



CHAPTER 11

FLOODPLAIN DELINEATION



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CHAPTER 11 FLOODPLAIN DELINEATION

1.1 INTRODUCTION

In order to regulate existing and new floodplain improvements and to reduce the amount of future losses due to flooding, flood hazard areas should be clearly identified, studied, and delineated.

Many drainageways have been analyzed by various local, state, and federal agencies, and the floodplain delineations can be found on either the Flood Insurance Rate Maps (FIRMs) published by the Federal Emergency Management Agency (FEMA) or the community's floodplain maps. However, throughout the State, numerous flood hazard areas that are subject to severe flooding have not yet been studied and delineated. As new developments occur in these undetermined flood hazard areas, local agencies and developers face the challenge of developing the flood hazard area information.



This chapter is intended to provide practical guidelines for delineation of flood hazard areas within the State of Colorado. Readers of this manual are encouraged to review the following publications for more detailed discussions on this subject:

- Federal Emergency Management Agency, NFIP Regulations, Title 44, Chapter 1, Part 65, Identification and Mapping of Special Hazard Areas, revised October 1999.
- Federal Emergency Management Agency, Guidelines and Specifications for Flood Hazard Mapping Partners, April 2003.

To modify or designate new flood hazard areas, the applicant should prepare and submit a Floodplain Modification Study to the local government agencies and the Colorado Water Conservation Board (CWCB) for their review and approval. If it is required or preferred to show the floodplain delineations on the FEMA Flood Insurance Rate Maps (FIRM), a LOMR request report should be prepared and submitted to FEMA for their review and approval. A LOMR request report may be submitted in place of a Floodplain Modification Study to the local agencies and the CWCB. Detailed discussions on the report contents and submittal requirements are provided in Chapter 5 of the Statewide Manual.

1.2 LEVEL OF STUDY

Flood hazard areas can be delineated based on two different analysis approaches: detailed and limited methods. The detailed study approach should be used when accurate floodplain information including floodplain limits, water surface elevations



and profiles, flood depths and velocities and, floodway limits, are needed for the drainageway being studied (Section 3, Chapter 10). The limited study method may be used when detailed floodplain information is not necessary. The limited study results in the delineation of approximate flood hazard areas without base flood elevations (Section 2, Chapter 10).

The following factors should be considered when deciding which study approach to use for a drainageway being studied:

- Size of the contributing watershed
- Size and stability of the drainageway
- Floodplain development pressure
- Existing and future floodplain encroachments
- Floodway delineation
- Watershed area plan
- FEMA submittals
- Flooding history

The detailed study approach should be used when a new development is proposed within or adjacent to the 100-year floodplain limits. The limited study method may be used to define the 100-year floodplain limits if no encroachment into the natural floodplain is proposed in the foreseeable future.

1.3 **WATERSHED DEVELOPMENT CONDITIONS**

The FEMA 100-year floodplain and floodway boundaries shown on the Flood Insurance Rate Maps (FIRM) are delineated based on the existing watershed and floodplain conditions at the time of the Flood Insurance Studies (FIS).

To be consistent, hydrologic and hydraulic analyses for all new floodplain delineation studies should be performed, at a minimum, to reflect the existing watershed and floodplain conditions. Public works projects in progress that are planned to be completed within 12 months following the study completion should be included in the analysis. Where construction of a publicly owned, operated and maintained flood control facility will not be completed within 12 months following completion of the study, but adequate progress has been made, the impact/benefit of the project may be included in the hydrologic analysis. The project engineer should coordinate with the public agency in charge of the facility design and construction, effected local agencies and Colorado Water Conservation Board (CWCB) to determine whether to include the subject facility in the existing conditions analysis or not.

Flood hazard areas can be delineated based on two different analysis approaches: detailed and limited methods.

Hydrologic and hydraulic analyses for all new floodplain delineation studies should be performed, at a minimum, to reflect the existing watershed and floodplain conditions. Local communities are encouraged to develop future (built-out) conditions floodplain information in addition to the existing conditions floodplains.



As new developments occur, the estimated existing conditions peak flows and associated floodplain limits may change depending on the nature and amount of new developments within a watershed. Therefore, local communities are encouraged to develop future (built-out) conditions floodplain information in addition to the existing conditions floodplains, especially when the area plan indicates substantial amount of future developments. Once developed, communities may request FEMA to show the future conditions floodplains on the community's FIRM maps in addition to the existing conditions floodplains.

1.4 FLOOD HAZARD ZONE DESIGNATIONS

Flood hazard zone designations are used to identify the level of study, severity of flooding conditions, type of flooding, and other floodplain information. The flood zone designations can be used by agencies to regulate their floodplain developments and by insurance agents in determining flood insurance rates for properties in the NFIP participating communities.

All new floodplains that are delineated to be shown on the FEMA Flood Insurance Rate Maps (FIRM) should be designated using the latest FEMA flood insurance rate zone designations. New floodplain delineations that are not prepared to be shown on the FIRM maps should be designated using the following flood zone designations.

100-year Floodplain (FEMA Zone AE)

100-year Floodplain boundaries are determined using the "detailed method" as described in Section 1.5, Chapter 11. The 100-year water surface elevations should be shown at a selected interval for this zone.

Approximate 100-year Floodplain (FEMA Zone A)

Approximate 100-year Floodplain boundaries are determined based on the "limited method" as described in Section 1.6, Chapter 11. Since no detailed hydraulic analyses are required for the limited method, the 100-year water surface elevations are not shown within this zone.

100-year Shallow Floodplain (FEMA Zone AO or Zone X)

100-year Shallow Floodplain boundaries are determined using the "detailed method" as described in Section 1.5, Chapter 11. Since it is often difficult to define the 100-year water surface elevations for areas of shallow flooding, average flood depths and limits (between 1 and 3 feet) should be shown instead. If the average flood depth is less than 1 foot, the floodplain should be designated as 100-year Shallow Floodplain (1 foot depth).

Special 100-year Floodplain

Special 100-year Floodplain boundaries are determined using the "detailed method" as described in Section 1.5, Chapter 11. The 100-year water surface elevations should be shown at a selected interval for this zone. The floodplain designation should clearly identify the type of flooding (mudflow, alluvial fan, fire area, ice flow, etc.)

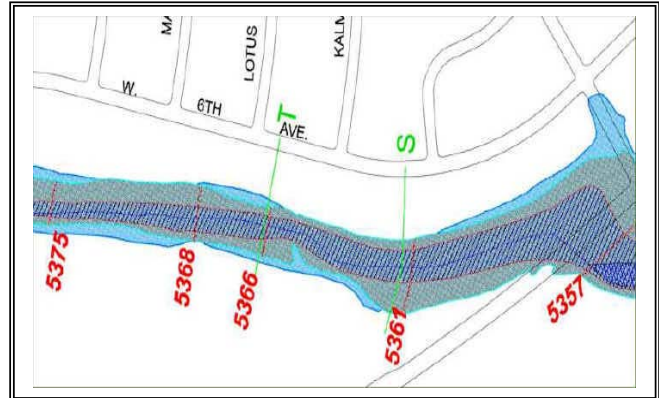


500-year Floodplain

500-year Floodplain boundaries are determined using the “detailed method” as described in Section 1.5, Chapter 11. The 500-year water surface elevations need not be shown.

1.5 DETAILED FLOODPLAIN DELINEATION METHOD

Detailed floodplain information including floodplain limits, water surface elevations and profiles, flood depths and velocities, and floodway limits can be generated for drainageways using the detailed hydraulic analysis method as outlined in Section 3, Chapter 10. The flood hazard zones delineated using the Detailed Method should be designated using the designations outlined in Section 1.4 of this chapter.



1.5.1 HYDROLOGIC ANALYSIS

Hydrologic analysis should be performed based on the criteria outlined in Chapter 9 of this manual. The analysis should include, at a minimum, calculations for the 10-, 50-, 100-, and 500-year frequency discharges. It is recommended that the peak discharge for 2- and 5-year flood events be calculated in addition to the other discharges. The 500-year flow rate may be estimated by multiplying the 100-year flow rate by a factor of 1.7 (FHWA, HEC-18).

Based on the analysis method selection criteria outlined in Section 1, Chapter 9, the flow rates should be computed using either Statistical Analysis and/or rainfall-runoff models. Rainfall –runoff models should be calibrated as discussed in Chapter 9.

1.5.2 TOPOGRAPHIC MAPPING

For discussions and specifications on the topographic mapping standards for detailed floodplain delineation studies, please refer to Chapter 8 of the Statewide Manual.

1.5.3 HYDRAULIC ANALYSIS

The detailed flood hazard area information should be developed based on the detailed hydraulic analysis criteria outlined in Section 3, Chapter 10. Detailed hydraulic analysis should be performed to define, at a minimum, the water surface profiles for the 10-, 50-, 100-, and 500-year flood frequencies and the 100- and 500-year floodplain boundaries. The 10-year floodplain boundaries should also be delineated if the 10-year flows are not confined within the channel. The floodplain boundaries shown on the floodplain



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delineation maps should be consistent with the calculated water surface profiles.

1.5.4 **FLOODPLAIN DELINEATION**

A stream reference/stationing line should be shown down the center of the low flow channel on the floodplain delineation map for all streams studied using the detailed method. The floodplain boundaries should be delineated based on one of the following methods:

a. Flood Contour Method

Flood contours (water surface elevation contours) derived from the computed water surface profile should be used to define the floodplain boundaries. The flood contours should have a vertical interval equal to the contour interval of the floodplain delineation map if the following criteria are met.

- The average slope of the computed water surface profile between cross sections is flatter than one percent,
- or the width of the floodplain is greater than 200 feet,
- or there are, in judgment of the engineer, unusual topographic features.

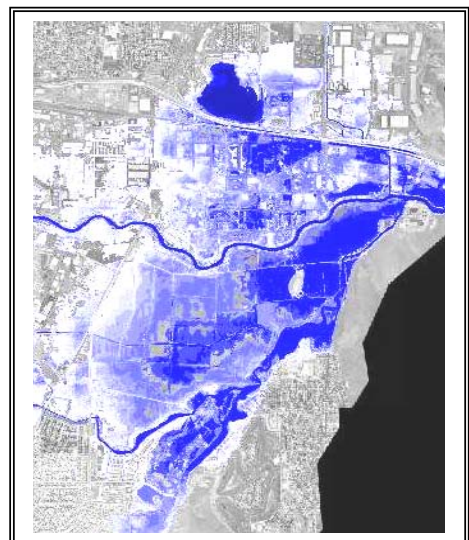
Alternate flood contour interval may be used in lieu of the above flood contour interval if the slope of the water surface profile in combination with the contour interval and map scale, would result in an average horizontal spacing between flood contours of less than 1 inch. However, in all cases, the flood contours should be appropriately spaced to be able to regenerate the water surface profile within 0.5-foot or better accuracy.

b. Map Contour Method

For the channel and floodplain cross sections used in the hydraulic analysis, the floodwater surface elevations and floodplain horizontal limits should be computed. The flood boundaries should be delineated between the cross sectional locations by transposing the water surface elevations to the topographic map. These intermediate locations should be correlated to the reference line and the flood profile as to their specific location and elevation.

c. Computer Automated Delineation

The computer programs developed to automate the floodplain delineation process (GEO-RAS, FLO-2D, etc.) may be used to generate floodplain boundaries. However, the computer generated floodplain boundaries should be checked for





accuracy and modified as deemed necessary.

1.5.5 **FLOODWAY DELINEATION**

The floodway is defined by FEMA as the channel, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year discharge can be conveyed with no more than one (1) foot rise in the water surface above the base flood elevations (BFE). The floodway represents the community's regulatory limit of encroachment into the 100-year floodplain for those watercourses with the established floodway boundaries. Communities may choose to delineate floodways based on FEMA's 1-foot rise criteria or based on stricter criteria by

Communities may choose to delineate floodways based on FEMA's 1-foot rise criteria or based on stricter criteria by allowing a lesser amount of rise above the base flood elevations.

allowing a lesser amount of rise above the base flood elevations (BFE). However, it should be noted, that only the floodway limits determined using the 1-foot rise criteria would be shown on the FEMA FIRM maps.

The project engineer should coordinate with the effected local agencies and the CWCB to determine whether a floodway should be delineated for the drainageway being studied or not. The floodway delineation should be clearly shown on the floodplain delineation map in addition to the floodplain boundaries.

1.5.6 **FLOODPLAIN DELINEATION MAP**

As a minimum, floodplain delineation maps should show the following flood hazard area information:

- 100-year floodplain (and floodway, if applicable) boundaries and zone designations
- 10-year (if applicable) and 500-year floodplain boundaries
- Location of all cross sections used in the hydraulic analysis
- A reference/stationing line drawn down the center of the low flow channel
- A sufficient number of 100-year flood contours that can be used to reconstruct the 100-year flood water surface profiles to an accuracy of 0.5-foot or better. Flood contours (BFE) should be shown as wavy lines drawn normal to the direction of flow of floodwater and should extend completely across the area of the 100-year floodplain. Each flood contour should indicate its elevation to the nearest whole foot.

An example detailed floodplain delineation map is shown on Figure CH11-F101. The floodplain delineation map scale should be 1-inch equals 200 feet (1" = 200') or other scales approved by the CWCB.

1.5.7 **WATER SURFACE PROFILES**

The following floodplain information should be provided, as a minimum, in the profile sheets:



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- The existing channel centerline ground profile. The channel stationing should match the centerline stations shown on the floodplain delineation maps.
- The computed water surface profiles and the peak flow rates for the 10-, 50-, 100-, and 500-year flood frequencies.
- All road crossings, railroads, culverts, bridges, levees, confluences, and other hydraulic structures should be shown and labeled.
- Location of all cross sections used in the hydraulic analysis.

A comparison of the calculated 100-year flood profile at the study limits with the previously approved profile information for the drainageway should be provided. Except where clearly identified changes in flooding characteristics or error in the existing profile can be shown, the proposed 100-year flood elevations at the study limits should agree with those of other contiguous studies on the same stream. The 100-year water surface elevations should be computed to match within +/- 0.5 foot of an existing valid elevation; however, the final published 100-year floodwater surface profile should be drawn to match the contiguous study exactly. Where elevations cannot be reconciled to within +/- 0.5 foot because of changed flooding conditions or an error in the previous analysis, a full explanation and justification for the difference should be provided.

1.6 LIMITED FLOODPLAIN DELINEATION METHOD

The limited method results in the delineation of approximate 100-year floodplain boundaries without base flood elevations (BFEs). The hydrologic and hydraulic analysis should include, at a minimum, determination of 100-year event discharge and floodplain limits.

The 100-year flood zone delineated using the Limited Method should be designated as "Approximate 100-year Floodplain".

1.6.1 HYDROLOGIC ANALYSIS

Hydrologic analysis should be prepared based on the criteria outlined in Chapter 9 of this manual. The analysis should include, at a minimum, calculations for the 100-year peak flow rates.

1.6.2 TOPOGRAPHIC INFORMATION

The best available topographic base map should be used to develop approximate floodplain information. Such work map should, at a minimum, be the most recent edition of 7.5-minute quadrangle maps as published by the U.S. Geological Survey (USGS).

1.6.3 HYDRAULIC ANALYSIS

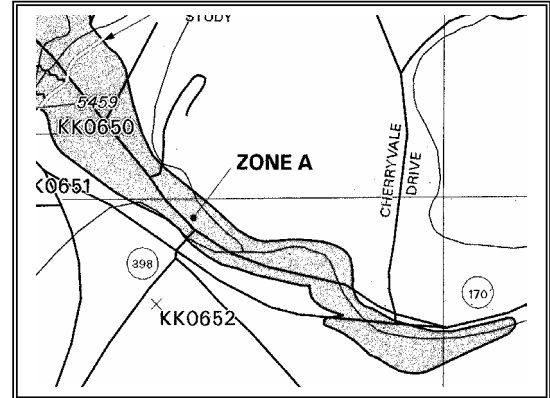
The approximate 100-year floodplain boundaries should be delineated based on the limited hydraulic analysis criteria outlined in Section 2, Chapter 10.



1.6.4 FLOODPLAIN DELINEATION

Approximate 100-year floodplain boundaries should be delineated based on the following method.

- Approximate floodplain limits for a stream reach can be delineated using the calculated 100-year water depths for the cross sections that are representative of the stream sub-reaches using normal depth calculations.
- Approximate floodplain limits at road crossings may be delineated using the estimated headwater and weir flow depths using FHWA culvert rating charts and broad crested weir flow computations.
- If sufficient amount of cross sections were used to compute water surface elevations for the stream reach, the Map Contour method, discussed previously in Section 1.5.4, may be used to delineate more accurate approximate floodplain limits.



If reliable surveyed high water marks from a previous flood event, close to a 100-year event, are available for the drainageway, the surveyed high water mark elevations may be used to supplement the computed 100-year water surface elevations in delineation of approximate floodplain limits.

1.6.5 FLOODPLAIN DELINEATION MAP

Floodplain delineation maps should be prepared using the best available topographic map to show the approximate 100-year floodplain boundaries and the location of all cross sections used in the limited hydraulic analysis. The floodplain delineation map scale should be 1-inch equals 400 feet (1" = 400') or other scales approved by the CWCB.



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