Vanasse & Associates inc
Transportation Engineers & Planners

35 New England Business Center Drive
Suite 140
Andover, MA 01810

Ref: 8670

January 28, 2021

Mr. Peter Bemis
Engineering Design Consultants, Inc.
520 Hartford Turnpike
32 Turnpike Road
Southborough, MA 01772

Re: Response to Comments – Hopping Brook Business Park Traffic Analyses
Holliston, Massachusetts

Dear Peter:

Vanasse & Associates, Inc. (VAI) has prepared this letter in response to the comments and questions that have been raised by the Town Peer Review Consultant, MDM Transportation Consultants, Inc. ("MDM"), concerning the VAI Transportation Impact Assessment (TIA) dated November 18, 2020 (hereafter referred to as the "November TIA") for the proposed 800,000 square feet (sf) of warehouse space to be located at 555 Hopping Brook Road as part of the Hopping Brook Business Park in Holliston, Massachusetts (hereafter referred to as the "Project"). The following information is provided in this letter:

i) A comparison of industry trip generation with local observed trip generation estimates,
ii) A review of alternative trip generation based on comments provided by MDM, and
iii) A "Sensitivity Analysis" of traffic operations at the Washington Street at Hopping Brook Road intersection to reflect the effects of alternative trip generation on the proposed intersection design.

TRIP GENERATION COMPARISONS

January 20, 2020 TIA Trip Generation

The Project initially submitted a TIA dated January 20, 2020 (hereafter referred to as the "January TIA"). Trip estimates were completed using research studies[1] resulting in vehicle-trip estimates for weekday daily and peak periods. Following that submittal and review, VAI was retained by the Applicant to prepare a revised traffic assessment. Accordingly, information was provided by the Applicant regarding the end user along with comments provided by the Massachusetts Department of Transportation (MassDOT) in their review of the Project. A revised approach to trip generation was used by VAI in preparing the November TIA to use the more appropriate Institute of Transportation Engineers (ITE) Land Use Code 150, Warehousing to generate trips for the Project. The results of these trip calculations are summarized and compared in Table 1.

[1]Florida Department of Transportation, Trip Generation Recommendations, prepared by Kimley Horn Associates, Inc., October 2014 and *Fulfillment Center Trip Generation*, prepared by Rajappan B., Taubeneck, L., and Patil, S., ITE Journal, pages 23-26, published July 2019.

Table 1
TRIP-GENERATION SUMMARY

Time Period/Direction	A November TIA LUC 150 Warehousing[a] (800,000 sf)	B January TIA Alternative Trip Estimates (800,000 sf)	C=B-A Difference (Increase/Decrease)
Weekday Daily	1,310	1,488	+178
Weekday Morning Peak Hour:			
Entering	105	52	-53
Exiting	31	52	+21
Total	136	104	-32
Weekday Evening Peak Hour:			
Entering	41	49	+8
Exiting	111	23	-88
Total	152	72	-80

[a]Based on ITE LUC 150, *Warehousing* (800,000 sf).

In comparison with the November TIA, the January TIA predicted 178 *additional* vehicle trips during the average weekday daily, 32 *fewer* vehicle trips during weekday morning peak hour, and 80 *fewer* vehicle trips during weekday evening peak hour. Since the intersection operations analysis uses peak hour trips and not daily trips, use of the LUC 150 data provides a higher estimate of site traffic generation leading to a more conservative analysis than was prepared in the January TIA.

The use of the warehouse code was warranted based on information provided by the Applicant that the proposed 800,000 sf building was being marketed to a standard warehouse tenant. This intention has been further corroborated in a January 25, 2021 letter from CRG Senior Vice President Frank Petkunas (the "Applicant") to Mr. David Thorn, Chairman of the Holliston Planning Board.

<u>Warehouse Traffic Count Observations</u>

In order to compare industry trip generation information with local data, vehicle trip rates were derived from traffic count observations conducted at a warehouse located in Bellingham, Massachusetts. The counts were conducted during the weekday morning (7:00 to 9:00 AM) and weekday evening (4:00 to 6:00 PM) peak periods in 2019. This data was used to establish trip rates (trips per 1,000 sf) for the weekday peak hours of the adjacent roadway, which were then compared to the trips rates estimated using Institute of Transportation Engineers (ITE),[2] Land Use Code (LUC) *150 Warehousing*. Table 2 summarizes the results.

[2]*Trip Generation*, 10th Edition; Institute of Transportation Engineers; Washington, DC; 2017.

Table 2
PROJECT TRIP-RATE SUMMARY

Time Period/Direction	ITE LUC150 (800,000 sf Warehousing) Vehicles/1,000 sf	Observed Trips (127,500 sf Warehousing) Vehicles/1,000 sf
Weekday Morning Peak Hour	0.17	0.12
Weekday Evening Peak Hour	0.19	0.18

As can be seen in Table 2, trip generation using the ITE data provides a conservative approach to trip calculations where the ITE trip rates are higher than observed trip rates during peak periods.

ALTERNATIVE TRIP GENERATION

The November TIA included an analysis of the remaining build-out of the Hopping Brook Business Park based on available property and likely land uses. Accordingly, this Ultimate-Build program assessed trips based on 700,000 sf of Warehouse space intended to represent the remaining development of the Park. However, in their review of the November TIA, MDM proposed the use of the ITE Land Use Code (LUC) 130, *Industrial Park* to generate trips associated with this phase. These trips are shown below in Table 3, using the remaining build-out development size of 700,000 sf.

Table 3
TRIP-GENERATION SUMMARY

Time Period	LUC 150 Warehousing (700,000 sf)	LUC 130 Industrial Park (700,000 sf)	Increase
Weekday Daily	1,152	2,360	+1,208
Weekday Morning Peak Hour:			
Entering	92	227	+135
Exiting	27	53	+26
Total	119	280	+161
Weekday Evening Peak Hour:			
Entering	36	59	+23
Exiting	97	221	+124
Total	133	280	+147

In comparison with the expected trip-generation totals from the November TIA, the use of the Industrial Park data results in projections of 1,208 additional vehicle trips during an average weekday daily, 161 additional vehicle trips during the weekday morning peak hour, and 147 additional vehicle trips during the weekday evening peak hour. ***It should be noted that, the applicant has no plans to develop the remaining buildout as an industrial park, and fully expects to develop this space as warehouse use.***

SENSITIVITY ANALYSIS FOR 1,500,000 SF INDUSTRIAL PARK

An additional analysis was conducted in response to MDM requests. This involved a Sensitivity Analysis for trip generation, using an even higher-intensity development program than that noted above for the remaining phase of the Ultimate Build-Out of the Park. This Sensitivity Analysis assumes that the entire program (including the currently proposed 800,000 sf warehouse and the remaining buildout of 700,000 sf) is developed not as warehouse, but instead as 1,500,000 sf of Industrial Park, using ITE LUC 130, *Industrial Park* data. This results in an even higher trip generation total than indicated in the previous section. These trips are shown below in Table 4 and are compared with those estimated in the November TIA based on the proposed 800,000 sf and remaining buildout of 700,000 sf of warehouse. ***To be clear, the Applicant has no plans to develop either the 800,000-sf current parcel or the remaining build-out of 700,000 sf of space as anything but warehouse.***

Table 4
TRIP-GENERATION SUMMARY

Time Period	A Proposed Warehousing[a] (1,500,000 sf)	B Assumed Industrial Park[b] (1,500,000 sf)	C=B-A Increase
Weekday Daily	2,462	5,056	+2,594
Weekday Morning Peak Hour:			
Entering	197	486	+289
Exiting	58	114	+56
Total	255	600	+345
Weekday Evening Peak Hour:			
Entering	77	126	+49
Exiting	208	474	+266
Total	285	600	+315

[a]Based on ITE LUC 150, *Warehouse* from November TIA.
[a]Based on ITE LUC 130, *Industrial Park.*

In comparison with the expected trip-generation totals from the November TIA, a *hypothetical* buildout of a 1,500,000 sf Industrial Park at Hopping Brook Business Park would result in 2,594 *additional* vehicle trips during an average weekday daily, 345 *additional* vehicle trips during the weekday morning peak hour, and 315 *additional* vehicle trips during weekday evening peak hour. ***It should be noted that the Project site is being developed and marketed as a warehouse and these alternative use scenarios are provided as a hypothetical exercise based on requests that have been raised by the Peer Reviewer only.***

Ultimate-Build Conditions Analysis

A last step in the Sensitivity Analysis involves the capacity analysis of both of the *hypothetical* 2027 Ultimate-Build conditions to reflect both MDM requests:

- The proposal for the 700,000-sf industrial park for the remaining buildout, keeping the 800,000-sf warehouse space as proposed, and
- The substitute 1,500,000 sf Industrial Park for the entire development.

Accordingly, new level-of-service and vehicle queue analyses were conducted for the study area intersection using the above conditions. Table 5 summarizes the intersection capacity and vehicle queuing analyses with the above-mentioned proposals and after installation of a traffic control signal at the intersection, as shown to be warranted in the November TIA .

Table 5
SIGNALIZED INTERSECTION CAPACITY ANALYSIS SUMMARY

	2027 Ultimate-Build (1,500,000 sf Warehouse, from November TIA)				2027 Ultimate-Build (800,000 sf Warehouse and 700,000 sf Industrial Park)				2027 Ultimate-Build (1,500,000 sf Industrial Park)			
Signalized Intersection/ Critical Movement/Peak Hour	V/C[a]	Delay[b]	LOS[c]	Queue[d] Ave/95th	V/C	Delay	LOS	Queue Ave/95th	V/C	Delay	LOS	Queue Ave/95th
Washington Street at Hopping Brook Road:												
Weekday Morning:												
Washington Street EB TH/RT	0.90	23.0	C	16/29	0.97	33.9	C	20/34	1.06	63.2	E	44/55
Washington Street WB LT	0.49	13.0	B	1/2	0.72	31.4	C	1/4	0.90	67.8	E	4/10
Washington Street WB TH	0.44	4.9	A	3/5	0.42	4.5	A	3/5	0.41	5.3	A	5/7
Hopping Brook Road NB LT	0.54	45.0	D	2/5	0.72	59.1	E	2/6	0.74	68.3	E	4/8
Hopping Brook Road NB RT	0.17	13.5	B	0/1	0.21	13.5	B	0/1	0.25	13.1	B	0/2
Overall	--	**18.0**	**B**	--	--	**26.7**	**C**	--	--	**48.0**	**D**	--
Weekday Evening:												
Washington Street EB TH/RT	0.79	23.6	C	12/18	0.84	27.6	C	12/21	0.98	54.8	D	18/26
Washington Street WB LT	0.21	9.9	A	1/1	0.34	13.6	B	1/1	0.29	14.3	B	1/1
Washington Street WB TH	0.87	25.4	C	14/23	0.90	28.9	C	14/23	0.96	44.0	D	17/27
Hopping Brook Road NB LT	0.82	39.9	D	7/13	0.92	52.8	D	10/18	0.99	62.0	E	12/21
Hopping Brook Road NB RT	0.27	5.5	A	0/2	0.29	5.0	A	0/2	0.31	3.9	A	0/2
Overall	--	**25.8**	**C**	--	--	**31.3**	**C**	--	--	**47.4**	**D**	--

[a]Volume-to-capacity ratio.
[b]Delay in seconds per vehicle.
[c]Level of service.
[d]Queue length, in vehicle.
NB = northbound; SB = southbound; EB = eastbound; WB = westbound; LT = left-turning movements; TH = through movements; RT = right-turning movements.

As shown in Table 5, the substitution of the 700,000 sf Industrial Park was shown to result in a degradation in overall level of service over the proposed 700,000 sf Warehouse during 2027 Ultimate Build conditions, from LOS B to LOS C during the weekday morning peak hour and from LOS D to LOS E for left-turn movements on Hopping Brook Road. This scenario retained the proposed 800,000 sf Warehouse of the November TIA in both conditions.

The substitution of the 1,500,000 Industrial Park was shown to result in a larger degradation in overall level of service over the proposed 1,500,000 sf warehouse from LOS B to LOS D during the weekday morning peak hour and from LOS C to LOS D during the weekday evening peak hour. Some movements were shown to operate at the capacity or LOS E during both peak periods.

TRAFFIC MONITORING

In addition to the mitigation of the traffic signal installation at the intersection of Hopping Brook Road and Washington Street and items referenced in the MassDOT Section 61 Finding such as designation of a transportation coordinator and providing amenities to discourage off-site trips, the Applicant is willing to undertake a Traffic Monitoring program to measure the trip generation of the 800,000 sf and 700,000 sf warehouse parcels, as well as the trip generation of the entire Park. Such monitoring is expected as a part of the MEPA approval for the Park and would include annual daily and peak-period counts for a five-year period commencing upon the 12-month anniversary of the occupancy of the various components. The Applicant will submit this data to the Town when a submittal to MassDOT is provided.

CONCLUSION

Based on the above, we conclude that the Hopping Brook Road intersection with Washington Street could accommodate additional (but unanticipated) traffic demands of the Park. The analysis indicates that the intersection can accommodate trip generation consistent with the use of ITE categories of Warehouse and Industrial Park, for both the 800,000-sf parcel as part of the Build condition and for the 1,500,000 sf Ultimate Build-Out of the remainder of the Hopping Brook Business Park. However, the Applicant is only proposing warehouse users for both the 800,000-sf parcel and for the remaining 700,000 sf parcel representing the final Build-Out of the Park. The Applicant referenced their intention to develop the 800,000 sf parcel as a warehouse facility in a January 25, 2021 letter to the Holliston Planning Board.

Should you have any questions on the above information, feel free to contact me.

Sincerely,

VANASSE & ASSOCIATES, INC.

Scott W. Thornton, P.E.
Principal

Attachment
- Technical Appendix

APPENDIX

TRIP GENERATION CALCULATIONS
CAPACITY ANALYSIS

TRIP-GENERATION CALCULATIONS

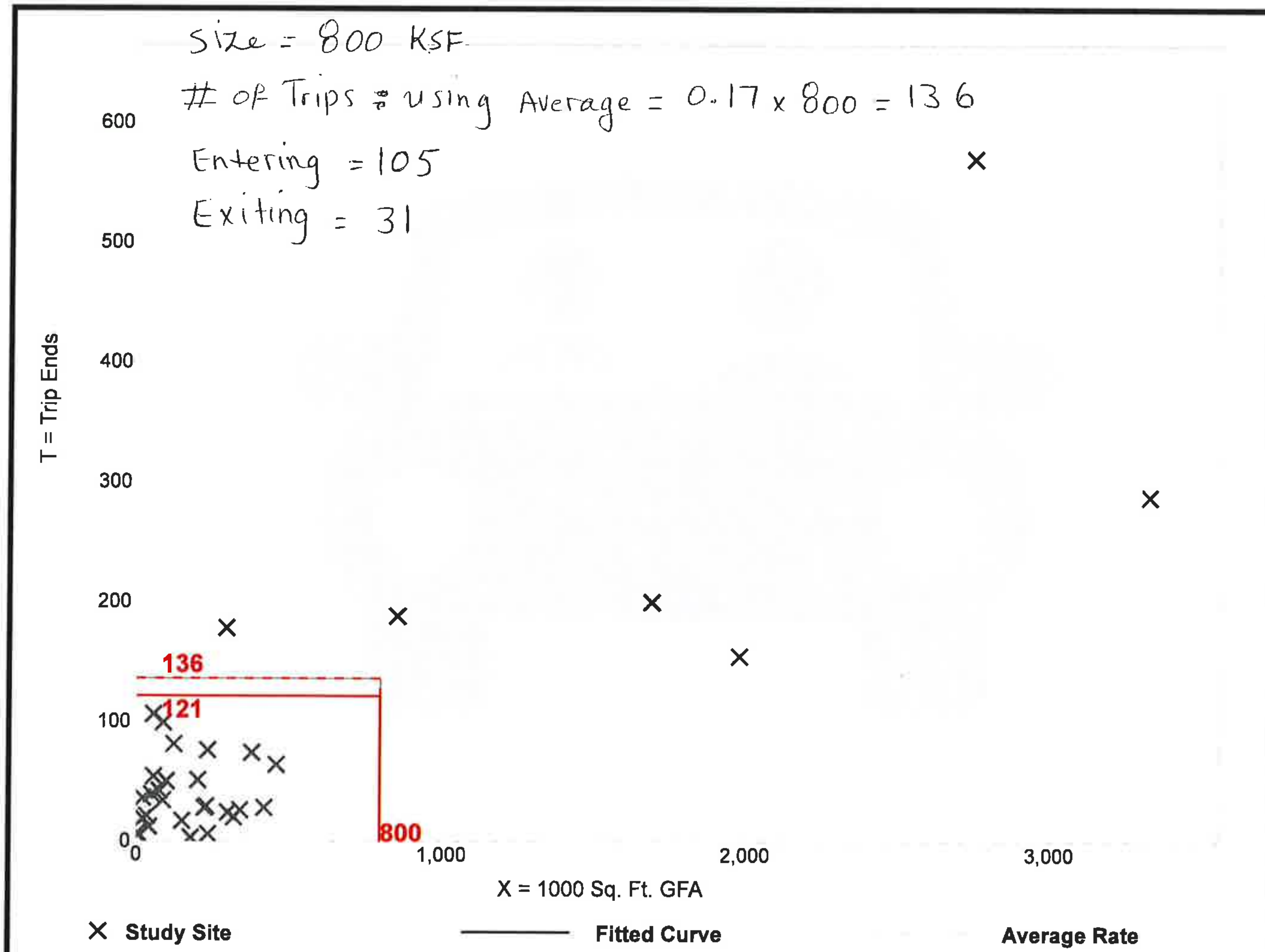
Warehousing
(150)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday, Peak Hour of Adjacent Street Traffic, One Hour Between 7 and 9 a.m.**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	34
Avg. 1000 Sq. Ft. GFA:	451
Directional Distribution:	77% entering, 23% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.17	0.02 - 1.93	0.20

Data Plot and Equation



Fitted Curve Equation: $T = 0.12(X) + 25.32$

R^2= 0.69

Warehousing
(150)

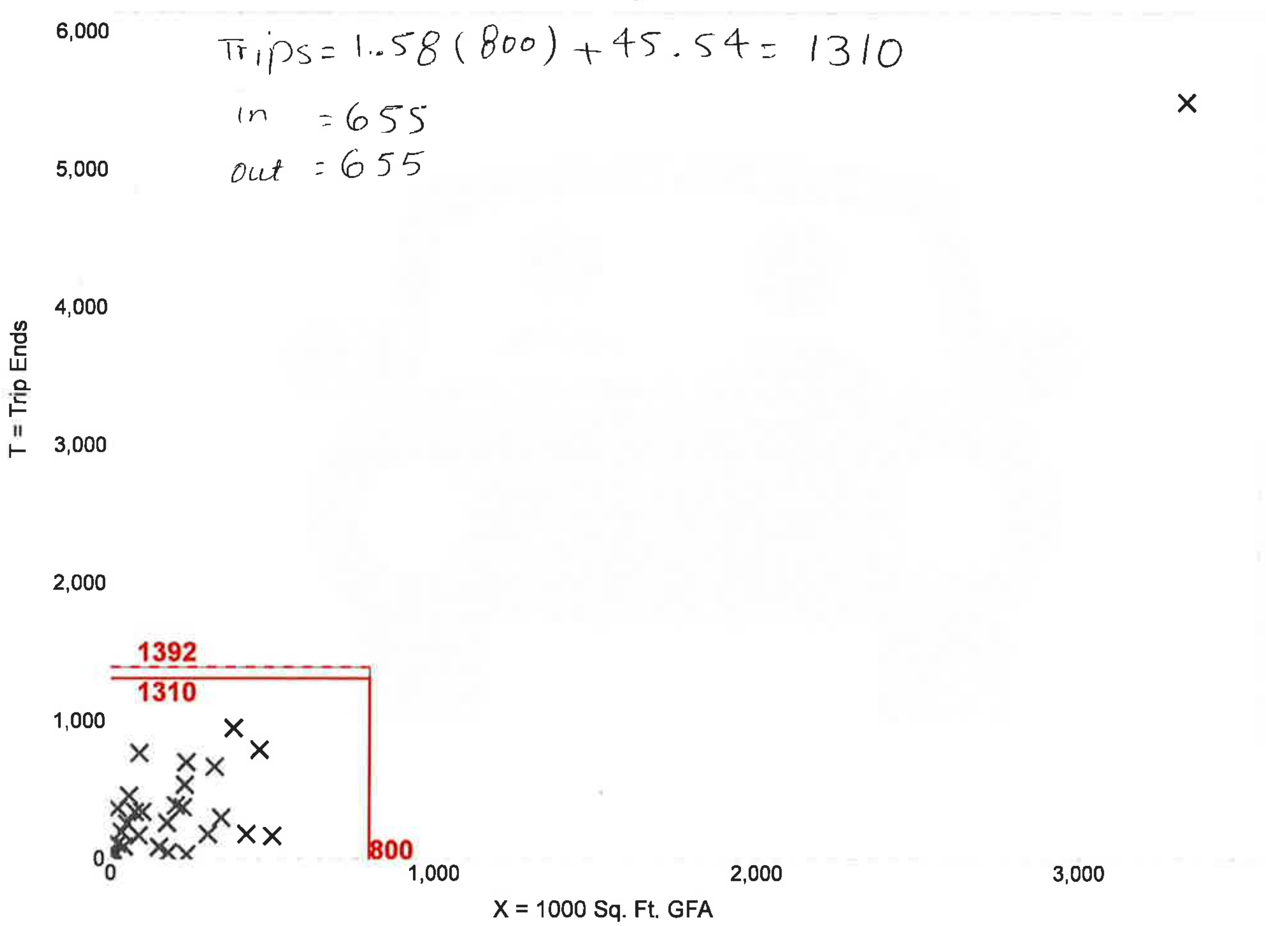
Vehicle Trip Ends vs: 1000 Sq. Ft. GFA
On a: Weekday

Setting/Location: General Urban/Suburban
Number of Studies: 29
Avg. 1000 Sq. Ft. GFA: 285
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
1.74	0.15 - 16.93	1.55

Data Plot and Equation



× **Study Site** ——— **Fitted Curve** **Average Rate**

Fitted Curve Equation: T = 1.58(X) + 45.54

R^2= 0.93 > 0.75

Warehousing
(150)

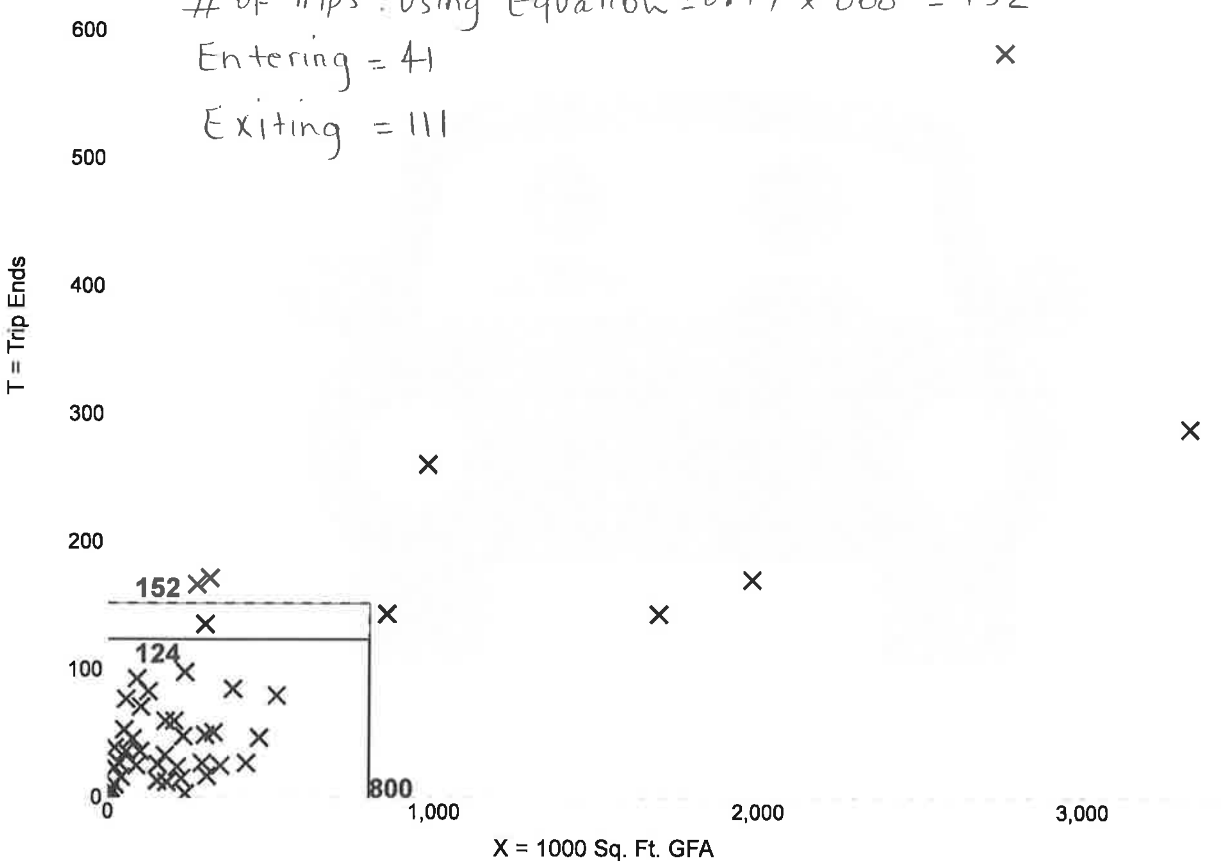
Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday,** **Peak Hour of Adjacent Street Traffic,** **One Hour Between 4 and 6 p.m.**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	47
Avg. 1000 Sq. Ft. GFA:	400
Directional Distribution:	27% entering, 73% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
0.19	0.01 - 1.80	0.18

Data Plot and Equation

Size = 800 ksf
# of Trips : using Equation = 0.19 x 800 = 152
Entering = 41
Exiting = 111



X **Study Site** ——— **Fitted Curve** **Average Rate**

Fitted Curve Equation: T = 0.12(X) + 27.82 **R^2= 0.65**

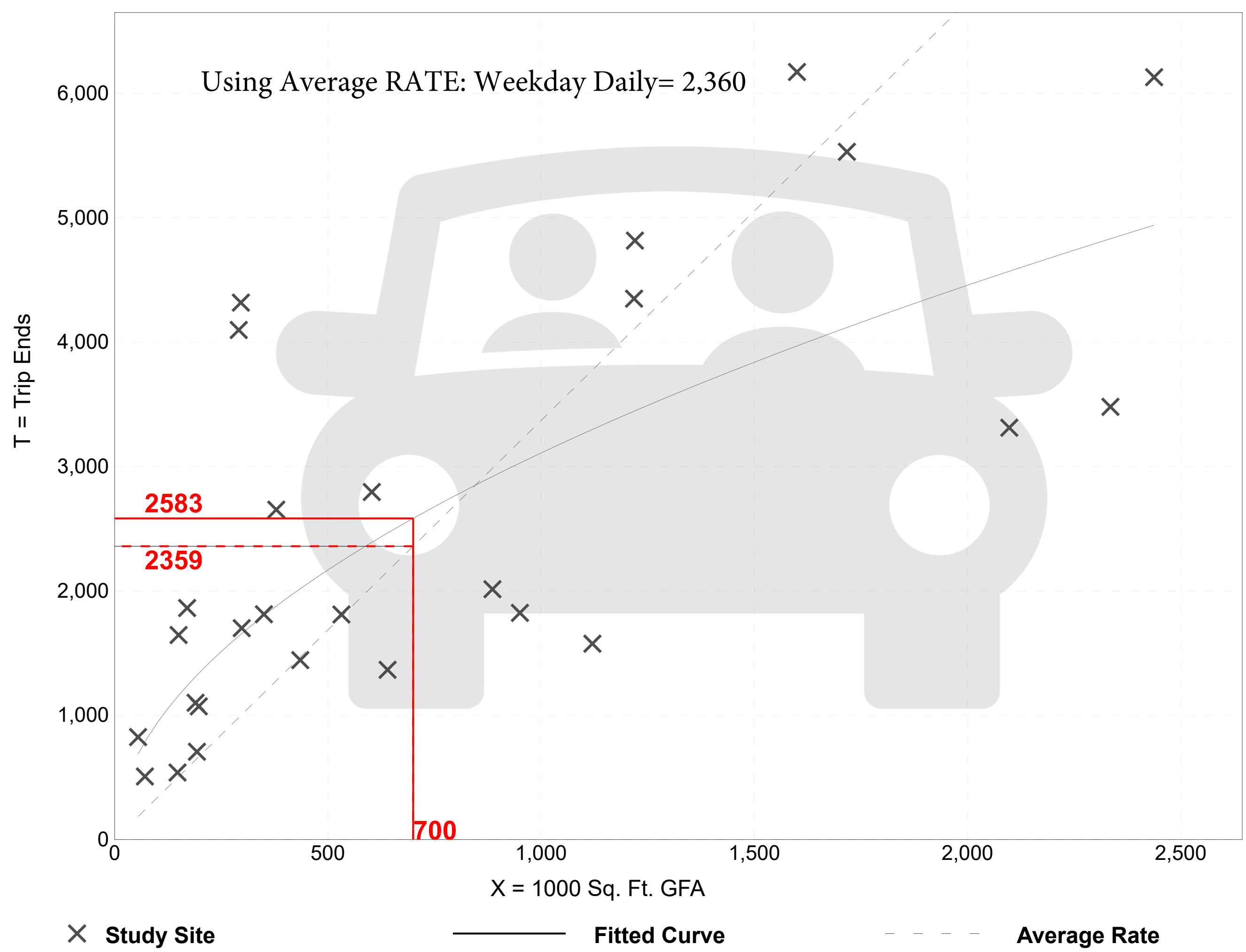
Industrial Park
(130)

Vehicle Trip Ends vs:	**1000 Sq. Ft. GFA**
On a:	**Weekday**
Setting/Location:	**General Urban/Suburban**
Number of Studies:	27
Avg. 1000 Sq. Ft. GFA:	762
Directional Distribution:	50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
3.37	1.41 - 14.98	2.60

Data Plot and Equation



Fitted Curve Equation: Ln(T) = 0.52 Ln(X) + 4.45 **R^2= 0.58**

Institute of Transportation Engineers (ITE)
Trip Generation, 10th Edition
Land Use Code (LUC) 130 - Industrial Park

Average Vehicle Trips Ends vs: 1000 Sq. Feet Gross Floor Area
Independent Variable (X): 700.00

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.40 * (X)
T = 0.40 * 700.00
T = 280.00
T = 280 vehicle trips
with 81% (227 vph) entering and 19% (53 vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.40 * (X)
T = 0.40 * 700.00
T = 280.00
T = 280 vehicle trips
with 21% (59 vph) entering and 79% (221 vph) exiting.

Industrial Park
(130)

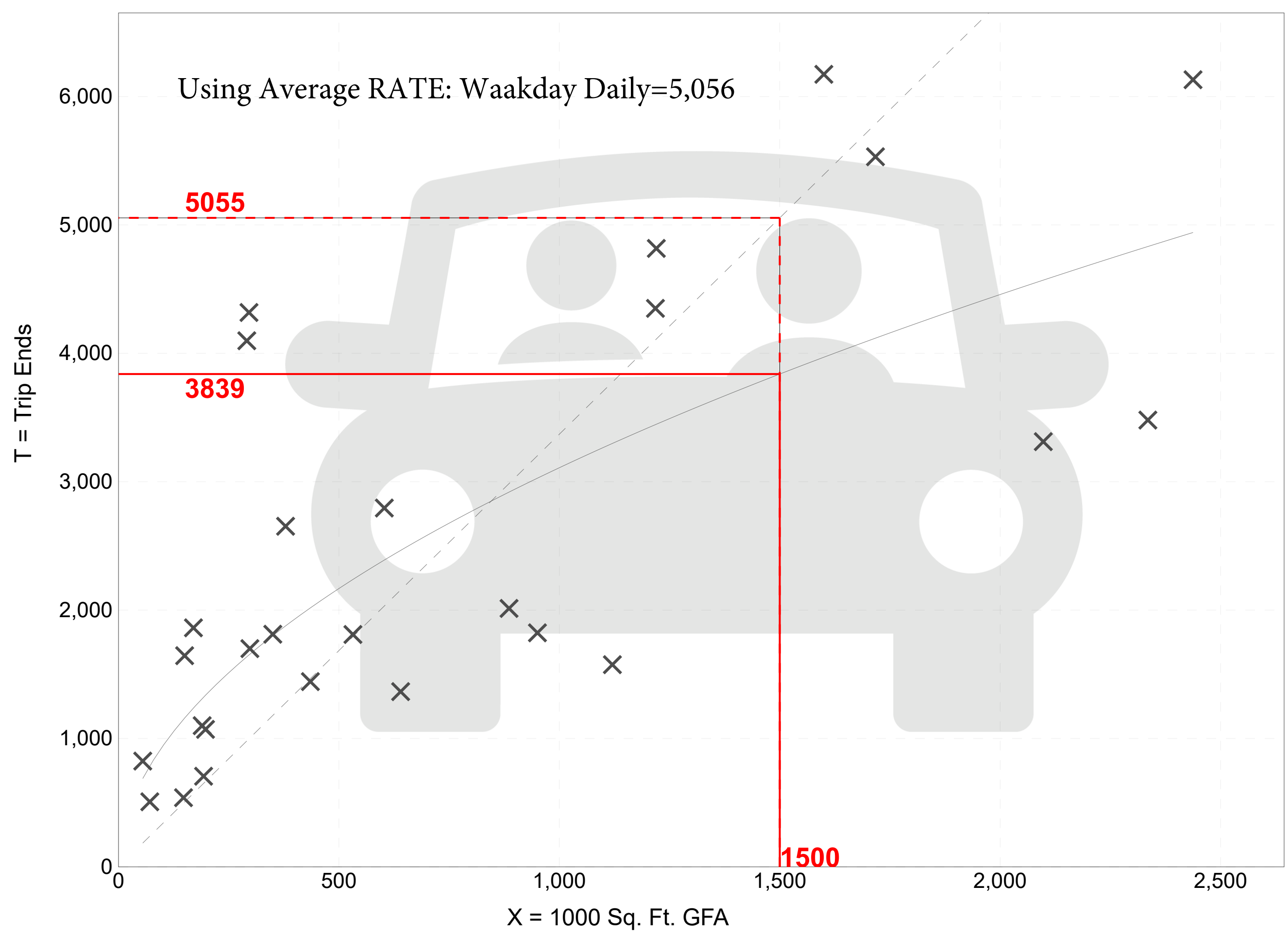
Vehicle Trip Ends vs: **1000 Sq. Ft. GFA**
On a: **Weekday**

Setting/Location: **General Urban/Suburban**
Number of Studies: 27
Avg. 1000 Sq. Ft. GFA: 762
Directional Distribution: 50% entering, 50% exiting

Vehicle Trip Generation per 1000 Sq. Ft. GFA

Average Rate	Range of Rates	Standard Deviation
3.37	1.41 - 14.98	2.60

Data Plot and Equation



× **Study Site** —— **Fitted Curve** - - - **Average Rate**

Fitted Curve Equation: Ln(T) = 0.52 Ln(X) + 4.45 **R^2= 0.58**

Institute of Transportation Engineers (ITE)
Trip Generation, 10th Edition
Land Use Code (LUC) 130 - Industrial Park

Average Vehicle Trips Ends vs: 1000 Sq. Feet Gross Floor Area
Independent Variable (X): 1500.00

WEEKDAY MORNING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.40 * (X)
T = 0.40 * ######
T = 600.00
T = 600 vehicle trips
with 81% (486 vph) entering and 19% (114 vph) exiting.

WEEKDAY EVENING PEAK HOUR OF ADJACENT STREET TRAFFIC

T = 0.40 * (X)
T = 0.40 * ######
T = 600.00
T = 600 vehicle trips
with 21% (126 vph) entering and 79% (474 vph) exiting.

CAPACITY ANALYSIS WORKSHEETS

CAPACITY ANALYSIS WORKSHEETS

Washington Street at Hopping Brook Road

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	685	461	145	554	119	41
Future Volume (vph)	685	461	145	554	119	41
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width (ft)	16	12	12	12	12	12
Grade (%)	0%			0%	0%	
Storage Length (ft)		150	150		0	0
Storage Lanes		0	1		1	1
Taper Length (ft)			25		25	
Satd. Flow (prot)	1974	0	1770	1900	1612	1568
Flt Permitted			0.074		0.950	
Satd. Flow (perm)	1974	0	138	1900	1612	1568
Right Turn on Red		Yes				Yes
Satd. Flow (RTOR)	83					45
Link Speed (mph)	40			40	30	
Link Distance (ft)	515			535	833	
Travel Time (s)	8.8			9.1	18.9	
Lane Group Flow (vph)	1246	0	158	602	129	45
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Detector Phase	4		3	8	2	2
Switch Phase						
Minimum Initial (s)	5.0		5.0	5.0	5.0	5.0
Minimum Split (s)	23.0		9.5	23.5	23.0	23.0
Total Split (s)	56.0		10.0	66.0	14.0	14.0
Total Split (%)	70.0%		12.5%	82.5%	17.5%	17.5%
Yellow Time (s)	3.0		3.5	3.5	3.0	3.0
All-Red Time (s)	2.0		1.0	2.0	2.0	2.0
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	0.0
Total Lost Time (s)	5.0		4.5	5.5	5.0	5.0
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	None		None	None	Min	Min
Act Effct Green (s)	49.8		60.3	59.3	8.7	8.7
Actuated g/C Ratio	0.63		0.77	0.76	0.11	0.11
v/c Ratio	0.97		0.72	0.42	0.72	0.21
Control Delay	33.9		31.4	4.5	59.1	13.5
Queue Delay	0.0		0.0	0.0	0.0	0.0
Total Delay	33.9		31.4	4.5	59.1	13.5
LOS	C		C	A	E	B
Approach Delay	33.9			10.1	47.3	
Approach LOS	C			B	D	
Queue Length 50th (ft)	496		24	83	63	0
Queue Length 95th (ft)	#863		#114	126	#146	29
Internal Link Dist (ft)	435			455	753	
Turn Bay Length (ft)			150			
Base Capacity (vph)	1313		220	1466	185	220
Starvation Cap Reductn	0		0	0	0	0

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Spillback Cap Reductn	0		0	0	0	0
Storage Cap Reductn	0		0	0	0	0
Reduced v/c Ratio	0.95		0.72	0.41	0.70	0.20

Intersection Summary	
Area Type: Other	
Cycle Length: 80	
Actuated Cycle Length: 78.5	
Natural Cycle: 100	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 0.97	
Intersection Signal Delay: 26.7	Intersection LOS: C
Intersection Capacity Utilization 90.9%	ICU Level of Service E
Analysis Period (min) 15	
# 95th percentile volume exceeds capacity, queue may be longer.	
Queue shown is maximum after two cycles.	

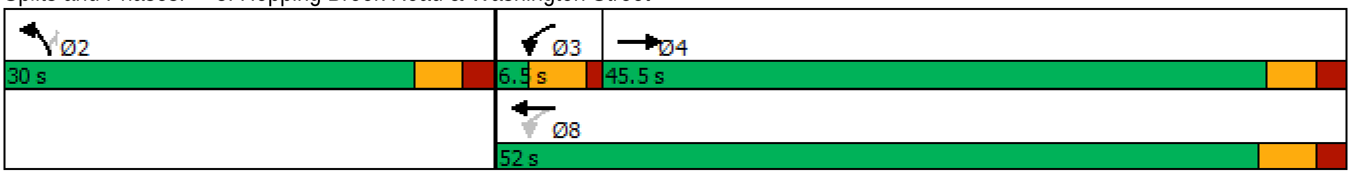
Splits and Phases: 3: Hopping Brook Road & Washington Street

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	584	106	49	823	463	171
Future Volume (vph)	584	106	49	823	463	171
Satd. Flow (prot)	1821	0	1805	1900	1626	1538
Flt Permitted			0.112		0.950	
Satd. Flow (perm)	1821	0	213	1900	1626	1538
Satd. Flow (RTOR)	16					186
Lane Group Flow (vph)	750	0	53	895	503	186
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Detector Phase	4		3	8	2	2
Switch Phase						
Minimum Initial (s)	5.0		5.0	5.0	5.0	5.0
Minimum Split (s)	23.0		9.5	23.5	23.0	23.0
Total Split (s)	45.5		6.5	52.0	30.0	30.0
Total Split (%)	55.5%		7.9%	63.4%	36.6%	36.6%
Yellow Time (s)	3.0		3.5	3.5	3.0	3.0
All-Red Time (s)	2.0		1.0	2.0	2.0	2.0
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	0.0
Total Lost Time (s)	5.0		4.5	5.5	5.0	5.0
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	None		None	None	Min	Min
Act Effct Green (s)	36.7		40.8	39.8	25.3	25.3
Actuated g/C Ratio	0.48		0.54	0.53	0.33	0.33
v/c Ratio	0.84		0.34	0.90	0.93	0.29
Control Delay	27.6		13.6	28.9	53.1	5.0
Queue Delay	0.0		0.0	0.0	0.0	0.0
Total Delay	27.6		13.6	28.9	53.1	5.0
LOS	C		B	C	D	A
Approach Delay	27.6			28.1	40.1	
Approach LOS	C			C	D	
Queue Length 50th (ft)	307		11	347	251	0
Queue Length 95th (ft)	#527		25	#561	#460	44
Internal Link Dist (ft)	435			455	753	
Turn Bay Length (ft)			150			
Base Capacity (vph)	992		157	1180	543	637
Starvation Cap Reductn	0		0	0	0	0
Spillback Cap Reductn	0		0	0	0	0
Storage Cap Reductn	0		0	0	0	0
Reduced v/c Ratio	0.76		0.34	0.76	0.93	0.29

Intersection Summary
Cycle Length: 82
Actuated Cycle Length: 75.7
Natural Cycle: 90
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.93

Intersection Signal Delay: 31.4 Intersection LOS: C
Intersection Capacity Utilization 77.7% ICU Level of Service D
Analysis Period (min) 15
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Hopping Brook Road & Washington Street



Lane Group	EBT	WBL	WBT	NBL	NBR
Lane Configurations					
Traffic Volume (vph)	685	190	554	143	61
Future Volume (vph)	685	190	554	143	61
Lane Group Flow (vph)	1368	207	602	155	66
Turn Type	NA	pm+pt	NA	Prot	Perm
Protected Phases	4	3	8	2	
Permitted Phases		8			2
Detector Phase	4	3	8	2	2
Switch Phase					
Minimum Initial (s)	5.0	5.0	5.0	5.0	5.0
Minimum Split (s)	23.0	9.5	23.5	23.0	23.0
Total Split (s)	78.0	15.0	93.0	22.0	22.0
Total Split (%)	67.8%	13.0%	80.9%	19.1%	19.1%
Yellow Time (s)	3.0	3.5	3.5	3.0	3.0
All-Red Time (s)	2.0	1.0	2.0	2.0	2.0
Lost Time Adjust (s)	0.0	0.0	0.0	0.0	0.0
Total Lost Time (s)	5.0	4.5	5.5	5.0	5.0
Lead/Lag	Lag	Lead			
Lead-Lag Optimize?	Yes	Yes			
Recall Mode	None	None	None	Min	Min
Act Effct Green (s)	73.1	88.4	87.4	14.7	14.7
Actuated g/C Ratio	0.65	0.79	0.78	0.13	0.13
v/c Ratio	1.06	0.90	0.41	0.74	0.25
Control Delay	63.2	67.8	5.3	68.3	13.1
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	63.2	67.8	5.3	68.3	13.1
LOS	E	E	A	E	B
Approach Delay	63.2		21.3	51.8	
Approach LOS	E		C	D	
Queue Length 50th (ft)	~1104	100	127	110	0
Queue Length 95th (ft)	#1382	#245	183	#191	41
Internal Link Dist (ft)	435		455	753	
Turn Bay Length (ft)		150			
Base Capacity (vph)	1291	232	1477	243	293
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.06	0.89	0.41	0.64	0.23

Intersection Summary	
Cycle Length: 115	
Actuated Cycle Length: 112.6	
Natural Cycle: 150	
Control Type: Actuated-Uncoordinated	
Maximum v/c Ratio: 1.06	
Intersection Signal Delay: 48.0	Intersection LOS: D
Intersection Capacity Utilization 101.6%	ICU Level of Service G
Analysis Period (min) 15	
~ Volume exceeds capacity, queue is theoretically infinite.	

Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.

Queue shown is maximum after two cycles.

Splits and Phases: 3: Hopping Brook Road & Washington Street

Lane Group	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations						
Traffic Volume (vph)	584	126	50	823	567	209
Future Volume (vph)	584	126	50	823	567	209
Satd. Flow (prot)	1809	0	1805	1900	1626	1538
Flt Permitted			0.103		0.950	
Satd. Flow (perm)	1809	0	196	1900	1626	1538
Satd. Flow (RTOR)	16					227
Lane Group Flow (vph)	772	0	54	895	616	227
Turn Type	NA		pm+pt	NA	Prot	Perm
Protected Phases	4		3	8	2	
Permitted Phases			8			2
Detector Phase	4		3	8	2	2
Switch Phase						
Minimum Initial (s)	5.0		5.0	5.0	5.0	5.0
Minimum Split (s)	23.0		9.5	23.5	23.0	23.0
Total Split (s)	37.0		9.0	46.0	36.0	36.0
Total Split (%)	45.1%		11.0%	56.1%	43.9%	43.9%
Yellow Time (s)	3.0		3.5	3.5	3.0	3.0
All-Red Time (s)	2.0		1.0	2.0	2.0	2.0
Lost Time Adjust (s)	0.0		0.0	0.0	0.0	0.0
Total Lost Time (s)	5.0		4.5	5.5	5.0	5.0
Lead/Lag	Lag		Lead			
Lead-Lag Optimize?	Yes		Yes			
Recall Mode	None		None	None	Min	Min
Act Effct Green (s)	34.8		40.7	39.7	31.0	31.0
Actuated g/C Ratio	0.43		0.50	0.49	0.38	0.38
v/c Ratio	0.98		0.29	0.96	0.99	0.31
Control Delay	54.8		14.3	44.0	62.0	3.9
Queue Delay	0.0		0.0	0.0	0.0	0.0
Total Delay	54.8		14.3	44.0	62.0	3.9
LOS	D		B	D	E	A
Approach Delay	54.8			42.4	46.4	
Approach LOS	D			D	D	
Queue Length 50th (ft)	~445		13	417	~311	0
Queue Length 95th (ft)	#663		31	#683	#532	42
Internal Link Dist (ft)	435			455	753	
Turn Bay Length (ft)			150			
Base Capacity (vph)	784		187	948	621	727
Starvation Cap Reductn	0		0	0	0	0
Spillback Cap Reductn	0		0	0	0	0
Storage Cap Reductn	0		0	0	0	0
Reduced v/c Ratio	0.98		0.29	0.94	0.99	0.31

Intersection Summary

Cycle Length: 82
Actuated Cycle Length: 81.2
Natural Cycle: 100
Control Type: Actuated-Uncoordinated
Maximum v/c Ratio: 0.99

Intersection Signal Delay: 47.4	Intersection LOS: D
Intersection Capacity Utilization 83.5%	ICU Level of Service E
Analysis Period (min) 15	

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

Splits and Phases: 3: Hopping Brook Road & Washington Street