Discrepancies between recently updated FEMA FIRM base flood elevation boundaries and LiDAR data in Buzzards Bay

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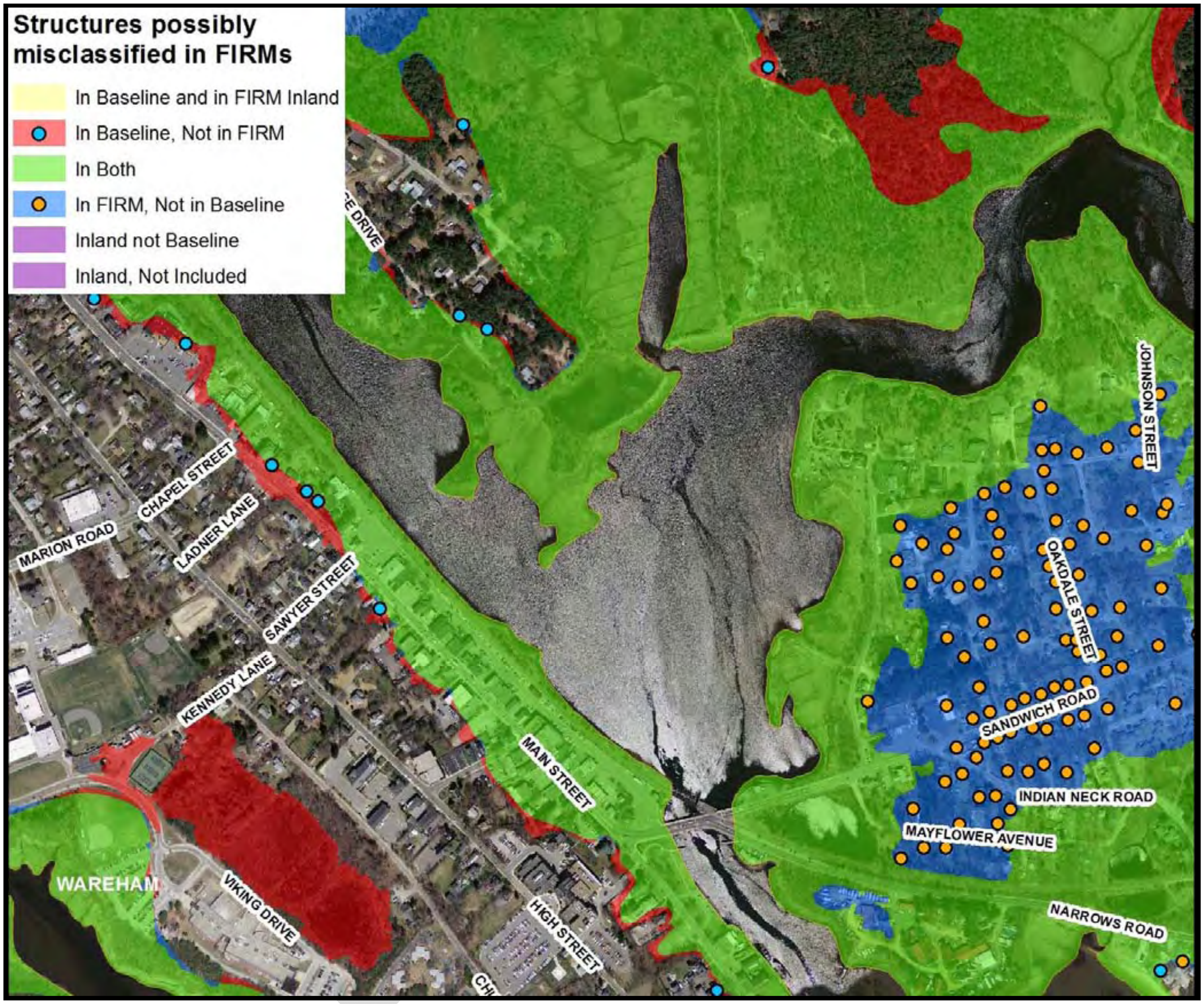

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Data at: http://www.buzzardsbay.org/floodzone-expansion-slr.html.

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Summary

Beginning in 2012, the Buzzards Bay National Estuary Program (BBNEP) and the Massachusetts Office of Coastal Zone Management began evaluating the potential expansion of the 1% floodplain[1] (also known as the 100-year floodplain in state and local laws and regulations) in seven Buzzards Bay watershed coastal communities (Westport, Dartmouth, New Bedford, Fairhaven, Mattapoisett, Marion, and Wareham). While undertaking this study, in certain areas, within all communities, we observed discrepancies between the landward extent of the 1% floodplain as mapped by the Federal Emergency Management Agency (FEMA) in their 2012 digital Flood Insurance Rate Map (FIRM) coverages, and LiDAR data sets (existing as both contour data and digital elevation models of bare earth). Many of these discrepancies are apparent errors that have resulted in the erroneous inclusion or exclusion of structures within the 1% floodplain in updated FIRMs approved in 2009 in Bristol County, and 2012 in Plymouth County.

A few of these discrepancies were conspicuous and could be captured by overlaying older digital products for the prior FIRMs (the so-called MassGIS Q3 data). The most dramatic errors were the result of a misclassification of land within certain "doughnut holes" in the digital FIRMs GIS data (apparent topology errors). Most of the other discrepancies, however, related to the shoreward extent of the corresponding flood zone not matching the correct LiDAR contour or other digital elevation data. Many of these discrepancies are minor, and cover small distances, or are within the elevation uncertainties of the data. Other discrepancies are more significant, and affect the regulatory placement of structures within the floodplain.

Among the seven communities evaluated, those FIRMs produced for the Bristol County communities (Dartmouth, Fairhaven, New Bedford, and Westport) approved in 2009 were most consistent with the LiDAR data, with the discrepancies resulting in relatively few structures likely to be misclassified. FIRMS produced for the Plymouth County communities (Mattapoisett, Marion, and Wareham) approved in 2012 were more inconsistent with the LiDAR data with the most number of areas seemingly misclassified.

Because of the cost and staff hours required to process Letters of Map Changes to the FIRMs, it is in the interest of FEMA to revise the approved maps with Letters of Map Revision Determination Documents.

[1] That is, the area inundated by a storm with a 1% chance of occurring in any particular year.

1. Introduction

FEMA Flood Insurance Rate Maps (FIRMs) are the basis for federal, state, and local hazard mitigation planning. They are also used to establish the regulatory jurisdiction for mandated flood insurance, and are used by building inspectors, conservation commissions, and other local regulators to establish standards for the siting, construction, and maintenance of buildings, sea walls, and land alteration. This area is commonly referred to as the "100-year floodplain" by insurers, state building regulations, and local bylaws and ordinances. This "100-year floodplain" is more precisely defined as the area that has a 1% of being flooded in any particular year (by what is commonly called the "100-year storm[2]"). In the coastal zone, these floodplains may be designated as being either in the Zone V (Velocity or V-zone); which are areas subjected to waves greater than 3 feet during a storm, or Zone A, which are areas subjected to waves less than 3 feet during a storm. Most typically in coastal areas, these two zones are assigned a base flood elevation (BFE). The BFE corresponds to the top of the wave crest during the projected 100-year storm. The methodology for determining these elevations and their boundaries is described in the *Guidelines and Specifications for Flood Hazard Mapping Partners, Volume 1: Flood Studies and Mapping* (FEMA, 2003).

The predicted landward limit of the floodplain, as depicted in the FEMA FIRMs, corresponds to a specific real-world elevation as defined by the BFE. The FIRMs prepared by FEMA are in fact an approximate depiction of which properties are in or out of the specified flood-zone elevation. While the FEMA FIRMs are generally good for broadly defining which homes are in or out of the jurisdictional floodplain, the maps are limited by the quality of topographic data that is available. Whether a particular structure near a mapped BFE boundary is actually in the floodplain can only be determined definitively by actual field surveys. In fact, FIRMs can be amended based on such field investigations, and often are.

In 2009 and 2012, FEMA updated the FIRMs in Bristol and Plymouth counties based on recent LiDAR[3] surveys, contracted by FEMA or United States Geological Survey (USGS), and limited new coastal engineering analyses[4]. The basis of the changes in the maps are summarized in Flood Insurance Studies for each county available on the FEMA website[5]. Due to funding limitations, FEMA was unable to do new engineering analyses for all portions of each community. These new maps have increased precision and reliability, although like any data set, they are subject to errors in interpretation and processing of the elevation data. Some of these inconsistencies are explained in the Methods section in the procedure to adjust the baseline floodplain to LiDAR elevations.

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[2] Many scientists and regulators encourage the use of the term "1% storm" and "1% storm floodplain", over "100-year storm" and "100-year floodplain" because of public misconceptions that a 100-year storm only occurs once in one hundred years. However, because the term "100-year floodplain" is so pervasive in regulations, in news reports, and the public vernacular, we used it here instead of the less commonly used term "1% floodplain."

[3] Light Detection And Ranging (also abbreviated LiDAR and LADAR) is an optical remote sensing technology that can measure the distance to a target by illuminating it with pulse of light from a laser.

[4] As part of FEMA's Map Modernization project, the 2009 and 2012 Flood Insurance Rate Maps have a new datum, NAVD88, or North American Vertical Datum of the 1988-2001 Tidal Epoch. For example, in Mattapoisett, the "old" elevation value for 0.0 feet using the National Geodetic Vertical Datum of 1929, or NGVD29 is equal to minus 0.837 feet NAVD88 (calculated for the harbor area near Town Wharf at http://www.ngs.noaa.gov/cgi-bin/VERTCON/vert_con.prl). These types of adjustments were made throughout both counties. In addition, the new maps show increased flood elevations in many areas that reflect improved flood hazard models, landscape changes, and better land elevation measurements.

[5] Go to: https://msc.fema.gov

For our sea level rise studies, we considered only the landward-most extent of the FIRM 100-year storm floodplain, and the published BFE, to define the adjusted baseline floodplain. In this study we compare our adjusted baseline floodplain to the geographic extent of new digital FIRM 1% floodplain.

In our analysis, we always assumed that the stated base flood elevation published in the digital FIRMs was correct. However, cases may exist where the geographic extent of the base flood elevation on the new FIRMs is correct, but the digital data set was not correctly annotated with a new correct base flood elevation. We leave the identification of this type of error to the staff at FEMA, or their contractors.

2. Methods

In this study, ArcGIS® software by Esri (ArcMap Desktop versions 9.3 and 10.1) was used to manipulate the various existing digital data sets, with some additional analysis completed in spreadsheets using pivot table functions. No field collection of data or ground truthing was required for this analysis. We used a 2007 LiDAR study contracted by FEMA, and described in detail in CDM-Smith's *Mapping Activities for Plymouth and Bristol Counties, Massachusetts. Task Order 18 Activity 1--Topographic Data Development / Acquisition Summary Report.* These LiDAR data were provided to the Buzzards Bay NEP as both 2-ft contour lines, and as digital elevation models in the form of Triangular Irregular Network (TIN) raster files. To a limited degree, for certain floodplain expansion areas we also used 2011 Northeast National Map LiDAR project data[6]. In general, the precision of the LiDAR data is 1 cm, but the accuracy is approximately 15 cm (6 inches) over the entire southeast study area. The relative accuracy over a small geographic area along the same flight path is considerably better[7].

For the parcel and structure values, we used 2012 MassGIS Level 3 parcel data and assessors records in each of the communities[8]. To assign the placement of building locations within the parcels, we used a draft MassGIS database of building footprints based on a 2011 aerial survey[9]. Because a single parcel may have more than 1 structure, points were automatically generated for the largest structure on each parcel using the Geospatial Modelling (sic) Environment Software[10]. Generally, the largest structure is the primary structure, but during the review of the placement of the label points within the parcel with respect to the floodplain, point placement was adjusted as necessary to correspond to the apparent primary structure[11].

[6] LiDAR for the Northeast (ARRA LiDAR Task Order, USGS Contract: G10PC00026, Task Order Number: G10PD02143, Task Order Number: G10PD01027), project meets U.S. Geological Survey National Geospatial Program Base LiDAR Specification, Version 12, see USGS (2009).Note that dates of LiDAR coverages collected under this contract range from 2009 to 2012.
[7] See details in USGS (2004)
[8] Available at: http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/l3parcels.html. Last download 1/8/2013.
[9] Courtesy Paul Nutting, MassGIS.
[10] Geospatial Modelling (sic) Environment (Version 0.7.2.1) (c) Hawthorne L. Beyer 2009-2012. Available at: www.spatialecology.com, email: hawthorne@spatialecology.com.
[11] For example, a point was moved in one instance from a large barn to the residence, which was easily discerned by features such as cows, driveways, vehicles, and apparent architecture.

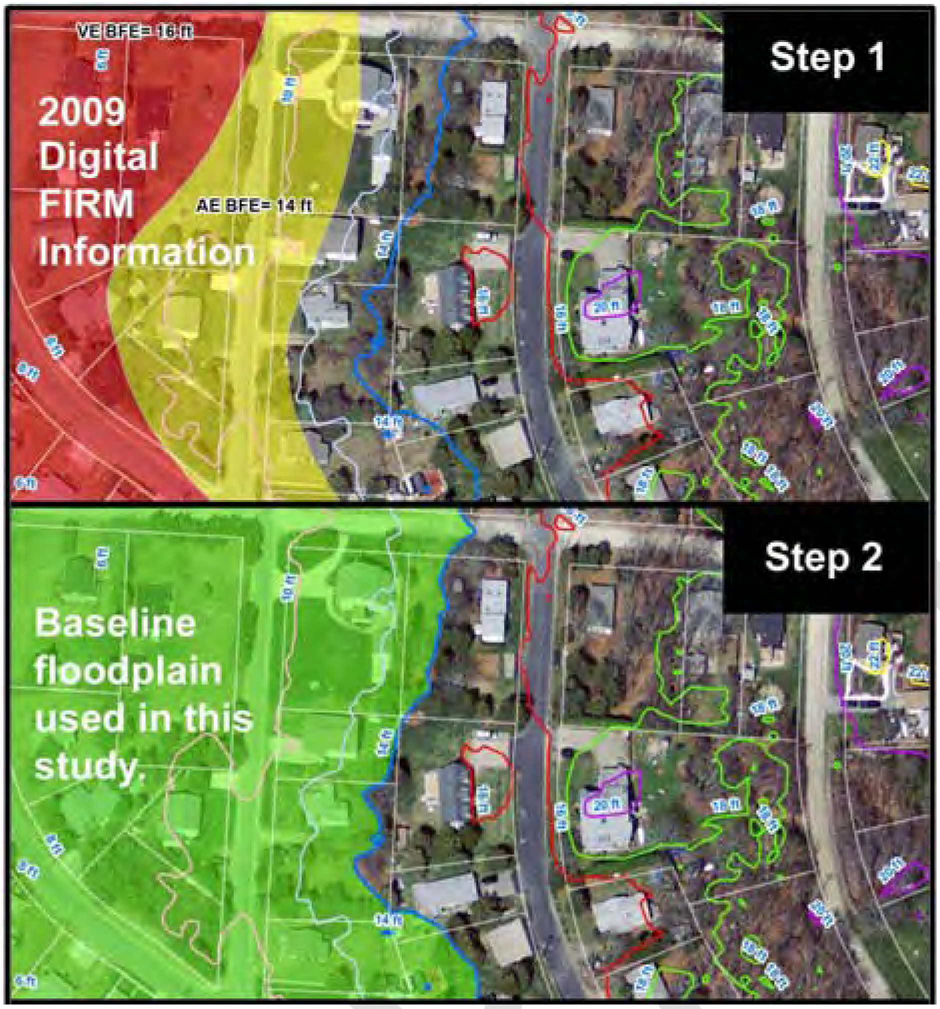

Fig. 1. Summary of approach for defining the baseline floodplain in this study. Step 1: The landward most base flood elevations for a 100-year storm from 2009 or 2012 digital FIRM data were compared to LiDAR contours (or digital elevation models). Step 2: An adjusted baseline floodplain area was defined (shaded green) for the purposes of this study. Step 3 (not shown): The adjusted baseline floodplain was compared to the original digital FIRM coverages to determine discrepancies (errors of apparent inclusion or omission)

Comments

The adjusted baseline floodplain developed for this study was based on the base flood elevations and other information contained in the 2009 or 2012 FIRM digital data set. At this site, the base flood elevation of the AE Zone or the 100-year storm was designated as 14ft.

An adjusted baseline floodplain was created for this study by precisely matching its boundary to the LiDAR contour elevations. In this case, the adjusted boundary was matched to the 14-ft LiDAR based contour line (blue line).

The adjusted baseline floodplain was compared to the original 1% floodplain to identify apparent errors of omission or inclusion.

The base flood elevations from the digital FIRMs released by FEMA for the study areas in 2009 and 2012 were overlain on the detailed LiDAR contour data (Fig. 1) and digital elevation models (Fig. 2). Typically, the LiDAR 2-ft elevation contour lines were adequate to estimate expansion or adjustments of the boundaries of each sea level rise scenario. However, where land slopes were slight, and the base flood elevation was set to an odd-number value, the digital elevation model TIN raster images were often used to visually estimate the respective new floodplain boundaries, (see Fig. 2). In this way, an adjusted baseline floodplain was defined and used as the initial conditions for the purposes of this study allowing for more meaningful and precise comparisons among the sea level rise scenarios.

In this study, we evaluated the coastal floodplain and ignored inland river flooding areas with few exceptions. In a few cases we reference recent map corrections specified in the Letter of Map Revision Determination Document (e.g. Case No.: 12-01-2089P) based on previous comments by the Buzzards Bay NEP and CZM forwarded to FEMA.

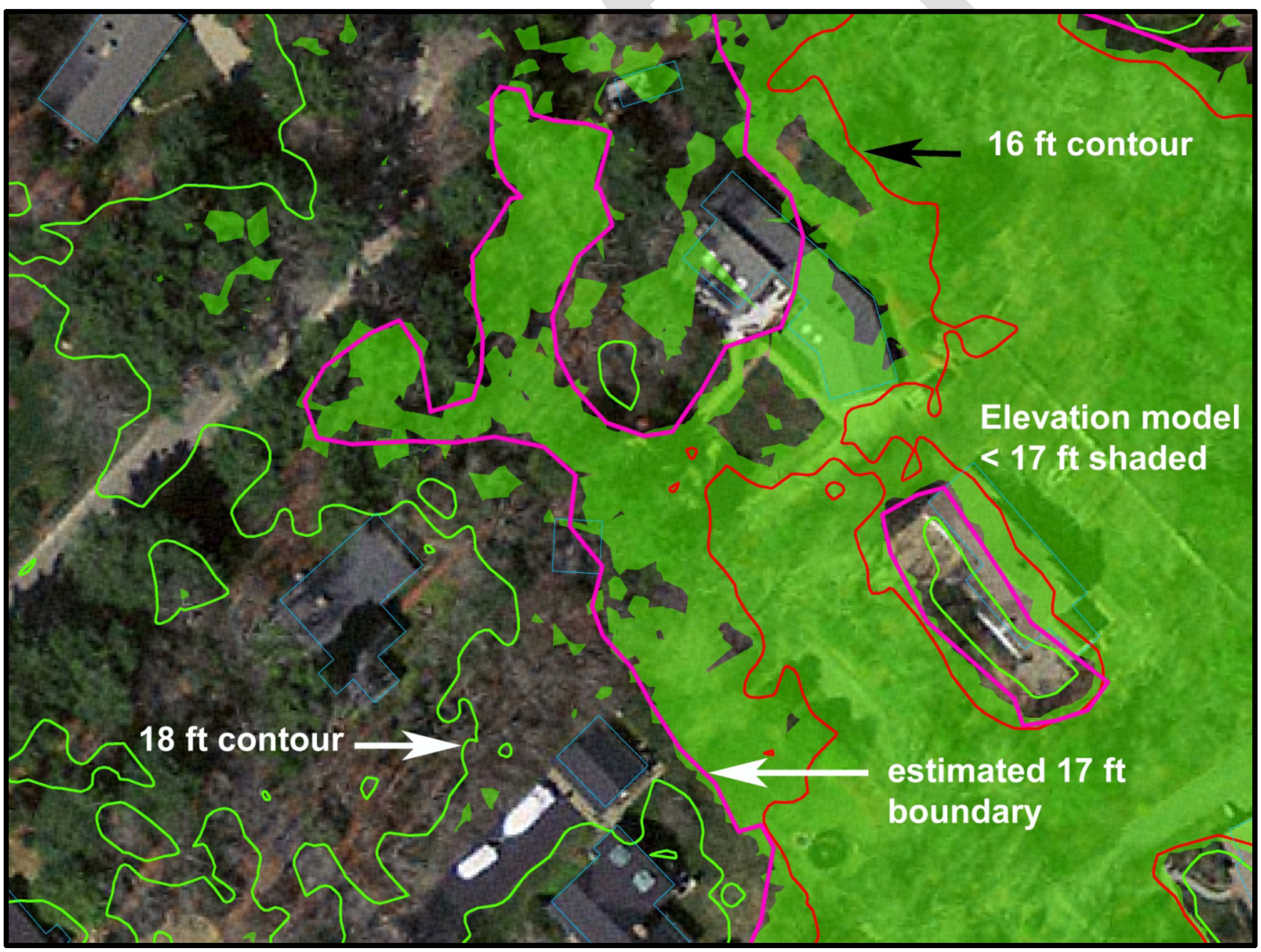

Fig. 2. Mapping Base flood elevations with odd numbered values. In areas where the base flood elevation was set to an odd number value and elevation contours wide spaced, the TIN raster digital elevation model files were coded to match the same base flood elevation boundaries. In this image, a floodplain scenario (shaded green, right) was used to estimate a 17-ft contour (shaded magenta).

After the adjusted baseline floodplain boundaries were created, assessors data were joined to the GIS parcel data set. In the first step to approximate the locations of buildings, a centroid label point was created for each parcel to represent the location of each house. The position of these points, representing the vulnerability of the structures to sea level rise, was carefully examined on aerial photograph base maps for all parcels crossed by a sea level rise scenario. The positions of these points were moved to precisely coincide with the house footprint. If a house was crossed by several floodplain scenarios, the point was placed in the lowest elevation scenario as illustrated in Fig. 3. Secondary or ancillary detached structures were ignored, and the property building value was assigned to the main structure, typically the primary residential structure. On some parcels, there are multiple detached dwelling units, but no parcels of this particular type were bisected by a floodplain in Mattapoisett.

Once the position of structures was set relative to the sea level rise scenarios, and assigned assessed values for total building structures on the parcel linked to these points, this digital point coverage was intersected with floodplain sea level rise scenario polygons. The resulting data set was processed in an Excel spreadsheet, and a pivot table was used to quantify building data using various classifications of

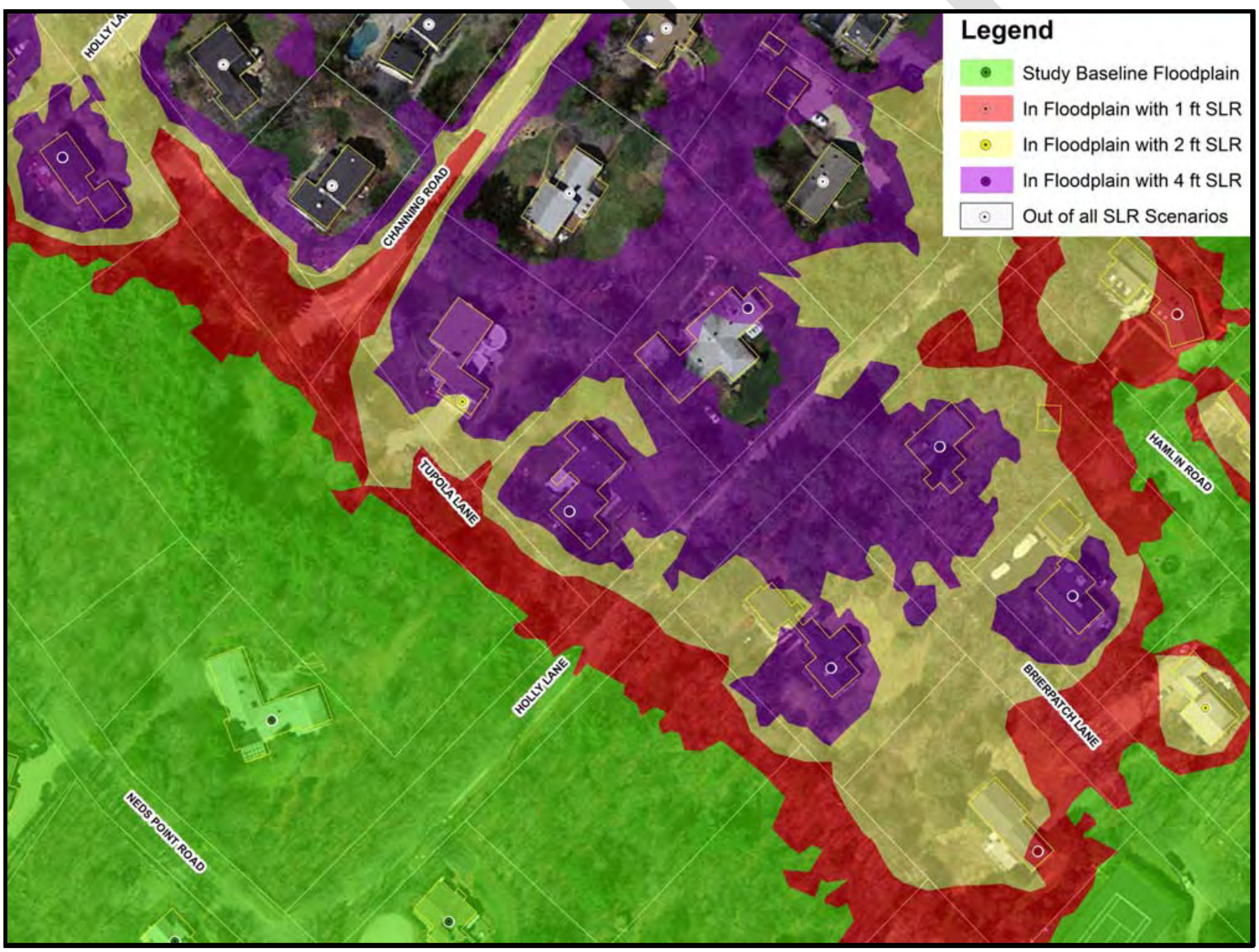

Fig. 3. Structure Assignment in Floodplain Expansion Areas with Different Sea Level Rise (SLR) Scenarios. Parcels (outlined in white) were converted to label points representing the position of structures. The precise placement of these points is important only for properties near one of the floodplain scenario boundaries. If a house was crossed by several scenarios, the point location was adjusted to place the building in the lowest elevation zone.

structures by floodplain scenario.

For this analysis, we also compared GIS data for the previously issued FIRMs from the 1980s and 1990s, to the newly issued FIRMs from 2009 and 2012. This data set, known as the "FEMA Q3 Flood" was made available by MassGIS in 1997[12]. This coverage has important limitations the most important of which was that fact that the maps lacked horizontal controls and the FEMA maps were georeferenced to roads, coastlines and other features. Despite this limitation, and despite the fact that the new FIRMs often changed base flood elevations in certain coastal areas, differences between the old and new FIRM coverages proved to be useful as a screening tool to identify potential problem areas in the new FIRMs. For this reason, maps comparing the two coverages are included in this report.

Various quality control and data validation approaches were implemented to ensure the accuracy of the data following the protocols described above. These validation techniques included check sum approaches to ensure property counts and values and other data are not inadvertently double counted or omitted. Additional information on the methods, the QAPP, and the digital data sets related to this study area available at the Buzzards Bay NEP website: http://www.buzzardsbay.org/floodzone-expansion-slr.html.

3. Results

In the sections below, for each town we provide maps and a brief description of changes between the old FIRMs and new, and between the baseline 1% floodplain used by the Buzzards Bay NEP and the new FIRMs. The latter description refers to maps found in Appendix A.

3a. Westport

Fig. 4 shows changes between the older FIRMs for Westport and the new FIRMs issued in 2009. As shown, the new FIRMs mostly expanded the floodplain (shaded red). Because the Town of Westport coastline is a drowned glacial river valley with a steep topography, the change in the floodplain mostly occurred in a narrow band along most portions of the coastline. The greatest single increase in the number of built properties included in the new 1% floodplain were found at the end of Horseneck Road (First, Second, and Third Streets).

Fig. 5 shows the discrepancies between the FIRM 100-year floodplain and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. In general, there was a high fidelity between the LiDAR interpreted base flood elevation boundaries, and the floodplain boundaries in the new FIRMs. Based on the LiDAR data, the FIRM 100-year floodplain was extended inland at Third Street, and this discrepancy may affect 13 primary structures (Appendix, Map 79). On the other hand, the floodplain may not have been extended far enough at the end of River Road (Appendix, Maps 76 and 77). Most boundary discrepancies are less than 100 feet wide, which in many instances will be within the boundaries near coastal parcels.

3b. Dartmouth

Fig. 6 shows changes between the older FIRMs for Dartmouth and the new FIRMs issued in 2009. As shown, the new FIRMs mostly expanded the floodplain (shaded red). Because the Town of Dartmouth coastline is a drowned glacial river valley with a steep topography, the change in the floodplain mostly

[12] Available at http://www.mass.gov/anf/research-and-tech/it-serv-and-support/application-serv/office-of-geographic-information-massgis/datalayers/q3.html, last accessed 30 April 2013

occurred in a narrow band along most portions of the coastline. The greatest single increase in the number of built properties included in the new 1% floodplain were found around Hetty Green Street.

Fig. 7 shows the discrepancies between the FIRM 100-year floodplain and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. In general, there was a high fidelity between the LiDAR interpreted base flood elevation boundaries, and the floodplain boundaries in the new FIRMs. The largest apparent discrepancies in relation to developed parcels occurred in areas or Map 69 and an elevated area at the boundary of Map 56 and 57.

3c. New Bedford

Fig. 8 shows changes between the older FIRMs for the City of New Bedford and the new FIRMs issued in 2009. Most of New Bedford is protected by a hurricane barrier, and areas within the harbor have a much lower base flood elevation than outside the hurricane barrier. As shown, the new FIRMS both expanded the floodplain (shaded red), and contracted it (shaded blue). Most of the changes in the new maps occurred within the hurricane barrier, but changes occurred also along Clarks Point. Another important change occurred in the area of the New Bedford wastewater facility at the tip of Clarks Point, which was constructed after the earlier FIRMs.

Fig. 9 shows the discrepancies between the FIRM 100-year floodplain and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. In general, there was very good agreement between the baseline floodplain derived from LiDAR data and the 2009 FIRMs, although on Clarks Point, the floodplain was consistently carried to a LiDAR elevation too high by a foot. Because of the steep topography, this inconsistent area occurs as a narrow band, and altogether only a few dozen properties may be affected (e.g. See Map 59).

3d. Fairhaven

Fig. 10 shows changes between the older FIRMs for the Town of Fairhaven and the new FIRMs issued in 2009. Like New Bedford, the northern area of Fairhaven is protected by a hurricane barrier, with much lower base flood elevations inside the harbor. As shown, the new FIRMs mostly expanded the floodplain (shaded red) in areas of the town. The greatest expansion of the floodplain occurred in the low-lying area on the east side of West Island.

Fig. 11 shows the discrepancies between the FIRM 100-year floodplain and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. The greatest discrepancies occurred in Maps 44, 52, 60, and 61 where it appears the FIRMs followed a LiDAR contour that was either too high or too low.

3e. Mattapoisett

Fig. 12 shows changes between the older FIRMs for the Town of Mattapoisett and the new FIRMs issued in 2012. As shown, the new FIRMs mostly expanded the floodplain (shaded red) in areas of the town, but there were several important contractions in the floodplain. One of these was at Centre Street near Aucoot Cove. This information was provided to FEMA, which identified it as a map error. The second reduction in floodplain area occurred along river road near Interstate 195 and in the vicinity of the Middle School.

Fig. 13 shows the discrepancies between the FIRM 100-year floodplain and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. Important discrepancies occurred again along River Road, and it appears that the areas removed from the flood plain should not only have remained but expanded in this area (see maps 34 and 38). Sites in Maps 40-42 should be reviewed further.

3f. Marion

Fig. 14 shows changes between the older FIRMs for the Town of Marion and the new FIRMs issued in 2012. As shown, the new FIRMs mostly expanded the floodplain (shaded red) in areas of the town, but there were several important contractions in the floodplain (shaded blue), as well. Important expansions of the flood plain occurred on Point Road near Route 6, in Marion Village center, on Parkway Lane, in the vicinity of Delano Road, on Planting Island, and the southernmost end of Point Road.

Fig. 15 shows the discrepancies between the FIRM 100-year floodplain in Marion and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. Important apparent discrepancies occurred in many of the areas changed with the FIRM updates, and other areas as well. For example, the base flood elevation in the area of Point Road near Route 6 appears to be 4 feet (2 LiDAR contours) too high. Similarly, some areas of the village center appear to be at too high an elevation to meet the FIRM base flood elevation. Maps 20, 27, 28, 31, and 32 have areas that need further review.

3g. Wareham

Fig. 16 shows changes between the older FIRMs for the Town of Wareham and the new FIRMs issued in 2012. As shown, the new FIRMs had some greatly expanded floodplain areas(shaded red) in multiple sections of the town. One of these sites includes 99 built parcels on a hill at the intersection of Route 6 (Sandwich Road) and Oakdale Street. This is a map topology error and will need to be corrected by FEMA (areas are more than 12 feet above the base flood elevation). Another broad expansion of the flood zone occurred in the Briarwood section of town (near Hathaway Road, Daniel Street, Dangelo Drive and vicinity), which are near a zone of floodplain contraction in the vicinity of Lynne Road. Other large expansions occurred around Arlington Road, the Cranberry Highway, and near Cleveland Avenue to name a few sites. A large contraction of the floodplain occurred west of Interstate 195 near the Marion border.

Fig. 17 shows the discrepancies between the FIRM 100-year floodplain in Wareham and the adjusted baseline floodplain used in the Buzzards Bay NEP's study of the expansion of the floodplain with sea level rise. The Buzzards Bay NEP omitted large areas north of Route 6 and Route 25 that are contained in the new FIRMs. Most of these areas in fact did not change since the earlier FIRMs prepared in the 1980s. The earlier FIRMs were created before the construction of Route 25. Because of the large amount of fill associated with this highway project, it is important that FEMA re-evaluate these areas of the upper coastal floodplain in the Town of Wareham. Another area of Wareham that needs careful review is in the vicinity of Swifts Beach Road and Sore Avenue that were not included in the floodplain in the new FIRMs, but are within the base flood elevations. This area includes dozens of homes that may need to be designated as within the floodplain.

3h. Summary of all towns

Altogether, 841 built parcels were found where the primary structure was contained in the baseline floodplain of the Buzzards Bay sea level rise study, but not found in the FEMA FIRM. The cumulative value of these primary structures was $183 million. Similarly 561 built parcels were found where the primary structure was contained in the FEMA FIRM 1% floodplain, but not in the baseline floodplain of the Buzzards Bay sea level rise study. The cumulative value of these primary structures was $269 million. The breakdown of these totals by municipality is shown in Table 1. As shown, most of these properties in both categories occur in the Town of Wareham.

Within the baseline floodplain, there were 31 properties with structures that did not have a "building" value assigned in the database. Most of these properties appeared to be companion lots with barns, sheds, etc. These properties were assigned the value in the "Other" building value in the database to ensure each identified primary structure had an assessed value assigned.

Table 1. Numbers of built parcels in each municipality where there was an inconsistency between the 1% FIRM floodplain and the baseline floodplain in the Buzzards Bay NEP sea level rise studies.

Condition	Count of developed parcels	Value of primary structures
In Baseline, Not in FIRM	**841**	**$183,308,900**
Dartmouth	*47*	*$16,438,600*
Fairhaven	*93*	*$10,025,500*
Marion	*95*	*$50,468,700*
Mattapoisett	*95*	*$23,868,700*
New Bedford	*4*	*$480,000*
Wareham	*474*	*$74,186,000*
Westport	*33*	*$7,841,400*
In FIRM, Not in Baseline	**561**	**$85,393,100**
Dartmouth	*18*	*$3,707,600*
Fairhaven	*22*	*$2,457,600*
Marion	*95*	*$20,879,300*
Mattapoisett	*25*	*$5,039,500*
New Bedford	*37*	*$4,307,000*
Wareham	*312*	*$41,115,600*
Westport	*52*	*$7,886,500*
Grand Total	**1402**	**$268,702,000**

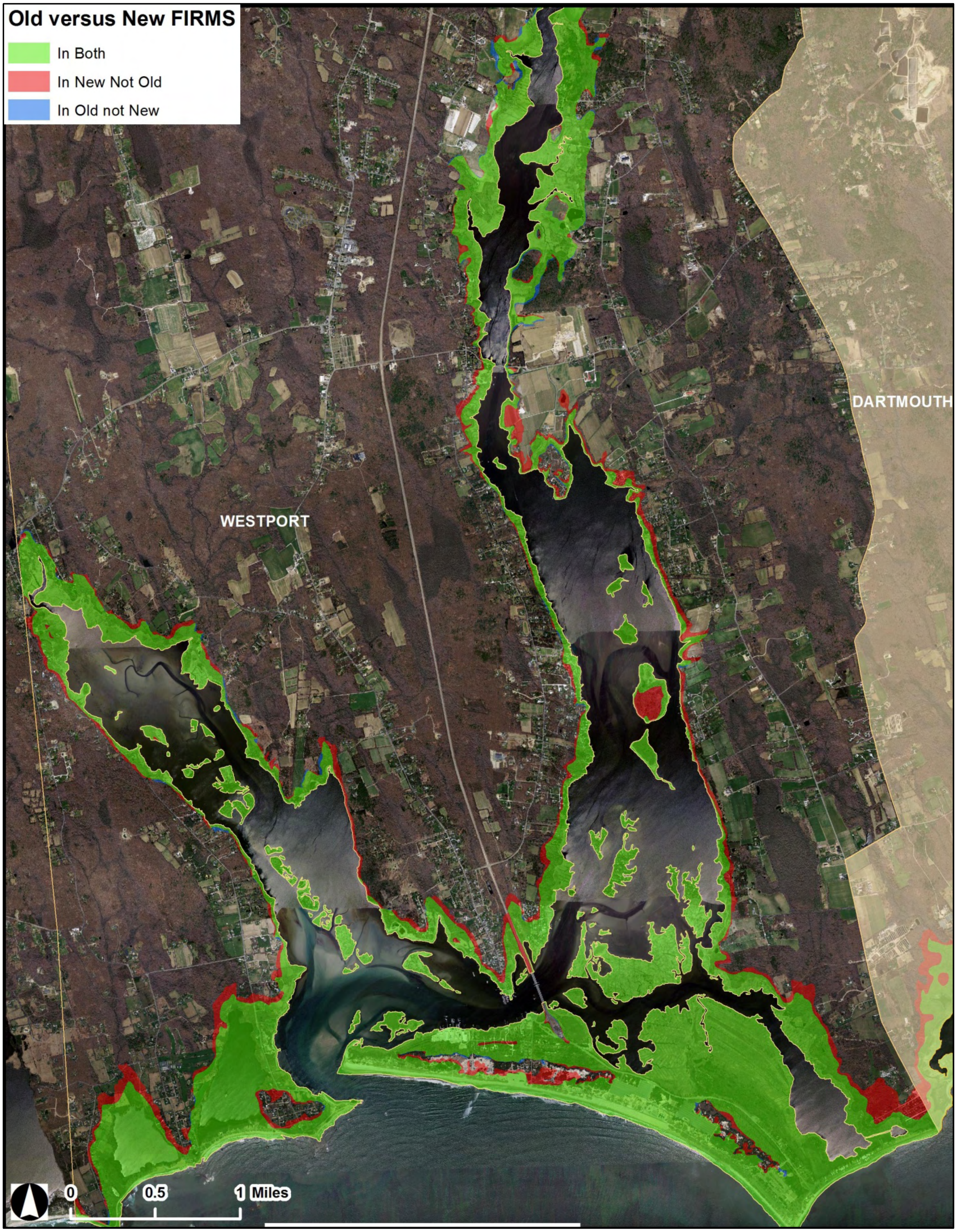

Fig. 4. Comparison of 2009 FIRM to 1985-1992 FIRMs in Westport.

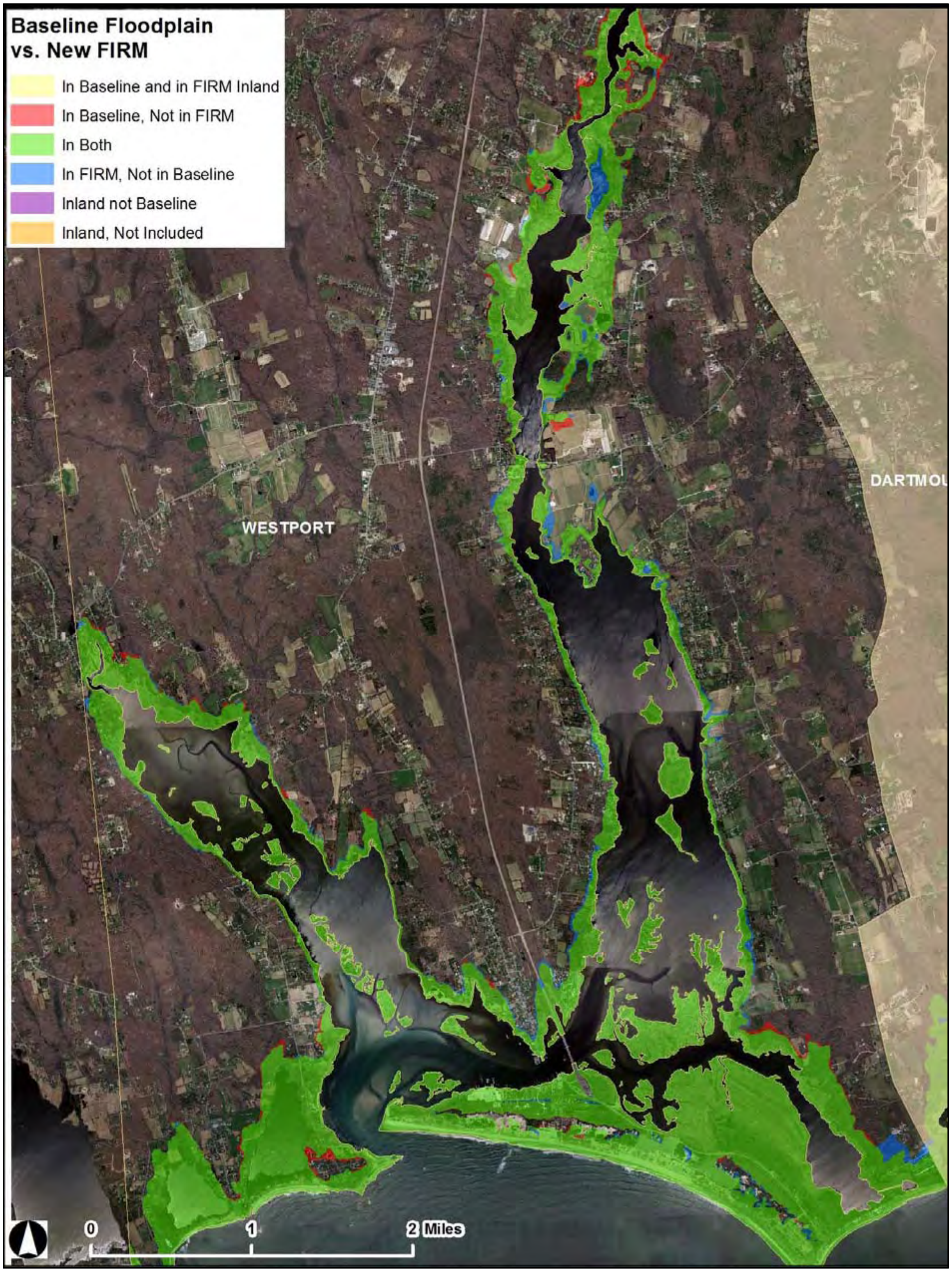

Fig. 5. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Westport. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2009 FIRMs 100-year (1% annual risk) coastal floodplain. Inland floodplain areas were excluded from the analysis.

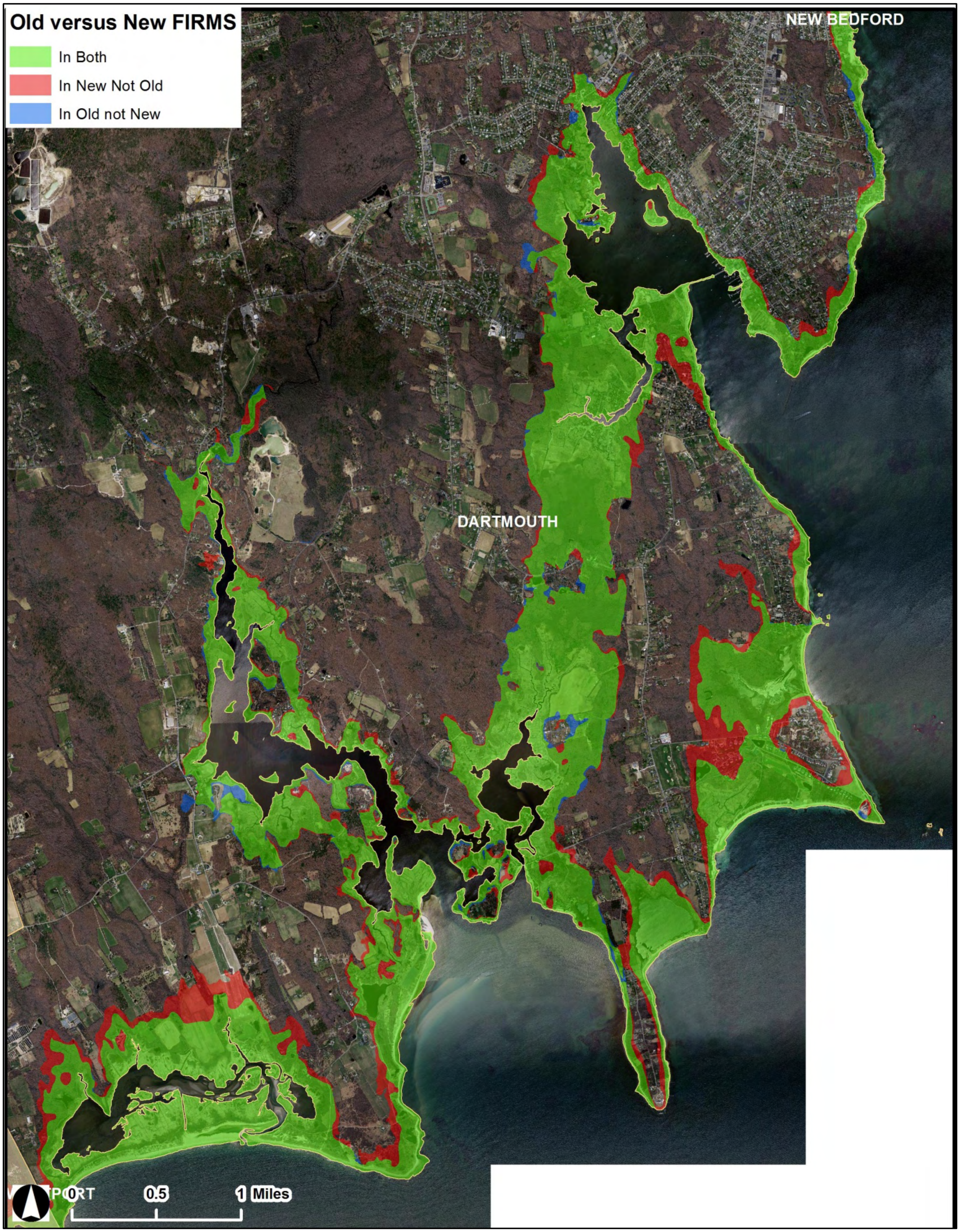

Fig. 6. Comparison of 2009 FIRM to 1983-1992 FIRMs in Dartmouth.

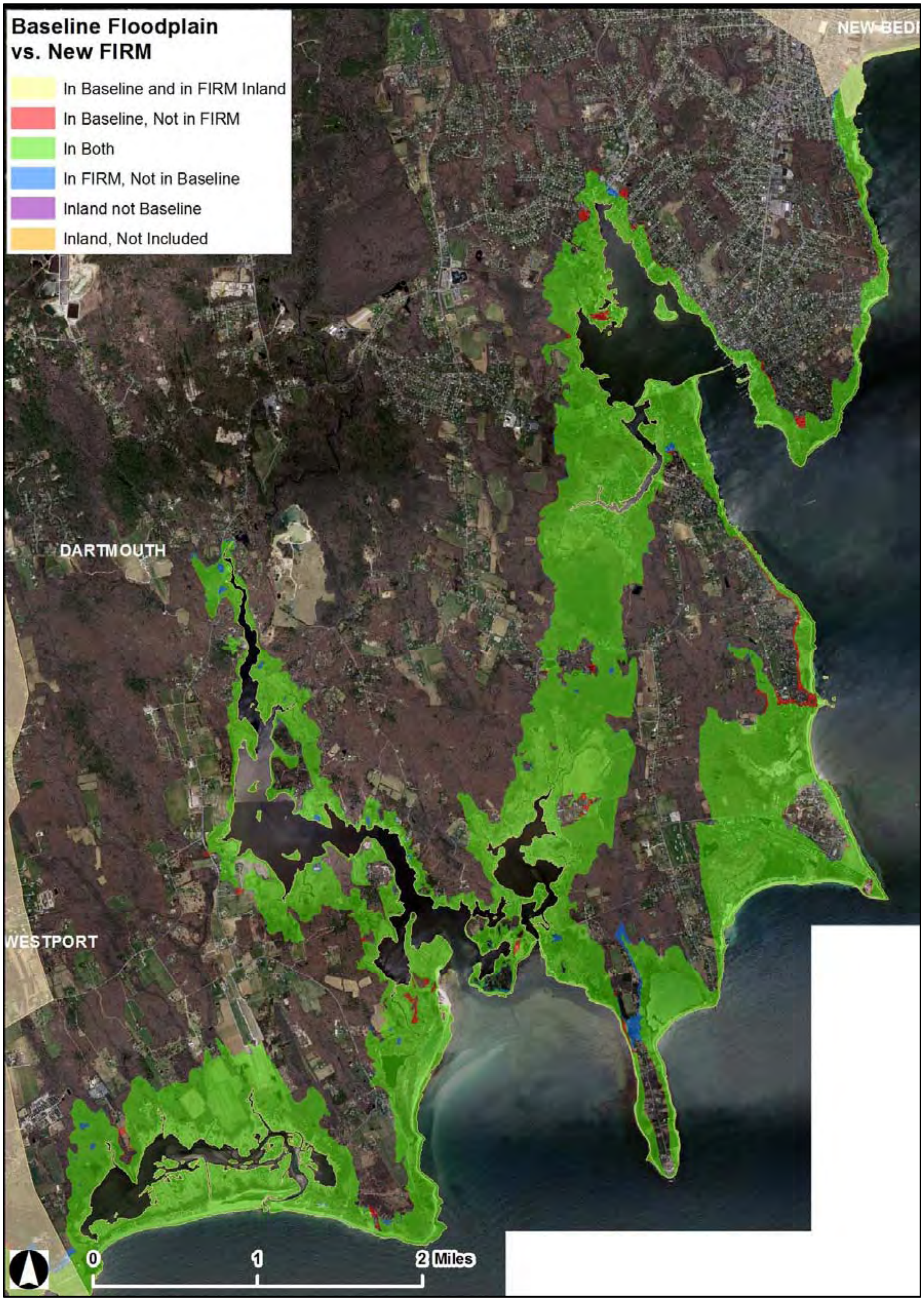

Fig. 7. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Dartmouth. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2009 FIRMs 100-year (1% annual risk) coastal floodplain. Inland floodplain areas were excluded from the analysis.

Fig. 8. Comparison of 2009 FIRM to 1983-1984 FIRMs in New Bedford.

Fig. 9. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in the south end of New Bedford. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2009 FIRMs 100-year (1% annual risk) coastal floodplain. Area inside the Hurricane barrier had negligible differences between the two coverages. Inland floodplain areas were excluded from the analysis.

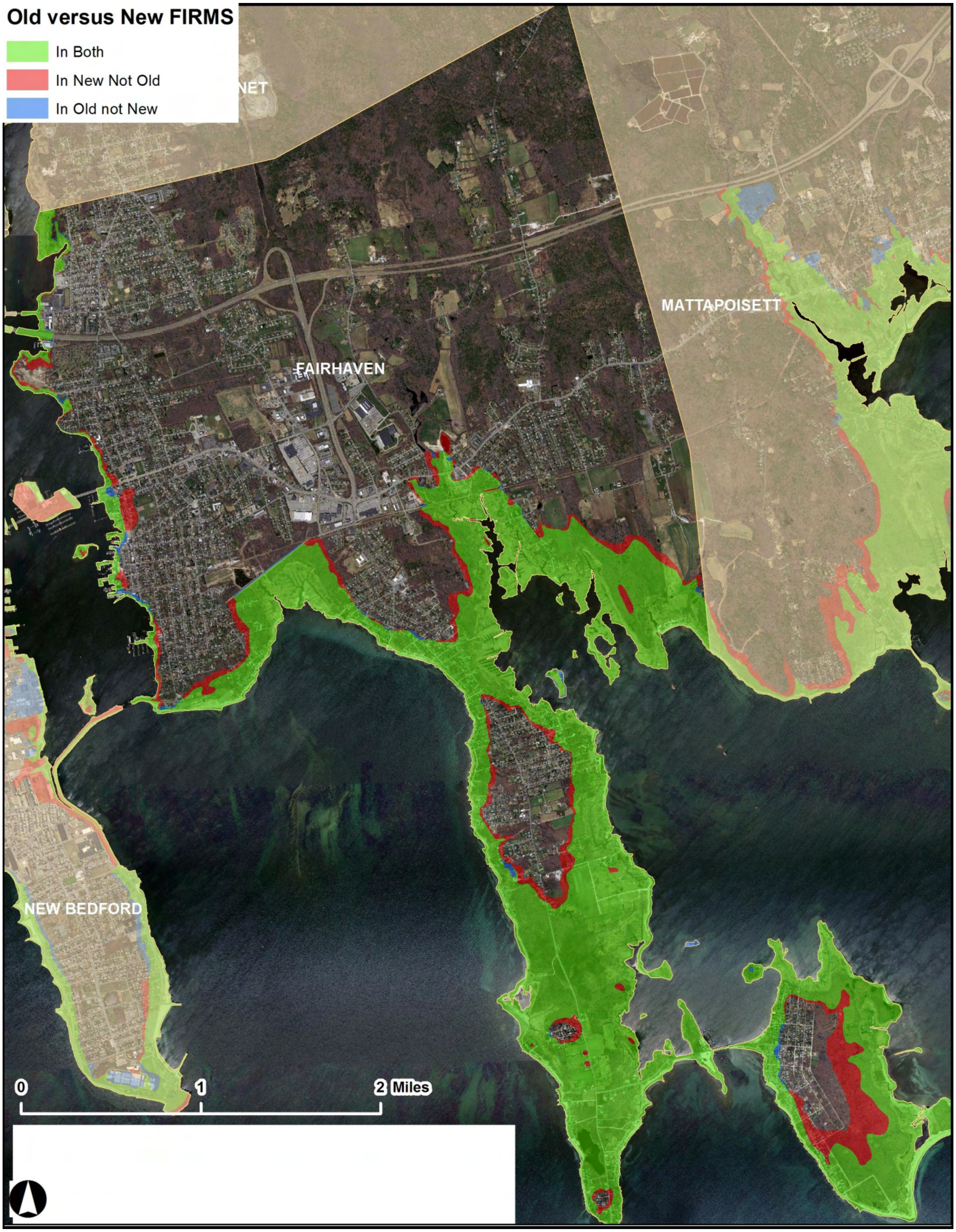

Fig. 10. Comparison of 2009 FIRM to 1985-1992 FIRMs in Fairhaven.

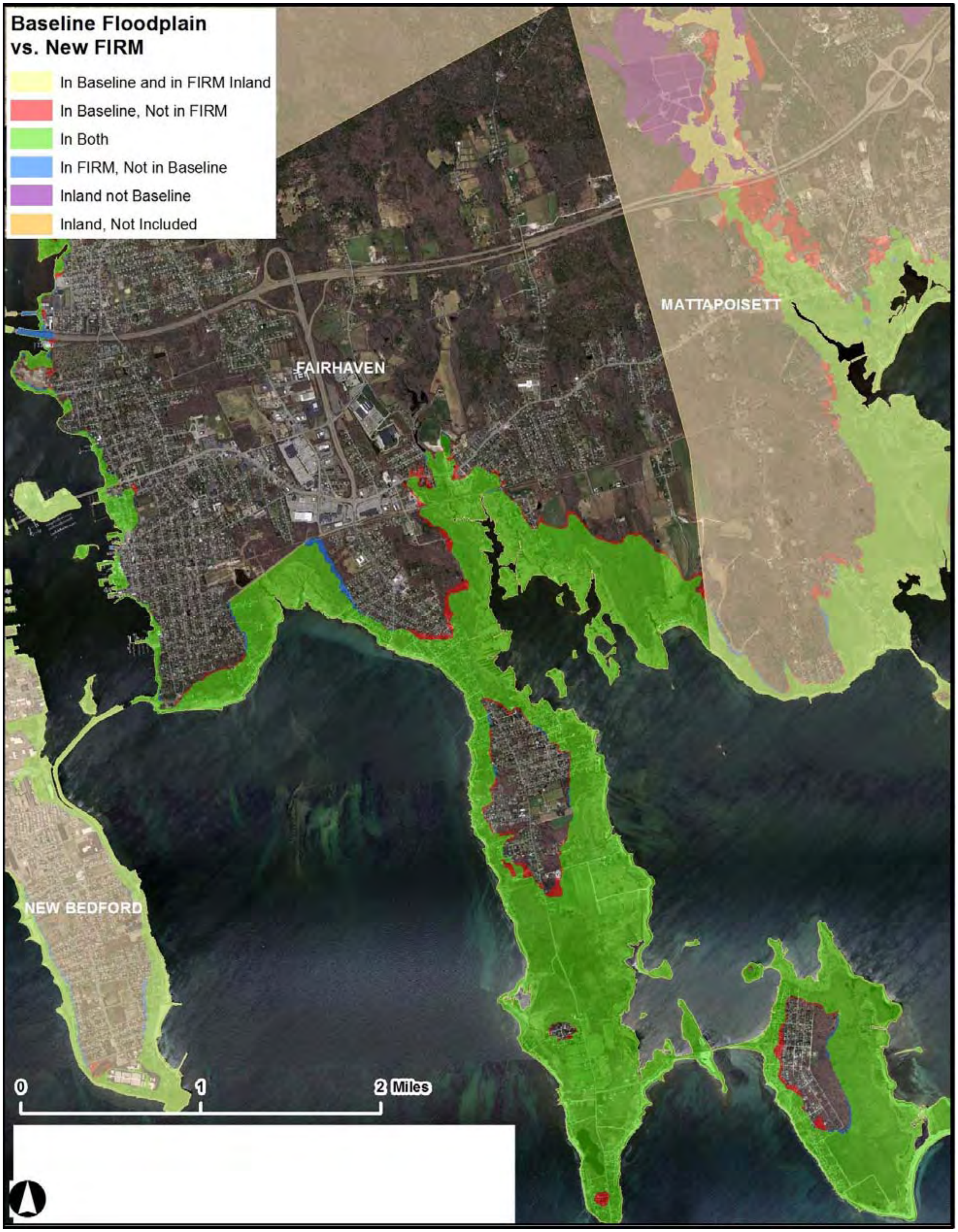

Fig. 11.Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Fairhaven.

Fig. 12. Comparison of 2009 FIRM to 1987-1995 FIRMs in Mattapoisett.

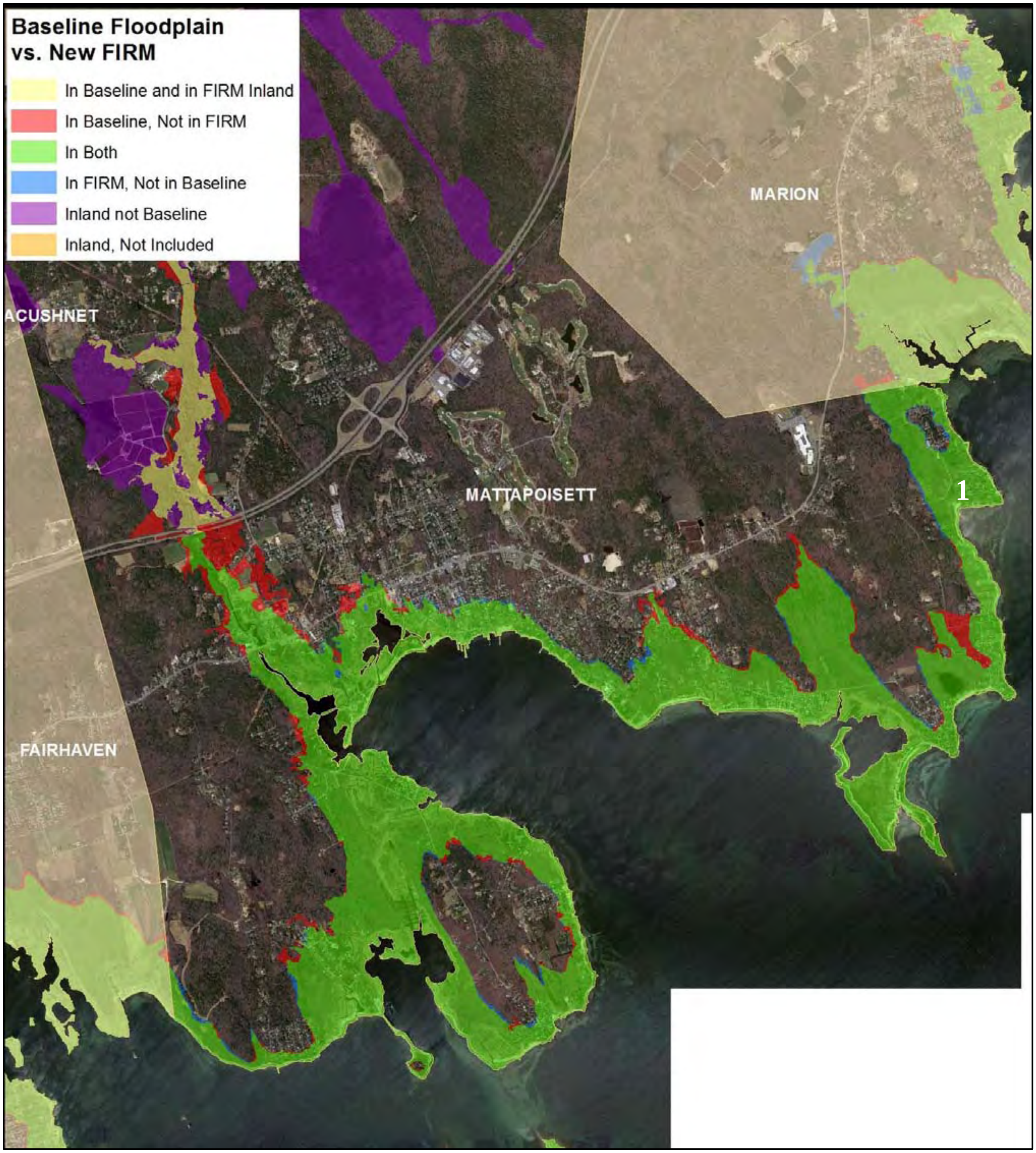

Fig. 13. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Mattapoisett. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2012 FIRMs 100-year (1% annual risk) coastal floodplain. Inland floodplain areas (shaded magenta, area north of Interstate 195) were excluded from the analysis. Building footprints are shown in yellow. The FIRM floodplain includes the map correction specified in the Letter Of Map Revision Determination Document (Case No.: 12-01-2089P, marked "1" on map above, center right), that will become effective February 22, 2013. This revision corrects a map error north of Hiller Cove identified by the Buzzards Bay NEP.

Fig. 14. Comparison of 2009 FIRM to 1988-1992 FIRMs in Marion.

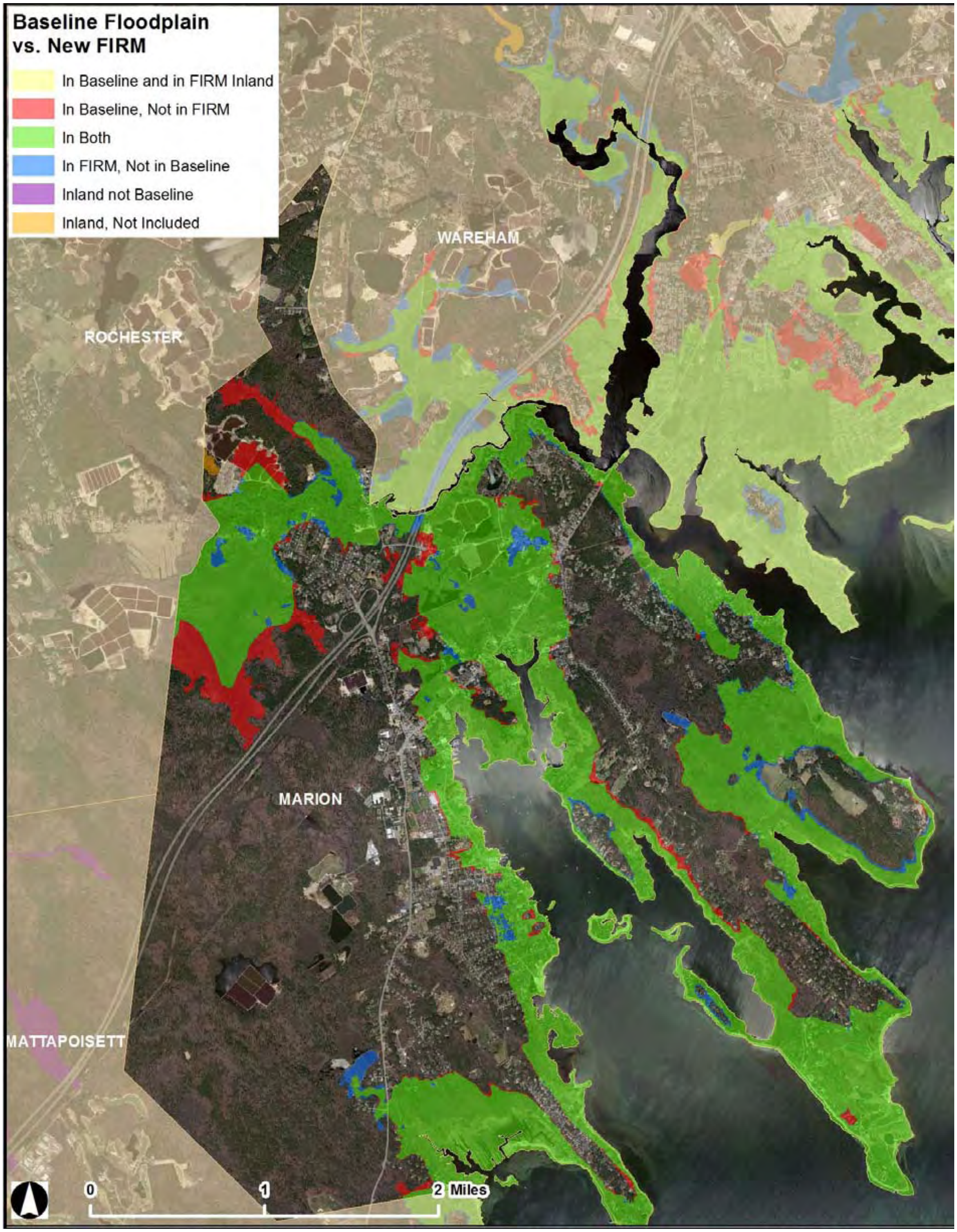

Fig. 15. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Marion. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2012 FIRMs 100-year (1% annual risk) coastal floodplain. Inland floodplain areas (shaded magenta, only one small area in northwest Marion) were excluded from the analysis.

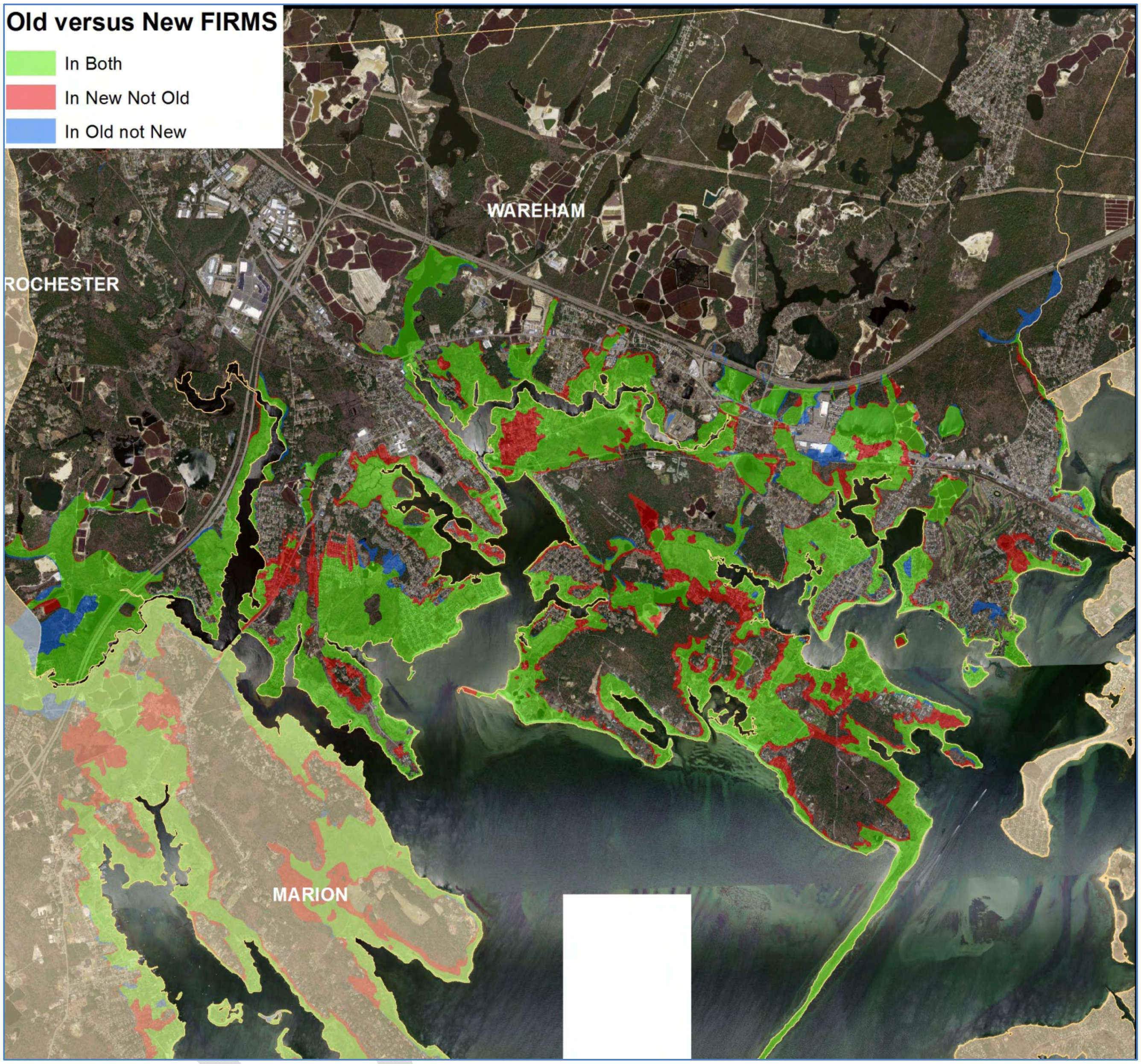

Fig. 16. Comparison of 2009 FIRM to 1987-1992 FIRMs in Wareham.

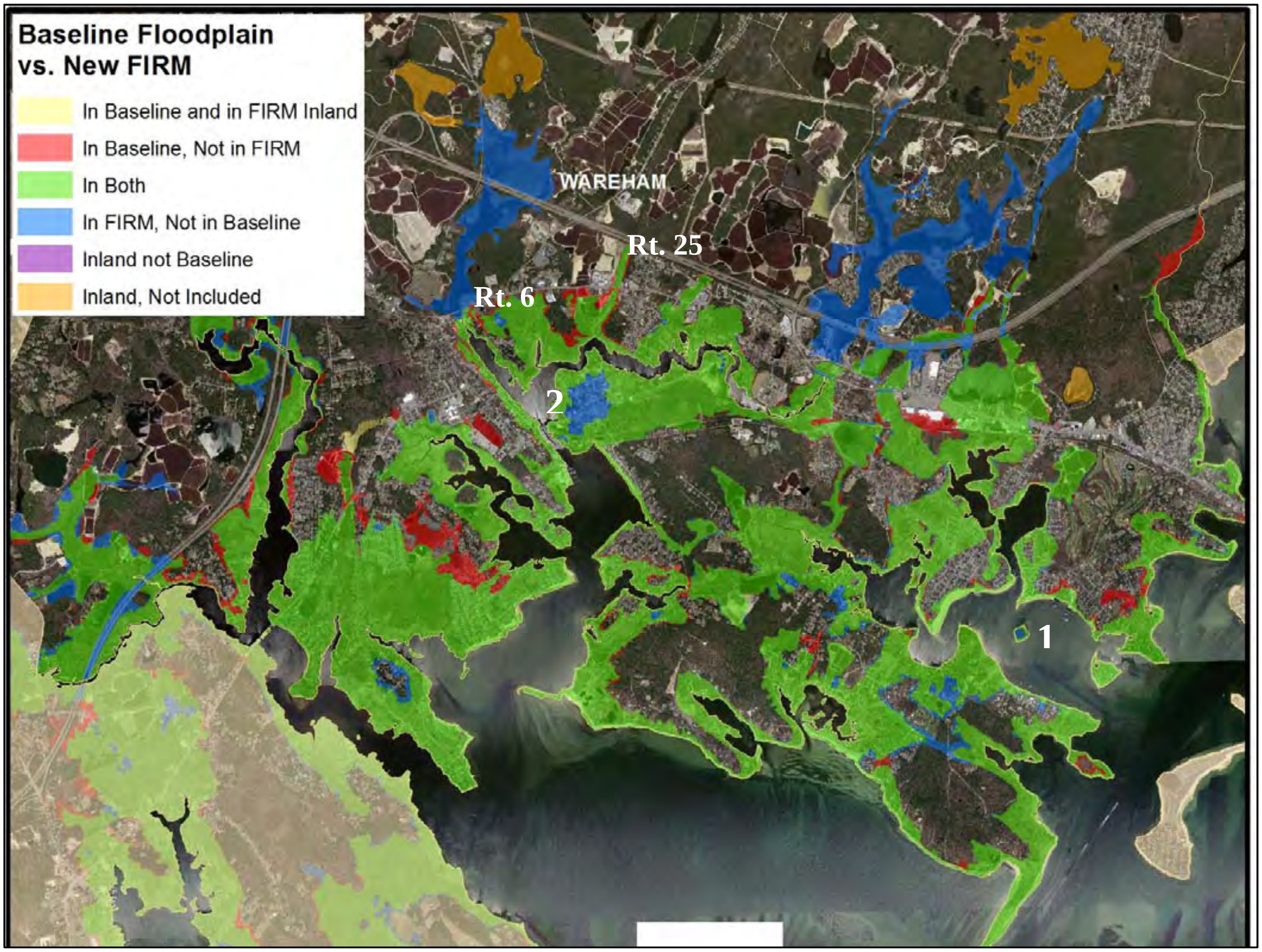

Fig. 17. Comparison of FIRM 100-yr Floodplain to Adjusted Baseline Floodplain in Wareham. Fig. shows the adjusted baseline floodplain conditions adopted in this study, and how it differed from the 2012 FIRMs 100-year (1% annual risk) coastal floodplain. Inland floodplain areas (shaded magenta, area north of Interstate 195) were excluded from the analysis. The FIRM floodplain includes the map correction for Onset Island specified in the Letter Of Map Revision Determination Document (Case No.: 12-01-2090P, marked "1" on map above, middle right), that will become effective February 22, 2013. This revision corrects a map error on Onset Island identified by the Buzzards Bay NEP, but does not include other needed corrections, such as the site marked '2' on the map.

Discussion

There are a number of uncertainties in the analysis presented. For example, there are both vertical and horizontal uncertainties associated with the 2007 LiDAR data that are articulated by CDM Smith (2008). Nonetheless, in most of Buzzards Bay, the boundary associated with the base flood elevation specified in the FIRMs matches nearly precisely a smoothed version of the corresponding LiDAR contours. This is particularly true for the FIRMS produced in 2009 for Bristol County (Dartmouth, Fairhaven, New Bedford, and Westport). However, in the case of the 2012 FIRMs for Plymouth County along Buzzards Bay (Marion, Mattapoisett, and Wareham), while again most base flood elevations do coincide with a smoothed-out LiDAR contour, there are many base flood elevation boundaries that seemingly correspond to the wrong LiDAR contour. There are also a number of apparent topology errors where "doughnut holes" within a flood zone were misclassified. All these areas need additional review by FEMA.

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Appendix A. Detailed maps showing the apparent discrepancies between adjusted baseline floodplain boundaries used in the author's sea level rise studies compared to the digital FIRM inland boundaries. Road locations and names from MassGIS DOT coverage and may contain errors.