Sea Level Rise and Casco Bay's Wetlands:

A Look at Potential Impacts

HARPSWELL EDITION

Casco Bay Estuary PARTNERSHIP

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Sea Level Rise and Casco Bay's Wetlands

A Look at Potential Impacts

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This report is one of a series of ten reports focusing on the following Casco Bay municipalities:

Brunswick	Phippsburg
Cape Elizabeth	Portland
Falmouth	South Portland
Freeport	West Bath
Harpswell	Yarmouth

Assistance with field work and other data collection provided by Melissa Anson and Melissa Smith.
GIS analysis provided by Lauren Redmond and Caitlin Gerber.

These reports were funded in whole or in part by the Maine Coastal Program under NOAA award no. NA10N0S4190188 and the US EPA under grant #CE 9614191.
The report does not necessarily reflect the views of the sponsoring agencies, and no official endorsement should be inferred.

Casco Bay Estuary Partnership 2013; Revised 6/2014

Overview

The Intergovernmental Panel on Climate Change (IPCC) released a report in 2007 documenting a rise in average global temperatures, ocean temperatures and sea level rise. The sea level off Maine's 3,478 miles of coastline, as measured by the Portland, Maine tide gauge, has been rising at a rate of 1.8 $\pm$ 0.1mm/yr since 1912. This is markedly similar to the global average sea level rise determined by the IPCC. The most likely impacts of sea level rise in Maine will be inland migration of beaches, dunes and salt marshes over the next century.

Coastal wetlands are economically, environmentally and socially significant resources. They provide flood storage, flood protection, storm surge buffers, erosion control, water quality improvements, and wildlife habitat. Commercial fishing, shellfishing and outdoor recreation also contribute millions of dollars to Maine's economy and are dependent on healthy wetlands. Coastal communities and those along critical watershed areas will have to plan a comprehensive response to the changes in topography suggested by the projected impacts of sea level rise.

The unique geological make-up of Maine's coastline is characterized by very different coastal estuarine environments which are a direct result of prehistoric glacial activity. This led geologists such as Joseph T. Kelley, to subdivide Maine's coastline into four distinct sub-regions approximately corresponding to Casco Bay, Saco Bay, Penobscot Bay, and the northeast region around Cobscook Bay. Consequently, Maine's tidal wetlands are diverse, and the impacts to, and responses of, those wetlands to sea level rise are likely to be markedly different in each of those four regions.

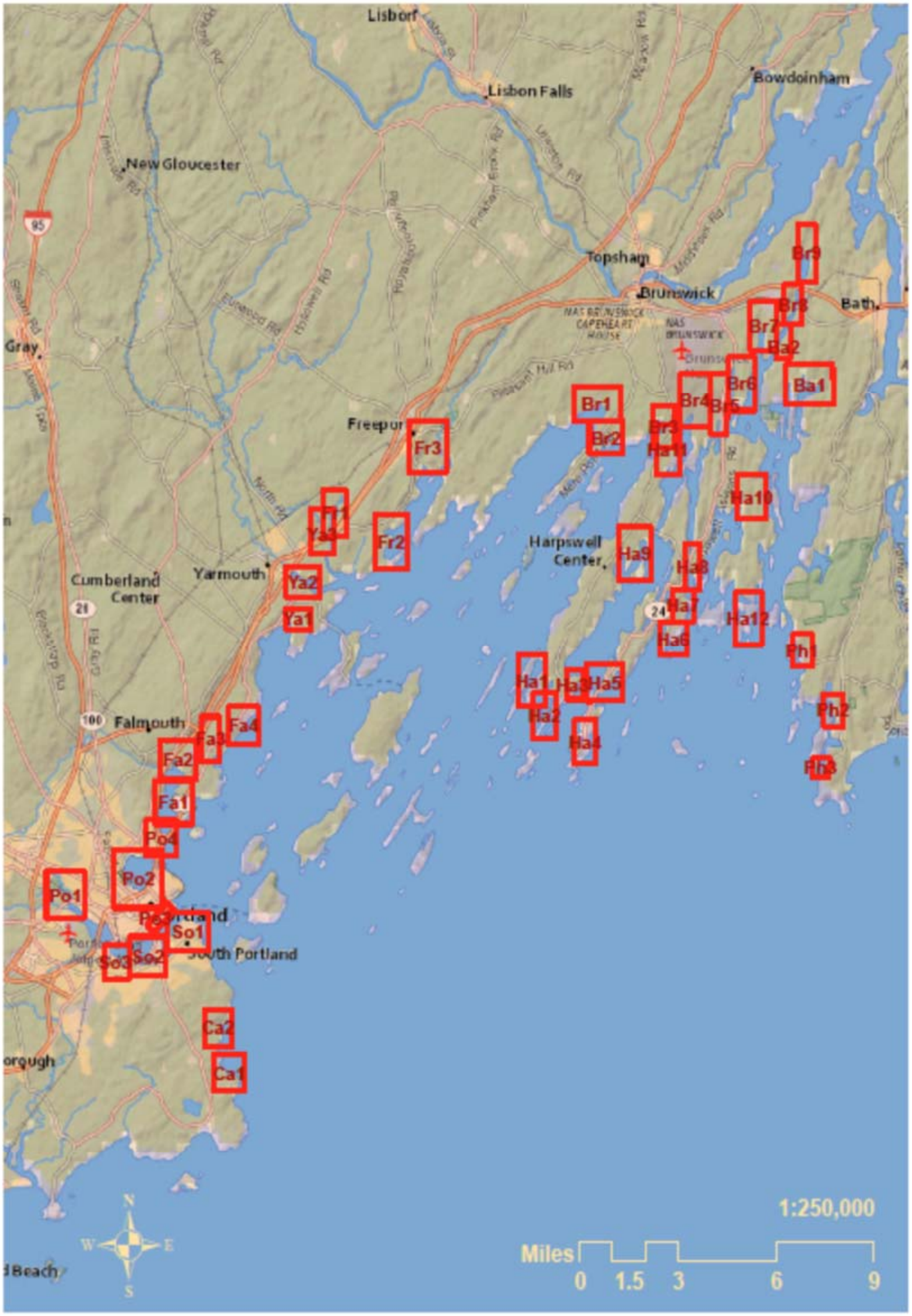
The Casco Bay Watershed comprises 986 square miles of land, and stretches from the mountains near Bethel to the coastal waters between Small Point in Phippsburg and Dyer Point in Cape Elizabeth. Home to nearly 20 percent of Maine's population, the watershed contains 44 municipalities, including some of the state's largest and fastest growing towns. The Casco Bay Estuary Partnership (CBEP), one of 28 National Estuary Programs nationwide, is a collaborative effort of people and organizations interested in protecting and restoring the Bay. Our partnership includes local, state and federal government organizations, non-profits, local businesses, citizens, universities and more.

The Study

CBEP looked at ten of the fourteen municipalities that line Casco Bay to identify potential areas of marsh migration and possible impacts to existing developed areas due to tidal inundation from sea level rise. Figure 1 shows focus areas across the study area.

FIGURE 1

Casco Bay Focus Areas



Harpswell, Maine

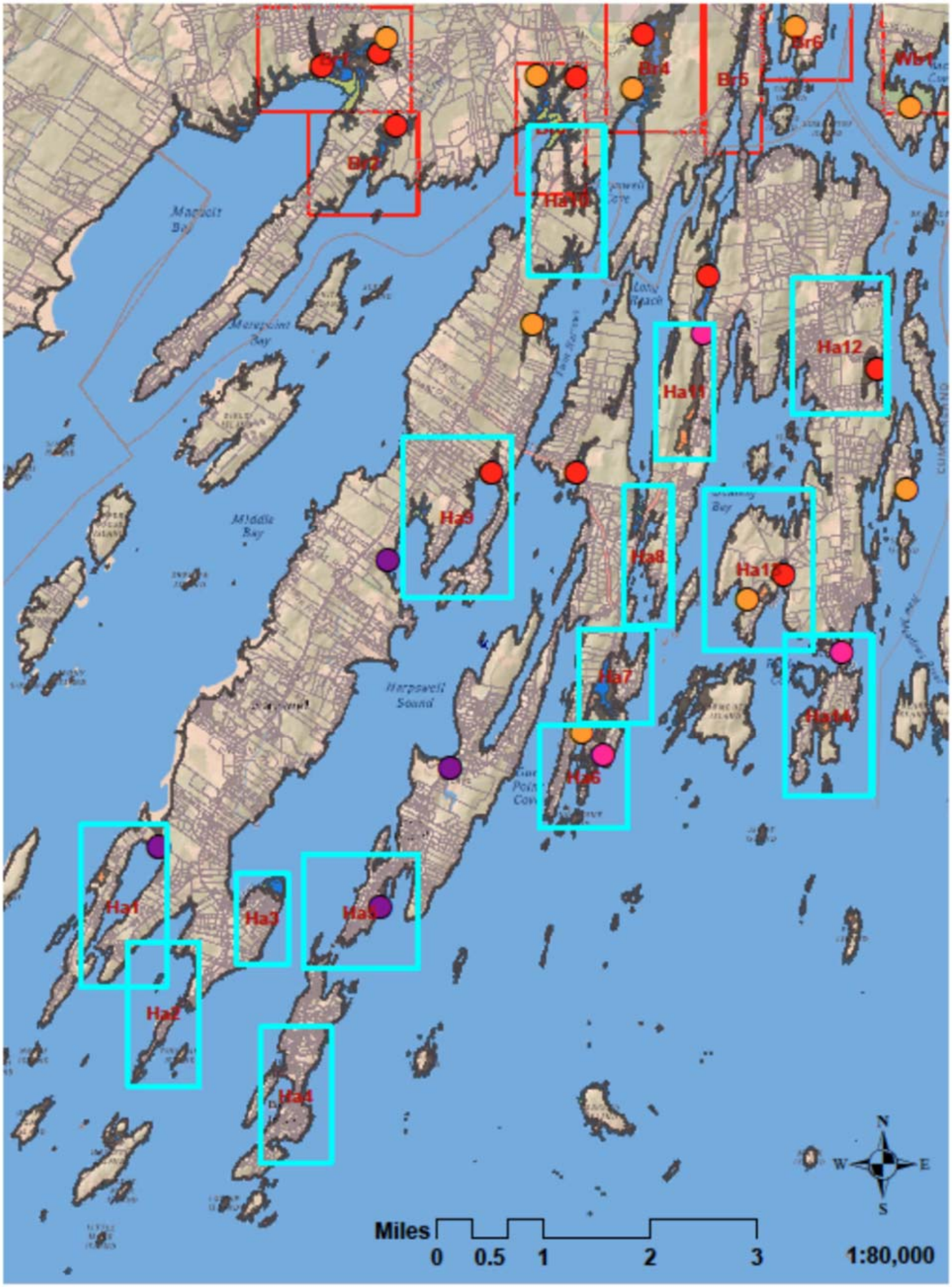
This report is designed to help municipal staff and decision makers understand risk levels and potential impacts associated with sea level rise, and to provide science-based projections to inform future policy-making responses. The U.S. Environmental Protection Agency (EPA) produced a publication titled *Synthesis of Adaptation Options for Coastal Areas* in January, 2009 which identifies several planning and management options for coastal communities.

The maps display places where roads, railroads, trails, dams, and other structures cross tidal wetlands. In most cases, these structures alter the way that water is passed from one side of the wetland to the other. When tidal exchange is restricted, even if it is restricted only during astronomical spring tides, long-term impacts to wetlands can develop that reduce ecosystem resiliency to respond to impacts such as sea level rise. Tidal restrictions also increase velocities in the creek channels, creating scour that may undermine structural integrity over time. Under the sea level rise scenarios illustrated in these maps, the impacts of roads and other crossings on wetland resiliency will only increase. At the same time, creek channel dimensions can be expected to grow significantly. As a result, one of the most effective adaptations steps that towns can take to protect existing infrastructure and allow for marsh migration is to increase the size of culverts beneath existing roads. Such sites are attractive opportunities to the habitat restoration funding community, and removal of existing tidal restrictions is a high priority for the Casco Bay Estuary Partnership. If your town is interested in exploring culvert replacement or removal projects and would like technical or grant writing assistance, contact CBEP staff for information on structural options, federal and state contacts, and funding opportunities.

In Harpswell, we have identified fourteen primary areas as either being at risk of conflict between rising seas and existing developed areas, and/or areas where we see potential marsh migration (Figure 2).

FIGURE 2

Harpswell Focus Areas



These areas are identified as:

Basin Cove
Potts Point Road
Stover's Point
Mackerel Cove
Wills Gut & Lowell Cove
Long Point Island
Long Point Road
Card Cove
Mill & Widgeon Cove
Middle Bay & Skolfield Cove
West Sebascodegan Island
Wallace Shore Road
Hen Cove
Ridley Cove Road

Two maps were produced for each of the areas above. The maps show existing infrastructure such as roads and dams, as well as existing wetlands (blue), then show how these resources are likely to be impacted by a 1' and then a 3' rise in sea level. Projected impacts are displayed as lost wetlands (yellow), and conflicts between existing infrastructure and sea level rise are shown in pink. Projected new wetlands are shown in orange.

As mentioned previously, caution must be taken when interpreting these maps because some of the areas may or may not pose any serious future risk for tidal inundation. Local knowledge of these areas will be necessary to more accurately gauge whether or not they are areas of concern for Harpswell according to current or future development plans, comprehensive plans, or conservation plans. Some areas may pose concern with regard to existing or future infrastructure, and other areas may see more significant changes with regard to wetland type and, subsequently, habitat.

Ha1: Basin Cove Area

Figures 3 and 4 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Basin Cove. Under a 1' increase in sea level (Fig. 3), there is potential conflict with Basin Cove Road at its northern end, where the road restricts tidal exchange with an impoundment upstream. Under a 3' rise in sea level (Fig. 4), the impacts to Basin Cove Road at this site are likely to increase. The elevations upstream are suitable for inland marsh migration. The analysis suggests potential for a great deal of wetland expansion on the west side of Basin Cove Road as well as along the area of potential conflict on the north end shown in Figure 3. The western wetland expansion does not appear to pose a significant threat to existing development at the 3 foot sea-level rise scenario. Figure 4 shows that the sites of greatest potential impact under a 3' increase in sea level are Basin Cove Road, Tide Mill Cove Road, the boatyard located off the southern end of Ash Point Road, and possibly some homes which are located on the cove.

Ha2: Potts Point Road Area

Figures 5 and 6 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Points Point. Figure 5 shows that a small amount of wetland would be lost along the coast, and gained as seas migrate inland. Figure 6 shows that the impact of a 3' increase in sea level will be more pronounced, particularly around Estes Lobster House and the adjacent causeway. There are existing homes and commercial buildings in this location which are at risk for tidal inundation, as are some homes along Potts Point Road.

Ha3: Stover's Point Area

Figures 7 and 8 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Stover Point. The area that poses the most immediate concern is the northern tip of Stover's Point. Homes which are located next to the water's edge on the northern end of Eider Road, Marshview Way, Irene Avenue, Stovers Point Road and Windsor Lane are at risk from tidal inundation at either the one–foot or three-foot sea level rise, but particularly if we experience a three-foot sea level rise. Additional potential conflict arises at the farthest east end of Intervale Road.

Ha4: Mackerel Cove Area

Figures 9 and 10 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Mackerel Cove on Bailey Island. Low-lying areas to the North of Abner Point Road are suitable for marsh migration inland if seas rise 1' to 3'. Impacts to existing developed areas can be anticipated with a 1' rise in sea level, and would be greatly increased if sea level rises by 3', affecting Abner Point Road itself, as well as surrounding homes and driveways. Accessibility to and from Abner Point will be at risk due to tidal inundation.

Ha5: Wills Gut & Lowell Cove Area

Figures 11 and 12 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Will Gut and Lowell Cove areas. Clearly the biggest area of concern is surrounding Cribstone Bridge. Homes which are located next to the existing wetland (in between Garrison Cove Road, Wentworth Lane and Harpswell Island Road) are potentially in conflict with tidal inundation at any sea level rise scenario. Cook's Lobster House may be in conflict at the three-foot sea level rise projection as well as roads and buildings further north near The Dock, Lowell's Cove Road, Lane Road, and the southern end of Johnson Point Road along Beal's Cove.

Ha6: Long Point Island Area

Figures 13 and 14 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Long Point Island.   A 1' increase in sea level would create a potential conflict around Little Crow Point and the already existing wetland area located where Little Crow Point and Long Point Road intersect. A 3' rise in sea level is projected to result in areas of new wetland formation due to marsh migration inland as tidal inundation increases significantly. With this scenario, Tuttle Road and the southern area surrounding Long Point Road are also at risk, and there is the potential for a significant amount of new wetland expansion between Long Point Road, Tuttle Road and continuing further north.

Ha7: Northern Long Point Road Area

Figures 15 and 16 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Long Point Island Road. Similar to the Long Point Island maps, a 3' increase in sea level would result in wetland expansion from the Little Crow Point and Tuttle Road area reaching north toward the inland water area that is west of Long Point Road and east of Gun Point Road. Buildings and roads around the northern end of Long Point Road, Gun Point Road and Quohog Lane are at risk from tidal inundation.

Ha8: Card Cove Area

Figures 17 and 18 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Card Cove. With a 1' increase in sea level, impacts would be limited. Some wetland would be lost at the southern end of Long Reach. At a 3' increase in sea level, the area along Harpswell Island Road at the northernmost end of Card Cove (between Stevens Corner Road and Old Orrs Island Road), the northernmost end of Long Point Road, and the southernmost end of Pinkman Point Road are at risk for tidal inundation. Extensive wetland loss could be expected in Long Reach if seas rise by 3', with little suitable terrain for marsh migration inland.

Ha9: Mill & Widgeon Cove Area

Figures 19 and 20 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Mill Cove and Widgeon Cove. If sea level rises by 1', some tidal wetlands along the edge of Widgeon Cove could be lost with minimal marsh migration, but otherwise, there do not seem to be many significant potential impacts in this area. Somewhat more marsh migration may occur along Widgeon Cove if sea level rises by 3'. At the head of Mill Cove, the presence of the High Head Road causeway currently restricts tidal exchange between the Cove and a small wetland to the north. This structure would likely limit the ability of marsh to migrate inland if seas rise by 1' or 3', but may be subject to sea level rise impacts.

Ha10: Middle Bay & Skolfield Cove Area

Figures 21 and 22 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Middle Bay and Skolfield Cove. The maps project a major loss of tidal wetlands with a 1’ or a 3’ increase in sea level along Middle Bay, with considerably less opportunity for marshes to migrate inland. Our analysis shows that conflicts with existing infrastructure are likely to occur at the Town’s border with Brunswick along Harpswell Road/Route 123, at 43.855249,-69.946492, from both Middle Bay to the west and Skolfield Cove to the east.

Ha11: West Sebascodegan Island

Figures 23 and 24 show projected sea level rise impacts on tidal wetlands and developed areas along Sebascodegan Island focused on the marsh system at the head of Doughty Cove, which is crossed by Long Reach Lane to the north, an old road bed (shown in pink), and a private road to the south (not shown). This system will undergo significant changes in 2013 when the current culvert beneath Long Reach Lane is replaced by a larger structure, allowing for improved tidal exchange with the upstream marsh and allowing for improved tidal wetland migration into low-lying, freshwater dominated areas. The analysis shows that with a 1’ increase in sea level, a large area south of the private road is suitable for marsh migration inland. If sea level rises by 3’, this area will increase, with some impact to existing road crossings to be expected. A rise in sea level greater than 3-feet, however, may impact parts of Harpswell Island Road that are to the east of the existing marsh.

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Ha12: Wallace Shore Road Area

Figures 25 and 26 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Wallace Shore Road. This area is subject to significant impacts related to sea level rise and impacts on existing developed areas. Where Wallace Shore Road runs parallel to the shore, a low-lying, undersized culvert is currently restricting tidal exchange with the wetland upstream. In both the 1’ and 3’ sea level rise scenarios, Wallace Shore Road and Shore Road would be subject to regular tidal inundation. At the three-foot sea level rise scenario, elevations are suitable for a significant amount of marsh migration and expansion around this existing wetland area.

Ha13: Hen Cove Area

Figures 27 and 28 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Hen Cove. If sea level rises by 1', our analysis does not project this area to be impacted. However, if sea level rises by 3', a significant amount of wetland migration inland is projected, particularly between Hen Cove and Quahog Bay just south of Little Ponds Road. There may be some potential conflict in this area due to tidal inundation along Bethel Point Road, Little Ponds Road, Hen Cove Road, and possibly Sage Road. The presence of an unknown structure, possibly a dam, to the west of Bethel Point Road (43.796699,-69.911847) may impact the extent of marsh migration in this area. This structure may be impacted by sea level rise.

Ha14: Ridley and Sandy Cove Area

Figures 29 and 30 show projected sea level rise impacts on tidal wetlands and developed areas in the vicinity of Hen Cove. If sea level rises by 1', our analysis does not project this area to be impacted. However, if sea level rises by 3', a significant amount of wetland migration inland is projected, particularly between Hen Cove and Quahog Bay just south of Little Ponds Road. There may be some potential conflict in this area due to tidal inundation along Bethel Point Road, Little Ponds Road, Hen Cove Road, and possibly Sage Road. The presence of an unknown structure, possibly a dam, to the west of Bethel Point Road (43.796699,-69.911847) may impact the extent of marsh migration in this area. This structure may be impacted by sea level rise.

FIGURE 3: Ha1

Basin Cove Area: 1 ft. Sea Level Rise

FIGURE 4: Ha1

Basin Cove Area: 3 ft. Sea Level Rise

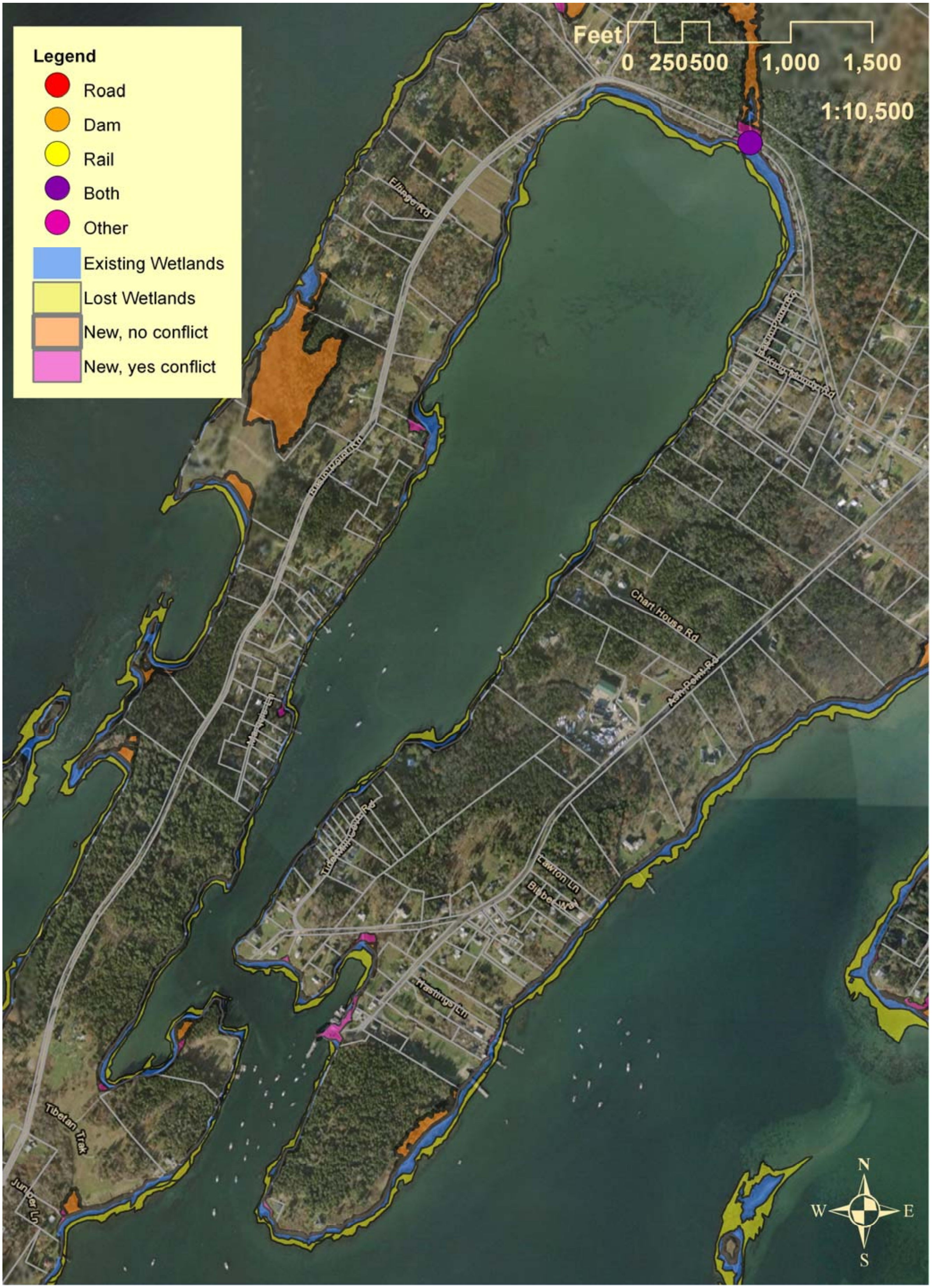


FIGURE 5: Ha2

Potts Point Road Area: 1 ft. Sea Level Rise

FIGURE 6: Ha2

Potts Point Road Area: 3 ft. Sea Level Rise

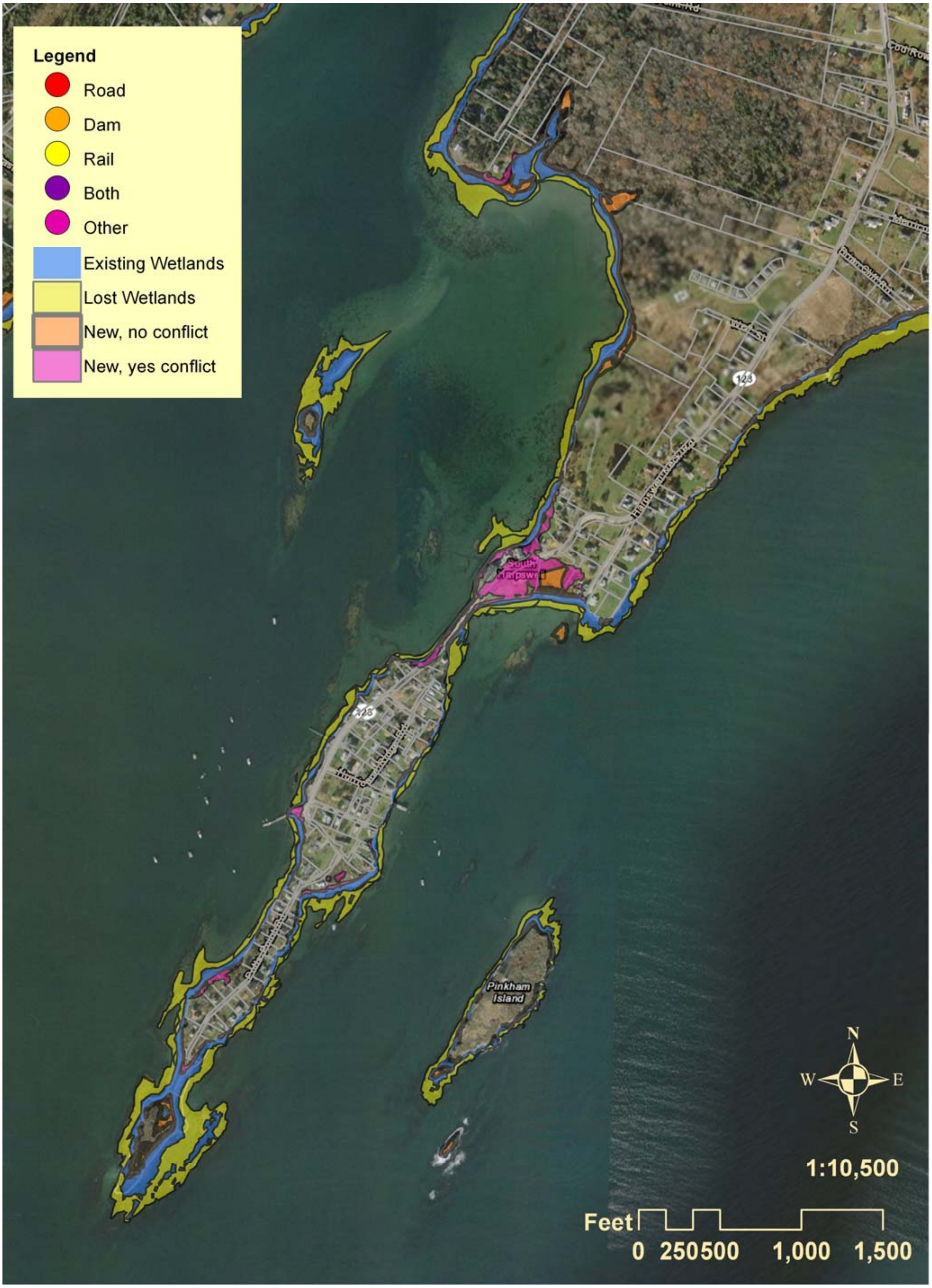


FIGURE 7: Ha3

Stover Point Area: 1 ft. Sea Level Rise

FIGURE 8: Ha3

Stover Point Area: 3 ft. Sea Level Rise

FIGURE 9: Ha4

Mackerel Cove Area: 1 ft. Sea Level Rise

FIGURE 10: Ha4

Mackerel Cove Area: 3 ft. Sea Level Rise

FIGURE 11: Ha5 **Wills Gut & Lowell Cove Area: 1 ft. Sea Level Rise**

FIGURE 12: Ha5 **Wills Gut & Lowell Cove Area: 3 ft. Sea Level Rise**

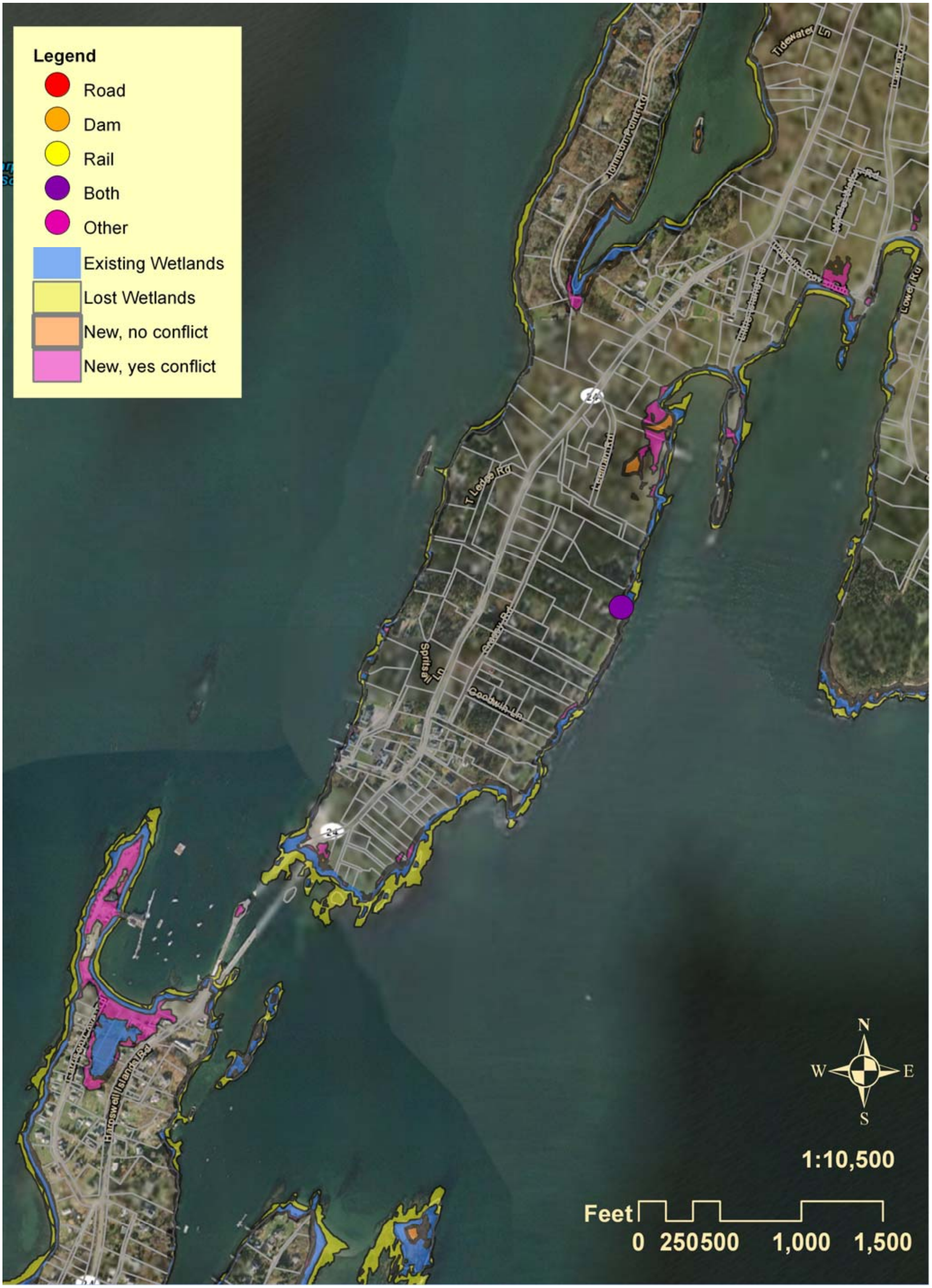


FIGURE 13: Ha6

Long Point Island Area: 1 ft. Sea Level Rise

FIGURE 14: Ha6

Long Point Island Area: 3 ft. Sea Level Rise

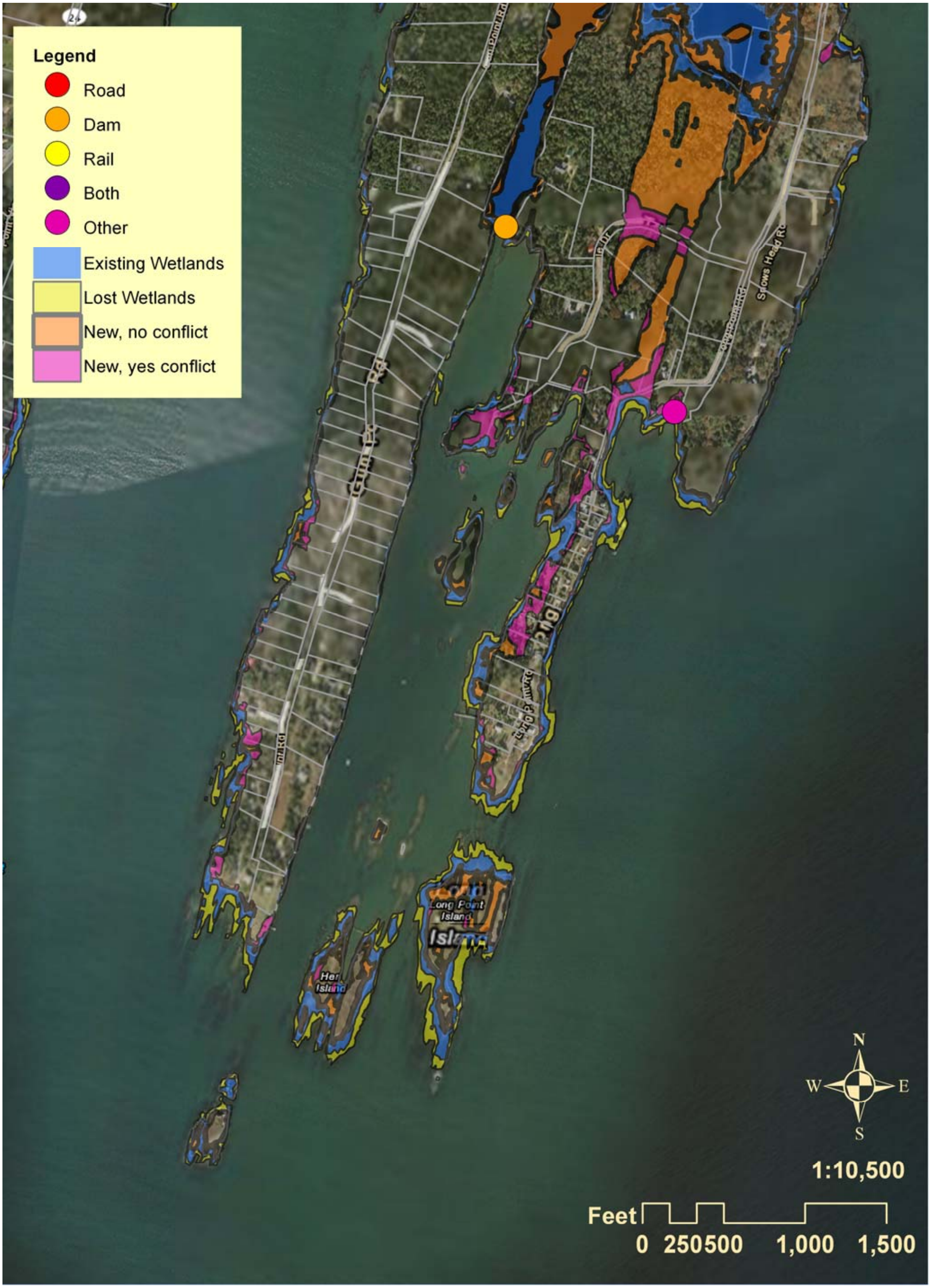


FIGURE 15: Ha7

Long Point Road Area: 1 ft. Sea Level Rise

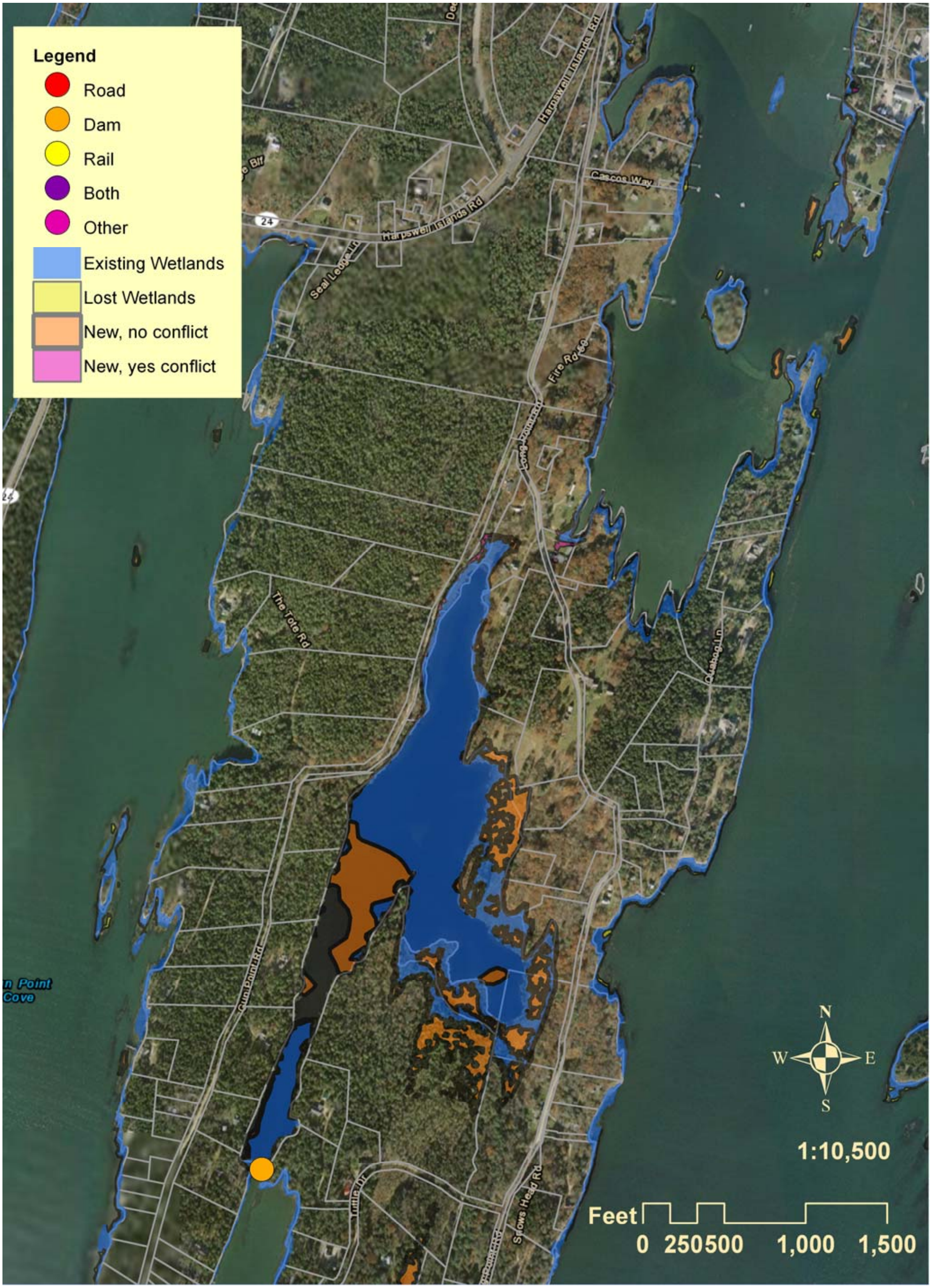


FIGURE 16: Ha7

Long Point Road Area: 3 ft. Sea Level Rise

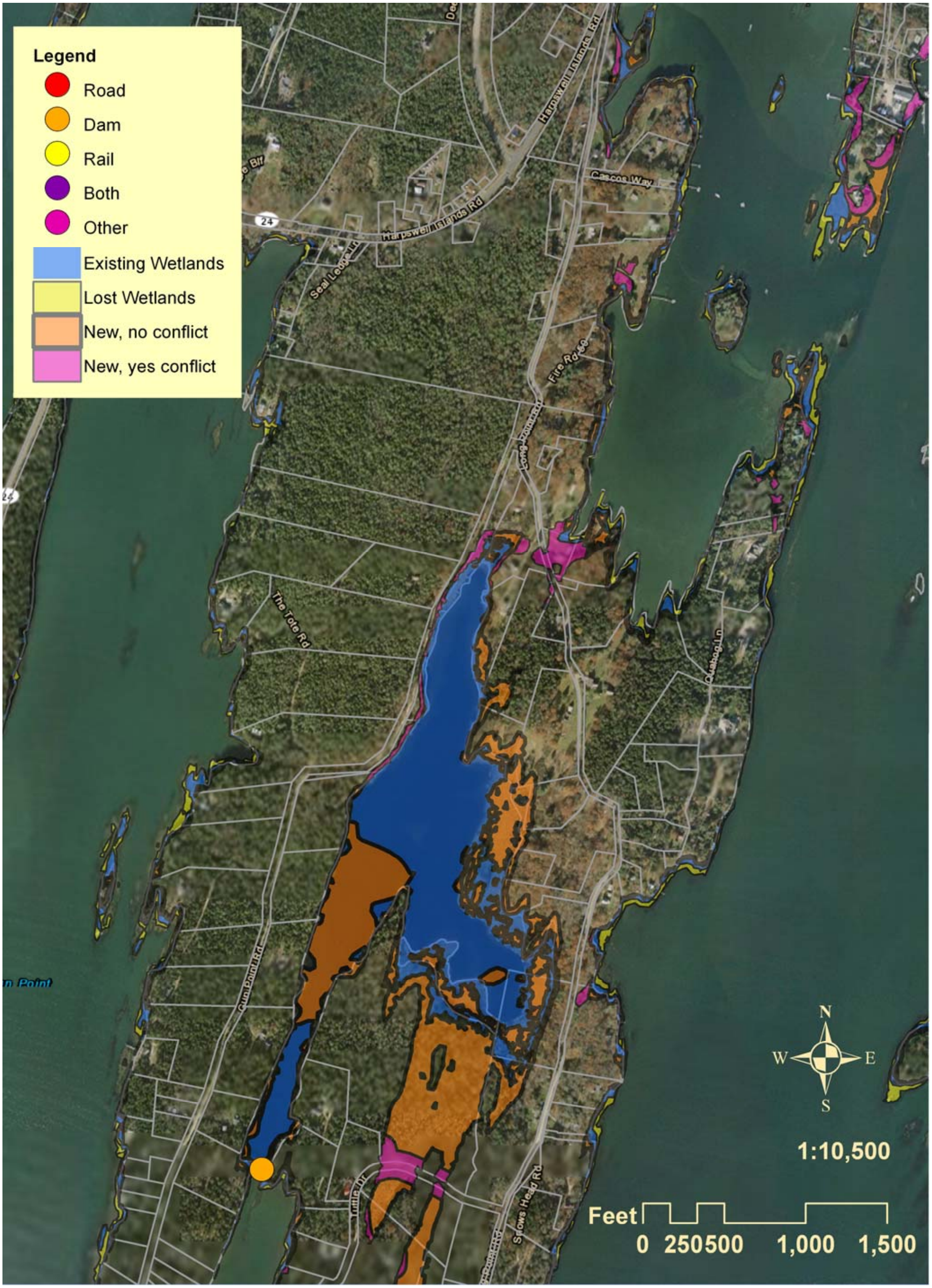


FIGURE 17: Ha8

Card Cove Area: 1 ft. Sea Level Rise

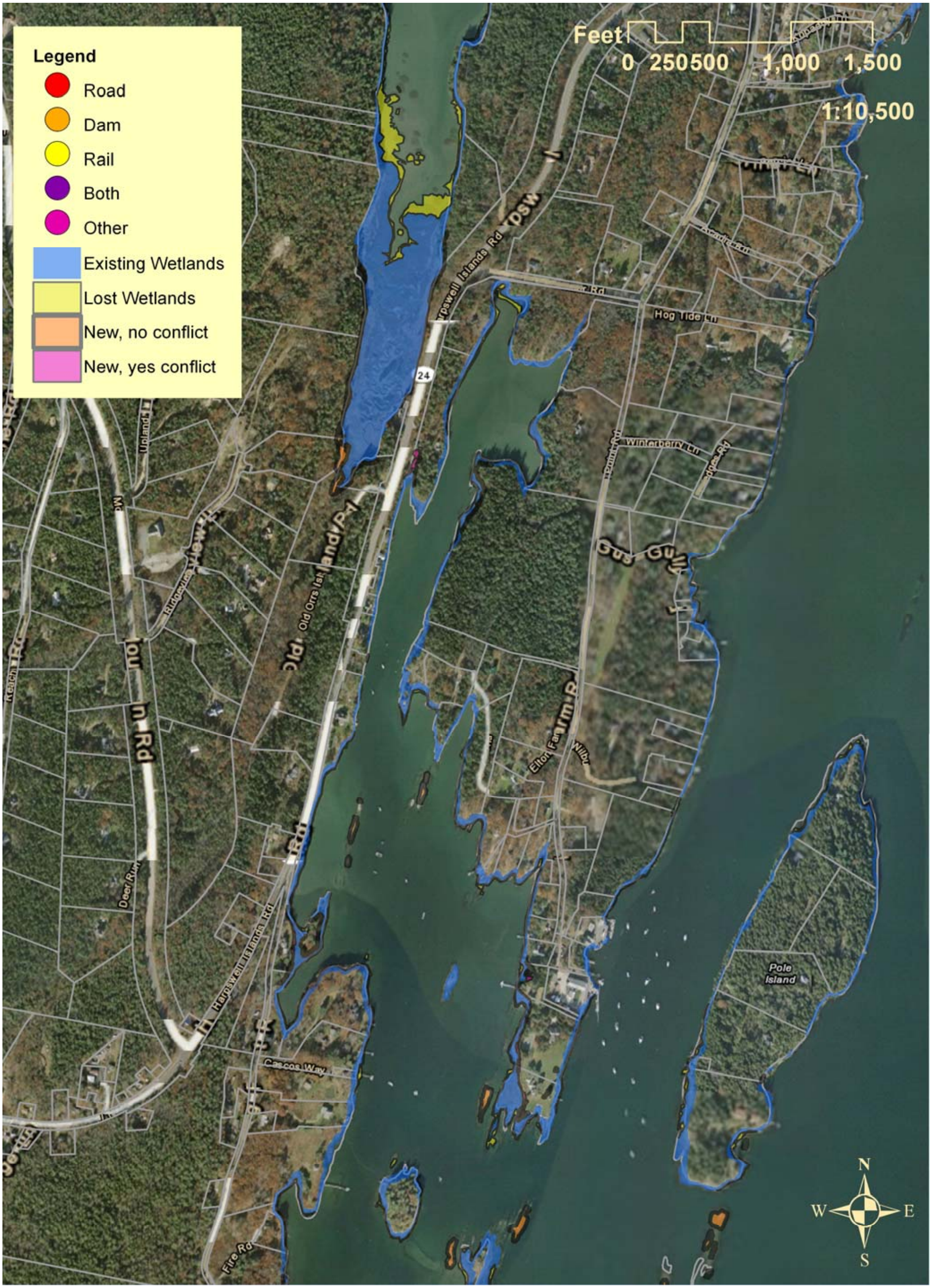


FIGURE 18: Ha8

Card Cove Area: 3 ft. Sea Level Rise

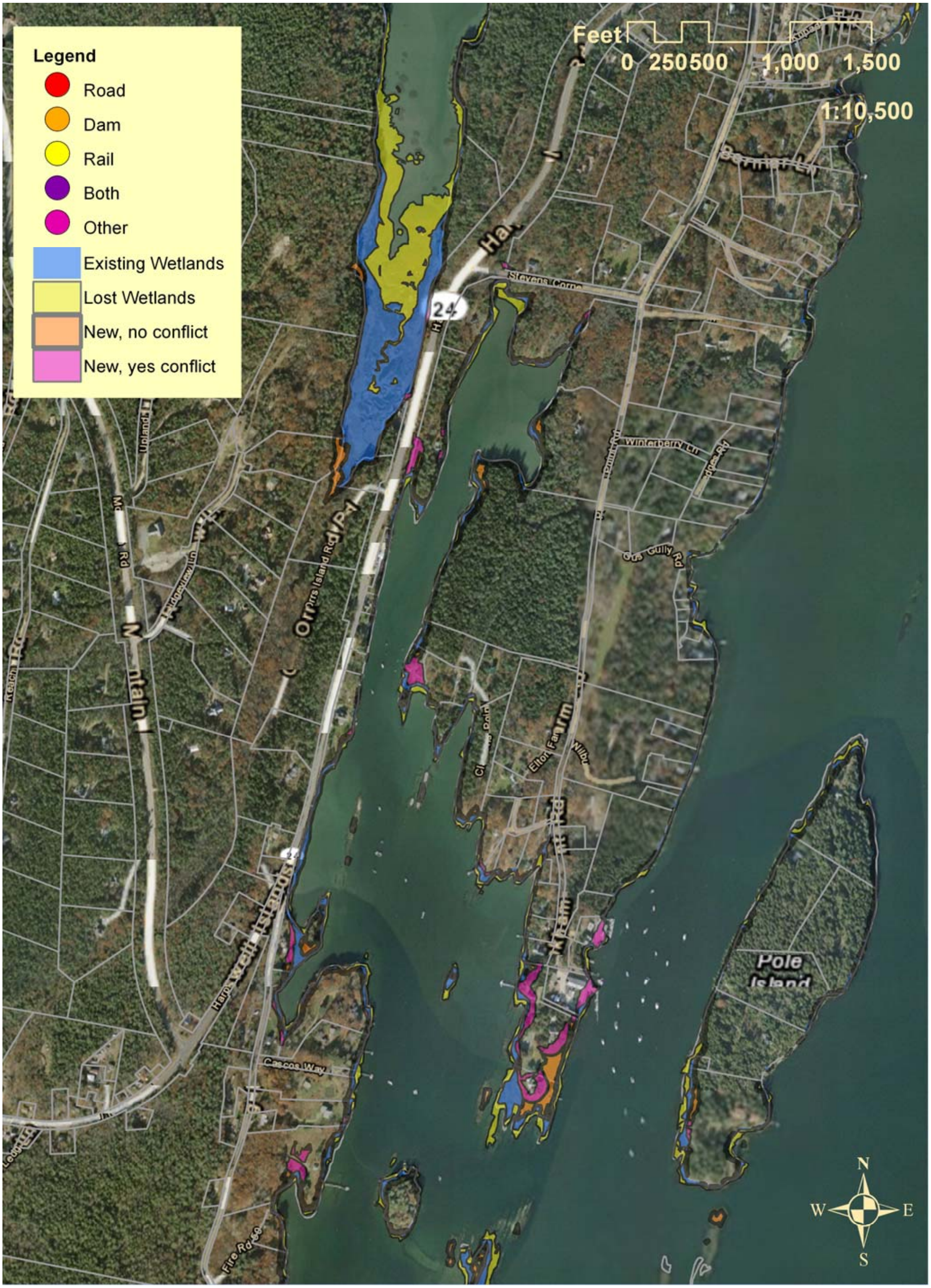


FIGURE 19: Ha9 Mill & Widgeon Cove Area: 1 ft. Sea Level Rise

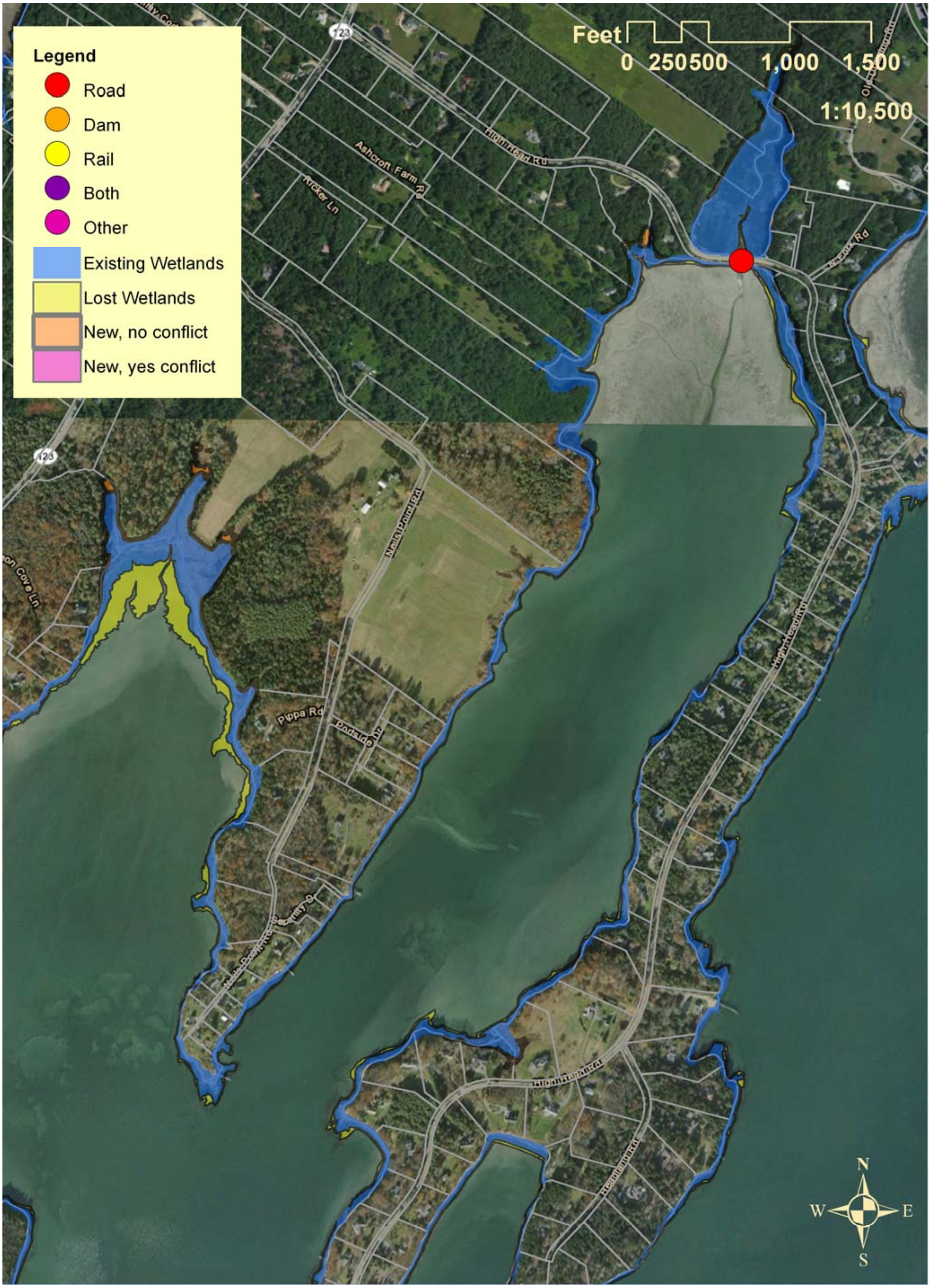


FIGURE 20: Ha9 Mill & Widgeon Cove Area: 3 ft. Sea Level Rise

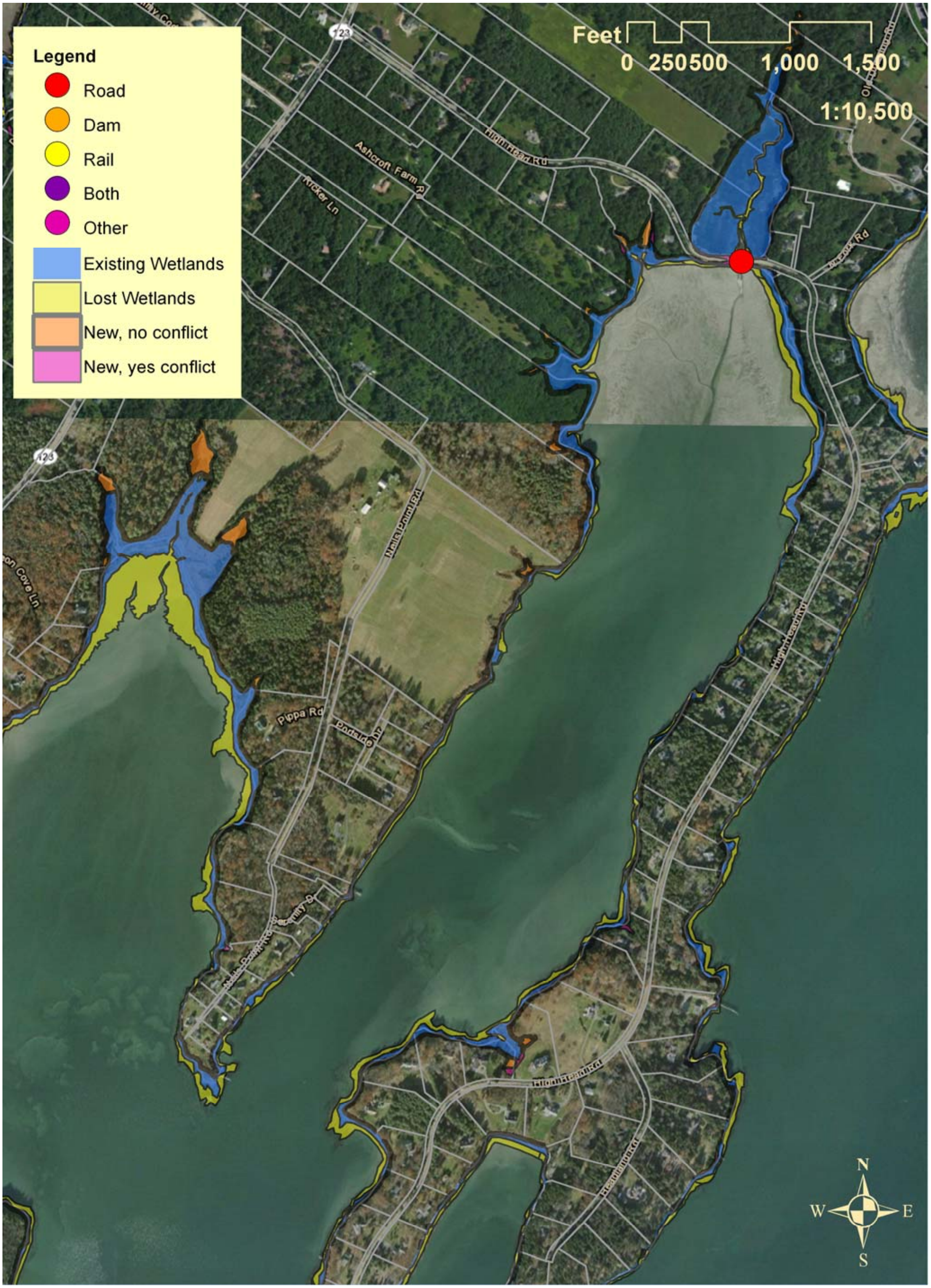


FIGURE 21: Ha10 **Middle Bay & Skolfield Cove Area: 1 ft. Sea Level Rise**

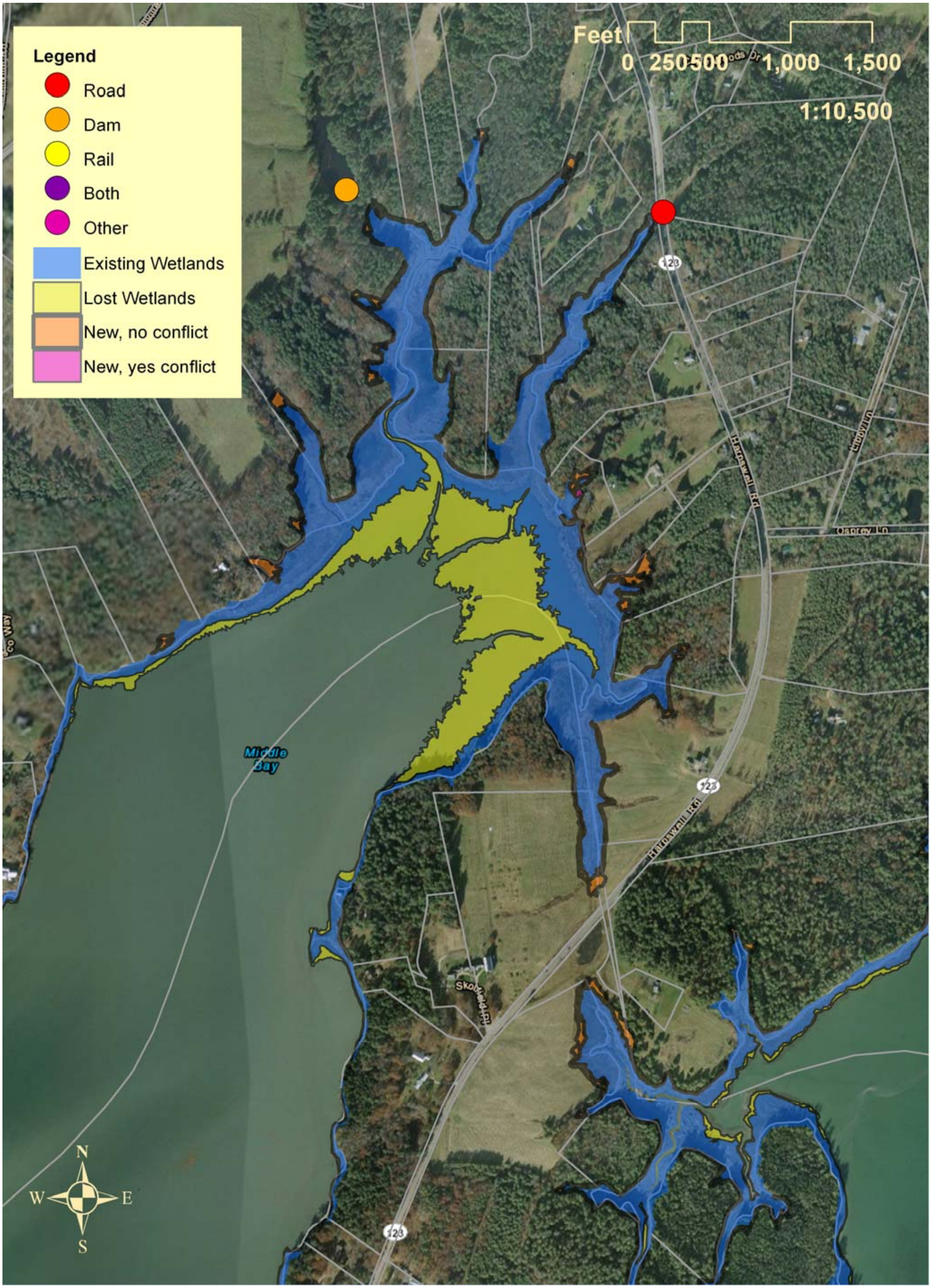


FIGURE 22: Ha10 **Middle Bay & Skolfield Cove Area: 3 ft. Sea Level Rise**

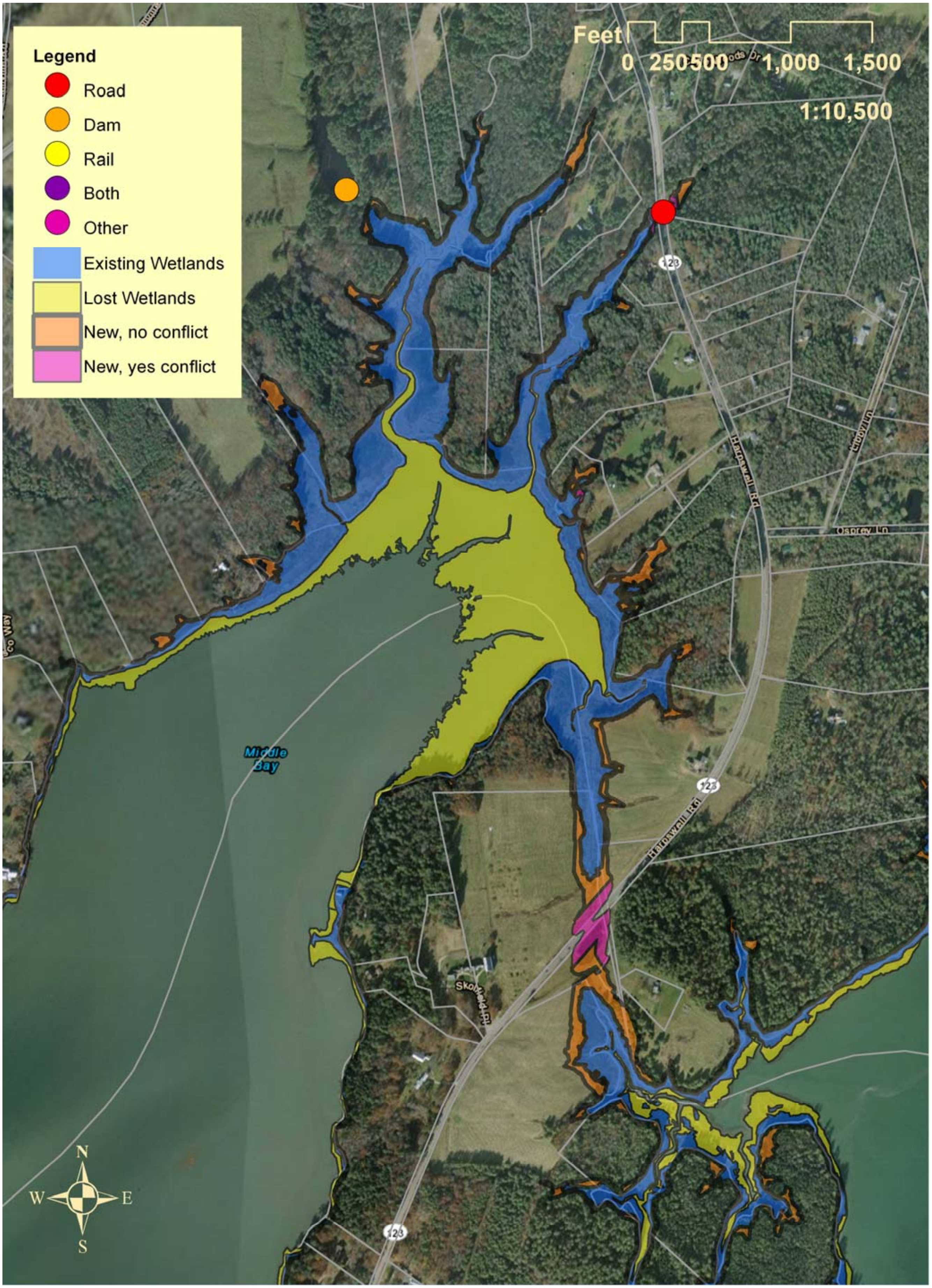


FIGURE 23: Ha11 **West Sebascodegan Island: 1 ft. Sea Level Rise**

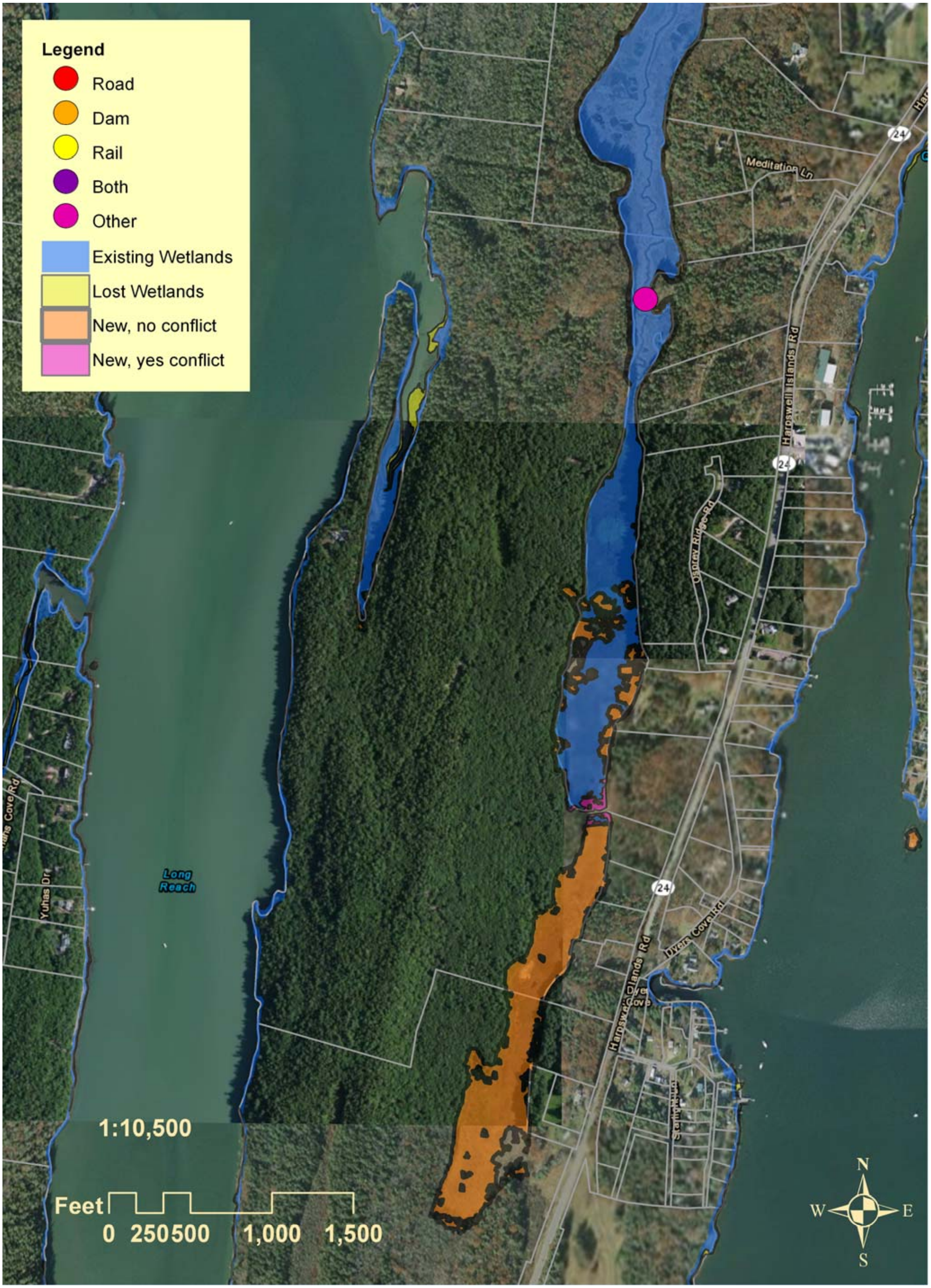


FIGURE 24: Ha11 **West Sebascodegan Island: 3 ft. Sea Level Rise**

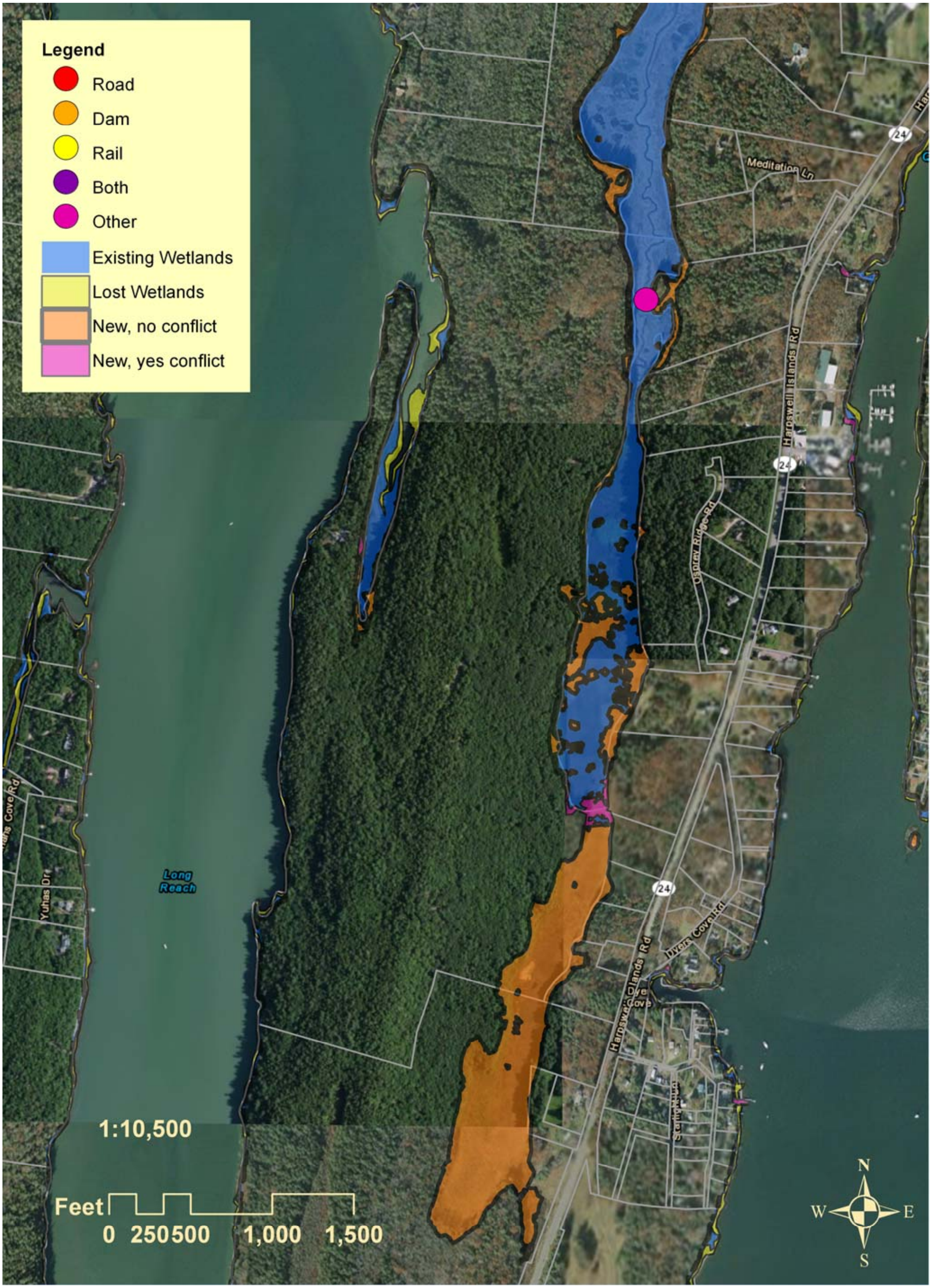


FIGURE 25: Ha12 **Wallace Shore Road Area: 1 ft. Sea Level Rise**

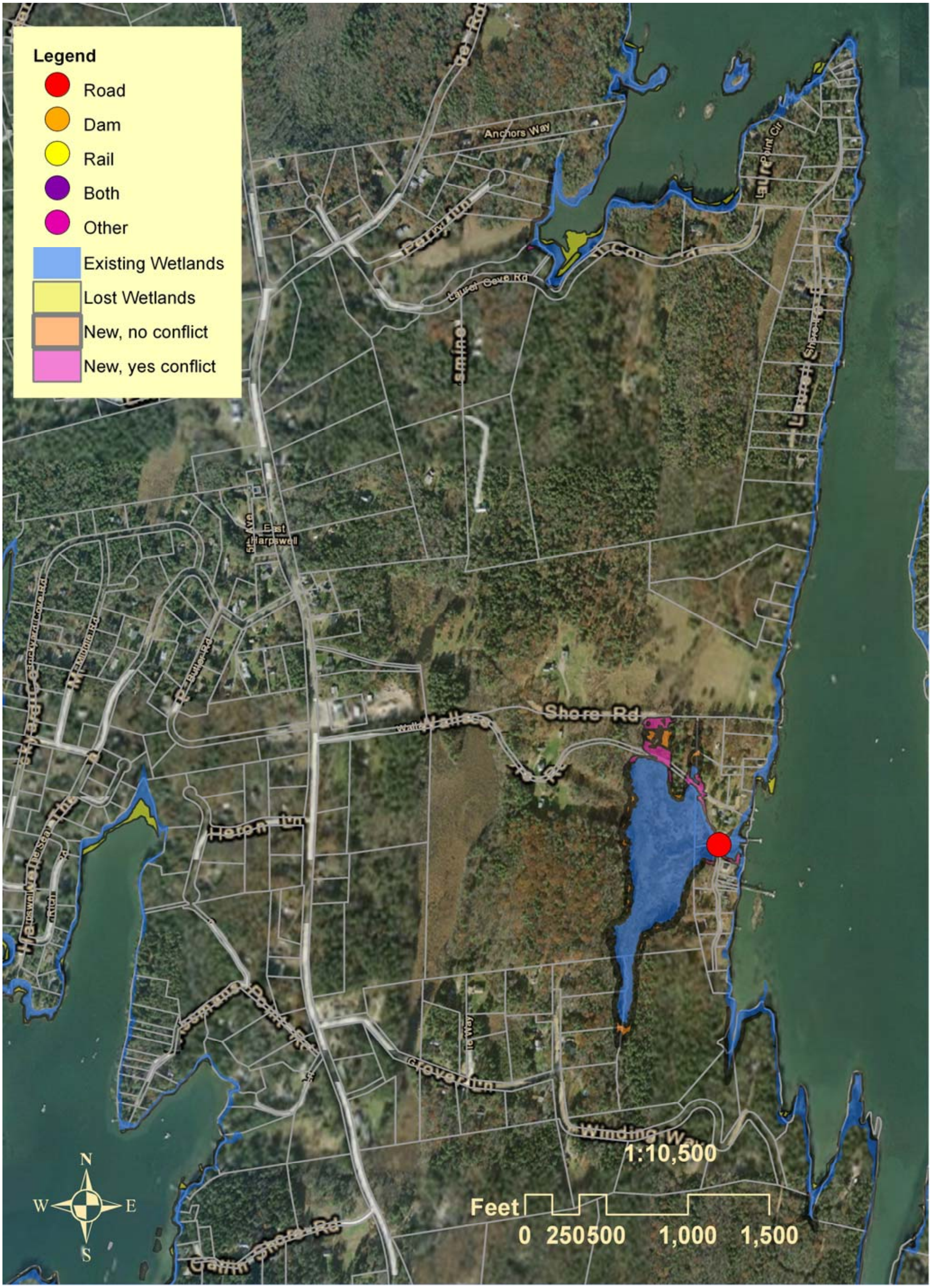


FIGURE 26: Ha12 **Wallace Shore Road Area: 3 ft. Sea Level Rise**

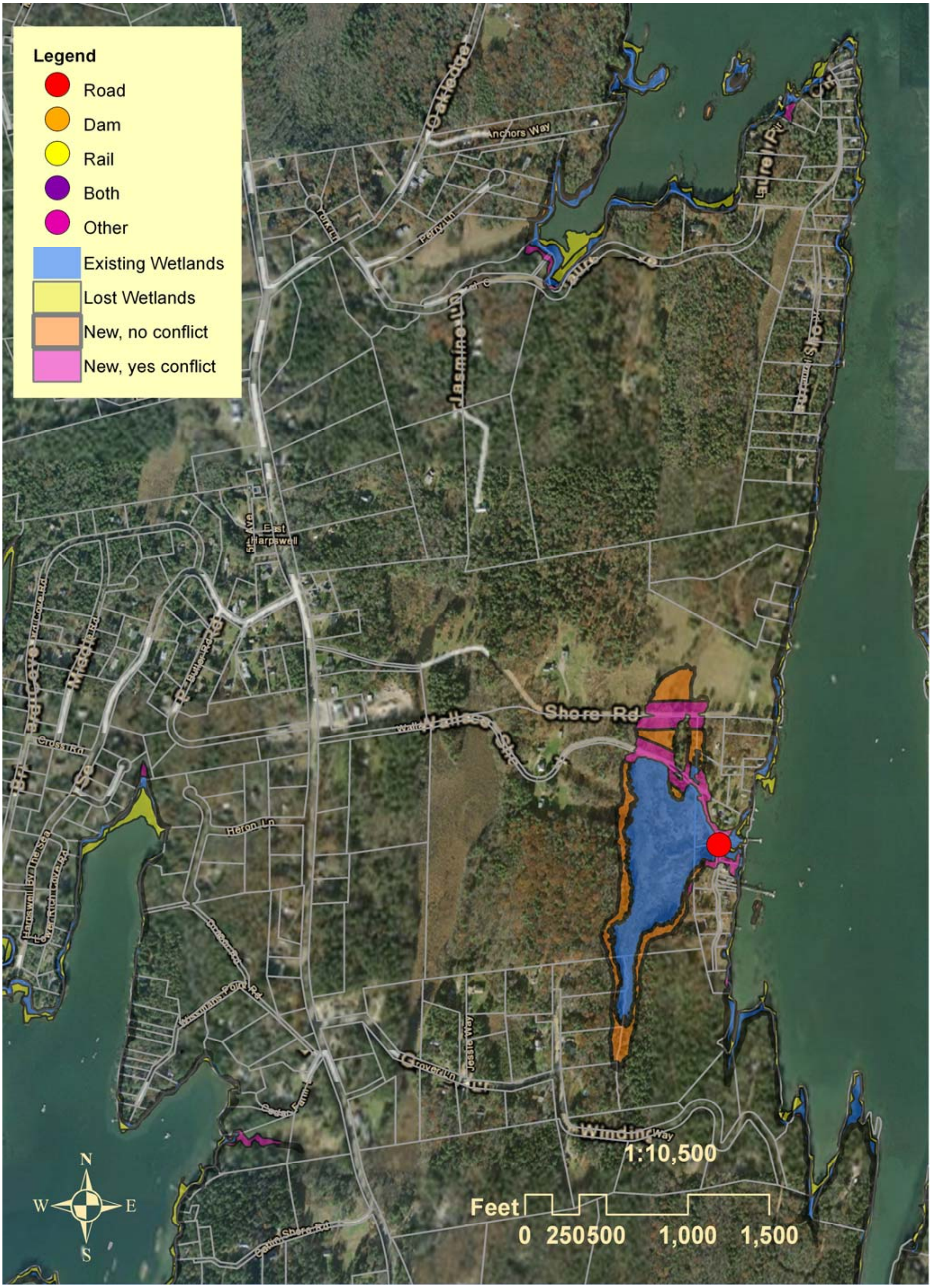


FIGURE 27: Ha13

Hen Cove Area: 1 ft. Sea Level Rise

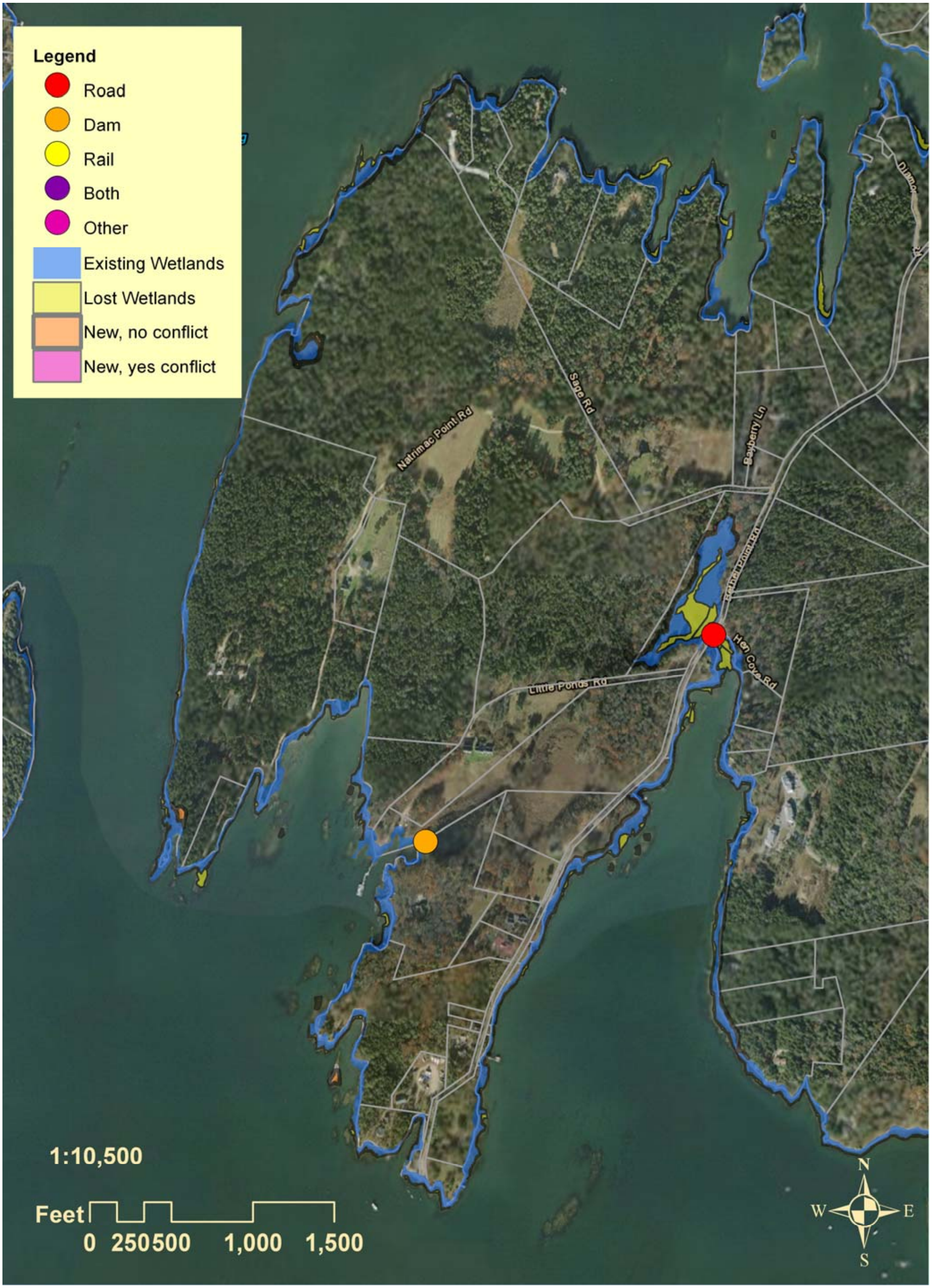


FIGURE 28: Ha13

Hen Cove Area: 3 ft. Sea Level Rise

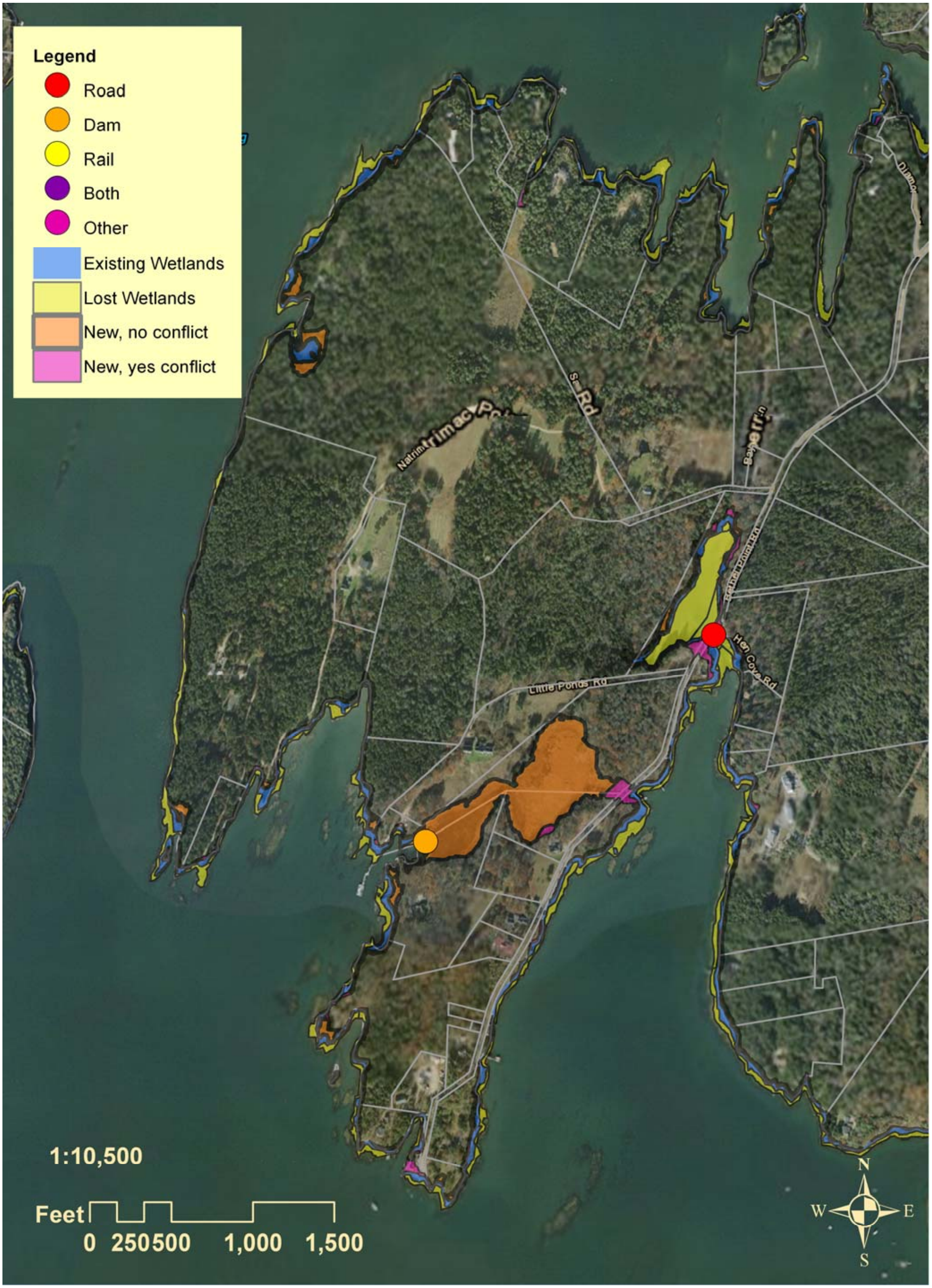


FIGURE 29: Ha14 **Ridley Cove Road Area: 1 ft. Sea Level Rise**

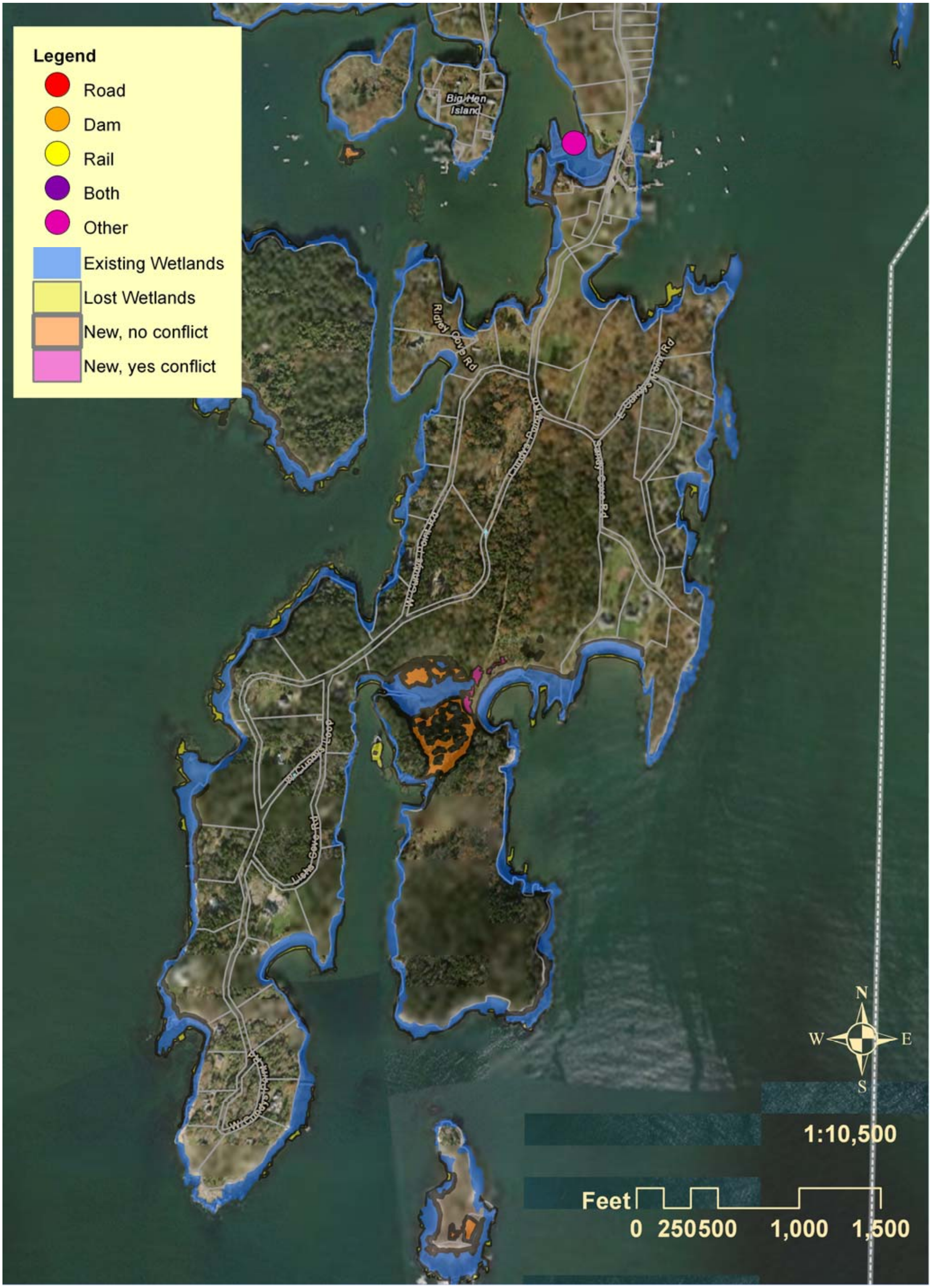
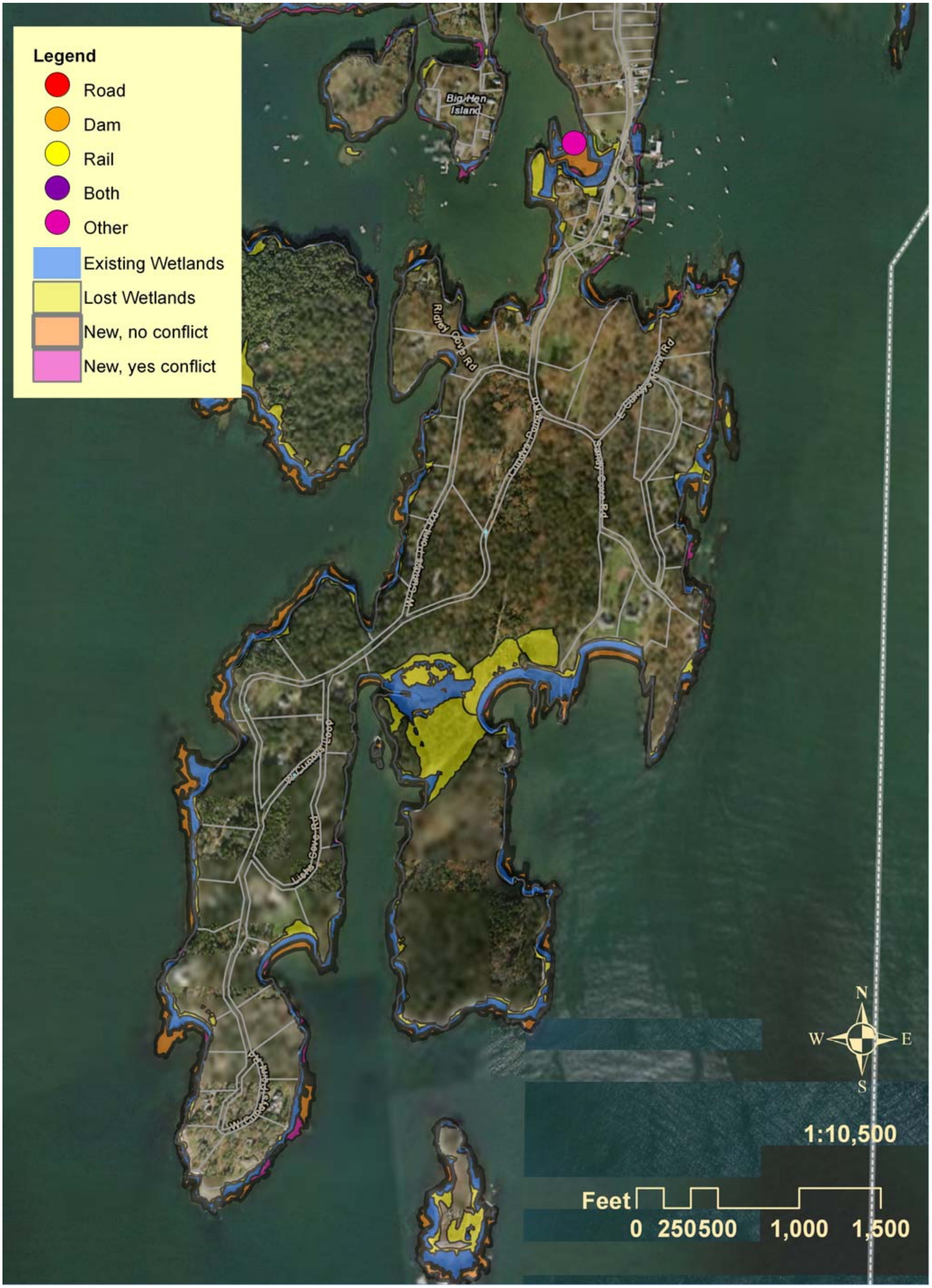


FIGURE 30: Ha14 **Ridley Cove Road Area: 3 ft. Sea Level Rise**



Suggested Uses of this Information:

The next logical questions after reviewing your town's report might be to ask "how do we use this information?" and "what can we do about the predicted effects of sea level rise on our coastal marshes?" As stand-alone information, your town's maps can provide the basis for starting community discussions on the potential impacts of sea level rise. These maps can be used in conjunction with current planning processes or documents in your town, such as municipal and Shoreland zoning, your comprehensive plan, open space plan, or capital improvement plan, and related ordinances such as your floodplain ordinance, to begin to develop adaptation strategies that would work best in your community in order to preserve and protect what is important to your community and reduce costs resulting from increasing levels and frequency of inundation. The following actions and questions can help your town begin to integrate this information into your community discussions and local decision-making:

- Review the maps to identify those areas where coastal marshes will try to migrate landward;
- Determine if there are obstacles to that happening. If not, who owns those lands? How might they be managed to allow marsh migration to occur in undeveloped areas? Are these areas part of the town's future investment and development strategies? If there is already development in those places, what stands in the way of marsh migration? Roads or other infrastructure? How vulnerable might that infrastructure be?
- If your town has zoning, how are those areas zoned now? Is that appropriate in light of the predicted effects of sea level rise?

The Maine Coastal Program, Maine Geological Survey and the Municipal Planning Assistance Program, all at the Maine Department of Agriculture, Conservation and Forestry, have been working with regional councils, communities and regions along the Maine coast to address these questions and develop local responses. Because the impacts are unique in each community, responses will be as well. To date, municipal responses that might be transferable to your community have included: changes to freeboard required in the flood plain ordinance; strategic conservation actions to ensure that marshes can migrate; adoption of Highest Annual Tide elevation from the LiDAR data into the Shoreland Zoning Ordinance; identification of tidal restrictions; and addition of sea level rise chapters into comprehensive plans. For more information on these or for help developing other adaptation strategies, contact your regional planning organization (Greater Portland Council of Governments or Midcoast Council of Governments) or the Municipal Planning Assistance Program at the Department of Agriculture, Conservation and Forestry.

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Appendix:

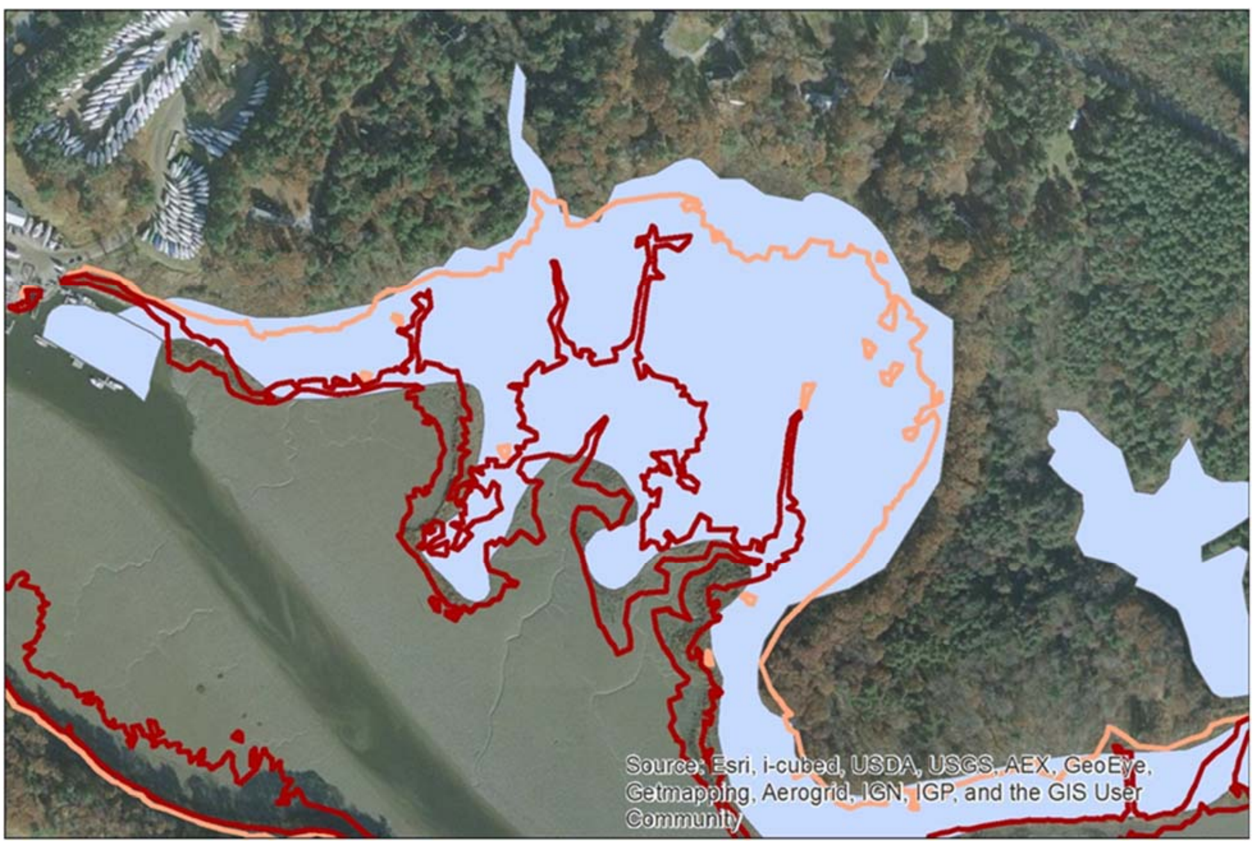
Methods:

The study is based on a detailed analysis of high resolution terrestrial elevations derived from "LIDAR" (Light Detection and Ranging) data. LIDAR is a technology similar to RADAR that uses light waves instead of radio waves to measure distance from a plane to the ground. Raw LIDAR data is post-processed to produce a "Digital Elevation Model" (DEM) that shows estimated ground elevations free of buildings, trees, and other obstructions. The resulting DEM can be highly accurate, with elevations estimated every few feet (horizontally), absolute vertical errors typically less than a foot, and relative vertical errors much smaller than that on a local scale.

Two sources of LIDAR data were used in this analysis: (1) FEMA South Coast LIDAR 2006, (2) LIDAR for the Northeast 2011. Both data sets were acquired as DEM tiles from the University of Southern Maine's Geographic Information Systems Laboratory in the spring of 2011. As received, the two data sets were based on different units of measure (feet vs. meters), so the LIDAR for the Northeast 2011 data set was scaled and resampled using bilinear interpolation before the two data sets were combined to produce a single composite LIDAR DEM for the study area.

LIDAR data was combined with information on tidal heights compiled by NOAA for the Portland tide gauge (station 8418150) in order to identify portions of the shoreline that lie within the upper intertidal zone (between the Mean Tide Level [MTL] and the Highest Annual Tide [HAT]). These elevations are roughly coincident with the lower (MTL) and upper (HAT) limit of tidal wetland development in Maine. Not every location between these elevations will develop tidal wetland. Tidal wetlands only occur where other environmental conditions are also suitable, such as having suitable soils, low slopes, and low to moderate wave exposure. Nevertheless, in areas with existing tidal wetland, the overlap between existing wetland and areas identified solely on the basis of elevation is quite good. Figure 31 shows an overlay of CBEP's elevation polygons (outlined in red and orange as high and low marsh areas) compared to wetlands identified in the National Wetlands Inventory (light blue), for a tidal wetland in Maine. The accuracy is sufficient for the purpose of this study.

FIGURE 31



It is important to note that the maps we have produced are not maps of flood risk, but maps of the projected upper intertidal zone. The areas highlighted in these maps are, in the absence of efforts to protect them from the ocean, expected to be flooded on a regular basis (ranging from daily to annually) due to the action of the tides. Significantly larger areas may be at risk of inundation or flooding due to storms. Because the maps we have produced to date are based solely on elevation, there may be areas in your community which show up as sitting at the proper elevation for tidal wetland development, but that do not now harbor wetlands. Typically such areas are beaches, rocky shores, or the base of steep bluffs, so there is little chance for confusion, but the maps need to be read with this in mind.

To predict where the upper intertidal zone (and thus tidal wetlands) may exist in the future, we developed a pair of maps showing elevations suitable for tidal wetland development, one showing a 1' rise in sea level, and one a 3' rise in sea level. While these scenarios are hypothetical, they are consistent with climate change and sea level rise modeling efforts. A recent analysis of climate change for the Casco Bay region commissioned by CBEP suggests that an increase in sea level on the order of 1' is likely by the middle of this century, while increases of 2' to well over 3' are possible by 2100 (Table 1).

In general, Casco Bay's shoreline is characterized by steep rocky slopes, so we are more fortunate than our southern neighbors in that our coastline may not be as affected by tidal inundation. However, where we have mapped upper intertidal zone areas, we do see places where existing development (as determined by 2007 data on impervious surfaces) may be vulnerable to inundation in the future, or may be in conflict with landward migration of tidal wetlands as sea level increases.

TABLE 1:

Estimates of future stillwater elevations at the Portland tide gauge under lower and higher greenhouse gas emissions scenarios (all estimates in feet relative to NAVD 1988; based on CBEP 2010 report).

Scenario	Lower Emissions		Higher Emissions	
Year	2050	2100	2050	2100
Subsidence	0.024	0.043	0.024	0.043
Dynamic	NE	0.52	NE	0.79
Eustatic	0.66	1.6	1.4	4.6
Total Predicted Stillwater Elevation (ft)	9.5	11.1	10.3	14.3
Net Change in Sea Level	**0.6**	**2.2**	**1.4**	**5.4**