Map MODERNIZATION

Federal Emergency Management Agency

FEMA's Flood Hazard Mapping Program

Guidelines and Specifications for Flood Hazard Mapping Partners

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Appendix H: Guidance for Evaluating Flood Protection Systems

FEDERAL EMERGENCY MANAGEMENT AGENCY

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Appendix H

Guidance for Mapping of Areas Protected by Levee Systems

H.1 Introduction

This Appendix describes the Federal Emergency Management Agency (FEMA) requirements and procedures for evaluating earthen levee systems and mapping the areas affected by those systems. Procedures for evaluating concrete dikes, floodwalls, seawalls, and other structures are not covered herein and shall be coordinated with and approved by the FEMA Regional Project Officer (RPO) or the Project Officer (PO) at FEMA Headquarters (HQ). Mapping Partners also must contact the RPO or PO to obtain the appropriate criteria for analyzing agricultural levees.

Specific guidance for the evaluation of coastal structures and the mapping of areas affected by these structures is contained in Appendix D of these Guidelines.

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H.2 Levee System Components and Terminology

A levee system usually consists of a main levee, tie back levees, a gravity outlet, and pumps. Some levee systems may also include pressure conduits, closure structures, ring levees, setback levees, sublevees, and spur levees. The most common components are defined below.

- *Levees*: Manmade structure, usually earthen embankments, designed and constructed in accordance with sound engineering practices to contain, control, or divert the flow of water so as to provide protection from temporary flooding.

- *Levee system*: A flood protection system which consists of a levee, or levees, and associated structures, such as closure and drainage devices, which are constructed and operated in accordance with sound engineering practices.

- *Main and tributary levees*: Levees that lie along a main stream and its tributaries, respectively.

- *Tie back levees*: Levees that extend from the main levee along a river, lake, or coast to a bluff line (high ground) and are part of the line-of-protection.

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- *Ring levees*: Levees that completely encircle or "ring" an area subject to inundation from all directions.

- *Setback levees*: Levees that are built landward of existing levees, usually because the existing levees have suffered distress or are in some way being endangered, as by river migration.

- *Sublevees*: Levees built for the purpose of under-seepage control. Sublevees encircle areas behind the main levee which are subject, during high-water stages, to high uplift pressures and possibly the development of sand boils. They normally tie into the main levee, thus providing a basin that can be flooded during high-water stages, thereby counterbalancing excess head beneath the top stratum within the basin. Sublevees are rarely employed as the use of relief wells or seepage berms make them unnecessary except in emergencies.

- *Berms*: Horizontal strips or shelves of material built contiguous to the base of either side of levee embankments for the purpose of providing protection from underseepage and erosion, therefore increasing stability of the embankment, or reducing seepage. Berms can be located on either side of levees, depending upon the berms' purpose.

- *Spur levees*: Levees that project from the main levee and serve to protect the main levee from the erosive action of stream currents. Spur levees are not true levees but training dikes.

- *Dikes*. Embankments constructed of earth or other suitable materials to protect land from overflows or to regulate water.

- *Floodwalls*: Cconcrete walls constructed adjacent to streams for the purpose of preventing flooding of property on the landside of the wall; normally constructed in lieu of or to supplement levees where the land required for levee construction is more expensive or not available.

- *Lines-of-protection*: Locations of levees or walls that prevent floodwaters from entering an area.

- *Pressure conduits*: Closed conduits designed to convey interior flows through the line-of–protection under internal pressure. The inlet to a pressure conduit that discharges interior flows by force of gravity must be at a higher elevation than the river stage against which it functions. Some pressure conduits may serve as discharge conduits from pumping stations.

- *Pumping stations*: Pumps located at or near the line-of-protection to discharge interior flows over or through the levees or floodwalls (or through pressure lines) when free outflow through gravity outlets is prevented by high exterior stages.

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- *Gravity outlets*: Culverts, conduits, or other similar conveyance openings through the line-of-protection that permit discharge of interior floodwaters through the line-of-protection by gravity when the exterior stages are relatively low. Gravity outlets are equipped with gates to prevent river flows from entering the protected area during time of high exterior stages.

- *Closure devices*: Any movable and essentially watertight barriers, used in flood periods to close an opening in a levee, securing but not increasing the levees' design level of protection.

- *Stop logs*: Logs, planks, cut timber, steel, or concrete beams fitting into end guides between walls or piers to close openings in levees, floodwalls, dams, or other hydraulic structures; the logs usually being handled or placed one at a time.

- *Street gates*: Closure gates used during flood periods to close roadway openings through levees or floodwalls.

The diagrams in Figure H-1 provide plan view and sectional view schematics of a standard levee system.

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H.3 Levee System Evaluation Criteria

In evaluating the ability of levee systems to provide protection from the 1-percent-annual-chance flood, the criteria outlined in Section 65.10 of the NFIP regulations and the step-by-step procedures as summarized on the following pages should be used. The Mapping Partner should always initiate analyses by evaluating the levee's freeboard and maintenance plan and should only proceed with further analyses if these requirements are met.

1. Freeboard. A minimum levee freeboard of 3 feet shall be necessary, with an additional 1 foot of freeboard within 100 feet of either side of structures within the levee or wherever the flow is constricted, such as at bridges. An additional 0.5 foot above this minimum is also required at the upstream end, tapering to the minimum at the downstream end of the levee. The criteria concerning freeboard are detailed in Paragraph 65.10(b)(1) of the NFIP regulations.

2. Structural Design Analyses. The Mapping Partner shall review the structural analyses which address closures, embankment protection, embankment and foundation stability, and settlement. The structural analyses must meet the criteria detailed in Paragraphs 65.10(b)(2),(3),(4) and (5) of the NFIP regulations.

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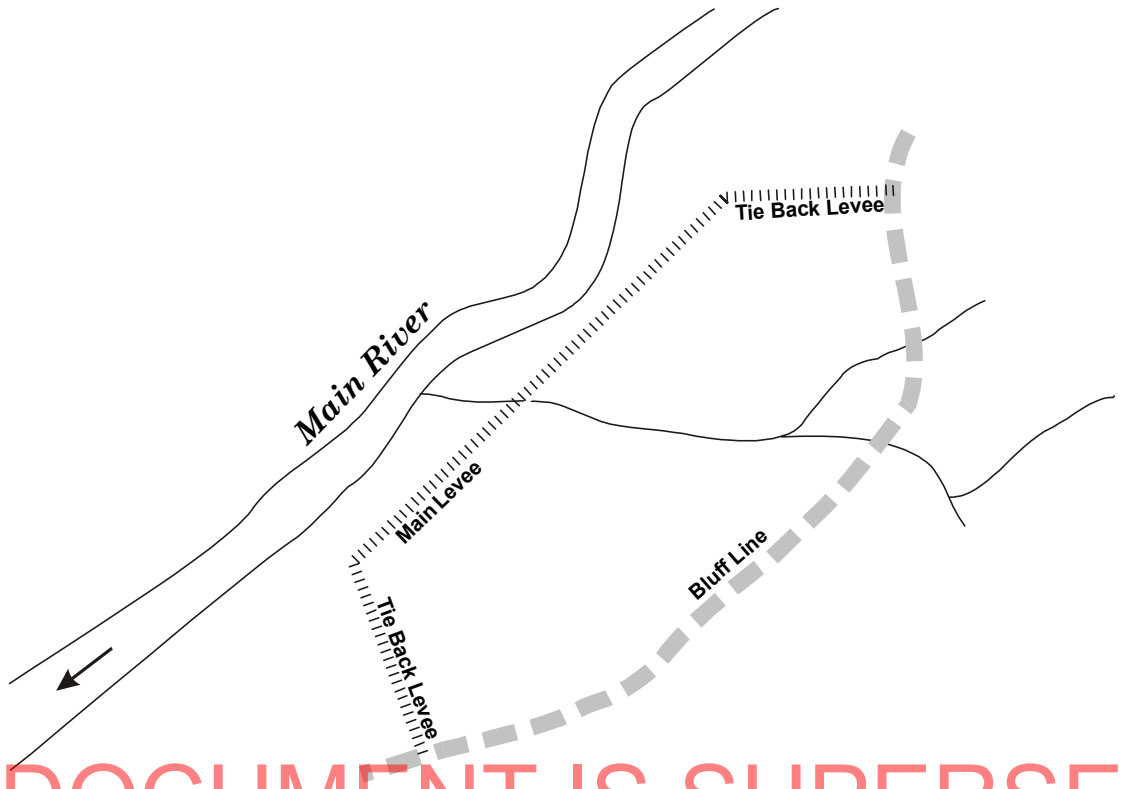
3. Interior Drainage. Where credit will be given to levees providing protection from the 1-percent-annual-chance flood, the adequacy of interior drainage systems shall be evaluated. Interior drainage systems associated with levee systems usually include storage areas, gravity outlets, pumping stations, or a combination thereof. These drainage systems will be recognized by FEMA as providing flood protection only if the criteria outlined in Paragraphs 65.10 (b)(6) and (c)(2) of the NFIP regulations are met.



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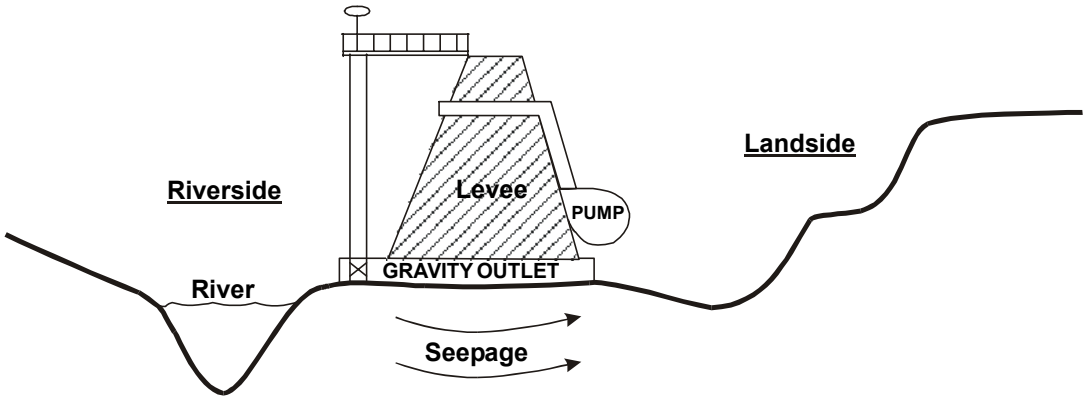
PLAN VIEW SCHEMATIC



SECTIONAL VIEW SCHEMATIC

Figure H-1. Plan View and Sectional View Schematics of Standard Levee System

4. Operations. In general, levee evaluation shall not consider human intervention (e.g., capping of levees by sandbagging, earthfill, or flashboards) for the purpose of increasing a levee's design level of protection during an imminent flood. Only in exceptional cases where no practicable alternative exists and technical justification is provided will FEMA permit sandbagging to satisfy freeboard requirements. The Mapping Partner shall coordinate all such cases with FEMA RPO. Human intervention will normally only be accepted for the operation of closure structures (e.g., gates or stoplogs) and manual back-up for pumping stations in a levee system designed to provide at least 1-percent-annual-chance flood protection, including adequate freeboard as described earlier. Where levee closures and/or pumping stations are involved, an officially adopted operations plan must be submitted that meets all the criteria set forth in Paragraphs 65.10(c)(1) and (2) of the NFIP regulations.

5. Maintenance. For a levee system to be recognized as providing protection from the 1-percent-annual-chance flood, the system must be maintained in accordance with an officially adopted maintenance plan, and a copy of this plan must be provided to FEMA by the owner of the levee system. The specific requirements of the maintenance plan are detailed in Paragraph 65.10(d) of the NFIP regulations. Note that a governmental agency must assume ultimate responsibility for maintenance plans.

6. Certification Requirements. All levee systems must be certified in accordance with Paragraph 65.10(e) of the NFIP regulations.

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7. Exception Procedures. FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide protection against the 1-percent-annual-chance flood in lieu of the requirements outlined in Paragraphs 65.10(b)(1) through (7) of the NFIP regulations. Under certain circumstances, FEMA may also grant exceptions to the above requirements or approve alternate analysis techniques.

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H.4 Criteria for Crediting Levee Systems on FIRMs

The Mapping Partner responsible for performing the hydrologic and hydraulic analyses shall follow the steps listed below in determining a levee system's ability to provide protection from the 1-percent-annual-chance flood. The final decision concerning the creditability of the levee system must be made by the RPO before the Mapping Partner proceeds with further hydraulic analyses.

1. The Mapping Partner shall identify the levee system to be studied, including all "levee elements" (e.g., main levee, tieback levee, railroad or highway embankment), interior drainage elements and any other elements required to form a stand-alone flood-control structure.

2. The Mapping Partner shall determine the ownership of each system element via telephone contact with community officials and/or appropriate State and Federal agencies.

3. The Mapping Partner shall determine the status of all system elements, as presently reflected on the effective FIRM (i.e., credited or uncredited, detailed or approximate study).

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4. The Mapping Partner shall obtain from the system element owner, operator (i.e., local, State, or Federal agency; or private individual or corporation), and/or the appropriate FEMA data repository, all available supporting documentation, including but not limited to "as-built" plans; survey data; geotechnical reports; structural analyses; interior drainage analyses; inspection reports; and operation and maintenance plans.

5. The Mapping Partner shall obtain written confirmation of any previous certification by the agency responsible for design and construction that the levee system or elements thereof are Federal projects that provide protection from the 1-percent-annual-chance flood, when appropriate.

6. The Mapping Partner shall make an individual inventory of data received for the levee system.

7. The Mapping Partner shall perform hydraulic analyses of the 10-, 2-, 1- and 0.2-percent-annual-chance floods, assuming the levee system to be in place if these water-surface profiles are not available. Otherwise, assess the available computations for present-day application and modify, if necessary.

8. The Mapping Partner shall use available "as-built" levee profiles or topographic data and the 1-percent-annual-chance water-surface profile obtained from the hydraulic analysis conducted with the levee in place to make a determination of the available freeboard of each system element.

9. The Mapping Partner shall contact the RPO immediately if any element of a levee system is found to provide less than the required freeboard and notify him or her of the level of freeboard deficiency identified. Based on this discussion and the availability of other design data, the RPO may request more detailed surveys of the levee profile or that a risk analysis be performed on uncertainties related to elements of levee design.

10. The Mapping Partner shall review the available operation and maintenance plans to determine whether the plans conform with the requirements of Section 65.10 (c) and (d) and document in writing to the RPO any noted deficiencies. The RPO will provide guidance on any supplemental investigations necessary to ascertain the adequacy of operation and maintenance plans.

11. The Mapping Partner shall summarize the results and conclusions of the above-mentioned levee investigation in a final letter report to the RPO and include as attachments and/or references all correspondence and reports of telephone conversations among the Mapping Partner, the RPO, local, State, and Federal entities, and levee owners; inventories of available data; and field inspection reports and photographs.

12. The Mapping Partner shall summarize the actions taken in the investigation, the ownership of each system element, and the outcome of the investigation in the draft of the FIS Report, under the section headed "Local Flood Protection Measures."

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H.5 Review Responsibilities

This section addresses the independent review responsibilities of the Mapping Partner responsible for preparing the Preliminary FIS report and FIRM (hereinafter referred to as reviewing Mapping Partner).

The reviewing Mapping Partner shall verify that all levees and structures intended to serve as levees for their effect on the 1-percent-annual-chance flood have been properly analyzed. The Mapping Partner shall conduct this review to ensure that all minimum design criteria requirements have been met before any levee system receives recognition on the NFIP map as providing protection from the 1-percent-annual-chance flood. . The Mapping Partner shall document any deviations or exceptions fully and ensure a technical basis for exceptions is provided. This independent review shall assess the conclusions reached by the Mapping Partner performing the hydrologic and hydraulic review and shall facilitate establishing appropriate flood risk zone determinations for the FIRM, and does not constitute a determination as to how a structure or system will perform during a flood event.

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H.5.1 Review Criteria

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The reviewing Mapping Partner shall conduct this review to ensure that the analysis was performed in accordance with the requirements detailed in Sections H.3 and H.4 of these Guidelines and in conformance with Section 65.10 of the NFIP regulations.

FEMA will not consider privately owned, operated, or maintained levee systems as providing protection from the 1-percent-annual-chance flood unless local ordinances or State statutes mandate operation and maintenance. Levee systems for which a community, State, or Federal agency has responsibility for operation and maintenance will be considered by FEMA if they meet, and continue to meet, minimum design, operation, and maintenance standards. These standards must be consistent with the level of protection sought through the comprehensive floodplain management criteria established in Section 60.3 of the NFIP regulations.

The minimum design requirements for both riverine and coastal levees that must be met, and therefore must be reviewed by the reviewing Mapping Partner, fall into the following categories: freeboard, closures, embankment protection, embankment and foundation stability, settlement, interior drainage, and other design criteria (as required by FEMA). The reviewing Mapping Partner shall review the detailed engineering analyses to be performed under each category to ensure that they comply with Paragraph 65.10(b) of the NFIP regulations. The level of effort to be expended by the reviewing Mapping Partner in reviewing levee structural design criteria shall be decided by the PO at FEMA HQ or his/her designee on a community-by-community basis.

For a levee to be recognized on the FIRM as providing protection from the 1-percent-annual-chance flood, the operation plans must comply with FEMA regulations as outlined in Paragraph

65.10(c) of the NFIP regulations. When required, the reviewing Mapping Partner shall review the plans to ensure compliance with FEMA regulations, particularly in the areas of closures and interior drainage systems.

The final criterion for levee certification is a functional maintenance plan that complies with Paragraph 65.10(d) of the NFIP regulations. The reviewing Mapping Partner shall review the plans to ensure that, at a minimum, they specify the maintenance activities to be performed, the frequency of performance, and the person(s) by name or title responsible for the performance.

It should be noted, however, that FEMA will accept certification from another Federal agency that an existing levee system is designed and constructed to provide base flood protection in lieu of the requirements outlined in Paragraphs 65.10(b)(1) through (b)(7) of the NFIP regulations. In addition, under certain circumstances, FEMA may also grant exceptions to the above requirements or approve alternative analysis techniques on a case-by-case basis.

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H.5.2 Levee Inventory

In addition, to the review responsibilities detailed above, the reviewing Mapping Partner shall ensure that all levees that have been identified and evaluated are documented and inventoried in accordance with the guidance provided in Volume 3, Subsection 3.2.7.3, of these Guidelines, which includes the requirements to prepare a Levee Inventory Data Entry Form to support the Credited Structures Inventory System.

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H.6 Floodplain Mapping and Flood Profiles

If the levee satisfies the appropriate aforementioned requirements, as verified by the RPO, the protected area (landward side of the levee) will be designated as Zone X or the appropriate zone determined by the interior drainage analysis such as Zone AH. If an interior drainage analysis does not exist or has been determined to be insufficient in the levee investigation, the Mapping Partner shall coordinate internal zone designations with the RPO.

If the subject levee does not meet the requirements stated in Section 65.10 of the NFIP regulations, as verified by the RPO, the 1-percent-annual-chance flood elevations will be recomputed as if the levee did not exist. None of the subject levee will be recognized as providing 1-percent-annual-chance flood protection unless there are portions of the levee system that can meet requirements of Section 65.10 of the NFIP regulations independent of the remaining levee system. The 1-percent-annual-chance flood levels on the unprotected side of the levee will be equal to the 1-percent-annual-chance water-surface elevations computed with the levees in place.

If the 1-percent-annual-chance flood level, with the levee in place, is higher than the top of the levee, the computed 1-percent-annual-chance flood levels shall be used on the river side of the levee. The 1-percent-annual-chance flood levels shall then be recomputed for the landward side of the unrecognized levee as if the levee did not exist.

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If water-surface elevations of the 10-, 2-, and 0.2-percent-annual-chance floods are higher than the top-of-levee elevations, those elevations shall also be considered equal to the top-of-levee elevations on the unprotected side. If those elevations are lower than the top-of-levee elevations, they will be shown as computed on the Flood Profile. Further analyses for the conditions without the levees shall not be made for frequency floods less than the 1-percent-annual-chance flood.

For the levees that do not satisfy the minimum requirements, a maximum of five Flood Profiles might be drawn on the profile sheet representing the 10-, 2-, and 1-percent-annual-chance floods with levee elevations, and the 1- and 0.2-percent-annual-chance floods without levee elevations.

If the "with levee" base (1-percent-annual-chance) flood elevations (BFEs) are higher than the "without levee" BFEs, the FIRM should show a line running along the levee centerline, separating the areas of different BFEs. Otherwise, only "without levee" BFEs will be shown.

The regulatory floodway widths shall be computed for the "without levee" condition if the levees do not meet the requirements of Section 65.10 of the NFIP regulations. The equal conveyance reduction method is to be used. The "Regulatory" column in the Floodway Data Table will include two BFEs, representing "river side" and "land side" conditions, if the former elevation is higher than the latter elevation. Otherwise, "without levee" BFEs are to be shown. At a tributary's confluence with the main stream, BFEs from the main stream are to be shown as the

regulatory elevations if they are higher than the "river side" or "land side" BFEs of the tributary.

The above procedures for the determination of elevations and regulatory floodways also shall be applied to the conditions where levees exist on both sides of the stream. If levees exist on both sides of a stream, the evaluation of levee systems shall consider the possibility of simultaneous levee failure, failure of only the left side, and failure of only the right side. Simultaneous levee failure shall be considered for both elevation and regulatory floodway computations.

Regulatory floodway boundaries are to be delineated at the landside toe of mainline and tributary levees that are recognized as providing 1-percent-annual-chance flood protection on a FIRM. Thus, the community's floodplain management ordinance must prohibit encroachment on the levee, which could jeopardize the levee's integrity or effectiveness. It may also be appropriate to place regulatory floodways at levees providing a lower level of protection if encroachment on the river side of the levee is of concern to the community. The Mapping Partner that is performing the analysis shall consult with community officials and the RPO to resolve this situation.

For levee systems where an area of land may be totally or partially surrounded by levees or where two or more flooding sources join that have levees on both sides of the stream, the Mapping Partner that is performing the analysis shall contact the RPO before proceeding with any analyses for levee failures. For these complex situations, the flood hazard in the area that would have been protected by the non-failed levee(s) should be based on selection of failure scenarios that yield the highest BFE or flood hazard.

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H.7 Flood Control Restoration Zones

When the Mapping Partner evaluating a flood protection system determines that a community is in the process of restoring the flood protection system to provide protection from the 1-percent-annual-chance (100-year) flood, that Mapping Partner shall follow the procedures outlined in Section 65.14 of the NFIP regulations and obtain the information required by FEMA. If the criteria of Section 65.14 are met, the Mapping Partner shall coordinate with the RPO or the PO at FEMA HQ to determine whether the FIRM should designate the temporary flood hazard areas as a flood control restoration zone (Zone AR). The Mapping Partner also shall coordinate with the RPO or the PO at FEMA HQ to determine whether SFHAs shown on the effective FIRM shall be designated as "dual" flood insurance rate zones (i.e., Zone AR/AE, Zone AR/AH, Zone AR/AO, Zone AR/A).

When the Mapping Partner evaluating a flood protection system determines that a restoration project has been completed and all required certifications and evidence have been submitted, that Mapping Partner shall coordinate with the RPO or the PO at FEMA HQ to determine whether the flood control restoration zone designation should be revised to Zone A99. The criteria outlined in Paragraph 65.14(h) of the NFIP regulations shall be the basis for this determination.

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