Example Ditch Design

This section provides guidance for the design of a conveyance ditch. A ditch running parallel to the roadway generally drains runoff into a cut section. This is different than a biofiltration swale (or bioswale), in that a ditch only conveys drainage runoff where as a bioswale both conveys runoff and provides runoff treatment by filtering the runoff through vegetation. Ditches should be designed using the 10 year 3 hour MRI (was the 10 year 24 hour storm). The depth of flow in the ditch should not be so high as to soak the base course. Velocities in the ditch should not exceed 6 ft/sec or be very steep; else designers should consider erosion and sediment control BMP's covered in Chapter 5 of the 2004 Highway Runoff Manual.

This example will walk through a quick method for designing ditches. For longer ditches or ditches that have infiltration, designers should consult the Bioswale tutorial in the Intermediate Storm Shed Class in addition to this Ditch Example.

For this example, it will be assumed there is no curb, rather the runoff will sheet flow off the road to the ditch.

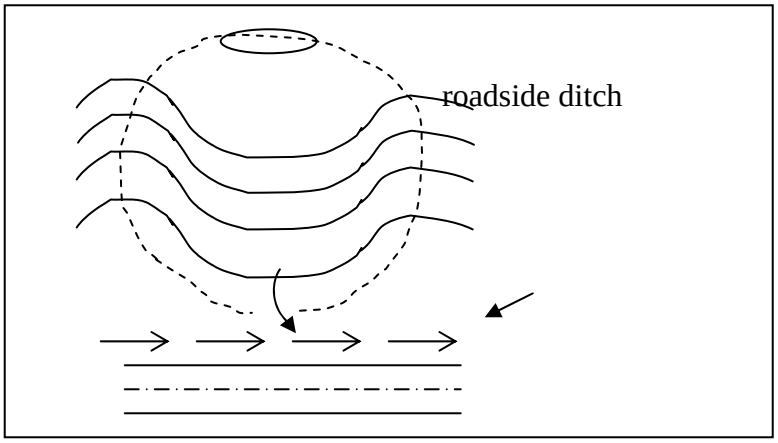


Figure 4-1. DBA mapping example

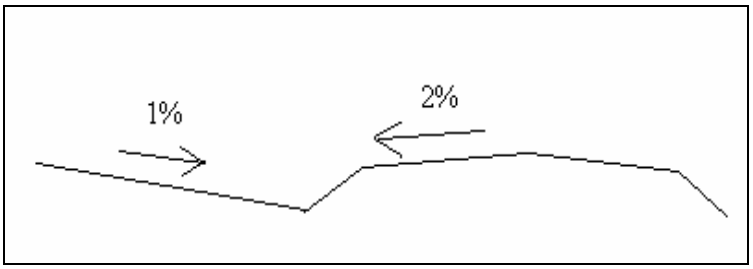
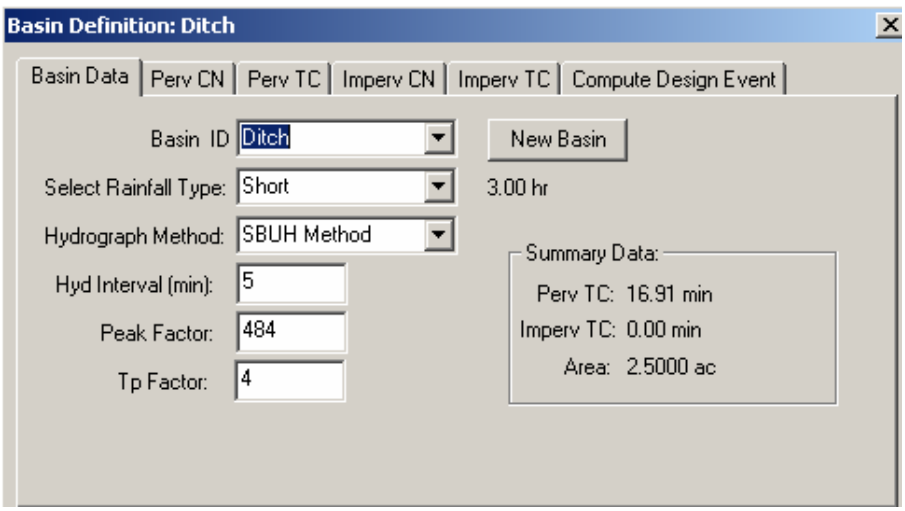


Figure 4-2 DBA Cross Section

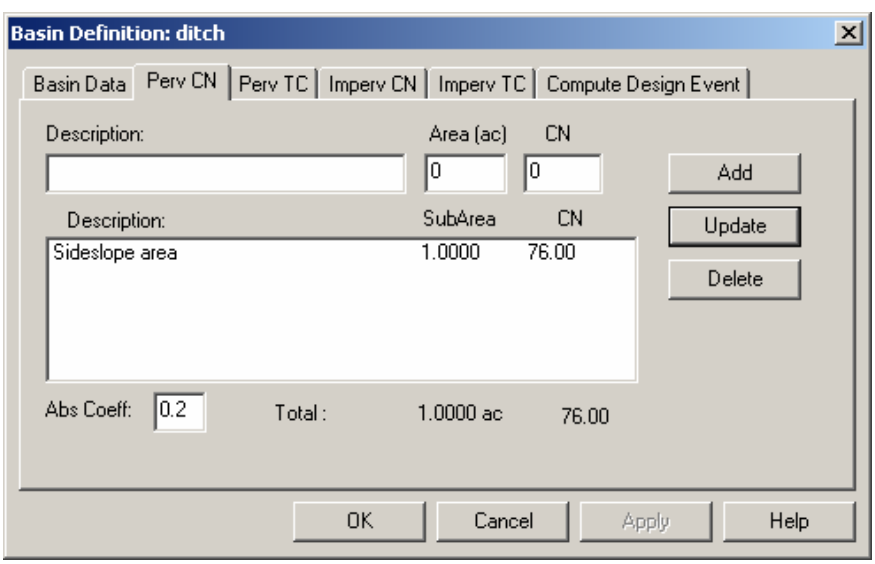
Quick Ditch Example

In conveyance design, the designer is only concerned with the developed conditions as this is the flow that the new conveyance structure will need to convey. Set up the Drainage Basin Area (DBA) for the roadside ditch shown in Figure 4-1 and 4-2 assuming the pervious area within WSDOT Right of Way side slopes contributing to and including the ditch is **1.0 acre**. The SCS soil type is Type C and the ground cover is primarily forest in fair conditions. The average slope of the ground is **1%**. The calculated time of concentration should be assumed that for the forested condition will be **50 feet** of sheet flow and **1750 feet** of shallow concentrated flow. The **20' x 900'** ***(0.413ac)*** roadway contributes to the ditch with a cross slope of **2%.** The ditch has a longitudinal slope of **1%,** with a ground cover as **nearly bare ground**, very little grass**.**

Create a new basin called Ditch.

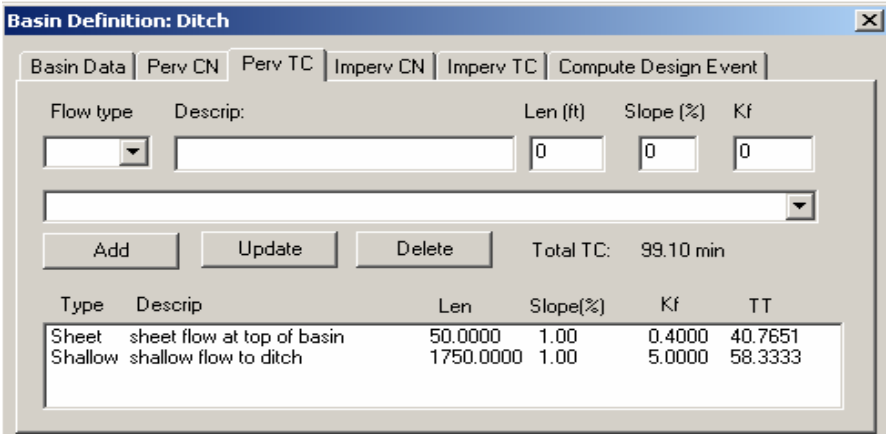


First, you want to define the pervious area site conditions.

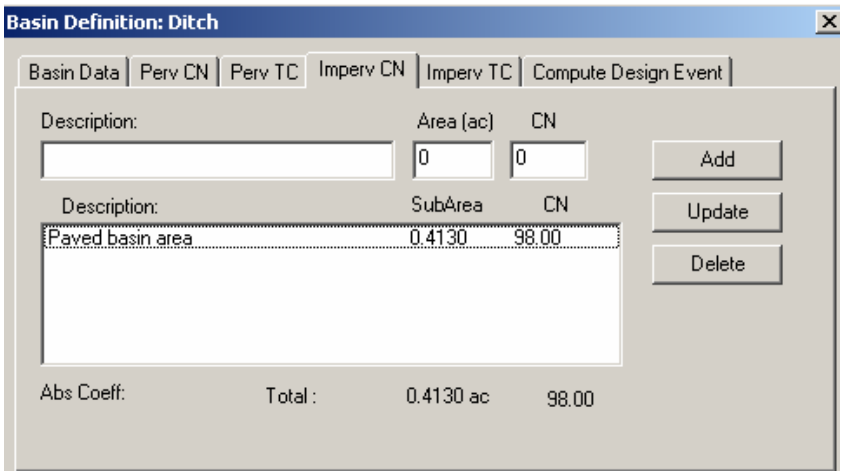


Next, define the pervious surface side slope area.

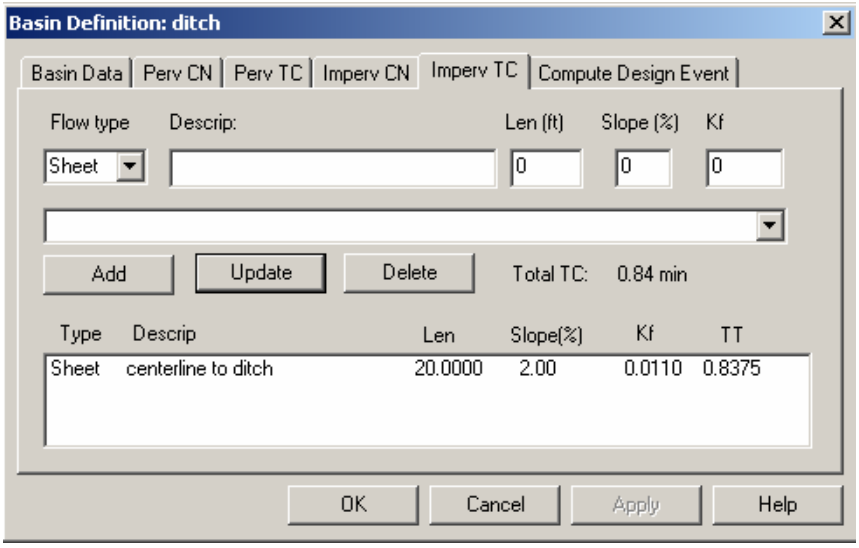
Example Ditch Design



Define the impervious basin area (roadway draining toward the ditch)

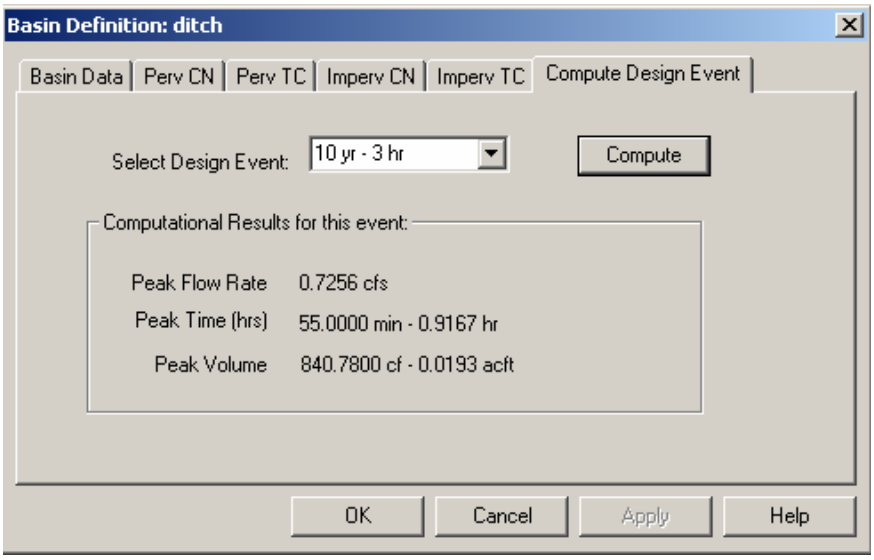


Define the flow path from the roadway, into the ditch.



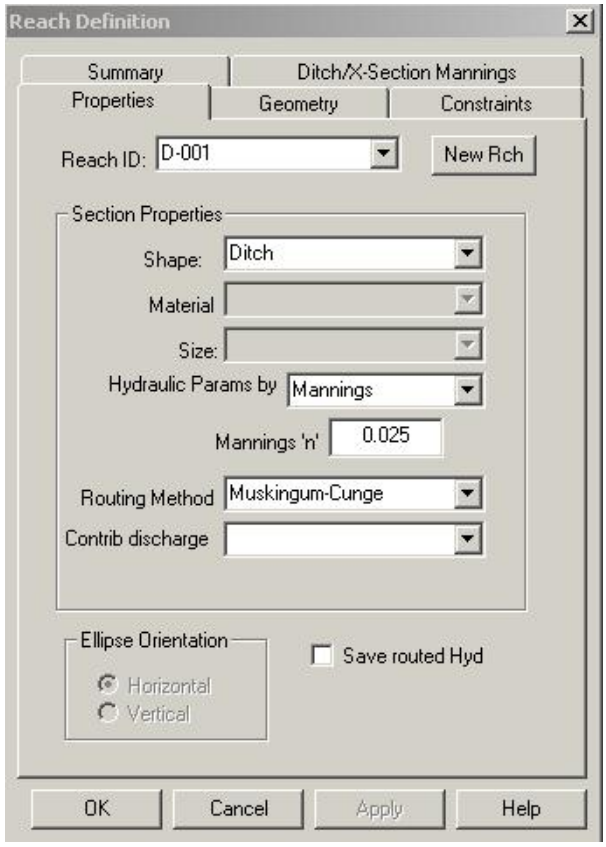
Example Ditch Design

Finally compute the 10yr 3 hour MRI



Based on the basin areas previously created, design a ditch utilizing the reach commands to convey the 10-year 3-hour design storm. The first step is to create a Reach in StormShed.

- In the Tree View, click on the "+" symbol next to the Reaches node.
- Double click on "PROTOTYPE" under the Reaches node.
- Click on the **New Rch** button in the Reach Definition dialog.
- Rename the default label to D-001 and Click **OK**

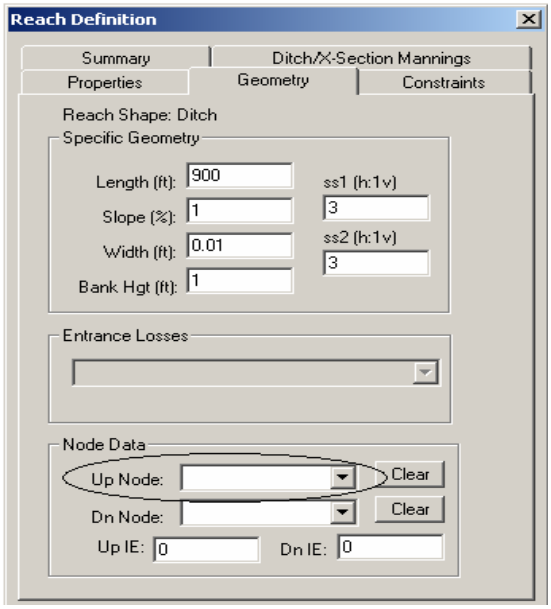


Ditch Reach Definition

- Change the "Shape" to Ditch by selecting from the drop down.
- Change the "Routing Method" to Muskingum-Cunge.

This is really an optional feature. Generally simple travel time translation is used, however, in this case we will take the opportunity to do something different. Simple travel time translation uses the Manning's equation to compute hydraulic parameters based of the peak flow rate. All the other options, including the Muskingum-Cunge routing method actually routes the hydrograph through the reach***, taking advantage of the storage that is available in the reach***. The result is a slightly modified hydrograph at the bottom end of the reach. This slightly modified hydrograph has an attenuated peak from the original.

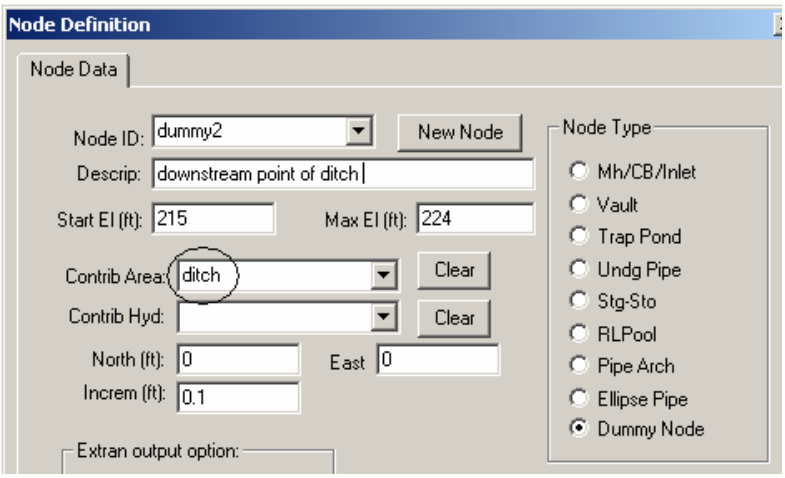
- Select the "Geometry" tab.



Ditch Geometry Settings

Note that no "Up Node" is defined. It is necessary to attach an "Up Node" to this reach so that flows can automatically be associated with it.

- Click on the **Close** button to close the dialog.
- Open the "PROTOTYPE" node in the Nodes section of the TreeView.
- Click on the **New Node** button.
- Rename the default node ID to dummy.
- Click on the **OK** button to close the autolabel dialog.

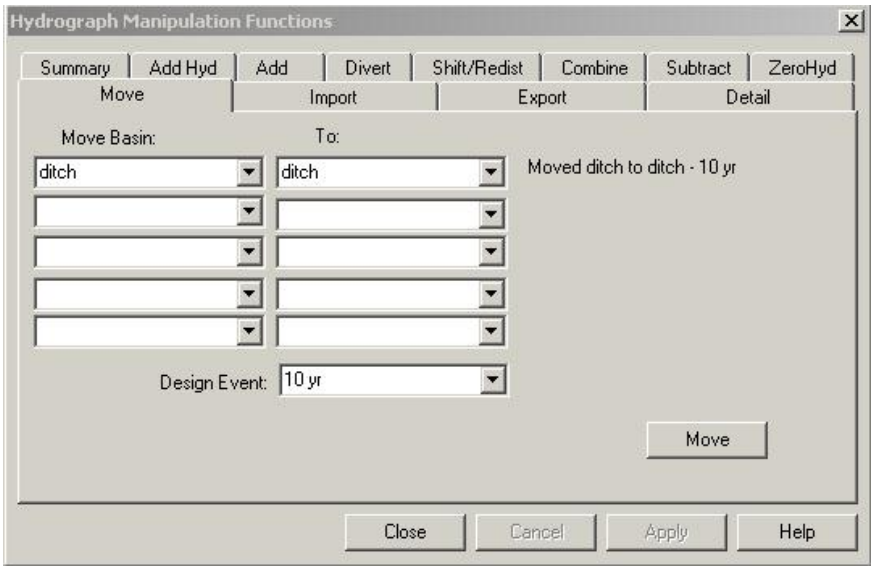


Note that the <u>entire basin</u> will be dumped into the "Up Node", providing conservative results. The basin would actually runoff into the ditch gradually over the entire length of the basin. If the results from this Quick Conveyance Ditch Example do not meet the design guidance noted in the first paragraph or for a longer ditch section, designers

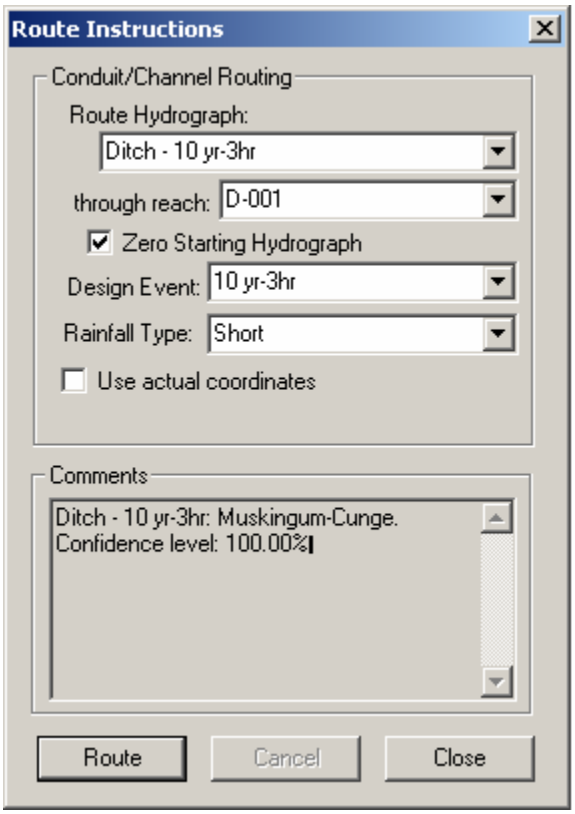
- Change the Node Type to Dummy Node.
- Under the “Contrib Area” input field, use the drop down and select the Ditch basin.
- Set the Start El and Max El as shown in Figure above.
- Click on the **OK** button to close the node dialog.
- Re-open the “D-001” reach in the Tree View
- Click on the “Geometry” tab.
- In the “Node Data” section, use the drop down to select **dummy**.
- Click on the **Close** button to close the dialog
- All that is left is to route a hydrograph through the **D-001** reach and see how it performs.
- Right Mouse click in the Tree View and select the *Route Hyd* menu selection.

The dialog box requires that a hydrograph is routed through a reach. You will need to create a hydrograph for the 10-year storm event for the Ditch basin.

The Move hydrograph dialog allows for up to five (5) drainage basins to be “moved” to a hydrograph at one time. Under the “Move Basin” column, select a previously defined basin. When a basin is selected, the “To” column will mirror the basin name as the default. When a Design Event is selected, and the “Move” button is pressed, the program will append the design event to the default ID in the “To” column. Note that the “To” column only mirrors and provides a recommended ID for the yet to be create hydrograph. It can be modified to whatever is appropriate. After the “Move” button has been pressed, a new hydrograph will be created. The summary data is visible in the “Summary” tab.



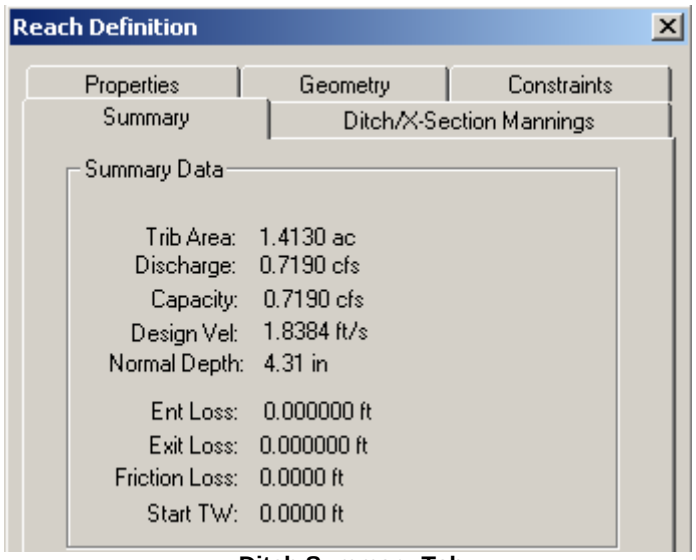
"Ditch – 10yr" is being used as a placeholder for the hydrograph. Since "Ditch" was defined as the Contributing Basin to "dummy" node, and "dummy" node is defined as the "Up Node" to the "D-001" reach, the "Zero Starting Hydrograph" checkbox must be checked so that only the hydrograph from the contributing basin is routed through the reach. If the "Zero Starting Hydrograph" checkbox is not checked, the program will first create a hydrograph from the contributing basin using a "10-year" Short Duration design event, then add it to the contents of "Ditch – 10-yr", then route it through the reach. The result would be twice the hydrograph peak and volume than intended.



Route Instructions for Ditch

- From the "Route Hydrograph" drop down; select the "Ditch – 10 yr" hydrograph that was previously created.
- Select the "D-001" reach from the second drop down.
- Check the "Zero Starting Hydrograph" check box.
- Select 10-year for the "Design Event".
- Select Short for the "Rainfall type"
- Click on the **Route** button.

- Click on the **Close** button
- Open the D-001 reach dialog and click on the "Summary" tab.



Ditch Summary Tab

The summary tab indicates that the velocity is 1.84 fps with a depth of 4.31 inches. The results are also acceptable, as the velocity is less than 6 ft/sec and the depth of runoff will not saturate the base course (assuming the subgrade is 6" deep).

The other area for results is in the History file, as shown below.

MOVEHYD [ditch] TO [ditch - 10 yr - 3 hr] AS [10 yr - 3 hr]
Peak Flow: 0.7256 cfs Peak Time: 0.92 hrs Hyd Vol: 840.78 cf - 0.0193 acft

ROUTEHYD [ditch - 10 yr - 3 hr] THRU [d-001] USING Short AND [10 yr - 3 hr] ZERO RELATIVE

Reach / Hyd	Area	Flow	Full Q	% Full	nDepth	Size	nVel	fVel	CBasin
-----	ac	cfs	cfs	ratio	ft	----	ft/s	ft/s	----------
d-001	1.4130	0.7190	----	1.00	0.3594	Ditch	1.8384	-----	ditch