Best Practices for PFD V-Zone and LiMWA Mapping Along California Coast

Photo by: Darryl Hatheway, 2011
Presentation Discussion

- Examine PFD V-Zone Mapping in Wave Runup Dominated West Coast
- Application of PFD V-Zone Mapping Criteria in Pacific G&S
- PFD V-Zone Mapping for Dunes with Coastal Structures
- Example Transects from Santa Cruz County (CA) at Pajaro Dunes
Presentation Discussion

- Limit of Moderate Wave Action (LiMWA) Definition
- LiMWA Operating Guidance Overview
- Challenges of Mapping LiMWA
- LiMWA examples for Coastal Counties
CCAMP/OPC Study Goals

Determine revised Base Flood Elevations (BFEs) and flood inundation boundaries for 1%-annual-chance (base) flood total water levels

Update the Flood Insurance Study (FIS) and Flood Insurance Rate Map (FIRM) Panels

Assist communities with incorporating this information into risk assessment and hazard mitigation planning
Best Practices for PFD V-Zone Mapping Along California Coast
NFIP Regulations — Coastal (PFD)

- **Part 59 — General Provisions, Definitions, and Program Description:**
  - **Area of Special Flood Hazard** — Areas subject to 1% or greater annual chance of flooding in given year. Includes Zone A, AE, AO, and V. 500-year floodplain is NOT an SFHA.
  - **Coastal High Hazard Area (V Zone)** — Area of Special Flood Hazard extending from offshore to inland limit of primary frontal dune along open coast and any other area subject to high velocity wave action from storms or seismic sources.
Definition: “a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward and adjacent to the beach and subject to erosion and overtopping from high tides and waves during major coastal storms...”

Landward extent: “a point where there is a distinct chance from a relatively steep slope to a relatively mild slope” (i.e., the dune heel)

Implications: The PFD represents the landward extension of the VE Zone

Purpose: Floodplain management tool to protect dunes and regulate coastal construction practices and building standards

Delineation of the PFD is mandated by FEMA regulations
FEMA PFD V-Zone Mapping

REGULATED PRIOR TO 1988

XZone

AE Zone

VE Zone

Wave Crest Profile
100-year SWEL
Mean sea level
FEMA PFD V-Zone Mapping

**REGULATED SINCE 1988**

- **XZone**
- **VE Zone**

**Legend:**
- **PFD Area VE Zone**
- **Erosion VE Zone**
- **540 ft² eroded**
- **Landward limit of storm-induced erosion**
- **Mean sea level**
- **100-year SWEL**
- **Wave Crest Profile**

- **Landward toe of dune**
FEMA PFD V-Zone Mapping

- Pacific G&S

Figure D.4.9-6a. Sandy Beach Backed by High Sand Dune with PFD Controlling the VE Zone
FEMA PFD V-Zone Mapping

- Pacific G&S

Figure D.4.9-7a. Sandy Beach Backed by Low Sand Dune with Overtopping Splash Controlling VE Zone
The following is an example of a complex Primary Frontal Dune (PFD) identification at adjacent transects in the Pajaro Dunes, southern Santa Cruz County, California.

The southern transect (Transect 1001) is protected by a rock revetment and backed by a condominium complex (Figure 1).

The northern transect (Transect 2) is approximately 290 ft north, unprotected, and backed by houses and a road.

Both have similar crest elevations.
Figure 1. Orthoimage of the Pajaro Dunes Transects. Dune toes (green square), crests (red squares), and heels (purple squares) are identified on adjacent transects 1001 and 1.
FEMA PFD V-Zone Mapping

- For Transect 1001, the dune heel has been selected at 4 m NAVD88 (Figure 2).
- This is a relatively straightforward application of the PFD definition as the dune is subject to erosion in the winter and there is an obvious landward inflection point, where the profile transitions from steep to flat.
- At the adjacent Transect 2 (Figure 3), there is also a dune that is subject to erosion.
However, there are multiple crests and inflection points to identify as the heel.

A heel is currently selected at a seaward inflection point behind the crest where the profile transitions from steep to flat at approximately 7 m NAVD88.

However, the dune crest is only about 1 m above this which seems small.

In addition, there is another small crest landward of this heel and another potential heel at approximately 3 m NAVD88.
Figure 2. Cross-shore profile of Transect 1001.
- Figure 3. Cross-shore profile of Transect 2.
FEMA PFD V-Zone Mapping

- The location of the heel designates the VE Zone at Transect 2 and has implications for the houses immediately adjacent to the transect.
- Although we feel that the heel has been accurately identified in this case, we are looking for clearer guidance to rule out the landward heel.
- The dune has been impacted by human development making it difficult to determine where the natural, undisturbed inflection points would be for mapping.
PFD V-Zone (red) with runup TWL of 17 ft (blue) at Transect 1001 extends from shoreline to heel. PFD heel difference with runup BFE +4 feet (17-13 ft)
PFD V-Zone (red) with runup TWL of 17 ft (blue) at Transect 2 (two PFD heel options) extends from shoreline to heel. First PFD heel difference with runup BFE -6 feet (17-23 ft); and second PFD heel difference with runup BFE +7 feet (17-10 ft).
Discussion:

- PFD V-Zone mapping will map as a horizontal elevation across beach, through the dune, and extend landward to dune heel no matter the elevation difference. Is there a better mapping method?
FEMA PFD V-Zone Mapping

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- PFD V-Zone mapping can result in large differences between the PFD heel location elevation on Pacific coasts with runup dominated BFEs (both positive or negative). How do we explain excessive elevation requirements for buildings (when true coastal risk is not apparent)?
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- PFD V-Zone mapping can result in large differences between the PFD heel location elevation on Pacific coasts with runup dominated BFEs (both positive or negative). How do we explain excessive elevation requirements for buildings (when true coastal risk is not apparent)?

- Many non-certified coastal structures (rock revetments) have dune-back shore-type and may not qualify for PFD V-Zone Mapping even if structure fails. Should we have an exemption criteria?
Primary Frontal Dunes

As the first line of defense against flooding, primary frontal dunes are typically mapped as a VE Zone.

This designation ensures that dunes are not subject to manmade alterations in a way that could increase potential flood damage.

What is a primary frontal dune?

A primary frontal dune (PFD) is defined by the National Flood Insurance Program (NFIP) as a continuous or nearly continuous mound or ridge of sand with relatively steep seaward and landward slopes immediately landward of and adjacent to the beach. PFDs are subject to erosion and may be vulnerable to overtopping or breaching from high water levels and waves during coastal storms. The NFIP recognizes the importance of dunes in reducing coastal flood hazards and has established specialized mapping, insurance, and floodplain management criteria designed to help communities protect the dunes.

How does FEMA assess the coastal flood hazards on a PFD?

FEMA works with scientists and engineers from Federal and State agencies, communities, Tribal entities, contractors, and other stakeholders to analyze flood hazards for coastal communities using the latest scientific methodologies. When FEMA last conducted these analyses, they found that the PFD is present in a study area, the project team analyses the dunes to determine how the dunes are likely to be affected by the 1% annual chance storm surge and wave hazards. The analysis considers whether the dune is large enough to survive a storm magnitude and estimates the extent of erosion expected during the storm. Analyses are also performed to estimate the flooding expected landward of the eroded dune.

The landward toe of a PFD located at the point where there is a distinct change from a relatively steep slope to a relatively mild slope. The VE Zone or VE Zone is extended inland to the landward PFD toe. This methodology establishes the minimum landward limit of the Coastal High Hazard Area (CHHA).

Risk MAP: Increasing Resilience Together

March 2014

www.fema.gov/plans/prevent/fm_home.htm - 1-877-FEMA MAP

PFD Fact Sheet (www.fema.gov)

PFD Fact Sheet (www.fema.gov)

Why did FEMA decide that a dune above the 1 percent annual chance flood level be included in an Special Flood Hazard Area (SFHA)? FEMA conducted an investigation in 1985 to evaluate the extent of storm-induced erosion on dunes. Based on data from historical flood events, FEMA concluded that most PFDs would experience some level of erosion during a 1 percent annual chance flood. Based on this conclusion, FEMA published regulations to protect PFDs from manmade impacts or physical alterations that could increase potential flood damage. These regulations also support hazard-specific building standards and land use requirements.

Protecting Primary Frontal Dunes

If dunes are mapped outside regulatory flood hazard areas, they become subject to potential development practices. Prior to the development of PFD regulations, dune areas saw construction with little or no requirements for structure elevation or special foundation types. This resulted in degradation of the protective quality of the dunes and put structures at risk from flooding. Structures built with walls on grade and even basement foundations failed during large coastal storms due to undermining of the foundations. Damage often precluded removal of structures due to increased erosion. In response to these issues, states and FEMA regulations requested more protection of the dunes. This resulted in development of the primary frontal dune definitions and regulation.

Risk MAP: Increasing Resilience Together

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www.fema.gov/plans/prevent/fm_home.htm - 1-877-FEMA MAP

Additional Resources

For more information, please visit FEMA’s Coastal website at www.fema.gov/coastal-flood-data.

For answers to questions about new PFDs, the status of a request, or other mapping issues:

FEMA Map Information Exchange 1-877-FEMA-MAP (1-877-336-6275)

FEMA Map Service Center

www.floodsmart.gov

For anyone interested in flood insurance:

www.fema.gov/flood-insurance

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www.fema.gov/plans/prevent/fm_home.htm - 1-877-FEMA MAP

For additional information on FEMA and its programs:

www.fema.gov
Best Practices of Limit of Moderate Wave Action (LiMWA) Mapping Along California Coast
The “Coastal A Zone” (CAZ) is defined in publications currently as the area landward of the V Zone and inland to the limit of the 1.5-ft breaking wave. This limit is defined as the Limit of Moderate Wave Action (LiMWA). For the purpose of this study the “Coastal A Zone” includes only the MoWA Zones.

Figure 5. Proposed coastal A Zone mapping concept being considered for revisions to ASCE 24-98 and ASCE 7-02.
LiMWA Mapping

The Moderate Wave Action Limit is delineated at the location where breaking wave heights are equal to 1.5 ft
Coastal A Zone

LiMWA Mapping

Riverine A/AE Zones

Coastal and Riverine A/AE Zones separated to define inland limit of MiWA Zone and Coastal AE Zone

Inland limit of mapped A/AE Zones or 1% stillwater elevation (SWEL) where mapping not available.

MiWA Zone

MoWA Zone (inland limit at 1.5-ft wave)

VE Zone (inland limit at 3-ft wave)

Coastal A Zone

Plan View

Elevation View

LiMWA @ 2-ft below 1% SWEL

VE Zone @ 4-ft below 1% SWEL
LiMWA Mapping

- NFIP regulations make no distinction between the design and construction requirements for coastal AE Zones and riverine AE Zones.
- Evidence suggests that design and construction requirements in some portions of the coastal AE Zone should be more like VE Zone requirements.
- In the wake of Hurricane Katrina, a large number of buildings in AE Zones were damaged.
- Laboratory tests have confirmed that wave heights as low as 1.5 ft can damage structures.
The LiMWA line on FIRMs is an information layer only.

I-Codes requires Zone VE construction standards in identified Coastal A Zone areas.

Communities that adopt Zone VE standards in the Coastal A Zone and reference the LiMWA area receive Community Rating System (CRS) credits, which could lower flood insurance premiums for residence and business owners.
LiMWA Mapping

- Allows communities and property owners to better understand flood risk to their property
- Helps identify on which side of the “line” a property sits (impacted by less or more than 1.5 ft of breaking waves) during a 1% event
- Areas exposed to a breaking wave higher than 1.5 ft are subjected to high-velocity flows and/or debris that can erode and scour foundations and possibly cause failure
FEMA issued an Operating Guidance (No 13-13) on October 30, 2013 to improve identification and mapping of the Limit of Moderate Wave Action (LiMWA)

OG 13-13 Replaces PM 50 (first guidance on LiMWA released in the wake of Hurricane Katrina in 2008)
### LiMWA on a FIRM

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<th>Example</th>
<th>Feature</th>
<th>Specification</th>
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</thead>
<tbody>
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<td>Limit of Moderate Wave Action Delineation</td>
<td>Solid black line 0.0194&quot; (1.4 points) in line weight, with black triangular marker symbols 0.1667&quot; (12 points) in height located on the left-hand-side of the line. Triangles oriented with one edge parallel to the line. Triangles spaced 46 points apart, with first triangle 8 points away from the line’s start.</td>
</tr>
<tr>
<td></td>
<td>Limit of Moderate Wave Action Label</td>
<td>Limit of Moderate Wave Action Label 10 Pt. Arial, ALL CAPS</td>
</tr>
</tbody>
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**LIMIT OF MODERATE WAVE ACTION**

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**NOTES TO USERS**

The AE Zone category has been divided by a Limit of Moderate Wave Action (LiMWA). The LiMWA represents the approximate seaward limit of the 1.0 foot breaking wave. State flood conditions between the VE Zone and the LiMWA will be similar to, but less severe than those in the VE Zone.

Contact the FEMA Map Service Center at 1-800-358-9677 for information on available products associated with this FIRM. Available products may include previously issued Letters of Map Change, a Flood Insurance Study report, and/or digital versions of the map. The FEMA Map Service Center may also be reached by fax at 1-800-358-9677 and its website at http://www.fema.gov.

If you have questions about this map or questions concerning the National Flood Insurance Program in general, please call 1-877-FEMA-MAP (1-877-336-3627) or visit the FIRM website at http://www.fema.gov.
LiMWA Mapping Basics

- The LiMWA should be mapped at the same time as the overland wave analysis results.
- The LiMWA should be interpolated between transects similarly to flood zone boundaries and gutters.
- Where possible, LiMWA should not cross flood zone boundaries and gutters.
LiMWA Mapping Basics

- The LiMWA **should not** be shown where the VE Zone is delineated based on the **Primary Frontal Dune** (PFD) or wave runup and/or wave overtopping.
- The LiMWA should be mapped where modeling results indicates it.
- The LiMWA should not overlap an existing gutter.
LiMWA Mapping Basics

- The LiMWA should be delineated **only** in conjunction with a VE Zone.
- For transects that originate on the open coast and cross barrier islands, **multiple LiMWAs may be delineated**, but only where there is a VE Zone associated with a shoreline.
• If inland wave heights fluctuate above and below 1.5 ft (due to regeneration and dissipation), only **one LiMWA** should be drawn - closest to the VE Zone
LiMWA Mapping Basics

- The LiMWA should not be depicted within the following zones:
  - VE Zone
  - Zone X (shaded or unshaded)
  - AE Zone in which wave action does not exist, such as an AE Zone with a BFE corresponding to the stillwater elevation
Conclusion

- An overview of how to map LiMWA and reasons to map LiMWA has been provided.
- The mapping of the LiMWA is subjected to specific criteria but a lot of interpretation is present and open to engineering judgment.
- Examples of LiMWA mapping have been presented. They are part of the FEMA Risk MAP vision and aim at facilitating the communication of risk.
Importance of the Limit of Moderate Wave Action (LIMWA)

The coastal population in the United States has increased significantly over the last few decades. With this growth, in populations increased coastal development has occurred, putting more buildings at risk from flooding and other coastal action. Low-lying coastal areas are especially vulnerable to damage from erosion, waves, and storm surge. The National Flood Insurance Program (NFIP) designates two coastal flood hazard zones on its Flood Insurance Rate Maps (FIRMs):

- Zone VE, where the flood elevation includes wave heights equal to or greater than 3 feet; and
- Zone AE, where the flood elevation includes wave heights less than 3 feet.

Past storm field tests and laboratory tests performed at the University of Florida and in cooperation with the United States Army Corps of Engineers have confirmed that wave heights as low as 1.5 feet can cause significant damage to structures that are constructed without considering coastal forces. FEMA has recently published an addendum to the National Flood Insurance Plan (NFIP) that includes a line showing the Limit of Moderate Wave Action, or LIMWA, which is the inland limit of the area expected to receive 1.5-foot or greater breaking waves during the 100-year annual chance flood event (see Figure 1).

Understanding LIMWA

The addition of the LIMWA area to FIRMs allows community planners and individuals to better understand the flood risks to their property. The LIMWA area alerts property owners on the coastal side of the line that although their property is in Zone AE, their property may be affected by 1.5-foot or higher breaking waves and may therefore be at an elevated risk during a 1 percent annual chance flood event. While not formally defined in the NFIP regulations or mapped in a flood zone, the area between Zone VE and the LIMWA is called the Coastal A Zone. This area is subject to flood hazards associated with flooding debris and high-velocity flow that can undermine and erode buildings foundations and, in extreme cases, cause foundation failure.

LIMWA Facts:
- Waves of 1.5 feet or higher have been shown to cause significant damage to structures
- A LIMWA is shown on FIRMs for areas along coastlines
- Structures A should be prohibited in the Coastal A Zone
- 1-Coastal insurance Zone VE construction standards in identified Coastal A Zone areas
- Structures in the Coastal A Zone should be built on piles or other suitable foundations
- Exposure zone under some structures should be limited to 10 percent of the area within the Coastal A Zone
- Values of elevated on the horizontal structural member of the lowest floor should be at least above the base flood elevation
- NEIS offers flood insurance rates for variability and catastrophic risk
- Coastal A Zone requirements apply to the Coastal A Zone
- A Coastal A Zone is one that employs typical residential and light commercial houses to elevate and support habitable space above the flood level to be susceptible to flood damage (Figure 2). Laboratory and field investigations confirm that breaking wave heights as small as 1.5 feet will cause failure of these types of walls
- Other flood hazards associated with coastal waves (e.g., wave debris, high velocity flow, erosion, and scour) also damage A Zone type construction in coastal areas (Figure 3)
- National Flood Insurance Program (NFIP) flood hazard maps are generally divided into two categories, V and A zones. In coastal areas, the A Zone category could be subdivided into “Coastal A Zone” and “A Coastal A Zone”
- Coastal A Zone: area landward of a V zone, or landward of an open coast without mapped V zones. In a Coastal A zone, the principal source of hazard will be astronomical tides, storm surges, waves or surges, or tides, and significant wind. During base flood conditions, the potential for wave heights between 2.5 and 3.7 foot exist. At least 2.5 to 3.7 of water depth in necessary to support these wave heights.
- Coastal A zone design and construction practices described herein are not mandated by the NFIP, but are recommended for communities that wish to adopt higher floodplain management standards. 
- For communities with NFIP credits, any flood insurance credits are available to do so. 
- Note to coastal builders: federal guidelines must be followed. Some Coastal A A zones may be affected by the International Building Code (IBC), through its reference to ASCE 24, Standard for Flood Resistant Design and Construction.
!! KNOW YOUR RISK !!

Build Safer

Build Higher
QUESTIONS?

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