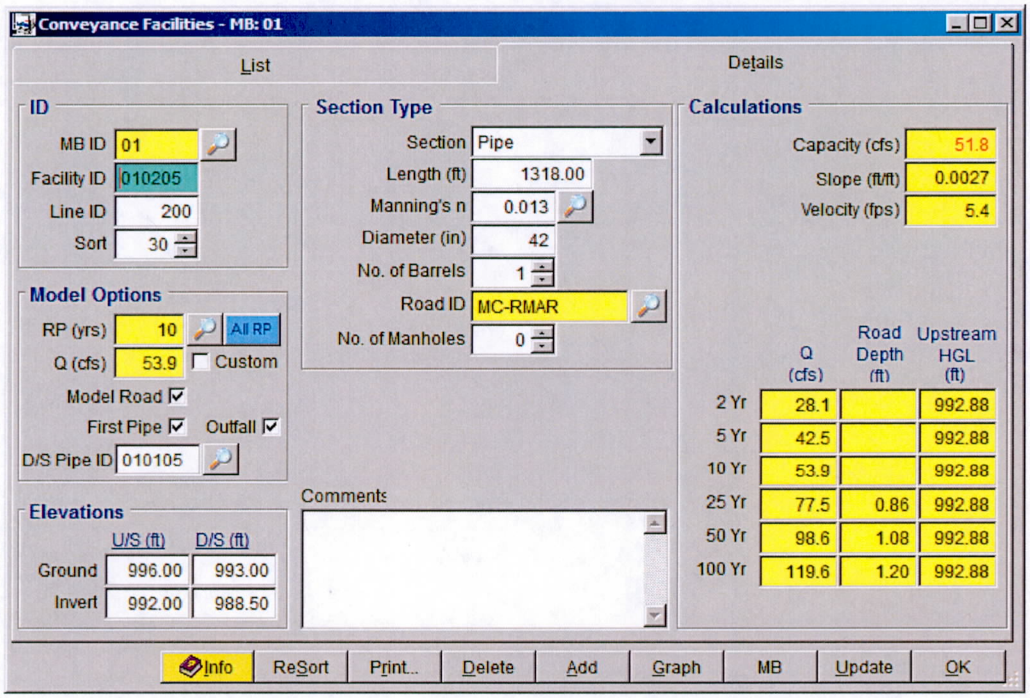
Outfall: If a **Facility ID** is an Outfall, then check the **Outfall** checkbox. In this case, there are two outfalls. They are **Facility IDs** *"010105"* and *"010205"* for **Line IDs** *"100"* and *"200"*, respectively.

D/S Pipe ID: If a **Facility ID** enters a downstream Line, then enter the **D/S Pipe ID.** In the case of **Facility ID** *"010205"* for **Line ID** *"200"*, enter **Pipe ID** *010105* (of **Line ID** *"100"*) as the **D/S Pipe ID**.

Manholes: Enter the number of manholes in each **Facility ID**.

Form screen captures for **Facility ID** *"010105"* and *"010205"* are shown below.



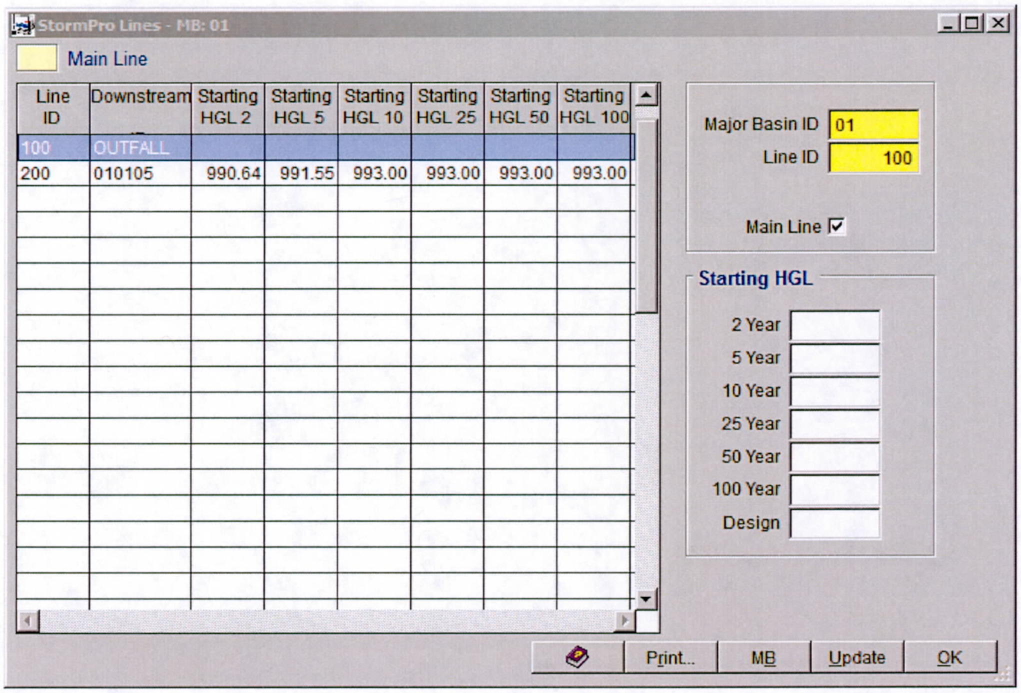


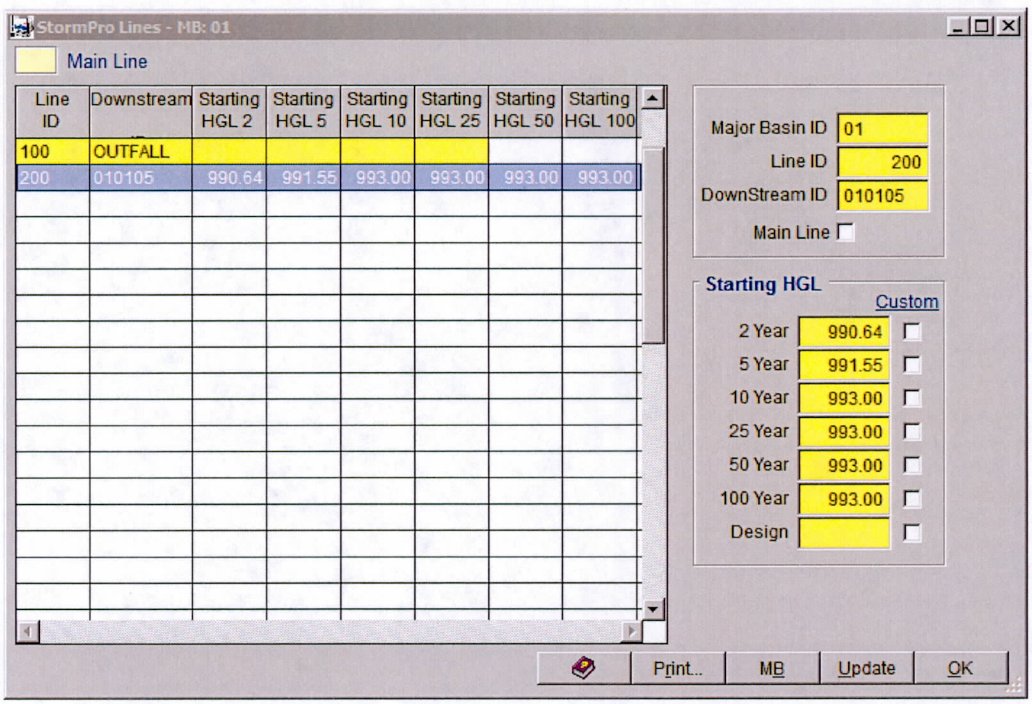
(C) Step 3 - Establish Line IDs (Hydraulics ➔ StormPro Backwater ➔ Lines)

When first going into this form, there will be no data and there will not be an **Add** button. The data for the Lines is established when clicking the **Update** button. In this case a warning will be given that there is no **Downstream ID** for **Line ID** *"100"* (because it is an **Outfall**). For this **Line ID** *"100"*, check **Main Line**. It is important to note that if the Conveyance Facilities are modified, then the **StormPro** Lines should be updated before running a **StormPro** Model.

For a **Main Line**, the Starting Hydraulic Grade Line for each return period can be entered. If left blank, the model uses the formula (Dc+D)/2, where Dc is the critical depth and D is the height of the **Facility ID**.

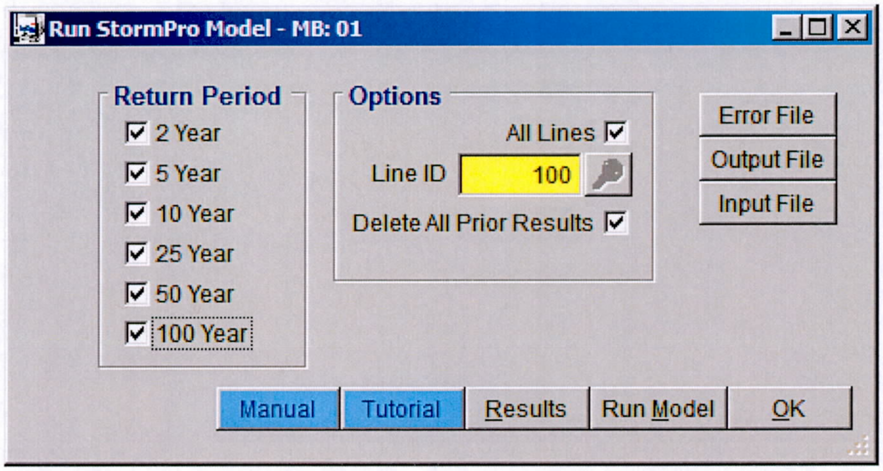
For Lines that are not a Main Line, a Starting Hydraulic Grade Line can be entered by checking the appropriate **Custom** for each return period. If left blank, the model establishes the value from the modeled Line that this Line enters.





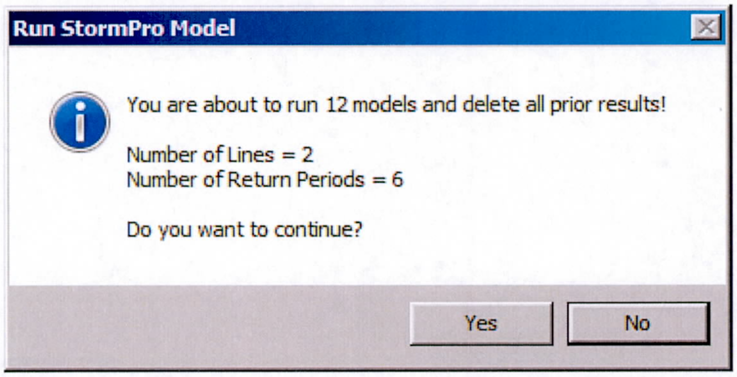
This is a view after the model has been run (**Starting HGL** is automatically loaded from results).

(D) Step 4 - Run Model (Hydraulics ➔ STORMPRO Backwater ➔ Model)

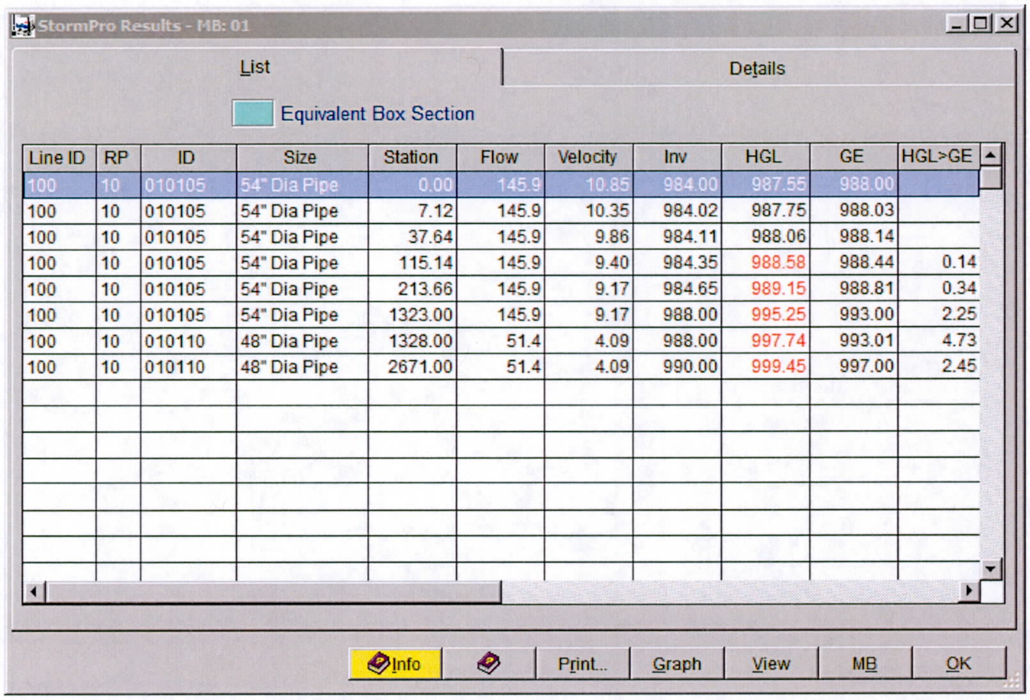


Options when running a **STORMPRO** Model include **Return Period**, **Line ID** and Delete Prior Results. If **All Lines** is checked, then **STORMPRO** will model all the selected return periods for **Line** *"100"* then model all the selected return periods for **Line** *"200"* (in that order).

Click **Run Model** to run the model. Click **Yes** to continue.

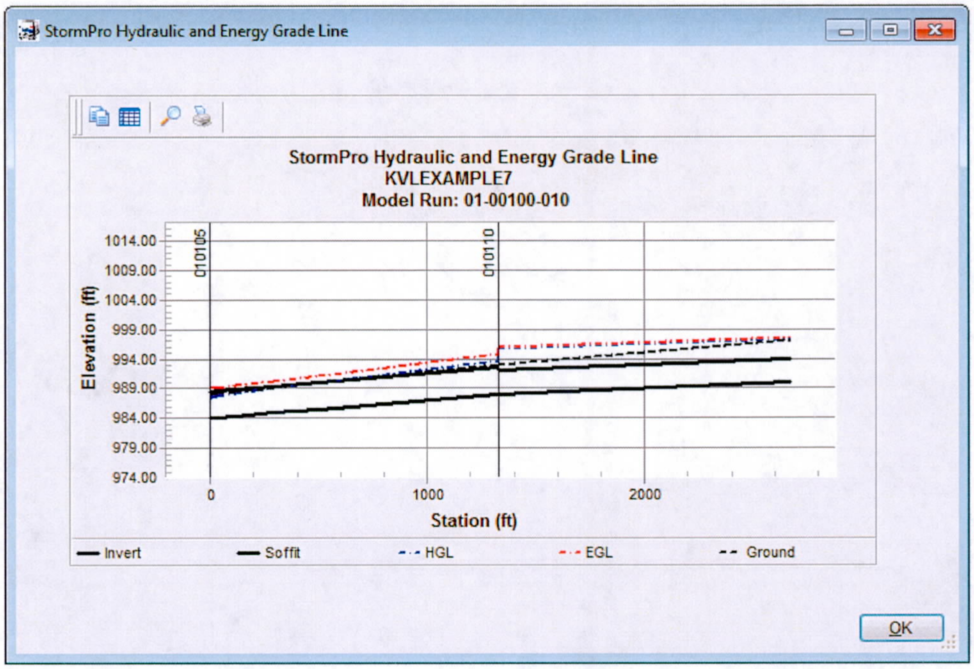


Click **Results** to view the model results.

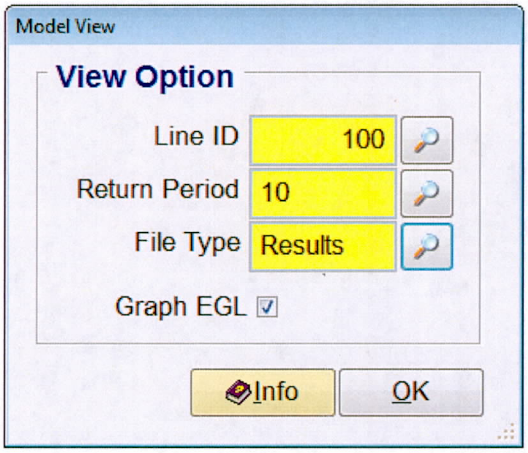


Line ID	RP	ID	Size	Station	Flow	Velocity	Inv	HGL	GE	HGL>GE
100	10	010105	54" Dia Pipe	0.00	145.9	10.85	984.00	987.55	988.00	
100	10	010105	54" Dia Pipe	7.12	145.9	10.35	984.02	987.75	988.03	
100	10	010105	54" Dia Pipe	37.64	145.9	9.86	984.11	988.06	988.14	
100	10	010105	54" Dia Pipe	115.14	145.9	9.40	984.35	988.58	988.44	0.14
100	10	010105	54" Dia Pipe	213.66	145.9	9.17	984.65	989.15	988.81	0.34
100	10	010105	54" Dia Pipe	1323.00	145.9	9.17	988.00	995.25	993.00	2.25
100	10	010110	48" Dia Pipe	1328.00	51.4	4.09	988.00	997.74	993.01	4.73
100	10	010110	48" Dia Pipe	2671.00	51.4	4.09	990.00	999.45	997.00	2.45

Click **Graph** to view the graph of the model results.



To view another line and/or return period, click the **View** button.



Options include selecting the **Line ID**, **Return Period**, **File Type** and an option to graph the Energy Grade Line (**Graph EGL**). When selecting a **File Type** the following options are available:

Results will select the data from the **STORMPRO RESULTS** filtered for the selected **Line ID** and **Return Period**.

HGL>GE will select the data from the **STORMPRO RESULTS** filtered for the selected **Line ID**, **Return Period** and sections where the hydraulic grade line is above the ground elevation.

Input, Output and *Warning* will open the model Input, Output and Warning files, respectively (See below for examples of the Input File, Output File, and Warning File).

INPUT FILE:

```
JD
T1          Flood Control District of Maricopa County
T2          File: 01-00100-010.SPI
T3          Major Basin: 01 - Line ID: 100 - RP: 10
SO     0.00 984.00  2
R   1323.00 988.00  2       .013                                         0   0.000
JX  1328.00 988.00  1  1    .000     94.5         988.00        90.0
R   2671.00 990.00  1       .013                                         0   0.000
SH  2671.00 990.00  1                               0.00
CD   1  4              4.00
CD   2  4              4.50

Q            51.4
```

OUTPUT FILE:

```
                                      Flood Control District of Maricopa County
                                      File: 01-00100-010.SPI
                                      Major Basin: 01 - Line ID: 100 - RP: 10
| STATION     INVERT    DEPTH      W.S.          Q      VEL      VEL    ENERGY  SUPER  CRITICAL             HGT/   BASE/    ZL  NO   AVBPR
              ELEV     OF FLOW     ELEV                          HEAD   GRD.EL. ELEV    DEPTH               DIA   ID NO.       PIER
| L/ELEM      SO                                                SF AVE    HF                      NORM DEPTH                   ZR
**************************************************************************************************************************************
|     0.00   984.00     3.55     987.55      145.9    10.85     1.83   989.38   0.00    3.55              4.50    0.00  0.00   0   0.00
|     7.12  0.00302                                          0.00566    0.04                    4.50                  0.00
|     7.12   984.02     3.73     987.75      145.9    10.35     1.66   989.42   0.00    3.55              4.50    0.00  0.00   0   0.00
|    30.52  0.00302                                          0.00518    0.16                    4.50                  0.00
|    37.64   984.11     3.95     988.06      145.9     9.86     1.51   989.57   0.00    3.55              4.50    0.00  0.00   0   0.00
|    77.50  0.00302                                          0.00486    0.38                    4.50                  0.00
|   115.14   984.35     4.23     988.58      145.9     9.40     1.37   989.95   0.00    3.55              4.50    0.00  0.00   0   0.00
|    98.52  0.00302                                          0.00510    0.50                    4.50                  0.00
|   213.66   984.65     4.50     989.15      145.9     9.17     1.31   990.45   0.00    3.55              4.50    0.00  0.00   0   0.00
|  1109.34  0.00302                                          0.00547    6.07                    4.50                  0.00
|  1323.00   988.00     7.25     995.25      145.9     9.17     1.31   996.56   0.00    3.55              4.50    0.00  0.00   0   0.00
|JUNCT STR  0.00000                                          0.00393    0.02                                          0.00
|  1328.00   988.00     9.74     997.74       51.4     4.09     0.26   998.00   0.00    2.15              4.00    0.00  0.00   0   0.00
|  1343.00  0.00149                                          0.00128    1.72                    3.04                  0.00
|  2671.00   990.00     9.45     999.45       51.4     4.09     0.26   999.71   0.00    2.15              4.00    0.00  0.00   0   0.00
```

WARNING FILE

```
T1          Flood Control District of Maricopa County
T2          File: 01-00100-010.SPI
T3          Major Basin: 01 - Line ID: 100 - RP: 10
SO      0.00 984.00  2
R    1323.00 988.00  2      .013                                           0   0.000
JX   1328.00 988.00  1  1   .000    94.5        988.00        90.0
R    2671.00 990.00  1      .013                                           0   0.000
SH   2671.00 990.00  1                           0.00
                                                          SP
                                   WATER SURFACE PROFILE - CHANNEL DEFINITION LISTING                   PAGE    1
 CARD  SECT  CHN   NO OF  AVE PIER  HEIGHT 1  BASE    ZL    ZR   INV   Y(1)  Y(2)  Y(3)  Y(4)  Y(5)  Y(6)  Y(7)  Y(8)  Y(9)  Y(10)
 CODE   NO   TYPE  PIERS   WIDTH    DIAMETER  WIDTH              DROP

 CD      1    4                       4.00
 CD      2    4                       4.50
EADING LINE NO 1 IS -
                                   Flood Control District of Maricopa County
EADING LINE NO 2 IS -
                                   File: 01-00100-010.SPI
EADING LINE NO 3 IS -
                                   Major Basin: 01 - Line ID: 100 - RP: 10
ELEMENT NO    1 IS A SYSTEM OUTLET        *        *     *
                 U/S DATA   STATION    INVERT  SECT                                  W S ELEV
                                0.00  984.00    2                                       0.00
ELEMENT NO    2 IS A REACH                *        *     *
                 U/S DATA   STATION    INVERT  SECT             N                                      RADIUS  ANGLE  ANG_PT  MAN_H  IMINORL  CMINORL
                             1323.00  988.00    2             0.013                                      0.00   0.00   0.00     0       0      0.000
ELEMENT NO    3 IS A JUNCTION             *        *     *    *             *             *             *
                 U/S DATA   STATION    INVERT  SECT LAT-1 LAT-2  N      Q3       Q4    INVERT-3 INVERT-4  PHI 3   PHI 4
                             1328.00  988.00    1     1     0 0.014    94.5     0.0   988.00     0.00  90.00    0.00
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
THE ABOVE ELEMENT CONTAINED AN INVERT ELEV WHICH WAS NOT GREATER THAN THE PREVIOUS INVERT ELEV -WARNING
ELEMENT NO    4 IS A REACH                *        *     *
                 U/S DATA   STATION    INVERT  SECT             N                                      RADIUS  ANGLE  ANG_PT  MAN_H  IMINORL  CMINORL
                             2671.00  990.00    1             0.013                                      0.00   0.00   0.00     0       0      0.000
ELEMENT NO    5 IS A SYSTEM HEADWORKS                *                *
                 U/S DATA   STATION    INVERT  SECT                                  W S ELEV
                             2671.00  990.00    1                                       0.00
```