## *EXERCISE 6: USE THE DISTANCE TOOLS*

The City of Lake Tahoe is thinking of building a park in Rockbound Valley. You will first use the straight line distance tools to determine how far the park site is from the city. Then you will use the weighted distance tools to find the best route for building roads to get to the proposed park.

### *1: FIND THE STRAIGHT-LINE DISTANCE TO ROCKBOUND VALLEY*

In this step, you will find the straight-line distance between the park site in Rockbound Valley and the City of South Lake Tahoe.

- ☐ Start *ArcMap* with A new empty map.
- ☐ Add all the layer files in your ... *Exercise10* folder.

Notice that Rockbound Valley and Roads are feature layers and that Lakes and Elevation are raster layers.
Before you begin the analysis, you need to set the analysis environment.

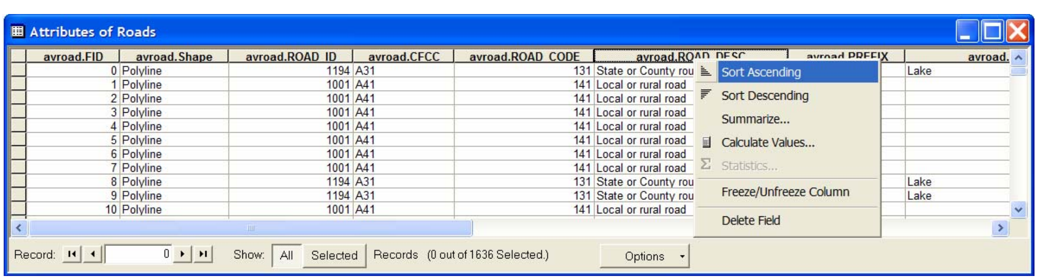
- ☐ Open the ArcToolbox window

- ☐ Set these Environment Settings:
  - Current Workspace: ... *Exercise10*
  - Scratch Workspace: ... *Exercise10*
  - Output Extent: *Same as Layer "Elevation"*
  - Cell Size: *Same as Layer "Elevation"*

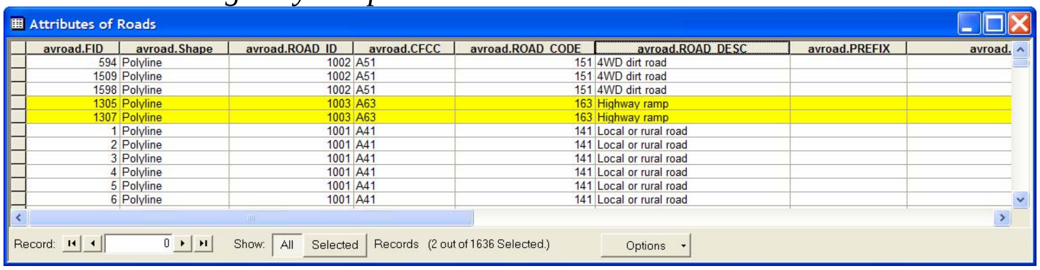
All measurements will be made from downtown South Lake Tahoe. Since it is difficult to find a single point to call 'downtown', you will use the highway ramp in the middle of the city. All the ArcGIS Spatial Analyst tools honor selections made on the input datasets. If you have a selection in an input dataset, only that selection will be used in the analysis. Now you will select the highway offramp features from the roads layer, so just the offramps are used in the analysis.

- ☐ Open the attribute table for the Roads layer.

- ☐ *Right-click* the field *avroad.ROAD_DESC* field and click *Sort Ascending.*



☐ Select the two *Highway ramp* features.



Attributes of Roads

| avroad.FID | avroad.Shape | avroad.ROAD_ID | avroad.CFCC | avroad.ROAD_CODE | avroad.ROAD_DESC | avroad.PREFIX | avroad. |
|---|---|---|---|---|---|---|---|
| 594 | Polyline | 1002 | A51 | 151 | 4WD dirt road | | |
| 1509 | Polyline | 1002 | A51 | 151 | 4WD dirt road | | |
| 1598 | Polyline | 1002 | A51 | 151 | 4WD dirt road | | |
| 1305 | Polyline | 1003 | A63 | 163 | Highway ramp | | |
| 1307 | Polyline | 1003 | A63 | 163 | Highway ramp | | |
| 1 | Polyline | 1001 | A41 | 141 | Local or rural road | | |
| 2 | Polyline | 1001 | A41 | 141 | Local or rural road | | |
| 3 | Polyline | 1001 | A41 | 141 | Local or rural road | | |
| 4 | Polyline | 1001 | A41 | 141 | Local or rural road | | |
| 5 | Polyline | 1001 | A41 | 141 | Local or rural road | | |
| 6 | Polyline | 1001 | A41 | 141 | Local or rural road | | |

Record: 0 Show: All Selected Records (2 out of 1636 Selected.) Options

Now you are ready to create distance surface from the highway ramps.

☐ *Run* > *Distance* > *Euclidean Distance*

- Input raster: select *roads*
- Accept the remaining defaults.

**NOTE: For this analysis, you do not need to create a direction raster. It is not important how to get back to the ramps. This analysis is only concerned with cells' distances from the ramps.**

☐ Change the name of the new layer to **Distance to Offramps**
☐ Move *Rockbound Valley* to the top of the *Table of Contents*
☐ Click the *Identify* tool.
☐ Click *Rockbound Valley* in the map.
☐ In the *Identify Results* dialog, for Layers, click *Distance to Offramps*.
☐ Identify Rockbound Valley in the map again.

The distance should be close to 20,500 meters, so Rockbound Valley is about 12.7 miles or 20.5 kilometers from downtown South Lake Tahoe.

☐ Close the *Identify Results* dialog.
☐ Close the legends of all the layers.

***STEP 2: CREATE A SPEED RASTER***

In this step, you will begin to create a cost surface for travel throughout the area. Logically, the first place to start is with the roads. You will assume that on-road travel cost is proportional to the speed limit. Also, you will assume that off-road travel is limited to 5 miles per hour. This is not a valid assumption; normally a cross-country mobility model is needed to derive travel rates based on factors like vegetation, soils, and so on. In the next step, you will adjust the 5 miles per hour using slope because it is more difficult to build a road across or drive on steep grades.

☐ Turn off the Distance to Offramps layer.

Currently, the offramps are selected in the roads layer. If you converted the roads to a raster dataset right now, only the offramps would be converted. You will clear the selection so all features are converted.

- ☐ From the *Selection menu*, click *Clear Selected Features*.
- ☐ *Run... > Conversion Tools> To Raster> Feature to Raster:*
- ☐ Input features: select **Roads**
- ☐ Field: select **Speed.speed**

  Note: The Speed field is a joined field from a table named Speed.dbf.

- ☐ Output raster: accept the default location and name
- ☐ Output cell size: type **30** meters
- ☐ Change the name of the resulting raster to **speed1**
- ☐ Turn off the Roads layer.

The new Speed1 layer is a raster representation of the roads and the values are the speed limits. Notice from the legend that the cells between the roads were assigned the NoData value. Your next step is to replace the NoData cells with a speed limit of 5.

- ☐ *Run ... > Map Algebra > Single Output Map Algebra:*
- ☐ Map Algebra expression: type
  **`CON(ISNULL(Speed1), 5, Speed1)`**
- ☐ Output raster: Accept the default
- ☐ Rename the new layer to **speed2**
- ☐ Close the legends for Speed1 and Speed2.

Every cell now has a speed limit value. But, there are still some problems. The speed limit for water is the same as for nonroad land, and the speed limit for nonroad land is the same for all terrain types.

## *STEP 3: ADJUST THE SPEED RASTER*

In this step, you will make your speed raster more realistic by taking slope and the water into account. You will assume that steeper slopes are harder to traverse, whether the slope is downhill or uphill. Since you want people to be able to drive to the park, you will also assume that you cannot drive across water. First you will create the slope raster from the elevation raster.

- ☐ *Run ... > Surface > Slope:*
- ☐ Input raster: select *Elevation*
- ☐ Accept the remaining defaults.
- ☐ Change the name of the resulting raster layer to *Slope of Elevation*

□ Turn off all layers and collapse their legends.

Since you will not be traveling by boat, you need to eliminate the lakes from the analysis. You will use the Set Null tool to create a new raster with all the lakes set to NoData. You will then use this raster as the mask for the analysis.

□ *Run.. > Conditional> Set Null:*
□ Input conditional raster: select **Lakes**
□ Input false raster or constant value: type **1**
□ Output raster: accept the default
□ Expression: type **value > 0**
□ Change the resulting default raster name to Mask
□ Turn off the Mask layer and close its legend.

Next, you will adjust the off-road speed limit based on slope (the more slope, the harder it is to travel), while using the Mask layer as part of your analysis environment.

□ *Run Single Output Map Algebra:*
□ *Map Algebra expression*: type

```
CON ( Speed2 eq 5, ( 5.0 / INT ( Slope of Elevation + 0.5 ) ), Speed2 )
```

□ Output raster: accept the default
□ Environments button:
  - Raster Analysis Settings > Mask: select Mask

□ Change the name of the resulting raster layer to **Final Speed**

Here is a description of the Map Algebra expression you just wrote:

If the speed equals five **CON(Speed2 eq 5**), the cell is off-road. For all off-road cells, round slope to an integer and divide the off-road speed limit by the integer slope 5.0 / INT (Slope of Elevation + 0.5). For on-road cells, return the speed limit Speed2.

The key is dividing the integer slopes into the off-road speed limit of 5.0. This overly simplistic model just reduces the speed limit based on the slope. For example, where slope is 1, the speed limit does not change ( 5 /1= 5), If the slope is 20, the speed limit will be much lower ( 5 / 20 = 0.25). Setting the speed limit as a decimal (5.0) forces the expression to return floating-point values; otherwise, most cells would be zero.

□ Turn off all layers and close their legends.

### *STEP 4: CREATE THE COST OF TRAVEL RASTER*

In this step you will calculate the cost to travel through every cell based on your Final Speed layer. The output will be the number of minutes it takes to drive through a cell. Later, you will use this raster to do pathfinding.

You will calculate travel costs as a function of the speed limit to create a cost surface. In the cost-weighted analysis, higher values mean more resistance. Speed limits are therefore not directly suitable as a travel cost measure. Cost-weighted analysis would determine that it is harder to travel on a road with a speed limit of 55 than on a road with a speed limit of 25 because 55 is ‘bigger’ than 25.

You want the final result of cost-weighted analysis to be in useful and meaningful measures. Cost-weighted analysis computes the cost to travel from one cell into the next by adding the costs of the two cells together, dividing by 2, and multiplying by the distance between their centers. If you can express the costs in terms of time per unit distance, where the distances are in the same units as the cell sizes (e.g., minutes per foot), then the distance units will cancel each other out and the result will be expressed in time units.

You will convert your miles-per-hour speed limits into minutes-per-meter speed limits by multiplying the speed limit (hours per mile) by a conversion constant that converts hours per mile into meters per minute. Then you will find the inverse to get minutes per meter. Expanded, your equation looks like this:

$$\frac{1\text{ mile}}{1\text{ hour}} = \frac{1609.344\text{ meters}}{60\text{ minutes}} = \frac{26.82\text{ meters}}{1\text{ minute}} \quad \text{Invert: } \frac{1}{\frac{26.82\text{ meters}}{1\text{ minute}}} = \frac{1\text{ minute}}{26.82\text{ meters}}$$

You will now invert the speed and create a cost of travel raster:

- ☐ Run Single Output Map Algebra:
- ☐ MapAlgebra expression: type
- ☐ **`1.0 / ( Final Speed * 26.82 )`**
- ☐ Output raster: accept the default
- ☐ Rename the new layer to Cost of Travel
- ☐ Collapse the legend for Cost of Travel.

In this step, you converted a miles-per-hour raster into a minutes-per-meter cost raster. You can use this cost raster to create a weighted distance raster.

## *STEP 5: CREATE THE WEIGHTED DISTANCE AND DIRECTION RASTERS*

In this step, you will create a weighted distance raster using the cost raster you created in the last step. As in the first step, where you generated straight line distances, the cost-weighted distance raster will use the highway offramps in town as the source for the calculations. First, you must select those features in the Roads layer.

- ☐ Open the attribute table for the *Roads* layer.
- ☐ *Right-click* on the column heading for the *avroad.ROAD_DESC* field and click *Sort Ascending*.

- ☐ Select the two *Highway ramp* features.
- ☐ Close the *Attributes* of Roads table.
- ☐ *Run .. > Distance> Cost Distance*:
  - Input raster or feature source data: select *Roads*
  - Input cost raster: select *Cost of Travel*
  - Output distance raster: accept the default
  - Maximum distance: accept the default
  - Output backlink raster: type ***BackLink***
- ☐ Rename the new layer (not backlink) to ***Travel Time***

The output from this analysis is two rasters: a backlink raster and a cost-weighted distance raster. You need the backlink raster to do pathfinding. It is less important to know which cells are closer to which highway ramp; this is why you will not create a cost allocation raster.

The current symbology for the Travel Time layer does not clearly show some of the important time breaks. For example, the first class goes from 0 to approximately 62 minutes. Now you will reclassify the Travel Time layer so you can see more variation in the lower travel times.

- ☐ Open the properties of the *Travel Time* layer.
- ☐ Click the *Symbology* tab.
- ☐ Change the *Classification Method* to *Quantile*.

**NOTE: Any classification is a form of generalization. You might want to get rid of all the redundant digits to the right of the decimal places under the Label column.**

- ☐ *Click OK*
- ☐ Close the legends for the Travel Time and backlink layers.

You now have a cost-weighted distance raster for downtown South Lake Tahoe. You could use this for determining drive times anywhere in the study area.

## *STEP 6: FIND THE BEST PATH TO ROCKSOUND VALLEY*

In this step, you will find the best path to the new Rockbound Valley park. The off- road part of the path is where the new road will be constructed for the park. The Cost Path tool creates a new shapefile of lines that connects the destinations to the sources.

- ☐ *Run.. > Distance> Cost Path:*
  - *Input raster* or feature destination data: select *Rockbound Valley*
  - Destination field: accept the default *GNIS_ID*
  - Input cost distance raster: select *Travel time*
  - Input cost backlink raster: select *backlink*
  - Output raster: accept the default
  - Path type: **EACH_ZONE**

**NOTE: For each zone on the input feature destination data, a single least-cost path is determined and saved on the output raster of the Cost Path tool. For each zone, the least-cost path begins from the cell with the lowest cost distance weighting in the zone.**

- □ Rename the new layer to **Best Path**
- □ Set the color for both of Best Path's symbols to **Black.**
- □ Turn off all the layers except Best Path and Rockbound Valley.

The legend for Best Path has two values. "1" is for the source cells (the offramps in downtown Lake Tahoe), and "3" is for the best path to Rockbound Valley.

- □ Exit ArcMap without saving your map.

***EXERCISE END***