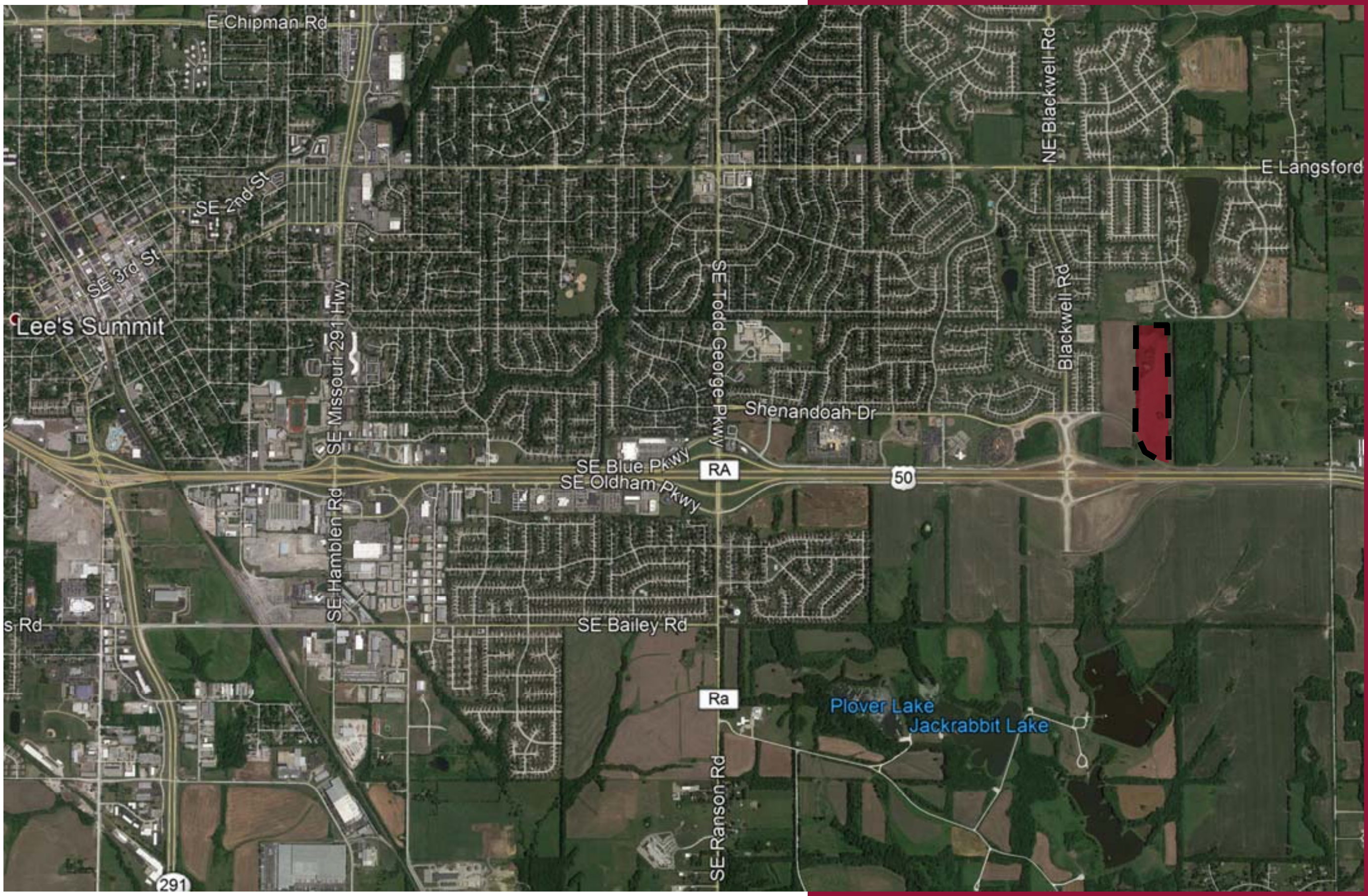
Lee's Summit Apartments Traffic Impact Study

Blackwell Road and Shenandoah Drive
Lee's Summit, Missouri



Prepared for:

Case & Associates Properties, Inc.

Prepared by TranSystems

March 2018

TranSystems
EXPERIENCE | Transportation

TranSystems
2400 Pershing Road
Suite 400
Kansas City, MO 64108
Tel 816 329 8600
Fax 816 329 8601
www.transystems.com

March 29, 2018

Mr. Justin W. Dixon
Case & Associates Properties, Inc.
4200 E. Skelly Drive, Suite 800
Tulsa, OK 74135

RE: Lee's Summit Apartments Traffic Impact Study
Blackwell Road and Shenandoah Drive
Lee's Summit, Missouri

Dear Mr. Dixon:

In response to your request and authorization, TranSystems has completed a traffic impact study for the proposed multi-family residential development to be located generally to the northeast of the US-50 Highway and Blackwell Road interchange in Lee's Summit, Missouri. The purpose of this study was to assess the impact of the proposed development on the surrounding transportation system.

Included in this study is a discussion of the anticipated impact of the proposed development on the adjacent street network and identified improvements to mitigate deficiencies for the following scenarios:

- Existing Conditions
- Existing plus Development Conditions
- Future Conditions

We trust that the enclosed information proves beneficial to you and the City of Lee's Summit in this phase of the development process. We appreciate the opportunity to be of service to you and will be available to review this study at your convenience.

Sincerely,
TRANSYSTEMS

By: ______________________ By: ______________________

Jeffrey J. Wilke, PE, PTOE   Tobin Bonnell, PE, PTOE

TTB:JJW/tb/P101180065
Enclosure

Introduction

TranSystems has completed a traffic impact study for the proposed multi-family residential development to be located generally to the northeast of US-50 and Blackwell Road in Lee's Summit, Missouri. The purpose of this study was to assess the impact of the proposed development on the surrounding transportation system. The location of the development site relative to the major streets in the area is shown on ***Figure A-1*** in ***Appendix A***.

This study also contains a description of the proposed development and the surrounding transportation infrastructure along with trip generation estimates, trip distribution estimates, capacity analyses, and a summary of the findings.

Proposed Development Plan

The proposed development consists of a 600-unit apartment complex. Access for the development will be provided from Shenandoah Drive, which serves as an outer road to the adjacent US-50 Highway. A new roadway to the north of Shenandoah Drive is planned to provide access to the proposed development and intersect Shenandoah Drive via a new roundabout intersection. This access road is planned to be directly to the west of the proposed development. In the southeast corner of the site, gated access directly to Shenandoah Drive is planned for emergency vehicles only. This emergency access point will not be reflected within the traffic analyses performed as a part of this study. A copy of the proposed site plan showing the proposed access points is included on ***Figure A-2*** in ***Appendix A*** for reference.

Study Area

To assess the impacts of the proposed development, the intersections listed below were identified for study during the A.M. and P.M. periods.

- Blackwell Road and Shenandoah Drive
- Site Entrances

Surrounding Land Uses and Street Network

The development site currently consists of undeveloped land used for agricultural purposes. There are several different land uses surrounding the site. To the east of the site, much of the adjacent land is undeveloped, with a few residential lots with acreage. Directly to the north of the site, Highland Park Elementary School is located on Millstone Avenue. With the exception of the elementary school, Millstone Avenue exclusively serves single-family residences. To the west of the site, there are also several single-family residential subdivisions.

The proposed development site is planned to be adjacent to the recently-constructed interchange improvements at US-50 and Blackwell Road. These improvements extended Blackwell Road south, creating a connection with US-50 via interchange ramps and the south outer road, Oldham Parkway. The intersections of Blackwell Road constructed with Shenandoah Drive and both ramp termini all feature roundabout configurations. The intersection of Blackwell Road and Shenandoah Drive is a dual-lane roundabout. The approaches to this roundabout are all dual-lane configurations, with the exception of the eastbound approach, which has just one lane.

The segment of Blackwell Road south of the intersection with Shenandoah Drive features two continuous lanes in each direction, with an additional right-turn lane for southbound traffic at the intersection of the westbound US-50 ramps. The segment of Blackwell Road north of the intersection with Shenandoah Drive features one lane in the northbound direction, and two lanes in the southbound direction. Both segments of Blackwell Road are currently classified as minor arterial street, with a posted speed limit of 35 miles per hour.

The segment of Shenandoah Drive east of the intersection with Blackwell Road generally features curb, gutter, sidewalk, and one travel lane in each direction, with an approximate 250-foot long left-turn lane at the westbound approach to Blackwell Road. Adjacent to the proposed development site, Shenandoah Drive is one travel lane with paved shoulder in both directions. This roadway is currently classified as a commercial/industrial collector street. There is a posted speed limit of 35 miles per hour in the vicinity of the intersection of Shenandoah Drive and Blackwell Road, while the segment of Shenandoah Drive adjacent to the proposed development site has a posted speed limit of 40 miles per hour.

Traffic Counts

Turning-movement traffic volume counts were collected at the study intersection of Blackwell Road and Shenandoah Drive on Thursday, March 15, 2018. The turning movement counts were collected from 7:00 to 9:00 A.M. and from 4:00 to 6:00 P.M. The A.M. peak hour for all intersections occurred between 7:30 and 8:30 A.M., while the P.M. peak hour occurred between 4:45 and 5:45 P.M. The existing lane configurations, traffic control devices, and peak hour traffic volumes have been illustrated on ***Figure A-3***.

As a part of this study, 24-hour traffic counts were recorded along Blackwell Road and Shenandoah Drive. Machine traffic volume counters were placed on Blackwell Road north of its intersection with Shenandoah Drive, and on Shenandoah Drive adjacent to the development site. Counts were recorded midday March 13, 2018 through March 15, 2018. The machine traffic volumes were used to verify the accuracy of the turning-movement counts, and determine approximately how many vehicles at the intersection of Blackwell Road and Shenandoah Drive are accessing the residential subdivision immediately to the east of the intersection. Based on this count, throughout the duration of a typical weekday, Blackwell Road to the north of the intersection serves 4,670 vehicles, while Shenandoah Drive to the east of the intersection serves 1,700 vehicles.

Analysis

The scope of analysis for the assessment of the proposed development's impact on the surrounding transportation system is based in large part on the recommended practices of the Institute of Transportation Engineers (ITE), as outlined in their Traffic Engineering Handbook. ITE is a nationally-recognized organization of transportation professionals with members from both private and public sectors. The analysis of the proposed development's impact included development of trip generation and trip distribution estimates as well as a traffic operations assessment for each study scenario. Each of the analysis methodologies and findings are described in the subsequent sections.

Trip Generation

Trip generation estimates were prepared using the Institute of Transportation Engineer's Trip Generation, 9th Edition. ***Table 1*** shows the expected trips to be generated by the proposed development.

Table 1
Development Trip Generation

Land Use	Intensity	ITE Code	Average Weekday	A.M. Peak Hour			P.M. Peak Hour		
				Total	In	Out	Total	In	Out
Apartments	600 du	220	3,760	298	60	238	348	227	121
Total New Development Trips			***3,760***	***298***	***60***	***238***	***348***	***227***	***121***

Trip Distribution

The estimated trips generated by the proposed development were distributed onto the street system based on the trip distributions summarized in ***Table 2***. These distributions are based on existing traffic patterns and engineering judgment. The detailed distribution patterns through the study intersections are shown in ***Appendix B***.

Table 2
Trip Distribution

Direction To/From	Percentage
North on Blackwell Road	10%
South on Blackwell Road (to/from US-50)	70%
West on Shenandoah Drive	15%
East on Shenandoah Drive	5%
Total	**100%**

Traffic Operation Assessment

An assessment of traffic operations was made for the scenarios listed below. These scenarios allowed for comparison of the before and after impacts of the proposed development on the street network.

- Existing Conditions
- Existing plus Development Conditions
- Future Conditions

The study intersections were evaluated using the Sidra Intersection 7.0 Plus traffic analysis software package. Calculations were performed based on the methodologies outlined in the Highway Capacity

Manual (HCM), 2010 Edition, which is published by the Transportation Research Board. The operating conditions at an intersection are graded by the "level of service" experienced by drivers. Level of service (LOS) describes the quality of traffic operating conditions and is rated from "A" to "F". LOS A represents the least congested condition with free-flow movement of traffic and minimal delays. LOS F generally indicates severely congested conditions with excessive delays to motorists. Intermediate grades of B, C, D, and E reflect incremental increases in the average delay per stopped vehicle. Control delay is measured in seconds per vehicle, with consideration given to the volume-to-capacity (v/c) ratio. ***Table 3*** shows the upper limit of delay associated with each level of service for roundabout intersections.

Table 3
Intersection Level of Service Delay Thresholds

Control Delay (s/veh)	Level of Service (LOS) by Volume-to-Capacity Ratio	
	v/c ≤ 1.0	v/c > 1.0
0-10	A	F
>10-15	B	F
>15-25	C	F
>25-35	D	F
>35-50	E	F
>50	F	F

The LOS rating deemed acceptable varies by community, facility type and traffic control device. The City of Lee's Summit, which has jurisdiction over the intersections analyzed as a part of this study, has identified LOS C as the minimum desirable goal for intersections in their community.

Existing Conditions

The results of the Existing Conditions intersection analyses are summarized below in ***Table 4***. The study intersection was evaluated with the lane configurations, traffic volumes, and traffic control devices shown on ***Figures A-3*** through ***Figure A-5***. The Sidra output files are included in ***Appendix C***.

Table 4
Intersection Operational Analysis
Existing Conditions

Intersection	A.M. Peak Hour			P.M. Peak Hour		
Movement	LOS[1]	Delay[2]	v/c[3]	LOS[1]	Delay[2]	v/c[3]
Blackwell Road and Shenandoah Drive						
Roundabout	*A*	*4.6*	*0.16*	*A*	*5.8*	*0.34*

1 – Level of Service
2 – Delay in seconds per vehicle
3 – Volume-to-Capacity Ratio

As shown in the table, the study intersection of Blackwell Road and Shenandoah Drive currently operates within the thresholds for acceptable levels of service during the peak hours. Further assessment of the analysis indicates that all approaches of the intersection operate at LOS A during both peak hours.

Existing plus Development Conditions

The results of the existing plus development conditions intersection analyses are summarized below in ***Table 5***. This study scenario assessed the street system with the addition of traffic generated by the proposed development. The study intersections were evaluated with the lane configurations, traffic volumes, and traffic control devices shown on ***Figures A-6*** through ***A-8***. For purposes of the analysis of the existing plus development conditions, it was assumed that the proposed roundabout at the intersection of Shenandoah Drive and the proposed access road would feature one continuous circulating lane as well as single lanes for all three approaches. The Sidra output files are included in ***Appendix C***.

Table 5
Intersection Operational Analysis
Existing plus Development Conditions

Intersection	**A.M. Peak Hour**			**P.M. Peak Hour**		
Movement	**LOS[1]**	**Delay[2]**	**v/c[3]**	**LOS[1]**	**Delay[2]**	**v/c[3]**
Blackwell Road and Shenandoah Drive						
Roundabout	*A*	*5.4*	*0.19*	*A*	*6.6*	*0.36*
Shenandoah Drive and Proposed Access Road						
Roundabout	*A*	*5.3*	*0.26*	*A*	*5.8*	*0.31*

1 – Level of Service
2 – Delay in seconds per vehicle
3 – Volume-to-Capacity Ratio

As shown in the table above, both study intersections are projected to operate within the thresholds for acceptable levels of service during the peak hours. Further assessment of the analysis indicates that all approaches of the intersections operate at LOS A during both peak hours.

Future Conditions

This study scenario assessed the street system with the additional traffic generated by the proposed development, as well as assumed traffic growth to/from the surrounding roadway network. Assumed traffic growth was based on TranSystems previous work on the US-50 and Blackwell Road interchange, as well as familiarity and knowledge of the City of Lee's Summit.

Specifically, it was assumed that the access road constructed to the west of the proposed development site would serve more residences in the future than what is represented with the proposed apartment development. There is undeveloped land between the proposed access road and the existing Joel Avenue that, in the future, is assumed to also be developed into apartments. For purposes of this study, this future apartment development was assumed to feature 300 dwelling units and utilize the same access to Shenandoah Drive as the proposed development. It was also assumed that undeveloped land between the westbound US-50 off-ramp and Shenandoah Drive would be developed. Based on the size of available developable land and the estimation that 20% of the available land would be developable, it was assumed that this future development would consist of a shopping center with approximately 150,000 square feet of gross leasable area. Trip generation estimates for the future developments were prepared in the same manner as the proposed development, using the Institute of Transportation Engineer's Trip Generation, 9th Edition. Likewise, these future developments were assumed to use the same trip distribution patterns as discussed regarding the proposed development. A two percent (2%) annual growth rate was applied over the planning horizon to the existing traffic volumes representing through traffic along Blackwell Road, while a four percent (4%) annual growth rate was applied to the existing traffic volumes representing through traffic along Shenandoah Drive. Growth of traffic volumes along the Blackwell Road and Shenandoah Drive corridors is based on review of existing traffic volumes and projections shown in the Access Justification Report for the US-50 and Blackwell Road interchange project, and comparison to the recently-collected counts performed with this study. The future condition traffic volumes are assumed to represent conditions in the year 2040.

For purposes of the analysis of the future conditions, it was assumed that the geometry of the existing roundabout at the intersection of Blackwell Road and Shenandoah Drive will remain the same into the future. It was furthermore assumed that the proposed roundabout at the intersection of Shenandoah Drive and the proposed access road would feature one continuous circulating lane and single lanes for all three approaches modeled in the existing plus development conditions analysis, as well as an additional single lane approach for the future shopping development to the south. Using iterations of the analysis process, it was confirmed that the eastbound approach at the intersection would benefit in the future from the addition of a right turn lane to accommodate the anticipated traffic volumes generated by the future shopping center development. As such, the future conditions analyses summarized below assume that the eastbound approach at the proposed access road roundabout will feature a dedicated right turn lane that "by-passes" the circulating lanes of the roundabout.

The results of the future conditions intersection analyses are summarized in ***Table 6***. The study intersections were evaluated with the lane configurations, traffic volumes, and traffic control devices shown on ***Figures A-9*** through ***Figure A-11***. The Sidra output files are included in ***Appendix C***.

Table 6
Intersection Operational Analysis
Future Conditions

Intersection	**A.M. Peak Hour**			**P.M. Peak Hour**		
Movement	**LOS[1]**	**Delay[2]**	**v/c[3]**	**LOS[1]**	**Delay[2]**	**v/c[3]**
Blackwell Road and Shenandoah Drive						
Roundabout	*A*	*7.8*	*0.38*	*C*	*17.6*	*0.76*
Shenandoah Drive and Proposed Access Road						
Roundabout	*A*	*7.5*	*0.47*	*B*	*13.3*	*0.70*

1 – Level of Service
2 – Delay in seconds per vehicle
3 – Volume-to-Capacity Ratio

The table indicates that delays are projected to increase at the study intersections with the addition of future traffic growth. However, both study intersections are projected to operate within the thresholds for acceptable levels of service during the peak hours.

In the future P.M. peak hour, the intersection of Blackwell Road and Shenandoah Drive is projected to operate at LOS C due to delays incurred at the northbound and eastbound approaches. Looking further into the analysis, the northbound right turn delay, which is projected to be the greatest in magnitude, is not projected to produce queuing that would impede upon movements at the adjacent intersection of Blackwell Road and the westbound US 50 ramps. Therefore, the projected increase in delay for the future would not require any geometric improvements to the existing intersection of Blackwell Road and Shenandoah Drive or any of the existing adjacent roadway network.

The intersection of Shenandoah Drive and the proposed access road is projected to operate at LOS B in the future P.M. peak hour. This represents a decrease in operations from LOS A in the existing plus development conditions scenario. While this is not considered to be unacceptable with respect to the City of Lee's Summit, anticipated queuing of vehicles at the proposed roundabout was examined for the P.M. peak hour. Looking further into the analysis results, the anticipated queue lengths could be accommodated within the future roadway and site design. Therefore, the analysis shows that one circulating lane within the roundabout would be sufficient in terms of future traffic operation, given the future adjacent land development assumed with this study.

Summary

TranSystems has completed a traffic impact study for the proposed multi-family residential development to be located generally to the northeast of US-50 and Blackwell Road in Lee's Summit, Missouri. The purpose of this study was to assess the impact of the proposed development on the surrounding transportation system.

The proposed development is projected to generate 298 new trips during the A.M. peak hour and 348 new trips during the P.M. peak hour. Development traffic will be distributed to a new collector roadway that will provide access to Shenandoah Drive by way of a proposed roundabout intersection.

No improvements are identified to mitigate the addition of development traffic to the existing intersection of Blackwell Road and Shenandoah Drive. This intersection, with the addition of traffic generated by the development of the proposed multi-family residential development discussed with this report, is projected to continue to operate at an acceptable level of service. Furthermore, the intersection of Blackwell Road and Shenandoah Drive can accommodate anticipated traffic generated by development that could potentially be implemented in the future, and, given the stated assumptions regarding future development, no improvements at this intersection would be required in the future.

The traffic analyses performed as a part of this study indicate that the proposed roundabout providing access to the proposed development can be designed with one continuous circulating lane as well as single entry/exit lanes for all three approaches. In the future, given the stated assumptions regarding future development, the single-lane roundabout configuration will continue to accommodate traffic generated by an additional multi-family residential development that will utilize the proposed access road, as well as a potential shopping center development that would utilize a fourth northbound approach. The future shopping center development could be accommodated by introducing a single entry/exit lane approach to the northbound leg of the proposed roundabout intersection, and providing a bypass lane for eastbound right turning vehicles entering the future site.

Appendix A - Figures

Figure A-1 Location Map
Figure A-2 Proposed Development Site Plan
Figure A-3 Existing Conditions Lane Configurations
Figure A-4 Existing Conditions A.M. Peak Hour Traffic Volumes
Figure A-5 Existing Conditions P.M. Peak Hour Traffic Volumes
Figure A-6 Existing plus Development Conditions Lane Configurations
Figure A-7 Existing plus Development Conditions A.M. Peak Hour Traffic Volumes
Figure A-8 Existing plus Development Conditions P.M. Peak Hour Traffic Volumes
Figure A-9 Future Conditions Lane Configurations
Figure A-10 Future Conditions A.M. Peak Hour Traffic Volumes
Figure A-11 Future Conditions P.M. Peak Hour Traffic Volumes

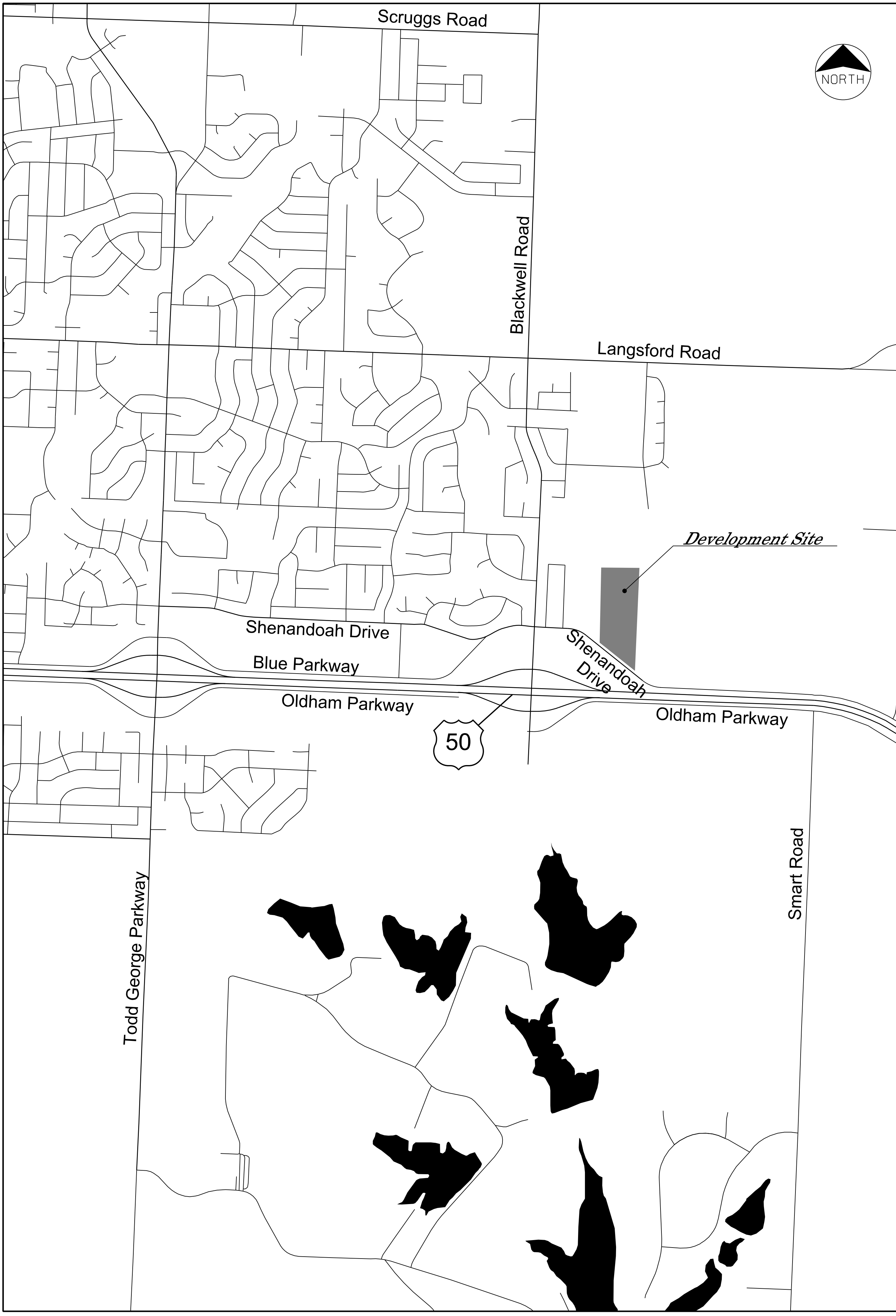


Figure A-1

March 2018

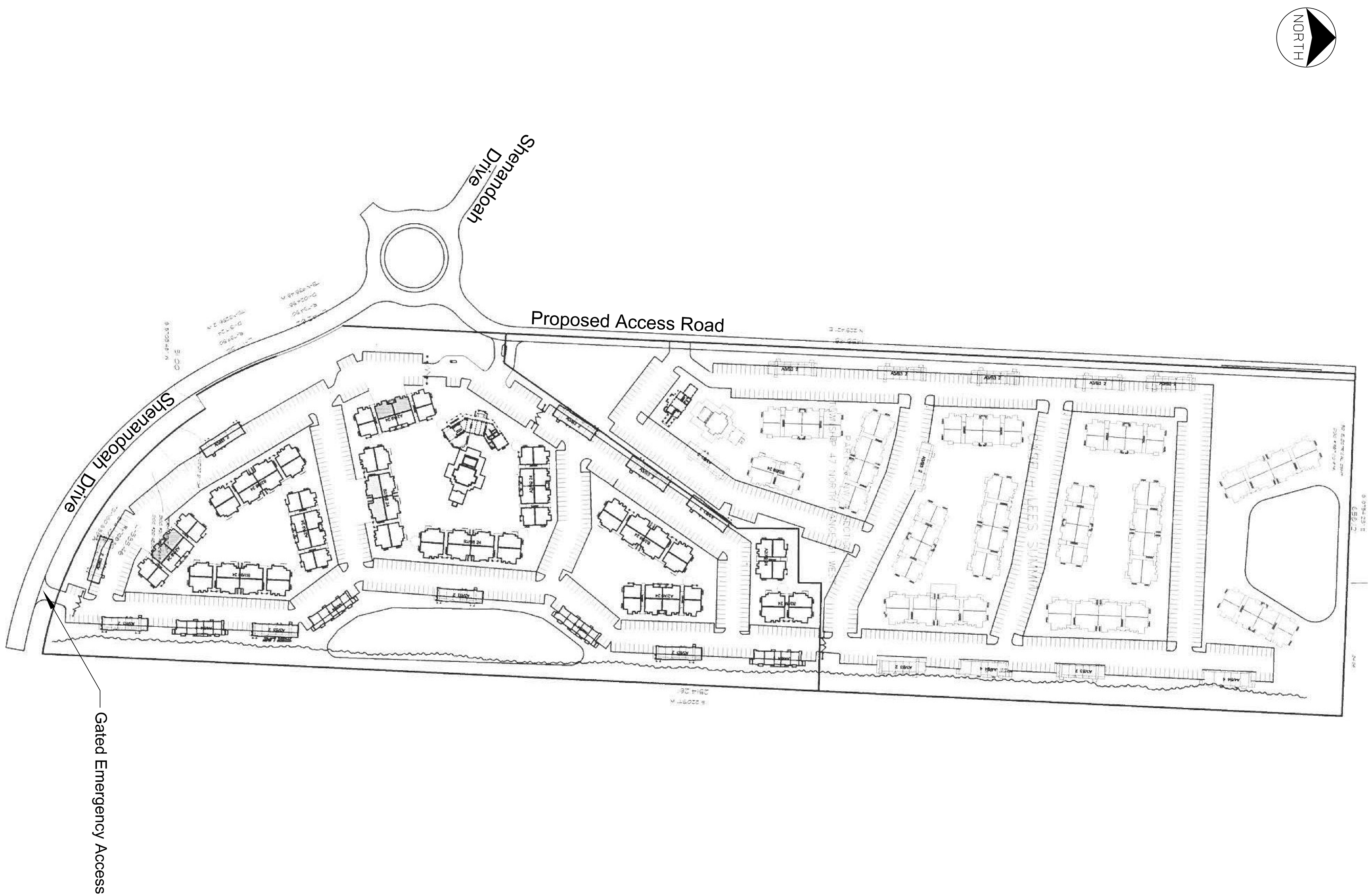
No Scale

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

LOCATION MAP

TranSystems

pw:\\hq-pwint01.a-e.transyscorp.com:transyscorp-pw1\Documents\Projects_2018\KC101 - Kansas City\P101180065 - Lee's Summit Apts TIS\310.00 - Traffic\figs_V8i_8.5x11



TranSystems

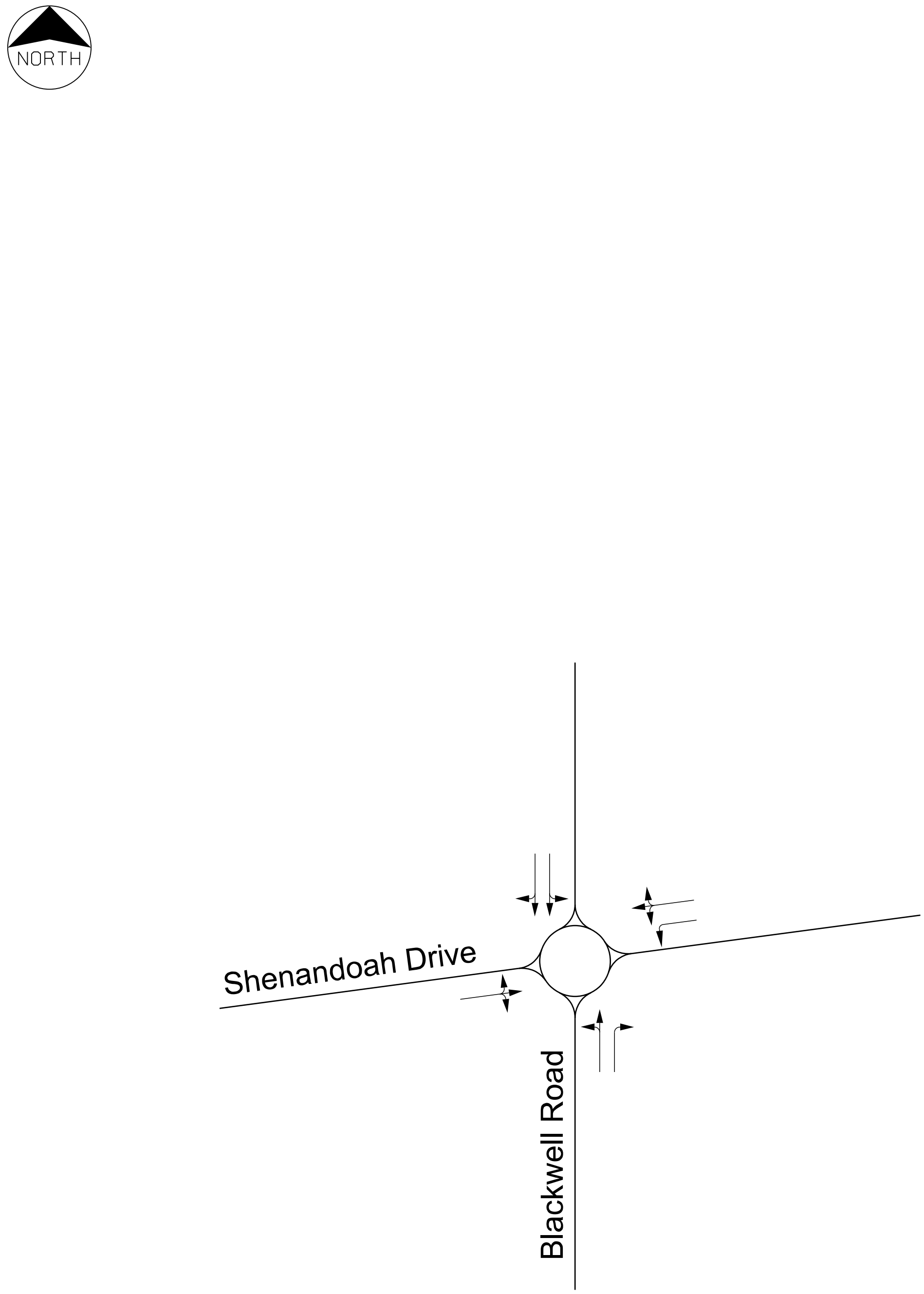
PROPOSED DEVELOPMENT
SITE PLAN

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

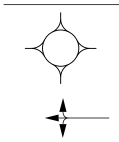
March 2018

No Scale

Figure A-2



Legend



EXISTING LANE CONFIGURATIONS

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

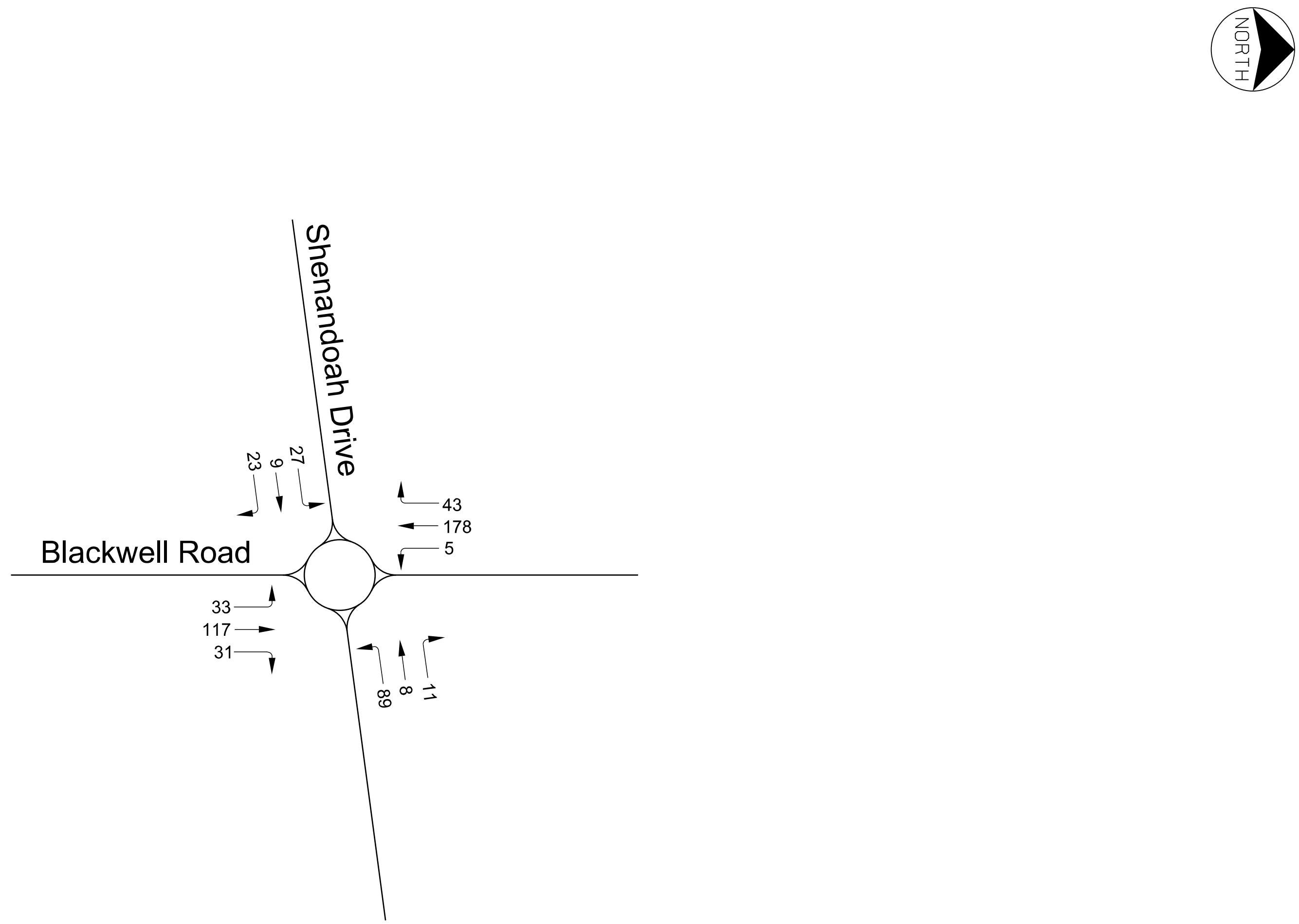
March 2018

No Scale

Figure A-3

TranSystems

pw:\\hq-pwint01.a-e.transyscorp.com:transyscorp-pw1\Documents\Projects_2018\KC101 - Kansas City\P101180065 - Lee's Summit Apts TIS\310.00 - Traffic\figs_V8i_8.5x11



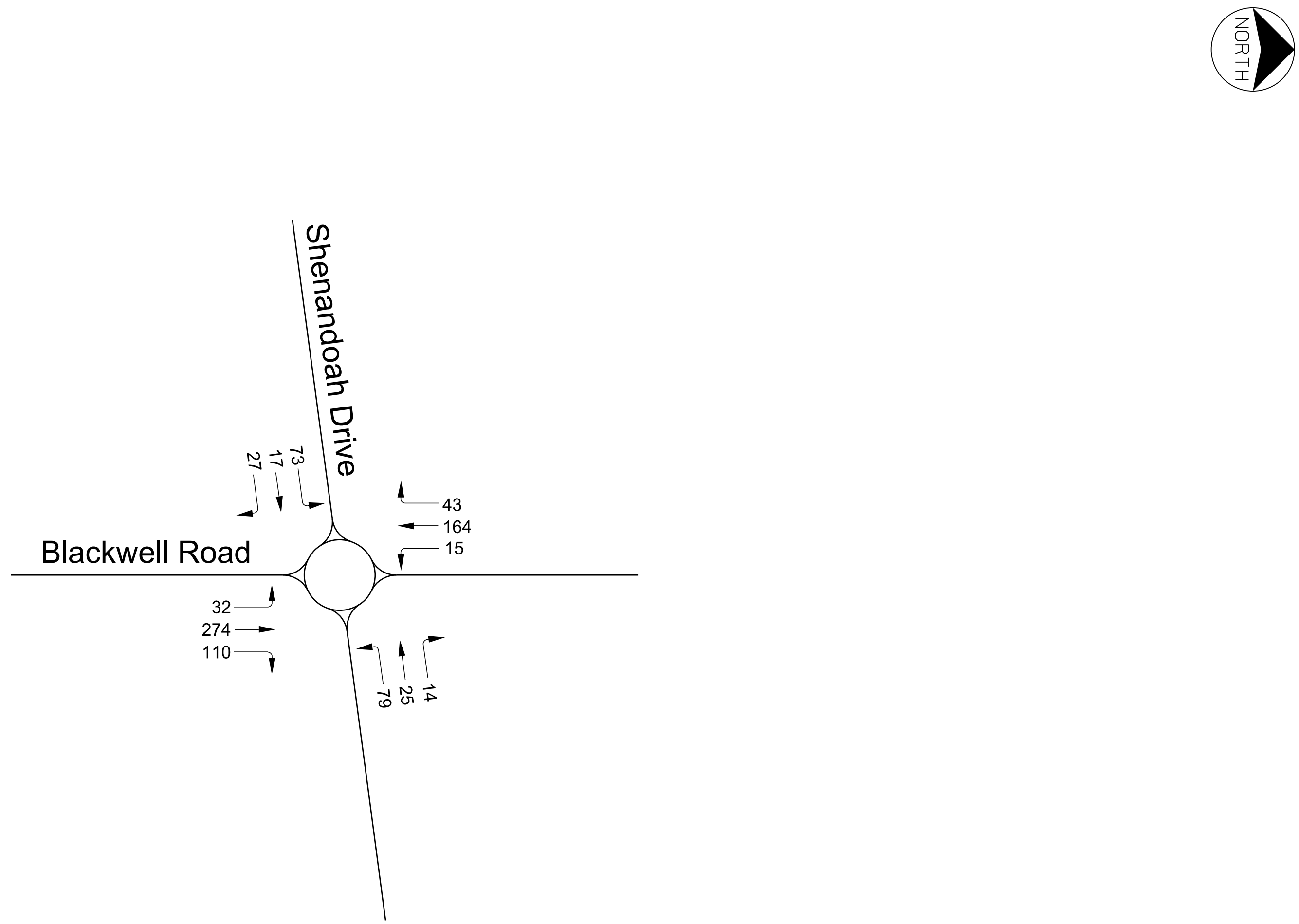
EXISTING A.M. PEAK HOUR
TRAFFIC VOLUMES

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-4



TranSystems

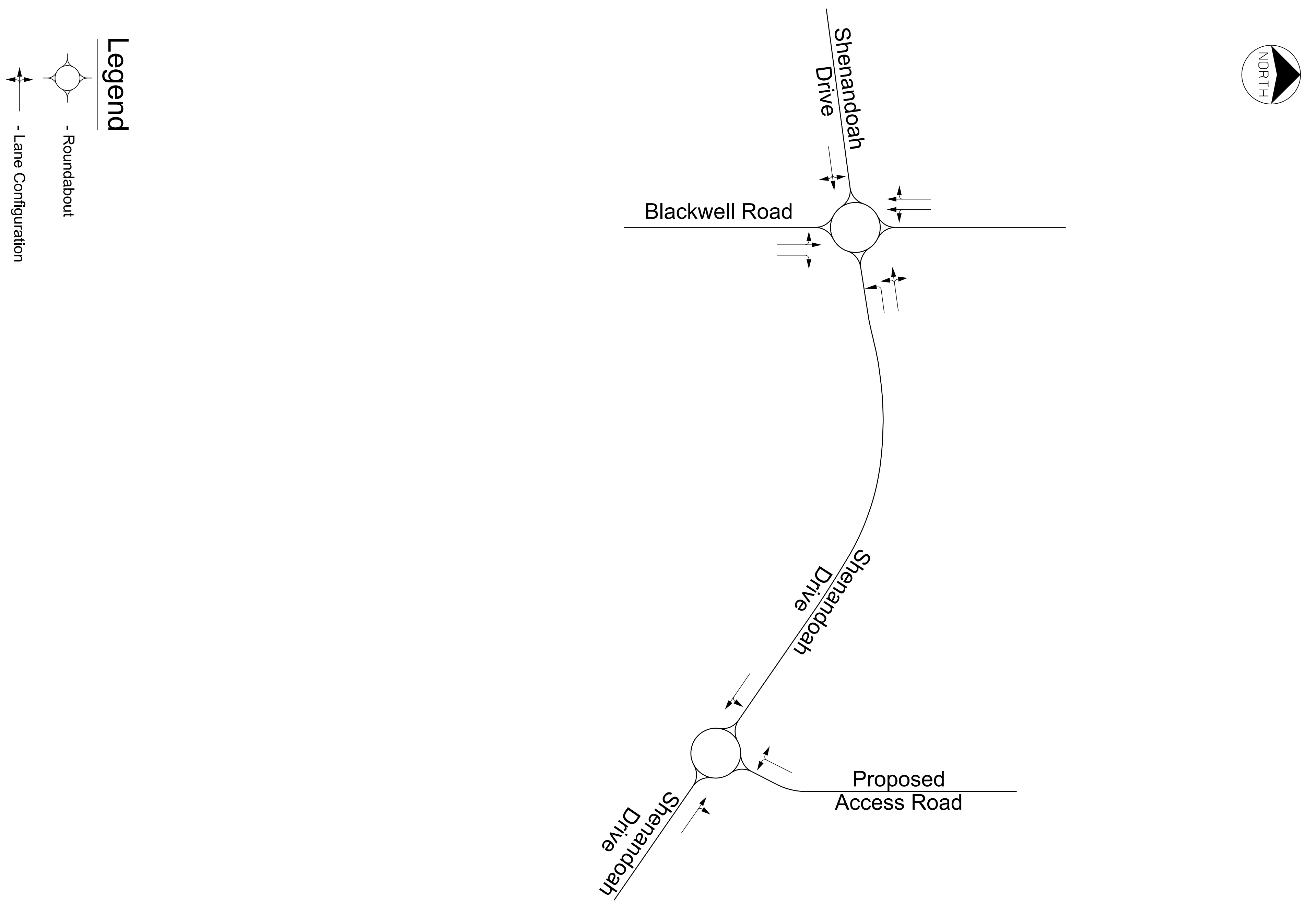
EXISTING P.M. PEAK HOUR
TRAFFIC VOLUMES

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-5



TranSystems

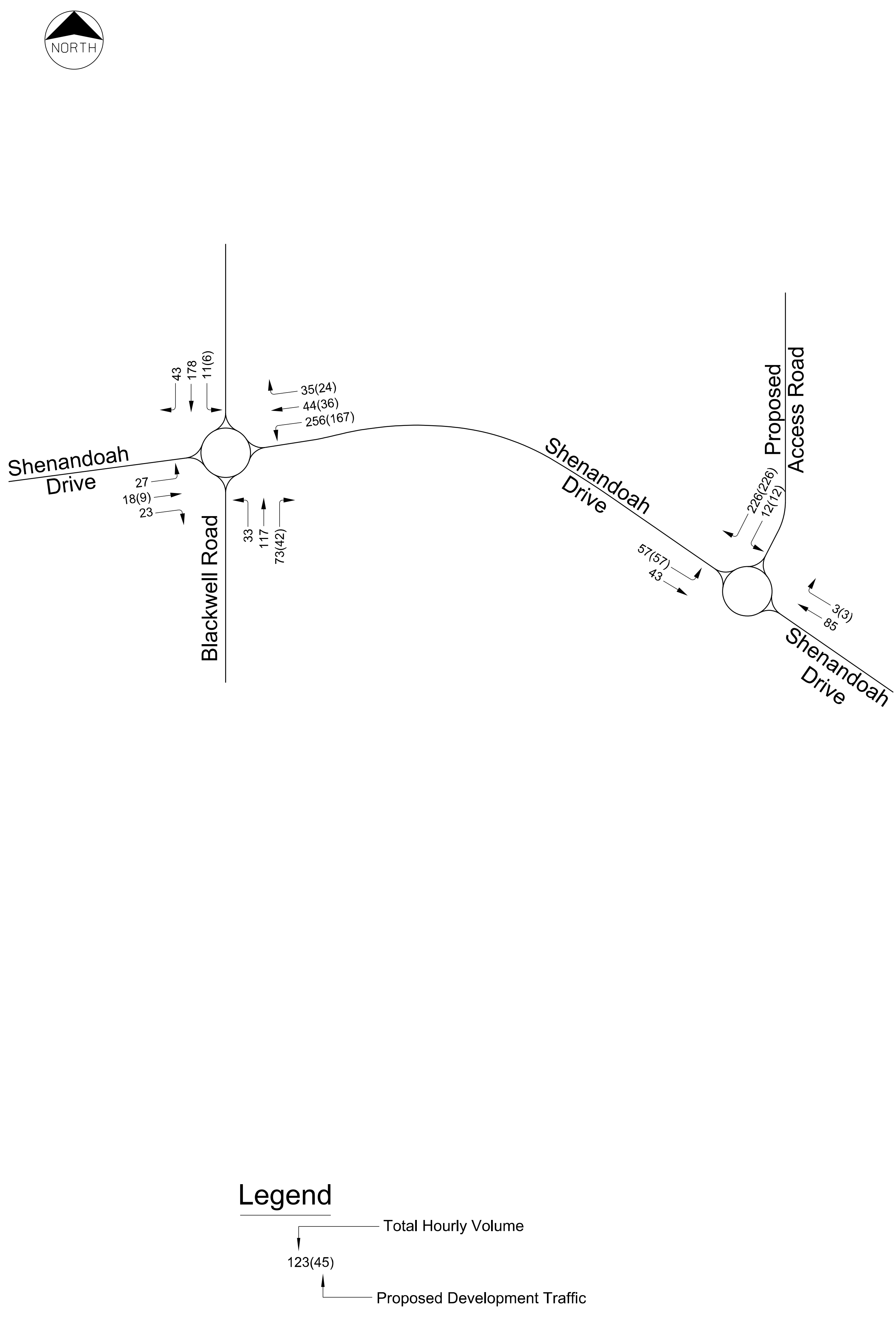
EXISTING PLUS DEVELOPMENT
LANE CONFIGURATIONS

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-6



EXISTING PLUS DEVELOPMENT
A.M. PEAK HOUR TRAFFIC VOLUMES

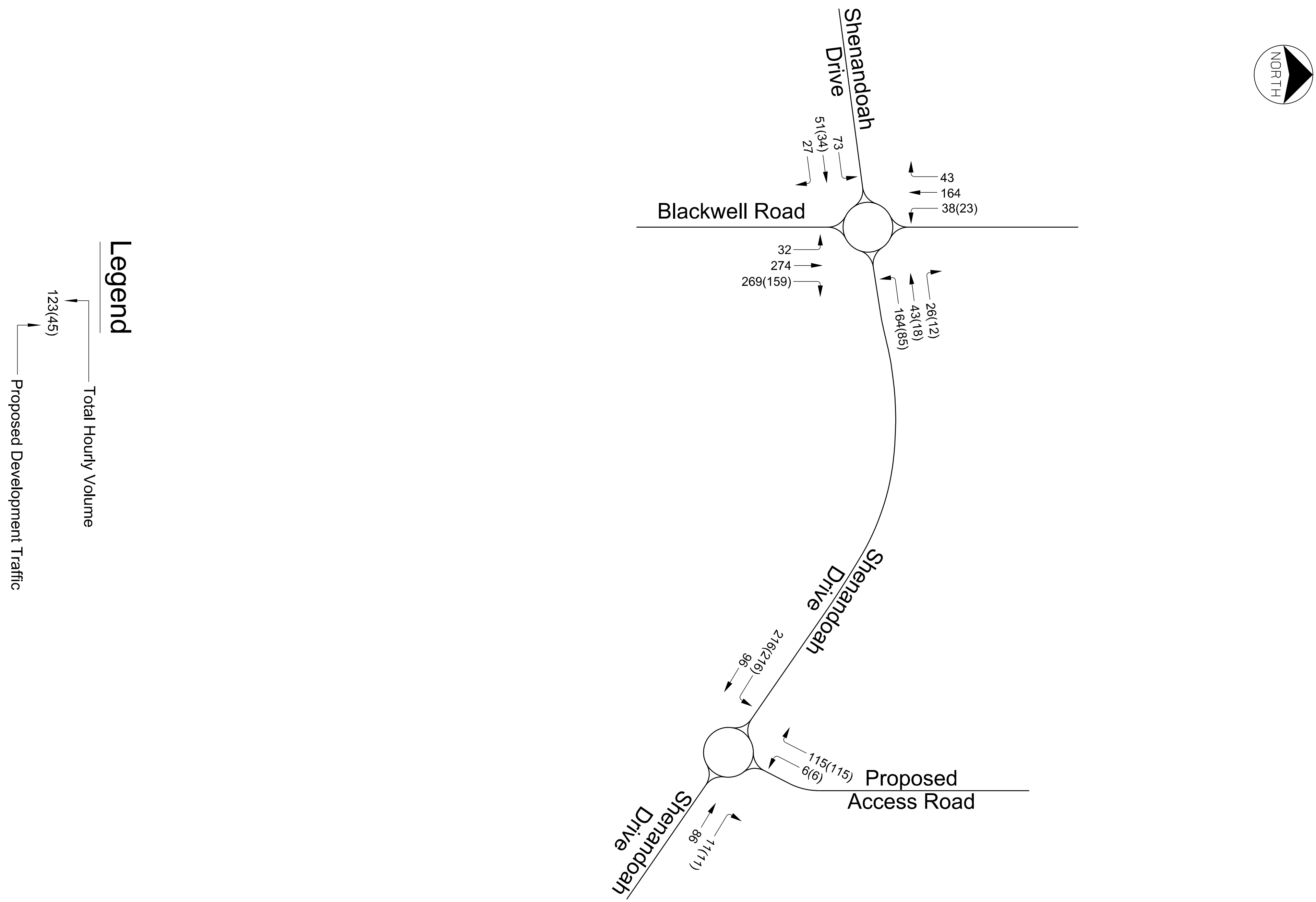
Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

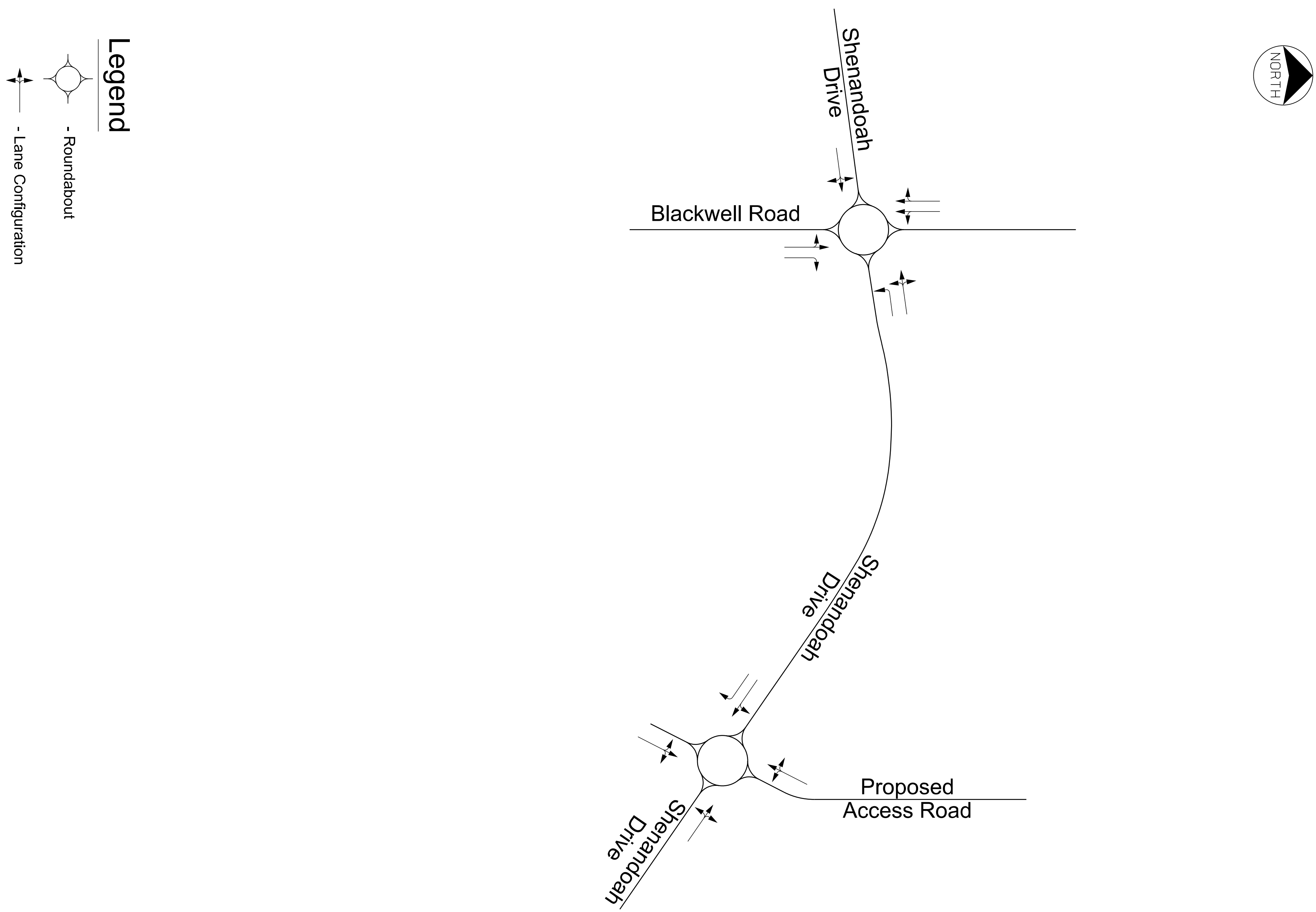
No Scale

Figure A-7

TranSystems®



TranSystems	EXISTING PLUS DEVELOPMENT P.M. PEAK HOUR TRAFFIC VOLUMES	Lee's Summit Apartments Traffic Impact Study Lee's Summit, Missouri	March 2018 No Scale	Figure A-8



TranSystems

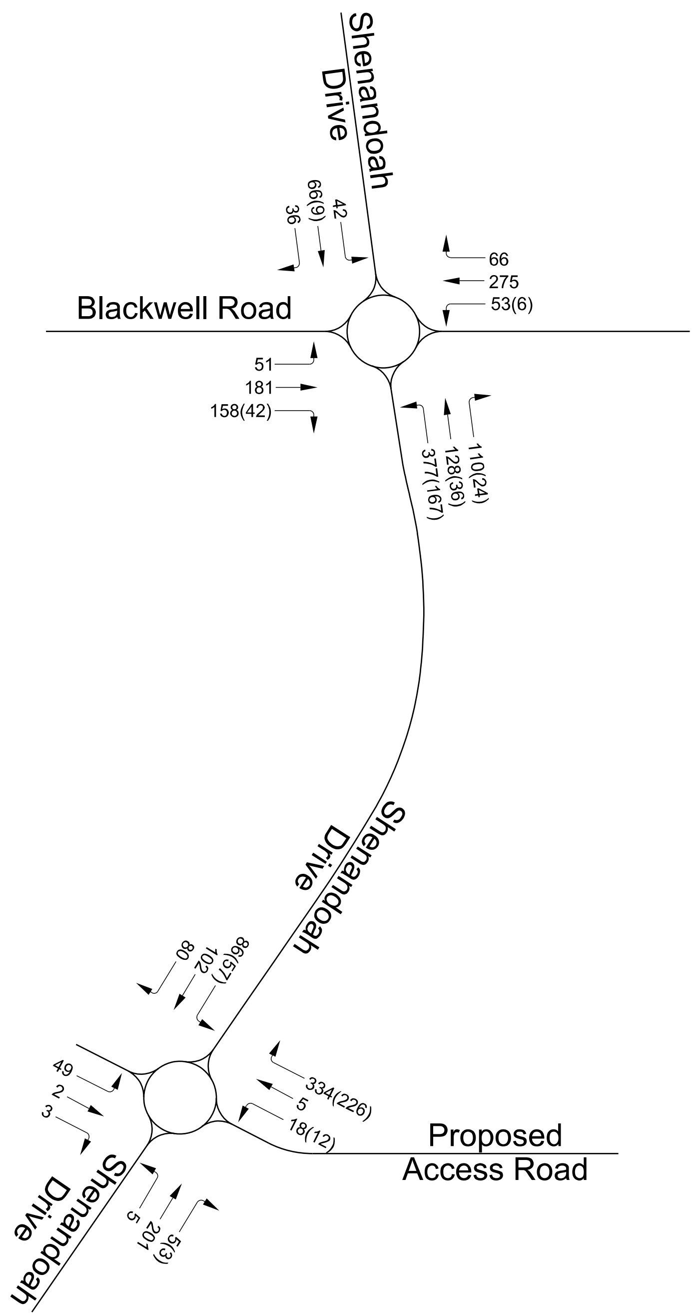
FUTURE LANE CONFIGURATIONS

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-9



Legend

123(45)

Total Hourly Volume

Proposed Development Traffic

TranSystems

FUTURE A.M. PEAK HOUR
TRAFFIC VOLUMES

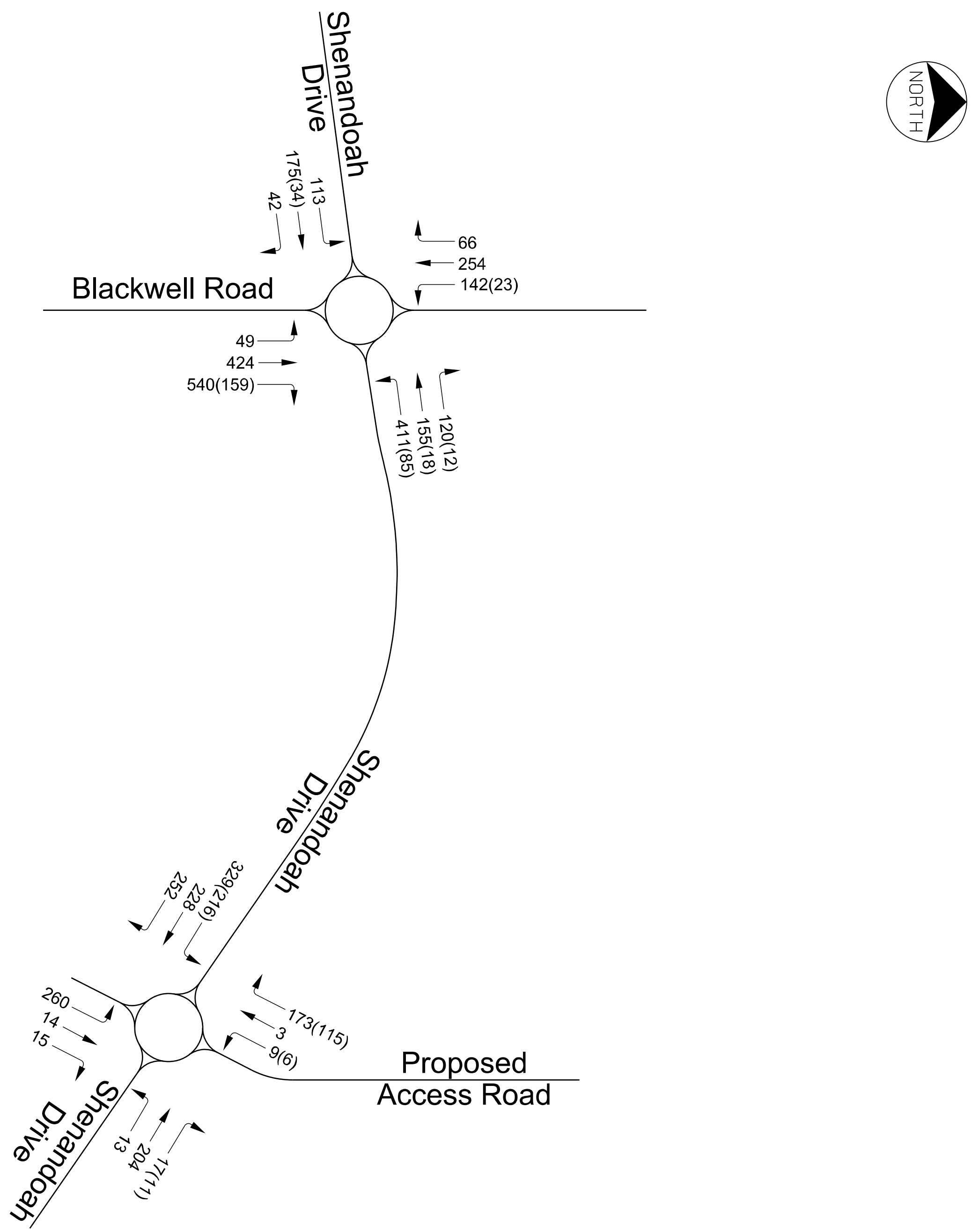
Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-10

pw:\\hq-pwint01.a-e.transyscorp.com:transyscorp-pw1\Documents\Projects_2018\KC101 - Kansas City\P101180065 - Lee's Summit Apts TIS\310.00 - Traffic\figs_V8i_8.5x11



Legend

123(45)

Total Hourly Volume

Proposed Development Traffic

TranSystems

FUTURE P.M. PEAK HOUR TRAFFIC VOLUMES

Lee's Summit Apartments
Traffic Impact Study
Lee's Summit, Missouri

March 2018

No Scale

Figure A-11

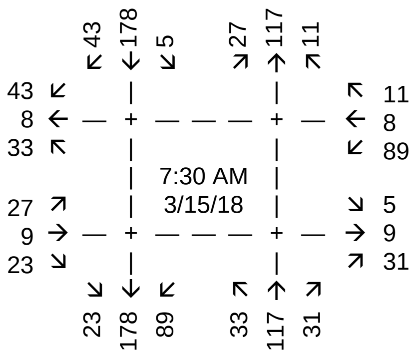
Appendix B – Traffic Volume Data and Trip Generation/Distribution

See attached worksheets.

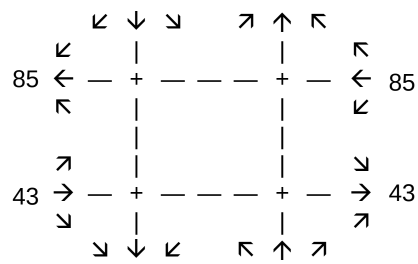
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Existing Traffic Volumes
A.M. Peak Hour

Blackwell and Shenandoah



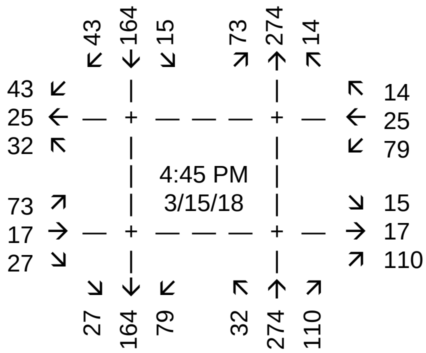
Shenandoah and Access Road



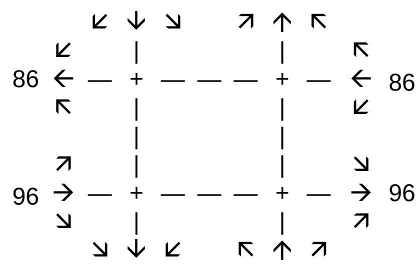
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Existing Traffic Volumes
P.M. Peak Hour

Blackwell and Shenandoah



Shenandoah and Access Road



Existing Tube Counts

		SB Blackwell	NB Blackwell	Total
3/13/2018	11:00 AM	95	100	195
3/13/2018	12:00 PM	105	73	178
3/13/2018	1:00 PM	104	136	240
3/13/2018	2:00 PM	143	153	296
3/13/2018	3:00 PM	202	239	441
3/13/2018	4:00 PM	249	322	571
3/13/2018	5:00 PM	187	211	398
3/13/2018	6:00 PM	164	163	327
3/13/2018	7:00 PM	74	143	217
3/13/2018	8:00 PM	43	78	121
3/13/2018	9:00 PM	32	33	65
3/13/2018	10:00 PM	9	19	28
3/13/2018	11:00 PM	8	3	11
3/14/2018	12:00 AM	2	3	5
3/14/2018	1:00 AM	0	3	3
3/14/2018	2:00 AM	0	3	3
3/14/2018	3:00 AM	10	3	13
3/14/2018	4:00 AM	45	11	56
3/14/2018	5:00 AM	169	33	202
3/14/2018	6:00 AM	229	113	342
3/14/2018	7:00 AM	220	89	309
3/14/2018	8:00 AM	152	105	257
3/14/2018	9:00 AM	105	71	176
3/14/2018	10:00 AM	102	77	179
3/14/2018	11:00 AM	111	119	230
3/14/2018	12:00 PM	94	81	175
3/14/2018	1:00 PM	107	123	230
3/14/2018	2:00 PM	168	170	338
3/14/2018	3:00 PM	203	257	460
3/14/2018	4:00 PM	226	335	561
3/14/2018	5:00 PM	193	216	409
3/14/2018	6:00 PM	140	163	303
3/14/2018	7:00 PM	81	129	210
3/14/2018	8:00 PM	52	69	121
3/14/2018	9:00 PM	24	38	62
3/14/2018	10:00 PM	7	9	16
3/14/2018	11:00 PM	5	6	11
3/15/2018	12:00 AM	6	2	8
3/15/2018	1:00 AM	2	2	4
3/15/2018	2:00 AM	0	2	2
3/15/2018	3:00 AM	11	7	18
3/15/2018	4:00 AM	36	15	51
3/15/2018	5:00 AM	172	33	205
3/15/2018	6:00 AM	238	129	367
3/15/2018	7:00 AM	212	109	321
3/15/2018	8:00 AM	105	85	190
3/15/2018	9:00 AM	99	80	179
3/15/2018	10:00 AM	107	110	217
3/15/2018	11:00 AM	105	87	192
3/15/2018	12:00 PM	81	94	175
3/15/2018	1:00 PM	108	134	242
3/15/2018	2:00 PM	166	181	347
3/15/2018	3:00 PM	185	265	450
3/15/2018	4:00 PM	116	165	281

Peak 24-hour Total

SB Blackwell	NB Blackwell	Total
2466	2251	4717

Existing Tube Counts

	EB Shenandoah	WB Shenandoah	Total
3/13/2018 11:00 AM	46	59	105
3/13/2018 12:00 PM	42	48	90
3/13/2018 1:00 PM	32	51	83
3/13/2018 2:00 PM	52	60	112
3/13/2018 3:00 PM	96	64	160
3/13/2018 4:00 PM	95	86	181
3/13/2018 5:00 PM	78	64	142
3/13/2018 6:00 PM	48	55	103
3/13/2018 7:00 PM	33	35	68
3/13/2018 8:00 PM	25	15	40
3/13/2018 9:00 PM	11	6	17
3/13/2018 10:00 PM	0	2	2
3/13/2018 11:00 PM	3	4	7
3/14/2018 12:00 AM	3	4	7
3/14/2018 1:00 AM	2	0	2
3/14/2018 2:00 AM	4	0	4
3/14/2018 3:00 AM	2	4	6
3/14/2018 4:00 AM	7	16	23
3/14/2018 5:00 AM	19	47	66
3/14/2018 6:00 AM	31	85	116
3/14/2018 7:00 AM	43	82	125
3/14/2018 8:00 AM	37	54	91
3/14/2018 9:00 AM	44	62	106
3/14/2018 10:00 AM	38	66	104
3/14/2018 11:00 AM	51	72	123
3/14/2018 12:00 PM	49	59	108
3/14/2018 1:00 PM	55	52	107
3/14/2018 2:00 PM	51	50	101
3/14/2018 3:00 PM	88	73	161
3/14/2018 4:00 PM	64	56	120
3/14/2018 5:00 PM	36	63	99
3/14/2018 6:00 PM	51	31	82
3/14/2018 7:00 PM	36	19	55
3/14/2018 8:00 PM	24	33	57
3/14/2018 9:00 PM	9	12	21
3/14/2018 10:00 PM	6	3	9
3/14/2018 11:00 PM	2	2	4
3/15/2018 12:00 AM	2	2	4
3/15/2018 1:00 AM	2	2	4
3/15/2018 2:00 AM	3	3	6
3/15/2018 3:00 AM	4	6	10
3/15/2018 4:00 AM	5	12	17
3/15/2018 5:00 AM	17	50	67
3/15/2018 6:00 AM	32	82	114
3/15/2018 7:00 AM	40	74	114
3/15/2018 8:00 AM	32	58	90
3/15/2018 9:00 AM	42	47	89
3/15/2018 10:00 AM	25	60	85
3/15/2018 11:00 AM	42	44	86
3/15/2018 12:00 PM	49	50	99
3/15/2018 1:00 PM	48	58	106
3/15/2018 2:00 PM	66	62	128
3/15/2018 3:00 PM	103	93	196
3/15/2018 4:00 PM	30	38	68

Peak 24-hour Total

EB Shenandoah	WB Shenandoah	Total
826	994	1820

Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri
Trip Generation - Proposed Development

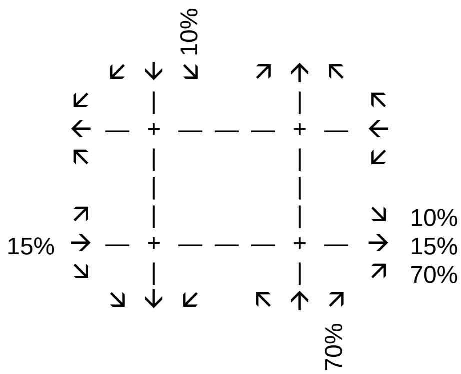
Land Use	Intensity	ITE Code	Daily	A.M. Peak Hour Total	A.M. % In	A.M. % Out	A.M. In	A.M. Out	P.M. Peak Hour Total	P.M. % In	P.M. % Out	P.M. In	P.M. Out
Apartments	600 du	220	3,760	298	20%	80%	60	238	348	65%	35%	227	121
Total Development Trips			***3,760***	***298***			***60***	***238***	***348***			***227***	***121***

Trip generation estimates based on 9th edition

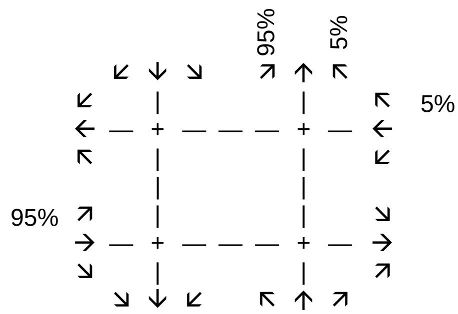
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Trip Distribution
INBOUND

Blackwell and Shenandoah



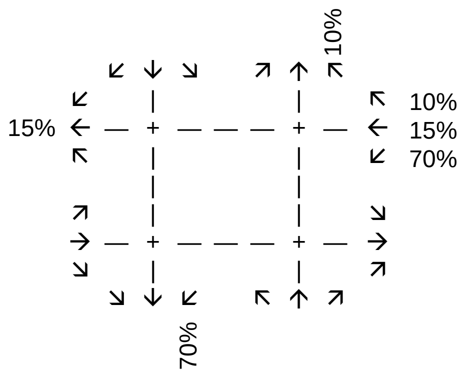
Shenandoah and Access Road



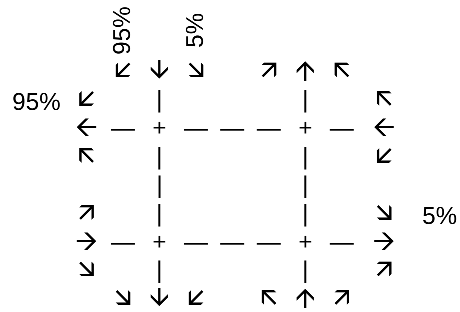
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Trip Distribution
OUTBOUND

Blackwell and Shenandoah



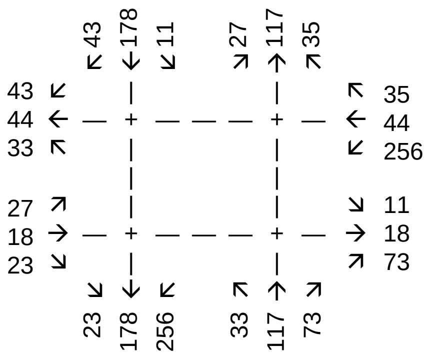
Shenandoah and Access Road



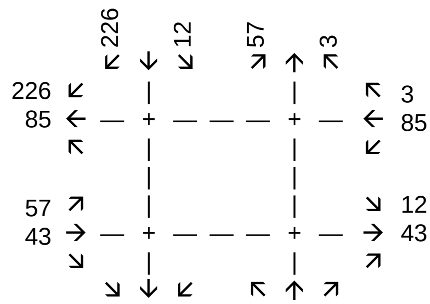
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Existing + Development Traffic Volumes
A.M. Peak Hour

Blackwell and Shenandoah



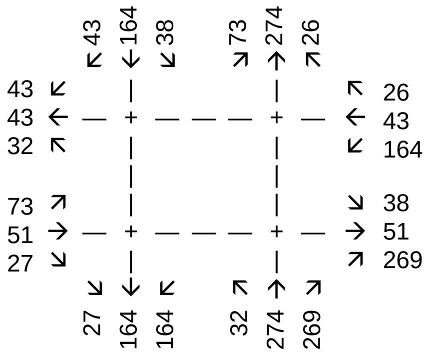
Shenandoah and Access Road



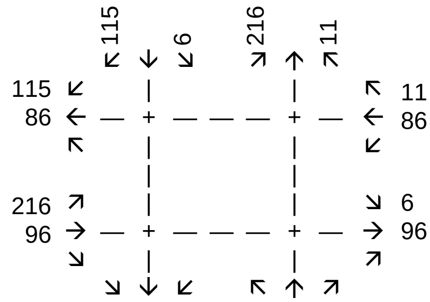
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Existing + Development Traffic Volumes
P.M. Peak Hour

Blackwell and Shenandoah



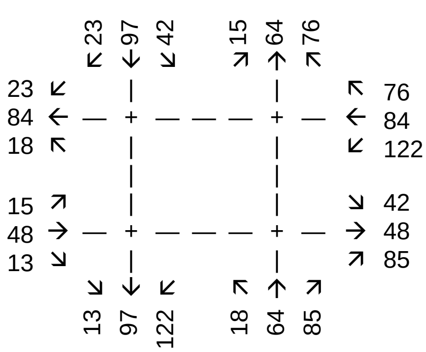
Shenandoah and Access Road



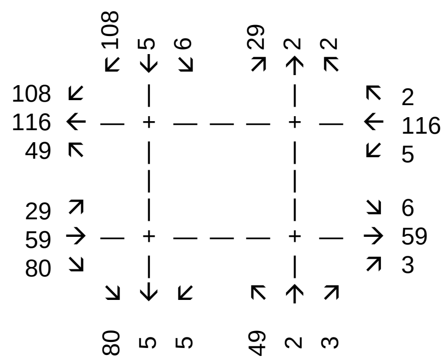
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Future Additional Traffic Volumes
A.M. Peak Hour

Blackwell and Shenandoah



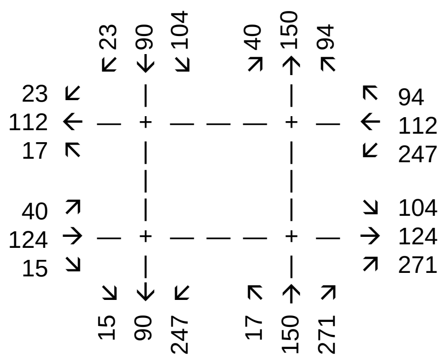
Shenandoah and Access Road



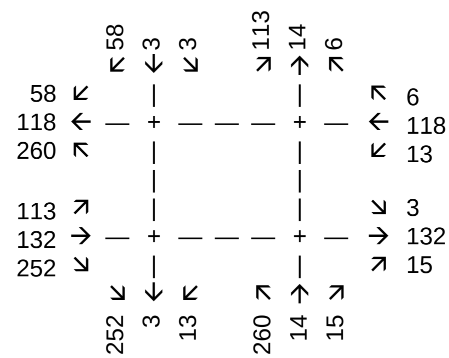
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Future Additional Traffic Volumes
P.M. Peak Hour

Blackwell and Shenandoah



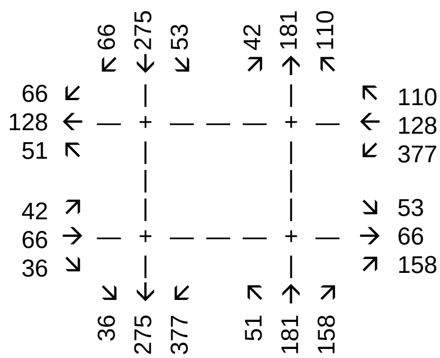
Shenandoah and Access Road



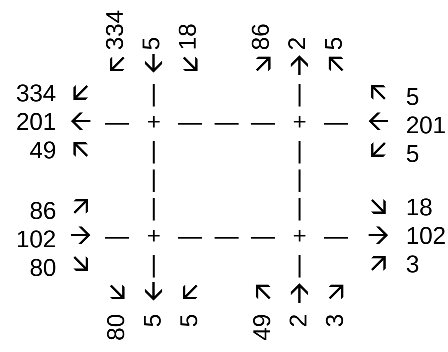
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Future Traffic Volumes
A.M. Peak Hour

Blackwell and Shenandoah



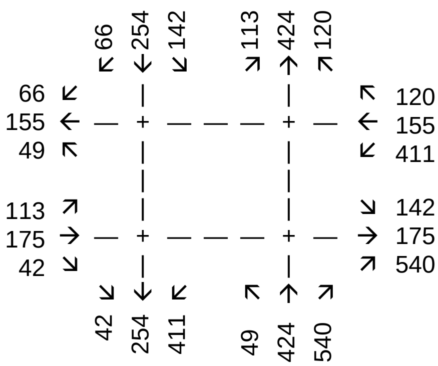
Shenandoah and Access Road



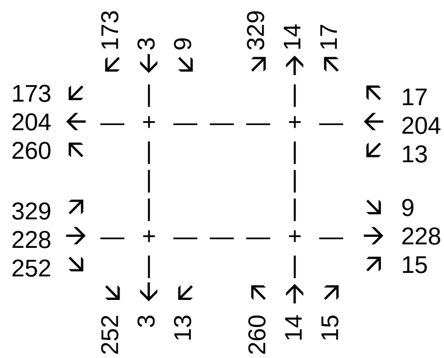
Lee's Summit Apartments Traffic Impact Study
Lee's Summit, Missouri

Future Traffic Volumes
P.M. Peak Hour

Blackwell and Shenandoah



Shenandoah and Access Road



Appendix C – Peak Hour Capacity Analysis Reports

See attached reports.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah AM Existing]

New Site
Roundabout

Intersection Performance - Hourly Values

Performance Measure	Vehicles		Persons	
Travel Speed (Average)	35.1	mph	35.1	mph
Travel Distance (Total)	401.0	veh-mi/h	481.2	pers-mi/h
Travel Time (Total)	11.4	veh-h/h	13.7	pers-h/h
Demand Flows (Total)	624	veh/h	749	pers/h
Percent Heavy Vehicles (Demand)	3.0	%		
Degree of Saturation	0.156			
Practical Spare Capacity	446.3	%		
Effective Intersection Capacity	4010	veh/h		
Control Delay (Total)	0.81	veh-h/h	0.97	pers-h/h
Control Delay (Average)	4.6	sec	4.6	sec
Control Delay (Worst Lane)	4.8	sec		
Control Delay (Worst Movement)	5.2	sec	5.2	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	4.6	sec		
Idling Time (Average)	3.5	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	0.6	veh		
95% Back of Queue - Distance (Worst Lane)	15.2	ft		
Queue Storage Ratio (Worst Lane)	0.01			
Total Effective Stops	70	veh/h	84	pers/h
Effective Stop Rate	0.11	per veh	0.11	per pers
Proportion Queued	0.19		0.19	
Performance Index	13.9		13.9	
Cost (Total)	162.83	$/h	162.83	$/h
Fuel Consumption (Total)	15.6	gal/h		
Carbon Dioxide (Total)	139.9	kg/h		
Hydrocarbons (Total)	0.012	kg/h		
Carbon Monoxide (Total)	0.172	kg/h		
NOx (Total)	0.211	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values

Performance Measure	Vehicles		Persons	
Demand Flows (Total)	299,478	veh/y	359,374	pers/y
Delay	386	veh-h/y	464	pers-h/y
Effective Stops	33,502	veh/y	40,202	pers/y
Travel Distance	192,475	veh-mi/y	230,971	pers-mi/y
Travel Time	5,484	veh-h/y	6,581	pers-h/y
Cost	78,160	$/y	78,160	$/y
Fuel Consumption	7,492	gal/y		
Carbon Dioxide	67,161	kg/y		
Hydrocarbons	6	kg/y		
Carbon Monoxide	83	kg/y		
NOx	101	kg/y		

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah AM Existing]

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	36	3.0	0.156	4.8	LOS A	0.6	15.2	0.15	0.06	35.6
8	T1	127	3.0	0.156	4.8	LOS A	0.6	15.2	0.15	0.06	35.3
18	R2	34	3.0	0.031	3.6	LOS A	0.1	2.7	0.07	0.02	35.4
Approach		197	3.0	0.156	4.6	LOS A	0.6	15.2	0.13	0.05	35.3
East: Shenandoah Drive											
1	L2	97	3.0	0.062	4.4	LOS A	0.2	4.1	0.23	0.15	33.8
6	T1	9	3.0	0.062	4.1	LOS A	0.2	4.1	0.23	0.14	34.1
16	R2	12	3.0	0.062	4.1	LOS A	0.2	4.1	0.23	0.14	32.9
Approach		117	3.0	0.062	4.4	LOS A	0.2	4.1	0.23	0.15	33.8
North: Blackwell Road											
7	L2	5	3.0	0.124	5.2	LOS A	0.3	8.3	0.20	0.12	36.3
4	T1	193	3.0	0.124	4.8	LOS A	0.3	8.3	0.20	0.12	36.1
14	R2	47	3.0	0.124	4.8	LOS A	0.3	8.3	0.20	0.12	34.8
Approach		246	3.0	0.124	4.8	LOS A	0.3	8.3	0.20	0.12	35.8
West: Shenandoah Drive											
5	L2	29	3.0	0.072	4.7	LOS A	0.2	4.6	0.28	0.21	34.8
2	T1	10	3.0	0.072	4.7	LOS A	0.2	4.6	0.28	0.21	34.6
12	R2	25	3.0	0.072	4.7	LOS A	0.2	4.6	0.28	0.21	33.5
Approach		64	3.0	0.072	4.7	LOS A	0.2	4.6	0.28	0.21	34.2
All Vehicles		624	3.0	0.156	4.6	LOS A	0.6	15.2	0.19	0.11	35.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah PM Existing]

New Site
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	34.6	mph	34.6	mph
Travel Distance (Total)	607.7	veh-mi/h	729.2	pers-mi/h
Travel Time (Total)	17.6	veh-h/h	21.1	pers-h/h
Demand Flows (Total)	949	veh/h	1139	pers/h
Percent Heavy Vehicles (Demand)	3.0	%		
Degree of Saturation	0.341			
Practical Spare Capacity	149.3	%		
Effective Intersection Capacity	2783	veh/h		
Control Delay (Total)	1.52	veh-h/h	1.82	pers-h/h
Control Delay (Average)	5.8	sec	5.8	sec
Control Delay (Worst Lane)	7.3	sec		
Control Delay (Worst Movement)	7.3	sec	7.3	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	5.8	sec		
Idling Time (Average)	4.2	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	1.6	veh		
95% Back of Queue - Distance (Worst Lane)	40.2	ft		
Queue Storage Ratio (Worst Lane)	0.03			
Total Effective Stops	165	veh/h	198	pers/h
Effective Stop Rate	0.17	per veh	0.17	per pers
Proportion Queued	0.26		0.26	
Performance Index	22.7		22.7	
Cost (Total)	250.68	$/h	250.68	$/h
Fuel Consumption (Total)	23.9	gal/h		
Carbon Dioxide (Total)	214.3	kg/h		
Hydrocarbons (Total)	0.018	kg/h		
Carbon Monoxide (Total)	0.264	kg/h		
NOx (Total)	0.324	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	455,478	veh/y	546,574	pers/y
Delay	729	veh-h/y	874	pers-h/y
Effective Stops	79,074	veh/y	94,888	pers/y
Travel Distance	291,685	veh-mi/y	350,022	pers-mi/y
Travel Time	8,437	veh-h/y	10,124	pers-h/y
Cost	120,329	$/y	120,329	$/y
Fuel Consumption	11,472	gal/y		
Carbon Dioxide	102,843	kg/y		
Hydrocarbons	9	kg/y		
Carbon Monoxide	127	kg/y		
NOx	156	kg/y		

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah PM Existing]

New Site
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	35	3.0	0.341	7.3	LOS A	1.6	40.2	0.31	0.19	34.7
8	T1	298	3.0	0.341	7.3	LOS A	1.6	40.2	0.31	0.19	34.4
18	R2	120	3.0	0.113	4.4	LOS A	0.4	10.6	0.12	0.04	34.9
Approach		452	3.0	0.341	6.5	LOS A	1.6	40.2	0.26	0.15	34.5
East: Shenandoah Drive											
1	L2	86	3.0	0.080	5.4	LOS A	0.2	5.4	0.35	0.30	33.5
6	T1	27	3.0	0.080	5.0	LOS A	0.2	5.2	0.34	0.29	34.7
16	R2	15	3.0	0.080	5.0	LOS A	0.2	5.2	0.34	0.29	33.4
Approach		128	3.0	0.080	5.3	LOS A	0.2	5.4	0.35	0.30	33.7
North: Blackwell Road											
7	L2	16	3.0	0.122	5.2	LOS A	0.3	8.2	0.20	0.12	35.9
4	T1	178	3.0	0.122	4.7	LOS A	0.3	8.2	0.20	0.12	35.9
14	R2	47	3.0	0.122	4.8	LOS A	0.3	8.1	0.20	0.12	34.8
Approach		241	3.0	0.122	4.8	LOS A	0.3	8.2	0.20	0.12	35.7
West: Shenandoah Drive											
5	L2	79	3.0	0.142	5.4	LOS A	0.4	9.6	0.29	0.23	34.0
2	T1	18	3.0	0.142	5.4	LOS A	0.4	9.6	0.29	0.23	33.7
12	R2	29	3.0	0.142	5.4	LOS A	0.4	9.6	0.29	0.23	32.7
Approach		127	3.0	0.142	5.4	LOS A	0.4	9.6	0.29	0.23	33.6
All Vehicles		949	3.0	0.341	5.8	LOS A	1.6	40.2	0.26	0.17	34.6

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah AM Existing + Development]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	34.3 mph	34.3 mph
Travel Distance (Total)	601.4 veh-mi/h	721.6 pers-mi/h
Travel Time (Total)	17.5 veh-h/h	21.0 pers-h/h
Demand Flows (Total)	933 veh/h	1119 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.192	
Practical Spare Capacity	342.5 %	
Effective Intersection Capacity	4855 veh/h	
Control Delay (Total)	1.40 veh-h/h	1.68 pers-h/h
Control Delay (Average)	5.4 sec	5.4 sec
Control Delay (Worst Lane)	5.8 sec	
Control Delay (Worst Movement)	6.3 sec	6.3 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	5.4 sec	
Idling Time (Average)	4.0 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	0.6 veh	
95% Back of Queue - Distance (Worst Lane)	15.4 ft	
Queue Storage Ratio (Worst Lane)	0.01	
Total Effective Stops	180 veh/h	216 pers/h
Effective Stop Rate	0.19 per veh	0.19 per pers
Proportion Queued	0.26	0.26
Performance Index	21.5	21.5
Cost (Total)	256.21 $/h	256.21 $/h
Fuel Consumption (Total)	24.1 gal/h	
Carbon Dioxide (Total)	216.3 kg/h	
Hydrocarbons (Total)	0.019 kg/h	
Carbon Monoxide (Total)	0.264 kg/h	
NOx (Total)	0.328 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	447,652 veh/y	537,183 pers/y
Delay	674 veh-h/y	809 pers-h/y
Effective Stops	86,487 veh/y	103,784 pers/y
Travel Distance	288,658 veh-mi/y	346,389 pers-mi/y
Travel Time	8,406 veh-h/y	10,087 pers-h/y
Cost	122,981 $/y	122,981 $/y
Fuel Consumption	11,583 gal/y	
Carbon Dioxide	103,820 kg/y	
Hydrocarbons	9 kg/y	
Carbon Monoxide	127 kg/y	
NOx	157 kg/y	

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah AM Existing + Development]

New Site
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	36	3.0	0.158	4.9	LOS A	0.6	15.4	0.18	0.08	35.6
8	T1	127	3.0	0.158	4.9	LOS A	0.6	15.4	0.18	0.08	35.2
18	R2	79	3.0	0.075	4.0	LOS A	0.3	6.7	0.11	0.04	35.1
Approach		242	3.0	0.158	4.6	LOS A	0.6	15.4	0.16	0.06	35.2
East: Shenandoah Drive											
1	L2	278	3.0	0.192	5.7	LOS A	0.6	14.5	0.26	0.19	33.3
6	T1	48	3.0	0.192	5.4	LOS A	0.6	14.1	0.26	0.18	33.9
16	R2	38	3.0	0.192	5.4	LOS A	0.6	14.1	0.26	0.18	32.7
Approach		364	3.0	0.192	5.7	LOS A	0.6	14.5	0.26	0.18	33.3
North: Blackwell Road											
7	L2	12	3.0	0.149	6.3	LOS A	0.4	10.2	0.34	0.29	35.5
4	T1	193	3.0	0.149	5.7	LOS A	0.4	10.2	0.34	0.29	35.4
14	R2	47	3.0	0.149	5.8	LOS A	0.4	10.1	0.33	0.29	34.3
Approach		252	3.0	0.149	5.8	LOS A	0.4	10.2	0.34	0.29	35.2
West: Shenandoah Drive											
5	L2	29	3.0	0.095	5.6	LOS A	0.2	6.2	0.37	0.33	34.5
2	T1	20	3.0	0.095	5.6	LOS A	0.2	6.2	0.37	0.33	34.3
12	R2	25	3.0	0.095	5.6	LOS A	0.2	6.2	0.37	0.33	33.2
Approach		74	3.0	0.095	5.6	LOS A	0.2	6.2	0.37	0.33	34.0
All Vehicles		933	3.0	0.192	5.4	LOS A	0.6	15.4	0.26	0.19	34.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Shenandoah Access AM Existing + Development]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	33.3 mph	33.3 mph
Travel Distance (Total)	287.9 veh-mi/h	345.5 pers-mi/h
Travel Time (Total)	8.6 veh-h/h	10.4 pers-h/h
Demand Flows (Total)	463 veh/h	556 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.259	
Practical Spare Capacity	227.7 %	
Effective Intersection Capacity	1785 veh/h	
Control Delay (Total)	0.68 veh-h/h	0.82 pers-h/h
Control Delay (Average)	5.3 sec	5.3 sec
Control Delay (Worst Lane)	6.2 sec	
Control Delay (Worst Movement)	6.2 sec	6.2 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	5.3 sec	
Idling Time (Average)	4.5 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	1.1 veh	
95% Back of Queue - Distance (Worst Lane)	28.0 ft	
Queue Storage Ratio (Worst Lane)	0.02	
Total Effective Stops	44 veh/h	53 pers/h
Effective Stop Rate	0.10 per veh	0.10 per pers
Proportion Queued	0.19	0.19
Performance Index	11.0	11.0
Cost (Total)	121.08 $/h	121.08 $/h
Fuel Consumption (Total)	11.8 gal/h	
Carbon Dioxide (Total)	105.4 kg/h	
Hydrocarbons (Total)	0.009 kg/h	
Carbon Monoxide (Total)	0.131 kg/h	
NOx (Total)	0.164 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	222,261 veh/y	266,713 pers/y
Delay	329 veh-h/y	394 pers-h/y
Effective Stops	21,238 veh/y	25,486 pers/y
Travel Distance	138,213 veh-mi/y	165,856 pers-mi/y
Travel Time	4,150 veh-h/y	4,980 pers-h/y
Cost	58,120 $/y	58,120 $/y
Fuel Consumption	5,644 gal/y	
Carbon Dioxide	50,590 kg/y	
Hydrocarbons	4 kg/y	
Carbon Monoxide	63 kg/y	
NOx	79 kg/y	

MOVEMENT SUMMARY

Site: 101 [Shenandoah Access AM Existing + Development]

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
East: Shenandoah Drive											
6	T1	92	3.0	0.093	4.3	LOS A	0.3	8.5	0.17	0.07	34.6
16	R2	3	3.0	0.093	4.3	LOS A	0.3	8.5	0.17	0.07	33.8
Approach		96	3.0	0.093	4.3	LOS A	0.3	8.5	0.17	0.07	34.6
North: Access Road											
7	L2	13	3.0	0.259	6.2	LOS A	1.1	28.0	0.25	0.14	33.5
14	R2	246	3.0	0.259	6.2	LOS A	1.1	28.0	0.25	0.14	32.8
Approach		259	3.0	0.259	6.2	LOS A	1.1	28.0	0.25	0.14	32.9
West: Shenandoah Drive											
5	L2	62	3.0	0.100	4.2	LOS A	0.4	9.3	0.07	0.02	33.3
2	T1	47	3.0	0.100	4.2	LOS A	0.4	9.3	0.07	0.02	33.4
Approach		109	3.0	0.100	4.2	LOS A	0.4	9.3	0.07	0.02	33.3
All Vehicles		463	3.0	0.259	5.3	LOS A	1.1	28.0	0.19	0.10	33.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah PM Existing + Development]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	34.0 mph	34.0 mph
Travel Distance (Total)	836.7 veh-mi/h	1004.1 pers-mi/h
Travel Time (Total)	24.6 veh-h/h	29.6 pers-h/h
Demand Flows (Total)	1309 veh/h	1570 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.363	
Practical Spare Capacity	133.8 %	
Effective Intersection Capacity	3600 veh/h	
Control Delay (Total)	2.40 veh-h/h	2.87 pers-h/h
Control Delay (Average)	6.6 sec	6.6 sec
Control Delay (Worst Lane)	8.0 sec	
Control Delay (Worst Movement)	8.0 sec	8.0 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	6.6 sec	
Idling Time (Average)	4.7 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	1.7 veh	
95% Back of Queue - Distance (Worst Lane)	42.6 ft	
Queue Storage Ratio (Worst Lane)	0.04	
Total Effective Stops	337 veh/h	404 pers/h
Effective Stop Rate	0.26 per veh	0.26 per pers
Proportion Queued	0.34	0.34
Performance Index	32.2	32.2
Cost (Total)	356.19 $/h	356.19 $/h
Fuel Consumption (Total)	33.6 gal/h	
Carbon Dioxide (Total)	301.5 kg/h	
Hydrocarbons (Total)	0.026 kg/h	
Carbon Monoxide (Total)	0.370 kg/h	
NOx (Total)	0.458 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	628,174 veh/y	753,809 pers/y
Delay	1,150 veh-h/y	1,380 pers-h/y
Effective Stops	161,667 veh/y	194,001 pers/y
Travel Distance	401,624 veh-mi/y	481,949 pers-mi/y
Travel Time	11,825 veh-h/y	14,190 pers-h/y
Cost	170,972 $/y	170,972 $/y
Fuel Consumption	16,145 gal/y	
Carbon Dioxide	144,717 kg/y	
Hydrocarbons	13 kg/y	
Carbon Monoxide	177 kg/y	
NOx	220 kg/y	

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah PM Existing + Development]

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	35	3.0	0.363	8.0	LOS A	1.7	42.6	0.39	0.29	34.4
8	T1	298	3.0	0.363	8.0	LOS A	1.7	42.6	0.39	0.29	34.0
18	R2	292	3.0	0.294	6.6	LOS A	1.3	33.1	0.27	0.15	33.7
Approach		625	3.0	0.363	7.3	LOS A	1.7	42.6	0.33	0.22	33.9
East: Shenandoah Drive											
1	L2	178	3.0	0.158	6.2	LOS A	0.4	11.3	0.38	0.34	33.1
6	T1	47	3.0	0.158	5.8	LOS A	0.4	11.0	0.37	0.33	34.0
16	R2	28	3.0	0.158	5.8	LOS A	0.4	11.0	0.37	0.33	32.8
Approach		253	3.0	0.158	6.1	LOS A	0.4	11.3	0.37	0.34	33.2
North: Blackwell Road											
7	L2	41	3.0	0.147	5.7	LOS A	0.4	10.1	0.29	0.22	35.0
4	T1	178	3.0	0.147	5.3	LOS A	0.4	10.1	0.28	0.22	35.3
14	R2	47	3.0	0.147	5.4	LOS A	0.4	9.9	0.28	0.21	34.5
Approach		266	3.0	0.147	5.4	LOS A	0.4	10.1	0.28	0.22	35.1
West: Shenandoah Drive											
5	L2	79	3.0	0.199	6.5	LOS A	0.5	14.0	0.36	0.33	33.9
2	T1	55	3.0	0.199	6.5	LOS A	0.5	14.0	0.36	0.33	33.6
12	R2	29	3.0	0.199	6.5	LOS A	0.5	14.0	0.36	0.33	32.6
Approach		164	3.0	0.199	6.5	LOS A	0.5	14.0	0.36	0.33	33.6
All Vehicles		1309	3.0	0.363	6.6	LOS A	1.7	42.6	0.34	0.26	34.0

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Shenandoah Access PM Existing + Development]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	32.7 mph	32.7 mph
Travel Distance (Total)	362.0 veh-mi/h	434.4 pers-mi/h
Travel Time (Total)	11.1 veh-h/h	13.3 pers-h/h
Demand Flows (Total)	576 veh/h	691 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.311	
Practical Spare Capacity	173.1 %	
Effective Intersection Capacity	1851 veh/h	
Control Delay (Total)	0.93 veh-h/h	1.12 pers-h/h
Control Delay (Average)	5.8 sec	5.8 sec
Control Delay (Worst Lane)	6.3 sec	
Control Delay (Worst Movement)	6.3 sec	6.3 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	5.8 sec	
Idling Time (Average)	5.1 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	1.5 veh	
95% Back of Queue - Distance (Worst Lane)	37.2 ft	
Queue Storage Ratio (Worst Lane)	0.03	
Total Effective Stops	46 veh/h	55 pers/h
Effective Stop Rate	0.08 per veh	0.08 per pers
Proportion Queued	0.15	0.15
Performance Index	14.1	14.1
Cost (Total)	157.01 $/h	157.01 $/h
Fuel Consumption (Total)	14.9 gal/h	
Carbon Dioxide (Total)	133.5 kg/h	
Hydrocarbons (Total)	0.012 kg/h	
Carbon Monoxide (Total)	0.164 kg/h	
NOx (Total)	0.207 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	276,522 veh/y	331,826 pers/y
Delay	447 veh-h/y	536 pers-h/y
Effective Stops	22,083 veh/y	26,499 pers/y
Travel Distance	173,744 veh-mi/y	208,492 pers-mi/y
Travel Time	5,313 veh-h/y	6,376 pers-h/y
Cost	75,365 $/y	75,365 $/y
Fuel Consumption	7,151 gal/y	
Carbon Dioxide	64,100 kg/y	
Hydrocarbons	6 kg/y	
Carbon Monoxide	79 kg/y	
NOx	99 kg/y	

MOVEMENT SUMMARY

Site: 101 [Shenandoah Access PM Existing + Development]

New Site
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
East: Shenandoah Drive											
6	T1	93	3.0	0.122	5.4	LOS A	0.4	11.1	0.36	0.26	34.1
16	R2	12	3.0	0.122	5.4	LOS A	0.4	11.1	0.36	0.26	33.3
Approach		105	3.0	0.122	5.4	LOS A	0.4	11.1	0.36	0.26	34.0
North: Access Road											
7	L2	7	3.0	0.132	4.8	LOS A	0.5	12.4	0.22	0.11	34.2
14	R2	125	3.0	0.132	4.8	LOS A	0.5	12.4	0.22	0.11	33.5
Approach		132	3.0	0.132	4.8	LOS A	0.5	12.4	0.22	0.11	33.5
West: Shenandoah Drive											
5	L2	235	3.0	0.311	6.3	LOS A	1.5	37.2	0.06	0.01	32.0
2	T1	104	3.0	0.311	6.3	LOS A	1.5	37.2	0.06	0.01	32.1
Approach		339	3.0	0.311	6.3	LOS A	1.5	37.2	0.06	0.01	32.0
All Vehicles		576	3.0	0.311	5.8	LOS A	1.5	37.2	0.15	0.08	32.7

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah AM Future]

New Site
Roundabout

Intersection Performance - Hourly Values

Performance Measure	Vehicles	Persons
Travel Speed (Average)	33.2 mph	33.2 mph
Travel Distance (Total)	1051.0 veh-mi/h	1261.2 pers-mi/h
Travel Time (Total)	31.6 veh-h/h	37.9 pers-h/h
Demand Flows (Total)	1635 veh/h	1962 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.381	
Practical Spare Capacity	123.0 %	
Effective Intersection Capacity	4288 veh/h	
Control Delay (Total)	3.56 veh-h/h	4.27 pers-h/h
Control Delay (Average)	7.8 sec	7.8 sec
Control Delay (Worst Lane)	8.6 sec	
Control Delay (Worst Movement)	9.0 sec	9.0 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	7.8 sec	
Idling Time (Average)	5.6 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	1.3 veh	
95% Back of Queue - Distance (Worst Lane)	34.4 ft	
Queue Storage Ratio (Worst Lane)	0.03	
Total Effective Stops	565 veh/h	678 pers/h
Effective Stop Rate	0.35 per veh	0.35 per pers
Proportion Queued	0.39	0.39
Performance Index	42.0	42.0
Cost (Total)	467.87 $/h	467.87 $/h
Fuel Consumption (Total)	43.3 gal/h	
Carbon Dioxide (Total)	387.6 kg/h	
Hydrocarbons (Total)	0.034 kg/h	
Carbon Monoxide (Total)	0.471 kg/h	
NOx (Total)	0.588 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values

Performance Measure	Vehicles	Persons
Demand Flows (Total)	784,696 veh/y	941,635 pers/y
Delay	1,708 veh-h/y	2,050 pers-h/y
Effective Stops	271,386 veh/y	325,663 pers/y
Travel Distance	504,472 veh-mi/y	605,366 pers-mi/y
Travel Time	15,179 veh-h/y	18,214 pers-h/y
Cost	224,580 $/y	224,580 $/y
Fuel Consumption	20,760 gal/y	
Carbon Dioxide	186,064 kg/y	
Hydrocarbons	16 kg/y	
Carbon Monoxide	226 kg/y	
NOx	282 kg/y	

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah AM Future]

New Site
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	55	3.0	0.267	6.5	LOS A	1.1	28.5	0.32	0.21	34.7
8	T1	197	3.0	0.267	6.5	LOS A	1.1	28.5	0.32	0.21	34.4
18	R2	172	3.0	0.174	5.3	LOS A	0.7	17.0	0.24	0.13	34.4
Approach		424	3.0	0.267	6.0	LOS A	1.1	28.5	0.29	0.18	34.4
East: Shenandoah Drive											
1	L2	410	3.0	0.381	8.6	LOS A	1.3	34.4	0.40	0.35	32.0
6	T1	139	3.0	0.381	8.3	LOS A	1.3	33.0	0.39	0.34	33.4
16	R2	120	3.0	0.381	8.3	LOS A	1.3	33.0	0.39	0.34	32.2
Approach		668	3.0	0.381	8.5	LOS A	1.3	34.4	0.39	0.35	32.3
North: Blackwell Road											
7	L2	29	3.0	0.273	9.0	LOS A	0.8	20.1	0.47	0.47	34.0
4	T1	299	3.0	0.273	8.3	LOS A	0.8	20.1	0.47	0.47	34.0
14	R2	58	3.0	0.273	8.3	LOS A	0.8	19.9	0.47	0.47	33.0
Approach		386	3.0	0.273	8.3	LOS A	0.8	20.1	0.47	0.47	33.8
West: Shenandoah Drive											
5	L2	46	3.0	0.243	8.6	LOS A	0.7	17.1	0.49	0.49	33.4
2	T1	72	3.0	0.243	8.6	LOS A	0.7	17.1	0.49	0.49	33.2
12	R2	39	3.0	0.243	8.6	LOS A	0.7	17.1	0.49	0.49	32.2
Approach		157	3.0	0.243	8.6	LOS A	0.7	17.1	0.49	0.49	33.0
All Vehicles		1635	3.0	0.381	7.8	LOS A	1.3	34.4	0.39	0.35	33.2

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Shenandoah Access AM Future]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	32.3 mph	32.3 mph
Travel Distance (Total)	602.5 veh-mi/h	723.0 pers-mi/h
Travel Time (Total)	18.7 veh-h/h	22.4 pers-h/h
Demand Flows (Total)	967 veh/h	1161 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.471	
Practical Spare Capacity	80.6 %	
Effective Intersection Capacity	2056 veh/h	
Control Delay (Total)	2.00 veh-h/h	2.40 pers-h/h
Control Delay (Average)	7.5 sec	7.5 sec
Control Delay (Worst Lane)	10.5 sec	
Control Delay (Worst Movement)	10.5 sec	10.5 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	7.5 sec	
Idling Time (Average)	5.9 sec	
Intersection Level of Service (LOS)	LOS A	
95% Back of Queue - Vehicles (Worst Lane)	2.4 veh	
95% Back of Queue - Distance (Worst Lane)	60.7 ft	
Queue Storage Ratio (Worst Lane)	0.05	
Total Effective Stops	256 veh/h	307 pers/h
Effective Stop Rate	0.26 per veh	0.26 per pers
Proportion Queued	0.34	0.34
Performance Index	28.6	28.6
Cost (Total)	264.61 $/h	264.61 $/h
Fuel Consumption (Total)	25.1 gal/h	
Carbon Dioxide (Total)	224.6 kg/h	
Hydrocarbons (Total)	0.020 kg/h	
Carbon Monoxide (Total)	0.277 kg/h	
NOx (Total)	0.349 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	464,348 veh/y	557,217 pers/y
Delay	961 veh-h/y	1,153 pers-h/y
Effective Stops	122,744 veh/y	147,293 pers/y
Travel Distance	289,188 veh-mi/y	347,026 pers-mi/y
Travel Time	8,953 veh-h/y	10,744 pers-h/y
Cost	127,012 $/y	127,012 $/y
Fuel Consumption	12,030 gal/y	
Carbon Dioxide	107,826 kg/y	
Hydrocarbons	9 kg/y	
Carbon Monoxide	133 kg/y	
NOx	168 kg/y	

MOVEMENT SUMMARY

Site: 101 [Shenandoah Access AM Future]

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Access Road											
3	L2	53	3.0	0.067	4.8	LOS A	0.2	5.9	0.33	0.22	32.3
8	T1	2	3.0	0.067	4.8	LOS A	0.2	5.9	0.33	0.22	32.4
18	R2	3	3.0	0.067	4.8	LOS A	0.2	5.9	0.33	0.22	31.7
Approach		59	3.0	0.067	4.8	LOS A	0.2	5.9	0.33	0.22	32.3
East: Shenandoah Drive											
1	L2	5	3.0	0.244	6.3	LOS A	1.0	25.4	0.32	0.21	33.4
6	T1	218	3.0	0.244	6.3	LOS A	1.0	25.4	0.32	0.21	33.5
16	R2	5	3.0	0.244	6.3	LOS A	1.0	25.4	0.32	0.21	32.8
Approach		229	3.0	0.244	6.3	LOS A	1.0	25.4	0.32	0.21	33.5
North: Access Road											
7	L2	20	3.0	0.471	10.5	LOS B	2.4	60.7	0.54	0.48	31.4
4	T1	5	3.0	0.471	10.5	LOS B	2.4	60.7	0.54	0.48	31.5
14	R2	363	3.0	0.471	10.5	LOS B	2.4	60.7	0.54	0.48	30.8
Approach		388	3.0	0.471	10.5	LOS B	2.4	60.7	0.54	0.48	30.9
West: Shenandoah Drive											
5	L2	93	3.0	0.192	5.2	LOS A	0.8	19.6	0.12	0.04	33.0
2	T1	111	3.0	0.192	5.2	LOS A	0.8	19.6	0.12	0.04	33.2
12	R2	87	3.0	0.080	4.0	LOS A	0.3	7.3	0.06	0.01	34.1
Approach		291	3.0	0.192	4.8	LOS A	0.8	19.6	0.10	0.03	33.4
All Vehicles		967	3.0	0.471	7.5	LOS A	2.4	60.7	0.34	0.26	32.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Blackwell Shenandoah PM Future]

New Site
Roundabout

Intersection Performance - Hourly Values

Performance Measure	Vehicles		Persons	
Travel Speed (Average)	29.1	mph	29.1	mph
Travel Distance (Total)	1732.9	veh-mi/h	2079.5	pers-mi/h
Travel Time (Total)	59.5	veh-h/h	71.3	pers-h/h
Demand Flows (Total)	2708	veh/h	3249	pers/h
Percent Heavy Vehicles (Demand)	3.0	%		
Degree of Saturation	0.763			
Practical Spare Capacity	11.4	%		
Effective Intersection Capacity	3549	veh/h		
Control Delay (Total)	13.24	veh-h/h	15.88	pers-h/h
Control Delay (Average)	17.6	sec	17.6	sec
Control Delay (Worst Lane)	23.8	sec		
Control Delay (Worst Movement)	23.8	sec	23.8	sec
Geometric Delay (Average)	0.0	sec		
Stop-Line Delay (Average)	17.6	sec		
Idling Time (Average)	12.4	sec		
Intersection Level of Service (LOS)	LOS C			
95% Back of Queue - Vehicles (Worst Lane)	7.2	veh		
95% Back of Queue - Distance (Worst Lane)	184.2	ft		
Queue Storage Ratio (Worst Lane)	0.15			
Total Effective Stops	2086	veh/h	2503	pers/h
Effective Stop Rate	0.77	per veh	0.77	per pers
Proportion Queued	0.69		0.69	
Performance Index	99.2		99.2	
Cost (Total)	897.66	$/h	897.66	$/h
Fuel Consumption (Total)	76.7	gal/h		
Carbon Dioxide (Total)	686.9	kg/h		
Hydrocarbons (Total)	0.062	kg/h		
Carbon Monoxide (Total)	0.822	kg/h		
NOx (Total)	1.043	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values

Performance Measure	Vehicles		Persons	
Demand Flows (Total)	1,299,652	veh/y	1,559,583	pers/y
Delay	6,353	veh-h/y	7,624	pers-h/y
Effective Stops	1,001,385	veh/y	1,201,662	pers/y
Travel Distance	831,809	veh-mi/y	998,171	pers-mi/y
Travel Time	28,537	veh-h/y	34,244	pers-h/y
Cost	430,876	$/y	430,876	$/y
Fuel Consumption	36,798	gal/y		
Carbon Dioxide	329,720	kg/y		
Hydrocarbons	30	kg/y		
Carbon Monoxide	395	kg/y		
NOx	501	kg/y		

MOVEMENT SUMMARY

Site: 101 [Blackwell Shenandoah PM Future]

New Site
Roundabout

Movement Performance - Vehicles											
Mov ID	OD Mov	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Blackwell Road											
3	L2	53	3.0	0.758	23.8	LOS C	6.4	163.2	0.83	0.97	27.8
8	T1	461	3.0	0.758	23.8	LOS C	6.4	163.2	0.83	0.97	27.6
18	R2	587	3.0	0.763	21.9	LOS C	7.2	184.2	0.82	0.93	27.4
Approach		1101	3.0	0.763	22.8	LOS C	7.2	184.2	0.82	0.95	27.5
East: Shenandoah Drive											
1	L2	447	3.0	0.549	14.5	LOS B	2.4	61.6	0.62	0.67	29.6
6	T1	168	3.0	0.549	13.9	LOS B	2.3	59.6	0.60	0.65	30.9
16	R2	130	3.0	0.549	13.9	LOS B	2.3	59.6	0.60	0.65	29.8
Approach		746	3.0	0.549	14.3	LOS B	2.4	61.6	0.61	0.66	29.9
North: Blackwell Road											
7	L2	154	3.0	0.375	10.8	LOS B	1.3	32.1	0.54	0.56	31.7
4	T1	276	3.0	0.375	10.2	LOS B	1.3	32.1	0.53	0.54	32.6
14	R2	72	3.0	0.375	10.3	LOS B	1.2	31.2	0.52	0.54	32.1
Approach		502	3.0	0.375	10.4	LOS B	1.3	32.1	0.53	0.55	32.3
West: Shenandoah Drive											
5	L2	123	3.0	0.615	18.6	LOS C	2.6	67.7	0.69	0.76	29.1
2	T1	190	3.0	0.615	18.6	LOS C	2.6	67.7	0.69	0.76	28.9
12	R2	46	3.0	0.615	18.6	LOS C	2.6	67.7	0.69	0.76	28.1
Approach		359	3.0	0.615	18.6	LOS C	2.6	67.7	0.69	0.76	28.9
All Vehicles		2708	3.0	0.763	17.6	LOS C	7.2	184.2	0.69	0.77	29.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

INTERSECTION SUMMARY

Site: 101 [Shenandoah Access PM Future]

New Site
Roundabout

Intersection Performance - Hourly Values		
Performance Measure	**Vehicles**	**Persons**
Travel Speed (Average)	29.5 mph	29.5 mph
Travel Distance (Total)	1034.5 veh-mi/h	1241.4 pers-mi/h
Travel Time (Total)	35.1 veh-h/h	42.1 pers-h/h
Demand Flows (Total)	1649 veh/h	1979 pers/h
Percent Heavy Vehicles (Demand)	3.0 %	
Degree of Saturation	0.702	
Practical Spare Capacity	21.1 %	
Effective Intersection Capacity	2350 veh/h	
Control Delay (Total)	6.10 veh-h/h	7.32 pers-h/h
Control Delay (Average)	13.3 sec	13.3 sec
Control Delay (Worst Lane)	15.9 sec	
Control Delay (Worst Movement)	15.9 sec	15.9 sec
Geometric Delay (Average)	0.0 sec	
Stop-Line Delay (Average)	13.3 sec	
Idling Time (Average)	10.9 sec	
Intersection Level of Service (LOS)	LOS B	
95% Back of Queue - Vehicles (Worst Lane)	6.8 veh	
95% Back of Queue - Distance (Worst Lane)	173.9 ft	
Queue Storage Ratio (Worst Lane)	0.14	
Total Effective Stops	646 veh/h	776 pers/h
Effective Stop Rate	0.39 per veh	0.39 per pers
Proportion Queued	0.46	0.46
Performance Index	64.1	64.1
Cost (Total)	514.80 $/h	514.80 $/h
Fuel Consumption (Total)	45.2 gal/h	
Carbon Dioxide (Total)	405.3 kg/h	
Hydrocarbons (Total)	0.036 kg/h	
Carbon Monoxide (Total)	0.491 kg/h	
NOx (Total)	0.621 kg/h	

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.

Intersection Performance - Annual Values		
Performance Measure	**Vehicles**	**Persons**
Demand Flows (Total)	791,478 veh/y	949,774 pers/y
Delay	2,928 veh-h/y	3,514 pers-h/y
Effective Stops	310,237 veh/y	372,284 pers/y
Travel Distance	496,554 veh-mi/y	595,864 pers-mi/y
Travel Time	16,834 veh-h/y	20,200 pers-h/y
Cost	247,104 $/y	247,104 $/y
Fuel Consumption	21,708 gal/y	
Carbon Dioxide	194,531 kg/y	
Hydrocarbons	17 kg/y	
Carbon Monoxide	236 kg/y	
NOx	298 kg/y	

MOVEMENT SUMMARY

Site: 101 [Shenandoah Access PM Future]

New Site
Roundabout

Movement Performance - Vehicles

Mov ID	OD Mov	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate per veh	Average Speed mph
South: Access Road											
3	L2	283	3.0	0.540	15.9	LOS C	2.8	71.1	0.71	0.77	27.9
8	T1	15	3.0	0.540	15.9	LOS C	2.8	71.1	0.71	0.77	28.0
18	R2	16	3.0	0.540	15.9	LOS C	2.8	71.1	0.71	0.77	27.5
Approach		314	3.0	0.540	15.9	LOS C	2.8	71.1	0.71	0.77	27.9
East: Shenandoah Drive											
1	L2	14	3.0	0.455	14.0	LOS B	2.1	52.6	0.67	0.72	29.9
6	T1	222	3.0	0.455	14.0	LOS B	2.1	52.6	0.67	0.72	30.0
16	R2	18	3.0	0.455	14.0	LOS B	2.1	52.6	0.67	0.72	29.4
Approach		254	3.0	0.455	14.0	LOS B	2.1	52.6	0.67	0.72	30.0
North: Access Road											
7	L2	10	3.0	0.313	9.7	LOS A	1.2	30.5	0.58	0.58	31.8
4	T1	3	3.0	0.313	9.7	LOS A	1.2	30.5	0.58	0.58	31.9
14	R2	188	3.0	0.313	9.7	LOS A	1.2	30.5	0.58	0.58	31.2
Approach		201	3.0	0.313	9.7	LOS A	1.2	30.5	0.58	0.58	31.2
West: Shenandoah Drive											
5	L2	358	3.0	0.702	14.4	LOS B	6.8	173.9	0.28	0.11	29.1
2	T1	248	3.0	0.702	14.4	LOS B	6.8	173.9	0.28	0.11	29.2
12	R2	274	3.0	0.702	10.0	LOS B	6.8	173.9	0.29	0.15	30.7
Approach		879	3.0	0.702	13.0	LOS B	6.8	173.9	0.28	0.12	29.6
All Vehicles		1649	3.0	0.702	13.3	LOS B	6.8	173.9	0.46	0.39	29.5

Site Level of Service (LOS) Method: Delay & v/c (HCM 2010). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 2010).
Roundabout Capacity Model: US HCM 2010.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: Traditional M1.
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.