Catchment Area Delineation Using GIS technique for Bekhma Dam

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SUMMARY

In this paper, we will perform drainage analysis on a terrain model for Bekhma area

The Arc Hydro tools are used to derive several data sets that collectivity describe the drainage patterns of the catchments. Raster analysis is performed to generate data on flow direction, flow accumulation, stream definition, stream segmentation, and watershed delineation. These data are then used to develop a vector representation of catchments and drainage lines from selected points. The utility of Arc Hydro tools is used to develop attributes that can be useful in hydrologic modeling. The main data is the DEM with 1 arc second to get as much accurate results as could. Using this technique the author got very good results by comparing the Russian results introduced using the topo maps, with GIS technique while they used the collection of hard copy maps and they extracted the DTM from the contour lines and calculated the catchment area.

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1. INTRODUCTION

DEMs are used in water resources projects to identify drainage features such as ridges, valley bottoms, channel networks, surface drainage patterns, and to quantify sub catchment and channel properties such as size, length, and slope. The accuracy of this topographic information is a function both of the quality and resolution of the DEM, and of the DEM processing algorithms used to extract this information.

Watershed delineation is one of the most commonly performed activities in hydrologic analyses. Digital elevation models (DEMs) provide good terrain representation from which watersheds can be derived automatically using GIS technology. The techniques for automated watershed delineation have been implemented in various GIS systems and custom applications (Garbrecht and Martz, 1999).

This paper represents a methodology for DEM pre-processing that provides the basis for fast and consistent watershed delineation on DEMs of any resolution and size using desktop GIS technology. This methodology was first developed in 1997 as part of the watershed delineation project developed for the Texas Natural Resources Conservation.

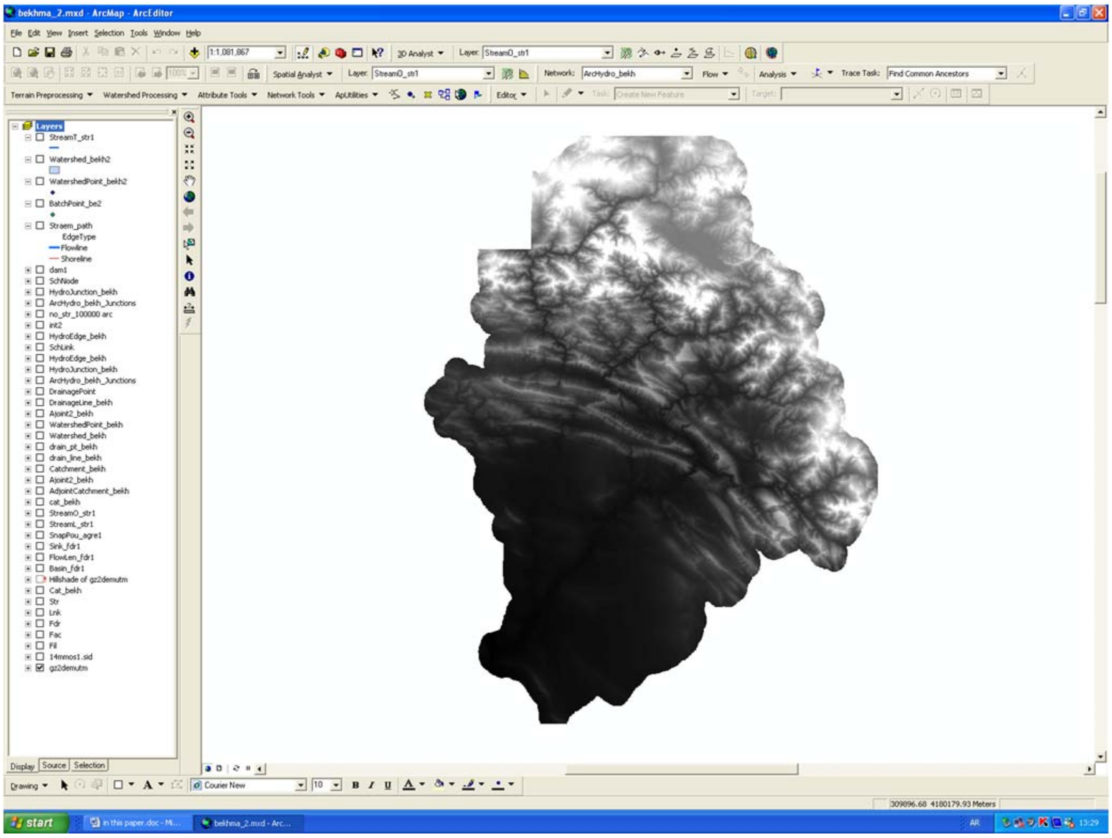
2. TERRAIN PROCESSING

Terrain processing uses DEM to satisfy the surface drainage pattern. Once preprocessed, the DEM and its derivatives can be used for efficient watershed delineation and stream network generation. All the steps in the Terrain Preprocessing menu should be performed in sequential order, from top to bottom. All of the preprocessing must be completed before watershed processing functions can be used. DEM reconditioning and filling sinks might not be required depending on the quality of the initial DEM. DEM reconditioning involves modifying the elevation data to be more consistent with the input vector stream. By doing the DEM reconditioning we can increase the degree of agreement between stream networks delineated from the DEM and the input vector stream.

3. DEM RECONDITIONING

This function modifies a DEM by imposing linear features onto it. The function needs as input a raw DEM and a linear feature class (like the river network) that both have to be present in the map document. From the Arc Hydro toolbar select
Terrain Preprocessing | DEM Reconditioning

Select the appropriate DEM (Mosaic dem) and linear feature (river).
The output is a reconditioning Agree DEM.

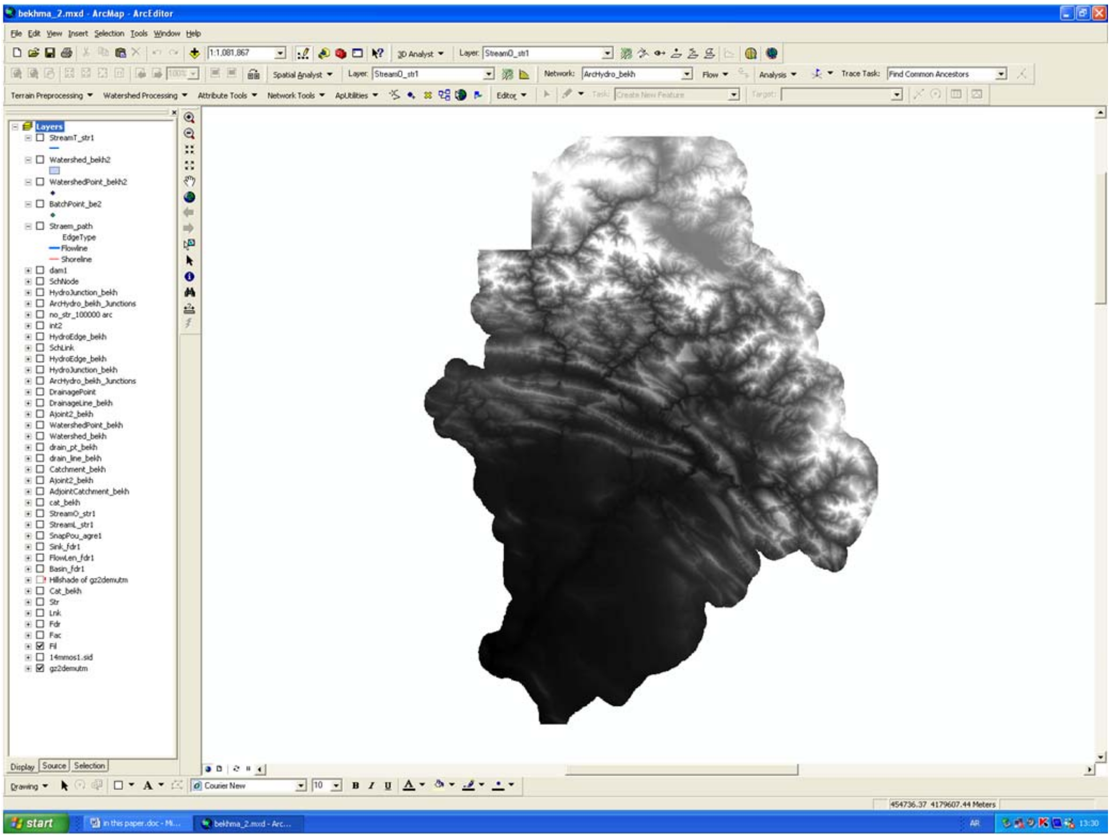


Now we examine the folder where we are working notice that a folder named Layers has been created. This is where Arc Hydro outputs its grid results. A personal geodatabase with the same name as the ArcMap document has also been created. This is where Arc Hydro outputs its vector feature class data.

4. FILL SINKS

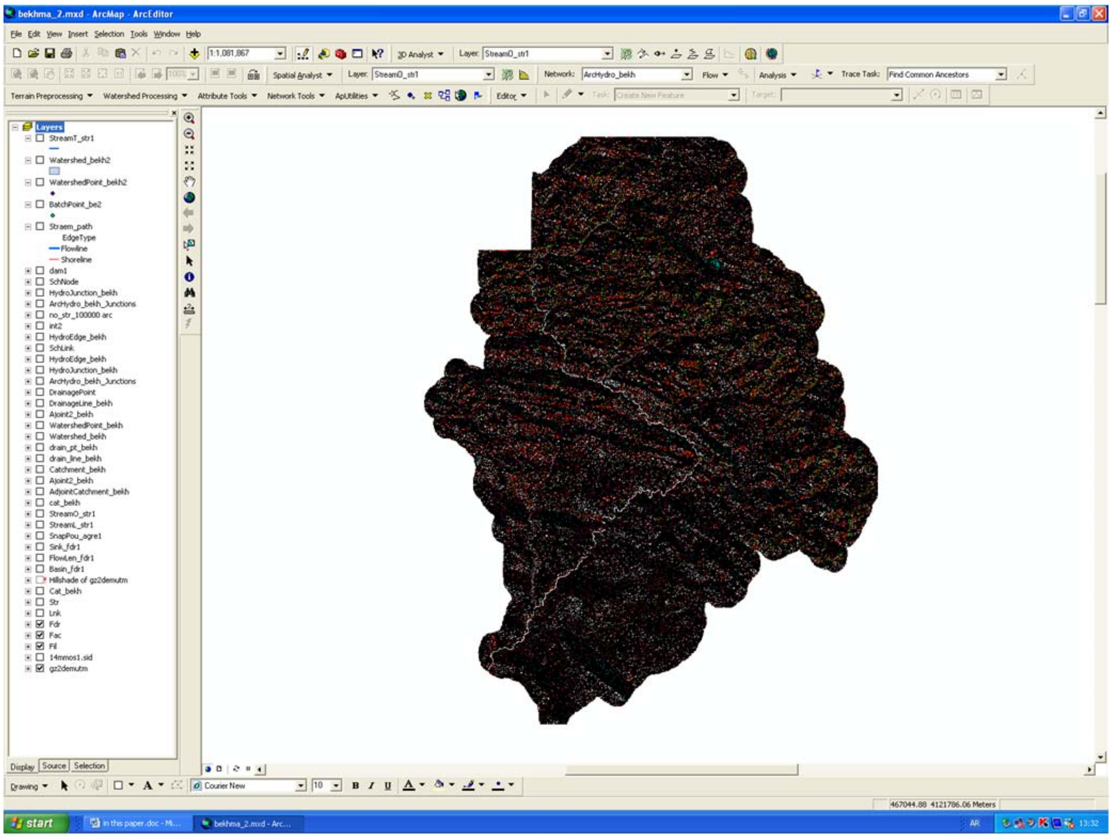
This function fills the sinks in a grid. If cells with higher elevation surround a cell, the water is trapped in that cell and cannot flow. The fill sinks function modifies the elevation value to eliminate these problems, Select
Terrain Preprocessing | Fill Sinks
Confirm that the input for DEM is "AgreeDEM ". The output is the HydroDEM layer, named by default "Fil ".

Press Ok, upon successful completion of the process, the "Fil" layer is added to the map.



5. FLOW DIRECTION

This function computes the flow direction for a given grid. The values in the cells of the flow direction grid indicate the direction of the steepest descent from that cell.
Select Terrain Preprocessing | Flow Direction
Confirm that the input for Hydro DEM is "Fil ". The output is the flow Direction Grid, named by default "Fdr".



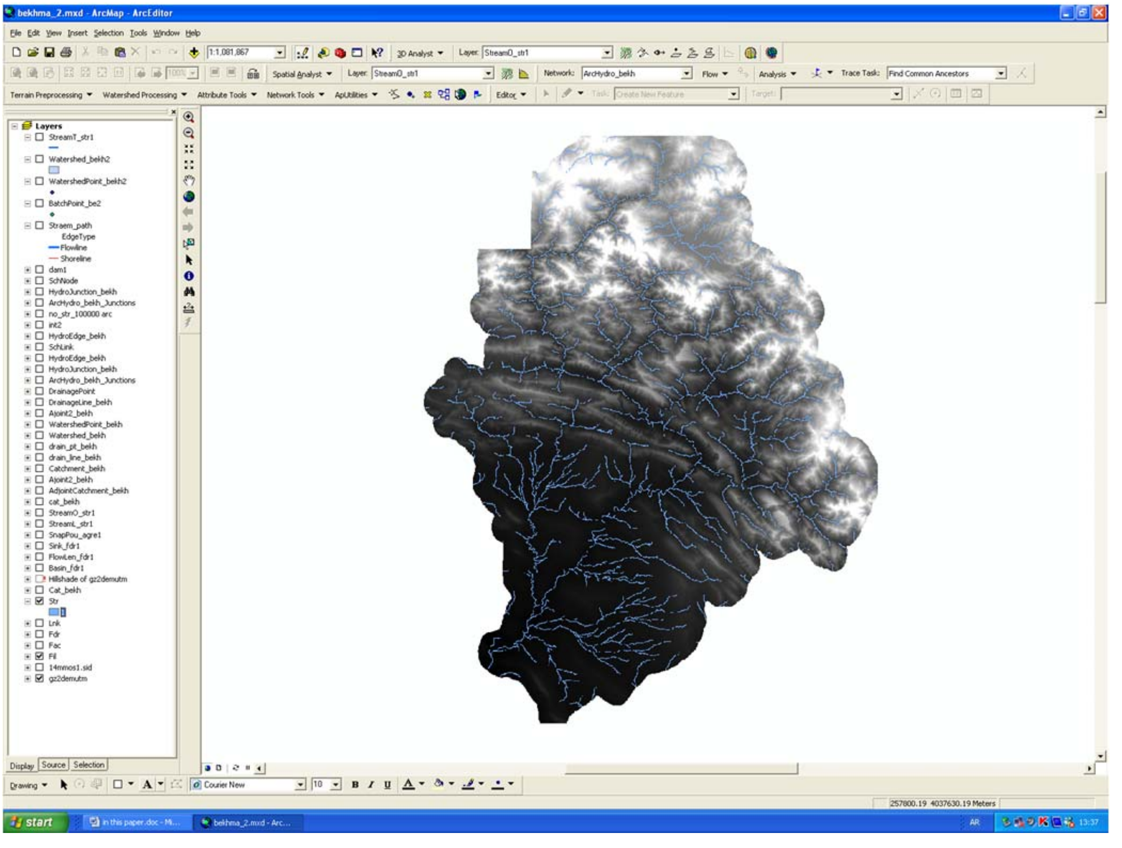
Press Ok, upon successful completion of the process, the flow direction grid "Fdr" is added to the map.

6. FLOW ACCUMULATION

This function computes the flows accumulation grid that contains the accumulated number of cells upstream of a cell, for each cell in the input grid.
Select terrain preprocessing | flow accumulation
Confirm that the input of the flow direction grid is "fdr". The output is the flow accumulation grid having a default name of "fac" is added to the map.
Add the contours of the original DEM so that | examine flow accumulation relative to the terrain as depicted by contours and relative to the streams layer. The following shows Fac in the neighborhood of the watershed outlet.

7. STREAM DEFINITION

This function computes a stream grid which contain a value of "|" for all the cells in the input flow accumulation grid that have a value greater than the given threshold. All other cells in the stream grid contain no data.
Select terrain Preprocessing | stream Definition
A smaller threshold will result in denser stream network and usually in a greater number of delineated catchment.



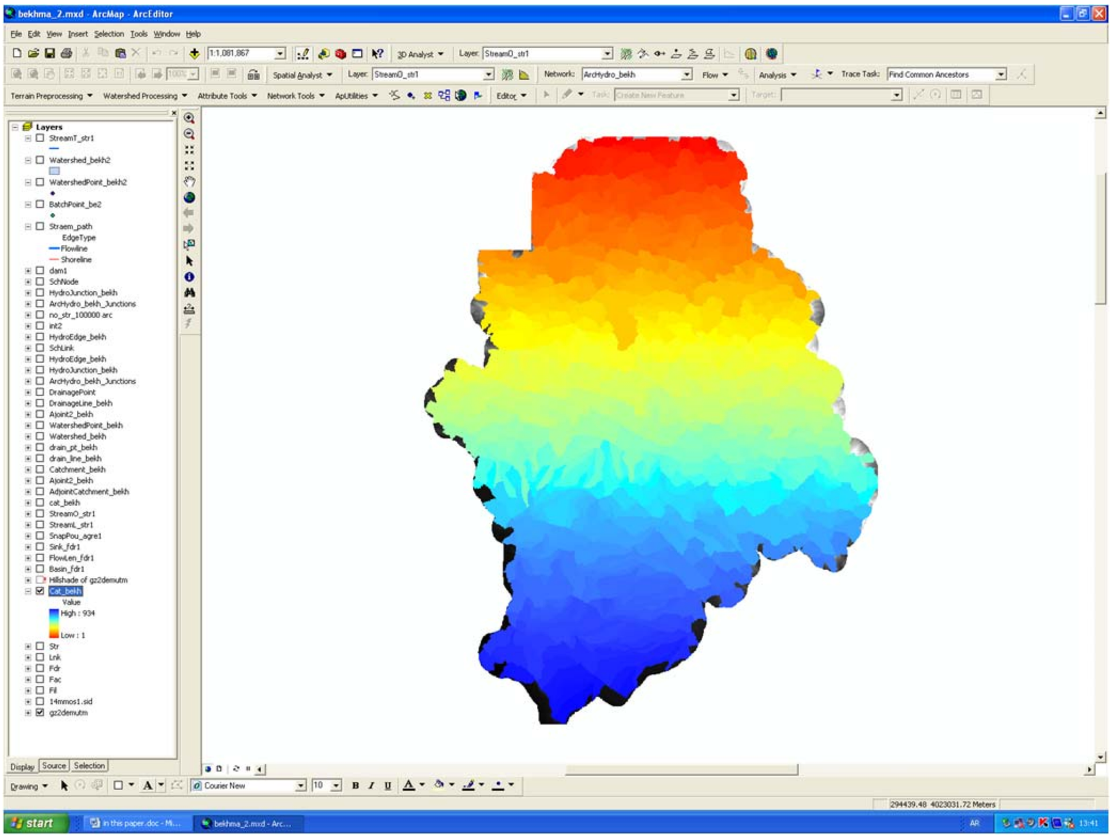
8. STREAM SEGMENTATION

This function creates a grid of stream segments that have a unique identification. Either a segment may be a head segment, or it may be defined as a segment between two junctions. All the cells in a particular segment have the same grid code that is specific to that segment.
Select terrain preprocessing | stream segmentation

Confirm that"fdr"and"str" are the inputs for the flow direction grid and the stream grid respectively. The output is the link grid, with the default name "luk" that can be overwritten.
Each link has a separate value.

9. CATCHMENT GRID DEFINITION

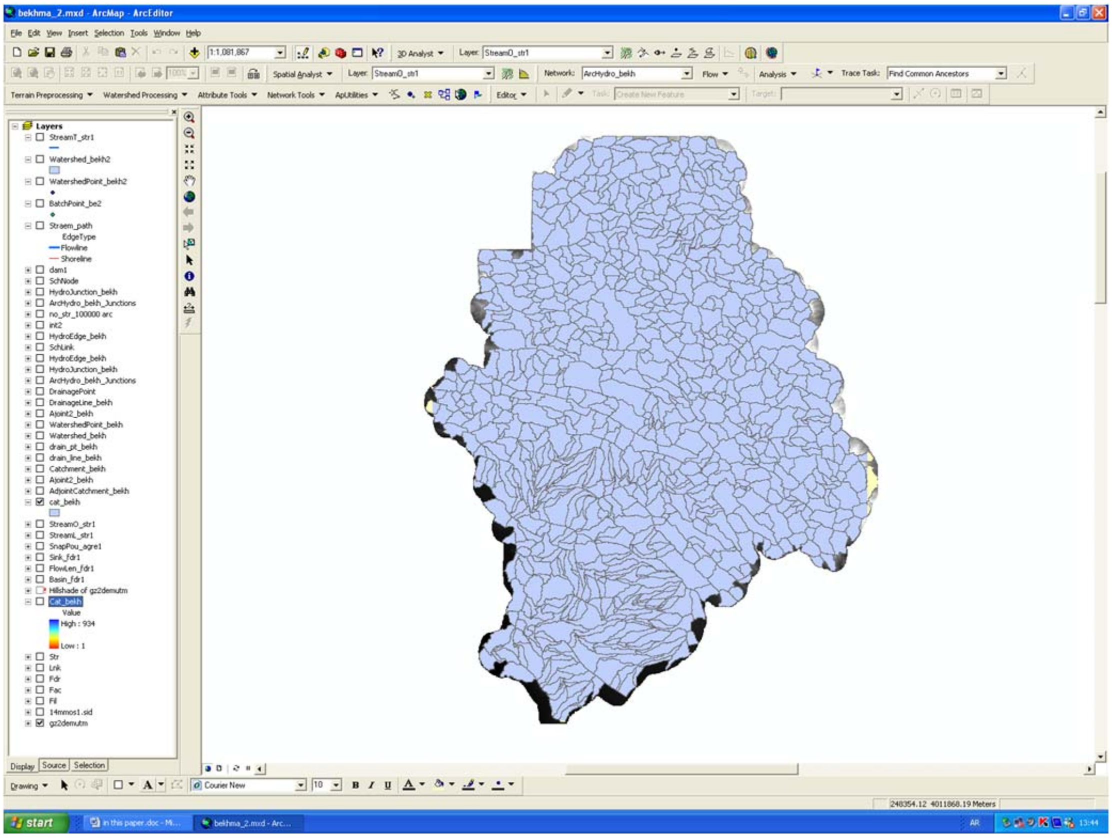
This function creates a grid in which each cell carries a value (grid code) indicating to which catchment the cell belongs. The value corresponds to the value carried by the stream segment that drains that area, defined in the stream segment link grid.
Select Terrain Preprocessing | Catchment Grid Delineation



Confirm that the input to the Flow Direction Grid and link Grid are " Fdr " and "Lnk" respectively. The output is the Catchment Grid layer. " Cat " is its default name.

10. CATCHMENT POLYGON PROCESSING

This function converts a catchment grid into a catchment polygon feature.
Select Terrain Preprocessing | Catchment Polygon Processing

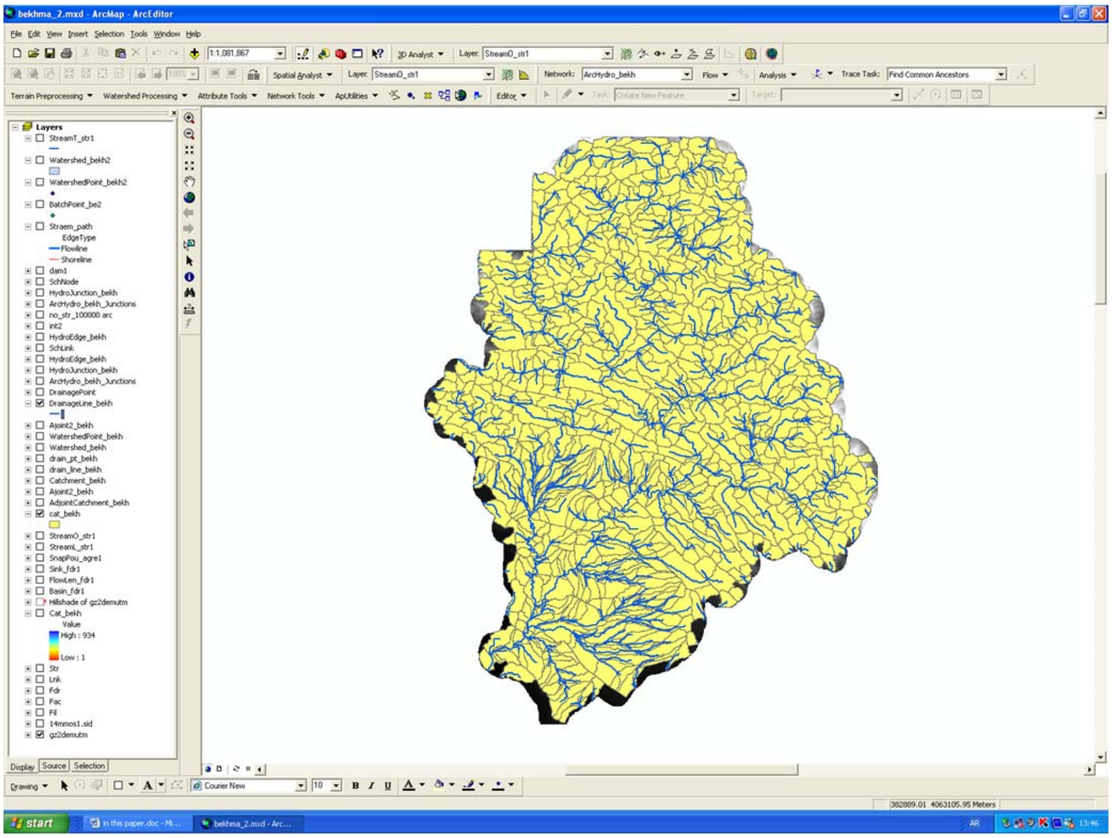


Confirm that the input to the Catchment Grid is " Cat ". The output is the catchment polygon feature class.

11. DRAINAGE LINE PROCESSING

This function converts the input stream link grid into a Drainage line feature class. Each line in the feature class carries the identifier of the catchment in which it resides.

Select Terrain preprocessing | Drainage Line Processing

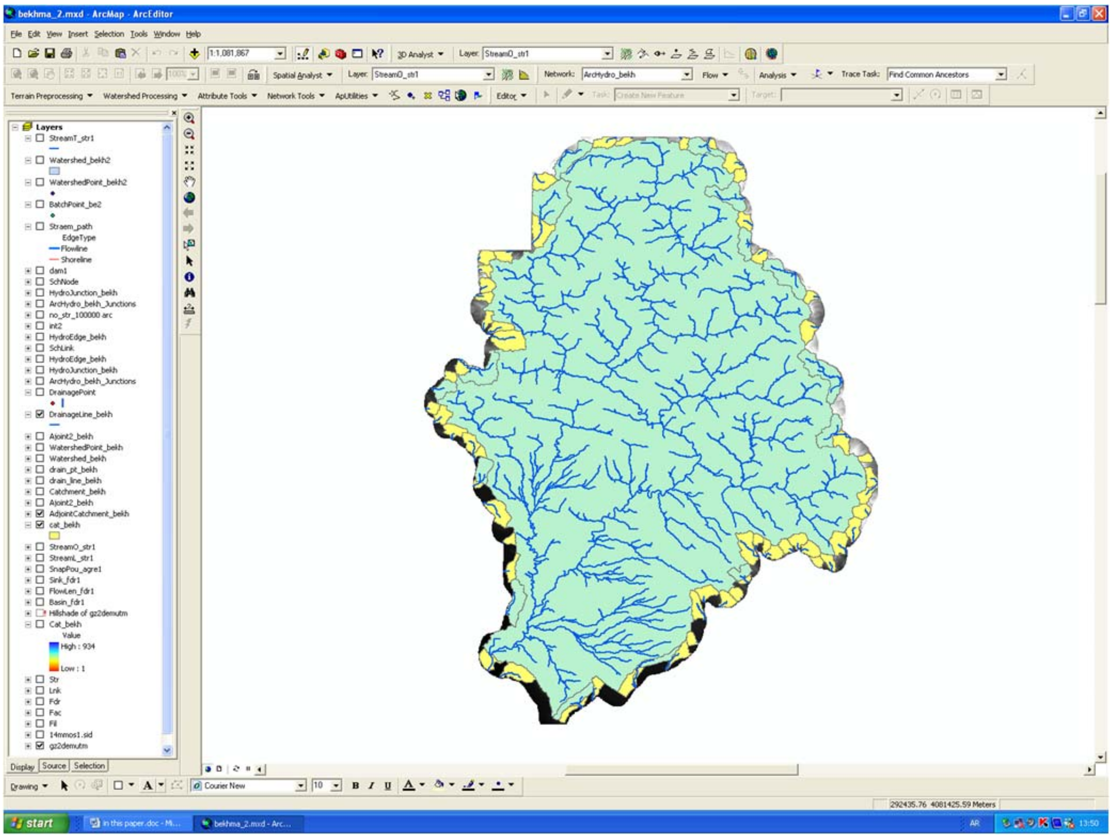


Confirm that the input to Link and to flow Direction Grid " Fdr ". The output Drainage Line has default name “Drainageline

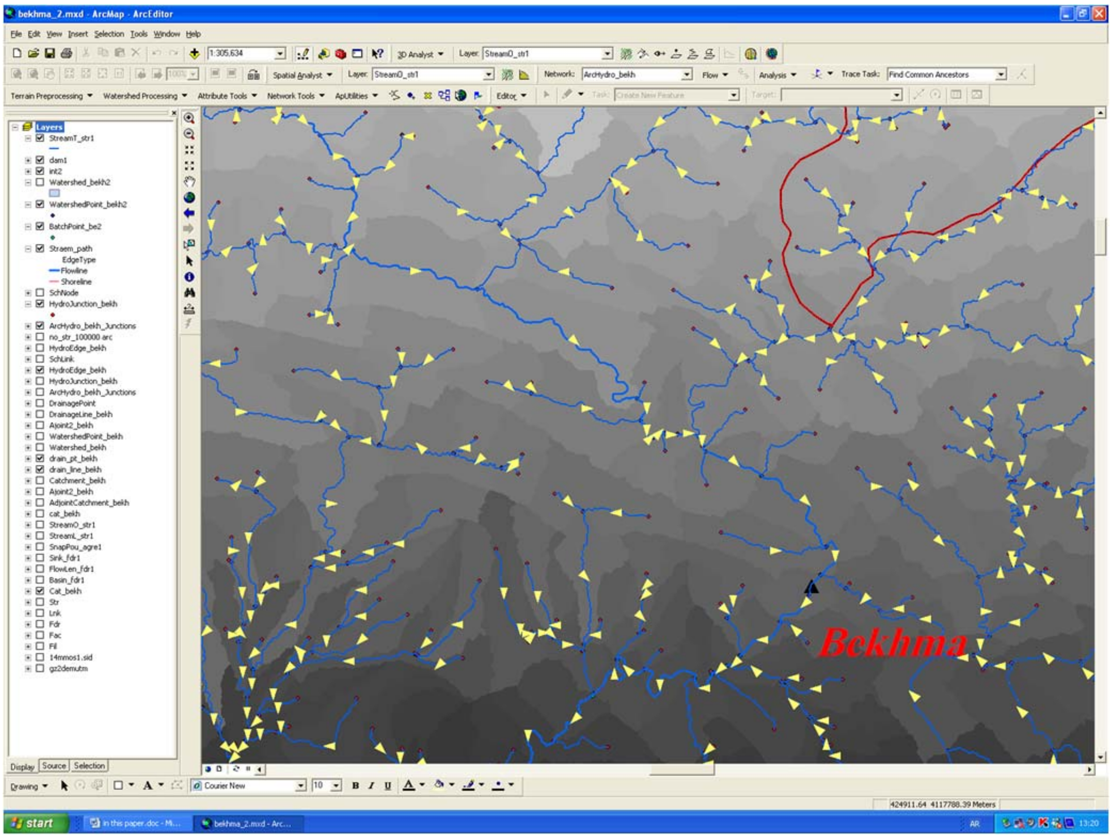
12. ADJOINT CATCGMENT PROCESS

This function generates the aggregated upstream catchments from the “Catchment” feature class. For each catchment that is not a head catchment a polygon representing the whole upstream area draining to its inlet point is constructed and stored in a feature class that has an “Adjoint Catchment " tag. This feature class is used to speed up the point delineation process.

Select Terrain Preprocessing | Drainage Point Processing



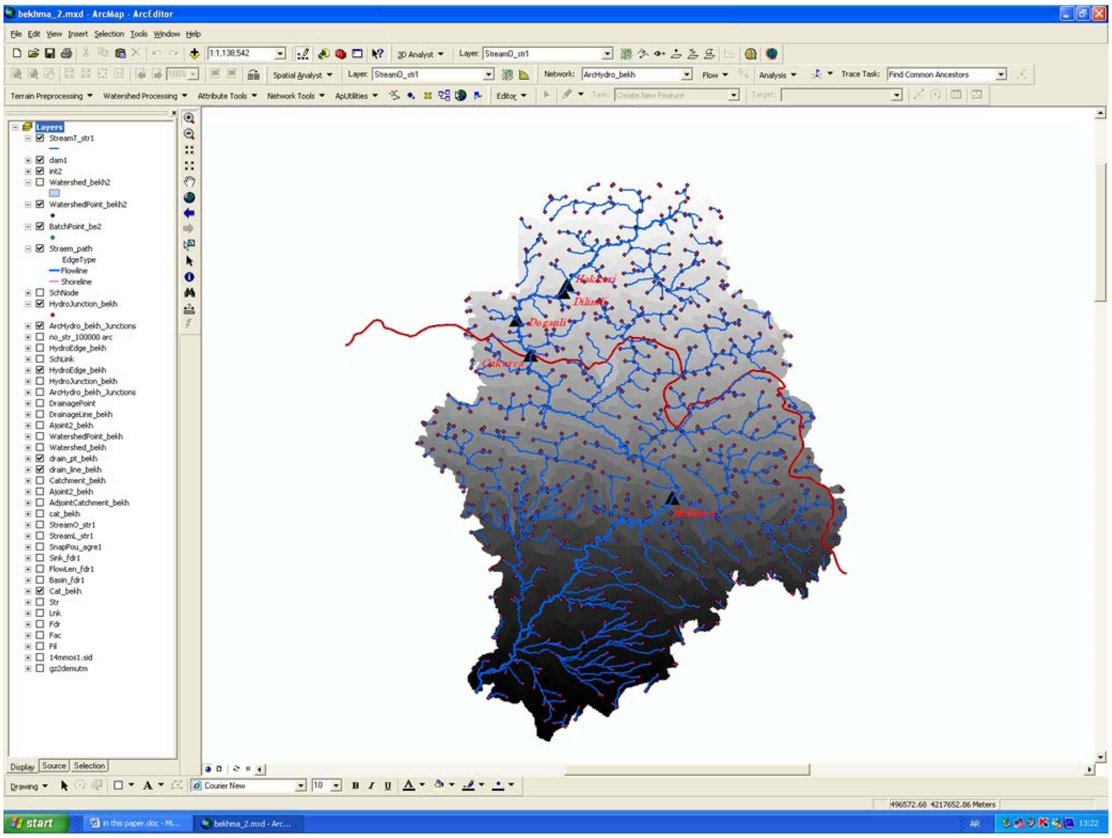
Confirm that the input to Drainage line is ' Drainageline" and the input to catchment is “Catchment ". The output is Drainage Point, having the default name “Drainage Point".



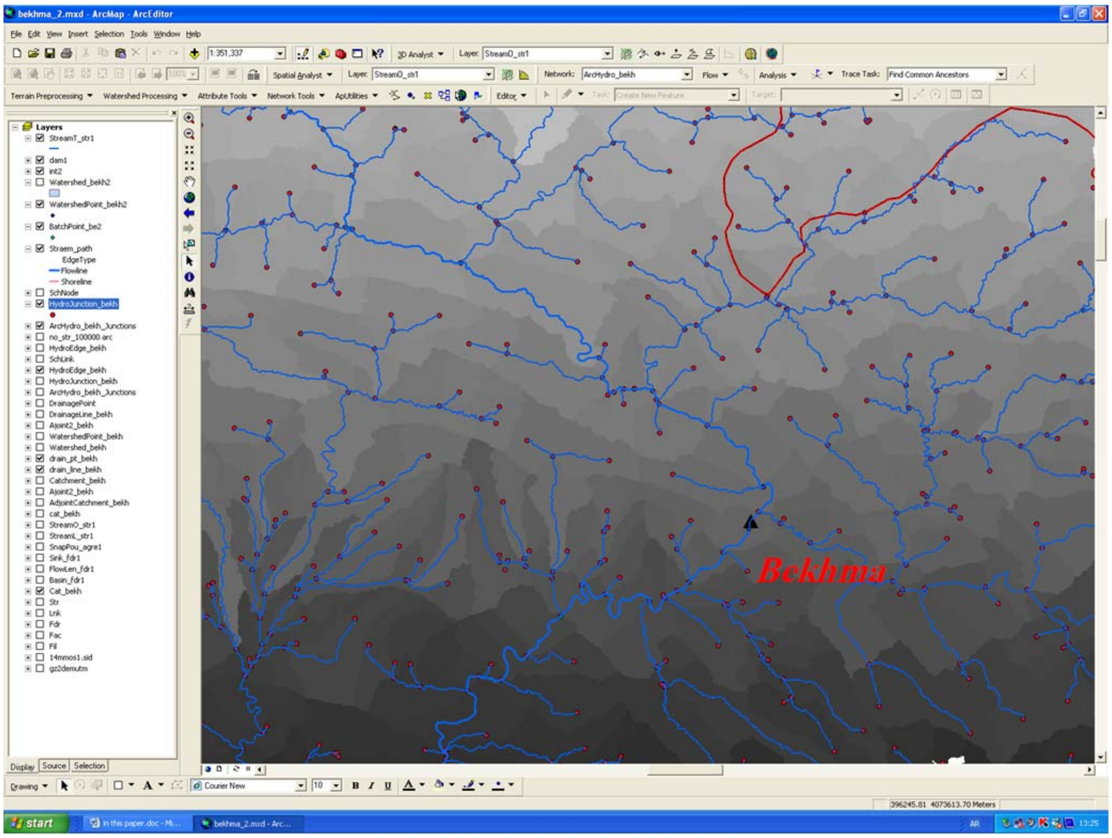
13. DRAINAGE NETWORK EXTRACTION

Then we would like to extract the drainage network from the DEM, to fix the direction of the flow line as well as the main nodes. These nodes may be signalized as outlets or inlets. The characteristics of the extracted network depend on the definition of channel sources on the digital land surface topography. Another issue with drainage networks extracted from DEMs is the precise positioning of channels in the digital landscape. Comparisons with actual maps or aerial photos often show discrepancies particularly in low relief landscapes. The primary reason of this discrepancy is that digital landscape cannot capture important topographic information below the DEM resolution.

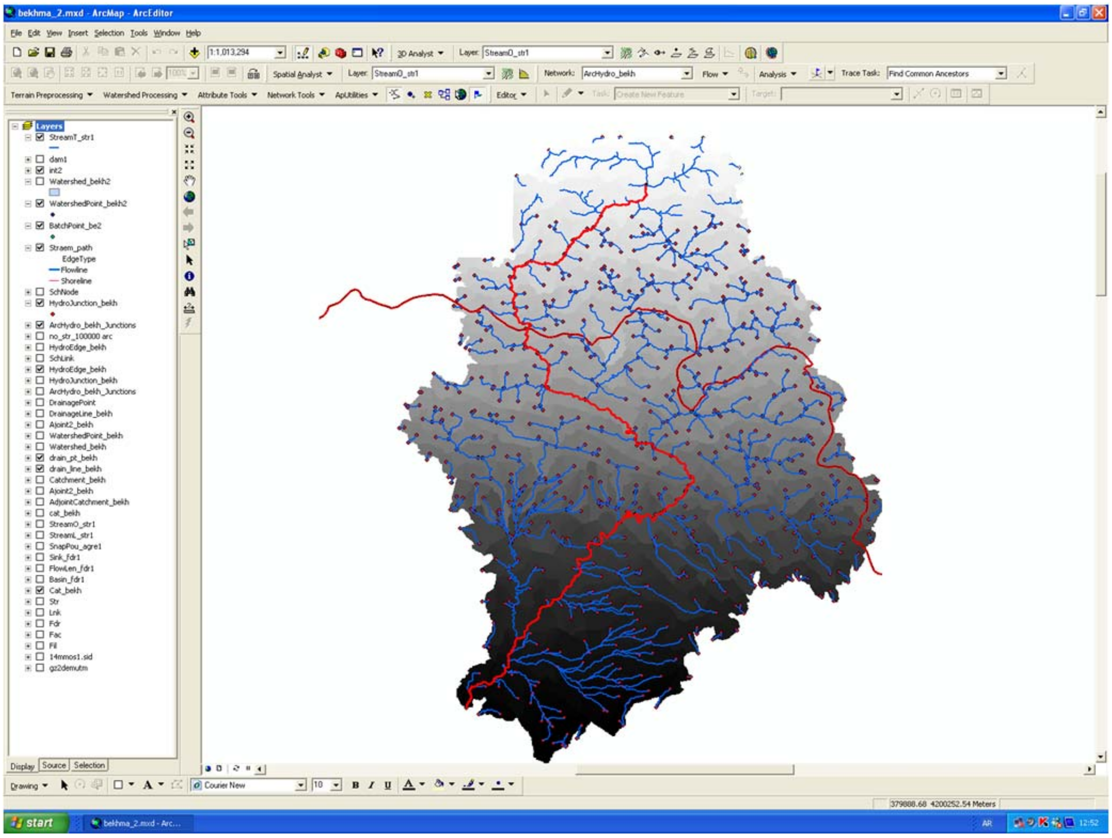
The nodes for the network for the whole area



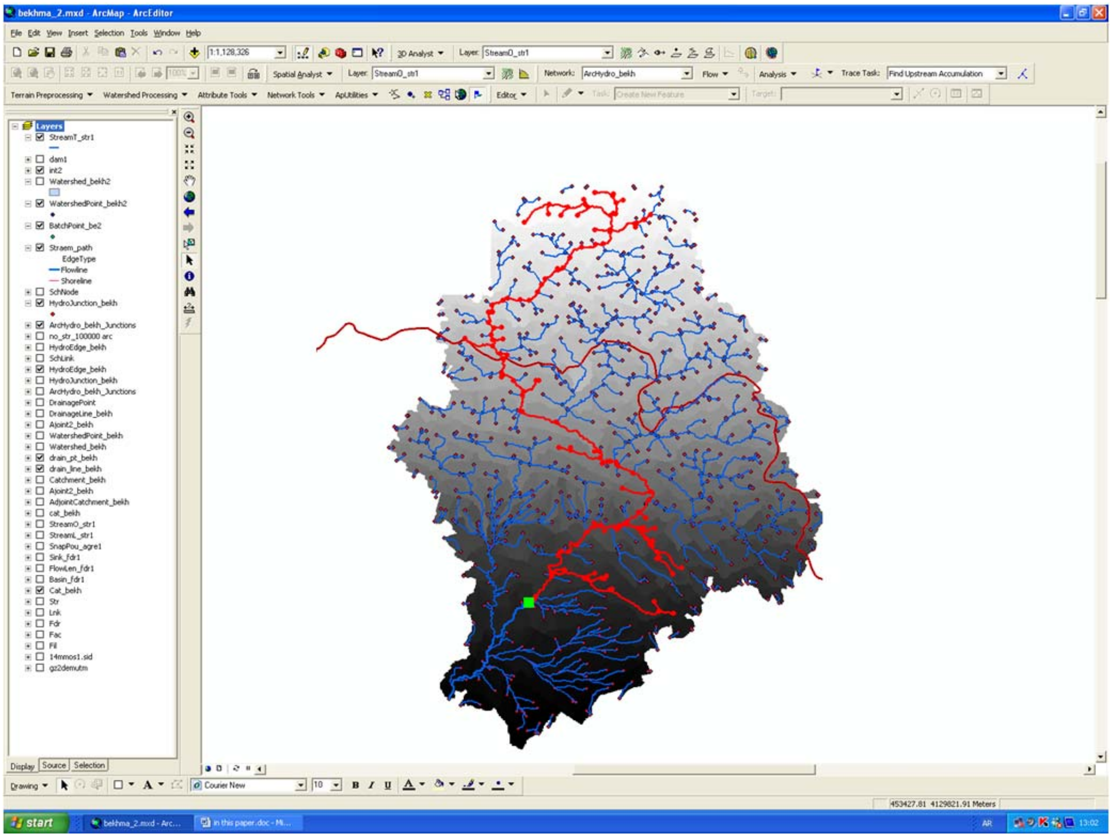
To make it clear with large scale we could identify the DEM near the proposed Bechma dam.


Bekhma

The analysis of water flow and trace the flow path on the map



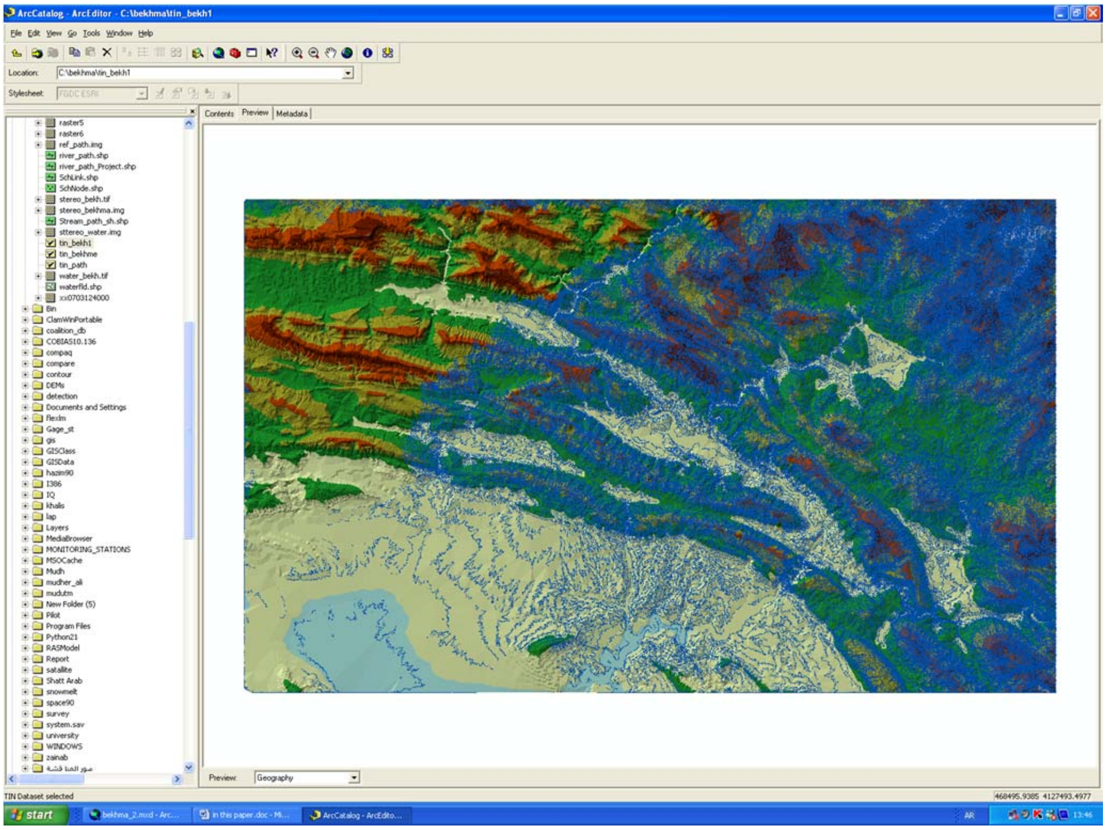
To find the Upstream Accumulation

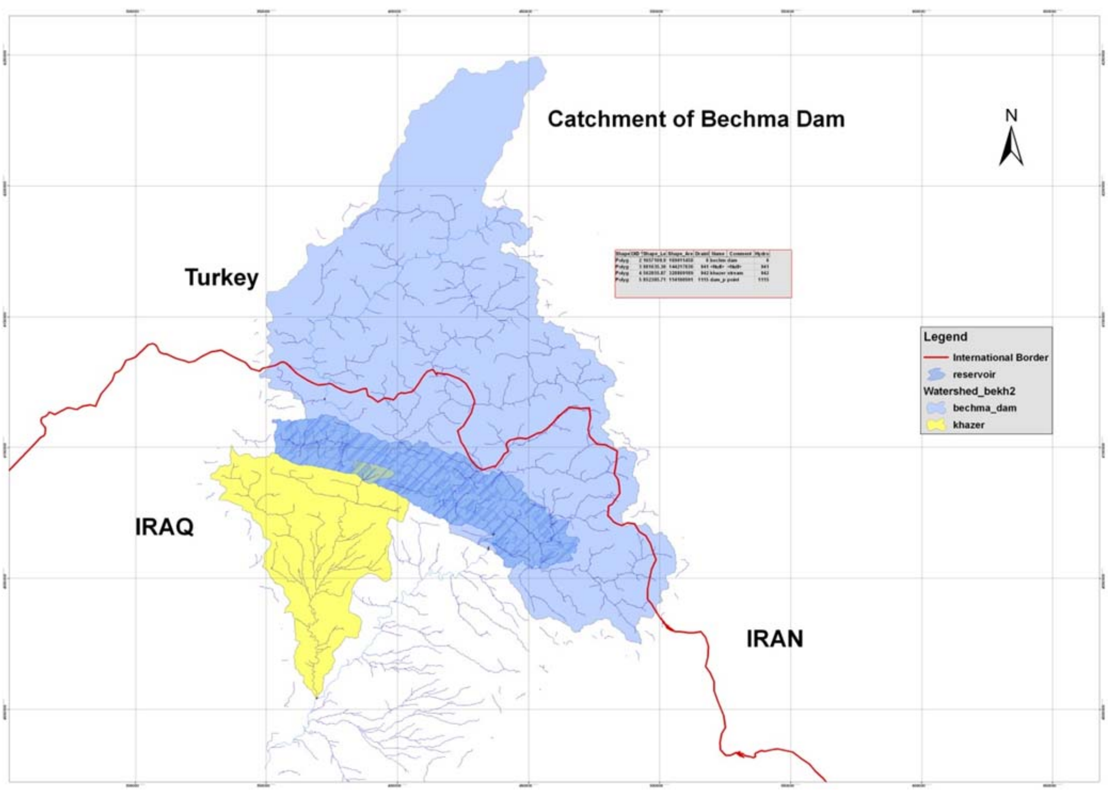


We could delineate any watershed area directly through the junction point which is its outlet and find the area of this watershed easily.

14. CREATION OF TIN

The triangulated irregular network (TIN) data consists of irregular spaced elevation points in x, y, z values that derived here from the contour lines created from the DEM.
We could identify the area for the reservoir of the proposed dam, as in fig. below




Catchment of Bechma Dam
N
Turkey
IRAQ
IRAN
Legend
International Border
reservoir
Watershed_bekh2
bechma_dam
khazer

15. PURPOSE OF ANALYSIS

The technological advances provided by GIS and the increasing availability and quality of DEMs have greatly expanded the application potential of DEMs to many hydrologic, hydraulic, water resources.

GIS ArcHydro provides increased efficiency, a typical hydrographical analysis was performed using GIS and using traditional methods. In a hydrographical analysis, efficiency means primarily minimizing the expense in acquiring data and time required for completing the analysis. A complete analysis of efficiency should consider a task once, but also the likelihood that some or all tasks may need to be performed more than once.

Hydrologic process and water resource issues are commonly investigated by use of distributed watershed models .These watershed models require physiographic information such as configuration of the channel network , location of drainage divides , channel length and slope , and sub catchment geometric properties . Traditionally, these parameters are obtained from maps or field surveys. Over the last two decades this information has been increasingly derived directly from digital representations of the topography (Jenson and Domingue, 1988; Mark, 1984 Moore et al.,1991 ; Martz and Garbrecht , 1992).

The automated derivation of topography watershed data from DEMs is faster, less subjective, and provides more reproducible measurements than traditional manual techniques applied to topographic maps. Digital data generated by this approach also have the advantage of being readily imported and analyzed by geographic information system (GIS).

The Russian in their strategic study for the water resources in Iraq defined the area of watershed for Bechma dam. They used the traditional method to estimate that area, which could be summarized as the reading of all the topo maps covered the area. They derived the catchment area for the dam using the contour lines which need an expert to define the catchment area. This method need also long time compared with the method described earlier using the DEM with GIS technique.

16. CONCLUSIONS

The described watershed delineation methodology is used to identify the area of interest for which the hydrologic modelling will be performed. Once this area is identified , a set of interactive tools are made available for refinement of the initial delineation such as merge and split current sub watershed, add sub basin outlet points from a file. The delineation functions (point, segment, and polygon) will also be included with this application to provide a full set of delineation tools.

The methodology used in this paper allows efficient and consistent watershed delineation on DEMs of any size. The speed of delineation can be controlled by the user during the pre-processing stages.

REFERENCES

1. Garbrecht, j., and L.W.Martz. 1996. comment on “Digital Elevation Model Grid Size, Landscape Representation, and Hydrologic Simulations” by Weihua Zhang and David R.Montgomery.

2. Verdin, K.L. and J.P.Verdin.1999.A topological system for delineation and codification of the earth’s river basins. Journal of Hydrology

3. Djokic, D., and D.R. Maidment.2000.Hydrologic and Hydraulic Modeling Support with Geographic Information Systems. Redlands Calif.: ESRI Press.