Guidance for Flood Risk Analysis and Mapping

Floodplain Boundary Standards

November 2024

FEMA

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Requirements for the 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 (https://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 https://www.fema.gov/resource-document-library.

Table of Revisions

The following summary of changes details revisions to this document subsequent to its most recent version in November 2019.

Affected Section or Subsection	Date	Description
1	Nov. 2024	Clarified that FBS should be applied only to the 1-percent-annual-chance floodplain boundary.
2	Nov. 2024	Revised language based on updates to FEMA SID 113, which was reworded to simplify application of the standard and encourage use of the highest risk class. Corrected Table 2 to match SID 113.
Attachment B	Nov. 2024	Converted the FBS Audit Self-Certification Report (formerly Attachment B) to a new template.
All	Nov. 2024	Various minor style updates and corrections to references.

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1. Floodplain Boundary Standards Overview

This document provides guidance for the implementation of Floodplain Boundary Standards (FBS), and the preparation for and performance of audits of compliance as part of the Risk MAP program. The reliability of the floodplain boundary delineation is quantified by comparing the computed flood elevation to the ground elevation at the mapped floodplain boundary. All Digital Flood Insurance Rate Maps (FIRMs) contracted after September 2, 2005 (Fiscal Year [FY] 2005 and subsequent years) must meet the FBS specified in Table 2.

The 1-percent-annual-chance floodplain with a model-backed water surface elevation needs to receive the FBS audit with completed self-certification documentation. This includes, but is not limited to, model-backed Zone A mapping, Special Flood Hazard Area (SFHA) data created in two-dimensional models such as StormWise (previously ICPR) or XP-SWMM, coastal SFHA floodplains delineated per topographic data, and/or Base Level Engineering (BLE) data that has received hydraulic refinement to create enhanced study modeling for a regulatory product.

For more information on BLE hydraulic analysis options and hydraulic refinement options, see Base Level Engineering Analyses and Mapping Guidance.

For flood risk studies that were contracted prior to FY 2005 that are not audited, the compliance levels within the FBS will be applied to the levels of study as shown in Table 1.

Table 1: Compliance Levels for Studies Contracted Prior to FY 2005

Level of Study	Percent of Stream Mile FBS Compliance
Digital Conversion	35% Enhanced; 75% Base Study
Redelineation	100%
New Enhanced Study	100%

2. Determining Flood Risk Class

2.1. Flood Risk Class Definition

The tolerance for how precisely the flood elevation and the ground elevation match varies based on the flood risk class, which is a function of population, population density, and/or anticipated growth in floodplain areas. Per Standard ID (SID) 113, a singular risk class may be used for all flooding sources to comply with FBS; however, if this is applied, then all flooding sources must meet the highest flood risk class (A) when evaluating FBS delineation reliability requirements.

Alternatively, the flood risk class may be determined for each flooding source to identify what FBS flood risk class must be met and what level of analysis is required.

2.2. Flood Risk Class by Flooding Source

If the flood risk class is determined by each flooding source, the following information provides specific guidance and criteria to meet FBS requirements. First, determine the flood risk class with input from state and local officials. The risk class determination can vary between each flooding source within a study area. The community, state, and FEMA region should agree on the risk classification and the topographic data source at the beginning of the study. FEMA makes the final determination of risk classification in cases of dispute. Five risk classes, as defined in SID 113, are shown in Table 2.

Table 2: Floodplain Boundary Standards for Flood Insurance Rate Maps

Risk Class	Characteristics	Delineation reliability of the floodplain boundary per study methodology[1]	
		Zone A (Non-Model-Backed)	All Other Zones (Enhanced Methods)
A	High population and densities within the floodplain and/or high anticipated growth	+/- 1/2 contour 95%	+/- 1.0 foot / 95%
B	Medium population and densities within the floodplain and/or modest anticipated growth	+/- 1/2 contour 90%	+/- 1.0 foot / 90%
C	Low population and densities within the floodplain and/or modest anticipated growth	+/- 1/2 contour 85%	+/- 1.0 foot / 85%
D	Undetermined risk, likely subject to flooding	N/A	N/A
E	Minimal risk of flooding; area not studied	N/A	N/A

[1] The difference between the ground elevation (defined from topographic data) and the computed flood elevation.

In addition to the vertical accuracy tolerances defined in Table 2, a horizontal accuracy of +/- 38 feet will be used to determine the compliance with the vertical tolerances defined for each risk class. This horizontal tolerance will address varying floodplain delineation techniques (automated versus non-automated) and map scale limitations.

To assist the risk classification process, a national Risk Analysis Census Block Group dataset (shapefile) has been compiled that contains the following risk parameters by block group:

- Population
- Population growth
- Housing units
- Flood insurance policies
- Flood insurance claims
- Repetitive loss claims
- Repetitive loss properties annually
- Declared flood disasters

The Regional Service Centers (RSCs) maintain this national Risk Analysis Census Block Group dataset. To obtain the latest version of this dataset please contact your RSC.
Each individual risk factor for each census block group was determined by taking the parameter value for each census block group and dividing it by the national total of the parameter. Each parameter was then ranked by decile. The parameter deciles were weighted and then added together. This sum was then divided by eight to determine the risk percentage of that census block group for the nation. The census block group risks were sorted in ascending order and given a deciles range, with "0 percent to 10 percent" as the top decile, followed by "10 percent to 20 percent," etc.

For risk class determination, the assigned risk class must be made at the stream level. The risk of the census block group can be used for guidance; however, these must be adjusted based upon the individual needs of the FEMA region, the state, or local government. For instance, if a stream is in a top decile group, such as 0 percent to 10 percent, then flows into a decile group of 80 percent to 90 percent, and then back out to a 0 percent to 10 percent decile group, the FEMA region may decide to study the entire length of the stream by full enhanced study methods, which would be Risk Class A.

Various factors can also be used to determine the risk class of an individual reach. These factors include:

- Census block group risk ranking
- Minimum length of classification of any individual flooding source segment
- State and local ordinances or regulations
- Critical facilities that are near the floodplain
- Mobility of the population group within the census block group
- Projected growth of the watershed
- State and local interviews
- Probability of the loss of life
- Probability of the loss of property

For new studies, the method described below can be used to determine preliminary risk classes for use in scoping meetings. Using the shapefile with the Preliminary National Risk Class, the RSCs can use geographic information system (GIS) methods to:

1. Select from this shapefile all the Block Groups that cover the study area.
2. Export the selected Block Groups to a new shapefile named X_RiskClassifications (where X = the study name).
3. Make a thematic map of the study boundaries with the corresponding Block Group Risk Classes.
4. Review risk classes with the region and other stakeholders at the scoping meeting.
5. Revise risk classes and the shapefile as necessary based on the results of the scoping meetings.
6. Finalize study risk classes in X_RiskClassifications.

2.2.1. DETERMINE ADEQUACY OF LEVEL OF STUDY

Once the flood risk class is defined a determination is to be made as to whether the level of study (e.g., base, enhanced, unstudied) on the effective map is appropriate for the risk class. If so, proceed to Section 2.3. If not, develop a new study/restudy and develop floodplain boundaries that comply with the standard for the risk class per SID 113. Floodplain boundaries must be delineated using topographic/terrain data that meet existing FEMA standards. If funds do not allow for development of a new study/restudy, FEMA, in conjunction with state and local officials, will decide whether to proceed with the project or defer to new engineering. Deferred projects will be captured as a community map in a geospatial database.

2.3. Determine Appropriate Method for Mapping Non-Revised Floodplains

For flooding sources that are not being newly studied or restudied, Mapping Partners should not be predisposed to simply transfer the boundaries from the effective FIRM to the new FIRM. Rather, the Mapping Partner must make an earnest effort to upgrade the floodplain boundaries using available resources. The three types of redelineation are listed below in preferred order of use:

- Case 1: Revised Topographic Delineation: Conduct research to determine whether topographic/terrain data are available from the state, community, or other source that are of better quality than that used to prepare the effective Flood Insurance Study (FIS) report and FIRM. Topographic data are considered of better quality if they are of a greater vertical accuracy, are more recent that that used to prepare the effective FIRM and meet FEMA's standards for topographic data. If higher quality topographic/terrain data are available, they should be obtained and used to redelineate the floodplain boundaries using the effective FIS report and/or published flood profiles.

- Case 2: Work-Map Based: if topographic data of better quality are not available, conduct research to determine whether the original work maps are available from the FEMA library or the state or community. If available, these work maps, which typically include detailed topographic strip mapping along the flooding source, should be used to digitize the floodplain boundaries and cross sections.
- Case 3: FIRM-Based: If better or equivalent quality topographic data and/or the original work maps are not available, and available documentation indicates that redelineation of the floodplain boundary onto available topographic data would degrade the quality of the delineation, the effective floodplains may be fit to the new base map features. In this case, the Mapping Partner must prepare a signed document denoting the quality of the best available topographic data and the quality of the topographic data that the effective boundaries have been delineated against and why neither are being used to redelineate the floodplain boundaries for this particular study. The FIRM-based method requires prior approval from the FEMA region.

Many projects will entail a combination of the above techniques. That is, some flooding sources will be newly studied or restudied, while others will involve transferring effective FIS information to the new FIRM. Additionally, the risk class may vary by flooding source or reach of the flooding source and thus, the floodplain reliability requirement will vary according to Table 2.

3. Pre-Audit Data Compilation

All new or updated FIRMs produced using Map Modernization or Risk MAP funding are eligible for audit.

Before the flood hazard boundary audit process begins, it is important to have all the appropriate files readily available in a format that can be used by an analyst performing a GIS-based audit. The data gathering process is critical to the success of the audit.

The data types below must be assembled before the flood hazard boundary audit can begin. Depending on the flood zone designations (base or enhanced), not all the below material may be available or relevant.

FIRM Database Files:

- Flood Hazard Boundaries – S_FLD_HAZ_LN and S_FLD_HAZ_AR
- Streamline – S_WTR_LN
- Hydraulic baseline – S_PROFIL_BASLN
- Digital cross sections – S_XS
- General Structures – S_GEN_STRUCT
- Base map information – one of the below, depending on base map:
  - S_TRANSPORT_LN or
  - Raster images, i.e., Digital Orthophoto Quarter Quads (DOQQs) or aerials

Support Files:

- Terrain Data – Digital Elevation Model (DEM), triangulated irregular network (TIN), mass points, Light Detection and Ranging (lidar), topographic contours
- FIS profile (with backwater added) and Floodway Data Table
- Historical (Pre-Map Modernization) Work Maps
- Modeled and mapped cross sections
- Hydraulic Data
- Coastal Stillwater Elevations (SWELs)
- Wave hazard analysis results
- Coastal Work Maps

It is important to obtain the exact terrain data source that was used to create the flood hazard boundary. For new or recent studies, this will be relatively easy, but older enhanced studies may not have available digital terrain data or work maps to use in the audit process. Please refer to the Elevation Guidance for additional considerations for terrain data.

4. FBS Self Certification

All FIRM Databases contracted in FY 2005 and subsequent years must meet the FBS and Mapping Partners must provide self-certification documentation reflecting the adherence of the FIRM Database to the standard. To satisfy the self-certification requirement, FIRM Databases will be deemed in compliance with the FBS provided that:

- A signed statement from the Mapping Partner (including a completed FBS Self-Certification Audit Report) stating delivered flood map products are in compliance (i.e., self-certification is completed) and is uploaded to the Mapping Information Platform (MIP) as an FBS Reports Product Type within the Data Upload section.

- The self-certification supporting information can be generated by either following the guidance provided in this document or developing processes that provide the necessary documentation to quantifiably demonstrate that the requirements specified in Table 2 have been satisfied.

A template for the FBS Self-Certification Audit Report is available on the FEMA Guidelines and Standards for Flood Risk Analysis and Mapping webpage. Mapping Partners shall provide the following information to satisfy the self-certification reports:

1. Mapping Partner performing the audit
2. Reference Information and identification of the study being certified
3. Self-Certification approver and date
4. Reviewer name and date submitted to the region
5. Description of materials used to perform the audit

6. Shapefile name of points tested including exceptions
7. Study Methods used in study
8. Number of floodplain boundary points audited by Study Method
9. Number of floodplain boundary points passed by Study Method
10. Number of floodplain boundary points failed by Study Method
11. Number of floodplain boundary point exceptions by Study Method
12. Pass percentages by Study Method
13. Pass/Fail percentages by study FBS risk class
14. Reasons for failed and/or excepted points by study FBS risk class
15. Names, study methods, and risk classes of stream reaches and/or coastal water bodies audited
16. Total stream length and/or shoreline length audited/passed
17. 100k National Hydrography Dataset (NHD) Subbasin Pass/Fail shapefile if reporting results below study level pass

If the entire study cannot meet the FBS, self-certification documentation, which is a required deliverable for every project, must be submitted on an NHD 100k subbasin level. The NHD 100k subbasin file can be obtained from your RSC. The audit procedures in Section 5 describe how to calculate the subbasin pass rates.

For mapping projects contractually tasked to meet the FBS outlined in Table 2, a Mapping Partner's signature on the Technical Support Data Notebook (TSDN) and self-certification report as referenced in the FBS Self-Certification Audit Report will mean (among other things) that the floodplain boundaries comply with the FBS. Audit and self-certification procedures are made available to all Mapping Partners that use an automated process as well as a non-automated GIS-based procedure to allow each Mapping Partner to check the quality of their floodplain boundary delineation. Consequently, the Mapping Partner should check as many points and flooding sources as they deem necessary to feel comfortable attesting to the floodplain boundary quality for all flood hazards in their study area. Further, areas found to fail the test can be referred to the local government for a ground truth assessment or concurrence that failed areas do not pose a flood risk to property and the public. If these assessments find the floodplain boundaries to be adequate (despite the audit result), the score will be revised to pass all points within the area assessed.

Self-certification documentation must be submitted to FEMA:

- Within 30 days of the issuance of a study as Preliminary, should any adjustments be made. Self-certification documentation must be submitted prior to Preliminary issuance.
- Within 30 days of the issuance of a study's Letter of Final Determination if the floodplain boundaries were modified during the post-preliminary processing of that study.

Meeting the vertical standard specified in Table 2 within the horizontal tolerance provided constitutes 100 percent compliance with the FBS. Maps selected for audit will proceed forward through the flood map production and adoption process as the audits are conducted.

The above timelines for self-certification represent the minimum requisite. FBS audit results and self-certification documentation should be submitted as soon as possible, which is likely at completion of Floodplain Mapping. Floodplain boundaries are generally finalized by this stage, with the completion of the Flood Risk Review Meeting and comment process. If boundaries are further refined as production moves into the Preliminary phase, a revised FBS audit self-certification would be submitted within 30 days of the issuance of the Preliminary study.

4.1. GIS Method for Assessing FBS Compliance for Riverine Floodplains Enhanced Study Methods

The procedures outlined in this section are intended to audit riverine floodplain boundaries in Zones AE, AH, and AO. The major processing steps are as follows:

1. Ensure that you have all digital and non-digital data, including the final X_RiskClassifications shapefile, defined in Section 2.1.
2. Start a new GIS project.
    a. Load all applicable digital data into the GIS project.
    b. Build a study level DEM/TIN = TIN_STUDYX or DEMSTUDYYX using the digital terrain information. (Perform this step only if the Mapping Partner does not provide a study level TIN.)
    c. If the study terrain data are non-digital, the terrain maps will have to be scanned and georeferenced so that ground elevations can be assigned to the points by hand.
3. Extract the enhanced 1-percent-annual-chance flood lines and export them to a new shapefile/feature class = ENHANCED_FLD_HAZ_LN_STUDYX.
    a. Example: ENHANCED_FLD_HAZ_LN_Henrico and add the new file to the GIS project.
4. Using the ENHANCED_FLD_HAZ_LN_STUDYX file, create a new point shapefile/feature class = TEST_PTS_STUDYX, which has points that are evenly spaced along the ENHANCED_FLD_HAZ_LN (every 100 ft.) and add the TEST_PTS_STUDYX to the GIS project.
5. Add the following fields to the TEST_PTS_STUDYX attribute table:
    a. FldELEV – type = numeric, 6, 2
    b. GrELEV – type = numeric, 6, 2
    c. ElevDIFF – type = numeric, 6, 2
    d. RiskClass – type = string, length = 2
    e. Status – type = string, length = 2

  f. Validation – type = string, length = 20
  g. Comment – type = string, length = 100

6. Zoom into a randomly selected enhanced stream.
7. For 1D Studied Stream Reaches, select the S_XS and TEST_PTS_STUDYX for that stream and export the selected S_XS and TEST_PTS_ STUDYX to new shapefiles/feature classes = S_XS_STREAM and TEST_PTS _STREAM, (example: TEST_PTS _GooseCk) and add them to the GIS project.
8. For 2D Studied Stream Reaches, export the selected TEST_PTS_STUDYX for that stream and export to new shapefile/feature class = TEST_PTS_STREAM and add them to the GIS project.
9. Review the TEST_PTS _STREAM and note any points that fall at or between general structures as exceptions = GS_Except in the validation column.
10. Review the TEST_PTS _STREAM for points that fall in backwater areas and assign them elevations based on their associated profile in the FldELEV attribute field.
    a. In some cases, the boundaries downstream of the first cross section on the tributary are in a transition area where a linear relationship does not govern the mapping of the floodplain boundaries. Test points falling in these areas will require assignment of study elevations using a combination of the cross-section data and profile information.
11. For 1D Studied Stream Reaches, Build a TIN = TIN_STREAM using the S_XS_STREAM file using the elevations stored in the WSEL_REG field.
12. For 2D Studied Stream Reaches, obtain or build (if the Mapping Partner does not provide) a TIN = TIN_STREAM using the grid values of the 2D 1% Water Surface Elevation (WSEL) data.
13. Intersect the TEST_PTS_STREAM with the TIN_STREAM to get the interpolated 1% WSEL elevations onto the TEST_PTS_STREAM FldELEV attribute field.
14. Continue processes until all enhanced streams are tested, ensuring that you save a TEST_PTS_STREAM and TIN_STREAM file for every stream tested.
15. Merge all your TEST_PTS_STREAM files into one AUDIT_STUDYX_PTS shapefile/feature class.
16. Intersect AUDIT_STUDYX_PTS with the TIN_STUDYX to transfer the interpolated terrain elevations onto the AUDIT_STUDYX_PTS GrdELEV attribute field. If terrain was not available in digital format, terrain elevations will have to be assigned by hand from the georeferenced terrain maps.
17. Determine if the AUDIT_STUDYX_PTS passes the equal to or greater than the 95-percent pass percentage at the +/- 1.0 foot threshold. If so, then the study passes and no more analysis needs to be done. Skip to Step 26.
18. If the AUDIT_STUDYX_PTS fails the equal to or greater than the 95-percent pass percentage at the +/- 1.0 foot threshold, then intersect the AUDIT_STUDYX_PTS with the X_RiskClassifications shapefile to transfer the Risk Classes onto the AUDIT_STUDYX_PTS.

19. Determine the status of each point based on tolerances of the risk class it belongs and calculate into the Status field the attribute Pass = “P” and Fail = “F”.
20. Select out the individual Risk Classes to their own AUDIT_STUDYX_PTS_RskClass shapefile/feature.
21. Now determine whether the AUDIT_STUDYX_PTS passes the equal to or greater than pass rate for each audit study’s risk classes. If it does, then the study passes and no more analysis needs to be done. Skip to Step 26.
22. If the AUDIT_STUDYX_PTS fails the equal to or greater than pass rate for each audit study’s risk classes then intersect the AUDIT_STUDYX_PTS with the NHD 100k subbasin shapefile.
23. Add new file attribute to the AUDIT_STUDYX_PTS file.
    a. Subbasin – type = string, length = 50.
24. Calculate the Subbasin field in the AUDIT_STUDYX_PTS file with the intersected NHD 100k subbasin shapefile.
25. Now determine the AUDIT_STUDYX_PTS pass rate for each audit study’s risk classes at the subbasin level.
26. Record/Report Results in the FBS Self-Certification Report.
27. Submit the FBS Self-Certification Report/Audit Report along with the audit spatial files to the MIP.
28. Repeat for all enhanced streams.

4.2. GIS Method for Assessing FBS Compliance for Coastal Floodplain Mapping Enhanced Study Methods

The procedures outlined in this section are intended to assess FBS compliance for coastal floodplain boundaries in Zones AE and VE developed by coastal flood hazard analyses. It should be noted that the purpose of these FBS procedures is solely to validate the SFHA boundary; it does not evaluate the mapping of intermediate zone breaks or the 0.2-percent-annual-chance floodplain boundary. It is possible for a map to pass the FBS audit but fail Quality Assurance/Quality Control floodplain mapping checks based on poor zone break delineations.

For the purposes of this procedure, reaches of coastal floodplain mapping must be segmented by primary flood hazard, i.e., overland wave propagation or wave runup and overtopping (Step 5 below). The SFHA boundary in areas of overland wave propagation will be evaluated based on the 1-percent-annual-chance stillwater elevation data. The SFHA boundary in areas of wave runup and overtopping will be evaluated based on mapped Base Flood Elevations (BFEs). Note that if spatial SWEL data are not available for the study, all areas will be evaluated based on mapped BFEs and segmentation of the floodplain by primary flood hazard is not necessary.

All new coastal studies should follow the steps described below. It may not be possible for coastal redelineation studies to adhere to this guidance if spatial information for the 1-percent-annual-chance SWEL does not exist. If a stillwater surface cannot be constructed from available data, the study may be audited based on the unrounded SWELs derived from the FIS report in the areas of overland wave propagation and by mapped BFEs in areas of wave runup. For more information on coastal redelineation procedures, see Coastal Floodplain Mapping Guidance.

The major processing steps for a coastal FBS self-certification are as follows:

1. Ensure that you have all digital and non-digital data, including the final X_RiskClassifications shapefile, defined in Section 2.1. Please contact the FEMA region to obtain the latest version of this file.
2. Start a new GIS project and load all applicable digital data into the GIS project including 1-percent-annual-chance SWEL spatial data file. Define the data frame projection using a projection measured in feet before adding your data.
3. Obtain or build (if the Mapping Partner does not provide) a study-level topographic/bathymetric TIN, DEM, or Esri Terrain using the digital terrain information that was used for the floodplain delineations. You may have to create several TINs that are tiled if the terrain data are too complex for creation at the study level. For the purposes of these audit procedures, use of a TIN = TIN_TOPO_STUDYX is assumed.
    a. If the study terrain data are non-digital, the terrain maps will have to be scanned and georeferenced so that ground elevations can be assigned to the points by hand.
4. Obtain or build (if the Mapping Partner does not provide) a study level TIN of the SWEL data = TIN_SWEL_STUDYX.
5. Create a polygon feature class to construct boundaries that differentiate areas where the SFHA boundary is mapped according to wave runup and overtopping and areas where the primary flood hazard is overland wave propagation where the SFHA boundary is mapped according to SWELs. Use this feature class to query for points in Steps 11 and 12. If spatial SWEL data are not available for the study, all areas will be evaluated based on mapped BFEs and segmentation of the floodplain by primary flood hazard is not necessary.
6. Extract the enhanced coastal 1-percent-annual-chance flood area polygons (Zones AE and VE) and export them to a new shapefile/feature class = COASTAL_FLD_HAZ_AR_STUDYX (example: COASTAL_FLD_HAZ_AR_LEE). Add the new file to the GIS project. Note: selecting features with STATIC_BFE > 0 will help ensure features are coastal flood zones.
7. Extract the 1 PCT ANNUAL CHANCE FLOOD HAZARD flood lines from S_FLD_HAZ_LN that share a line segment with COASTAL_FLD_HAZ_AR_STUDYX. Export them to a new shapefile/feature class = COASTAL_FLD_HAZ_LN_STUDYX (example: COASTAL_FLD_HAZ_LN_LEE) and add the new file to the GIS project.
8. Start an editing session and merge all features in the COASTAL_FLD_HAZ_LN_STUDYX.

9. In ArcCatalog, create a new point shapefile/feature class = AUDIT_STUDYX_PTS, and add the following fields to the AUDIT_STUDYX_PTS attribute table.
    a. FldELEV – type = numeric (double), 6, 2
    b. GrELEV – type = numeric (double), 6, 2
    c. ElevDIFF – type = numeric (double), 6, 2
    d. RiskClass – type = string (text), length = 2
    e. Status – type = string (text), length = 2
    f. Validation – type = string (text), length = 20
    g. Comment – type = string (text), length = 100
10. Begin editing the AUDIT_STUDYX_PTS to populate the feature class with points that are evenly spaced (every 100 feet) along the COASTAL_FLD_HAZ_LN_STUDYX features. To do this,
    a. Be sure that the empty AUDIT_STUDYX_PTS file is selected as the target for editing.
    b. Select the line on which you need to create your points (created in Step 8).
    c. Using the "divide" option in the editor menu, select "Place points every 100 units" (assuming the projection is in feet). Note that ArcMap may add a point at the end of the line segment, even if the line segment ends before reaching 100 feet.
11. For points in overland wave propagation areas, use the Add Z Information tool in 3D Analyst on AUDIT_STUDYX_PTS to obtain interpolated SWELs from TIN_SWEL_STUDYX. Use the attribute field calculator to populate the FldELEV attribute field.
    a. If the coverage of the stillwater surface does not encompass all the AUDIT_STUDYX_PTS features, elevations must be manually assigned to the points by extrapolation of the SWEL surface information. Ensure that extrapolation assumptions are consistent with those applied in mapping the 1-percent-annual-chance floodplain boundary.
    b. If spatial SWEL data are not available in digital format, process all points as described in Step 12.
12. Populate AUDIT_STUDYX_PTS in wave runup areas with BFEs.
    a. Join the AUDIT_STUDYX_PTS with COASTAL_FLD_HAZ_AR_STUDYX by performing a spatial join. Use the "is closest to" option. This will create a new feature class with the points from AUDIT_STUDYX_PTS and the attributes from the point and polygon feature classes.
    b. Use the attribute calculator to populate the FldELEV field with the values from the STATIC_BFE field. Be sure not to overwrite elevations for wave propagation areas while performing this calculation.

    c. After populating the FldELEV field, remove all additional fields from the new AUDIT_STUDYX_PTS that resulted from the join with COASTAL_FLD_HAZ_AR_STUDYX.

13. Using 3D analyst, use the Add Z Information tool to obtain the interpolated terrain elevations from TIN_TOPO_STUDYX. Use the attribute field calculator to populate the GrdELEV attribute field. If terrain was not available in digital format, terrain elevations will have to be assigned by hand from the georeferenced terrain maps.
14. Calculate the ElevDIFF field of AUDIT_STUDYX by taking the absolute value of the difference between FldELEV and GrELEV.
15. Assign the Risk Classification to the audit points by performing a spatial join of AUDIT_STUDYX_PTS and the X_RiskClassifications shapefile. Determine the status of each point based on tolerances of the risk class it belongs and calculate into the Status field the attribute Pass = “P” and Fail = “F”. It may be necessary to evaluate points for horizontal tolerance.
16. Note any points that do not pass due to accepted coastal mapping practices as exceptions in the validation column and calculate into the Status field the attribute Exception = “Ex”. Detailed descriptions of the justification for these exceptions is provided in Section 6.4. Each exception should be classified as one of the following in the Validation column:
    a. “PFD_Except” for points located along a boundary based on delineation of the primary frontal dune (PFD).
    b. “Erosion_Except” for points located along a boundary where the topographic data differ from the eroded profile used in the wave hazard modeling.
    c. “Runup_Except” for points located along the boundary where it is transitioning between runup reaches that differ by multiple feet.
    d. “Combined_Except” in areas being audited based on BFE polygons, for points located along the boundary where zones have been combined due to map scale limitations and the BFE is not equal to the flood elevation controlling the SFHA boundary.
    e. “OT_Except” for points along the SFHA boundary delineated based on an overtopping zone.
    f. “River_Coast_Except” for points located along a boundary where BFEs have been derived from a combined stillwater frequency curve based on both coastal and riverine flooding contributions.
17. Determine if the AUDIT_STUDYX_PTS passes the equal to or greater than the 95-percent pass percentage at the +/- 1.0 foot threshold, or the appropriate percentage for each risk class. If it does, then the study passes and no more analysis needs to be done. Skip to Step 18. Exception points should not be included in establishing the point total for the purpose of calculating the pass/fail percentage rate for a study audit.
18. Record/Report results in the FBS Self-Certification Report.
19. Submit the FBS Self-Certification Report along with the audit spatial files to the MIP.

4.3. GIS Method for Assessing FBS Compliance for Riverine Floodplain Mapping Base Study Methods (Zone A)

The Zone A floodplain boundaries are not associated with a given BFE in the FIRM Database; therefore, a more general approach must be taken to assess the floodplain boundaries. However, there may be instances where a stream studied by base methods has a model or cross sections with water surface elevations. If this is the case, the enhanced study procedure can and should be used.

The following is the proposed approach to be used when water surface elevations for streams studied by base methods are not readily available. Ensure that you have all digital and non-digital data, including the final X_RiskClassifications shapefile, as defined in Section 2.1.

1. Start a new GIS project.
2. Load all applicable digital data into the GIS project.
3. Build a study level TIN = TIN_STUDYX using the digital terrain information. If the study terrain data are non-digital, the terrain maps will have to be scanned and georeferenced so that ground elevations can be assigned to the points by hand.
4. Extract the Zone A 1-percent-annual-chance flood lines and export them to a new shapefile/feature class = APPROX_FLD_HAZ_LN_STUDYX. Add the new file to the GIS project.
5. Extract the Zone A 1-percent-annual-chance flood polygons and export them to a new shapefile/feature class = APPROX_FLD_HAZ_PLY_STUDYX. Add the new file to the GIS project.
6. Clip the S_WTR_LN with the APPROX_FLD_HAZ_PLY_STUDYX polygon feature to create a new APPROX_WTR_LN shapefile/feature class.
7. Note: If there is no S_WTR_LN in the ZONE A areas, one will have to be created manually using the base map information before the clipping can occur.
8. Using the APPROX_WTR_LN file, create a new point shapefile/feature class = A_WTR_PTS_STUDYX, which has points that are evenly spaced along the APPROX_WTR_LN (every 500 feet). Add the TEST_PTS_STUDYX to the GIS project.
9. Create a new line shapefile/feature class; audit cross-section lines (A_XS_STUDYX) by drawing audit cross sections perpendicular to APPROX_WTR_LN at the A_WTR_PTS_STUDYX.
10. Assign every A_XS_STUDYX a unique ID.
11. Intersect the A_XS_STUDYXs with the APPROX_FLD_HAZ_LN_STUDYX and use the intersection points of the two to create a new point shapefile/feature class AUDIT_STUDYX_PTS being sure to transfer the A_XS_STUDYXs unique IDs to the AUDIT_STUDYX_PTS.
12. Add the following fields to the TEST_PTS_STUDYX attribute table.
    a. GrELEV1 – type = numeric, 6, 2
    b. GrELEV2 – type = numeric, 6, 2
    c. ElevDIFF – type = numeric, 6, 2

    d. RiskClass – type = string, length = 2
    e. Status – type = string, length = 2
    f. Validation – type = string, length = 20
    g. Comment – type = string, length = 100

13. Intersect AUDIT_STUDYX_PTS with the TIN_STUDYX to transfer the interpolated terrain elevations onto the AUDIT_STUDYX_PTS GrdELEV attribute field.
14. Note: If terrain was not available in digital format, terrain elevations will have to be assigned by hand from the georeferenced terrain maps.
15. Break the resulting AUDIT_STUDYX_PTS into two new shapefile/feature classes by doing a unique selection on the attribute XS_ID field and export the first selection to AUDIT_STUDYX_PTS1. Reverse the selection and export the second selection to AUDIT_STUDYX_PTS2.
16. Do a table join of AUDIT_STUDYX_PTS2 to AUDIT_STUDYX_PTS1.
17. Calculate the ElevDIFF of AUDIT_STUDYX_PTS1 by subtracting GrELEV1 from GrELEV2.
18. Determine if the AUDIT_STUDYX_PTS1 passes the equal to or greater than the 95-percent pass percentage at the +/- ½ contour threshold. If so, then the study passes and no more analysis is necessary. Skip to Step 27.
19. If the AUDIT_STUDYX_PTS1 fails the equal to or greater than the 95-percent pass percentage at the +/- ½ contour threshold, then intersect the AUDIT_STUDYX_PTS1 with the X_RiskClassifications shapefile to transfer the Risk Classes onto the AUDIT_STUDYX_PTS1.
20. Determine the status of each point based on tolerances of its risk class and calculate into the Status field the attribute Pass = “P” and Fail = “F”.
21. Select out the individual Risk Classes to their own AUDIT_STUDYX_PTS1_RskClass shapefile/feature.
22. Determine the pass rate for each audit study’s risk class. If the study now passes at the Risk Class level, no more analysis is necessary. Skip to Step 27.
23. If the AUDIT_STUDYX_PTS fails the equal to or greater than pass rate for each audit study’s risk classes, then intersect the AUDIT_STUDYX_PTS with the NHD 100k subbasin shapefile.
24. Add a new field attribute to the AUDIT_STUDYX_PTS file.
    a. Subbasin – type = string, length = 50
25. Calculate the Subbassin field in the AUDIT_STUDYX_PTS file with the intersected NHD 100k subbasin shapefile.
26. Now determine the AUDIT_STUDYX_PTS pass rate for each audit study’s risk classes at the subbasin level.
27. Record/Report Results in the FBS Self-Certification Report.
28. Submit the FBS Self-Certification Report along with the spatial files to the MIP.

5. Audit Procedures

This section describes procedures for evaluating the reliability of a study's floodplain boundaries. If conducted, the FBS Self-Certification Audit will entail a review of the FBS Self-Certification Report and supporting data that have been uploaded to the MIP to ensure adequate information to quantifiably demonstrate that the requirements specified in Table 2 have been satisfied.

If chosen, maps will be audited either before they are issued Preliminary or after they go Effective. They will not be audited during the post-preliminary period prior to the effective date of the new maps. The topographic data used by the Mapping Partners to create the FIRM Database will be used for the audit unless that topographic data are no longer available. If the source topographic data are not available or cannot be determined, then the FIRM Database will not be audited. These flooding sources will be considered noncompliant with the FBS in their entirety unless documentation from the FEMA region indicates that redelineation of the floodplain boundary onto available topographic data would degrade the quality of the delineation. Receipt of this documentation from the FEMA region would serve as compliance with the FBS.

The results of all audits performed (pass or fail) will be provided first to the FEMA region and then the Mapping Partner at the direction of the FEMA region. In the event a particular study fails the audit, the Mapping Partner will be given the opportunity to review and respond to the audit results. A project may fail to meet the FBS for a variety of reasons, and the Mapping Partner will be given ample opportunity to provide justification. Copies of the justifications must be provided to the auditor, FEMA headquarters, and the FEMA region. The FEMA region will be the final adjudicator of all justifications submitted. If the justifications are found to be acceptable (by the region), the floodplain boundaries in question would be considered to pass the FBS audit and counted toward Congressional Goal 2. Examples of potentially legitimate justifications are provided below:

1. Original topographic mapping used to prepare the effective FIS report and FIRM could not be found, but as documented in the FIS report, it was of better detail and accuracy than the data used to run the check AND making the boundaries fit the ground elevation data used in the check would result in a less reliable product (This assumes that the original topographic map was used to redelineate the boundary and not just digitize the effective FIRM. FEMA's legacy inventory [FIRMs effective prior to FY 2003] is not horizontally set to a coordinate system; therefore, many of the boundaries were forced within a small local area for "relative" accuracy).
2. An existing feature not reflected in the topographic data was accounted for when preparing the mapped floodplain boundary.

Mapping projects that fail the audit will not be considered to meet the FBS, but the stream miles that meet the standard will count toward Congressional Goal 2. For such projects, FEMA will work with the state, communities, and the Mapping Partner to determine the appropriate course of action for the project, such as initiating a new flood map update or leaving the product "as is" until a later date. Factors to consider when making this decision might include community and state desires, availability of resources, capitalizing on the utility of the product, impact on Congressional Goal 2, timeliness of the audit in relation to the effective date, relative flood risk, and others.

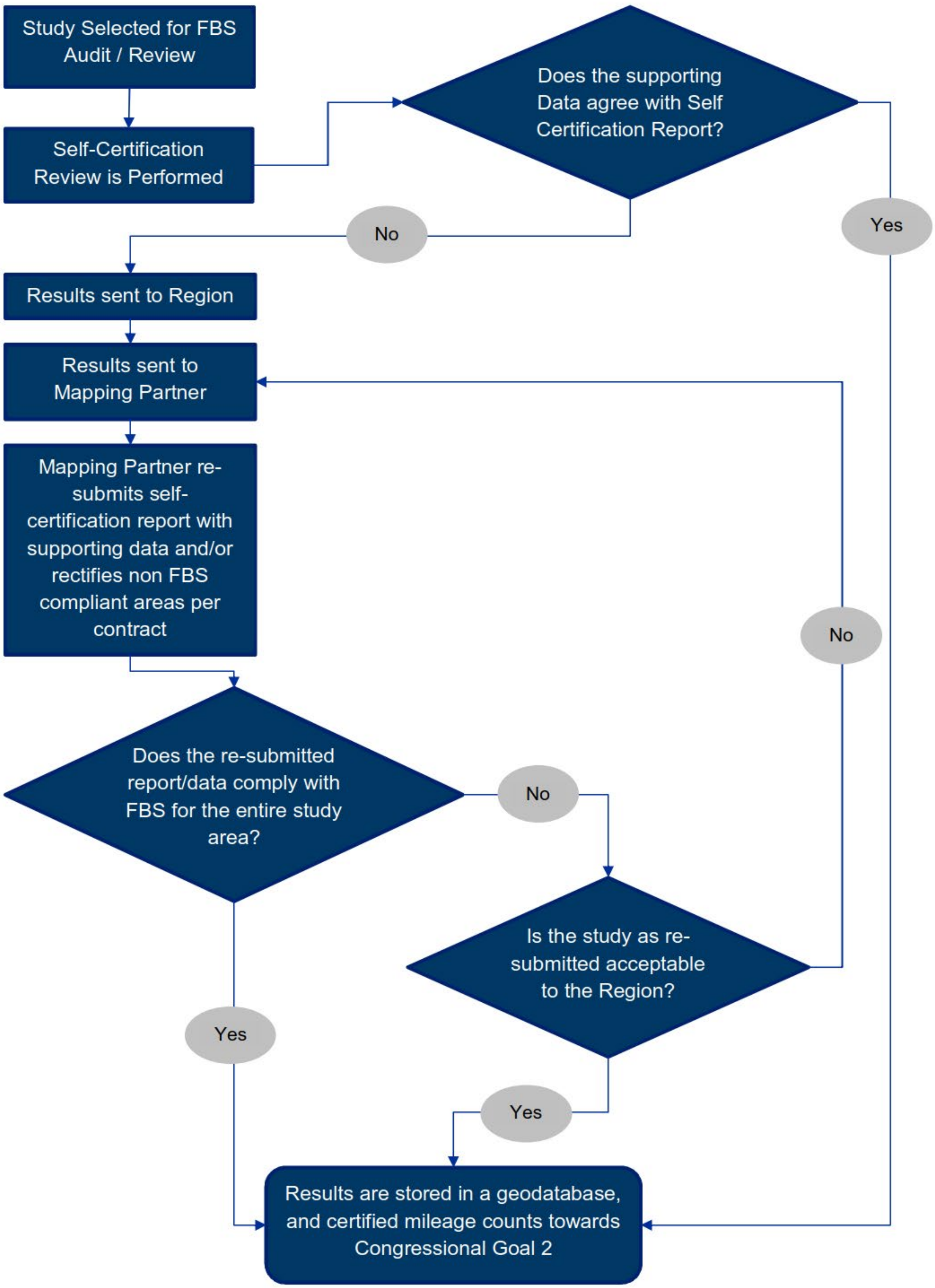

Figure 1: Auditing Process Flowchart

5.1. FBS Exceptions

Areas around hydraulic structures cause unique challenges for the self-certification and audit processes, and therefore will require special handling to ensure false results are not reported. Similarly, many aspects of coastal analysis and mapping procedures can result in points that fail the standard audit process. Challenges described in the following subsections that impact failed points will be screened by FEMA's Contractor performing the audit, flagged as exceptions = "Ex" in the status column, and be made available to the regions for review. The type of exception should be noted in the Validation column. Exception points should not be included in establishing the point total for the purpose of calculating the pass/fail percentage rate for a study audit. The impact of exception points will be reported to the region to help determine compliance with the standard.

5.2. Hydraulic Structures

At many bridges and culverts, hydraulic structures are not overtopped. If the floodplains are mapped solely on elevation, this would result in floodplains that stop just downstream of roads and then resume upstream of the roads. Instead, the floodplain is usually mapped to the width of the floodway through the structure, or just wider than the floodway. Therefore, these points should not be considered in establishing the pass/fail percentage rate for a study audit and marked as exceptions (Hydro_Except) in the audit report.

5.3. Levees

Current FEMA mapping procedures call for the mapping of the floodplain boundary at accredited levees to be delineated either at the levee center line or the landward toe of the levee. Either of these practices result in boundary delineations along ground elevations that are most likely not equal to the BFE. Test points in these areas should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (Levee_Except) in the audit report.

5.4. Primary Frontal Dunes

Current policy requires the Zone VE to extend to the landward heel of the PFD and that the BFE be the wave height or wave runup elevation encountered at the dune face. Since there is not a hydraulic relationship between the ground elevation and the Zone VE boundary, failed points that fall along a Zone VE based on the PFD should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (PFD_Except) in the audit report.

5.5. Modeled Erosion Areas

Exception areas may exist where the terrain was modified by episodic erosion analysis during the coastal flood hazard modeling. The erosion analysis results in a profile with elevations lower than those that are reflected in original terrain data. As a result, SWELs and mapped BFEs may be lower than ground elevations and still be correct and accurately mapped. Test points in these areas should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (Erosion_Except) in the audit report.

5.6. Wave Runup Areas

Other exception areas may exist in areas of wave runup and barrier overtopping. Flood zones mapped on the basis of wave runup may differ by multiple feet across a single gutter; the SFHA boundary at that gutter will need to transition between the elevations of the two zones. Test points in these transition areas should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (Runup_Except) in the audit report.

5.7. Coastal SFHA Combined Areas

Exception areas may also exist where zones are combined near the SFHA boundary due to map-scale limitations. These areas result in the SFHA boundary being delineated at an elevation not equal to the BFE in certain coastal areas where large changes in the BFE may occur over a short distance. This issue should only affect audit points in areas of overland wave propagation where a stillwater surface was not available, and therefore, the FldELEV is based on the static BFE. In such cases, test points should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (Combined_Except) in the audit report.

5.8. Overtopping Zones

An overtopping zone is mapped behind coastal flood protection structures or steep shorelines where wave runup exceeds the crest of the barrier. The BFE is based on the runup elevation which can be significantly greater than the ground elevation in overtopping zones. If an SFHA boundary is mapped at the landward boundary of the overtopping zone, the ground elevation will likely not be equal to the BFE. In such cases, test points should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (OT_Except) in the audit report.

5.9. Riverine/Coastal Transition Zones

Exception areas may also exist in areas where the BFE is based on the combined probability of riverine and coastal flooding. These riverine/coastal transition zones may exist in the lower reaches of all tidal rivers. If the transition zones are mapped as riverine areas with BFE lines, they should be audited with the riverine methodology and audit points that fail are not granted exception status. However, if the area is mapped as a coastal flood zone, audit points may fail since the SFHA boundary is mapped to the BFE which will be greater than the independent coastal SWEL that is specified to be used in the audit procedure. In such cases, failed points should not be considered in establishing the pass/fail percentage rate for a study audit and should be marked as exceptions (River_Coast_Except) in the audit report.