Final Report

New York/New Jersey Coastal Advisory Flood Hazard Information Development

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ABFE	Advisory Base Flood Elevation
BFE	Base Flood Elevation
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
DEM	Digital Elevation Model
DFIRM	Digital Flood Insurance Rate Map
DTM	Digital Terrain Model
FEMA	Federal Emergency Management Agency
FGDB	File Geodatabase
FIRM	Flood Insurance Rate Maps
FIS	Flood Insurance Study
LiMWA	Limit of Moderate Wave Action
LiDAR	Light Detection and Ranging
MOWA	Area of Moderate Wave Action
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
PFD	Primary Frontal Dune
QA/QC	Quality Assurance/Quality Control
RAMPP	Risk Assessment, Mapping and Planning Partners
SFHA	Special Flood Hazard Area
SWAN	Simulating Waves Nearshore Model
SWEL	Stillwater Elevation
USGS	U.S. Geological Survey
USNGA	U.S. National Geospatial-Intelligence Agency
WHAFIS	Wave Height Analysis for Flood Insurance Studies

SECTION ONE INTRODUCTION

Hurricane Sandy struck the Mid-Atlantic States of New Jersey and New York as a Category 1 storm on October 24, 2012. The effects of the storm continued through October 31 and resulted in 60 reported casualties in New York State (48 in New York City alone), and 34 casualties in New Jersey. With the highest storm surge levels on record, Sandy produced widespread damage to coastal and inland communities in both States and estimated damages of $42 billion in New York and $30 billion in New Jersey.

Prior to Sandy, the Federal Emergency Management Agency (FEMA) had initiated an update to the coastal storm surge and Flood Insurance Studies (FISs) for many of the counties later affected by Sandy. By the time Sandy made landfall, the coastal analyses for these counties had advanced to a stage where the data could be leveraged to develop conservative, technically backed advisory flood hazard information for Sandy recovery. The use of this advisory flood hazard information (as opposed to the effective Flood Insurance Rate Maps or FIRMs) by State agencies, communities, and residents will result in reconstruction and recovery that aligns with the preliminary FIRMs scheduled for issuance in late 2013. It is important to note the purpose of the advisory elevation products is to provide elevation guidance for rebuilding. The information they provide is not intended to support regulatory floodplain designations or insurance ratings.

Following Sandy, FEMA contracted Risk Assessment, Mapping, and Planning Partners (RAMPP) to develop coastal advisory flood hazard information for affected counties in New York and New Jersey.

This report documents the methodologies, assumptions, and data sources used to develop the coastal advisory flood hazard information and associated map products.

1.1 FEMA ADVISORY PRODUCTS

The advisory flood hazard information developed for New York City and coastal New Jersey included coastal analyses and mapping that resulted in the following:

1. Advisory Flood Zones that provide full geospatial representation of the Advisory Base Flood Elevations (ABFEs) (1- and 0.2-percent-annual-chance coastal flood hazards), including both storm surge and wave components;
2. Advisory Limit of the Special Flood Hazard Area (SFHA) to provide a geospatial limit to the ABFEs, as well as an updated representation of the 1-percent-annual-chance coastal flood hazard area;
3. Advisory Zone V-A Boundary, which delineates the confluence of Zone V and Zone A SHFAs, to approximate the landward limit of the 3-foot breaking wave;
4. Advisory Limit of Moderate Wave Action (LiMWA) to approximate the landward limit of the 1.5-foot breaking wave;
5. Advisory Area of Moderate Wave Action (MOWA) to approximate the extent of breaking waves less than 3 feet and greater than 1.5 feet in height; and

6. Advisory Limit of ABFEs to define the transition of the coastal advisory data to the effective FIRM at riverine confluences.

The advisory map products that were developed include:

1. Display of the advisory geospatial information on FEMA's GeoPortal; and
2. PDF mapping of the advisory flood hazard information.

1.2 SCOPE OF WORK

RAMPP was contracted to develop advisory products for the following jurisdictions:

- State of New York: **Kings (Brooklyn), Richmond (Staten Island), Queens, Bronx, New York (Manhattan), Rockland, Westchester, Nassau, and Suffolk Counties**
- **State of New Jersey:** Atlantic, Bergen. Burlington, Cape May (Atlantic Ocean side), Essex, Hudson, Monmouth, Middlesex, Ocean, and Union Counties

SECTION TWO DATA ACQUISITION

Table 1 summarizes the data collected for development of the advisory flood information products and their origins.

Table 1: Data Sources / Notes

Data	Source / Notes
Stillwater Elevations	Preliminary coastal FEMA FIS update for New York City, Westchester County, Rockland County, and New Jersey Coastal Counties, 2012.
Bathymetry Data	National Oceanic and Atmospheric Administration (NOAA) National Geophysical Data Center; NOAA Office of Coast Survey; U.S. Army Corps of Engineers, New York and Philadelphia Districts; New York State Geographic Information System (GIS) Clearinghouse; and the New Jersey Department of Environmental Conservation. Details of terrain processing can be found in the report titled "Region II Coastal Terrain Processing Methodology Documentation Report," dated December 2011 and prepared by RAMPP.
Shoreline Data	Shoreline data used in this study were developed digitally as part of the FEMA Region II Coastal Study Task Order.
Topography Data	**New York:** the following topographic data were used: • NYC: Topographic information developed in 2010 by the Research Foundation of the City University of New York as part of the Light Detection and Ranging (LiDAR) Campaign (New York, NY); and • Westchester and Rockland Counties: Coastal New York LiDAR, New York Department of Environmental Conservation, 2012. **New Jersey:** the following topographic data were used for New Jersey counties: • Bergen, Hudson, Essex, Union, Middlesex, and Upper Monmouth: LiDAR (USNGA), December 2006 to February 2007; • Lower Monmouth, Ocean and Atlantic: LiDAR, April 2010; • Burlington: 5-foot contour, April 2005 and 2011 LiDAR; and • Cape May, Cumberland, and Salem Counties: LiDAR, April 2008.
Effective FIRM Data	Effective data for the study area were obtained from published FIRM databases and the National Flood Hazard Layer.
Base Map	Microsoft Bing® road map layer was used with permission from Microsoft as the source of base mapping.
CBRA Data	The Coastal Barrier Resources Act (CBRA) established the John H. Chafee Coastal Barrier Resources System (CBRS), a defined set of geographic units along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts. All CBRA data were made available by the U.S. Fish and Wildlife Service, which oversees the CBRS.

SECTION THREE METHODOLOGY

3.1 ABFE COASTAL ANALYSIS AND MAPPING (ALL COUNTIES EXCEPT NASSAU AND SUFFOLK)

The ABFEs developed for the geospatial and map products provide a full representation of the surge and wave components of the coastal flood hazard. The foundation of the advisory elevations was the draft preliminary coastal storm surge stillwater elevations (SWELs) from the ongoing FEMA Region II coastal analyses. This coastal study includes the entire Atlantic coastlines of New Jersey and New York City; the Hudson Estuary to the Troy Dam; and Westchester County, New York. The advisory information does not include Nassau County east of Jamaica Bay or Suffolk County, New York. The draft preliminary SWELs do not include overland wave effects, which are a key component of the Base Flood Elevations (BFEs) presented on effective FIRMs. Unfortunately, the ongoing New York/New Jersey coastal update had not fully progressed to the stage that these data could be leveraged to support the advisory products. As a result, in most locations the overland wave effects were estimated using depth-limited wave calculations rather than the Wave Height Analysis for Flood Insurance Studies (WHAFIS) model.

To compensate for this unavailable data, depth-limited wave theory was applied to estimate the wave effects concomitant with the 1- and 0.2-percent-annual-chance coastal SFHAs. Application of the depth-limited wave equation to the draft preliminary surge data provided a proxy for estimating overland wave effects and the resulting BFEs. This approach was used in the Hurricane Katrina recovery maps for Mississippi, and has been successfully applied in many other areas of coastal engineering practice.

The depth-limited approach produces more conservative results than the in-progress detailed overland wave models. In contrast to the WHAFIS model, the depth-limited approach relies solely on depth-limiting relationships for wave breaking and does not consider wave attenuation by obstructions. The overland wave height elevations, in lieu of WHAFIS modeling, were estimated by multiplying the SWEL by a factor of 0.55. This value represents a simplification of:

> Estimation of the controlling or breaking wave height (H_c) by depth (d) via the empirical factor 0.78: $H_c = 0.78 * d$; and
>
> Adjustment of the wave height to represent approximately 70% of the wave being above stillwater: $0.7 * H_c$.

The advisory elevation was then calculated by adding the estimated wave elevations on top of the corresponding SWEL (1- or 0.2-percent-annual-chance). For example, the ABFE for the 1-percent-annual-chance SWEL was estimated using the following formula:

$$\text{Advisory elevation} = 1\%\ \text{SWEL} + (d * 0.55)$$

The approach was implemented through the following steps:

- Creation of flood depth grids for the 1- and 0.2-percent-annual-chance SWEL;
- Calculation of the depth-limited wave envelope;
- Calculation of the ABFE surface layer based on the identified formula, applied in the geospatial environment, and resulting in a continuous raster elevation model for each sub-geography; and
- Smoothing of the resultant surface to promote less convoluted line work.

Advisory Zone VE Determination

The coastal high hazard zone, or advisory Zone VE, was established by combining the depth-limited method with data from the effective Zone VE mapping and draft preliminary primary frontal dune (PFD) delineation (where available). The production process consisted of the following:

- Extraction of the depth contour corresponding to the limiting depth of the 3-foot wave (which occurs at the 3.85-foot stillwater depth contour);
- Creation of a depth-limited advisory Zone VE polygon;
- Merging of the depth-limited advisory Zone VE polygon with the effective Zone VE mapping or draft preliminary PFD delineations; and
- Selection of the landward-most location of the three layers to provide the most conservative estimate of the advisory Zone VE boundary.

LiMWA Determination

The advisory LiMWA was established through the depth-limited method. The production process consisted of the following:

- Extraction of the depth contour corresponding to the limiting depth of the 1.5-foot wave (1.92 feet); and
- Creation of a depth-limited advisory Coastal Zone A polygon.

The approach was implemented in ModelBuilder within the ArcGIS 10.0 environment to produce both the 1- and 0.2-percent-annual-chance surface elevation models, which were then used to generate the advisory mapping layers. The mapping layer production process consisted of the following:

- Extraction of the 0.5-foot contours (consistent with BFE zone elevation breaks for FIRM mapping) for the range of elevations in the ABFE surface raster;
- Creation of polygons from the extracted contours;
- Editing of the 1- and 0.2-percent-annual-chance floodplain polygons to remove small polygons (generally less than 160,000 square feet) or narrow pieces of the SFHA (generally less than 400 feet in width);

- Editing of the 1- and 0.2-percent-annual-chance SFHAs to remove areas in close proximity to the shoreline or in areas subject to significant erosion;
- Clipping of the advisory elevation polygons to the edited advisory 1-percent-annual-chance SFHA;
- Spatial calculation of the appropriate advisory elevation value by polygonal area from the advisory elevation surface elevation model;
- Automated removal of undesired small advisory elevation polygons;
- Manual merging of advisory elevation zones at the edges of land areas and within the advisory flood hazard area, as needed, to reduce product complexity while providing appropriate hazard representation;
- Intersection of the advisory elevation polygon to identify advisory Zone V and editing of the advisory Zone V/A boundary;
- Simplification of the vector line work for the advisory LiMWA; and
- Final simplification of advisory zone line work.

Accuracy of Advisory Elevations Compared to Detailed Modeling:

In support of this effort, RAMPP evaluated the proposed depth-limited approach against WHAFIS modeling within the study area. It was found that advisory elevations produced using the proposed method are predominantly equal to or higher than the elevations derived from WHAFIS modeling with few exceptions (90 percent of points evaluated). Where advisory elevations were lower than WHAFIS-derived BFEs (10 percent occurrence in sampled area), 95 percent of the locations were on the beach face, which is subject to erosion in the coastal modeling process.

The remaining 5 percent were within the coastal floodplain and appeared adjacent to an advisory elevation higher than the WHAFIS BFE output. This initial comparison included point-specific locations and did not factor in merging of the ABFE polygonal areas.

Representation of Erosion:

Due to the time constraints of this product, an erosion analysis was not included in the ABFE analysis.

Assessment of Wave Runup:

Runup modeling is complex and dependent on localized runup slopes. Based on a review of current modeling efforts in New York City, it was not possible to perform a detailed analysis of runup for every slope. However, a basic evaluation of near shore slopes was conducted for the entire study area by looking at the contour change within a distance from the start of the shoreline. If the slope was steep enough, a buffer of approximately 40 to 60 feet landward of the slope crest to the advisory Zone VE was added (to extend the advisory Zone VE further inland).

In areas identified as runup dominated, where the ground elevation rises above the surge SWEL, the Zone VE advisory elevation is the slope crest elevation plus 3 feet to account for larger runup elevations and overtopping areas. Where bluff crests were significant (60 to 100 feet), runup was not accounted for and the advisory elevations were based on the surge SWELs and the previously described depth-limited wave heights. In areas where steep slopes existed near the shoreline and limited fetches diminished wave energy, wave runup elevations were limited to 1 to 2 feet above the depth-limited wave crest elevation and were mapped as Zone A.

Figure 1 shows the Advisory Polygon Production Process RAMPP developed for this study.

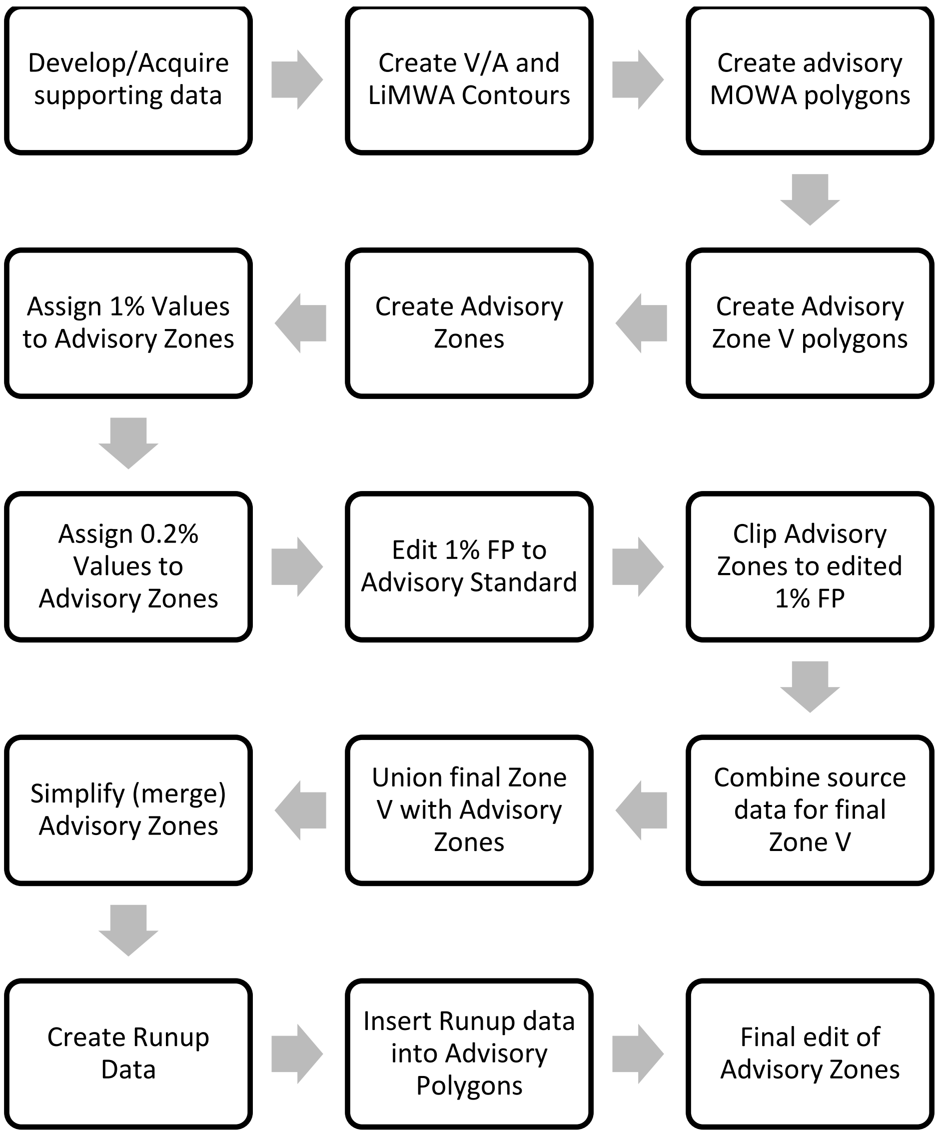

Figure 1: Advisory Polygon Production Process

Special Considerations for the Advisory Elevation Product

To achieve FEMA's goal of providing cartographically simple products that are easy to use, the following processes were implemented:

- Merging of smaller ABFE zones into larger, adjacent ABFE zones to minimize variation in line work and ABFE values;
- Merging of narrow ABFE zones at the land/water interface to reduce the number of zones mapped in the final product. This procedure merged zones into the best representative value, often adopting the shoreline zone elevation in a similar practice as that typically undertaken in coastal FIRM mapping;
- Removal of 0.2-percent-annual-chance flood hazard areas and Zone X to promote cartographic simplicity. In general, areas less than 160,000 square feet were targeted for removal. Some areas were allowed to remain based on site-specific factors;
- Removal of 0.2-percent-annual-chance flood hazard areas and Zone X near the shoreline and/or in areas subject to significant erosion;
- Areas identified as fetch-limited and not subject to significant wave action will have the ABFE values reduced to the appropriate SWEL (wave effects removed). These areas typically had fetch lengths less than 0.5 mile and did not have WHAFIS-modeling transect coverage in the preliminary FIS update. The 2D wave modeling results from the preliminary FIS described below were also used to inform where wave heights would not contribute to the ABFE;
- In some areas, the depth limited wave calculation produced Zone V and/or MOWA areas that extended far inland, behind elevated roads, or depressions in the terrain. These areas were mapped as Zone A.

Use of Preliminary Flood Insurance Study Data

Data from the ongoing New York City and New Jersey coastal analyses were used to assist in decision making and as supplemental data in the ABFE production process. The following summarizes the use of these data:

- SWEL surfaces were used as the foundation of the ABFE calculation;
- WHAFIS modeling transect layouts were used to identify areas that should have overland wave effects. Areas without transects were typically reduced to the SWEL, and wave effects were removed from the ABFE value.
- Starting shoreline wave height values from the FIS surge modeling effort were used to determine the limits of Zone V and MOWA extents along shorelines. These wave heights were output from the 2D Simulating Waves Nearshore (SWAN) Model and are input into WHAFIS for each transect as starting wave conditions in an FIS.
- The preliminary PFD line was used as an input into the advisory Zone V. Where the advisory Zone V was seaward of the PFD line, the zone was extended to the PFD line location.
- In some areas, draft wave runup calculations from the FIS study were available to help inform the reasonableness of the mapped advisory runup elevations.

Steps taken in the analysis and production process are detailed in Appendix A of this report.

3.2 UPDATE TO NEW YORK CITY ADVISORY BASE FLOOD ELEVATION COASTAL ANALYSIS & MAPPING

Upon further review, the draft advisory information for New York City was updated to incorporate recently completed coastal modeling information. This update was a collaborative effort between New York City officials, the City's consultants, FEMA, and FEMA's consultants. The revisions focused on areas with no Atlantic Ocean coastline and limited width water bodies fronting the shoreline. The modeling behind the revision was under development for the FIS and FIRM products for New York City and Coastal New Jersey Counties due out later in the year.

The detailed and refined coastal modeling provides for a more complete assessment of the physical processes that result in the coastal flood hazards. The same base storm surge SWELs that were used for the original advisory information were used for the more detailed coastal modeling; hence, advisory flood hazard boundaries were not updated. A detailed overland wave analysis using refined wave conditions and an assessment of land-use conditions that would reduce wave heights were used. In addition, detailed wave runup analyses were performed for structures and steep shorelines. Zone designations and ABFEs were revised based on these new data. The resulting advisory mapping in these areas is similar to what will be produced for the FIS reports.

3.3 ADVISORY GUIDANCE – NASSAU AND SUFFOLK

RAMPP developed a stand-alone technical memorandum on advisory guidance for Nassau and Suffolk Counties, NY. This memorandum can be found in Appendix B.

3.4 QUALITY ASSURANCE AND QUALITY CONTROL

All the products developed in this study were developed using FEMA-approved Quality Assurance/Quality Control (QA/QC) procedures consistent with the RAMPP Quality Management Plan.

Process documents were developed, refined, and used in product development to ensure consistency in quality assurance procedures. Quality review checklists were developed and used to ensure complete and consistent product reviews. The reviews, including intermediate product reviews, were strategically integrated into the process to maximize efficiency, ensure accuracy, and minimize rework. The QA/QC products involved the following:

- **Coastal Analysis and ABFE:**
    - Detail Checks performed by the production firm.
    - Independent Technical Review performed by the RAMPP Joint Venture (JV) partner firm.
    - Review by FEMA Coastal Subject Matter Expert

- **PDFs and Changes Since Last FIRM Products:**
    - Detail Checks performed by the production firm.
    - Independent Technical Review performed by the JV partner firm

SECTION FOUR SUMMARY OF FINDINGS

Advisory Base Flood Elevations

Table 2: ABFE Summary

State	County	1% annual chance ABFE Minimum (ft, NAVD88)	1% annual chance ABFE Maximum (ft, NAVD 88)
New York	New York City (5 Boroughs)	8	27
	Rockland	10	12
	Westchester	9	31
New Jersey	Atlantic	8	19
	Bergen	8	18
	Burlington	10	14
	Cape May	8	18
	Essex	10	14
	Hudson	8	23
	Middlesex	12	27
	Monmouth	7	20
	Ocean	7	15
	Union	11	17

SECTION FIVE REFERENCES

RAMPP, Advisory Elevation Data for New Jersey and New York Counties, July 2013.

Delaware Valley Regional Planning Commission, Burlington County 5' contour data, April 2005.

FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Bergen County, NJ, September 2005.

FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Essex County, NJ, June 2007.

FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Union County, NJ, September 2006.

FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Hudson County, August 2006.

FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Middlesex County, NJ, July 2006.

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FEMA, Flood Insurance Study and Flood Insurance Rate Map Database for Ocean County, NJ, September 2006.

Lower Monmouth, Ocean and Atlantic Counties Light Detection and Ranging, April 2010.

RAMPP, Region II Coastal Terrain Processing Methodology Documentation Report DRAFT, December 2011.

New York Department of Environmental Conservation, Coastal New York Light Detection and Ranging, 2012.

RAMPP, Preliminary Coastal FEMA Flood Insurance Study Update for New York City and New Jersey, 2012.

RAMPP, Light Detection and Ranging Data for Burlington County, NJ, under FY 10 Elevation Task Order, June 2011.

Research Foundation of the City University of New York, Light Detection and Ranging Campaign (New York, NY), May 2010.

U.S. Geological Survey, Rapid Deployment Gauges and High Water Marks (provisional data dated 11/27/2012, current data at http://water.usgs.gov/floods/events/2012/sandy/).

USGS and New Jersey Department of Environmental Protection, Cape May, Cumberland, and Salem Counties Light Detection and Ranging, April 2008 and March 2009.

USNGA, Bergen, Hudson, Essex, Union, Middlesex, and Upper Monmouth Counties Light Detection and Ranging, December 2006 to February 2007.

Appendix A

COASTAL ANALYSIS METHODOLOGY AND PRODUCTION PROCESS

Production Process Steps

1. Development/Acquisition of Supporting Data
   The following data elements were required to produce ABFE polygons:
   - Digital Elevation Model (DEM)
   - 1- and 0.2-percent-annual-chance SWEL rasters
   - Effective Zone VE polygons
   - Draft Preliminary PFD delineation
   - Vector shoreline

2. Creation of Zone V/A and MOWA Contours:

   The process of creating the Zone V/A boundary and LiMWA was automated within ArcGIS 10 ModelBuilder. The tool process generated a depth grid that was smoothed to promote cartographic simplicity. The appropriate contours were then extracted from the depth grid and short segments of contour line were removed to eliminate small areas from the final product.

   Inputs:

   - DEM
   - 1-percent-annual-chance SWEL surface
   - Minimum Length – the minimum length of a contour line that can be included in the output (Default = 2,000 feet)

   Outputs:

   - Smoothed LiMWA Gutter
   - Smoothed Zone V/A Gutter
   - 1-percent-annual-chance Depth Grid

3. Creation of Advisory MOWA, Zone V polygons:

   Two tools were created in ArcGIS 10 ModelBuilder to automate the following tasks:
   - Tool 1 – addition of bounding line work to facilitate polygon creation
   - Tool 2 – calculation of values in each polygon to provide an initial selection of polygons to include in the MOWA and Zone V output.

   Inputs:

   - 1-percent-annual-chance Depth Grid
   - LiMWA or Zone V/A Gutter, depending on tool

Output:

- Polygons created through the process
- MOWA of Zone VE: Polygons representing Zone V or area of MOWA.

Process Notes:

- The output was checked against the line work input into the tool, and for large zones that did not become polygons.
- Where polygons did not generate, unsnapped or non-intersecting ends of line work were corrected and extended to ensure polygon creation.
- The tool was rerun to generate polygons subsequent to corrections when/if the initial run failed to create all areas.
- Output polygons were reviewed to ensure all features represented the Zone V or MOWA.
- Resultant polygons were edited to remove all "island" polygons except those that covered significant land areas and are justified by lack of land cover and/or other justifying factors.

4. Creation of Advisory Zones:

The ABFE polygon generation process was automated within ArcGIS 10 ModelBuilder. A tool was created to generate the 1- and 0.2-percent-annual-chance ABFE surfaces by applying depth-limited wave theory. The tool then generalized the surface and extracted and smoothed contour lines to create the ABFE polygon coverage.

Inputs:

- DEM
- 1-percent-annual-chance SWEL raster
- 0.2-percent-annual-chance SWEL raster
- Minimum Length: the minimum length of a contour line that can be included in the output (Default = 2,000 feet)

Outputs:

- Advisory Polygons: Polygons for all the advisory zones, pre-populated with fields for following steps
- Advisory Contours: Contours, or gutters at half-foot elevations for the above polygons. This layer was intended to be used as a quality check against the output polygons
- Smoothed 1-percent-annual-chance Advisory Elevation Surface: Surface elevation model of 1-percent-annual-chance Advisory Elevations
- Smoothed 0.2-percent-annual-chance Advisory Elevation Surface: Surface elevation model of 0.2-percent-annual-chance Advisory Elevations

Process Notes:

- The advisory contours were used as a QC measure to ensure all polygons were generated
- Where polygons were not created, unsnapped or non-intersecting ends of line work were checked and extended to intersect as needed to create polygons
- The “Fix Polygons” tool with the line input file was rerun iteratively once any necessary corrections were made to the line work

5. Assignment of 1-percent-annual-chance annual chance SWEL to Advisory Zones:

   This task was performed to assign advisory elevations to the established polygons using the following steps:

   a. “Zonal Statistics as Table” was run.
      Inputs:
      - Input raster or feature zone data: ABFE Polygons
      - Zone field: IDs
      - Input value raster: 1-percent-annual-chance ABFE Surface Raster
      - Output Table: name as desired
      - Statistics Type: Mean
   b. The output table was joined to the ABFE polygons.
   c. The mean value field was rounded to the nearest whole integer and populated into the appropriate field.
   d. Joins were removed.
   e. NULL ABFE polygons, which occurred on the coverage edges, were removed.
   f. Sliver ABFE polygons were eliminated.

6. Assignment of 0.2-percent-annual-chance annual chance SWEL to Advisory Zones:

   This task was performed to assign advisory elevations to the established polygons using the following steps:
   a. “Zonal Statistics as Table” was run.
      Inputs:
      - Input raster or feature zone data: ABFE Polygons
      - Zone field: IDs
      - Input value raster: 0.2% ABFE Surface Raster
      - Output Table: name as desired
      - Statistics Type: Mean
   b. The output table was joined to the ABFE polygons.
   c. The mean value field was rounded to the nearest whole integer and populated into the appropriate field.
   d. Joins were removed.

7. Edit the 1-percent-annual-chance SFHA to Advisory Standard:

   This step was intended to remove Zone X from areas that required advisory guidance.

   Minimum Inclusion Area:
   The advisory map panels were produced at a scale of 1:1,000 feet. At this scale, and in light of the desire for a cartographically simple product, the minimum distance for line work spacing was set at 400 feet. This standard allowed a sufficient amount of space between line work to promote identification of underlying and adjacent features.

   The square of the minimum line work spacing provided for a minimum area of 160,000 square feet. Polygons less than 160,000 square feet were typically removed from the advisory coverage.

   Areas Inundated by Sandy:
   Areas inundated during Sandy should not be shown as Zone X, unless extenuating circumstances occur. The analysis utilized the "Preliminary Field Verified 10-meter Storm Surge Extent," a Sandy inundation extent developed by the FEMA Modeling Task Force to screen Zone X areas from the advisory product. FEMA guidance was to remove and/or edit Zone X areas where inundation occurred during Sandy. This applied only to isolated Zone X areas (areas surrounded by inundation). The landward extent of Zone X was not edited for advisory purposes.

   General Rules for Exclusion: The following are some rules of exclusion followed in the mapping process.

Narrow X or 0.2-percent-annual-chance zones above area criteria If less than 400 feet apart, areas were generally removed.	
Zone X areas above the minimum area cut, but below the width criterion were generally removed. Width for this example is approximately 200 feet.	

Erodible dune features were removed	
Features subject to failure during the 1-percent-annual-chance event or noted as failing during Sandy were removed. Example shows a boardwalk.	
Zone X areas at or near the apparent tipping point of inundation (above flood elevation). Subject to analyst judgment, but typically evidenced by street-level flooding and side intrusion of boundary at isolated Zone Xs. These areas should be verified by querying the topographic DEM against the SWEL surface.	

Zone X areas above the minimum area criterion that do not fully enclose any structures.	

8. Clipping Advisory Zones to edited 1-percent-annual-chance SFHAs:

   On completion of the editing to the 1-percent-annual-chance SFHA polygon, the ABFE polygons were clipped to the edited SFHA polygon.

9. Combining source data for the advisory Zone V:

   This step was performed to combine all best available data on the Zone V footprint to establish the most landward extent for the advisory maps.

   a. <u>Effective Flood Hazard Area Polygons.</u> The effective Zone VE area was selected and exported to a separate shapefile.
   b. <u>Combination of the Effective VE and Depth-Limited Zone V Polygons.</u> The effective Zone VE area was merged into the depth-limited Zone V polygon.
   c. <u>Integration of the Preliminary Study Primary Frontal Dune Line.</u> For FIS studies, the Zone V is extended to the PFD line during the mapping process. To ensure the advisory Zone V would not be seaward of the revised FIS PFD, the combined Zone V polygon was compared to the preliminary FIS PFD delineation line. The combined Zone V polygon was then edited to ensure it extended to the preliminary PFD line. When necessary, engineering judgment was applied to transition the combined polygon to and away from the PFD line work. Completion of this step provided for the draft advisory Zone V polygon.
   d. <u>Review Edited Zone V.</u> The advisory Zone V polygon was reviewed for harsh transitions or undesirable geometry resulting from the merger with the effective Zone VE. Editing was performed as necessary to improve the cartographic representation of the boundary. The edited polygon was reviewed for disconnected Zone V “islands,” or areas that theoretically represented interior areas of wave height

regeneration. Typically, island Zone V areas were removed unless engineering judgment indicated the area should be retained.

e. Check Against Wave Height Outputs from Surge Model: A secondary check on the validity of the Zone V designation was conducted on an as-needed basis when the area extended into sheltered areas or continued for a considerable distance away from open water. In such cases, wave height data from the SWAN model were evaluated to confirm wave elevations. In cases where the SWAN data did not confirm the Zone V designation, the polygon was edited to provide a more accurate representation based on the available data.

f. Removal of Limited Fetch Areas: The advisory Zone V was reviewed for narrow areas of Zone V propagation, such as narrow channels. These areas were removed from the advisory Zone V.

10. Combining final Zone V with Advisory Zones:

This step was performed to merge Zone V polygons into the Advisory Zone polygons to designate the Zone V.

a. Integrate Zone V into Advisory Polygons. The final advisory Zone V polygon was unioned into the ABFE polygons. The resulting coverage was exploded and sliver polygons introduced into the ABFE coverage were eliminated.

11. Simplifying (merging) Advisory Zones:

This step merged polygons to create relatively simpler and larger areas of Advisory Elevation.

Guidance: Polygons were merged to create a simplified representation of advisory zones. Stillwater values, WHAFIS transect layouts for the study updates, and aerial photography were used to facilitate decision making.

- Advisory coverage was checked against the WHAFIS modeling transect layout. Advisory areas that will not have WHAFIS modeling were mapped to the local SWEL.
- Smaller polygons were merged into larger polygons to simplify line work.
- Areas were typically merged to the higher elevation; however, zones were merged within a ±1-foot range subject to analyst judgment to obtain the best representative value for the area.
- Higher elevations were merged to lower elevations when the lower elevations were more representative, for example:
    - Small zones of higher elevation surrounded by lower elevation; and

    - Zones of higher elevation that overlay land cover that would prevent significant wave propagation as compared to adjacent areas with lower advisory elevations (dense buildings, vegetation).
- Bounding polygons (at shoreline) were merged to a representative value. The ±1-foot range was not applied in these areas. Analyst judgment was applied in these areas.
- Special attention was given while merging polygons seaward of Zone V to develop the most representative value. Advisory Elevations were brought in from the seaward side of the dune to the PFD in a practice similar to FEMA coastal mapping.

12. Creation of Runup Data:

The steps for runup evaluation included the following:

1. Determine nearshore runup slope crest;
2. Determine where the 1-percent-annual-chance SWEL flood hazard area does not extend inland past the crest;
3. Set the advisory elevation in these areas at 3 feet above the crest (some averaging out of elevations along the coast was performed to avoid multiple zone changes along the shore); and
4. Extend the advisory flood hazard area 50 feet landward of crest.

The above methodology is fast and efficient, does not require engineering judgment, is a consistent method across all areas, is easy to explain, and captures any structures that may have been damaged by runup and overtopping by Sandy. It is also consistent with mapping maximum runup in an effective FIS (3 feet above crest).

A drawback is the possible mapping of runup elevations that greatly exceed what would be mapped in an FIS when the runup model or calculation does not reach the crest. However, because no structures should be located seaward of the runup crest, mapping the higher elevation will have no impact. The approach will lead to conservative results landward of the crest. However, if a landward structure was not damaged by Sandy, the higher runup elevation would not affect rebuilding efforts, except to relay the risk posed by future storm events greater than Sandy. There may also be unrealistic elevations, such as an extreme runup slope crest (100 feet or more), but these can be determined by engineering judgment and avoided.

Data Finalization

1. All comments from Detailed Checks and Independent Technical Reviews were resolved.
2. Final Edits of MOWA:
    a. ABFE polygons were dissolved by Zone and then limited to Zone V.
    b. The spatial extent of the advisory Zone V polygon was erased from the MOWA polygon.

c. Any resultant sliver polygons, or remnant areas seaward of the Zone V polygon, were identified and removed.

3. Polyline Features were generated for Map Production.
    a. Zone V/A Boundary:
        i. The advisory Zone V polygon was converted to polyline.
        ii. Resultant line work was edited to leave only the line between the Zones V and A (bounding line work, i.e., line work at the county boundary and open water boundary of the ABFE polygons was removed).

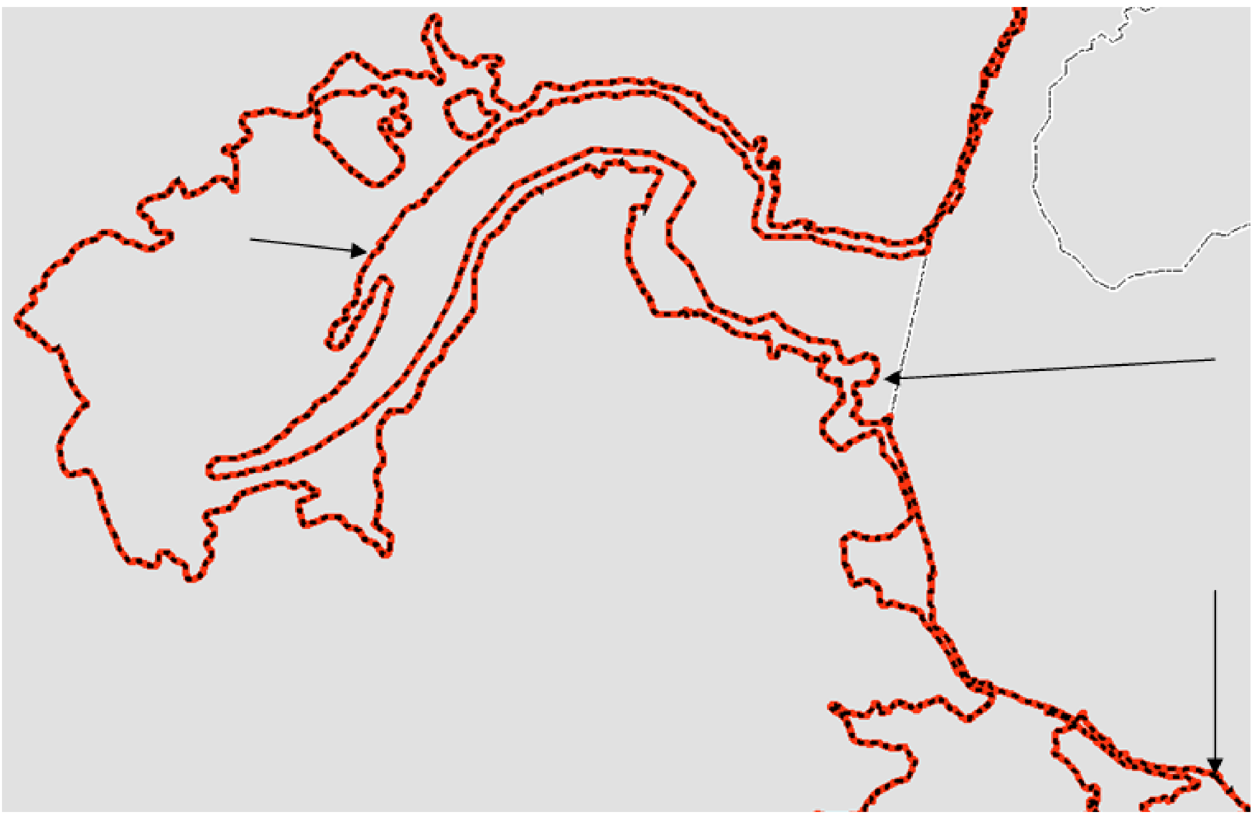

Figure A-1: Example of Line Work at the Open Water Boundary of the VE Polygon that was Removed to Fully Prepare the Zone V/A Boundary Line

    b. LiMWA:
        i. The MOWA polygon was converted to polyline.
        ii. The Zone V polygon was used in an erase operation against the resultant line feature to remove line work coincident with the Zone V/A boundary.
        iii. Resultant line work was edited to leave only the line at the landward edge of the LiMWA (removing remaining bounding line work – i.e., county boundary).
    c. 1-percent-annual-chance Floodplain Boundary Line:

   i. The ABFE polygons were dissolved then converted to polyline.
   ii. Resultant line work was edited to leave only the SFHA boundary (bounding line work, such as lines along the county boundaries and the open water edge of the ABFEs, were removed).

4. Shaded Zone X polygons were created for areas between the 1- and 0.2-percent-annual-chance flood hazard area boundaries and merged into advisory zones:
   a. 0.2-percent-annual-chance flood hazard areas were clipped to the county boundaries.
   b. The spatial extent of the ABFE coverage, clipped to the 1-percent-annual-chance flood hazard area, was erased from the edited 0.2-percent-annual-chance flood hazard area.
   c. Narrow areas below the advisory cartographic specification were typically removed.

5. All data were re-projected into WGS_1984_Web_Mercator_Auxiliary_Sphere.

6. County file geodatabase (FGDB) was prepared to receive data:
   a. FGDB template was copied into county folder.
   b. "_CountyTemplate" portion of the FGBD was renamed with studied county name, ie, "_EssexNJ" for Essex County, New Jersey.
   c. Layers that have a "Adv_XX_" nomenclature.
      i. "XX" portion of layer was renamed with the first two letters of the county name (all upper case), i.e., "XX" portion of Essex NJ layer will be renamed as "ES."

7. Data were loaded into the County Level FGDB with Advisory Schema.

8. County and State Attributes were added to all Layers.

9. FGDB was provided to data manager and the Project Manager was notified.

10. Preparing Shapefiles for Geospatial Deliverable:
   a. FGDB Feature Classes exported to shapefile.

Appendix B

NASSAU SUFFOLK ADVISORY GUIDANCE MEMORANDUM

A JV of Dewberry, URS, and ESP
RAMPP
Risk Assessment, Mapping, and Planning Partners

Memorandum

Date:	*January 24, 2013*
To:	*Rick Sacbibit*
From:	*Jeff Gangai*
Cc:	*Mike McGinn, Luis Rodriguez, Todd Steiner, Jonathan Westcott* *Jean Huang, Vikram Shrivastava*
Subject:	*Advisory Information for Nassau and Suffolk Counties, NY*

BACKGROUND

Given the level of reconstruction anticipated along the Atlantic coast of New Jersey and New York, FEMA would like to provide the best available data for reconstruction purposes in the form of Advisory Base Flood Elevations (ABFEs) for those communities most impacted. This data must be available as quickly as possible to best inform those reconstruction efforts.

For New Jersey and New York City, FEMA has undertaken a full scale restudy of the coastal flood hazards with the development of regulatory products which are anticipated to be delivered in mid 2013. This new coastal study data was utilized to support the advisory guidance and mapping.

For Nassau and Suffolk Counties, NY, (see Figure 1) a recent surge and coastal analysis was completed a few years ago with the FISs and FIRMs becoming effective in 2009. The initial review of available Hurricane Sandy tide gage data indicated that for some areas, the event was likely greater than a 1-percent annual chance event based on a comparison to stillwater levels taken from the 2009 FIS. No new coastal analysis and mapping projects are underway for this area; however, it is recommended that advisory elevations be provided for people wanting to rebuild stronger. The current Region II storm surge model does not provide sufficient detail to allow for a depth grid analysis as was done for New York City and the New Jersey Atlantic coast. Therefore, RAMPP conducted post-disaster flood hazard verification analyses to develop freeboard recommendations to be applied to the effective flood hazard information to use as advisory information. This analysis composed of comparing the elevations and flood extent that Hurricane Sandy achieved versus the 2009 effective information. The area of Nassau County affected by flooding from Jamaica Bay was also evaluated against the updated coastal surge analysis for New York City which includes Jamaica Bay.

Figure 1 - Area of Study

DATA COLLECTION

The two main data sources that were used in this assessment were the effective flood mapping for Nassau and Suffolk Counties along with Sandy observed flooding extents and elevations.

For the effective information the DFIRM databases for each county were obtained and the flood hazard area polygons extracted.

The Sandy flooding extent and corresponding elevations were obtained from the FEMA Modeling Task Force (MOTF) Hurricane Sandy Impact Analysis efforts. A high resolution inundation polygon was obtained that showed the flooding extent of Sandy. Also, a raster was obtained that contained the Sandy flood elevation information that was used to produce the flooding extent boundary. These products were based on the High Water Marks (HWMs) and gage data collected by the USGS. This means that the data has the same limitations as HWMs, such as whether they represent true surge or include wave heights or wave runup. These limitations of the HWM were considered in evaluating the impacts to Nassau and Suffolk County.

Analysis Method

As an initial assessment of the differences between Sandy inundation limits versus the effective 1-percent annual chance boundary, the two boundary limits were reviewed geospatially to see if an overall single trend could be seen. From this, it could be seen that the Sandy inundation limit is landward of the effective 1-percent boundary and greater than or very close to the 0.2-percent boundary for almost all of Nassau County's south shore but landward of only about half of Suffolk County 1-percent boundary on the County's south shore.

On the east end of Long Island, where Sandy had a lesser impact, the effective 1-percent flood extent is only slightly greater than Sandy. However, the Sandy surge levels were very close to the effective 1-percent annual chance stillwater levels but below the 0.2-percent annual chance levels.

For the north shores of both Nassau and Suffolk, the effective mapping is dominated by wave runup elevations. Due to the predominantly bluff shorelines there were limited Sandy HWMs that represent wave runup elevations. However, a few HWMs appear to represent wave runup. Figure 2 provides a comparison of the effective wave runup mapping in an area along the north shore of Nassau County. Here the effective BFE is 17 ft and the Sandy debris line HWM is 15.6 ft; differences in the topographic information used for mapping the effective versus the Sandy inundation or the accuracy of the location of the HWM may account for the discrepancy between the elevations and the effective flooding extent. The effective surge levels were based on a tidal gage analysis and interpolated between them. Areas where the inundation limit was not based on wave runup, but surge alone, the effective mapping appears landward of the Sandy flooding extent. As it is at the east end of Long Island, based on the HWMs, the north shore area saw Sandy surge levels that came very close to the effective 1-percent annual chance levels.

Figure 2 Wave Runup Comparison on North Shore of Nassau County

A series of paneled PDFs for Nassau and Suffolk Counties were prepared to show the differences in the flooding extent of Sandy versus the effective flood hazard areas.

To further investigate the comparison on the south shore of Long Island a flood area change analysis was performed similar to the changes since last FIRM product, Figures 3 and 4 below. A GIS change polygon was created that shows areas where both Sandy and the effective 1-percent annual chance flood show as flooded, where only Sandy flooded, and where only the effective 1-percent floodplain shows as flooded. From a review of this polygon, it was determined that Sandy flooding dominated for all of Nassau County's south shore over the effective. In the area of Nassau County affected by flooding from Jamaica Bay, Sandy was less than the 2009 effective levels, but more than the proposed LOMR based on the new NYC storm surge study (where the 1-percent surge elevations were reduced by approximately 2 ft below the effective).

Figure 3 Nassau County Flood Area Change

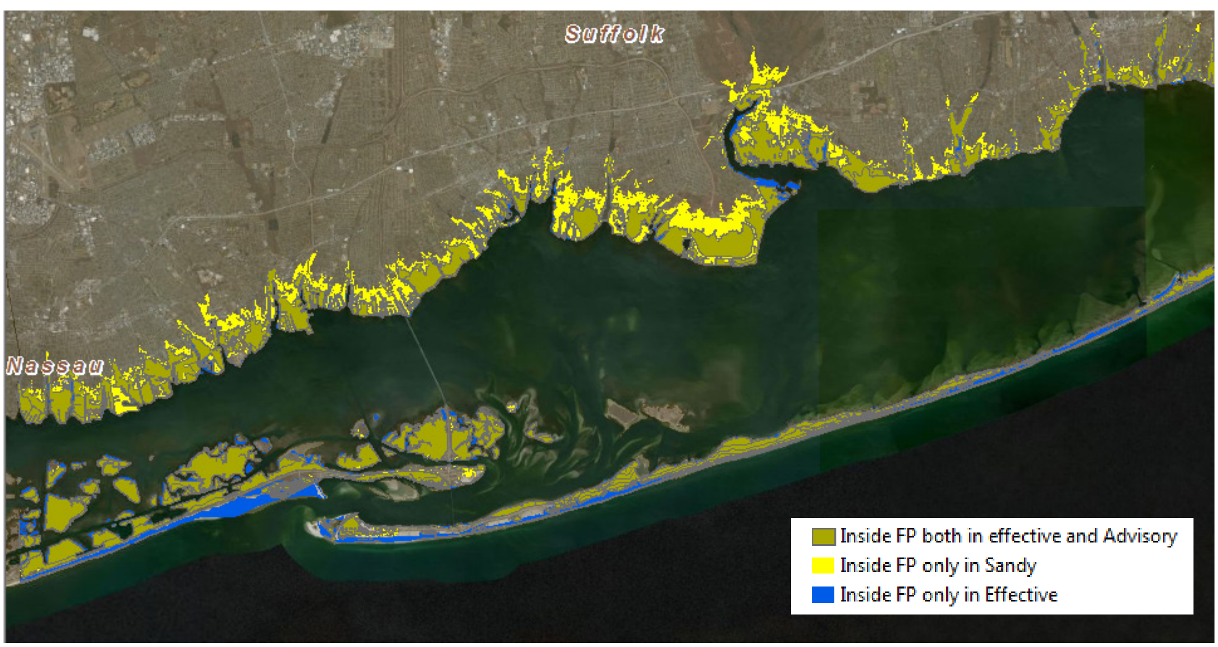

Figure 4 Suffolk County Flood Area Change

For Suffolk County, Sandy only dominated the inland flood extent over the effective until just west of Mastic Beach at William Floyd Parkway or Smith Point Park on Fire Island, as shown in Figure 5.

Figure 5 Change Point from Sandy dominance to Effective
(Blue=effective dominates, Yellow=Sandy dominates)

An initial review of the Sandy raster surface, and the USGS HWMs from which it was derived, revealed a few questionable HWMs; areas where the resulting raster and flooding limit should be ignored at these locations. The HWMs may be accurate at their specific location; however, due to the sparseness of HWMs in some areas and across transitional areas, the interpolation between the HWMs do not accurately represent the true surge profile. Figures 6 and 7 show areas in Suffolk and Nassau where a large open coast HWM is influencing the raster much further inland. This causes the Sandy elevations to be much larger on the bay side and mainland than they actually were. There also appears to be a limited amount of HWMs on the barrier islands, especially on Fire Island in Suffolk County.

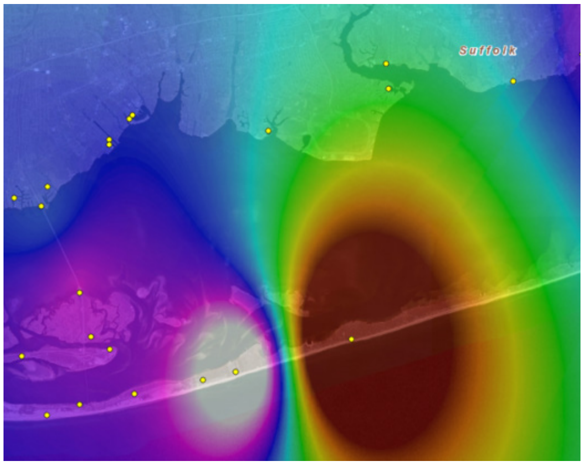

Figure 6 Suffolk: High Water Marks
Raster Interpolation

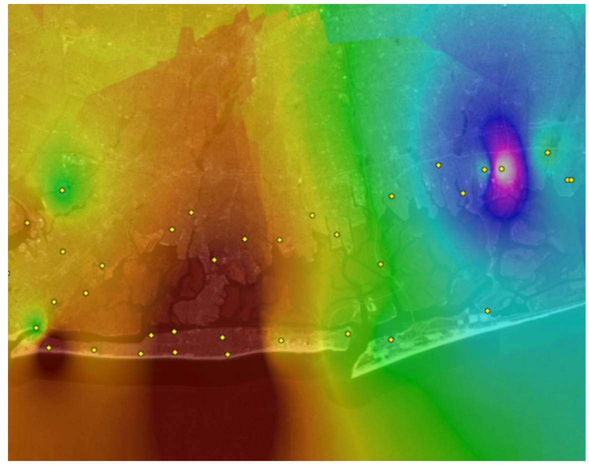

Figure 7 Nassau: High Water Marks
Raster Interpolation

In order to establish the magnitude of Sandy in comparison to the effective, the Sandy HWM raster was used to extract elevations within the change polygons for the areas where both the Sandy and effective floodplains exist. The Sandy elevations were averaged within each polygon. The Sandy elevations were than subtracted from the effective BFEs to obtain the magnitude of the difference. The most relevant data is along the inland floodplain boundary where the influence of waves is minimized.

For *Nassau County*, the elevation difference can be divided into three areas. The area affected by the flooding from Jamaica Bay showed that Sandy produced surge levels 1-2 ft greater that the proposed LOMR, as shown in Figure 8, where the differences are equal to the effective BFE minus the Sandy surge elevations. East of Jamaica Bay, the western half of Nassau County has Sandy elevations that are 1-2 ft above the effective while the eastern half has Sandy elevations 0-1 ft above the effective. The large differences in the middle of the bay on the order of 3 to 5 ft is due to the large HWM on the barrier island that is getting pulled across the bay as mentioned above and shown in Figure 7.

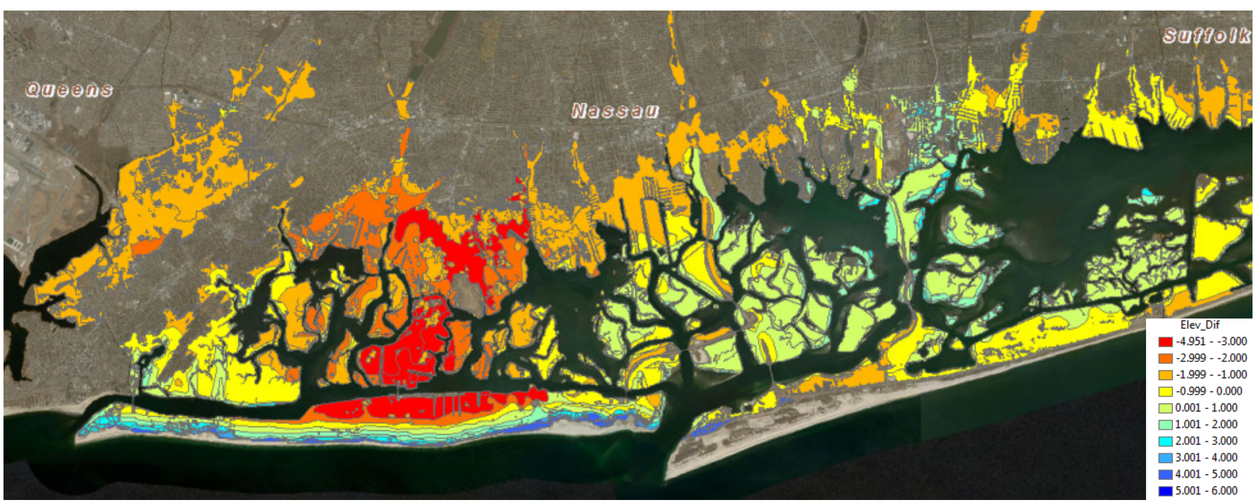

Figure 8 – Nassau County, Effective BFE minus Sandy Elevations

For *Suffolk County*, the Sandy elevations were higher than the effective ranging mostly from 1-2 feet except for the eastern end of Great South Bay where the difference was between 0-1 ft, as shown in Figures 9 and 10. In the areas where the range was 1-2 ft the majority of the differences are less than 1.5 ft. The eastern side of Figure 9, around Heckscher State Park, the darker reds indicates that Sandy was 3-4 ft higher than the effective. This area is an artifact of the single HWM on the open coast pointed out in

Figure 6 above and these large differences should be ignored in this area. East of Smith Point Park where Sandy was at or slightly less than the effective the differences were less than 1 ft.

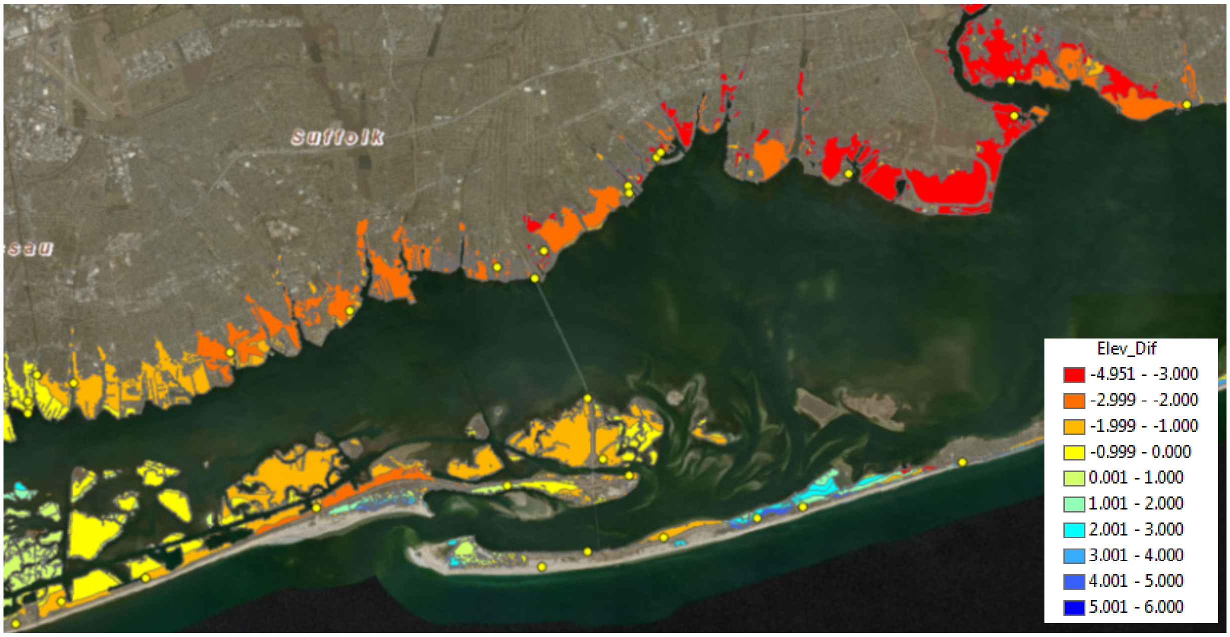

Figure 9 - Suffolk County, Effective BFE minus Sandy Elevations

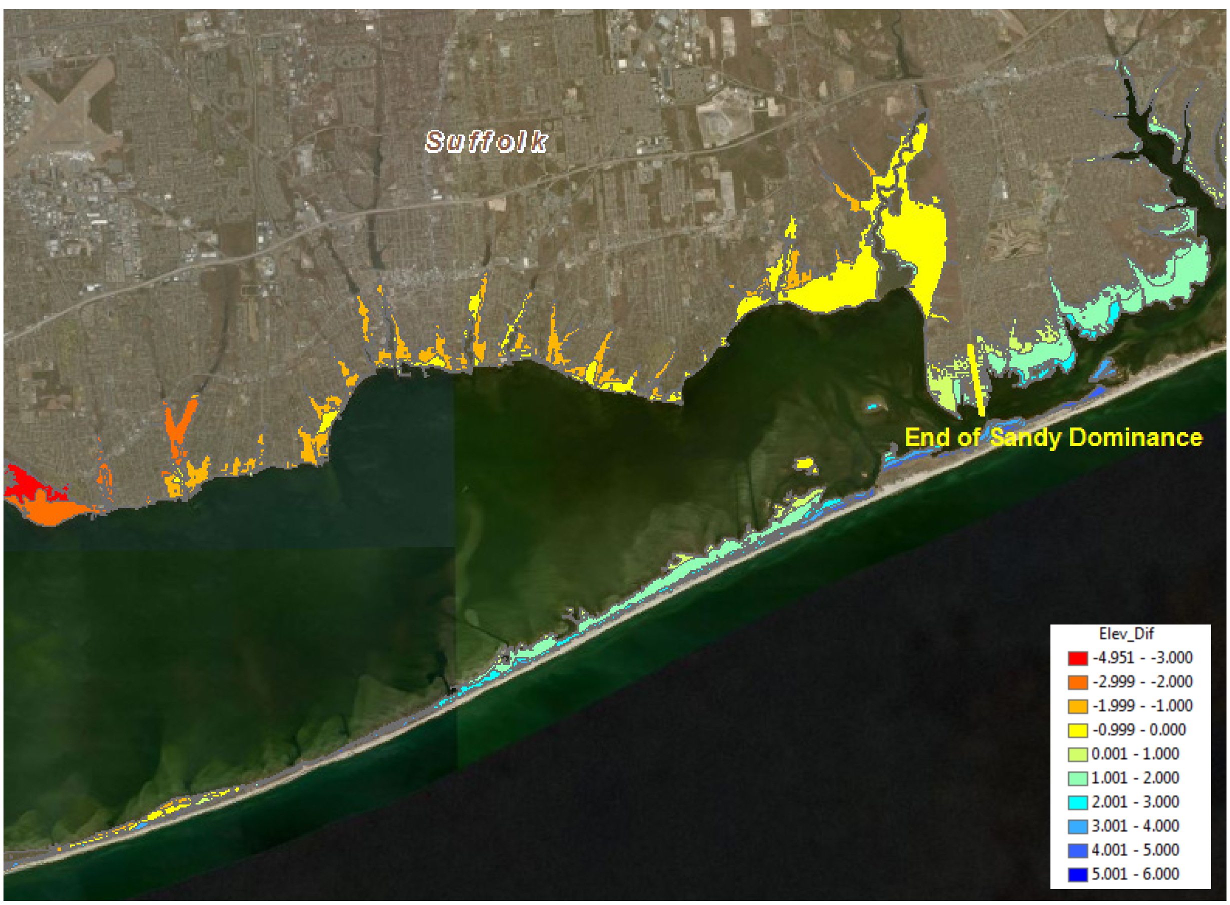

Figure 10 - Suffolk County, Effective BFE minus Sandy Elevations

RECOMMENDATIONS

For *Nassau County*, 2 ft of freeboard over the effective is recommended. For the area of Nassau affected by Jamaica Bay flooding, the 2009 effective BFEs could be used as a conservative Sandy advisory level or 2 ft of freeboard over the new surge study and LOMR could be used as a minimum.

For *Suffolk County*, where the Sandy levels were more than the effective, use of a 2 ft freeboard over the effective up to the point indicated above in Figures 3 and 8 at Mastic Beach. Anywhere on the barrier islands of the south shore of Nassau and Suffolk Counties due to the erosion potential and large surge overtopping, 3 ft of freeboard over the effective is recommended. East of Mastic Beach, between the North and South Forks of eastern Long Island and for the north shores of both Nassau and Suffolk where Sandy levels appear to be at or slightly lower than the effective, the effective plus 2 ft of freeboard is also recommended.

These recommendations are as conservative as the New York State Building Code recommendation of 2 foot freeboard. The recommendations are consistent across the counties. Finally, Sandy levels appear to be no more than 2 ft above the effective levels in these counties.

SUMMARY OF FREEBOARD RECOMMENDATIONS
Nassau County - 2 ft freeboard
Nassau Jamaica Bay – Min LOMR plus 2 ft Freeboard, Max Effective
Suffolk County – 2 ft freeboard
Barrier Islands of the south shore of Nassau and Suffolk Counties – 3 ft freeboard.