CAPE COD COMMISSION

Route 28 Centerville-Hyannis Corridor Study

Old Stage Road to Bearses Way

February 2016

COUNTY OF BARNSTABLE MASSACHUSETTS

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Executive Summary

Route 28 in Barnstable is a key east-west travel corridor that provides access into Hyannis, the largest commercial area on Cape Cod. The 2.5-mile section of Route 28 between Old Stage Road and Bearses Way was identified as a priority for investigation based on demonstrated safety and congestion issues and a need to improve accommodation for all users.

> *The purpose of this study is to develop alternatives that will provide safe and convenient access within the study area for all users of the roadway system including pedestrians, bicyclists, and motorists.*

With the benefit of active participation by members of the community, a detailed analysis of existing conditions was conducted to pinpoint issues along the corridor. Beginning with recommendations from the public and working closely with Town staff, a host of potential improvement options were developed throughout the corridor. Alternatives were examined in the context of several different issue areas such as traffic congestion, safety, and bicycle/pedestrian accommodation. Below is a summary of the areas examined along the corridor:

- Options for Corridor Improvements with Concept Plans
  - Route 28 from Old Stage Road to Phinneys Lane
- Identification and Preliminary Analysis of Intersection Improvements
  - Route 28 at Old Stage Road
  - Route 28 at Phinneys Lane
  - Route 28 at West Main Street
  - Route 28 at Pitchers Way
  - Various other improvements along the corridor
- Coordination with and Support of Other Planning Efforts
  - Route 28 at Strawberry Hill Road (Road Safety Audit and MassDOT FY2016 Construction Project)
  - Route 28 at Barnstable Senior Center/Intermediate School (Town-led comprehensive analysis of access issues)
  - Route 28 at Lincoln Road (Town-led traffic calming project on Lincoln Road)
  - Route 28 at Bearses Way (MassDOT FY15 Construction Project)

Rather than identify a single preferred alternative, this report outlines the host of improvement options that can be considered and advance as funding becomes available. To assist in prioritizing improvements, the report identifies the relative time frame, cost, and expected benefit in terms of safety and congestion, including bicycle and pedestrian accommodation for each potential improvement. A summary of the improvement options is presented on the following page.

TABLE 1 - SUMMARY OF IMPROVEMENT OPTIONS

Potential Enhancement	Time Frame	Cost	Expected Benefit		
			Safety	Congestion	Bike/Ped
1. Route 28 at Old Stage Road					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Expand SB approach to three full lanes	Long-Term	Medium-High	Low	Low-Medium	-
2. Route 28 at Four Lane Segment (Old Stage Road to Phinneys Lane)					
A. 4-Lane, continuous median within ROW	Long-Term	High	High	High	Medium-High
B. 4-Lane, median with turn pockets within ROW	Long-Term	High	High	Medium-High	Medium
C. 5-Lane, undivided with (2WB, 2EB, and TWLTL) within ROW	Unsafe, should not be advanced				
D. 4-Lane, median with turn pockets, expanded ROW	Long-Term	High	High	Medium-High	Medium-High
E. 4-Lane, median with signal within ROW	Long-Term	High	High	Medium	Medium
F. 3-Lane, undivided with (1WB, 1EB, and TWLTL) within ROW	Long-Term	High	High	-	Medium
3. Route 28 at Phinneys Lane					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Realignment	Long-Term	High	High	Medium	Medium
D. Roundabout	Long-Term	High	High	TBD	Medium
4. Route 28 at West Main Street					
A. ADA pedestrian accommodation upgrades	Mid-Term	Medium	Low	-	Medium
B. Designate WB left lane as LT only	Mid-Term	Low	Low-Medium	-	-
5. Route 28 at Strawberry Hill Road					
A. Signal equipment and phasing upgrades, pavement marking, ADA pedestrian accommodation upgrades	MassDOT project funded for FY2016	± $500,000	Medium	Low-Medium	High
B. Re-grading and realignment	Long-Term	High	Medium	Low	Low
6. Route 28 at Barnstable Senior Center/Intermediate School					
A. New/enhanced crosswalks and sidewalks	Mid-Term	Medium	Medium	-	High
B. Signal or Roundabout	Long-Term	High	High	TBD	High
7. Route 28 at Lincoln Road					
Results of the traffic calming measures on Lincoln Road should be assessed before altering the intersection					
A. Add WB LT lane	Long-Term	High	Medium	TBD	-
B. Signal or Roundabout	Long-Term	High	High	TBD	Low-Medium
8. Route 28 at Pitchers Way					
A. Retiming with LT phase	Mid-Term	Medium	Medium	Low-Medium	-
B. ADA pedestrian accommodation upgrades including north-south crosswalk	Mid-Term to Long-Term	Medium-High	Medium-High	-	Medium-High
9. Route 28 at Bearses Way					
A. Intersection reconstruction with additional lanes and bike/ped improvements (includes work to Cape Cod Mall entrance)	MassDOT project funded for FY2015	± $6 Million	High	High	High
10. Other Potential Enhancements					
A. Multi-use path maintenance/rehabilitation	Ongoing	Low-Medium	Low-Medium	-	Low-Medium
B. Multi-use path signage and way-finding	Mid-Term	Low-Medium	Low	-	Low-Medium
C. Address gaps in sidewalks	Mid-Term	Medium-High	Medium-High	-	Medium-High
D. Improve/increase north-south pedestrian crossing	Long-Term	Medium-High	High	-	High
E. Add north side sidewalk where appropriate	Long-Term	High	Medium-High	-	Medium-High
F. Review/revise bus stop locations	Short-Term	Low	Medium	-	Medium
G. Bus shelters	Mid-Term	Medium	Low	-	Low
H. Bus turnouts	Long-Term	High	Medium	Low-Medium	Medium
I. Corridor-wide landscaping upgrades	Mid-Term	Medium-High	Low	-	Low
J. Stormwater management upgrades	Long-Term	Medium-High	Low	-	Low
K. Access management	Ongoing	-	High	High	High
Notes: ADA = Americans with Disabilities Act; EB = eastbound; NB = northbound; SB = southbound; WB = westbound; LT = left turn; TWLTL = two-way left-turn lane; ROW = Right of way; TBD = to be determined (additional analysis would be required)					

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Introduction

Route 28 in Barnstable is one of three major regional east-west transportation corridors on Cape Cod, as well as a commercial destination for visitors and residents alike, with numerous attractions, businesses, hotels and restaurants. The section of Route 28 from Old Stage Road to Bearses Way has been identified as a priority for investigation. This section of roadway is often congested, particularly in the summer months. Congestion is a barrier to reliable and convenient access to Hyannis; the largest commercial destination on Cape Cod and the location of the Cape Cod Hospital, the Barnstable Municipal Airport, the Cape Cod Regional Transportation Authority, the Hyannis Transportation Center, and the Steamship Authority.

In addition to congestion issues, high traffic volumes, geometric problems, and a large number of curb cuts on portions of the corridor have resulted in transportation safety issues. One location where concerns have been raised recently is the four-lane, undivided section of Route 28 just east of Old Stage Road where there has been a pair of fatalities in recent years. Another high-crash location is at the intersection of Route 28 and Bearses Way. Plans for reconstruction of this intersection are currently underway as part of an approximately $6 million Massachusetts Department of Transportation (MassDOT) project with construction to begin in 2016.

Also of key concern is accommodation for all road users including motorists, pedestrians, bicyclists, and transit users ("non-motorists"). This is a heavily used corridor for non-motorized users. Non-motorists can access many jobs and retail destinations from their neighborhoods. The need is particularly pronounced given that much of the corridor is within and adjacent to Environmental Justice communities with a high number of households that may not have access to automobiles and may rely on other forms of transportation to perform their daily tasks. Comments received at public outreach meetings indicate that there is a large number of seasonal foreign workers who travel along this corridor by non-motorized means.

Any potential improvements along this corridor must be balanced with impacts on the environment and neighboring properties which includes a significant number of commercial and residential parcels.

STUDY AREA

The segment of Route 28 in Barnstable identified as the study area is approximately 2.5 miles from Old Stage Road in the Village of Centerville to Bearses Way in the Village of Hyannis. This will build on previous work underway on Route 28 in Barnstable including the Hyannis Access Study that extended as far west as the Cape Cod Mall entrance and the Bearses Way improvement project that picked up at the Cape Cod Mall entrance and will extend through the Bearses Way intersection. The study area is shown in the following figure.

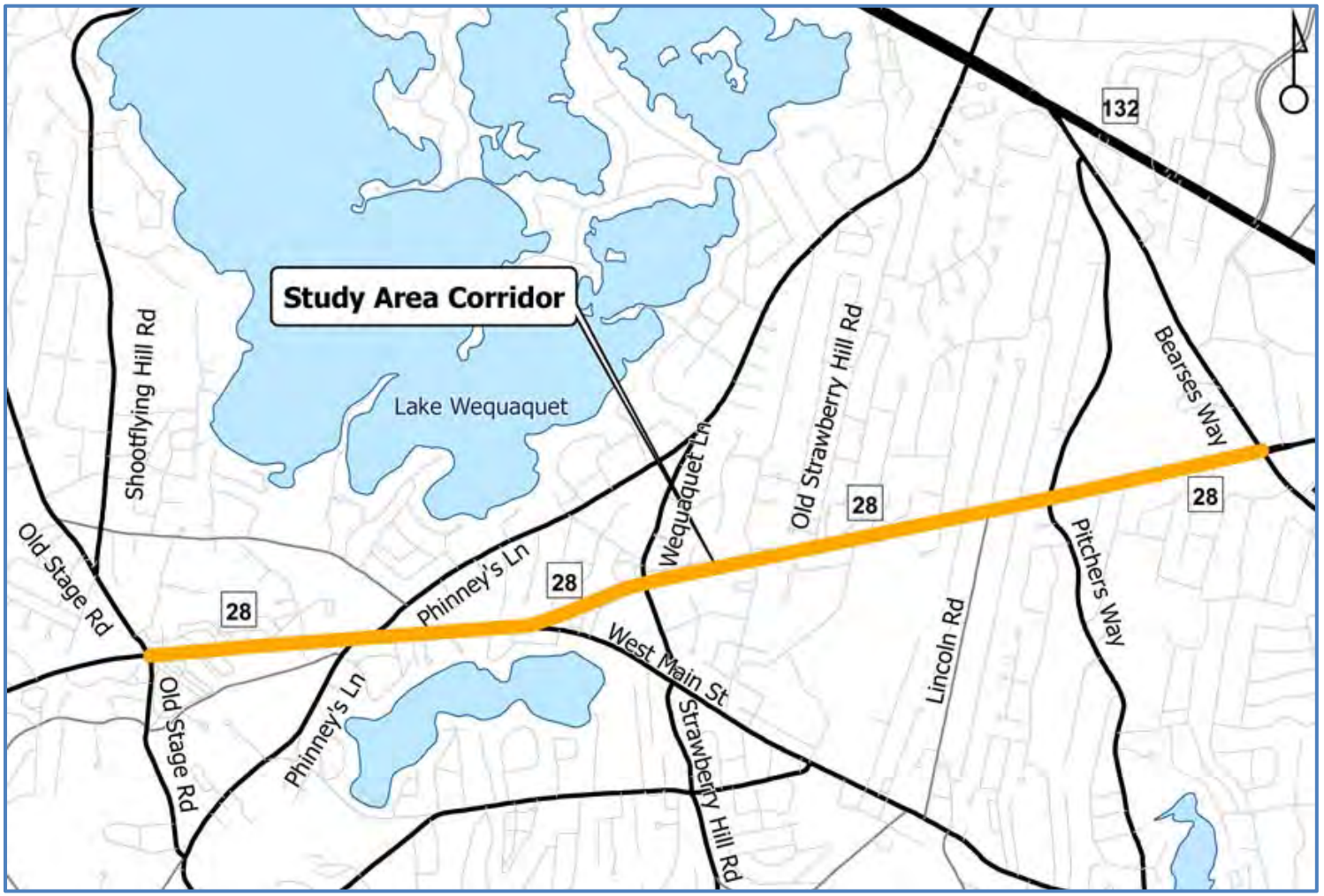

FIGURE 1 - STUDY AREA

STUDY GOALS

The purpose of this study is to develop alternatives that will provide safe and convenient access within the study area for all users of the roadway system including pedestrians, bicyclists, and motorists. The goals of this study are to:

- Improve Safety
- Reduce congestion
- Improve accommodation of all users

PREVIOUS AND ONGOING STUDIES AND PLANS

Cape Cod Commission staff reviewed a number of previous studies and plans as well as those that are currently underway. These included:

- Lane Departure Road Safety Audit for Route 28 in Barnstable, Massachusetts (2007)
- Hyannis Access Study (August 2008)
- Road Safety Audit: Route 28 (Falmouth Road)/Bearses Way Town of Barnstable (May 2009)
- Hyannis Access Study *Implementation* (June 2013)
- Road Safety Audit: Route 28 (Falmouth Road) at Strawberry Hill Road Town of Barnstable (May 2015) [MassDOT Project 607753 funded in FY2018]
- Function Design Report (2013) and Design Plans for Route 28 at Bearses Way [MassDOT Project 606394 funded in FY2015] (see following figure)
- Barnstable Senior Center/Barnstable Intermediate School access improvement development (ongoing)
- Lincoln Road traffic calming installation (ongoing)

FIGURE 2. ROUTE 28 AT BEARSES WAY MASSDOT PROJECT

Existing Conditions

Commission staff began this study by conducting a thorough analysis of the existing conditions of the study area. This included reviewing the zoning, land use, bicycle and pedestrian accommodations, transit connections, traffic volumes, speed limit, and crash history. Combining the existing conditions analysis with observations made during site visits, the corridor was characterized into different areas.

ZONING AND LAND USE

Zoning and land use varies through the corridor as shown in the figures below. The western end of the corridor is primarily developed commercial lots consist with the Highway Business (HB) and Highway Office Business (HO) zoning. The rest of the corridor is a mix of residential, business, and government uses some of which fall under their zoning designation while others are pre-existing uses.

FIGURE 3 – EXISTING CONDITIONS: ZONING

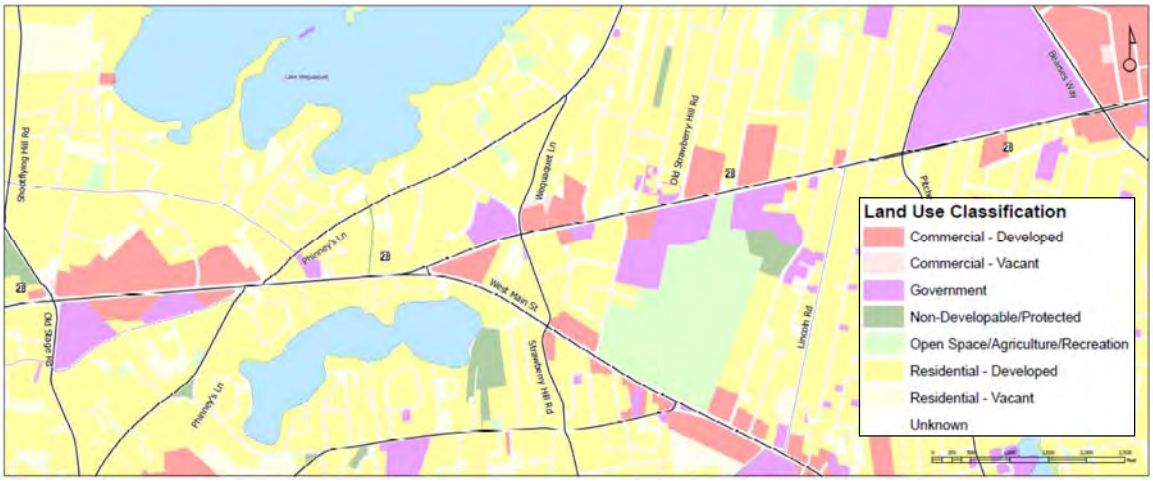

FIGURE 4 – EXISTING CONDITIONS: LAND USE

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BICYCLE/PEDESTRIAN ACCOMMODATIONS AND TRANSIT CONNECTIONS

In addition to serving motorists, the Route 28 corridor provides an important link for bicyclists, pedestrians and transit users. The figures below show the bicycle, pedestrian, and transit accommodations within the corridor along with the transit routes in the vicinity of the corridor. While many multi-modal accommodations exist, there are still deficiencies along the corridor, such as a lack of safe north-south pedestrian connections, which will be discussed later in this report.

FIGURE 5 – EXISTING CONDITIONS: BICYCLE/PEDESTRIAN ACCOMMODATION

FIGURE 6 – EXISTING CONDITIONS: TRANSIT

TRAFFIC VOLUMES

Average daily traffic volumes on Route 28 vary from 15,000 to 25,000 vehicles in the off-peak months to over 32,000 during peak months. As shown in the figure below, during a July 4-5pm peak hour the traffic volumes range from 1,700 to 2,300 vehicles per hour with lesser volumes on the intersecting roadways. Location-specific traffic volume data are included in the appendix.

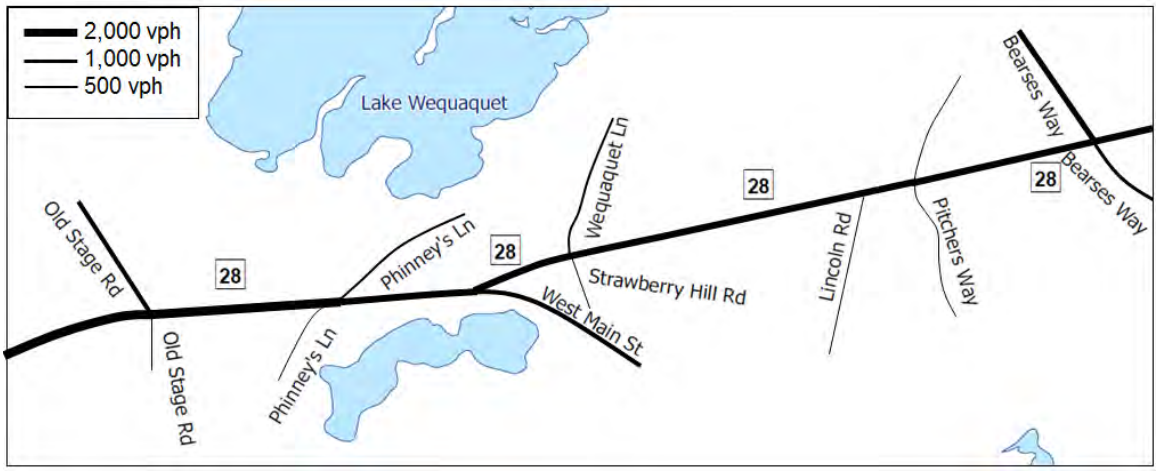

FIGURE 7 – EXISTING CONDITIONS: JULY 4-5PM TRAFFIC VOLUMES

SPEED LIMITS AND CRASH HISTORY

The posted speed limit on the roadway is 45 mph throughout the corridor with the exception of the vicinity of West Main Street where the speed limit drops to 40 mph. There is also a school zone in front of the Barnstable Intermediate School where the speed limit is posted at 20 mph when flashing.

Crash records from the MassDOT online crash portal as well as crash reports from the Barnstable Police Department were reviewed to establish the crash history of the corridor. A total of 389 crashes were reported on this stretch of roadway from 2011 through 2013 as shown in the following figure.

The highest crash locations along Route 28 were at the intersections: Old Stage Road (41), Bearses Way (37), the Centerville Shopping Area (33), Pitchers Way (28), Lincoln Road (27), the Bell Tower Mall Shopping Plaza (27), Phinneys Lane (23), and Strawberry Hill Road (17). With the exception of the Bearses Way intersection since it will soon be reconstructed by MassDOT, staff compiled detailed collision diagrams of these locations as included in the appendix.

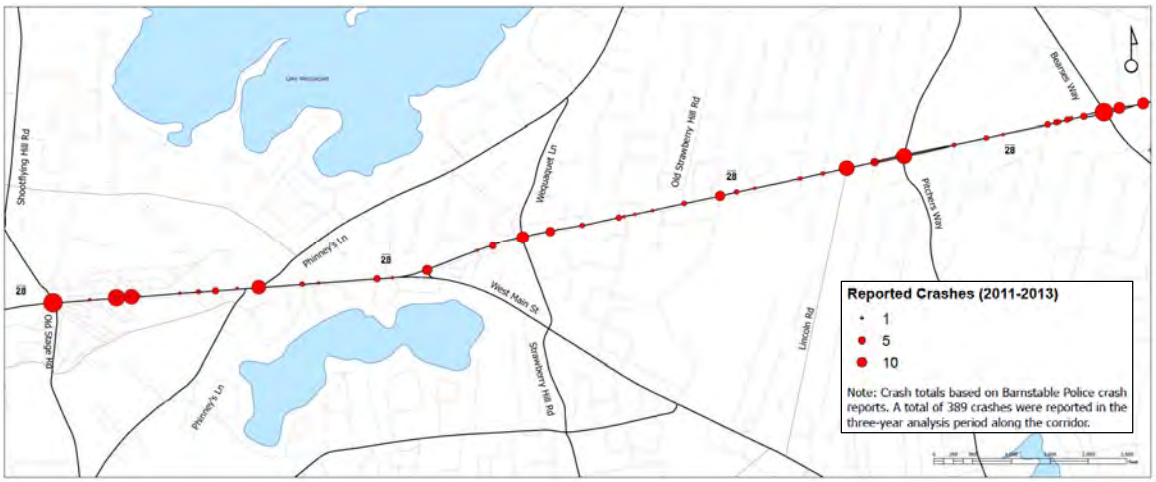

FIGURE 9 – EXISTING CONDITIONS: CRASH HISTORY

SITE VISITS

To take accurate measurements and gain a more complete awareness of conditions along the corridor, Commission staff made a number of site visits. As shown in the figure below, staff noted vehicle congestion and confusion, multi-use path design and maintenance issues, drainage issues, and evidence of pedestrian desire lines where no accommodations exist.

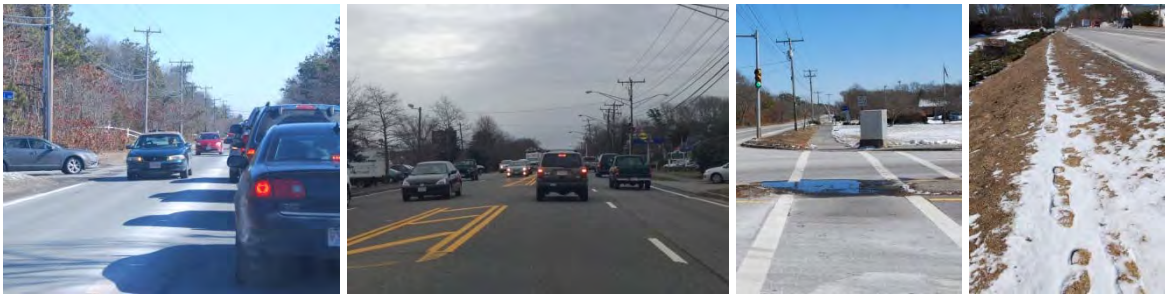

FIGURE 10 – SITE VISIT PHOTOGRAPHS

Plan Development

From the outset, the Barnstable 28 Corridor Study project has benefitted from a robust public participation process with the following goals:

- Gather input from community stakeholders and the public to establish a vision for the corridor;
- Develop a forum for ideas aimed at achieving this vision as well as concerns regarding potential changes; and
- Solicit feedback of potential alternatives.

As the project advanced, several parallel planning initiatives took place including:

- Road Safety Audit at the intersection of Route 28 at Strawberry Hill Road,
- Development of a plan for improved access to the Barnstable Senior Center/Barnstable Intermediate School, and
- Development of traffic calming options on Lincoln Road.

TABLE 2 – KEY PROJECT MEETINGS

Type	Date	Attendees	Purpose
Kickoff Meeting with Town Staff	February 14, 2014	Town Staff, CCC Staff	To refine the project Scope of Work
Initial Kickoff Meeting	March 27, 2014	Public	To present existing conditions, identify issues along the corridor
Coordination with Senior Center and Intermediate School	April 30, 2014	Senior Center and School Staff, Town Staff, CCC Staff	To discuss site access issues
Focused Listening Sessions	May 28, 2014	Public	Gather comments and feedback on potential solutions to issues
Online Comments (Barnstable iForum)	June 2014	Public	Gather comments
Alternatives Development Discussion	August 27, 2014	Town Staff, CCC Staff	Present concepts for prioritization and solicit endorsement to further study
Coordination with Parallel Planning Efforts	Various September 2014-15	Various	Participate in planning efforts and integrate with corridor study
Alternatives Review	September 2015	Town Staff, CCC Staff	To discuss alternatives and identify next steps

Initial Kickoff Meeting

The first step of the project was to meet with local stakeholders including local residents, local business owners, and other interested parties. The purpose of this meeting was to review and prioritize project goals and identify opportunity areas and constraints.

The presentation from the meeting, meeting notes, and the map based activity are included in the appendix. The map-based activity proved particularly useful in identifying issues along the corridor. The figure below shows a sample of feedback from the map-based activity.

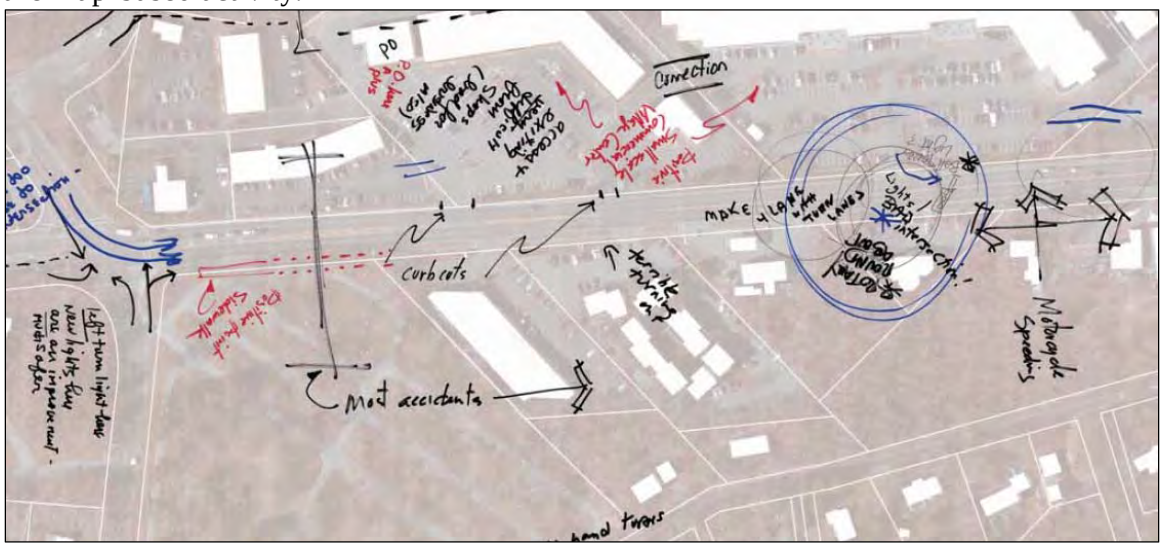

FIGURE 11 – MAP-BASED ACTIVITY SAMPLE

Some of the strengths and issues along the corridor that were identified include:

Strengths

- Services like Post Office, Dunkin Donuts, banks, convenience stores
- Road is pretty mostly with trees
- Bike/multi-use path gets used
- Sidewalks leading to corridor
- Private easements for sidewalks
- Mixed use is a plus with small shops and residential
- Access to Hyannis
- Local businesses

Issues

- Speeding vehicles and motorcycles as threat to pedestrians
- Left turns
- Signals are not coordinated and to not react to traffic
- 4 lanes to 2 lanes to 4 lanes
- Lack of safe pedestrian crossing and connections to the “mall area”
- Speeding vehicles and motorcycles as threat to pedestrians
- Traffic enforcement
- Interconnect not possible between Centerville Shopping Center and Bell Tower Mall
- Pedestrians in the road

Focused Listening Sessions

Commission staff facilitated a targeted listening session with local landowners and other stakeholders to gather comments and provide feedback on potential solutions for the issues identified in the kickoff meeting.

Following the public meetings, and considering all public comments received, staff developed a set of potential improvement alternatives that are discussed later in this report.

List of Potential Alternatives from Public Input

1. Old Stage Road Intersection
    - Retiming
    - Addition of LTR Lanes (Particularly SB Leg)
2. Centerville 4 Lane Segment
    - Median/ Boulevard
    - Left Turn Pockets
    - Center Turn Lane
    - New Signal
3. Phinneys Lane Intersection
    - Retiming
    - Realignment
    - Roundabout
4. West Main St Intersection
    - LT lanes WB
5. Strawberry Hill intersection
    - LT signal phase
    - Ped phase
    - Regrade and realignment
6. Barnstable Intermediate School Entrance/ High School Back Entrance
    - Signal
7. Lincoln Road
    - Turn Lane
    - Signal
    - Roundabout
8. Pitchers Way Intersection
    - Retiming
    - Addition of LT Phase
9. Other Ideas
    - Multi-Use Signage and Maintenance
    - Abandoned Gas Station options
        - Bus Turnout
        - Landscaping
    - Access Management
    - Back Access to Strip Malls
    - Sidewalk Connectivity
    - Southside Drainage
    - More Pedestrian Crossings
    - North side Sidewalk on East end
    - Bus Stop at Pitchers Intersection
    - Bus Stop Pullouts

Consideration of Comments

Commission staff reviewed comments made during the public meetings, from the online Barnstable iForum, and via email. These comments helped to inform the development of alternatives.

Alternative Development and Review

Commission staff met with Town staff to review the potential alternatives for consideration and prioritize the alternatives for further review. Further discussion of alternatives is presented in the following section of the report.

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Alternatives Development

The following study goals were used in selecting alternatives for further evaluation:

- *Improve safety*
- *Reduce congestion*
- *Improve accommodation of all users*

The alternatives discussed in this section are summarized in the following table. Each option was characterized by time frame (short-, mid-, or long-term); cost (low, medium, high); and magnitude (low, medium, high) of expected benefit to each of three priority areas: safety, congestion, and bicycling/pedestrian needs. It is important to note that the assessments of benefits are developed as an overall comparative measure. While there are not "preferred" alternatives selected for the study area locations, the expected benefits and potential costs can assist decision-makers in selecting projects for implementation.

TABLE 3 - SUMMARY OF IMPROVEMENT OPTIONS

Potential Enhancement	Time Frame	Cost	Expected Benefit		
			Safety	Congestion	Bike/Ped
1. Route 28 at Old Stage Road					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Expand SB approach to three full lanes	Long-Term	Medium-High	Low	Low-Medium	-
2. Route 28 at Four Lane Segment (Old Stage Road to Phinneys Lane)					
A. 4-Lane, continuous median within ROW	Long-Term	High	High	High	Medium-High
B. 4-Lane, median with turn pockets within ROW	Long-Term	High	High	Medium-High	Medium
C. 5-Lane, undivided with (2WB, 2EB, and TWLTL) within ROW	Unsafe, should not be advanced				
D. 4-Lane, median with turn pockets, expanded ROW	Long-Term	High	High	Medium-High	Medium-High
E. 4-Lane, median with signal within ROW	Long-Term	High	High	Medium	Medium
F. 3-Lane, undivided with (1WB, 1EB, and TWLTL) within ROW	Long-Term	High	High	-	Medium
3. Route 28 at Phinneys Lane					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Realignment	Long-Term	High	High	Medium	Medium
D. Roundabout	Long-Term	High	High	TBD	Medium
4. Route 28 at West Main Street					
A. ADA pedestrian accommodation upgrades	Mid-Term	Medium	Low	-	Medium
B. Designate WB left lane as LT only	Mid-Term	Low	Low-Medium	-	-
5. Route 28 at Strawberry Hill Road					
A. Signal equipment and phasing upgrades, pavement marking, ADA pedestrian accommodation upgrades	MassDOT project funded for FY2016	± $500,000	Medium	Low-Medium	High
B. Re-grading and realignment	Long-Term	High	Medium	Low	Low
6. Route 28 at Barnstable Senior Center/Intermediate School					
A. New/enhanced crosswalks and sidewalks	Mid-Term	Medium	Medium	-	High
B. Signal or Roundabout	Long-Term	High	High	TBD	High
7. Route 28 at Lincoln Road					
Results of the traffic calming measures on Lincoln Road should be assessed before altering the intersection					
A. Add WB LT lane	Long-Term	High	Medium	TBD	-
B. Signal or Roundabout	Long-Term	High	High	TBD	Low-Medium
8. Route 28 at Pitchers Way					
A. Retiming with LT phase	Mid-Term	Medium	Medium	Low-Medium	-
B. ADA pedestrian accommodation upgrades including north-south crosswalk	Mid-Term to Long-Term	Medium-High	Medium-High	-	Medium-High
9. Route 28 at Bearses Way					
A. Intersection reconstruction with additional lanes and bike/ped improvements (includes work to Cape Cod Mall entrance)	MassDOT project funded for FY2015	± $6 Million	High	High	High
10. Other Potential Enhancements					
A. Multi-use path maintenance/rehabilitation	Ongoing	Low-Medium	Low-Medium	-	Low-Medium
B. Multi-use path signage and way-finding	Mid-Term	Low-Medium	Low	-	Low-Medium
C. Address gaps in sidewalks	Mid-Term	Medium-High	Medium-High	-	Medium-High
D. Improve/increase north-south pedestrian crossing	Long-Term	Medium-High	High	-	High
E. Add north side sidewalk where appropriate	Long-Term	High	Medium-High	-	Medium-High
F. Review/revise bus stop locations	Short-Term	Low	Medium	-	Medium
G. Bus shelters	Mid-Term	Medium	Low	-	Low
H. Bus turnouts	Long-Term	High	Medium	Low-Medium	Medium
I. Corridor-wide landscaping upgrades	Mid-Term	Medium-High	Low	-	Low
J. Stormwater management upgrades	Long-Term	Medium-High	Low	-	Low
K. Access management	Ongoing	-	High	High	High
Notes: ADA = Americans with Disabilities Act; EB = eastbound; NB = northbound; SB = southbound; WB = westbound; LT = left turn; TWLTL = two-way left-turn lane; ROW = Right of way; TBD = to be determined (additional analysis would be required)					

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LOCATION 1: OLD STAGE ROAD INTERSECTION

This signalized intersection (shown in the following figure) consists of a variety of approach lane characteristics:

- Route 28 (east leg): left turn lane, through lane, through/right turn lane; two receiving lanes for outbound traffic. Includes a pedestrian push button/signal head and crosswalk with faded pavement markings. A sidewalk is available on the north side, a shared-use path is available on the south side.
- Route 28 (west leg): left turn lane, through lane, through/right turn lane; two receiving lanes for outbound traffic.
- Old Stage Road (north leg): left turn lane, through lane with right-turn slip lane & island; narrow landscaped median; wide receiving lane for outbound traffic (can accommodate two cars side-by-side). Includes a pedestrian push button/signal head and crosswalk with faded pavement markings.
- Old Stage Road (south leg): through/left turn lane, right/through lane; median island; single receiving lane for outbound traffic. Includes a pedestrian push button/signal head and crosswalk with faded pavement markings. A sidewalk is available on the east side.

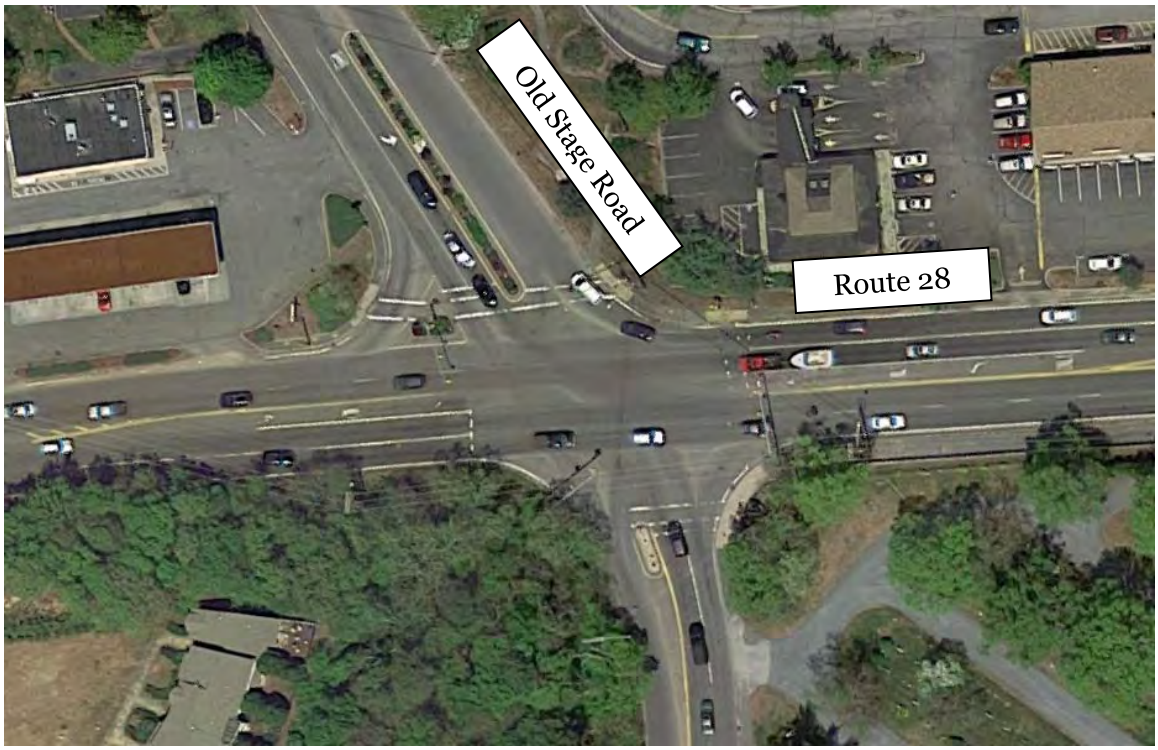

FIGURE 12 - ROUTE 28 AT OLD STAGE ROAD (AERIAL VIEW)

Options

Possible improvements at this location are listed as follows:

Option 1A (short-term): Signal Retiming

This is a low-cost option that can be expected to provide low-medium congestion benefits and low safety benefits. By optimizing the signal timing and phasing the intersection will operate more efficiently and the reduced delay should minimize driver frustration.

Option 1B (medium-term): ADA Pedestrian Accommodation Upgrades

This option addresses the need to accommodate users in conformance with the Americans with Disabilities Act (ADA). Upgrades include crosswalk installations/modifications to accommodate wheelchairs and low-vision users. The implementation cost of this option is in the low-medium range and is expected to have low safety and bicycle/pedestrian benefits.

Option 1C (long-term): Expand Old Stage Road Southbound Approach to Three Full Lanes

As a medium-high cost option, the expansion of the southbound approach from the current two-lane configuration to three lanes (allowing for dedicated left-turn, through-, and right-turn lanes) is expected to provide low safety benefits and low-medium congestion benefits.

LOCATION 2: CENTERVILLE FOUR-LANE SEGMENT

From Old Stage Road to Phinneys Lane, Route 28 in Centerville consists of two travel lanes in each direction within an available right-of-way of 80 feet of width. A narrow sidewalk exists on the north side, often directly adjacent to the traveled way and protected by granite curbing. On the south side there is a substandard bike path approximately 8 feet wide that functions as a wide sidewalk. There are numerous curb-cuts and commercial sites on both sides of the road, including two major shopping centers on the north side of Route 28 and a variety of commercial businesses on the south side. Detailed concept plans for this segment of Route 28 are available in the appendix.

FIGURE 13 - AERIAL VIEW - ROUTE 28 CENTERVILLE FOUR-LANE SEGMENT - EXISTING CONDITIONS

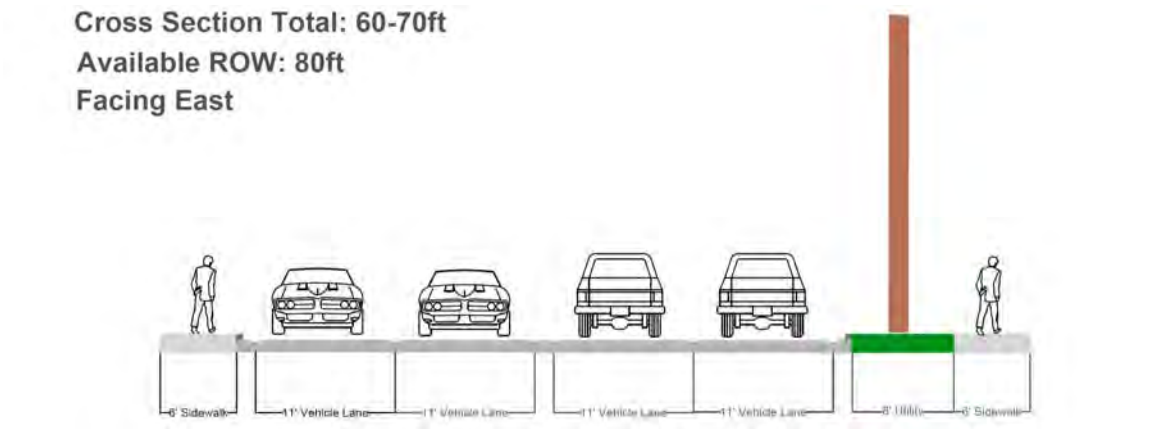

FIGURE 14 - ROUTE 28 CENTERVILLE FOUR-LANE SEGMENT CROSS-SECTION - EXISTING CONDITIONS

Mainline traffic waiting to turn left into one of the commercial sites often must wait for a gap in the oncoming traffic, thus blocking other through vehicles and generating queues. To a lesser extent, queueing also occurs due to waiting for right-turning vehicles. For vehicles exiting one of the many site drives and wishing to turn left onto Route 28, these motorists are often faced with the irregular behavior of Route 28 motorists, some of which, but not all, may stop to allow traffic to exit the driveway. When this happens the site traffic noses out into the first (right) lane of Route 28 and then must wait for a

patient second (left) lane motorist willing to stop and let the motorist proceed. Once this portion of the maneuver is completed the site motorist must still find a gap in traffic to merge to complete the left turn.

All of these difficulties that are characteristic of undivided four-lane roadways (and other concerns such as the potential head-on collisions) have led to strategies and policies that fall under the Safety goal of the Cape Cod Regional Transportation Plan (RTP):

RTP Safety Policy:

- *For proposed roadways with cross-sections of four or more lanes, landscaped median dividers shall be included to provide a reasonable level of safety and access management.*

RTP Safety Strategy:

- *Existing multilane roads (cross-sections of four or more lanes) are recommended to be modified via removal of unneeded lanes or installation of landscaped median dividers to provide a reasonable level of safety and access management.*

Options

Possible improvements at this location are listed as follows:

Option 2A (long-term): Four-Lane, Median, Within Existing Right-Of-Way

FIGURE 15 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION – OPTION 2A

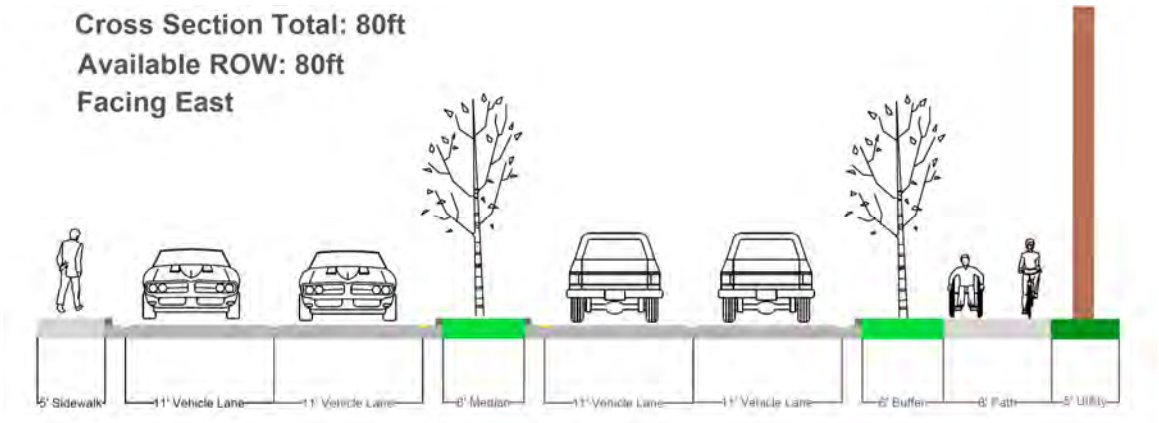

FIGURE 16 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2A

In this option, the roadway within the available right-of-way would be reconfigured to include a six foot landscaped uninterrupted median. An additional change would be to relocate the utilities along roadway on the south side of Route 28 to the southern edge of the right-of-way. This option is estimated to have high cost and provide high safety and congestion benefits and medium-high bicycle/pedestrian benefits.

Option 2B (long-term): Four –Lane, Median w/Turn Pockets, Within Existing Right-Of-Way

FIGURE 17 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION – OPTION 2B

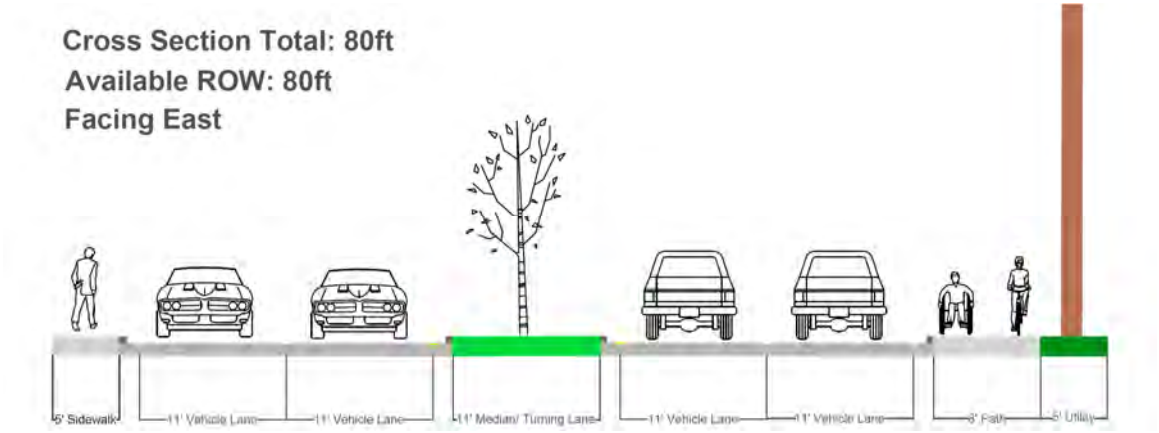

FIGURE 18 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2B

This option includes an eleven foot landscaped median with left turn pockets located at high-volume driveways. The south side bike path would be adjacent to the traveled way and the utilities would be relocated to the southern edge of the right-of-way. This option is estimated to have high cost and provide high safety and bicycle/pedestrian benefits and medium-high congestion benefits.

Option 2C: Five-Lane, Undivided (Two Eastbound Lanes, Two Westbound Lanes, a Two-Way Left Turn Lane, Within Existing Right-Of-Way

FIGURE 19 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION – OPTION 2C

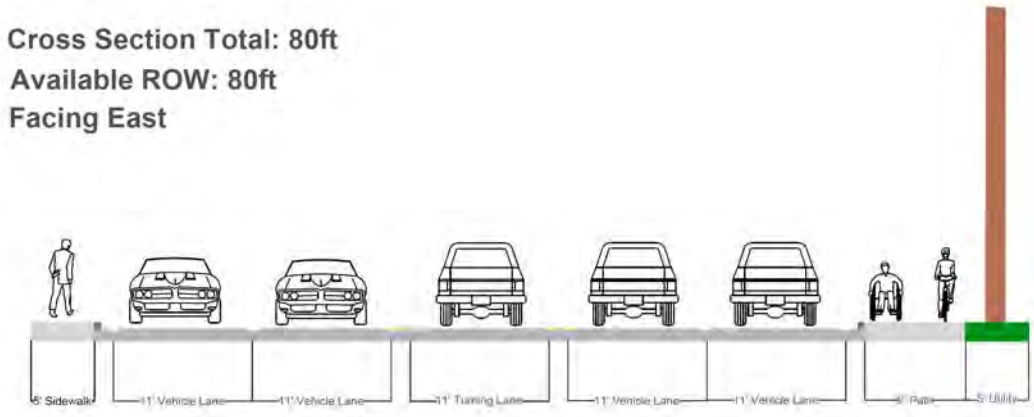

FIGURE 20 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2C

Using nearly the entire right-of-way, this high-cost option includes an eleven-foot wide two-way left turn lane (TWLTL). The south side bike path would be adjacent to the traveled way and the utilities would be relocated to the southern edge of the right-of-way. Due to safety concerns associated with a five-lane TWLTL, this option is not recommended for further consideration. Expansion of this roadway is inconsistent with the Regional Transportation Policy: "For proposed roadways with cross-sections of four or more lanes, landscaped median dividers shall be included to provide a reasonable level of safety and access management." A roadway expansion such as identified in this alternative would not be eligible for federal or state funding.

Option 2D (long-term): Four-Lane, Median w/Turn Pockets, Expanded Right-Of-Way

FIGURE 21 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION – OPTION 2D

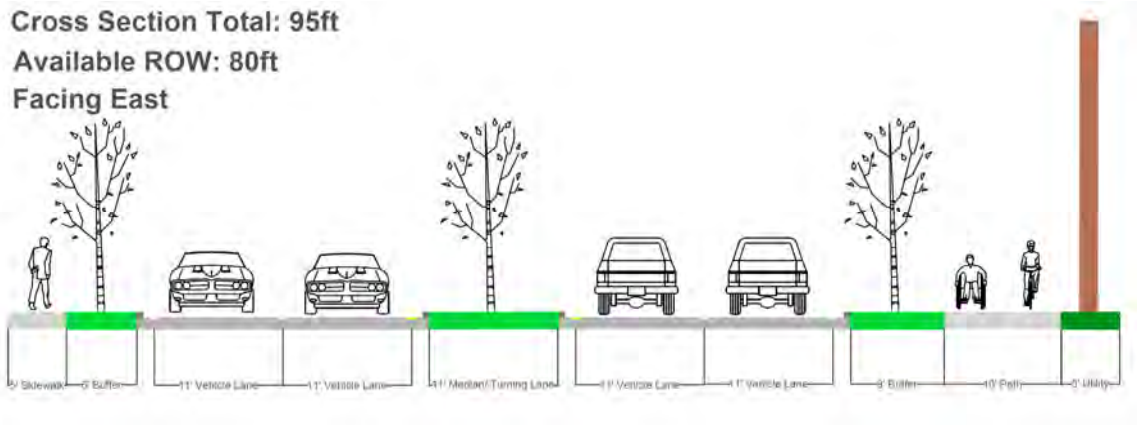

FIGURE 22 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2D

By acquiring an additional fifteen feet of right-of-way, this option includes an eleven-foot landscaped median with turning lanes at high-volume driveways. There would be landscaped buffers adjacent to both sides of the road and the utilities would be relocated to the southern edge of the right-of-way. This option is estimated to have high cost and provide high safety benefits and medium-high congestion and bicycle/pedestrian benefits.

Option 2E (long-term): Four –Lane, Median, Added Traffic Signal, Within Existing Right-Of-Way

FIGURE 23 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION OPTION 2E

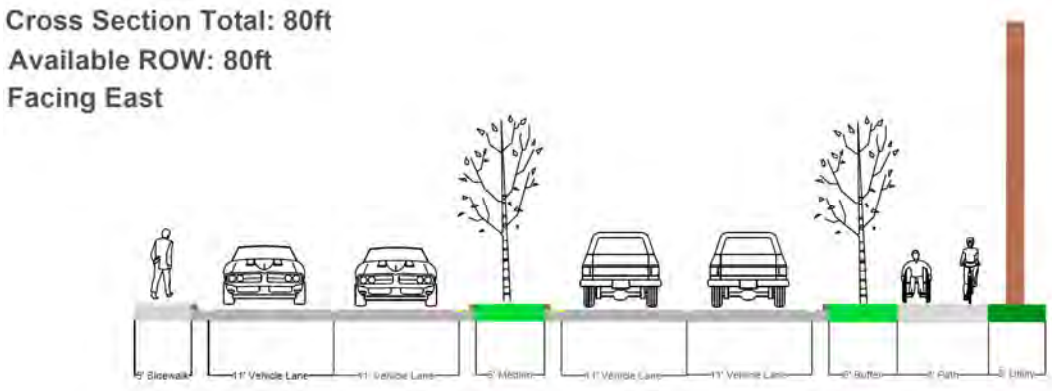

FIGURE 24 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2E

Identical in typical cross section to Option 2A, the roadway within the available right-of-way would be reconfigured to include a six foot landscaped median. Utilities along the roadway on the south side of Route 28 would be relocated to the southern edge of the right-of-way. This option differs from Option 2A by including a median-break in the vicinity of the major shopping center near the mid-point to allow for the installation of a signal-controlled intersection. This option is estimated to have high cost and provide high safety benefits and medium congestion and bicycle/pedestrian benefits.

Option 2F (long-term): Three-Lane, Undivided (One Eastbound Lane, One Westbound Lane, a Two-Way Left Turn Lane, within Existing Right-Of-Way

FIGURE 25 - AERIAL VIEW – ROUTE 28 CENTERVILLE CROSS-SECTION – OPTION 2F

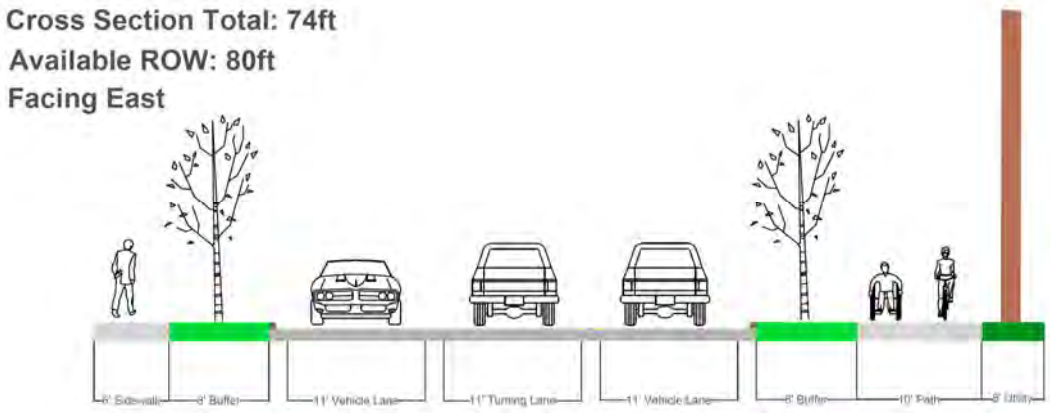

FIGURE 26 - ROUTE 28 CENTERVILLE CROSS-SECTION - OPTION 2F

In this option the number of travel lanes is reduced from four to two, and includes an eleven-foot wide two-way left turn lane (TWLTL). The utilities would be relocated to the southern edge of the right-of-way and landscaped buffers would be provided adjacent to both edges of the roadway. This option is estimated to have high cost and provide high safety benefits and medium bicycle/pedestrian benefits. Commission staff is concerned with the vehicle queuing and congestion impacts associated with this option.

LOCATION 3: PHINNEY'S LANE INTERSECTION

This signalized intersection (shown in the following figure) consists of a variety of approach lane characteristics:

- Route 28 (east leg): left turn lane and two through lanes. From the right through lane there is a dedicated right turn slip lane approximately fifty feet in advance of the traffic signal. There are two outbound receiving lanes. A substandard multi-use path is provided along the south side of Route 28.
- Route 28 (west leg): left turn lane and two through lanes. From the right through lane there is a dedicated right turn slip lane approximately sixty feet in advance of the traffic signal. There are two outbound receiving lanes. This section of Route 28 includes a substandard multi-use path provided along the south side of Route 28 and a push button activated pedestrian crossing connecting to a narrow sidewalk that has been installed along the north side of Route 28.
- Phinneys Lane (north leg): left turn lane, through/right turn lane. There is one receiving lane for outbound traffic.
- Phinneys Lane (south leg): left turn lane, through/right turn lane. This approach includes a push-button activated pedestrian crossing to serve the substandard multi-use path. There is one receiving lane for outbound traffic.

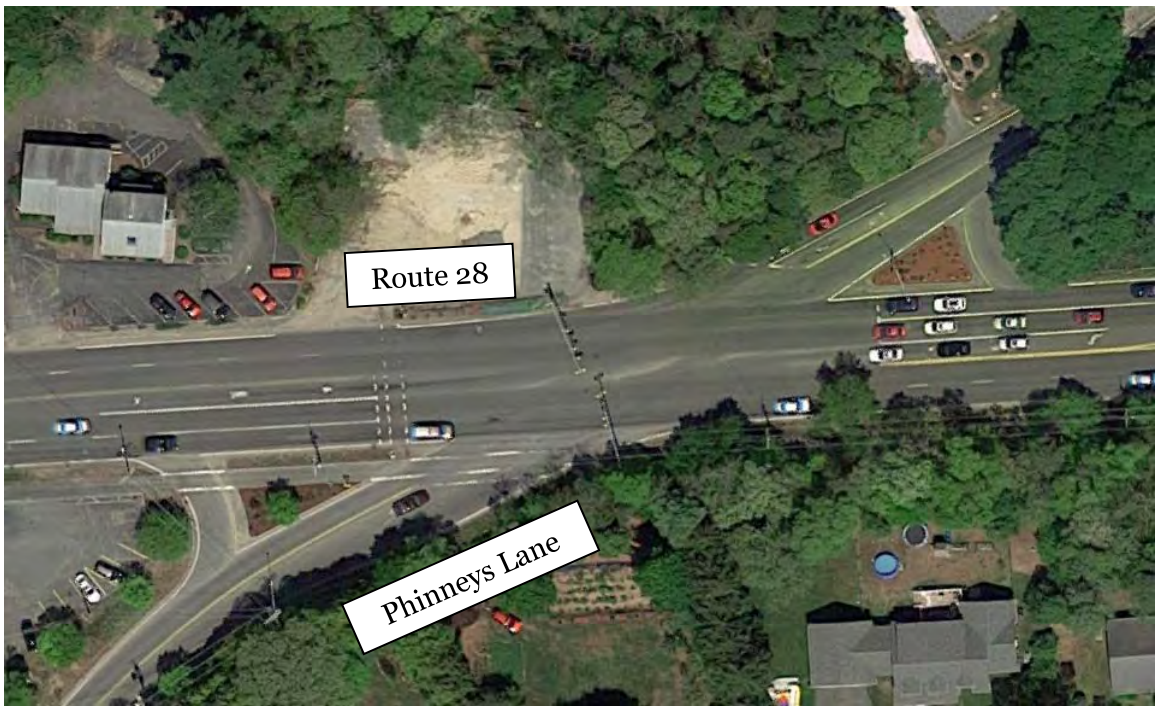

FIGURE 27 - ROUTE 28 AT PHINNEYS LANE (AERIAL VIEW)

The acute approach angles (approximately 30°) of both legs of Phinneys Lane create safety and operations problems at this intersection. For example, motorists on Phinneys Lane attempting to make a right turn onto Route 28 are forced to turn to look over their left shoulder before pulling out into traffic – and have great difficulty in also monitoring the actions of vehicles immediately in front of them. For Phinneys Lane motorists turning left, there is a large amount of pavement to traverse to reach the correct lane, this lengthy maneuver degrades the ability of the intersection to process vehicles efficiently.

Options

Possible improvements at this location are listed as follows:

Option 3A (short-term): Signal Retiming

This is a low-cost option that can be expected to provide low-medium congestion benefits and low safety benefits. By optimizing the signal timing and phasing the intersection will operate more efficiently and the reduced delay should minimize driver frustration.

Option 3B (medium-term): ADA Pedestrian Accommodation Upgrades

This option addresses the need to accommodate users in conformance with ADA requirements. Upgrades include crosswalk installations/modifications to accommodate wheelchairs and low-vision users. The implementation cost of this option is in the low-medium range and is expected to have low safety and bicycle/pedestrian benefits.

Option 3C (long-term): Intersection Realignment

This option would address the difficulties experienced by motorists turning into or out of the minor street approaches by improving the alignment of the minor-street approaches. This high-cost option may require an extensive right-of-way acquisition in order to provide safe approach angles. It is expected to have high safety benefits and medium safety and bicycle/pedestrian benefits.

Option 3D (long-term): Conversion to Modern Roundabout

The well-documented safety and traffic flow benefits of modern roundabouts could be achieved at this location by realigning the roadway approaches and construction of a circulating roadway with pedestrian refuge islands on each approach. The lower design speeds of roundabouts would have a speed-calming effect both upstream and downstream from the facility. This high-cost option would require substantial right-of-way acquisition and is expected to result in high safety benefits, medium bicycle/pedestrian benefits, and possible congestion benefits.

CAPE COD COMMISSION

LOCATION 4: WEST MAIN STREET INTERSECTION

This signalized intersection includes the following characteristics:

- Route 28 (east leg): left turn/through lane, through lane. There is one receiving lane for outbound traffic and a multi-use path along the south side of the roadway.
- Route 28 (west leg): through lane, right turn slip lane approximately 100 feet in advance of the intersection. There are two outbound receiving lanes and a substandard multi-use path along the south side of the roadway.
- West Main Street (south leg): left turn lane, left turn/right turn lane. There is one receiving lane for outbound traffic and a pedestrian crosswalk connecting the substandard multi-use path. There are sidewalks along both sides of the road.

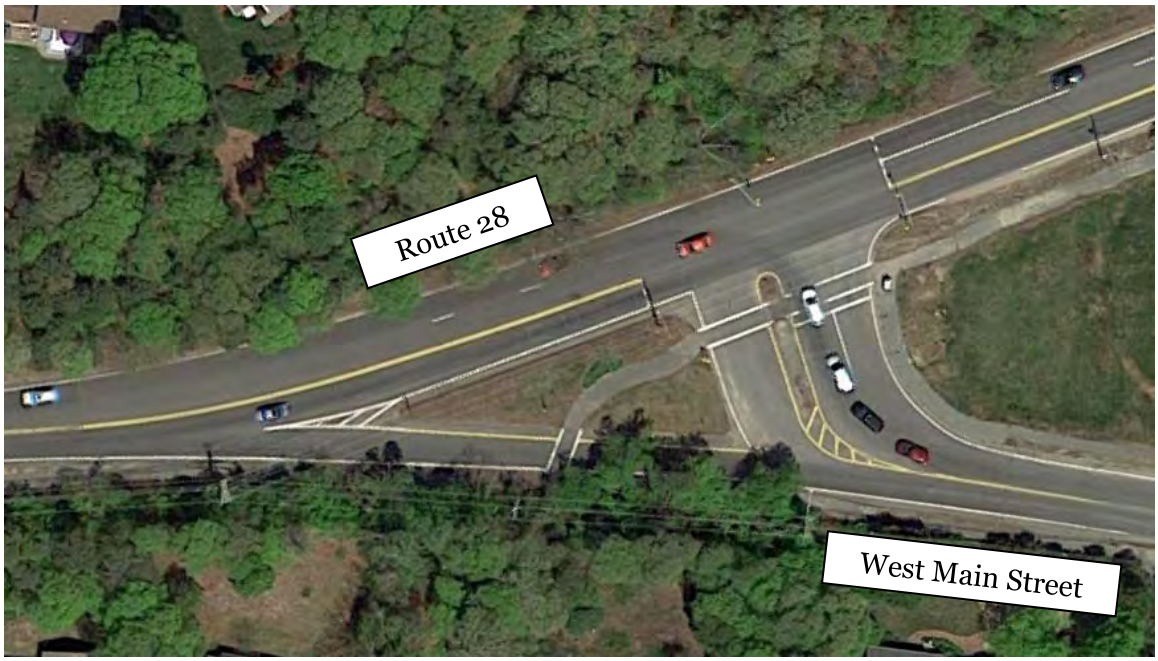

FIGURE 28 - ROUTE 28 AT WEST MAIN STREET (AERIAL VIEW)

The general alignment of West Main Street is approximately at a thirty degree angle – allowing for the right turn slip lane from the west leg of Route 28 to operate at higher speeds – creating potential conflicts at the merge with left-turning vehicles from the east leg of Route 28.

The connection of West Main Street's southwestern sidewalk to Route 28's south side multi-use path is near roadway grade – leading to an accumulation of sand and road debris.

Options

Possible improvements at this location are listed as follows:

Option 4A (medium-term): ADA Pedestrian Accommodation Upgrades

This option addresses the need to accommodate users in conformance with ADA requirements. Upgrades include crosswalk installations/modifications to accommodate wheelchairs and low-vision users. The implementation cost of this option is in the medium range due to the need for additional signal equipment and is expected to have low safety and bicycle/pedestrian benefits.

Option 4B (medium-term): Designate Route 28 Westbound Lane for Left-Turn Use Only

Currently westbound Route 28 as it approaches the West Main Street intersection consists of a right-side through lane and a left-side lane used for left-turning and through traffic. This option would prohibit the through movement from the left lane by pavement markings and signage. This low-cost option is expected to have low-medium safety benefits. Further investigation would be required to determine the impacts that this option would have on intersection operations.

LOCATION 5: STRAWBERRY HILL INTERSECTION

This signalized intersection includes the following characteristics:

- Route 28 (east leg): left turn lane, through/right turn lane; with one receiving lane for outbound traffic. There is a pedestrian crosswalk and a substandard multi-use path along the south side of the roadway. A short segment of sidewalk is available along the north-side of Route 28 within the frontage of the CVS pharmacy.
- Route 28 (west leg): left turn lane, through/right turn lane; with one receiving lane for outbound traffic. There is a substandard multi-use path along the south side of the roadway.
- Strawberry Hill Road (north leg): left turn lane, through/right turn lane; with one receiving lane for outbound traffic. There is a sidewalk with landscaped buffer along the east side of the roadway.
- Strawberry Hill Road (south leg): single lane for all movements and one receiving lane for outbound traffic. There is a pedestrian crosswalk connecting the substandard multi-use path.

FIGURE 29 - ROUTE 28 AT STRAWBERRY HILL ROAD (AERIAL VIEW)

Strawberry Hill Road from the north descends on a downgrade to Route 28; conversely, the southern leg approaches the intersection on an upgrade. This creates a "rollercoaster" effect for Strawberry Hill Road through traffic and affects safe stopping distance for southbound motorists and acceleration times for northbound vehicles waiting at red signals.

A Roadway Safety Audit was completed in the spring of 2015 and is included in the appendix. The audit identified six Safety Issue areas including potential enhancements:

Roadway Safety Audit Safety Issue #1: Traffic Control

Potential Enhancements:

- Evaluate speeding enforcement along the Route 28 corridor and at Strawberry Hill Road.
- Consider signal coordination between the study area intersection and the Route 28 intersections with West Main Street, the Senior Center Driveway, and Pitchers Way to help manage traffic flows throughout the corridor.
- Evaluate the existing signal timings, specifically the clearance intervals, and propose new timing plans catered to time of day and/or time of year.
- Check the functionality of signal detection on Route 28 and either repair as needed and/or consider dilemma zone detection for the intersection.
- Consider installation of left-turn signal arrows and protected left-turn phasing to minimize angle collisions at the intersection.
- Consider the implementation of a traffic circle at the intersection of Strawberry Hill Road and Wequaquet Lane, north of the Route 28 intersection to slow the southbound approach speeds.
- Install backplates with reflective borders for overhead signals to minimize the effects of solar glare.
- Install advance warning signage on all approaches.
- Consider incorporating emergency preemption to improve emergency response and decrease crash risks.

Roadway Safety Audit Safety Issue #2: Traffic Operations

Potential Enhancements:

- Evaluate re-grading at the Strawberry Hill Road southbound approach of the intersection, in the area of the Route 28 gutter line, to improve operations.

- Consider extending the storage length of the left turn lane at the westbound approach of the intersection to avoid excessive queueing.
- Consider the implementation of a right-turn lane at the westbound approach of the intersection to improve traffic operations.
- Consider the implementation of a left-turn lane at the northbound approach of the intersection to improve traffic operations.

Roadway Safety Audit Safety Issue #3: Intersection Alignment/Visibility

Potential Enhancements:

- Evaluate lane and/or roadway alignment for both Strawberry Hill Road approaches of the intersection to improve sight distance and reduce the risk of head-on collisions.
- Install an Intersection Ahead (or Signal Ahead) warning sign on the southbound approach, prior to the horizontal curve.
- Consider trimming the vegetation within the roadway right-of-way on the Strawberry Hill Road northbound approach to improve visibility.
- Evaluate the feasibility of obtaining easements for vegetation trimming on private property along the northbound approach of the intersection to improve visibility.
- Evaluate existing right-of-way restrictions and proposed widening improvements where feasible to create a consistent cross section along Strawberry Hill Road, specifically the northbound approach of the intersection.

Roadway Safety Audit Safety Issue #4: Pedestrian and Bicycle Accommodations

Potential Enhancements:

- Evaluate ramps for compliance with ADA standards.
- Install pedestrian signals and push button actuation at the signalized intersection.
- Evaluate the installation of crosswalks on the southbound and eastbound legs of the intersection.
- Construct sidewalks adjacent to the intersection to help guide pedestrians around the traffic signal and provide improved access to the church located in the northwestern quadrant of the intersection.
- Consider improvements of the mixed use path at the southeast corner of the intersection on Route 28.
- Evaluate crosswalk signage and pavement markings to ensure that they are visible.

- Evaluate "STOP" sign height on southwest side of the mixed use path.
- Evaluate lighting along the mixed use path to provide additional safety for pedestrians and cyclists.

Roadway Safety Audit Safety Issue #5: Roadway Conditions

Potential Enhancements:

- Evaluate existing pavement markings and consider re-striping the approaches from Strawberry Hill Road to ensure visibility.
- Repair or replace the damaged curbing on the northwest corner of the intersection.
- Encourage coordination between Barnstable Department of Public Works and MassDOT for snow plowing activities at the intersection.

Roadway Safety Audit Safety Issue #6: Access Management

Potential Enhancements:

- Implement a structural barrier on Route 28 and/or a raised driveway island at the CVS driveway access onto Route 28 to prevent left turn movements.
- Encourage the use of shared driveways and/or internal driveways along the Route 28 corridor to reduce amount of access point that could cause potential crashes.

Options

Improvements at this location are listed as follows:

Option 5A (MassDOT project funded for FY2016): Signal Equipment and Phasing Upgrades, Improved Pavement Markings, ADA Pedestrian Accommodation Upgrades

This project, currently approved for funding in Federal Fiscal Year 2016, includes improvements to traffic signal operations that are expected to result in medium safety benefits and low-median congestion benefits. Crosswalk and other enhancements are expected to result in high bicycle/pedestrian benefits.

Option 5B (long-term): Intersection re-grading and realignment

This option would address the difficulties experienced by motorists turning into or out of Strawberry Hill Road by properly aligning the approaching traffic and adjusting the grade of the approaches. This high-cost option may require an extensive work zone in order to accommodate safe slopes of approach and along the sides of Strawberry Hill Road. It is expected to have medium safety benefits and low safety and bicycle/pedestrian benefits. This option is shown in the following graphic:

FIGURE 30 - ROUTE 28/STRAWBERRY HILL RD OPTION 5B

LOCATION 6: BARNSTABLE SENIOR CENTER/INTERMEDIATE SCHOOL ACCESS

This intersection is heavily used during school arrival/departure hours and serves as an important facility for residents and visitors accessing the Barnstable Senior Center and Barnstable High School's recreational fields. It provides direct Route 28 access to Barnstable High School (main access from West Main Street) and secondary access for Barnstable Intermediate School.

FIGURE 31 - ROUTE 28 AT SENIOR CENTER/INTERMEDIATE SCHOOL ACCESS

In 2015 the Commission staff performed extensive data collection at the intersection and adjacent roadway segments. Town of Barnstable staff are currently developing concepts to address safety, traffic congestion, and improved bicycle/pedestrian accommodation.

Options

Possible improvements at this location are listed as follows:

Option 6A (medium-term): Install New and Enhance Existing Crosswalks and Sidewalks

This medium-cost option involves installation of crosswalks across Route 28 and across the school access drive, and new sidewalk along the school access drive and on the north side of Route 28 between this intersection and adjacent intersections in order to accommodate users from north-side neighborhoods. This option is expected to provide medium safety benefits and high bicycle/pedestrian benefits.

Option 6B (long-term): Install Traffic Signal or Modern Roundabout

To safely accommodate turning traffic this high-cost option would include installation of a new traffic signal or modern roundabout. High safety and bicycle/pedestrian benefits would be expected as a result of this option. Further analysis is required to quantify congestion benefits.

LOCATION 7: LINCOLN ROAD INTERSECTION

This unsignalized intersection includes the following characteristics:

- Route 28 (east leg and west leg): one multipurpose lane and one receiving lane for outbound traffic. There is a multi-use path along the south side of the roadway separated by a landscaped buffer.
- Lincoln Road (south side): one multipurpose lane and one receiving lane for outbound traffic. This approach includes a crosswalk connecting the multi-use path. This approach is stop-sign controlled.
- Lincoln Road Extension (north side): there are no lane demarcations. Pavement width is sufficient to replicate one multipurpose lane and one receiving lane for outbound traffic. This approach is also stop-sign controlled.

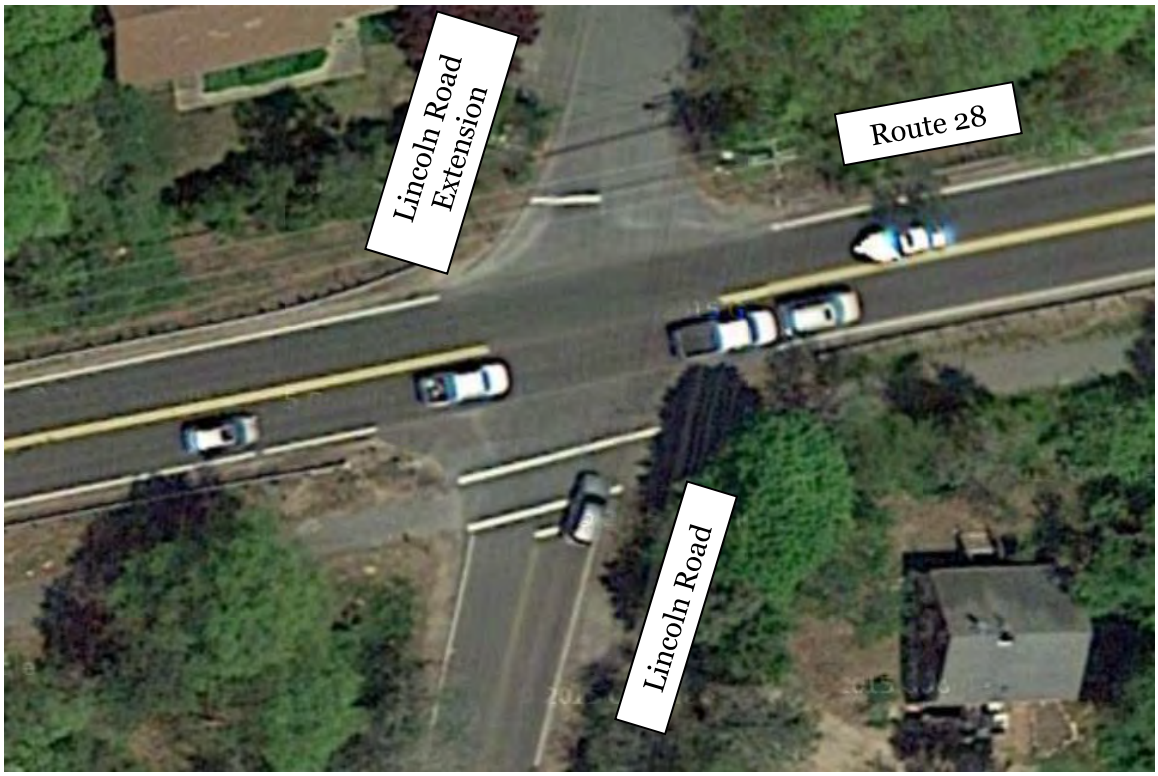

FIGURE 32 - ROUTE 28 AT LINCOLN ROAD (AERIAL VIEW)

The Town of Barnstable is expected to construct traffic calming devices (including nine speed humps along Lincoln Road and a raised crosswalk across West Main Street). Commission staff look forward to a before-and-after analysis to review the traffic calming's effects on safety and traffic flow both along Lincoln Road and at the intersection with Route 28.

Options

Possible improvements at this location are listed as follows:

Option 7A (long-term): Construct Dedicated Left-Turn Lane for Westbound Route 28

Under this high-cost option, Route 28 would be widened to accommodate a left turn lane for westbound traffic. This is expected to provide medium safety benefits and possible congestion benefits.

Option 7B (long-term): Install Traffic Signal or Modern Roundabout

In order to accommodate vehicles entering from the side street and better control other maneuvers, this option would replace the two-way stop controlled intersection with a traffic signal or roundabout. To mitigate congestion impacts a signal installation would likely require turning lanes. This high-cost option is expected to have high safety benefits and low-medium bicycle/pedestrian benefits, and possible congestion benefits.

LOCATION 8: PITCHERS WAY INTERSECTION

This signalized intersection includes the following characteristics:

- Route 28 (east and west legs): left turn lane, right turn/through lane and one receiving lane for outbound traffic. There is a multi-use path along the south side of the roadway separated by a landscaped buffer.
- Pitchers Way (north leg): left/through lane, right turn lane, and one receiving lane for outbound traffic.
- Pitchers Way (south leg): left/through lane, right turn lane, and one receiving lane for outbound traffic. This approach includes a crosswalk connecting the multi-use path.

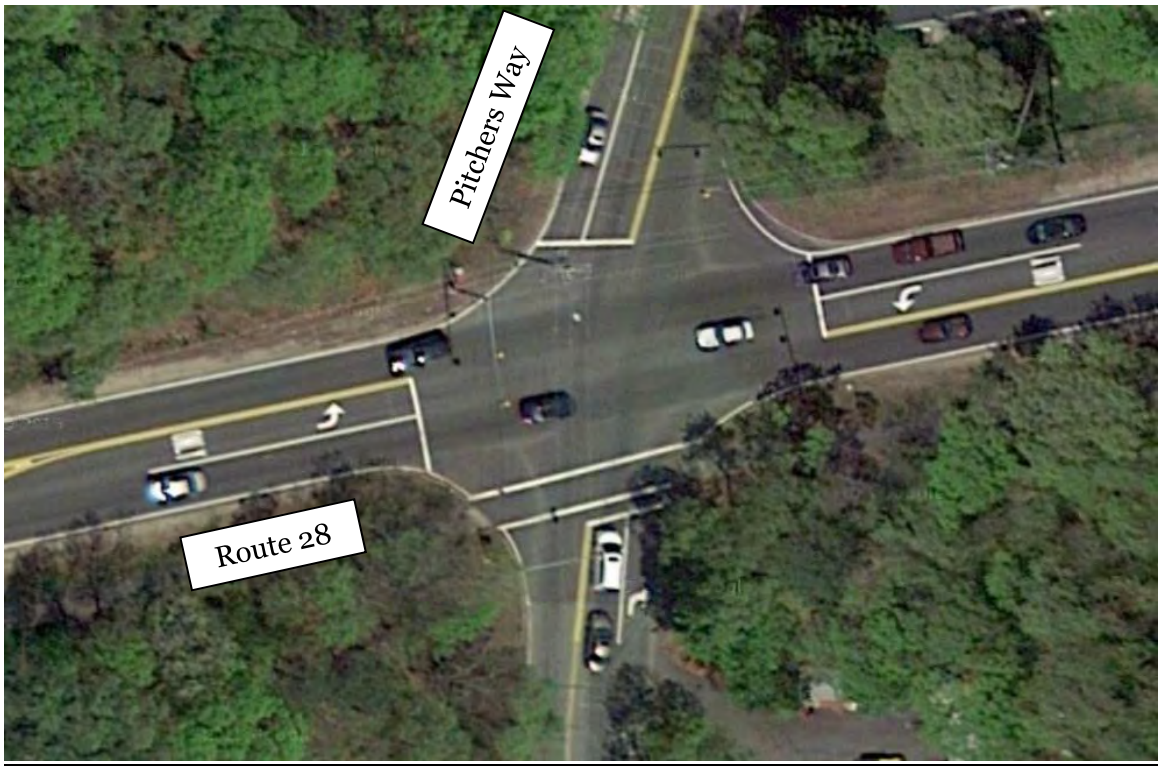

FIGURE 33 - ROUTE 28 AT PITCHERS WAY (AERIAL VIEW)

Options

Possible improvements at this location are listed as follows:

Option 8A (medium-term): Retime Traffic Signal and Include Left-Turn Phase

This is a medium-cost option that can be expected to provide low-medium congestion benefits and medium safety benefits. By optimizing the signal timing and phasing the intersection will operate more efficiently and the reduced delay should minimize driver frustration. The addition of a left-turn phase will offer motorists improved safety by providing protected gaps in the traffic stream in order to turn left.

Option 8B (medium- to long-term): ADA Pedestrian Accommodation Upgrades Including Route 28 Crosswalk

This option addresses the need to accommodate users in conformance with ADA requirements. Upgrades include crosswalk installations/modifications to accommodate wheelchairs and low-vision users, including a new crossing of Route 28. The implementation cost of this option is in the medium-high range due to the need for additional signal equipment, integration of the south-side Route 28 bike path and is expected to have medium-high safety and bicycle/pedestrian benefits.

LOCATION 9: BEARSES WAY INTERSECTION

This signalized intersection includes the following characteristics:

- Route 28 (east leg): left turn lane, through lane, and a right turn/through lane with two outbound receiving lanes.
- Route 28 (west legs): left turn lane, through lane, and a right turn/through lane with two outbound receiving lanes. The multi-use path along the south side of Route 28 terminates at the commercial site drive approximately 150 feet in advance of the intersection.
- Bearses Way (north leg): left turn lane, through lane, right turn lane and one receiving lane for outbound traffic. There is a curbed sidewalk immediately adjacent to the east side of the roadway.
- Bearses Way (south leg): left turn lane, right/through lane and one receiving lane for outbound traffic. There is a sidewalk separated by a landscaped buffer along the east side of the roadway.

FIGURE 34 - ROUTE 28 AT BEARSES WAY (AERIAL VIEW)

The northwest quadrant is under municipal control (wastewater treatment facility). There a commercial properties situated in the remaining quadrants of the intersection. There are no bicycle/pedestrian accommodations to serve the many destinations to the east (e.g., Cape Cod Mall etc.) and the residential areas accessible from the west via the multi-use path.

Options

Improvements at this location are listed as follows:

Option 9A (MassDOT project funded for FY2015): Intersection Reconstruction with Additional Lanes and Bicycle/Pedestrian Improvements

As part of a larger project including the segment of Route 28 to the Cape Cod Mall intersection, this project is approved for funding in Federal Fiscal Year 2015. The intersection reconstruction includes enhanced bicycle and pedestrian accommodations, such as shoulders, sidewalks, pedestrian refuge islands, and optimized signal phasing and timing. The project is expected to have high safety, congestion, and bicycle/pedestrian benefits. A graphic detailing some of the improvements is shown in the figure below:

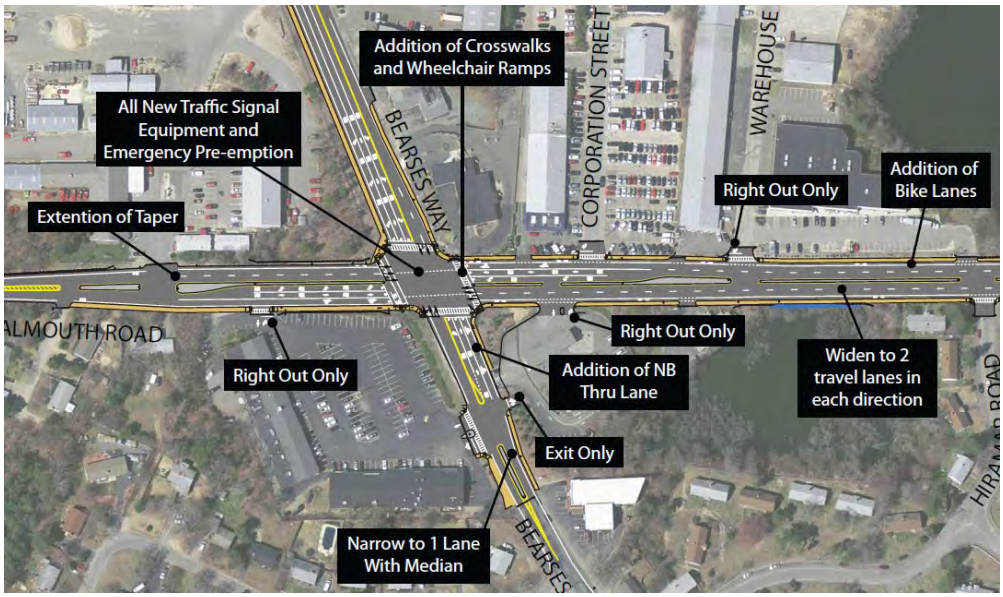

FIGURE 35 - ROUTE 28 AT BEARSES WAY MASSDOT PROJECT

BICYCLE/PEDESTRIAN CONNECTIVITY

The existing conditions of the corridor currently lack the definition with a focus primarily on vehicular movement. Although there is a multi-use path available for pedestrians and cyclists, this path is not connected to other facilities in order to increase the multi modal network in and around Route 28, the Town of Barnstable, or other parts of the Cape. The following figure shows the corridor of Route 28 as a series of nodes between each of the various major intersections. For example, from Old Stage Road on the left (west) side of the figure to the Phinneys Lane the development pattern is primarily commercial in nature. This shifts to a residential pattern from Phinneys Lane to West Main Street. From West Main Street to Pitchers Way we see a mixture of residential and institutional uses and from Pitchers Way to Bearses Way at the right (east) side of the figure there is primarily commercial and office use. The orange-colored bands show the approximate locations of sidewalks along the Route 28 corridor.

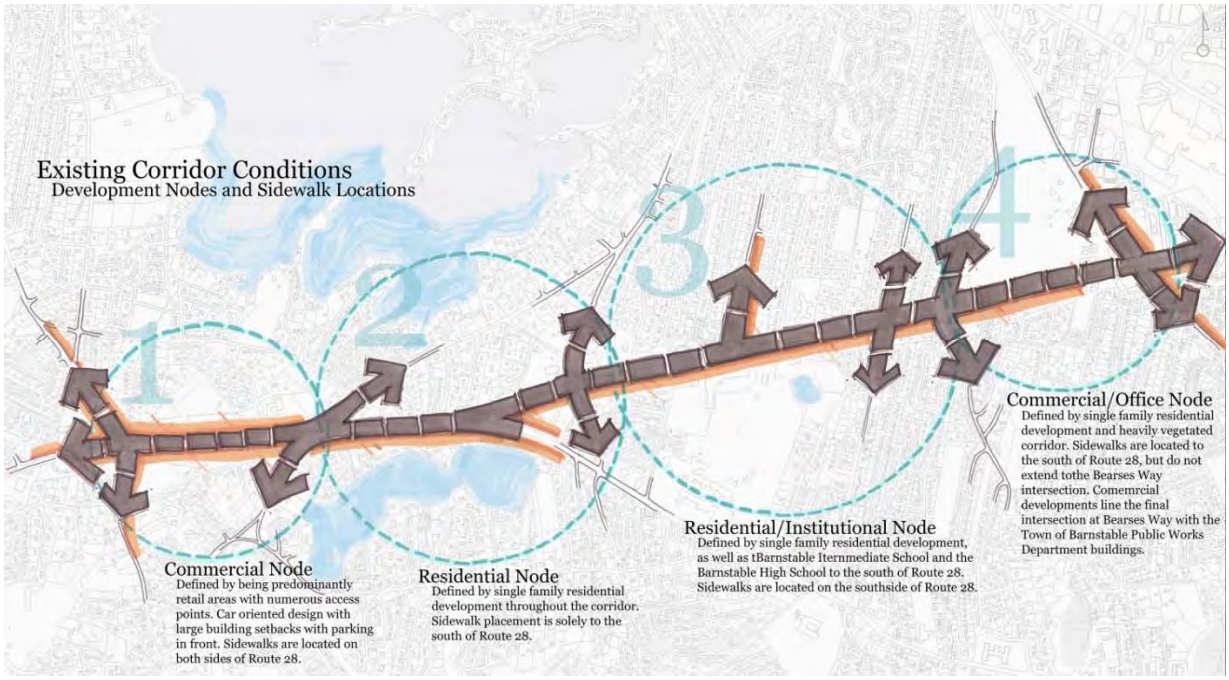

FIGURE 36 - STUDY AREA DEVELOPMENT NODES AND SIDEWALK LOCATIONS

The Route 28 corridor includes the following general patterns of development:

- Commercial (Old Stage Road to Phinneys Lane): which includes the areas along the Route 28 corridor that give access to the Bell Tower Mall, the Centerville Plaza, the Bayberry Square, and the Post Office Plaza.
- Residential (Phinneys Lane to West Main Street): which is mainly defined by single-family residential development on both the North and South side of Route 28.
- Residential/Institutional (West Main Street to Pitchers Way): which also includes highly residential development along the corridor, but that also introduces the Barnstable Intermediate School and connects to the Barnstable High School.

- Commercial/Office (Pitchers Way to Bearses Way): presents single-family residential development, a dense natural buffer along the Route 28 corridor, commercial development at the intersection of Bearses Way, and the office of the Town of Barnstable Public Works Department buildings.

Complete Street design promotes enhancements that make road networks safer, more livable, and welcoming to everyone (including bicyclists, public transportation vehicles and riders, pedestrians of all ages and abilities. Living Street design expands upon the Complete Street concept by combining elements of environmental engineering with pedestrian enhancements to create roadways that benefit and enhance the community.

An important principle of Living Street design is one of context: more precisely, how the street relates to its surrounding environment. From the previous figure, the characteristics outlined describe the land uses surrounding the Route 28 corridor and the function of that portion of the corridor. The recommended design for these areas does not look to revise or change the existing attributes, but emphasize the differences of the areas, and determine what design principles can best serve the area and the users. These recommendations are shown in the following figure:

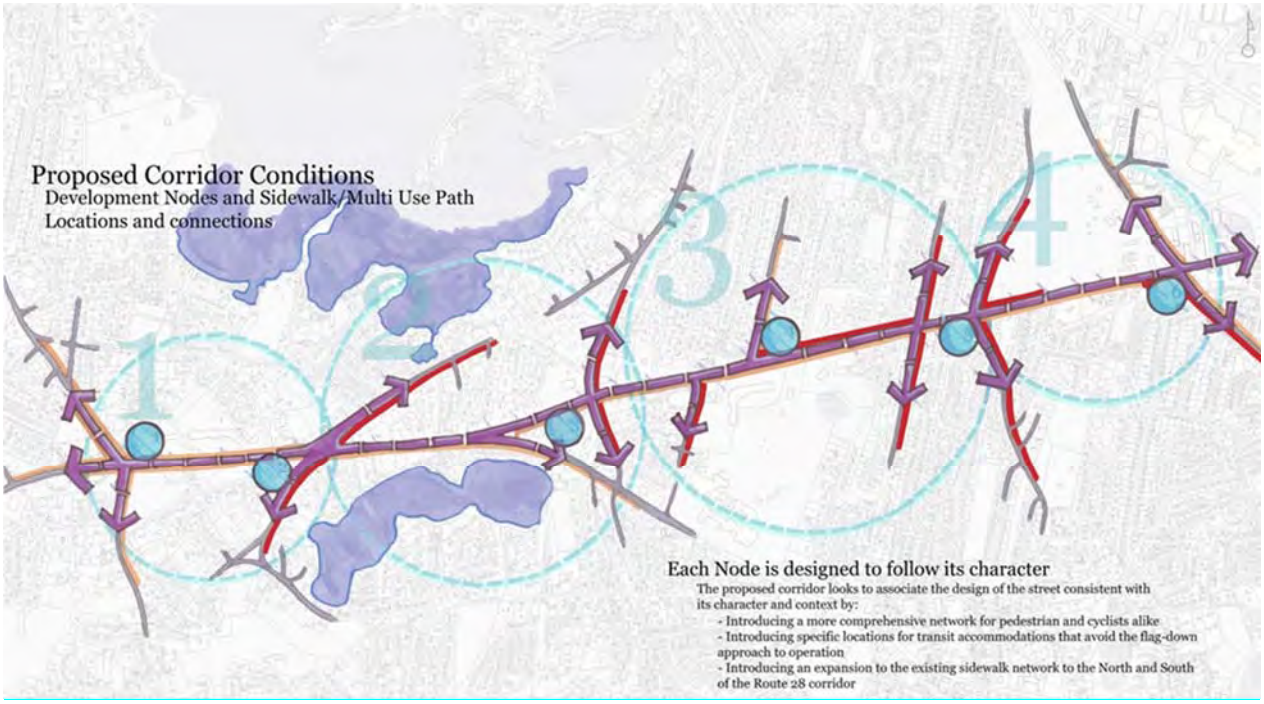

FIGURE 37 - PROPOSED CONDITIONS FOR DEVELOPMENT NODES AND SIDEWALK/MULTI-USE PATH

Many towns on the Cape have made great strides in integrating streets into the public realm. This study looks to further those efforts by giving special care to pedestrian amenities which encourage safe and comfortable walking, biking and social interaction along the roadway. The study recommends the placement of pedestrian scaled lighting at

gateway intersections, in primary economic zones and at crosswalks, to increase safety and add aesthetic value to the right of way. Joint ventures with local artists toward creating benches and trash receptacles placed at frequent intervals would also serve to improve the pedestrian experience, and could double as public art pieces to add a sense of place to the different nodes of the corridor. One recommendation looks to improve the condition of crosswalks throughout the corridor or installing special pavement treatments to calm traffic and improve roadway appearance. Another idea would be to improve the wayfinding capacities by incorporating a comprehensive directional signage program for the corridor, which would enhance the sense of place of the corridor.

Transforming a corridor that was designed to mainly accommodate vehicles into a public amenity for all modes of transportation is a hefty task to accomplish. The expansion of the multi-use path for the corridor lends itself as well to the Shared Use Path Vision Map shown in the following figures. Completion of a shared use path would provide additional options for travel along Route 28, but more importantly, the potential of secondary route connection networks to other existing trails, as well as proposed trails for the region.

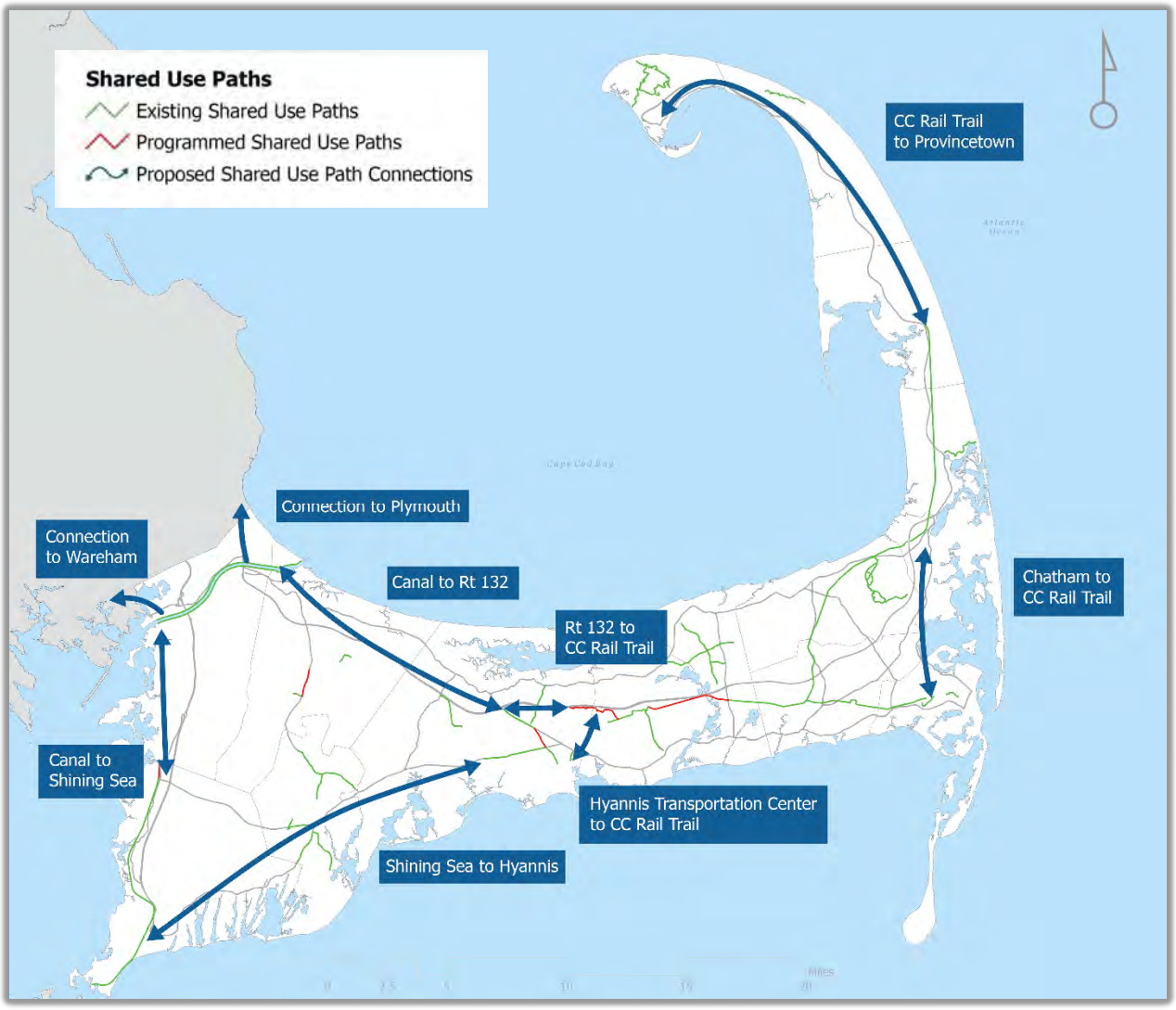

FIGURE 38 - CAPE COD SHARED USE PATH VISION MAP

The figure below presents the Shared Use Vision Map with the Barnstable area enlarged to show detail:

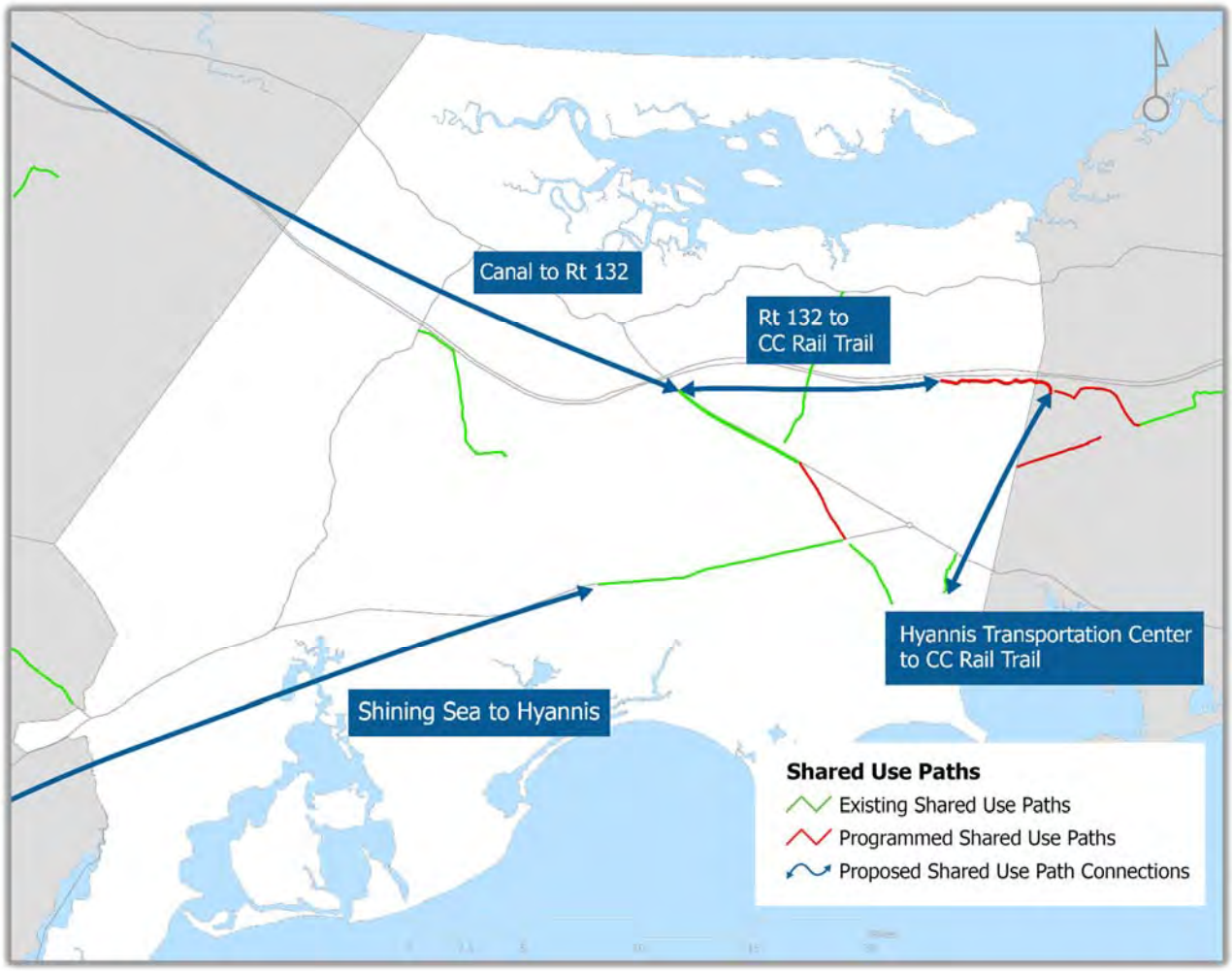

FIGURE 39 - CAPE COD SHARED USE PATH VISION MAP - BARNSTABLE AREA

Options

Possible improvements along the study area corridor are listed as follows:

Option 10A (ongoing): Multi-use path maintenance/rehabilitation

This low/medium-cost option includes the rehabilitation of the paved surface of the multi-use path and ongoing maintenance (e.g., debris removal and tree-trimming). This option is expected to provide low-medium safety and bicycle/pedestrian benefits.

Option 10B (medium-term): Multi-use path signage and wayfinding

By providing wayfinding features and routing and safety-related signage along the shared use path, this low/medium-cost option is expected to provide low-medium safety and bicycle/pedestrian benefits.

Option 10C (medium-term): Address gaps in sidewalks

Under this medium/high-cost option, new sidewalk facilities would be constructed to connect to existing sections of sidewalks. Medium/high benefits are expected for safety and bicycle/pedestrian issue areas.

Option 10D (long-term): Improve/increase north-south pedestrian crossings

Under this medium/high cost option, new cross walks would be installed at strategic intersections and mid-block locations to facility movements across Route 28. This option is expected to provide high safety and bicycle/pedestrian benefits.

Option 10E (long-term): Add north side sidewalk where appropriate

This high-cost option involves construction of a new sidewalk along the north side of Route 28 for much of the study area corridor. Some segments may be exempt (e.g., the frontage of the wastewater treatment plant). This option is expected to provide medium/high safety and bicycle/pedestrian benefits.

TRANSIT ENHANCEMENTS

The Cape Cod Regional Transit Authority (CCRTA) buses that travel through the Route 28 corridor employ a flag-down approach to their operation to supplement designated stops along the route. The Sealine service travels between Falmouth and the Hyannis Transportation Center generally on Route 28. There is a diversion to Osterville and historic Centerville village to the west of the study area corridor. The route rejoins Route 28 via Old Stage Road. The only scheduled/designated bus stop within the study area corridor is at the intersection of Route 28/West Main Street.

This study recommends additional dedicated bus stops to accommodate transit users along the corridor. These bus stops may be designated with a simple sign and bench or more elaborate public art piece, to lessen rider confusion and create a sense of place. One alternative, as depicted by the following figure, is to provide bus turnouts which incorporate a bus shelter. This configuration would increase safety measures throughout the corridor by separating the users of the corridor and provide greater visibility of multimodal options.

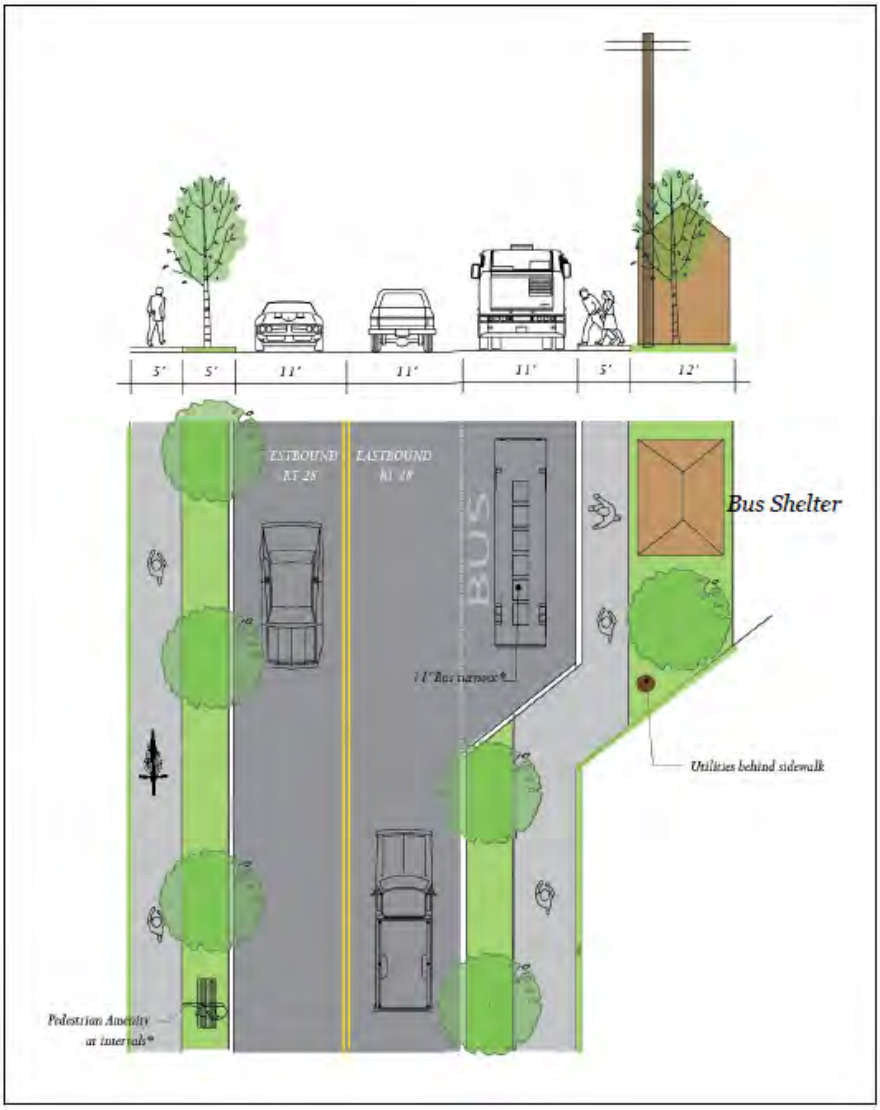

FIGURE 40 - POTENTIAL BUS TURNOUT DESIGN DEISPLAYING A BUS SHELTER AND ADDITIONAL PEDESTRIAN AMENITIES.

Options

Possible improvements at this location are listed as follows:

Option 10F (short-term): Review/revise bus stop locations

This low-cost option involves reviewing the adequacy of existing bus stop locations and identifying new or revised locations to improve the customer experience and transit system efficiency. Expected medium safety and bicycle/pedestrian benefits would be provided by this option.

Option 10G (medium-term): Bus shelters

Construction of new bus shelters as part of this medium-cost option is expected to provide low safety and bicycle/pedestrian benefits.

Option 10H (long-term): Bus turnouts

Selective widening of Route 28 to provide space for bus turnouts is a high-cost option that is expected to provide medium safety and bicycle benefits and low/medium congestion benefits.

LANDSCAPING

The landscape recommendations focus less on functionality and more on the form and structure of the corridor. The landscape elements look to enhance and enforce the site's functions while building a natural character that could potentially describe the variations in identity between the different areas and types of landscape on the Cape. Put simply, the landscape character is what makes a site unique. It is defined as a distinct, recognizable and consistent pattern of elements throughout the corridor that define and enhance the user's experience.

The study also recommends the implementation of a landscape design that incorporates local plant material, non-invasive materials, and environmentally friendly design that emphasizes on the Cape's unique landscape heritage. This study looks to present the following plan for the Commercial Node area as a first step of possible landscape revitalization efforts.

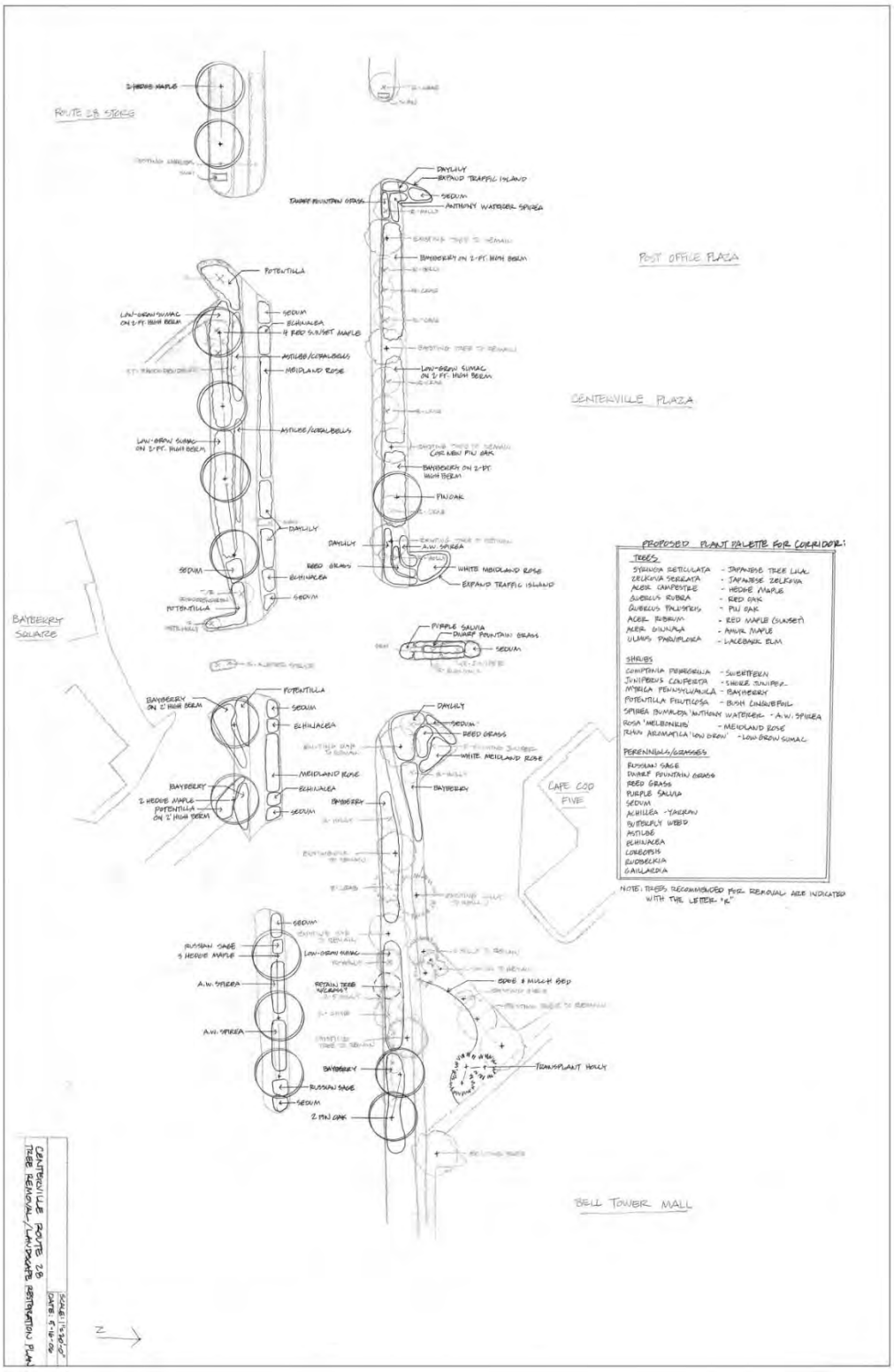

FIGURE 41 – TREE REMOVAL AND LANDSCAPE RESTORATION PLAN EXAMPLE FOR THE COMMERCIAL NODE OF THE ROUTE 28 CORRIDOR.

Possible improvements at this location are listed as follows:

Option 10I (medium-term): Corridor-wide landscaping upgrades

This medium/high cost option includes improved landscaped buffers and plantings within existing vegetated spaces, thus increasing the on-site processing of stormwater as well as better defining the separation of non-motorized users from motor vehicles. This option is expected to provide low safety and bicycle/pedestrian benefits.

STORMWATER MANAGEMENT

The goals of stormwater management are

1) To remove water from the roadway surface (thereby reducing hazards such as hydroplaning) and
2) To provide treatment to eliminate untreated stormwater discharging directly to groundwater and surface water sources.

Inherent in this goal is the proper management and use of available green space both within and without of the available right-of-way in the Study Area. Staff recommends that MassDOT encourage the use of easements from public and private entities to accommodate the location, construction and maintenance of stormwater infrastructure where limited state road right-of-way would prohibit or complicate Best Management Practices (BMP) siting, construction or maintenance.

To ensure proper treatment, staff has identified the contaminants of concern for the Study Area, estimated Water Quality Volume, required land area and the BMPs best suited to capture and treat target contaminants.

BEST MANAGEMENT PRACTICES (BMPS)

Bioretention

Bioretention is a method of treating stormwater by ponding water in shallow depressions underlain by a sandy engineered soil media through which most of the runoff passes.

Bioretention systems can easily be incorporated into the landscape to address and maintain many of the natural hydrologic functions. Pollutants within these systems are removed through both chemical and physical means within the bioretention soil mix (BSM). Bioretention systems also encourage biological treatment of nutrients, such as nitrogen, through nutrient uptake by vegetation within the system. Bioretention tends to work best in sandy soils such as are present in many areas of Cape Cod.

Bioretention systems achieve excellent removal efficiencies for a wide range of pollutants including Total Suspended Solids (TSS), petroleum hydrocarbons, nitrogen, metals, phosphorus and bacteria.

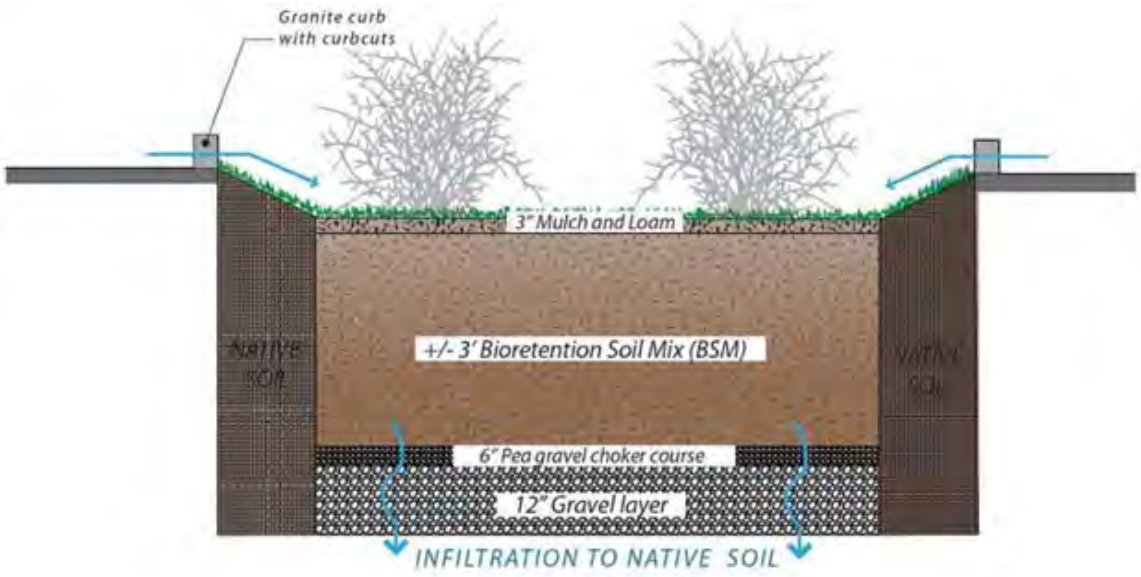

FIGURE 42 - CROSS SECTION OF A COMMON BIORETENTION SYSTEM

Leaching Catch Basins

A leaching catch basin is similar to a traditional catch basin with the added ability to permit the infiltration of captured runoff. Leaching basins are often installed in series with a deep sump catch basin that providing. Because of this pretreatment, the catch basin/leaching basin combination is preferable to the leaching catch basin as a higher removal of TSS may be achieved while also extending the life and minimizing maintenance on the leaching catch basin. Leaching catch basins and leaching basins should only be used in areas with highly permeable soils, making these basins a popular stormwater control throughout the Cape.

Leaching catch basins, in series with pre-treatment catch basins, achieve excellent TSS removal in addition to constituents that sorb to fine particulates including petroleum hydrocarbons and metals.

Sub-Surface Sediment Chambers

Sub-surface sediment chambers function similarly to surface sedimentation systems. Sediment trapping systems remove pollutants (mainly particulates) from stormwater runoff through a pretreatment sedimentation area followed by an infiltration bed containing filter media (typically sand, soil, gravel or a combination of media). This infiltration bed removes fines and the pollutants adsorbed, or attached, to these particulates. Various contaminants including, but not limited to metals, petroleum

hydrocarbons and bacteria may sorb to fines allowing infiltration systems to achieve removal efficiencies in these categories though the physical process of filtration.

Sub-surface sediment chambers traditionally discharge directly to groundwater however systems can be designed with an outflow mechanism returning treated flow to a stormwater conveyance system.

FIGURE 43 - HDPE SUB-SURFACE TREATMENT CHAMBERS

Options

Possible improvements at this location are listed as follows:

Option 10J (long-term): Stormwater management upgrades

Under this medium/high cost option, new roadside features would be installed to manage stormwater impacts including vegetated swales and infiltration systems. Low safety and bicycle/pedestrian benefits would be expected from this option. More detailed descriptions of proposed stormwater improvements are available in the appendix.

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OTHER POTENTIAL IMPROVEMENTS

PEDESTRIAN AMENITIES- LIGHTING, CROSSWALKS, STREET FURNITURE

Special care was taken throughout the planning study to consider pedestrian amenities which encourage safe and comfortable walking, biking and social interaction along the roadway. The study recommends the placement of pedestrian scaled lighting at gateway intersections, in primary economic zones and at crosswalks, to increase safety and add aesthetic value to the right of way. Benches and trash receptacles placed at frequent intervals would also serve to improve the pedestrian experience, and could double as public art pieces to add a sense of place to the commercial district. It is recommended that crosswalks utilize pavers or stamped concrete over simple striping, to calm traffic and improve roadway appearance.

Amenities such as lighting and street furniture fall outside the purview of typical MassDOT road improvements. The town may wish to consider funding such improvements with Chapter 90 funds or MassWorks grants.

ACCESS MANAGEMENT

In accordance with earlier planning studies of this roadway, this report recommends that the town work to consolidate curb cuts in order to improve traffic flow on Route 28 and coordinate efforts of future layout alterations with an access management protocol. This work could include an assessment of individual curb cuts, permit search and determination of non-conforming lots according to MassDOT standards. This can result in a formally endorsed access management plan.

Option 10K (ongoing): Access management

As opportunities arise through property redevelopment and roadway upgrades, this option includes reduction of widths and total numbers of curb cuts, shared access, and other access management techniques that would be expected to provide high safety, congestion, and bicycle/pedestrian benefits.

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Summary of Alternatives

A host of potential enhancements were identified in the previous sections of this report. The following table presents the relative time frame and cost, and expected benefit in terms of safety, congestion, and for bicycle and pedestrian accommodation.

CONCLUSION & INTERIM STEPS

This report lays out a host of potential improvement along the Route 28 corridor. As these potential enhancements are advanced, further analysis will be required.

Many of the improvements require many years to implement given the design, permitting, and funding hurdles they face. While medium-term and long-term improvements detailed in the following table are taken under consideration, interim steps to make improvements in the area could be pursued. Along with the short-term improvements identified in the following table, the actions outlined below could prove beneficial to visitors and residents alike:

- Repainting of existing crosswalks with additional signage as appropriate.
- Continue working with abutting properties on access management.
- Locating CCRTA bus stops, shelters, and bicycle racks in key locations as recommended.
- Implementing ADA ramps at problematic locations.
- Continue working with local garden clubs and landscaping companies to sponsor landscaping improvements and/or seasonal displays.

TABLE 4 - SUMMARY OF IMPROVEMENT OPTIONS

Potential Enhancement	Time Frame	Cost	Expected Benefit		
			Safety	Congestion	Bike/Ped
1. Route 28 at Old Stage Road					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Expand SB approach to three full lanes	Long-Term	Medium-High	Low	Low-Medium	-
2. Route 28 at Four Lane Segment (Old Stage Road to Phinneys Lane)					
A. 4-Lane, continuous median within ROW	Long-Term	High	High	High	Medium-High
B. 4-Lane, median with turn pockets within ROW	Long-Term	High	High	Medium-High	Medium
C. 5-Lane, undivided with (2WB, 2EB, and TWLTL) within ROW	Unsafe, should not be advanced				
D. 4-Lane, median with turn pockets, expanded ROW	Long-Term	High	High	Medium-High	Medium-High
E. 4-Lane, median with signal within ROW	Long-Term	High	High	Medium	Medium
F. 3-Lane, undivided with (1WB, 1EB, and TWLTL) within ROW	Long-Term	High	High	-	Medium
3. Route 28 at Phinneys Lane					
A. Retiming	Short-Term	Low	Low	Low-Medium	-
B. ADA pedestrian accommodation upgrades	Mid-Term	Low-Medium	Low	-	Low
C. Realignment	Long-Term	High	High	Medium	Medium
D. Roundabout	Long-Term	High	High	TBD	Medium
4. Route 28 at West Main Street					
A. ADA pedestrian accommodation upgrades	Mid-Term	Medium	Low	-	Medium
B. Designate WB left lane as LT only	Mid-Term	Low	Low-Medium	-	-
5. Route 28 at Strawberry Hill Road					
A. Signal equipment and phasing upgrades, pavement marking, ADA pedestrian accommodation upgrades	MassDOT project funded for FY2016	± $500,000	Medium	Low-Medium	High
B. Re-grading and realignment	Long-Term	High	Medium	Low	Low
6. Route 28 at Barnstable Senior Center/Intermediate School					
A. New/enhanced crosswalks and sidewalks	Mid-Term	Medium	Medium	-	High
B. Signal or Roundabout	Long-Term	High	High	TBD	High
7. Route 28 at Lincoln Road					
Results of the traffic calming measures on Lincoln Road should be assessed before altering the intersection					
A. Add WB LT lane	Long-Term	High	Medium	TBD	-
B. Signal or Roundabout	Long-Term	High	High	TBD	Low-Medium
8. Route 28 at Pitchers Way					
A. Retiming with LT phase	Mid-Term	Medium	Medium	Low-Medium	-
B. ADA pedestrian accommodation upgrades including north-south crosswalk	Mid-Term to Long-Term	Medium-High	Medium-High	-	Medium-High
9. Route 28 at Bearses Way					
A. Intersection reconstruction with additional lanes and bike/ped improvements (includes work to Cape Cod Mall entrance)	MassDOT project funded for FY2015	± $6 Million	High	High	High
10. Other Potential Enhancements					
A. Multi-use path maintenance/rehabilitation	Ongoing	Low-Medium	Low-Medium	-	Low-Medium
B. Multi-use path signage and way-finding	Mid-Term	Low-Medium	Low	-	Low-Medium
C. Address gaps in sidewalks	Mid-Term	Medium-High	Medium-High	-	Medium-High
D. Improve/increase north-south pedestrian crossing	Long-Term	Medium-High	High	-	High
E. Add north side sidewalk where appropriate	Long-Term	High	Medium-High	-	Medium-High
F. Review/revise bus stop locations	Short-Term	Low	Medium	-	Medium
G. Bus shelters	Mid-Term	Medium	Low	-	Low
H. Bus turnouts	Long-Term	High	Medium	Low-Medium	Medium
I. Corridor-wide landscaping upgrades	Mid-Term	Medium-High	Low	-	Low
J. Stormwater management upgrades	Long-Term	Medium-High	Low	-	Low
K. Access management	Ongoing	-	High	High	High
Notes: ADA = Americans with Disabilities Act; EB = eastbound; NB = northbound; SB = southbound; WB = westbound; LT = left turn; TWLTL = two-way left-turn lane; ROW = Right of way; TBD = to be determined (additional analysis would be required)					

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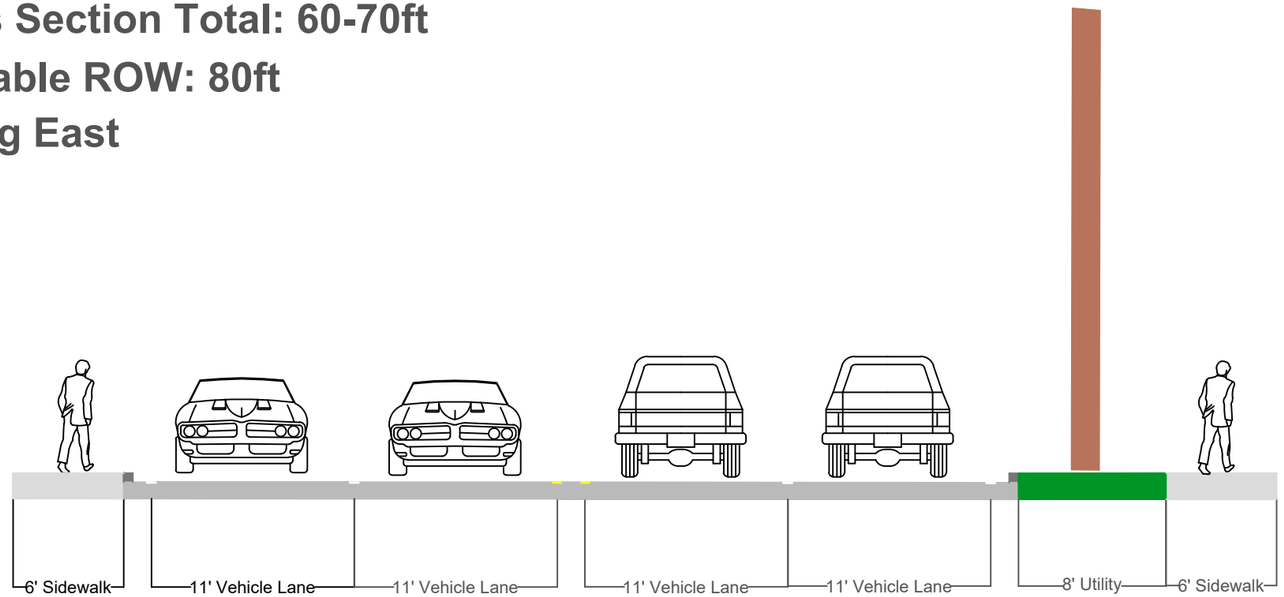
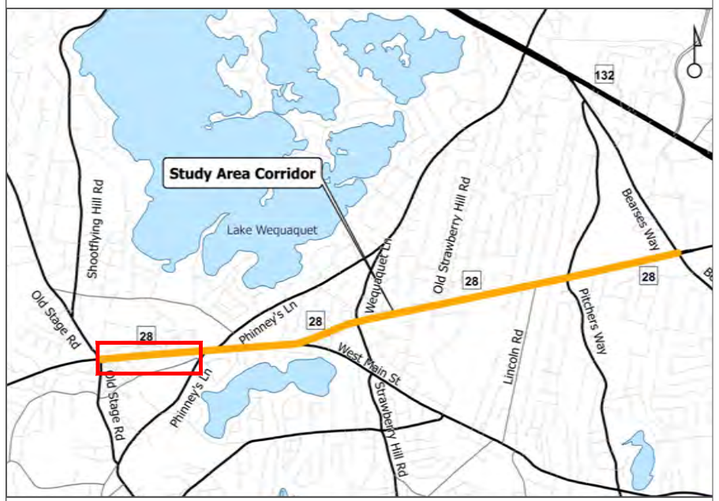
Appendix A - Existing Conditions Map

Cross Section Total: 60-70ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Existing Conditions

Existing Conditions: Four Lanes undivided
Cape Cod Commission Technical Services Staff

Draft February 2015

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

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Appendix B - Traffic Count Data

Count Volumes

Intersection: **Rt 28 @ Lincoln** **Timing Plan:** **NA** **Site Code:** **3867**
Node #:
Count Date: 7/9/2014 **TEV** 1530

	Lincoln Road			Rt 28			Lincoln Road			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM	8	0	9	8	692	119	72	1	19	16	576	10
PHF	0.5	0	0.5	0.667	0.887	0.826	0.818	0.25	0.792	0.667	0.828	0.5
			36	0.1					154	0.3		

Intersection: **Rt 28 @ Pitchers Way** **Timing Plan:** **Yes** **Site Code:** **2811**
Node #:
Count Date: 6/13/2013 **TEV** 1703

	Pitchers Way			Rt 28			Pitchers Way			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM	89	110	15	15	799	86	71	97	36	56	264	65
PHF	0.787	0.886	0.7	0.714	0.931	0.764	0.9	0.925	0.683	0.719	0.981	0.971
			391	0.8					288	0.6		

Intersection: **Rt 28 @ Strawberry Hill Rd** **Timing Plan:** **Yes** **Site Code:** **2829**
Node #:
Count Date: 6/20/2013 **TEV** 1677

	Strawberry Hill Rd			Rt 28			Strawberry Hil Rd			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM	31	143	60	52	594	55	60	155	11	9	466	41
PHF	0.675	0.865	0.75	0.639	0.906	0.819	0.739	0.854	0.833	0.75	0.949	0.485
			482	1					218	0.4		

Intersection:	**Rt 28 @ West Main St**				**Timing Plan:**	**Yes**					**Site Code:**	**2836**
Node #:												
Count Date:	6/13/2013										**TEV**	2308
				Rt 28			West Main St			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM					662	7	16		589	488	546	
PHF					0.88	0.583	0.667		0.909	0.897	0.904	
			0	0					1084	2.2		

Intersection:	**Rt 28 @ Phinneys**				**Timing Plan:**	**Yes**					**Site Code:**	**3798**
Node #:												
Count Date:	6/18/2013										**TEV**	2731
	Phinneys Ln			Rt 28			Phinneys Ln			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM	243	101	33	32	1069	66	80	106	29	27	790	155
PHF	0.959	0.86	0.615	0.8	0.957	0.77	0.74	0.625	0.682	0.615	0.846	0.845
			670	1.3					223	0.4		

Intersection:	**Rt 28 @ Old Stage**				**Timing Plan:**	**Yes**					**Site Code:**	**2852**
Node #:												
Count Date:	6/12/2013										**TEV**	2917
	Old Stage Rd			Rt 28			Old Stage Rd			Rt 28		
	From North			From East			From South			From West		
Time Period	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left	Right	Thru	Left
4:00 - 5:00 PM	53	130	315	360	857	48	46	197	84	33	716	78
PHF	0.764	0.777	0.89	0.915	0.874	0.739	0.662	0.891	0.804	0.875	0.946	0.913
			1133	2.3					295	0.6		

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Appendix C - Crash Diagrams

COLLISION DIAGRAM

Location: Falmouth Road at Old Stage Road

Period: Jan 2011– Jan 2014

Total Crashes: 39 Injury Crashes: 13 Fatal Crashes: 0 EPDO: 91

Collisions located in diagram: 38 NOT located in diagram (see reverse): 1

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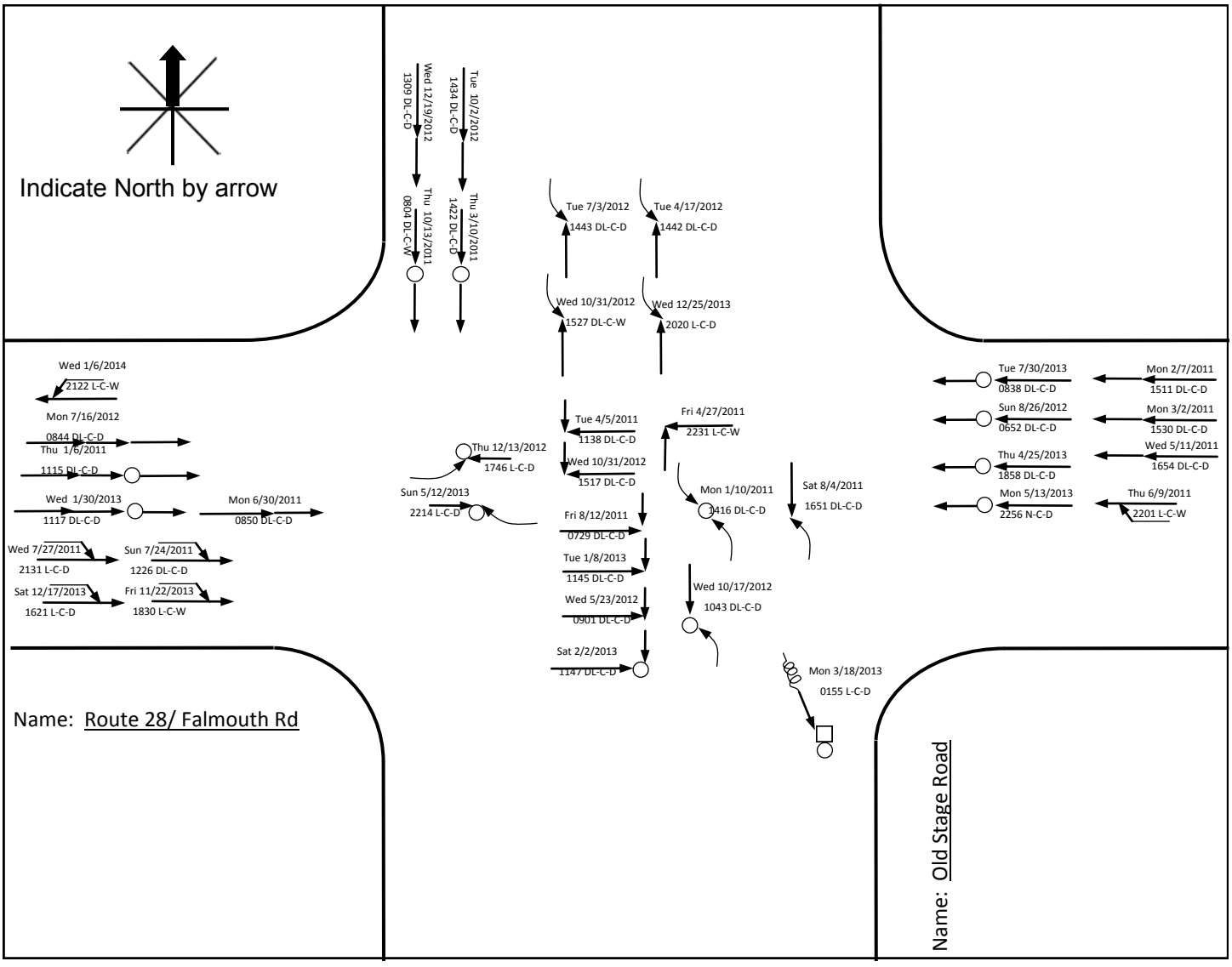

SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE

WED 1/1/2011 1502 DL-C-D

Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES: Many crashes are due to running a red light

# of Wet Crashes: 6

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES
1/15/2011	2210	Two Vehicle, none injured. Fault was failure to yield while turning left

COLLISION DIAGRAM

Location: Falmouth Road at Centerville Shopping Plaza

Period: May 2011— September 2013

Total Crashes: 25 Injury Crashes: 11 Fatal Crashes: 0 EPDO: 69

Collisions located in diagram: 25 NOT located in diagram (see reverse): 0

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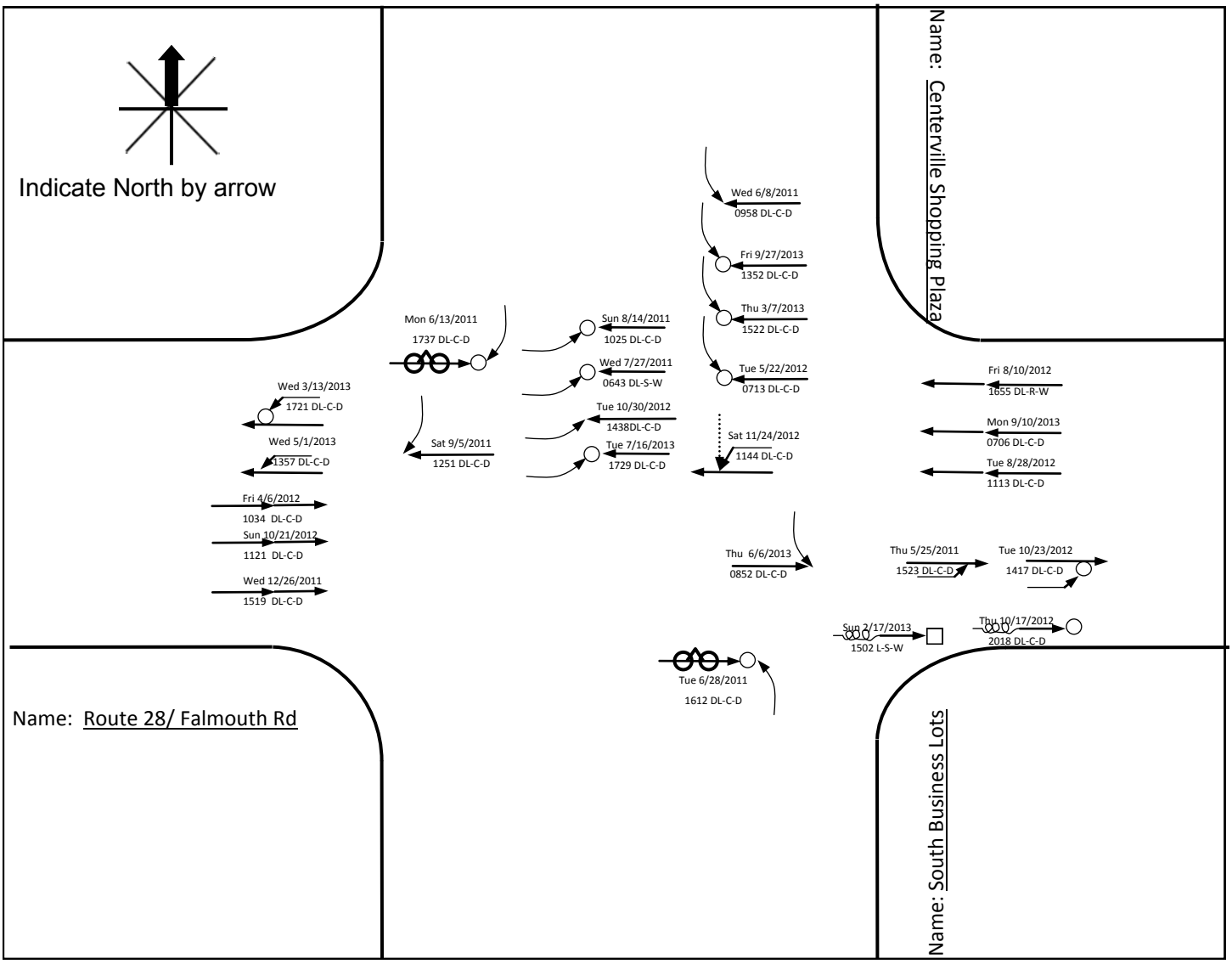


SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

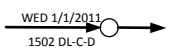
LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE



Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES:
Many complaints about sun disabling vision
# of Wet Crashes: 3

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES

COLLISION DIAGRAM

Location: Falmouth Road at Bell Tower Mall

Period: April 2011— November 2013

Total Crashes: 21 Injury Crashes: 8 Fatal Crashes: 0 EPDO: 53

Collisions located in diagram: 21 NOT located in diagram (see reverse): 0

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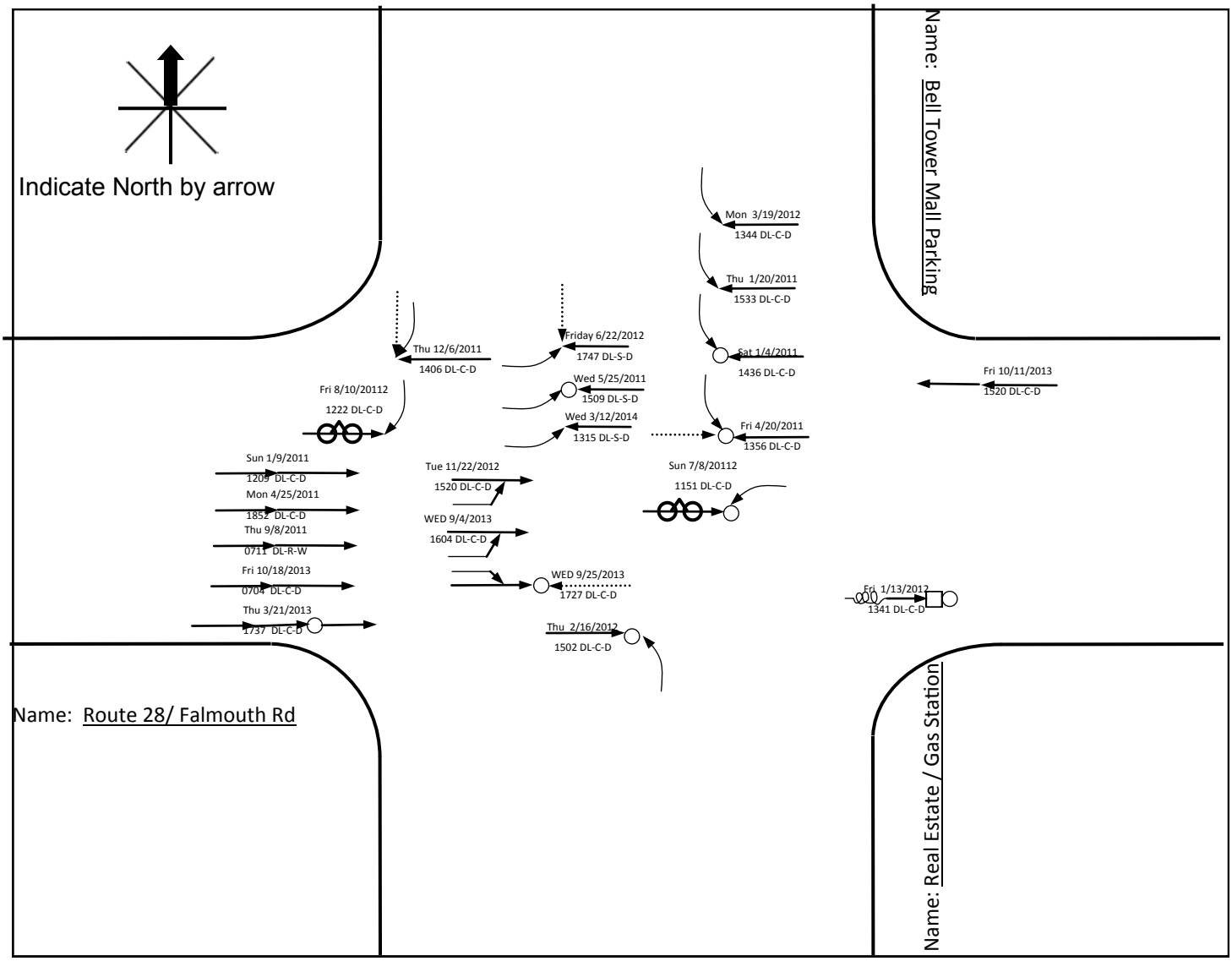


SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE

WED 1/1/2011
1502 DL-C-D

Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES

# of Wet Crashes: 1

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES

COLLISION DIAGRAM

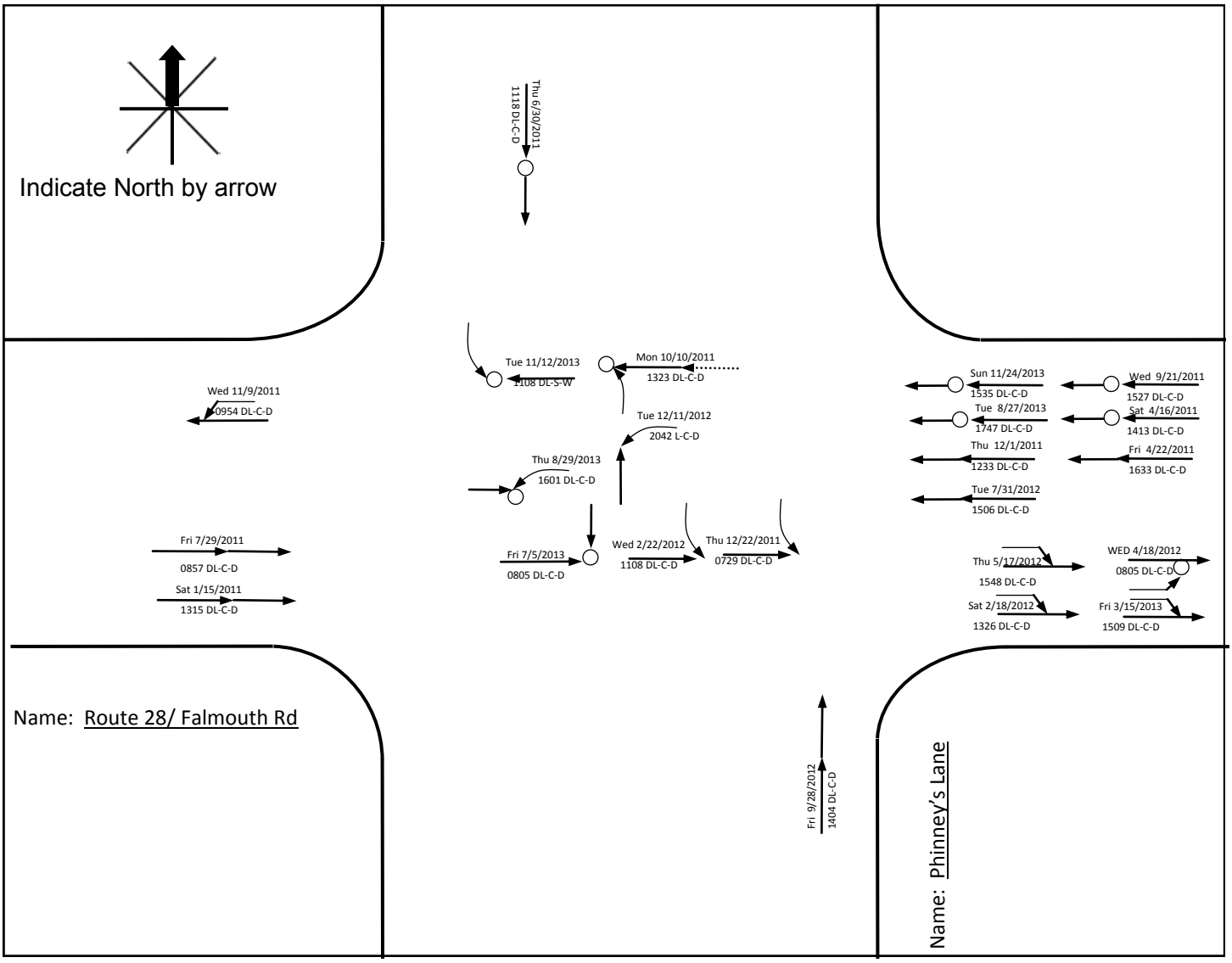
Location: Falmouth Road at Phinney's Lane

Period: Jan 2011– Nov 2013

Total Crashes: 23 Injury Crashes: 10 Fatal Crashes: 0 EPDO: 63

Collisions located in diagram: 23 NOT located in diagram (see reverse): 0

CAPE COD COMMISSION



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

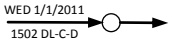
LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE



Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES: Many crashes are due to running a red light

# of Wet Crashes: 1

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES

COLLISION DIAGRAM

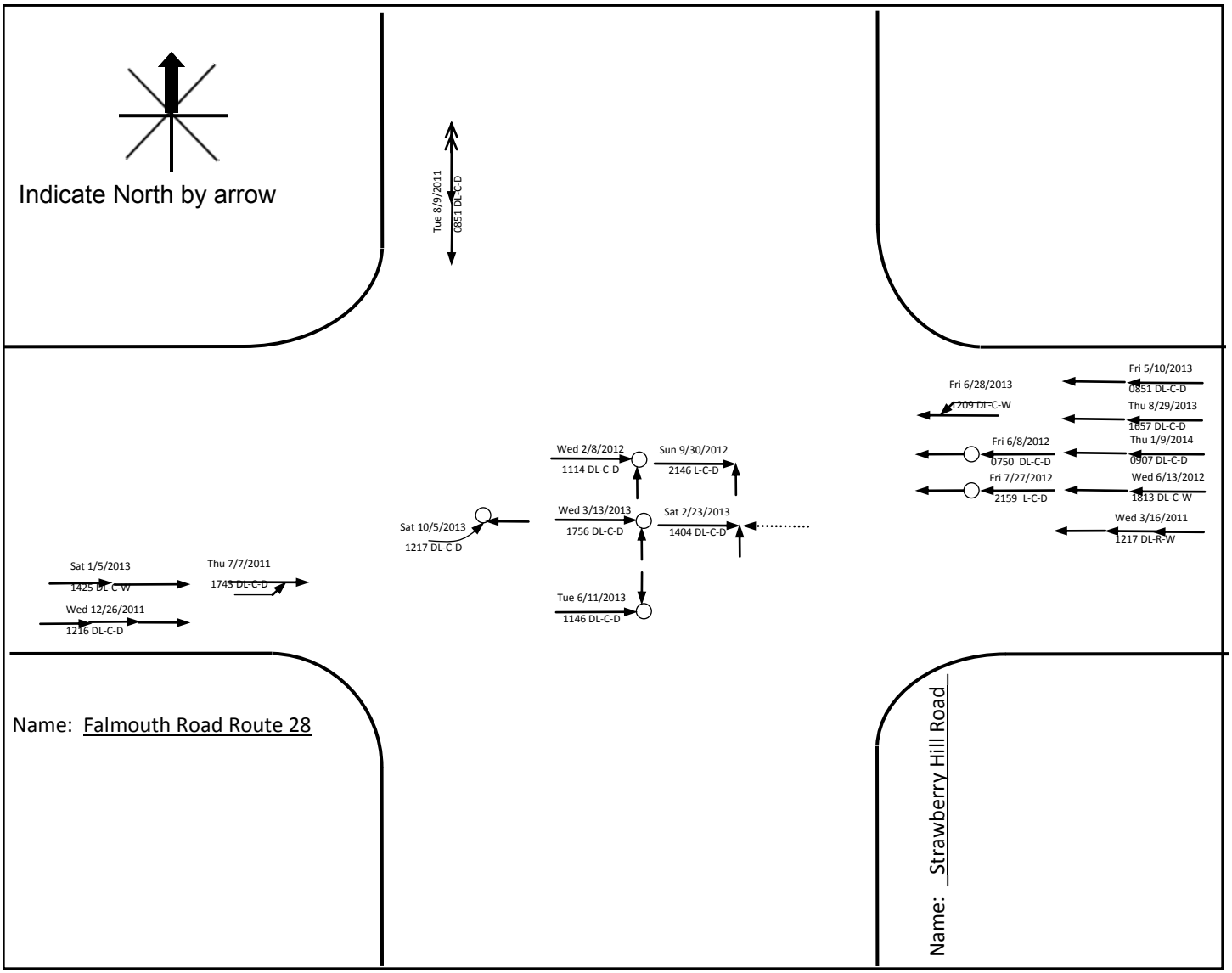
Location: Route 28 Falmouth Road at Strawberry Hill Road

Period: January 2011 - January 2014

Total Collisions: 18 Injuries: 6 Fatalities: 0 EPDO: 42

Collisions located in diagram: 17 NOT located in diagram (see reverse): 1

CAPE COD COMMISSION



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

LIGHTING-WEATHER-PAVEMENT

Lighting
- DL Daylight
- N Dark - No Lights
- L Dark - Lighted

Weather
- C Clear, Cloudy
- R Rain
- F Foggy
- S Snowy, Icy
- O Other

Pavement
- D Dry
- W Wet

EXAMPLE

WED 1/1/2011
1502 DL-C-D

Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES

4 Wet Crashes

Prepared on: 7/8/2014 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES
12/10/2011	13:25	Single Vehicle Crashed into a T-pole, None injured, Travel Direction Unknown

COLLISION DIAGRAM

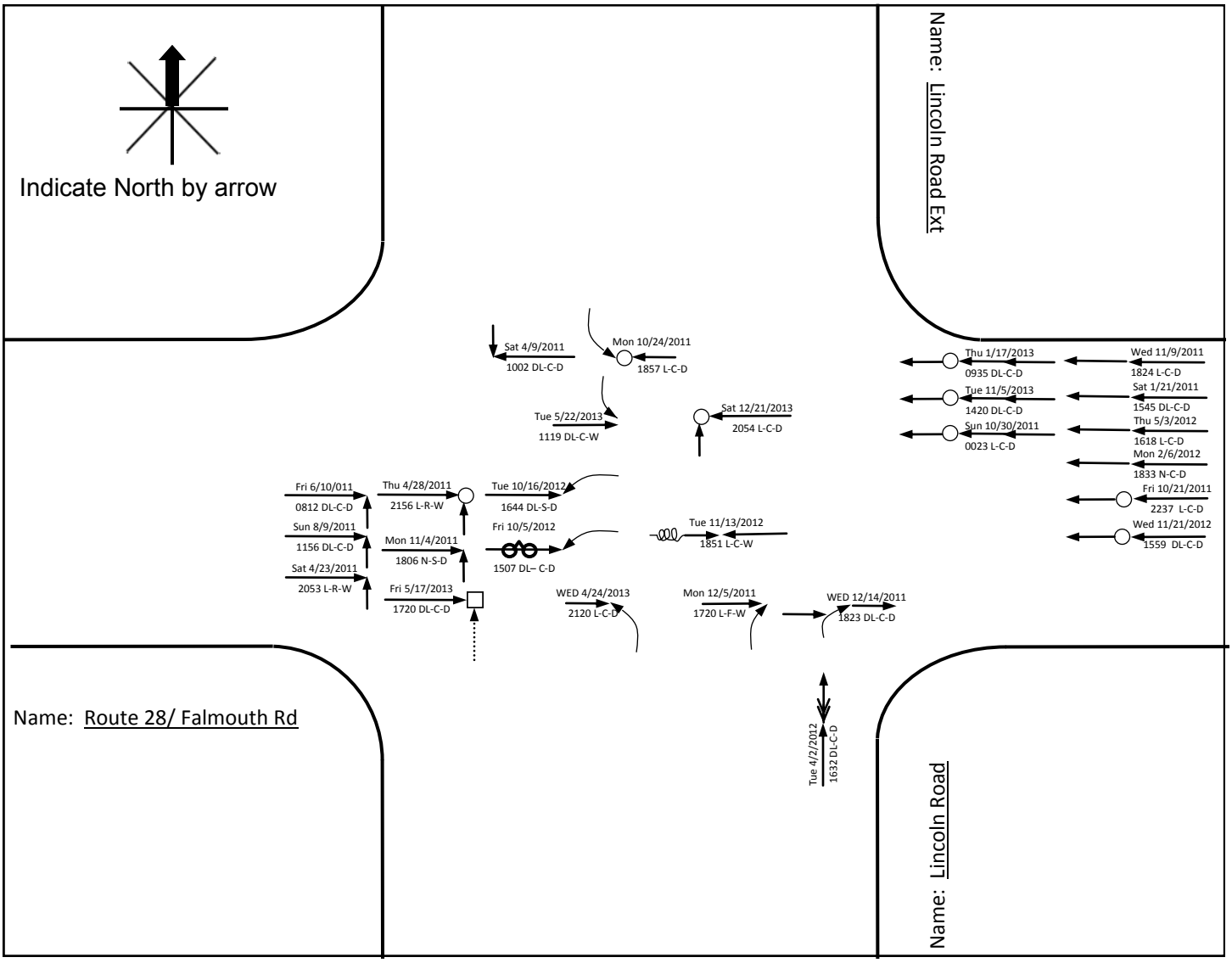
Location: Falmouth Road at Lincoln Road

Period: April 2011— November 2013

Total Crashes: 28 Injury Crashes: 9 Fatal Crashes: 0 EPDO: 73

Collisions located in diagram: 27 NOT located in diagram (see reverse): 1

CAPE COD COMMISSION



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE

WED 1/1/2011
1502 DL-C-D

Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES

# of Wet Crashes: 5

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES
5/29/2012	1412	Three Car Rear End on Route 28, Direction Unknown, Non-Fatal Injuries Occured

COLLISION DIAGRAM

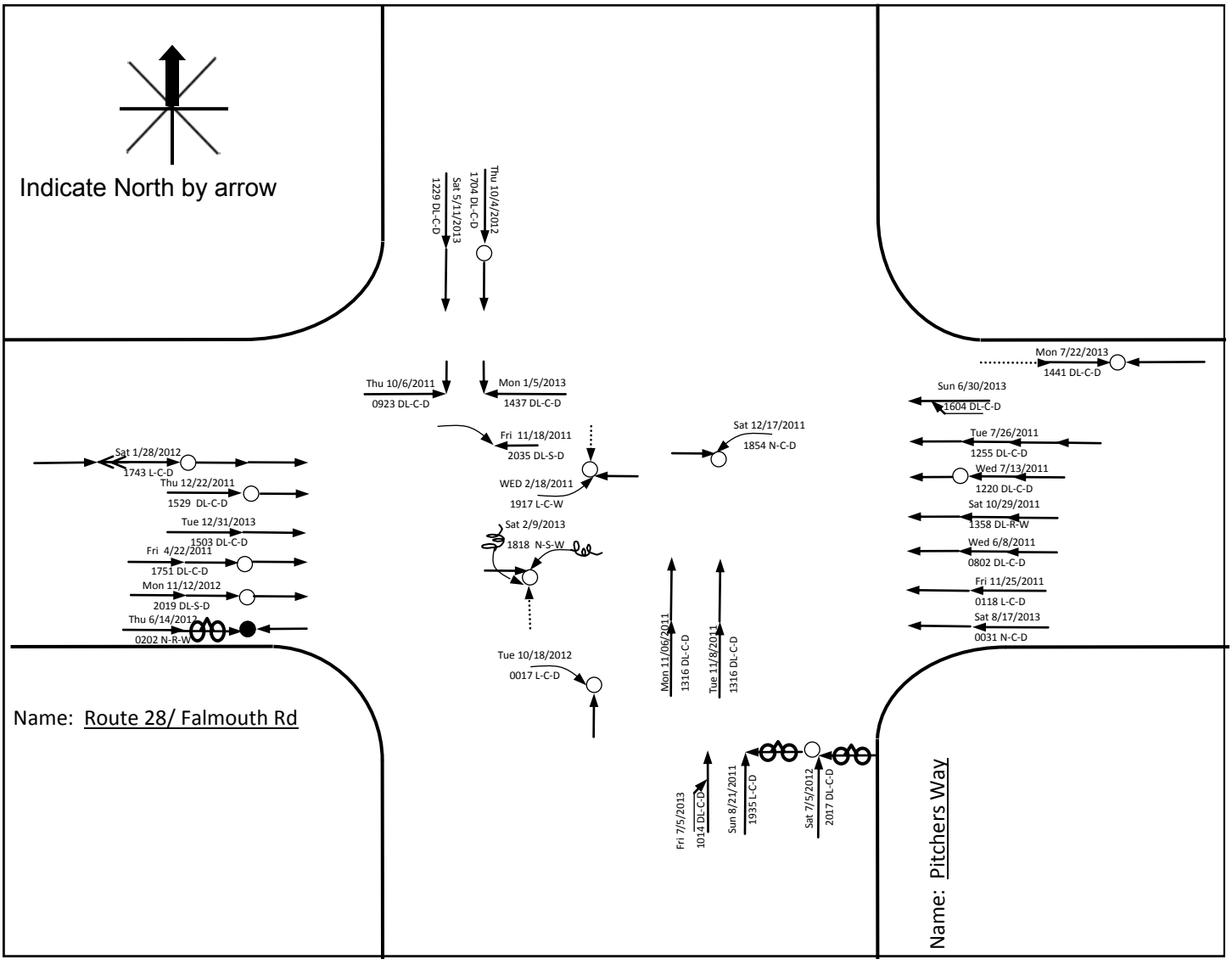
Location: Falmouth Road at Pitchers Way

Period: Jan 2011– Dec 2013

Total Crashes: 29 Injury Crashes: 13 Fatal Crashes: 1 EPDO: 91

Collisions located in diagram: 28 NOT located in diagram (see reverse): 1

CAPE COD COMMISSION



SYMBOLS

- Moving Vehicle
- Backing Vehicle
- Indirectly Involved Vehicle
- Pedestrian
- Bike
- Parked Vehicle
- Fixed Object
- Injury Accident
- Fatal Injury

COLLISION TYPE

- Rear End
- Head On
- Out of Control
- Sideswipe
- Angle
- Turning Movement

LIGHTING-WEATHER-PAVEMENT

Lighting
DL Daylight
N Dark - No Lights
L Dark - Lighted

Weather
C Clear, Cloudy
R Rain
F Foggy
S Snowy, Icy
O Other

Pavement
D Dry
W Wet

EXAMPLE

WED 1/1/2011
1502 DL-C-D

Rear End collision with injury at 3:02 PM on Wednesday, January 1st, 2012 in the daylight, with clear weather, and dry pavement

NOTES

# of Wet Crashes: 5

Prepared on: 6/16/2013 by: Patrick Tierney

Crashes with Unknown Location

DATE	TIME	NOTES
7/26/2011	1255	ID: 11-684, at Pitchers Way Intersection, 4 Vehicles, Property Damage Only

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Appendix D - Kickoff Meeting Materials and Notes

3225 MAIN STREET • P.O. BOX 226
BARNSTABLE, MASSACHUSETTS 02630

(508) 362-3828 • Fax (508) 362-3136 • www.capecodcommission.org

CAPE COD COMMISSION

Notes from Route 28 Centerville-Hyannis Corridor Study Community Kickoff Meeting

March 17, 2014 - 6:00 p.m. - Hearing Room, Barnstable Town Hall

Attendees

Steven Tupper, Cape Cod Commission
Glenn Cannon, Cape Cod Commission
Sharon Rooney, Cape Cod Commission
Garry Meus, Cape Cod Commission
Jo Anne Miller Buntich, Town of Barnstable
Roger Parsons, Town of Barnstable
Steve Seymour, Town of Barnstable
Mike Trovato, Town of Barnstable
Timothy Kochan, MassDOT
Pamela Haznar, MassDOT
Doug Warren
Peggy Warren
Peter Murray
Raymond B. Lang
Rick Pisano
Ray Tomlinson
Jim Walker
Antome Seoiless
Clay Schofield
Eric Steinhilber
Shirley Fisher
Pete Fisher
Jessica Syver
Meg Loughran
Jim Skinner
Ali Maroney
Randy Childs
Mark H. Boudren
Roy Richardson
Georgia Shilling
Ted Shilling
Marcel Rene Poyant
Frederick Chirigotis
Sue Rohrback

Introduction

Project team introduced. Agenda reviewed (attached).

Presentation on Project Goals and Existing Conditions

See attached presentation.

Map Visioning Exercise

Public comments were recorded on maps of the three segments of the corridor:

- Segment 1: Old Barnstable Road to Phinneys Lane
- Segment 2: Phinneys Lane to Old Strawberry Hill Road
- Segment 3: Old Strawberry Hill Road to Bearses Way

See attached maps with comments.

Group Discussion

Group discussion focused on things people liked about the corridor (strengths), things people disliked (issues), things people would like to see changes (changes), and other ideas. The following is a summary of the comments.

Strengths

- Services like Post Office, Dunkin Donuts, banks, convenience stores
- Road is pretty mostly with trees
- Bike/multi-use path gets used
- Sidewalks leading to corridor
- Private easements for sidewalks
- Mixed use is a plus with small shops and residential
- Access to Hyannis
- Local businesses

Issues

- Speed!!
- Left turns
- Signals are not coordinated and to not react to traffic
- 4 lanes to 2 lanes to 4 lanes
- Lack of safe pedestrian crossing and connections to the “mall area”
- Speeding vehicles and motorcycles as threat to pedestrians
- Traffic enforcement
- Interconnect not possible between plazas (segment 1)
- Pedestrians in the road

Changes

- Double left off Old Stage Road southbound
- Coordinate the signals
- Turning arrows
- Sidewalks on north side of segment 3
- Pedestrian bridge at intersection
- Better landscaping on private properties along the corridor
- Bell Tower Drive traffic signal or roundabout
- Redirect some traffic to other roadways East-West or North-South
- Interconnect parcels!
- Zoning change
- Improve access at CVS and gas stations
- Speed control

Other Ideas

- Coordination with the state [MassDOT] is critical to avoid pitfalls
- CVS and gas stations attract significant traffic

Closing

The group was informed about the next steps in the project which will include a listening session with more focused discussion of each segment. Each attendee who signed in with contact information will be notified of the date, time, and location of the next meeting. Additionally, the meeting announcement will be publicized through various outlets. [Scheduled for May 28, 2014 at 6pm at the Barnstable Senior Center, 825 Falmouth Road (Route 28), Hyannis]

For those who could not attend

Project materials are available to on the Cape Cod Commission project website at: http://www.capecodcommission.org/departments/technicalservices/transportation/projects. A video recording of the meeting is available on the Town of Barnstable at http://www.townofbarnstable.us/OnDemand/All_Videos.asp. Comments can be sent to Steven Tupper at stupper@capecodcommission.org.

All of the comments heard during this meeting and received through the project will be taken into consideration in the during the concept development and concept refinement phases of this project.

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(508) 362-3828 • Fax (508) 362-3136 • www.capecodcommission.org

CAPE COD COMMISSION

Route 28 Centerville-Hyannis Corridor Study Community Kickoff Meeting Agenda

March 17, 2014
6:00 p.m. - 8:00 p.m.
Hearing Room, Barnstable Town Hall

1. Introductions

2. Presentation on Project Goals and Existing Conditions

3. Visioning Exercise

- Map Exercise
- Group Discussion

4. Next Steps

LIVING STREETS Cape Cod

See back side for information on Living Streets

To learn more about the project visit:
www.capecodcommission.org/departments/technicalservices/transportation/projects

◇

Email stupper@capecodcommission.org to be added to the project email list.

If you are deaf or hard of hearing or are a person with a disability who requires an accommodation, please contact the Cape Cod Commission at 508-362-3828 or TTY 508-362-5885.
The public discussion of CCJTC and MPO related items at CCJTC, MPO, and transportation public meetings is part of the public hearing requirements of FTA's Section 5307 program. This public notice/meeting is to satisfy the FTA Program of Projects requirements.
"This meeting is accessible to people with disabilities and those with limited English proficiency. Accessibility accommodations and language services will be provided free of charge, upon request, as available.
"Title VI Notice of Nondiscrimination: The Cape Cod MPO through the Cape Cod Commission complies with Title VI of the Civil Rights Act of 1964 and related federal and state statutes and regulations. It is the policy of the Cape Cod MPO to ensure that no person or group of persons shall on the grounds of Title VI protected categories, including race, color, national origin, or under additional federal and state protected categories including sex, age, disability, sexual orientation, gender identity or expression, religion, creed, ancestry, veteran's status (including Vietnam-era veterans), or background, be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity administered by the Cape Cod MPO. To request additional information about this commitment, or to file a complaint under Title VI or a related nondiscrimination provision, please contact the Cape Cod Commission's Title VI Specialist by phone at (508)362-3828, TTY at 508-362-5885, *fax (508) 362-3828 or by e-mail at* MASSDOT.CivilRights@dot.state.ma.us.

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Bicycle Access & Safety

Pedestrian Connectivity

Wet weather management

Improved Traffic Flow

What is a Living Street?

A Living Street *considers the needs of all users (Children, bicyclists, the disabled, motorists) to design context-sensitive solutions to improve the streetscape.*

LIVING STREETS Cape Cod

Living Street Design can help to improve:

- Roadway performance
- Streets that are unsafe for pedestrians and bicyclists
- Inconvenient street crossings
- Uninviting or unsightly streets
- Runoff systems that funnel water into the street or into impaired waterbodies



Recent studies show:

- For every $1 million spent, bicycle/pedestrian projects create a total of 11.4 jobs, versus road only projects which create 7.8 jobs.*
- Transportation related green infrastructure has been found to reduce costs associated with flood management, pavement maintenance, operations and land acquisition.
- The promotion of healthy, active living benefits the local tourism economy and quality of life, raising local land values

**Banking on Green, ASLA.org, Alliance for Biking and Walking Study*

See ***Complete Streets/Living Streets: A Design Manual for Cape Cod*** for more information. Available on the Cape Cod Commission website at:

http://www.capecodcommission.org/resources/design/CompleteStreetsLivingStreetsDesignManual2012.pdf

CAPE COD COMMISSION

Route 28 Centerville-Hyannis Corridor Study

March 17, 2014

Project Kickoff Meeting

Reducing Congestion, Improving Safety, and Accommodating All Users

Today's Agenda

CAPE COD COMMISSION

LIVING STREETS Cape Cod

- Welcome / Introductions
- Project Purpose
- Existing Conditions Overview
- Visioning Exercise
- Next Steps

Key Project Team Members

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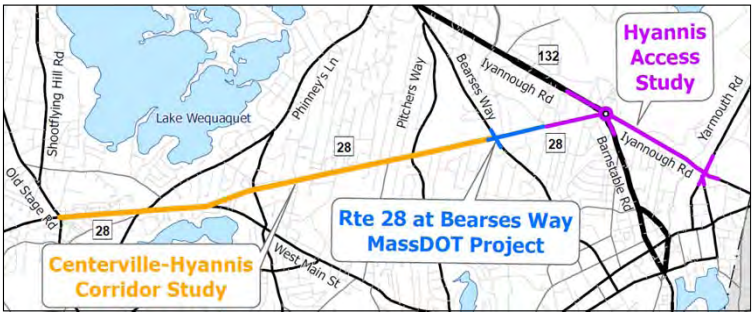
- **CCC Project Team**
  - Steven Tupper – Technical Services Planner
  - Glenn Cannon – Technical Services Director
  - Lev Malakoff – Senior Transportation Engineer
  - Sharon Rooney – Chief Planner
  - Phil Dascombe – Senior Community Design Planner
  - Garry Mues – Regulatory Planner II
- **Town of Barnstable Staff**
  - Jo Anne Miller Buntich – Director, Growth Management Department (GMD)
  - Roger Parsons – Town Engineer, DPW
  - Elizabeth Jenkins, Principal Planner GMD
  - Stephen Seymour, Special Projects Manager/Parking & Traffic Engineer GMD
  - Art Traczyk, Regulatory/Design Review Planner GMD
  - Michael Trovato, Economic Development Specialist GMD

Project Purpose

CAPE COD COMMISSION

- **Identified as priority corridor for a planning study to be completed by the Cape Cod Commission under the 2014 Unified Planning Work Program (UPWP) with the Massachusetts Department of Transportation (MassDOT)**



Project Goals

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Improve Safety

Reduce Congestion

Accommodate All Users

Project Timeline

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Task	Product	NOV '13 - JAN '14	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Task 1: Project Initiation	*SOW & PPP*									
Task 2: Data Collection, Mapping, and On-Site Reconnaissance	*Data and Maps for Other Tasks*									
Task 3: Kickoff Meeting - Opportunities and Constraints	*Summary of Opportunities & Constraints*			★						
Task 4: Listening Sessions	*Summary of Listening Sessions*									
Task 5: Concept Development	*Preliminary Concepts and Feedback Summary*									
Task 6: Concept Refinement	*Draft Report*									
Task 7: Public Presentation and Final Report	*Final Report*									

Study Area

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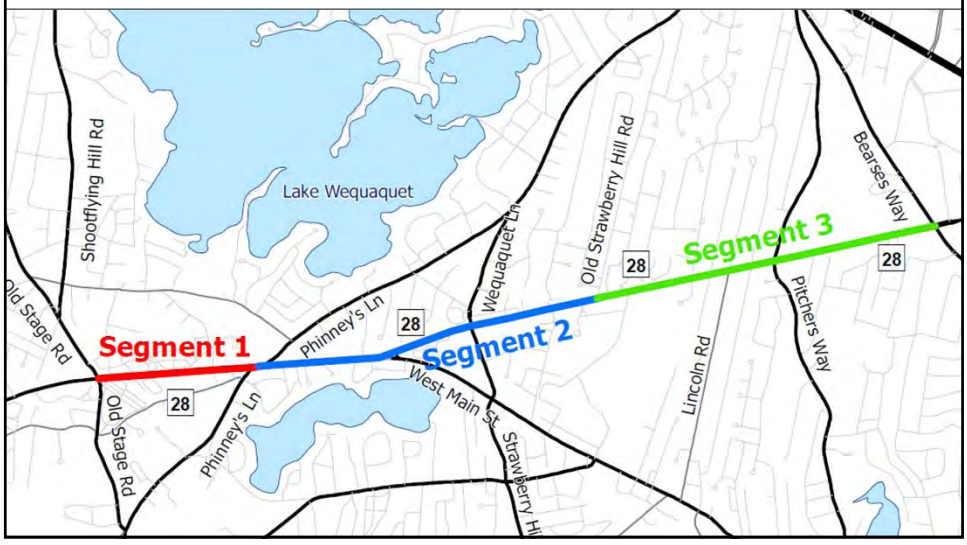

Existing Conditions Overview

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- **Traffic Count Data**
  - Summer 2013 and planned Spring 2014 to capture school trips
- **Crash Data**
  - Crash reports from Barnstable Police Department (2011-2014)
- **Site Visits**
  - Preliminary visits conducted, more planned in the spring

Traffic Counts: Existing Traffic Volumes

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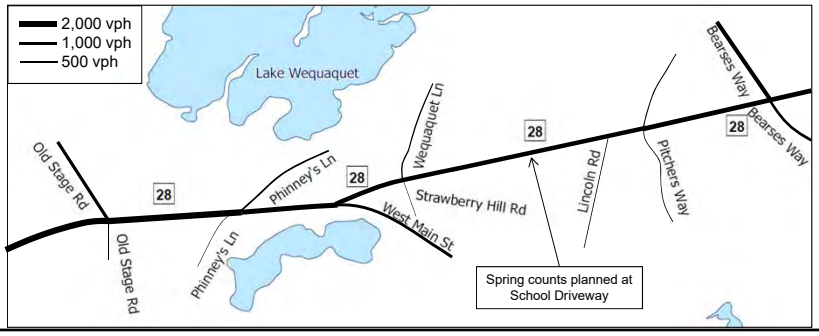
- **Rte 28 traffic ranges from 1,700 to 2,300 vehicles per hour (vph) during the July 4-5pm hour**
- **Relative volumes on intersecting roadways are shown below (summer 2013 volumes)**



Preliminary Crash Analysis

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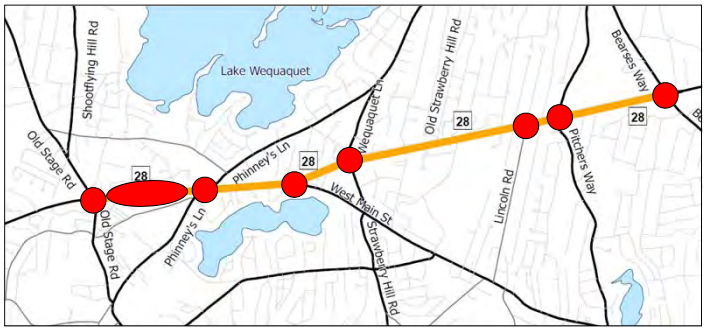
- Over **200 crashes** along the 2.5 mile corridor from 2011 through 2013
- Below are intersections with highest crash totals



Based on preliminary analysis of MassDOT (2009-2011) and Barnstable Police Department records (2011-2013). Results may be refined with further analysis.

Site Visit


NO
MOTOR
VEHICLES


OLD STAGE RD
Mobil
MOTORCYCLES
ARE
EVERYWHERE!!!!

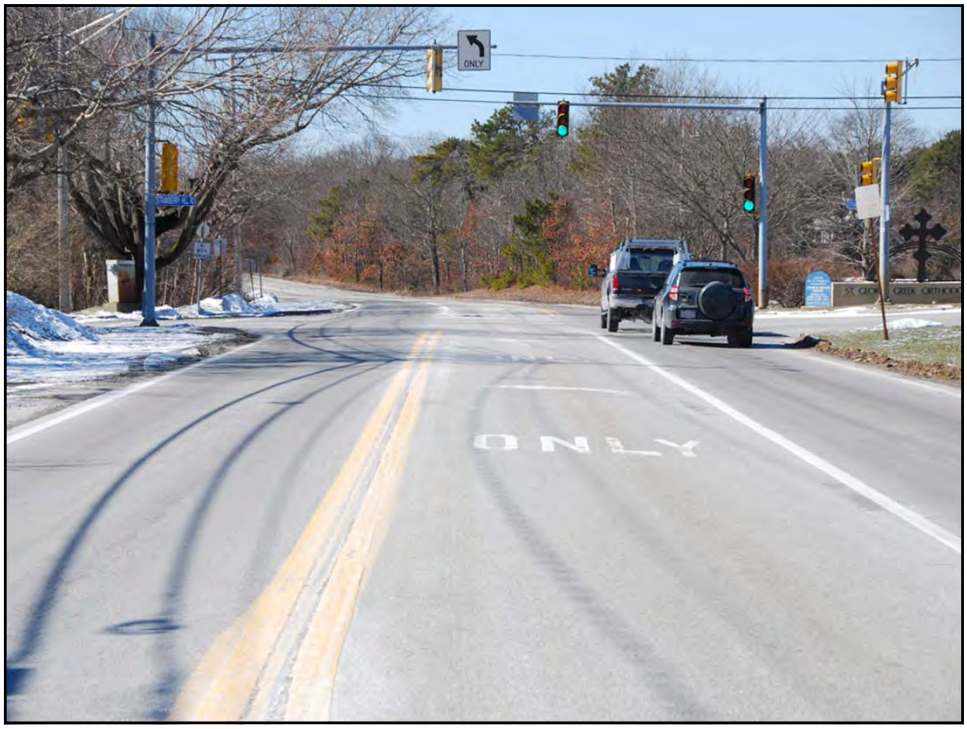

Centerville
SHOPPING
CENTER
THE CAPE COD FIVE CENTS SAVINGS BANK
Tedeschi FOOD SHOPS
TD's Bank
THE GYM EXPRESS
DUNKIN' DONUTS
DOWLING OPTICAL
TANLINES
INNOVATIONS HAIR, SKIN, NAILS
SASSY NAILS
FEIN THINGS
Cards & Gifts
The Tech Depot
BREAKAWAY


LEFT LANE
MUST
TURN LEFT


ONLY


UST
N LEFT
NO
MOTOR
VEHICLES


28 SOUTH
S. YARMOUTH
CHATHAM
HYANNIS
W. MAIN ST.
HYANNIS
CENTER


ONLY
ONLY


Rte 2
Falmouth
HESS


Visioning Exercise

Visioning Exercise

- **What are the things you like in this area?**
- **What are the issues you see?**
- **What would you like to see changed?**
- **Focus on the roadway, sidewalks, and paths.**
- **ALL thoughts are welcomed.**

Sign up on the maps to be involved with follow-up meetings and be included in the project email list.

Next Steps

- **Review Issue Areas/Problem Identification**
- **Next Meeting – Focused Listening Sessions**
  - Last Week of April, Time and Date TBD
- **Analyses and Development of Alternatives**
- **Concept Refinement**
- **Technical Review**
- **Presentation of Draft Report**
- **Recommendations/Final Report**

Feedback?

CAPE COD COMMISSION

Contact

Steven Tupper

Technical Services Planner

Phone: 508-362-3828

stupper@capecodcommission.org

Thank You for attending!

Project materials available at:

www.capecodcommission.org/departments/technicalservices/transportation/projects

Corridor Study - Route 28 (Falmouth Road), Barnstable - Segment 1 [Old Stage Road to Phinney's Lane]

Date: 3/14/2014
User: BWalsh

Old Stage Rd
Camp Opechee Rd
Tom Mullen plan DPW commitment plan 1 space
PO
Connection
Curb cuts
Most accidents
Falmouth Rd (Rte 28)
Left turn lane exists
Sidewalk
Old Stage Rd
Richardson's
NO LEFT TURNS to/ROUNDABOUTS?
Old Post Rd
Most accidents
Possible pumping station idea
Green Spaces?
TAKE THIS LAND
Phinney's Ln
Speed issue
Should be 4 LANE
Falmouth Rd (Rte 28)
Church
Open space
Dangerous by T can't be modified?
Services
Village center
Job center
Convenient w/ access

Name	Email Address or Phone Number

Name	Email Address or Phone Number
Wm Skinner (Segment 1) (Segment 2)	[redacted]
Muriel Reed Bryant	
Fred Chiriaetti	
Peter Murray	
Sue Rehnbach	
Peter + Shirley FISHER	
Donna & Doug Warren	
Ted Schilling	

To learn more about the project:
www.capecodcommission.org/departments/technicalservices/transportation/projects

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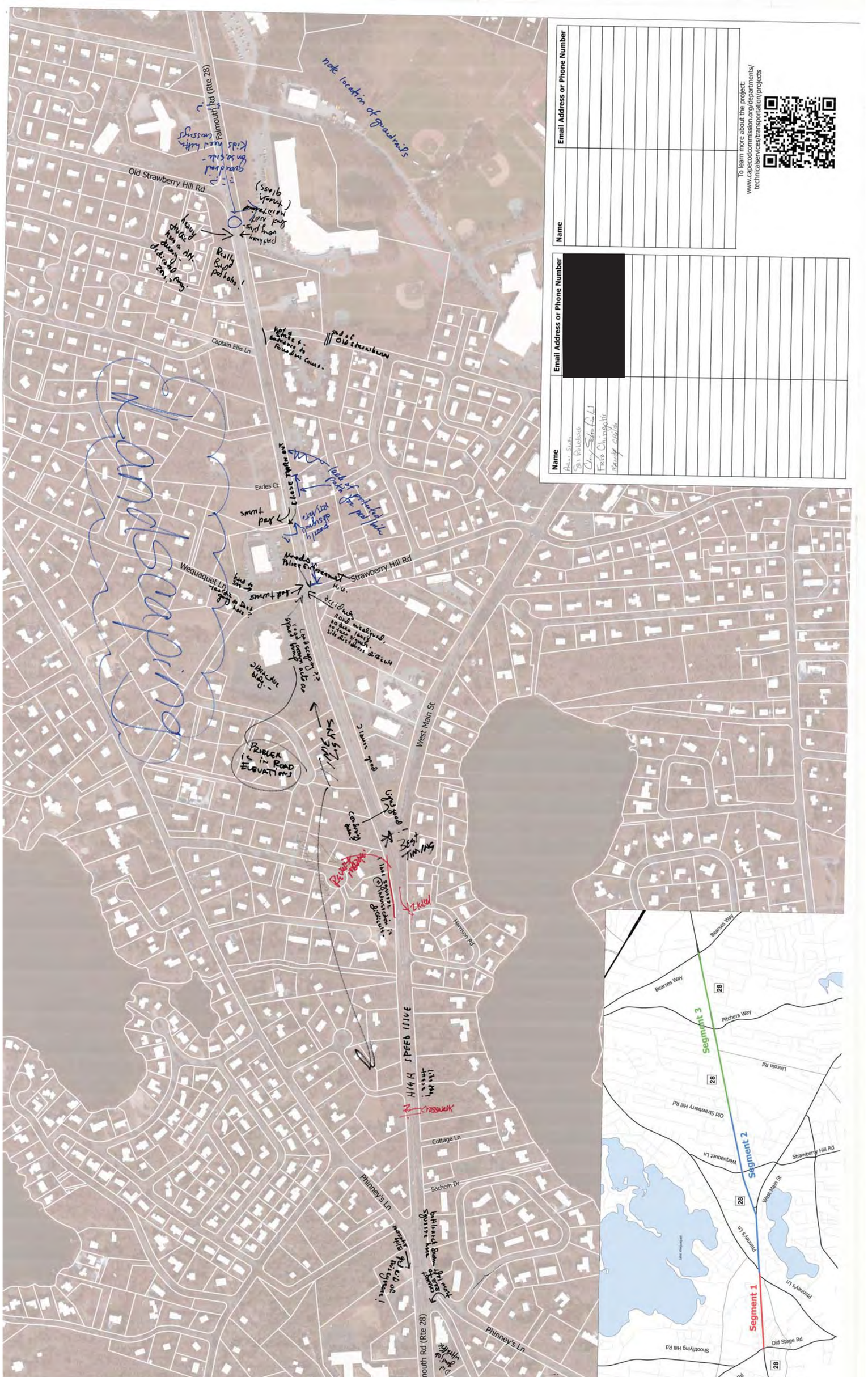

Name	Email Address or Phone Number

Name	Email Address or Phone Number
[redacted]	

To learn more about the project:
www.capecodcommission.org/departments/technicalservices/transportation/projects

orridor Study - Route 28 (Falmouth Road), Barnstable - Segment 2 [Phinney's Lane to Old Strawberry Hill Road]

formation depicted on these maps is for planning purposes only. It is not use for legal boundary definition, regulatory interpretation, or parcel level is. It should not substitute for actual on-site survey, or supersede deed research.

Date: 3/14/2014
User: BWhiteley

1 inch = 125 feet

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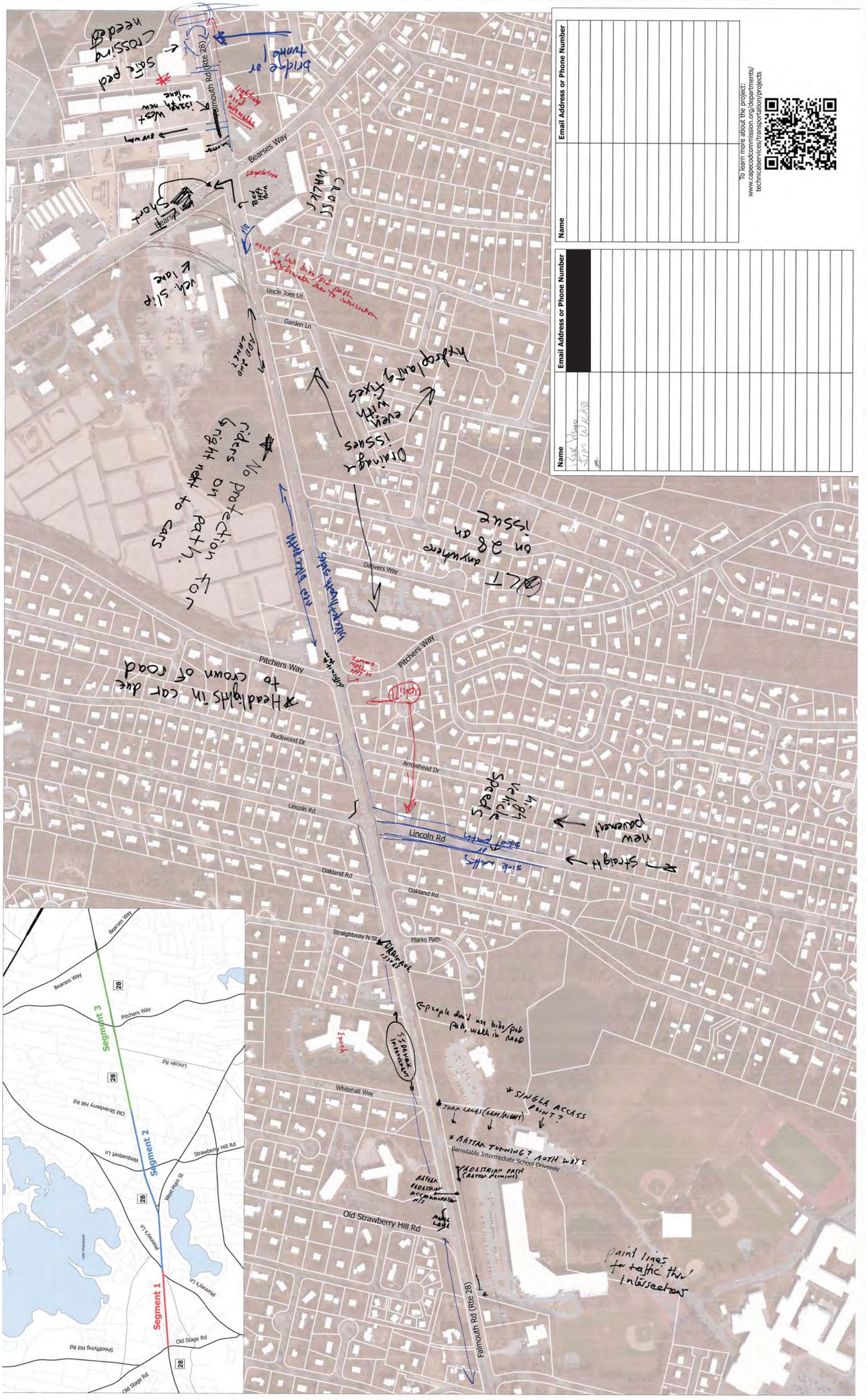

Name	Email Address or Phone Number

To learn more about this project:
www.capecodcommission.org/departments/technicalservices/transportation/projects

Name	Email Address or Phone Number

Corridor Study - Route 28 (Falmouth Road), Barnstable - Segment 3 [Old Strawberry Hill Road to Bearses Way]

Date: 5/14/2014
User: BWhitley

1 inch = 125 feet
0 50 100 200 300 400 500 600 700 800 900 1,000 Feet

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Appendix E – Stormwater Management

Stormwater Management

A strong stormwater management plan is essential to meeting the safety, environmental and public access goals for the RT 28 Study Area goals. The following plan describes stormwater issues and a recommended strategy.

PROJECT DRAINAGE GOALS

As put forth in the Massachusetts Storm Water Manual and adopted by the Cape Cod Commission, the primary goal of the proposed stormwater management strategy is to eliminate untreated stormwater discharging directly to groundwater and surface water sources. To ensure proper treatment, Commission Staff will determine the contaminants of concern for the Study Area, estimated Water Quality Volume, required land area and the Best Management Practices (BMPs) best suited to capture and treat target contaminants.

Inherent in this goal is the proper management and use of available green space both within and without of the available right-of-way in the Study Area. The Cape Cod Commission recommends that MassDOT encourage the use of easements from public and private entities to accommodate the location, construction and maintenance of stormwater infrastructure where limited state road right-of-way would prohibit or complicate BMP siting, construction or maintenance.

CHARACTERIZATION OF STUDY AREA EXISTING CONDITIONS

Segments of the study which do not always drain adequately during storm events have been mapped by local stakeholders to assist Commission Staff in the creation of this report. These locations include, but are not limited to, properties on the south side of RT 28 between Pitchers Way and Garden Lane, the intersection between RT 28 and Straightaway N and the entrance to Cape Maid Farms. Depending on storm conditions, portions of the Study Area, described in detail below, may flood with significant sheet flow over the surface, pond in low

areas, and/or retain large volumes of water at the road edge-of-pavement. With the exception of the stretch of RT 28 adjacent to the Bell Tower Plaza, the roadway does not have a paved shoulder; instead, the edge of pavement is typically finished with a low paved curb, which has the effect of collecting and channelizing stormwater. Sheet flow off of the roadway, or traditional country drainage, is inhibited by the presence of this paved curb and channels the runoff to roadway intersections and connected driveways.

The Route 28 Study Area remains fairly consistent with each section containing similar right-of-way width, pavement edge, median and existing stormwater controls. These analysis segments, in conjunction with elevation above sea level, are depicted in

Figure 3 below and summarized in Table 1.

TABLE 1: ROUTE 28 STUDY AREA SEGMENT OVERVIEW

Section (West to East)	# lanes	Row Width	Shoulders	Pavement Edge	Median	Stormwater Controls
Old Stage Rd. to Phinneys Ln	4	70 - 80 ft.	< 1 ft.	Granite Curb	None	Leaching Catch Basins
Phinneys Ln to W. Main St.	2	70 - 80 ft.	< 1 ft. to 3 ft.	Granite Curb for 800 ft then Bermed	None	Country Drainage[1]
W. Main St. to Strawberry Hill Rd.	2W, 1E	70 - 80 ft.	< 1ft.	Bermed	None	Country Drainage
Strawberry Hill Rd. to Bearses Way	2	60 - 80 ft.	< 1ft.*	Bermed	None	Country Drainage

[1] Limited Leaching Catch Basins

Many potential drainage issues are alleviated by the highly porous soils on Cape Cod making leaching catch basins and country drainage and attractive and affordable option. Even with the benefit of porous soils, drainage problems arise affecting pedestrian access, increasing drivers hydroplaning risk and transporting contaminated runoff into our surface and ground waters. While drainage issues may not arise in each drainage sub-section (Table 4) stormwater controls may still be required to capture and treat contaminated runoff from contributing to water quality problems as listed in Table 3. As such, the entire Study Area should be considered for upgraded stormwater controls.

Figure 1 depicts the Study Area for this report including locations where Route 28 intersects nitrogen sensitive watersheds and Wellhead Protection Areas (WHPA) as defined in the 2009 Cape Cod Commission Regional Policy Plan. Nitrogen sensitive watersheds have been determined by the Massachusetts Estuaries Project (MEP) and nitrogen removal percentages provided in Figure 1 reflect those put forth by the MEP analysis. Many Cape Cod watersheds listed as

nitrogen sensitive through the MEP process have been assigned a TMDL for nitrogen from the Department of Environmental Protection (DEP). Many of the watersheds not yet assigned a TMDL have pending TMDLS. Pending TMDLs should be considered finalized for the purpose of this analysis.

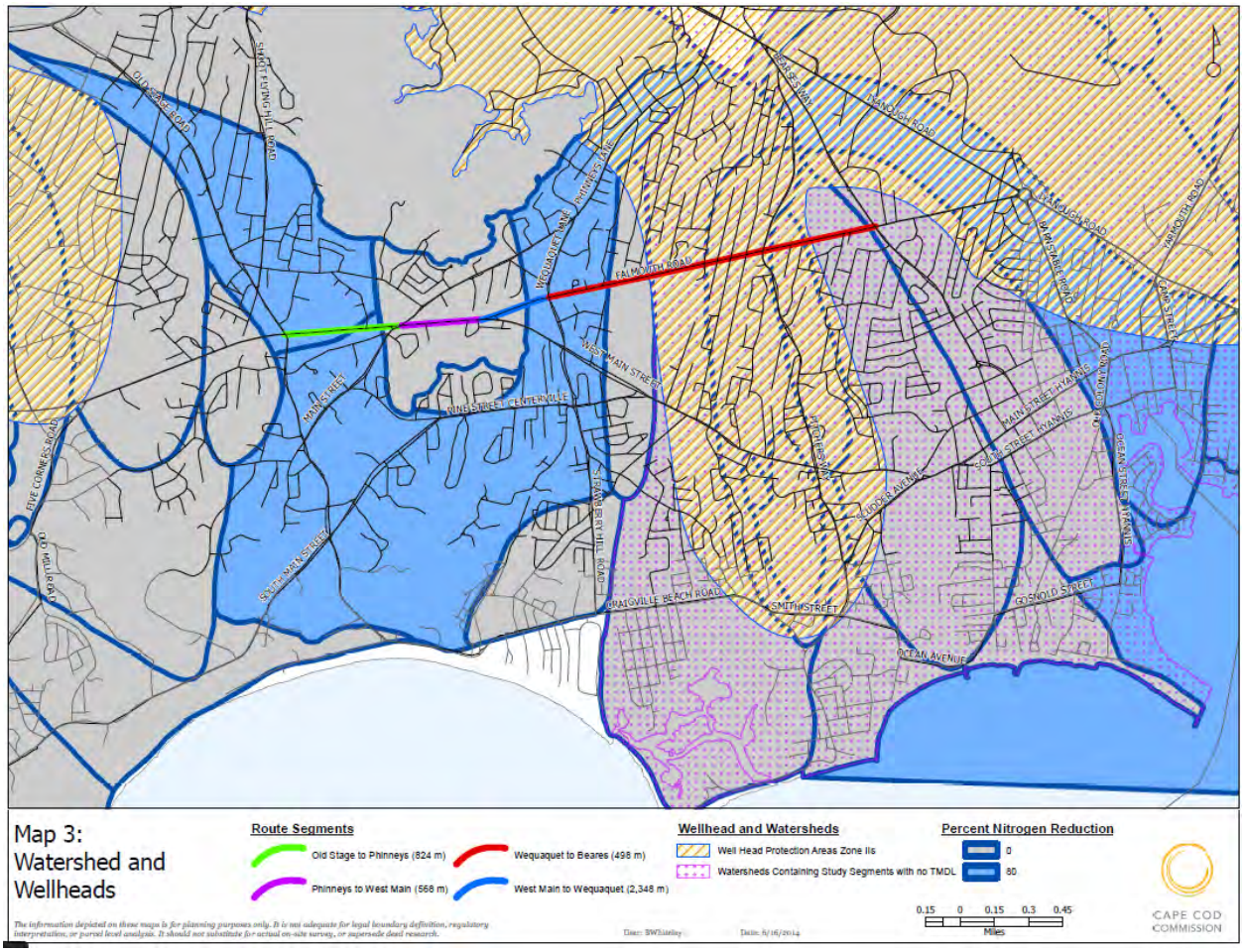

FIGURE 1: NITROGEN SENSITIVE WATERSHEDS AND WELLHEAD PROTECTION AREAS

Figure 2 includes locations where Route 28 contributes to water bodies mapped as impaired on the MassDEP 2012 Integrated List. Water body categories provided in Figure 2 reflect those put forth by MassDEP and depict varying types of impairment and TMDL status. Under section 303(d) of the Clean Water Act, States are required to develop lists of impaired waters. These waters are too polluted or otherwise degraded to meet acceptable water quality standards. The law requires that priority rankings are established for waters on the lists in addition to developing TMDLs for these waters. For more detailed information visit the MassDEP website at (http://www.mass.gov/eea/docs/dep/water/resources/07v5/12list2.pdf).

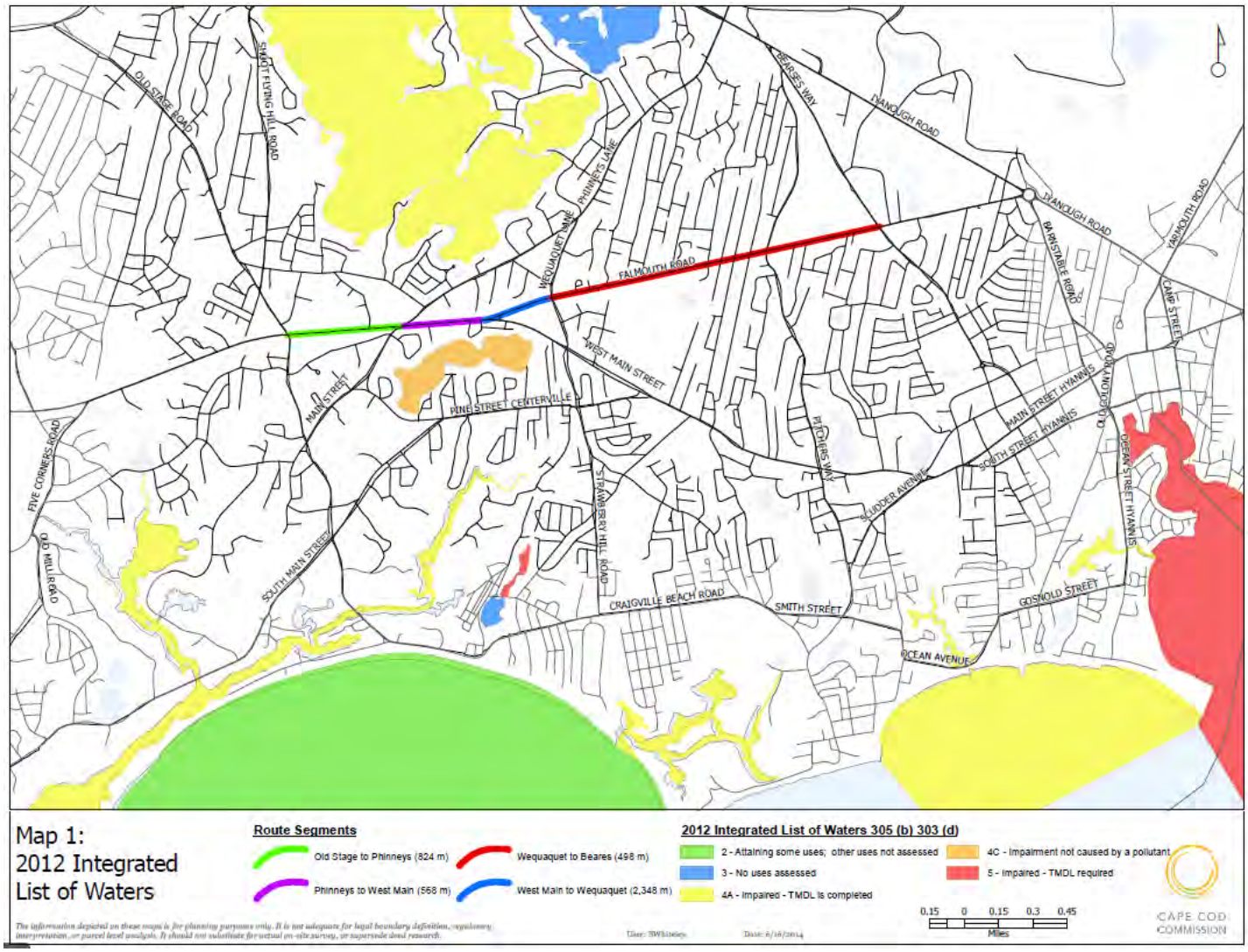

FIGURE 2: MASSACHUSSETS DEPARTMENT OF ENVIRONMENTAL PROTECTION 2012 INTEGRATED LIST OF WATERS 305 (B), 303 (D)

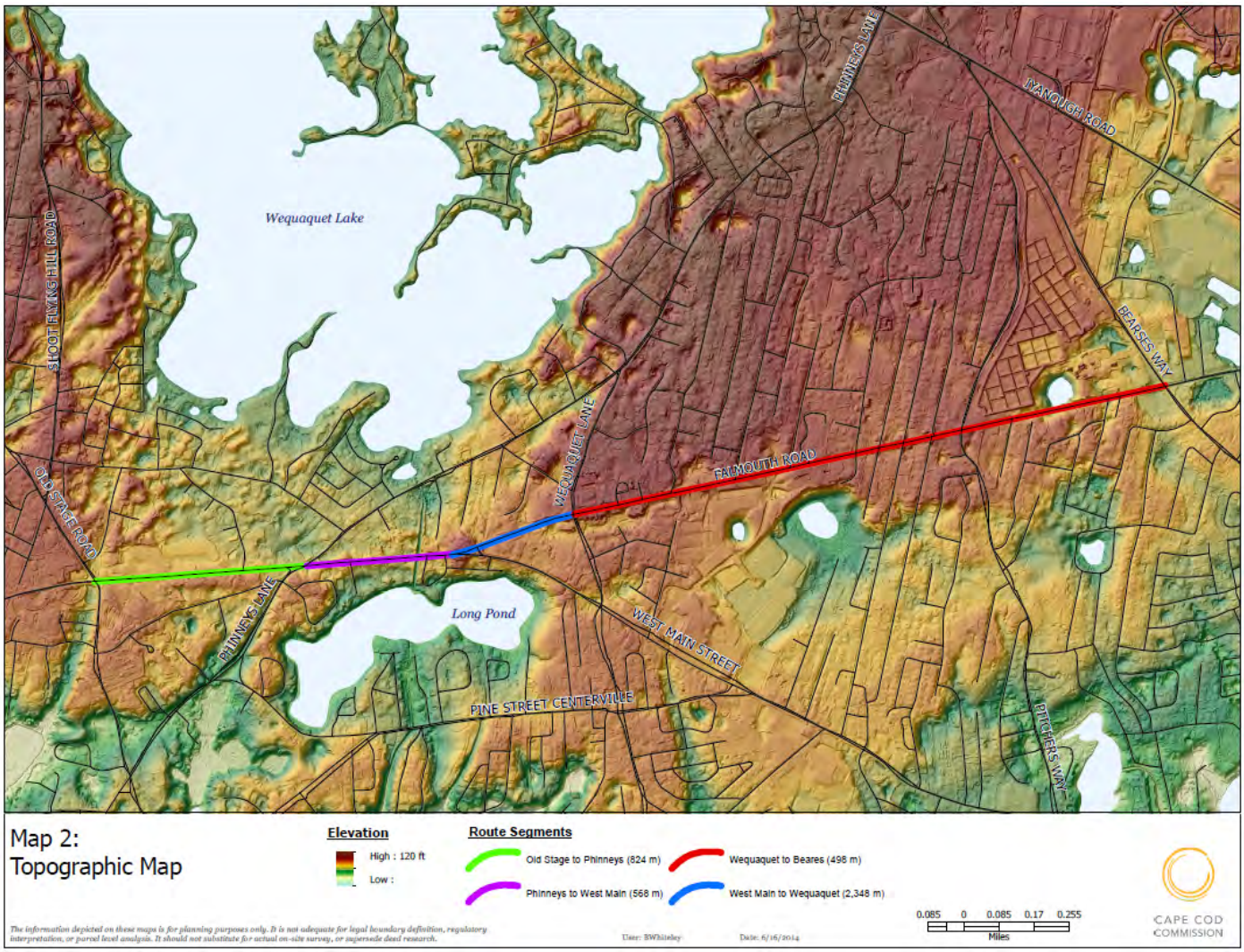

FIGURE 3: ROUTE 28 HYDROPLANING STUDY ANALYSIS SEGMENTS

Figure 3 depicts elevation above sea level in addition to Study Area planning segments. Depth to groundwater is a significant factor in BMP selection and placement and will play an important role in the formation of any drainage plan.

CONTAMINANTS OF CONCERN

The Study Area crosses across two major watersheds, Centerville River and Lewis Bay, and a number of sub-watersheds including; Centerville River East, Long Pond, Craigville Wells #8, Halls Creek, Simmons Hyannisport Wells, Fawcetts Pond and Stewarts Creek. As shown in Figure 1 and Figure 2, nitrogen sensitive watersheds and impaired water bodies are defined in Table 2 and Table 3.

Table 2: MEP Watershed Nitrogen TMDL Status

Water Body	MEP Nutrient TMDL Status
Centerville Harbor	Final
Lewis Bay	Draft

Table 3: MassDEP 2012 Integrated List

Water Body	Integrated List Category	Impairment Cause
Centerville Harbor	Category 2	Attaining some uses; other uses not assessed
Centerville River	Category 4A	Estuarine Bioassessments, Fecal Coliform and Nitrogen
Long Pond	Category 4C	Non-Native Aquatic Plants (TMDL not required)
Lake Elizabeth	Category 3	No uses assessed
Red Lilley Pond	Category 5	Fecal Coliform and Nutrient/Eutrophication Biological Indicators
Halls Creek	Category 4A	Fecal Coliform
Stewarts Creek	Category 4A	Fecal Coliform
Lewis Bay	Category 5	Estuarine Bioassessments, Fecal Coliform

According to the MEP Technical Report the Centerville River East sub-embayment requires a 62% reduction in the total controllable nitrogen load to prevent eutrophication of the water body. Seven (7) percent of the total controllable nitrogen load contributing to Centerville River East is from impervious sources with an additional 4% from fertilizer sources. In addition to nitrogen loading impairments, the MassDEP 2012 List of Impaired Waters Centerville River and Red Lilley Pond are both impaired by fecal coliform (Table 3).

According to the MEP Technical Report Lewis Bay proper requires a 16% reduction in the total controllable nitrogen load to prevent eutrophication of the water body. Nine (9) percent of the total controllable nitrogen load contributing to Lewis Bay is from impervious sources with an additional 6% from fertilizer sources. While Lewis Bay proper requires an overall reduction in nitrogen, the

sub-watersheds intersected by the study are currently un-impaired by nutrients. As such, focus should be placed on fecal coliform which each sub-watershed intersected by the Study Area is listed as impaired on the 2012 Integrated list (Table 3).

NITROGEN

Transported by stormwater runoff, pollutants from land use development, including nitrogen, find their way into the ground and surface waters throughout the Cape. These waters, along with their increased pollutant loads ultimately discharge to coastal embayments. The presence of increased nitrogen loading from land use development has a significant effect on the nitrogen-limited coastal embayments. Nitrogen limited ecosystems are ecosystems that have adapted under low nitrogen conditions. When an excess of nitrogen is introduced to an embayment changes in the community composition will occur. A common result from excess nitrogen loading is the increase of fast growing species (i.e. algae), which often outcompete other life forms resulting in the loss of species diversity and community richness. This is referred to as the process of eutrophication. In some severe cases eutrophication creates anoxic environments resulting in fish kills and aesthetically unpleasing conditions. The nitrogen load that changes a healthy system to a eutrophic condition is defined as a critical threshold, which under the federal Clean Water Act is referred to as a Total Maximum Daily Load (TMDL) and requires the restoration of impaired surface water bodies.

There are a limited number of stormwater management technologies which effectively remove nitrogen from stormwater. The primary method of effective bacteria removal for BMPs through creating an anoxic, or oxygen free, environment for denitrifying bacteria to convert nitrogen in stormwater to inert nitrogen gas. These practices include primarily bioretention systems, sub-surface constructed wetlands and Retention Ponds. A number of BMPs such as tree box and various media filters achieve lesser nitrogen removal through nutrient uptake.

BACTERIA (Fecal Coliform)

Sources of bacteria in stormwater vary and may include animal wastes, agricultural activities, untreated human wastes, landfills, inappropriate discharges from residential or commercial activities and naturally occurring sources. Understanding sources of bacteria is essential while selecting

appropriate BMPs. As with all sources of pollutants, proper management of the source is the most effective and often the cheapest course of action.

There are few stormwater management technologies which effectively remove bacteria from stormwater with a number of BMPs actually increasing bacterial pollution. The primary method of effective bacteria removal for BMPs is by filtration through a filter media. These filtration approaches vary and include tree box filters, bioretention systems, porous pavements, constructed wetlands and sub-surface sediment chambers. This last approach is commonly manufactured and marketed as a proprietary solution.

RECOMMENDED BEST MANAGEMENT PRACTICES

BIORETENTION

Bioretention is a method of treating stormwater by ponding water in shallow depressions underlain by a sandy engineered soil media through which most of the runoff passes ("Design considerations associated with bioretention practices" 20th Anniversary Conference on Water Management in the'90s Coffman et al., 1993).

Bioretention systems can easily be incorporated into the landscape to address and maintain many of the natural hydrologic functions. Pollutants within these systems are removed through both chemical and physical means within the bioretention soil mix (BSM). Bioretention systems also encourage biological treatment of nutrients, such as nitrogen, through nutrient uptake by vegetation within the system. Bioretention tends to work best in sandy soils such as are present in many areas of Cape Cod.

Bioretention systems achieve excellent removal efficiencies for a wide range of pollutants including TSS, petroleum hydrocarbons, nitrogen, metals, phosphorus and bacteria.

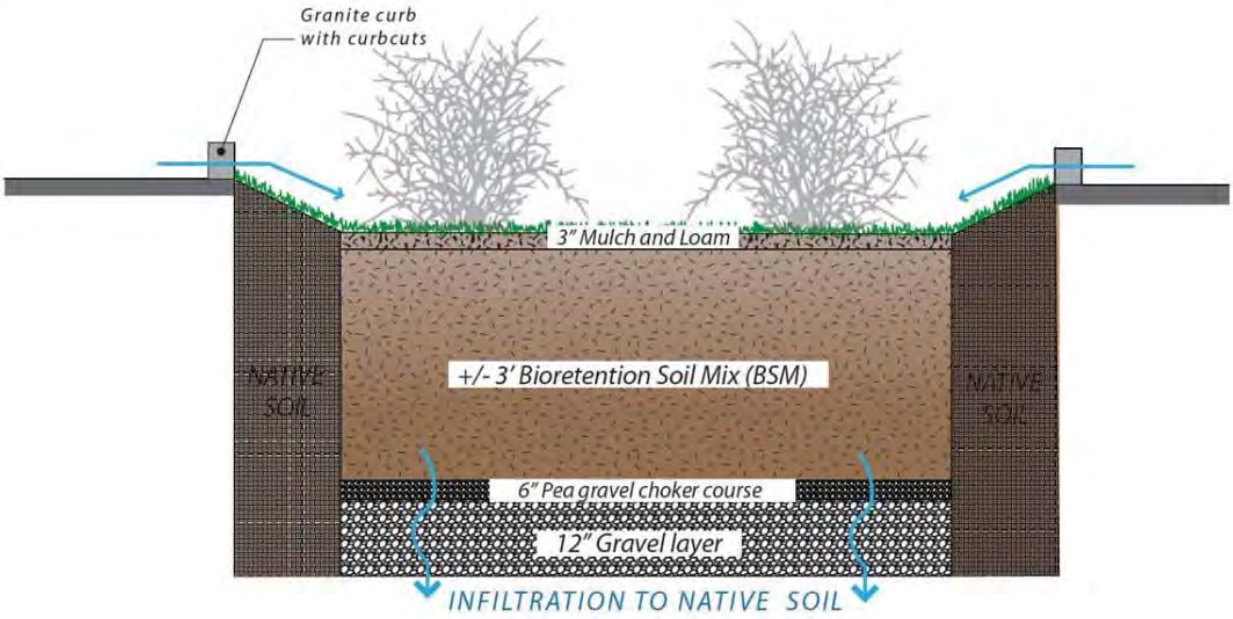

FIGURE 4: CROSS SECTION OF A COMMON BIORETENTION SYSTEM

LEACHING CATCH BASINS

A leaching catch basin is similar to a traditional catch basin with the added ability to permit the infiltration of captured runoff. Leaching basins are often installed in series with a deep sump catch basin that providing. Because of this pretreatment, the catch basin/leaching basin combination is preferable to the leaching catch basin as a higher removal of TSS may be achieved while also extending the life and minimizing maintenance on the leaching catch basin. Leaching catch basins and leaching basins should only be used in areas with highly permeable soils, making these basins a popular stormwater control throughout the Cape.

Leaching catch basins, in series with pre-treatment catch basins, achieve excellent TSS removal in addition to constituents that sorb to fine particulates including petroleum hydrocarbons and metals.

SUB-SURFACE SEDIMENT CHAMBERS

Sub-surface sediment chambers function similarly to surface sedimentation systems. Sediment trapping systems remove pollutants (mainly particulates) from stormwater runoff through a pretreatment sedimentation area followed by an infiltration bed containing filter media (typically sand, soil, gravel or a combination of media). This infiltration bed removes fines and the pollutants sorbed, or attached, to these particulates. Various contaminants including, but not limited to metals, petroleum hydrocarbons and bacteria may sorb to fines

allowing infiltration systems to achieve removal efficiencies in these categories though the physical process of filtration.

Sub-surface sediment chambers traditionally discharge directly to groundwater however systems can be designed with an outflow mechanism returning treated flow to a stormwater conveyance system.

FIGURE 5: HDPE SUB-SURFACE TREATMENT CHAMBERS (PHOTO COURTESY LINDSAY COOK, CAPE COD CONSERVATION DISTRICT INTERN)

WATER QUANTITY

In natural ecosystems runoff is infiltrated into groundwater and slowly discharged, in some cases over tens to hundreds of years, to freshwater streams, ponds, lakes, rivers and marine estuaries. Flooding is less significant in these natural systems due to the presence of pervious surfaces passing runoff from the surface to the groundwater. In urbanized areas these natural systems are replaced with dense impervious cover reducing the amount of infiltration that can occur. Even in the Cape, an area with a naturally high infiltration rate, flooding can occur in urbanized areas causing damage to infrastructure and making roadways unsafe for travel.

WATER QUALITY VOLUME

The Water Quality Volume (WQV) represent the runoff generated by a design depth of rainfall from a given drainage area. This provides a minimum quantity (ft^3) of water to capture and treat for the constituents of concern. To capture the full volume of each rain event would be costly and require large dedicated portions of land. In its essence, the goal of stormwater management is twofold and includes treating contaminated runoff and minimizing flooding issues for the majority of storm events. The WQV calculation guarantees that the most contaminated runoff, or the first flush, of each event is captured. The first flush typically includes the most polluted runoff of an event as it re-suspends contaminants that have been gathering on impervious surfaces during dry periods. Therefore, guaranteeing the capture and treatment of this initial runoff stream is the most important from a water quality standpoint.

As defined by the Massachusetts Stormwater Design Handbook, the required WQV for the below land use types equals 1.0” of runoff times the total impervious area. The remaining land use types require a design depth of 0.5.”

- from a land use with a higher potential pollutant load;
- within an area with a rapid infiltration rate (greater than 2.4 inches per hour);
- within a Zone II or Interim Wellhead Protection Area;
- near or to the following critical areas:

- Outstanding Resource Waters,
- Special Resource Waters,
- Bathing beaches,
- Shellfish growing areas,
- Cold-water fisheries.

For the purposes of this report the WQV is calculated following Equation 1 and as defined below.

EQUATION 1: WATER QUALITY VOLUME CALCULATION

$$WQV = P * Rv * I * A$$

Where:

P = precipitation (in.)

Rv = unitless volumetric runoff coefficient

I = percent impervious cover draining to structure

A = contributing drainage area to BMP (acre)

REQUIRED LAND AREA

The drainage areas for the sub-sections (Table 4) include all land area within the ROW for the Study Area (Appendix A). While this approach likely overestimates the actual WQV for the Study Area, the values below will provide a high end estimate for stormwater quantity management. Contributions from minor intersections are not included in the estimated drainage area and should be included in a more detailed drainage analysis.

TABLE 4: DRAINAGE SUB-SECTIONS AND ASSOCIATED WQV AND DRAINAGE AREAS

Drainage Sub-Section	Drainage Area	WQV[1] (0.5")	WQV[1] (1.0")	Gravel Wetland Estimated Land Area[2]	Bioretention Estimated Land Area[3]
	acre	ft^3	ft^3	acre	acre
Old Stage Rd. Intersection	3.8	5,931	11,863	0.48	0.12
Old Stage Rd. to Phinneys Ln	2.9	4,495	8,990	0.36	0.09
Phinneys Ln Intersection	1.9	2,897	5,794	0.23	0.06
Phinneys Ln to W. Main St.	2.4	3,702	7,404	0.30	0.07
W. Main St. Intersection	1.8	2,839	5,677	0.23	0.06
W. Main St. to Strawberry Hill Rd.	1.1	1,707	3,414	0.14	0.03
Strawberry Hill Rd. Intersection	1.4	2,175	4,350	0.17	0.04
Strawberry Hill Rd. to Bearses Way	11.9	18,626	37,252	1.49	0.37
Bearses Way Intersection	2.9	4,567	9,135	0.37	0.09
Total	30.1	46,940	93,879	3.8	0.9

[1]Assumes 90% Impervious Cover (I=0.9)

[2]Values Estimated from UNHSC 2012 Biennial Report for Gravel Wetlands

[3]Values Estimated from UNHSC 2012 Biennial Report for Bioretention (Parking Lot Landscaped Area Retrofit System Bio-4)

Leaching catch basins, which are widely used on Cape Cod, may receive runoff from an acre or less. However, traditional spacing on roadways tends to reduce catchment area further. For the purposes of this report leaching catch basins will be spaced 250' apart as suggested in the spacing guidelines put forth in the MassDOT Design Guide: Chapter 8. This spacing approach will drive cost estimates for areas of the study segment utilizing leaching catch basins as a component of the stormwater management approach.

SUGGESTED STORMWATER MANAGEMENT APPROACH

In short, the suggested stormwater management approach for the Route 28 Study area is that nitrogen reducing technologies would benefit Segment #1 the greatest, a small portion of the easternmost stretch of Segment #3, and a portion of the westernmost section of Segment #4. In all other locations local drainage concerns and addressing the pathogen TMDL's is of most importance. The removal of berms from the non-nitrogen sensitive sections may decrease pathogens from stormwater in addition to subsurface infiltration systems similar to those going in near Salt Pond in Eastham. Lastly, any areas with known drainage/safety issues should have strategic flood control methods implemented.

COSTS

The following table presents estimated costs for various stormwater management techniques.

Table 2. UNHSC SCM Installation and Maintenance Cost Data, with Normalization per Hectare of IC Treated

Parameter	Vegetated swale	Wet pond	Dry pond	Sand filter	Gravel wetland	Bioretentio
Original capital cost ($)	29,700	33,400	33,400	30,900	55,600	53,300
Inflated 2012 capital cost ($)	36,200	40,700	40,700	37,700	67,800	63,200
Maintenance-capital cost comparison (year)[a]	15.9	5.2	6.6	5.2	12.2	12.8
Personnel (h/year)	23.5	69.2	59.3	70.4	53.6	51.1
Personnel ($/year)	2,030	7,560	5,880	6,940	5,280	4,670
Materials ($/year)	247	272	272	272	272	272
Subcontractor Cost ($/year)	0	0	0	0	0	0
Annual O&M Cost ($/year)	2,280	7,830	6,150	7,210	5,550	4,940
Annual maintenance/capital cost (%)	6	19	15	19	8	8

Note: Calculations based on original data with BGS units of $/acre and h/acre.
[a]Number of years at which amortized maintenance costs equal capital construction costs.

DRAINAGE SUB-SECTION FIGURES

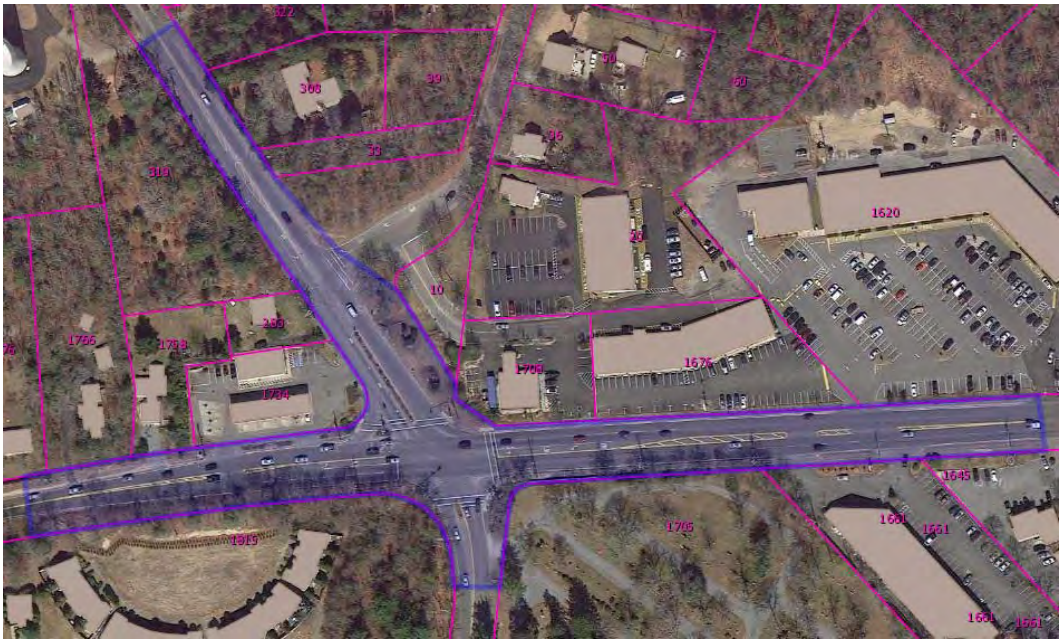

FIGURE 6: OLD STAGE RD INTERSECTION

FIGURE 7: SECTION BETWEEN OLD STAGE RD AND PHINNEYS LN

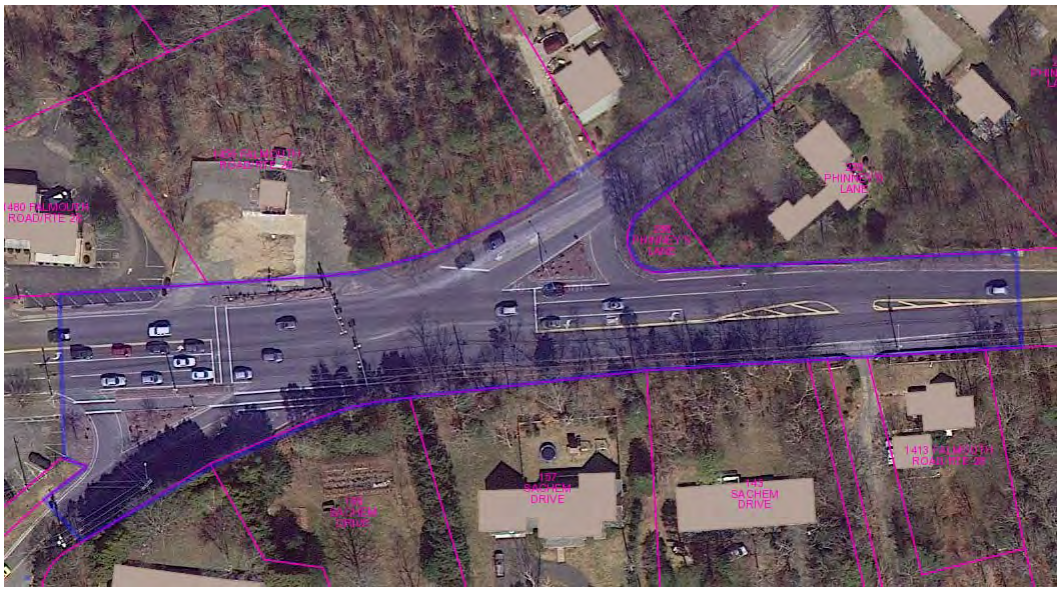

FIGURE 8: PHINNEYS LN INTERSECTION

FIGURE 9: SECTION BETWEEN PHINNEYS LN AND W. MAIN ST.

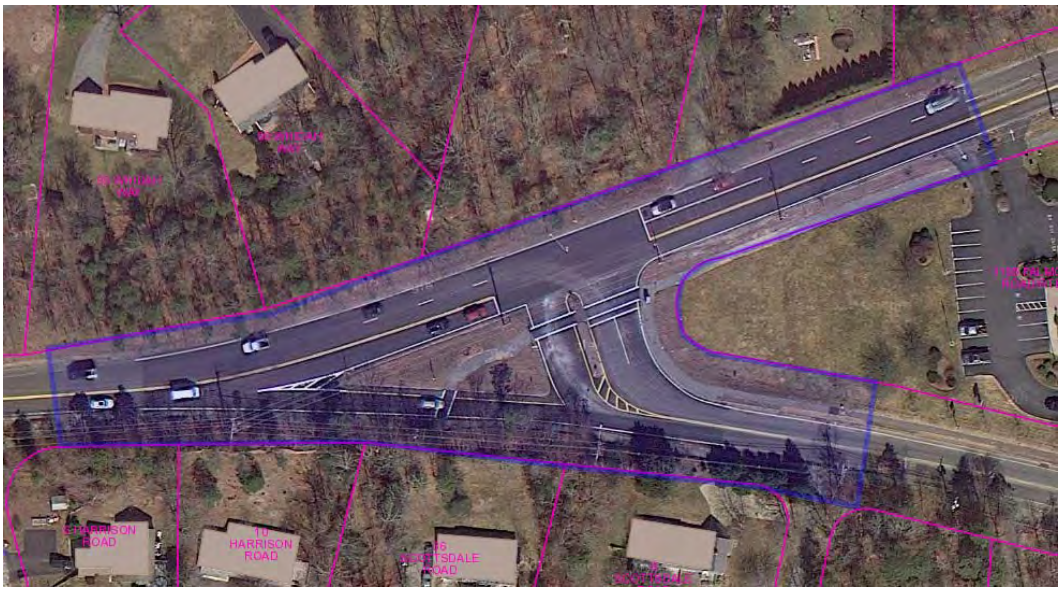

FIGURE 10: W. MAIN ST. INTERSECTION

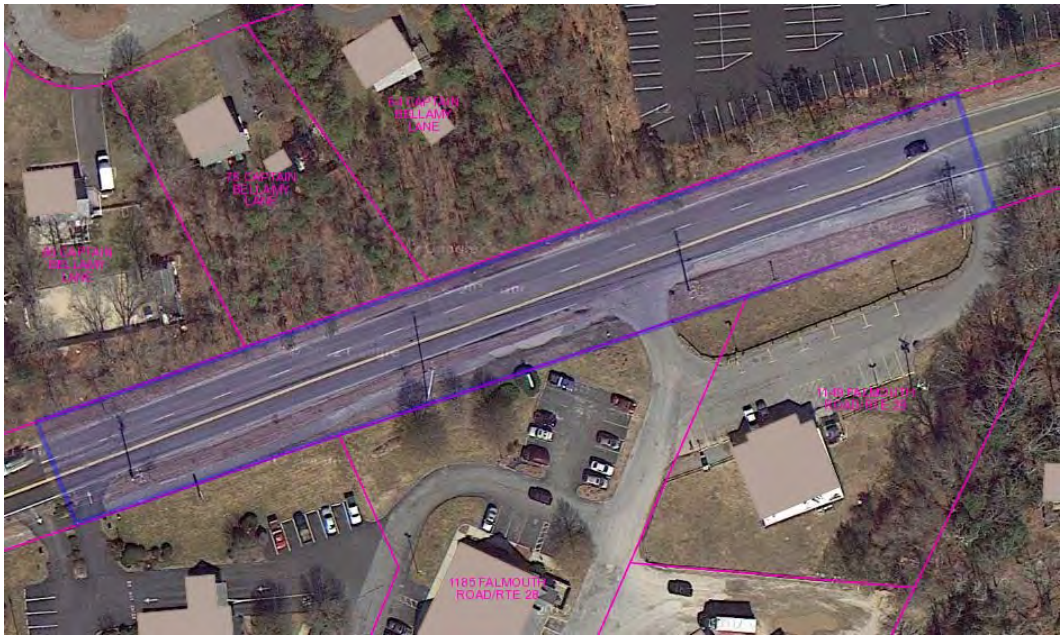

FIGURE 11: SECTION BETWEEN W. MAIN ST. AND STRAWBERRY HILL RD.

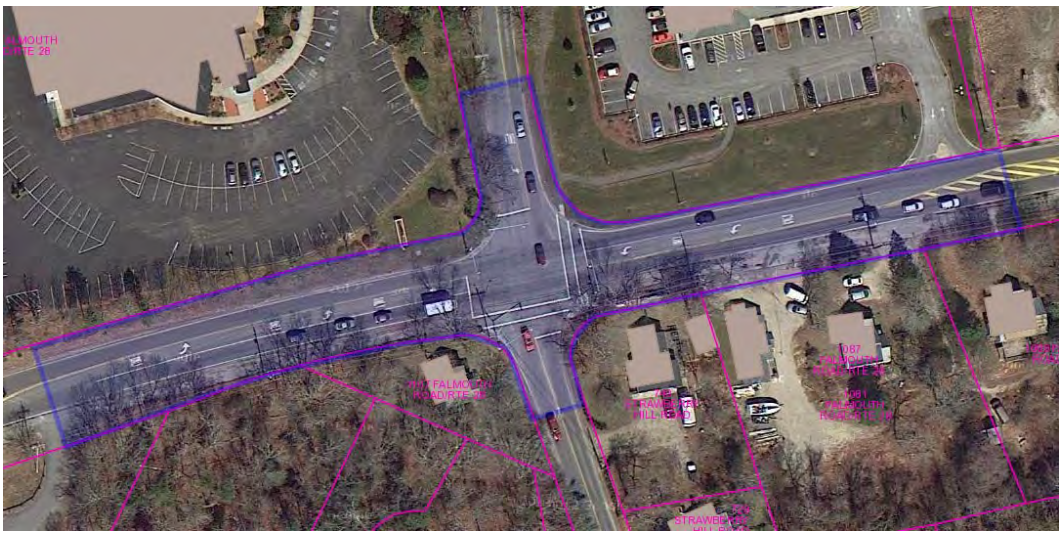

FIGURE 12: STRAWBERRY HILL RD. INTERSECTION

FIGURE 13: SECTION BETWEEN STRAWBERRY HILL RD. AND BEARSES WAY

FIGURE 14: BEARSES WAY INTERSECTION

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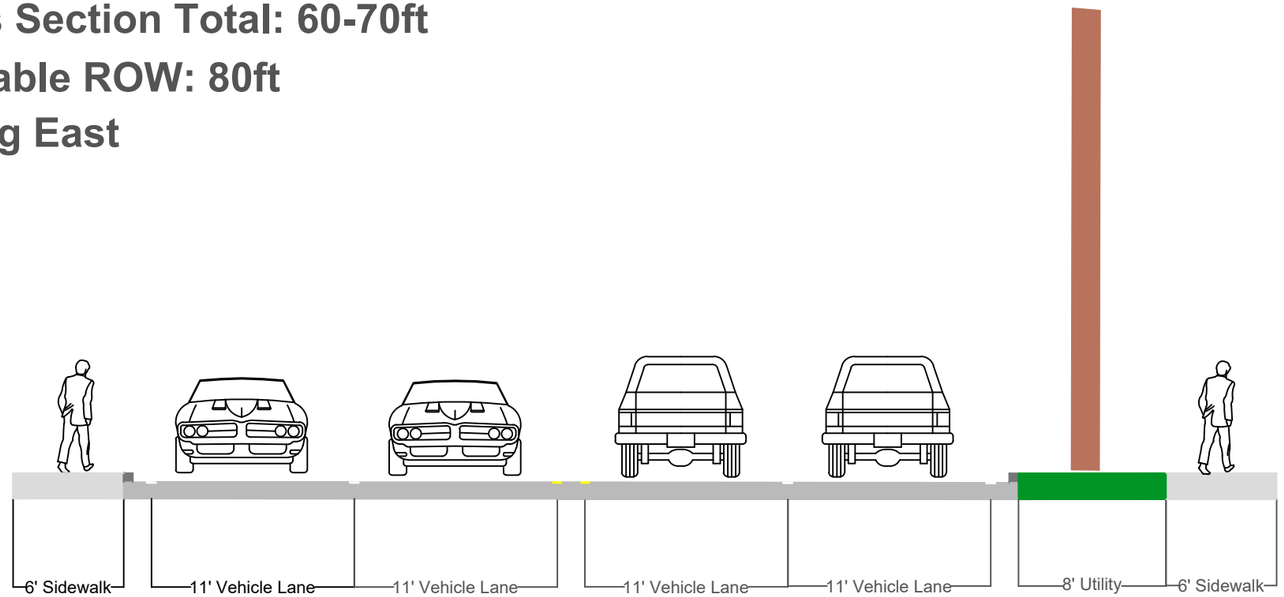
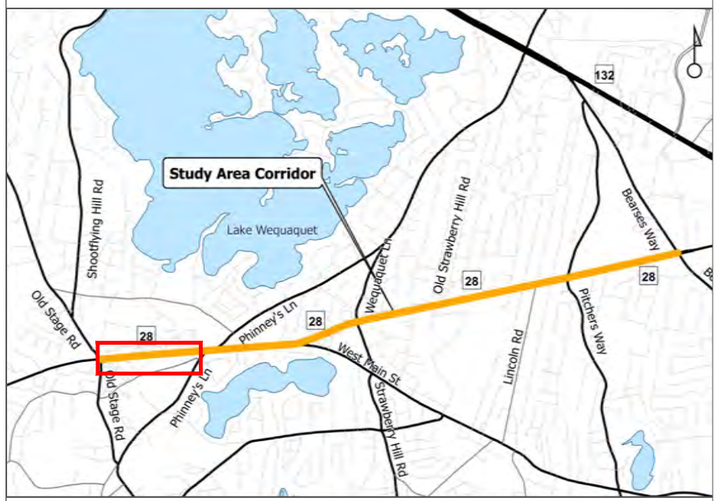
Appendix F - Concept Plans

Cross Section Total: 60-70ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Existing Conditions

Existing Conditions: Four Lanes undivided
Cape Cod Commission Technical Services Staff

Draft February 2015

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

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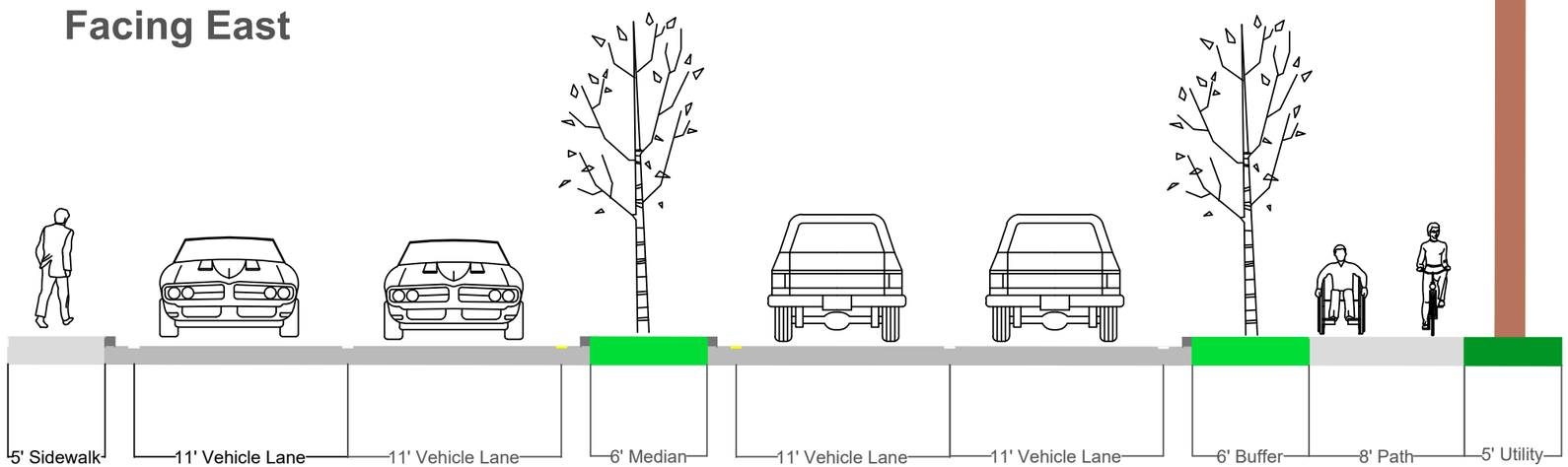
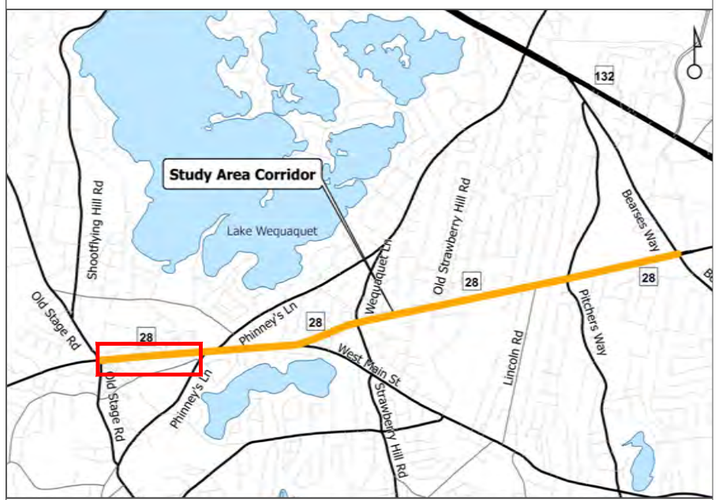
Cross Section Total: 80ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Alternative One

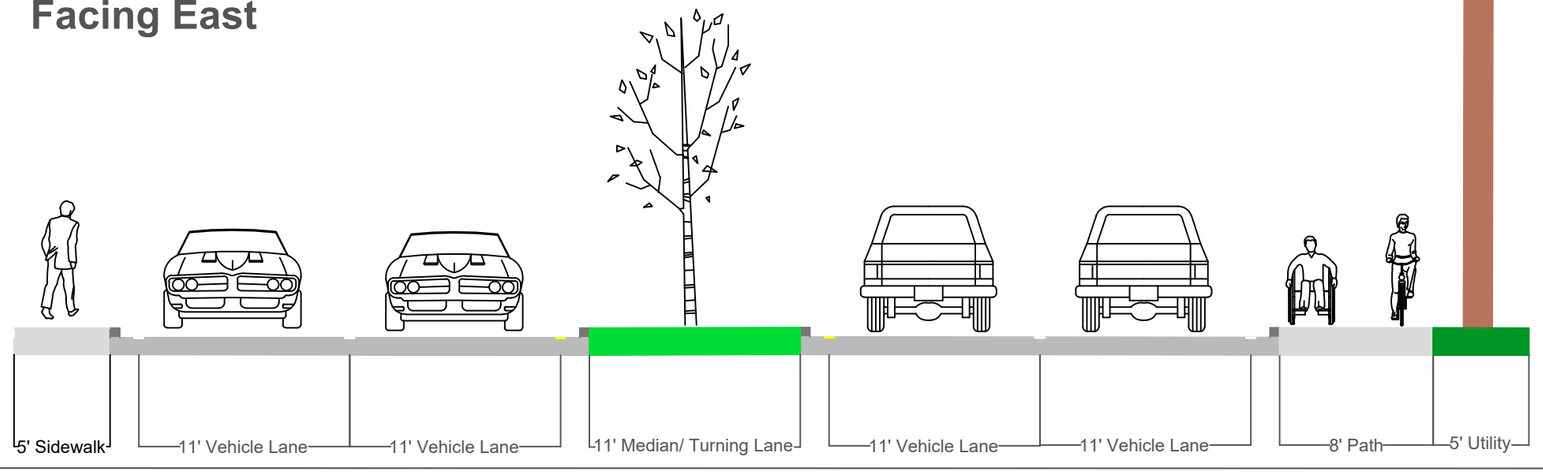
Alternative One: 6' Median without turn lanes, within 80' ROW
Cape Cod Commission Technical Services Staff

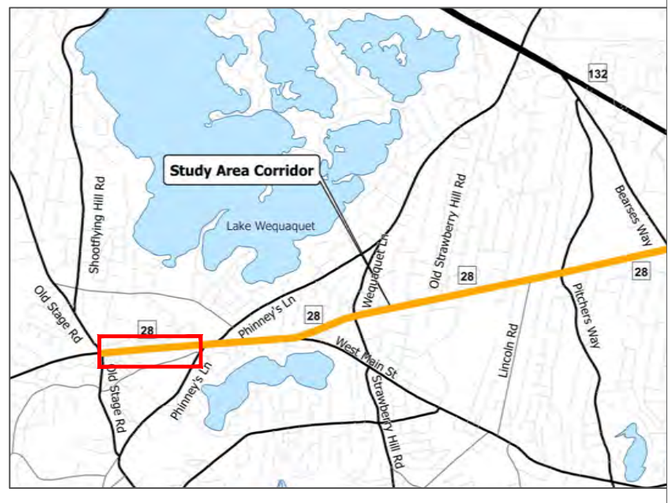
Draft October 2014

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

CAPE COD COMMISSION

Cross Section Total: 80ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Alternative Two

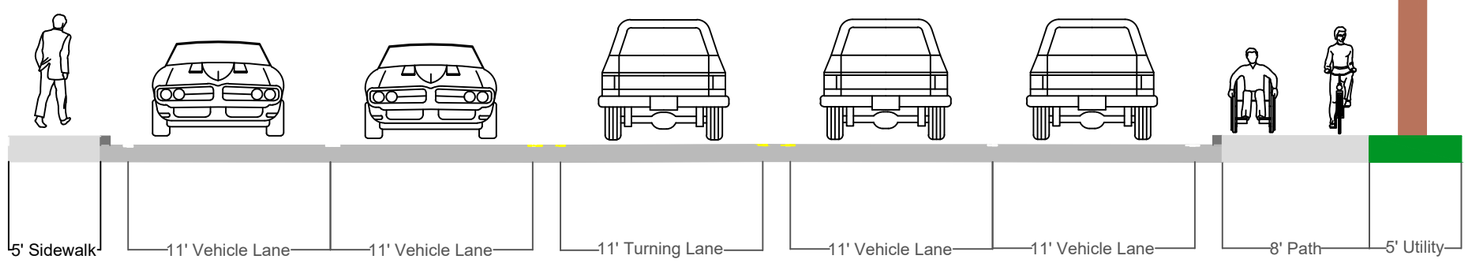
Alternative two: 11' Median with turn lanes, within 80' ROW
Cape Cod Commission Technical Services Staff

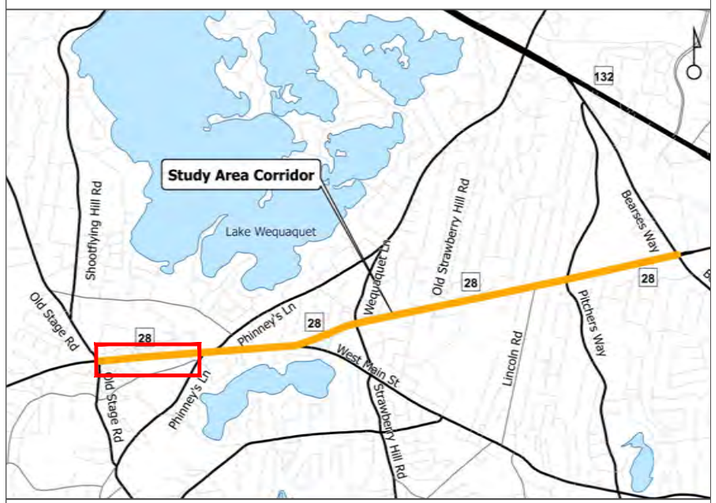
Draft October 2014

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

CAPE COD COMMISSION

Cross Section Total: 80ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Alternative Three

Alternative Three: 11' center turning lane, within 80' ROW
Cape Cod Commission Technical Services Staff

Draft October 2014

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

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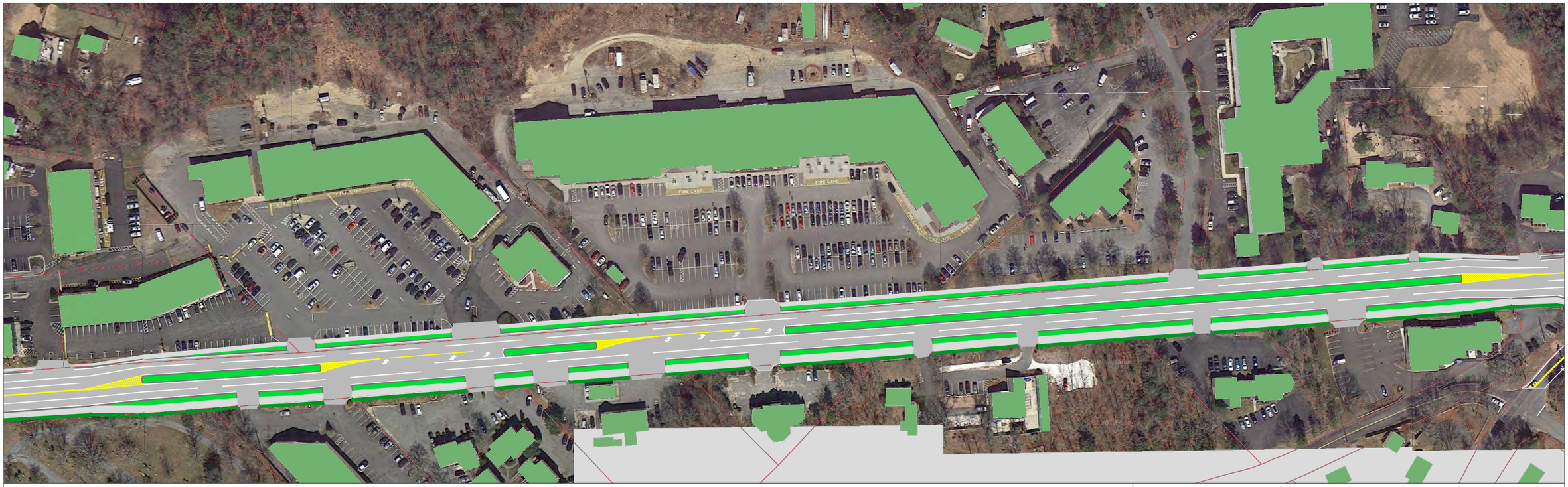
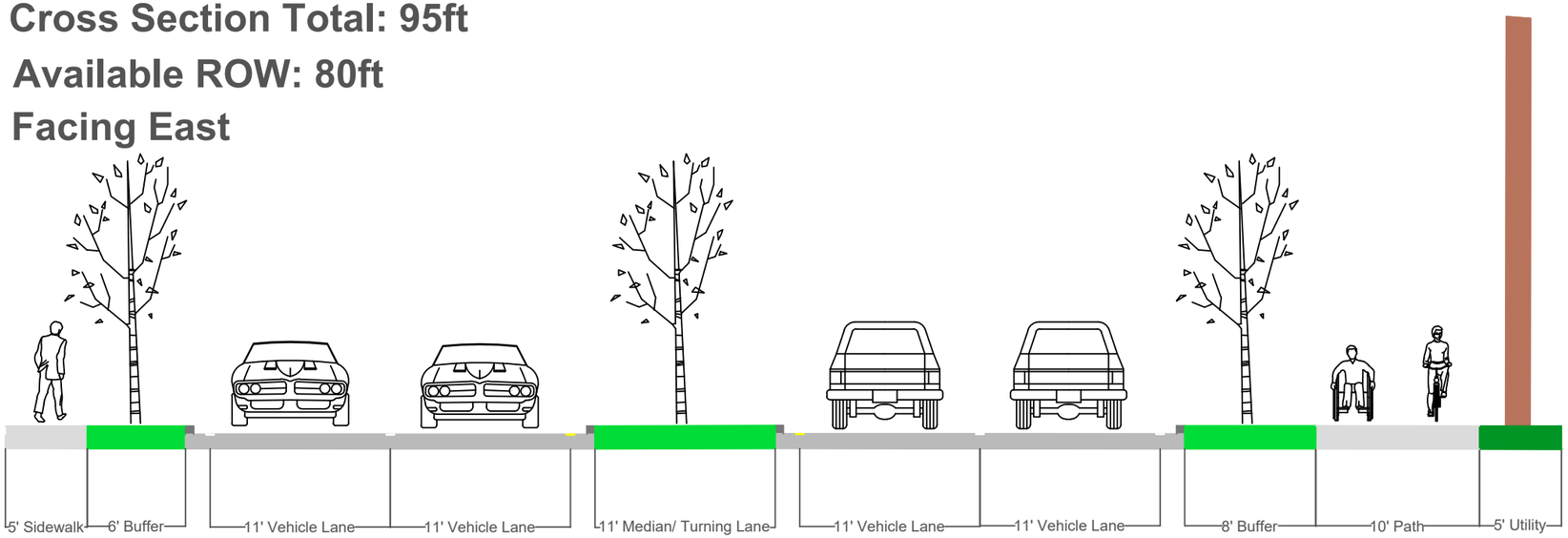
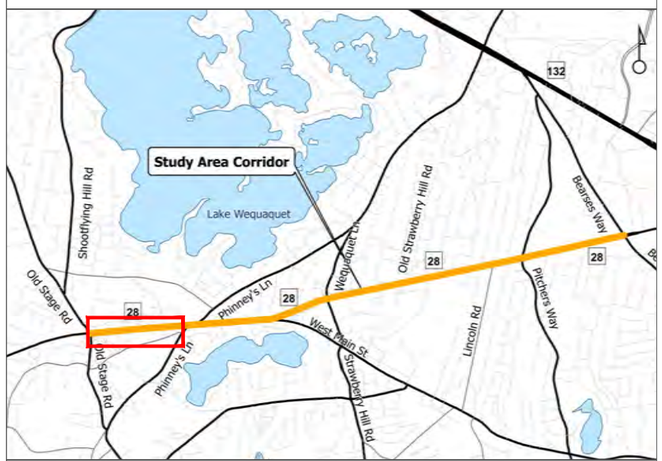


Cross Section Total: 95ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration - Alternative Four

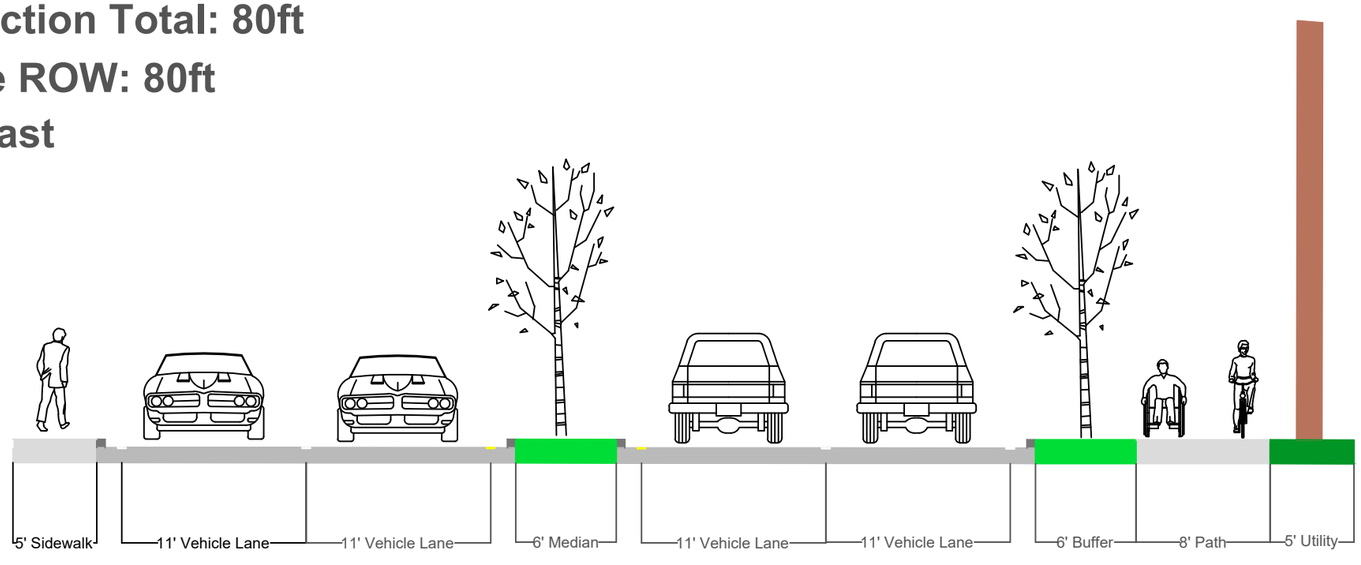
Alternative Four: 11' median with turn lanes, expanding ROW to 95'
Cape Cod Commission Technical Services Staff

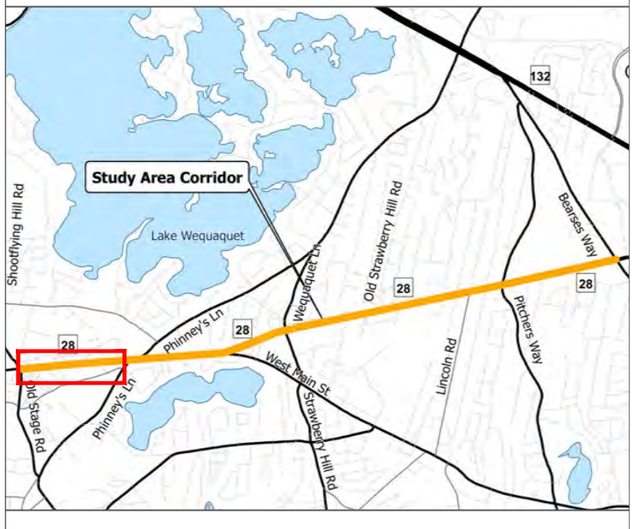
Draft October 2014

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

CAPE COD COMMISSION

Cross Section Total: 80ft
Available ROW: 80ft
Facing East





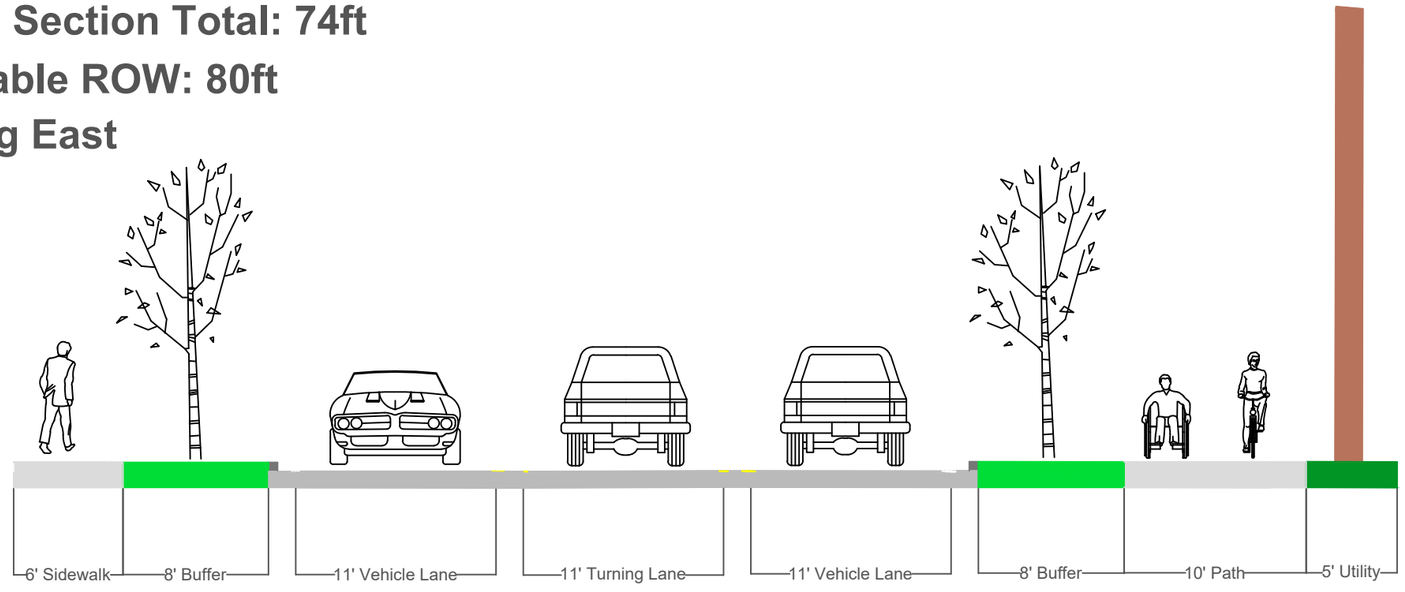
Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration Alternatives

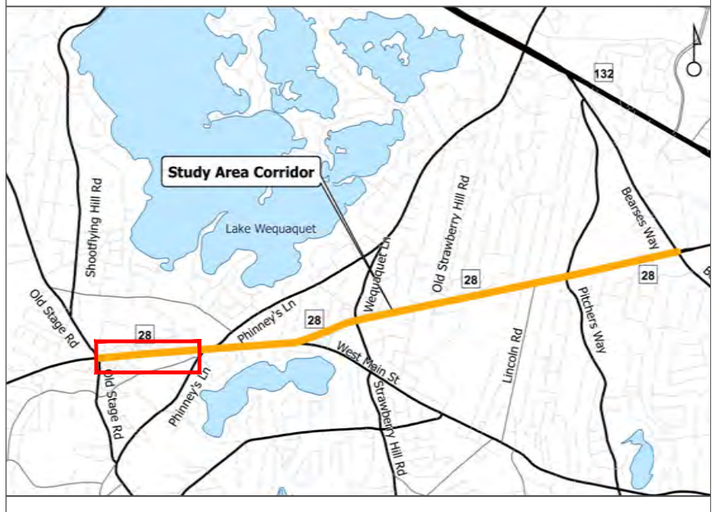
Alternative Five: 6' median with new signalized intersection Draft October 2014
Cape Cod Commission Technical Services Staff

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

CAPE COD COMMISSION

Cross Section Total: 74ft
Available ROW: 80ft
Facing East





Barnstable Route 28 Corridor Study: Old Stage Road to Phinney's Lane Four-Lane Reconfiguration- Alternative Six

Alternative Six: 11' center turning lane, within 80' ROW, removing one lane in each direction

Draft February2015

Cape Cod Commission Technical Services Staff

NOTE: Not to scale, location of 80 ft ROW approximate, survey would be required for additional precision

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Appendix G - Road Safety Audit: Route 28 (Falmouth Road) at Strawberry Hill Road Town of Barnstable [May 2015]

ROAD SAFETY AUDIT

Route 28 (Falmouth Road) at Strawberry Hill Road

Town of Barnstable

May 2015

Prepared For:
MassDOT

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Background

The Federal Highway Administration (FHWA) defines a Road Safety Audit (RSA) as the formal safety examination of an existing or future road or intersection by an independent, multidisciplinary team. The purpose of an RSA is to identify potential safety issues and possible opportunities for safety improvements considering all roadway users. A key objective of the RSA is to identify both short-term and long-term safety improvements that can be made at the subject intersections. This RSA evaluates the intersection of Route 28 and Strawberry Hill Road in Barnstable, MA, as shown in Figure 1.

Project Data

A Road Safety Audit was completed for the intersection of Route 28 at Strawberry Hill Road in the Town of Barnstable on April 24, 2015. The agenda for the RSA meeting held at the Barnstable Senior Center is provided in Appendix A of this report. As shown below in Table 1, the audit team consisted of a multidisciplinary team with representatives from state, regional and local agencies providing expertise in the engineering, planning, maintenance and emergency response fields. Contact information for the RSA attendees is provided in Appendix B of this report.

Table 1. Participating Audit Team Members

Audit Team Member	Agency/Affiliation
Kevin Chiang	MassDOT - Boston Traffic
Richard Madsen	MassDOT – District 5 Projects
Patrick Tierney	Cape Cod Commission
Jo Anne Miller Buntich	Town of Barnstable - Growth Management
Michael Perry	Town of Barnstable - Highway Division
Clay Schofield	Town of Barnstable - Department of Public Works
Phil Viveiros	McMahon Associates
Alex Bulhoes	McMahon Associates

Within the email invitation sent on April 15, 2015 to each participant in the RSA, background material was provided. This information included turning movement counts, local speed regulations, collision diagrams, and MassDOT crash data summaries. During the RSA meeting, these materials were reviewed as a group before the team discussed potential safety issues and solutions for the intersection.

Project Location and Description

Study Area Roadways

As shown in Figure 1, Route 28 is generally a three-lane roadway west of the Strawberry Hill Road intersection and a two-lane roadway east of the intersection within the study area. It should be noted that Route 28 is designated as a North-South highway, with Route 28 North oriented to the west at this particular intersection. However, through the Town of Barnstable, Route 28 generally runs in an east-west direction and the intersection approaches will be classified as eastbound and westbound throughout the rest of this report. At its intersection with Strawberry Hill Road, Route 28 is a two-lane roadway in both

the eastbound and westbound directions; in addition, an exclusive left-turn lane is provided for both the eastbound and westbound approaches. The speed limit on Route 28 is posted as 45 miles per hour in both directions. Direct access to retail and residential land uses is provided by Route 28 while generally running parallel to Route 6. Route 28 also provides access to the Barnstable Municipal Airport at its intersection with Route 132, approximately 2 ¼ miles east of the Route 28 at Strawberry Hill Road intersection. In addition, Route 28 provides access to subdivisions on its northern side and to schools (Barnstable Intermediate School and Barnstable High School) and the Barnstable Senior Center on its southern side via a shared driveway. The Cape Cod Hospital also uses Route 28 as an emergency vehicle access corridor. Route 28 is classified as an urban principal arterial under MassDOT jurisdiction. Within the immediate vicinity of the study area intersection, Route 28 is approximately 34 feet wide with 11-foot travel lanes and shoulders measuring less than 1 foot on either side. There is a multi-use path located on the southern side of Route 28 for use by cyclists and pedestrians. While sidewalks are present directly adjacent to the CVS/pharmacy located at the northeast corner of the Strawberry Hill Road intersection, there are otherwise no sidewalks present along the northern side of Route 28.

Strawberry Hill Road is a two-lane urban minor arterial under Town of Barnstable jurisdiction that runs in a north-south direction through Barnstable. Strawberry Hill Road has a single lane of travel in either direction on the northbound approach with lane widths measuring 12 feet wide at the intersection with Route 28. At the southbound approach of the intersection with Route 28, there is also a left-turn lane present with varying lane widths. While sidewalks are present directly adjacent to the CVS/pharmacy located at the northeast corner of the Route 28 intersection, there are otherwise no sidewalks or shoulders present on either side of Strawberry Hill Road.

Study Area Intersections

The intersection of Route 28 at Strawberry Hill Road is a four-legged signalized intersection maintained by MassDOT. The eastbound and westbound approaches each consist of a left-turn lane and a shared through-right travel lane. The northbound approach consists of a single lane and the southbound approach consists of a left-turn lane and a shared through-right travel lane. The storage lengths provided for the left turn lanes on the westbound and eastbound approaches are approximately 250 feet and 300 feet, respectively. The southbound left turn lane provides a storage length of approximately 50 feet. The traffic signals for all four approaches are mounted on mast arms, either overhead or on the mast arm shaft. The multi-use path on the southern side of Route 28 traverses the southbound approach of the intersection at Strawberry Hill Road. The CVS in the northeast corner has access points onto both Route 28 and Strawberry Hill Road near the intersection. There is also a driveway for the Saint George Greek Orthodox Church located on the southbound approach of Strawberry Hill Road near the intersection. There are pedestrian crosswalks located at the northbound and westbound approaches, but there is no signal equipment in place for pedestrians at the intersection. There are also residential driveways located along the eastern side of Route 28 from the intersection. The intersection is also situated in a region that experiences a significant seasonal peak in traffic, with buses potentially stopping safely along Route 28 to the west of the intersection to pick up patrons that wave them down.

Crash Data

Crash data was received from MassDOT for the three years between 2010 and 2012. Based on this data, there were a total of 16 crashes reported from the beginning of 2010 through the end of 2012 at the intersection of Route 28 and Strawberry Hill Road. Of the crashes that occurred, eight (50%) were angle collisions, including two crashes in the eastbound direction and three crashes in the westbound direction on Route 28. Additionally, there were six rear-end collisions, one single vehicle crash, and one pedestrian related crash reported at the intersection. Of the reported crashes, nine resulted in property damage and

seven resulted in personal injury; no fatalities were reported at the intersection. Based on the crash data, it appeared that neither driver age nor lighting conditions were significant factors in the observed crashes.

Detailed crash diagrams are provided in Appendix C.

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0 125 250 500 Feet

FIGURE 1
SITE LOCATION MAP
ROAD SAFETY AUDIT
BARNSTABLE, MA

Road Safety Audit Observations and Potential Improvements

During the RSA meeting, a brief introduction of the RSA process and a summary of the study area and crash information were presented to the audit participants. Following this brief presentation, the members of the audit team were asked to discuss the existing issues that may affect safety at the intersection of Route 28 at Strawberry Hill Road. Provided below is a list of the safety concerns that were identified during the RSA along with potential enhancements that address these concerns.

Safety Issue #1: Traffic Control

Observations:
Traffic control at the intersection of Route 28 and Strawberry Hill Road is impacted by the traffic signal, access to nearby land uses, and the seasonal peak volumes. During the RSA discussion, there was a strong concern surrounding the speeding on Strawberry Hill Road, specifically from the southbound approach. According the team, the speeding appeared to be a result of impatient drivers attempting to avoid impediment at a red light, and the issue is related to all four of the approaches. Upon review of the past three years of crash data, it becomes apparent that a number of the rear end crashes throughout the intersection could be a result of the traffic control. Another observation was made regarding the significant morning peak volume in the eastbound direction at the intersection. Although the intersection possesses exclusive left turn lanes in both the eastbound and westbound directions, there is a lack of a left-turn signal arrow in either direction. Given the seasonal peak volume on Route 28 in combination with the speed limit of 45 mph, the lack of a left turn signal arrow presents a safety concern.

Lack of Backplates on Existing Signal Heads

In regards to the signal visibility, it was mentioned that the solar glare, specifically in the eastbound and westbound directions, presented a safety concern. During the site visit, the RSA team witnessed that the signal heads are lacking backplates, which improve the visibility issues pertaining to solar glare. Crash data supports solar glare potentially being an issue, as 38% of crashes occurring at this intersection are during the 4 pm to 6 pm time frame, when solar glare is at a maximum. In addition, review of the crash data presented a recurring issue of rear-end crashes, which accounted for six (38%) of the total crashes. The significant amount of rear-end crashes in the eastbound and westbound directions appear to coincide with the fact that the signal heads are lacking backplates.

Audit members noticed a general lack of signage at all approaches to the intersection, particularly along the southbound approach, to warn of the traffic signal and the potential presence of pedestrian and bicyclists. Also, the emergency response was discussed during the RSA and the majority agreed that there is a need for emergency preemption equipment, particularly as the intersection borders two of the town's fire districts.

Enhancements:

- Evaluate speeding enforcement along the Route 28 corridor and at Strawberry Hill Road.
- Consider signal coordination between the study area intersection and the Route 28 intersections with West Main Street, the Senior Center Driveway, and Pitchers Way to help manage traffic flows throughout the corridor.
- Evaluate the existing signal timings, specifically the clearance intervals, and propose new timing plans catered to time of day and/or time of year.
- Check the functionality of signal detection on Route 28 and either repair as needed and/or consider dilemma zone detection for the intersection.
- Consider installation of left-turn signal arrows and protected left-turn phasing to minimize angle collisions at the intersection.
- Consider the implementation of a traffic circle at the intersection of Strawberry Hill Road and Wequaquet Lane, north of the Route 28 intersection to slow the southbound approach speeds.
- Install backplates with reflective borders for overhead signals to minimize the effects of solar glare.
- Install advance warning signage on all approaches.
- Consider incorporating emergency preemption to improve emergency response and decrease crash risks.

Safety Issue #2: Traffic Operations

Observations:
The intersection of Route 28 and Strawberry Hill Road is impacted by traffic operations on the Route 28 corridor. The RSA team mentioned the impact of the steep roadway grades on the northbound and southbound approaches of the intersection. The discussion pertained to the crown and gutter line on the southbound approach, as well as the uphill grade on the northbound approach of Strawberry Hill Road. During the field visit, the RSA team observed the influence of the grade on traffic operations along the Strawberry Hill Road approaches. A member of the RSA team also raised a concern regarding the excessive queuing that occurs beyond the left-turn lane on the westbound approach along Route 28. The traffic operations can be impacted in scenarios where the queuing exceeds the storage length of the left-turn lane, which can result in a safety issue.

Enhancements:

- Evaluate re-grading at the Strawberry Hill Road southbound approach of the intersection, in the area of the Route 28 gutter line, to improve operations.
- Consider extending the storage length of the left turn lane at the westbound approach of the intersection to avoid excessive queueing.
- Consider the implementation of a right-turn lane at the westbound approach of the intersection to improve traffic operations.
- Consider the implementation of a left-turn lane at the northbound approach of the intersection to improve traffic operations.

Safety Issue #3: Intersection Alignment / Visibility

Observations:
During the RSA discussion, some members of the team provided insight on the current alignment of the northbound and southbound approaches of Strawberry Hill Road at the intersection with Route 28. The concern focused on the offset of the roadway at the intersection and the perception of drivers that they may be directed toward the opposing lanes as they approach the intersection. Another discussion point related to the visibility of signal heads, specifically on the northbound and southbound approaches to the intersection, which is impacted by vegetation encroaching on the roadway.


Roadway Alignment and Grade from Strawberry Hill Road Northbound Approach

Sight distance at the intersection was also raised as an issue by several RSA participants. From the northbound approach, the sight distance is impacted by vegetation on the southeast corner that is encroaching onto the roadway, as well as the uphill grade on the northbound approach. In regards to the southbound approach, there is a horizontal curve at the intersection of Strawberry Hill Road and Wequaquet Lane, which impacts the sight distance of drivers approaching the intersection.

Enhancements:
- Evaluate lane and/or roadway alignment for both Strawberry Hill Road approaches of the intersection to improve sight distance and reduce the risk of head-on collisions.
- Install an Intersection Ahead (or Signal Ahead) warning sign on the southbound approach, prior to the horizontal curve.
- Consider trimming the vegetation within the roadway right-of-way on the Strawberry Hill Road northbound approach to improve visibility.
- Evaluate the feasibility of obtaining easements for vegetation trimming on private property along the northbound approach of the intersection to improve visibility.
- Evaluate existing right-of-way restrictions and proposed widening improvements where feasible to create a consistent cross section along Strawberry Hill Road, specifically the northbound approach of the intersection.

Safety Issue #4: Pedestrian and Bicycle Accommodations


Existing Crosswalk Markings and Ramp

Observations:
Observations made during the RSA indicate that the intersection is lacking pedestrian amenities, including pedestrian signals and sidewalks on the northern side of Route 28. Another observation was made regarding the lack of tactile pads on the existing handicapped ramps. It was also mentioned that the residential neighborhoods on the north side of Route 28 lack pedestrian connectivity due to the lack of pedestrian

amenities and the operations on Route 28 effectively acting as a barrier. There is a significant amount of the pedestrian movement across Route 28 to the east dedicated to the Barnstable Intermediate School and Barnstable High School.

During the discussion, it was also mentioned that there is a corridor study currently being conducted by the Cape Cod Commission along Route 28 in the vicinity of the intersection. Due to the intersection's close proximity to the Barnstable Senior Center and Barnstable High School, the safety implications involved with both inexperienced and older drivers were considered during the RSA. In addition, the crosswalk signage may need improvement to avoid compromising the safety of the pedestrians that are utilizing the crosswalks.

In regards to the mixed use path, the section that is located on the eastern side of the intersection exhibits poor conditions and the lack of curbing presents a safety concern. During the field visit, it was observed that the mixed use path stop sign height may present an issue for cyclists crossing the southern leg of the intersection. The group also recognized the lack of lighting along the mixed use path and raised that as a safety concern.

Mixed Use Path on Southeastern Corner of Route 28 and Strawberry Hill Road Intersection

Enhancements:

- Evaluate ramps for compliance with ADA standards.
- Install pedestrian signals and push button actuation at the signalized intersection.
- Evaluate the installation of crosswalks on the southbound and eastbound legs of the intersection.
- Construct sidewalks adjacent to the intersection to help guide pedestrians around the traffic signal and provide improved access to the church located in the northwestern quadrant of the intersection.
- Consider improvements of the mixed use path at the southeast corner of the intersection on Route 28.
- Evaluate crosswalk signage and pavement markings to ensure that they are visible.
- Evaluate "STOP" sign height on southwest side of the mixed use path.
- Evaluate lighting along the mixed use path to provide additional safety for pedestrians and cyclists.

Safety Issue #5: Roadway Conditions

Observations:
During the site visit portion of the RSA, the team observed the conditions of the existing roadway. In general, the pavement conditions at the intersection of Strawberry Hill Road at Route 28 did not appear to exhibit significant signs of distress. However, some of the observations were related to the conditions of the pavement markings on the approaches on Strawberry Hill Road. In addition, there was a portion of curbing that appeared to be damaged on the northeast corner of the intersection.

Throughout the discussion, one of the RSA team members presented a safety issue related to the snow plowing efforts at the intersection. The issue pertains to the placement of the snow bank on the southwest corner of the intersection during snow removal. In regards to safety, the snow bank must be placed further back to avoid impeding traffic on that particular leg of the intersection. It was noted that MassDOT performs plowing along Route 28, while the Town plows Strawberry Hill Road, which often leaves the intersection corners unplowed during snowstorms.

Curbing Damage on Northeastern Corner of Intersection

Enhancements:

- Evaluate existing pavement markings and consider re-striping the approaches from Strawberry Hill Road to ensure visibility.
- Repair or replace the damaged curbing on the northwest corner of the intersection.
- Encourage coordination between Barnstable Department of Public Works and MassDOT for snow plowing activities at the intersection.

Safety Issue #6: Access Management

Observations:

Throughout the Route 28 corridor, there are several driveways that provide access to commercial and residential land uses. According to members of the RSA team, efforts have been made to minimize the amount of access points along the corridor through the use of shared driveways. One particular driveway discussed during the audit was the "right-in, right-out" CVS driveway east of the intersection, which provides access from and to Route 28 in the westbound direction. The egress point of the driveway onto the corridor is currently restricted to right turns only by a sign and a scored median. However, the consensus amongst the RSA team was that left turns into and out of this driveway continue to occur, creating a potential safety risk. In general, the concerns in terms of access management related to the egress from the CVS driveway onto Route 28, as well as the frequency of driveways along the corridor.

Egress Point from CVS to Route 28

Enhancements:

- Implement a structural barrier on Route 28 and/or a raised driveway island at the CVS driveway access onto Route 28 to prevent left turn movements.
- Encourage the use of shared driveways and/or internal driveways along the Route 28 corridor to reduce amount of access point that could cause potential crashes.

Recommendations

After the discussing the various safety deficiencies within the study area, participants discussed potential solutions. The audit participants were encouraged to consider both short and long-term improvements for each of the existing safety issues. Each improvement considered has been categorized as short-term, mid-term, or long-term based on the definitions shown in Table 2. Additionally, a cost category has been assigned to each improvement based on the parameters set forth in Table 2.

Table 2. Estimated Time Frame and Costs Breakdown

Time Frame		Costs	
Short-Term	<1 Year	Low	<$10,000
Mid-Term	1-3 Years	Medium	$10,001-$50,000
Long-Term	>3 Years	High	>$50,000

Summary of Road Safety Audit

A summary of the potential recommendations discussed by the RSA audit team are summarized in Table 3. The recommendations are summarized based on the potential safety payoff, time frame, approximate cost and responsible agency. The safety payoff is a subjective judgment of the potential effectiveness of the safety recommendations listed below.

Table 3. Potential Safety Enhancement Summary

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsible Agency
Route 28 at Strawberry Hill Road					
Traffic Control	Evaluate speeding enforcement along the Route 28 corridor and at Strawberry Hill Road	Medium	Short-Term	Medium	Town of Barnstable
Traffic Control	Consider signal coordination between the study area intersection and the Route 28 intersections with West Main Street, the Senior Center Driveway, and Pitchers Way	Medium	Mid-Term	Medium	MassDOT
Traffic Control	Evaluate the existing signal timings, specifically the clearance intervals, and propose new timing plans	Medium	Short-Term	Low	MassDOT
Traffic Control	Check the functionality of signal detection on Route 28 and either repair as needed and/or consider dilemma zone detection	Medium	Mid-Term	Medium	MassDOT
Traffic Control	Consider installation of left-turn signal arrows and protected left-turn phasing	High	Mid-Term	High	MassDOT
Traffic Control	Consider the implementation of a traffic circle at the intersection of Strawberry Hill Road and Wequaquet Lane to slow southbound approach speeds	Medium	Long-Term	High	Town of Barnstable
Traffic Control	Install backplates with reflective borders for overhead signals	Medium	Short-Term	Low	MassDOT
Traffic Control	Install advance warning signage on all approaches.	Medium	Short-Term	Low	MassDOT/Town of Barnstable
Traffic Control	Consider incorporating emergency preemption	Medium	Mid-Term	Medium	MassDOT/Town of Barnstable
Traffic Operations	Evaluate re-grading at the Strawberry Hill Road southbound approach	Medium	Long-Term	High	MassDOT/Town of Barnstable

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsible Agency
Traffic Operations	Consider extending the storage length of the left turn lane at the westbound approach of the intersection	Medium	Mid-Term	High	MassDOT
Traffic Operations	Consider the implementation of a right turn lane on the westbound approach of the intersection	Medium	Long-Term	High	MassDOT
Traffic Operations	Consider the implementation of a left turn lane on the northbound approach of the intersection	Medium	Long-Term	High	MassDOT/Town of Barnstable
Intersection Alignment / Visibility	Evaluate lane and/or roadway alignment for both Strawberry Hill Road approaches of the intersection	High	Long-Term	High	MassDOT/Town of Barnstable
Intersection Alignment / Visibility	Install an Intersection Ahead (or Signal Ahead) warning sign on the southbound approach	Medium	Short-Term	Low	Town of Barnstable
Intersection Alignment / Visibility	Consider trimming the vegetation within the roadway right-of-way on the Strawberry Hill Road northbound approach	High	Short-Term	Low	Town of Barnstable
Intersection Alignment / Visibility	Evaluate the feasibility of obtaining easements for vegetation trimming on private property	High	Mid-Term	Medium	Town of Barnstable
Intersection Alignment / Visibility	Evaluate existing right-of-way restrictions and propose widening improvements to create a consistent cross section along Strawberry Hill Road	High	Long-Term	High	MassDOT/Town of Barnstable
Pedestrian Accommodations	Evaluate ramps for compliance with ADA standards	Medium	Mid-Term	Medium	MassDOT/Town of Barnstable
Pedestrian Accommodations	Install pedestrian signals and push button actuation	High	Mid-Term	Medium	MassDOT
Pedestrian Accommodations	Evaluate the installation of crosswalks across the southbound and eastbound approaches of the intersection	Medium	Mid-Term	Medium	MassDOT/

Safety Issue	Potential Safety Enhancement	Safety Payoff	Time Frame	Cost	Responsible Agency
Pedestrian Accommodations	Construct sidewalks adjacent to the intersection to help guide pedestrians around the traffic signal and provide enhanced access to the church located in the northwestern quadrant of the intersection	Medium	Long-Term	High	MassDOT/Town of Barnstable
Pedestrian Accommodations	Consider improvements of mixed use path at the southeast corner of the intersection	Medium	Mid-Term	Medium	MassDOT/Town of Barnstable
Pedestrian Accommodations	Evaluate crosswalk signage and pavement markings to ensure that they are visible	Medium	Short-Term	Low	MassDOT/ Town of Barnstable
Pedestrian Accommodations	Evaluate “STOP” sign height on southwest side of the mixed use path	Low	Short-Term	Low	Town of Barnstable
Pedestrian Accommodations	Evaluate lighting along the mixed use path	Low	Mid-Term	Low	Town of Barnstable
Roadway Conditions	Evaluate existing pavement markings and consider re-striping the approaches from Strawberry Hill Road	Low	Short-Term	Low	Town of Barnstable
Roadway Conditions	Repair or replace the damaged curbing on the northwest corner of the intersection	Low	Short-Term	Medium	MassDOT
Roadway Conditions	Encourage coordination between Barnstable Department of Public Works and MassDOT for snow plowing activities	Low	Short-Term	Low	MassDOT/Town of Barnstable
Access Management	Implement a structural barrier on Route 28 and/or a raised driveway island at the CVS driveway on Route 28 to prevent left turn movements	High	Long-Term	High	MassDOT
Access Management	Encourage the use of shared driveways and/or internal driveways along the Route 28 corridor	Medium	Long-Term	High	Town of Barnstable

Appendix A. RSA Meeting Agenda

Agenda

Road Safety Audit

Falmouth Rd (Route 28) at Strawberry Hill Rd, Barnstable, MA

Meeting Location: Barnstable Senior Center (Library Room)
825 Falmouth Road, Hyannis, MA
April 24, 2015
9:00 AM – 11:00 AM

Type of meeting:	**High Crash Location – Road Safety Audit**
Attendees:	**Invited Participants to Comprise a Multidisciplinary Team**
Please bring:	**Thoughts and Enthusiasm!!**
9:00 AM	**Welcome and Introductions**
9:15 AM	**Review of Site Specific Material** • Crash, Speed & Volume Summaries– provided in advance • Existing Geometries and Conditions
10:00 AM	**Visit the Site** • Drive to LOCATION • As a group, identify areas for improvement
10:30 AM	**Post Visit Discussion / Completion of RSA** • Discuss observations and finalize findings • Discuss potential improvements and finalize recommendations
11:00 AM	**Adjourn for the Day – but the RSA has not ended**

Instructions for Participants:

- **Before attending the RSA on DATE, participants are encouraged to drive through the intersection and complete/consider elements on the RSA Prompt List with a focus on safety.**
- **All participants will be actively involved in the process throughout. Participants are encouraged to come with thoughts and ideas, but are reminded that the synergy that develops and respect for others' opinions are key elements to the success of the overall RSA process.**
- **After the RSA meeting, participants will be asked to comment and respond to the document materials to assure it is reflective of the RSA completed by the multidisciplinary team.**

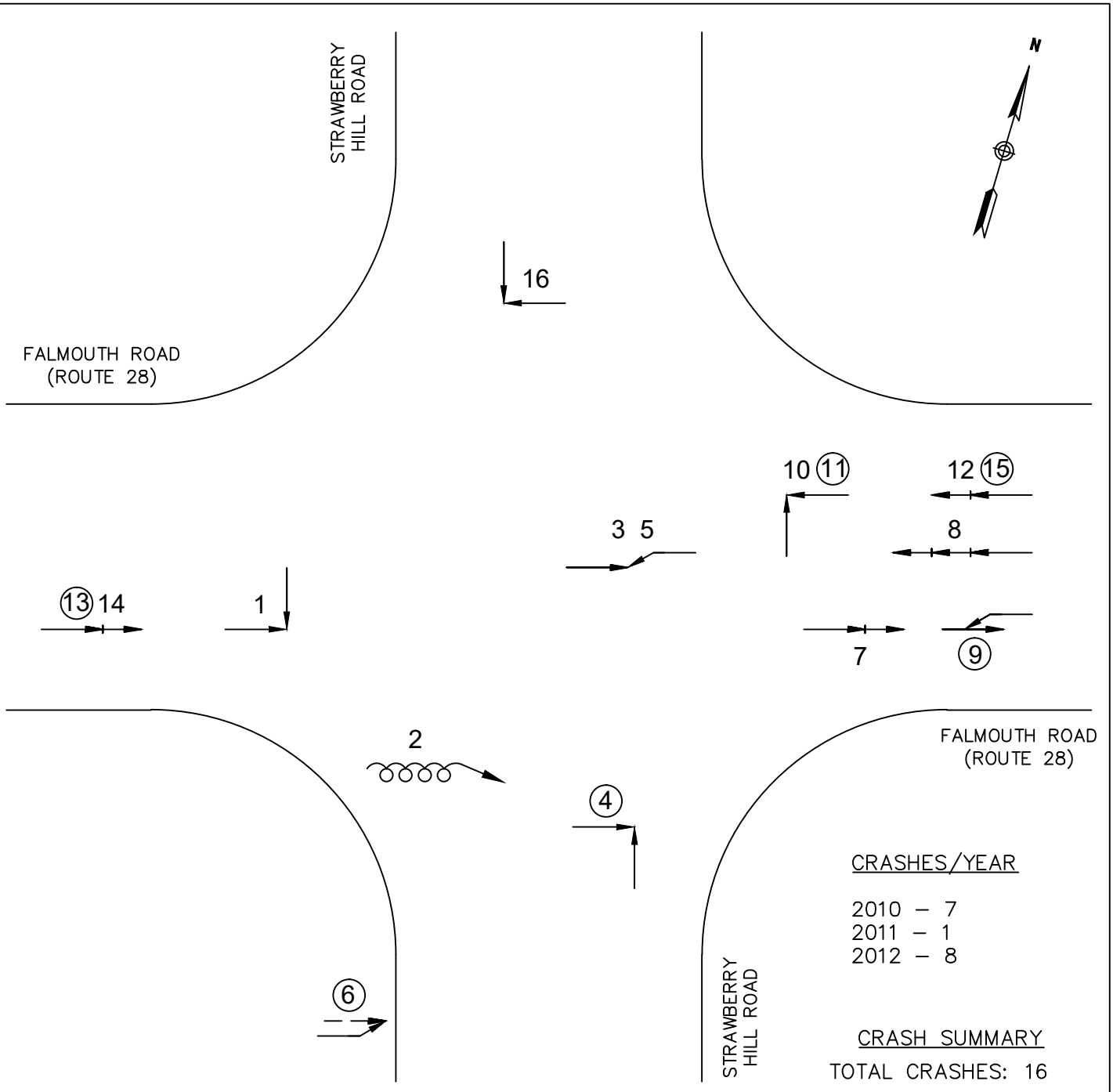
Appendix B. RSA Audit Team Contact List

Participating Audit Team Members

Date: April 24, 2015 Location: Barnstable Senior Center, Barnstable, MA

Audit Team Members	Agency/ Affiliation	Email Address	Phone Number
Kevin Chiang	MassDOT - Boston Traffic	kevin.chiang@dot.state.ma.us	978-368-9626
Richard Madsen	MassDOT – D5 Projects	richard.madsen@dot.state.ma.us	508-885-4241
Patrick Tierney	Cape Cod Commission	ptierney@capecodcommision.org	508-362-3828
Jo Anne Miller Buntich	Town of Barnstable Growth Management	joanne.buntich@town.barnstable.us	508-862-4735
Michael Perry	Town of Barnstable Highway Division	michael.perry@town.barnstable.ma.us	508-790-6330
Clay Schofield	Town of Barnstable Department of Public Works	clay.schofield@town.barnstable.ma.us	508-790-6400
Phil Viveiros	McMahon Associates	pviveiros@mcmahonassocaites.com	508-823-2245
Alex Bulhoes	McMahon Associates	abulhoes@mcmahonassociates.com	774-849-1767

Appendix C. Detailed Crash Data



SYMBOL	ACCIDENT TYPE
MOVING VEHICLE	REAR END
BACKING VEHICLE	HEAD ON
NON–INVOLVED VEHICLE	SIDE–SWIPE
PEDESTRIAN	OUT OF CONTROL
PARKED VEHICLE	LEFT TURN
FIXED OBJECT	RIGHT ANGLE
FATAL ACCIDENT	
INJURY ACCIDENT	

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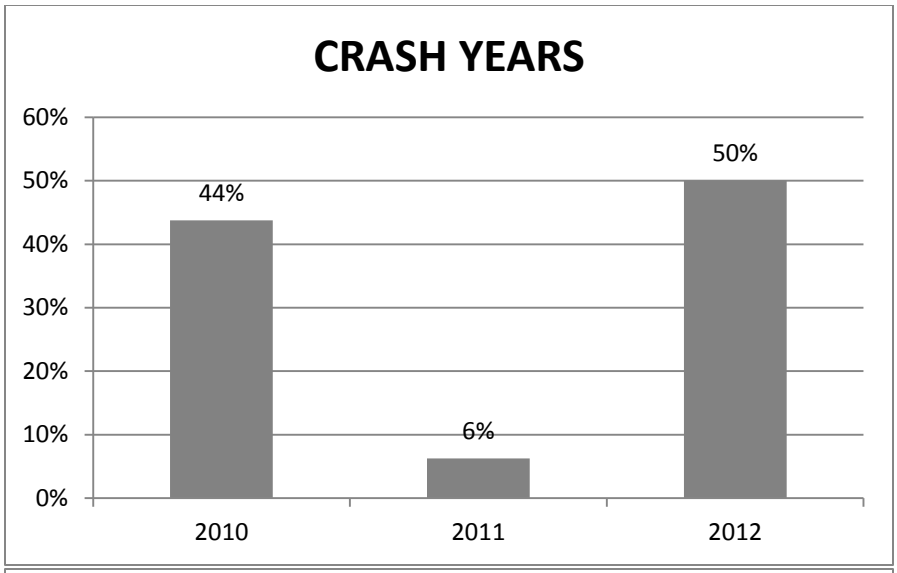
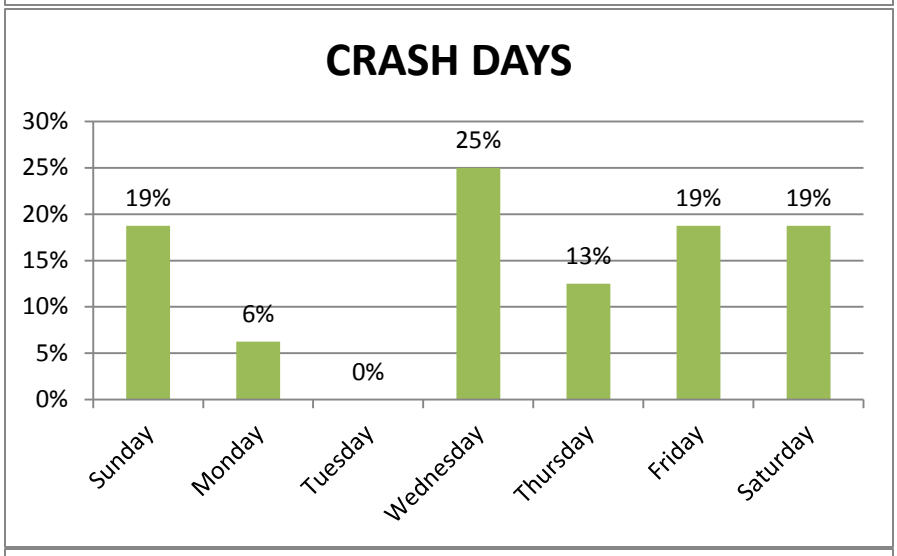
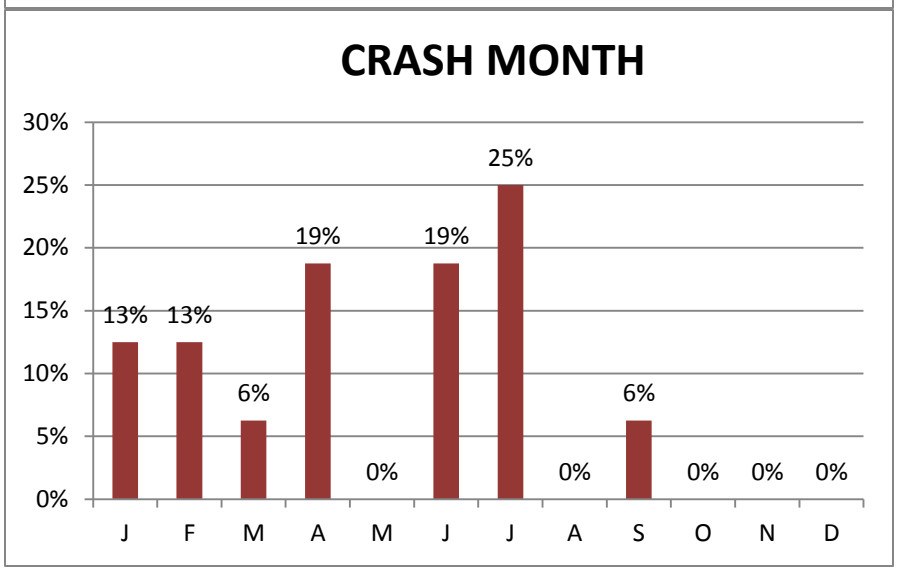
Crash Diagram 2010-2012
Falmouth Road (Route 28) / Strawberry Hill Road
Barnstable, Massachusetts

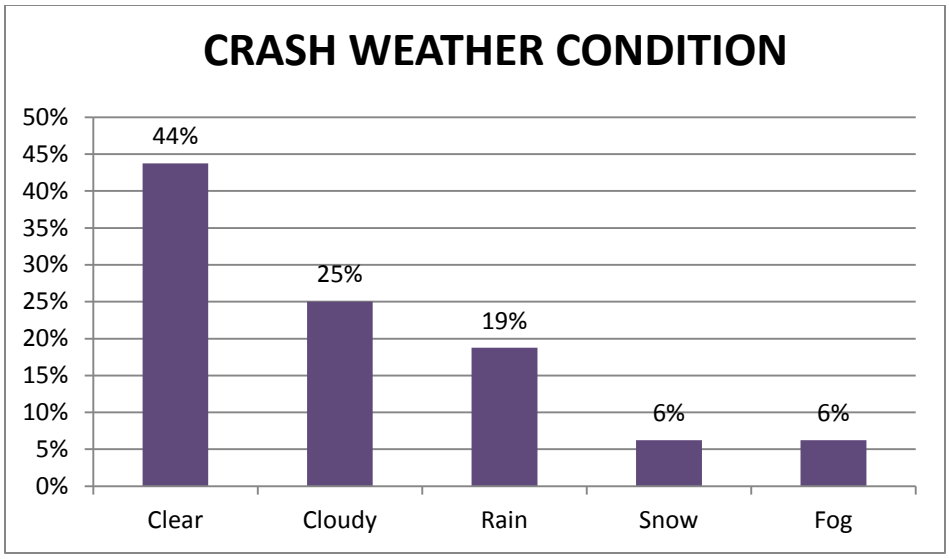
Falmouth Road (Route 28) at Strawberry Hill Road

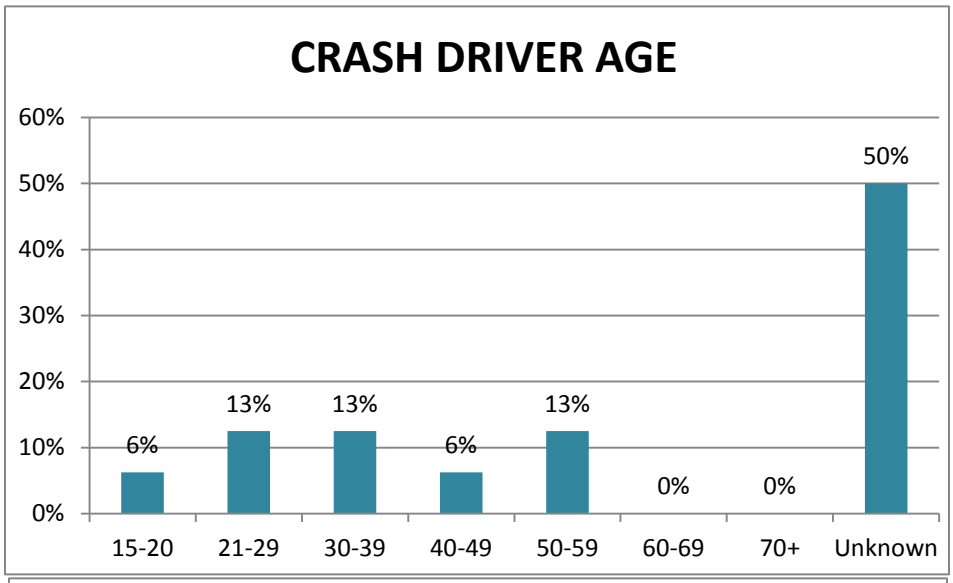
Number	Crash Date	Crash Day	Crash Time	Crash Severity	Manner of Collision	Driver Behavior	Driver Age Striking Veh	Ambient Conditions	Weather Condition	Roadway Condition	Comments
1	1/31/2010	Sunday	2:37 PM	Property damage	Angle	Red light running	Unknown	Daylight	Clear	Dry	Veh 1 ran red light and struck Veh 2
2	4/14/2010	Wednesday	5:49 PM	Property damage	Single vehicle crash	Operating vehicle in reckless manner	Unknown	Daylight	Clear	Dry	Veh 1 entered roadway from bike path at high speed, went airborn, struck the curb and stopped
3	4/25/2010	Sunday	11:14 AM	Property damage	Angle	Red light running	Unknown	Daylight	Rain	Wet	Veh 1 ran the red light, struck the left-turning Veh 2, causing Veh 2 to spin and strike stopped Veh 3
4	6/3/2010	Thursday	4:53 PM	Non-fatal injury	Angle	Red light running	Unknown	Daylight	Cloudy	Dry	Veh 1 ran the red light and struck Veh 2
5	7/10/2010	Saturday	5:28 PM	Property damage	Angle	Failed to yield right of way	Unknown	Daylight	Cloudy	Dry	Veh 1 turned left in front of Veh 2 traveling straight, Veh 2 then struck Veh 1
6	7/10/2010	Saturday	9:55 PM	Non-fatal injury	Pedestrian	Inattention	Unknown	Dark	Fog	Dry	During an altercation at 1107 Falmouth Rd, a vehicle turning left out of the residence struck an involved party
7	7/16/2010	Friday	7:08 PM	Property damage	Rear-end	Inattention	Unknown	Daylight	Clear	Dry	Veh 1 stopped for turning traffic after intersection, Veh 2 was travelling behind Veh 1 and failed to stop
8	3/16/2011	Wednesday	12:17 PM	Property damage	Rear-end	Loss of vehicle control	Unknown	Poor visibility	Rain	Wet	Veh 1 and Veh 2 were stopped, Veh 3 struck Veh 2, Veh 2 then struck Veh 1
9	1/21/2012	Saturday	4:16 PM	Non-fatal injury	Angle	Loss of vehicle control	58	Daylight	Snow	Snow	Veh 1 began swerving due to snow and struck Veh 2 which was traveling in the opposite direction
10	2/8/2012	Wednesday	11:14 AM	Non-fatal injury	Angle	Red light running	28	Daylight	Clear	Dry	Veh 1 ran red light and struck Veh 2
11	2/9/2012	Thursday	11:48 AM	Non-fatal injury	Angle	Red light running	56	Daylight	Clear	Dry	Veh 1 ran red light and struck Veh 2
12	4/16/2012	Monday	5:39 PM	Property damage	Rear-end	Inattention	18	Daylight	Clear	Dry	Veh 1 approaching red light when struck by following Veh 2
13	6/8/2012	Friday	5:50 PM	Non-fatal injury	Rear-end	Inattention	26	Daylight	Clear	Dry	Both vehicles were travelling in the same direction, Veh 1 struck Veh 2 from behind
14	6/13/2012	Wednesday	6:13 PM	Property damage	Rear-end	Inattention	39	Daylight	Rain	Wet	Veh 1 slowed for yellow light, Veh 2 struck Veh 1 from behind
15	7/27/2012	Friday	9:59 PM	Non-fatal injury	Rear-end	Inattention	46	Dark	Cloudy	Dry	Veh 1 was stopped for approximately 30 seconds, was struck by Veh 2 from behind
16	9/30/2012	Sunday	9:46 PM	Property damage	Angle	Mechanical failure (brakes)	34	Dark	Cloudy	Dry	Veh 1's brakes failed when approaching intersection, struck Veh 2 traveling through intersection

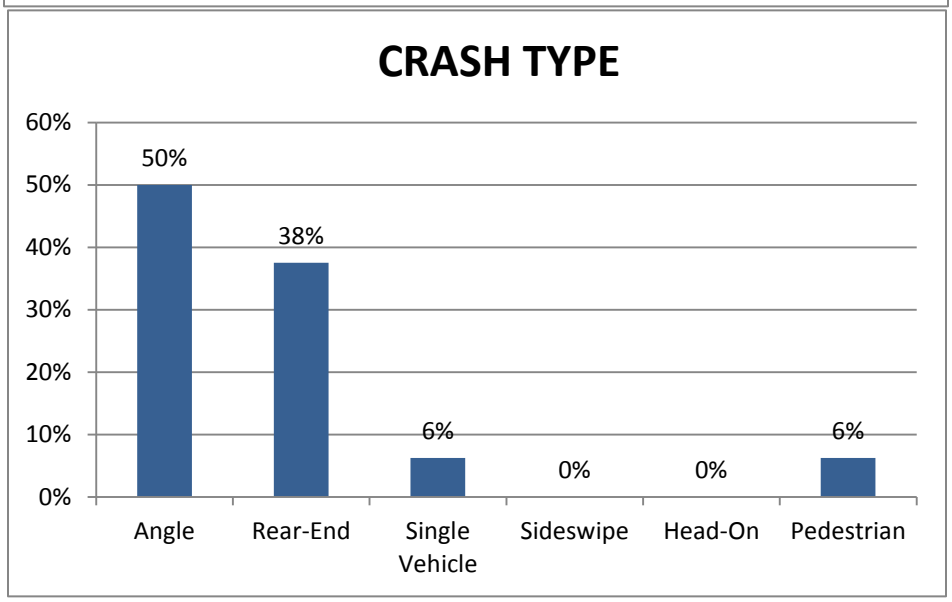

CRASH YEARS
60%
50%
40%
30%
20%
10%
0%
44%
6%
50%
2010
2011
2012

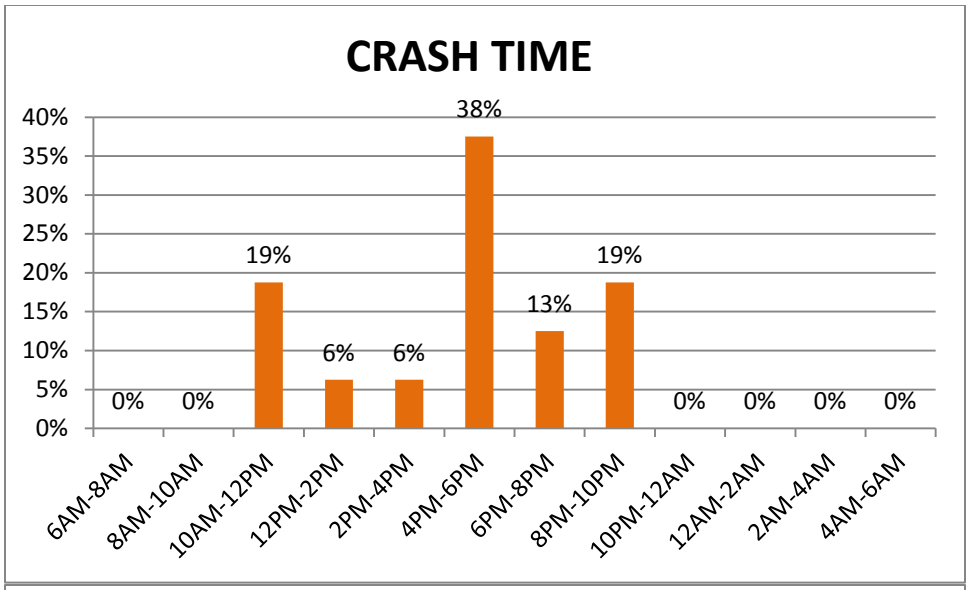

CRASH DAYS
30%
25%
20%
15%
10%
5%
0%
19%
6%
0%
25%
13%
19%
19%
Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

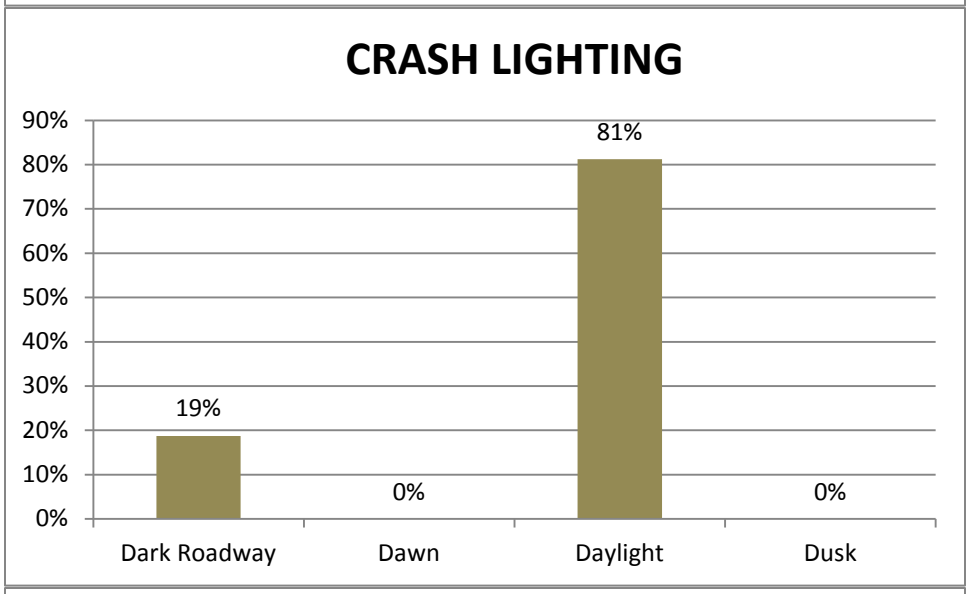

CRASH MONTH
30%
25%
20%
15%
10%
5%
0%
13%
13%
6%
19%
0%
19%
25%
0%
6%
0%
0%
0%
J
F
M
A
M
J
J
A
S
O
N
D

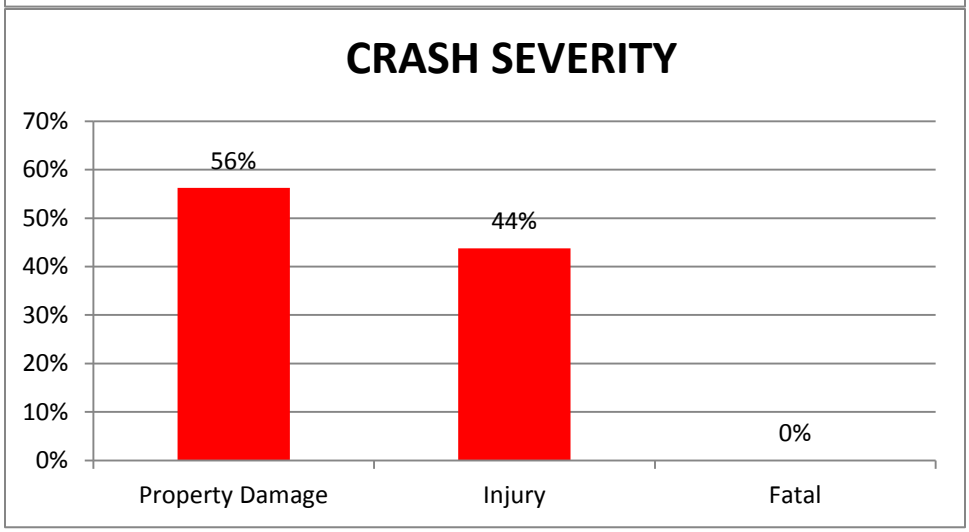

CRASH WEATHER CONDITION
50%
45%
40%
35%
30%
25%
20%
15%
10%
5%
0%
44%
25%
19%
6%
6%
Clear
Cloudy
Rain
Snow
Fog


CRASH DRIVER AGE
60%
50%
40%
30%
20%
10%
0%
6%
13%
13%
6%
13%
0%
0%
50%
15-20
21-29
30-39
40-49
50-59
60-69
70+
Unknown


CRASH TYPE
60%
50%
40%
30%
20%
10%
0%
50%
38%
6%
0%
0%
6%
Angle
Rear-End
Single Vehicle
Sideswipe
Head-On
Pedestrian


CRASH TIME
40%
35%
30%
25%
20%
15%
10%
5%
0%
0%
0%
19%
6%
6%
38%
13%
19%
0%
0%
0%
0%
6AM-8AM
8AM-10AM
10AM-12PM
12PM-2PM
2PM-4PM
4PM-6PM
6PM-8PM
8PM-10PM
10PM-12AM
12AM-2AM
2AM-4AM
4AM-6AM


CRASH LIGHTING
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
19%
0%
81%
0%
Dark Roadway
Dawn
Daylight
Dusk


CRASH SEVERITY
70%
60%
50%
40%
30%
20%
10%
0%
56%
44%
0%
Property Damage
Injury
Fatal

CAPE COD COMMISSION

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