Creating Watersheds from a DEM in ArcGIS 9.x

These instructions enable you to create watersheds (a.k.a. catchments or basins) using a good quality Digital Elevation Model (DEM) in ArcGIS 9.1. The modeling is performed in ArcMap with the aid of the Spatial Analyst extension's Hydrology tools.

This procedure is useful if you wish to delineate topographic boundaries based on drainage basins in your study area. The following lists the data layers used for this instruction set (simply substitute your file names):

ORIGINAL DATA

DEM	raster grid coverage of elevation information for the study area – 90 m cells

CREATED DATA

Fill	raster grid of the "depressionless" DEM that has had all the sinks filled
FlowDir	raster grid indicating the direction of flow for each cell based on the elevation of neighboring cells
FlowAcc	raster grid indicating where water is likely to accumulate into a drainage network
Drainage	raster grid resulting from a threshold applied to the FlowAcc
Drainage.shp	line shapefile resulting from converting Drainage to features
Drain_end.shp	point shapefile resulting from converting drainage features to end vertices
Watersheds	raster grid of basins draining into the drain_end pour points

Start ArcMap and set up the map document:

1. Open ARCMAP and start using with a new empty map document
2. Click on the ADD DATA button and add the **DEM** raster

SEE THE INSTRUCTION SET ON 'How to Subset a Raster/DEM' IF YOU NEED TO EXTRACT A SMALLER EXTENT TO WORK ON!

Enable the Spatial Analyst extension and make the toolbar and ArcToolbox visible:

3. Choose TOOLS >>> EXTENSIONS and check beside SPATIAL ANALYST
4. Choose VIEW >>> TOOLBARS and check beside Spatial Analyst
5. Click on the SHOW ARCTOOLBOX button in the Standard Toolbar
6. On the toolbar, choose SPATIAL ANALYST >>> OPTIONS and set your GENERAL working directory, EXTENT to same as DEM, and CELL SIZE to same as DEM
7. Click OK

Apply the hydrology tools:

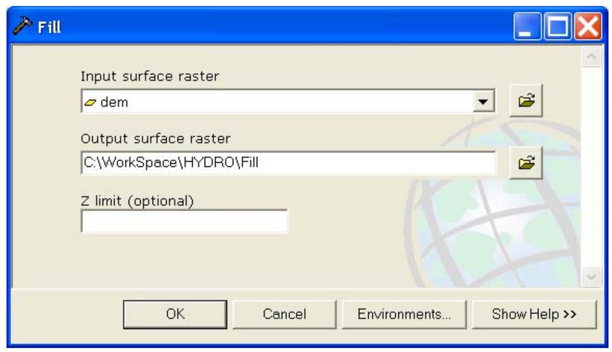
The following four steps are performed in sequence to model watersheds from the DEM using the Hydrology Modeling toolbar:

- Fill the sinks in the DEM to create a depressionless surface
- Calculate the direction of flow for each cell
- Calculate the flow accumulation
- Calculate the watersheds based on minimum cell count

Filling the sinks:

8. Choose SPATIAL ANALYST TOOLS >>> HYDROLOGY >>> FILL
9. Select **DEM** as the Input Surface Raster
10. Specify the Output Surface Raster; e.g. C:\WorkSpace\HYDRO**Fill**
11. Click OK

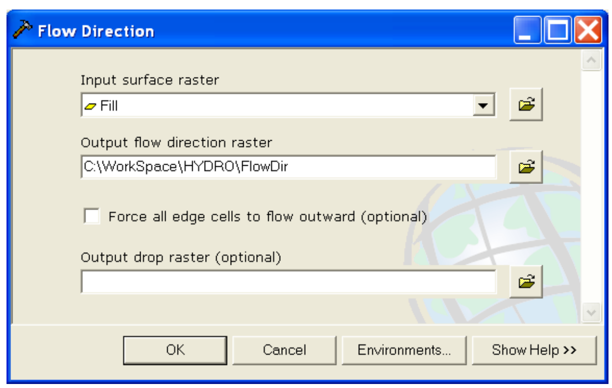
The resulting grid is essentially a smoothed-over DEM in which extreme topographic differences are filled in. This is required so the Flow Direction and Flow Accumulation algorithms don't get stuck in a hole with nowhere to go.



Calculating flow direction:

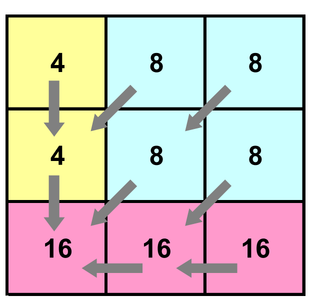
12. Choose SPATIAL ANALYST TOOLS >>> HYDROLOGY >>> FLOW DIRECTION
13. Select **Fill** as the Input Surface
14. Specify an output file; e.g. C:\WorkSpace\HYDRO**FlowDir**
15. Optionally, set the other parameters
16. Click OK

This results in a grid in which each cell is assigned a code indicating the direction of flow based on it's neighboring cells. See below.

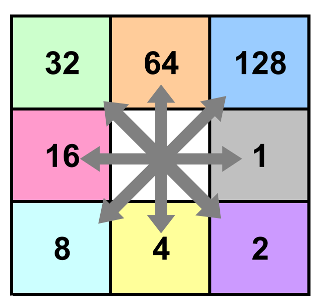


980	1020	1050
890	970	1000
820	950	990

***Input:* [fill]**



***Output:* [direction]**

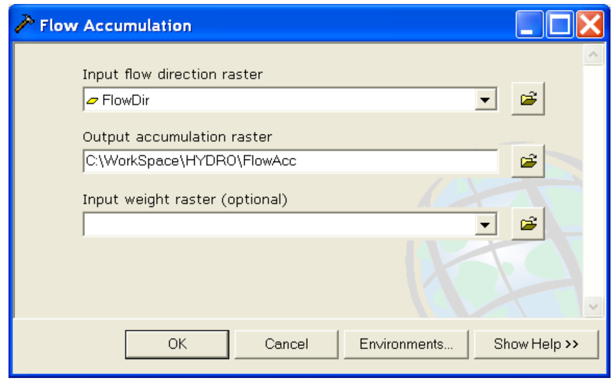


Coding for Direction Raster

Calculating flow accumulation:

17. Choose HYDROLOGY >>> FLOW ACCUMULATION
18. Select **FlowDir** as the Input Flow Direction Raster
19. Specify the Output Accumulation Raster; e.g. C:\WorkSpace\HYDRO**FlowAcc**
20. Click OK

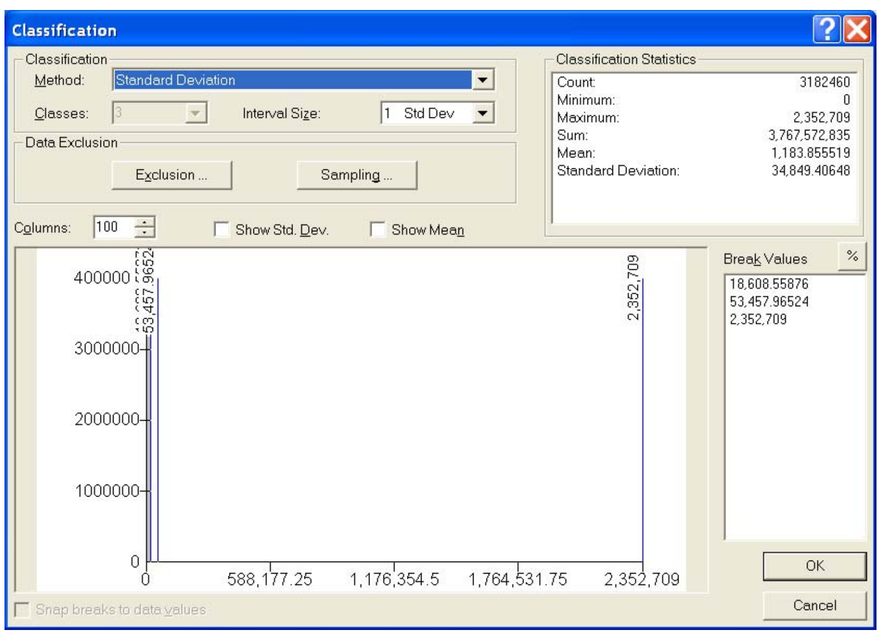
The resulting raster essentially indicates the drainage network.



Creating a drainage network and end points (pour points):

Visualize an adequate threshold for defining a stream network:

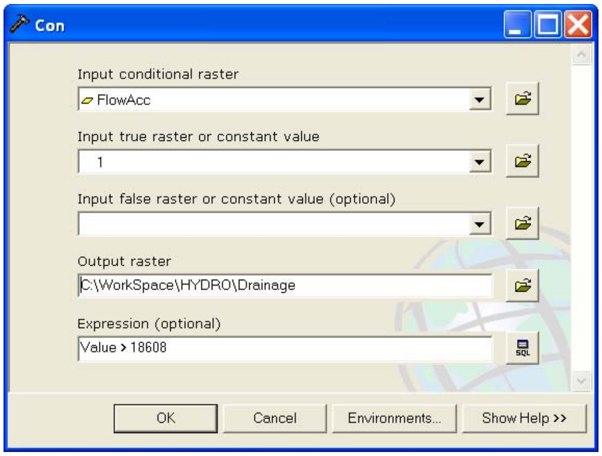
21. In the Table of Contents, double click on the **FlowAcc** layer name to access the Layer Properties
22. Click on the SYMBOLOGY tab
23. Select to Show as CLASSIFIED and click on the CLASSIFY button
24. Select STANDARD DEVIATIONS as the Classification Method



25. Click OK twice

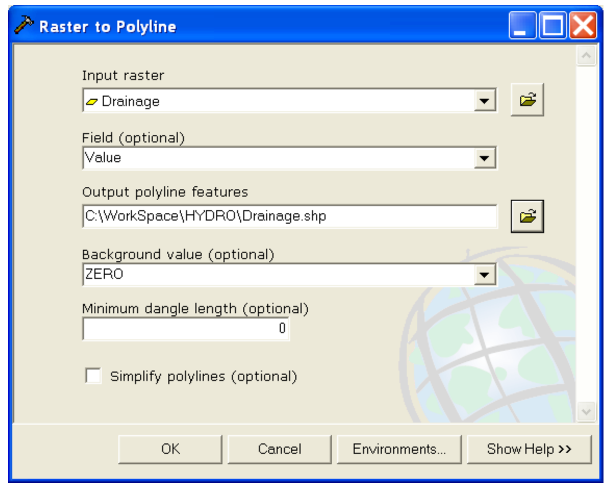
The first break value (e.g. 18608) will be used as the threshold value in the following tool:

26. In ArcToolbox, choose SPATIAL ANALYST TOOLS >>> CONDITIONAL >>> CON
27. Specify **FlowAcc** as the Input Conditional Raster
28. Specify **1** as the true constant value



29. Specify the Output Raster; e.g. C:\WorkSpace\HYDRO**Drainage**
30. Specify the expression; e.g. **Value > 18608**
31. Click OK

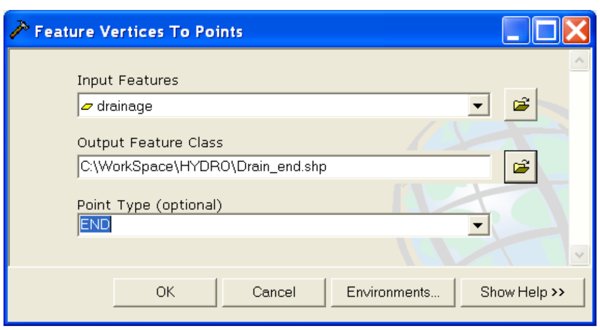
The expression created a raster where the value 1 represents a stream network on a background of NoData.



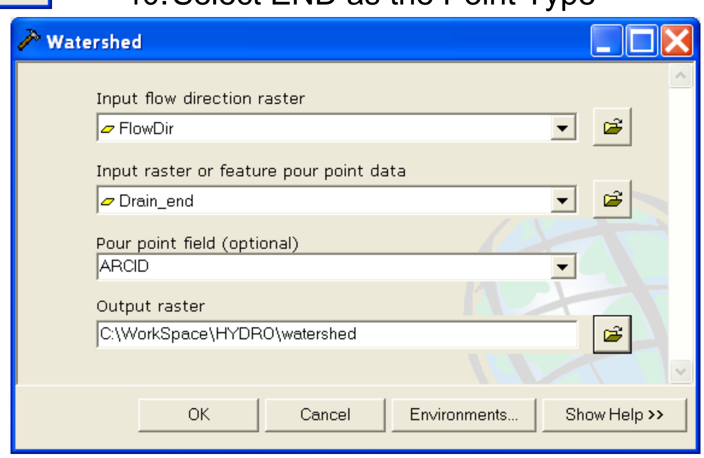
Convert the raster to features:

32. In ArcToolbox, choose CONVERSION TOOLS >>> FROM RASTER >>> TO POLYLINE
33. Specify **Drainage** as the Input Raster
34. Specify **Drainage.shp** as the Output Polyline Features
35. UNCHECK the box beside 'Simplify polylines'
36. Click OK

Create drainage endpoints for use as pour points:



37. In ArcToolbox, choose DATA MANAGEMENT TOOLS >>> FEATURES >>> FEATURE VERTICES TO POINTS
38. Specify **Drainage.shp** as the Input Features
39. Specify **Drain_end.shp** as the Output Feature Class
40. Select END as the Point Type
41. Click OK



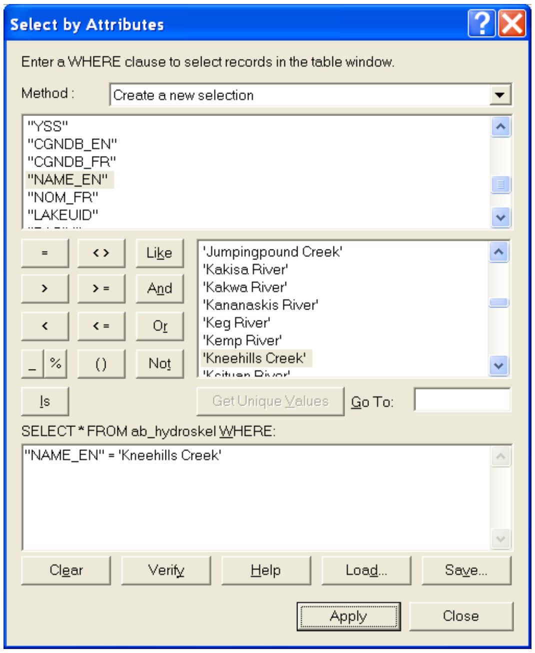
Calculating watersheds:

42. Choose SPATIAL ANALYST >>> HYDROLOGY >>> WATERSHED
43. Select **FlowDir** as the Input flow Direction Raster
44. Select **Drain_end.shp** as the Input Pour Point Data
45. Accept the default **ARCID** as the Pour Point Field

46. Specify an Output Raster; e.g. C:\WorkSpace\HYDRO**Watershed**
47. Click OK

Method 1 – Defining ONE watershed at a time:

This may be done by aggregating sub-watersheds (see below) to create required watersheds or by simply by selecting a single endpoint that corresponds to the river/stream section of interest.



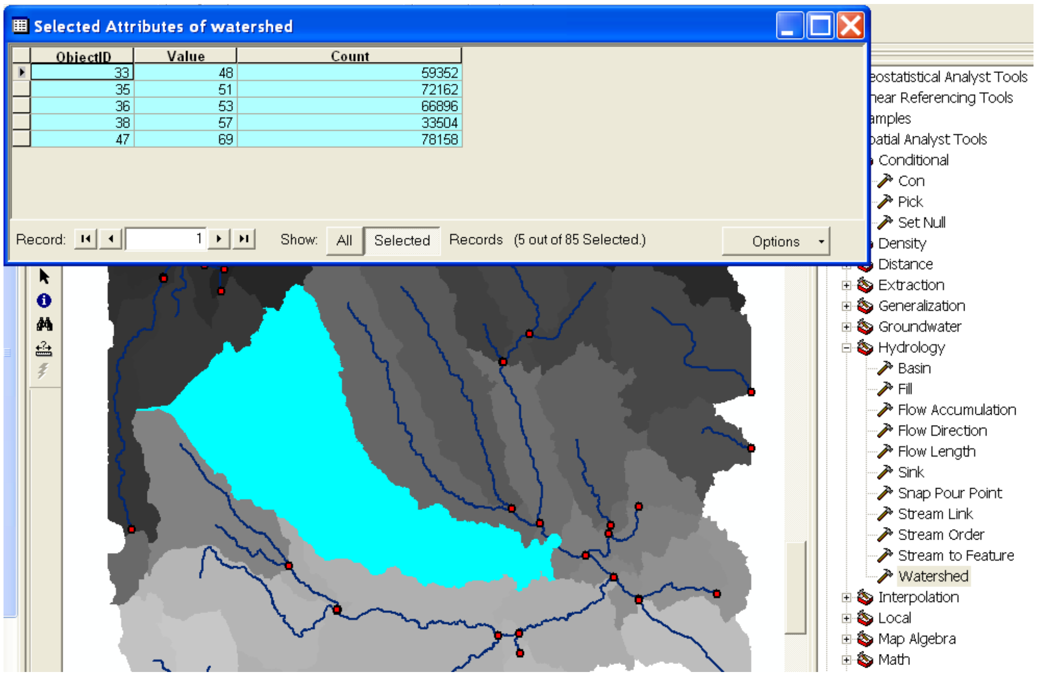
48. ADD DATA: **ab_hydroskel.shp** is a good layer to try since it has most rivers/streams named for all of Alberta
49. In the table of contents, right click on **ab_hydroskel** ands choose OPEN ATTRIBUTE TABLE
50. Choose OPTIONS >>> SELECT BY ATTRIBUTES
51. Enter the expressions: **"NAME_EN" = 'Kneehills Creek'**
52. Click APPLY
53. CLOSE the table
54. ZOOM TO SELECTED FEATURES to view the highlighted section(s)
55. With the Drain_end layer visible, ZOOM IN to the end point that corresponds with the highlighted ab_hydroskel 
56. Use the SELECT FEATURES tool to interactively click and highlight the point 
57. Repeat the above instructions for SPATIAL ANALYST >>> HYDROLOGY >>> WATERSHED:
    - Use the exact same inputs – the only difference is that you are applying the tool to a selected pour point!
    - Specify an new Output Raster; e.g. C:\WorkSpace\HYDRO**Kneehills**
58. Click OK

Method 2 – Defining ONE watershed at a time:

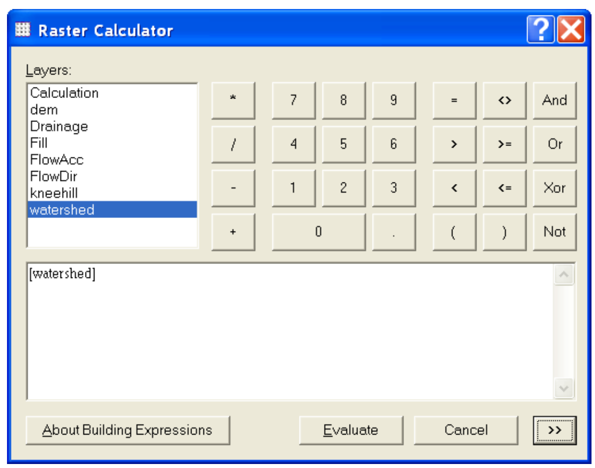
When defining a single aggregated watershed, the alternative (to running the watershed tool again on a selected pour point) is to reclassify the first Watershed raster into two classes: one which includes all values of sub-watersheds to be included, and zero for all others.

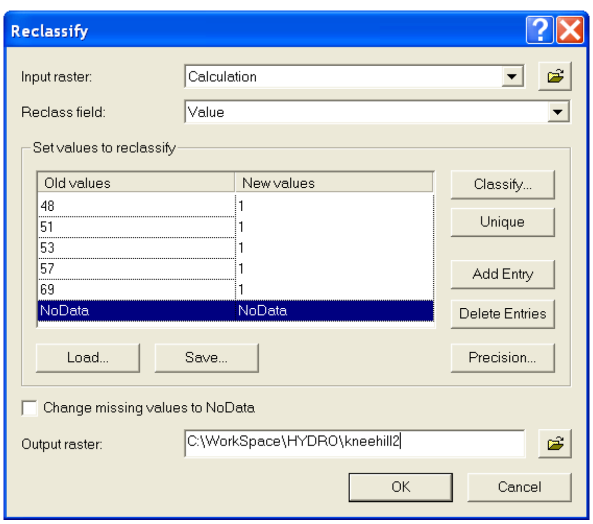
59. Use the SELECT FEATURES tool to interactively select all **Drain_end** features that are associated with the Kneehills Creek (or other desired river/stream)
60. OPEN ATTRIBUTE TABLE for **Drain_end** and examine the unique Ids
61. OPEN ATTRIBUTE TABLE for **Watershed** and interactively select the VALUEs that are the same as those selected in the **Drain_end** table

62. Visually inspect the selected cells in the data frame – *these should be all the selected sub-watersheds; therefore use these values in the RECLASSIFY tool*



63. While the cell values are still selected in the Watershed raster, in the toolbar, choose SPATIAL ANALYST >>> RASTER CALCULATOR
64. Enter the expression: **[Watershed]**
65. Click EVALUATE



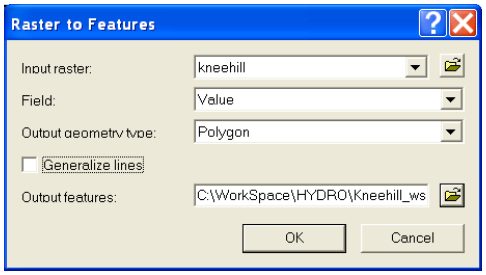


66. Choose SPATIAL ANALYST >>> RECLASSIFY
67. Set **Calculation** as the Input Raster
68. Replace all NEW VALUES to **1**
69. Specify an Output Raster; e.g. C:\WorkSpace\HYDRO**Kneehills2**
70. Click OK
71. REPEAT the aggregation (i.e. interactive selection, calculation, and reclassification) for any other pour points

Converting watersheds from raster to vector:

If you require your watershed to be in vector shapefile format (e.g. to use in vector Geoprocessing), then perform the following steps.

72. Choose SPATIAL ANALYST >>> CONVERT >>> RASTER TO FEATURES



73. Specify **Kneehill** as the Input Raster
74. Specify Output Features; e.g. C:\WorkSpace\HYDRO**Kneehill_wshd.shp**
75. Click OK

See figure below for final result…