Work Book

Blue Water Poster for the Nile Sub Basin

GIS Exercise - 24th September 2005

Information Products for Nile Basin Water Resources Management
www.faonile.org

Introduction

Requirements

This exercise requires a PC running Windows 95/98, NT/2000/XP, with ArcView 3.x including Spatial Analyst. The necessary data and extensions are provided.

Objectives

The main objective of this exercise is to demonstrate the potential of ArcView for visual explanation. A graphic or map has proven a powerful means for making information more accessible and for supporting a communication process.

As a practical example, the basic hydrology of a selected area will be explained to a group of non-hydrologist by means of a poster.

At the end of the exercise, the trainees will be able to:

- Use ArcView extensions to perform geo-processing operations on feature and grid layers;
- Present a hill-shaded digital elevation model (DEM);
- Extract summary information from an Access database and import the results in ArcView;
- Use ArcView extensions to extend the functionality of the software.

Task

Prepare a poster presenting the surface water runoff for the Kenyan Lake Victoria basin.

Preparation

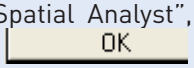
Before starting the exercise, will add three extensions – *Xtools* ,*Memo Tools*, and *Customlines* - to ArcView. All were obtained from the ESRI home page www.esri.com, following the path "Support" => "Downloads" => "ArcScripts". *Memo Tools* contains some 100 useful scripts for working with feature layers and tables, while *Xtools* is used for geo-processing feature themes. The latter includes functions like Clip, Merge, Union, and Intersect. Customlines is used to modify the presentation of line segments.

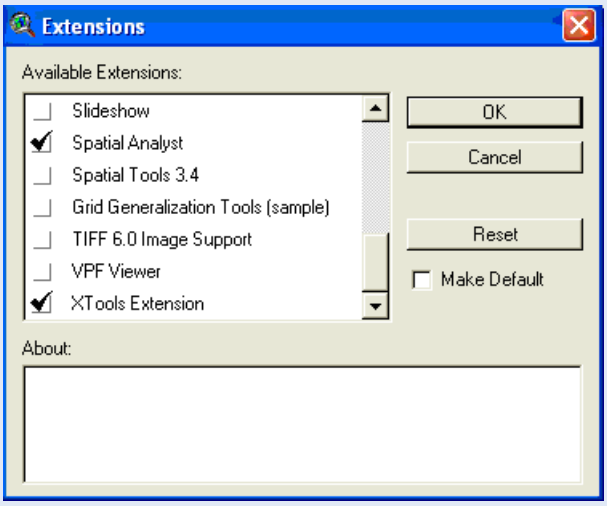
The three extensions are located in the following folder on the workshop CD:

"First-GIS-Workshop\Exercise-BlueWaterPoster_OriginalDataSet\ArcViewExtensions"

Browse to this folder, and select files *Memo_Tools.avx, XTOOLS.AVX*, and *Customlines.avx*. Copy the three files to folder C:\ESRI\AV_GIS30\ARCVIEW\EXT32.

Open ArcView  . Select "File" => "Extensions..." to activate the Extension dialog box.

Check "Spatial Analyst", "Memo Tools" and "Xtools". Click OK 



Procedure

Step 1

Create dem and hillshade layers

Open a new View. Add grid layer "dem_s20e020" stored on the workshop CD in folder:

First-GIS-Workshop\Exercise-BlueWaterPoster_OriginalDataSet

This public domain Digital Elevation Model (DEM) has a resolution of 90 m and has been developed by the Shuttle Radar Topography Mission (SRTM). It is now available for the entire world at http://srtm.usgs.gov/.

Activate layer "dem_s20e020". This particular tile contains parts of Africa and the Middle East, with lower-left corner: latitude –20∞, longitude 20∞. As the file size of this layer is too large for further processing, we need to cut it to our window of analysis. The Kenyan Lake Victoria basin is defined by:

Left: 33.50∞ - Right: 36.50∞ - Top: +1.5∞ - Bottom: -2.5∞

Click "Analysis" => "Properties". Set the analysis extent to the above window.

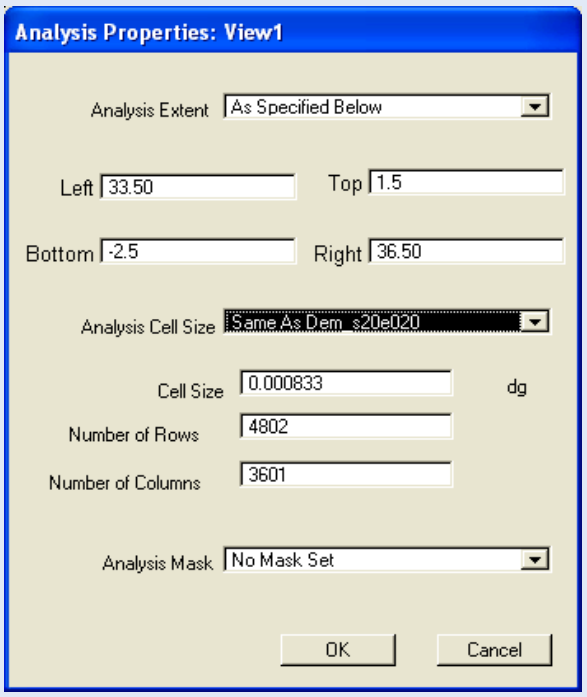
Use the same analysis cell size as "dem_s20e020".

Click OK.

Click "Analysis" => "map calculator". In the calculation window, multiply layer "dem_s20e020" by 1, as shown below.

Click "Evaluate".

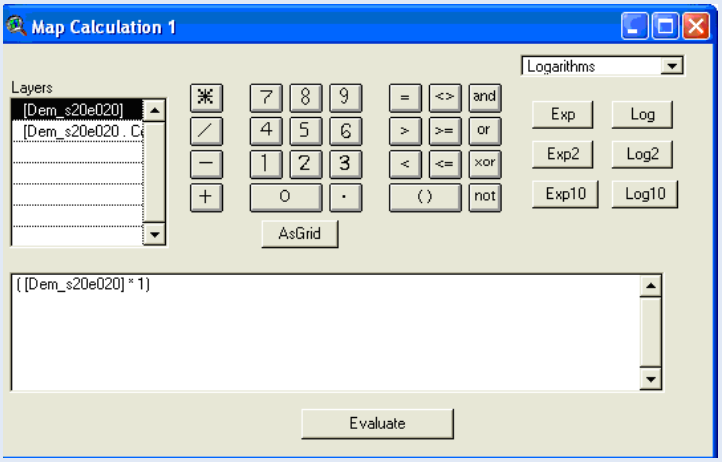
Close calculation window and activate new theme.



Delete layer "dem_s20e020" and zoom in to the new grid layer.

Click "Theme" => "Convert to Grid" to store the new layer in an appropriate folder, with file name "dem_lvk". Please note that grid naming conventions limits the file name to 8 characters.

Add "dem_lvk" to the view and remove "Map Calculation1".



Double click theme "dem_lvk" to activate the legend editor.

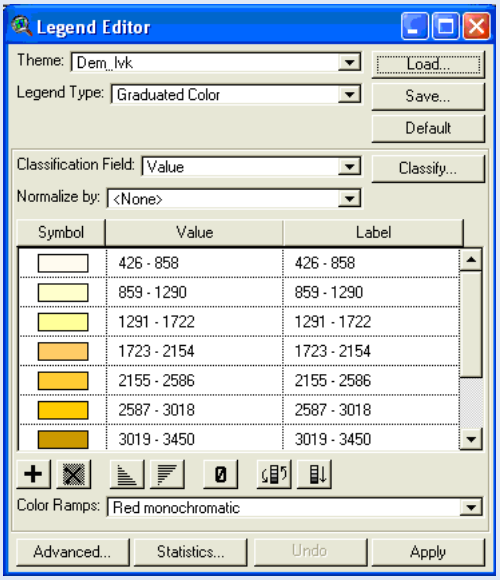
Click "Load" and navigate to folder "First-GIS-Workshop\ExerciseBlueWaterPoster_OriginalDataSet\ Legends" on the workshop CD.

Select legend file "dem_leg2.avl" and click OK.

Set "Field" to "Value" and click OK.

Click "Apply" to activate the new legend. Close the legend editor.

Click "Theme" => "Hide/Show Legend" to hide the legend.



To increase contrast and better distinguish terrain features, a hill shade theme is added to a DEM. ArcView Spatial Analyst includes a standard tool to calculate hill shade. Click "Surface" => "Compute Hillshade". However, in this particular case the latitude (x) and longitude (y) coordinates are in decimal degrees, while the elevation (z) is in meters. This difference of units will severely distort the hill shade and hence a correction is needed. As a rule of thumb, one degree at the equator represents some 100 km = 100,000 m. To bring all three dimensions (x,y,z) in similar units, we will thus divide the elevation value with 100,000.

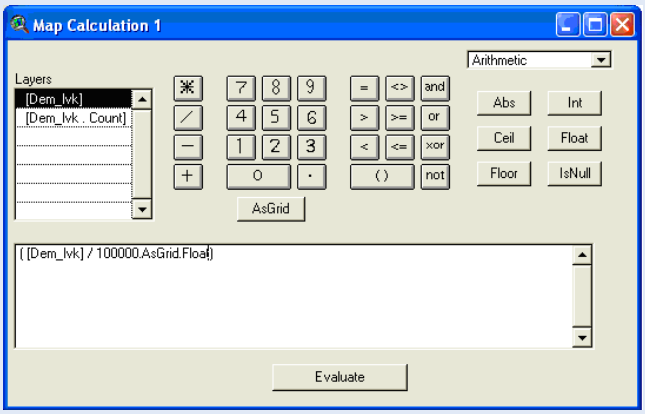
Click "Analysis" => "Map Calculator"

Divide theme "dem_lvk" by 100,000 (do not include a comma). Click "as Grid".

To ensure that the calculation results in real values instead of integers, select "Arithmetic" and click "Float".

Click "Evaluate"

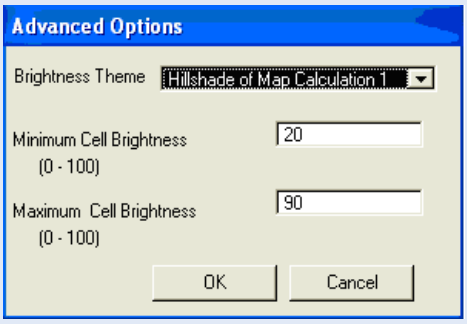
A new grid theme is added to the view.



Activate this theme, called "Map Calculation 1", and click "Surface" => "Compute Hillshade". A dialog box appears to select the parameters. Accept the standard values and click OK. Check the hillshade. De-activate this layer after studying.

Double click theme "dem_lvk" to activate the legend editor. Click "Advanced" and select brightness theme "Hillshade of Map Calculation 1". Leave the remaining parameters as they are.

Click OK. Click Apply. Study the new elevation layer. Note the rift and the old crater next to Mount Elgon.



While the image is certainly interesting and informative, it is clear that adding the hill-shade theme has altered the color palette. Especially the elevation values from 2000 to 2700 meter have become lighter and now resemble lower altitudes. To correct this, activate the color palette in the legend editor. Use custom mode to change these values as follows:

Altitude	Hue	Saturation	Value
2000-2100	31	159	197
2100-2200	30	160	191
2200-2300	29	161	186
2300-2400	28	162	182
2400-2500	26	163	178
2500-2600	24	164	173
2600-2700	23	165	168
2700-2800	22	165	164

Save the new Legend

Procedure

Step 2

Add and Manipulate Topographic Layers

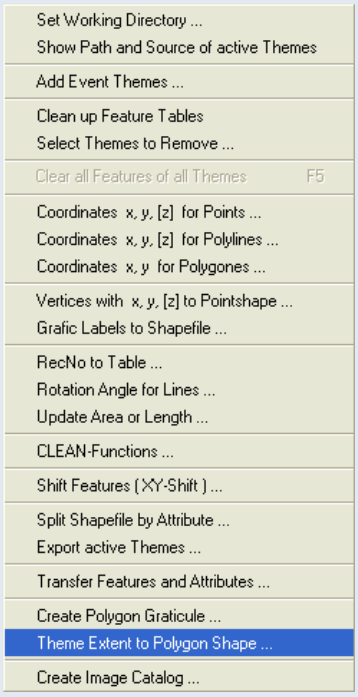
Add the below themes from the workshop CD:

Kenya_boundary.shp
Tanzania_boundary.shp
Uganda_boundary.shp

Create a new shape with the extent of the DEM. This layer will be used to clip the boundary themes to the analysis window.

Click "Memo Thm" => "Theme Extent to Polygon Shape..."

Select "dem_lvk" as source theme; click OK. Navigate to the appropriate folder and name the new theme "Ex_box"; click OK.



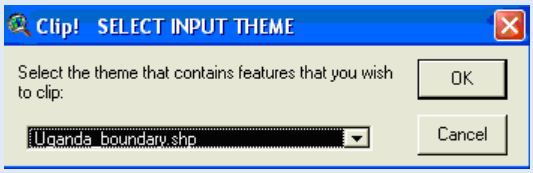
Click "Xtools" => "Clip with Polygon(s)"

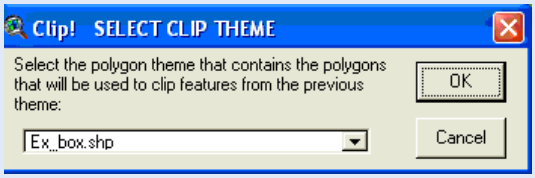
Select "Uganda-boundary.shp", click OK

Use "Ex_box.shp" to set the clip extent, click OK.

Add the new theme to the view. Repeat the procedure for the Kenyan and Tanzanian national boundaries.

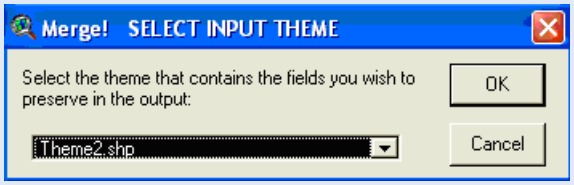
Remove the original boundary themes for the East African countries (except "Kenya_boundary.shp", which will be used later.





Click "Xtools" => "Merge Themes"

Use the last created theme as input. Click OK. Select the remaining two clipped national boundary themes. Click OK. Add the new theme to the view. Use the legend editor to only present the outline with line width value of 2. Remove all clipped national boundary themes from the view.



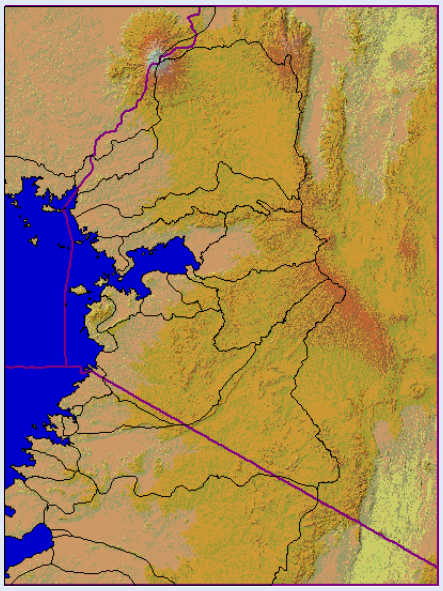
Add the below themes from the workshop CD:

Lakevic&islands.shp
Lv_subbasins.shp
nilebasin.shp

Use the above described procedure to clip these layers to the analysis window.

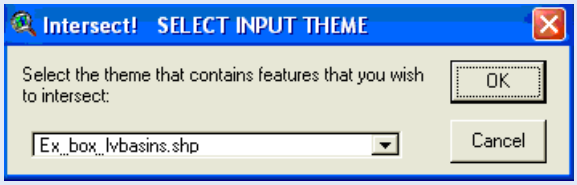
Use the legend editor to set the appropriate colors and layer width. Prepare a map similar to the one presented at the right hand side.

Note that the image does not intuitively focus on the Kenyan Lake Victoria basin. The following steps will extract only the Kenyan part of the basin.

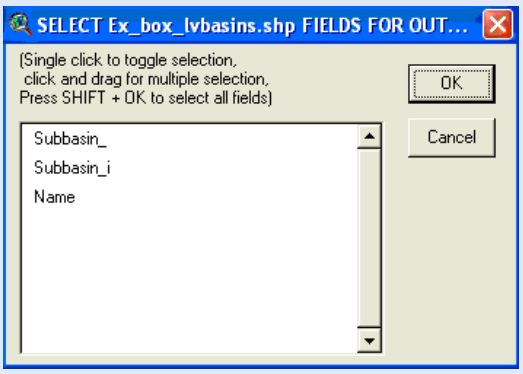


Click "Xtools" => "Intersect Themes"

Select the clipped lvbasin theme as input. Click OK

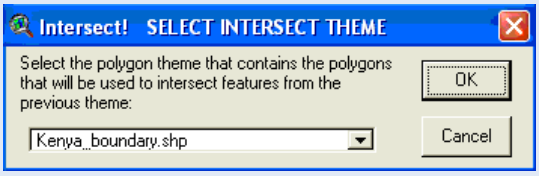


Select all fields, and click OK



Select "Kenya_boundary.shp" as Intersect theme. Click OK.

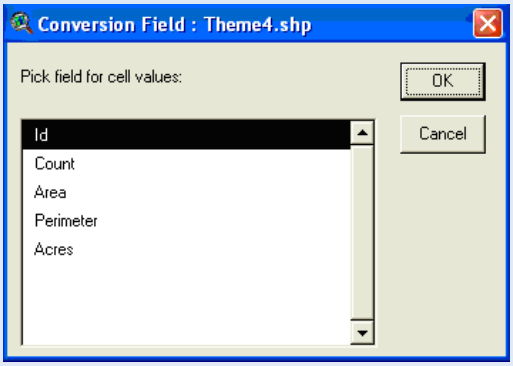
Add the new theme to the view. It contains a number of polygons with the Kenyan Lake Victoria sub basins.



Use Xtools to clip the Lake Victoria basin from "NileBasin.shp". The result is one single polygon for the Kenyan Lake Victoria area.

Activate the new theme and click "Theme" => "Convert to Grid". Give an appropriate file name.

Select "ID" as conversion field. Click OK. Add the new grid to the view.



Select the new grid and click "Analysis" => "Reclassify". Set 0 => 1 and No Data => No Data. Click OK.

Click "Analysis" => "Map Calculator" and multiply the re-classified grid with the "dem_lvk" grid layer.

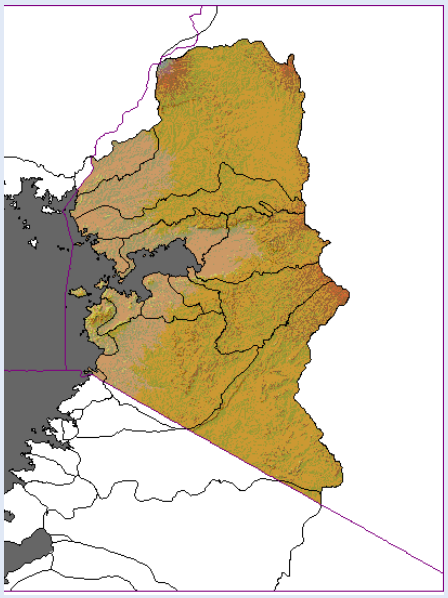
Only values inside the Kenyan Lake Victoria basin now have an elevation value.

Use "Theme" => "Convert to Grid" to give an appropriate name to the new layer, for instance "ken_lvd".

Add this theme to the view. Use the legend editor to load the legend previously created in this exercise. Make sure to also use the brightness theme.

Place this layer below all topology themes.

The result is an image similar to the one on the right hand side.



Place the hill-shade layer as background. To reduce contrast, activate the color palette in the legend editor. Use custom mode to change these values as indicated below.

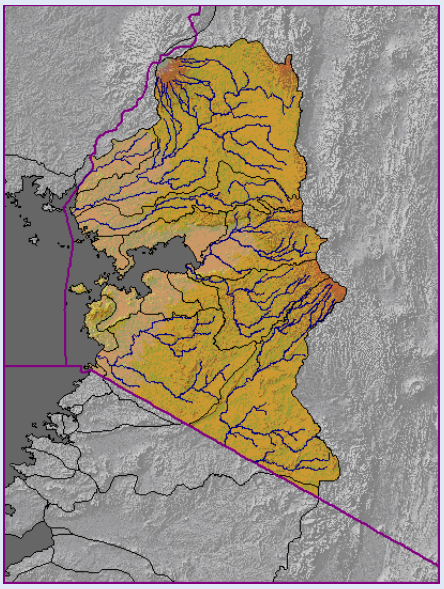
Hill shade	Hue	Saturation	Value
0-167	0	0	120
168-175	0	0	130
176-178	0	0	140
179-180	0	0	150
181-182	0	0	160
183-184	0	0	170
185-188	0	0	180
189-196	0	0	190
197-254	**0**	**0**	**200**

Add the below theme from the workshop CD:

Ex_box_Kenya-rivers.shp

The outcome is the image presented on the right-hand side.

This is the base map for the blue water poster. The next step is to add hydrological data.



Procedure

Step 3

Manipulate and add Hydrologic Data

The exercise uses MS Access and MS Excel to prepare the hydrological summary data for the study area. A selected set of hydrological time series is stored in MS Access file "KEN-LV_SelectedHydroData", which can be found in the below folder on the workshop CD:

"First-GIS-Workshop\ExerciseBlueWaterPoster_OriginalDataSet"

MS Access procedures will be demonstrated to:

a) Determine average annual discharge for each station;
b) Determine average monthly discharge for each station;
c) Export station coordinates to dbf format.

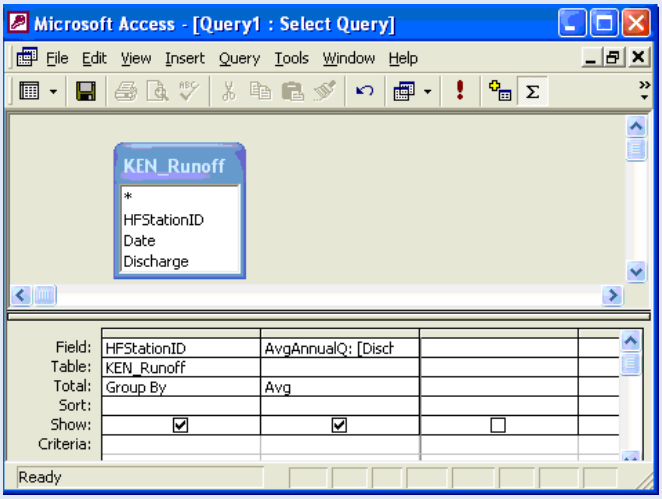
Activate MS Access and open file "KEN-LV_SelectedHydroData". It contains two tables: 1) KEN_Runoff and 2) Ken_HydroStations.

A: Determine average annual discharge for each station

Open a new query in design view. Add the "KEN-Runoff" table to the query.

Drag the fields "HFStationID" and "Discharge" to the query.
Click the Total button Σ, and change the totals row to "Group By" for "HFStationID" and "Avg" for "Discharge".

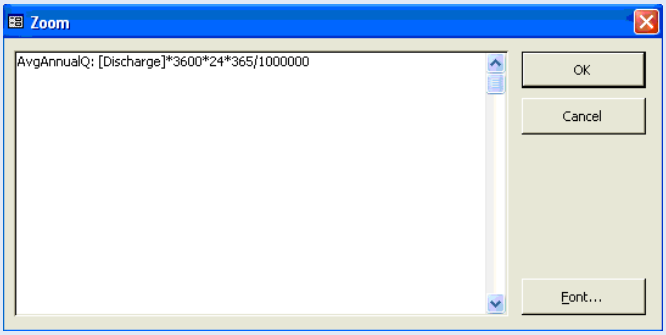
Run the query. The average discharge per station is calculated in [m3 / s].



Instead of [m3 /s], the poster will present runoff values in million cubic meters per year [mcm/ y].

Place the cursor in the field row of the second query column and click [Shift] [F2]. This will zoom the field.

Type: AvgAnnualQ: [Discharge] * 3600 * 24 * 365 / 1000000, as indicated in the right hand figure. Click OK and run the query.

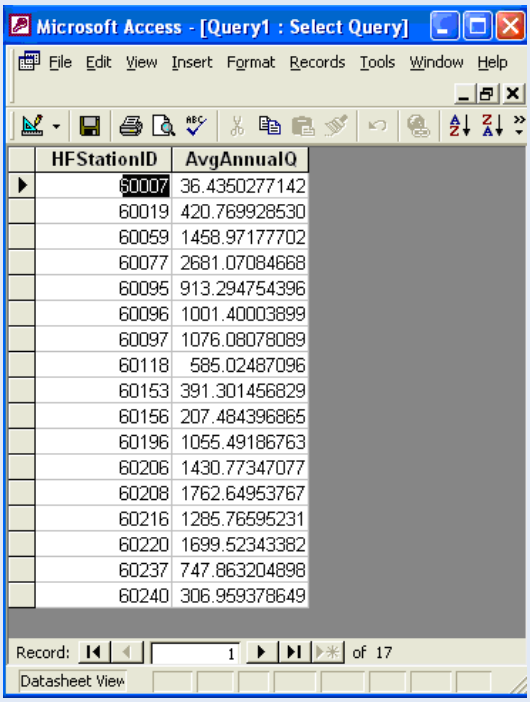


The results are presented at the left hand side. It shows the average annual runoff in million cubic meters for 17 stations in the Kenyan Lake Victoria basin.

Select all records by clicking on the upper right hand corner of the query results, and use "copy" and "paste" to export the query results to a MS Excel worksheet.

Shave the worksheet as "Ken-LV_SummaryHydroData".

Save the query as "AvgAnnQ"



B: Determine average monthly discharge for each station

Open a new query in design view. Add the "KEN-Runoff" table to the query.

Drag the fields "HFStationID", "Date", and "Discharge" to the query.

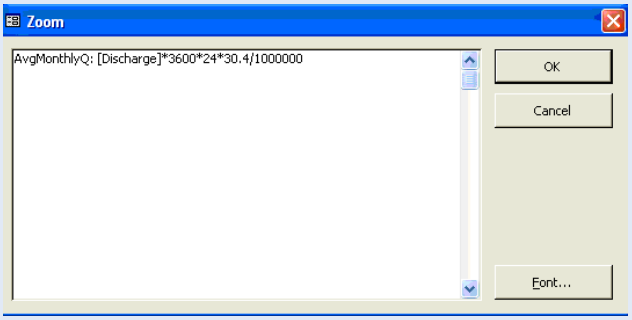
Click the Total button Σ, and change the totals row to "Group By" for "HFStationID", "Group By" for "Date", and "Avg" for "Discharge".

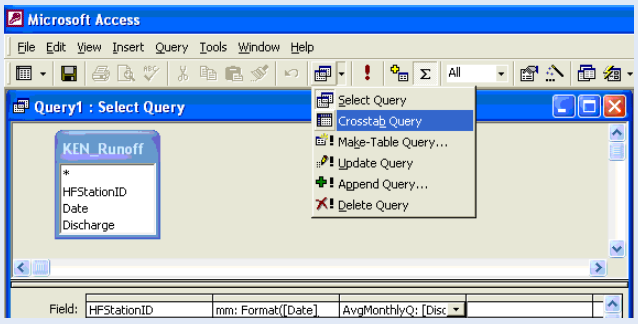
Use [Shift] [F2] to zoom to the month field and change to:

mm: format([Date],"mm")

Use [Shift] [F2] to zoom to the discharge field and change to:

AvgMonthlyQ: [Discharge] * 3600 * 24 * 30.4 / 1000000



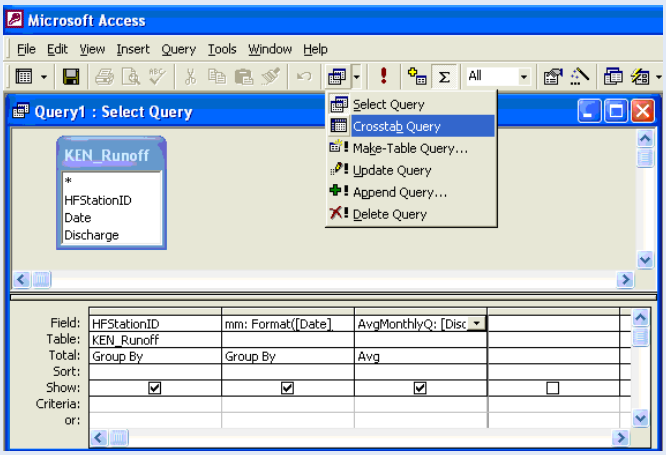


Run the query. ! The average monthly discharge per station is calculated in [mcm].

The outcome presents the monthly discharge for all stations in one long list. This is not convenient for analysis purposes, for which a tabular format would be preferred. The latter can be achieved by using a "Crosstab Query".

Go back into design view  . Click the query type button and select "Crosstab Query".

Set the crosstab fields as indicated below:

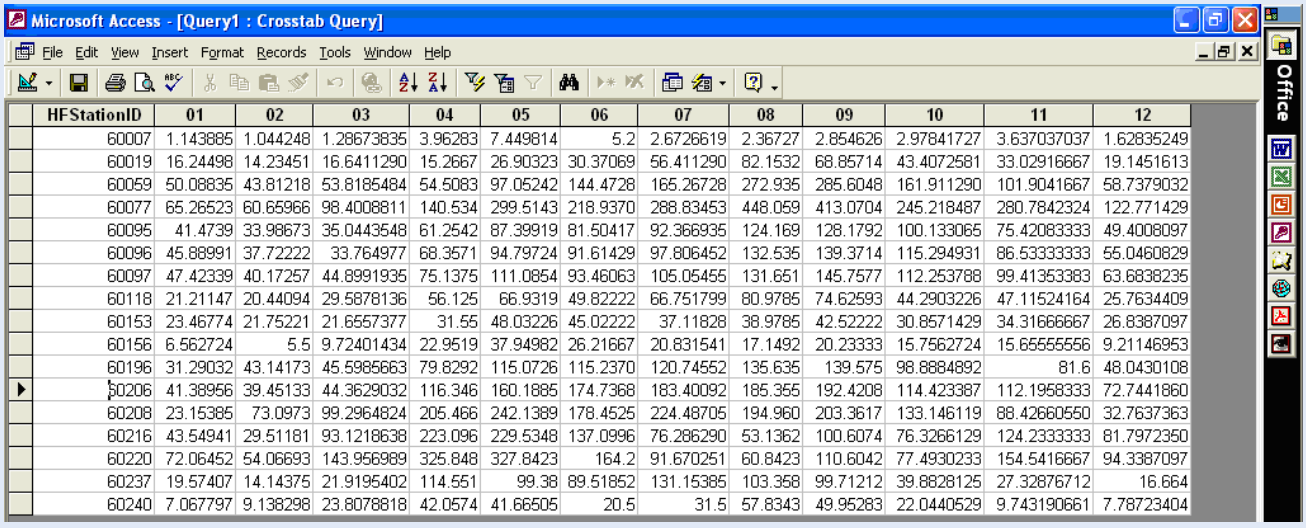


HFStationID: Row heading
MM: Column heading
AvgMonthlyQ: Value

When running this query, in some occasions an error message is received. Data fields are truncated due to limited space. This can be avoided by using the Format function in column 3. Place the cursor in this column and click [Shift] [F2]. Change the heading to:

AvgMonthlyQ: Format([Discharge]*3600*24*30.4/1000000,"#.00")

Run the query  The below results are obtained. Export this table to MS Excel.



HFStationID	01	02	03	04	05	06	07	08	09	10	11	12
60007	1.143885	1.044248	1.28673835	3.96283	7.449814	5.2	2.6726619	2.36727	2.854626	2.97841727	3.637037037	1.62835249
60019	16.24498	14.23451	16.6411290	15.2667	26.90323	30.37069	56.411290	82.1532	68.85714	43.4072581	33.02916667	19.1451613
60059	50.08835	43.81218	53.8185484	54.5083	97.05242	144.4728	165.26728	272.935	285.6048	161.911290	101.9041667	58.7379032
60077	65.26523	60.65966	98.4008811	140.534	299.5143	218.9370	288.83453	448.059	413.0704	245.218487	280.7842324	122.771429
60095	41.4739	33.98673	35.0443548	61.2542	87.39919	81.50417	92.366935	124.169	128.1792	100.133065	75.42083333	49.4008097
60096	45.88991	37.72222	33.764977	68.3571	94.79724	91.61429	97.806452	132.535	139.3714	115.294931	86.53333333	55.0460829
60097	47.42339	40.17257	44.8991935	75.1375	111.0854	93.46063	105.05455	131.651	145.7577	112.253788	99.41353383	63.6838235
60118	21.21147	20.44094	29.5878136	56.125	66.9319	49.82222	66.751799	80.9785	74.62593	44.2903226	47.11524164	25.7634409
60153	23.46774	21.75221	21.6557377	31.55	48.03226	45.02222	37.11828	38.9785	42.52222	30.8571429	34.31666667	26.8387097
60156	6.562724	5.5	9.72401434	22.9519	37.94982	26.21667	20.831541	17.1492	20.23333	15.7562724	15.65555556	9.21146953
60196	31.29032	43.14173	45.5985663	79.8292	115.0726	115.2370	120.74552	135.635	139.575	98.8884892	81.6	48.0430108
60206	41.38956	39.45133	44.3629032	116.346	160.1885	174.7368	183.40092	185.355	192.4208	114.423387	112.1958333	72.7441860
60208	23.15385	73.0973	99.2964824	205.466	242.1389	178.4525	224.48705	194.960	203.3617	133.146119	88.42660550	32.7637363
60216	43.54941	29.51181	93.1218638	223.096	229.5348	137.0996	76.286290	53.1362	100.6074	76.3266129	124.2333333	81.7972350
60220	72.06452	54.06693	143.956989	325.848	327.8423	164.2	91.670251	60.8423	110.6042	77.4930233	154.5416667	94.3387097
60237	19.57407	14.14375	21.9195402	114.551	99.38	89.51852	131.15385	103.358	99.71212	39.8828125	27.32876712	16.664
60240	7.067797	9.138298	23.8078818	42.0574	41.66505	20.5	31.5	57.8343	49.95283	22.0440529	9.743190661	7.78723404

C: Export station coordinates to dbf format

In table view select table "Ken_HydroStations". Click "File" => "Export". Navigate to an appropriate folder. Set "File Name" to "hydstat" and set "Save as type" to "dBASE 5". Saving the export file in dbase format is necessary as ArcView cannot read MS Access files. Click "Save".

This concludes the MS Access part of the exercise. Close MS Access.

Procedure

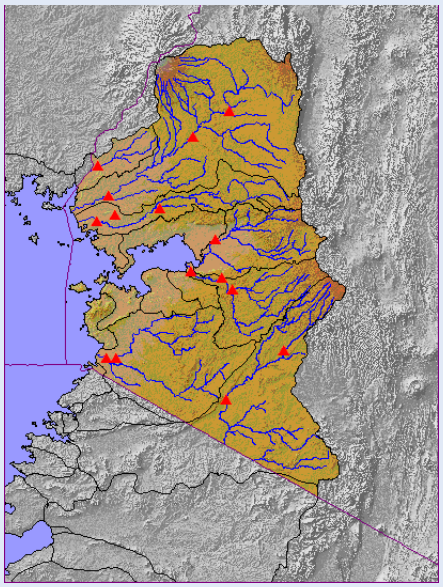
Step 4

Import Dbase file in Arcview

Start ArcView and go to tables . Click "Add" and navigate to the folder storing the "hydstat.dbf" file. Select this file and click OK.

Go to the view containing the Kenyan Lake Victoria layers. Click "View" => "Add Event Theme". Select the "hydstat" table and set the appropriate x and y fields. Click OK. Activate the new station layer and use the legend editor to set an appropriate marker.

The result is presented on the right.



Procedure

Step 5

Adding blue water features

The blue water poster aims to visualize the distribution of water resources in the study area. To this effect, line segments will be created for each distinct river reach. The width of these segments is set proportional to the relative discharge contribution of the tributary.

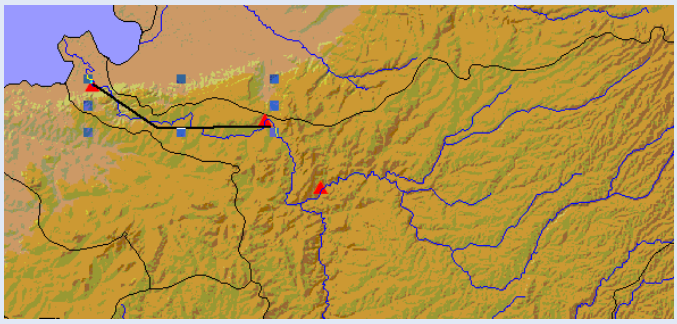
In this exercise Sondu is selected as example. Data are available for three stations on this river. Check the MS Access queries to establish the below station characteristics:

Station 60208 =>	average annual flow =	1.76 [bcm]
Station 60206 =>	average annual flow =	1.43 [bcm]
Station 60196 =>	average annual flow =	1.06 [bcm]

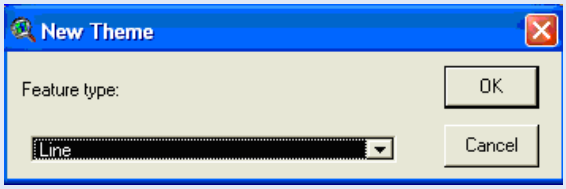
Click the "Draw Line" button to draw a line segment broadly following the river reach.

The first segment goes from station 60208 to 60206. Do not use more than 4 connection points.

Click "Edit" => "Cut Graphic"



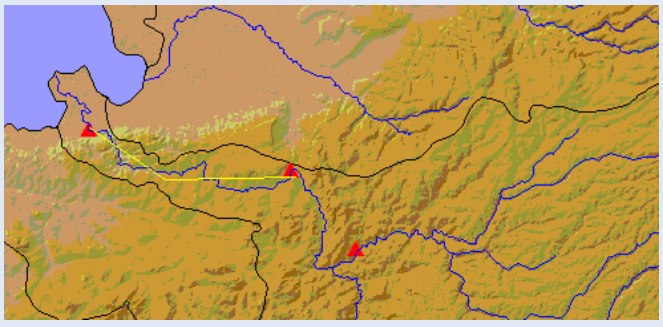
Click "View" => "New Theme". Select Line as feature type. Click OK. Navigate to an appropriate folder and name the new layer "Sondu_Segment1.shp".



Add the new theme to the view. You can see it is in editing mode.

Click "Edit" => "Paste" to add the line segment to the new layer.

Click "Theme" => "Stop Editing" to save the changes. The result is shown in the right hand window.



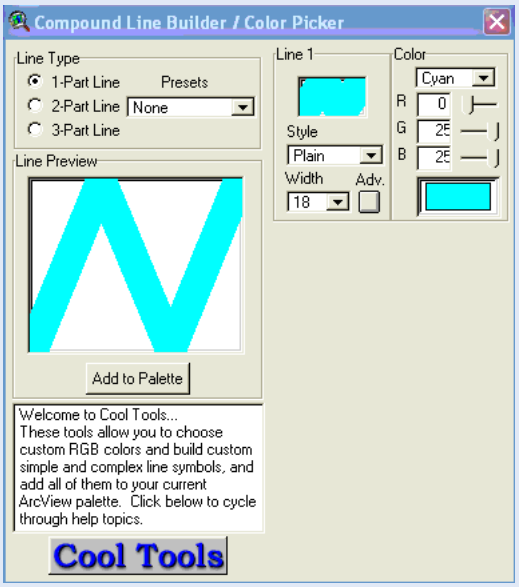
Activate the "Custom Line Symbol Tools" extension. A "Custom Line Builder" button is added to the toolbar. Click this button.

The box similar to the right-hand window appears.

Average annual discharge of this river reach is 1.76 [bcm].

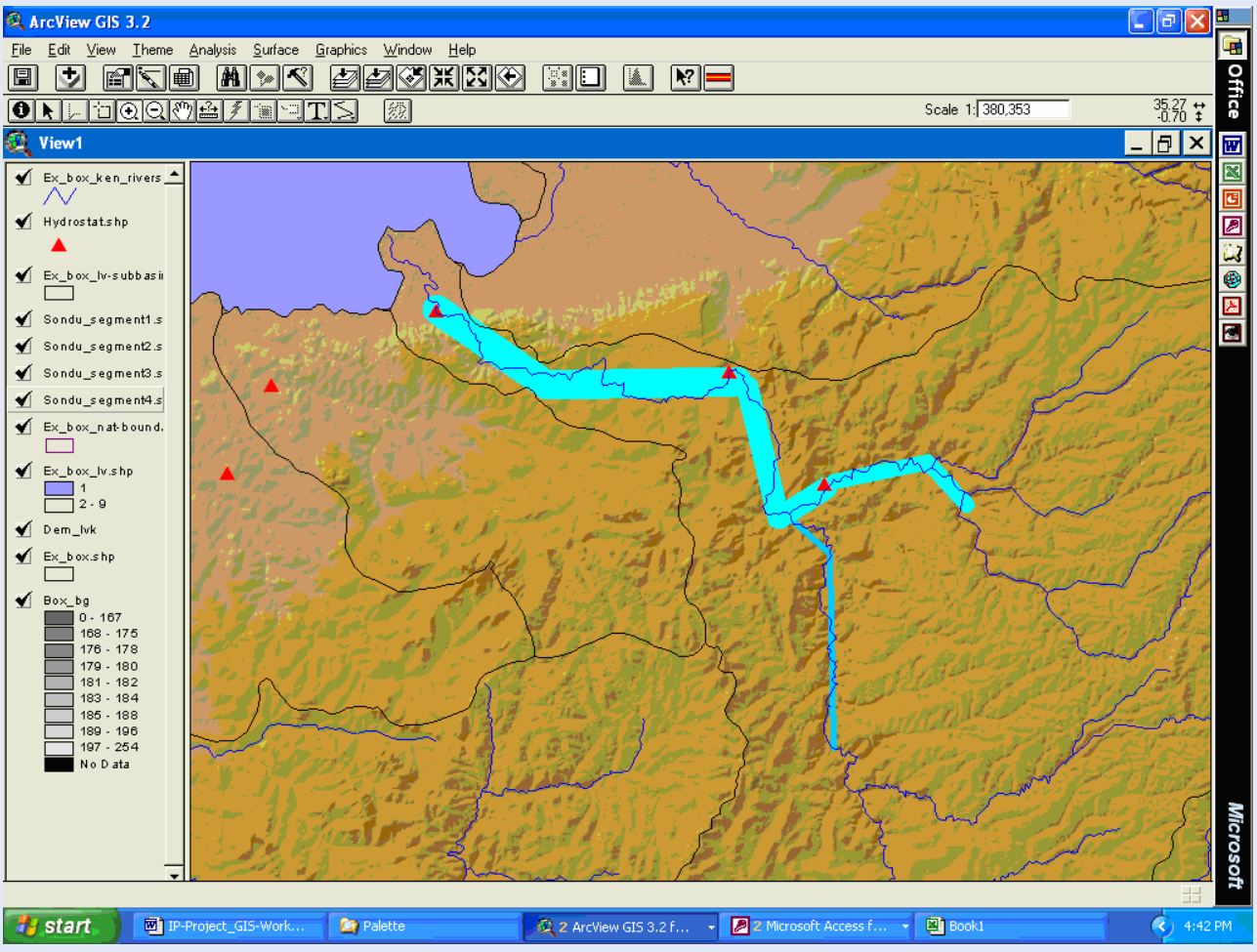
Hence, set line width to 18. If necessary use the "Adv" button (for advanced). Select "Cyan" as line color.

Click "Add to Palette"



Use the legend editor to change the appearance of the "Sondu_Segment1.shp" layer.

Repeat the above exercise for the other reaches of Sondu for which data are available or can be derived. The result is shown below.



If time allows, add more river segments.

Use Layout to customize the map. These standard ArcView procedures are not covered in this exercise.

Standard MS Excel procedures are used to create graphs of average monthly runoff per station, as illustrated in the right hand window.

Add these illustrations to the poster.