REVIEW QUESTIONS

1. Describe the two types of input data required for viewshed analysis.
2. The output from a viewshed analysis is a binary map. What does a binary map mean in this case?
3. Some researchers have advocated probabilistic visibility maps. Why?
4. What parameters can we choose for viewshed analysis?
5. Suppose you are asked by the U.S. Forest Service to run viewshed analysis along a scenic highway. You have chosen a number of points along the highway as viewpoints. You want to limit the view to within 2 miles from the highway and within a horizontal viewing angle from due west to due east. What parameters will you use? What parameter values will you specify?
6. What does the parameter of OFFSETA do for viewshed analysis in ArcGIS?
7. Besides the examples cited in Chapter 14, could you think of another viewshed application from your discipline?
8. Draw a diagram that shows the elements of watershed, topographic divide, stream section, stream junction, and outlet.
9. What is a filled DEM? Why is a filled DEM needed for a watershed analysis?
10. The example in Figure 14.8 shows an eastward flow direction. Suppose the elevation of the lower-left cell is changed from 1025 to 1028. Will the flow direction remain the same?
11. What kinds of criticisms has the D8 method received?
12. How do you interpret a flow accumulation raster (Figure 14.10)?
13. Deriving a drainage network from a flow accumulation raster requires the use of a threshold value. Explain how the threshold value can alter the outcome of the drainage network.
14. To generate areawide watersheds from a DEM, we must create several intermediate rasters. Draw a flow chart that starts with a DEM, followed by the intermediate rasters, and ends with a watershed raster.
15. A watershed identified for a pour point is often described as a merged watershed. Why?
16. Describe the effect of DEM resolution on watershed boundary delineation.
17. Describe an application example of watershed analysis in your discipline.

APPLICATIONS: VIEWSHEDS AND WATERSHEDS

This applications section includes four tasks. Task 1 covers viewshed analysis and the effect of the viewpoint's height offset on the viewshed. Task 2 creates a cumulative viewshed by using two viewpoints, one of which is added through on-screen digitizing. Task 3 covers the steps for deriving areawide watersheds from a DEM. Task 4 uses the output from Task 3 to derive point-based watersheds. Task 4 also shows the importance of snapping points of interest to the stream channel. Viewshed tools are available through Spatial Analyst, 3-D Analyst, and ArcToolbox in ArcGIS. Watershed tools are available through Spatial Analyst and ArcToolbox. You will use Spatial Analyst for Tasks 1, 2, and 4, and ArcToolbox for Task 3.

Task 1: Perform Viewshed Analysis

What you need: *plne,* an elevation raster; and *lookout.shp,* a lookout point shapefile.

The lookout point shapefile contains a viewpoint. In Task 1, you first create a hillshade map of *plne* to better visualize the terrain. Next you run a viewshed analysis without specifying any parameter value. Then you add 15 meters to the height of the viewpoint to increase the viewshed coverage.

1. Launch ArcCatalog and connect to the Chapter 14 database. Start ArcMap, and rename the data frame Tasks 1&2. Add *plne* and *lookout.shp* to Tasks 1&2. First, create a hillshade map of *plne*. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and select Hillshade. Select *plne* for the input surface and take the default values for the other parameters. Click OK to dismiss the dialog. *Hillshade of plne* is added to the map. Right-click *Hillshade of plne* and select Properties. On the Display tab, enter 30% transparent. The 30% transparency allows *Hillshade of plne* to be superimposed with other layers.
2. Now run a viewshed analysis. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and select Viewshed. Make sure that the input surface is *plne* and the observer point is from *lookout*. Opt for a temporary output raster. Click OK to run the viewshed analysis.
3. *Viewshed of lookout* separates visible areas from not-visible areas. Open the attribute table of *Viewshed of lookout*. The table shows the cell counts for the visibility classes of 0 (not visible) and 1 (visible).

Q1. What area percentage of *plne* is visible from the viewpoint?

4. Suppose the viewpoint has a physical structure that adds a height of 15 meters. You can use the field OFFSETA to include this height in viewshed analysis. Open ArcToolbox. Double-click the Add Field tool in the Data Management Tools/Fields toolset. Select *lookout* for the input table, enter OFFSETA for the field name, and click OK. Double-click the Calculate Field tool in the Data Management Tools/Fields toolset. Select *lookout* for the input table, select OFFSETA for the field name, enter 15 for the expression, and click OK. Open the attribute table of *lookout* to make sure that the offset is set up correctly.
5. Follow Step 2 to run another viewshed analysis with the added height of 15 meters to the viewpoint. The result should show an increase of visible areas.

Q2. What area percentage of *plne* is visible from the viewpoint with the added height?

Task 2: Create a New Lookout Shapefile for Viewshed Analysis

What you need: *plne* and *lookout.shp,* same as in Task 1.

Task 2 asks you to digitize one more lookout location before running a viewshed analysis. The output from the analysis represents a cumulative viewshed.

1. Select Copy from the context menu of *lookout* in the table of contents. Select Paste Layer(s) from the context menu of Tasks 1&2. The copied shapefile is also named *lookout.* Right-click the top *lookout,* and select Properties. On the General tab, change the layer name from *lookout* to *newpoints.*
2. Make sure that the Editor toolbar is available. Click Editor's dropdown arrow, select Start Editing, and choose the Shapefile to edit. The task is to Create New Feature and the target is *newpoints.*
3. Next add a new viewpoint. To find suitable viewpoint locations, you can use *Hillshade of plne* as a guide and the Zoom In tool for close-up looks. You can also use *plne* and the Identify tool to find elevation data. When you are ready to add a viewpoint, click the Sketch tool first and then click the intended location of the point. The new viewpoint has an OFFSETA value of 0. Open the attribute

table of *newpoints*. For the new point, enter 15 for OFFSETA and 2 for the ID. Click the Editor menu and select Stop Editing. Save the edits. You are ready to use *newpoints* for viewshed analysis.

4. Click the Spatial Analyst dropdown arrow, point to Surface Analysis, and select Viewshed. Make sure that the input surface is *plne* and the observer points are from *newpoints*. Opt for a temporary output raster. Click OK to run the operation.
5. *Viewshed of newpoints* shows visible and not-visible areas. The visible areas represent the cumulative viewshed. Portions of the viewshed are visible to only one viewpoint, whereas others are visible to both viewpoints. The attribute table of *Viewshed of newpoints* provides the cell counts of visible from one point and visible from two points.

Q3. What area percentage of *plne* is visible from *newpoints*? Report the increase in viewshed from one to two viewpoints.

6. To save *newpoints* as a shapefile, right-click *newpoints,* point to Data, and select Export Data. In the Export Data dialog, specify the path and name of the output shapefile.

Task 3: Delineate Areawide Watersheds

What you need: *emidalat,* an elevation raster; and *emidastrm.shp,* a stream shapefile.

Task 3 shows you the process of delineating areawide watersheds using an elevation raster, which is converted from a DEM, as the data source. *emidastrm.shp* serves as a reference.

1. Insert a new data frame in ArcMap. Rename the new data frame Task 3, and add *emidalat* and *emidastrm.shp* to Task 3. If necessary, click Show/Hide ArcToolbox Window to open the ArcToolbox window. Set the Chapter 14 database as the current workspace.
2. First check to see if there are any sinks in *emidalat.* Double-click the Flow Direction tool in the Spatial Analyst Tools/Hydrology toolset. Select *emidalat* for the input surface raster, enter *temp_flowd* for the output flow direction raster, and click OK. Double-click the Sink tool. Select *temp_flowd* for the input flow direction raster, specify *sinks* for the output raster, and click OK.

Q4. How many sinks does *emidalat* have? Describe where these sinks are located.

3. This step fills the sinks in *emidalat.* Double-click the Fill tool. Select *emidalat* for the input surface raster, specify *emidafill* for the output surface raster, and click OK.
4. You will use *emidafill* for the rest of Task 3. Double-click the Flow Direction tool. Select *emidafill* for the input surface raster, and specify *flowdirection* for the output flow direction raster. Run the command.

Q5. If a cell in *flowdirection* has a value of 64, what is the cell's flow direction? (Use the index of Flow Direction tool/command in ArcGIS Desktop Help to get the answer.)

5. Next create a flow accumulation raster. Double-click the Flow Accumulation tool. Select *flowdirection* for the input flow direction raster, enter *flowaccumu* for the output accumulation raster, and click OK.

Q6. What is the range of cell values in *flowaccumu*?

6. Next create a source raster, which will be used as the input later for watershed delineation. Creating a source raster involves two steps. First select from *flowaccumu* those cells that have more than 500 cells (threshold) flowing into them. Double-click the Con tool in the Spatial Analyst Tools/Conditional toolset. Select *flowaccumu* for the input conditional raster, enter 1 for the input true raster or constant value, specify *net* for the output raster, and enter Value > 500 for the expression. Run the command. Second, assign a unique value to each section of *net* between junctions

(intersections). Go back to the Hydrology toolset. Double-click the Stream Link tool. Select *net* for the input stream raster, select *flowdirection* for the input flow direction raster, and specify *source* for the output raster. Run the command.

7. Now you have the necessary inputs for watershed delineation. Double-click the Watershed tool. Select *flowdirection* for the input flow direction raster, select *source* for the input raster, specify *watershed* for the output raster, and click OK. Change the symbology of *watershed* to that of unique values so that you can see individual watersheds.

Q7. How many watersheds are in *watershed*?

Q8. If the flow accumulation threshold were changed from 500 to 1000, would it increase, or decrease, the number of watersheds?

8. Using the command line option, you can run the commands in Task 3 all at once. This is particularly useful if the study area is large and you do not want to wait between dialogs. To use this option, first click Show/Hide Command Line Window in ArcMap to open the command line window. Type the first command line, and press Ctrl-Enter to enter the second and subsequent lines. Assuming that the workspace is c:\chap14 and the workspace contains *emidalat,* the following lists the command lines needed to complete Task 3:

```
Workspace c:\chap14
FlowDirection emidalat temp_flowd
Sink temp_flowd sinks
Fill emidalat emidafill
FlowDirection emidafill flowdirection
FlowAccumulation flowdirection flowaccumu
Con flowaccumu 1 net # "Value > 500"
StreamLink net flowdirection source
Watershed flowdirection source watershed
```

After these command lines are entered, press Enter to execute them. The bottom part of the command line window shows the progress. It also displays error messages if there are any syntax errors.

Task 4: Derive Upstream Contributing Areas at Pour Points

What you need: *flowdirection, flowaccumu,* and *source,* all created in Task 3; and *pourpoints.shp,* a shapefile with two points.

In Task 4, you will derive a specific watershed (i.e., upstream contributing area) for each point in *pourpoints.shp.* All operations in Task 4 are performed using Spatial Analyst.

1. Insert a data frame in ArcMap and rename it Task 4. Add *flowdirection, flowaccumu, source,* and *pourpoints.shp* to Task 4.

2. First convert *pourpoints* to a raster. Select Options from the Spatial Analyst dropdown menu. On the General tab, select the Chapter 14 database for the working directory. On the Extent tab, select *flowaccumu* for the analysis extent. On the Cell Size tab, select *flowaccumu* for the analysis cell size. Click the Spatial Analyst dropdown arrow, point to Convert, and select Feature to Raster. Select *pourpoints* for the input features, enter *pourptgd* for the output raster, and click OK to convert.

3. Select Raster Calculator from the Spatial Analyst dropdown menu. Enter the following expression in the expression box: watershed([flowdirection], [pourptgd]). Click Evaluate. The command creates *Calculation* as a temporary raster.

Q9. How many cells are associated with each of the pour points?

4. Zoom in on a pour point. The pour point is not right on *source,* the stream link raster created in Task 3. It is the same with the other point. This is why the pour points generated very small watersheds in Step 3. ArcGIS has a SnapPour command, which can snap a pour point to the cell with the

highest flow accumulation value within a search distance. Use the Measure tool to measure the distance between the pour point and the nearby stream segment. A snap distance of 90 meters (3 cells) should place the pour points onto the stream channel.

5. Select Raster Calculator from the Spatial Analyst dropdown menu. Enter the following expression in the expression box: snappour([pourptgd], [flowaccumu], 90). Click Evaluate. The command creates *Calculation2* as a temporary grid.
6. Run the Watershed command again. Enter the following expression in the Raster Calculator's expression box: watershed([flowdirection], [Calculation2]). Click Evaluate. *Calculation3* should have many more cells for each snapped pour point.

Q10. How many cells are associated with each of the new pour points?

Challenge Task

What you need: access to the Internet.

This challenge task asks you to find the upstream contributing area for a USGS gauge station in your local area.

1. The first step is to locate a station in your local area. The USGS maintains a National Water Information System (NWIS) website, which provides a wide variety of water resource data. Go to **http://nwis.waterdata.usgs.gov/nwis.** Click on Real-time Data. You can now select a site location by state. Click the button for summary of additional data for this site. Write down the latitude and longitude readings of the gauge station as well as the datum (NAD27 or NAD83).
2. Next get a 30-meter DEM for the area around the selected station. Go to the GIS Data Depot website **(http://www.geocomm.com)** to download the DEM. To import a USGS DEM in SDTS format, you can use either the Import From SDTS tool in the Coverage Tools/Conversion/To Coverage toolset (for users with an ArcInfo license) or the SDTS Raster to Grid tool in ArcView 8x Tools (for users with an ArcView license). Name the imported elevation raster *elev*, and add *elev* to a new data frame in ArcMap.
3. You need to go through a couple of steps to add the station to ArcMap. Convert the latitude and longitude readings of the station from DMS (degrees-minutes-seconds) to DD (decimal degrees). Prepare a comma delimited text file for the station. The first line of the text file has the headings ID, longitude, and latitude. The second line has the station ID (e.g., 1) and the station's longitude and latitude readings. Name the text file *gauge.txt.* Use the ADD XY Data tool in ArcMap to add *gauge.txt.* Export *gauge.txt* Events to a point shapefile and call the shapefile *gauge.shp.*
4. *gauge.shp* has an undefined coordinate system. First define its geographic coordinate according to the listed datum on the USGS website (NAD27 or NAD83). Then project the shapefile by importing the coordinate system from *elev,* which is most likely the UTM (Universal Transverse Mercator) coordinate system. Name the projected output shapefile *gageutm.shp.*
5. Add *gageutm.shp* back to ArcMap. Make sure the Spatial Analyst's analysis environment (i.e., extent and cell size) is set to be the same as *elev.* Then convert *gageutm.shp* to a raster and name the raster *gagegd.*
6. Derive a flow direction raster from *elev,* and then use *gagegd* and the flow direction raster to derive the watershed for the station.
7. If the watershed from Step 6 is very small, it means that the station is not on the stream channel. Follow the same procedure as in Task 4 to snap the station to the stream channel, before running another watershed analysis.