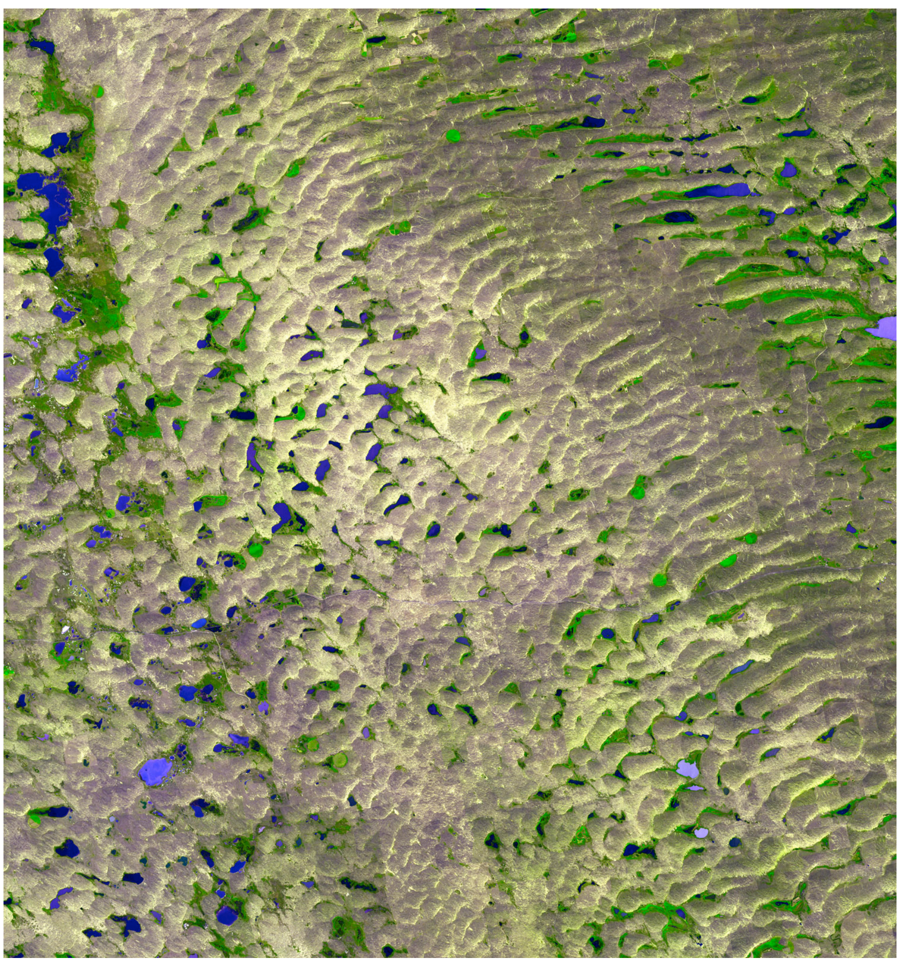
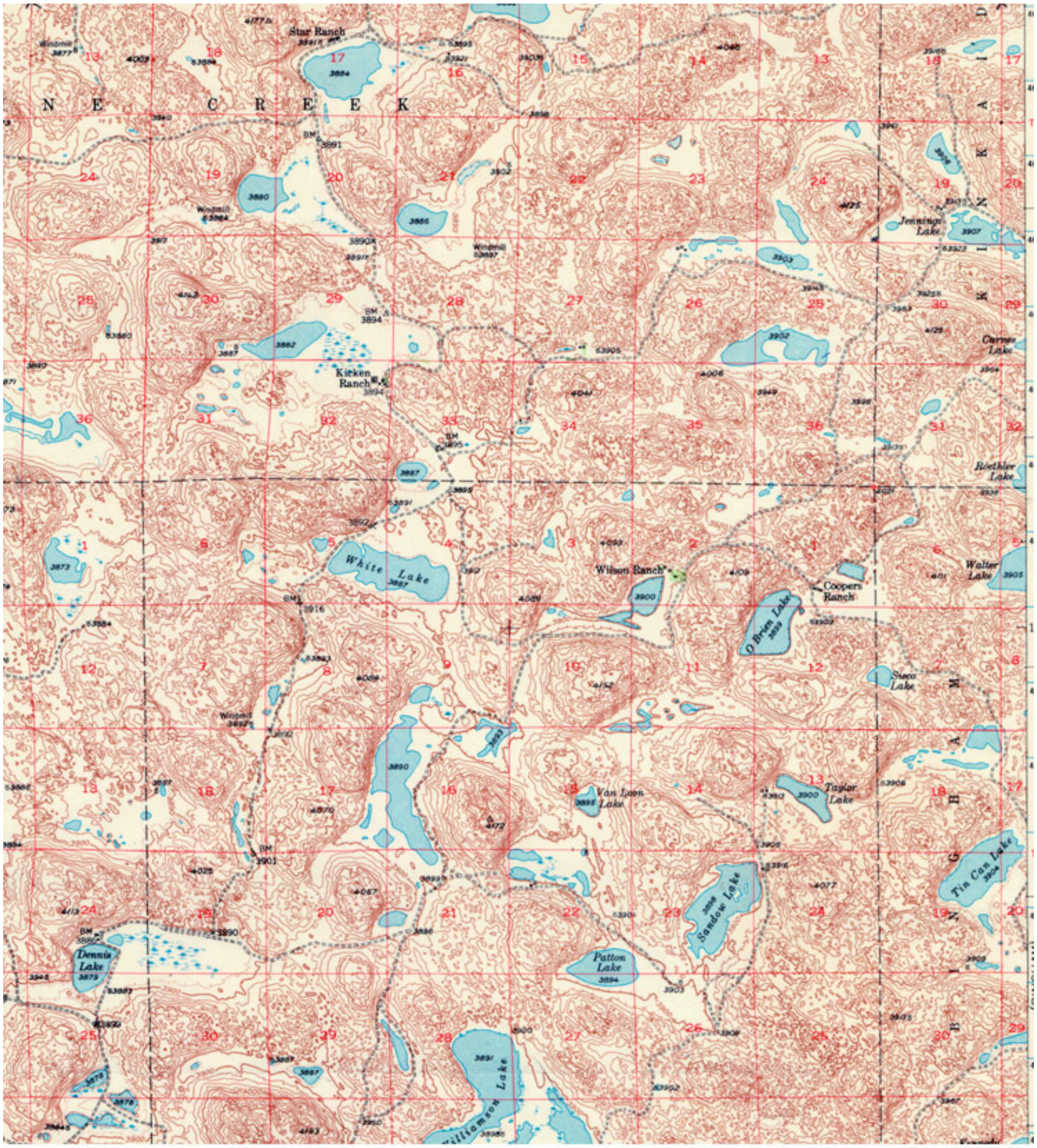
Geology 309

Construction of Water Table Maps Using GIS

Geographic Information Systems (GIS) provide useful tools that enable easy construction of water table maps. In this exercise you will use lake elevation data from an area in western Nebraska to construct a flow net. You can use these same techniques to construct flow nets from water level data in wells.

The largest dune field in North America lies in western Nebraska and was formed under dryer climatic conditions during the Pleistocene. Today this area, known as the Sand Hills, is a hummocky region that contains numerous small shallow lakes. The lakes occupy the bottom of blowouts and generally have no inlet or outlet streams and are thus classified as seepage lakes. The dune sand in this region is highly permeable allowing water to flow in and out of the lake through the groundwater system. Thus, the lakes are, for the most part, "windows" into the groundwater system and we can use the lake elevations in the same way we use the elevation of groundwater in wells. This is not always the case. Some seepage lakes become isolated from the groundwater system due to the accumulation of less permeable lake sediments and organic-rich peat.





Section of Lakeside Nebraska 15 minute quadrangle (USGS, 1948)

Procedure

1. Start both ArcCatalog and ArcMap.

2. The data for this exercise is located in Q:\classes\groundwater. Using ArcCatalog select the Lakeside1 raster dataset and drag into a blank project in ArcMap. The topographic map should appear in the map window. Drag the LakeElev shapefile into the ArcMap project window. Points should appear in the center of all the lakes with elevation data. Zoom in and examine the map. What kind of dunes are present? Note all map symbols.

3. Turn off the viewing of the topographic map by deselecting the checkbox next to Lakeside1. Only the points data will now be shown. Examine the elevation data associated with the points by opening the attribute table. To open the attribute table, right click the mouse on LakeElev and select **Open Attribute Table** from the pull down menu.

   Attributes of LakeElev

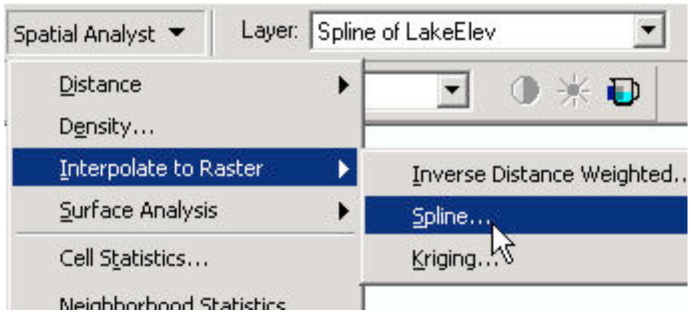
FID	Shape*	Id	Elevation
0	Point	0	3838
1	Point	0	3842
2	Point	0	3855
3	Point	0	3857
4	Point	0	3857

   Close the attribute table by clicking in the x box in the upper right corner of the table.

4. Right click on *Lake Elev* and select *Properties* from the pull down menu. Select the *Labels* tab in the *Layer Properties* dialogue. In the label field, select *Elevation* from the pull down menu. Check that the *Label Features in this Layer* box has been selected. Click OK. This will display the appropriate elevation next to each of the data points.

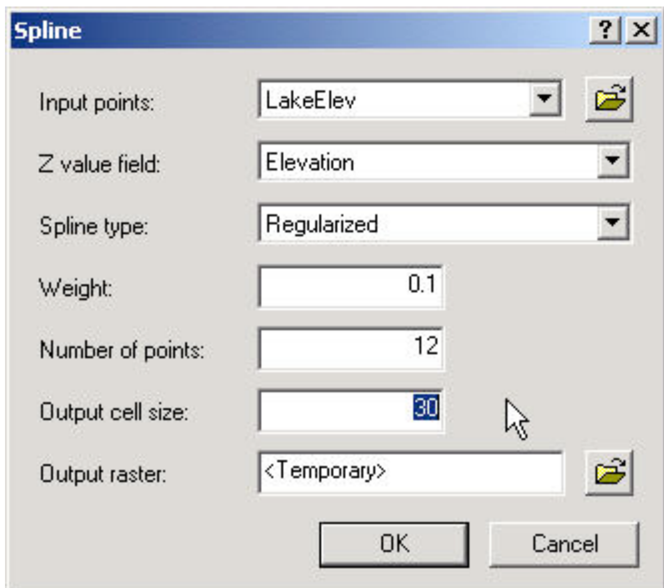
5. Under the **Tools** pull down menu, select **extensions** and make sure that the **3d Analyst** and **Spatial Analyst** boxes are checked. Then make sure the toolbars for these two extension are turned on in the **Toolbars** option under the **View** pull down menu,

6. Select the **Spline** command within **Interpolate to Raster** under the **Spatial Analyst** pull down menu. This brings up the **Spline** dialogue box. This operation will convert the points data to raster data with the value of each cell the elevation at that point. The computer will use a spline curve to determine the values of cells between the known point elevations.



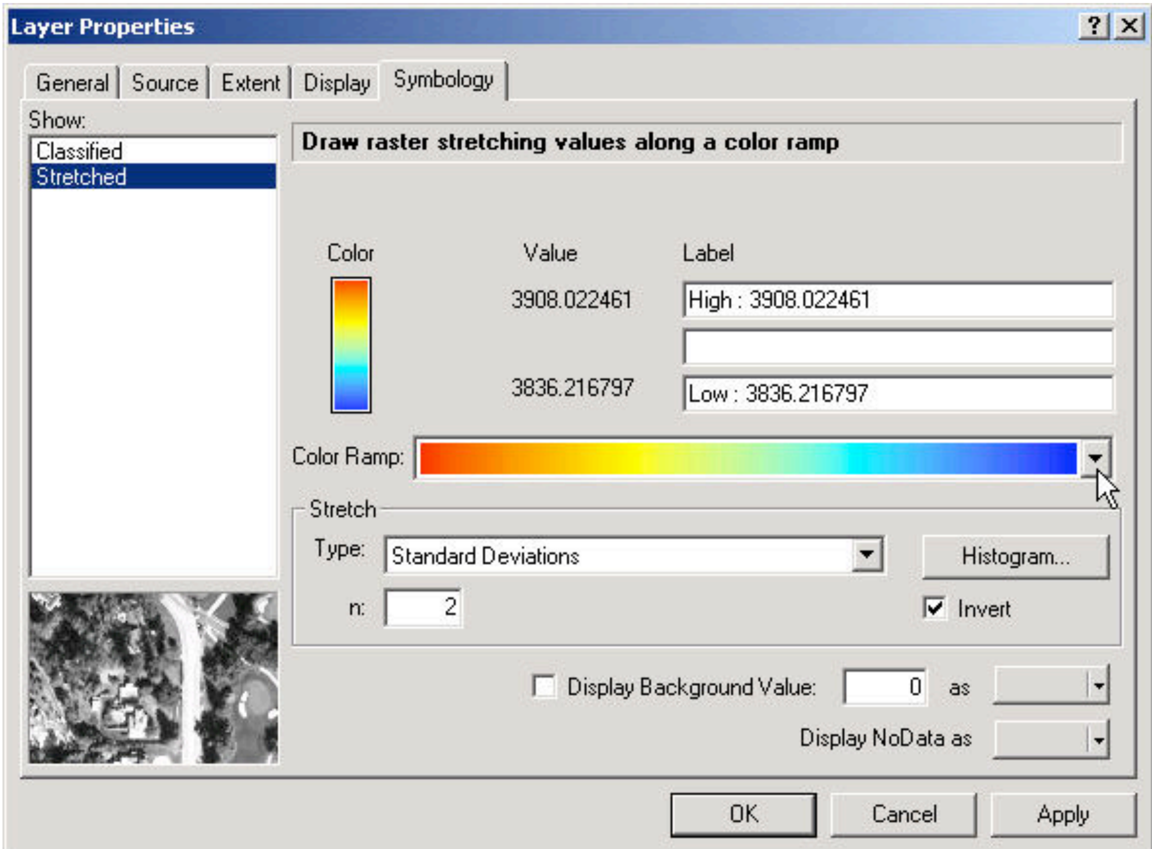
In the **Spline** dialogue make sure the following has been set:

Input points is *LakeElev*.
Z value field is *Elevation*.
Spline type is *Regularized*.
Output cell size is *30*.



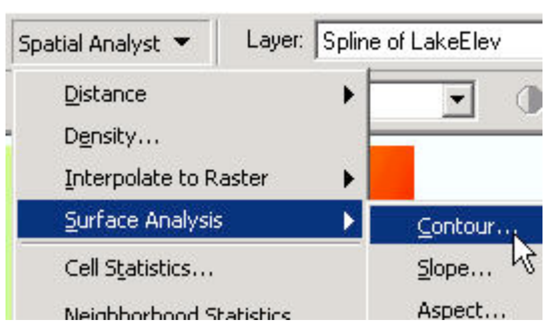
Click OK and a raster image of the groundwater head surface will be calculated.

6. Change the display of the spline surface to a continuous color banding. To do this double click on *Spline of LakeElev* in the map legend to bring up the **Layer Properties** dialogue.

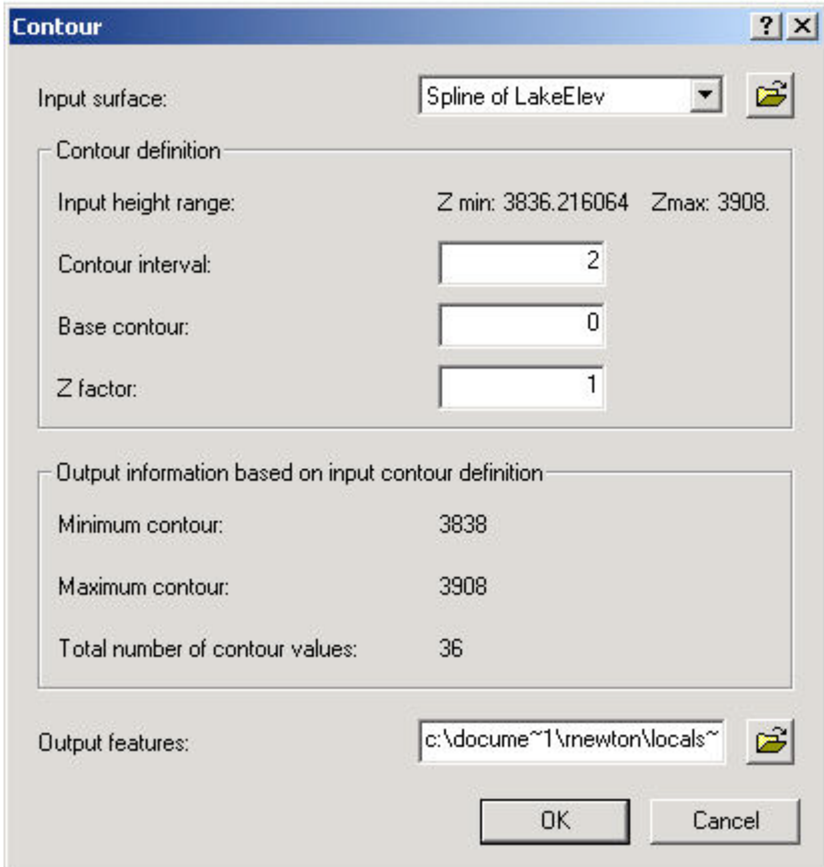


Select *Stretched* and change to the red to blue color ramp and click the *Invert* checkbox. Click **OK**. This will apply the color ramp making blue correspond to low elevations and red to high elevations.

7. Turn off the viewing of the LakeElev points. Add contours to the map. To add contours use the **Contour** option within the **Spatial Analysis** item under the **Spatial Analyst** pull down menu.

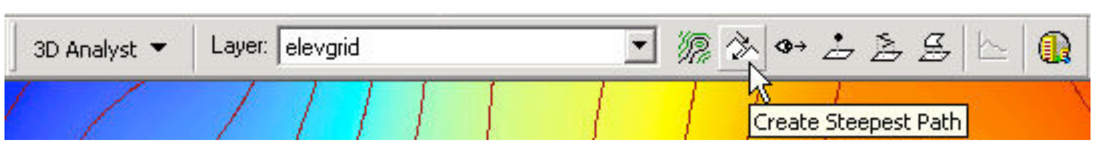


This will bring up the **Contour** dialogue box.



Make sure that Spline of LakeElev is selected as the Input surface and that the contour interval is 2, then click OK. The contour lines will now be drawn on the map and a line file will be added to the map legend.

8. Add flowlines to the contour map. This can easily be done using the steepest path tool in 3D Analyst. Click on the tool then click anywhere on the map and a line will be drawn down the steepest path which by definition means that lines will be drawn perpendicular to the contour lines (equipotential lines in this case).



Turn in a printed copy of your map and answer the following questions.

Questions

1. Flow lines converge at some locations on the map. What does this indicate about the groundwater flow system? What must be happening at these locations?

2. Flow lines diverge (flow in opposite directions) at some locations on the map. What does this indicate about the groundwater flow system?

3. Parallel flow lines get further apart in some areas. What does this indicate about the groundwater flow system?

4. What is the relative salinity of Hancock Lake (located just west of the town of Lakeside) as compared to Peter Long Lake in the NW corner of the map?

Sand Hills References

Gosselin, D.C., 1997, Major-ion chemistry of compositionally divers lakes, Western Nebraska, USA: implications for paleoclimatic interpretations, Journal of Paleolimnology v. 17, pp. 33-49.

Gosselin, D.C., Venkataramana, S., Harvey, F.E. and J.W. Goeke, 2006, Hydrological effects and groundwater fluctuations in interdunal environments in the Nebraska Sandhills, *Great Plains Research*, v.16 pp. 17-28.

Mason, J.A., Swinehart, J.B., Goble, R.J. and D.B. Loope, 2004, Late-Holocene dune activity linked to hydrological drought, Nebraska Sand Hills, USA, *The Holocene*, v.14, pp. 209-217.