AYER ROAD

DRAFT FUNCTIONAL DESIGN REPORT

Prepared for:

Town of Harvard, Massachusetts

CDM
56 Exchange Terrace
Providence, Rhode Island

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Contents

Appendices

Section 1
Introduction

This Functional Design Report (FDR) presents the functional design for potential roadway and intersection improvements along Ayer Road from the Route 2 interchange northerly to the Harvard-Ayer Town Line. The primary focus of this FDR is to identify safety deficiencies along the corridor, develop conceptual improvements that will provide improved safety for motorists, pedestrians, and bicyclists, as well as an access management plan to promote responsible and sustainable development.

Ayer Road is functionally classified as an Urban Principal Arterial according to the Executive Office of Transportation Planning and provides a major north-south connection between Route 2 and Route 2A in Ayer. In accordance with the 2002 Master Plan, the Town of Harvard wishes to rehabilitate Ayer Road in context with a "Village Center" approach, welcoming all corridor users including pedestrians and bicyclists as well as the motoring public. As part of the "Village Center" approach, the Town would like to encourage appropriate development along the corridor with access management techniques applied.

This FDR also evaluates the following intersections along Ayer Road within the corridor limits:

- Ayer Road at Dunkin Donuts Access Drive
- Ayer Road at the Post Office Access Drive
- Ayer Road at Lancaster County Road
- Ayer Road at Poor Farm Road
- Ayer Road at South Shaker Road
- Ayer Road at Old Mill Road
- Ayer Road at Myrick Lane

Section 2
Existing Conditions

2.1 Location

Ayer Road provides a major north-south connection between Route 2 in Harvard and Route 2A in Ayer. Ayer Road is also known as State Numbered Routes 110 and 111, from the Route 2 interchange northerly to the Harvard-Ayer Town Line. However, according to the Massachusetts Executive Office of Transportation Roadway Inventory Map, the Massachusetts Highway Department (MassHighway) jurisdiction over Routes 110/111 terminates at the ramps from Route 2. The Town of Harvard Department of Public Works (DPW) is responsible for the ownership and maintenance of Ayer Road beyond the state highway limits.

Therefore, the project limits illustrated in this FDR are from north of the Route 2 interchange to the Harvard - Ayer Town Line, a distance of approximately 9,000 feet. Also included are the approaches of all side streets within the project limits. The project limits are illustrated in *Figure 1 – Locus Map.*

2.2 Roadway and Intersection Descriptions

2.2.1 General

Ayer Road is functionally classified as a Rural Principal Arterial according to the Executive Office of Transportation Planning. Ayer Road is also part of the National Highway System (NHS) and primarily consists of one travel lane with a shoulder in each direction. Beyond the southern project limits, Ayer Road widens to two lanes in each direction at the Route 2 interchange.

2.2.2 Bridges

While there are several small culvert crossings along Ayer Road, the most notable waterway crossing is the bridge over Bowers Brook, located approximately 120 feet south of Lancaster County Road. Lancaster County Road also crosses Bowers Brook approximately 60 feet west of Ayer Road. The bridge over Bowers Brook is under MassHighway jurisdiction (#H-09-004) and the routine inspection report is included in Appendix A. According to the inspection, the bridge is not in immediate need of repair, but will eventually require work to be prioritized by MassHighway.

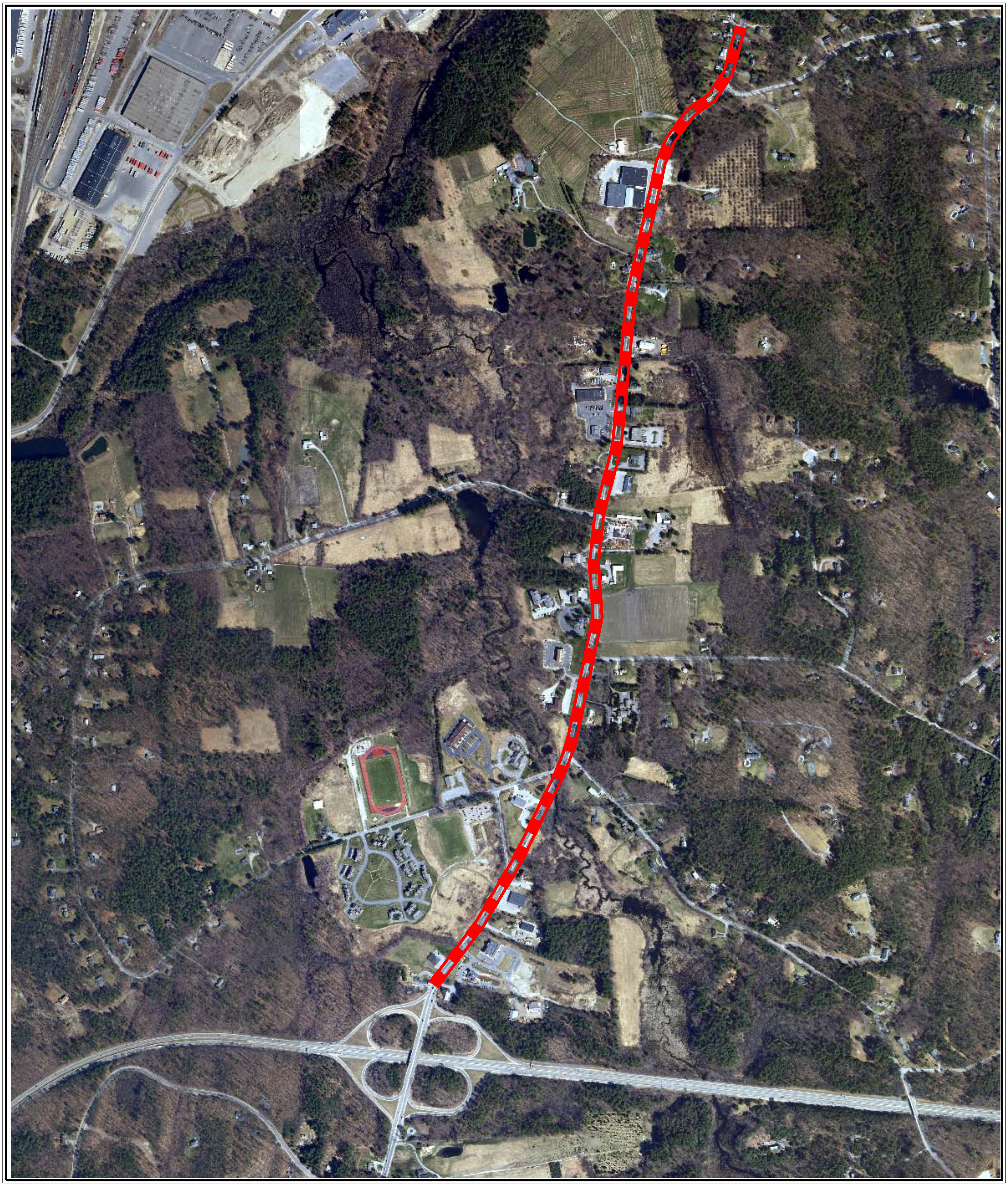
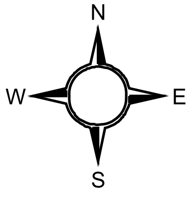


FIGURE 1 - LOCUS MAP



AYER ROAD
HARVARD, MASSACHUSETTS

PROJECT AREA

2.2.3 Pavement Markings

2.2.3.1 General

Pavement markings along Ayer Road within the project limits primarily consist of double yellow center lines with solid white edge lines. Throughout the project limits, the existing pavement markings are visible with some faded markings near the Dunkin Donuts Access Drive. At most of the minor intersections, stop bars are absent along the minor streets. The shoulders along Ayer Road vary in width from 1- to 2-feet, while the travel lanes vary from 11- to 12-feet.

2.2.3.2 Pedestrian Accommodation

There are no pedestrian accommodations provided along Ayer Road within the project limits. Sidewalks, handicapped ramps and crosswalk markings are all absent along the corridor.

2.2.4 Intersection Descriptions

One of the main purposes of this FDR is to identify safety deficiencies along the corridor. Critical to this evaluation is the assessment of intersection safety. Ayer Road is intersected by six streets within the project limits:

- Ayer Road at Gebo Lane
- Ayer Road at Lancaster County Road
- Ayer Road at Poor Farm Road
- Ayer Road at South Shaker Road
- Ayer Road at Old Mill Road
- Ayer Road at Myrick Lane

In addition, the Town of Harvard has requested that the following existing access drives be evaluated for safety deficiencies:

- Ayer Road at Dunkin Donuts Access Drive
- Ayer Road at the Post Office Access Drive

For the purposes of this FDR, the locations are described below in a north to south progression along Ayer Road from the southern study corridor limits at the Route 2 interchange.

2.1.1.1 Ayer Road at Dunkin Donuts Access Drive

The Dunkin Donuts Access Drive is a shared drive with the Harvard Office Park at #188 and is located on the east side of Ayer Road. The intersection of Ayer Road at the Dunkin Donuts Access Drive is located approximately 350 feet north of the southern project limits at the Route 2 interchange. The Ayer Road northbound approach consists of one lane, while the Ayer Road southbound approach consists of what appears to be an exclusive left-turn lane and through lane provided via faded pavement markings.

2.1.1.2 Ayer Road at Gebo Lane

Gebo Lane is a local roadway providing access between Ayer Road and Lancaster County Road. The intersection of Ayer Road at Gebo Lane is located approximately 700 feet north of the Dunkin Donuts Access Drive. The intersection is a three-way unsignalized intersection, with the Gebo Lane approach under STOP control and the Ayer Road approaches are uncontrolled. Gebo Lane intersects Ayer Road on a 35 degree angle. The intersection of Gebo Lane at Lancaster County Road is also a three-legged unsignalized intersection, located approximately 560 feet west of Ayer Road.

2.1.1.3 Ayer Road at Post Office Access Drive

The Post Office is located on a triangular shaped parcel of land contained by Ayer Road, Gebo Lane and Lancaster County Road. Access to the Post Office from Ayer Road is provided via an Entrance-only drive located approximately 630 feet north of Gebo Lane. Motorists leaving the post office must use an Exit-only drive located approximately 230 feet south of the Entrance drive. A third access point is provided onto Lancaster County Road, located approximately 400 feet west of Ayer Road.

2.1.1.4 Ayer Road at Lancaster County Road

Lancaster County Road is a local roadway located on the west side of Ayer Road, providing access to a sports track, residential community and office building. Lancaster County Road intersects Ayer Road approximately 290 feet north of the Post Office Entrance drive. The intersection is an unsignalized three-legged intersection, with Lancaster County Road eastbound approach under STOP control and the Ayer Road approaches uncontrolled. Lancaster County Road intersects Ayer Road at a 46 degree angle.

2.1.1.5 Ayer Road at Poor Farm Road

Poor Farm Road is a local roadway located on the east side of Ayer Road, providing access to residential areas. Poor Farm Road intersects Ayer Road approximately 110 feet north of Lancaster County Road. The Poor Farm Road westbound approach is under STOP control while the Ayer Road approaches are uncontrolled.

2.1.1.6 Ayer Road at South Shaker Road

South Shaker Road is a local roadway located on the east side of Ayer Road, providing access to the Shaker Village Historic area. South Shaker Road intersects Ayer Road approximately 780 feet north of Poor Farm Road at an approximately 90 degree angle. The South Shaker Road westbound approach is under STOP control while the Ayer Road approaches are uncontrolled.

2.1.1.7 Ayer Road at Old Mill Road

Old Mill Road is a local roadway located on the west side of Ayer Road approximately 1100 feet north of South Shaker Road. Old Mill Road provides access to residential areas as well as Old Mill Pond and dead-ends at a golf course. The intersection of Old Mill Road at Ayer Road is a three-legged unsignalized intersection with the Old Mill Road eastbound approach under STOP control and the Ayer Road approaches uncontrolled.

2.1.1.8 Ayer Road at Myrick Lane

Myrick Lane is a local roadway located approximately ½ mile north of Old Mill Road on the east side of Ayer Road. Situated in a residential area, Myrick Lane provides access to several residential developments. The intersection of Myrick Lane at Ayer Road is also a three-legged unsignalized intersection with the Myrick Lane approach under STOP sign control and the Ayer Road approaches uncontrolled.

2.2 Sight Distance

Stopping Sight Distance (SSD) is the minimum distance required for a vehicle traveling at a certain speed to safely stop before reaching a stationary object in the road. The values are based on a driver perception and reaction time of 2.5 seconds and a braking distance calculated for wet, level pavements. When the roadway is either on an upgrade or downgrade, grade correction factors are applied. Stopping sight distance is measured from an eye height of 3.5 feet to an object height of 2 feet above street level.

A design speed of 45 to 50 mph would be appropriate for Ayer Road under existing conditions according to the 85th percentile speed data collected (See Section *3.2 Speed*). According to AASHTO[1] the appropriate stopping sight distances for a 50 mph design speed is 425 feet, with an adjustment up to 446 feet for a 3 percent downgrade and 405 feet for a 3 percent upgrade.

Intersection sight distance (ISD) is the minimum distance required for a motorist exiting a minor street to turn onto the major street, without being overtaken by an approaching vehicle reducing its speed from the design speed to 70 percent of the design speed. Intersection sight distance is measured from an eye height of 3.5 feet to an object height of 3.5 feet above street level. According to AASHTO, the appropriate intersection sight distance for a 50 mph design speed is 555 feet. Adjustments are necessary for side street grades greater than 3 percent and for trucks.

SSD is generally more important as it represents the minimum distance required for safe stopping while ISD is based upon acceptable speed reductions to the approaching

[1] "A Policy on Geometric Design of Highways and Streets 2004", American Association of State Highway and Transportation Officials", Washington D.C., 2004.

traffic stream. However, the ISD must be equal to or greater than the minimum required SSD in order to provide safe operations at the intersection.

The existing SSD and ISD were evaluated in the field along the Ayer Road corridor as part of this FDR. The existing sight distance measurements are illustrated in *Table 2.2*.

Based on a design speed of 50 mph, the existing stopping sight distances along Ayer Road are sufficient at each intersection with the exception of the following:

- Traveling northbound (360 feet of SSD) and southbound (430 feet of SSD) at the Dunkin Donuts Access Drive
- Traveling southbound(420 feet of SSD) at South Shaker Road

With respect to intersection sight distance (ISD), existing vegetation blocks measurement of the existing ISD at the intersections at Gebo Lane, Lancaster County Road, Poor Farm Road, South Shaker Road and Old Mill Road. The only locations with ISD available for measurement were the Dunkin Donuts access drive, the Post office access drive, and Myrick Lane.

According to the field measurements, the existing ISD at the Dunkin Donuts access drive is less than the recommended ISD and even less than the recommended SSD. This means that vehicles exiting the Dunkin Donuts access drive do not have sufficient sight distance to even see a vehicle approaching with enough time for that vehicle to safely stop, let alone avoid causing the approaching vehicle to reduce its speed by 30 percent.

According to the field measurements, the existing intersection sight distance for the Post Office exit drive is above the recommended 555 feet.

The measurements at Myrick Lane indicate the ISD looking southbound is less than the recommended 555 feet, but equal to the required SSD for safe operations.

TABLE 2.2
Sight Distance Summary

Major Street	Design Speed (mph)	Intersection Control (Major Street Approaches)	Recommended Stopping Sight Distance (feet)*	Avail. Stopping Sight Distance (feet)		Intersecting Street	Intersection Control (Minor Street Approaches)	Recommended Intersection Sight Distance (feet)*	Avail. Intersection Sight Distance (feet)	
				Traveling Northbound	Traveling Southbound				Looking south	Looking north
Ayer Road	50	Uncontrolled	425	360	430	Dunkin Donuts Access Drive	Stop	555	360	430
Ayer Road	50	Uncontrolled	425	490	600+	Gebo Lane	Stop	555	Blocked by vegetation	
Ayer Road	50	Uncontrolled	425	600+/600+	400/590	Post Office Access Drive	Stop	555	600+	590
Ayer Road	50	Uncontrolled	425	600+	550	Lancaster County Road	Stop	555	Blocked by vegetation	
Ayer Road	50	Uncontrolled	425	600+	590	Poor Farm Road	Stop	555	Blocked by vegetation	
Ayer Road	50	Uncontrolled	425	500	420	South Shaker Road	Stop	555	Blocked by vegetation	
Ayer Road	50	Uncontrolled	425	500	605	Old Mill Road	Stop	555	Blocked by vegetation	
Ayer Road	50	Uncontrolled	425	440	560	Myrick Lane	Stop	555	440	560

*Recommended distances illustrated in "A Policy on Geometric Design of Highways and Streets 2004", American Association of State Highway and Transportation Officials", Washington D.C., 2004.
The Post Office Access has been evaluated for stopping sight distance at both access drives; the intersection sight distance is evaluated only for the Exit drive.

Recommended Stopping Sight Distance per AASHTO

Speed (mph)	Level Terrain	3% upgrade	3% downgrade
30	200	200	205
35	250	237	257
40	305	289	315
45	360	344	378
50	425	405	446
55	495	469	520

Recommended Intersection Sight Distance per AASHTO

Speed (mph)	Case B1 Left Turn from Stop
30	335
35	390
40	445
45	500
50	555
55	610

2.3 Right of Way

According to the assessor maps, the existing right-of-way along Ayer Road measures at approximately 65-70 feet between the Route 2 interchange and just north of the Dunkin Donuts access driveway, where it narrows to 50 feet and remains this width until the Ayer town-line (project limits).

2.4 Land Use

2.4.1 General

Ayer Road is a primarily rural area, with a variety of land uses located throughout the corridor. While there are still some residential parcels predominantly located along the northern portion of the corridor, Ayer Road is primarily home to professional offices, as well as a post office, an apple orchard, tractor supply store, pizza restaurant, bank, community church, dance school and Dunkin Donuts.

Ayer Road also functions as a regional roadway, providing access from Route 2 to the Nashoba Valley Medical Center community hospital.

2.4.2 Physical Resources

2.4.2.1.1 Conservation Land

In addition to the land uses, conservation land is present along the Ayer Road corridor. There are two signed conservation areas including the east side of Ayer Road south of Poor Farm Road, as well as the area on the west side of Ayer Road north of Lancaster County Road.

2.4.2.1.2 Rivers and wetland areas

As mentioned previously, Ayer Road crosses Bowers Brook south of Lancaster County Road. According to the MassGIS website, in addition to the wetland areas surrounding the brook, there are also wetland areas near Gebo Lane (culvert crossing Gebo Lane), along both sides of Ayer Road at Old Mill Road (Old Mill Pond), and an area approximately 700 feet south of Myrick Lane along the east side of Ayer Road. Field observations also indicate a culvert crossing on Ayer Road near the Harvard-Ayer Town Line.

Any proposed improvements will likely require at a minimum a Request for Determination of Applicability (RDA) in the vicinity of these wetland areas.

2.4.2.1.3 Natural Heritage

A NHESP MA Priority Habitat for State-Protected Rare Species area extends along Ayer Road, from Gebo Lane to approximately 2,000 feet north of Old Mill Road.

2.4.2.2 Historic Properties

According to the Massachusetts Historic Commission database, the property located at 310 Ayer Road is considered historical for agricultural and architectural reasons.

3.

Section 3
Traffic Conditions

3.1 Traffic Volumes

Traffic data were collected at various locations along the Ayer Road corridor and study intersections. The raw data from these counts have been used to perform a variety of analyses in this FDR. In addition, the data were compared with statistical count data from the Montachusett Regional Planning Commission (MRPC) and were used to develop basic design control criteria. The traffic data were collected in April 2007 for this FDR and all data is included in Appendix B.

3.1.1 Automatic Traffic Recorder Counts

Forty-eight-hour (48) ATR counts were performed along the Ayer Road corridor and each approach to the study intersections. During the work week, south of South Shaker Road, the traffic volumes indicate that Ayer Road carries 14,290 vehicles per day (vpd). Traveling northbound, these volumes drop down to 13,483 vpd north of Old Mill Road and 13,597 vpd south of the Harvard-Ayer Town Line. On a Saturday, traffic volumes indicate Ayer Road carries 10,488 vpd south of South Shaker Road. Again traveling northbound, these volumes decrease to 9,712 north of Old Mill Road and 9,729 south of the Harvard-Ayer town line.

Additional ATR counts performed in May 2006 on Ayer Road south of Lancaster County Road were collected from a private development study for the proposed "Village at Harvard" 40B project prepared by MS Transportation Systems, Inc. According to an evaluation of historic traffic data, the Ayer Road corridor has historically experienced a 2 percent or less per year growth rate. Therefore, the volumes obtained during May 2006 have been projected to 2007 using a 2 percent growth rate. (Refer to Appendices A and F for more information on historical count data and growth rates).

Traffic on a given roadway typically fluctuates throughout the year depending on the area and the type of roadway. To determine if the April traffic volume data needed to be adjusted to account for this fluctuation, traffic-volume data from Massachusetts Highway Department (MassHighway) Statewide Traffic Data Collection were researched.[2] Based on the MassHighway traffic-volume data, traffic during the month of April represents higher than average month conditions. Historic count data from the MRPC also indicates April is an above average month for traffic flow in the region. The observed traffic volumes were accordingly used with no seasonal adjustments to reflect conservative, above average month analysis conditions. The MassHighway traffic data are provided in Appendix B. The 2007 average daily traffic volumes and statistics are depicted in *Table 3.1.1 – 2007 Traffic Volume Summary.*

[2]*MassHighway 2005 Traffic Volumes – Station 403, Route 2 Concord – Route 2 east of Concord Rotary*

Table 3.1.1
2007 TRAFFIC VOLUME SUMMARY

Location/Peak Hour	Daily Volume (vpd)[a]	Peak Hour Volume (vph)[b]	K Factor[c]	Directional Distribution[d]
Ayer Road south of Lancaster County Road				
Weekday AM	14,818	1196	8.1%	56% SB
Weekday PM		1115	7.5%	57% NB
Saturday	10,899	951	8.7%	53% SB
Ayer Road south of South Shaker Road				
Weekday AM	14,290	1302	9.1%	58% SB
Weekday PM		1188	8.3%	55% NB
Saturday	10,488	960	9.2%	52% SB
Ayer Road north of Old Mill Road				
Weekday AM	13,483	1192	8.8%	58% SB
Weekday PM		1132	8.4%	56% NB
Saturday	9,712	900	9.3%	52% SB
Ayer Road south of town line				
Weekday AM	13,597	1247	9.2%	58% SB
Weekday PM		1112	8.2%	58% NB
Saturday	9,729	873	9.0%	50% SB
Lancaster County Road				
Weekday AM	888	21	2.4%	86% WB
Weekday PM		59	6.6%	54% EB
Saturday	990	71	7.1%	58% EB
Poor Farm Road				
Weekday AM	1,395	133	9.5%	68% EB
Weekday PM		125	9.0%	75% WB
Saturday	1,237	102	9.0%	56%WB
South Shaker Road				
Weekday AM	859	62	7.2%	58% WB
Weekday PM		55	6.4%	54% EB
Saturday	831	62	7.5%	58% EB
Old Mill Road				
Weekday AM	416	33	7.9%	67% EB
Weekday PM		31	7.5%	62% WB
Saturday	410	26	6.3%	54% WB
Myrick Lane				
Weekday AM	679	56	8.2%	71% WB
Weekday PM		67	9.9%	57% EB
Saturday	644	56	8.7%	50% WB

[a]Vehicles per day; [b]Vehicles per hour according to TMC counts; [c]Percentage of daily traffic occurring during the peak hour; [d]EB = eastbound; WB = westbound; NB = northbound; SB = southbound.

Table 3.1.2 illustrates the percent heavy vehicles traveling along Ayer Road on a weekday as well as a Saturday.

Table 3.1.2
2007 DAILY PERCENT HEAVY VEHICLES ON AYER ROAD

Time Period/Location	Northbound	Southbound	Combined
Weekday			
Ayer Road north of Old Mill Road	10.3%	7.6%	9.0%
Ayer Road south of Town line	18.6%	11.1%	15.0%
Saturday			
Ayer Road north of Old Mill Road	7.5%	3.9%	5.7%
Ayer Road south of Town line	15.4%	8.2%	11.8%

3.1.2 Manual Turning Movement Counts

Manual turning movement/vehicle classification counts (TMC) and automatic traffic recorder (ATR) counts were performed by *Accurate Counts* in April 2007. Turning movement counts were performed for the following intersections between 7:00 and 9:00 AM and between 4:00 and 6:00 PM on non-holiday weekdays and between 11:00 AM and 2:00 PM on Saturday. The intersection of Ayer Road and the Post Office Access Drive was counted on Saturday during business hours from 9:00 AM to 12:00 PM. *Table 3.1.3* illustrates the individual peak hours at each intersection counted. The 2007 turning movement volumes are illustrated in *Figure 2 -2007 Peak Hour Turning Movement Volumes.*

Table 3.1.3
2007 PEAK HOURS

Location	WEEKDAY MORNING PEAK HOUR	EVENING PEAK HOUR	SATURDAY MID-DAY PEAK HOUR
Dunkin Donuts Access Drive	7:15-8:15	4:00-5:00	12:00-1:00
Gebo Lane	7:15-8:15	4:00-5:00	12:15-1:15
Post Office	---	---	10:15-11:15
Lancaster County/Poor Farm Road	7:30-8:30	5:00-6:00	12:00-1:00
South Shaker Road	7:30-8:30	4:00-5:00	12:00-1:00
Old Mill Road	7:30-8:30	4:15-5:15	12:00-1:00
Myrick Lane	7:30-8:30	4:30-5:30	12:00-1:00

---Post office was counted from 9:00AM to 12:00PM Saturday only

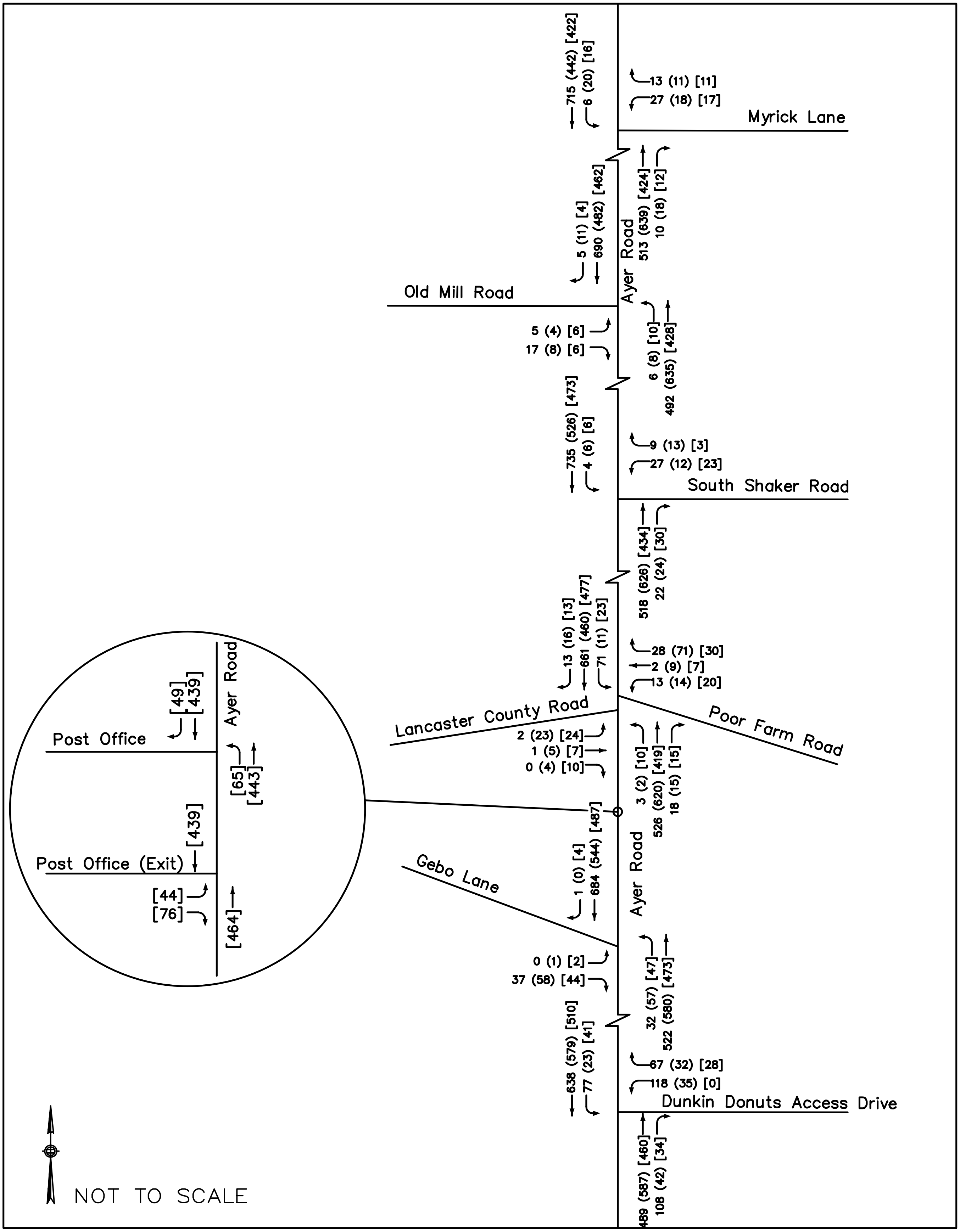


Figure No. 2
2007 Existing AM(PM) [SAT]
Peak Hour Traffic Volumes

3.2 Speed

3.2.1 Posted Speed

According to MassHighway District 3 Traffic Operations, there is no special speed regulation on file for Ayer Road.

Speed limit signs are posted along Ayer Road in few locations:

Traveling northbound from Route 2, the speed limit is posted at 40 miles per hour (mph) along Ayer Road. The speed limit reduces to 35mph south of the apple orchard areas. The speed limit is posted at 35mph again at the Harvard-Ayer town line.

Traveling southbound, the speed limit is posted at 35mph within the town of Ayer and posted again at 35mph approximately 680 feet north of Myrick Lane. The speed limit is then posted at 40mph traveling southbound south of the apple orchard areas. There are no additional speed limit signs traveling south along the corridor.

3.2.2 Observed Travel Speed

In addition to ATR counts, speed data was collected along Ayer Road. This data is presented in *Table 3.2.1 – Observed Travel Speeds* and included in Appendix C. According to the data collected, the average speed is above the limit posted in the vicinity of the Town line. North of Old Mill Road, the average speed is consistent with the posted speed limit. However, the 85th percentile speed for both directions is higher than the posted speed limit.

Table 3.2.1
OBSERVED TRAVEL SPEEDS

Location along Ayer Road/ Direction	Number of Observations	Average Speed[a]	85th Percentile Speed[b]	Pace Speed	Percent in Pace
North of Old Mill Road/ Northbound	18,207	40mph	45mph	36-45mph	76.2%
North of Old Mill Road/ Southbound	18,072	39mph	44mph	36-45mph	77.0%
South of Harvard-Ayer Town Line/ Northbound	18,311	44mph	50mph	41-50mph	68.0%
South of Harvard-Ayer Town Line / Southbound	18,033	40mph	45mph	36-45mph	71.9%

[a]In miles per hour (mph).
[b]Speed at, or below which 85 percent of all observed vehicles travel. It is commonly used for posting speed limits.

3.2.3 Design Speed

Based on the observed travel speeds, a design speed in the range of 45 mph would be appropriate for Ayer Road. However, this appears contradictory to the goals of the Master Plan, which stressed the importance of slowing traffic along Ayer Road to compliment the planned village center. According to the 2006 MassHighway Project Development and Design Guidebook (PDDG), the design speed for a rural village area is recommended to be in the range of 30 to 45 mph. See Section 4.5.2 for speed control options.

3.3 Traffic Signal Warrant Analysis

While not typically associated with rural areas, traffic signals can provide a safety improvement over unsignalized intersections, especially where traffic volumes are high and sight distance is limited. Ornamental and black signal equipment has been used in several 'village' type areas for traffic control.

Typically, an unsignalized intersection is evaluated for criteria warranting a traffic signal installation as dictated by the *Manual on Uniform Traffic Control Devices* (MUTCD) a Federal Highway Administration Publication. Likewise, a signalized intersection is evaluated to determine whether the existing signal installation is still warranted or not. Detailed signal warrant analyses have been performed at the main intersections along the Ayer Road corridor and are included in Appendix C. The specific warrants reviewed include: Warrant 1 – Condition A - Minimum Vehicular Volume; Warrant 1 – Condition B - Interruption of Continuous Traffic; Warrant 1 - Combination of Warrants 1A and 1B; Warrant 2 - Four Hour Warrant; and Warrant 3 – One-Hour Warrant. *Table 3.3.1* illustrates the results of the warrant analyses.

Table 3.3.1
TRAFFIC SIGNAL WARRANT ANALYSIS

Intersection	Warrant 1A	Warrant 1B	Warrant 1 Combo	Warrant W2	Warrant W3
Ayer Rd. at Lancaster Cnty.Rd.	No 0 of 8 hours	No 1 of 8 hours	No 0 of 8 hours	No 1 of 4 hours	**Yes** 1 of 1 hour
Ayer Rd. at Poor Farm Rd.	No 0 of 8 hours	No 4 of 8 hours	No 0 of 8 hours	**Yes** 4 of 4 hours	**Yes** 1 of 1 hour
Ayer Rd. at South Shaker Rd.	No 0 of 8 hours	No 0 of 8 hours	No 0 of 8 hours	No 0 of 4 hours	No 0 of 1 hour
Ayer Rd. at Old Mill Rd.	No 0 of 8 hours	No 0 of 8 hours	No 0 of 8 hours	No 0 of 4 hours	No 0 of 1 hour
Ayer Rd. at Myrick Lane	No 0 of 8 hours	No 0 of 8 hours	No 0 of 8 hours	No 0 of 4 hours	No 0 of 1 hour

Based on the results of the traffic signal warrant analysis, the intersections of Ayer Road at South Shaker Road, Old Mill Road and Myrick Lane do not warrant traffic signal installation. The volumes through the intersection of Ayer Road at Lancaster County Road cross the thresholds for traffic signal warrant 3, the one hour warrant. The volumes through the intersection of Ayer Road at Poor Farm Road cross the thresholds for traffic signal warrants 2 and 3, the four hour warrant and the one hour warrant, respectively. In addition, the intersection volumes cross the thresholds established for traffic signal warrant 1B during four of eight hours evaluated. This intersection should be further considered for traffic signal installation.

3.4 Collision History

According to the 2002 Master Plan for the Town of Harvard:

> "As residents, business owners, and the Harvard Police Department know well, there are a number of traffic, safety problems on Ayer Road north of Route 2. These problems include traffic volumes and speed, truck traffic generated by Devens industrial establishments, and conflicts between through traffic, neighborhood traffic, and drivers entering or exiting business establishments in the C District. Ayer Road is the most accident-prone roadway in Harvard and it will remain so until a comprehensive program of transportation improvements is planned and implemented."

Collision data for the intersections along the Ayer Road corridor were obtained from the Town of Harvard Police Department's accident database for the most recent available three-year period (2004 through 2007). Summaries of the actual collisions are included in Appendix E.

3.4.1 Intersection Collision History

Table 3.4.1 illustrates the results of the collision analysis over the past three years of data available at the intersections evaluated. Of the 8 locations evaluated, there are 4 which experienced more than 1 collision per year during the period analyzed.

3.4.1.1 Crash Rating

Collision or crash occurrence should be compared to the volume of traffic through a particular intersection to determine any statistical significance. Accordingly, the crash rates were calculated for the intersection and compared with the statewide average. An intersection crash rate is a measure of the frequency of accidents compared to the volume of traffic through an intersection and is presented in accidents per million entering vehicles (acc/mev). For unsignalized intersections, the statewide average is 0.66 acc/mev while the District 3 average is 0.79 acc/mev. A comparison of the calculated accident rate to these averages can be used to establish the significance of crash occurrence and whether or not potential safety problems exist. The crash rate worksheets are included in Appendix E.

3.4.1.2 Dunkin Donuts Access Drive

The intersection of Ayer Road at the Dunkin Donuts driveway has experienced seven collisions since opening in 2005. Seventy-one percent of the collisions are classified as angle collisions, indicative of a need for improved traffic control. Fifty-seven percent of the collisions involve vehicles taking a left-turn out of the driveway. Field observations indicate that stopping sight distance between the Route 2 interchange and the driveway is not sufficient for an operating speed of 45-50mph on Ayer Road.

3.4.1.3 Post Office Access Drives

The intersection of Ayer Road at the Post Office has experienced six accidents over the past three years. Although stopping sight distance appears adequate for the northbound approach, sixty-seven percent of the collisions were rear-end collisions attributed to northbound vehicles striking vehicles stopped to take left-turns into the Post Office driveway.

3.4.1.4 Poor Farm Road

The intersection of Ayer Road at Poor Farm Road is the most collision-prone intersection along the corridor based on the history. The intersection has experienced 12 collisions over the past three years. While angle collisions would be the most likely accident due to sight distance issues, the predominant type of collision at Poor Farm Road is rear-end collisions, representing 58% of the total collisions. These rear-end collisions are likely due to frequent starting/stopping of motorists trying to exit Poor Farm Road. In addition, motorists exiting Lancaster County Road may enter the traffic stream on Ayer Road and then quickly stop to allow motorists to exit Poor Farm Road. The intersection also has a crash rating of 0.66 equivalent to the statewide average, but slightly less than the District 3 average for unsignalized intersections.

3.4.1.5 South Shaker Road

The intersection of Ayer Road at South Shaker Road has experienced 4 collisions over the past three years. Seventy-five percent of the collisions are angle collisions, indicative of a need for improved sight distance and/or traffic control.

Table 3.4.1

CRASH HISTORY

	Number of Collisions			Crash Type [a]			Collision Manner [b]				Percent During
Location on Ayer Rd.	Total	Avg Per Year	Crash Rating	F	I	PDO	A	RE	Ped.	Other	Peak Hours
Dunkin Donuts Access Drive	7	3	0.52	0	2	5	5	0		2	57%
Gebo Lane	1	0	0.06	0	0	1	1	0	0	0	0
Post Office	6	2	0.40	0	2	4	1	4	0	1	0.2%
Lancaster County Road	0	0	0	0	0	0	0	0	0	0	0
Poor Farm Road	12	4	0.66	0	3	9	2	7	0	3	33%
South Shaker Road	4	1	0.25	0	2	2	3	0	0	1	0
Old Mill Road	0	0	0	0	0	0	0	0	0	0	0
Myrick Lane	0	0	0	0	0	0	0	0	0	0	0

Source: Town of Harvard Police Department 2004 - 2007
[a]F = Fatality; I = Personal Injury Accident; PDO = Property Damage Only;
[b]A = Angle; RE = rear end; Ped. = pedestrian; Other indicates fixed object, sideswipe or head-on collisions

3.4.2 Corridor Collision History

In addition to the collisions that have occurred at intersections, corridor-wide collision history has also been evaluated. According to the Town of Harvard Police Department collision records, 24 collisions have occurred along the corridor (not at a specific intersection). Thirty-eight percent of the corridor collisions were classified as rear-end collisions while 21 percent were collisions involving deer. The Hundred Million Vehicle Miles traveled (HMVM) crash rate was also determined for the corridor. Based on the latest three years of crash data available, crash rates should be calculated for roadway segments based on Hundred Million Vehicle Miles traveled (HMVM) as follows:

HMVM = (A x 100,000,000)/ (ADT x D x L)

A = number of total crashes at the study location during a given period

ADT = Average Daily Traffic

D = number of days in the study period

L = length of study location in miles

Roadway: Ayer Road from Route 2 to Harvard-Ayer Town Line (does not include collisions at any intersection within the study area)

A =	24
ADT=	13,483 vehicles per day
D=	1,095 (3 years)
L=	1.7 miles
HMVM=	**95.6**

Based on the most recent motor vehicle safety data from the Nation Highway Traffic Safety Administration (NHSTA), there was a national average crash rate of 221 crashes per hundred million vehicle miles traveled in 2002. Thus, any rate higher than 221 may be indicative of a safety concern. The Ayer Road HMVM has been calculated as 95.6; this does not illustrate a significant safety concern for the corridor.

This calculation does not, however, address the lack of pedestrian and bicyclist accommodation along the corridor.

Section 4
Future Conditions

4.1 General

The primary objectives of this FDR are to identify ways to improve safety and traffic flow, provide pedestrian accessibility in compliance with ADA, provide bicycle accommodation, and improve access management.

However, the improvement alternatives for the Ayer Road corridor must take into account the potential development along the corridor and the goals of the town's 2002 Master Plan.

4.2 Master Plan

The 2002 Master Plan for Harvard identifies Ayer Road north of Route 2 as the designated Commercial District (District C) for the town. According to the Master Plan, goals Ayer Road include:

- Creation of a bustling village business district while minimizing new road construction
- Focus on traffic controls, intersection improvements, traffic calming techniques and pedestrian and bicycle access to make the roadway safe for local and non-local traffic.
- Traffic management, intersection control & traffic calming via narrowed pavement striping, nature strips, signage, roundabouts, pedestrian crossing controls and speed alerts
- Preserve rural character of Harvard
- Plan for a bicycle path system that encourages non-vehicular travel between the Town Center, the Community Commercial District and Devens
- Consider traffic signals and other 'congestion' points to create gaps in traffic that can be used safely by drivers entering a main road from its side streets
- Consider providing clear driveway guidelines – Several businesses have curbed driveways while others are more rural with dirt aprons. Driveway locations are not predictable for traffic on Ayer Road, particularly between Old Mill road and Route 2.

4.3 Future Traffic Volumes

Determination of future traffic volumes along Ayer Road requires evaluation of two components of traffic growth – background growth and future development.

4.3.1 Background growth

According to MassHighway traffic data, the District 3 region has experienced a decrease in traffic volumes of 0.6% from 2004 to 2005 in rural areas. However, a comparison between traffic data collected on Ayer Road in 2007 and historic traffic data collection by MRPC indicates that Ayer Road has experienced a background traffic growth rate of 1.6 percent per year compounded over the past 10 years, and a 1.1 percent per year compounded growth rate over the past 5 years.

A corridor study in any community surrounding Fort Devens (Devens) would be remiss if the impact of Devens redevelopment were not at least reviewed. According to review of the Devens Traffic Monitoring Program – 2005 – 5 Year Traffic Report, a 1.77 percent per year background growth rate was used for the region. The Devens documents do not explicitly evaluate an increase in traffic along Ayer Road in Harvard between Route 2 and the Harvard-Ayer town line due to the Devens redevelopment. Therefore, since substantial redevelopment of Devens has been ongoing it is anticipated that any increases in traffic due to Devens along Ayer Road would be included in the background growth rate.

Conversations with the town of Ayer planning department indicate there are no significant developments at this time expected to increase traffic along Ayer Road. Conversations with MRPC indicate that their regional growth rate for rural areas is 2.08%; MRPC concurs with application of a 2.0% per year compounded growth rate for Ayer Road. Appendix F includes calculations for the background growth rate as well as emails related to the conversations mentioned above.

Therefore, for the purposes of this FDR, a 2.0% per year compounded growth rate has been applied to the 2007 traffic data to project to a 20-year design horizon (2027). This represents a 49 percent increase in traffic along Ayer Road. *Table 4.3.1* illustrates the projected volumes along Ayer Road. The 2027 turning movement volumes are illustrated in *Figure 3 -2027 Peak Hour Turning Movement Volumes.*

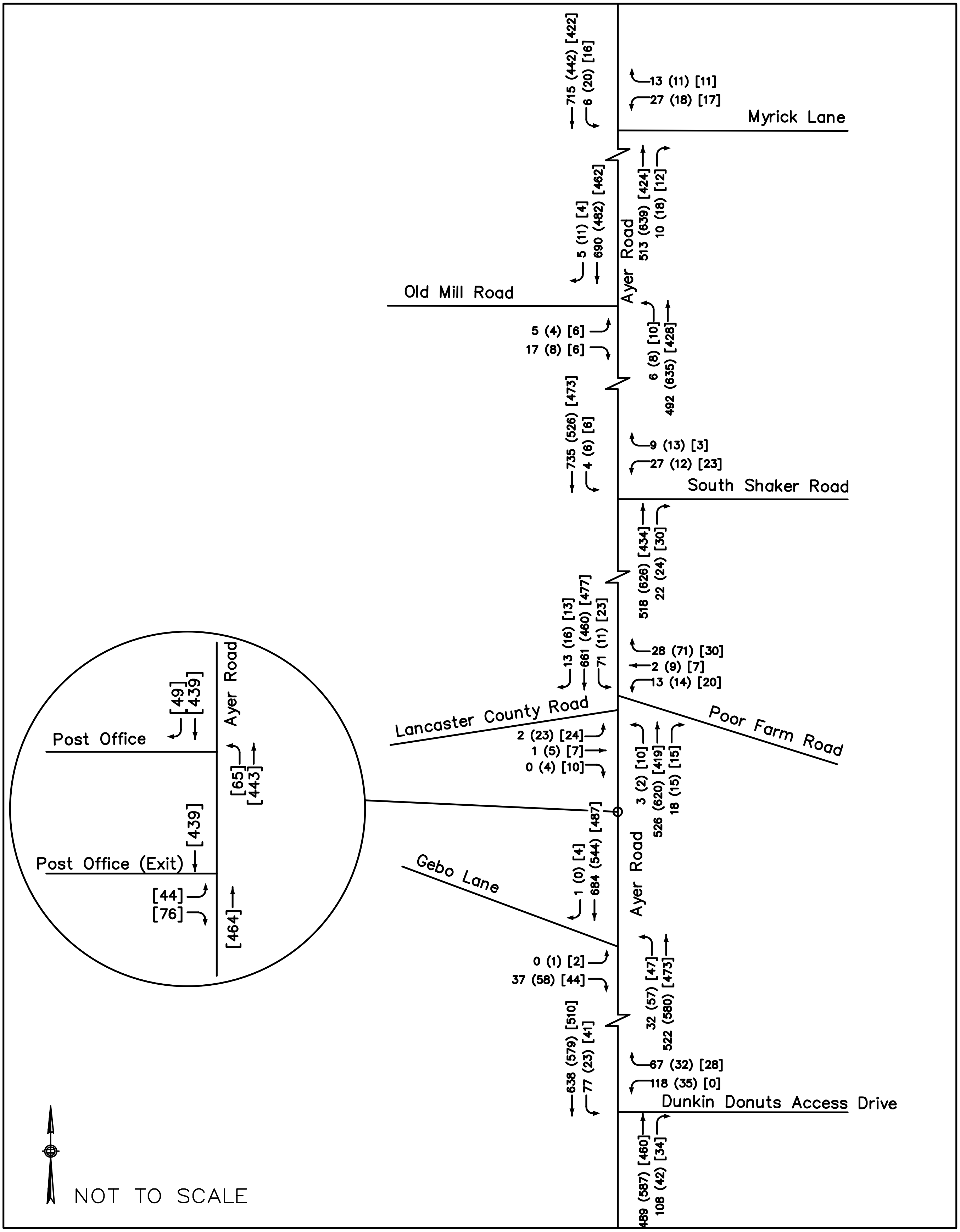


Figure No. 3
2027 No Build AM(PM) [SAT]
Peak Hour Traffic Volumes

CDM

Table 4.3.1
2027 BACKGROUND GROWTH TRAFFIC VOLUME SUMMARY

Location/Peak Hour	Daily Volume (vpd)[a]	Peak Hour Volume (vph)[b]	K Factor[c]	Directional Distribution[d]
Ayer Road south of Lancaster County Road				
Weekday AM	22,019	1777	8.1%	56% SB
Weekday PM		1657	7.5%	57% NB
Saturday	16,195	1413	8.7%	53% SB
Ayer Road south of South Shaker Road				
Weekday AM	21,234	1935	9.1%	58% SB
Weekday PM		1765	8.3%	55% NB
Saturday	15,585	1427	9.2%	52% SB
Ayer Road north of Old Mill Road				
Weekday AM	20,035	1771	8.8%	58% SB
Weekday PM		1682	8.4%	56% NB
Saturday	14,432	1337	9.3%	52% SB

[a]Vehicles per day; [b]Vehicles per hour according to TMC counts; [c]Percentage of daily traffic occurring during the peak hour; [d]EB = eastbound; WB = westbound; NB = northbound; SB = southbound.

4.3.2 Traffic Signal Warrant Analysis

Based on a projected background growth of 2 percent per year (49 percent increase overall), the intersections were again evaluated for traffic signal warrants based on the projected volumes. *Table 4.3.2* illustrates the results of the traffic signal warrant analysis using 2027 volumes.

Table 4.3.2
2027 TRAFFIC SIGNAL WARRANT ANALYSIS

Intersection	Warrant 1A	Warrant 1B	Warrant 1 Combo	Warrant W2	Warrant W3
Ayer Rd. at Lancaster County Rd.	No 1 of 8 hours	No 5 of 8 hours	No 1 of 8 hours	No 1 of 4 hours	**Yes** 1 of 1 hour
Ayer Rd. at Poor Farm Rd.	No 2 of 8 hours	**Yes** 8 of 8 hours	No 1 of 8 hours	**Yes** 4 of 4 hours	**Yes** 1 of 1 hour
Ayer Rd. at South Shaker Rd.	No 0 of 8 hours	No 4 of 8 hours	No 0 of 8 hours	No 2 of 4 hours	No 0 of 1 hour
Ayer Rd. at Old Mill Rd.	No 0 of 8 hours	No 0 of 8 hours	No 0 of 8 hours	No 0 of 4 hours	No 0 of 1 hour
Ayer Rd. at Myrick Lane	No 0 of 8 hours	No 1 of 8 hours	No 0 of 8 hours	No 1 of 4 hours	No 0 of 1 hour

Based on the results of the traffic signal warrant analysis, the intersections of Ayer Road at South Shaker Road, Old Mill Road and Myrick Lane would not warrant traffic signal installation. The projected volumes through the intersection of Ayer Road at Lancaster County Road cross the thresholds for traffic signal warrant 3, the one hour warrant and 5 of 8 hours of Warrant 1B. The projected volumes through the intersection of Ayer Road at Poor Farm Road cross the thresholds for traffic signal warrants 1B, 2 and 3. This intersection should still be further considered for traffic signal installation.

4.3.3 Potential Development

Potential future development along Ayer Road must also be considered in addition to the background growth rate evaluation.

4.3.3.1 Zoning

Ayer Road is currently zoned under two different districts:

AR = Agricultural-Residential

C=Commercial

According to the Master Plan, there are approximately 13,380 acres of AR zoned land along Ayer Road and approximately 440 acres of C zoned land, less than half of which is commercially or industrially developed. Furthermore, the Master Plan states "the C District on Ayer Road has room for 11.8 million square feet of new commercial development."

Based on Protective Bylaw 125, the development along Ayer Road within the Commercial District is limited to 8,000sf of floor area or 10 percent of the total lot area, whichever is greater. In addition, Mixed-Use Village Developments (MUVD) and Ayer Road Village (ARV) developments are permissible under a Special Permit. The MUVD permit indicates that multi-family residential development can occur as long as 30 percent of the development is committed to retail. ARV permit is only applicable to parcels with 300 feet or more of frontage along Ayer Road.

A variety of permitted uses along Ayer Road vary from small scale commercial uses (office use, travel agency, photo studio, florist, gift shop, etc.) to medium scale commercial uses (medical or dental office, beauty shop, appliance repair, nursery school, and retail stores, including grocery, not exceeding 15,000 square feet of gross floor area building space) as well as large scale uses such as a commercial greenhouse or entertainment and recreation. Developments larger than these permitted uses will require a special permit.

4.3.3.2 Current Proposals

According to the planning office, the Proposed Village at Harvard 40B Project is currently in front of the Zoning Board of Appeals (ZBA). According to the Traffic Study prepared by MS Transportation Systems, Inc. for the Callahan Realty trust property (the former Kubota tractor and equipment sales and service center), the project consists of 8,000 square feet (sf) of retail and 32 one and two-bedroom condominiums. The project is expected to generate 588 daily trips on a weekday; it is also expected to generate 29 trips during the morning peak hour and 54 trips during the evening peak hour. While there is a retail component of the development, the Saturday mid-day peak hour was not evaluated.

In addition to the Village at Harvard, a conceptual plan dated March 2007 has been discussed for the Old Mill Realty property on the southwest corner of the intersection of Ayer Road and Old Mill Road. There is no traffic study on file for this potential project, but the project would include 61 assisted living units and 16,000sf of retail space. Calculations indicate this development would generate approximately 850 daily trips during a weekday and 934 trips on a Saturday. The development would also generate 62 trips during the morning peak hour, 205 trips during the evening peak hour and 263 trips during the Saturday peak hour.

4.3.3.3 Vacant Parcel Development

A parcel by parcel site-specific inventory is required for each parcel along Ayer Road to appropriately identify the maximum possible development opportunity based on requirements for open space, wetland impacts, and appropriate setbacks from any street right-of-way as well as parking requirements. A site-specific inventory is beyond the scope of this FDR.

As such, calculations to determine the potential increase in traffic along Ayer Road due to development of the existing vacant parcels must make some assumptions with respect to development possibilities and are as follows.

<u>Assumptions Regarding Land Development:</u>

- Parcels located in the AR District are restricted to residential development
- Chapter 61 land is not available for redevelopment
- Institute of Transportation Engineers (ITE) Trip Generation rates for Land Use Codes: Office (710), Shopping Center (820), Supermarket (850) and Residential Townhouse/Condominium (230) have been used to generate anticipated vehicular trips
- A 25% pass-by rating (permissible by MEPA) has been applied to the retail (shopping center) portion of the anticipated development
- The total increase in trips does <u>not</u> reflect a reduction for internal site trips for mixed-use village developments

In addition to the assumptions above, potential trips generated by development have been evaluated under two different alternatives as follows:

- Alternative 1:
  - All vacant parcels in the C District would be developed under a MUVD permit and would assume a distribution of floor area as follows:

    - Office (30%)
    - Retail (30%)
    - Residential (40%)
    - Two parcels would be considered for a MUVD with a grocery store of 15,000sf (the remaining land use would be distributed according to the breakdown above)

- Alternative 2:
  - All vacant parcels in the C District would be developed under a MUVD permit and those eligible would be developed under an ARV permit (with 20% of total lot available for floor area) and would assume a distribution of floor area as follows:
    - Office (30%)
    - Retail (30%)
    - Residential (40%)
    - One parcel would be considered for a ARV permit with a grocery store of 60,000sf (the remaining land use would be distributed according to the breakdown above)

4.3.3.4 Summary of Potential Development

Based upon the assumptions illustrated in 4.3.3.3 and the current proposals for development along Ayer Road, calculations to determine the total increase in trips along Ayer Road have been performed; the results of which are illustrated in *Table 4.3.3.4*. Detailed calculations are included in Appendix F.

The results of the calculations indicate the daily increase in traffic along Ayer Road with development of the vacant parcels ranges from approximately 11,700 vehicles per day to 17,650 vehicles per day (vpd) during the work week. Approximately 835 to 1,120 trips are expected during the morning peak hour of adjacent street traffic (typically 7:00AM to 9:00AM) and 2,660 to 3,360 trips are expected during the evening peak hour of adjacent street traffic (typically 4:00PM to 6:00PM). Volumes along Ayer Road may increases by approximately 12,300 to 20,400vpd on a Saturday and approximately 2,270 to 2,960 during the Saturday mid-day peak hour.

Table 4.3.3.4
Anticipated Trips Generated by Potential Development

	Daily (vpd)	AM Peak Hour (vph)	PM Peak Hour (vph)	Saturday (vpd)	Saturday Peak Hour (vph)
Alternative 1	11,689	836	2,657	12,315	2,271
Alternative 2	17,649	1,123	3,361	20,409	2,956

Based on these calculations, *Table 4.3.3.5* illustrates the overall 2027 projected traffic volume summary with anticipated development of vacant parcels. The ranges illustrated vary from Alternative 1 and Alternative 2. If all of the vacant parcels available for development are developed to the maximum extent granted either under a MUVD permit or an ARV permit, Ayer Road may carry anywhere from 31,000 to 40,000 vpd on a weekday and anywhere from 26,000 to 36,000 vpd on a Saturday. While the weekday morning peak hour may carry between 2,600 and 3,000 vph, the evening peak hour may carry between 4,300 and 5,100 vph, and the Saturday mid-day peak hour may carry between 3,600 and 4,400 vph.

Table 4.3.3.5
2027 PROJECTED TRAFFIC VOLUME SUMMARY (WITH BUILD-OUT)

Location/Peak Hour	Daily Volume (vpd)[a]	Peak Hour Volume (vph)[b]
Ayer Road south of Lancaster County Road		
Weekday AM	33,708 to 39,668	2,613 to 2,900
Weekday PM		4,314 to 5,018
Saturday	28,510 to 36,604	3,684 to 4,369
Ayer Road south of South Shaker Road		
Weekday AM	32,293 to 38,883	2,771 to 3,058
Weekday PM		4,422 to 5,126
Saturday	27,900 to 35,994	3,698 to 4,383
Ayer Road north of Old Mill Road		
Weekday AM	31,724 to 37,684	2,607 to 2,894
Weekday PM		4,339 to 5,043
Saturday	26,747 to 34,841	3,608 to 4,293

[a]Vehicles per day; [b]Vehicles per hour according to TMC counts

Again, these calculations are conservative in that the total floor area of development is based on the total acreage for each lot; lots will require a site-specific survey to determine the actual maximum floor area based on requirements for open space, wetland impacts, and appropriate setbacks from any street right-of-way as well as parking requirements.

4.4 Access Management

The Town of Harvard is taking a proactive step towards responsible development along Ayer Road. Instead of allowing developments to occur randomly, the Town is interested in developing an access management strategy before these developments are constructed.

The following access management discussion will be contingent upon the overall treatment determined for the Ayer Road corridor. Access management is divided into two categories: Site specific access points, where recommendations are provided for individual access treatments and Corridor access, where overall corridor treatments are discussed.

4.4.1 Site Specific Access Points

According to the MassHighway PDDG as well as the October 2000 Iowa Access Management Handbook (a comprehensive design guide for access management throughout the country) access management techniques for site driveways and intersections include:

4.4.1.1 Limited Access Points and driveway openings

- Proposed developments along Ayer Road should have only one full access drive, with supplemental right-turn in, right-turn out drives
- Proposed developments on intersection corners should be encouraged to access the side street with their full access drive to minimize conflicts on Ayer Road.
- Minimum driveway spacing along Ayer Road is recommended at 275 feet between adjacent driveways and 300 feet between opposite right spaced driveways.
- Driveways should not be situated within the functional boundary of at-grade intersections (including space for turn lanes, deceleration and acceleration). The Harvard bylaws dictate a 100 foot separation between an access driveway and the side line of an intersecting street.
- Shared driveways/frontage roads. The Harvard bylaws dictate that no more than 4 lots of which no more than two shall be hammerhead or backland lots may be connected to or otherwise share the same driveway. In the interest of providing a so-called 'frontage road' to connect several properties to one main access point onto Ayer Road, this bylaw should be revisited.
- Standardize driveway openings. While the existing driveways along Ayer Road are a mixture of paved and unpaved aprons, the overall approach should be to standardize driveway openings in width and material such that driveway openings are more visible to the driver.

4.4.1.2 Turn Lanes

- Left turn lane installation is warranted based upon traffic volumes. According to the PDDG, left-turn lanes are warranted if the thresholds listed below are reached or exceeded.

Left Turn Lane Warrant Calculation					
Unsignalized Intersection (Two-Lane Roads and Streets)					
		Advancing Volume (vph)			
Design Speed (mph)	Opposing Volume (vph)	5% left turns	10% left turns	20% left turns	30% left turns
30 (or less)	200	720	530	390	335
	400	570	430	305	275
	600	460	345	250	225
	800	370	265	195	185
Design Speed (mph)	Opposing Volume (vph)	5% left turns	10% left turns	20% left turns	30% left turns
40	200	640	470	350	305
	400	510	380	275	245
	600	410	305	225	200
	800	330	240	180	160
Design Speed (mph)	Opposing Volume (vph)	5% left turns	10% left turns	20% left turns	30% left turns
50	200	550	400	300	270
	400	430	320	240	210
	600	350	260	195	170
	800	280	210	165	135
Design Speed (mph)	Opposing Volume (vph)	5% left turns	10% left turns	20% left turns	30% left turns
60	200	450	330	250	215
	400	365	270	200	175
	600	290	210	160	140
	800	230	170	125	115

Source: MassHighway Project Design and Development Guidebook (2006); Highway Capacity Manual (2000).

- In the case of Ayer Road, under an existing condition design speed of 45-50mph, the volume of left-turns would need to be approximately 28 vehicles or more per hour, opposed by 200 vehicles or more per hour. Under existing traffic volume conditions, left-turn lanes are warranted at the following intersections:
    - Ayer Road northbound at Gebo Lane
    - Ayer Road southbound at Dunkin Donuts Access Drive
    - Ayer Road southbound at Poor Farm Road
- Under future conditions if the design speed can be reduced to 40mph or less for a village center, a left-turn volume of 32 vehicles or less will warrant a left-turn lane.

- Potential developments along Ayer Road should include left-turn lane warrant analysis in site specific traffic studies.

- Potential developments along Ayer Road should also include a right-turn lane warrant analysis in site specific traffic studies. A right-turn lane is typically warranted when the volume of right-turning vehicles reaches 300 vehicles per hour (vph) at the same time the advancing volume reaches 300 vph. However, an engineering evaluation of the potential for a right-turn lane should also be included in site specific traffic studies; while the volume of right-turning vehicles may not reach 300vph, the installation of a right-turn lane or deceleration lane should be evaluated from an engineering judgment standpoint.

4.4.1.3 Sight Distance

- Sight distances for both stopping sight distance and intersection sight distance must be evaluated for each proposed development driveway. While stopping sight distance is the minimum distance required for safe operations, it is also critical to have at least the same distance for intersection sight distance to ensure that motor vehicles will not enter the traffic stream on Ayer Road in front of a vehicle that does not have sufficient time to see the vehicle, react, and decelerate to avoid a collision.

4.4.2 Corridor Access

Access management of the Ayer Road corridor may involve the provision of turn lanes or the installation of median islands.

4.4.2.1 Turn Lanes

In addition to the discussion above on the installation of turn lanes, an additional option exists which would provide turn lanes throughout the Ayer Road corridor. The installation of a two-way left turn lane (TWLTL) can provide improved access management by providing an auxiliary lane in which turning vehicles can leave or join the Ayer Road corridor without seriously impacting the through moving vehicles. While left-turn lanes have the advantage of reducing left-turns from through lanes, and providing operational flexibility for emergency vehicles, two-way left-turn lanes also encourage random access along the corridor, offer no refuge for pedestrians, and allow head-on collisions. A two-way left-turn lane is effective along two-lane roadways that carry between 10,000 and 28,000 vpd.

While the installation of turn lanes, it should be noted that the installation of turn lanes, whether left-turn lanes, two-way left-turn lanes, or right-turn lanes will not effect a reduction in travel speed along Ayer Road. In fact, by pulling the turning vehicles away from the main travel lane, vehicles speeds will be maintained.

4.4.2.2 Median Islands

Median islands are an effective way to promote access management. Median islands can be installed in specific locations to limit access or can be installed throughout the length of a corridor to enforce full access management. Median islands can provide an area for low-growth landscaping, encourage reduced travel speeds, and significantly reduce the number of angle collisions along a corridor. Median islands discourage strip development, allows better control of land uses by local government, can provide pedestrian refuge and separates opposing traffic flows. Unfortunately median islands may also have the disadvantage of reducing emergency vehicle flexibility, increases left-turn volumes at median openings, and limits direct access to property.

4.5 Potential Corridor Improvements

Potential corridor improvements are improvements that would be applied to the entire corridor along Ayer Road and not just at specific locations.

Functionally classified as a Rural Principle Arterial, Ayer Road has certain lane and width requirements in accordance with AASTHO guidelines as well as the 2006 MassHighway Project Development and Design Guidebook (PDDG). While Ayer Road is under the jurisdiction of the town, it is recommended that MassHighway guidelines be followed at a minimum.

4.5.1 Lane and Shoulder Widths

Therefore, the minimum lane width recommended for Ayer Road is 11-feet, with a minimum shoulder width of 4-feet to provide bicycle accommodation. Based on today's volumes and even 2027 No Build volumes, Ayer Road can likely sustain the traffic flow with one lane in each direction. However, if the vacant parcel development occurs as predicted above, Ayer Road may in fact require two lanes in each direction.

It is recommended that regardless of the proposed cross-section for Ayer Road that is selected based upon this study, the town should be prepared to require developments to donate frontage along Ayer Road for the purposes of potentially widening the roadway in the future.

4.5.2 Speed Control

According to the Master Plan, data collection and field observations, motorists are traveling at a speed higher than that desired on Ayer Road. Eight-five percent of motorists traveling along Ayer Road are exceeding the current speed limit. If a full speed study were performed simply to post new signs along Ayer Road (in conformance with MassHighway standards) the posted speed would likely be higher than 40mph based on existing conditions.

The goal of the "village" setting must work together with a reduction in speed along Ayer Road. Traffic calming techniques are available that will encourage a reduction in speed without shifting volumes onto local area streets (there really is no north-south alternative to Ayer Road for cut-through traffic to use). Traffic calming options along Ayer Road include:

Median islands

Roundabouts

Raised crosswalk or intersection areas

Automated permanently installed speed alert signs

4.5.3 Intersection Control

4.5.3.1 Traffic Signals

The evaluation of traffic signal warrants indicates the only location eligible for traffic signal installation would be the intersection of Poor Farm Road. Since the location does not currently meet the 8 hour signal warrant and may only do so if traffic volumes increase by 49 percent or more, it is suggested that in coordination with the vegetation trimming, re-grading on the corners as well as the closure of access from Lancaster County Road, that the intersection of Poor Farm Road be further monitored for collisions and traffic volume increases. Any potential development along Poor Farm Road should also be monitored for traffic volume increases.

4.5.3.2 Roundabouts

As an alternative to traffic signal control or the installation of left-turn lanes, the installation of a roundabout is a suitable intersection control feature that can accomplish a variety of goals. It is the opinion of CDM that modern roundabouts can be an effective intersection improvement alternative where properly designed and warranted. Ongoing research in the United States and Europe is indicative of an alleviation of certain types of collisions, as well as an overall improvement to traffic flow under the 'slow and go' versus 'stop and go' scenario.

Roundabouts function differently from rotaries in that the overall size of a roundabout is much smaller than that of a rotary and the approach angles encourage vehicles to yield to motorists in the roundabout. Roundabouts also have the ability to conform to both rural and village center characteristics.

Capacity analysis at a roundabout is typically evaluated as the volume to capacity ratio. This is an indication of how many vehicles a roundabout can process, given the geometry (single lane or double lane). In general, according to 1996 FHWA Roundabout Information Guide (RIG), a single lane roundabout can process 20,000 vpd. Based on this information, proposed single lane roundabouts may reach capacity in 2027 without full build-out of vacant parcels on Ayer Road. If full build-out occurs, the roundabouts would have to be converted to double lane roundabouts.

Translated to hourly volumes, based on Exhibit 4-6 in RIG, a single lane roundabout can accommodate approximately 1,200 vehicles per hour (veh/h) entering and a circulating volume of 1,800 veh/h. A double lane roundabout can accommodate slightly less than 2,500 veh/h entering flow and 3,000 veh/h circulating flow.

"Are Roundabouts Good for Business?" According to a study prepared by LSC Transportation Consultants, Inc.:

"The installation of a series of roundabouts along a commercial arterial corridor provided a more aesthetically pleasing area, while maintaining traffic flow and providing additional pedestrian protection…the roundabouts resulted in a corridor where traffic moves slowly, vehicles experience little delay at major intersections, and pedestrians can readily access the many businesses in the area. The net result is a vibrant commercial corridor."[3]

[3] "Are Roundabouts Good for Business?", Alex J. Arinello, LSC Transportation Consultants, Inc., December 1, 2004, Denver, Colorado

Section 5
Capacity Analysis

5.1 Capacity Analysis Methodology

A primary result of capacity analysis is the assignment of levels of service to traffic facilities under various traffic flow conditions. The capacity analysis methodology is based on the concepts and procedures in the *Highway Capacity Manual* (HCM).[4] The concept of level of service (LOS) is defined as a qualitative measure describing operational conditions within a traffic stream and their perception by motorists and/or passengers. A level-of-service definition provides an index to quality of traffic flow in terms of such factors as speed, travel time, freedom to maneuver, traffic interruptions, comfort, convenience, and safety.

Six levels of service are defined for each type of facility. They are assigned letter designations from A to F, with LOS A representing the best operating conditions and LOS F the worst. Since the level of service of a traffic facility is a function of the traffic flows placed upon it, such a facility may operate at a wide range of levels of service, depending on the time of day, day of week, or period of year.

A description of the operating condition under each level of service is provided below:

LOS A describes conditions with little to no delay to motorists.

LOS B represents a desirable level with relatively low delay to motorists.

LOS C describes conditions with average delays to motorists.

LOS D describes operations where the influence of congestion becomes more noticeable. Delays are still within an acceptable range.

LOS E represents operating conditions with high delay values. This level is considered by many agencies to be the limit of acceptable delay.

LOS F is considered to be unacceptable to most drivers with high delay values that often occur, when arrival flow rates exceed the capacity of the intersection.

5.1.1 Unsignalized Intersections

Levels of service for unsignalized intersections are calculated using the operational analysis methodology of the HCM. The procedure accounts for lane configuration on both the minor and major street approaches, conflicting traffic stream volumes, and the type of intersection control (STOP, YIELD, or all-way STOP control). The definition of level of service for unsignalized intersections is a function of average *control* delay. Control delay includes initial deceleration delay, queue move-up time,

[4]*Highway Capacity Manual 2000*, Transportation Research Board; Washington, D.C.; 2001.

stopped delay, and final acceleration delay. The level-of-service criteria for unsignalized intersections are shown in *Table 4*.

5.1.2 Roundabouts

The HCM does not provide level of service criteria for vehicle traffic at roundabouts. In aaSIDRA, the signalized intersection LOS criteria are applied to roundabouts. *Table 5.1* illustrates the level-of-service criteria for Roundabouts, based on the criteria for signalized intersections.

Table 5.1
Level of Service Criteria

Level of Service	**Unsignalized Intersection Criteria** Average Control Delay (Seconds per Vehicle)	**Roundabout Criteria** Average Control Delay (Seconds per Vehicle)
A	≤10	≤10
B	>10 and ≤15	>10 and ≤20
C	>15 and ≤25	>20 and ≤35
D	>25 and ≤35	>35 and ≤55
E	>35 and ≤50	>55 and ≤80
F	>50	>80

Source: *Highway Capacity Manual 2000*, Transportation Research Board, 2000, pages 16-2 and aaSidra Manual.

For unsignalized intersections, this delay criterion may be applied in assigning level-of-service designations to individual lane groups or to individual intersection approaches. According to aaSIDRA:

> "the gap acceptance parameters are related to roundabout geometry as well as circulation and entry flows. Follow-up headway decreases with increasing diameter of the roundabout, increasing circulation flow, decreasing number of circulation lanes, and increasing number of entry lanes. Critical gap is proportional to the follow-up headway. The ratio of the critical gap to the follow-up headway is in the range 1.1 to 2.1, and decreases with increasing circulation flow, number of circulating lanes, and average entry lane width. Thus, driver behavior changes with roundabout geometry as well as increased circulation flows (more vehicles can depart through an acceptable gap, and shorter critical gaps are accepted.)"

In other words, the analysis procedures illustrated in the aaSIDRA analysis are more involved than a simple gap acceptance analysis. According to Sidra Solutions (http://www.akcelik.com.au/SIDRA/SIDRAforRoundabouts.htm#Calibrating%20aaSIDRA) calibration of the analysis model to account for local conditions is recommended. Therefore, the *Environmental Factor* has been set at 1.0 to reflect a proposed roundabout to the area. A roundabout will not be a new type of traffic control to this area since there is a rotary on Ayer Road approximately 500 yards north of the project limits.

As illustrated in *Table 5.1*, a good LOS consists of minimal delays, while a poor LOS consists of extended delays. Delays can be correlated to the ratio between traffic volume and capacity. For example if the volume of traffic approaching an intersection is greater than the capacity for that volume of traffic, the end result is a poor LOS. Conversely, if the volume of traffic approaching an intersection is significantly less than the capacity, the end result is a good LOS.

5.2 Capacity Analysis Results

The study intersections were analyzed using Synchro 5 and aaSidra, MassHighway approved software packages. The intersections have been reviewed under three different analysis scenarios during both the morning and evening peak hours:

- 2007 Existing Conditions;
- 2027 No Build Conditions; and
- 2027 Improved Conditions.

The 2007 Existing Conditions analysis evaluates the intersections under current traffic volume and geometric conditions. The 2027 No Build Condition evaluates the intersections under future traffic volume conditions (2% growth rate for 20 years) but does not include future traffic volumes associated with potential future development. As mentioned previously, a site specific survey is required to identify the actual maximum potential development for each parcel. Only then can individual intersections be evaluated based on full build out of the corridor.

The 2027 Improved Conditions evaluates the intersections under single lane roundabout control. *Tables 5.2-1* through *5.2-8* illustrates the results of the capacity analyses.

5.2.1 Analysis Results

5.2.1.1 Ayer Road at Dunkin Donuts Access Drive

The critical movement at the intersection of Ayer Road and Dunkin Donuts Driveway is the Dunkin Donuts driveway westbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the westbound approach is expected to experience a LOS F during the morning peak hour with a V/C of 1.39; delay and queue length cannot be accurately reported with a V/C greater than 1.2. During the evening peak hour, the movement experiences a V/C of 0.35 and a LOS D with an average control delay of 30.0 seconds. The approach experiences a queue length of 50 feet. The Dunkin Donuts driveway approach has a LOS B during the Saturday midday peak hour with a delay of 12.7 seconds, a V/C of 0.09 and a queue of 25 feet. Under the 2027 No Build Conditions, during the morning peak hour, the intersection continues to experience a LOS A on the Ayer Road approaches, and a LOS F on the westbound Dunkin Donuts approach. During the evening peak hour, the Ayer Road approaches continue to experience a LOS A; however, the westbound Dunkin Donuts approach decreases to a LOS F, with a V/C of 1.26. During the Saturday midday peak, the Ayer Road approaches continue to experience a LOS A. The Dunkin Donuts driveway approach experiences a LOS C, with a V/C of 0.19 and delay of 17.6 seconds. Under the 2027 Build Condition, the Ayer Road northbound approach continues to experience a LOS A with a V/C of 0.71 and queue length of 300 feet during the morning peak hour. The Ayer Road southbound approach experiences a LOS B with a V/C of 0.91 and a queue length of 625 feet. The Dunkin Donuts westbound approach experiences a LOS B with a V/C of 0.46 and a queue length of 125 feet. During the evening peak hour, the Ayer Road approaches experience a LOS A; the northbound approach has a queue length of 225 feet and the southbound approach has a queue length of 250. The westbound approach improves to a LOS B, with a delay of 16.4 seconds and a queue length of 50 feet.

5.2.1.2 Ayer Road at Gebo Lane

The critical movement at the Ayer Road and Gebo Lane intersection is the Gebo Lane eastbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the eastbound movement is expected to experience a LOS C during the morning peak hour with a delay of 15.5 seconds, V/C of 0.18 and queue length of 25 feet. The intersection will experience a delay of 15.6 seconds with a V/C of 0.23, and a queue length of 25 feet during the evening peak hour; the location also experiences a LOS C during this peak hour. The Ayer Road at Gebo Lane location will experience a LOS B during the Saturday midday peak hour with a delay of 13.8 seconds, a V/C of 0.20 and a queue of 25 feet. Under 2027 No Build Conditions, the Ayer Road approaches will continue to experience a LOS A for both the morning and evening peak hours; the Gebo Lane eastbound approach will decrease to a LOS D. During the Saturday midday peak, the Ayer Road approaches will continue to experience a LOS A; however, the eastbound approach will experience a LOS C with a queue of 75 feet. Under the 2027 Build Condition, the Ayer Road approaches will experience a LOS A for all three peak hours. The Gebo Lane eastbound approach will experience a LOS B during the morning, evening, and Saturday midday peak hours.

5.2.1.3 Ayer Road at Post Office Access Drive

Traffic data was collected at the Ayer Road at Post Office Driveway locations only during the Saturday Midday period as the hours of operation for the Post Office begin later, and end earlier, than the expected morning and evening peak hours. Also, the Post Office driveways are marked as one entrance and one exit location. There are no critical approaches at the entrance to the Post Office. However, the critical movement at the intersection of Ayer Road and the Post Office exit is the driveway eastbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the westbound movement is expected to experience a LOS C during the Saturday midday peak hour with a V/C of 0.36, an average control delay of 18.5 seconds, and a queue length of 50 feet. Under the 2027 No Build Condition, the Ayer Road approaches will continue to experience a LOS A; however, the Post Office eastbound approach will decrease to a LOS F with a delay of 60.4 seconds and a queue of 150 feet. A roundabout is not considered at the Ayer Road and Post Office Access Drive location.

5.2.1.4 Ayer Road at Lancaster County Road

The critical movement at the Ayer Road and Lancaster County Road intersection is the Lancaster County Road eastbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the eastbound movement is expected to experience a LOS D during both the morning and evening peak hours. During the morning peak hour, this approach experiences a V/C of 0.08, an average delay of 31.5 seconds and a queue length of 25 feet; during the evening peak hour, the approach has a V/C of 0.26, a delay of 34.0 seconds and a queue of 25 feet. During the Saturday midday peak hour, the approach experiences a V/C of 0.31 with delay of 23.9 seconds and a 50 foot queue; the movement experiences a LOS C during this time. Under the 2027 No Build Condition, during the morning peak hour, the Ayer Road approaches continue to experience a LOS A; however, the South Shaker Road approach decreases to a LOS F with a V/C of 1.25. During the evening peak hour, the Ayer Road approaches experience a LOS A. The westbound approach experiences a LOS F with a delay of 62.6 seconds. During the Saturday midday peak, the Ayer Road approaches experience a LOS A; the South Shaker Road approach experiences a LOS E with a delay of 46.9 seconds. For the 2027 Build Condition at this location, the proposed roundabout geometry consists of four-approaches with Ayer Road northbound, Ayer Road southbound, Lancaster County Road eastbound and Poor Farm Road westbound. Under the 2027 Build Condition, for all three peak hours, the Ayer Road approaches experience a LOS A and the South Shaker Road approach experiences a LOS B. The Poor Farm Road westbound approach, under the morning peak hour, experiences a LOS C with a delay of 21.8 seconds. During the evening peak hour, the westbound approach experiences a LOS B with a delay of 14.1 seconds. The Poor Farm Road approach, during the Saturday midday peak, experiences a LOS B with a delay of 13.7 seconds.

5.2.1.5 Ayer Road at Poor Farm Road

The critical movement at the intersection of Ayer Road and Poor Farm Road is the Poor Farm Road westbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the westbound movement is expected to experience a LOS D during the morning and evening peak hours; and a LOS C during the Saturday midday peak hour. In the morning peak hour, the approach experiences a delay of 27.1 seconds with a V/C of 0.27 and a queue length of 50 feet. During the evening peak hour, the Poor Farm Road movement has a V/C of 0.39, a delay of 26.7 seconds and a queue of 50 feet. The movement, during the Saturday midday peak, experiences 20.1 seconds of delay, with a V/C of 0.26 and a 50 foot queue length. Under 2027 No Build Conditions, the Ayer Road approaches experience a LOS A for all analysis periods. During the morning peak hour, the eastbound approach experiences a LOS E with a delay of 45.2 seconds. During the evening and Saturday midday peak hours, the Old Mill Road approach experiences a LOS D. For the 2027 Build Condition at this location, the proposed roundabout geometry consists of four-approaches with Ayer Road northbound, Ayer Road southbound, Lancaster County Road eastbound and Poor Farm Road westbound. Under the 2027 Build Condition, for all three peak hours, the Ayer Road approaches experience a LOS A and the South Shaker Road approach experiences a LOS B. The Poor Farm Road westbound approach, under the morning peak hour, experiences a LOS C with a delay of 21.8 seconds. During the evening peak hour, the westbound approach experiences a LOS B with a delay of 14.1 seconds. The Poor Farm Road approach, during the Saturday midday peak, experiences a LOS B with a delay of 13.7 seconds.

5.2.1.6 Ayer Road at South Shaker Road

The critical movement at the Ayer Road and South Shaker Road intersection is the South Shaker Road westbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the westbound movement is expected to experience a LOS D during the morning peak hour with a V/C of 0.32, a delay of 34.6 seconds, and a queue length of 50 feet. During the both the evening peak hour, the approach has a V/C of 0.14, a delay of 21.1 seconds, and a queue of 25 feet. The approach experiences a LOS C during this peak. The South Shaker Road movement, during the Saturday midday peak, experiences a V/C of 0.11 with an average delay of 20.4 seconds, a LOS C, and a 25 foot queue length. Under 2027 No Build Conditions, the

5.2.1.7 Ayer Road at Old Mill Road

The critical movement at the intersection of Ayer Road and Old Mill Road is the Old Mill Road eastbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the eastbound approach is expected to experience a LOS C with a 25 foot queue during the morning, evening and Saturday midday peak hour periods. In the morning peak hour, the V/C for this approach is 0.14 with an average delay of 18.7 seconds. During the evening peak hour, the Old Mill Road movement has a V/C of 0.05 with a delay of 16.0 seconds. The eastbound approach, during the Saturday midday peak, experiences 15.7 seconds of delay with a V/C of 0.05.

5.2.1.8 Ayer Road at Myrick Lane

The critical movement at the intersection of Ayer Road and Myrick Lane is the Myrick Lane westbound shared left-turn/right-turn movement. Under 2007 Existing Conditions, the westbound approach is expected to experience a LOS D during the morning peak hour with a V/C of 0.27, an average delay of 28.9 seconds, and a 50 foot queue. The Myrick Lane approach will experience a LOS C, with a 25 foot queue, during the evening and Saturday midday peak hours. During the evening peak hour, the westbound movement experiences 22.2 seconds of delay with a V/C of 0.15. The approach will experience a V/C of 0.10, with 17.1 seconds of delay, during the Saturday midday peak hour. Under 2027 No Build Conditions, for both the morning and evening peak hours, the Ayer Road approaches experience a LOS A and the Myrick Lane westbound approach decreases to a LOS F. During the Saturday midday peak hour, the Ayer Road approaches experience a LOS A; the westbound approach experiences a LOS D. Under the 2027 Build Condition, for all analysis periods, the Ayer Road approaches experience a LOS A and the Myrick Lane approach experiences a LOS B.

The analyses are included in Appendix G.

Table 5.2-1 Ayer Road at Dunkin Donuts Access Drive, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build (Roundabout)			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Dunkin Donuts Driveway												
Weekday AM												
Ayer Road NBTR	0.42	0.0	A	0	0.63	0.0	A	0	0.71	6.5	A	300
Ayer Road SBLT	0.09	2.3	A	25	0.18	5.8	A	25	0.91	12.5	B	625
DD Driveway WBLR	1.39	--	F	--	6.08	--	F	--	0.46	17.1	B	125
Weekday PM												
Ayer Road NBTR	0.43	0.0	A	0	0.63	0.0	A	0	0.64	5.5	A	225
Ayer Road SBLT	0.03	0.8	A	25	0.06	1.8	A	25	0.63	5.7	A	250
DD Driveway WBLR	0.34	29.6	D	50	1.26	--	F	--	0.17	16.4	B	50
Saturday Midday												
Ayer Road NBTR	0.35	0.0	A	0	0.53	0.0	A	0	0.53	5.5	A	150
Ayer Road SBLT	0.05	1.2	A	25	0.09	2.5	A	25	0.51	5.5	A	175
DD Driveway WBLR	0.09	12.7	B	25	0.19	17.6	C	25	0.06	10.7	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95th Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

Table 5.2-2 Ayer Road at Gebo Lane, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build (Roundabout)			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Gebo Lane												
Weekday AM												
Ayer Road NBLT	0.05	1.2	A	25	0.09	2.9	A	25	0.52	5.5	A	200
Ayer Road SBTR	0.44	0.0	A	0	0.65	0.0	A	0	0.70	5.7	A	250
Gebo Lane EBLR	0.18	15.5	C	25	0.43	29.3	D	50	0.13	15.3	B	25
Weekday PM												
Ayer Road NBLT	0.07	1.7	A	25	0.13	3.8	A	25	0.59	5.7	A	225
Ayer Road SBTR	0.39	0.0	A	0	0.58	0.0	A	0	0.60	5.9	A	175
Gebo Lane EBLR	0.23	15.6	C	25	0.55	32.8	D	100	0.15	11.6	B	50
Saturday Midday												
Ayer Road NBLT	0.05	1.4	A	25	0.09	2.5	A	25	0.48	5.6	A	150
Ayer Road SBTR	0.31	0.0	A	0	0.46	0.0	A	0	0.53	5.6	A	150
Gebo Lane EBLR	0.20	13.8	B	25	0.45	23.9	C	75	0.11	10.7	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95^{th} Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

Table 5.2-3 Ayer Road at Post Office Access Drive, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Post Office Access Drive												
Saturday Midday												
Ayer Road NBLT	0.0	0.0	A	0	0.0	0.0	A	0	NA	NA	NA	NA
Ayer Road SBTR	0.27	0.0	A	0	0.41	0.0	A	0	NA	NA	NA	NA
Post Office Exit EBLR	0.36	18.5	C	50	0.80	60.4	F	150	NA	NA	NA	NA
Ayer Road at Post Office Entrance												
Saturday Midday												
Ayer Road NBLT	0.07	1.9	A	25	0.13	3.2	A	25	NA	NA	NA	NA
Ayer Road SBTR	0.31	0.0	A	0	0.46	0.0	A	0	NA	NA	NA	NA
Myrick Lane EBLR	-	-	-	0	-	-	-	0	NA	NA	NA	NA

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95th Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

Table 5.2-4 Ayer Road at Lancaster County Road, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build (Roundabout)[f]			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Lancaster County Road												
Weekday AM												
Ayer Road NBLT	0.0	0.1	A	0	0.01	0.3	A	25	0.63	6.1	A	200
Ayer Road SBTR	0.45	0.0	A	0	0.67	0.0	A	0	0.73	6.1	A	350
Lancaster Co. Road EBLR	0.09	36.4	E	25	0.40	133.6	F	50	0.11	13.6	B	25
Poor Farm Road WBLR [f]									0.01	21.8	C	25
Weekday PM												
Ayer Road NBLT	0.0	0.1	A	0	0.0	0.2	A	0	0.67	5.6	A	250
Ayer Road SBTR	0.36	0.0	A	0	0.53	0.0	A	0	0.50	5.6	A	175
Lancaster Co. Road EBLR	0.26	34.0	D	25	1.00	219.1	F	125	0.28	16.1	B	75
Poor Farm Road WBLR [f]									0.04	14.1	B	25
Saturday Midday												
Ayer Road NBLT	0.01	0.3	A	25	0.02	0.6	A	25	0.50	5.8	A	150
Ayer Road SBTR	0.33	0.0	A	0	0.49	0.0	A	0	0.54	5.9	A	175
Lancaster Co. Road EBLR	0.30	23.6	C	50	0.92	119.0	F	175	0.12	12.5	B	25
Poor Farm Road WBLR [f]									0.05	13.7	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95th Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported
[f] 4-approach roundabout with Ayer Road, Lancaster County Road, and Poor Farm Road

Table 5.2-5 Ayer Road at Poor Farm Road, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build (Roundabout)			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Poor Farm Road												
Weekday AM												
Ayer Road NBTR	0.39	0.0	A	0	0.58	0.0	A	0	0.63	6.1	A	200
Ayer Road SBLT	0.09	2.2	A	25	0.17	6.0	A	25	0.73	6.1	A	350
Poor Farm Road WBLR	0.27	27.1	D	50	1.09	218.7	F	175	0.01	21.8	C	25
Lancaster Co. Road EBLR [f]									0.11	13.6	B	25
Weekday PM												
Ayer Road NBTR	0.49	0.0	A	0	0.74	0.0	A	0	0.67	5.6	A	250
Ayer Road SBLT	0.02	0.5	A	25	0.04	1.1	A	25	0.50	5.6	A	175
Poor Farm Road WBLR	0.38	26.3	D	50	1.26	--	F	250	0.04	14.1	B	25
Lancaster Co. Road EBLR [f]									0.28	16.1	B	75
Saturday Midday												
Ayer Road NBTR	0.33	0.0	A	0	0.49	0.0	A	0	0.50	5.8	A	150
Ayer Road SBLT	0.02	0.7	A	25	0.05	1.2	A	25	0.54	5.9	A	175
Poor Farm Road WBLR	0.26	20.1	C	50	0.75	72.1	F	125	0.05	13.7	B	25
Lancaster Co. Road EBLR [f]									0.12	12.5	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95th Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported
[f] 4-approach roundabout with Ayer Road, Lancaster County Road, and Poor Farm Road

Table 5.2-6 Ayer Road at South Shaker Road, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at South Shaker Road												
Weekday AM												
Ayer Road NBTR	0.38	0.0	A	0	0.56	0.0	A	0	0.52	5.2	A	175
Ayer Road SBLT	0.0	0.1	A	0	0.01	0.5	A	25	0.75	5.6	A	375
South Shaker Road WBLR	0.32	34.6	D	50	1.25	--	F	175	0.09	17.2	B	25
Weekday PM												
Ayer Road NBTR	0.39	0.0	A	0	0.58	0.0	A	0	0.61	5.2	A	200
Ayer Road SBLT	0.01	0.2	A	25	0.02	0.5	A	25	0.52	5.2	A	175
South Shaker Road WBLR	0.14	21.1	C	25	0.48	62.6	F	75	0.07	17.0	B	25
Saturday Midday												
Ayer Road NBTR	0.34	0.0	A	0	0.50	0.0	A	0	0.44	5.1	A	125
Ayer Road SBLT	0.01	0.2	A	0	0.01	0.3	A	25	0.49	5.3	A	150
South Shaker Road WBLR	0.11	20.4	C	25	0.33	46.9	E	50	0.05	15.4	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95^{th} Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

Table 5.2-7 Ayer Road at Old Mill Road, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Old Mill Road												
Weekday AM												
Ayer Road NBLT	0.01	0.2	A	25	0.02	0.5	A	25	0.47	5.2	A	150
Ayer Road SBTR	0.44	0.0	A	0	0.66	0.0	A	0	0.65	5.3	A	225
Old Mill Road EBLR	0.14	18.7	C	25	0.43	45.2	E	50	0.07	16.3	B	25
Weekday PM												
Ayer Road NBLT	0.01	0.2	A	25	0.02	0.5	A	25	0.60	5.2	A	225
Ayer Road SBTR	0.32	0.0	A	0	0.47	0.0	A	0	0.47	5.3	A	125
Old Mill Road EBLR	0.05	16.0	C	25	0.13	28.4	D	25	0.03	12.1	B	25
Saturday Midday												
Ayer Road NBLT	0.01	0.3	A	25	0.02	0.6	A	25	0.42	5.2	A	125
Ayer Road SBTR	0.29	0.0	A	0	0.43	0.0	A	0	0.45	5.2	A	125
Old Mill Road EBLR	0.04	15.6	C	25	0.12	26.2	D	25	0.03	12.8	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95^{th} Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

Table 5.2-8 Ayer Road at Myrick Lane, Capacity and Queue Analysis Summary

	2007 Existing				2027 No-Build				2027 Build			
Intersection/Peak Hour/Movement	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Ayer Road at Myrick Lane												
Weekday AM												
Ayer Road NBTR	0.36	0.0	A	0	0.53	0.0	A	0	0.50	5.1	A	150
Ayer Road SBLT	0.01	0.2	A	0	0.01	0.6	A	25	0.74	5.6	A	375
Myrick Lane WBLR	0.27	28.9	D	50	1.01	192.8	F	150	0.09	15.5	B	25
Weekday PM												
Ayer Road NBTR	0.41	0.0	A	0	0.61	0.0	A	0	0.65	5.3	A	225
Ayer Road SBLT	0.02	0.7	A	25	0.05	1.3	A	25	0.47	5.5	A	150
Myrick Lane WBLR	0.15	22.2	C	25	0.51	70.9	F	75	0.09	19.1	B	25
Saturday Midday												
Ayer Road NBTR	0.32	0.0	A	0	0.48	0.0	A	0	0.43	5.1	A	125
Ayer Road SBLT	0.02	0.5	A	25	0.03	0.8	A	25	0.44	5.4	A	125
Myrick Lane WBLR	0.10	17.0	C	25	0.27	32.4	D	50	0.05	13.5	B	25

[a] Volume to Capacity ratio
[b] Average control delay in seconds per vehicle
[c] Level of Service
[d] 95th Percentile queue length vehicles
[*] V/C>1.2 an accurate delay cannot be reported

5.3 Queue Analysis Methodology

In addition to capacity analysis, queue length is an integral part of intersection evaluation. Queue length represents the number of vehicles stacked per approach at an intersection, and assumes that each vehicle is 25 feet in length (including headways). Synchro 7 was used to evaluate the expected queue lengths for the stop controlled intersections; aaSidra 2.1 was used to evaluate the expected queues for the roundabouts. *Tables 5.2-1* through *5.2-8* in the Capacity Analysis Results section illustrate the maximum back of queue for the 95th percentile queue analysis results.

Section 6 Recommendations

6.1 Short Term Improvements

Regardless of the potential build-out along Ayer Road, alleviation of some of the safety concerns at the existing intersections along Ayer Road may be possible through the use of what is considered "short-term" improvements. Short-term improvements are small scale changes along the corridor that can be requested of private developers proposing development along the corridor or through the use of local funds. The following are recommended short-term improvements along Ayer Road:

- Install W2-2 intersection warning signs for both approaches to each intersection; there is currently no advance warning of intersecting streets along Ayer Road.
- Install W11-3 deer crossing warning signs at the beginning of the corridor (one in each direction).
- Re-install chevron warning signs and curve ahead signs at Doe's corner to alert motorists of an approaching curve.
- Vegetation trimming and re-grading along the intersection corners at Gebo Lane, Poor Farm Road, Lancaster County Road, South Shaker Road, Old Mill Road, and Myrick lane.
- Vegetation trimming and re-grading along the curves at Doe's Corner.
- Restrict Lancaster County Road to one-way in from Ayer Road; motorists can access Ayer Road from Lancaster County Road via Gebo Lane. This will reduce the number of conflicts with the intersection of Ayer Road at Poor Farm Road and will result in redirecting approximately 500 vehicles daily.
- Change in access to the post office; it is recommended that the entrance on Ayer Road be closed to remove the number of conflicts within the area surrounding the Post Office. Motorists can access the post office via the side entrance on Lancaster County Road.
- Consider realigning Gebo Lane to a more 90 degree intersection with Ayer Road; this may have wetland impacts, may require culvert extension and small land takings.
- Consider realigning Poor Farm Road to a more 90 degree intersection with Ayer Road; this may require small land takings.

6.2 Long Term Improvements

Based upon evaluations of existing conditions, the goals of the Master Plan, and the potential future development along Ayer Road, several corridor-wide improvements have been considered and are compared herein. These options consider the short-term improvements to be completed and that access management techniques are also applied in conjunction with these alternatives.

6.2.1 Safety

- **Dunkin Donuts Access Drive** – Extend the Route 2/Ayer Road median down to the Dunkin Donuts Access Drive. Narrow the Route 2 Bridge to 1-lane in either direction, consider a "shared" access with the abutters north of this site. Close off the existing access or limit it to right turns in, right turns out.

- **Doe's Corner** – Reconstruct the curves to meet current highway standards for horizontal curvatures.

- **Realign Intersections** – Intersections not specifically addressed during the short-term improvements should be addressed in long term improvements for safety reasons. The following intersections should be realigned with Ayer Road to create a more uniform and symmetrical "T" intersection; Gebo Lane, Poor Farm Road, South Shaker Road, Myrick Lane (with improvements to Doe's Corner).

6.2.2 Corridor

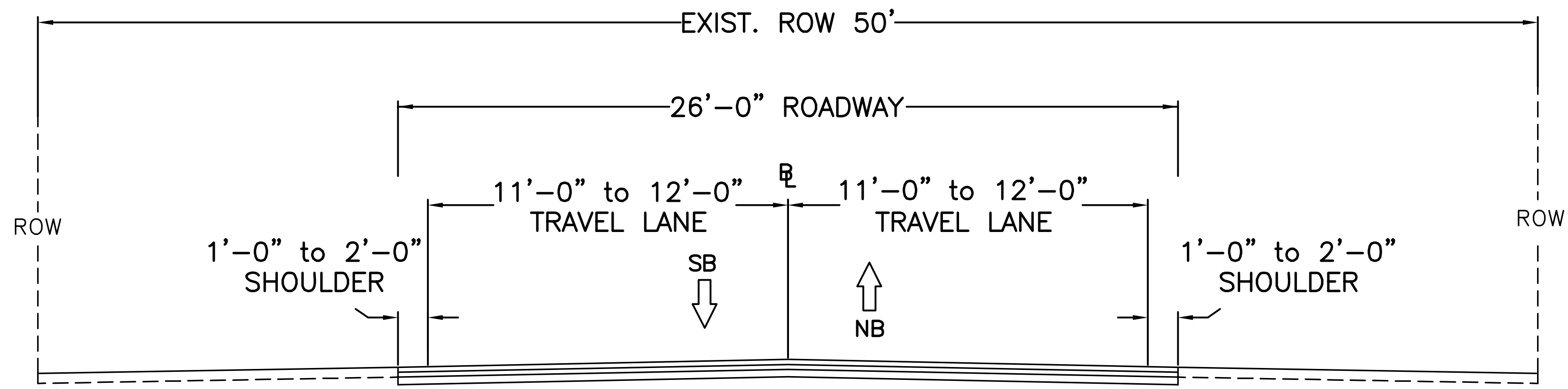
- **Existing cross-section -** The "do-nothing" alternative keeps Ayer Road as is with 26 feet of pavement width and no accommodation for pedestrians or bicyclists.

- **Alternative 1** – Alternative 1 slightly widens Ayer Road to provide one 11-foot travel lane with 4-foot shoulder in each direction (30 feet of pavement). In addition, a 4-foot grass buffer and 6-foot footpath are provided on either side. This alternative will sufficiently accommodate pedestrians and bicyclists throughout the corridor and does not require corridor-wide strip land takings. The installation of left-turn lanes at appropriate locations may also be considered with this alternative, but those will require land takings.

- **Alternative 2 –** Alternative 2 widens Ayer Road to provide a two-way left turn lane throughout the corridor. This left-turn lane would be converted to an exclusive left-turn lane for both northbound and southbound approaches at intersections and potential future development locations (based upon individual traffic studies). Again, provision of a 4-foot shoulder, 3-foot grass buffer and 6' footpath is included. While this alternative will ensure equal access to all parcels and will remove left-turn lanes from the traffic flow, this alternative will require land takings, as the layout of Ayer Road would widen to 60 feet.

- **Alternative 3 –** Alternative 3 involves the installation of a median island throughout the corridor limits along Ayer Road. This alternative also includes an 11-foot travel lane and 4-foot shoulder on either side with a 3-foot grass buffer and 6′ foot path. While left-turn lanes may be provided at the intersections, in conjunction with this alternative, the installation of roundabouts at each of the intersections is recommended. Alternative 3 will also require land takings, as the proposed layout would be 60 feet along the corridor and larger to accommodate the roundabouts.

Each alternative cross-section is illustrated on the following sheets.



TYPICAL SECTION – AYER ROAD

EXISTING LAYOUT – 50 FEET

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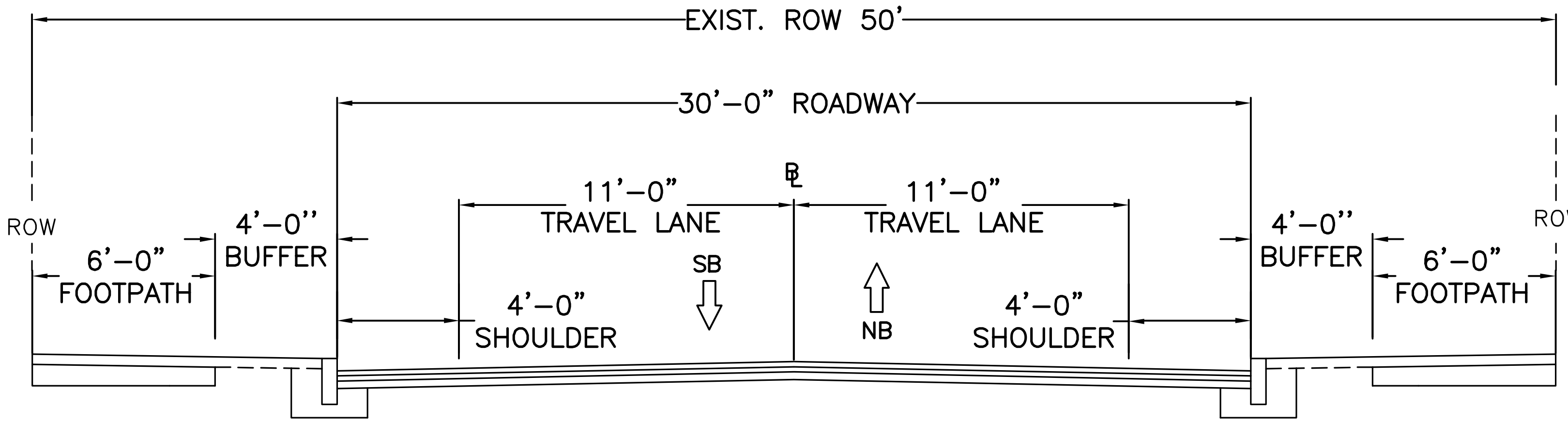
EXISTING TYPICAL CROSS SECTION AYER ROAD

DATE: JUN 2007
SHEET: 1 OF 4
SCALE: N.T.S



<u>ALTERNATIVE 1 TYPICAL SECTION – AYER ROAD</u>

LAYOUT – 50 FEET

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engineering
construction
operations

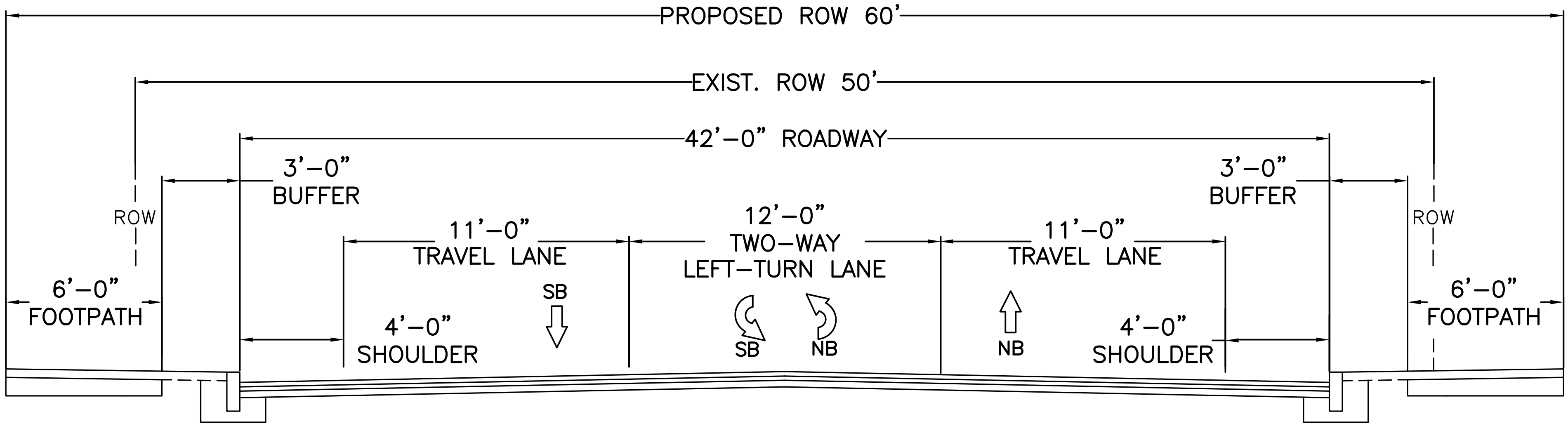
TOWN OF HARVARD, MASSACHUSETTS

ALTERNATIVE 1 TYPICAL CROSS SECTION
AYER ROAD

DATE: JUN 2007
SHEET: 2 OF 4
SCALE: N.T.S

Two-Way Left Turn Lane

Advantages	Disadvantages
Makes use of odd-lanes	Encourages random access
Reduces left turns from through lanes	Illegally used as a paasing or acceleration lane
Provides operational flexibility for emergency	Offers no refuge for pedestrians
Safer than roads with no left-turn lanes or medians	Higher maintenance costs
Facilitates detours	Operates poorly under high volumes of through traffic
Seperates opposing traffic	Allows head-on crashes



ALTERNATIVE 2 TYPICAL SECTION – AYER ROAD

LAYOUT – 60 FEET

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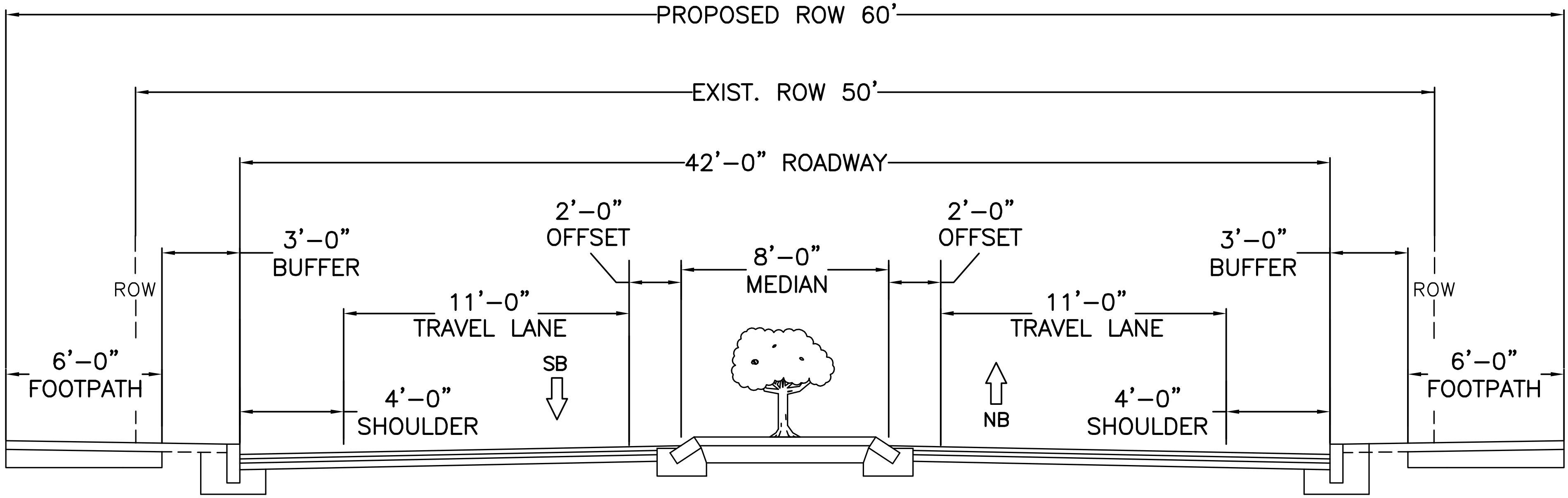
TOWN OF HARVARD, MASSACHUSETTS

ALTERNATIVE 2 TYPICAL CROSS SECTION
AYER ROAD

DATE: JUN 2007
SHEET: 3 OF 4
SCALE: N.T.S

Raised Median

Advantages	Disadvantages
Discorages strip development	Reduces operational flexibility for emergency vehicles
Allows better control of land uses by local government	Increases left turn volumes at median openings
Reduces number of conflicting maneuvers at driveways	Increases travel time and circuity for some motorists
Provides pedestrian refuge	May increase crashes at openings
If continuous, restricts access to right turns only	Limits direct access to property
Reduces crashes in mid-block areas	Operating speed usually limited to 45 miles per hour
Seperates opposing traffic	



ALTERNATIVE 3 TYPICAL SECTION – AYER ROAD

LAYOUT – 60 FEET

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TOWN OF HARVARD, MASSACHUSETTS

ALTERNATIVE 3 TYPICAL CROSS SECTION
AYER ROAD

DATE: JUN 2007

SHEET: 4 OF 4

SCALE: N.T.S

The "do nothing" alternative is clearly not an option for the proactive residents of Harvard. The lack of pedestrian and bicyclist accommodations along the corridor, the desire to reduce speeds, create a village atmosphere and the intention to have responsible development along Ayer Road has been well documented in the Master Plan. Therefore, it is recommended that each alternative be considered by the Town of Harvard for improvements along Ayer Road with the following caveats in mind:

- Based on the potential for future development, Ayer Road may require widening to two lanes in each direction. Therefore, regardless of which alternative is selected, it behooves the Town of Harvard to require donation of strip land takings from proposed developments approximately 10 feet in width along both sides of Ayer Road to provide for future expansion as needed. This strip taking would be a condition of site plan approval. Sites located near existing intersections may be required to donate more land to provide turn lanes or an expanded double lane roundabout.

- Traffic calming measures such as raised crosswalks or intersections can be included with Alternative 1 but are not readily implemented with Alternative 2.

- Alternative 3 is a corridor-wide traffic calming and village concept. Alternative 3, in conjunction with roundabout installation at the intersections will limit access to right-turns throughout the corridor, will encourage slower speeds, and will provide a landscaped median that maintains the rural character of the surrounding community. By providing the roundabouts, all motorists will have an opportunity to "u-turn" as needed at each of the roundabouts. The proposed median island has been designed with sloped granite curbing to allow for emergency vehicle access.

Appendices

Not included in this Draft FDR submittal