Low Moor Interchange Study

VDOT Prepared for the Virginia Department of Transportation

Interstate 64 Exit 21 (Low Moor) Area
Alleghany County

Submitted: November 30th, 2007

HNTB

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Interstate 64 Exit 21 (Low Moor)

November 2007

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HNTB

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Executive Summary

The purpose of this study was to determine what improvements are necessary to facilitate the movement of traffic at the interchange and the surrounding area around Interstate 64 exit 21 (Low Moor) within Alleghany County.

The study area, shown in the figure below, is bounded by Arh Lane on the south, Commerce Center on the west, north of the JenFab plant to the north, and Clifton Middle School/Mountain View Elementary School to the east.

Low Moor - Exit 21 Interchange

A. Issues:

Traffic utilizing the Low Moor Interchange (Exit 21 off I-64) produces AM and PM backups. The worst case scenario is seen in the AM at the eastbound exit of I-64 based on the number of vehicles turning left at the ramp intersection. Backups can extend to the mainline of I-64 during the AM peak period hindering the capacity of I-64. Although this backup is seen only rarely at the present time, it is anticipated to increase as traffic demand continues to increase in the area. Both buses to/from the Middle and Elementary Schools and other passenger vehicles are mixing with trucks traveling from the MeadWestvaco facility located near the Hospital complex to the storage facility located off Winterberry Avenue in the AM peak period as well as throughout the day causing congestion on cross-streets along SR-696.

With the possibility of the High School relocation to east on Winterberry Avenue, additional

traffic will be generated specifically in the AM peak period when school is beginning as well as when residents are attempting to get to work. The PM peak hour is not as congested given that the school peak traffic generation occurs earlier than the peak traffic generation of the surrounding land uses.

B. Assumptions:

For the assessment of future conditions, the Study Team forecasted traffic for the years 2012 and 2030. The land use assumptions used in the forecasting of traffic are included in the table below.

Table – Land Use Generators used in Traffic Projections

Year 2012	Year 2030
• Completion of a 50 room hotel off Karns Road	• All 2012 assumptions
• Completion of the YMCA at Commerce Center and Winterberry (50,000 sq ft of recreational building space)	• The remaining 60% of 150 acres north on Commerce Center to be developed industrial/manufacturing/commercial
• Development of 40% of 150 acres north on Commerce Center as industrial/manufacturing/commercial	
• Increase in traffic due to background traffic at a rate of 2%/year except Winterberry Avenue east of SR-696 which was grown at 1%/year.	
• No changes to the existing street system including any widening of roadways for additional lanes or turn lanes.	

In addition to the land use generators listed above, the analysis forecasted what traffic demand in the study area would be with and without the relocation of the High School to the area adjacent to the existing Middle and Elementary for both future year analyses.

C, Solutions:

Based on the number of vehicles that are anticipated to travel to/from I-64 at Exit 21 as well as those vehicles utilizing Winterberry Avenue and SR-696, the interchange ramp areas are anticipated to operate at congested levels in both the AM and PM peak hour with the AM peak anticipated to operate with higher traffic volumes than the PM in the area. Two options were considered and are listed below:

1. Roundabout Option:

Under this option, three roundabouts would be constructed. The first roundabout would be constructed at the I-64 eastbound ramps, the second at the I-64 westbound ramps and the third at the Winterberry Avenue and SR-696 intersection. The roundabouts serving the I-64 westbound ramps and Winterberry Avenue/SR-696 would be constructed in a teardrop, or dog-bone, configuration allowing for a direct connection between these two intersections (See Figure below). While the traffic analysis indicates that by 2030 two-lane roundabouts would be needed to accommodate the demand, the implementation of the two-lane roundabout would be costly,

as a result of the need to replace the existing bridge over Interstate 64. A one-lane roundabout would accommodate traffic volumes slightly lower than the forecasted 2030 volumes. Since the study team considers that the traffic forecasting methodology used in this study was conservative (assumes higher traffic growth than would likely materialize), the study team recommends the implementation of the one-lane roundabout option. This alternative includes the construction of a one lane roundabout at the I-64 EB off-ramps and a one-lane teardrop roundabout at the I-64 WB off-ramp/Winterberry Avenue intersections. Each roundabout would accommodate one lane of traffic and allow for free-flow of vehicles through the area. The additional right-of-way necessary is minimal and the existing bridge along SR-696 connecting the eastbound and westbound off-ramps would remain with very little modification necessary.

Roundabout Schematic

2. Signalization of intersections:

Under this option the following three intersections would be signalized: I-64 eastbound ramps & SR-696, I-64 westbound ramps & SR-696, Winterberry Avenue and SR-696 (See figure below). The intersections of I-64 wb/SR-696 and Winterberry Avenue/SR-696 would be coordinated to allow for thru-movement from the I-64 wb/SR-696 intersection through the Winterberry Avenue/SR-696 intersection to minimize congestion in the area. Additional left turn lanes would be constructed on

all appropriate directions at each of the intersections to allow for additional capacity.

Signalized Intersection Location Schematic

D. Planning Level Cost Estimates:

Planning level cost estimates were prepared for both alternatives with order of magnitude totals of:

Roundabout Construction (for one lane roundabout(s)): $660,000

Signal Installation (3 signals): $600,000

In addition to the cost of the facility and hardware, a few other items should be considered including:

- Sidewalk (cement concrete) costs approximately $60/sy
- Sidewalk ramps costing approximately $1,500 per occurrence.
- Procurement of right-of-way and maintenance: TBD

E. Summary of Findings and Recommendations:

The study team found that the two mitigation alternatives, signalization of three intersections or construction of roundabouts, are feasible and address the 2030 needs whether or not the high school relocates. The roundabout option is preferred because installation and maintenance of three signalized intersections within Low Moor is unnecessary when adequate operations can be provided through the use of existing right-of-way and roundabout construction

LOW MOOR INTERCHANGE STUDY

I-64 EXIT 21 AREA - ALLEGHANY COUNTY

INTRODUCTION

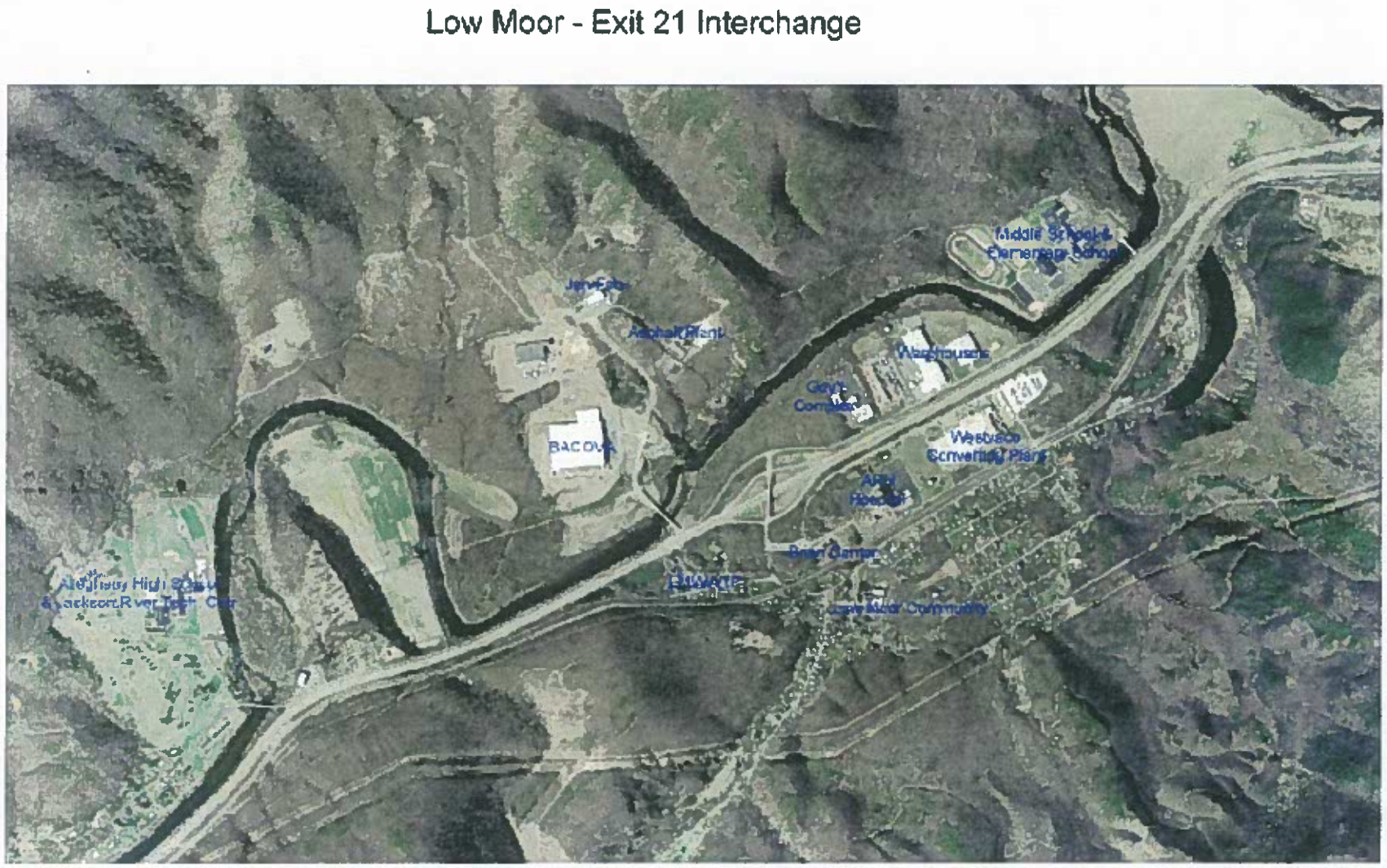
The purpose of this study is to determine what improvements are necessary to facilitate the movement of traffic at the interchange and the surrounding area around Interstate 64 exit 21 (Low Moor) within Alleghany County.

The study area shown in Figure 1, is bounded by Arh Lane on the south, Commerce Center on the west, north of the JenFab plant to the north, and Clifton Middle School/Mountain View Elementary School to the east.

The Low Moor interchange (Exit 21) currently connects I-64 with Route 696 in Covington, VA. The existing high school located to the west of the study area is over 30 years old and located within a flood plain. The school district is considering movement of the high school within the study area off Winterberry Avenue and co-located with the existing Elementary and Middle Schools.

This report provides an overview of existing and future conditions within the study area. It covers travel demand model validation, existing and future traffic volumes and level of service, pedestrian and bicycle travel, geometric deficiencies, and two alternative future scenarios.

Figure 1: Study Area



Aerial Photography © 2002 Commonwealth of Virginia

EXISTING CONDITIONS

A. Existing Traffic Operations

Current year traffic volumes were used to analyze existing intersection levels of service. This analysis was done for morning and afternoon peak commuting periods when overall traffic volumes for the study area are maximized.

Traffic volumes came from two main sources:

1. VDOT tube counts conducted for this study.
2. VDOT manual turning movement counts conducted for this study.

Volumes from different days were balanced to create a consistent set of turning movements from which intersection levels of service could be calculated. Traffic assignments are shown in Appendix A.

B. Travel Demand Model Validation

Travel demand estimation was used in this study to analyze future traffic patterns within the study area. VDOT maintains a region-wide travel demand forecast model. Model estimated daily traffic was validated from traffic counts and turning movement counts conducted by VDOT in mid-June 2007 prior to using the model for future travel demand estimation. The results of the validation are presented in this section.

Some modifications have been made to the existing year turning movements to obtain the balancing of traffic at intersections. Figures and tables shown in Appendix A and B show the existing year network with these balanced turning movements. Existing VDOT raw data counts can be found in Appendix C.

HNTB compared the peak hour link volumes from the travel demand forecasting model against VDOT reported traffic volumes. As shown in Table 1, the existing year travel demand forecasting model is validated by the VDOT reported volumes.

Year 2012 travel demand forecasting model refinements are underway and will be reported in the next phase of this study.

Table 1: Base Year Travel Demand Model Link Volume Comparisons

Road	From	To	VDOT Reported Daily Traffic (2007)	HNTB Model Estimated Daily Traffic (2007)
SR-696	Winterberry Avenue	WB I-64 ramps	*12,000*	*12,550*
SR-696	WB I-64 ramps	EB I-64 ramps	*12,000*	*13,500*
SR-696	EB I-64 ramps	Arh Lane	*12.000*	*12,000*
Winterberry Avenue	SR-696	Commerce Center	*3,050*	*3,330*
Winterberry Avenue	SR-696	Alleghany County Government Complex	*3,225*	*3,225*
Arh Lane	SR-696	Hospital	*5,300*	*5,300*

Note: Daily traffic was calculated as 8% of PM peak hour

LEVEL OF SERVICE

Level of Service (LOS) is an estimate of the performance efficiency and quality of an intersection or roadway as established by the Transportation Research Board's (TRB) *Highway Capacity Manual* (2000) methodology. The TRB methodology measures the degree of delay at intersections using the letter rating "A" for the least amount of congestion and letter rating "F" for the most amount of congestion, as shown in Table 2 and Figure 2. A LOS of "C" or better is typically considered to be acceptable for a rural setting during non-peak hours. During peak hours, LOS "D" is predominantly the threshold. If the LOS falls below the allowable threshold, improvements are required to improve the capacity of the intersection or roadway section in question.

Table 2: Level of Service Standards for Intersections

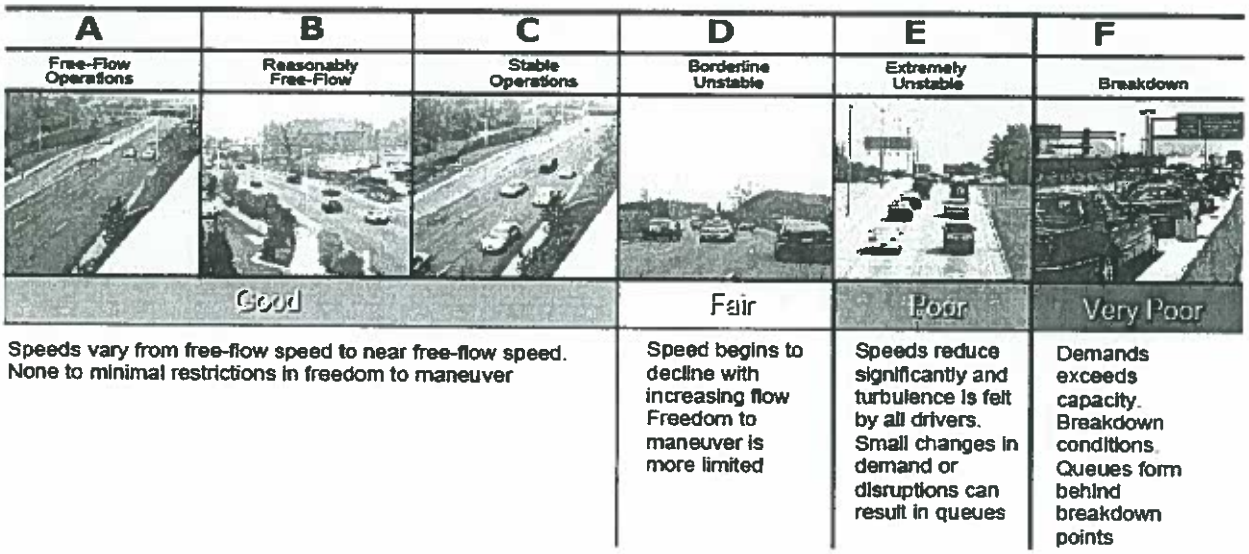
Level of Service	Signalized Intersections	Unsignalized Intersections	Intersection Capacity Utilization*	Expected Delay to Minor Street Traffic
A	delay ≤ 10 seconds	delay < 10 seconds	> 50%	Little or no delay
B	10 seconds < delay ≤ 20 seconds	10 seconds < delay ≤ 15 seconds	50%-60%	Short traffic delay
C	20 seconds < delay ≤ 35 seconds	15 seconds < delay ≤ 25 seconds	60%-75%	Average traffic delay
D	35 seconds < delay ≤ 55 seconds	25 seconds < delay ≤ 35 seconds	75%-85%	Long traffic delay
E	55 seconds < delay ≤ 80 seconds	35 seconds < delay ≤ 50 seconds	85%-95%	Very long traffic delay
F	80 seconds < delay	50 seconds < delay	95%+	Even longer traffic delays

Source: Highway Capacity Manual, 2000, page 10-16 and 17-32

* Intersection Capacity Utilization is calculated within the Synchro Traffic Simulation software. Intersection Capacity Utilization is the maximum of the combined times for through and right turn sections, divided by the reference cycle length. It is similar to, but not exactly the same as the intersection volumes to capacity ratio. A value less than 100% indicates that the intersection has extra capacity. A value greater than 100% indicates the intersection is over capacity.

ICU level of service gives insight into how an intersection is functioning and how much extra capacity is available to handle traffic fluctuations and incidents. ICU is not a value that can be measured with a stopwatch, but it does give a good reading on the conditions that can be expected at the intersection.

Figure 2: LOS Designations



The analysis tool used in conjunction with the LOS calculations was the traffic micro-simulation model Synchro 7. Synchro 7 differs from HCM analysis by taking into account upstream and downstream flow. The LOS designation, as analyzed in Synchro 7 for unsignalized intersections, is based on the Intersection Capacity Utilization Rate or how much of the total capacity of the intersection is being accommodated by the anticipated traffic. Where HCM uses a designation of A-F, Synchro 7 calculations have added the LOS designations of G and H (both above a 100% Intersection Capacity Utilization Rate) to show further congestion of the operation of an intersection. The tables below utilize the Synchro analysis procedure for the unsignalized intersection(s) as a whole and the HCM for individual turning movement analysis.

Levels of service were calculated using Synchro 7 traffic analysis software. The results are shown in Table 3. At present all intersections as a whole operate at acceptable levels of service during the peak hours.

Table 3: Existing Intersection Level of Service

Intersection	AM Peak Hour Average Delay (seconds/vehicle)	AM Peak Hour LOS	PM Peak Hour Average Delay (seconds/vehicle)	PM Peak Hour LOS
Arh Lane/SR-696	6.1	A	6.3	A
I-64 EB ramps/SR-696	12.3	B	4.8	A
I-64 WB ramps/SR-696	17.1	C	5.1	A
Winterberry Ave/SR-696	55.1	C*	10.2	A
Winterberry Ave/Commerce Center	1.0	A	2.0	A

* NOTE: The westbound left turn lane operates at LOS F in the AM peak hour with an approach delay of 171 seconds per vehicle.

Although the intersections as a whole operate within acceptable LOS as seen above, there are significant delays in certain movements that should be noted. Table 4 shows the delay per vehicle in each direction for the intersections analyzed.

Table 4: Existing Intersection Delay and LOS by Movement (in seconds)

	Eastbound				Westbound				Northbound				Southbound			
	AM		*PM*		*AM*		*PM*		*AM*		*PM*		*AM*		*PM*	
	Delay	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*
Arh Lane/SR-696	--	--	--	--	15.1	C	14.5	B	0.0	A	0.0	A	4.7	A	4.4	A
I-64 EB ramps/SR-696	31.1	D	14.2	B	--	--	--	--	0.0	A	0.0	A	3.7	A	4.9	A
I-64 WB ramps/SR-696	--	--	--	--	40.2	E	17.2	C	3.1	A	5.4	A	0.0	A	0.0	A
Winterberry Ave/SR-696	13.2	B	9.4	A	171.0	F	17.5	C	3.8	A	3.7	A	--	--	--	--
Winterberry Ave/Commerce Center	1.9	A	0.0	A	0.0	A	0.0	A	--	--	--	--	11.1	B	10.0	A

NOTE: all intersections are one lane providing movement to left, thru, and right turns.

The westbound traffic at the intersection of Winterberry Avenue and SR-696 in the AM has an average vehicle delay of over 171 seconds (just under 3 minutes and a LOS F). The delay per vehicle during the AM peak at the I-64 EB ramps intersection with SR-696 is calculated at 31.1 seconds (LOS D), and the AM I-64 WB ramps intersection with SR-696 is calculated at 40.2 seconds per vehicle (LOS E). All intersections operate at LOS A – C during the PM peak hour. One factor of the improved LOS in the PM peak is that school traffic is not included in that count given high school instructional hours are from 8:30AM to 3:25PM (with teachers arriving at 8:10AM). It should be noted that Mt. View Elementary teachers are to arrive by 7:30AM with the instructional day from 8:10AM to 2:35PM and Clifton Middle School teachers arrive at 8:05AM and instruction is from 8:30AM to 3:25PM. All three of these schools end the instructional day prior to the PM peak hour.

C. Crash Analysis

The analysis of vehicular crashes for the study area went from March, 2004 to May, 2007 with a total of 11 crashes in that time on SR-696 and I-64 in the study area. Table 5 shows the accident data for the study area around Exit 21 on I-64.

Table 5:Crash Data

Location	Date of crash	Collision Type	# of Vehicles	# of Fatalities	# of Injuries	# of Property Damage Only (PDO)
SR-696 between EB and WB I-64 interchanges	4/6/04	Angle	2	0	1	--
SR-696 at EB I-64 ramps	3/4/04	Sideswipe	2	0	--	1
SR-696 at EB I-64 ramps	5/21/07	Rear-end	4	0	--	1
I-64 EB 1.5 mi SW of exit 21	5/2/04	Deer hit	1	0	--	1
I-64 EB 1.5 mi SW of exit 21	1/1/07	Fixed object	1	0	2	--
I-64 EB 0.75 mi SW of exit 21	2/24/07	Fixed object	1	0	--	1
I-64 WB 4 mile SE of exit 21	4/16/06	Non-collision	1	1	--	--
I-64 WB-0.5 mi SW of exit 21 ramp	6/26/04	Sideswipe	2	-	-	1
I-64 WB - 0.3 mi SW of exit 21 ramp	12/5/06	Fixed object	1	-	-	1
I-64 WB -0.25 mi SW of exit 21 ramp	2/25/07	Fixed object	1	-	1	-
I-64 WB - at exit 21 ramp	5/17/05	Fixed object	1	-	1	-
Totals				1	5	6

The one fatality occurred on 2-24-2007 on a rainy morning at 8:35am resulting in the death of a single 43 year old female when the vehicle veered off the road and into the ditch.

D. School Bus

There is no existing transit network within the study area. The buses seen in the study area include approximately 28 buses traveling on Winterberry Avenue at some point between the existing Alleghany High School and Clifton Middle/Mountain View Elementary Schools at some point in the AM and afternoon hours. Eleven of these buses do two runs each resulting in a total of 38 trips in each the AM and afternoon hours. Breaking these numbers down further: 10 buses travel to/from Alleghany High School; 7 buses travel to Clifton Middle School; and 8 buses travel to Mountain View Elementary; with the remaining three buses used as special education transport Callaghan Elementary, Sharon Elementary, and Shenandoah Autism Center respectively. Actual bus routes vary by year depending on the needs of the student body.

E. Bicycle and Pedestrian Issues

There are no existing bicycle facilities in the study area. Many streets have no sidewalks at all. To make matters more difficult for pedestrians, the streets lacking sidewalks also have minimal or no

shoulders. With the existence of the middle school and elementary school east on Winterberry, the access from bicycle and pedestrian modes is limited.

F. Geometric Issues

A few primary geometric issues are present within the study area.

1. The distance between the WB I-64 ramps and Winterberry Avenue is substandard. Sharply acute angles can be problematic on several fronts. Sight distance tends to be poor and vehicles making turns can easily encroach onto other lanes.
2. Several streets in the study area are quite narrow and have no shoulders. Improvement may be warranted on these streets.
3. The queue length for left turning vehicles from the I-64 EB off-ramp in the AM peak hour exceeds capacity resulting in backups along I-64. Improvements such as roundabouts, signals and retiming, as well as a change to the traffic flow pattern should be considered.

FUTURE CONDITIONS AND ALTERNATIVES ANALYSIS

A. Future No-Build Traffic Operations

Using the existing traffic count data and geometric limitations summarized above, traffic was grown to simulate no-build conditions in two future years: 2012 and 2030. Table 6 lists the assumptions that were included in the no-build models for the 2012 and 2030 model year.

Table 6: No-Build Assumptions

2012 No-Build	2030 No-Build
• Completion of a 50 room hotel off Karns Road	• All 2012 assumptions
• Completion of the YMCA at Commerce Center and Winterberry (50,000 sq ft of recreational building space)	• The remaining 60% of 150 acres north on Commerce Center to be developed industrial/manufacturing/commercial
• Development of 40% of 150 acres north on Commerce Center as industrial/manufacturing/commercial	
• Background traffic grown at 2%/year except Winterberry east of SR-696 which was grown at 1%/year.	
• No changes to the existing street system including the widening of any roadways for turn lanes.	

Traffic volumes in 2012 and 2030 were estimated for the study area based on the assumption that background traffic volumes would increase two-percent annually except on Winterberry Avenue east of SR-696 where the traffic volumes were increased by one-percent annually. The growth factor of two-percent per year was based on projected average annual population and labor force growth and is conservatively high, therefore resulting in a worst case scenario of traffic for each model year.

1. Trip Generation

The analysis conducted for the future year conditions assumed that certain land uses would exist for both the 2012, and 2030 year timeframes. The Institute of Transportation Engineers *Trip Generation Manual* (7th Edition, 2000) calculates trip generation for different types of land use as shown in Table 7. These land uses were then used in calculating the projected number of additional trips associated with the development which was then assigned to the existing street network.

Table 7: Trip Generation

2012 No-Build Trip Generation				Vehicular trips			
				Weekday AM		Weekday PM	
Land Use	ITE Code	Quantity	Rate	Enter	Exit	Enter	Exit
YMCA	495	5 acres	1.62	15	9	7	17
Industrial/Manufacture	130	60 acres	4.4	219	45	40	150
Hotel	310	50 rooms	0.75	17	11	16	14
High School - Existing	530	1,200 students	0.5	339	153	79	89
High School - Future *	530	1,500 students	0.5	424	191	99	111

2030 No-Build Trip Generation				Vehicular trips			
				Weekday AM		Weekday PM	
Land Use	ITE Code	Quantity	Rate	Enter	Exit	Enter	Exit
YMCA	495	5 acres	1.62	15	9	7	17
Industrial/Manufacture	130	150 acres	4.4	548	112	100	376
Hotel	310	50 rooms	0.75	219	45	40	150
High School - Existing	530	1,200 students	0.5	339	153	79	89
High School - Future *	530	1,500 students	0.5	424	191	99	111

* High School Future numbers are related to the number of student anticipated in the 2012 and 2030 year analysis.

2. Level of Service (LOS)

For future conditions, given the background traffic that will exist, a LOS of "D" and sometimes "E" or better is the acceptable threshold.

a. 2012 Analysis

Levels of service were calculated using Synchro 7 traffic analysis software. The results are shown in Table **8** for the entire intersection in 2012 and Table **9** for each movement in 2012.

Table 8: Intersection Level of Service - 2012

	AM Peak Hour			PM Peak Hour		
Intersection	Average Delay (sec/veh)	Intersection Capacity Rate	LOS	Average Delay (sec/veh)	Intersection Capacity Rate	LOS
Arh Lane/SR-696	*	57.2%	B	*	56.0%	B
Karns Rd/SR-696	*	25.2%	A	*	25.3%	A
I-64 EB ramps/SR-696	*	79.2%	D	*	71.3%	C
I-64 WB ramps/SR-696	*	104.7%	G	*	81.8%	D
Winterberry Ave/SR-696	*	96.8%	F	*	72.7%	C
Winterberry Ave/Commerce Center	*	68.0%	C	*	49.6%	A

NOTE: Although LOS within the *Highway Capacity Manual* (HCM) ranges from A-F, the computer software (Syncho 7) categorizes intersections from A-H using the same formulas for the intersection capacity rate as the HCM for the range of A-F and then extrapolating for LOS G and H.
* Intersection Average Delay was not calculated for unsignalized intersections. Individual movement delay and LOS is provided in the next table.

Although the intersections as a whole operate within acceptable LOS with the exception of the I-64WB/Exit 21 and Winterberry Ave/SR-696 intersections, there are significant delays in certain movements that should be noted at the I-64/SR-696 interchange intersections as well as the Winterberry Ave/SR-696 intersection. Table **9** shows the delay per vehicle in each direction for the intersections analyzed and the LOS for that movement.

Table 9: Intersection Delay and LOS by Movement (in seconds) - 2012

	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	18.8	C	17.6	C	0.0	A	0.0	A	4.9	A	4.3	A
Karns Rd/SR-696	12.1	B	12.2	B	--	--	--	--	0.1	A	0.1	A	0.0	A	0.0	A
I-64 EB ramps/SR-696	499.2	F	175.3	F	--	--	--	--	0.0	A	0.0	A	4.6	A	7.6	A
I-64 WB ramps/SR-696	--	--	--	--	461.3	F	65.0	F	2.8	A	6.8	A	0.0	A	0.0	A
Winterberry Ave/SR-696	131.1	F	14.3	B	**	F	842.9	F	7.6	A	5.5	A	--	--	--	--
Winterberry Ave/Commerce Cntr	3.6	A	0.5	A	0.0	A	0.0	A	--	--	--	--	19.9	C	30.2	D

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** *Delay was to large to calculate.*

The study team calculated queue lengths for the intersection of Winterberry Ave/SR-696. The analysis indicates that the WB left turn lane at this intersection will have long queues. This is a result of the stop configuration on Winterberry in both the EB and WB directions to allow for free flow movement northbound on SR-696.

A simple mitigation measure to alleviate some of the delay would be to provide a left turn only lane at Winterberry/SR-696 in both the NB and WB directions as well as a left turn lane at each of the interchange intersections as necessary. Other possible mitigation measures provided under Section E

b. 2030 Analysis

Similar to the 2012 analysis, Levels of Service were calculated for the 2030 model year. Again using Synchro 7 Table **10** shows the LOS for the intersection as a whole while Table **11** looks at singular movements for each intersection.

Table 10: Intersection Level of Service - 2030 No-build

Intersection	AM Peak Hour				PM Peak Hour		
	Average Delay (sec/veh)	Intersection Capacity Rate	LOS		Average Delay (sec/veh)	Intersection Capacity Rate	LOS
Arh Lane/SR-696	+	72.6%	C		+	73.4%	D
Karns Rd/SR-696	+	28.6%	A		+	31.0%	A
I-64 EB ramps/SR-696	+	115.9%	H		+	109.2%	H
I-64 WB ramps/SR-696	+	167.3%	H		+	139.5%	H
Winterberry Ave/SR-696	+	153.9%	H		+	128.2%	H
Winterberry Ave/Commerce Center	+	121.0%	H		+	97.6%	F

* NOTE: Although LOS within the *Highway Capacity Manual* (HCM) ranges from A-F, the computer software (Syncho 7) continues to categorize intersections from A-H using the same formulas for the intersection capacity rate as the HCM for the range of A-F and then extrapolating for LOS G and H.

+ Intersection Average Delay was not calculated for unsignalized intersections. Individual movement delay and LOS is provided in the next table.

As seen in the 2012 no-build alternative, the interchange intersections are operating with severe delays to vehicles using the off-ramps from I-64. Without additional capacity (more lanes) available at certain intersections, the LOS can not be brought into acceptable thresholds. While the intersections as a whole do not operate within acceptable thresholds, individual movements show that the majority of left turn movements from any intersection operate at LOS F (see Table **11**).

Table 11: Intersection Delay and LOS by Movement (in seconds) - 2030 No-build

	Eastbound				Westbound				Northbound				Southbound			
	AM		*PM*		*AM*		*PM*		*AM*		*PM*		*AM*		*PM*	
	Delay	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*	*Delay*	*LOS*
Arh Lane/SR-696	--	--	--	--	77.0	F	64.0	F	0.0	A	0.0	A	6.2	A	5.1	A
Karns Rd/SR-696	13.9	B	14.6	B	--	--	--	--	0.1	A	0.1	A	0.0	A	0.0	A
I-64 EB ramps/SR-696	**	F	**	F	--	--	--	--	0.0	A	0.0	A	6.5	A	17.1	C
I-64 WB ramps/SR-696	--	--	--	--	**	F	**	F	4.9	A	24.7	C	0.0	A	0.0	A
Winterberry Ave/SR-696	**	F	191.3	F	**	F	**	F	23.1	C	6.8	A	--	--	--	--
Winterberry Ave/Commerce Cntr	9.3	A	0.9	A	0.0	A	0.0	A	--	--	--	--	559.8	F	716.1	F

NOTE: all intersections are one lane providing movement to left, thru, and right turns.

** *Delay was to large to calculate.*

The first step to mitigating the no-build scenario is to use the same mitigation that was proposed to the 2012 no-build (the construction of: a left turn lane at both the EB and WB off-ramps; On Winterberry WB at SR-696; and the addition of a left turn lane at Commerce Center SB at Winterberry Avenue).

Additional mitigation will be necessary in the 2030 no-build to bring the intersections into compliance with LOS thresholds. One of the most viable options would be the installation of signals at the most congested intersections allowing for sufficient gaps for left turning vehicles (See Alternative 2 description and analysis below).

FUTURE BUILD ALTERNATIVES

To alleviate some of the congestion seen in the I-64/SR-696 area, two alternatives were considered: the use of roundabouts, and the use of signals. In addition, the Alleghany School District is reviewing the possibility of relocating the existing Alleghany High School located to the west of the study area to co-locate with the Clifton Middle School and the Mountain View Elementary School located to the east along Winterberry Avenue.

Therefore, the following alternatives and scenarios were considered:

Alternative 1: Roundabout construction. A roundabout would be constructed at each of the two interchange intersections allowing for free flow of traffic at these locations. The roundabout at the north end of SR-696 (WB I-64 traffic) would fold in the existing intersection of Winterberry and 696 (See Figure 3).

Note: to minimize the land necessary, as well as the movement of the ramp termini locations and therefore, the inclusion of FHWA into any design improvements, the northern roundabout (I-64 WB and Winterberry Avenue) have been compressed into a teardrop configuration. This configuration would necessitate vehicles wishing to travel southbound from the westbound off-ramp to maneuver north through the teardrop roundabout and then continue southbound. The maximum speed limit in and around the roundabout(s) would be 30 mph with buses/trucks likely operating at 25 mph around the roundabout(s).

Only the results of the intersections involved in the roundabout operation are shown in the tables for this alternative. The remaining intersections would result in operations as shown for each alternative under the signalized intersection alternative (Alternative 2 below) for the correct Scenario.

Scenario 1: With the high school remaining at it's current location

Scenario 2: With the high school relocating to the east along Winterberry co-locating with the existing elementary and middle schools.

Alternative 2: Signal construction and installation. Signals would be installed and coordinated at the interchange intersections.

Scenario 1: With the high school remaining at it's current location

Scenario 2: With the high school relocating to the east along Winterberry co-locating with the existing elementary and middle schools.

Tables 12-13 show the LOS of each intersection as a whole for 2012 and Tables 14-17 show the LOS by movement for 2012. Similarly, Tables 18-19 show the LOS of each intersection as a whole for 2030 with Tables 20-23 showing the LOS by movement for 2030. Please note that for the roundabout scenarios, SIDRA version 3.2 was utilized per VDOT's request.

Figure 3: Roundabout Schematic

Table 12 Roundabout Level of Service – 2012 Build Scenario

	Alterantive 1 - Roundabout Construction											
	Scenario 1-High School Remains at Current Location						Scenario 2 - High School Relocates to New Location on Winterberry Ave.					
	AM			PM			AM			PM		
	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS
I-64 EB ramps/SR-696	7.1	515%	A	6.00	34%	A	9.1	66%	A	6.4	36%	A
I-64 WB Ramps/SR-696/Winterberry	7.3	67%	A	5.40	22%	A	11.4	84%	B	5.3	23%	A

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.

Table 13 Signalized Intersection(s) Level of Service – 2012 Build Scenario

	Alternative 2 - Signal Construction and Installation											
	Scenario 1-High School Remains at Current Location						Scenario 2 - High School Relocates to New Location on Winterberry Ave.					
	AM			PM			AM			PM		
	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS
Arh Lane/SR-696	+	57.1%	B	+	55.3%	B	+	56.9%	B	+	55.2%	B
I-64 EB ramps/SR-696	14.0	68.0%	B	8.7	48.0%	A	24.7	85.0%	C	10.3	58.0%	B
I-64 WB ramps/SR-696	13.5	68.0%	B	7.4	43.0%	A	28.8	91.0%	C	8.8	51.0%	A
Winterberry Ave/SR-696	+	83.5%	E	+	53.2%	A	+	104.1%	G	+	59.8%	B
Winterberry Ave/Commerce Ctr	+	52.9%	A	+	32.2%	A	+	43.6%	A	+	30.4%	A

NOTE: all intersections are one lane providing movement to left, thru, and right turns.

** *Delay was to large to calculate.*

* Intersection Average Delay was not calculated for unsignalized intersections. Individual movement delay and LOS is provided in the next table.

Table 14: Roundabout Delay and LOS by Movement (in seconds) - 2012 Build Scenario

	Alternative 1 - Roundabout Construction															
	Scenario 1 - High School Remains at current location															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
I-64 EB ramps/SR-696	13.0	B	11.7	B	--	--	--	--	7.2	A	6.2	A	4.0	A	5.4	A
I-64 WB ramps/SR-696/Winterberry Ave	--	--	--	--	13.2	B	8.9	A	2.7	A	5.4	A	10.8	B	10.9	B

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.
** Delay was to large to calculate.

Table 15: Roundabout Delay and LOS by Movement (in seconds) - 2012 Build Scenario

	Alternative 1 - Roundabout Construction															
	Scenario 2 - High School Relocates to New Location on Winterberry Ave															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
I-64 EB ramps/SR-696	15.4	B	11.9	B	--	--	--	--	8.9	A	6.6	A	4.2	A	5.5	A
I-64 WB ramps/SR-696/Winterberry Ave	--	--	--	--	25.4	C	9.0	A	2.2	A	5.0	A	10.9	A	10.9	B

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.
** Delay was to large to calculate.

Table 16: Signalization Delay and LOS by Movement (in seconds) - 2012 Build Scenario

	Alternative 2 - Signal Construction and Installation															
	Scenario 1 - High School Remains at current location															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	18.7	C	17.4	C	0.0	A	0.0	A	5.0	A	4.4	A
I-64 EB ramps/SR-696	20.3	C	24.2	C	--		--	--	7.4	A	3.5	A	11.6	B	5.9	A
I-64 WB ramps/SR-696	--	--	--	--	21.4	C	23.0	C	8.4	A	4.8	A	7.7	A	4.0	A
Winterberry Ave/SR-696	26.1	D	10.5	B	**	F	64.5	F	6.0	A	4.7	A	--	--	--	--
Winterberry Ave/Commerce Cntr	2.8	A	0.3	A	0.0	A	0.0	A	--	--	--	--	14.7	B	12.9	B

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** Delay was to large to calculate.

Table 17: Signalization Delay and LOS by Movement (in seconds) - 2012 Build Scenario

	Alternative 2 - Signal Construction and Installation															
	Scenario 2 - High School Relocates to New Location on Winterberry Ave															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	18.6	C	17.3	C	0.0	A	0.0	A	4.9	A	4.4	A
I-64 EB ramps/SR-696	35.3	D	24.3	C	--	--	--	--	11.7	B	5.1	A	19.0	B	7.2	A
I-64 WB ramps/SR-696	--	--	--	--	47.2	D	24.1	C	23.3	C	6.2	A	11.1	B	5.7	A
Winterberry Ave/SR-696	103.2	F	10.6	B	**	F	110.5	F	3.6	A	2.7	A	--	--	--	--
Winterberry Ave/Commerce Cntr	2.9	A	0.4	A	0.0	A	0.0	A	--	--	--	--	12.1	B	11.9	B

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** Delay was to large to calculate.

Table 18 Roundabout Level of Service - 2030 Build Scenario

	Alterantive 1 - Roundabout Construction											
	Scenario 1-High School Remains at Current Location						Scenario 2 - High School Relocates to New Location on					
	AM			PM			AM			PM		
	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS	Delay (sec/veh)	Intersection Capacity Rate	LOS
I-64 EB ramps/SR-696	7.1	515%	A	6.00	34%	A	9.1	66%	A	6.4	36%	A
I-64 WB Ramps/SR-696/Winterberry Ave	7.3	67%	A	5.40	22%	A	11.4	84%	B	5.3	23%	A

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.

Table 19 Signalized Intersection Level of Service - 2030 Build Scenario

	Alternative 2 - Signal Construction and Installation											
	Scenario 1-High School Remains at Current Location						Scenario 2 - High School Relocates to New Location on Winterberry Ave.					
	AM			PM			AM			PM		
	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS
Arh Lane/SR-696	+	70.9%	C	+	71.2%	C	+	71.2%	C	+	71.3%	C
I-64 EB ramps/SR-696	13.1	66.8%	B	32.6	85.8%	C	132.4	124.0%	F	143.9	130.0%	F
I-64 WB ramps/SR-696	7.3	66.8%	A	32.1	93.6%	C	289.6	175.0%	F	441.3	300.0%	F
Winterberry Ave/SR-696	+	116.7%	H	+	79.3%	D	+	141.0%	F	+	85.9%	E
Winterberry Ave/Commerce Ctr	+	86.6%	E	+	52.6%	A	+	77.3%	D	+	50.8%	A

NOTE: all intersections are one lane providing movement to left, thru, and right turns.

* Intersection Average Delay was not calculated for unsignalized intersections. Individual movement delay and LOS is provided in the next table.

Table 20: Roundabout Delay and LOS by Movement (in seconds) - 2030 Build Scenario

	Alternative 1 - Roundabout Construction															
	Scenario 1 - High School Remains at current location															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
I-64 EB ramps/SR-696	33.9	C	14.5	B	--	--	--	--	14.2	B	10.9	B	4.6	A	6.1	A
I-64 WB ramps/SR-696/Winterberry Ave	--	--	--	--	375.4	F	9.8	A	2.6	A	5.4	A	11.3	B	12.1	B

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.
** Delay was to large to calculate.

Table 21: Roundabout Delay and LOS by Movement (in seconds) - 2030 Build Scenario

	Alternative 1 - Roundabout Construction															
	Scenario 2 - High School Relocates to New Location on Winterberry Ave															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
I-64 EB ramps/SR-696	123.4	F	15.5	B	--	--	--	--	21.6	C	12.4	B	4.7	A	6.2	A
I-64 WB ramps/SR-696/Winterberry Ave	--	--	--	--	658.9	F	10.1	B	2.2	A	5.1	A	11.2	B	12.2	B

NOTE: all roundabouts are one lane. Only intersections included in the roundabount(s) are listed here.
** Delay was to large to calculate.

Table 22: Signalization Delay and LOS by Movement (in seconds) - 2030 Build Scenario

	Alternative 2 - Signal Construction and Installation															
	Scenario 1 - High School Remains at current location															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	73.5	F	54.2	F	0.0	A	0.0	A	6.2	A	5.4	A
I-64 EB ramps/SR-696	20.0	B	60.7	E	--	--	--	--	8.7	A	5.1	A	11.6	B	41.6	D
I-64 WB ramps/SR-696	--	--	--	--	4.9	A	65.5	E	6.7	A	58.3	E	11.7	B	7.5	A
Winterberry Ave/SR-696	**	F	15.9	C	**	F	**	F	9.5	A	5.5	A	--	--	--	--
Winterberry Ave/Commerce Cntr	4.6	A	0.4	A	0.0	A	0.0	A	--	--	--	--	43.6	E	44.1	E

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** Delay was to large to calculate.

Table 23: Signalization Delay and LOS by Movement (in seconds) - 2030 Build Scenario

	Alternative 2 - Signal Construction and Installation															
	Scenario 2 - High School Relocates to New Location on Winterberry Ave															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	66.9	F	54.7	F	0.0	A	0.0	A	6.2	A	5.4	A
I-64 EB ramps/SR-696	170.6	F	16.2	B	--	--	--	--	22.0	C	10.9	B	145.7	F	315.9	F
I-64 WB ramps/SR-696	--	--	--	--	407.4	F	16.1	B	351.0	F	1391.9	F	17.7	B	33.2	C
Winterberry Ave/SR-696	**	F	16.1	C	**	F	**	F	8.6	A	4.2	A	--	--	--	--
Winterberry Ave/Commerce Cntr	4.3	A	0.5	A	0.0	A	0.0	A	--	--	--	--	26.1	D	31.7	D

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** Delay was to large to calculate.

A. Summary of Operational Analysis

Without adding additional capacity to the system in the form of additional lanes, the roundabout scenario performs better than the signalized intersections. The 2030 AM Build scenario results in LOS F for both the worst movement and the Overall LOS due to the large number of entering

vehicles (2,426). A single-lane roundabout operates best at 1,800 vehicles/hour or less. Table **24** shows the summary table for the roundabout option and specifically the number of entering vehicles into the roundabout and the worst calculated movement for each of the scenarios. Table **25** shows the summary table for the signal option and specifically the delay and LOS for the Overall and worst movement at each intersection.

Table 24: Roundabout Entering Volumes and LOS - Summary Table.

	Intersection of 696/I-64 WB Ramps		Intersection of 696/I-64 EB Ramps	
	Overall LOS (entering volume)	Worst Movement LOS	Overall LOS (entering volume)	Worst Movement LOS
Scenario 1: High school remains in current location				
2012 Build AM	A (1435)	B	A (1123)	B
2012 Build PM	A (960)	B	A (935)	B
Scenario 1: High school remains in current location				
2030 Build AM	F (2173)	F	B (1595)	C
2030 Build PM	A (1496)	B	A (1362)	B
Scenario 2: High school relocates				
2012 Build AM	B (1689)	C	A (1277)	B
2012 Build PM	A (1047)	B	A (978)	B
Scenario 2: High school relocates				
2030 Build AM	F (2426)	F	E (1747)	F
2030 Build PM	A (1582)	B	A (1406)	B

Table 25: Signalized Intersection Delay and LOS - Summary Table.

	SR-696/Winterberry Ave		SR-696/I-64 WB Ramps		SR-696/I-64 EB Ramps		Winterberry Ave/Commerce Cntr	
	Overall LOS	Worst Movement LOS	Overall LOS	Worst Movement LOS	Overall LOS	Worst Movement LOS	Overall LOS	Worst Movement LOS
Scenario 1: High school remains in current location								
2012 Build AM	E	F	B	C	B	C	A	B
2012 Build PM	A	F	A	C	A	C	A	B
Scenario 1: High school remains in current location								
2030 Build AM	F	F	C	D	C	D	A	B
2030 Build PM	B	F	A	C	B	C	A	B
Scenario 2: High school relocates								
2012 Build AM	+	F	C	D	C	D	+	B
2012 Build PM	+	F	A	C	B	C	+	B
Scenario 2: High school relocates								
2030 Build AM	+	F	F	F	F	F	+	D
2030 Build PM	+	F	F	F	F	F	+	D

* Intersection Average Delay was not calculated for unsignalized intersections. Individual movement delay and LOS is provided in a separate table.

As can be seen in Table **24** and Table **25** above, the construction of a one-lane roundabout in 2012 produces the best LOS for all intersections. The signal scenario in 2012 with and without the relocation of the high school still results in LOS E and F at Winterberry Ave/SR-696 intersection. The remainder of the intersections operate at acceptable LOS with signals installed

at the I-64 Interchange intersections.

In 2030 the volumes anticipated overload the one-lane roundabout(s) resulting in LOS F and long delays through the corridor in the AM peak period. Similarly, the LOS is F at all three intersections along SR-696 in both the AM and PM peaks in 2030 if the high school relocates and signals are installed at each of the interchange intersections. If the high school remains in its current location, and signals are installed, in 2030 the intersection of SR-696 and Winterberry Avenue operates at LOS F in the AM peak period.

B. Mitigation

The Study Team has identified two possible mitigation options.

1. Mitigation Option 1

Mitigation Option 1 includes the following improvements and applies to Alternative 1 (construction of roundabouts):

A. Construct two-lane roundabout at the I-64/SR-696/Winterberry Avenue intersection: This would necessitate some modifications to the existing on-off ramps in the WB direction.

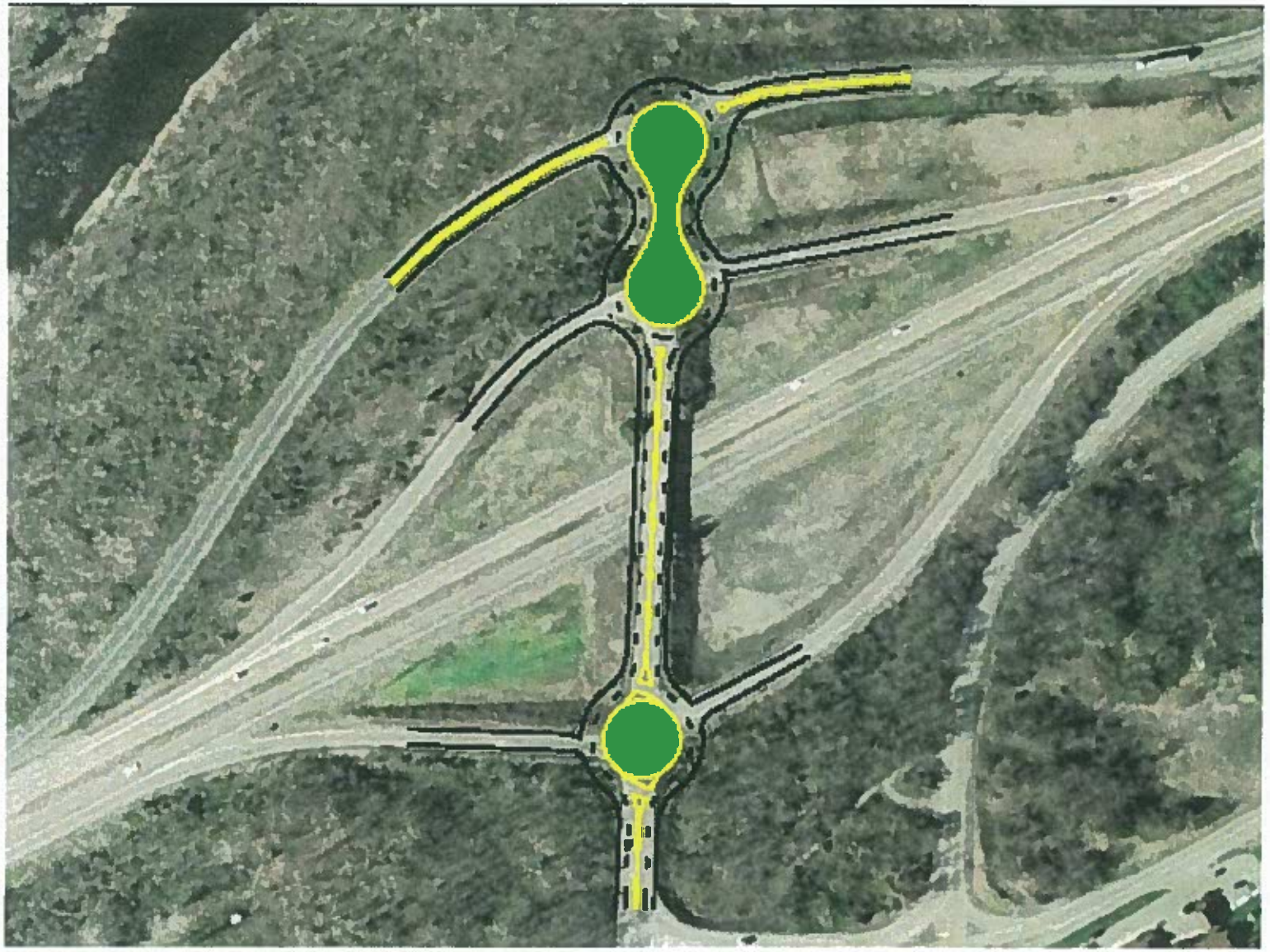
B. Construct a two-lane roundabout at the intersection of I-64 and the EB ramps: There is not sufficient room to construct a two-lane roundabout at the EB ramps without reconstructing the bridge.

Figure 4 shows a schematic of this scenario. It should be noted that significant improvements to the ramp termini and existing I-64 overpass bridge would be necessary to accommodate the 2-lane roundabout (50-foot center island radius with 30-foot of roadway). As a worst case scenario the schematic shows a new bridge carrying two lanes in each direction. While the four lane roadway may not be necessary in the 2030 build scenario, it would improve operations at each of the roundabouts. To accommodate the anticipated vehicle traffic, modifications to the existing bridge would be necessary to allow enough room for the proposed two-lane roundabout from both the EB and WB off-ramps. The EB off-ramp is constrained due to the bridge location.

a. Analysis

As stated before, a one-lane roundabout operates best at 1,800 vehicles per hour or less. The 2030 analysis shows more than 1,800 vehicles in the AM peak period if the High School relocates with the anticipated growth of industrial/manufacturing land located on Commerce Center. Although analysis shows that a two-lane roundabout would operate within acceptable LOS for each of the interchange intersections given the proposed 2030 trip generation, the cost associated with constructing a two-lane roundabout(s) must include the modifications to the existing bridge and ramp termini. Given the growth forecasts are conservative it is more realistic to anticipate the construction of one-lane roundabout(s) at the ramp termini as shown in Figure 3 would accommodate traffic through 2020 and likely beyond.

Figure 4: Roundabout Schematic (2-lane roundabout(s))



2. Mitigation Option 2

Mitigation Option 2 includes the following and applies to Alternative 2 (signalization of intersections):

A. Signalize the intersection of Winterberry Ave/SR-696 and coordinate signal timing to allow for free-flow movement of vehicles from south of the I-64WB/SR-696 signalized intersection

B. Add left turn lane on the following approaches:
   1. WB Winterberry Ave/SR-696 and NB (2 lefts/1 right total)
   2. WB and NB I-64WB ramps/SR-696
   3. EB and SB I-64EB ramps/SR-696
   4. SB and EB Commerce Center/Winterberry Ave

C. Add right turn lane on the following approaches
   1. NB Winterberry Ave/SR-696 (2 lefts/1 right total)
   2. SB I-64 WB ramps/SR-696
   3. NB I-64 EB Ramps/SR-696
   4. WB Commerce Center/Winterberry Avenue

Please note that additional right-of-way may be necessary at the above intersections to accomplish the lane configuration as listed. The acquiring of right-of-way was not analyzed in this report.

a. Analysis

Using the configurations above, Synchro was used to analyze the intersections within the Study Area. Table **26** and Table **27** shows that by coordinating the three signals and providing additional turning lanes at intersections, all intersections will operate at LOS D or better and all movements can be brought to LOS D or better (with the exception of WB Arh Lane/SR-696 which operates at LOS F).

Table 26: Mitigation Option 2 - Signalized Intersections and Lane Geometry Modifications - Delay and LOS for Intersection (2030)

	Scenario 1-High School Remains at Current Location					
	AM			PM		
	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS
Arh Lane/SR-696	11.0	61.3%	B	8.6	56.8%	A
I-64 EB ramps/SR-696	20.9	84.8%	C	11.3	61.8%	B
I-64 WB ramps/SR-696	29.7	94.8%	C	10.7	61.8%	B
Winterberry Ave/SR-696	19.9	70.8%	B	23.3	68.6%	C
Winterberry Ave/Commerce Ctr	2.8	52.7%	A	14.0	41.8%	B

	Scenario 2 - High School Relocates to New Location on					
	AM			PM		
	Delay (sec/veh)	Intersection Capacity Utilization	LOS	Delay (sec/veh)	Intersection Capacity Utilization	LOS
Arh Lane/SR-696	20.7	71.2%	C	8.6	57.0%	A
I-64 EB ramps/SR-696	21.8	104.4%	C	12.4	62.5%	B
I-64 WB ramps/SR-696	40.9	104.4%	D	10.3	62.5%	B
Winterberry Ave/SR-696	21.5	72.5%	C	26.2	70.3%	C
Winterberry Ave/Commerce Ctr	2.5	52.7%	A	12.0	40.0%	B

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
* Intersection Average Delay was not calculated for unsignalized intersections. For individual movement delay and LOS see next table

Table 27: Mitigation Option 2 - Signalized Intersections and Lane Geometry Modifications - Delay and LOS by Movement (2030)

	Scenario 1 - High School remains at Current Location															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	34.7	D	21.0	C	0.0	A	0.0	A	6.2	A	5.4	A
I-64 EB ramps/SR-696	36.5	D	32.7	C	--	--	--	--	24.7	C	12.3	B	7.3	A	2.4	A
I-64 WB ramps/SR-696	--	--	--	--	35.6	D	33.0	C	28.2	C	6.6	A	32.7	C	9.5	A
Winterberry Ave/SR-696	41.3	D	31.3	C	26.7	C	21.0	C	13.0	B	11.0	B	--	--	--	--
Winterberry Ave/Commerce Cntr	11.0	B	7.8	A	0.0	A	0.0	A	--	--	--	--	19.0	C	27.0	D

	Scenario 2 - High School Relocates to New Location on Winterberry Ave															
	Eastbound				Westbound				Northbound				Southbound			
	AM		PM		AM		PM		AM		PM		AM		PM	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
Arh Lane/SR-696	--	--	--	--	77.0	F	21.1	C	0.0	A	0.0	A	6.2	A	5.4	A
I-64 EB ramps/SR-696	35.2	D	33.8	C	--	--	--	--	29.3	C	13.5	B	7.5	A	3.4	A
I-64 WB ramps/SR-696	0.0	A	0.0	A	53.4	D	32.6	C	54.4	D	5.1	A	24.1	C	9.3	A
Winterberry Ave/SR-696	47.6	D	31.8	C	30.8	C	36.1	D	22.2	C	12.9	B	--	--	--	--
Winterberry Ave/Commerce Cntr	10.1	B	7.7	A	0.0	A	0.0	A	--	--	--	--	14.3	B	21.6	C

NOTE: all intersections are one lane providing movement to left, thru, and right turns.
** Delay was to large to calculate.

Appendix H - Cost Estimates

Planning level cost estimates as shown in the body of the report are based on the following items.

Alternative 1 - Roundabout Construction

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
Demolition	4,500	SY	$10	$45,000
Roadway paving - Asphalt Concrete Pavement (including basecours	4,200	TON	$75	$315,000
Cement Concrete Curb & Gutter	1,350	LF	$50	$67,500
Landscaping (10% of paving cost)	10%	LS		$38,250
Engineering (50% of construction costs)	50%	LS		$191,250
Drainage (20% of construction costs)	20%	LS		$76,500
Grading (20% of construction costs)	20%	LS		$76,500
Mobilization (10% of construction costs)	10%			$38,250
Total				$657,000

Alternative 2 - Signal Installation

DESCRIPTION	QUANTITY	UNIT	UNIT PRICE	TOTAL COST
Signal hardware and installation	3	LS	$200,000	$600,000
paint striping for division of lanes (100-feet for each location)	700	LF	$1	$700
Total				$600,700

C. Cost Estimates

Planning level cost estimates were prepared for both alternatives and are included in Appendix H with totals listed below:

Roundabout Construction (for one lane roundabout(s)): $660,000

Signal Installation (3 signals): $600,000

In addition to the cost of the facility and hardware, a few other items should be considered including:

Sidewalk (cement concrete) costs approximately $60/sy

Sidewalk ramps costing approximately $1,500 per occurrence.

Procurement of right-of-way: TBD

D. Summary of Findings and Recommendations

The study team found that the two mitigation alternatives, signalization of three intersections or construction of roundabouts, are feasible and address the 2030 needs whether or not the high school relocates. The roundabout option is preferred because installation and maintenance of three signalized intersections within Low Moor is unnecessary when adequate operations can be provided through the use of existing right-of-way and roundabout construction

While the traffic analysis indicates that by 2030 two-lane roundabouts would be needed to accommodate the demand, the implementation of the two-lane roundabout would be costly. A one-lane roundabout would accommodate traffic volumes slightly lower than the forecasted 2030 volumes. Since the study team considers that the traffic forecasting methodology used in this study was conservative (assumes higher traffic growth than would likely materialize), the study team recommends the implementation of the one-lane roundabout option. This alternative includes the construction of a one lane roundabout at the I-64 EB off-ramps and a one-lane teardrop roundabout at the I-64 WB off-ramp/Winterberry Avenue intersections.

Bicycle and pedestrian facilities within the Study Area need improvement. The improvements should include the construction of sidewalks specifically in the corridor between the existing Middle School/Elementary School/Proposed relocation of the High School site (west on Winterberry Avenue) to the location of the YMCA at Winterberry Avenue and Commerce Center. The construction of sidewalks would provide for a safe-haven that both pedestrians and bicyclists could use connecting the two sites.