# Guidance for Flood Risk Analysis and Mapping

## Redelineation Guidance

November 2015


FEMA

Requirements for the Federal Emergency Management Agency (FEMA) Risk Mapping, Assessment, and Planning (Risk MAP) Program are specified separately by statute, regulation, or FEMA policy (primarily the Standards for Flood Risk Analysis and Mapping). This document provides guidance to support the requirements and recommends approaches for effective and efficient implementation. Alternate approaches that comply with all requirements are acceptable.

For more information, please visit the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage (www.fema.gov/guidelines-and-standards-flood-risk-analysis-and-mapping). Copies of the Standards for Flood Risk Analysis and Mapping policy, related guidance, technical references, and other information about the guidelines and standards development process are all available here. You can also search directly by document title at www.fema.gov/library.

# Document History

| Affected Section or Subsection | Date | Description |
|---|---|---|
| First Publication | November 2015 | Initial version of new transformed guidance. The content was derived from the Guidelines and Specifications for Flood Hazard Mapping Partners, Procedure Memoranda, and/or Operating Guidance documents. It has been reorganized and is being published separately from the standards. |
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# Table of Contents



# List of Figures



# List of Tables

# 1.0 Definition

Redelineation is the method of updating effective flood hazard boundaries to match updated topographic data based on the computed water surface elevations from effective models. The results of a redelineation update are more accurate floodplain boundaries when compared to current ground conditions. Redelineation of floodplain boundaries can be applied to both riverine and coastal studies. No new engineering analyses are performed as part of the redelineation methodology; however, redelineation can be paired with new engineering studies as part of a larger update. For riverine studies, effective flood profiles and data tables from the Flood Insurance Study (FIS) report, Base Flood Elevations (BFEs) from the Flood Insurance Rate Maps (FIRMs), and supporting hydrologic and hydraulic analyses are used in conjunction with the updated topographic data to formulate new floodplain boundaries. The coastal redelineation method also typically involves no new analyses. This method combines effective information from the FIRM and FIS Report and the supporting analyses with new, more detailed, or more up to-date topographic data to redelineate coastal high hazard areas (V zones).

The redelineation of the effective flood hazard boundaries should only be completed when the stream or shoreline reach is classified as VALID in the Coordinated Needs Management Strategy (CNMS) database, the effective floodplain boundary delineations are inadequate, and updated topographic data is available. It is imperative to verify that the new topographic data source is superior to the existing data and that no changes in the hydraulic characteristics of the floodplain indicate that the existing study is no longer appropriate.

# 2.0 General Process

## 2.1 Data Acquisition

To begin a redelineation study, the Mapping Partner should first obtain copies of the backup data for the analysis shown on the effective study's hydraulic models, work maps or latest FIRM, Flood Hazard Boundary Map (FHBM), FIS Report, and Letters of Map Amendment (LOMRs), if applicable. If the study is currently in digital format, the Mapping Partner should acquire data from the National Flood Hazard Layer (NFHL) that covers the redelineation study's footprint. This is to ensure that the most recent flood hazard dataset, including all current LOMRs, is being used.

## 2.2 Capture Non-Digital Information

If the study has not yet been converted to digital format, the Mapping Partner must capture the effective spatial data (cross sections, structures, and profile baselines) in order to relate water surface elevation information with the topography.

The Mapping Partner should georeference the scanned copies of the effective work maps or FIRMs and digitize the cross sections, general structures and profile baselines using hard features such as roads to shift the scanned map over georeferenced aerial imagery.

Profile baselines are to be digitized from the effective study's work maps or latest FIRM, FHBM and LOMRs, if applicable. Work maps obtained from the FEMA Engineering Library may contain the most accurate depiction of the profile baseline. It may be necessary to make spatial adjustments when digitizing profile baselines if there is a clear shift or offset between the

effective map and aerial imagery. For more information on profile baselines, see the Profile Baseline Guidance document.

## 2.3 Cross Sections

In order to redelineate a riverine study, the spatial orientation of each cross section used in the hydraulic model must be defined and the flood elevations associated with that cross section must be known. If both the spatial orientation and water-surface elevation data of each cross section used in the model are reflected on the FIRM, the set of cross sections is complete.

If data are not available for all cross sections, the Mapping Partner must generate the missing data using the Flood Profiles exhibit in the FIS Report. Missing cross section data are evident where flood profiles change slope (known as inflection points), but no cross section is identified on the FIRM at that profile station. The Mapping Partner must delineate missing cross sections at the position along the stream or profile baseline indicated by the flood profile station. The cross sections must traverse the floodplain and be oriented perpendicular to the direction of flow. Flood elevation data should be obtained from the Floodway Data Table (FDT), flood profile, or FIRM, in order of descending preference.

## 2.4 Profile Baselines

The flood profiles and the Z- and M-values stored in the S_Profil_Basln feature class of the FIRM database can be used to locate unmapped cross sections along the profile baseline. Once the profile baseline is created, each S_Profil_Basln feature's M-value should be calibrated using the linear referencing tools in GIS and the mapped cross sections and locations of structures as calibration points for the profile station. Unmapped cross sections can then be located at the appropriate profile station or M-value.

Once all of the modeled cross sections are located along the profile baseline, the Z-values of the profile baseline can be calibrated using the water surface elevations at each cross section in the same way as described above.

Since the profile baseline represents the flood flow path for the effective FIRM/hydraulic analyses, it may fall outside the redelineated Special Flood Hazard Area (SFHA). The following note should be included in the Notes to Users section of the FIRM and Figure 2 of the FIS Report (Notes to Users) when profile baselines fall outside if redelineated floodplains:

> The map reflects more detailed and up-to-date stream channel configurations than those shown on the previous FIRM for this jurisdiction. The floodplains and floodways that were transferred from the previous FIRM may have been adjusted to conform to these new stream channel configurations. As a result, the Flood Profiles and FDTs may reflect stream channel distances that differ from what is shown on the map.

## 2.5 Floodplain Delineation

Once all modeled cross sections have been spatially located along the profile baseline, the floodplains can be delineated using the water surface elevation at each cross section. This process should be completed using automated methods, essentially identifying the intersection of the water surface elevation across the stream with the ground elevation based on

topographic data. For more information on the delineation of floodplains, see the Riverine Mapping & Floodplain Boundaries Guidance document.

### 2.6 Profiles and Floodway Data Tables

For riverine redelineation on non-digital studies, effective flood profiles and floodway data information may also need to be converted to digital format. The effective profile and floodway data information may be manually read or digitally captured and entered into the FIRM database. Once populated, RASPLOT V.3 is able to directly generate flood profiles from the FIRM database. The FIS Report Technical Reference should be referenced for additional information regarding the flood profiles in the FIS Report. Once published, the Flood Profile Guidance document will contain additional guidance regarding the creation and display of flood profile information for select flooding sources in the FIS Report.

## 3.0 Topographic Data

Updated topographic data are an essential component of a redelineation study. As stated in program Standard ID #104, "Redelineation shall only be used when the terrain source data is better than the effective and the stream reach is classified as VALID in the CNMS database." The Mapping Partner should consult with the FEMA Project Officer to decide whether the topographic data intended for use on redelineation will be an improvement over that used to map the effective floodplains.

In evaluating the suitability of updated topographic data, the Project Management Team shall consider both the contour interval and the currency of data. Significant changes (e.g., bridges, culverts, stream channelization, and natural erosion/sedimentation processes) may have occurred since the effective data were developed. If a question about the currency of the data exists, "spot checks" may be performed to verify the accuracy of effective data.

Updated topographic data may be an improvement over effective data even if it does not capture all newly built features. Comparing historical and current aerial imagery and land use data can assist in the determination of overall changes to the floodplain and evaluate the suitability of updated topographic data. Please refer to the Elevation Data Guidance for additional information on assessing the appropriate use of leveraged topographic data.

## 4.0 Datum Conversion

Every FIS and FIRM that contain the results of hydrologic and hydraulic flood hazard analyses are referenced to a specific vertical datum. The National Geodetic Vertical Datum of 1929 (NGVD29) was the vertical datum that most FISs and FIRMs utilized until the mid-1990s. After that time, the North American Vertical Datum of 1988 (NAVD88) became the vertical datum of choice for FIS/FIRM production. In some cases, the existing flooding hazard data may still be referenced to NGVD29; therefore a Mapping Partner performing a redelineation study may need to convert unrevised flood elevations to NAVD88. It is FEMA's goal to convert all flood maps in the contiguous United States from NGVD29 to NAVD88. Please refer to the document Guidance: Vertical Datum Conversion (May 2014) for more details.

When redelineating flood hazard areas, it is essential that the water surface elevations and the topographic data used as the basis of the redelineation are in the same vertical datum. In some cases the topographic data may need to be adjusted.

# 5.0 Missing Effective Data

As discussed in Section 2.2, if cross section data are not available for all cross sections, the Mapping Partner must generate the missing data using the Flood Profiles exhibit in the FIS Report as a guide to place cross sections along the profile baseline. If flood elevation data are not available, the elevations must be obtained from the effective profile. The Mapping Partner must use the complete set of cross sections to develop the required flood profiles. The effective hydraulic model can also provide missing information regarding unmapped cross sections.

In some rare cases, an AE or numbered A zone from an effective map may not have a corresponding flood profile in the FIS text. If this were to occur, the effective model and the mapped and unmapped cross sections should be used to determine water surface elevations along that particular stream.

If the effective map has no mapped cross sections and the effective hydraulic model is unavailable, the Mapping Partner may need to use the BFEs on the effective map to redelineate the floodplain. In this case, mapped BFEs would be digitized like cross sections and used as mapping cross sections for the floodplain mapping. The Mapping Partner should consult with the FEMA Project Officer to determine if the stream should still be considered VALID and redelineation is appropriate. If redelineation is appropriate, the Mapping Partner should consult with the FEMA Project Officer to determine if flood profiles should be developed using the mapped BFEs.

# 6.0 Effective Data Mismatches

## 6.1 Along County Boundaries

Streams frequently make up the boundary between communities, including counties and states. The Mapping Partner should ensure that all communities impacted by a redelineated flooding source are evaluated during the redelineation process. There may be cases were the effective studies of neighboring communities have effective BFEs that are not in agreement and are based on different hydraulic models. Part of the redelineation process should be to evaluate the various overlapping effective models and decide which is more representative of the current flood risk. The water surface elevations from the most recent study should be used to redelineate the floodplain boundaries and update the flood profiles and BFEs.

The following considerations should be taken into account when evaluating overlapping hydraulic studies:

- Age of the study
- Methods and procedures used
- Topographic data source used
- Hydrologic methods, data and procedures used

Edge-matching ensures consistency in studies across community boundaries in the attempt to make the national dataset a seamless product. Detailed guidance on edge-matching is available within the Guidance: Flood Insurance Rate Map (FIRM) Database (May 2015) document.

## 6.2 Across Regulatory Products

It is vital to have information that is consistent across the FIRM database, FIRM panels, FIS Report, and FDT. See Section 10.0, Quality Control, of this report for more information on consistency for redelineation studies.

If mismatch between information in the effective FIRM database, FIRM panel, FIS Report and FDT is identified, it is the responsibility of the Mapping Partner to bring the products into agreement. This may require consultation with the FEMA Project Officer. Table 1, shown below, describes some common mismatches and potential solutions.

**Table 1: Effective Data Mismatches**

| Problem | Probable Root Cause(s) | Potential Solution(s) |
|---|---|---|
| Water Surface Elevations (WSELs) in the FDT do not match those on the profile | • Typo on FDT<br>• Error on profile<br>• Missed backwater effects | • Obtain WSEL from hydraulic model results (preferred method, if available).<br>• Compare to mapped BFEs and see if agreement can be found between two products.<br>• Review potential backwater impacts from other flooding sources. |
| Distances between cross sections on the profile do not match those on the map panel | • Inaccuracy in older mapping methods<br>• Mislabeled cross sections | • Review effective work maps and model to see if problem source can be identified.<br>• Digitize profile baseline and cross sections as shown the map and calibrate M-value of S_Profil_Basln based on profile or FDT distances. |
| Cross sections and road crossing relationship is not consistent between FIRM and flood profile (one is shown upstream of bridge, other is shown downstream) | • Mislabeled cross sections<br>• Bridge replacement<br>• Error on profile | • Review effective work maps and model to see if problem source can be identified<br>• See if aerial imagery indicates new bridge replacement<br>• If model is unavailable, relationship between WSEL changes and structure may clarify which is correct. It is expected that a jump in WSEL would occur upstream, rather than downstream, of a road crossing. |

| Problem | Probable Root Cause(s) | Potential Solution(s) |
|---|---|---|
| Profile stations in FDT and flood profile do not match | • Typo on FDT<br>• Mislabeled cross sections<br>• Profile station labels off by one or more grid blocks (typically 500 or 1000 feet) | • Review effective work maps and model to see if problem can be identified.<br>• Compare WSEL at same cross sections. If they are in agreement and the partner is confident they represent the same modeled section, update the FDT station values to match the profile. |
| Floodway widths in FDT do not match the effective floodway width at the corresponding cross section | • Typo on FDT<br>• Mapping errors or limitations in older products | • Obtain effective models and work maps to determine which is correct, the FDT or mapped floodway.<br>• If the FDT values provide a closer match to the floodplain redelineation, adjust the mapped floodway to match the FDT width.<br>• If the effective floodway delineation provides a closer match to the floodplain redelineation, adjust the FDT to match the floodway width. In this case, a note should be added to the FDT floodway width stating "Widths have been adjusted from the previous effective FDT to match the redelineated floodway." This solution should only be used if the effective model is unavailable to verify floodway widths and the stream is still considered VALID. |

## 7.0 Unverified Studies

During the redelineation process the Mapping Partner may discover discrepancies between the updated redelineated floodplain boundaries and the existing planimetric data. These discrepancies can indicate the need to invalidate the supporting effective data. The Mapping Partner should alert and discuss the apparent issues with the FEMA Project Officer to determine how to proceed with mapping the study.

According Standard ID #104, redelineation shall only be used when the stream reach is classified as VALID in the CNMS database. Prior to redelineating effective floodplain boundaries, the assigned Mapping Partner shall perform the following activities to assess the appropriateness of this approach:

- Review the planimetric features surveyed during the topographic data development process to ensure that the horizontal accuracy of the planimetric features is compatible with the selected FIRM base map.
- Review the effective 1- and 0.2-percent-annual-chance flood elevations to ensure that they are valid and usable for the floodplain boundary redelineation process. If conditions have changed such that the flood profiles included in the effective FIS Report no longer

represent existing conditions (e.g., if bridge or culvert construction has occurred), the assigned Mapping Partner may need to perform updated hydrologic and hydraulic analyses. The assigned Mapping Partner shall obtain the required approval from the FEMA Project Officer before proceeding with such analyses.

- Investigate changed planimetric or topographic conditions that indicate the need for updated analyses and may preclude the use of this method. Such situations include significant discrepancies in planimetric features or stream distance between Flood Profiles and topographic mapping. The assigned Mapping Partner shall bring these situations to the attention of the FEMA Project Officer.

Per Standard ID #134, if the updated topographic data indicates that the effective hydraulic analyses are no longer valid, further actions must be coordinated with the FEMA Project Officer and the CNMS database for the stream reach must be updated and classified as UNVERIFIED. The effective hydraulic analyses, or a portion of the analyses, may not be valid if:

- The effective floodway is outside the redelineated floodplain.
- The effective profile baseline or stream centerline is outside the redelineated floodplain.

Table 2 describes some common observations that may indicate an invalid study and potential solutions.

**Table 2: Redelineation Problems and Validity Concerns**

| Problem | Potential Solution(s) |
|---|---|
| The effective floodway is outside the redelineated floodplain | • Large differences may indicate a need to invalidate the study.<br>• Minor differences may be addressed by shifting the location of the floodway (see Section 9.0, Floodway Redelineation)<br>• If the problem only occurs between modeled cross sections, this may be due to mismatches in topographic data sources and the floodway should be redrawn between cross sections.<br>• If the problem occurs in limited locations, one option may be to expand the floodplain width to match the effective floodway. Note, the delineation of the SFHA will then not match the BFEs and terrain. The FEMA Project Officer should be consulted to determine if this approach should be utilized. |
| The effective profile baseline or stream centerline is outside the redelineated floodplain. | • Large differences may indicate a need to invalidate the study.<br>• If distances between cross sections are generally correct, this may be due to inaccuracies in older mapping methods.<br>• If the study is deemed to still be valid despite the profile baseline shown outside of the redelineated floodplain, add notes to the FIRM panel and FIS Report, see Section 2.4. |

| Problem | Potential Solution(s) |
|---|---|
| BFEs are below ground according to the updated topographic data (i.e., no floodplain is delineated) | • Significant differences likely indicate a need to invalidate the study, particularly on flatter sloped streams.<br>• Small variations in the locations of mapped cross sections along steep streams may cause "dry areas."<br>• If occurring along small reaches of stream, only these reaches may need to be deemed invalid. The FEMA Project Officer may choose to identify these areas as in need of an updated study and retain the effective floodplain boundary where a redelineated boundary is unavailable.<br>• Base level modeling methods may be utilized to replace stream reaches that have been deemed no longer valid, but funding is unavailable to perform an enhanced modeling update. |
| BFEs indicate a significant increase in flood depth and a much broader floodplain is redelineated. | • Significant increases in the floodplain width likely indicate a need to invalidate the study.<br>• A First Order Approximation can be run to validate the redelineated floodplain widths. |

## 8.0 Coastal Redelineation

Per Standard ID #137, redelineation of coastal flood hazard areas requires the revision of the 1-percent-annual-chance SFHA boundary, the 0.2%-annual-chance floodplain boundary, and the primary frontal dune delineation. Generally, a coastal redelineation will revise the most landward extent of an AE or VE flood hazard boundary based upon the updated topographic data. In addition, depending on the amount of shoreline change since the effective study, it may not be appropriate to make adjustments to flood hazard zone breaks between neighboring AE or VE zones with different BFEs without an updated coastal analysis to support the revision.

For additional information, consult the document Coastal Floodplain Mapping Guidance.

## 9.0 Floodway Redelineation

The effective floodway boundaries are to be taken from the NFHL. If the study is not yet available in the NFHL, the floodway boundaries should be digitally captured from the georeferenced effective FIRM panels. There may be situations where it is appropriate to make adjustments to the location or shape of the floodway. Because the floodway is the community's tool to mitigate flood losses by restricting encroachments into the floodplain, Mapping Partners must coordinate all regulatory floodway determinations with community officials, was well as the State National Flood Insurance Program Coordinator and FEMA, as early as possible in the study process.

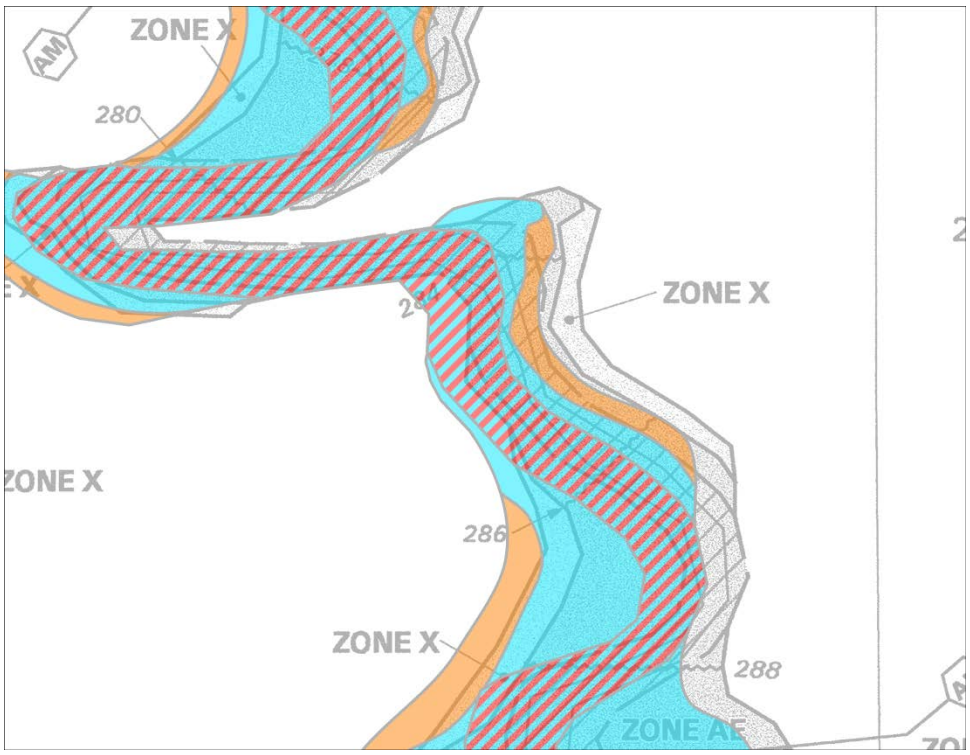
For updated hydraulic studies, floodways are delineated at the encroachment stations (limits of conveyance) at cross sections and interpolated between cross sections. The interpolated boundaries are smooth lines following the general flow direction of floodwaters, gradually widening or narrowing to reflect the changes in width between cross sections. The floodway

boundaries should be mapped at the channel bank stations when the floodway surcharge elevation is lower than the channel bank elevations and the base flood is contained within the channel.

Reflecting on this approach for the original delineation of a floodway, suggests that a redelineation study may reconsider the interpolation of the floodway boundaries between the modeled cross sections. When discrepancies between the redelineated floodplain and the floodway occur a Mapping Partner may determine that the effective floodway is still valid, however the floodway should be adjusted.

One such situation occurs when the effective floodway and redelineated floodplain are in close agreement; however the floodway appears to be shifted outside the floodplain. See Figure 1 for an example of this floodway shift. In this case, the Mapping Partner should consider maintaining the shape and width of the effective floodway, but sliding it across the stream to fall within the redelineated floodplain. These areas should be documented and the FEMA Project Officer and community officials should be consulted.

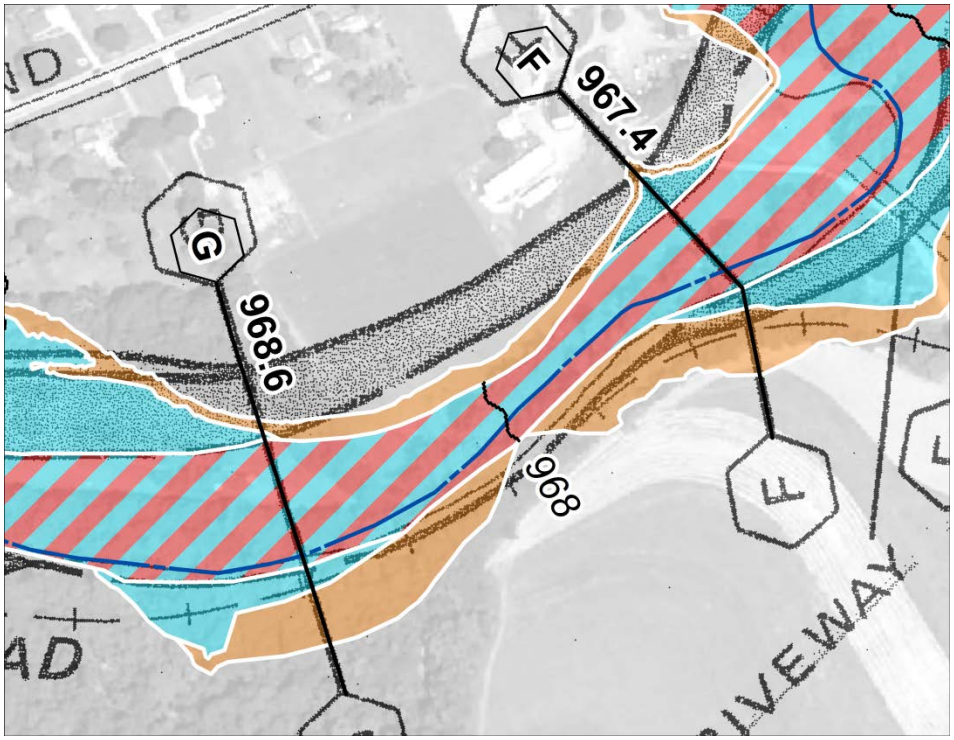
**Figure 1 – Floodway Shift**




In some situations, the floodway shape may not match that of the floodplain as evident by the redelineated floodplain or the topographic data. If the study is still deemed to be valid, the floodway may be reshaped in between the modeled cross sections, as was done during the original hydraulic study, as discussed above. In this situation, the floodplain width at modeled cross sections should be maintained in order to match the encroachments within the effective model and the floodway width in the FDT. The Mapping Partner should avoid reshaping the floodway if it appears that the differences between the effective SFHA and the topographic data

is due to fill placed in the floodway. In this case, the Mapping Partner should flag this as a potential violation and notify the FEMA Project Officer.

**Figure 2 – Floodway Redelineation**




## 10.0 Deliverables

A redelineation study is considered part of the Floodplain Mapping/Redelineation task in the Mapping Information Platform (MIP). The Mapping Partner responsible for a redelineation study must submit the deliverables outlined in Section 6.9, Floodplain Mapping/Redelineation, of the *Technical Reference: Data Capture (Nov 2014).* These deliverables include a draft FIS Report, project narrative, certification, metadata, FIRM database files, updated topographic data (if not submitted under a Terrain task), correspondence and supplemental data including rectified effective maps and any other data that were used to re-create effective profiles and delineations. For details on the FIRM database files, refer to the Technical Reference: Flood Insurance Rate Map (FIRM) Database (May 2015), located at www.fema.gov/media-library/assets/documents/34519 and Guidance: Flood Insurance Rate Map (FIRM) Database (May 2015), located at www.fema.gov/media-library/assets/documents/34953.

## 11.0 Quality Control

The Mapping Partner shall ensure that proper quality control checks are performed throughout the redelineation process. Since profile baselines serve as the link between hydraulic models, the FIRM, the Flood Profiles, and the FDT, it is a key component in many of the quality reviews used to ensure consistency between these study products. Stream distances reported in the FDTs, Profiles, and FIRM database must be measured along the profile baseline; therefore the profile baseline itself should be reviewed prior to conducting these consistency checks. The

capturing of profile baselines from effective FIRM, FHBM, or work maps should be reviewed to ensure the effective data was both georeferenced and digitally captured correctly.

Additional reviews should be focused on consistency across all associated files including the FIS, FDT and FIRM panels and database. The auditor should ensure agreement across all the data by comparing water surface elevations, profile stations and floodway widths at modeled cross sections. Any inconsistencies in data should be addressed by the Mapping Partner.

Any redelineated flood hazard boundaries must undergo a Floodplain Boundary Standard (FBS) audit. One of the goals of Risk MAP Program is to provide reliable and defendable flood hazard maps. The FBS audit checks that the actual end product of the flood boundary matches the best available terrain data. The reliability of the floodplain boundary delineation is quantified by comparing the computed flood elevation to the ground elevation at the mapped floodplain boundary. The tolerance for how precisely the flood elevation and the ground elevation must match varies based on the flood risk class, which is a function of population, population density, and/or anticipated growth in floodplain areas. The Mapping Partner should refer to Floodplain Boundary Standard Guidance document for more information related to the FBS audit.