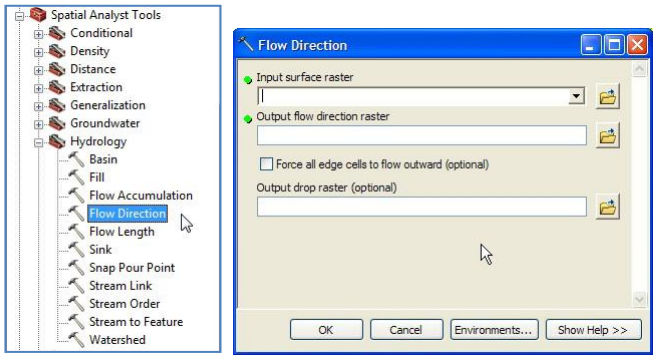
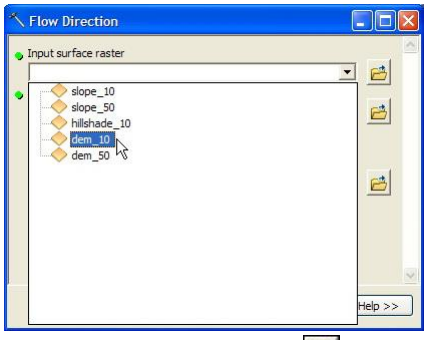
Step 4. Making flow direction data

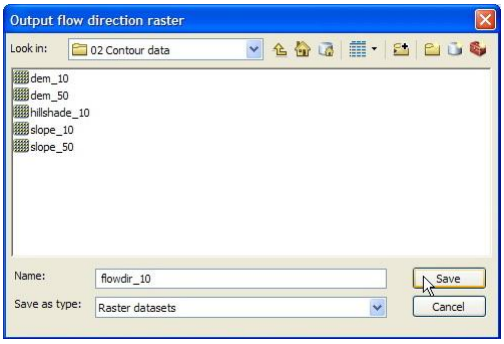
1) The first step in hydrology analysis is making flow direction data. On Arc Toolbox window, click symbol + on Spatial Analyst Tools → Hydrology, double click Flow Direction. Next will appear Flow Direction window.



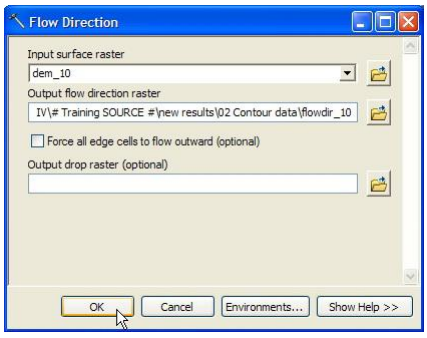
2) On Input surface raster combo box, choose “dem_10” layer.



3) On Output flow direction raster combo box, click  symbol, save the file into folder: Data source for training/02 Contour data. On Name text box, write “flowdir_10”. Click Save button.



4) On Flow Direction window, click OK button.

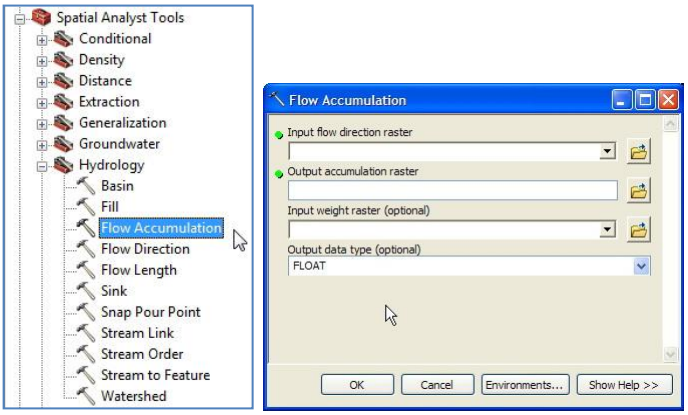


5) Do steps 1 – 4 above to obtain flow direction data from processing dem_50 data (pixel size 50m). Give the file name with “flowdir_50”.

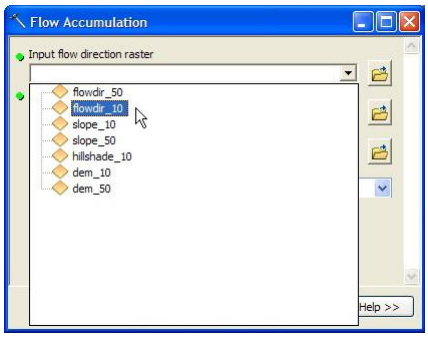
6) Here is a view of flow direction data.

Step 5. Making flow accumulation data

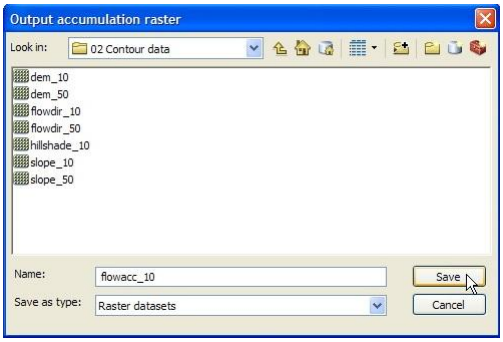
1) The next step is making flow accumulation data. Click Flow Accumulation on Hydrology toolbox. Next will appear Flow Accumulation window.



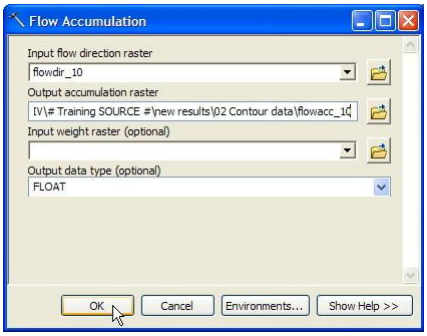
2) On Input flow direction raster combo box, choose “flowdir_10” layer.



3) On Output accumulation flow raster text box, click  symbol, save the file into folder: Data source for training/02 Contour data. On text box Name, write “flowacc_10”. Click Save button.

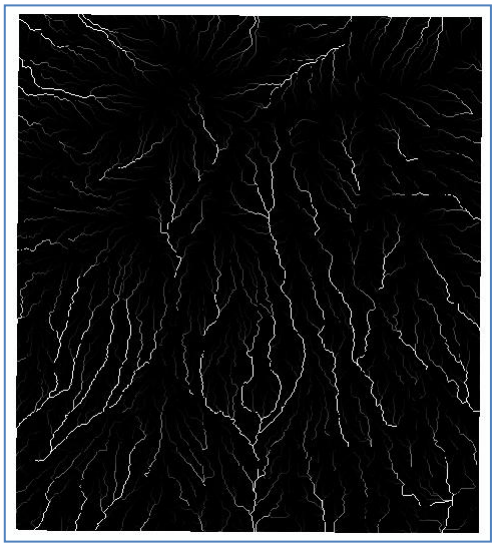


4) On Flow Accumulation window, click OK button.



5) Do steps 1 – 4 above to obtain flow accumulation data from processing slope_50 data (pixel size 50m). Give the file name with “flowacc_50”.

6) Here is a view of flow accumulation data.

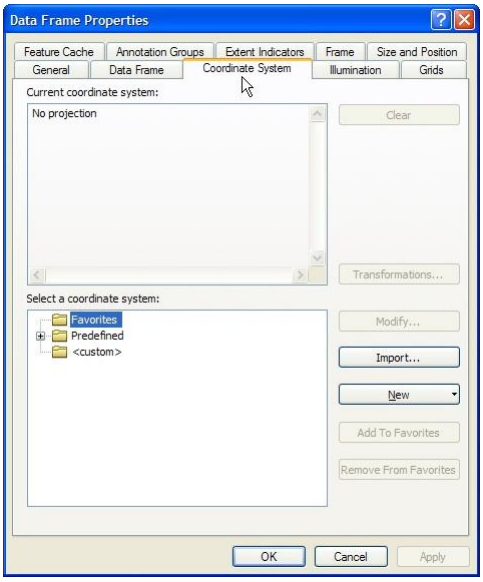


7) To save the workspace, click Save  button on Standard toolbar, or press Ctrl+S button on computer keyboard. Save the MXD file into folder: Data source for training\02 Contour data, give the name file “contour”, and then click Save button.

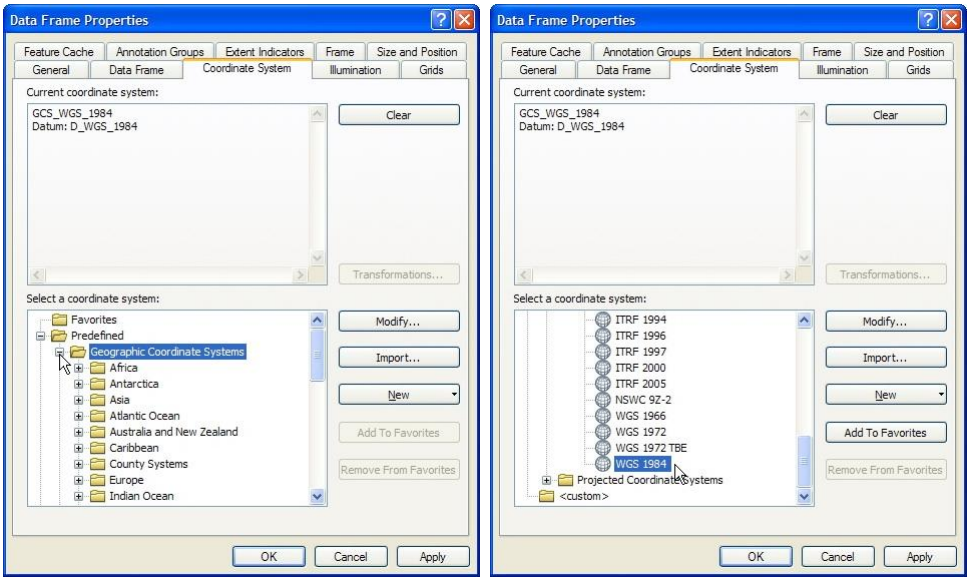
I.3. Georeferencing geological map and digitations geological elements

Step 1. Georeferencing geological map

1) Open/run ArcMap, choose Blank Map.
2) To set the projection and coordinate system of ArcMap workspace, right click Layers in Table of Contents and then click Properties. Next will appear Data Frame Properties window.
3) Click Coordinate System tab.

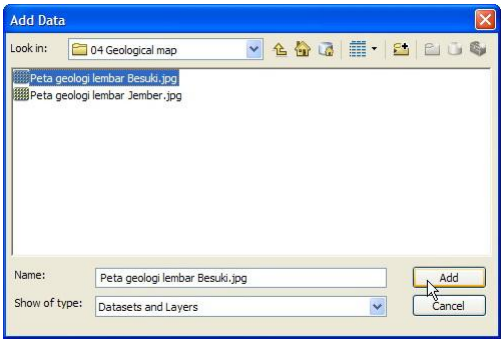


4) On part Select a coordinate system, click symbol + on Predefined → Geographic Coordinate System → World, and choose WGS 1984. Click OK button on Data Frame Properties window.



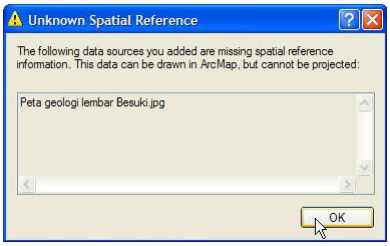
At this time, ArcMap workspace has had projection system of WGS 1984 and LatLon coordinate system.

5) Click Add Data button. Enter into folder: Data source for training\04 Geological map, choose file “Peta geologi lembar Besuki.jpg”, and then click Add button.

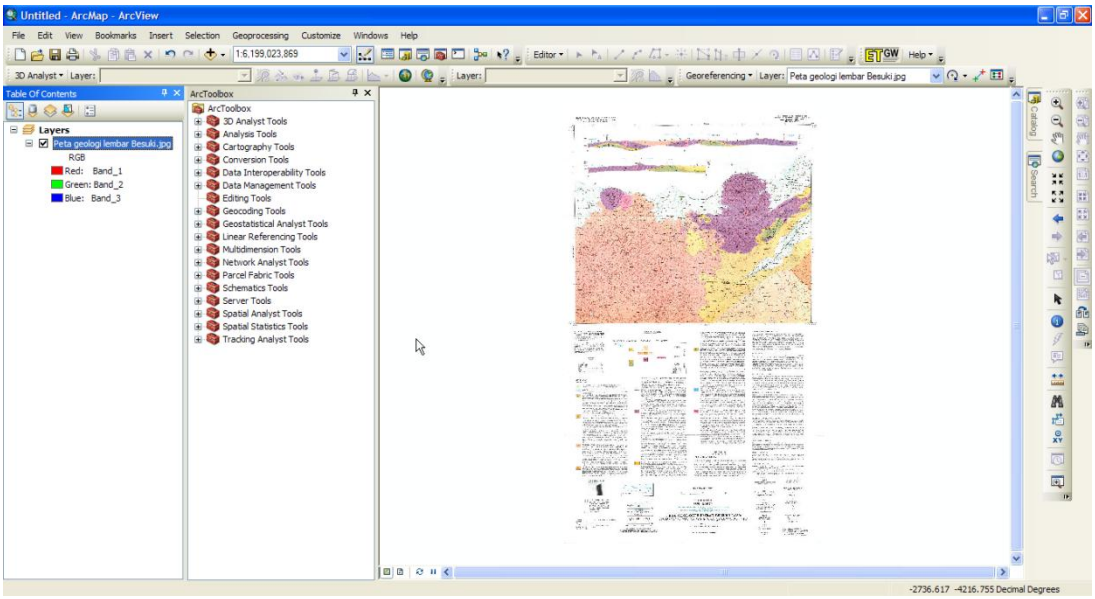


6) If data that will be inserted into the ArcMap workspace is a raster data, there will be a confirmation whether we want to create a "pyramid" for this data. Making pyramid is useful to smoothen the process of data loading and zooming. Click the Yes button.

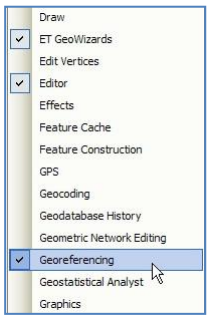
7) Raster file that we will enter, not yet have a geospatial reference, so there will appear a message like below. Click OK button.



8) The following is a geological map that are inserted.



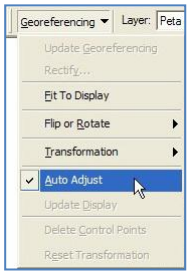
9) Because the geological map has not georeferenced yet, so for georeferencing purpose we need Georeferencing toolbar. Right click on any empty space on ArcMap workspace and then click Georeferencing.



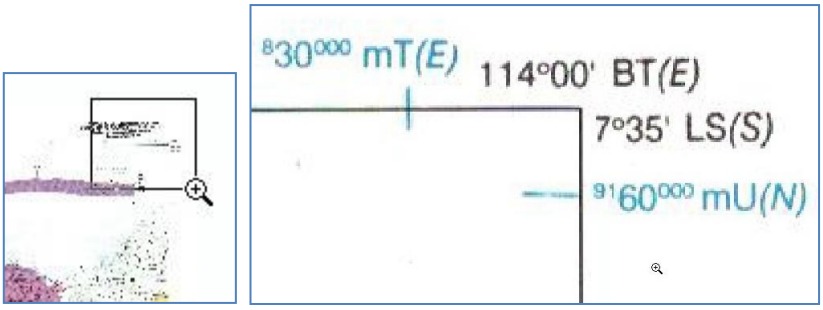
10) Next, will appear Georeferencing toolbar as below. Place the toolbar on the upper side of ArcMap workspace.

11) On Georeferencing toolbar, make sure that file that is chosen on Layer combo box is the data that will be georeferenced. This should be considerable concern if there are several image layers on the Table of Contents. On this step, layer that should be chosen is "Peta geologi lembar Besuki" layer.

12) To choose georeference method, click Georeferencing button, and click Auto Adjust.

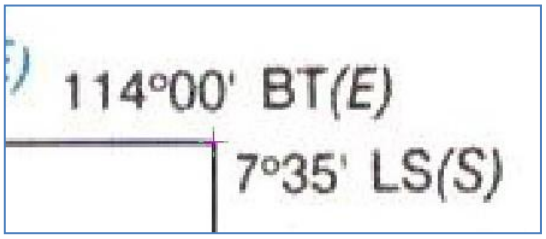


13) To make this geological map become georeferenced, we will make actual coordinate of four-frame corner of the geological map.
Click Zoom In button on Tools toolbar, and then zoom the upper right corner of geological map frame until the corner can be seen clearly.

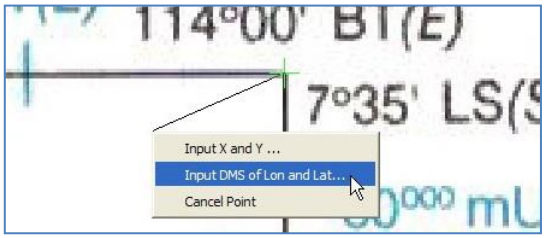


14) To start georeferencing process, click Add Control Points button on Georeferencing toolbar.

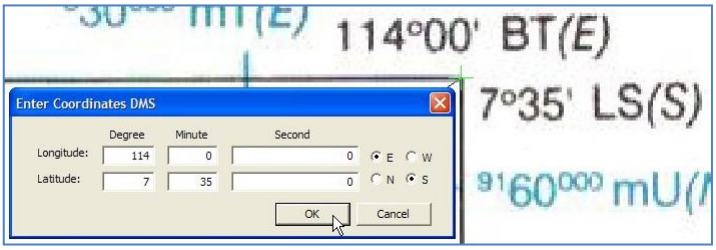
15) Point the + cursor, as precise as possible to upper right corner of geological map frame, and then click one time.



16) After the + cursor becomes green and attached on the upper right corner of geological map frame, right click on any space. There will appear an option to input the coordinate. Choose Input DMS of Lon and Lat.

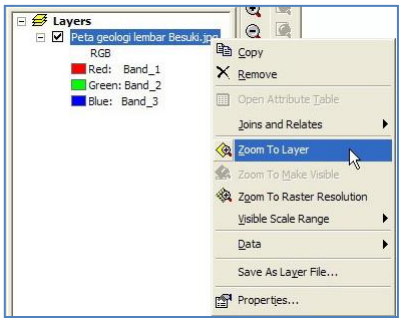


17) On Enter Coordinates DMS window, write on the text box the value of Longitude and Latitude according to lat long value of the geological map frame. Click OK button.



Because the georeferencing method that we choose is Auto Adjust, so after we press OK button, on Enter Coordinates DMS window, the geological map will move according the actual position of the upper right corner of geological map frame.

18) Right click “Peta geologi lembar Besuki” layer, then click Zoom To Layer. At this time, the ArcMap workspace will show “Peta geologi lembar Besuki” layer as a whole.



19) When finished setting the actual coordinates of the upper right corner, next we set the actual coordinates of the lower left corner of the geological map. The procedure according to the step 1:13 - 1:17 above.

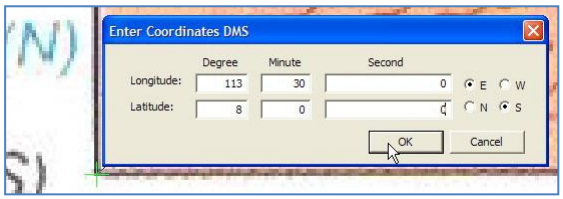
Click the Zoom In button on the toolbar Tools, and then zoom the lower left corner of the frame until the corner of the geological map is clearly visible.

20) Click the Add Control Points button on the Georeferencing toolbar.

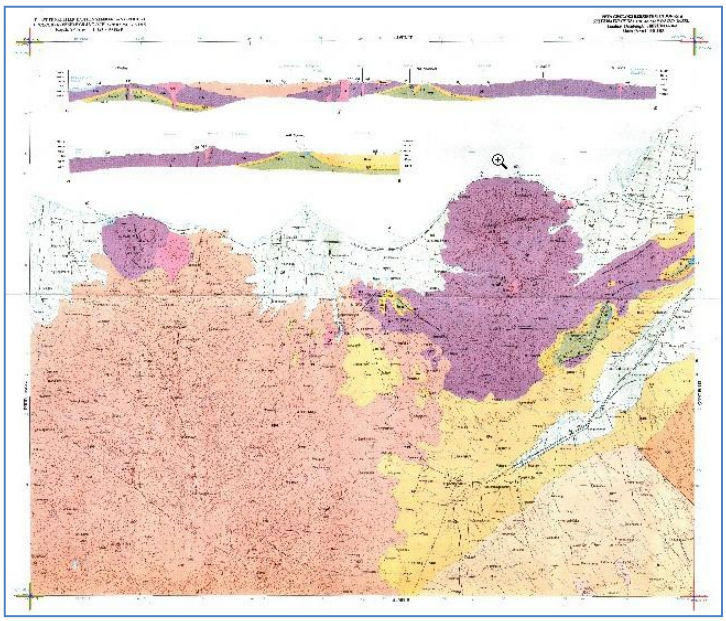
21) Move + cursor as precisely as possible with the lower left corner of the geological map frame, then left click one time.

22) Once the green + cursor attached to the frame corner of geological map, right click in any place. There will appear an option to enter the coordinate. Select Input DMS of Lon and Lat.

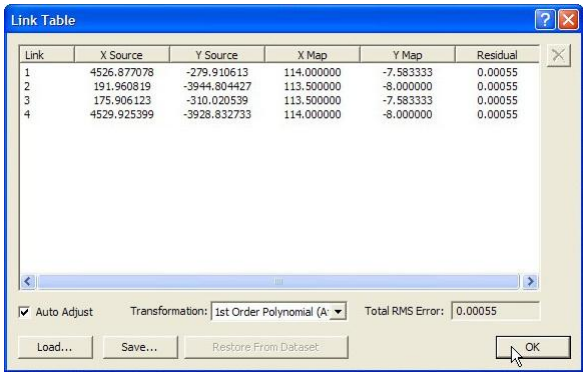
23) On Enter Coordinates DMS window, fill in the fields of Latitude and Longitude, according to latitude and longitude value of frame corner of the geological map. Then click OK button.



24) Repeat the procedure according with Stage 1:13 – 1:17 or Stage 1:18 – 1:23 for upper left corner and bottom right corner of geological maps frame. The figure below shows the four corners of the geological map frame that has set the actual coordinates.



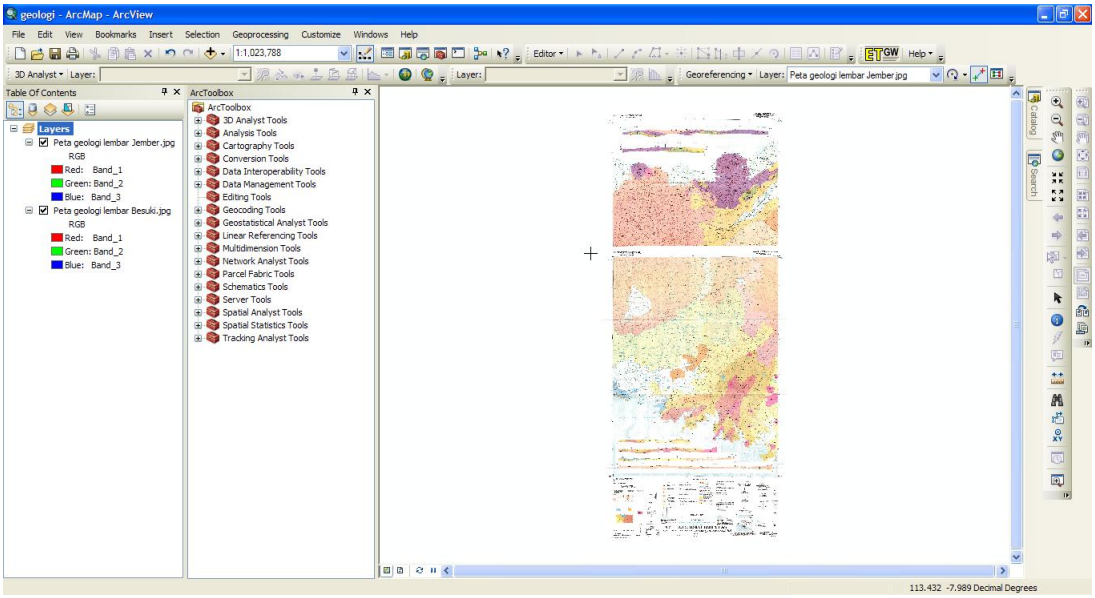
25) To see the error rate of coordinates setting, click  button on Georeferencing toolbar to bring up Link Table window. Column "Residual" shows the error values contained in each frame corner. We can see the total Root Mean Square (RMS) error on the lower right corner. All units of this value is in degrees.
Click OK button to continue.



26) To set the final stage georeference, click Georeferencing button, then click Update Georeferencing. Once this button is pressed, all the red/green + on the four-frame corner, geological map will disappear.

27) In total there are four geological maps that should be georeferenced. Therefore do the georeference procedure according with step 1.5 - Phase 1:17.

28) The following is a view of two geological map after going through stages of georeferenced.



29) Save the ArcMap work in the folder: Data source for training\04 Geological map, with the name "Geologi.mxd".

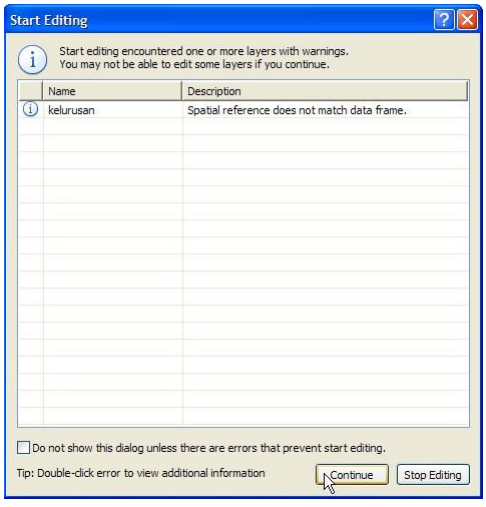
Step 2. Digitize geological element

1) There are two types of geological elements that will be digitized from geological map. Those element are lineament and fault. The procedure that will be used is refer to Chapter I.1 Step 2 which is procedure to make data if past landslide data.

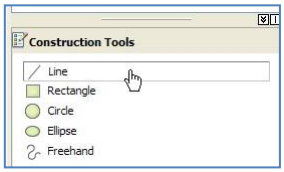
2) By using Catalog that is on the right ArcMap workspace, make a new shapefile with the name of “lineament”, feature type: polyline, and coordinate system “WGS_1984_UTM_Zone_49S”.

3) On Editor toolbar, click Editor button and click Start Editing.

4) Next will appear Start Editing window that give information that the coordinate system of lineament (UTM 49) is different with the coordinate system of ArcMap workspace (lat-long). This is no problem because both still in the same projection system (WGS 84).
Click Continue button to continue.

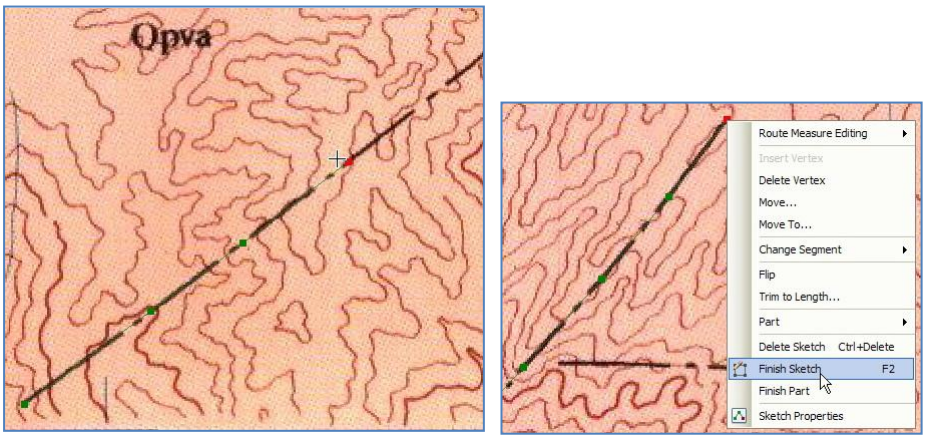


5) On Create Features window, click lineament; and on Construction Tools window, click Line.



6) Zoom-in in such a way the geological map so the objects on the map such as lineament and fault can be seen clearly.

7) Find the lineament object, and begin the digitization process by following the lineament object. After completion of the digitized object, press F2 key.



Find another lineament object on the study area, and start again the digitations process.

8) Once all the lineament objects of the study area has been completed digitized, on Editor toolbar, click Editor button, click Save edits, and click Stop Editing.

9) According to the geological map, the areas covered in the study area does not have fault data, so the fault data can be skipped.

10) For the purposes of this training, we use the file "kelurusan ref.shp" contained in the folder: Ref.

11) Save the ArcMap workspace into folders: Data source for training\04 Geological map. Give it the name "Geologi.mxd".

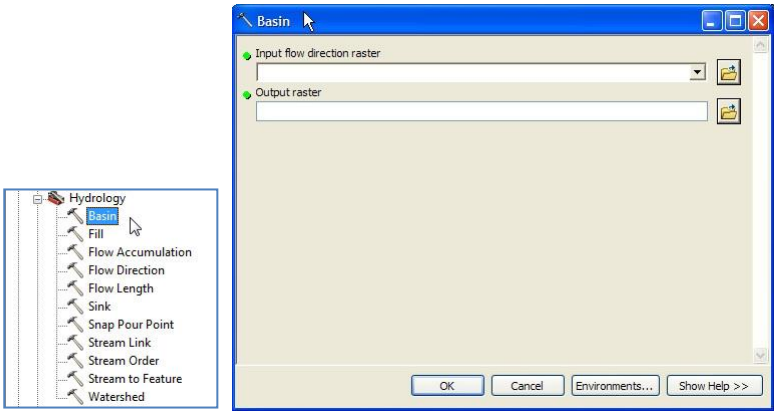
I.4. Making basin, Catchment area and sub-area

Catchment area is an area of land, which is a unity with the river and its tributaries, which serve to accommodate, store, and stream water originating from rainfall to the lake or the sea naturally, where the boundary on land is topographical separators and the boundary at sea until the waters are still affected land activities.

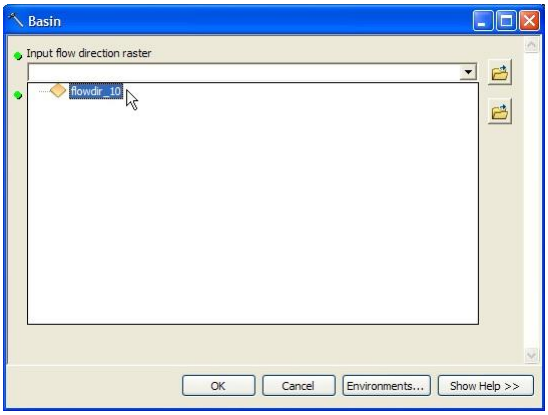
Basin or micro-watershed is a hollow in the landscape where the water flows in a ditch. Catchment area is an amalgamation from several basin.

Step 1. Making basin data

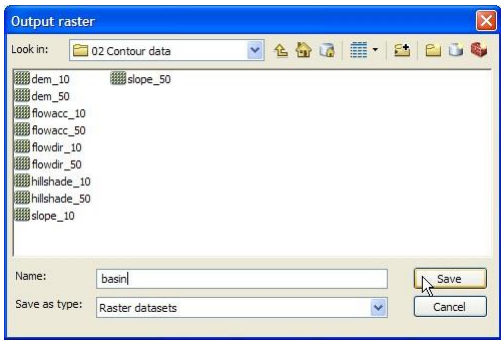
1) Open/run ArcMap, choose Blank Map.
2) Enter "flowdir_10" data from the folder: Data source for training/02 Contour data.
3) On Arc Toolbox window, click + symbol on Spatial Analyst Tools → Hydrology, then double click Basin. Next will appear Basin window.



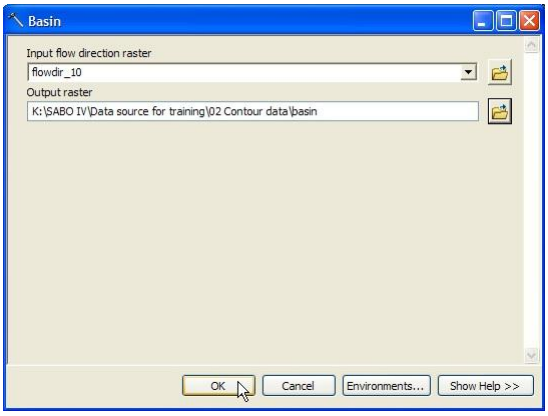
4) On combo box Input flow direction raster, choose layer "flowdir_10".



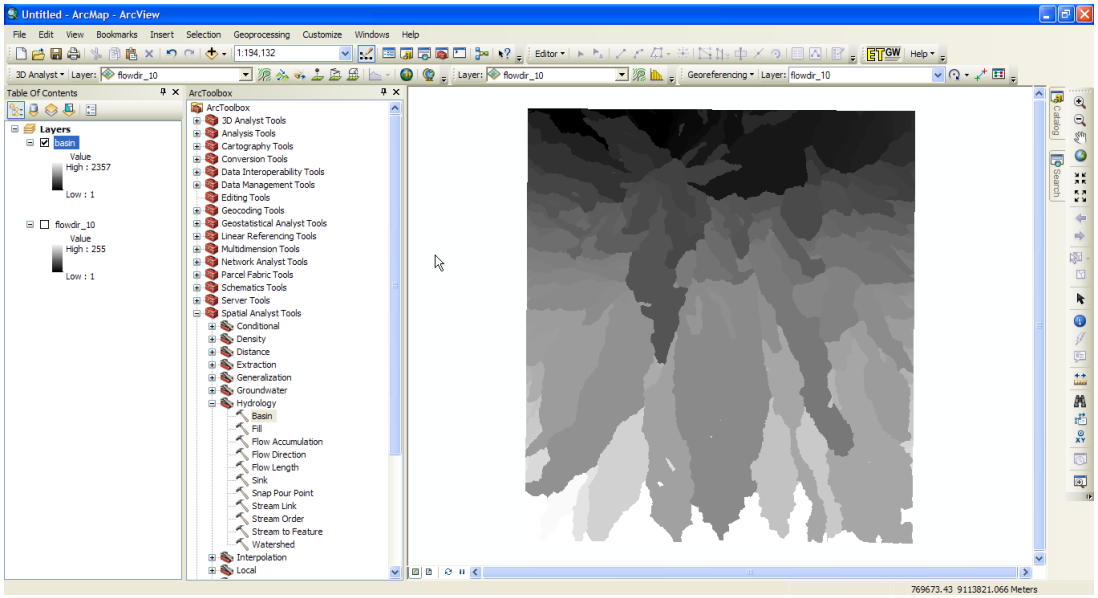
5) On text box Output raster, click  symbol, save the file into the folder: Data source for training/02 Contour data. On text box Name, fill in with the name of "basin". Click Save button.



6) Click OK button on Basin window.

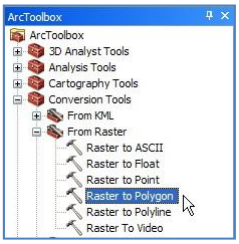


7) The figure below is a view of basin data. This data will be used for analysis of watershed determination.

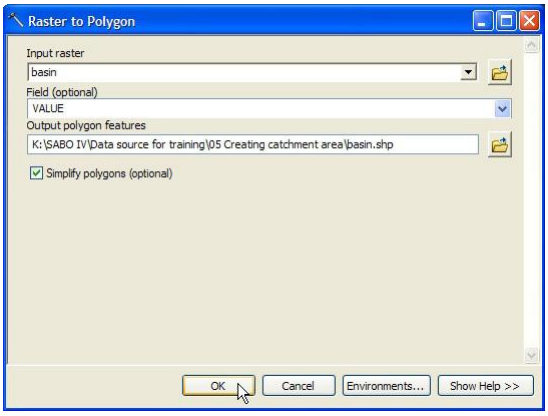


Step 2. <u>Choosing basin for making catchment area</u>

1) On ArcToolbox, click + symbol on Conversion Tool → From Raster, then double click Raster to Polygon. Next will appear Raster to Polygon window.



2) On Input raster combo box, choose “basin”. On Field combo box, choose Value. Save the data into folder: Data source for training\05 Creating catchment area, and give the name of “basin.shp”. Give check sign on Simplify polygons check box. Click OK button.

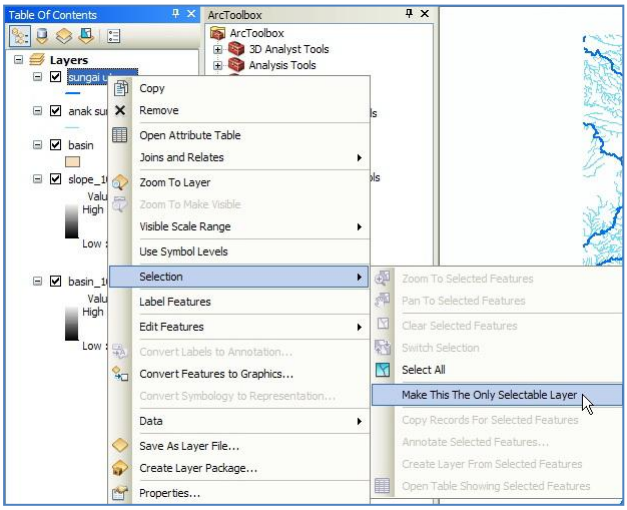


Once the process is complete, automatically there will be a new layer named "basin" (polygon).

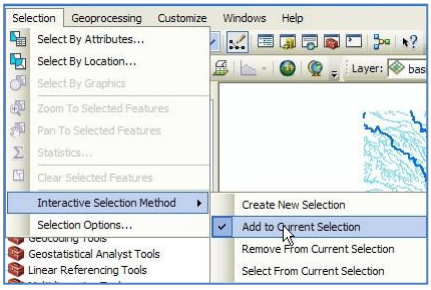
3) Add “sungai utama.shp” and “anak sungai.shp” data from the folder: Data source for training\03 River vector data.

4) To determine the boundary of catchment area manually, focus on one of the main river that has flow from upstream to downstream. And then focus on the seasonal river that connect to the main river.

The first step, focus the one of main river object. To choose/select the object that we want, right click “sungai utama” layer -- > Selection, click Make This Only Selectable Layer

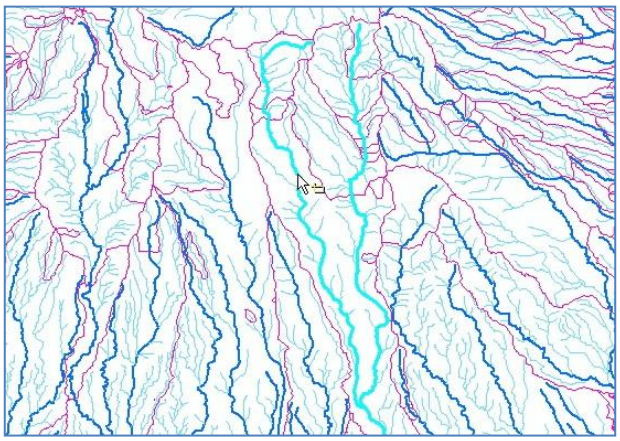


5) To make continuous selection, click Selection on ArcMap main menu → Interactive Selection Method, click Add to Current Selection.

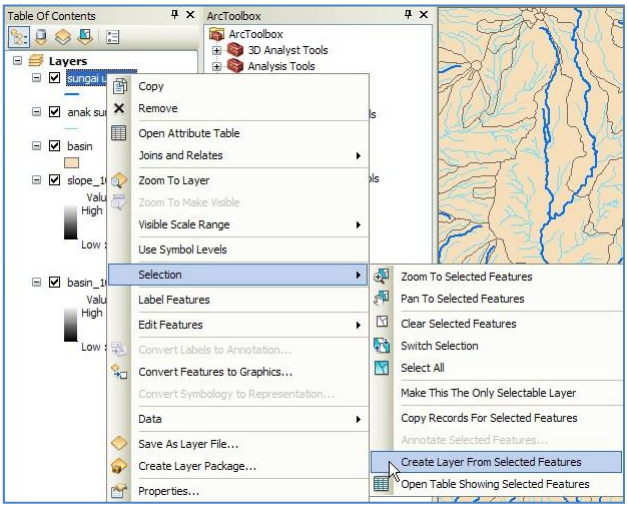


6) Click Select Features by Rectangle  button on Tools toolbar.

7) Select one of the main river object. Zoom-in or zoom out the view to ease the selection process.



8) Right-click on layer "sungai utama", point the mouse cursor to Selection, then click Create Layer From Selected Features.

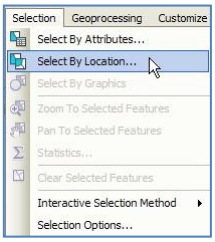


9) Automatically, will form a new layer called "sungai utama selection".

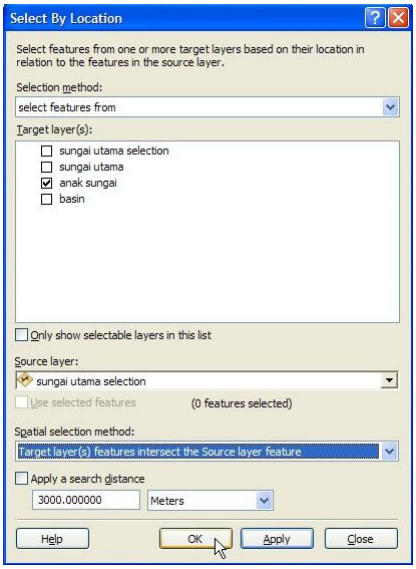
10) Press Clear Selected Features  button on Tools toolbar to clear the previous selected object.

11) To clarify the view of "sungai utama selection" layer, uncheck or turn off the “sungai utama” layer.

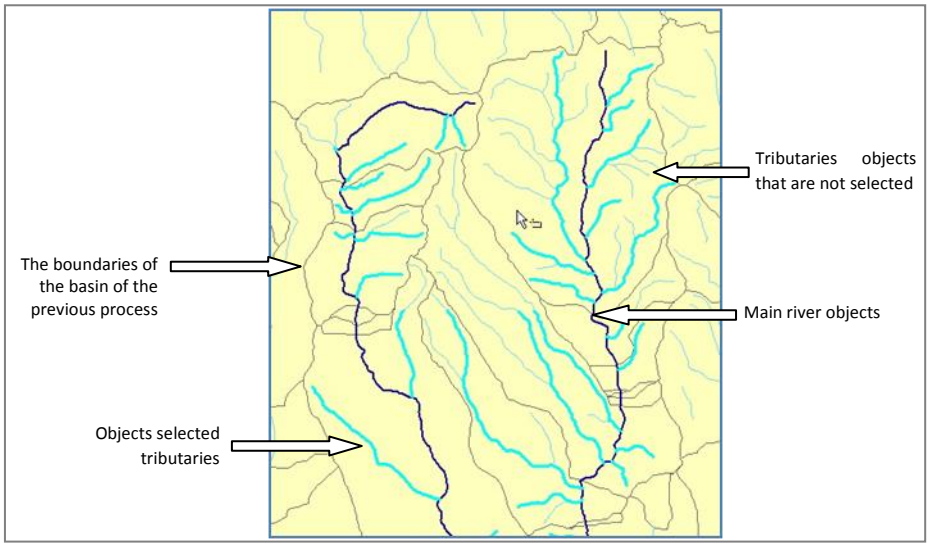
12) The second phase, focus on the seasonal river object which is a tributary branch of the main rivers of the previous selection ("sungai utama selection" layer). To assist in selecting an object which is a tributary branch of the main river, click Selection in ArcMap main menu, then click Select By Location. The next window will appear Select By Location.



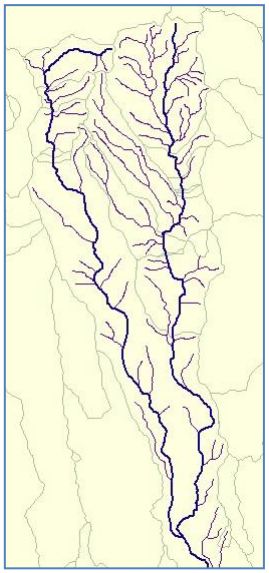
13) On Selection method combo box, choose “select features from”. On part of Target layer(s), choose “anak sungai”. On Source layer combo box, choose “sungai utama selection” layer. On Spatial selection method combo box, choose “Target layer(s) features intersect the Source layer feature”. Click OK button.



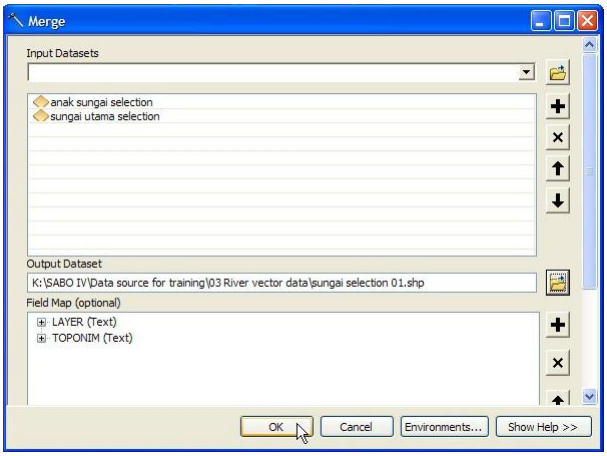
14) The selected tributary is the objects that connect or intersect the main river object. There will be tributary object that wasn’t not selected, one of the cause is that object is a second branch (the position was not intersect with main river, but still is branch of main river. We can select the tributary objects by manually regarding process on previous step 4 – 7.



15) After all of tributary that are the branch of main river are selected, the next step is making a new layer based on this selected tributary.
Right click on “anak sungai” layer → Selection, click Create Layer From Selected Features. Automatically, there will form a new layer named “anak sungai selection”. Figure on below is the view of “anak sungai selection” layer and “sungai utama selection” layer.

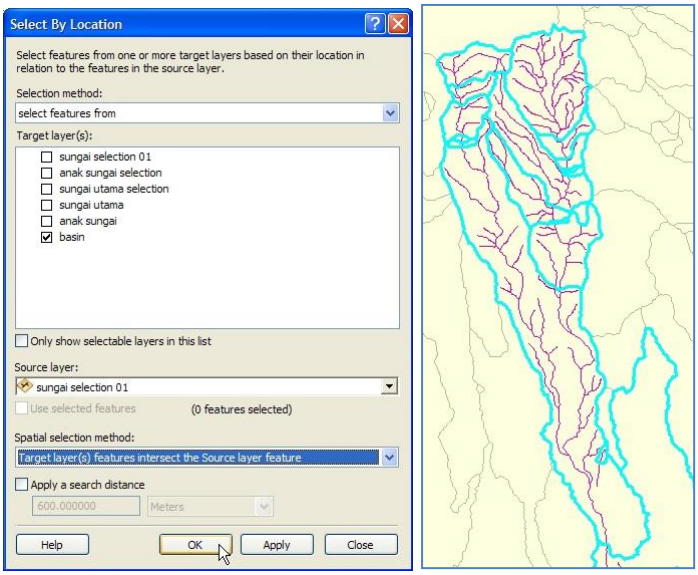


16) The next step is combining “sungai utama selection” layer and “anak sungai selection” layer. On ArcToolbox window, click + symbol on Data Management Tools, → General, double click Merge. Next will appear Merge window.
17) On Input Datasets combo box, insert “sungai utama selection” and “anak sungai selection” layer. On Output Dataset, save the process result into the folder: Data source for training\03 River vector data. Give the name of “sungai selection 01.shp”. click OK button. Automatically, will form a new layer on Table of Contents named “sungai selection 01”.

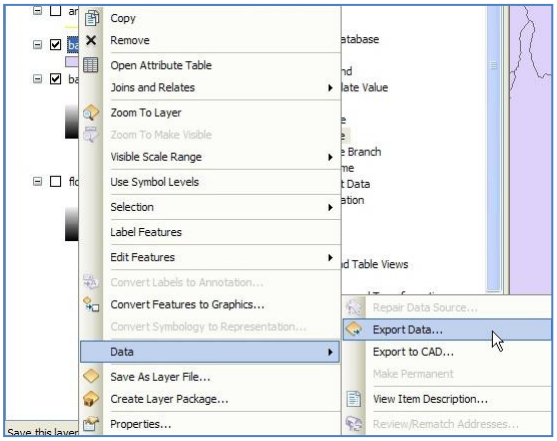


18) Uncheck or turn off the "main stream selection" layer and "selection creeks" layer.
19) Next we will select the basin (sub-DAS) that are part of this river object. Click Selection on ArcMap main menu, and then click Select By Location. Next will appear Select By Location window.

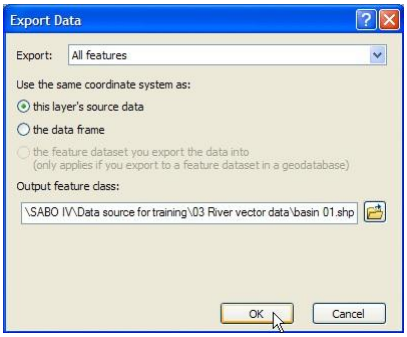
20) On Selection method combo box, choose “select features from”. On Target layer (s) check box, check or choose “basin”. On Source layer combo box, choose “sungai selection 01”. On combo box of Spatial selection method, choose Target layer(s) features intersect the source layer feature. Click OK button. We will see the selection result of several basin objects.



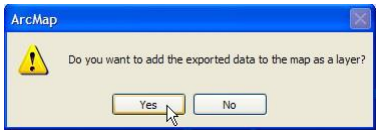
21) To make shapefile data based on this selection result, right click “basin” layer, point the mouse cursor to Data, and then click Export Data. Next will appear Export Data window.



22) Click  button on text box of Output feature class. Save the new shapefile into the folder: Data source for training\05 Creating catchment area, with a name of “basin 01.shp”.



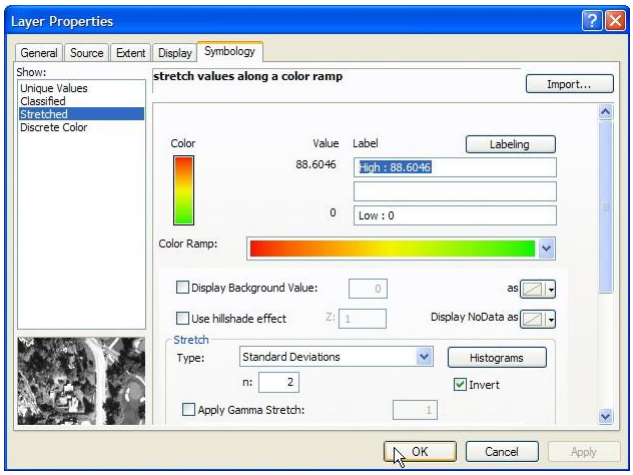
23) If a window appears asking if the exported data will be incorporated into ArcMap as a layer, press the Yes button.



24) Save the ArcMap workspace into the folder: Data source for training\05 Creating catchment area. Give the name as "DAS 1.mxd".

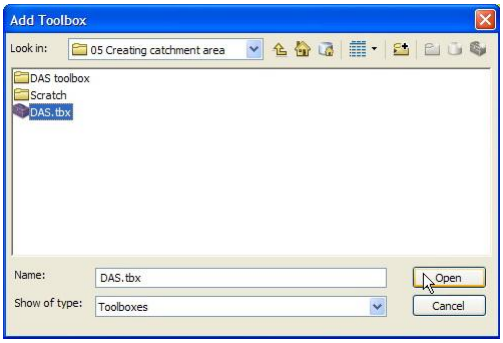
Step 3. Determining downstream part of catchment area

1) On this step we will determine the downstream part of a catchment area based on topographic slope. Open/run ArcMap, choose Blank Map.
2) Input "sungai selection 01.shp" data from the folder: Data source for training\03 River vector data.
3) Input "basin_01.shp" data from the folder: Data source for training\05 Creating catchment area.
4) Change the symbol view of "basin_01" layer, by changing Fill Color become No Color, Outline Width: 1.5, and Outline Color: Blue (Lapis Lazulli).
5) Input the "flowdir_10", "flowacc_10", and "slope_10" data from the folder: Data source for training\02 Contour data. If there are questions to make the Pyramids, click the Yes button.
6) Right click "slope_10" layer, and click Properties.
7) On Layer Properties window, click Symbology tab, choose Stretched on part of Show, choose the color gradation green to red on part of Color Ramp, click Invert on part of Stretch, choose Type Stretch Standard Deviation with n: 2. Click OK button.



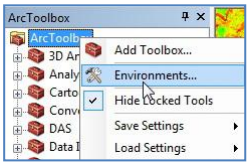
8) On ArcToolbox window, right click ArcToolbox, choose Add Toolbox.

9) Next will appear Add Toolbox window. Point into the folder: Data source for training\05 Creating catchment area, choose DAS.tbx, click Open button.

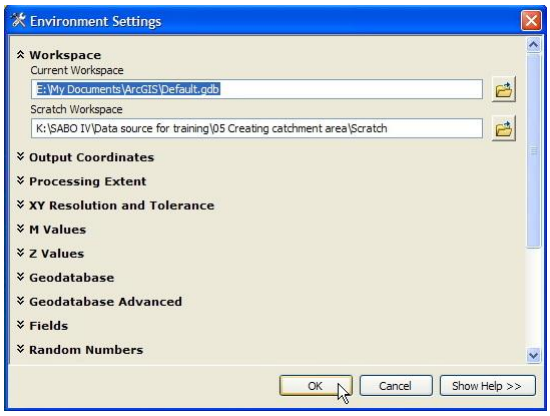


Automatically, on ArcToolbox window, will add a new Toolbox named DAS.

10) Right click ArcToolbox and then click Environments.



11) On Environments window, click Workspace. On text box of Scratch Workspace, click button and point the mouse cursor into the folder: Data source for training\05 Creating catchment area\Scratch. Click OK button.



12) Make sure that “snapped_pour.shp” and “watershed.shp” file has been erased or there should be no in the folder: Data source for training\05 Creating catchment area\Scratch. If these two files are in the folder, using the Catalog, delete both files.

13) Click + symbol on DAS toolbox and then double click “Membuat DAS”.

14) Next will appear Membuat DAS window. Click Add feature button and then point the cursor to the river flow on the upstream area, that has topographic slope which began sloping. Click the cursor on that position.