Nitsch Engineering

Sherwood Middle School

Traffic Impact and Access Study

October 28, 2009

Prepared for:

Lamoureux Pagano Associates
14 East Worcester Street
Worcester, MA 01604

Submitted by:

Nitsch Engineering
186 Lincoln Street, Suite 200
Boston, MA 02111

Nitsch Engineering Project #7683

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TRAFFIC IMPACT AND ACCESS STUDY
SHERWOOD MIDDLE SCHOOL
SHREWSBURY, MASSACHUSETTS
Nitsch Project #7683
October 28, 2009

INTRODUCTION

General/Site Location

Nitsch Engineering has been retained by Lamoureux Pagano Associates to prepare a qualitative assessment of safety, traffic circulation, traffic access/egress, and parking impacts, for the proposed construction of a new Sherwood Middle School in Shrewsbury, Massachusetts. The project consists of approximately 130,000 square feet middle school buildings.

The existing Sherwood Middle School abuts the Oak Middle School and both share athletic fields and parking. The area surrounding the middle schools generally consists of residential neighborhoods. The major access roads within the study area are: Oak Street, that extends from Maple Avenue to South Quinsigamond Avenue and runs in the North/South directions, Crescent Street, that begins at Maple Avenue and ends at Boston Worcester Turnpike (Route 9), and Maple Avenue, that extends from Main Street to Boston Worcester Turnpike (Route 9) and runs in the East/West directions. The local access roads to the Middle Schools include Sherwood Avenue, Hutchins Street, and Oak Street.
Figure 1 shows the site locus map. The proposed option contains the following design changes:

1. Construct a new building west of the existing building
2. Introduce a new access road to Sherwood Middle School from Crescent Street
3. Reconfigure parking

The construction of an access point off of Crescent Street will shift traffic patterns around the site. Impacts generated by the site will be derived from the change in traffic due to student enrollment and traffic redistribution due to the new access to the proposed building. Figure 2 shows the proposed Sherwood Middle School.

Figure 1 - Locus Map - Existing Sherwood Middle School

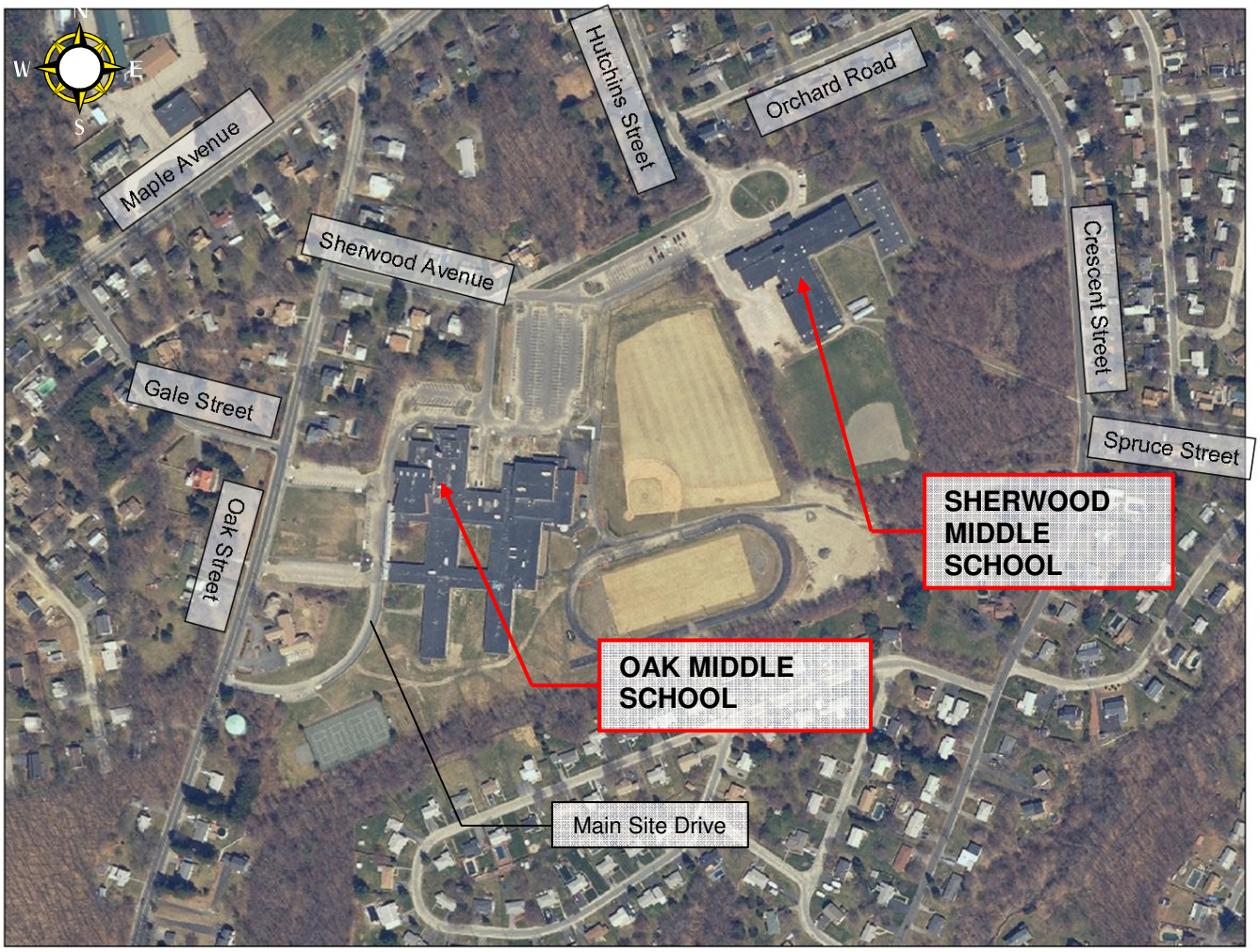
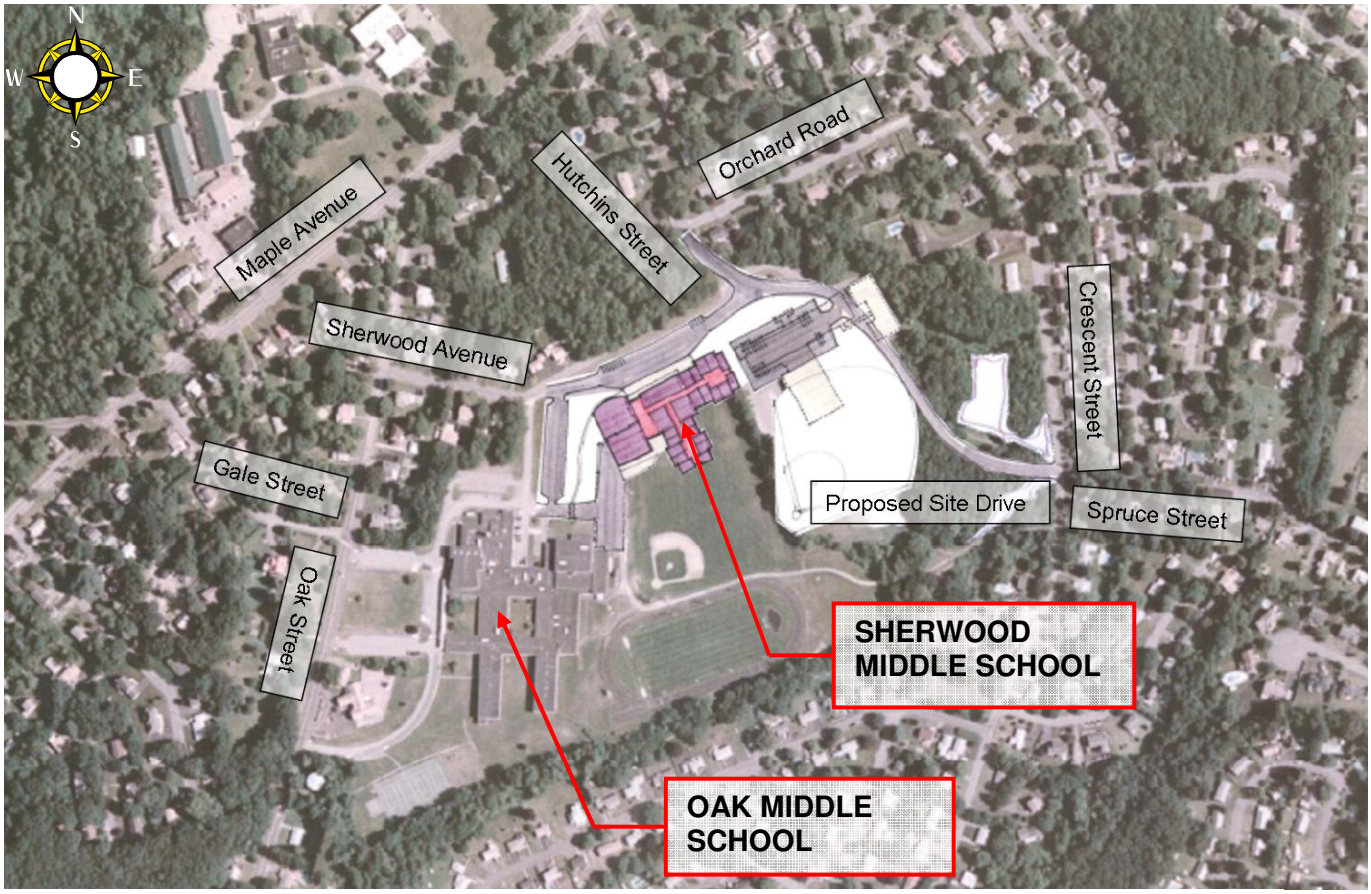


Figure 2 - Proposed - Sherwood Middle School



LAMOUREUX · PAGANO ASSOCIATES, ARCHITECTS
14 EAST WORCESTER STREET, WORCESTER, MASSACHUSETTS 01604
TELEPHONE 508.762.2001 • www.lamoureuxpagano.com

Proposed Sherwood Middle School
New Construction - Oak / Sherwood Connection Option

EXISTING CONDITIONS

Field Reconnaissance

Nitsch Engineering conducted field reconnaissance on Thursday July 30, Wednesday September 16, Thursday September 17, and Monday October 26, 2009 to observe traffic operations, geometric conditions, parking accommodations, pedestrian accommodations, signing, pavement markings, local site access/egress, and overall roadway and intersection conditions.

The following external intersections were included in the study area; all intersections are unsignalized:

- Oak Street/Gale Avenue
- Oak Street/Sherwood Avenue

- Hutchins Street/Orchard Road
- Crescent Street/Spruce Street

In addition, the internal circulation of the site was reviewed, including the intersection of:

- Sherwood Avenue/Site Drive

Below is a description of each of the study area intersections with corresponding photos of the locations.

Oak Street /Gale Avenue

This four-legged unsignalized intersection consists of Oak Street approaching from the north and south, Gale Avenue approaching from the west, and the School Driveway approaching from the East. Gale Avenue intersects Oak Street adjacent to the School Driveway, on the northern side. Cars traveling between Gale Avenue and the School Driveway must turn right and then left, rather than travelling straight through. Along the school side of Oak Street, and along the south side of Gale Street, 4-foot wide sidewalks exist that are separated from the road by a narrow strip of grass. A 6-foot wide crosswalk is marked across Oak Street, between School Street and Gale Avenue. Pedestrian ramps are present on the School Driveway sidewalk, but there are no ramps facing the crosswalk, or on the western side of the street. The pavement is cracked at the end of the crosswalk. There were no speed limit signs posted on any of the approaches.

Oak Street northbound and southbound has a double yellow centerline separating two (2) 14-foot wide travel lanes. There is no shoulder provided from the edge of pavement. We observed warning signs that inform drivers of a school crossing at the intersection. Oak Street allows travel is both directions.

The School Driveway only allows passenger vehicles to travel west towards Oak Street, the only incoming traffic allowed are buses. The School Driveway is 19 feet wide with no lane markings. Gale Avenue is 20 feet wide with no lane markings.

Aside from Oak Street traffic, the primary land uses in the vicinity of this intersection include residential uses.

Oak Street, looking north

Gale Avenue, looking east

Oak Street/Sherwood Avenue

This three-legged unsignalized intersection consists of Oak Street approaching from the north and south and Sherwood Avenue approaching from the east. 4-foot wide sidewalks exist along the east side of Oak Street

and along both sides of Sherwood Avenue separated from the edge of pavement by a narrow strip of grass. Although there are no crosswalks within the intersection, pedestrian ramps are present on both sides of the Sherwood Avenue, but do not comply with MassHighway and ADA guidelines.

Oak Street has a double yellow centerline separating a 15-foot and a 14-foot wide travel lane in the north and southbound directions respectively. No edgeline pavement markings are present. Oak Street allows travel in both directions. At this intersection, Oak Street is the major street; therefore no stop lines are marked on either approach, and there is no stop sign necessary. We observed a warning sign, located north of the intersection, advising drivers to slow for school children. In addition, there are “SLOW” and “SCHOOL” pavement markings on the southbound side of Oak Street. Sherwood Avenue westbound is 24 feet wide with no lane markings. Both streets allow two-way traffic.

Aside from Oak Street traffic, the primary land uses in the vicinity of this intersection include residential uses.

Oak Street, looking north

Sherwood Avenue, looking west

Hutchins Street/Orchard Road

This three-legged intersection consists of Hutchins Street approaching from the north and south, and Orchard Road approaching from the east. Along both sides of the northbound approach of Hutchins Street, and along the south side of Orchard Road is a 6-foot wide sidewalk. A 4-foot wide sidewalk is present along the southbound side of Orchard Road. A wide strip of grass and trees separates the sidewalk and the pavement. Although there are no crosswalks within the intersection, pedestrian ramps are present on both sides of Orchard Road, but do not comply with MassHighway and ADA guidelines.

Hutchins Street has a single white centerline separating 13-foot and 14-foot wide travel lanes in the northbound direction. There is no shoulder provided from the edge of pavement. Hutchins Street allows travel in both directions, but only during off-peak hours. During the hours of 7:00 AM to 8:30 AM, and 2:00 PM to 3:30PM, there is no southbound traffic allowed on Hutchins Street. There is a stop sign and stop line located on both the Hutchins Street northbound and the Orchard Road westbound approaches. There are regulatory signs along the southbound approach of Hutchins Street, restricting traffic during school hours. The speed limit on Hutchins Street is indicated by a 15 mile per hour sign located to the south of the intersection.

Orchard Road is 24 feet wide with no lane markings. We observed a regulatory sign, located on the west side of the intersection, across from Orchard Road, restricting left turns during the hours of 7:00 AM to 8:30 AM, and 2:00 PM to 8:30 PM. Orchard Road allows two-way traffic.

The primary land uses in the vicinity of this intersection are residential uses.

Hutchins Street, looking south

Orchard Road, looking west

Crescent Street/Spruce Street

This three-legged unsignalized intersection consists of Crescent Street approaching from the north and south and Spruce Street approaching from the east. A 4-foot wide sidewalk exists on the north side of Spruce Street and on the east side of Crescent Street, north of Spruce Street, where it is separated from the edge of pavement by a narrow strip of grass. There is a crosswalk across the north side of Crescent Street that goes to a pedestrian walkway into the site. There are no pedestrian ramps present on either side of Crescent Street, and this does not comply with MassHighway and ADA guidelines.

Crescent Street is 23 feet wide and has no double yellow centerline separating travel in the north and southbound directions. No edgeline pavement markings are present. Crescent Street allows travel in both directions. At this intersection, Crescent Street is the major street; there is a stop line marked on the Spruce Street westbound approach, and there is a stop sign facing this approach as well. Spruce Street westbound is 19 feet wide with no lane markings. Both streets allow two-way traffic.

Aside from Crescent Street traffic, the primary land uses in the vicinity of this intersection include residential uses.

Crescent Street, looking south

Spruce Street, looking west

Sherwood Avenue/Main Site Drive

This four-legged unsignalized intersection consists of Sherwood Avenue approaching from the east and west, and the Main Site Drive approaching from the south and southeast. Site Drive intersects Sherwood Avenue in two adjacent locations on the southern side of Sherwood Avenue. Vehicles continuing along the Site Drive in the eastbound direction must turn right, and vehicles continuing in the southbound direction must turn left, rather than travelling straight through the intersection. A 4-foot wide sidewalk is present along both sides of Sherwood Avenue eastbound, and along the north side of Sherwood Avenue westbound. They are separated from the road by a narrow strip of grass. A 6-foot wide sidewalk runs along the edge between the northbound site drive and the westbound site drive. An 8-foot wide crosswalk is marked across the northbound site drive. Pedestrian ramps are present on both ends of the crosswalk, but they do not comply with ADA guidelines. The pavement is cracked along the edges of the sidewalk and in the middle of the intersection. If left unrepaired, this could worsen the pavement conditions and create safety concerns for traffic and pedestrians.

Sherwood Avenue is 24 feet wide and allows two-way traffic, but has no centerline. There is no shoulder provided at the edge of pavement. A Yield sign controls traffic on Sherwood Avenue eastbound.

The northbound site drive is 24-feet wide and allows two-way traffic, but has no centerlines, no stop line, and no shoulders. The westbound site drive is 30-feet wide, and has a white centerline separating traffic into two 15-foot travel lanes, and a stop line is present on the westbound approach. This site drive allows two-way traffic.

This intersection is where bus traffic conflicts with the parent pick-up drop-off traffic. Buses turn right at this intersection from the northbound site drive and continue eastbound towards Sherwood Middle School. In order for them to navigate the turn safely, all other traffic must come to a stop. This causes problems with traffic operations and results in traffic backing up on Sherwood Avenue, onto Oak Street, and eventually Maple Street.

The primary land uses in the vicinity of this intersection are residential uses.

Sherwood Avenue, looking east

Site Drive, looking north

Internal Circulation

There are two key access routes within the site - one is for parent pick-up drop-off, and one is for buses. Buses enter the site from Oak Street, and exit the site at Hutchins Street. Parents can only enter and exit the site from Sherwood Avenue, and must use the designated pick-up/ drop-off area around the edges of parking lot P10.

Site Drive 1 is located along Oak Street and allows one-way traffic eastbound into the site. This drive travels east for about 150 feet before gradually turning north, becoming the main site drive. Site Drive 2 is located about 270 feet to the north of site drive 1. This access point only allows one-way eastbound travel into the school drive. This segment travels east for about 270 feet before intersecting the Main Site Drive. Site Drive 3 intersects Oak Street about 225 feet to the north of Site Drive 2. This driveway intersects Oak Street adjacent to Gale Avenue at its western end, and intersects the Main Site Drive approximately 225 feet east of Oak Street. Site Drive 3 acts as an exit point for passenger vehicles, and an entrance point for buses. However, it is not wide enough for both buses and passenger vehicles to comfortably maneuver simultaneously.

The main site drive continues north 130 feet, where it turns sharply east and splits into two roads. The southern road is one-way eastbound, and the northern road is one-way westbound, creating a loop around two parking aisles (P5 and P6). To the east of the P5 and P6, the Site Drive turns north again for 270 feet before reaching Sherwood Avenue. There is a large parking lot (P7) to the east of this roadway that contains access points at its southern end, across from P5, and at its northern end off of Sherwood Avenue. This parking lot, P7, is the location of the pick-up/ drop-off area.

To the north of P7, the Site Drive continues east towards Sherwood Middle School. Again, the roadway splits around a parking lot (P8) creating a one-way loop. The eastbound traffic travels along the southern end of the parking lot, and the westbound traffic travels along the northern end of the parking lot.

At the eastern end of P8, the site drive ends at a roundabout, with Hutchins Avenue intersecting the roundabout from the north, and the site drive intersecting the roundabout from the west. To the south of the roundabout, in front of the school, is where buses queue for pick-up/ drop-off. There are currently 33 – 35 buses on site, circulating in a staggered fashion.

The existence of multiple one-way roadway sections is confusing to drivers maneuvering through the site. There are missing centerlines on many of the two-way sections, which cause confusion to drivers. Figure 3 shows the names and locations of the parking areas and internal roadways. Figure 4 depicts the internal traffic circulation.

Figure 3 - Parking Locations

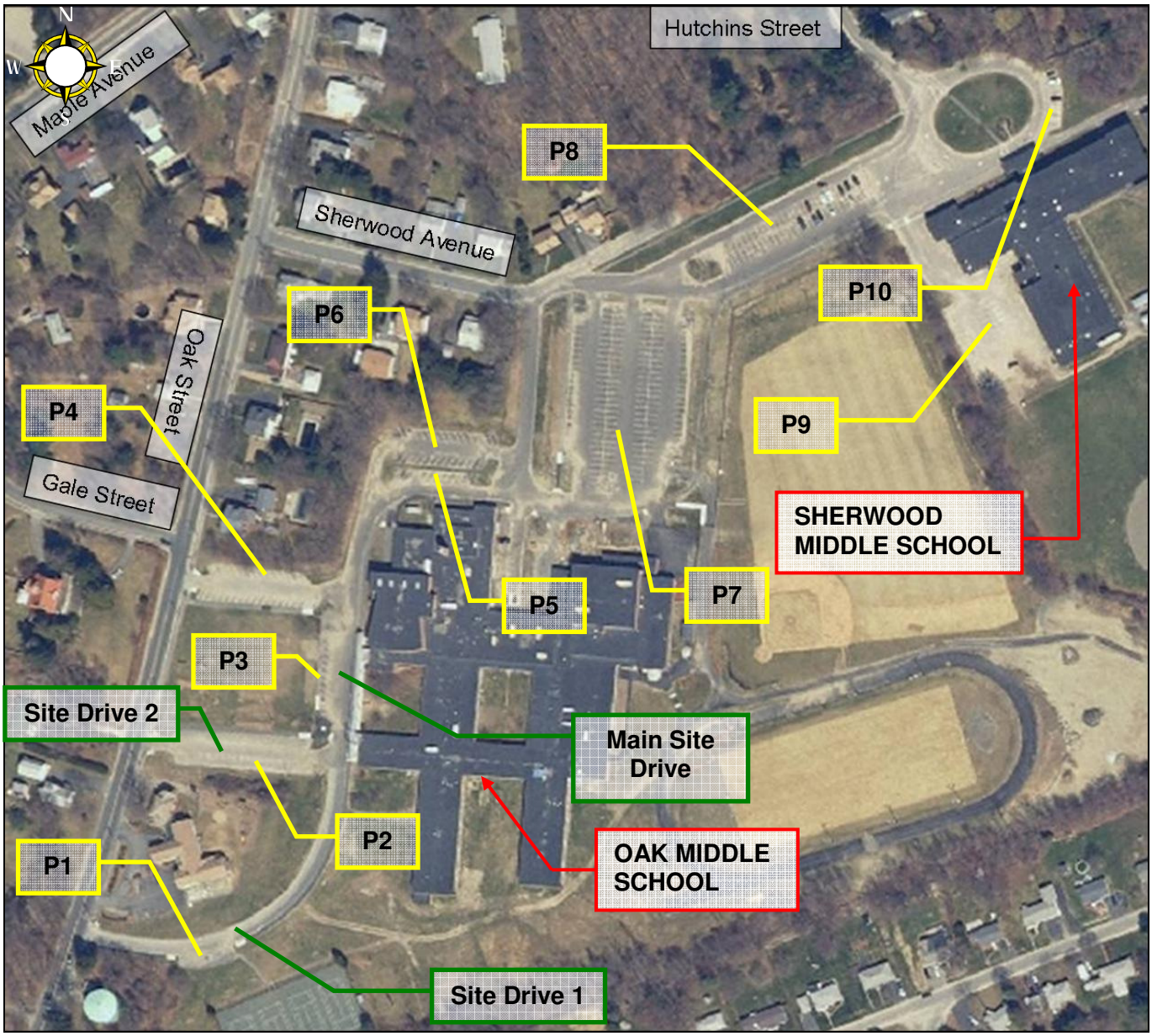
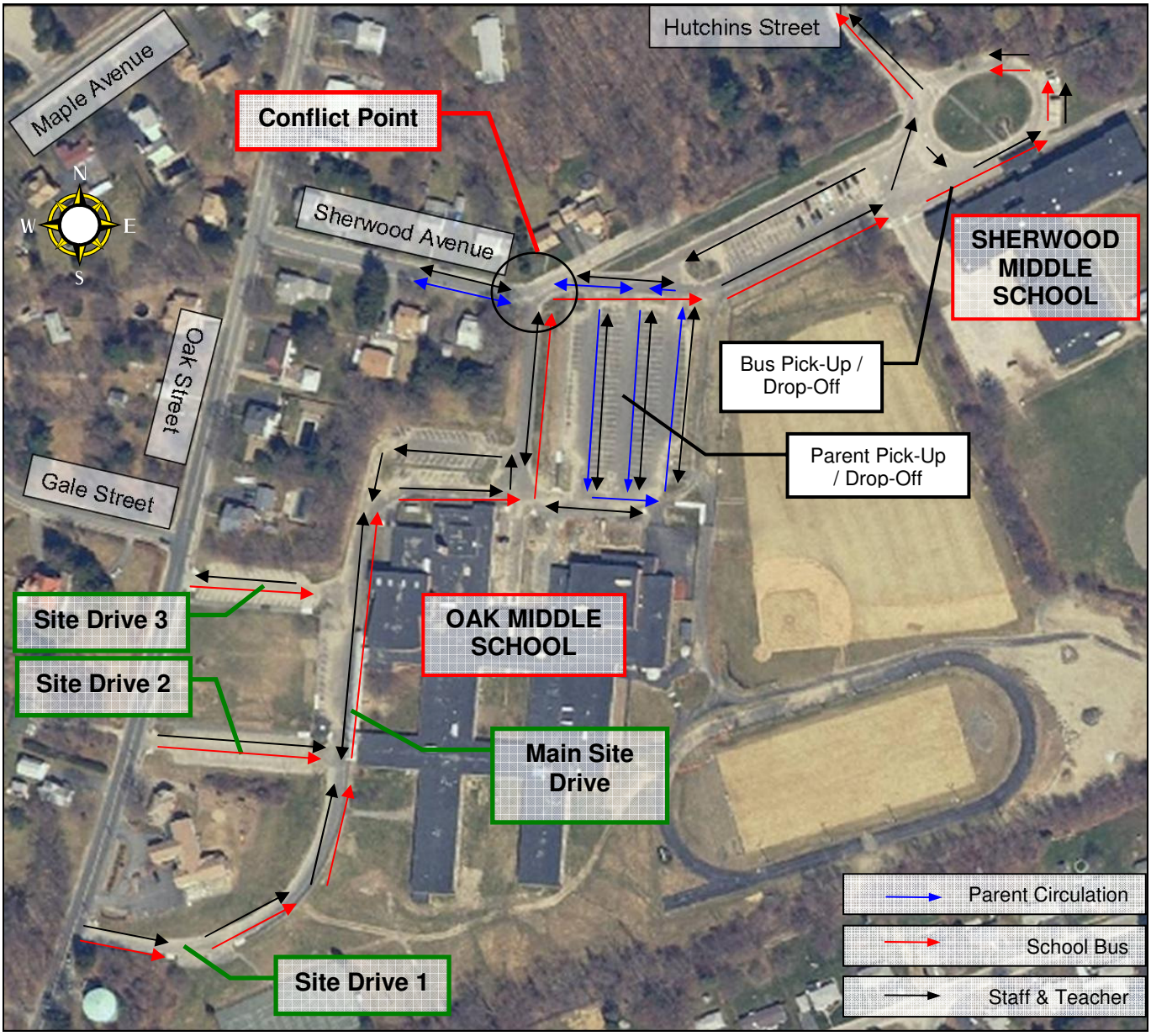


Figure 4 - Circulation



Crash Data

Nitsch Engineering analyzed crash data for the study area intersections. We queried MHD's crash record database for the Town of Shrewsbury, and identified two (2) crashes in 2006, one is at the intersection of Oak Street and Gale Avenue, and one is at the intersection of Oak Street and Sherwood Avenue. Both crashes involved two vehicles and caused property damage only. No reported crashes occurred at the intersection of Hutchins Street/Orchard Road. We did not check the town police records for any crash information. Typically police records are not available for public use at the level of details shown on the MHD database.

In addition, there were a number of Crashes located at intersections along the school access roads. There were six (6) crashes at the intersection of Oak Street and Maple Avenue. Three (3) crashes occurred in 2005, one (1) crash occurred in 2006, and two (2) crashes occurred in 2007. All of the crashes involved two vehicles. Five (5) of the crashes caused property damage only, and one (1) crash caused a non-fatal injury. There was also one (1) crash in 2007 at the intersection of Hutchins Street and Maple Avenue which involved two cars and caused a non-fatal injury. Two (2) other crashes occurred along Oak Street during this time. One crash occurred in 2006 and was a single-vehicle crash involving property damage only. The other crash occurred in 2007, involving two vehicles and caused a non-fatal injury. Table 1 summarizes the results of the crash analyses.

Table 1 - Crash Summary

Location	Number of Crashes		Severity				Manner of Collision					Percent During	
	Total	Year	PD[a]	PI[b]	NR[j]	F[c]	CM[d]	RE[e]	HO[f]	Ped[g]	Other[h]	Peak Hours	Wet/Icy Conditions
Oak Street/ Gale Avenue	1	2006	1	-	-	-	1	-	-	-	-	100%	0%
Oak Street/ Sherwood Avenue	1	2006	1	-	-	-	-	1	-	-	-	100%	0%
Total	2		2	-	-	-	1	1	-	-	-	100%	0%

[a]Property Damage Only; [b]Personal Injury; [c]Fatality; [d]Cross Movement (or angle); [e]Rear end; [f]Head on; [g]Pedestrian [j]Not reported or unknown in term of severity; [h]Sideswipe, opposite direction; sideswipe, same direction, signal vehicle crash, not reported, unknown etc.

Sight Distance Evaluation

Nitsch Engineering performed a stopping sight distance (SSD) and Intersection sight distance (ISD) evaluation at the intersection of Crescent Street and Spruce Street. SSD is the minimum visibility required for a vehicle on the major street to observe the presence, and safely stop the vehicle to prevent collision with an object/vehicle from the minor street. ISD is the minimum visibility for a vehicle stopped on the minor street to observe and assess the major street traffic to enter the intersection. We used the Project Development and Design Guide[1] to establish the required minimum SSD and ISD. We used the Existing Conditions Plan, prepared by Waterman Design Associates, Sheet CO.04, along with Ortho imagery from Google Earth to determine the available SSD and ISD.

[1] Project Development and Design Guide, Massachusetts Highway Department, 2006

Table 2 - Sight Distance Evaluation

Intersection	Posted Speed Limit	Stopping Sight Distance (SSD)		Intersection Sight Distance (ISD)	
	Speed[1] (in mph)	Required[2]	Available[3]	Required	Available
Crescent Street/Spruce Street					
Crescent Street, south of Intersection	25	115	310		
Crescent Street, north of Intersection	25	115	395		
Spruce Street, looking left	25*			280	330
Spruce Street, looking right	25*			240	285

[1] Posted in miles per hour (mph).
[2] Required in feet (ft) - Project Development and Design Guide, Massachusetts Highway Department, *Chapter 3 – Basic Design*
[3] Measured in feet (ft), rounded to the nearest five feet
* Speed limit assumed based on cross street speed limit and area characteristics.

As seen from Table 2, the available SSD and ISD exceeds the required minimum. Additionally, there were no crashes at this intersection from 2005-2007, which does not indicate safety deficiencies from lack of sight distance.

2009 Existing Traffic Data

Nitsch Engineering collected Turning Movement Counts (TMCs) on Wednesday September 16 and Thursday September 17, 2009 while school was in session. The TMC data was collected from 7:00 AM to 9:00 AM, during school drop-off session, and from 2:15 PM to 4:15 PM, during school pick-up session. The data collected included all vehicle volumes at the intersection of Sherwood Avenue and the Site Drive. This intersection is the conflict point in Figure 4.

The traffic consists of three groups, buses, parent pick-up/drop-off, and employees. The buses come from the south (Site Drive) and turn east to continue on toward Sherwood Middle School. The incoming pick-up/drop-off traffic comes from the west, and turns right into the designated parking area. The outgoing pick-up/drop-off traffic comes from the parking lot to the south of the intersection, and generally turns left to exit via Sherwood Avenue. Some traffic turns right and continues through the site to Hutchins Street, although this movement is prohibited. The incoming employees generally come in from Sherwood Avenue, and continue straight through the site towards the teacher parking lot. The outgoing employees come from the eastern Site Drive and continue straight onto Sherwood Avenue.

Based on the data collected, the AM peak hour at the Sherwood Avenue and Site Drive intersection occurs from 7:15 AM to 8:15 AM and the PM peak hour occurs from 2:15 PM to 3:15 PM. During the pick up period in the afternoon, many vehicles come early and wait for the students, so the peak hour for the incoming traffic does not correspond to the peak hour for the outgoing traffic. The outgoing traffic indicates the total number of students picked up and the exiting traffic from the parking lot, since some of the vehicles had arrived before the counts took place. This includes all the pick-up/ drop-off traffic, all the bus traffic, and a portion of the employee traffic for both Sherwood and Oak Middle Schools.

Table 3 shows the breakdown of traffic at this intersection during the peak hours. This includes all the pick-up/ drop-off traffic, all the bus traffic, and a portion of the employee traffic for both Sherwood and Oak Middle Schools.

Table 3 - TMC Data Summary

Time Period	Buses	Incoming Pick-Up/ Drop-Off	Outgoing Pick-Up/ Drop-Off	Incoming Employees	Outgoing Employees
AM Peak 7:15 AM – 8:15 AM	35	217	183	74	15
PM Peak 2:15 PM – 3:15 PM	32	93	130	28	36

In addition to TMCs, there were Automatic Traffic Recorder (ATR) counts taken from September 17 to September 20, 2009. The ATR data included 96-hour continuous traffic counts on Oak Street, Crescent Street, and Sherwood Avenue. Oak Street and Sherwood Avenue are access roads to the middle school campus. Crescent Street is the location of a future access road. Hutchins Street allows only outgoing traffic, and was not included in the study due to the low volume of traffic and unchanging nature of the access. Table 4 provides a summary of our observations.

Table 4 - Peak Hour and Daily (Weekday) Traffic Volumes by Location

Location	School AM Peak		School PM Peak		ADT[1] (vpd)	"k" factor	Direction	Directional Distribution
	Hour	Volume	Hour	Volume				
Oak Street -north of Sherwood Avenue	7:45 – 8:45	549	2:45 – 3:45	395	3,742	0.15	NB/SB	AM: 43%/57% PM: 51%/49% DAILY: 49%/51%
Crescent Street -north of Spruce Street	7:15 – 8:15	160	2:15 – 3:15	147	1,772	0.09	NB/SB	AM: 39%/61% PM: 32%/68% DAILY: 34%/66%
Sherwood Avenue -east of Oak Street	7:15 – 8:15	502	2:30 – 3:30	305	1,294	0.39	EB/WB	AM: 63%/37% PM: 54%/46% DAILY: 61%/39%

[1]Average Daily Traffic

Table 4 indicates that the volumes on Oak Street are approximately twice as high as the Crescent Street volumes, which are approximately 30% higher than Sherwood Avenue volumes, except during the peak hours, when volumes on Sherwood Avenue are significantly higher than those on Crescent Street. The Highway Capacity Manual (HCM) defines the k-factor as the percentage of daily traffic flowing during the single highest peak hour on an average day. Engineers use the k-factor to compute crash rate at an intersection in the absence of field data. The k-factors on Oak Street, Crescent Street, and Sherwood Avenue were 0.15, 0.09, and 0.39 respectively. The normal range of k-factors is 0.07 to 0.11. Both Oak Street and Sherwood Avenue have a greater than normal k-factor. This is due to the school peak hours creating a spike in volumes on streets which otherwise experiences low volumes.

Directional distribution of traffic on Oak Street is 49% traveling northbound and 51% traveling southbound. Oak Street and Crescent Street are a local roads providing access to Maple Avenue in the north and Route 9 in the south. Except during school peak hours, Nitsch Engineering anticipates traffic on Oak Street to be cut-through traffic from Route 9 to access points east and west on Maple Avenue. Directional distribution on Crescent Street is 34% traveling northbound and 66% traveling southbound. During the school AM peak hour, we observed 61% of traffic heading south on Crescent Street. During the school PM peak hour, we observed 68% of traffic heading south on Crescent Street indicating a more balanced distribution during the AM peak hour than the PM peak hour. Sherwood Avenue is a local road that provides access from Oak Street to Oak Middle School and Sherwood Middle School. Nitsch Engineering anticipates traffic on

Sherwood Avenue to be primarily school related at all hours of the day, with minimal residential and cut-through traffic. Directional distribution on Sherwood Avenue shows 61% travelling eastbound and 39% travelling westbound. This is because traffic can exit the school site via both Sherwood Avenue and Hutchins Street, but traffic can only enter the site from Sherwood Avenue during school hours.

Based on the ATR data, the AM peak hour on Oak Street is from 7:45 to 8:45 AM and the PM peak hour is from 2:45 to 3:45 PM. The AM peak hour on Crescent Street is from 7:15 to 8:15 AM. We observed the PM peak traffic to be from 5:15 PM to 6:15 PM. The PM peak period on Crescent Street also experienced a spike from 2:15 to 3:15 PM coinciding with the school PM peak hour, but the volumes during 5:15 to 6:15 PM were slightly higher than the school peak hour volumes. The AM peak hour on Sherwood Avenue occurs between 7:15 and 8:15 AM, and the PM peak occurs between 2:30 and 3:30 PM. This is fairly consistent with the peak hour determined by the turning movement counts taken on Sherwood Avenue.

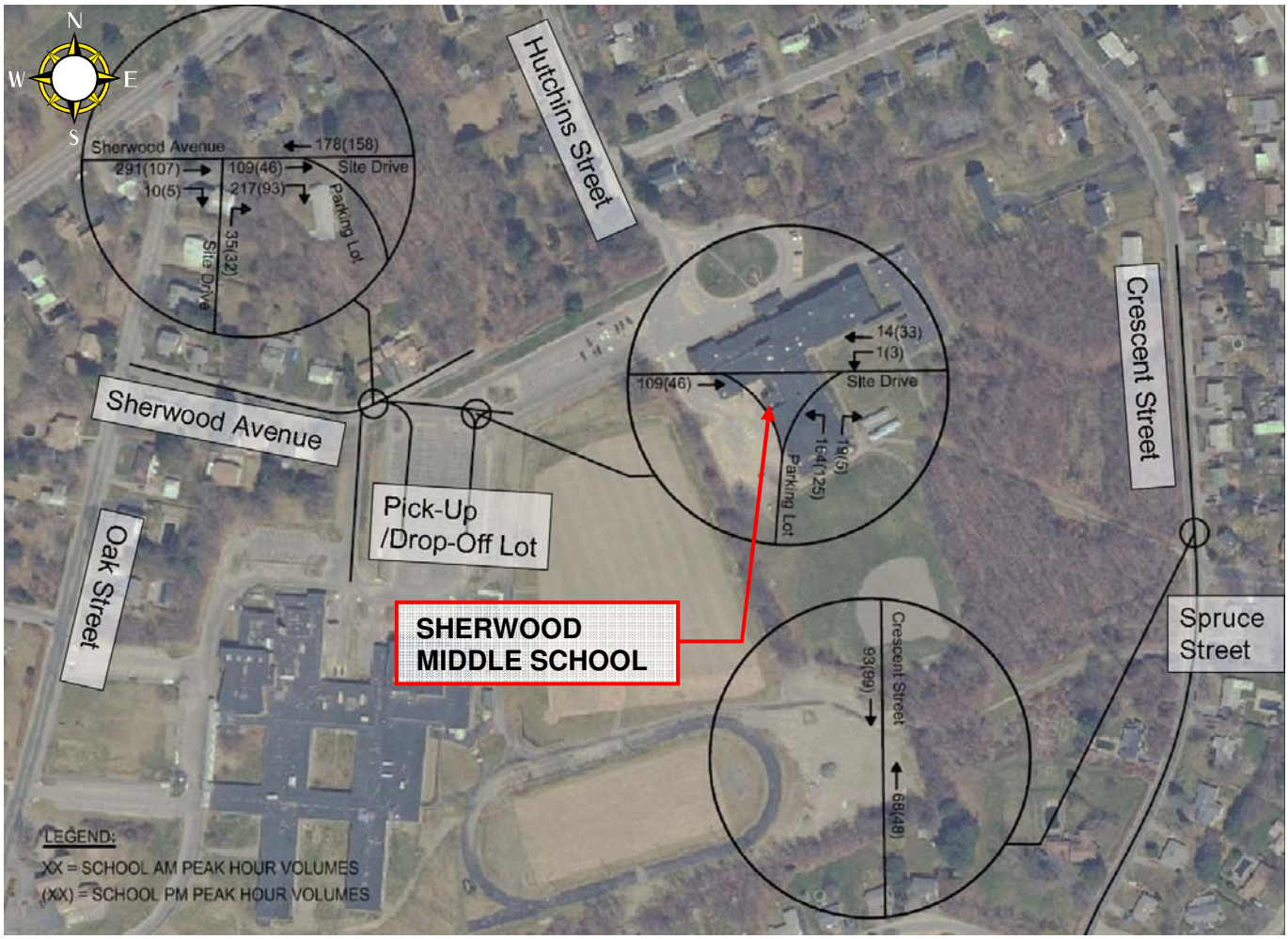
The Average Daily Traffic (ADT) during the weekday on Oak Street, Crescent Street, and Sherwood Avenue is 3,742 vehicles per day (vpd), 1,772 vpd, and 1,294 vpd respectively. With the proposed school construction, we anticipate the daily traffic on Crescent Street to increase during peak hours, based on a new entrance to the school off of Crescent Street. There will also be a decrease in traffic on Oak Street and Sherwood Avenue during peak hours due to a shift in traffic to Crescent Street.

Seasonal Adjustments

Traffic volumes fluctuate monthly throughout the year. Based on regular traffic counts at MassHighway's permanent count stations, adjustment factors can be calculated and applied to existing traffic counts to meet average-month volumes. The data from MassHighway's count stations from 2006[2] indicate that the average volumes in August are slightly higher than the yearly average. We did not adjust the traffic counts, in order to remain conservative. Figure 5 shows the existing traffic volumes.

[2] Massachusetts Highway Department (MHD) Traffic Volume Counts, Monthly ADT Comparisons, 2006.

Figure 5 - 2009 Existing Traffic Volumes



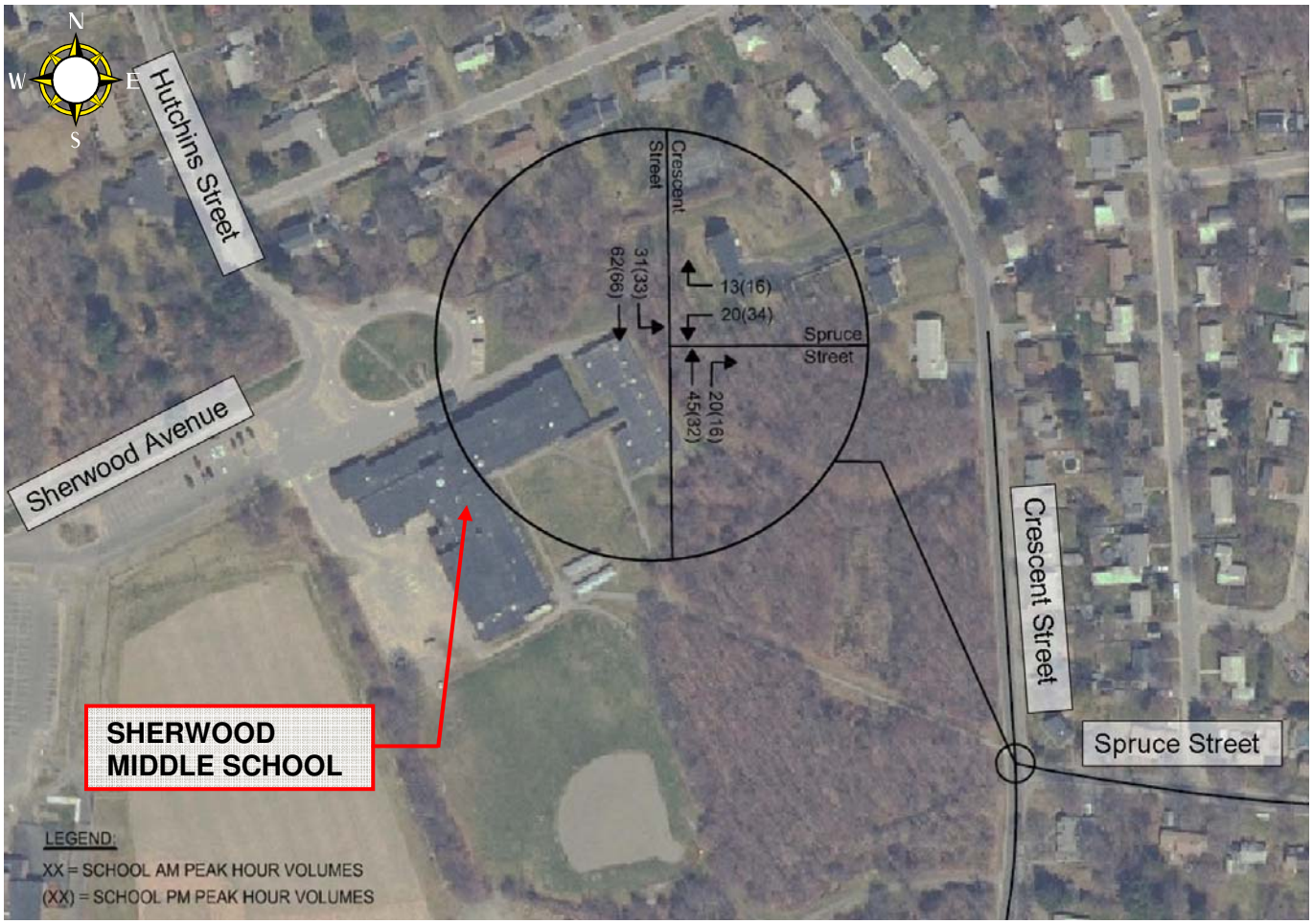
Spruce Street Redistribution

The traffic counts on Crescent Street were taken to the north of the intersection with Spruce Street. In order to analyze the intersection of Crescent Street at Spruce Street, assumptions were made about the volume of traffic on Spruce Street. Spruce Street is a local roadway connecting Crescent Street and Lake Street. Traffic travelling northbound on Crescent Street consists of residential traffic and traffic from Route 9. Traffic travelling westbound on Spruce Street consists of residential traffic, and traffic from Lake Street and Edgewood Road.

As seen in Figure 5, volumes on Crescent Street are low, particularly in the northbound direction, which is the direction that contains the traffic from Spruce Street. Low traffic volumes indicate that Crescent Street is not a preferred route for cut-through traffic. This suggests that a significant portion of the traffic travelling northbound on Crescent Street is residential in nature. Crescent Street, south of Spruce Street, is approximately twice as long, with two times as many residences as Spruce Street. Therefore, one third of the traffic on Crescent Street travelling northbound was assigned to Spruce Street, with two thirds remaining on

Crescent Street. Figure 5 also indicates that the directional split on Crescent Street favors the southbound direction, with 61% of all traffic travelling southbound during the AM peak hour and 68% travelling southbound during the PM peak hour. The same split was used for Spruce Street, to assign traffic turning left from Spruce Street westbound onto Crescent Street southbound, and traffic turning right from Crescent Street northbound onto Spruce Street eastbound. Figure 6 shows the 2009 volumes redistributed at Crescent Street and Spruce Street.

Figure 6 - 2009 Redistributed Traffic Volumes



Intersection Operations

Highway Capacity Software Methodology

We conducted a Level of Service (LOS) analysis at the study area intersections using the procedures outlined in the 2003 Highway Capacity Manual (HCM)[3]. The intersections were analyzed using SYNCHRO Version 6 computer software, which is accepted by MHD as a standard procedure. The HCM bases its LOS results solely on average vehicle delay. MassHighway considers, LOS A – D as acceptable in urban/suburban areas, and LOS E and LOS F as unacceptable.

[2] *2003 Highway Capacity Manual;* Transportation Research Board.

The intersection of Sherwood Avenue at the Site Drive is not a typical intersection. The turning movements occur at two different locations along the Site Drive. In order to analyze it in Synchro it was split into two intersections, Sherwood Avenue at Site Drive (West) and Sherwood Avenue at Site Drive (East). The western intersection was analyzed as an all-way stop. The eastern intersection was analyzed as a traditional unsignalized intersection with a free movement in the eastbound and westbound direction, and a stop control on the northbound approach.

Crescent Street and Spruce Street was analyzed as a three legged, unsignalized intersection with a stop control on the westbound approach of Spruce Street. Table 5 summarizes the 2009 existing condition traffic operations.

Table 5 - Level of Service Summary - 2009 Existing Condition

Intersection	Movement/Approach	Weekday School AM Peak Hour		Weekday School PM Peak Hour	
		LOS[1]	Delay[2] (sec)	LOS	Delay (sec)
Sherwood Avenue and Site Drive (West)	Eastbound	A	9.9	A	7.9
	Westbound	A	8.8	A	8.2
	Northbound	A	9.6	A	8.9
Sherwood Avenue and Site Drive (East)	Westbound Left	A	0.5	A	0.6
	Northbound	B	11.6	B	10.1
Crescent Street and Spruce Street	Westbound Left	A	9.4	A	9.5
	Southbound	A	2.6	A	2.6

[1] LOS = level of service
[2] Average delay in seconds per vehicle

The traffic at the intersection of Sherwood Avenue and Site Drive is not very high; therefore the LOS is adequate by Mass Highway standards. This analysis shows that the volume of traffic is not the cause of the queuing observed in the field. However, the organization of the pick-up/drop-off and the layout of the intersection are very confusing to drivers. This forces drivers to react slowly, and causes traffic to back up. Additionally, every time a bus turns right at this intersection, all traffic must stop in order for them to maneuver safely. The intersection is unsignalized, but it is controlled by school employees directing traffic. This is necessary to control the flow of traffic through the intersection and prevent collisions.

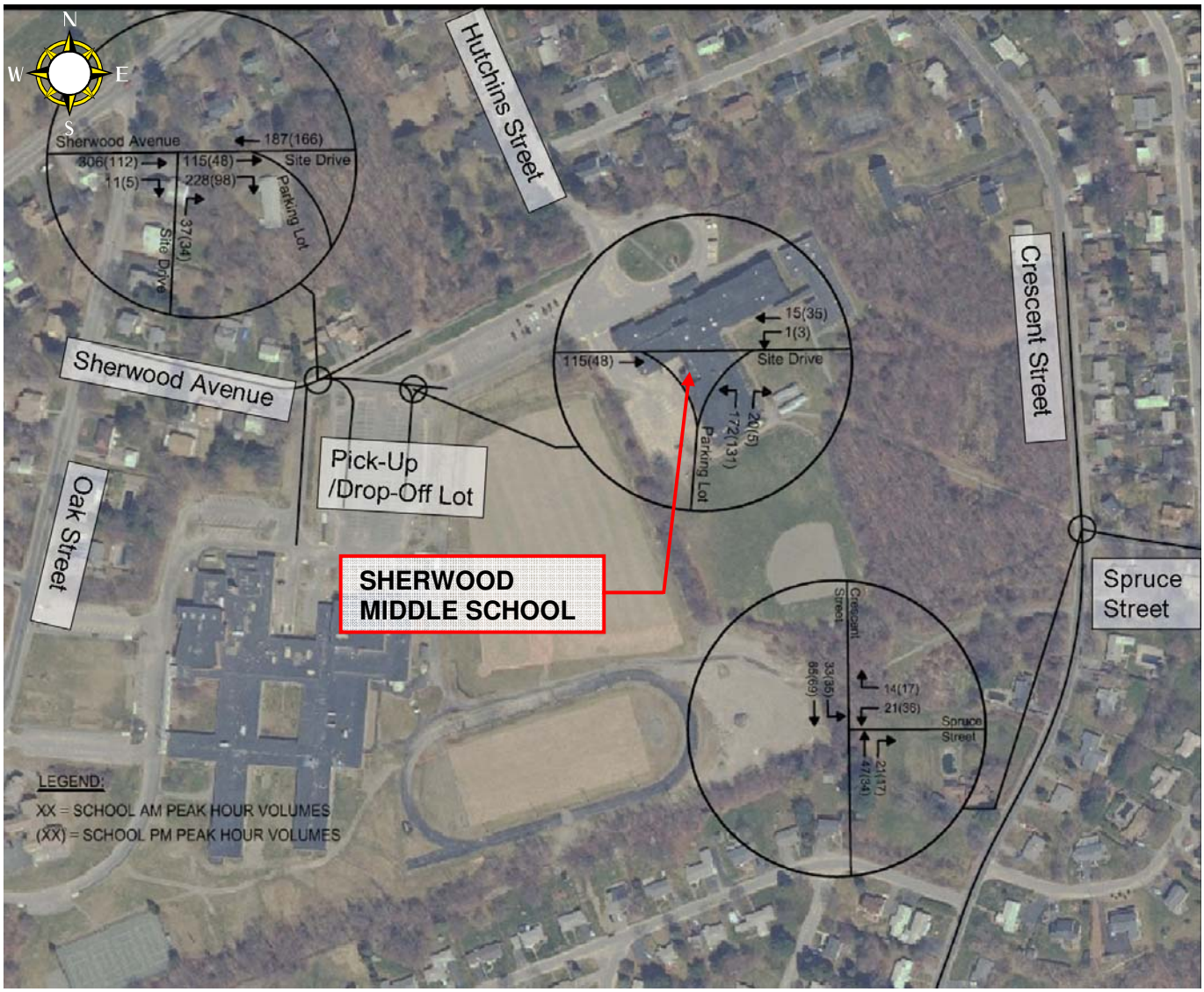
The existing LOS at Crescent Street and Spruce Street is adequate by Mass Highway standards for both the AM and PM peak periods.

2014 No-Build Traffic Volumes

Nitsch Engineering used data from MassHighway's traffic volume counts to determine the background growth in the Town of Shrewsbury[4]. Based on the Average Annual Daily Traffic (AADT) data available, the traffic volumes at count station 3125 on Oak Street, north of Route 9 saw a -2% volume change between 1999 and 2005. However, in order to remain conservative Nitsch Engineering used a background growth rate of 1%. We applied the background growth factor to the 2009 existing traffic volumes to develop the 2014 traffic volumes. The five-year time frame conforms to the Executive Office of Environmental Affairs/Executive Office of Transportation (EOEA/EOT) guidelines for traffic impact assessments.

[4] Massachusetts Highway Department, City/Town Traffic Volume Count Listing, 2007

Figure 7 - 2014 No-Build Traffic Volumes



Nitsch Engineering performed a Level of Service analysis using the 2014 No-Build volumes. Table 6 summarizes the results of the 2014 No-Build condition LOS analysis.

Table 6 - Level of Service Summary - 2014 No-Build

Intersection	Movement/Approach	Weekday School AM Peak Hour		Weekday School PM Peak Hour	
		LOS[1]	Delay[2] (sec)	LOS	Delay (sec)
Sherwood Avenue and Site Drive (West)	Eastbound	B	10.2	A	7.9
	Westbound	A	8.9	A	8.3
	Northbound	A	9.7	A	9.0
Sherwood Avenue and Site Drive (East)	Westbound Left	A	0.5	A	0.6
	Northbound	B	11.9	B	10.2
Crescent Street and Spruce Street	Westbound Left	A	9.5	A	9.6
	Southbound	A	2.6	A	2.6

[1] LOS = level of service
[2] Average delay in seconds per vehicle

The analysis indicates that there would be a minor degradation in LOS (from LOS A to LOS B) on the eastbound approach of Sherwood Avenue and Site Drive (West) in the AM peak for the No-Build conditions when compared to the Existing conditions. It is still an acceptable LOS by Mass Highway Standards.

PROPOSED SHERWOOD MIDDLE SCHOOL

The proposed Sherwood Middle School will be built to the west of the existing middle school, on the existing P7 parking lot and the fields to the east of the lot. The new building will be fully constructed before the old building is demolished. The parking lots at P7, P8, P9, and P10 will be demolished, and replaced with new lots. There will be a new access point to the site off of Crescent Street, across from Spruce Street. The access to Hutchins Street and Sherwood Avenue will be reconfigured.

Oak Middle School will remain unchanged during construction of Sherwood Middle School. The existing site access off of Sherwood Avenue will be reconfigured due to the proposed development.

Vehicle Trip Generation

A typical component of traffic impact studies is a trip generation forecast for the project. Such forecast is based on either established data compiled by the Institute of Transportation Engineers (ITE)[5] or on existing vehicle counts to determine a trip generation rate. Nitsch Engineering used ITE data for trip generation (under Land Use Code (LUC) 522 – Middle School/Junior High School) to estimate the proposed trips to the middle school. The school enrollment as of October 2008 was 917 students, with 123 staff during the 2008-2009 school year. The proposed school will accommodate 900 students.

Using the proposed student population of approximately 900 students, Table 7 below shows school-generated peak hour trips calculated using ITE trip data for middle schools. The volumes only show the traffic associated with Sherwood Middle School, and does not include the traffic for Oak Middle School. This data was used rather than the existing counts, because the existing counts only included the traffic at Sherwood Avenue and Site Drive, and did not include the traffic volumes at other site drives. The trip generation includes all pick-up/ drop-off, employee, and bus traffic.

[5] *Trip Generation, Seventh Edition*; Institute of Transportation Engineers; Washington, D.C.; 2003

Table 7 - Trip Generation - Sherwood Middle School

Time Period	ITE Volumes[3]		
	In	Out	Total
School AM Peak Hour	267	219	486
School PM Peak Hour	126	153	279

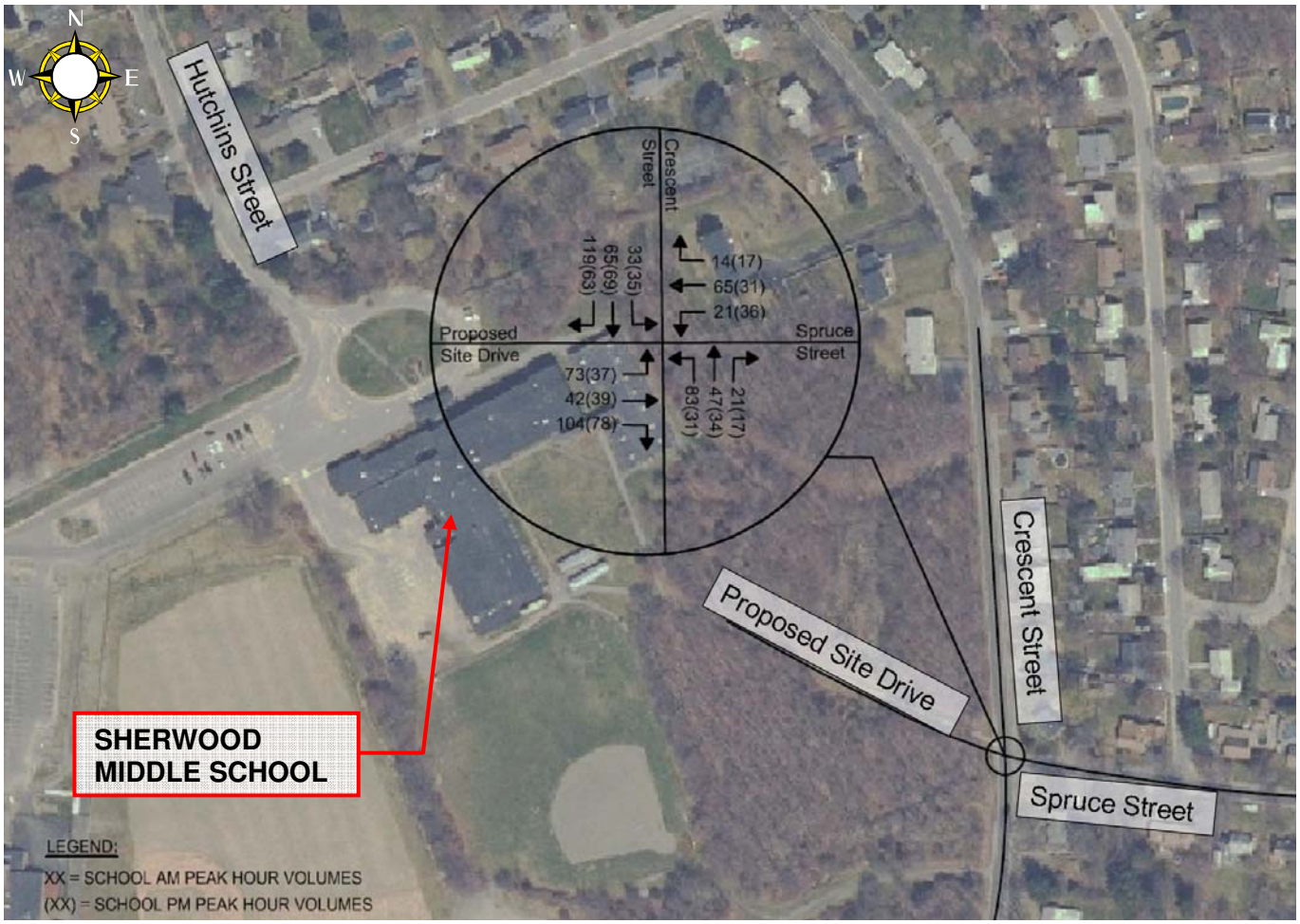
2014 Build Traffic Volumes

There are multiple site drives to the proposed Sherwood Middle School. The incoming and outgoing traffic will be split between the various site drives. For the traffic analysis, Nitsch Engineering assigned all school trips for the proposed school to the intersection of Crescent Street and the Proposed Site Drive to establish a conservative 2014 Build condition. The Proposed Site Drive intersects Crescent Street across from Spruce Street. Nitsch Engineering used trip distribution patterns from the existing (redistributed) traffic volumes to determine the trip distribution for the proposed school. The percentages are shown in Table 8. Significantly less traffic will be using the existing site entrance off of Sherwood Avenue. Since the intersection of Sherwood Avenue and Site Drive achieves an acceptable LOS under existing and no-build conditions, it was not analyzed with a reduction in traffic under build conditions. Figure 8 shows 2014 traffic volumes with the assigned school trips.

Table 8 - Trip Distribution - Sherwood Middle School

Time Period	Incoming			Outgoing		
	NB	SB	WB	NB	SB	EB
School AM Peak Hour	31%	44%	24%	34%	47%	19%
School PM Peak Hour	24%	51%	25%	24%	51%	25%

Figure 8 - 2014 Build Traffic Volumes



2014 Build Level of Service Analysis

Nitsch Engineering performed a Level of Service analysis using the 2014 Build condition traffic network. The intersection of Crescent Street, Spruce Street, and the Proposed Site Drive was analyzed as a four legged, unsignalized intersection with stop control on the eastbound (Site Drive) approach and the westbound (Spruce Street) approach and no control on Crescent Street. Table 9 summarizes the results of the 2014 Build condition LOS analysis.

Table 9 - Level of Service Summary - 2014 Build Condition

Intersection	Movement/Approach	Weekday School AM Peak Hour		Weekday School PM Peak Hour	
		LOS[1]	Delay[2] (sec)	LOS	Delay (sec)
Crescent Street and Proposed Site Drive	Eastbound	C	16.3	B	11.6
	Westbound	C	16.2	B	12.7
	Northbound	A	4.5	A	3.0
	Southbound	A	1.3	A	1.7

[1] LOS = level of service; [2] Average delay in seconds per vehicle

The proposed site drive on Crescent Street maintains an acceptable LOS by Mass Highway standards. In addition, the layout of the intersection is straightforward and does not require the presence of school employees to direct traffic flow. Buses would be prohibited at this access point. This would simplify the pick-up/drop-off and reduce congestion at the existing Site Drive on Sherwood Avenue. A signal warrant analysis at this intersection is not required because the volume of traffic is very low.

PARKING ASSESSMENT

Nitsch Engineering observed parking activities on Thursday, July 30 to determine the current number of parking spaces available. There are a number of different parking areas throughout the site that are shared with the Oak Middle School. The location of the parking lots is shown in Figure 3. Table 10 summarizes the existing parking supply at Sherwood and Oak Middle Schools.

Table 10 - Existing Parking Supply

Lot	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	**TOTAL**
Total Spaces	9	41	11	30	11	28	167	58	36	8	**399**
Handicap Spaces		3	4				2			3	**12**

During our site visit, we observed 399 general parking spaces and twelve (12) handicap accessible spaces. There are presently 399 parking spaces for approximately 1870 (920 Sherwood Middle School, 950 Oak Middle School) students, generating a parking ratio of 0.21 spaces per student.

The ITE Parking Generation Manual[6] suggests a parking ratio of 0.11 spaces per student, or 1.6 spaces per employee for a Junior/High School. Applying this parking ratio to a student population of 900, the required parking spaces for the Sherwood Middle School would be 99 spaces. Applying a parking ratio of 1.6 spaces per employee for 123 employees, the Sherwood Middle School would require 197 spaces.

Oak Middle School has approximately 950 students and 112 employees. Applying the same parking ratios listed above, the required parking spaces would be 105 based on the student population and 180 based on the number of employees. Using the most conservative estimates, the total number of required parking spaces for both schools is 377.

[6] Institute of Transportation Engineers, Parking Generation, 7th Edition, LUC 522 Middle, Junior/High School

The proposed parking supply is generally higher than the parking demand if we use the existing and ITE's parking ratio. The local zoning for the Town of Shrewsbury requires one (1) parking space for each classroom or office and one (1) parking space for each three (3) seats in an auditorium, whichever is greater. Based on the proposed school size, we anticipate that the total number of required parking spaces would not exceed 377.

CONCLUSIONS/ RECOMMENDATIONS

The existence of multiple one-way roadway sections is confusing to drivers maneuvering through the site. There are missing centerlines on many of the two-way sections, which makes it hard to differentiate between one-way and two-way roadways. The existing configuration of Sherwood Avenue and Site Drive is confusing to drivers and requires attention. School employees are being used to direct traffic flow during the morning and afternoon hours. The buses conflict with the pick-up/ drop-off and employee traffic. This causes extensive queuing on Sherwood Avenue and the Site Drive.

With the proposed school construction, we anticipate the daily traffic on Crescent Street to increase during peak hours, based on a new entrance to the school off of Crescent Street. There will also be a decrease in traffic on Oak Street and Sherwood Avenue during peak hours due to a shift in traffic to Crescent Street. The existing traffic volumes on Crescent Street are low, and should be able to accommodate a shift in traffic without compromising on safety and capacity. Crescent Street is similar in nature and function to Oak Street with access to Route 9 and Maple Street. Redistributing traffic from Oak Street to Crescent Street would not disrupt existing traffic routes for motorists.

The existing parking capacity is sufficient, and any proposals should retain the current number of parking spaces.

Nitsch Engineering makes the following recommendations to reduce delays, enhance safety, and improve efficiency of traffic operations within the Sherwood Middle School campus.

- Move the Sherwood Middle School pick-up/ drop-off to the east side of the proposed school building to reduce conflicts at the intersection of Sherwood Avenue and Site Drive.

- Provide a single school bus pick-up/ drop-off area for both Oak Middle School and Sherwood Middle School to improve the efficiency of the school bus circulation. This should be located at the new parking lot that replaces P7.

- Relocate the Oak Middle School parent pick-up/ drop-off to the parking areas at Site Drive 2 and Site Drive 3 near Oak Street. This would provide an improved flow of traffic for vehicles entering and exiting the site.

- Provide signage and pavement markings to the north and south of the new access point off of Crescent Street, notifying drivers that they are in a school zone.
    - A warning sign should be introduced advising drivers to slow down for school children.
    - Pavement markings "SLOW" and "SCHOOL", similar to the existing markings on Oak Street, should be introduced on Crescent Street.

With these changes we anticipate a majority of conflicts between buses and pick-up/ drop-off traffic to be eliminated, and the pick-up/ drop-off traffic to get split between Oak Street and Crescent Street. Figure 9 shows the proposed pick-up/ drop-off locations and circulation changes.

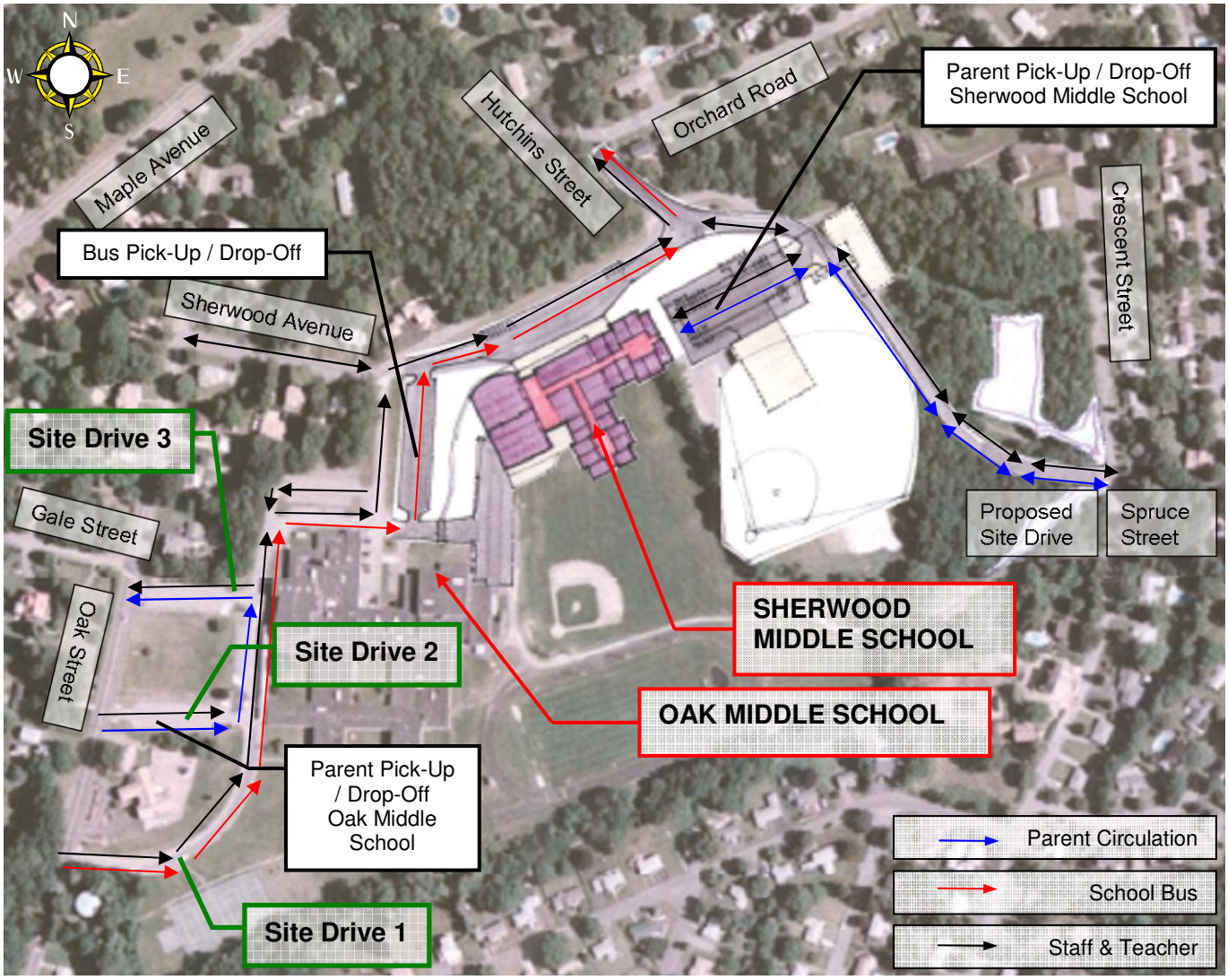



Figure 9 - Recommendations