
GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

GRADING — Dam with Emergency Spillway

Grading can be a complicated task. With 2008 there are still some quirks with the program. I can not stress enough how often you should SAVE YOUR WORK! We are told the quirks get less with 2009 and by 2010 they are pretty much all worked out. Until then be patient and SAVE OFTEN!!!

This example is going to take a simple grading task of grading a dam a few steps further... we're going to build an emergency spillway and a semicircular berm around the pipe inlet. The advantage of doing so is being able to get accurate cut and fill volumes! Since our other Help Sheet on dams does not cover **stage storage**, I will cover that here as well.

Like everything in CAD there are multiple ways to complete the task. Challenge yourself once you learn these steps to try new ways - then share with your co-workers and the CAD Team!

STAGE STORAGE

- Start with an existing ground surface (with the contours showing).
- Draw in the Centerline of the dam embankment. Often times you will survey in “hubs” which represent markers along the centerline of your dam embankment.
- Offset the top of the dam an appropriate amount (often between 10-15') upstream.
- From Surface > Utilities > Extract Object from Surface.
 - Make sure the major and minor contours are selected and hit “OK”
- You now can click individually on any contour line. (Your surface, which acts as a single object, is still under the contour lines).
- Trim each of the contour lines that go beyond the downstream side of the offset line.
- Use the “List” command to find the area of each contour.
- Use this to enter into the “Pond” Spreadsheet to complete your dam design! For this example we will be using the data on the next 2 pages.

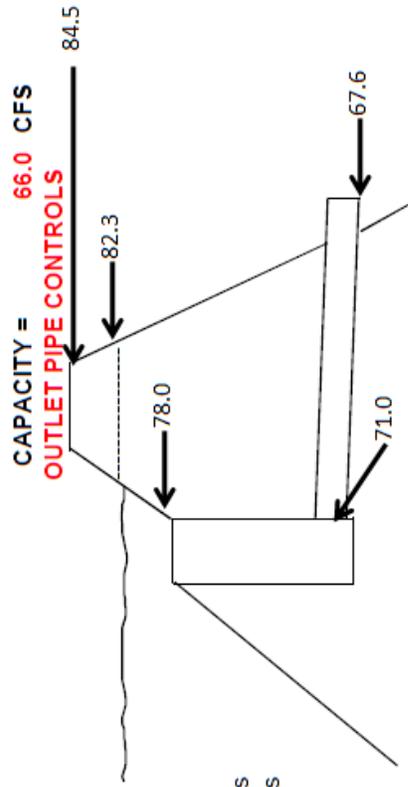
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DESIGN SHEET USED FOR THIS EXAMPLE

PIPE DROP INLET STRUCTURE

CLIENT: _____ DATE: _____
 DSN BY: _____ DATE: _____
 COUNTY: _____
 COMMENTS: _____
 CHK BY: _____

top of embankment elev	84.50
emergency elevation	82.30
water elevation	82.30
front slope ratio (? : 1)	3
back slope ratio (? : 1)	2



RISER DETAILS

diameter or width of riser	36.00	inches
length of riser opening	78.00	inches
riser elevation	71.00	
bottom of riser elevation		

OUTLET PIPE DETAILS

outlet pipe diameter	30.00	inches
type of pipe - #	3	
length of outlet pipe	75	feet
invert outlet elevation	67.60	
Mannings 'n' outlet pipe	0.025	
Kp out	0.0341	
Is there tailwater? (yes=1, no=2)	2	

Size of antiseep collars (ft)
 Number of anti-seep collars needed

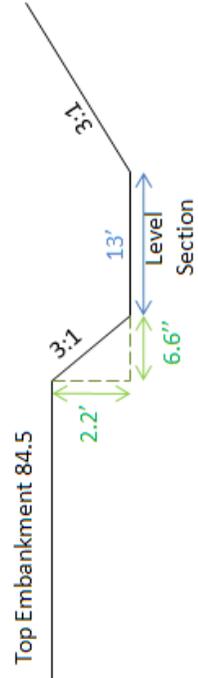
5
3.80

PIPE TYPE TABLE

- 1= PVC
- 2= PE
- 3= CMP
- 4= N12
- 5= HCMP
- 6= CONC

Auxiliary Spillway

Outlet slope range 3.8-13%
 Level Section 20' Long X 13' Wide
 Depth = Hp (1.2') + 1' Freeboard = 2.2'

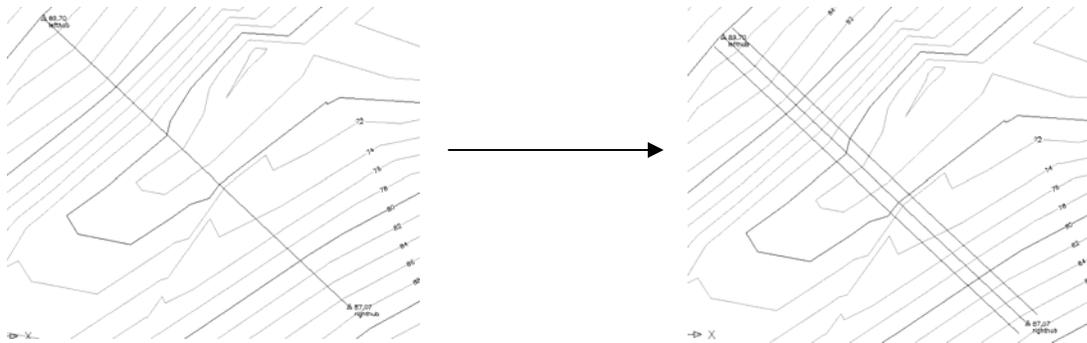


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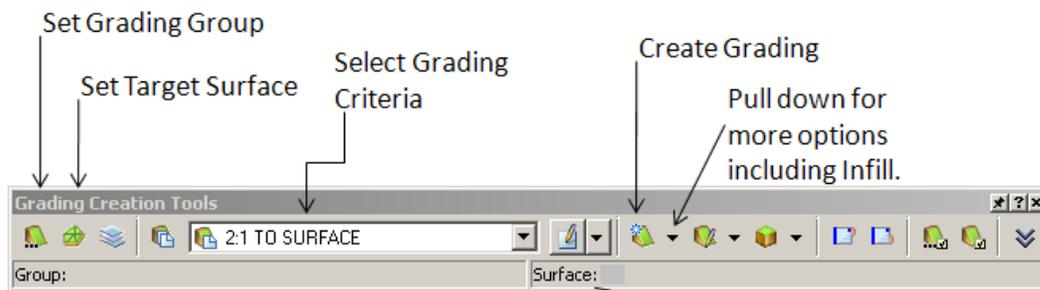
I am now assuming you have designed your dam, and you are ready to draft. If you need to grade the slopes to find appropriate elevations to plug into the spreadsheet you can do so by following the first few steps in this help sheet.

DRAFTING A DAM

- Set the elevation of your centerline to be the elevation of the top of your dam (constructed el). Many folks like to have a crown in your dam, to do so click to add vertices at the location where you want to specify different elevations.
- Make sure the centerline of your embankment goes beyond the elevation the top of the dam. For example, if the top of your dam is 84.5 make sure your centerline reaches at a minimum the 85 el. contour!
 - If you need to stretch your centerline use the “lengthen” command.
- Offset the centerline half the distance of your embankment top width in each direction (upstream and downstream). The top of our Example Dam is 10’ so you would offset the centerline 5’ in each direction.



- You will now create a grading group by going to Grading > Create Grading
 - The “Grading Creation Tools” toolbar will appear



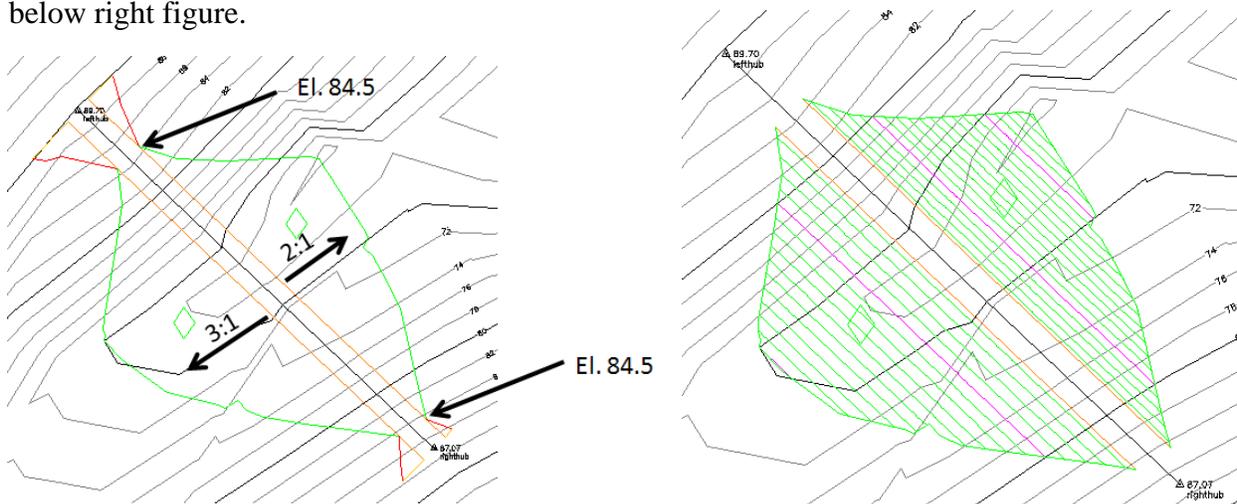
Once Grading Group and Target Surface are set, they will appear in these areas.

GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

- Click on the “Set Grading Group” icon
 - Give the Grading Group a name (such as Dam)
 - Make sure you select “Automatic Surface Creation”
 - Click “OK”
- Click on the “Set Target Surface” icon
 - Choose the surface you want to grade to (most likely EG)
 - Click “OK”
- Click the Grading Criteria from the dropdown
 - Most likely 3:1 for the frontslope and 2:1 for the backslope
- Click on the “Create Grading” icon
 - If you want, you can change options in the “Create Feature Line” dialog box
 - Follow the command line prompts
 - Change the Grading Criteria and repeat for the other side of the dam

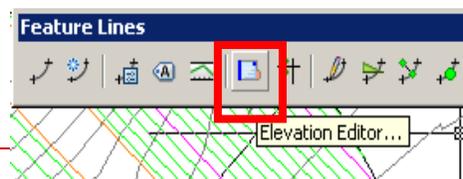
Your drawing should now look similar to the below left figure. The point where the fill (green lines) meets the cut (red lines) is where your design elevation is at (the top of your dam embankment).

You can drag the endpoints of your feature lines back to the design elevation by O-Snapping to the endpoint of the feature line, dragging the line towards the point where the cut meets the fill, and O-Snapping to the endpoint at the cut/fill location. The end result should look like the below right figure.



IMPORTANT NOTE

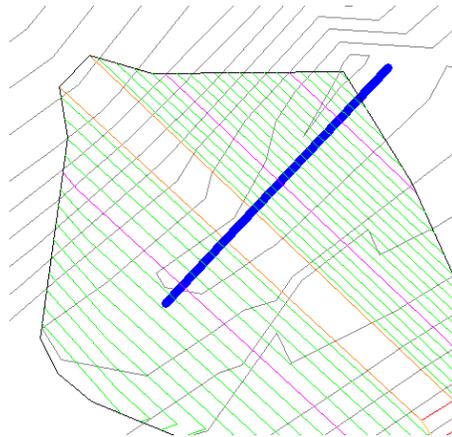
If you added additional vertices in the top of embankment polylines, you need to go into the Feature Line Editor (found on the Feature Line Toolbar) and edit the elevations for the top of embankment lines.



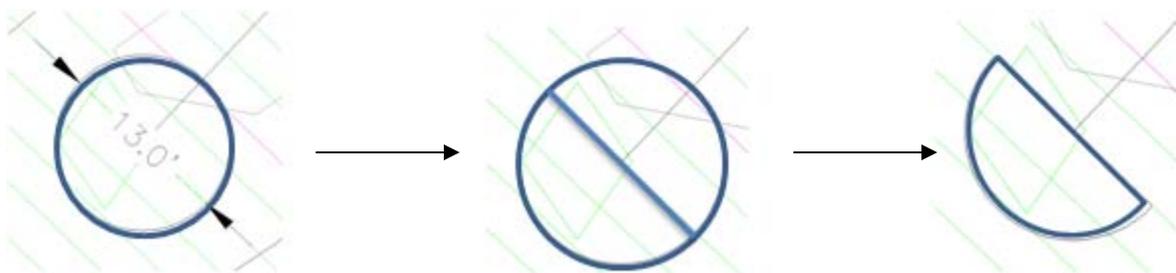
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We are going to use the Dam contours to set our inlet pipe elevation and draw our semicircular berm around the pipe inlet.

- The first step is to draw in the pipe, which will be placed perpendicular to the centerline of the dam embankment. The design sheet states the inlet elevation (start of pipe) and the approximate length of the pipe.
- You can start by drawing a polyline in the upstream ditch at the inlet elevation, and O-snapping perpendicular to the dam embankment. You can then use the Lengthen command to lengthen the line the approximate length of the pipe. If all goes well, the pipe should extend past the downstream toe!



- According to the Pond Standard: The semicircular berm shall be 5' from the edge of the pipe. So for this example our riser is 3' in diameter, that means the diameter of the semicircular berm needs to be $5' + 3' + 5' = 13'$.
 - Draw a circle with a diameter of 13' from the pipe inlet (O-Snap to the endpoint of the polyline that represents the riser/pipe).
 - Draw a polyline from El. 78 on one side of the circle, to El. 78 on the other side of the circle
 - Trim the back of the circle
 - Make sure the semicircular berm is set to the proper elevation (78.0) by using the properties dialog box.



GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE**NOTES ON GRADING OBJECTS**

CAD can not handle grading on top of grading, therefore we are going to grade the dam in individual pieces so the grading doesn't overlap each together. In the end we will bring all the pieces together to form a surface from which CAD can calculate cuts and fills.

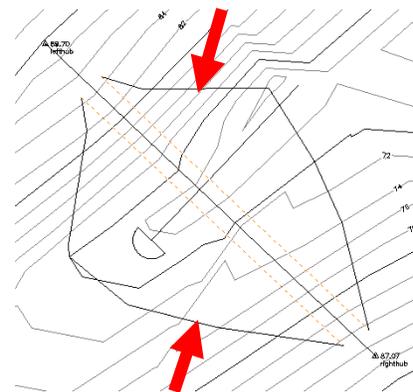
- Using the Explode command found on the Modify toolbar (or type EXPLODE at the command line), explode the daylight lines of the grading object.



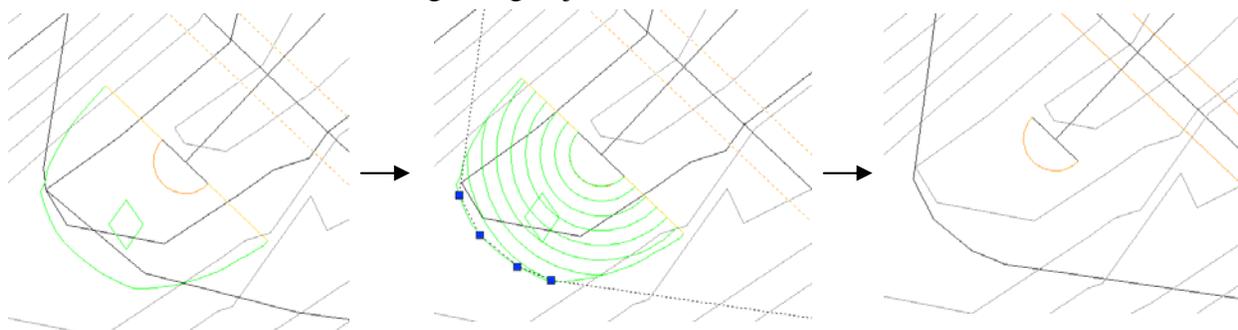
The daylight lines become 3D polylines.

Notice how the contour lines disappear. That is ok!

The result should look similar to:



- Now Grade the semicircular berm around the pipe inlet at a 3:1
- Click on the 3D polyline to move the vertices to match the new daylight line of the semicircular berm
- Erase the semicircular berm grading object.

**IMPORTANT NOTE**

If you need to add additional vertices on the 3D Polyline to be able to accurately “trace around” the new daylight line follow these steps:

At the command line type **PEDIT** > Click on your Polyline you want to edit > Type **E** to edit > hit enter (**N**) to advance around the polyline > Type **I** when you are ready to insert a new vertices. If you need to go back type **P** for previous vertices.

Just be sure to follow the command line the whole time or reference the Help section in CAD if you have any questions!

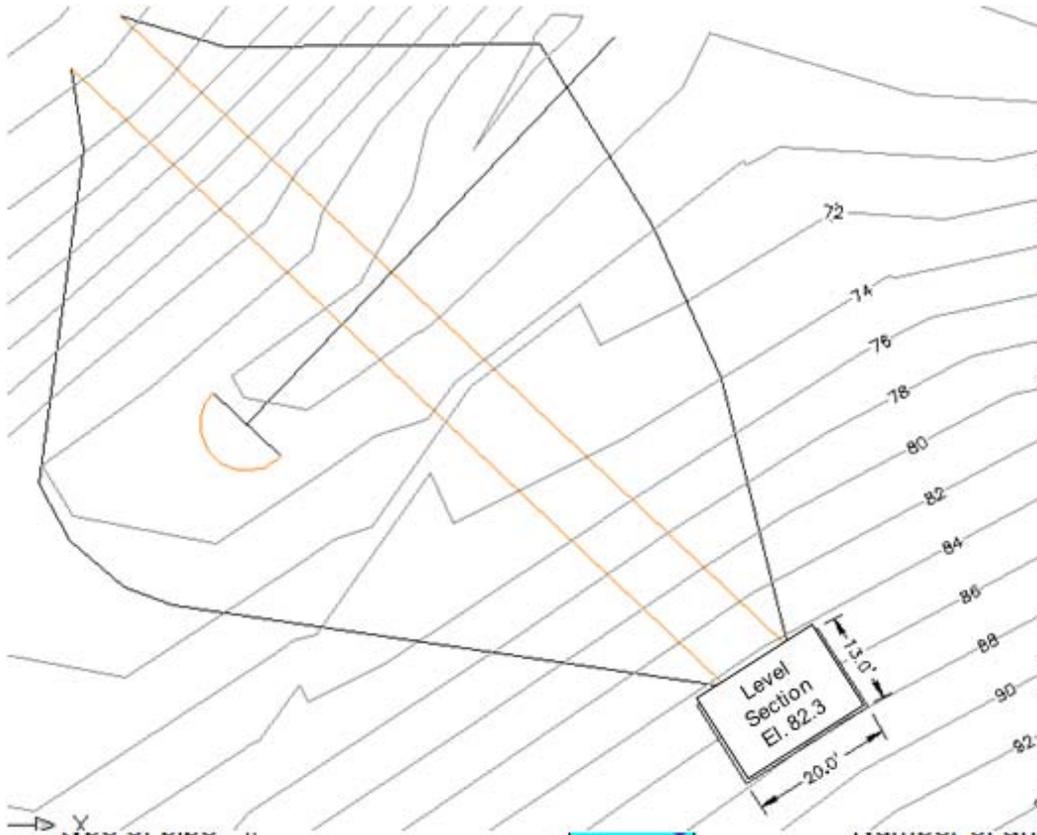
GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

We are now going to work on drawing the Emergency Spillway. This example has a level section 13' wide X 20' long. If possible the entire level section should be cut into the hillside.

Placement of the level section (and the entire emergency spillway) is an art. There are many possibilities to placing and drawing the spillway, experience and trial and error are needed. If you don't have experience, work with another technician or engineer for any questions you have!

- Start out by drawing a rectangle that is 20' X 13' and set the elevation to the emergency elevation (in this case 82.3). Then rotate and move the rectangle until it fits the site.

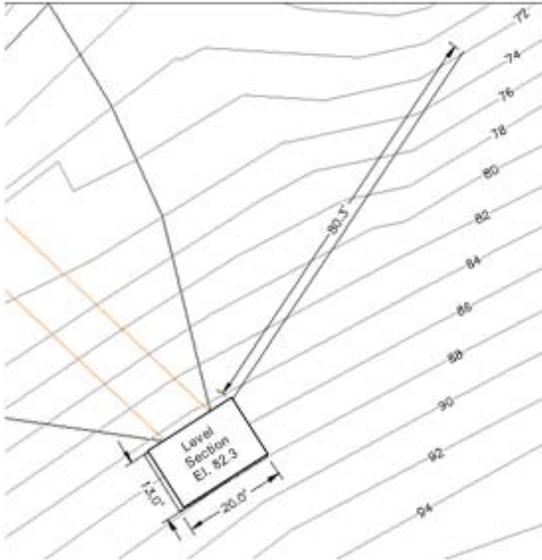
For this example I'm going to place the level section so ~10' of length extends upstream and downstream from the center line of the embankment. The elevation of the level section is 82.3, so I'm going to make sure this is all placed in an area that is at a higher elevation so that it will need to be cut down to be constructed.



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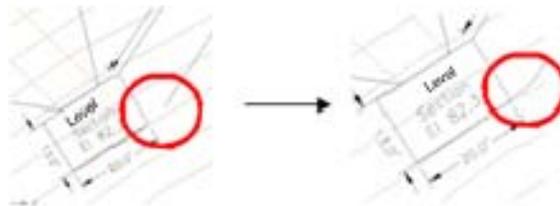
Next is drawing the inlet and outlet channels. We'll start with the outlet channel. A few things to keep in mind.

- The outlet channel needs to go past the downstream toe (you don't want this water to wash out the back of your dam!)
 - Try to keep as straight as possible (as the site allows)
 - Check to see what slope range your channel needs. This design calls for an outlet channel between 3.8 to 13%.
 - Remember this is an art!
- Start by drawing one side of the outlet channel using a 3D Polyline.
 - Use your O-Snaps to avoid elevations going to zero!
 - Check the length
 - Check the elevation difference between level section and outlet elevation
 - Make sure the slope is in the proper range.
 - This may take some trial and error... be patient!



This example has a length of 80.3 feet and an elevation difference of 10.3'. The slope is ~8%

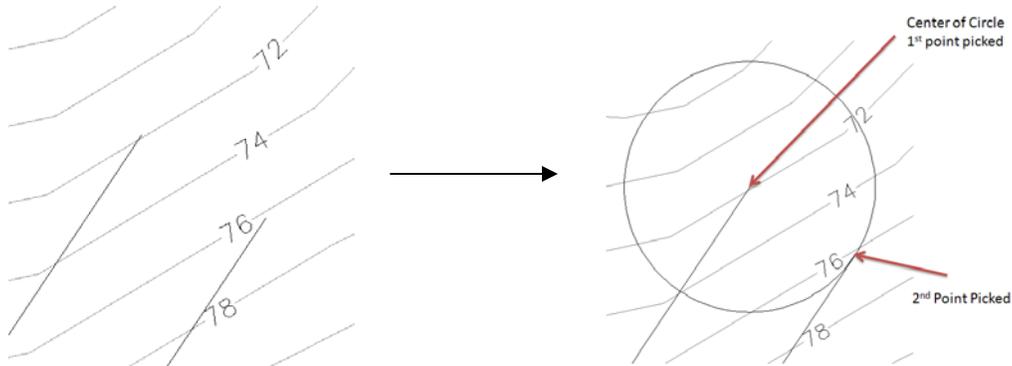
- Next offset the channel the width of the emergency spillway (this example is 13') using the Stepped Offset command  (found on the feature line toolbar).
- Notice how there is some “dead space” between the level section and the start of the channel slope. Use a 3D Polyline to connect these objects.



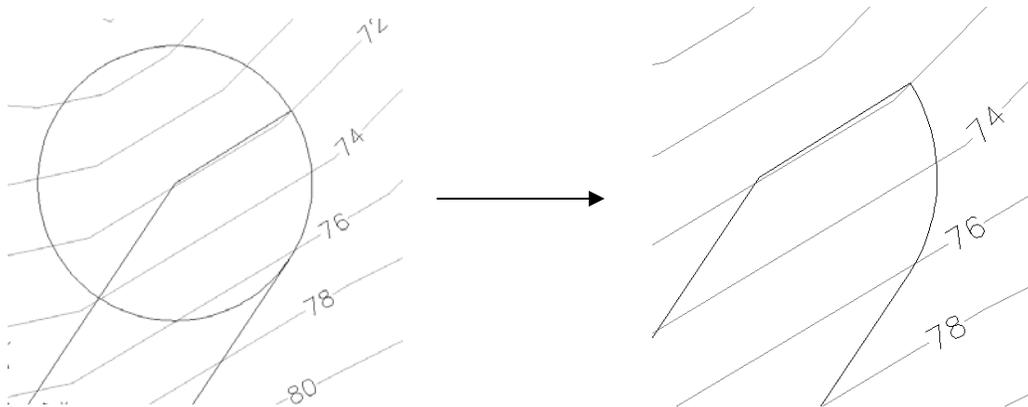
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Next we need to doctor up the outlet of the channel!

- Draw a circle that starts at the endpoint of the lower elevation line and connects to the endpoint of the line at the higher elevation.



- Draw a polyline connecting the 2 points on the outlet elevation (el. 72.0) and the circle
- Trim the remainder of the circle



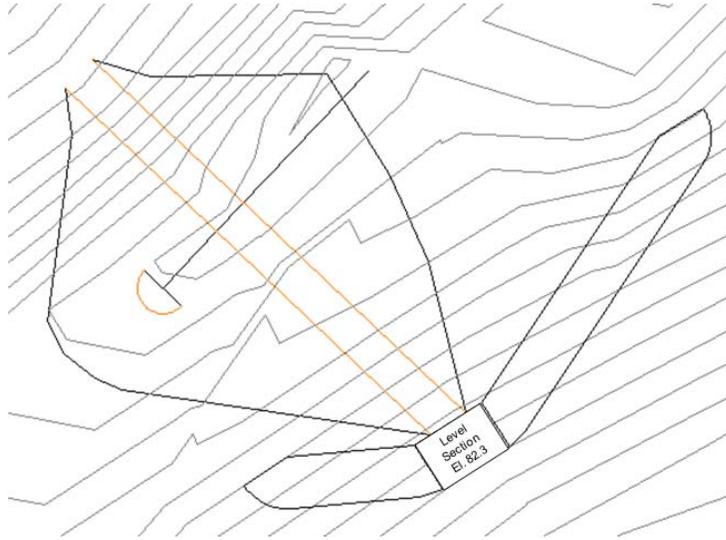
Your dam should now look similar to this:



**Repeat this same procedure for the inlet channel.
Be sure to check the channel slope!**

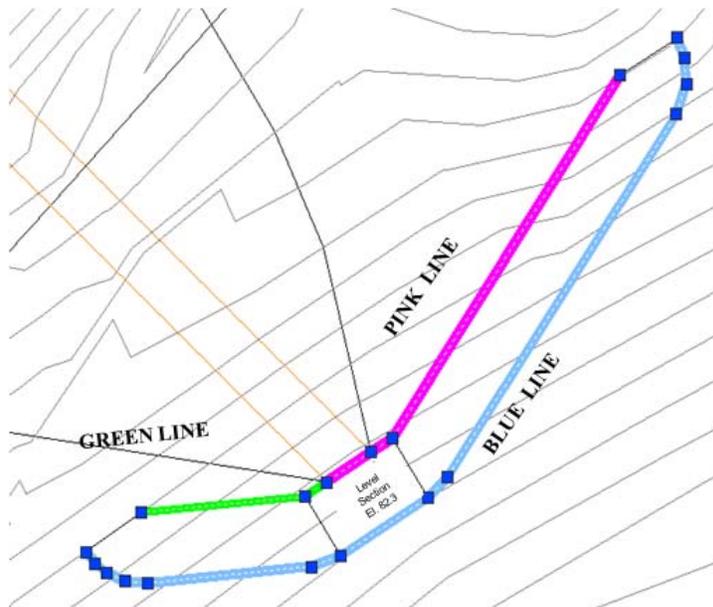
GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

Now that the inlet and outlet channel slopes are drawn the dam should look similar to this:



We are ready to finish grading the Emergency Spillway!

- Start by drawing three 3D polylines. (see the different colors shown below) over the emergency spillway channel. We will grade from these 3 sections!

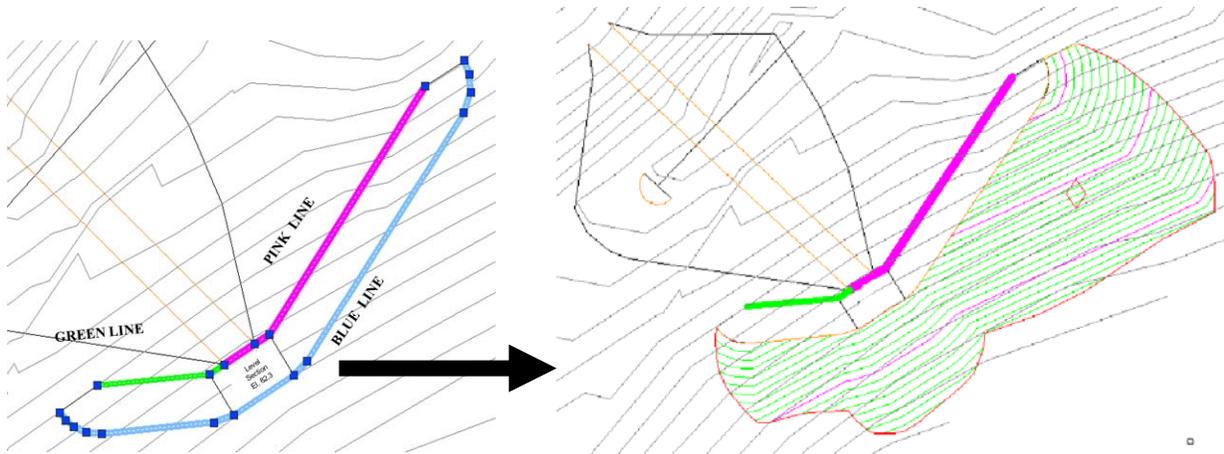


Now is a really good time to double check the elevations of ALL your 3D and Feature Lines!!!!

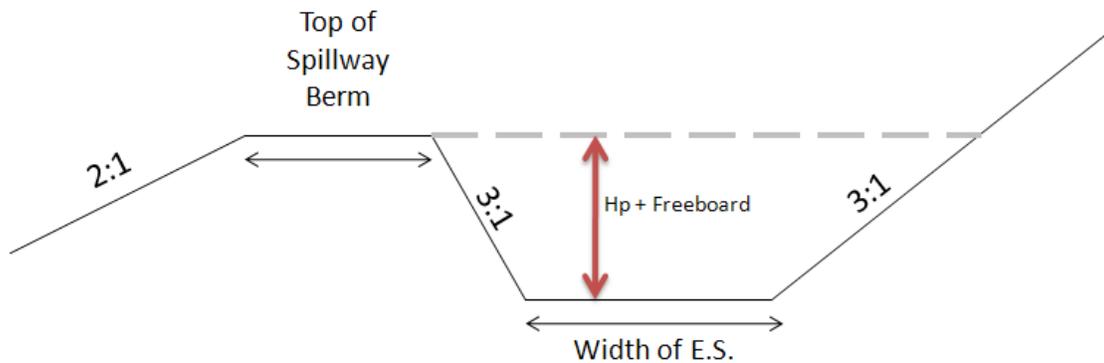
GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

Let's start with the easy stuff!

- The blue line is graded at a 3:1 to the existing ground.

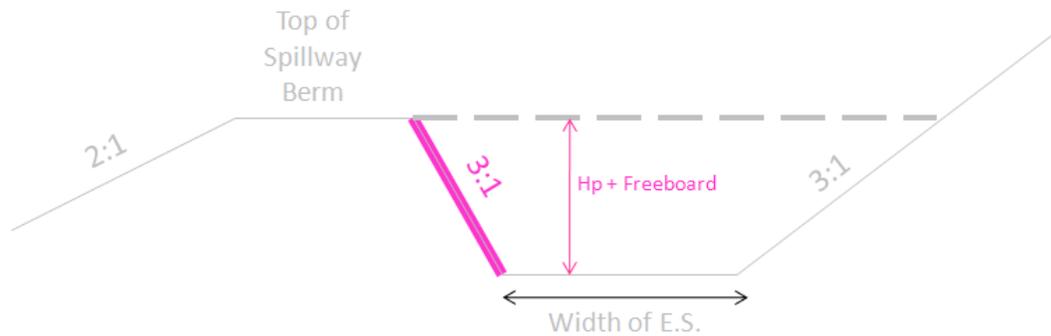


- The **pink line** is a little more complicated since we need to create a spillway berm that runs parallel to the emergency spillway! A cross section of the completed downstream area of the emergency spillway and spillway berm will look like this:



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Start by grading the pink line at a 3:1 up to the top of the spillway berm



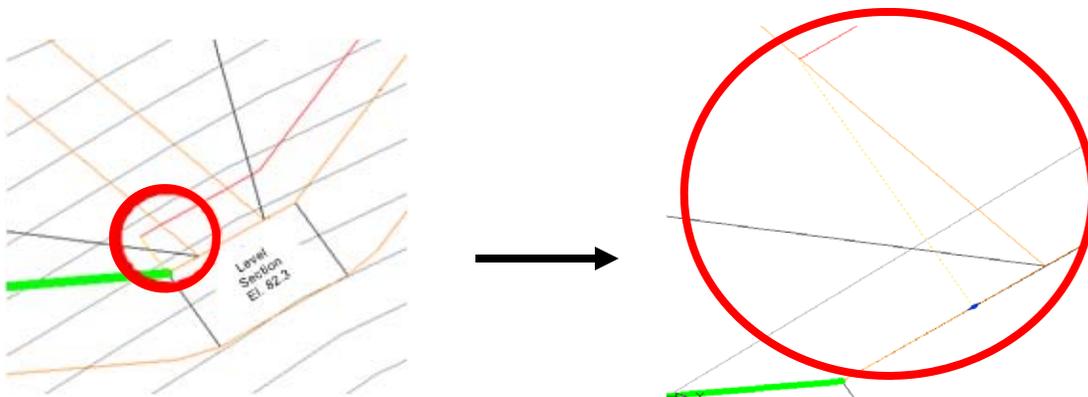
- Select the “Grade to Relative Elevation” as the Grading Criteria
 - Select the pink line, go through the Create Feature Line dialog box, and follow the command line.
 - Relative Elevation is the Hp + Freeboard (in this example 2.2’)
 - Slope is typically 3:1

Typically the grading object will not meet exactly at the edge of the dam embankment. There are 2 ways to fix this.

- 1) Explode the grading object. This results in a 3D Polyline which you can move the end vertex to the edge of the embankment (be sure to use O-Snap).

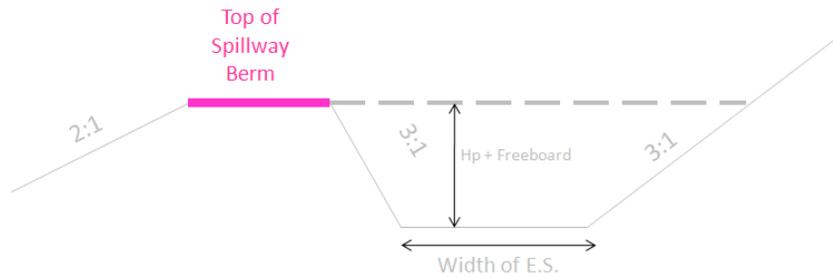
OR

- 2) Click on the daylight line and move the “blue triangle” until the ends line up better.



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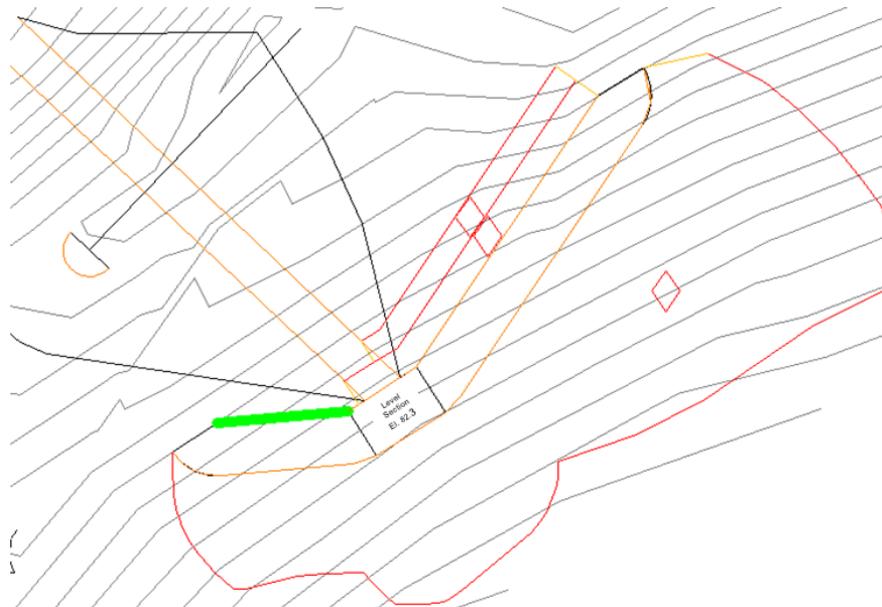
We are now going to grade the top of the spillway berm.



- Select the “Grade to Distance” as the Grading Criteria
 - Select either the 3D Polyline (you got from exploding) or the red line of the grading object (this will depend on what step you did last) and follow the command line.
 - Distance is the width of the berm (typically 3-8’) our example uses 6’
 - Change the format to GRADE and use 0%

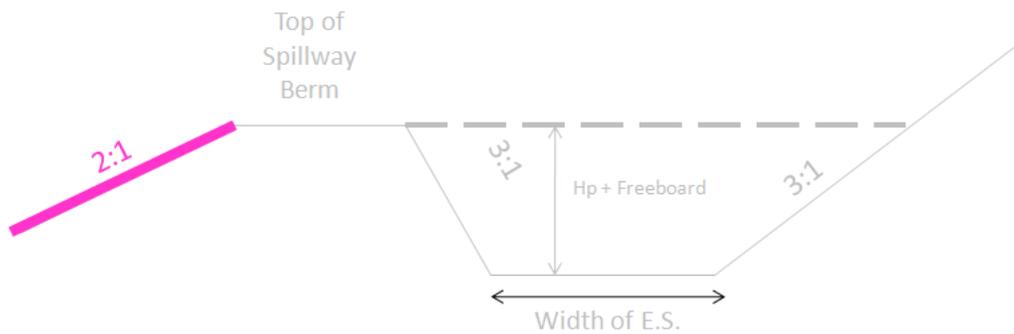
Once again your grading object will not line up exactly with the embankment edge. You will have to adjust this by exploding and moving the resulting 3D Polyline or by moving the “blue triangle” of the grading object.

The result so far should look similar to this:



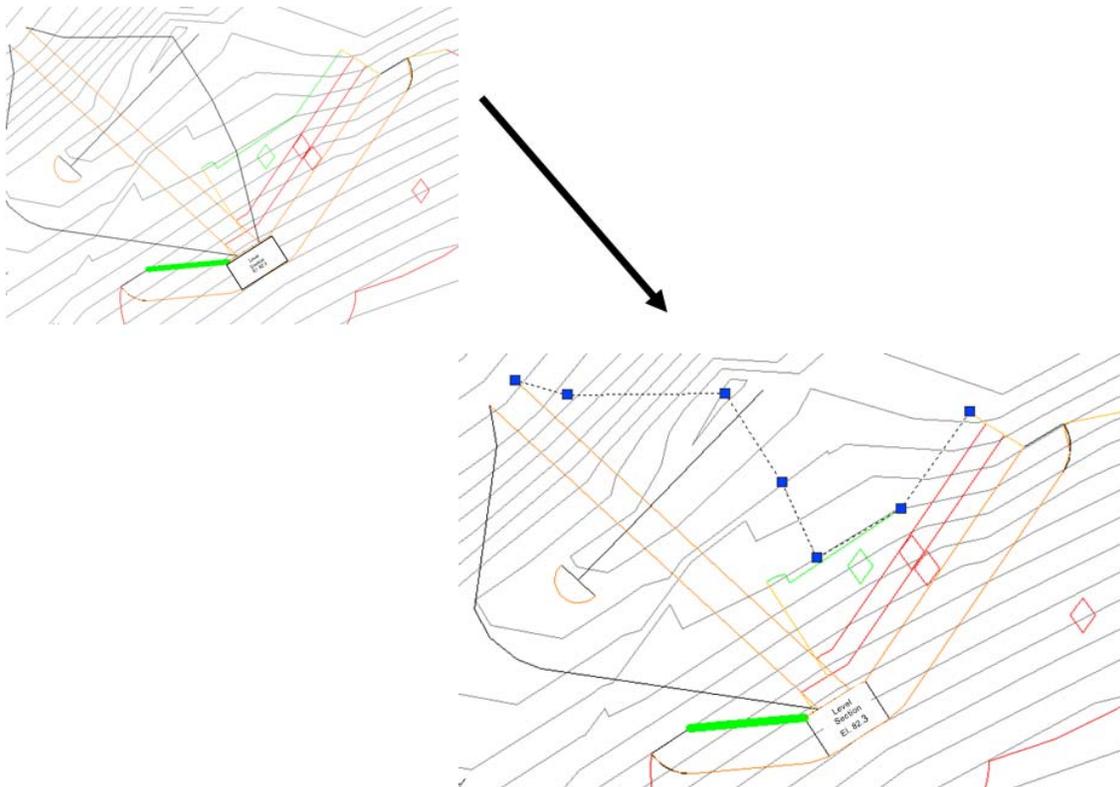
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The last step is to grade the top of the spillway berm at a 2:1 back down the slope.



- Select the “2:1 to Surface” as the Grading Criteria
 - Select either the 3D Polyline (you got from exploding) or the red line of the grading object (this will depend on what step you did last) and follow the command line

You now need to match up the dam embankment daylight line (black line) with the spillway berm daylight line (green line). You can do this by simply moving the vertices of the black line. If needed you can edit the black line (PEDIT) and insert vertices to “trace over” the green line. Once finished you can delete the last grading object (grading from top of spillway berm at a 2:1)



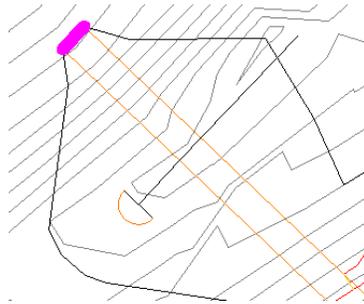
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The last component of the emergency spillway is grading the inlet channel (the green line)

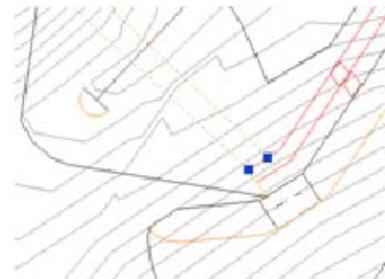
- The green line is graded at a 3:1, there are 2 ways to do this:
 1. Depending on your dam and where your inlet channel is this may be as simple as moving the embankment daylight line to the end of the inlet channel.
 2. Or you may have to create a surface for the dam and daylight to the Dam Surface.

I'll show you the second option since you can complete the first option with no further help!

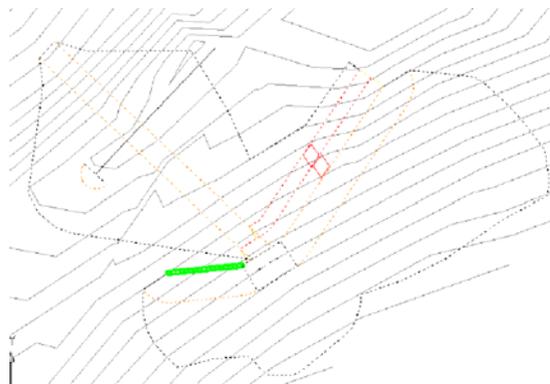
- Start by deleting any extra lines you have drawn in, so you don't accidentally pick those.
- Draw in the end of the dam if you haven't already (pink line in figure below).



- Drag the endpoints of your embankment so they meet your grading lines on the end of your emergency spillway.



- Create a New Surface (if you don't already have a dam surface created).
- Add Breaklines
 - Select all the lines that define the dam (grading lines, 3D Polyines, daylight lines, top of embankment, berm, etc)

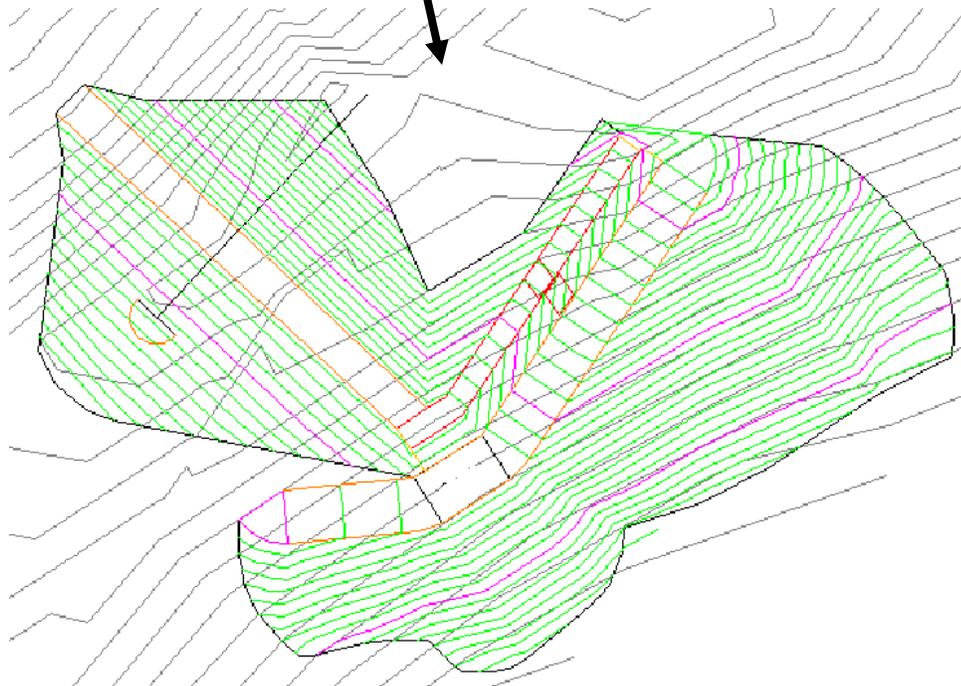
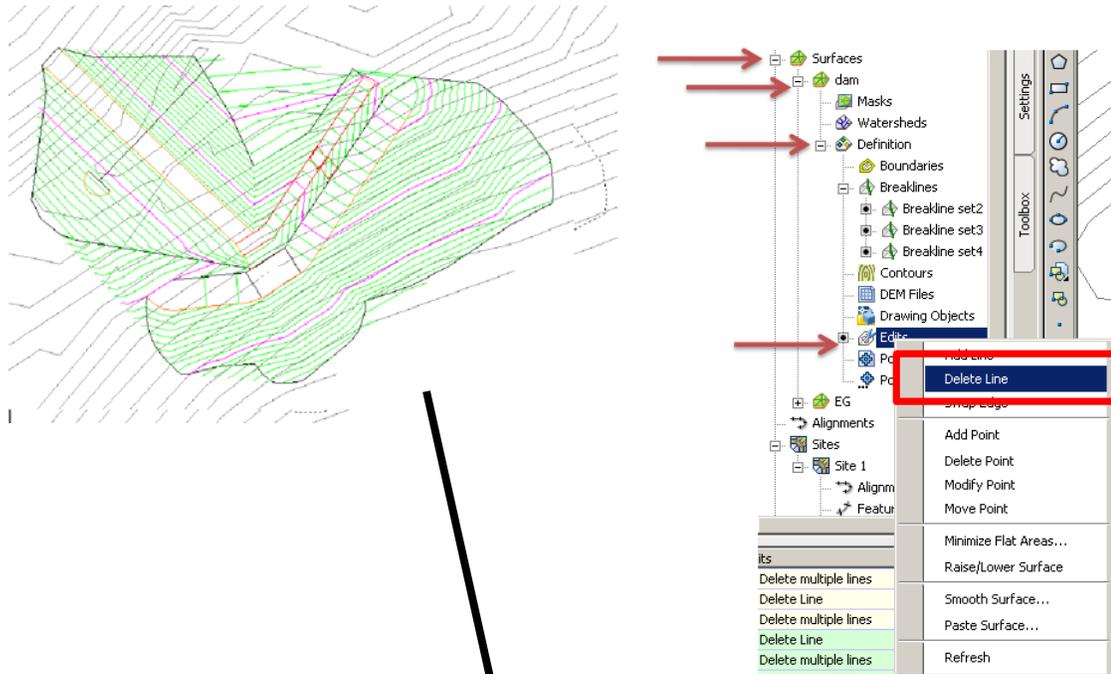


- Click "OK" and the surface will be created!

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You’ve probably noticed there are some areas in the surface that could use some “clean up”, areas that show contours where they shouldn’t be. This is an easy fix!.

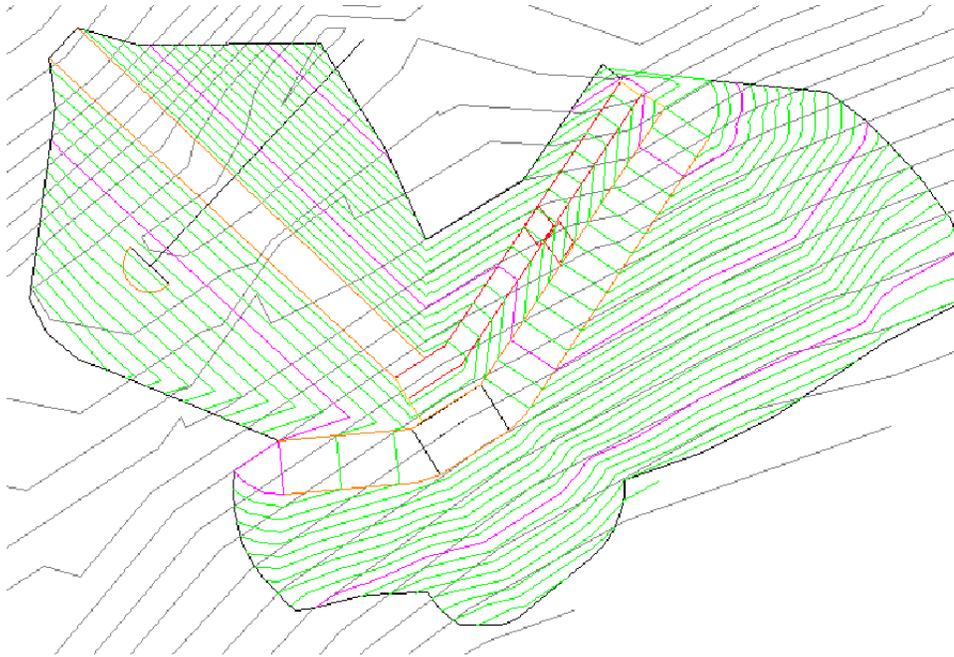
Change your surface style to “Triangles and Contours” and delete out any unwanted tin lines.



GRADING — DAM WITH AN EMERGENCY SPILLWAY EXAMPLE

- Now create a new Grading Group that uses a Target Surface of the DAM Surface.
- Grade the inlet channel at a 3:1 to the Dam
- Add the daylight line to the Surface as a breakline

You should have a finished dam!



You can now complete Profiles, Cross Sections, and add all the dimensions and text you want.

Quantities are done by comparing 2 surfaces (EG vs. DAM).

Surface > Utilities > Volumes

Index	Surface Pair		Volume		
	Base Surface	Comparison Surface	Cut	Fill	Net
1	EG	dam	1341 Cu. Yd.	1863 Cu. Yd.	522 Cu. Yd. <Fill>