Traffic Impact Assessment

TEC Project File No. T1215

Proposed Industrial Development

Littleton, Massachusetts

Submitted to: **Town of Littleton**
37 Shattuck Street
Littleton, MA 01460

On Behalf of: **V.M.D. Companies, LLC**
733 Turnpike St, Route 114
North Andover, MA 01845

Prepared by: **TEC, Inc.**
146 Dascomb Road
Andover, Massachusetts 01810

I have reviewed this document as it relates to the proposed design and have determined the design to be safe for public health and welfare in conformity with accepted engineering standards.

Elizabeth M. Oltman, PE
Director, Transportation Planning & ITS

March 29, 2022

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I. INTRODUCTION

TEC, Inc. (TEC) has been retained by V.M.D Companies, LLC, to prepare a Traffic Impact Assessment (TIA) associated with a proposed industrial development ("the Project") to be located on Monarch Drive in Littleton, Massachusetts. This TIA evaluates the existing conditions, access and egress, trip generation, traffic operations and identifies any off-site mitigation and safety improvements.

The Project will entail construction of a 98,000 Square Feet (SF) industrial building at the terminus of Monarch Drive, opposite the existing commercial development located at 1 Monarch Drive. Access and egress for the site will be provided via the Monarch Drive connection to Taylor Street via three driveways that will intersect the east side of Monarch Drive.

METHODOLOGY

TEC has evaluated the traffic operations for the study area under existing and future conditions consistent with the *Transportation Impact Assessment (TIA) Guidelines* issued by the Massachusetts Department of Transportation (MassDOT)[1] and the standards of the traffic engineering and transportation planning professions for the preparation of such reports. The future planning horizon examines traffic operations under existing pre-COVID conditions (2019), as well as a 10-year planning horizon (2029) for traffic volume projections, which includes an evaluation of the No Build conditions (without the proposed project), Build conditions (with the proposed project), and Build with Mitigation conditions (with the proposed project and any proposed mitigation). These conditions are compared to determine what, if any, additional off-site mitigation is necessary to provide reasonable traffic operations in the area after the project is complete.

[1] *Transportation Impact Assessment (TIA) Guidelines*; Massachusetts Department of Transportation; March 13, 2014.

II. EXISTING CONDITIONS

TRAFFIC STUDY AREA

A comprehensive field inventory of existing traffic conditions on the study area corridors and intersections was conducted during various site visits by TEC staff. The field investigations consisted of existing roadway geometrics, operating characteristics, study area safety concerns, and multi-modal accommodations. The study area was selected to contain the major roadways providing local access/egress to/from the project site.

Study Area Intersections

The study area was selected to contain the major roadways providing local access/egress to/from the project site. This includes an evaluation of intersections in which the Project site generated trips increase the peak hour traffic volume by more than 5 percent and/or by more than 100 vehicles per hour per MassDOT's *TIA Guidelines* (Section 3.I.C). The following intersections were evaluated as part of the study area:

1. Route 2 Eastbound Ramps / Taylor Street
2. Route 2 Westbound Ramps / Taylor Street
3. Taylor Street / Amazon Driveway
4. Taylor Street / Monarch Drive
5. Taylor Street / Foster Street

The study area intersections and project limits are shown graphically in Figure 1.

GEOMETRY

The field inventory included collection of existing roadway geometrics, pedestrian and bicycle accommodations, traffic volumes, sight distances, and safety data for the existing study area. A description of the existing roadway and intersection inventory is provided below.

Roadways

Taylor Street

Taylor Street traverses the study area in a general north-south alignment. Taylor Street is under Town of Littleton jurisdiction and is designated as an urban major collector in the vicinity of

Monarch Drive. In the vicinity of its full interchange with Route 2, Taylor Street is designated as an urban minor arterial under MassDOT jurisdiction. Taylor Street connects to Harvard Road and King Street to the north through the Town of Littleton and Hill Road and Liberty Square Road to the south. Taylor Street is generally 44-feet wide, providing one 12-foot travel lane and a 10-foot shoulder in each direction and is separated by a double-yellow centerline. Taylor Street has a posted speed limit of 40 miles per hour (MPH) in both directions. Land uses along Taylor Street near Monarch Drive consists of mainly industrial uses and areas of open and wooded space. There is a six-foot wide sidewalk provided along the west side of the roadway on the Route 2 and I-495 overpasses. There are no formal bicycle accommodations provided along Taylor Street.

Intersections

Route 2 Westbound Ramps / Taylor Street

The Route 2 Westbound ramps intersect Taylor Street from the west to form a three-legged, unsignalized intersection. The Taylor Street northbound approach consists of a single general purpose travel lane for through and left turn movements. The Taylor Street southbound approach consists of a through lane and a channelized right-turn lane. The Route 2 Westbound off-ramp approach consists of an exclusive left-turn lane and a channelized, exclusive right-turn lane. The Route 2 Westbound off-ramps operate under STOP sign control for the left turns and under YIELD sign control for the right turns. Taylor Street operates under free-flow conditions.

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Taylor Street / Amazon Driveway

The Amazon Driveway intersects Taylor Street from the west to form a three-legged, unsignalized intersection. The Taylor Street northbound and southbound approaches consist of a single general purpose travel lane with directional traffic separated by a double-yellow centerline. A 10-foot-wide shoulder is provided on both sides of the roadway. The Amazon Driveway eastbound approach consists of single wide general-purpose lane with directional flow separated by a raised landscaped median island. The Taylor Street northbound and southbound approaches operate under free-flowing conditions while the Amazon Driveway eastbound approach operates under STOP sign control. Right-turn prohibitions are posted for trucks exiting the Amazon Driveway except for local deliveries.

Taylor Street / Monarch Drive

Monarch Drive intersects Taylor Street from the west to form a three-legged, unsignalized intersection. The Taylor Street northbound and southbound approaches consist of a single general purpose travel lane with directional traffic separated by a double-yellow centerline. A 10-foot-wide shoulder is provided on Taylor Street southbound. The Monarch Drive eastbound approach consists of a single general purpose lane with directional travel separated by a double-

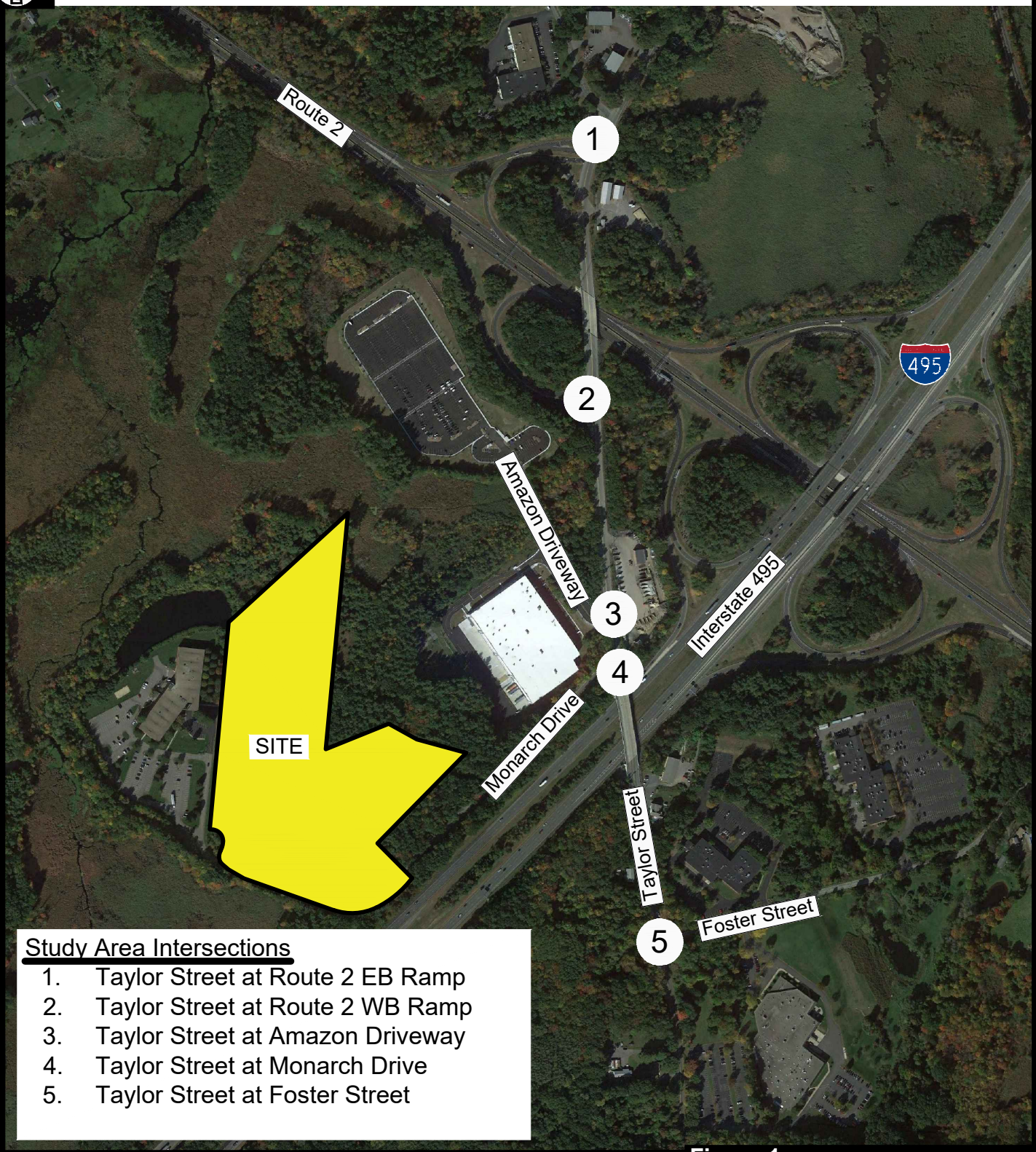
yellow centerline. The Taylor Street northbound and southbound approaches operate under free-flow conditions while the Monarch Drive eastbound approach operates under STOP sign control. Illuminations are provided at this intersection by way of streetlights mounted on utility poles.

Taylor Street / Foster Street

Foster Street intersects Taylor Street from the east to form a three-legged, unsignalized intersection. The Taylor Street northbound and southbound approaches consist of a single general purpose travel lane with directional traffic separated by a double-yellow centerline. A 10-foot-wide shoulder is provided on Taylor Street southbound. The Foster Street westbound approach consists of a single general purpose lane with directional travel separated by a single yellow centerline. The Taylor Street northbound and southbound approaches operate under free-flow conditions while the Foster Street westbound approach operates under STOP sign control.

North

1" = 600'



Study Area Intersections

1. Taylor Street at Route 2 EB Ramp
2. Taylor Street at Route 2 WB Ramp
3. Taylor Street at Amazon Driveway
4. Taylor Street at Monarch Drive
5. Taylor Street at Foster Street

Figure 1

Locus Map
Study Area Intersections

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PUBLIC TRANSPORTATION

The public transportation services are not provided along Taylor Street adjacent to the Project site; however, the Massachusetts Bay Transportation Authority (MBTA) provides commuter rail services via the Fitchburg Line, with the Littleton/Route 495 Commuter Rail Station located at Grimes Lane and Foster Street in Littleton, approximately 1.4 miles from the Project. The Fitchburg Line provides access to the North Station in Boston, where connections can be made to the MBTA Subway Orange Line, Green Line D and Green Line E. A surface parking lot is provided at this station which provides total of 226 parking spaces.

PEDESTRIAN AND BICYCLE ACCOMMODATIONS

There is a six-foot wide sidewalk provided along the west side of Taylor Street at the Route 2 and I-495 overpasses. No crosswalks or formal bicycle accommodations are provided within the study area.

EXISTING TRAFFIC VOLUMES

Traffic volume data for this report was obtained from Manual Turning Movement Counts (TMCs) and supplemented with Automatic Traffic Recorder (ATR) counts conducted at the study area intersections. The details of the data collection effort for this study are described below.

Turning Movement Counts

To establish existing traffic volume conditions within the study area, manual Turning Movement Counts (TMCs) were conducted during a typical weekday morning (7:00 AM – 9:00 AM) and weekday evening (4:00 PM – 6:00 PM) peak periods on Thursday, March 10, 2022. Area schools were in regular session during the time of the traffic counts.

Due to the impact of the COVID-19 pandemic and in order to confirm area traffic patterns, historic counts at the study area intersections were reviewed that were collected in October 2019 in conjunction with a Traffic Impact and Access Study that was conducted by Greenman-Pederson, Inc.[2] ("GPI 2019 Traffic Study"). These counts were performed during the weekday morning (6:00 AM to 9:00 AM) and weekday evening (3:00 PM to 6:00 PM) on Thursday October 10, 2019 at the following study locations:

1. Route 2 Eastbound Ramps / Taylor Street
2. Route 2 Westbound Ramps / Taylor Street
3. Taylor Street / Amazon Driveway
4. Taylor Street / Foster Street.

A detailed summary of the 2022 and 2019 turning movement counts, partitioned into 15-minute intervals, is provided within Appendix A.

Seasonal Adjustments

In accordance with MassDOT standards, traffic volumes are typically adjusted to average month conditions. To account for seasonal adjustment, TEC utilized MassDOT's weekday seasonal and

[2] Traffic Impact and Access Study; Proposed E-Commerce Distribution Center-Littleton Massachusetts; Greenman-Pedersen, Inc., October 2019

axle correction factors as published in 2019 (most recent publication). The factors provide a month-to-month overview of traffic volumes statewide by roadway functional classification and land (urban vs. rural) type. For urban major arterials, traffic volumes in the months of March and October were approximately 5.0 and 4.0 percent higher than average month conditions, respectively. In order to provide conservative analysis condition, the traffic volumes were not adjusted downward. The seasonal adjustment data is provided in Appendix B.

Please note that for comparison purposes, both the March 2022 and October 2019 traffic volumes were adjusted to average-month condition.

COVID 19 Pandemic Adjustments

Traffic volumes have been affected by and since the onset of the COVID-19 pandemic. TEC evaluated the March 2022 traffic counts based on a comparison with historic traffic volumes collected in October 2019. The TMCs collected in 2019 and 2022 were both adjusted to average-month conditions and the 2019 traffic volumes were expanded to 2022 by applying a background traffic growth rate of 1.0 percent per year (upwardly adjusted based upon MassDOT background growth rates). The direct traffic volume comparison shows that traffic volumes for March 2022 experienced significant fluctuations and changes in traffic patterns for the individual turning movements as compared with the 2019 pre-pandemic traffic volumes during weekday morning and weekday evening peak hours. Some of the 2022 individual turning movements were up to 60 percent less than the 2019 volumes on the same movement. This may be due to the proximity of this area to the commuter rail service, Interstate 495 (I-495) and Route 2, where commuter trips have been reduced, and it is not clear when or if the traffic pattern will return to pre-pandemic conditions. Therefore, to provide a conservative analysis of “normal” conditions, TEC utilized the October 2019 traffic volumes as the 2019 Baseline conditions. The specific turning movements entering and exiting Amazon Driveway and Monarch Drive were derived from the March 2022 counts.

The compiled COVID-19 comparison data is provided in Appendix C. The 2019 Baseline condition weekday morning and weekday evening peak hour traffic volume networks are illustrated in Figure 2.

Vehicle Speeds

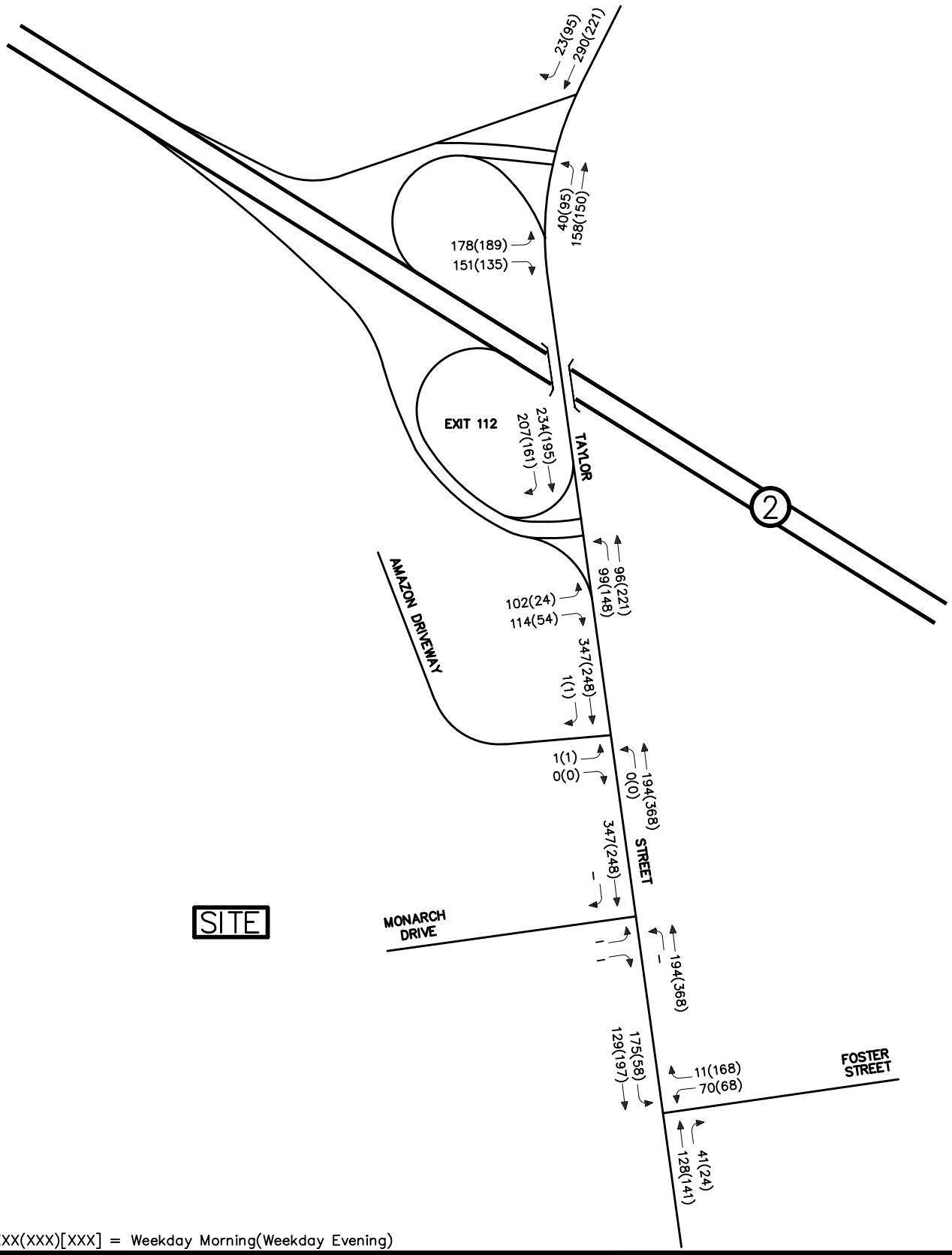
Automatic Traffic Recorder (ATR) counts were conducted for a continuous 48-hour mid-week period on Taylor Street, south of Monarch Drive on Wednesday, March 9, 2022 through Thursday, March 10, 2022 to determine vehicle speeds. A summary of the vehicle speed data is presented in Table 1. A detailed summary of the ATR data, partitioned into 15-minute intervals, is provided within Appendix A.

Table 1 – Vehicle Travel Speed Measurements

	Taylor Street	
	Northbound	**Southbound**
Mean Travel Speed (mph)	38	39
85th Percentile Speed (mph)	43	45
Posted Speed Limit (mph)	40	40

mph = miles per hour

As can be seen in Table 1, the mean vehicle travel speeds along Taylor Street in the vicinity of the Project site were found to be 38 mph in the northbound direction and 39 mph southbound. The measured 85th percentile vehicle travel speeds were found to be 43 mph in the northbound direction and 45 mph southbound, which is 3 to 5 mph above the posted speed limit of 40 mph.



XXX(XXX)[XXX] = Weekday Morning(Weekday Evening)

Figure 2

2019 Base
Weekday Morning and Weekday Evening
Peak Hour Traffic Volumes

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SAFETY ANALYSIS AND REVIEW

Sight Distance

TEC visited the site in March 2022 and measured the available sight distances at the Monarch Drive intersection with Taylor Street. The available sight lines were compared to minimum requirements established by the American Association of State Highway and Transportation Officials (AASHTO).

Sight distance represents the length of roadway that is visible to a driver traveling within the roadway. Two types of sight distance are typically evaluated for driveways and intersections: stopping sight distance (SSD) and intersection sight distance (ISD). SSD is the minimum distance required for a driver traveling along a roadway to perceive an object in the roadway and stop safely in advance of the object when traveling on a wet pavement surface. SSD is measured from an eye height of 3.5 feet to an object height of 2 feet above the ground, which is equivalent to a driver viewing the taillight of a vehicle ahead. SSD is measured along the centerline of the travel lane approaching the driveway or intersection.

ISD represents the length of the roadway visible to a driver waiting to exit a driveway or minor street. Minimum ISD requirements are based on the distance required for a driver to exit a minor street onto a major street without requiring an approaching vehicle to reduce its speed from the design speed to less than 70 percent of the design speed. ISD is measured from an eye height of 3.5 feet to an object height of 3.5 feet and is measured from a distance 15 feet beyond the edge of the travel-way of the major roadway to represent a driver waiting to exit a driveway or minor roadway.

SSD is typically considered the critical sight distance, as it represents the minimum distance required for safe stopping, while ISD represents and acceptable speed reduction for approaching vehicles. The ISA, however, must be at least equal to the minimum required SSD in order to prevent a driver from entering the roadway when an approaching vehicle is too close to safely stop. The guidance provided by AASHTO states:

> *"If the available sight distance for an entering or crossing vehicle is at least equal to the appropriate stopping sight distance for the major road, then drivers have sufficient sight distance to anticipate and avoid collisions. However, in some cases, this may require a major-road vehicle to stop or slow to accommodate the maneuver by a minor-road vehicle. To enhance traffic operations, intersection sight distances that exceed stopping sight distances are desirable along the major road."*

Tables 2 provides a summary of the available sight distances at Monarch Drive at Taylor Street.

Table 2 – Driveway Sight Distance Measurements

Approach / Direction	Operating Speed	AASHTO Recommended Minimum	Measured SSD/ISD
Taylor Street at Monarch Drive			
Stopping Sight Distance:			
North of Monarch Drive	45 MPH	360 FT	>500FT
South of Monarch Drive	45 MPH	360 FT	>500 FT
Intersection Sight Distance:			
Looking North (left)	45 MPH	360 FT	>500FT
Looking South (right)	45 MPH	360 FT	±400FT

Operating speed based upon 2022 recorded 85th percentile speeds along Taylor Street.

As shown in Table 2, the SSD along Taylor Street and minimum ISD for vehicles exiting Monarch Drive exceed AASHTO's minimum recommendations for safe operations at the intersection.

Crash History and Summary

Crash data for the study area intersections were compiled and analyzed for the most recent consecutive three-year period (2017-2019) of complete data on file with the MassDOT Interactive Mapping Portal for Analysis and Crash Tracking (IMPACT) online website. The motor vehicle crash data was reviewed to determine if any crash trends exist within the study area.

Crash Rate Worksheets

In addition to examining the number of crashes on the study corridor, an intersection crash rate was calculated to compare the occurrence of crashes to the volume of traffic passing through the study intersections. The crash rate per million entering vehicles (MEV) for intersections was calculated using the weekday evening peak hour volumes from the TMCs (2019 Baseline), a calculated K-factor obtained from the 2019 traffic volumes, and the total years of analyzed crash data. The crash rate at the intersections was compared to the statewide and district-wide averages published by MassDOT in June 2018 for intersections to determine the significance of the crash occurrence. The statewide average for unsignalized intersections is 0.57 crashes per MEV, and the District 3 average is 0.61 crashes per MEV. A summary of the vehicle crash data is provided in Table 3 and Appendix D.

Crash Data Summary

Route 2 Eastbound and Westbound Ramps at Taylor Street

Each of these intersections experienced one collision over the study period for an average of less than a collision per year. The crash rate of 0.11 and 0.13 at these intersections are well below the statewide and District 3 average for unsignalized intersections indicating no notable crash trends.

TEC acknowledges that the Town previously expressed concern regarding the number of collisions on the Taylor Street Ramps to/from Route 2 within the review of the GPI 2019 Traffic Study. Since these concerns were last raised, MassDOT conducted a resurfacing and improvement project for the Route 2 Ramps at Taylor Street, lengthening the merge and diverge areas at the ramps. Since 2019, a total of six (6) crashes occurred at the ramps, all resulting in

property damage only or non-fatal injuries. Five (5) of these were single vehicle crashes indicating no notable crash trends.

Taylor Street at Foster Street

The intersection of Taylor Street at Foster Street experienced three (3) collisions over the study period or an average of one collision per year. These crashes were angle crashes (2 of 3) and a single vehicle crash, which resulted in property damage only and non-fatal injury. The crash rate of 0.46 is below the statewide and District 3 average for signalized intersections period indicating no notable crash trends.

Taylor Street at Amazon Driveway and Monarch Drive

No crashes were occurred at the intersections of Taylor Street at Amazon Driveway and Taylor Street at Monarch Drive indicating no notable crash trends.

Table 3 – Crash Data Summary

Parameter		Route 2 WB Ramps at Taylor St.	Route 2 EB Ramps at Taylor St.	Taylor St. at Amazon Dwy.	Taylor St. at Monarch Dr.	Taylor St. at Foster St.
Type		Unsignalized	Unsignalized	Unsignalized	Unsignalized	Unsignalized
Crash Year	2017	1	1	0	0	1
	2018	0	0	0	0	2
	2019	0	0	0	0	0
	TOTAL	***1***	***1***	***0***	***0***	***3***
Average Annual		***0.30***	***0.30***	***0.00***	***0.00***	***1.0***
Crash Rate		***0.11***	***0.13***	***0.00***	***0.00***	***0.46***
Manner of Collision	Angled	1	0	0	0	2
	Rear-end	0	0	0	0	0
	Sideswipe	0	0	0	0	0
	Single Vehicle	0	1	0	0	1
	Head-On	0	0	0	0	0
	Ped / Bike	0	0	0	0	0
	Not Reported	0	0	0	0	0
	TOTAL	***1***	***1***	***0***	***0***	***3***
Road Surface Conditions	Dry	1	1	0	0	3
	Wet	0	0	0	0	0
	Snow / Ice	0	0	0	0	0
	Other / Unknown	0	0	0	0	0
	TOTAL	***0***	***1***	***0***	***0***	***0***
Injury Status (Crash Severity)	Property Damage	1	1	0	0	2
	Non-Fatal Injury	0	0	0	0	1
	Fatal Injury	0	0	0	0	0
	Not Reported	0	0	0	0	0
	TOTAL	***1***	***1***	***0***	***0***	***3***
Day of Week	Monday through Friday	1	1	0	0	3
	Saturday-Sunday	0	0	0	0	0
	TOTAL	***1***	***1***	***0***	***0***	***3***
Time of Day	6:00AM-9:00AM	0	0	0	0	1
	9:00AM-3:00PM	1	0	0	0	1
	3:00PM-6:00PM	0	0	0	0	1
	6:00PM-6:00AM	0	1	0	0	0
	TOTAL	***1***	***1***	***0***	***0***	***3***

III. FUTURE CONDITIONS

Traffic volumes in the study area were projected to the year 2029, which reflects a 10-year planning horizon from the 2019 Baseline condition. The traffic conditions for the year 2029, under No Build conditions, were developed to document the operating conditions independent of the potential development, including all existing traffic and new traffic resulting from background growth. Anticipated site generated traffic volumes for the potential development were superimposed upon the No Build traffic networks to reflect the Build conditions with the potential new development traffic.

BACKGROUND TRAFFIC GROWTH

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. Traffic engineers frequently employ an annual percentage increase in traffic growth, which is applied to all traffic volumes under study. The drawback to such a procedure is that some turning volumes may actually grow at either a greater or a lesser rate at particular intersections.

An alternative procedure identifies the location of other developments already in the permitting process, 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 potential growth in population and development external to the study area are not accounted for in the traffic projections.

To provide a conservative analysis framework, both procedures were used.

General Ambient Growth

To determine future traffic growth projections, TEC used the MassDOT published year-by-year annual growth data between 2016 and 2019. The data indicates that traffic volumes grew by approximately 0.8 percent per year on average between 2016 and 2019. In order to provide a conservative analysis scenario, a 1.0 percent per year compounded annual background traffic growth rate was used to account for potential future traffic growth external to the study area and any presently unforeseen development. The annual growth data is included in Appendix E.

Specific Developments by Others

TEC consulted with the Town of Littleton Planning Department to identify nearby private / public development projects in the vicinity of the study area that are either in the planning process or were recently approved by the municipal Planning Board / Zoning Board of Appeals. Based on

this consultation, the following developments were found that are anticipated to contribute significant amount of additional traffic volumes to the study area:

225 Taylor Street - Proposed Office/Research and Development (R&D)

This project entails the construction of 330,000 SF office/R&D to be located at 225 Taylor Street. The project was first approved in 2003, but the property has not been developed for its permitted use. Per discussions with the Planning Department, construction of the development is not imminent, therefore, the traffic associated with this development was not included as a specific adjacent development.

E-Commerce Distribution Development (Amazon Facility)

This project consists of constructing a ±143,640 SF last-mile, e-commerce distribution facility on the 151 Taylor Street parcel and overflow van parking on the 153 Taylor Street parcel. This development is currently constructed and operational. Since the project was not included in 2019 traffic volumes, the site generated traffic volumes were added to the roadway network using the March 2022 traffic counts performed at the driveway intersection with Taylor Street. TEC notes that the actual traffic generated by the facility during the commuter peak hours is slightly lower than that projected in the GPI 2019 Traffic Study.

Durkee Farm Estates

This project is located off Foster Street and Grimes Lane in Littleton and originally consisted of constructing 30 single-family homes, which has recently been expanded to 54 homes. According to the GPI 2019 Traffic Study, approximately 50 percent of the homes were constructed (15 homes) and occupied in 2019. At present, 48 homes are occupied, and 6 homes are under construction. In order to account for any additional traffic generated by this site subsequent to the 2019 counts, the trip generation projections for the original 30 single family homes were superimposed on the study area per the Traffic Impact and Access Study[3] submitted to the Town.

Single Family Homes

This project entails construction of 6 single-family homes off Grimes Lane. This project is currently under construction. The trips associated with this project were obtained from ITE for LUC 210 – Single-Family Detached Housing and assigned to the study area roadway networks.

No other future developments were found that are expected to result in an increase in traffic within the study area beyond the general background traffic growth rate. The background development networks are presented in Appendix F.

[3] *Traffic Impact and Access Study – Proposed Durkee Farm Estates*; MDM Transportation Consultants, Inc.; February 2016.

Area Roadway Projects

TEC coordinated with the Town of Littleton and MassDOT to identify nearby public roadway improvement projects in the vicinity of the study area that were in the design or planning process that may alter traffic flow at the intersection. The following project was identified:

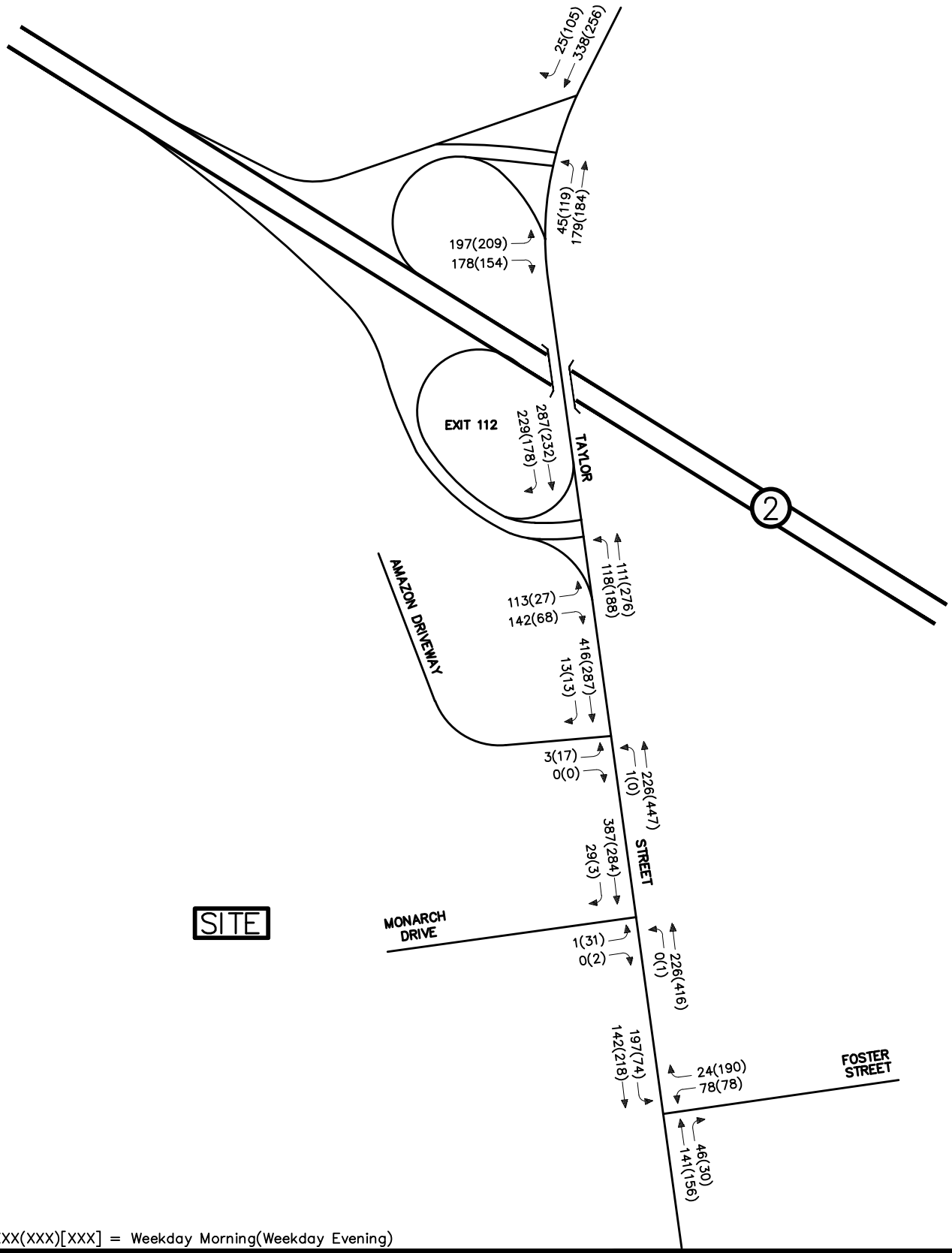
Reconstruction of Foster Street (MassDOT Project No. 609504)

The project consists of full-depth reconstruction of Foster Street from Taylor Street to Balsam Lane. Roadway reconstruction includes 10-foot-wide travel lanes with 2-foot-wide shoulders in either direction, construction of a 10-foot-wide shared-use path along the north side of Foster Street, separated from vehicles by a 3-foot wide concrete and crosswalk and wheelchair ramps at intersections. The Town of Littleton has raised funding for the design work for the next segment of reconstruction of Foster Street from Harwood Avenue to Tahattawan Road. These improvements are not expected to increase traffic or change the traffic pattern within the study area but provide additional opportunities for multi-modal users.

No other roadway improvement projects were identified.

2029 NO BUILD TRAFFIC VOLUMES

The 2029 No Build Condition weekday morning and weekday evening peak hour traffic volume networks were developed by applying the 1.0 percent per year compounded annual background traffic growth rate on the 2019 Baseline peak hour traffic volumes over the 10-year design horizon the adding the projected traffic generated by identified developments by others. The resulting 2029 No Build Condition weekday morning and weekday evening peak hour traffic volume networks are illustrated in Figure 3.



XXX(XXX)[XXX] = Weekday Morning(Weekday Evening)

Figure 3

2029 No-Build
Weekday Morning and Weekday Evening
Peak Hour Traffic Volumes

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Andover, MA 01810

SITE GENERATED TRAFFIC

The proposed Project consists of a 98,000 SF Industrial Building. Since a specific tenant has not been identified, three potential land uses were considered to estimate the Project trip generation. TEC estimated the site generated traffic based on industry standard trip rates published in the Institute of Transportation Engineers (ITE) publication, *Trip Generation, 11th Edition* for Land Use Codes (LUC) 110 – General Light Industrial, LUC 140 – Manufacturing, and LUC 150 – Warehousing. Table 4 provides a summary of the resulting trip generation estimate. The detailed trip generation calculation worksheets are provided in Appendix G.

Table 4 – Trip Generation Summary

Time Period	General Light Industrial LUC (110)	Warehousing (LUC 150)	Manufacturing (LUC 140)
Weekday Daily			
IN	210	97	233
OUT	210	97	233
TOTAL	420	194	466
Weekday Morning			
IN	62	13	51
OUT	8	4	16
TOTAL	70	17	67
Weekday Evening			
IN	6	5	23
OUT	34	13	50
TOTAL	40	18	73

As shown in Table 4, a 98,000 SF manufacturing land use is anticipated to generate approximately 466 new vehicle trips during the average weekday, while a 98,000 SF warehouse development is anticipated to generate approximately 194 new vehicle trips and a 98,00 SF general light industrial building is anticipated to generate 420 new vehicle trips. The manufacturing land use is projected to generate 67 new vehicle trips (51 entering and 16 exiting) during the weekday morning peak hour and 73 new vehicle trips (23 entering and 50 exiting) during the weekday evening peak hour, the highest of the three land uses considered.

In order to provide the most conservative (worst-case) analysis condition, the trip generation associated with a manufacturing land use was used for this analysis.

TRIP DISTRIBUTION

The distribution of site generated traffic volumes for employees was based on a gravity model using 2011-2015 U.S. Census Bureau Journey-to-Work/Home data for the Town of Littleton. The employee distribution models the commutes of residents of top 50 workforce cities and towns to Littleton, which represent approximately 80 percent of total Littleton commuters. The top 80 percent of workforce communities generally allow for an approximation of overall distribution of traffic. Additional communities at this level each contribute less than 0.5 percent of the Littleton workforce each which is deemed to not change the distribution of traffic calculations significantly.

The resulting trip distribution is provided in Table 5 with the gravity model included in Appendix H.

Table 5 – Trip Distribution Summary

Direction	Employees
Route 2 to/from east	60%
Route 2 to/from west	15%
Taylor Street to/from north	15%
Taylor Street to/from south	5%
Foster Street to/from east	5%
Total	**100%**

The trip distribution patterns for employees are depicted on Figure 4 with site generated trips presented in Figures 5.

2029 BUILD TRAFFIC VOLUMES

The 2029 Build Condition traffic volume networks consist of 2029 No Build Condition peak hour traffic volumes with the addition of the additional site generated traffic. The resulting 2029 Build Condition weekday morning and weekday evening traffic volume networks are presented in Figure 6.

Traffic Volume Increases

A summary of peak hour projected traffic volume increase outside of the study area that is the subject of this assessment is shown in Table 6. These increases are associated with the new traffic generated by the Project.

Table 6 – Traffic Volume Increases

Time Period	2029 No Build	2029 Build	Volume Increase	Percent Increase over No Build Condition
Taylor Street, north of Route 2 WB Ramps				
Weekday Morning	739	749	10	1.4
Weekday Evening	754	764	10	1.3
Route 2 WB, west of Taylor Street [a]				
Weekday Morning	1,659	1,693	34	2.0
Weekday Evening	3,203	3,225	22	0.7
Route 2 EB, west of Taylor Street [a]				
Weekday Morning	3,117	3,134	17	0.5
Weekday Evening	1,615	1,648	33	2.0
Foster Street, east of Taylor Street				
Weekday Morning	345	348	3	0.8
Weekday Evening	372	377	5	1.3
Taylor Street, south of Foster Street				
Weekday Morning	407	410	3	0.7
Weekday Evening	482	485	3	0.6

[a] Route 2 volumes recorded at Permanent Count Station 3072 in May 2021 with background growth rate applied.

As it can be seen in Table 6, Project related traffic volume increases beyond the study area over No Build conditions are anticipated to be less than 2% during the peak periods. This increase is negligible and would not be noticeable outside of the study area.

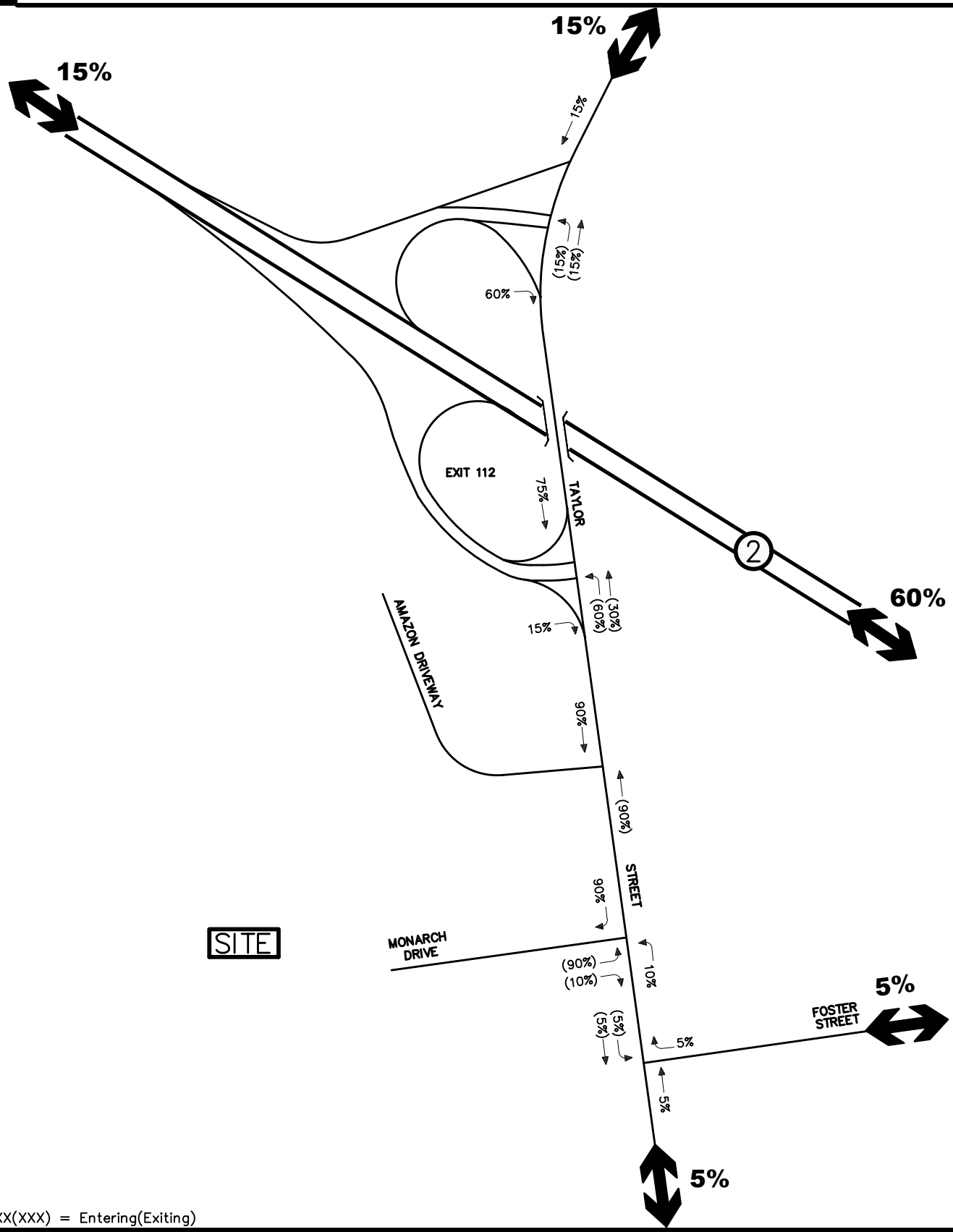
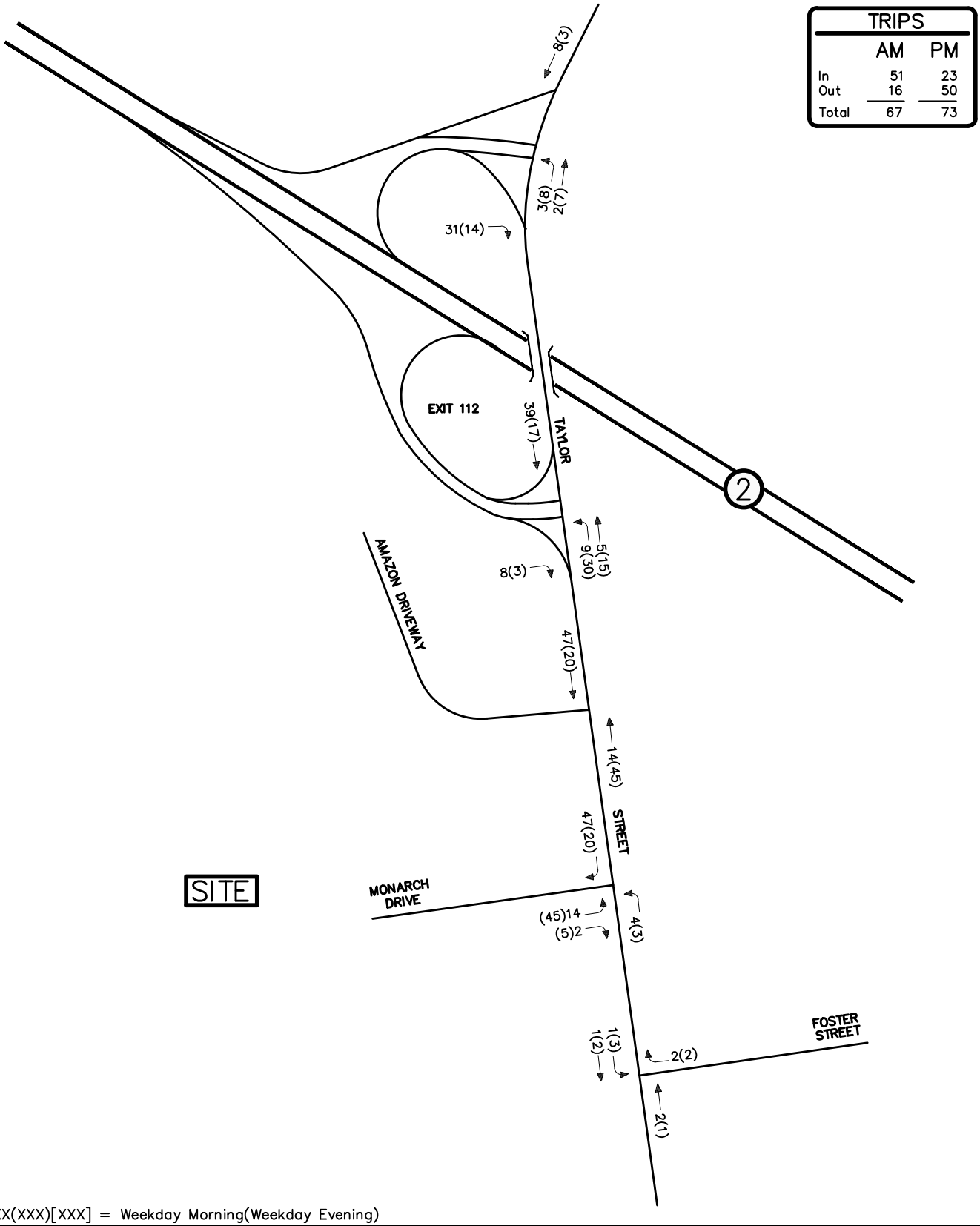


Figure 4

Trip Distribution

TEC, Inc.
146 Dascomb Road
Andover, MA 01810

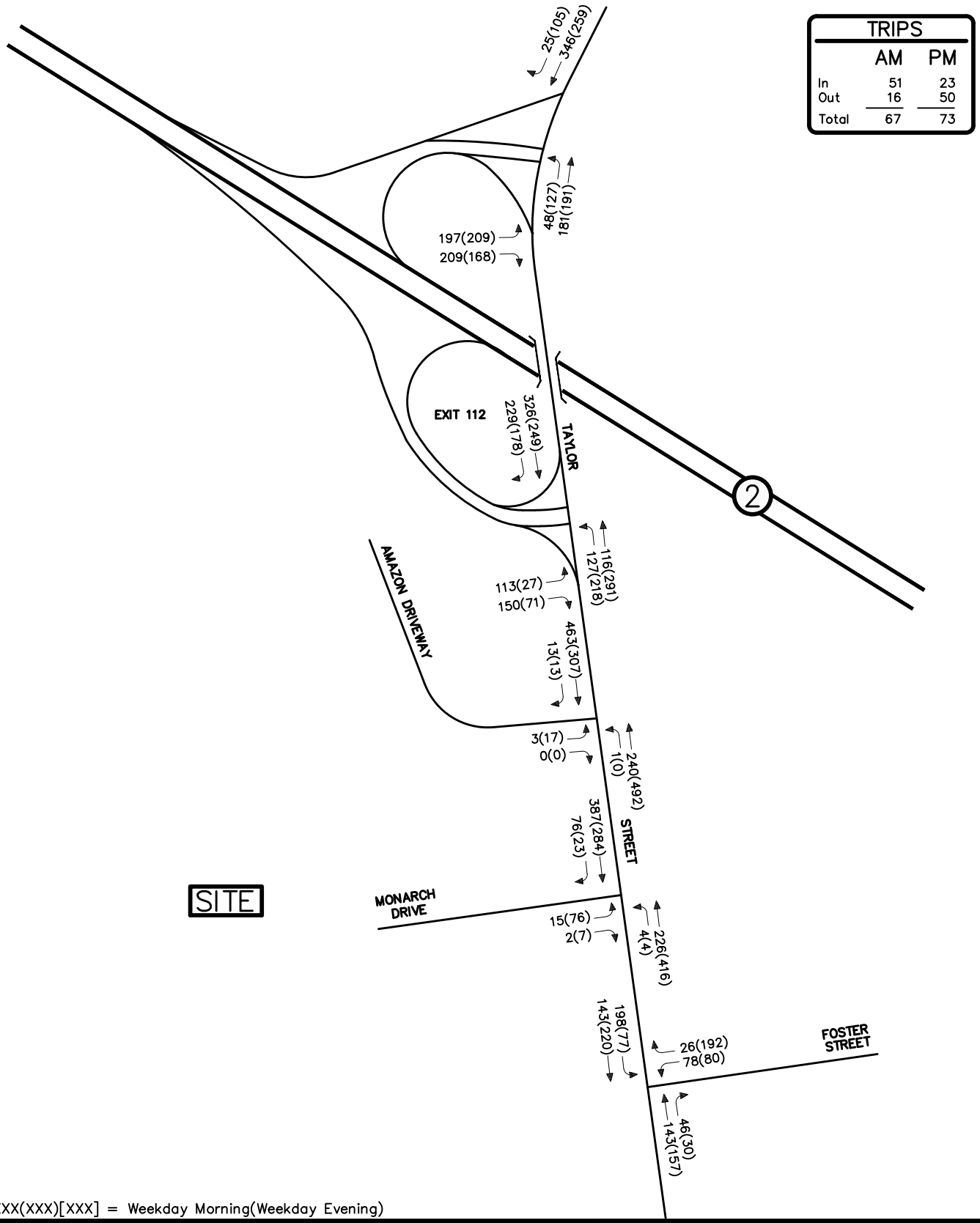


XXX(XXX)[XXX] = Weekday Morning(Weekday Evening)

Figure 5

Site-Generated Traffic
Weekday Morning and Weekday Evening
Peak Hour Traffic Volumes

TEC, Inc.
146 Dascomb Road
Andover, MA 01810



XXX(XXX)[XXX] = Weekday Morning(Weekday Evening)

Figure 6

2029 Build
Weekday Morning and Weekday Evening
Peak Hour Traffic Volumes

TEC, Inc.
146 Dascomb Road
Andover, MA 01810

IV. 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

Unsignalized Intersections

The levels of service of two-way stop-controlled unsignalized intersections are determined by application of a procedure described in the *HCM* 6th Edition. 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 *HCM* 2000.

Table 7 summarizes the relationship between LOS and control delay. The tabulated control delay criterion may be applied in assigning LOS designations to individual lane groups, to individual intersection approaches, or to entire intersections.

Table 7 – Level of service Criteria for Unsignalized Intersections [a]

Level of Service (v/c ≤ 1.0)	Level of Service (v/c > 1.0)	Average Control Delay (sec/veh)	Description
A	F	≤10.0	LOS A represents a condition with little or no control delay to minor street traffic.
B	F	10.1 to 15.0	LOS B represents a condition with short control delays to minor street traffic.
C	F	15.1 to 25.0	LOS C represents a condition with average control delays to minor street traffic.
D	F	25.1 to 35.0	LOS D represents a condition with long control delays to minor street traffic.
E	F	35.1 to 50.0	LOS E represents operating conditions at or near capacity level, with very long control delays to minor street traffic.
F	F	>50.0	LOS F represents a condition where minor street demand volume exceeds capacity of an approach lane, with excessive control delays resulting.

[a] Source: *Highway Capacity Manual 6th Edition*; Transportation Research Board; Washington D.C.; 2017

TRAFFIC IMPACT ANALYSIS RESULTS

Level of service analyses were conducted for the 2019 Baseline condition, 2029 No Build condition and 2029 Build condition for the study area intersections. The results of the intersection capacity analysis are summarized in Table 8. The capacity analysis worksheets are provided in Appendix I.

Taylor Street / Route 2 Westbound Ramps

In the No Build condition, all movements are expected to operate at acceptable levels of service (LOS D or better) during both peak hours studied. In addition, the volume-to-capacity (V/C) ratios on each movement are anticipated to be well below 1.00, indicating that adequate capacity is provided on each approach. In the Build condition, these LOS are generally maintained, with only the eastbound left turn movement operating with a LOS E during the evening peak hour. The Project does not add any vehicles to this movement. The increase in delay to the movement is an average of 3 seconds per vehicle during the peak period. The addition of the site generated vehicles will not noticably impact the operation of the intersection during the peak hours.

Taylor Street / Route 2 Eastbound Ramps

In the No Build condition, all movements are expected to operate at acceptable levels of service (LOS D or better) during both peak hours studied. In addition, the volume-to-capacity (V/C) ratios on each movement are anticipated to be well below 1.00, indicating that adequate capacity is provided on each approach. In the Build condition, these LOS are maintained. The addition of the site generated vehicles will not noticably impact the operation of the intersection during the peak hours.

Taylor Street / Amazon Driveway

Under 2029 No Build and Build conditions, all movements at this intersection are expected to operate with acceptable levels of service (LOS C or better) during peak periods with minimal vehicle queuing.

Taylor Street / Monarch Drive

Under 2029 No Build and Build conditions, all movements at this intersection are expected to operate with acceptable levels of service (LOS C or better) during peak periods with minimal vehicle queuing.

Taylor Street / Foster Street

Under 2029 No Build and Build conditions, all movements at this intersection are expected to operate with acceptable levels of service (LOS C or better) during peak periods with minimal vehicle queuing.

Table 8 – Intersection Capacity and Queue Analysis Summary-Unsignalized

	2019 Baseline				2029 No Build				2029 Build			
Intersection / Lane Group	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Taylor Street at Route 2 Westbound Ramps												
Weekday Morning Peak Period												
Rte. 2 WB Ramp EBL	0.42	18.4	C	50	0.53	23.9	C	78	0.55	24.9	C	80
Rte. 2 WB Ramp EBR	0.22	11.4	B	<25	0.29	12.4	B	30	0.34	13.1	B	38
Taylor Street NB	0.04	8.1	A	<25	0.04	8.2	A	<25	0.05	8.3	A	<25
Weekday Evening Peak Period												
Rte. 2 WB Ramp EBL	0.54	23.9	C	78	0.66	34.1	D	113	0.70	37.9	E	123
Rte. 2 WB Ramp EBR	0.19	10.7	B	<25	0.22	11.1	B	<25	0.24	11.3	B	<25
Taylor Street NB	0.08	8.0	A	<25	0.10	8.1	A	<25	0.11	8.2	A	<25
Taylor Street at Route 2 Eastbound Ramps												
Weekday Morning Peak Period												
Rte. 2 EB Ramp EBL	0.33	20.1	C	35	0.40	24.0	C	45	0.44	27.8	D	53
Rte. 2 EB Ramp EBR	0.20	11.8	B	<25	0.25	12.7	B	25	0.28	13.5	B	28
Taylor Street NB	0.10	8.1	A	<25	0.11	8.3	A	<25	0.12	8.5	A	<25
Weekday Evening Peak Period												
Rte. 2 EB Ramp EBL	0.10	19.7	C	<25	0.15	25.7	D	<25	0.18	30.9	D	<25
Rte. 2 EB Ramp EBR	0.08	10.3	B	<25	0.11	10.8	B	<25	0.11	11.0	B	<25
Taylor Street NB	0.12	8.0	A	<25	0.16	8.2	A	<25	0.18	8.4	A	<25
Taylor Street at Amazon Driveway												
Weekday Morning Peak Period												
Amazon Driveway EBL	--	--	--	--	0.01	15.1	C	<25	0.01	16.6	C	<25
Amazon Driveway EBR	--	--	--	--	0.00	0.0	A	<25	0.00	0.0	A	<25
Taylor Street NB	--	--	--	--	0.00	8.3	A	<25	0.00	8.4	A	<25
Weekday Evening Peak Period												
Amazon Driveway EBL	--	--	--	--	0.05	15.7	C	<25	0.06	16.9	C	<25
Amazon Driveway EBR	--	--	--	--	0.00	0.0	A	<25	0.00	0.0	A	<25
Taylor Street NB	--	--	--	--	0.00	0.0	A	<25	0.00	0.0	A	<25

See notes at the end of the table.

Table 8 – Intersection Capacity and Queue Analysis Summary-Unsignalized (Continued)

	2019 Baseline				2029 No Build				2029 Build			
Intersection / Lane Group	V/C[a]	Delay[b]	LOS[c]	Queue[d]	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Taylor Street at Site Driveway												
Weekday Morning Peak Period												
Site Driveway EB	--	--	--	--	0.04	13.6	B	<25	0.04	14.2	B	<25
Taylor Street NBL	--	--	--	--	0.00	0.00	A	<25	0.00	8.4	A	<25
Weekday Evening Peak Period												
Site Driveway EB	--	--	--	--	0.09	15.5	C	<25	0.24	17.7	C	25
Taylor Street NBL	--	--	--	--	0.00	9.2	A	<25	0.01	9.3	A	<25
Taylor Street at Foster Street												
Weekday Morning Peak Period												
Foster Street WB	0.34	22.4	C	35	0.34	21.7	C	38	0.37	23.2	C	40
Taylor Street NB	0.00	0.0	A	<25	0.00	0.0	A	<25	0.00	0.0	A	<25
Taylor Street SB	0.17	8.2	A	<25	0.20	8.2	A	<25	0.16	8.1	A	<25
Weekday Evening Peak Period												
Foster Street WB	0.41	13.7	C	50	0.45	15.1	C	58	0.48	15.9	C	65
Taylor Street NB	0.00	0.0	A	<25	0.00	0.0	A	<25	0.00	0.0	A	<25
Taylor Street SB	0.00	0.00	A	<25	0.06	7.9	A	<25	0.06	7.9	A	<25

[a] Volume-to-capacity ratio,
[b] Delay expressed in seconds per vehicle (average)
[c] Level of service,
[d] 50th/95th Percentile Queue [95th Percentile Queue only for unsignalized intersections]

V. TRANSPORTATION DEMAND MANAGEMENT

The Applicant will provide a dynamic Transportation Demand Management (TDM) program in order to reduce Single Occupancy Vehicle (SOV) trips to/from the site. At this time, the Applicant is committed to provide the following TDM measures:

Public Transportation Measures

- Maps / Schedules – Provide public transportation schedules with transit maps for the MBTA Commuter Rail to each employee and will be posted within the employee break areas of the building.

- Transportation Management Association (TMA) – Coordinate with the Cross Town Connect TMA within the Town of Littleton for potential membership and participation in a commuter shuttle route to the site.

Bicycle and Pedestrian Measures

- Bicycle Racks - Provide secure bicycle parking racks within the Project site.

Parking Accommodations

- Preferential Parking Spaces – Provide preferential parking spaces for carpools and provide reserved electric vehicle (EV) charging stations (at least 10 EV stations to be provided).

Other Measures

- Marketing of Transportation Options and Benefits **–** A welcome packet for all employees will be distributed that includes information for all transportation related benefits, promotions, and local transportation options; including location of MBTA stops, transit schedules, EV and carpool parking locations, and any other emerging new mobility locations.

- Rideshare pick up/drop off location – Locate a safe, efficient pick up/drop off location for rideshare services that is outside of any heavy truck traffic flow. Provision for efficient access to ridesharing services aids in the reduction of need for employee personal vehicles.

- On-site Amenities – Provide a breakroom equipped with a microwave and refrigerator; offering direct deposit of paychecks, allowing telecommuting or flexible work schedules and other such measures within the Project building to reduce the number of employees convenience trips by automobile.

VI. CONCLUSION

TEC has examined the potential traffic impacts associated with the proposed Industrial Development in Littleton, Massachusetts on the study area roadways. The following is a summary of the results and conclusions of this effort:

- The proposed industrial development consists of 98,000 SF industrial development to be located at Monarch Drive.

- Since specific tenant is not finalized, the most conservative (worst case) land use code for a manufacturing end user was used to project the traffic to be generated by the proposed Project. The Project is anticipated to generate approximately 466 new vehicle trips (233 entering and 233 exiting) during the average weekday with 67 new vehicle trips (51 entering and 16 exiting) during the weekday morning peak hour and 73 new vehicle trips (23 entering and 50 exiting) during the weekday evening peak hour.

- The study area intersections operate with acceptable levels of service under the 2029 Build Conditions, indicating that the proposed Project will not significantly impact peak hour traffic operations throughout the study area.

- Movements exiting Monarch Drive are expected to operate at LOS C or better with minimal vehicle queuing. The available Intersection Sight Distances at the Monarch Drive intersection with Taylor Street are in excess of AASHTO minimum requirements.

- No safety deficiencies were noted regarding the crash history at the study area intersections, with all the intersections having average crash rates less than MassDOT statewide and District 3 average crash rates for similar intersections and no discernable crash trends.

- The Applicant will provide a dynamic and extensive TDM program in order to reduce SOV trips to/from the site and promote multi-modal travel. A full compilation of TDM measures have been identified and include provisions to promote transit use to/from the Project and decrease the impacts of vehicle emissions.

In conclusion, the proposed industrial development can be safely and efficiently accommodated within the study area intersections and does not warrant any additional project-specific transportation mitigation.