Nitsch Engineering

Hillside Elementary School
Needham, MA

Draft Transportation Feasibility Study

October 6, 2015

Prepared for:

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Nitsch Project #10828.2

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1 INTRODUCTION

Nitsch Engineering has been retained by Dore & Whittier Architects, Inc. to prepare a qualitative assessment of safety, traffic circulation, and traffic access/egress, associated with the feasibility study and schematic design for the Hillside Elementary School project in Needham, Massachusetts. Two (2) options are considered for the reconstruction. The first option would be to construct a new Hillside Elementary School building and grounds on the site of the existing school, located at 28 Glen Gary Road Needham, Massachusetts. The second option would be to construct a new elementary school building and grounds on an existing site located off Central Avenue, approximately ¾ mile west of the existing Hillside Elementary School site.

This report will outline the existing and proposed traffic volumes, operations, and safety of the adjacent surrounding roadways and intersections; traffic patterns of the existing Hillside Elementary School, including site access/egress, parent and bus pick-up/drop-off, traffic circulation, and parking supply/demand. The report will use this information to project future conditions for both the Hillside Elementary School option and the Central Avenue option.

The Locus Map of the study area is shown in Figure 1, a map of the existing Hillside Elementary School site is shown in Figure 2, and the map of the Central Avenue Site is shown in Figure 3.

Figure 1: Locus Map
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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Figure 2: Hillside Elementary School
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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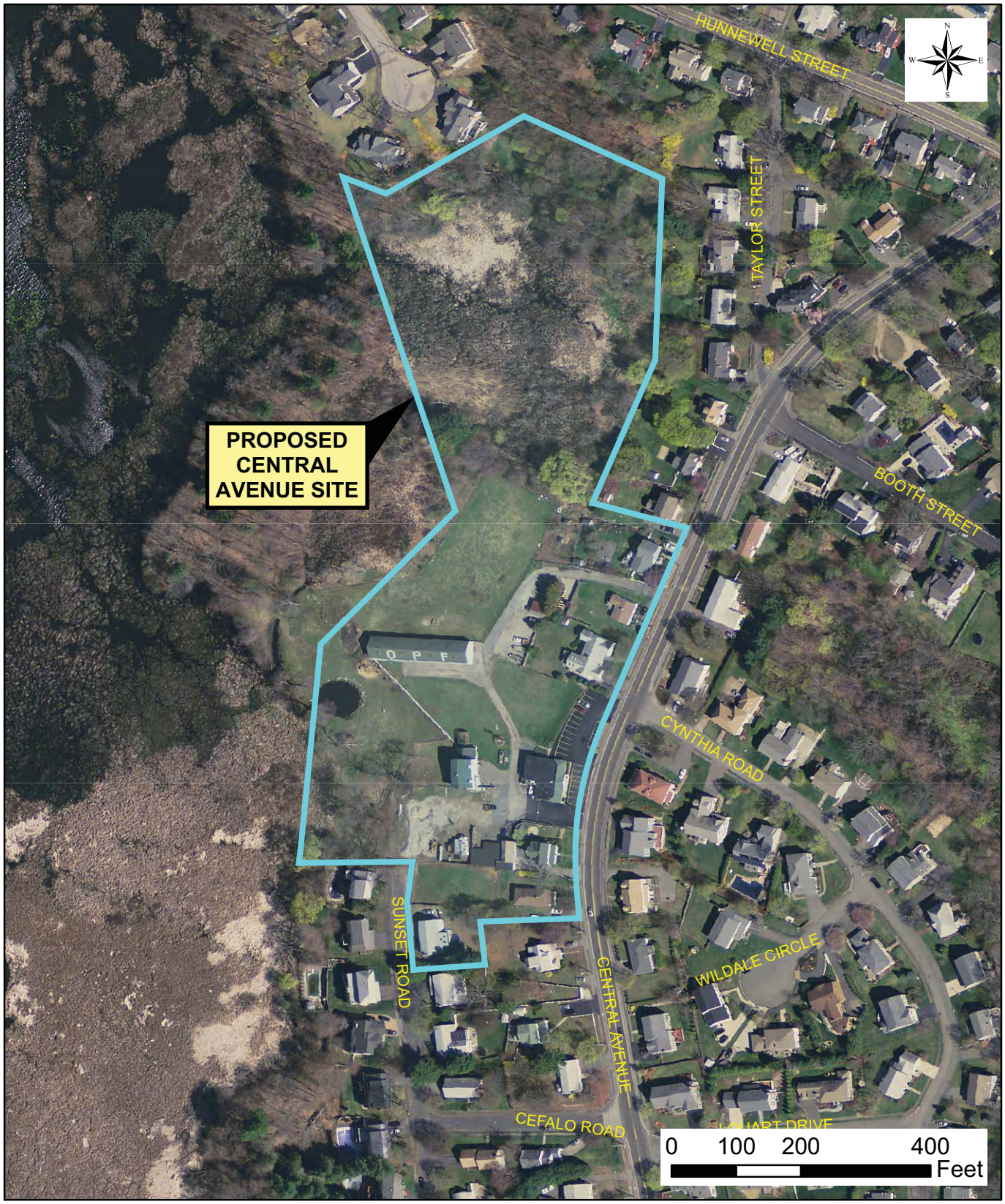

Figure 3: Central Avenue Site
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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2 EXISTING CONDITIONS

2.1 Study Area Roadways

To examine the existing conditions, we studied and collected data at the following roadways:

1. West Street; and
2. Central Avenue

West Street

West Street is classified by Massachusetts Department of Transportation (MassDOT) as a local road and runs in the east-west directions between Webster Street and Central Avenue in Needham. The posted speed limit along the roadway is 30 miles per hour, except for the vicinity of the Hillside Elementary School, which the speed gets reduced to 20 miles per hour. The land use is primarily residential. The roadway is within the jurisdiction of the Town of Needham.

Central Avenue

Central Avenue is classified by Massachusetts Department of Transportation (MassDOT) as a rural major connector or urban minor arterial and runs in the northeast-southwest directions. Central Avenue is present between Centre Street/Central Avenue Bridge over Charles River in the Town of Dover at its southwest terminus and Eliot Street/Central Avenue Bridge over the Charles River at its northeast terminus near the City of Newton. The posted speed limit along the roadway is 35 miles. The land use is primarily residential or open space. The roadway is within the jurisdiction of the Town of Needham.

2.2 Study Area Intersections

To examine the existing conditions, we included the following intersections in the study area. The intersection locations are shown in Figure 4.

1. West Street at Central Avenue
2. Central Avenue at Booth Street/Taylor Street
3. Central Avenue at Hunnewell Street (signalized)

West Street at Central Avenue

West Street and Central Avenue intersect as a three-way “T”-type intersection with West Street approaching from the east, and Central Avenue from north and south. Central Avenue operates freely with no control and West Street operates under “STOP” control. One crosswalk is present at the intersection crossing West Street.

From south, Central Avenue is approximately 38 feet wide and contains one (1) travel lane in each direction. From north, Central Avenue is approximately 38 feet wide and contains one (1) travel lane in each direction. From the east, West Street is approximately 30 feet wide and contains one (1) travel lane in each direction. Continuous bituminous concrete sidewalks are present on both sides of the roadways at the intersection.

Central Avenue at Booth Street/Taylor Street

Central Avenue, Booth Street and Taylor Street intersect as a four-way unsignalized intersection, with Central Avenue from north and south, Booth Street approaching from east, and Taylor Street approaching from northwest. Central Avenue operates freely with no control. Taylor Street is a one-way approach and operates under “YIELD” control. Booth Street is a Private Way with no control. There are no crosswalks present at the intersection.

At the intersection, Central Avenue is approximately 38 feet wide and contains one (1) travel lane in each direction. Taylor Street is approximately 14 feet wide and contains one (1) one-way travel lane approaching the intersection. From the east, Booth Street is approximately 38 feet wide Private Way and contains one (1) travel lane in each direction. Continuous bituminous concrete sidewalks are present on both sides of Central Avenue. There are no sidewalks present at Booth Street and Taylor Street.

Central Avenue at Hunnewell Street

Central Avenue and Hunnewell Street intersect as a four-way intersection with Central Avenue approaching from the southwest and northeast, and Hunnewell Street approaching from northwest and southeast. Crosswalks are present at all approaches.

From southwest, Central Avenue is a two-way roadway with one lane in each direction, separated by double yellow centerline. Approaching the intersection, the approach consists of two (2) lanes, the left lane permits a left turn only movement that transitions to the northwest on Hunnewell Street, and the right lane permits a through movement and a right turn that transitions to the southeast onto Hunnewell Street. Central Avenue is approximately 32 feet wide at the intersection. Bituminous concrete sidewalks are present on both sides of Central Avenue.

From northeast, Central Avenue is a two-way roadway with one lane in each direction, separated by double yellow centerline. Approaching the intersection, the approach consists of one (1) lane to permit through, left and right movements that transitions to the southwest on Central Avenue and northwest and southeast on Hunnewell Street. Central Avenue is approximately 32 feet wide at the intersection. Bituminous concrete sidewalks are present on both sides of Central Avenue.

From northwest, Hunnewell Street is a two-way roadway with one lane in each direction, separated by double yellow centerline. Approaching the intersection, the approach consists of one (1) lane to permit through, left and right movements that transitions to the southeast on Hunnewell Street and northeast and southwest on Central Avenue. Hunnewell Street is approximately 26 feet wide at the intersection. Bituminous concrete sidewalks are present on both sides of Hunnewell Street.

From southeast, Hunnewell Street is a two-way roadway with one lane in each direction, separated by double yellow centerline. Approaching the intersection, the approach consists of one (1) lane to permit through, left and right movements that transitions to the northwest on Hunnewell Street and southwest and northeast on Central Avenue. Hunnewell Street is approximately 26 feet wide at the intersection. Bituminous concrete sidewalks are present on both sides of Hunnewell Street.

The fully actuated traffic signal operates in four (4) phases. The following movements are permitted or protected, as noted, during each of the phases.

First phase:

- Central Avenue southbound; and
- Central Avenue northbound, permitted phase for left-turn onto Hunnewell Street.

Second phase:

- Central Avenue northbound, permitted phase for left-turn onto Hunnewell Street.

Third phase (if actuated):

- Exclusive pedestrian phase for crossing Central Avenue northbound, Central Avenue southbound, Hunnewell Street northbound, and Hunnewell Street southbound.

Fourth phase:

- Hunnewell Street northbound,
- Hunnewell Street southbound.

Figure 4: Intersection Locations

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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2.3 Hillside Elementary School Site Visit

Nitsch Engineering conducted a site visit on Wednesday September 9, 2015 to observe the site circulation associated with the weekday morning drop-off, weekday afternoon pick-up and general queue lengths around the school site; and quantified the general traffic circulation at Hillside Elementary School. The weekday morning drop-off observation occurred during clear and sunny conditions with a temperature of 88 degrees. The weekday afternoon pick-up activity occurred during clear and sunny conditions with a temperature of 91 degrees. The Site Circulation is shown in Figure 6.

2.4 Hillside Elementary School Site Access and Egress

Hillside Elementary School is located to the north of West Street. The single access and egress driveway to Hillside Elementary School exists south of the school at the intersection of Castle Place and Glen Gary Road. Pedestrian access to the school is also present north of Hillside Elementary School via a paved path to Booth Street. The driveway to Hillside Elementary School is a two-way two lane driveway. This driveway is the southern leg of a semi-circular driveway in front of Hillside Elementary School, with the northern leg located approximately 200 feet north of the southern leg. Sidewalks are present on both sides of Castle Place and Glen Gary Road, which connect to the sidewalks along the school driveway providing pedestrian access to Hillside Elementary School. A crosswalk exists crossing the school driveway at the intersection of Castle Place and Glen Gary Road.

2.5 Hillside Elementary School Traffic Circulation and Pick-up/Drop-off

Existing Morning Drop-off Circulation

Buses and vehicles drop off students via the driveway at the intersection of Castle Place and Glen Gary Road. The Hillside Elementary School traffic arrive at West Street from 8:05 AM through 8:30 AM. Parents arrive from West Street and enter McCulloch Street to arrive at the school through Castle Place, and drop-off their children either at the parking lot or in the front. The Principal and a couple of the teachers are waiting along the curbside to greet the children. A total of 76 parental drop-off was observed during morning. Buses enter and exit the site from Glen Gary Road. A total of 6 buses and 1 minibus drop off students at the school. Even though the arrival times are outside the normal morning peak hour of 7:00 AM to 8:00 AM, we observed that traffic condition on West Street becomes relatively congested due to the school traffic. A police detail/crossing guard is employed to assist parents and children cross West Street, as well as directing traffic in and out of Glen Gary Road. 99 vehicles entering the site were travelling northbound on West Street while 40 vehicles were traveling southbound.

Existing Afternoon Pick-up Circulation

The afternoon pick-up period occurs approximately from 2:30 to 3:00 PM. Parents arrive normally around 2:30 PM and queue up at the school driveway to wait for their children. The live lane at the school driveway can accommodate only 6 vehicles. The additional vehicles queue on Castle Place, McCulloch Street and West Street and wait their turn. The School Principal directs this operation. Once they have collected their children they leave via Glen Gary Road, and normal traffic returns around 3:15 PM. A total of 49 parental pick-up vehicles were observed during afternoon dismissal. Buses enter and exit the site from Glen Gary Road. A total of 6 buses and 1 minibus pick up students at the school.

Table 1 quantifies the parent and bus drop-off/pick-up totals for the school.

Table 1 – Hillside Elementary School Pick-Up/Drop-Off Quantity

Type	Parent		Bus	
Time	Drop-Off	Pick-Up	Drop-Off	Pick-Up
8:00 - 8:15	43		4 *	
8:15- 8:30	33		3	
2:30 - 2:45		10		4 *
2:45 - 3:00		39		3
Total	76	49	6	6

* One of the buses is a Mini-Bus

2.6 Hillside Elementary School Parking Supply and Demand

Nitsch Engineering performed a parking supply and demand count on September 9, 2015. The utilization of the lot was taken at 9:30 AM. Figure 6 shows an overview of the Hillside Elementary School parking lot, the total parking spaces, parking space type, and lot utilization.

Figure 5: Site Circulation

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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Figure 6: Parking Lot Overview
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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As can be seen from Figure 6, a total of 50 parking spaces were counted within the Hillside Elementary School, including two (2) of which being accessible spaces. This meets the Architectural Access Board (AAB) Code of Massachusetts Regulations (521 CMR) for the required number of handicapped parking spaces. In addition to the parking spaces, 10 vehicles were parked within the isles and the outside perimeter of the parking lot due to parking space shortage. The two (2) accessible spaces were not utilized. The overall lot utilization was 116%.

3 SAFETY ANALYSIS

3.1 Crash Data

Nitsch Engineering reviewed the crash data available from MassDOT for the three (3) most recent years available – 2011 to 2013 – for the study intersections. A summary of the crashes, including the severity, and the manner of collision are shown in Table 2.

Table 2 - Crash Summary

Location	Number of Crashes			Severity				Manner of Collision					Percent During	
	Year	Total Crashes	Average	PD[a]	PI[b]	NR[c]	F[d]	A[e]	RE[f]	HO[g]	Other[h]	Incl. Ped-Bike[j]	Peak Hours[k]	Wet/Icy Conditions
Central Ave at West St	2011	4	2.0	4	0	0	0	2	1	0	1	0	50%	25%
	2012	1		1	0	0	0	1	0	0	0	0	0%	100%
	2013	1		0	1	0	0	1	0	0	0	0	0%	0%
Central Ave at Hunnewell St	2011	2	1.0	2	0	0	0	2	0	0	0	0	50%	0%
	2012	1		1	0	0	0	0	1	0	0	0	0%	100%
	2013	0		0	0	0	0	0	0	0	0	0	0%	0%
Central Ave at Booth St and Taylor St	2011	1	0.3	1	0	0	0	1	0	0	0	0	100%	0%
	2012	0		0	0	0	0	0	0	0	0	0	0%	0%
	2013	0		0	0	0	0	0	0	0	0	0	0%	0%
Total	ALL	**10**	**1.1**	**9**	**1**	**0**	**0**	**7**	**2**	**0**	**1**	**0**	40%	30%

[a]Property Damage Only; [b]Personal Injury Only (non-Fatal Injury); [c]Not Reported; [d]Fatality; [e]Angle; [f]Rear end; [g]Head on; [h]Sideswipe, opposite direction; sideswipe, same direction, single vehicle crash, rear-to-rear, not reported, unknown, etc.; [j]Includes pedestrian or cyclist; [k]Occurred between 7-9am or 4-6pm

A total of 10 crashes were reported within the study areas for the three locations from 2011 to 2013. In terms of severity, 9 of the crashes involved property damage, 1 reported personal injury. In terms of manner of collision, 7 of the crashes were angle collisions, another 2 were rear end, and 1 was of other type. None of the crashes involved a pedestrian. Approximately 40% of the crashes occurred during the peak hours of 7:00 to 9:00 AM or 4:00 to 6:00 PM and 30% occurred during wet/icy conditions. Analyzing the crash data, as most crashes were of angle or rear-end type, the crashes were most likely caused by driver carelessness or inattentiveness.

4 EXISTING TRAFFIC CONDITIONS

4.1 2015 Traffic Count Data

Automatic Traffic Recorder (ATR) Data

Nitsch Engineering retained Precision Data Industries, LLC (PDI) of Berlin, Massachusetts to conduct 24-hour Automatic Traffic Recorder (ATR) vehicle traffic counts throughout the study area; on Wednesday, September 9, 2015. Table 3 summarizes the ATR data. A copy of the raw traffic count data is included in Appendix A-1.

Table 3 - Automatic Traffic Recorder (ATR) Summary

LOCATION	PERIOD	ADT[a]			PEAK HOUR TRAFFIC				K factor[d]
		VOLUMES (vpd)[b]	DIRECTIONAL DISTRIBUTION		PERIOD	VOLUMES (vph)[c]	DIRECTIONAL DISTRIBUTION		
Central Avenue north of Cefalo Road	Weekday	15,034	52%	NB	Morning	1,204	75%	NB	0.08
					Evening	1,249	68%	SB	0.08
West Street west of Glen Gary Road	Weekday	6,785	53%	EB	Morning	560	58%	EB	0.08
					Evening	522	54%	EB	0.08

[a] Average Daily Traffic; [b] Vehicles per day; [c] Vehicles per hour; [d] Percent of daily traffic

Turning Movement Count (TMC) Data

PDI collected Turning Movement Counts (TMC) data for the study area intersections outside of the Hillside Elementary School access and egress points on Wednesday, September 9, 2015 from 6:00 AM to 8:00 AM and 1:30 PM to 3:30 PM to capture both the school morning and afternoon peak periods. The TMC data included bicycle and pedestrian counts.

Nitsch Engineering conducted TMC data at the school access and egress points during the Site Visits at the intersections of West Street at Gary Glen Road, and West Street at McCulloch Street. We collected weekday morning and afternoon data on September 9, 2015. Nitsch Engineering did not collect bicycle and pedestrian data at the Hillside Elementary School access and egress points.

The peak hours within the study area were established as 7:45 AM to 8:45 AM during the weekday morning period and 2:15 PM to 3:15 PM during the afternoon period. The 2015 existing traffic volumes are shown in Figure 9, the 2015.

Vehicle Travel Speeds

PDI measured vehicle travel speeds at the ATR locations at the time of the traffic count. The 85th percentile speed, meaning the speed at which 85% of the vehicles are at or below, is noted because of its importance in determining appropriate roadway speed limits and for calculating required sight distance. The speed data is shown in Table 4.

Table 4 - Vehicle Travel Speeds

INTERSECTION	POSTED SPEED (MPH[a])	85th PERCENTILE SPEED (MPH[a])
Central Avenue north of Cefalo Road		
Northbound	35	35
Southbound	Not Posted	35
West Street between Birch Street and Glen Gary Road		
Eastbound	Not Posted	38
Westbound	30	40

a = Miles per hour

Note: 85th Percentile Speeds were averaged between the full two days of data collected

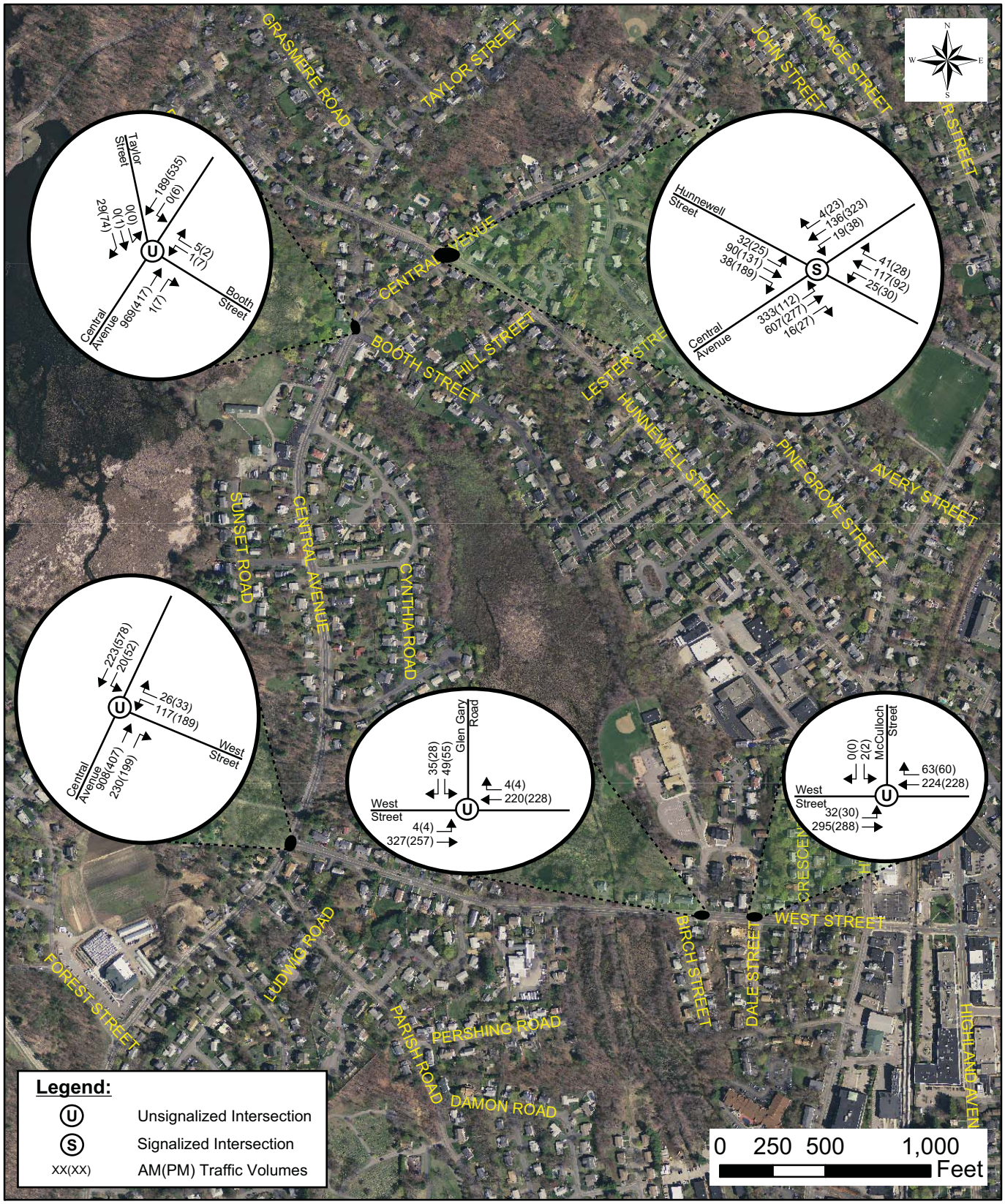

Figure 7: 2015 Existing Traffic Volumes

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
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4.2 Seasonal Adjustment

Nitsch Engineering researched data from MassDOT to establish if any seasonal adjustment to the traffic counts was necessary. We researched and used the MassDOT's 2007 Weekday Seasonal Adjustment Factors, which is the latest data set available. The data compares monthly traffic volumes from different types of roadways across the Commonwealth to compare the traffic volumes from each individual month to the annual average. During the month of September on urban arterials and collectors, traffic volumes are approximately 8% higher than an average month. Additionally, the counts were performed while school was in full session, so the traffic counts represent the average condition with respect to traffic within the study area. Therefore, we made no adjustment to the collected volumes. The Weekday Seasonal Adjustment Factors are included in Appendix A-2.

5 FUTURE NO-BUILD TRAFFIC CONDITIONS

5.1 Background Growth

Consistent with recent MassDOT projects in eastern Massachusetts, we used an annual background traffic growth factor of 0.5%.

5.2 No-Build Traffic Volumes

The 2020 No-Build Traffic Volumes are shown in Figure 12 and are derived by applying the traffic growth rate of 0.5% per year over the ten-year design horizon to project the 2025 traffic counts.

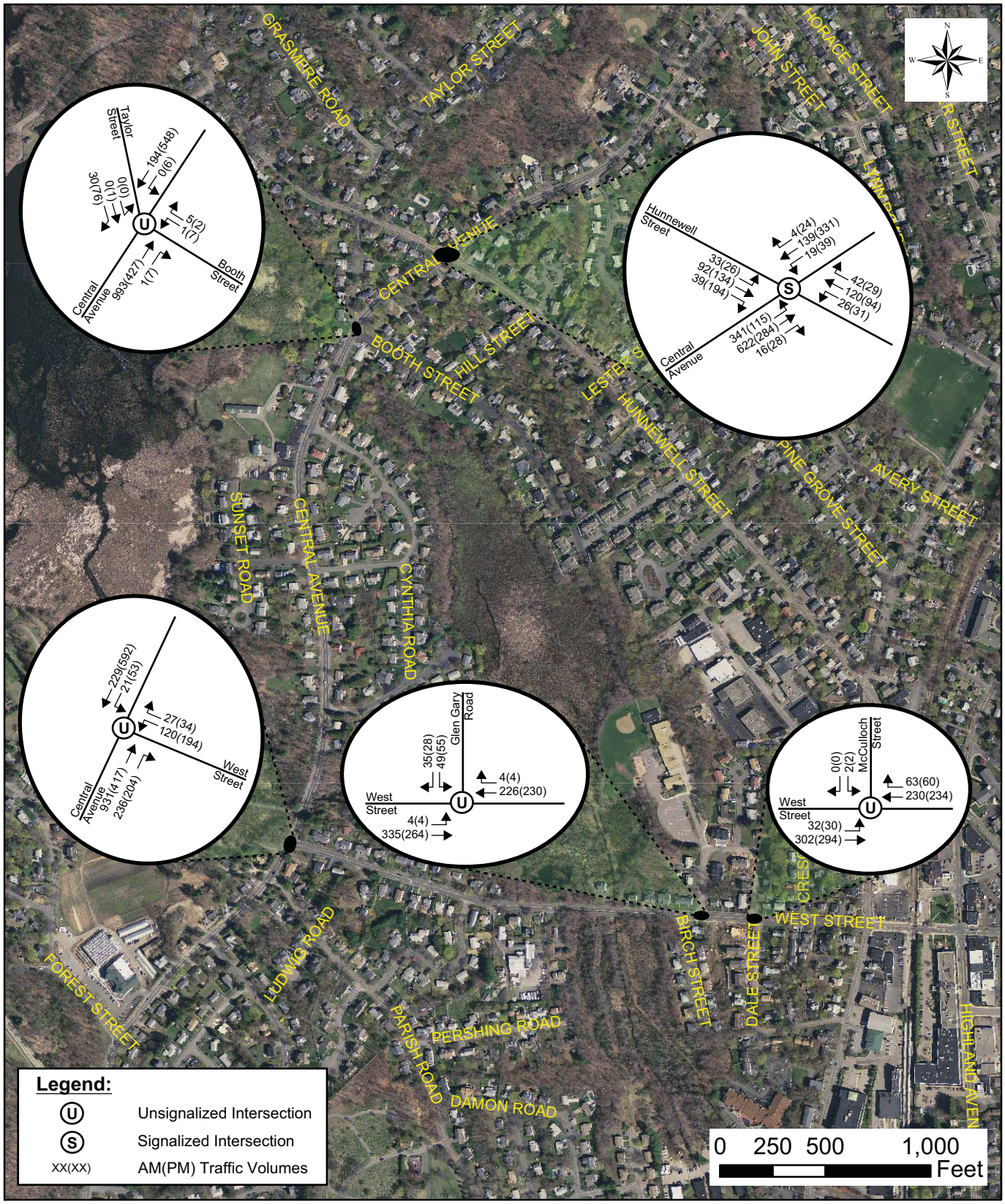

Figure 8: 2020 No-Build Traffic Volumes

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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6 FUTURE CONDITIONS

We examined the proposed future conditions with respect to the feasibility of constructing a new Hillside Elementary School building and grounds on Central Avenue site.

6.1 Proposed Trip Generation

The increase in traffic volumes at Central Avenue due to the new site for the school during the weekday morning drop-off and weekday afternoon pick-up, are outlined in Table 5.

Table 5 - Existing and Proposed Trip Generation

TRIP DIRECTION/TYPE	Weekday Morning Peak[b]	Weekday Evening Peak[b]
Entering	**AM**	**PM**
Central Avenue	101	96
Exiting	**AM**	**PM**
Central Avenue	101	96
Total Future	**202**	**192**

[a]Morning Peak Hour, 7:00 - 8:00 AM; [b]Afternoon Peak Hour, 2:30- 3:30 PM

As shown in Table 5, the proposed Hillside Elementary School at Central Avenue site would result in approximately 202 additional entering and exiting trips during the weekday morning drop-off, and approximately 196 additional entering and exiting trips during the weekday afternoon pick-up. The increase also accounts for vehicular traffic associated with teachers and staff at the new school, as well as the additional student drop-off and pick-up during adverse weather.

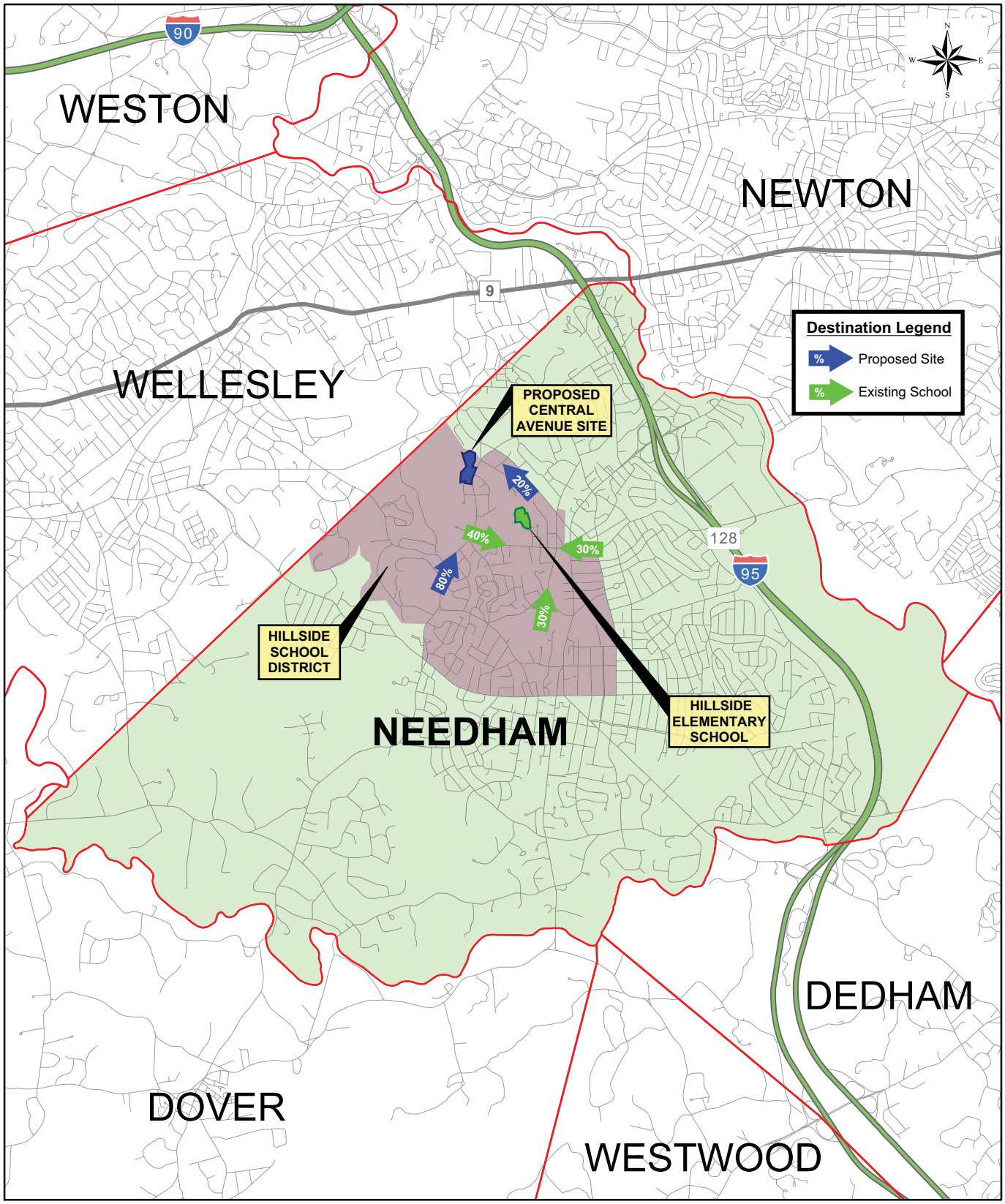

Figure 9: Regional Trip Distribution
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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6.2 Proposed Hillside Elementary School on Central Avenue Site

A sketch plan of the redevelopment of Hillside Elementary School on the Central Avenue Site is shown in Appendix A-4. The sketch plan shows the proposed driveway location of the school on an existing base map with the site location and outline.

Site Layout

For the construction of the new Hillside Elementary School building and grounds on the Central Avenue site, the building would be constructed orientated north-south on the west side of Central Avenue, opposite Cynthia Road, located approximately one tenth of a mile south of the intersection of Central Avenue at Hunnewell Street.

Parking

Parking would be provided onsite east of the proposed school building. In all, 100 parking spaces are proposed.

Sight Distance

Stopping Sight Distance (SSD) is the length of the roadway ahead that is visible to the driver and should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path. Stopping sight distance is the sum of the distance traversed by the vehicle from the instant the driver sights an object necessitating a stop to the instant the brakes are applied and the distance needed to stop the vehicle from the instant brake application begins.

Intersection Sight Distance (ISD) is the length of the leg of the departure sight triangle along the major road in both directions for a vehicle stopped on the minor road waiting to depart. The critical departure sight triangles for the Hillside Elementary School driveway is for traffic approaching from either the left or right for left turns from the driveways onto the main road. The methods for determining the sight distances needed by drivers approaching intersections are based on the same principles as stopping sight distance, but incorporate modified assumptions based on observed driver behavior at intersections.

The SSD and ISD values associated with a given design speed is shown in Table 6. The proposed site driveway is highlighted in Figure 10. The site distance evaluations for the Central Avenue Site is shown in Table 7.

Table 6 – Sight Distance Criteria

DESIGN SPEED	DESIGN STOPPING SIGHT DISTANCE VALUE[1] (SSD)	RECOMMENDED INTERSECTION SIGHT DISTANCE VALUE[2] (ISD)
(MPH)	(FT)	(FT)
15	80	170
20	115	225
25	155	280
30	200	335
35	250	390
40	305	445
45	360	500
50	425	555
55	495	610
60	570	665
65	645	720
70	730	775
75	820	830
80	910	885

Source: *A Policy on Geometric Design of Highways and Streets, AASHTO, Washington DC (2011)*

[1]Design value based on a grade of less than 3%, a brake reaction distance predicted on a time of 2.5 seconds and a deceleration rate of 11.2 ft/s^2

[2]Recommended value based on Case B1 - a stopped passenger car to turn left onto a two-lane highway with no median and grades 3% or less

The higher of the posted, or 85th percentile, speed was used to calculate the minimum sight distance to be conservative.

At Central Avenue at Proposed Hillside Elementary School Driveway the SSD's exceed the minimum values as well as the ISD for right turning vehicles onto Central Avenue. It should be noted that the 85th percentile speed of 35 miles per hour was used to calculate the minimum SSD and ISD values.

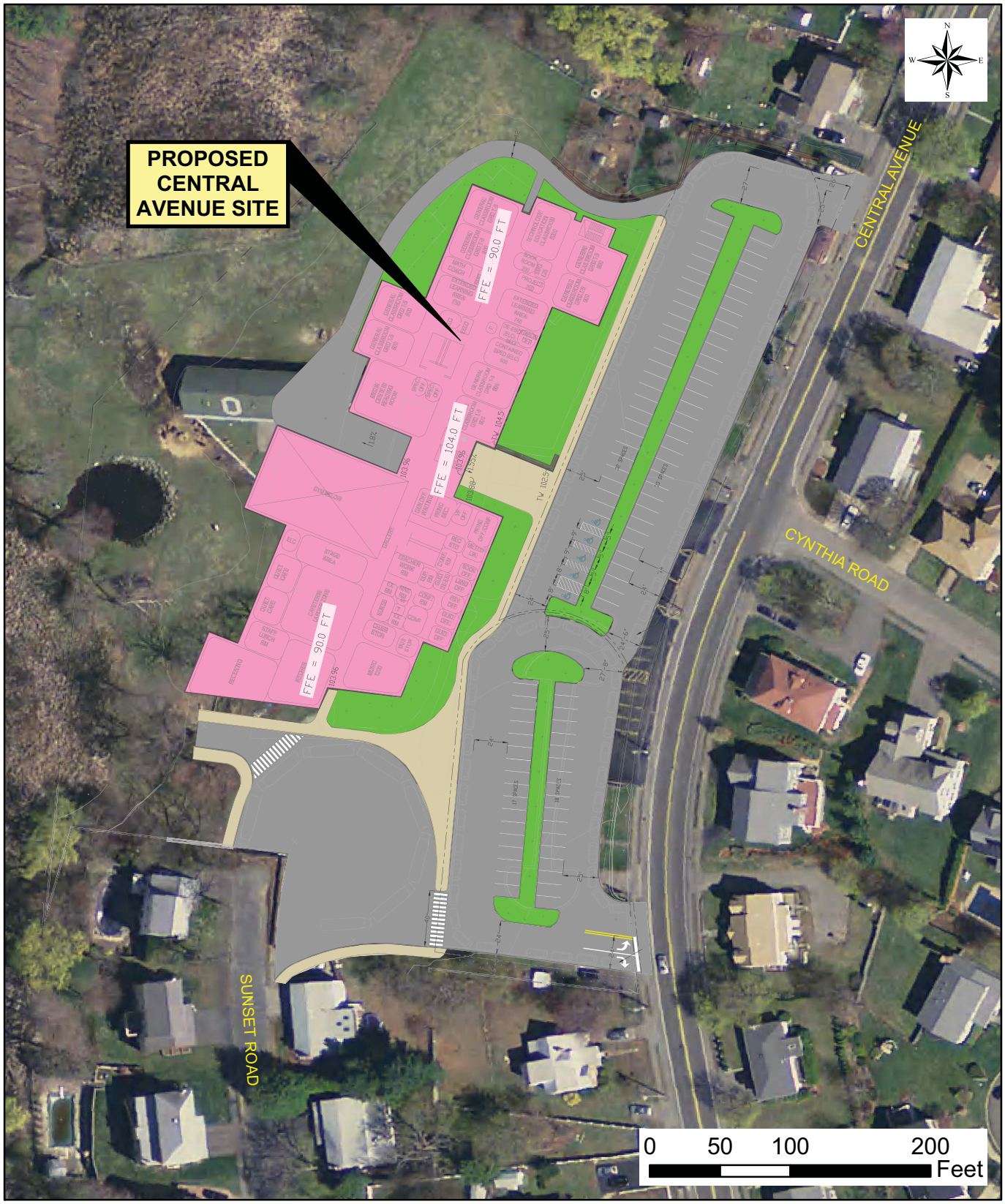

Figure 10: Proposed Site Driveway
Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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Table 7 - Proposed Sight Distance Evaluation

INTERSECTION	POSTED SPEED (MPH)	85th PERCENTILE SPEED (MPH)	MINIMUM (FEET)[1,2]	MEASURED (FEET)	OBSTRUCTION
Central Avenue at Potential Site Driveway					
Stopping Sight Distance:					
Central Avenue Northbound	35	35	250	400	Vertical curve
Central Avenue Southbound	Not Posted	35	250	600	Horizontal curve
Intersection Sight Distance:					
Looking to the right from Potential Site Driveway	35	35	390	420	Vertical curve
Looking to the left from Potential Site Driveway	Not Posted	35	390	625	Horizontal curve, utility pole

Source: A Policy on Geometric Design of Highways and Streets, AASHTO, Washington DC (2011)

[1] Table 3-1. Stopping Sight Distance on Level Roadways

[2] Table 9-6. Design Intersection Sight Distance - Case B1, Left Turn from Stop

Vehicle Access/Egress, Circulation, Bus and Parent Pick-Up/Drop-Off

Vehicle access and egress will be provided by two curb cuts:

- One located on the south side of the proposed school site on Central Avenue, approximately 200 feet south of the intersection of Central Avenue and Cynthia Road providing both access and egress.
- One located on the north side of the proposed school site on Central Avenue, approximately 150 feet north of the intersection of Central Avenue and Cynthia Road providing emergency access.

The curb cut will provide direct access to the school parking lot, and a one-way counter-clockwise parent pick-up/drop-off loop around it.

The bus pick-up/drop-off will occur at the designated bus loop located west of the school. The access to the bus loop will be off of Central Avenue via Cefalo Street and Sunset Road.

Trip Distribution, Diversion, and Assignment

The trips to/from the Central Avenue Site will be distributed and assigned based on the exiting travel patterns and logical travel routes, which are based on the existing roadway network both within the Town of Needham and the surrounding region.

In order to properly assess the effect of trips to the Central Avenue Site, drop-off and pick-up trips at the existing Hillside Elementary School must be assigned to the Central Avenue Site. The Trip Distribution Percentages specific to the Central Avenue Site is shown in Figure 9.

The resultant trip assignment volumes for both the weekday morning and weekday afternoon peak hours were calculated by multiplying the trip distribution by the trip generation from Table 8, and are shown in Figure 10 for the weekday morning and the weekday afternoon peak hours.

Proposed 2020 Build Volumes

For the Central Avenue Site, the corresponding trip assignment volumes were added to the 2020 No-Build Volumes to yield the 2020 Build Volumes. The 2020 Build Volumes for the Central Avenue Site are shown in Figure 11.

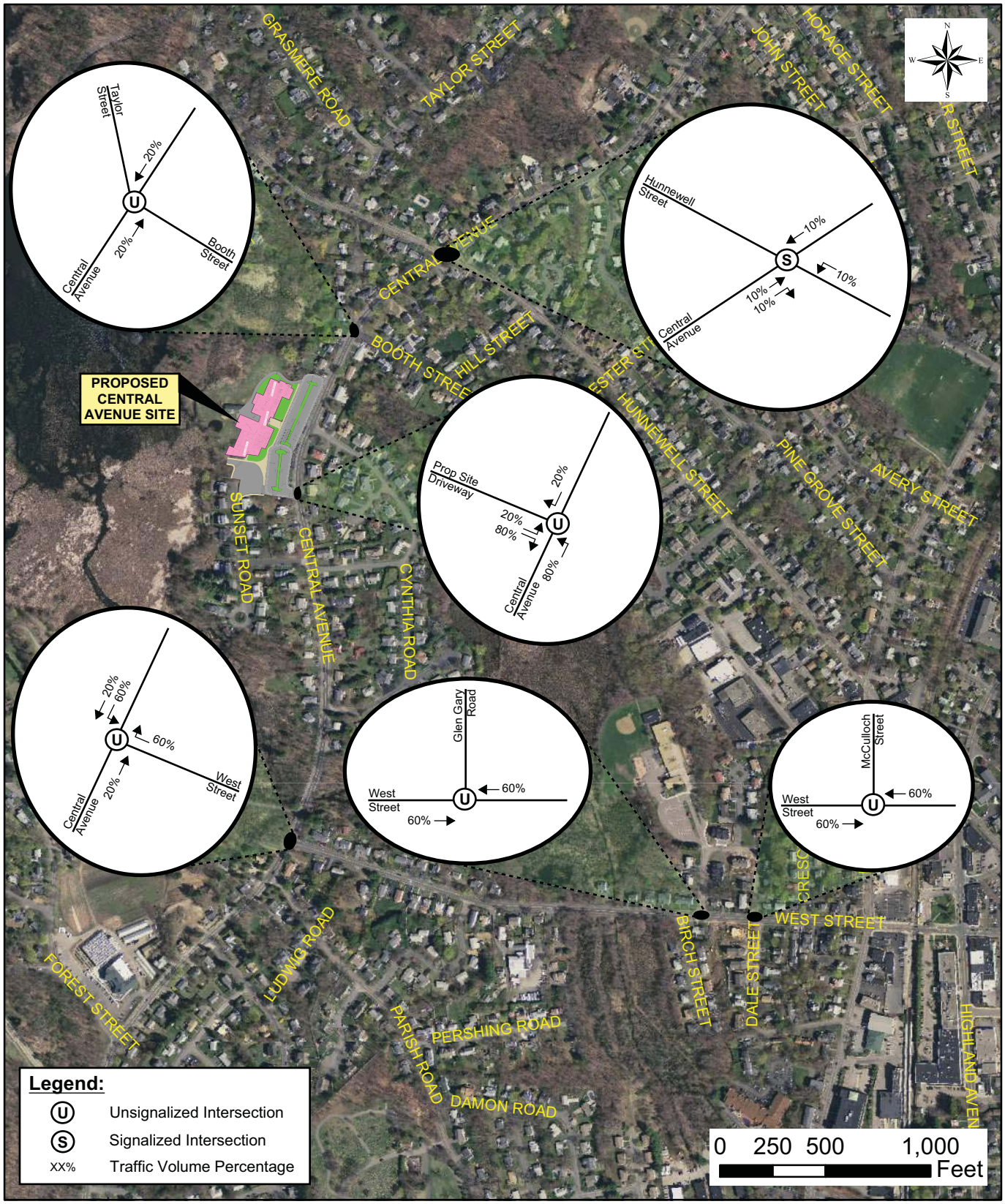

Figure 11: Trip Distribution

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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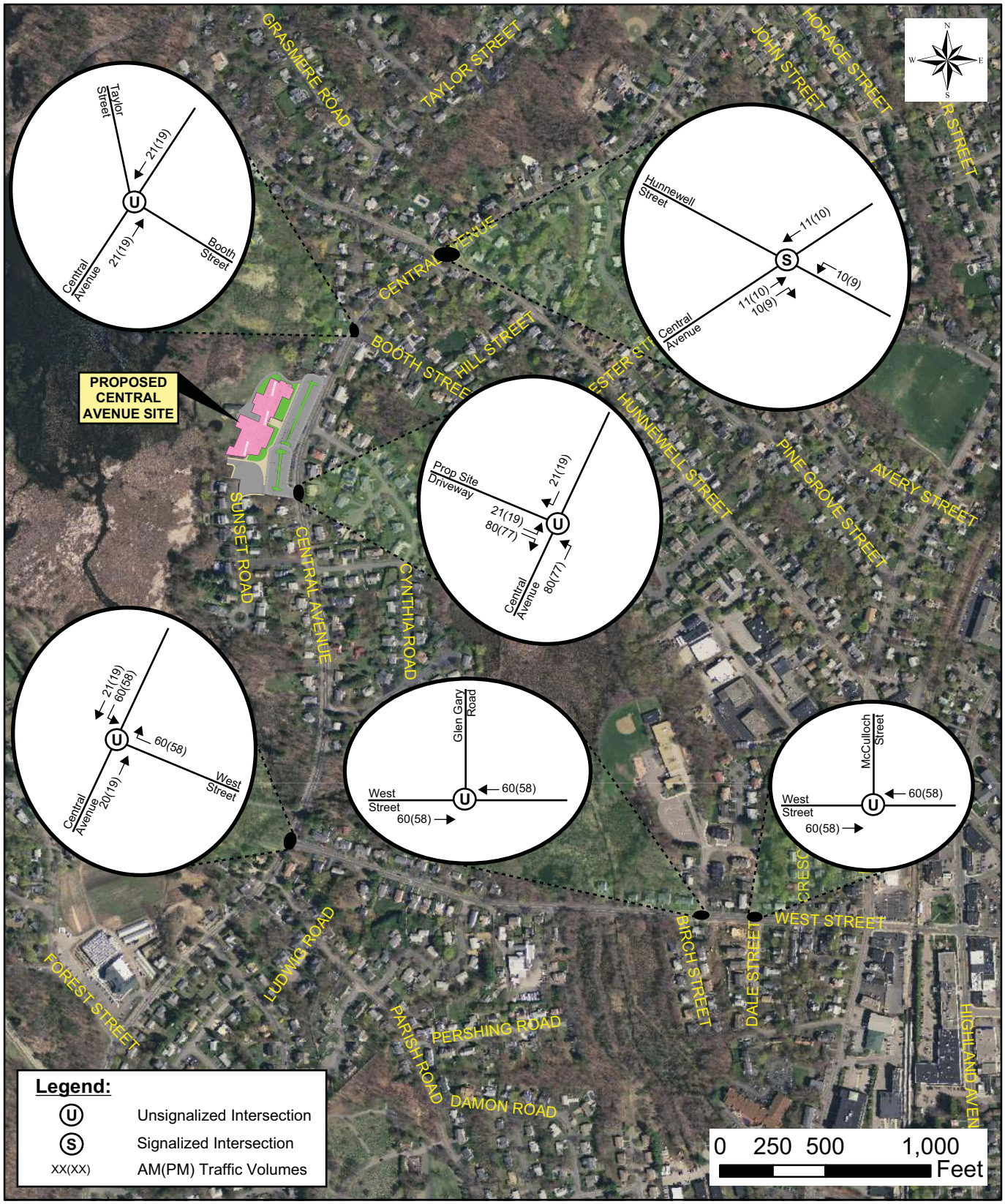

Figure 12: Trip Assignment

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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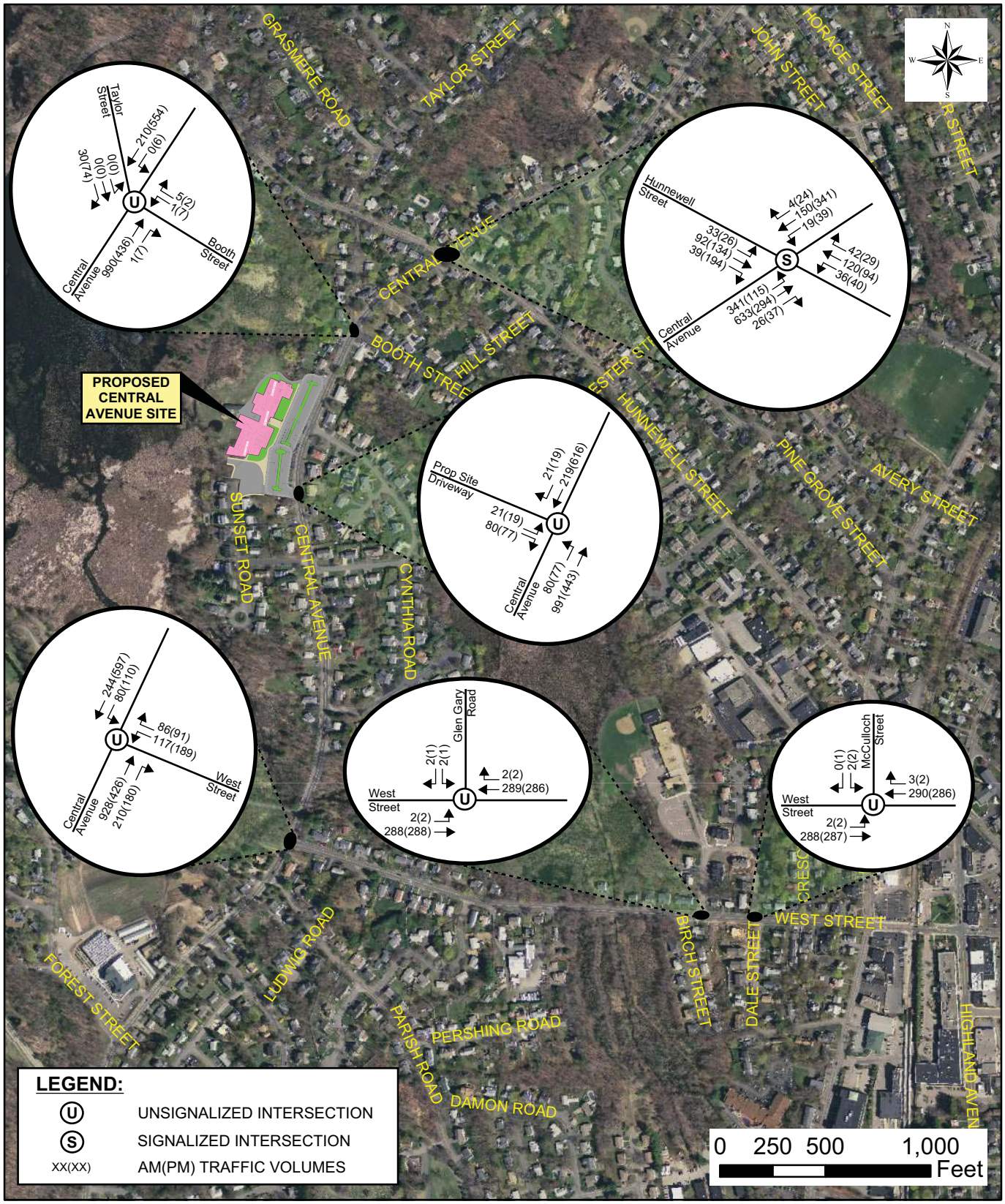

Figure 13: 2020 Future Build Traffic Volumes

Hillside Elementary School
Needham, Massachusetts

Data Source: MassGIS
Nitsch Project #10828

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7 OPERATIONS ANALYSIS

7.1 Level of Service Criteria

Level of Service (LOS) is a qualitative measure describing operational conditions within a traffic stream. Six (6) LOS criteria are used to describe the quality of traffic flow for any type of facility controls. LOS A represents the best operating conditions, and LOS-F represents the worst operating conditions. Nitsch Engineering analyzed the levels of service for signalized intersections using Synchro 8 software, which is based on the traffic operational analysis methodology of the Highway Capacity Manual[1] (HCM). The methodology for signalized intersections assesses the effects of signal type, timing, phasing, progression, vehicle mix, and geometrics on control delay. Control delay includes initial deceleration delay, queue move-up time, stopped delay, and final acceleration delay. Table 8 summarizes the relationship between LOS and average control delay for signalized and unsignalized intersections.

Table 8 - Level of Service Criteria

SIGNALIZED INTERSECTIONS		UNSIGNALIZED INTERSECTIONS		
Level of Service	Control Delay (seconds/vehicle)	Level of Service by Volume-to-Capacity (v/c) Ratio		Control Delay (seconds/vehicle)
		v/c ≤ 1.0	v/c > 1.0	
A	0 to 10	A	F	0 to 10
B	>10 to 20	B	F	>10 to 15
C	>20 to 35	C	F	>15 to 25
D	>35 to 55	D	F	>25 to 35
E	>55 to 80	E	F	>35 to 50
F	>80	F	F	>50

Source: 2010 Highway Capacity Manual, Transportation Research Board, Washington D.C. 2010

7.2 Capacity Analysis

Nitsch Engineering performed traffic analyses to evaluate traffic operations for the 2015 Existing Conditions, 2020 No-Build Conditions, and 2020 Build Conditions – Hillside Elementary School at Central Avenue Site during the weekday morning and weekday afternoon peak hours at the study intersections. The analyses depict the volume-to-capacity (v/c) ratio, vehicle delay, LOS, and the 50th/95th percentile vehicle queues.

7.3 2015 Existing Capacity Analysis

Nitsch Engineering analyzed the 2015 Existing Conditions traffic operations at the study intersection based on the existing traffic counts performed by PDI and Nitsch Engineering in September 2015. The Level of Service Summary is shown in Table 9. The analysis worksheets are provided in Appendix A-6.

[1] Highway Capacity Manual, 2010 Edition, Transportation Research Board (TRB), Washington, D.C.

Table 9 – Level of Service Summary - 2015 Existing Conditions

INTERSECTION	MOVEMENT	WEEKDAY MORNING PEAK HOUR					WEEKDAY EVENING PEAK HOUR				
		V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]	V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]
West St at McColluch	West St EB - LT	0.03	1.0	A	-	2	0.03	1.0	A	-	2
	West St WB - TR	0.18	0	A	-	0	0.19	0	A	-	0
	McColluch - LR	0.01	13.8	B	-	0	0.01	13.7	B	-	0
	Overall	0.18	0.6	A			0.19	0.6	A		
West St at Glen Gary	West St EB - LT	0.0	0.1	A	-	0	0.0	0.1	A	-	0
	West St WB - TR	0.14	0	A	-	0	0.15	0	A	-	0
	Glen Gary -LR	0.16	12.7	B	-	15	0.16	12.5	B	-	14
	Overall	0.16	1.7	A			0.16	1.9	A		
West Street at Central Ave	Central Ave NB - TR	0.73	0	A	-	0	0.39	0	A	-	0
	Central Ave SB - LT	0.04	1.4	A	-	3	0.06	1.6	A	-	5
	West St WB- LR	0.96	117.9	F	-	182	1.28	210.6	F	-	335
	Overall	0.96	11.3	B			1.28	32.7	D		
Central Ave at Hunnewell St	Central Ave NB - L	0.47	18.0	B	143	209	0.21	14.6	B	40	70
	Central Ave NB - TR	0.63	19.5	B	336	470	0.32	14.0	B	120	178
	Central Ave SB - LTR	0.36	29.8	C	97	161	0.69	39.1	D	261	379
	Hunnewell St EB-LTR	0.78	66.5	E	117	#220	1.15	135.2	F	~297	#490
	Hunnewell St WB -LTR	0.77	63.4	E	136	#238	0.89	88.0	F	113	#244
	Overall	0.78	30.9	C			1.15	62.3	E		

[1] Volume to Capacity Ratio; [2] Vehicle Delay, measured in seconds; [3] Level Of Service; [4] 50th Percentile Queue (in feet); [5] 95th Percentile Queue (in feet) based upon 22 feet per vehicle; * = Defacto Left Lane; # = volume exceeds capacity, queue may be longer; m = 95th percentile queue is metered by upstream signal; ~ = Volume exceeds capacity, queue is theoretically infinite

7.4 2020 No-Build Capacity Analysis

Nitsch Engineering analyzed the 2020 No-Build Conditions traffic operations at the study intersection. The 2020 No-Build Condition represents the 2015 Existing Conditions and projects a traffic increase at the rate of 0.5% per year between 2015 and 2020. The Level of Service Summary is shown in Table 10. The analysis worksheets are provided in Appendix A-6.

7.5 2020 Build Capacity Analysis

Nitsch Engineering analyzed the 2025 Build Conditions traffic operations at the study intersection for reconstruction of a new Hillside Elementary School on the Central Avenue site. The 2020 Build Conditions represents the 2020 No-Build Conditions traffic volumes and adds the Trip Assignment Volumes for the Hillside Elementary School on the Central Avenue Site. The Level of Service Summary is shown in Table 11. The analysis worksheets are provided in Appendix A-6.

7.6 Traffic Signal Warrant Methodology

To quantify if additional mitigation would be necessary at the Hillside Elementary School on the Central Avenue Site, based on the expanded student population, or at the access and egress points to the Central Avenue Site, we performed Traffic Signal Warrant Analyses.

We performed the warrants based on the procedures outlined in the *Manual on Uniform Traffic Control Devices*[2] (MUTCD), 2009 edition. The MUTCD indicates nine (9) separate conditions under which a traffic signal warrant can be met, and they are shown below.

1. Warrant 1: Eight-Hour Vehicular Volume;
2. Warrant 2: Four-Hour Vehicular Volume;
3. Warrant 3: Peak Hour;
4. Warrant 4: Pedestrian Volume;
5. Warrant 5: School Crossing;
6. Warrant 6: Coordinated Signal System;
7. Warrant 7: Crash Experience;
8. Warrant 8: Roadway Network; and
9. Warrant 9: Intersection Near A Grade Crossing.

[2] Manual on Uniform Traffic Control Devices for Streets and Highways, 2009 Edition, Federal Highway Administration

Table 10 – Level of Service Summary - 2020 No-Build Conditions

INTERSECTION	MOVEMENT	WEEKDAY MORNING PEAK HOUR					WEEKDAY EVENING PEAK HOUR				
		V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]	V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]
West St at McColluch	West St EB - LT	0.03	1.0	A	-	2	0.03	1.0	A	-	2
	West St WB - TR	0.19	0	A	-	0	0.19	0	A	-	0
	McColluch - LR	0.01	14.0	B	-	0	0.01	13.8	B	-	0
	Overall	0.19	0.6	A			0.19	0.6	A		
West St at Glen Gary	West St EB - LT	0.0	0.1	A	-	0	0.0	0.1	A	-	0
	West St WB - TR	0.15	0	A	-	0	0.15	0	A	-	0
	Glen Gary -LR	0.17	12.9	B	-	15	0.16	12.6	B	-	14
	Overall	0.17	1.7	A			0.16	1.8	A		
West Street at Central Ave	Central Ave NB - TR	0.75	0	A	-	0	0.40	0	A	-	0
	Central Ave SB - LT	0.04	1.5	A	-	3	0.06	1.6	A	-	5
	West St WB- LR	1.04	144.0	F	-	204	1.38	249.4	F	-	369
	Overall	1.04	13.8	B			1.38	38.8	E		
Central Ave at Hunnewell St	Central Ave NB - L	0.49	18.5	B	143	209	0.22	14.8	B	41	71
	Central Ave NB - TR	0.65	20.1	C	336	470	0.43	15.8	B	178	255
	Central Ave SB - LTR	0.38	30.5	C	97	161	0.77	43.6	D	278	406
	Hunnewell St EB-LTR	0.79	67.5	E	117	#220	1.19	149.8	F	~315	#510
	Hunnewell St WB -LTR	0.78	64.3	E	136	#238	0.92	94.6	F	118	#254
	Overall	0.79	31.6	C			1.19	65.1	E		

[1] Volume to Capacity Ratio; [2] Vehicle Delay, measured in seconds; [3] Level Of Service; [4] 50th Percentile Queue (in feet); [5] 95th Percentile Queue (in feet) based upon 22 feet per vehicle; * = Defacto Left Lane; # = volume exceeds capacity, queue may be longer; m = 95th percentile queue is metered by upstream signal; ~ = Volume exceeds capacity, queue is theoretically infinite

Table 11 – Level of Service Summary - 2020 Build Conditions

INTERSECTION	MOVEMENT	WEEKDAY MORNING PEAK HOUR					WEEKDAY EVENING PEAK HOUR				
		V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]	V/C[1]	DELAY[2]	LOS[3]	50th Q[4]	95th Q[5]
West St at McColluch	West St EB - LT	0.0	0.1	A	-	0	0.03	0.1	A	-	0
	West St WB - TR	0.19	0	A	-	0	0.18	0	A	-	0
	McColluch - LR	0.0	13.2	B	-	0	0.01	12.1	B	-	0
	Overall	0.19	0.1	A			0.18	0.1	A		
West St at Glen Gary	West St EB - LT	0.0	0.1	A	-	0	0.0	0.1	A	-	0
	West St WB - TR	0.19	0	A	-	0	0.18	0	A	-	0
	Glen Gary -LR	0.01	11.6	B	-	1	0.0	11.5	B	-	0
	Overall	0.19	0.1	A			0.18	0.1	A		
West Street at Central Ave	Central Ave NB - TR	0.73	0	A	-	0	0.39	0	A	-	0
	Central Ave SB - LT	0.15	4.8	A	-	14	0.13	3.1	A	-	11
	West St WB- LR	1.59	356.2	F	-	390	1.19	176.9	F	-	288
	Overall	1.59	44.4	E			1.19	25.1	D		
Central Ave at Proposed School Driveway	Proposed Driveway EB - LR	0.29	18.5	C	-	30	0.32	21.1	C	-	33
	Central Ave NB - LT	0.07	1.9	A	-	5	0.09	2.4	A	-	8
	Central Ave NB - TR	0.15	0	A	-	0	0.41	0	A	-	0
	Overall	0.15	2.8	A			0.41	2.6	A		
Central Ave at Hunnewell St	Central Ave NB - L	0.54	24.4	C	168	242	0.23	18.2	B	48	82
	Central Ave NB - TR	0.72	26.8	C	416	573	0.36	17.2	B	157	227
	Central Ave SB - LTR	0.57	42.1	D	122	205	0.76	46.4	D	311	443
	Hunnewell St EB-LTR	0.59	52.9	D	123	200	1.29	189.8	F	~342	#540
	Hunnewell St WB -LTR	0.82	72.0	E	159	#281	0.80	73.3	E	129	#231
	Overall	0.82	36.6	D			1.29	77.3	E		

[1] Volume to Capacity Ratio; [2] Vehicle Delay, measured in seconds; [3] Level Of Service; [4] 50th Percentile Queue (in feet); [5] 95th Percentile Queue (in feet) based upon 22 feet per vehicle; * = Defacto Left Lane; # = volume exceeds capacity, queue may be longer; m = 95th percentile queue is metered by upstream signal; ~ = Volume exceeds capacity, queue is theoretically infinite

7.7 Traffic Signal Warrant

We performed the Signal Warrant Analysis for West Street at Central Avenue, and Central Avenue at the Potential Site Driveway.

Given the criteria set forth in the MUTCD and the assumptions above, the Peak Hour Warrant for the Central Avenue at West Street traffic signal warrant was met. However, based on engineering judgement, the peak hour warrant is generally not accepted unless accompanied by an additional warrant. We believe that the recommendations outlined in Section 8.2 would represent the best return on investment with regards to handling the estimated traffic to and from the Central Avenue Site. The Traffic Signal Warrant Analysis is included in Appendix A-5.

8 CONCLUSIONS AND RECOMMENDATION

8.1 Conclusions

Nitsch Engineering has been retained by Dore & Whittier Architects, Inc. to prepare a qualitative assessment of safety, traffic circulation, and traffic access/egress, associated with the feasibility study and schematic design for the Hillside Elementary School project in Needham, Massachusetts. Two (2) options are considered for the reconstruction. The first option would be to construct a new Hillside Elementary School building and grounds on the site of the existing school, located at 28 Glen Gary Road Needham, Massachusetts. The second option would be to construct a new elementary school building and grounds on an existing site located off Central Avenue, approximately ¾ mile west of the existing Hillside Elementary School site.

We examined the future conditions, as well as site circulation with respect to the projected student drop-off and pick-up at the new Hillside Elementary School at the Central Avenue site. This would result in an increase in traffic volumes within the study area during the weekday morning drop-off and weekday afternoon pick-up, totaling approximately 202 additional trips (entering and exiting) during the weekday morning drop-off, and approximately 192 additional trips (entering and exiting) during the weekday afternoon pick-up. The parking lot will contain 100 spaces, and the curb at the car loop can accommodate approximately 57 vehicles.

We anticipate that the following summarizes the vehicular circulation at the school during morning drop-off and afternoon pick-up periods:

- During the morning drop-off, the parents (approximately 101 vehicles) will arrive between 7:30 and 8:00 AM. They will drop-off their children at the car loop and exit the school. Our analysis indicate that during the morning drop-off, the 95th Percentile Queue length on the School driveway for the left and right turns to Central Avenue will be 30 feet (approximately 2 vehicles), and the 95th Percentile Queue length on Central Avenue for the left turn to the School driveway will be 5 feet (approximately one vehicle).
- During the afternoon pick-up, the parents (approximately 96) will start arriving between 2:00 and 2:30 PM. The parking lot can accommodate approximately 80 vehicles to park along the car loop curb line without spilling out of the car loop and blocking the driveway. Once the parents have picked up their children, they will proceed to exit the parking lot and the school. Our analysis indicate that during the afternoon pick-up, the 95th Percentile Queue length on the School driveway for the left and right turn to Central Avenue will be 33 feet (approximately 2 vehicles), , and the 95th Percentile Queue length on Central Avenue for the left turn to the School driveway will be 8 feet (approximately one vehicle).

The existing roadway network contains heavy traffic volumes and delays during the weekday morning peak hours, as the Hillside Elementary School pick-up and drop-off traffic overlaps slightly with the peak hour of the commuter traffic, as well as two other schools in the vicinity. Relocating the Hillside Elementary School to the Central Avenue site location may add impacts on the off-site intersections. To mitigate the impacts, minor geometric improvements and signal optimization may be necessary. Nitsch Engineering has outlined recommendations to improve traffic conditions based on the estimated increase in traffic volumes due to the Hillside Elementary School relocation.

8.2 Recommendations

Based on the proposed Hillside Elementary School at Central Avenue Site, Nitsch Engineering offers the following recommendations:

- Designate the area as a School Zone under State and local statute, and install the appropriate School Zone signs, which can also act as traffic culming devices.
- Improve pedestrian experience along Central Avenue, including improving the sidewalks on both sides of the roadway to accommodate safe walk to school; and providing advanced warning signing of school entering and exiting traffic.
- Install ADA accessible crosswalks.
- Reach out to parents via social media to increase safety awareness.