SOUTH DAKOTA NRCS CIVIL 3D 2010 DRAFTING NOTE

DAM – GRADING

CREATING A DAM EMBANKMENT AND THE AUXILIARY SPILLWAY

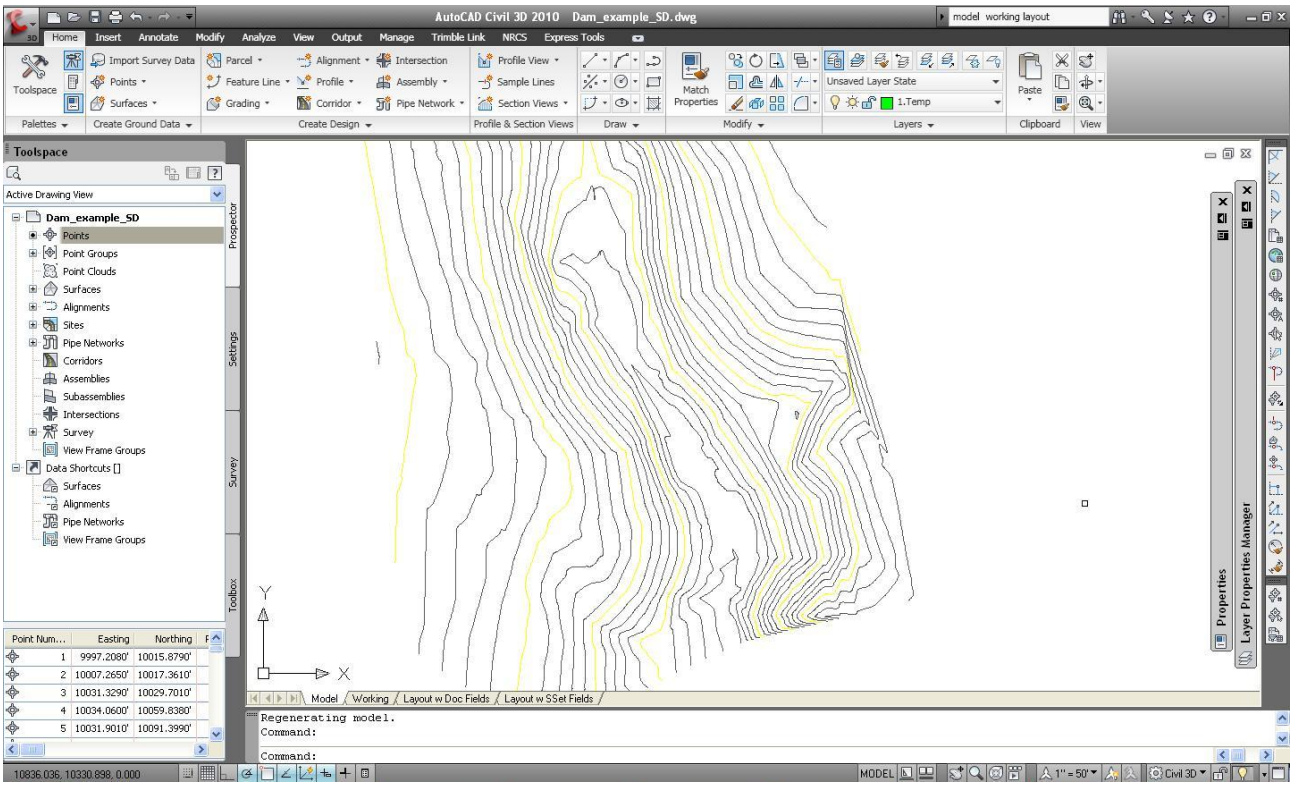
The design of a dam using Grading is going to be demonstrated in AutoCAD Civil 3D 2010. The following design parameters for the dam are going to be used. The top width of the dam is 12 feet with 3:1 sideslopes. The auxiliary spillway is 60 feet wide with a level inlet and a 5% slope outlet. The elevations for the example are 1745.0 for the top of dam, 1742.0 for the auxiliary spillway, and 1740.0 for the inlet of the principal spillway. A berm is going to be placed on the upstream or pool side of the dam. The berm is 16 feet wide with an elevation change of 1.2 feet across the width. The elevations are 1740.4 and 1739.2 for the edges of the berm. For more information, see MN NRCS AutoCAD Civil 3D Quick Reference Guide Section 800 for grading.

In this example, the auxiliary spillway and dam embankment will be created in the Site (in Toolspace) called Dam.

Add Contour Line for the Top of Dam

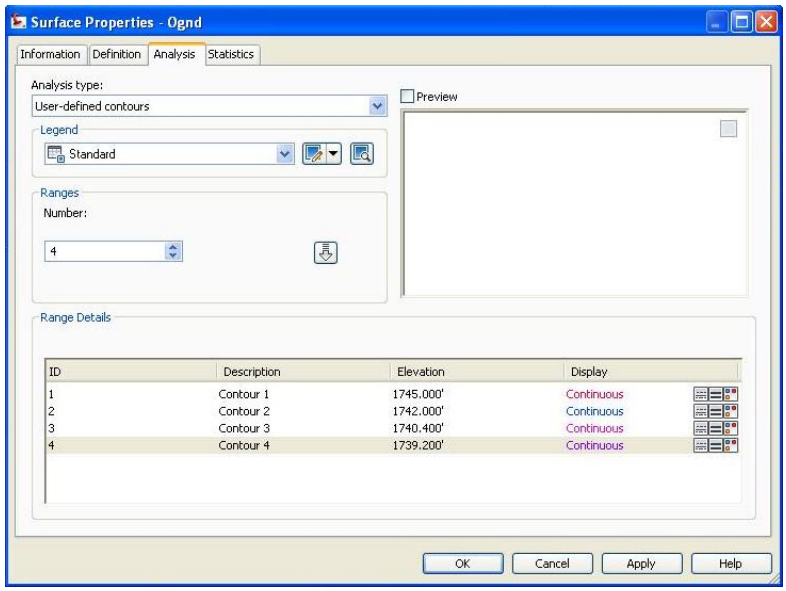
The first step is to start with a survey and have a ground surface developed and in this example is called Ognd. Note that the intermediate contours (layer C.Topo.Ognd.Intr) have their color changed from the Red (20) to Gray (252) in the Layer Properties Manager for clarity in the example.

Figure 1: Screen view of the Civil 3D 2010 with the Toolspace on the left and the Ognd Surface displayed with contours with major interval at 10 feet and minor interval at 2 feet.



Now add contour lines at elevations 1745.0, 1742.0, 1740.4, and 1739.2 to aid in drawing in the top of the dam, auxiliary spillway, and the wave berm. Right click on the Ognd Surface in the Toolspace and click on Surface Properties. Go to the Analysis tab in the Surface Properties window (Figure 2) and change the Analysis Type to User – Defined contours. Change the Ranges Number to 4 and click on the down arrow to the right. Change the elevations for ID 1, 2, 3, and 4 in the Range Detail Box to the four elevations.

Figure 2: The Surface Properties window with the Analysis tab open.



Create Feature Lines for Top of Dam

In Civil 3D, a site is a collection of parcels, alignments, grading objects and feature lines that share a common topology. Civil 3D objects that are on the same site are related to and interact with each other. Objects that react to each other are called site geometry objects. First a new Site will be created in the Toolspace under Sites. Right click on and then select New and call the new Site Dam. This site will contain the feature lines that will be created for the top of the dam. A feature line is a 3d line with an x, y, and z dimensions and is recognized when using grading commands.

Using the Polyline from the Draw panel on the Home ribbon tab, draw the centerline of the dam and snap to the elevation 1745 contour at each end. The polylines can be converted to feature lines. Offset the centerline 6 feet on both sides using the offset command on the Modify panel. After offsetting the centerline, notice how the upstream and downstream top of dam edges are too long or too short from the 1745 contour line in Figure 4.

Figure 3: The draw polyline on the Home Ribbon.

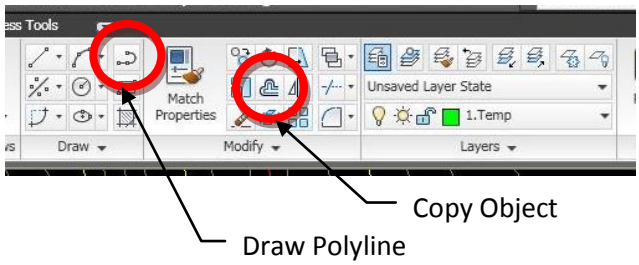
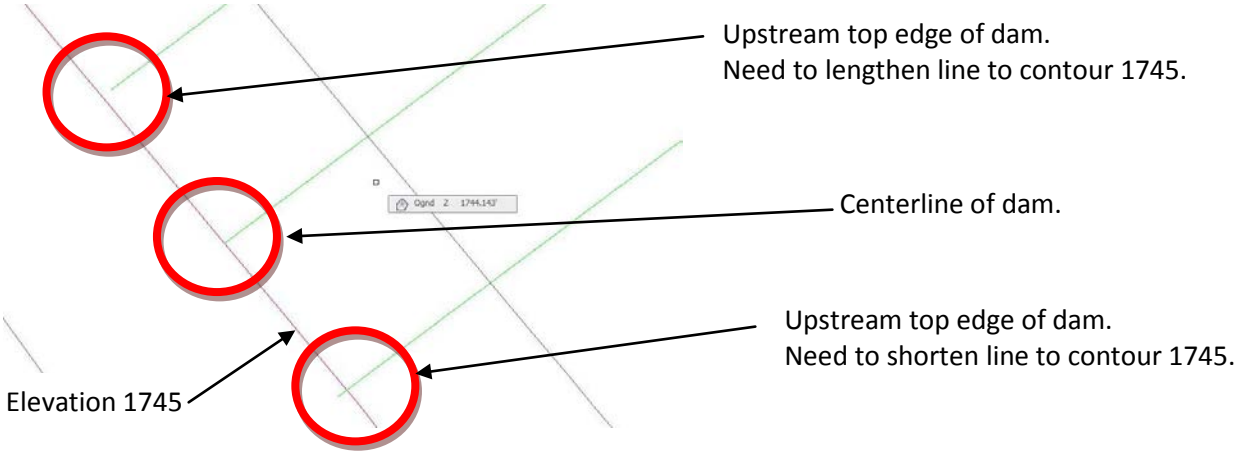


Figure 4: Polylines for the top of the dam at elevation 1745.



In order to trim or extend the lines, the contour lines need to be made into polylines. On the Modify Ribbon Tab, click on Surface under the Ground Data Panel. This will bring up the Surface ribbon contextual tab. Click on the Extract Objects. Now select the Ognd Surface and this will open a window. Just have the User Contour checked. The major and minor contours do not need to be extracted. Now the three user contours at elevations 1745, 1740.4 and 1739.2 have polylines created. The 1749.4 and 1739.2 polylines can be deleted. Now the top of the dam polylines can be trimmed or extended to the 1745 contour polyline as shown in Figure 6. Once the top of dam polylines are trimmed or extended, the 1745 contour polyline can be deleted.

Figure 5: Extract objects command

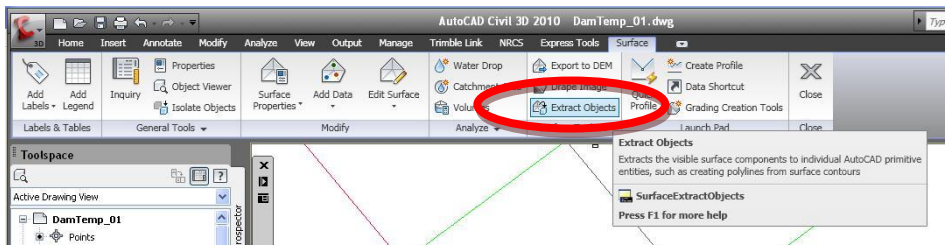
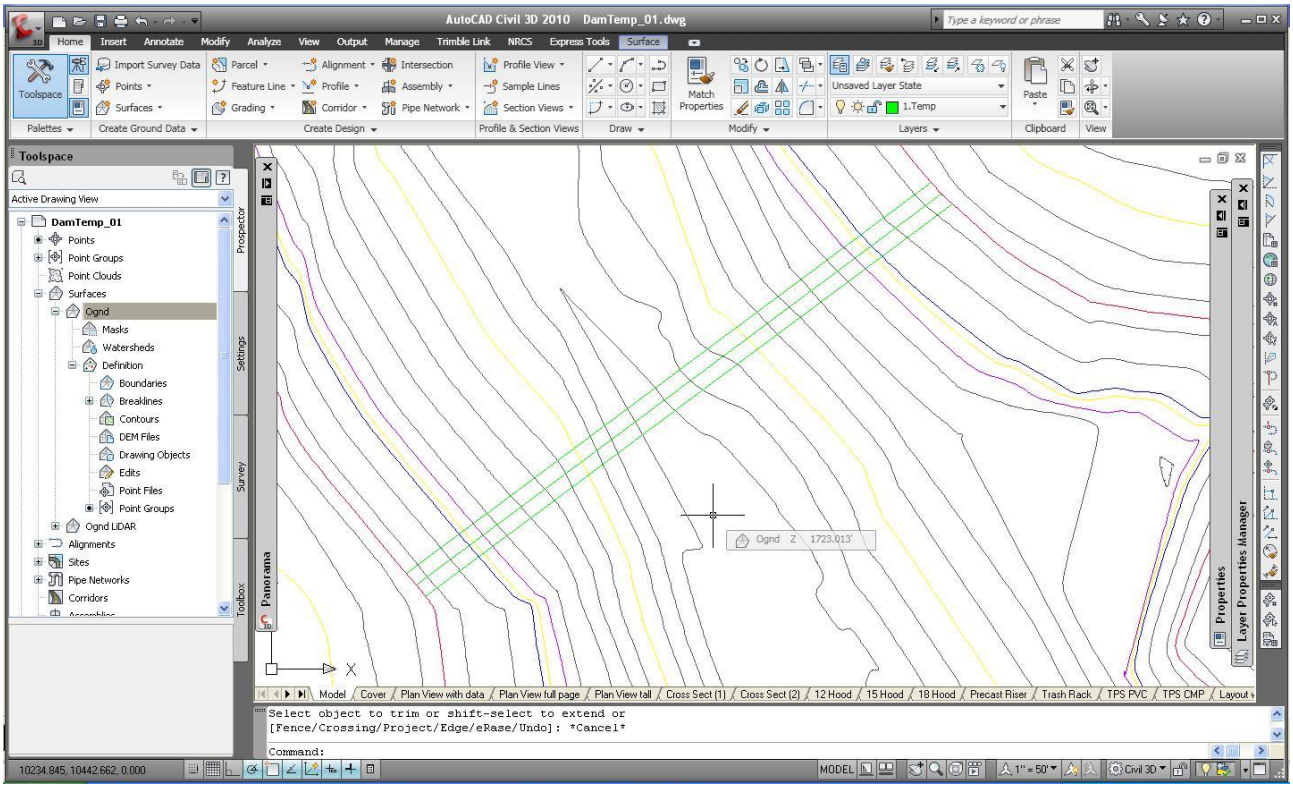


Figure 6: Trimmed lines for the top of the dam.



The create feature lines from Objects tool converts lines, arcs, polylines, and 3D polylines into feature lines. The three polylines will be converted into a feature line using this tool as shown in Figure 7. The Site should be Dam, the style Embankment Feature Line and the Layer 1.C3d.Feat. This will need to be done three times, once for each line. Change the style to Embankment Feature Line.

Figure 7: The feature line command.

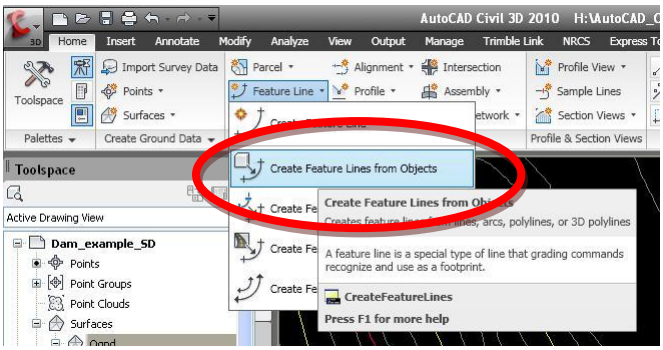
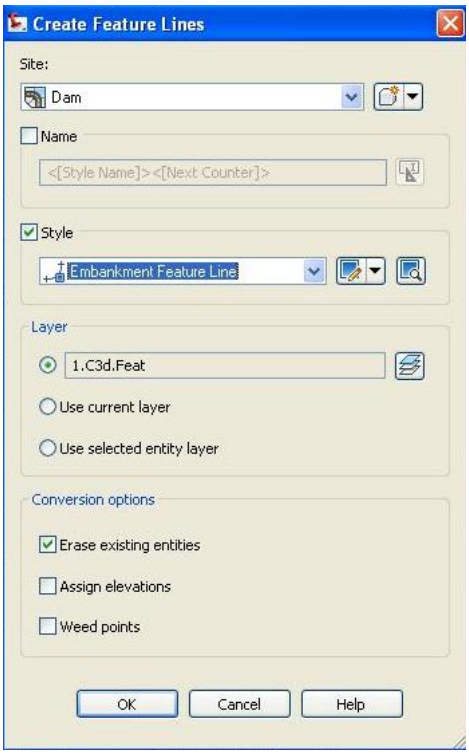
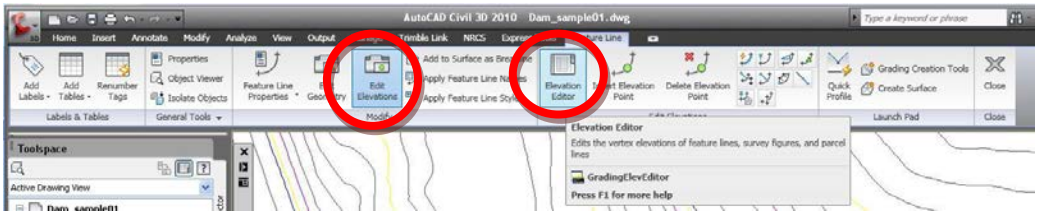


Figure 8: Create Feature Line Window



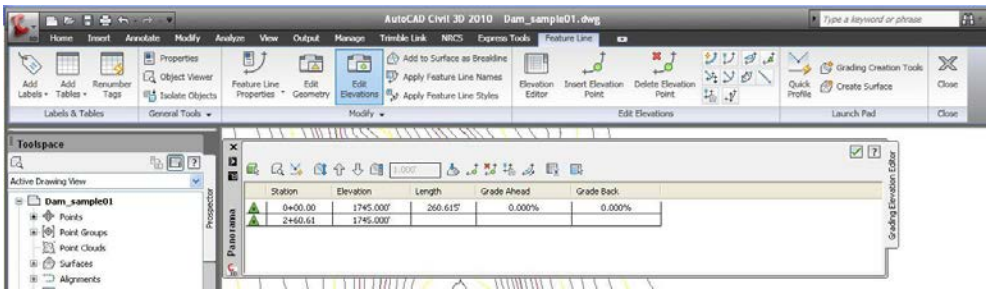
Make sure that the feature lines are at elevation 1745.0 by going to Modify ribbon tab and then Feature Line. Under the Feature Line Ribbon contextual tab, click on the Elevation Editor command. The Edit Elevations needs to be highlighted for the Elevation Editor to be visible in Figure 9. The elevation editor panorama is shown in Figure 10 and the elevation of the feature line can be adjusted.

Figure 9: Elevation Editor.



Click Edit Elevations first. Then click on Elevation Editor.

Figure 10: Elevation Editor Panorama.



Create Feature Lines for Auxiliary Spillway

The NRCS tool Layout Auxiliary Spillway will be used to create the auxiliary spillway. The auxiliary spillway will be 60 feet wide and the other dimensions are shown in Figure 12.

Figure 11: The Layout Auxiliary Spillway feature on the NRCS ribbon.

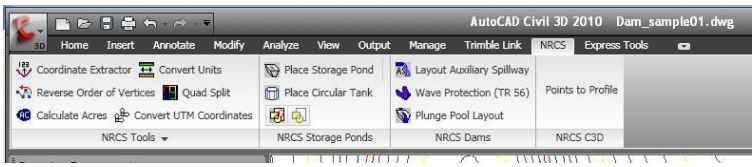
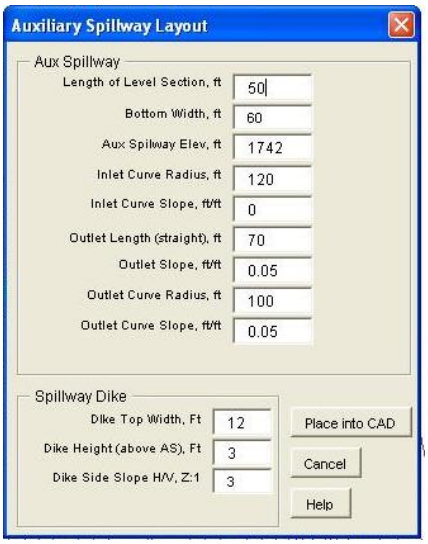


Figure 12: The Auxiliary Spillway Layout Window.



In this example, the auxiliary spillway needs to be mirrored and rotated so the level section is on the upstream end as shown in Figure 15. Figure 14 shows the layout after the spillway is mirrored. The problem with using the mirror command is that it changes the elevations of the polylines. The mirror and rotate command buttons are located on the Home ribbon under the Draw tab.

Figure 13: The inserted auxiliary spillway

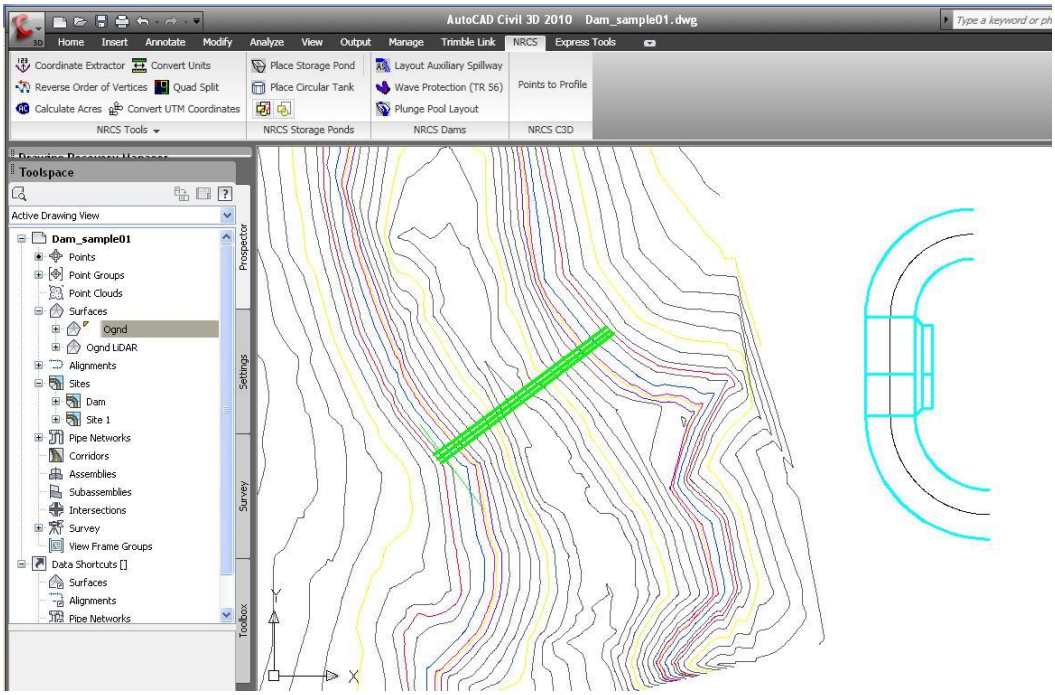


Figure 14: The auxiliary spillway after it is mirrored.

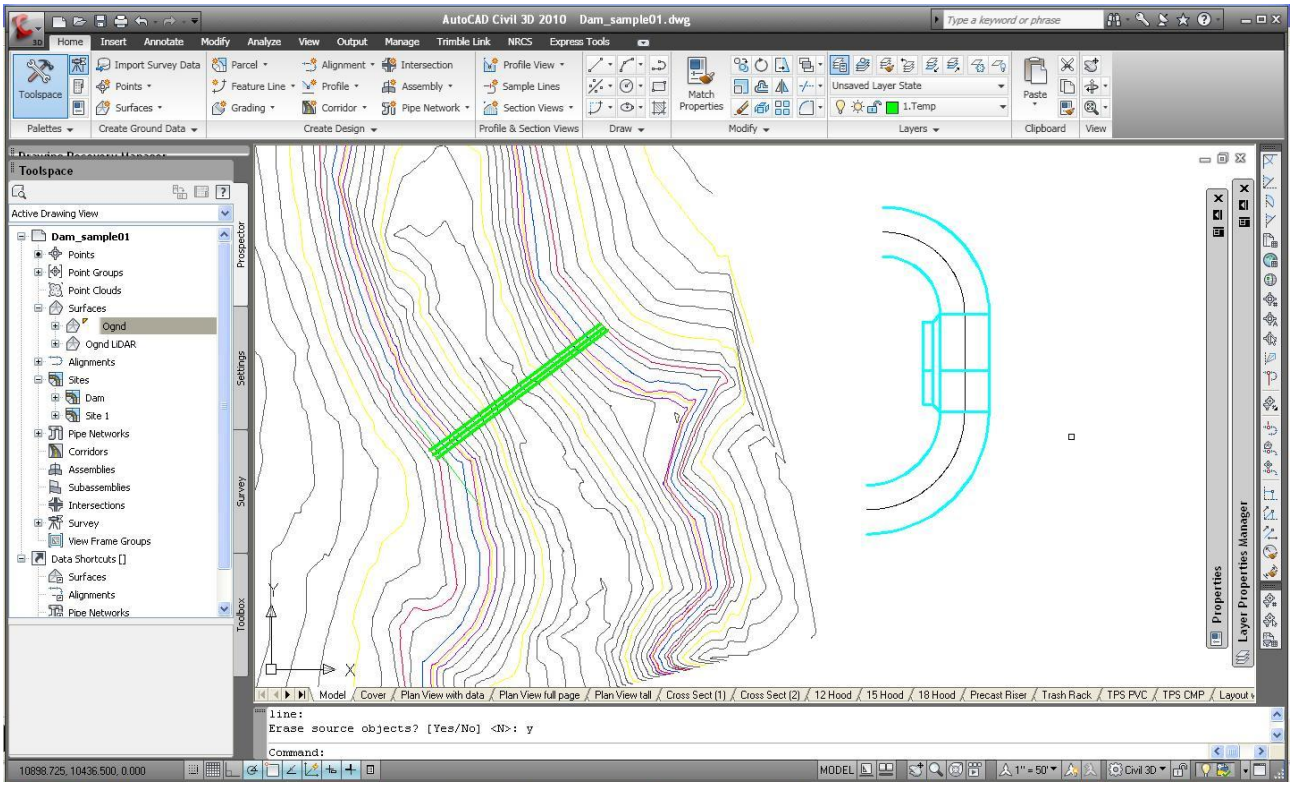
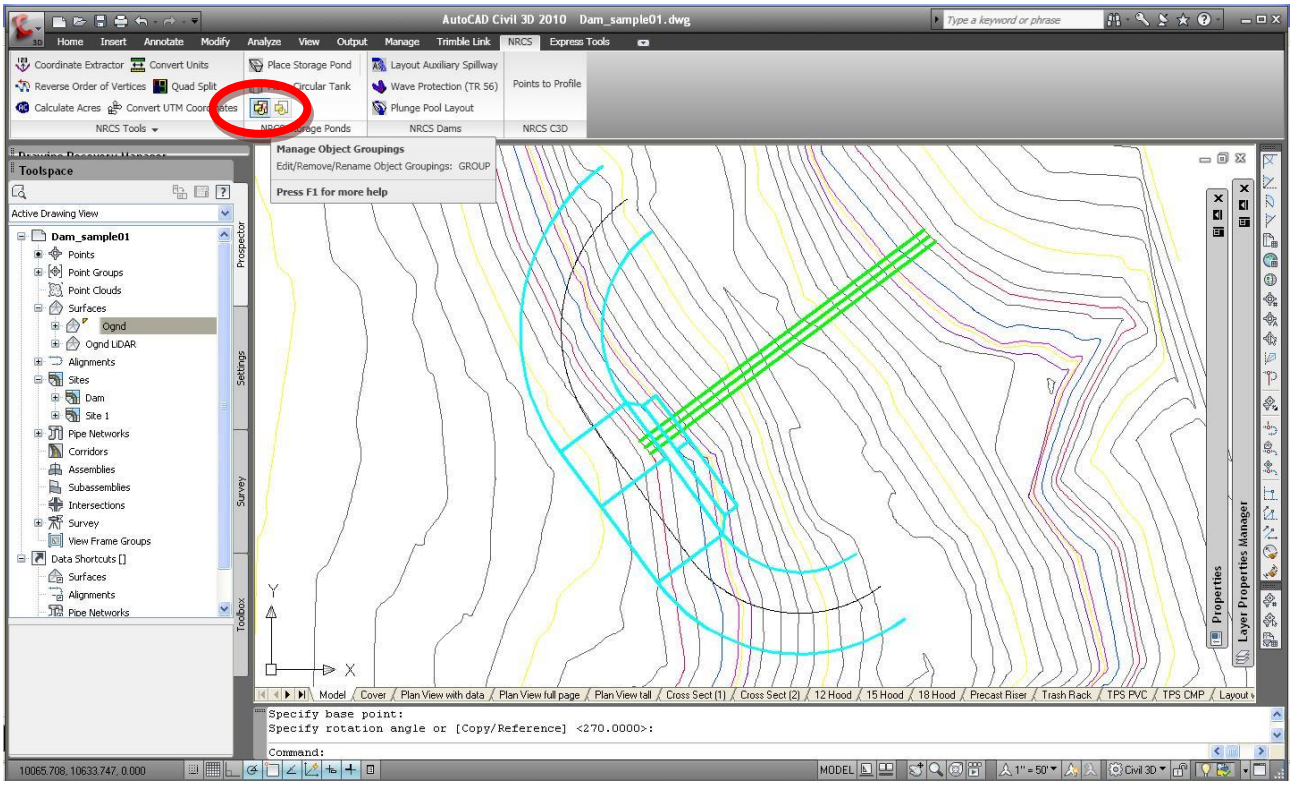
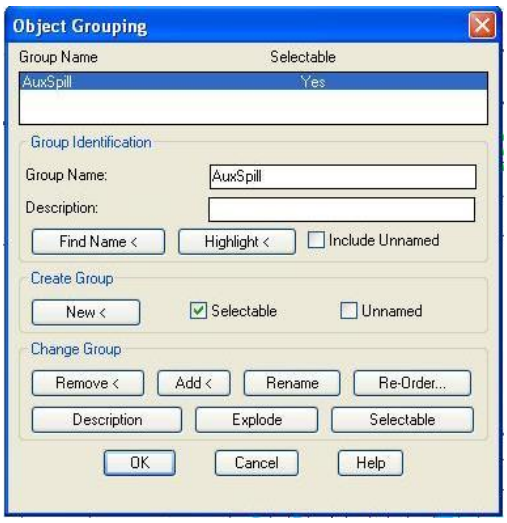


Figure 15: The Manage Object Grouping on the NRCS Ribbon



After the spillway is located properly, the Manage Object Groupings on the NRCS ribbon needs to be used to remove the spillway group. Highlight AuSpill under the Group Name in Figure 16 and click Remove. By removing the group, the individual polylines can be modified.

Figure 16: The NRCS Manage Object Groupings window.



Now convert the polylines into feature lines by selecting Create Feature Lines from Objects under Feature Lines under the Home ribbon. Change the style to Auxiliary Spillway Feature Line.

Figure 17: Create Feature Lines window.

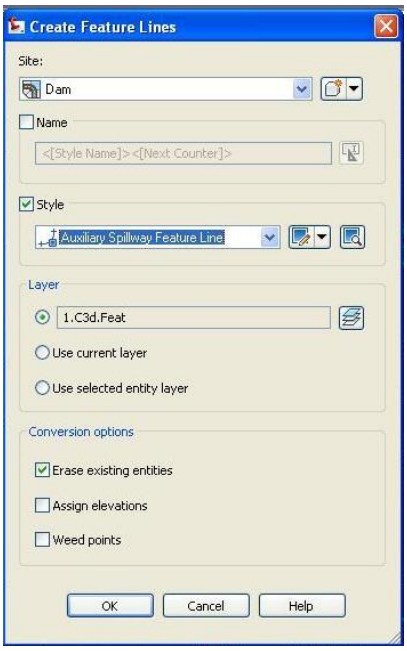
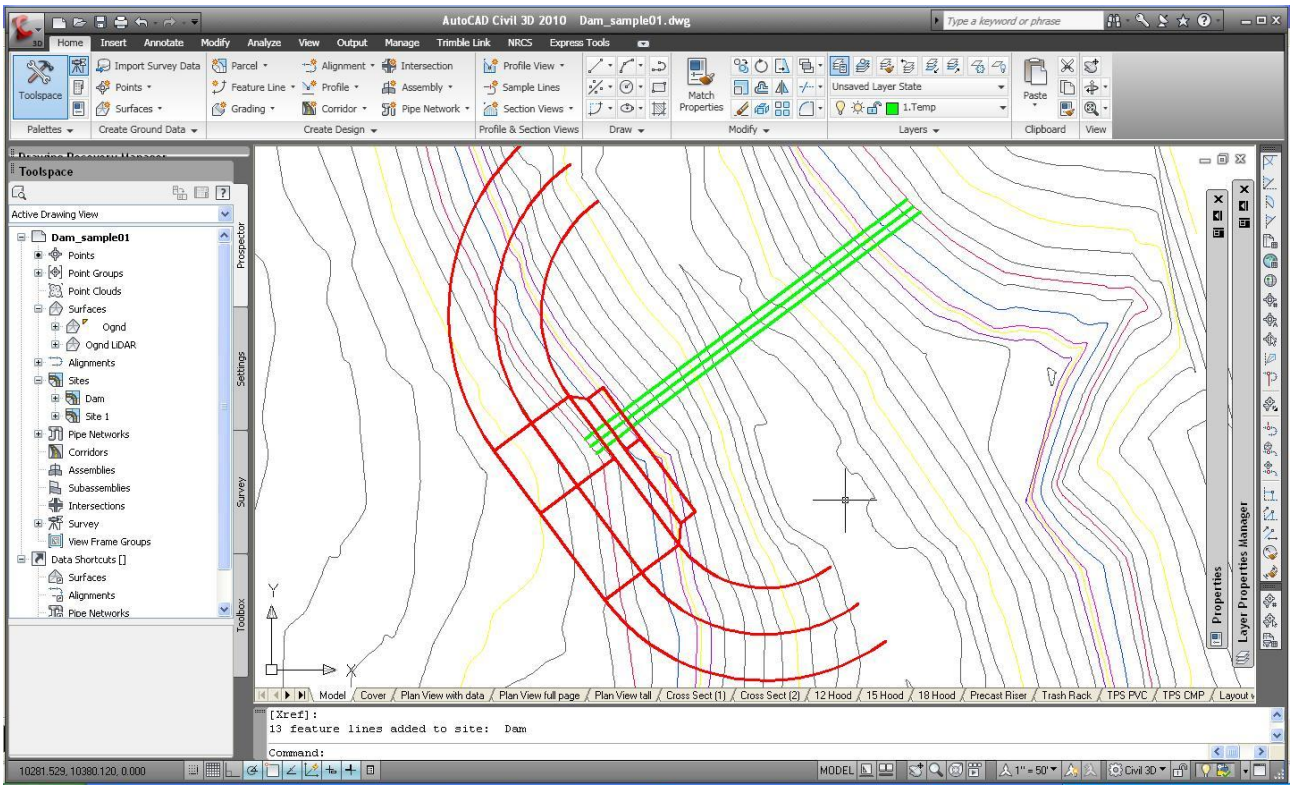


Figure 18: The feature lines for the auxiliary spillway after they are converted from polylines.



The elevation editor is used to check and adjust the elevations of the feature lines. To open the elevation editor, go to the Modify Ribbon, click on Feature Line, make sure Edit Elevations is highlighted and then click on Elevation Editor as shown in Figure 19.

Figure 19: The location of the Elevation Editor for feature lines.

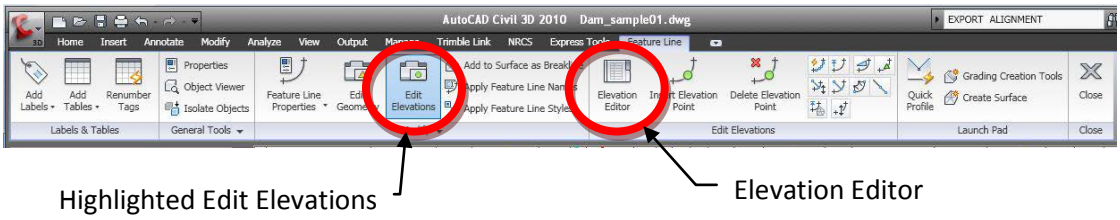
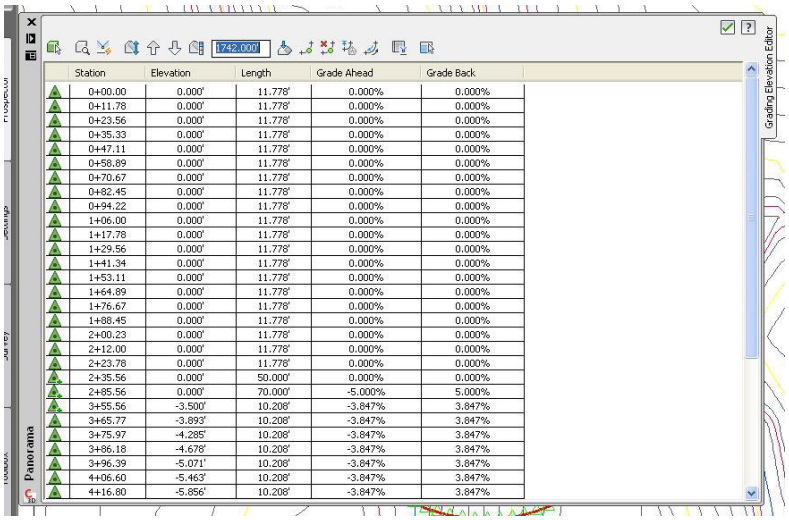
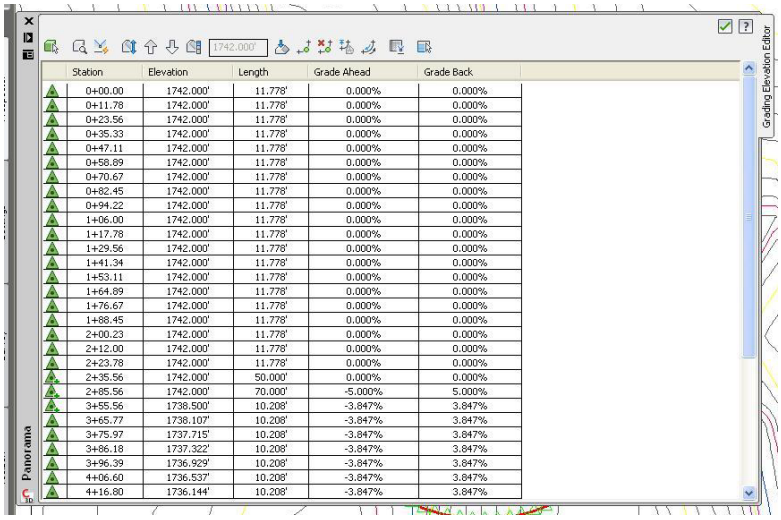


Figure 20: The Grading Elevation Editor for the outside bottom edge of the auxiliary spillway with the incorrect elevations.



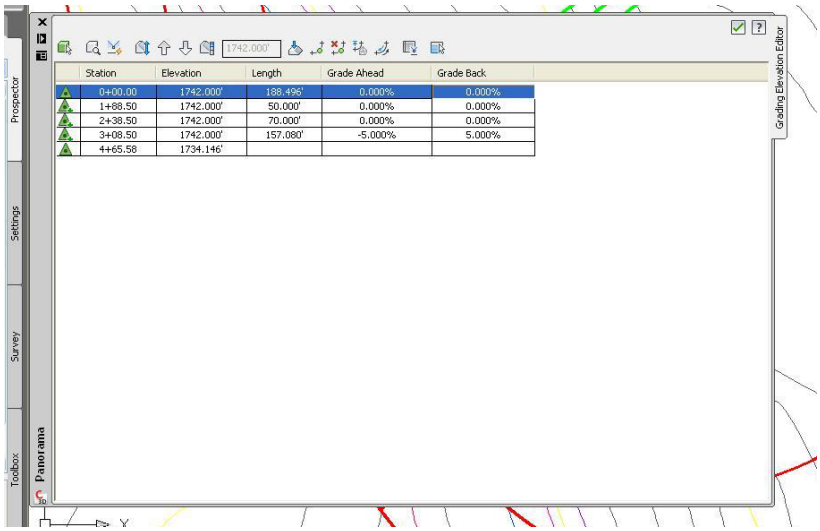
Station	Elevation	Length	Grade Ahead	Grade Back
0+00.00	0.000'	11.778'	0.000%	0.000%
0+11.78	0.000'	11.778'	0.000%	0.000%
0+23.56	0.000'	11.778'	0.000%	0.000%
0+35.33	0.000'	11.778'	0.000%	0.000%
0+47.11	0.000'	11.778'	0.000%	0.000%
0+58.89	0.000'	11.778'	0.000%	0.000%
0+70.67	0.000'	11.778'	0.000%	0.000%
0+82.45	0.000'	11.778'	0.000%	0.000%
0+94.22	0.000'	11.778'	0.000%	0.000%
1+06.00	0.000'	11.778'	0.000%	0.000%
1+17.78	0.000'	11.778'	0.000%	0.000%
1+29.56	0.000'	11.778'	0.000%	0.000%
1+41.34	0.000'	11.778'	0.000%	0.000%
1+53.11	0.000'	11.778'	0.000%	0.000%
1+64.89	0.000'	11.778'	0.000%	0.000%
1+76.67	0.000'	11.778'	0.000%	0.000%
1+88.45	0.000'	11.778'	0.000%	0.000%
2+00.23	0.000'	11.778'	0.000%	0.000%
2+12.00	0.000'	11.778'	0.000%	0.000%
2+23.78	0.000'	11.778'	0.000%	0.000%
2+35.56	0.000'	50.000'	0.000%	0.000%
2+85.56	0.000'	70.000'	-5.000%	5.000%
3+55.56	-3.500'	10.208'	-3.847%	3.847%
3+65.77	-3.893'	10.208'	-3.847%	3.847%
3+75.97	-4.285'	10.208'	-3.847%	3.847%
3+86.18	-4.678'	10.208'	-3.847%	3.847%
3+96.39	-5.071'	10.208'	-3.847%	3.847%
4+06.60	-5.463'	10.208'	-3.847%	3.847%
4+16.80	-5.856'	10.208'	-3.847%	3.847%

Figure 21: The Grading Elevation Editor for the outside bottom edge of the auxiliary spillway with all the elevations increased 1742 feet relative to the original elevations as shown in Figure 20.



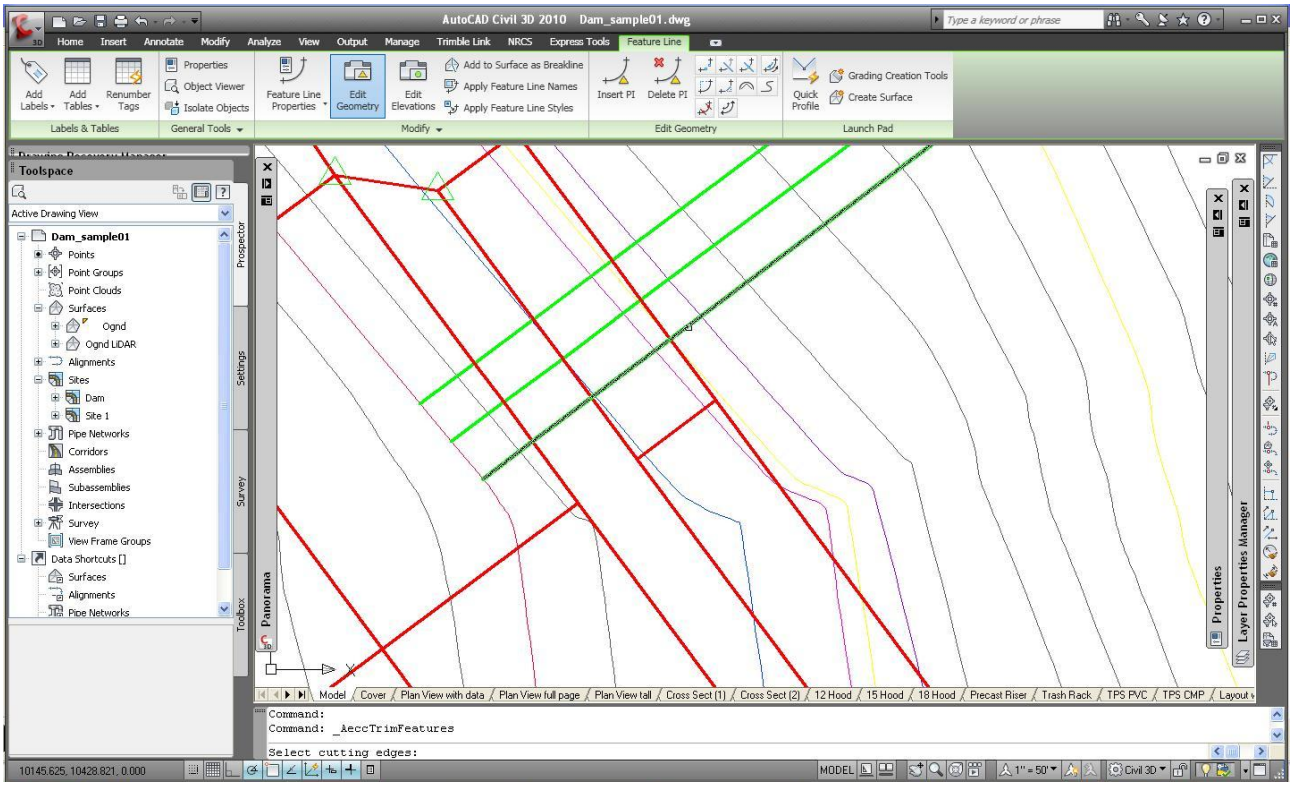
Station	Elevation	Length	Grade Ahead	Grade Back
0+00.00	1742.000'	11.778'	0.000%	0.000%
0+11.78	1742.000'	11.778'	0.000%	0.000%
0+23.56	1742.000'	11.778'	0.000%	0.000%
0+35.33	1742.000'	11.778'	0.000%	0.000%
0+47.11	1742.000'	11.778'	0.000%	0.000%
0+58.89	1742.000'	11.778'	0.000%	0.000%
0+70.67	1742.000'	11.778'	0.000%	0.000%
0+82.45	1742.000'	11.778'	0.000%	0.000%
0+94.22	1742.000'	11.778'	0.000%	0.000%
1+06.00	1742.000'	11.778'	0.000%	0.000%
1+17.78	1742.000'	11.778'	0.000%	0.000%
1+29.56	1742.000'	11.778'	0.000%	0.000%
1+41.34	1742.000'	11.778'	0.000%	0.000%
1+53.11	1742.000'	11.778'	0.000%	0.000%
1+64.89	1742.000'	11.778'	0.000%	0.000%
1+76.67	1742.000'	11.778'	0.000%	0.000%
1+88.45	1742.000'	11.778'	0.000%	0.000%
2+00.23	1742.000'	11.778'	0.000%	0.000%
2+12.00	1742.000'	11.778'	0.000%	0.000%
2+23.78	1742.000'	11.778'	0.000%	0.000%
2+35.56	1742.000'	50.000'	0.000%	0.000%
2+85.56	1742.000'	70.000'	-5.000%	5.000%
3+55.56	1738.500'	10.208'	-3.847%	3.847%
3+65.77	1738.107'	10.208'	-3.847%	3.847%
3+75.97	1737.715'	10.208'	-3.847%	3.847%
3+86.18	1737.322'	10.208'	-3.847%	3.847%
3+96.39	1736.929'	10.208'	-3.847%	3.847%
4+06.60	1736.537'	10.208'	-3.847%	3.847%
4+16.80	1736.144'	10.208'	-3.847%	3.847%

Figure 22: The grading elevation editor for inside bottom edge of the auxiliary spillway with the correct elevations.



The embankment feature lines need to be trimmed so they connect with the berm feature lines on the outlet of the auxiliary spillway.

Figure 23: Edit Geometry command to modify the feature lines.



After the dam embankment lines are trimmed, the downstream dam embankment feature line and the berm feature line are joined into one line in order to make the grading the surface easier. Under the Modify ribbon, click on Feature Line under the Design section. This will display the Feature Line Ribbon as shown in Figure 24. The Join icon is located on the Edit Geometry section.

Figure 24: Connect the dam embankment feature lines and the spillway dike.

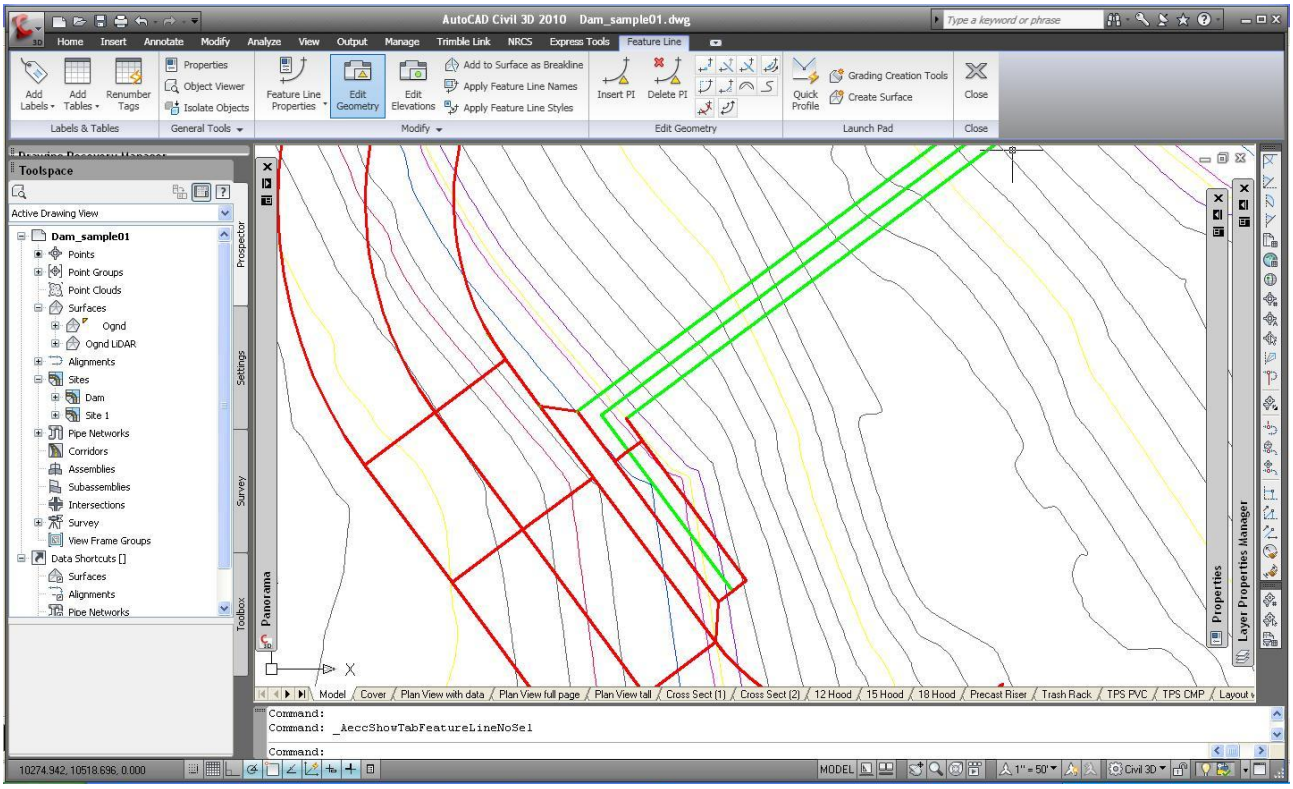
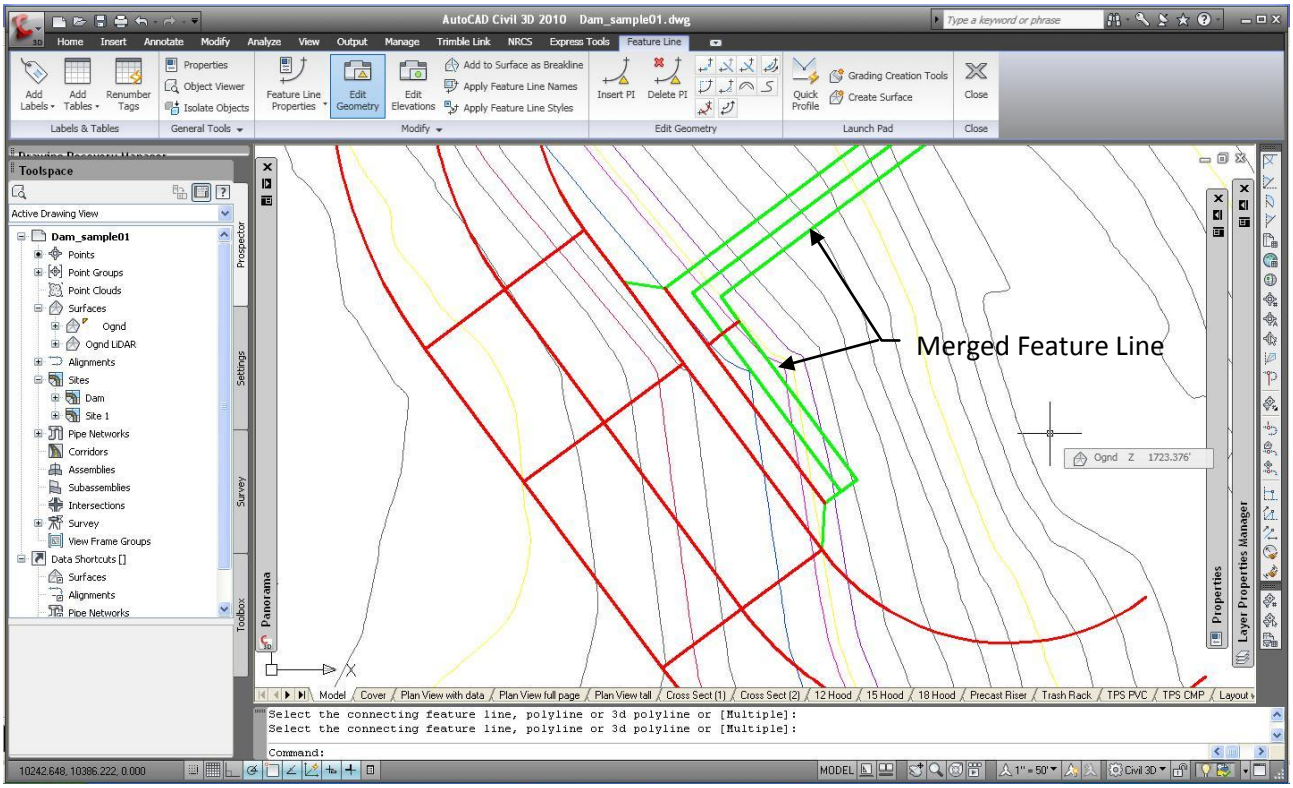


Figure 25: The connected auxiliary spillway dike and the dam embankment feature line.



Under the Modify Ribbon, click on Surface, which will display the Surface ribbon. Use the Extract Objects to create a polyline from the elevation 1742.0 contour line from the Ogrnd surface.

Figure 26: The Modify Ribbon.

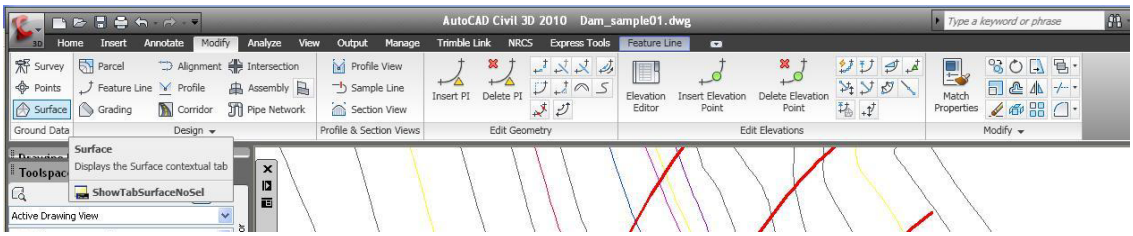


Figure 27: Extract the objects from a surface

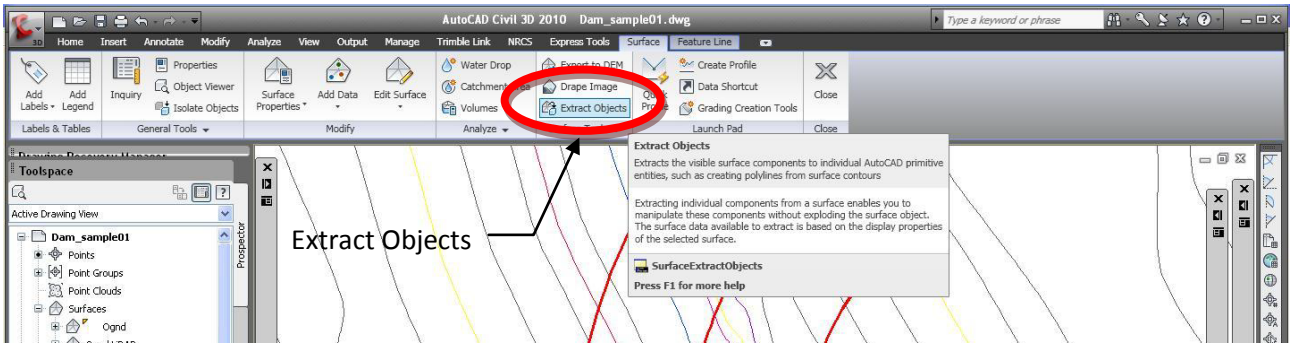


Figure 28: The Extract Objects from Surface Window.

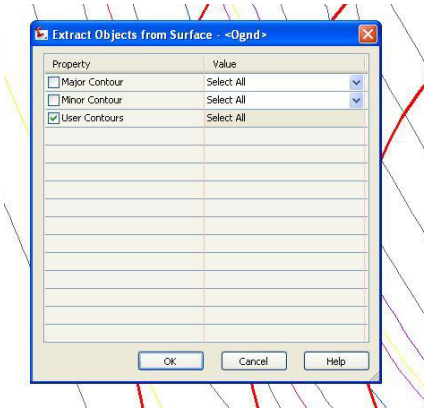


Figure 29: Select the 1742.0 elevation contour to create a polyline of the 1742.0 contour.

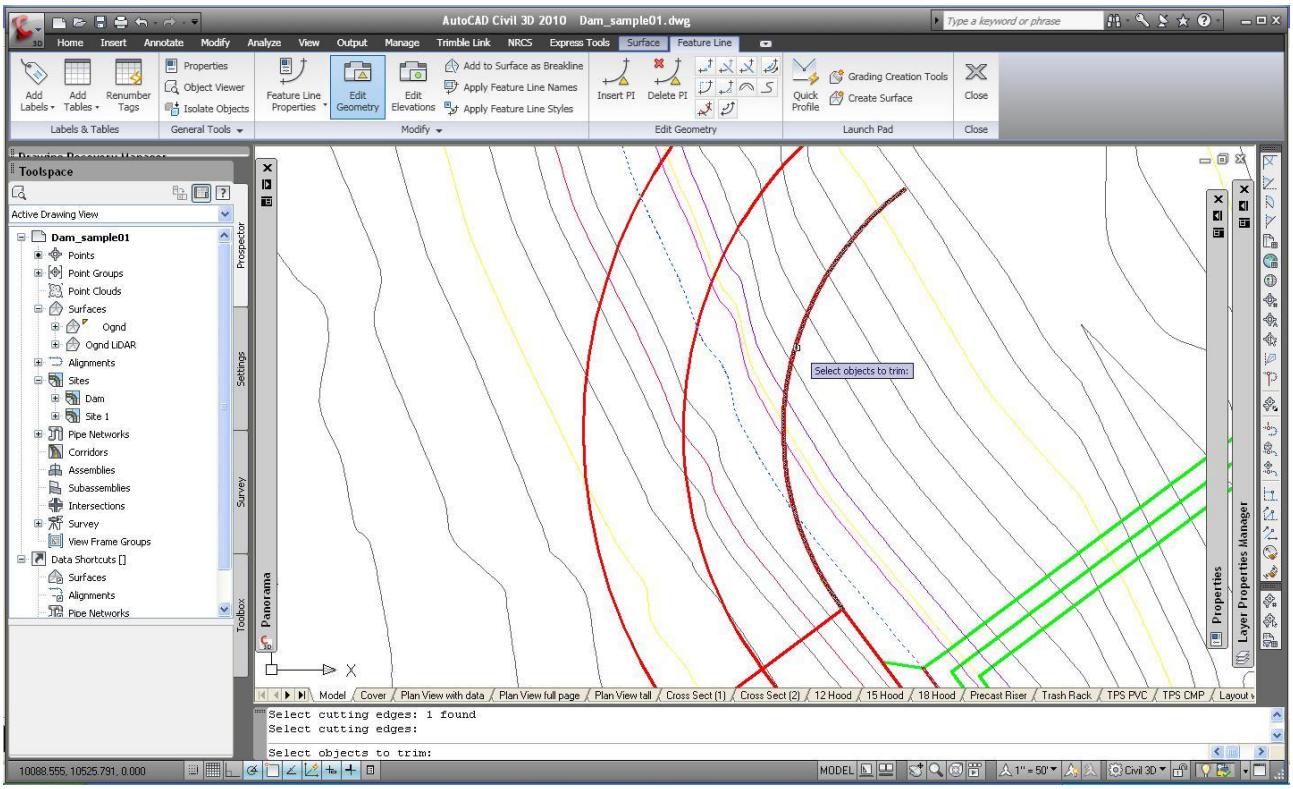


Figure 30: Trim the auxiliary spillway feature lines to the elevation 1742.0 contour.

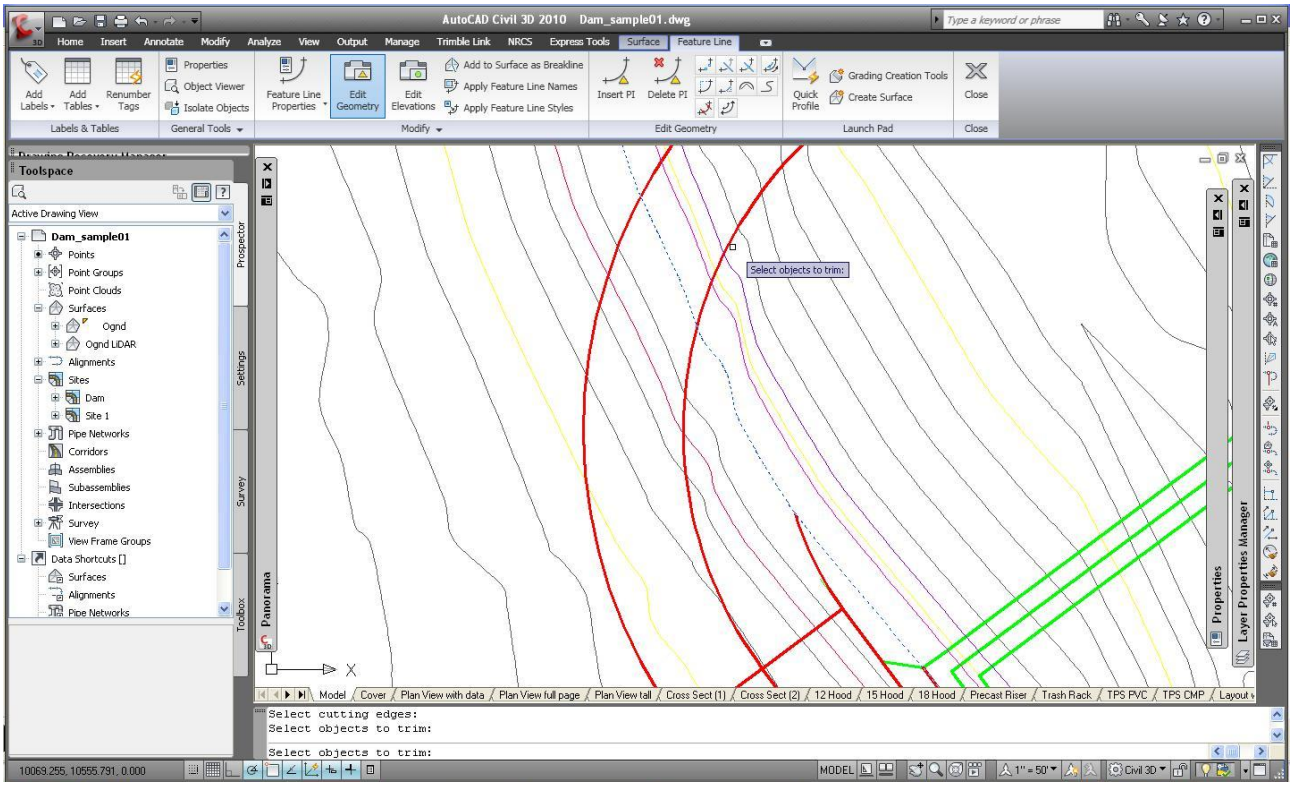
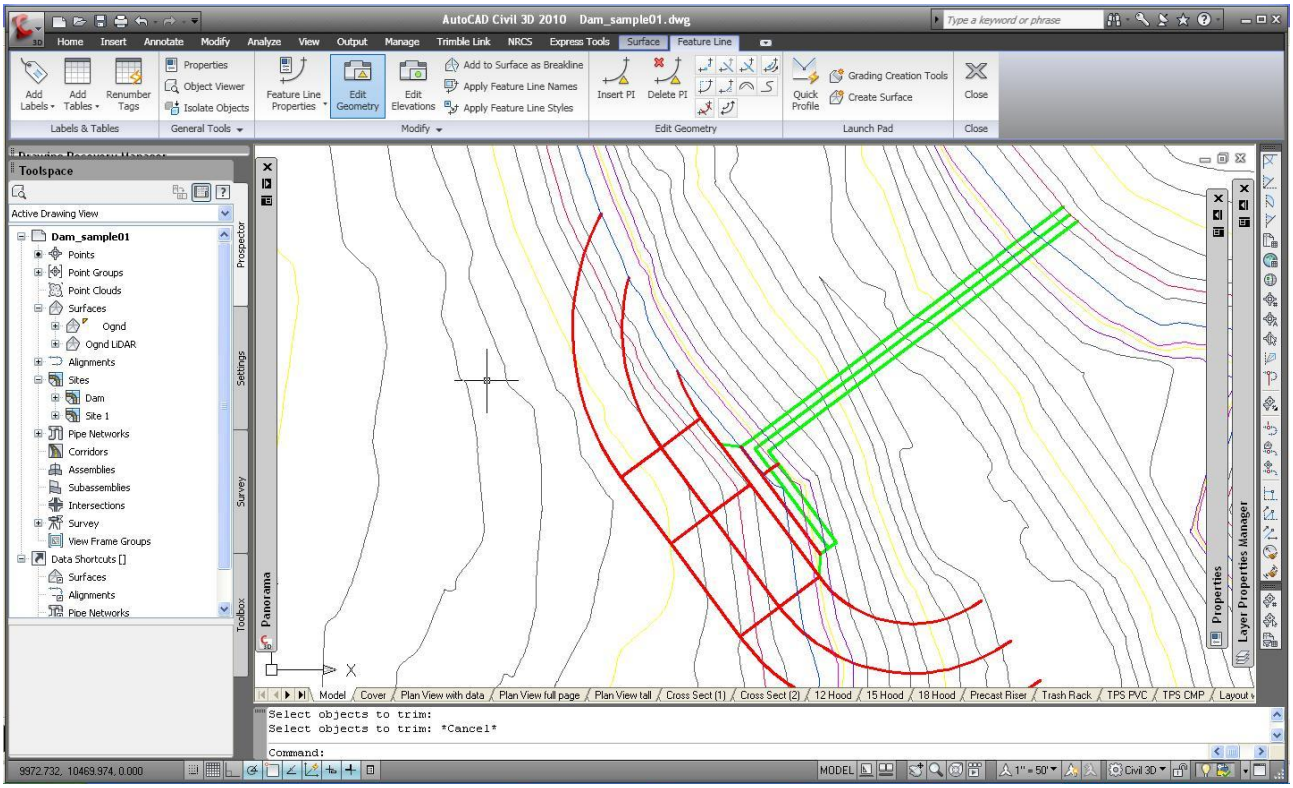


Figure 31: The trimmed auxiliary spillway inlet to elevation 1742.0.



Grade the Auxiliary Spillway to Determine the Outlet

In order to determine where the slope of the outlet channel of the auxiliary spillway intercepts the original ground, the outlet will be graded. A polyline will be drawn to trim the auxiliary spillway feature lines. If feature lines are graded, they cannot be trimmed. So, the grading will be deleted and then the feature lines will be trimmed.

To start grading the surface go to the Home Ribbon Tab, click on Grading, and the Grading Creation Tools. This will bring up the Grading Creation Tools Toolbar. Set the Cut Style to Auxiliary Spillway Grading and Fill Slope Styles to: Embankment Grading.

Figure 32: The Grading Creation Tool.

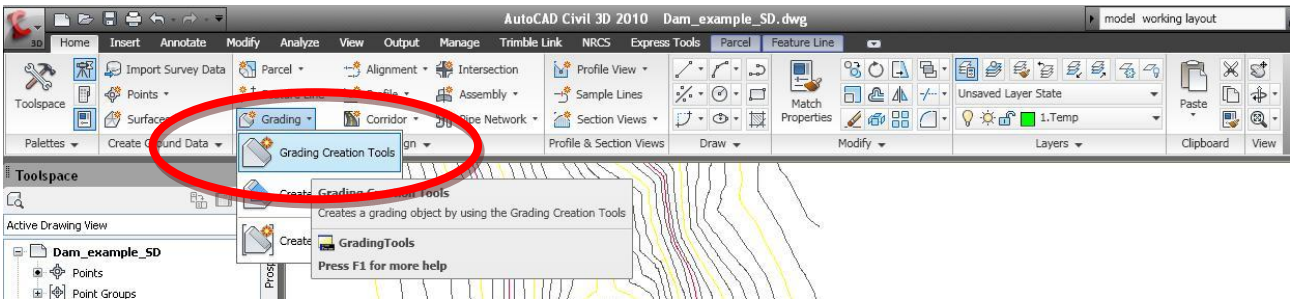
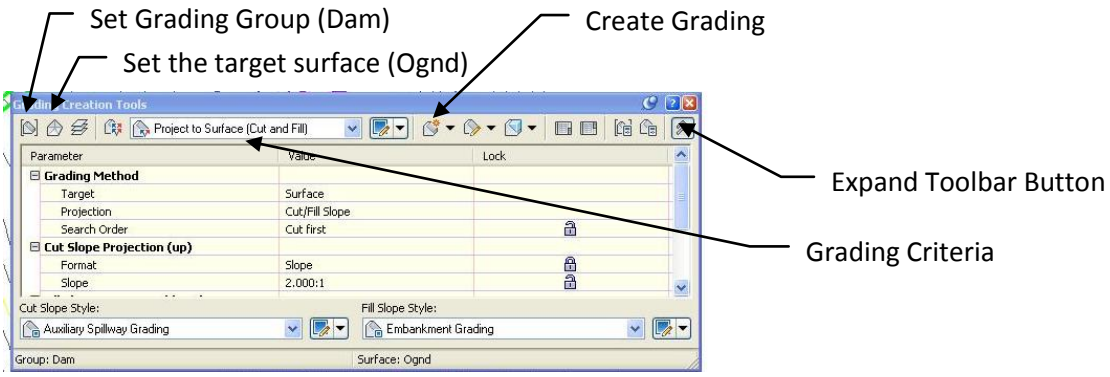


Figure 33: The Grading Creation Tools window used to create grading objects.



To start grading the auxiliary spillway, click on the Create Grading icon on the Home ribbon. The command prompt will ask some questions to grade the surface. Repeat for both sides of the auxiliary spillway.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select the grading side (click anywhere on the side where the grading slope will be located)
- Select on end of the feature line (0+00)
- Select on the other end of the feature line (End of the feature line)
- Cut Slope (3:1)
- Fill Slope (3:1)

Figure 34: The auxiliary spillway with both sides graded.

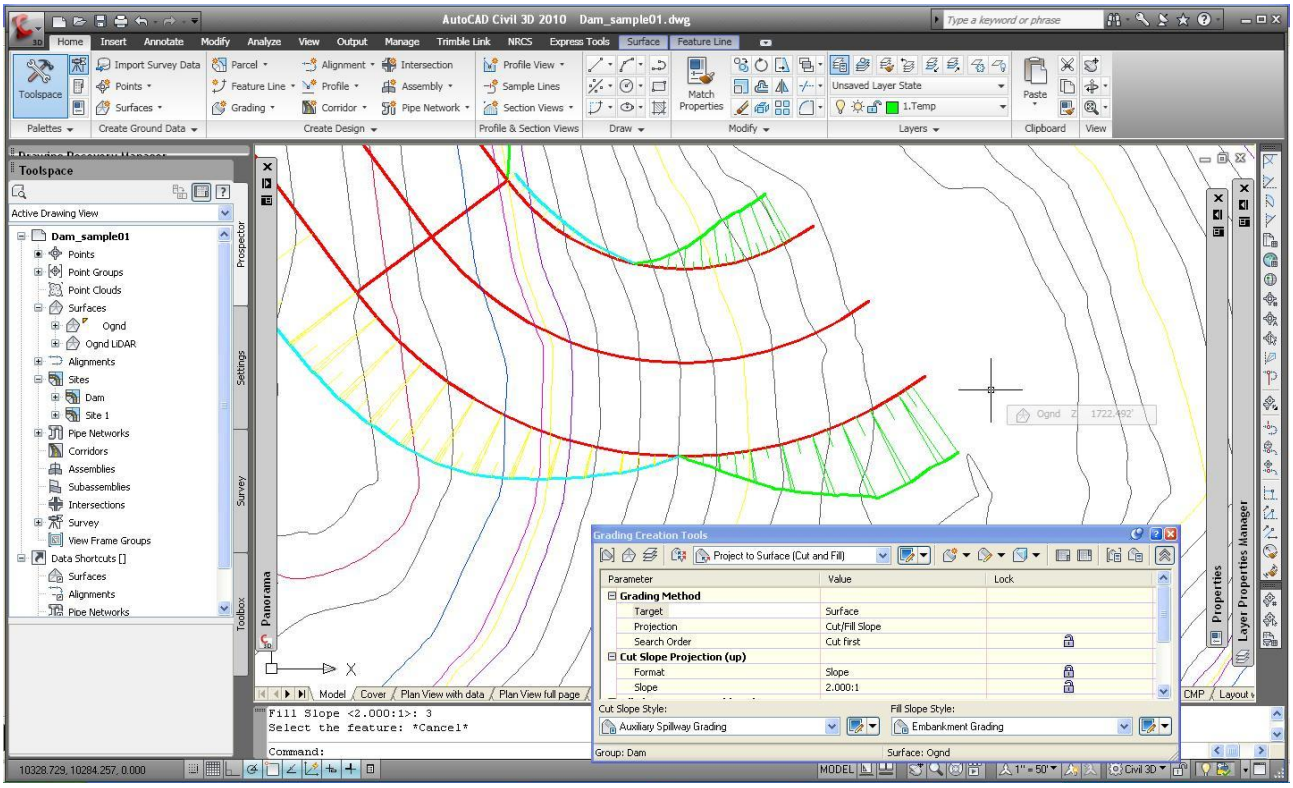
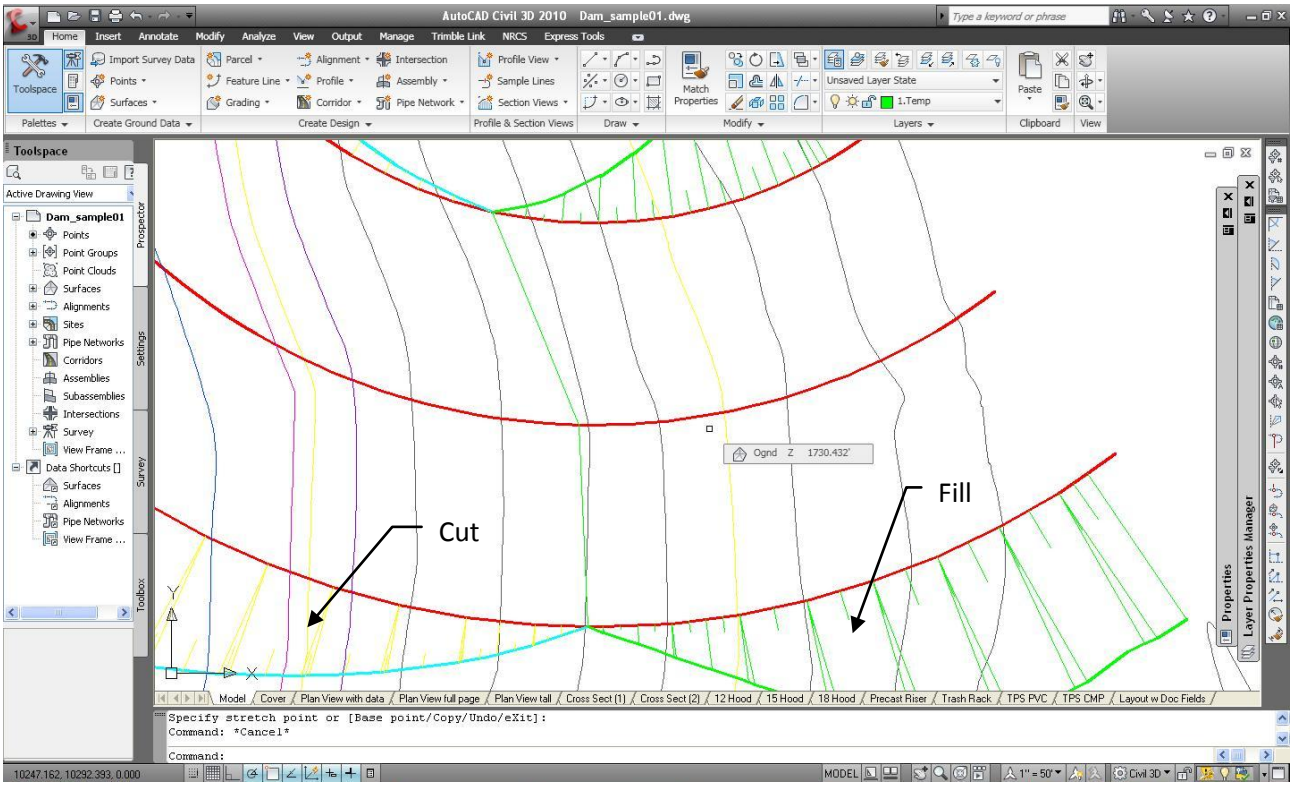
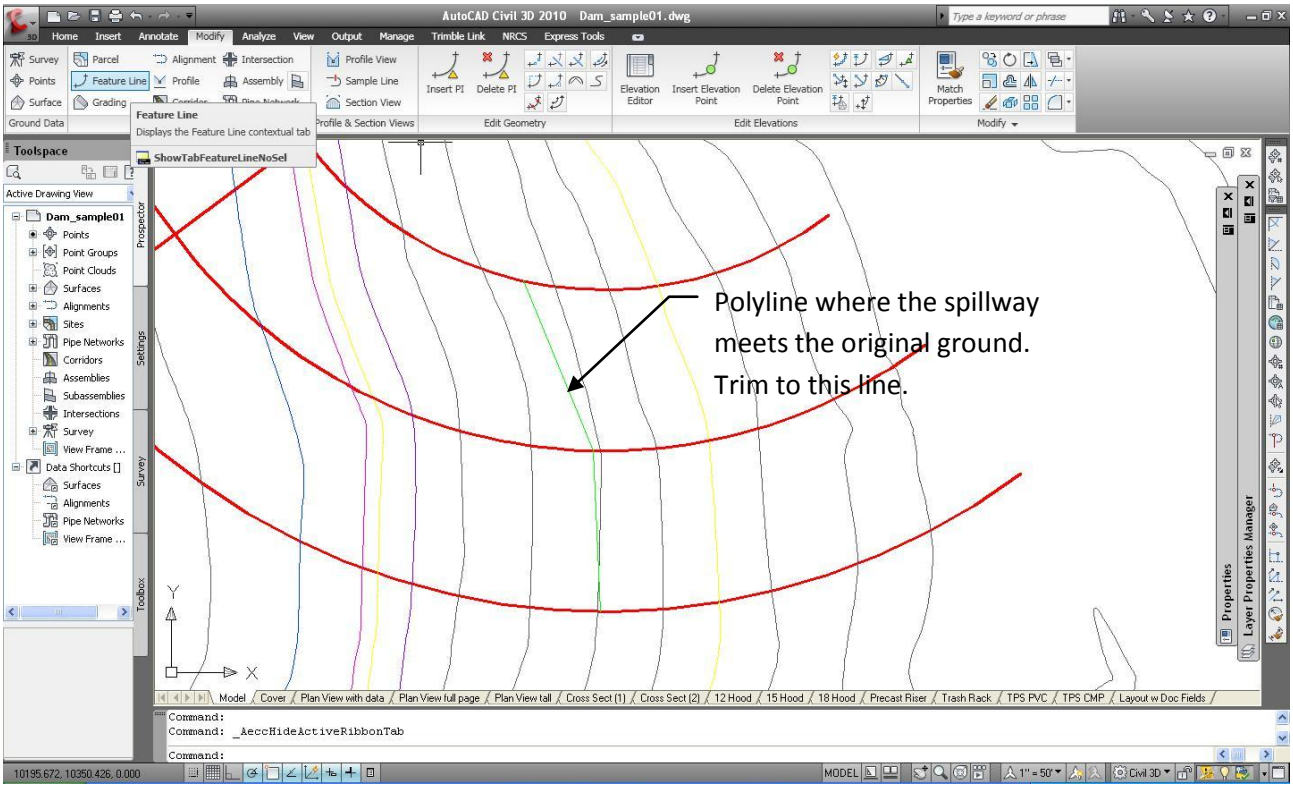


Figure 35: The polyline connecting the zero cut and fill locations.



Delete the gradings on both sides. Trim the auxiliary spillway feature lines to the polyline.

Figure 36: The auxiliary spillway with the polyline and the gradings deleted.

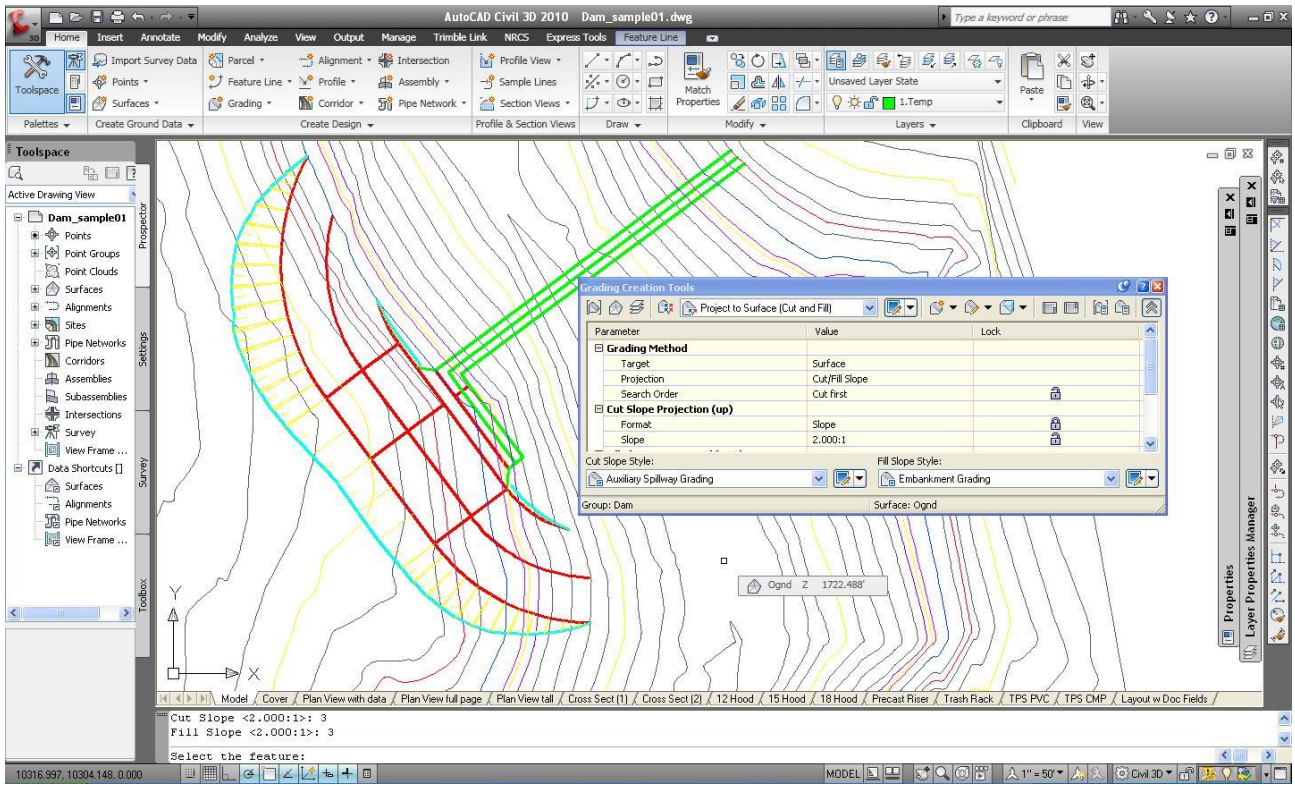


Grade the Auxiliary Spillway

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select the grading side (click anywhere downstream of the feature line)
- Select on end of the feature line (0+00)
- Select on the other end of the feature line (2+61.89)
- Cut Slope (3:1)

Figure 37: The grading for the auxiliary spillway.



Grade the Downstream Slope

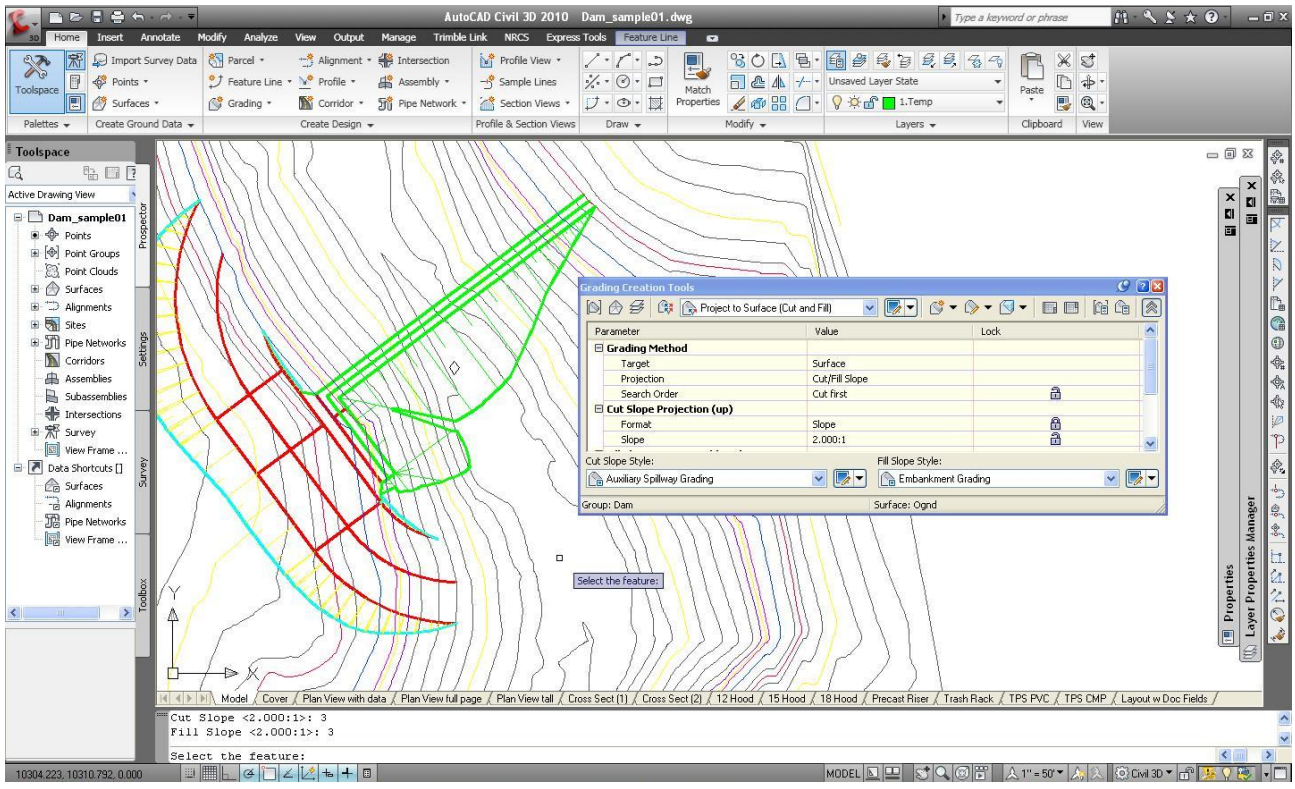
To start grading the downstream side of the embankment, click on the Create Grading icon. The command prompt will ask some questions to grade the surface.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select the grading side (click anywhere downstream of the feature line)
- Select on end of the feature line (0+00)
- Select on the other end of the feature line (2+61.89)
- Cut Slope (3:1)
- Fill Slope (3:1)

By not selecting the entire length, the user has more control to control how the object is graded. The length of the feature line that is graded can be lengthened or shortened. However, on the downstream side, grading the entire length of the feature line is graded.

Figure 38: The grading for the downstream embankment.



Grade the Upstream Slope with the Wave Berm

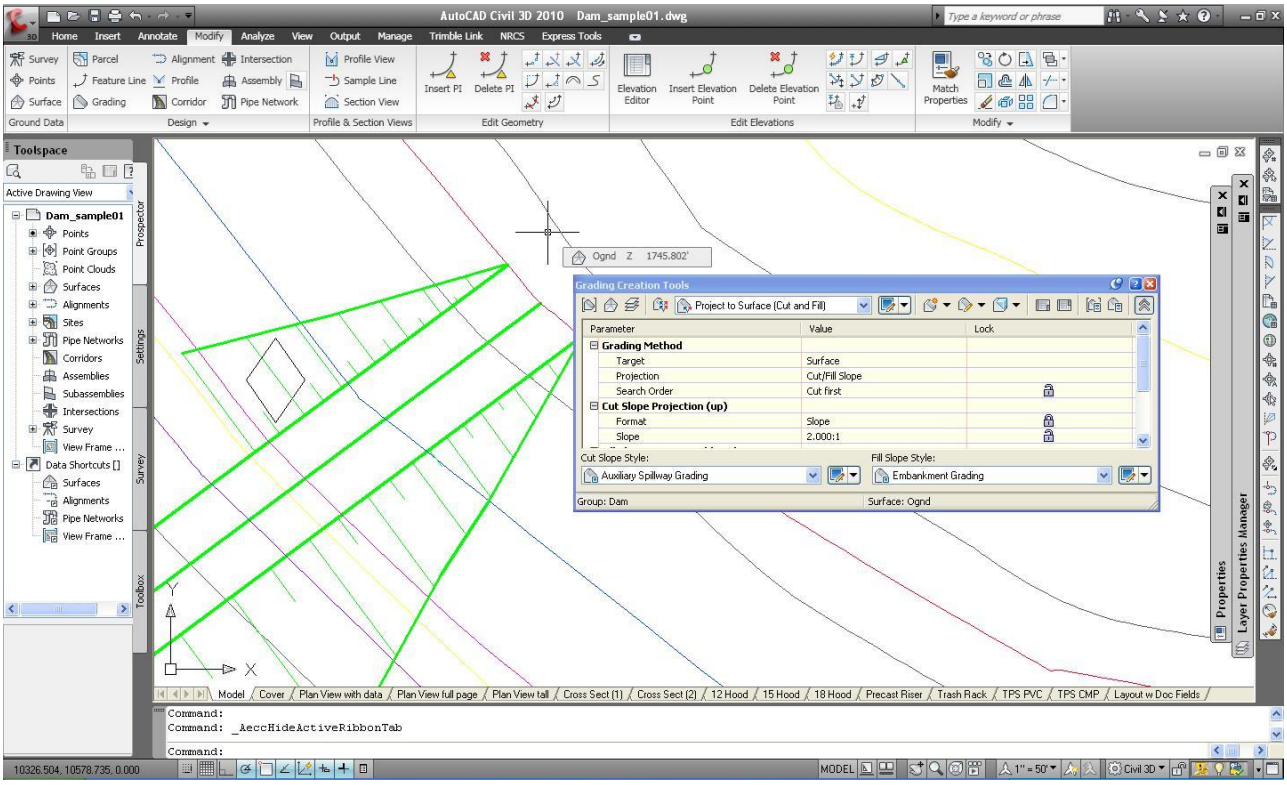
Now the grading on the upstream side is more complicated since a sloped wave berm is going to be added. Contours at elevations 1740.4 and 1739.2 are displayed to aid in the grading of the wave berm. These were added at the same time the user defined contour was added for the top of dam.

To start the grading of the upstream slope, the embankment will be graded to elevation 1740.4. Use the grading style Project to Surface (Cut and Fill) to grade the beginning section of the upstream face of the dam.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select the grading side (click anywhere downstream of the feature line)
- Select on end of the feature line (0+00)
- Select on the other end of the feature line (Select the station on the feature line so the grading will end at elevation 1740.4)
- Cut Slope (3:1)
- Fill Slope (3:1)

Figure 39: Grading of the upstream embankment from the end to the starting location of the wave berm.

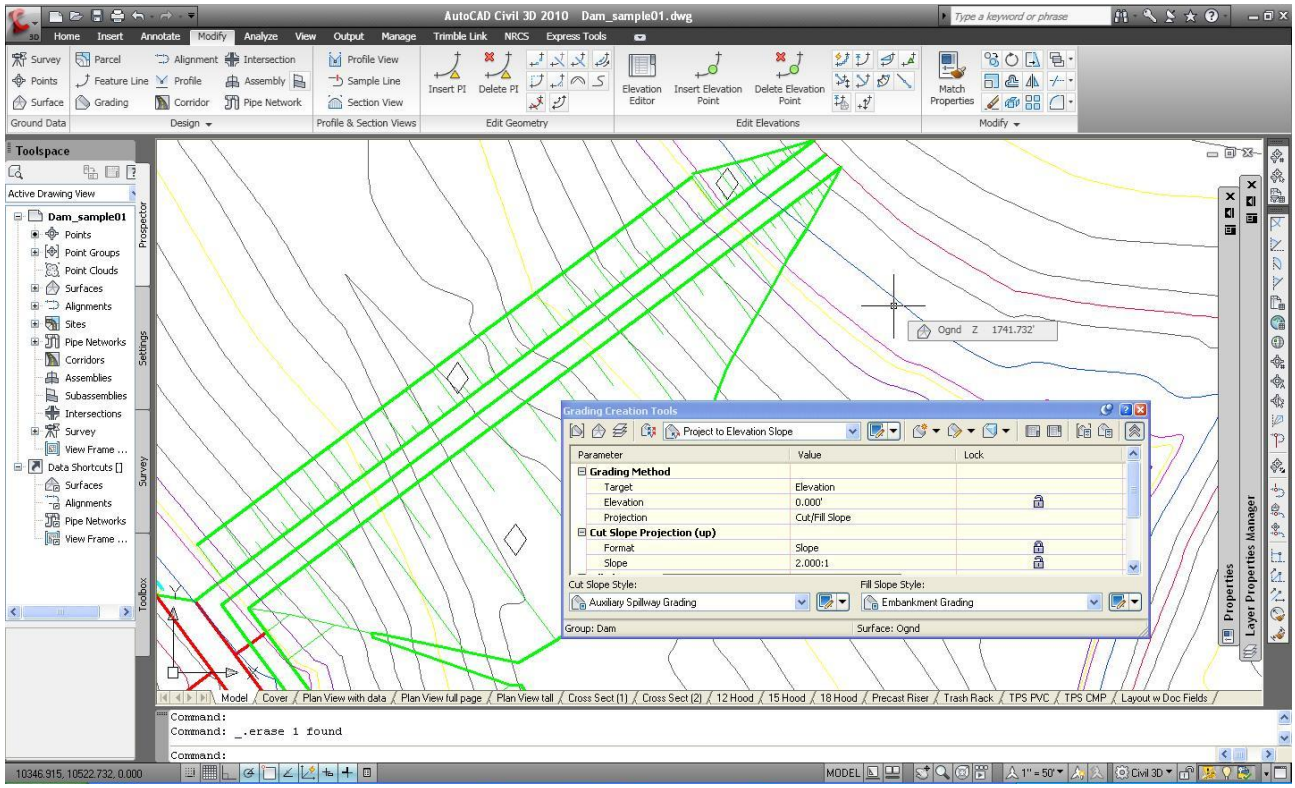


To grade the slope between the top of dam to the edge of the wave berm, use Project to Elevation Slope as the grading criteria. This grading criteria allows the user to select an elevation to grade to at an entered slope.

The grading criteria is set to Project to Elevation Slope.

- Select the feature (downstream feature line)
- Select the grading side (click anywhere upstream of the feature line)
- Apply to entire length (No)
- Select the beginning and ending stations
- Elevation (1740.4)
- Cut Slope (3:1)
- Fill Slope (3:1)

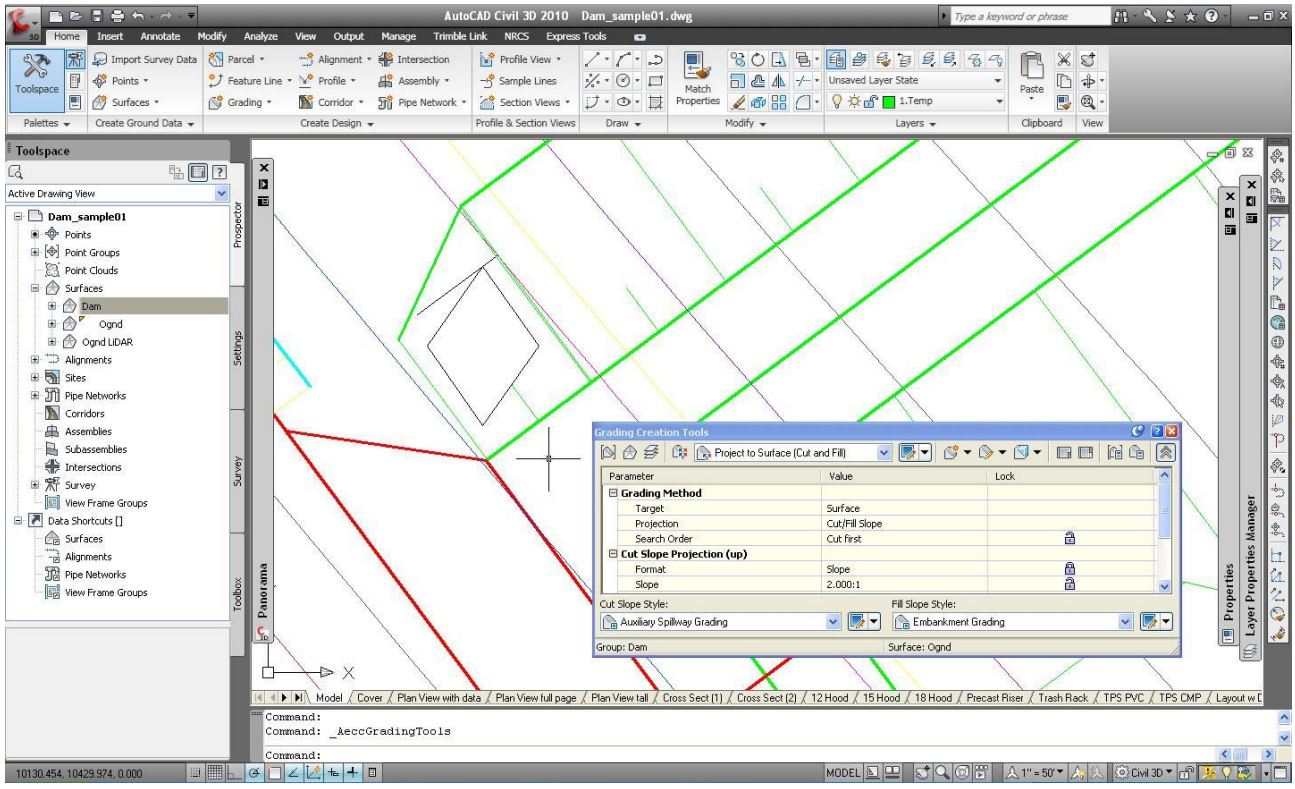
Figure 40: Grading of the slope between the top of dam and the wave berm.



The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select the grading side (click anywhere upstream of the feature line)
- Select on end of the feature line (Select at the end of the previous grading)
- Select on the other end of the feature line (End of the embankment top)
- Cut Slope (3:1)
- Fill Slope (3:1)

Figure 41: Grading of the upstream embankment from the end of the wave berm to the end of the embankment.

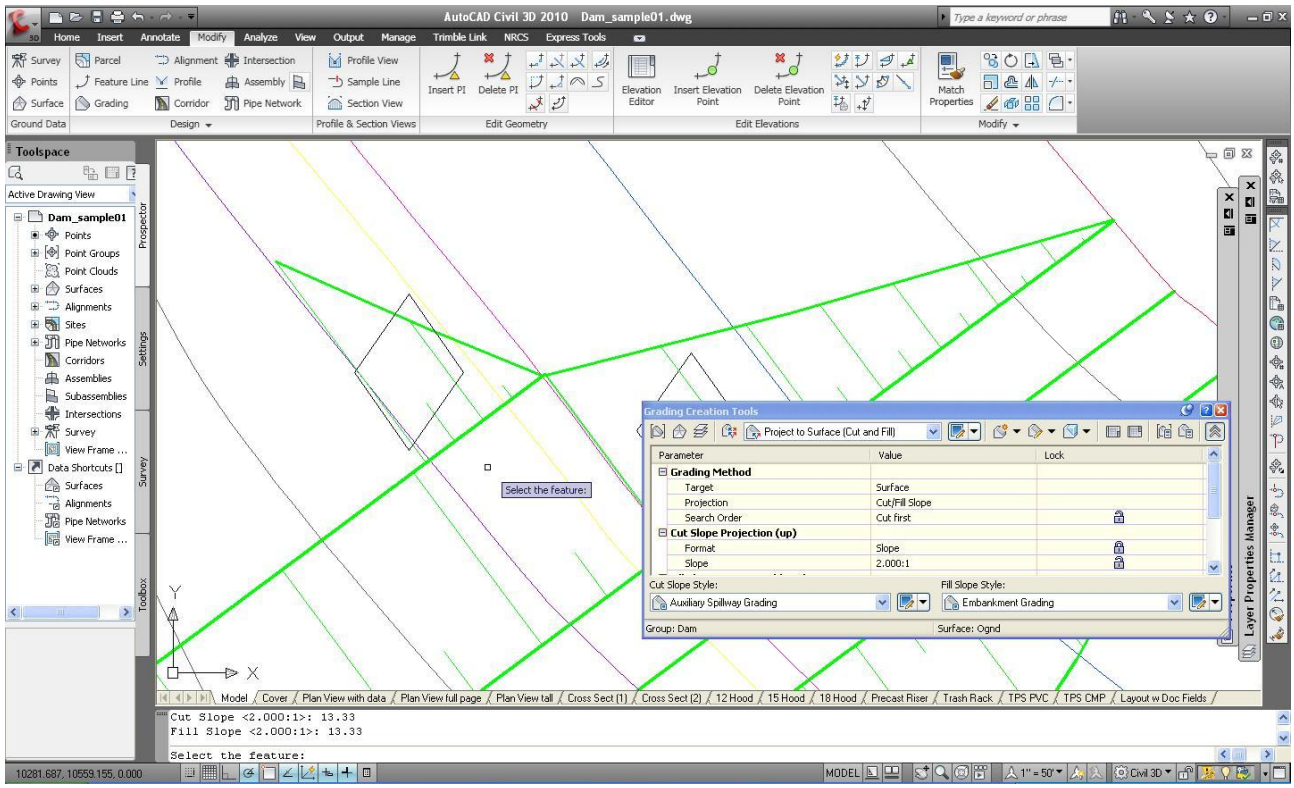


The grading of the wave berm from the end to elevation 1739.2.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select on end of the feature line (0+00)
- Select on the other end of the feature line (Station where elevation 1739.2 starts)
- Cut Slope (13.33:1)
- Fill Slope (13.33:1)

Figure 42: The grading of the beginning of the wave berm.

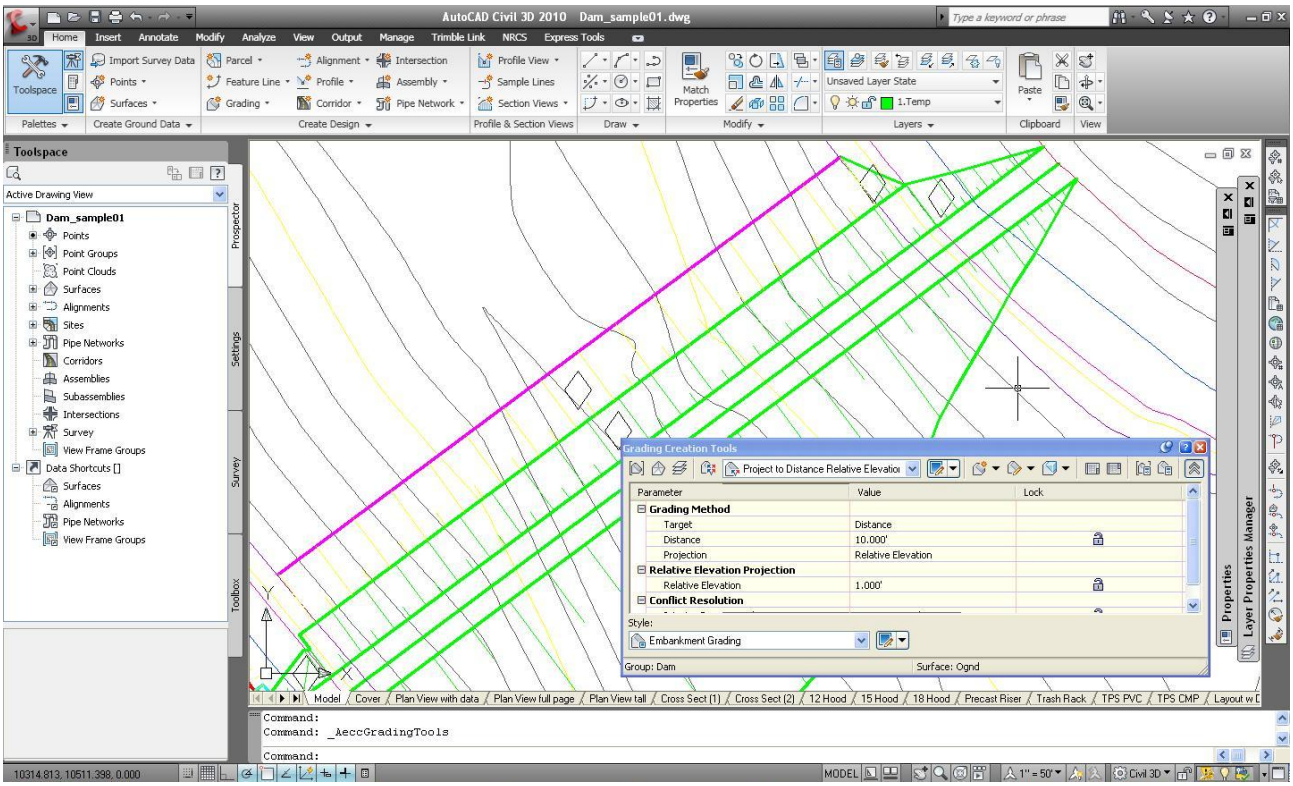


The grading of the wave berm between contour elevation 1739.2 on each ends.

The Grading Criteria is set to Project to Distance Relative Elevation.

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select on end of the feature line (Station where elevation 1739.2 starts)
- Select on the other end of the feature line (Station where elevation 1739.2 ends)
- Distance (16 feet)
- Relative Elevation (-1.2)

Figure 43: The grading of the wave berm between elevation contours 1739.2.

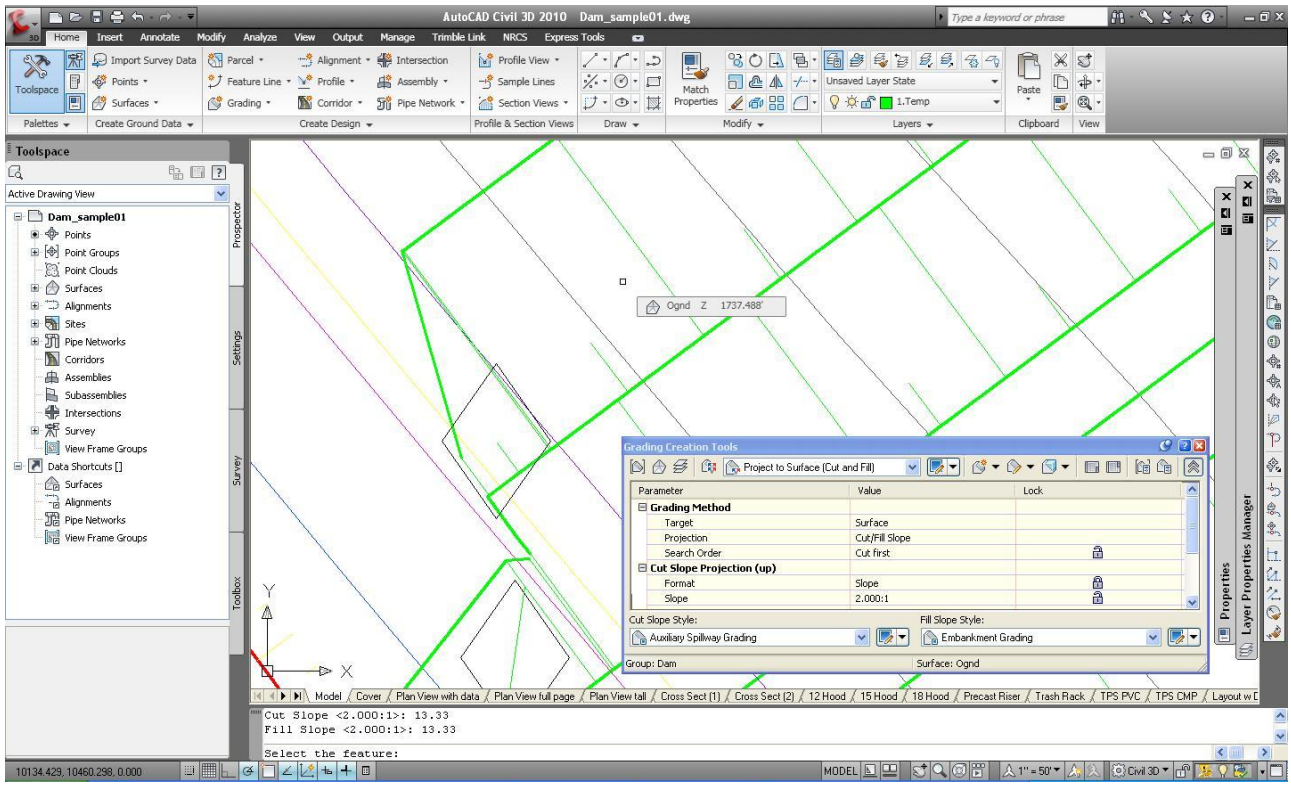


Grade the end of the wave berm.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (downstream feature line)
- Apply to entire length (No)
- Select on end of the feature line (Station where elevation 1739.2 ends)
- Select on the other end of the feature line (End of the wave berm)
- Cut Slope (13.33:1)
- Fill Slope (13.33:1)

Figure 44: The grading of the end of the wave berm.

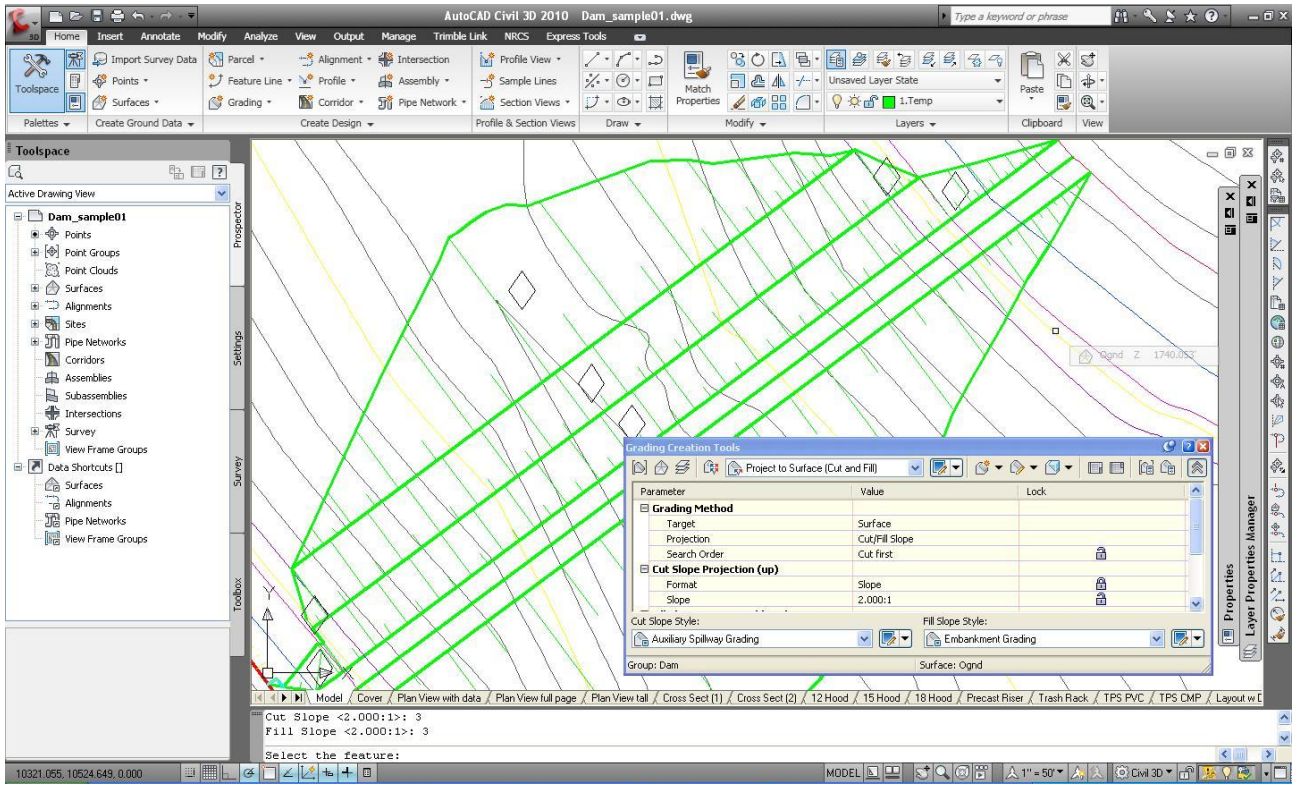


To grade from the edge of the wave berm to the original ground use the Project to Surface (Cut and Fill) grading criteria.

The Grading Criteria is set to Project to Surface (Cut and Fill).

- Select the feature (edge of the wave berm)
- Apply to entire length (No)
- Select the grading side (click anywhere upstream of the feature line)
- Select on one end of the feature line
- Select on the other end of the feature line
- Cut Slope (3:1)
- Fill Slope (3:1)

Figure 45: The creation of the upstream slope of the embankment.



Create the Surface for the Dam

Create the surface of the dam. Under the Toolspace Palette, expand the Sites, Dam, Grading Group, and Dam. Right click on Dam and click on Properties. When you place a check mark next to Dam under Automatic Surface Creation, a Create Surface window will open. Change the surface Style to _Triangles (Red) and click OK. This will return to the Grading Group Properties window.

The Volume Base Surface should be checked with the surface set to Ognd and click OK to create the surface named Dam.

Figure 46: The Grading Group Properties window.

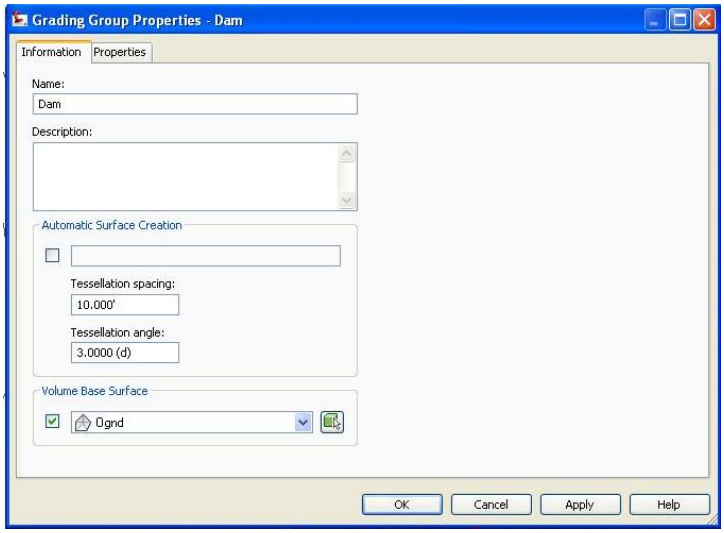
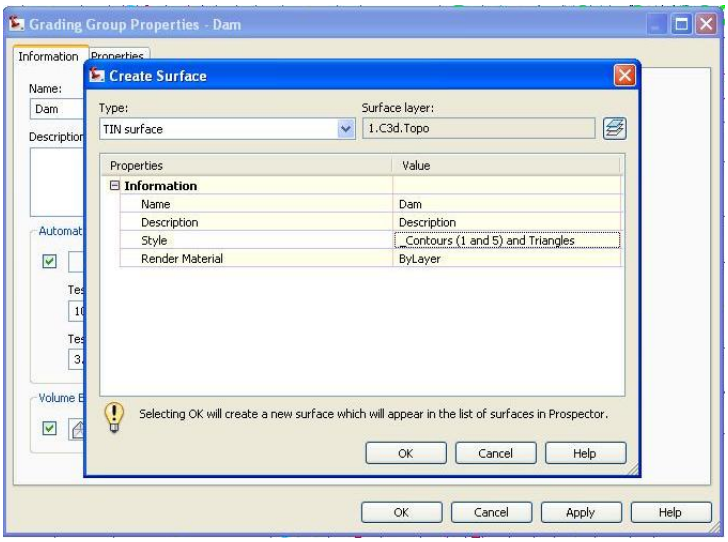
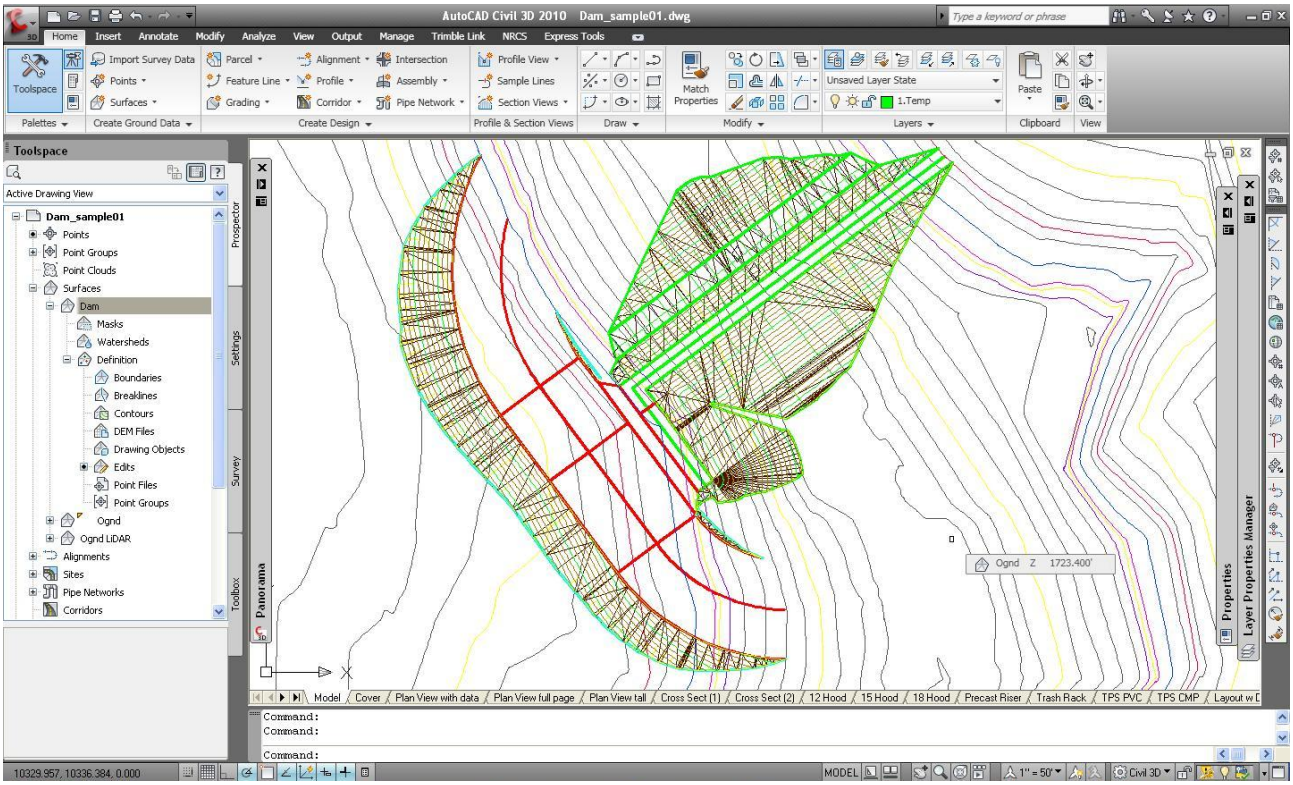


Figure 47: Create a surface from the grading group properties.



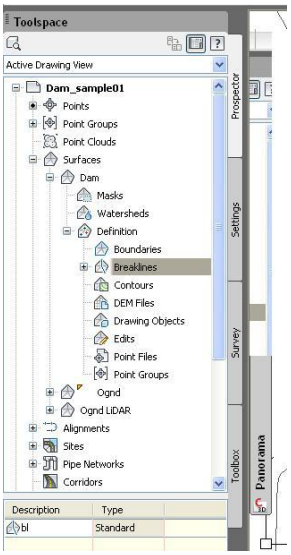
The surface has been created with the surface shown as contours (1 and 5) and triangles. Notice how the triangles do not cross the top of the embankment or in the bottom of the auxiliary spillway or between the spillway and the dam embankment in Figure 50. This means that the surface was not created for the top of the embankment or the auxiliary spillway bottom. The next step will complete the surface.

Figure 48: Grading surface showing the triangles, but the surface is not covering the top of dam or the auxiliary spillway.



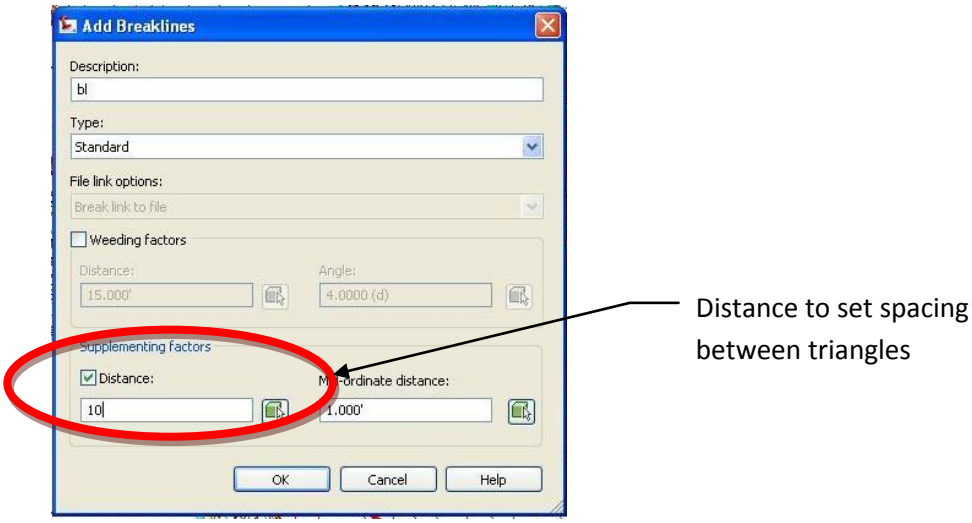
The feature lines will be added to the Dam surface as breaklines. Under Surfaces, Dam, Definition, right click on Breaklines and add Breaklines. Click on Add to Surface as Breakline. Add to the Dam surface.

Figure 49: Adding breaklines to the embankment surface.



Then the Add Breaklines window appears. Change the Supplementing factors distance 10 feet. The supplementing factor distance controls how the triangles are created by spacing the triangles at 10 feet.

Figure 50: Add breaklines window.



In Figure 51, the triangulation incorrectly goes from the embankment to the inlet and outlet of the auxiliary spillway and need to be deleted. Under Surfaces in the Toolspace, expand the Dam surface, expand Definition, and right click on Edits. Select Delete Line. Select the lines to delete and follow the command prompts. Select the lines that should not connect the embankment to the auxiliary spillway.

Figure 51: The surface style is set with the triangles turned on.

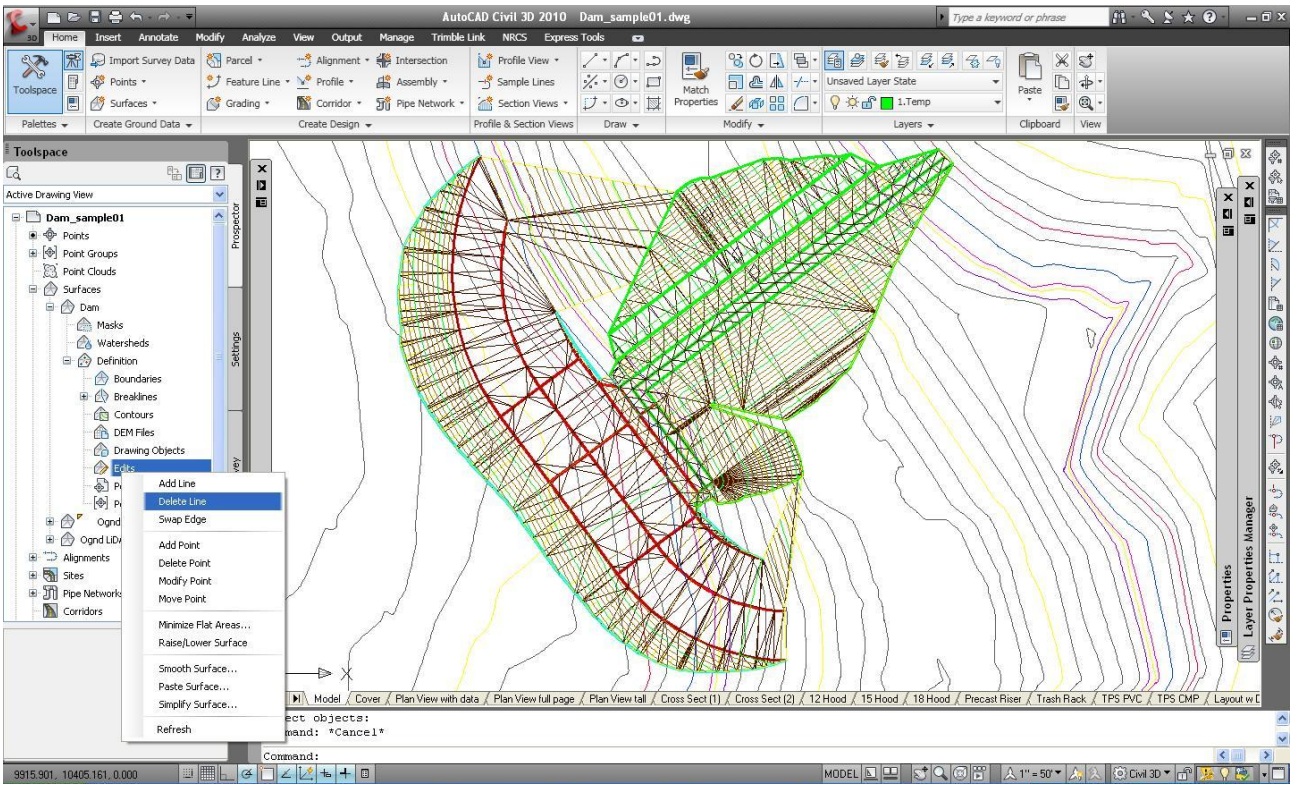


Figure 52: The finished surface with contours and triangles after the extra triangles are deleted.

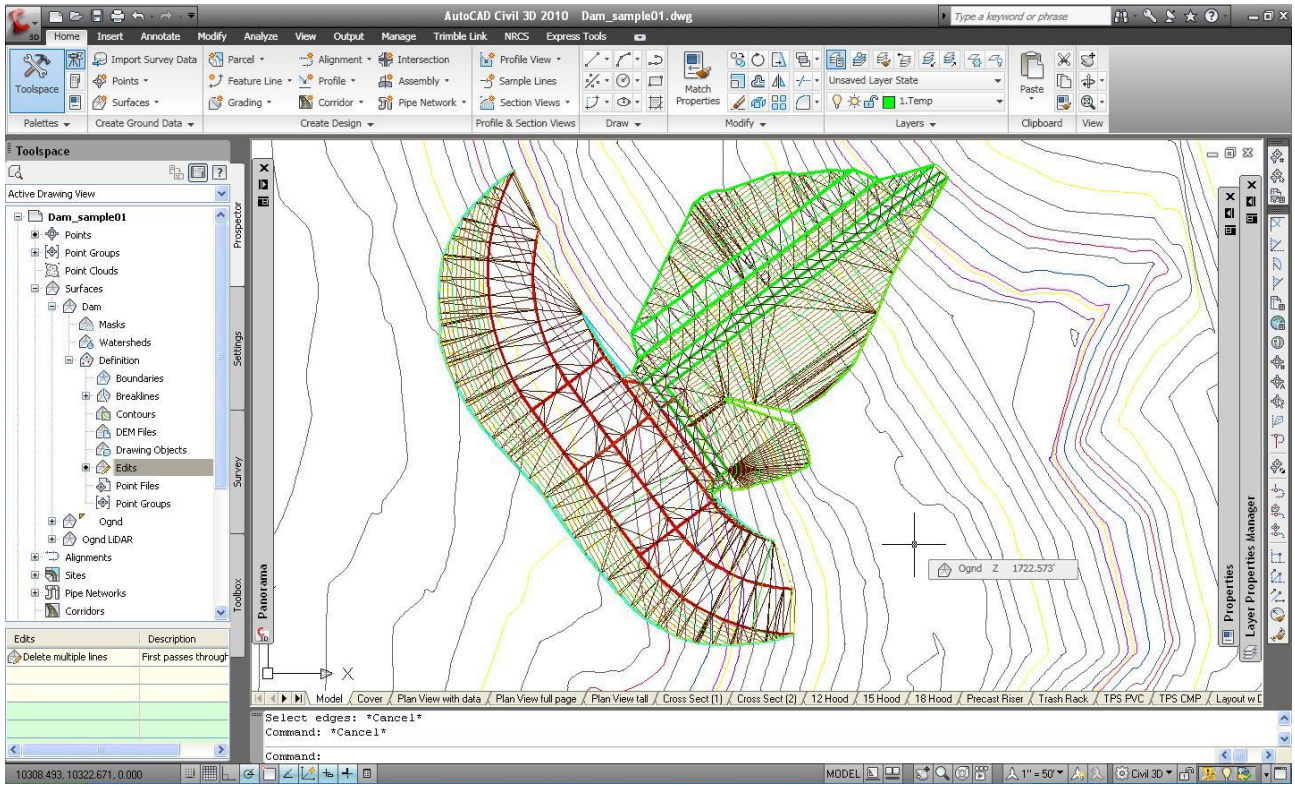
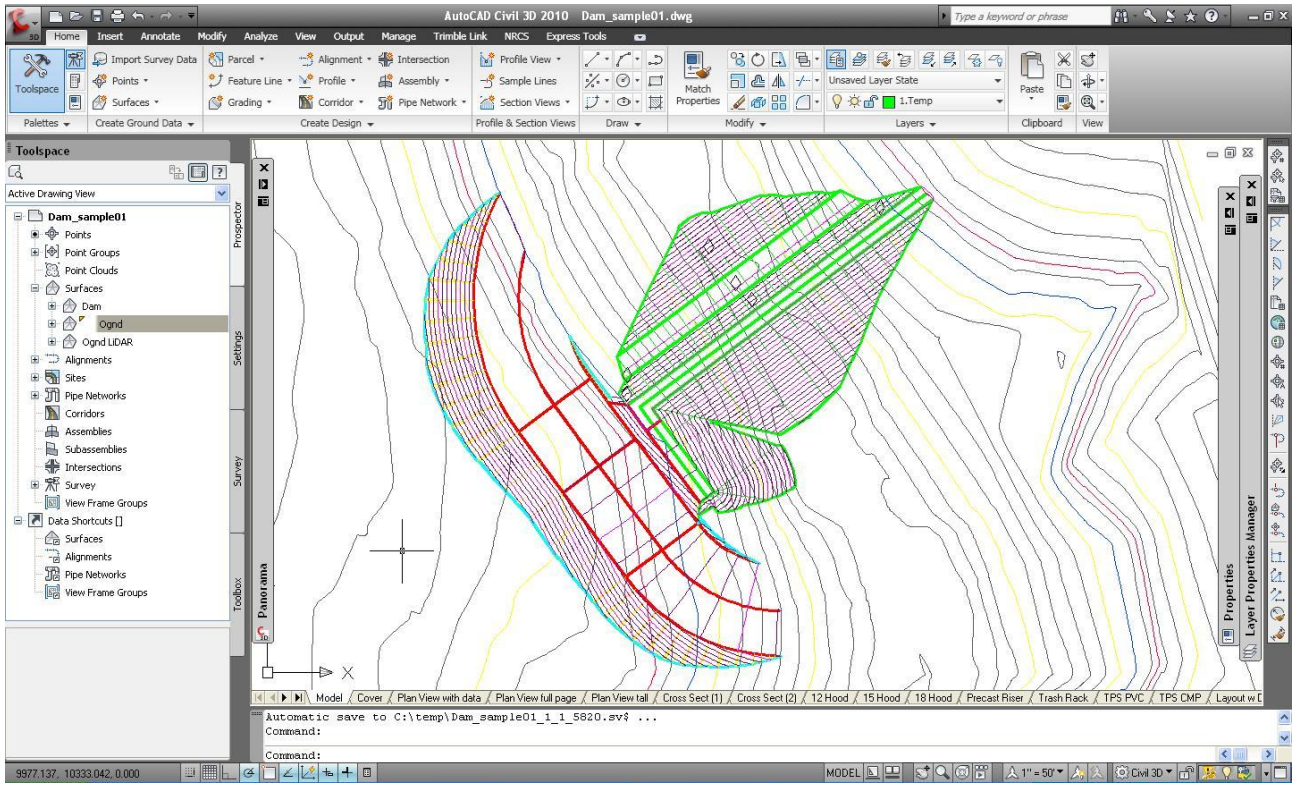


Figure 53: The finished dam surface with just contours.



Compute the Earthwork Volumes

To compute the volumes between the Ognd surface and the Dam surface go to the Analyze Ribbon Tab and click on volumes. This will open the Panorama Palette with the Compute Volumes window. Click on Create New Volume Entry (the leftmost icon) and enter the two surfaces. Use the Ognd as the Base surface and Dam as the Comparison surface. The dam has an earth fill of 7045 cubic yards in the embankment and 4739 cubic yards of excavation in the auxiliary spillway.

Figure 54: The volume calculation command.

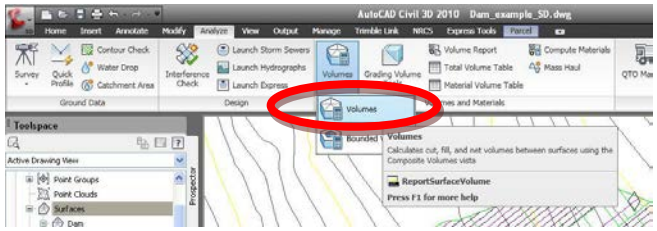


Figure 55: The Panorama with the Volumes Between Surfaces.