LD20493

From AutoCAD Civil 3D to Storm and Sanitary Analysis - Pond Design Using Volume-Grading Tools

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<td>• Perform Stage Storage takeoff, and export data to SSA for analysis</td>
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<td>• Import Stage Storage Data into an SSA model to accurately simulate pond performance.</td>
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Description

This class will demonstrate the use of AutoCAD Civil 3D software grading objects and volume grading tools to design a stormwater pond based on a desired storage volume. The completed design will then be exported using the Stage Storage tool and imported into Storm and Sanitary Analysis software for analysis. This session features AutoCAD Civil 3D.

Your AU Expert

As a senior designer at LSC Design in York Pennsylvania, Kevin Larkin brings over 10 years of CAD experience in the civil infrastructure field. Larkin is a specialist in earthwork and grading, and he excels at devising creative solutions to unfamiliar land development situations and problems. He is passionate about technology, and has taught courses in AutoCAD Civil 3D, InfraWorks 360, AutoCAD Map 3D, AutoCAD, and Storm and Sanitary Analysis as an Autodesk Certified Instructor and Applications Engineer.
Designing stormwater ponds using AutoCAD Civil 3D

Designing a stormwater detention ponds can be a challenging task. Ponds that need to fit into tight areas or oddly shaped sites can make it difficult to make sure the pond that fits on the site has the required volume to meet the projects stormwater needs. The process grading a pond, calculating the storage volume, and checking this against the stormwater requirements can be a lengthy process. Especially when the initial design doesn't work, and you have to go back to square one to start the whole process over. And let’s face it, when does the first thing you draw up ever just work! Luckily Civil 3D and Storm and Sanitary Analysis have a few tools to quickly create, modify, export and analyze pond geometry, to get you to a working pond design with less time-consuming design iterations.

Dynamically model stormwater ponds using AutoCAD Civil 3D grading objects

Being able to efficiently build a surface model of the physical properties of a pond is the first key to a good design. In Civil 3D there are many ways to build a surface model. They can be built using breaklines, contours, points, etc., but most of these methods require a lot of rework when the design is changed. In this example, grading objects will be used to define pond geometry from a single base feature line. When changes are made to that base line the rest of the pond will update. This allows for easy manipulation of pond geometry, and many pond shapes can be quickly explored to find the best one. A reference surface will also be used to allow the pond to be resized based on the desired storage volume, but more on that later...

Prepare to Create Grading Objects

1. Open the file named A1 - Prep for Grading Objects.dwg located in the provided course files. This file contains a single feature line defining the bottom of the detention pond.

2. First, it's a good idea to verify the elevations of the feature line make sense to create a grading object. If a feature line has an elevation that is not realistic the grading object will not be created, or even worse, Civil 3D will crash. To avoid this it's a best practice to check the elevations before creating the grading object. Select the feature line just north of the proposed drive. In the contextual Feature Line ribbon click the Elevation Editor. Panorama will open with a Grading Elevation Editor tab showing the elevations for all of the feature line vertices. Notice they are all 0.000’. You will need to set an elevations closer to the existing ground surface before creating grading objects.
3. Select the first PI in the elevation editor, then press Ctrl + A on the keyboard to select all the PIs. Now left click on one of the elevation values in the elevation column to edit it. Enter 1123 and press enter. Notice all the PI elevations change to 1123.000’. This will be the starting elevation for the bottom of the pond. Now you are ready to create grading objects.

TIP: Notice there are no curves in the pond bottom feature line. It’s a good practice to use a simple shape (i.e. no curves and as few vertices as possible) for your feature line when beginning a pond design. This will simplify the process of changing the model in the early design. Adding details like radii to the corners is easily accomplished later using the Feature Line > Edit Geometry Tools.

Create a Grading Group

4. Open the Grading creation tools by selecting Grading on the Home ribbon, Create design panel.

5. Grading objects must be part of a grading group contained in the same Civil 3D site as the feature lines you create them from. In this example a Pond Grading Site has already been created. Assign the Grading Group by clicking the Set Grading Group icon. When prompted Set the Site to Pond Grading and click OK.

6. Since no grading groups are present in the Pond Grading site, the Create Grading Group dialog will open. Enter Pond Volume in the name field, check Automatic surface creation, check Use the Group name, and set the Surface Style to Contours 1’ and 5’ (Design). Also check the box for Volume base Surface and select the “Freeboard Elevation” surface in the pull down. You will use this option to control the volume of the pond in the next section. Leave the remaining options at their default values and click OK.

7. Next, the Create Surface dialogue box will appear. Verify the surface name is Pond Volume and the style is set to Contours 1’ and 5’ (Design), then click OK to accept. In prospector you should now have a surface called Pond Grading.
Create Grading objects for the Inside of the Pond

8. Start by selecting the “Grade to Surface” criteria in the grading criteria drop down, then click the create grading icon. Notice the Freeboard Elevation surface is already active in the Grading Creation Tools. This is because of the Volume base surface options selected in step 6. Following the command line prompts, select the bottom of pond feature line and enter the following values:

- Grading Side: Click outside of the pond feature line
- Apply to entire length: Yes
- Cut Format: Slope
- Cut Slope: 3:1
- Fill Format: Slope
- Fill Format: 3:1

9. The next step is to create a grading object to fill in the flat bottom on the inside of the pond. Select the Create Infill tool from the create grading pull down. Select a point inside the bottom of the pond. An infill is created and the interior of the pond model is completed. This is the portion of the pond that will be adjusted to meet a specific stormwater detention volume later in the exercise.
Create a Grading Group for the Pond Berm

10. Next you will use grading objects to build the remaining pond geometry, including the pond berm and daylight to the existing ground surface. You will need to create a new grading group for this part of the pond to keep it separate from the pond volume portion of the model. Click the Set Grading Group icon. The Select Grading Group dialog will open.

11. Verify the Site name is “Pond Grading”. Next click the Create a Grading Group icon to the far right of the Group name pulldown. The Create Grading Group dialog will open.

12. Enter Pond Berm in the name field, check Automatic surface creation, check Use the Group name, and set the Surface Style to Contours 1’ and 5’ (Design). Leave the remaining options at their default values and click OK.

13. Next, the Create Surface dialogue box will appear. Verify the surface name is Pond Berm and the style is set to Contours 1’ and 5’ (Design), then click OK to accept. In prospector you should now have a surface called Pond Berm.

Create Grading objects for the Pond Berm

14. Change the grading criteria to “Grade to Relative Elevation” and click create grading. This time select the outside edge pond volume grading created in step 8. Use the values below when prompted.

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
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<tbody>
<tr>
<td>Apply to the entire length</td>
<td>Yes</td>
</tr>
<tr>
<td>Relative Elevation:</td>
<td>2’</td>
</tr>
<tr>
<td>Format:</td>
<td>Slope</td>
</tr>
<tr>
<td>Slope:</td>
<td>3:1</td>
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15. Next select the “Grade to Distance” criteria in the grading criteria drop down, then click the create grading icon. Following the command line prompts, select the grading object feature line created in the previous step:

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply to entire length:</td>
<td>Yes</td>
</tr>
<tr>
<td>Specify distance:</td>
<td>10'</td>
</tr>
<tr>
<td>Format:</td>
<td>Grade</td>
</tr>
<tr>
<td>Grade:</td>
<td>2.00%</td>
</tr>
</tbody>
</table>

You have now created a grading object representing a 10’ berm around the top of the pond. Next you need to will need to tie the edge of the berm into the existing ground surface.

16. Click the Set the Target Surface icon. In the select surface dialog, choose Existing Ground from the pulldown and click OK. The Existing Ground surface is now active in the Grading Creation Tools toolbar.

17. Change the grading criteria to Daylight Ratio Slope and click create grading. This time select the outside edge of the berm created in step 15. Use the values below when prompted.

<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apply to the entire length:</td>
<td>Yes</td>
</tr>
<tr>
<td>Cut Format:</td>
<td>Slope</td>
</tr>
<tr>
<td>Cut Slope:</td>
<td>3:1</td>
</tr>
<tr>
<td>Fill Format:</td>
<td>Slope</td>
</tr>
<tr>
<td>Fill Slope:</td>
<td>3:1</td>
</tr>
</tbody>
</table>

18. Civil 3D has now created a grading object that ties into the existing ground surface at a 3:1 slope. The pond is now completely graded. This is a good time to select the two pond surfaces and select object viewer from the contextual ribbon to visually inspect the pond. Note: The grading extends past the property lines, and the pond is much larger than necessary for small 8 lot subdivision. In the next section you will modify the pond geometry to produce a pond that fits better in the lot, and will use the volume grading tools to achieve a desired storage volume.
Understand how to control pond geometry to achieve a desired storage volume using the Volume Grading Tools

Now that the pond has been modeled, the next step is to modify that model to fit both the geometric constraints of the lot, and the storage volume constraints based on stormwater analysis of the proposed site. Because the pond was modeled using grading objects, changing the shape of the pond will be a fairly simple and fast task. The grading volume tools for grading groups will also provide a simple method for adjusting the storage volume. For this exercise, you will assume the need to detain approximately 15,000 cubic feet of water during the 100 year storm event, make the post discharge match the pre.

Modify Pond Geometry Using Grip Edits

1. Continue working in the file from the previous exercise or open the file named B1 - Revise Pond - Feature Line.dwg located in the provided course files.

2. Editing the geometry of the pond is a fairly simple task. Everything created in the previous section is based on a single feature line. To modify this feature line simply select it. The contextual Feature Line ribbon tab will display. From here you can use any of the tools on the Edit Geometry or Edit Elevations panels to modify the feature line. In this case however the most efficient way to revise the pond shape will be to grip edit the feature line.

TIP: You may find it difficult to select the feature line at the bottom of the pond. This problem can be cause by the surface contour being drawn “above” the feature line. You may need to hold shift + space bar while selecting the bottom pond contour to cycle through objects. Once the feature line is highlighted press enter to select it.

TRICK: To possibly avoid this problem altogether you can raise, or lower the elevation of a feature line by 0.01’. In this case lowering the pond bottom to 1122.99 could make selecting the feature line easier without the need to cycle, depending on your zoom factor. This change does not really affect the pond design, but can make the process of modifying the feature line much easier. This trick also can help when contours draw incorrectly for flat bottom ponds.
3. Next select one of the grips along the feature lines north edge. Move it to a location inside the pond being careful not to snap to any lines or contours. If you do snap to an object the elevation of the feature line will change. Notice the grading objects all change to reflect the new shape of the feature line.

**TIP:**
In some cases you need to use Object Snaps to position feature line vertices but don’t necessarily want to change their elevation or Z value. Object Snap point filter can help. First left click the vertex you wish to move. Next hold the shift key and right click. Select Point Filters > .Z from the Object Snap Override list. Your next click will set the Z value of your point. Again, left click the point you wish to move. Now snap to the location you wish to move the vertex to. The vertex is now moved but has maintained its original elevation.

4. Continue to grip edit the feature line until the pond looks something like the image below:
Modify Pond Geometry Using Feature Line Tools

5. Once comfortable with the pond geometry, more detail can be added to the pond design. In this example you will add radii to the edges of the pond bottom. Select the pond bottom feature line.

6. From the contextual Feature Line ribbon > Edit Geometry panel select the Fillet tool. Select the Radius option from the command line.

7. At the prompt enter a radius value of 5.00’.

8. Pick the four corners of the feature line to add a radius to each corner. Notice the grading objects continue to reflect the changes. Press enter to exit the command. Next the Freeboard elevation will be modified.
Modify Pond Geometry Using the Freeboard Reference Surface

In the Create Grading Objects for the Inside of the Pond section of this exercise a grading object was created that graded from the bottom of the pond to a reference surface called Freeboard Elevation. This detail will be used in the next section to adjust the storage volume of the pond, but it can also be used to control pond berm elevation by raising or lowering the surface.

9. Zoom out until the entire subdivision is visible in the CAD window. Notice there is a large rectangular feature line. This feature line defines the Freeboard Elevation surface and all of its vertices are currently set to an elevation of 1128.00. Select the feature line.

10. From the contextual Feature Line ribbon > Edit Elevations panel select the Raise/Lower tool.

11. At the prompt enter an elevation of -1.00 to lower the feature line 1’. Notice the pond grading objects and surfaces do not change.

12. In the Prospector tree, expand the surface collection. Right click the Freeboard Elevation and select “Rebuild”. Notice the grading object and surface now update to reflect the new freeboard elevation of 1127.
Change the Storage Volume of the Pond

The last part of the pond that needs to be modified is the storage volume. Because the inside of the pond was modeled using the Freeboard Elevation surface as a volume base surface, the volume grading tools can be used to set the desired volume of the inside of the pond. Civil 3D will then raise or lower the pond bottom feature line to achieve the specified volume. This saves time by taking the manual calculation (or trial and error method!) out of the process.

13. From the Analyze ribbon > Volumes and Materials panel select the Grading Volume Tools. Select the Radius option from the command line. The Select Grading Group dialog opens.

14. Set the Site name to Pond Grading and the Group name to Pond Volume. Click OK. The Grading Volume Tools Open. Click the chevron at the top right of the dialog to expand the Volume information. Here the current cut and fill values are shown. In this case the cut value represents the volume between the Freeboard Elevation Surface and the Pond Volume surface. The pond needs to detain approximately 9,000 square feet, which converts to 333.33 cubic yards. For this example you will round up to 350 cubic yards.

15. To adjust the volume click the “Automatically raise/lower to balance the volumes” icon at the top right of the dialog. The Auto-Balance Volumes dialog opens.

16. Enter -350 Cu. Yd. for the Required volume and click OK. This value must be negative for cut. A positive value would raise the bottom of the pond above the Freeboard Elevation surface.

17. A new entry is added to the History area of the Grading Volume Tools dialog with a description indicating that Auto-balance lowered the grading group 1.15’ to achieve the enter value.
18. Close the Grading Volume Tools. The pond is now complete. Next, Stage storage data will be exported for analysis in Storm and Sanitary Analysis.
Perform Stage Storage takeoff, and export data to SSA for analysis

Perform a Stage Storage Calculation

1. Continue working in the file from the previous exercise or open the file named *C1 - Stage Storage.dwg* located in the provided course files.

2. From the Analyze ribbon > Design panel click the Design pulldown and select Stage Storage. The Stage Storage dialog opens.

3. Choose “Define Basin” from the stage storage dialog.

4. In the define basin from entities dialog, make sure Define Basin from Polylines is toggled and then click Extract Objects from Surface. Click on the Pond Volume surface and the polylines will be extracted from the surface.

5. Next click Extract Objects from Surface again to extract polylines from the Pond Berm surface.
6. Next, click "Define" and pick all of the contours in the interior of the pond up to the berm. Then press enter. The stage storage table should appear in the Stage Storage dialog:

![Stage Storage Dialog](image)

7. You can insert this table into the drawing by clicking the Insert button at the bottom right of the Stage Storage dialog. Next select a point in model space where you would like the table drawn. This inserts the data as an AutoCAD table. The table does not appear immediately, but will be visible after exiting the dialog. Before exiting however, proceed to step 8. This is good to use as a reference in drawing, but keep in mind that this table does not update if the pond design is revised.

8. To use the stage storage data in Autodesk Storm and Sanitary Analysis you must first export it. Choose Save Table for the stage storage dialog. The Save Stage Storage dialog open.

![Save Stage Storage Dialog](image)

9. The file will be saved in the .AeccSST file format. Browse to the location where the course files are stored and save the file as Pond Design.AeccSST. Next this information will be imported into the SSA model for analysis.

10. Close the Stage Storage dialog by clicking cancel and save and close the .dwg file.
Import Stage Storage Data into an SSA model to accurately simulate pond performance.

The stage storage data exported from Civil 3D can now be imported as a storage curve for use in Storm and Sanitary Analysis. The course file has already been configured to analyze the 100 year storm event. However a junction will need to be converted and configured as a storage node.

Configure a Storage Node to use Stage Storage Data

1. Open Storm and Sanitary Analysis. Then open the file named D1 - Pond Analysis.spf located in the provided course files.

2. Locate the Jun-01 located in the pond. Right click and select Convert to > Storage Node.

3. Double click on the storage node to open the storage node dialog.

4. Change the Storage Node ID to Pond_A. Enter 1122 for the Invert elevation, 1129 for the Maximum elev, and 1122 for the WSEL initial.
5. Next change the Storage Type to Storage Curve. Then click the ellipsis to the right of Storage curve. The Storage Curves dialog will open.

6. Click Add at the top right.

7. Now click Load at the top right. Browse to the location of the stage storage file saved in the last section. You may need to change the file type to .AeccSST.

8. Enter Pond_A in the Curve ID field. Also notice the depth field of the Storage curve data lists the elevation not the depth. This seems to be an error that occurs on import. Luckily this isn’t too difficult to fix.

9. Notice the depth field of the Storage curve data lists the elevation not the depth. This seems to be an error that occurs on import. Luckily this isn’t too difficult to fix. Starting at line 1, renumber the Depth Column staring with 0 up to 7. Click close to exit the dialog.

10. Verify Pond_A is listed for the storage curve. Then click Close to exit the Storage node dialog.

11. Click Perform Analysis. If the analysis does not run correctly review the error report and check back through the previous steps and try to run the analysis again.

12.
13. Double click the storage node. Take note of the Analysis summary, including the max water elevation. The goal was for this value to be lower than the freeboard elevation. Take note of the Peak inflow as well. Click close.

14. Next double click the outfall at the northwest corner of the pond lot. Take note of the peak inflow here as well. The pond and outlet configuration has reduced the peak flow by approximately 6.75 cfs.

15. To view hydrographs for the analysis select the time series plots icon from the reports toolbar.
Additional Resources

Grading Volume Tools:

Grading Volume Tools https://knowledge.autodesk.com/

About Storm and Sanitary Analysis:

Storm and Sanitary Analysis https://knowledge.autodesk.com/

SSA User Guide