

FILE

TRAFFIC IMPACT AND ACCESS STUDY

Proposed Residential Development – Grafton, Massachusetts

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NOV - 6 2014

REF: NHX-2009600.01

DATE: November 5, 2014

PLANNING BOARD
GRAFTON, MA

TO: Mr. Normand Gamache, Jr., P.L.S.
Guerriere & Halnon, Inc.
1029 Providence Road
Whitinsville, MA 01588

RECEIVED

NOV - 6 2014

FROM: Ms. Erica L. Guidoboni, P.E.
Ms. Susannah E. Barnes, E.I.T.

PLANNING BOARD
GRAFTON, MA

RE: Traffic Impact and Access Study
Proposed Residential Development
Institute Road – Grafton, Massachusetts

INTRODUCTION

Greenman-Pedersen, Inc. (GPI) has prepared this Traffic Impact and Access Study (TIAS) for a proposed residential development project to be located on Institute Road, south of Westboro Road (Route 30) in Grafton, Massachusetts. The site is currently undeveloped. As proposed, the development consists of constructing approximately 46 to 51 single-family homes, with the range of homes representing a conventional subdivision (46 units) and flexible subdivision (51 units). This TIAS evaluates the traffic impacts and access/egress requirements for the proposed development, at its most.

The site is bounded by undeveloped land to the west and south, Institute Road to the east, and Westboro Road to the north. Access to the site is proposed via two unsignalized full access and egress roadways on Institute Road. Both Institute Road and Westboro Road are under local jurisdiction, classified as a local road and rural major collector, respectively. The site location in relation to the surrounding roadways is shown in Figure 1.

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EXISTING CONDITIONS

Study Area

Evaluation of the traffic impacts associated with the proposed project requires an evaluation of existing and projected traffic volumes on the adjacent streets, the volume of traffic expected to be generated by the project, and the impact that this traffic will have on the adjacent streets and nearby intersections. In preparing the TIAS for the proposed site, the following intersections have been analyzed and evaluated:

- Westboro Road (Route 30) and Institute Road (unsignalized)
- Institute Road and East Street (unsignalized)

Westboro Road (Route 30) at Institute Road

Westboro Road (Route 30) and Institute Road intersect to form a three-way unsignalized intersection. The Westboro Road eastbound and westbound approaches each provide a single general purpose travel lane operating under free-flowing conditions. Directional travel along Westboro Road is separated by a double-yellow centerline. Institute Road is not striped in the vicinity of the intersection with Westboro Road but is 18 feet wide, providing adequate width for northbound and southbound traffic flow. Traffic on Institute Road is under STOP-sign control. The STOP-sign on Institute Road is located in advance of the STOP-line due to vegetation along the easterly side of Institute Road that would obscure the sign if placed near the STOP-line. The STOP-sign appears to be within the required maximum distance from the STOP-line based on Manual of Uniform Traffic Control Devices (MUTCD) standards.¹ In order to increase driver awareness of the approaching intersection, it is recommended that a STOP AHEAD (W3-1) sign be posted on Institute Road at least 125 feet in advance of the STOP-line at Westboro Road with a distance plaque (W16-2a) sign mounted below to indicate the distance to the STOP-line. No sidewalks, crosswalks or bicycle accommodations are provided in the vicinity of the intersection.

Institute Road at East Street

Institute Road and East Street intersect to form three unsignalized intersections. Neither Institute Road nor East Street is striped but both are 18 feet wide and provide two-directional travel. The northern intersection consists of the intersection of Institute Road and East Street (North). Institute Road northbound and southbound approaches are free-flowing and the East Street eastbound approach operates under STOP-sign control. The southern intersection consists of the intersection of Institute Road and East Street (South). The Institute Road northbound and East Street eastbound approaches are free-flowing, and the Institute Road southbound approach operates under STOP-sign control. The western intersection consists of the intersection of East

¹Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition; Federal Highway Administration; December 2009.

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Street, East Street (North), and East Street (South). The East Street (North) southbound approach to the intersection operates STOP-sign control. No sidewalks, crosswalks or bicycle accommodations are provided in the vicinity of the intersection.

Traffic Volumes

Base traffic conditions within the study area were developed by conducting automatic traffic recorder (ATR) counts, manual turning movement counts (TMCs), and vehicle classification counts. The ATR counts were conducted along Institute Road adjacent to the site for a 48-hour period to record weekday daily traffic volume information in April 2014. The TMCs and vehicle classification counts were performed during the weekday morning peak period (7:00 to 9:00 AM) and the weekday evening peak period (4:00 to 6:00 PM) in April 2014. All traffic count data are provided in the Appendix.

Traffic on a given roadway typically fluctuates throughout the year depending on the area and the type of roadway. To determine if the April traffic volume data required adjustment to account for this fluctuation, historical traffic volume data were reviewed from the Massachusetts Department of Transportation (MassDOT) records.² This information revealed that typically April traffic volumes are 1.0 percent above average month conditions. To provide a conservative analytical framework (higher than average), the collected data were used as counted to reflect an above average month analysis condition. The MassDOT seasonal adjustment data are provided in the Appendix.

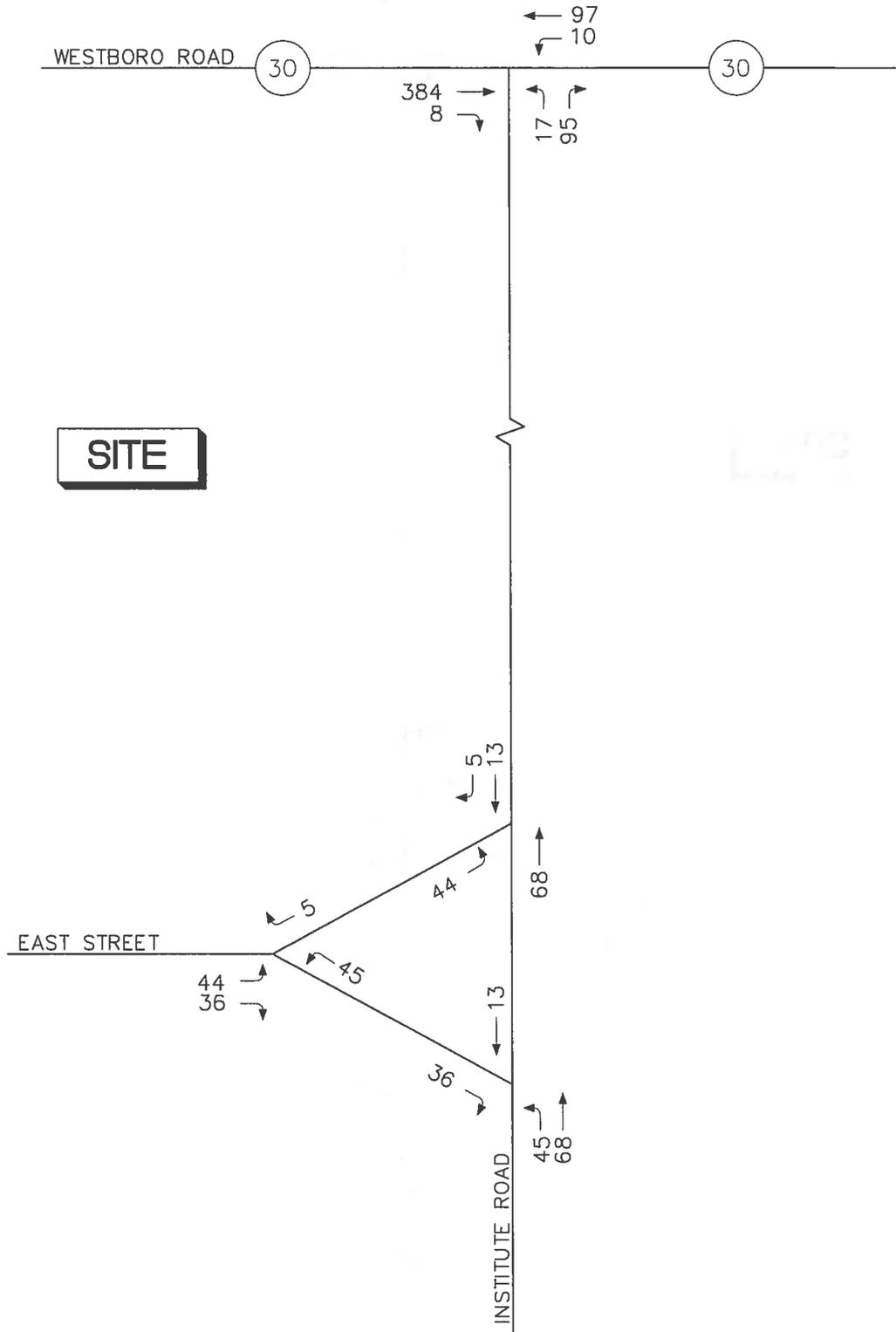
It should be noted that peak hour traffic volumes travelling northbound and southbound along Institute Road are slightly imbalanced from East Street to Westboro Road (Route 30) within the raw traffic counts. This imbalance can be attributed to vehicular activity associated with the institutional facilities (Commonwealth of Massachusetts property) located at 34-42 Institute Road. The peak hour volumes equate to approximately 5 and 7 vehicles in the weekday morning and evening peak hours, respectively, which is considered minor. In addition, the access road to the institutional facility is under State Institutional jurisdiction, and therefore not under Town right-of-way. For reference, raw traffic count data figures are provided in the Appendix.

Table 1 summarizes the existing daily and peak hour traffic volumes on Institute Road adjacent to the site. The balanced 2014 Existing traffic volume networks for the weekday morning (AM) and weekday evening (PM) peak hours are shown graphically on Figures 2 and 3, respectively.

²MassDOT 2009 Traffic Volumes; Permanent Count Station 310 – Route 146, south of Purgatory Road (Sutton).

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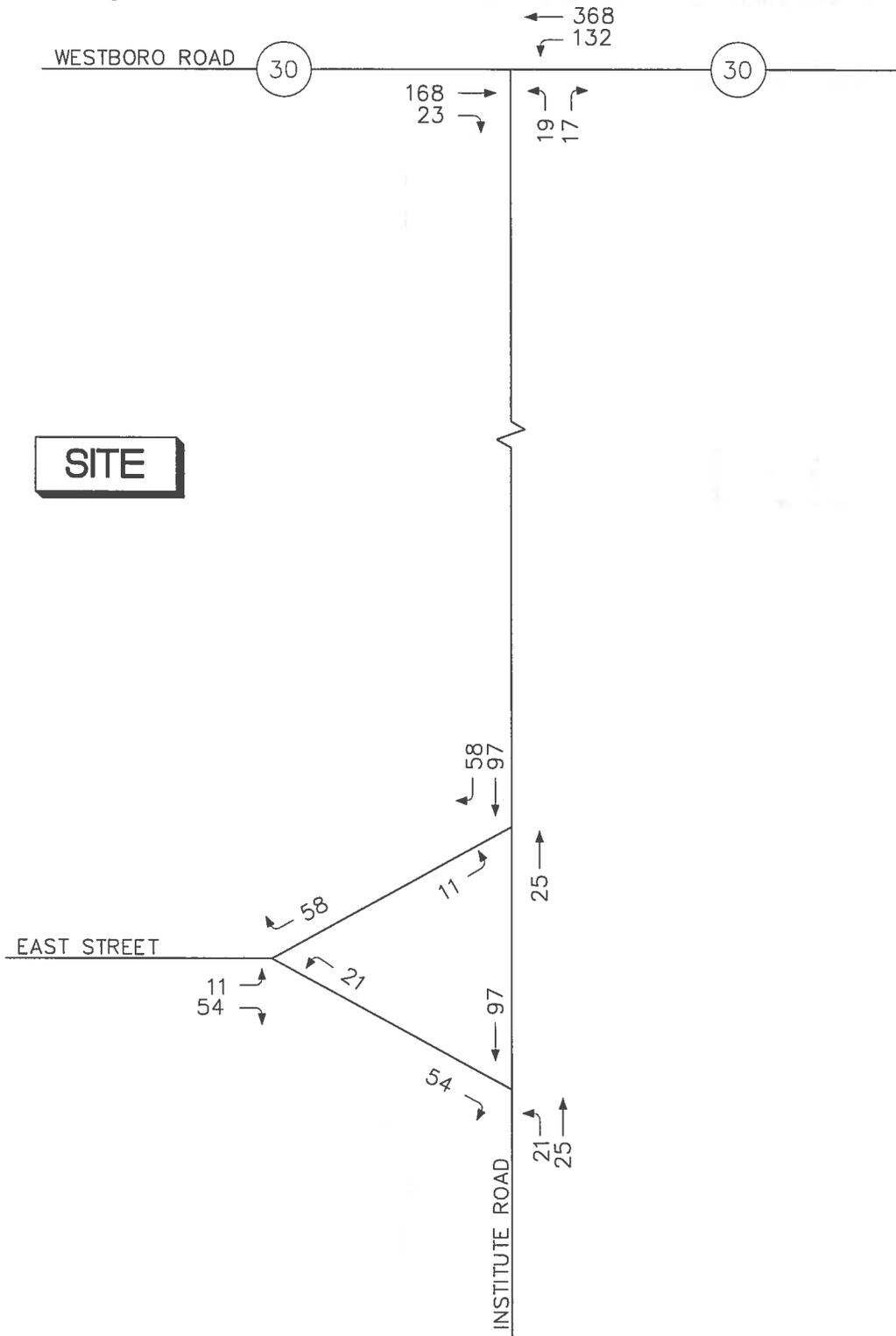


NOT TO SCALE

Figure 2
2014 Existing
Weekday AM
Peak Hour Traffic Volumes

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NOT TO SCALE

Figure 3
2014 Existing
Weekday PM
Peak Hour Traffic Volumes

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Table 1
EXISTING TRAFFIC VOLUME SUMMARY

Location/Time Period	Daily Volume (vpd) ^a	Peak Hour Volume (vph) ^b	K Factor (%) ^c	Directional Distribution ^d
Institute Rd. south of Westboro Rd.:				
Weekday Daily	1,400			
Weekday AM Peak Hour		130	9.3	86% NB
Weekday PM Peak Hour		191	13.6	81% SB

^a Vehicles per day.

^b Vehicles per hour.

^c Percentage of daily traffic occurring during the peak hour.

^d NB= northbound; SB = southbound.

Collision Analysis

Collision data for the study area intersections were obtained from MassDOT for the latest three years available (2009 through 2011). Collision records were also requested from the Grafton Police Department for the latest three years available (2011 through 2013), which resulted in no crashes at the two study area intersections. A summary of the crash data at the study area intersections is provided in Table 2.

In addition to the collision summary, crash occurrence also should be compared to the volume of traffic through a particular intersection to determine any significance. Accordingly, the crash rates were calculated for each study area intersection and compared with the statewide and district-wide (District 3) averages. An intersection crash rate is a measure of the frequency of collisions compared to the volume of traffic through an intersection and is presented in crashes per million entering vehicles (c/mev). For unsignalized intersections, the statewide average is 0.60 c/mev and the district-wide average is 0.66 c/mev. A comparison of the calculated crash rate to these averages can be used to establish the significance of collision occurrence and whether potential safety problems exist. Crash rate worksheets are provided in the Appendix.

The intersection of Westboro Road at Institute Road experienced one reported collision over the three-year study period. The rear-end collision occurred in snowy conditions and resulted in property damage only, no personal injuries reported. The calculated crash rate for the intersection is 0.17 c/mev, which is well below the statewide and district-wide averages for unsignalized intersections. The intersection of Institute Road at East Street experience one reported collision over the three-year study period. The collision was a sideswipe in the same direction and occurred in dry conditions, resulting in property damage only, no personal injury. Additionally, the crash rate (0.47 c/mev) is well below the statewide and district-wide averages for unsignalized intersections.

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**Table 2
COLLISION SUMMARY**

Location	Number of Collisions			Severity ^a			Collision Type ^b					Percent During	
	Total	Average per Year	Crash Rate ^c	PD	PI	F	CM	RE	HO	FO	Ped	Commuter Peak ^d	Wet/Icy Conditions
MassDOT (2009-2011)													
Westboro Road at Institute Road	1	0.33	0.17	1			1					0%	100%
Institute Road at East Street	1	0.33	0.47	1			1					0%	0%

Source: Grafton Police Department Records (2011-2013) and MassDOT Database (2009-2011).

^a PD = property damage only; PI = personal injury; F = fatality.

^b CM = cross movement/angle; RE = rear end; HO = head on; FO = fixed object; Ped = pedestrian.

^c Measured in crashes per million entering vehicles.

^d Percent of vehicle collisions that occurred during the weekday AM and weekday PM commuter peak periods.

Vehicle Speeds

Speed measurements were conducted along Institute Road adjacent to the site by measuring the elapsed time for vehicles traveling a short, pre-measured distance between two checkpoints. The travel time was recorded using ATRs and the speed was derived by dividing the elapsed time into the measured distance between checkpoints. The primary use for this information is explained in the *Sight Distance* section of this study where the speeds are correlated to sight distance measurements taken at the locations of the site roadways to assure that adequate sight distance exists at these roadways to provide safe operation. The results of the speed measurements are summarized in Table 3.

**Table 3
OBSERVED TRAVEL SPEEDS^a**

Location/Direction	Enforced Speed Limit	Average Speed	85 th Percentile Speed ^b
Institute Road adjacent to the site:			
<i>Northbound</i>	30	39	43
<i>Southbound</i>	30	37	42

^a miles per hour (mph).

^b speed at, or below which 85 percent of all observed vehicles travel.

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As shown in Table 3, the average speed on Institute Road adjacent to the site was found to be between 37 to 39 miles per hour (mph) with the 85th percentile speed between 42 and 43 mph. The speeds along Institute Road were observed to be higher than the enforced speed limit of 30 mph and are likely the result of low traffic volumes and the limited number of curb cuts on the roadway.

Sight Distance

Access to and egress from the site is proposed to be provided via two unsignalized site roadways on Institute Road approximately 750 feet and 1,800 feet south of Westboro Road. To identify potential safety concerns associated with site access and egress, sight distances have been evaluated at the proposed site roadway locations to determine if the available sight distances for vehicles exiting the site meet or exceed the minimum distances required for approaching vehicles to safely stop. The available sight distances were compared with minimum requirements, as established by the American Association of State Highway and Transportation Officials (AASHTO)³. AASHTO is the national standard by which vehicle sight distance is calculated, measured, and reported. MassDOT and the Executive Office of Energy and Environmental Affairs (EEA) require the use of AASHTO sight distance standards when preparing traffic impact assessments and studies, as stated in their guidelines for traffic impact assessments.

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

Intersection sight distance (ISD) is provided on minor street approaches to allow the drivers of stopped vehicles a sufficient view of the major roadway to decide when to enter the major roadway. By definition, ISD is the minimum distance required for a motorist exiting a minor street to turn onto the major street, without being overtaken by an approaching vehicle reducing its speed from the design speed to 70 percent of the design speed. The ISD is measured from an eye height of 3.5 feet to an object height of 3.5 feet above street level. The use of an object height equal to the driver eye height makes intersection sight distances reciprocal (i.e., if one driver can see another vehicle, then the driver of that vehicle can also see the first vehicle).

³A Policy on Geometric Design of Highways and Streets; American Association of State Highway and Transportation Officials (AASHTO); 2004.

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When the minor street is on an upgrade that exceeds 3 percent, grade correction factors are applied.

The SSD is generally more important as it represents the minimum distance required for safe stopping while the ISD is based only upon acceptable speed reductions to the approaching traffic stream. The ISD, however, must be equal to or greater than the minimum required SSD in order to provide safe operations at the intersection. In accordance with the AASHTO manual, *“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.”* Accordingly, ISD should be at least equal to the distance required to allow a driver approaching the minor road to safely stop.

The available SSD and ISD at the proposed site roadway locations were measured and compared to minimum requirements as established by AASHTO. Since the distance required to stop a vehicle is dependent on the speed of that vehicle, speed studies were conducted as presented in the *Vehicle Speeds* section of this study. Based on both the enforced speed limit and the observed speeds, the SSD and ISD requirements at the proposed site roadway intersections were calculated. The required minimum sight distances for each speed are compared to the available distances, as shown in Table 4.

**Table 4
SIGHT DISTANCE SUMMARY**

Location/Direction	Stopping Sight Distance (feet)		Intersection Sight Distance (feet)		
	Measured	Minimum Required ^a	Measured	Minimum Required ^a	Desirable ^b
Institute Road at North Site Roadway:					
North of intersection (SB)	+600	327	+600	327	335
South of intersection (NB)	350	338	370	338	335
Institute Road at South Site Roadway:					
North of intersection (SB)	425	327	440	327	335
South of intersection (NB)	505	338	480	338	335

^a Values based on AASHTO requirements for 85th percentile speeds of 43 mph and 42 mph on Institute Road northbound (south of intersection) and southbound (north of intersection), respectively.

^b Values based on AASHTO requirements for enforced speed limit of 30 mph on Institute Road.

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As indicated in Table 4, available sight distances at the site roadways exceed the minimum and desirable SSD and ISD requirements for safe operation. These sight distance measurements assume minimal trimming of vegetation along the site frontage to maximize visibility. It is recommended that any proposed landscaping in the vicinity of the roadways be located sufficiently back from Institute Road or kept low to the ground so as not to impede the available sight distances.

Public Transportation

The Massachusetts Bay Transit Authority (MBTA) provides a commuter rail service to Grafton approximately ½-mile east of the proposed site. The station is located on Pine Street just north of the intersection of Pine Street and Westboro Road. The Framingham/Worcester line provides service between Union Station in Worcester and South Station in Boston, and travels as far north as Auburndale, West Newton, and Newtonville. The Framingham/Worcester line runs between 4:20 AM and 1:30 AM on weekdays and between 6:40 AM and 12:30 AM on Saturdays. The MBTA Framingham/Worcester commuter rail route information is provided in the Appendix.

FUTURE CONDITIONS

To estimate the impact of site-generated traffic within the study area, existing traffic volumes were projected to the year 2021, representing a seven-year design horizon in accordance with state guidelines. The proposed development is expected to be completed and fully operational well within this time frame. Future traffic volumes on the roadway network will include existing traffic, new traffic due to regional traffic growth, and traffic related specifically to any significant developments expected to be completed within the area by 2021. Consideration of these factors resulted in the development of 2021 No-Build traffic volumes, which assume that the proposed development is not built. The incremental impacts of the proposed project may then be determined by adding site-generated traffic volumes (Build conditions) and making comparisons to the No-Build conditions.

Traffic Growth

To develop the 2021 No-Build forecast volumes, two components of traffic growth were considered. First, an annual growth percentage was determined. Based on historic traffic volume counts provided by MassDOT, traffic volumes in the area have been decreasing at a rate of approximately -0.15 percent per year.⁴ However, to provide a conservative analysis scenario, a

⁴MassDOT 2009 *Traffic Volumes and MassDOT Transportation Data Management System*; Station 3187 (Route 140 east of South Street, Grafton), Station 3306 (Route 140 south of Oak Street), Station 3307 (Route 140 north of Route 122).

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1.0 percent compounded annual growth was assumed for the project area. The MassDOT adjustment data are provided in the Appendix.

Second, any traffic that may be generated by planned developments that could add substantial volume of traffic through the study area within the next seven years was considered. Based on discussions with officials from the Towns of Grafton, Shrewsbury, and Westborough as well as with officials from the Central Massachusetts Regional Planning Commission (CMRPC), the following projects were identified:

- *Tufts University Grafton Campus Development Program* – The campus development program includes the construction of a 702,000 square foot Grafton Science Park and the expansion of the existing campus infrastructure by approximately 256,790 square feet. The development will be phased over the next 20 years, with Phase I projected to have been completed in 2011, though it has not been completed at the time of this study, and Phase II to be completed in 2026. As such, only Phase I was taken into account within the design horizon for this study. Phase I of this project includes 348,000 square feet of the science park development and 104,400 square feet of the campus expansion. Only the 35,000 square foot New England Regional Biosafety Laboratory has been constructed and occupied at the time of this study. Traffic associated with this project was obtained from the traffic study prepared for the development.⁵
- *CenTech Park* – This development is comprised of biotechnology, light manufacturing, and research and development (R&D) uses to be located on Pine Street in Grafton and Shrewsbury. There are two remaining parcels that will comprise approximately 10 percent of the total 650,000 square foot development. Although the project has received all approvals, the timeframe for completion of the remaining buildings is dependent on the market for this type of space and may not occur within the next seven years. For a conservative (worse-case) analysis scenario, however, all remaining space was assumed to be built and occupied with the next seven years. The remaining CenTech Park traffic was estimated using the Institute of Transportation Engineers (ITE) *Trip Generation* manual for Land Use Code (LUC) 130 (Industrial Park).⁶
- *CenTech Park East* – This project will accommodate 600,000 square feet of development that will mirror the zoning and uses of CenTech Park. CenTech Park East will be located in Grafton and Shrewsbury adjacent to CenTech Park. Although the project has received all approvals, the timeframe for construction and occupancy of the buildings is dependent on the market for this type of space and may not occur within the next seven years. For a conservative (worse-case) analysis scenario, all space was assumed to be built and occupied with the next seven years. Traffic associated with this project was obtained

⁵*Traffic Impact and Access Study, Tufts University Grafton Campus Master Plan Update*; Grafton, Massachusetts; Prepared by Vanasse and Associates, Inc.; January, 2006.

⁶*Trip Generation, 8th Edition*; Institute of Transportation Engineers; Washington, DC; 2003.

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from information provided in the Tufts University Grafton Campus Development Program traffic study.⁷

- *Convenience Store/Gas Station* – This project will include a gas station development with convenience store/ co-brand coffee tenant and car wash at the intersection of Route 20 and Centech Boulevard in Shrewsbury. The facility is proposed to include 12 vehicle fueling positions (six gas pumps), a ±3,500 square-foot convenience market with a co-brand coffee counter and drive-thru window, and a car wash (automated drive-thru facility and three self-service (hand wash) bays). Traffic volumes for this development were obtained from the Proposed Convenience Store/Gas Station *Traffic Impact and Access Study* technical memorandum.⁸
- *Single-Family Detached Living* – This project will include 13 single-family detached homes on Arch Street in Westborough. Traffic volumes for this residential development were estimated using the Institute of Transportation Engineers (ITE) *Trip Generation* manual for Land Use Code (LUC) 210 (Single-Family Detached Housing).⁹
- *Westboro Village* – This project will be a transit-oriented residential development located approximately ½-mile from the Westborough MBTA commuter rail station at Smith Parkway and Fisher Street in Westborough. The project consists of a 2,500 square foot convenience store, a 2,500 square foot restaurant, 10,000 square feet of office space, and 276 residential units. The residential units will be a mix of single-family homes, townhouses, and condominiums. Traffic volumes for this development were obtained from the Westboro Village *Response to Peer Review Traffic Comments* technical memorandum.¹⁰
- *Cherry Street Industrial Development* – This project included the construction of 180,000 square feet of mixed office, warehouse, and industrial space near the intersection of Route 20 and Cherry Street in Shrewsbury. This project did not move forward; instead a solar field was developed on this land. Therefore, no increases in traffic on the study area roadways are expected.
- *9 Otis Street* – A total of 60,000 square feet of R&D or manufacturing space has been approved at 9 Otis Street in Westborough. This project is not anticipated to result in significant increases in traffic on the study area roadways and has been assumed to be included in the background growth factor.

⁷*Traffic Impact and Access Study, Tufts University Grafton Campus Master Plan Update*; Grafton, Massachusetts; Prepared by Vanasse and Associates, Inc.; January, 2006.

⁸*Traffic Impact and Access Study, Proposed Convenience Store/Gas Station*; Shrewsbury, Massachusetts; Prepared by MDM Transportation Consultants, Inc.; September, 2013.

⁹*Trip Generation, 8th Edition*; Institute of Transportation Engineers; Washington, DC; 2003.

¹⁰*Response to Peer Review Traffic Comments, Westboro Village*; Westborough, Massachusetts; prepared by Abend Associates; February 16, 2006.

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Other projects in Westborough that are not anticipated to result in significant increases in traffic on the study area roadways that have been assumed to be included in the background growth factor are: a warehouse/shipping expansion of 20 additional workers at 26 Otis Street, Danafilms relocating and expanding from Route 30 in Grafton to 5 Otis Street in Westborough, and Moe's Restaurant on Otis Street.

Based on discussions with officials from the Towns of Grafton, Shrewsbury, and Westborough as well as officials from the CMRPC, there are no roadway improvements planned within the study area. It was mentioned by the Grafton Department of Public Works (DPW) that Wesson Street from North Street to the west to Old Westboro Road to the east and sections of Route 30 might receive some preventative maintenance to try and adhere to the Town's pavement management program.

No-Build Conditions

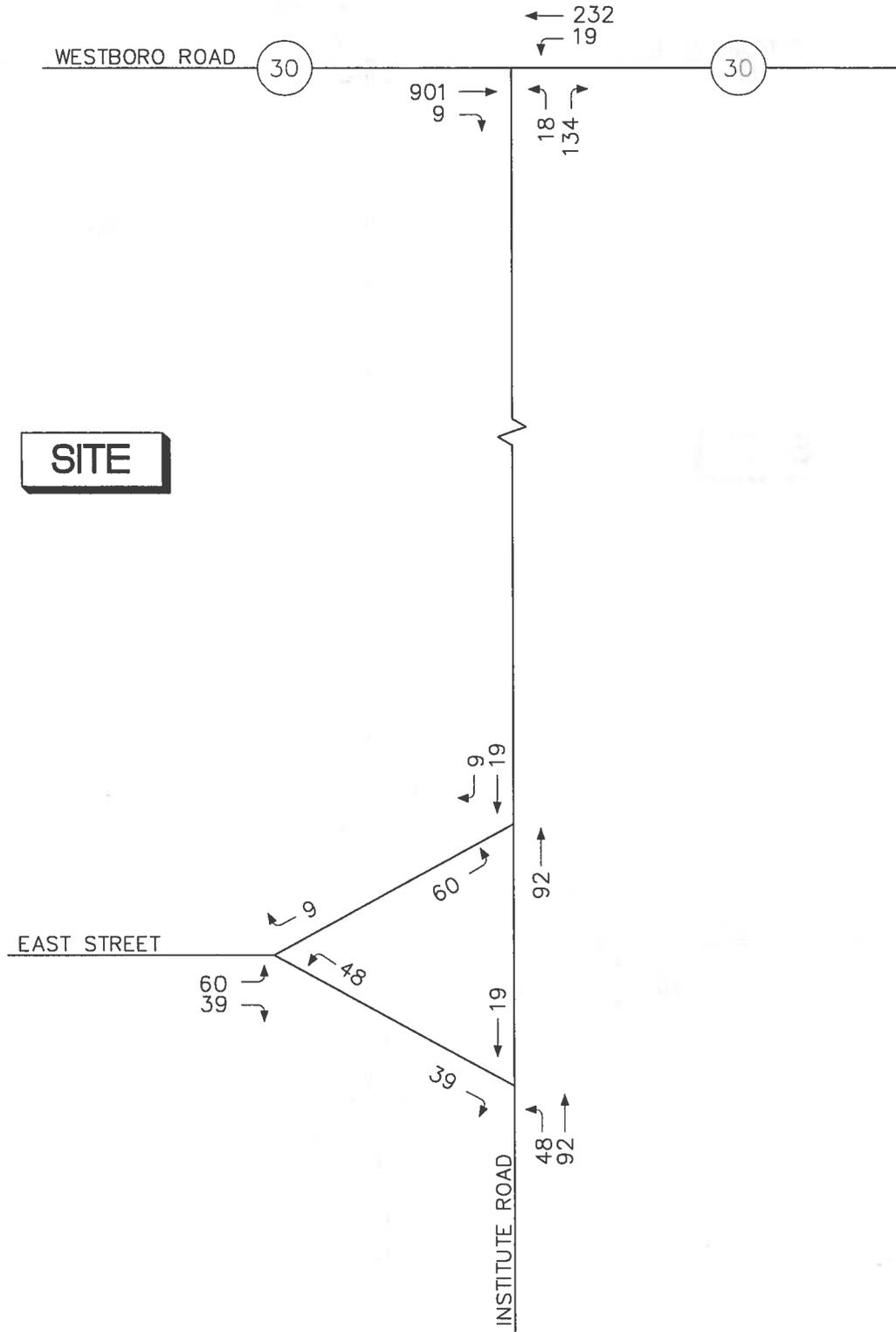
The 2021 No-Build peak hour traffic volumes were accordingly developed by applying a 1.0 percent compounded annual traffic growth rate (7.2 percent over seven years) to the 2014 Existing traffic volumes and adding the traffic to be generated by the background developments. The 2021 No-Build traffic volumes are shown graphically on Figures 4 and 5 for the weekday AM and weekday PM peak hours, respectively.

Trip Generation

As currently planned, the proposed development consists of constructing approximately 46 to 51 single-family homes. These unit counts represent a conventional development option (46 units) and flexible development option (51 units), both of which are viable. For comparison purposes, Table 5 summarizes the projected site-generated traffic volumes for both 46 and 51 residential units. Traffic to be generated by the proposed development was forecast using the trip rates contained in the ITE *Trip Generation* manual for LUC 210 (Single-Family Detached Housing). All trip generation data are provided in the Appendix. In order to provide a conservative analysis under Build conditions, trip generation associated with the project were projected for the maximum number of 51 homes.

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SITE

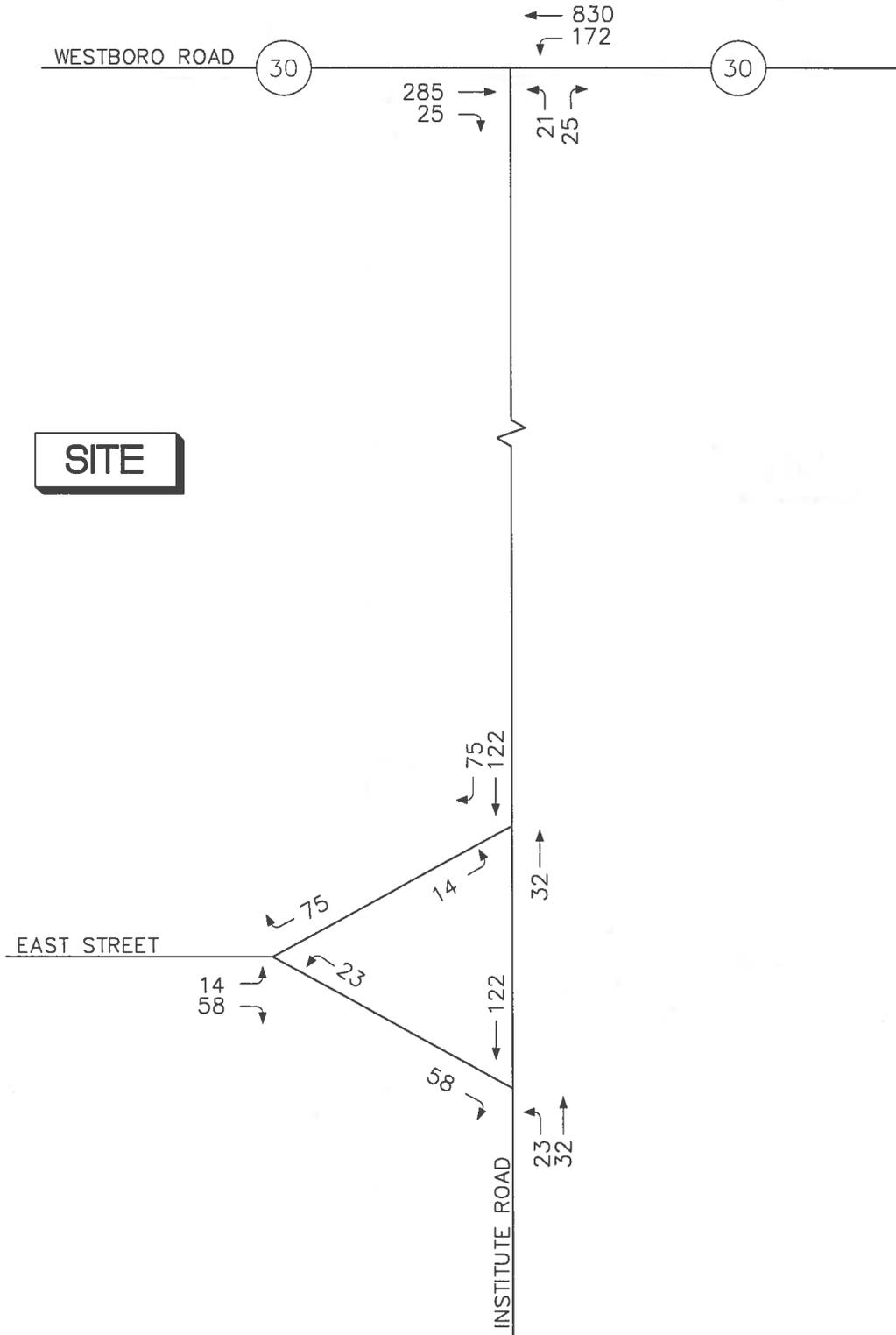


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Figure 4
2021 No-Build
Weekday AM
Peak Hour Traffic Volumes

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Figure 5

2021 No-Build
Weekday PM
Peak Hour Traffic Volumes

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Table 5
TRIP GENERATION SUMMARY

Time Period/Direction	Proposed Trips ^a	
	Conventional Subdivision (46 residential units)	Flexible Subdivision (51 residential units)
Weekday Daily	514	566
Weekday AM Peak Hour:		
<i>Enter</i>	11	11
<i>Exit</i>	<u>32</u>	<u>34</u>
<i>Total</i>	43	45
Weekday PM Peak Hour:		
<i>Enter</i>	33	37
<i>Exit</i>	<u>19</u>	<u>21</u>
<i>Total</i>	52	58

^a ITE LUC 210 (Single-Family Detached Housing)

As shown in Table 5, at its most the proposed (Flexible Subdivision option – 51 units) development is expected to generate 45 total vehicle trips (11 entering and 34 exiting) during the weekday AM peak hour, and 58 total vehicle trips (37 entering and 21 exiting) during the weekday PM peak hour. In order to provide a conservative impact analysis for this study, no credit was applied to the vehicular trips for the use of public transportation, though the Grafton commuter rail station is within walking distance of the project site.

Trip Distribution

Having estimated project-generated vehicle trips, the next step is to determine the distribution of project traffic and assign these trips to the local roadway network. The directional distribution of site traffic is dependent on expected travel routes to and from the site, and existing travel patterns. The distribution of site traffic is shown in Table 6.

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Table 6
TRIP DISTRIBUTION SUMMARY

<u>Roadway</u>	<u>Direction To/From</u>	<u>Percent of Site Traffic</u>
Westboro Road	West	35%
Westboro Road	East	40%
East Street	West	15%
<u>Institute Road</u>	<u>South</u>	<u>10%</u>
TOTAL		100%

Site Access

As proposed, access to the site will be provided via two unsignalized full access and egress roadways on Institute Road approximately 750 feet and 1,800 feet south of Westboro Road. The proposed site roadways will be designed to accommodate the appropriate truck traffic as well as conform to current local and state standards, as applicable.

To ensure the safe and efficient flow of traffic to and from the proposed site, any plantings, vegetation, landscaping, and signs along the site frontage should be kept low to the ground or set back from the edge of the roadway to allow for adequate sight distance at the site roadways.

Build Traffic Volumes

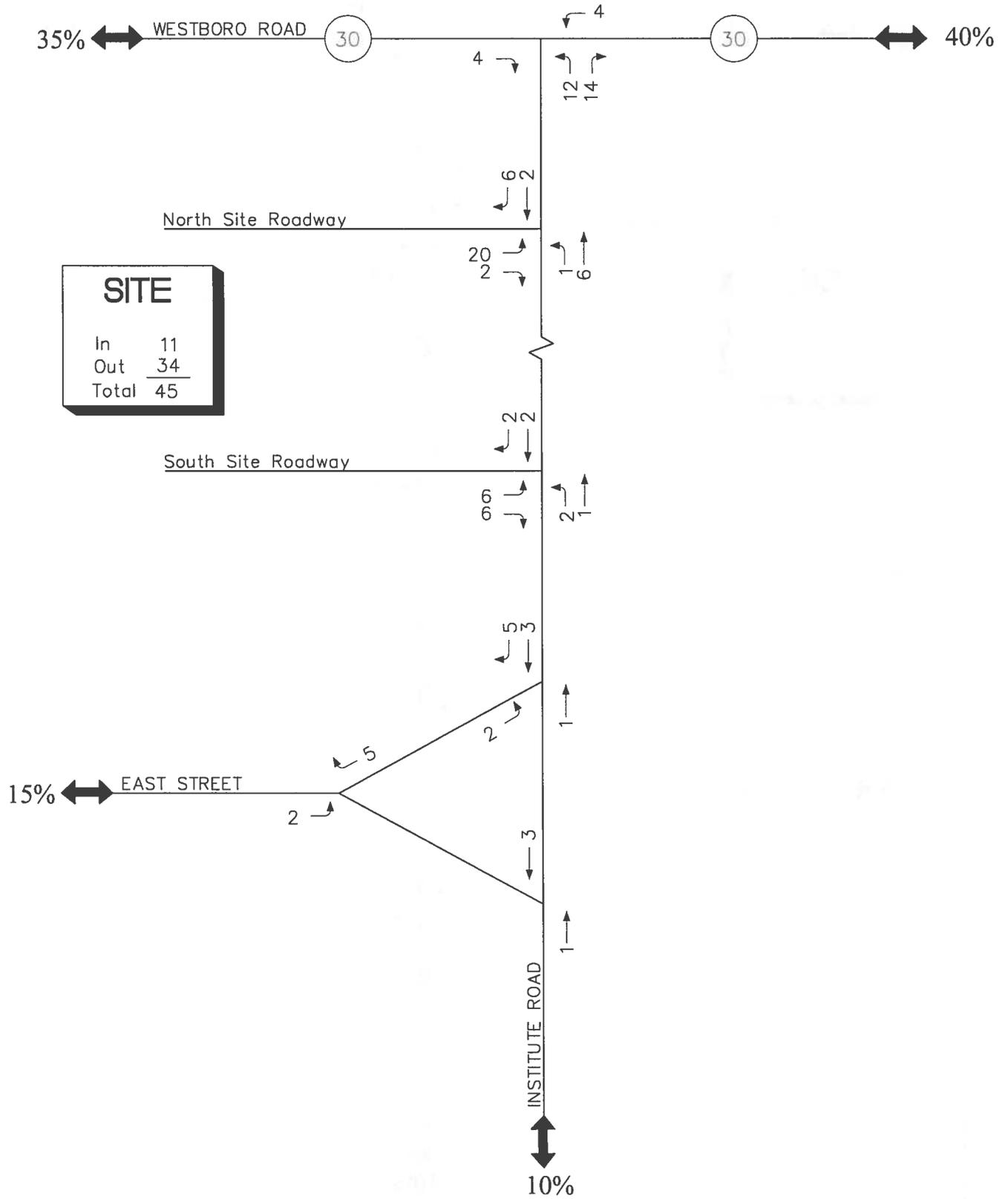
Based on the traffic generation and distribution estimates for this project, the traffic volumes associated with the proposed project (Flexible option – 51 units) were assigned to the roadway network. The site-generated traffic networks are shown on Figures 6 and 7 for the weekday AM and weekday PM, respectively. The site-generated traffic volumes were then combined with the 2021 No-Build traffic volumes to develop the 2021 Build peak-hour traffic-volume networks. The 2021 Build weekday AM and weekday PM peak hour traffic volumes are illustrated on Figures 8 and 9, respectively.

Traffic Increases

The proposed development project will result in increases in traffic on the study area roadways, at its most. As shown on Figures 6 and 7, traffic volume increases beyond the study area during the peak hours are expected to be in the range of 16 to 24 vehicles on Westboro Road, 7 to 8 vehicles on East Street, and 4 to 6 vehicles on Institute Road south of East Street. These

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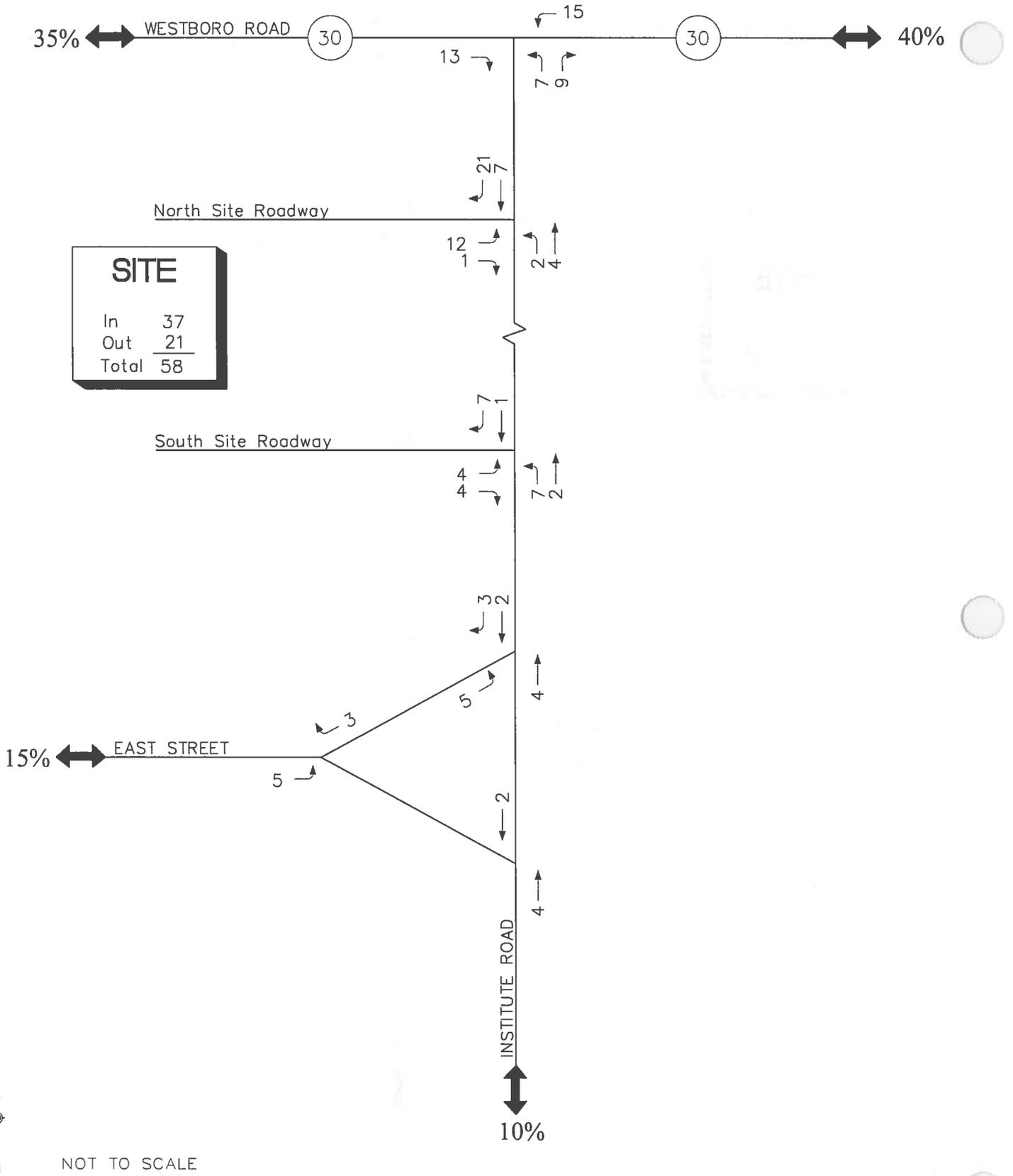
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Figure 6

Site-Generated
Weekday AM
Peak Hour Traffic Volumes

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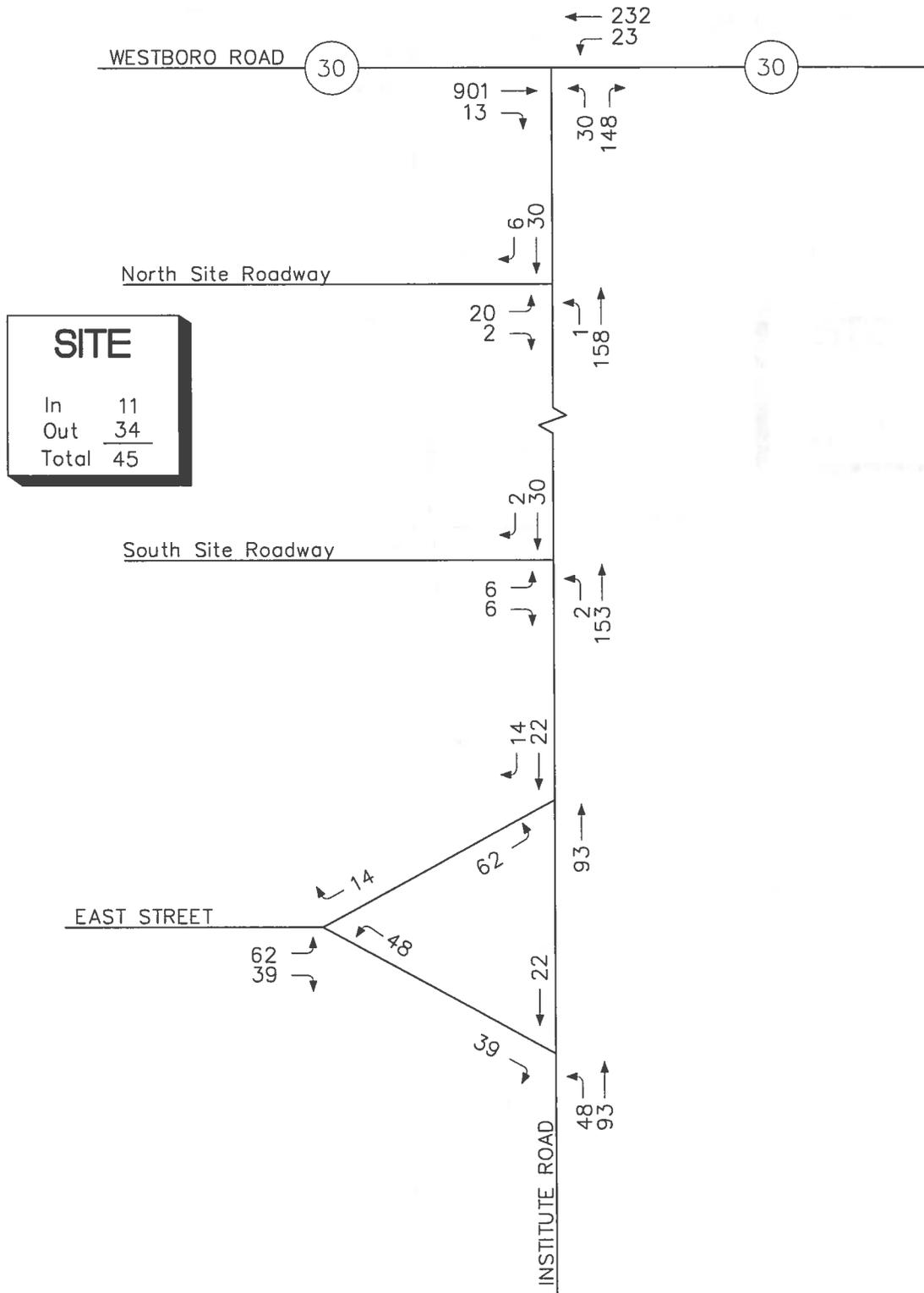


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Figure 7
Site-Generated
Weekday PM
Peak Hour Traffic Volumes

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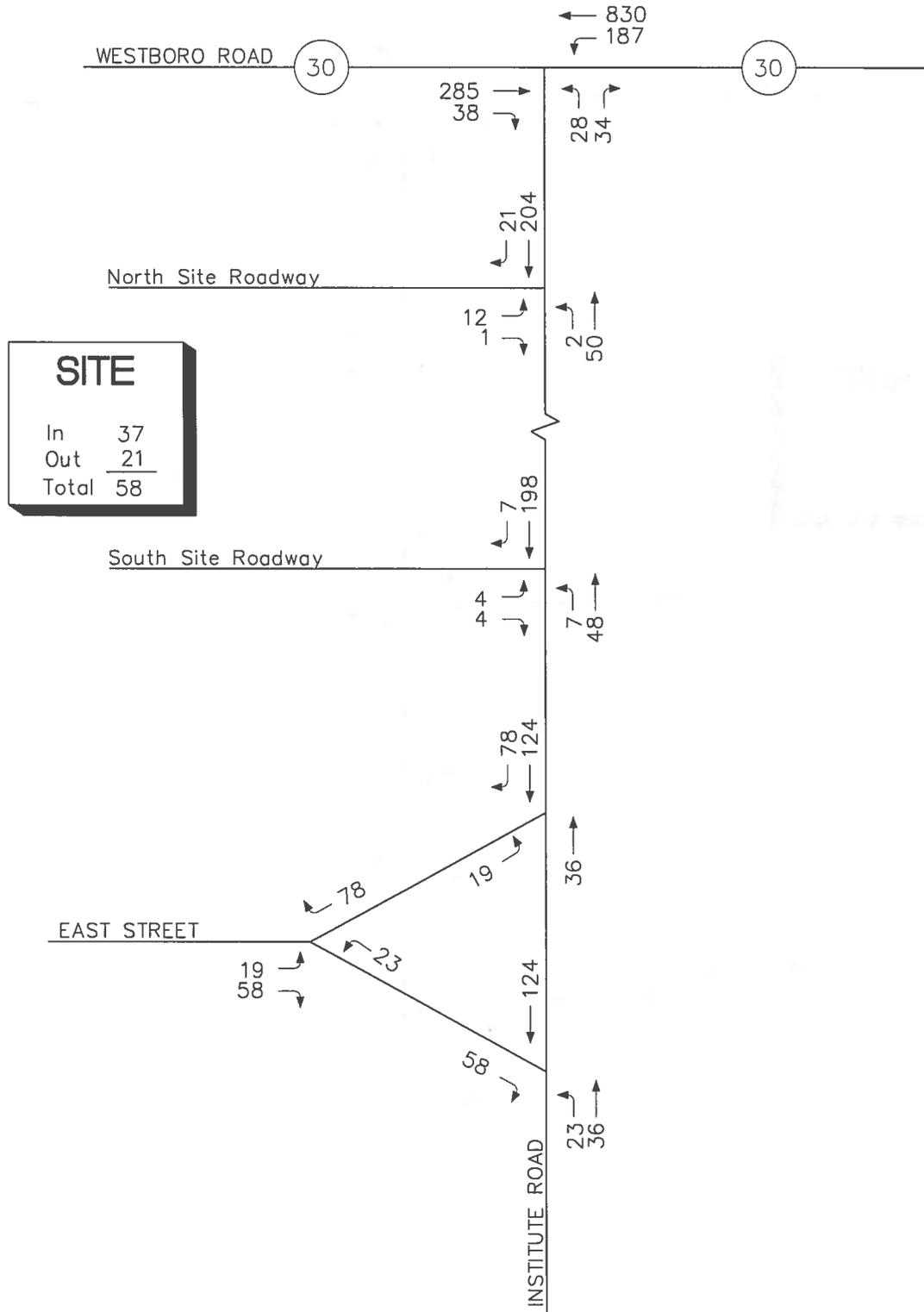
NOT TO SCALE

Figure 8

2021 Build
Weekday AM
Peak Hour Traffic Volumes

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NOT TO SCALE

Figure 9

2021 Build
Weekday PM
Peak Hour Traffic Volumes

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increases represent, on average, less than one additional vehicle every three minutes during the peak hours.

CAPACITY AND QUEUE ANALYSIS

Capacity and queue analyses were conducted at all study area intersections under 2014 Existing, 2021 No-Build, and 2021 Build traffic volume conditions. The impact of site-generated traffic can be measured by comparing 2021 No-Build conditions to 2021 Build conditions.

Methodology

The capacity analysis methodology is based on the concepts and procedures in the *Highway Capacity Manual* (HCM)¹¹ and is described in the Appendix. The level of service results are presented and discussed below and the analysis worksheets for all conditions are provided in the Appendix.

For unsignalized intersections, the 95th percentile queue represents the length of queue of the critical minor-street movement that is not expected to be exceeded 95 percent of the time during the analysis period (typically one hour). In this case, the queue length is a function of the capacity of the movement and the movement's degree of saturation.

Analysis Results

The results of the level of service (LOS) and queue analyses are shown in Table 7 and are discussed below. Capacity and queue analyses were conducted at the study area intersections utilizing the latest version of *Synchro* software.¹²

Westboro Road at Institute Road

All movements at the intersection of Westboro Road and Institute Road currently operate at acceptable levels of service (LOS C or better). Although traffic exiting Institute Road onto Westboro Road is anticipated to experience delay during the weekday AM and PM peak hours under 2021 No-Build and Build conditions, queues on Institute Road are not expected to exceed eight vehicles. Additionally, the volume-to-capacity (v/c) ratio will be below 1.00, indicating adequate capacity to accommodate the anticipated traffic volumes. The large volume of traffic generated by the background developments assumed within this study significantly increases

¹¹ *HCM 2010: Highway Capacity Manual*. Washington, D.C.: Transport Research Board, 2010.

¹² *Synchro plus SimTraffic 8*; Trafficware Ltd.; Sugar Land, TX; 2011.

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delays on the Institute Road approach. The background developments, however, do not have a specific timeline for completion and may not be occupied within the seven-year design horizon. Therefore, a sensitivity analysis has been conducted for the intersection to determine the project's impact on the intersection if the traffic from the CenTech Park and CenTech Park East is not realized. The results of the sensitivity analysis are provided in the Appendix and indicate that all movements at the intersection will operate at LOS D or better under 2014 No-Build and Build conditions without CenTech Park and CenTech Park East development traffic.

Institute Road at East Street

All movements at the three intersections of Institute Road and East Street are anticipated to operate at LOS B or better during the weekday AM and PM peak periods under all scenarios. Additionally, queues are not anticipated to exceed one vehicle and v/c ratios will be well below 1.00, indicating adequate capacity to accommodate the anticipated traffic volumes.

Institute Road at Site Roadways (North and South)

All movements at the intersections of Institute Road with the site roadways are anticipated to operate at LOS A during the weekday AM and PM peak periods under 2014 Build conditions. Additionally, queues are not anticipated to exceed one vehicle and v/c ratios will be well below 1.00, indicating there will be adequate capacity to accommodate the anticipated traffic volumes.

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**Table 7
INTERSECTION CAPACITY ANALYSIS SUMMARY**

Intersection/Peak Hour/Lane Group	2014 Existing				2021 No-Build			2021 Build				
	V/C ^a	Delay ^b	LOS ^c	Queue ^d	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Westboro Road at Institute Road												
<i>Weekday AM:</i>												
Westboro Road WB left-turns/through	0.01	8.3	A	0	0.04	10.6	B	3	0.05	10.6	B	3
Institute Road NB left/right-turns	0.23	13.0	B	23	0.73	50.2	F	128	0.90	79.5	F	193
<i>Weekday PM:</i>												
Westboro Road WB left-turns/through	0.11	8.0	A	10	0.16	8.5	A	15	0.18	8.6	A	15
Institute Road NB left/right-turns	0.13	15.7	C	13	0.47	51.6	F	55	0.70	81.7	F	98
Institute Road at East Street (North)												
<i>Weekday AM:</i>												
Institute Road NB left-turns/through	0.00	0.0	A	0	0.00	0.0	A	0	0.00	0.0	A	0
East Street EB left/right-turns	0.06	9.2	A	5	0.08	9.6	A	8	0.08	9.6	A	8
<i>Weekday PM:</i>												
Institute Road NB left-turns/through	0.00	0.0	A	0	0.00	0.0	A	0	0.00	0.0	A	0
East Street EB left/right-turns	0.02	9.7	A	3	0.03	10.0	B	3	0.04	10.1	B	3

^a Volume-to-capacity ratio.

^b Average control delay in seconds per vehicle.

^c Level of service.

^d 95th percentile queue length in feet per lane (assuming 25 feet per vehicle).

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**Table 7 (continued)
INTERSECTION CAPACITY ANALYSIS SUMMARY**

Intersection/Peak Hour/Lane Group	2014 Existing				2021 No-Build			2021 Build				
	V/C ^a	Delay ^b	LOS ^c	Queue ^d	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Institute Road at East Street (West)												
<i>Weekday AM:</i>												
East Street EB left-turns/through	0.03	7.4	A	3	0.04	7.4	A	3	0.05	7.4	A	3
Institute Road SB left/right-turns	0.01	8.6	A	0	0.01	8.6	A	0	0.02	8.6	A	0
<i>Weekday PM:</i>												
East Street EB left-turns/through	0.01	7.3	A	0	0.01	7.3	A	0	0.02	7.3	A	3
Institute Road SB left/right-turns	0.08	8.7	A	5	0.10	8.8	A	8	0.10	8.8	A	8
Institute Road at East Street (South)												
<i>Weekday AM:</i>												
Institute Road NB left-turns/through	0.00	0.0	A	0	0.00	0.0	A	0	0.00	0.0	A	0
Institute Road SB through/right-turns	0.02	9.3	A	3	0.03	9.4	A	3	0.03	9.5	A	3
<i>Weekday PM:</i>												
Institute Road NB left-turns/through	0.00	0.0	A	0	0.00	0.0	A	0	0.00	0.0	A	0
Institute Road SB through/right-turns	0.15	9.8	A	13	0.20	10.1	B	18	0.20	10.2	B	18

^a Volume-to-capacity ratio.

^b Average control delay in seconds per vehicle.

^c Level of service.

^d 95th percentile queue length in feet per lane (assuming 25 feet per vehicle).

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**Table 7 (continued)
INTERSECTION CAPACITY ANALYSIS SUMMARY**

Intersection/Peak Hour/Lane Group	2014 Existing				2021 No-Build			2021 Build				
	V/C ^a	Delay ^b	LOS ^c	Queue ^d	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Institute Road at North Site Roadway												
<i>Weekday AM:</i>												
Site Roadway EB left/right-turns	--	--	--	--	--	--	--	--	0.03	9.7	A	3
Institute Road NB left-turns/through	--	--	--	--	--	--	--	--	0.00	7.3	A	0
<i>Weekday PM:</i>												
Site Roadway EB left/right-turns	--	--	--	--	--	--	--	--	0.03	9.7	A	3
Institute Road NB left-turns/through	--	--	--	--	--	--	--	--	0.00	7.3	A	0
Institute Road at South Site Roadway												
<i>Weekday AM:</i>												
Site Roadway EB left/right-turns	--	--	--	--	--	--	--	--	0.02	9.1	A	0
Institute Road NB left-turns/through	--	--	--	--	--	--	--	--	0.00	7.3	A	0
<i>Weekday PM:</i>												
Site Roadway EB left/right-turns	--	--	--	--	--	--	--	--	0.02	9.1	A	0
Institute Road NB left-turns/through	--	--	--	--	--	--	--	--	0.00	7.3	A	0

^a Volume-to-capacity ratio.

^b Average control delay in seconds per vehicle.

^c Level of service.

^d 95th percentile queue length in feet per lane (assuming 25 feet per vehicle).

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SENSITIVITY ANALYSIS

The results of the capacity and queue analyses discussed previously assume that full build-out of CenTech Park and CenTech Park East will be reached within the seven-year design horizon. The large volume of traffic projected to be generated by the background developments significantly increases delays on the northbound Institute Road approach to Westboro Road. The background developments, however, do not have a specific timeline for completion and may not be occupied within the seven-year design horizon. Therefore, a sensitivity analysis has been conducted for the intersection to determine the proposed residential project's impact on the intersection if the traffic from the CenTech Park and CenTech Park East is not realized. The results of the sensitivity analysis are shown in Table 8.

As shown in Table 8, all movements at the intersection of Westboro Road and Institute Road are expected to operate at LOS D or better during the weekday AM and PM peak periods under both 2014 No-Build and Build scenarios if CenTech Park and CenTech Park East are not fully constructed and occupied. The additional traffic generated by the proposed residential development is expected to result in minimal increases to delays (less than 6 seconds) and queues (less than one vehicle) through the intersection.

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**Table 8
INTERSECTION CAPACITY ANALYSIS SUMMARY – SENSITIVITY ANALYSIS**

Intersection/Peak Hour/Lane Group	2014 Existing				2021 No-Build without CenTech Park and CenTech Park East				2021 Build without CenTech Park and CenTech Park East			
	V/C ^a	Delay ^b	LOS ^c	Queue ^d	V/C	Delay	LOS	Queue	V/C	Delay	LOS	Queue
Westboro Road at InSTITUTE Road												
<i>Weekday AM:</i>												
Westboro Road WB left-turns/through	0.01	8.3	A	0	0.03	9.2	A	3	0.04	9.2	A	3
Institute Road NB left/right-turns	0.23	13.0	B	23	0.46	21.5	C	60	0.56	25.7	D	83
<i>Weekday PM:</i>												
Westboro Road WB left-turns/through	0.11	8.0	A	10	0.15	8.3	A	13	0.17	8.4	A	15
Institute Road NB left/right-turns	0.13	15.7	C	13	0.28	25.4	D	28	0.40	31.2	D	45

^a Volume-to-capacity ratio.

^b Average control delay in seconds per vehicle.

^c Level of service.

^d 95th percentile queue length in feet per lane (assuming 25 feet per vehicle).

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CONCLUSIONS AND RECOMMENDATIONS

Existing and future conditions in the study area have been described, analyzed, and evaluated with respect to traffic operations and the impact of the proposed residential development. Conclusions of this effort and recommendations are presented below.

- As currently planned, the project consists of the construction of approximately 46 to 51 single-family residences. Access to and egress from the site is proposed via two unsignalized full access and egress roadways on Institute Road approximately 750 feet and 1,800 feet south of Westboro Road.
- The proposed development is expected to generate 45 total vehicle trips (11 entering and 34 exiting) during the weekday AM peak hour, and 58 total vehicle trips (37 entering and 21 exiting) during the weekday PM peak hour. These increases represent, on average, less than one additional vehicle every three minutes during the peak hours on roadways beyond the study area. No credit was applied to the vehicular trips for the use of public transportation, though the Grafton commuter rail station is within walking distance of the project site.
- Traffic exiting Institute Road northbound onto Westboro Road is expected to experience delay under 2014 No-Build and Build traffic-volume conditions during the weekday AM and weekday PM peak hours. The large volume of traffic projected to be generated by CenTech Park and CenTech Park East significantly increases delays on the Institute Road approach. These projects, however, do not have a specific timeline for completion and may not be occupied within the seven-year design horizon. Therefore, a sensitivity analysis has been conducted for the intersection to determine the proposed residential project's impact on the intersection if the traffic from the CenTech Park and CenTech Park East is not realized. The results of the sensitivity analysis indicate that all movements at the intersection will operate at LOS D or better under 2014 No-Build and Build conditions without CenTech Park and CenTech Park East traffic.
- All movements at the Institute Road intersections with East Street and the site roadways are anticipated to operate at LOS B or better during the weekday AM and PM peak periods. Queues are not anticipated to exceed one vehicle and v/c ratios will be well below 1.00, indicating adequate capacity will exist to accommodate the anticipated traffic volumes.
- It is recommended that a STOP AHEAD (W3-1) sign be posted on Institute Road at least 125 feet in advance of the STOP-line at Westboro Road with a distance plaque (W16-2a) sign mounted below to indicate the distance to the STOP-line.

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- The available sight distances at the proposed site roadways are anticipated to be adequate to provide safe operations assuming minimal trimming of vegetation along the site frontage. Any proposed landscaping or signs in the vicinity of the site roadways should be located sufficiently back from Institute Road, or kept low to the ground, so as not to impede the available sight distances.

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APPENDIX

**TRAFFIC COUNT DATA
TRAFFIC VOLUME ADJUSTMENT DATA
CRASH RATE WORKSHEETS
PUBLIC TRANSPORTATION
BACKGROUND DEVELOPMENT DATA
TRIP GENERATION CALCULATIONS
CAPACITY ANALYSIS METHODOLOGY
CAPACITY AND QUEUE ANALYSIS WORKSHEETS
SENSITIVITY ANALYSIS DATA**
