

# Guidance for Flood Risk Analysis and Mapping

## Mapping Base Flood Elevations on Flood Insurance Rate Maps

November 2014



**FEMA**

This guidance document supports effective and efficient implementation of flood risk analysis and mapping standards codified in the Federal Insurance and Mitigation Administration Policy FP 204-07801.

For more information, please visit the Federal Emergency Management Agency (FEMA) Guidelines and Standards for Flood Risk Analysis and Mapping webpage (<http://www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping>), which explains the policy, related guidance, technical references, and other information about the guidelines and standards process.

Nothing in this guidance document is mandatory other than standards codified separately in the aforementioned Policy. Alternate approaches that comply with FEMA standards that effectively and efficiently support program objectives are also acceptable.

## Document History

Affected Section or Subsection	Date	Description
First Publication	November 2014	Initial version of new transformed guidance. The content was derived from the <i>Guidelines and Specifications for Flood Hazard Mapping Partners</i> , Procedure Memoranda, and/or Operating Guidance documents. It has been reorganized and is being published separately from the standards.

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## 1.0 Background

Water-surface elevations of the 1-percent annual chance (base) flood are called Base Flood Elevations (BFEs). These BFEs may be designated on the Flood Insurance Rate Map (FIRM) using BFE lines or at Cross Section lines with the appropriate elevation labels. BFEs are placed on the FIRM to assist users in determining the elevation of the 1% annual chance flood elevation anywhere within the floodplain.

For the purpose of this guidance, the term BFE refers to:

- The 1% Annual Chance elevation shown on cross section lines, as noted in the FIRM Database <WSEL\_REG> field and as shown at cross-section L in Figure 1, or
- The 1% Annual Chance elevation shown on the BFE lines (a traditional wavy cartographic line) as noted in the FIRM Database <BFE> field and as demonstrated by elevation 462.2 in Figure 1. These BFEs may be shown as whole foot rounded values or to the 1/10th of a foot, depending on stream slope and map scale. They will be placed along the profile baseline at inflection points not already captured by cross sections, or as needed in areas of backwater, ponding, complex flow areas, overflow areas off the profile baseline, at node areas of Interconnected Channel and Pond Routing (ICPR) and similar models in very flat areas of Florida, or other areas needed per engineering judgment.

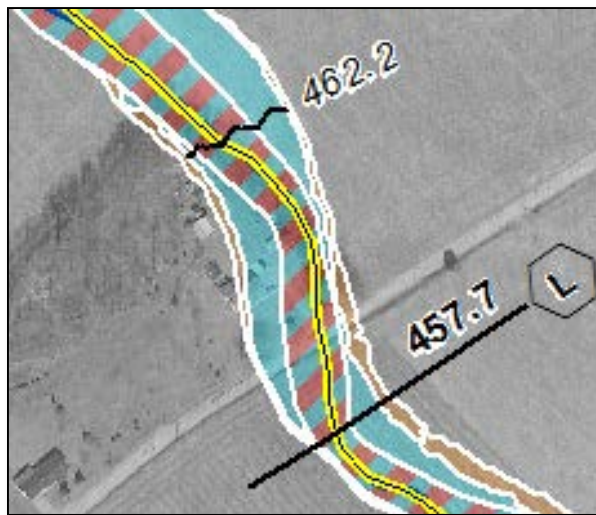


Figure 1: Two BFE depictions on a FIRM

The FEMA standard id (SID) for riverine BFEs (SID 374) is as follows:

- BFEs (i.e., cross-section values supplemented with BFE lines where needed) must be shown at appropriate locations to allow map users to accurately interpolate flood elevations both horizontally and vertically.

Because this standard is results-focused, there is no specific or prescriptive requirements associated with map spacing or flood elevation rise between BFEs. The intent is that map users can accurately interpret flood elevations on the FIRM and that BFEs are placed strategically and at reasonable intervals to enable this intent.

The remainder of this guidance document is devoted to providing examples and guidance that enables SID 374 to be reasonably met. This include examples of poor BFE mapping for context, backwater BFEs, converting effective unrevised BFEs (riverine, ponding and lacustrine) to 10th foot values; and coastal BFEs.

## 2.0 BFE Plotting Guidance

As implied in the FEMA standard, the goal in BFE plotting is to enable the map user to make an accurate flood elevation determination. To enable this standard to be met, it is important to note that applying a rules-based mapping protocol where one-size fits all may yield undesirable results. As such, Mapping Partners must evaluate map scale, stream slope and proximity to development when determine the best approach for plotting BFEs on the FIRM. BFE lines should only be placed “where needed” for new or revised riverine floodplains and to an appropriate level of precision based on the stream slope and map scale.

### 2.1 Plotting BFEs on New or Revised Riverine Study

For all new or revised riverine flood elevations, riverine BFEs lines should be placed only “where needed” both horizontally and vertically to enable accurate interpretation of the water surface elevations, and those BFEs should be expressed as values either to the 1/10th of a foot or as whole-foot rounded values (without a decimal place shown) depending on the stream slope and map scale. In areas of significant stream slope, where precision in BFE mapping would be problematic, the BFEs may be best expressed as whole foot rounded values, while in areas of gentle stream slope BFEs may be best expressed as 10th foot values. It is encouraged that lakes and ponding areas be expressed as 1/10th foot values if they have been calculated to that level of precision; however, until such time as SID 106 can be officially revised, showing lakes and ponds with 1/10th foot BFEs will require a project-specific exception.

It is further recommended that BFEs shown on individual flooding sources all follow the same protocol with limited exceptions. If some parts of the stream will support showing BFEs to the 1/10th of a foot, it is recommended that all parts of the stream be shown the same way to avoid confusion amongst end-users. The notable exception is to show backwater arms similar to what is shown in Figure 2 as whole foot rounded values if sufficient confidence in the true backwater elevation is not present. Likewise, if a flooding source is determined to not support the accuracy implied by showing BFEs to the 1/10th of a foot due to map scale or stream slope, then it is recommended that all BFEs for the entire flooding source be shown as whole foot rounded values without the

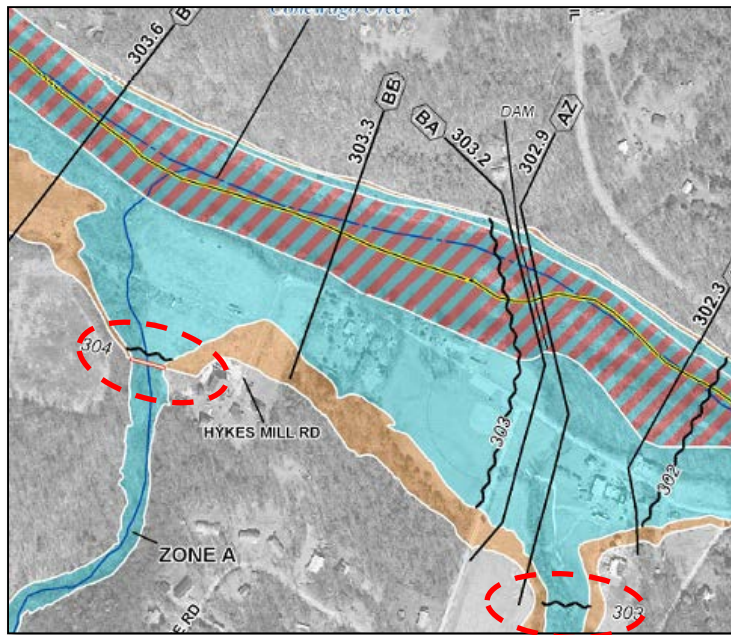


Figure 2: Areas of rounded backwater BFEs

decimal shown (i.e., 423, not 423.0).

Following this approach will enable a level of precision to be represented on the FIRM when that level of precision is supported by the mapping and associated data. All new studies must map base flood elevations (whether on cross sections or supplemental “BFE”) at their true location, not just placed somewhere within a half foot vertical accuracy, or moved to please cartographic readability.

Lastly, it is encouraged that the need for additional BFEs added to the FIRM be reduced whenever possible. Cross sections should suffice in most straightforward riverine situations.

### 2.1.1 Other Considerations

The following are additional considerations for riverine BFEs.

- Streams that are only experiencing redelineation based on new terrain data would not be considered new or revised flood elevations.
- Showing flood elevations on backwater tributaries to the 1/10th of a foot is optional and will be based on the relative accuracy of expressing the backwater elevation to the 1/10th of a foot value. The relative accuracy will be dependent on the accuracy of the available topographic data, profile and map scale, and stream slope. If sufficient confidence in representing the backwater elevation to the 1/10th of a foot is not present, then the backwater BFE should be shown as a whole foot rounded elevation, without the 1/10th of a foot decimal shown.
- For small floodplain segments that are not able to graphically “carry” a BFE line due to their small size, the BFE label should only be shown to the 1/10th of a foot if there is sufficient confidence in the flood elevation at that location. Otherwise it should be shown as a whole foot rounded elevation without the decimal.

## 2.2 Plotting BFEs in Areas of Complex Overbank Flow

Figure 3 demonstrates an area of complex overbank flow that would benefit from additional BFEs “bent” using available terrain data and engineering judgment to reflect flow patterns in overbank areas and to ultimately enable an accurate representation of flood elevations at all points within the floodplain. These BFEs shall traverse the entire floodplain to reflect the consistent 1% annual chance water surface elevation in the overbank areas with the BFEs drawn



Figure 3: Area of complex overbank flow patterns

perpendicular to the flow path. Care should be taken with the depiction of these BFEs as a mechanism to enhance clarity of the changing water surface elevations in relation to other features represented on the FIRM. Placement and orientation of cross-sections and use of BFEs should be evaluated to ensure that water surface elevations are accurately and clearly conveyed.

### 2.3 Avoiding Overcrowding of BFEs

FEMA standards regarding BFE plotting was focused on a specific allowable rise between BFEs and stream gradient. While these are important considerations, it is important to note that mandating (for example) a one foot rise maximum between plotted BFEs could result in overcrowding on the FIRM as demonstrated in Figure 4, which shows an extreme crowding effect caused by placing BFEs at every whole foot in an area of significant stream slope. Figure 5 demonstrates an area of regular stream slope with sufficient cross-sections to represent flood elevations but with several unnecessary BFE lines placed to meet the prior standard of showing whole foot BFEs at every foot of vertical rise.

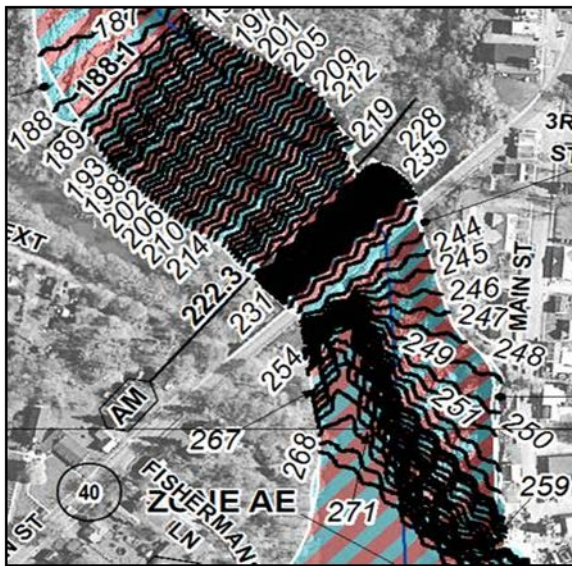


Figure 4: BFEs Plotted at every whole foot on a stream with significant slope

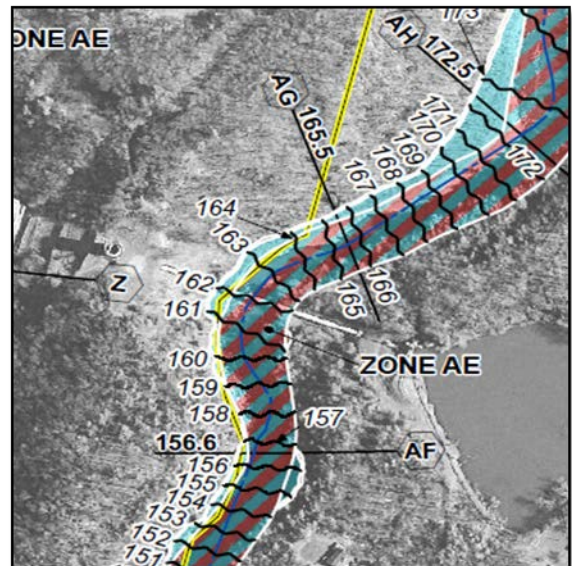


Figure 5: Several Unnecessary Whole Foot Elevations

### 2.4 Ponding, Lacustrine and Coastal BFEs

FEMA standard 106 states:

- BFEs for ponding and lacustrine areas must be expressed to the 10th of a foot if they have been calculated to that level of precision; otherwise they should be shown as whole-foot rounded elevations. Unrevised lake and ponding elevations may be converted to 10th foot elevations if supported by technical data on a project-by project basis in coordination with the FEMA Project Officer. BFEs for coastal flood zones must be shown as whole foot elevations.



Care must be taken in the decision to convert unrevised ponding and lake elevations. If the hydraulic analysis used to derive the elevations shown on the prior FIRM supports this level of precision, and as such, a conversion of this sort, then the Mapping Partner may proceed. When in doubt, it is recommended that the Mapping Partner consult with the FEMA Project Officer.

### 2.4.1 Coastal BFEs

Coastal BFEs will be shown as whole foot rounded values for new studies and unrevised coastal flood elevations will normally not be updated to 10th foot values. There are specific exceptions that may be granted through coordination with the FEMA Project Officer and via the FEMA Guidelines and Standards Exceptions Process.

### 2.5 BFEs for Unrevised Flooding Sources

Unrevised BFE lines may be converted to 1/10th of a foot values as a project-specific option, based on Regional discretion. For example, if 90% of the streams are being revised, a decision may be made to convert the remaining BFEs to 1/10th of a foot values, if this level of precision is determined to be warranted and justifiable.

Before converting unrevised BFEs, a decision must be made regarding the ability to derive accurate flood elevations from the FIRM. For example, if the flood elevations are not attributes of the profile baseline (i.e., older studies) and the Flood Profile is shown at a vertical scale of 1 inch = 20 feet, it may not be possible or reasonable to convert the unrevised flood elevations with a high degree of accuracy. The test for this would be that the accuracy of the converted BFEs should enable recreation of the Flood Profile to within ½ foot at any location. For many unrevised flooding sources this may require the addition of more BFE lines to meet this accuracy requirement.

Effective (unrevised) lake elevations may be shown to 1/10th of a foot only if supported by a Summary of Stillwater Elevations table in the Flood Insurance Study (FIS) report (and as noted

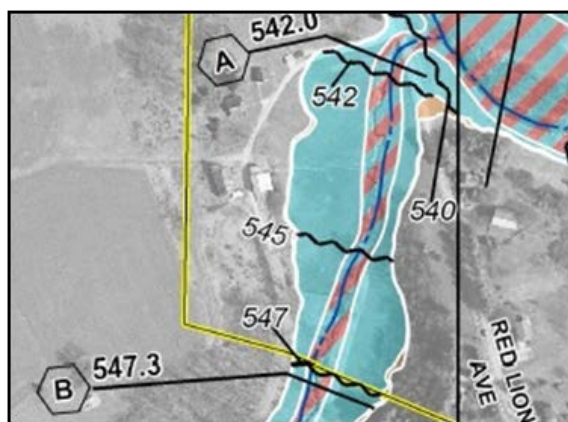


Figure 6: Unrevised BFEs

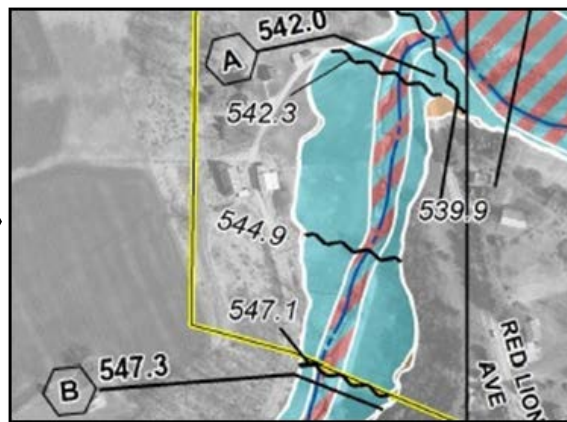
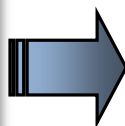


Figure 7: Unrevised BFEs Converted to 1/10<sup>th</sup> foot values

earlier) the hydraulic analysis used for the prior FIRM.

Figures 6 and 7 demonstrate how an unrevised stream with BFEs converted from whole foot rounded values to the 10th of a foot value may appear.

Unrevised BFE lines may, with Regional discretion, be converted to 1/10 foot values if it is determined that stream slope and map scale enable accurate interpretation of the effective flood elevations. When making a decision to convert unrevised flood elevations to 1/10th of a foot value, the following factors should be considered:

- **Cost:** How many flooding sources (and stream miles) contain unrevised BFEs on FIRM panels being revised is an important factor.
- **Consistency:** Having all BFEs on a FIRM shown to the 1/10th of a foot to minimize end-user confusion. If 90% of the streams on a FIRM are being revised, it may be worth converting the unrevised flood elevations as well. Note: Since accuracy of the BFE information on the FIRM is dependent on stream slope and map scale, the conversion of all streams to this standard may not be reasonable or realistic in all cases.
- **Accuracy:** The perceived or relative accuracy of the conversion. If the flood elevations are not attributes of the profile baseline (i.e., older studies) and the Flood Profile is shown at a vertical scale of 1 inch = 20 feet, it may not be possible to convert the unrevised flood elevations with a high degree of accuracy.

Each Region will need to make individual decisions on the conversion of unrevised flood elevations based on the perceived value of doing so and the actual benefit to map users.