Map MODERNIZATION

Federal Emergency Management Agency

FEMA's Flood Hazard Mapping Program

Guidelines and Specifications *for* Flood Hazard Mapping Partners

Appendix E: Guidance for Shallow Flooding Analyses and Mapping

FEDERAL EMERGENCY MANAGEMENT AGENCY

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All policy and standards in this document have been superseded by the FEMA Policy for Flood Risk Analysis and Mapping. However, the document contains useful guidance to support implementation of the new standards.

Table of Revisions for Appendix E, Guidance for Shallow Flooding Analyses and Mapping

The following Summary of Changes details revisions of Appendix E subsequent to the initial publication of the *Guidelines* in February 2002. These changes represent new or updated guidance for Flood Hazard Mapping Partners.

Date	Affected Section (s)	Summary of Change
April 2003		No guidance was revised.

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Appendix E

Guidance for Shallow Flooding Analyses and Mapping

This Appendix contains an explanation of shallow flooding, guidance on the scope of shallow flooding analyses, a list of the Flood Insurance Risk Zones that may be affected by shallow flooding hazards, a description of shallow flooding classifications, and guidance on the conduct of shallow flooding hazard analyses.

E.1 What is Shallow Flooding? [February 2002]

For purposes of the National Flood Insurance Program (NFIP), shallow flooding is defined as that with a 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 that remain unconfined, such as on delta formations;
- Overland flow in urban areas; and
- Flows collecting in depressions to form ponding areas.

The procedures described in this Appendix are applicable to flows for which the effects of sediment on the flow regime can be ignored. Procedures for analyzing alluvial fan flooding, which considers sediment transport, are provided in Appendix G.

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E.2 Study Scope **[February 2002]**

Given the current state of the art for determining shallow flooding hazards and the prohibitive cost of making these determinations, Mapping Partners shall follow certain parameters to limit the amount of area studied in detail for shallow flooding hazard determinations. Drainage area size is to be considered in determining whether shallow flooding hazards are analyzed using detailed or approximate methods. Mapping Partners generally shall not study flooding conditions resulting from drainage areas of less than 1.0 square mile using detailed study methods. Using approximate-study methods to identify flood hazards and delineate floodplain boundaries (described in more detail later in this Appendix) generally is sufficient. Flooding from sources with drainage areas less than 1.0 square mile is considered to be a local drainage problem.

Depths of flooding determined from the detailed study of shallow flooding hazards need be computed only to the nearest whole foot.

Detailed study is to be limited to only those areas that have a history of destructive flooding or that have a significant potential for damage to future development, and where expected 1-percent-annual-chance flood depths are 1.0 foot or greater.

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E.3 Applicable Flood Insurance Risk Zones [February 2002]

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

Zone A — Zone A is the flood insurance risk zone that corresponds to the 1-percent-annual-chance floodplains that are determined by approximate-study methods. Because detailed hydraulic analyses are not performed for such areas, no 1-percent-annual-chance flood elevations or depths are shown within this zone on the FIRM.

Zone AO — Zone AO is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1.0 and 3.0 feet. Average whole-foot depths derived from the detailed hydraulic analyses are shown within this zone on the FIRM.

Zone AH — Zone AH is the flood insurance risk zone that corresponds to the areas of 1-percent-annual-chance shallow flooding (usually areas of ponding) where average depths are between 1.0 and 3.0 feet. Whole-foot Base Flood Elevations (BFEs) derived from the detailed hydraulic analyses are shown within this zone on the FIRM.

Zone X — Zone X is the flood insurance risk zone that corresponds to areas outside the 0.2-percent-annual chance floodplain, and includes the following areas within the 0.2-percent-annual-chance floodplain:

- Those areas of 1-percent-annual-chance flooding where average depths are less than 1.0 foot
- Those areas of 1-percent-annual-chance flooding where the contributing drainage area is less than 1.0 square mile, and areas protected from the 1-percent-annual-chance flood of the main flooding source by levees.

No 1-percent-annual-chance flood elevations or depths are shown within this zone on the FIRM.

Areas designated as Zones A, AO, and AH shall be shaded as 1-percent-annual-chance floodplains. Mapping Partners shall shade as 0.2-percent-annual-chance floodplains those areas designated Zone X that: are within the 0.2-percent-annual-chance floodplain; represent areas of 1-percent-annual-chance flood hazards with average depths of less than 1.0 foot or where the contributing drainage area is less than 1.0 square mile; or represent areas protected from the 1-percent-annual-chance flood of the main flooding source by levees. Areas designated Zone X that are outside the 0.2-percent-annual-chance floodplain shall not be shaded. Specifications for the screens to be used are listed in Appendix K.

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E.4 Shallow Flooding Classifications and Descriptions

[February 2002]

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 purposes of the NFIP.

E.4.1 Ponding **[February 2002]**

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 fills, 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.

E.4.2 Sheet Runoff **[February 2002]**

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, and overflow from a perched channel onto deltas or plains of lower elevation. 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.

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E.5 Study Procedures **[February 2002]**

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 shall extend the flood insurance risk zone designations across the entire inundated area without separate designation of Zone X areas at the edges of Zones AO or AH. Thus, the Mapping Partner shall use Zone X areas only when the average depth across the entire inundated area is less than 1.0 foot. The Mapping Partner shall not use a Zone AO at the edge of a Zone AE where the 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 shall delineate the entire area susceptible to this unpredictable flow as an area of equal risk.

The Mapping Partner shall ignore small-scale topographic relief that is not evident on existing topographic mapping and that might lead to "islands" of one flood insurance risk zone within larger areas of another. When this situation occurs, FEMA will issue Letters of Map Amendment to individual property owners as necessary.

Shallow flooding areas are to 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 shall delineate ponding areas with a constant 1-percent-annual-chance flood elevation as Zone AH with a whole-foot BFE on the work map. Mapping Partners shall delineate areas of sheet runoff as Zone AO with average flooding depths above the ground surface, rounded to the nearest whole foot, indicated on the work map. However, where the slope of the water surface is extremely low and uniform BFEs can be established for large land areas, Zone AH with a BFE is preferred.

The Mapping Partner shall not calculate the 10-, 2-, or 0.2-percent-annual-chance flood elevations, delineate 0.2-percent-annual-chance floodplain boundaries or regulatory floodways, or develop Flood Profiles in shallow flooding areas. If these items can be readily determined, the Mapping Partner shall not use shallow flooding procedures.

The Mapping Partner shall assess historical information, local citizen reports, existing physical features, and previous reports discovered during the bibliography search for information on possible flooding conditions. Where any information shows possible local flooding depths, or other hazards more severe than those determined by the study procedures in these Guidelines, that information and reference must be included in the FIS Report to fully alert community officials, citizens, and other users to the potential hazard.

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E.5.1 Approximate Study Methods [February 2002]

For areas of expected shallow flood hazard that have no significant development pressure for the near future, the Mapping Partner performing a study shall use approximate study methods.

Normally, only the designation Zone A is to be used in these areas, with two possible exceptions. In many areas of 1-percent-annual-chance shallow flooding, average flood depths can often be readily determined to be below 1.0 foot by simple and inexpensive methods. In this situation, with a very limited study, shallow flooding areas may be designated as Zone X. The Mapping Partner shall also use Zone X whenever the contributing drainage area causing 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.

E.5.2 Detailed Study Methods: Ponding [February 2002]

Areas of ponding can be identified through historic data on past flooding, local inquiries, examination of topographic maps, and field reconnaissance. The Mapping Partner performing the study shall determine inflow to, and outflow from, the ponding area and calculate the storage volume and elevations using a simple reservoir routing analysis. Hydrographs, empirical formulas, and design equations for culverts and other manmade structures are to be considered. Determination of stage-storage relationships requires some topographic information. Wherever adequate contour interval mapping is available, the Mapping Partner shall determine storage volumes directly from those maps. Otherwise, the Mapping Partner shall survey a limited number of cross sections to determine storage volumes. The number of cross sections needed will depend on the size of the ponding area, but usually one along the major axis and two perpendicular to that axis will be sufficient.

Where volumes of inflow to ponding areas are sufficient to fill the available storage volume behind low dikes or other large, uniform obstructions, their crest elevation will determine the elevation of flooding in the ponding area. Such areas can usually be delineated based on field reconnaissance, in conjunction with an examination of topographic maps, without detailed calculations or field surveys.

Based on the findings from the detailed study, the Mapping Partner shall establish one BFE for each ponding area; this BFE will appear under the Zone AH designation on the FIRM.

E.5.3 Detailed Study Methods: Sheet Runoff [February 2002]

Areas of sheet runoff can be identified from historic data and local inquiries, supplemented by field reconnaissance and examination of topographic maps and aerial photographs. However, the lack of adequate data (e.g., small-interval contour mapping) and costly analytical methods pose problems for detailed study of these areas.

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. For flood insurance purposes, once a determination has been made that flooding depths are less than 1.0 foot, the area is to be designated as Zone X and more detailed analysis is not required. In certain situations, however, sheet runoff depths may

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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. The Mapping Partner shall identify those areas where depths averaging more than 1.0 foot could occur and then undertake a more detailed analysis of these areas. In the unlikely occurrence of sheet runoff with an average depth of more than 3.0 feet, the Mapping Partner shall contact the Regional Project Officer for guidance. The Mapping Partner shall select the specific methods to be used in the detailed analysis; however, normal depth calculations are usually used, with effective-flow areas established using available topographic information, historical information, and engineering judgment. Losses through ground infiltration normally are not to be considered.

The Mapping Partner shall determine the 1-percent-annual-chance flood discharge at the head of a sheet flow area by an appropriate method. In the absence of a permanent manmade channel or large-scale topographic features to restrict its flow, the Mapping Partner shall route this discharge uniformly across the entire area susceptible to sheet flow. The Mapping Partner shall obtain cross section and slope information to determine average flood depths across the area. Whenever small-interval contour mapping exists, the Mapping Partner shall develop cross sections directly from those maps; otherwise, the Mapping Partner shall take a limited number of cross sections across the area to determine average flood depths. Cross sections are to be maintained perpendicular to flow over the surface.

Methods of determining what areas to include in a particular shallow flooding area can vary significantly based on the available data, type of study, and analysis used. Typically, average flood depths from representative cross sections taken from available topographic information 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 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.

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. Such problems, if amenable to detailed study at all, are exceedingly costly to analyze. Because such areas are already developed, improved drainage systems may be the only short-term solution to the problem. Analysis of local drainage problems is considered beyond the scope of these Guidelines. Therefore, the Mapping Partner shall rely on historic data and the reports of local engineers and residents to identify such areas, and use field reconnaissance and engineering judgment to delineate them.

The procedures outlined in this Appendix are adequate to determine areas susceptible to sheet flow flooding, but they may not indicate the severity of the possible local hazard. The Mapping Partner

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shall include any available information - 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.

E.5.4 Deliverable Products **[February 2002]**

The Mapping Partner performing a study shall submit the following information to the Mapping Partner preparing the FIS Report and FIRM:

- A description of the cause of shallow flooding and the method used to determine its extent;
- A determination of the discharge at the head of the sheet flow area or the discharge hydrograph or the runoff volume at the ponded area;
- A topographic map with a suitable scale showing the location of the cross sections or the ponded area;
- A stage-storage relationship of the ponded area or the normal depth computations at the cross sections, the average depth at each cross section, and weighted depth for selected reaches for sheet flow areas;
- A map with a suitable scale showing the Zone AH with BFE and/or Zone AO with computed weighted average depths; and
- Any other available information, including reports of local residents, historical data, and photographs of past floods.

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