GY301 Geomorphology
Laboratory 6: Construction of Topographic Contours and Profiles

Introduction

Topographic *contours* allow the depiction of *topography*, the landform features present on a topographic map. A definition of a contour line is simply a line that represents many connected points of equal value. In this course contour lines on a map will often (but not always) will represent elevations of the land surface above *mean sea level*. Mean sea level is the average elevation of the surface of the ocean and is assigned the value of "0" elevation. A single contour line represents all points of equal elevation above mean sea level that can be located adjacent to each other. Contour lines always start at a zero value and increase at regular intervals. In fact, the shoreline of an ocean is the zero contour line by definition. The interval by which contour lines increase or decrease in value is termed the *contour interval*. The contour interval is always printed as one of the components of the topographic map legend. If the contour interval were 20 feet, for example, and, the minimum and maximum elevations on the map were 15 and 87 feet above mean sea level respectively, we should expect to find the 20, 40, 60, and 80 foot contours on the map. Note that this does not mean that we should only find 4 distinct contour lines on the map; any given contour line value may appear many times over the map area depending on the topography of the area. In addition, although contour lines begin numerically at mean sea level (i.e. 0), the lowest contour value on a given topographic map will no be 0 unless that map contains a coastline.

Some of the contour lines on USGS topographic maps will be thicker than others; generally, they will occur at every fifth contour starting with the zero contour line. These contours should be referred to as the *index contours*. The contour interval may change from one map area to another as the landform changes from relatively flat to rugged terrain. For example, a quadrangle from the state of Colorado may have contour intervals as high as 100 feet, while Florida quadrangles may have intervals as low as 2 feet. Sometimes *supplementary contours* are present on a map and represent half the normal contour interval. These contour lines are dashed. In the future, contour intervals will be given metric units as USGS maps are converted to the metric system.

Contour maps are produced from pairs of aerial photographs and from elevation control points. Elevation control points are simply identified points on the topographic map where the elevation has been measured. Normally there are two types of elevation present on the map and they basically differ only in precision. *Spot elevations* will be marked by a "X" on the map. Next to the "X" will be printed a number that represents the elevation above mean sea level for the center of the "X". This measurement is accurate to within ±2 meters. Another type of elevation data, a *benchmark*, is marked by a triangle symbol and is a more accurate measure of the land surface elevation. Benchmarks are more or less permanently marked; usually by the placement of a plate embedded in concrete at the measurement site. The steel plate is engraved with the elevation and benchmark number. On a map, a benchmark elevation number is always preceded by the characters "BM". If you are asked to contour a map and you find spot elevations or benchmarks, you should always use these points to control the placement of your contours.

Construction of Contours

Contours may be constructed from elevation data with the aid of a few simple rules. Below are the *rules of contouring* that must be followed regardless of the type of data to be contoured:

- 1. When contours lines cross streams, they will always form a V-shape that points toward the upstream (higher elevation) portion of the stream valley.
- 2. Contours do not intersect or merge unless the ground surface is vertical or has a negative slope. Because this is rare in nature, you will not usually encounter this situation in the lab unless you are investigating man-made topographic structures.
- 3. Closed contours that form circular or elliptical patterns represent locally high areas that are termed *hills* or *hogbacks*.
- 4. Closed contours that are marked by short tic marks- termed *hachures* -indicate a bowl-shaped depression. The hachures are always on the lower elevation side of the contour and point toward the bottom of the *depression*.
- 5. Steep slopes are indicated by closely spaced contour lines, while low slopes are indicated by widely spaced contours. Furthermore, if contour lines are straight and maintain a constant spacing, a planar inclined surface is indicated.
- 6. The difference between the lowest and highest points on the map is termed the *topographic relief* of that area.
- 7. A change of slope direction will cause a repeat of at least one contour line in the direction of travel. Imagine that you were traversing a hill with an elevation of 105 feet. On a topographic map you would have to cross the 100 foot contour line twice- once going uphill, the second time while traveling downhill.

The above rules should serve as guidelines when you construct a contour map, but how does one begin to mechanically draw in the contour lines on a map such as

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Figure 1? A good approach is to use the "divide and conquer" approach. Suppose that you select two of the spot elevations on the map to work with, and suppose that their elevations are 75 and 102 feet above sea level. Also suppose that the contour interval will be 10 feet. Now sketch in a light pencil line between the two spot elevation points. You should imagine that this line is actually a gradually sloping surface with endpoints at 75 and 100 feet elevation. If this is true, then the 80, 90 and 100 foot contours must cross this line at three different positions. Visually estimate the position of each crossing using proportions. For example, the total elevation difference between the two points is 102 - 75 = 27 feet. The 80 foot contour line is 80 - 75 = 5 feet above the low end (75) end of the pencil line. Therefore, the position of the 80 foot contour line crossing should be 5/27 x 100, or approximately 20% of the total length of the line from the 75 spot elevation. After some practice you will become good enough so that you will not have to draw the pencil line. Don't use a calculator to calculate exact proportions, it's not worth the effort. Just visually estimate the proportion and draw in a dot where one of the contour lines crosses. Be sure to label each of the points with the appropriate elevation value. After you do this for all of the spot elevation pairs in a given area, you will have an excellent grid upon which you can constrain where the contour lines must lie. Note that the "divide and conquer" approach does not work across a change in slope direction since one or more contour lines are repeated. Instead, you should apply the rule from the slope direction break to the adjacent contour lines- i.e. only apply the rule along contours that are consistently increasing or decreasing in value.

Topographic Profiles

A *topographic profile* is a graph or diagram which attempts to display the cross-sectional or "cut-away" view of the land surface topography. These types of profiles may be constructed in any given direction on a topographic map. The contour lines contain the information necessary to construct this type of diagram. The *vertical scale* of the diagram is the scale used to determine elevations above sea level for a particular diagram. The ratio of this vertical scale to that of the *horizontal scale* (map scale) is termed the *vertical exaggeration*:

$$\text{Vertical exaggeration} = \frac{\text{Vertical Scale}}{\text{Horizontal (map) scale}}$$

As an example, if the vertical scale of the topographic profile were 1"=1000', and that of the horizontal scale were 1"=2000', then the vertical exaggeration would be calculated as below:

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$$V.E. = \frac{\frac{1}{1000}}{\frac{1}{2000}}$$

The vertical exaggeration enhances the topographic relief of the map area when it has a value greater than one; if it is less than one the profile relief is more subdued as compared to the actual topographic relief. Typically, the vertical exaggeration is greater than one so as to accentuate topographic features like ridges and river valleys.

Constructing a Topographic Profile

A topographic profile is a diagram that displays a side or cutaway view of the Earth's topography. The maps that we have investigated so far are all constructed from a birds-eye or plan view of the earth. As the name implies, the topography is presented in "profile" by a topographic profile. Before actually constructing the profile, however, the student should be able to qualitatively determine the results of the profile before beginning. For example, if the line of the profile crosses a portion of the map that contains closely spaced contour lines, we should expect that the profile will be steep, whereas the profile will indicate a shallow slope angle where contours are widely spaced. The student should also calculate the vertical exaggeration of the map profile so as to recognize the extent of the distortional effects on the profile. Most topographic profiles are exaggerated to various extents because natural slopes are usually very low and, therefore, do not show terrain features well with no exaggeration (VE = 1). To give you a familiar landform to work with, the following problem set contains a topographic profile problem for the University of South Alabama campus area (Figure 2). Below are step instructions to follow while constructing a topographic profile:

1. Determine the line of the cross-section profile. You will either find this as a straight line on the map, or will be given instructions that determine the endpoints of the profile. Sketch the line, if necessary, onto the base map with a pencil. Label one end of the profile line "A", the other end "A' ".

2. On a page of graph paper draw the profile line horizontally across the bottom portion of the page. Make sure that the profile line is exactly the same length as the original profile line. This insures that the horizontal scale of the profile is the same as the topographic base map scale. Next, determine the elevation grid

spacing for the profile. This will already be set if you are instructed to use a specific VE. For example, if the map scale was 1"=2000', and you must use a VE of 4, then the vertical scale of the profile is 1"=500'. Therefore, each 0.1" vertical spacing on the graph paper represents 50'. Mark off the elevation grid by drawing horizontal lines above the initial profile line at intervals representative of the contour interval of the base map. You may be given a grid already constructed for some exercises- if so the vertical scale is predetermined.

3. Place a clean sheet of paper edgewise along the line of profile on the map. Make a pencil mark on the paper where the profile begins and ends (A and A' points). In addition, at every place that a contour line intersects the edge of the paper make a mark and label that mark with the value of the contour line. Inspect all of the contour elevations to determine the lowest and highest elevation value. The difference between these values is the *relief* of the map area along the profile.

4. Label the elevation grid lines on the graph paper starting with the line immediately above the line of the profile. Its value should be one contour interval lower than the lowest elevation encountered in step 3. Label the successively higher elevation grid lines according to the contour interval. The last value should be at least one contour interval above that of the highest contour elevation encountered in step 3. If is not, the vertical scale must be decreased (vertical exaggeration decreased) and the grid reconstructed according to the new scale.

5. Place the paper edgewise along the profile line of the graph paper making sure that the "A" point of the paper aligns with that end of the graph paper "A" point. This will align the "A' " points also. At each tic mark use a ruler to mark a point that is vertically above that point but also on one of the elevation grid lines that matches the elevation value of that particular contour line. Do this for all of the marks made on the paper.

6. Draw a smooth curve through the points. This represents the topographic profile surface. Make sure that the profile surface never crosses an elevation level not indicated by the topographic contours of the base map. Also note that hilltops and the bottom of depressions and valleys do not come to a sharp "cusp" in natural profiles but rather have rounded changes in slope direction.

7. To further refine the profile one should go back and record significant cultural and physiographic features that occur along the line of the profile- such as rivers, creeks, towns, roads, and the summit points of hills. It may be necessary in areas

of low slope to interpolate elevation values between actual contours so as to draw a smooth curve for the profile. Label the horizontal and vertical scales in appropriate places on the profile, and list the vertical exaggeration value in the margin of the map.

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EXERCISE 2: CONTOUR MAP AND TOPOGRAPHIC PROFILE CONSTRUCTION

Problem 1

Figure 1 contains a map with spot elevation data on it. The spot elevations are marked by an "X", with an adjacent elevation value in feet above mean sea level. Using the spot elevations, construct a contour map on the map in Figure 1. When constructing the contour map, label every contour with the elevation value. Note that the contour interval is 10ft. In addition to constructing the contour map, calculate the relation fraction (RF) of this map given the graphic bar scale on the map. Write this value just below the bar scale in Figure 1.

Problem 2

Figure 3 is a topographic map of the square mile (one section) University of South Alabama campus property. The scale of the map is 1"=850ft. On this map is a topographic profile line labeled A-A'. For this problem construct the topographic profile along A-A' on the profile grid in Figure 2. The grid provides space for labeling elevation values along the left margin- use the contour interval of the map for labeling each grid line. Also note that the "A" and "A'" are already on the profile grid, as are the vertical and horizontal scales. In addition to constructing the profile onto Figure 2, calculate the vertical exaggeration of the profile and write the value in the space provided. Include Three Mile Creek and the soccer fields as landmarks on the profile.

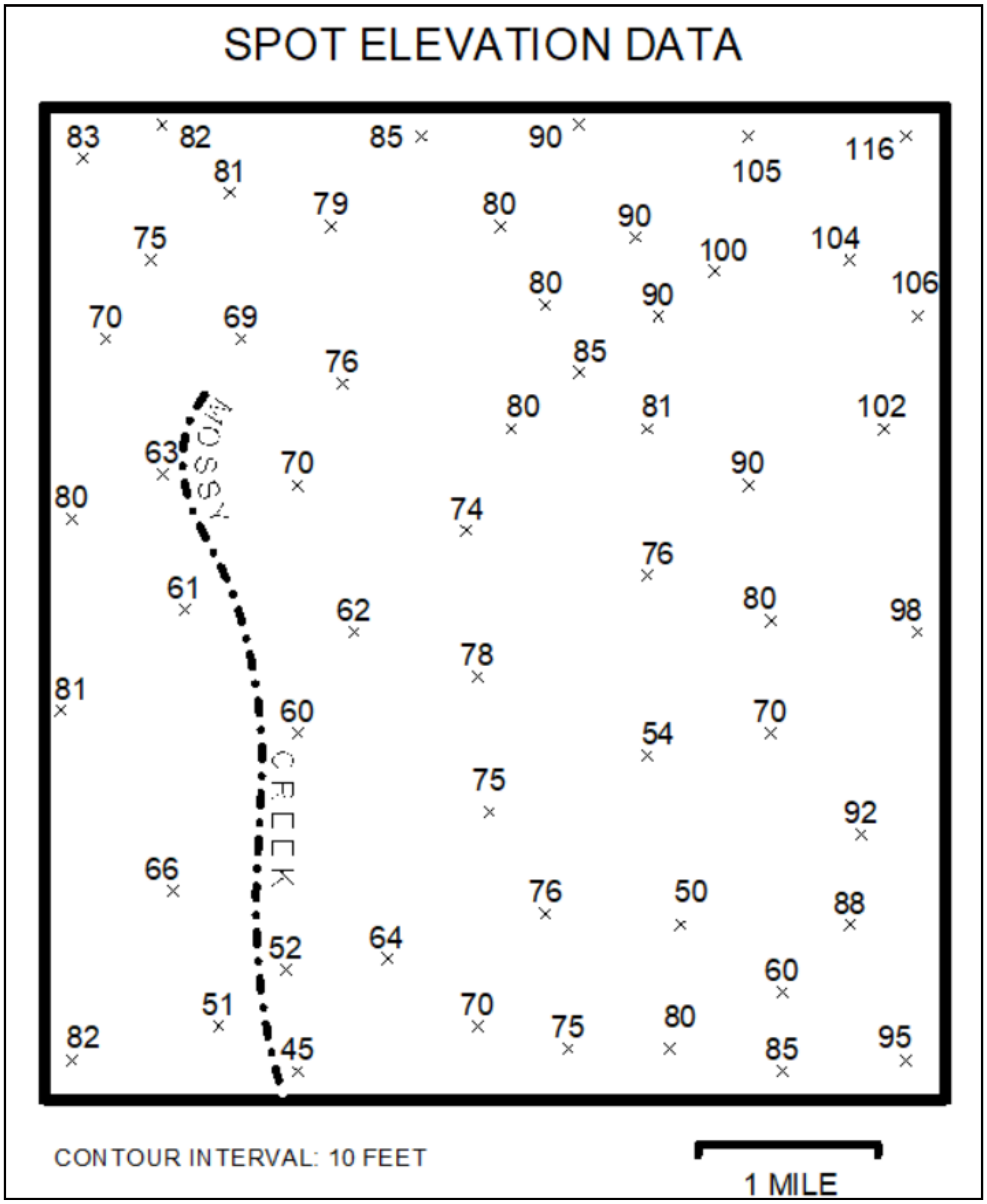

Figure 1. Spot elevations to be used for constructing topographic contours.

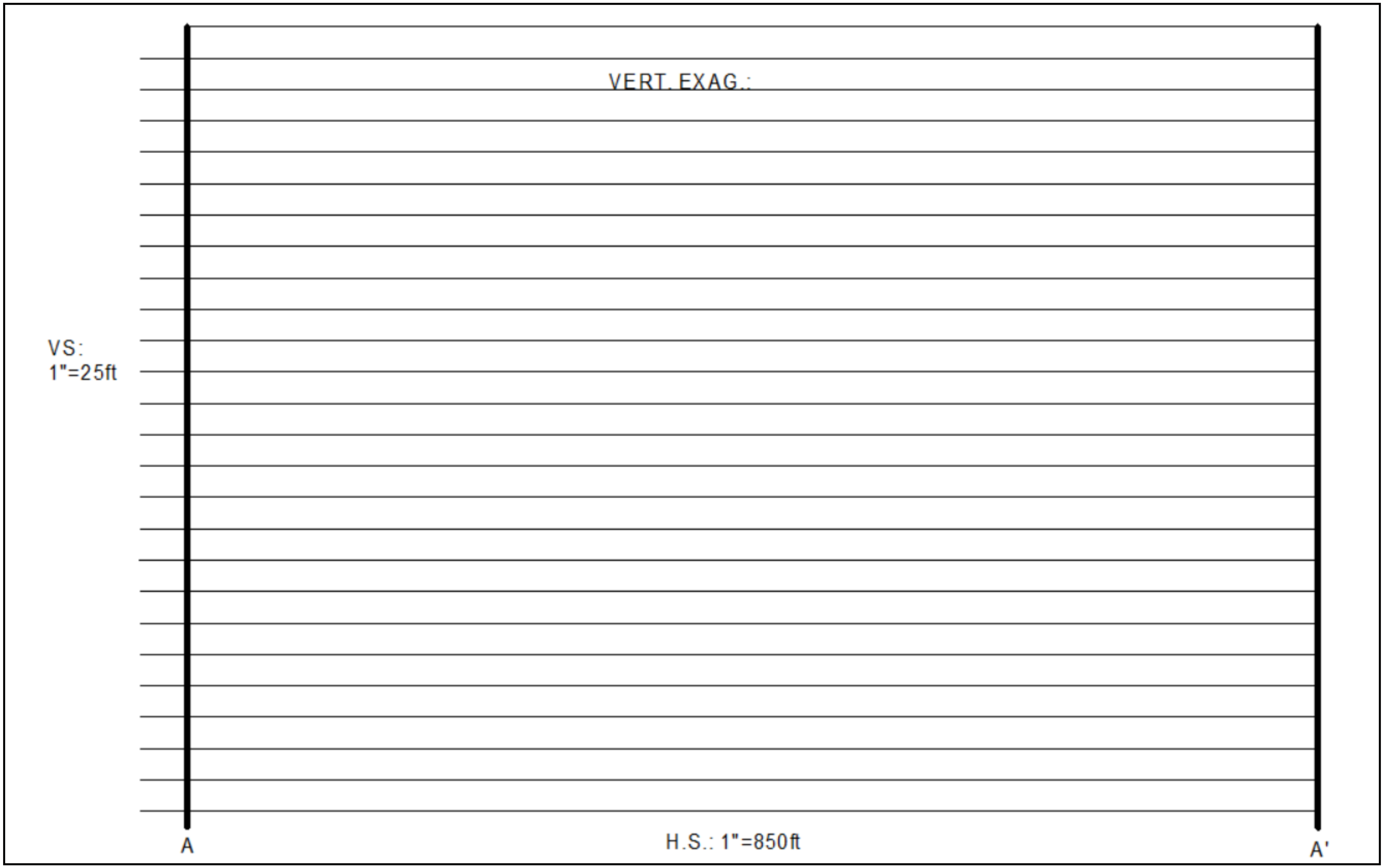

Figure 2. Topographic profile grid for campus map.

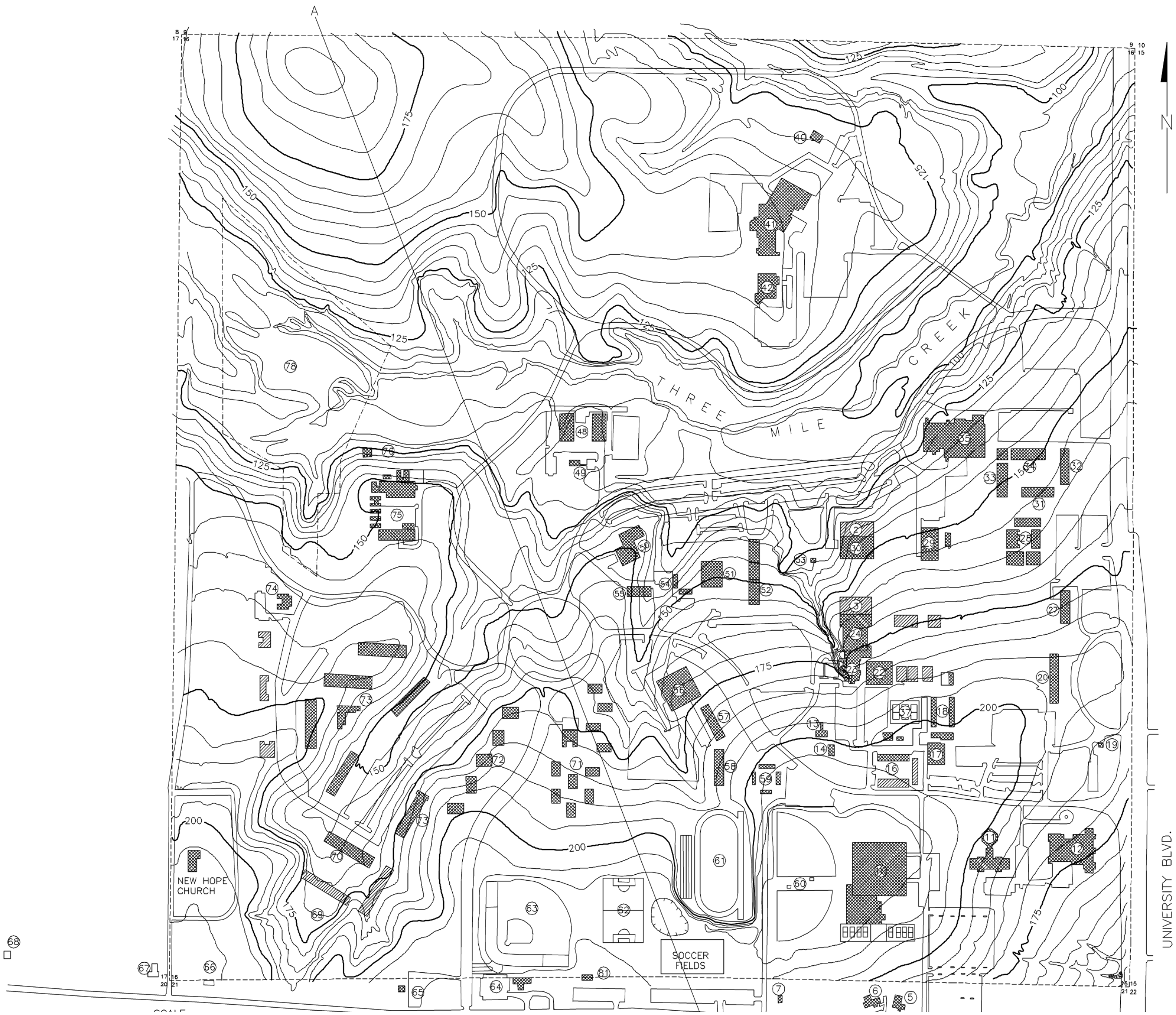

Figure 3. USA campus topographic map.

NOTE: **Figures 1-3** are contained in separate image files (Lab6_Fig*.tif; 150 DPI) that will print to the correct scale – download them on the web site page for GY301:

Figure 1: http://www.usouthal.edu/geography/allison/GY301Llab6_Fig1.tif
Figure 2: http://www.usouthal.edu/geography/allison/GY301/Lab6_Fig2.tif
Figure 3: http://www.usouthal.edu/geography/allison/GY301/Lab6_Fig3.tif