

# Making the Grade! Grading Techniques Using AutoCAD® Civil 3D®

Ron Couillard – CADSoft Consulting

**CV118-6L** AutoCAD Civil 3D has a lot of great tools for performing grading tasks. However, just because there are several different ways to approach grading, it doesn't mean that you have to pick one method and stick with just that one—even in the same project or drawing! In this 90-minute lab, we will cover some basic grading functionality, and we will explore what I refer to as the “Hybrid” method of grading. Simply put, this class will show how you can combine different methods of grading together to get what everyone is looking for—The Finished Grade!

## About the Speaker:

Ron has over 10 years experience in civil CAD construction-document production for commercial, military, and airport projects. He provides technical expertise and training, including software installations and product customization, in the support of AutoCAD® Civil 3D®, AutoCAD® Land Desktop, Civil Design and Survey, and AutoCAD Map 3D software products. He is also an Autodesk Certified Instructor and a Certified Technical Trainer. Ron is also an Implementation Certified Expert in both Civil 3D and AutoCAD Map 3D. In addition, Ron has instructed sessions at Autodesk University as well as at AUGI Cad Camps and various other events.

[ron.couillard@cadsoft-consult.com](mailto:ron.couillard@cadsoft-consult.com)

## Introduction

There are a lot of great tools in Civil 3D to produce grading. The great part about it is that with all of the options, you do not have to stick to one method. You can even combine methods to achieve the grading that you need. Although this class is designed to target all levels, there is a lot to cover and it would be a good idea to download the materials after the session to practice some of the techniques.

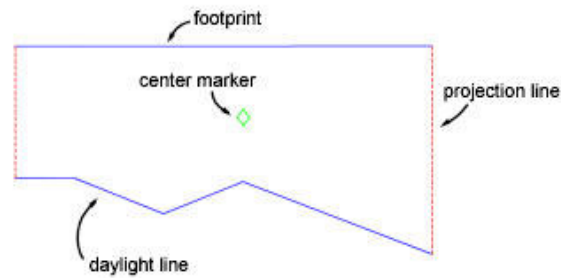
After attending this session, you will be able to:

- Create grading criteria and feature lines.
- Create drainage basins using feature lines and grading criteria.
- Use feature line editing commands and describe what each will do.
- Create grading objects that contain multiple grading criteria and features.
- Explain the process of using multiple feature lines to produce a complex grading object.
- Produce a finished grade surface using grading objects and 3d objects (hybrid method).

## Grading Basics

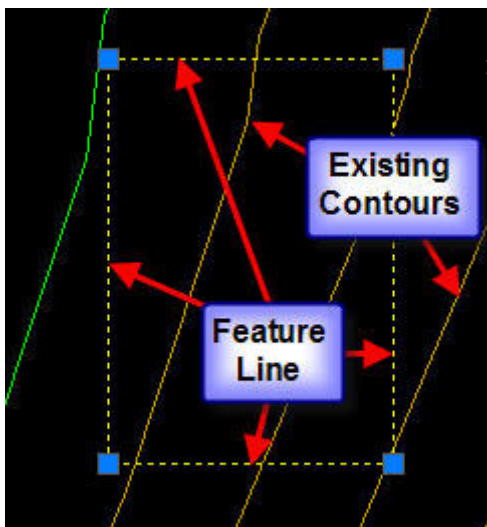
This class was designed to be for all levels so because of this I want to make sure that no one is left behind. So, let's discuss some basics of grading with Civil 3D. We all know what grading is, but grading in Civil 3D has some terminology, settings, and object types that we need to discuss.

First, we will discuss grading objects. What are grading objects? "Grading objects are objects created by grading"! Well, that's an answer that has some truth in it but it's not a complete answer. A grading object usually has a footprint, a daylight line, projection lines, and the face. The face is the area surrounded by the lines that define the grading. It is marked with a center marker which resembles a diamond. **Figure 1** below shows an example of a grading object and its items.



**Figure 1 – Grading Object and Components**

Next, let's talk about feature lines. Feature lines are lines in Civil 3D that we can create grading from. Feature lines are very powerful tools. We can use them the same way we have used 3d polylines in the past. With that being said, they usually have an elevation assigned to them (if not in the beginning then at least in the end resulting grading). A feature line represents an important feature in the drawing, such as the edge of pavement or the bottom of a basin. A feature line can be drawn by hand or created from polylines, lines, and arcs. Feature lines can also be extracted from corridor models. One other thing about feature lines is that it is the only object that grading criteria can be applied to. We will discuss grading criteria shortly. **Figures 2A** and **2B** below show an example of a feature line and its properties. In this example, the feature is for the bottom of a proposed basin that we will create using grading.



**Figure 2A – Feature Line**

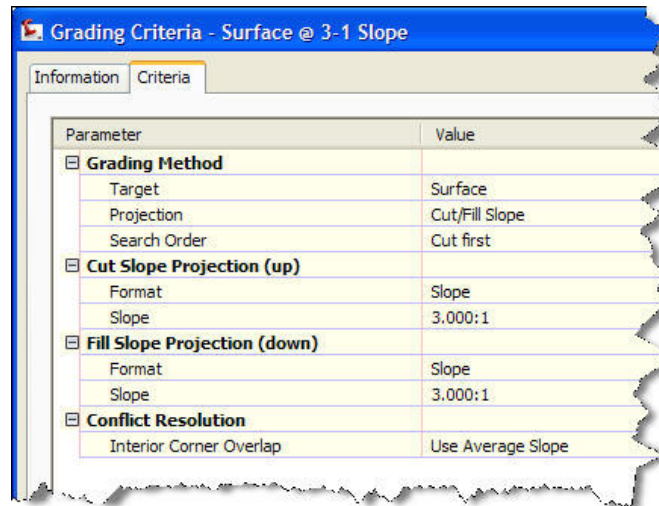
Property	Value
Number of Points	4
PI Points	4
Elevation Points	0
2D Length	152.626m
3D Length	152.626m
Area	1410.81sq.m
Minimum Elevation	198.000m
Maximum Elevation	198.000m
Minimum Grade	0.000%
Maximum Grade	0.000%

**Figure 2B – Feature Line Properties**

Styles for feature lines reside on the settings tab of the toolspace under "general", then "feature line styles". Feature line styles control how the feature line displays. Options such as layer, color and linetype can be controlled through the feature line style.

Now it's time to discuss grading criteria. Grading criteria is actually a setting, well, sort of. It resides on the settings tab of the toolspace. It is where we specify the actual grading methods

and numbers to be performed. For example, if we want to grade to a specific surface at say a 3:1 slope, grading criteria is where we specify this. Once we create the criteria, it is saved in the drawing or drawing template for later use. To use this criteria, it gets applied to a feature line in Civil 3D. Figure 3 below shows an example of grading criteria.



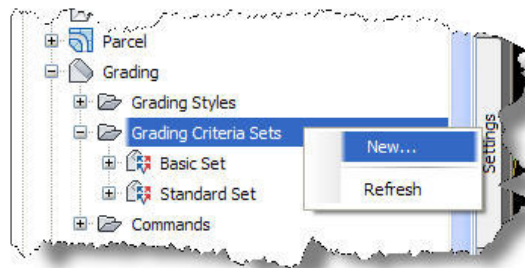
**Figure 3 – Grading Criteria**

Now that we have discussed some of the basics for grading in Civil 3D, let's start to work on some of the exercises for this class.

### **Exercise 1 – Creating Grading Criteria and Criteria Sets**

For the first exercise, we will create the grading criteria and criteria set that will be used for future exercises. Use the following steps to guide you through this exercise:

1. Open the "grading criteria.dwg" file in the exercises folder.
2. If the toolspace is not open, turn it on by either typing in "toolspace" or by going to the "home" tab of the ribbon and clicking on the "toolspace" button.
3. Go to the settings tab of the toolspace.
4. Expand "grading", then "grading criteria sets". Notice that currently there are two criteria sets, "basic set" and "standard set". We will create a new criteria set.
5. Right click on "grading criteria sets" and choose "new" as shown in **figure 4** below.



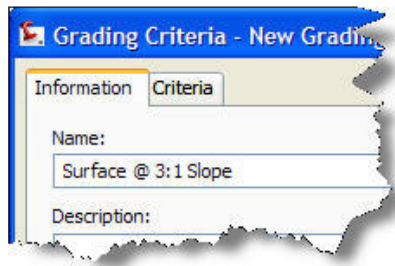
**Figure 4 – Create New Grading Criteria Set**

6. In the grading criteria set properties dialog box we will enter a name and a description.
7. For the name, enter "Basin Criteria".
8. For the description, which is totally optional, enter "criteria used to create basins" then click "ok".
9. Notice that there is now a new criteria set created but unlike the others, there is no "+" sign next to it. This is because there are no criteria under the set. We will now create a new grading criteria under the criteria set.
10. Right click on the newly created "basin criteria" and choose "new" as shown in **figure 5** below.



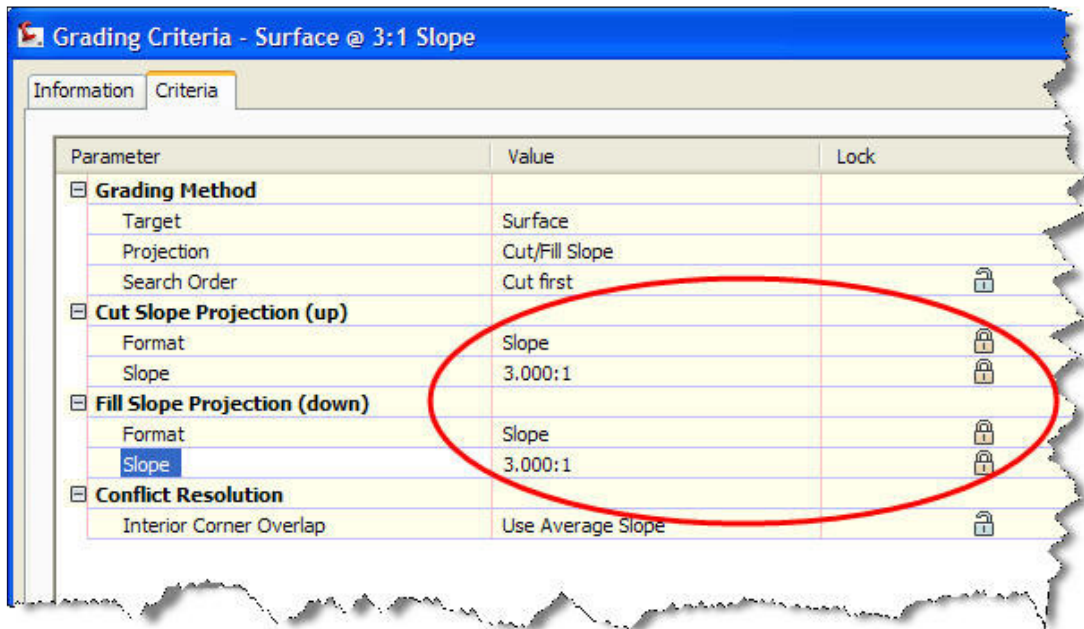
**Figure 5 – Create New Grading Criteria**

11. In the "grading criteria-new grading criteria" dialog box, go to the information tab.
12. For the name enter "Surface @ 3:1 Slope" as seen in **figure 6**.



**Figure 6 – New Grading Criteria Name**

13. Next, go to the "criteria" tab to begin input of the grading criteria properties. For all of the entries we will put in here, you will be able to refer to **figure 7**.
14. First, under "grading method" click in the value column for "target". Notice that there are four targets to choose from. For this example we will use "surface".
15. We will leave "projection" and search order" as is.
16. Next, under "cut slope projection" and "fill slope projection", we will ensure that for "format", "slope" is selected and locked.
17. Lastly, for both "slope" values enter "3:1" and lock those values as shown in **figure 7**, and click "ok".
18. You may be asking why we locked some values down. If you look at the values that were locked, they match the name of the grading criteria. If the values are not locked down, you will be prompted at the command line to choose from the available properties or to enter a specific value. When the values are locked, you are not prompted thus saving you clicks.

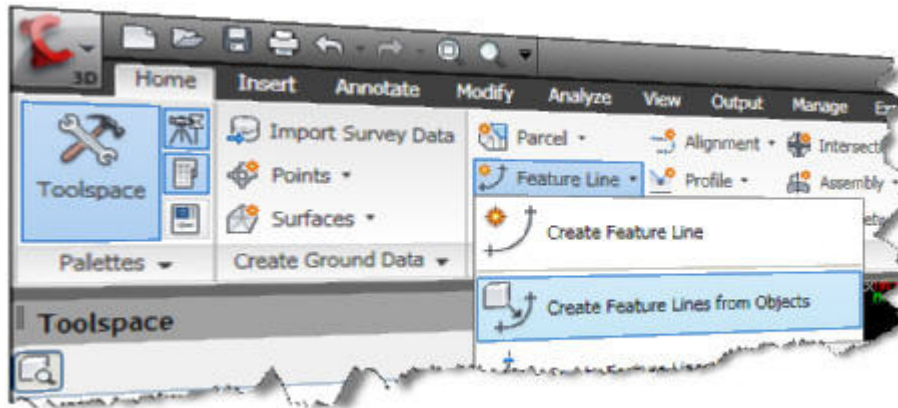


*Figure 7 – Grading Criteria Properties*

## Exercise 2 – Creating a Feature Line and a Basin

For this exercise, we will first create a feature line from an existing object. Then we will create a basin using the newly created feature line from object by applying the grading criteria we created in the last exercise to the feature line. Use the following steps to guide you through this exercise:

1. open the "feature line and basin.dwg" file in the exercises folder.
2. Zoom into the rectangular shape in the Northeast corner of the surface.
3. Once zoomed in, select the object and type in "li" for list to review the object's properties. Notice that it is a polyline that has an elevation assigned to it. This elevation was calculated for the bottom of the proposed basin that we will create. If an elevation was not pre-assigned then you have the option of assigning elevations during the feature line creation process as you will see shortly.
4. After looking at the object's properties, go to the "home" tab of the ribbon. On the "create design panel click on the "feature line: button and then choose "create feature lines from objects" as shown in **figure 8** below.

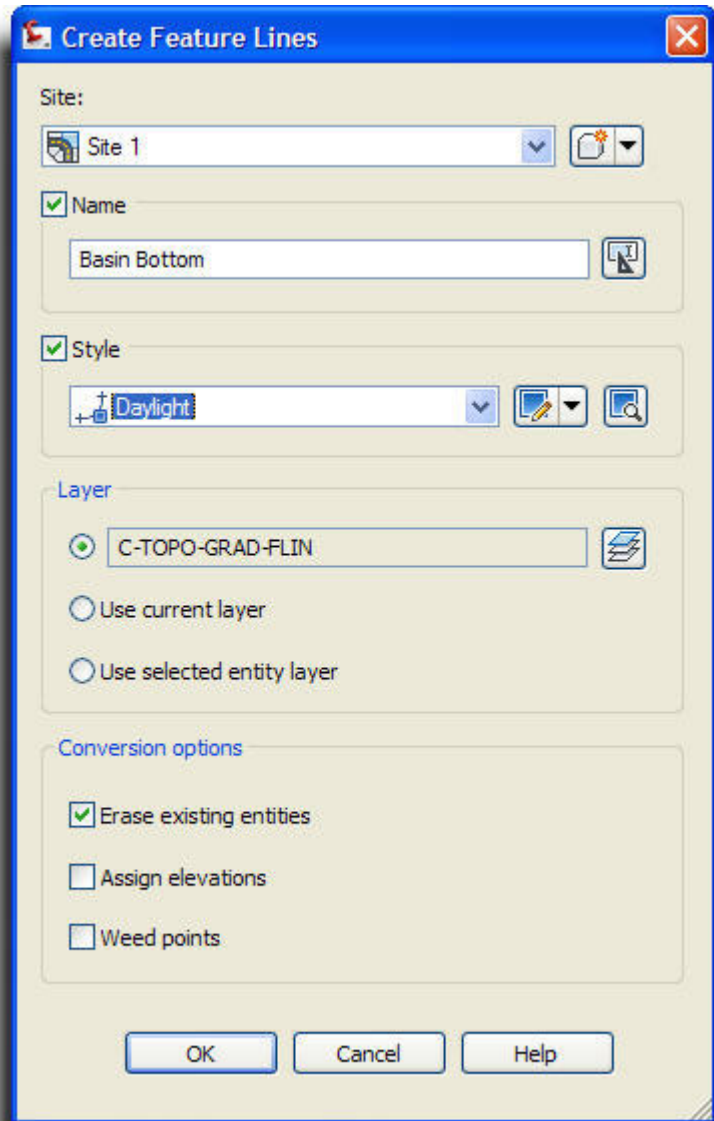


**Figure 8 – Create Feature Lines from Objects**

5. When prompted to select objects, select the rectangular polyline, and right click to select enter to turn it into a feature line that will become the bottom of the new basin. The next steps refer to **figure 9** below.
6. When the “create feature lines” dialog box appears, first, choose the site that you want the feature line to be placed on. If you are using multiple sites it is important that you choose the correct site.
7. Next, click on the “name” option and enter the name “basin bottom” as shown in **figure 9**. By naming your feature lines, it will make it easier for management when you have several in your drawing.
8. The next option in this dialog box is the style option. If you want your feature line to look like a specific style then you can choose this option and select one. For this exercise we will use the “daylight” style as shown in **figure 9**.
9. Next in this dialog box is the layer for the feature line to be placed on. For this exercise we will accept the default layer as shown in **figure 9**. Note the other layer options as well.



10. Lastly before clicking "ok" notice the choices for "conversion options". For this exercise, we will choose to erase the existing entities. **\*NOTE\*** If an elevation was not already assigned to the object selected to create a feature line, then you would check on the "assign elevations" option. With this option selected, when you click "ok", it brings you to another dialog box that gives you three choices for assigning elevations:
  1. enter an actual elevation.
  2. elevations from gradings.
  3. elevations from a surface.
11. Finally, click "ok" and you will notice that the rectangular object is now yellow. It has taken on the "daylight" feature line style. If you click on it, you will notice that the contextual feature line ribbon tab appears. This gives us access to feature line related commands without having to go dig for them.



**Figure 9 –Create Feature Lines Dialog Box**

12. Now that we have our feature line created it is time to create our basin so go to the "home" tab on the ribbon. On the "create design" panel click on the "grading" button and select the "grading creation tools" command as shown in **figure 10** below.
13. This command will bring up the "grading creation tools" toolbar as shown in **figure 11**.

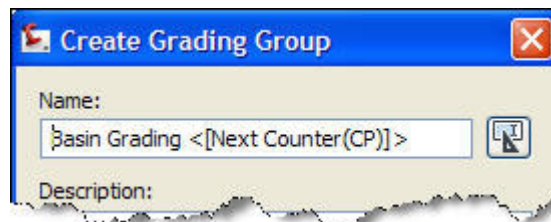


**Figure 10 –Grading Creation Tools**



**Figure 11 – Grading Creation Tools Toolbar**

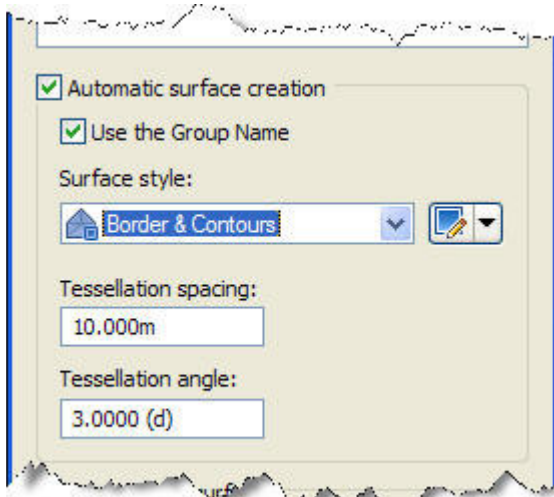
14. On the grading creation tools toolbar, we will select each of the first few buttons starting from the left side.
15. Select the first button which is to set the grading group. If a grading group has not been created then the "create grading group" dialog box will appear.
16. First, give the grading group a name. For this exercise, we will call the group "Basin Grading" as shown in **figure 12**.



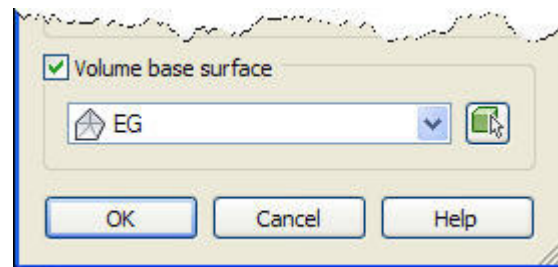
**Figure 12 – Grading Group Name**

17. Next, click on the option for "automatic surface creation" as shown in **figure 13**. This will allow for a surface to be created from the grading object. Leave the box checked on for "use the group name" as the new surface will be called "basin grading".

18. Change the surface style to "border & contours" as shown in **figure 13**.
19. Next, check on the box for "volume base surface" and select "eg" from the drop down list as shown in **figure 14**.

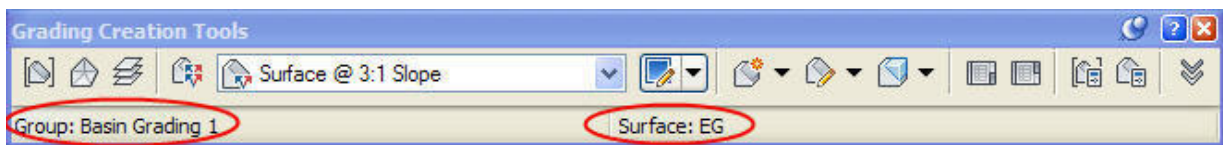


**Figure 13 – Automatic Surface Creation**



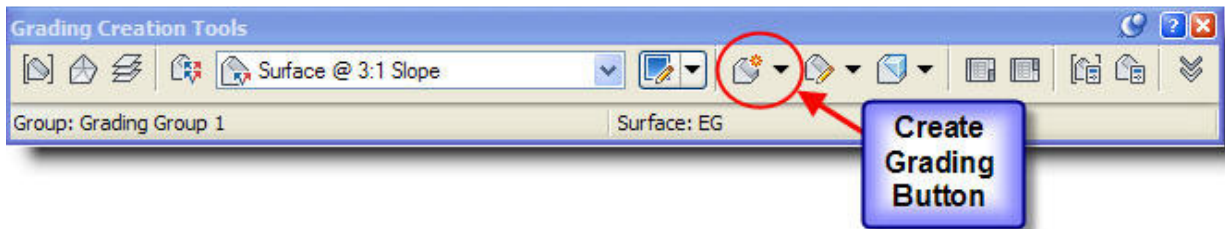
**Figure 14 – Volume Base Surface**

20. Now click the "ok" button and the "create surface" dialog box appears. The surface settings should be the same as what we had selected when we chose to automatically create a surface. Review the settings and click the "ok" button.
21. At this point you will notice that both the grading group and the target surface are set as seen in **figure 15** below. Because of this we can jump over to the third button on the "grading creation tools" toolbar which is the "set the grading layer" button.



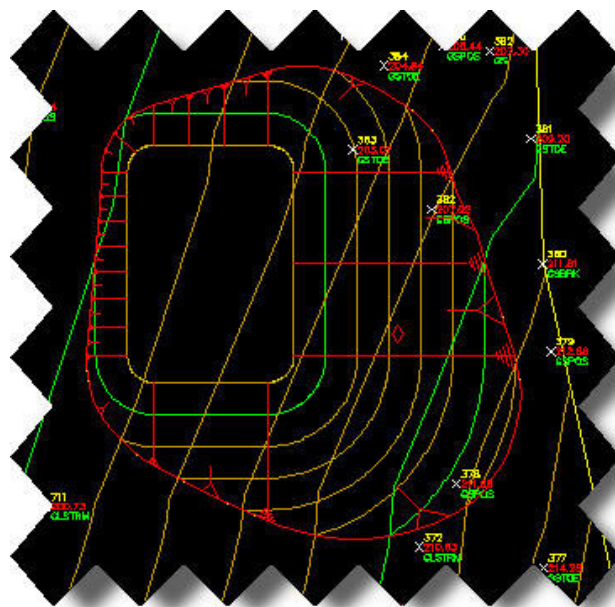
**Figure 15 – Grading Group and Target Surface**

22. Check to see that the layer is set to "c-topo-grad" for this exercise.
23. Next, click the fourth button which is the "select a criteria set" button. In the resulting dialog box select "basin criteria", then click the "ok" button. At this point you will notice that the grading criteria we created earlier will be visible in the window of the toolbar.
24. We are now ready to apply the grading criteria that we created earlier. Go to the "create grading" button as indicated by **figure 16** below.

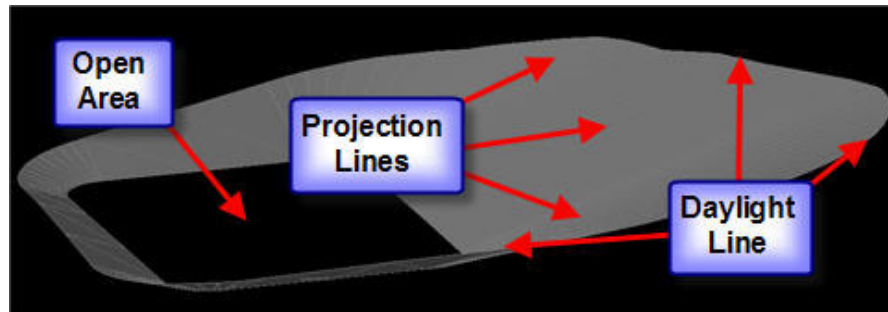


**Figure 16 – Create Grading Button**

25. After selecting this button you will be prompted to select the feature. At this point select the basin bottom feature line.
26. Next, you will be prompted to select the grading side. Pick anywhere on the outside of the feature line.
27. You will then be asked if you want to “apply to entire length”, meaning apply the grading to the entire geometry of the feature line. For this exercise choose “yes”.
28. At this point you will have a grading object and a surface that looks like **figure 17** below.
29. Click on one of the new contours to select the surface, then right click and choose “object viewer” to see the surface in 3D. **Figure 18** shows the results. Notice the open area at the bottom of the basin that will need to be filled in.



**Figure 17 – Grading Object and Surface**



**Figure 18 – Grading Surface Components**

30. To fill in the bottom area of the basin we will use the “create infill” command as shown in **figure 19**.



**Figure 19 – Create Infill Command**

31. You will then be prompted to “select an area to infill”, at which point you will select in the middle of the bottom of basin.

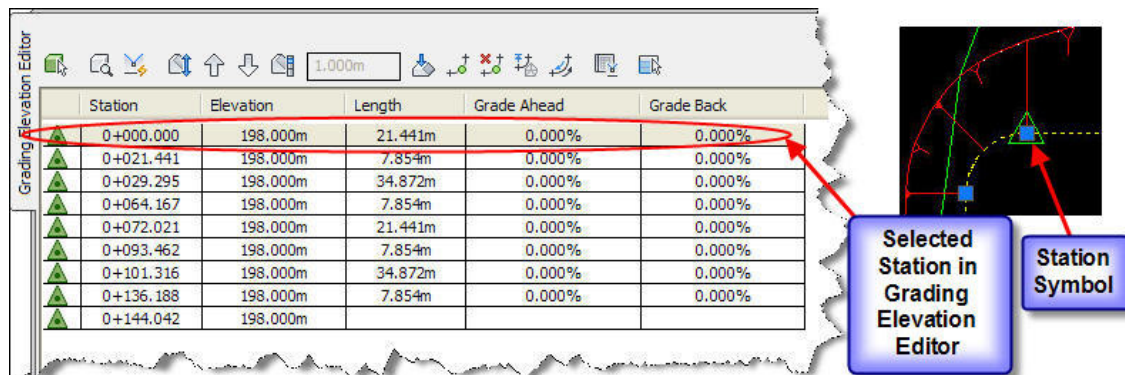
32. Right click to enter and you will notice a diamond shape in that area. This is the symbol to show that the area has been filled in. If you now look at the surface or grading object in the object viewer you will see that the bottom has been filled in. We now have a completed basin! Leave this drawing open so we can use it for the next exercise.

### **Exercise 3 – Feature Line Editing**

For this exercise, we will use feature line editing commands to edit the basin that we just created. We will be able to perform edits such as elevation changes and geometry changes. Let’s get started! First, let’s do some elevation editing. We can access feature line editing commands in one of two ways: 1. from the “modify” tab on the ribbon. 2. from selecting the feature line and then accessing the commands from the contextual ribbon.

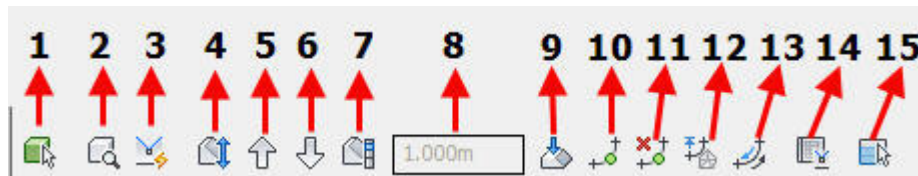


1. First, to be able to easily select the feature line, select the surface and change its style to “\_no display”.
2. Select the feature line to make the contextual ribbon available. On the “modify” tab you will see the “edit elevations” button. Select it to make the “edit elevations” panel visible.
3. On the “edit elevations” panel select the “elevation editor” button which will bring up the “grading elevation editor” inside of the panorama window. **Figure 20** below shows the elevation editor and also shows an inset picture that shows the station symbol on the feature when a specific station is selected in the elevation editor.



**Figure 20 – Grading Elevation Editor**

4. In the panorama we can edit elevations, lengths, grades, etc. For this exercise, edit the elevation of station 0+000 by raising it to 200m. Observe the changes to the grade ahead and grade back in the panorama and the changes to the grading object in the model.



**Figure 21 – Grading Elevation Editor Buttons**

5. Let's briefly take a look at each one of the tools in the editor from left to right as shown in **figure 21** above: 1. select a feature line 2. zoom to 3. quick profile 4. raise/lower

5. raise incrementally 6. lower incrementally 7. set increment 8. increment window 9. flatten grade or elevations 10. insert elevation point 11. delete elevation point 12. elevations from surface 13. reverse the direction 14. show grade breaks only 15. unselect all rows.

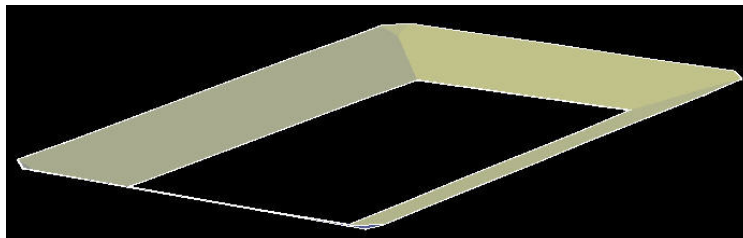
6. Take some time to try some of these editing commands and observe the changes.

#### **Exercise 4 – Using Multiple Grading Criteria and Feature Lines**

For this exercise, we will use multiple grading criteria and multiple feature lines to produce a complex grading solution.

1. Open the "feature lines-merged.dwg" file.
2. Go to the "home" ribbon tab on the "create design" panel and select the "grading" button. Then select "grading creation tools".
3. As we did previously, start with the first button to the left to select or create the grading group.
4. In the "create grading group" dialog box, enter the name "complex basin".
5. Turn on the options for "automatic surface creation" and "use the group name".
6. Change the surface style to "contours 1m and 5m (design)".
7. Turn on the option for "volume base surface" and ensure that "eg" is selected, then click "ok".
8. In the "create surface" dialog box, ensure that the settings match what we previously specified and click "ok".
9. On the "grading creation tools" toolbar click on the "select a criteria set" button. Choose "basin criteria" and click "ok".
10. First, we will grade the inner feature line. From the drop down list for criteria choose "grade to distance @ slope", then click the "create grading" button.

11. When prompted to select the feature, pick the inner most feature line and pick to the inside of it when prompted to select the grading side.
12. Accept the default "yes" to apply the criteria to the entire length of the feature line.
13. When prompted to specify distance enter "10" for 10 meters and click enter.
14. When prompted to select the slope enter "-3" so that it grades to a minus 3:1 slope.
15. Observe the results in the drawing and select one of the new contours, then, right click and select "object viewer". Your grading should look like **figure 22** below.



**Figure 22 – Grading @ -3:1 Slope**

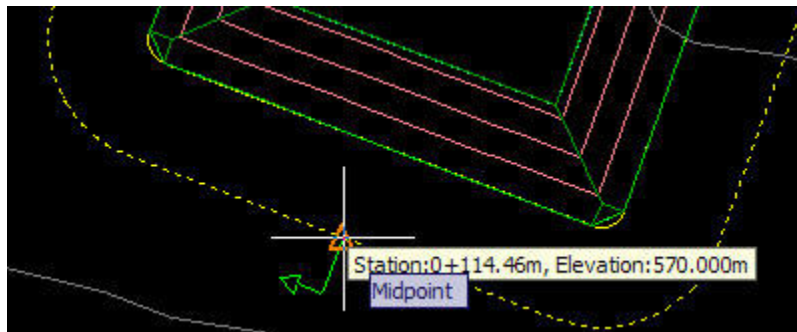
16. At this point let's create an infill for the bottom area of the basin in the same manner that we did in the previous exercise.
17. Now that our basin bottom is filled in, let's apply grading to the outer feature line. On the "grading creation tools" toolbar, click the dropdown for criteria and select the "surface @ 3:1 slope" criteria.
18. Click the "create grading" button and when prompted to select the feature select the outermost feature line.
19. When prompted to select the grading side select the outside of the feature line.
20. This time for "apply to entire length" type in "n" for no. We will apply this criteria to one half of the feature and another criteria to the other half.
21. Using the midpoint osnap select the point on the feature line as shown on **figure 23a** to select the beginning point to apply the criteria and click enter. Then using the



midpoint osnap select the midpoint as shown on **figure 23b** to select the ending point to apply the grading to then click enter and observe the results.

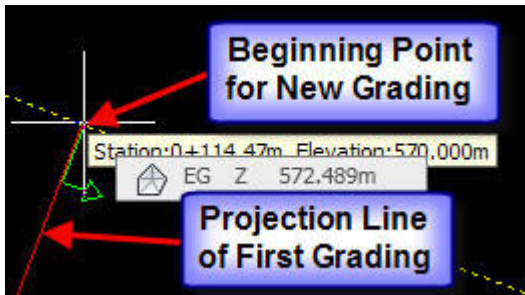


**Figure 23a – Beginning Grading Point**

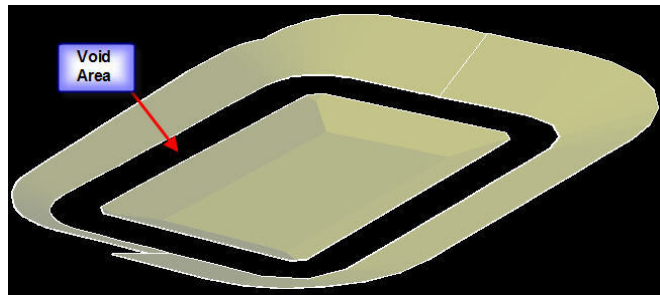


**Figure 23b – Ending Grading Point**

22. Now we will apply different criteria to the other half of the feature line. On the “grading creation tools” toolbar, select “grade to distance @ slope” from the criteria pulldown.
23. Select the “create grading” button and when prompted to select the feature, select the outer feature again as before.
24. Pick the outside for the grading side again and this time, go to the southernmost side of the feature line first and pick close to the same points as before as shown in **figure 24**. Notice the direction of the green arrow. Do not select the same points as it will override the previous grading applied to this feature line.
25. Press enter after each point selection. When prompted to enter a distance enter “20” for 20 meters and press enter. When prompted to enter a slope enter “3” for a 3:1 slope and press enter. Observe the results in the drawing. Your grading should like the grading in **figure 25** when viewed in the object viewer.



**Figure 24 – Beginning Grading Point**



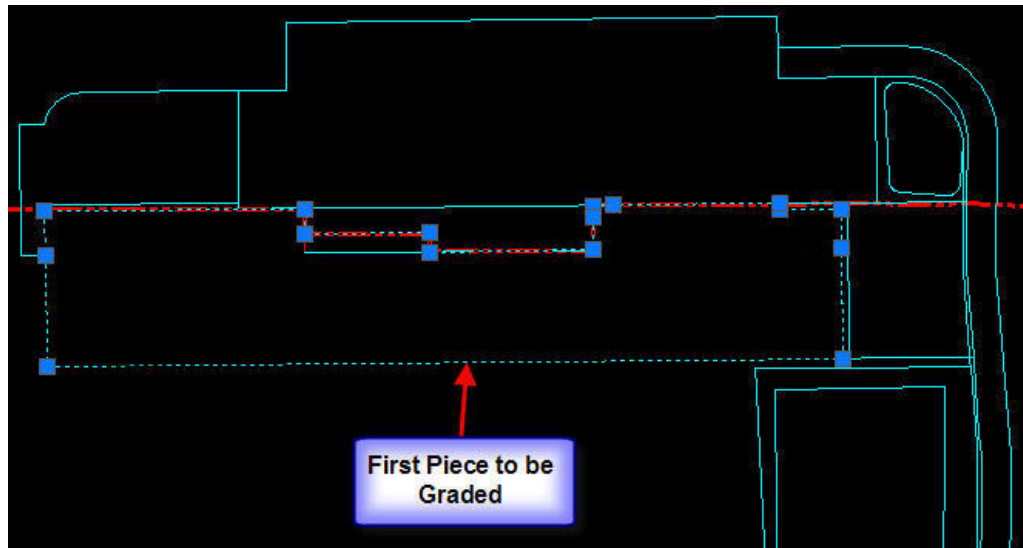
**Figure 25 –Grading Surface**

26. At this point all that is left is to create an infill for the void area between the two feature lines as shown in **figure 25**. Notice how all of the grading that we have done has created one finished surface. This is because all of the feature lines belong to the same grading group. If we had created the feature lines on different grading groups then each grading would have produced its own separate surface.

### **Exercise 5 – The Hybrid Surface Creation Method**

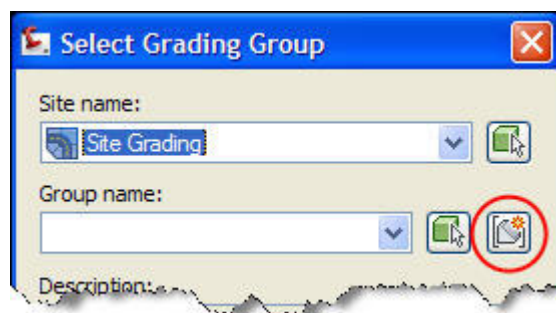
For this last exercise, we use feature lines in a couple of different ways to create a surface; we will apply grading to the feature lines as we had done previously and we will simply just add some feature lines to a surface. We will also apply some of the techniques we learned in previous exercises such as applying grading only to certain points. In this example the red polyline in the drawing represents a no disturb area that we can not grade into. We will grade up to this boundary as another agency will handle the grading inside of the boundary. As far as the other elements in this drawing, the majority of the linework had been turned into feature lines already to save time. Converting polylines into feature lines is a good practice as the feature lines give us a bit more flexibility. For this exercise we will only grade a few of the feature lines, not everything. There are a few key things to remember to get this method to work for you; 1. remember to have all the feature lines that you want for a specific surface to be in the same grading group. If they are in different groups different surfaces will be produced. 2. if you are working with complicated shapes for feature lines, it is a good idea to chop them up into smaller ones. One thing you can try before chopping up feature lines is apply grading along portions of the feature line, not along the entire length. Be sure to save and save often! With that being said, let's get started!

1. open the "grading base.dwg" file.
2. to start, we will grade the part indicated in **figure 26** below.



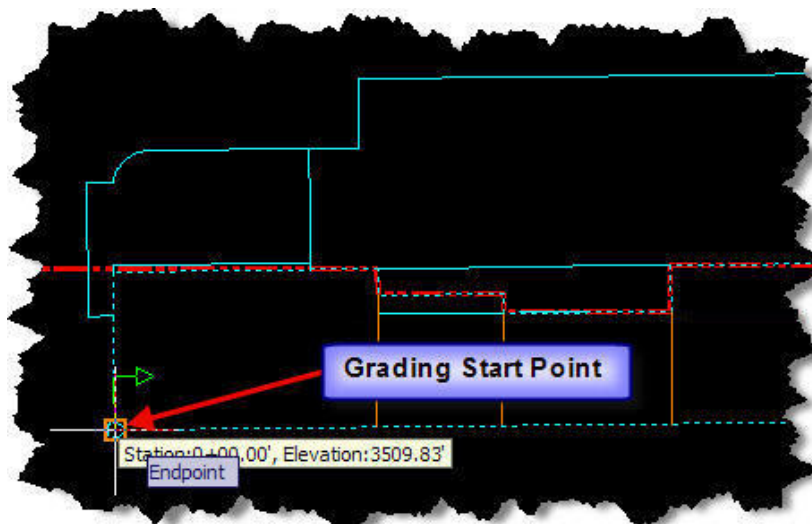
**Figure 26 – First Grading Piece**

3. as we did in the previous exercises go to the "home" tab on the ribbon. On the "create design" panel click on the "grading" button and select the "grading creation tools" command.
4. on the "grading creation tools" toolbar select the "set the grading group" button.
5. in the "select grading group" dialog box click on the "create a grading group" button as indicated in **figure 27**.



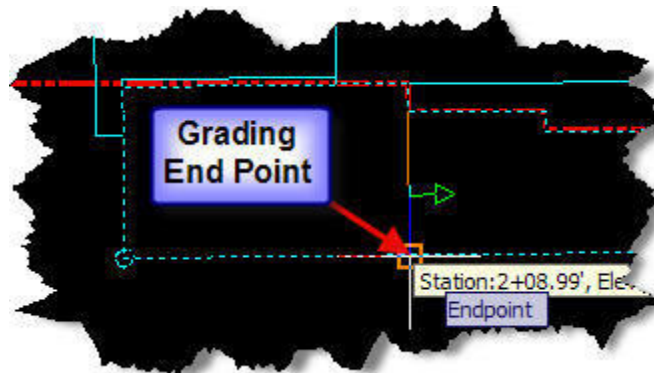
**Figure 27 – Create a Grading Group Button**

6. in the "create grading group" dialog box, enter the name "proposed grading" if it is not already present. Turn on the options for "automatic surface creation" and "use the group name". Then select "triangles only" for the surface style and click "ok". Since we do not have an existing surface the volume surface option is not available.
7. verify the settings in the "create surface" dialog box and click "ok" and then click "ok" in the "select grading group" dialog box.
8. **\*NOTE\*** before we can pick grading points we need to thaw the layer "C-CNST-LINE" so that we can see the construction lines for our grading points. Choose the "grade to distance" criteria from the drop down on the "grading creation tools" toolbar, then click the "create grading" button.
9. when prompted to select a feature select the feature line a previously shown in **figure 26** above.
10. for the grading side select in the middle of the feature line and for "apply to entire length", type in "n" for no.
11. for the starting point, use the endpoint osnap and select the lower left corner of the feature line as shown in **figure 28** which should show as station 0+00. Click enter to accept this station.



**Figure 28 – Beginning Grading Point**

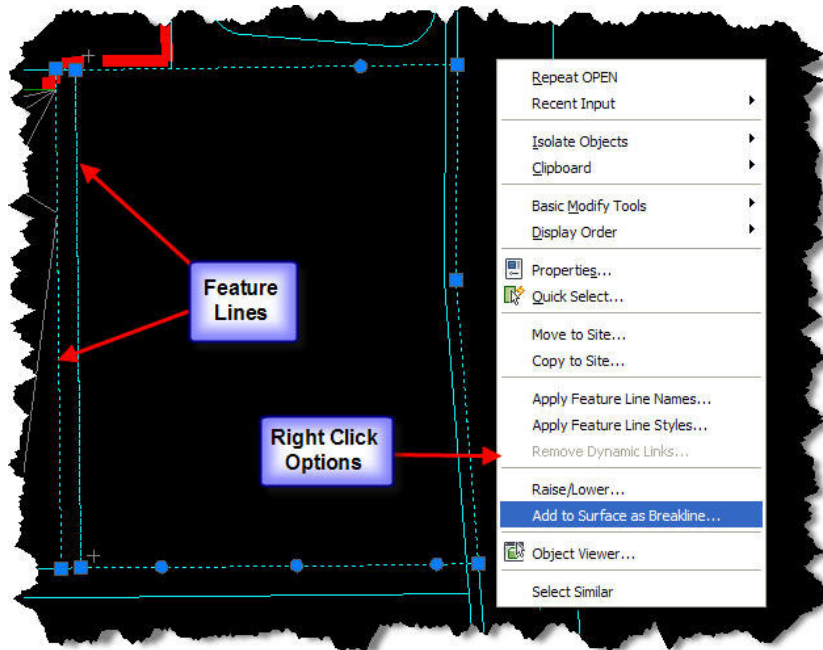
12. For the next point we will use the endpoint of the orange construction line to the east as shown in **figure 29**. This station should be 2+08.99. Click enter to accept this station.



**Figure 29 – Ending Grading Point**

13. when prompted to specify the distance enter "125". This will take our first grading pass out to the first encountered limits.
14. when prompted to specify the grade enter "-.50%". Click enter and observe the new grading in the drawing. Now that we have done our first pass we will fill in the rest of the grading on this feature line to be able to fill in the rest up to the limits.
15. we will start next to the point we finished the previous grading at. We will get close to the previous end point and when we see station 2+08.99 we will accept it.
16. Then we will go to the endpoint of the next orange line and use that as the ending point.
17. When prompted for the distance enter "104.33" and when prompted for the grade hit enter to accept the default of "-.50%".
18. At this point, fill in the remaining three pieces of grading using the following distances in order from the next piece to the right: 1. 89 2. 125 3. 120.
19. After filling in the last three pieces, our final step for this exercise is that we will add two already graded feature lines to our surface. Select the feature lines as shown in

**figure 30** below then right click and select “add to surface as breakline”. Click “ok” in the “select surface” dialog box and the “add breaklines” dialog box.



**Figure 30 – Feature Lines Added to Surface**

20. Notice that the feature lines were added to the surface without the need of applying grading to them. If polylines are turned into featurelines you will have this right click ability. If not, polylines can be added to a surface through surface edits.

## Conclusion

In this class we started by covering grading basics. We then covered creating grading criteria and criteria sets. Next we covered how to create a feature line from an object and then we created a basin from it by applying the grading criteria we had created to the feature line. After that we did some feature line editing and discussed some of the editing commands and what they will do for us. Then we covered using multiple grading criteria and multiple feature lines to produce a complex grading solution. Finally we went over the “hybrid surface creation method” which consisted of using grading and 3d objects such as feature lines or polylines to create a surface. Hopefully the methods learned from this class will help you in “Making the Grade” for your projects.