



6.0 Transportation Analysis

6.1 Introduction

While hurricanes are relatively unusual for Massachusetts, tropical cyclones pushing north can impact the state bringing dangerous weather conditions to its residents and visitors. These storm systems can bring flooding along the coast from storm surge and inland flooding from excessive rainfall, as well as tornadoes and associated wind damage. During these events, state and local emergency management officials may be required to call for evacuations of the Massachusetts coast. These protective action decisions could result in the local and regional road network having to process a significant number of vehicles in a relatively short period of time. Congestion, especially during the summer, can be quite heavy. Frequent daily backups occur from just normal daily traffic demands; therefore, massive traffic congestion in the event of an evacuation could be a realistic possibility.

In August 1991, the approach of Hurricane Bob, a weakening Category 2 hurricane, caused the evacuation of over 50,000 homes, mostly from Cape Cod. The resulting evacuation spawned an 11 mile backup at the Sagamore Bridge that stretched all the way back to beyond the Prospect St/State Route 149 interchange on US 6. In any of the references to this event, there was no discussion about how long the bottleneck took to clear; nonetheless, the experience reportedly still lives on vividly in the minds of some modern Cape Codders.

In the near quarter century since Hurricane Bob, local growth in both permanent residents on the Cape and potential tourists travelling there each summer have only made the problem worse. The Barnstable County permanent resident population has grown by 15% during that time period according to the US Census Bureau. Concurrently, tourist revenues have almost doubled in the same timeframe, strongly indicating vigorous growth in the potential number of visitors on Cape Cod on any given summer day.

In 2012, the Federal Emergency Management Agency (FEMA) and the United States Army Corps of Engineers (USACE), New England District, funded the Southern New England Hurricane Evacuation Study (HES). That same year, Atkins was retained to complete the HES transportation analysis and then the Technical Data Report (TDR). The HES develops technical data concerning hurricane hazards; the vulnerability of the resident and tourist populations; public response to evacuation advisories; evacuation timing; and sheltering needs for various hurricane threat situations. A critical component in the HES is the transportation analysis to determine how many people and vehicles would be involved if a hurricane forced an evacuation of Massachusetts's coastal jurisdictions.

The principal purpose of the transportation analysis is to: 1) determine the time required to evacuate the vulnerable population (clearance times), and 2) evaluate general traffic control



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measures that could improve the flow of evacuating traffic. This chapter documents the basic inputs and findings of the study analysis. The list of the jurisdictions involved in the Massachusetts HES TDR is displayed in Table 6-1, and a map of the study area is located in Figure 6-1.

Table 6-1: Massachusetts HES TDR Study Area

County	Communities
Barnstable County	Barnstable; Bourne; Brewster; Chatham; Dennis; Eastham; Falmouth; Harwich; Mashpee; Orleans; Provincetown; Sandwich; Truro; Wellfleet; and Yarmouth
Bristol County	Acushnet; Berkley; Dartmouth; Dighton; Fairhaven; Fall River; Freetown; New Bedford; Raynham; Rehoboth; Seekonk; Somerset; Swansea; Taunton; and Westport
Dukes and Nantucket Counties	Aquinnah; Chilmark; Edgartown; Oak Bluffs; Tisbury; West Tisbury; and Nantucket
Essex County	Beverly; Danvers; Essex; Gloucester; Ipswich; Lynn; Manchester; Marblehead; Nahant; Newbury; Newburyport; Peabody; Rockport; Rowley; Salem; Salisbury; Saugus; and Swampscott
Middlesex County	Arlington; Belmont; Cambridge; Everett; Malden; Medford; Newton; Somerville; Waltham; Watertown; and Winchester
Norfolk County	Braintree; Brookline; Cohasset; Milton; Quincy; and Weymouth
Plymouth County	Duxbury; Hingham; Hull; Kingston; Marion; Marshfield; Mattapoisett; Plymouth; Rochester; Scituate; and Wareham
Suffolk County	Boston; Chelsea; Revere; and Winthrop



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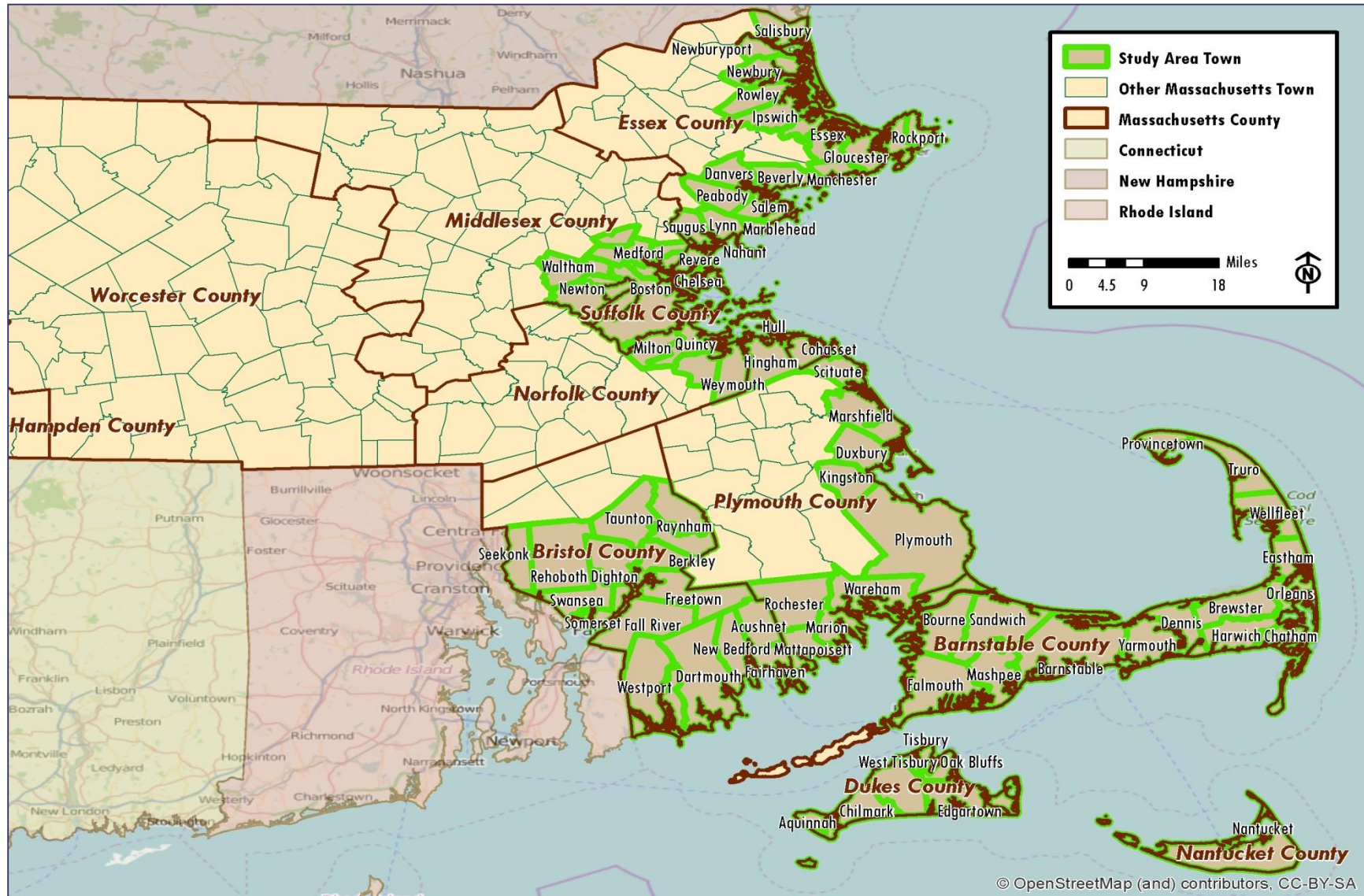


Figure 6-1: Massachusetts HES TDR Study Area



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6.2 Analysis Objectives

During a hurricane evacuation, a large number of vehicles will have to travel through the local and regional road network. The number of evacuating vehicles will vary depending upon the intensity of the hurricane, publicity and warnings given about the storm, and certain behavioral response characteristics of the vulnerable population. During a typical evacuation, vehicles enter the road network at different times depending on the evacuees' response relative to an evacuation order or storm advisory. Conversely, vehicles leave the roadway system depending on both the planned destinations of evacuees and the availability of acceptable destinations, such as public shelters, hotel/motel units, churches, and friend's or relative's homes in non-surge prone areas. Vehicles move across the road network from trip origin to destination at a speed dependent on the rate of traffic flowing on various roadway segments, and the number of vehicles per hour those segments can handle. Clearance times must be calculated and evacuation advisories issued so that evacuees can reach a relatively safe destination prior to the arrival of sustained tropical storm force winds.

The main objective of the transportation analysis performed for the Massachusetts HES TDR was to estimate evacuation clearance times; the time it takes to clear the roadway of all evacuating vehicles. To make these estimates, the evacuation road network had to be defined and general traffic control issues had to be examined. Clearance time is a value resulting from transportation engineering analysis performed under a specific set of assumptions. During an actual tropical cyclone event, it must be considered in conjunction with a pre-landfall hazards time to determine the optimal timeframe for issuing an evacuation order. The pre-landfall hazards time is the period before the forecast arrival of tropical storm force winds and/or the onset of roadway flooding prior to landfall of a hurricane.

The transportation analysis task initially identified traffic movements associated with a hurricane evacuation. Basic assumptions for the transportation analysis were related to storm scenarios, vulnerable population, behavioral and socioeconomic characteristics, as well as the roadway system and traffic control. A transportation model and the evacuation roadway system were developed for the Massachusetts study area to facilitate model application and development of clearance times. The major components involved in the transportation analysis were as follows:

1. Establish evacuation zones with the cooperation of Massachusetts's state and local emergency management agencies;
2. Quantify the potential evacuation population for each mapped evacuation zone using socioeconomic and behavioral data;



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3. Identify the existing evacuation roadway network, recognizing any recent or future infrastructure improvements, as well as state and local traffic control measures;
4. Using the evacuation road network develop:
 - Directional service volume per roadway segment;
 - Evacuation traffic congestion by roadway segment by storm scenario;
5. Identify local and regional bottlenecks/critical roadway segments;
6. Determine regional evacuation traffic that is expected to cross state and county lines and move inland;
7. Use evacuation zones and traffic management plans to complete transportation modeling and clearance time calculations;
8. Develop hurricane evacuation clearance times.

6.3 Transportation Analysis and Input Assumptions

Since all hurricanes differ from one another, it is necessary to establish clear assumptions about storm characteristics and evacuees' expected responses before transportation modeling can begin. Not only does a storm vary in its track, intensity, and size, but also in the way the populations in vulnerable areas perceive it. Even the time of day that a storm makes landfall influences the time parameters of an evacuation. All these factors can have a major impact on evacuation response timing and hence the clearance times ultimately developed by this analysis.

Given that a real tropical cyclone's characteristics may well differ from the simulated storms used to develop the clearance times provided in this analysis, a sensitivity analysis was performed during the transportation modeling. Since many of the factors that influence an evacuation can change dramatically prior to a storm making landfall, the sensitivity analysis determines which model variables will have the most impact on the transportation analysis results. Therefore, those characteristics (storm intensity, level of background traffic, tourist occupancy, traffic loading rate, etc.) having the greatest influence on clearance times were identified and then varied to establish the logical range within which the input values may fall. Key assumptions guiding the transportation analysis include the following:

- Traffic evacuation zones;
- Housing unit and population data;
- Behavioral assumptions of the evacuating population; and
- Roadway network and traffic control assumptions.



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6.4 Traffic Analysis Zones

The foundational geographical unit of this transportation analysis is a system of hurricane evacuation zones established by USACE, FEMA, state and local emergency management officials for every surge vulnerable community in the state. The hurricane evacuation zones used in this study are based on vulnerability data provided by the USACE, New England District in the form of the storm tide limits delineated in the storm surge maps. The storm surge maps were developed from the results of the National Oceanic and Atmospheric Administration's (NOAA) Sea, Lake and Overland Surges from Hurricanes (SLOSH) model for the Providence/Boston 2 Basin.

The primary purpose of the hurricane evacuation zones is to specify which locales and populations will be directed to evacuate by local emergency management in response to Category 1 through 4 storms. Where possible, the evacuation zone boundaries depicted in Chapter 3 of this study are tied to identifiable landmarks, such as roads, and other features like community boundaries. These evacuation zones can also be combined to encompass more than one level of storm intensity.

The majority of towns in the Massachusetts portion of the study employ a basic two-zone system for evacuations. In these towns, Zone A corresponds to all Category 1 and Category 2 storms, while Zone B corresponds to all Category 3 and 4 storms. As noted in Chapter 3, due to geography and population density, Boston and Cambridge each have an additional Zone C to better match their operational needs.

Storm inundation severity is determined by a number of factors including the direction of a storm track as well as the geography of the area of impact. Storms that are projected to make a direct, close to perpendicular landfall are anticipated to have a greater impacts than those that are projected to make a glancing blow or skirt the coast altogether. Planners from both Boston and Cambridge looked at the track of hypothetical storms from WNW through NE, with WNW being the most potentially severe and NE having the least potential severity, to inform which storm categories would make up their mapped evacuation zones.

For Boston, the mapped evacuation Zone A corresponds with a "next to worst case" Category 1 storm, the mapped evacuation Zone B corresponds with a "worst case" Category 1 storm up to "next to worst case" Category 2 storm, and the mapped evacuation Zone C corresponds with a "worst case" Category 2, Category 3 and Category 4 storms. For Cambridge, the mapped evacuation Zone A corresponds with Category 1 storm and a "next to worst case" Category 2 storm, the mapped evacuation Zone B corresponds with a "worst case" Category 2, a "next to



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worst case” Category 3, and “next to worst case” Category 4 storms, and the mapped evacuation Zone C corresponds with “worst case” Category 3 and Category 4 storms.

The zone designation equivalents between both Boston and Cambridge and the other study area communities is presented below.

Boston:	All Other Communities
Evac Zone A: NWC Cat 1	Evac Zone A: Cat 1 & 2
Evac Zone B: WC Cat 1, NWC Cat 2	Evac Zone A: Cat 1 & 2
Evac Zone C: WC Cat 2, All Cat 3 & 4	Evac Zone B: Cat 3 & 4
Cambridge:	All Other Communities
Evac Zone A: NWC Cat 2	Evac Zone A: Cat 1 & 2
Evac Zone B: WC Cat 2, NWC Cat 3 & 4	Evac Zone B: Cat 3 & 4
Evac Zone C: WC Cat 3 & 4	Evac Zone B: Cat 3 & 4

Note: Next to Worst Case (NWC) means all storms except those moving in a west-northwest or northwest direction, Worst Case (WC) means all storms

These evacuation zones are the basis for the traffic analysis zones used in the transportation study described in this chapter. Therefore, the traffic analysis zones in this chapter exactly mimic the hurricane evacuation zones depicted in Chapter 3 of the TDR.

The emergency management community, including the communities in Massachusetts participating in this study, typically use the term “scenario” to refer to an area of evacuation. The terms “scenario” and “zone” are also often used interchangeably. Because the hypothetical storms that are used to establish evacuation zones are different for both Boston and Cambridge compared to the other communities, this report has attempted to avoid the use of the term “scenario” and when used, it is done so in a purely generic sense except in Chapter 7 when it refers to a specific HURREVAC functionality.

Areas of evacuation presented on maps are referred to as zones. Tables are labeled to match the presented data with a specific levels of storm intensity. Because the zones for Boston and Cambridge do not correspond with the same set of storms as one another or the other study area communities, their data is presented separately at the end of each affected table.

It is important to note that state and local officials are responsible for ensuring that the hurricane evacuation zones encompass all surge, and where applicable wind vulnerable residents and that evacuation advisories during a hurricane threat will adequately direct those living in evacuation zones to take action. Maps of the traffic evacuation zones for each



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individual jurisdiction are provided in Figures 6-2 through 6-80 as listed below, and are also available in the File Bank section as interactive maps:

- Figure 6-2: Traffic Analysis Zones – Barnstable County / Barnstable
- Figure 6-3: Traffic Analysis Zones – Barnstable County / Bourne
- Figure 6-4: Traffic Analysis Zones – Barnstable County / Brewster
- Figure 6-5: Traffic Analysis Zones – Barnstable County / Chatham
- Figure 6-6: Traffic Analysis Zones – Barnstable County / Dennis
- Figure 6-7: Traffic Analysis Zones – Barnstable County / Eastham
- Figure 6-8: Traffic Analysis Zones – Barnstable County / Falmouth
- Figure 6-9: Traffic Analysis Zones – Barnstable County / Harwich
- Figure 6-10: Traffic Analysis Zones – Barnstable County / Mashpee
- Figure 6-11: Traffic Analysis Zones – Barnstable County / Orleans
- Figure 6-12: Traffic Analysis Zones – Barnstable County / Provincetown
- Figure 6-13: Traffic Analysis Zones – Barnstable County / Sandwich
- Figure 6-14: Traffic Analysis Zones – Barnstable County / Truro
- Figure 6-15: Traffic Analysis Zones – Barnstable County / Wellfleet
- Figure 6-16: Traffic Analysis Zones – Barnstable County / Yarmouth
- Figure 6-17: Traffic Analysis Zones – Bristol County / Acushnet
- Figure 6-18: Traffic Analysis Zones – Bristol County / Berkley
- Figure 6-19: Traffic Analysis Zones – Bristol County / Dartmouth
- Figure 6-20: Traffic Analysis Zones – Bristol County / Dighton
- Figure 6-21: Traffic Analysis Zones – Bristol County / Fairhaven
- Figure 6-22: Traffic Analysis Zones – Bristol County / Fall River
- Figure 6-23: Traffic Analysis Zones – Bristol County / Freetown
- Figure 6-24: Traffic Analysis Zones – Bristol County / New Bedford
- Figure 6-25: Traffic Analysis Zones – Bristol County / Raynham and Taunton
- Figure 6-26: Traffic Analysis Zones – Bristol County / Rehoboth and Skeeconk
- Figure 6-27: Traffic Analysis Zones – Bristol County / Somerset
- Figure 6-28: Traffic Analysis Zones – Bristol County / Swansea
- Figure 6-29: Traffic Analysis Zones – Bristol County / Westport
- Figure 6-30: Traffic Analysis Zones – Dukes County / Aquinnah
- Figure 6-31: Traffic Analysis Zones – Dukes County / Chilmark
- Figure 6-32: Traffic Analysis Zones – Dukes County / Edgartown
- Figure 6-33: Traffic Analysis Zones – Dukes County / Oak Bluffs
- Figure 6-34: Traffic Analysis Zones – Dukes County / Tisbury



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- Figure 6-35: Traffic Analysis Zones – Dukes County / West Tisbury
- Figure 6-36: Traffic Analysis Zones – Essex County / Beverly
- Figure 6-37: Traffic Analysis Zones – Essex County / Danvers
- Figure 6-38: Traffic Analysis Zones – Essex County / Essex
- Figure 6-39: Traffic Analysis Zones – Essex County / Gloucester
- Figure 6-40: Traffic Analysis Zones – Essex County / Ipswich
- Figure 6-41: Traffic Analysis Zones – Essex County / Lynn
- Figure 6-42: Traffic Analysis Zones – Essex County / Manchester
- Figure 6-43: Traffic Analysis Zones – Essex County / Marblehead
- Figure 6-44: Traffic Analysis Zones – Essex County / Nahant
- Figure 6-45: Traffic Analysis Zones – Essex County / Newbury
- Figure 6-46: Traffic Analysis Zones – Essex County / Newburyport
- Figure 6-47: Traffic Analysis Zones – Essex County / Rockport
- Figure 6-48: Traffic Analysis Zones – Essex County / Rowley
- Figure 6-49: Traffic Analysis Zones – Essex County / Salem
- Figure 6-50: Traffic Analysis Zones – Essex County / Salisbury
- Figure 6-51: Traffic Analysis Zones – Essex County / Saugus
- Figure 6-52: Traffic Analysis Zones – Essex County / Swampscott
- Figure 6-53: Traffic Analysis Zones – Middlesex County / Arlington
- Figure 6-54: Traffic Analysis Zones – Middlesex County / Cambridge
- Figure 6-55: Traffic Analysis Zones – Middlesex County / Everett
- Figure 6-56: Traffic Analysis Zones – Middlesex County / Malden
- Figure 6-57: Traffic Analysis Zones – Middlesex County / Medford
- Figure 6-58: Traffic Analysis Zones – Middlesex County / Somerville
- Figure 6-59: Traffic Analysis Zones – Middlesex County / Watertown
- Figure 6-60: Traffic Analysis Zones – Nantucket County / Nantucket
- Figure 6-61: Traffic Analysis Zones – Norfolk County / Braintree
- Figure 6-62: Traffic Analysis Zones – Norfolk County / Brookline
- Figure 6-63: Traffic Analysis Zones – Norfolk County / Cohasset
- Figure 6-64: Traffic Analysis Zones – Norfolk County / Quincy
- Figure 6-65: Traffic Analysis Zones – Norfolk County / Weymouth
- Figure 6-66: Traffic Analysis Zones – Plymouth County / Duxbury
- Figure 6-67: Traffic Analysis Zones – Plymouth County / Hingham
- Figure 6-68: Traffic Analysis Zones – Plymouth County / Hull
- Figure 6-69: Traffic Analysis Zones – Plymouth County / Kingston



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- Figure 6-70: Traffic Analysis Zones – Plymouth County / Marion
- Figure 6-71: Traffic Analysis Zones – Plymouth County / Marshfield
- Figure 6-72: Traffic Analysis Zones – Plymouth County / Mattapoisett
- Figure 6-73: Traffic Analysis Zones – Plymouth County / Plymouth
- Figure 6-74: Traffic Analysis Zones – Plymouth County / Scituate
- Figure 6-75: Traffic Analysis Zones – Plymouth County / Wareham
- Figure 6-76: Traffic Analysis Zones – Suffolk County / Boston
- Figure 6-77: Traffic Analysis Zones – Suffolk County / Boston
- Figure 6-78: Traffic Analysis Zones – Suffolk County / Chelsea
- Figure 6-79: Traffic Analysis Zones – Suffolk County / Revere
- Figure 6-80: Traffic Analysis Zones – Suffolk County / Winthrop



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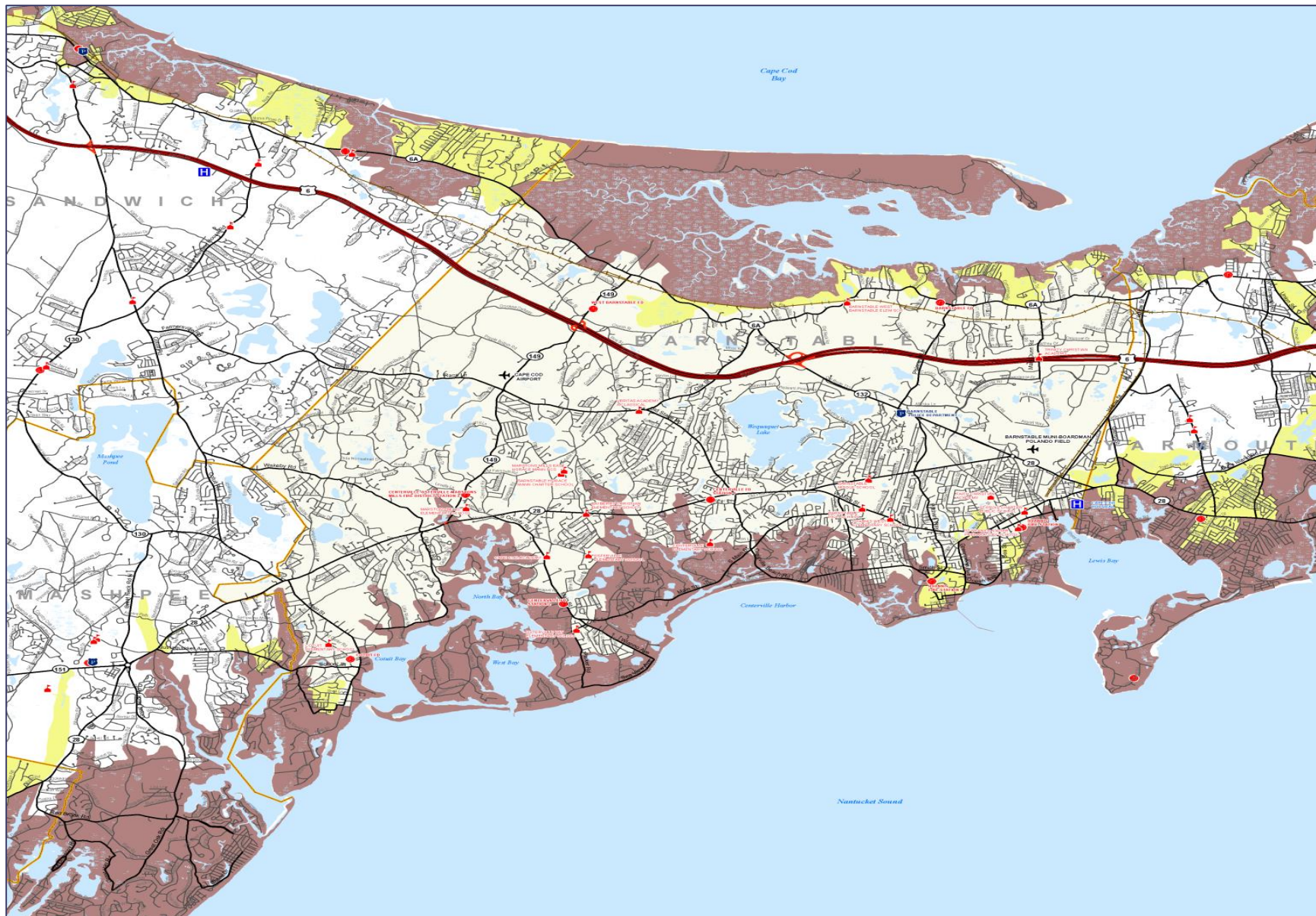


Figure 6-2: Traffic Analysis Zones – Barnstable County / Barnstable



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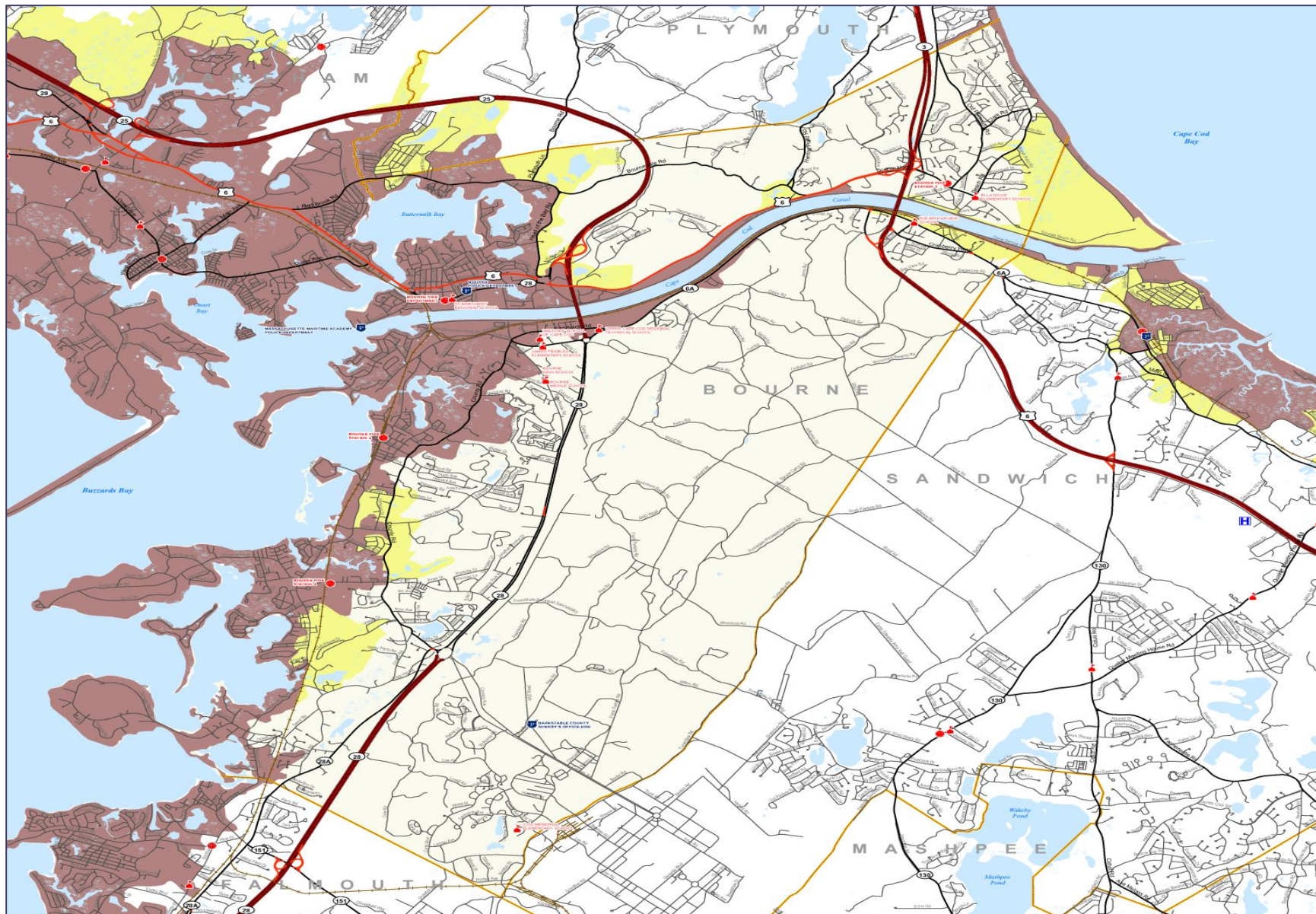


Figure 6-3: Traffic Analysis Zones – Barnstable County / Bourne

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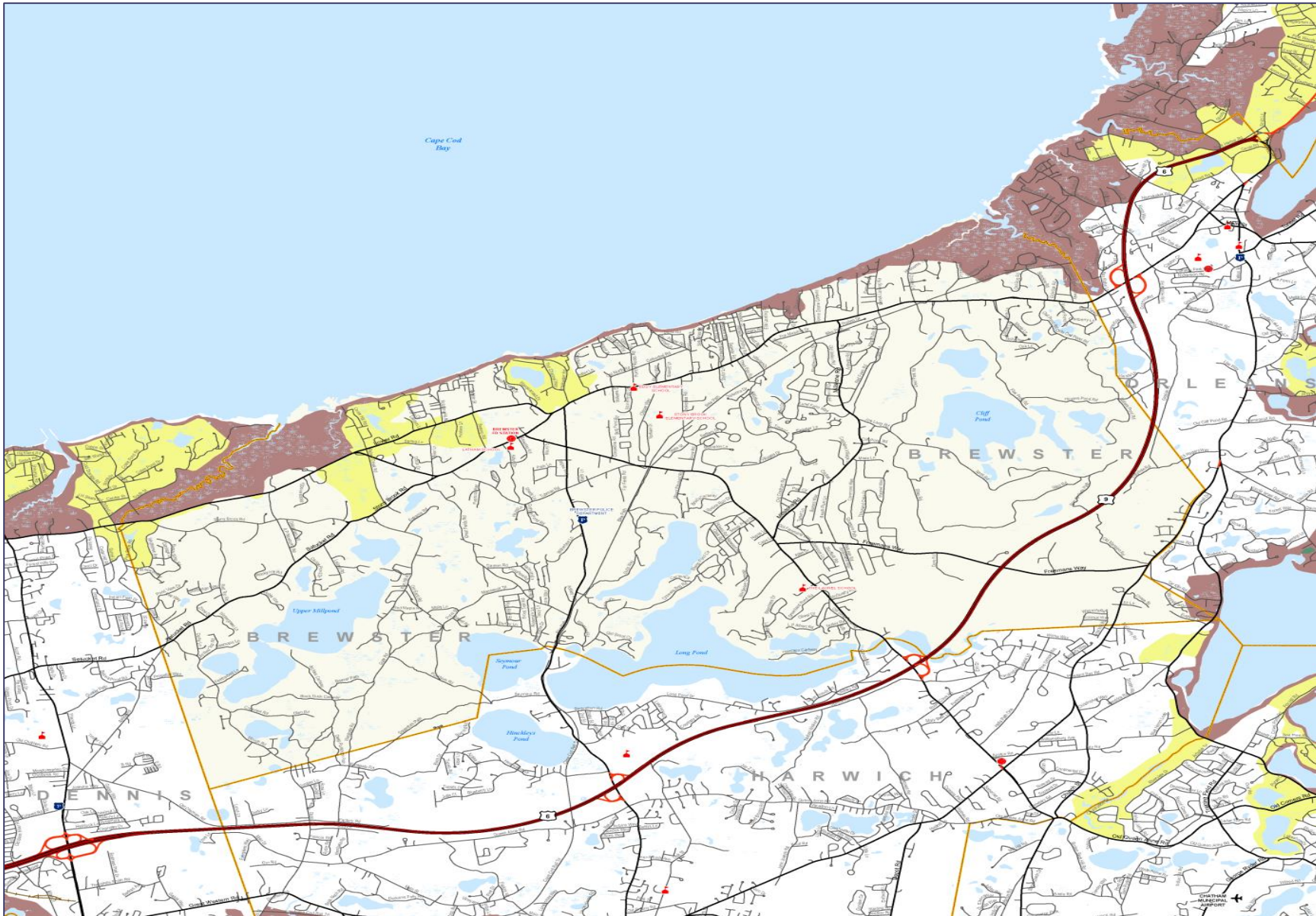


Figure 6-4: Traffic Analysis Zones – Barnstable County / Brewster



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Figure 6-5: Traffic Analysis Zones – Barnstable County / Chatham

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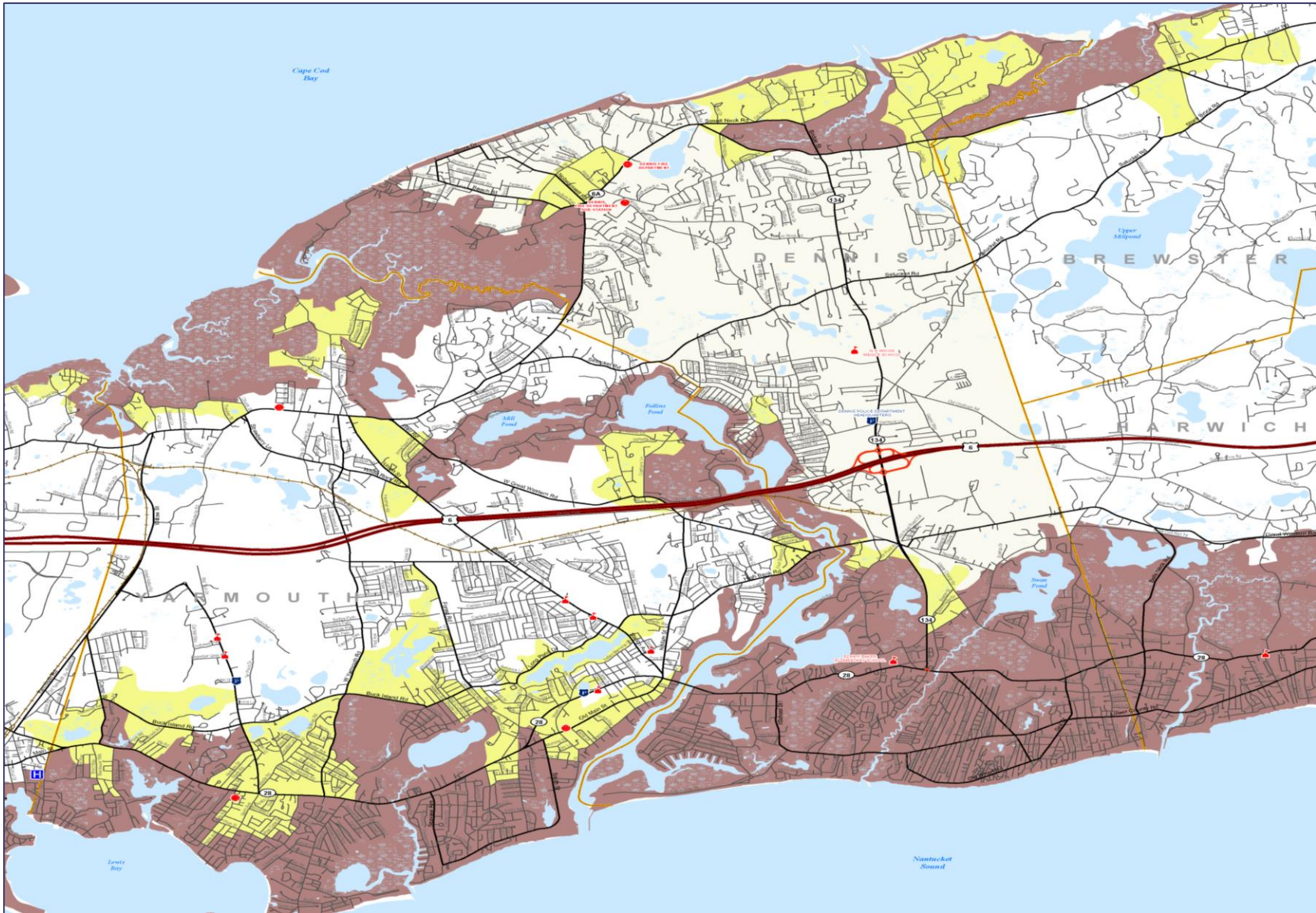


Figure 6-6: Traffic Analysis Zones – Barnstable County / Dennis



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Figure 6-7: Traffic Analysis Zones – Barnstable County / Eastham

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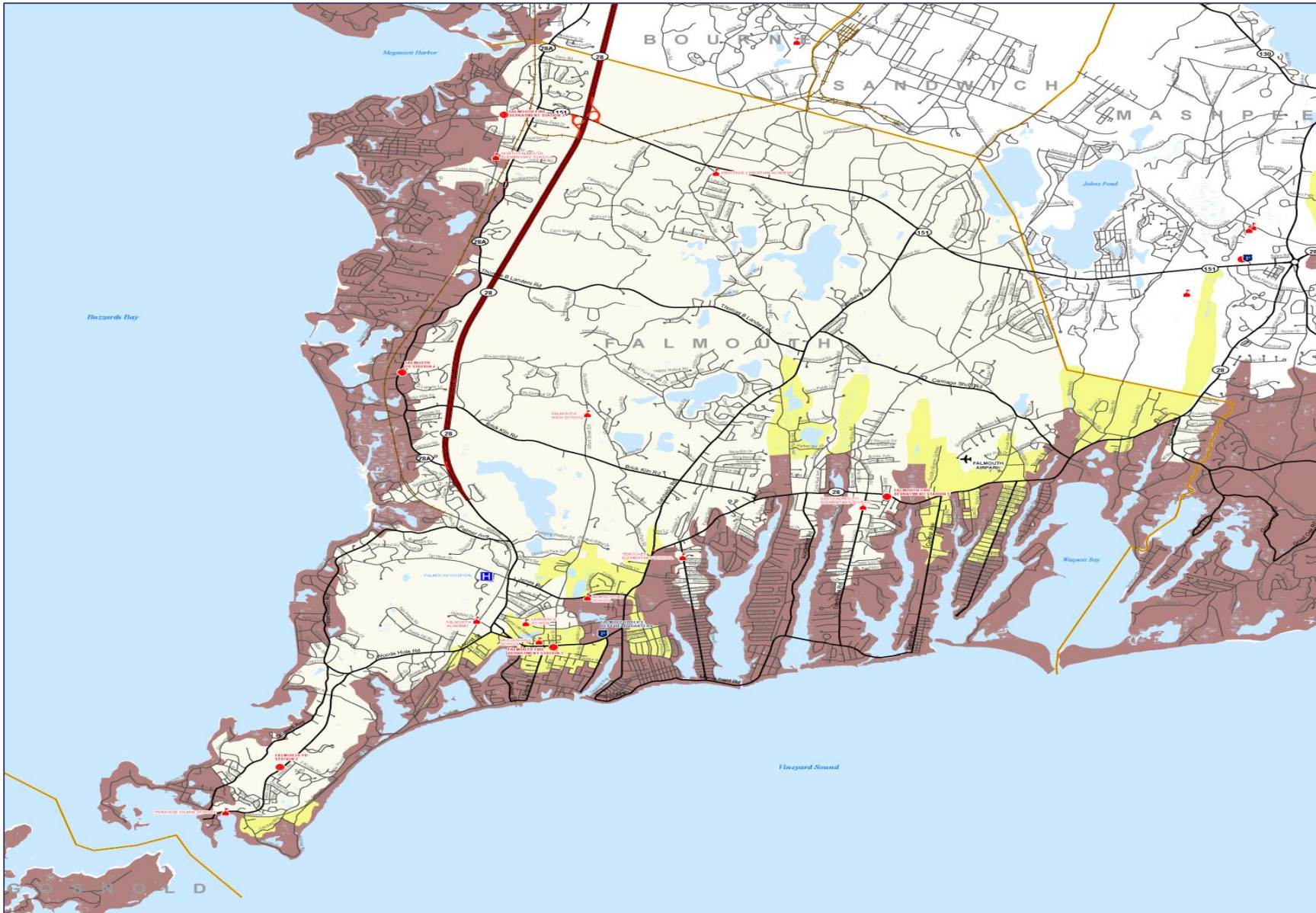


Figure 6-8: Traffic Analysis Zones – Barnstable County / Falmouth



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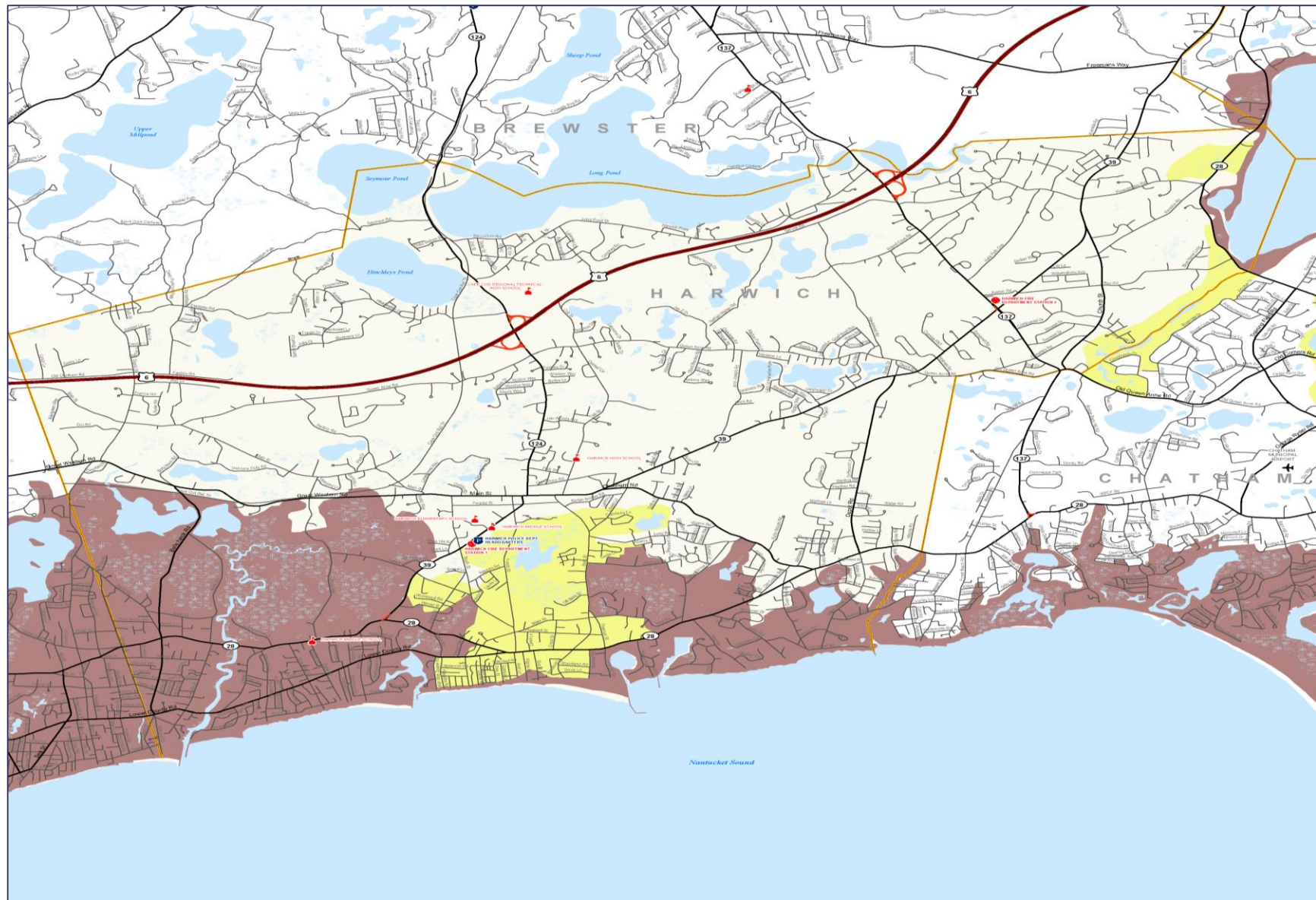


Figure 6-9: Traffic Analysis Zones – Barnstable County / Harwich

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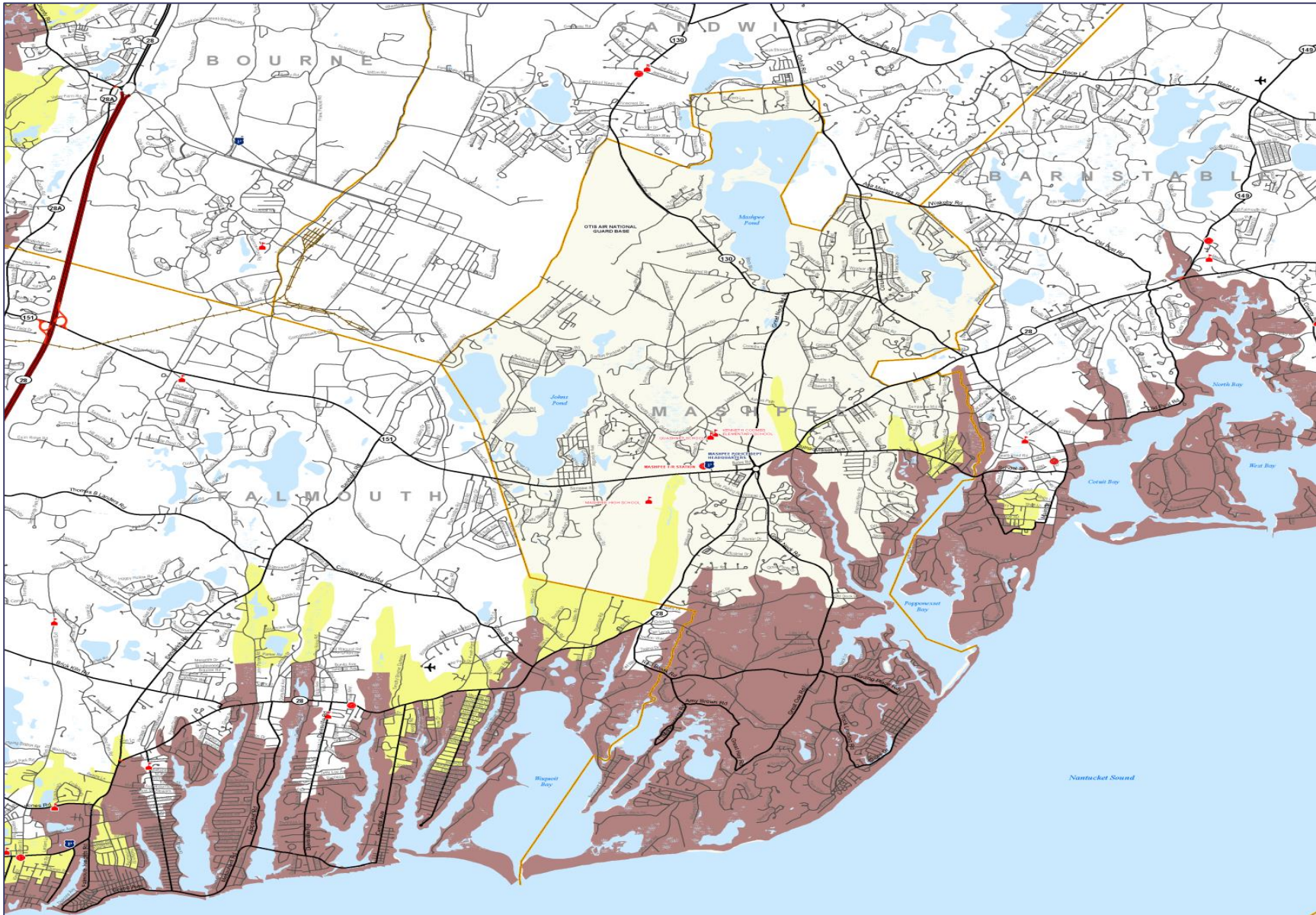


Figure 6-10: Traffic Analysis Zones – Barnstable County / Mashpee



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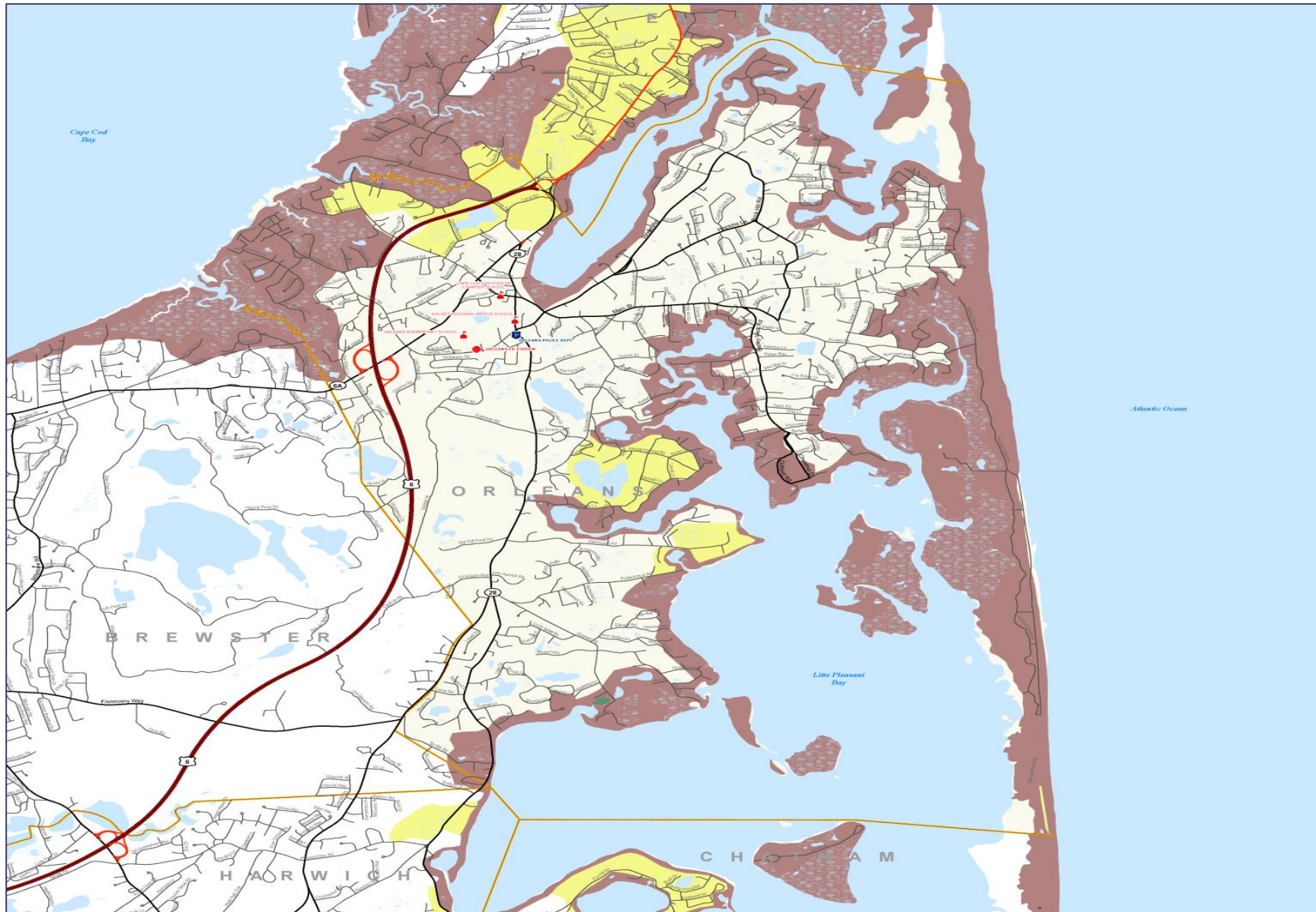


Figure 6-11: Traffic Analysis Zones – Barnstable County / Orleans



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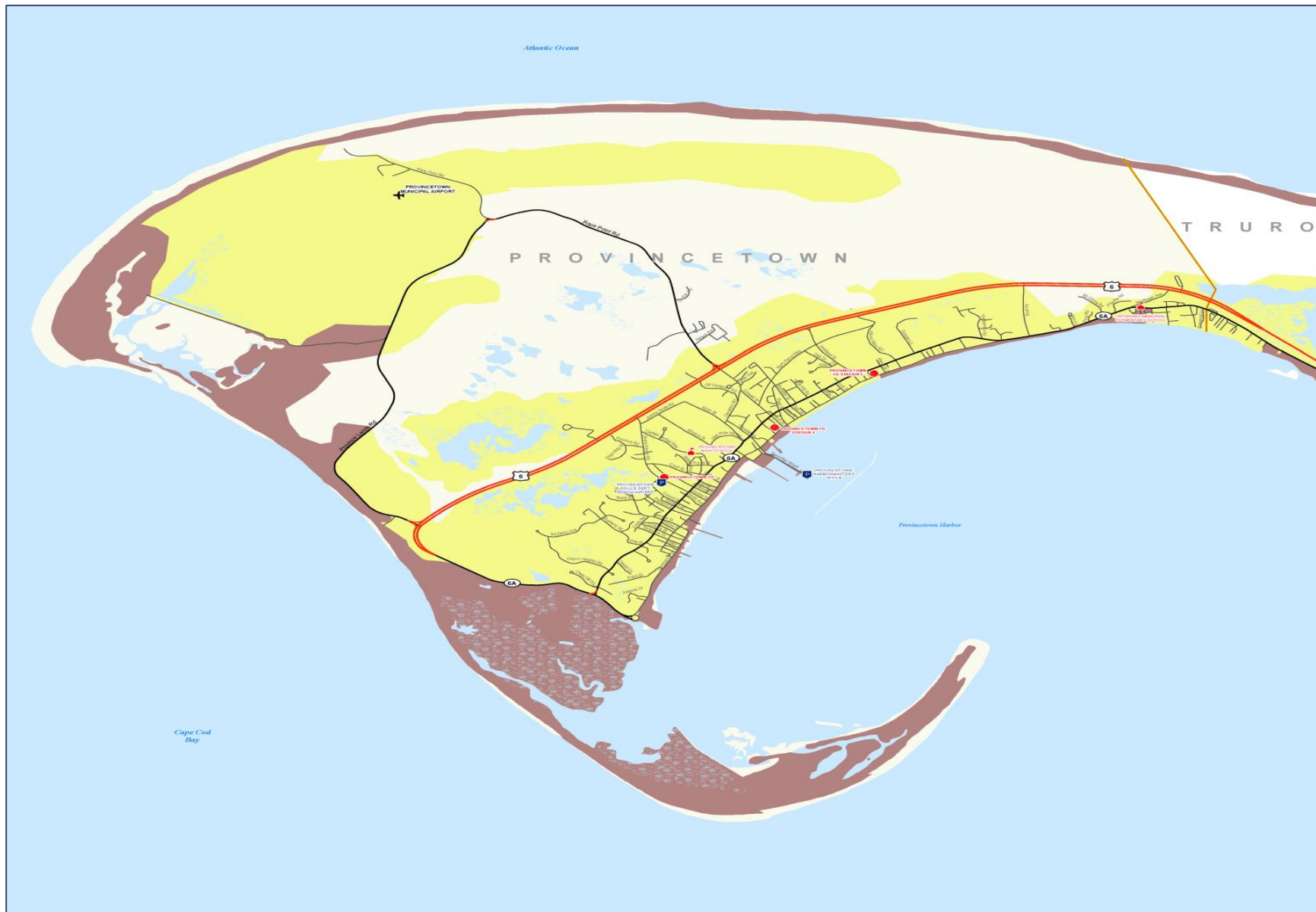


Figure 6-12: Traffic Analysis Zones – Barnstable County / Provincetown



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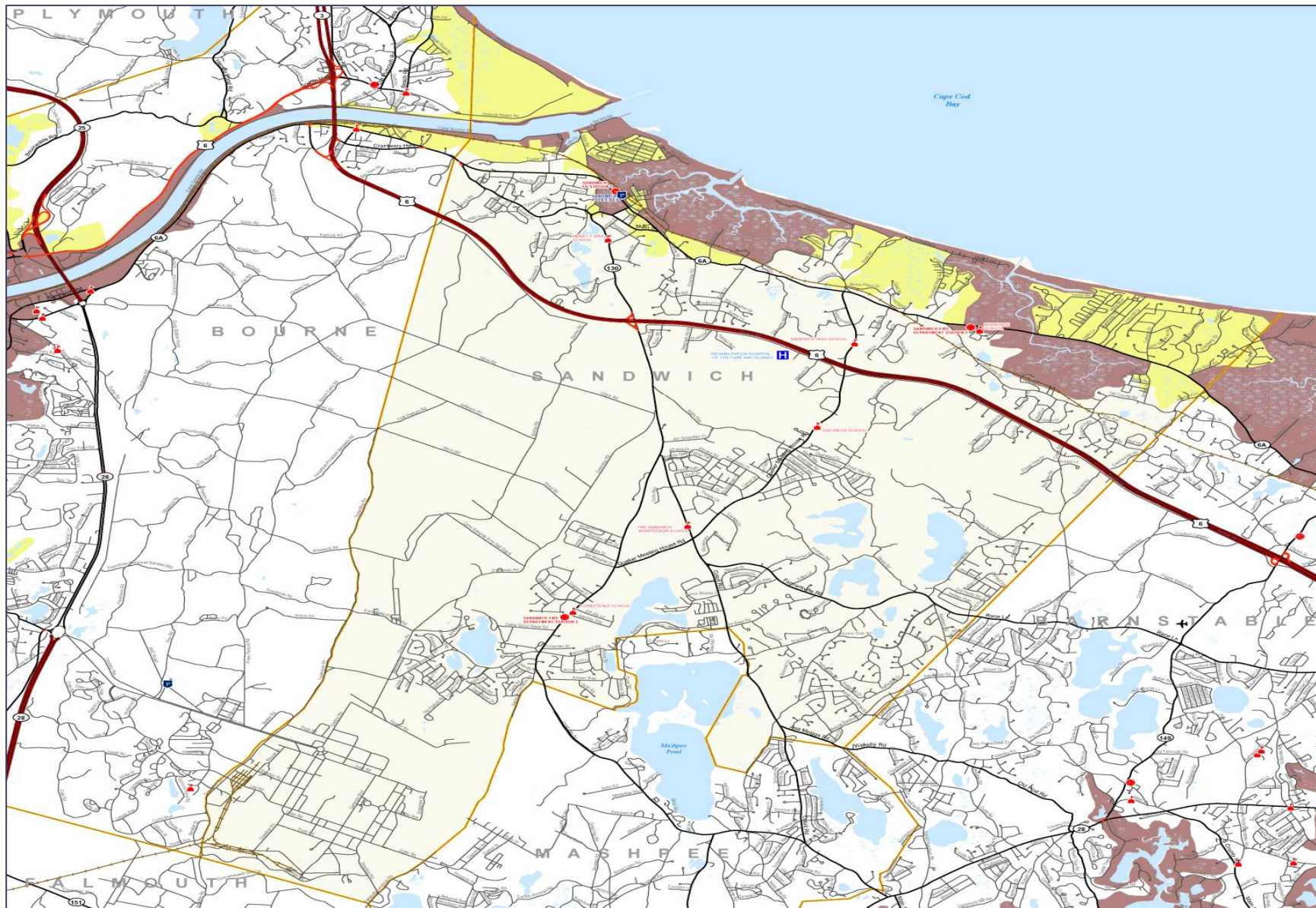


Figure 6-13: Traffic Analysis Zones – Barnstable County / Sandwich



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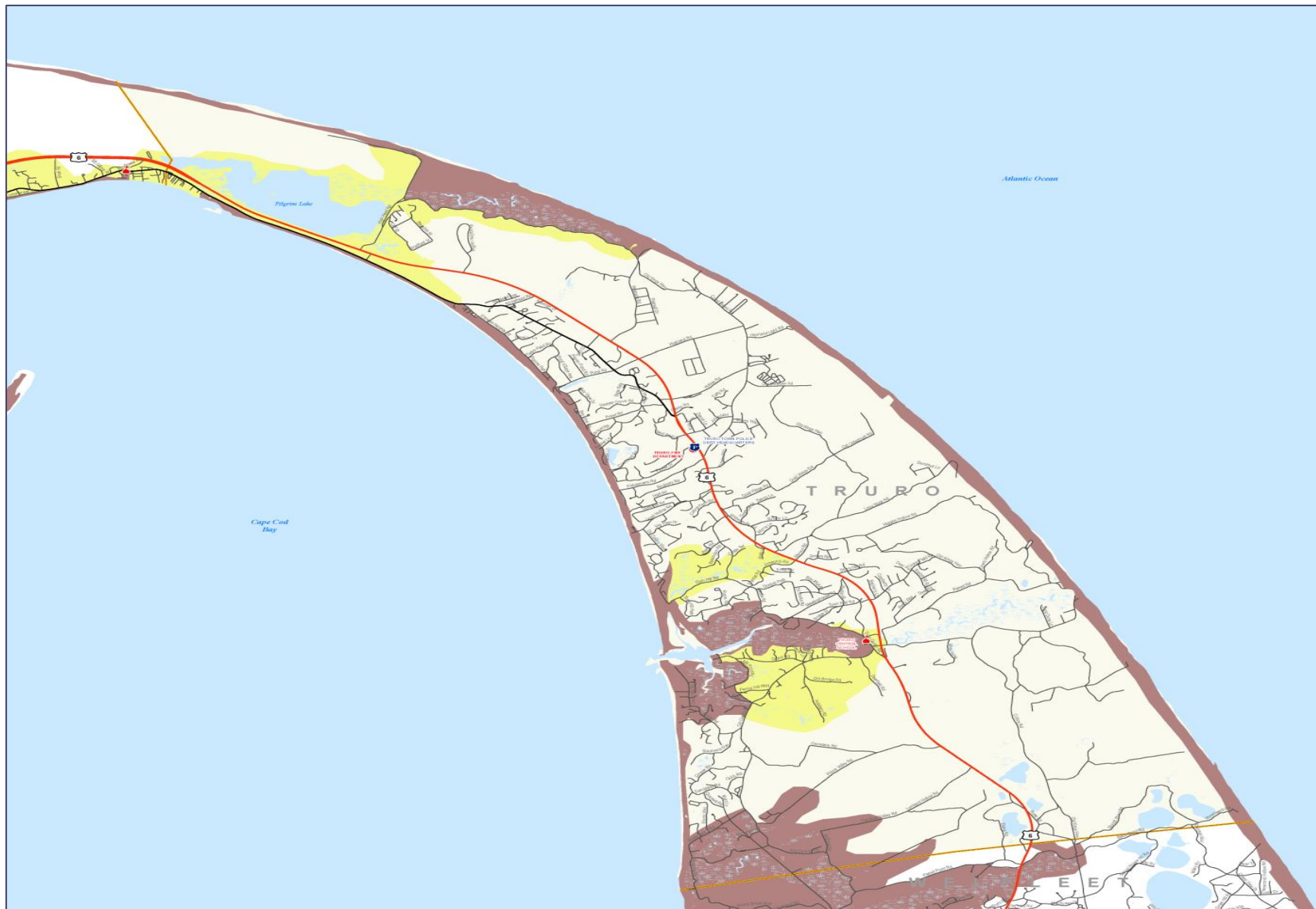


Figure 6-14: Traffic Analysis Zones – Barnstable County / Truro



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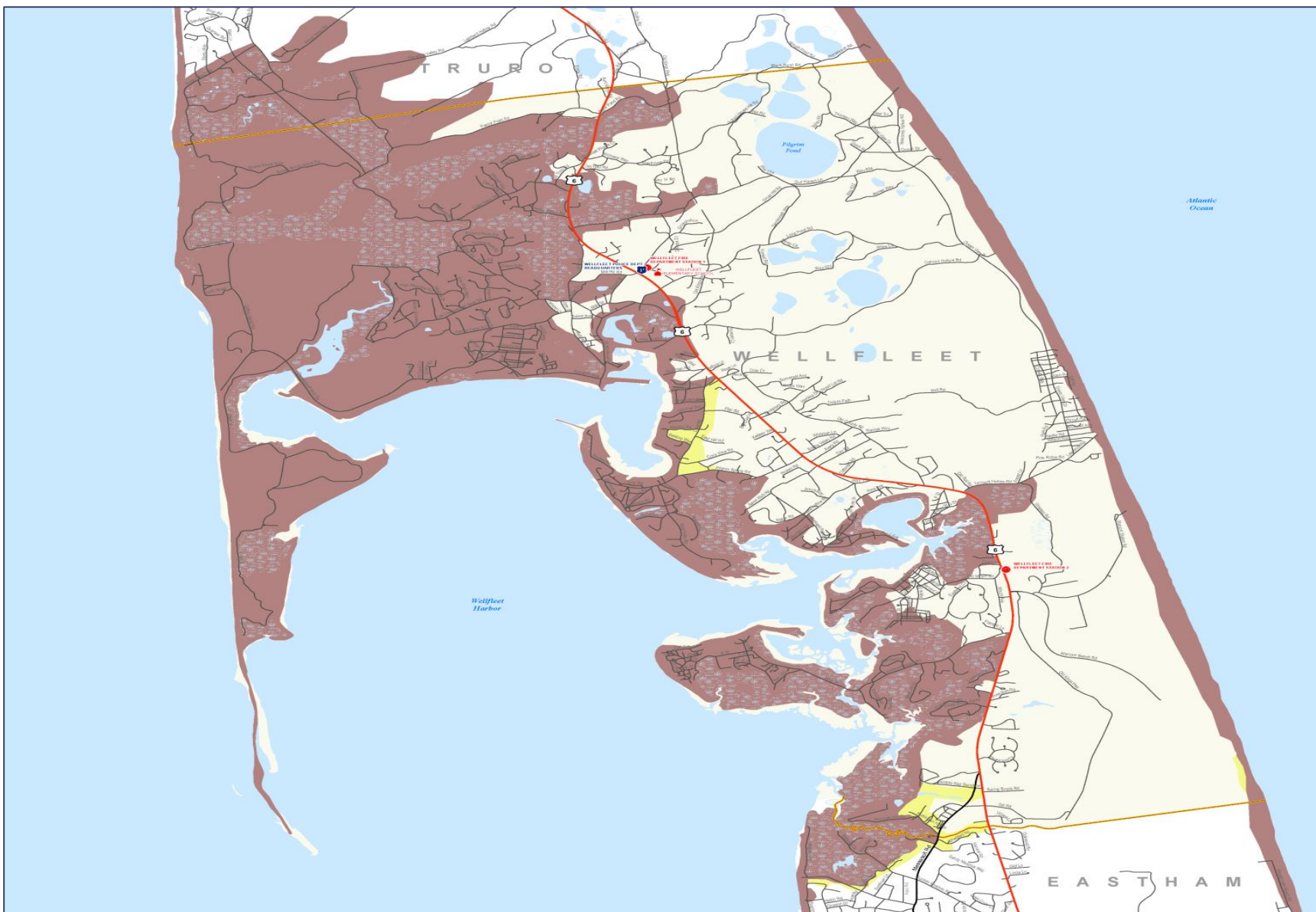


Figure 6-15: Traffic Analysis Zones – Barnstable County / Wellfleet

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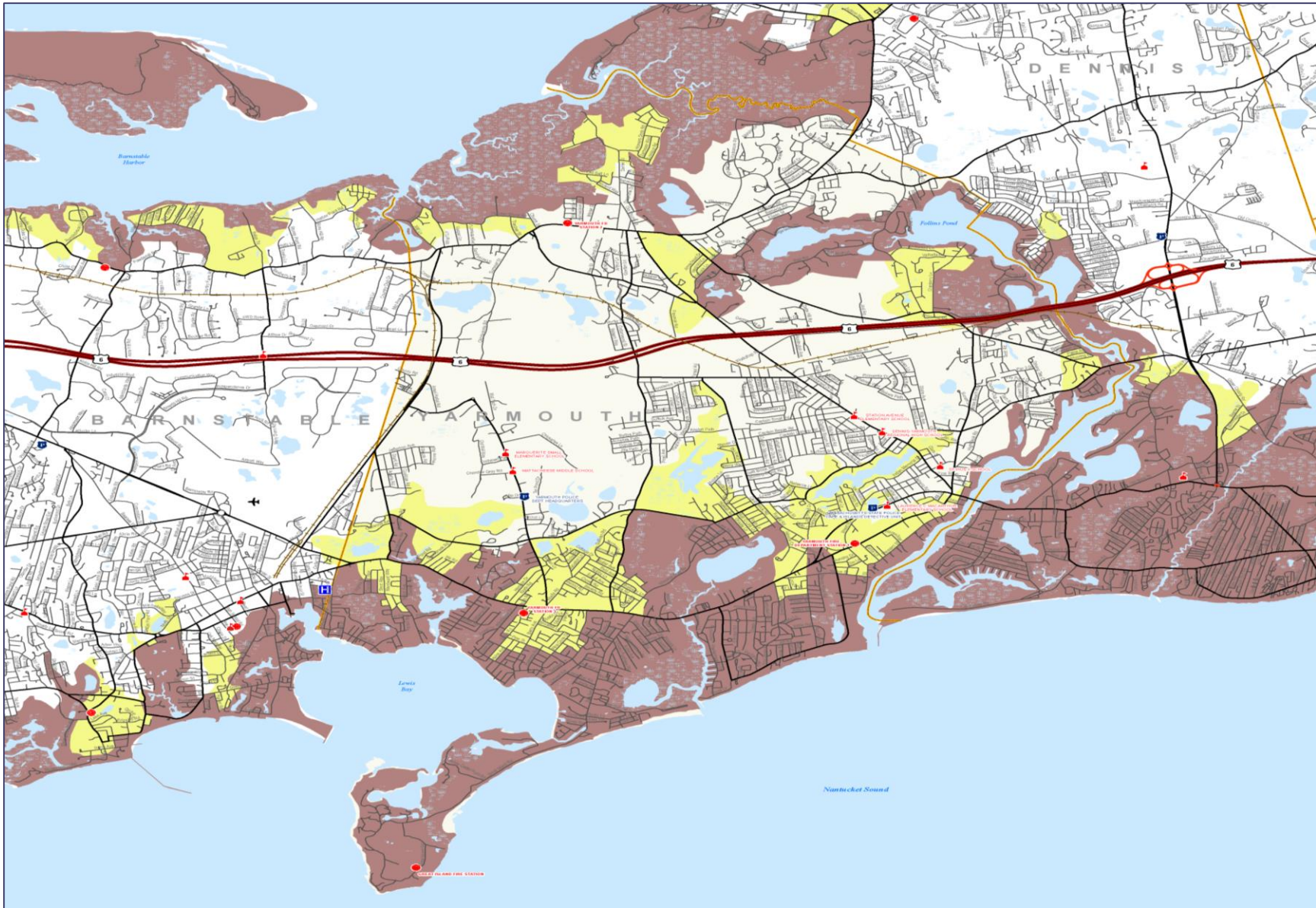


Figure 6-16: Traffic Analysis Zones – Barnstable County / Yarmouth



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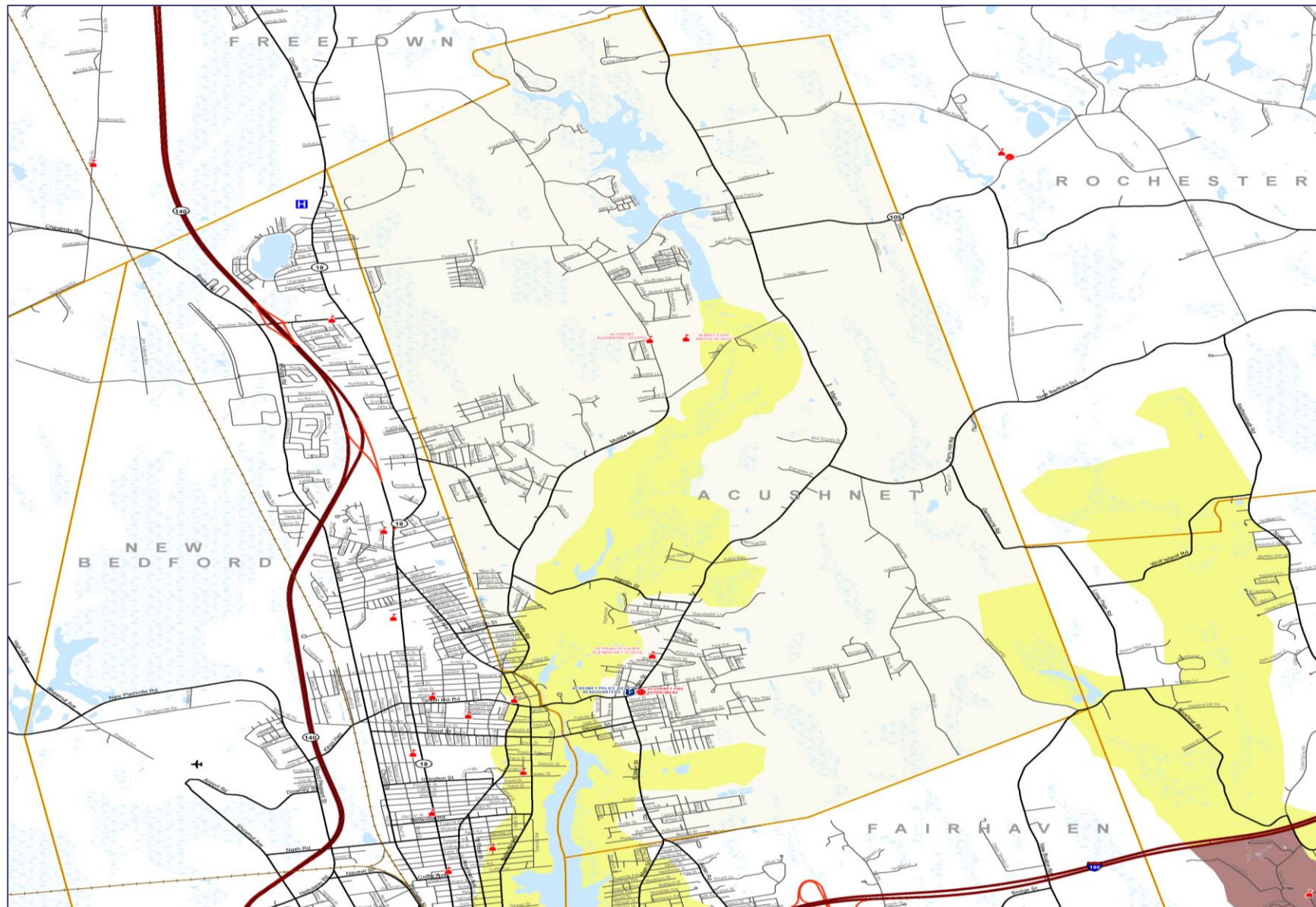


Figure 6-17: Traffic Analysis Zones – Bristol County / Acushnet



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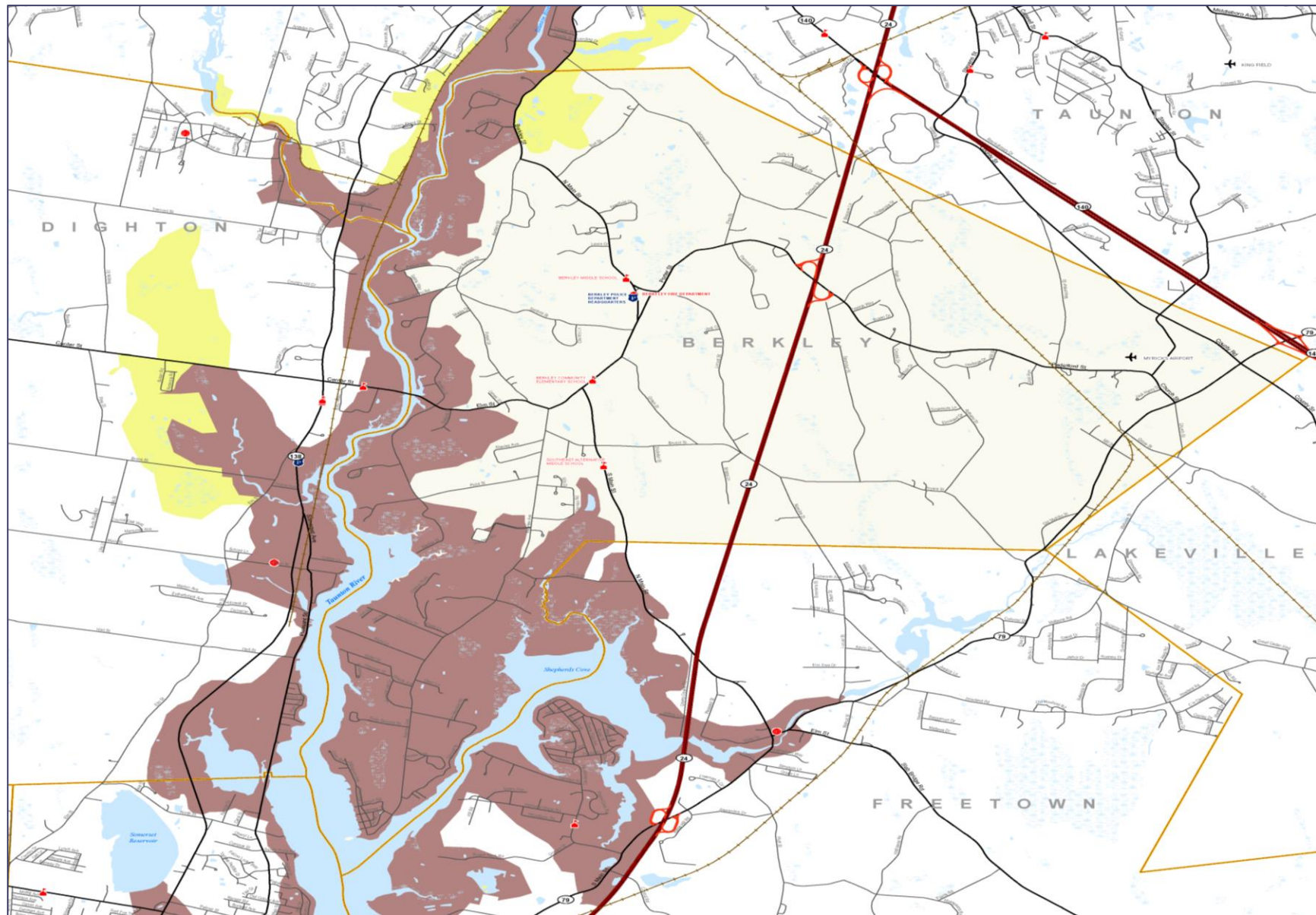


Figure 6-18: Traffic Analysis Zones – Bristol County / Berkley



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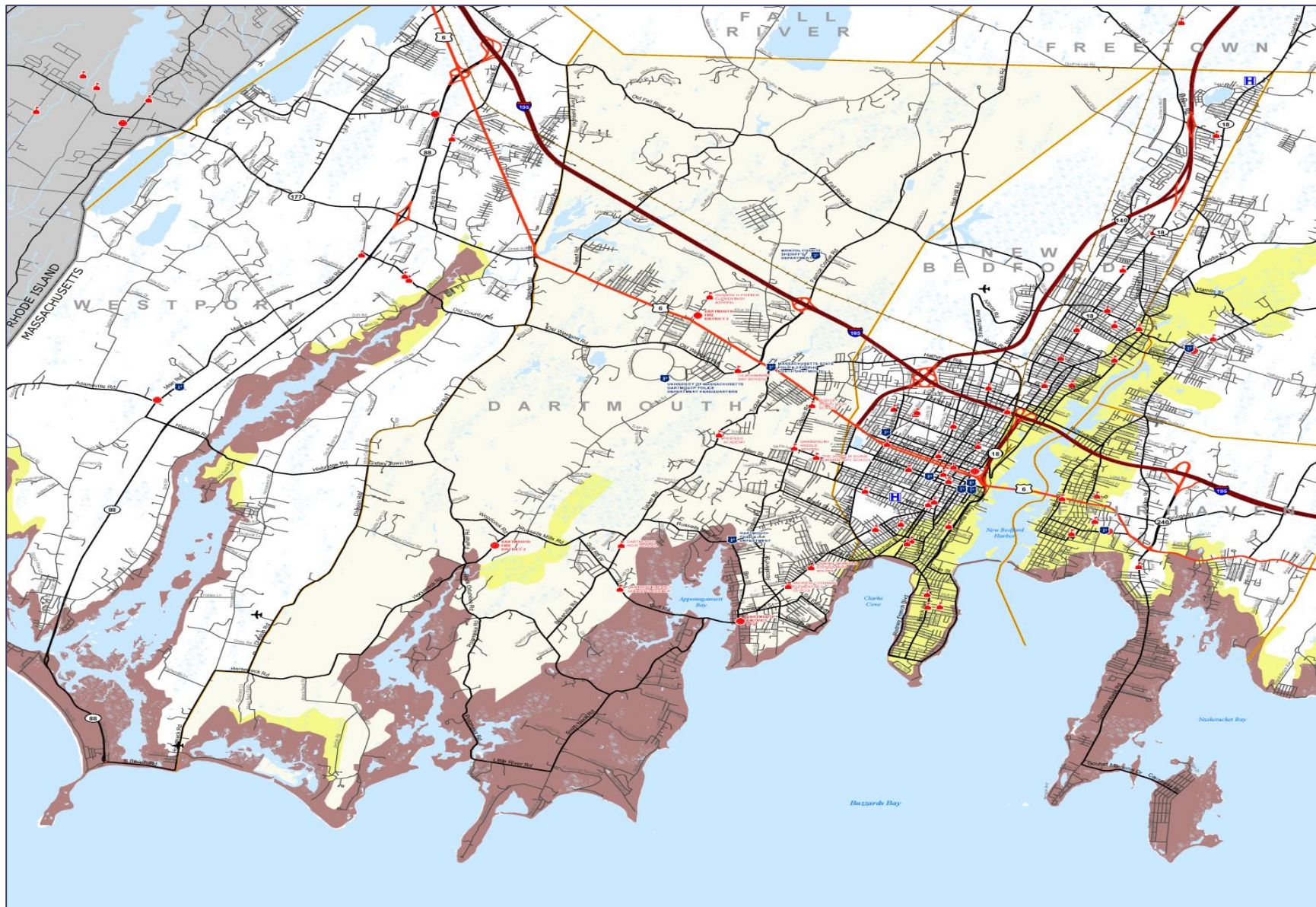


Figure 6-19: Traffic Analysis Zones – Bristol County / Dartmouth



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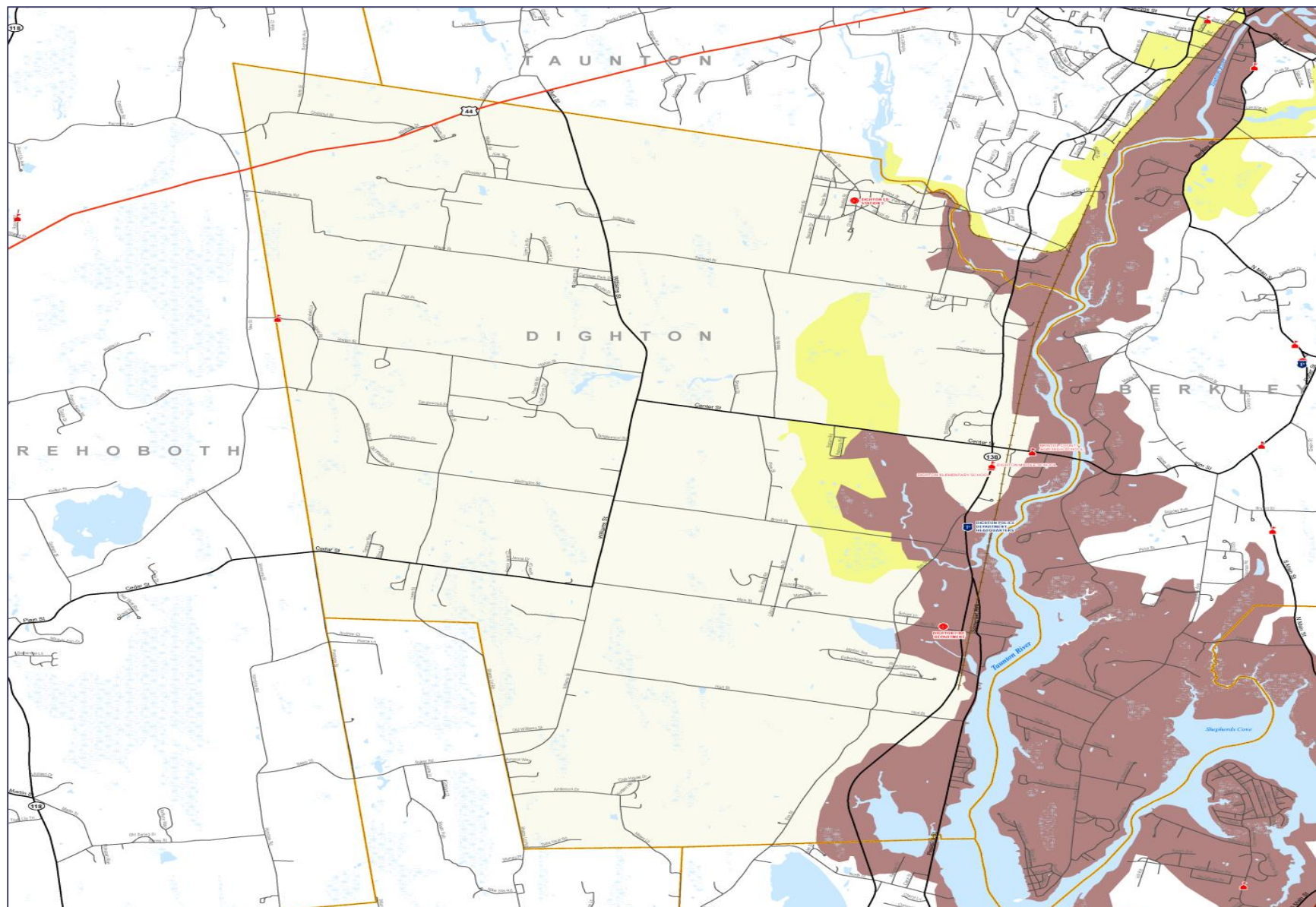


Figure 6-20: Traffic Analysis Zones – Bristol County / Dighton



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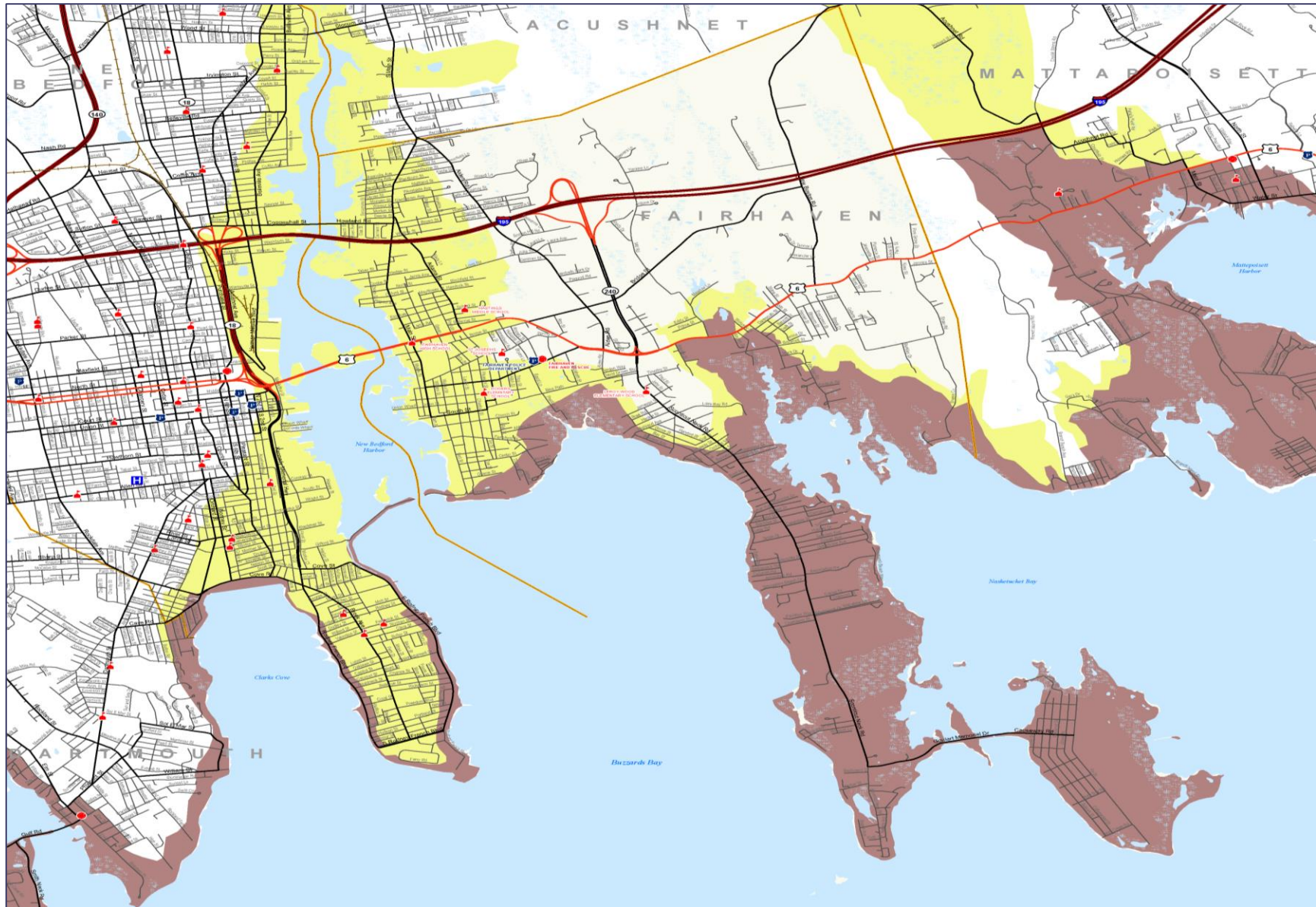


Figure 6-21: Traffic Analysis Zones – Bristol County / Fairhaven



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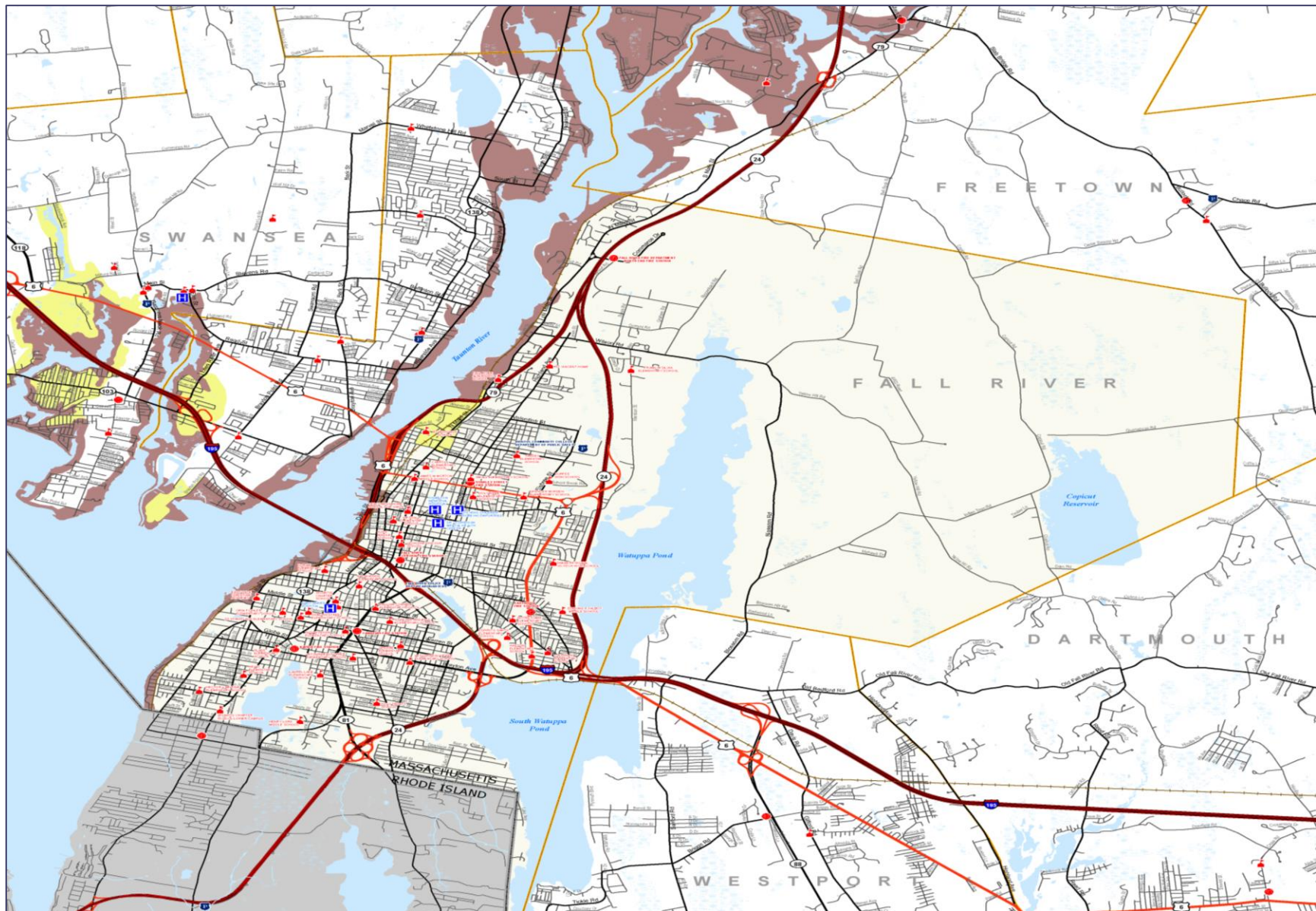


Figure 6-22: Traffic Analysis Zones – Bristol County / Fall River



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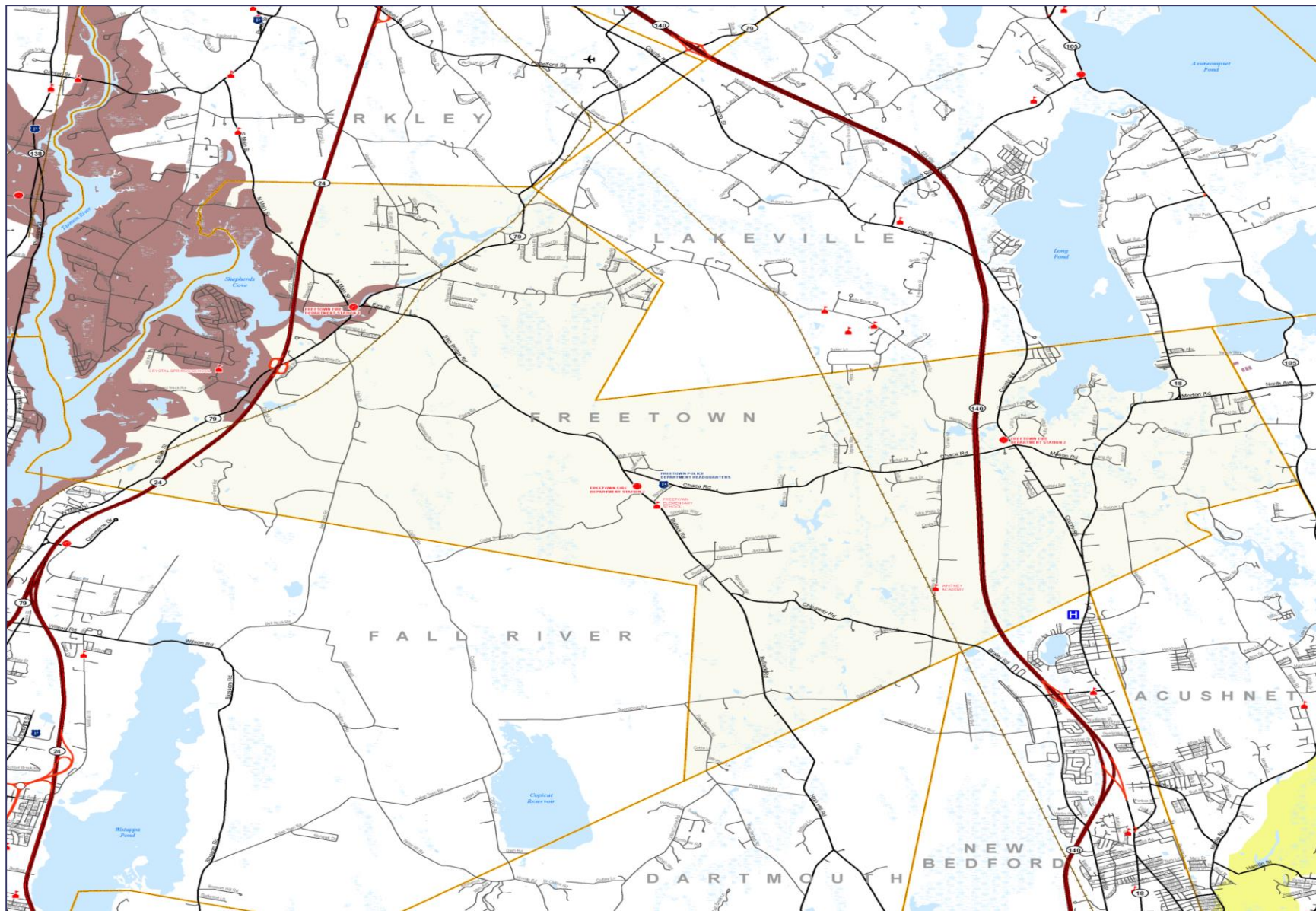


Figure 6-23: Traffic Analysis Zones – Bristol County / Freetown



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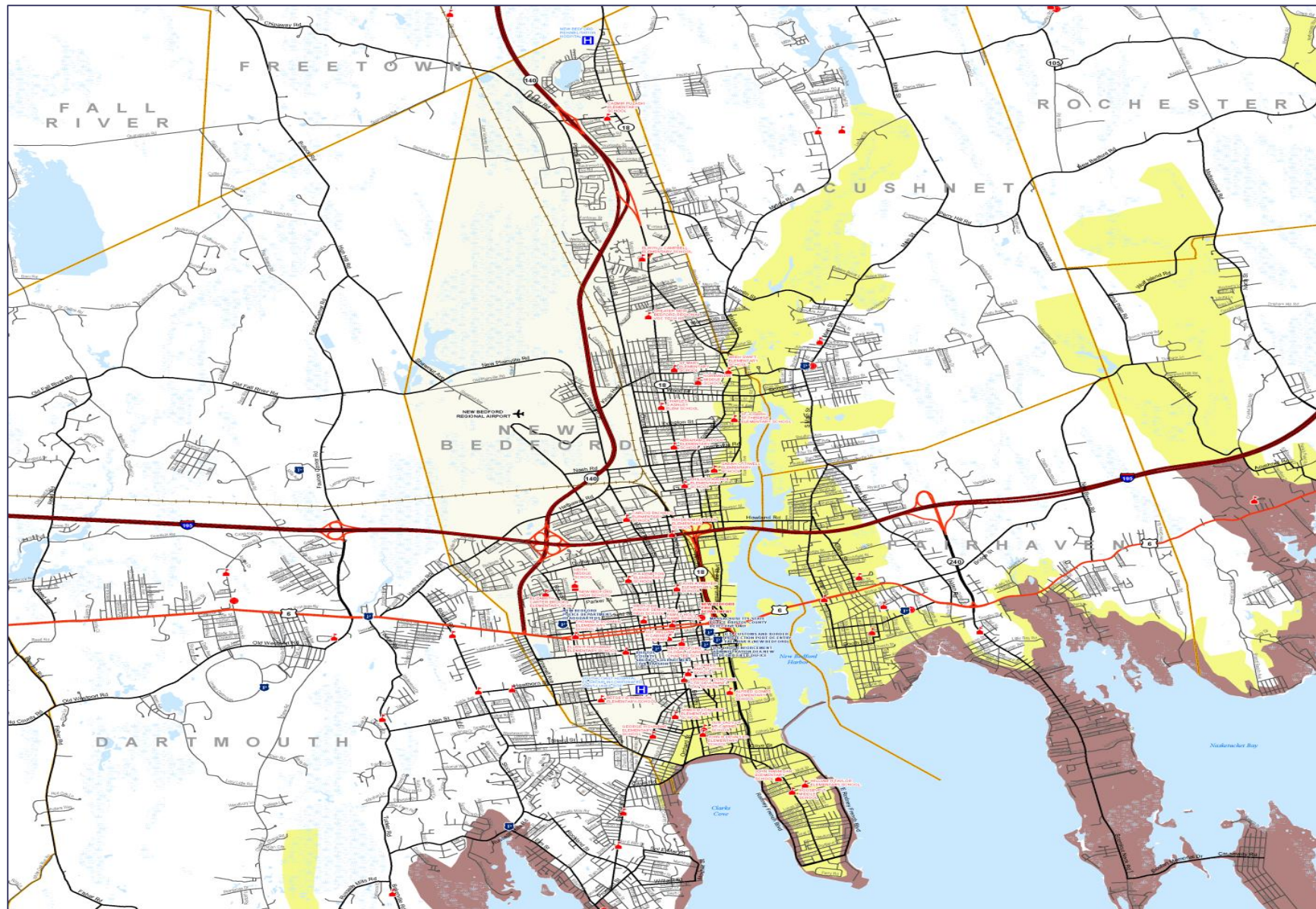


Figure 6-24: Traffic Analysis Zones – Bristol County / New Bedford



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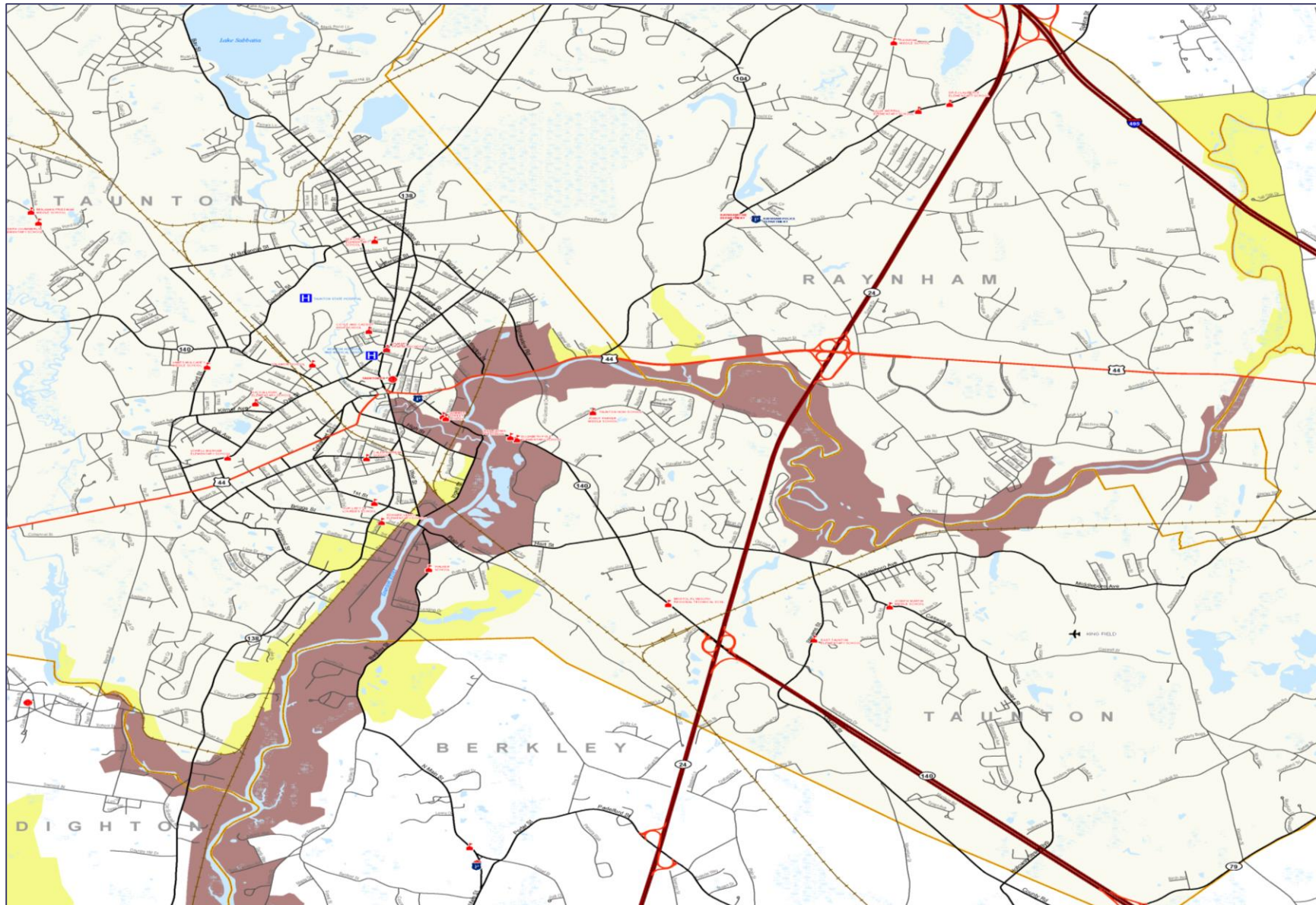


Figure 6-25: Traffic Analysis Zones – Bristol County / Raynham and Taunton



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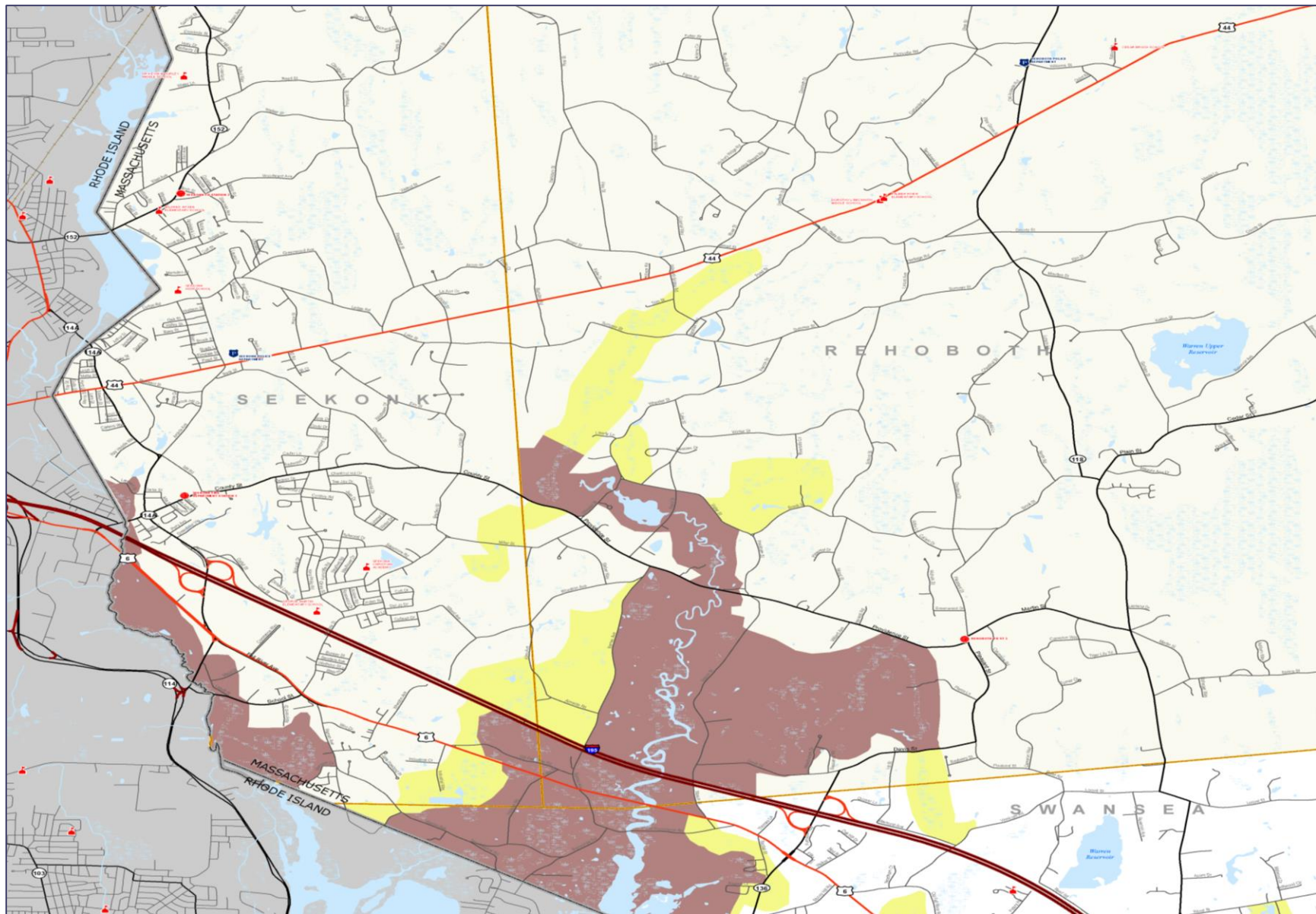


Figure 6-26: Traffic Analysis Zones – Bristol County / Rehoboth and Sseekonk



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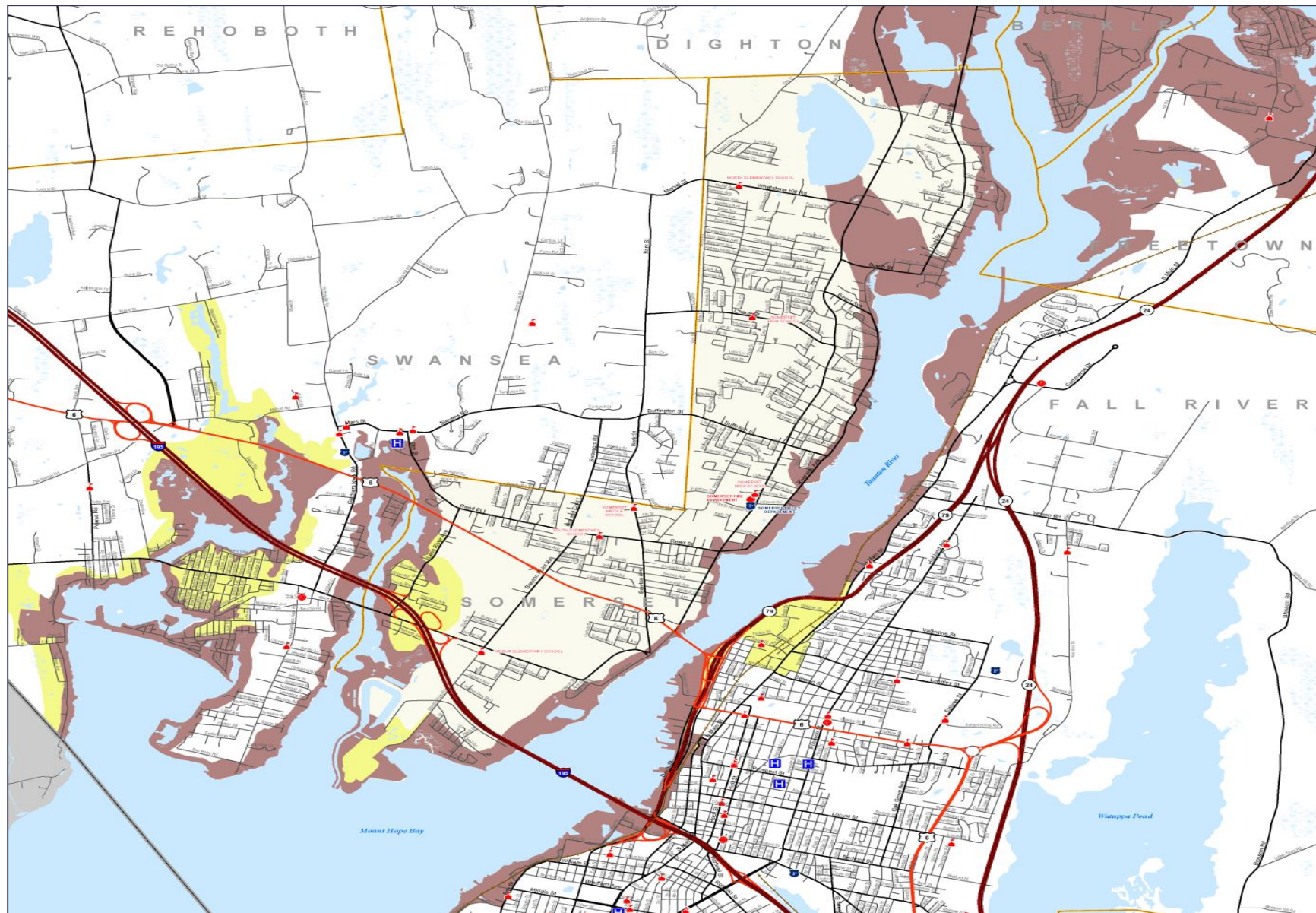


Figure 6-27: Traffic Analysis Zones – Bristol County / Somerset



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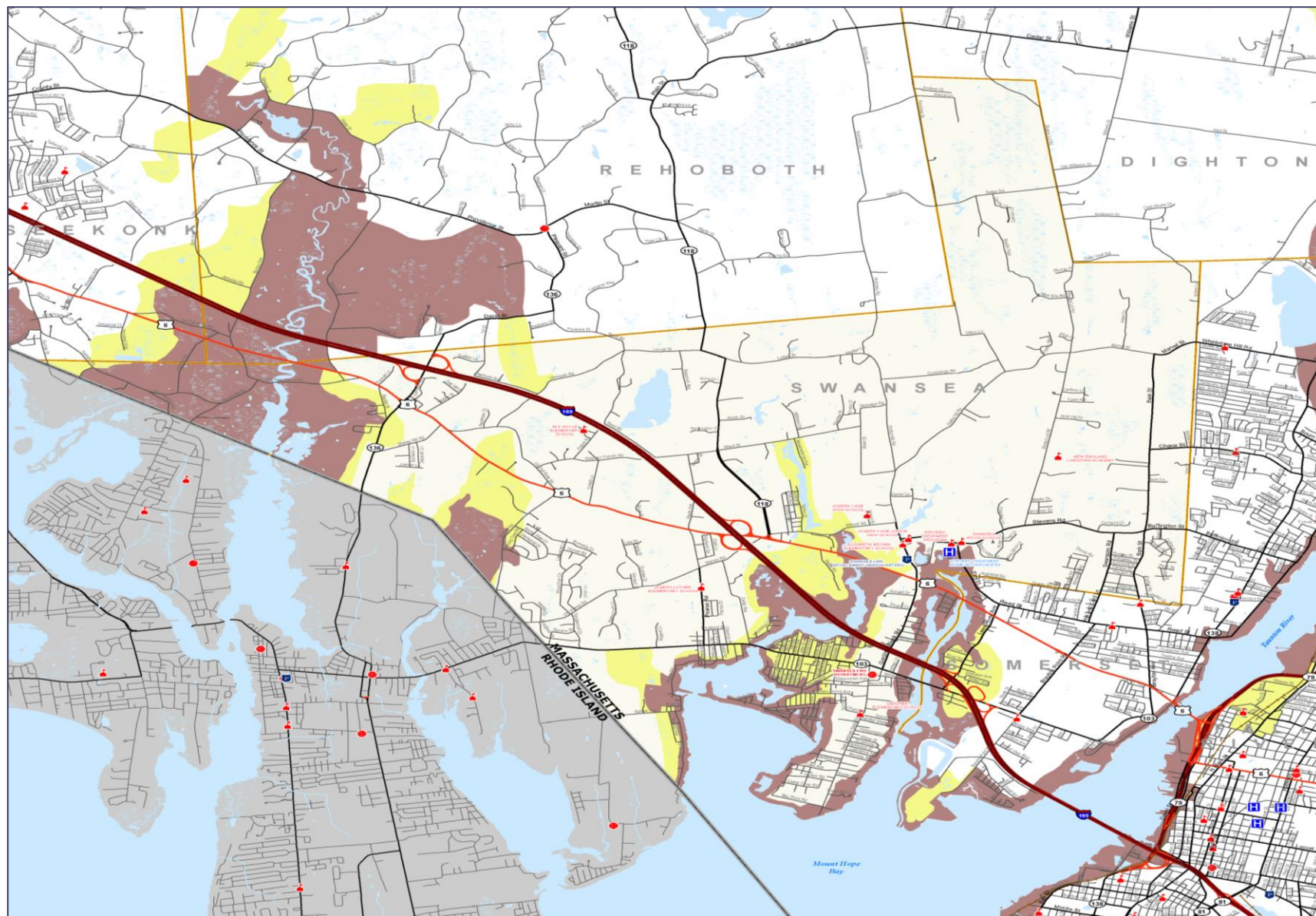


Figure 6-28: Traffic Analysis Zones – Bristol County / Swansea

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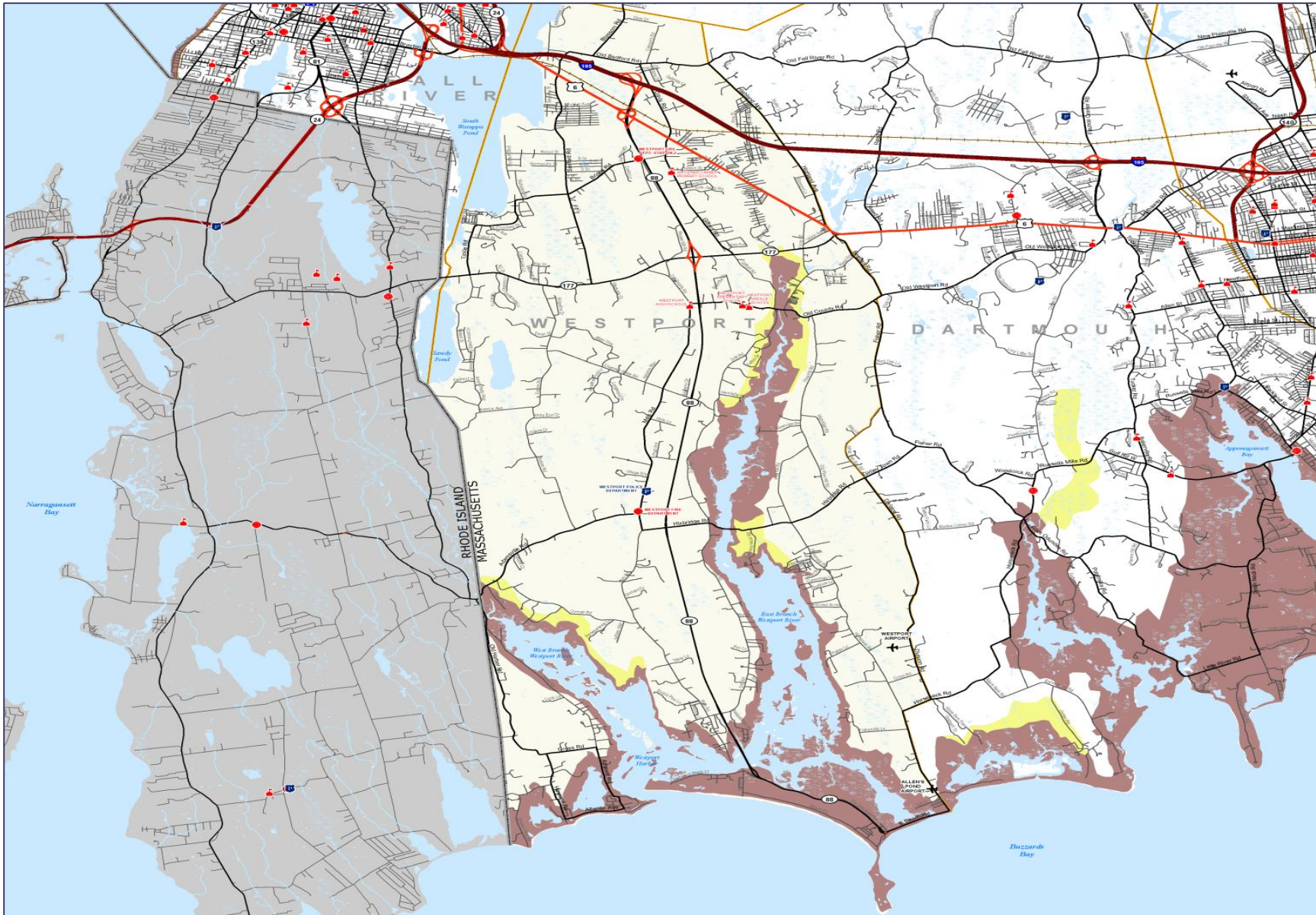


Figure 6-29: Traffic Analysis Zones – Bristol County / Westport



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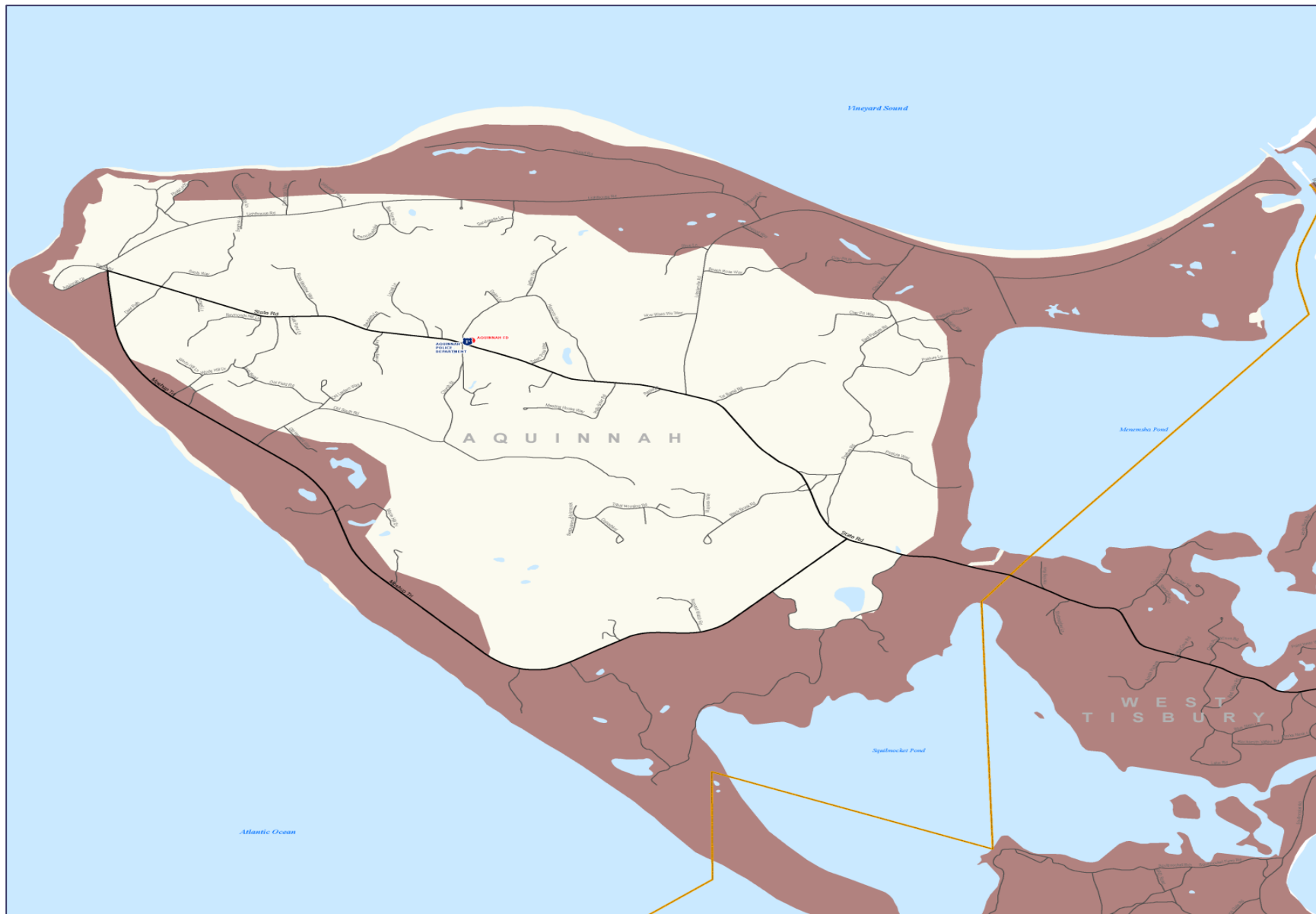


Figure 6-30: Traffic Analysis Zones – Dukes County / Aquinnah

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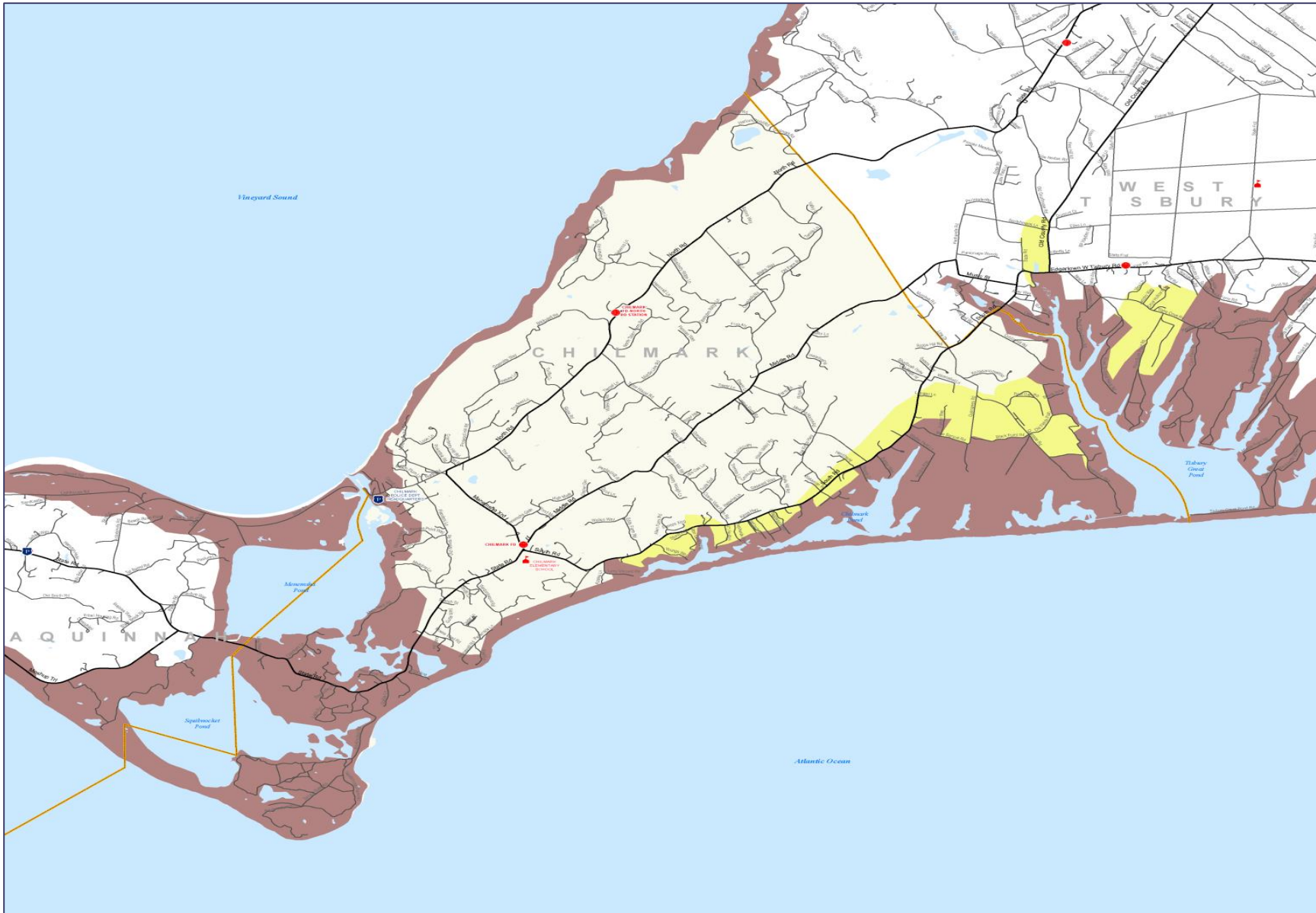


Figure 6-31: Traffic Analysis Zones – Dukes County / Chilmark



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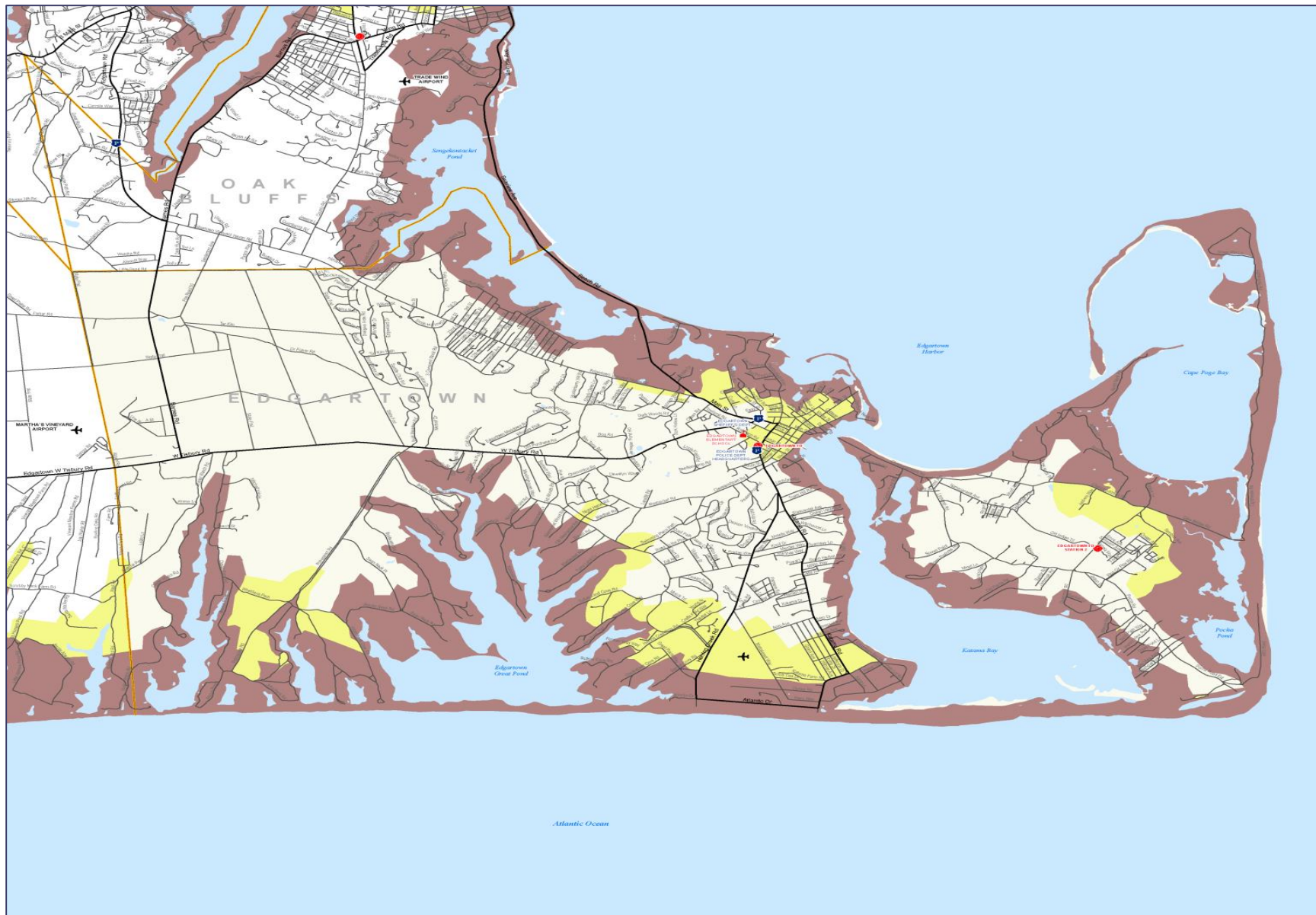


Figure 6-32: Traffic Analysis Zones – Dukes County / Edgartown



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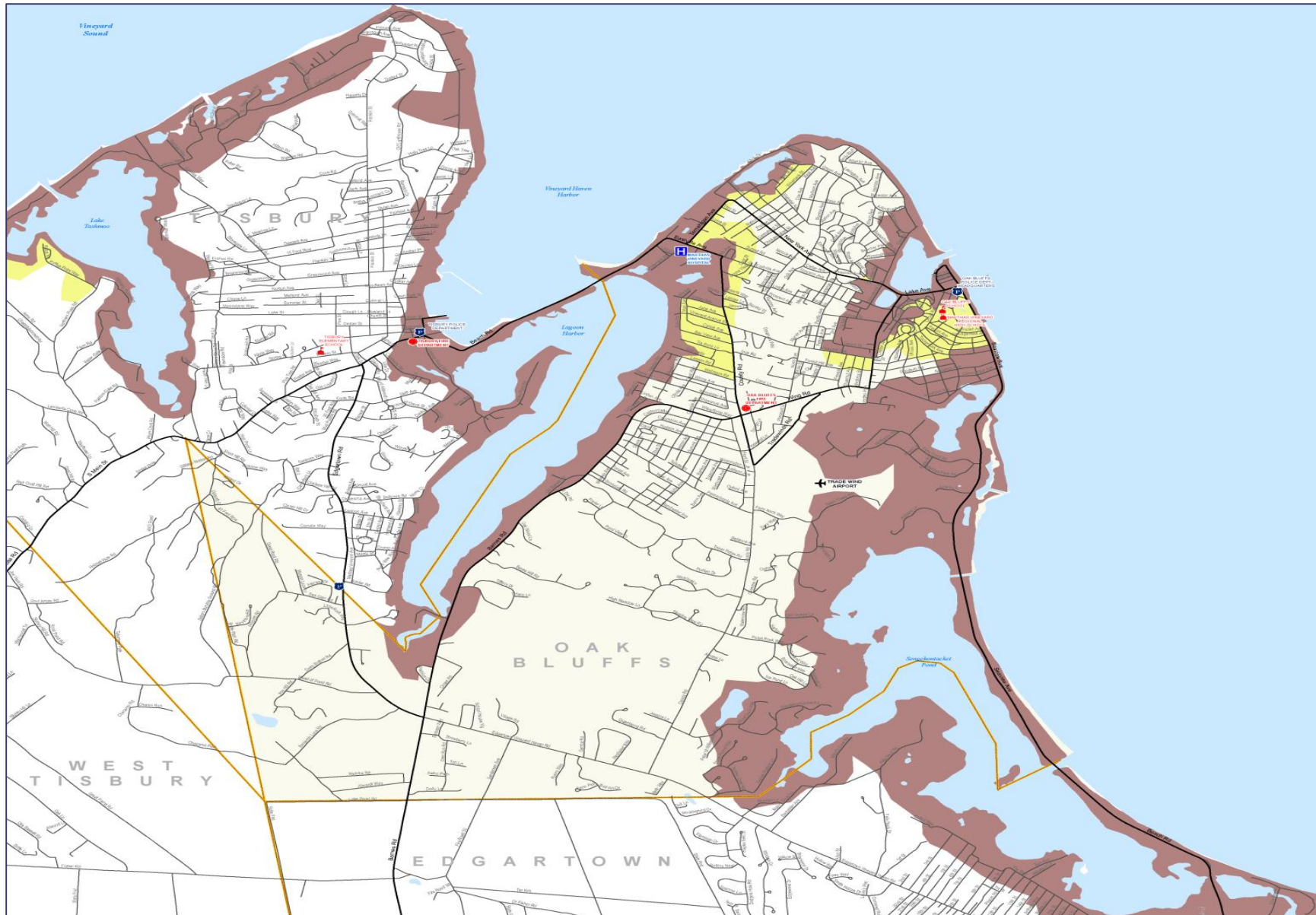


Figure 6-33: Traffic Analysis Zones – Duques County / Oak Bluffs

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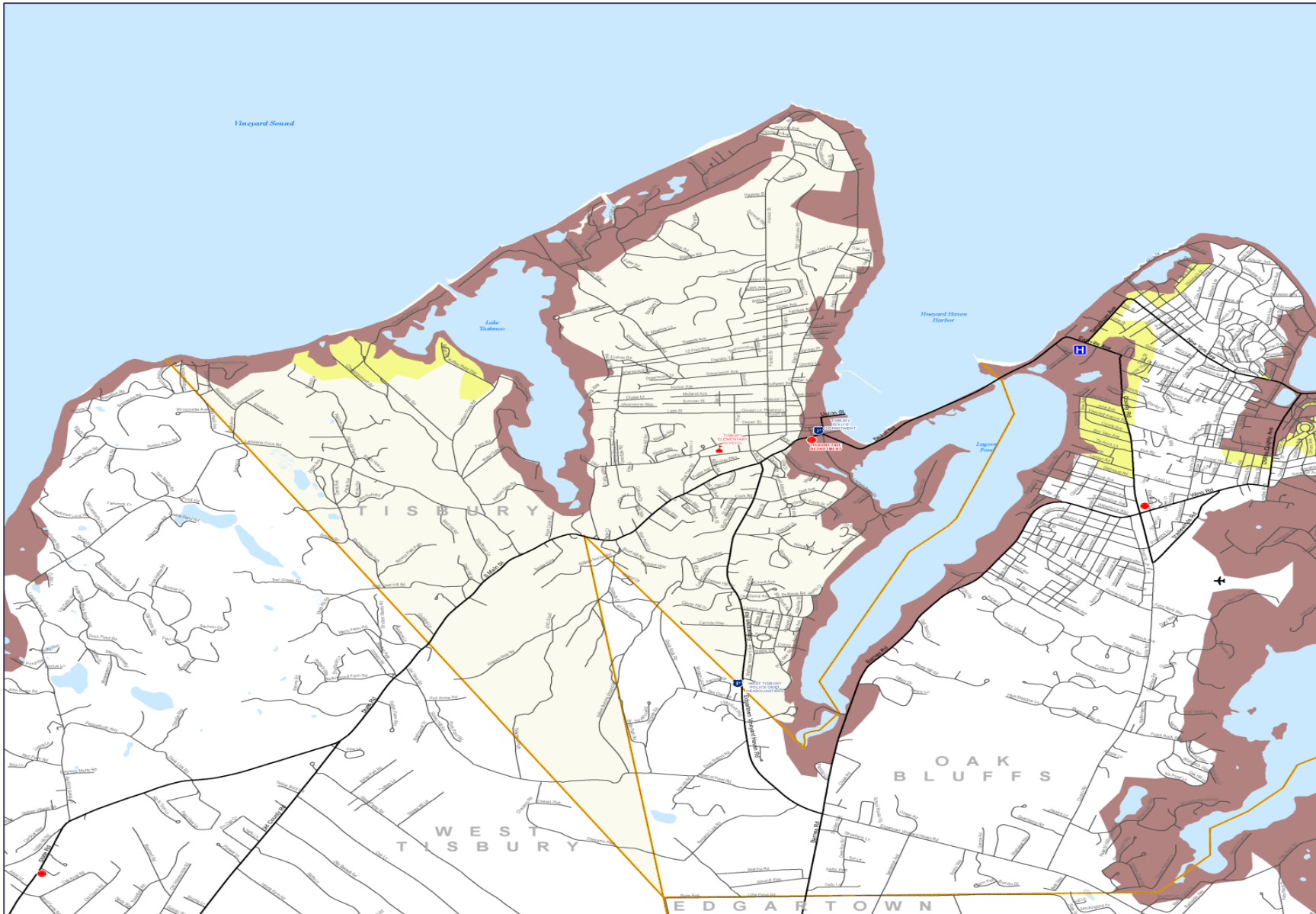


Figure 6-34: Traffic Analysis Zones – Dukes County / Tisbury

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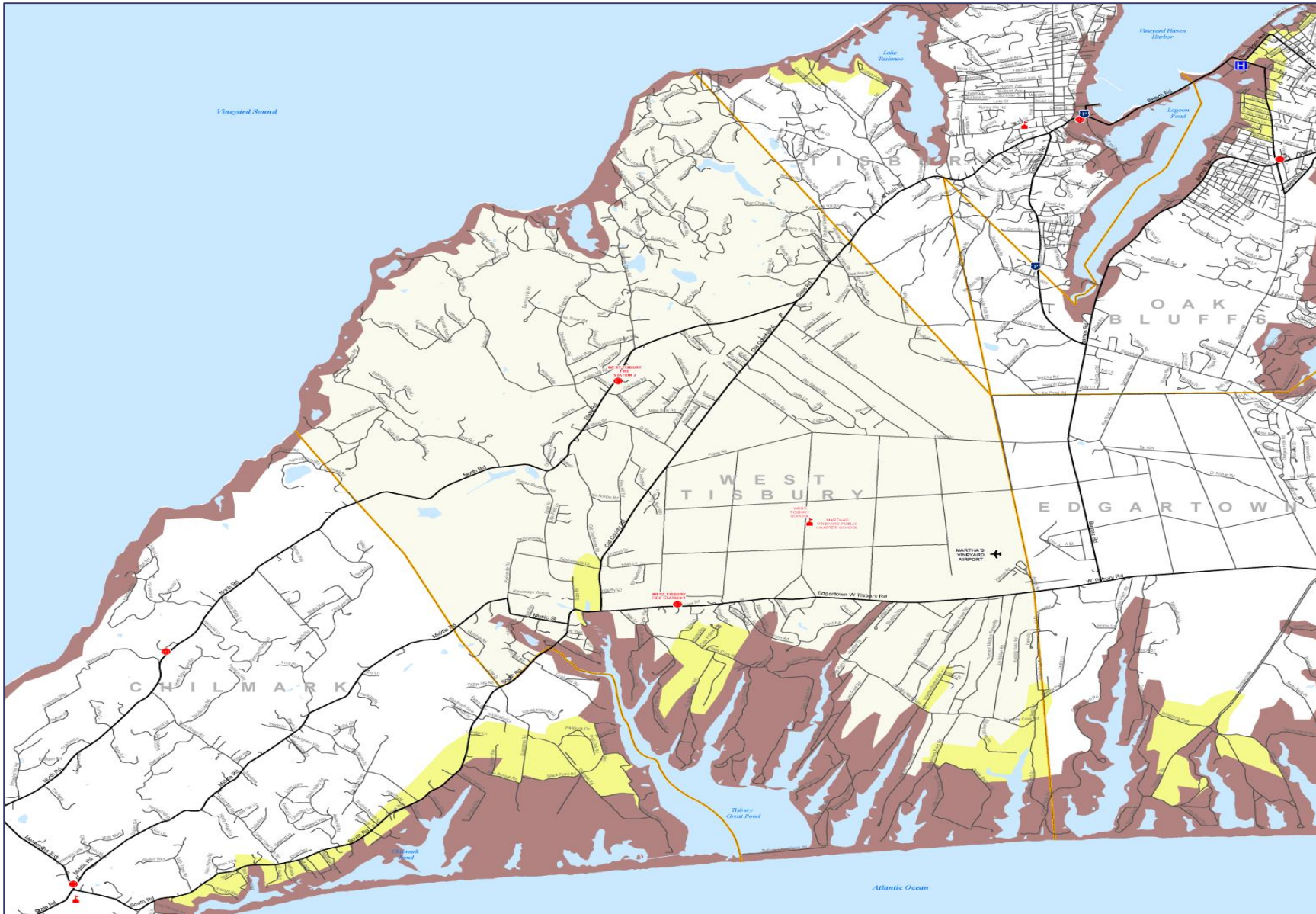


Figure 6-35: Traffic Analysis Zones – Dukes County / West Tisbury



6.0 Transportation Analysis

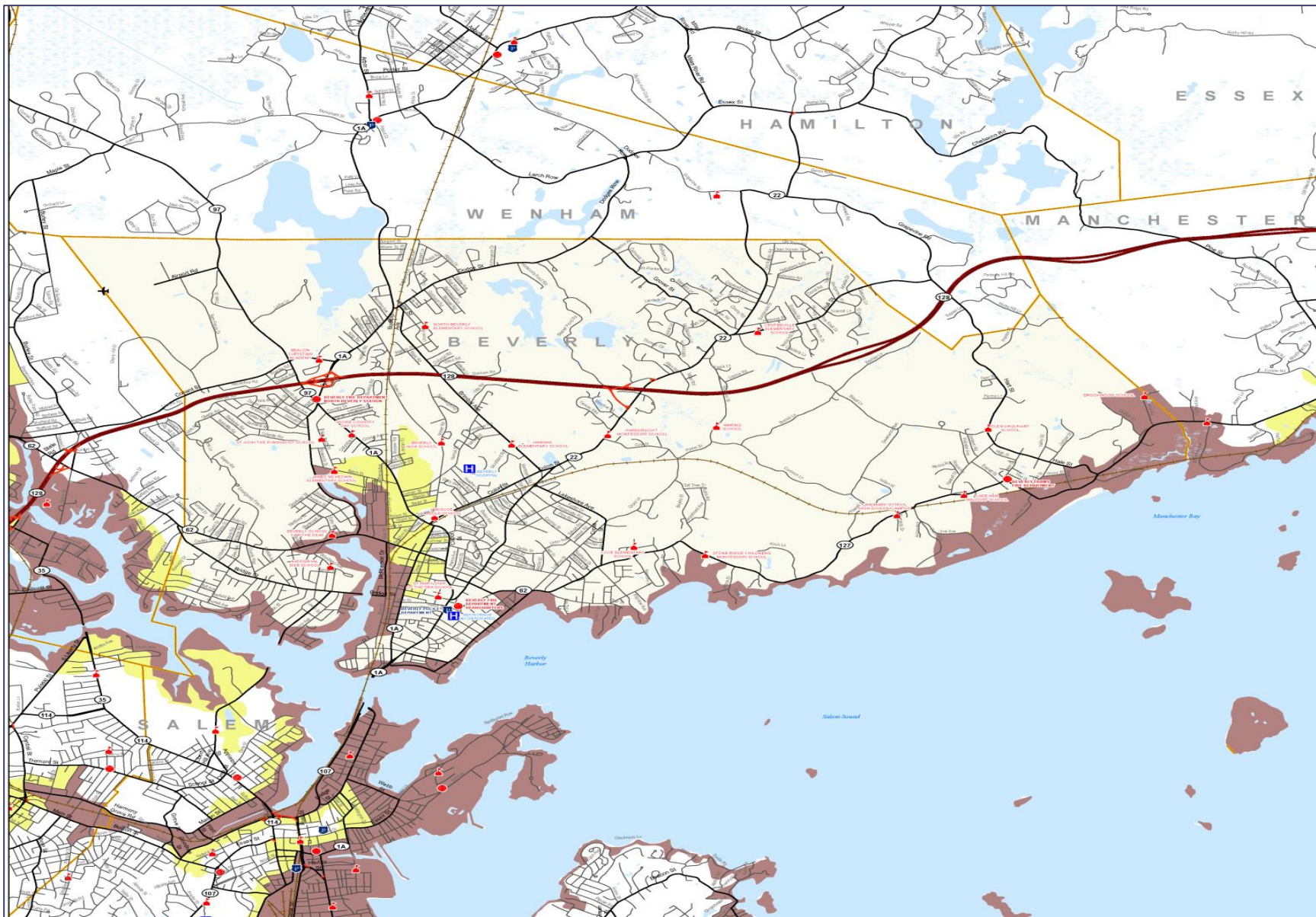


Figure 6-36: Traffic Analysis Zones – Essex County / Beverly



6.0 Transportation Analysis

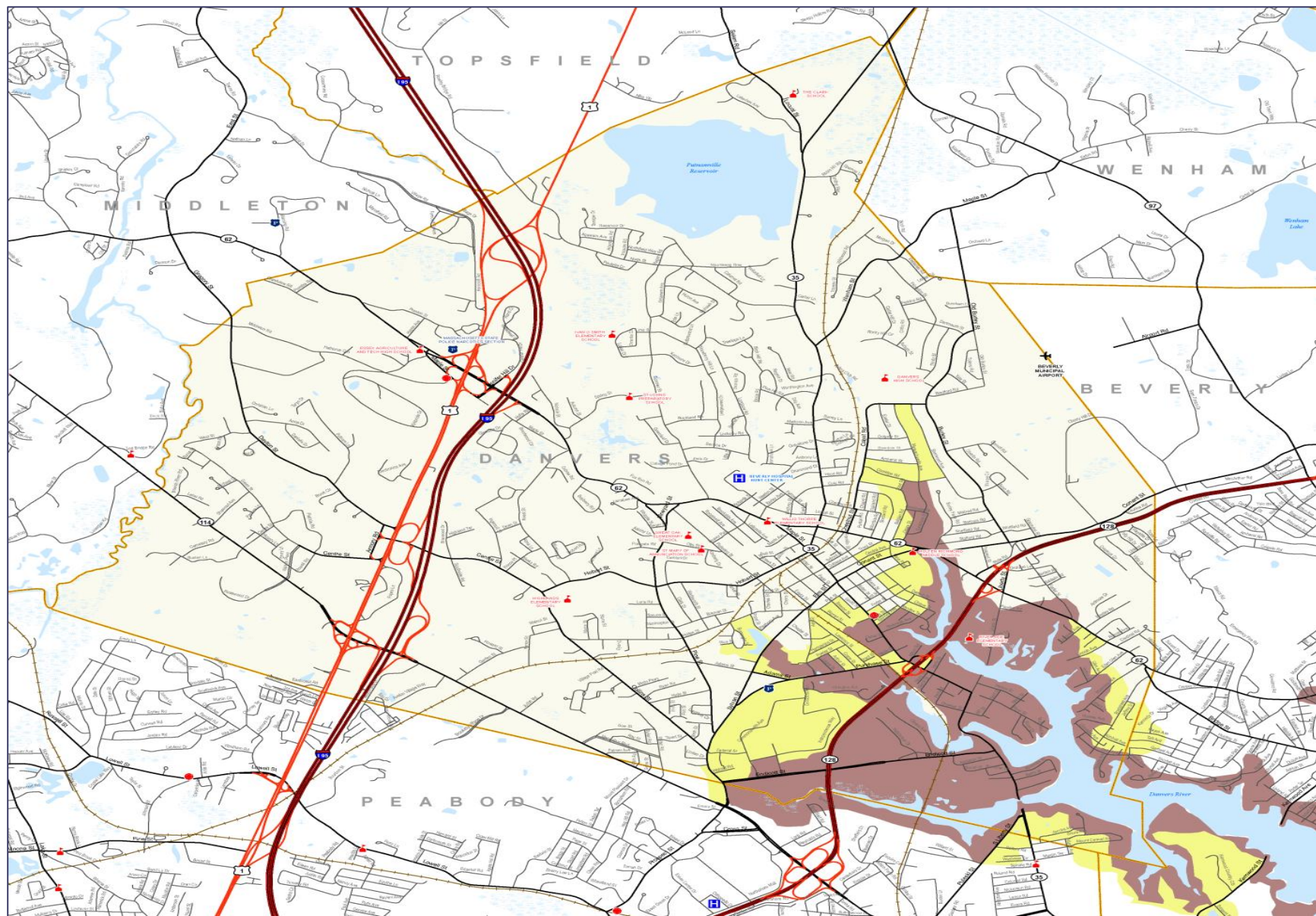


Figure 6-37: Traffic Analysis Zones – Essex County / Danvers



6.0 Transportation Analysis

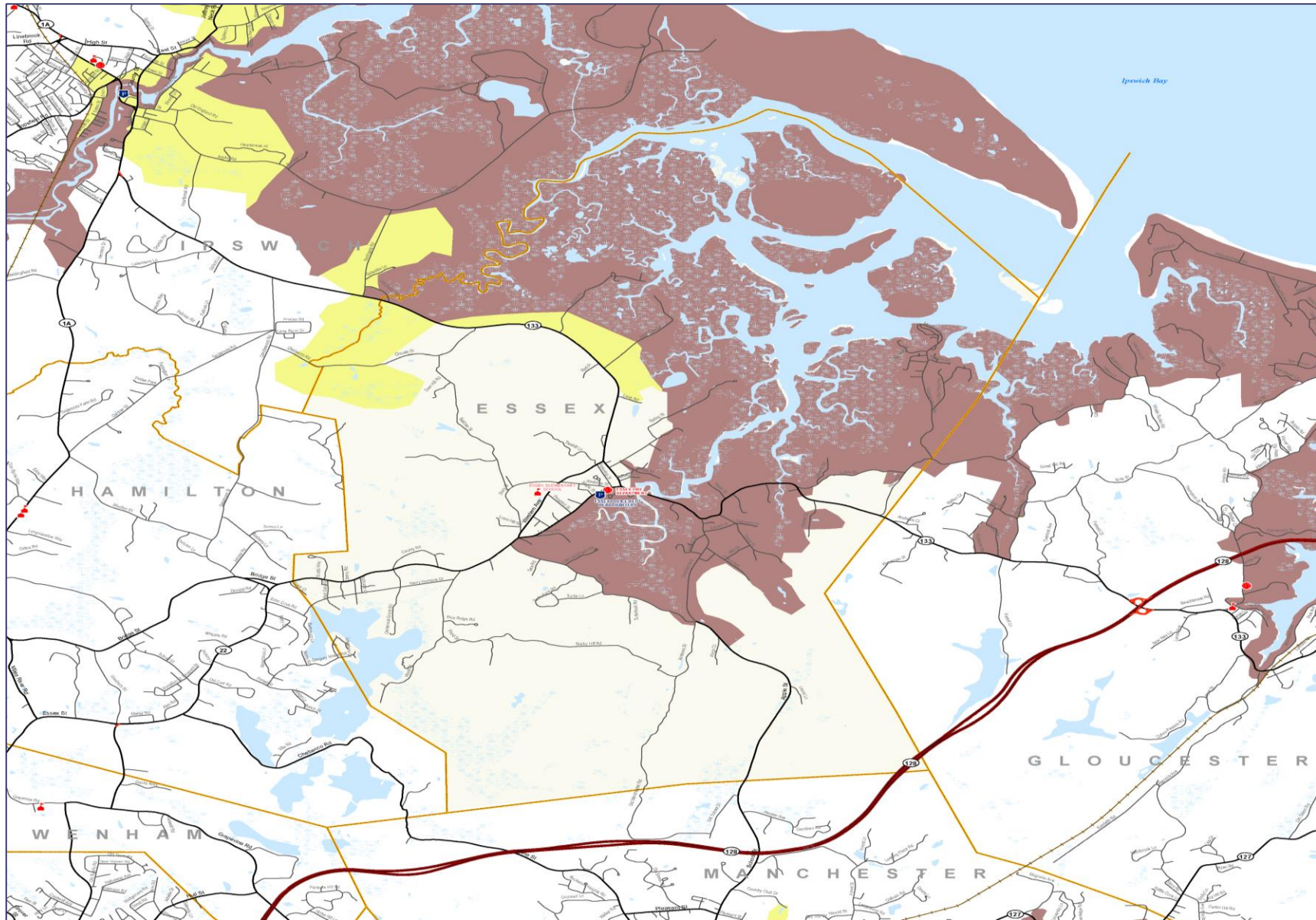


Figure 6-38: Traffic Analysis Zones – Essex County / Essex

6.0 Transportation Analysis

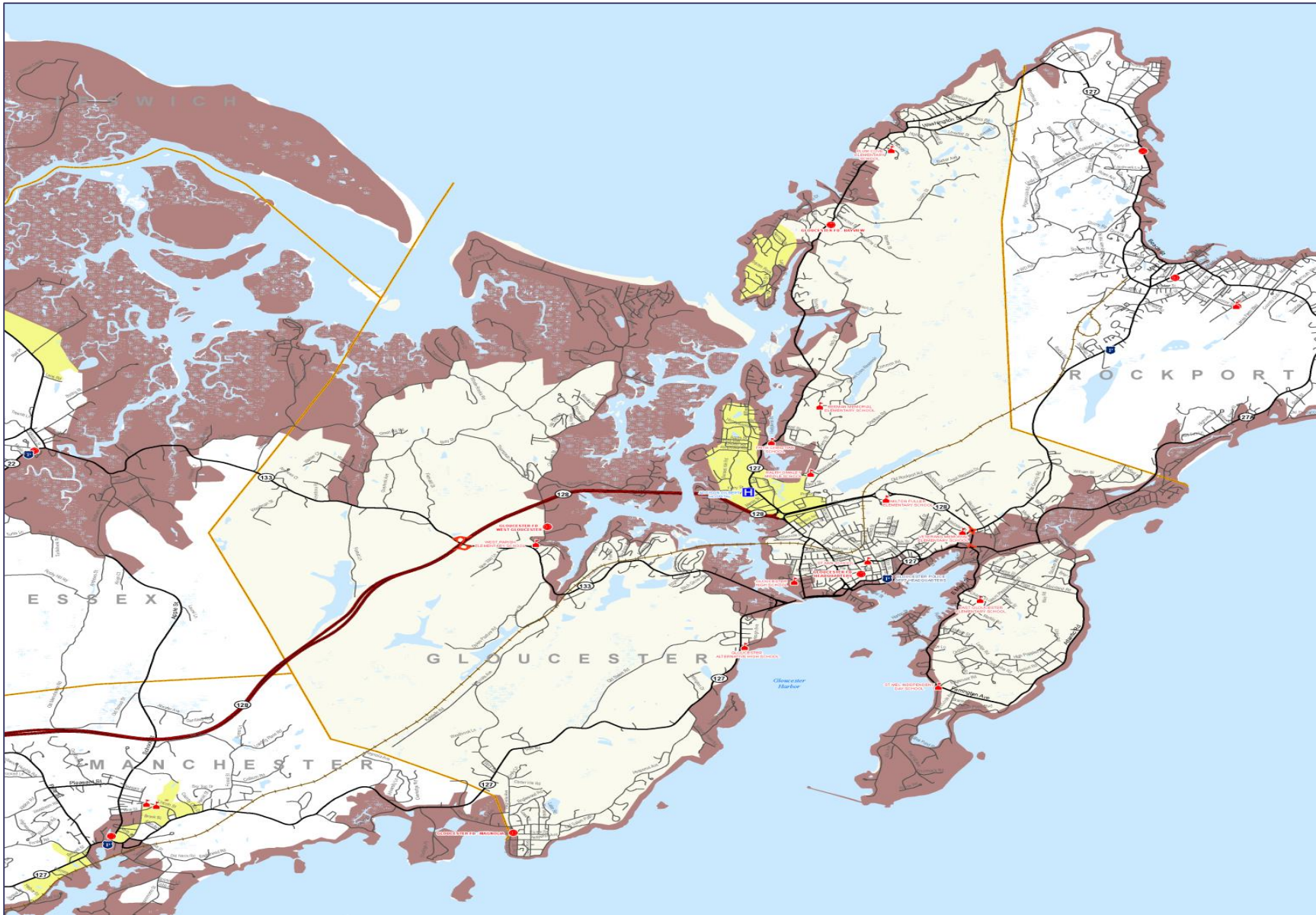


Figure 6-39: Traffic Analysis Zones – Essex County / Gloucester



6.0 Transportation Analysis

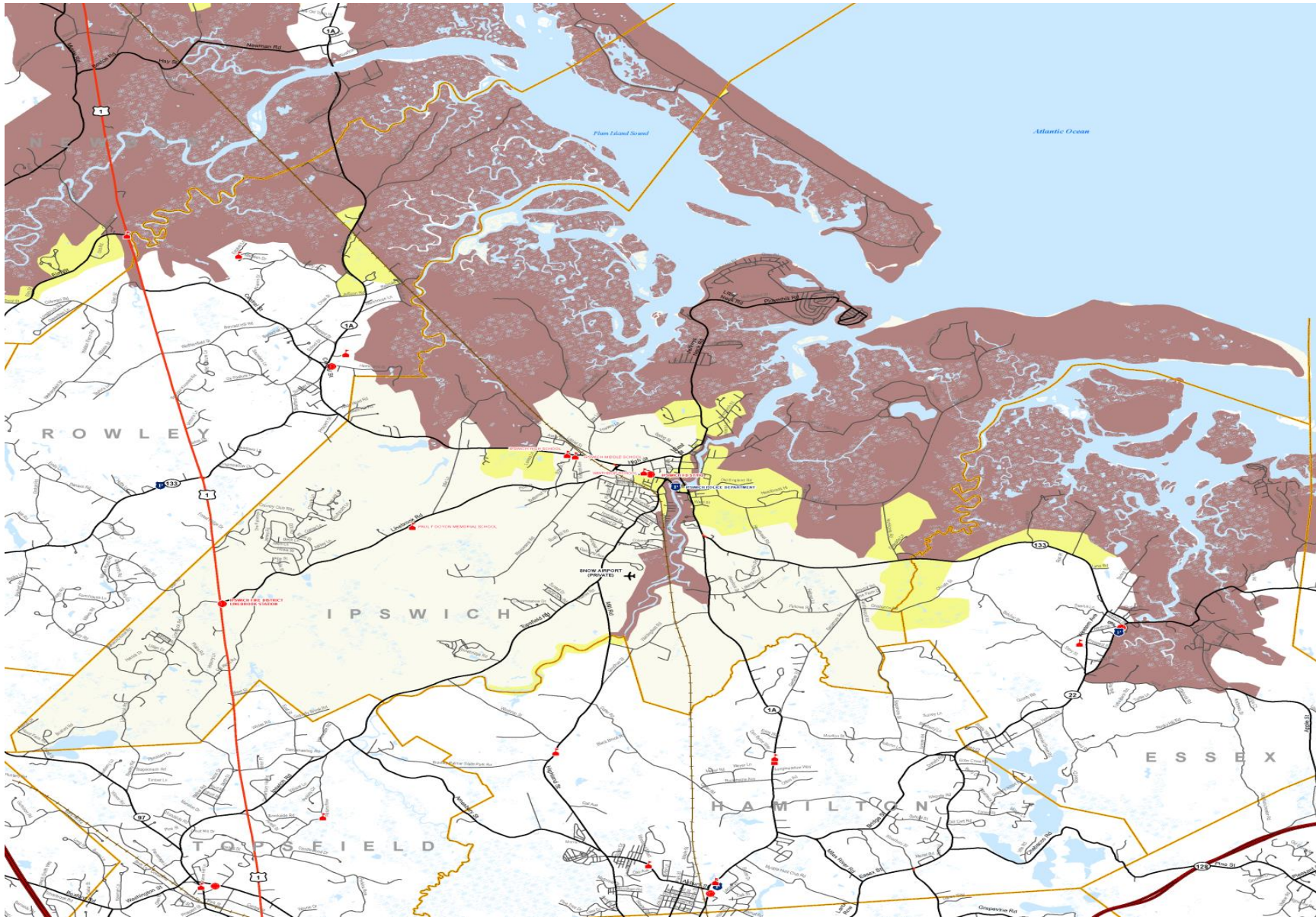


Figure 6-40: Traffic Analysis Zones – Essex County / Ipswich

6.0 Transportation Analysis

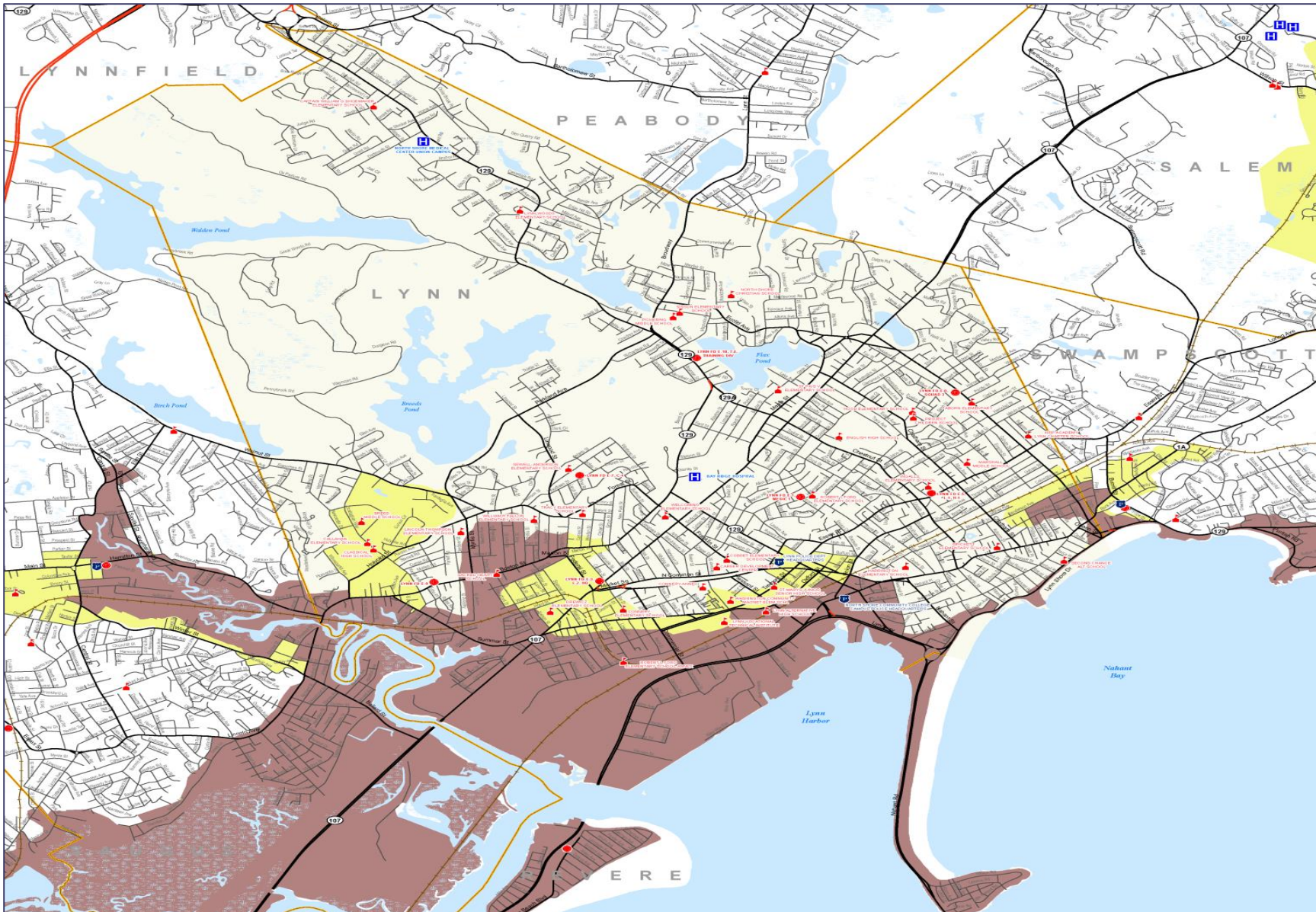


Figure 6-41: Traffic Analysis Zones – Essex County / Lynn



6.0 Transportation Analysis

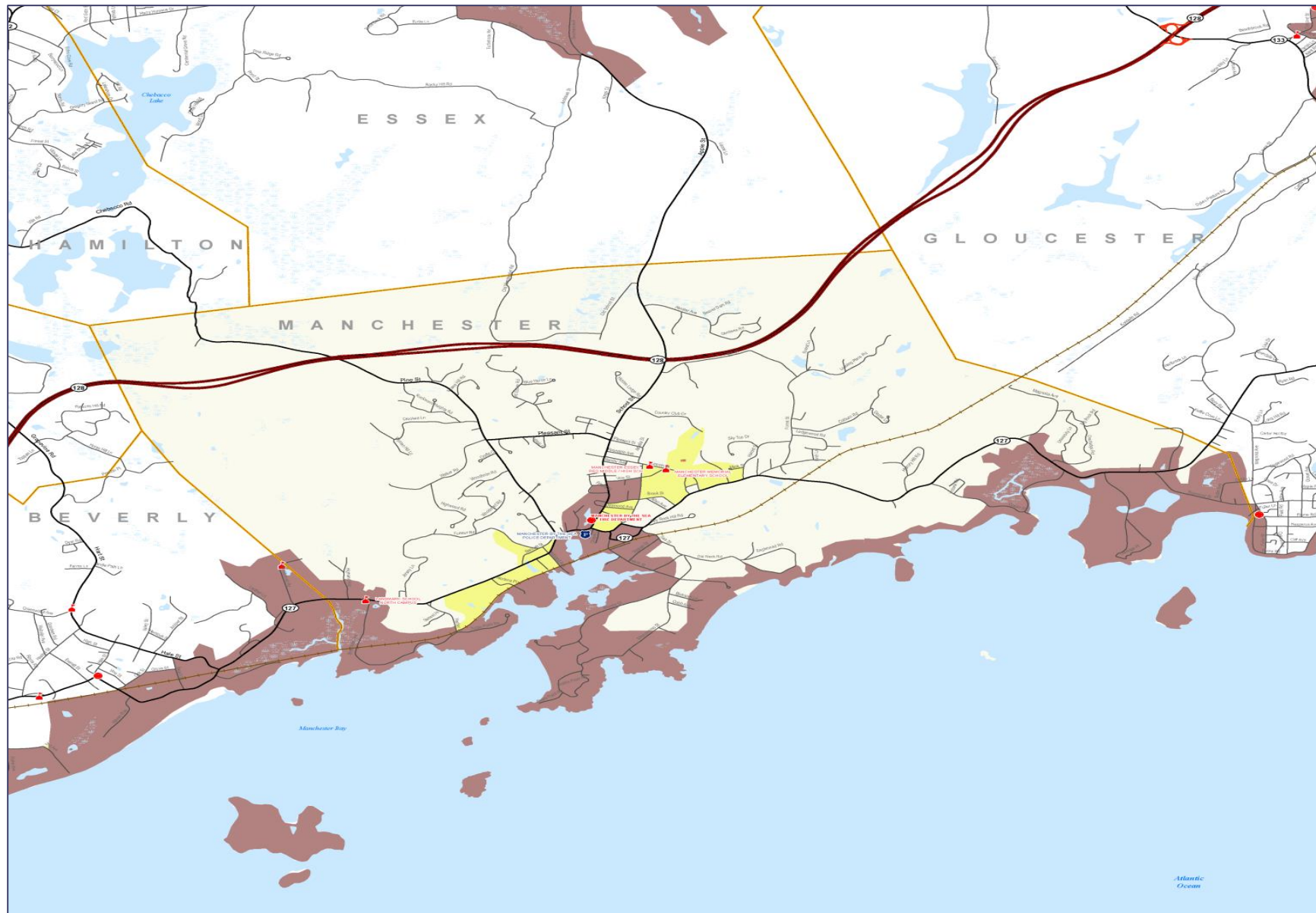


Figure 6-42: Traffic Analysis Zones – Essex County / Manchester



6.0 Transportation Analysis

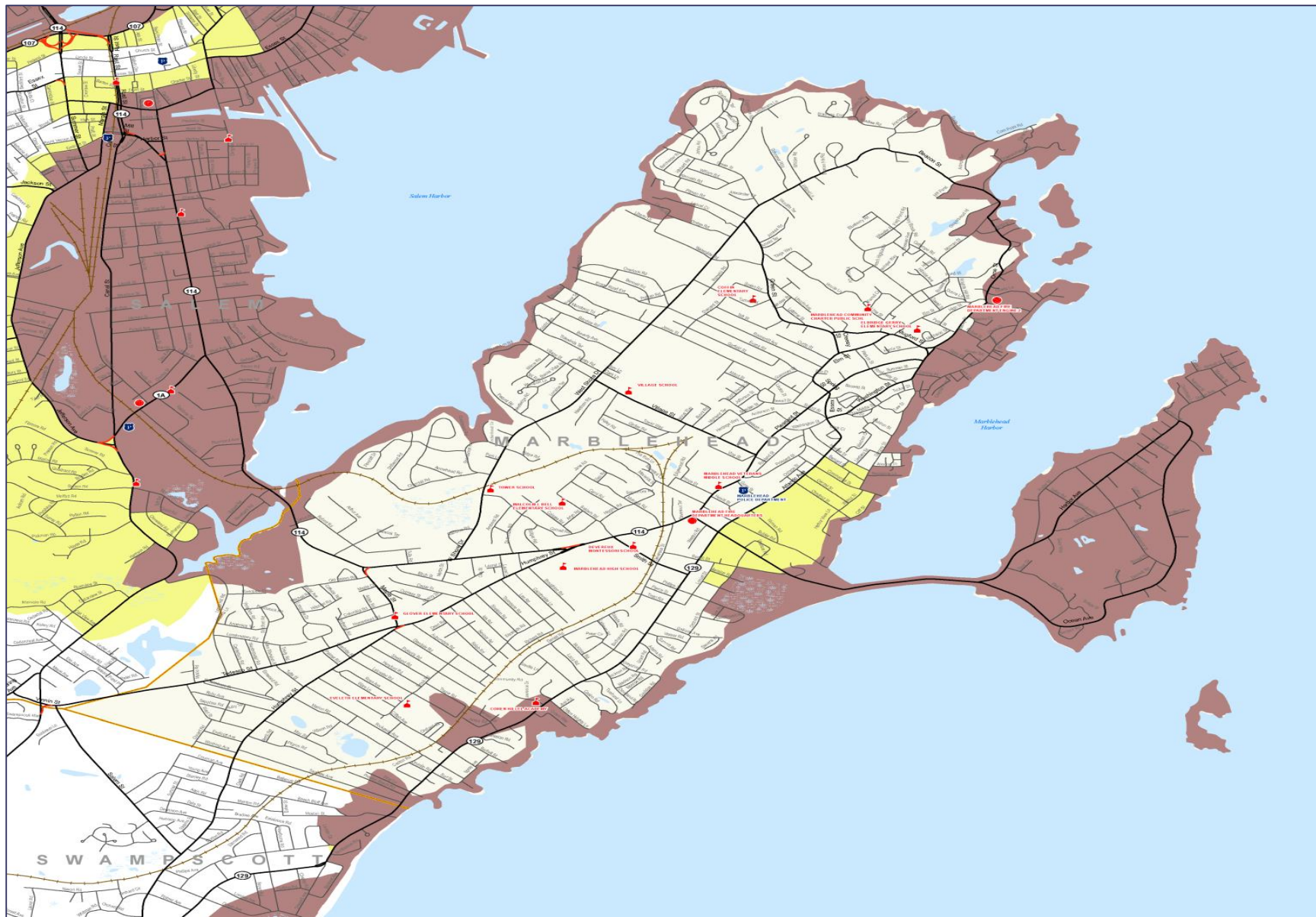


Figure 6-43: Traffic Analysis Zones – Essex County / Marblehead



6.0 Transportation Analysis

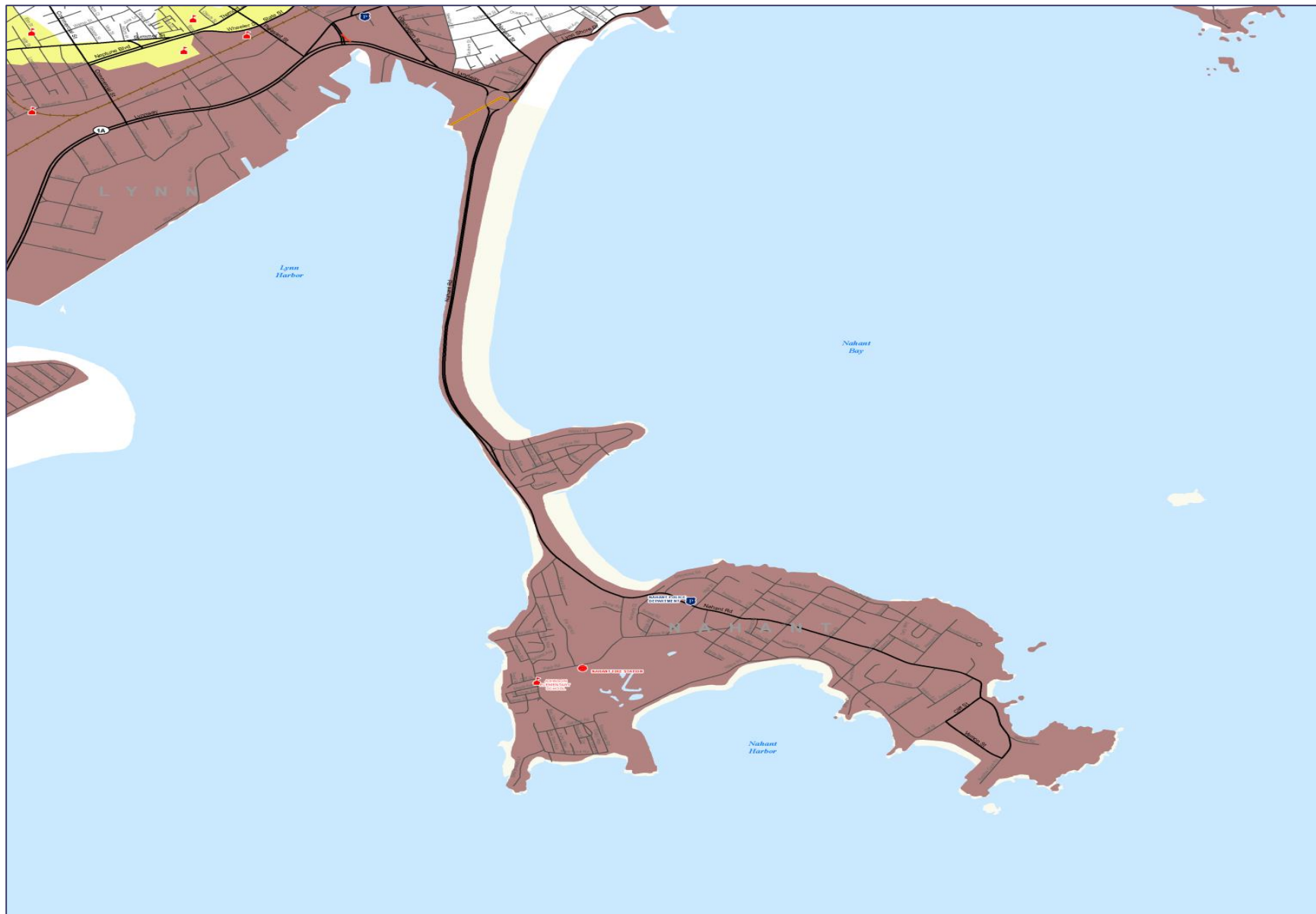


Figure 6-44: Traffic Analysis Zones – Essex County / Nahant



6.0 Transportation Analysis

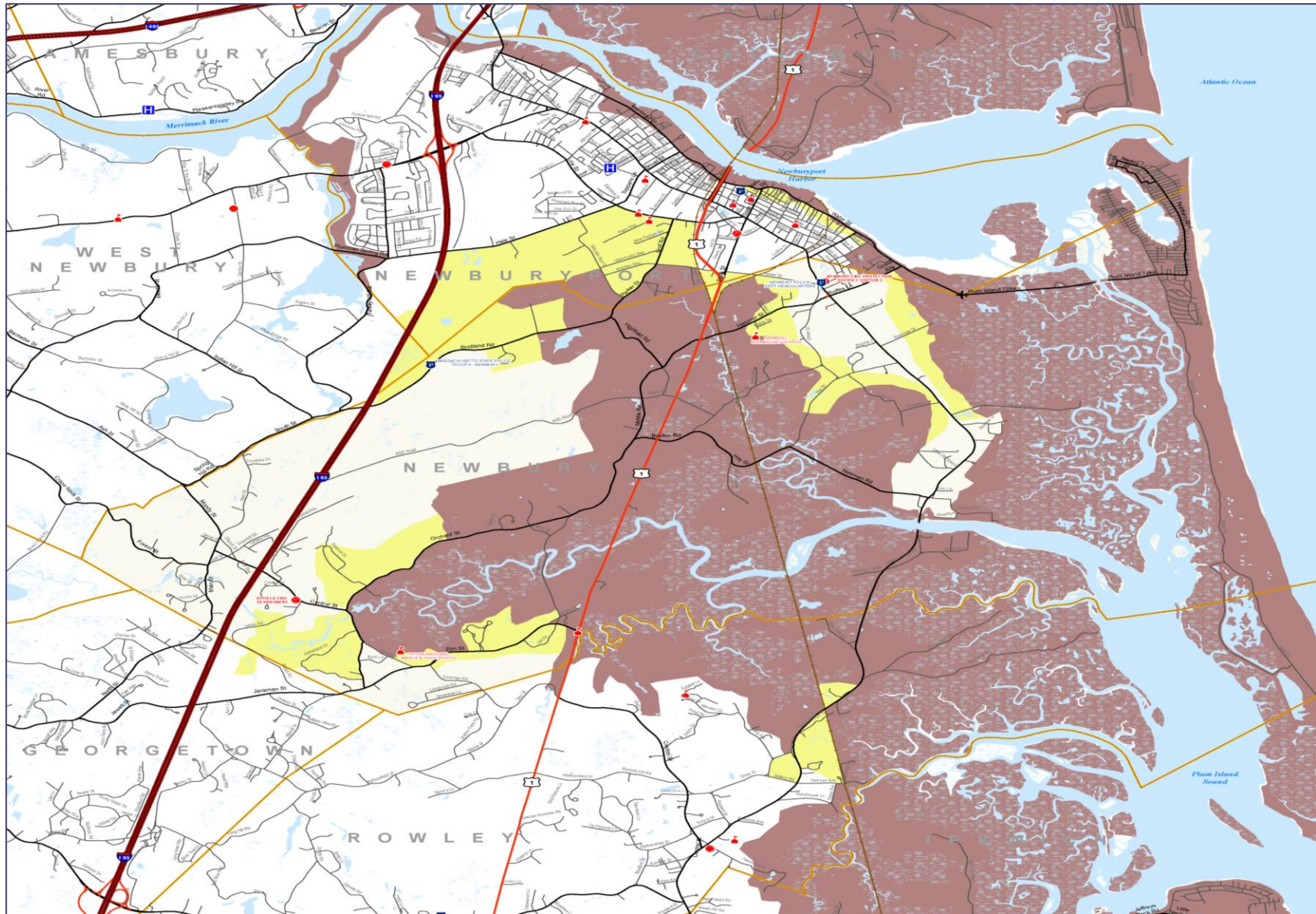


Figure 6-45: Traffic Analysis Zones – Essex County / Newbury



6.0 Transportation Analysis

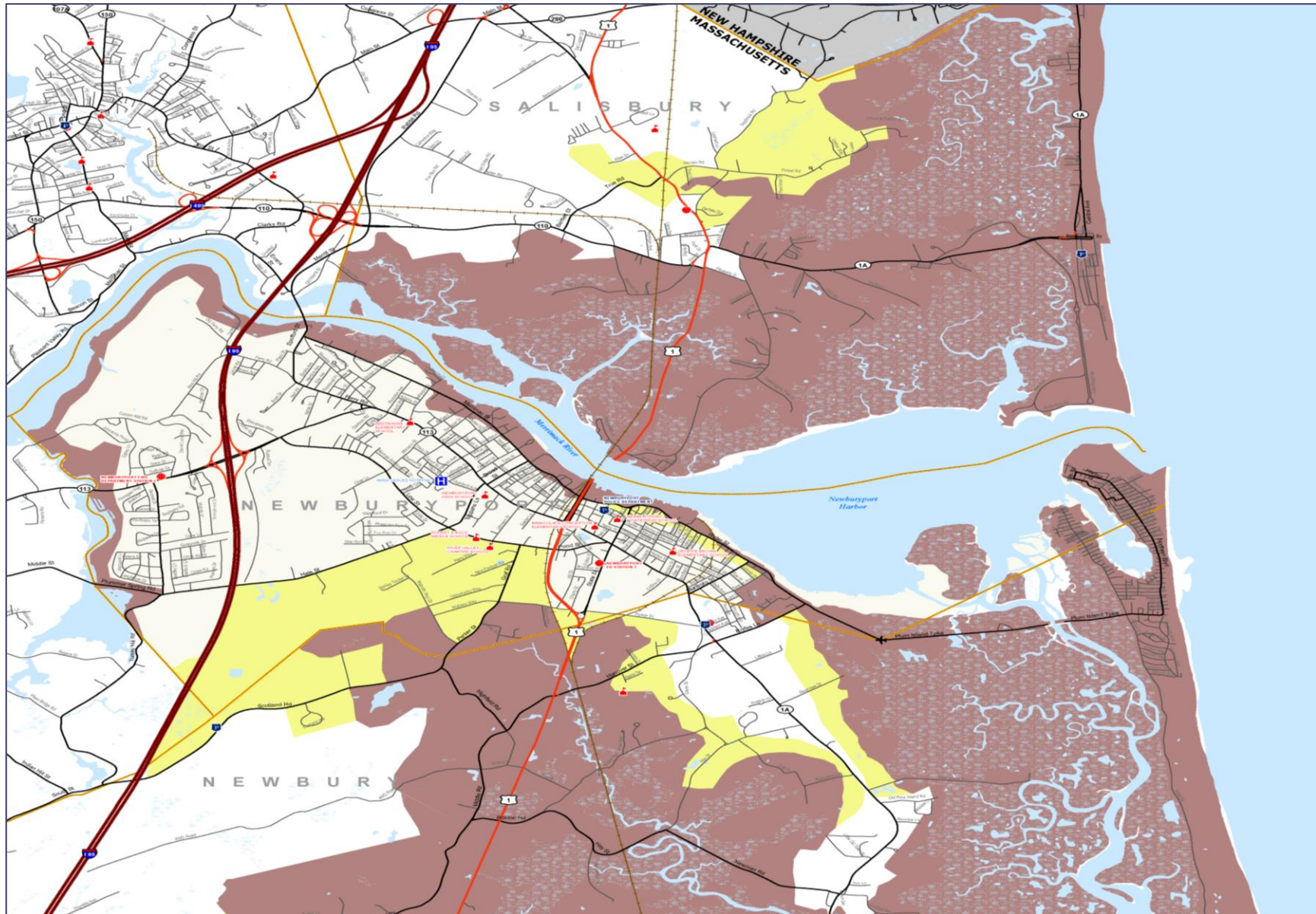


Figure 6-46: Traffic Analysis Zones – Essex County / Newburyport

6.0 Transportation Analysis

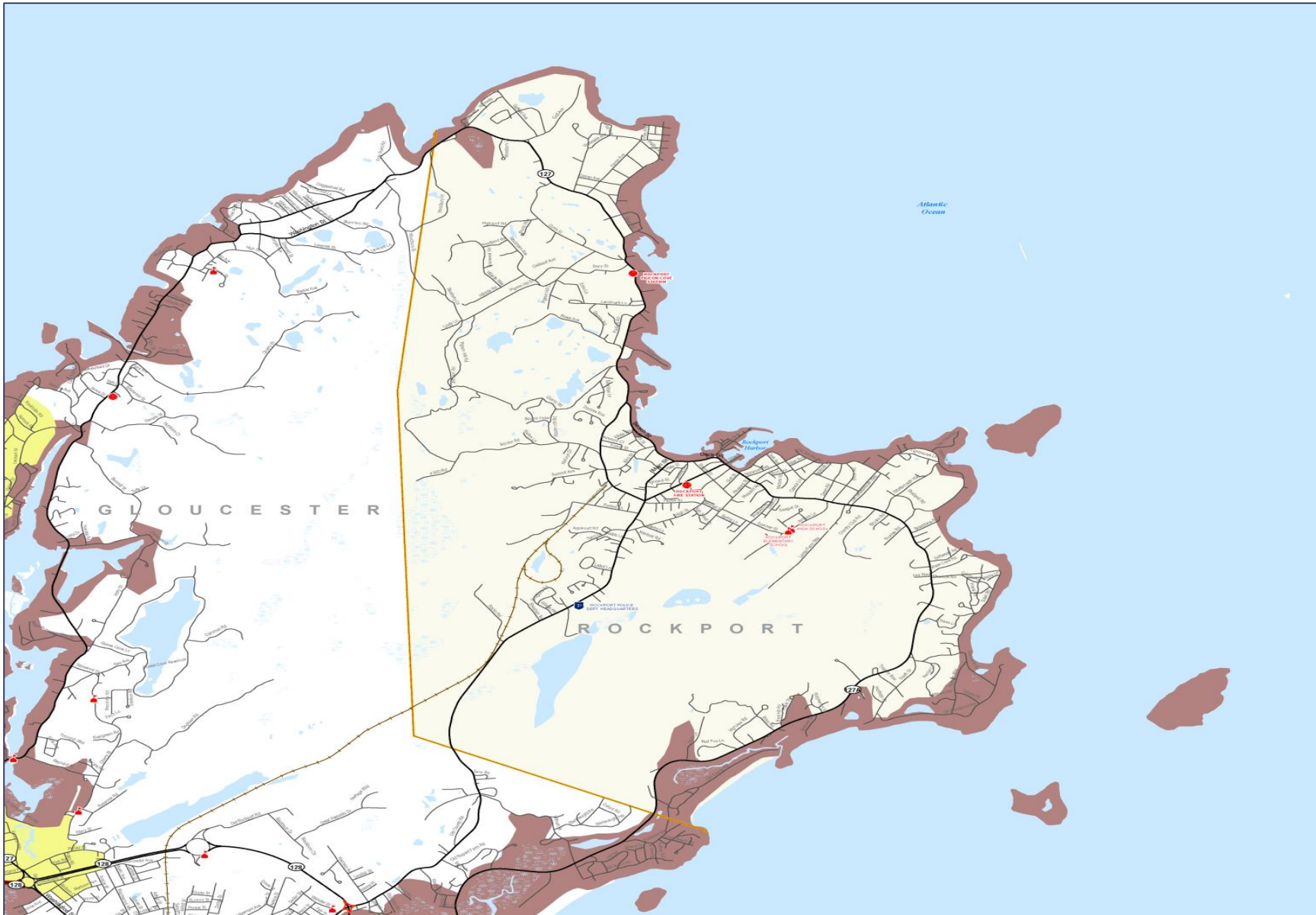


Figure 6-47: Traffic Analysis Zones – Essex County / Rockport



6.0 Transportation Analysis

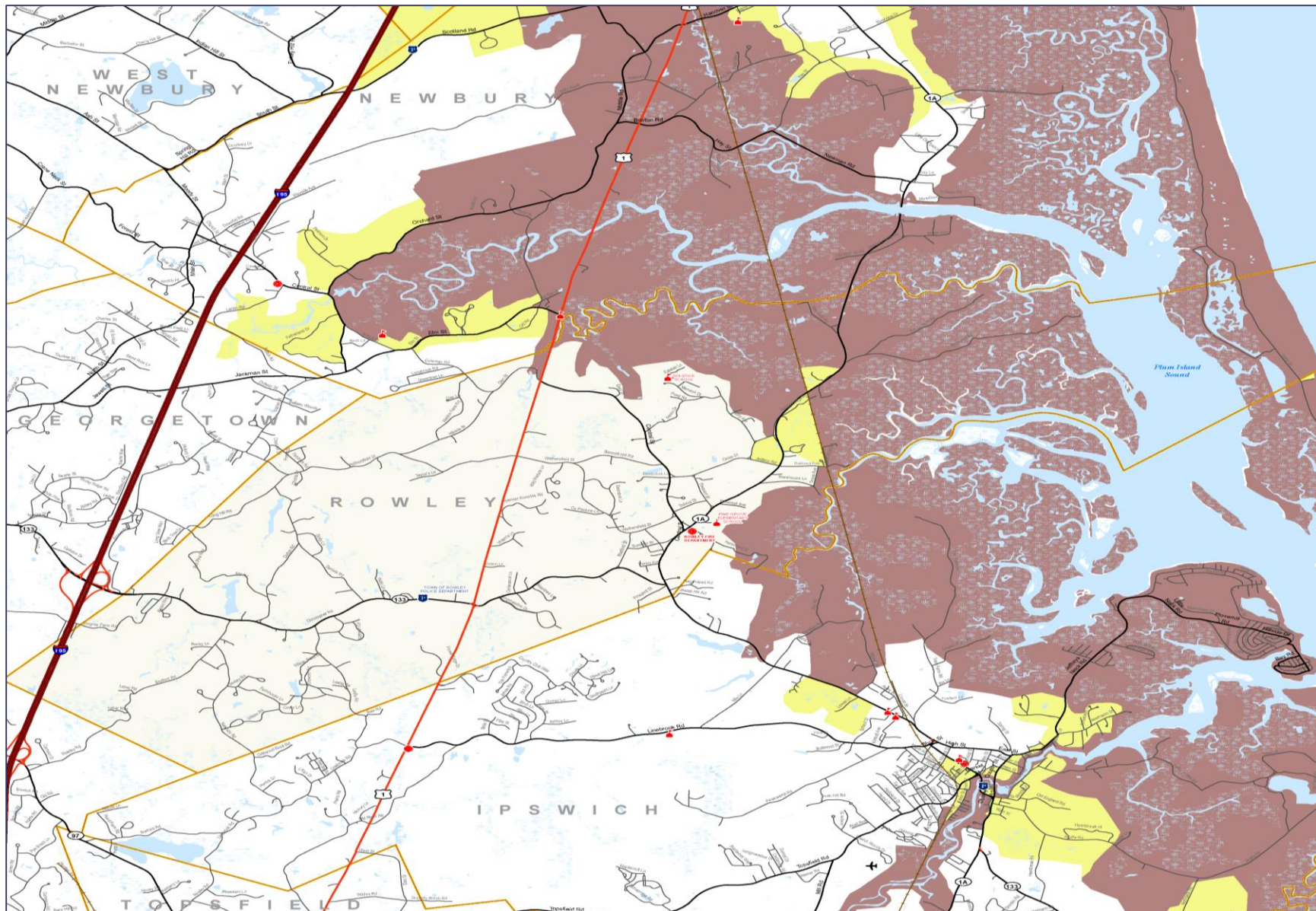


Figure 6-48: Traffic Analysis Zones – Essex County / Rowley



6.0 Transportation Analysis

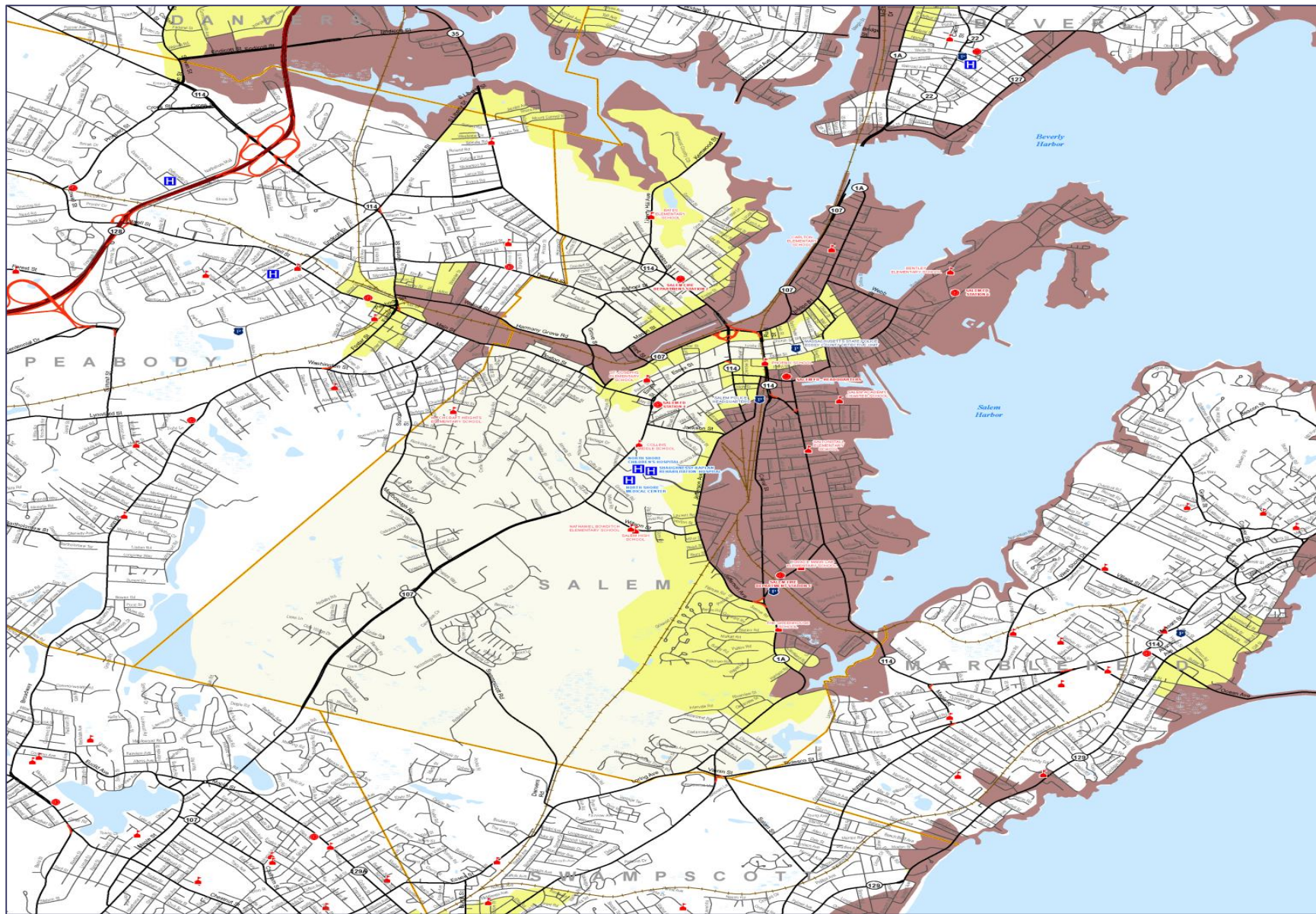


Figure 6-49: Traffic Analysis Zones – Essex County / Salem



6.0 Transportation Analysis

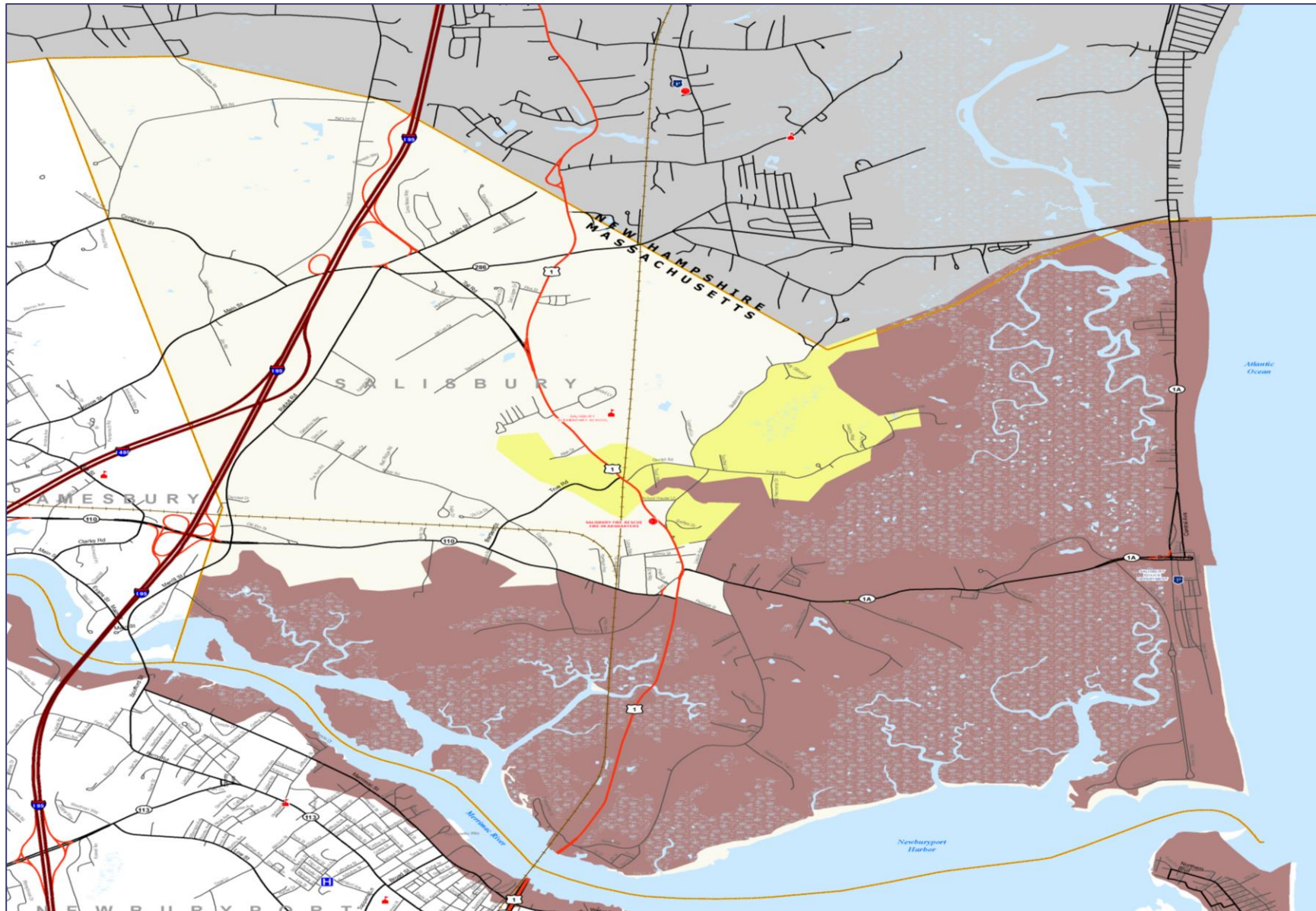


Figure 6-50: Traffic Analysis Zones – Essex County / Salisbury

6.0 Transportation Analysis

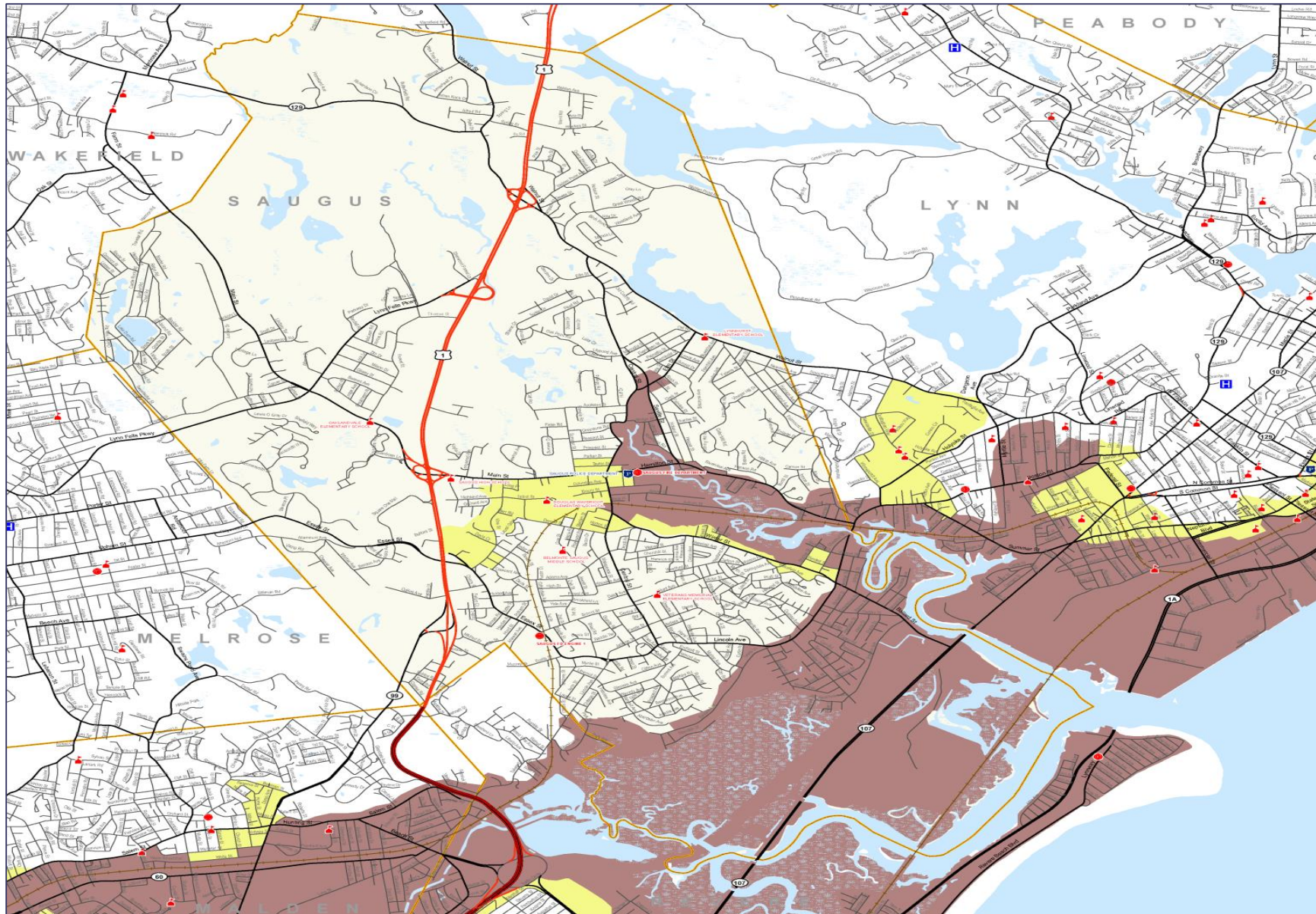


Figure 6-51: Traffic Analysis Zones – Essex County / Saugus

6.0 Transportation Analysis

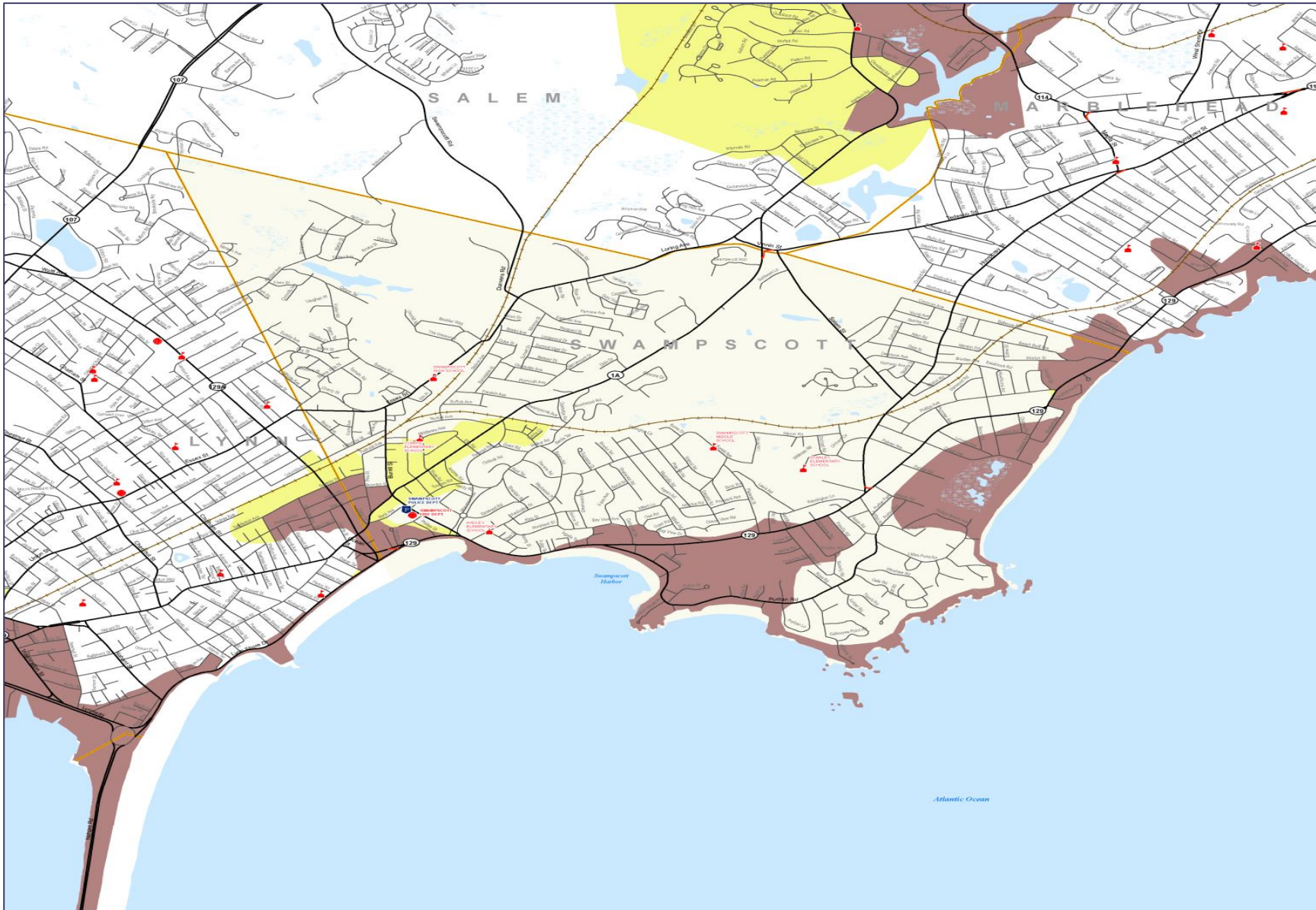


Figure 6-52: Traffic Analysis Zones – Essex County / Swampscott

6.0 Transportation Analysis

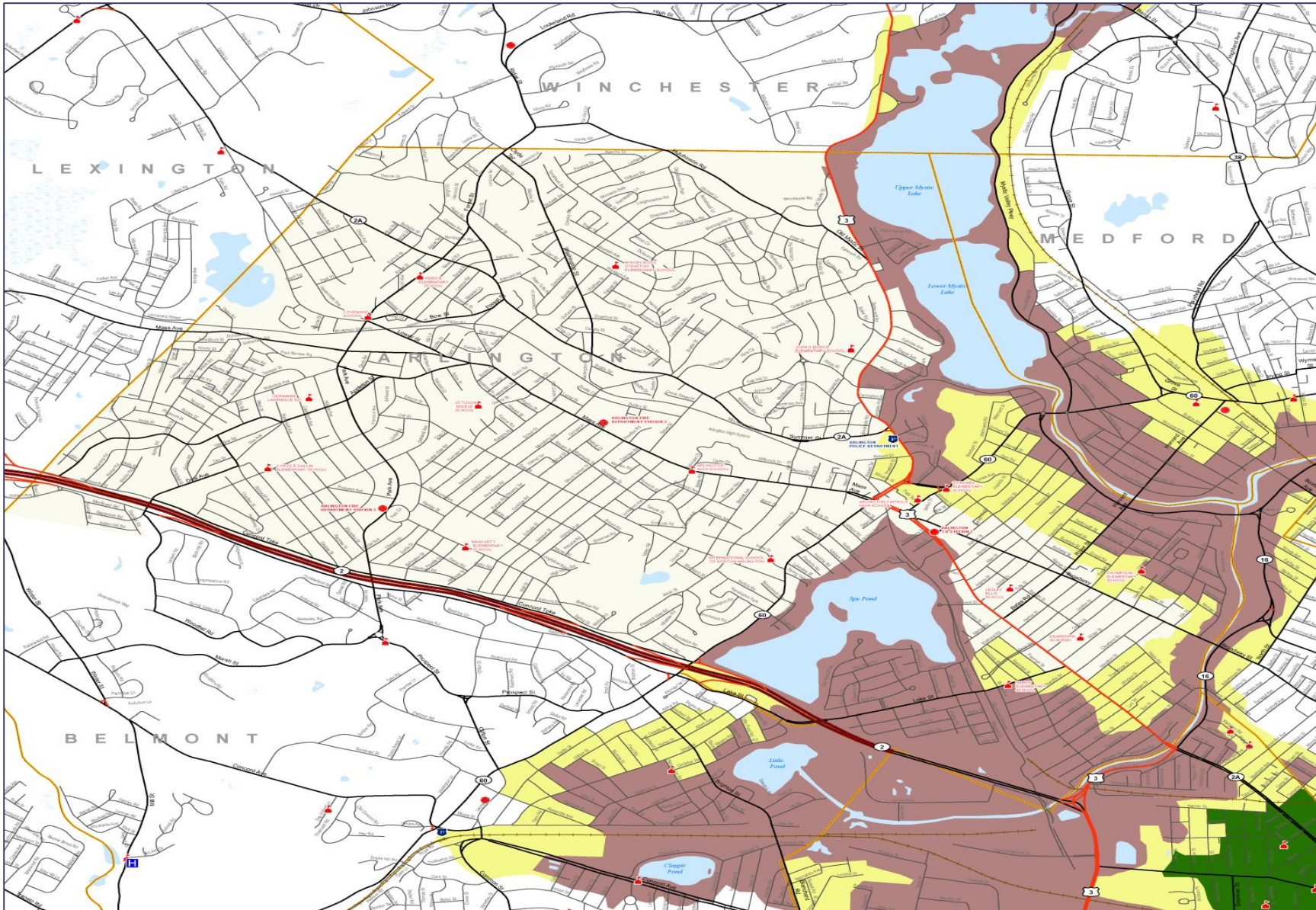


Figure 6-53: Traffic Analysis Zones – Middlesex County / Arlington

6.0 Transportation Analysis

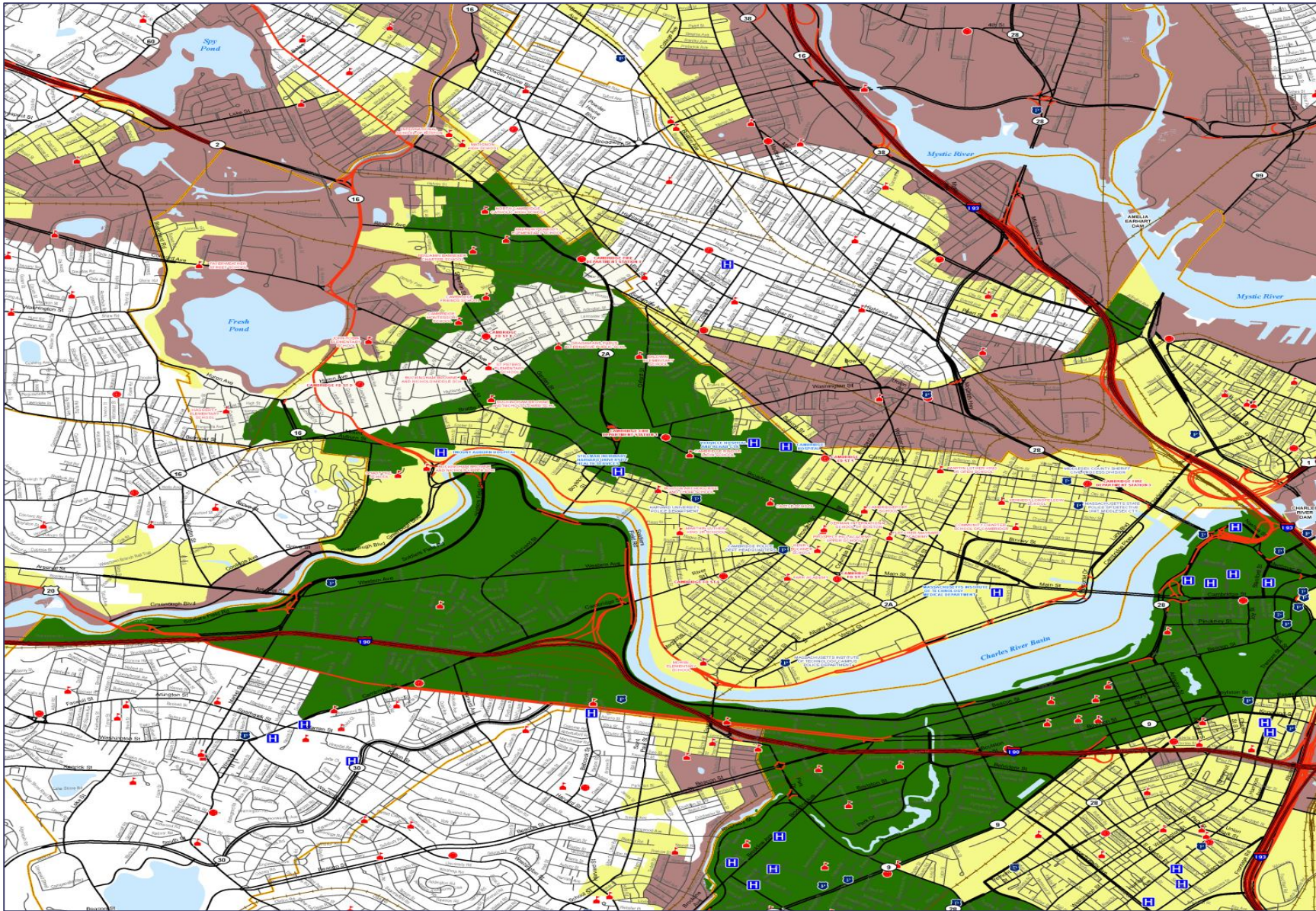


Figure 6-54: Traffic Analysis Zones – Middlesex County / Cambridge



6.0 Transportation Analysis

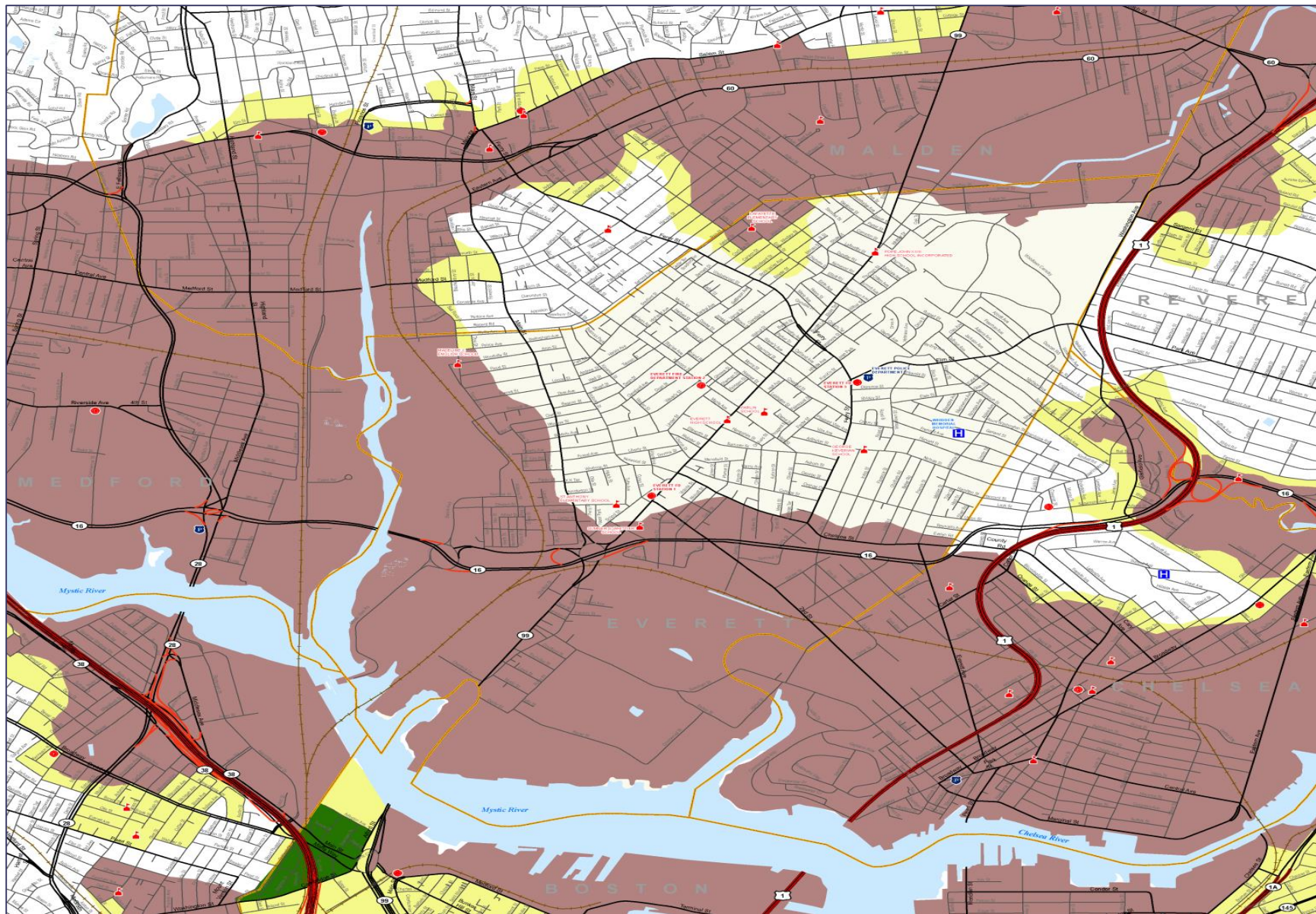


Figure 6-55: Traffic Analysis Zones – Middlesex County / Everett



6.0 Transportation Analysis

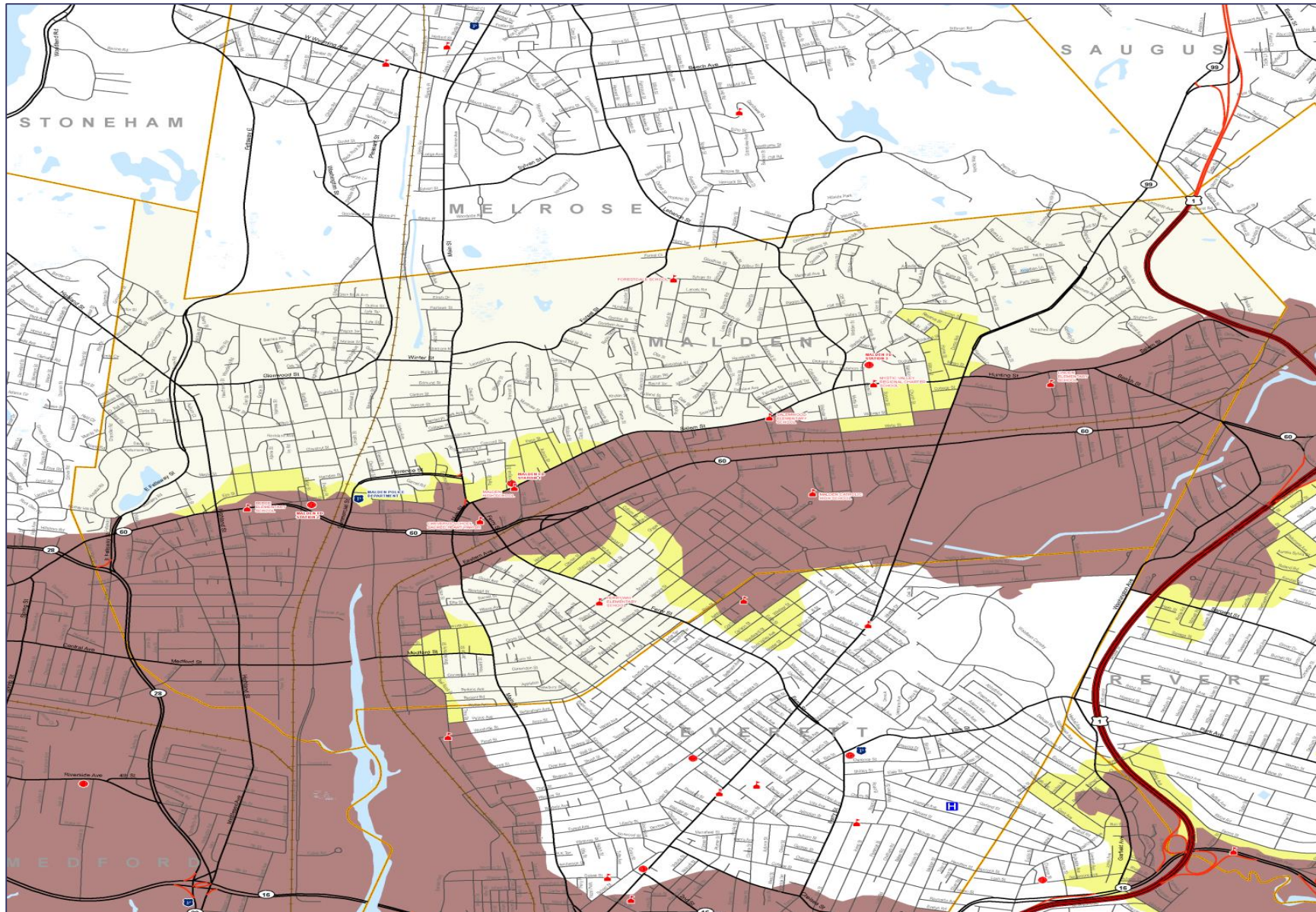


Figure 6-56: Traffic Analysis Zones – Middlesex County / Malden



6.0 Transportation Analysis

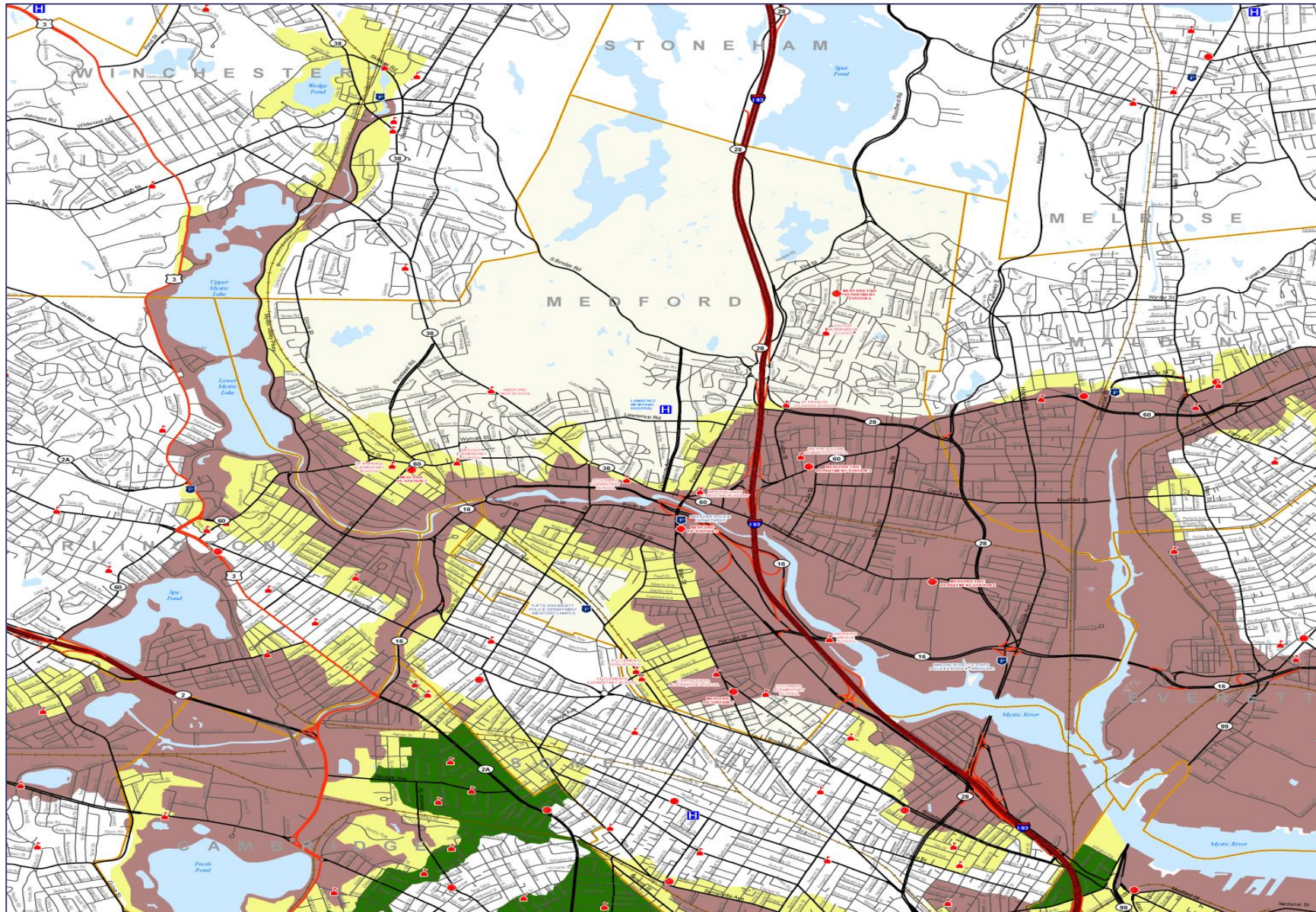


Figure 6-57: Traffic Analysis Zones – Middlesex County / Medford

6.0 Transportation Analysis

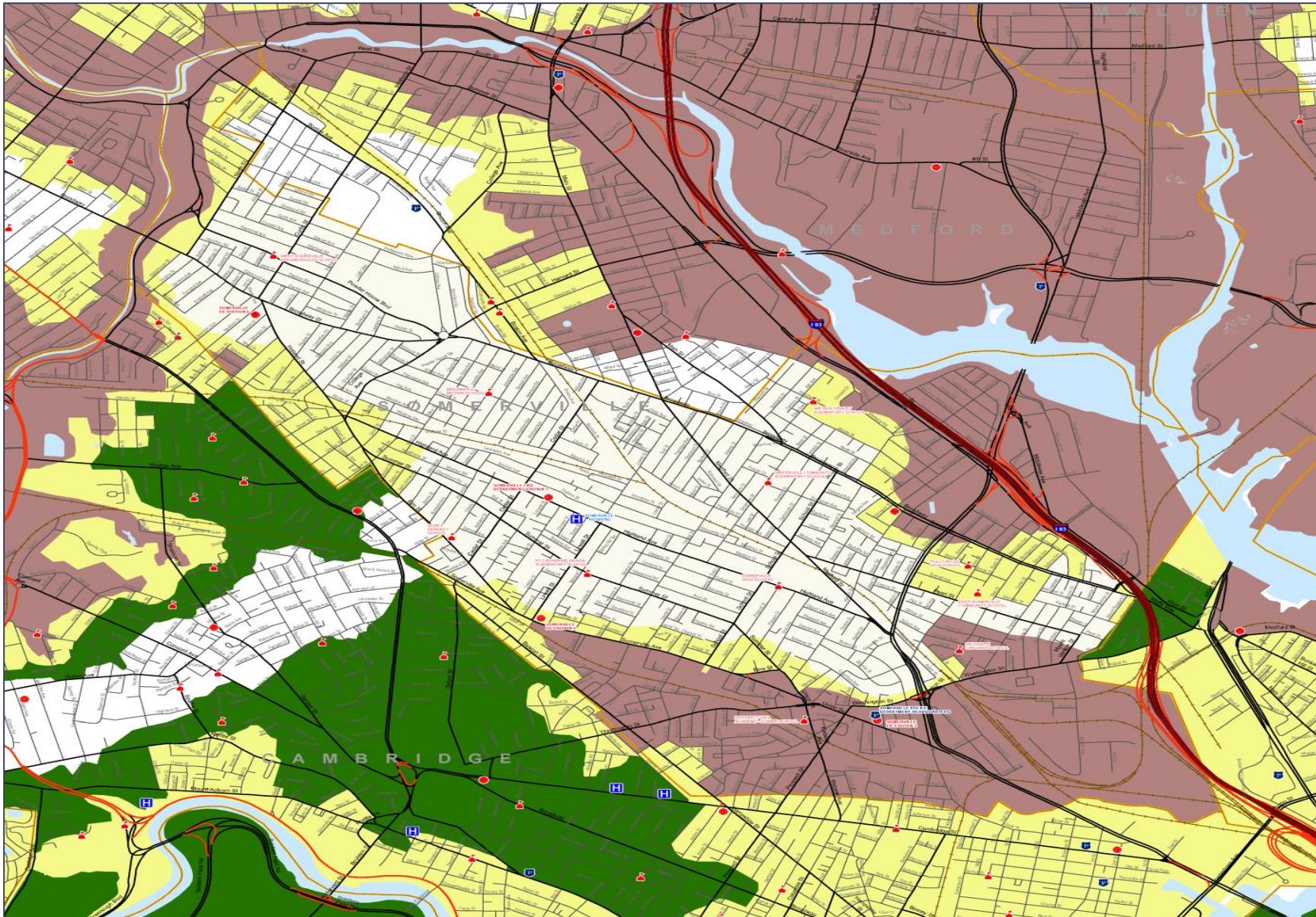


Figure 6-58: Traffic Analysis Zones – Middlesex County / Somerville



6.0 Transportation Analysis

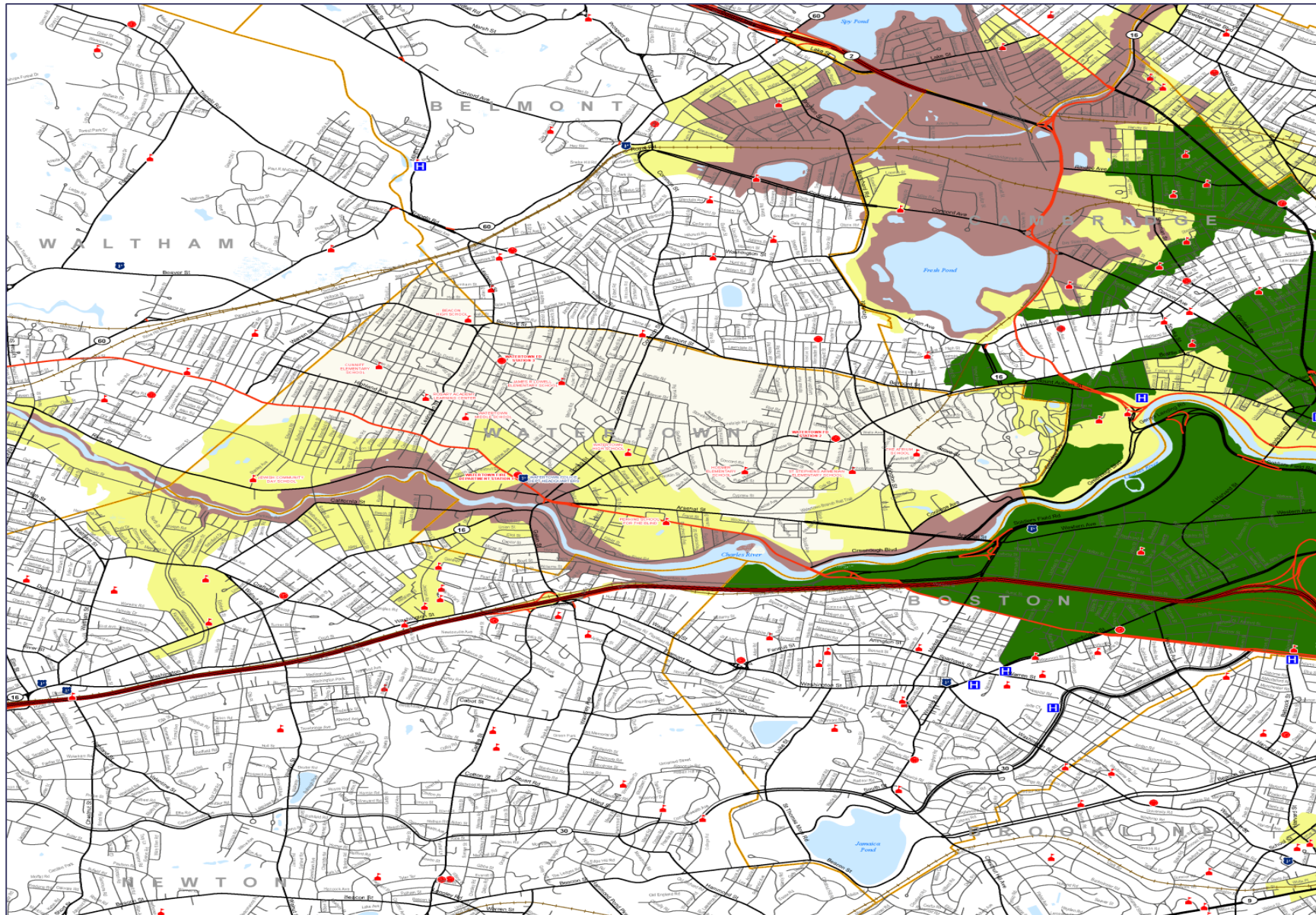


Figure 6-59: Traffic Analysis Zones – Middlesex County / Watertown



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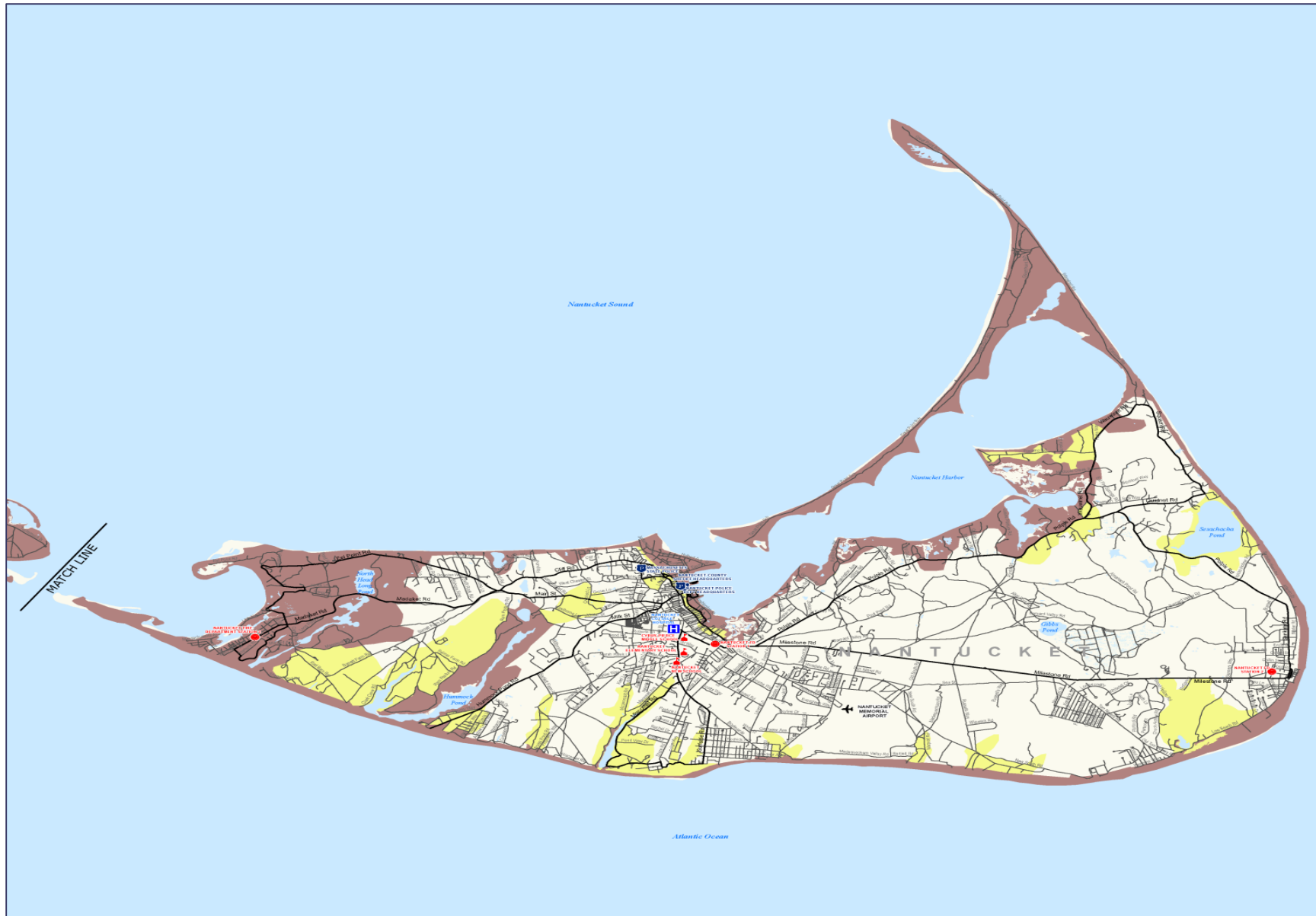


Figure 6-60: Traffic Analysis Zones – Nantucket County / Nantucket

6.0 Transportation Analysis

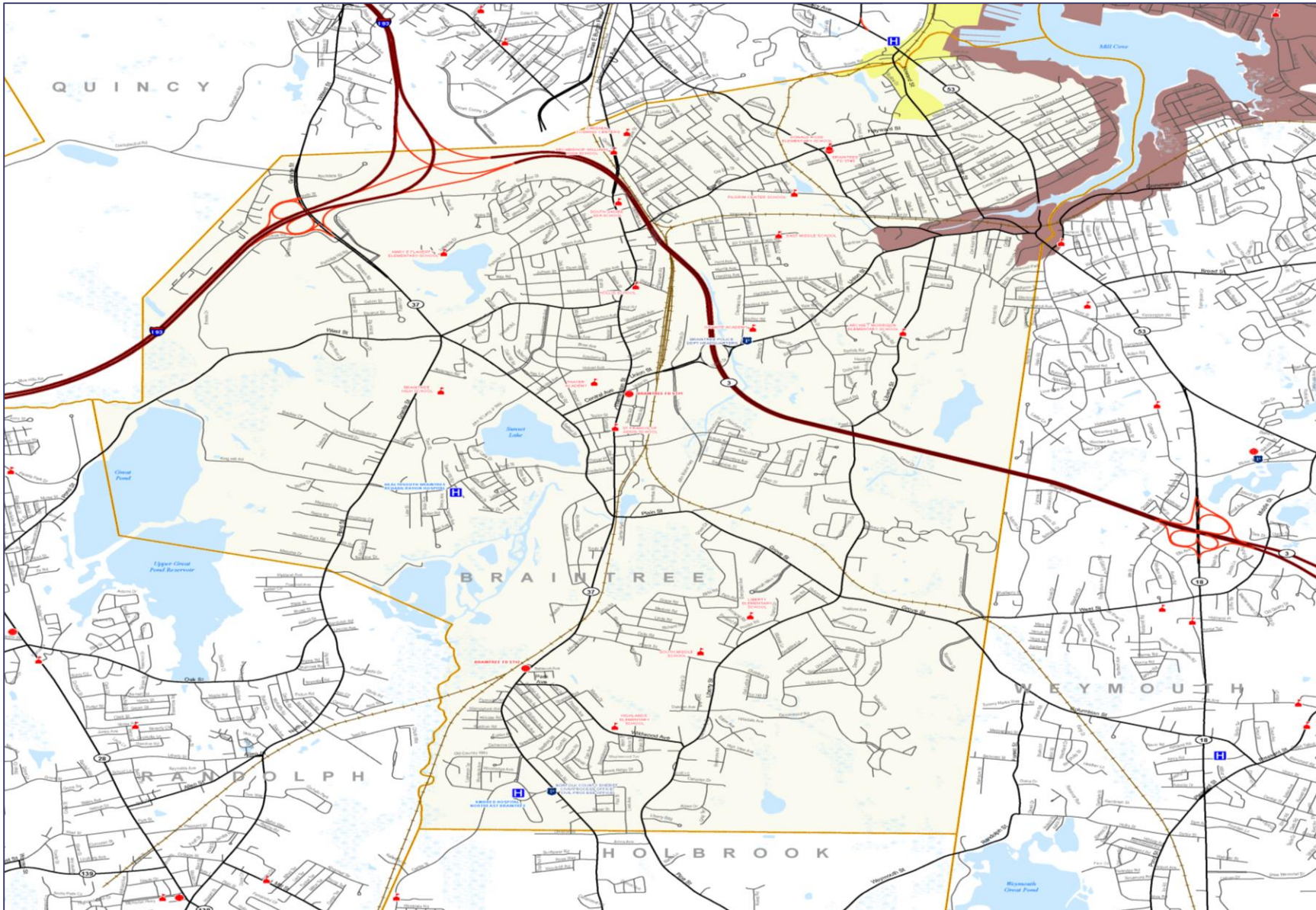


Figure 6-61: Traffic Analysis Zones – Norfolk County / Braintree

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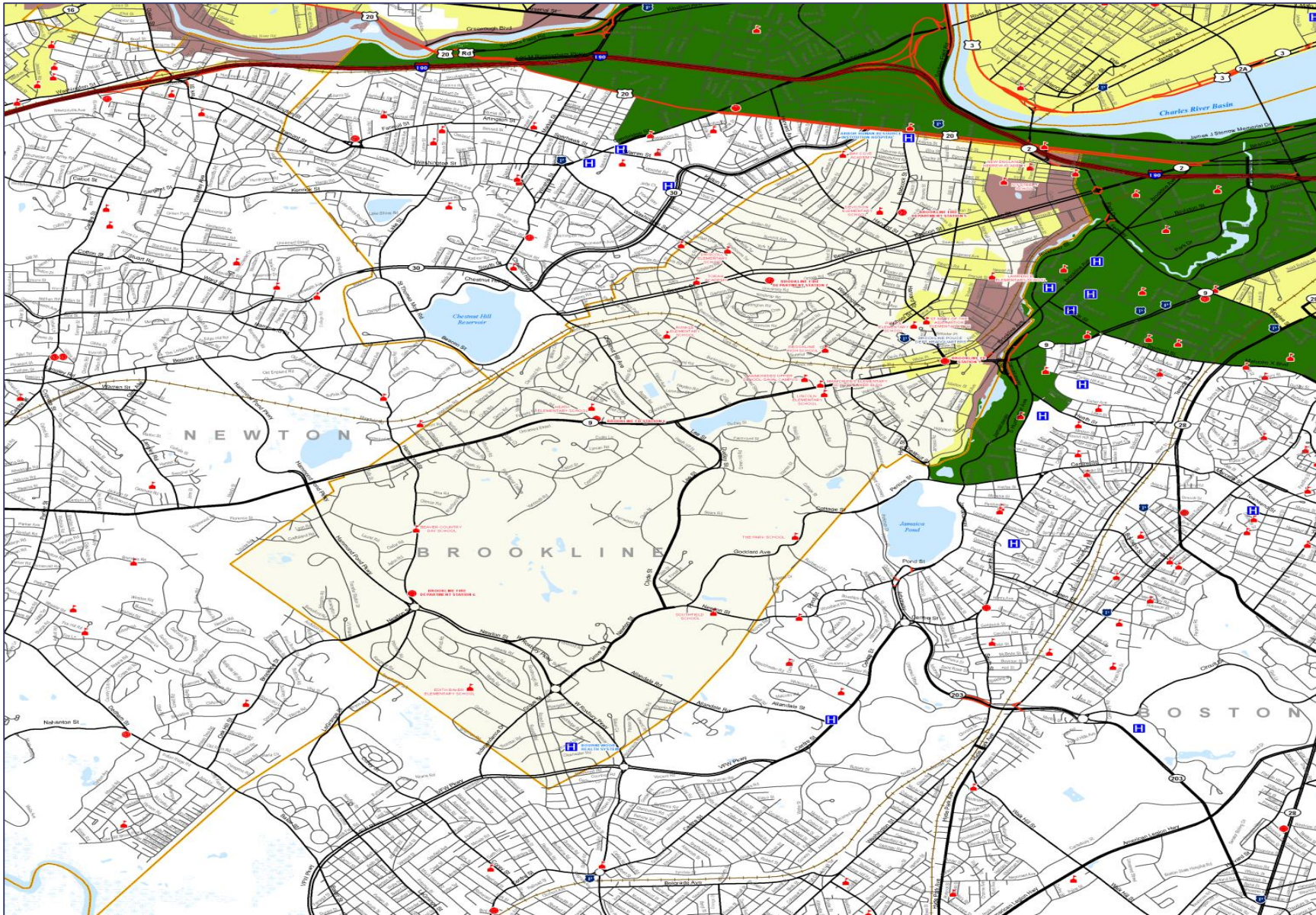


Figure 6-62: Traffic Analysis Zones – Norfolk County / Brookline



6.0 Transportation Analysis

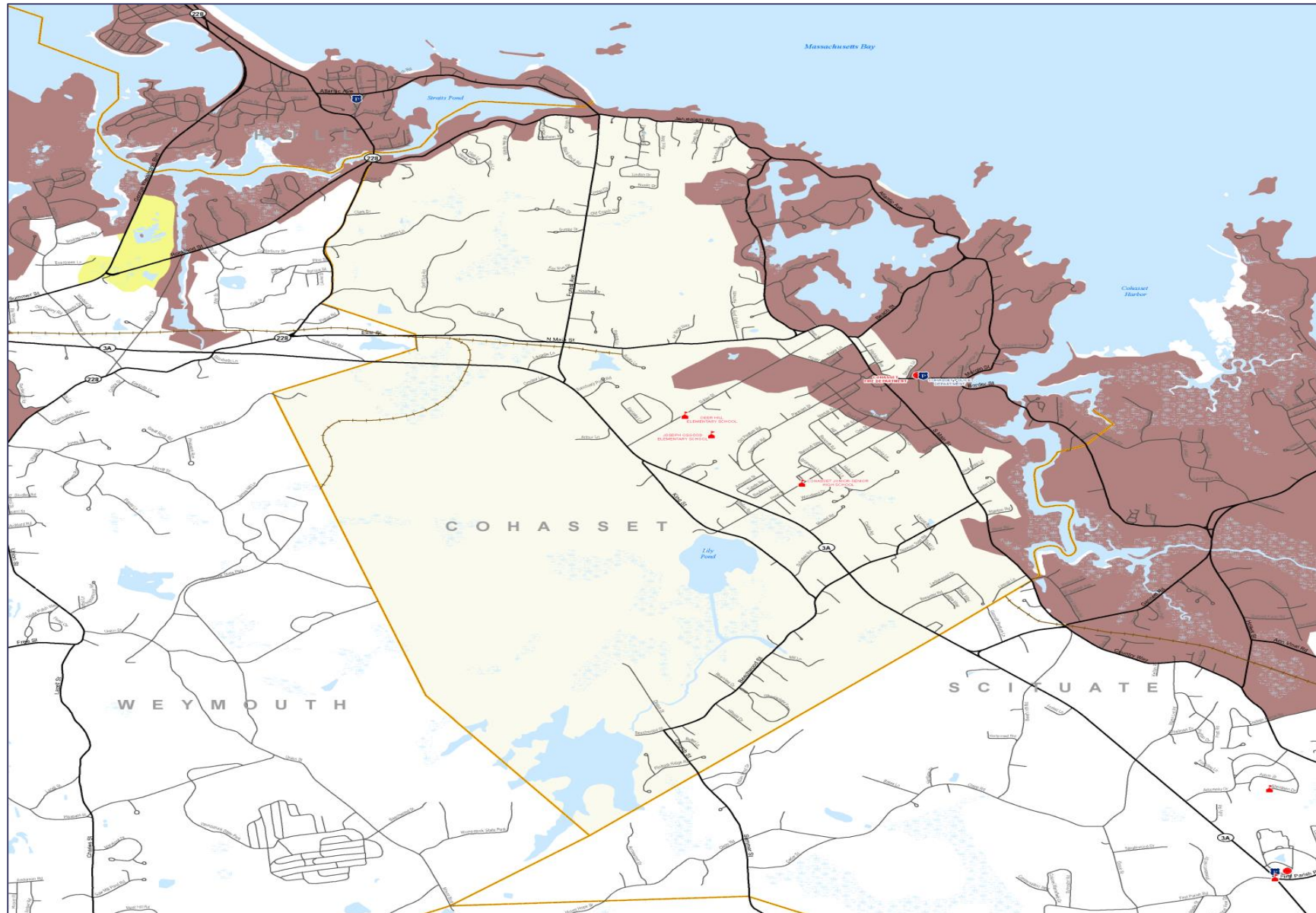


Figure 6-63: Traffic Analysis Zones – Norfolk County / Cohasset

6.0 Transportation Analysis

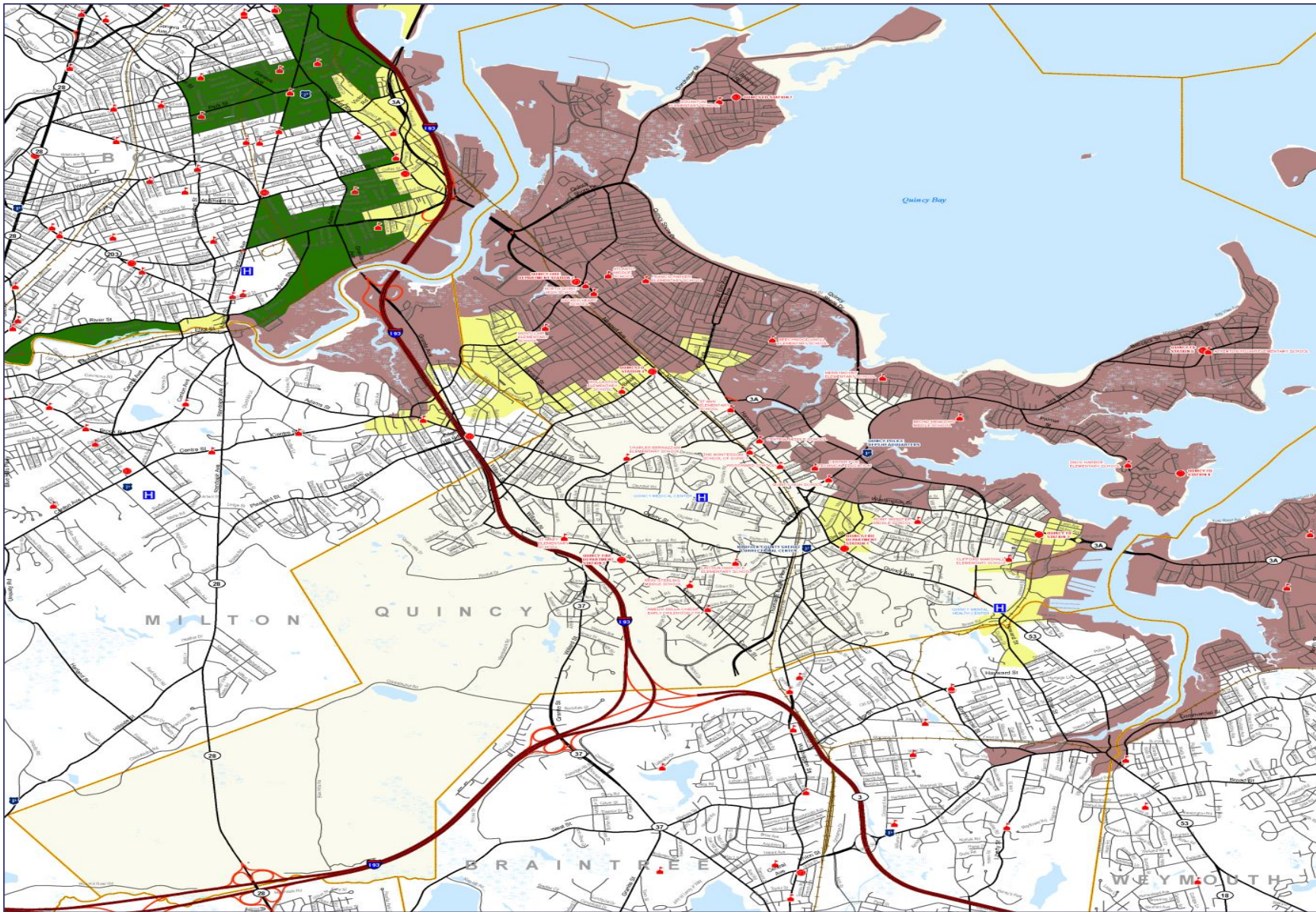


Figure 6-64: Traffic Analysis Zones – Norfolk County / Quincy

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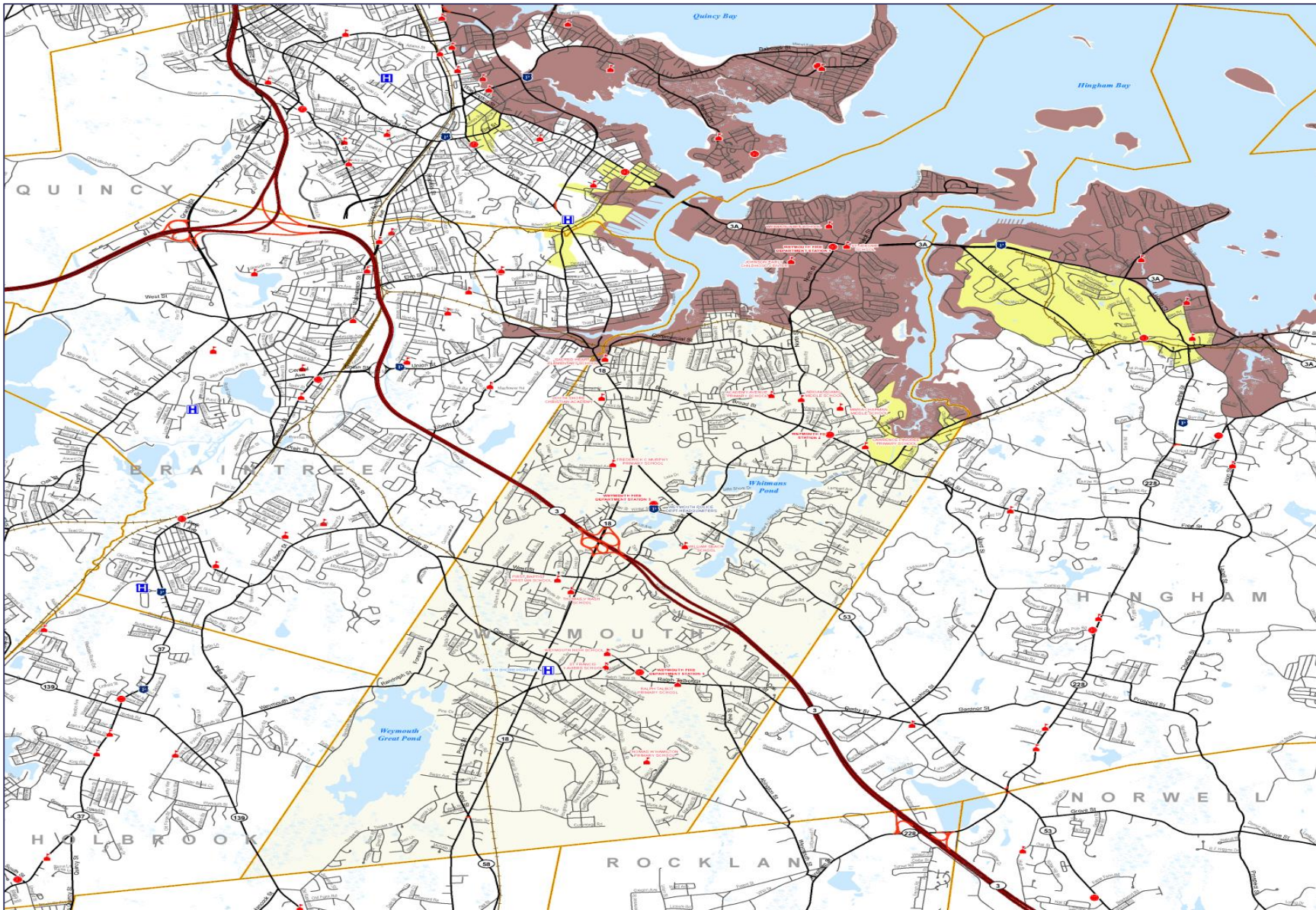


Figure 6-65: Traffic Analysis Zones – Norfolk County / Weymouth



6.0 Transportation Analysis

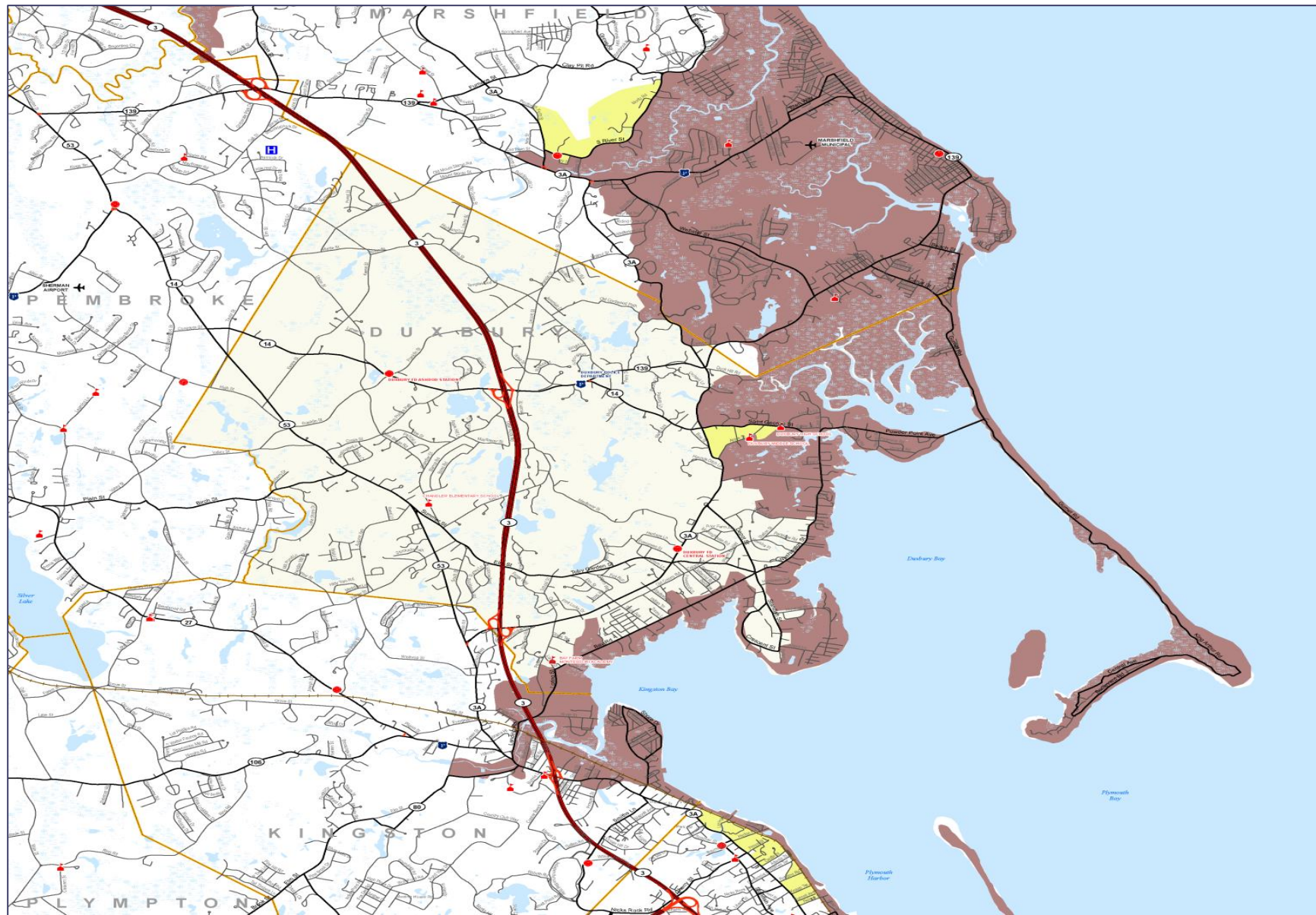


Figure 6-66: Traffic Analysis Zones – Plymouth County / Duxbury



6.0 Transportation Analysis

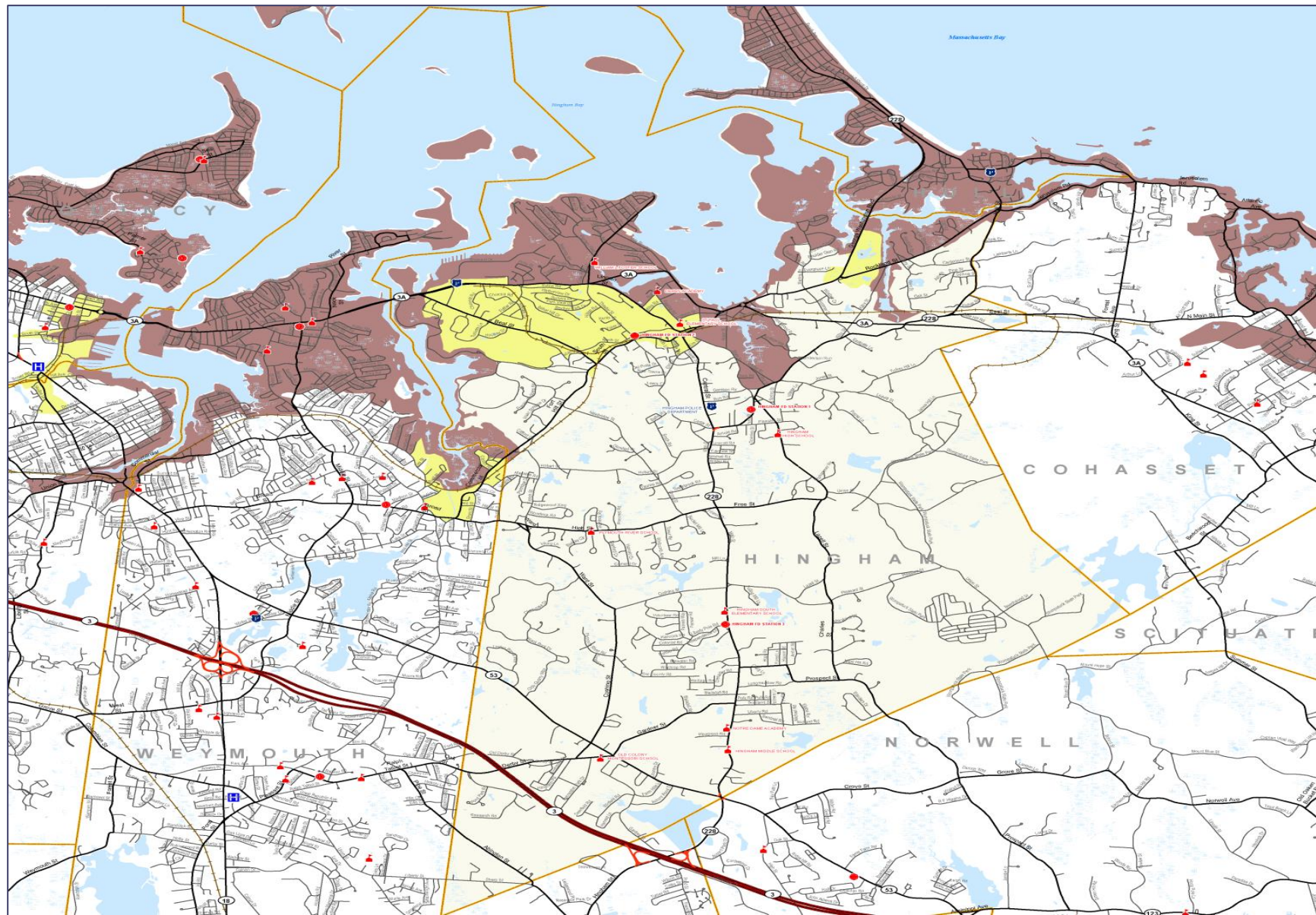


Figure 6-67: Traffic Analysis Zones – Plymouth County / Hingham

6.0 Transportation Analysis

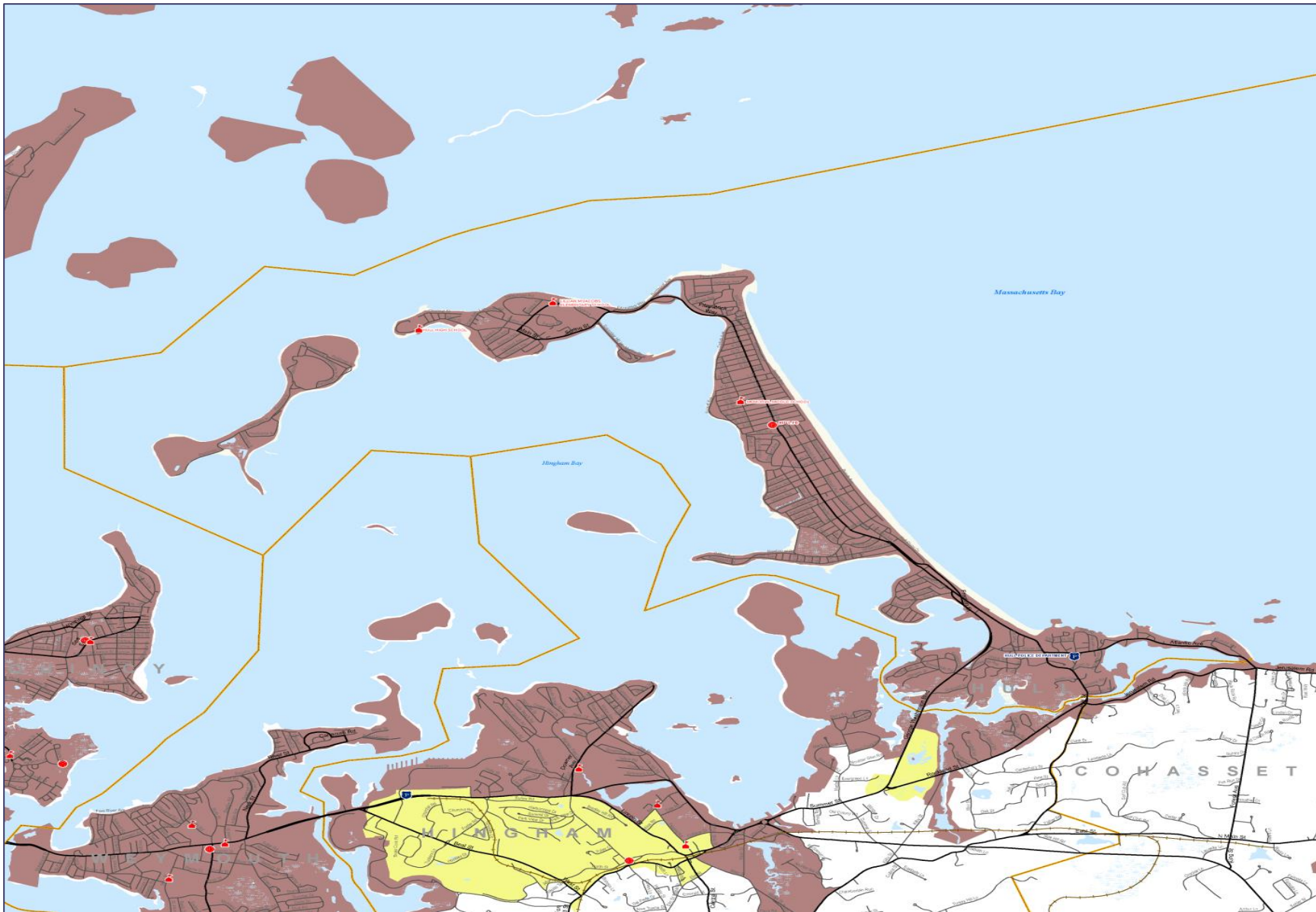


Figure 6-68: Traffic Analysis Zones – Plymouth County / Hull



6.0 Transportation Analysis

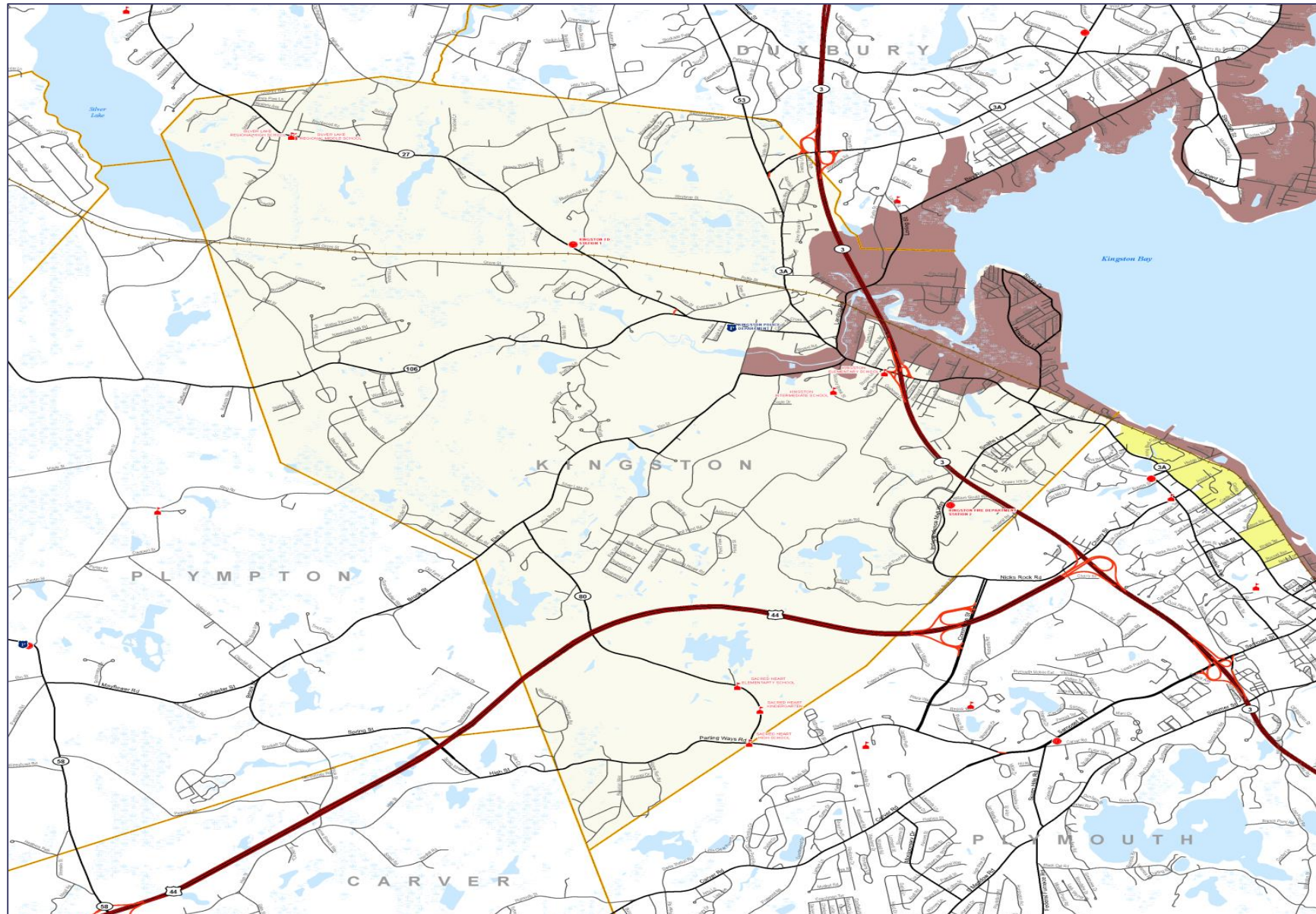


Figure 6-69: Traffic Analysis Zones – Plymouth County / Kingston



6.0 Transportation Analysis

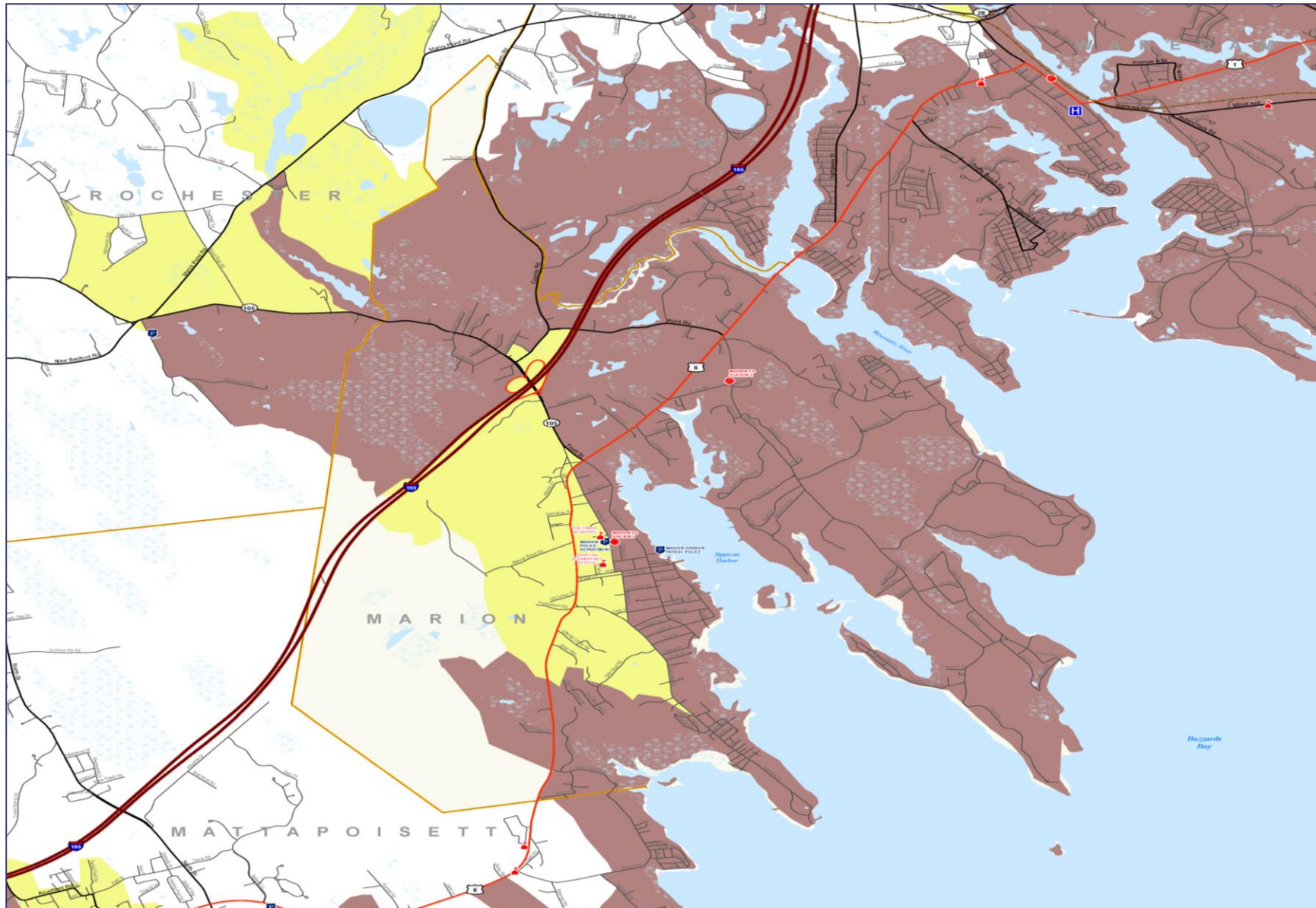


Figure 6-70: Traffic Analysis Zones – Plymouth County / Marion



6.0 Transportation Analysis

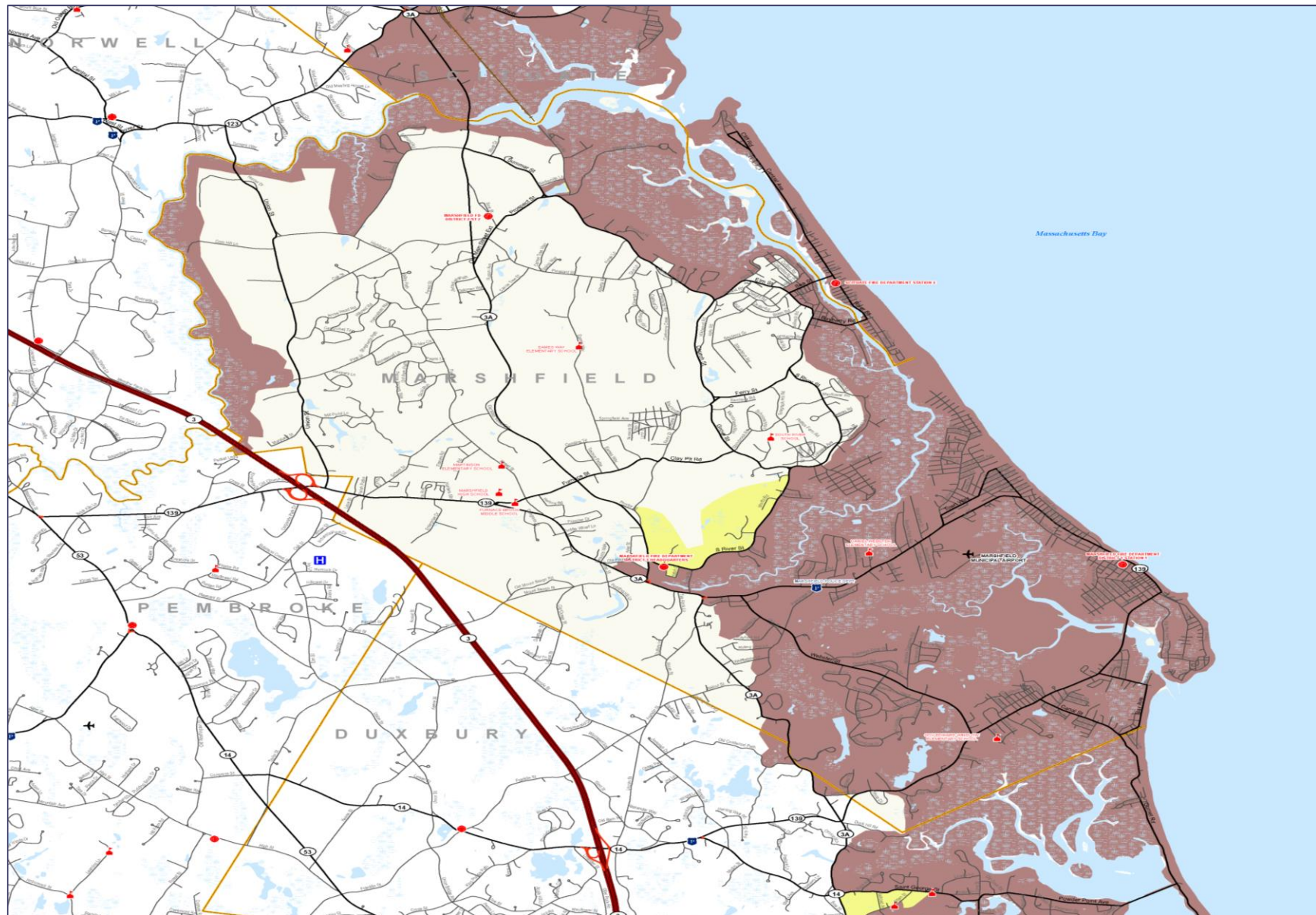


Figure 6-71: Traffic Analysis Zones – Plymouth County / Marshfield



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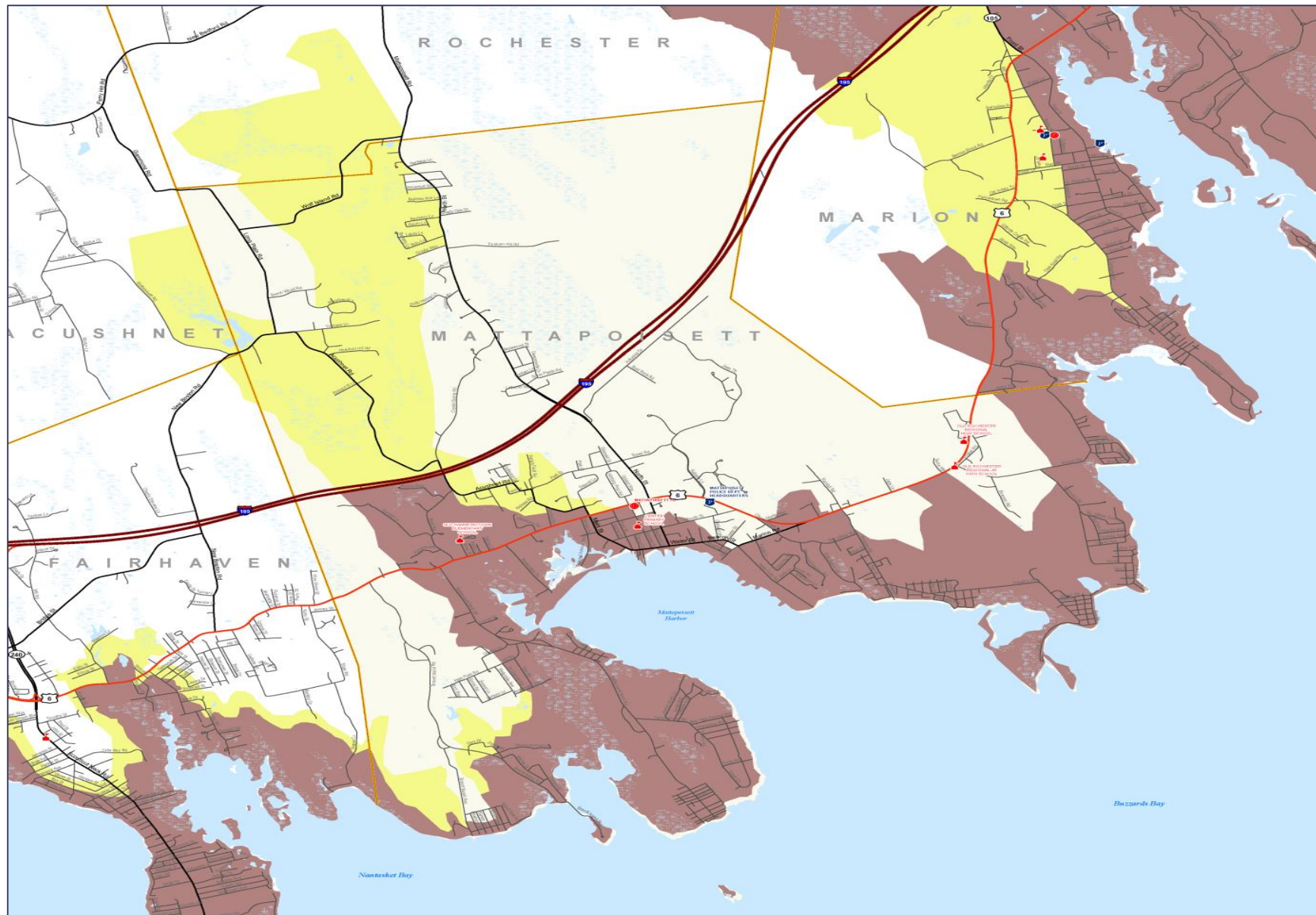


Figure 6-72: Traffic Analysis Zones – Plymouth County / Mattapoisett



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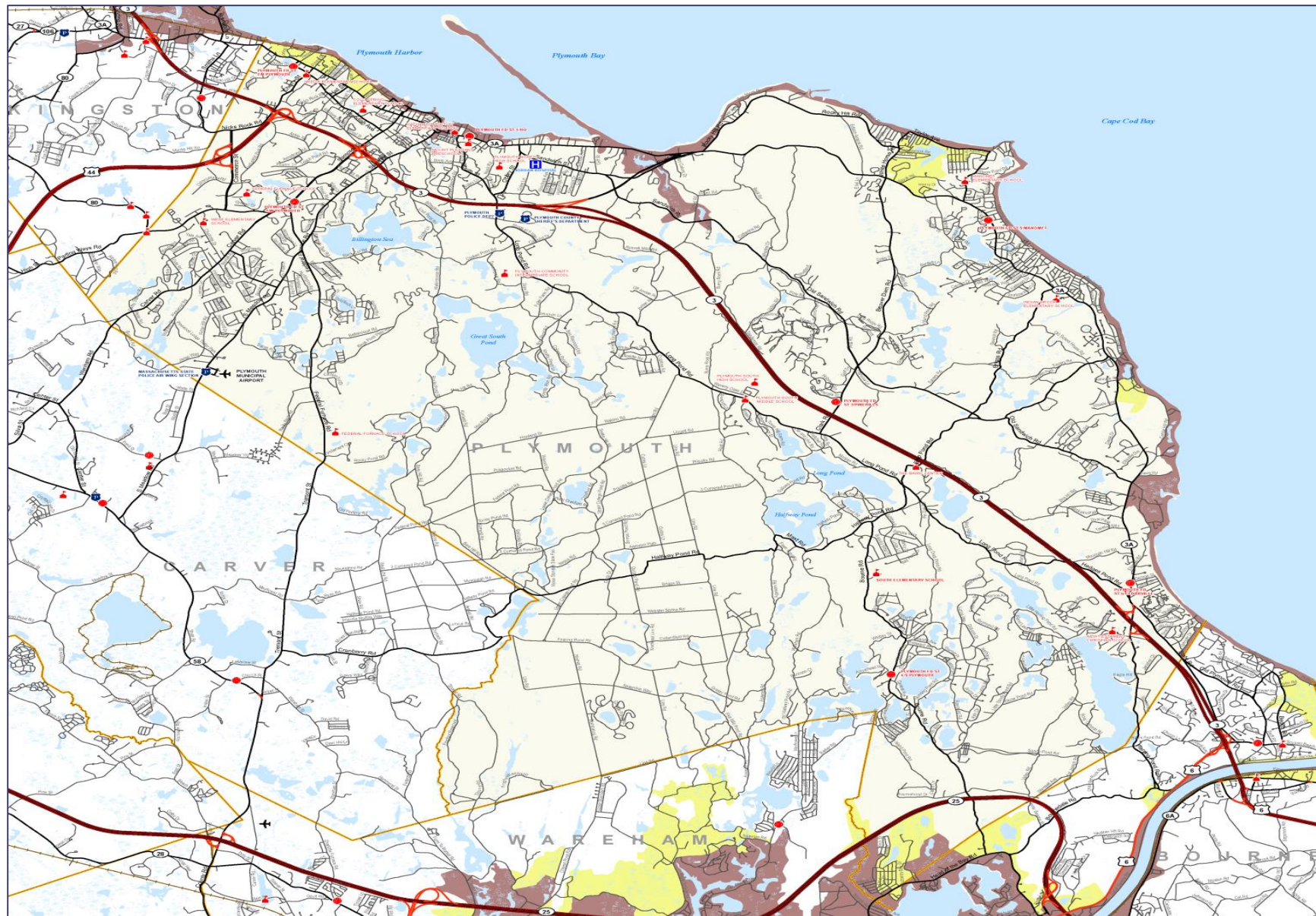


Figure 6-73: Traffic Analysis Zones – Plymouth County / Plymouth



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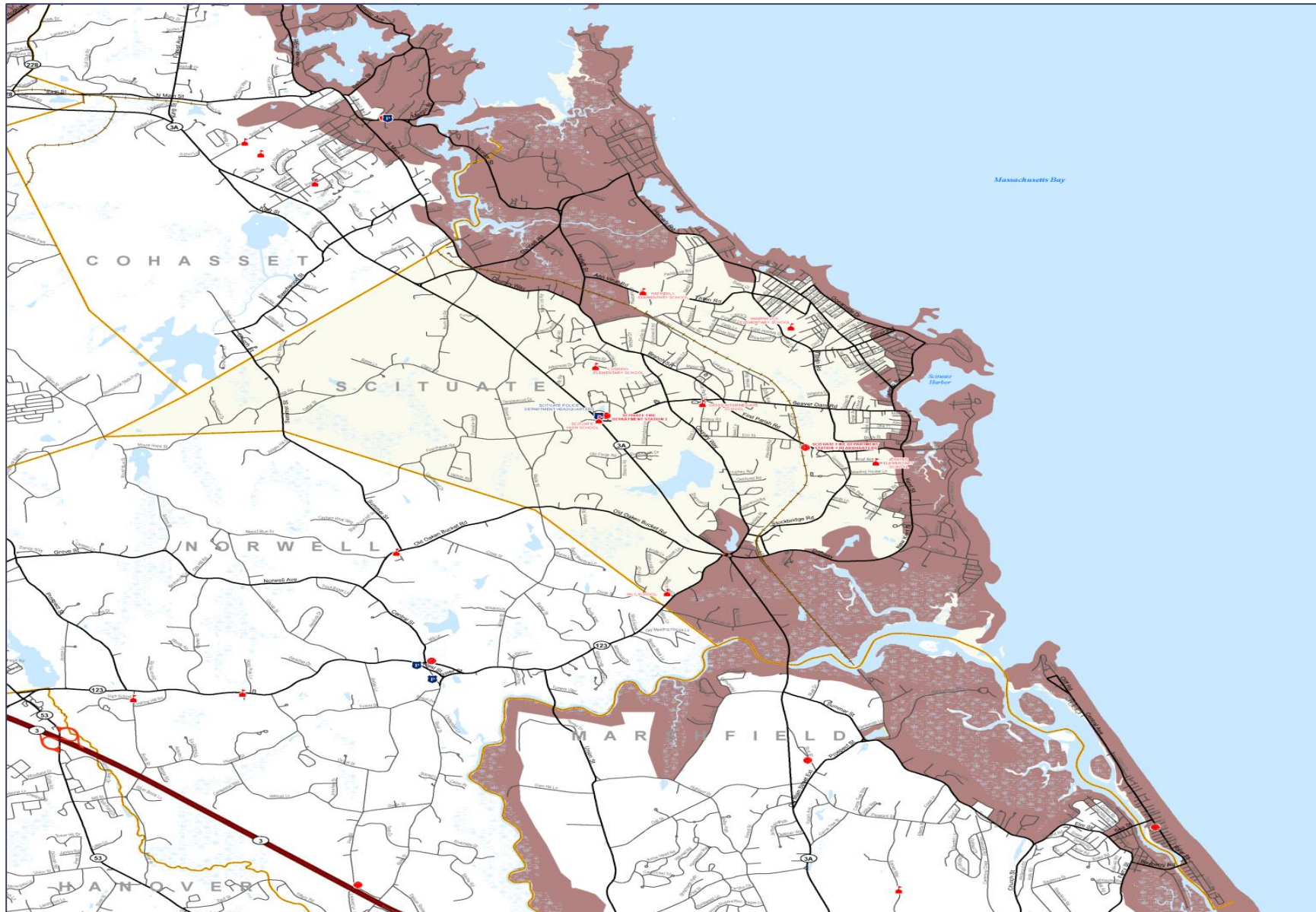


Figure 6-74: Traffic Analysis Zones – Plymouth County / Scituate



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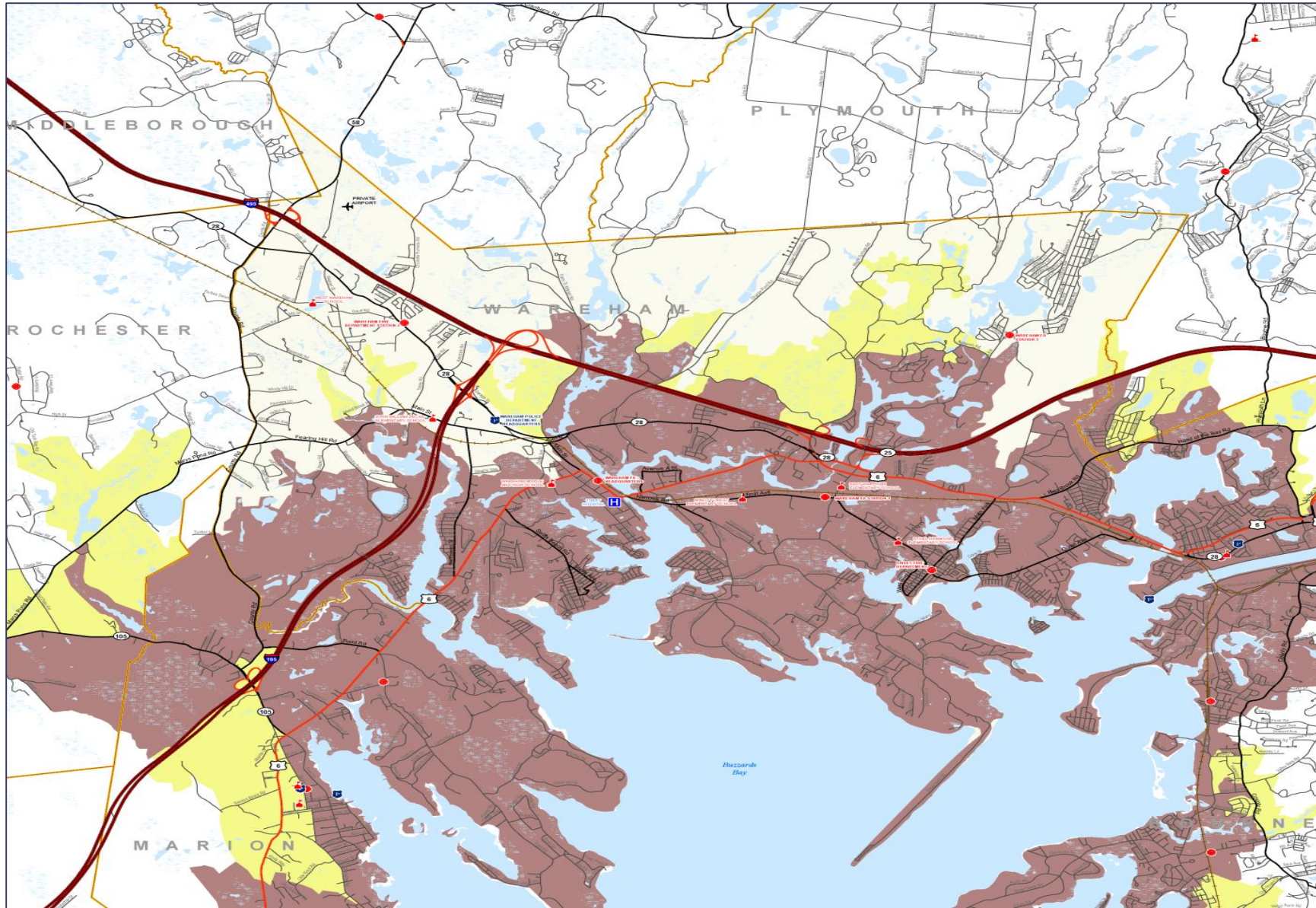


Figure 6-75: Traffic Analysis Zones – Plymouth County / Wareham



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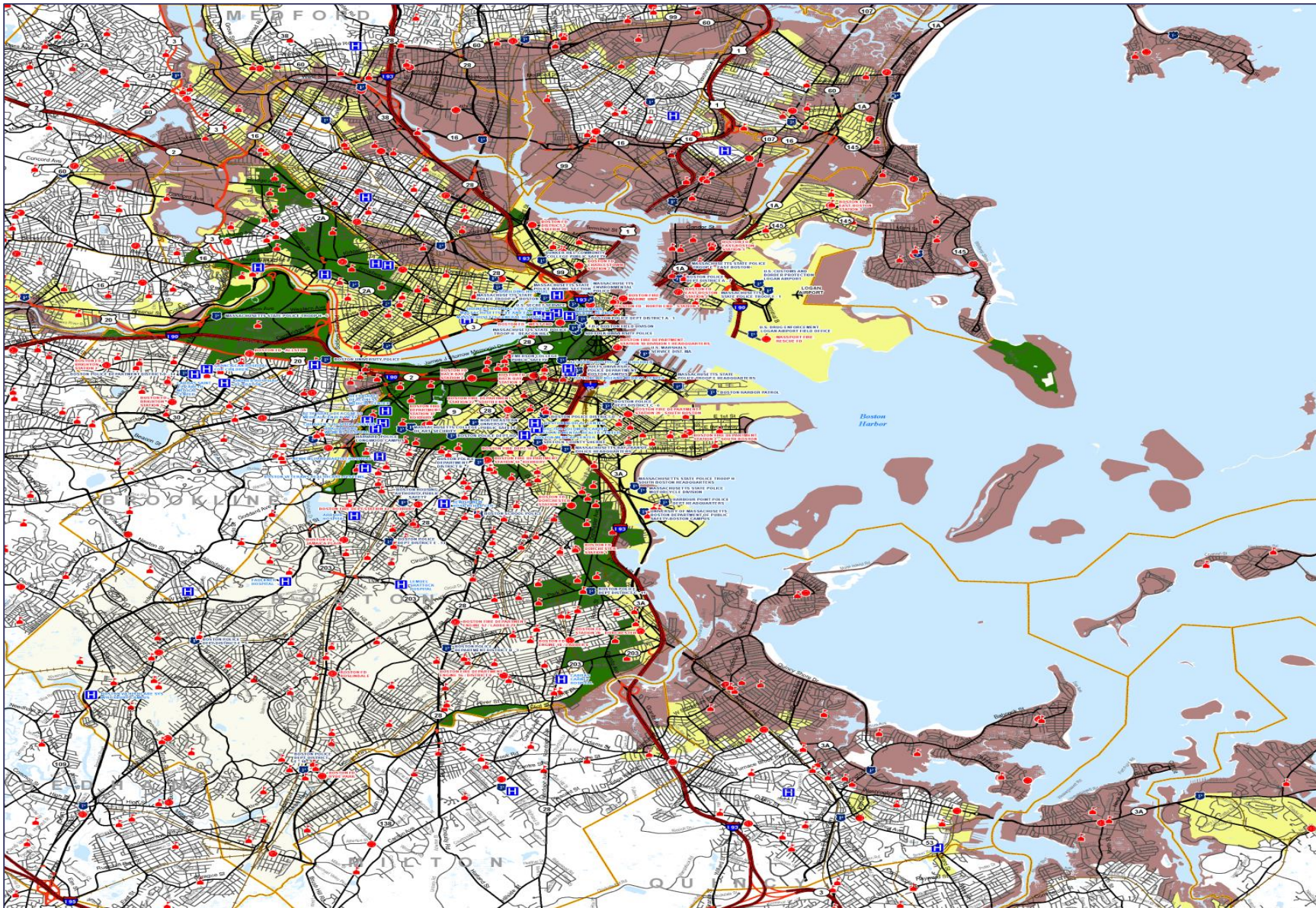


Figure 6-76: Traffic Analysis Zones – Suffolk County / Boston



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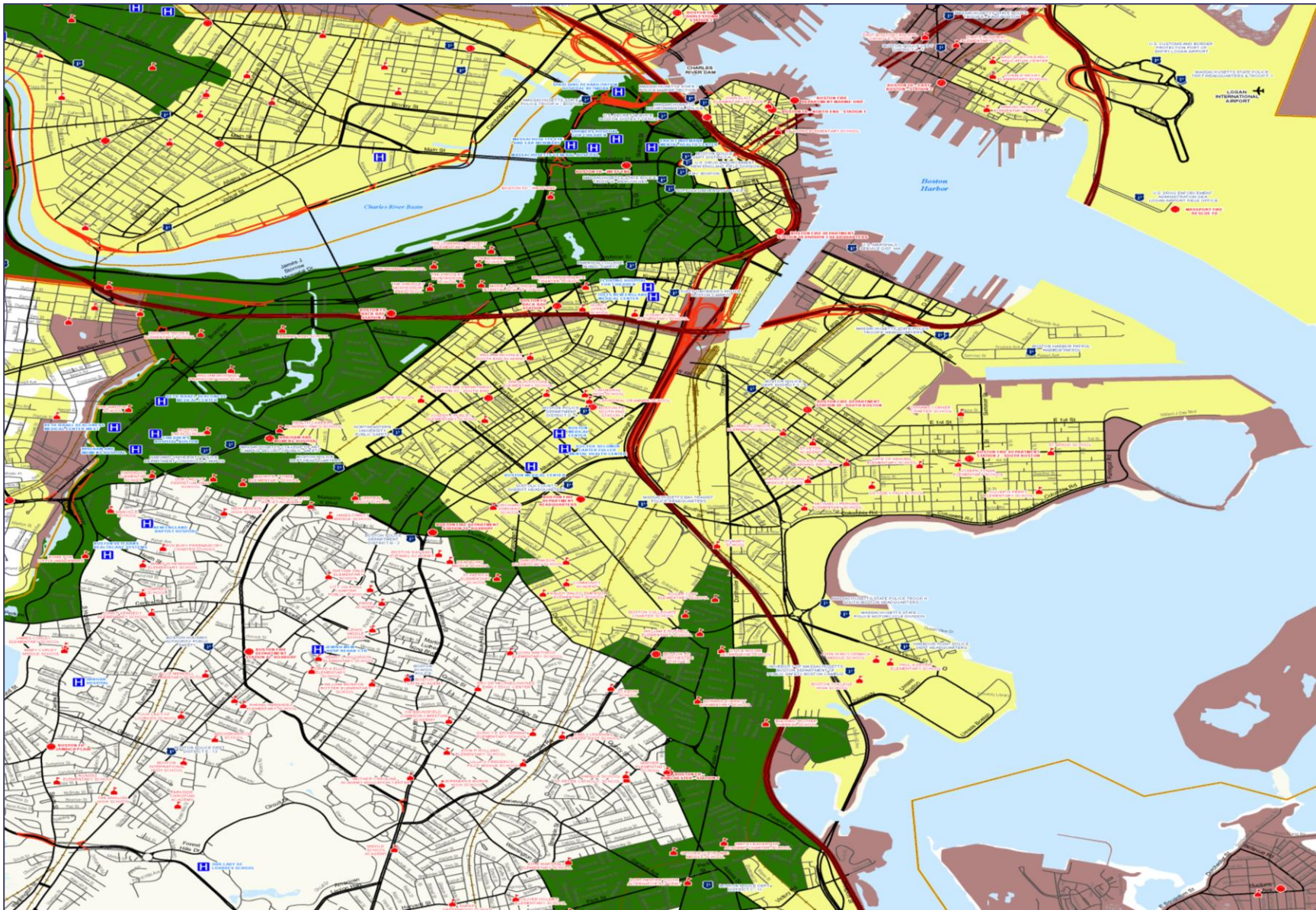


Figure 6-77: Traffic Analysis Zones – Suffolk County / Boston

6.0 Transportation Analysis

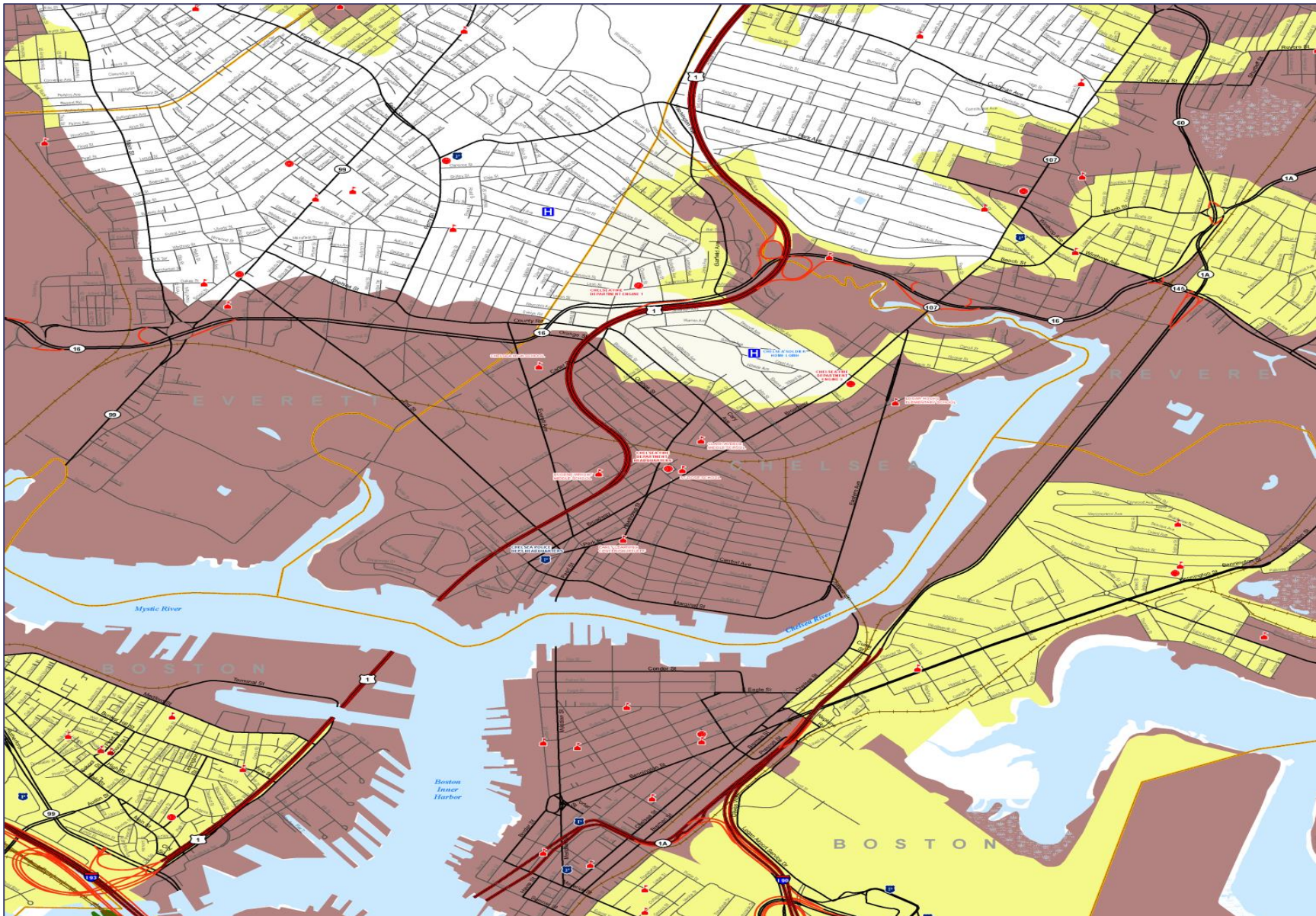


Figure 6-78: Traffic Analysis Zones – Suffolk County / Chelsea



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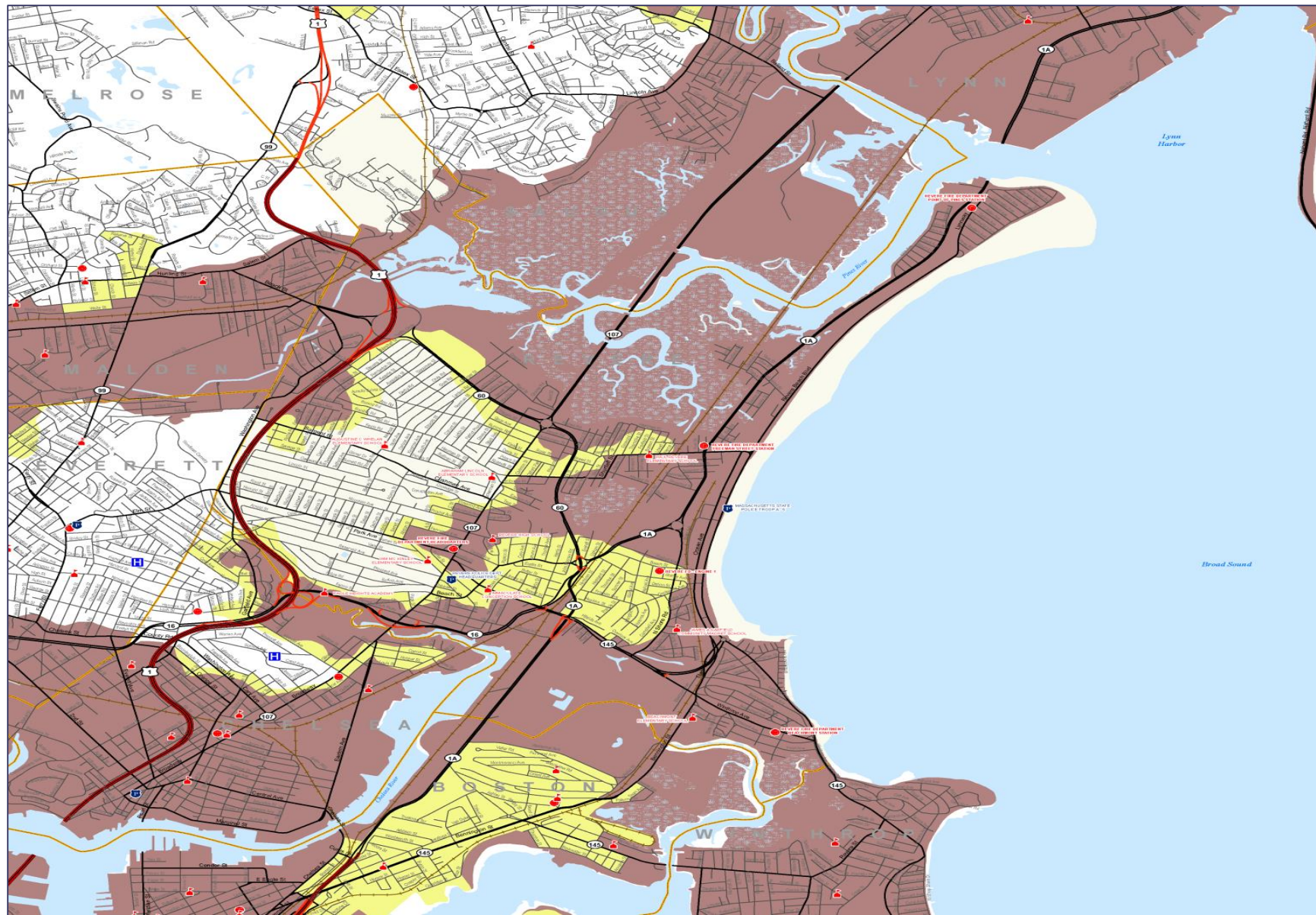


Figure 6-79: Traffic Analysis Zones – Suffolk County / Revere



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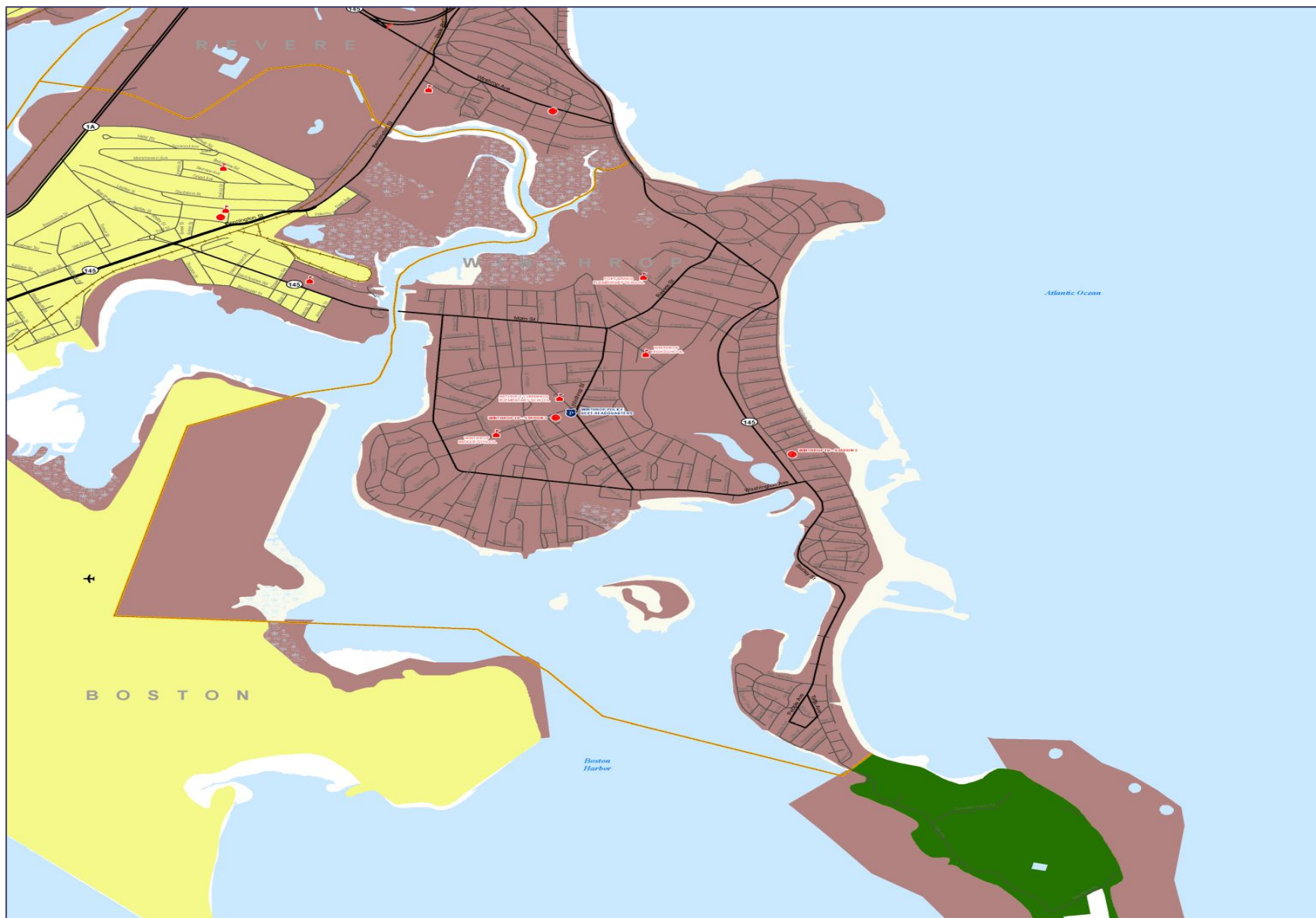


Figure 6-80: Traffic Analysis Zones – Suffolk County / Winthrop



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6.5 Housing Unit and Population Data

All housing unit and other socioeconomic data was developed for each traffic evacuation zone based on data prepared by the U.S. Census Bureau for the 2010 decennial census, as well as 5-year projections from the 2013 American Community Survey. Geographic Information Systems (GIS) were used to further reconfigure the census data to conform to the evacuation/traffic analysis zones that formed the basic unit for this study. In addition the U.S. Census also provided the data for the seasonal/vacation units in each traffic evacuation zones. The number of hotel and motel units on the other hand were obtained by a thorough investigation of various tourist information sites on the internet. Table 6-2 summarizes the key socioeconomic data by county used for the Massachusetts HES TDR locations, as well as jurisdiction-wide averages for the number of people and vehicles per unit for every evacuation zone in the study area.

Table 6-3 shows the socioeconomic data for the Massachusetts HES TDR locations by vulnerability zone. This table represents the total aggregate number located in each vulnerability zone within a county and not the specific population and units that would be directed to evacuate from each sector. Tables 6-4 through Tables 6-8 provide further detail on a community basis for each county as follows:

- Table 6-4: Key Socioeconomic Data – Barnstable County
- Table 6-5: Key Socioeconomic Data – Bristol County
- Table 6-6: Key Socioeconomic Data – Dukes County
- Table 6-7: Key Socioeconomic Data – Essex County
- Table 6-8: Key Socioeconomic Data – Middlesex County
- Table 6-9: Key Socioeconomic Data – Nantucket County
- Table 6-10: Key Socioeconomic Data – Norfolk County
- Table 6-11: Key Socioeconomic Data – Plymouth County
- Table 6-12: Key Socioeconomic Data – Suffolk County

The socioeconomic data used in the transportation model focuses on three types of housing units to determine the vulnerability data included in the evacuation statistics. The most important housing category is occupied residential; these are the full time inhabitants most likely to be impacted by evacuation decisions throughout the hurricane season, especially if located in storm surge areas. Also included in this resident group is the student population, especially in Boston and Cambridge, since this segment of the demographic will be present during the later portions of any hurricane season. The model also factors in occupied, mobile homes residences because of their vulnerability to hurricane winds, regardless of distance from



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the storm tide limits or proximity to the coast. The third housing type used in the model is seasonal/vacation and tourist units; people in these units, although their numbers may vary from day to day during the hurricane season, are more likely to evacuate and will usually travel further to do so.

In the transportation model, each housing type described above will have specific socioeconomic and behavioral variables assigned to it to ensure that the inherent differences in the responses of their inhabitants during a hurricane event are factored into the vulnerability data. For instance the number of vehicles and people per unit will vary, in some cases dramatically, between occupied residential and seasonal/tourist units. Furthermore, this degree of specificity allows the model to factor in variations in occupancy levels, especially with respect to visitor units.



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Table 6-2: Key Socioeconomic Data

County	Population ¹	Permanent Occupied Units ¹	Mobile Home Units ¹	Seasonal Vacation Units ¹	Tourist Motel / B&B Units ²	Average People per Occupied Housing Unit ¹	Average Vehicle per Occupied Housing Unit ¹
Barnstable County	215,450	95,538	1,102	56,724	12,459	2.10	1.69
Bristol County	411,553	162,822	1,527	2,481	1,154	2.49	1.80
Dukes County	16,460	7,329	153	9,079	747	2.17	1.32
Essex County	412,247	166,554	1,407	4,796	3,598	2.29	1.60
Middlesex County	650,902	266,379	224	1,553	6,339	2.41	1.42
Nantucket County	10,179	4,232	147	24,883	1,956	2.28	1.61
Norfolk County	276,778	114,600	203	870	1,286	2.35	1.45
Plymouth County	199,289	76,579	2,041	9,388	716	2.41	1.76
Suffolk County	878,605	358,814	409	3,239	19,341	2.23	0.98
Totals / Averages	3,071,463	1,252,847	7,213	113,013	47,596	2.30	1.51

1. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
2. Obtained from various Massachusetts lodging websites.



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Table 6-3: Housing Unit and Population Data by Evacuation Zone

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Barnstable County	44,144	20,909	328	26,961	4,802	2.02	1.68
	21,285	10,437	11	6,875	1,946	2.05	1.67
	150,021	64,192	763	22,888	5,711	2.22	1.71
Bristol County	22,650	9,462	16	1,407	207	2.34	1.76
	40,928	16,865	29	95	70	2.42	1.73
	347,975	136,495	1,482	979	877	2.71	1.91
Dukes County	2,016	976	4	2,615	328	2.03	1.36
	1,006	506	19	1,179	188	2.21	1.13
	13,438	5,847	130	5,285	231	2.27	1.49
Essex County	75,461	32,376	103	2,951	524	2.31	1.69
	29,598	12,164	0	154	254	2.20	1.49
	307,188	122,014	1,304	1,691	2,820	2.37	1.62
Middlesex County	88,283	37,793	72	137	760	2.33	1.48
	136,488	59,251	11	425	3,123	2.39	1.37
	48,163	21,032	0	213	319	2.29	0.96
	377,968	148,303	141	778	2,137	2.54	1.44
Nantucket County	636	317	39	1,790	276	2.01	1.73
	724	304	1	656	86	2.38	1.50
	8,819	3,611	107	4,279	100	2.44	1.62
Norfolk County	59,837	25,381	13	233	140	2.47	1.54
	16,789	7,413	0	47	235	2.01	1.21
	200,152	81,806	190	590	911	2.56	1.59

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



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Table 6-3: Housing Unit and Population Data by Evacuation Zone (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Plymouth County	64,641	26,752	644	6,835	344	2.43	1.89
	8,001	3,273	0	220	0	2.30	1.60
	126,647	46,554	1,397	2,333	372	2.49	1.79
Suffolk County	101,230	40,225	146	444	1,875	2.50	1.44
	196,260	88,843	24	844	8,719	1.92	0.85
	225,198	90,619	25	1,607	8,673	2.49	0.83
	355,917	139,127	214	344	74	2.01	0.80
Totals / Averages	458,898	194,191	1,365	43,373	9,256	2.27	1.62
	451,079	199,056	95	10,495	14,621	2.21	1.39
	273,361	111,651	25	1,820	8,992	2.39	0.90
	1,888,125	747,949	5,728	39,167	13,233	2.40	1.55
Overall Totals / Averages	3,071,463	1,252,847	7,213	94,855	46,102	2.32	1.37

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



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Table 6-4: Key Socioeconomic Data – Barnstable County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Barnstable	5,461	2,549	0	2,462	550	2.14	1.74
	1,207	574	0	383	76	2.10	1.54
	38,343	15,996	58	2,916	1,830	2.40	1.76
Bourne	7,641	3,016	0	1,724	36	2.53	1.74
	1,491	675	0	115	0	2.21	1.82
	10,597	4,165	163	380	505	2.54	1.85
Brewster	207	105	0	168	119	1.98	1.84
	303	150	0	175	16	2.01	1.87
	9,276	4,113	0	2,790	701	2.26	1.83
Chatham	979	488	8	1,334	256	2.01	1.51
	545	304	0	211	0	1.80	1.80
	4,614	2,300	0	2,346	248	2.01	1.62
Dennis	5,545	2,883	31	5,221	902	1.92	1.51
	768	358	0	382	6	2.14	1.63
	7,855	3,668	185	2,309	20	2.14	1.61
Eastham	629	320	0	539	3	1.96	1.52
	888	428	0	467	29	2.07	1.50
	3,428	1,634	0	2,315	470	2.10	1.88
Falmouth	9,717	4,689	118	4,772	572	2.07	1.72
	4,153	1,995	0	572	62	2.08	1.60
	17,721	7,412	0	1,769	170	2.39	1.76

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-4: Key Socioeconomic Data – Barnstable County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Harwich	2,046	1,058	0	1,810	233	1.93	1.80
	1,088	621	0	726	25	1.75	1.53
	9,089	3,935	32	1,620	29	2.31	1.70
Mashpee	2,696	1,285	0	2,332	33	2.10	1.95
	192	89	0	34	0	2.16	1.78
	11,112	4,741	110	1,042	131	2.34	1.67
Orleans	1,129	529	0	660	20	2.14	1.74
	341	145	0	102	45	2.36	1.73
	4,406	2,270	50	1,288	226	1.94	1.74
Provincetown	123	82	0	347	177	1.51	1.14
	2,632	1,584	11	1,997	951	1.66	1.13
	209	113	0	46	0	1.85	1.14
Sandwich	770	347	0	353	70	2.22	1.86
	1,997	913	0	514	30	2.19	1.83
	17,848	6,493	0	422	192	2.75	1.94
Truro	113	62	0	397	119	1.81	1.83
	164	79	0	188	228	2.07	1.82
	1,411	688	25	1,090	677	2.05	1.81
Wellfleet	1,433	749	171	1,717	26	1.91	1.74
	46	23	0	33	0	2.00	1.84
	1,511	713	123	1,245	288	2.12	1.76

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-4: Key Socioeconomic Data – Barnstable County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Yarmouth	5,655	2,747	0	3,125	1,686	2.06	1.52
	5,470	2,499	0	976	478	2.19	1.60
	12,601	5,951	17	1,310	224	2.12	1.63
Totals / Averages	44,144	20,909	328	26,961	4,802	2.02	1.68
	21,285	10,437	11	6,875	1,946	2.05	1.67
	150,021	64,192	763	22,888	5,711	2.22	1.71
Overall Totals / Averages	215,450	95,538	1,102	56,724	12,459	2.10	1.69

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-5: Key Socioeconomic Data – Bristol County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Acushnet	0	0	0	0	0	0.00	0.00
	1,949	779	18	2	0	2.50	1.83
	8,365	3,159	177	19	0	2.65	1.98
Berkley	1,647	560	0	16	0	2.94	2.12
	108	36	0	1	0	2.97	2.13
	4,697	1,527	17	1	0	3.08	2.13
Dartmouth	2,897	1,241	16	505	0	2.33	2.03
	276	111	0	2	0	2.49	2.13
	31,138	9,977	47	158	0	3.12	1.91
Dighton	939	349	0	9	0	2.69	2.12
	332	110	0	1	0	3.01	2.13
	5,842	2,022	9	13	0	2.89	2.12
Fairhaven	2,831	1,243	0	416	0	2.28	1.85
	8,353	3,655	11	39	2	2.29	1.60
	4,767	1,807	29	19	0	2.64	1.83
Fall River	1,383	778	0	10	0	1.78	1.05
	1,241	639	0	1	0	1.94	1.40
	86,194	37,021	49	89	82	2.33	1.30
Freetown	1,186	432	0	9	0	2.75	2.14
	0	0	0	0	0	0.00	0.00
	7,737	2,749	0	45	0	2.81	2.14

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-5: Key Socioeconomic Data – Bristol County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
New Bedford	856	356	0	6	0	2.40	1.42
	23,904	9,663	0	24	0	2.47	1.14
	70,167	28,682	58	87	3	2.45	1.35
Raynham	399	132	0	0	0	3.02	1.91
	121	43	0	0	68	2.81	1.90
	12,901	4,714	361	14	205	2.74	1.87
Rehoboth	501	184	0	1	0	2.73	2.39
	327	121	0	1	0	2.71	2.40
	10,836	3,816	0	26	0	2.84	2.24
Seekonk	232	82	0	2	103	2.83	1.98
	178	65	0	0	0	2.73	1.99
	13,519	5,000	15	23	302	2.70	2.06
Somerset	2,677	1,096	0	17	104	2.44	1.94
	353	124	0	1	0	2.86	1.80
	15,210	5,897	10	41	0	2.58	1.89
Swansea	2,799	1,166	0	29	0	2.40	1.98
	2,117	863	0	4	0	2.45	1.91
	11,034	4,083	0	20	0	2.70	2.19
Taunton	3,236	1,348	0	0	0	2.40	1.57
	1,370	535	0	3	0	2.56	1.59
	51,347	20,481	697	49	155	2.51	1.63

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-5: Key Socioeconomic Data – Bristol County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Westport	1,067	495	0	387	0	2.16	1.92
	299	121	0	16	0	2.46	2.03
	14,221	5,560	13	375	130	2.56	2.06
Totals / Averages	22,650	9,462	16	1,407	207	2.34	1.76
	40,928	16,865	29	95	70	2.42	1.73
	347,975	136,495	1,482	979	877	2.71	1.91
Overall Totals / Averages	411,553	162,822	1,527	2,481	1,154	2.49	1.80

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-6: Key Socioeconomic Data – Dukess County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Aquinnah	33	18	0	114	0	1.83	1.61
	0	0	0	0	0	0.00	0.00
	278	127	3	231	0	2.19	1.64
Chilmark	129	61	4	380	0	2.11	1.59
	68	29	0	78	0	2.34	1.69
	669	308	15	730	0	2.17	1.66
Edgartown	466	221	0	942	114	2.11	0.37
	324	184	0	586	131	1.76	0.50
	3,277	1,389	0	1,730	34	2.36	1.20
Oak Bluffs	706	336	0	746	95	2.10	1.40
	528	253	19	454	57	2.09	1.39
	3,293	1,400	28	1,008	9	2.35	1.43
Tisbury	463	234	0	306	119	1.98	1.58
	5	1	0	12	0	5.00	1.59
	3,481	1,571	37	811	188	2.22	1.49
West Tisbury	219	106	0	127	0	2.07	1.58
	81	39	0	49	0	2.08	1.59
	2,440	1,052	47	775	0	2.32	1.53
Totals / Averages	2,016	976	4	2,615	328	2.03	1.36
	1,006	506	19	1,179	188	2.21	1.13
	13,438	5,847	130	5,285	231	2.27	1.49
Overall Totals / Averages	16,460	7,329	153	9,079	747	2.17	1.32

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-7: Key Socioeconomic Data – Essex County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Beverly	2,863	1,299	0	38	0	2.20	1.54
	2,931	1,190	0	3	0	2.46	1.32
	34,225	13,568	19	79	112	2.52	1.62
Danvers	3,542	1,525	0	11	129	2.32	1.68
	2,140	877	0	8	121	2.44	1.72
	21,211	8,374	190	46	1,065	2.53	1.75
Essex	1,163	484	0	101	35	2.40	1.96
	116	41	0	0	0	2.80	1.98
	2,267	893	0	23	0	2.54	1.94
Gloucester	7,088	3,290	0	827	62	2.15	1.70
	2,041	708	0	67	0	2.88	1.68
	19,912	8,598	20	405	277	2.32	1.54
Ipswich	3,224	1,358	0	213	10	2.37	1.84
	1,400	575	0	10	0	2.44	1.63
	8,728	3,603	0	53	29	2.42	1.86
Lynn	12,721	5,157	0	19	0	2.47	1.12
	7,776	2,905	0	3	0	2.68	1.15
	70,333	25,417	33	53	0	2.77	1.31
Manchester	1,070	497	0	66	0	2.15	1.77
	520	243	0	8	0	2.14	1.77
	3,595	1,427	0	46	0	2.52	1.77

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-7: Key Socioeconomic Data – Essex County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Marblehead	3,246	1,401	0	137	20	2.32	1.68
	688	293	0	4	0	2.35	1.84
	16,023	6,511	41	171	0	2.46	1.69
Nahant	3,432	1,550	0	65	0	2.21	1.70
	0	0	0	0	0	0.00	0.00
	0	0	0	0	0	0.00	0.00
Newbury	3,017	1,284	0	225	15	2.35	2.03
	947	318	0	6	0	2.98	2.03
	2,767	1,017	0	8	0	2.72	2.03
Newburyport	2,185	1,007	0	138	0	2.17	1.71
	684	343	0	7	0	1.99	1.71
	14,699	6,339	0	106	61	2.32	1.65
Peabody	1,437	652	0	0	0	2.20	1.37
	1,087	608	0	1	0	1.79	1.41
	48,997	20,165	778	84	742	2.43	1.64
Rockport	661	359	0	325	104	1.84	1.64
	0	0	0	0	0	0.00	0.00
	6,378	2,894	0	448	197	2.20	1.62
Rowley	378	131	0	15	0	2.88	2.03
	119	42	0	0	0	2.81	2.03
	5,417	2,002	0	12	0	2.70	2.05

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-7: Key Socioeconomic Data – Essex County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Salem	18,589	7,801	0	38	86	2.38	1.26
	5,947	2,722	0	32	133	2.19	1.35
	17,382	7,569	0	64	0	2.30	1.38
Salisbury	4,643	2,104	98	706	63	2.21	1.75
	312	116	0	1	0	2.70	1.83
	3,440	1,268	134	10	0	2.71	1.86
Saugus	4,324	1,629	5	2	0	2.65	1.90
	1,785	772	0	2	0	2.31	1.68
	20,935	8,078	89	17	337	2.59	1.84
Swampscott	1,878	848	0	25	0	2.22	1.81
	1,105	411	0	2	0	2.69	1.60
	10,879	4,291	0	66	0	2.54	1.66
Totals / Averages	75,461	32,376	103	2,951	524	2.31	1.69
	29,598	12,164	0	154	254	2.20	1.49
	307,188	122,014	1,304	1,691	2,820	2.37	1.62
Overall Totals / Averages	412,247	166,554	1,407	4,796	3,598	2.29	1.60

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-8: Key Socioeconomic Data – Middlesex County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Arlington	7,691	3,594	0	20	100	2.14	1.37
	4,286	1,970	0	7	0	2.18	1.34
	31,326	13,608	7	67	0	2.30	1.46
Belmont	2,386	1,002	0	6	0	2.38	1.76
	1,327	485	0	4	0	2.74	1.73
	21,228	8,247	10	57	0	2.57	1.59
Cambridge	3,500	1,577	0	5	121	2.22	1.47
	86,339	37,703	11	342	3,123	2.29	1.05
	48,163	21,032	0	213	319	2.29	0.96
	8,895	3,901	0	44	0	2.28	1.12
Everett	7,573	2,840	0	8	0	2.67	1.26
	996	358	0	1	0	2.79	1.31
	33,519	12,502	15	15	0	2.68	1.30
Malden	21,255	8,328	56	16	50	2.55	1.25
	5,806	2,263	0	5	0	2.57	1.20
	32,740	13,222	52	18	0	2.48	1.21
Medford	28,615	12,508	0	42	157	2.29	1.41
	8,254	3,533	0	10	0	2.34	1.46
	19,735	6,944	12	26	0	2.84	1.55

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-8: Key Socioeconomic Data – Middlesex County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Newton	558	245	0	1	0	2.28	1.46
	3,529	1,506	0	6	0	2.34	1.53
	82,208	29,813	26	299	894	2.76	1.66
Somerville	14,498	6,560	0	26	332	2.21	1.68
	15,244	6,487	0	15	0	2.35	1.14
	45,954	19,555	0	48	0	2.35	1.14
Waltham	147	67	0	0	0	2.20	1.36
	1,568	719	0	7	0	2.18	1.27
	59,598	23,170	19	115	1,243	2.57	1.54
Watertown	1,827	989	16	13	0	1.85	1.36
	7,422	3,496	0	17	0	2.12	1.36
	23,097	10,423	0	33	0	2.22	1.45
Winchester	233	83	0	0	0	2.80	1.94
	1,717	731	0	11	0	2.35	1.68
	19,668	6,918	0	56	0	2.84	1.81
Totals / Averages	88,283	37,793	72	137	760	2.33	1.48
	136,488	59,251	11	425	3,123	2.39	1.37
	48,163	21,032	0	213	319	2.29	0.96
	377,968	148,303	141	778	2,137	2.54	1.44
Overall Totals / Averages	650,902	266,379	224	1,553	6,339	2.41	1.42

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-9: Key Socioeconomic Data – Nantucket County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Nantucket County	636	317	39	1,790	276	2.01	1.73
	724	304	1	656	86	2.38	1.50
	8,819	3,611	107	4,279	100	2.44	1.62
Overall Totals / Averages	10,179	4,232	147	6,725	462	2.28	1.62

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-10: Key Socioeconomic Data – Norfolk County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Braintree	1,360	510	0	1	0	2.67	1.51
	428	172	0	0	0	2.48	1.46
	34,260	13,170	0	41	206	2.60	1.67
Brookline	3,610	1,703	0	21	35	2.12	0.90
	7,333	3,359	0	34	235	2.18	0.93
	47,826	20,032	27	192	241	2.39	1.17
Cohasset	2,269	884	0	52	0	2.57	2.07
	0	0	0	0	0	0.00	0.00
	5,646	1,973	27	34	0	2.86	2.07
Milton	642	236	0	0	0	2.72	1.90
	976	353	0	1	0	2.76	1.90
	25,475	8,716	0	58	0	2.92	1.73
Quincy	42,544	18,075	13	122	105	2.35	1.29
	7,435	3,268	0	12	0	2.27	1.19
	42,615	19,457	14	158	464	2.19	1.31
Weymouth	9,412	3,973	0	37	0	2.37	1.59
	617	261	0	0	0	2.36	1.80
	44,330	18,458	122	107	0	2.40	1.58
Totals / Averages	59,837	25,381	13	233	140	2.47	1.54
	16,789	7,413	0	47	235	2.01	1.21
	200,152	81,806	190	590	911	2.56	1.59
Overall Totals / Averages	276,778	114,600	203	870	1,286	2.35	1.45

- Key: Zone A Zone B Inland (Non-Surge Areas)
- Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.
- Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-11: Key Socioeconomic Data – Plymouth County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Duxbury	2,695	1,013	0	243	0	2.66	2.04
	136	46	0	1	0	2.93	2.14
	12,295	4,308	0	100	0	2.85	2.09
Hingham	4,654	1,755	0	24	0	2.65	1.80
	2,766	1,248	0	19	0	2.22	1.77
	14,909	5,527	34	70	0	2.70	1.82
Hull	10,308	4,639	0	800	105	2.22	1.57
	11	3	0	0	0	3.67	1.66
	0	0	0	0	0	0.00	0.00
Kingston	1,751	745	0	94	0	2.35	1.98
	0	0	0	0	0	0.00	0.00
	10,922	3,937	241	35	0	2.77	1.96
Marion	4,037	1,618	0	414	0	2.50	2.00
	819	261	0	18	0	3.13	2.00
	59	20	0	0	0	2.95	2.00
Marshfield	14,083	5,440	135	1,048	0	2.59	1.87
	145	52	0	0	0	2.77	2.08
	11,078	4,099	14	47	0	2.70	2.04
Mattapoissett	2,780	1,231	0	559	0	2.26	1.80
	978	369	0	8	0	2.65	1.81
	2,329	921	0	73	0	2.53	1.78

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

Table 6-11: Key Socioeconomic Data – Plymouth County (continued)

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Plymouth	2,336	1,049	0	652	239	2.23	1.86
	2,481	1,054	0	167	0	2.35	1.80
	52,155	19,351	634	1,718	372	2.70	1.88
Rochester	98	41	0	0	0	2.43	2.32
	508	184	0	5	0	2.76	2.36
	4,692	1,611	0	15	0	2.91	2.36
Scituate	6,206	2,497	0	772	0	2.49	1.87
	0	0	0	0	0	0.00	0.00
	11,975	4,381	51	102	0	2.73	1.92
Wareham	15,693	6,724	509	2,229	0	2.33	1.67
	157	56	0	2	0	2.82	1.94
	6,233	2,399	423	173	0	2.60	1.89
Totals / Averages	64,641	26,752	644	6,835	344	2.43	1.89
	8,001	3,273	0	220	0	2.30	1.60
	126,647	46,554	1,397	2,333	372	2.49	1.79
Overall Totals / Averages	199,289	76,579	2,041	9,388	716	2.41	1.76

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



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Table 6-12: Key Socioeconomic Data – Suffolk County

Evacuation Zones ¹	Population ²	Permanent Occupied Units ²	Mobile Home Units ²	Seasonal Vacation Units ²	Tourist Motel / B&B Units ³	Average People per Occupied Housing Unit ²	Average Vehicle per Occupied Housing Unit ²
Boston	34,959	13,539	0	262	1,520	2.58	1.53
	179,731	82,677	24	823	8,719	2.17	1.28
	225,198	90,619	25	1,607	8,673	2.49	0.83
	334,517	131,150	198	307	74	2.55	1.07
Chelsea	24,500	8,813	0	20	128	2.78	1.05
	4,139	1,437	0	4	0	2.88	1.00
	5,535	1,922	0	5	0	2.88	1.00
Revere	24,234	9,973	146	95	227	2.43	1.71
	12,390	4,729	0	17	0	2.62	1.12
	15,865	6,055	16	32	0	2.62	1.12
Winthrop	17,537	7,900	0	67	0	2.22	1.45
	0	0	0	0	0	0.00	0.00
	0	0	0	0	0	0.00	0.00
Totals / Averages	101,230	40,225	146	444	1,875	2.50	1.44
	196,260	88,843	24	844	8,719	1.92	0.85
	225,198	90,619	25	1,607	8,673	2.49	0.83
	355,917	139,127	214	344	74	2.01	0.80
Overall Totals / Averages	878,605	358,814	409	3,239	19,341	2.17	1.01

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)

2. Data represented in this table reflects data obtained and/or calculated from the 2009-2013 American Community Survey 5-Year Estimates.

3. Obtained from various Massachusetts lodging websites.



6.0 Transportation Analysis

6.6 Behavioral Assumptions of the Evacuating Population

An evacuation of the Massachusetts coast will involve decision making by thousands of individuals and households. In order to develop meaningful behavioral assumptions that account for these variations in decision making, the model incorporates data from the *Massachusetts Hurricane Evacuation Study Behavioral Analysis Survey Data Report* (September 13, 2013) conducted by Dr. Jay Baker of Hazards Management Group (HMG). Chapter 4 of the TDR contains the analysis of the behavioral report. Other behavioral trends from around the coastal United States were also considered in developing behavioral assumptions for the transportation analysis.

The contractor used this data source and nationwide experience to focus the transportation analysis on the following behavioral aspects:

- Participation rates - what percent of the population in different areas will evacuate their dwelling units for hurricane threats?
- Response rates (timing) - how quickly will evacuees respond to what local officials are telling them to do?
- Destination percentages - what percent of the population by evacuation zone, will evacuate to local destinations (public shelters, hotel/motels, churches, friends' and relatives' homes) or out of the area entirely?
- Vehicle usage - of the vehicles available to the households, what percent of those vehicles will be used in an evacuation?

6.6.1 Participation Rates

One of the biggest challenges in developing the evacuation model for this area is choosing the appropriate participation rates that should be used for each storm intensity scenario. Where possible, this report and the evacuation transportation model incorporate the participation rates provided in the September 2013 behavioral survey cited above. Nonetheless, in the interests of public safety, this transportation analysis assumes a 100 percent participation rate for all residential and tourist units in each storm surge evacuation zone for the corresponding intensity scenario. For example, in the transportation model, all permanent residents and visitors in the Scenario A evacuation zone are considered evacuees, regardless of what percentages were provided in the behavioral analysis. Clearly, it is understood that not all households will evacuate their residences, regardless of the intensity, during an actual tropical cyclone event; nonetheless this assumption results in clearance times that provide the opportunity for all evacuees to leave regardless of their propensity to do so. This ensures that local lead times used in decision making will not result in potential evacuees stranded in their



6.0 Transportation Analysis

vehicles waiting to leave the vulnerable zones as hazardous conditions begin. Nonetheless, it should be noted that even in coastal regions of the United States that have a lot of hurricane experience, participation rates among surge vulnerable residents have been no more than approximately 90 percent. In some of the noteworthy hurricanes in urban areas, the surge zone participation rates have been as low as 70 percent.

Although it generally can be said people living close to the coastline are more likely to evacuate than those living further inland, proximity to water is not always a good indicator of how severe hurricane hazards will be, or predicting peoples' propensity to evacuate. Consequently, some residents outside surge vulnerable areas, fearing for their safety, may elect to evacuate, even in the absence of a directive from local officials to do so. Post event behavioral survey results show that in past evacuations, a percentage of households not under a specific order from local officials will decide to leave their residences anyway. In areas with a lot of hurricane evacuation experience, these "shadow" participation rates can typically run from 10 to 30 percent of the populations not directed to evacuate during a particular scenario. For instance, in Hurricane Floyd (Southeast U.S. coast) and Hurricane Rita (Houston), inland participation rates were higher due to mixed messages that residents were receiving through various media releases and from local statements that abandoned the surge area risk concept.

For the Massachusetts HES TDR, based on the behavioral hypothetical responses provided in the 2013 study cited above, the average shadow participation rate was 70 percent. Clearly, based on a hypothetical scenario, especially in the inland areas, there is a tendency for households to over-evacuate. Nonetheless, these shadow evacuation figures were judged to be too extreme for use in the latest evacuation model, and figures more consistent with locally established norms were used. Therefore, based on planning guidance from Hazards Management Group regarding the shadow evacuation percentages, figures of 5 to 15 percent were used depending on intensity scenario and evacuation zone.

Tables 6-12 through 6-11 below detail the participation rates used in the transportation model and not those from the behavioral surveys discussed above. These tables are arranged alphabetically by each town and by county. The figures are further segregated by evacuation zones and response scenarios.



6.0 Transportation Analysis

Table 6-13: Assumed Participation Rates by Evacuation Zone – Barnstable County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Barnstable	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Bourne	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Brewster	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Chatham	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Dennis	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Eastham	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Falmouth	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-13: Assumed Participation Rates by Evacuation Zone – Barnstable County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Harwich	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Mashpee	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Orleans	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Provincetown	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Sandwich	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Truro	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Wellfleet	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-13: Assumed Participation Rates by Evacuation Zone – Barnstable County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Yarmouth	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-14: Assumed Participation Rates by Evacuation Zone – Bristol County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Acushnet	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Berkley	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%
Dartmouth	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	10%	75%	100%	100%
Dighton	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%
Fairhaven	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Fall River	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Freetown	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-14: Assumed Participation Rates by Evacuation Zone – Bristol County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
New Bedford	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Raynham	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%
Rehoboth	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%
Seekonk	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	5%	50%	50%	50%	10%	75%	100%	100%
Somerset	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	5%	50%	50%	50%	10%	75%	100%	100%
Swansea	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Taunton	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-14: Assumed Participation Rates by Evacuation Zone – Bristol County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Westport	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-15: Assumed Participation Rates by Evacuation Zone – Dukess County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Aquinnah	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Chilmark	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Edgartown	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Oak Bluffs	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
Tisbury	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%
West Tisbury	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-16: Assumed Participation Rates by Evacuation Zone – Essex County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Beverly	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Danvers	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Essex	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Gloucester	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Ipswich	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Lynn	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Manchester	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-16: Assumed Participation Rates by Evacuation Zone – Essex County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Marblehead	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Nahant	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Newbury	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Newburyport	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Peabody	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Rockport	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Rowley	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-16: Assumed Participation Rates by Evacuation Zone – Essex County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Salem	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Salisbury	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Saugus	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Swampscott	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



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Table 6-17: Assumed Participation Rates by Evacuation Zone – Middlesex County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units
Arlington	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Belmont	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Everett	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Malden	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Medford	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Newton	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Somerville	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-17: Assumed Participation Rates by Evacuation Zone – Middlesex County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units
Waltham	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Watertown	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Winchester	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

Evacuation Zones ¹	Cat 1 & 2 (not worst case) Hurricane				Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane				Cat 3 & 4 (worst case) Hurricane			
	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units
Cambridge	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	1%	80%	50%	50%	80%	100%	80%	80%	90%	100%	100%	100%
	0%	50%	50%	50%	1%	75%	50%	50%	80%	100%	100%	100%
	0%	50%	50%	50%	0%	75%	50%	50%	15%	100%	100%	100%

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-18: Assumed Participation Rates by Evacuation Zone – Nantucket County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Nantucket	100%	100%	100%	100%	100%	100%	100%	100%
	25%	80%	90%	90%	65%	100%	100%	100%
	10%	50%	50%	50%	20%	80%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-19: Assumed Participation Rates by Evacuation Zone – Norfolk County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Braintree	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Brookline	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Cohasset	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Milton	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Quincy	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Weymouth	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A

Zone B

Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-20: Assumed Participation Rates by Evacuation Zone – Plymouth County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Duxbury	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Hingham	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Hull	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Kingston	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Marion	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Marshfield	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Mattapoisett	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-20: Assumed Participation Rates by Evacuation Zone – Plymouth County (continued)

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units	Permanent Units	Mobile Home Units	Seasonal Units	Tourist Units
Plymouth	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Rochester	40%	100%	100%	100%	65%	100%	100%	100%
	5%	70%	90%	90%	25%	100%	100%	100%
	1%	50%	50%	50%	10%	75%	100%	100%
Scituate	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%
Wareham	100%	100%	100%	100%	100%	100%	100%	100%
	15%	70%	90%	90%	55%	100%	100%	100%
	5%	50%	50%	50%	15%	75%	100%	100%

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-21: Assumed Participation Rates by Evacuation Zone – Suffolk County

Evacuation Zones ¹	Category 1 & 2 Hurricane				Category 3 & 4 Hurricane			
	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units
Chelsea	100%	100%	100%	100%	100%	100%	100%	100%
	5%	70%	50%	50%	55%	100%	100%	100%
	1%	50%	5%	5%	5%	75%	100%	100%
Revere	100%	100%	100%	100%	100%	100%	100%	100%
	5%	70%	50%	50%	55%	100%	100%	100%
	1%	50%	5%	5%	5%	75%	100%	100%
Winthrop	100%	100%	100%	100%	100%	100%	100%	100%
	5%	70%	50%	50%	55%	100%	100%	100%
	1%	50%	5%	5%	5%	75%	100%	100%

Evacuation Zones ¹	Cat 1 (next to worst case) Hurricane				Cat 1 (worst case) & Cat 2 (not worst case) Hurricane				Cat 2 (worst case) & Cat 3 & 4 Hurricane			
	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units	Perm. Units	Mobile Home Units	Seasonal Units	Tourist Units
Boston	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
	80%	100%	100%	100%	90%	100%	100%	100%	100%	100%	100%	100%
	2%	70%	1%	1%	5%	100%	50%	50%	90%	100%	100%	100%
	1%	50%	0%	0%	2%	100%	5%	5%	5%	100%	100%	100%

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

6.6.2 Response Rates

A critical behavioral assumption used in the transportation analysis is to establish how quickly after an evacuation order is issued will the vulnerable population in a community begin their evacuation trips, referred to as response time. Behavioral data from past hurricane evacuation research demonstrates wide variations in this evacuation response time ranging from a few hours to days, depending on the circumstances. To account for this disparity, clearance times were tested for three evacuation response rates represented by different behavioral response curves.

The resulting behavioral response curves describing mobilization by the vulnerable population define the rate at which evacuating vehicles will load onto the evacuation roadway network for each hourly interval relative to an evacuation order or advisory. These curves depict slow, medium and rapid responses by the public to an evacuation order. Typically, a small percentage of households will start evacuating before an order is issued. Upon receiving the evacuation order, some percentage of households will leave within an hour, others within two hours, some within three, etc. A curve can be drawn to show the cumulative percentage of households that have entered the evacuation network over a number of hours. A rapid loading of the network produces a steep curve; a medium loading scenario produces a flatter curve, etc. The response curves in Figure 6-81 reflect rapid, medium and long responses and are designed to include a range of mobilization times that may be experienced in a hurricane evacuation situation. For this analysis, the mobilization/ traffic loading time varied between 3 and 9 hours. These mobilization times are generally based on the behavioral response curves discussed in Chapter 4 and shown below in Figure 6-81. From a traffic perspective, a more gradual loading of the network is preferred as the rapid loading of vehicles onto a transportation system results in heavier congestion and roadways reaching saturation levels very early on in an evacuation event.

The response curves depicted in the figure directly below relate to the following real-world examples regarding their use during an actual tropical cyclone response. A long response would be an appropriate clearance time assumption during nighttime hours, or during the middle of a normal weekday when most families are scattered to work, school and other routine activities away from home. A medium response curve would be appropriately applied during weekend days and any evening hours when most families have been rejoined at their residences and can be informed and mobilized in relatively short order. A rapid response relates to periods when most families are together and can be alerted and motivated to respond quickly, such as in the morning before most families have left from normal daytime activities and before schools and businesses are opened.



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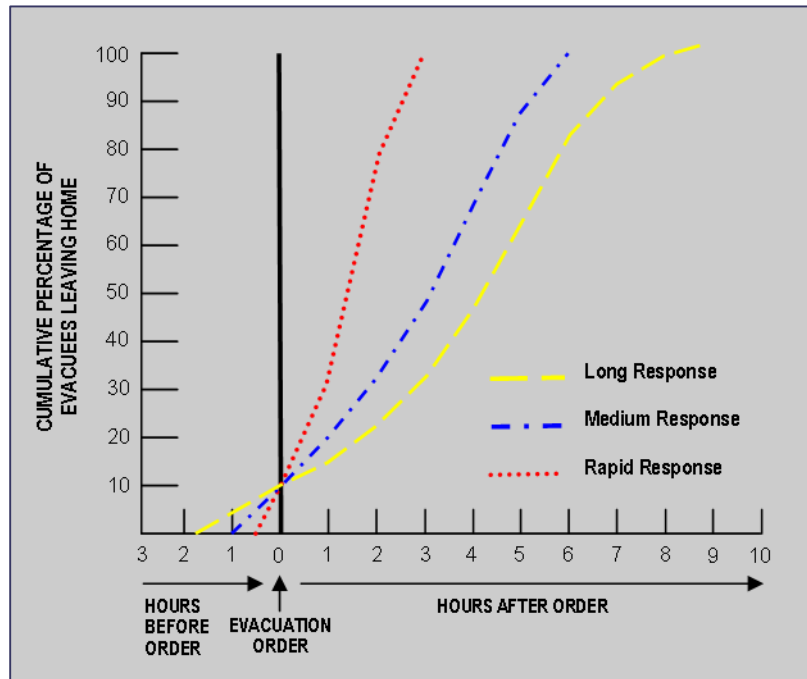


Figure 6-81: Behavioral Response Curve

6.6.3 Destination Percentages

Another essential input into the transportation analysis involves the destination percentages of evacuees. Generally, the traffic movements associated with hurricane evacuation have been identified by five general travel patterns as follows:

1. Internal Trips (In-Jurisdiction Origins to In-Jurisdiction Destinations)

Vehicles primarily traveling from storm surge vulnerable areas and all mobile home units to destinations within the same community, such as public shelters, hotel and motel units, churches, and friends or relatives outside the storm surge vulnerable areas. An example of this pattern is a family leaving a home in Plymouth and evacuating to a shelter in Kingston.

2. External Trips (In-Jurisdiction Origins to Out-Of-Jurisdiction Destinations)

Evacuation travel that originates in an individual community and ends in other jurisdictions within the study area or outside the region entirely. Generally, the more intense the storm scenario, the larger the percent assumed to be exiting the jurisdiction.



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These trips are the most common for tourists, such as a couple vacating a hotel room in Hyannis and evacuating to their home in Boston.

3. Entering Trips (Out-Of-Jurisdiction Origins to In-Jurisdiction Destinations)

Vehicles entering a jurisdiction after having evacuated from another community within or outside the study area. Rhode Island evacuees traveling to seek destinations in Fall River are an example of these kinds of trips.

4. Pass Through Trips (Out-of-Jurisdiction Origins to Out-of-Jurisdiction Destinations)

These trips pass through an individual jurisdiction while traveling from one jurisdiction in the study area to another or outside the study area entirely; for instance, a vehicle evacuating Newport, Rhode Island and traveling through Massachusetts to reach Nashua, New Hampshire.

5. Background Traffic

Trips made by persons preparing for the arrival of hurricane conditions; these trips are primarily shopping trips to gather supplies. Background traffic can also include transit vehicles (vans/ buses) used to pick up evacuees without personal transportation.

Destinations are related to evacuees' proximity to the coast and socio-economic conditions. For instance, more affluent evacuees, who normally live closer to the coast, do not utilize public shelters as much as the remainder of the population, especially the more inland populations. Persons of lower income generally utilize public shelters more because of the problems they may have with transportation and their inability to find affordable hotel/motel destinations.

For the Massachusetts HES TDR study area destination options focused on: local public shelters, "other" local destinations, and out of the county destinations. Based on responses received during the behavioral analysis for the Massachusetts coastal areas, destination percentages were varied for each traffic evacuation zone in the study area depending on the category of risk (distance from the coastline and water bodies). Assumptions were also varied for permanent residents versus tourist/seasonal populations. With each increase in storm intensity, a larger percentage of evacuees were assumed to go out of community, which is consistent with what has been learned in actual evacuations. The percent of permanent residents and mobile home evacuees going out of community ranged from 10 to 90 percent, with the highest percentages leaving from Barnstable County and Buzzards Bay. The percent of permanent residents and mobile home evacuees going to local public shelter ranged between 5 and 10 percent depending on type of unit and location. For modeling purposes, the remaining residents would



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then be seeking other safe locations, such as friends and relatives, within their own local jurisdictions. Table 6-21 below provides details on the percentages of evacuating vehicles going to each of those destinations.

The destinations of the visitor populations were also factored into the transportation model since they are another important component of the evacuating people and vehicles figures. Visitor populations also have an impact on public shelter use, albeit smaller than the permanent residents in those communities. The basic assumptions regarding all visitor populations is that regardless of whether they are in seasonal/vacation units, or hotel rooms they are more likely to leave the community and become exiting evacuees. Only a very small percentage of visitors, only 1 percent, are assumed to remain in community, usually seeking public shelters space.

6.6.4 Vehicle Usage

The final set of behavioral assumptions concerns vehicle usage rates during an evacuation. Vehicle usage rates pertain to the percentage of vehicles available at the home origin, assumed to be used in the evacuation. Some households will not evacuate using all of the vehicles at their disposal, choosing instead to consolidate their trips for fear of becoming separated along the route. Others will take all vehicles fearing damage to their automobiles. Vehicle usage percentages have been measured during actual evacuations and are consistently in the 60 to 80 percent range in all parts of the coastal United States. In this analysis, the percentage ranged from 70 to 80 percent for permanent residents and 100 percent for tourist/seasonal populations.

The key behavioral concepts and assumptions used for the study are summarized in Table 6-22. These evacuating destination figures were developed from the behavioral characteristics provided in the most recent behavioral survey in Massachusetts.



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Table 6-22: Behavioral Assumptions for Permanent Resident Destinations

Evacuation Zones ¹	Permanent Resident/Mobile Home Destination Percentages					
	Percent to In-County Locations		Percent to Public Shelters		Percent to Out of Community Locations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Barnstable County	45%	10%	5%	5%	55%	90%
	45%	10%	5%	5%	55%	90%
	45%	10%	10%	10%	55%	90%
Bristol County	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	10%	10%	35/55%	35/60%
Dukes County	90%	75%	5%	5%	10%	25%
	90%	75%	5%	5%	10%	25%
	90%	75%	10%	10%	10%	25%
Essex County	45%	40%	5%	5%	55%	60%
	45%	40%	5%	5%	55%	60%
	45%	40%	10%	10%	55%	60%
Middlesex County	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	10%	10%	35/55%	35/60%
Nantucket County	90%	75%	5%	5%	10%	25%
	90%	75%	5%	5%	10%	25%
	90%	75%	10%	10%	10%	25%
Norfolk County	45%	40%	5%	5%	55%	60%
	45%	40%	5%	5%	55%	60%
	45%	40%	10%	10%	55%	60%
Plymouth County	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	5%	5%	35/55%	35/60%
	45/65%	40/65%	10%	10%	35/55%	35/60%
Suffolk County	45%	40%	5%	5%	55%	60%
	45%	40%	5%	5%	55%	60%
	45%	40%	10%	10%	55%	60%

1. Key: Zone A Zone B Zone C (Providence Only) Inland Area (Non-Surge)



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Table 6-22: Behavioral Assumptions for Permanent Resident Destinations

Evacuation Zones ¹	Permanent Resident/Mobile Home Destination Percentages								
	Percent to In-County Locations			Percent to Public Shelters			Percent to Out of Community Locations		
	Cat 1 (next to worst case) Hurr	Cat 1 (worst case) & Cat 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 Hurr	Cat 1 (next to worst case) Hurr	Cat 1 (worst case) & Cat 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 Hurr	Cat 1 (next to worst case) Hurr	Cat 1 (worst case) & Cat 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 Hurr
Boston	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	10%	10%	10%	55%	60%	60%

Evacuation Zones ¹	Permanent Resident/Mobile Home Destination Percentages								
	Percent to In-County Locations			Percent to Public Shelters			Percent to Out of Community Locations		
	Cat 1 & 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurr	Cat 3 & 4 (worst case) Hurr	Cat 1 & 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurr	Cat 3 & 4 (worst case) Hurr	Cat 1 & 2 (not worst case) Hurr	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurr	Cat 3 & 4 (worst case) Hurr
Cambridge	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	5%	5%	5%	55%	60%	60%
	45%	40%	40%	10%	10%	10%	55%	60%	60%

1. Key: Zone A Zone B Zone C (Providence Only) Inland Area (Non-Surge)



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6.7 Transportation Modeling Methodology

6.7.1 Introduction

The general philosophy supporting all hurricane evacuation clearance time work around the country is that the analysis must be technically complex enough to produce reliable estimates of hurricane evacuation clearance times, yet clear enough for the emergency management community to be able to review key modeling assumptions and products. A brief overview of the steps in the modeling process and a description of the modeling framework are discussed in this section.

It is important to understand while applying the information in this section that the transportation analysis is predicated on the following important assumptions concerning traffic operations and other conditions:

- The evacuation of all vehicles will occur prior to the arrival of sustained tropical storm force winds (39 mph) and storm inundation of evacuation routes.
- Provisions will be made for the removal of vehicles in distress on the network through aggressive incident management and agreements worked out with tow truck operators.
- Traffic signals will be implemented to provide the most “green time” for movements away from the coast.
- Bridges will close when the wind speed exceeds that which is safe for the throughput of vehicles.
- Tunnels will be closed before flooding causes them to become impassable.

6.8 The Transportation Model

The model used for the Massachusetts HES TDR transportation analysis is a series of spreadsheets that consolidate all of the data collected during the study, as well as hazards information, the socioeconomic data, behavioral assumptions combined with the public shelter information, and the roadway network attributes. This transportation model is based on the same model used for HESs throughout the United States. The minor difference between the model developed for this region and other studies was required to account for the specific variations and circumstances related to the Massachusetts coastal communities. Nonetheless, the model process and methodology used in this study are essentially the same as those employed in other areas.

The primary results from the transportation analysis are clearance time calculations and an abbreviated version of the model. The model clearance times provide guidance to emergency managers and other local officials regarding the lead time needed to allow all evacuating



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vehicles the opportunity to reach their intended safe objective before the arrival of tropical storm force winds. This model has been updated over the past several years and enhanced for greater accuracy. Furthermore, an abbreviated version of the transportation model is provided as a customary component of the study results which allows greater transparency for the study users. With this abbreviated model, the assumptions, data sources and basic processes used to calculate the figures provided in this report are much more readily apparent and can be updated to account for annual developments and variations. The major inputs and outputs of the overall process are illustrated in Figure 6-82.

Basically, the basic key modeling steps used in this analysis for the Massachusetts jurisdictions are as follows:

- Development of Evacuation Zones and Data - Identifies who is vulnerable and who is evacuating; socioeconomic data is stratified by evacuation zones; data includes numbers of permanent residential dwelling units, mobile homes, and seasonal units compiled by zone.
- Trip Generation - Calculates how many people and vehicles will move for a particular hurricane category originating from each evacuation zone.
- Trip Distribution - Determines where evacuees will go (to destinations within the originating jurisdiction or out of area).
- Development of Evacuation Road Network – This step identifies which roads can be used for evacuation and includes the assignment of reasonable vehicle carrying capacities during an evacuation.
- Trip Assignment - Determines what route(s) evacuees will take to get from their point of origin to their destination based on shortest travel time. Additionally, terminating trips entering the jurisdiction of interest from other locations and pass-through vehicles are accounted for in this step of the modeling process.
- Calculation of Clearance Time – Determines how much time it will take for all evacuees to clear evacuation network bottlenecks including time for the “last vehicle” to reach assumed safety point. This modeling step also factors in the impacts of background traffic (those vehicles on the roadway that are not expressly evacuating, but instead traveling on local evacuation routes to prepare for the storm or to conduct other daily activities). The end product of this major step is the development of clearance times for each storm category for the Massachusetts jurisdictions.



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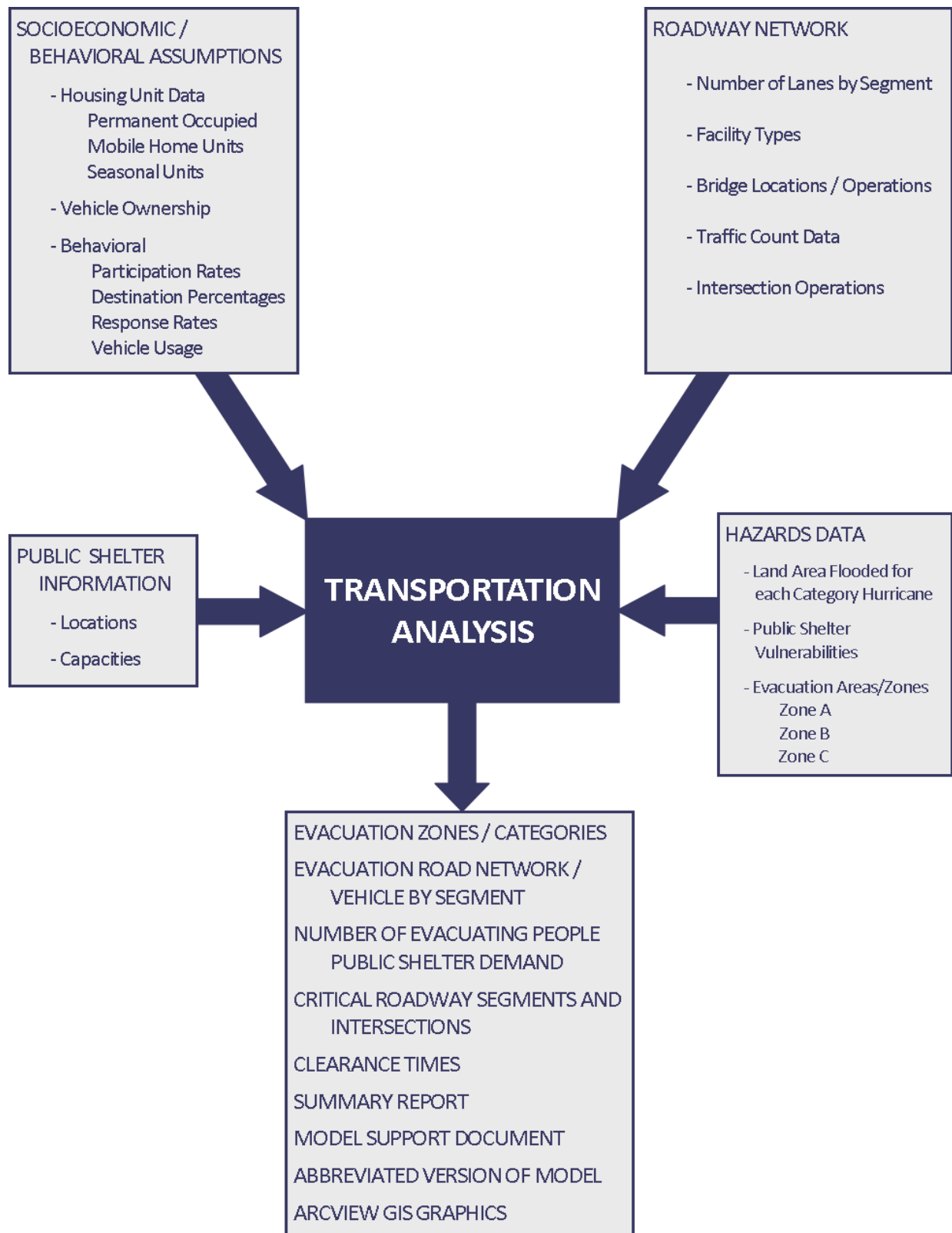


Figure 6-82: Clearance Time Model Process



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At the conclusion of the study, the USACE, New England District; FEMA; and the Massachusetts Emergency Management Agency (RIEMA); as well as each community in the study area received a simplified spreadsheet tool that allows officials to make changes to critical socioeconomic, behavioral, and roadway assumptions. This dynamic transportation model (DTM) was developed in order to facilitate the ability of the emergency management and other local officials to update clearance times in an efficient manner.

6.9 Transportation Modeling Process

The first step in developing the hurricane evacuation transportation model for the region was to assess the myriad roads in the region to determine which should be included primary evacuation routes. In addition, roadways that would logically be used by the surrounding populace were considered for inclusion in the model. Once the all roadways were identified, the network was mapped using GIS and incorporated into the model. A “link-node” system was used to characterize the selected roadway sections and create a reasonable representation of the evacuation roadway system for the Massachusetts communities. Nodes are used to identify the intersection of two roadways or changes in roadway characteristics. Links are the roadway segments between nodes with each link identified by a letter designation. Figures were developed illustrating the coded evacuation network with link designations. These are displayed in Figures 6-83 through 6-170 as follows:

- Figure 6-83: Evacuation Roadway Network – Barnstable County / Barnstable
- Figure 6-84: Evacuation Roadway Network – Barnstable County / Bourne
- Figure 6-85: Evacuation Roadway Network – Barnstable County / Brewster
- Figure 6-86: Evacuation Roadway Network – Barnstable County / Chatham
- Figure 6-87: Evacuation Roadway Network – Barnstable County / Dennis
- Figure 6-88: Evacuation Roadway Network – Barnstable County / Eastham
- Figure 6-89: Evacuation Roadway Network – Barnstable County / Falmouth
- Figure 6-90: Evacuation Roadway Network – Barnstable County / Harwich
- Figure 6-91: Evacuation Roadway Network – Barnstable County / Mashpee
- Figure 6-92: Evacuation Roadway Network – Barnstable County / Orleans
- Figure 6-93: Evacuation Roadway Network – Barnstable County / Provincetown
- Figure 6-94: Evacuation Roadway Network – Barnstable County / Sandwich
- Figure 6-95: Evacuation Roadway Network – Barnstable County / Truro
- Figure 6-96: Evacuation Roadway Network – Barnstable County / Wellfleet
- Figure 6-97: Evacuation Roadway Network – Barnstable County / Yarmouth
- Figure 6-98: Evacuation Roadway Network – Bristol County / Acushnet
- Figure 6-99: Evacuation Roadway Network – Bristol County / Berkley



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- Figure 6-100: Evacuation Roadway Network – Bristol County / Dartmouth
- Figure 6-101: Evacuation Roadway Network – Bristol County / Dighton
- Figure 6-102: Evacuation Roadway Network – Bristol County / Fairhaven
- Figure 6-103: Evacuation Roadway Network – Bristol County / Fall River
- Figure 6-104: Evacuation Roadway Network – Bristol County / Freetown
- Figure 6-105: Evacuation Roadway Network – Bristol County / New Bedford (north)
- Figure 6-106: Evacuation Roadway Network – Bristol County / New Bedford (central)
- Figure 6-107: Evacuation Roadway Network – Bristol County / New Bedford (south)
- Figure 6-108: Evacuation Roadway Network – Bristol County / Raynham
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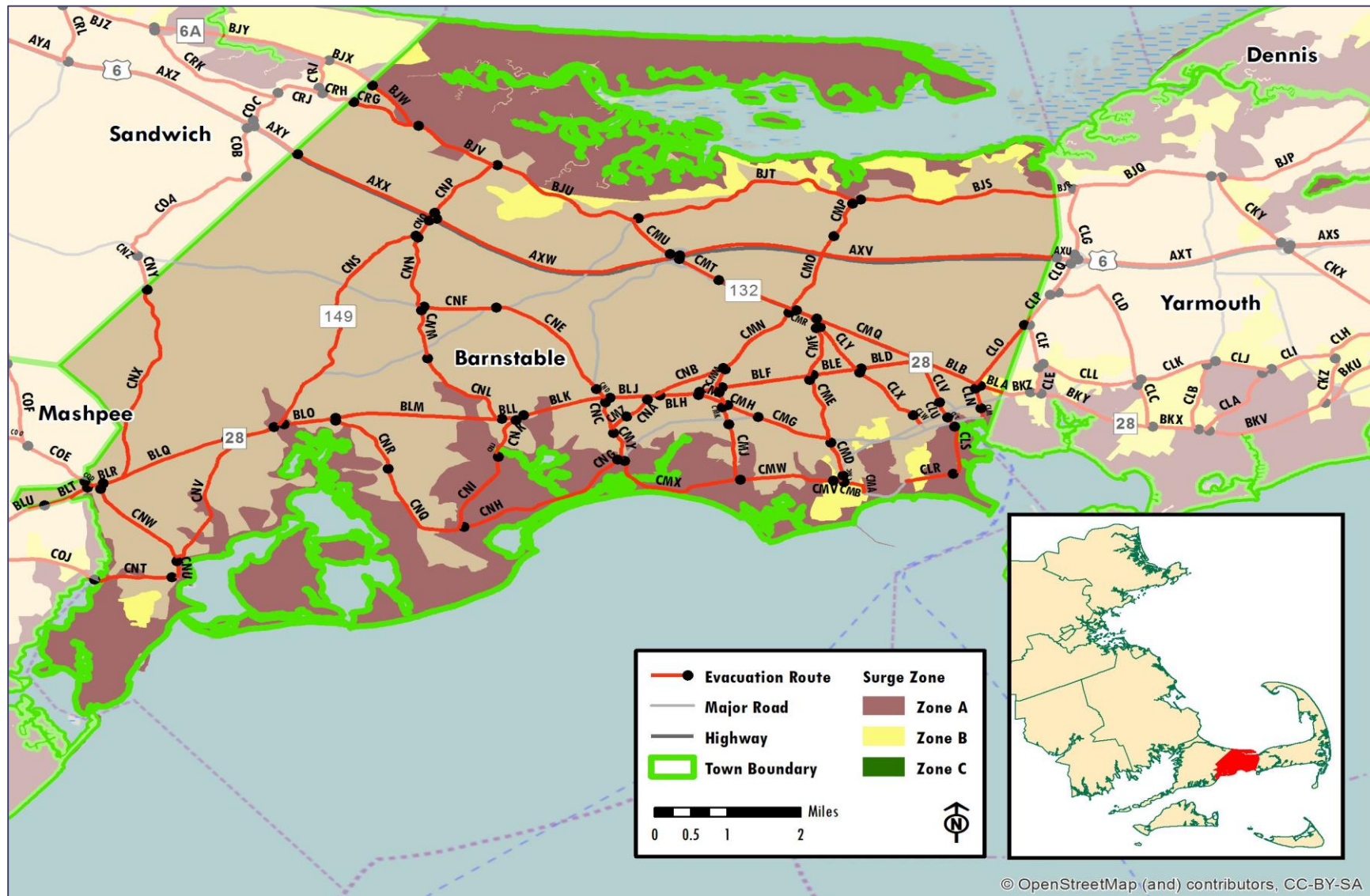


Figure 6-83: Evacuation Roadway Network – Barnstable County / Barnstable



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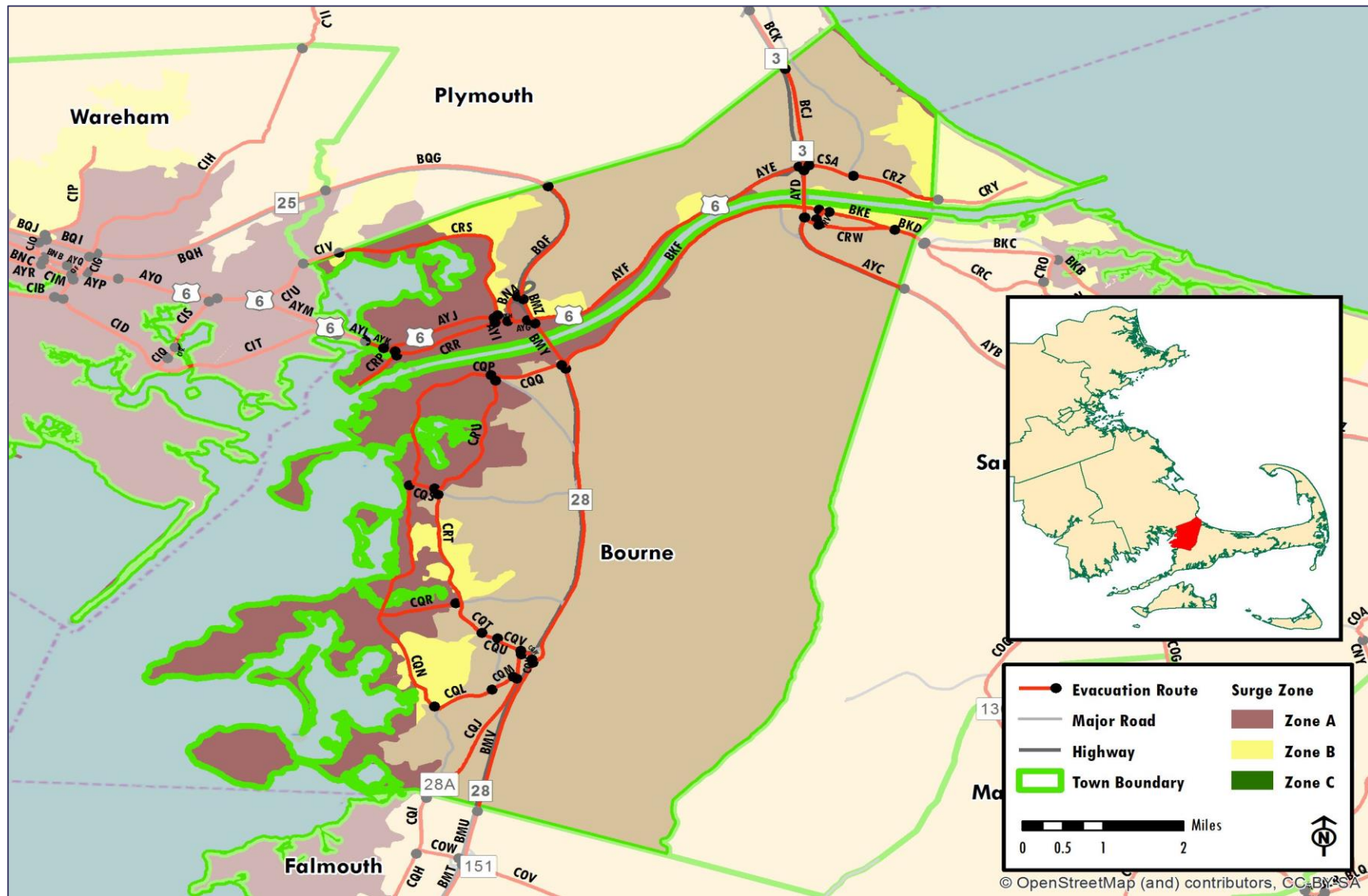


Figure 6-84: Evacuation Roadway Network – Barnstable County / Bourne



6.0 Transportation Analysis

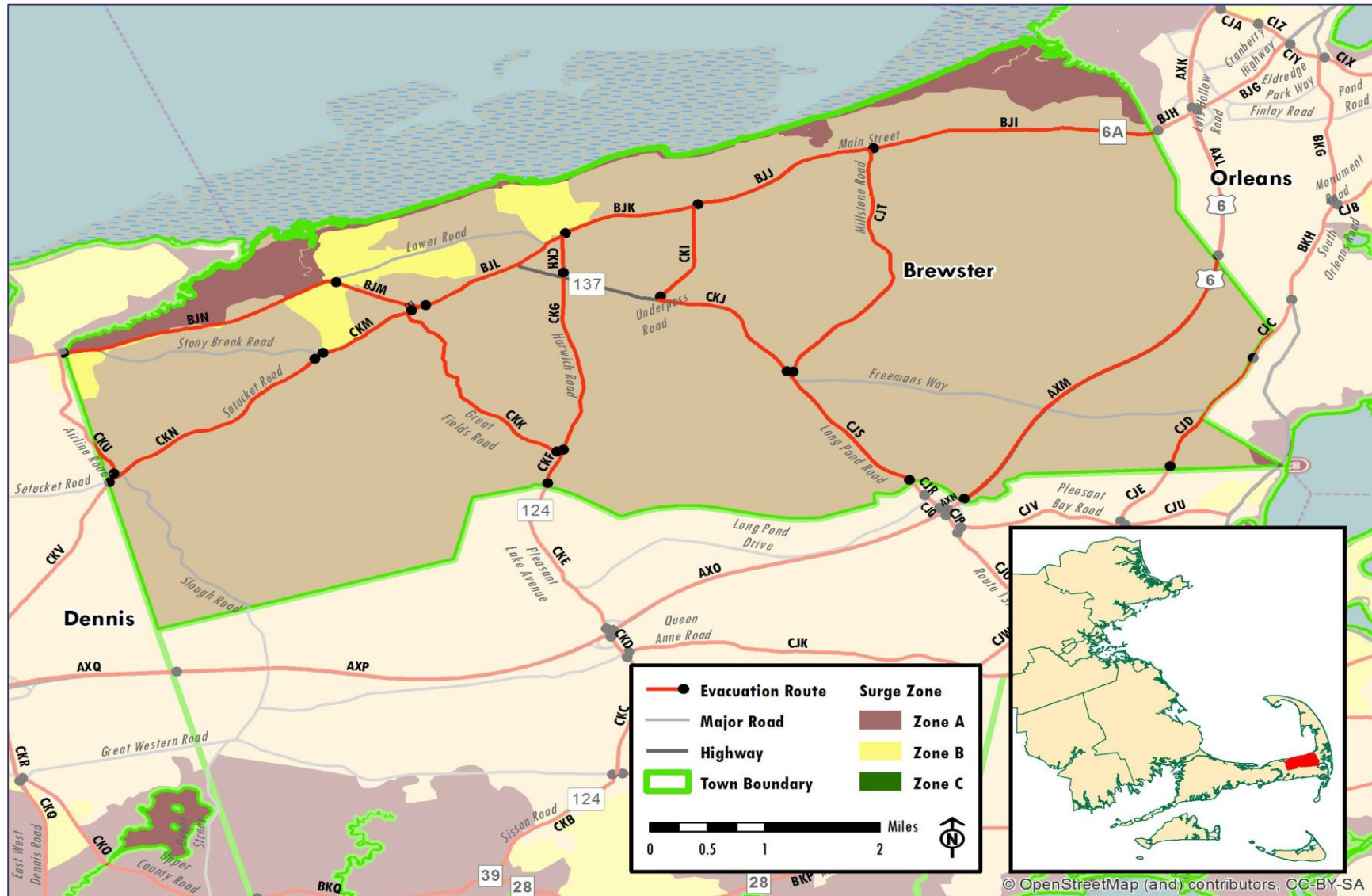


Figure 6-85: Evacuation Roadway Network – Barnstable County / Brewster



6.0 Transportation Analysis

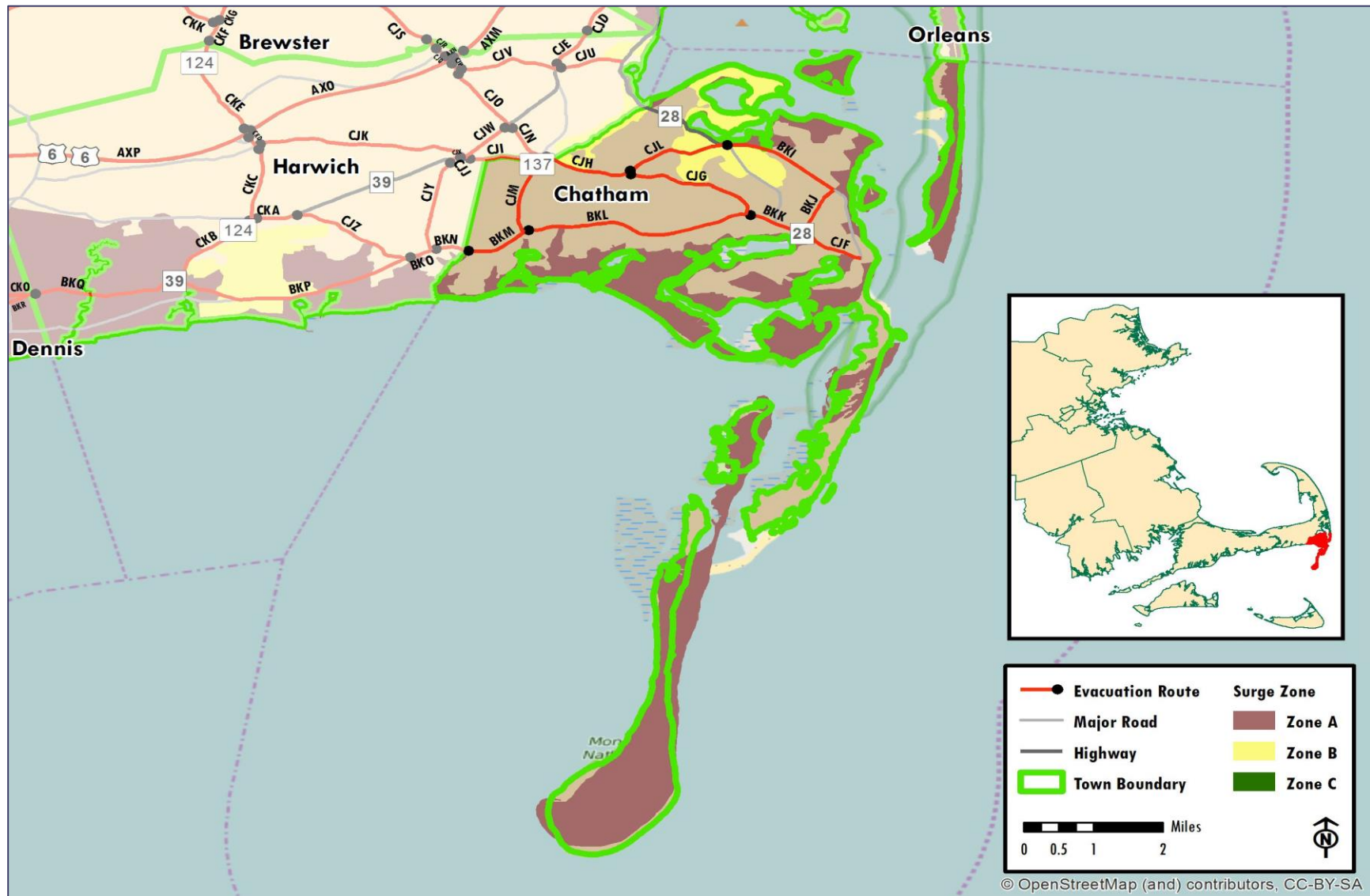


Figure 6-86: Evacuation Roadway Network – Barnstable County / Chatham



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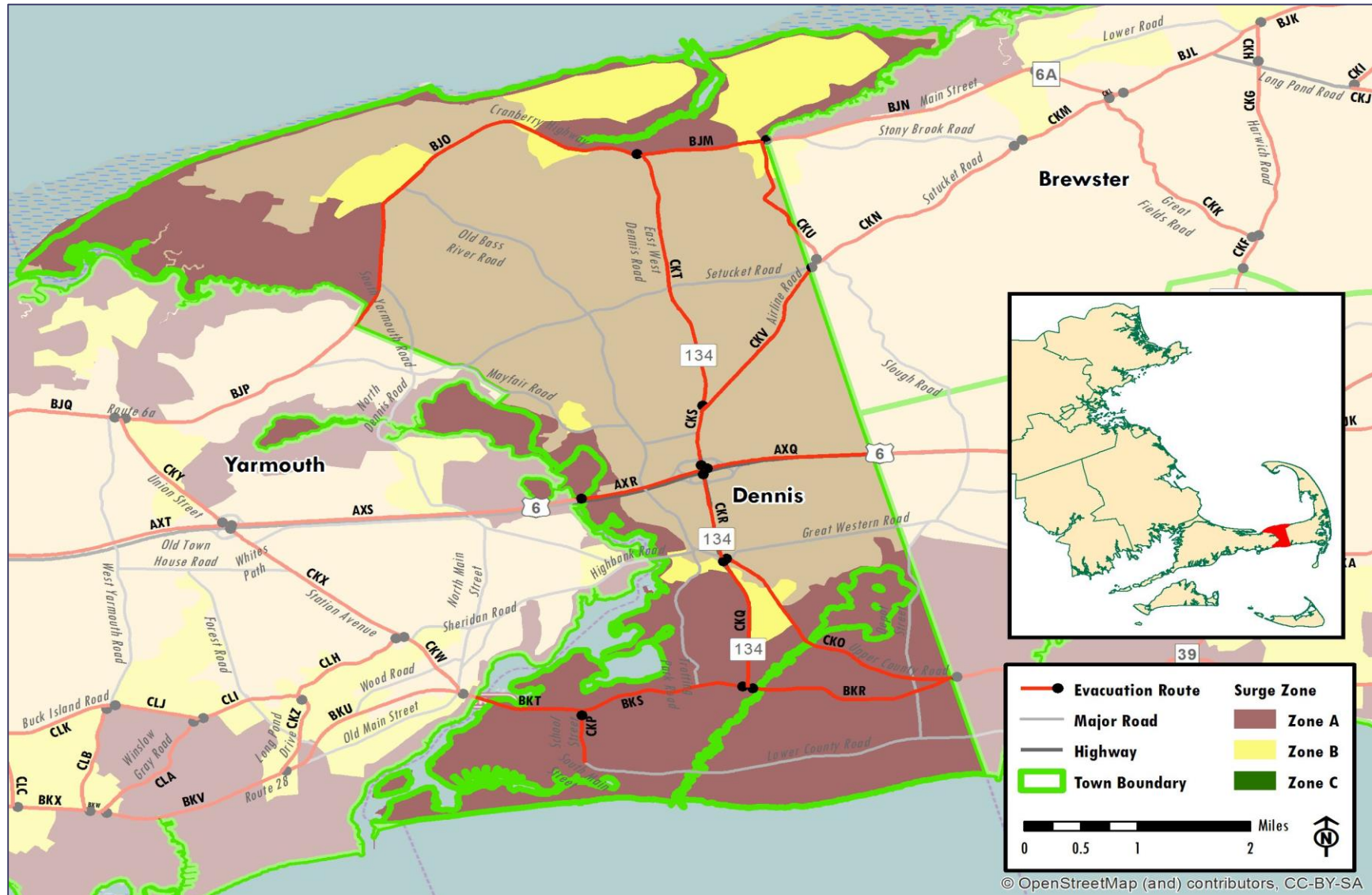


Figure 6-87: Evacuation Roadway Network – Barnstable County / Dennis



6.0 Transportation Analysis

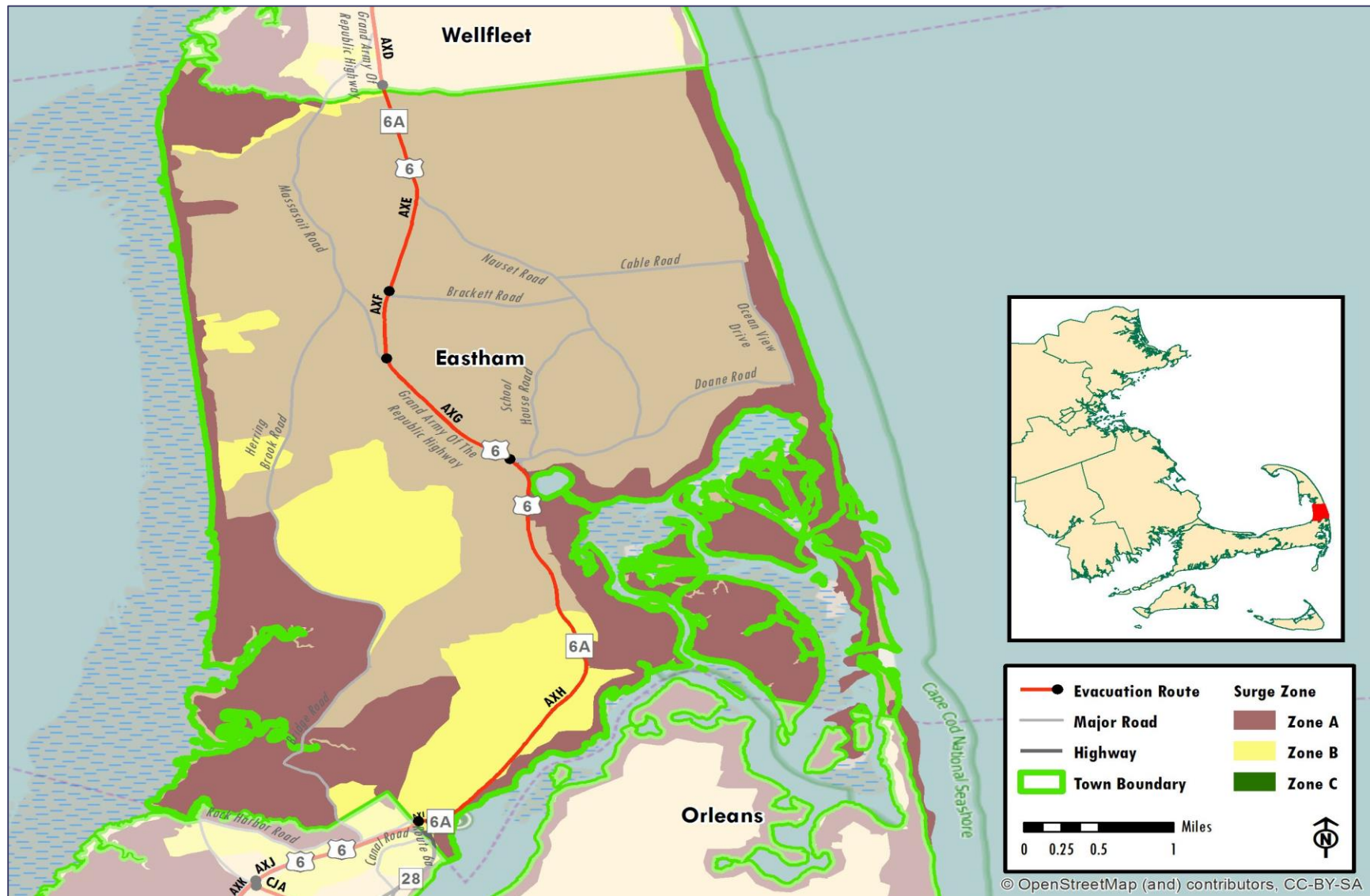


Figure 6-88: Evacuation Roadway Network – Barnstable County / Eastham



6.0 Transportation Analysis

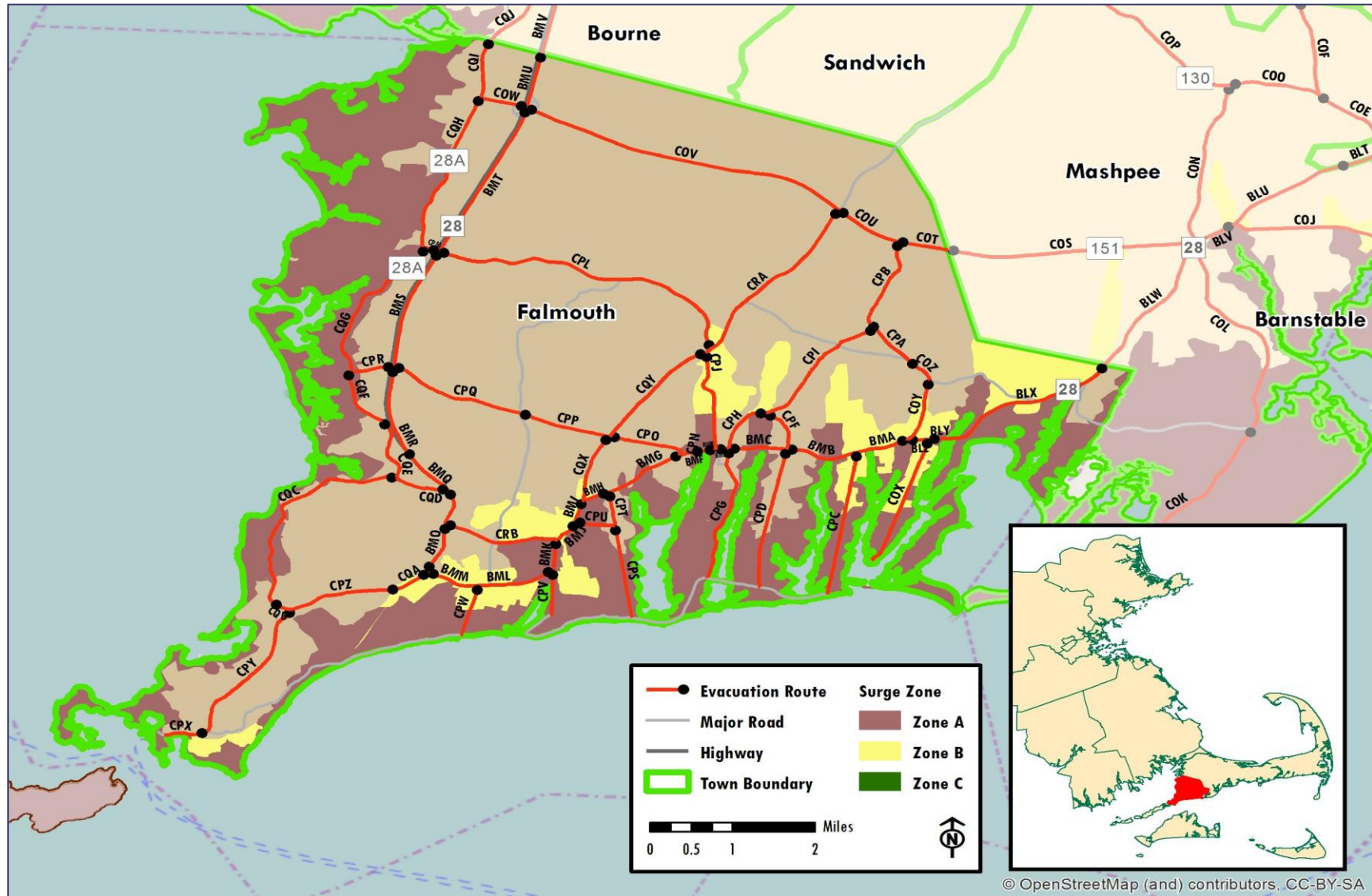


Figure 6-89: Evacuation Roadway Network – Barnstable County / Falmouth



6.0 Transportation Analysis

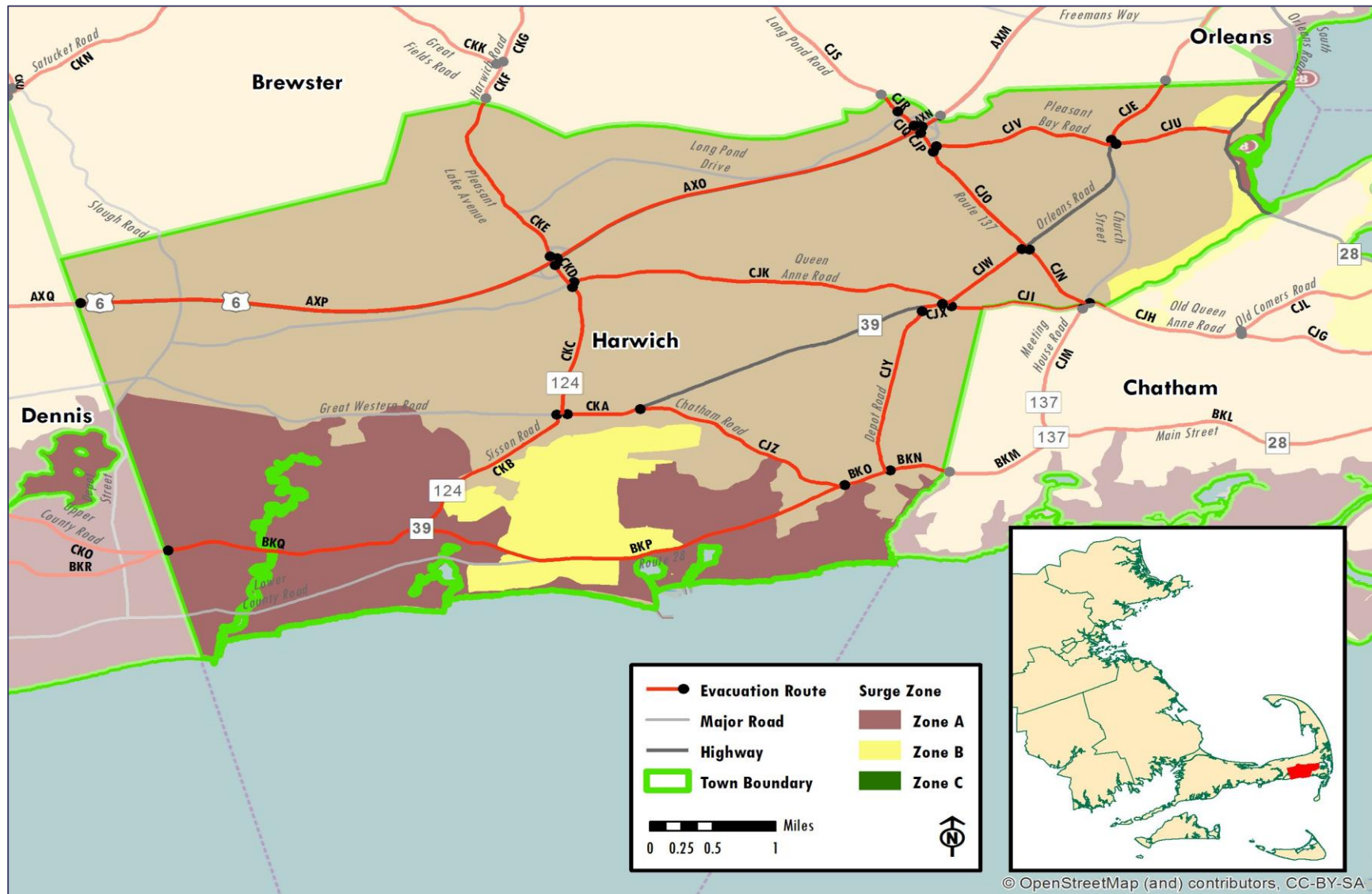


Figure 6-90: Evacuation Roadway Network – Barnstable County / Harwich



6.0 Transportation Analysis

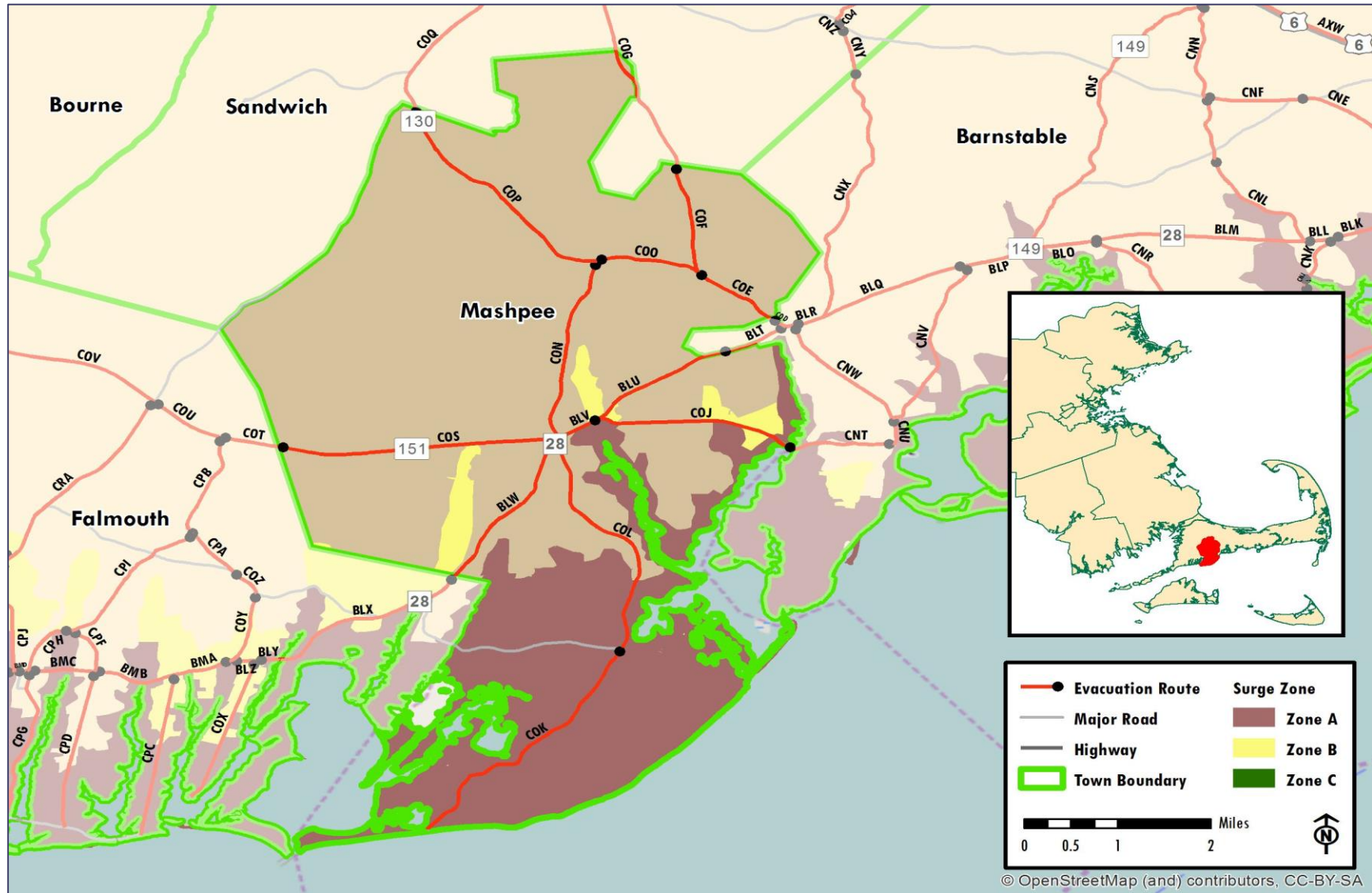


Figure 6-91: Evacuation Roadway Network – Barnstable County / Mashpee



6.0 Transportation Analysis

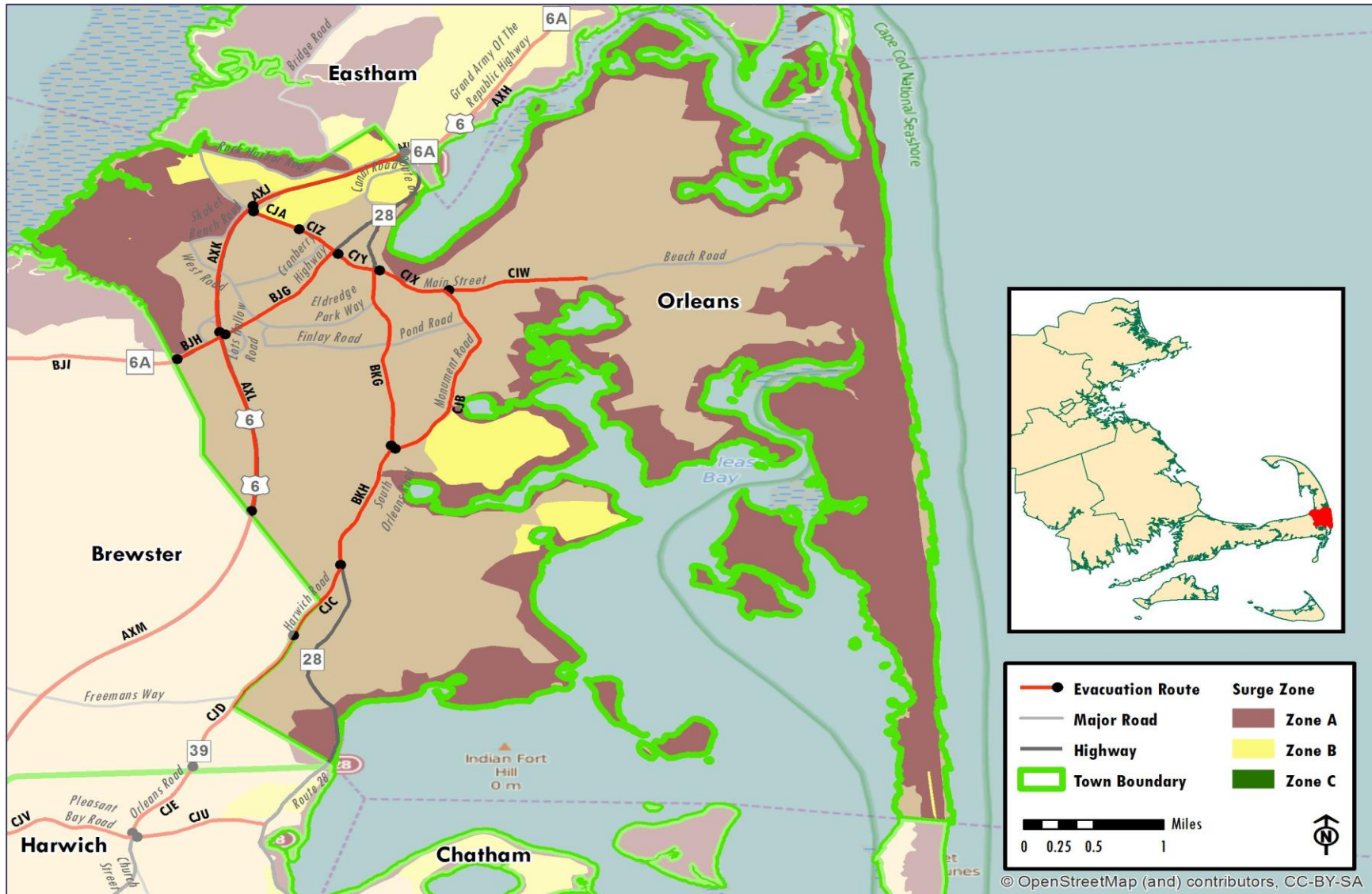


Figure 6-92: Evacuation Roadway Network – Barnstable County / Orleans



6.0 Transportation Analysis

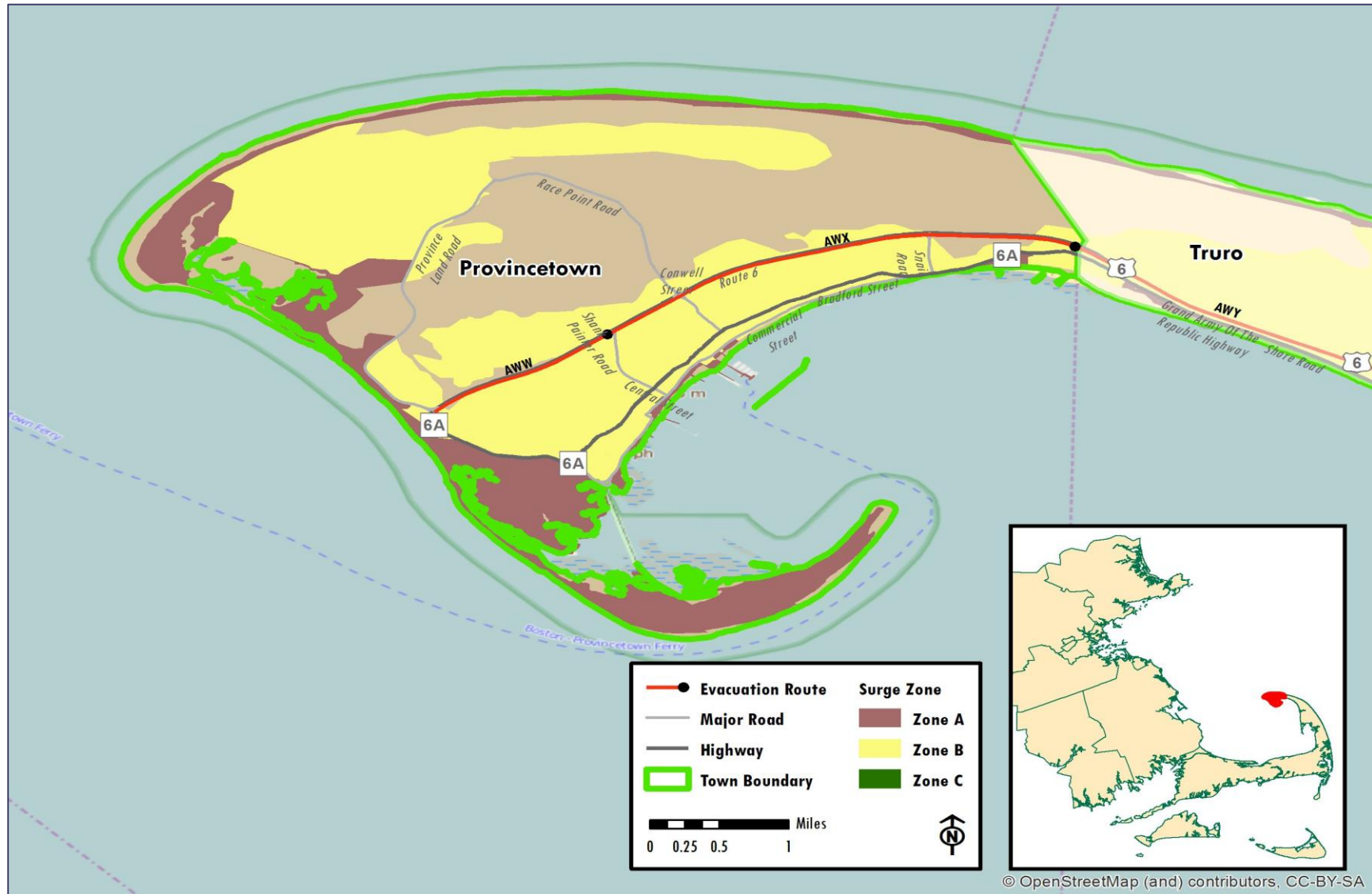


Figure 6-93: Evacuation Roadway Network – Barnstable County / Provincetown



6.0 Transportation Analysis

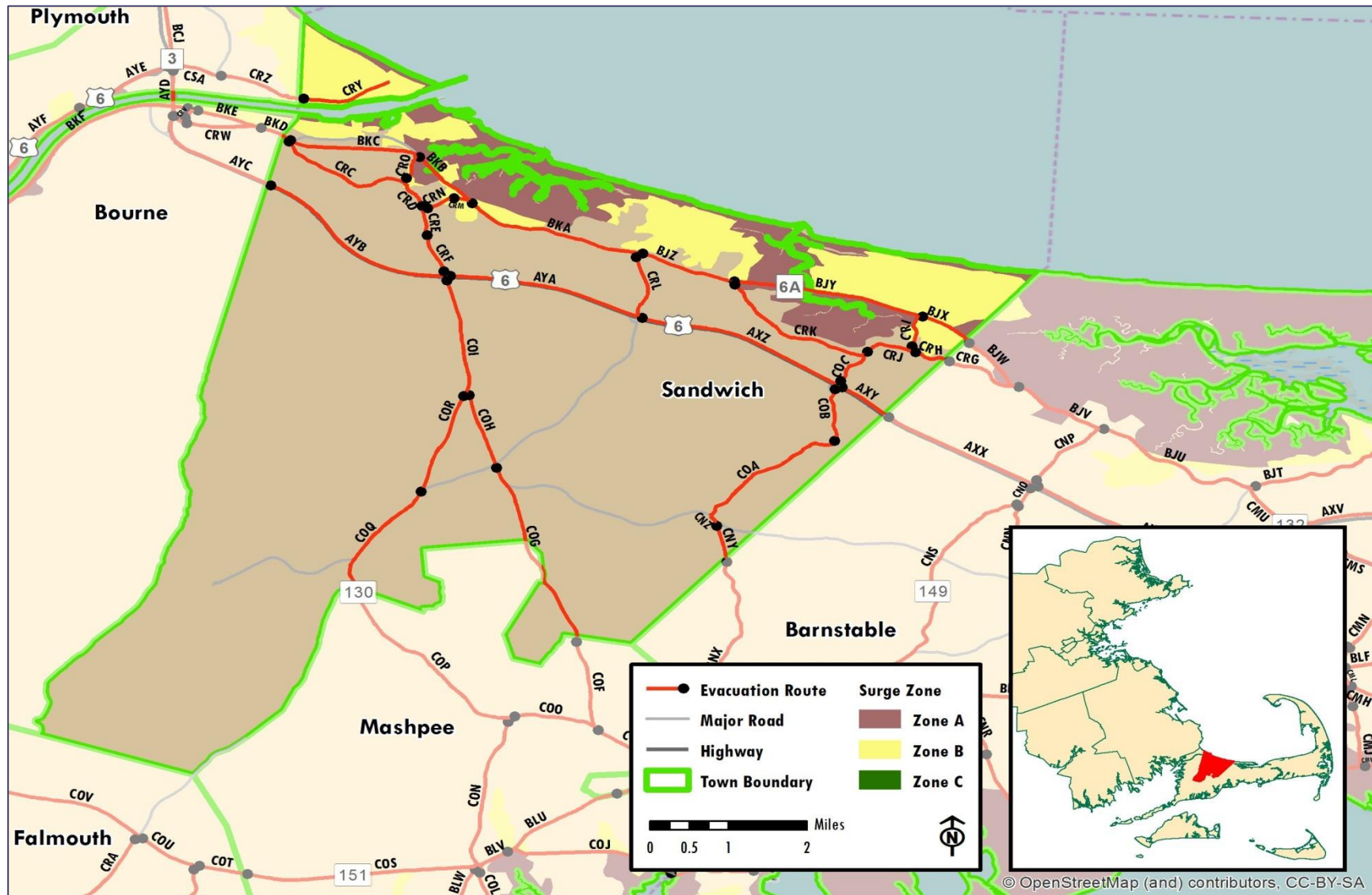


Figure 6-94: Evacuation Roadway Network – Barnstable County / Sandwich



6.0 Transportation Analysis

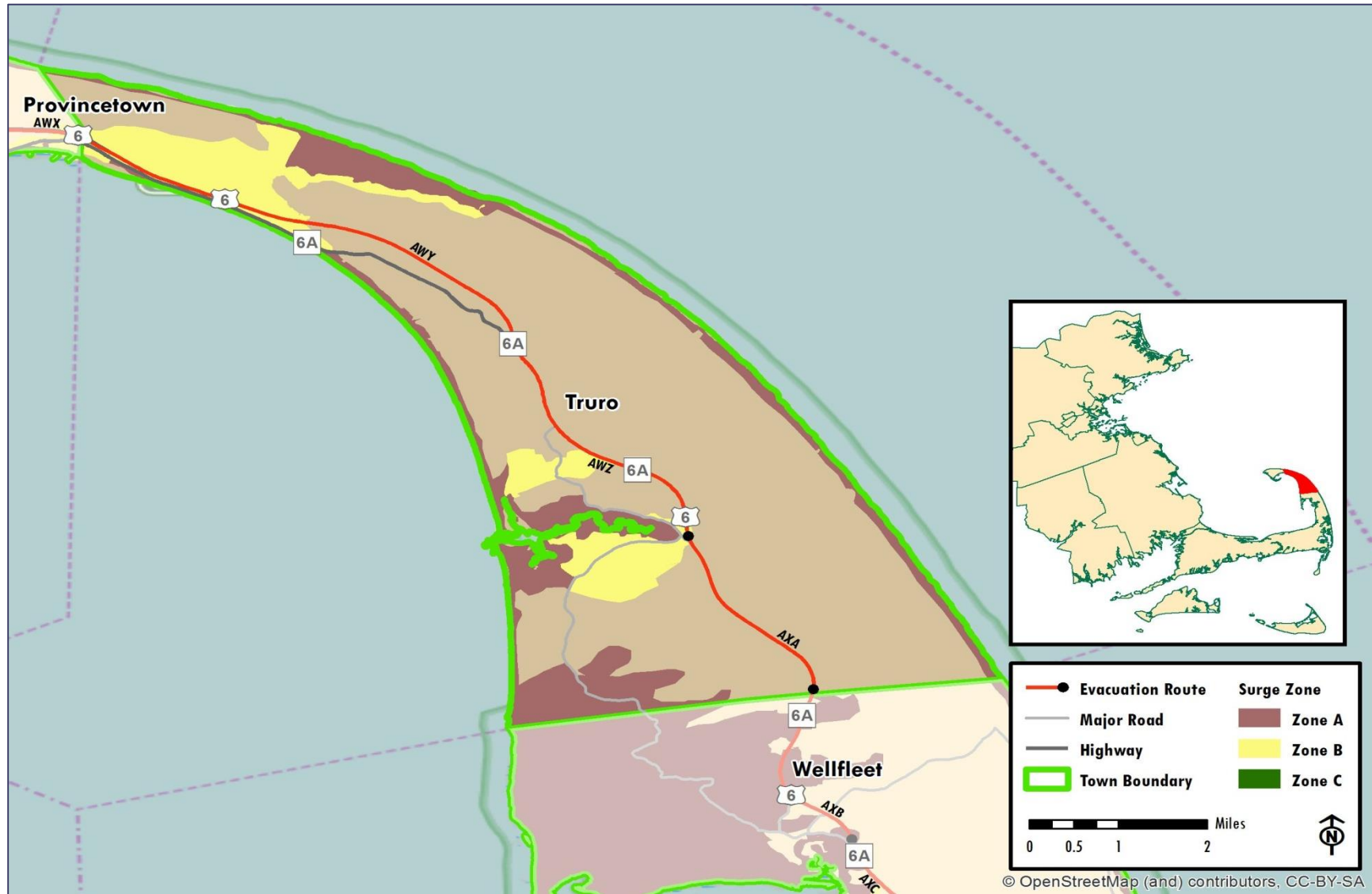


Figure 6-95: Evacuation Roadway Network – Barnstable County / Truro



6.0 Transportation Analysis

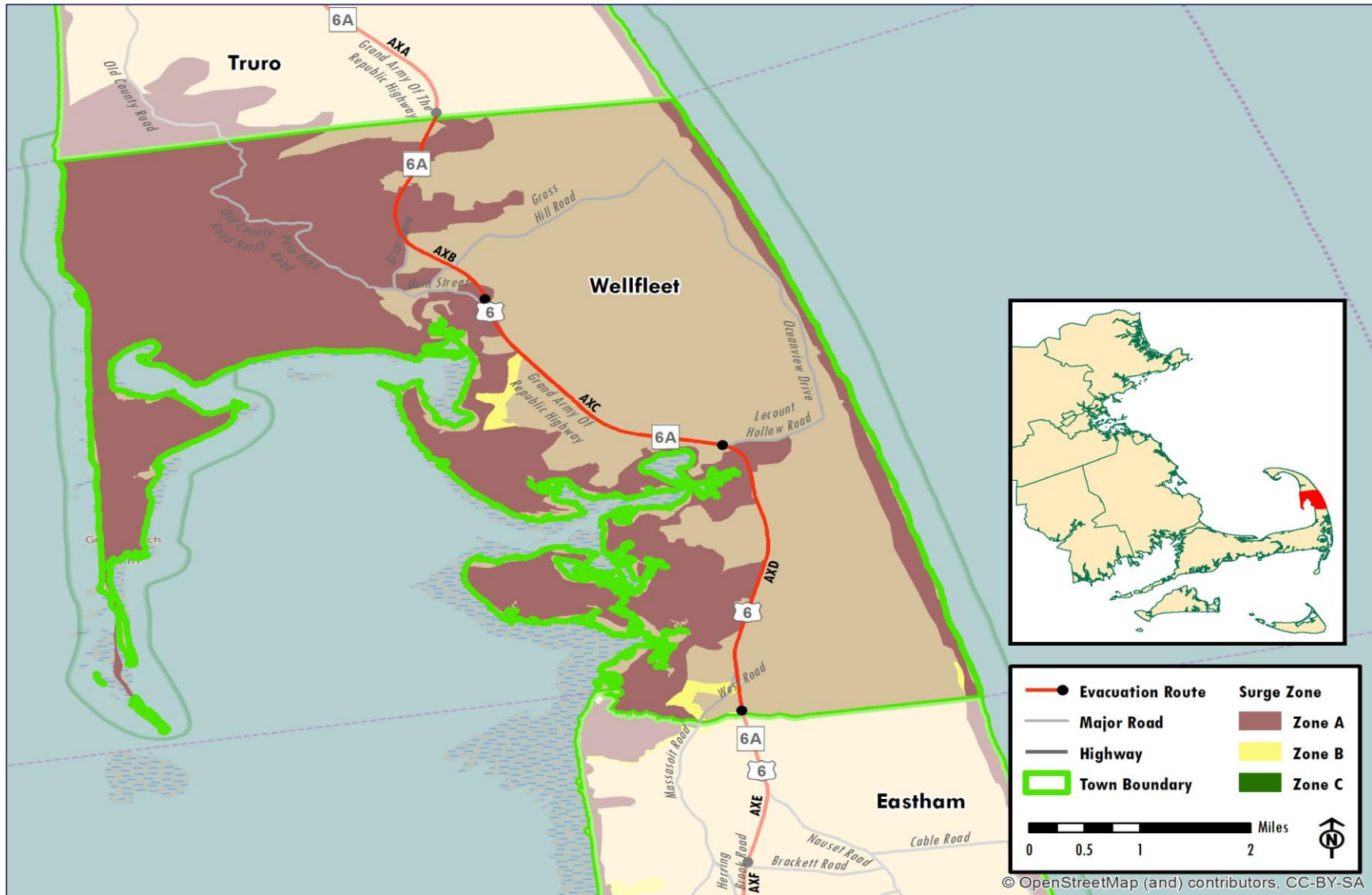


Figure 6-96: Evacuation Roadway Network – Barnstable County / Wellfleet



6.0 Transportation Analysis

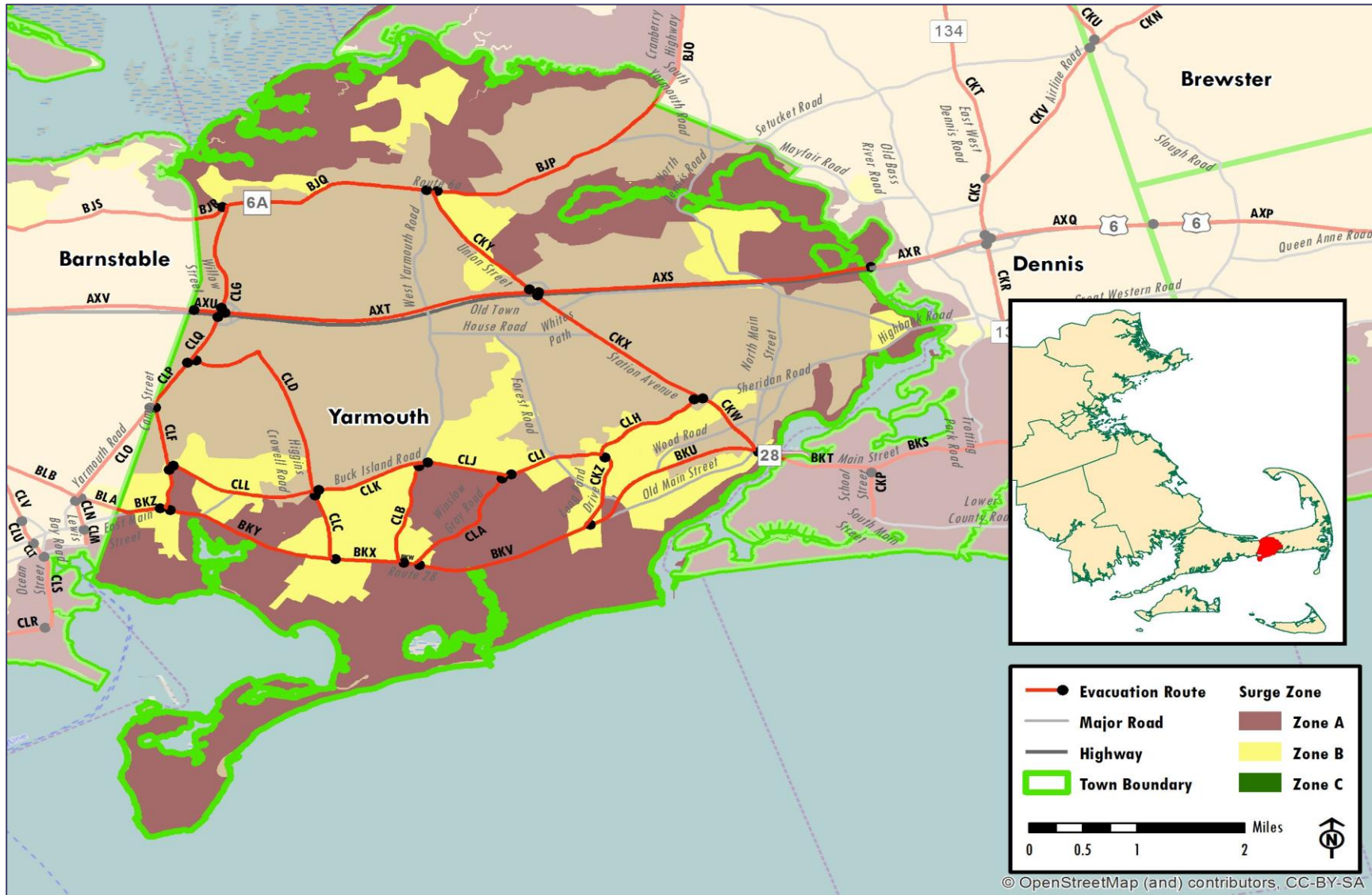


Figure 6-97: Evacuation Roadway Network – Barnstable County / Yarmouth



6.0 Transportation Analysis

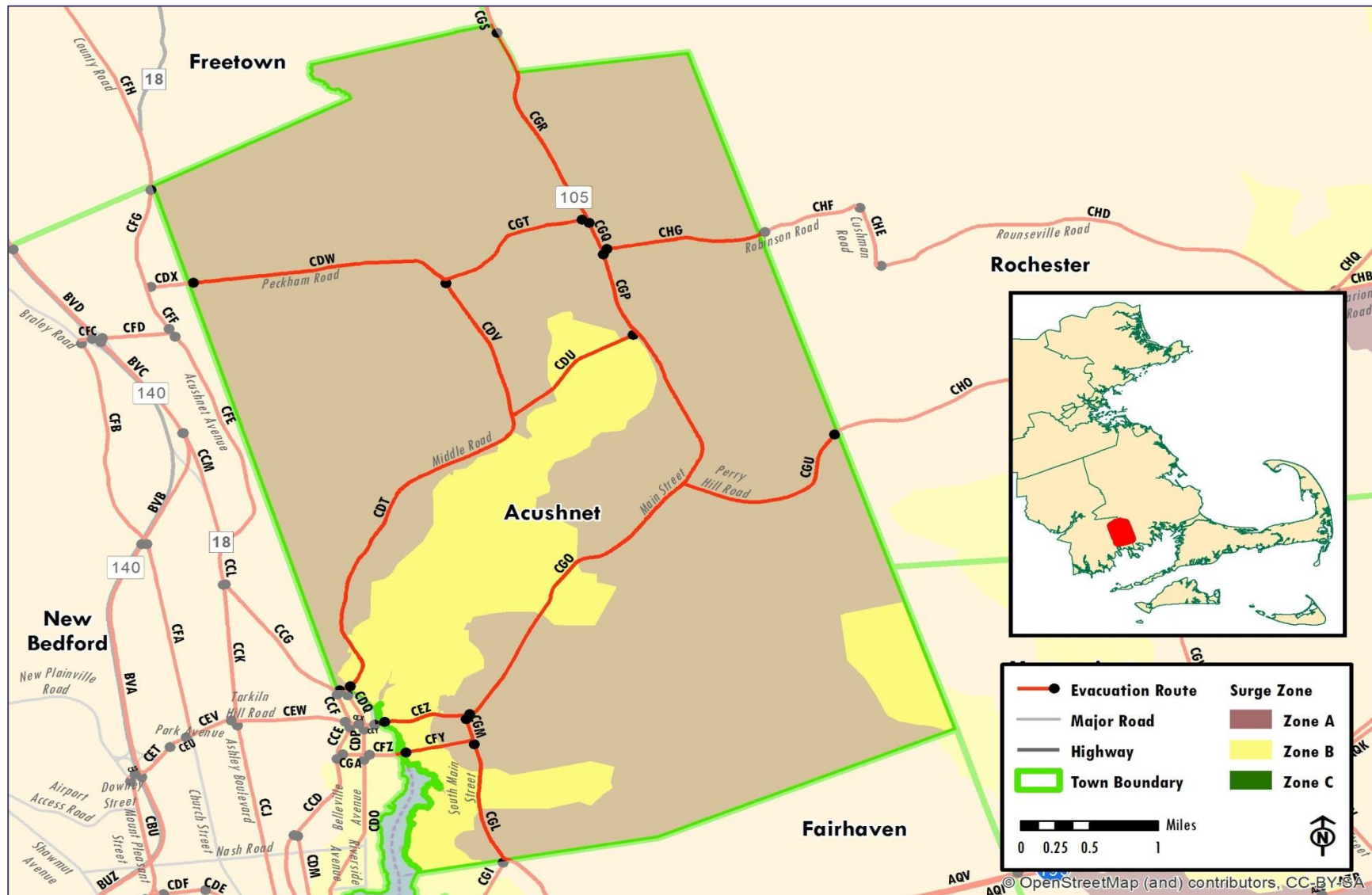


Figure 6-98: Evacuation Roadway Network – Bristol County / Acushnet



6.0 Transportation Analysis

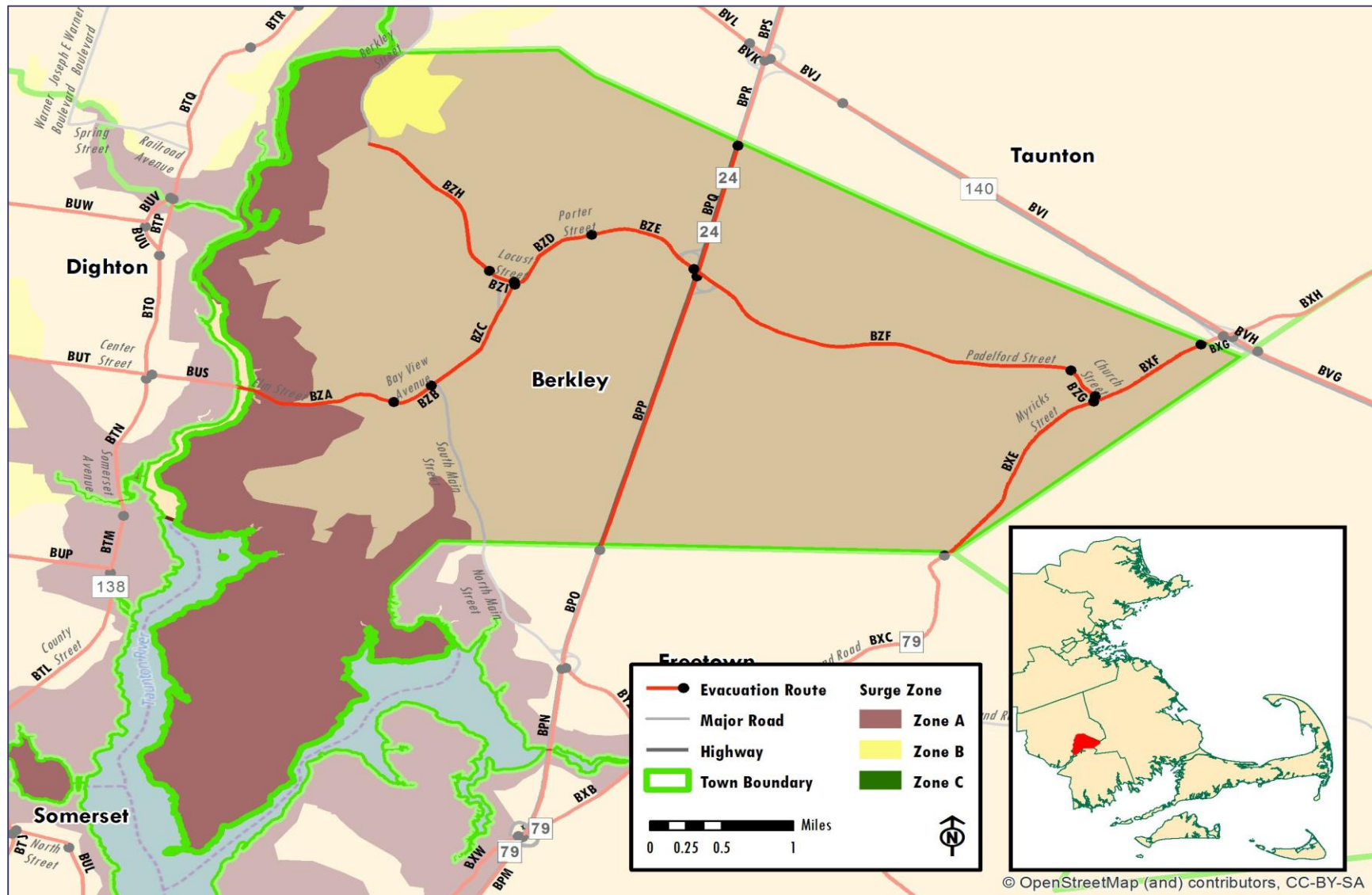


Figure 6-99: Evacuation Roadway Network – Bristol County / Berkley



6.0 Transportation Analysis

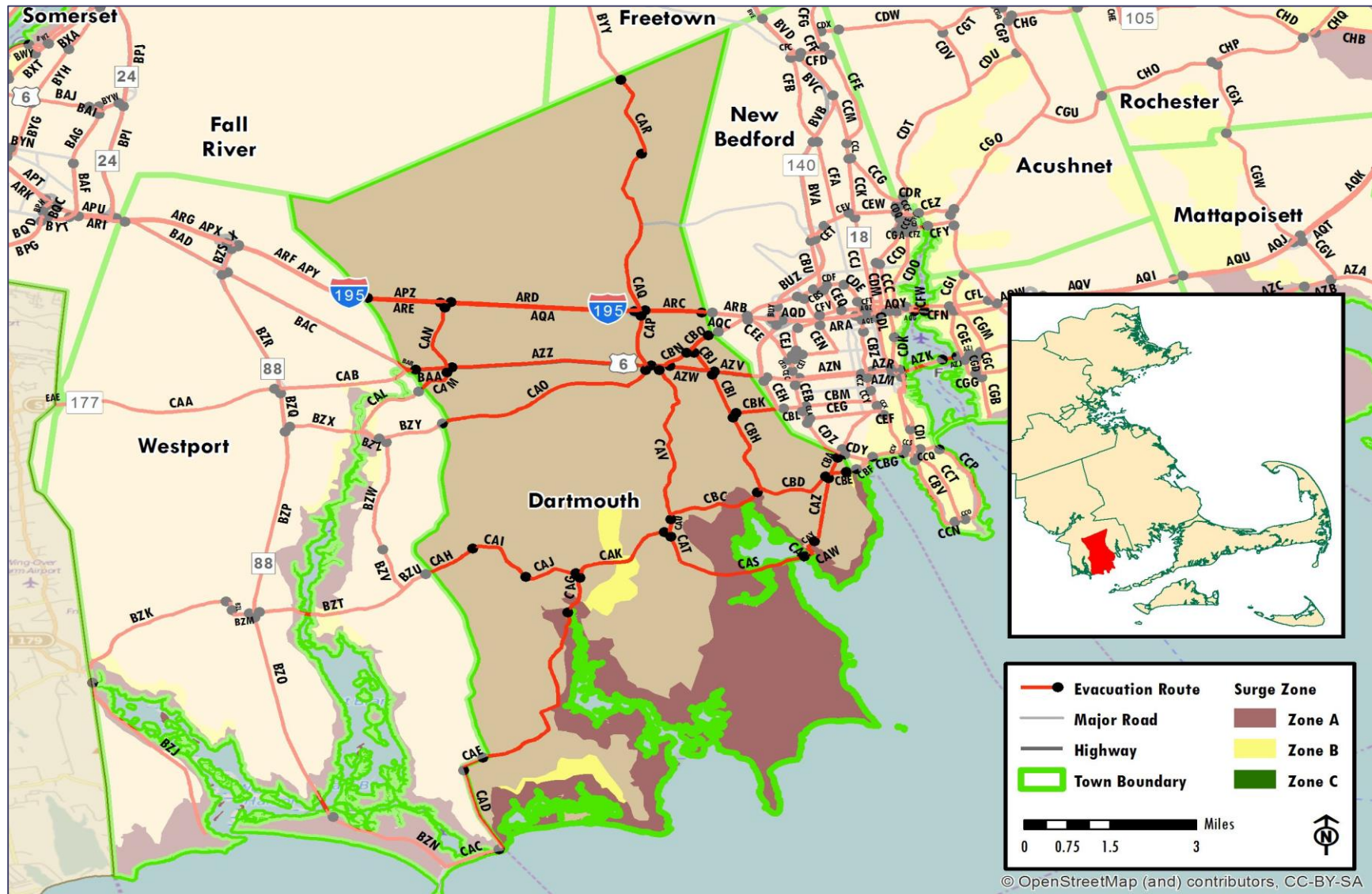


Figure 6-100: Evacuation Roadway Network – Bristol County / Dartmouth



6.0 Transportation Analysis

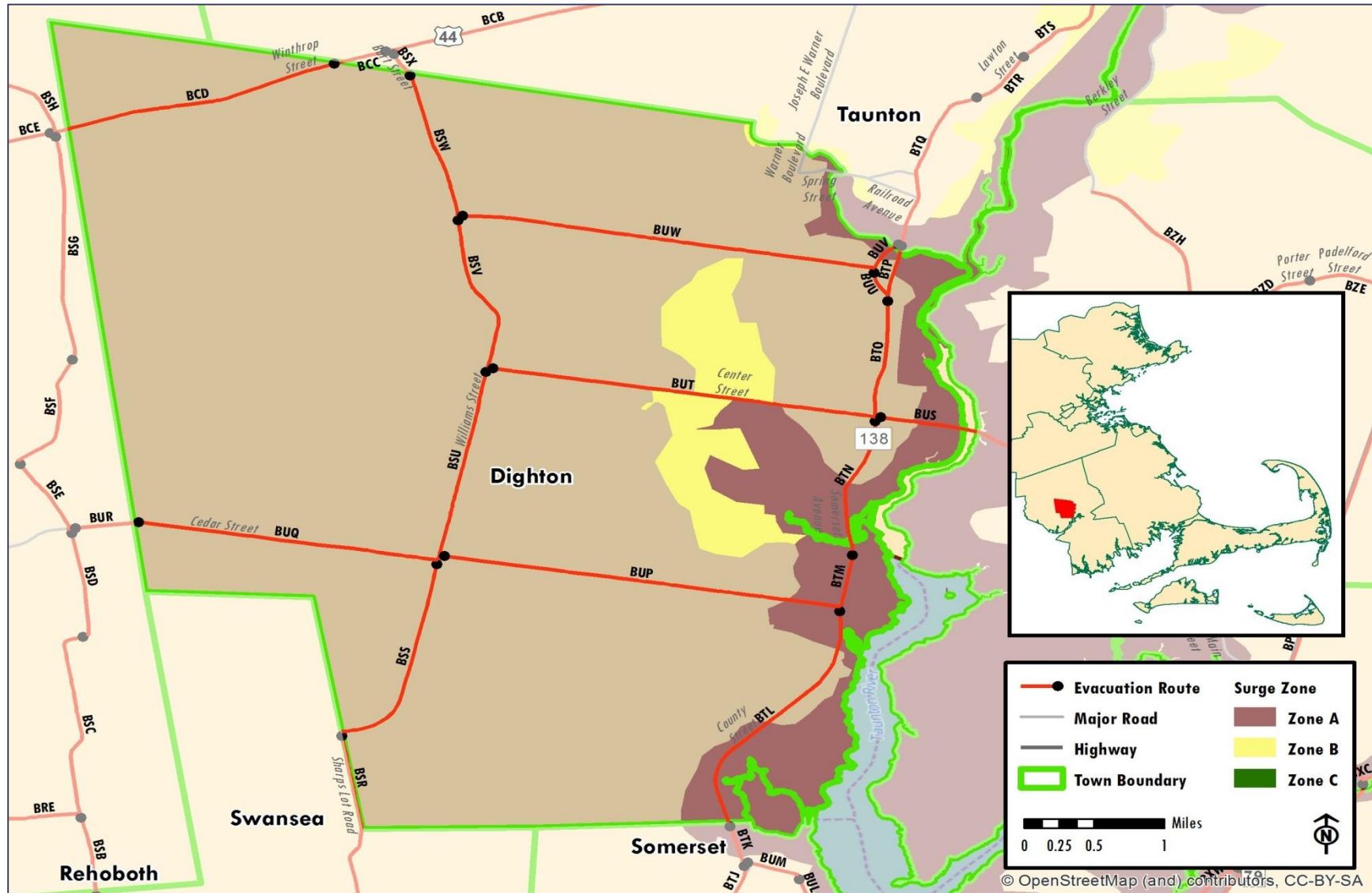


Figure 6-101: Evacuation Roadway Network – Bristol County / Dighton



6.0 Transportation Analysis

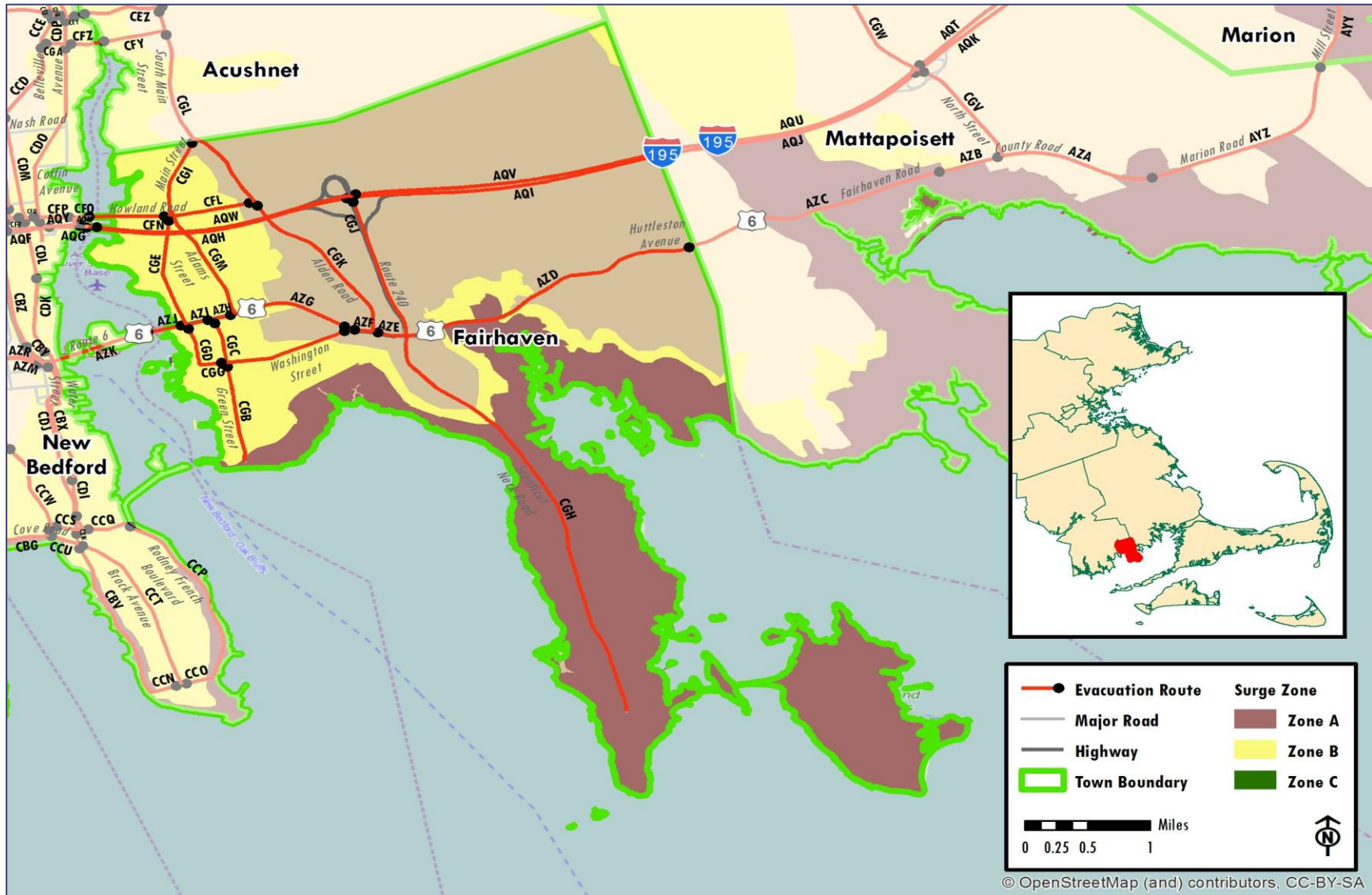


Figure 6-102: Evacuation Roadway Network – Bristol County / Fairhaven



6.0 Transportation Analysis

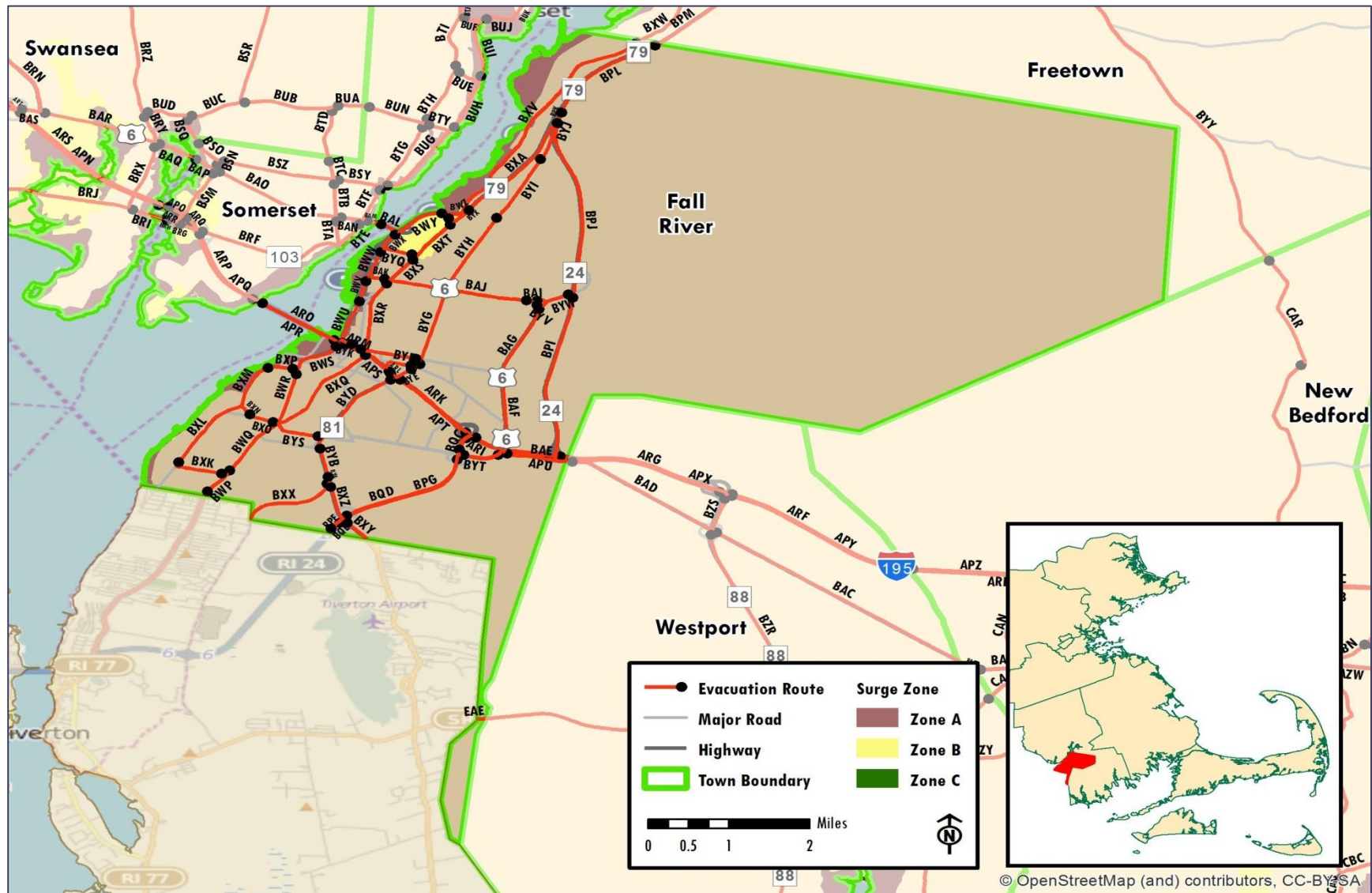


Figure 6-103: Evacuation Roadway Network – Bristol County / Fall River



6.0 Transportation Analysis

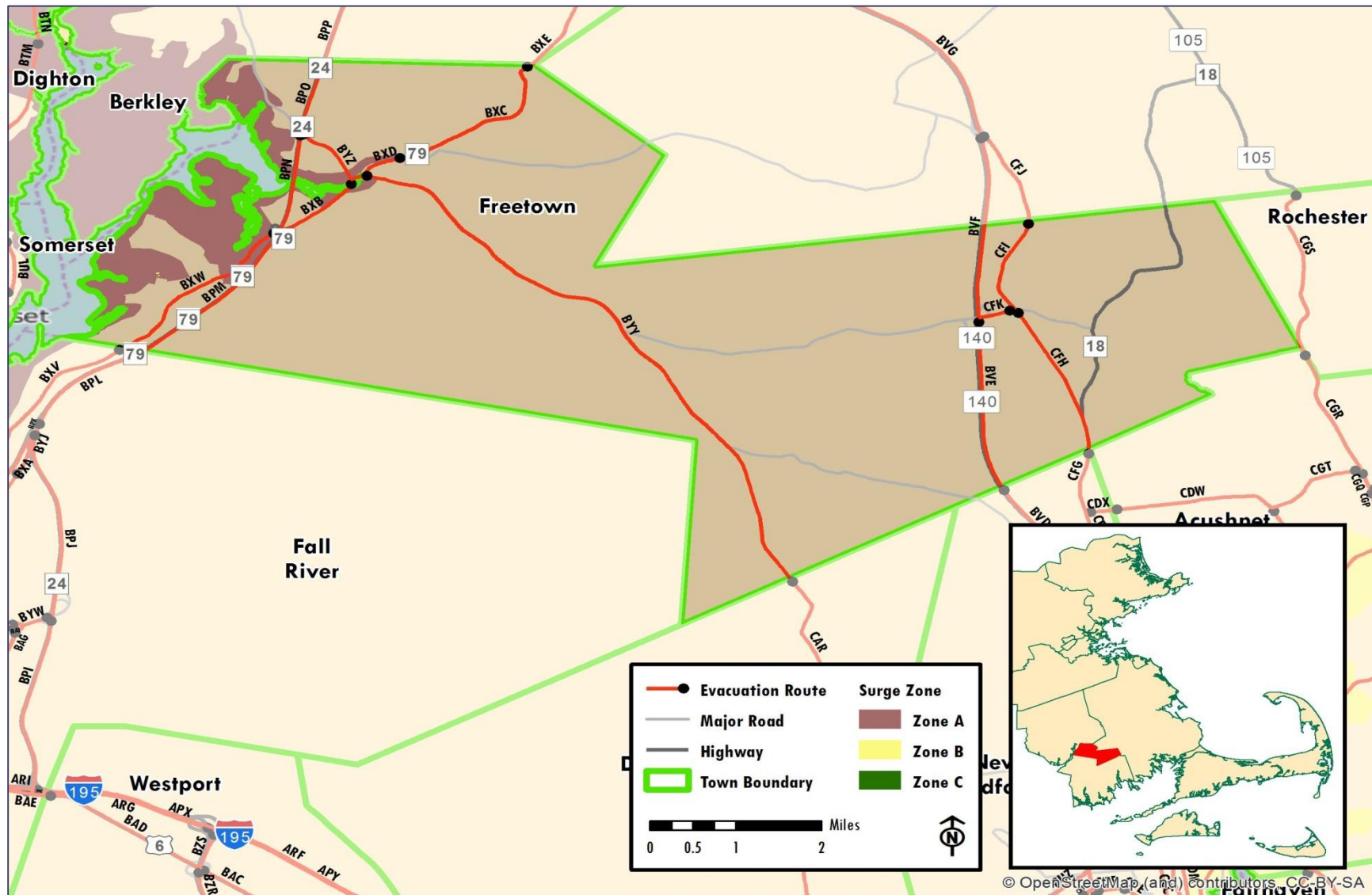


Figure 6-104: Evacuation Roadway Network – Bristol County / Freetown



6.0 Transportation Analysis

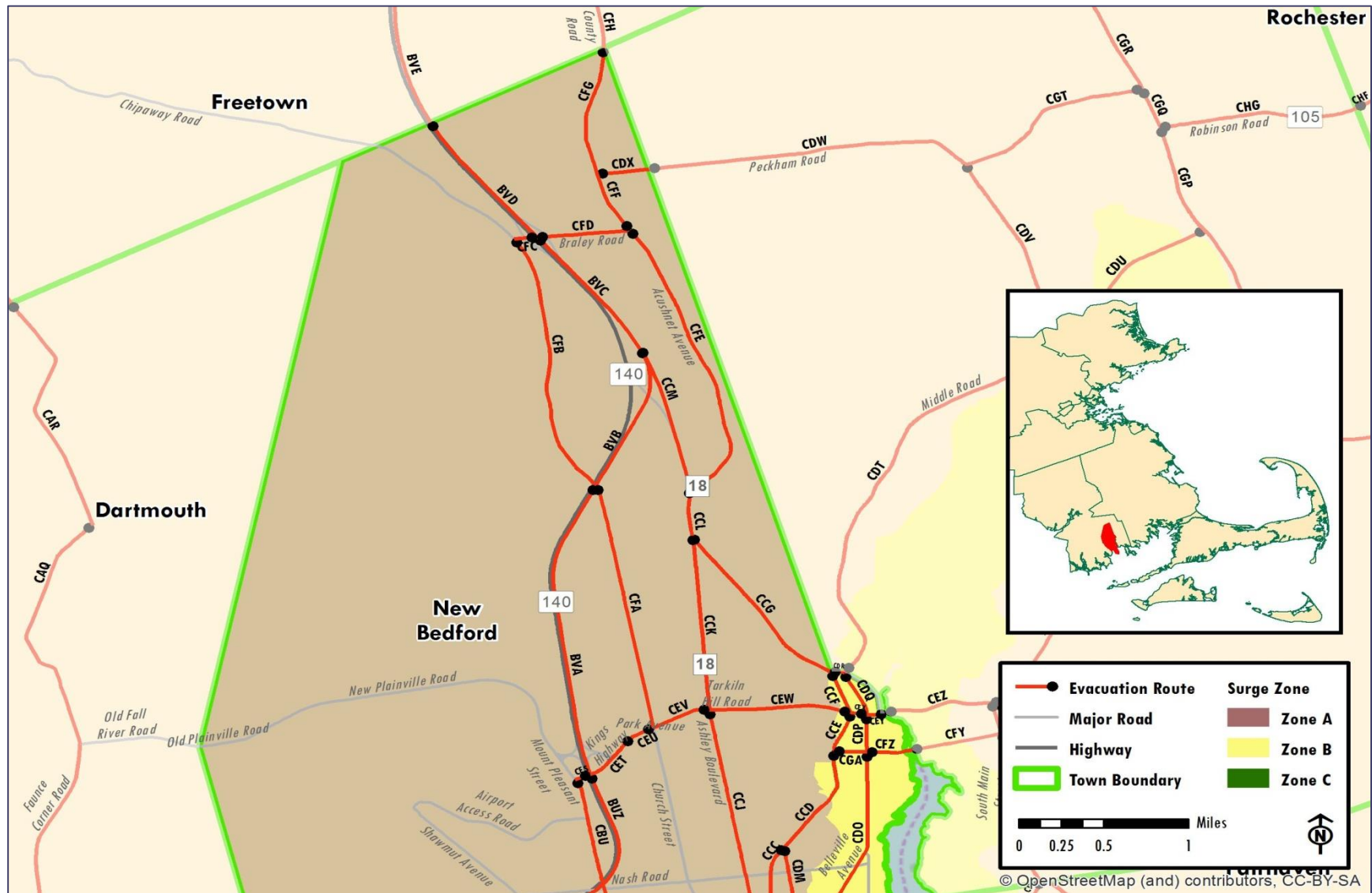


Figure 6-105: Evacuation Roadway Network – Bristol County / New Bedford (north)



6.0 Transportation Analysis

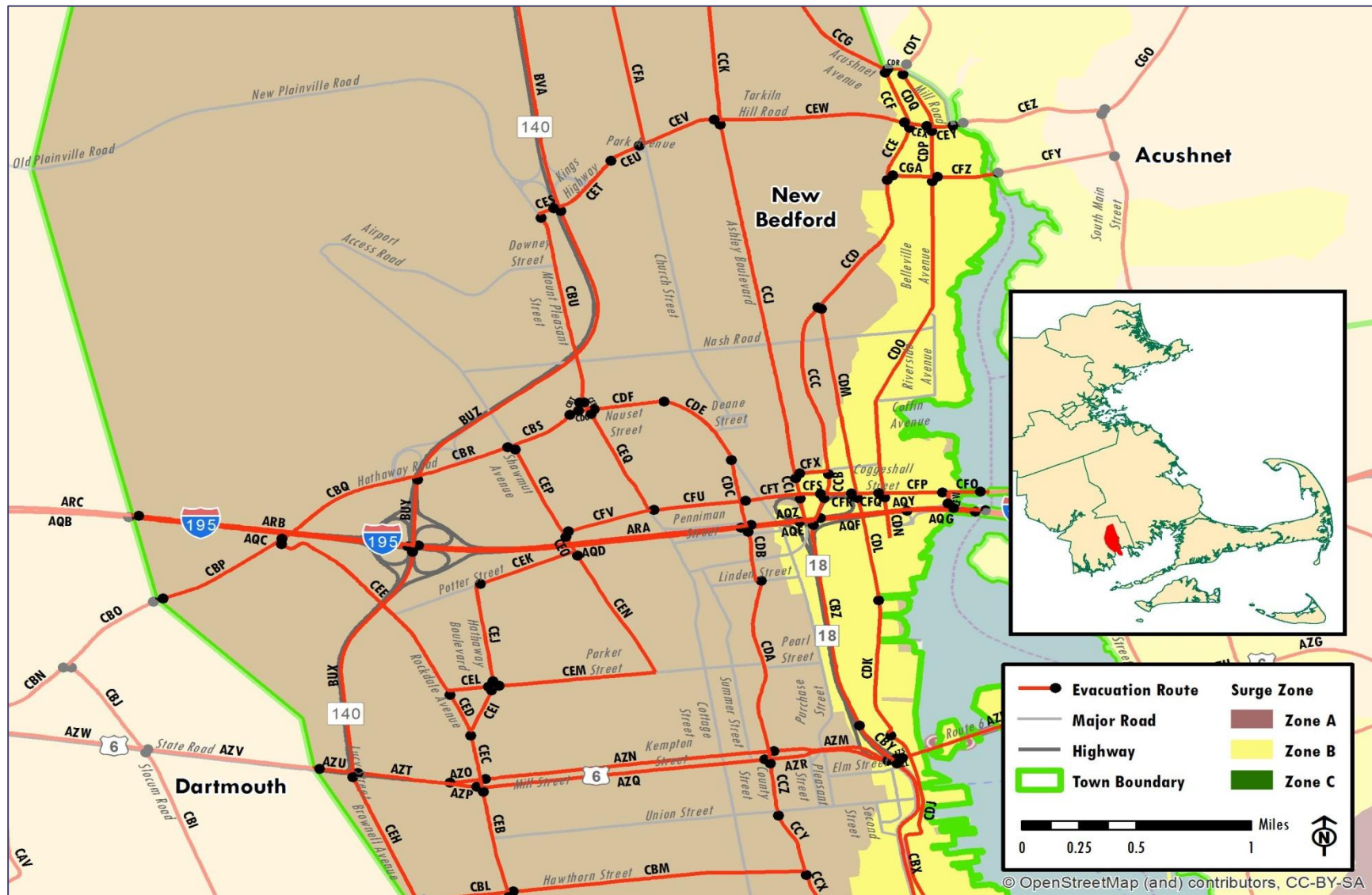


Figure 6-106: Evacuation Roadway Network – Bristol County / New Bedford (central)



6.0 Transportation Analysis

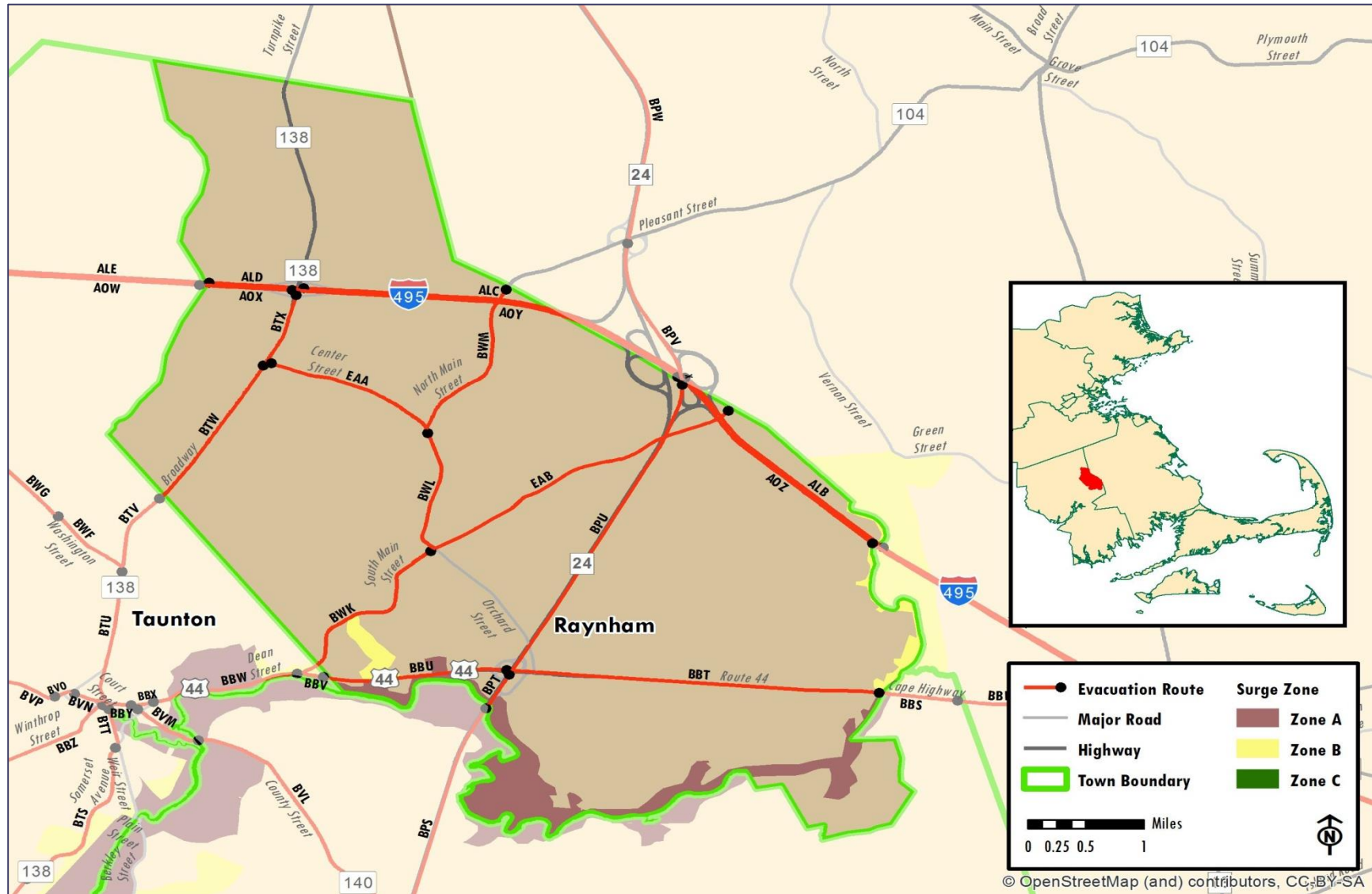


Figure 6-108: Evacuation Roadway Network – Bristol County / Raynham



6.0 Transportation Analysis

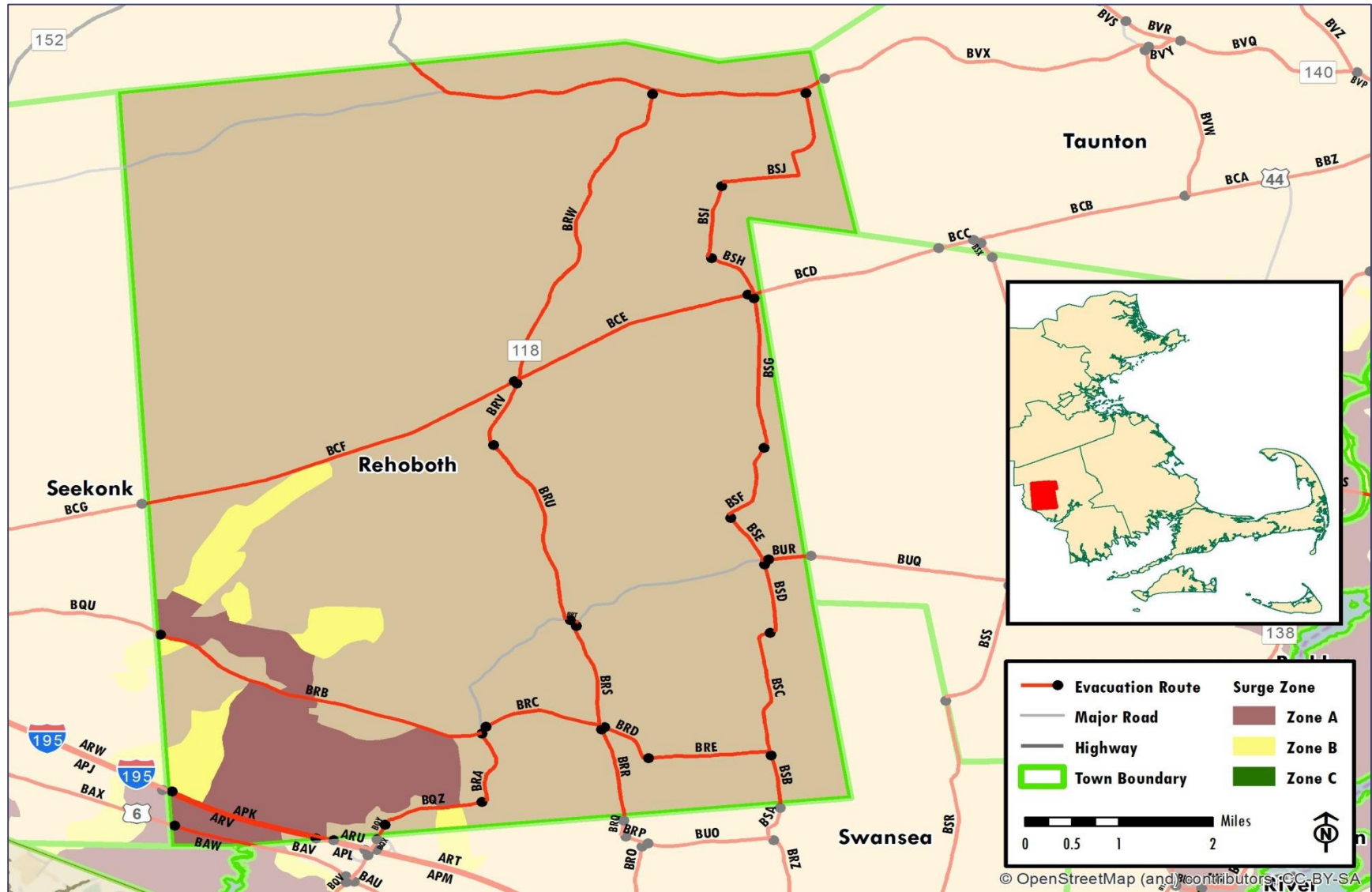


Figure 6-109: Evacuation Roadway Network – Bristol County / Rehoboth



6.0 Transportation Analysis

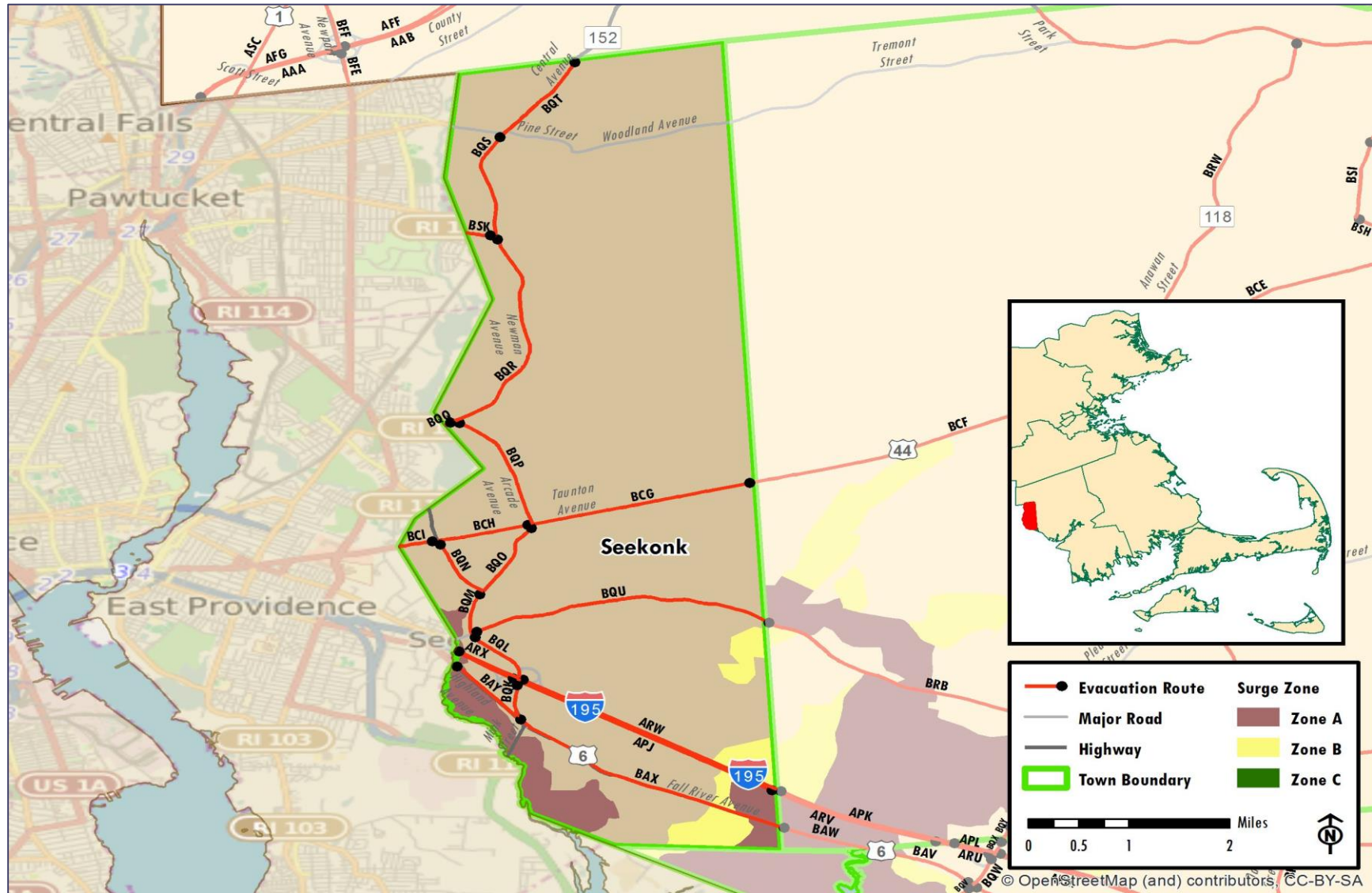


Figure 6-110: Evacuation Roadway Network – Bristol County / Seekonk



6.0 Transportation Analysis

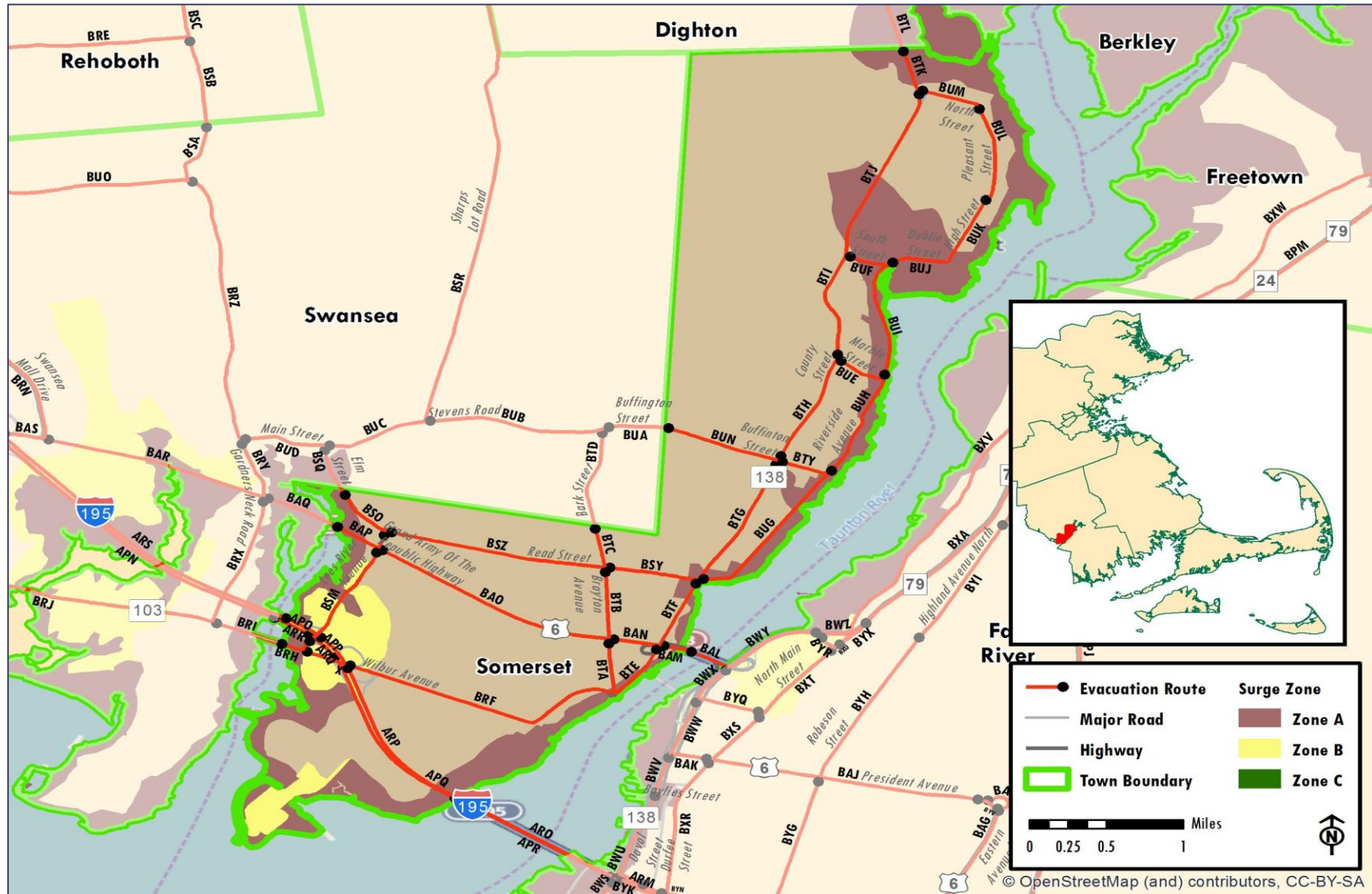


Figure 6-111: Evacuation Roadway Network – Bristol County / Somerset



6.0 Transportation Analysis

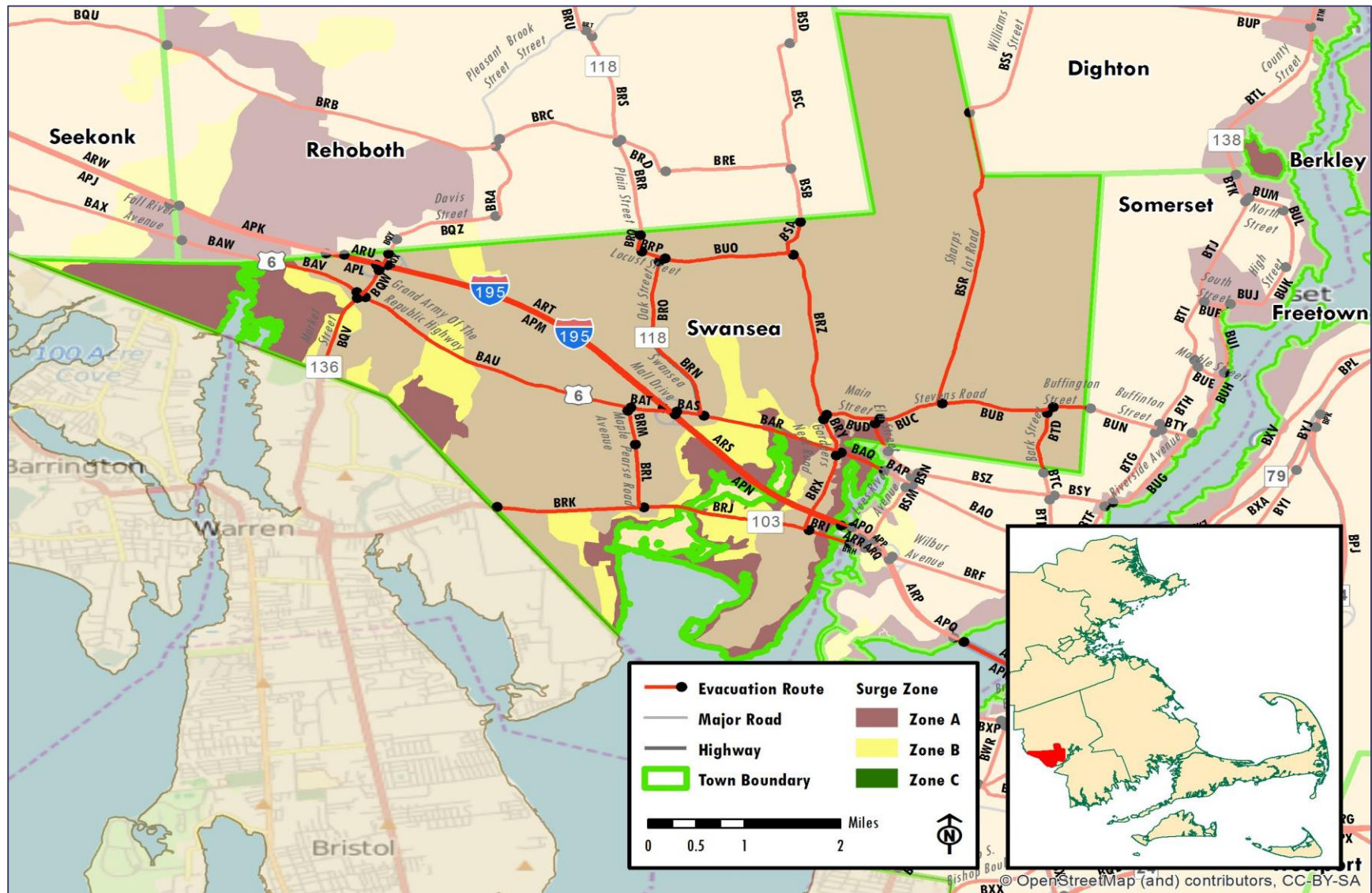


Figure 6-112: Evacuation Roadway Network – Bristol County / Swansea



6.0 Transportation Analysis

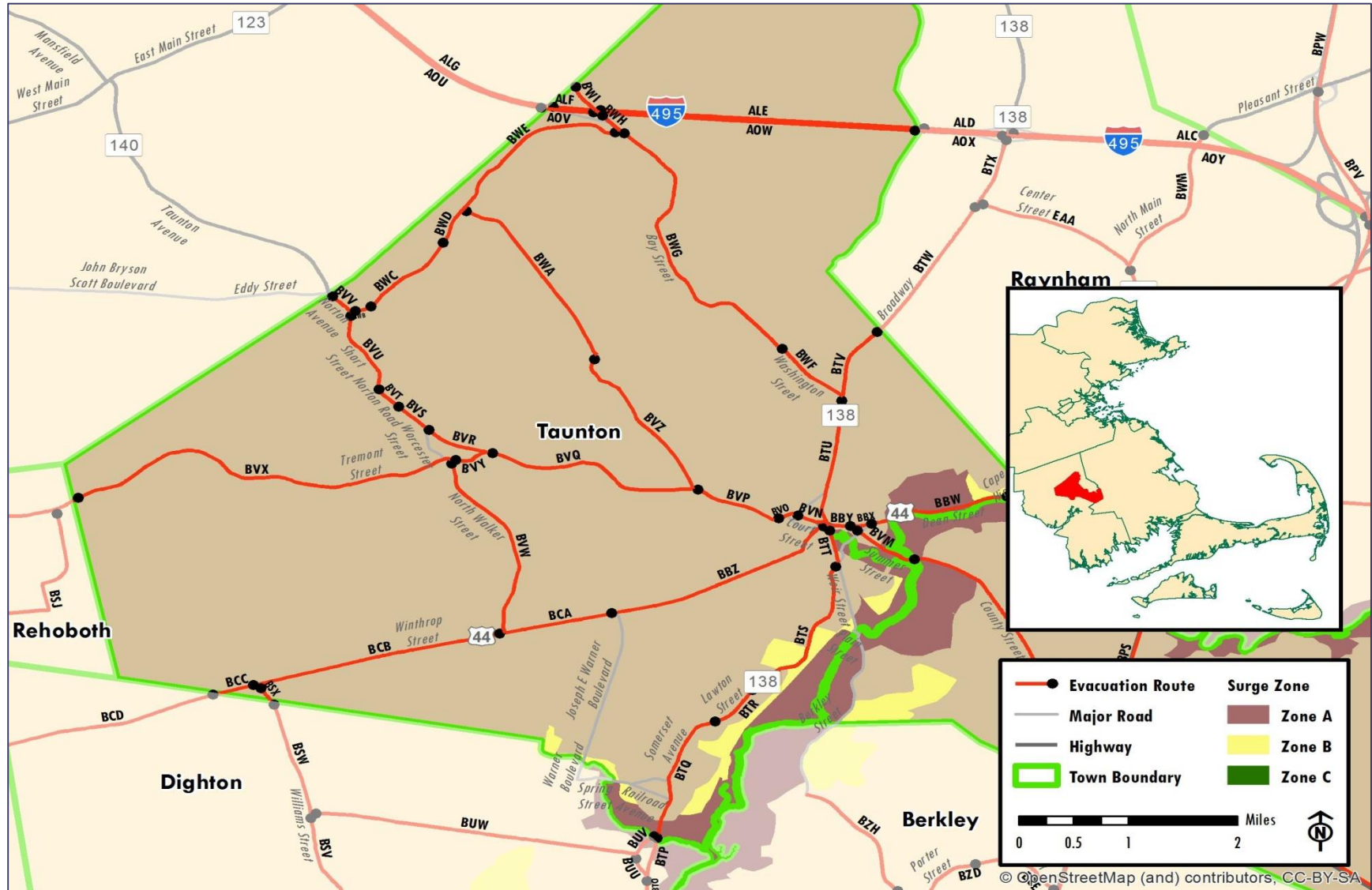


Figure 6-113: Evacuation Roadway Network – Bristol County / Taunton (west)



6.0 Transportation Analysis

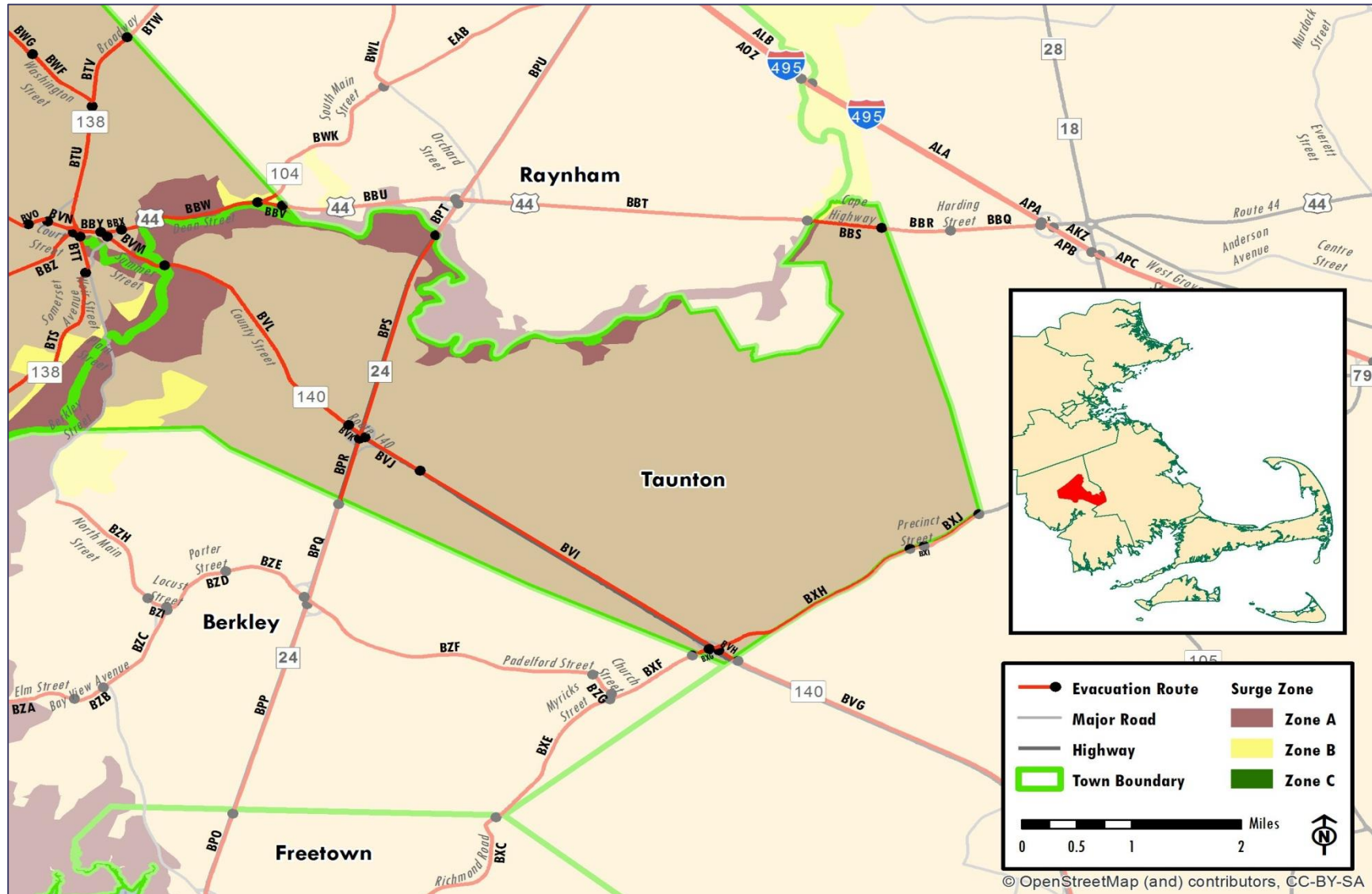


Figure 6-114: Evacuation Roadway Network – Bristol County / Taunton (east)



6.0 Transportation Analysis

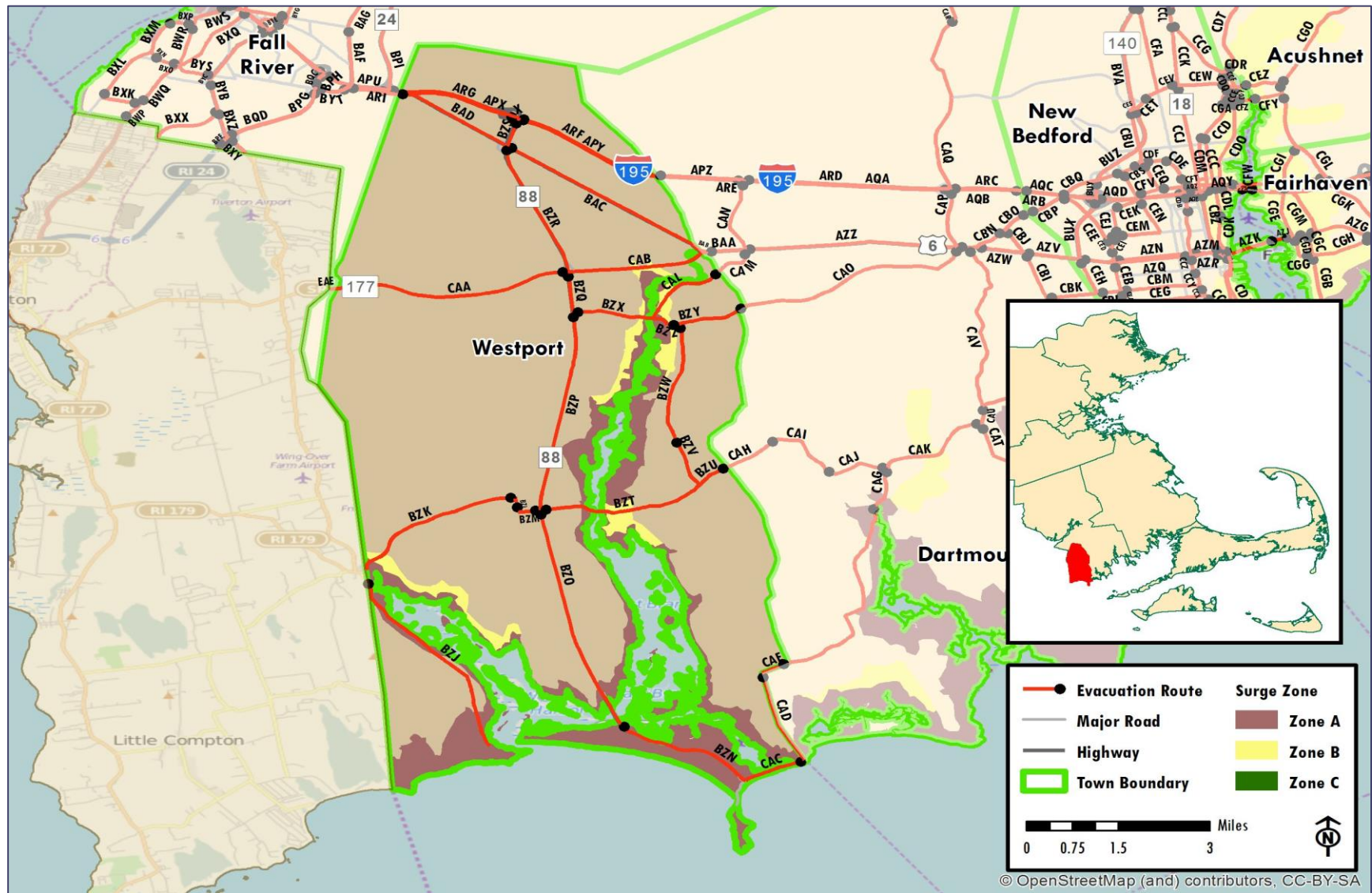


Figure 6-115: Evacuation Roadway Network – Bristol County / Westport



6.0 Transportation Analysis

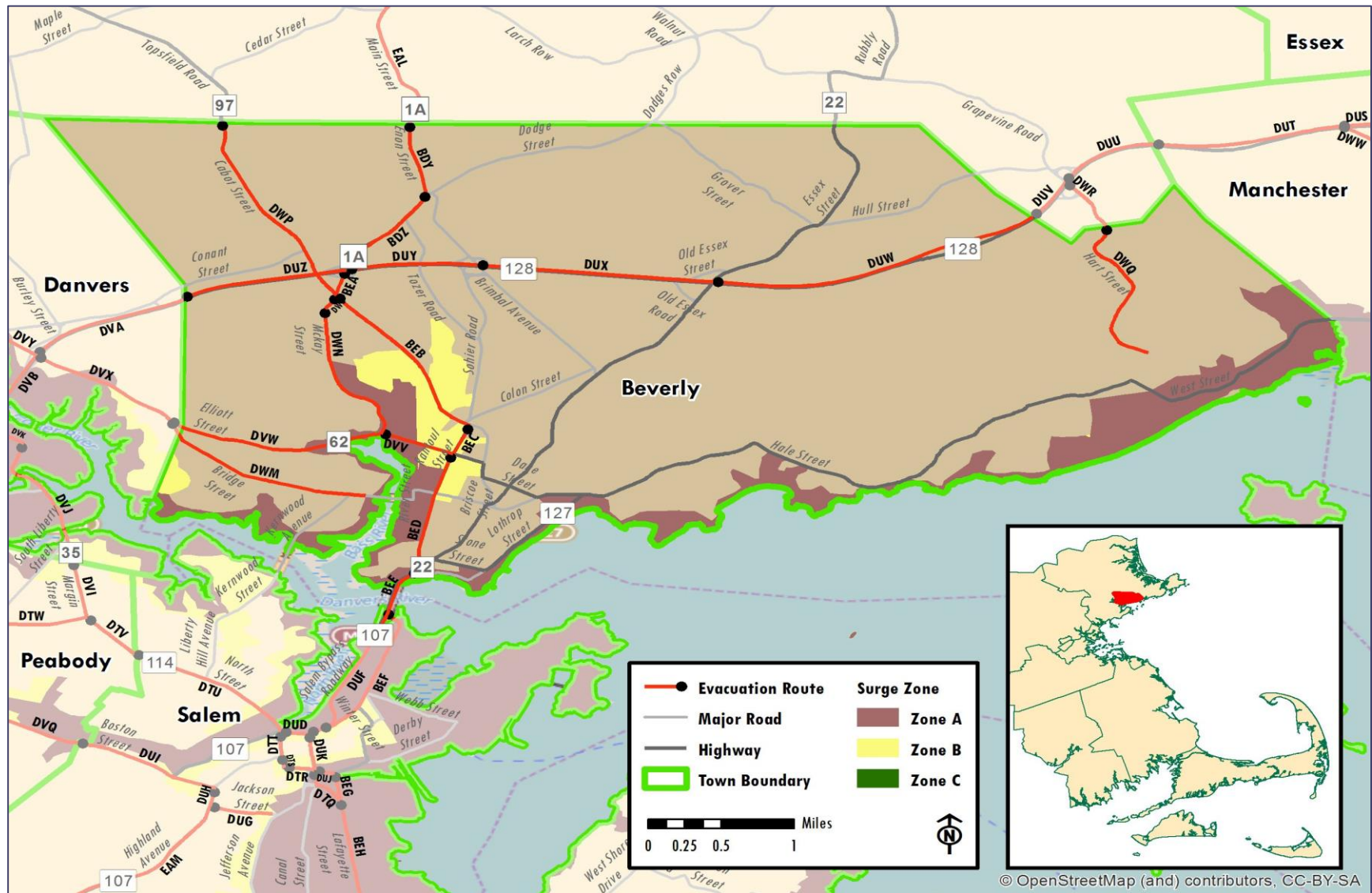


Figure 6-116: Evacuation Roadway Network – Essex County / Beverly



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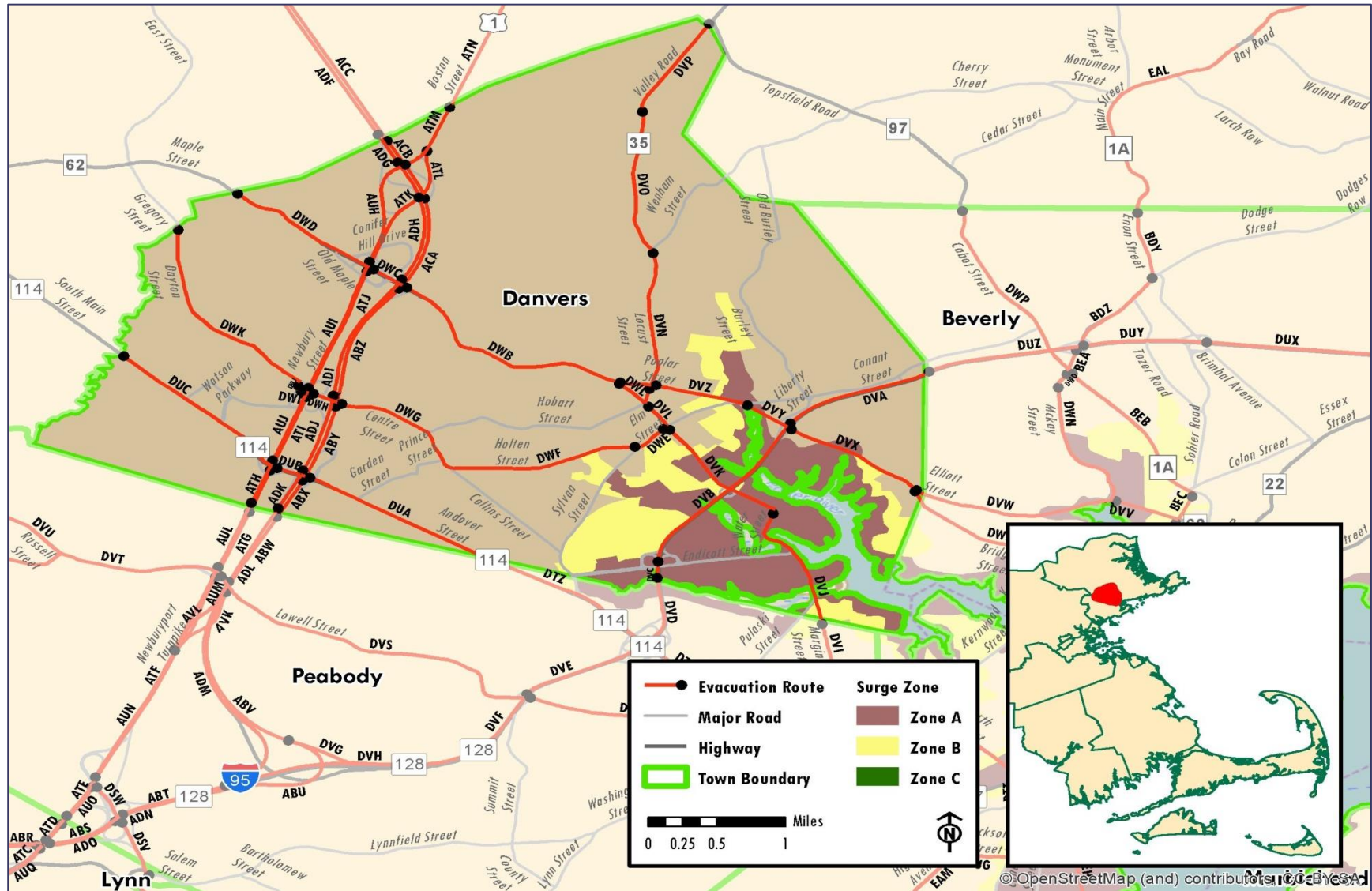


Figure 6-117: Evacuation Roadway Network – Essex County / Danvers



6.0 Transportation Analysis

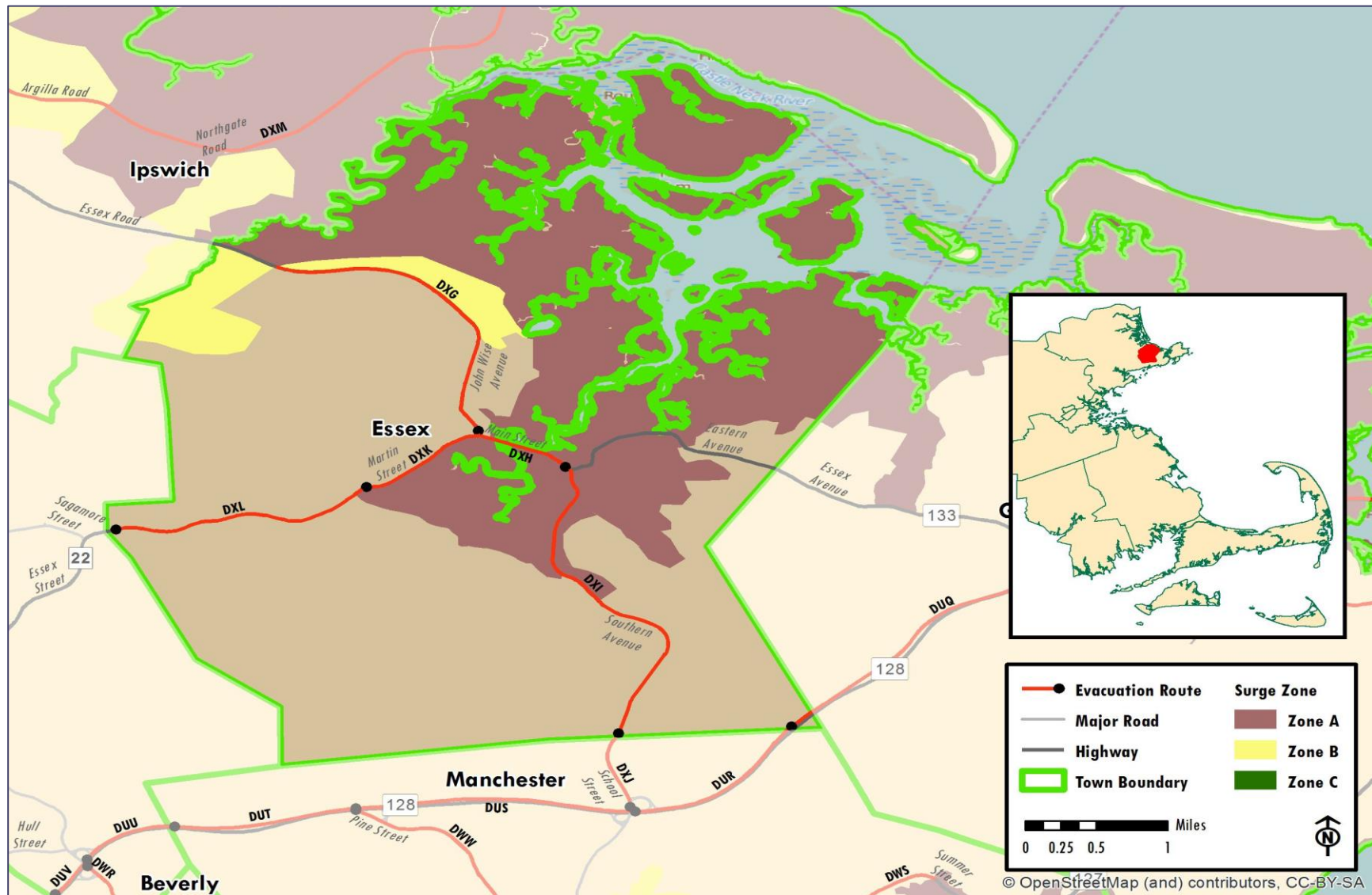


Figure 6-118: Evacuation Roadway Network – Essex County / Essex



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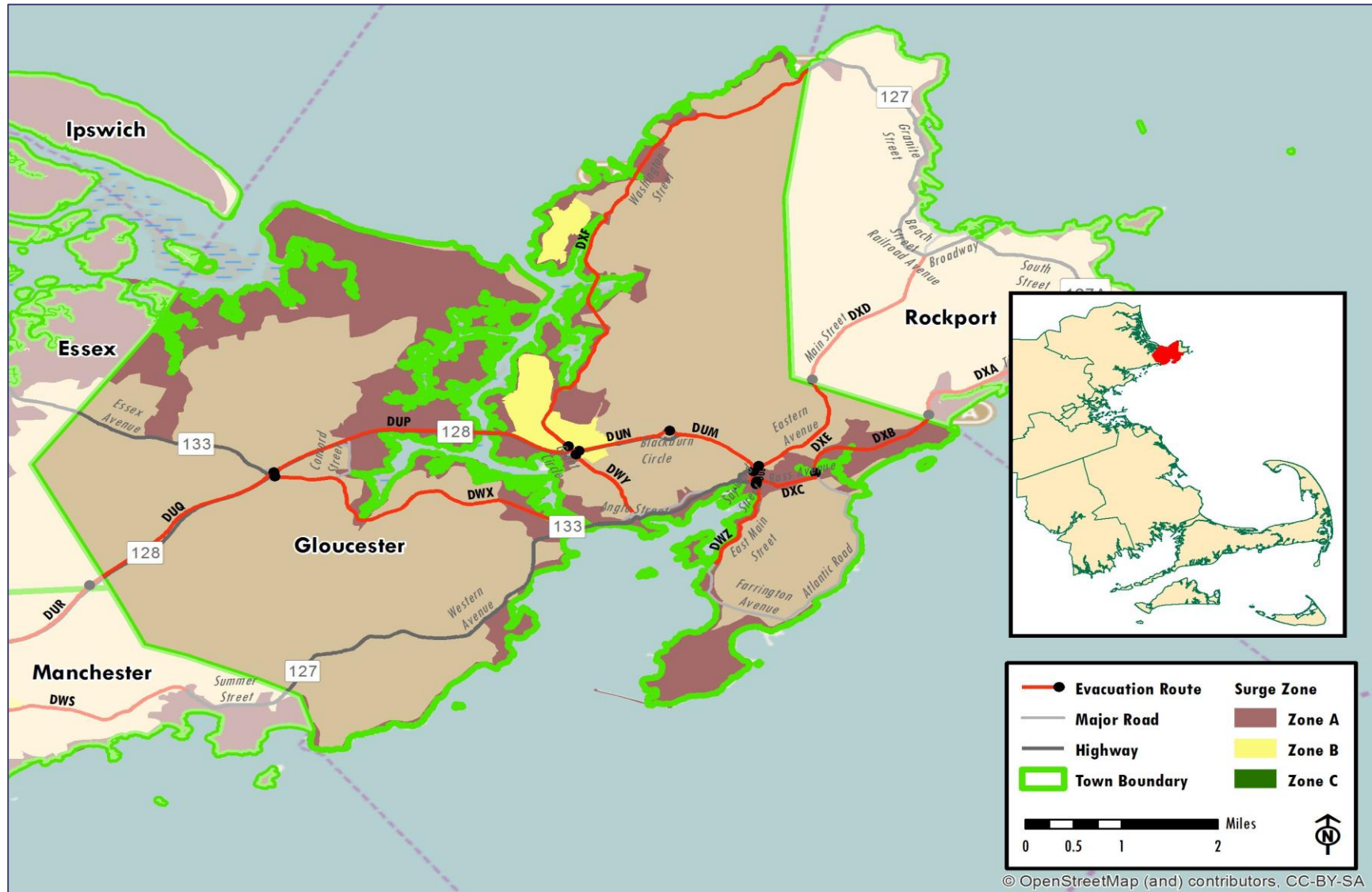


Figure 6-119: Evacuation Roadway Network – Essex County / Gloucester



6.0 Transportation Analysis

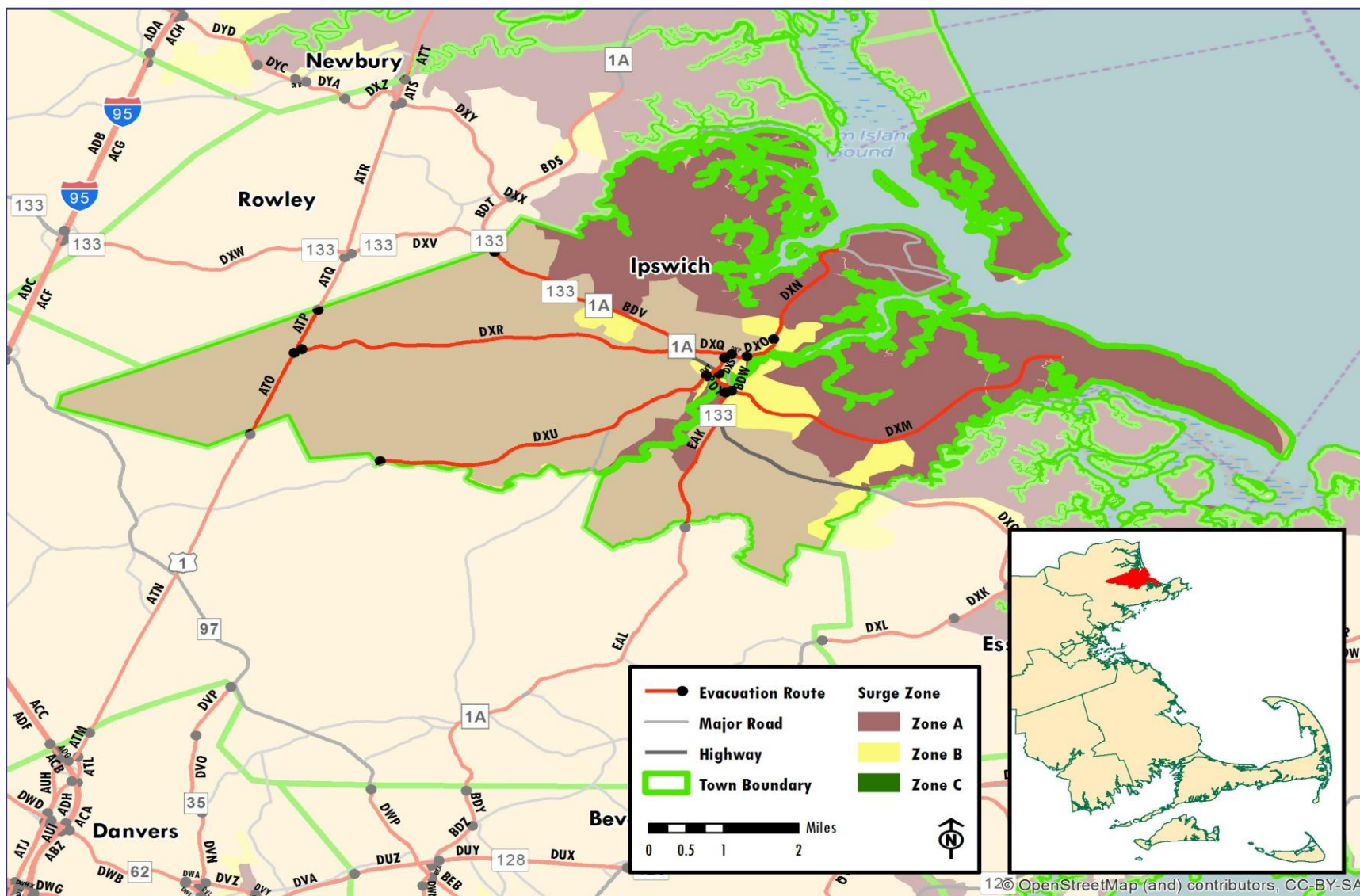


Figure 6-120: Evacuation Roadway Network – Essex County / Ipswich



6.0 Transportation Analysis

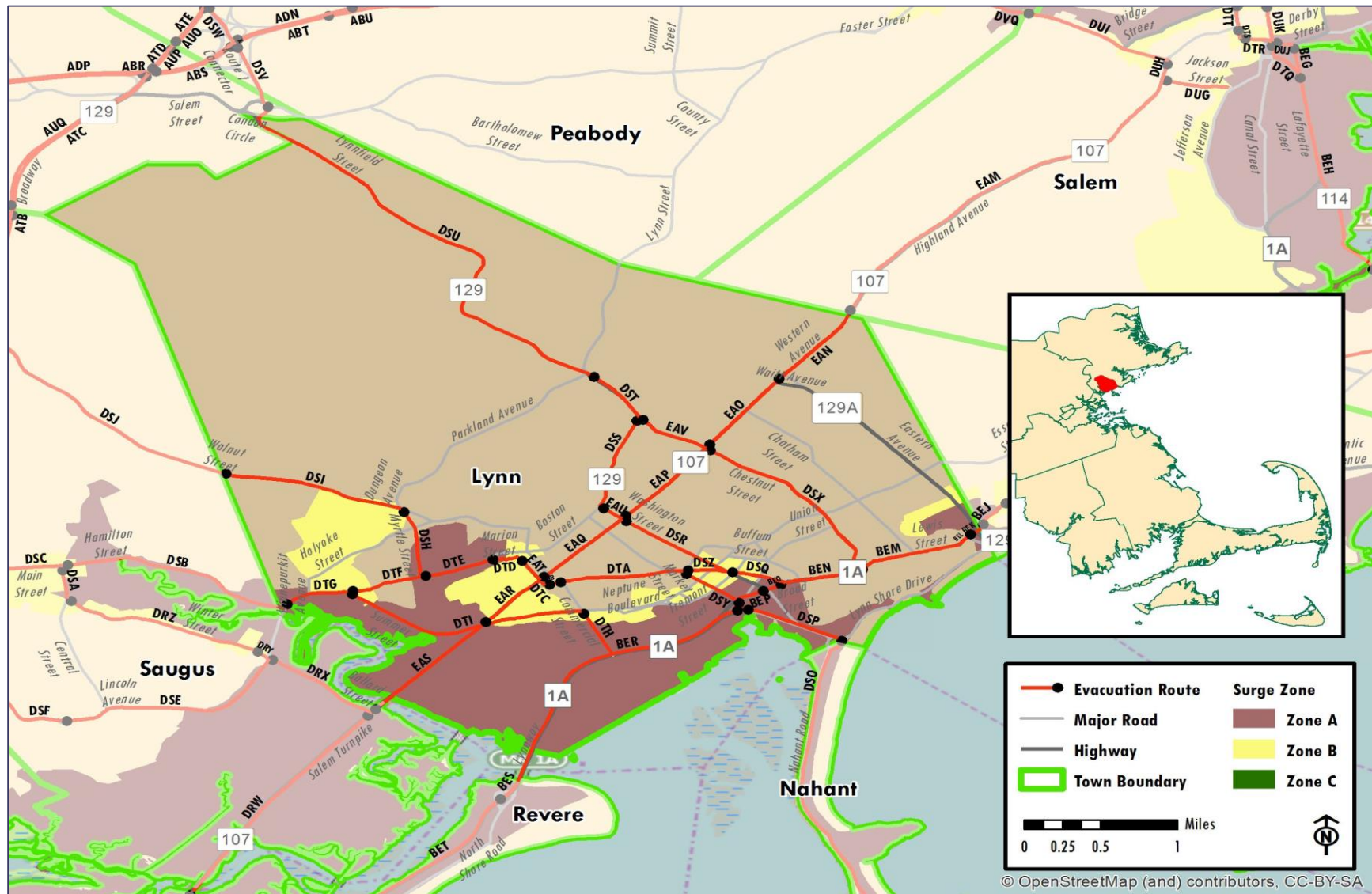


Figure 6-121: Evacuation Roadway Network – Essex County / Lynn



6.0 Transportation Analysis

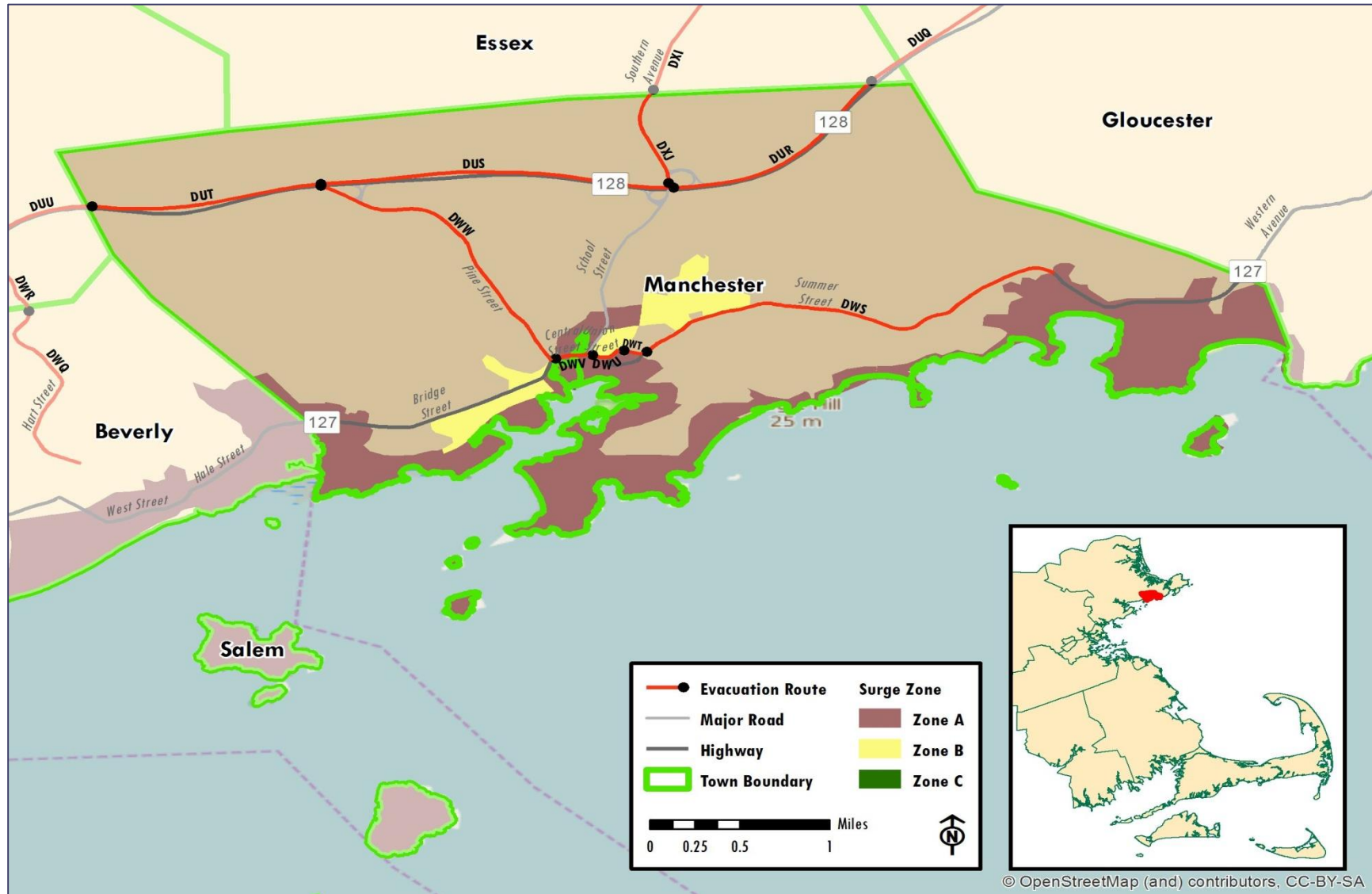


Figure 6-122: Evacuation Roadway Network – Essex County / Manchester



6.0 Transportation Analysis

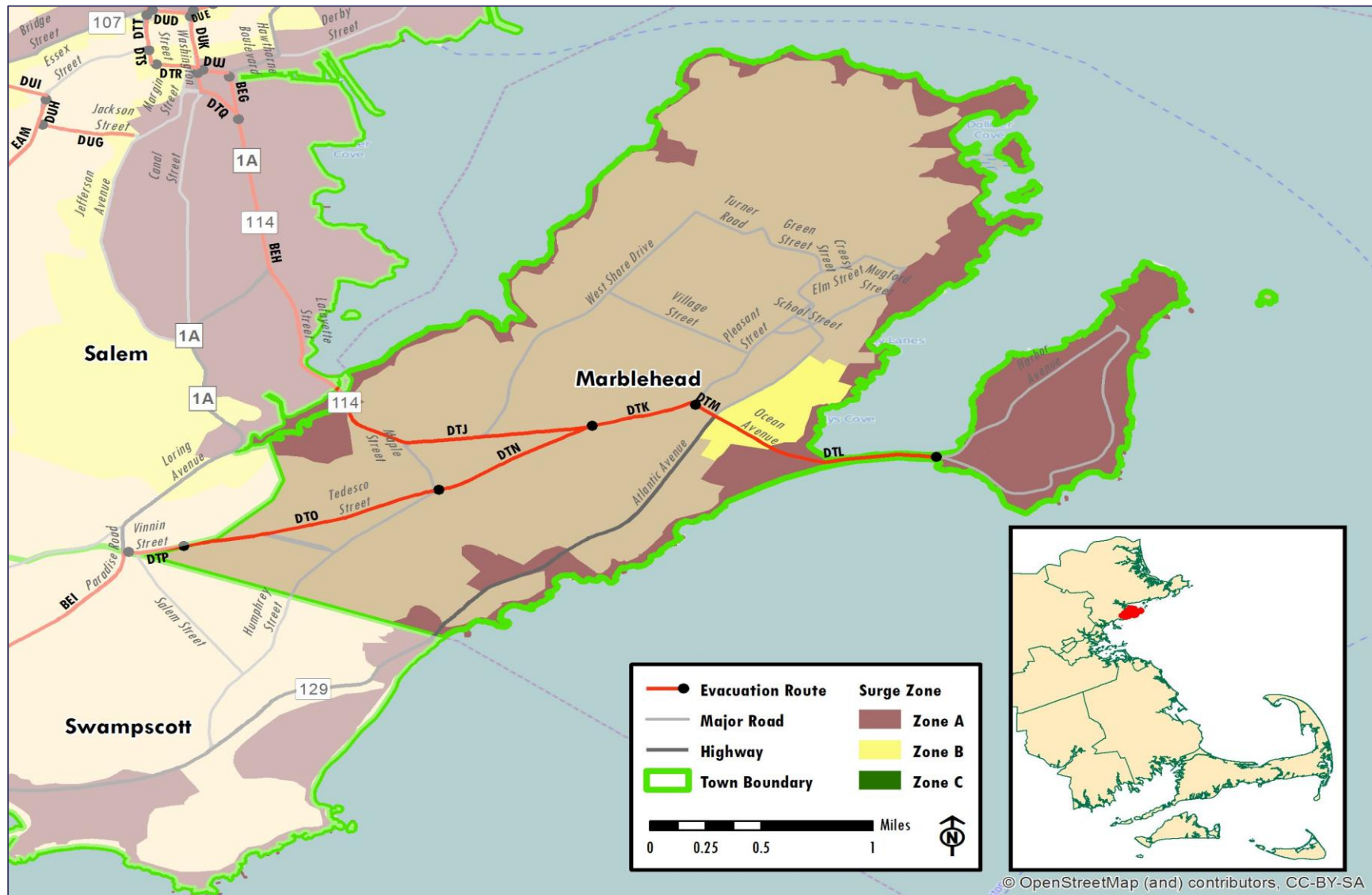


Figure 6-123: Evacuation Roadway Network – Essex County / Marblehead



6.0 Transportation Analysis

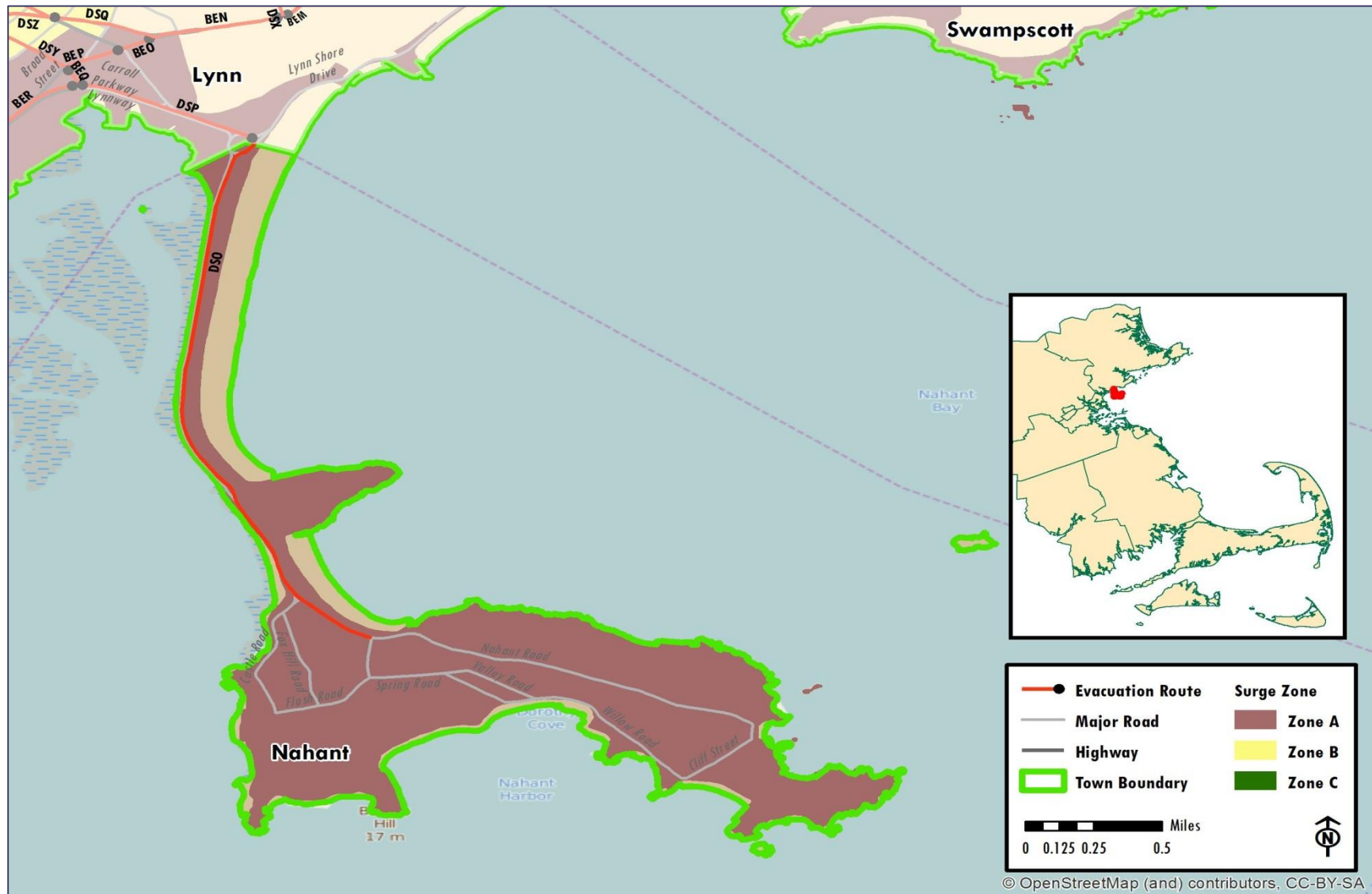


Figure 6-124: Evacuation Roadway Network – Essex County / Nahant



6.0 Transportation Analysis

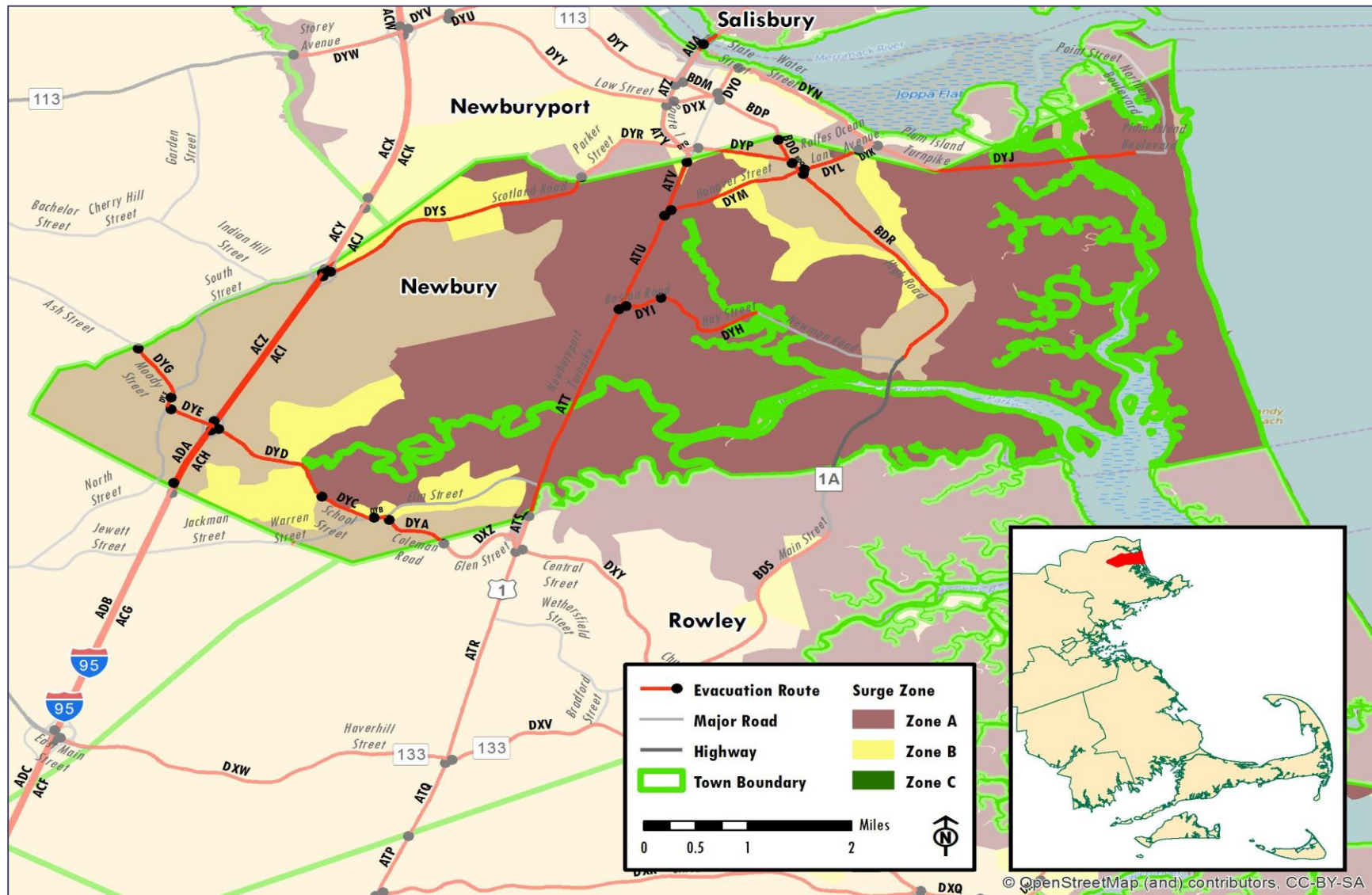


Figure 6-125: Evacuation Roadway Network – Essex County / Newbury



6.0 Transportation Analysis

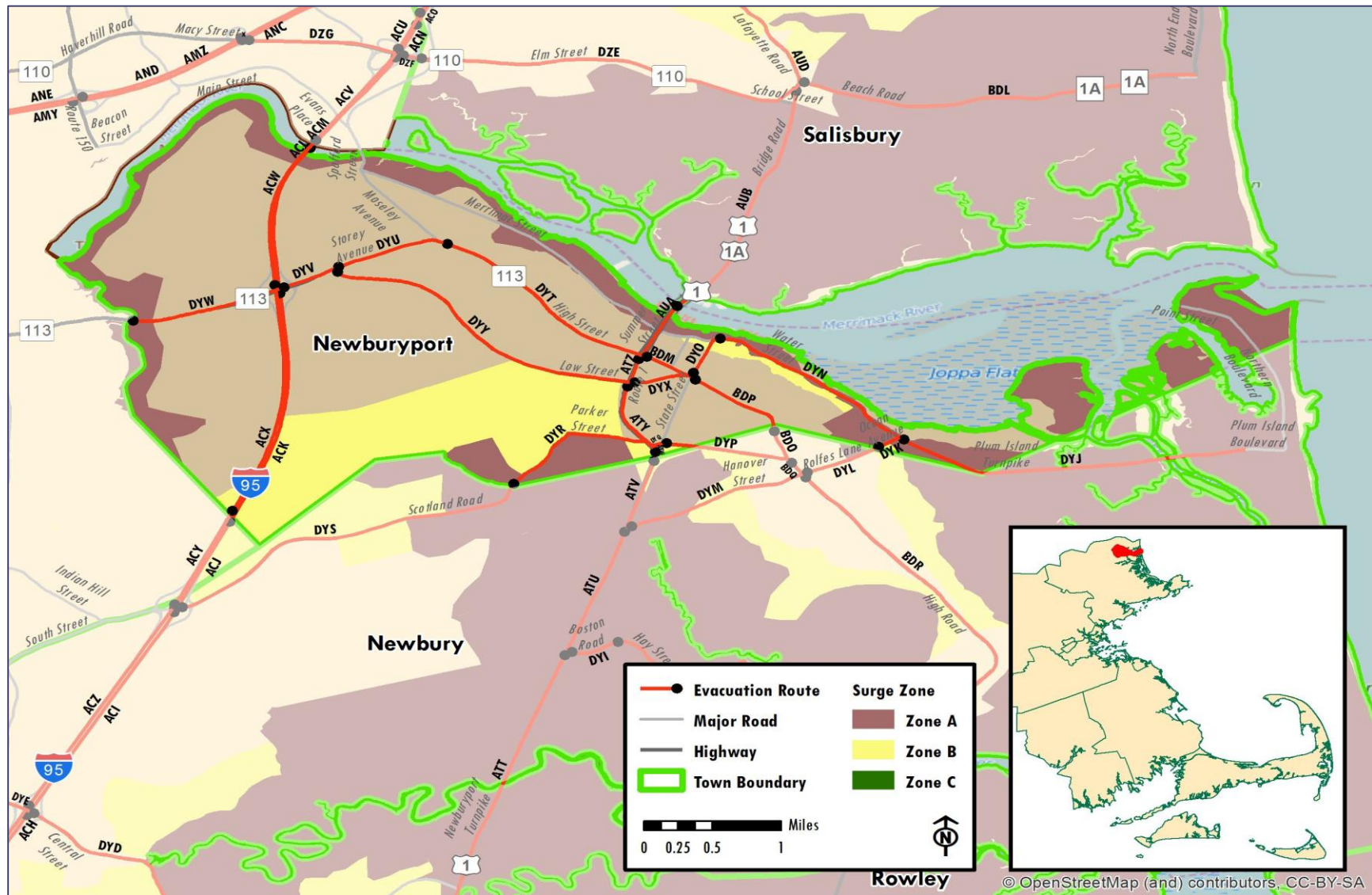


Figure 6-126: Evacuation Roadway Network – Essex County / Newburyport



6.0 Transportation Analysis

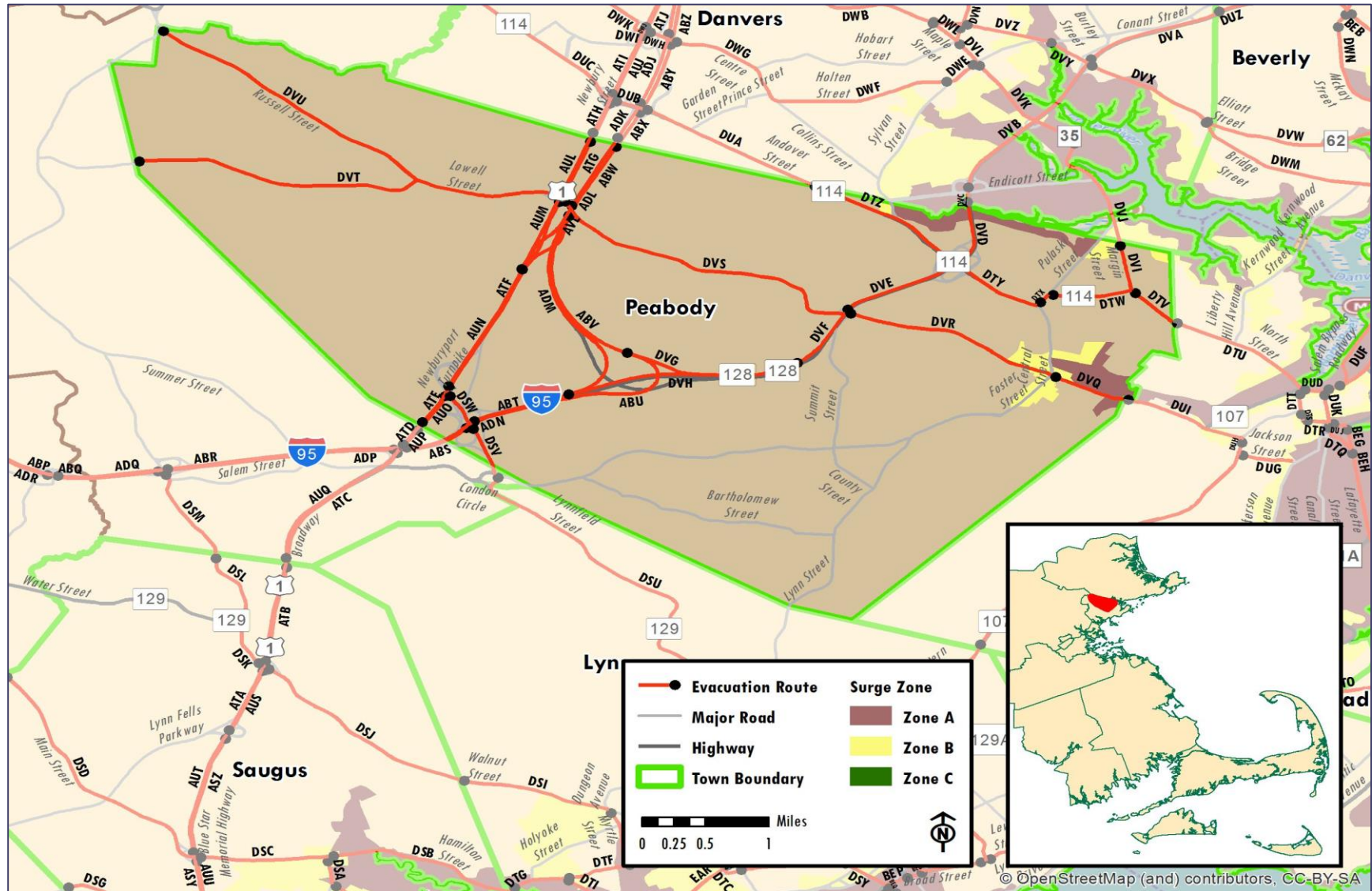


Figure 6-127: Evacuation Roadway Network – Essex County / Peabody



6.0 Transportation Analysis

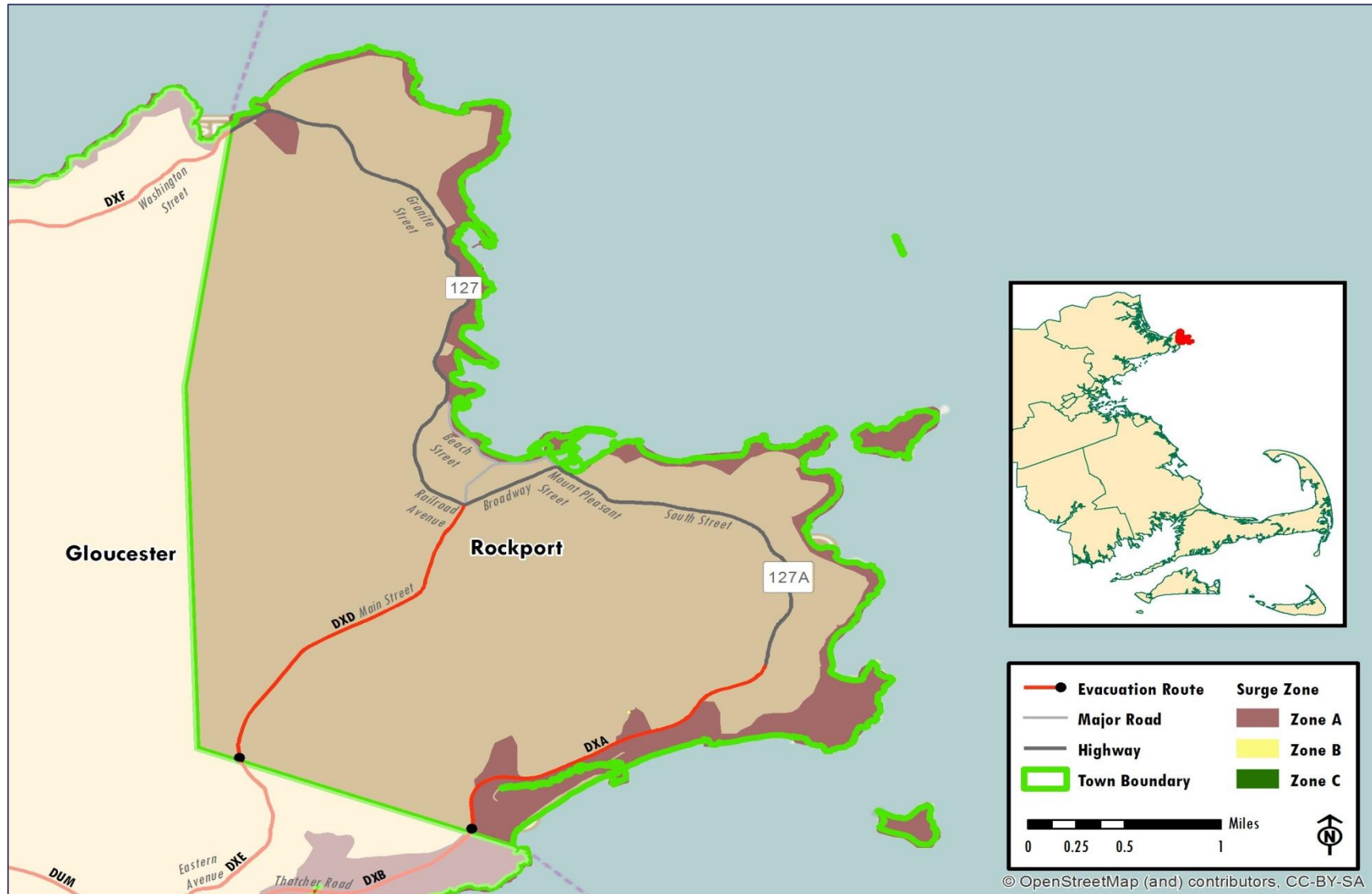


Figure 6-128: Evacuation Roadway Network – Essex County / Rockport



6.0 Transportation Analysis

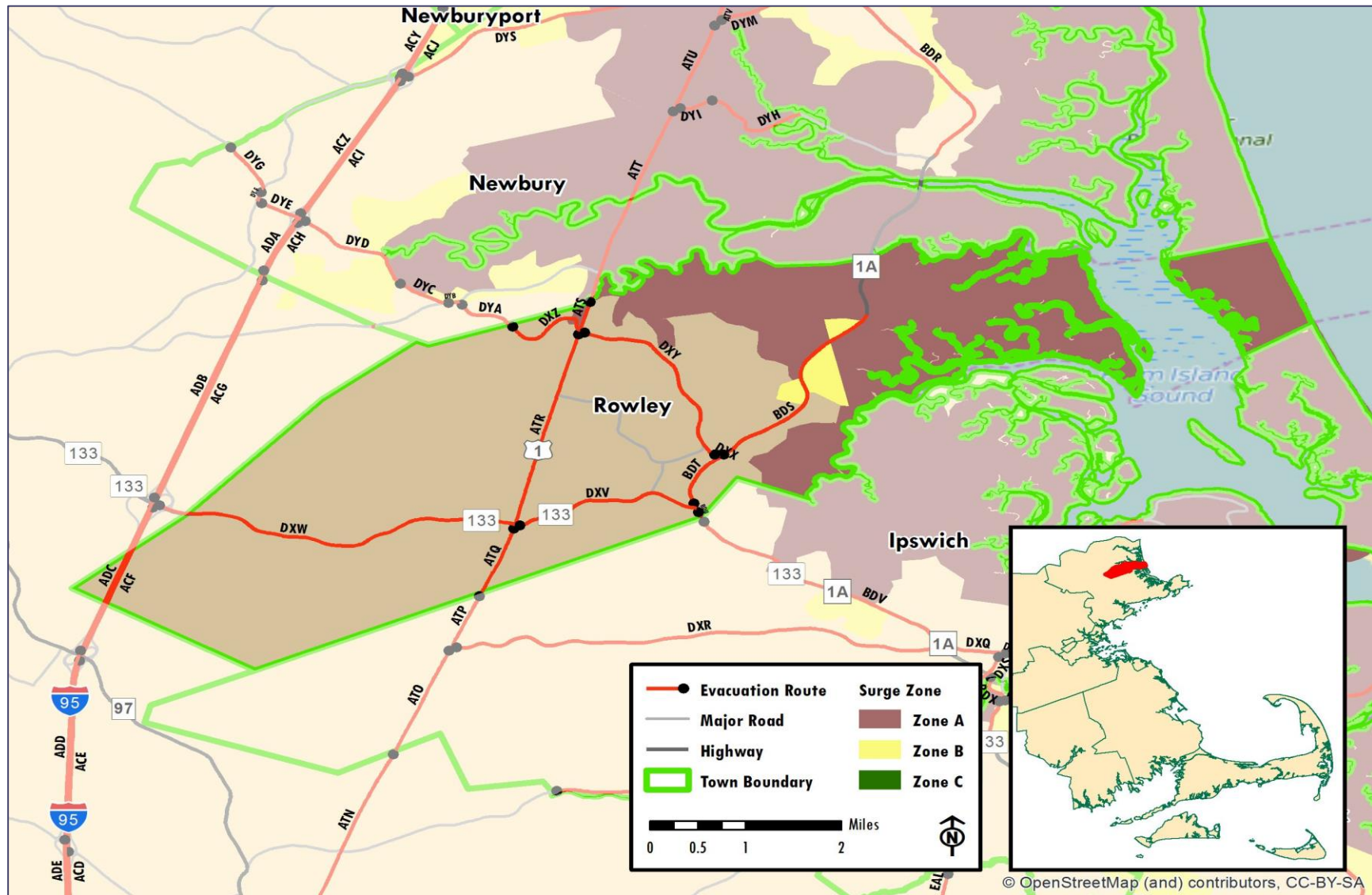


Figure 6-129: Evacuation Roadway Network – Essex County / Rowley



6.0 Transportation Analysis

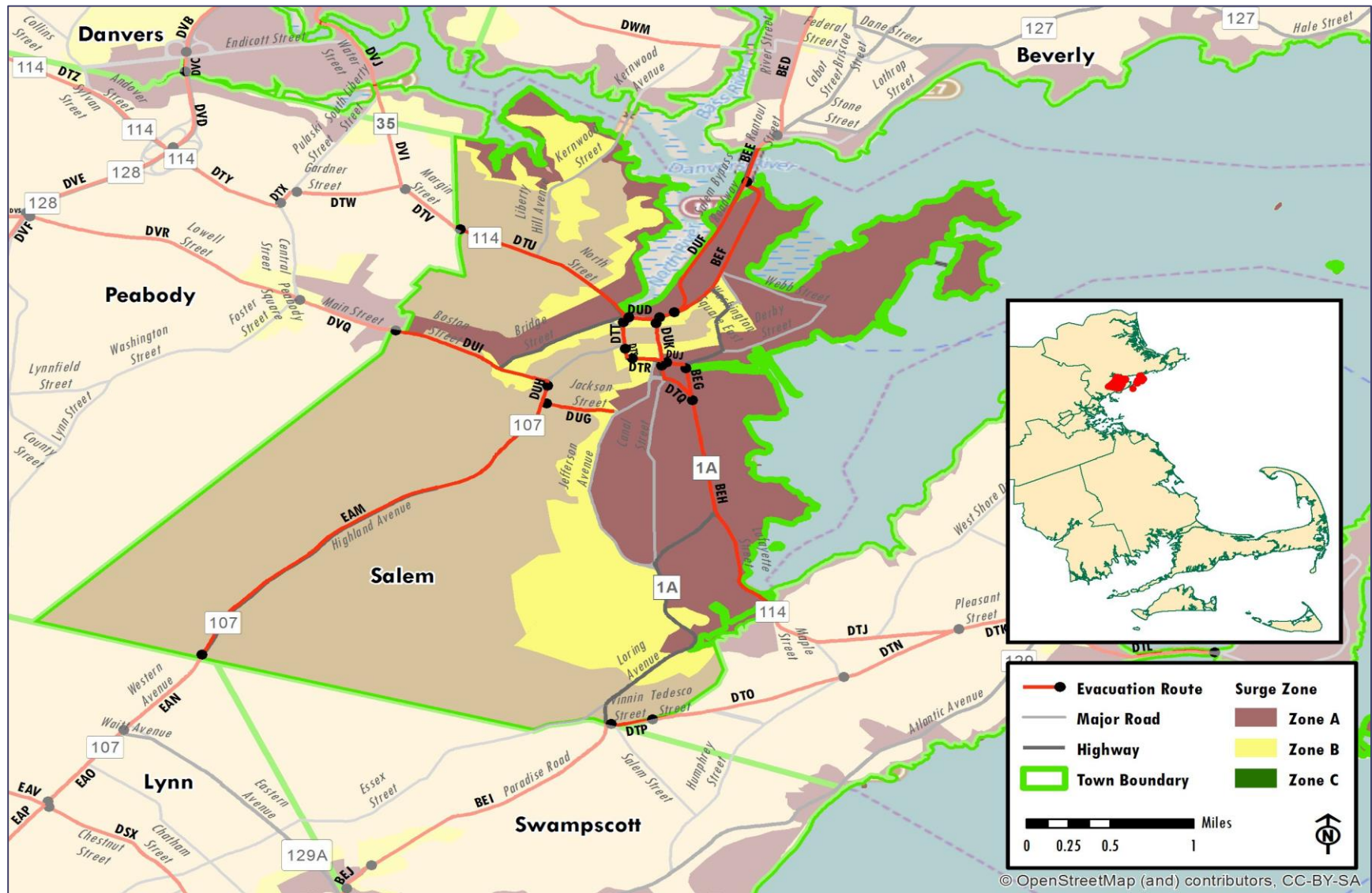


Figure 6-130: Evacuation Roadway Network – Essex County / Salem



6.0 Transportation Analysis

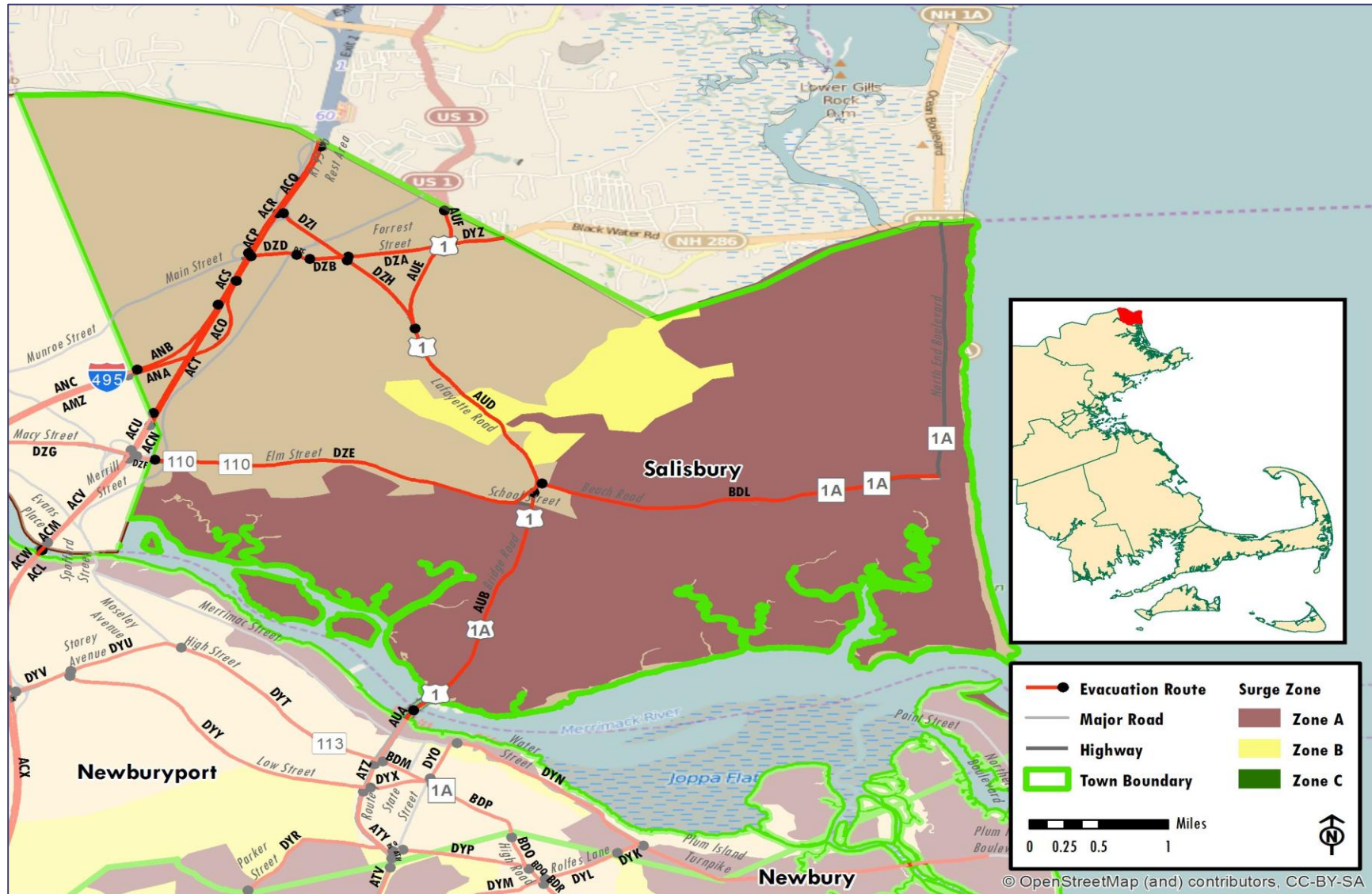


Figure 6-131: Evacuation Roadway Network – Essex County / Salisbury



6.0 Transportation Analysis

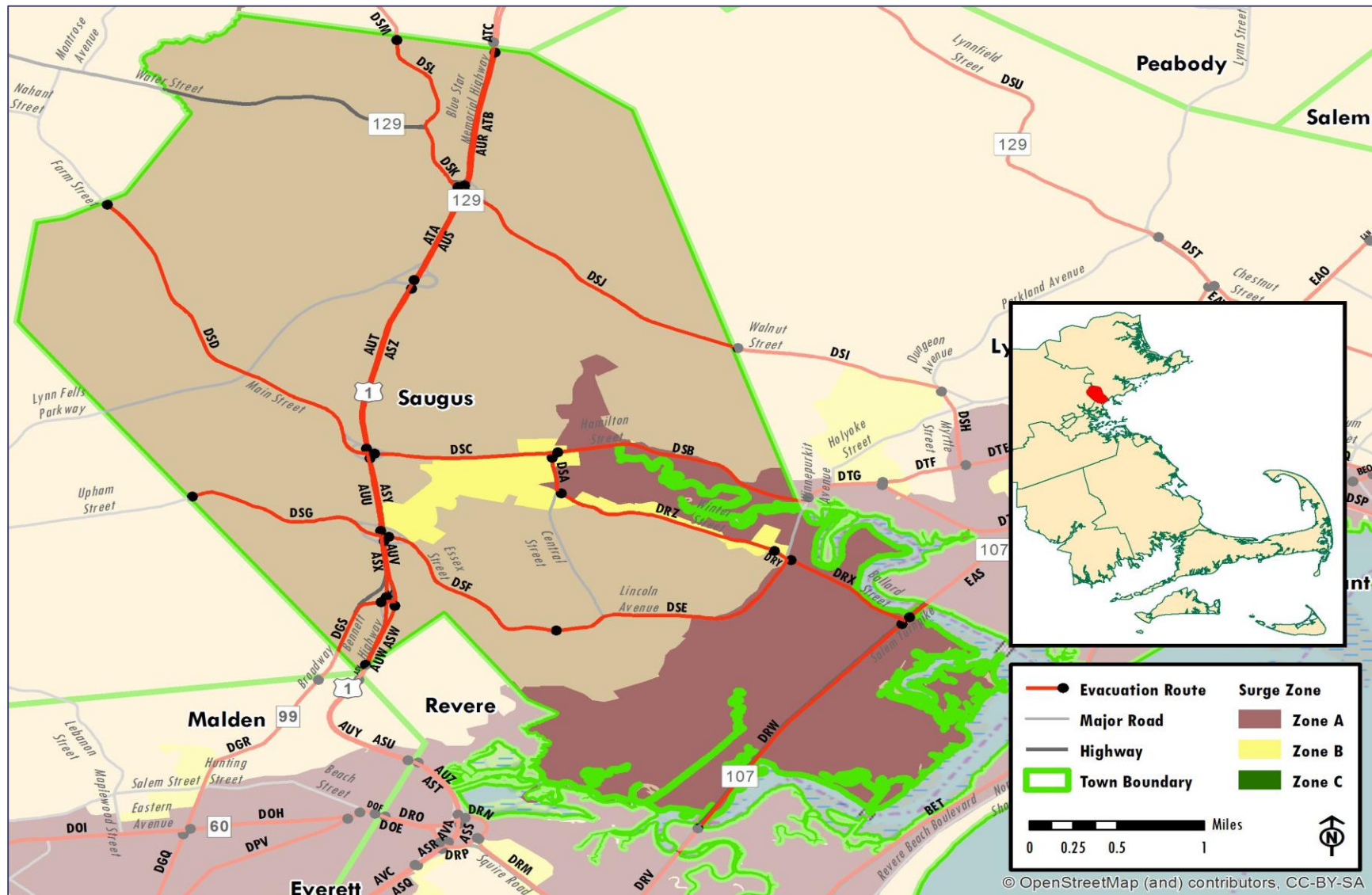


Figure 6-132: Evacuation Roadway Network – Essex County / Saugus



6.0 Transportation Analysis

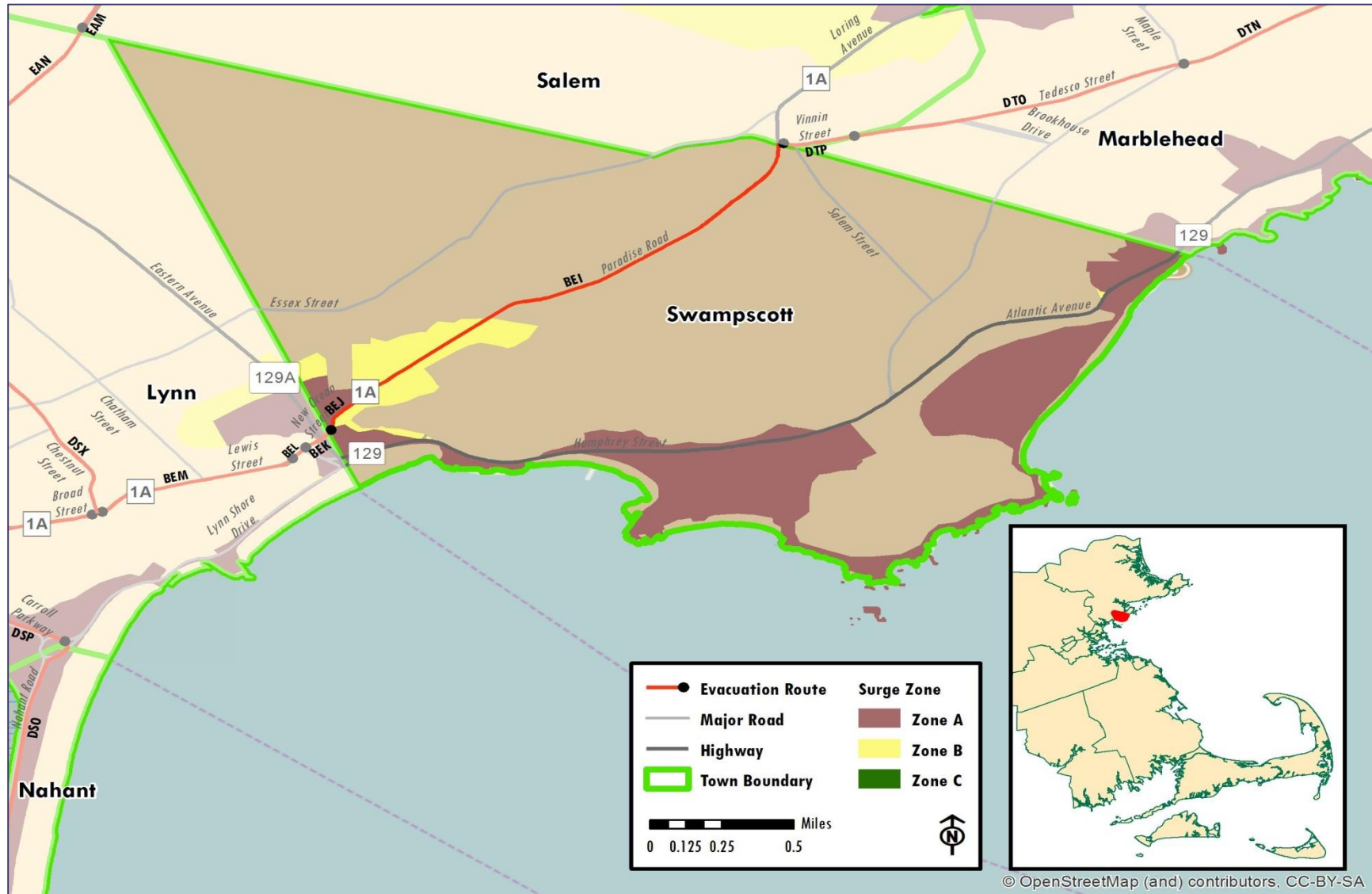


Figure 6-133: Evacuation Roadway Network – Essex County / Swampscott



6.0 Transportation Analysis

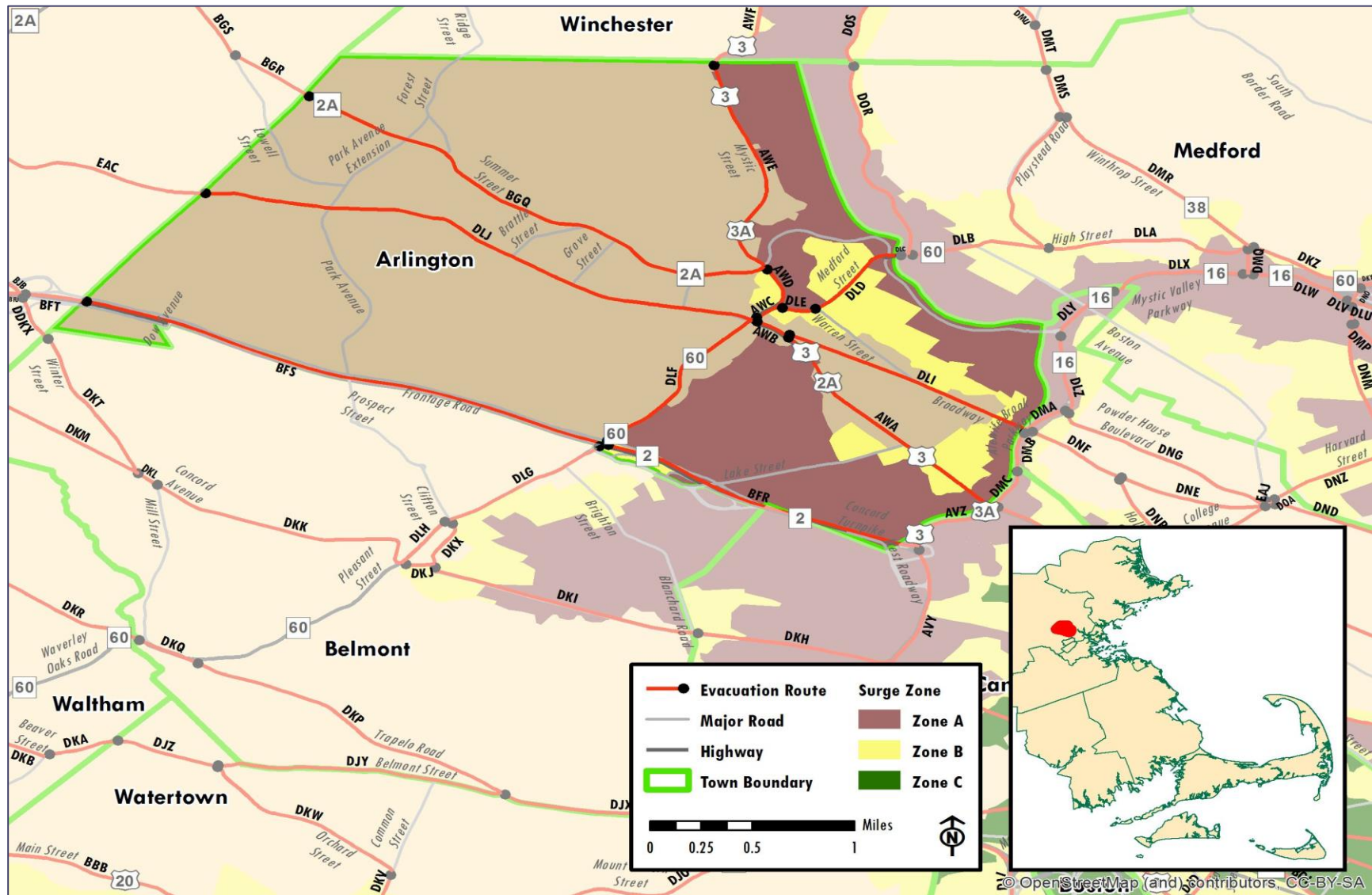


Figure 6-134: Evacuation Roadway Network – Middlesex County / Arlington



6.0 Transportation Analysis

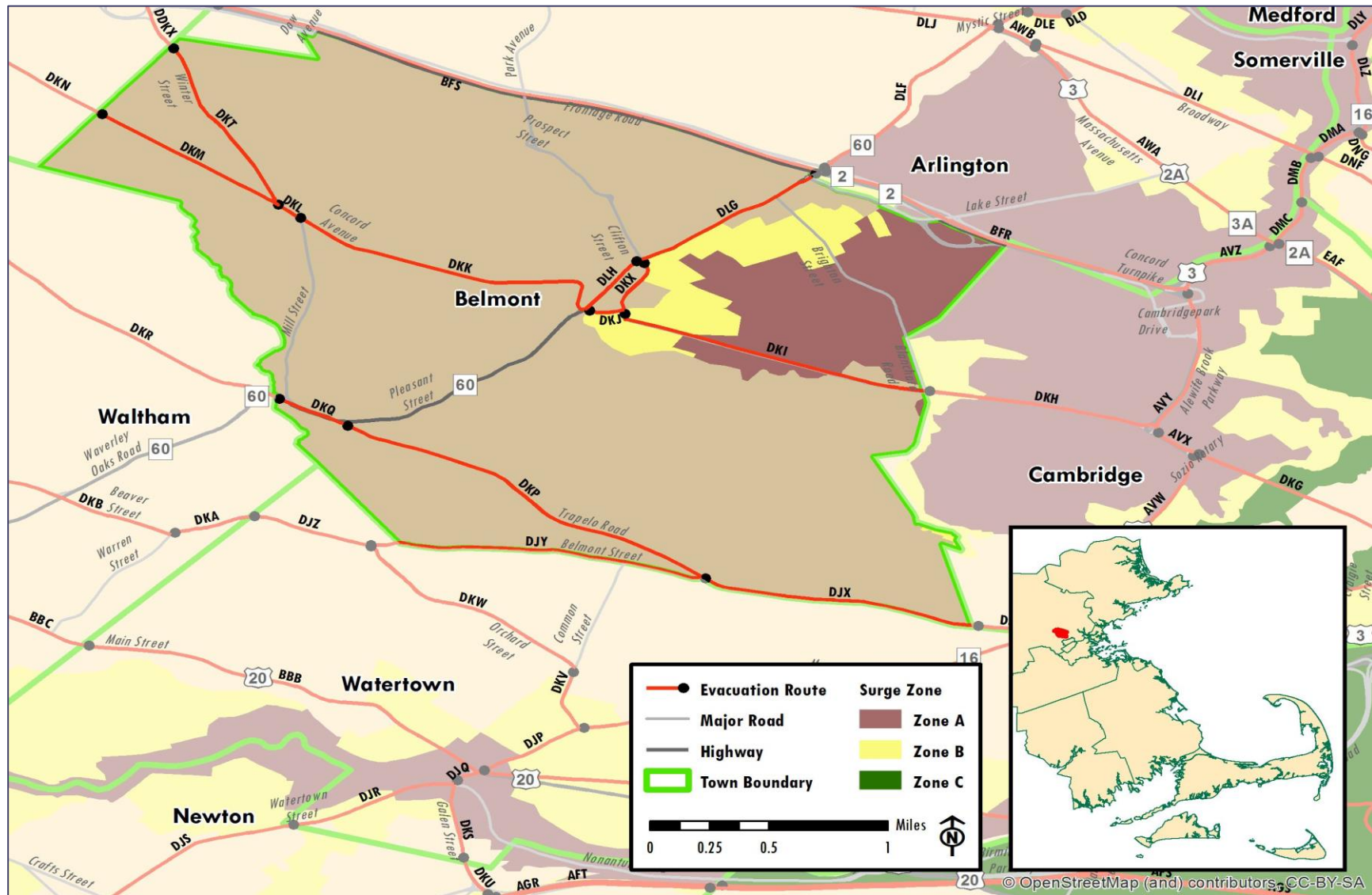


Figure 6-135: Evacuation Roadway Network – Middlesex County / Belmont



6.0 Transportation Analysis

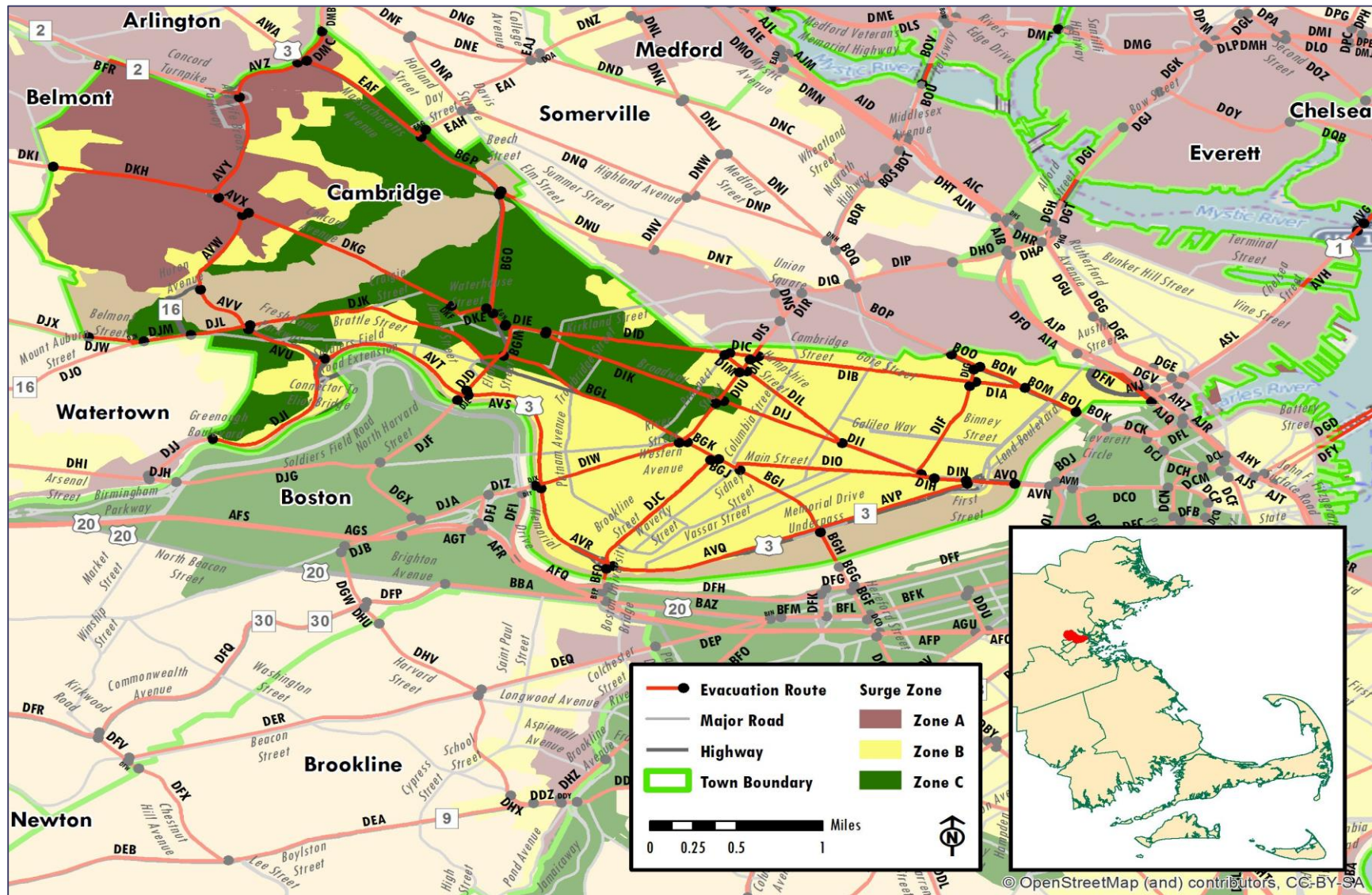


Figure 6-136: Evacuation Roadway Network – Middlesex County / Cambridge



6.0 Transportation Analysis

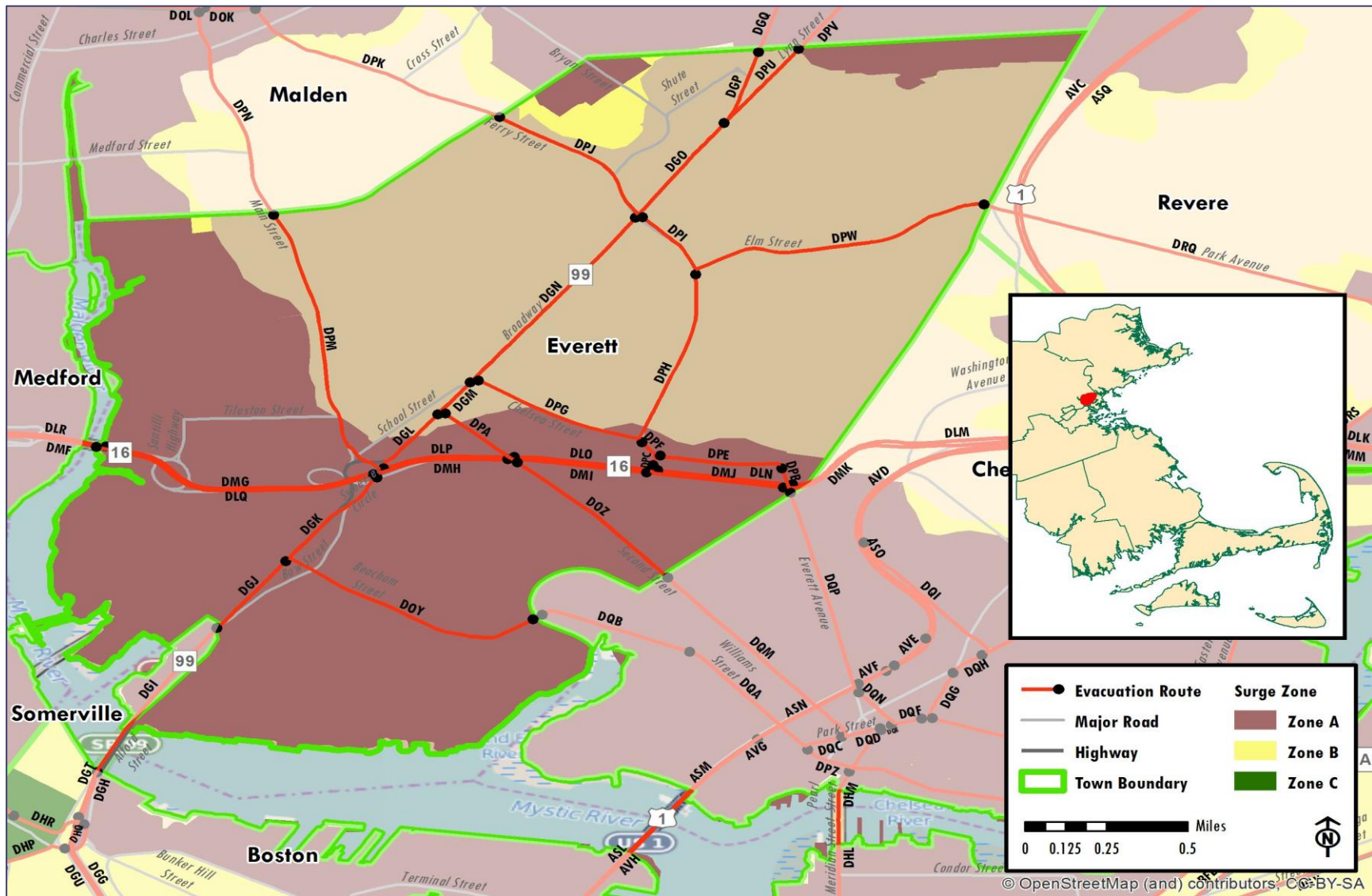


Figure 6-137: Evacuation Roadway Network – Middlesex County / Everett



6.0 Transportation Analysis

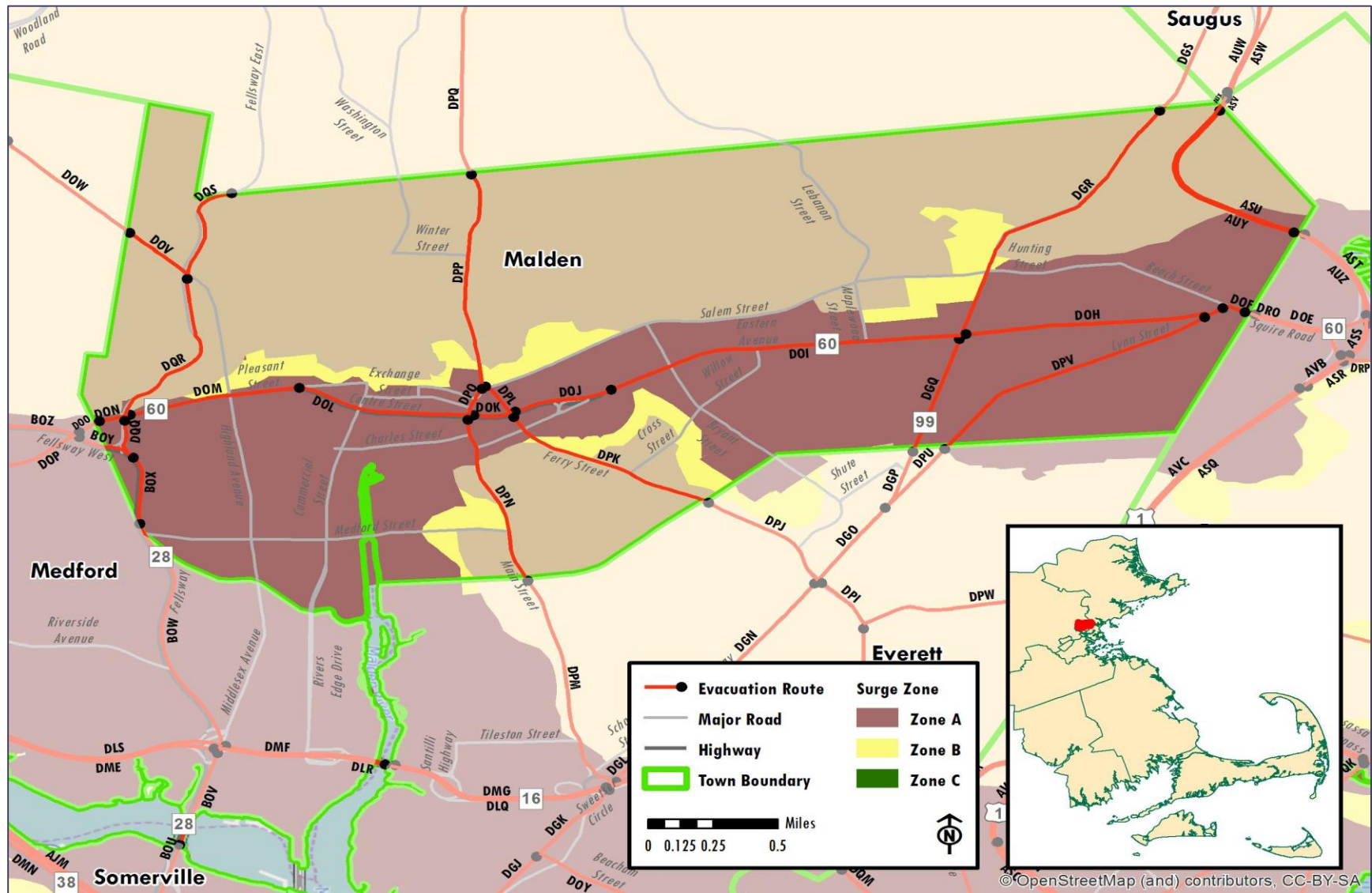


Figure 6-138: Evacuation Roadway Network – Middlesex County / Malden



6.0 Transportation Analysis

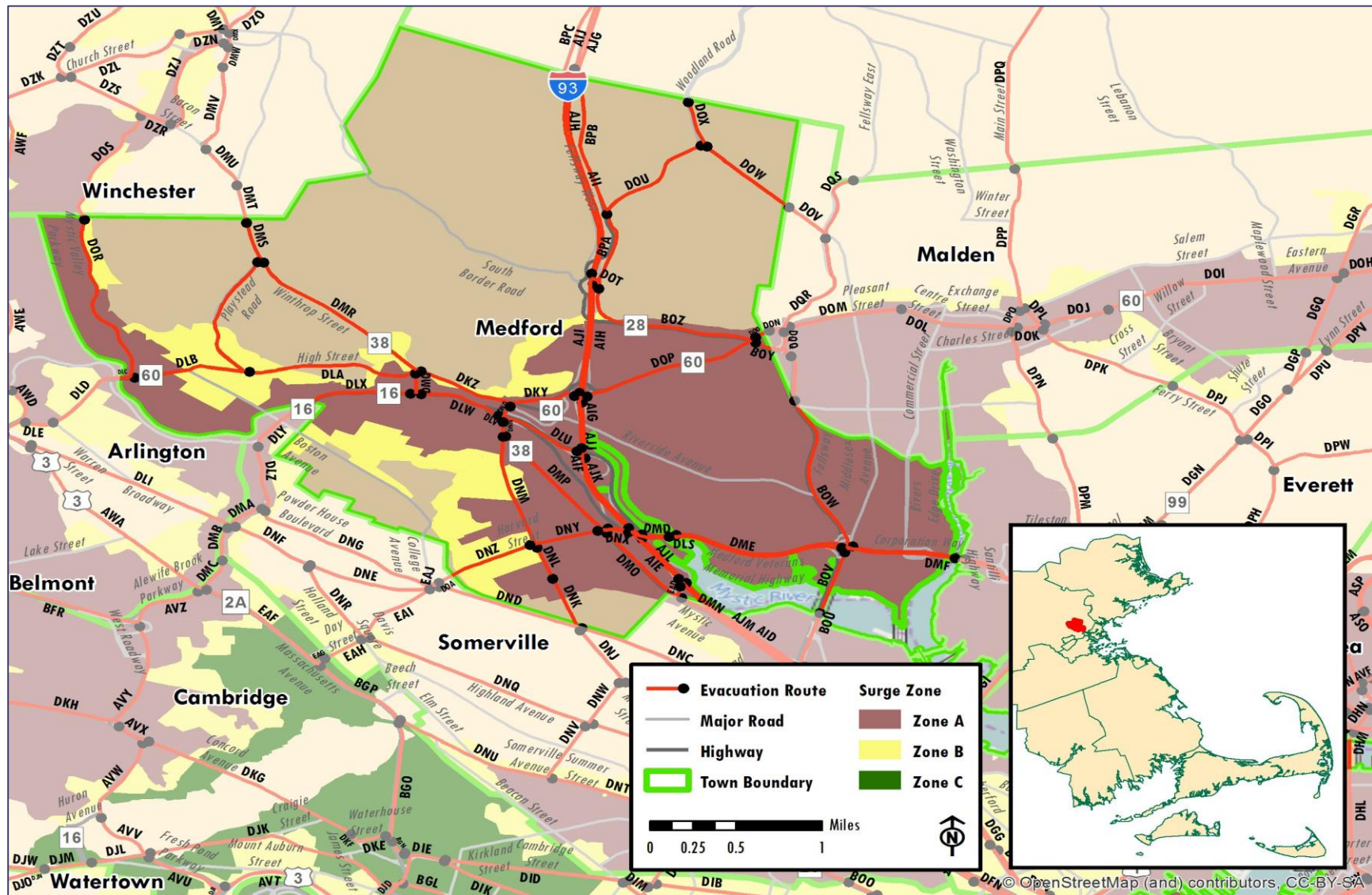


Figure 6-139: Evacuation Roadway Network – Middlesex County / Medford



6.0 Transportation Analysis

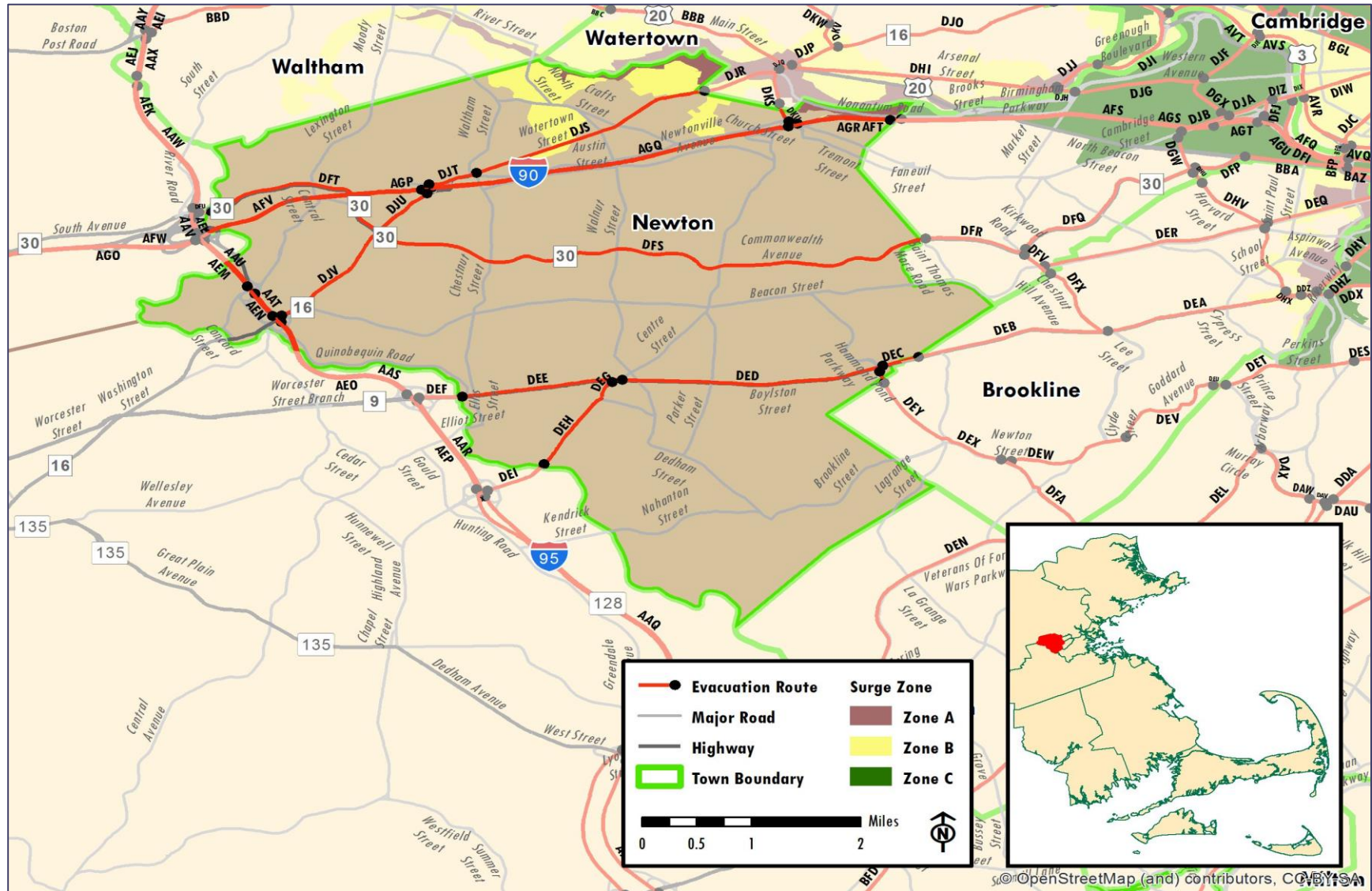


Figure 6-140: Evacuation Roadway Network – Middlesex County / Newton



6.0 Transportation Analysis

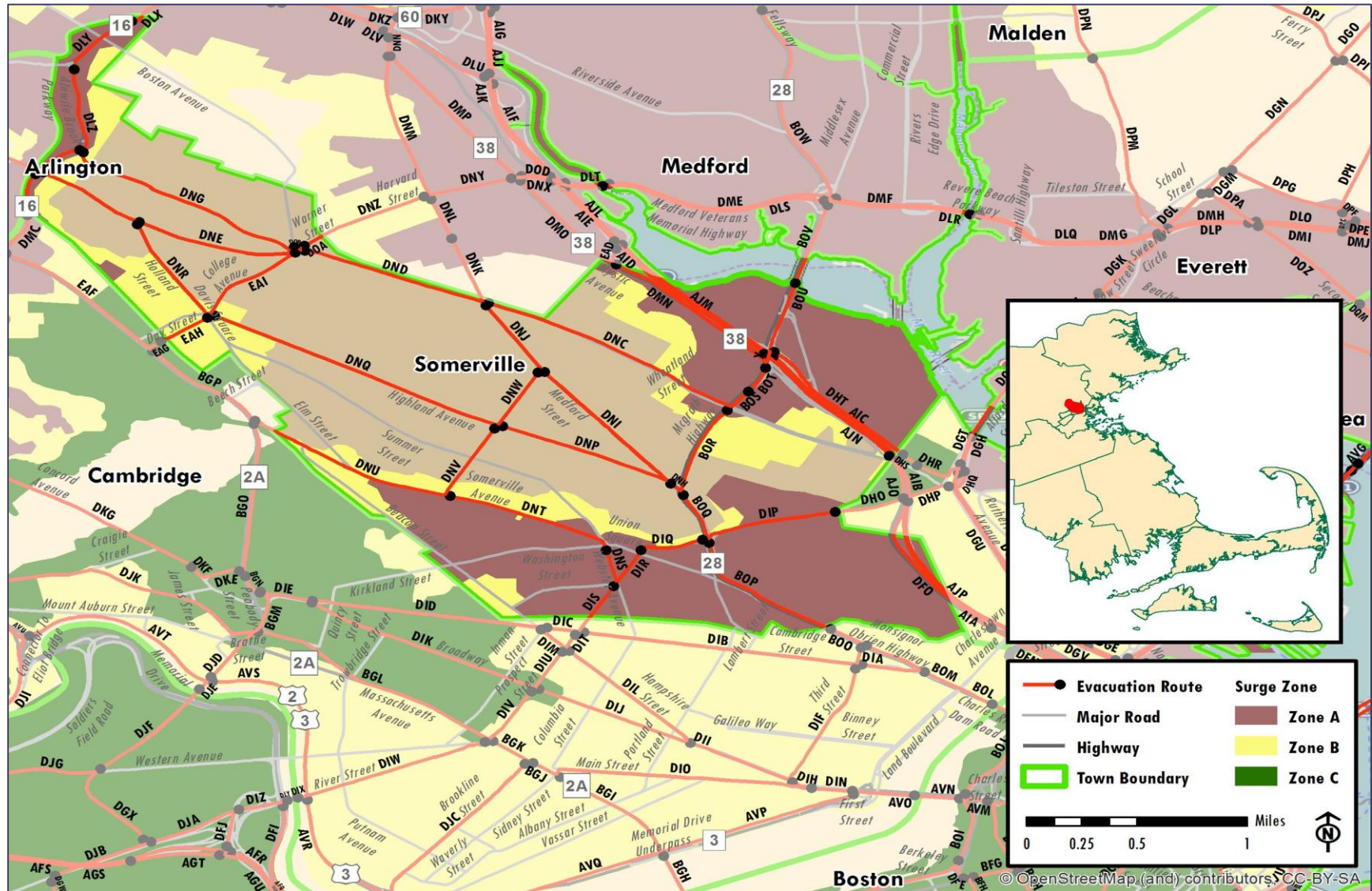


Figure 6-141: Evacuation Roadway Network – Middlesex County / Somerville



6.0 Transportation Analysis

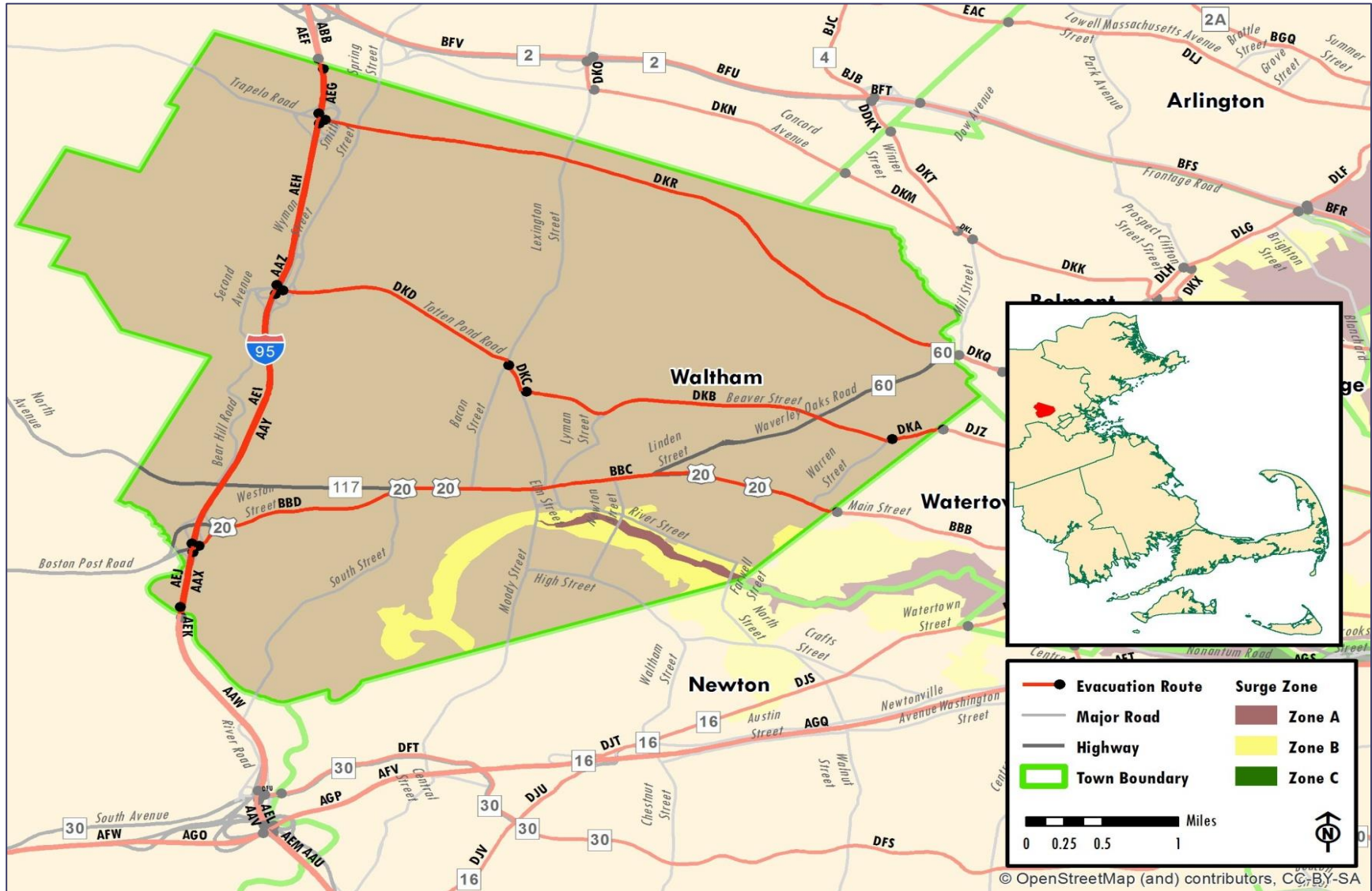


Figure 6-142: Evacuation Roadway Network – Middlesex County / Waltham



6.0 Transportation Analysis

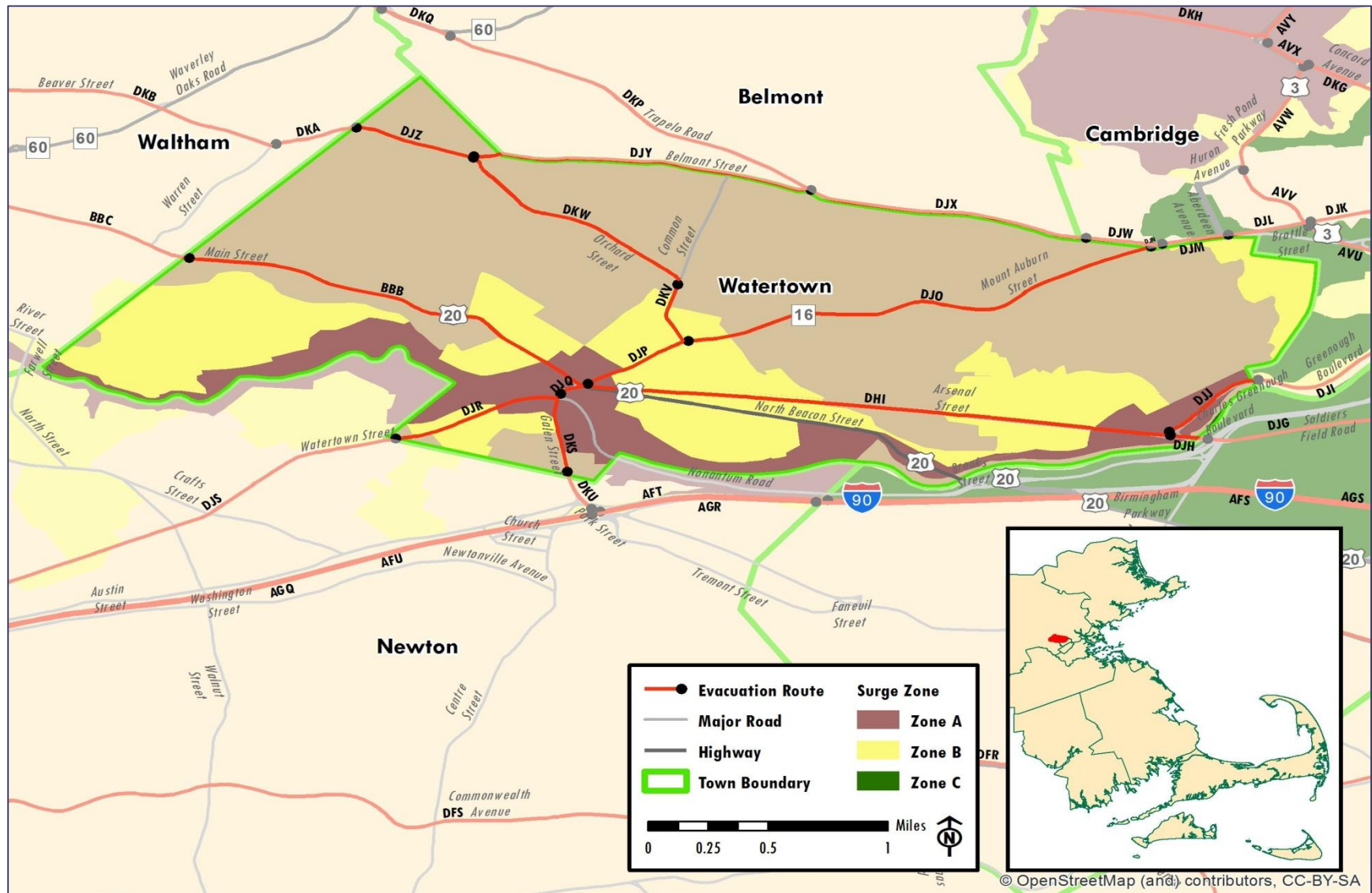


Figure 6-143: Evacuation Roadway Network – Middlesex County / Watertown



6.0 Transportation Analysis

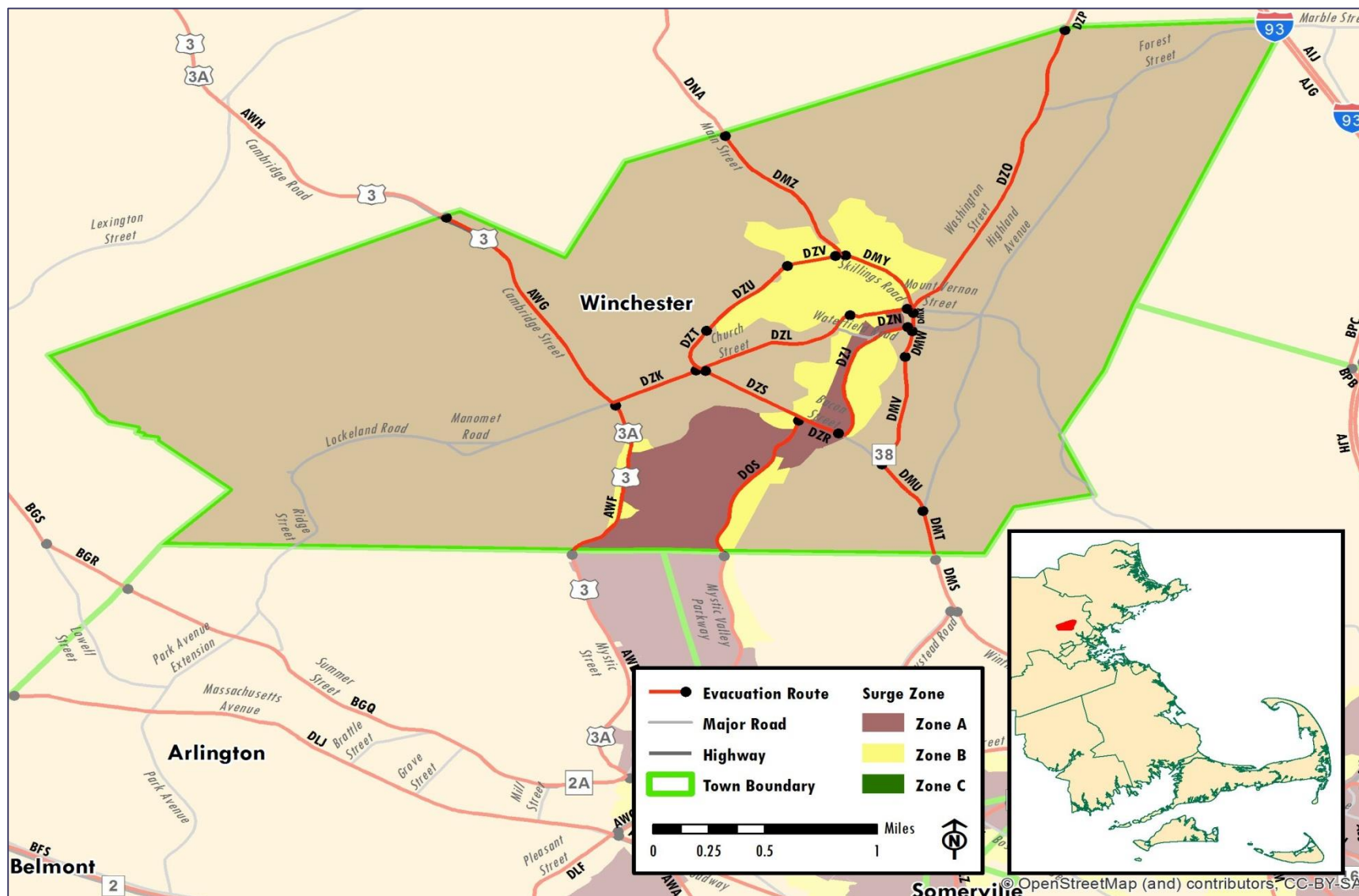


Figure 6-144: Evacuation Roadway Network – Middlesex County / Winchester



6.0 Transportation Analysis

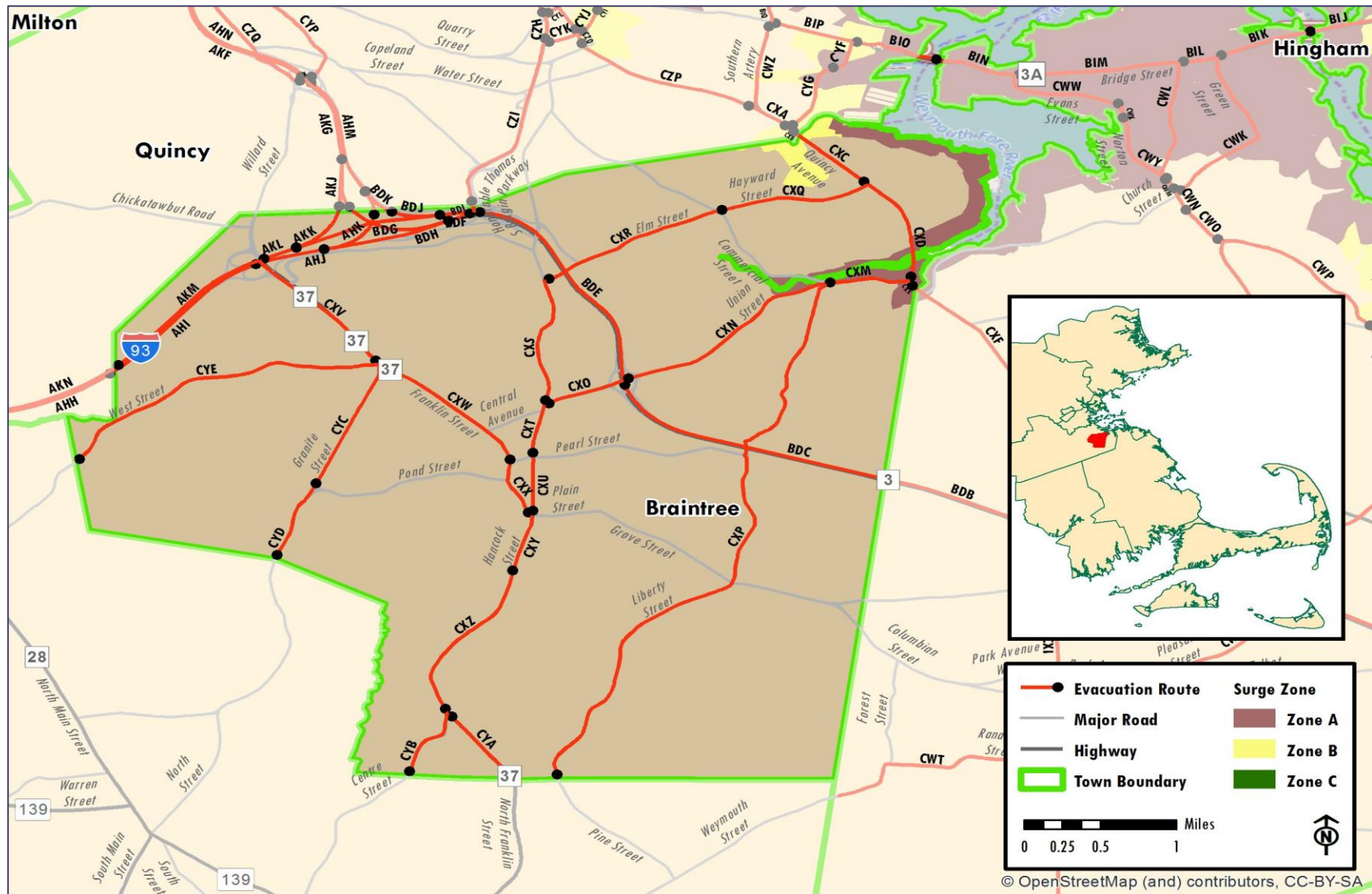


Figure 6-145: Evacuation Roadway Network – Norfolk County / Braintree



6.0 Transportation Analysis

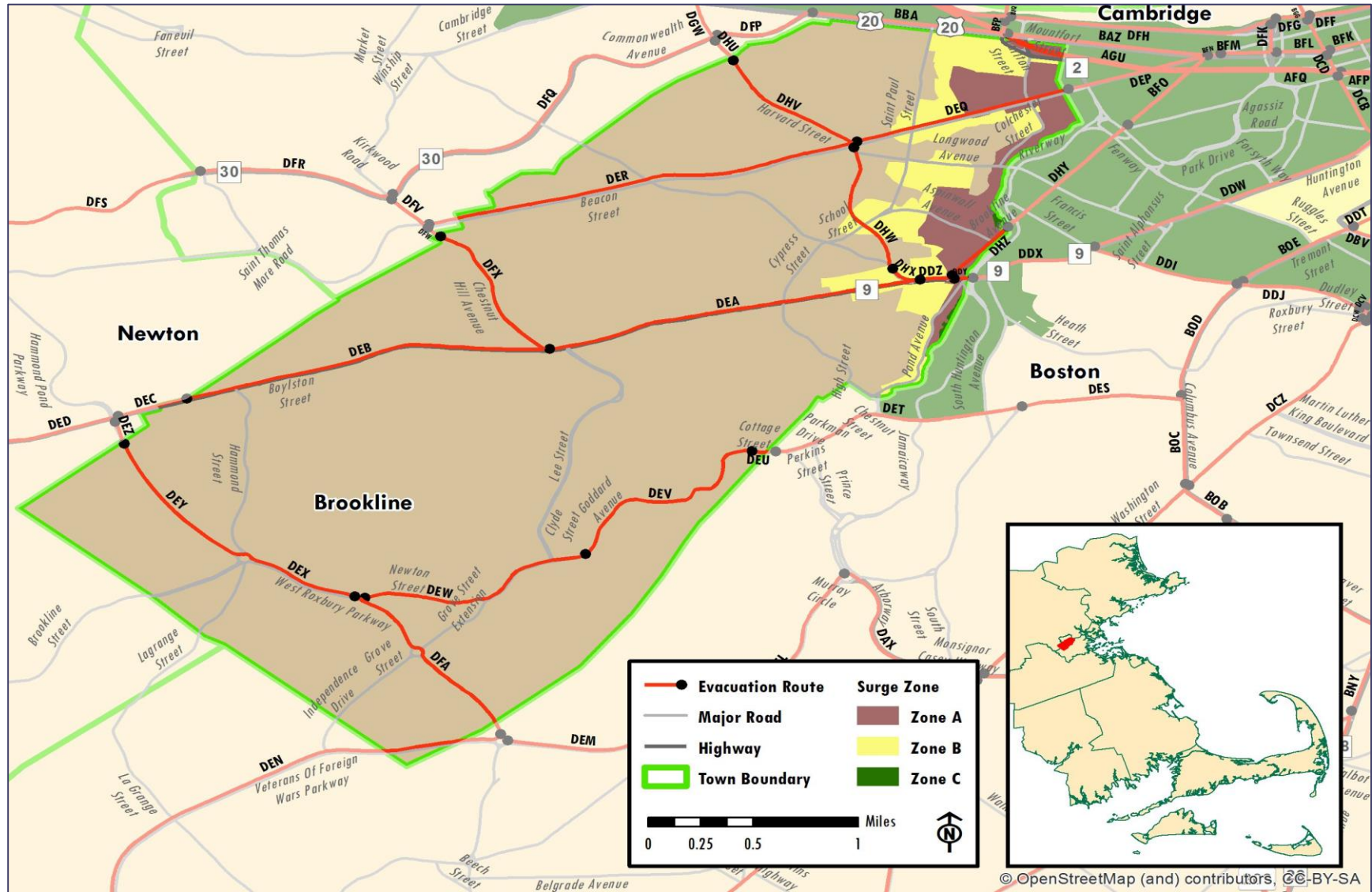


Figure 6-146: Evacuation Roadway Network – Norfolk County / Brookline



6.0 Transportation Analysis

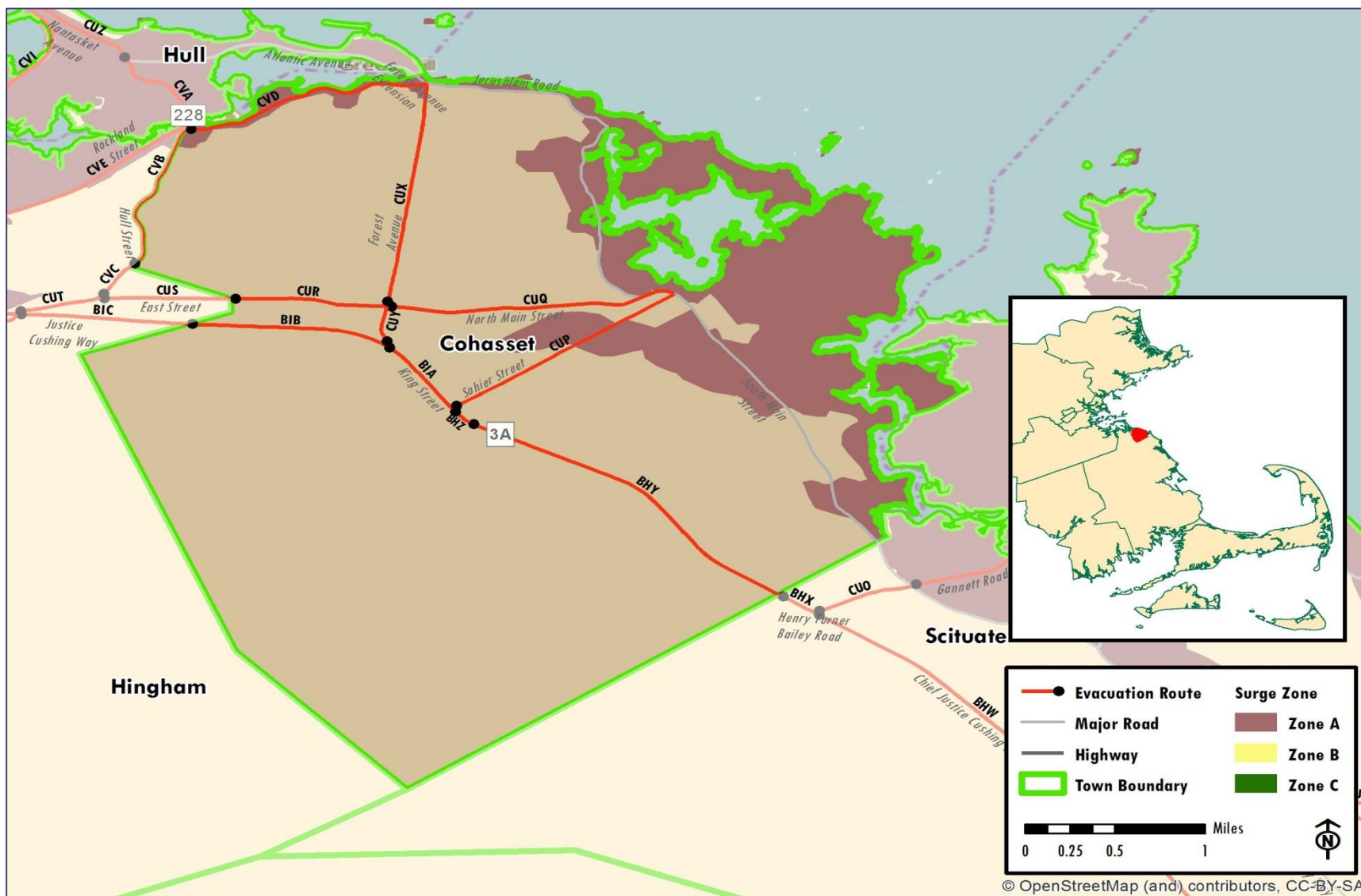


Figure 6-147: Evacuation Roadway Network – Norfolk County / Cohasset



6.0 Transportation Analysis

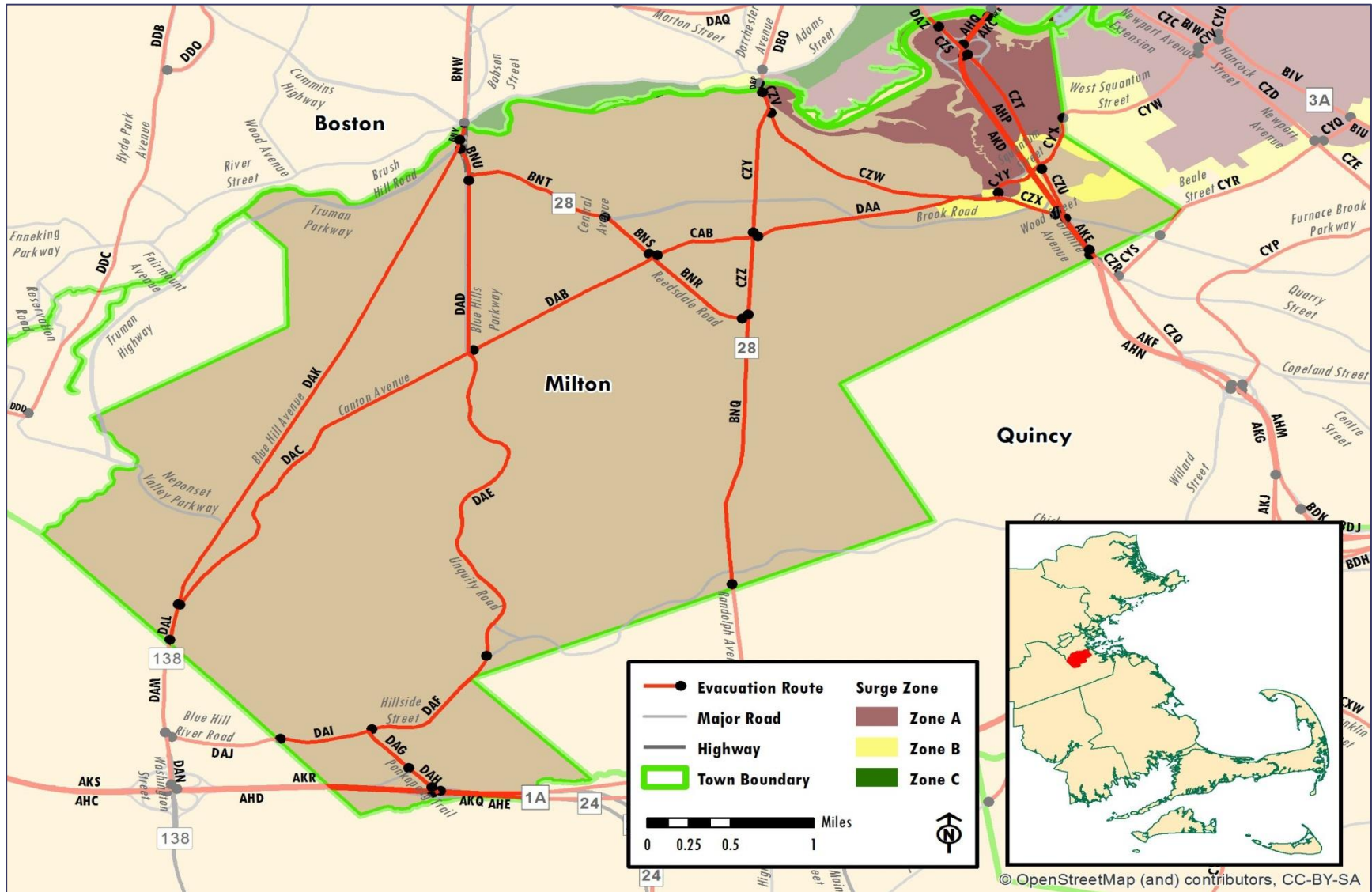


Figure 6-148: Evacuation Roadway Network – Norfolk County / Milton



6.0 Transportation Analysis

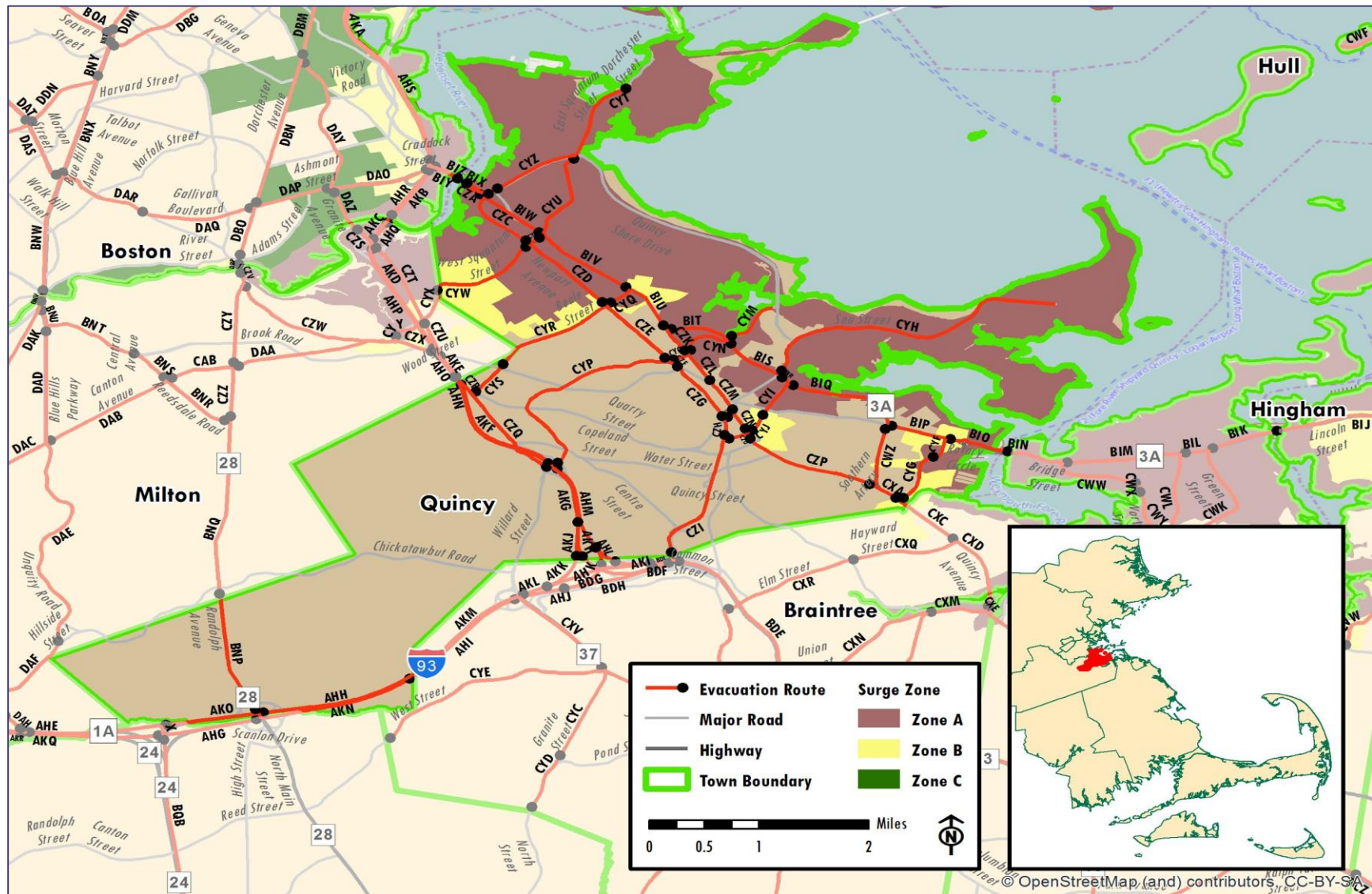


Figure 6-149: Evacuation Roadway Network – Norfolk County / Quincy



6.0 Transportation Analysis

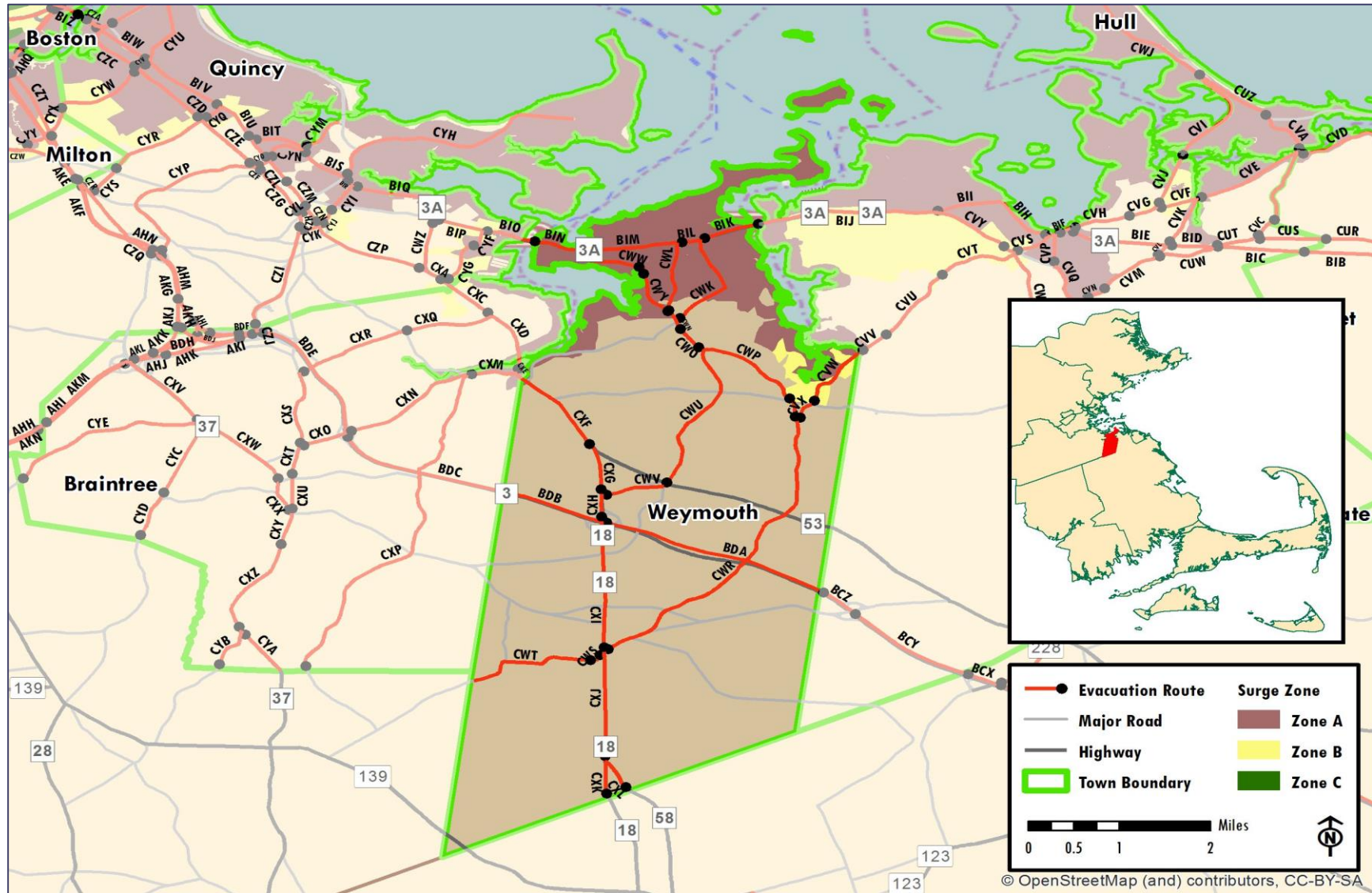


Figure 6-150: Evacuation Roadway Network – Norfolk County / Weymouth



6.0 Transportation Analysis

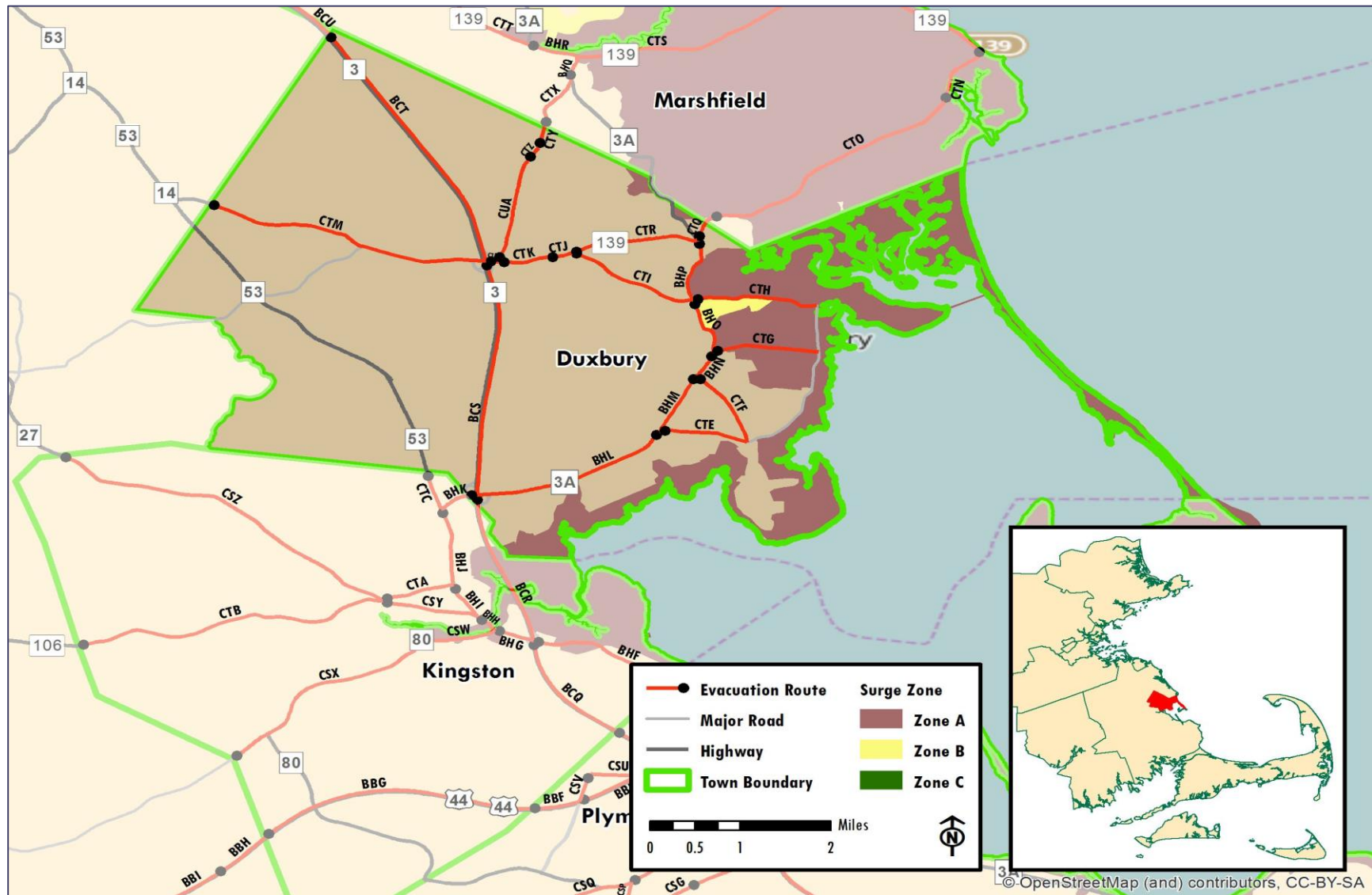


Figure 6-151: Evacuation Roadway Network – Plymouth County / Duxbury



6.0 Transportation Analysis

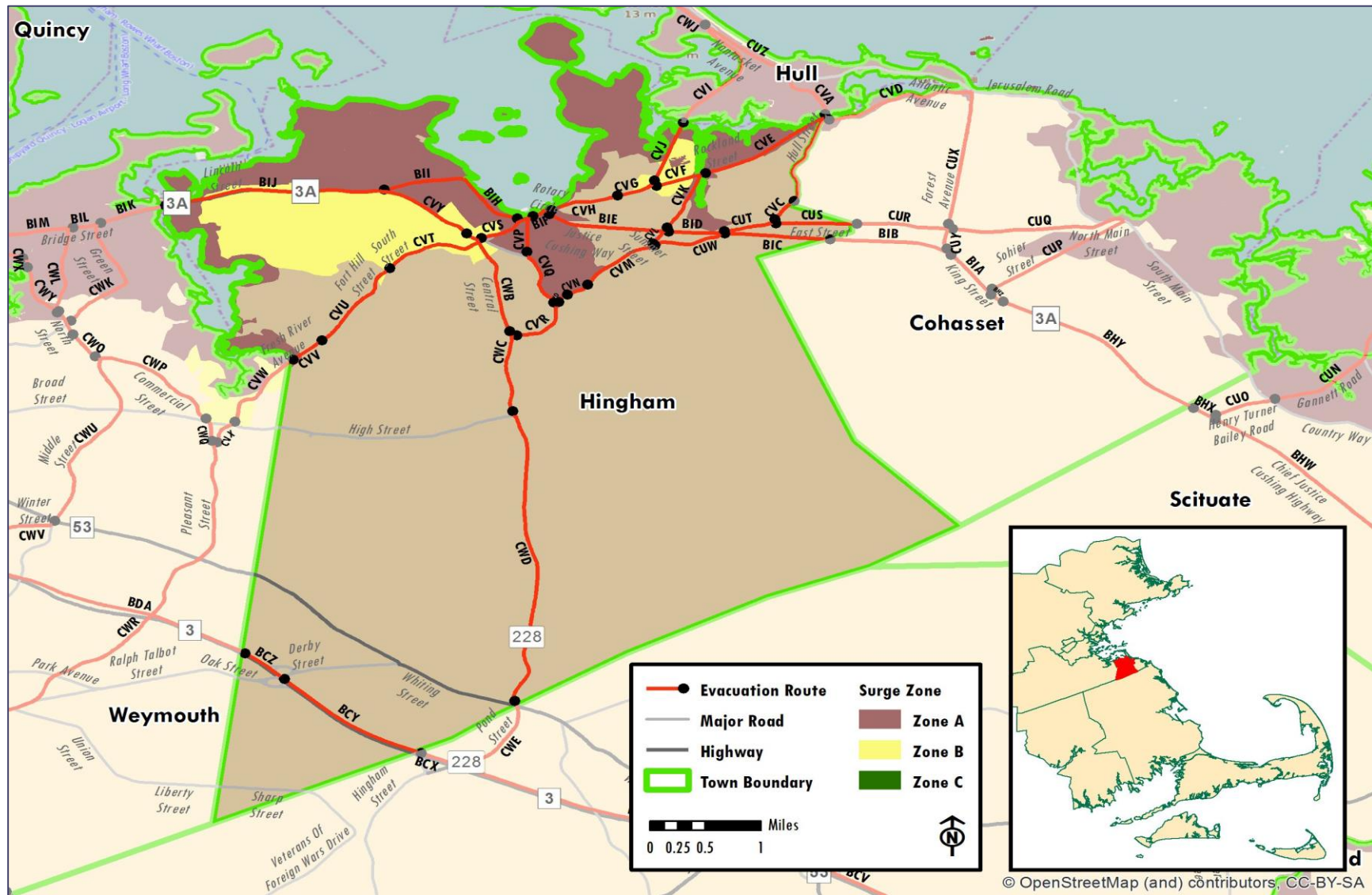


Figure 6-152: Evacuation Roadway Network – Plymouth County / Hingham



6.0 Transportation Analysis

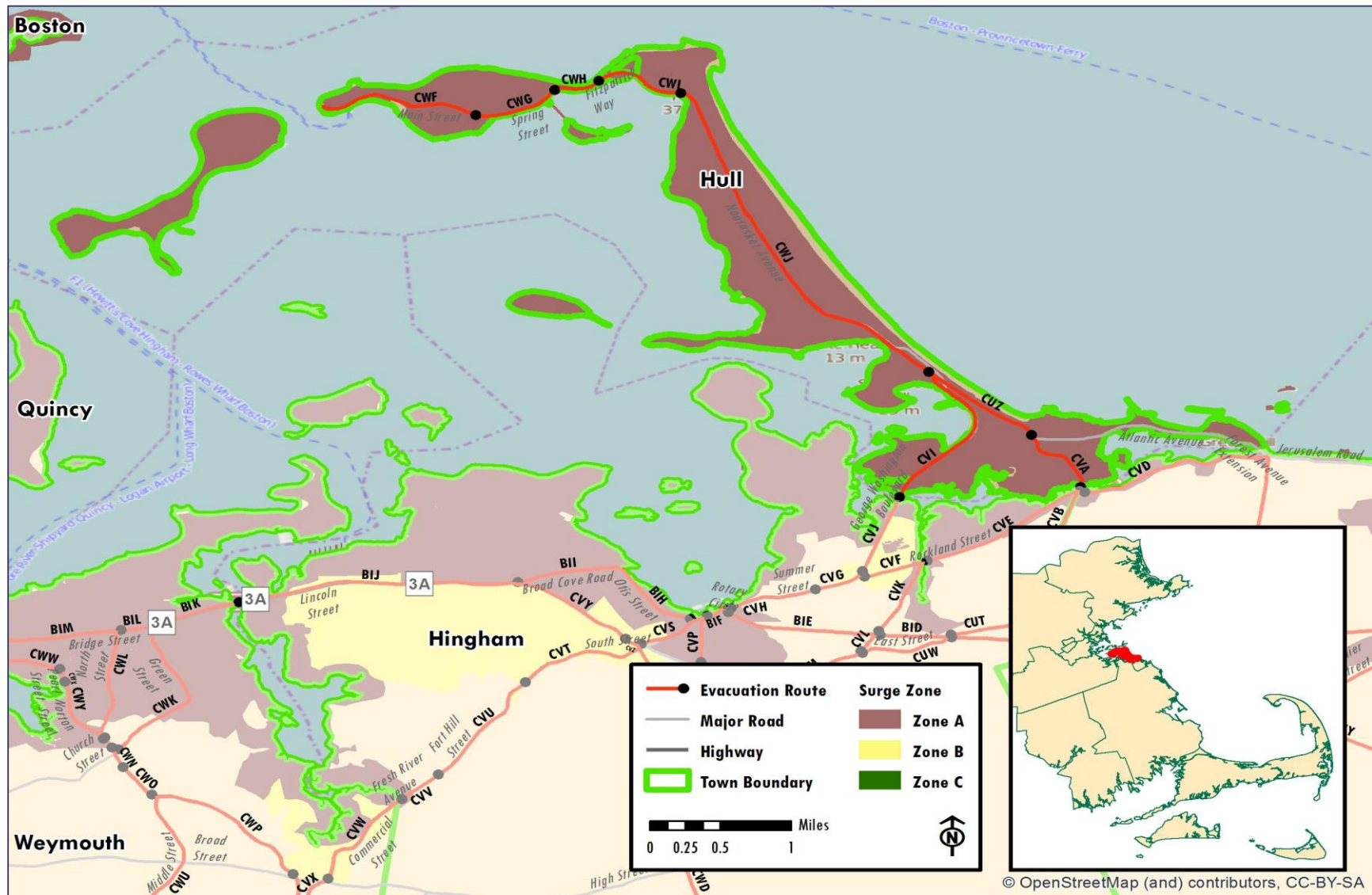


Figure 6-153: Evacuation Roadway Network – Plymouth County / Hull



6.0 Transportation Analysis

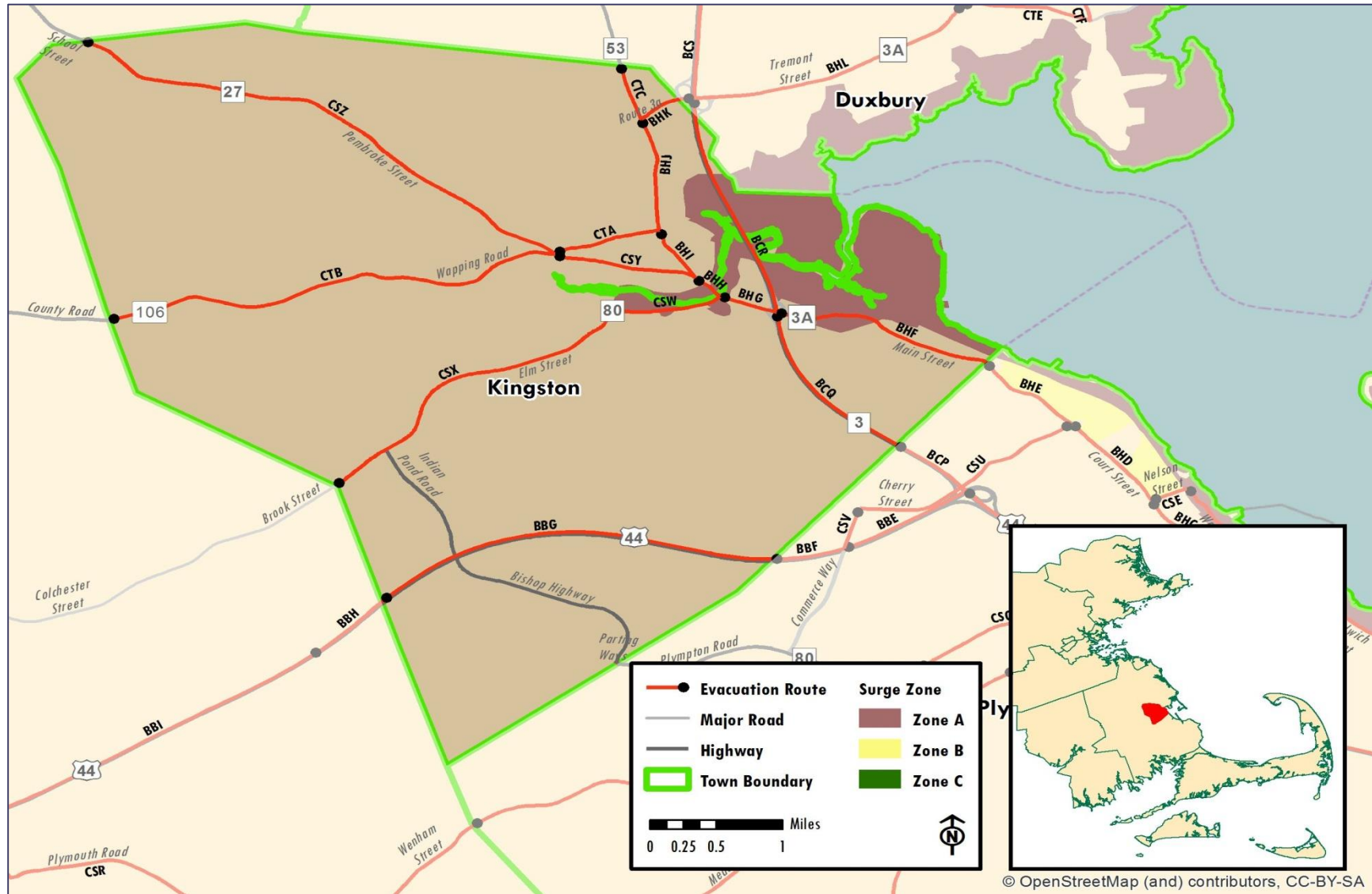


Figure 6-154: Evacuation Roadway Network – Plymouth County / Kingston



6.0 Transportation Analysis

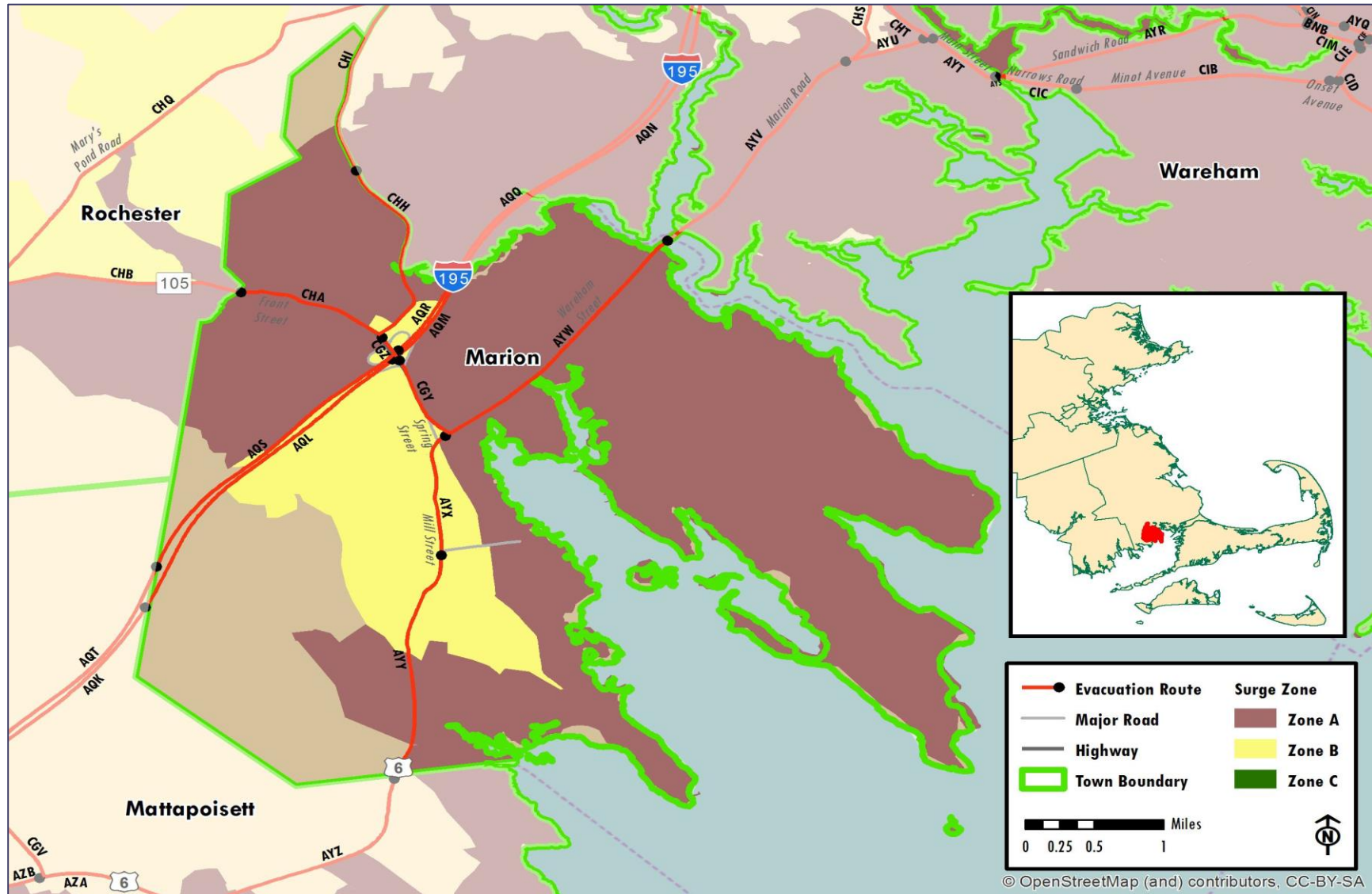


Figure 6-155: Evacuation Roadway Network – Plymouth County / Marion



6.0 Transportation Analysis

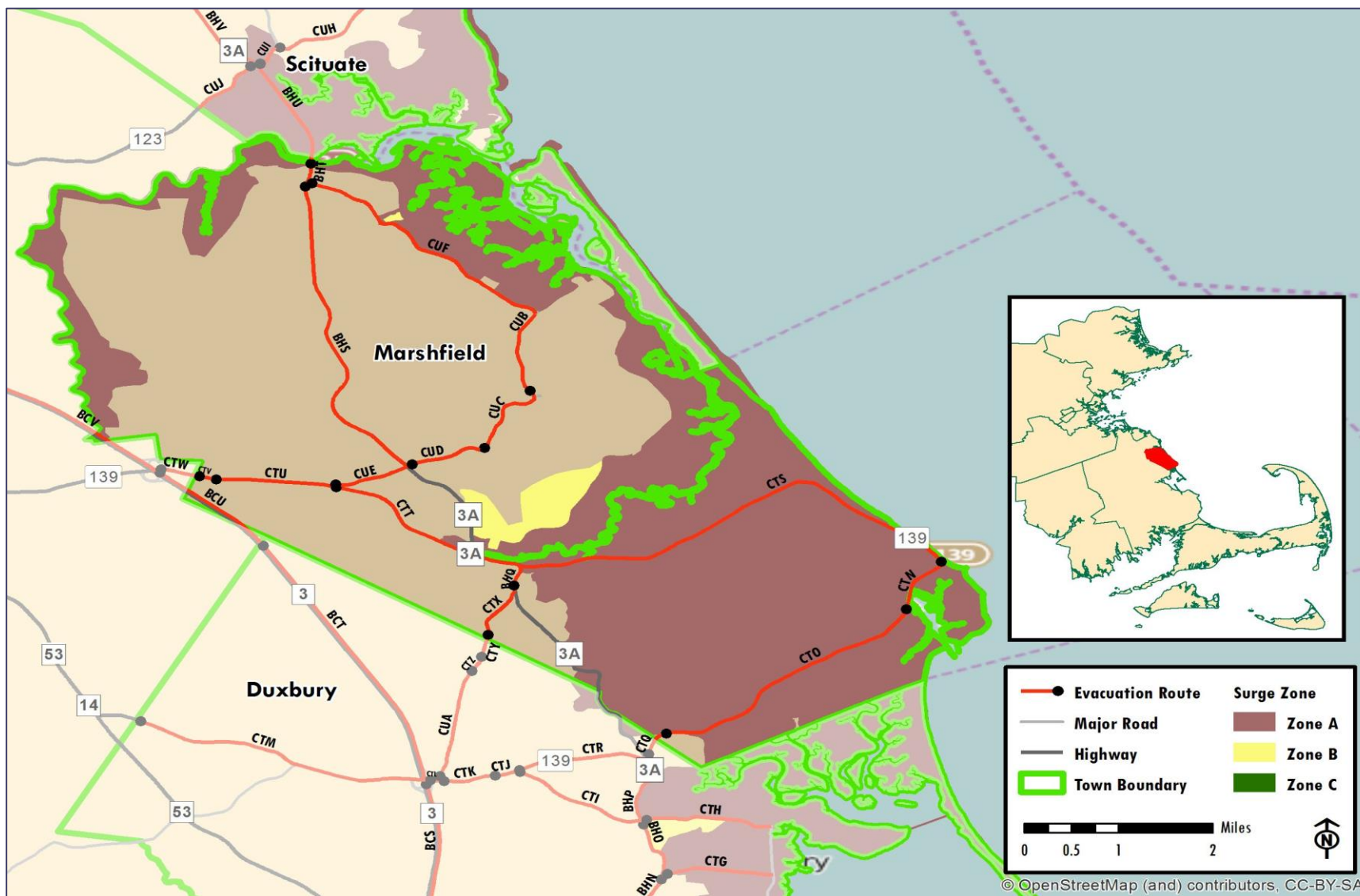


Figure 6-156: Evacuation Roadway Network – Plymouth County / Marshfield



6.0 Transportation Analysis

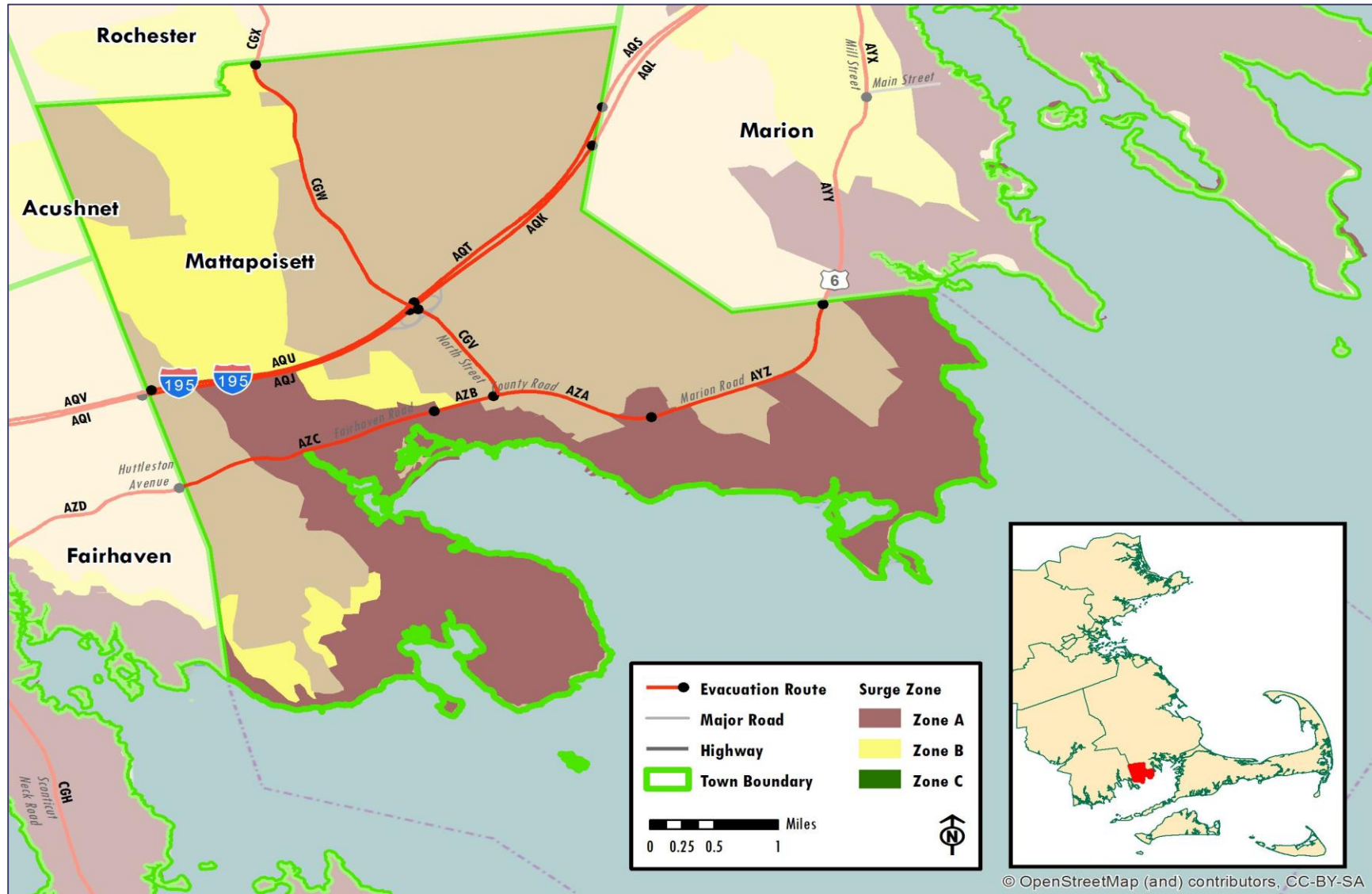


Figure 6-157: Evacuation Roadway Network – Plymouth County / Mattapoisett



6.0 Transportation Analysis

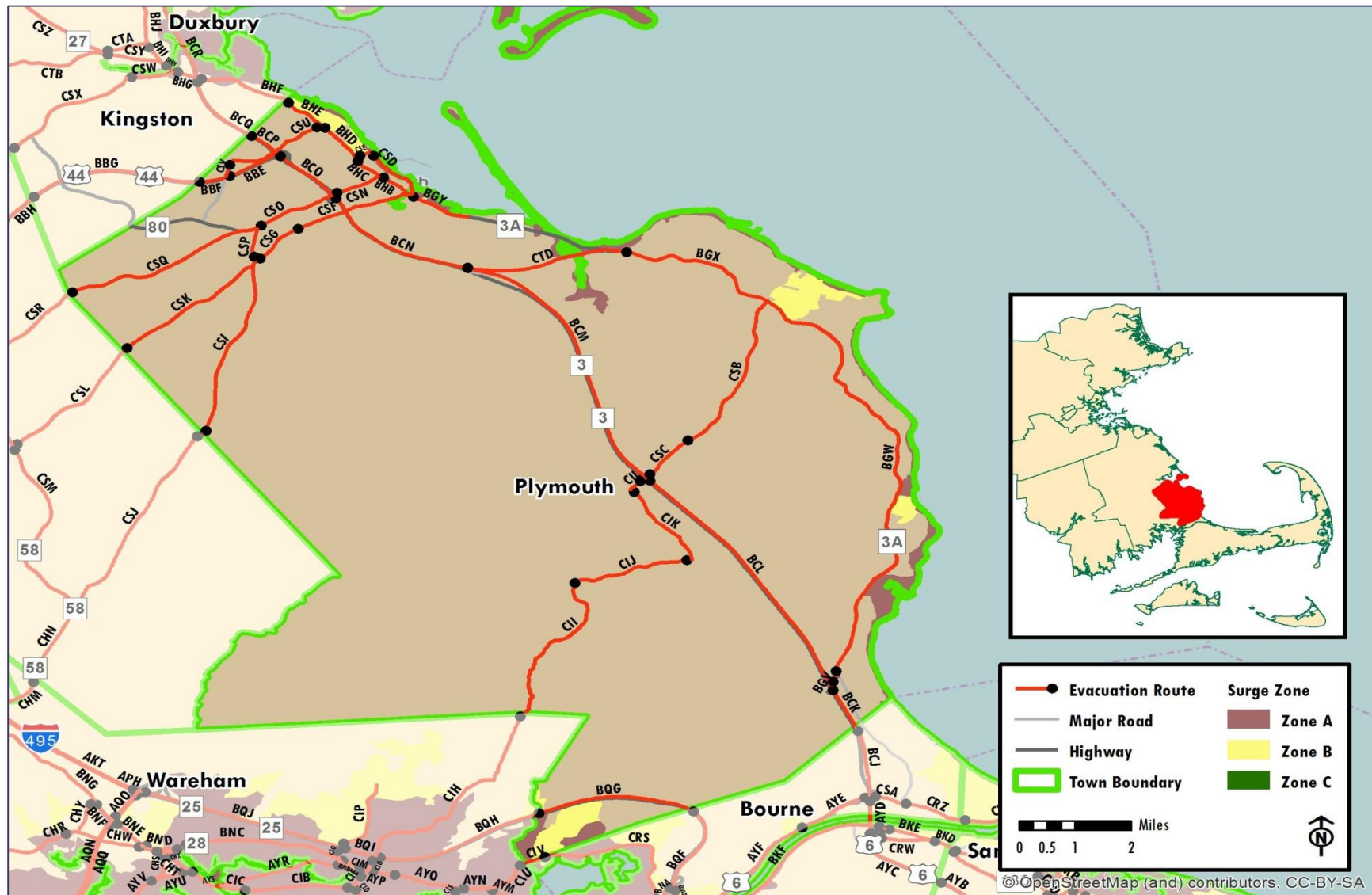


Figure 6-158: Evacuation Roadway Network – Plymouth County / Plymouth



6.0 Transportation Analysis

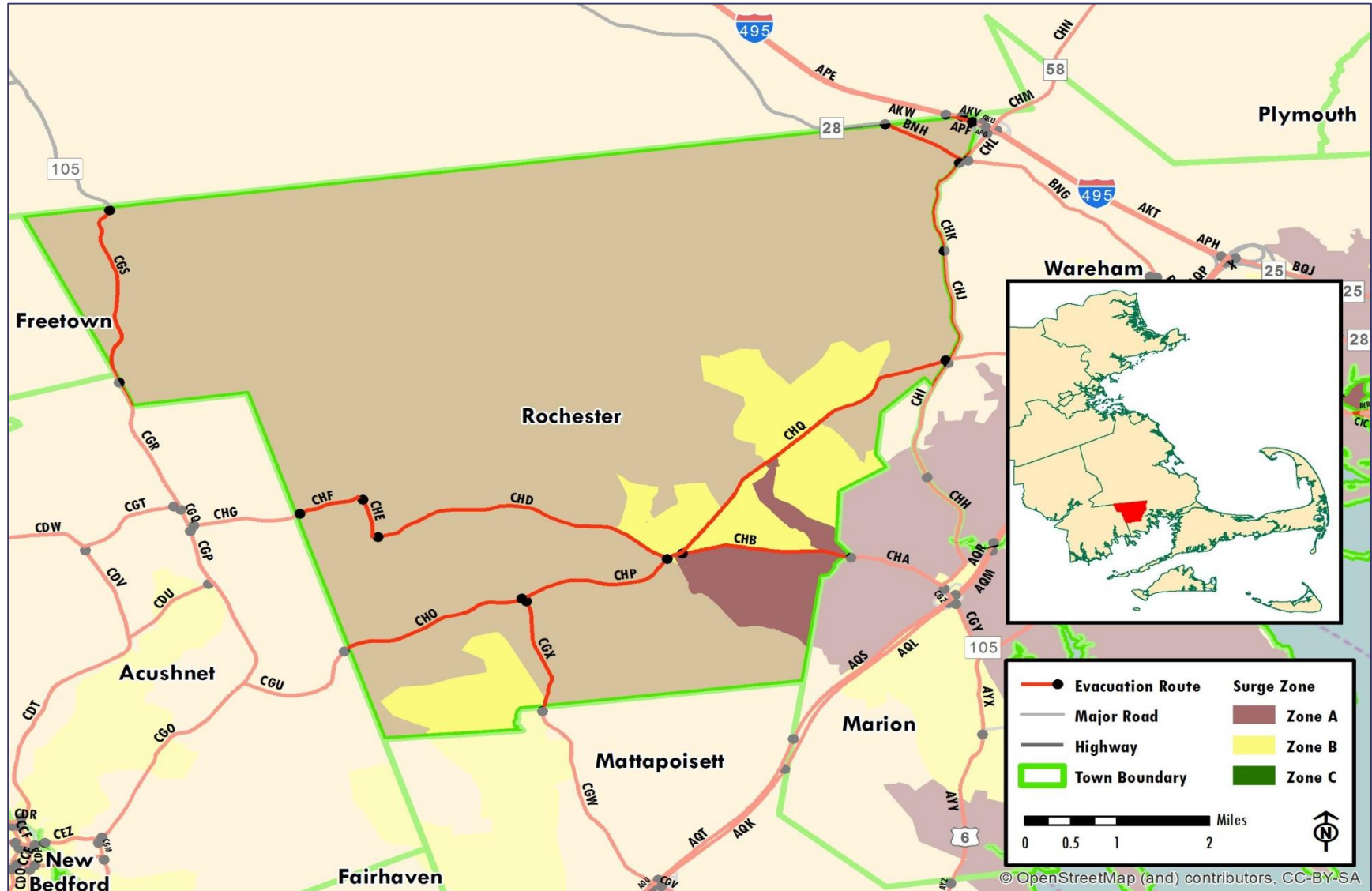


Figure 6-159: Evacuation Roadway Network – Plymouth County / Rochester



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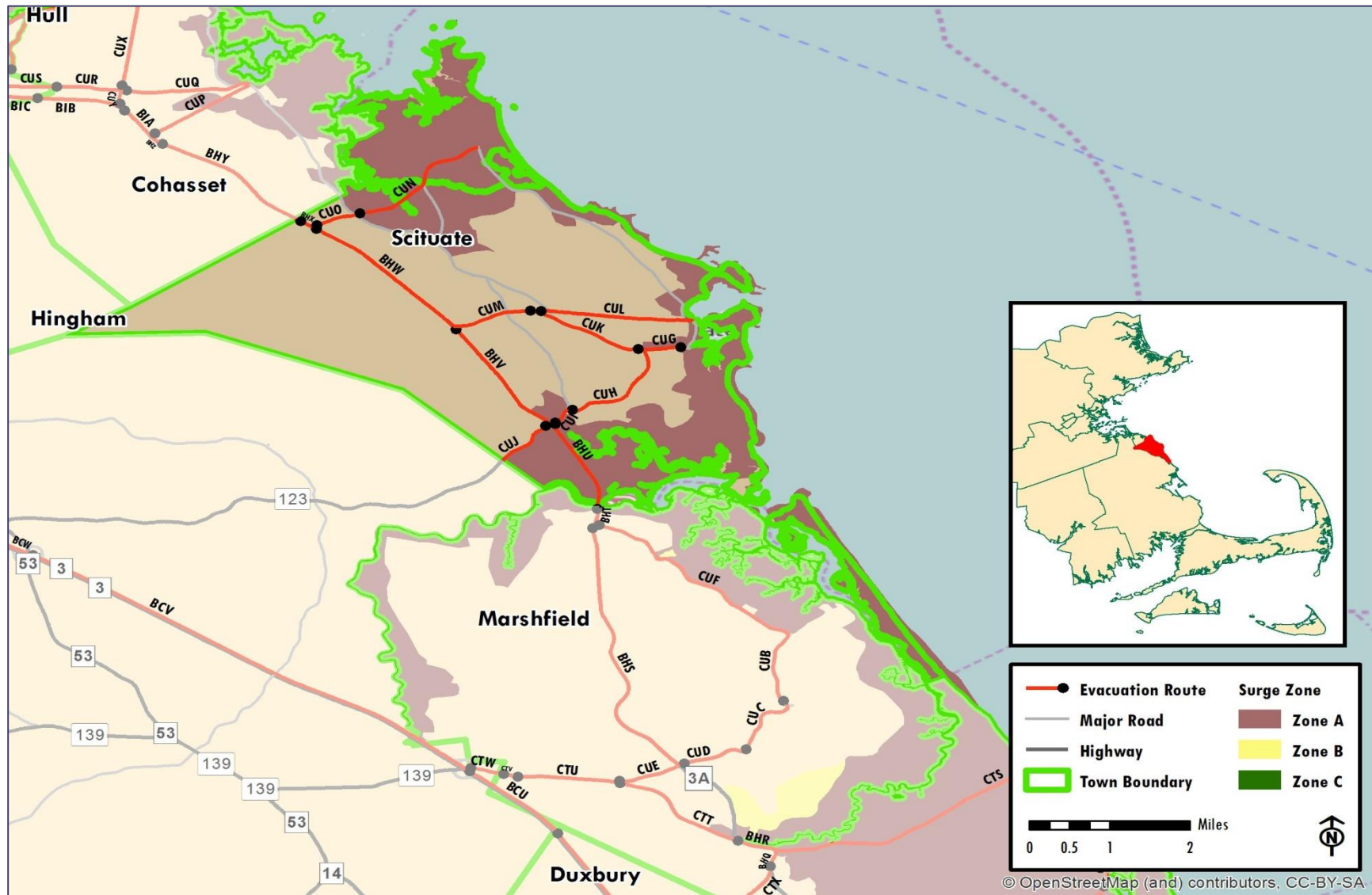


Figure 6-160: Evacuation Roadway Network – Plymouth County / Scituate



6.0 Transportation Analysis

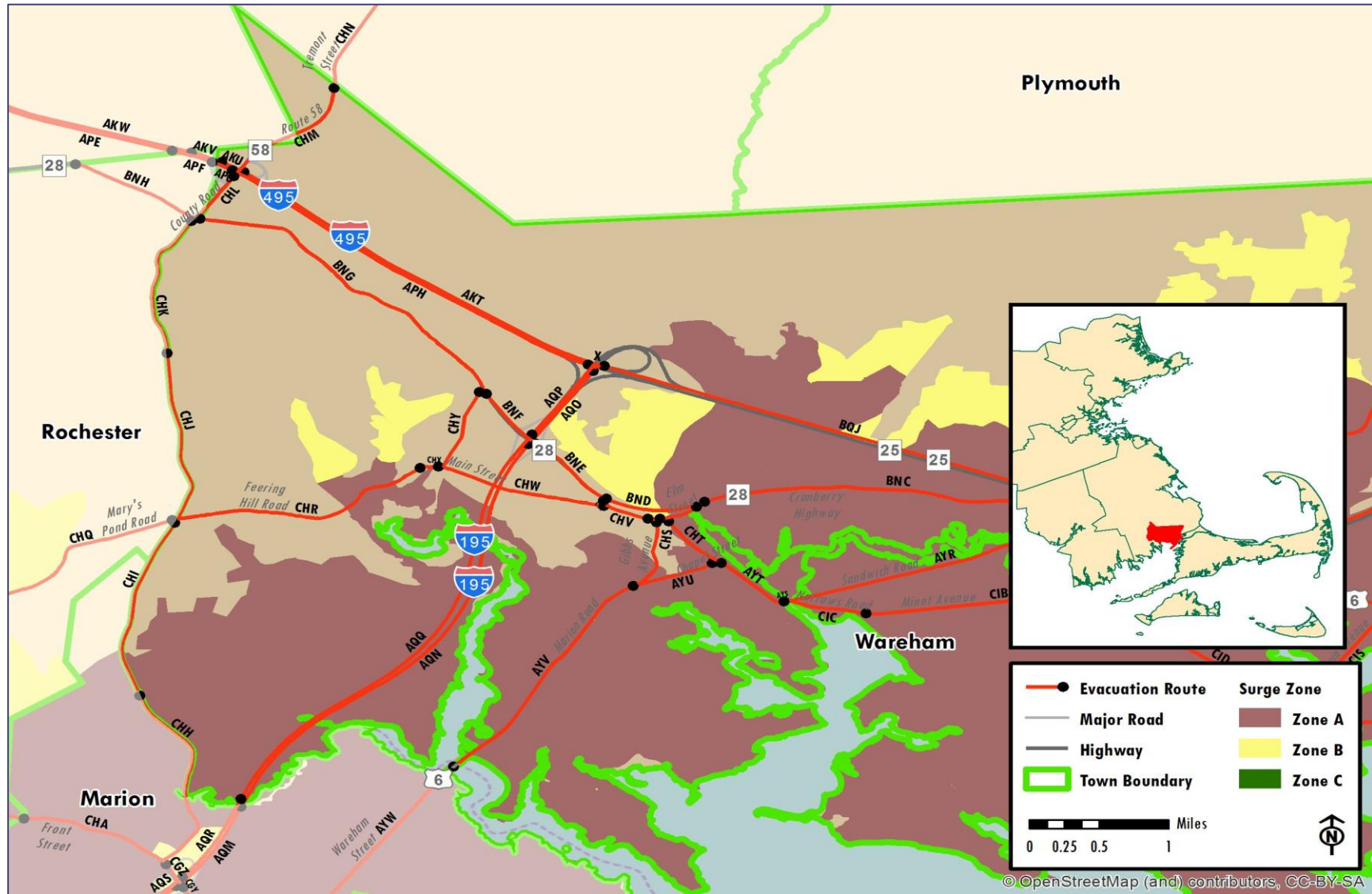


Figure 6-161: Evacuation Roadway Network – Plymouth County / Wareham (west)



6.0 Transportation Analysis

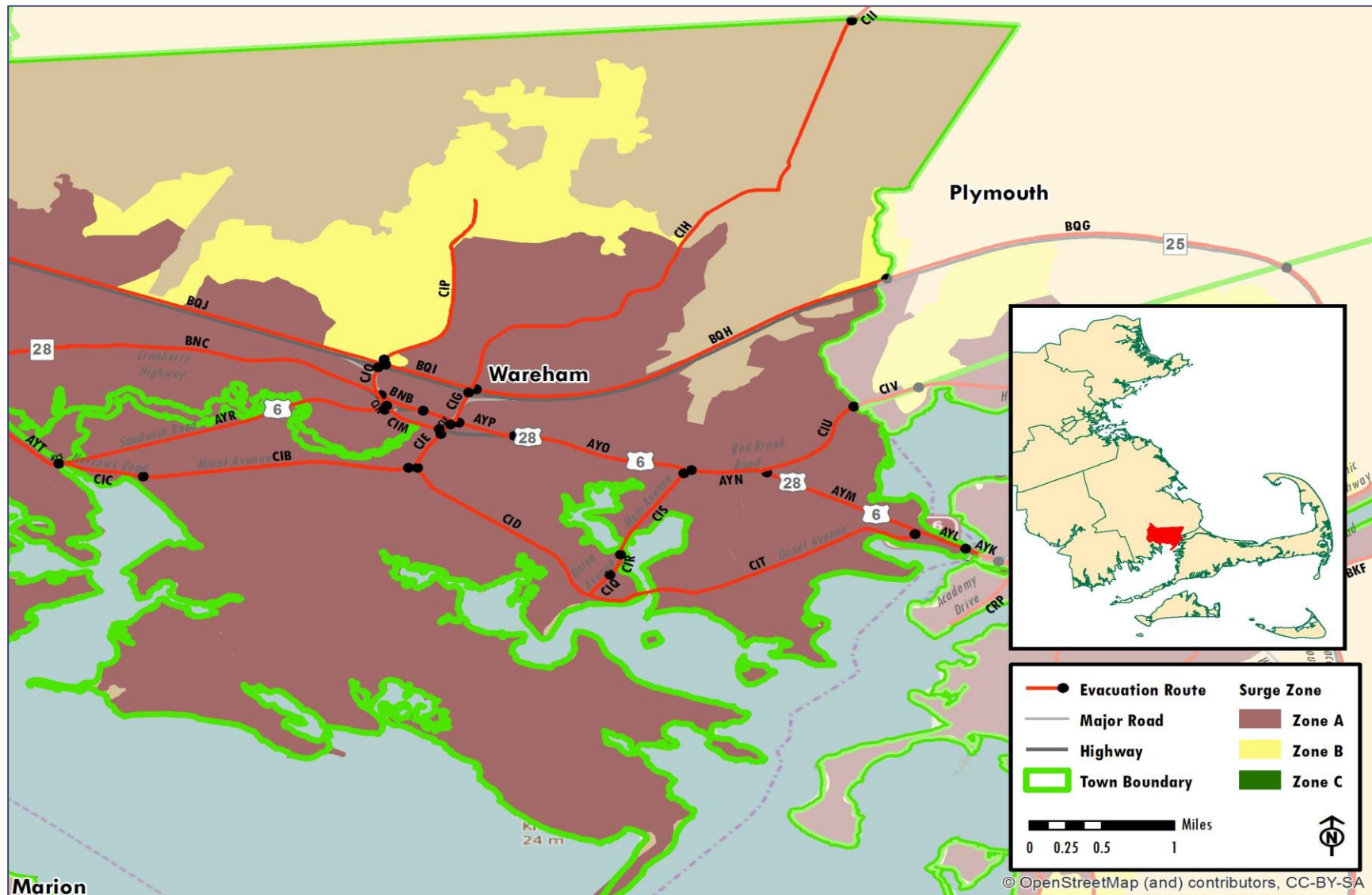


Figure 6-162: Evacuation Roadway Network – Plymouth County / Wareham (east)



6.0 Transportation Analysis

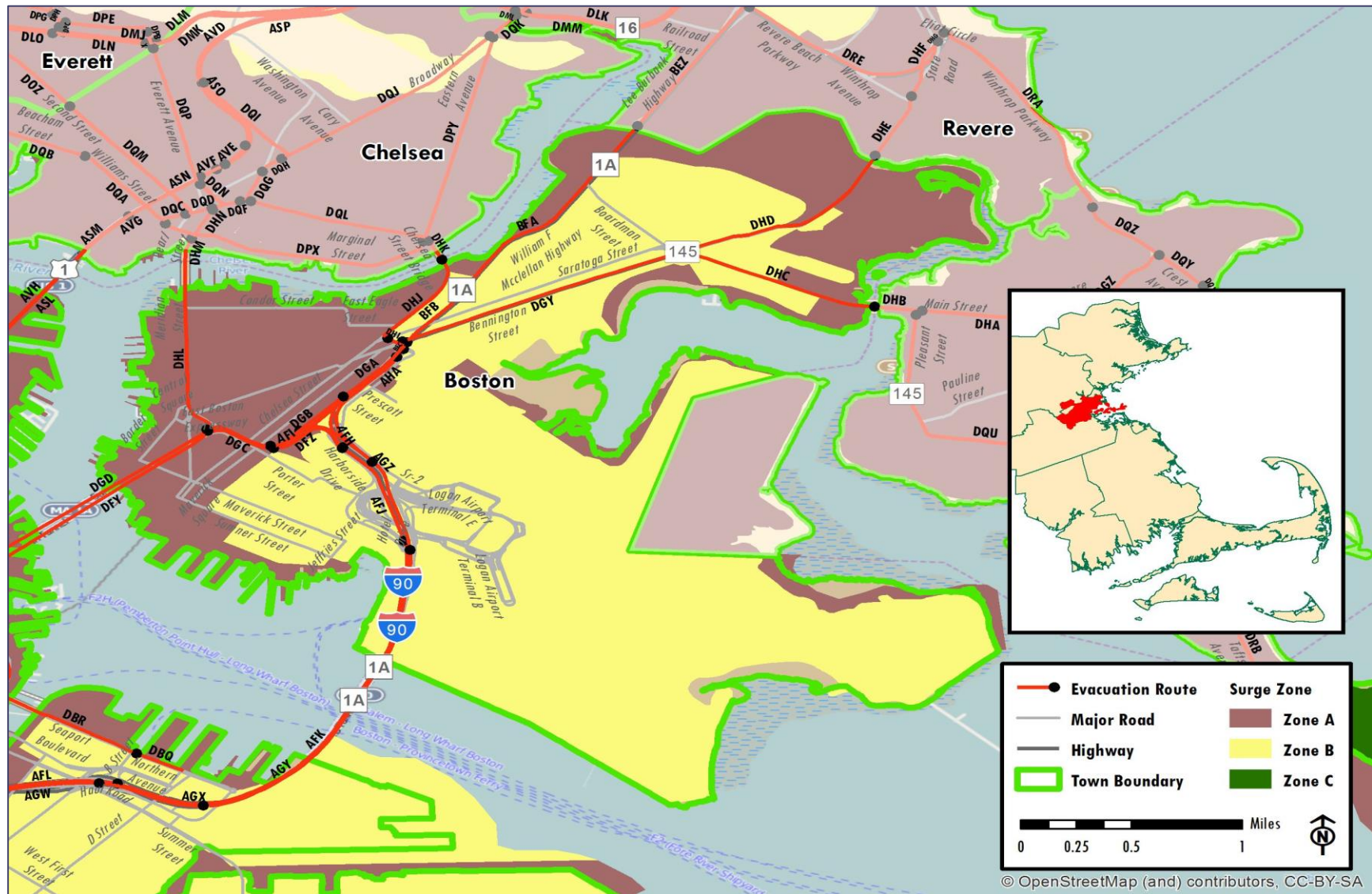


Figure 6-163: Evacuation Roadway Network – Suffolk County / Boston (East Boston, Logan International Airport)



6.0 Transportation Analysis

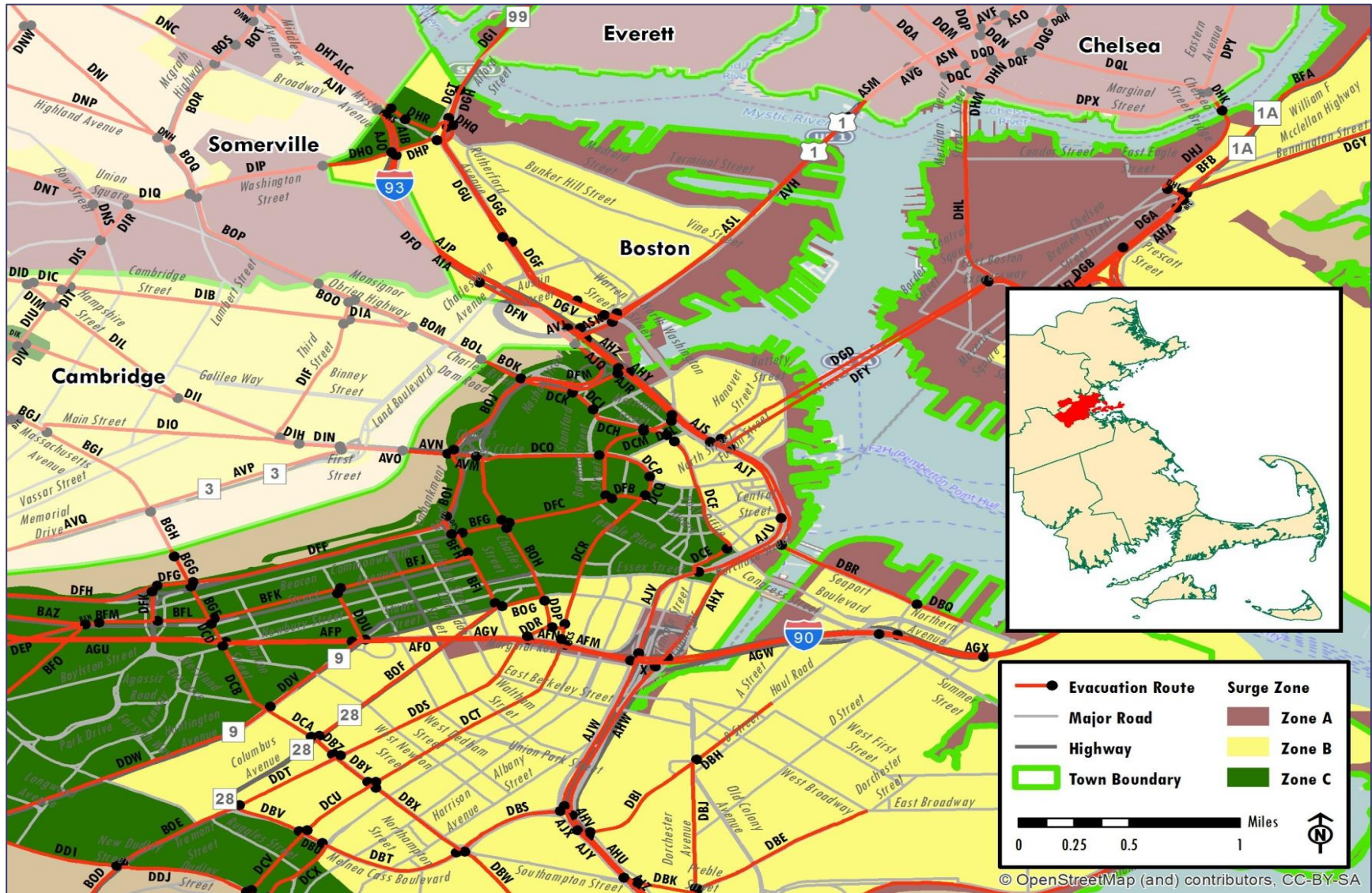


Figure 6-164: Evacuation Roadway Network – Suffolk County / Boston (Downtown, Charlestown)



6.0 Transportation Analysis

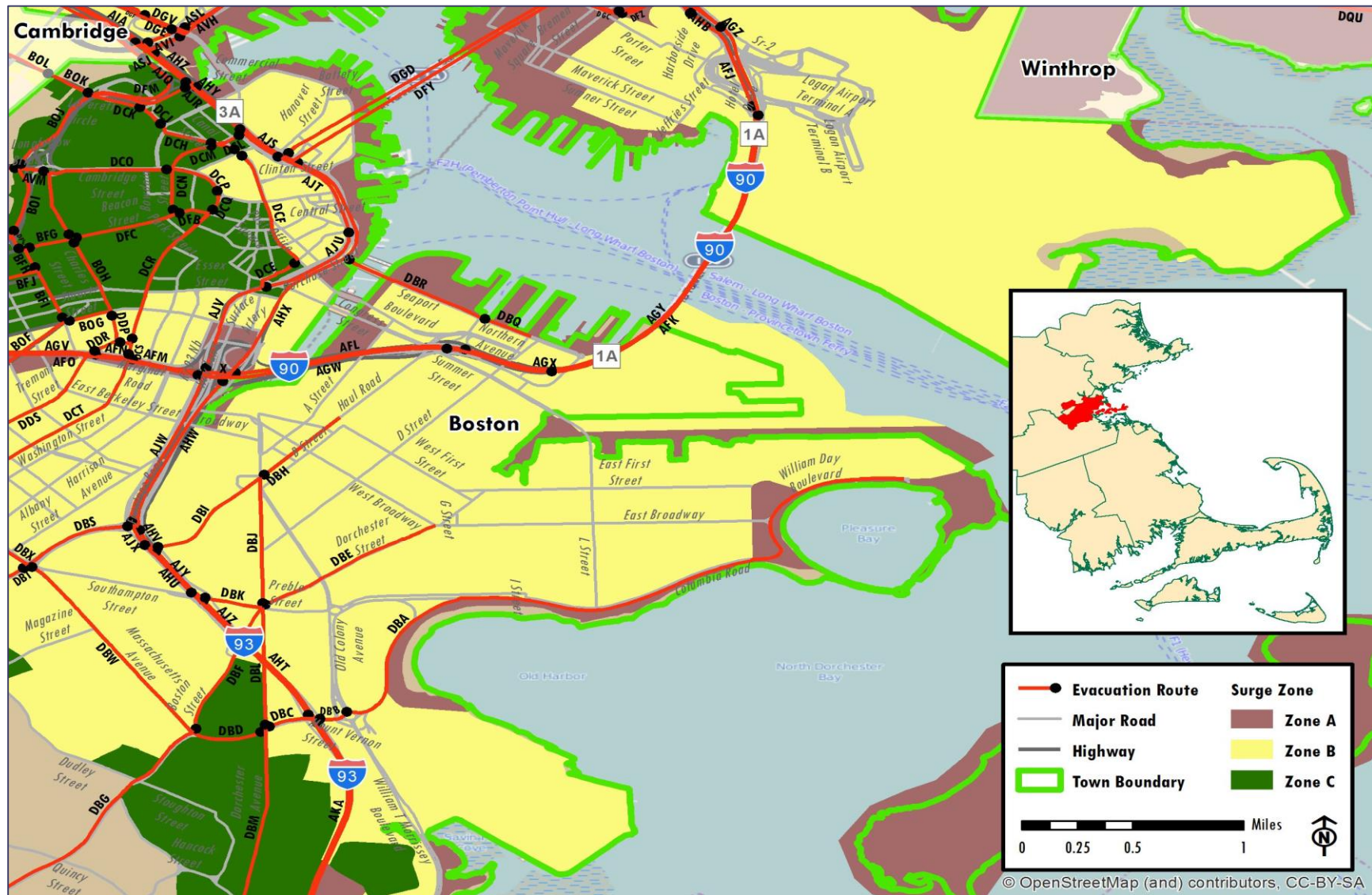


Figure 6-165: Evacuation Roadway Network – Suffolk County / Boston (South Boston)



6.0 Transportation Analysis

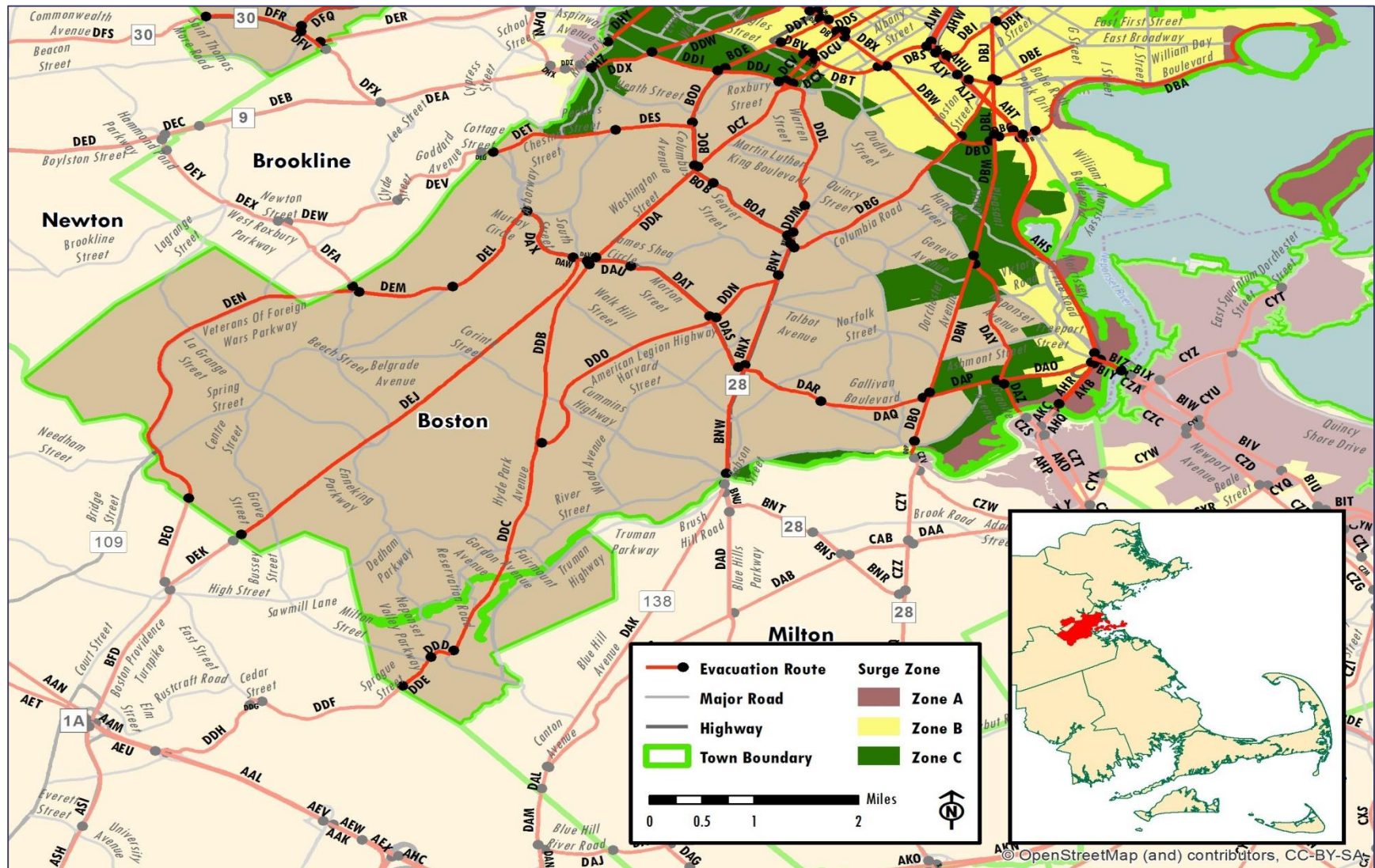


Figure 6-166: Evacuation Roadway Network – Suffolk County / Boston (Dorchester, Mid Dorchester, Mattapan, Roslindale, Hyde Park, West Roxbury)



6.0 Transportation Analysis

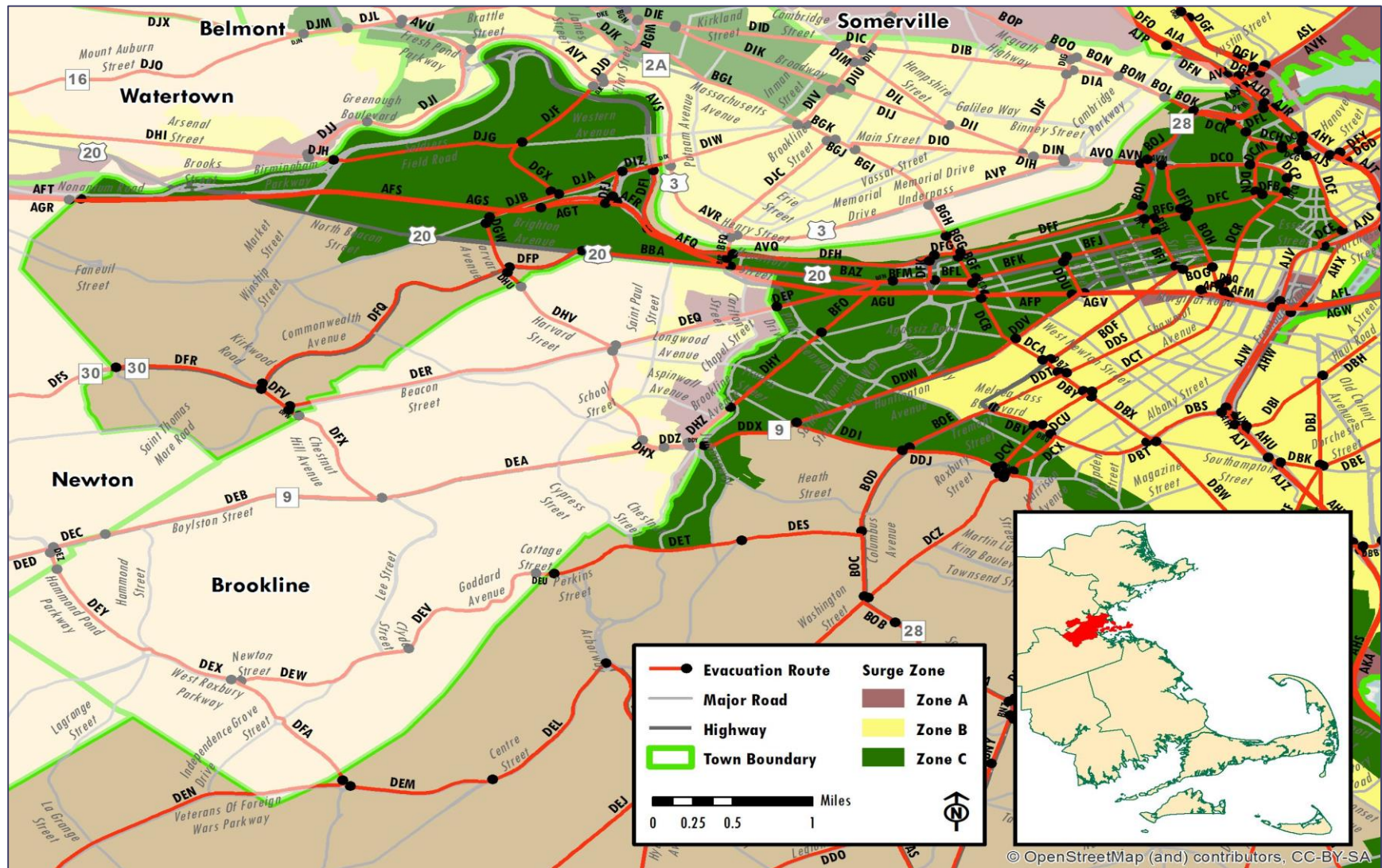


Figure 6-167: Evacuation Roadway Network – Suffolk County / Boston (Roxbury, South End, Jamaica Plain, Mission Hill, Fenway/Kenmore, Allston, Brighton)



6.0 Transportation Analysis

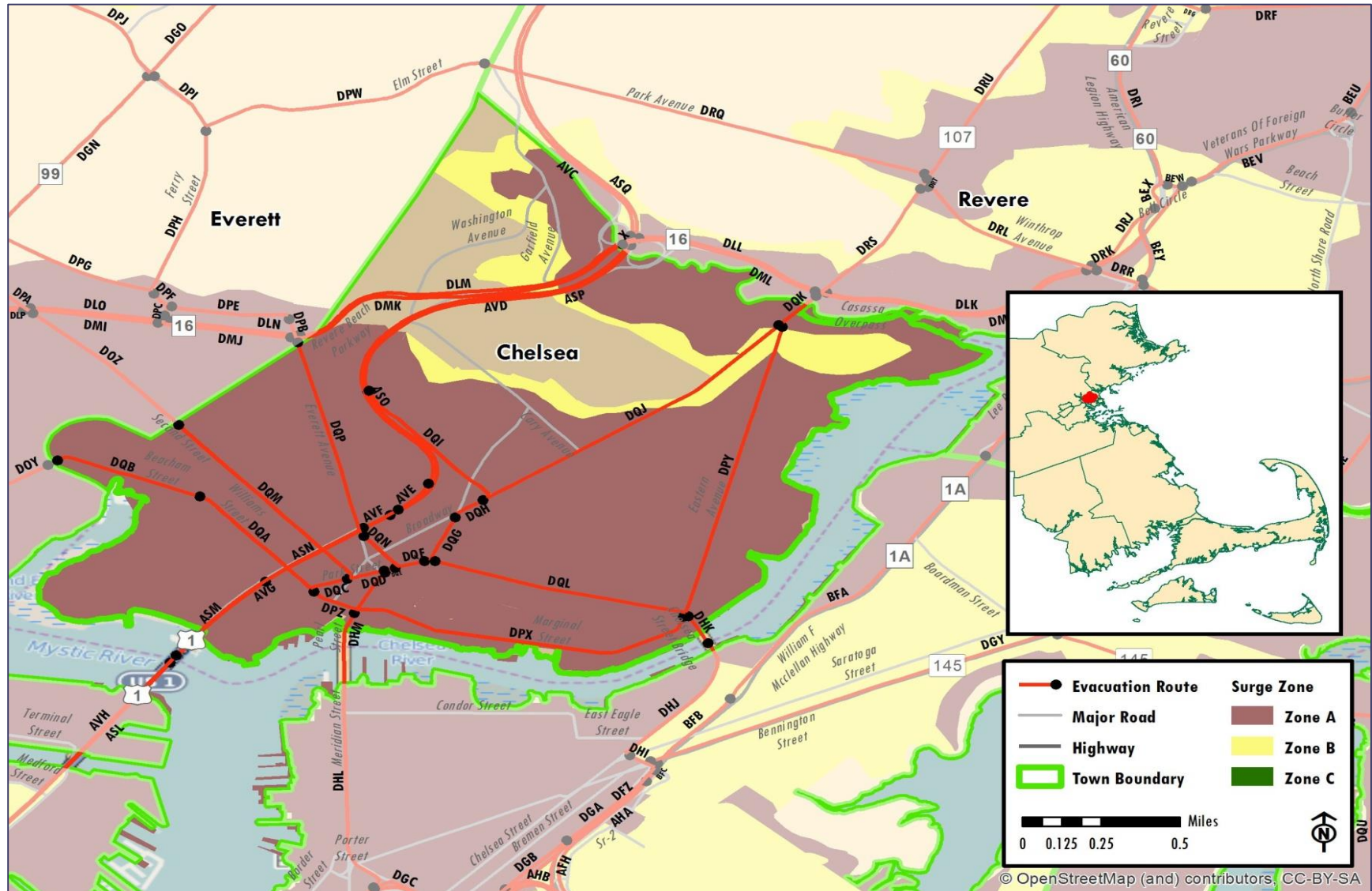


Figure 6-168: Evacuation Roadway Network – Suffolk County / Chelsea



6.0 Transportation Analysis

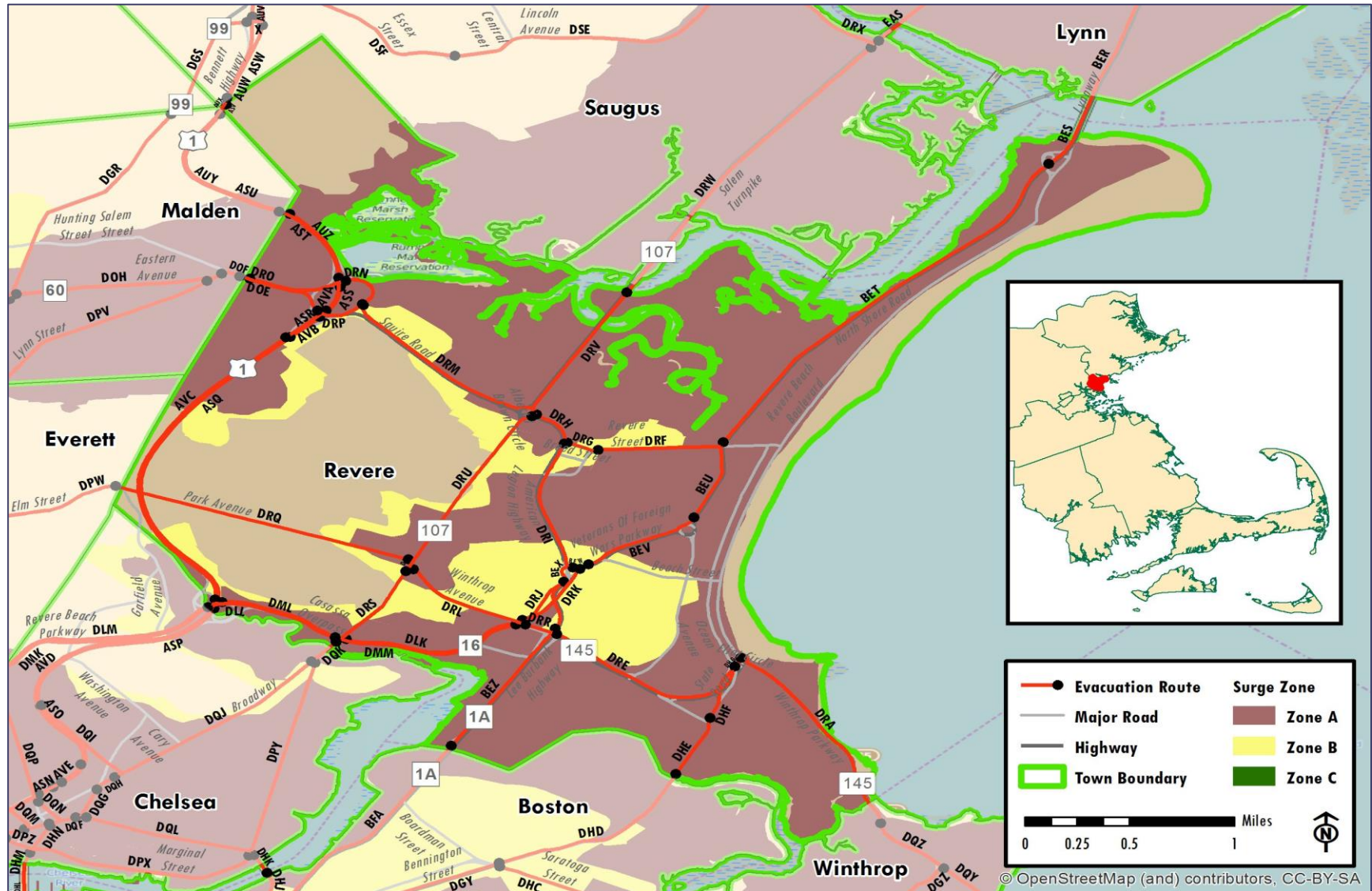


Figure 6-169: Evacuation Roadway Network – Suffolk County / Revere



6.0 Transportation Analysis

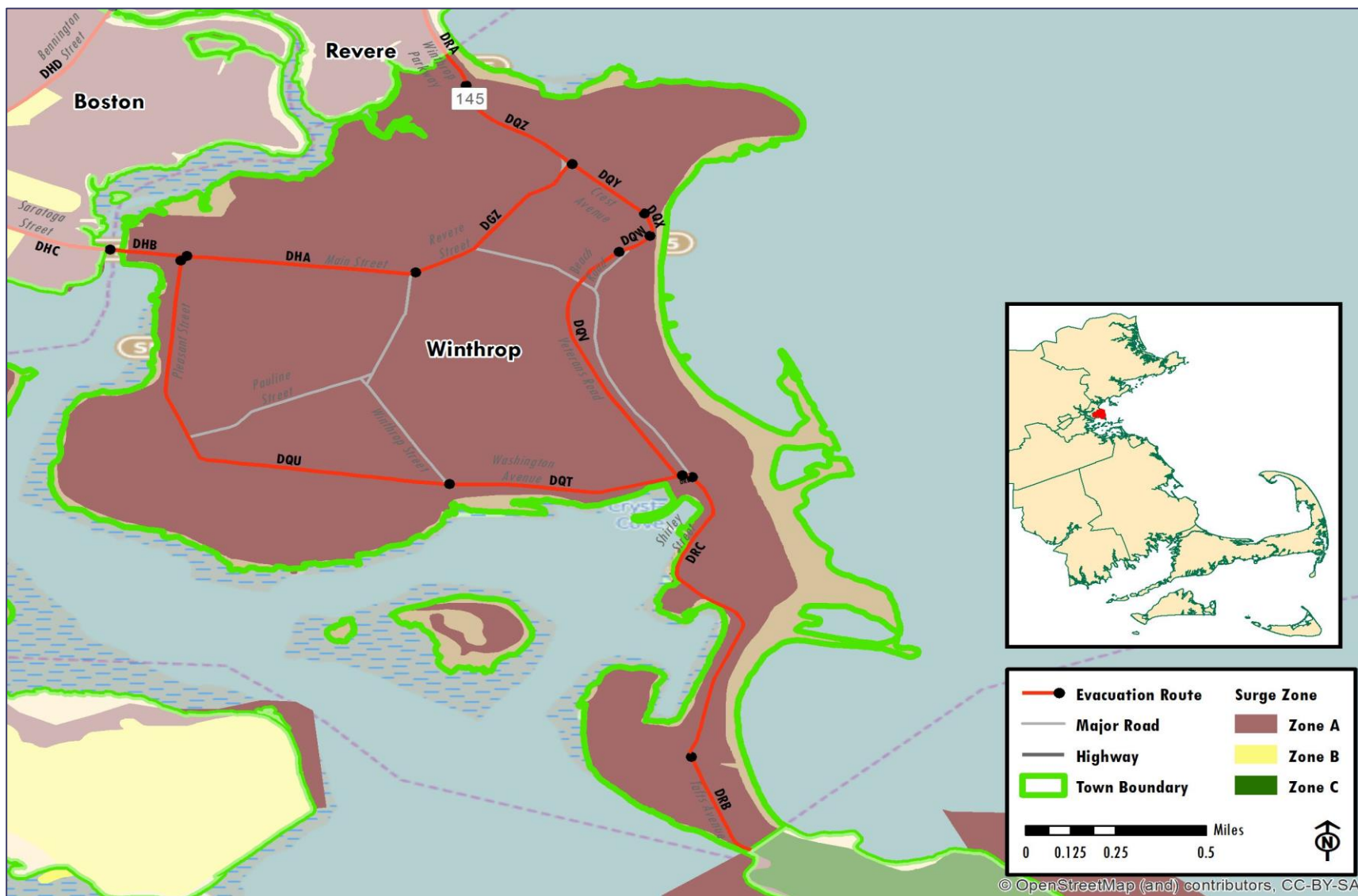


Figure 6-170: Evacuation Roadway Network – Suffolk County / Winthrop



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With the roadway network broken down into its component parts, the next key step in the process was to quantify the performance of the roadway system (i.e., defining the capability of the roadway network to convey traffic) under hurricane evacuation conditions. Such characteristics as number of lanes, type of roadbed, surrounding land uses, number and spacing of traffic signals are important determinants in assessing a roadway's ability to convey traffic. Using aerial imagery, derivations of level of service tables and peak hour traffic counter data, a specific value which represents an hourly directional peak service volume was assigned to each of the roadway segments identified above.

The assigned service volume for each roadway segment is an approximation of how many vehicles can flow through a roadway segment in one direction in one hour. With the roadway characteristic information described above, these capacity estimates can be derived from commonly used and widely recognized transportation planning guidance called Level of Service (LOS) tables from the Highway Capacity Manual. Using a LOS D figure, which is the category just below "free flow" conditions, each segment is associated with a number that represents its capacity to process vehicles under the less than optimal circumstances that normally will exist during a hurricane evacuation.

Another important variable in assessing roadway capacities is to investigate any traffic operations or other infrastructure related measures that may help or hinder the flow of vehicles during an evacuation. Contra flow, roadway barriers and diversions, toll operations as well as other traffic management schemes, especially if implemented to specifically control the flow of evacuating vehicles, can also have a significant impact on the service volume figures assigned to each roadway segment in the model.

Once the characteristics of the roadway system have been established, the travel demand (number of evacuating vehicles) is loaded by the model at the node assigned to each traffic evacuation zone. Those vehicles are then manually routed link by link through the entire evacuation roadway network from their originating node to their assumed safe destination points. Where the evacuation streams from traffic evacuation zones converge and/or overlap will determine those critical links requiring specialized attention over the course of an event. The application of this specialized transportation model allows the cumulative impacts of the multiple evacuation paths from competing vulnerability zones to be quantified and expressed as a period of time. Ultimately, the clearance time for a locale, jurisdiction, or region will be determined by the most congested roadway segment between the point of origin and the most distant destination node.



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Those key roadway segments, once they are established as the most critical by virtue of their relative congestion, are subjected to additional, more detailed traffic analysis for clearance time development. The listing of the critical roadway network segments and their directional service volume is provided in Table 6-23. The selection of these network focal points is not meant to be a complete listing of every traffic control point or problem spot during an evacuation. It is meant to capture the controlling bottlenecks and provide enough coverage and complexity so that clearance times can be calculated adequately and officials can make informed decisions from an evacuation timing standpoint.



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Table 6-23: Critical Roadway Segments

Bottleneck Location	Critical Roadway Segments	Directional Service Volume
Eastham	Grand Army of the Republic Hwy/US 6 @ Nauset Rd (AXE)	1,000
Orleans	Mid Cape Hwy/US 6 @ Cranberry Hwy/MA 6A (AXL)	1,000
Harwich	MA 137 @ Mid Cape Hwy/US 6 (CJP)	820
Harwich	Mid Cape Hwy/MA 6 @ Lake Pleasant Ave/MA 124 (AXO)	1,000
Harwich	Lake Pleasant Ave/MA 124 @ Mid Cape Hwy/US 6 (CKD)	820
Dennis	East West Dennis Rd/MA 134 @ Mid Cape Hwy/US 6 (CKS)	720
Yarmouth	Station Ave @ Mid Cape Hwy/US 6 (CKX)	720
Yarmouth	Mid Cape Hwy/MA 6 @ Station Ave (AXS)	3,420
Barnstable	Iyannough Rd/MA 132 @ Mid Cape Hwy/US 6 (CMT)	1,810
Barnstable	Mid Cape Hwy/US 6 @ Iyannough Rd MA 132 interchange (AXW)	3,420
Falmouth	MA 28 @ Nathan Ellis Hwy/MA 151 (BMU)	3,420
Bourne	Bourne Bridge/MA 28 (BMY)	2,980
Bourne	Mid Cape Hwy/US 6 Bridge over the Cape Cod Canal (AYD)	3,420
Wareham	I-495 north of MA 58 interchange (AKU)	3,420
Achushnet	Alfred Bessette Mem Hwy / MA 140 @ Braley Rd interchange (BVC)	3,580
Fall River	MA 24/79 north of MA 24/79 junction (BPL)	3,580
Raynham	MA 24 @ US 44 interchange (BPT)	3,420
Bridgewater	Amvets Mem Hwy/MA 24 north of I-495 interchange (BPV)	3,420
Seekonk	I-195 @ MA/RI state line (ARX)	5,280
Plymouth	Pilgrim Hwy/MA3 @ US 44 interchange (BCP)	3,420
Duxbury	Pilgrim Hwy/MA3 @ Tremont St/MA 3A interchange (BCR)	3,420
Duxbury	Pilgrim Hwy/MA3 @ Congress St/MA 14 interchange (BCS)	3,420
Pembroke	Pilgrim Hwy/MA3 @ Church St/MA 139 interchange (BCV)	3,420
Hingham	Geo Washington Blvd @ Rockland St (CVJ)	1,550
Hingham	Summer St/MA 3A @ Water St (BIF)	1,810
Quincy	Hancock St/MA 3A @ Beale St	1,100
Braintree	Pilgrim Hwy/MA3 @ I-93 interchange	5,280
Boston	I-93 @ Columbia Rd interchange (AHS)	5,800
Boston	Bowdoin St between Cambridge St and Beacon St (DCN)	1,100
Boston	Huntington Ave/MA 9 @ Boylston St (DEB)	1,800
Brookline	Boylston St/MA 9 @ Hammond Pond Pky (DEC)	2,400
Cambridge	Prospect St @ Massachusetts Ave/MA 2A (DIV)	1,100
Somerville	Broadway @ Holland St (DNE)	1,100



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Table 6-23: Critical Roadway Segments (continued)

Bottleneck Location	Critical Roadway Segments	Directional Service Volume
Medford	Harvard St/MA 16 @ Main St (DNY)	1,100
Revere	Revere Beach Pky/MA 145 @ MA 1A (DRE)	1,800
Revere	Revere Beach Pky/MA 16 @ Broadway (DLK)	1,800
Randolf	Amvets Mem Hwy/MA 24 @ I 93 interchange (BQB)	3,420
Canton	I-95 @ I-93/US 1 interchange (inner loop)(AAJ)	5,800
Weston	I-95 @ I 90 interchange (inner loop)(AAU)	5,800
Weston	I-90 @ I 95 interchange (AFW)	4,500
Lexington	MA 2 @ I-95 interchange (BFW)	4,500
Lexington	I-95 @ MA 2 interchange (inner loop)(ABB)	5,800
Burlington	US 3 @ Burlington Rd/MA 62 interchange (AWJ)	5,280
Burlington	I-95 @ US 3 interchange (inner loop)(ABE)	5,800
Reading	I-93 @ I-95 interchange (AIL)	5,800
Reading	I-95 @ I-93 interchange (inner loop)(ABK)	5,800
Reading	Fellsway/MA 28 @ I-95 interchange (BPE)	1,860
Peabody	US 1 @ I-95/MA 28 (ATC)	5,530
Reading	I-95 @ I-93 interchange (outer loop)(ADV)	5,800
Burlington	I-95 @ US 3 interchange (outer loop)(AEB)	5,800
Lexington	I-95 @ MA 2 interchange (outer loop)(AEE)	5,800
Weston	I-95 @ I 90 interchange (outer loop)(AEK)	5,800
Peabody	Yankee Div. Hwy/I-95/MA 128 @ US 1 Connector interchange (ADO)	5,530
Saugus	Main St @ US 1 interchange (DSC)	760
Lynn	Lewis St/ MA1A/129 @ Chestnut St/MA 129A (BEM)	860
Peabody	Yankee Division Hwy/MA 128 @ Lowell St interchange (DVF)	3,230
Beverly	Yankee Division Hwy/MA 128 @ Dodge St/MA 1A (DUZ)	3,420
Gloucester	Yankee Division Hwy/MA 128 bridge @ Annisquam River ((DUP)	3,420
Rowley	Haverhill St/MA 133 @ I-95 interchange (DXW)	870
Newburyport	Storey Ave/MA113 @ I-95 interchange (DYV)	820
Newburyport	I-95 @ Storey Ave/MA113 interchange ACW)	7,140
Amesbury	Macy Street @ I-95 interchange (DZE)	820
Amesbury	I-95 @ Macy Street interchange (ACV)	7,140
Salisbury	I-95 @ MA/NH state line (ACQ)	7,140
Andover	I-93 @ I-495 (AIQ)	5,280
Methuen	I-93 @ MA/NH state line (AIV)	5,280



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6.10 Model Results

The transportation modeling completed for Massachusetts resulted in the items listed below. These are the most critical outputs for planning for shelter needs, anticipating bottlenecks and defining the timing requirements of an evacuation.

- Evacuating people and vehicle statistics by evacuation zone by storm category for each community;
- Shelter demand and capacity considerations by storm category for each community;
- Traffic volumes and critical roadway segments by storm category for each community;
- Estimated clearance times by response scenario for each community in Massachusetts.

6.10.1 Evacuating People and Vehicles

The transportation model distributes the evacuating vehicles and people generated by each evacuation scenario to three destinations. The destination types in the model are: to in-jurisdiction public shelters; to other refuges (internal hotels/motels, friends and family) within the originating community; and those leaving the community altogether. The evacuation statistics include scenarios for each level of storm intensity (Evacuation Zones A through C) as well as high and low tourist occupancy levels. Low tourist occupancy was assumed to be 30 percent and high was set at 90 percent.

Tables 6-24 through 6-41 shows how many residents and tourists are estimated to leave the vulnerability areas by storm intensity and low or high tourist occupancy level, as well as the number of evacuating vehicles. The tables also include the number of vehicles remaining in-county, as well as those leaving. Tables 6-42 and 6-43 provide a summarization of Tables 6-24 through 6-41 by county and zone. Whereas the county and statewide totals are for each zone within all county, the bottom line state sum are cumulated by all zones for all counties. Data for Boston and Cambridge, due to the unique storm categories compromising their evacuation zones are presented at the end of each table.

It must be noted that these figures may be higher than the actual number of people and vehicles that may evacuate during a real storm event. The assumed 100 percent participation rate used for the residents and visitors in the Evacuation Zone A, regardless of storm intensity, cause the bias in these evacuation statistics to favor a higher, rather than a lower, estimate. For the residents and visitors in each of the other storm tide vulnerability areas (Evacuation Zones B and C), the model also assumes a 100 percent participation rate for the corresponding storm category, again to assure that sufficient time is provided for everyone to safely leave the zone. Consequently, by design, these figures actually err on the side of public safety since it is usually



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better to have the planning expectations and the response measures exceed the actual impacts of an event, especially when lives are at stake.



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Table 6-24: Evacuating People and Vehicles – Low Occupancy – Barnstable County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Barnstable	13,572	13,572	6,384	6,384	1,624	383	4,760	6,001
	674	1,198	295	575	76	44	220	530
	6,039	12,050	2,748	5,482	908	414	1,840	5,068
Bourne	9,225	9,225	4,743	4,743	1,891	424	2,853	4,319
	466	1,073	263	635	104	60	159	575
	1,665	3,247	785	1,529	292	128	493	1,401
Brewster	466	466	245	245	70	16	175	229
	231	369	107	198	24	14	83	183
	2,499	4,997	1,076	2,152	242	116	834	2,036
Chatham	2,426	2,426	1,101	1,101	275	65	826	1,036
	308	545	163	334	47	27	116	306
	1,629	3,257	670	1,339	122	60	548	1,279
Dennis	11,114	11,114	5,441	5,441	1,600	371	3,841	5,071
	506	848	219	406	50	30	169	376
	2,032	3,985	885	1,728	237	107	648	1,621
Eastham	1,116	1,116	561	561	177	41	384	520
	624	1,024	261	470	56	33	206	437
	1,596	3,192	654	1,307	101	52	553	1,256
Falmouth	31,529	31,529	14,161	14,161	3,051	737	11,110	13,425
	1,552	3,270	780	1,760	272	158	508	1,602
	2,645	5,290	1,220	2,440	415	189	805	2,251
Harwich	3,884	3,884	2,167	2,167	692	159	1,475	2,008
	880	1,383	391	699	82	49	309	651
	1,688	3,361	748	1,488	222	102	526	1,386

1. Key: Zone A Zone B Inland (Non-Surge Areas)



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Table 6-24: Evacuating People and Vehicles – Low Occupancy – Barnstable County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Mashpee	4,824	4,824	2,755	2,755	912	208	1,843	2,546
	76	155	39	88	13	8	26	80
	1,768	3,484	803	1,580	280	125	523	1,455
Orleans	1,741	1,741	949	949	333	76	616	874
	204	354	89	169	22	13	67	156
	1,170	2,321	545	1,078	140	65	405	1,013
Provincetown	594	594	239	239	35	9	204	230
	3,060	4,382	1,179	1,812	163	98	1,016	1,714
	42	83	16	33	4	2	12	31
Sandwich	1,150	1,150	649	649	234	53	416	596
	940	1,788	467	984	142	83	325	901
	2,061	4,122	977	1,955	397	178	580	1,777
Truro	577	577	254	254	43	11	211	243
	378	481	145	201	13	8	132	193
	962	1,914	382	757	49	26	332	731
Wellfleet	3,328	3,328	1,828	1,828	581	133	1,247	1,695
	38	59	17	31	4	2	13	29
	971	1,890	405	779	76	34	329	744
Yarmouth	9,985	9,985	4,861	4,861	1,521	350	3,340	4,511
	2,545	4,864	1,160	2,402	341	199	819	2,203
	1,969	3,930	932	1,860	313	143	619	1,718
Totals	136,749	174,447	64,759	82,609	18,246	5,603	46,516	77,007

1. Key: Zone A Zone B Inland (Non-Surge Areas)



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Table 6-25: Evacuating People and Vehicles – High Occupancy – Barnstable County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Barnstable	18,994	18,994	8,281	8,281	1,643	402	6,639	7,880
	1,417	2,024	556	864	78	47	477	816
	10,310	20,593	4,243	8,472	923	444	3,320	8,028
Bourne	12,393	12,393	5,852	5,852	1,902	436	3,950	5,416
	652	1,279	328	708	105	61	223	647
	2,461	4,839	1,064	2,086	295	133	769	1,952
Brewster	983	983	426	426	72	18	354	408
	541	714	216	318	25	16	190	303
	5,641	11,282	2,176	4,351	253	138	1,922	4,213
Chatham	5,288	5,288	2,102	2,102	285	75	1,817	2,027
	650	925	283	467	48	29	235	438
	3,963	7,926	1,487	2,973	130	77	1,357	2,897
Dennis	22,135	22,135	9,298	9,298	1,638	409	7,660	8,889
	1,135	1,547	439	650	52	32	387	618
	4,128	8,176	1,618	3,195	244	121	1,374	3,073
Eastham	2,091	2,091	902	902	181	44	722	858
	1,427	1,916	542	782	58	36	484	746
	4,102	8,205	1,531	3,062	110	69	1,421	2,993
Falmouth	41,149	41,149	17,528	17,528	3,085	770	14,443	16,758
	2,579	4,411	1,139	2,160	275	162	864	1,998
	4,390	8,780	1,831	3,662	421	201	1,410	3,460
Harwich	7,562	7,562	3,454	3,454	705	172	2,749	3,282
	2,097	2,735	817	1,172	86	53	730	1,119
	3,172	6,330	1,267	2,527	227	112	1,040	2,415

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-25: Evacuating People and Vehicles – Low Occupancy – Barnstable County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Mashpee	9,081	9,081	4,245	4,245	927	223	3,318	4,021
	131	217	59	109	14	8	45	101
	2,823	5,595	1,172	2,319	284	132	888	2,187
Orleans	2,964	2,964	1,377	1,377	337	80	1,040	1,297
	442	618	172	261	22	14	149	247
	2,533	5,047	1,022	2,032	145	74	877	1,957
Provincetown	1,536	1,536	569	569	38	12	531	557
	7,836	9,688	2,851	3,669	180	116	2,671	3,552
	83	167	31	62	4	2	27	60
Sandwich	1,912	1,912	916	916	236	56	680	860
	1,822	2,768	776	1,327	145	86	630	1,241
	2,613	5,227	1,171	2,341	399	182	772	2,160
Truro	1,506	1,506	579	579	46	14	533	565
	1,052	1,230	381	463	16	11	365	452
	2,552	5,094	938	1,870	55	37	883	1,833
Wellfleet	6,466	6,466	2,926	2,926	592	144	2,334	2,782
	91	118	36	51	4	2	32	49
	2,350	4,648	887	1,744	81	44	807	1,700
Yarmouth	18,645	18,645	7,892	7,892	1,551	380	6,341	7,512
	4,901	7,482	1,985	3,318	349	208	1,636	3,110
	3,349	6,692	1,415	2,827	318	152	1,097	2,675
Totals	233,948	298,978	98,780	126,189	18,584	6,034	80,193	120,152

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-26: Evacuating People and Vehicles – Low Occupancy – Bristol County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Acushnet	0	0	0	0	0	0	0	0
	326	1,119	178	612	80	245	98	367
	661	1,624	346	849	154	337	191	512
Berkley	673	1,085	385	623	247	402	138	221
	6	28	3	15	2	9	1	5
	74	510	36	247	23	160	13	87
Dartmouth	3,389	3,389	2,205	2,205	922	820	1,283	1,385
	43	154	27	98	12	39	15	59
	1,702	3,367	723	1,430	314	552	408	877
Dighton	384	618	240	388	154	250	86	137
	17	84	9	44	6	29	3	16
	77	616	39	314	24	202	15	113
Fairhaven	3,205	3,205	1,973	1,973	830	738	1,143	1,235
	1,304	4,657	680	2,443	301	972	379	1,471
	285	790	137	380	60	150	77	231
Fall River	1,392	1,392	656	656	424	424	232	232
	187	684	101	369	65	240	35	129
	4,444	13,169	1,732	5,134	1,108	3,303	623	1,831
Freetown	483	779	298	482	192	312	106	171
	0	0	0	0	0	0	0	0
	98	814	48	427	27	268	22	159
New Bedford	861	861	407	407	183	162	225	245
	3,605	13,169	1,247	4,556	558	1,820	689	2,737
	3,620	10,712	1,396	4,132	622	1,642	774	2,490

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-26: Evacuating People and Vehicles – Low Occupancy – Bristol County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Raynham	160	259	81	132	36	53	45	79
	61	92	22	37	2	6	21	30
	722	2,228	332	1,039	134	389	198	650
Rehoboth	201	327	141	229	91	148	49	80
	17	83	11	55	7	35	4	19
	120	1,107	64	606	39	389	25	217
Seekonk	188	246	85	118	24	34	61	84
	9	44	5	24	2	10	3	15
	843	1,676	423	841	168	296	255	544
Somerset	1,180	1,849	718	1,143	442	718	276	424
	18	89	9	42	5	27	3	15
	792	1,577	404	805	258	515	146	290
Swansea	2,825	2,825	1,856	1,856	831	739	1,025	1,117
	321	1,168	186	681	83	272	103	409
	561	1,673	316	945	141	375	175	569
Taunton	1,294	2,103	677	1,100	440	715	237	385
	71	345	33	161	21	104	12	57
	1,479	6,629	665	3,007	412	1,913	253	1,093
Westport	1,415	1,415	880	880	343	305	538	576
	58	179	32	107	12	41	20	66
	955	2,613	489	1,373	185	487	304	886
Totals	40,126	91,353	20,295	42,965	9,984	20,647	10,309	22,315

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-27: Evacuating People and Vehicles – High Occupancy – Bristol County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Acushnet	0	0	0	0	0	0	0	0
	329	1,122	179	613	80	245	99	369
	678	1,658	352	861	154	337	197	524
Berkley	702	1,114	395	633	247	402	148	231
	8	30	4	15	2	9	2	6
	75	512	36	248	23	160	13	87
Dartmouth	4,298	4,298	2,524	2,524	926	823	1,598	1,700
	46	157	28	99	12	39	16	60
	1,845	3,652	773	1,529	315	553	458	976
Dighton	400	634	245	393	154	250	91	143
	19	86	10	45	6	29	4	16
	89	639	43	322	24	202	19	121
Fairhaven	3,954	3,954	2,235	2,235	833	741	1,402	1,494
	1,371	4,731	703	2,469	301	972	402	1,497
	303	824	143	392	60	150	83	242
Fall River	1,410	1,410	662	662	424	424	238	238
	189	685	101	370	65	240	36	130
	4,598	13,476	1,785	5,242	1,109	3,304	677	1,938
Freetown	499	795	304	488	192	312	112	176
	0	0	0	0	0	0	0	0
	138	896	63	455	27	269	36	187
New Bedford	872	872	411	411	183	162	229	249
	3,644	13,212	1,261	4,571	558	1,820	702	2,752
	3,700	10,874	1,424	4,189	622	1,642	802	2,546

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-27: Evacuating People and Vehicles – High Occupancy – Bristol County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Raynham	160	259	81	132	36	53	45	79
	171	214	61	80	2	7	59	73
	919	2,623	401	1,177	135	390	266	787
Rehoboth	203	329	141	229	91	148	50	81
	19	84	12	55	7	35	5	20
	144	1,154	72	622	39	389	33	234
Seekonk	377	435	151	184	24	35	127	149
	9	44	5	24	2	10	3	15
	1,136	2,261	526	1,046	169	298	357	747
Somerset	1,398	2,067	794	1,219	443	719	351	500
	20	91	9	43	5	27	4	16
	829	1,652	417	831	259	515	158	316
Swansea	2,878	2,878	1,874	1,874	831	739	1,043	1,135
	327	1,175	189	683	83	272	105	411
	579	1,709	322	957	141	376	181	582
Taunton	1,294	2,103	677	1,100	440	715	237	385
	76	351	34	162	21	104	14	59
	1,663	6,996	730	3,135	413	1,914	317	1,221
Westport	2,113	2,113	1,124	1,124	345	307	780	817
	84	208	41	117	13	41	29	76
	1,410	3,523	648	1,691	187	490	461	1,201
Totals	44,976	97,900	21,990	45,251	10,003	20,669	11,989	24,586

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-28: Evacuating People and Vehicles – Low Occupancy – Dukes County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Aquinnah	136	136	59	59	21	17	38	42
	0	0	0	0	0	0	0	0
	135	269	53	105	15	24	38	81
Chilmark	479	479	202	202	76	62	127	140
	80	114	31	48	8	18	23	31
	412	817	159	315	41	64	118	251
Edgartown	1,416	1,416	398	398	62	49	336	349
	662	856	221	271	18	34	203	237
	1,122	2,243	394	789	108	175	287	614
Oak Bluffs	1,463	1,463	640	640	340	281	300	359
	578	843	226	352	75	143	152	209
	820	1,627	314	622	140	226	174	396
Tisbury	846	846	429	429	267	222	162	208
	11	14	4	5	0	1	3	4
	839	1,661	341	674	167	270	174	405
West Tisbury	333	333	174	174	121	101	53	74
	60	97	26	46	11	23	15	23
	647	1,273	260	510	125	200	135	311
Totals	10,039	14,487	3,931	5,639	1,595	1,910	2,338	3,734

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-29: Evacuating People and Vehicles – High Occupancy – Dukes County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Aquinnah	341	341	131	131	22	17	109	114
	0	0	0	0	0	0	0	0
	343	685	125	250	16	24	110	226
Chilmark	1,163	1,163	442	442	78	62	364	380
	207	255	76	98	9	18	67	80
	1,069	2,131	389	775	43	64	346	711
Edgartown	3,317	3,317	1,063	1,063	69	49	994	1,014
	1,823	2,147	627	722	22	34	605	689
	2,709	5,418	950	1,900	113	175	837	1,725
Oak Bluffs	2,977	2,977	1,170	1,170	346	281	824	889
	1,405	1,763	516	674	78	143	438	531
	1,735	3,457	634	1,263	143	226	491	1,037
Tisbury	1,611	1,611	697	697	270	222	427	476
	30	36	11	12	0	1	10	12
	1,738	3,459	656	1,304	170	270	486	1,034
West Tisbury	562	562	254	254	122	101	132	154
	139	185	53	77	11	23	42	54
	1,345	2,668	504	998	128	200	376	799
Totals	22,514	32,175	8,298	11,830	1,640	1,910	6,658	9,925

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-30: Evacuating People and Vehicles – Low Occupancy – Essex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Beverly	2,898	2,898	1,612	1,612	720	640	892	972
	442	1,615	178	651	80	260	98	391
	1,821	5,342	810	2,383	351	930	459	1,453
Danvers	3,668	3,668	2,087	2,087	920	818	1,167	1,270
	426	1,293	206	662	77	249	129	413
	1,801	4,542	802	2,058	284	687	518	1,371
Essex	1,285	1,285	801	801	342	304	460	498
	17	64	9	34	4	14	5	20
	124	361	64	189	27	73	37	116
Gloucester	7,889	7,889	4,748	4,748	2,013	1,790	2,735	2,958
	360	1,182	153	513	61	197	92	316
	1,326	3,635	580	1,617	214	563	366	1,054
Ipswich	3,424	3,424	2,070	2,070	901	801	1,169	1,269
	218	779	108	390	47	155	61	235
	473	1,383	247	728	105	281	141	447
Lynn	12,738	12,738	4,637	4,637	2,084	1,853	2,553	2,785
	1,169	4,280	377	1,380	169	552	208	828
	3,586	10,667	1,189	3,535	531	1,407	657	2,127
Manchester	1,129	1,129	725	725	317	282	408	443
	85	293	51	180	22	71	29	109
	201	581	96	279	40	106	56	173
Marblehead	3,388	3,388	1,933	1,933	848	754	1,085	1,179
	106	382	62	224	27	89	35	135
	929	2,634	436	1,244	184	476	252	767

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-30: Evacuating People and Vehicles – Low Occupancy – Essex County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Nahant	3,491	3,491	2,133	2,133	951	845	1,182	1,288
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
Newbury	3,233	3,233	2,157	2,157	937	833	1,220	1,324
	147	526	74	268	33	107	42	162
	142	422	74	219	33	87	41	133
Newburyport	2,309	2,309	1,423	1,423	621	552	802	871
	108	383	68	245	30	97	38	148
	810	2,355	392	1,150	165	439	227	710
Peabody	1,437	1,437	715	715	322	286	393	429
	164	599	97	354	43	141	53	212
	3,767	9,511	1,731	4,395	722	1,656	1,009	2,738
Rockport	1,047	1,047	608	608	214	190	394	417
	0	0	0	0	0	0	0	0
	609	1,537	266	697	75	200	191	497
Rowley	391	391	218	218	96	85	122	133
	18	66	10	35	4	14	5	21
	276	823	145	434	65	172	81	262
Salem	18,700	18,700	7,913	7,913	3,544	3,150	4,369	4,763
	1,026	3,420	461	1,569	187	607	274	962
	898	2,665	377	1,120	165	440	212	680
Salisbury	5,552	5,552	3,321	3,321	1,388	1,234	1,933	2,087
	48	173	24	88	11	35	13	53
	358	797	171	382	76	152	95	230

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-30: Evacuating People and Vehicles – Low Occupancy – Essex County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Saugus	4,339	4,339	2,481	2,481	1,116	992	1,365	1,489
	269	984	146	534	66	214	81	321
	1,322	3,633	635	1,762	261	661	374	1,101
Swampscott	1,901	1,901	1,235	1,235	552	491	683	744
	167	610	74	271	33	108	41	163
	574	1,692	260	771	113	300	148	471
Totals	102,606	148,048	51,190	71,178	22,191	27,440	29,000	43,738

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-31: Evacuating People and Vehicles – High Occupancy – Essex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Beverly	2,967	2,967	1,636	1,636	720	640	916	996
	447	1,620	180	653	80	260	100	393
	1,993	5,686	870	2,503	352	931	518	1,572
Danvers	3,920	3,920	2,176	2,176	921	819	1,255	1,357
	635	1,526	279	744	77	250	202	494
	2,800	6,541	1,152	2,758	288	694	865	2,064
Essex	1,530	1,530	887	887	343	305	545	582
	17	64	9	34	4	14	5	20
	145	403	72	204	27	73	44	131
Gloucester	9,489	9,489	5,308	5,308	2,019	1,796	3,289	3,513
	468	1,302	191	555	61	197	130	357
	1,939	4,862	795	2,046	216	567	579	1,479
Ipswich	3,825	3,825	2,211	2,211	902	802	1,308	1,408
	235	797	114	396	48	155	67	241
	547	1,530	273	779	106	282	167	498
Lynn	12,773	12,773	4,649	4,649	2,084	1,853	2,565	2,797
	1,174	4,285	379	1,382	169	552	209	830
	3,634	10,763	1,205	3,568	531	1,408	674	2,161
Manchester	1,247	1,247	766	766	317	282	449	484
	98	308	55	185	22	71	33	114
	242	665	110	309	40	106	70	202
Marblehead	3,670	3,670	2,032	2,032	849	755	1,183	1,277
	113	389	64	227	27	89	37	137
	1,083	2,942	490	1,352	185	478	305	874

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-31: Evacuating People and Vehicles – High Occupancy – Essex County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Nahant	3,608	3,608	2,174	2,174	951	845	1,223	1,328
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
Newbury	3,666	3,666	2,309	2,309	939	835	1,370	1,474
	157	537	78	272	33	107	45	166
	149	437	76	225	33	87	44	138
Newburyport	2,558	2,558	1,510	1,510	622	553	888	957
	120	395	72	249	30	97	42	152
	960	2,656	445	1,255	165	440	279	814
Peabody	1,437	1,437	715	715	322	286	393	429
	165	600	97	354	43	141	54	213
	4,511	10,999	1,992	4,915	724	1,662	1,267	3,254
Rockport	1,819	1,819	878	878	217	193	661	685
	0	0	0	0	0	0	0	0
	1,189	2,697	469	1,103	77	204	392	899
Rowley	419	419	228	228	96	86	132	142
	18	66	10	35	4	14	5	21
	287	845	149	442	65	172	85	270
Salem	18,923	18,923	7,991	7,991	3,545	3,151	4,446	4,840
	1,294	3,718	554	1,674	188	608	367	1,065
	955	2,780	397	1,160	165	440	231	720
Salisbury	6,937	6,937	3,805	3,805	1,392	1,239	2,413	2,567
	49	174	25	88	11	35	14	53
	367	816	175	388	76	152	98	237

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-31: Evacuating People and Vehicles – High Occupancy – Essex County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Saugus	4,343	4,343	2,482	2,482	1,116	992	1,366	1,490
	273	988	147	536	66	214	82	322
	1,641	4,271	746	1,985	262	663	484	1,322
Swampscott	1,946	1,946	1,251	1,251	552	491	698	760
	171	613	76	273	33	108	42	164
	634	1,811	281	813	113	301	169	512
Totals	113,587	163,163	55,035	76,470	22,228	27,495	32,805	48,975

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-32: Evacuating People and Vehicles – Low Occupancy – Middlesex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Arlington	7,799	7,799	3,972	3,972	2,558	2,558	1,415	1,415
	649	2,364	299	1,091	193	708	106	383
	1,604	4,771	710	2,113	455	1,360	255	753
Belmont	2,392	2,392	1,408	1,408	914	914	494	494
	202	734	96	348	62	226	34	123
	1,100	3,255	475	1,406	303	902	172	504
Everett	7,580	7,580	2,867	2,867	1,289	1,146	1,578	1,721
	150	549	53	194	24	77	29	116
	1,703	5,072	578	1,720	259	686	319	1,034
Malden	21,458	21,458	8,407	8,407	5,451	5,451	2,956	2,956
	875	3,198	306	1,118	198	726	108	392
	1,710	5,024	587	1,724	380	1,117	207	607
Medford	28,794	28,794	14,128	14,128	9,143	9,143	4,985	4,985
	1,246	4,549	581	2,125	376	1,379	205	746
	1,016	3,010	388	1,151	250	743	139	408
Newton	559	559	287	287	186	186	101	101
	534	1,947	261	951	168	617	92	334
	4,683	13,459	1,935	5,596	1,138	3,397	798	2,199
Somerville	14,820	14,820	8,930	8,930	3,969	3,528	4,961	5,402
	2,299	8,398	836	3,055	374	1,220	462	1,835
	2,319	6,936	788	2,356	351	936	437	1,419
Waltham	147	147	73	73	47	47	25	25
	241	869	105	380	67	246	38	134
	3,616	10,199	1,476	4,198	822	2,455	653	1,743

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-32: Evacuating People and Vehicles – Low Occupancy – Middlesex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Watertown	1,869	1,869	1,096	1,096	710	710	386	386
	1,127	4,098	540	1,967	348	1,275	192	692
	1,170	3,495	533	1,594	343	1,029	190	565
Winchester	233	233	129	129	84	84	45	45
	267	955	142	511	90	330	52	181
	1,008	3,000	448	1,335	286	857	162	479
Totals	113,170	171,533	52,434	76,230	30,838	44,053	21,596	32,177

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane
Cambridge	3,613	3,613	3,613	1,894	1,894	1,894	835	742	742	1,059	1,152	1,152
	2,443	80,537	80,849	850	27,713	27,822	142	10,702	10,702	707	17,011	17,119
	239	38,914	43,826	84	11,441	12,888	1	4,524	5,090	83	6,917	7,798
	20	307	1,374	7	144	663	0	52	260	7	92	403
Cambridge Totals	6,315	123,371	129,662	2,835	41,192	43,267	978	16,020	16,794	1,856	25,172	26,472

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-33: Evacuating People and Vehicles – High Occupancy – Middlesex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Arlington	8,015	8,015	4,048	4,048	2,558	2,558	1,490	1,490
	660	2,377	303	1,096	193	708	110	388
	1,665	4,891	731	2,155	455	1,361	276	795
Belmont	2,403	2,403	1,412	1,412	914	914	498	498
	209	741	98	351	62	226	37	125
	1,152	3,359	493	1,442	303	903	190	540
Everett	7,595	7,595	2,872	2,872	1,289	1,146	1,583	1,726
	152	551	54	194	24	77	30	117
	1,717	5,099	582	1,729	259	686	323	1,043
Malden	21,577	21,577	8,448	8,448	5,451	5,451	2,997	2,997
	883	3,207	309	1,121	198	726	111	396
	1,726	5,057	592	1,735	380	1,117	213	618
Medford	29,153	29,153	14,253	14,253	9,144	9,144	5,109	5,109
	1,263	4,567	587	2,131	376	1,379	211	752
	1,039	3,057	396	1,167	250	743	147	424
Newton	561	561	287	287	186	186	101	101
	544	1,957	264	955	168	617	96	338
	5,757	15,606	2,311	6,347	1,142	3,404	1,170	2,943
Somerville	15,465	15,465	9,155	9,155	3,971	3,530	5,184	5,625
	2,324	8,425	845	3,065	375	1,220	470	1,845
	2,362	7,022	803	2,386	351	937	451	1,449
Waltham	147	147	73	73	47	47	25	25
	252	882	109	385	67	246	42	139
	4,838	12,644	1,904	5,053	827	2,463	1,077	2,590

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-33: Evacuating People and Vehicles – High Occupancy – Middlesex County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Watertown	1,893	1,893	1,104	1,104	710	710	395	395
	1,155	4,129	550	1,978	348	1,275	202	703
	1,200	3,555	544	1,615	343	1,029	200	585
Winchester	233	233	129	129	84	84	45	45
	285	975	148	518	90	330	58	188
	1,059	3,100	466	1,370	286	857	180	513
Totals	117,284	178,243	53,870	78,574	30,851	44,074	23,021	34,502

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane
Cambridge	3,840	3,840	3,840	1,973	1,973	1,973	835	743	743	1,138	1,230	1,230
	5,561	86,150	87,086	1,941	29,677	30,005	153	10,722	10,725	1,788	18,956	19,280
	718	39,680	44,784	251	11,709	13,223	3	4,527	5,093	249	7,182	8,130
	60	386	1,454	21	172	691	0	52	260	21	119	431
Cambridge Totals	10,179	130,056	137,164	4,186	43,531	45,892	991	16,044	16,821	3,196	27,487	29,071

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-34: Evacuating People and Vehicles – Low Occupancy – Nantucket County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Nantucket	2,574	2,574	1,143	1,143	450	369	694	774
	784	1,141	297	457	80	167	217	290
	2,983	5,914	1,159	2,293	429	686	730	1,608
Totals	6,341	9,629	2,599	3,893	959	1,222	1,641	2,672

1. Key: Zone A Zone B Inland (Non-Surge Areas)

Table 6-35: Evacuating People and Vehicles – High Occupancy – Nantucket County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Nantucket	6,292	6,292	2,445	2,445	463	369	1,982	2,075
	1,986	2,477	717	924	84	167	633	757
	6,924	13,796	2,538	5,052	443	686	2,095	4,367
Totals	15,202	22,565	5,700	8,421	990	1,222	4,710	7,199

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-36: Evacuating People and Vehicles – Low Occupancy – Norfolk County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Braintree	1,361	1,361	619	619	278	247	340	371
	64	235	28	104	13	41	16	62
	1,824	5,362	811	2,393	348	927	463	1,466
Brookline	3,661	3,661	1,243	1,243	552	490	692	753
	536	4,275	176	1,367	53	514	123	853
	608	7,612	209	2,605	79	989	130	1,616
Cohasset	2,316	2,316	1,481	1,481	659	586	822	895
	0	0	0	0	0	0	0	0
	336	936	168	469	73	184	95	286
Milton	642	642	358	358	161	143	197	215
	49	538	25	278	11	111	14	167
	268	3,874	110	1,603	48	634	63	969
Quincy	42,780	42,780	18,768	18,768	8,414	7,479	10,354	11,288
	1,125	4,100	441	1,608	197	642	244	966
	2,426	6,975	997	2,883	406	1,077	591	1,806
Weymouth	9,445	9,445	5,070	5,070	2,276	2,023	2,794	3,047
	93	339	53	194	24	78	29	116
	2,412	6,966	1,108	3,205	491	1,269	617	1,936
Totals	69,946	101,417	31,665	44,248	14,083	17,434	17,584	26,812

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-37: Evacuating People and Vehicles – High Occupancy – Norfolk County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Braintree	1,363	1,363	619	619	278	247	341	372
	64	235	28	104	13	41	16	62
	2,047	5,807	889	2,549	348	928	540	1,621
Brookline	3,762	3,762	1,279	1,279	552	491	726	788
	875	4,759	295	1,537	54	516	240	1,021
	803	8,391	277	2,878	80	991	197	1,886
Cohasset	2,411	2,411	1,514	1,514	660	586	855	928
	0	0	0	0	0	0	0	0
	367	996	179	490	73	184	105	307
Milton	642	642	358	358	161	143	197	215
	51	540	26	278	11	111	15	167
	294	3,978	119	1,640	48	635	72	1,005
Quincy	43,189	43,189	18,911	18,911	8,415	7,481	10,496	11,430
	1,145	4,122	448	1,616	197	642	251	974
	2,985	8,093	1,193	3,275	407	1,081	785	2,194
Weymouth	9,513	9,513	5,094	5,094	2,277	2,024	2,817	3,070
	93	339	53	194	24	78	29	116
	2,508	7,159	1,142	3,273	491	1,270	650	2,003
Totals	72,112	105,299	32,424	45,609	14,089	17,449	18,332	28,159

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-38: Evacuating People and Vehicles – Low Occupancy – Plymouth County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Duxbury	2,914	2,914	1,732	1,732	746	663	986	1,069
	21	75	11	41	5	16	6	25
	660	1,935	331	977	142	378	189	599
Hingham	4,676	4,676	2,536	2,536	1,138	1,011	1,398	1,524
	430	1,539	254	918	112	365	142	553
	823	2,368	386	1,113	169	437	217	676
Hull	11,122	11,122	6,095	6,095	2,618	2,327	3,478	3,768
	2	6	1	2	0	1	0	1
	0	0	0	0	0	0	0	0
Kingston	1,836	1,836	1,210	1,210	531	472	678	737
	0	0	0	0	0	0	0	0
	896	2,171	440	1,067	196	423	244	645
Marion	4,409	4,409	2,718	2,718	1,166	1,037	1,552	1,682
	138	467	64	221	26	86	37	135
	3	9	1	4	1	2	1	3
Marshfield	15,375	15,375	8,662	8,662	3,753	3,336	4,910	5,326
	22	80	12	45	6	18	7	27
	594	1,733	311	909	136	358	174	551
Mattapoissett	3,282	3,282	1,945	1,945	798	709	1,147	1,236
	153	545	77	278	34	110	44	168
	150	415	69	196	26	69	43	126
Plymouth	3,138	3,138	1,845	1,845	707	629	1,138	1,217
	508	1,516	261	834	96	313	164	521
	4,403	10,987	2,020	5,104	764	1,785	1,256	3,319

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-38: Evacuating People and Vehicles – Low Occupancy – Plymouth County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Rochester	39	64	30	49	20	32	11	17
	30	132	18	83	11	53	7	30
	54	483	29	271	17	173	12	98
Scituate	6,901	6,901	3,978	3,978	1,683	1,496	2,295	2,481
	0	0	0	0	0	0	0	0
	715	1,993	346	969	148	375	197	594
Wareham	18,888	18,888	10,382	10,382	4,363	3,879	6,019	6,503
	25	88	13	45	5	18	7	27
	939	1,915	465	949	197	359	268	591
Totals	83,146	101,062	46,242	55,178	19,614	20,930	26,627	34,249

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-39: Evacuating People and Vehicles – High Occupancy – Plymouth County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Duxbury	3,351	3,351	1,885	1,885	747	664	1,138	1,221
	23	77	12	42	5	16	7	25
	750	2,115	363	1,040	142	379	220	661
Hingham	4,719	4,719	2,551	2,551	1,138	1,011	1,413	1,539
	461	1,573	265	930	112	365	153	565
	886	2,493	408	1,157	169	437	239	720
Hull	12,751	12,751	6,666	6,666	2,623	2,333	4,042	4,333
	2	6	1	2	0	1	0	1
	0	0	0	0	0	0	0	0
Kingston	2,006	2,006	1,269	1,269	532	473	737	796
	0	0	0	0	0	0	0	0
	928	2,234	451	1,089	196	423	255	667
Marion	5,153	5,153	2,979	2,979	1,169	1,039	1,810	1,940
	167	499	74	232	27	86	47	146
	3	9	1	4	1	2	1	3
Marshfield	17,262	17,262	9,323	9,323	3,759	3,343	5,563	5,980
	22	80	12	45	6	18	7	27
	637	1,818	325	939	137	358	189	581
Mattapoissett	4,288	4,288	2,297	2,297	801	713	1,496	1,584
	166	559	82	283	34	110	48	173
	216	548	92	242	26	70	66	172
Plymouth	4,741	4,741	2,406	2,406	713	634	1,694	1,772
	779	1,817	355	940	97	314	258	625
	6,284	14,748	2,678	6,421	771	1,798	1,907	4,623

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-39: Evacuating People and Vehicles – High Occupancy – Plymouth County (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Rochester	39	64	30	49	20	32	11	17
	38	141	21	86	11	53	10	33
	67	510	34	280	17	173	16	107
Scituate	8,291	8,291	4,464	4,464	1,688	1,501	2,776	2,963
	0	0	0	0	0	0	0	0
	807	2,177	378	1,033	149	376	229	658
Wareham	22,900	22,900	11,786	11,786	4,377	3,893	7,409	7,893
	28	92	14	46	5	18	8	29
	1,095	2,226	520	1,058	198	360	322	699
Totals	98,860	119,248	51,742	61,544	19,670	20,993	32,071	40,553

1. Key: Zone A Zone B Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-40: Evacuating People and Vehicles – Low Occupancy – Suffolk County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Chelsea	24,634	24,634	7,450	7,450	3,332	2,962	4,118	4,488
	209	2,280	55	594	24	237	30	357
	56	835	14	203	6	81	7	123
Revere	24,878	24,878	13,944	13,944	6,230	5,538	7,714	8,406
	627	6,830	201	2,190	89	874	112	1,316
	181	2,440	54	732	24	289	30	443
Winthrop	17,597	17,597	9,185	9,185	4,124	3,666	5,061	5,519
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
Totals	68,182	79,494	30,903	34,298	13,829	13,647	17,072	20,652

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane
Boston	36,563	36,563	36,563	16,839	16,839	16,839	7,460	6,631	6,631	9,379	10,208	10,208
	13,333	170,397	188,370	4,707	72,887	80,824	1,803	28,597	31,772	2,904	44,291	49,053
	4,640	15,948	211,992	1,079	3,418	48,941	479	1,067	18,975	600	2,351	29,966
	3,598	7,213	17,574	1,494	2,991	7,213	672	1,195	2,863	822	1,796	4,350
Boston Totals	58,134	230,121	454,499	24,119	96,135	153,817	10,414	37,490	60,241	13,705	58,646	93,577

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



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Table 6-41: Evacuating People and Vehicles – High Occupancy – Suffolk County

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane	Cat 1 & 2 Hurricane	Cat 3 & 4 Hurricane
Chelsea	24,900	24,900	7,543	7,543	3,333	2,963	4,210	4,580
	212	2,287	56	597	24	237	32	359
	56	844	14	207	6	81	8	126
Revere	25,458	25,458	14,147	14,147	6,232	5,540	7,915	8,607
	642	6,861	207	2,201	89	874	117	1,327
	184	2,498	55	752	24	289	31	463
Winthrop	17,718	17,718	9,227	9,227	4,124	3,666	5,103	5,561
	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0
Totals	69,170	80,566	31,249	34,674	13,832	13,650	17,416	21,023

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane
Boston	39,771	39,771	39,771	17,374	17,374	17,374	7,465	6,637	6,637	9,908	10,737	10,737
	21,920	187,573	205,546	6,138	75,750	83,687	1,818	28,625	31,800	4,321	47,125	51,887
	4,825	25,200	230,496	1,109	4,960	52,025	479	1,082	19,006	631	3,878	33,019
	3,598	7,247	18,260	1,494	2,997	7,328	672	1,195	2,864	822	1,801	4,463
Boston Totals	70,114	259,791	494,073	26,115	101,081	160,414	10,434	37,539	60,307	15,682	63,541	100,106

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-42: Summary of Evacuating People and Vehicles – Low Occupancy

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Barnstable	95,531	95,531	46,338	46,338	13,039	3,036	33,301	43,304
	12,482	21,793	5,575	10,764	1,409	826	4,168	9,936
	28,736	57,123	12,846	25,507	3,798	1,741	9,047	23,767
Bristol	17,650	20,353	10,602	12,192	5,159	5,820	5,444	6,371
	6,043	21,895	2,543	9,244	1,156	3,849	1,386	5,395
	16,433	49,105	7,150	21,529	3,669	10,978	3,479	10,549
Dukes	4,673	4,673	1,902	1,902	887	732	1,016	1,172
	1,391	1,924	508	722	112	219	396	504
	3,975	7,890	1,521	3,015	596	959	926	2,058
Essex	78,819	78,819	40,817	40,817	17,886	15,900	22,932	24,919
	4,770	16,649	2,098	7,398	894	2,910	1,204	4,489
	19,017	52,580	8,275	22,963	3,411	8,630	4,864	14,330
Middlesex	85,651	85,651	41,297	41,297	24,351	23,767	16,946	17,530
	7,590	27,661	3,219	11,740	1,900	6,804	1,318	4,936
	19,929	58,221	7,918	23,193	4,587	13,482	3,332	9,711
Nantucket	4,673	4,673	1,902	887	1,016	1,172	4,673	1,902
	1,391	1,924	722	112	396	504	1,924	508
	3,975	7,890	3,015	596	926	2,058	7,890	1,521
Norfolk	60,205	60,205	27,539	27,539	12,340	10,968	15,199	16,569
	1,867	9,487	723	3,551	298	1,386	426	2,164
	7,874	31,725	3,403	13,158	1,445	5,080	1,959	8,079
Plymouth	72,580	72,605	41,133	41,152	17,523	15,591	23,612	25,560
	1,329	4,448	711	2,467	295	980	414	1,487
	9,237	24,009	4,398	11,559	1,796	4,359	2,601	7,202

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-42: Summary of Evacuating People and Vehicles – Low Occupancy (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Suffolk	67,109	67,109	30,579	30,579	13,686	12,166	16,893	18,413
	836	9,110	256	2,784	113	1,111	142	1,673
	237	3,275	68	935	30	370	37	566
Totals	486,891	489,619	242,109	242,703	105,887	89,152	140,016	155,740
	37,699	114,891	16,355	48,782	6,573	18,589	11,378	31,092
	109,413	291,818	48,594	122,455	20,258	47,657	34,135	77,783
Overall Totals	634,003	896,328	307,058	413,940	132,718	155,398	185,529	264,615

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 (not worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (not worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (not worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (not worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane
Boston	36,563	36,563	36,563	16,839	16,839	16,839	7,460	6,631	6,631	9,379	10,208	10,208
	13,333	170,397	188,370	4,707	72,887	80,824	1,803	28,597	31,772	2,904	44,291	49,053
	4,640	15,948	211,992	1,079	3,418	48,941	479	1,067	18,975	600	2,351	29,966
	3,598	7,213	17,574	1,494	2,991	7,213	672	1,195	2,863	822	1,796	4,350
Boston Totals	58,134	230,121	454,499	24,119	96,135	153,817	10,414	37,490	60,241	13,705	58,646	93,577

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



6.0 Transportation Analysis

Table 6-42: Summary of Evacuating People and Vehicles – Low Occupancy (continued)

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane
Cambridge	3,613	3,613	3,613	1,894	1,894	1,894	835	742	742	1,059	1,152	1,152
	2,443	80,537	80,849	850	27,713	27,822	142	10,702	10,703	707	17,011	17,119
	239	38,914	43,826	84	11,441	12,888	1	4,524	5,090	83	6,917	7,798
	20	307	1,374	7	144	663	0	52	260	7	92	403
Cambridge Totals	6,315	123,371	129,662	2,835	41,192	43,267	978	16,020	16,795	1,856	25,172	26,472

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



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Table 6-43: Summary of Evacuating People and Vehicles – High Occupancy

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Barnstable	152,705	152,705	66,347	66,347	13,238	3,235	53,111	63,112
	26,773	37,672	10,580	16,319	1,457	881	9,118	15,437
	54,470	108,601	21,853	43,523	3,889	1,918	17,964	41,603
Bristol	20,558	23,261	11,618	13,208	5,169	5,830	6,451	7,377
	6,312	22,190	2,637	9,346	1,157	3,850	1,480	5,500
	18,106	52,449	7,735	22,697	3,677	10,989	4,058	11,709
Dukes	9,971	9,971	3,757	3,757	907	732	2,850	3,027
	3,604	4,386	1,283	1,583	120	219	1,162	1,366
	8,939	17,818	3,258	6,490	613	959	2,646	5,532
Essex	85,077	85,077	43,008	43,008	17,907	15,923	25,100	27,086
	5,434	17,382	2,330	7,657	896	2,912	1,434	4,742
	23,076	60,704	9,697	25,805	3,425	8,660	6,271	17,147
Middlesex	87,042	87,042	41,781	41,781	24,354	23,770	17,427	18,011
	7,727	27,811	3,267	11,794	1,901	6,804	1,367	4,991
	22,515	63,390	8,822	24,999	4,596	13,500	4,227	11,500
Nantucket	60,880	60,880	27,775	27,775	12,343	10,972	15,432	16,803
	2,228	9,995	850	3,729	299	1,388	551	2,340
	9,004	34,424	3,799	14,105	1,447	5,089	2,349	9,016
Norfolk	152,705	152,705	66,347	66,347	13,238	3,235	53,111	63,112
	26,773	37,672	10,580	16,319	1,457	881	9,118	15,437
	54,470	108,601	21,853	43,523	3,889	1,918	17,964	41,603
Plymouth	85,501	85,526	45,656	45,675	17,567	15,636	28,089	30,038
	1,686	4,844	836	2,606	297	981	538	1,624
	11,673	28,878	5,250	13,263	1,806	4,376	3,444	8,891

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



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Table 6-43: Summary of Evacuating People and Vehicles – High Occupancy (continued)

Evacuation Zones ¹	Evacuating People		Evacuating Vehicles		Evacuating Vehicles to In County Destinations		Evacuating Vehicles to Out of County Destinations	
	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Suffolk	68,076	68,076	30,917	30,917	13,689	12,169	17,228	18,748
	854	9,148	263	2,798	113	1,111	149	1,686
	240	3,342	69	959	30	370	39	589
Totals	722,515	725,243	337,206	338,815	118,412	91,502	218,799	247,314
	81,391	171,100	32,626	72,151	7,697	19,027	24,917	53,123
	202,493	478,207	82,336	195,364	23,372	47,779	58,962	147,590
Overall Totals	1,006,399	1,374,550	452,168	606,330	149,481	158,308	302,678	448,027

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane
Boston	39,771	39,771	39,771	17,374	17,374	17,374	7,465	6,637	6,637	9,908	10,737	10,737
	21,920	187,573	205,546	6,138	75,750	83,687	1,818	28,625	31,800	4,321	47,125	51,887
	4,825	25,200	230,496	1,109	4,960	52,025	479	1,082	19,006	631	3,878	33,019
	3,598	7,247	18,260	1,494	2,997	7,328	672	1,195	2,864	822	1,801	4,463
Boston Totals	70,114	259,791	494,073	26,115	101,081	160,414	10,434	37,539	60,307	15,682	63,541	100,106

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



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Table 6-43: Summary of Evacuating People and Vehicles – High Occupancy (continued)

Evacuation Zones ¹	Evacuating People			Evacuating Vehicles			Evacuating Vehicles to In County Destinations			Evacuating Vehicles to Out of County Destinations		
	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane
Cambridge	3,840	3,840	3,840	1,973	1,973	1,973	835	743	743	1,138	1,230	1,230
	5,561	86,150	87,086	1,941	29,677	30,005	153	10,722	10,725	1,788	18,956	19,280
	718	39,680	44,784	251	11,709	13,223	3	4,527	5,093	249	7,182	8,130
	60	386	1,454	21	172	691	0	52	260	21	119	431
Cambridge Totals	10,179	130,056	137,164	4,186	43,531	45,892	991	16,044	16,821	3,196	27,487	29,071

1. Key: Zone A Zone B Zone C Inland (Non-Surge Areas)



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6.10.2 Shelter Demand and Capacity Considerations

The potential public shelter lists provided in Chapter 5 in the TDR include the locations and capacities of those facilities. The opening and management of public shelters is an integral part of any evacuation operation, especially since mobile home residents typically have the highest propensity to use those facilities as their refuge location. For the Massachusetts study, shelter demand was determined using assumptions derived from data in the behavioral analysis.

Tables in Chapter 5 compares for A, B and C response scenarios the estimated public shelter demand with the available spaces in each jurisdiction to determine whether it has a surplus or deficit of spaces. The shelter locations and capacities provided in Chapter 5 were compiled by the USACE, New England District from data provided by state and the American Red Cross from the National Shelter System (NSS) database.

6.10.3 Traffic Volumes and Critical Roadway Segments

Once the evacuation statistics for each vulnerability area and evacuation zone have been developed and the departing vehicles distributed to the three major destinations mentioned above, the transportation model apportions the external trips to the routes that exit the jurisdiction. This allocation is particularly important because the vehicles leaving the community altogether will usually have to travel the furthest, over more segments than local trips, thereby increasing the likelihood that they will have to pass through one of the most congested segments identified in the model. These external trips will also spend more time traveling to their ultimate safe destination. In recognition of the relative difficulties associated with these out of jurisdiction vehicles, each evacuation sector is assigned a specific set of percentages that represent the proportion of those evacuating vehicles using each of the exiting routes. Although it is understood that a small number of evacuees will also take less obvious local roadways (those not specifically identified as evacuation routes) out of their communities, those number are very small and not significant in determining clearance times or any of the other transportation model results.

Table 6-44 displays the assumed percentage of all exiting vehicles on evacuation roadways leaving each community within the study region. The out route assumptions provided in Table 6-44 were derived from the behavioral data provided in the 2013 Behavioral Analysis. The specific per zone assignments can be found in the Massachusetts ATM which was developed to facilitate the ability of the emergency management and other local officials to update clearance times in an efficient manner.

Once the vehicle trips from each evacuation sector have been distributed according to the three destination categories, the model actually routes those vehicles from the start point of



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each evacuation sector to the three assumed safe objective points. The two types of internal trips and one external for every evacuation zone are assigned to the critical links, if warranted, and cumulated to provide a total number of evacuating vehicles for that key segment. Table 6-45 displays those figures for the most critical roadway segments by county and community. The volumes of traffic include both local and out of county movements for each response scenario and tourist occupancy scenario. The volumes shown also include vehicles that may be passing through coastal Massachusetts on their way out of the area.

The transportation model also factors in background traffic, namely those vehicles using the evacuation routes for purposes other than evacuating. These trips include travel associated with households procuring last minute supplies, individuals returning home to begin the evacuation process and other activities not at all related to the approaching storm. These background traffic figures were developed from peak hour, directional traffic counter data provided by Massachusetts Department of Transportation; and in that respect factor in the highest average number of vehicles observed on each modeled roadway regardless of circumstances. Depending on the time and day the evacuation order is issued (such as morning or afternoon rush hour), background congestion could prove to be a significant hindrance for those vehicles using the same road network to escape the impacts of a tropical cyclone threat.

The predicted traffic volume is based upon the specific behavioral assumptions employed in the transportation analysis. Assumptions regarding participation rates and tourist occupancy are the most critical. Since the Massachusetts area has very limited evacuation experience and since this analysis assumes full participation by the areas that should evacuate, actual volumes could be lower than the data presented in these tables. Many who should evacuate in lesser categories of hurricanes will underestimate the impact of a storm and will choose not to evacuate. However, clearance times calculated for this transportation analysis should allow for people to evacuate whether they choose to or not.



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Table 6-44: Out Route Initial Assignment Assumptions

County	Town	Critical Roadway Segment	Initial % Assignment
Barnstable County	Barnstable	MA 6A westbound	2%
		High St westbound	3%
		US 6 westbound	50%
		Newtown Rd northbound	5%
		MA 130 northbound	19%
		MA 28 westbound	16%
		School St westbound	5%
	Bourne	MA 3 northbound	5%
		MA 25 northbound	85%
		US 6/MA 28 westbound	10%
	Brewster	MA 137 southbound	20%
		MA 124 southbound	26%
		Satucket Rd westbound	50%
		MA 6A westbound	4%
	Chatham	Queen Anne Rd westbound	65%
		MA 28 westbound	35%
	Dennis	Airline Rd westbound	10%
		MA 6A westbound	10%
		US 6 westbound	55%
		MA 28 westbound	25%
	Eastham	US 6 westbound	100%
	Falmouth	MA 28A westbound	10%
		MA 28 westbound	90%
	Harwich	US 6 westbound	60%
		MA 28 westbound	40%
	Mashpee	MA 151 northbound	60%
		MA 130 westbound	35%
		Cotuit Rd northbound	5%
	Orleans	MA 6 westbound	5%
		US 6 westbound	85%
MA 28 eastbound		10%	
Provincetown	US 6 westbound	100%	



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Barnstable County (continued)	Sandwich	MA 6A westbound	40%
		US 6 westbound	60%
	Truro	US 6/MA 6A westbound	100%
	Wellfleet	US 6/MA 6A westbound	100%
	Yarmouth	MA 6A westbound	15%
		US 6 westbound	50%
		MA 28 westbound	35%
Bristol County	Acushnet	Slocum St westbound	35%
		Main St westbound	52%
		Peckham Rd westbound	5%
		MA 105 northbound	5%
		MA 105 southbound	1%
		Perry Hill Rd eastbound	2%
	Berkley	Elm St westbound	5%
		MA 24 eastbound	90%
		MA 79 northbound	5%
	Dartmouth	US 6 westbound	7%
		I-195 northbound	13%
		High Hill Rd northbound	5%
		I-195 southbound	2%
		Hathaway Rd eastbound	13%
		US 6 eastbound	45%
		Dartmouth St northbound	10%
		Cove Rd eastbound	5%
	Dighton	Cedar St westbound	1%
		US 44 westbound	5%
		US 44 eastbound	1%
		MA 138 eastbound	85%
		Center St eastbound	8%
	Fairhaven	US 6 westbound	30%
		I-195 northbound	50%
		Howland Rd westbound	2%
		Main St northbound	12%
		I-195 southbound	5%
		US 6 eastbound	1%



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Bristol County (continued)	Fall River	I-195 northbound	10%
		US 6 westbound	2%
		N Main St northbound	5%
		MA 24/79 eastbound/northbound	70%
		I-195 southbound	10%
		US 6 eastbound	3%
	Freetown	MA 24 eastbound	93%
		MA 79 northbound	5%
		MA 140 westbound	2%
	New Bedford	Hawthorne St westbound	1%
		US 6 westbound	3%
		Hathaway Rd westbound	1%
		I-195 northbound	10%
		MA 140 westbound	65%
		MA 18 westbound	8%
		Tarkiln Hill Rd eastbound	1%
		Wood St eastbound	2%
		Coggeshall St eastbound	2%
		I-195 southbound	6%
		US 6 eastbound	1%
	Raynham	US 44 westbound	20%
		I-495 northbound	30%
		MA 104 eastbound	2%
		MA 24 eastbound	40%
		Pleasant St eastbound	1%
		US 44 eastbound	7%
	Rehoboth	US 6 westbound	5%
		I-195 northbound	22%
		Prov St westbound	5%
		US 44 westbound	5%
		MA 118 westbound	5%
		MA 118 eastbound	5%
US 44 eastbound		28%	
I-195 southbound		25%	



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Bristol County (continued)	Seekonk	US 6 westbound	5%
		I-195 northbound	20%
		US 44 westbound	2%
		MA 15 northbound	1%
		MA 152 southbound	11%
		US 44 eastbound	35%
		County St eastbound	1%
		I-195 southbound	20%
		US 6 eastbound	5%
	Somerset	I-195 northbound	17%
		US 6 westbound	5%
		Read St northbound	2%
		Brayton Ave northbound	3%
		Buffington St westbound	1%
		MA 138 eastbound	7%
		US 6 eastbound	15%
		I-195 southbound	50%
	Swansea	US 6 westbound	5%
		I-195 northbound	23%
		Kingsley Wy northbound	2%
		MA 118 westbound	6%
		Hortonville Rd northbound	7%
		Sharps Lot Rd northbound	6%
		Elm St eastbound	1%
		US 6 eastbound	5%
		I-195 southbound	40%
		MA 103 southbound	5%
	Taunton	US 44 westbound	8%
		Tremont St westbound	2%
		MA 140 westbound	2%
		I-495 northbound	38%
		Bay St northbound	2%
		I-495 southbound	5%
MA 138 eastbound		3%	
US 44 eastbound		40%	



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Bristol County (continued)	Westport	MA 177 southbound	0%
		US 6 westbound	10%
		I-195 northbound	45%
		I-195 southbound	5%
		US 6 eastbound	15%
		Reed Rd eastbound	10%
		Old Country Rd eastbound	10%
		Hix Bridge Rd eastbound	2%
		E Beach Rd eastbound	3%
Dukes County	Aquinnah	Vineyard Haven Ferry	100%
	Chilmark	Vineyard Haven Ferry	100%
	Edgartown	Vineyard Haven Ferry	100%
	Oak Bluffs	Vineyard Haven Ferry	0%
		Oak Bluffs Ferry	100%
	Tisbury	Vineyard Haven Ferry	100%
	Westbury	Vineyard Haven Ferry	100%
Essex County	Beverly	MA 62 westbound	21%
		MA 128 westbound	69%
		MA 97 northbound	5%
		MA 1A northbound	5%
	Danvers	MA 128 westbound	45%
		I-95 southbound	7%
		US 1 southbound	5%
		MA 114 westbound	5%
		Dayton St northbound	1%
		MA 62 westbound	3%
		I-95 northbound	27%
		US 1 northbound	5%
		MA 35 northbound	2%
		Essex	Southern Ave southbound
	MA 22 westbound		15%
	Gloucester	MA 128 westbound	100%
	Ipswich	MA 1A southbound	55%
		Topsfield Rd westbound	5%
		US 1 southbound	10%
		US 1 northbound	10%
MA 1A northbound		20%	



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Essex County (continued)	Lynn	MA 1A southbound	5%
		MA 107 southbound	5%
		Boston St westbound	45%
		Walnut St westbound	30%
		MA 129 northbound	15%
	Manchester	MA 128 westbound	100%
	Marblehead	Vinnin St westbound	70%
		MA 114 westbound	30%
	Nahant	Nahant Rd northbound	100%
	Newbury	US 1 southbound	5%
		I-95 southbound	50%
		Moody St westbound	5%
		I-95 northbound	32%
		US 1 northbound	7%
		MA 1A northbound	1%
	Newburyport	US 1 southbound	3%
		Scotland Rd westbound	2%
		I-95 southbound	45%
		MA 113 southbound	10%
		I-95 northbound	33%
		US 1 northbound	7%
	Peabody	I-95 southbound	67%
		US 1 southbound	0%
		Lowell St westbound	5%
		Russell St westbound	5%
		MA 114 westbound	23%
	Rockport	Washington St northbound	30%
		Main St southbound	52%
		MA 127A southbound	18%
	Rowley	US 1 southbound	10%
		MA 133 westbound	55%
		Glen St westbound	25%
		US 1 northbound	10%
Salem	Boston St westbound	5%	
	MA 114 westbound	90%	
	MA 1A northbound	5%	



6.0 Transportation Analysis

Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Essex County (continued)	Salisbury	US 1 southbound	5%
		I-95 southbound	35%
		I-495 southbound	30%
		I-95 northbound	25%
		US 1 northbound	5%
	Saugus	MA 107 southbound	5%
		US 1 southbound	45%
		MA 99 southbound	10%
		Essex St westbound	5%
		Main St northbound	5%
		Walnut St northbound	10%
	US 1 northbound	20%	
	Swampscott	MA 1A southbound	100%
Middlesex County	Arlington	US 3 southbound	25%
		MA 60 westbound	5%
		MA 2 westbound	35%
		Mass. Ave westbound	5%
		MA 2A westbound	5%
		US 3 northbound	5%
		MA 60 eastbound	20%
	Belmont	Belmont St westbound	5%
		MA 60 westbound	10%
		Concord Ave westbound	10%
		Winter St westbound	5%
		MA 2 westbound	35%
		MA 60 eastbound	15%
		Concord Ave eastbound	20%
	Cambridge	MA 28 eastbound	5%
		MA 2A eastbound	8%
		River St westbound	22%
		JFK St. southbound	12%
		MA 16 westbound	3%
		Belmont St westbound	6%
Concord Ave westbound		7%	
MA 2 westbound		7%	
MA 16 eastbound		5%	
Day St northbound		10%	
Prospect St northbound	15%		



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Middlesex County (continued)	Everett	MA 99 southbound	20%
		MA 16 westbound	52%
		Main St northbound	4%
		Ferry St northbound	6%
		MA 99 northbound	8%
		MA 16 westbound	10%
	Malden	Lynn St southbound	2%
		MA 99 southbound	5%
		Ferry St southbound	1%
		Main St southbound	4%
		MA 28 eastbound	8%
		MA 28 westbound	13%
		Pleasant St westbound	35%
		Highland Ave northbound	2%
		Fellsway E. northbound	5%
		MA 99 northbound	15%
		MA 60 eastbound	10%
	Medford	MA 28 eastbound	5%
		I-93 southbound	12%
		Medford St southbound	5%
		Harvard St southbound	5%
		MA 16 westbound	18%
		MA 60 westbound	5%
		Mystic Valley Pky northbound	5%
		MA 38 northbound	5%
		I-93 northbound	25%
		MA 28 westbound	10%
		Woodland Rd northbound	5%
	Newton	Hammond Pond Pkwy southbound	2%
		Needham St westbound	4%
		MA 9 southbound	2%
		MA 16 westbound	25%
		I-90 westbound	40%
		MA 30 westbound	2%
		MA 16 eastbound	20%
	Centre St northbound	5%	



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Middlesex County (continued)	Somerville	MA 28 eastbound	2%
		Prospect St southbound	12%
		Somerville Ave westbound	11%
		Broadway westbound	24%
		Powder House Blvd westbound	9%
		MA 16 eastbound	15%
		Medford St northbound	12%
		MA 28 westbound	15%
	Waltham	I-95 southbound	50%
		Trapelo Rd westbound	5%
		I-95 northbound	45%
	Watertown	Galen St southbound	20%
		MA 16 westbound	5%
		US 20 westbound	25%
		Belmont St westbound	5%
		Trapelo Rd westbound	5%
		Brattle St northbound	40%
	Winchester	MA 38 eastbound	4%
		Mystic Valley Pky. Southbound	1%
		US 3 southbound	10%
		US 3 northbound	5%
MA 38 westbound		5%	
Washington St northbound		75%	
Nantucket County	Nantucket	Nantucket Ferry	100%
Norfolk County	Braintree	MA 53 southbound	5%
		Liberty St southbound	2%
		MA 37	8%
		South St	1%
		Pond St	3%
		West St	1%
		I-93 southbound	30%
		I-93 northbound	45%
		MA 53 northbound	5%
	Brookline	W Roxbury Pky southbound	5%
		MA 9 westbound	10%
		Beacon St/MA 30 westbound	15%
		Commonwealth Ave/US 20 westbound	10%
		I-90 westbound	35%
		Harvard St northbound	25%



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Norfolk County (continued)	Cohasset	MA 3A northbound	60%
		N. Main St westbound	35%
		Jerusalem Rd westbound	5%
	Milton	I-93 southbound	30%
		MA 28 eastbound	3%
		Hillside St southbound	2%
		MA 138 westbound	2%
		MA 28 westbound	5%
		Adams St northbound	7%
		Granite Ave northbound	1%
		I-93 northbound	50%
		Quincy	I-93 southbound
	MA 3 northbound		15%
	I-93 northbound		10%
	MA 3A southbound		2%
	Quincy Ave southbound		3%
	MA 3 southbound		30%
	Weymouth	MA 58 westbound	3%
		MA 18 westbound	6%
		Randolph St westbound	1%
MA 3 northbound		35%	
MA 3A northbound		55%	
Plymouth County	Duxbury	MA 14 westbound	5%
		MA 3 northbound	95%
	Hingham	MA 228 westbound	13%
		Fresh River Ave southbound	2%
		MA 3A northbound	85%
	Hull	MA 228 westbound	10%
		G Washington Blvd southbound	90%
	Kingston	US 44 westbound	10%
		MA 80 westbound	1%
		MA 106 westbound	3%
		MA 27 northbound	5%
		MA 53 northbound	5%
		MA 3 northbound	76%
	Marion	US 6 westbound	1%
		I-195 northbound	4%
		MA 105 northbound	3%
County Rd northbound		22%	
I-195 southbound		45%	
US 6 eastbound	25%		



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Plymouth County (continued)	Marshfield	MA 139 southbound	45%
		Acorn St westbound	2%
		MA 139 northbound	50%
		MA 3A northbound	3%
	Mattapoisett	US 6 westbound	2%
		I-195 northbound	8%
		North St northbound	5%
		I-195 southbound	75%
		US 6 eastbound	10%
	Plymouth	Fed. Furnace Rd westbound	3%
		S. Meadow Rd westbound	1%
		Carver Rd westbound	4%
		US 44 westbound	10%
		MA 3 northbound	80%
		MA 3A northbound	2%
	Rochester	New Bedford Rd westbound	3%
		MA 105 northbound	7%
		MA 28 westbound	5%
		I-495 northbound	85%
	Scituate	MA 3A northbound	100%
Wareham	US 6 westbound	1%	
	I-195 northbound	2%	
	MA 28 westbound	6%	
	I-495 northbound	90%	
	Plymouth Ave northbound	1%	
Suffolk County	Boston	I-93 southbound	5%
		Dorchester Ave southbound	6%
		MA 28 southbound	9%
		Hyde Park Ave southbound	3%
		Washington St westbound	2%
		VFW Pky westbound	6%
		Huntington Ave/MA 9 westbound	19%
		SR 30 westbound	3%
		Beacon St westbound	2%
		I-90 westbound	14%
		MA 3 northbound	3%
		MA 28 westbound	3%
		I-93 northbound	20%
US 1 northbound	5%		



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Table 6-44: Out Route Initial Assignment Assumptions (continued)

County	Town	Critical Roadway Segment	Initial % Assignment
Suffolk County (continued)	Chelsea	Meridian St southbound	4%
		US 1 southbound	16%
		MA 16 westbound	33%
		US 1 northbound	43%
		MA 107 northbound	4%
	Revere	MA 1A southbound	4%
		MA 107 southbound	12%
		US 1 southbound	38%
		MA 16 westbound	10%
		Park Ave westbound	2%
		MA 60 westbound	14%
		US 1 northbound	20%
	Winthrop	MA 145 southbound	5%
		MA 145 northbound	95%

Once the vehicle trips generated within each evacuation zone in each town have been aggregated and distributed according to the above assumptions, critical roadways segments can be determined and the number of evacuating vehicles calculated. This step in the development of the transportation model is called trip assignment and involves the routing of evacuating vehicles onto specific roadways. Table 6-45 below details the number of vehicles assigned to each critical roadway segment from all evacuating towns, by scenario and tourist occupancy. The bottleneck locations in this table relate to the town in which the critical roadway segment is physically situated rather than for which community the segment determines the clearance time. Bear in mind that in many cases the critical link that determines a town's clearance time will be located outside its jurisdiction. The table that relates the below listed critical bottlenecks to the specific towns they impact can be found in Table 6-44.



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Table 6-45: Evacuating Vehicle Volume (Total Volume of Vehicles)

Bottleneck ¹ Location	Critical Roadway Segments ²	Evacuating Vehicles			
		Low Tourist Occupancy		High Tourist Occupancy	
		Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Eastham	Grand Army of the Republic Hwy/US 6 @ Nauset Rd (AXE)	2,788	4,532	6,740	9,517
Orleans	Mid Cape Hwy/US 6 @ Cranberry Hwy/MA 6A (AXL)	5,803	9,932	12,914	19,664
Harwich	MA 137 @ Mid Cape Hwy/US 6 (CJP)	3,422	5,860	7,244	11,096
Harwich	Mid Cape Hwy/MA 6 @ Lake Pleasant Ave/MA 124 (AXO)	9,450	15,954	20,358	30,931
Harwich	Lake Pleasant Ave/MA 124 @ Mid Cape Hwy/US 6 (CKD)	2,686	3,514	4,499	5,874
Dennis	East West Dennis Rd/MA 134 @ Mid Cape Hwy/US 6 (CKS)	2,944	4,136	5,461	7,495
Yarmouth	Station Ave @ Mid Cape Hwy/US 6 (CKX)	3,883	5,197	6,763	8,780
Yarmouth	Mid Cape Hwy/MA 6 @ Station Ave (AXS)	10,477	17,500	22,427	33,247
Barnstable	Iyannough Rd/MA 132 @ Mid Cape Hwy/US 6 (CMT)	7,504	10,660	12,691	17,131
Barnstable	Mid Cape Hwy/US 6 @ Iyannough Rd MA 132 interchange (AXW)	15,901	27,298	32,419	49,005
Falmouth	MA 28 @ Nathan Ellis Hwy/MA 151 (BMU)	10,475	17,179	17,741	26,365
Bourne	Bourne Bridge/MA 28 (BMY)	14,667	21,726	21,223	32,060
Bourne	Mid Cape Hwy/US 6 Bridge over the Cape Cod Canal (AYD)	20,622	35,060	37,767	58,383
Wareham	I-495 north of MA 58 interchange (AKU)	19,542	26,945	26,649	37,332
Acushnet	Alfred Bessette Mem Hwy / MA 140 @ Braley Rd interchange (BVC)	4,281	8,871	5,149	10,021
Fall River	MA 24/79 north of MA 24/79 junction (BPL)	2,087	4,160	2,419	4,619
Raynham	MA 24 @ US 44 interchange (BPT)	8,225	17,346	9,521	19,155
Bridgewater	Amvets Mem Hwy/MA 24 north of I-495 interchange (BPV)	11,121	17,148	14,689	22,302
Seekonk	I-195 @ MA/RI state line (ARX)	1,275	2,076	1,666	2,687
Plymouth	Pilgrim Hwy/MA3 @ US 44 interchange (BCP)	21,431	37,002	38,588	60,496
Duxbury	Pilgrim Hwy/MA3 @ Tremont St/MA 3A interchange (BCR)	21,926	37,702	38,965	61,024



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Table 6-45: Evacuating Vehicle Volume (Total Volume of Vehicles) (continued)

Bottleneck ¹ Location	Critical Roadway Segments ²	Evacuating Vehicles			
		Low Tourist Occupancy		High Tourist Occupancy	
		Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Duxbury	Pilgrim Hwy/MA3 @ Congress St/MA 14 interchange (BCS)	22,594	38,528	39,444	61,555
Pembroke	Pilgrim Hwy/MA3 @ Church St/MA 139 interchange (BCV)	27,177	43,594	44,300	66,777
Hingham	Geo Washington Blvd @ Rockland St (CVJ)	5,170	5,229	5,689	5,749
Hingham	Summer St/MA 3A @ Water St (BIF)	11,305	12,676	12,336	13,754
Quincy	Hancock St/MA 3A @ Beale St	12,888	15,824	13,778	16,795
Braintree	Pilgrim Hwy/MA3 @ I-93 interchange (BDF)	24,032	39,754	39,036	60,208
Brookline	Boylston St/MA 9 @ Hammond Pond Pky (DEC)	8,144	12,912	8,787	13,757
Somerville	Broadway @ Holland St (DNE)	8,058	11,517	8,316	11,823
Medford	Harvard St/MA 16 @ Main St (DNY)	10,012	12,790	10,366	13,261
Revere	Revere Beach Pky/MA 145 @ MA 1A (DRE)	8,588	9,180	8,655	9,253
Revere	Revere Beach Pky/MA 16 @ Broadway (DLK)	6,209	7,279	6,349	7,453
Randolf	Amvets Mem Hwy/MA 24 @ I 93 interchange (BQB)	7,896	12,175	10,430	15,834
Canton	I-95 @ I-93/US 1 interchange (inner loop)(AAJ)	27,138	44,140	42,046	64,636
Weston	I-95 @ I 90 interchange (inner loop)(AAU)	20,598	38,843	37,000	56,880
Weston	I-90 @ I 95 interchange (AFW)	16,887	23,593	18,931	26,311
Lexington	MA 2 @ I-95 interchange (BFW)	6,310	8,698	7,146	9,821
Lexington	I-95 @ MA 2 interchange (inner loop)(ABB)	17,564	28,594	27,284	41,951
Burlington	US 3 @ Burlington Rd/MA 62 interchange (AWJ)	3,338	4,697	4,076	5,695
Burlington	I-95 @ US 3 interchange (inner loop)(ABE)	15,648	25,478	24,316	37,388
Reading	I-93 @ I-95 interchange (AIL)	23,212	32,035	25,119	34,488
Reading	I-95 @ I-93 interchange (inner loop)(ABK)	11,975	19,490	18,588	28,580



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Table 6-45: Evacuating Vehicle Volume (Total Volume of Vehicles) (continued)

Bottleneck ¹ Location	Critical Roadway Segments ²	Evacuating Vehicles			
		Low Tourist Occupancy		High Tourist Occupancy	
		Category 1 & 2 Hurricane	Category 3 & 4 Hurricane	Category 1 & 2 Hurricane	Category 3 & 4 Hurricane
Reading	Fellsway/MA 28 @ I-95 interchange (BPE)	10,892	13,595	11,647	14,532
Peabody	US 1 @ I-95/MA 28 (ATC)	11,566	16,766	12,122	17,483
Reading	I-95 @ I-93 interchange (outer loop)(ADV)	20,989	30,650	27,958	40,525
Burlington	I-95 @ US 3 interchange (outer loop)(AEB)	18,608	27,170	24,755	35,881
Lexington	I-95 @ MA 2 interchange (outer loop)(AEE)	16,469	24,044	21,883	31,718
Weston	I-95 @ I 90 interchange (outer loop)(AEK)	14,128	20,627	18,788	27,232
Peabody	Yankee Division Hwy/I-95/MA 128 @ US 1 Connector interchange (ADO)	23,774	34,736	31,920	46,278
Saugus	Main St @ US 1 interchange (DSC)	4,130	5,552	4,225	5,706
Lynn	Lewis St/ MA1A/129 @ Chestnut St/MA 129A (BEM)	3,166	4,467	3,255	4,599
Peabody	Yankee Division Hwy/MA 128 @ Lowell St interchange (DVF)	17,536	24,499	19,253	26,935
Beverly	Yankee Division Hwy/MA 128 @ Dodge St/MA 1A (DUZ)	11,464	15,689	13,076	17,807
Gloucester	Yankee Division Hwy/MA 128 bridge @ Annisquam River (DUP)	4,957	6,481	6,023	7,913
Rowley	Haverhill St/MA 133 @ I-95 interchange (DXW)	661	1,063	714	1,125
Newburyport	Storey Ave/MA113 @ I-95 interchange (DYV)	1,651	2,381	1,816	2,592
Newburyport	I-95 @ Storey Ave/MA113 interchange ACW)	9,844	14,936	23,439	34,011
Amesbury	Macy Street @ I-95 interchange (DZE)	1,402	1,623	1,701	1,924
Amesbury	I-95 @ Macy Street interchange (ACV)	4,732	7,139	11,597	16,745
Salisbury	I-95 @ MA/NH state line (ACQ)	12,823	19,394	20,188	29,721
Andover	I-93 @ I-495 (AIQ)	20,891	28,832	22,607	31,040
Methuen	I-93 @ MA/NH state line (AIV)	7,958	11,075	8,698	12,025



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Table 6-45: Evacuating Vehicle Volume (Total Volume of Vehicles) (continued)

Bottleneck ¹ Location	Critical Roadway Segments ²	Evacuating Vehicles					
		Low Tourist Occupancy			High Tourist Occupancy		
		Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane	Cat 1 (next to worst case) Hurricane	Cat 1 (worst case) & Cat 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 Hurricane
Boston	I-93 @ Columbia Rd interchange (AHS)	180	21,351	21,805	208	23,707	24,182
Boston	Bowdoin St between Cambridge St and Beacon St (DCN)	961	6,533	9,650	1,035	6,942	10,141
Boston	Huntington Ave/MA 9 @ Boylston St (DEB)	1,675	7,391	11,600	1,932	8,026	12,434

Bottleneck ¹ Location	Critical Roadway Segments ²	Evacuating Vehicles					
		Low Tourist Occupancy			High Tourist Occupancy		
		Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane	Cat 1 & 2 (not worst case) Hurricane	Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane	Cat 3 & 4 (worst case) Hurricane
Cambridge	Prospect St @ Massachusetts Ave/MA 2A (DIV)	1,688	12,717	13,297	2,045	13,316	13,966

1. Bottleneck location is the community in which the bottleneck is physically located, not the community for which it constitutes the critical link.
2. The letters in parenthesis pertain to the road segment designators from the maps contained in Figures 6-83 to 6-170.



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6.10.4 Compatibility with Other Hurricane Evacuation Related Studies

Three other studies exist in Massachusetts that directly address hurricane evacuation issues for the coastal and near-coastal inland areas. All three studies were prepared to address other issues initially but could be applied to evacuations for tropical cyclones. This report and the data therein has been developed in full recognition of those other studies, and to the extent possible, has attempted to be compatible with all three of those studies.

The first study and closest fit to this study is the 2014 MBHSR evacuation planning project which provided evacuation clearance times for various hazards, natural and human caused, including hurricanes. In the conduct of this study, the roadway networks were compared and the evacuation corridors included in the 2014 MBHSR study were incorporated into this analysis. Furthermore, the vehicle numbers in all three evacuation zones at the key critical bottlenecks identified in the 2014 MBHSR were considered in developing the trip distribution and assignments, as well as the routing schemes in this study. As a result, many of the base evacuating vehicle numbers by critical segment are consistent between the two studies. Nonetheless, in some cases the vehicle numbers in this study, especially with respect to MA 3, I-93, I-95 and some other roadway segments mostly in the Boston area, are significantly higher because this analysis includes vehicles from the entire coastal area of New England. For those roadways and critical links shared by the two studies that are mostly devoid of regional and interstate traffic, the numbers are compatible.

A second transportation analysis considered in the development of this study is a KLD Engineering report titled “Cape Cod Traffic Study” which was completed also in 2014. KLD prepared this study as a supplement to their previously issued “Pilgrim Nuclear Power Station Development of Evacuation Time Estimates” report. This document, however, provides the results for evacuating all of Cape Cod for any disaster natural or man-made. This analysis’ behavioral variables for Barnstable County do reflect slightly higher percentages for participation rates and exiting trips than the rest of Massachusetts in recognition of the higher behavioral variables reported in the KLD report. Both reports are in somewhat good agreement on the clearance time estimates for the Bourne and Sagamore Bridges. Nonetheless, it must be recognized that significant variations in the methodologies used to estimate populations, assign roadway capacities and develop routing schemes make quantifying the causes for any differences between the two studies difficult. A major difference is that the KLD study seems to concentrate on the two bridges across the Cape Cod Canal as determining the clearance time, whereas this analysis identifies that US 6 further east in the community of Harwich is more problematic in establishing the regional clearance time for Cape Cod.



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Finally, a third study was commissioned by the Southeast Massachusetts Planning Commission to identify roadway corridors that are considered as evacuation routes for tropical cyclones or any other disaster. The focus of this study was the area from Seekonk in the west to Wareham in the east. In addition to the coastal communities between the above referenced locations, this study includes some second tier inland communities with identified storm tide inundation limits. In essence this study is a collection of maps that establish which federal, state and local road corridors in the study communities should be identified as evacuation routes. The report does not quantify the capacity of any of those roadways, the number of vehicles or the clearance times for any other communities or the area in general. Nonetheless, this study does include all roadways identified in this report as evacuation routes for the hurricane transportation analysis done for this study.

6.10.5 Martha's Vineyard and Nantucket Ferries

The population and vehicles that evacuate both Islands via the Vineyard Haven to Woods Hole, the Oak Bluffs to Woods Hole and the Nantucket to Hyannisport ferries have been factored into the transportation figures for Barnstable County. The evacuating vehicle numbers used in the transportation analysis were provided by the Steamship Authority based on vehicle counts obtained during tropical cyclones Irene and Sandy during 2011 and 2012 respectively.

The assumptions used in determining the number of evacuating vehicles from both islands were based on the number of evacuation sorties occurring over three days. According to the Steamship Authority data, it appears that for Hurricane Irene, a category 2 hurricane occurring during the end of high tourist season, the total number of daily trips off both islands was significantly higher than normal for three days before the storm made landfall.

Based on Hurricane Sandy figures from the Steamship Authority, the actual counts for low tourist season for both evacuation zones (A and B) could not realistically be used since many trips ferried no vehicles, only passengers. Therefore, to develop a daily number the calculation was based on the average maximum capacity for all ships in service during that event. For Martha's Vineyard the figures used in the transportation model were based on a maximum total of 1,000 vehicles a day, whereas for Nantucket the average maximum capacity was assumed at 500 vehicles a day. Only in the case of the low tourist occupancy for Zone A evacuation from Martha's Vineyard did the assumed ferry capacity exceed the evacuation demand calculated by the transportation model.

For the high tourist season on Martha's Vineyard, the average daily vehicle counts for Hurricane Irene of 1,400 vehicles over three days was used for Scenario A. For Scenario B off of Martha's Vineyard however, to take into account a greater tendency of evacuees to want to leave the island entirely, a 90% of average maximum capacity for all ferries in service during Hurricane



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Irene was used. The assumed number of vehicles for Zone A and B evacuations on the Nantucket to Hyannisport run, is based on the theoretical average maximum for all ferries in service during Hurricane Irene (since it occurred during the high season).

In all but one case, the capacity of the ferries was the limiting factor on how many vehicles from Martha’s Vineyard and Nantucket were introduced into the overall Cape Cod evacuation situation. Once the vehicles were delivered by the ferries to Woods Hole and Hyannisport, the assumption was that all of them would evacuate off Cape Cod to the mainland. Table 6-46 details the assumed numbers evacuating from Martha’s Vineyard and Nantucket.

Table 6-46: Evacuating Vehicles from Martha’s Vineyard and Nantucket Using the Ferries

	Category 1 & 2 Hurricane		Category 3 & 4 Hurricane	
	Low Tourist Occupancy	High Tourist Occupancy	Low Tourist Occupancy	High Tourist Occupancy
Martha’s Vineyard	2,338	4,200	3,000	5,850
Nantucket	1,500	1,900	1,500	1,900

6.10.6 Estimated Evacuation Clearance Times

The most important product of the transportation analysis is the clearance times developed by storm category and by behavioral characteristics for each group of counties. Clearance time is one of two major considerations involved in issuing an evacuation or storm advisory. Clearance time must be weighed with the forecast arrival of sustained tropical storm winds to make a prudent evacuation decision. Figure 6-171 illustrates these two timing issues of evacuation and their relationship to each other.

Clearance time is the time required to clear the roadway of all vehicles evacuating in response to a hurricane situation. Clearance time begins when the first evacuating vehicle enters the road network and ends when the last evacuating vehicle reaches an assumed point of safety. Clearance time includes the time required by evacuees to secure their homes and prepare to leave (referred to as mobilization time). Clearance time also encompasses the time spent by evacuees traveling along the road network (referred to as travel time), and the time spent by evacuees waiting along the road network due to traffic congestion (referred to as queuing delay time). Clearance time does not relate to the time any one vehicle spends traveling on the road network and does not include time needed for local officials to assemble and make a decision to evacuate.



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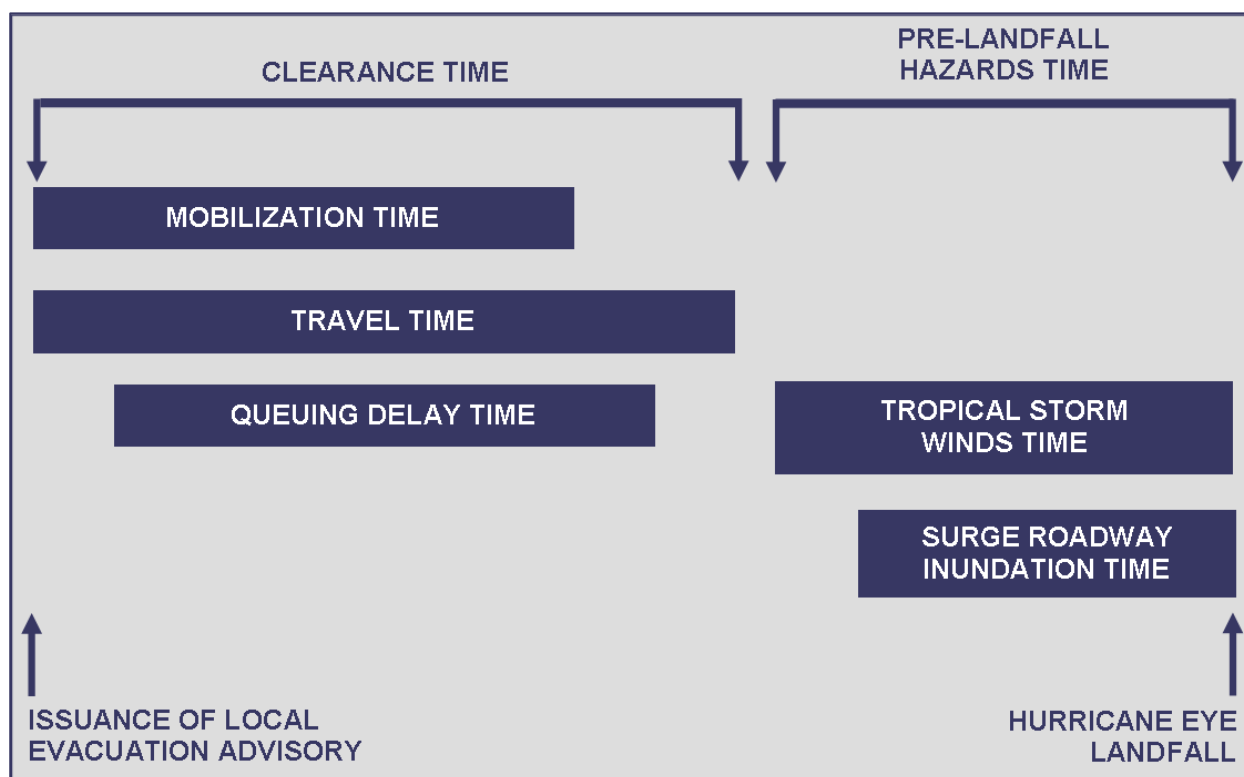


Figure 6-171: Components of Evacuation Timing

Clearance times for Massachusetts were calculated by metering expected traffic through each regional and local route focal point location for every response and tourist occupancy scenario. A critical assumption for making these calculations is the hourly vehicular flow rate assumed at each focal point. Evacuation traffic flow assumptions are based on traffic counter data collected over time in other states after actual hurricane evacuations that show typical traffic movement is near maximum capacity at the beginning of the evacuation. Then for each quarter of the evacuation thereafter, the service volume is reduced. In the last quarter of the evacuation, the flow rate “recovers” to near capacity. This approach does an excellent job of mirroring what actually happens in most evacuations where the public responds to evacuation advisories and loads the roadway gradually over an approximate eight hour time period (medium response rate). Another important element to recognize in the calculations is the presence of a certain amount of background traffic (non-evacuee) that may be on the road network at the start of the evacuation. These movements may include residents going to stores for supplies or even a work to home movement. Depending on the normal daily congestion in an area, this can add up to a significant increase in time in an area like Massachusetts.



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Table 6-47 below details the clearance times for each individual community broken out by slow, medium and fast response times according to storm category, as well as by low and high tourist occupancy. As noted, most communities have two evacuation zones; while Boston and Cambridge have three evacuation zones. The critical links that determine the clearance times in certain nearby communities (Arlington, Belmont, Brookline, Chelsea, Everett, Malden, Medford, Newton, Revere, Somerville, Waltham, Watertown, Winchester and Winthrop) will also experience the significantly larger traffic volumes caused by the evacuation of those additional zones. Consequently, evacuation decisions made in Boston and Cambridge will have an impact on the decision times of those adjoining communities. Therefore, the Zone B clearance times for these adjoining communities account for the additional vehicles caused by a Zone C evacuation in Boston and Cambridge. Table 6-46 referenced above details which of all the roadway segments labeled as critical links will determine the clearance time for each community in the study area. For many communities these “controlling” roadway segments are outside their jurisdictional control which indicates a need to coordinated operations at these locations to ensure as smooth an evacuation as possible.

The single largest factor influencing clearance times is response scenario. For many communities in Massachusetts, even in the worst case Zone B and C storms, times are comfortably below the 24 hour time frame for even a high tourist occupancy scenario. The exception to this statement applies to many of the communities in Barnstable County where even the Zone A figures approach or exceed that threshold, especially in the high tourist occupancy scenario. Table 6-47 shows the regional clearance times for Massachusetts and Table 6-48 lists the critical links that determine those clearance times for each community.



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Table 6-47: Evacuation Clearance Times (in hours)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Barnstable	Barnstable	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Bourne	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Brewster	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Chatham	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Dennis	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Eastham	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Falmouth	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Harwich	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Mashpee	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Orleans	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Provincetown	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Sandwich	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Truro	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Wellfleet	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
Yarmouth	12.1	16.7	15.5	23.3	10.6	15.2	12.7	18.4	9.3	14.1	11.5	17.4	
Bristol	Acushnet	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Berkley	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Dartmouth	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Dighton	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Fairhaven	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Fall River	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9



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Table 6-47: Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response				
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4		
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	
Bristol (continued)	Freetown	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	New Bedford	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Raynham	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Rehoboth	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Seekonk	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Somerset	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Swansea	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Taunton	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Westport	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
	Dukes	Aquinnah	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
		Chilmark	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
		Edgartown	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
		Oak Bluffs	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
		Tisbury	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
West Tisbury		8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3	
Essex	Beverly	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8	
	Danvers	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8	
	Essex	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8	
	Gloucester	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8	
	Ipswich	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8	
	Lynn	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2	



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Table 6-47: Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Essex (continued)	Manchester	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Marblehead	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Nahant	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
	Newbury	9.6	10.0	11.4	12.1	8.1	8.6	10.0	10.6	6.7	7.2	8.7	9.3
	Newburyport	9.6	10.0	11.4	12.1	8.1	8.6	10.0	10.6	6.7	7.2	8.7	9.3
	Peabody	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Rockport	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Rowley	9.6	10.0	11.4	12.1	8.1	8.6	10.0	10.6	6.7	7.2	8.7	9.3
	Salem	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Salisbury	9.6	10.0	11.4	12.1	8.1	8.6	10.0	10.6	6.7	7.2	8.7	9.3
	Saugus	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
Swampscott	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2	
Middlesex	Arlington	4.3	4.4	4.9	5.1	3.6	3.7	4.2	4.4	2.9	3.1	3.5	3.7
	Belmont	4.3	4.4	4.9	5.1	3.6	3.7	4.2	4.4	2.9	3.1	3.5	3.7
	Everett	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Malden	10.8	11.1	12.5	12.9	9.1	9.5	10.8	11.3	7.5	7.8	9.3	9.7
	Medford	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Newton	9.3	9.8	11.0	11.7	8.0	8.5	9.7	10.3	6.7	7.2	8.5	9.1
	Somerville	16.7	17.3	17.3	18.0	15.7	16.3	16.3	17.0	15.3	16.0	16.0	16.7
	Waltham	9.3	9.8	11.0	11.7	8.0	8.5	9.7	10.3	6.7	7.2	8.5	9.1
	Watertown	9.3	9.8	11.0	11.7	8.0	8.5	9.7	10.3	6.7	7.2	8.5	9.1
Winchester	10.8	11.1	12.5	12.9	9.1	9.5	10.8	11.3	7.5	7.8	9.3	9.7	



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Table 6-47: Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Nantucket	Nantucket	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
Norfolk	Braintree	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
	Brookline	9.0	9.3	11.3	11.7	7.7	8.0	0.0	0.0	6.3	6.6	0.0	0.0
	Cohasset	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
	Milton	6.7	6.7	10.9	11.4	5.0	5.0	9.1	9.6	3.0	3.0	7.3	7.8
	Quincy	17.2	18.1	20.3	21.3	16.2	17.1	19.2	20.2	15.7	16.7	18.9	20.0
	Weymouth	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
Plymouth	Duxbury	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Hingham	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Hull	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Kingston	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Marion	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Marshfield	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Mattapoisett	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Plymouth	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Rochester	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Scituate	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Wareham	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
Suffolk	Chelsea	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Revere	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Winthrop	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9



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Table 6-47: Evacuation Clearance Times (in hours) (continued)

Suffolk County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Boston	8.5	8.6	10.9	11.4	12.9	13.5	7.3	7.4	9.1	9.6	12.2	12.7	6.1	6.2	7.3	7.8	11.9	12.4

Middlesex County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Cambridge	5.1	5.5	16.7	17.3	17.3	18.0	4.2	4.6	15.7	16.3	16.3	17.0	3.3	3.7	15.3	16.0	16.0	16.7



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Table 6-48: Clearance Time Determining Critical Links

County	Impacted Communities	Name of Link	Physical Location
Barnstable	Brewster Chatham Eastham Harwich Orleans Provincetown Truro Wellfleet	Mid Cape Hwy/MA 6 @ Lake Pleasant Ave/MA 124 (AXO)	Harwich
	Barnstable Dennis Mashpee Sandwich Yarmouth (Scenario B)	Mid Cape Hwy/US 6 Bridge over the Cape Cod Canal (AYD)	Bourne
	Bourne	Pilgrim Hwy/MA3 @ US 44 interchange (BCP)	Plymouth
	Falmouth	Bourne Bridge/MA 28 (BMY)	Bourne
	Yarmouth (Scenario A)	Station Ave @ Mid Cape Hwy/US 6 (CKX)	Yarmouth
Bristol	Acushnet Berkley Dartmouth Dighton Fairhaven Fall River Freetown New Bedford Raynham Rehoboth Seekonk Somerset Swansea Taunton	Amvets Mem Hwy/MA 24 north of I-495 interchange (BPV)	Bridgewater



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Table 6-48: Clearance Time Determining Critical Links (continued)

County	Impacted Communities	Name of Link	Physical Location
Bristol	Westport	Amvets Mem Hwy/MA 24 north of I-495 interchange (BPV)	Bridgewater
Dukes	Aquinnah Chilmark Edgartown Oak Bluffs Tisbury West Tisbury	Bourne Bridge/MA 28 (BMY)	Bourne
Essex	Beverly Danvers Essex Gloucester Ipswich Manchester Marblehead Peabody Rockport Salem	Yankee Division Hwy/MA 128 @ Lowell St interchange (DVF)	Peabody
	Lynn Nahant Saugus Swampscott	Main St @ US 1 interchange (DSC)	Saugus
	Newbury Newburyport Rowley Salisbury	Yankee Division Hwy/I-95/MA 128 @ US 1 Connector interchange (ADO)	Peabody
Middlesex	Arlington Belmont	MA 2 @ I-95 interchange (BFW)	Lexington
	Everett Medford	Harvard St/MA 16 @ Main St (DNY)	Medford



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Table 6-48: Clearance Time Determining Critical Links (continued)

County	Impacted Communities	Name of Link	Physical Location
Middlesex	Malden Winchester	I-93 @ I-95 interchange (AIL)	Reading
	Newton Waltham Watertown	I-90 @ I 95 interchange (AFW)	Weston
	Cambridge Somerville	Prospect St @ Massachusetts Ave/MA 2A (DIV)	Cambridge
Norfolk	Braintree Cohasset Weymouth	Pilgrim Hwy/MA3 @ I-93 interchange (BDF)	Braintree
	Brookline	Boylston St/MA 9 @ Hammond Pond Pky (DEC)	Brookline
	Milton	I-93 @ Columbia Rd interchange (AHS)	Boston
	Quincy	Hancock St/MA 3A @ Beale St (BIU)	Quincy
Plymouth	Duxbury Kingston Marshfield Plymouth	Pilgrim Hwy/MA 3 @ Church St/MA 139 interchange (BCV)	Pembroke
	Hingham Hull Scituate	Summer St/MA 3A @ Water St (BIF)	Hingham
	Marion Mattapoisett Rochester Wareham	Amvets Mem Hwy/MA 24 north of I-495 interchange (BPV)	Bridgewater
Suffolk	Boston (scenario A)	Revere Beach Pky/MA 16 @ Broadway (DLK)	Revere
	Boston (scenario B)	I-93 @ Columbia Rd interchange (AHS)	Boston
	Boston (scenario C)	Bowdoin St between Cambridge St and Beacon St (DCN)	Boston
	Chelsea Revere Winthrop	Harvard St/MA 16 @ Main St (DNY)	Medford



6.0 Transportation Analysis

The presentation of multiple clearance times can be confusing; the highest clearance time is the time to be used for decision making. Other times are shown so that local and state officials realize that once a roadway's congestion problem is "solved", the next most congested segment or corridor must be addressed. None of these clearance times factor in the effect of accidents, breakdowns or other exigent circumstances that may occur during an evacuation event. Although slow, medium and rapid scenarios have been included in the clearance time results, none of the figures take into account the adverse impacts of construction on the listed roadways, or the additional travel demand created by short duration, well attended special events in the area such as a local festival, or a professional football game.

Additionally, the clearance times provided in both of the above tables are for an evacuation of the general population and not access and functional needs evacuees. The evacuation of assisted or group living facilities and hospitals is driven more by operational constraints associated with the availability of adequate transportation and the time needed to prepare the evacuees, rather than any congestion or limitations to the roadway network. Therefore, no determination was made for the time required to evacuate nursing homes and other population groups with access and functional needs.

Evacuations in this area will be problematic both for decision makers and the public given that in this part of the Atlantic coast, the forward speed of tropical cyclones is usually relatively fast and accelerating due to their proximity to the jet stream. Consequently, depending on the clearance time, the decision to evacuate may have to occur when the storm is still far from the forecast landfall point, well before the weather has begun to deteriorate and the need to evacuate becomes evident to at-risk populations.

For evacuations to be successful, the public will have to start their movements in earnest, well before the threat is imminent, and at least a portion of the evacuees must be moving at the beginning of the clearance time period. Individual household evacuation commutes will be longer for those leaving in the middle of the evacuation for a major storm event. Evacuations must be started early enough so that movements are complete before the arrival of sustained tropical storm winds. Given the public's relative dearth of hurricane evacuation experience in many of Massachusetts's coastal communities, it is possible that many evacuees may attempt to leave very late in the process. The flooding of roads may also force many residents to alter their evacuation plans. All of these factors can have a significant impact on the actual time it takes to clear the roadways in any of the jurisdictions within the region.



6.0 Transportation Analysis

6.11 State to State Trips and Clearance Time Impacts

As an additional aid to hurricane and emergency preparedness planners, the transportation model calculated the number of vehicles moving between the states of Connecticut, Rhode Island and Massachusetts. This section will also address those vehicles that are introduced into the study region from the adjoining states of New York, Maine and New Hampshire to determine their impacts on the above clearance times.

Table 6-49 details the numbers of evacuating vehicles that will cross state lines during each response scenario. Only major highways are included in these tables since they are the corridors that have the most potential to impose enough traffic on their adjoining state roadways and thereby have an effect on clearance times. Only those roadways impacted by evacuations in Boston and Cambridge will have numbers in the final column of the table which corresponds with their Zone C evacuations.

Table 6-50 details the impacts on clearance times caused by the infusion of extra-state vehicles on the clearance times provided above in Table 6-47. For Massachusetts, the exiting vehicles from Rhode Island and Connecticut do not have a substantive impact on any critical bottlenecks, and therefore their effects are not measurable. Evacuations in Maine and New Hampshire, on the other hand, will only increase some clearance times in the northern part of the study area, mainly in towns along the Essex County coastline. Finally, to expand upon all the clearance time tables above, Table 6-51 provides the revised clearance times for a multi-state evacuation. In addition to all three of the states in the study region, these tables include total clearance time figures that factor in simultaneous evacuations in Maine and New Hampshire.



6.0 Transportation Analysis

Table 6-49: Interstate Trips by Evacuation Zone and Tourist Occupancy

Major In / Out Routes	From / To	Zone A		Zone B		Worst Case	
		Low Tourism	High Tourism	Low Tourism	High Tourism	Low Tourism	High Tourism
I-95 NB	From Rhode Island	2,306	3,080	4,423	5,322	4,476	5,381
I-195 NB	From Rhode Island	154	198	349	403	357	412
RI 24 NB	From Rhode Island	1,084	1,420	1,681	2,081	1,084	1,420
I-95 SB	From Maine/New Hampshire	4,018	10,714	6,309	15,746		
I-195 SB	To Rhode Island	1,275	2,076	1,666	2,687		
I-95 NB	To Maine/New Hampshire	6,231	9,772	10,570	6,688	10,451	11,311

Note: Worst Case = All communities' Zone B plus Boston and/or Cambridge Zone C.



6.0 Transportation Analysis

Table 6-50: Change to Evacuation Clearance Times (in additional hours)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Barnstable	Barnstable	0	0	0	0	0	0	0	0	0	0	0	0
	Bourne	0	0	0	0	0	0	0	0	0	0	0	0
	Brewster	0	0	0	0	0	0	0	0	0	0	0	0
	Chatham	0	0	0	0	0	0	0	0	0	0	0	0
	Dennis	0	0	0	0	0	0	0	0	0	0	0	0
	Eastham	0	0	0	0	0	0	0	0	0	0	0	0
	Falmouth	0	0	0	0	0	0	0	0	0	0	0	0
	Harwich	0	0	0	0	0	0	0	0	0	0	0	0
	Mashpee	0	0	0	0	0	0	0	0	0	0	0	0
	Orleans	0	0	0	0	0	0	0	0	0	0	0	0
	Provincetown	0	0	0	0	0	0	0	0	0	0	0	0
	Sandwich	0	0	0	0	0	0	0	0	0	0	0	0
	Truro	0	0	0	0	0	0	0	0	0	0	0	0
	Wellfleet	0	0	0	0	0	0	0	0	0	0	0	0
Yarmouth	0	0	0	0	0	0	0	0	0	0	0	0	
Bristol	Acushnet	0	0	0	0	0	0	0	0	0	0	0	0
	Berkley	0	0	0	0	0	0	0	0	0	0	0	0
	Dartmouth	0	0	0	0	0	0	0	0	0	0	0	0
	Dighton	0	0	0	0	0	0	0	0	0	0	0	0
	Fairhaven	0	0	0	0	0	0	0	0	0	0	0	0
	Fall River	0	0	0	0	0	0	0	0	0	0	0	0



6.0 Transportation Analysis

Table 6-50: Change to Evacuation Clearance Times (in additional hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Bristol (continued)	Freetown	0	0	0	0	0	0	0	0	0	0	0	0
	New Bedford	0	0	0	0	0	0	0	0	0	0	0	0
	Raynham	0	0	0	0	0	0	0	0	0	0	0	0
	Rehoboth	0	0	0	0	0	0	0	0	0	0	0	0
	Seekonk	0	0	0	0	0	0	0	0	0	0	0	0
	Somerset	0	0	0	0	0	0	0	0	0	0	0	0
	Swansea	0	0	0	0	0	0	0	0	0	0	0	0
	Taunton	0	0	0	0	0	0	0	0	0	0	0	0
Dukes	Westport	0	0	0	0	0	0	0	0	0	0	0	0
	Aquinnah	0	0	0	0	0	0	0	0	0	0	0	0
	Chilmark	0	0	0	0	0	0	0	0	0	0	0	0
	Edgartown	0	0	0	0	0	0	0	0	0	0	0	0
	Oak Bluffs	0	0	0	0	0	0	0	0	0	0	0	0
	Tisbury	0	0	0	0	0	0	0	0	0	0	0	0
	West Tisbury	0	0	0	0	0	0	0	0	0	0	0	0
Essex	Beverly	0	0	0	0	0	0	0	0	0	0	0	0
	Danvers	0	0	0	0	0	0	0	0	0	0	0	0
	Essex	0	0	0	0	0	0	0	0	0	0	0	0
	Gloucester	0	0	0	0	0	0	0	0	0	0	0	0
	Ipswich	0	0	0	0	0	0	0	0	0	0	0	0
	Lynn	0	0	0	0	0	0	0	0	0	0	0	0



6.0 Transportation Analysis

Table 6-50: Change to Evacuation Clearance Times (in additional hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Essex (continued)	Manchester	0	0	0	0	0	0	0	0	0	0	0	0
	Marblehead	0	0	0	0	0	0	0	0	0	0	0	0
	Nahant	0	0	0	0	0	0	0	0	0	0	0	0
	Newbury	0.7	2.0	1.2	2.9	0.8	2.0	1.1	2.9	0.8	2.1	1.2	3.1
	Newburyport	0.7	2.0	1.2	2.9	0.8	2.0	1.1	2.9	0.8	2.1	1.2	3.1
	Peabody	0	0	0	0	0	0	0	0	0	0	0	0
	Rockport	0	0	0	0	0	0	0	0	0	0	0	0
	Rowley	0.7	2.0	1.2	2.9	0.8	2.0	1.1	2.9	0.8	2.1	1.2	3.1
	Salem	0	0	0	0	0	0	0	0	0	0	0	0
	Salisbury	0.7	2.0	1.2	2.9	0.8	2.0	1.1	2.9	0.8	2.1	1.2	3.1
	Saugus	0	0	0	0	0	0	0	0	0	0	0	0
Swampscott	0	0	0	0	0	0	0	0	0	0	0	0	
Middlesex	Arlington	0	0.1	0	0.1	0	0.1	0	0.1	0	0	0	0.1
	Belmont	0	0.1	0	0.1	0	0.1	0	0.1	0	0	0	0.1
	Everett	0	0	0	0	0	0	0	0	0	0	0	0
	Malden	0	0	0	0.1	0	0	0.1	0.1	0	0.1	0	0.1
	Medford	0	0	0	0	0	0	0	0	0	0	0	0
	Newton	0.1	0.1	0.1	0.1	0	0	0	0.1	0	0.1	0	0.1
	Somerville	0	0	0	0	0	0	0	0	0	0	0	0
	Waltham	0.1	0.1	0.1	0.1	0	0	0	0.1	0	0.1	0	0.1
	Watertown	0.1	0.1	0.1	0.1	0	0	0	0.1	0	0.1	0	0.1
Winchester	0	0	0	0.1	0	0	0.1	0.1	0	0.1	0	0.1	



6.0 Transportation Analysis

Table 6-50: Change to Evacuation Clearance Times (in additional hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Nantucket	Nantucket	0	0	0	0	0	0	0	0	0	0	0	0
Norfolk	Braintree	0	0	0	0	0	0	0	0	0	0	0	0
	Brookline	0	0	0	0	0	0	0	0	0	0	0	0
	Cohasset	0	0	0	0	0	0	0	0	0	0	0	0
	Milton	0	0	0	0	0	0	0	0	0	0	0	0
	Quincy	0	0	0	0	0	0	0	0	0	0	0	0
	Weymouth	0	0	0	0	0	0	0	0	0	0	0	0
Plymouth	Duxbury	0	0	0	0	0	0	0	0	0	0	0	0
	Hingham	0	0	0	0	0	0	0	0	0	0	0	0
	Hull	0	0	0	0	0	0	0	0	0	0	0	0
	Kingston	0	0	0	0	0	0	0	0	0	0	0	0
	Marion	0	0	0	0	0	0	0	0	0	0	0	0
	Marshfield	0	0	0	0	0	0	0	0	0	0	0	0
	Mattapoisett	0	0	0	0	0	0	0	0	0	0	0	0
	Plymouth	0	0	0	0	0	0	0	0	0	0	0	0
	Rochester	0	0	0	0	0	0	0	0	0	0	0	0
	Scituate	0	0	0	0	0	0	0	0	0	0	0	0
	Wareham	0	0	0	0	0	0	0	0	0	0	0	0
Suffolk	Chelsea	0	0	0	0	0	0	0	0	0	0	0	0
	Revere	0	0	0	0	0	0	0	0	0	0	0	0
	Winthrop	0	0	0	0	0	0	0	0	0	0	0	0



6.0 Transportation Analysis

Table 6-50: Change to Evacuation Clearance Times (in additional hours)

Suffolk County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Boston	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Middlesex County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Cambridge	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0



6.0 Transportation Analysis

Table 6-51: Multi-State Evacuation Clearance Times (in hours)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Barnstable	Barnstable	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Bourne	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Brewster	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Chatham	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Dennis	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Eastham	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Falmouth	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Harwich	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Mashpee	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Orleans	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Provincetown	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
	Sandwich	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
	Truro	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1
Wellfleet	21.4	24.1	20.1	33.8	12.2	22.1	18.1	31.7	11.7	22.0	17.8	32.1	
Yarmouth	12.1	16.7	15.5	23.3	10.6	15.2	12.7	18.4	9.3	14.1	11.5	17.4	
Bristol	Acushnet	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Berkley	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Dartmouth	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Dighton	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Fairhaven	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Fall River	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Freetown	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9



6.0 Transportation Analysis

Table 6-51: Multi-State Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Bristol (continued)	New Bedford	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Raynham	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Rehoboth	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Seekonk	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Somerset	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Swansea	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Taunton	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
Westport	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9	
Dukes	Aquinnah	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Chilmark	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Edgartown	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Oak Bluffs	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	Tisbury	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
	West Tisbury	8.7	11.3	11.5	15.5	7.9	10.5	10.7	14.6	7.3	10.0	10.2	14.3
Essex	Beverly	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Danvers	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Essex	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Gloucester	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Ipswich	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Lynn	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
	Manchester	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Marblehead	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8



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Table 6-51: Multi-State Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Essex (continued)	Nahant	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
	Newbury *	10.3	12.0	12.6	15.0	8.9	10.6	11.1	13.5	7.5	9.3	9.9	12.4
	Newburyport *	10.3	12.0	12.6	15.0	8.9	10.6	11.1	13.5	7.5	9.3	9.9	12.4
	Peabody	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Rockport	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Rowley *	10.3	12.0	12.6	15.0	8.9	10.6	11.1	13.5	7.5	9.3	9.9	12.4
	Salem	12.6	13.2	15.0	15.9	10.9	11.5	13.4	14.2	9.3	9.9	11.9	12.8
	Salisbury *	10.3	12.0	12.6	15.0	8.9	10.6	11.1	13.5	7.5	9.3	9.9	12.4
	Saugus	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
	Swampscott	11.3	11.5	13.5	13.7	10.0	10.1	12.1	12.3	8.7	8.9	11.0	11.2
Middlesex	Arlington *	4.3	4.5	4.9	5.2	3.6	3.8	4.2	4.5	2.9	3.1	3.5	3.8
	Belmont *	4.3	4.5	4.9	5.2	3.6	3.8	4.2	4.5	2.9	3.1	3.5	3.8
	Everett	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Malden *	10.8	11.1	12.5	13.0	9.1	9.5	10.9	11.4	7.5	7.9	9.3	9.8
	Medford	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Newton *	9.4	9.9	11.1	11.8	8.0	8.5	9.7	10.4	6.7	7.3	8.5	9.2
	Somerville	16.7	17.3	17.3	18.0	15.7	16.3	16.3	17.0	15.3	16.0	16.0	16.7
	Waltham *	9.4	9.9	11.1	11.8	8.0	8.5	9.7	10.4	6.7	7.3	8.5	9.2
	Watertown *	9.4	9.9	11.1	11.8	8.0	8.5	9.7	10.4	6.7	7.3	8.5	9.2
	Winchester *	10.8	11.1	12.5	13.0	9.1	9.5	10.9	11.4	7.5	7.9	9.3	9.8



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Table 6-51: Multi-State Evacuation Clearance Times (in hours) (continued)

County	Town	SLOW Response				MEDIUM Response				RAPID Response			
		Category 1-2		Category 3-4		Category 1-2		Category 3-4		Category 1-2		Category 3-4	
		Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Nantucket	Nantucket	10.6	16.4	15.5	23.3	9.6	15.4	14.5	22.3	8.9	14.9	14.0	22.1
Norfolk	Braintree	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
	Brookline	9.0	9.3	11.3	11.7	7.7	8.0	9.9	10.3	6.3	6.6	8.7	9.1
	Cohasset	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
	Milton	6.7	6.7	10.9	11.4	5.0	5.0	9.1	9.6	3.0	3.0	7.3	7.8
	Quincy	17.2	18.1	20.3	21.3	16.2	17.1	19.2	20.2	15.7	16.7	18.9	20.0
	Weymouth	10.8	14.1	14.3	18.7	9.3	12.6	12.8	17.2	7.9	11.3	11.5	16.1
Plymouth	Duxbury	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Hingham	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Hull	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Kingston	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Marion	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Marshfield	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Mattapoisett	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Plymouth	14.2	19.9	19.7	27.5	12.9	18.6	18.3	26.1	11.8	17.8	17.6	25.7
	Rochester	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
	Scituate	10.7	16.5	15.9	23.9	9.9	15.6	15.1	23.0	9.3	15.3	14.8	23.0
	Wareham	8.6	9.8	10.6	12.4	7.3	8.5	9.3	11.1	6.0	7.3	8.1	9.9
Suffolk	Chelsea	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Revere	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9
	Winthrop	13.6	13.9	16.5	17.0	12.7	13.1	15.6	16.1	12.3	12.7	15.4	15.9

* When evacuating with simultaneous evacuations in New Hampshire and Maine.



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Table 6-51: Multi-State Evacuation Clearance Times (in hours) (continued)

Suffolk County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane		Cat 1 (next to worst case) Hurricane		Cat 1 (worst case) & Cat 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Boston	8.5	8.6	10.9	11.4	12.9	13.5	7.3	7.4	9.1	9.6	12.2	12.7	6.1	6.2	7.3	7.8	11.9	12.4

Middlesex County	SLOW Response						MEDIUM Response						RAPID Response					
	Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane		Cat 1 & 2 (not worst case) Hurricane		Cat 2 (worst case) & Cat 3 & 4 (not worst case) Hurricane		Cat 3 & 4 (worst case) Hurricane	
	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.	Low Tour Occ.	High Tour Occ.
Cambridge	5.1	5.5	16.7	17.3	17.3	18.0	4.2	4.6	15.7	16.3	16.3	17.0	3.3	3.7	15.3	16.0	16.0	16.7



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6.12 Traffic Control Measures

6.12.1 General Recommendations

Most residents in Massachusetts, especially near Boston, are aware of the long traffic jams that occur during every day commutes. Officials from local jurisdictions must manage traffic flow along major routes. In addition, the movement of traffic through tunnels must be facilitated. Emergency tow trucks should be in position to remove broken down vehicles blocking travel. Roadway maintenance and minor construction blockages must be cleared to allow for evacuee traffic. To lessen the amount of background traffic, officials at the highest levels must discourage home to work and school related movements on the day of an evacuation.

Massachusetts is fortunate to have an extensive transportation network that is further enhanced by a robust Intelligent Transportation System (ITS) framework. Real time traveler information systems such as “511” and other programs are not only useful for the users of the roadway network, but also the traffic managers and emergency management officials, especially during hurricane evacuation operations. As mentioned earlier, since these clearance times do not factor in the impacts of any incidents, it is of paramount importance that any temporary impediments to traffic flow are resolved quickly and efficiently, especially at those locations specified in Table 6-20. All measures should be undertaken to be able to continuously monitor the flow of traffic at these locations and insure that incident management teams are pre-positioned nearby to handle any exigent circumstances. These locations in Table 6-20 should all have traffic cameras, or real-time traffic counters (preferably measuring vehicle counts and average speed), or other remote sensing capabilities, permanently emplaced with a means of getting the observations into the state and local Emergency Operations Centers (EOCs) and dispatch centers as they are collected.

While Massachusetts maintains the Cape Cod Emergency Traffic Plan to expedite the egress of vehicles over the Bourne and Sagamore Bridges, the following are some additional general observations and recommendations concerning evacuation not only for Barnstable County but the rest of the coastal area as well:

- In the behavioral analysis included in this report, it says, “One way of looking at the numbers would be to say that there was under-response in [the Scenario A Zone] in all three scenarios [Cat 2, 3 and 4]; over-response in [the Scenario B Zone] in the Category 2 scenario but under-response in the other two [Cat 3 and 4]; and over-response in the non-surge area in all three scenarios.” Given the high percentages of inland residents who indicated that they would evacuate in the 2013 Behavioral Analysis commissioned by the USACE, it is imperative that public information before and during the disaster specifically address who should not evacuate, as well as who should. Indications are



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these inland residents who are electing to leave their homes may be the largest component of the evacuating population in many jurisdictions, regardless of storm intensity. During Hurricane Floyd in 1999, many of the southeastern states learned from experience, that it is as important for local officials to clearly specify who is not ordered to evacuate, rather than concentrating solely on those who should.

- Where counties and the communities have sufficient personnel resources, officers should be stationed at critical intersections to facilitate traffic flow, especially those identified in Table 6-20 if not all of those in 6-14 and 6-18. Where intersections will continue to have signalized control, signal patterns should provide the most “green time” for the roadways identified and mapped as evacuation routes in this study.
- If possible, arrangements should be made with tow truck operators so that they are prepositioned along key travel corridors and critical roadway facilities such as bridges.
- High level bridges need to be monitored for the early arrival of sustained tropical storm winds. High profile vehicles such as recreational vehicles (RVs), trucks and buses could be adversely affected before the evacuation at ground level is completed or terminated.

6.12.2 Specific Recommendations

Except in the case of Cape Cod, this study shows that a considerable burden on the regional evacuation roadway network is caused by the vehicles evacuating within the local area and not necessarily by the evacuees traveling long distances. Those vehicles relocating to friends and family, as well as to public shelters in-county, impact the critical links identified in the report as much, and in some instances more, than the exiting trips. To accommodate all the evacuation movements in the Massachusetts coastal region the following specific recommendations are provided for consideration by federal, state and local officials:

- All draw/swing bridges needed for evacuation should be locked in the “down” position during a hurricane warning, if possible. The following bridges have the potential to exacerbate traffic congestion on all adjacent evacuation routes if allowed to open while an evacuation is underway:
 - US 1/MA 1A bridge over the Merrimac R. (AUA and AUB);
 - MA 107 bridge over the Saugus R. (EAS);
 - MA 1A/Gen. Edwards Bridge (BER);
 - MA 28/Charles River Dam Bridge (BOK);
 - Chelsea St Bridge (DHK);
 - Andrew McArdle Bridge (DHL and DHM);
 - MA 99/Alford St bridge (DGI);
 - Granite Ave bridge over the Neponset R. (DAZ);
 - MA 3A/Washington St bridge over the Weymouth Fore R. (BIO);



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- US 6 bridge over the Acushnet R. (AZK); and
- US 6 bridge over the Taunton R. (BAL).

Boat owners must be made aware of flotilla plans and time requirements for securing vessels.

- Coordinate with CSX, Pan American (PA), Massachusetts Coastal (MC), AmTrak and Metropolitan Boston Transit Authority (MBTA) to coordinate train schedules. Some railroad crossings are directly across the roadway and could complicate evacuations if long trains cause major delays on evacuation routes. The following evacuation route segments are all included in the transportation model that have railroad crossings that could be an impediment to evacuation traffic:
 - Hannover St (DYM) in Newbury (MBTA);
 - Topsfield Rd (DXU) in Ipswich (PA and MBTA);
 - MA 1A/Cabot St (BEB) in Beverly (PA and MBTA);
 - MA 62/Elliot St (DVV) in Beverly (PA and MBTA);
 - Eastern Ave (DPY) in Chelsea (PA and MBTA);
 - Everett Ave (DQP) in Everett (PA and MBTA);
 - Second St (DOZ) in Everett (PA and MBTA);
 - Cambridge St (DIB) in Cambridge (CSX);
 - Broadway (DII) in Cambridge (CSX);
 - Main St (DIO) in Cambridge (CSX);
 - First Parish Rd (CUK) in Scituate (MBTA);
 - Beaver Dam Rd (CUL) in Scituate (MBTA);
 - Gannett Rd (CUN) in Scituate (MBTA);
 - King St (CUY) in Cohasset (MBTA);
 - N. Main St (CUR) in Cohasset (MBTA);
 - MA 228 Hull St (CVC) in Hingham (MBTA);
 - Kilby St (CVK) in Hingham (MBTA);
 - Water St (CVP) in Hingham (MBTA);
 - Commercial St (CVW) in Weymouth (MBTA);
 - Willow St (CLG) in Yarmouth (MC);
 - Hyannis Barnstable Rd (CMP) in Barnstable (MC);
 - MA 149/Meetinghouse Way (CNP) in Barnstable (MC); and
 - Barlow's Landing Rd (CQR) in Borne (MC).
- Upon the Governor's signing of an emergency declaration in response to an approaching hurricane and subsequent evacuation all tolls should be lifted to expedite travel away from the coast and inland. Some evacuees may be dissuaded from using viable roadways because of tolls or the perception of long lines at toll plazas. In addition the



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toll plazas will constitute a traffic impediment, especially for those that do not have Fast Lane. Among the roadways with tolls that should be lifted are:

- The Massachusetts Turnpike (at least to I-495);
 - The Sumner Tunnel (since the toll is collected only for Boston-bound traffic);
 - The Ted Williams Tunnel (like the Sumner Tunnel); and
 - The Tobin Memorial Bridge.
- The implementation of more robust ITS measures in more states and urban jurisdictions makes effective coordinated communication among all response agencies responsible for evacuations all the more important. The Department of Transportation Traffic Management Centers (TMCs), Emergency Management EOCs, Law Enforcement Command Posts (CPs) and American Red Cross (ARC) Chapters should all be communicating and sharing data to ensure that all aspects of implementing evacuation operations from decision making to traffic management to sheltering are coordinated. Furthermore, it will be imperative for inland communities to know what level of evacuation may be coming their way and when it will start.
 - Consider the development and implementation measures necessary to reverse lane US 6 from the MA 6 A interchange in Orleans to the MA 134 interchange in Dennis during a Scenario B evacuation. The reverse lane would be reserved for traffic entering the operation at the beginning terminus (US 6A interchange), with traffic from the MA 137 and MA 124 interchanges only allowed to get on US 6 in the normal travel lanes. The reverse lane could be transitioned to the normal lanes at the ending terminus with the construction of a paved crossover. This operation would be relatively easy to implement, especially with the prepositioning of required maintenance of traffic (MOT) and other equipment, and would enhance the conveyance of vehicles through the most congested evacuation roadway segments in the state.
 - Additionally, more vehicles from the communities of eastern Cape Cod could be diverted to MA 6A, even if their intended route is US 6. The vehicles shunted to this alternate roadway could be allowed to enter onto US 6 at the MA 134 and Willow St interchange in Dennis. This measure would bypass the same very congested roadway portion of US 6 from Orleans through Harwich and Dennis, with the vehicles from MA 6A entering US 6 after the roadway has widened to a four lane facility.

6.13 Report Summary

Fortunately, Massachusetts maintains a well-developed transportation system that provides a great deal of capacity during hurricane evacuations. Most of the communities, especially Boston and south are part of the Boston-Washington urban corridor, complete with a robust



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and sophisticated transportation network. The roadway network developed for daily commuting lends itself well to providing evacuation corridors for nearby coastal residents

Despite the potential for a hurricane to require the evacuation of many residents from communities along the coast, and the ensuing large volume of vehicles that such an exodus would create, the network is generally able to accommodate the demand. The clearance times provided in this report, except in the case of a major evacuation of the Cape Cod region, are within relatively reasonable limits when compared with other areas around the country. Other than the instance mentioned above, the clearance times, even for a major hurricane event, are within the protective action implementation timeframes allowed under a Hurricane Warning from the National Hurricane Center (NHC). That being said, the figures provided in the report are high enough to warrant any and all efforts to decrease those numbers and employ measures to lessen the burden, or maximize the flow of traffic on those roadways away from the coast.

Any exigent circumstances on the evacuation roadway network could dramatically increase the time needed to clear the transportation system of all vehicles using it to flee the storm. Also, differences between a hurricane's actual approach and its forecast with respect to intensity, track, size, or storm characteristics can significantly compress the amount of time communities have to implement appropriate protective actions.

During the approach of a hurricane, any failure in the traffic management system to facilitate flow through any of the critical links identified in this report could significantly increase the above clearance times. Additionally, such uncontrollable factors as accidents, poor driving and roadway conditions and even the time of day an evacuation order is issued can serve to exacerbate the situation and inflate the timeframes provided in this report.

Furthermore, the speed at which some tropical cyclones can move forward at these latitudes means that protective actions may have to be implemented, and possibly even completed, before the weather begins to exhibit deteriorating conditions. They can also be erratic in their track, intensity and predicted effects, which may not always allow local officials sufficient time to complete all the appropriate protective actions before the arrival of hazards. Given that some of the identified critical roadway segments on the regional evacuation network are located near the coastline, vehicles queues of evacuating vehicles could easily extend back into the hazard areas, thereby trapping evacuees in harm's way.

Therefore, concerted planning efforts to facilitate hurricane protective actions along the coast must continue, especially in Cape Cod and coastal Plymouth County. In addition to the roadway and traffic control measures described above, planning measures should include any means to limit traffic demand on the identified critical bottlenecks throughout the region. Hurricane



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evacuation planning issues should also include: identifying viable shelter facilities between the coast and the critical links provided in this study to intercept those evacuating vehicles before they reach those most congested roadway segments; preparing public information to better inform not only who should evacuate, but also who should not; and any measures to encourage evacuees to use less obvious and alternative routes away from the coast. In implementing the above measures, it is hoped that the information contained in this report will serve to increase the margin of safety for the residents and visitors of Massachusetts and enhance the degree of comfort that local officials will need in implementing the necessary protective actions for any hurricane threat.