

Two Foot Contours and Breaklines: How good is good enough?

You may have found yourself asking:

“So what is the big deal about breaklines anyway?”

“If we need them for 2ft contours, how do we know how many breaklines we need, and of what kind?”

“What is the standard?”

Breaklines are vector features (lines, polygons) that are created to enhance a topographic data product and improve both accuracy and cartographic quality. The creation and use of breaklines could take an entire chapter of a textbook, but this outline is designed to help you understand enough to compare and understand your options, and make better sense of vendor quotes and RFP specifications. First, it is important to understand that there are no set standards when it comes to breakline development for achieving accuracy goals for contours or digital elevation models (DEMs). Datasets differ widely in the accuracies and specifications to which they were collected and there is a wide range of complexities in each collection area, so there is no “one size fits all” solution for applying breaklines to improving LiDAR data. There is even an increasing sentiment that because of the point density in many LiDAR collections, breaklines may not even be necessary for certain applications. This means you should have at least some ideas on how you are going to use the data in order to better assess what kinds and how many of breaklines you may need, or if you need them at all.

At GroundPoint Technologies, we divide the Breakline development effort into four distinct categories:

Slope Breaklines
Hydrographic Breaklines

Transportation Breaklines
Hydrologic Structures

It is important to understand that different users will have different requirements for breaklines. With most modern software packages, it is relatively straight forward to add breaklines to an elevation project. This may be an important consideration when planning project based versus enterprise based projects. The development of breaklines for improving digital elevation models and contour maps is not intended to, nor should it ever be a replacement for planimetric mapping.

The Stereo Method versus the LiDAR Method: Which Method is the Best?

Prior to the advent of LiDAR technology, breaklines were created exclusively from stereo imagery. This process is mature and requires both a skilled analyst and stereo aerial photography. As the industry moved to softcopy (digital) analysis, automated methods have been developed to support the creation of stereo derived breaklines, but the process is still recognized to be the most labor intensive, and also the most accurate, option for breakline development. For some LiDAR collections, stereo imagery may not be available, or stereo processing may be prohibitively expensive. It is possible to develop breaklines using existing orthophotography coupled with new LiDAR data, or from the new LiDAR data itself. In either case, lines are placed on the map by a trained analyst and three dimensional coordinate values are extracted or interpolated from the LiDAR data and assigned to the vertices of the breakline. Finally, the LiDAR Method has proven to be highly successful in identifying features that might otherwise be obscured by high vegetation or shadows in an image.

It is important to understand the importance and role of aerial photography in both the Stereo Method and the LiDAR Method for identifying and locating key breakline features, as well as some of the challenges that result. Without supporting photography, it can be difficult to accurately locate and characterize breaklines because the resolution of a LiDAR dataset is typically lower (coarser) than photography. However, when the photography was not simultaneously collected with the LiDAR data, the potential exists for a horizontal registration offset to exist between the two datasets. This is most common when the aerial photography and the LiDAR are from different collections. A few vendors now offer simultaneous collections from the same aircraft. Under optimal conditions, LiDAR and aerial photography are typically collected at different altitudes and with different flight plans. In either case, the budget and project goals should help dictate whether one method or the other is preferred for any given project.

Slope Breaklines

Slope breaklines delineate key changes in slope in order to improve the accuracy of the derived surface. It is important to note that they delineate CHANGES in slope, not simply steep slopes themselves. Surface roughness and slope index maps may be used to indicate places where breaklines are needed, but typically include natural features such as ridges, valleys, bluffs, and cliffs. They may delineate stream banks or roadside ditches depending on the size of the features. Key terrain may also include man-made features such as dams, retaining wall or road cut structures or embankments that affect the slope of the overall ground surface. These breaklines are often the simplest to generate and are generally well supported with automated methods.

Hydrographic Breaklines

Hydrographic breaklines are critical if the elevation data are to be used to support hydrologic flow modeling or routing, and can significantly enhance the cartographic quality of contour maps. In general, these consist of both two dimensional water bodies (ponds, lakes, wide rivers or streams) and stream centerlines. They can also include the cross sectional details of a stream, to include the top and bottom of the stream banks or flood plain edge. These data are typically collected from available airborne imagery, augmented with the LiDAR intensity and point density data to determine the extent of relevant water bodies and streams. Standards for hydrographic breaklines vary from project to project, but typically might represent stream center lines for stream channels smaller than 5m across as well as the edge of each stream bank for stream channels larger than 5m across. Hence a stream segment may have anywhere from one (stream centerline) to seven breaklines (centerline, edge of water, edge of channel on either side, and top of bank on either side). The National Hydrography Dataset (NHD) may be used as a first approximation for the amount and type of hydrographic breaklines needed. For ponds, lakes and other standing water, after the water feature is digitized, the entire polygon is assigned a "pool elevation" equal to the height of the standing water. For rivers and streams, the breaklines are assigned elevation values at the vertices or nodes. It is important to further ensure a consistent downward slope for such breaklines, referred to as "monotonicity". Ultimately, hydrographic breaklines help to ensure that resulting contours do not cut across ponds and are accurately delineated at streams and across rivers. The effort is largely manual, executed by trained analysts who look at every stream segment and every water body.

Transportation Breaklines

Transportation breaklines are important to support DOT related projects and transportation planning, and also enhance the cartographic quality of contour maps. If the elevation data is used for aerial image registration, transportation breaklines can also significantly enhance the resulting image quality. Similar to Hydrographic Breaklines, transportation breaklines are typically collected from available airborne imagery, augmented with LiDAR intensity data, particularly in areas of dense foliage where the roadways may be visibly obscured or in shadow on an image. The level of detail required is dependent both on the intended use as well as the available budget. At a minimum, breaklines should represent the crown of the road (road centerline), but may also include the edge of the roadway (outer edge of the shoulder), and the centerline of any roadside ditches. Depending on the application, end users may also want to delineate the edge of pavement as a separate breakline.

Hydrologic Structures

Bridges, retaining walls, and other man-made features can represent special conditions for projects requiring hydraulic analysis. Hydraulics refers to engineering evaluations of water flow and depth. If hydraulics are important for your project, these kinds of breaklines may be required in order to more accurately delineate the boundary conditions of flow in specific, targeted areas. Bridges, while typically removed from the bare earth surface initially, may have wing walls, abutments, and other structural features that are important to capture as part of the channel characterization. Culverts, as distinguished from bridges, are typically not removed from the bare earth surface. In order to support hydrologic routing, breaklines connectors may be added as necessary indicating continuing flow under the roadway through culverts. These connectors do not affect the physical representation of the topographic surface, but can be a valuable addition to the project deliverables.