CE322650

Feature Lines: Best Practices and Intuitive Site-Design Workflows

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Learning Objectives

- Learn how to edit Feature Lines and discover how they contribute to Surface TIN Line and TIN Point definition.
- Learn how to solve the problem of static Feature Line elevations by using the “Relative to Surface” command.
- Learn how to differentiate design data using multiple sites and prioritize design data with the Feature Line "Style Hierarchy".
- Learn how to create intuitive models with regions of simple vertical behavior that automate the slopes of complicated horizontal data.

Description

Site grading is a complicated task, and users are presented with a number of different options. Corridors are stable but require deep knowledge of the toolset; Grading Objects are easy to use but unstable. Feature Lines are a great option for site grading because they are simple enough to be used effectively by newer users and are very stable. However, poorly drawn Feature Lines leave designers with choppy surface contours, flat spots, and an urge to draw contours manually. In this class, we’ll review the fundamentals of Feature Lines and their interactions with surfaces. Students will be directed in workflows using the right Feature Line editing tool in the right situation. Students will then be shown how to best use the "Relative to Surface" feature (new in version 2018) and other examples of best practices for Feature Lines to optimize their designs. Finally, we’ll cover a workflow for creating dynamic, variable-depth datum surfaces for parking-lot grading.

About the Speaker

As a member of the Civil and Infrastructure team at ATG, Kyle has spent the last two years supporting customers with specialized training, technical support, and consultation services. Prior to working at ATG, he worked on land development projects for solid waste, residential and commercial projects. Kyle received his B.S. in Geological Engineering from the University of Wisconsin-Madison. He is passionate about creative and sustainable solutions to the problems of today & tomorrow.

Overview

Drainage across most sites is relatively simple – we want water to drain to a specific location with a moderate slope, possibly with some high points or flow paths to help us get there. The hard part is calculating spot grades along our complicated horizontal geometry and confirming those slopes. The first task is to set up a "Grid Drainage" Surface which represents our major sectors of flow, and is subdivided by as many high points or swales as is necessary for our final design.
Next, we will discuss how to design our curb, and how do get back to existing grade where appropriate. ATG has presented versions of this workflow that use grading objects to produce the curb of our site. This has some advantages, including the ability to easily create a Surface with "islands" of information. The primary disadvantage of grading objects, however, is their instability. Therefore, this workflow will show how to get around that taking advantage of a number of subtle nuances of the Feature Line toolset. Grading objects will be used to daylight to existing grade, but we will break the Grading Object to avoid the tool's inherent instability.
Lastly, we will present a method of creating a dynamic Surface to represent our Datum, or bottom of engineered materials in our site. This Surface is actually a composite of the rest of our site, and again harnesses some of the often overlooked details of how "regular" and Volume TIN Surfaces are defined. This will result in a Datum Surface that can be shared with the rest of the project team (including the contractors), and another that will tell us our earthwork balance across the site.

Understanding the Tools

Before we discuss the workflow, we need to know how the tools work so that we can exploit their finer points to our advantage.

TIN Surfaces

TIN stands for "Triangulated Irregular Network". What this means to us as design professionals is that:

- Every point (TIN Point) used in the definition of a Surface is connected to another TIN Point by a straight line.
- Every straight line (TIN Line) is a linear interpolation between TIN Points (which are different from COGO Points).
- All contours are **results** of points of equal elevation along the TIN Lines, and are only displayed as defined by the current Civil 3D Surface Style.

To illustrate:

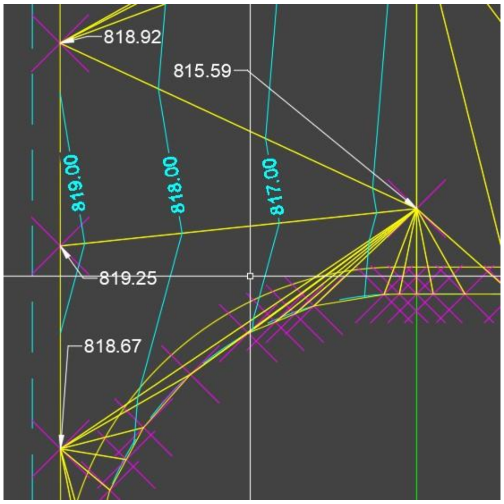

FIGURE 1
COMPONENTS OF A TIN SURFACE

MAGENTA– TIN POINTS
WHITE – SPOT ELEVATIONS
YELLOW – TIN LINES
CYAN – CONTOURS

Additionally:

- Surfaces are built one operation at a time. The relative order of these build operations can be changed in the Surface Properties > Definition tab > bottom half. The bottom of the list is the most recent operation.
- If an "Outer" type boundary is used, it should be the last operation in the Surface definition. Do not repeatedly add the same boundary to the same Surface.
- "Minor" edits like swapping edges, modifying points, etc. should be avoided to the greatest extent possible. If you don't like the result of your Surface, go back and edit the source data. Garbage in = garbage out.
- All TIN Surfaces are planes – even "Volume" TIN Surfaces. A Volume Surface is the result of the equation: $Z_{\text{Base Surface}} - Z_{\text{Comparison Surface}} = Z_{\text{Volume Surface}}$. A quick unit analysis shows proves that addition or subtraction between two linear quantities results in a linear quantity- not a volumetric one!

Feature Lines

Feature Lines are a designer's best friend for defining features in a site. We need to understand that:

- Feature Lines are grouped together in Sites.
- Sites are bins of information that talk only to each other.
- Feature Lines within the same site can only have one elevation if they cross.
  - Normally, the one last edited controls the elevation.
  - A setting called the "Feature Line Style Hierarchy" (FLSH) can force a Feature Line of a particular Style at a higher priority to always retain its elevation when it crosses a Feature Line with a Style of lower priority.
    - Define in Toolspace>Prospector>Sites Collection>(pick a Site) Right Click>Properties.
- A "PI" is a traditional vertex – the X, Y, and Z coordinates can all be specified at any time.
- An "Elevation Point" (Elev. Pt.) must follow the path between two PI's. The X and Y coordinates are defined by the line or arc segment, but the Z value can be changed at any Elevation Point.
- Any PI or Elev. Pt. that is green can be edited directly. Grey symbols mean that some other factor is controlling the elevation/slope and cannot be directly edited as part of that Feature Line.
- Elev. Pts. should be added to a Feature Line any time we are interested in modeling a grade break.
- Feature Lines are the primary data we will add to a proposed Surface. When adding to a Surface as Breakline data, we should consider:
  - <u>Weeding Factor</u>: This reduces the number of PI's and Elev. Pts. that will be converted to TIN Points. This useful for Feature Lines that used to be a SPOLYLINE, 3D Polyline, or Contour extracted from a Surface as a Polyline.
  - <u>**Supplementing Factor:**</u> The opposite of weeding, this adds in extra TIN Points between PI's and Elev. Pts. along the Feature Line. This gives us better Surface data by increasing the number of TIN Points (and TIN Lines), which will make contours smoother.
  - 10-25 feet is a good starting value.

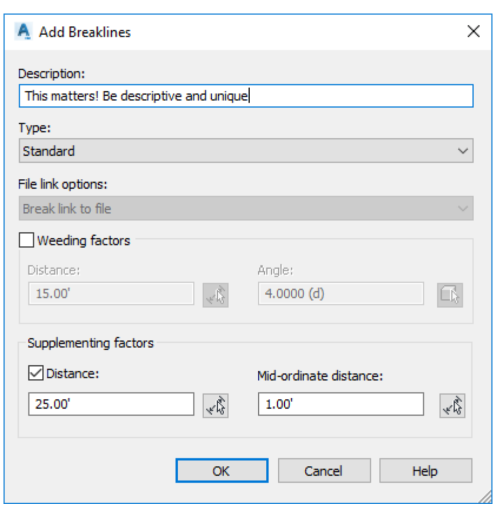

***FIGURE 2** – THE "ADD BREAKLINES TO SURFACE" DIALOG*

- Mid-Ordinate Distance: Surfaces don't build true curves; they approximate them with chords. This value determines the maximum distance between the true curve and the midpoint of the chord. The smaller this value is, the more chords will be generated to approximate a curve, and the more data your Surface will hold. 0.1 to 1.0 is a good range of values.

- To edit the elevations of Feature Lines, two commands will be used most of the time. They are:
  - Quick Elevation Edit – Allows redefinition of either the elevation of a point, or the slope between two points. Ideal for designing and updating flowpaths.
  - Elevation Editor – Shows a table of all PI's and Elev. Pts. for a particular Feature Line. Typically only recommended for global viewing or editing operations.

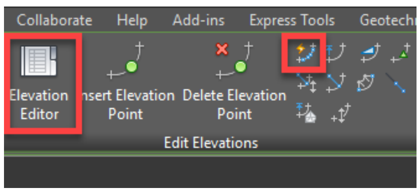

FIGURE 3

A PANEL IN THE FEATURE LINES CONTEXTUAL RIBBON

WORKFLOW

1. Create the "Grid Drainage" Surface to define sheet flow across the project site using Feature Lines
   a. Keeping the boundary as rectangular as possible will make changes easier.
   b. Add Elev. Pts. where necessary for key grade breaks.
   c. Add additional Feature Lines to represent high points, swales, and/or additional TIN definition for the Surface and smoother contours
   d. Every Feature Line should be connected to at least one other Feature Line. These Feature Lines are going to be interactive to each other, and should reflect their changes

Note: The exception to this is a manually drawn Feature Line to represent tying into existing conditions.

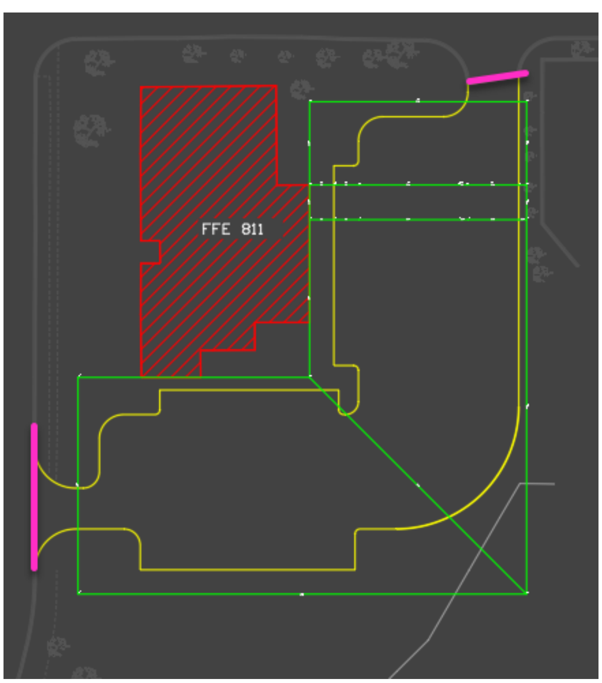

FIGURE 4

GREEN – GRID DRAINAGE FEATURE LINES (TOP FLSH)

YELLOW – EDGE OF CURB

MAGENTA – FEATURE LINES REPRESENTING THE TIE-IN POINT, ELEVATIONS FROM EG SURFACE. ALSO DEFINED WITH THE TOP FLSH.

e. To prioritize design information, consider using different Feature Lines Styles and their position in the Feature Line Style Hierarchy (FLSH). This Hierarchy controls what happens when Feature Lines cross.
   i. When two Feature Lines of the same Style cross, the last one edited will define the elevation.
   ii. When two Feature Lines of different Styles cross, the one who's Style is higher will always control.

f. For any Feature Lines that will be in the within the boundary of the FG Surface pavement, trace over them with Feature Lines of the lowest Style in the Hierarchy.
   i. This will ensure proper TIN definition of the FG Surface.
   ii. To prevent an error for crossing breaklines, stop or trim them to be within the curb flowlines.

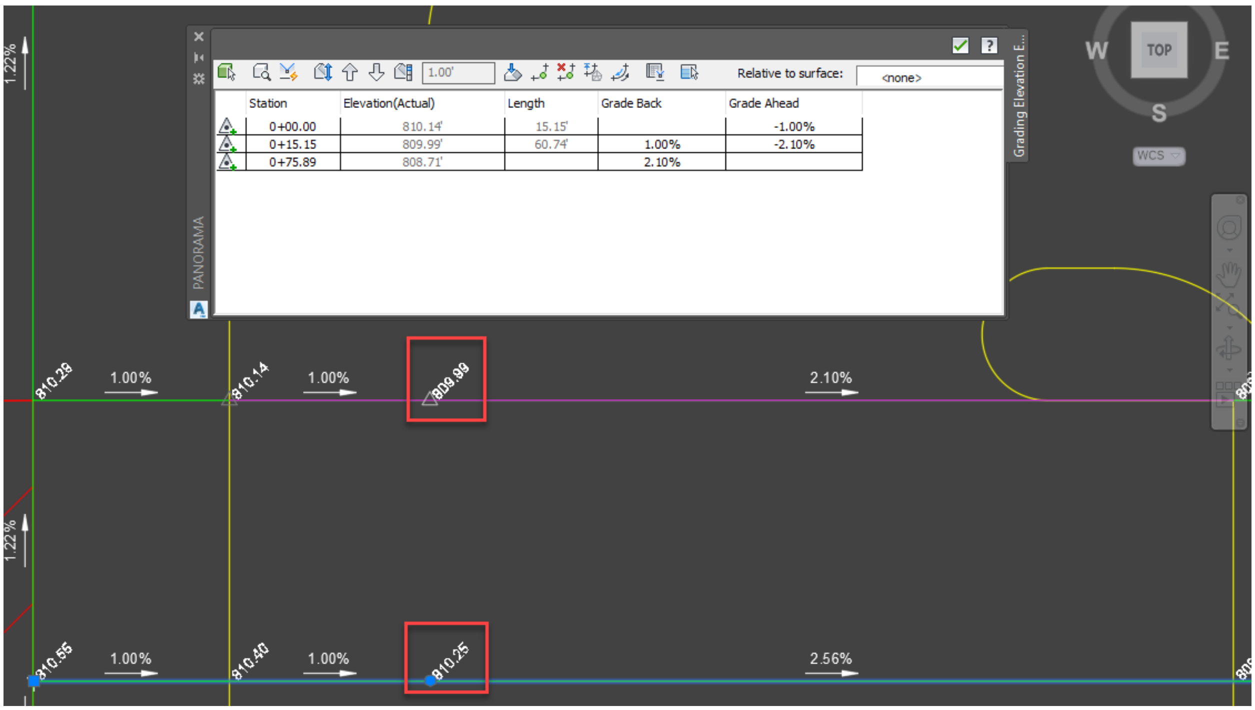

FIGURE 5

TWO GREEN FL (HIGHER FLSH) ARE DRAWN WITH ELEV. PTS. SHOWN BOXED IN RED. WHEN A LOWER FLSH FEATURE LINE (MAGENTA) IS TRACED ON TOP OF ANOTHER FL IN THE SAME SITE IT AUTOMATICALLY PICKS UP ANY ELEV. PTS, DYNAMICALLY TRACKING GRADE BREAKS IN A SURFACE

2. Create curb flowlines as Polylines. Once their location is finalized, convert them to Feature Lines in a new site for all linework defining the FG Surface.
3. Add Elev. Pts. along FG Feature Lines to pick up any grade breaks from the Grid Drainage Feature Lines.
   a. After this is done, OFFSETFEATURE for the top and back of curb. Elevation does not matter if the Drainage Surface is beyond the top back of curb.
   b. Elev. Pts. on curves may require touch-ups if the crossing feature is not radial to the curve.
4. Set curb Feature Line elevations "Relative to Surface" from the Grid Drainage Surface. Note that Each Feature Line can only be relative to one Surface.

5. To daylight from a known design element, use the Grading Object.
   a. Explode the resultant Feature Line to remove the Grading Object Explode the resultant Feature Line to remove the Grading Object.
   b. Recreate a Feature Line from the previously created Feature Line

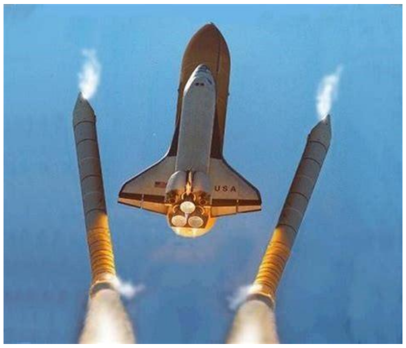

FIGURE 6

GRADING OBJECTS ARE USEFUL, BUT IN OUR DESIGN THEY ARE DEAD WEIGHT AFTER THEY ACCOMPLISH THEIR JOB. JUST LIKE ROCKET BOOSTERS ON A SPACE SHUTTLE, THEIR JOURNEY ENDS BEFORE THE FINAL DESTINATION IS REACHED.

SOURCE: NASA

6. Continue to add Feature Lines to FG Surface to design the rest of your site, keeping in mind the build order of the Surface Properties>Definition tab.

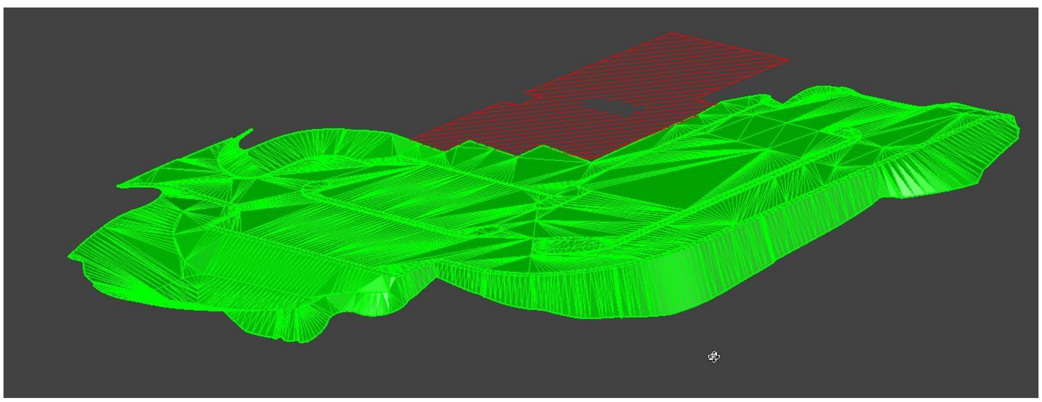

FIGURE 7
COMPLETED FG SURFACE (GREEN) WITH BUILDING FOR REFERENCE (RED).

Congratulations! You now have a site with a complete FG Surface! Proceed to get a Datum Surface to provide for the contractor, and to find out how to calculate your site-wide earthwork balance.

7. Chop up the site into the different depths between FG and the Datum Surface.
   a. Create a Polyline representing the border of each area. Where they overlap, do a small offset (0.1 feet will suffice).
   b. Assign a positive elevation to the Polylines equal to the depth below FG for that material. For example, topsoil respread would be Z=0.5 ft, sidewalk areas may be Z=0.67 ft, etc.
   c. Hatches are optional.

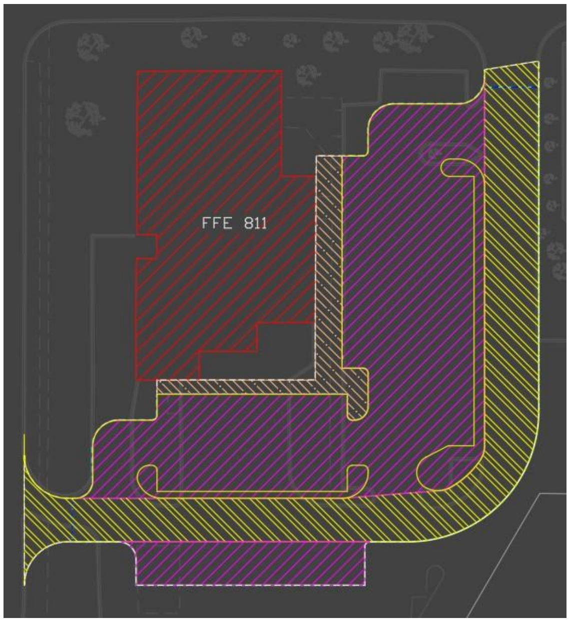

FIGURE 8
VISUAL REFERENCE OF ENGINEERED MATERIALS

YELLOW, DOUBLE STRIPE – HEAVY DUTY PAVE

MAGENTA, SINGLE STRIPE – STANDARD DUTY PAVE

GOLD, DASHED STRIPE – SIDEWALK

8. Create a Surface called “Subgrade Depth”. It is defined by the POLYLINEs from the previous step.
9. Create a Volume Surface defined by:
   a. Base Surface = Subgrade Depth, Comparison Surface = FG
   b. Recall that all Surfaces are planes. Volume Surfaces just happen to have an elevation of $Z_{\text{Volume Surface}} = Z_{\text{Base Surface}} - Z_{\text{Comparison Surface}}$.
   c. Play with which Surface is Base and Comparison, but make sure in Object Viewer that your new Volume Surface is right below FG.
   d. This Surface is our Datum Surface and can be sent to the contractor.

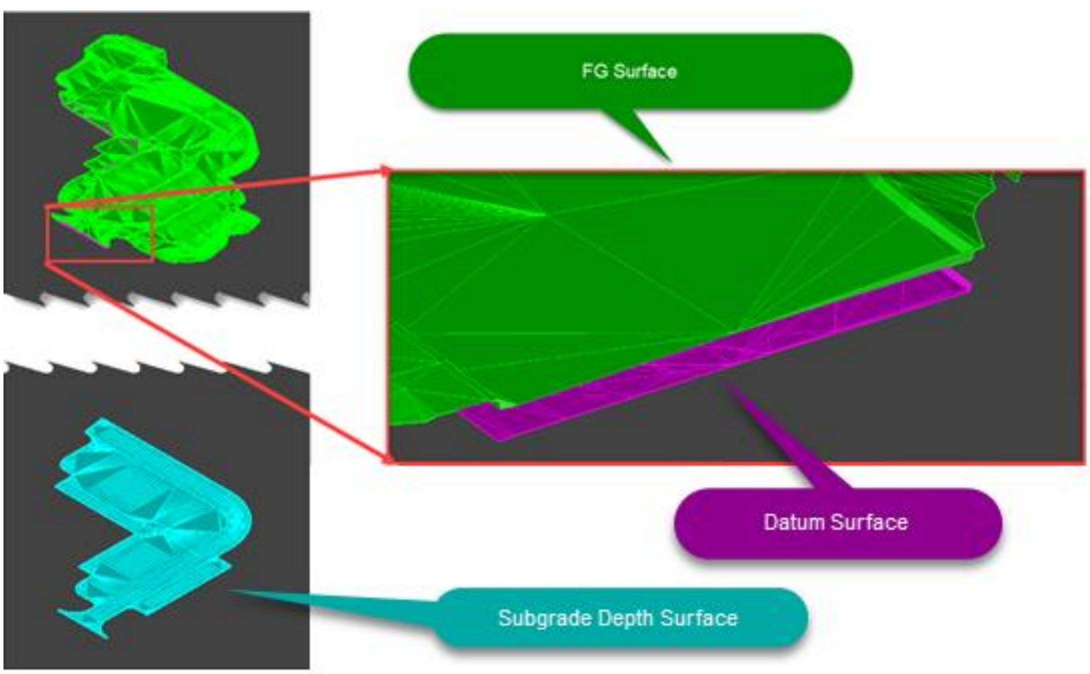

FIGURE 9
OUR FG, SITE DATUM, AND SUBGRADE DEPTH SURFACES SHOWN IN OBJECT VIEWER

10. If we want to find out the site's earthwork balance, we have one more step to go through…
    a. The volume we are interested in is comparing EG to the Datum.
    b. Volume Surfaces cannot use another Volume Surface as an input
    c. Define a new regular TIN Surface, the "Conversion" Surface with an Edit>Paste Surface of the Surface from the previous step.
    d. Create a final Volume Surface comparing EG to the "Conversion" Surface from above. Check the results in the Surface Properties or the Volumes Dashboard.

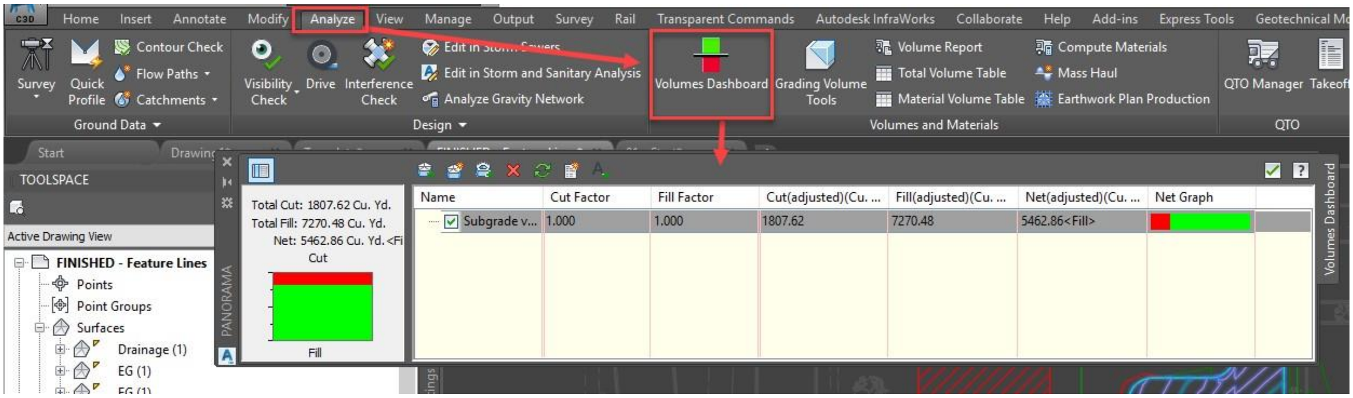

FIGURE 10
THE VOLUMES DASHBOARD REPORTING OUR SITE'S EARTHWORK BALANCE