

TRAFFIC IMPACT ASSESSMENT

PROPOSED DRIVE-THRU COFFEE SHOP

Northwood, New Hampshire

October 2019

Prepared for

New Hampshire Land Consultants, PLLC



**Stephen G. Pernaw
& Company, Inc.**

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NORTHWOOD, NEW HAMPSHIRE
October 22, 2019**

INTRODUCTION

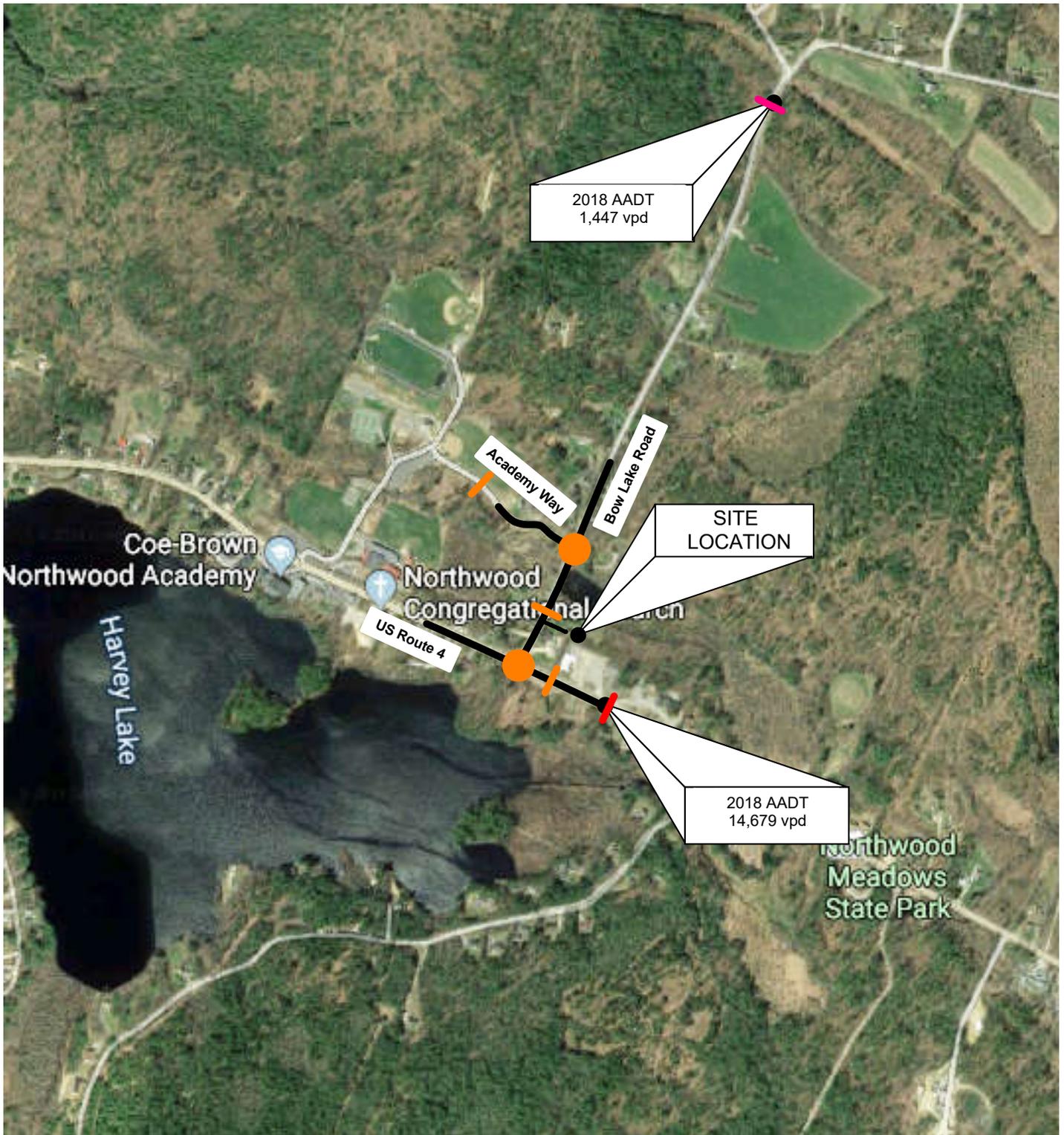
This study has been prepared for New Hampshire Land Consultants, PLLC on behalf of their client Michael Sullivan and it addresses the traffic impacts associated with the Drive-Thru Coffee Shop that is proposed on Bow Lake Road in Northwood, New Hampshire. The subject site is located on the northeast corner of the US4/Bow Lake Road intersection. The scope of this study was based on input received from our client and Town officials and includes the installation of three automatic traffic recorders in the study area, weekday morning (AM) and evening (PM) peak period traffic counts at two study area intersections, and future traffic projections for 2020 (Opening Year) and 2030 (Horizon Year) with and without the proposed development, and several technical analyses. The existing residential driveway on Bow Lake Road was not included in the analysis contained herein as this driveway is proposed to be closed.

This report is intended to summarize our findings and recommendations relative to traffic operations, capacity, and safety.

PROPOSAL

The development proposal calls for the construction of a one-story drive-thru only coffee shop with a gross floor area of approximately 866 sf and two service windows, a walk-up window with patio seating, and on-site parking for 14 vehicles. The proposed parking areas will also provide access to the small greenhouse retail area (250 sf), a single-family residence, and a small office (203 sf). The plan entitled “*Proposed Site Plan - Drive Thru Coffee Shop,*” Sheet SP-1, prepared by New Hampshire Land Consultants, PLLC, dated June 3, 2019 (revised 9/20/19) is included in Appendix A.

Vehicular access to the site is proposed via one full-access driveway on the east side of Bow Lake Road located approximately 270-feet north of US4. The existing residential driveway on Bow Lake Road will be eliminated and access to this building (and the greenhouse retail shop) will be provided via the proposed site driveway. Figure 1 shows the general location of the site with respect to the area highway system, the location of the nearest NHDOT traffic recorder station, and the three automatic traffic recorder locations.



- = AUTOMATIC TRAFFIC RECORDER LOCATION (NHDOT)
- = AUTOMATIC TRAFFIC RECORDER LOCATION (Pernaw)
- = INTERSECTION TURNING MOVEMENT COUNT LOCATION (Pernaw)



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Figure 1

Site Location

Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire

EXISTING CONDITIONS

ROADWAYS

US4 (and US202 & NH9) functions as a rural arterial highway that carries through traffic in a general east-west direction between Epsom to the west and Nottingham to the east, and points beyond. In the immediate study area US4 is a three-lane highway that provides one travel lane in each direction and a center lane that is delineated as an exclusive left-turn lane (for Bow Lake Road) or as a continuous two-way left-turn lane (in the area of Coe-Brown Northwood Academy to the west and the Town Offices to the east). Along the site frontage the pavement is delineated with two-way left-turn lane markings and four-inch white edge lines. Paved and/or gravel shoulders of variable width are present along both sides of the highway. A sidewalk is present along the north side of US4 and is separated from the paved shoulder by a vertical granite curb.

The horizontal alignment of the highway follows a straight tangent section and the vertical alignment is generally flat in this area. The speed limit on this section of US4 is posted at 45 miles per hour in both directions. This section of highway is under the jurisdiction of NHDOT District 6.

Bow Lake Road functions as a rural collector roadway that provides access to numerous abutting parcels and intersecting streets and it carries through traffic between US4 and the town of Strafford. There are no pavement markings along this roadway and the speed limit is posted at 25 miles per hour.

Academy Way extends from the west side of Bow Lake Road to Faculty Way and provides access to the Coe-Brown Northwood Academy campus. This two-way school driveway is delineated with a single four-inch yellow centerline and there is a gate system located west of Bow Lake Road.

TRAFFIC VOLUMES

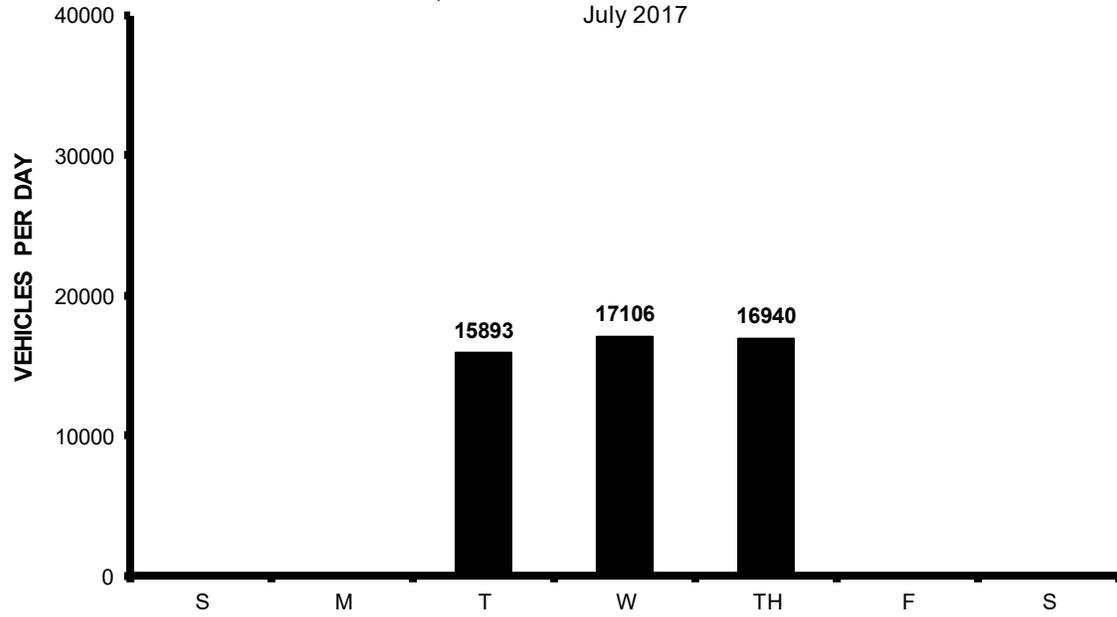
The New Hampshire Department of Transportation maintains a short-term traffic recorder station on US4 a short distance to the east of the subject site. According to NHDOT estimates this section of highway carried an estimated Annual Average Daily Traffic (AADT) volume of 14,679 vehicles per day (vpd) in 2018, up slightly from 14,391 vpd in 2017.

Several facts and conclusions are evident from the July 2017 count data:

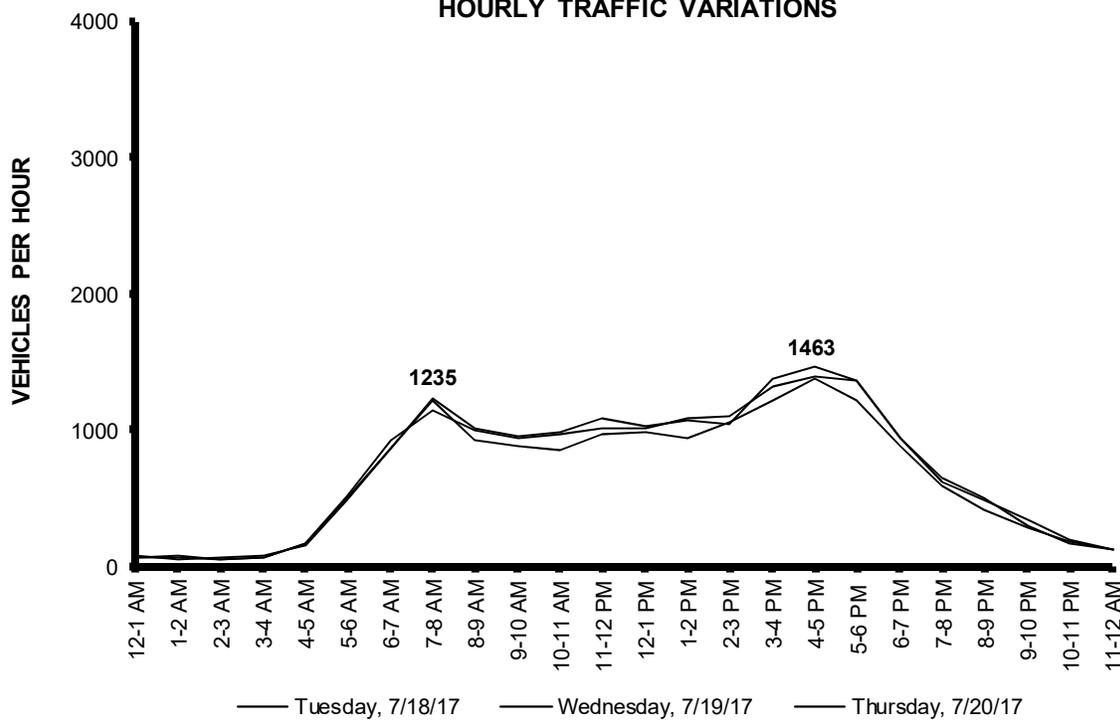
- The daily traffic volume averaged 16,646 vpd in July 2017 (when nearby schools are not in session).
- This data demonstrates that the traffic demand on US4 reached peak levels during the typical AM (7:00 to 8:00) and PM (4:00 to 5:00) commuter periods on weekdays.
- The number of vehicles passing the site averaged 1,198 (AM) and 1,413 (PM) vehicles

The 2017 traffic volumes are summarized graphically in terms of daily and hourly variations on Page 4 (see Appendix B).

DAILY TRAFFIC VARIATIONS
 Northwood, NH - US4/US202/NH9 - East of Bow Lake Road
 July 2017



HOURLY TRAFFIC VARIATIONS



At the request of the Town of Northwood, Pernaw & Company, Inc. installed automatic traffic recorders on US4 (east of Bow Lake Road), Bow Lake Road (south of Academy Way) and on Academy Way (west of Bow Lake Road) in September 2019 while school is in session. The following table summarizes the data in terms of traffic volume, vehicle speeds, and vehicle classification. Appendix B contains additional summaries and the detail sheets pertaining to these counts.

Automatic Traffic Recorder Summary - Average Weekday Conditions

	Daily Traffic Volume	AM Peak Hour ¹	PM Peak Hour ²	Speeds Avg (85th)	Percent Trucks / Busses
US Route 4	15,316 vpd	1,414 vph	1,310 vph	44 (52) mph	16%
Bow Lake Road	1,841 vpd	226 vph	201 vph	33 (39) mph	7%
Academy Way	448 vpd	168 vph	63 vph	18 (23) mph	7%

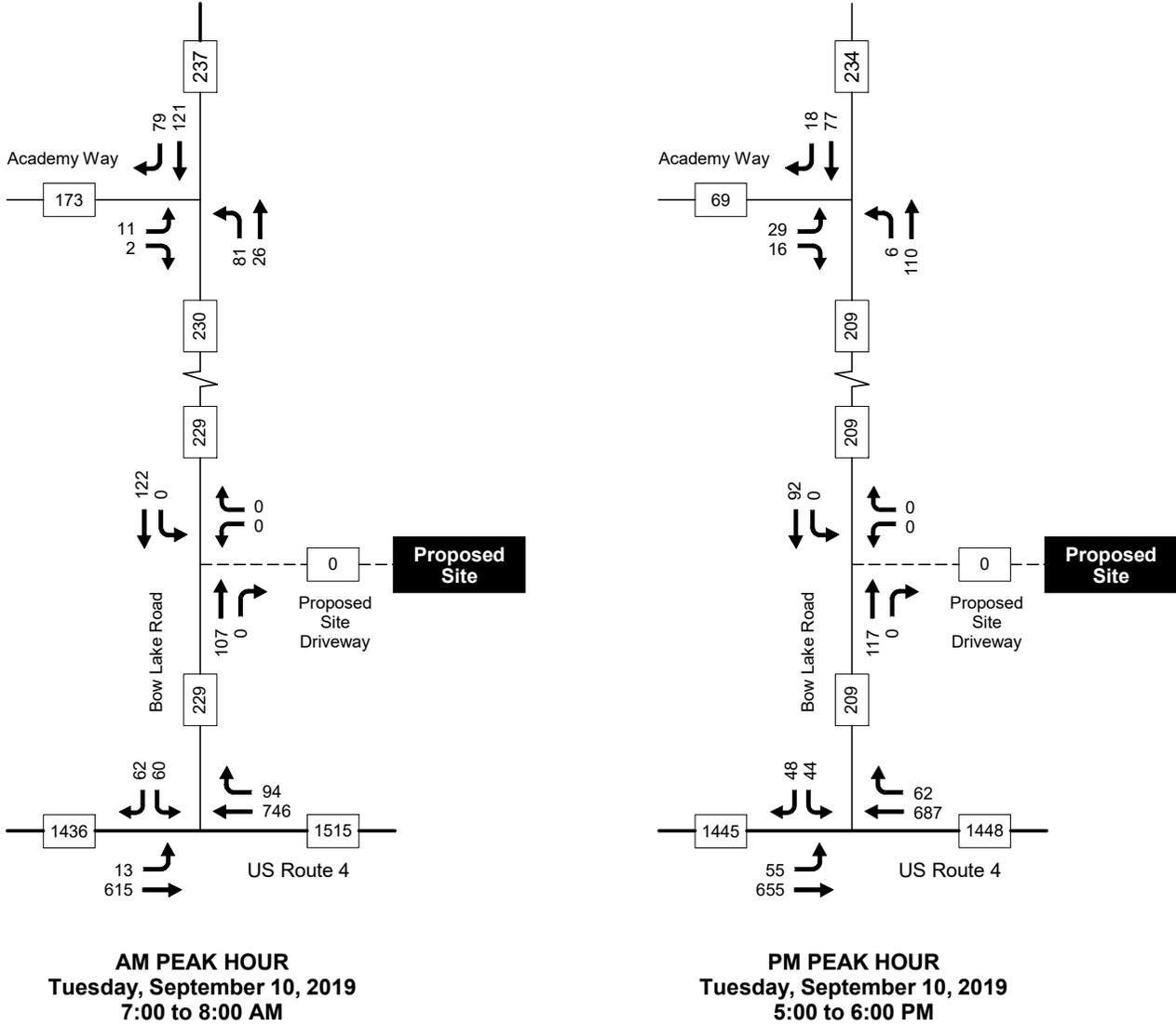
¹ One hour traffic volume between 7-9 AM

² One hour traffic volume between 4-6 PM

To supplement this data, Pernaw & Company, Inc., conducted intersection turning movement and vehicle classification counts at the US4 / Bow Lake Road and Bow Lake Road / Academy Way intersections on Tuesday, September 10, 2019. These counts were conducted simultaneously at both study area intersections from 7:00 to 9:00 AM and from 2:00 to 6:00 PM. The highest hourly traffic volume occurred from 7:00 to 8:00 AM and from 5:00 to 6:00 PM. The peak hour count data for the study area intersections are summarized on Figure 2. Several facts and conclusions are evident from this data:

- During the AM peak hour the two-way traffic volume passing the subject site (east of Bow Lake Road) totaled 1,515 vehicles and the higher directional traffic flow was in the westbound direction (55% WB). During the PM peak hour period 1,448 vehicles passed the site and 52% traveled in the westbound direction.
- The two-way traffic volume on Bow Lake Road traveling past the Proposed Site Driveway intersection totaled 229 (AM) and 209 (PM) vehicles during the peak hour periods. The majority traveled in the southbound direction during the morning and reversed to the northbound direction during the evening peak hour.
- The departures from Bow Lake Road on to US4 were relatively equal in each direction. Most vehicles turning onto Bow Lake Road did so from points east on US4 (right-turn arrivals).
- Academy Way accommodated 173 (AM) and 69 (PM) vehicles during the peak hour periods. The majority traveled to/from points north on Bow Lake Road.
- Truck traffic on US4 accounted for approximately 6-7% of the traffic flow during the AM peak hour and approximately 2-3% during the PM peak hour. Truck traffic on Bow Lake Road accounted for approximately 4% (AM) and 1% (PM) of the total traffic flow.
- Pedestrian activity at the US4/Bow Lake Road intersection was minimal: 3 pedestrians and 1 bicyclist were observed during the 7-9 AM count, and none from 3-6 PM. Only one bike (motorized?) was observed at the Bow Lake Road/Academy Way intersection (at 3:15 PM).

Appendix C contains the detail sheets summarizing the raw turning movement count data.



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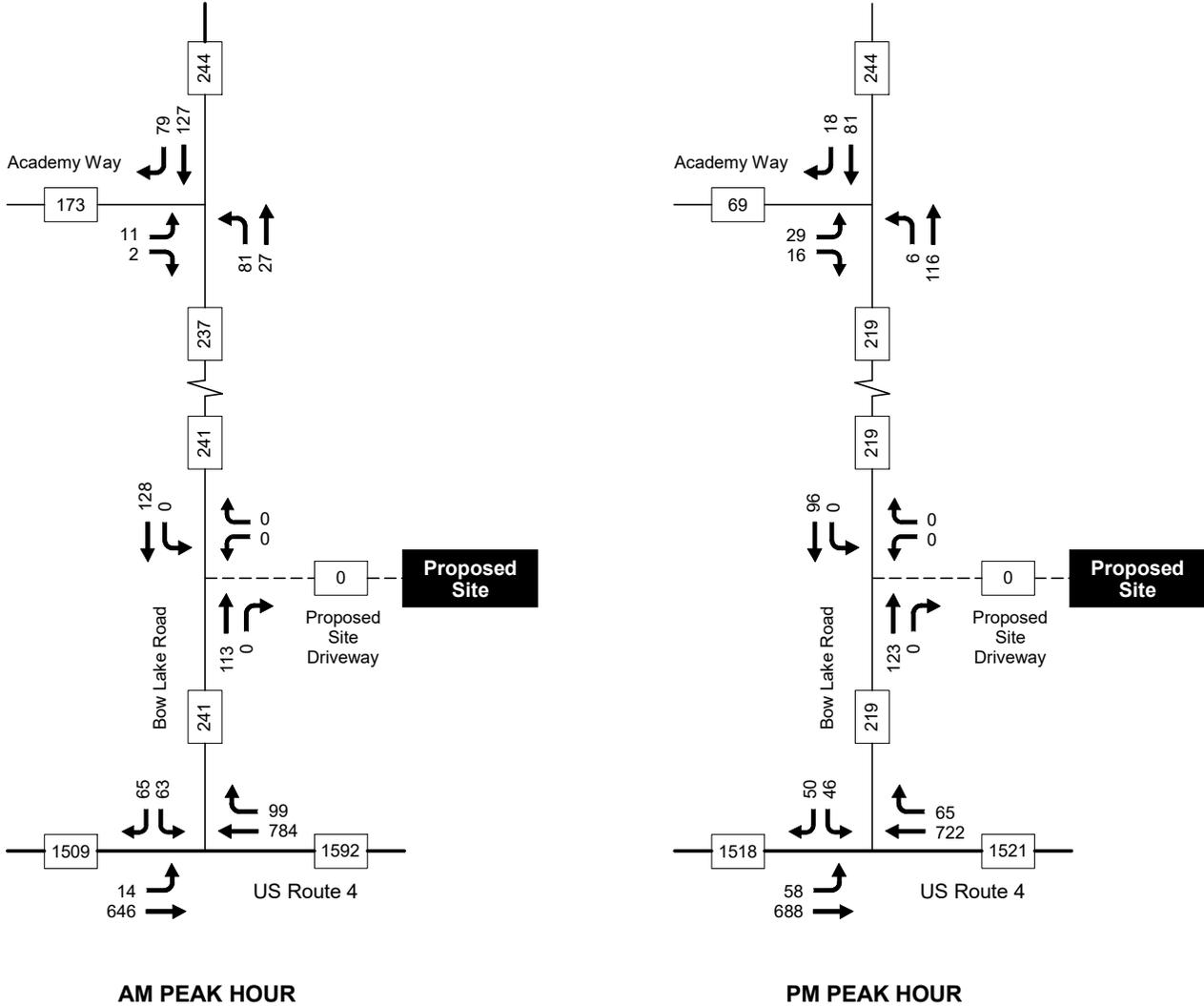
Figure 2

2019 Existing Traffic Volumes
Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire

NO-BUILD TRAFFIC VOLUMES

In order to identify the net impact that the proposed development will have in the study area, future traffic projections with and without the proposed drive-thru coffee shop are necessary. The future traffic projections without the proposed development are referred to as the “No-Build” traffic projections and these are summarized on Figure 3 (2020) and Figure 4 (2030). These projections are based on the September 2019 traffic counts (Figure 2), a 1.0 percent annual background traffic growth rate (compounded annually) to account for normal growth in the area, and a 1.04 peak-month adjustment factor.

The No-Build traffic projections therefore reflect worst-case, peak-month, peak-hour conditions. Calculations pertaining to the derivation of the background traffic growth rate are found in Appendix D.

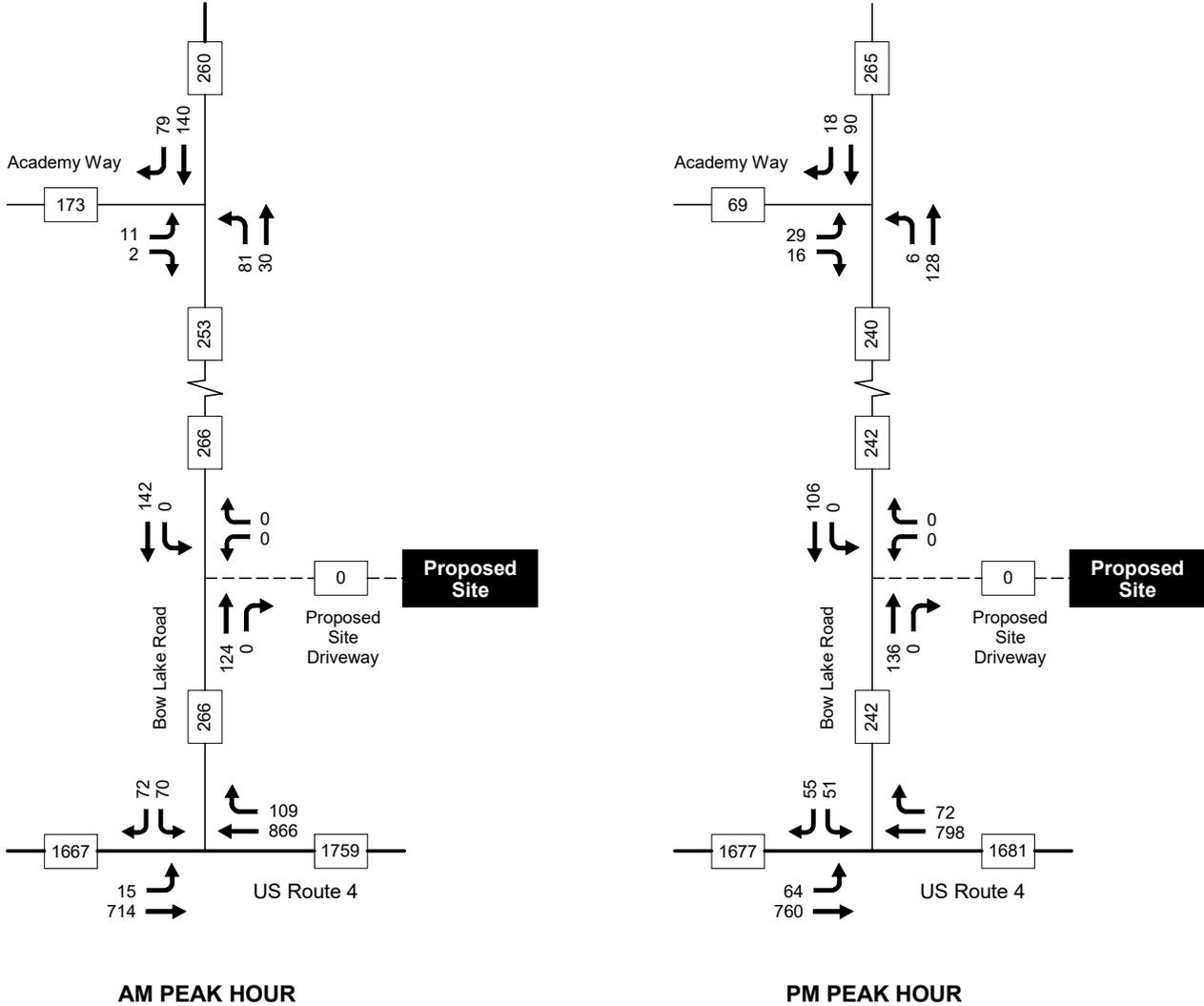


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Figure 3

2020 No-Build Traffic Volumes
Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire



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Figure 4

2030 No-Build Traffic Volumes
Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire

SITE GENERATED TRAFFIC

To estimate the quantity of vehicle trips that will be produced by the proposed drive-thru coffee shop, Pernaw & Company, Inc. considered using the standard trip generation rates published by the Institute of Transportation Engineers (ITE)¹. However, Land Use Code (LUC) 938 (Coffee/Donut Shop with Drive-Through Window and No Indoor Seating) pertains to sites with a very small gross floor area (90 sf average). For this type of land use our experience has confirmed that the traffic volume passing a coffee shop is a far better indicator of vehicle-trips than the square footage of the building.

Consequently, transaction data for a similar drive-thru Aroma Joe's in Tilton, New Hampshire was obtained and combined with Tilton traffic count data to establish a local "capture rate" for that store. The Tilton site is an excellent match as it is also located on a state-maintained highway with a high school located nearby. The AM and PM capture rates were then applied to the 2030 No-Build traffic volumes passing the Northwood site to arrive at the trip generation estimates for the proposed coffee shop. The vehicle-trips associated with the greenhouse shop, office, and single-family residence were estimated using ITE Land Use Codes 820, 712 and 210, respectively. Table 1 on Page 11 summarizes the trip generation estimates for the subject site. The site driveway on Bow Lake Road is expected to accommodate approximately 93 vehicle-trips (47 arrivals, 46 departures) during the morning peak hour and 35 vehicle-trips (17 arrivals, 18 departures) during the evening peak hour period.

It should be noted that the majority of the vehicle-trips generated by the site will be drawn from the existing traffic stream on US4 as "pass-by" trips. According to ITE statistics, approximately 89% of the coffee shop trips will be pass-by trips. The high percentage of pass-by traffic means that that net increases on the adjacent street system will be much less than the total trips shown in Table 1; particularly where the "primary" trips or new trips to the area will be split between points east and west on the highway (and on Bow Lake Road).

Appendix E shows the travel patterns and traffic volumes associated with both trips types, along with the derivation of the trip generation estimates.

¹ Institute of Transportation Engineers, *Trip Generation*, 10th edition (Washington, D.C., 2017). 1951A

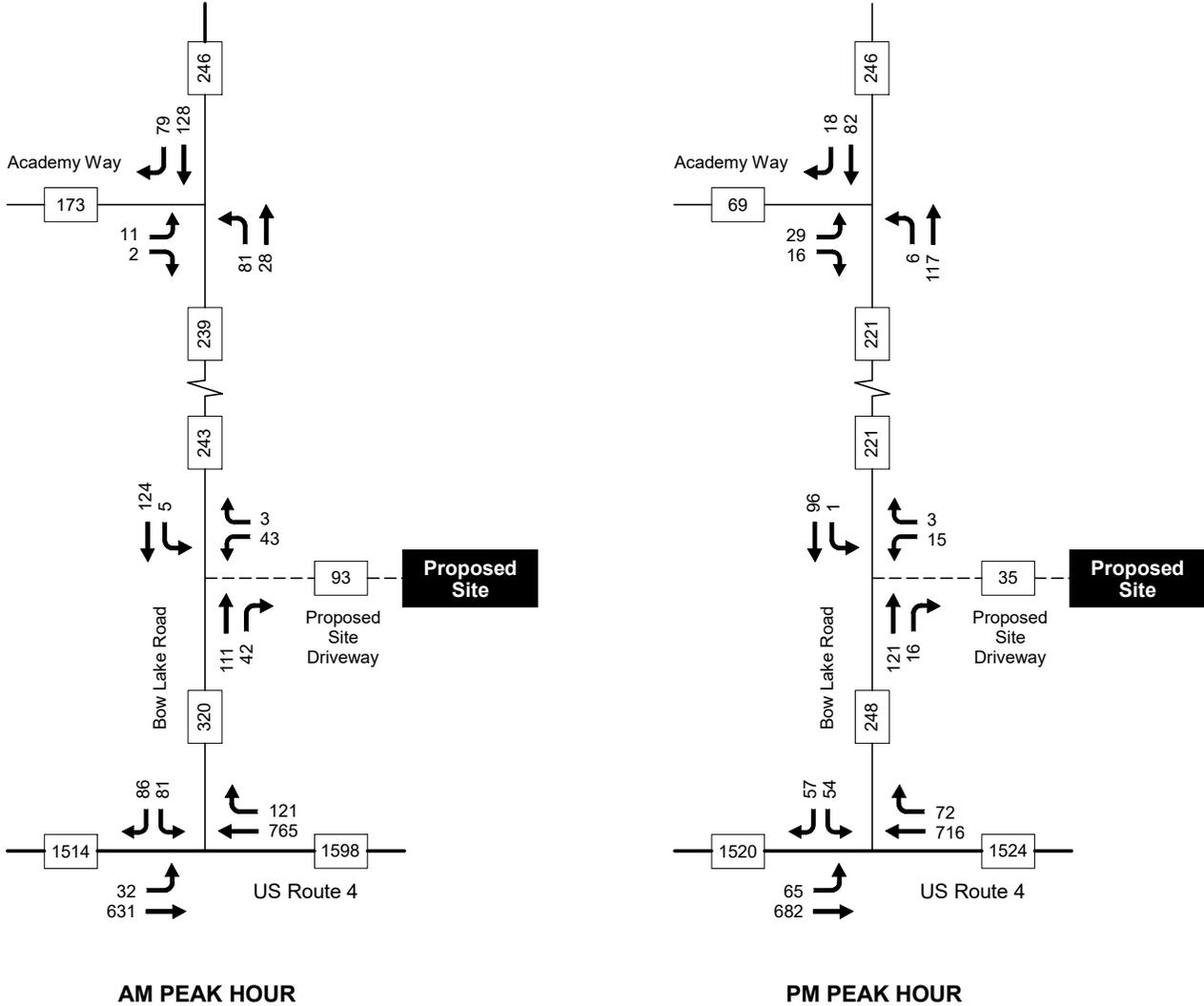
Table 1 **Trip Generation Summary**

	Coffee Shop (965 sf)		Retail ² (250 sf)	Office ³ (203 sf)	Single-Family Residence ⁴	2030 Total	Primary Trips	Pass-By Trips ⁵
	2020 Estimate ¹	2030 Estimate ¹						
AM Peak Hour	Entering	41 veh	1 veh	1 veh	0 veh	47 veh	7 veh	40 veh
	Exiting	<u>41 veh</u>	<u>0 veh</u>	<u>0 veh</u>	<u>1 veh</u>	<u>46 veh</u>	<u>6 veh</u>	<u>40 veh</u>
	Total	82 trips	90 trips	1 trips	1 trips	93 trips	13 trips	80 trips
PM Peak Hour	Entering	14 veh	0 veh	0 veh	1 veh	17 veh	3 veh	14 veh
	Exiting	<u>14 veh</u>	<u>16 veh</u>	<u>1 veh</u>	<u>0 veh</u>	<u>18 veh</u>	<u>4 veh</u>	<u>14 veh</u>
	Total	28 trips	32 trips	1 trips	1 trips	35 trips	7 trips	28 trips

¹ Trip Generation Computations (See Appendix E)
² ITE Land Use Code 820 - Shopping Center (250 sf)
³ ITE Land Use Code 712 - Small Office Building (203 sf)
⁴ ITE Land Use Code 210 - Single-Family Detached Housing (1 Dwelling Unit)
⁵ ITE Land Use Code 938 - Pass-By Trips = 89%, Page 216 of ITE Handbook

BUILD TRAFFIC VOLUMES

The future traffic projections with the proposed drive-thru coffee shop in full operation are referred to as the “Build” traffic projections and these are summarized schematically on Figure 5 (2020) and Figure 6 (2030). These traffic projections are based on the No-Build projections (Figures 3 & 4), the site generated traffic levels depicted in Table 1, and the expectation that the new trips will be distributed accordingly: 40% to/from points east on US4, 40% to/from points west on US4, and 20% to/from points north via Bow Lake Road. The pass-by trips are expected to be distributed in proportion to the approach volumes observed at the US4/Bow Lake Road intersection during the peak hour periods.



AM PEAK HOUR

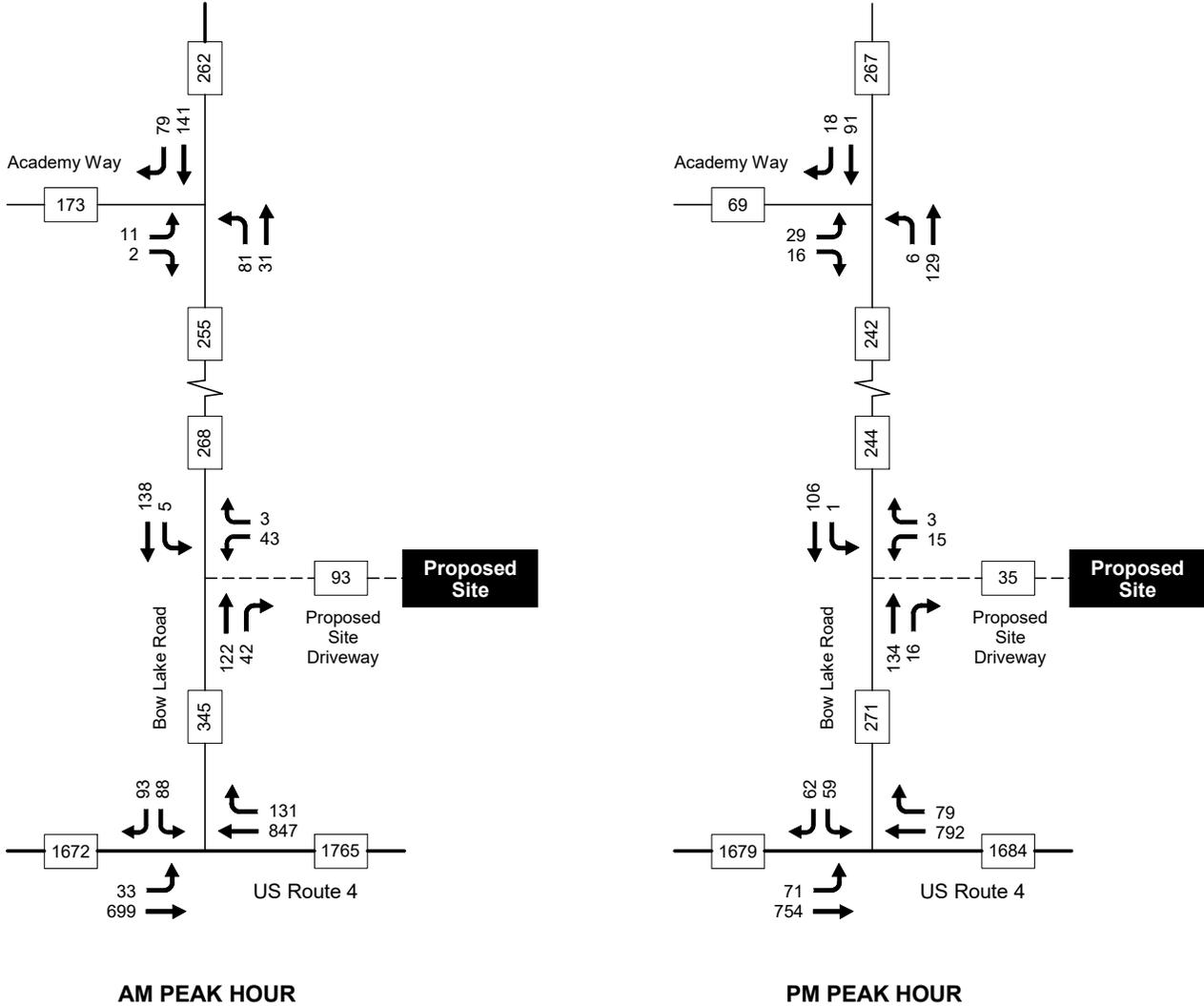
PM PEAK HOUR



Figure 5

2020 Build Traffic Volumes

Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire



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Figure 6

2030 Build Traffic Volumes
Traffic Impact Assessment, Proposed Drive-Thru Coffee Shop, Northwood, New Hampshire

IMPACT SUMMARY

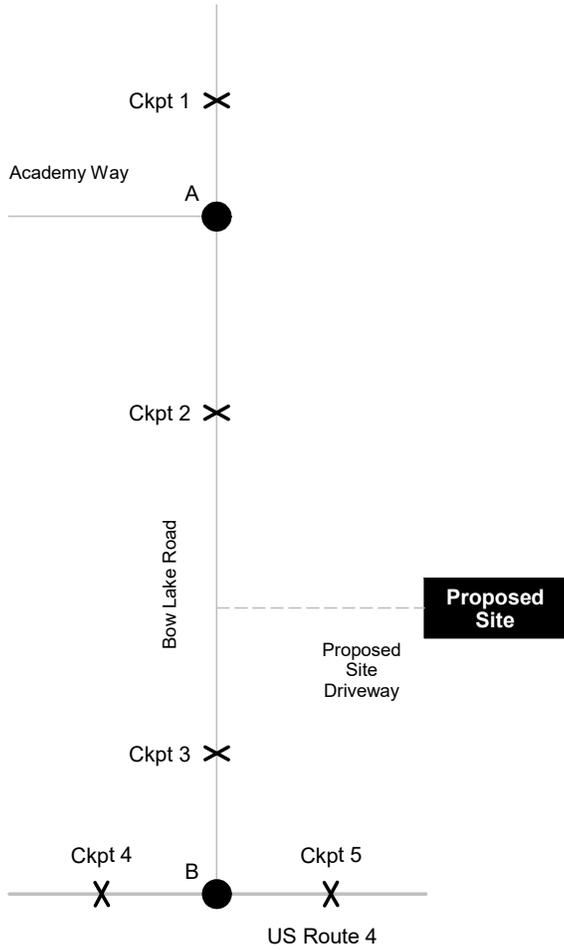
TRAFFIC VOLUME INCREASES

The net impact that the proposed drive-thru coffee shop (with small greenhouse shop, small office, and one residence) will have on area roadway and intersection traffic volumes can be estimated by comparing the No-Build traffic projections with the Build projections. A comparison for the two peak hour cases is summarized on Figure 7.

In terms of roadways, this analysis shows that the proposed development will increase the two-way traffic volume on US4 by less than +1% during both peak hour periods. The net increases are minimal (six or fewer vehicles) over the course of the one-hour period.

In terms of intersections, the volume of traffic entering the US4/Bow Lake Road intersection will increase by approximately +3% (AM) and +1% (PM) during the peak hour periods as a result of the proposed development. This translates into approximately +45 vehicles during the morning peak hour and +17 vehicles during the evening peak hour.

To put these increases into perspective, the raw traffic count data collected on US4 (east of Bow Lake Road) revealed that the morning peak hour traffic demand ranged from 1,250 to 1,549 vehicles over the course of the week, or by as much as +24%. Stated another way; normal variations in random traffic flow from one day to the next account for greater impacts than will be created by the proposed coffee shop.



AM Peak Hour				
Location	2020 No-Build	2020 Build	Change	% Change
Intersection A	327	329	+2 veh	1%
Intersection B	1671	1716	+45 veh	3%
Checkpoint 1	244	246	+2 veh	1%
Checkpoint 2	241	243	+2 veh	1%
Checkpoint 3	241	320	+79 veh	33%
Checkpoint 4	1509	1514	+5 veh	<1%
Checkpoint 5	1592	1598	+6 veh	<1%

PM Peak Hour				
Location	2020 No-Build	2020 Build	Change	% Change
Intersection A	266	268	+2 veh	1%
Intersection B	1629	1646	+17 veh	1%
Checkpoint 1	244	246	+2 veh	1%
Checkpoint 2	219	221	+2 veh	1%
Checkpoint 3	219	248	+29 veh	13%
Checkpoint 4	1518	1520	+2 veh	<1%
Checkpoint 5	1521	1524	+3 veh	<1%



Figure 7

2020 Impact Summary
Traffic Impact Assessment, Proposed Drive Thru Coffee Shop, Northwood, New Hampshire

TRAFFIC OPERATIONS AND SAFETY

INTERSECTION CAPACITY – UNSIGNALIZED INTERSECTIONS

The short-range (2020) and long-range (2030) traffic projections form the basis for assessing traffic operations at the two existing study area intersections and the proposed site driveway intersection Bow Lake Road from a capacity and delay standpoint. These intersections were analyzed according to the methodologies of the *Highway Capacity Manual*² as replicated by the latest edition of the *Synchro Traffic Signal Coordination Software (Version 10)*, which also performs unsignalized intersection capacity analyses.

Capacity and Level of Service (LOS) calculations pertaining to unsignalized intersections address the quality of service for those vehicles turning into and out of intersecting side streets. The availability of adequate gaps in the traffic stream on the major street (US4 or Bow Lake Road) actually controls the potential capacity for vehicle movements to and from the minor approaches. Levels of Service are simply letter grades (A-F) that categorize the vehicle delays associated with specific turning maneuvers. Table 2 describes the criteria used in this analysis.

Table 2	Level-of-Service Criteria for Unsignalized Intersections
Level of Service	Control Delay (seconds/vehicle)
A	≤ 10.0
B	> 10.0 and ≤ 15.0
C	> 15.0 and ≤ 25.0
D	> 25.0 and ≤ 35.0
E	> 35.0 and ≤ 50.0
F	> 50.0

Source: Transportation Research Board, *Highway Capacity Manual* 2010.

The results of the analysis for the US4/Bow Lake Road intersection are summarized on Table 3. The results confirm the obvious: drivers turning left from Bow Lake Road on to US4 eastbound currently experience long delays, more so during the morning peak hour than the evening peak hour (due to the influence of the nearby school), while waiting for an acceptable gap in the two-way traffic stream on US4. Unfortunately, the predicted delay for left-turn departures from Bow Lake Road during the AM peak hour (106 seconds) does not correlate well with the actual delays that were measured in the field (45 seconds). For this reason, the predicted capacities and delay estimates shown on Table 3 are considered to be unrealistically conservative, thus caution should be used in interpreting the results.

When drivers encounter long delays exiting left from a minor approach, and a wide painted median is present on the highway (center turn lane), some drivers will make the left-turn movement in two stages (first cross the near-side lane, then wait in the median area for an acceptable gap in the far-side lane, and then proceed). This is known as “two-stage gap

² Transportation Research Board, *Highway Capacity Manual* (Washington, D.C., 2000). 1951A

acceptance.” The actual hourly capacity for left-turn departures from Bow Lake Road likely falls between the two predicted values found on Table 3.

Drivers turning right from Bow Lake Road (onto US4 westbound) and those turning left from US4 (onto Bow Lake Road) currently operate at LOS C or higher during all hours of the day. The capacity and Level of Service results for these movements are higher (better) as there is only one conflicting traffic stream for the driver to negotiate. These traffic movements will continue to operate at LOS C or higher in 2020 with the proposed development in full operation. By 2030 the right-turn departure movement from Bow Lake Road is expected to operate at LOS D during the morning peak hour (only).

Table 3	STOP-Controlled Intersection Capacity Analysis US Route 4 / Bow Lake Road							
	Weekday AM Peak Hour				Weekday PM Peak Hour			
	Delay ¹	V/C ²	LOS ³	Queue ⁴	Delay ¹	V/C ²	LOS ³	Queue ⁴
US Route 4 - EB Left Turns Arrivals								
2019 Existing	10.9	0.03	B	<1	9.7	0.08	A	<1
2020 No Build	11.2	0.03	B	<1	10.0	0.08	A	<1
2020 Build	11.5	0.07	B	<1	10.0	0.09	B	<1
2030 No Build	12.0	0.04	B	<1	10.4	0.10	B	<1
2030 Build	12.3	0.08	B	<1	10.5	0.11	B	<1
Bow Lake Road - Left-Turn Departures								
2019 Existing (1 Stage) ⁵	106.3 *	0.71	F	4	83.2	0.62	F	3
2019 Existing (2 Stage) ⁶	27.5	0.30	D	1	25.4	0.27	D	1
2020 No Build (1 Stage)	146.2	0.84	F	4	110.6	0.73	F	4
2020 Build (1 Stage)	237.9	1.14	F	7	140.4	0.86	F	5
2020 No Build (2 Stage)	30.1	0.33	D	1	27.6	0.30	D	1
2020 Build (2 Stage)	35.4	0.44	E	2	29.6	0.36	D	2
2030 No Build (1 Stage)	300.7	1.24	F	6	224.1	1.06	F	6
2030 Build (1 Stage)	>300	1.63	F	9	296.4	1.26	F	7
2030 No Build (2 Stage)	37.9	0.42	E	2	34.1	0.38	D	2
2030 Build (2 Stage)	46.5	0.54	E	3	37.5	0.45	E	2
Bow Lake Road - Right-Turn Departures								
2019 Existing	19.0	0.21	C	1	15.4	0.17	C	1
2020 No Build	20.3	0.24	C	1	16.2	0.19	C	1
2020 Build	21.2	0.30	C	1	16.4	0.21	C	1
2030 No Build	24.0	0.30	C	1	18.1	0.23	C	1
2030 Build	25.6	0.37	D	2	18.5	0.26	C	1

¹ HCM Control Delay (seconds per vehicle), ² HCM Volume to Capacity Ratio, ³ HCM Level of Service, ⁴ HCM 95th Percentile Queue (vehicles)

⁵ Single-stage gap acceptance (driver seeks an acceptable gap in both the EB and WB traffic streams simultaneously)

⁶ Two-stage gap acceptance (driver seeks acceptable gap in the WB stream, then waits for an acceptable gap in the EB traffic stream)

* Actual measured delay = 45 seconds (See Appendix F)

Analysis of traffic operations at the existing Bow Lake Road/Academy Way intersection is summarized on Table 4 and it confirmed that all applicable traffic movements currently operate well below capacity and at LOS B or better during the morning and evening peak hour periods. Analysis of the post-development traffic volumes at this intersection revealed that site traffic is not of sufficient magnitude to alter the prevailing Levels of Service. By 2030, all applicable traffic movements at this intersection will continue to operate below capacity and at Level of Service B or better regardless of the proposed development.

Table 4 **STOP-Controlled Intersection Capacity Analysis**
Bow Lake Road / Academy Way

	Weekday AM Peak Hour				Weekday PM Peak Hour				
	Delay ¹	V/C ²	LOS ³	Queue ⁴	Delay ¹	V/C ²	LOS ³	Queue ⁴	
Bow Lake Road - NB Left Turns									
2019 Existing	8.1	0.13	A	<1	7.5	0.01	A	<1	
2020 No Build	8.2	0.13	A	<1	7.5	0.01	A	<1	
2020 Build	8.2	0.13	A	<1	7.5	0.01	A	<1	
2030 No Build	8.2	0.13	A	1	7.5	0.01	A	<1	
2030 Build	8.2	0.13	A	1	7.5	0.01	A	<1	
Academy Way - EB Left & Right-Turn Departur									
2019 Existing	13.7	0.06	B	<1	10.5	0.17	B	1	
2020 No Build	13.9	0.07	B	<1	10.6	0.17	B	1	
2020 Build	13.9	0.07	B	<1	10.7	0.17	B	1	
2030 No Build	14.2	0.07	B	<1	10.8	0.17	B	1	
2030 Build	14.2	0.07	B	<1	10.9	0.17	B	1	

¹ HCM Control Delay (seconds per vehicle), ² HCM Volume to Capacity Ratio, ³ HCM Level of Service, ⁴ HCM 95th Percentile Queue (vehicles)

Analysis of the Proposed Site Driveway intersection on Bow Lake Road is summarized on Table 5 and shows that all applicable traffic movements will operate below capacity and at LOS B or better through 2030 with the proposed site in full operation.

Table 5 **STOP-Controlled Intersection Capacity Analysis**
Bow Lake Road / Proposed Site Driveway

	Weekday AM Peak Hour				Weekday PM Peak Hour				
	Delay ¹	V/C ²	LOS ³	Queue ⁴	Delay ¹	V/C ²	LOS ³	Queue ⁴	
Proposed Site Driveway - WB LT & RT Departures									
2020 Build	11.6	0.09	B	<1	10.1	0.03	B	<1	
2030 Build	12.0	0.09	B	<1	10.3	0.03	B	<1	
Bow Lake Road - NB Left-Turn Arrivals									
2020 Build	7.9	0.00	A	<1	7.5	0.00	A	<1	
2030 Build	7.9	0.01	A	<1	7.5	0.00	A	<1	

¹ HCM Control Delay (seconds per vehicle), ² HCM Volume to Capacity Ratio, ³ HCM Level of Service, ⁴ HCM 95th Percentile Queue (vehicles)

Appendix F contains the computations pertaining to the intersection capacity and LOS analyses.

AUXILIARY TURN LANES

Determining the appropriate design of the site driveway intersection on Bow Lake Road should take into account the hourly traffic volumes and turning movement patterns, vehicle types and speeds, and the projected Level of Service and capacity analysis results. This intersection was also analyzed to determine the ideal approach lane configuration for providing safe and efficient traffic operations.

Left-Turn Treatment – The type of treatment needed to accommodate left-turning vehicles from any street or highway to an intersecting side street (or driveway) can range from no treatment where turning volumes are low; to the provision of a formal center turn lane used exclusively by left-turning vehicles for deceleration and storage while waiting to complete their maneuvers.

Analysis of the 2030 Build traffic volume projections using NCHRP 457 guidelines is summarized in Table 6 and confirms that left-turn treatment is not necessary to accommodate the anticipated volume of vehicles turning left into the site from Bow Lake Road. This means that the existing southbound travel lane on the roadway will function adequately as a shared through-left lane.

Table 6	Left-Turn Lane Warrants Analysis Bow Lake Road / Proposed Site Driveway	
	2030 AM Build Volumes	2030 PM Build Volumes
Peak Hour Inputs		
Left-Turn Volume (SB)	5	1
Advancing Volume (SB)	143	107
Opposing Volume (NB)	164	150
Percent Lefts	3.5%	0.9%
Speed (mph)	25	25
Limiting Advancing Volume (veh/h)	913	>1000
Conclusion		
Left-Turn Treatment Warranted	NO	NO

Right-Turn Treatment – The type of treatment needed to accommodate right-turning vehicles from any street or highway to any intersecting side street (or driveway) can range from a corner radius only, where turning volumes are low; to the provision of a short 10:1 right-turn taper; to the addition of an exclusive right-turn lane, where turning volumes and through traffic volumes are significant.

Analysis of the 2030 Build traffic volume projections and NCHRP 457 guidelines is summarized in Table 7 and confirms that right-turn treatment is not warranted at the proposed site driveway location. This finding means that the existing northbound lane on Bow Lake Road will function safely and adequately as a shared through-right lane.

Table 7	Right-Turn Lane Warrants Analysis Bow Lake Road / Proposed Site Driveway	
	2030 AM Build Volumes	2030 PM Build Volumes
Peak Hour Inputs		
Right-Turn Volume (NB)	42	16
Total Approach Volume (NB)	164	150
Speed (mph)	25	25
Limiting Right-Turn Volume (veh/h)	>1000	>1000
Conclusion		
Add Right-Turn Bay	NO	NO

Minor-Road Approach Analysis – The type of treatment needed to accommodate exiting vehicles from the minor-road approach at a stop-controlled intersection can range from a single lane (shared left-right lane) in low-volume conditions, to two exit lanes (exclusive left-turn lane and exclusive right-turn lane) where turning volumes and through traffic volumes are significant, to multiple exit lanes in extreme cases.

Analysis of the Proposed Site Driveway intersection on Bow Lake Road using the 2030 traffic volumes and NCHRP 457 guidelines is summarized on Table 8 below and confirms that one shared left-right lane on the site driveway approach to the Bow Lake Road is sufficient for the anticipated traffic volumes. Auxiliary turn lanes are not warranted at the Bow Lake Road/Academy Way intersection.

Table 8	Minor-Road Approach Geometry Bow Lake Road / Proposed Site Driveway	
	2030 AM Build Volumes	2030 PM Build Volumes
Peak Hour Inputs		
Major-Road Volume (NB-SB)	307	257
% Right-Turns on Minor (WB)	7	17
Minor-Road Approach Volume	46	18
Limiting Minor-Road Volume (veh/h)	352	393
Conclusion		
Consider TWO Approach Lanes	NO	NO

Appendix G contains the auxiliary turn Lane warrants analyses computations.

TRAFFIC CONTROL DEVICES

The appropriate form of traffic control at the Proposed Site Driveway intersection on Bow Lake Road is STOP sign control (MUTCD #R1-1) on the minor approach. This should be supplemented with a 12-inch (minimum) stop line, and a short section of four-inch double-yellow centerline pavement markings.

STUDY FINDINGS AND RECOMMENDATIONS

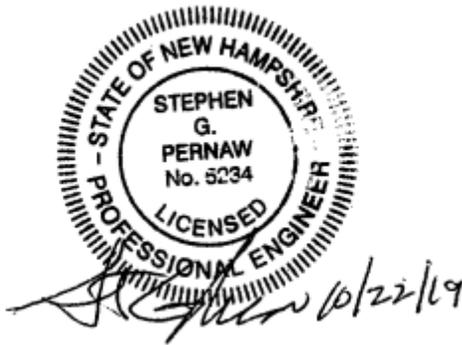
Based on the existing traffic data available on US4 and Bow Lake Road in the vicinity of the subject site, the anticipated traffic increases resulting from the proposed drive-thru coffee shop (with small greenhouse shop, small office, and one residence), and the analysis of future traffic levels in the study area, Pernaw & Company, Inc. concludes:

1. Traffic on US4 in the study area reached peak levels from 7:00 to 8:00 AM in the morning, and from 5:00 to 6:00 PM in the evening. The two-way traffic volume on US4 along the site frontage totaled 1,515 vehicles (AM) and 1,448 vehicles (PM) during the peak hour periods in September 2019. Bow Lake Road (north of US4) carried 229 (AM) and 209 (PM) vehicles during these hours. Similarly, Academy Way carried 173 (AM) and 69 (PM) vehicles during the peak hour periods.
2. The results of the trip generation analysis indicate that the subject site will generate approximately 93 vehicle-trips (47 arrivals, 46 departures) during the AM peak hour, and 35 vehicle-trips (17 arrivals, 18 departures) during the PM peak period. These estimates do not represent all new vehicles to the study area; rather a high percentage of the customers will be drawn from the existing traffic stream on US4.
3. Analysis of the traffic operations at the proposed site driveway intersection on Bow Lake Road confirmed that all applicable traffic movements will operate well below capacity during all hours of the day through 2030 and beyond. All applicable traffic movements will operate at Level of Service B or higher through 2030. Vehicle queuing at the proposed site driveway will be minimal during the worst-case peak hour periods. Analysis of the Bow Lake Road/Academy Way intersection produced similar results.
4. Analysis of the traffic operations at the existing US4/Bow Lake Road intersection confirmed that left-turn departures from Bow Lake Road currently involve long delays during the peak hour periods. The Highway Capacity Manual computations contained herein estimate that the left-turn departures encounter approximately 106 seconds of delay (LOS F) during the morning peak hour period. Field measurements confirm that this is quite overstated; the actual delay averaged 45 seconds (LOS E) per vehicle. Fortunately, Bow Lake Road has been widened to provide two separate exit lanes. This serves to minimize delays and queuing and maximize the egress capacity of Bow Lake Road.
5. The auxiliary turn lane warrants analysis indicates that turn lanes are not warranted at the Bow Lake Road/Proposed Site Driveway intersection. This means that one shared general-use approach lane is sufficient on each leg of this intersection. Auxiliary turn lanes are also not warranted at the Bow Lake Road/Academy Way intersection.

Study recommendations include the following:

- A. Closure of the existing residential driveway on Bow Lake Road and provide access to said residence via the Proposed Site Driveway.
- B. Locate the Proposed Site Driveway at least 200-feet from US4 and provide one inbound lane and one outbound lane.
- C. Install stop sign control on the Proposed Site Driveway approach to Bow Lake Road. Supplement this with a 12" (minimum) white stop line.

- D. Install a short section of 4" double-yellow centerline pavement markings on the site driveway to separate inbound and outbound vehicles.
- E. Maintain clear "sight distance triangles" looking left and right from the Proposed Site Driveway approach by clearing and maintaining roadside vegetation (and snow banks). Prohibit any signs or landscaping that may block the view for exiting drivers.
- F. Provide a pedestrian pathway that extends from the existing sidewalk on US4 to the proposed patio area. Install a marked crosswalk across the two travel lanes within the site.



APPENDIX

Appendix A	Proposed Site Plan
Appendix B	Automatic Traffic Recorder Counts
Appendix C	Intersection Turning Movement Counts
Appendix D	Seasonal Adjustment Factors / Historical Growth Rates
Appendix E	Site Generated Traffic Volumes / Trip Distribution
Appendix F	Capacity and Level of Service Calculations – Unsignalized
Appendix G	Auxiliary Turn Lane Warrants Analysis
Appendix H	Sight Distance Photographs