D.2.11 Mapping of Flood Insurance Risk Zones and Base Flood Elevations

This subsection provides guidance to Mapping Partners on the delineation of coastal flood insurance risk zones and BFEs.

D.2.11.1 Review and Evaluation of Basic Results

Before mapping the flood elevations and flood insurance risk zones, the Mapping Partner should review results from the models and assessments from a common-sense viewpoint and compare them to available historical flood data. When using models, there is the potential to forget that transects represent real shorelines being subjected to high water, waves, and winds. Familiarity and experience with the coastal area being modeled, or with similar areas, should provide an idea of a "reasonable" result.

The main point to be emphasized is that the results should not be blindly accepted. There are many uncertainties and variables in coastal processes during an extreme flood, and many possible adjustments to methodologies for treating such an event. The validity of any model is demonstrated by its success in reproducing recorded events. Therefore, the model results must be in basic agreement with past flooding patterns, and historical data must be used to evaluate these results.

It would be very convenient if data from a storm closely approximating the 1-percent-annual-chance flood were available, but this is seldom the case. Although most historical flood data are for storms less intense than a 1-percent-annual-chance flood, these data will still indicate, at a minimum, the areas that should be within a flood zone. For instance, if a storm that produced a flood below the 1-percent-annual-chance flood elevation generally caused structural damage to houses 100 feet from the shoreline, a "reasonable" VE Zone width must be at least 100 feet. Similarly, houses that collected flood insurance claims for the same storm (without building foundation or structural damages) should at least be located in an AE, AH, or AO Zone. If the analyses of the 1-percent-annual-chance flood produce flood zones and elevations indicating lesser hazards than those recorded for a more common storm, the analyses should be reevaluated. One possible explanation for changes in flood patterns because the historical flood event might be that a new coastal structure now acts to reduce flood hazards in the local area.

If there are indications that a reevaluation is needed, the Mapping Partner should determine whether the results of the assessment are appropriate. The Mapping Partner should attempt to compare all aspects of the coastal hazard assessment to past effects, whether in the form of data, profiles, photographs, or anecdotal descriptions. The Mapping Partner should examine other data input to the assessments for wave effects (wave setup, wave height, wave runup, and wave overtopping). This includes checking that the stillwater levels are correct and that the results of wave analyses are consistent with the historical data. The Mapping Partner should use judgment and experience to project previous storm effects onto the 1-percent-annual-chance conditions and to ensure that the coastal assessment results are consistent with previous observed events.

D.2.11.2 Identification of Flood Insurance Risk Zones

The Mapping Partner should identify the flood insurance risk zones and BFEs, including the wave effects, to be identified on each transect plot before delineating the flood insurance risk zones on the work maps. The existing topography, eroded topography, presence of PFDs, coastal structure effects, combined wave analyses (wave runup, overtopping, and overland propagation) are all important for the proper identification of flood insurance risk zones. Hazard zones that are generally mapped in coastal areas include VE, AE, AH, AO, and X.[16]

D.2.11.2.1 VE Zone

VE Zones are coastal high hazard areas where wave action and/or high-velocity water can cause structural damage during the 1-percent-annual-chance flood. VE Zones are identified using one or more of the following criteria for the 1-percent-annual-chance flood conditions:

- The ***wave runup zone*** occurs where the (eroded) ground profile is 3.0 feet or more below the 2-percent wave runup elevation.
- The ***wave overtopping splash zone*** is the area landward of the crest of an overtopped barrier, in cases where the potential 2-percent wave runup exceeds the barrier crest elevation by 3.0 feet or more ($\Delta R > 3.0$ feet). (See Subsection D.2.8.2.)
- The ***breaking wave height zone*** occurs where 3-foot or greater wave heights could occur (this is the area where the wave crest profile is 2.1 feet or more above the total stillwater level).
- The ***primary frontal dune zone***, as defined in 44 CFR Section 59.1 of the NFIP regulations (see Subsection D.2.9.3.1 of this document for more details).

The actual VE Zone boundary shown on the FIRM is defined as the farthest inland extent of any of the four criteria listed above. VE Zones are subdivided into elevation zones, and whole-foot BFEs should be assigned (see Subsection D.2.11.4).

When the potential runup is at least 3.0 feet above the barrier crest (criterion 2), a VE Zone is delineated landward of the barrier. The BFE for that VE Zone is capped at 3 feet above the crest of the barrier. When the runup depth in excess of the barrier crest is 0.1 to 1.5 feet, the VE Zone BFE is the runup elevation (rounded to the nearest whole foot), and an AO Zone with a depth of 1 foot should be mapped landward until another flooding source is encountered (Zone AE) or the floodplain limit is reached (Zone X). Similarly, for a runup depth of 1.5 to 2.9 feet above the barrier crest, the VE Zone BFE is the runup elevation (rounded to the nearest whole foot). In this case, however, an AO Zone with a depth of 2 feet should be mapped, then transitioned landward into an AO Zone with a depth of 1 foot, and into subsequent flood insurance risk zones, if any.

VE Zone criterion 3, the designation of a 30-foot splash zone, should be applied to both vertical walls and sloping barriers upon the identification of wave overtopping hazards (D.2.8.2).

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[16] For a complete list of flood insurance risk zones, refer to Volume 1, Section 1.4.2.7, of the *Guidelines and Specifications*.

Delineation of the landward limit of the VE Zone based on the PFD (criterion 4) requires detailed topographic data and engineering judgment. Identifying the PFD heel, "the point where there is a distinct change from a relatively steep slope to a relatively mild slope" (per Section 59.1 of the NFIP regulations) can be particularly challenging when there are inadequate topographic data and/or encroachments into the dune ridge system that obscure this slope change.

The Mapping Partner should review the available topographic data and, if necessary, conduct field verification to delineate PFDs in the study area. Previous flood insurance studies may have identified PFDs and used these features as the basis of the effective FIRM's VE Zone; such information should be reviewed to aid in locating PFDs that exist at the time of the restudy. The Mapping Partner is cautioned to carefully evaluate any preexisting methods for PFD heel delineation to ensure that a reasonable approach is applied to the study area.

It is possible that a PFD may be identified landward of a shore protection structure. If the structure can be certified per the criteria in the April 23, 1990, FEMA memorandum (FEMA, 1990), *Criteria for Evaluating Coastal Flood Protection Structures for National Flood Insurance Program Purposes* (see Subsection D.2.10.2.1), the VE Zone should be delineated based on the wave analyses for that transect (criteria 1-3, as applicable), not on the PFD heel. If the structure cannot be certified and will partially or completely fail during the base flood, the VE Zone should be mapped to the PFD landward heel. Certified structures with a crest at or below the dune toe or the 10-year flood level will provide little more than protection from toe scour to a dune and will not protect inland areas or dunes from hazardous flood conditions. Low-crested structures would warrant PFD VE Zone determinations landward if deemed appropriate based on wave runup and wave height propagation analysis.

In all cases where the PFD is the basis of the VE Zone, the BFE to be applied will be the wave height or wave runup elevation encountered at the dune face; see Examples 1 and 2 in Subsection D.2.11.5 (Figures D.2.11-3 and D.2.11-4) for more information.

D.2.11.2.2 AE Zone

AE Zones are areas of inundation by the 1-percent-annual-chance flood, including areas with wave heights less than 3.0 feet and runup elevations less than 3.0 feet above the ground. These areas are subdivided into elevation zones, and BFEs are assigned. The AE Zone will generally extend inland to the limit of the 1-percent-annual-chance flood SWEL.

D.2.11.2.3 AH Zone

AH Zones are areas of shallow flooding or ponding, with average water depths between 1.0 foot and 3.0 feet. These areas are usually not subdivided, and a BFE is assigned.

D.2.11.2.4 AO Zone

AO Zones are areas of sheet-flow shallow flooding, or where the potential runup is less than 3.0 feet above an overtopped barrier crest (ΔR<3.0 feet). The sheet flow in these areas will either flow into another flooding source (AE Zone), result in ponding (AH Zone), or deteriorate because of ground friction and energy losses to merge into the X Zone. AO areas are designated with 1-, 2-, or 3-foot depths of flooding.

D.2.11.2.5 X Zone

X Zones are areas above the 1-percent-annual-chance flood level. On the FIRM, a shaded X Zone area is inundated by the 0.2-percent-annual-chance flood, and an unshaded X Zone area is above the 0.2-percent-annual-chance flood.

D.2.11.3 Wave Envelope

The seaward portion of the wave envelope is a combination of the potential wave runup elevation and the controlling wave crest elevation profile. The wave crest elevation profile is plotted along a transect (from the 0.0 map datum elevation landward) based on the results of the WHAFIS model or other methodology. A horizontal line is extended seaward from the potential wave runup elevation to its intersection with the wave crest profile to obtain the wave envelope, as shown in Figure D.2.11-2. If the runup elevation is greater than the maximum wave crest elevation, the wave envelope will be represented as a horizontal line (extending to the elevation 0.0 location on the transect) at the runup elevation, and the BFE for mapping purposes will be based on that elevation. Conversely, if the wave runup is negligible, the wave crest elevation profile becomes the wave envelope.

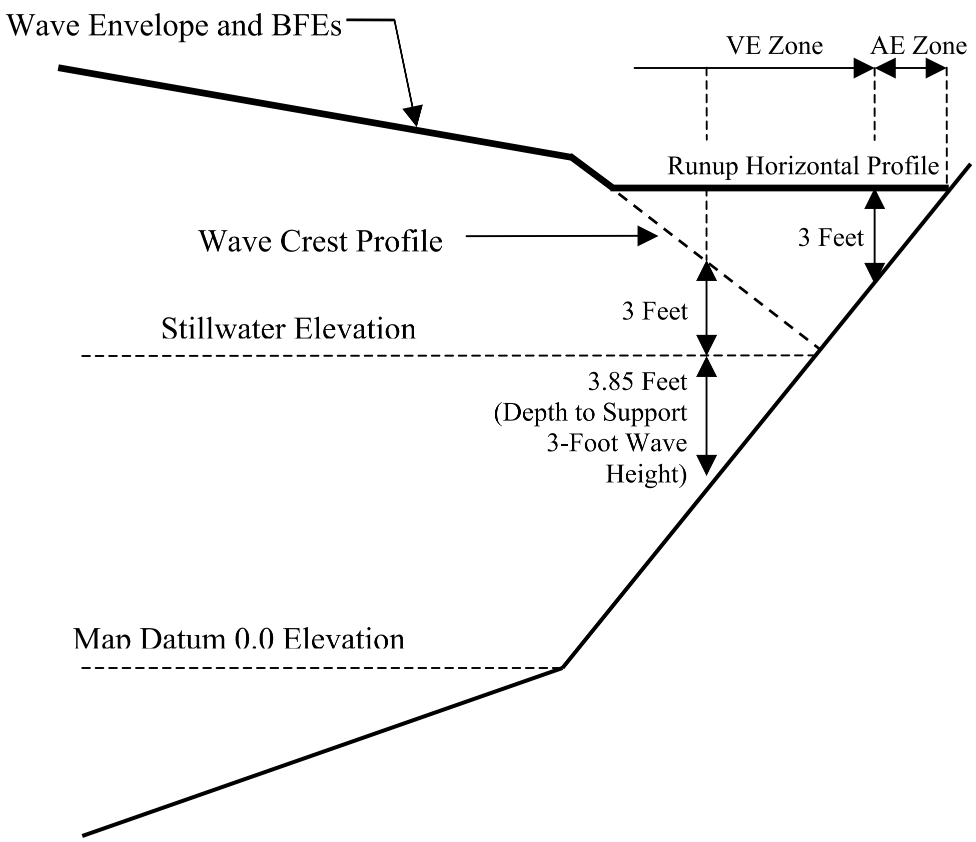

Figure D.2.11-2. Seaward Portion of Wave Envelope Based on Combination of Nearshore Crest Elevations and Shore Runup Elevation (figure not to scale)

D.2.11.4 Criteria for Flood Boundary and Hazard Zone Mapping

The first step in identifying the flood insurance risk zones along a transect is locating the inland extent of the VE Zone, also known as the VE/AE boundary. The mapped VE/AE Zone boundary is based on the most landward limit of the four criteria outlined in Subsection D.2.11.2.1. The Mapping Partner should extend the AE Zone from the VE/AE boundary to the inland limit of 1-percent-annual-chance inundation, which is a ground elevation equal to the potential runup elevation, or the 1-percent-annual-chance SWEL if runup is negligible. The Mapping Partner may designate additional areas of 1-percent-annual-chance flooding caused by wave overtopping sheet flow and shallow flooding or ponding as the AO Zone and/or the AH Zone. The Mapping Partner should label all areas above 1-percent-annual-chance inundation as the X Zone (shaded for areas affected by the 0.2-percent-annual-chance flood and unshaded for areas above the 0.2-percent-annual-chance flood level).

The Mapping Partner should then subdivide the VE and AE Zone areas into elevation zones, with whole-foot BFEs assigned according to the wave envelope. Generally, the VE Zone is subdivided first. Initially, the Mapping Partner should mark the location of all elevation zone boundaries on a transect. Because whole-foot BFEs are being used, these should always be mapped at the location of the half-foot elevation on the wave envelope. However, the Mapping Partner should not subdivide the horizontal runup portion of the seaward wave envelope (see Figure D.2.11-2). The BFE should simply be the runup elevation, rounded to the nearest whole foot.

Ideally, the Mapping Partner would establish an elevation zone for every BFE in the wave envelope; however, because these zones are mapped on the FIRM so that buildings or property can be located in a flood insurance risk zone, the Mapping Partner should use a minimum width for the mapped zone to provide a usable FIRM. For coastal areas, the general guidance is to have a minimum zone width of 0.2 inch on the FIRM. The mapping criteria and the ability to map all coastal BFE and hazard zone changes is dependent upon the scale of the FIRM. The minimum zone width is 0.2 times the final FIRM scale; for example, a width of 80 feet for a FIRM at a scale of 1 inch equals 400 feet, or a width of 100 feet for a FIRM at a scale of 1 inch equals 500 feet. Because digital FIRM data can easily be enlarged, the map scale limitations should be reviewed by the Mapping Partner with the FEMA Study Representative and community officials.

The Mapping Partner should combine elevation zones that do not meet the minimum width requirement with an adjacent zone or zones to yield an elevation zone equal to or wider than the minimum width. The BFE for this combined zone is a weighted average of the combined zones, rounded to the nearest whole foot. When combining VE Zones, the Mapping Partner should not reduce the maximum BFE at the shoreline by averaging.

The AE Zone, if wide enough, should be subdivided in the same manner. If the total AE Zone width is less than the minimum width requirement, the VE Zone with the lowest elevation is usually assigned to that area. This situation typically occurs for steep or rapidly rising ground profiles, and it is not unreasonable to designate the entire inundated area as a VE Zone. In some cases, however, it may be appropriate for the Mapping Partner to extend the AE Zone slightly into the next zone seaward to satisfy the minimum width requirement.

Relatively low areas landward of zones subject to wave effects may be subject to shallow flooding or the ponding of floodwater; the Mapping Partner should designate these areas as AO or AH Zones. Such designations can be relatively common landward of coastal structures, bluffs, ridges, and dunes, where wave overtopping occurs.

Identifying appropriate zones and elevations may require particular care for dunes, given that the entire PFD is defined as a coastal high hazard area. Although the analyses may have determined that a dune will not completely erode and that the wave action should stop at the retreated dune face with only overtopping possibly propagating inland, the Mapping Partner should designate the entire dune as a VE Zone, as defined in the NFIP regulations. The Mapping Partner should assign the last calculated BFE at the open-coast dune face (whether VE or AE Zone) to be the dominant VE Zone BFE for the entire PFD and should extend this value to the landward limit of the PFD. It may seem unusual to use a BFE lower than the ground elevation, but this is fairly common. Most of the BFEs for areas where the dune was assumed to be eroded are also below existing ground elevations. In these cases, it is the VE Zone designation that is most important to the NFIP because, under current regulations, structures in VE Zones must be built on pilings and alterations to the dunes are prohibited.

D.2.11.5 Transect Examples

Settings occurring along the Atlantic and Gulf coastlines include the following:

- Sandy beach backed by a low sand dune or sand berm
- Sandy beach backed by a high sand dune formation
- Sandy beach backed by shore protection structures
- Cobble, gravel, shingle, or mixed-grain-size beach and berms
- Erodible coastal bluffs
- Non-erodible coastal bluffs or cliffs
- Tidal flats and wetlands

The examples discussed below depict idealized transects for these beach settings, where erosion, wave runup, and overtopping are the dominant coastal processes, to illustrate common flood hazard zonations in a quantitative way. The BFEs shown are arbitrary and are included for illustrative purposes only.

> **Example 1.** Figures D.2.11-3a and D.2.11-3b illustrate flood hazard mapping for a transect where the dune or sand berm does not meet the 540-foot criterion and will be removed in the erosion assessment, allowing wave heights to dominate the flood insurance risk zones throughout the 1-percent-annual-chance floodplain. In this scenario, the WHAFIS (or a similar wave-height model) results can be mapped directly, with only zone averaging required for any flood zones that cannot be mapped at the final map scale.

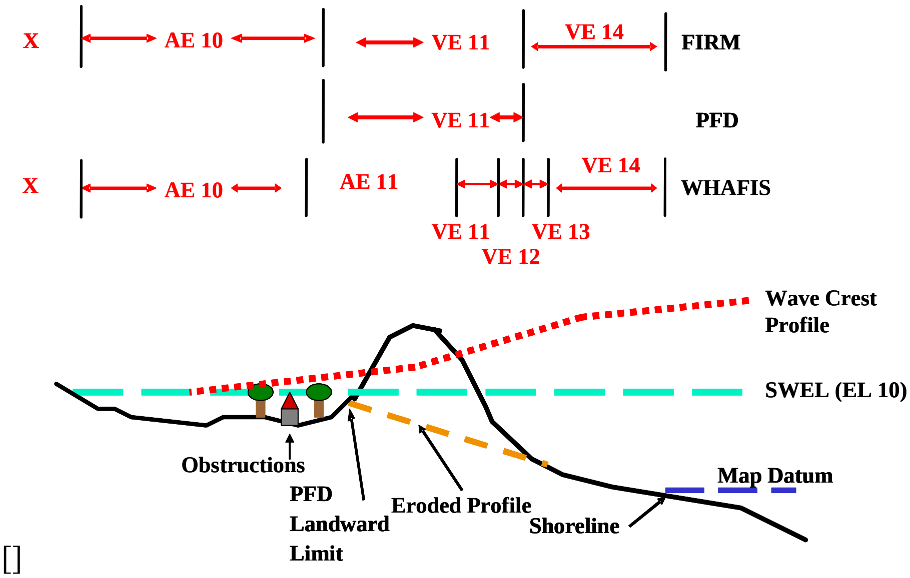

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Figure D.2.11-3a. Example 1: Sandy Beach backed by Low Dune, with Wave Height Propagation and PFD Controlling the Flood insurance risk zone Mapping.

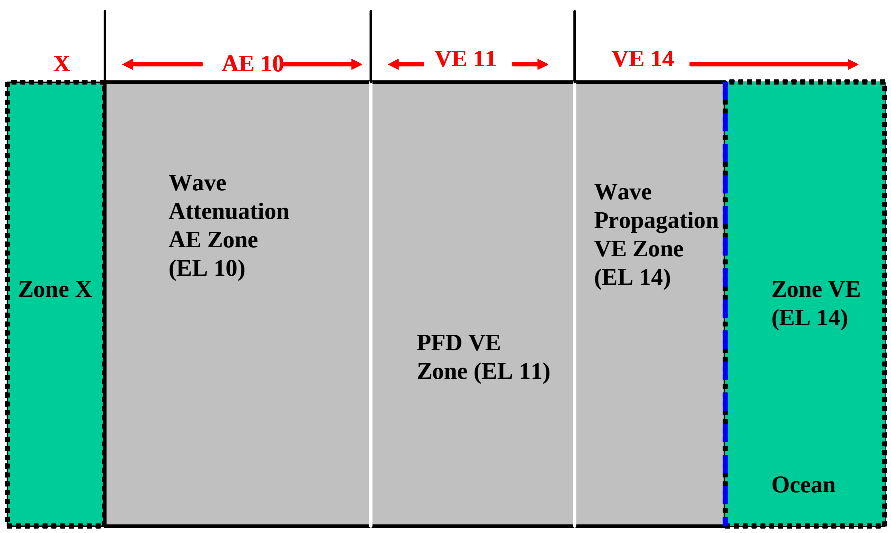

Figure D.2.11-3b. Example 1: Sandy Beach backed by Low Dune, with Wave Height Propagation and PFD Controlling the Flood insurance risk zone Mapping.

Example 2. Figures D.2.11-4a and D.2.11-4b illustrate flood hazard mapping for a low coastal dune where the dune cross section is insufficient to prevent removal by the 1-percent-annual-chance flood. The eroded profile is calculated and adjusted (see Subsection D.2.9), then the resulting profile is checked for inundation, overland wave propagation, wave runup, and overtopping. In the example shown, the remnant dune crest is not inundated, so overland wave propagation is not mapped. Instead, hazard zones are mapped based on the combined effects of wave runup, overtopping splash (runup extends more than 3.0 feet above the crest in this example), and PFD. Guidance for determining AO zone depths based on the overtopping rate is provided in Subsection D.2.8.2.3. In this example, the overtopping splash zone extends farther landward than the PFD and determines the VE/AO boundary.

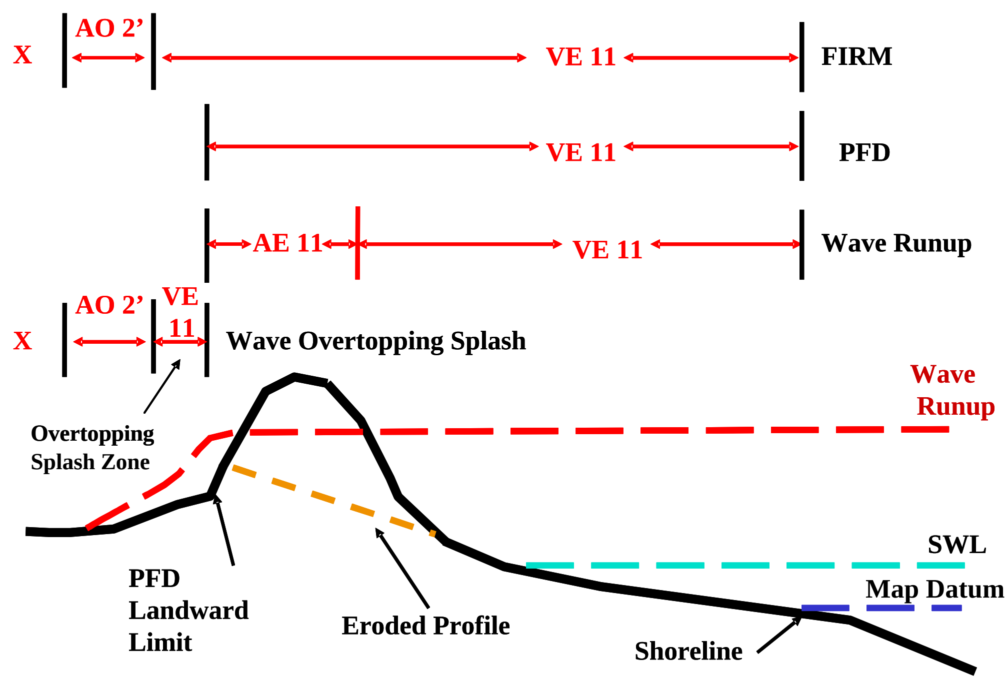

Figure D.2.11-4a. Example 2: Sandy Beach Backed by Low Sand Dune with Overtopping Splash Controlling VE Zone

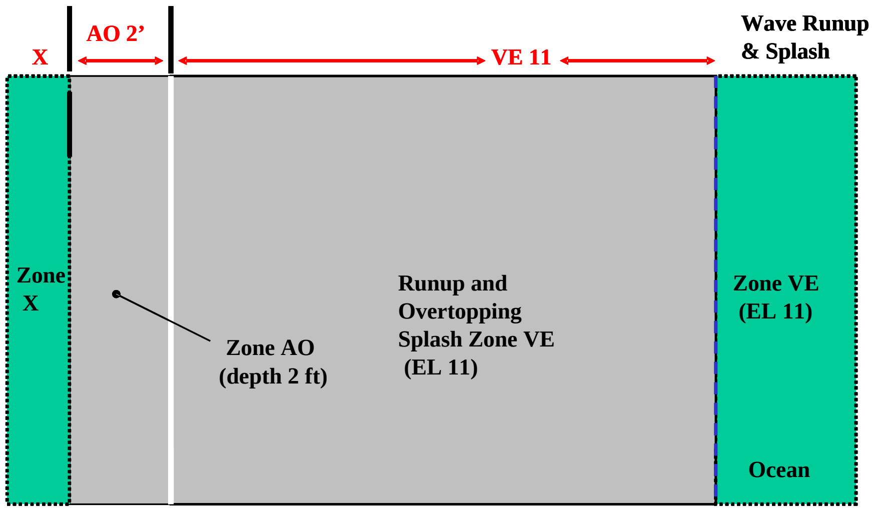

Figure D.2.11-4b. Example 2: Sandy Beach Backed by Low Sand Dune with Overtopping Splash Controlling VE Zone

Example 3. Figures D.2.11-5a and D.2.11-5b illustrate flood hazard mapping for a PFD that is large enough (in cross section) to prevent its removal and high enough to prevent overtopping during 1-percent-annual-chance flood conditions. In the example shown, the eroded profile is first generated according to the dune retreat erosion regime (D.2.9), then wave runup on eroded profile is calculated (D.2.8). The 2-percent wave runup elevation is mapped. In the absence of a PFD designation, the area seaward of the eroded dune face would be mapped as an AE Zone, where the runup depth is less than 3.0 feet, or as a VE Zone where the runup depth is greater than 3.0 feet. The area landward of the eroded dune face would be mapped as X Zone. However, given the PFD designation, the area between the shoreline and the landward heel of the dune will be mapped as a VE Zone; the BFE at the dune face (EL 13) will be continued landward to the PFD landward limit. Note that this is the only mapping scenario where the hazard zone (landward of the dune face) is based on coastal morphology, not on actual flood hazards during the 1-percent-annual-chance flood. Likewise, the BFE landward of the dune face is an extension of the BFE at the dune face, not representative of the actual flood profile.

If the dune in Figure D.2.11-5a were not high enough to prevent overtopping and the potential runup extended more than 3.0 feet above the crest, an overtopping splash VE Zone would be indicated on the landward side of the eroded crest. In all cases, the BFEs landward of the eroded dune crest would be mapped at the higher BFE (PFD or splash zone) at any given point along the transect.

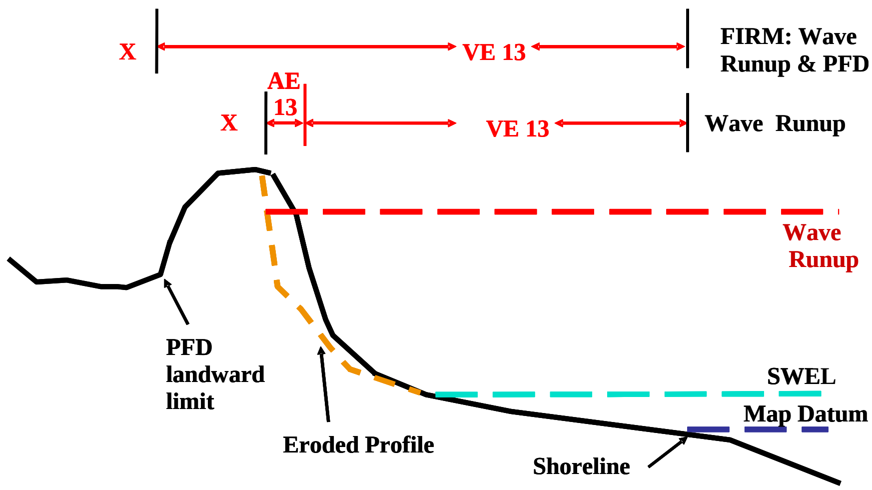

Figure D.2.11-5a. Example 3: Sandy Beach Backed by High Sand Dune with PFD Controlling the VE Zone

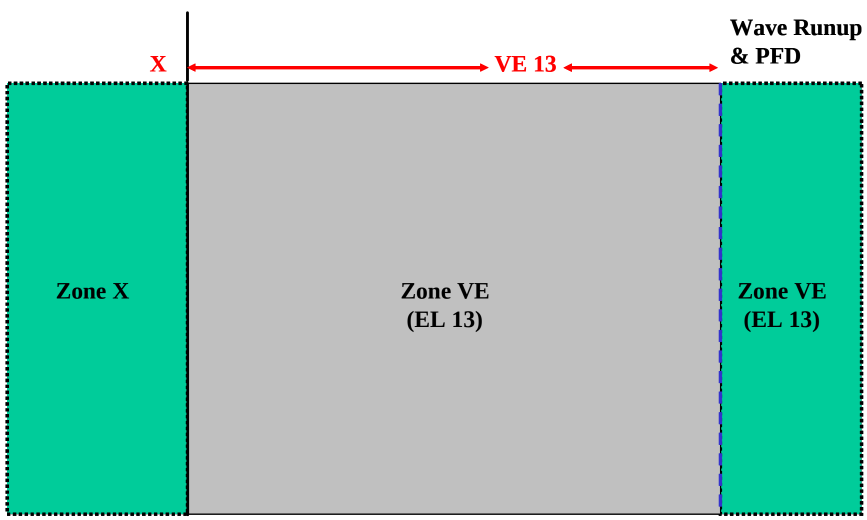

Figure D.2.11-5b. Example 3: Sandy Beach Backed by High Sand Dune with PFD Controlling the VE Zone

Example 4. Figures D.2.11-6a and D.2.11-6b illustrate flood hazard mapping for an overtopped coastal structure that remains intact during the 1-percent-annual-chance flood (see Subsection D.2.10.3 for a discussion of structure failure and local scour considerations). In this example, the potential runup reaches an elevation greater than 3.0 feet above the crest of the structure; therefore, an overtopping splash VE Zone is mapped landward of the structure crest. If the potential runup is less than 3.0 feet above the crest, no VE overtopping splash zone should be mapped; an AO sheet flow zone should be mapped instead. Guidance for determining AO zone depths based on the overtopping rate is provided in Subsection D.2.8.2.3. The same basic procedure is used for vertical and sloping structures, with the principal difference being the equations used to calculate wave runup and splash distances. Thus, if this particular structure was assumed to sustain total or partial failure during the 1-percent-annual-chance flood, a similar procedure would be applied, but with sloping structure equations rather than vertical structure equations.

For shore structures with steep slopes, runup elevations are relatively high and a wide range of wave hazards can occur, including erosion or scour near the structure. These circumstances may result in a variety of distinct and compact situations where appreciable engineering judgment can be required for the appropriate assessment of flood hazards.

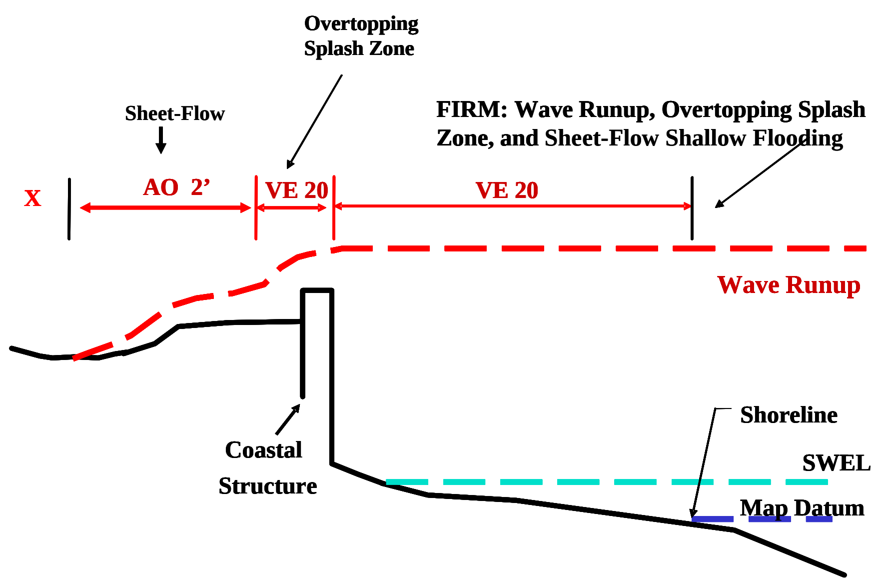

Figure D.2.11-6a. Example 4: Sandy Beach Backed by Shore Protection Structure with VE Zone Controlled by the Splash Zone from Wave Overtopping

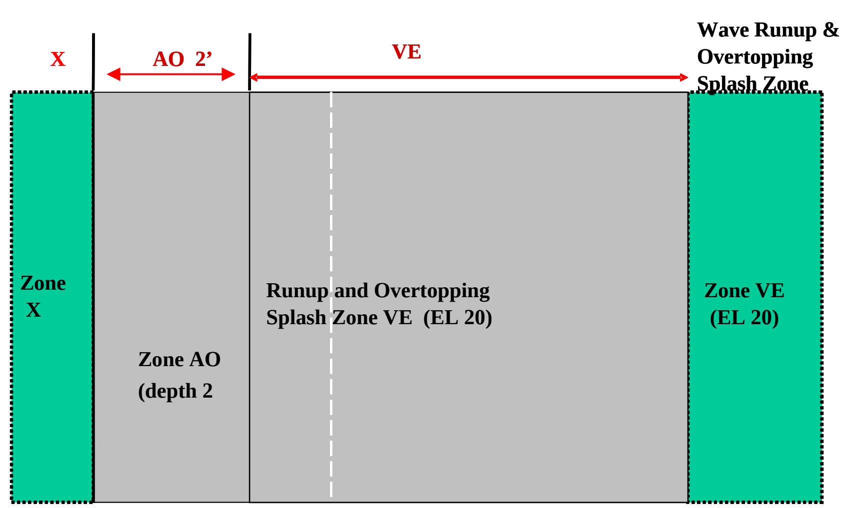

Figure D.2.11-6b. Example 4: Sandy Beach Backed by Shore Protection Structure with VE Zone Controlled by the Splash Zone from Wave Overtopping

Example 5. Figures D.2.11-7a and D.2.11-7b illustrate flood hazard mapping for a beach composed of gravel, cobble, or mixed-grain sizes. In this example, the profile configuration should be determined in accordance with Subsection D.2.9.3.2, and the wave hazards should be modeled using the eroded profile. There will be no PFD designation for a gravel, cobble, or mixed-grain-size profile, so the mapped hazard zones and BFEs will reflect calculated flood hazards only.

In this example, the potential runup is assumed to reach more than 3.0 feet above the crest, so an overtopping splash zone is mapped landward of the profile crest, with an AE Zone to the rear. The AE Zone is mapped instead of the AO Zones shown in Examples 3 and 4, because the overtopping ponds are in the area behind the crest in this case. The mean overtopping rate calculations (see Subsection D.2.8.2.2) should be used to determine the volume of water overtopping the barrier during the 1-percent-annual-chance flood conditions, and the BFE in the AE Zone should be determined by the overtopping volume and the local topography.

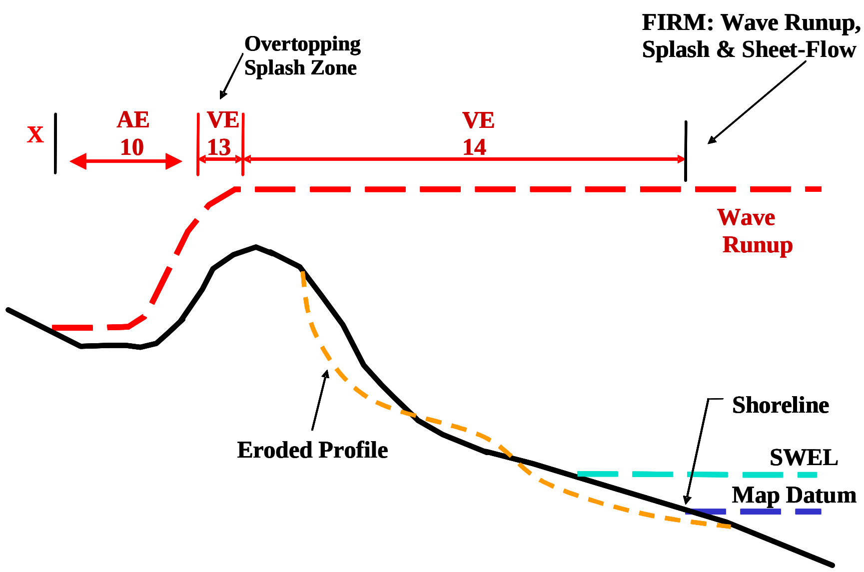

Figure D.2.11-7a. Example 5: Cobble, Gravel, Shingle, or Mixed-Grain-Sized Beach with VE Zone Controlled by Wave Runup and Overtopping Splash

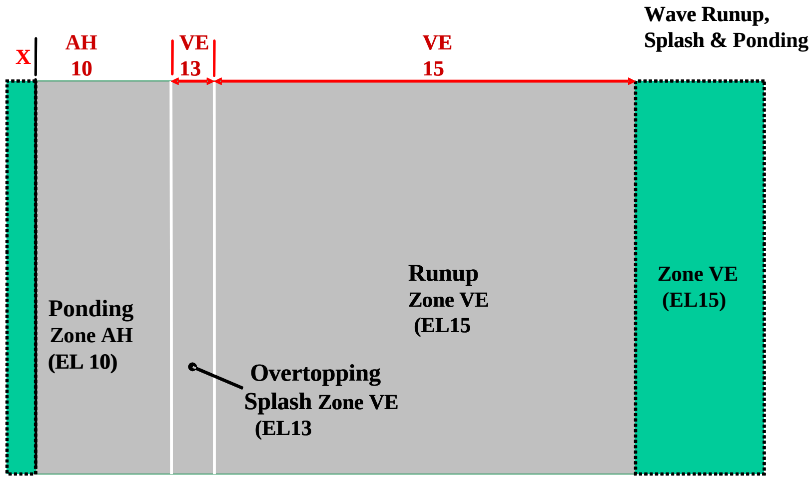

Figure D.2.11-7b. Example 5: Cobble, Gravel, Shingle or Mixed-Grain-Sized Beach with VE Zone Controlled by Wave Runup and Overtopping Splash

Example 6. Figures D.2.11-8a and D.2.11-8b illustrate flood hazard mapping for an erodible coastal bluff that is not high enough to prevent overtopping and where the potential runup reaches higher than 3.0 feet above the crest. In this example, the eroded profile is calculated first using procedures described in Subsection D.2.9, then wave runup and overtopping are mapped against the eroded profile. The area seaward of the bluff will be mapped as the VE Zone, with a BFE set at the potential runup elevation. The area immediately landward of the eroded bluff face will be mapped as a VE Zone based on the presence of an overtopping splash zone. BFEs in the VE splash zone will be based on the calculated water-surface profile decay (see Subsection D.2.5.3.3).

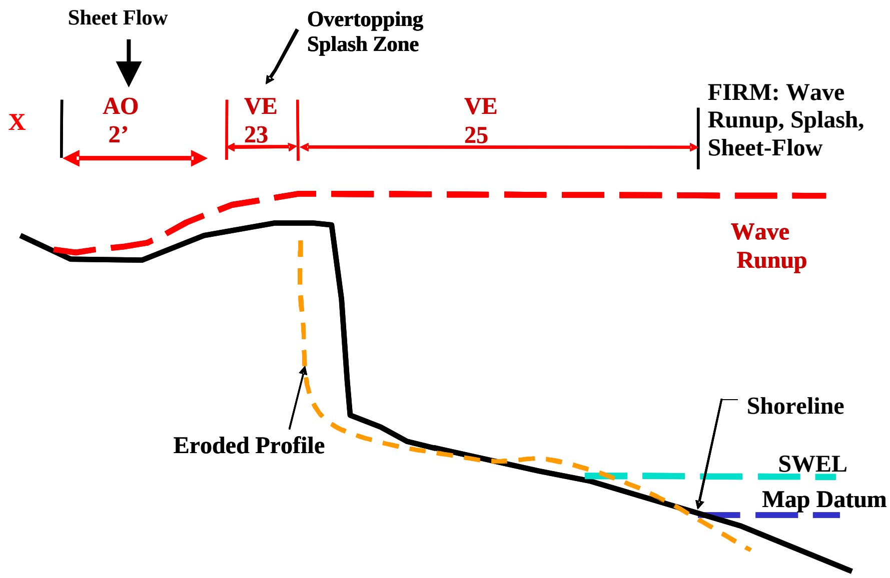

Figure D.2.11-8a. Example 6: Erodible Low Coastal Bluff with VE Zone Controlled by Wave Runup and Overtopping Splash

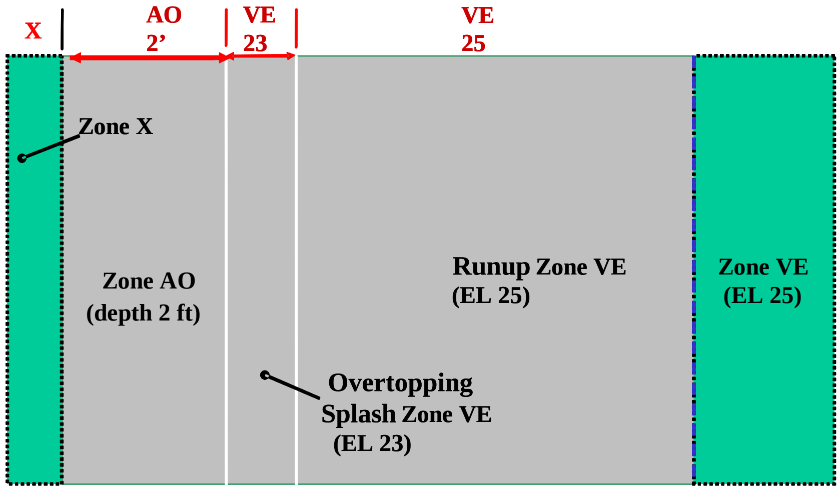

Figure D.2.11-8b. Example 6: Erodible Low Coastal Bluff with VE Zone Controlled by Wave Runup and Overtopping Splash

Example 7. Figures D.2.11-9a and D.2.11-9b illustrate flood hazard mapping for a non-erodible coastal bluff high enough to prevent overtopping during 1-percent-annual-flood conditions. The area seaward of the bluff will be mapped as the VE Zone, with a BFE set at the potential runup elevation. The area landward of the bluff face will be mapped as X Zone (unshaded).

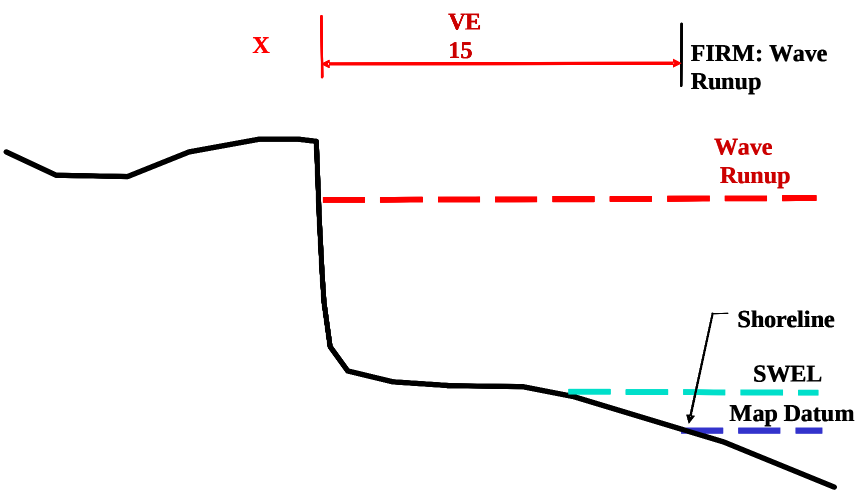

Figure D.2.11-9a. Example 7: Non-erodible High Coastal Bluff with VE Zone Controlled by Wave Runup (No Overtopping)

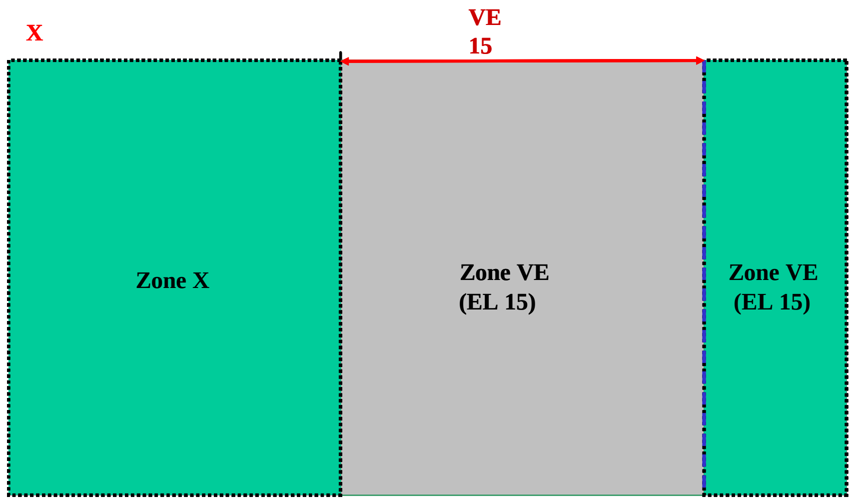

Figure D.2.11-9b. Example 7: Plan View of Flood insurance risk zones and BFEs, Non-erodible High Coastal Bluff with VE Zone Controlled by Wave Runup (No Overtopping)

Example 8 (no figure). For cases in which a profile is inundated by the static water level during the 1-percent-annual-chance flood – such as a tidal wetland, low sand beach, or other flooded low-lying area – wave runup and overtopping do not need to be calculated and mapped. Instead, the hazard zones and BFEs should be mapped with the results of the WHAFIS model (see Subsection D.2.4.3.3) or other similar analysis. The VE Zone should be mapped where the vertical difference between the wave crest elevation and the static water level is equal to or greater than 2.1 feet; the AE Zone should be mapped where the difference is less than 2.1 feet. BFEs should be mapped at even-foot increments, in a stairstep fashion, following the wave crest profile.

D.2.11.6 Mapping Procedures

This subsection presents guidance for mapping newly studied coastal zones and remapping or redelineating coastal flood insurance risk zones. In redelineation, effective SWELs and BFEs are remapped using new or more detailed topographic data and base maps, or to implement a vertical datum conversion. Included below are the requirements for reviewing the initial model results and identifying flood insurance risk zones, guidance and examples for determining transects, and guidance for depicting the analysis on the FIRM.

D.2.11.6.1 Newly Studied Coastal Zones

A properly integrated delineation of the results of flooding analyses involves judgment and skill in reading topographic and land-cover maps. The time and effort put forth to determine the flood elevations and flood zone extents will be negated if the results of these analyses are not properly delineated on the FIRM. Provided below is a description of the general process by which the coastal analyses are to be transformed from a series of flood zones and BFEs calculated along numerous transects to a mapped product consistent with these mapping guidelines and specifications.

The preliminary FIRM is usually produced from engineering work maps based on the coastal analyses. Therefore, the Mapping Partner should transfer the flood zones and elevations identified on each transect's wave profile to the work maps and interpolate boundaries between transects. To do so, the Mapping Partner should set up the work maps with contour lines, buildings, structures, vegetation, and transect lines clearly located. Because roads are often the only fixed physical features shown on the FIRM, the Mapping Partner should ensure that other features and the flood zone boundaries are properly located on the work maps in relation to the centerline of the roads as they will appear on the FIRM. The starting point (0 Station) for each transect should be clearly annotated on the work maps.

The Mapping Partner should transfer the identified elevation zones from the wave profile to the work maps, marking the location of the flood zone boundaries along the transect line so that boundary lines can be interpolated between transects. The Mapping Partner should ensure that boundaries are marked at the correct location. Because of erosion assumptions, the location of the 0.0-foot elevation at the shoreline can change on the transect, but the 0 Station, the point from which the flood zone changes from the wave profile are referenced, must remain fixed on the work map. As discussed in Subsection D.2.11.4, some flood zones on the wave envelope may be too narrow to map at the current map scale. Thus, some zones must be eliminated, and elevations must be averaged. The Mapping Partner should measure the widths of the resulting flood zones carefully; zones that narrow to less than 0.2 inch at map scale must be tapered to an end. Likewise, if the averaged flood zone becomes much wider, it may be possible to break the averaged zone back into two (or more) separate elevation zones.

With final elevations from the wave profile plotted on the work maps and any zone averaging completed, the Mapping Partner should determine the location of each flood zone change in relation to a physical feature (e.g., ground contour, back side of a row of houses, 50 feet into a vegetated area) and delineate the boundary for the area represented by that transect along this feature. For example, if the BFE for a VE Zone decreases from 14 feet to 13 feet coincident with change from a residential area to a forest, the Mapping Partner should examine the land use data and follow the boundary of the forest to the left and right of the transect line to extend the delineation of the flood zone change.

One of the more difficult steps in delineating coastal flood zones and elevations is the transition between transects. Good judgment and an understanding of typical flooding patterns are the best tools for this job. Initially, the Mapping Partner should locate the area of transition (an area not exactly represented by either transect) on the work maps. The Mapping Partner should then delineate the floodplain boundaries for each transect up to this transition area. The Mapping Partner should examine how a transition can be made across this area to connect matching zones and still have the boundaries follow logical physical features. Other transects similar to this area could give an indication of flooding. Sometimes the elevation zones for the two contiguous transects are not the same; in such cases, the Mapping Partner may have to taper the zones to an end or enlarge the zones and subdivide them in the transition area.

With the advent of computer applications that can quickly pre- and post-process terrain, land-use, and other data to support wave analyses, coastal transects can now be generated at narrow alongshore spacings that approximate 2-D modeling. While the selection of the transect spacing is left to the judgment of the Mapping Partner, there is a point of diminishing returns beyond which the addition of more transects will not appreciably improve the final product. Furthermore, increasing the transect density may not fully resolve flood zone transition problems that occur coincident with physical features that end abruptly (e.g., boundaries between densely developed parcels and open space/parks; at the ends of shore protection structures). The Mapping Partner must determine the transect spacing that will be adequate to accurately model the base flood conditions and interpolate the results. The Mapping Partner should also recognize that it may not be possible to show all transects on the work maps or FIRM, or include all results in the FIS text tables or other derivative products associated with the mapping project. Care must be taken to ensure that the final work map or FIRM is consistent with the modeling completed by the Mapping Partner, and that transects shown on the final maps are, in fact, representative of these results.

In some cases, fewer transects may be adequate to characterize flood hazards in geographically separate but physically similar shoreline reaches. Areas with significant flooding hazards from wave runup may have one transect representing multiple alongshore reaches because the areas have similar shore slopes. In this case, the Mapping Partner should identify the different areas and delineate the results of the typical transect in each area. Transition zones may be necessary between areas with high runup elevations to avoid large differences in BFEs, and to smooth the change in flood zone boundaries. These zones should be fairly short and cover the shore segment with a slope not exactly typical of either area. The Mapping Partner should determine the transition elevation using judgment in examining runup transects with similar slopes. The Mapping Partner should not use transition zones if there is a very abrupt change in topography, such as at the end of a coastal structure.

Lastly, after plotting flood zones and BFEs and interpolating results between transects, the Mapping Partner should map the X Zone areas. The Mapping Partner should show areas below the 0.2-percent-annual-chance SWEL that are not covered by any other flood zone as X Zone (shaded) on the FIRM. Often, the maximum runup elevation associated with the base flood is higher than the 0.2-percent-annual-chance SWEL. In such cases, the X Zone (shaded) designation will not be used in that area. All other areas are designated X Zone without shading.

Because flood elevations are rounded to the nearest whole foot, the Mapping Partner does not need to spend time resolving a minor elevation difference. Also, because coastal structures must be located on the FIRM, the Mapping Partner should attempt, whenever possible, to smooth the boundary lines and to follow a fixed feature such as a road. In preparing the FIRM, the Mapping Partner should ensure that the mapped results are technically correct and that the FIRM is easy for the community official, engineer, surveyor, and insurance agent to use.

D.2.11.6.2 Redelineation of Coastal Zones

During the project scoping phase, coastal reaches may be identified where new surge modeling and detailed wave analyses are not required. In these cases, the Mapping Partner will be responsible for remapping or redelineating the effective coastal flood hazard data onto the new FIRM. When determining how a coastal area should be redelineated, the Mapping Partner should consider the availability of new or more detailed topographic data, the base map being used for the revised FIRM (including any new shoreline position), and whether a vertical datum conversion is necessary.

Although these guidelines provide information on the most common redelineation aspects and a general approach for identifying issues, each effective coastal flood hazard dataset can pose unique problems that could, in some instances, require new modeling to resolve. For this reason, it is critical that the Mapping Partner fully investigate redelineation issues and identify the most appropriate methodology early in the scoping process (see Subsection D.2.1.2), coordinating closely with the FEMA Study Representative to resolve any issues that are discovered.

Several typical redelineation scenarios, and the methods available to map the effective flood data, are presented below. Of the known redelineation concerns, shoreline retreat and datum conversions have the most significant impacts on remapping flood zone boundaries. For organizational purposes, the guidance and illustrative examples have been subdivided based on the degree of shoreline retreat at the study site. The discussion is further subsequently subdivided to present the effects of new topographic data and/or datum conversions on the redelineation process. The Mapping Partner should review *all* scenarios for relevant guidance. As redelineation is a relatively new activity for Mapping Partners, these scenarios should not be considered all-inclusive; the guidelines will be revised and supplemented in the future, as warranted.

Scenario 1: Minimal to No Shoreline Retreat

In this setting, the new base map being used for the FIRM shows that the shoreline (typically the High Water Line for vector-based maps, or the wet-dry line at the time of the collection for aerial photographic base maps) has undergone minimal net landward retreat in the time elapsed because the effective FIRM was published. That is, the new shoreline still lies within the same outermost VE Zone shown on the effective FIRM (see Figure 2.11-10). (Seaward progradation of the shoreline would also fit this scenario.)

- **If no new topographic data are being utilized and no datum conversion from NGVD29 to NAVD88 is required**, the redelineation will consist of duplicating the effective flood zone boundary locations, including the VE/AE boundary associated with the PFD (where applicable) and the 1-percent and 0.2-percent-annual-chance floodplain boundaries, exactly as they are shown on the effective FIRM.

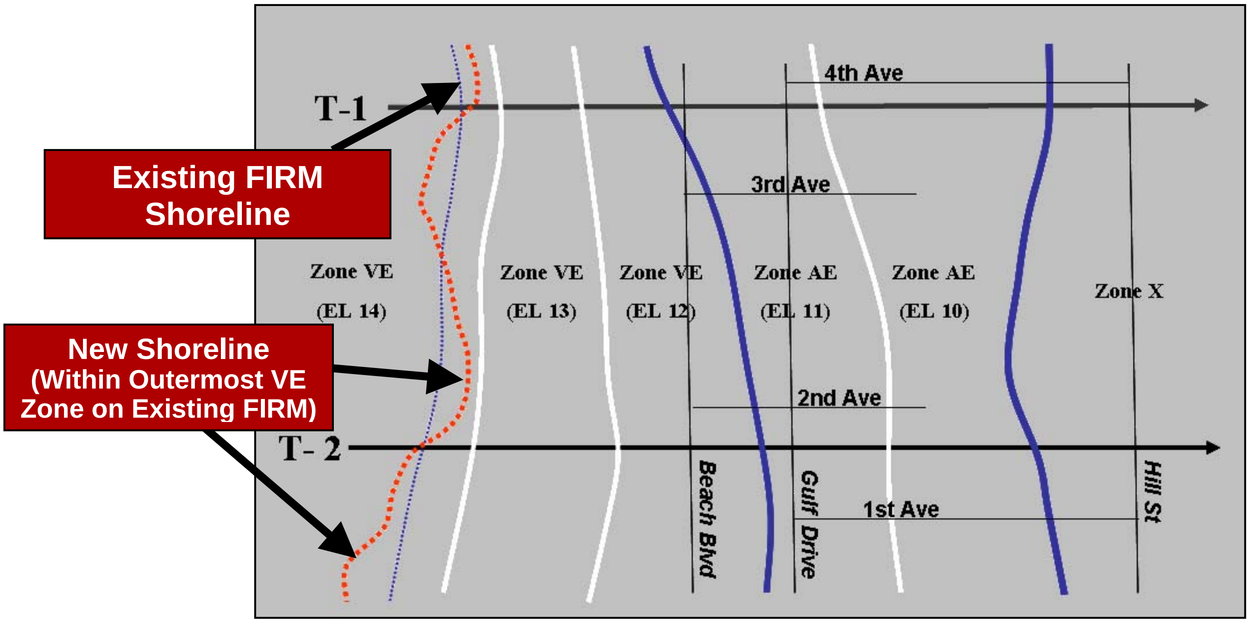

Figure D.2.11-10. Work map depicting the flood zones, BFEs, and shoreline from the effective FIRM and the new shoreline position (modified from DiCamillo et al., 2005). T-1 and T-2 represent transect locations. Because the shoreline retreat is restricted to the outermost VE Zone (EL 14), it has no impact on remapping of flood zones.

- **If new topographic data are being used** as the basis of the FIRM update, multiple flood zone boundaries can be redefined based on the new data, specifically the 1-percent and 0.2-percent-annual-chance floodplain limits and any PFD-based VE/AE boundary. Prior to redelineating the limit of the 1-percent and 0.2-percent-annual-chance floodplains, the Mapping Partner shall use the guidance below to review the effective FIS and FIRM and to determine the controlling factor for the limit of flooding in an area and determine the appropriate elevation(s) for redelineation:

  Identify the final flood insurance risk zone and BFE before the limit of the 1-percent-annual-chance floodplain. Because coastal flood insurance risk zones and BFEs are frequently averaged when the zones are too narrow to be mapped, and coastal BFEs may include a wave height component, the Mapping Partner should not assume that the final whole-foot BFE immediately seaward of the limit of the 1-percent-annual-chance floodplain is the appropriate elevation to use to redelineate the floodplain boundary. Where applicable, the Mapping Partner shall evaluate the effective modeling for areas where Zone AO is the final flood insurance risk zone to determine the appropriate elevation for redelineation of the 1-percent-annual-chance floodplain boundary. Also, in areas where Zone X is mapped immediately adjacent to the open coast, the Mapping Partner should consult the new topographic data and delineate the PFD landward heel.

  The Mapping Partner shall locate the effective transect nearest to the area being redelineated and determine the 1-percent and 0.2-percent-annual-chance SWELs from the "Transect Data Table" or "Transect Description Table" in the FIS. If the area being redelineated is along a tidally influenced stream, river, or other sheltered waters where there are no transects, the Mapping Partner shall obtain the 1-percent and 0.2-percent-annual-chance SWELs from the "Summary of Stillwater Elevations" table and/or Flood Profiles in the FIS. The Mapping Partner shall determine whether wave setup is included in the 1-percent-annual-chance SWELs reported in the FIS and ensure that the elevation used for redelineation of the 1-percent-annual-chance floodplain does not include wave setup.

When wave runup is the controlling factor for the limit of the 1-percent-annual-chance floodplain, the elevation being used to map the limit will be higher than the SWEL presented in the FIS. The Mapping Partner shall consult the FIS, FIRM, aerial photography, and/or topographic data to determine areas where wave runup is the dominant hazard. In these areas, the 0.2-percent-annual-chance runup elevation should be used to redelineate the limit of the 1-percent-annual-chance floodplain.

When redelineating the 1-percent and 0.2-percent-annual-chance floodplains between transects, there will be areas where the Mapping Partner must transition from one elevation to another, such as when there are flooding sources with varying SWELs or areas with varying runup elevations. For this reason, the Mapping Partner shall determine the appropriate elevation for mapping of the 1-percent and 0.2-percent-annual-chance floodplains at each transect prior to redelineation. In areas of transition between transects, the general shape of the effective boundaries should be maintained, but offset to follow the new topographic data (see Figure 2.11-11).

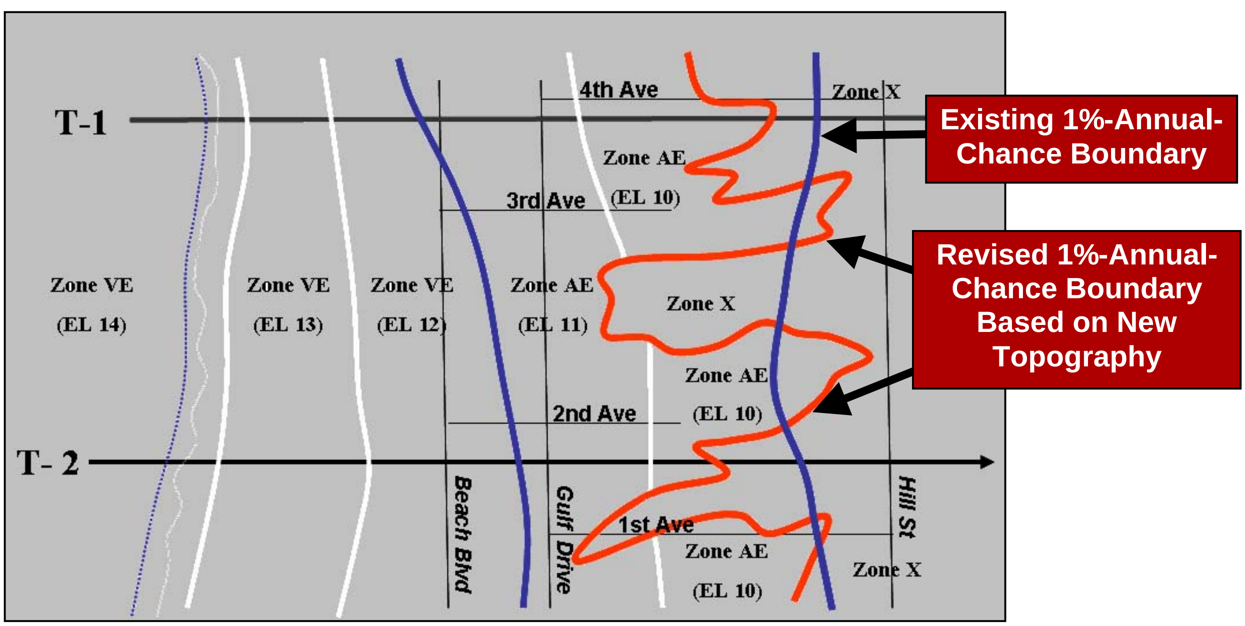

Figure D.2.11-11. Work map depicting the existing 1-percent-annual-chance floodplain boundary from the effective FIRM, and the new boundary redelineated based on the effective SWEL and new topographic data (modified from DiCamillo et al., 2005).

As shown in Figure 2.11-11, the redelineated limit of the 1-percent-annual-chance floodplain may impinge upon or cross flood zone boundaries located farther seaward. Similarly, a redelineated PFD limit may intersect flood zone boundaries located landward of the effective FIRM's PFD limit. The Mapping Partner shall not revise the location of gutter lines affected by the new 1-percent-annual-chance and PFD limits without first performing updated modeling; instead, these gutter lines should be clipped at the revised limit of flooding or PFD, as shown in Figure 2.11-11.

- **If no datum conversion is being performed**, the Mapping Partner shall ensure that all gutter lines separating flood insurance risk zones of differing BFEs (except for the PFD-based VE/AE boundary, if redelineated) will remain in the same location and orientation as on the effective FIRM. This is true even when new topographic data are utilized in the study. While topography is a key factor in establishing the wave profile from which the coastal gutter locations are derived, it is not the only factor.

- **If the study includes a datum conversion**, the complexity and level of effort required by the Mapping Partner to complete the redelineation may increase significantly. That is because datum conversions may require coastal gutters separating BFEs to be moved. Recall that each BFE is a whole-foot elevation that actually represents flood elevations from 0.5 feet below to 0.4 feet above the BFE. With the exception of the PFD-based VE/AE boundary, the coastal gutters are located at the half-foot elevations along the wave profile (see map and upper panel [A] on Figure 2.11.-12). When the *vertical* datum conversion is applied, the *horizontal* location (or station) of each half-foot elevation shifts either landward or seaward on each transect's wave profile (see lower panel [B] on Figure 2.11-12).

  Typically a datum conversion of more than 0.1 foot can have a significant impact to gutter locations, depending on the topography. If the land is relatively steep, the impact could be minimal. If the land has a gentle slope, the impact can be much greater because the distance between half-foot elevations along the wave elevation profile can be large. If a datum conversion is around 1.0 foot, then the gutters can remain in the same location with just a change in the BFEs by 1 foot. The Mapping Partner shall determine the conversion factor, review the topography, and propose a method for redelineating coastal flood hazards in the different datum to the FEMA Study Representative. Once the Mapping Partner has determined the location of the gutters along each transect, the flood insurance risk zones and BFEs shall then be mapped as discussed in previous subsections.

  Redelineation of coastal gutter locations can be accomplished efficiently if the effective wave transect modeling results are available. In cases where the modeling results are not available, the Mapping Partner shall propose an approach for the datum conversion and present it to the FEMA Study Representative for approval. One option may be to construct a simplified wave profile based on the effective gutter locations, interpolating the wave height between the half-foot elevations (e.g., Figure 2.11-12). Application of this approach must be limited to transects where wave heights were the dominant hazard in the effective study and no PFD was mapped.

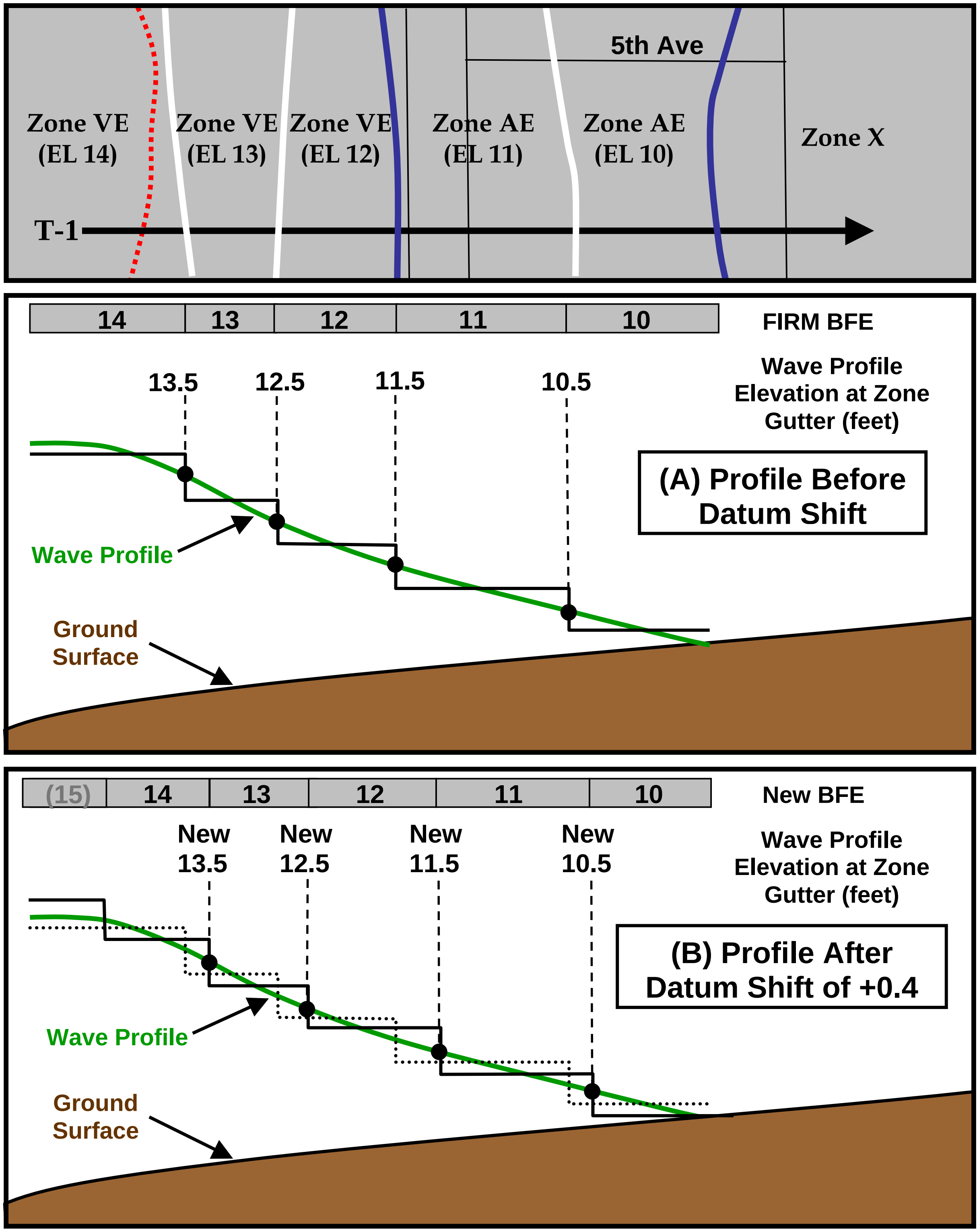

Figure D.2.11-12. Comparison of gutter locations prior to a datum conversion (A) and after (B). Although Zone VE (EL 15) can be identified on the new wave profile, it lies seaward of the mapped shoreline position and thus may not need to be included on the FIRM.

Scenario 2: Moderate Shoreline Retreat

In this setting, the new base map being used for the FIRM shows that the shoreline has retreated far enough landward that one or more effective VE Zones are now located in open water. If a Zone VE gutter falls seaward of the open-coast shoreline on the new base map, the Mapping Partner shall adjust the gutter to be coincident with or just landward of the shoreline. If multiple Zone VE gutters fall seaward of the open-coast shoreline on the new base map, the intermediate zones can be completely removed. The VE Zone with the highest BFE shall be adjusted so that the gutter is coincident with or just landward of the shoreline. The Mapping Partner shall use caution to not increase the flood insurance risk zone designation or BFE for any properties without modeling to justify such an increase. Incorporation of new or improved topographic data and/or a datum conversion by the Mapping Partner shall follow the guidelines provided earlier in this subsection.

Scenario 3: Significant Shoreline Retreat

This setting would apply in areas where the new base map indicates that the shoreline has retreated landward past the effective FIRMs VE/AE boundary (Figure 2.11-13). Such a scenario is possible (1) on coasts subject to chronic, long-term erosion; (2) where a severe storm (or series of storms) has eroded the shoreline and beach recovery has not yet occurred; (3) adjacent to dynamic tidal inlets; or (4) downdrift of shore protection structures that impede longshore transport of sediment.

While it is not advisable to redelineate coastal flood hazards in areas where significant changes to the open-coast shoreline have occurred since the effective coastal modeling was completed, the Mapping Partner shall utilize the following guidance to ensure that the effective flood hazards are transferred to the new base map in a logical, consistent manner:

> If the gutter separating the VE Zone and AE Zone flood hazard areas along the open coast falls seaward of the shoreline on the new base map, the Mapping Partner shall adjust the VE/AE gutter to be just landward of the shoreline and adjust the seaward VE Zone gutter with the highest BFE to be coincident with the shoreline and remove any intermediate gutters, taking care not to increase the flood insurance risk zone designation or BFE for any properties without modeling to justify such an increase. If this situation occurs with any frequency, the Mapping Partner should consider utilizing the effective shoreline rather than the shoreline from the new base map for the revised FIRM and discuss this with the FEMA Study Representative.
>
> In areas other than the open coast where shoreline changes result in gutters located in open water, the Mapping Partner shall use best judgment in evaluating the nature of the BFE change (wave regeneration over open fetches, wave damping due to vegetation, buildings, etc.) and shift the gutters as necessary to provide a logical identification of flood hazards on the new base map. Again, the Mapping Partner shall use caution to not increase the flood insurance risk zone designation or BFE for any properties without modeling to justify such an increase.

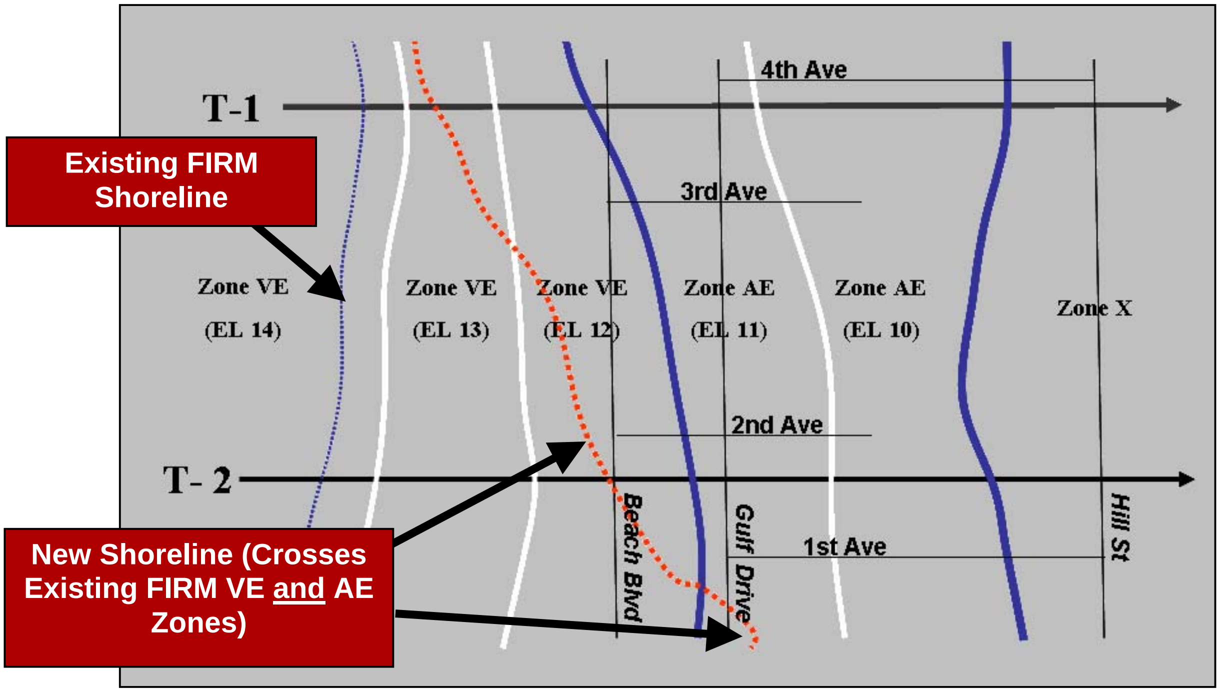

Figure D.2.11-13. Work map depicting existing shoreline position from the effective FIRM and the new shoreline location (modified from DiCamillo et al., 2005). Because the shoreline retreat extends landward of the effective VE/AE boundary, reanalysis of flood hazards may be warranted (in lieu of redelineation).