Transportation Impact Assessment

Proposed Medical Office Building
15 Pleasant Valley Road
Sutton, Massachusetts

Prepared for:

Torrington Properties, Inc.
Boston, Massachusetts

June 2022

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EXECUTIVE SUMMARY

Vanasse & Associates, Inc. (VAI) has prepared this Transportation Impact Assessment (TIA) in order to evaluate the potential traffic impacts associated with the proposed development of a medical office building to be located at 15 Pleasant Valley Road in Sutton, Massachusetts. This study evaluates the following specific areas as they relate to the Project: i) access requirements; ii) potential off-site improvements; and iii) safety considerations; and identifies and analyzes existing traffic conditions and future traffic conditions, both with and without the Project.

As documented in this assessment:

- Project-related traffic increases are expected to amount to 186 new vehicle trips (93 entering and 93 exiting) on a typical weekday, including 16 new vehicle trips (13 entering and 3 exiting) during the weekday morning peak hour and 20 new vehicle trips (6 entering and 14 exiting) during the weekday evening peak hour;

- Available sight lines exceeding the minimum requirements to ensure safe access to and from the Project;

- In comparison to future No-Build traffic volumes, Project-related traffic increases amount to an increase in peak hour traffic volumes of approximately one percent or less;

- Project-related traffic conditions are expected to amount to no notable increase to delays as compared to future No-Build conditions.

The following recommendations are provided to ensure safe and efficient access to the Project.

RECOMMENDATIONS

Site Access

Access to the Project site is proposed via a new one-way right-in-only entrance drive from Route 146 and a full access and egress driveway onto Pleasant Valley Road. It is recommended that the proposed Pleasant Valley Road driveway be placed under STOP-sign control, with a painted STOP bar at the driveway approach to Pleasant Valley Road. In order to ensure safe and efficient access to the Project and that adequate sightlines are provided in both directions along Pleasant Valley Road, all signs and landscaping should be designed as to not impede lines of sight in both directions. Signage and pavement markings, including Do Not Enter signage should be placed at the Route 146 driveway to enforce the one-way traffic flow at this location prohibiting exiting traffic onto Route 146.

CONCLUSION

In summary, the addition of Project-related traffic to study area roadways and intersections is not anticipated to significantly impact traffic operations within the study area over No-Build conditions. As documented in this report, Project-related traffic increases do not result in significant impact to area traffic operations, with only minimal increases to motorist delays projected at the signalized intersection of Route 146 with Boston Road. With implementation of the above recommendations, the proposed Project can be built with minimal traffic impact on the surrounding roadway system.

INTRODUCTION

Vanasse & Associates, Inc. (VAI) has prepared this Transportation Impact Assessment (TIA) in order to evaluate the potential traffic impacts associated with the proposed development of a medical office building to be located at 15 Pleasant Valley Road in Sutton, Massachusetts. This study evaluates the following specific areas as they relate to the Project: i) access requirements; ii) potential off-site improvements; and iii) safety considerations; and identifies and analyzes existing traffic conditions and future traffic conditions, both with and without the Project.

PROJECT DESCRIPTION

The Project site is situated on an approximate 1.25± acre parcel of land located in the southeast quadrant of the intersection of Route 146 with Pleasant Valley Road in Sutton, Massachusetts. The Project site is generally bounded by Route 146 to the west, Pleasant Valley Road to the north, and private properties to the east and south. Access to the Project site is currently provided by a single right-in/right-out driveway onto Route 146.

The Project entails the construction of a new approximate 5,150± square foot (sf) medical office building providing a total of forty (40) parking spaces, including two (2) handicap accessible parking spaces. Access to the Project is proposed via a new full access driveway onto Pleasant Valley Road, with the existing site access onto Route 146 modified and restricted to a one-way entrance only driveway.

The location of the Project site relative to the surrounding roadway network is displayed in Figure 1.

Figure 1

Site Location Map

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STUDY METHODOLOGY

This study was prepared in consultation with the Town of Sutton and in accordance with the Massachusetts Department of Transportation (MassDOT) Guidelines for traffic impact assessments and the standards of the Traffic Engineering and Transportation Planning professions for the preparation of such reports; and was conducted in three distinct stages. The first stage involved an assessment of existing conditions in the study area and included an inventory of roadway geometrics; pedestrian facilities; observations of traffic flow; review of safety characteristics along area roadways and collection of daily and peak period traffic counts. In the second stage of the study, future traffic conditions were projected and analyzed. Specific travel demand forecasts for the Project were assessed along with future traffic demands due to expected traffic growth independent of the Project. A seven-year time horizon was selected for analyses consistent with state guidelines for the preparation of TIAs. The traffic analysis conducted in stage two identifies existing or projected future roadway capacity, traffic safety, and site access issues. The third stage of the study presents and evaluates measures to address traffic and safety issues, if any, identified in stage two of the study.

EXISTING CONDITIONS

A comprehensive field inventory of existing conditions within the study area was conducted in April of 2022. The field investigation consisted of an inventory of existing roadway geometrics, pedestrian facilities, traffic volumes, and operating characteristics; as well as posted speed limits and land use information for the major roadways that provide access to the Project including Route 146 and Pleasant Valley Road, including the key intersections which are expected to accommodate the majority of Project-related traffic. The study area for the project is listed below and graphically depicted in Figure 2.

1. Route 146 at Pleasant Valley Road
2. Route 146 at Boston Road
3. Pleasant Valley Road at Boston Road and Dudley Road

The following describes the study area roadways and intersections:

GEOMETRY

Roadways

Worcester-Providence Turnpike

Route 146 (Worcester-Providence Turnpike) is a limited access median divided four-lane principal arterial roadway under the jurisdiction of MassDOT that traverses the study area in a general north-south orientation. Within the study area, Worcester-Providence Turnpike provides two approximate 12-foot travel lanes in the each direction separated by a jersey barrier median. An approximate 8-foot paved shoulder is provided along both sides of the corridor in the vicinity of the Project. Along the site frontage The posted speed limit along Worcester-Providence Turnpike is 40 miles per hour (mph) in the vicinity of the project site and 50 mph north of the project site. Land use along Worcester-Providence Turnpike consists of a mix of office, commercial and residential properties.

Intersections

Worcester-Providence Turnpike at Boston Road

Boston Road intersects Worcester-Providence Turnpike from the east and west to form a four-way intersection that operates under traffic signal control. The Boston Road eastbound approach provides an approximate 12-foot wide exclusive left-turn lane, and approximate 12-foot wide through lane and an

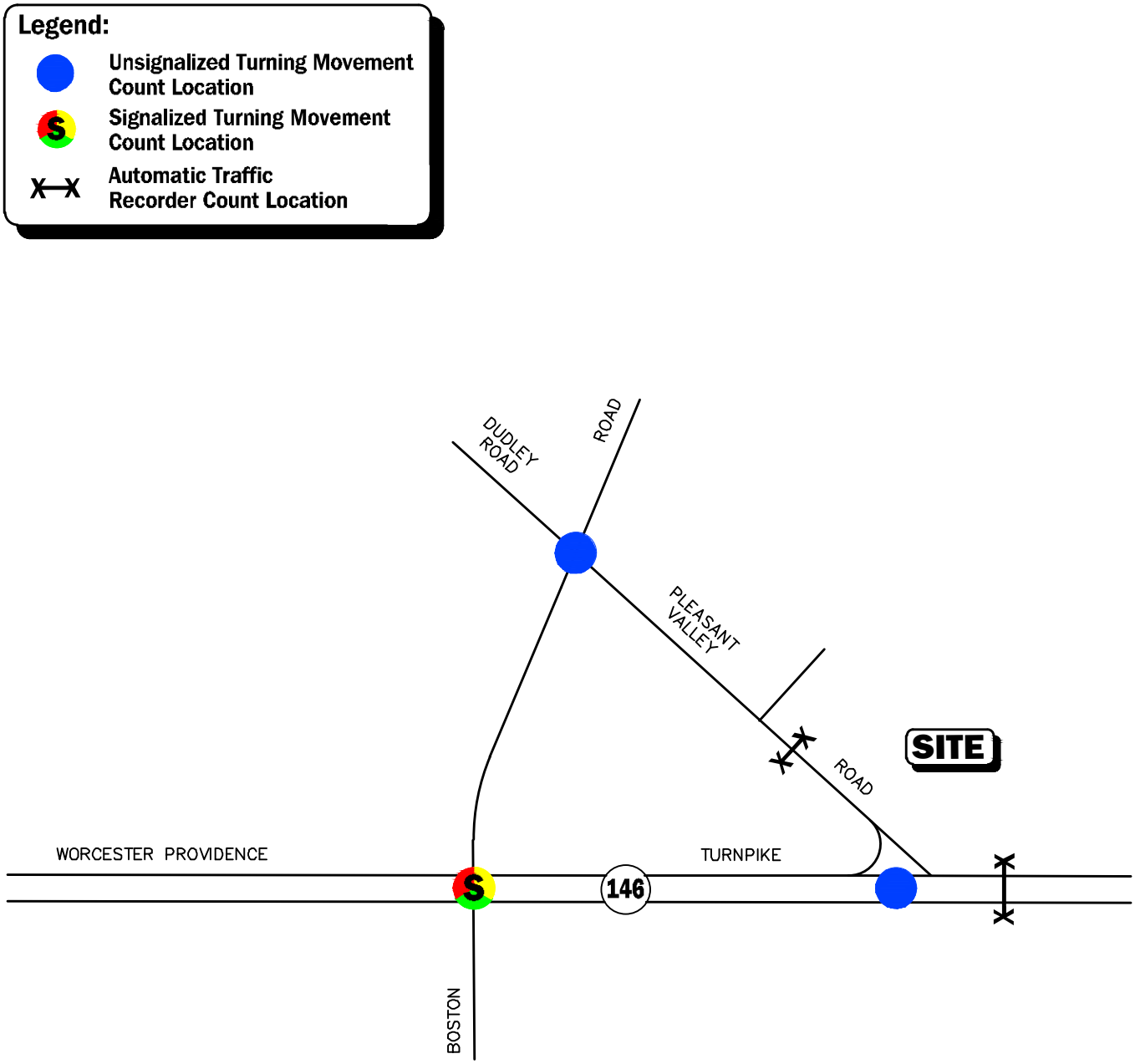

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Figure 2

Traffic Count Locations

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approximate 12-foot wide channelized exclusive right-turn lane. The Boston Road westbound approach provides two approximate 12-foot wide exclusive left-turn lanes, an approximate 12-foot wide through lane and an approximate 12-foot wide exclusive right-turn lane. The Worcester-Providence Turnpike northbound approach provides two approximate 12-foot wide through lanes and an approximate 12-foot wide shared through/right-turn lane. The Worcester-Providence Turnpike southbound approach provides two approximate 12-foot wide exclusive left-turn lanes, three approximate 12-foot wide through lanes and an approximate 12-foot wide exclusive right-turn lane. The traffic signal at this location operates under a four-phase signal operation with a protected left-turn phase for southbound traffic on Worcester-Providence Turnpike and an exclusive left-turn phase for the eastbound and westbound Boston Road approaches. Land use in the vicinity of this intersection consists primarily commercial uses including a restaurant, gas station and drive-through bank.

Route 146 at Pleasant Valley Road

Pleasant Valley Road intersects Route 146 from the east to form a three-way intersection that operates under STOP-sign control. The Pleasant Valley Road westbound approach provides a single approximate 12-foot wide exclusive right-turn lane that operates under STOP-sign control. The Route 146 northbound approach provides three approximate 12-foot wide through lanes and an approximate 12-foot wide exclusive right-turn lane onto Pleasant Valley Road. Land use in the vicinity of this intersection consists primarily of commercial properties.

Boston Road at Pleasant Valley Road and Dudley Road

Pleasant Valley Road and Dudley Road intersect Boston Road from the south and north, respectively, to form a four-way intersection that operates under STOP-sign control. The Pleasant Valley Road eastbound approach provides two approximate 12-foot wide general purpose travel lanes. The Pleasant Valley Road westbound approach provides two approximate 12-foot wide general purpose travel lanes, with a channelized right-turn lane onto Dudley Road provided that operates under YIELD-sign control. The Pleasant Valley Road northbound approach provides an approximate 16-foot wide general purpose travel lane that operates under STOP-sign control. The Dudley Road southbound approach provides an approximate 13-foot wide general purpose travel lane that operates under STOP-sign control. Lane use in the vicinity of this intersection consists of a mix of commercial and residential properties.

EXISTING TRAFFIC VOLUMES

In order to determine existing traffic-volume demands and flow patterns within the study area, traffic counts were conducted along both Route 146 and Pleasant Valley Road by way of an automatic traffic recorder (ATR) count in April 2022. Additionally, peak period turning movement counts were conducted at all study area locations between the hours of 7:00 and 9:00 AM, and 4:00 and 6:00 PM. These time periods represent the peak period of roadway and commuter traffic. Based on a review of the collected data, the peak hours of roadway traffic generally occurred between 7:00 and 8:00 AM during the weekday morning and between 4:30 and 5:30 PM during the weekday evening.

Seasonal Variation

In order to identify whether traffic volumes collected in April are representative of typical traffic conditions, seasonal adjustment data published by MassDOT were reviewed. Route 146 falls within Group U2 – "Rural Freeway and Expressway." Based on a review of this data, April traffic volumes are approximately 7 percent higher than average annual conditions, and therefore the collected data represent a conservative analysis scenario.

Route 146, along the northbound side of the corridor, in the vicinity of the Project, was found to accommodate approximately 20,609 vehicles on an average weekday (24-hour, two-way volume), with approximately 2,118 vehicles per hour (vph) during the weekday morning peak hour and 1,504 vph during the weekday evening peak hour.

Pleasant Valley Road, east of Route 146, currently accommodates approximately 1,803 vpd, including approximately 162 vph during the weekday morning peak hour, and 152 vph during the weekday evening peak hour.

A review of the peak-period traffic counts indicates that the weekday morning peak hour generally occurs between 7:00 and 8:00 AM, with the weekday evening peak hour, generally occurring between 4:30 and 5:30 PM.

The 2022 Existing traffic volumes are summarized in Table 1, with the weekday morning and evening peak-hour traffic volumes graphically depicted on Figures 3.

Table 1
EXISTING ROADWAY TRAFFIC-VOLUME SUMMARY

		Weekday Morning Peak Hour (8:00 – 9:00 AM)			Weekday Afternoon Peak Hour (4:30 – 5:30 PM)		
Location	Daily Volume (vpd)[a]	Volume (vph)[b]	Percent of Daily Traffic[c]	Predominant Flow	Volume (vph)	Percent of Daily Traffic	Predominant Flow
Route 146, south of Pleasant Valley Road	20,609	2,118	10.3	100% NB	1,504	7.3	100% NB
Pleasant Valley Road, east of Route 146	1,803	162	9.0	98% EB	152	8.4	94% EB

Source: Automatic traffic recorder counts and manual turning movement counts conducted in April 2022.
[a]Two-way daily traffic expressed in vehicles per day.
[b] Manual turning movement counts conducted in April 2022.
[c]The percent of daily traffic that occurs during the peak hour.
EB = eastbound, NB = northbound

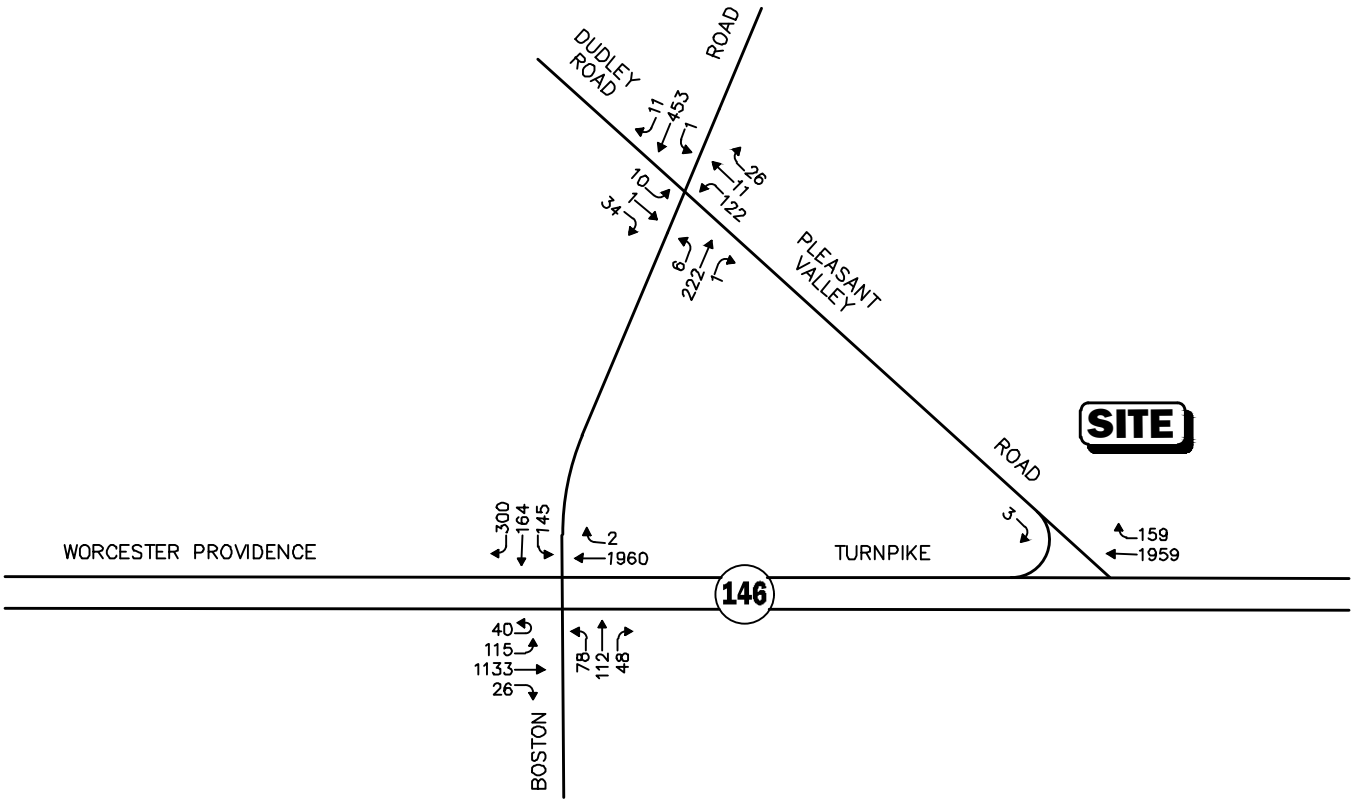
PEDESTRIAN AND BICYCLE FACILITIES

A comprehensive field inventory of pedestrian and bicycle facilities within the study area was undertaken in April of 2022. The field inventory consisted of a review of the location of sidewalks and pedestrian crossing locations along the study area roadways and at the study area intersections. In general, pedestrian accommodations are not currently provided within the study area, with no sidewalk or marked pedestrian crossings provided. Sharrows are provided along Boston Road in both the eastbound and westbound directions to accommodate bicycle traffic along this corridor.

PUBLIC TRANSPORTATION

Public transportation services are not currently provided within the immediate study area, though the Town of Sutton is served by SCM Elderbus, which provides transportation services to all Sutton residents aged 60 or older, as well as residents with disabilities.

WEEKDAY MORNING PEAK HOUR (7:00 - 8:00 AM)



SATURDAY EVENING PEAK HOUR (4:30 - 5:30 PM)

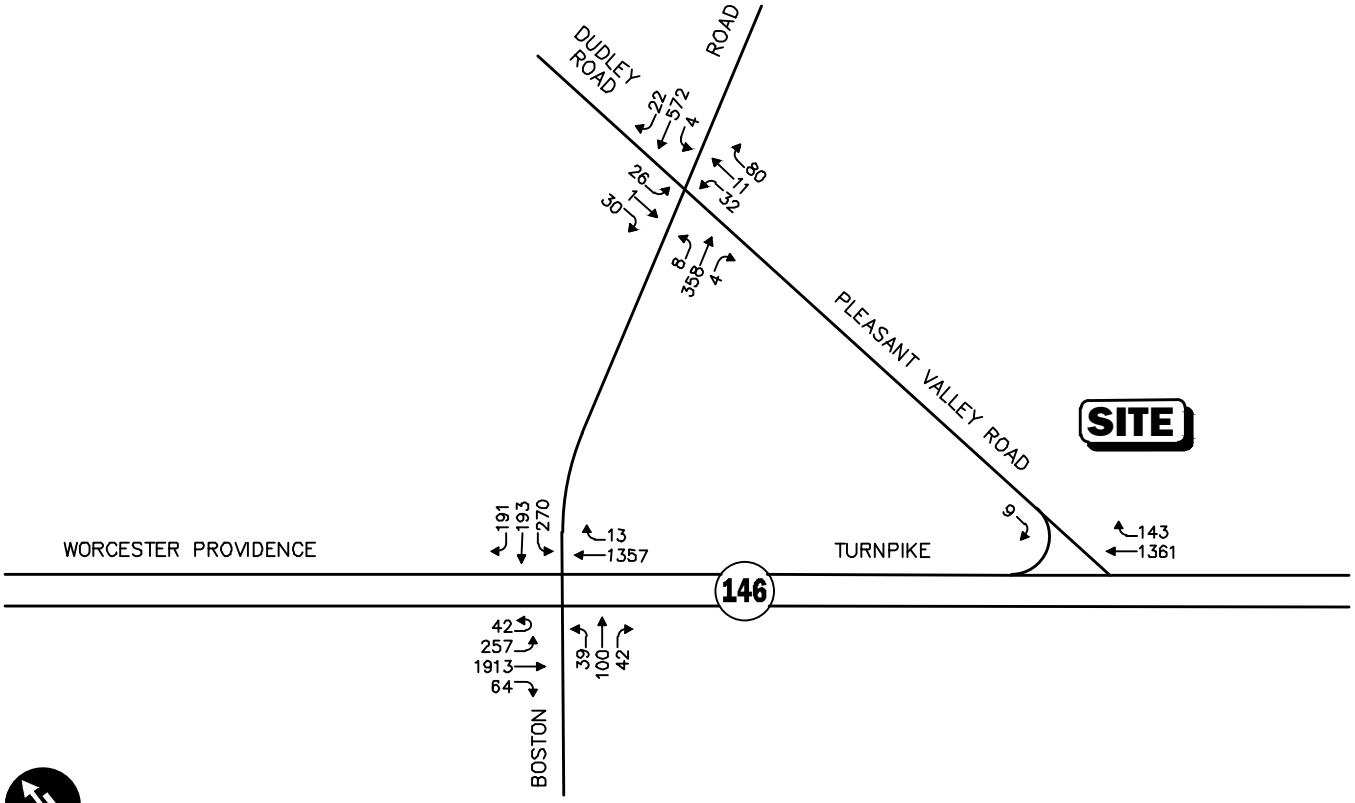


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Figure 3

2022 Existing
Peak-Hour Traffic Volumes

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MOTOR VEHICLE CRASH DATA

Motor vehicle crash information for the study area intersections was provided by the MassDOT Highway Division Safety Management/Traffic Operations Unit for the most recent five-year period available (2016 through 2020 inclusive) in order to examine motor vehicle crash trends occurring within the study area. The data is summarized by intersection, type, and severity, and is presented in Table 2.

As summarized in Table 2, the intersection of Route 146 with Boston Road experienced the highest frequency of accidents over the five-year review period with a total of 123 collisions reported at the intersection, averaging 24.6 crashes per year. The majority of accidents involved property damage only, occurred on dry pavement, and involved rear-end collisions. The motor vehicle crash rate for this location falls above MassDOT's average crash rate for signalized intersections in this MassDOT District.

The intersection of Boston Road with Pleasant Valley Road experienced a total of 10 motor vehicle collisions over the five-year review period, averaging 2.0 crashes per year. The majority of crashes involved property damage only, occurred on dry pavement, and involved angle type collisions. The motor vehicle crash rate for this location falls below MassDOT's average crash rate for unsignalized intersections in this MassDOT District.

The remaining study area location exhibited significantly lower crash frequency, all locations exhibiting crash rates below the District average in which the project is located (District 3). No fatalities were reported at any of the study area intersections over the five-year period reviewed.

The Highway Safety Improvement Program (HSIP) database was reviewed to identify whether any of the study area intersections are listed as HSIP-eligible clusters in the most recent (2017-2019) HSIP cluster listing. Based on this review, the intersection of Route 146 with Boston Road was identified as HSIP-eligible cluster location and Top 200 Crash Cluster location for the years 2017-2019. It is noted that this intersection was reconstructed in 2016 to enhance traffic operations and safety at this location, including geometric improvements and the elimination of northbound left-turn movements from Route 146 to Boston Road westbound.

SIGHT DISTANCE ANALYSIS

In order to ensure safe and efficient access will be provided to and from the Project site, a sight distance analysis was conducted for the proposed site driveway with Pleasant Valley Road. Specifically, available sight lines at the proposed driveway location were compared to the sight distance requirements as defined by the American Association of State Highway and Transportation Officials (AASHTO).

The posted speed limit on Pleasant Valley Road is 30 miles per hour. Based on AASHTO requirements a total of 200 feet of available sight distance is required at the proposed driveway location. Field measurements indicate that following removal of vegetation along the site frontage in conjunction with the development of the property, in excess of 250 feet of sight distance will be available in both direction, exceeding the AASHTO requirements.

Table 2
MOTOR VEHICLE CRASH DATA SUMMARY[a]

Scenario	Route 146 at Boston Road	Boston Road at Pleasant Valley Road	Route 146 at Pleasant Valley Road
Year:			
2016	31	3	1
2017	22	2	0
2018	27	1	1
2019	27	1	0
2020	19	3	0
Total	126	10	2
Average[b]	24.6	2.0	0.4
Crash Rate[c]	1.39	0.42	0.07
Significant[d]	Yes	No	No
Type:			
Angle	14	8	0
Rear-End	80	0	1
Head-On	2	0	0
Sideswipe	16	2	0
Fixed Object	13	0	1
Unknown/Other	1	0	0
Total	126	10	2
Day:			
Weekday	84	8	2
Saturday	20	1	0
Sunday	22	1	0
Total	126	10	2
Lighting Conditions:			
Daylight	89	9	1
Dawn/Dusk	4	0	1
Dark (lit)	7	0	0
Dark (unlit)	25	1	0
Unknown	1	0	0
Total	126	10	2
Pavement Conditions			
Dry	92	10	2
Wet	21	0	0
Snow	9	0	0
Ice	1	0	0
Unknown(Other)	3	0	0
Total	126	10	2
Severity:			
Property Only	91	7	2
Injury Accident	35	3	0
Fatal Accident	0	0	0
Unknown/Other	0	0	0
Total	126	10	2

[a]Source: MassDOT, 2016 through 2020
[b]Average crashes over five-year period.
[c]Crash rate per million entering vehicles (mev).
[d]Unsignalized intersections are significant if rate >0.57 crashes per million vehicles
[e]Signalized intersections are significant if rate >0.73 crashes per million vehicles

FUTURE CONDITIONS

Traffic volumes in the study area were projected to the year 2029, which reflects a seven-year planning horizon consistent with State Traffic Study Guidelines. Independent of the Project, traffic volumes on the roadway network in the year 2029 under No-Build conditions include all existing traffic and new traffic resulting from background traffic growth. Anticipated Project-generated traffic volumes superimposed upon this 2029 No-Build traffic network reflect the 2029 Build conditions with the Project.

FUTURE TRAFFIC GROWTH

Future traffic growth is a function of the expected land development in the immediate area and the surrounding region. Several methods can be used to estimate this growth. A procedure frequently employed estimates an annual percentage increase in traffic growth and applies that percentage to all traffic volumes under study. The drawback to such a procedure is that some turning volumes may actually grow at either a higher or a lower rate at particular intersections.

An alternative procedure identifies the location and type of planned development, estimates the traffic to be generated, and assigns it to the area roadway network. This procedure produces a more realistic estimate of growth for local traffic. However, the drawback of this procedure is that the potential growth in population and development external to the study area would not be accounted for in the traffic projections.

To provide a conservative analysis framework, both procedures were used, the salient components of which are described below.

Background Traffic Growth

In order to account for background growth in traffic, independent of any specific area development projects, a one percent annual compounded growth rate was applied to area traffic volumes over the seven year planning horizon. This growth rate is consistent with the background growth rate utilized for other recently conducted area traffic assessments.

Specific Developments by Others

In addition to the aforementioned background growth rate, traffic volumes associated with the following area development projects were identified based on a review of the Town of Sutton's development project database, and have been incorporated into the analysis of future traffic conditions.

UN1F1ED Sutton, 105 Providence Road, Sutton Massachusetts **–** The 1165R Massachusetts Avenue development project entails construction of two warehouse and distribution buildings totaling approximately 995,000 sf. Additional traffic expected to be generated by this project were obtained from the traffic impact assessment[1] prepared for this development, and have been included in the analysis of future traffic conditions.

Blackstone Logistics Center, Sutton Massachusetts **–** The Blackstone Logistics Center development project, to be located in the Towns of Sutton, Douglas and Uxbridge, entails construction of an approximate 650,000 sf warehouse facility on Lackey Dam Road. Additional traffic expected to be generated by this project were obtained from the traffic impact assessment[2] prepared for this development, and have been included in the analysis of future traffic conditions.

No other developments were identified that are expected to result in an increase in traffic within the study area beyond the general background traffic growth rate.

ROADWAY IMPROVEMENT PROJECTS

The Town of Sutton Planning Department and MassDOT were contacted to identify if any roadway or traffic signal improvement projects are proposed within the study area that would affect future traffic operations within the study area. Based on these discussions, the no specific roadway improvement projects were identified within the study area that are expected to influence future traffic conditions.

NO-BUILD TRAFFIC VOLUMES

The 2029 No-Build peak-hour traffic-volume networks were developed by applying the background growth rate to the 2022 Existing traffic volumes, as well as traffic associated with the aforementioned background development project. The resulting 2029 No-Build weekday morning and weekday evening peak-hour traffic volume networks are shown on Figure 4.

PROJECT-GENERATED TRAFFIC

The proposal entails the development of an approximate 5,150± sf medical office building. In order to develop the traffic characteristics of this project, trip-generation statistics published by the Institute of Transportation Engineers (ITE)[3] for LUC 720 – *Medical-Dental Office Building* were used. This land use code represent the most appropriate category for the proposed development of the site. The trip generation projections are summarized in Table 3.

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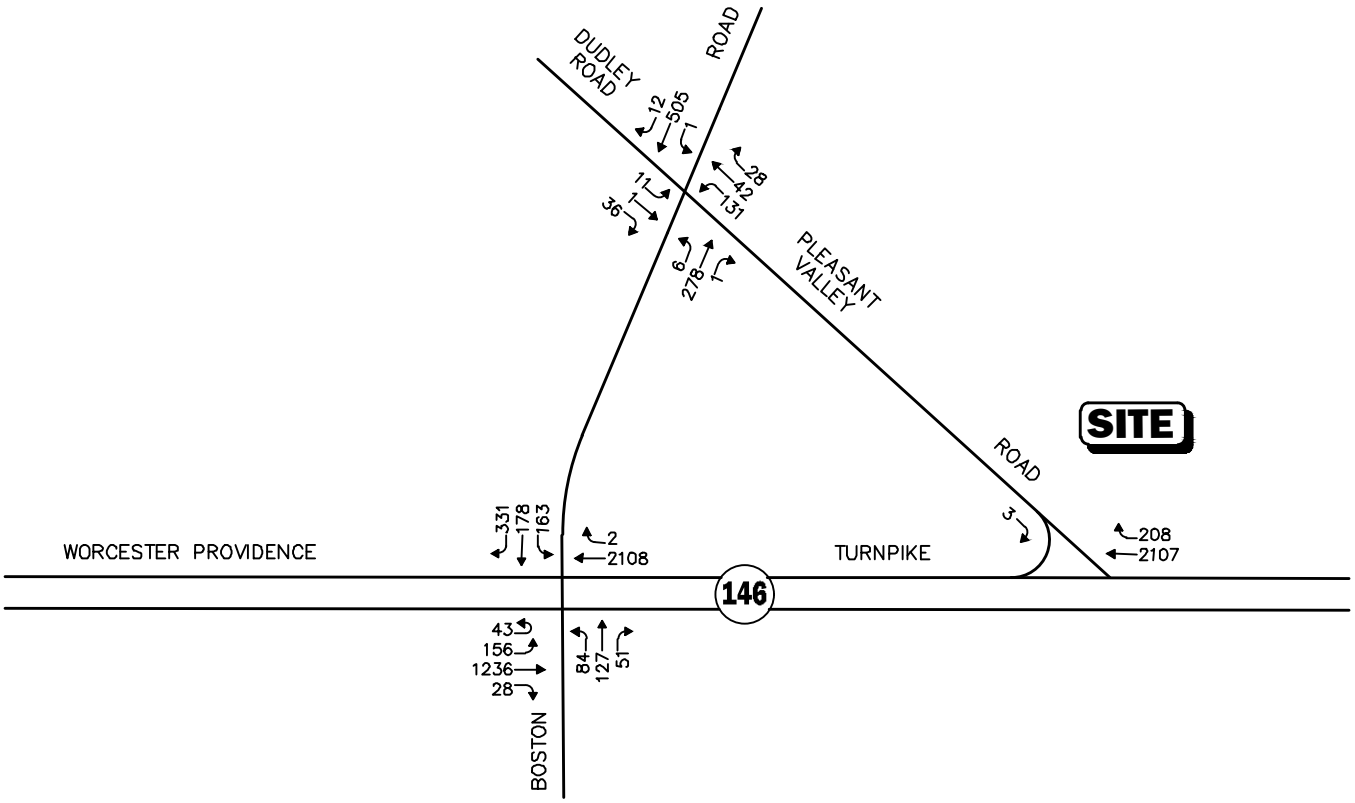
[1] *Traffic Impact Evaluation – 105 Providence Road, Sutton, MA;* VHB, March 30, 2022.

[2] *Traffic Impact and Access Study – Blackstone Logistics Center, Sutton, Douglas and Uxbridge, MA;* VHB, January 11, 2021.

[3] *Trip Generation*, 11th Edition; Institute of Transportation Engineers; Washington, DC; September 2021.

WEEKDAY MORNING PEAK HOUR (7:00 - 8:00 AM)



SATURDAY EVENING PEAK HOUR (4:30 - 5:30 PM)

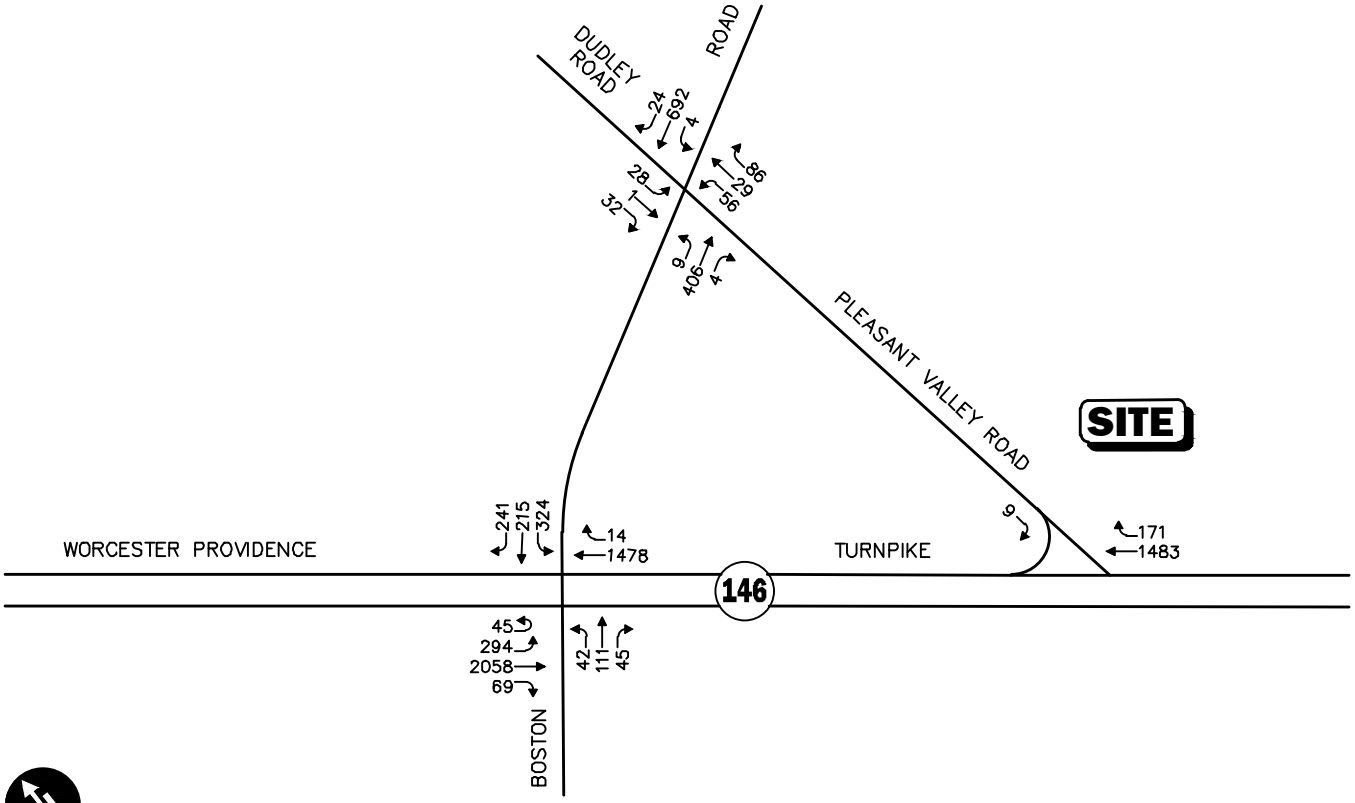


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Figure 4

2029 No-Build
Peak-Hour Traffic Volumes

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Table 3
TRIP GENERATION SUMMARY[a]

Time Period/ Directional Distribution	Total Trips
Weekday Daily	186
Weekday Morning Peak Hour:	
Entering	13
Exiting	3
Total	16
Weekday Evening Peak Hour:	
Entering	15
Exiting	10
Total	25

[a]Based on ITE LUC 720 – *Medical-Dental Office Building – Stand Alone*, 5,150 sf.

As summarized in Table 3, the Project is expected to generate approximately 186 vehicle trips on a typical weekday (93 entering and 93 exiting), including 16 vehicle trips (13 entering and 3 exiting) during the weekday morning peak hour and 20 vehicle trips (6 entering and 14 exiting) during the weekday evening peak hour.

TRIP DISTRIBUTION AND ASSIGNMENT

The directional distribution of the site-generated trips to and from the proposed development was determined based on a review of existing traffic patterns along the Route 146 and Boston Road corridors and the anticipated arrival and distribution patterns for employee and patient traffic. In general, it is expected that 35 percent of Project-related traffic will be oriented to and from Route 146, south of the site; 35 percent to and from Route 146, north of the site; 20 percent to and from Boston Road, east oof the site; and 10 percent to and from Boston Road, west of the site.

The general trip distribution for the project is summarized in Table 5 and displayed on Figure 5. The weekday morning and weekday evening peak-hour traffic volumes expected to be generated by the Project were assigned on the study area roadway network based on these patterns, as shown on Figure 6.

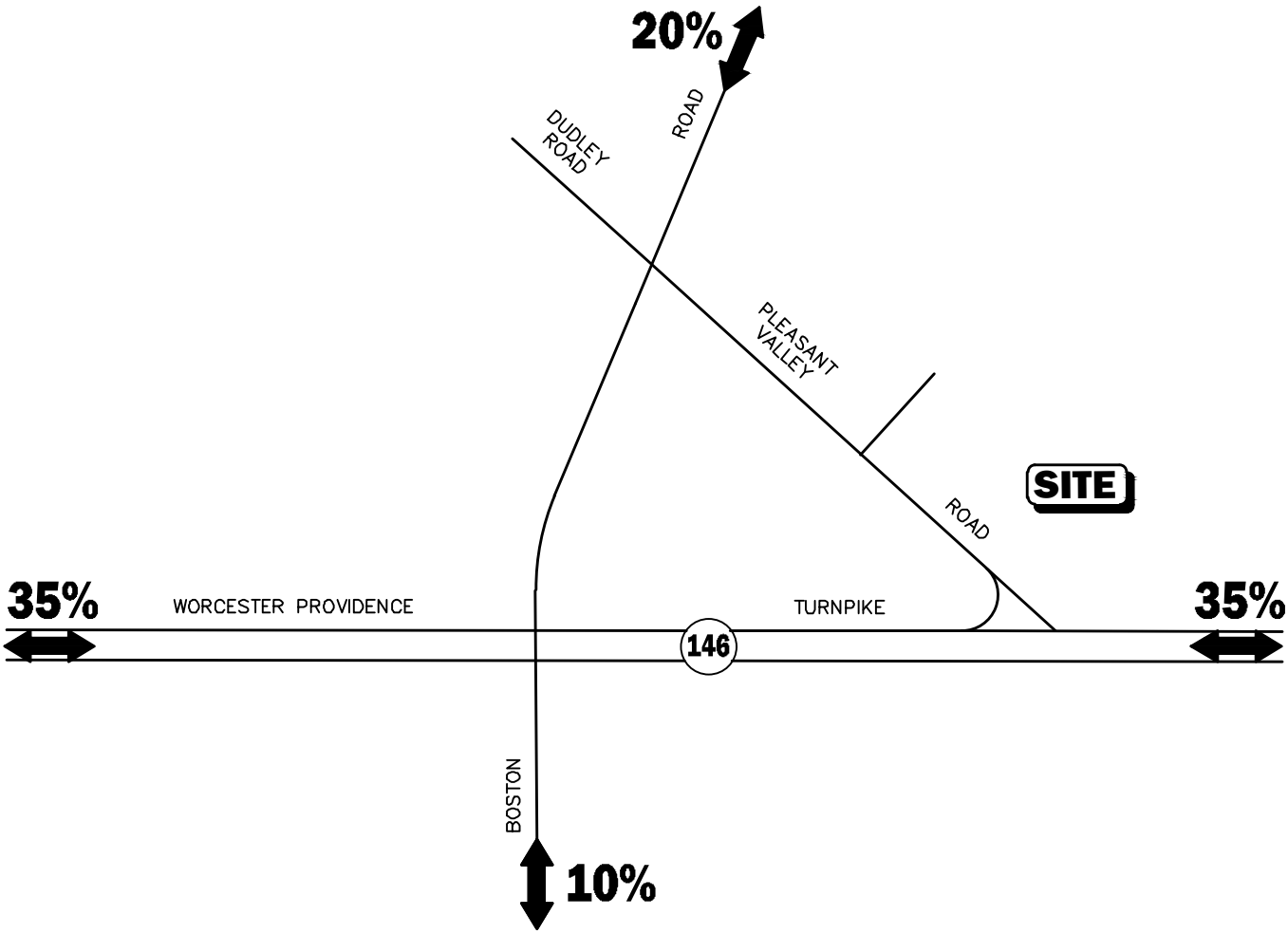

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Figure 5

Trip Distribution Map

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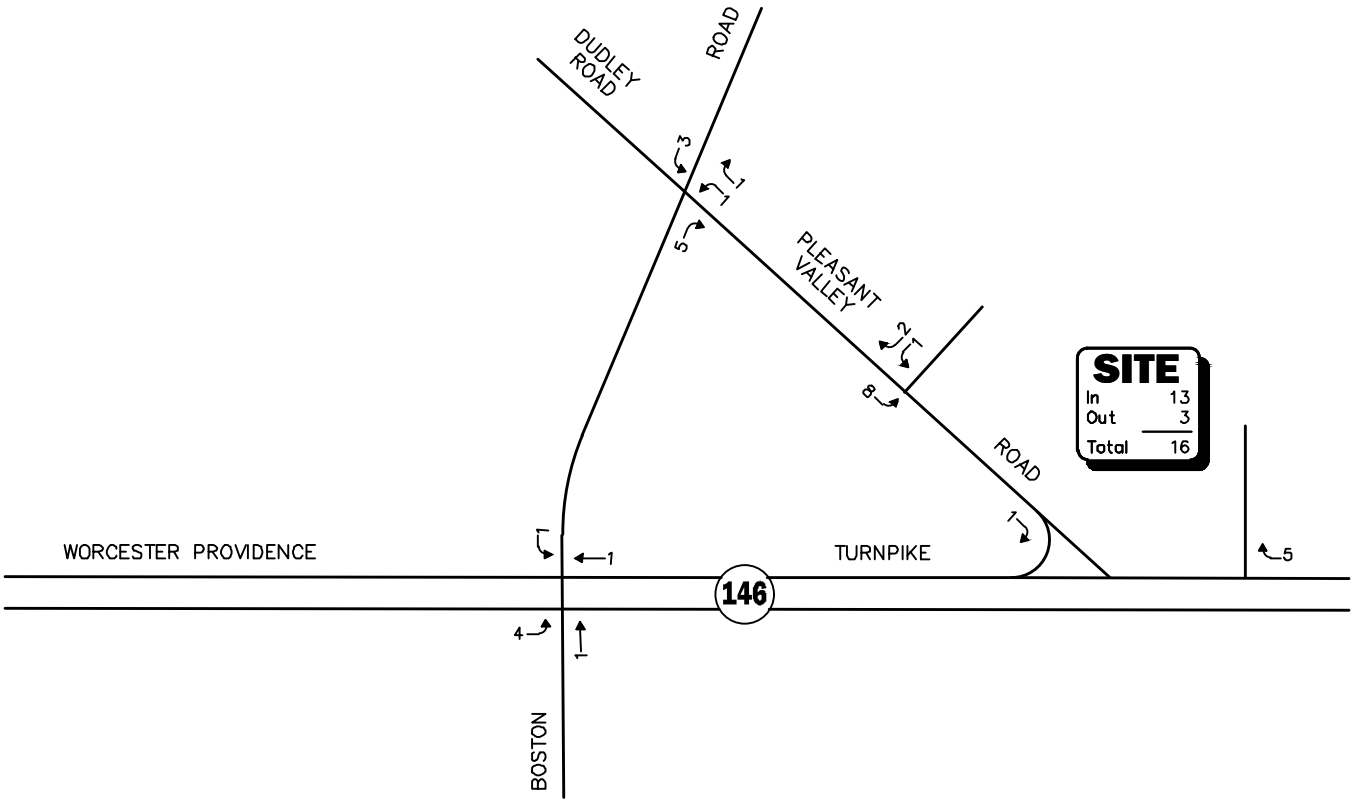
WEEKDAY MORNING PEAK HOUR (7:00 - 8:00 AM)



SATURDAY EVENING PEAK HOUR (4:30 - 5:30 PM)

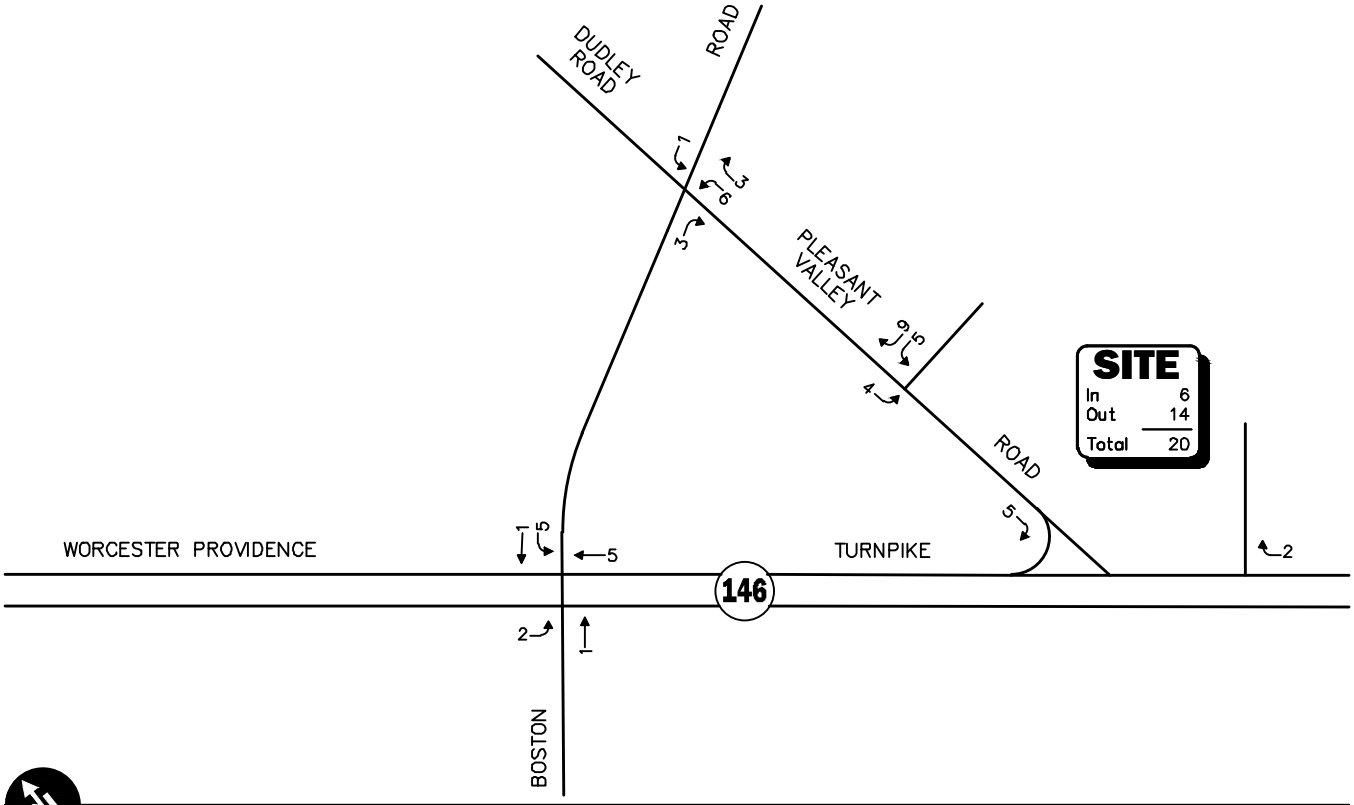


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Figure 6

Project-Generated Peak-Hour Traffic Volumes

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Table 5
TRIP-DISTRIBUTION SUMMARY

Roadway	Direction (To/From)	Percentage (%)
Route 146	North	35%
Route 146	South	35%
Boston Road	East	20%
Boston Road	West	10%
TOTAL		**100%**

FUTURE TRAFFIC VOLUMES - BUILD CONDITION

The 2029 Build condition networks consist of the 2029 No-Build traffic volumes with the anticipated Project-generated traffic added to them. The 2029 Build weekday morning and weekday evening peak-hour traffic volume networks are graphically depicted on Figure 7.

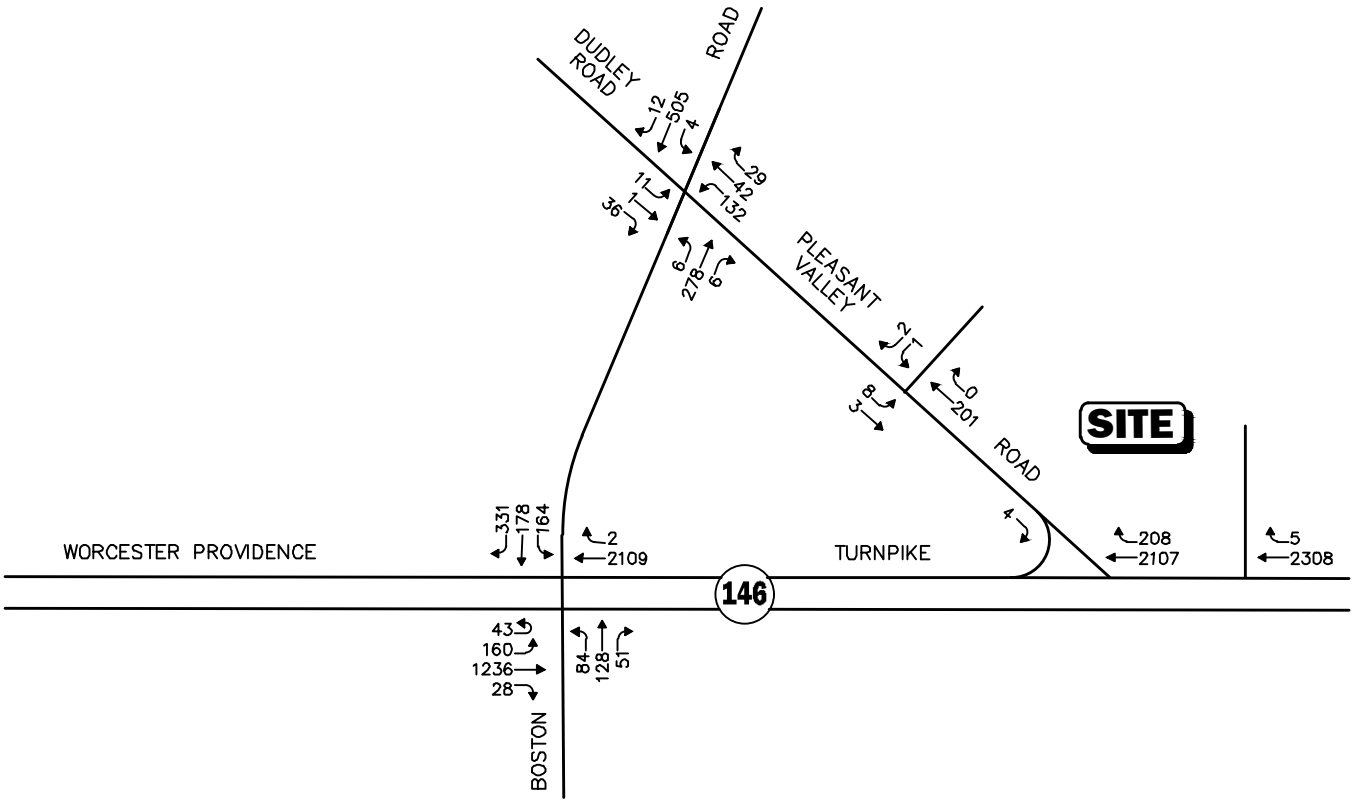
A summary of peak-hour projected traffic-volume increases external to the study area that is the subject of this assessment is shown in Table 6. These volumes are based on the expected increases from the Project.

Table 6
PEAK HOUR TRAFFIC-VOLUME INCREASES

Location/Peak Hour	2029 No-Build	2029 Build	Traffic Volume Increase Over No-Build	Percent Increase Over No-Build
Route 146 at Boston Road:				
Weekday Morning	4,507	4,514	7	0.2
Weekday Evening	4,936	4,950	14	0.3
Route 146 at Pleasant Valley Road:				
Weekday Morning	2,311	2,312	1	0.0
Weekday Evening	1,663	1,668	5	0.3
Boston Road at Pleasant Valley Road:				
Weekday Morning	1,052	1,062	10	1.0
Weekday Evening	1,371	1,384	13	0.9

As summarized in Table 6, in comparison to future 2029 No-Build conditions, overall traffic volumes are expected to increase by approximately 0.0 to 1.0 percent at all off-site locations evaluated as part of this assessment, with overall volumes expected to increase by approximately 1 to 14 vehicles per hour, or approximately one new vehicle trip every 4 to 60 minutes.

WEEKDAY MORNING PEAK HOUR (7:00 - 8:00 AM)



SATURDAY EVENING PEAK HOUR (4:30 - 5:30 PM)

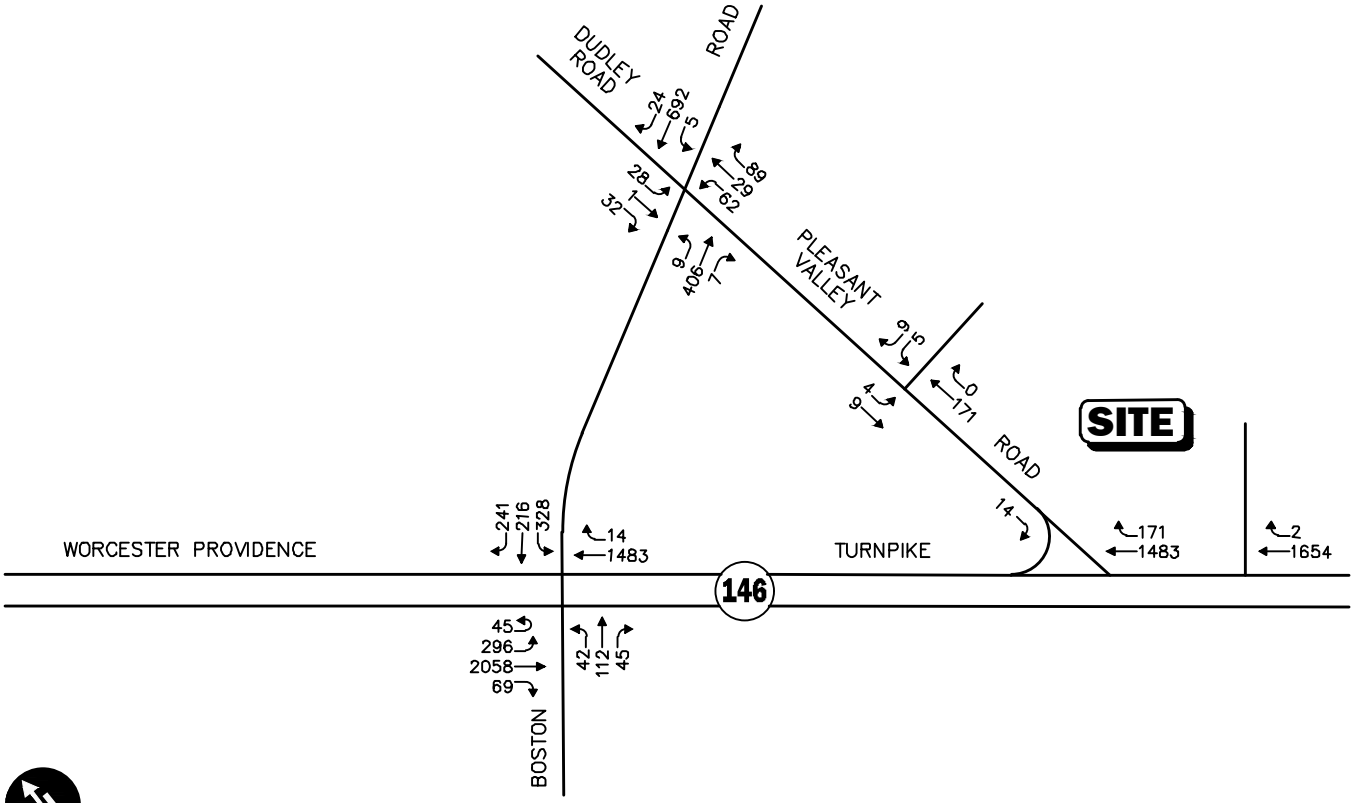


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Figure 7

2029 Build
Peak-Hour Traffic Volumes

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TRAFFIC OPERATIONS ANALYSIS

Measuring existing and future traffic volumes quantifies traffic flow within the study area. To assess quality of flow, roadway capacity and vehicle queue analyses were conducted under Existing, No-Build and Build traffic volume conditions. Capacity analyses provide an indication of how well the roadway facilities serve the traffic demands placed upon them, with vehicle queue analyses providing a secondary measure of the operational characteristics of an intersection or section of roadway under study.

METHODOLOGY

Levels of Service

A primary result of capacity analyses is the assignment of level of service to traffic facilities under various traffic-flow conditions.[4] The concept of level of service 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 given letter designations from A to F, with level-of-service (LOS) A representing the best operating conditions and LOS F representing congested or constrained operating conditions.

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.

Signalized Intersections

The six levels of service for signalized intersections may be described as follows:

- *LOS A* describes operations with very low control delay; most vehicles do not stop at all.

[4]The capacity analysis methodology is based on the concepts and procedures presented in the *Highway Capacity Manual;* Transportation Research Board; Washington, DC; 2010.

- *LOS B* describes operations with relatively low control delay. However, more vehicles stop than LOS A.

- *LOS C* describes operations with higher control delays. Individual cycle failures may begin to appear. The number of vehicles stopping is significant at this level, although many still pass through the intersection without stopping.

- *LOS D* describes operations with control delay in the range where the influence of congestion becomes more noticeable. Many vehicles stop and individual cycle failures are noticeable.

- *LOS E* describes operations with high control delay values. Individual cycle failures are frequent occurrences.

- *LOS F* describes operations with high control delay values that often occur with over-saturation. Poor progression and long cycle lengths may also be major contributing causes to such delay levels.

Levels of service for signalized intersections were calculated using the Percentile Delay Method implemented as a part of the Synchro™ 8 software as suggested by MassDOT in order to compensate for errors found when employing the 2010 *Highway Capacity Manual* methodology as a part of the software. The Percentile Delay Method assesses the effects of signal type, timing, phasing, and progression; vehicle mix; and geometrics on "percentile" delay. Level-of-service designations are based on the criterion of percentile delay per vehicle and is a measure of: i) driver discomfort; ii) motorist frustration; and iii) fuel consumption; and includes a uniform delay based on percentile volumes using a Poisson arrival pattern, an initial queue move-up time, and a queue interaction delay that accounts for delays resulting from queues extending from adjacent intersections. Table 7 summarizes the relationship between level-of-service and percentile delay, and uses the same numerical delay thresholds as the HCM method. The tabulated percentile delay criterion may be applied in assigning level-of-service designations to individual lane groups, to individual intersection approaches, or to entire intersections.

Table 7
LEVEL-OF-SERVICE CRITERIA
FOR SIGNALIZED INTERSECTIONS[a]

Level of Service	Percentile Delay Per Vehicle (Seconds)
A	≤10.0
B	10.1 to 20.0
C	20.1 to 35.0
D	35.1 to 55.0
E	55.1 to 80.0
F	>80.0

Unsignalized Intersections

The six levels of service for unsignalized intersections may be described as follows:

- *LOS A* represents a condition with little or no control delay to minor street traffic.

- *LOS B* represents a condition with short control delays to minor street traffic.

- *LOS C* represents a condition with average control delays to minor street traffic.
- *LOS D* represents a condition with long control delays to minor street traffic.
- *LOS E* represents operating conditions at or near capacity level, with very long control delays to minor street traffic.
- *LOS F* represents a condition where minor street demand volume exceeds capacity of an approach lane, with extreme control delays resulting.

The levels of service of unsignalized intersections are determined by application of a procedure described in the 2010 *Highway Capacity Manual.*[5] Level of service is measured in terms of average control delay. Mathematically, control delay is a function of the capacity and degree of saturation of the lane group and/or approach under study and is a quantification of motorist delay associated with traffic control devices such as traffic signals and STOP signs. Control delay includes the effects of initial deceleration delay approaching a STOP sign, stopped delay, queue move-up time, and final acceleration delay from a stopped condition. Definitions for level of service at unsignalized intersections are also given in the 2010 *Highway Capacity Manual*. Table 8 summarizes the relationship between level of service and average control delay for two way stop controlled and all-way stop controlled intersections.

Table 8
LEVEL-OF-SERVICE CRITERIA FOR UNSIGNALIZED INTERSECTIONS[a]

Level-Of-Service by Volume-to-Capacity Ratio		Average Control Delay (Seconds Per Vehicle)
v/c ≤ 1.0	v/c > 1.0	
A	F	≤10.0
B	F	10.1 to 15.0
C	F	15.1 to 25.0
D	F	25.1 to 35.0
E	F	35.1 to 50.0
F	F	>50.0

[a]Source: *Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2010; page 19-2.

ANALYSIS RESULTS

Level-of-service analyses were conducted for 2022 Existing, 2029 No-Build and 2029 Build conditions for the intersections within the study area. The results of the intersection capacity analyses for signalized and unsignalized intersections are summarized in Table 9 through Table 10, with detailed analysis results provided in the Appendix. The following is a summary of the level-of-service and delay analyses for the intersections within the study area:

[5]*Highway Capacity Manual*; Transportation Research Board; Washington, DC; 2010.

Table 9
SIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2022 Existing			2029 No-Build			2029 Build		
Location/Time Period/Movement	V/C[a]	Delay[b]	LOS[c]	V/C	Delay	LOS	V/C	Delay	LOS
Route 146 at Boston Road									
Weekday Morning:									
Boston Road EB	0.79	72	E	0.90	82	F	0.91	82	F
Boston Road WB	1.01	91	F	1.11	115	F	1.11	115	F
Route 146 NB	0.78	30	C	0.86	36	D	0.86	36	D
Route 146 SB	0.52	18	B	0.59	20	B	0.59	20	B
Overall	--	**38**	**D**	--	**46**	**D**	--	**46**	**D**
Weekday Evening:									
Boston Road EB	0.59	63	E	0.62	65	E	0.62	65	E
Boston Road WB	0.68	56	E	0.77	58	E	0.78	59	E
Route 146 NB	0.57	29	C	0.64	32	C	0.64	32	C
Route 146 SB	0.67	24	C	0.81	27	C	0.81	27	C
Overall	--	**32**	**C**	--	**35**	**D**	--	**35**	**D**

[a]Volume to capacity ratio.
[b]Delay in seconds per vehicle.
[c]Level of service.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound

Signalized Intersection Capacity Analysis Results

Route 146 at Boston Road

Under 2022 Existing conditions the intersection of Route 146 with Boston Road currently operates at an overall LOS D or better during the weekday morning and weekday evening peak hours. Under future 2029 No-Build conditions, this intersection is projected to operate at LOS D during both the weekday morning peak and weekday evening peak hours. Under future Build conditions this location is projected to continue to operate at LOS D during both the weekday morning and weekday evening peak hours, with Project-related traffic increases resulting in increases to overall delays of less than one second per vehicle, as compared to No-Build conditions.

Table 10
UNSIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2022 Existing			2029 No-Build			2029 Build		
Location/Time Period/Movement	V/C[a]	Delay[b]	LOS[c]	V/C	Delay	LOS	V/C	Delay	LOS
Boston Road at Pleasant Valley Road and Dudley Road									
Weekday Morning Peak Hour									
Boston Road EB	0.01	<5	A	0.01	<5	A	0.01	<5	A
Boston Road WB	0.00	<5	A	0.00	<5	A	0.00	<5	A
Pleasant Valley Road NB	0.38	18	C	0.59	27	D	0.60	28	D
Dudley Road SB	0.08	12	B	0.11	13	B	0.11	13	B
Weekday Evening Peak Hour									
Boston Road EB	0.01	<5	A	0.01	<5	A	0.01	<5	A
Boston Road WB	0.00	<5	A	0.00	<5	A	0.01	<5	A
Pleasant Valley Road NB	0.36	18	C	0.56	29	D	0.60	31	D
Dudley Road SB	0.18	18	C	0.28	26	D	0.28	26	D
Route 146 at Pleasant Valley Road									
Weekday Morning Peak Hour									
Pleasant Valley Road WB	0.02	25	C	0.02	27	D	0.03	27	D
Route 146 NB	0.00	<5	A	0.00	<5	A	0.00	<5	A
Weekday Evening Peak Hour									
Pleasant Valley Road WB	0.03	17	C	0.04	18	C	0.06	19	C
Route 146 NB	0.00	<5	A	0.00	<5	A	0.00	<5	A
Pleasant Valley Road at Site Driveway									
Weekday Morning Peak Hour									
Pleasant Valley Road WB	--	--	--	--	--	--	0.01	<5	A
Site Driveway NB	--	--	--	--	--	--	0.00	9	A
Weekday Evening Peak Hour									
Pleasant Valley Road WB	--	--	--	--	--	--	0.00	<5	A
Site Driveway NB	--	--	--	--	--	--	0.02	9	A

[a]Volume to capacity ratio.
[b]Delay in seconds per vehicle.
[c]Level of service.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound

Unsignalized Capacity Analysis Results

Boston Road at Pleasant Valley Road and Dudley Road

Under 2022 Existing conditions, mainline traffic volumes along Boston Road, at its intersection with Pleasant Valley Road and Dudley Road, currently operate at LOS A conditions during both the weekday morning and weekday evening peak hours, with all movements from Pleasant Valley Road and Dudley Road operating at LOS C or better during both peak periods. Under future 2029 No-Build conditions, mainline traffic volumes on Boston Road are projected to continue to operate at LOS A, with all movements from Pleasant Valley Road and Dudley Road projected to operate at LOS D or better during both the weekday morning and weekday evening peak hours. Under future 2029 Build conditions, mainline traffic volumes on Boston Road are projected to continue to operate at LOS A, with all movements from Pleasant Valley Road and Dudley Road continuing to operate at LOS D or better during both the weekday morning and weekday evening peak hours. Project-related traffic increases are projected to result in minimal increases to side street delays, on the order of 1 to 2 second per vehicle.

Route 146 at Pleasant Valley Road

Under 2022 Existing conditions, critical movements at this unsignalized intersection (right-turns from Pleasant Valley Road) currently operate at LOS C or better during the weekday morning and weekday evening peak hours. Under future 2029 No-Build conditions, right-turns from Pleasant Valley Road are projected to operate at LOS D or better during the weekday morning and weekday evening peak hours. Under future 2029 Build conditions, right-turns from Pleasant Valley Road are projected to continue to operate at LOS D or better, with Project-related traffic volumes resulting in minimal increases to approach delays for this movement.

Pleasant Valley Road at Site Driveway

Under future 2029 Build conditions, mainline traffic volumes along Pleasant Valley Road, at its intersection with the proposed site driveway are projected to operate at LOS A during both the weekday morning and weekday evening peak hours, with the site driveway northbound approach operating at LOS A during both peak periods.

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

As documented in this report, the Project is expected to generate approximately 186 vehicle trips on a typical weekday (93 entering and 93 exiting), including 16 vehicle trips (13 entering and 3 exiting) during the weekday morning peak hour and 20 vehicle trips (6 entering and 14 exiting) during the weekday evening peak hour. In comparison to future No-Build conditions, Project-related traffic increases are expected to amount to only a 0.0 to 1.0 percent increase to traffic volumes at intersections located within the study area that are expected to accommodate the majority of Project-related traffic activity.

An analysis of traffic operations at the study area intersections indicates that in general, the Project will not result in a notable impact on motorist delays at study area intersections as compared to future No-Build conditions, with no notable impact to mainline traffic operations along either the Route 146, Boston Road or Pleasant Valley Road corridors.

RECOMMENDATIONS

Site Access

Access to the Project site is proposed via a new one-way right-in-only entrance drive from Route 146 and a full access and egress driveway onto Pleasant Valley Road. It is recommended that the proposed Pleasant Valley Road driveway be placed under STOP-sign control, with a painted STOP bar at the driveway approach to Pleasant Valley Road. In order to ensure safe and efficient access to the Project and that adequate sightlines are provided in both directions along Pleasant Valley Road, all signs and landscaping should be designed as to not impede lines of sight in both directions. Signage and pavement markings, including Do Not Enter signage should be placed at the Route 146 driveway to enforce the one-way traffic flow at this location prohibiting exiting traffic onto Route 146.

CONCLUSION

In summary, the addition of Project-related traffic to study area roadways and intersections is not anticipated to significantly impact traffic operations within the study area over No-Build conditions. As documented in this report, Project-related traffic increases do not result in significant impact to area traffic operations, with only minimal increases to motorist delays projected at the signalized intersection of Route

146 with Boston Road. With implementation of the above recommendations, the proposed Project can be built with minimal traffic impact on the surrounding roadway system.