D.4.7 Coastal Structures

D.4.7.1 Purpose and Overview

This section outlines methods for analyzing the stability and effects of coastal structures during 1% annual chance flood conditions.

Coastal structures can significantly affect local topography and flood hazards, and the evaluation of coastal structures is a necessary part of any flood hazard study. The evaluation should, where possible, determine whether a coastal structure will survive (and provide protection to upland areas from) the 1% annual chance flood.

- If a particular structure is expected to remain intact through the 1% annual chance flood, the structure geometry shall be used in all ensuing Flood Insurance Study (FIS) analyses that accompany the flood event (e.g., event-based erosion, wave runup and overtopping, and determination of wave crest elevations).

- If a particular structure is expected to fail during the 1% annual chance flood, the coastal structure shall either be removed entirely before ensuing analyses, or be replaced by an appropriate failed configuration before ensuing analyses.

- If the performance of a particular structure is uncertain, both intact and failed configurations should be analyzed, and the most hazardous flood conditions should be mapped.

For the purposes of these guidelines and specifications, coastal structures are classified as follows:

- **Coastal Armoring Structures:** Generally shore-parallel structures constructed to prevent erosion of uplands and mitigate coastal flood effects (e.g., seawalls, revetments, bulkheads, and levees). Note that coastal levees are classified as armoring structures here, but are often referred to as flood control structures.

- **Beach Stabilization Structures:** Structures intended to stabilize or reduce erosion of the beach, and by so doing, to afford some protection to upland areas (e.g., groins, breakwaters, sills, and reefs).

- **Miscellaneous Structures:** Structures not included above that can affect flood hazards, especially in sheltered waters (e.g., piers, port and navigation structures, bridges, culverts, and tide gates).

Criteria for evaluating the stability and performance of coastal armoring structures for FIS purposes are well-developed, and are discussed in detail. Criteria for evaluating beach stabilization structures are not yet developed, and only basic guidance is provided. Criteria for evaluating miscellaneous structures are not standardized, and only basic guidance is provided.

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.

D.4.7.2 Evaluation Criteria

Mapping Partners are not required to perform detailed engineering evaluations of all coastal structures within the study area, and in fact, rarely do so. However, when such an evaluation is performed, there are specific evaluation criteria that must be applied.

D.4.7.2.1 Detailed Engineering Evaluation of Coastal Armoring Structures

Specific criteria for evaluating coastal armoring structures are contained in an April 23, 1990 Federal Emergency Management Agency (FEMA) memorandum (FEMA, 1990), "Criteria for Evaluating Coastal Flood Protection Structures for National Flood Insurance Program Purposes."[1]

The evaluation criteria applicable to coastal armoring structures include the following:

- Design Criteria
  - Water levels and wave (height and period) conditions
  - Minimum freeboard
  - Toe protection
  - Backfill protection
  - Structure alignment and terminations

- Structural Stability
  - Flood-induced erosion and toe scour analyses
  - Geotechnical analysis
  - Structure sliding, rotation, and overturning
  - Stability of riprap, armor stone, and filters
  - Breaking wave forces
  - Material adequacy (suitability and durability)
  - Ice and impact forces

- Adverse Impact Evaluation

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[1] The criteria discussed in this memorandum are based in large part on Technical Report 89-15 prepared by the U.S. Army Corps of Engineers, Coastal Engineering Research Center (USACE CERC) for FEMA, Criteria for Evaluating Coastal Flood-Protection Structures (Walton et al., 1989). The criteria in the memorandum have been adopted as the basis for NFIP accreditation of new or proposed coastal structures to reduce the flood hazard areas and elevations designated on NFIP maps, but can be applied to existing coastal structures.

Where a Mapping Partner chooses to perform a detailed engineering evaluation of an existing coastal armoring structure during an FIS, FEMA requires the evaluation to be based upon the criteria outlined in the April 23, 1990 FEMA memorandum, and upon as-built documentation. When as-built documents are not available, the evaluation should be based upon best available data, standard design and engineering assumptions, and conservative estimates of material properties. The evaluation should be confirmed and documented by past performance during severe storm events. The underlying requirement is that the evaluation must yield an accurate assessment of coastal structure performance during the 1% annual chance flood, based upon available evidence.

It should be noted, however, that the state of the art of coastal structure evaluation is constantly evolving. Thus, the Mapping Partner may choose to propose evaluation criteria that differ from those contained in the April 23, 1990 FEMA memorandum (e.g., from the Coastal Engineering Manual [CEM] [USACE, 2003], or from other authoritative and accepted references). However, alternate evaluation procedures and criteria should not be used in an FIS without permission from the FEMA study representative.

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- Community and/or State Review
- Maintenance Plan
- Certification

D.4.7.2.2 Coastal Armoring Structure Evaluation Based on Limited Data and Engineering Judgment

For the purposes of an FIS, the Mapping Partner may not have sufficient resources and time to conduct a detailed evaluation of each coastal armoring structure within the study area. In such cases, the Mapping Partner can apply engineering judgment (albeit, guided by the FEMA memorandum and *Technical Report 89-15* criteria) to determine likely stability of each structure during the 1% annual chance flood. These conclusions may largely be based upon available archive information and local observations. Note that any data and procedures used in the evaluations shall be documented (see Subsections D.4.7.6 and D.4.7.7), and communities and property owners shall be made aware that these evaluations are for mapping purposes only.

If the available information does not clearly point to survival or failure of a coastal structure, the Mapping Partner may either:

a) Conduct a detailed evaluation based on the FEMA criteria (April 23, 1990), or

b) Perform the erosion and wave analyses for both the intact and failed structure cases, and map the flood hazards associated with the more hazardous case.

If option b) is selected, the Mapping Partner shall clearly document the results of all cases investigated and specify which case is used for mapping purposes. It should be noted that a failed coastal structure may or may not yield the greatest flood hazards. Therefore, coastal flood analyses for the intact and failed conditions should be performed, with the greatest resulting flood hazard being mapped. Maintaining results of all analyses may be useful in the event map revisions are requested by property owners based upon certified structures[2].

D.4.7.2.3 Evaluation of Beach Stabilization Structures

Guidance on how to predict the survival or failure of groins, which usually fail by loss of profile (through settlement, displacement, or deterioration) and/or by becoming detached at their landward ends, is not readily available. Likewise, guidance on how to predict the failure of breakwaters, sills, and reefs (usually through loss of profile) is not readily available. Some information on failure modes may be available in technical or historical literature, and should be consulted by the Mapping Partner.

[2] Often, property owners request revisions to the Flood Insurance Rate Map (FIRM) based upon existing, new, or proposed coastal structures. Map revisions based upon coastal structures require a detailed evaluation and certification by a professional engineer registered in the subject state. FEMA has distributed the *Coastal Structure Form* (MT-2, Form 5, available at <http://www.fema.gov/pdf/fhm/mt2_f5.pdf>) to evaluate coastal structures as the basis for map revisions.

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If a Mapping Partner chooses to evaluate beach stabilization structures during an FIS, the proposed evaluation methods and procedures should be discussed with the FEMA study representative, in advance, and approval by FEMA must be obtained before the evaluations can be carried out.

D.4.7.3 FIS Treatment of Coastal Armoring Structures

Technical Report 89-15 identifies four primary functional types of coastal flood protection structures: gravity seawalls, pile-supported seawalls, anchored bulkheads, and dikes or levees. A fifth type, revetment, is added here (see Figure D.4.7-1).

Technical Report 89-15 recommends as a general policy that "FEMA not consider anchored bulkheads [as providing flood protection] during large storms". Thus, the default assessment for open coast anchored bulkheads should be that they are assumed to fail during the 1% annual chance flood. Mapping Partners may choose to treat some anchored bulkheads as surviving the flood and/or providing some degree of flood protection, but those instances may be limited (e.g., in sheltered waters, when the bulkhead is stable during the 1% annual chance flood conditions).

Many seawalls, revetments, and (some) bulkheads may be recognized on flood hazard maps if they remain intact during the 1% annual chance storm (in some cases, even if overtopped). These structures may provide total or limited protection against flooding, erosion, and waves, depending upon their location, strength, and dimensions.

D.4.7.3.1 Failure and Removal of Coastal Armoring Structures

In the event that a coastal structure is determined to fail, the Mapping Partner shall remove the structure entirely from the analysis transect, or estimate the partial collapse of the structures where appropriate (see Subsection D.4.7.3.2). If the failed structure is removed entirely, the remaining soil profile should be altered to achieve its likely slope immediately after structure failure. Information on slopes behind failed structures is limited. These slopes may vary from 1 on 100 (v:h) for unconsolidated sands to 1:1 or steeper for consolidated material landward of the failed structure.

This post-failure slope for this analysis should be in the range of 1:1 to 1:1.5 (v:h). Note that the post-failure slope may not necessarily match the long-term stable slope, but will serve as the basis for subsequent site-specific, event-based erosion wave height, wave runup, and wave overtopping analyses.

D.4.7.3.2 Partial Failure of Coastal Armoring Structures

Frequently, coastal structures are constructed of either concrete or large individual armor units. Consequently, it is improbable that the structural components will be completely destroyed or removed from the vicinity during the 1% annual chance flood. It may be appropriate to assume partial failure of such structures and to model accordingly.

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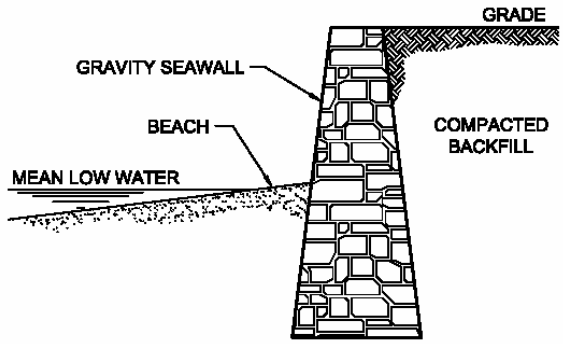
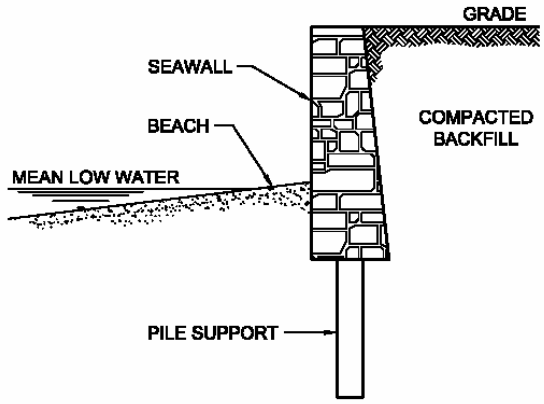
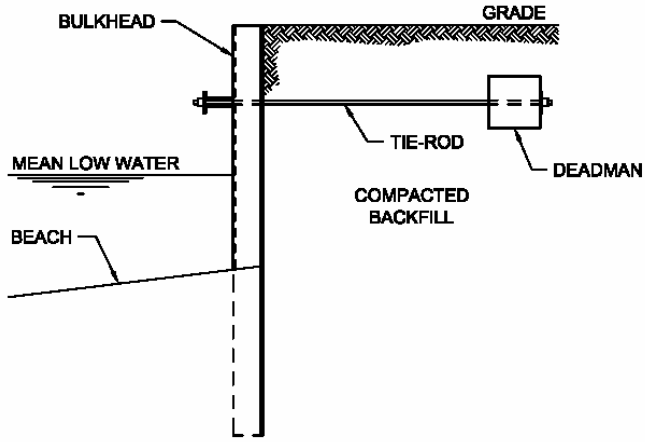


GRAVITY SEAWALL



PILE SUPPORTED SEAWALL



ANCHORED BULKHEAD

PRIMARY FUNCTIONAL TYPE OF COASTAL ARMORING STRUCTURES

Figure D.4.7-1a. General Classification of Coastal Armoring Structures

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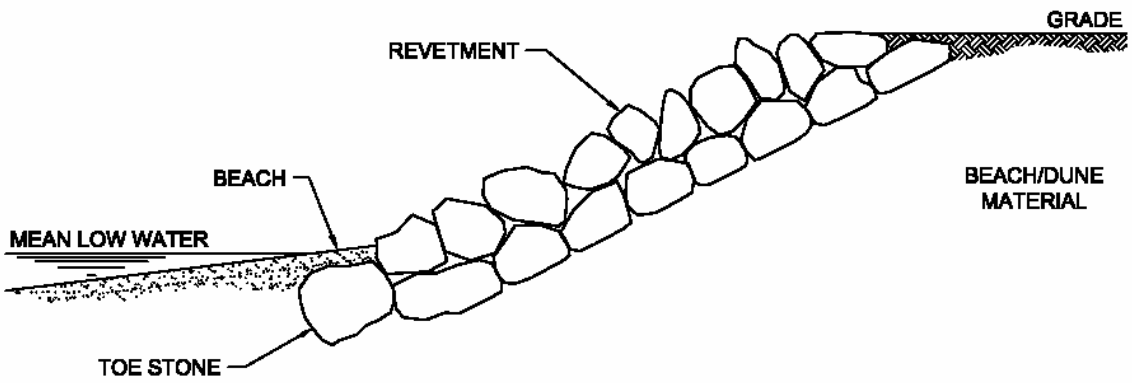
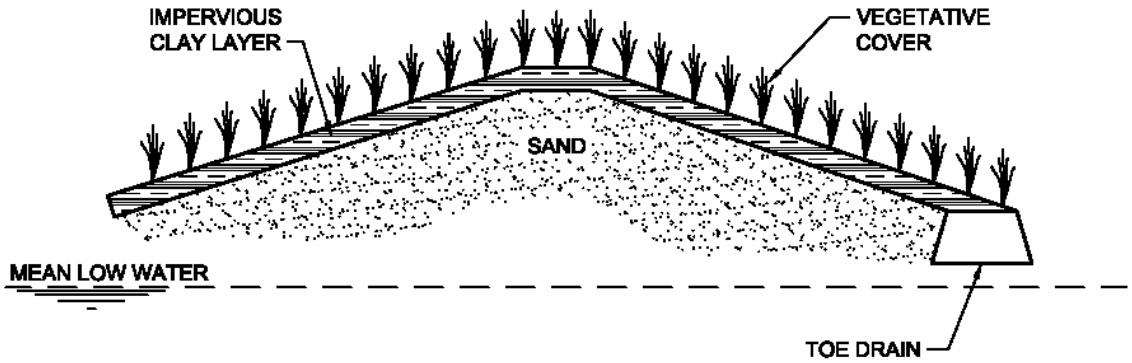


REVETMENT



DIKES OR LEVEES

PRIMARY FUNCTIONAL TYPE OF COASTAL ARMORING STRUCTURES

Figure D.4.7-1b. General Classification of Coastal Armoring Structures

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A recommended simple geometric approach for approximating partial failure of a vertical or near-vertical coastal armoring structure is as follows (see Figure D.4.7-2):

1. Estimate toe scour at the subject structure based upon the methods described in the CEM (USACE, 2003).

2. Assume the structure fails and falls into a rough, porous slope at 1:1.5 (v:h).

3. Extend the 1:1.5 failure slope from the depth of scour at the structure toe landward to the point where it intersects the existing grade.

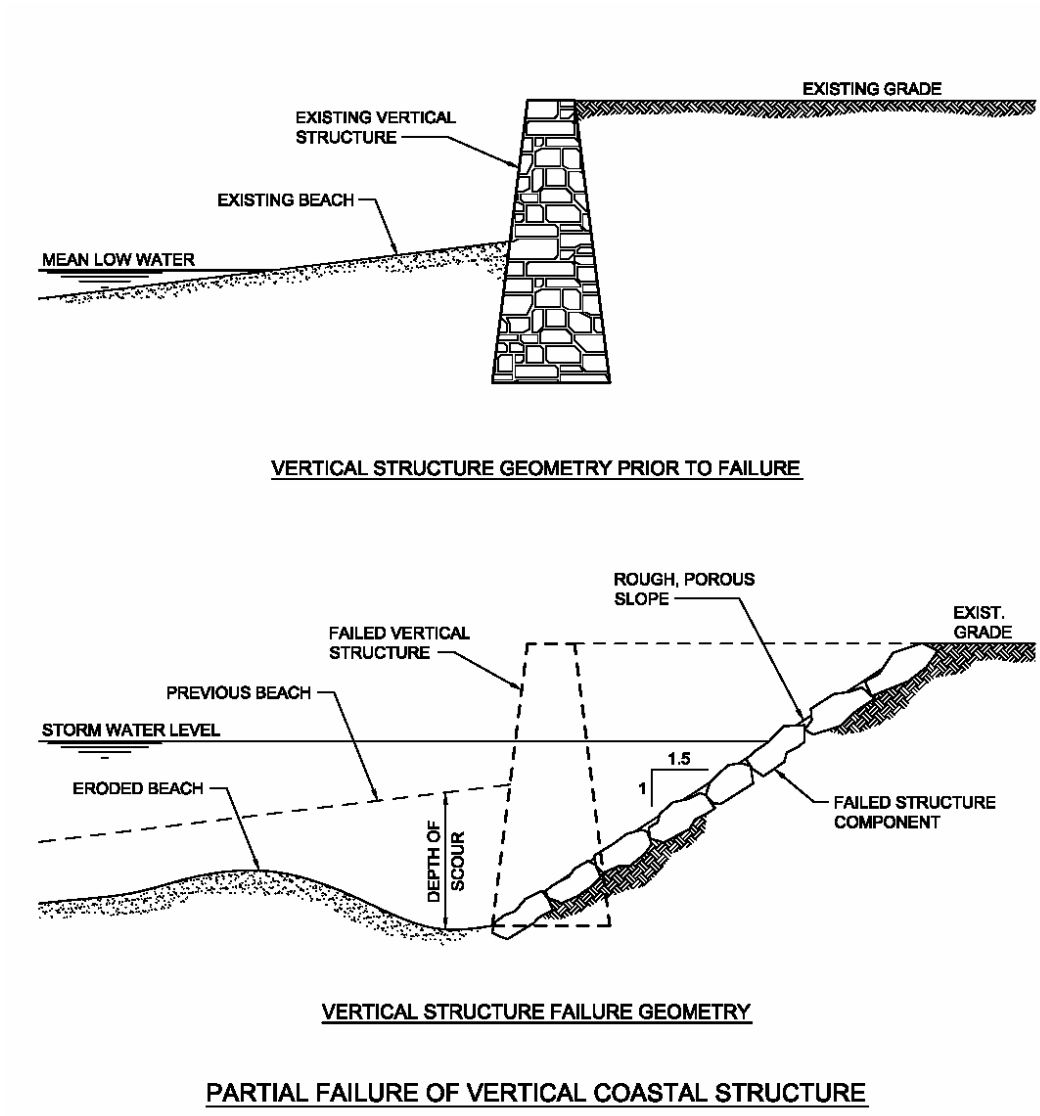

Figure D.4.7-2. Partial Failure of Vertical Coastal Structure

A recommended approach for approximating partial failure of a sloping revetment (due to undermining at the toe, or to collapse at the top due to erosion behind the structure) is as follows (see Figure D.4.7-3):

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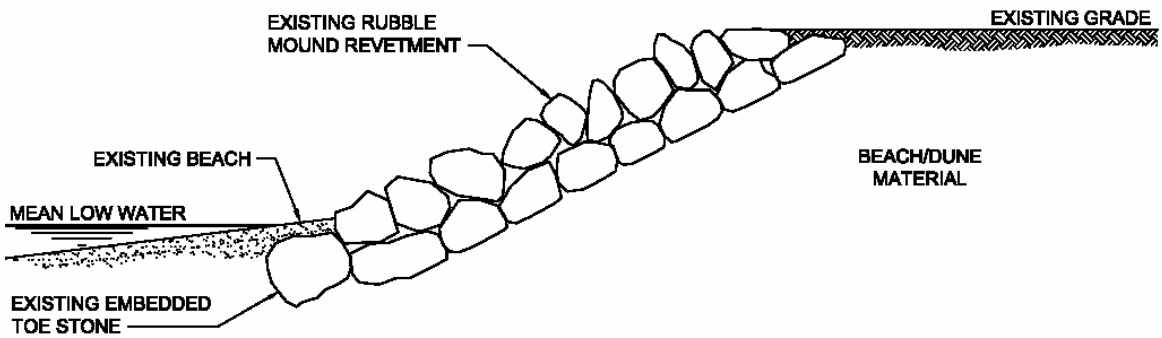
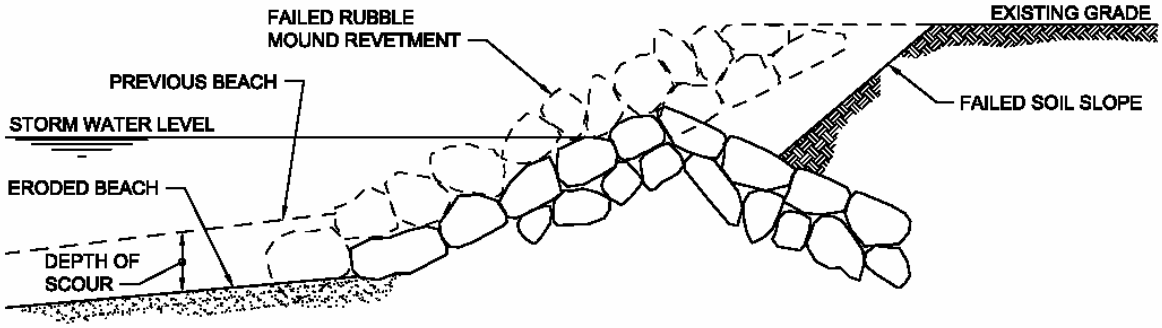


REVETMENT GEOMETRY PRIOR TO FAILURE



REVETMENT FAILURE GEOMETRY

PARTIAL FAILURE OF A SLOPING REVETMENT

Figure D.4.7-3. Partial Failure of a Sloping Revetment

1. Assume the structure will collapse in place into a triangular section throughout the structure footprint, with side slopes equal to the original structure slope.

2. Assume the landward side of the failed configuration will be half exposed and half buried. Approximate the soil slope landward from the failed structure at a slope in the range of 1:1 to 1:1.5 (v:h).

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After determining an appropriate failure configuration, the Mapping Partner shall conduct wave height and wave runup analyses upon the failed structure, as discussed in preceding sections. The Mapping Partner shall select an appropriate roughness factor when conducting runup and overtopping analyses on the failed structure.

In some cases, the assumed failed slope may result in the undermining of buildings located landward of the coastal structure. If this occurs, the building shall be removed from the analysis transect and not considered during subsequent wave effects modeling.

D.4.7.3.3 Buried Coastal Structures

In some instances, coastal structures may be covered or buried by sediments, and not readily observable during FIS site reconnaissance. For example, Figure D.4.7-4 shows two photographs in the Pacific City, Oregon, area taken approximately 10 years apart (courtesy of Paul Komar). The top photo was taken in 1978, and shows a revetment that was constructed to protect development from El Niño-related erosion. The bottom photo, taken in 1988, shows the same site once the El Niño had subsided and large quantities of sediment had moved back onto the beach. This is one example where a buried structure is of a size and construction to possibly affect coastal flood hazards, and should—like exposed structures—be considered during the FIS.

The Mapping Partner is responsible for inquiring as to whether buried coastal structures exist within the study area during the preliminary investigation phase of the FIS, and should include input from the community. The Mapping Partner should also carefully review aerial photographs of the study area to locate buried structures.

Once the Mapping Partner has determined that a coastal structure is likely buried at a site, the next steps are to collect information about the structure and follow the study process outlined in Figure D.4.7-5. Conducting the erosion analysis outlined in Section D.4.6 is part of the process, and may result in two outcomes: 1) the buried structure will remain buried during the 1% annual chance flood (see Figure D.4.7-6), or 2) the buried structure will be exposed by the 1% annual chance flood (see Figure D.4.7-7).

Note that the buried structure study process need not be followed unless the presence of buried structures is known or is highly likely, and that the *Guidelines and Specifications* do not require field investigations to identify buried coastal structures. There may be some instances where limited field work (such as soil probes to locate the structure) might be useful, but this should be limited to cases where large buried structures are known to exist.

D.4.7.3.4 Coastal Levees

Levees are man-made structures (usually earthen embankments that may or may not have their slopes and crest armored) that prevent flooding of low-lying areas. A *levee system* consists of a levee, or levees, and associated structures, such as closure and drainage devices, that are constructed and operated to prevent flooding of interior areas.

For any protective effects of coastal levees or levee systems to be recognized by the National Flood Insurance Program (NFIP) and incorporated into flood hazard maps, they must be designed, constructed, operated, and maintained to resist erosion and prevent any flooding or

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Figure D.4.7-4. Example of a Buried Coastal Structure that Could Affect Flood Hazard Zones and BFEs (top photo taken in 1978, bottom photo taken in 1988 – courtesy of Paul Komar)

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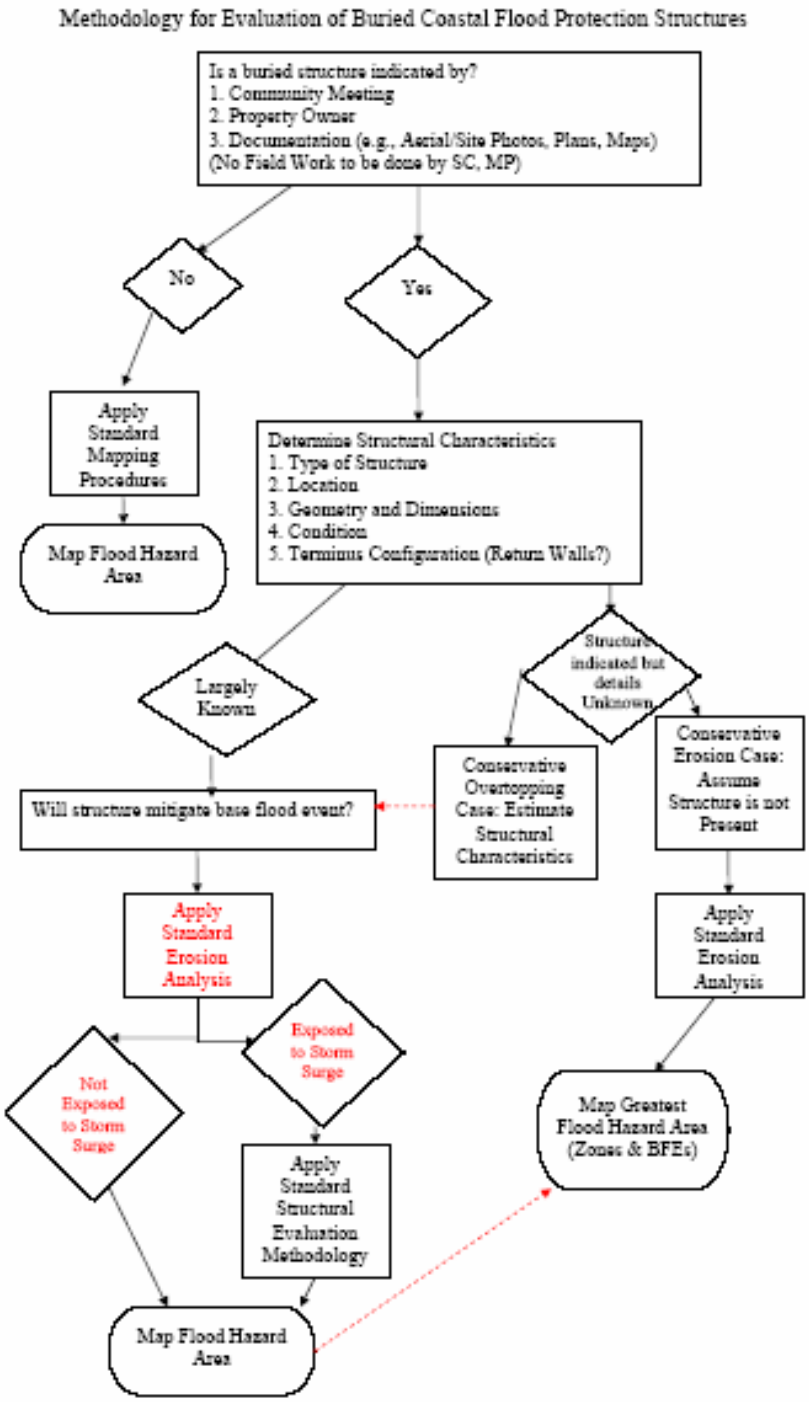

Figure D.4.7-5. Methodology for Evaluating Buried Coastal Structures

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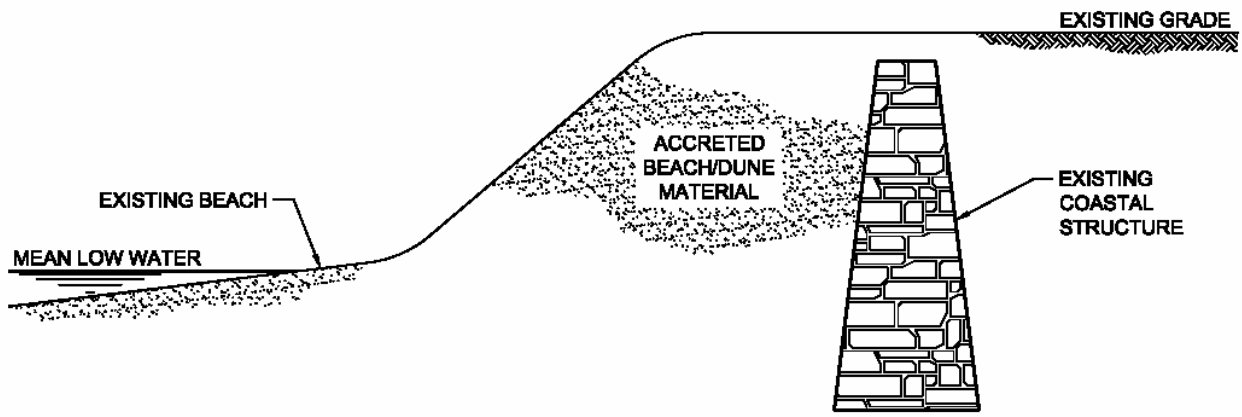
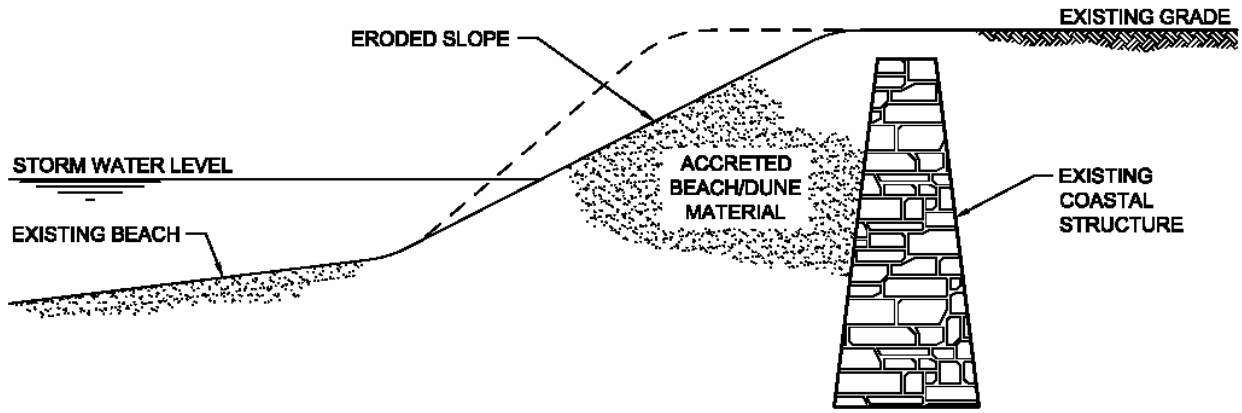


EXISTING GEOMETRY - COASTAL STRUCTURE BURIED BY ACCRETED SEDIMENTS



POST-EROSION GEOMETRY - BURIED STRUCTURE

NON-EXPOSURE OF BURIED STRUCTURE DURING 1% ANNUAL CHANCE FLOOD

Figure D.4.7-6. Buried Structure Remains Buried During 1% Annual Chance Flood

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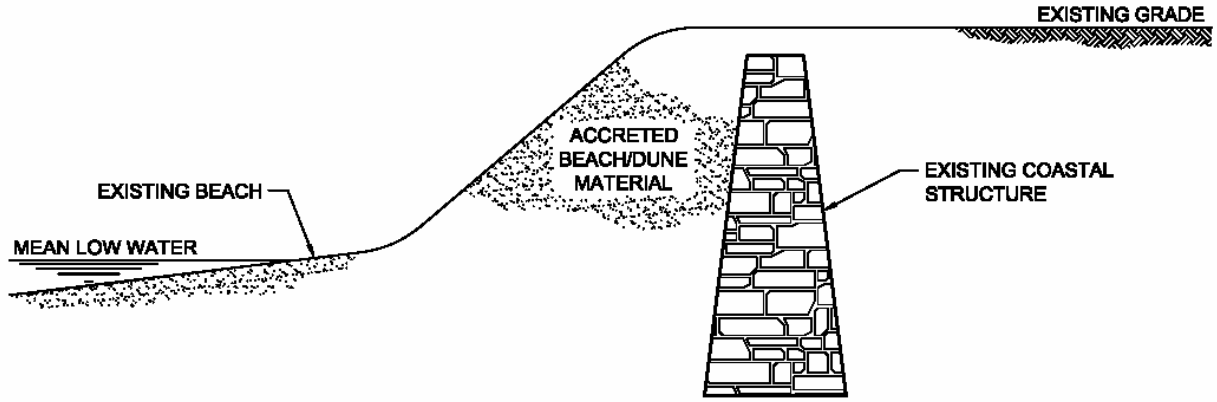
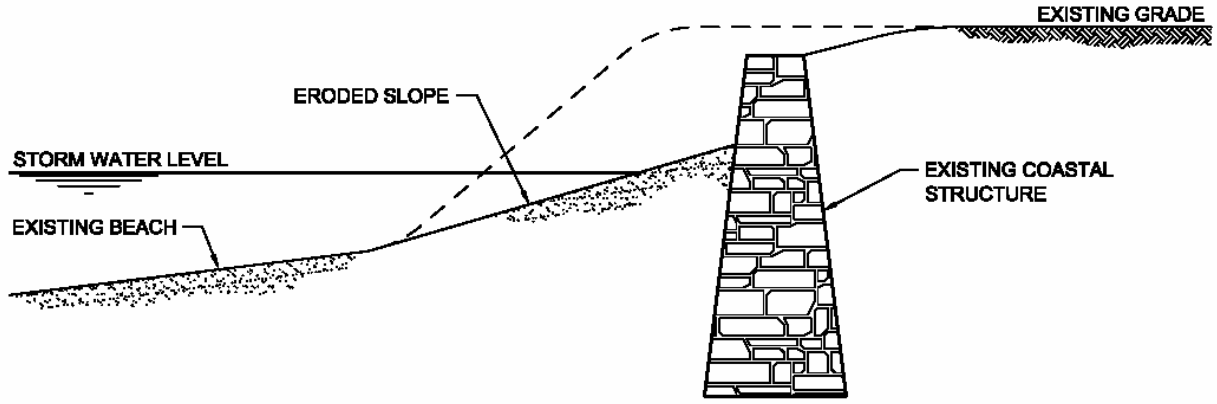


EXISTING GEOMETRY - COASTAL STRUCTURE BURIED BY ACCRETED SEDIMENTS



POST-EROSION GEOMETRY - BURIED STRUCTURE

EXPOSURE OF BURIED STRUCTURE DURING 1% ANNUAL CHANCE FLOOD

Figure D.4.7-7. Buried Structure Exposed During 1% Annual Chance Flood

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wave overtopping landward of the levee crest during 1% annual chance flood conditions; also, the levee or levee system must be certified as providing that level of protection. NFIP regulations (44 CFR Part 65.10) detail the requirements for a levee to be recognized as providing protection from flooding, including a freeboard requirement specific to coastal levees — the crest elevation of the levee must be elevated at least 2 feet above the 1% annual chance still water elevation, and 1 foot above the 1% annual chance wave height or the maximum wave runup elevation (whichever is greater)[3]. Additional guidance for evaluating levees can be found in Appendix H of the *Guidelines and Specifications*.

For consideration of a coastal levee as the basis of a map revision, the "Riverine Structure Form" (MT-2, Form 3, available at <http://www.fema.gov/pdf/fhm/mt2_f3.pdf>) must be completed in addition to the "Coastal Structure Form".

For consideration of levees that are subject to both coastal and riverine conditions, the Mapping Partner shall determine freeboard requirements using water levels determined using the methods contained in Section D.4.4 and Section D.4.5. Because Base Flood Elevations (BFEs) are required to be mapped to within a 0.5-foot tolerance (*Guidelines and Specifications* Appendix C.6.3), the combined still water and riverine flood profile shall be adjusted to an inland extent where the effects of waves and/or runup diminish to 0.5 foot or less. The resulting flood profile shall be compared to the crest elevations of flood protection along the combined tidal-river reach to determine if interior areas are sufficiently protected.

D.4.7.3.4.1 Levee Failure and Removal

Current FEMA policy states that in instances where levees cannot meet the requirements for recognition by the NFIP, the levees shall be "removed" from the analysis. Two scenarios are considered here: 1) a single levee on an analysis transect, and 2) multiple levees along an analysis transect.

Single Levee Case: If a community cannot provide the Mapping Partner with evidence that a levee is certified as meeting FEMA's requirements in 44 CFR 65.10, then the Mapping Partner shall remove the levee from subsequent analyses. In such a case, the Mapping Partner shall:

1. Modify the topography along the transect by erasing the levee cross-section and joining the ground elevations on each side of the levee with a straight line.

2. If the Mapping Partner determines that the failed levee provides substantial (but not complete) protection against incident wave action during 1% annual flood conditions, the Mapping Partner shall assume no wave action penetrates beyond the failed levee, and that only still water flooding (tide + wind setup) and locally generated waves (i.e., waves generated in the region behind the levee) shall affect the flooded area behind the levee.

[3] To be recognized by the NFIP, riverine levees require a minimum of 3 feet of freeboard above the 1% annual chance flood elevation and a minimum of 4 feet of freeboard within 100 feet of locations where the flow is constricted (e.g., a bridge); in addition, the upstream end of the levee must provide an additional 0.5 foot of freeboard added to the minimum.

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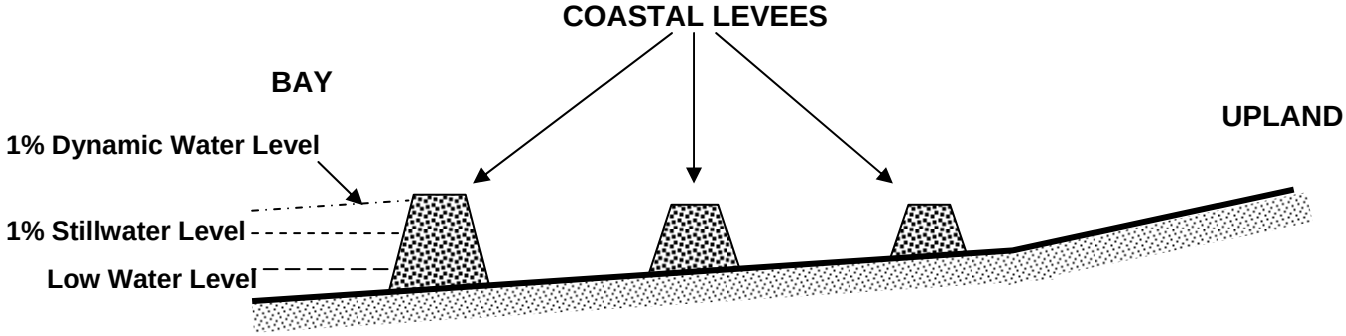
3. If the Mapping Partner determines that the failed levee provides minimal protection against incident wave action during 1% annual flood conditions, the Mapping Partner shall consult with the FEMA study representative to determine whether subsequent analyses should assume incident wave action penetrates beyond the failed levee.

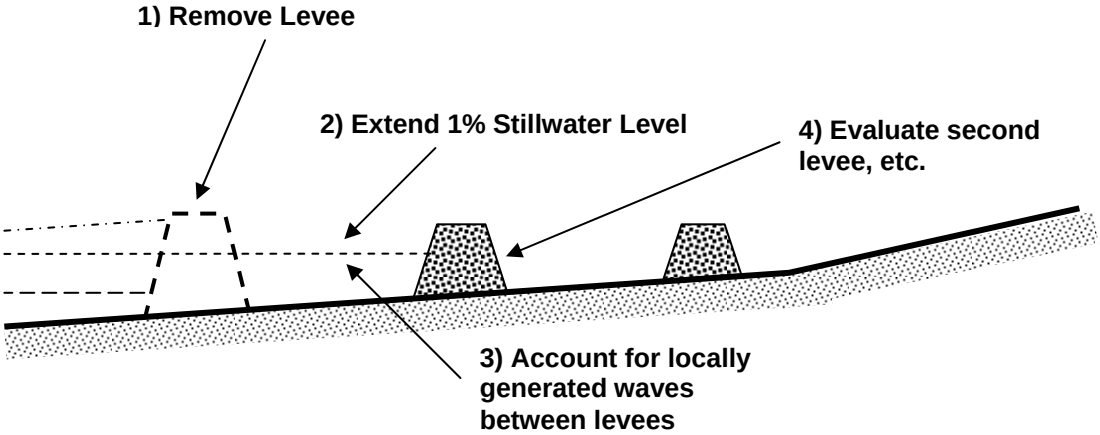
Multiple Levee Case: If a community cannot provide the Mapping Partner with evidence that the outer levee is certified as meeting FEMA's requirements in 44 CFR 65.10, then the Mapping Partner shall remove the outer levee from subsequent analyses. In such a case, the Mapping Partner shall:

1. Modify the topography along the transect by erasing the outer levee cross-section and joining the ground elevations on each side of the levee with a straight line.

2. If the Mapping Partner determines that the failed outer levee provides substantial (but not complete) protection against incident wave action during 1% annual flood conditions, the Mapping Partner shall assume no wave action penetrates beyond the outer levee, and that only still water flooding (tide + wind setup) and locally generated waves (i.e., waves generated in the region behind the levee) shall affect the next landward levee (see Figure D.4.7-8).



Multiple Levee Scenario, Prior to Levee Evaluation and Removal



Multiple Levee Scenario, Outer Levee Removal (prior to inner levee evaluations)

Figure D.4.7-8. Levee Removal, Multiple Levee Situation

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3. If the Mapping Partner determines that the failed outer levee provides minimal protection against incident wave action during 1% annual flood conditions, the Mapping Partner shall consult with the FEMA study representative to determine whether subsequent analyses should assume incident wave action penetrates beyond the failed outer levee.

4. The Mapping Partner shall repeat steps 1 through 3 for each additional levee along the transect, for which certification cannot be supplied by the community.

D.4.7.3.5 Operation and Maintenance

Both the FEMA memorandum (April 23, 1990) and the NFIP regulations indicate that an operation and maintenance plan is required as part of certification that a coastal structure will withstand the 1% annual chance flood. At a minimum, the plan must document the formal procedure to maintain the stability, height, and overall integrity of the structure and its associated structures and systems.

NFIP regulations, 44 CFR Part 65.10, require that all maintenance activities must be under the jurisdiction of a federal or state agency, an agency created by federal or state law, or an agency of the community participating in the NFIP that must assume ultimate responsibility for maintenance. Often, the aforementioned government entities are unable to take responsibility for maintenance of private structures. However, a government agency can recognize private property owners as the responsible party for maintenance of an existing structure.

For the purposes of an FIS, the Mapping Partner shall ascertain (through discussions with the community and property owners) whether operation and maintenance plans exist for coastal structures that are expected to remain intact during 1% annual chance flood conditions. Mapping Partners may not have sufficient resources and time to conduct detailed evaluations of the operation and maintenance of each coastal structure within the study area. In such cases, the Mapping Partner shall make an engineering judgment about the adequacy of structure operation and maintenance. The Mapping Partner must document data, materials and assumptions associated with the flood hazard determinations related to structure operation and maintenance. Communities and property owners should be made aware that these evaluations are for mapping purposes only.

D.4.7.4 FIS Treatment of Beach Stabilization Structures

If a Mapping Partner chooses to evaluate beach stabilization structures (e.g., groins, jetties, sills, or similar structures) during an FIS, the following approach is recommended:

- Identify any beach stabilization structures during the FIS reconnaissance phase.

- Use historical evidence and engineering judgment to determine whether the structures (or similar structures nearby) have been damaged or detached (during prior storms or gradually over time).

- Document prior damage to the stabilization structures and any resulting shoreline recession attributable to the structural damage.

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- Notify the FEMA study representative if the Mapping Partner intends to remove beach stabilization structures or reduce their effects during the FIS analyses. Obtain FEMA concurrence before proceeding with the following steps.

- Use historical evidence and engineering judgment to predict the likely shoreline configuration (in plan view and elevation) if the structures fail during 1% annual chance flood conditions.

- Subject the modified shoreline and profile to typical FIS analyses (e.g., event-based erosion analysis, wave runup and overtopping analysis, and wave height analysis).

- Note that in the case of some stabilization structures, it is unlikely that their failure will require "removal" from analysis transects; the effects of the structure failure on the shoreline configuration, however, should be considered by the analyses.

D.4.7.5 FIS Treatment of Miscellaneous Structures

Current FEMA guidance does not address the effects of miscellaneous structures (e.g., piers, port and navigation structures, bridges, culverts, tide gates, etc.) on coastal flood hazard analysis and mapping. This section provides general guidance for identifying and analyzing the effects of miscellaneous structures on flooding in sheltered water areas as follows:

- The Mapping Partner shall identify structures – in addition to the coastal armoring and beach stabilization structures addressed above – that could exert a significant influence on nearshore waves and currents, coastal sediment transport, or ponding in backshore areas, during 1% annual flood conditions, particularly in sheltered waters. This should be done during the FIS reconnaissance phase.

- Once identified, the Mapping Partner shall use historical evidence, other readily available data, and engineering judgment to determine whether the miscellaneous structures are likely to survive the 1% annual flood conditions. If the structures are likely to fail, then they (and their effects on the shoreline and flooding) should be removed from subsequent analyses.

- The Mapping Partner shall notify the FEMA study representative as to how he/she intends to address miscellaneous structures and their effects during the FIS analyses, and obtain FEMA concurrence before proceeding.

D.4.7.5.1 Piers, Navigation Structures, and Port Facilities

The Mapping Partner shall review navigation charts, aerial photographs, and other information relative to piers, navigation structures, and port facilities (including dredged channels) that may affect the propagation and transformation or dissipation of waves within a sheltered water body, or that may affect littoral sediment transport. The Mapping Partner shall consider the range of possible effects of these structures and facilities during 1% annual flood conditions, using readily available data and site characteristics as a guide.

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However, the document contains useful guidance to support implementation of the new standards.

The Mapping Partner shall verify basic structure and facility information with local agencies and communities to determine the location, extent, and influence of these features. If there is any uncertainty concerning major features and their potential effects on upland flood hazards, limited field surveys or additional data collection shall be considered to augment existing data.

D.4.7.5.2 Bridges, Culverts, and Tide Gates

The shorelines of sheltered waters are often paralleled by roads and railroads in backshore areas. The effect of these structures on coastal flooding can be most pronounced where they intersect tidally influenced creeks, river channels, and floodplains. The Mapping Partner shall consider the presence and influence of roadways, railways, embankments and abutment fill, and bridge piers on flood hazards during 1% annual flood conditions.

The Mapping Partner shall identify the location and condition of culverts, tide gates, and other flow control structures in the vicinity of the study site and evaluate their potential to affect interior flood elevations. Design calculations and reports for individual culverts and tide gates, and storm drainage master plans for larger drainage systems shall be obtained and reviewed by the Mapping Partner to understand design criteria and provide data for hydraulic calculations and hazard zone delineation.

D.4.7.6 Data Requirements

The Mapping Partner shall obtain documentation for each coastal structure that could provide protection during 1% annual chance flood conditions, or significantly affect flood hazards in the study area. That documentation should include, but not be limited to, the following:

- Type, location, layout, dimensions, and crest elevation of structure;
- Dominant site particulars (e.g., local water depth, tide, surge and wave conditions, erosion rate, sediment characteristics and geotechnical conditions, debris hazards, and ice climate);
- Construction materials and present integrity;
- Historical record for structure, including construction date, plans, and specifications; recent inspection reports and photographs; maintenance plan and responsible party; and dates and descriptions of damage, repairs, and modifications; and
- Clear indications of effectiveness or ineffectiveness.

The Mapping Partner shall develop much of this information through office activity, including a careful review of aerial and site photographs, reports and information provided by the community and property owners, and other readily available information. In the case of some major coastal structures, site inspection would be advisable to confirm preliminary judgments.

Note that the level and detail of the structure and site data collected should be consistent with the level of analysis undertaken by the Mapping Partner. An analysis based on engineering judgment, or multiple analyses assuming different structure responses during 1% annual chance

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flood conditions (e.g., structure survives intact, partial failure, complete failure), will require less detailed and precise information than a structural engineering and geotechnical evaluation of a coastal structure.

D.4.7.7 Study Documentation

If coastal structures are present in the study area, the Mapping Partner shall document the data (see Subsection D.4.7.2.1), methods, and procedures used to evaluate the adequacy of the structures to survive 1% annual chance flood conditions. This documentation shall include any assumptions or approximations used in the analyses. The same documentation shall be required in the event that coastal structures are indicated by information collected during the FIS, but are apparently buried and not visible during the study.

The Mapping Partner shall document the results of all analyses of coastal structures conducted for the FIS. In cases where the study contractor could not determine whether a given structure would survive the 1% annual chance flood intact, and where multiple analyses were conducted for the structure (i.e., intact condition, failed condition, and removed from the analysis transect), the Mapping Partner shall document each analysis and record the structure condition that was used to map flood hazard zones and BFEs. This information will be useful in the event a map revision is requested based upon a structure condition different from that used as the basis for the FIRM.

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