Tools, Tips and Workflows

Thinning Feature Vertices in LP360

LP360, 2017.1

B S A T | A W

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We have lot of LP360 customers with a variety of disparate feature collection and editing needs. To begin to address these needs, we introduced a completely new set of Feature Edit tools in the 2016/2017 releases of LP360[1] (standalone). Last month I introduced the new Feature Analyst tool that will be available in LP360 2017.1 (As mentioned in the beginning of the newsletter, we reset our version numbering scheme, moving the December releases to January). These new versions are slated for release on 23 January (yes, of 2017!).

In this article, I want to look at a few tools that you can use to intelligently thin feature vertices. You may need to thin vertices for a variety of reasons. A primary driver is to improve the appearance of line work – that is, sacrifice a small bit of accuracy to improve the looks. In volumetrics, where we do not care so much about how good the stockpile toe looks, thinning will improve the volumetric computation speed. Finally, there are many downstream applications that cannot support features with overly dense vertices.

Let's consider the feature (shown in blue) of Figure 1. This is an outline of a water body (about 8/10th of an acre) created via a semi-automated process. It is shown in the context of the LIDAR data (displayed as a Triangulated Irregular Network, TIN) from which it was extracted. Note that even in the zoomed-out view, I can see some objectionable meanderings in this boundary. Selecting with the vertex edit tool shows 1,502 vertices spanning a total length (perimeter) of about 1,000 feet.

[1] Anytime I say LP360, I am referring to the 64-bit standalone version. The extension for ArcGIS will always be referred to as "LP360 for ArcGIS."

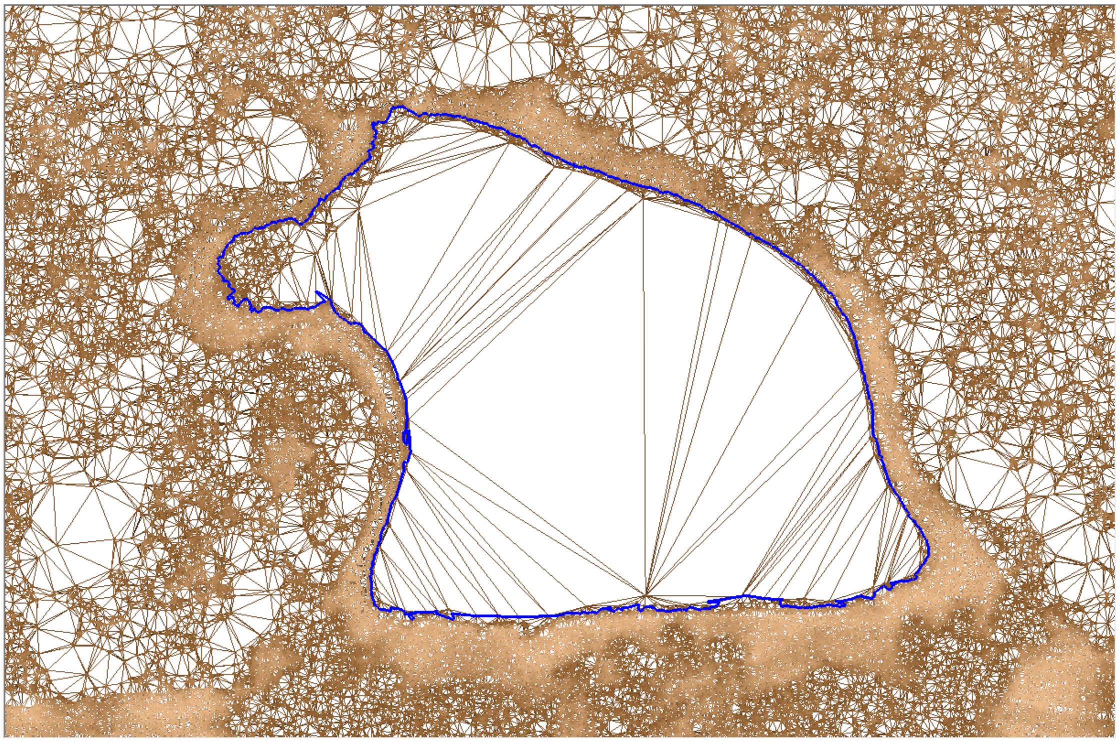


Figure 1: The original water body polygon

There are several tools in the latest release of LP360 for cleaning up polygons/polylines such as this one. The first one to consider is the Simplify Geometry tool on the Feature Edit toolbar. This tool implements a 3D Ramer-Douglas-Peucker (RDP) line smoothing algorithm. RDP allows you to set a deviation tolerance. The algorithm then removes vertices from the feature such that no point on the original feature (vertex or otherwise) is repositioned by more than your specified deviation. Note that in LP360, the RDP algorithm is available both as a Point Cloud Task[2] (PCT) called "Smoothing/Respacing" and directly on the new Feature Edit toolbar ("Simplify Geometry").

Before we begin this work, I am going to create a grid over my work area. I find this useful when experimenting so that I do not have to continuously access the measure tool. Huh, makes me realize we need to add a gradicules option to the Map View (we already have one in the Profile View). This is very quickly accomplished with the new grid generation Point Cloud Task (PCT). The settings that I used are depicted in Figure 2. I just dragged a rectangle with the Rectangle PCT tool over my polygon to define the grid area.

[2] Also available in LP360 for ArcGIS

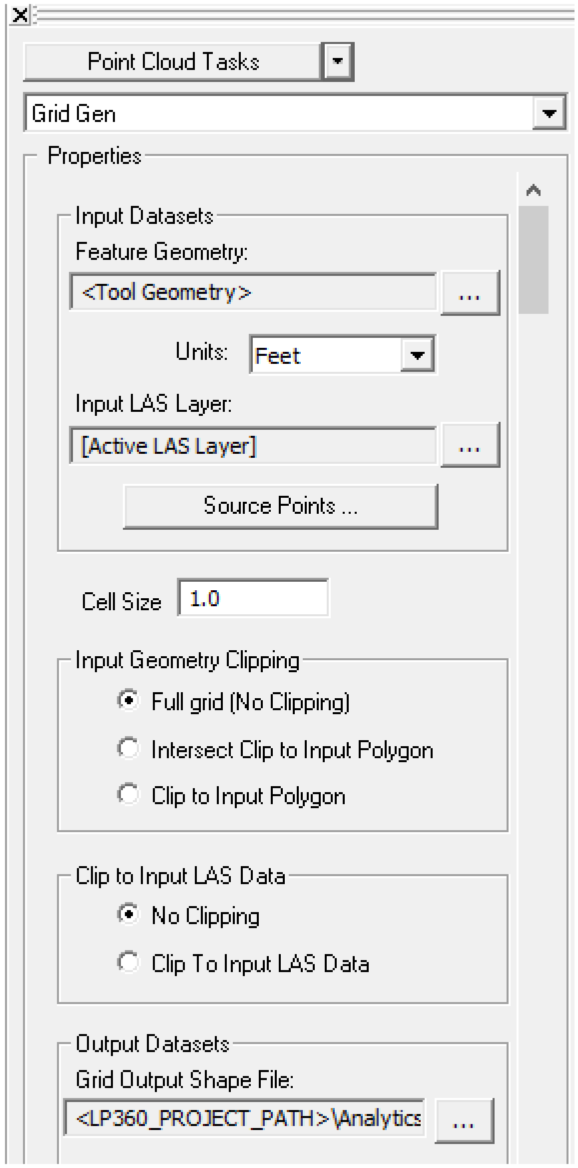


Figure 2: Grid Generator

The result of the grid generation is depicted in Figure 3. I moved the shape I am working on so it would be above the grid in the table of contents (TOC). Note that this step is completely optional – you will probably not bother once you have a feel for the effect of the different smoothing tools.

Figure 3: The generated grid

I strongly encourage you to use the smoothing (RDP) tool to thin vertices as the first step in most smoothing operations. The settings for the interactive smoothing tool are on the Geometry tab of the Feature Edit options dialog. I have set my smoothing parameter to 0.5 "layer units." Since this layer is in US Survey feet, the thinning will be such as to allow the line work to deviate from its current position by up to ½ foot in either direction. A zoomed in section of the line, prior to thinning, is depicted in Figure 4. Note the vertex count of 1,502 in the lower right of window status readout.

Figure 4: A section of the polygon, pre-thinning

With the feature selected, I pressed the Smoothing tool to apply the RDP algorithm to the feature. The result is shown in Figure 5. I have superimposed the thinned polygon over the original to make the effect of vertex reduction clear. Note that the vertex count has been reduced to 261. This will be significantly easier to work with than the original dense polygon. The grid (whose spacing is 1-foot x 1-foot) makes it clear that we have not violated our ½ foot move limit.

Figure 5: The thinned polygon

At this point, the boundary looks considerably more appealing to the eye but it still has the occasional objectionable cartographic anomaly. For example, consider the area shown in Figure 6. These “loopbacks” are common in automatically generated features (especially contours, for example).

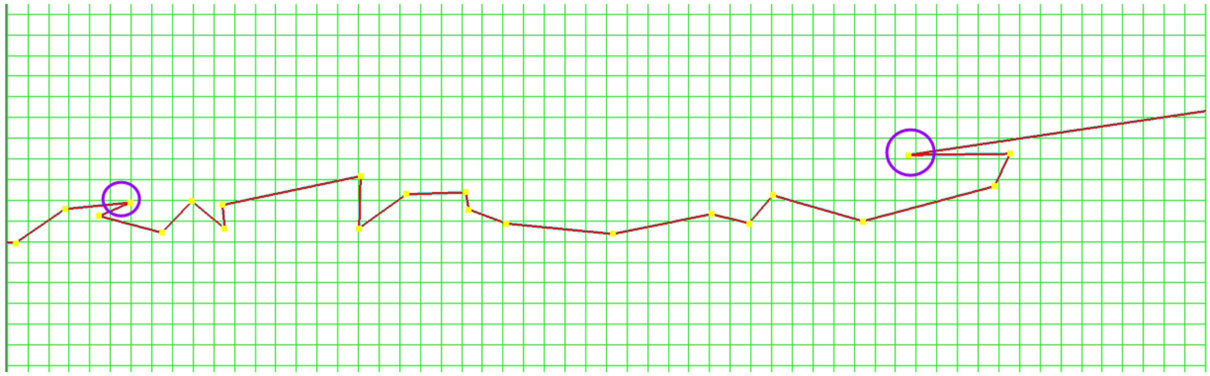


Figure 6: "Loopbacks" (circled in purple)

To remove these with the RDP smoothing algorithm, you would have to make the error tolerance larger than you can generally accept; a different approach is needed.

The characteristic of loopbacks are large planimetric ("XY") angles (large as we define line angles in LP360). Figure 7 shows how we define XY angles in LP360. As we move along the vertices from low to high, we look at the amount of rotation that occurs at the vertex (Θ in Figure 7). We extend the line segment leading to vertex n (the segment defined by vertex n-1 to vertex n). This is the straight blue arrow in Figure 7. We then look at the rotation required to align with the next segment (the segment defined between n and n+1). This is the angle Θ in Figure 7. If we rotated counter-clockwise, the angle is positive. If we rotated clockwise, the angle is negative. The angle depicted in Figure 7 is about 172°. It is positive due to the counter-clockwise rotation. The angle is simply how much you need to pivot the current segment to align with the next segment. Note that the maximum possible angle is ±180°.

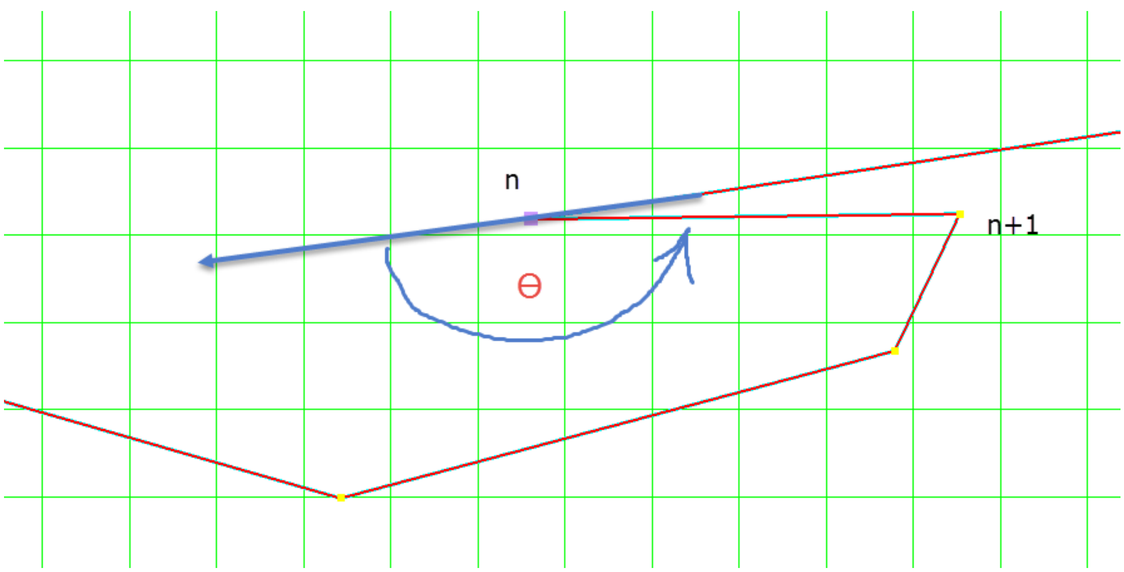


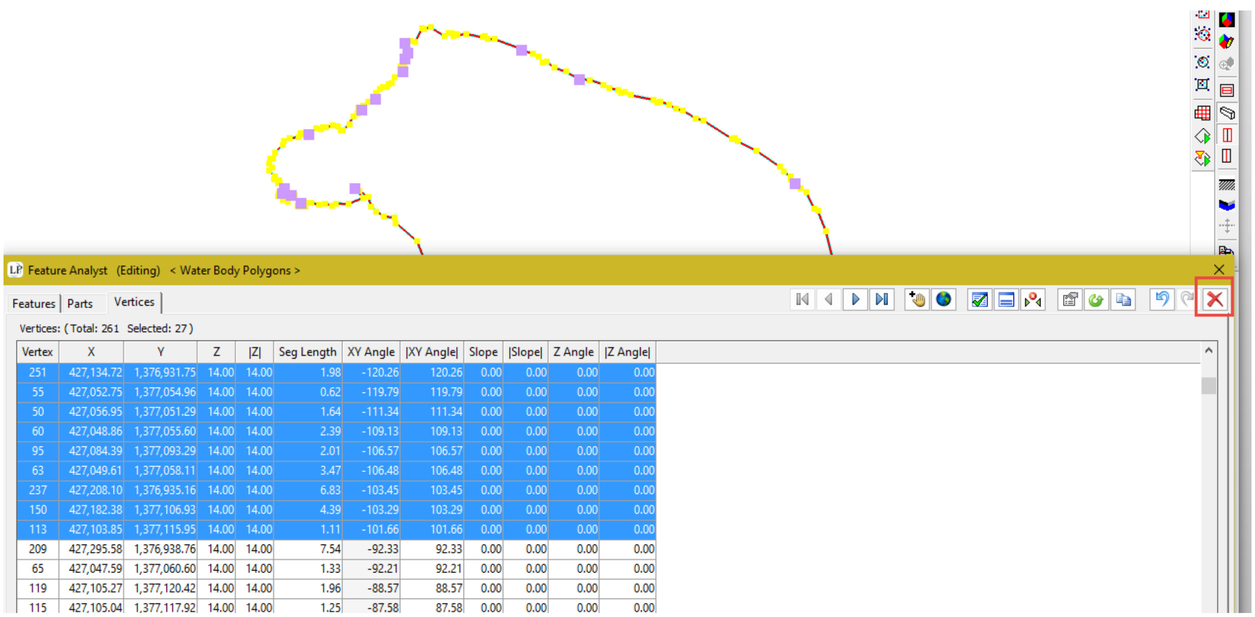
Figure 7: XY Angle definition (this angle is +172°)

One of the measured attributes in Feature Analyst is XY angle as well as the absolute value of this angle (|XY|). Thus, the general strategy is to sort vertices by angle and delete these large angles. You can see from Figure 7 that a line begins to wrap back on itself at angles larger than |±90°|. We have found that the best results are obtained the following process (but you are strongly encouraged to experiment):

1. Sort the Vertex view in Feature Analyst by XY angle (not by |XY|)
2. Pick your angle threshold – for example, all angles larger than 100 degrees
3. *Select* this group in the angle sorted vertex list – you multi-select in Feature Analyst the same as you would in Windows Explorer – hold down CTL to do disparate selects and Shift to select groups.
4. Press the delete tool in the upper right of Feature Analyst
5. Now reverse sort the vertex list by XY angle
6. Delete the negative angles that are above the threshold (angles less than -100 degrees, in our example)
7. Repeat this process until no angles exceed the threshold on the positive or negative side.

Figure 8 depicts the vertices sorted by negative XY angle with all less than -100 degrees selected. This alternating negative, positive delete works better than simply using the absolute value of angle XY because the deletion of angle of one sign often simultaneously removes the large corresponding angle of the other sign.

Notice that when you select vertices in the Feature Analyst table, the corresponding vertices are selected in the geometry in the Map View (and Profile View, if you have the feature displaying in this view). You can see the vertices selected in purple at the top of Figure 8.



<table>
<tr><th>Vertex</th><th>X</th><th>Y</th><th>Z</th><th>|Z|</th><th>Seg Length</th><th>XY Angle</th><th>|XY Angle|</th><th>Slope</th><th>|Slope|</th><th>Z Angle</th><th>|Z Angle|</th></tr>
<tr><td>251</td><td>427,134.72</td><td>1,376,931.75</td><td>14.00</td><td>14.00</td><td>1.98</td><td>-120.26</td><td>120.26</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>55</td><td>427,052.75</td><td>1,377,054.96</td><td>14.00</td><td>14.00</td><td>0.62</td><td>-119.79</td><td>119.79</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>50</td><td>427,056.95</td><td>1,377,051.29</td><td>14.00</td><td>14.00</td><td>1.64</td><td>-111.34</td><td>111.34</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>60</td><td>427,048.86</td><td>1,377,055.60</td><td>14.00</td><td>14.00</td><td>2.39</td><td>-109.13</td><td>109.13</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>95</td><td>427,084.39</td><td>1,377,093.29</td><td>14.00</td><td>14.00</td><td>2.01</td><td>-106.57</td><td>106.57</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>63</td><td>427,049.61</td><td>1,377,058.11</td><td>14.00</td><td>14.00</td><td>3.47</td><td>-106.48</td><td>106.48</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>237</td><td>427,208.10</td><td>1,376,935.16</td><td>14.00</td><td>14.00</td><td>6.83</td><td>-103.45</td><td>103.45</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>150</td><td>427,182.38</td><td>1,377,106.93</td><td>14.00</td><td>14.00</td><td>4.39</td><td>-103.29</td><td>103.29</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>113</td><td>427,103.85</td><td>1,377,115.95</td><td>14.00</td><td>14.00</td><td>1.11</td><td>-101.66</td><td>101.66</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
<tr><td>209</td><td>427,295.58</td><td>1,376,938.76</td><td>14.00</td><td>14.00</td><td>7.54</td><td>-92.33</td><td>92.33</td><td>0.00</td><td>0.00</td><td>0.00</td><td>0.00</td></tr>
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</table>

Figure 8: Sorting of vertices by negative XY angle just prior to deletion

Note that the undo capability is fully functional during angle culling (or any other action within Feature Analyst). Thus, if you do not like the result of a particular pass of deletions, just press the undo button to move back a step. In fact, you can use the undo feature when complete to "replay" the changes that have been made! I find this to be a very cool feature – you can animate each step of change by just repeatedly pressing Undo. To restore, just repeatedly press redo until the redo arrow is disabled.

> ***NOTE***: When you commit a feature edit session by pressing the Save button on the Feature Edit toolbar or by some action (such as running a point cloud task) that asked you to save the edit session via pressing OK on the notification dialog, you will no longer be able to perform undo operations on that edit session.

My example required two full iterations of angle culling before all vertices exhibited angles in the culling range (-100° < ϴ < 100°) were removed. Note in the result of Figure 9 that the two loopbacks of Figure 6 have been removed. The angle culling process removed an additional 36 vertices, reducing the vertex count to 225.

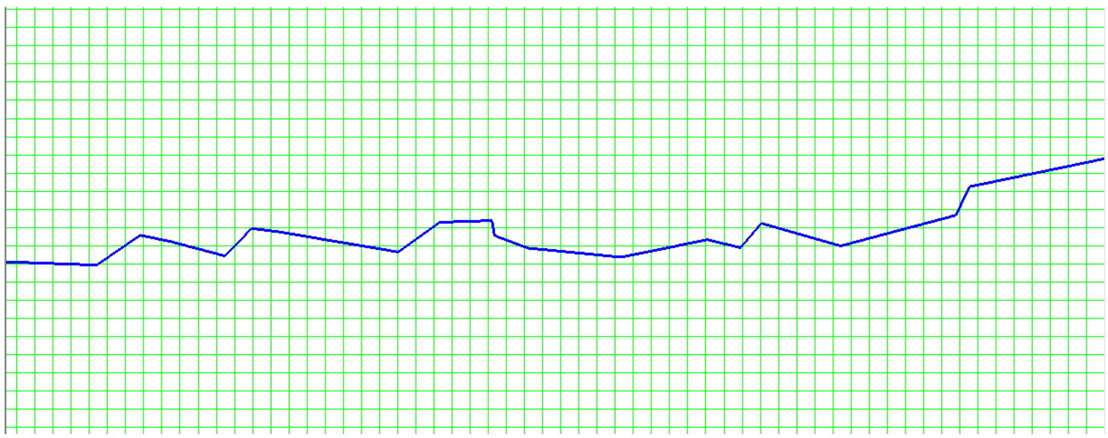

Figure 9: Line segment of Figure 6 after angle culling at a threshold of 100 degrees

The final action is the run the line smoothing one additional time with the accuracy parameter unchanged. This final step reduced my vertex count to 203 vertices. The final polygon is shown in blue in Figure 10. It is superimposed over the original polygon (shown in magenta). Clearly we have very faithfully maintained the "shape" of the original boundary polygon while reducing the vertex count from about 1,500 to about 200 and removing all the loopbacks.

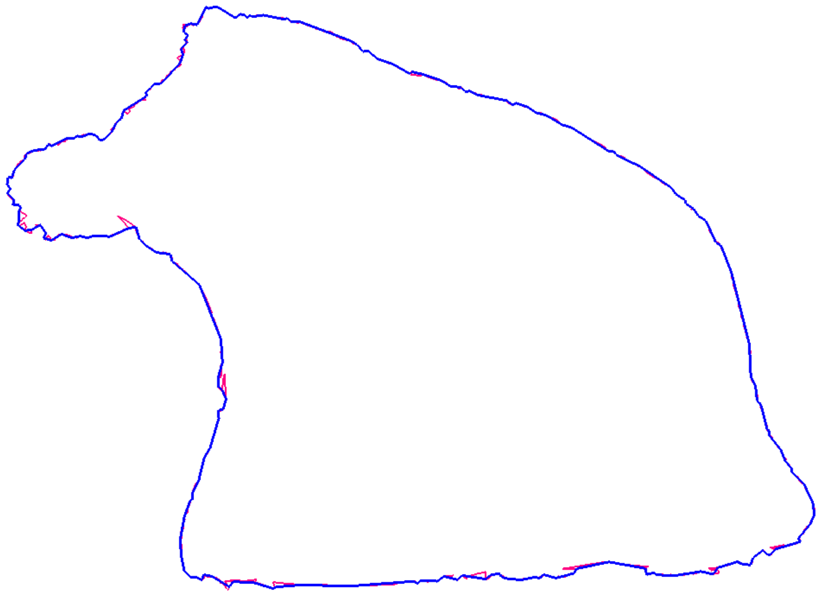

Figure 10: The final result (blue) superimposed over the original (magenta)

There are many other similar techniques that you can apply in Feature Analyst. I would strongly encourage you to run the smoothing algorithm prior to tailored Feature Analyst culling since it is always easier to work with a smaller set of vertices.

As we continue to develop our Feature Editing tools, some of the most promising algorithms (such as angle culling) will be added as feature tools. This will make it faster and easier to apply the most common and/or useful algorithms. That said, we have just touched the surface of the power of Feature Analyst. If you do a lot of line editing such as in hydro modeling preparation work, do some experimentation! I would love to hear feedback from you on the tools in general and any particularly effective algorithms you might discover!