Guidance for Flood Risk Analysis and Mapping

Floodway Analysis and Mapping

November 2016

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.

Table of Revisions

Affected Section or Subsection	Date	Description
First Publication	November 2016	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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1.0 Introduction

This document provides guidance for floodway analysis, and all the components that accompany it. A floodway is a tool to assist communities in balancing development within the floodplain against the resulting increase in flood hazard. A regulatory floodway is defined as the channel of a river or other watercourse and the adjacent land area that is reserved from encroachment in order to discharge the base flood without cumulatively increasing the water-surface elevation by more than a designated height. NFIP regulations and Standard SID 69 and 70 state: *"Floodway surcharge values must be between zero and 1.0 ft. If the State (or other jurisdiction) has established more stringent regulations, these regulations take precedence over the NFIP regulatory standard. Further reduction of maximum allowable surcharge limits can be used if required or requested and approved by the communities impacted.", and "If a stream forms the boundary between two or more States and/or tribes, either the 1.0-foot maximum allowable rise criterion or existing floodway agreements between the parties shall be used."* The portions of the floodplain beyond the floodway are called the floodway fringe. The community is responsible for maintaining the floodway to mitigate flood hazards; the community must not allow any activities causing a rise in the Baes Flood Elevation (BFE) in the regulatory floodway.

The baseline model for the allowable surcharge is the model used to determine the BFEs the first time a floodway was adopted for the reach. Unless it is demonstrated that the model should be revised for reasons other than encroachments into the floodplain, all subsequent revisions to the floodway are limited to the maximum allowable surcharge above the elevations determined in the base model. That way, as hydraulic models are updated to reflect encroachments into the floodway fringe, the cumulative effect of those and future encroachments is limited to the maximum allowable surcharge. If the model is revised for reasons other than encroachments into the floodplain (such as increased discharges, shift in channel, modeling software advancements), the revised model, excluding any revisions attributable to loss of conveyance areas resulting from floodplain encroachment, is the base model for future floodway analyses.

Regulatory floodways are not normally delineated in coastal high-hazard areas (i.e., Zones V1-30, VE, and V). The computation of regulatory floodways on riverine flooding sources in coastal floodplains is based on the base flood discharge and elevations of the riverine flooding source only. The regulatory floodway must be terminated at the boundary of the V1-30, VE, or V Zone, or where the mean high tide exceeds the 1-percent-annualchance riverine flood elevation, whichever occurs further upstream.

The following sections provide guidance and requirements associated with floodway determinations.

2.0 Floodway Coordination

The Mapping Partner ought to coordinate with the community when developing floodways. FEMA typically starts with an equal conveyance methodology to determine the floodway. However, 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, as well as the State NFIP Coordinator and FEMA, as early as possible in the study process.

Where communities have adopted a regulatory floodway, the Mapping Partner must use the configuration of the adopted floodway to the extent practical to compute floodway data along restudied streams. If the surcharge values are greater than the maximum allowable above the base condition, the Mapping Partner must inform the FEMA Project Officer and community. In such cases, the Mapping Partner must coordinate a revised configuration with the community and the FEMA Project Officer.

Where communities have not adopted a regulatory floodway or where the scope of work calls for a revised configuration, the Mapping Partner must coordinate the floodway configuration with the community and FEMA Project Officer. The Mapping Partner must discuss options for determining the floodway with community officials and the FEMA Project Officer. Those discussions should include:

- The establishment of the base condition for this floodway determination and future floodway revisions;
- The effects of high velocities on fill, and structures and preferences the community may have for restricting encroachments into high velocity areas or encroachments that may result in high velocities elsewhere;
- The restrictive nature of the regulatory floodway and means to distribute the restrictions evenly, such as determining the limits through equal conveyance reduction on both sides of the channel; and
- The use of public land such as parkland to offset restrictions in other parts of the floodplain.

The agreed upon approach must be fully documented in the hydraulics report including the reasoning leading to the encroachment methods and minutes of coordination meetings. Meeting minutes must include the date, time, and location of the meeting and a list of attendees. If the community cannot agree upon an approach, the Mapping Partner must consult the FEMA Project Officer for direction.

If more than one community is affected by the floodway, all affected communities must be included in the discussions. In the case that one of the communities sharing the same reach has a more stringent allowable maximum surcharge, the Mapping Partner must describe any differences in maximum allowable surcharge values and facilitate an agreement among the communities as to the maximum surcharge and the floodway configuration to be applied to the shared reaches. That agreement must be fully documented including the date, time, and location of the meeting, and signed by all parties in attendance. If such an agreement cannot be reached, the Mapping Partner must seek guidance from the FEMA Project Officer.

If the state or community in which the mapping project is being performed has established more stringent regulations for the maximum allowable rise in water-surface elevations, through legally enforceable statutes, these regulations take precedence over the NFIP regulatory standard. In the case of streams that form the boundary between two or more states, the 1.0-foot maximum allowable rise criterion should be used unless the states have previously agreed on a lesser rise criterion. The Mapping Partner must obtain written approval of the Regional Project Officer before computing or mapping a second regulatory floodway based on a criterion established by the community.

When the floodway has been established for either or both upstream or downstream communities, the Mapping Partner must coordinate with all involved communities to create a smooth transition of floodway surcharges and ensure the surcharges are within the maximum allowable limit.

3.0 Steady State Floodway Analysis

Floodways are determined by modeling the floodway fringe as a non-conveyance area by encroaching the effective flow area. The technique of using artificially high roughness coefficients must not be used for floodway analyses in one-dimensional steady flow analysis. The Mapping Partner should use the most recent existing conditions model, or base model discussed in section 1.0 as the base for the floodway analysis limiting surcharges to the maximum allowable above the base conditions 1-percent-annual-chance profile. Typically, the Mapping Partner should use an equal conveyance reduction method to establish the regulatory floodway.

When flow is in the supercritical regime for man-made channels, or where velocity conditions are such that normal encroachment analyses are not possible or are inappropriate, the encroachment stations should be computed so that the allowable rise in water-surface elevation matches the target water surface without exceeding the target energy grade line.

3.1 Boundary of Floodway Analyses

Most floodways are determined using a step-backwater model. If a floodway exists at the downstream limit of study on the same stream as the study reach, the floodway must be configured so that the floodway data at the downstream limit of study match the floodway data at the upstream limit of the existing study. See Section 6 of the Contiguous Community Mapping Guidance for more information about study tie-ins.

In case a discrepancy is identified between the floodway data table and floodway model, the Mapping Partner must document the magnitude of and reason for the mismatch and suggest remedies to the FEMA Project Officer. Once the data match, the floodway analysis is based on a starting water-surface elevation associated with the maximum allowable surcharge, or the water surface elevation resulting from application of a more restrictive requirement imposed by a state or other jurisdiction. That way, future (allowable) revisions to the downstream floodway should not create surcharges greater than the maximum allowable in the study reach.

If the study reach begins at the mouth of the stream, the Mapping Partner must start the encroachment analysis at a width yielding the maximum allowable surcharge, or the water surface elevation resulting from application of a more restrictive requirement imposed by a state or other jurisdiction, for a normal depth calculation using the same friction slope as the unencroached

profile. If a floodway does not exist immediately downstream of the study reach, the Mapping Partner should start the analysis sufficiently downstream of the downstream limit of study so that differences in the starting conditions do not create surcharges greater than the maximum allowed within the study reach. That way, future floodway designations downstream should not create surcharges greater than the maximum allowable in the study reach.

If a floodway exists at the upstream limit of study, the floodway must be configured so that the floodway data at the upstream limit of the study match the floodway data at the downstream limit of the existing study. If the relevancy of the existing study is in question issues associated with tying into the existing analysis should be investigated and the Mapping Partner must seek guidance from the FEMA Project Officer.

3.2 Storage Considerations

Storage considerations in hydrologic and hydraulic modeling of the unencroached condition should be revised to reflect any encroachment into storage areas indicated by the floodway configuration.

If designated storage areas behind structures are accounted for in the flood discharge computations by routing the base flood hydrograph, no encroachment is to be allowed; and the floodway encroachment stations should be equal to the base floodplain boundary of the storage area designating the storage area as part of the floodway. In this case, the Mapping Partner should use the same flood discharge for the unencroached and encroached profiles in the step-backwater analysis to determine the surcharge values. However, if the storage capacity exists but is not accounted for in the routing base flood hydrograph, it can be encroached; the Mapping Partner should determine the flood discharges for the encroached profile downstream of the structure by routing the 1-percent-annual-chance flood hydrograph through the reduced storage area. In this case, the flood discharge for the encroached profile may be greater than the flood discharge for the unencroached profile in the step-backwater analysis.

3.3 Tributary, Split and Diverted Flows

The regulatory floodway on a tributary stream is based on the base (1-percent-annual-chance) flood discharge and elevation of that stream only and normally should not include consideration of any backwater flooding from the main stream. Therefore, the floodway elevations in the lower reach of a tributary subject to backwater flooding may be lower than those used to plot the Flood Profiles. See section 7 of the FIS Report Technical Reference to see how this is portrayed in the FIS.

The Mapping Partner should re-compute flood flow values along each flow path associated with reaches with split and/or diverted flow situations, as described in Split Flow under Section 2.1.7, in the Hydraulics One-Dimensional Analysis Guidance, under encroached (floodway) conditions. If the primary flow path (originating reach) can safely carry the entire base flood flow without increasing flood heights more than the maximum allowable surcharge, only the primary flow path requires a floodway. If not, other flow paths require floodways.

The Mapping Partner should ensure that the overland flow segment on the mainstream remains open by determining a separate regulatory floodway for the overflow path, or by a note on the FIRM stating that the overflow area should remain unencroached until a detailed hydraulic

analysis is performed to establish a regulatory floodway. The Mapping Partner must inform the FEMA Project Officer when overland flow paths lead into another jurisdiction where a regulatory floodway has not been computed, thus necessitating that the overflow area remains unencroached.

The FEMA Project Officer may approve, as an alternative, that the Mapping Partner determine the regulatory floodway on the main channel downstream of the overflow area by determining the floodway profile with the total flow (including the flow lost as overflow). The Mapping Partner should compare the water-surface elevations from the floodway profile to the water-surface elevations of the 1-percent-annual-chance Flood Profile reflecting existing conditions (whose discharges in the main channel have been reduced because of flow lost as overflow) to determine surcharges. If the calculated surcharge is less than or equal to the allowable surcharge, the regulatory floodway is depicted on the main channel only.

Otherwise, a separate regulatory floodway is defined for the overflow path. The Mapping Partner should add a note to the Floodway Data Table or the FIRM to identify the segment of floodway where the surcharge was computed using the reduced flow. The floodway should be revised when the diverted flow does not occur anymore and the flow is fully carried by the main stream.

3.4 Negative Surcharge Values

Surcharge values must be between zero and the maximum allowable value in the respective community. Negative values in output data generally indicate excessive changes in velocity, conveyance capacity, or floodway width at or downstream of the cross section with the negative surcharge. Floodway configurations should be revised until all surcharge values are between zero and the maximum allowable value. Reasons for deviating from this practice should be coordinated with the FEMA Project Officer.

4.0 Unsteady State Floodway Analysis

The equal conveyance reduction approach is most applicable to a steady state, one-dimensional model. In certain situations, equal conveyance reduction cannot be practically achieved in defining the floodway configuration. The Mapping Partner may use one of the alternative methods discussed below to determine the regulatory floodway configuration. Use of an alternative method must be approved by the FEMA Project Officer and agreed to by the communities involved.

Steady state models do not consider lost storage in both effective and ineffective flow areas and its impacts on flow rates and timing. However, for unsteady state models, encroachment into the floodway fringe would impact flow rates; the degree depends on the amount of storage lost. Encroachments result in storage decreases in both off-channel storage modeled with an elevation-storage curve, and in non-conveyance areas modeled with artificially high roughness coefficients. Input data for the elevation-storage curve or the values of roughness coefficients should be revised to reflect the lost storage.

4.1 One-Dimensional Unsteady Floodway Analysis

The loss of storage in the floodway fringe of an unsteady model makes it likely that the peak discharge in the floodway model will be larger than that in the unencroached analyses. The flow rate increases are likely to cause elevation increases downstream even if the base flood is fully

within the channel. If surcharges increase when unsteady state modeling is used for a reach with a previously determined steady-state floodway, the floodway width should be increased to meet the maximum allowable surcharge limit, or other more restrictive requirements of a state or other jurisdiction.

The equal conveyance reduction method can be performed in unsteady state modeling through an iterative process. In general, the Mapping Partner should follow procedures described in the HEC-RAS User's Manual (HEC, 2016) to perform unsteady flow floodway analyses. The procedure uses a steady flow encroachment analysis to establish an approximate floodway and import the encroachment stations to the unsteady flow model to verify that the surcharge is within the maximum allowable limit. The Mapping Partner should incorporate peak flows from unsteady flow runs to the steady flow model to estimate the encroachment stations. When rerunning the steady flow model with encroachment stations, Mapping Partners should adjust downstream boundary conditions to reflect increases of water-surface elevation due to encroachment.

An alternative method is to perform floodway analysis using an unsteady state model directly. The Mapping Partner should use the base flood hydrograph as the inflow hydrograph and determine encroachment stations by the equal conveyance reduction method.

Equal storage reduction may be applied in the floodway determination for streams with flooding dominated by storage. In such systems, the difference between the equal conveyance reduction method and equal storage reduction method is usually not significant. The equal storage reduction method is simpler in both concept and application, and could be considered as an alternative approach for floodway determination.

4.2 Two-Dimensional Unsteady Floodway Analysis

When a hydrograph is routed downstream and constrained within the floodway with a given surcharge, it moves water downstream at a different rate. If the floodway fringe is encroached, the water that previously inundated the floodway fringe areas is pushed downstream due to reduction of storage and may result in increased flow rate and water-surface elevation on the downstream floodplain. The storage routing floodway procedure fills the floodplain grid elements up to the maximum allowable surcharge before distributing flow to contiguous floodplain grid elements. Because the maximum allowable surcharge is defined by the user, this procedure can easily satisfy the floodway surcharge requirement. The method does not explicitly compute and compare conveyance reductions; the Mapping Partner must get pre-approval from the FEMA Project Officer to use this method and coordinate with the communities to get an approved floodway configuration.

If the floodway was previously determined by a one-dimensional model, the Mapping Partner should incorporate the encroachment stations into a two-dimensional model and run the two-dimensional model to verify that the maximum allowable surcharge is not exceeded.

5.0 Floodway Boundary Mapping

Floodways are delineated at the encroachment stations (limits of conveyance) at cross sections, nodes or grid elements and interpolated between. For more information, see section 5 of the Riverine Mapping and Floodplain Boundaries Guidance**.**

Where the floodway is mapped differently than the model results to meet State requirements, the Mapping Partner should document the State requirements and the location(s) that discrepancies occur.

6.0 Floodway Data Table

For each floodway determined under the scope of work, the Mapping Partner must create a Floodway Data Table (FDT). The FDT developed as part of this analysis must contain an entry for each cross section in the model to fully document the floodway analysis (this does not imply that all cross sections will be shown in the FDT published in the FIS report). For more information about the contents and appearance of the FDT see section 4 of the FIS Report Technical Reference.

Existence of high ground in the middle of a cross section would reduce the floodway width, computed as distance between two encroachment stations. In such a case, the width of floodway should be the width as mapped and a note should be added to the FDT to explain the difference.

When creating a FDT based on a HEC-RAS unsteady flow floodway analysis, the Mapping Partner should use floodway parameters (floodway width, section area, mean velocity of with-floodway and without-floodway water-surface elevation) associated with the maximum discharge at each cross section from the unsteady floodway run.

Most two-dimensional models do not use cross sections. In those cases, the Mapping Partner should create a set of cross sections and an associated FDT. The cross sections should be placed at BFE contour lines and extend into the floodway fringe on both sides of the floodway. Cross sections should be placed at changes in floodway width, spaced adequately to represent stream characteristics, and with enough numbers to sufficiently represent the variation in floodway data.

7.0 Deliverable Products

The floodway analysis and mapping must be submitted as part of the hydraulics and floodplain submittal described in Section 6.6 and Section 6.9 of the Data Capture Technical Reference, and Section 9 of the FIRM Database Technical Reference. The Mapping Partner must submit files via the MIP; other media may be acceptable if coordinated with FEMA.

8.0 Floodway Analysis Review

The reviewing Mapping Partner will be responsible for performing hydraulic and floodway reviews as described below. The reviewing Mapping Partner is responsible for determining whether the proposed analyses are reasonable. Section 9 of the General Hydraulics Guidance provides requirements and criteria that should be used to determine if the hydraulic and floodway analyses are reasonable.

Related Templates associated with this Guidance

Note:

The following templates will be a tool to help practitioners comply with the guidance contained in this document and will help with overall program consistency. Once they have been reviewed and comments have been addressed, the templates will be stored individually on the fema.gov G&S web page under the "Templates and Other Resources" link (http://www.fema.gov/media-library/assets/documents/32786?id=7577). They are merely provided here to aid in the consolidation of review comments to one document.