

Guidance for Flood Risk Analysis and Mapping

Shallow Flooding Analyses 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 Overview

This document provides guidance to support the identification of shallow flooding hazards and the application of shallow flooding hazard determinations to National Flood Insurance Program (NFIP) products. This guidance document pertains to the study of flows for which the effects of sediment on the flow regime can be ignored. Guidance related to alluvial fan flooding, which considers sediment transport, can be accessed from the [Alluvial Fan Guidance](#) document.

2.0 Shallow Flooding Defined

For the purposes of the NFIP, shallow flooding is defined as flooding with an average depth limited to 3.0 feet or less where no defined channel exists.

Different types of shallow flooding commonly occur throughout the United States. Types of flows that result in shallow flooding include the following:

- Unconfined flows over broad, relatively low relief areas, such as alluvial plains;
- Intermittent flows in arid regions that have not developed a system of well-defined channels;
- Overbank flows which are independent from the main channel;
- Overland flow in urban areas; and
- Flows collecting in depressions to form ponding areas.

3.0 Applicable Flood Hazard Zones

The flood hazard zones shown on the Flood Insurance Rate Map (FIRM) that are relevant to areas susceptible to shallow flooding are listed and described below.

Table 1: Flood Hazard Zones

| Flood Hazard Zone | Shallow Flooding Description |
|-------------------|---|
| Zone A | Area of special flood hazards without water surface elevations determined. ¹ Zone A is the flood hazard zone that corresponds to the 1-percent-annual-chance floodplains that are determined by Zone A study methods in shallow flooding areas. No 1-percent-annual-chance flood elevations or average depths are shown within this zone on the FIRM. |

| Flood Hazard Zone | Shallow Flooding Description |
|-------------------|--|
| Zone AO | <p>Area of special flood hazards having shallow water depths and/or unpredictable flow paths between (1) and (3) ft.¹</p> <p>In other words, Zone AO corresponds to the areas of the 1-percent-annual-chance flooding (usually sheet flow on undulating terrain) where average depths are between 1.0 and 3.0 feet. Average whole-foot depths derived from the hydraulic analysis are shown within this zone on the FIRM.</p> |
| Zone AH | <p>Areas of special flood hazards having shallow water depths and/or unpredictable flow paths between (1) and (3) feet, and with water surface elevations determined.¹</p> <p>In other words, Zone AH corresponds to the areas of 1-percent-annual-chance shallow flooding (usually ponding or sheet flow on uniformly sloping terrain) where average depths are between 1.0 and 3.0 feet. Base Flood Elevations (BFEs) derived from the hydraulic analysis are shown within this zone on the FIRM.</p> |
| Zone X (shaded) | <p>Area of moderate flood hazards.¹</p> <p>In the case of shallow flooding areas, Zone X (shaded refers to those areas of the 1-percent-annual-chance flooding where average depths are less than 1.0 foot.</p> |

¹as defined by 44CFR64.3

Graphics specifications for the depiction of shallow flooding hazards on FIRM panels are located in the [FIRM Panel Technical Reference](#).

4.0 Shallow Flooding Classifications and Descriptions

Shallow flooding can occur as the result of several meteorological and watershed conditions. However, two broad classifications of shallow flooding into which almost all individual cases can be assigned—ponding and sheet runoff—have been determined to be sufficient for the purposes of the NFIP.

4.1 Ponding

Ponding is the result of runoff or flows collecting in a depression that may have no outlet, subterranean outlets, rim outlets or manmade outlets such as culverts or pumping stations. Impoundments behind manmade obstructions (e.g., levees, road fill, railroad grades, canal banks, or similar structures) are included in this type of shallow flooding as long as they are not backwater from a defined channel or do not exceed 3.0 feet in depth.

4.2 Sheet Runoff

Sheet runoff is the broad, relatively unconfined downslope movement of water across sloping terrain that results from many sources, including intense rainfall and/or snowmelt, overflow from a channel that crosses a drainage divide, overflow from a perched channel onto deltas or plains

of lower elevation, and overland flow in urban areas. Generally, sheet runoff enters a channel or drainage system that intersects its flow, but occasionally it dissipates before reaching a channel. Sheet runoff is typical in areas of low topographic relief and poorly established drainage systems and should not exceed depths of 3.0 feet.

5.0 Study Procedures

The general guidelines cited herein are applicable to all areas of shallow flooding. They are indicative of the general approach taken to the study of shallow flooding problems in order to fulfill the requirements of the NFIP.

The Mapping Partner performing the study shall average small-scale topographic variations across inundated areas in determining depths to keep the effort and results commensurate with the obtainable accuracy of shallow flooding study methods. The Mapping Partner should ignore small-scale topographic relief that might lead to “islands” of one flood hazard zone within larger areas of another. The Letter of Map Amendment process can be used to evaluate and remove warranted structures and properties that are not within the accuracy limits to show on the FIRM.

The Mapping Partner should extend the flood hazard zone designations across the entire width of the inundated area without separate designation of Zone X (shaded) areas at the edges of Zones AO or AH. Thus, the Mapping Partner should use Zone X (shaded) areas only when the average depth across the entire inundated area is less than 1.0 foot. Similarly, the depth associated with a Zone AO should be reported as the average depth across the entire width of the inundated area to avoid the presence of concentric depth rings or parallel depth bands. The Mapping Partner should not use a Zone AO at the edge of a Zone AE based solely on where the average depth is less than or equal to 3.0 feet.

Shallow flooding is often characterized by highly unpredictable flow direction because of low relief or shifting channels and debris loads. Where such conditions exist, the Mapping Partner should delineate the entire area susceptible to the unpredictable flow as an area of equal risk.

Shallow flooding areas can be designated as either Zone AH or Zone AO depending on the relative accuracy with which flood elevations or depths can be determined. Mapping Partners should delineate ponding areas with a constant 1-percent-annual-chance flood elevation as Zone AH with a BFE on the FIRM. Mapping Partners should delineate areas of sheet runoff as Zone AO with average flooding depths above the ground surface indicated on the FIRM and/or Zone AH with BFE. Where the slope of the terrain and the water surface are uniform for large areas, Zone AH with a BFE is preferred.

5.1 Base Level Methods

Recent advances in hydraulic and hydrologic modeling software have made it practical for all flood hazard zones associated with shallow flooding hazards to be computer model-based. As a result, shallow flooding hazards are generally identified using the same computer software platforms whether or not there is a need to determine BFEs and/or depths. The reasonability of reporting BFEs and/or depths is largely dependent on the quality of terrain available and the computational parameters selected.

For areas of expected shallow flood hazard that have no significant development pressure for the near future, base level methods are often sufficient. Normally, only the Zone A designation is used in these areas, with two possible exceptions. When the 1-percent-annual-chance shallow flood hazard is determined to be below 1.0 foot, the shallow flooding areas may be designated as Zone X (shaded). When the Mapping Partner is conducting a new flood study and an effective SFHA has not been established, the Zone X (shaded) designation may also be used when the contributing drainage area causing the shallow flooding is less than 1.0 square mile and there is no history of destructive flooding or no significant potential to damage future development. Existing SFHAs may only be removed using shallow flooding determinations which show that the average depth of shallow flooding is less than 1.0 foot in average depth. These areas would be designated as Zone X (shaded) on the FIRM.

5.2 Detailed Study Methods: Ponding

Areas of ponding can be identified through historic data on past flooding, coordination with local stakeholders, examination of topographic data, and field reconnaissance. Ponding shallow flood hazards can be identified by determining the inflow to and outflow from the ponding area and calculating the storage volume and elevations using reservoir routing analysis. Determination of stage-storage relationships requires some topographic information. High-quality terrain datasets are generally adequate for this purpose. In the absence of terrain data with sufficient resolution to reliably determine storage volume, limited survey cross-sections may be needed. A variety of hydrologic and hydraulic modeling software platforms are available for computing ponding elevations. For more information on modeling considerations, please refer to the [General Hydraulic Considerations Guidance](#) document, the [Hydraulics: One-Dimensional Modeling Analyses Guidance](#) document and the [Hydraulics: Two-Dimensional Modeling Analyses Guidance](#) document.

Based on the findings from the study, the Mapping Partner should establish one BFE for each ponding area.

5.3 Detailed Study Methods: Sheet Runoff

Areas of sheet runoff can be identified from historic data and coordination with local stakeholders, supplemented by field reconnaissance and examination of topographic data and aerial imagery. Recent advances in modeling software and the availability of high resolution terrain data have increased the practicality, efficiency and reliability of BFE and/or depth determination for sheet runoff studies.

Sheet runoff typically takes place across broad areas of low relief. This makes it likely that sheet runoff depths will be less than 1.0 foot. In certain situations, however, sheet runoff depths may average more than 1.0 foot. Such may be the case, for instance, when the channel capacity of a perched stream is exceeded, as on a delta formation. Losses through ground infiltration normally are not considered. Multiple 2D hydraulic modeling software platforms have added a reliable computational approach to sheet flow analysis. For more information on 2D modeling considerations, please refer to the [Hydraulics: Two-Dimensional Modeling Analyses Guidance](#) document.

Methods of determining what areas to include in a particular shallow flood area can vary significantly based on the available data, type of study, and analysis used. Typically, average flood depths from representative cross sections take from available topographic data are used in selecting a reach. Generally, the average flow depth at a cross section in a shallow flooding (Zone AO) area is obtained by dividing the flow area with the water-surface top width. A weighted average of all the average flow depths at all cross sections within a selected reach length would be used to define the extent of the shallow flooding zones. For NFIP mapping purposes, areas of shallow flooding with average depths of 1.0 foot or less are designated as Zone X. Areas of shallow flooding with average depths between 1.0 and 1.5 feet are designated as Zone AO (DEPTH 1'); between 1.5 and 2.5 feet, Zone AO (DEPTH 2'); between 2.5 and 3.0 feet, Zone AO (DEPTH 3'). Only after the average depth for a selected reach is determined would that value, for NFIP mapping purposes, be rounded to the nearest whole foot.

Another method to determine the average depth is using a volumetric average depth, and may be appropriate given certain 1D or 2D flooding situations. For instance, for 2D studies, the average depth for all cells in the shallow flooding zone should be calculated. In the event that the 2D model uses an irregular mesh, a weighted average depth should be calculated.

In urban areas, sheet runoff is affected by buildings, sewer and drainage systems, and street design. In many cases, storm sewer and street systems are intended to carry the total discharges of only relatively frequent floods. Less frequent floods, including the 1-percent-annual-chance flood, will often result in shallow flooding as the capacity of designed drainage networks is exceeded. The Mapping Partner should coordinate with local stakeholders to gather historic data to identify such areas and select an appropriate method to analyze the shallow flooding hazard.

BFEs and/or depth alone may not indicate the severity of the possible local hazard. Therefore, given certain flooding circumstances, the Mapping Partner may include any available information (e.g. reports of local residents, historical data, and especially photographs of past floods) in the FIS report to document velocity, depth, debris, and shifting channel hazards that may exist. Graphics specifications for the labeling of shallow flooding hazard features on FIRM panels are located in the [FIRM Panel Technical Reference](#).

5.4 Deliverable Products

All NFIP products, models and supporting documentation associated with shallow flood hazard studies shall be delivered in accordance with [Data Capture Technical Reference](#).