FINAL DESIGN
NOISE IMPACT ANALYSIS
TECHNICAL REPORT

WARRENTON SOUTHERN INTERCHANGE US 15/17/29
DESIGN-BUILD PROJECT

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1.0 EXECUTIVE SUMMARY

This report describes the details of a final design noise impact assessment completed for the US 15/17/29 Interchange project in Fauquier County, Virginia. The noise analysis was conducted in accordance with Federal Highway Administration (FHWA) and Virginia Department of Transportation (VDOT) noise assessment regulations and guidelines. The FHWA regulations are set forth in 23 CFR Part 772. VDOT's revised policy was updated most recently on February 20, 2018.

The US 15/17/29 Interchange project proposes to replace the existing at-grade signalized intersection of US 15/17/29, US 15/17/29 Business and Route 880 (Lord Fairfax Drive) with a grade separated facility to improve safety and capacity. The project is expected to improve traffic flow and reduce congestion.

The study involved monitoring of existing noise conditions and modeling of existing (2017) and design year (2040) noise conditions in the study area with the FHWA-approved computerized Traffic Noise Model. Modeling accounted for the existing terrain and buildings and for existing and proposed roadways with projected loudest-hour traffic which was found to be the Saturday peak hour. Noise impact was assessed for the 2040 Build alternative and is summarized by FHWA land use activity category in the table below. Two residential units are impacted in the existing and future conditions as they exceed threshold for Activity Category B (approach or exceed 67 dBA). There are no impacts associated with the "substantial increase above existing" impact threshold.

TABLE 1
NOISE IMPACT SUMMARY

Scenario	Impact Type[1]	Number of Impacted Units by Land Use and FHWA Activity Category[2]				
		Residential Exterior (B)	Recreational Exterior (C)	Institutional Interior (D)	Commercial Exterior (E)	Total
Existing	NAC	2	n/a	n/a	n/a	2
Build	NAC	2	n/a	n/a	n/a	2

[1] "NAC" = Noise levels approach or exceed the FHWA Noise Abatement Criteria (NAC) for applicable Activity Category.

[2] The FHWA Activity Category is shown in parenthesis.

The proposed Project is not related to the interstate system nor does it result in a "constructive use" of a Section 4(f) property. Consequently, this final design noise study does

not include an analysis of traffic noise levels for the design year No-build (2040) alternative, consistent with VDOT's State Noise Abatement Policy.

Noise abatement must be considered where noise impact is predicted to occur with the 2040 Build alternative. Noise abatement is evaluated to determine if it is warranted, feasible, and reasonable. Table 2 summarizes the total length, estimated cost, and benefits that would be provided by the noise barriers that were evaluated in this study. Barrier B was found to be feasible and not reasonable, based on cost-effectiveness. Noise abatement was found to be not feasible at one location along the project corridor where existing driveway access to US 15/17/29 is to be maintained in the design year (CNE D).

TABLE 2
SUMMARY OF NOISE BARRIERS EVALUATED IN THIS STUDY

Barrier ID	Number of Impacted Receptors	Impacted & Benefitted Receptors	Non-Impacted & Benefitted Receptors	Noise Barrier Details				Surface Area/ Benefitted Receptor (SF/BR)	Feasible?	Reasonable?
				Length (ft)	Height (ft)	Surface Area (sq ft)	Cost at $42/sq feet			
B	1	1	1	467	9-10'	4587	$192,654	2294	Yes	No
D	1	0	0	n/a	n/a	n/a	n/a	n/a	No	n/a

This final design noise analysis was completed to assess the design modifications associated with the Design Build contract awarded to Shirley Contracting Company (Shirley) and Dewberry Consultants (Dewberry). The preliminary noise analysis was based on a design concept for a diamond interchange with signalized ramp terminals. The Shirley/Dewberry team developed an alternative design concept (ATC01) during the design/build bid process referred to as "Modified Barbell." This design includes unsignalized roundabout intersections located at both the northbound and southbound ramp terminals. The onramp to northbound US 15/17/29 (Ramp C) was modified to go underneath the proposed bridge as opposed to placing the onramp adjacent to a residential area on Turkey Run Drive. The overpass bridge and the

roundabouts were shifted north in the proposed design, allowing more of Ramp G (southbound US 15/17/29 onramp) to be maintained on its existing profile. In addition, the park and ride was moved north between Lord Fairfax Road and Ramp F to allow more direct access to the interchange. The revisions allowed Lord Fairfax Road to be realigned further away from the adjacent residential area on Travelers Way. The redesign of Ramp C moved the onramp away from homes on Turkey Run Drive, reducing noise impacts from those identified during the Preliminary Engineering (PE) noise assessment. Similarly, shifting Lord Fairfax Road away from the residential areas along Travelers Way eliminated noise impacts identified during the PE noise assessment.

Part 2, Section 2.4.8 of the design build RFP requires the noise consultant that completed the Final Design Noise Analysis to review the sound barrier plan set and certify the proposed design meets the noise abatement requirements. The results of the noise analysis conclude there are not noise barriers that are feasible and reasonable, and therefore noise barriers have not been included in the plan set. The design outlined in the design build plan set was used for this noise analysis and Skelly and Loy certifies that the design is reflected accurately in the noise modeling.

Construction activity may cause intermittent fluctuations in noise levels. The Design-Builder's operations shall be performed so that exterior noise levels measured during a noise-sensitive activity shall not exceed 80 decibels. If construction noise levels exceed 80 decibels during noise sensitive activities, the Design-Builder shall take corrective action before proceeding with operations.

2.0 INTRODUCTION

2.1 BACKGROUND AND PURPOSE

A final design traffic noise analysis was performed for the US 15/17/29 Interchange project located in Fauquier County, Virginia. All highway noise impact assessment procedures, noise abatement criteria, and documentation are in accordance with the Federal Highway Administration (FHWA) and Virginia Department of Transportation (VDOT) noise assessment regulations and guidelines. FHWA regulations for highway traffic noise for federal-aid highway projects are contained in Title 23 of the United States Code of Federal Regulations Part 772 (23 CFR 772), updated July 13, 2011. The current VDOT State Noise Abatement Policy became effective on July 13, 2011, and was updated on February 20, 2018. The FHWA regulations for mitigation of highway traffic noise in the planning and design of federally aided highway projects contained in 23 CFR 772 state that a “Type I” traffic noise impact analysis is required when there is the addition of through-traffic lanes or ramps in an interchange.

This report documents a summary of the roadway improvements under study, description of noise terminology, the applicable standards and criteria, a description of the computations of existing and future noise levels, a projection of future noise levels, identification of potential noise impacts, evaluation of measures to mitigate noise impacts, noise abatement, a discussion of construction noise, and information to assist local officials.

2.2 PROJECT DESCRIPTION

The purpose of this project is to replace the existing at-grade signalized intersection of Route 15/17/29 (Eastern Bypass), Route 15/17/29 Business and Route 880 (Lord Fairfax Drive) with a grade-separated interchange to improve safety and capacity. Traffic conditions at this location include a high volume of northbound left turns into the town of Warrenton, a high volume of truck traffic, and local traffic associated with Lord Fairfax Community College, the Fauquier County landfill, and homes nearby.

This project will replace the existing intersection with a grade separated interchange for improved safety and traffic flow. The interchange design will remove the existing traffic signal on the Eastern Bypass, allowing free flow of through traffic. Motorists on the Eastern Bypass

will use ramps to access Route 15/17/29 Business and Lord Fairfax Drive, which will cross the Eastern Bypass on a new overpass bridge with roundabouts at each end.

This final design noise analysis was completed to assess the design modifications associated with the Design Build contract awarded to Shirley Contracting Company (Shirley) and Dewberry Consultants (Dewberry). The preliminary noise analysis was based on a design concept for a diamond interchange with signalized ramp terminals. The Shirley/Dewberry team developed an alternative design concept (ATC01) during the design/build bid process referred to as "Modified Barbell." This design includes unsignalized roundabout intersections located at both the northbound and southbound ramp terminals. The eastern roundabout onramp to US 15/17/29 bypass was modified to go underneath the proposed bridge, as opposed to placing the onramp adjacent to a residential area on Turkey Run Drive. The overpass bridge and the roundabouts were shifted north in the proposed design, allowing more of Ramp G (southbound US 15/17/29 onramp) to be maintained on its existing profile. In addition, the park and ride was moved north between Lord Fairfax Road and Ramp F to allow more direct access to the interchange. The revisions allowed Lord Fairfax Road to be realigned further away from the adjacent residential area on Travelers Way.

2.3 STUDY AREA DESCRIPTION AND LAND USE

Noise sensitive land uses in the project study area include single-family residences along Route 29/15/17 Business, Turkey Run Drive, Travelers Way, and along Route 29/15/17 south of the proposed interchange. Following VDOT and FHWA policies and procedures, the receptors used in the model to represent exterior activity areas at noise-sensitive land uses were grouped into Common Noise Environments (CNEs). Receptors in a CNE are exposed to similar noise sources and levels. The modeled receptors for the analysis were grouped into the following CNEs:

- CNE A is located along the east side of Route 29/15/17 Business, just north of the proposed interchange, and consists of two single-family homes.
- CNE B is located on the east side of Route 29/15/17 Bypass, from the approximate location of the proposed interchange to the northern project limit, and consists of 15 single-family homes on Turkey Run Drive.

- CNE C is located on the east side of Route 29/15/17, just south of the proposed interchange, and consists of four single-family homes on Travelers Way.
- CNE D is located on the west side of Route 29/15/17, within 500 feet of the southern project limit, and consists of one single-family home.

Figure 1 shows the location of the study area and the noise monitoring locations, which are discussed in detail in Section 4.1.

3.0 METHODOLOGY

The Noise Control Act of 1972 gives the United States Environmental Protection Agency (U.S. EPA) the authority to establish noise regulations to control major noise sources, including motor vehicles and construction equipment. Furthermore, the U.S. EPA is required to set noise emission standards for motor vehicles used for interstate commerce and the FHWA is required to enforce the U.S. EPA noise emission standards through the Office of Motor Carrier Safety. The National Environmental Policy Act (NEPA) of 1969 gives broad authority and responsibility to federal agencies to evaluate and mitigate adverse environmental impacts caused by federal actions. FHWA is required to comply with NEPA including mitigating adverse highway traffic noise effects. The Federal-Aid Highway Act of 1970 mandates FHWA to develop standards for mitigating highway traffic noise. It also requires FHWA to establish traffic noise level criteria for various types of land uses. The Act prohibits FHWA approval of federal aid highway projects unless adequate consideration has been made for noise abatement measures to comply with the standards. FHWA regulations for highway traffic noise for federal-aid highway projects are contained in 23 CFR 772. The regulations contain noise abatement criteria, which represent the maximum acceptable level of highway traffic noise for specific types of land uses. The regulations do not mandate that the abatement criteria be met in all situations, but rather require that reasonable and feasible efforts be made to provide noise mitigation when the abatement criteria are approached or exceeded.

The State Noise Abatement Policy was developed to implement the requirements of 23 Code of Federal Regulations (CFR) Part 772 Procedures for Abatement of Highway Traffic Noise and Construction Noise (July 13, 2011), FHWA's Highway Traffic Noise Analysis and Abatement Policy and Guidance (December 2011), and the noise related requirements of The National Environmental Policy Act of 1969. The current VDOT State Noise Abatement Policy became effective on July 13, 2011, and was updated on February 20, 2018.

Noise is generally defined as unwanted or annoying sound. Airborne sound occurs by a rapid fluctuation of air pressure above and below atmospheric pressure. Sound pressure levels are usually measured and expressed in decibels (dB). The decibel scale is logarithmic and expresses the ratio of the sound pressure unit being measured to a standard reference level.

Most sounds occurring in the environment do not consist of a single frequency, but rather a broad band of differing frequencies. The intensities of each frequency add to generate sound. Because the human ear does not respond to all frequencies equally, the method

commonly used to quantify environmental noise consists of evaluating all of the frequencies of a sound according to a weighting system. It has been found that the A-weighted filter on a sound level meter, which includes circuits to differentially measure selected audible frequencies, best approximates the frequency response of the human ear.

Although the A-weighted noise level may adequately indicate the level of environmental noise at any instant in time, community noise levels vary continuously. Most environmental noise includes a conglomeration of noise from distant sources, creating a relatively steady background noise in which no particular source is identifiable. To describe the time-varying character of traffic noise, a statistical noise descriptor called the equivalent hourly sound level, or Leq(h), is commonly used. Leq(h) describes a noise sensitive receptor's cumulative exposure from all noise-producing events over a one-hour period.

Because decibels are logarithmic units, sound levels cannot be added by ordinary arithmetic means. The following general relationships provide a basic understanding of sound generation and propagation.

- An increase, or decrease, of 10 dB will be perceived by a receptor to be a doubling, or halving, of the sound level.
- Doubling the distance between a highway and receptor will produce a 3 dB sound level decrease.
- A 3 dB sound level increase is barely detectable by the human ear.

The State Noise Abatement Policy has adopted the Noise Abatement Criteria (NAC) that have been established by FHWA (23 CFR 772) for determining traffic noise impacts for a variety of land uses. The NAC, listed in Table 3 for various activities, represents the upper limit of acceptable traffic noise conditions and also a balancing of that which may be desirable with that which may be achievable. The NAC applies to areas having regular human use and where lowered noise levels are desired. They do not apply to the entire tract of land on which the activity is based, but only to that portion where the activity takes place. The NAC is given in terms of the hourly, A-weighted, equivalent sound level in decibels (dBA). The noise impact assessment is made using the guidelines listed in Table 3. Noise-sensitive sites potentially affected by this project are classified as Category B.

TABLE 3
FHWA NOISE ABATEMENT CRITERIA
HOURLY A-WEIGHTED SOUND LEVEL DECIBELS (Leq(h) in dB(A))

Activity Category	Activity Criteria Leq(h)	Evaluation Location	Activity Description
A	57	Exterior	Lands on which serenity and quiet are of extraordinary significance and serve an important public need and where the preservation of those qualities is essential if the area is to continue to serve its intended purpose
B*	67	Exterior	Residential
C*	67	Exterior	Active sport areas, amphitheaters, auditoriums, campgrounds, cemeteries, daycare centers, hospitals, libraries, medical facilities, parks, picnic areas, places of worship, playgrounds, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, recreation areas, Section 4(f) sites, schools, television studios, trails, and trail crossings
D	52	Interior	Auditoriums, day care centers, hospitals, libraries, medical facilities, places of worship, public meeting rooms, public or nonprofit institutional structures, radio studios, recording studios, schools, and television studios
E*	72	Exterior	Hotels, motels, offices, restaurants/bars, and other developed lands, properties or activities not included in A-D or F
F	--	--	Agriculture, airports, bus yards, emergency services, industrial, logging maintenance facilities, manufacturing, mining, rail yards, retail facilities, shipyards, utilities (water resources, water treatment, electrical), and warehousing
G	--	--	Undeveloped lands that are not permitted
Source: 23 CFR Part 772			
*: Includes undeveloped lands permitted for this activity category			

Traffic noise impacts occur if either of the following two conditions is met.

- The predicted traffic noise levels (future design year) approach or exceed the NAC, as shown in Table 3. The VDOT State Noise Abatement Policy defines an approach level to be used when determining a traffic noise impact. The “Approach” level has been defined by VDOT as 1 dB(A) less than the Noise Abatement Criteria for Activity Categories A to E. For example, for a Category B receptor, 66 dBA would be approaching 67 dBA and would be considered an impact. If design year noise levels “approach or exceed” the NAC, then the activity is impacted and a series of abatement measures must be considered.

- The predicted traffic noise levels are substantially higher than the existing noise levels. A substantial noise increase has been defined by VDOT when the predicted (future design year) highway traffic noise levels exceed existing noise levels by 10 dBA or more for all noise sensitive exterior activity categories. For example, if a receptor's existing noise level is 50 dBA and if the future noise level is 60 dBA, then it would be considered an impact. The noise levels of the substantial increase impact do not have to exceed the appropriate NAC. Receptors that satisfy this condition warrant consideration of highway traffic noise abatement.

If a traffic noise impact is identified within the project corridor, then consideration of noise abatement measures is necessary. The final decision on whether or not to provide noise abatement along a project corridor will take into account the feasibility of the design and overall cost weighted against the environmental benefit.

Since roadway noise levels can be determined accurately through computer modeling techniques for areas that are dominated by road traffic, design year traffic noise calculations have been predicted using the FHWA's Traffic Noise Model (FHWA TNM®) Version 2.5, which is the latest approved version. The FHWA TNM® was developed and sponsored by the U.S. Department of Transportation and John A. Volpe National Transportation Systems Center, Acoustics facility. The TNM estimates vehicle noise emissions and resulting noise levels based on reference energy mean emission levels. The existing and proposed alignments (horizontal and vertical) are input into the model, along with the receptor locations, traffic volumes of cars, medium trucks (vehicles with two axles and six tires), heavy trucks, average vehicle speeds, pavement type, and any traffic control devices. The TNM uses its acoustic algorithms to predict noise levels at the selected receptor locations by taking into account sound propagation variables such as, atmospheric absorption, divergence, intervening ground, barriers, building rows, and sometimes heavy vegetation.

4.0 EXISTING NOISE ENVIRONMENT

This section of the report describes the noise monitoring and the investigation of undeveloped lands and permitted developments. The noise monitoring and existing conditions modeling contained in Section 4.1, 4.2 and 4.3 and used for this assessment was completed in 2017 by HMMH as documented in the "*Preliminary Noise Analysis Technical Report for Route 29/15/17*" (March 2017).

4.1 MONITORING OF EXISTING NOISE LEVELS

A noise monitoring program was conducted within the US 15/17/29 Interchange project study area consistent with FHWA and VDOT recommended procedures. The objectives of the monitoring program were to document existing ambient noise levels in noise-sensitive locations and to provide a means for validation of the traffic noise prediction model.

Noise monitoring was conducted at four short-term (30 minutes in duration) sites on January 5, 2017. Measurement sites were generally located in areas with the highest noise exposures, adjacent to first-row properties. Traffic classification counts on the roadways nearest each measurement site were conducted simultaneously with each noise measurement. The short-term measurements characterized existing noise levels in the study area but were not necessarily conducted during the loudest hour of the day. They included contributions from sources other than traffic, such as aircraft. Figure 1 shows the locations of the noise measurement sites within the project study area. The short-term noise monitoring locations are shown in the study area graphic and are labeled with the prefix "M."

Short-term noise monitoring is not a process to determine design-year noise impacts or barrier locations. Short-term noise monitoring provides a level of consistency between what is present in real-world situations and how that is represented in the computer noise model. Short-term monitoring does not need to occur within every CNE to validate the computer noise model.

Short-term noise measurements were conducted using an HMMH-owned Larson-Davis 824 (ANSI Type I, "Precision") integrating sound level meter. HMMH's noise measurement instruments are calibrated annually at a certification laboratory, with calibrations traceable to the National Institute of Standards and Technology. During the monitoring program, the sound level meters were calibrated in the field using a handheld acoustic calibrator at the beginning and end

of each measurement period. The short-term data collection procedure involved measurement of one-second equivalent sound levels (Leqs) over a period of 30 minutes.

The measured noise levels appear in Table 4 as equivalent sound levels (Leq). As described above, the Leq is a sound-energy average of the fluctuating sound level (in A-weighted decibels, dBA) measured over a specified period of time. Table 4 provides the site address, as well as the date, start time, and duration of each measurement. The measurements ranged from a low of 58 dBA at 6860 Traveler's Way (Site M3) to a high of 74 dBA at 8598 James Madison Highway (Site M4).

TABLE 4
SHORT-TERM NOISE MONITORING SUMMARY

Site ID	Address	Date	Time Start	Duration (minutes)	Monitored Leq (dBA)
M1	8485 Turkey Run Drive	Jan. 5, 2017	12:23	30	62
M2	8484 Turkey Run Drive	Jan. 5, 2017	11:17	30	60
M3	6860 Traveler's Way	Jan. 5, 2017	9:40	30	58
M4	8598 James Madison Hwy	Jan. 5, 2017	13:34	30	74

Source: HMMH, 2017

Traffic on US 15/17/29 Bypass, US 15/17/29 Business, and Lord Fairfax Road was the dominant source of noise. Other sources of noise in the existing environment included but were not limited to aircraft overflights (near and far), biogenic sounds (birds and dogs), and distant electrical equipment. Appendix A provides details of the data acquired by HMMH during the noise measurement program including noise monitor output, site sketches, photographs, noise level data with site summary results, and traffic counts with hourly totals. The locations of the measurement sites are shown on the overview map in Figure 1.

4.2 NOISE MODEL VALIDATION

The noise monitoring data are primarily used to validate the computer model used to predict existing and future levels. Upon measurement of the existing noise levels, a three-dimensional noise model of the existing roadway network was constructed which incorporates all significant terrain features that define the propagation path between the roadway and noise-

sensitive receptors. Traffic volumes, composition, and speeds that were observed during the short-term monitoring periods were used as inputs to generate the validation models sound levels. FHWA and VDOT consider a difference of ±3 dBA or less between the measured noise levels and the computer modeled noise levels is considered acceptable. This computer model validation verifies that the sound propagation paths within the model are accurate and that the modeling techniques are correct and ensures that reported changes between the existing and future design-year conditions are due to changes in traffic or propagation path and not discrepancies between monitoring and modeling techniques.

The model validation was performed for the existing traffic conditions observed and recorded during the measurement period. As these noise measurements were not necessarily obtained during the existing loudest hour, the existing noise levels obtained during the 30-minute short-term monitoring session were not reported as the project's existing noise levels. Instead, the validated existing conditions TNM noise model was used to generate existing loudest-hour noise levels by using Design Hour Volumes and truck percentages supplied by the traffic engineers as model inputs (refer to Section 5.2).

A summary of the model validation is presented in Table 5. At three out of four sites, the differences between measured and predicted noise levels fall within three decibels, which is the accepted level of accuracy in the noise model. The Project-wide average difference between calculated noise levels and monitored noise levels was 1.8 decibels (over all four sites), which generally shows excellent agreement between monitored and modeled sound levels and suggests confidence in the modeling assumptions.

TABLE 5
COMPUTED VS. MEASURED SOUND LEVELS AT MEASUREMENT SITES

Site ID	CNE	Address	Monitored Leq (dBA)	TNM-Computed Leq (dBA)	Difference (dBA)
M1	B	8485 Turkey Run Drive	62.0	64.8	2.7
M2	B	8484 Turkey Run Drive	60.4	64.5	4.1
M3	C	6860 Traveler's Way	58.3	59.4	1.1
M4	D	8598 James Madison Hwy	74.4	73.9	-0.5
				Average difference:	1.8
				Standard deviation of difference	2.0

Source: HMMH, 2017

The validation results at Site M2 were slightly outside the normally acceptable range. As shown in Table 5, the difference between the TNM-computed noise level and the monitored level was 4.1 decibels, suggesting that TNM is slightly over-predicting at this location. The validation exercise included many refinements to the modeling assumptions to achieve the best possible agreement with monitored noise level data. The discrepancy may be a result of TNM over predicting the effects of accelerating vehicles at the signalized intersection and propagation over complex terrain/ground cover.

4.3 PREDICTED EXISTING NOISE LEVELS

For calculation of loudest-hour noise levels throughout the study area, additional receiver locations were added to the measurement sites in the TNM to provide a comprehensive basis of comparison for the analysis of noise impacts from the existing and future project conditions. Using the appropriate loudest-hour traffic data, existing and future traffic noise levels were predicted for the measurement sites and the additional receiver locations. The computation methods and predicted noise levels are presented in the next section of this report.

The noise measurements provided valuable information on current noise conditions and the effects of terrain and shielding on sound propagation from the roadway to the nearby residential land uses. However, because existing noise levels are not always measured during the loudest hour of the day, estimates of the loudest-hour existing noise levels were computed using the appropriate traffic data as input. These predicted estimates of existing noise levels for

the loudest hour of the day are then used as the baseline against which probable future noise levels are compared and potential noise impacts assessed. Additional information on the computation methods and computed levels used in this study are provided in Section 5.0.

4.4 UNDEVELOPED LANDS AND PERMITTED DEVELOPMENTS

Highway traffic noise analyses are (and will be) performed for developed lands as well as undeveloped lands if they are considered "permitted." Undeveloped lands are deemed to be permitted when there is a definite commitment to develop land with an approved specific design of land use activities as evidenced by the issuance of at least one building permit.

In accordance with the VDOT Traffic Noise Policy, an undeveloped lot is considered to be planned, designed, and programmed if a building permit has been issued by the local authorities prior to the Date of Public Knowledge for the relevant project. VDOT considers the "Date of Public Knowledge" as the date that the final National Environmental Protection Act (NEPA) approval is made. VDOT has no obligation to provide noise mitigation for any undeveloped land that is permitted or constructed after this date. The NEPA Document was approved by VA Division FHWA on 4/25/2017.

While the project corridor contains undeveloped lands, there are no planned or permitted lands or developments with noise-sensitive land use within a 500-foot buffer zone around the project roadways.

5.0 FUTURE NOISE ENVIRONMENT

This section discusses the noise prediction model and traffic data used as input to the noise prediction model and then presents a summary of the predicted noise levels.

5.1 NOISE PREDICTION MODEL

Since roadway noise levels can be determined accurately through computer modeling techniques for areas that are dominated by road traffic, design year traffic noise calculations have been predicted using the FHWA's Traffic Noise Model (FHWA TNM) Version 2.5, which is the latest approved version. The FHWA TNM® was developed and sponsored by the U.S. Department of Transportation and John A. Volpe National Transportation Systems Center, Acoustics facility. The TNM estimates vehicle noise emissions and resulting noise levels based on reference energy mean emission levels. The existing and proposed alignment (horizontal and vertical) are input into the model, along with the receptor locations, traffic volumes of cars, medium trucks (vehicles with two axles and six tires), heavy trucks, average vehicle speeds, pavement type, and any traffic control devices. The TNM uses its acoustic algorithms to predict noise levels at the selected receptor locations by taking into account sound propagation variables such as, atmospheric absorption, divergence, intervening ground, barriers, building rows, and sometimes heavy vegetation.

Future build TNM runs were developed by modifying the validated existing condition model (HMMH, 2017) to account for the new interchange. Roadway design engineering files and future terrain contour files were supplied by Dewberry. The modeling accounted for the variability in the local terrain and included the following parameters that affect the propagation of traffic noise: terrain lines, ground zones, and fixed height barriers to represent buildings. The default ground type used in the modeling was "lawn." The noise model also included a number of "empty" lanes (e.g., roadways without traffic) to represent paved shoulders and side streets. The dual roundabouts included in the ATC01 design were modeled according to Appendix B (Signalized Interchanges, Intersections, and Roundabouts) of the National Cooperative Highway Research Program (NCHRP) Report 791, Supplemental Guidance on the Applications of FHWA's TNM.

To fully characterize future noise levels at all noise-sensitive land uses in the study area, noise prediction receivers (also called "receptors" and/or "sites") were added to the

measurement sites in the TNM runs. The study area consists primarily of exterior residential (Category B) land use and lands that are currently undeveloped and not permitted (Category G) adjacent to project roadways.

5.2 TRAFFIC DATA FOR NOISE PREDICTION

As stipulated in the RFP technical requirements (Part 2, Section 2.4.8 Noise Mitigation), the final noise mitigation design shall utilize the design year traffic volumes that were used as part of the Preliminary Noise Study unless otherwise directed due to traffic updates. The Shirley/Dewberry design build team recently completed an updated Traffic Analysis Report (May 25, 2018) to reflect the changes made to the interchange design (Modified Barbell). This report concludes that the Level of Service (LOS) for all intersections is equal to or better than the RFP concept and operates at a LOS A or LOS B. Peak Hour traffic data were supplied by Dewberry as AM Peak Hour, PM Peak Hour, and Saturday Peak Hour volumes for both the Existing and the Design Year for each roadway in the local network, consistent with the time periods analyzed during the Preliminary Noise Study. Truck percentages and speed limits also were provided for each roadway in the local network. The traffic report and associated data are located in Appendix B.

The traffic data used in the noise analysis must produce sound levels representative of the loudest hour of the day in the future design year, per FHWA and VDOT policy. Given the low number of receptors in the study area, traffic noise levels were calculated at all of the receptors in the study area, using the traffic data for each of the three peak hour conditions. For both Existing conditions and the Design Year Build alternative, the Saturday Peak Hour produced higher noise levels at a majority of the modeled receptors. The PM Peak Hour produced the next highest noise levels at the modeled receptor locations. Appendix B provides the loudest-hour traffic data that were used as input to the TNM (e.g., Saturday Peak Hour). Since only 22 noise-sensitive receptors were modeled for this proposed Project, Appendix C also provides a table that shows the computed traffic noise levels at each receptor location using the traffic data for each of the three peak hours.

The proposed project is not related to the interstate system nor does it result in a “constructive use” of a Section 4(f) property. Consequently, this preliminary noise study does not include an analysis of traffic noise levels for the design year No-build (2040) alternative, consistent with VDOT’s State Noise Abatement Policy.

5.3 PRESENTATION OF RESULTS

The study area primarily consists of exterior residential (Category B) land use and undeveloped lands that are not permitted (Category G).

Table 6 summarizes the range of predicted noise levels by CNE. The table includes a description of each CNE and its land use, the FHWA Activity Category, and the loudest-hour traffic noise levels, which are presented in terms of the A-weighted equivalent sound level, or Leq, in dBA. Loudest-hour noise levels were computed for Existing conditions as well as the design-year (2040) Modified Barbell interchange design.

TABLE 6
RANGES OF PREDICTED EXTERIOR NOISE LEVELS FOR THE WORST HOUR

CNE	Land Use- Description	Range of Predicted Exterior Noise Levels for the Worst Hour (dBA)		
		Activity Category	Existing	2040 Build
A	Single-family homes on Route 29/15/17 Bus.	B	58-60	59-61
B	Single-family homes on Turkey Run Dr.	B	45-67	49-68
C	Single-family homes on Travelers Way	B	56-63	59-63
D	Single-family home on Route 29/15/20	B	75	76

Figure 2 provides a location map for the CNEs, noise-sensitive receptors, 66 dBA Leq "contour" for the 2040 Build alternative, and potential noise barrier location. Each receptor is shown in Figure 2 with a color-coded dot that indicates the status of each receptor according to its 2040 Build noise level.

Future loudest hour noise levels are predicted to range from 59 to 61 dBA within CNE A. A 1 dBA increase in the design year within CNE A is attributable to an increase in overall traffic volumes throughout the roadway network.

Future loudest hour noise levels are predicted to range from 49 to 68 dBA within CNE B. A maximum 8 dBA increase in the design year within CNE B is attributable to an increase in overall traffic volumes throughout the roadway network as well as a significant alteration in the source/receiver noise propagation path resulting from the construction of the new interchange.

Future loudest hour noise levels are predicted to range from 59 to 63 dBA within CNE C. A 1 dBA increase in the design year within CNE C is attributable to an increase in overall traffic volumes throughout the roadway network.

Future loudest hour noise levels are predicted to be 76 dBA within CNE D. A 1 dBA increase in the design year within CNE D is attributable to an increase in overall traffic volumes throughout the roadway network.

5.4 NOISE IMPACT ASSESSMENT

The potential noise impact of the US 15/29/17 Interchange Project was assessed according to FHWA and VDOT noise assessment guidelines, described in detail in Section 2. In summary, noise impact would occur wherever noise levels are expected to approach within one decibel, or exceed 67 dBA Leq, at noise-sensitive land uses in Activity Category B (exterior residential) during the loudest hour of the day. Noise impact also would occur wherever noise levels cause a substantial increase over existing noise levels—an increase of 10 dB or more is considered substantial by VDOT.

Table 7 provides tables that list the computed sound levels at all of the modeled receptors included in the noise assessment. The noise impacted sites have been highlighted in red. Receptors B-004 and D-001 exceed the 67 dBA Leq impact threshold in both the existing and 2040 Build scenario. There are no impacts associated with the "substantial increase above existing" impact threshold.

TABLE 7
EXISTING AND FUTURE PREDICTED NOISE LEVELS

CNE	Site ID	Address	Dwelling Units	Activity Category	Land Use	NAC	Loudest-hour Leq (dBA)	
							Existing	2040 Build
A	A-001	8413 James Madison Hwy	1	B	Residential	67	60	61
A	A-002	8415 James Madison Hwy	1	B	Residential	67	58	59
B	B-001	8453 Turkey Run Dr	1	B	Residential	67	62	63
B	B-002	8450 Turkey Run Dr	1	B	Residential	67	59	59
B	B-003	8454 Turkey Run Dr	1	B	Residential	67	65	65
B	B-004	8464 Turkey Run Dr	1	B	Residential	67	67	68

B	B-005	8474 Turkey Run Dr	1	B	Residential	67	61	62
B	B-006	8484 Turkey Run Dr	1	B	Residential	67	62	63
B	B-007	8506 Turkey Run Dr	1	B	Residential	67	59	62
B	B-008	8516 Turkey Run Dr	1	B	Residential	67	51	59
B	B-009	8549 Turkey Run Dr	1	B	Residential	67	45	49
B	B-010	8525 Turkey Run Dr	1	B	Residential	67	50	56
B	B-011	8513 Turkey Run Dr	1	B	Residential	67	50	54
B	B-012	8505 Turkey Run Dr	1	B	Residential	67	52	54
B	B-013	8483 Turkey Run Dr	1	B	Residential	67	52	53
B	B-014	8479 Turkey Run Dr	1	B	Residential	67	52	52
B	B-015	8467 Turkey Run Dr	1	B	Residential	67	54	55
C	C-001	6860 Travelers Way	1	B	Residential	67	63	63
C	C-002	6854 Travelers Way	1	B	Residential	67	56	59
C	C-003	6850 Travelers Way	1	B	Residential	67	59	60
C	C-004	6838 Travelers Way	1	B	Residential	67	58	59
D	D-001	8598 James Madison Hwy	1	B	Residential	67	75	76

Table 8 presents a summary of the predicted noise impact for the Existing and 2040 Build alternative. The impacts are summarized for the entire study area, separately by FHWA Activity Category.

TABLE 8
NOISE IMPACT SUMMARY

Scenario	Impact Type[1]	Number of Impacted Units by Land Use and FHWA Activity Category[2]				
		Residential Exterior (B)	Recreational Exterior (C)	Institutional Interior (D)	Commercial Exterior (E)	Total
Existing	NAC	2	n/a	n/a	n/a	2
Build	NAC	2	n/a	n/a	n/a	2

[1] "NAC" = Noise levels approach or exceed the FHWA Noise Abatement Criteria (NAC) for applicable Activity Category.

[2] The FHWA Activity Category is shown in parenthesis.

Table 9 presents a summary of the predicted noise impact for the 2016 Existing and 2040 Build alternative by CNE.

TABLE 9
PREDICTED TRAFFIC NOISE IMPACT BY COMMON NOISE ENVIRONMENT (CNE)

CNE	Land Use- Description	Number of Impacted Dwellings		
		Activity Category	Existing	2040 Build
A	Single-family homes on Route 29/15/17 Bus.	B	0	0
B	Single-family homes on Turkey Run Dr.	B	1	1
C	Single-family homes on Travelers Way	B	0	0
D	Single-family home on Route 29/15/20	B	1	1
		TOTALS	**2**	**2**

6.0 NOISE ABATEMENT DETERMINATION

Noise Abatement Determination is a three-phased approach. The first phase of the process is to determine if highway traffic noise abatement consideration is warranted for the affected communities and/or affected receptors. The warranted criterion specifically pertains to traffic noise impacted receptors, defined in Section 5. Since predicted noise levels for the future design year build (2040) condition either approach or exceed the NAC and/or meet the substantial increase criterion, per VDOT's State Noise Abatement Policy, noise abatement considerations are warranted for these impacted noise sensitive areas. Satisfying the warranted criterion is considered to be the first phase (Phase 1) of the three-phased noise abatement determination. Phases 2 and 3, determining feasibility and reasonableness, are discussed below. Following completion of all three phases, a determination can be made related to the feasibility and reasonableness of the noise abatement options.

Noise sensitive sites behind existing noise barriers that are predicted to be impacted by traffic noise under the future design year build condition are subject to the following evaluation. This is due to the fact that noise barriers posts and foundations are uniquely designed for each noise barrier; as such, retrofitting a noise barrier to address new noise impacts is not possible. This methodology determines if the existing noise barrier is still feasible and reasonable under VDOT's State Noise Abatement Policy, and is as follows:

- Determine the future design year noise levels with and without the existing noise barrier.
  - If the noise barrier is determined to be feasible and reasonable, then the process shall stop.
  - If the existing barrier is not feasible and/or reasonable, a new feasible barrier shall be evaluated.
    - If the new noise barrier being evaluated is determined to not be feasible and/or not reasonable, the existing noise barrier will be left in place without modification. The reasonableness calculation must include the cost of demolition of the existing barrier (and/or retaining wall)
    - If the new noise barrier being evaluated is determined to be both feasible and reasonable (including the appropriate demolition costs), the new barrier will be recommended for further consideration.

6.1 ABATEMENT MEASURES EVALUATION

VDOT guidelines recommend a variety of mitigation measures that should be considered in response to transportation-related noise impacts. While noise barriers and/or earth berms are generally the most effective forms of noise mitigation, additional mitigation measures exist which have the potential to provide considerable noise reductions, under certain circumstances. Mitigation measures considered for this project include

- Traffic Control Measures,
- Alteration of Horizontal and Vertical Alignments,
- Acoustical Insulation of Public-Use and Non-Profit Facilities,
- Acquisition of Buffer Land,
- Construction of Earth Berms, and
- Construction of Noise Barriers.

6.1.1 Traffic Control Measures (TCM)

Traffic control measures such as speed limit restrictions, truck traffic restrictions, and other traffic control measures that may be considered for the reduction of noise emission levels are not practical for this project. Reducing speeds will not be an effective noise mitigation measure since a substantial decrease in speed is necessary to provide adequate noise reduction. Typically, a 10 mph reduction in speed will result in only a 2 dBA decrease in noise level, which would not eliminate all impacts. Additionally, a reduction in speed is not practical for a limited access highway.

6.1.2 Alteration of Horizontal and Vertical Alignments

The alteration of the horizontal and vertical alignment is not practical for this project due to ROW constraints.

6.1.3 Acoustical Insulation of Public-Use and Non-Profit Facilities

This noise abatement measure option applies only to public and institutional use buildings. Since no public use or institutional structures are anticipated to have interior noise levels exceeding FHWA's interior NAC, this noise abatement option will not be applied.

6.1.4 Acquisition of Buffering Land

The purchase of property for noise barrier construction or the creation of a “buffer zone” to reduce noise impacts is only considered for predominantly unimproved properties because the amount of property required for this option to be effective would create significant additional impacts (e.g., in terms of residential displacements), which were determined to outweigh the benefits of land acquisition.

6.1.5 Construction of Berms / Noise Barriers

Construction of noise barriers can be an effective way to reduce noise levels at areas of outdoor activity. Noise barriers can be wall structures, earthen berms, or a combination of the two. The effectiveness of a noise barrier depends on the distance and elevation difference between roadway and receptor and the available placement location for a barrier. Gaps between overlapping noise barriers also decrease the effectiveness of the barrier, as opposed to a single connected barrier. The barrier’s ability to attenuate noise decreases as the gap width increases.

Noise walls and earth berms are often implemented into the highway design in response to the identified noise impacts. The effectiveness of a freestanding (post and panel) noise barrier and an earth berm of equivalent height are relatively consistent; however, an earth berm is perceived as a more aesthetically pleasing option. In contrast, the use of earth berms is not always an option due to the excessive space they require adjacent to the roadway corridor. At a standard slope of 2:1, every one foot in height would require four feet of horizontal width. This requirement becomes more difficult to meet in urban settings where residential properties often abut the proposed roadway corridor. In these situations, implementation of earth berms can require significant property acquisitions to accommodate noise mitigation, and the cost associated with the acquisition of property to construct a berm can significantly increase the total costs to implement this form of noise mitigation and make it unreasonable.

Availability of fill material to construct the berm also needs to be considered. On proposed projects where proposed grading yields excess waste material, earth berms are often cost effective mitigation options. On balance or borrow projects, the implementation of earth berms is often an expensive solution due to the need to identify, acquire, and transport the

material to the project site. Berms were not considered for this project due to right-of-way constraints.

As a general practice, noise barriers are most effective when placed at a relatively high point between the roadway and the impacted noise sensitive land use. To achieve the greatest benefit from a potential noise barrier, the goal of the barrier should focus on breaking the line-of-sight (to the greatest degree possible) from the roadway to the receptor. In roadway fill conditions, where the highway is above the natural grade, noise barriers are typically most effective when placed on the edge of the roadway shoulder or on top of the fill slope. In roadway cut conditions, where the roadway is located below the natural grade, barriers are typically most effective when placed at the top of the cut slope. Engineering and safety issues have the potential to alter these typical barrier locations.

The effectiveness of a noise barrier is measured by examining the barrier's capability to reduce future noise levels. Noise reduction is measured by comparing design year pre- and post-barrier noise levels. This difference between unabated and abated noise levels is known as insertion loss (IL).

Additionally, the Noise Policy Code of Virginia (HB 2577, as amended by HB 2025) states: Whenever the Commonwealth Transportation Board or the Department plan for or undertake any highway construction or improvement project and such project includes or may include the requirement for the mitigation of traffic noise impacts, first consideration should be given to the use of noise reducing design and low noise pavement materials and techniques in lieu of construction of noise walls or sound barriers. Vegetative screening, such as the planting of appropriate conifers, in such a design would be utilized to act as a visual screen if visual screening is required. This documentation is located in **Appendix D**.

6.2 FEASIBILITY, REASONABLENESS, AND DESIGN GOALS

According to FHWA and VDOT guidelines, potential mitigation measures for warranted receptors must also be assessed for feasibility and reasonableness. Noise mitigation is required to be both "feasible" and "reasonable" to be recommended for construction.

6.2.1 Feasibility Criterion for Noise Barriers

All receptors that meet the warranted criterion must progress to the “feasible” phase. Phase 2 of the noise abatement criteria requires that both of the following acoustical and engineering conditions be considered. The noise abatement measure is said to be feasible if it meets both criteria.

- At least a 5 dB(A) highway traffic noise reduction at impacted receptors. Per 23 CFR 772, FHWA requires the highway agency to determine the number of impacted receptors required to achieve at least 5 dB(A) of reduction. VDOT requires that 50% or more of the impacted receptors experience 5 dB(A) or more of insertion loss to be feasible and

- The determination that it is possible to design and construct the noise abatement measure. The factors related to the design and construction include safety, barrier height, topography, drainage, utilities, and maintenance of the abatement measure, maintenance access to adjacent properties, and general access to adjacent properties (i.e., arterial widening projects).

6.2.2 Reasonableness Criterion for Noise Barriers

All receptors that meet the feasibility criterion must progress to the “reasonableness” phase. Phase 3 of the noise abatement criteria requires that all of the following conditions be considered.

- **The Viewpoints of the Benefited Receptors:** VDOT shall solicit the viewpoints of all benefited receptors through certified mailings and obtain enough responses to document a decision as to whether or not there is a desire for the proposed noise abatement measure. Fifty percent (50%) or more of the respondents shall be required to favor the noise abatement measure in determining reasonableness. Community views in and of themselves are not sufficient for a barrier to be found reasonable if one or both of the other two reasonableness criteria are not satisfied.

- **Cost-effectiveness:** Typically, the limiting factor related to barrier reasonableness is the cost-effectiveness value, where the total surface area of the barrier is divided by the number of benefited receptors receiving at least a 5 dBA reduction in noise level. VDOT’s approved cost is based on a maximum square footage of abatement per benefited receptor, a value of 1,600 square feet per benefited receptor.

Where multi-family housing includes balconies at elevations that exceed a 30-foot high barrier or the topography causes receptors to be above the elevation of a 30-foot barrier, these receptors are not assessed for barrier benefits and are not included in the computation of the barrier's reasonableness.

For non-residential properties such as parks and public use facilities, a special calculation is performed in order to quantify the type and duration of activity and compare to the cost effectiveness criterion. The determination is based on cost, severity of impact (both in terms of noise levels and the size of the impacted area and the activity it contains), and amount of noise reduction.

6.2.3 Noise Reduction Design Goals

The design goal is a reasonableness factor indicating a specific reduction in noise levels that VDOT uses to identify that a noise abatement measure effectively reduces noise. The design goal establishes a criterion, selected by VDOT, which noise abatement must achieve. VDOT's noise reduction design goal is defined as a 7 dB(A) of insertion loss for at least one impacted receptor, meaning that at least one impacted receptor is predicted to achieve a 7 dB(A) or greater noise reduction with the proposed barrier in place. The design goal is not the same as acoustic feasibility, which defines the minimum level of effectiveness for a noise abatement measure. Acoustic feasibility indicates that the noise abatement measure can, at a minimum, achieve a discernible reduction in noise levels.

Noise reduction is measured by comparing the future design year build condition pre- and post-barrier noise levels. This difference between unabated and abated noise levels is known as "insertion loss" (IL). It is important to optimize the noise barrier design to achieve the most effective noise barrier in terms of both noise reduction (insertion losses) and cost. Although at least a 5 dB(A) reduction is required to meet the feasibility criteria, the following tiered noise barrier abatement goals are used to govern barrier design and optimization.

- Reduction of future highway traffic noise by 7 dB(A) at one or more of the impacted receptor sites (required criterion).
- Reduction of future highway traffic noise levels to the low-60-decibel range when practical (desirable).
- Reduction of future highway traffic noise levels to existing noise levels when practical (desirable).

6.3 NOISE ABATEMENT RESULTS

As outlined in Section 5.4, there are two receptors that warrant abatement consideration in CNE B and CNE D (B-0004 and D-001, respectively). The residence in CNE D has an existing driveway access onto Route 15/29/15 that will be maintained with the design year Build alternative. A noise barrier is not feasible for this residential receptor since driveway access via Route 29/15/17 must be maintained.

A noise barrier was evaluated to mitigate the predicted noise impact at the single family home located at 8464 Turkey Run Drive in CNE B.

The most cost-effective design that provides a minimum 5-dB noise reduction for at least 50% of the impacted receptors and the noise reduction goal of 7-dB for at least one impacted receptor is summarized in Table 10. Barrier B would be 9 to 10 feet high and 467 feet long, with a surface area of 4,587 square-feet. This noise barrier wall would benefit the 1 impacted receptor, plus 1 additional non-impacted receptor. The noise barrier would meet the noise reduction goal at the impacted receptor. Although Barrier B was found to be feasible, it was found to be not reasonable with a surface area per benefited receptor value of 2,294 SF/BR. The warranted, feasible, and reasonable worksheets are locations in Appendix E.

TABLE 10
SUMMARY OF POTENTIAL NOISE BARRIERS EVALUATED IN THIS STUDY

Barrier ID	Noise Barrier Details						Number of Receptors				Surface Area/ Benefited Receptor (SF/BR)[2]	Feasible?	Reasonable?
	Noise Reduction (dBA)		Length (ft)	Height (ft)	Surface Area (sq ft)	Cost[1] at $42/sq feet	Impacted	Impacted & Benefited	Not Impacted & Benefited	Total Benefited			
	Range	Average											
B	6-7	6.1	467	9-10'	4587	$192,654	1	1	1	2	2294	Y	N

1.) This unit cost is a statewide average based on the three most recent years of historic data and only includes noise barrier material and installation costs.
2.) Where SF/BR exceeds VDOT's maximum of 1600, a noise barrier would not be considered cost-reasonable.

7.0 PUBLIC INVOLVEMENT/LOCAL OFFICIALS COORDINATION

FHWA and VDOT policies require that VDOT provide certain information to local officials within whose jurisdiction the highway project is located in order to minimize future traffic noise impacts of Type I projects on currently undeveloped lands. (Type I projects involve highway improvements with noise analysis.) This information must include details on noise-compatible land-use planning and noise impact zones for undeveloped lands within the project corridor. The aforementioned details are provided below. Additional information about VDOT's noise abatement program has also been included in this section.

7.1 NOISE-COMPATIBLE LAND-USE PLANNING

Sections 12.1 and 12.2 of VDOT's current noise policy outline VDOT's approach to communication with local officials and provides information and resources on highway noise and noise-compatible land-use planning. VDOT's intention is to assist local officials in planning the uses of undeveloped land adjacent to highways to minimize the potential impacts of highway traffic noise.

Entering the Quiet Zone is a brochure that provides general information and examples to elected officials, planners, developers, and the general public about the problem of traffic noise and effective responses to it. A link to this brochure on FHWA's website is provided: http://www.fhwa.dot.gov/environment/noise/noise_compatible_planning/federal_approach/land_use/qz00.cfm.

A wide variety of administrative strategies may be used to minimize or eliminate potential highway noise impacts, thereby preventing the need or desire for costly noise abatement structures such as noise barriers in future years. There are five broad categories of such strategies:

- Zoning,
- Other legal restrictions (subdivision control, building codes, health codes),
- Municipal ownership or control of the land,
- Financial incentives for compatible development, and
- Educational and advisory services.

The Audible Landscape: A Manual for Highway and Land Use is a well-written and comprehensive guide addressing these noise-compatible land-use planning strategies, with significant detailed information. This document is available through FHWA's Website, at http://www.fhwa.dot.gov/environment/noise/noise_compatible_planning/federal_approach/audible_landscape/al00.cfm.

7.2 NOISE IMPACT ZONES IN UNDEVELOPED LAND ALONG THE STUDY CORRIDOR

Also required under the revised 2011 FHWA and VDOT noise policies is information on the noise impact zones adjacent to project roadways in undeveloped lands. To determine these zones, noise levels are computed at various distances from the edge of the project roadways in each of the undeveloped areas of the project study area. Then, the distances from the edge of the roadway to the noise abatement criteria sound levels are determined through interpolation. Distances vary in the project corridor due to changes in traffic volumes, or terrain features. Any noise sensitive sites within these zones should be considered noise impacted if no barrier is present to reduce sound levels.

Noise level contours are lines of equal noise exposure that typically parallel roadway alignments and are often times useful to local officials in undeveloped corridors. Highway traffic noise is considered a linear noise source and sound levels can drop considerably over distance. The degree that sound levels decrease can vary based on a number of different factors including objects that shield the roadway noise, terrain features and ground cover type (e.g., pavement, grass or snow). The use of noise level contours have become increasingly popular over the last several years, as they have been implemented in planning programs for undeveloped areas with roadway noise influence. Through conscious planning efforts and noise contour generation, municipal officials can restrict future development inside the noise impact zone (i.e., the area within the 66-dBA noise contour). Figure 2 shows the approximate 66-dbA noise level contours for the study area when considering the proposed improvements and the Design Year (2040) traffic volumes, speeds and composition. This 66-dBA noise contour can be used to approximate the distance away from US 29/17/15 Bypass in which the NAC will be exceeded for an Activity Category B receptor (e.g., the most common receptor). Any noise-sensitive property within this 66-dBA contour should be considered to be noise-impacted.

7.3 VDOT'S NOISE ABATEMENT PROGRAM

Information on VDOT's noise abatement program is available on VDOT's Website at http://www.virginiadot.org/projects/pr-noise-walls-about.asp. The site provides information on VDOT's noise program and policies, noise walls, and a downloadable noise wall brochure.

Consistent with the 2017 Preliminary Noise Analysis, there are no noise barriers within the study area that have been found to be both feasible and reasonable. Public coordination related to the reasonableness determination is not required because the mitigation devices analyzed are outside the cost/effectiveness threshold of 1600 SF/BR.

8.0 CONSTRUCTION NOISE

Throughout the construction of the US 15/17/20 Interchange, noise sensitive land uses that are analyzed for traffic noise impacts are also susceptible to construction noise impacts. Typical highway construction/reconstruction equipment such as loaders, dump trucks, graders, bulldozers, etc. is likely to temporarily elevate noise within the project area. Sensitive receptors within 100 to 200 feet of construction activities may experience varying periods and degrees of noise impacts, with potential noise levels between 75 dBA and 85 dBA, depending on the nature of the construction activity, the type of equipment in use, and the relative nearness to the activity.

VDOT is concerned with noise generated during the construction phase of the proposed project. While the degree of construction noise impact will vary, it is directly related to the types and number of equipment used and the proximity to the noise-sensitive land uses within the project area. Land uses that are sensitive to traffic noise, are also potentially considered to be sensitive to construction noise. Any construction noise impacts that do occur as a result of roadway construction measures are anticipated to be temporary in nature and will cease upon completion of the project construction phase. A method of controlling construction noise is to establish the maximum level of noise that construction operations can generate. In view of this, VDOT has developed and FHWA has approved a specification that establishes construction noise limits. This specification can be found in VDOT's Design-Build Standard Template Documents, Part 5, 2016 Division I Amendments. The contractor will be required to conform to this specification to reduce the impact of construction noise on the surrounding community.

Construction noise can be minimized by implementing specific measures to help mitigate the noise at the source. The contractor shall exercise proper maintenance procedures for all construction equipment regularly and thoroughly. Replacement of failing or ineffective muffling and exhaust systems, periodic lubrication of moving parts, and properly tuned engines are necessary in order to keep construction equipment noise emissions to a minimum. The Design-Builder's operations shall be performed so that exterior noise levels measured during a noise-sensitive activity shall not exceed 80 decibels. If construction noise levels exceed 80 decibels during noise sensitive activities, the Design-Builder shall take corrective action before proceeding with operations.

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APPENDIX A

APPENDIX B

APPENDIX C

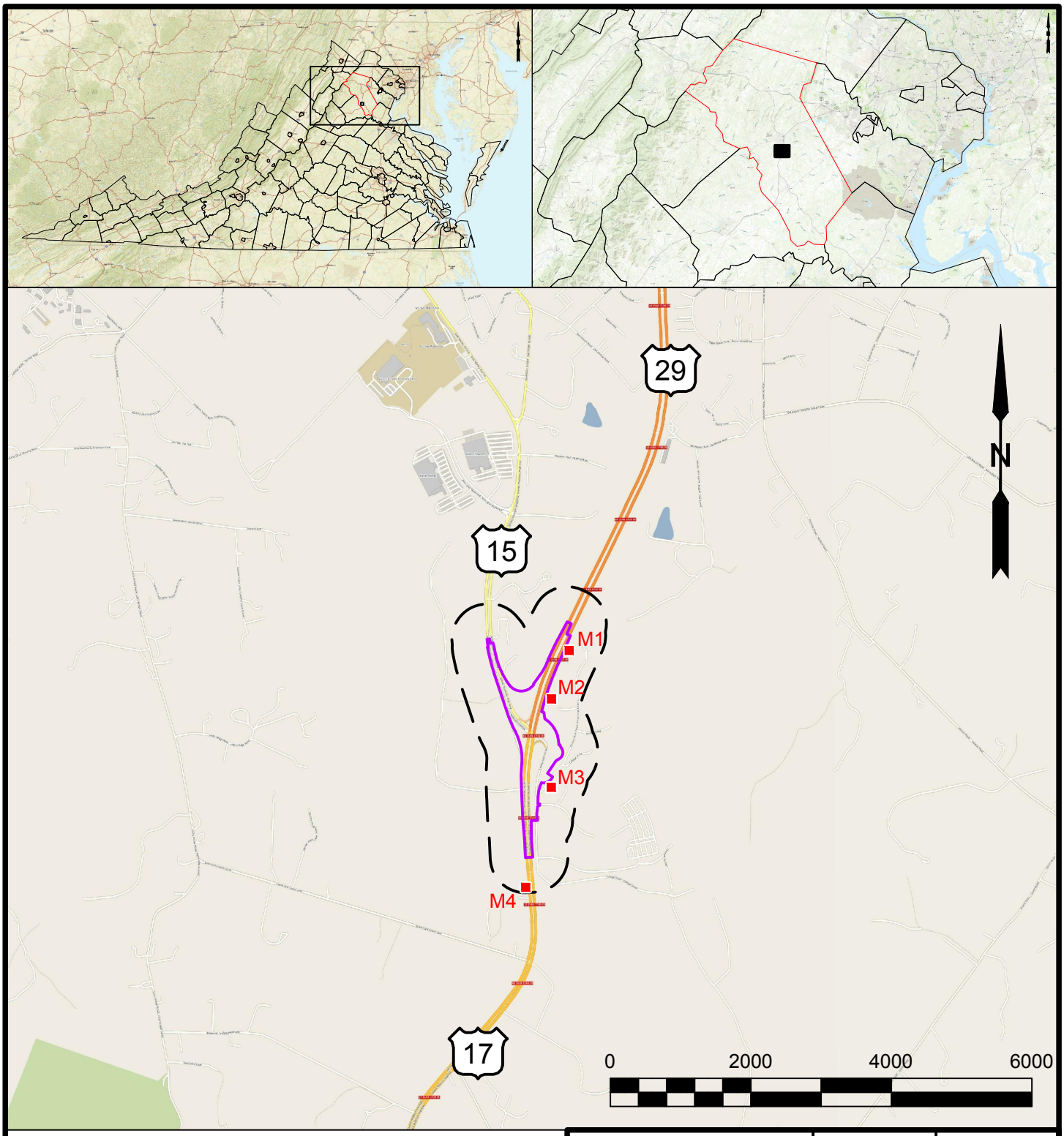
Warrenton Southern Interchange US 15/17/29
State Project 0029-030-121, P101, R201, C501, B616
Federal Project No.: STP-032-7 (032)
Design Build Contract ID Number: C00077384DB100

APPENDIX D

APPENDIX E

APPENDIX F

Warrenton Southern Interchange US 15/17/29
State Project 0029-030-121, P101, R201, C501, B616
Federal Project No.: STP-032-7 (032)
Design Build Contract ID Number: C00077384DB100



Proposed Improvements

Noise Study Buffer (500 ft)

Project Location

Project Measurement Site

SKELLY and LOY, Inc.	Jul., 2018	Figure 1

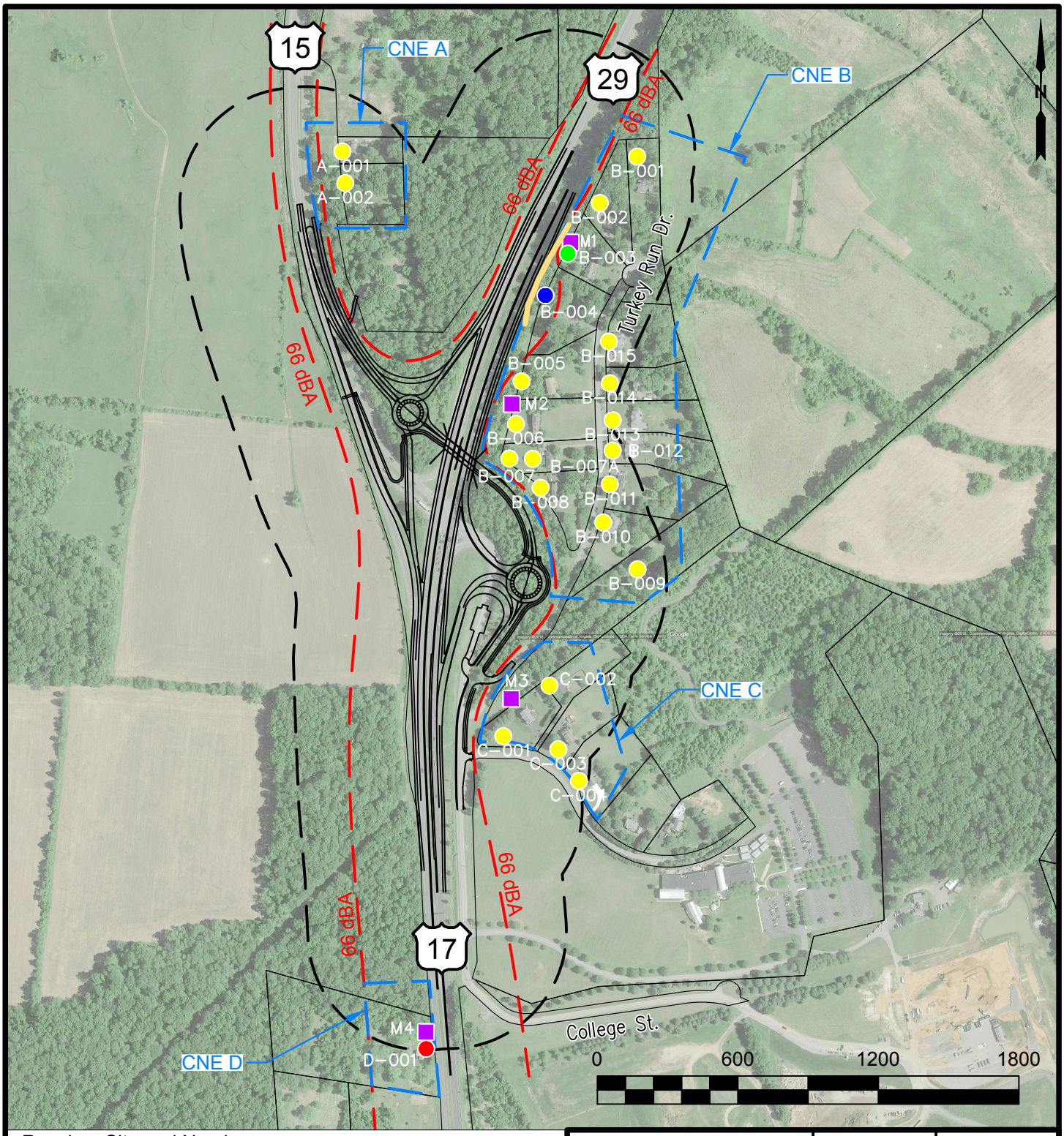
Virginia DOT
Route 15/17/29 Interchange Project

Project Location Map

Warrenton and Fauquier Counties, Virginia

Job No.:R17-0318.000	Scale:As Shown

Plotted on: 2018-07-11
Dwg: W:\Projects\2017 Projects and Proposals\R17-0318.P00 Dewberry Warrenton Interchange DB\CAD Files\Figures1.dwg
By: DJohnston



Receiver Site and Number
- Impacted and 7 dBA or more Insertion Loss
- Impacted but Not Benefited
- Benefited but Not Impacted
- Not Benefited or Impacted

Noise Barriers
- Feasible and Not Reasonable

- Measurement Site
- CNE Boundary
- 66 dBA Noise Contour
- 500' Noise Study Area

SKELLY and LOY, Inc.	Jul., 2018	Figure 2

Virginia DOT
Route 15/17/29 Interchange Project

Location Map for Common Noise Environments, Receptors, Build Contours and Barriers

Warrenton and Fauquier Counties, Virginia

Job No.:R17-0318.000	Scale: 1" = 600'

Plotted on: 2018-07-12

Dwg: W:\Projects\2017 Projects and Proposals\R17-0318.P00 Dewberry Warrenton Interchange DB\CAD Files\Figures.dwg By: DJohnston

APPENDIX A

APPENDIX D NOISE MEASUREMENT DATA

This appendix includes data acquired during the site visit and noise measurement program, including noise monitor calibration data, site sketches, photographs, field noise and traffic data sheets. Also included are noise measurement results spreadsheets, which include site summary results, noise monitor acoustic data with L_{eq} calculations, and simultaneous traffic count data.

Sound Level Meter / RTA Settings							
Translated:	5-Jan-17	22:37:03					
File Translated:							
Model Number:	824						
Serial Number:	A3048						
Firmware Rev:	4.23						
Software Version:	3.12						
Name:	Harris Miller Miller & Hanson						
Descr1:	77 s Bedford Street Suite 120						
Descr2:	Burlington MA 01803						
Setup:	RT28.ssa						
Setup Descr:	RT28						
Location:							
Note 1:							
Note 2:							
Sound Level Meter / RTA Settings							
Bandwidth:	1						
Detector:	Fast						
Weighting:	A						
Peak-1 Weighting:	Flat						
Second Display:	TWA						
Gain:	0						
RTA Detector:	Fast						
RTA Weighting:	Flat						
AC Output Control:	AC-1 AC-2						
Ln							
Ln:	Disabled						
Ln Start Level:	15	dB					
Spectral Ln Option:	None						
Ln Percentiles							
Ln Percentiles							
L 1.0							
L 10.0							
L 33.0							
L 50.0							
L 90.0							
L 99.0							
Intervals							
Intervals:	Enabled						
Interval Time Sync:	Yes						
Interval Save Ln:	No						
Interval Save Ln Table:	No						
Interval Auto Stop:	No						
Interval Period:	0:01:00						

Interval Threshold:	0						
Interval Exchange Rate:	3	dB					
Interval Spectra Option:	None						
Time History							
Time History:	Enabled						
Time History Period:	1						
Time History Units:	1.0 seconds						
Resolution:	0.1	dB					
Timer							
Timer Mode:	Off						
Start Date:	1-Jan-00						
Stop Date:	31-Dec-99						
Start Time 1:	8:00						
Start Time 2:	0:00						
Stop Time 1:	17:00						
Stop Time 2:	0:00						
824 System Settings							
Translated:	5-Jan-17	22:37:03					
Calibration							
Calibrator S/N:	LD4182						
Calibrator Level:	114	dB					
Auto. Calibration:	No						
Calibration Time:	23:59						
Transducer:	Electret						
Noise Floor:	8	dB					
Rand. Inc Correction:	Disabled						
Linear Engineering Units:	Disabled						
Power Monitor							
Power Off Mode:	Manual Off						
Backlight:	Off						
LCD Contrast:	60						
Controls							
Logic Input Mode:	None						
Logic Output:	Off						
Modem Settings							
Modem control:	Disabled						
Dial out mode:	<none>						
Telephone Number:	<none>						
Monitor Number:	0						

Modem Init String:	X4 E0 Q0 V0 T M1 S0=5 &D						
824 SLM/RTA Run/Stop Log							
Translated:	5-Jan-17	22:37:03					
Rec #	Date	Time	R/S Num	Type	Cause	Time Hist Num	
1	5-Jan-17	9:27:04	1	Run	Key	1	
2	5-Jan-17	9:32:12	1	Stop	Key	309	
3	5-Jan-17	9:39:11	2	Run	Key	310	
4	5-Jan-17	10:10:17	2	Stop	Key	2177	
5	5-Jan-17	11:10:18	3	Run	Key	2178	
6	5-Jan-17	11:47:11	3	Stop	Key	4392	
7	5-Jan-17	12:22:35	4	Run	Key	4393	
8	5-Jan-17	12:53:14	4	Stop	Key	6232	
9	5-Jan-17	13:30:00	5	Run	Key	6233	
10	5-Jan-17	14:04:12	5	Stop	Key	8286	
Calibration Check Log							
Translated:	5-Jan-17	22:37:03					
Rec #	Date	Time	Level	Offset	Mode	Status	
1	5-Jan-17	10:11:14	113.9	-5.00E+01	Manual	Stable	
2	5-Jan-17	11:06:40	114	-5.00E+01	Manual	Stable	
3	5-Jan-17	11:47:57	113.9	-5.00E+01	Manual	Stable	
4	5-Jan-17	12:19:26	113.4	-5.00E+01	Manual	Stable	
5	5-Jan-17	12:19:50	113.4	-5.00E+01	Manual	Stable	
6	5-Jan-17	12:54:00	113.6	-5.00E+01	Manual	Stable	
7	5-Jan-17	13:27:55	114	-5.00E+01	Manual	Stable	
8	5-Jan-17	14:04:47	114.1	-5.00E+01	Manual	Stable	

SHORT-TERM NOISE MEASUREMENT DATA SHEET

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

MEASUREMENT SITE NO.: M1 PERSONNEL: ZFW

ADDRESS/DESCRIPTION: 8454 Turkey Run Dr. DATE: 1/5/17

#	1 Minute Period Starting	Meas'd Leq (dBA)	√ or X	Autos	Medium Trucks	Heavy Trucks	Other Noise Sources	COMMENTS (Include Calibration Data)
1	12:23	63.3						Cal: 113.4 dB
2	12:24	57.7						
3	12:25	63.2						
4	12:26	63.2						:15-27:30 apl. m/g
5	12:27	59.3						
6	12:28	65.2						:30-29:00 apl.
7	12:29	62.0						
8	12:30	59.0						
9	12:31	62.8						
10	12:32	59.5						:35-:40 dog barks
11	12:33	63.2						↳ intermittent afterwards,
12	12:34	61.8						but no noticible SLM effect
13	12:35	59.3						
14	12:36	58.1						
15	12:37	64.2						
16	12:38	60.6						:40-39:15 barks
17	12:39	62.5						:50 dual HT passby
18	12:40	64.8						
19	12:41	60.4						
20	12:42	62.6						:30-45:00 intermittent barks
21	12:43	64.6						
22	12:44	59.6						
23	12:45	61.2						
24	12:46	61.6						
25	12:47	60.7						
26	12:48	62.8						
27	12:49	59.7						
28	12:50	62.0						
29	12:51	63.1						
30	12:52	61.7						Cal: 113.6 dB

TOTAL Leq = SUBSET Leq =

√ = Other sources contributed to Leq X = Exclude period - contaminated by non-characteristic sources

>> ADD SKETCH AND WEATHER CONDITIONS TO REVERSE OR OTHER SHEET <<

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

SHORT-TERM NOISE MEASUREMENT SITE LOG

ASSESSMENT AREA: _____ MEASUREMENT SITE NO.: M1

ADDRESS: 8454 Turkey Run Dr.

OWNER:

DESCRIPTION:

NOISE SOURCES: Mainline, Loud & Faint Airplanes, Dog Barks, Birds

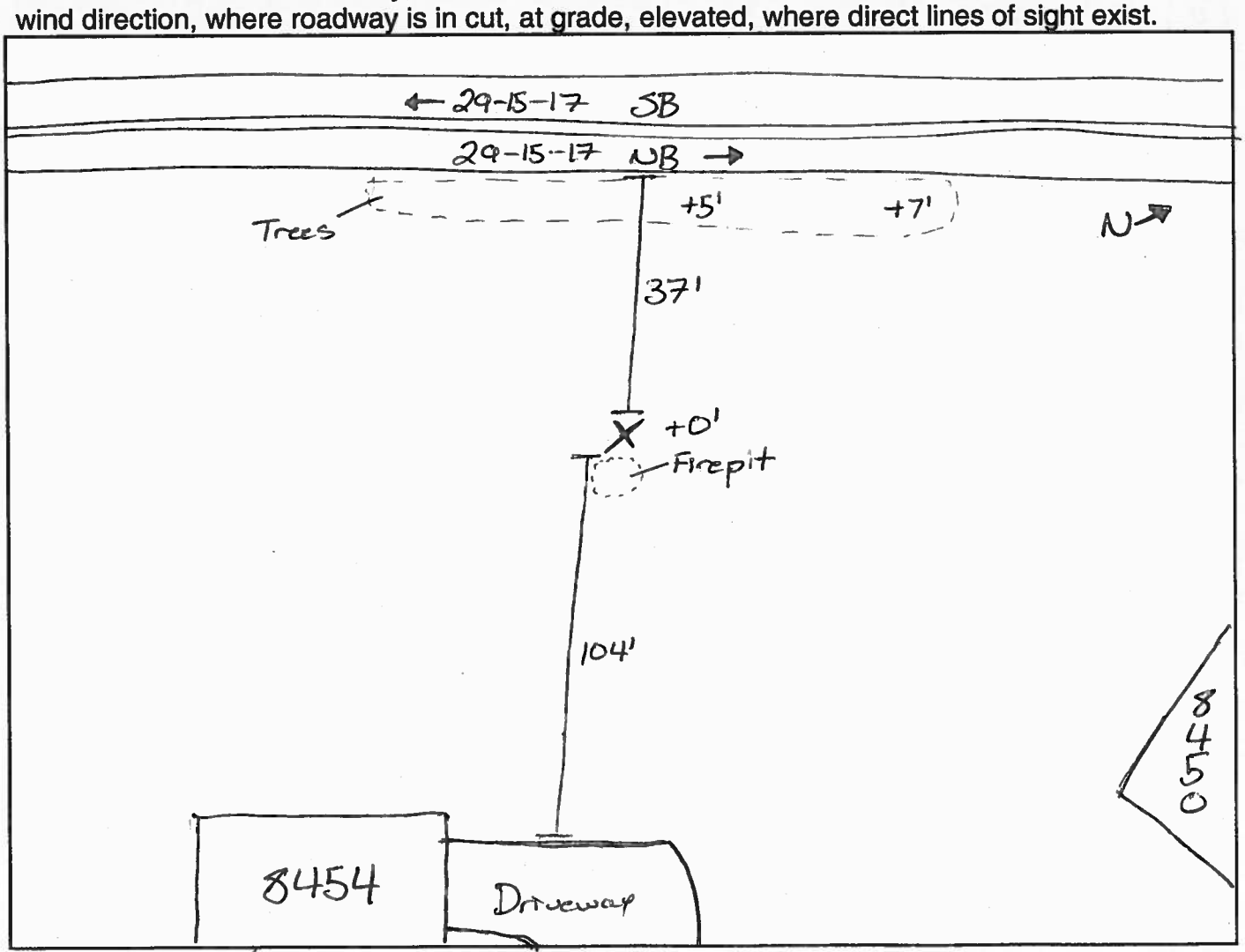
NOISE MONITOR: LD824 S/N: A3048

MICROPHONE/PREAMP: GRAS 40AQ / PRM902 S/N: 33135 / 4477

CALIBRATOR: CAL200 S/N: 9045

TEMP. RANGE (°F): 36°/46 °o /Rel. Humidity WEATHER CONDITIONS: Overcast

SITE SKETCH: Show roadway, homes, local roads, reference distances, arrows for North & wind direction, where roadway is in cut, at grade, elevated, where direct lines of sight exist.



PHOTOS: ✓ GPS COORDINATES: N. 38.68955°; W 77.78524°

Site M1: looking east at microphone position and single-family home
UPC 77384

SHORT-TERM NOISE MEASUREMENT DATA SHEET

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

MEASUREMENT SITE NO.: M2 PERSONNEL: ZFW

ADDRESS/DESCRIPTION: 8484 Turkey Run Dr. DATE: 1/5/17

#	1 Minute Period Starting	Meas'd Leq (dBA)	√ or X	Autos	Medium Trucks	Heavy Trucks	Other Noise Sources	COMMENTS (Include Calibration Data)
1	11:17	63.2						Cal: 114.0 dB
2	11:18	56.8						
3	11:19	59.7						
4	11:20	61.7						
5	11:21	56.5						:30 SB Backup
6	11:22	60.5						:30 SB 60
7	11:23	61.3						
8	11:24	55.0						
9	11:25	62.8						:00 Backup → :15 60
10	11:26	61.8						
11	11:27	56.2					:55 HT Idle	:20 Backup
12	11:28	64.5						:15 60
13	11:29	59.3						
14	11:30	60.5						
15	11:31	62.2						
16	11:32	59.2						:25 Backup
17	11:33	61.4						:15 60
18	11:34	60.0						
19	11:35	59.1						:25 Backup
20	11:36	60.0						:05 60
21	11:37	60.0						:45 Backup
22	11:38	55.7					:55 60	:15-:20 HF Brakes
23	11:39	63.2						
24	11:40	57.7						
25	11:41	56.4						:05 Backup
26	11:42	62.8						:00 60
27	11:43	59.7						
28	11:44	59.3						:15 Backup → :50 60
29	11:45	60.3						
30	11:46	55.3						Cal 114.0 dB

TOTAL Leq = SUBSET Leq =

√ = Other sources contributed to Leq X = Exclude period - contaminated by non-characteristic sources

>> ADD SKETCH AND WEATHER CONDITIONS TO REVERSE OR OTHER SHEET <<

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

SHORT-TERM NOISE MEASUREMENT SITE LOG

ASSESSMENT AREA: _____ MEASUREMENT SITE NO.: M2

ADDRESS: 8484 Turkey Run Dr.

OWNER: _____

DESCRIPTION: _____

NOISE SOURCES: Mainline

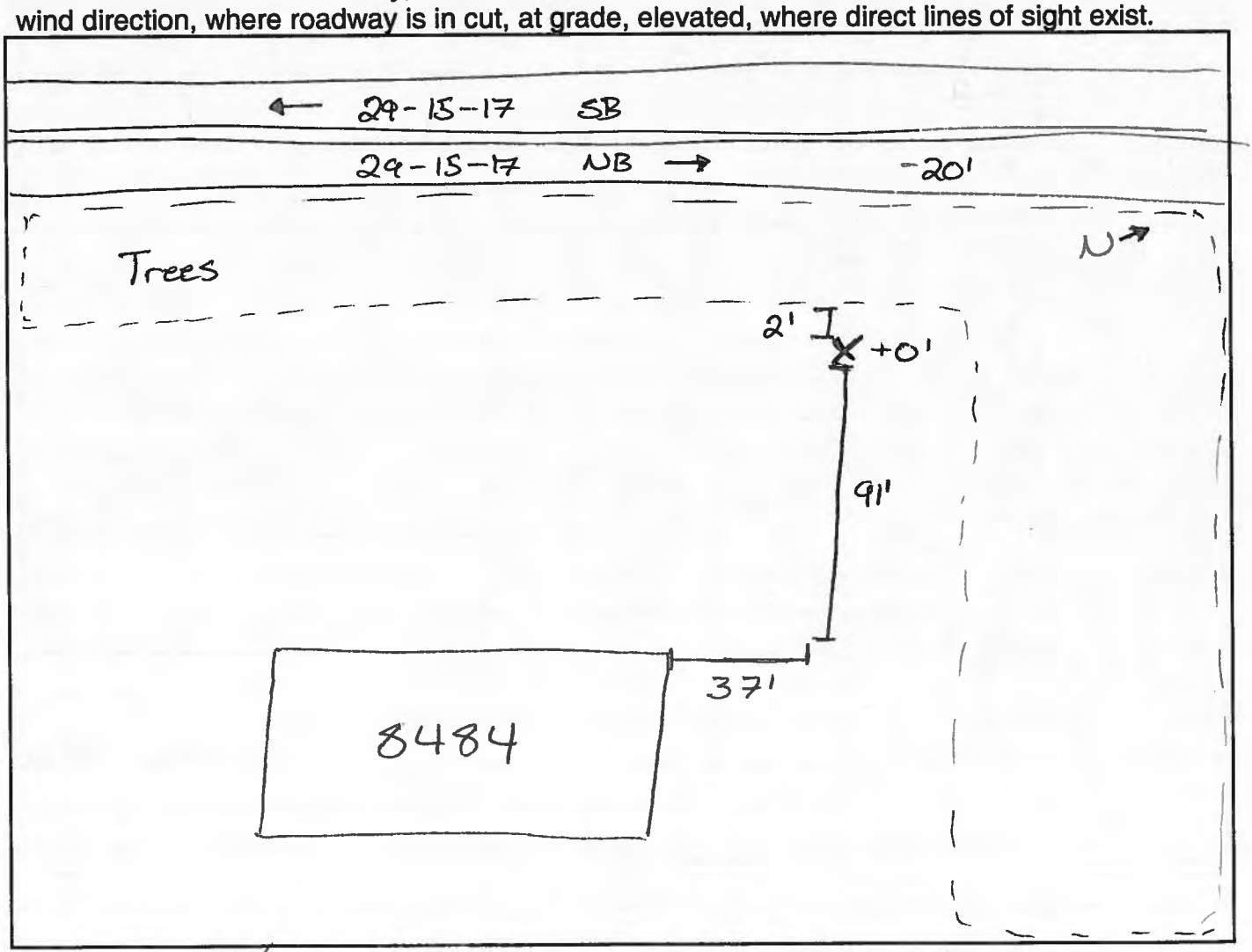
NOISE MONITOR: LD824 S/N: A3048

MICROPHONE/PREAMP: GRAS 40AQ / PRM902 S/N: 33135 / 4477

CALIBRATOR: CAL200 S/N: 9045

TEMP. RANGE (°F): 37° / 51% /Rel. Humidity WEATHER CONDITIONS: Overcast

SITE SKETCH: Show roadway, homes, local roads, reference distances, arrows for North & wind direction, where roadway is in cut, at grade, elevated, where direct lines of sight exist.



PHOTOS: ✓ GPS COORDINATES: N. 38.68772°; W. 77.786080

Site M2: looking south (along right-of-way) at microphone position
UPC 77384

SHORT-TERM NOISE MEASUREMENT DATA SHEET

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

MEASUREMENT SITE NO.: M3 PERSONNEL: ZFW

ADDRESS/DESCRIPTION: 6860 Traveler's Way DATE: 1/5/17

#	1 Minute Period Starting	Meas'd Leq (dBA)	√ or X	Autos	Medium Trucks	Heavy Trucks	Other Noise Sources	COMMENTS (Include Calibration Data)	
1	9:40	56.2						114.1 dB Cal	
2	9:41	59.6							
3	9:42	54.2							
4	9:43	59.1							
5	9:44	58.1							
6	9:45	58.3							
7	9:46	59.3						:45 Dumptruck NB	POCA
8	9:47	57.9						:15 Dumptruck NB	Ld. FFX POCA
9	9:48	58.7						:30 Dumptruck SB	POCA
10	9:49	60.6						:50 Dumptruck NB	POCA
11	9:50	55.8							
12	9:51	58.9						:25 Dumptruck SB	Ld. FFX POCA
13	9:52	63.3						:15 Loud HT POCA	
14	9:53	57.0							
15	9:54	58.3							
16	9:55	61.3							
17	9:56	54.7							
18	9:57	55.5							
19	9:58	57.2							
20	9:59	59.4							
21	10:00	55.7							
22	10:01	58.5							
23	10:02	59.6						:20 HT POCA	
24	10:03	55.5						:15 Dumptruck NB	POCA Ld. FFX
25	10:04	55.5							
26	10:05	59.6						:55 Dual Dumptruck	POCA
27	10:06	56.7						(NB&SB Ld. FFX)	
28	10:07	57.8							
29	10:08	57.1							
30	10:09	54.2						113.9 dB Cal	

TOTAL Leq = SUBSET Leq =

√ = Other sources contributed to Leq X = Exclude period - contaminated by non-characteristic sources

>> ADD SKETCH AND WEATHER CONDITIONS TO REVERSE OR OTHER SHEET <<

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

SHORT-TERM NOISE MEASUREMENT SITE LOG

ASSESSMENT AREA: _____ MEASUREMENT SITE NO.: M3

ADDRESS: 6860 Traveler's Way

OWNER:

DESCRIPTION:

NOISE SOURCES: Mainline, Lord Fairfax Rd., Faint Electrical Equipment, Faint aircraft

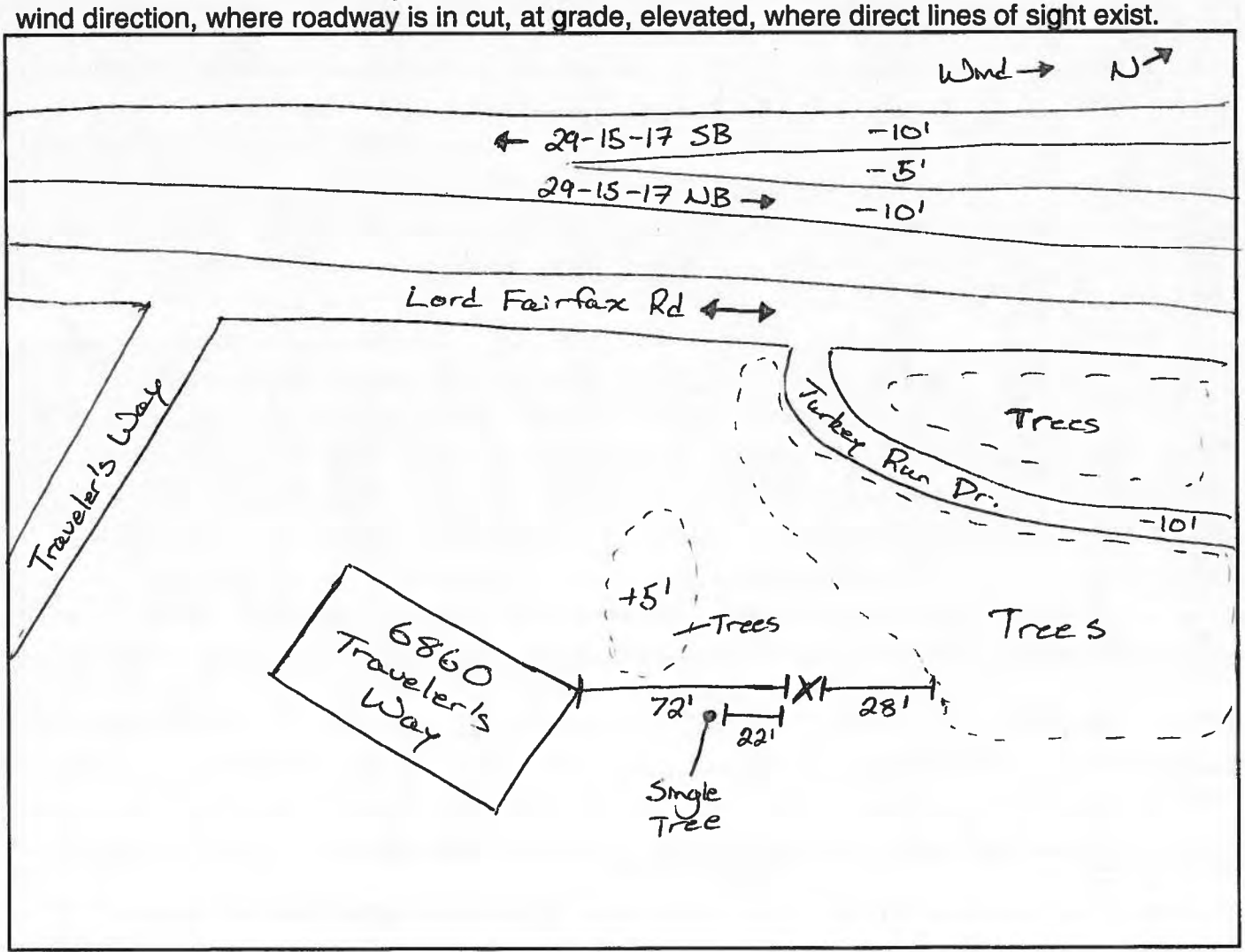
NOISE MONITOR: LD824 S/N: A3048

MICROPHONE/PREAMP: GRAS 40AQ / PRM902 S/N: 33135 / 4477

CALIBRATOR: CAL200 S/N: 9045

TEMP. RANGE (°F): 32°/64% /Rel. Humidity WEATHER CONDITIONS: Overcast

SITE SKETCH: Show roadway, homes, local roads, reference distances, arrows for North & wind direction, where roadway is in cut, at grade, elevated, where direct lines of sight exist.



PHOTOS: ✓ GPS COORDINATES: N 38.68419° ; W 77.78620°

HARRIS MILLER MILLER & HANSON INC.

Site M3: looking west at microphone position
UPC 77384

SHORT-TERM NOISE MEASUREMENT DATA SHEET

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

MEASUREMENT SITE NO.: M4

PERSONNEL: ZFW

ADDRESS/DESCRIPTION: 8598 James Madison Highway

DATE: 1/5/17

#	1 Minute Period Starting	Meas'd Leq (dBA)	√ or X	Autos	Medium Trucks	Heavy Trucks	Other Noise Sources	COMMENTS (Include Calibration Data)
1	13:34	73.4						Cal: 114.0 dB
2	13:35	76.7						34:10 54dBA (Almost Ambient)
3	13:36	70.8						:20 HT passby SB
4	13:37	70.1						
5	13:38	76.7						:05 HT passby SB
6	13:39	73.2						
7	13:40	67.1						
8	13:41	75.8						
9	13:42	73.5						
10	13:43	76.5						
11	13:44	76.7						:50 dual HT passby SB
12	13:45	74.3					:55 NB HT	Trace Snowfall Begins
13	13:46	69.7						
14	13:47	71.3						:35 SB HT
15	13:48	76.6						
16	13:49	75.5						
17	13:50	69.0						
18	13:51	77.2						
19	13:52	73.5						Slightly More Snow
20	13:53	75.5						
21	13:54	71.8						
22	13:55	76.8						
23	13:56	72.2						Moderate Snow
24	13:57	74.9						
25	13:58	74.5						
26	13:59	73.9						
27	14:00	76.4						:15-:45 Quiet Convo
28	14:01	68.3						
29	14:02	75.8						:50 SB HT
30	14:03	71.8						Cal: 114.1 dB

TOTAL Leq =

SUBSET Leq =

√ = Other sources contributed to Leq

X = Exclude period - contaminated by non-characteristic sources

>> ADD SKETCH AND WEATHER CONDITIONS TO REVERSE OR OTHER SHEET <<

PROJECT: Route 29-15-17 Interchange Improvement Project

JOB NO.: UPC 77384; HMMH 306780.011

SHORT-TERM NOISE MEASUREMENT SITE LOG

ASSESSMENT AREA: _____ MEASUREMENT SITE NO.: M4

ADDRESS: 8598 James Madison Highway

OWNER:

DESCRIPTION:

NOISE SOURCES: Mainline

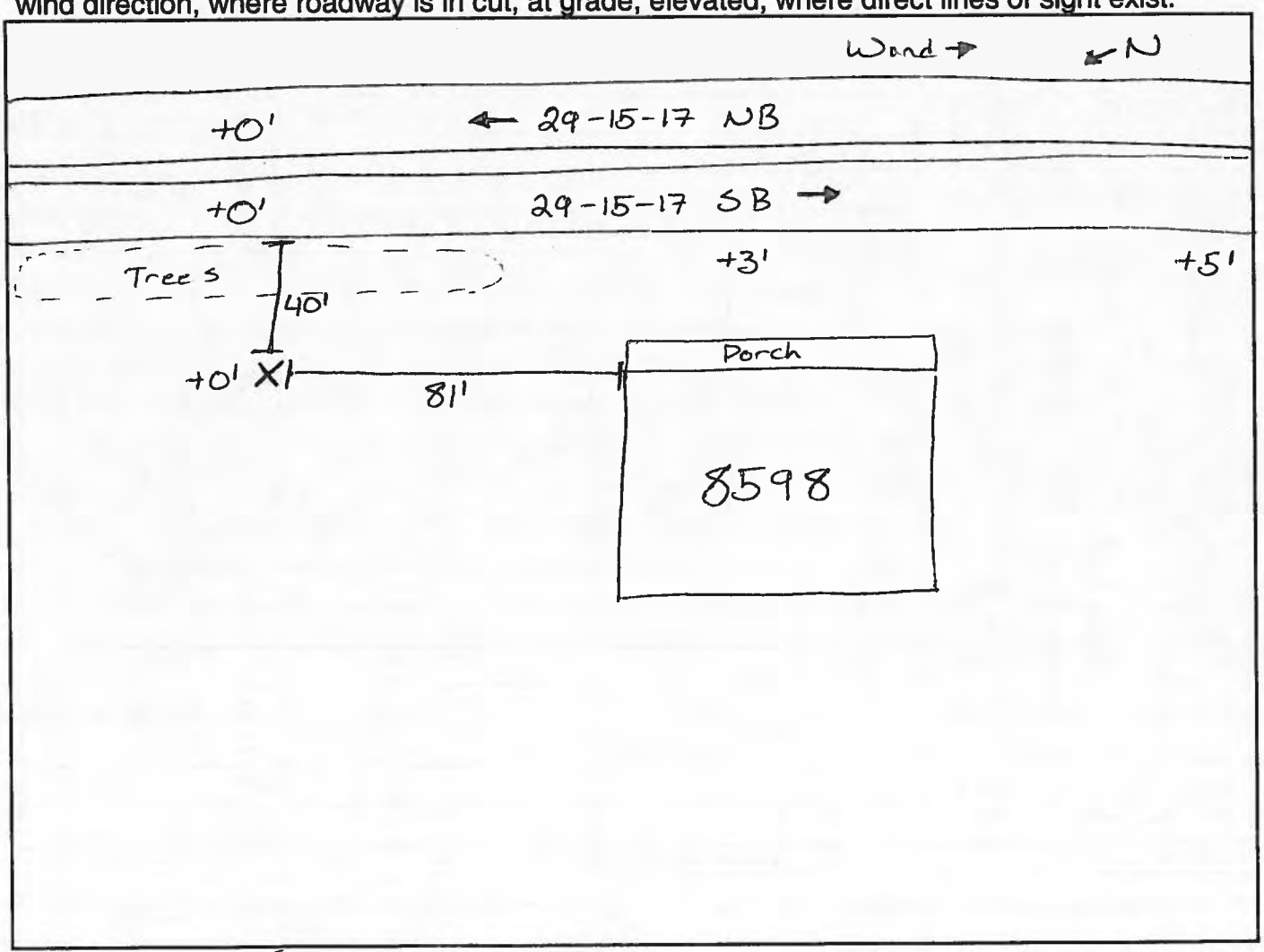
NOISE MONITOR: LD824 S/N: A3048

MICROPHONE/PREAMP: GRAS 40AQ / PRM902 S/N: 33135 / 4477

CALIBRATOR: CAL200 S/N: 9045

TEMP. RANGE (°F): 36°/45°F WEATHER CONDITIONS: Overcast / Light Snow

SITE SKETCH: Show roadway, homes, local roads, reference distances, arrows for North & wind direction, where roadway is in cut, at grade, elevated, where direct lines of sight exist.



PHOTOS: ✓ GPS COORDINATES: N 38.68032°; W 77.78757°

HARRIS MILLER MILLER & HANSON INC.

Site M4: looking south at microphone position
UPC 77384

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA:
MEASUREMENT SITE NO.: M1
ADDRESS/DESCRIPTION: 8454 Turkey Run Dr.

START TIME: 12:23
END TIME: 12:53
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes** **Start Time:** 12:23			
	Automobiles	86	
	Medium Trucks (6 Tires)	6	
	Heavy Trucks (>6 Tires)	9	
	Average speed (mph)		
Second Sample: 5 **minutes** **Start Time:** 12:29			
	Automobiles		86
	Medium Trucks (6 Tires)		5
	Heavy Trucks (>6 Tires)		12
	Average speed (mph)		
Third Sample: 5 **minutes** **Start Time:** 12:35			
	Automobiles	61	
	Medium Trucks (6 Tires)	2	
	Heavy Trucks (>6 Tires)	9	
	Average speed (mph)		
Fourth Sample: 5 **minutes** **Start Time:** 12:41			
	Automobiles		89
	Medium Trucks (6 Tires)		4
	Heavy Trucks (>6 Tires)		17
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA: _____
MEASUREMENT SITE NO.: M1
ADDRESS/DESCRIPTION: 8454 Turkey Run Dr.

START TIME: 12:23
END TIME: 12:53
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes**			
Start Time: 12:47			
	Automobiles	62	71
	Medium Trucks (6 Tires)	4	8
	Heavy Trucks (>6 Tires)	9	14
	Average speed (mph)		
Second Sample: ____ **minutes**			
Start Time: _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Third Sample: _____ **minutes**			
Start Time: _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Fourth Sample: _____ **minutes**			
Start Time: _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA: _____
MEASUREMENT SITE NO.: M2
ADDRESS/DESCRIPTION: 8484 Turkey Run Dr.

START TIME: 11:11
END TIME: 11:46
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 minutes, **Start Time:** 11:11			
	Automobiles	60	
	Medium Trucks (6 Tires)	7	
	Heavy Trucks (>6 Tires)	7	
	Average speed (mph)		
Second Sample: 5 minutes, **Start Time:** 11:17			
	Automobiles		83
	Medium Trucks (6 Tires)		6
	Heavy Trucks (>6 Tires)		18
	Average speed (mph)		
Third Sample: 5 minutes, **Start Time:** 11:23			
	Automobiles	81	
	Medium Trucks (6 Tires)	5	
	Heavy Trucks (>6 Tires)	20	
	Average speed (mph)		
Fourth Sample: 5 minutes, **Start Time:** 11:29			
	Automobiles		76
	Medium Trucks (6 Tires)		2
	Heavy Trucks (>6 Tires)		14
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA: _____
MEASUREMENT SITE NO.: M2
ADDRESS/DESCRIPTION: 8484 Turkey Run Dr.

START TIME: 11:11
END TIME: 11:46
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes** **Start Time:** 11:35			
	Automobiles	50	
	Medium Trucks (6 Tires)	2	
	Heavy Trucks (>6 Tires)	9	
	Average speed (mph)		
Second Sample: 5 **minutes** **Start Time:** 11:41			
	Automobiles		63
	Medium Trucks (6 Tires)		5
	Heavy Trucks (>6 Tires)		11
	Average speed (mph)		
Third Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Fourth Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA: _____
MEASUREMENT SITE NO.: M3
ADDRESS/DESCRIPTION: 6860 Traveler's Way

START TIME: 9:40
END TIME: 10:15
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 minutes, **Start Time:** 9:40			
	Automobiles	96	
	Medium Trucks (6 Tires)	3	
	Heavy Trucks (>6 Tires)	13	
	Average speed (mph)	56,58,54,61	
Second Sample: 5 minutes, **Start Time:** 9:46	29-15-17		
	Automobiles		78
	Medium Trucks (6 Tires)		3
	Heavy Trucks (>6 Tires)		14
	Average speed (mph)		
Third Sample: 5 minutes, **Start Time:** 9:52	Lord Fairfax Rd.		
	Automobiles	12	9
	Medium Trucks (6 Tires)	0	1
	Heavy Trucks (>6 Tires)	1	2
	Average speed (mph)		
Fourth Sample: 5 minutes, **Start Time:** 9:58	29-15-17		
	Automobiles	102	
	Medium Trucks (6 Tires)	8	
	Heavy Trucks (>6 Tires)	8	
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA:		START TIME:	9:40
MEASUREMENT SITE NO.:	M3	END TIME:	10:16
ADDRESS/DESCRIPTION:	6860 Travelers Way	DATE:	1/5/17
		PERSONNEL:	DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes** **Start Time:** 10:04			
	Automobiles		70
	Medium Trucks (6 Tires)		9
	Heavy Trucks (>6 Tires)		8
	Average speed (mph)		59,67,66,53
Second Sample: 5 **minutes** **Start Time:** 10:10	Lord Fairfax Rd.		
	Automobiles	7	8
	Medium Trucks (6 Tires)	1	2
	Heavy Trucks (>6 Tires)	2	3
	Average speed (mph)	30,31,35	30,32,36
Third Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Fourth Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA:		START TIME:	13:34
MEASUREMENT SITE NO.:	M4	END TIME:	14:04
ADDRESS/DESCRIPTION:	8598 James Madison Hwy	DATE:	1/5/17
		PERSONNEL:	DSC/ZFW

ROADWAY:	Bingham Rd.	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes** **Start Time:** 13:34			
	Automobiles	6	6
	Medium Trucks (6 Tires)	0	0
	Heavy Trucks (>6 Tires)	0	1
	Average speed (mph)		
Second Sample: 5 **minutes** **Start Time:** 13:40	29-15-17		
	Automobiles		36
	Medium Trucks (6 Tires)		3
	Heavy Trucks (>6 Tires)		6
	Average speed (mph)		65, 55
Third Sample: 5 **minutes** **Start Time:** 13:46	29-15-17		
	Automobiles	82	
	Medium Trucks (6 Tires)	7	
	Heavy Trucks (>6 Tires)	7	
	Average speed (mph)	58	
Fourth Sample: 5 **minutes** **Start Time:** 13:52	29-15-17		
	Automobiles		92
	Medium Trucks (6 Tires)		4
	Heavy Trucks (>6 Tires)		15
	Average speed (mph)		

PROJECT: Route 29-15-17 Interchange Improvement Project
JOB NO.: UPC 77384; HMMH 306780.011

TRAFFIC VOLUME COUNT DATA SHEET

ASSESSMENT AREA: _____
MEASUREMENT SITE NO.: M4
ADDRESS/DESCRIPTION: 8598 James Madison Hwy

START TIME: 13:34
END TIME: 14:04
DATE: 1/5/17
PERSONNEL: DSC/ZFW

ROADWAY:	29-15-17	DIRECTION 1: NB	DIRECTION 2: SB
First Sample: 5 **minutes** **Start Time:** 13:58			
	Automobiles	81	
	Medium Trucks (6 Tires)	5	
	Heavy Trucks (>6 Tires)	15	
	Average speed (mph)		
Second Sample: ____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Third Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		
Fourth Sample: _____ **minutes** **Start Time:** _____			
	Automobiles		
	Medium Trucks (6 Tires)		
	Heavy Trucks (>6 Tires)		
	Average speed (mph)		

APPENDIX B

LD-450
7/01/09

COMMONWEALTH of VIRGINIA
DEPARTMENT OF TRANSPORTATION
DIVISION: LOCATION & DESIGN

REPORT COVER SHEET

Traffic Analysis (TA) Report
Warrenton Southern Interchange US 15/17/29 Design-Build
Fauquier County, Virginia

May 25, 2018

Prepared By:

Dewberry

COMMONWEALTH OF VIRGINIA
GERARD MRYKALO
Lic. No. 047293
5/25/18
PROFESSIONAL ENGINEER

Dewberry Engineers Inc.
Fairfax, Virginia
TRAFFIC ENGINEER

Responsible for All Pages

Project Description	**Warrenton Southern Interchange US 15/17/29**
From:	**0.416 Miles South of US 15/17/29 Business**
To:	**0.356 Miles North of US 15/17/29 Business**
Project UPC No.:	**77384 (Proj No: 0029-030-121, P101, R201, C501, B616)**

TRAFFIC ANALYSIS (TA) REPORT

Warrenton Southern Interchange
May 25, 2018

Introduction

Shirley Contracting Company, LLC (Shirley) and Dewberry Consultants LLC (Dewberry) have prepared this Traffic Analysis (TA) Report in conformance with the requirements specified in Section 2.2 of Part 2 of the RFP. This report is required as our proposed interchange configuration differs from the RFP Conceptual Plans. The format of this report matches the format of the Operational Analysis Technical Memorandum submitted by Shirley during the procurement process for ATC 1, and the results are almost identical. Small variations between the results presented in this report versus the procurement analysis are attributed to minor final design geometric adjustments and optimizations. The purpose of this report is to document the operational differences between the RFP Concept and the proposed design.

This report details the analysis methodology, describes the operational characteristics of our design, and compares the operation of our design to the RFP design operations. As required, analysis was performed for both the AM and PM peaks for the 2040 Build Scenario. Analysis tools utilized were SIDRA for roundabouts, Synchro for signalized and un-signalized intersections, and HCS for merges and diverges, matching the analysis tools used in the RFP traffic analysis. As detailed in this report, our design, referred to as the "Modified Barbell", meets the requirement that "that proposed concept overall operates equal to or better than the RFP Concept".

Please note that additional design details, such as AutoTurn simulations for turn movements, are prepared under separate cover as part of the 1st submission roadway plans and the package of documents to be submitted to the Central Office Roundabout Review Committee.

Traffic Analysis Assumptions, Methodology, and Input Values

SIDRA Version 7.0, Synchro Version 9, and HCS+ 2010 were utilized to analyze our proposed design. These programs are the same tools utilized by VDOT in the preparation of Table 17 of the RFP *US Route 15/17/29 & US Route 15/17/29 Business Interchange - Traffic Analyses Report* dated April 10, 2017, and therefore allows for a direct comparison of the RFP Concept to our proposed design (the "Modified Barbell").

Matching Table 17 of the RFP *Traffic Analyses Report*, the 2040 operational analyses conducted were for the weekday AM, weekday PM, and Saturday peaks (although Section 3.6.1 of Part 1 of the RFP only requires analysis of the weekday AM and weekday PM peaks). All models were developed following the assumptions, methodology, and input values included in the RFP *Traffic Analyses Report,* the RFP *Traffic Analyses Report* analysis files (received from VDOT as an

advanced copy of Addendum 2), and applicable guidance of VDOT's *Traffic Operations and Safety Analysis Manual (TOSAM) – Version 1.0.* Although a modeling parameters table was not included in the RFP *Traffic Analyses Report*, Table 1 on the following page has been developed to summarize these assumptions and input values used in the development of our traffic models (which match the RFP Concept analysis values).

To accurately provide analysis comparisons for Table 17, the study was broken up into three parts. HCS merge and diverge analyses were performed for US 15/17/29 interchange ramps (free flow facilities), SIDRA analyses were performed for the roundabouts, and Synchro analyses were performed for the intersections.

Table 1: Traffic Modeling Parameters, Assumptions, and Input Values

Parameter	Value
HCS+ 2010 Version	6.80 *
SIDRA Version	7.0 *
Synchro Version	9 *
Heavy Vehicle Percentages	**US 15/17/19 NB:** AM: 13% PM:11% (Merge) 12% (Diverge) **US 15/17/19 SB:** AM: 19% (Diverge) 10% (Merge) PM:10% (Diverge) 18% (Merge) **All other roads / connections:** Matched RFP SIDRA and Synchro files
Grades	Matched RFP analyses (Used proposed grades where applicable)
Roadway Speeds	US 15/17/29 & US 15/17/29 Bypass: 55 mph US 15/17/29 Business: 40 mph Lord Fairfax Rd: 35 mph Travelers Way: 30 mph College St: 30 mph Turkey Run Dr: 30 mph
Peak Hour Factors	Matched RFP analyses for each movement

Note:
* These are current versions, with analyses methodologies and equations matching versions used with the *US Route 15/17/29 & US Route 15/17/29 Business Interchange - Traffic Analyses Report*

Operational Characteristics of the Modified Barbell

Our proposed design, the "Modified Barbell", reconfigures the eastern roundabout to take the on-ramp to US 15/17/29 bypass leg underneath the proposed bridge, eliminating the need for a large retaining wall in the northeast quadrant. No additional legs or conflict points are added, and this ramp leg is relocated approximately 90 degrees counterclockwise to the south side of Lord Fairfax Rd. The overpass bridge and the roundabouts are shifted north in our proposed design, allowing more of Ramp G to be maintained on its existing profile. Also Ramp G enters southbound US 15/17/29 as a two lane ramp after merging with Ramp C, providing additional capacity for this merge. Another feature of our proposed design is that the park and ride is moved north to between Lord Fairfax Rd and Ramp F for reduced travel times on and off of US 15/17/29, with access provided by adding a 4th leg to the intersection of Lord Fairfax Rd.

Besides these major features of the "Modified Barbell", our operational characteristics generally match the RFP Concept (interchange configuration, number of lanes, turn lanes, and conflict points). Exhibit 1 on page 4 graphically depicts the lane configurations and operational characteristics of the "Modified Barbell".

Roundabout intersections are provided at both the northbound ramp terminal and southbound ramp terminal (matching RFP), and un-signalized intersections are provided at the same intersections as the RFP Concept. As noted on the previous page, with the "Modified Barbell" configuration, the modified park and ride location provides more direct access to the interchange.

For the heavy US 15/17/29 Business to southbound US 15/17/29 movement, the "Modified Barbell" improves operations compared to the RFP Concept by providing a two lane on-ramp to southbound US 15/17/29. For the heavy northbound US 15/17/29 to US 15/17/29 Business movement, the "Modified Barbell" provides a similar configuration to the RFP Concept, but does improve upon the RFP Concept by reducing the number of roundabout legs that this traffic traverses at the eastern roundabout (based on the shifted location of the Ramp B leg), and reduces the number of pedestrian conflict points.

Finally, our proposed design facilitates the future 6-lane configuration on US 15/17/29 mainline (by others, and not included in the 2040 operational analyses).

Traffic Volume Development

The RFP *Traffic Analyses Report* was used as the basis for the 2040 weekday AM, weekday PM, and Saturday peak volumes. These base volumes are graphically depicted on Figure 20 of the RFP *Traffic Analyses Report*. All base volumes west of mainline US 15/17/29 were unchanged, as the proposed geometric configurations do not differ from the RFP Concept. East of mainline US 15/17/29, base volumes were shifted at the eastern roundabout for the re-location of the Ramp B leg, but volumes were unchanged. To account for the relocated park and ride location, volumes on Lord Fairfax Rd were re-distributed between Turkey Run Dr and the southern project terminus (along Bingham Rd) for park and ride volumes.

Specifically, volumes at the RFP Concept intersections of Lord Fairfax Rd / Bingham Rd and College St, Lord Fairfax Rd and Travelers Way, and Lord Fairfax Rd and Turkey Run Dr, were re-distributed for park and ride volumes. The RFP *Traffic Analyses Report* and RFP *Traffic Analyses Report* analysis files did not specify the specific volumes associated with the park and ride. Therefore, *ITE Trip Generation, 7th Edition* was utilized to estimate park and ride volumes (pages 78 and 79 for AM and PM park and ride trips). Utilizing this methodology, 15 trips were projected for the weekday AM, 12 trips were projected for the weekday PM, and 13 trips were projected for the Saturday peak.

Figure 20 from the RFP *Traffic Analyses Report* detailing the RFP 2040 peak hour volumes is included on page 5. Also included for comparison is Figure 20-1 on page 6, which details the re-distributed peak hour volumes for the "Modified Barbell". The RFP base volumes were simply re-distributed, and not increased, decreased, or manipulated in any other way.

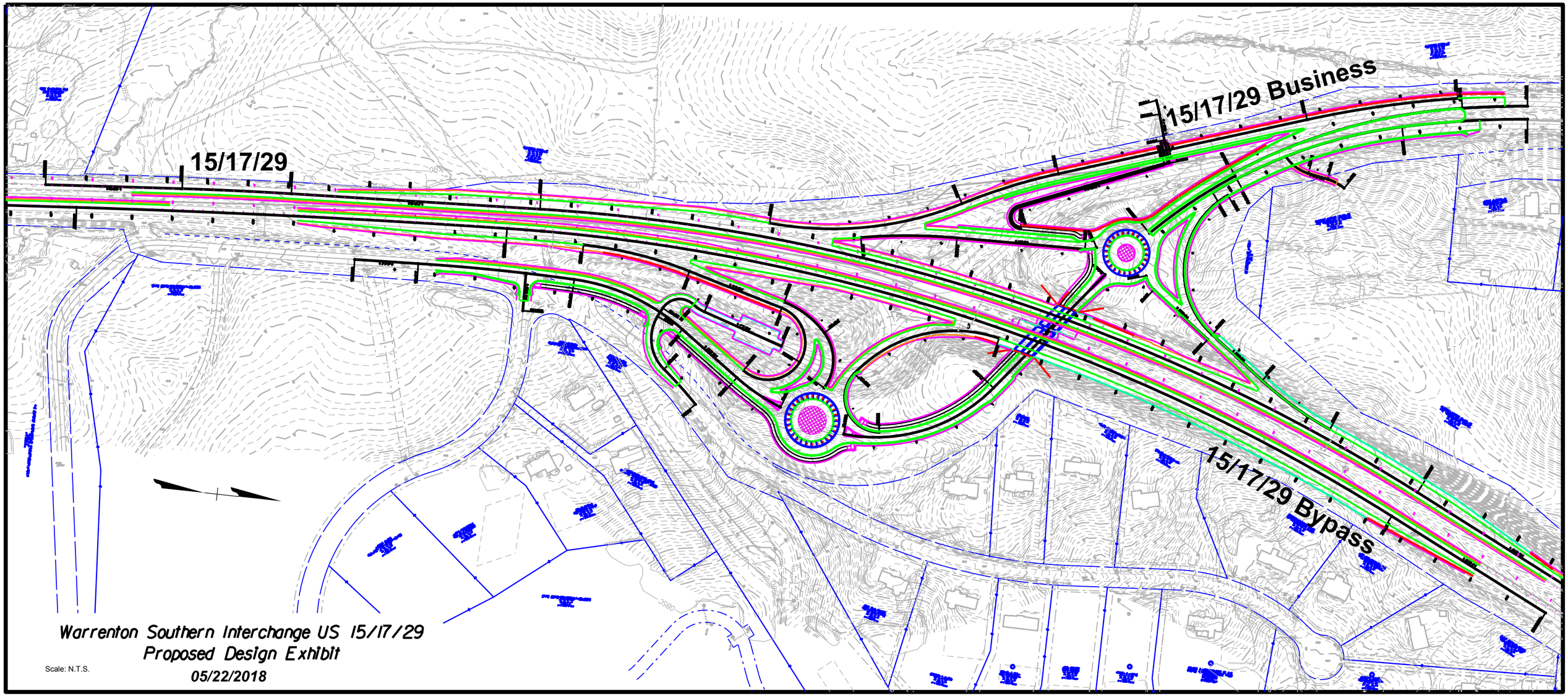

15/17/29
15/17/29 Business
15/17/29 Bypass
Warrenton Southern Interchange US 15/17/29
Proposed Design Exhibit
05/22/2018
Scale: N.T.S.

Figure 20: Build Design Year 2040 Peak Hour Traffic Volumes

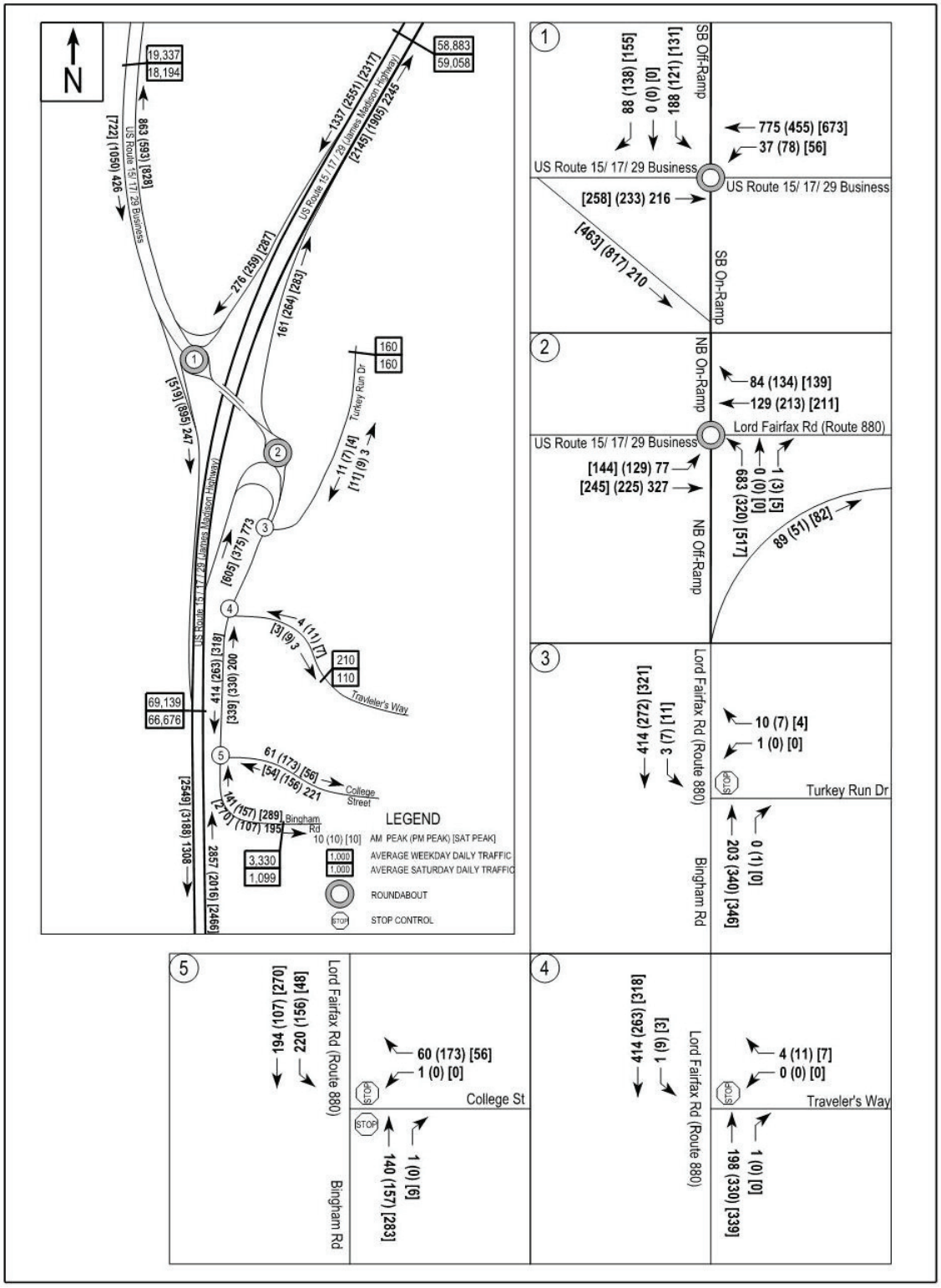
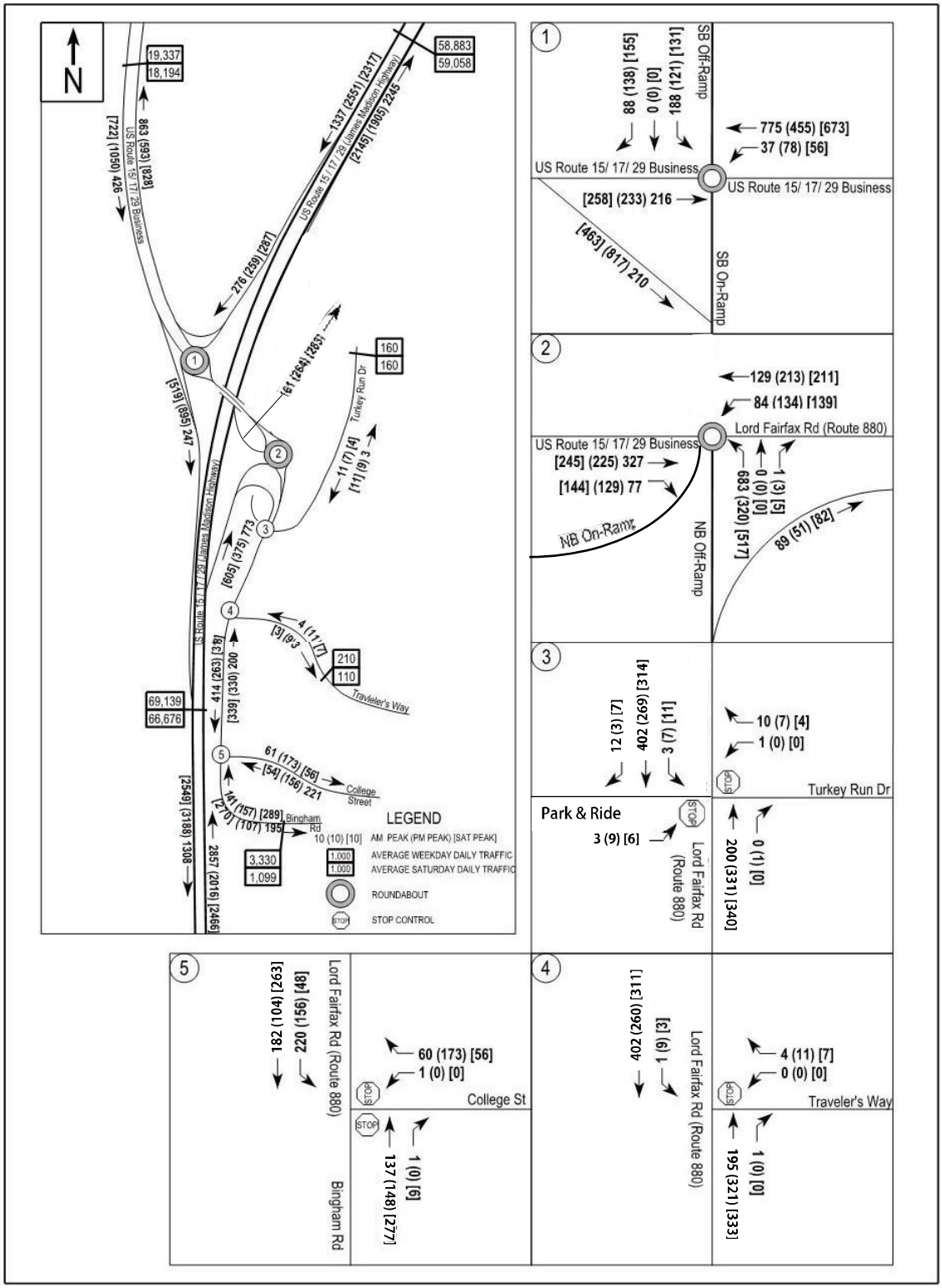


Figure 20-1: Build Design Year 2040 Peak Hour Traffic Volumes - ATC 1



Analysis Results and Summary of Conclusions

Utilizing the format of Table 17 of the RFP *Traffic Analyses Report*, the 2040 operational analyses were conducted using SIDRA for roundabouts, Synchro for signalized and un-signalized intersections, and HCS for merges and diverges for the Weekday AM, Friday PM, and Saturday peaks.

To compare our "Modified Barbell" to the RFP Concept, we created Table 17-1 which follows the format and results included in the RFP *Traffic Analyses Report*. As described in further detail below, we matched the exact reported metrics and measures of effectiveness as Table 17 of the RFP *Traffic Analyses Report*. In Table 17-1, intersections and merge / diverges that improved in LOS compared to the RFP Concept are highlighted in green. These tables are found in this report on pages 10 -11, and demonstrates that our proposed design "overall operates equal to or better than the RFP Concept". LOS results are also depicted graphically on Table 24 (RFP Results from *Traffic Analyses Report*) and on Table 24-1 (proposed "Modified Barbell" results) on pages 12 and 13.

US 15/17/29 Mainline Merge & Diverge Results:

For the US 15/17/29 mainline merge and diverge operations for ramp movements, the metric reported included LOS (per movement) and Density (pc/hr/lane). Matching Table 17 of the *Traffic Analyses Report*, analyses were performed for all, ramp merge, and ramp diverge segments. The movements analyzed for the "Modified Barbell" are identical to the RFP Concept, as the number of merge and diverge points is unchanged. The Measure Of Effectiveness (MOEs) utilized to compare the RFP Concept to the "Modified Barbell" is density. In addition, Level of Service (LOS) is utilized to describe and illustrate this density by applying a letter grade to a specified range of values. For Tables 17 and 17-1, LOS is applied to the density values per VDOT methodology also explained in Chapter 4 of the *TOSAM*.

Summary: As can be seen in Table 17-1 on page 11, the "Modified Barbell" Level of Service for all merge, and diverge movements is equal to or better than the RFP Concept (which is depicted on Table 17). For the southbound on-ramp (Ramp G), the operations with our proposed design is a significant improvement over the RFP Concept (improved LOS in all periods) since this is brought onto mainline US 15/17/29 as a two-lane ramp. For all other movements, there are only small deviations in density values for each concept. These small deviations are a result of geometric differences between the RFP concept and the "Modified Barbell", such as the re-alignment of Ramp B to travel under the proposed bridge.

Intersections Results:

For the operations of intersections along US 15/17/29 Business and Lord Fairfax Road, Table 17 metrics reported included LOS (per movement), Delay (seconds), and Queue Length (feet). Matching Table 17 of the *Traffic Analyses Report*, analyses were performed for all intersections. The segments analyzed for the "Modified Barbell" are identical to the RFP Concept, as our design concept includes the same intersections as the RFP Concept. While our proposed design

has the same number of intersections, there are geometric differences (as explained in the Operational Characteristics section on pages 2 and 3). Most notably, the "Modified Barbell" reconfigures the position of the northbound on-ramp to US 15/17/29 mainline, and adds a 4th leg to the intersection with Turkey Run Drive to accommodate the relocated park and ride. No conflict points are added with this park and ride relocation (it is simply relocated), as the RFP Concept park and ride intersection (along Bingham Road) is eliminated with our proposed design.

The Measures Of Effectiveness (MOEs) utilized to compare the RFP Concept to the "Modified Barbell", as defined by Chapter 4 of VDOT's *TOSAM,* are delay and queue length. In addition, Level of Service (LOS) is utilized to describe and illustrate these MOEs by applying a letter grade to a specified range of values. For Tables 17 and 17-1, LOS is applied to the delay values. As explained in the Assumptions, Methodology, and Input Values section, SIDRA was used to analyze the roundabouts (the northbound and southbound ramp terminal intersections) and Synchro was used to analyze conventional signalized and un-signalized intersections.

Summary: As can be seen in Table 17-1 on page 11, the "Modified Barbell" Level of Service for all intersections is equal to or better than the RFP Concept (which is depicted on Table 17). All intersections for both periods operate at LOS A or LOS B, matching the results of the RFP. In general, there are only small deviations in delay and queue for each concept. These small deviations are a result of geometric differences between the RFP concept "Modified Barbell", such as the re-alignment of Ramp B at the eastern roundabout and the relocation of the park and ride facility.

In addition to delay, the queues with the "Modified Barbell" concept are similar to the RFP Concept, with no significant differences or operational concerns (such as spillback to the adjacent intersection). The longest queue length associated with the "Modified Barbell" is 190' in the AM peak for Ramp F (northbound off-ramp), which is well within the available ramp storage area, and shorter than the RFP Concept maximum queue.

Conclusions:

Table 2 below presents a summary of key operational differences that are discussed above and detailed in Table 17-1 for the AM and PM peaks. The "overall operations" row at the bottom of the table is the sum of the individual component LOS, indicating the overall operations of the interchange as a whole. As reported in this report, our proposed design clearly meets the requirement "that proposed concept overall operates equal to or better than the RFP Concept".

Table 2: Measure of Effectiveness Comparison

Measure of Effectiveness (MOE)	RFP Concept	Modified Barbell	Equal to or Better than RFP
Eastern Ramps Intersection LOS	LOS (B) in AM LOS (A) in PM	LOS (B) in AM LOS (A) in PM	**Equal**
Western Ramps Intersection LOS	LOS (A) in AM LOS (A) in PM	LOS (A) in AM LOS (A) in PM	**Equal**
Turkey Run Dr Intersection LOS	LOS (A) in AM LOS (A) in PM	LOS (A) in AM LOS (A) in PM	**Equal**
Travelers Way Intersection LOS	LOS (A) in AM LOS (A) in PM	LOS (A) in AM LOS (A) in PM	**Equal**
College St Intersection LOS	LOS (B) in AM LOS (A) in PM	LOS (B) in AM LOS (A) in PM	**Equal**
US 15/17/29 Mainline Merge & Diverge LOS	3 at LOS (B), 1 at LOS (C) in AM 2 at LOS (B), 1 at LOS (C), 1 at LOS (D) in PM	1 at LOS (A), 2 at LOS (B), 1 at LOS (C) in AM 2 at LOS (B), 2 at LOS (C) in PM	**Better**
Overall Operations	**3 at LOS (A), 5 at LOS (B), 1 at LOS (C) in AM 5 at LOS (A), 2 at LOS (B), 1 at LOS (C), 1 at LOS (D) in PM**	**4 at LOS (A), 4 at LOS (B), 1 at LOS (C) in AM 5 at LOS (A), 2 at LOS (B), 2 at LOS (C) in PM**	**Better**

Table 17 – 2040 Build Analysis Results

Intersection	Traffic Control	Lane Group/ Approach	AM Peak Hour			PM Peak Hour			Sat Peak Hour		
			LOS	Delay (sec)	Back of Queue (in feet)	LOS	Delay (sec)	Back of Queue (in feet)	LOS	Delay (sec)	Back of Queue (in feet)
US Route 15/17/29 NB Ramps & US Route 15/17/29 Business/Lord Fairfax Rd	Roundabout	EB/LT	A	9.1	68	A	9.1	47	A	9.1	61
		EB LOS	A	2.1	**N/A**	A	3.4	**N/A**	A	3.4	**N/A**
		WB/TR	C	30.3	168	B	15.1	103	C	26.7	212
		WB LOS	C	25.2	**N/A**	A	9.9	**N/A**	C	21.5	**N/A**
		NB/LT	B	18.0	284	A	9.1	44	B	11.8	121
		NB/R	A	1.8	0	A	1.7	0	A	1.8	0
		NB LOS	B	16.1	**N/A**	A	8.1	**N/A**	B	10.3	**N/A**
		Overall	B	13.4	**N/A**	A	7.1	**N/A**	B	11.3	**N/A**
US Route 15/17/29 SB Ramps & US Route 15/17/29 Business/Lord Fairfax Rd	Roundabout	EB/T	A	2.4	40	A	1.8	32	A	1.9	42
		EB/R	A	2.8	0	A	2.8	0	A	2.8	0
		EB LOS	A	2.6	**N/A**	A	2.6	**N/A**	A	2.5	**N/A**
		WB/LT	A	9.5	0	A	8.7	0	A	8.4	0
		WB LOS	A	1.2	**N/A**	A	2.1	**N/A**	A	1.4	**N/A**
		SB/LT	C	22.4	87	B	10.7	21	B	14.3	37
		SB/R	A	1.4	0	A	1.4	0	A	1.4	0
		SB LOS	B	15.7	**N/A**	A	5.7	**N/A**	A	7.3	**N/A**
		Overall	A	4.3	**N/A**	A	2.9	**N/A**	A	2.8	**N/A**
Lord Fairfax Rd & Turkey Run Dr	Unsignalized	WB/LR	A	9.9	25	B	10.4	0	B	10.4	0
		NB/TR	A	0	0	A	0	0	A	0	0
		SB/LT	A	0.1	0	A	0.2	0	A	0.3	0
		Overall	A	0.2	**N/A**	A	0.2	**N/A**	A	0.2	**N/A**
Lord Fairfax Rd & Traveler's Way	Unsignalized	WB/LR	A	9.9	0	B	11.1	25	B	11.1	0
		NB/TR	A	0	0	A	0	0	A	0	0
		SB/LT	A	0	0	A	0.3	0	A	0.1	0
		Overall	A	0.1	**N/A**	A	0.4	**N/A**	A	0.2	**N/A**
Lord Fairfax Rd/Bingham Rd & College St	Unsignalized	WB/LR	A	8.3	25	A	8.9	25	A	8.3	25
		NB/TR	A	9.5	25	A	10	25	B	11.7	58
		SB/LT	B	13.2	25	B	10.8	25	B	11.1	58
		Overall	B	11.9	**N/A**	A	10	**N/A**	B	11.1	**N/A**
NB Off-ramp	Diverge	NB	C	25.5	N/A	B	17.2	N/A	C	20.7	N/A
NB On-ramp	Merge	NB	B	19.6	N/A	B	17.2	N/A	B	18.9	N/A
SB Off-ramp	Diverge	SB	B	11.7	N/A	C	22.7	N/A	C	20.1	N/A
SB On-ramp	Merge	SB	B	12.3	N/A	D	33.1	N/A	C	24.3	N/A

All queue lengths calculated to be non-zero and less than 25-ft have been rounded up to 25-ft

Density (pc/mi/ln)

Table 17-1 - 2040 Build Analysis Results - ATC 1 Modified Barbell Interchange

Intersection	Traffic Control	Lane Group/ Approach	AM Peak Hour			PM Peak Hour			Sat Peak Hour		
			LOS	Delay (sec)	Back of Queue (in feet)	LOS	Delay (sec)	Back of Queue (in feet)	LOS	Delay (sec)	Back of Queue (in feet)
US Route 15/17/29 NB Ramps & US Route 15/17/29 Business/Lord Fairfax Rd	Roundabout	EB/T	A	3.8	89	A	3.9	62	A	5.0	85
		EB/R	A	4.9	89	A	4.7	62	A	6.0	85
		EB LOS	A	4.0	**N/A**	A	4.2	**N/A**	A	5.4	**N/A**
		WB/L	C	21.6	125	B	11.8	74	B	17.3	136
		WB/T	B	15.7	125	A	5.8	74	B	10.3	136
		WB LOS	B	17.9	**N/A**	A	8.1	**N/A**	B	13.3	**N/A**
		NB/L	B	14.8	190	B	11.4	45	B	11.9	93
		NB/R	A	3.2	0	A	3.1	0	A	3.2	0
		NB LOS	B	13.5	**N/A**	B	10.2	**N/A**	B	10.7	**N/A**
		Overall	B	11.4	**N/A**	A	7.5	**N/A**	A	9.6	**N/A**
US Route 15/17/29 SB Ramps & US Route 15/17/29 Business/Lord Fairfax Rd	Roundabout	EB/T	A	5.3	41	A	4.6	32	A	4.7	42
		EB/R	A	3.4	0	A	3.5	0	A	3.4	0
		EB LOS	A	4.3	**N/A**	A	3.7	**N/A**	A	3.9	**N/A**
		WB/L	B	11.9	0	A	10.0	0	A	10.0	0
		WB/T	A	3.8	0	A	3.4	0	A	3.5	0
		WB LOS	A	4.2	**N/A**	A	4.4	**N/A**	A	4.0	**N/A**
		SB/L	C	22.8	79	B	12.8	25	B	16.1	35
		SB/R	A	2.9	0	A	2.9	0	A	2.9	0
		SB LOS	B	16.5	**N/A**	A	7.5	**N/A**	A	9.0	**N/A**
		Overall	A	6.5	**N/A**	A	4.4	**N/A**	A	4.7	**N/A**
Lord Fairfax Rd & Turkey Run Dr	Unsignalized	EB/LTR	C	15.3	0	C	15.1	25	C	16.3	25
		WB/LTR	B	10.0	25	B	10.3	0	B	10.4	0
		NB/TR	A	0.0	0	A	0.0	0	A	0.0	0
		SB/LT	A	0.1	0	A	0.2	0	A	0.3	0
		Overall	A	0.5	**N/A**	A	0.4	**N/A**	A	0.4	**N/A**
Lord Fairfax Rd & Traveler's Way	Unsignalized	WB/LR	A	9.9	0	B	11.0	25	B	11.0	0
		NB/TR	A	0.0	0	A	0.0	0	A	0.0	0
		SB/LT	A	0.0	0	A	0.3	0	A	0.1	0
		Overall	A	0.1	**N/A**	A	0.3	**N/A**	A	0.2	**N/A**
Lord Fairfax Rd/Bingham Rd & College St	Unsignalized	WB/LR	A	8.2	25	A	8.9	25	A	8.3	25
		NB/TR	A	9.4	25	A	9.9	25	B	11.6	55
		SB/LT	B	12.7	88	B	10.7	45	B	10.9	55
		Overall	B	11.5	**N/A**	A	10.0	**N/A**	B	11.0	**N/A**

NB Off-ramp	Diverge	NB	C	26.8	N/A	B	18.6	N/A	C	22.1	N/A
NB On-ramp	Merge	NB	B	18.3	N/A	B	15.1	N/A	B	16.7	N/A
SB Off-ramp	Diverge	SB	B	12.6	N/A	C	23.6	N/A	C	21.1	N/A
SB On-ramp	Merge	SB	A	9.2	N/A	C	24.4	N/A	B	19.0	N/A

All queue lengths calculated to be non-zero and less than 25-ft have been rounded up to 25-ft

Density (pc/mi/ln)

Figure 24: Year 2040 Build Level of Service Results

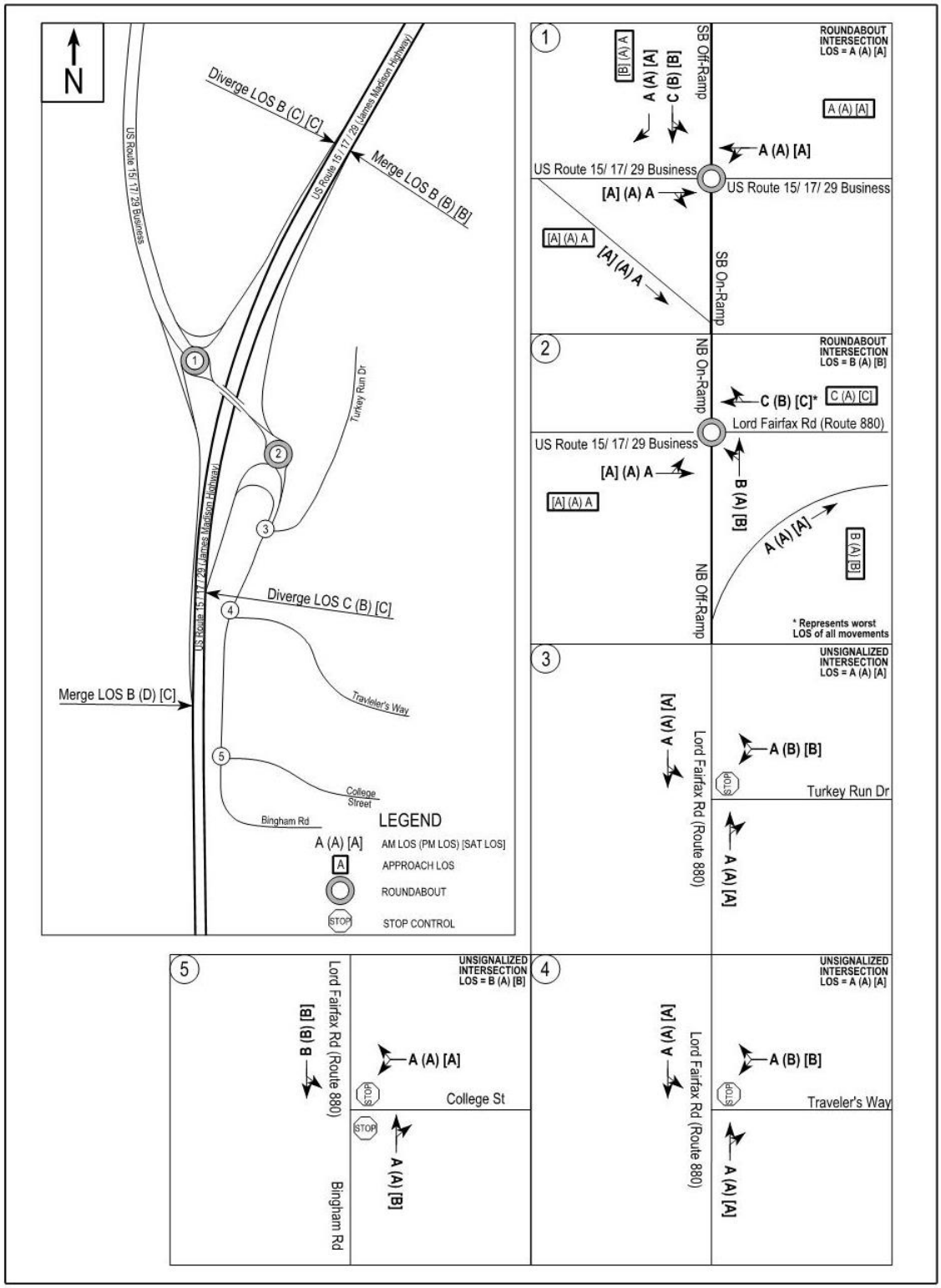
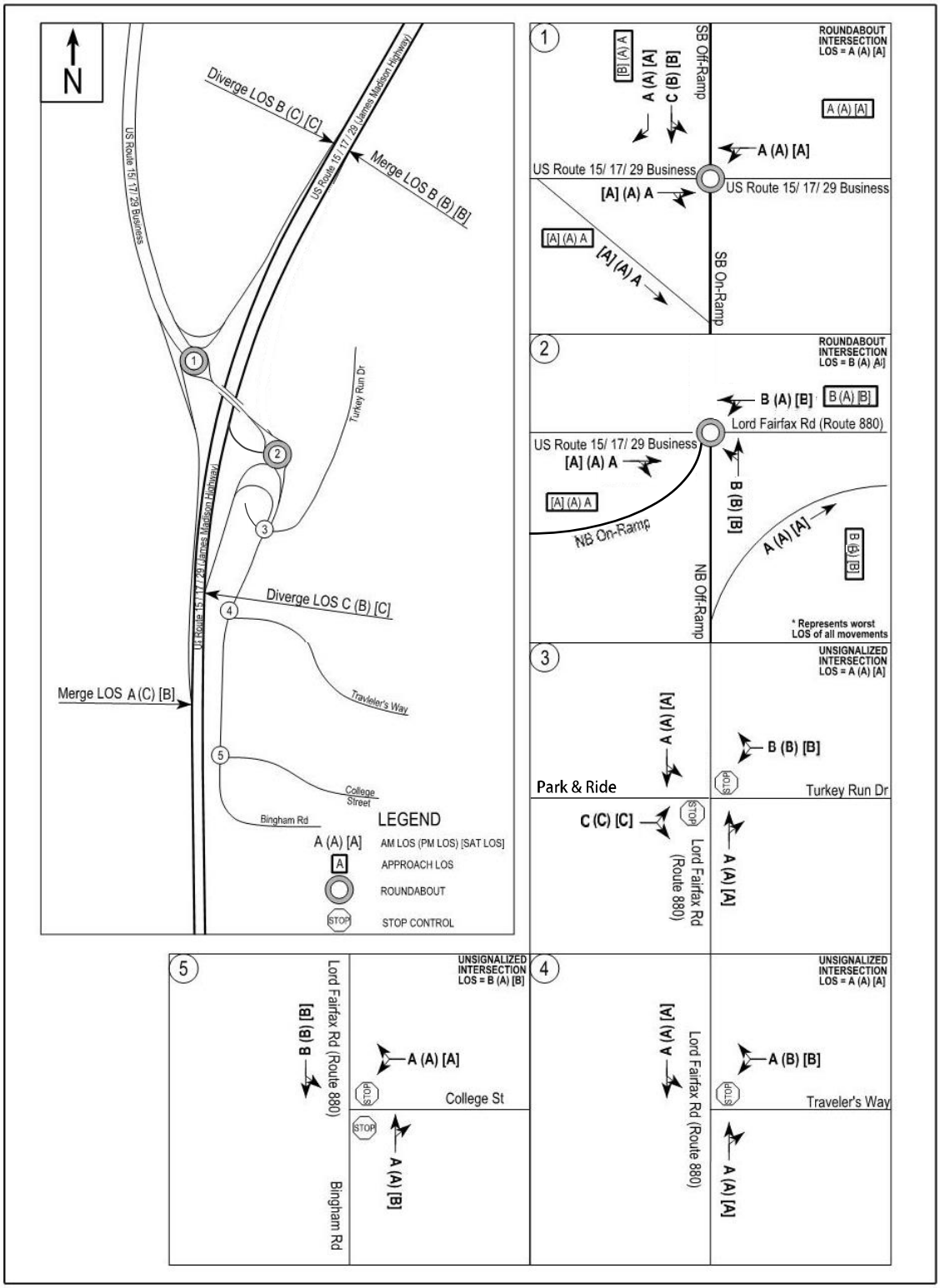


Figure 24-1: Year 2040 Build Level of Service Results - ATC 1



Appendix A

Mainline Merge & Diverge Results Data (HCS Output)

RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	AM Peak	Analysis Year	2040

Project Description Roundabout Ramp Leg to Northbound US 15/17/19

Inputs

Upstream Adj Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 975 ft

V_u = 773 veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	1070
Deceleration Lane Length L_D	
Freeway Volume, V_F	2084
Ramp Volume, V_R	161
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	30.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	2084	0.95	Level	13	0	0.939	1.00	2336
Ramp	161	0.95	Level	16	0	0.926	1.00	183
UpStream	773	0.95	Level	18	0	0.917	1.00	887
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 2336 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	2519	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2519	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 18.3 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.305 (Exibit 13-11)

S_R= 51.0 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 51.0 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	PM Peak	Analysis Year	2040

Project Description Roundabout Ramp Leg to Northbound US 15/17/19

Inputs

Upstream Adj Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 975 ft

V_u = 375 veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	1070
Deceleration Lane Length L_D	
Freeway Volume, V_F	1641
Ramp Volume, V_R	264
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	30.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	1641	0.95	Level	12	0	0.943	1.00	1831
Ramp	264	0.95	Level	5	0	0.976	1.00	285
UpStream	375	0.95	Level	5	0	0.976	1.00	405
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 1831 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	2116	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2116	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 15.1 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.289 (Exibit 13-11)

S_R= 51.2 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 51.2 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	SAT Peak	Analysis Year	2040

Project Description Roundabout Ramp Leg to Northbound US 15/17/19

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☑ Yes ☐ On	Freeway Number of Lanes, N: 2	☐ Yes ☐ On
☐ No ☑ Off	Ramp Number of Lanes, N: 1	☑ No ☐ Off
L_{up} = 975 ft	Acceleration Lane Length, L_A: 1070	L_{down} = ft
V_u = 605 veh/h	Deceleration Lane Length L_D:	V_D = veh/h
	Freeway Volume, V_F: 1861	
	Ramp Volume, V_R: 283	
	Freeway Free-Flow Speed, S_{FF}: 55.0	
	Ramp Free-Flow Speed, S_{FR}: 30.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	1861	0.95	Level	5	0	0.976	1.00	2008
Ramp	283	0.95	Level	6	0	0.971	1.00	307
UpStream	605	0.95	Level	6	0	0.971	1.00	656
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 2008 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * $V_{12}/2$ ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	2315	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2315	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 16.7 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.296 (Exibit 13-11)

S_R= 51.1 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 51.1 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * $V_{12}/2$ ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	AM Peak	Analysis Year	2040

Project Description Northbound US 15/17/29 Diverge to Lord Fairfax Rd

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	550
Freeway Volume, V_F	2857
Ramp Volume, V_R	773
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	40.0

Downstream Adj Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 975 ft

V_D = 161 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2857	0.95	Level	13	0	0.939	1.00	3203
Ramp	773	0.95	Level	18	0	0.917	1.00	887
UpStream								
DownStream	161	0.95	Level	16	0	0.926	1.00	183

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 3203 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	3203	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	2316	Exhibit 13-8	4500	No
V_R	887	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	3203	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 26.8 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.443 (Exhibit 13-12)

S_R= 49.2 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 49.2 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	PM Peak	Analysis Year	2040

Project Description Northbound US 15/17/29 Diverge to Lord Fairfax Rd

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	550
Freeway Volume, V_F	2016
Ramp Volume, V_R	375
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	40.0

Downstream Adj Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 975 ft

V_D = 264 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2016	0.95	Level	11	0	0.948	1.00	2239
Ramp	375	0.95	Level	5	0	0.976	1.00	405
UpStream								
DownStream	264	0.95	Level	2	0	0.990	1.00	281

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 2239 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	2239	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	1834	Exhibit 13-8	4500	No
V_R	405	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2239	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 18.6 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

D_s = 0.399 (Exhibit 13-12)

S_R= 49.8 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 49.8 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Northbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	SAT Peak	Analysis Year	2040

Project Description Northbound US 15/17/29 Diverge to Lord Fairfax Rd

Inputs

Upstream Adj Ramp
- ☐ Yes ☐ On
- ☑ No ☐ Off
- L_{up} = ft
- V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	550
Freeway Volume, V_F	2466
Ramp Volume, V_R	605
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	40.0

Downstream Adj Ramp
- ☑ Yes ☑ On
- ☐ No ☐ Off
- L_{down} = 975 ft
- V_D = 283 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2466	0.95	Level	4	0	0.980	1.00	2648
Ramp	605	0.95	Level	6	0	0.971	1.00	656
UpStream								
DownStream	283	0.95	Level	6	0	0.971	1.00	307

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 2648 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	2648	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	1992	Exhibit 13-8	4500	No
V_R	656	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2648	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 22.1 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.422 (Exhibit 13-12)

S_R= 49.5 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 49.5 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	AM Peak	Analysis Year	2040

Project Description US 15/17/19 Business Ramp to Southbound US 15/17/19

Inputs

Upstream Adj Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 1500 ft

V_u = 276 veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	2
Acceleration Lane Length, L_A	250
Deceleration Lane Length L_D	
Freeway Volume, V_F	1062
Ramp Volume, V_R	247
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	35.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	1062	0.95	Level	18	0	0.917	1.00	1219
Ramp	247	0.95	Level	12	0	0.943	1.00	276
UpStream	276	0.95	Level	2	0	0.990	1.00	293
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 1219 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	1495	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	1495	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 9.2 (pc/mi/ln)

LOS = A (Exhibit 13-2)

Speed Determination

M_S = 0.251 (Exibit 13-11)

S_R= 51.7 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 51.7 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	PM Peak	Analysis Year	2040

Project Description US 15/17/19 Business Ramp to Southbound US 15/17/19

Inputs

Upstream Adj Ramp

☑ Yes ☐ On

☐ No ☑ Off

L_{up} = 1500 ft

V_u = 259 veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	2
Acceleration Lane Length, L_A	250
Deceleration Lane Length L_D	
Freeway Volume, V_F	2293
Ramp Volume, V_R	895
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	35.0

Downstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{down} = ft

V_D = veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	v = V/PHF x f_{HV} x f_p
Freeway	2293	0.95	Level	10	0	0.952	1.00	2534
Ramp	895	0.95	Level	3	0	0.985	1.00	956
UpStream	259	0.95	Level	5	0	0.976	1.00	279
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 2534 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	3490	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	3490	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 24.4 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

M_S = 0.361 (Exibit 13-11)

S_R= 50.3 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 50.3 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/19
Agency or Company	Dewberry	Junction	
Date Performed	9/20/2017	Jurisdiction	
Analysis Time Period	SAT Peak	Analysis Year	2040

Project Description US 15/17/19 Business Ramp to Southbound US 15/17/19

Inputs

Upstream Adj Ramp		Downstream Adj Ramp
☑ Yes ☐ On	Freeway Number of Lanes, N: 2	☐ Yes ☐ On
☐ No ☑ Off	Ramp Number of Lanes, N: 2	☑ No ☐ Off
L_{up} = 1500 ft	Acceleration Lane Length, L_A: 250	L_{down} = ft
V_u = 287 veh/h	Deceleration Lane Length L_D:	V_D = veh/h
	Freeway Volume, V_F: 2030	
	Ramp Volume, V_R: 519	
	Freeway Free-Flow Speed, S_{FF}: 55.0	
	Ramp Free-Flow Speed, S_{FR}: 35.0	

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2030	0.95	Level	7	0	0.966	1.00	2212
Ramp	519	0.95	Level	3	0	0.985	1.00	555
UpStream	287	0.95	Level	3	0	0.985	1.00	307
DownStream								

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = 1.000 using Equation (Exhibit 13-6)

V_{12} = 2212 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * $V_{12}/2$ ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}	2767	Exhibit 13-8		No

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}	2767	Exhibit 13-8	4600:All	No

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = 19.0 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

M_S = 0.296 (Exibit 13-11)

S_R= 51.2 mph (Exhibit 13-11)

S_0= N/A mph (Exhibit 13-11)

S = 51.2 mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = using Equation (Exhibit 13-7)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * $V_{12}/2$ ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F		Exhibit 13-8		
$V_{FO} = V_F - V_R$		Exhibit 13-8		
V_R		Exhibit 13-10		

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

D_s = (Exhibit 13-12)

S_R= mph (Exhibit 13-12)

S_0= mph (Exhibit 13-12)

S = mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	AM Peak	Analysis Year	2040

Project Description Southbound US 15/17/29 Diverge to US 15/17/29 Business

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	540
Freeway Volume, V_F	1337
Ramp Volume, V_R	276
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	40.0

Downstream Adj Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 1500 ft

V_D = 247 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	1337	0.95	Level	19	0	0.913	1.00	1541
Ramp	276	0.95	Level	1	0	0.995	1.00	292
UpStream								
DownStream	247	0.95	Level	2	0	0.990	1.00	263

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 1541 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	1541	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	1249	Exhibit 13-8	4500	No
V_R	292	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	1541	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 12.6 (pc/mi/ln)

LOS = B (Exhibit 13-2)

Speed Determination

D_s = 0.389 (Exhibit 13-12)

S_R= 49.9 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 49.9 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	PM Peak	Analysis Year	2040

Project Description Southbound US 15/17/29 Diverge to US 15/17/29 Business

Inputs

Upstream Adj Ramp

☐ Yes ☐ On

☑ No ☐ Off

L_{up} = ft

V_u = veh/h

Freeway Number of Lanes, N	2
Ramp Number of Lanes, N	1
Acceleration Lane Length, L_A	
Deceleration Lane Length L_D	540
Freeway Volume, V_F	2551
Ramp Volume, V_R	259
Freeway Free-Flow Speed, S_{FF}	55.0
Ramp Free-Flow Speed, S_{FR}	40.0

Downstream Adj Ramp

☑ Yes ☑ On

☐ No ☐ Off

L_{down} = 1500 ft

V_D = 895 veh/h

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2551	0.95	Level	10	0	0.952	1.00	2820
Ramp	259	0.95	Level	5	0	0.976	1.00	279
UpStream								
DownStream	895	0.95	Level	2	0	0.990	1.00	952

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 2820 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	2820	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	2541	Exhibit 13-8	4500	No
V_R	279	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2820	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 23.6 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.388 (Exhibit 13-12)

S_R= 50.0 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 50.0 mph (Exhibit 13-13)

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RAMPS AND RAMP JUNCTIONS WORKSHEET

General Information / Site Information

Analyst		Freeway/Dir of Travel	Southbound US 15/17/29
Agency or Company	Dewberry	Junction	
Date Performed	9/19/2017	Jurisdiction	
Analysis Time Period	SAT Peak	Analysis Year	2040

Project Description Southbound US 15/17/29 Diverge to US 15/17/29 Business

Inputs

Upstream Adj Ramp		Freeway Number of Lanes, N	2	Downstream Adj Ramp	
☐ Yes	☐ On	Ramp Number of Lanes, N	1	☑ Yes	☑ On
☑ No	☐ Off	Acceleration Lane Length, L_A		☐ No	☐ Off
L_{up} =	ft	Deceleration Lane Length L_D	540	L_{down} =	1500 ft
V_u =	veh/h	Freeway Volume, V_F	2317	V_D =	519 veh/h
		Ramp Volume, V_R	287		
		Freeway Free-Flow Speed, S_{FF}	55.0		
		Ramp Free-Flow Speed, S_{FR}	40.0		

Conversion to pc/h Under Base Conditions

(pc/h)	V (Veh/hr)	PHF	Terrain	%Truck	%Rv	f_{HV}	f_p	$v = V/PHF \times f_{HV} \times f_p$
Freeway	2317	0.95	Level	7	0	0.966	1.00	2524
Ramp	287	0.95	Level	3	0	0.985	1.00	307
UpStream								
DownStream	519	0.95	Level	3	0	0.985	1.00	555

Merge Areas

Estimation of v_{12}

$V_{12} = V_F (P_{FM})$

L_{EQ} = (Equation 13-6 or 13-7)

P_{FM} = using Equation (Exhibit 13-6)

V_{12} = pc/h

V_3 or V_{av34} pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☐ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☐ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_{FO}		Exhibit 13-8		

Flow Entering Merge Influence Area

	Actual	Max Desirable		Violation?
V_{R12}		Exhibit 13-8		

Level of Service Determination (if not F)

$D_R = 5.475 + 0.00734\, v_R + 0.0078\, V_{12} - 0.00627\, L_A$

D_R = (pc/mi/ln)

LOS = (Exhibit 13-2)

Speed Determination

M_S = (Exibit 13-11)

S_R= mph (Exhibit 13-11)

S_0= mph (Exhibit 13-11)

S = mph (Exhibit 13-13)

Diverge Areas

Estimation of v_{12}

$V_{12} = V_R + (V_F - V_R)P_{FD}$

L_{EQ} = (Equation 13-12 or 13-13)

P_{FD} = 1.000 using Equation (Exhibit 13-7)

V_{12} = 2524 pc/h

V_3 or V_{av34} 0 pc/h (Equation 13-14 or 13-17)

Is V_3 or V_{av34} > 2,700 pc/h? ☐ Yes ☑ No

Is V_3 or V_{av34} > 1.5 * V_{12}/2 ☐ Yes ☑ No

If Yes, V_{12a} = pc/h (Equation 13-16, 13-18, or 13-19)

Capacity Checks

	Actual	Capacity		LOS F?
V_F	2524	Exhibit 13-8	4500	No
$V_{FO} = V_F - V_R$	2217	Exhibit 13-8	4500	No
V_R	307	Exhibit 13-10	2100	No

Flow Entering Diverge Influence Area

	Actual	Max Desirable		Violation?
V_{12}	2524	Exhibit 13-8	4400:All	No

Level of Service Determination (if not F)

$D_R = 4.252 + 0.0086\, V_{12} - 0.009\, L_D$

D_R = 21.1 (pc/mi/ln)

LOS = C (Exhibit 13-2)

Speed Determination

D_s = 0.391 (Exhibit 13-12)

S_R= 49.9 mph (Exhibit 13-12)

S_0= N/A mph (Exhibit 13-12)

S = 49.9 mph (Exhibit 13-13)

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Appendix B

Intersection Results Data (SIDRA Roundabout Output)

INTERSECTION SUMMARY

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	36.1	mph	36.1	mph
Travel Distance (Total)	937.6	veh-mi/h	1125.2	pers-mi/h
Travel Time (Total)	25.9	veh-h/h	31.1	pers-h/h
Demand Flows (Total)	1594	veh/h	1912	pers/h
Percent Heavy Vehicles (Demand)	17.0	%		
Degree of Saturation	0.629			
Practical Spare Capacity	35.1	%		
Effective Intersection Capacity	2532	veh/h		
Control Delay (Total)	2.86	veh-h/h	3.43	pers-h/h
Control Delay (Average)	6.5	sec	6.5	sec
Control Delay (Worst Lane)	22.8	sec		
Control Delay (Worst Movement)	22.8	sec	22.8	sec
Geometric Delay (Average)	4.5	sec		
Stop-Line Delay (Average)	1.9	sec		
Idling Time (Average)	1.0	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	2.8	veh		
95% Back of Queue - Distance (Worst Lane)	79.0	ft		
Queue Storage Ratio (Worst Lane)	0.35			
Total Effective Stops	764	veh/h	916	pers/h
Effective Stop Rate	0.48	per veh	0.48	per pers
Proportion Queued	0.19		0.19	
Performance Index	34.0		34.0	
Cost (Total)	468.73	$/h	468.73	$/h
Fuel Consumption (Total)	62.6	gal/h		
Carbon Dioxide (Total)	575.2	kg/h		
Hydrocarbons (Total)	0.045	kg/h		
Carbon Monoxide (Total)	0.546	kg/h		
NOx (Total)	2.664	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	764,968	veh/y	917,962	pers/y
Delay	1,372	veh-h/y	1,647	pers-h/y
Effective Stops	366,488	veh/y	439,786	pers/y
Travel Distance	450,069	veh-mi/y	540,083	pers-mi/y
Travel Time	12,455	veh-h/y	14,946	pers-h/y
Cost	224,992	$/y	224,992	$/y
Fuel Consumption	30,067	gal/y		
Carbon Dioxide	276,086	kg/y		
Hydrocarbons	22	kg/y		
Carbon Monoxide	262	kg/y		
NOx	1,279	kg/y		

INTERSECTION SUMMARY

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	37.1	mph	37.1	mph
Travel Distance (Total)	1149.2	veh-mi/h	1379.0	pers-mi/h
Travel Time (Total)	30.9	veh-h/h	37.1	pers-h/h
Demand Flows (Total)	1939	veh/h	2327	pers/h
Percent Heavy Vehicles (Demand)	2.7	%		
Degree of Saturation	0.551			
Practical Spare Capacity	77.9	%		
Effective Intersection Capacity	3519	veh/h		
Control Delay (Total)	2.39	veh-h/h	2.87	pers-h/h
Control Delay (Average)	4.4	sec	4.4	sec
Control Delay (Worst Lane)	12.8	sec		
Control Delay (Worst Movement)	12.8	sec	12.8	sec
Geometric Delay (Average)	4.0	sec		
Stop-Line Delay (Average)	0.4	sec		
Idling Time (Average)	0.0	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)	32.0	ft		
Queue Storage Ratio (Worst Lane)	0.09			
Total Effective Stops	868	veh/h	1042	pers/h
Effective Stop Rate	0.45	per veh	0.45	per pers
Proportion Queued	0.10		0.10	
Performance Index	37.6		37.6	
Cost (Total)	483.93	$/h	483.93	$/h
Fuel Consumption (Total)	57.9	gal/h		
Carbon Dioxide (Total)	518.5	kg/h		
Hydrocarbons (Total)	0.047	kg/h		
Carbon Monoxide (Total)	0.611	kg/h		
NOx (Total)	0.903	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	930,695	veh/y	1,116,834	pers/y
Delay	1,150	veh-h/y	1,379	pers-h/y
Effective Stops	416,640	veh/y	499,968	pers/y
Travel Distance	551,599	veh-mi/y	661,919	pers-mi/y
Travel Time	14,852	veh-h/y	17,822	pers-h/y
Cost	232,286	$/y	232,286	$/y
Fuel Consumption	27,801	gal/y		
Carbon Dioxide	248,876	kg/y		
Hydrocarbons	23	kg/y		
Carbon Monoxide	293	kg/y		
NOx	434	kg/y		

INTERSECTION SUMMARY

Site: SAT Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	37.1	mph	37.1	mph
Travel Distance (Total)	1110.8	veh-mi/h	1333.0	pers-mi/h
Travel Time (Total)	29.9	veh-h/h	35.9	pers-h/h
Demand Flows (Total)	1885	veh/h	2262	pers/h
Percent Heavy Vehicles (Demand)	3.7	%		
Degree of Saturation	0.493			
Practical Spare Capacity	72.3	%		
Effective Intersection Capacity	3821	veh/h		
Control Delay (Total)	2.49	veh-h/h	2.98	pers-h/h
Control Delay (Average)	4.7	sec	4.7	sec
Control Delay (Worst Lane)	16.1	sec		
Control Delay (Worst Movement)	16.1	sec	16.1	sec
Geometric Delay (Average)	4.0	sec		
Stop-Line Delay (Average)	0.7	sec		
Idling Time (Average)	0.2	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)	41.4	ft		
Queue Storage Ratio (Worst Lane)	0.15			
Total Effective Stops	844	veh/h	1013	pers/h
Effective Stop Rate	0.45	per veh	0.45	per pers
Proportion Queued	0.13		0.13	
Performance Index	37.3		37.3	
Cost (Total)	453.18	$/h	453.18	$/h
Fuel Consumption (Total)	52.7	gal/h		
Carbon Dioxide (Total)	473.4	kg/h		
Hydrocarbons (Total)	0.043	kg/h		
Carbon Monoxide (Total)	0.546	kg/h		
NOx (Total)	0.965	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	904,696	veh/y	1,085,635	pers/y
Delay	1,194	veh-h/y	1,432	pers-h/y
Effective Stops	405,039	veh/y	486,047	pers/y
Travel Distance	533,208	veh-mi/y	639,849	pers-mi/y
Travel Time	14,372	veh-h/y	17,247	pers-h/y
Cost	217,525	$/y	217,525	$/y
Fuel Consumption	25,312	gal/y		
Carbon Dioxide	227,244	kg/y		
Hydrocarbons	20	kg/y		
Carbon Monoxide	262	kg/y		
NOx	463	kg/y		

LANE LEVEL OF SERVICE

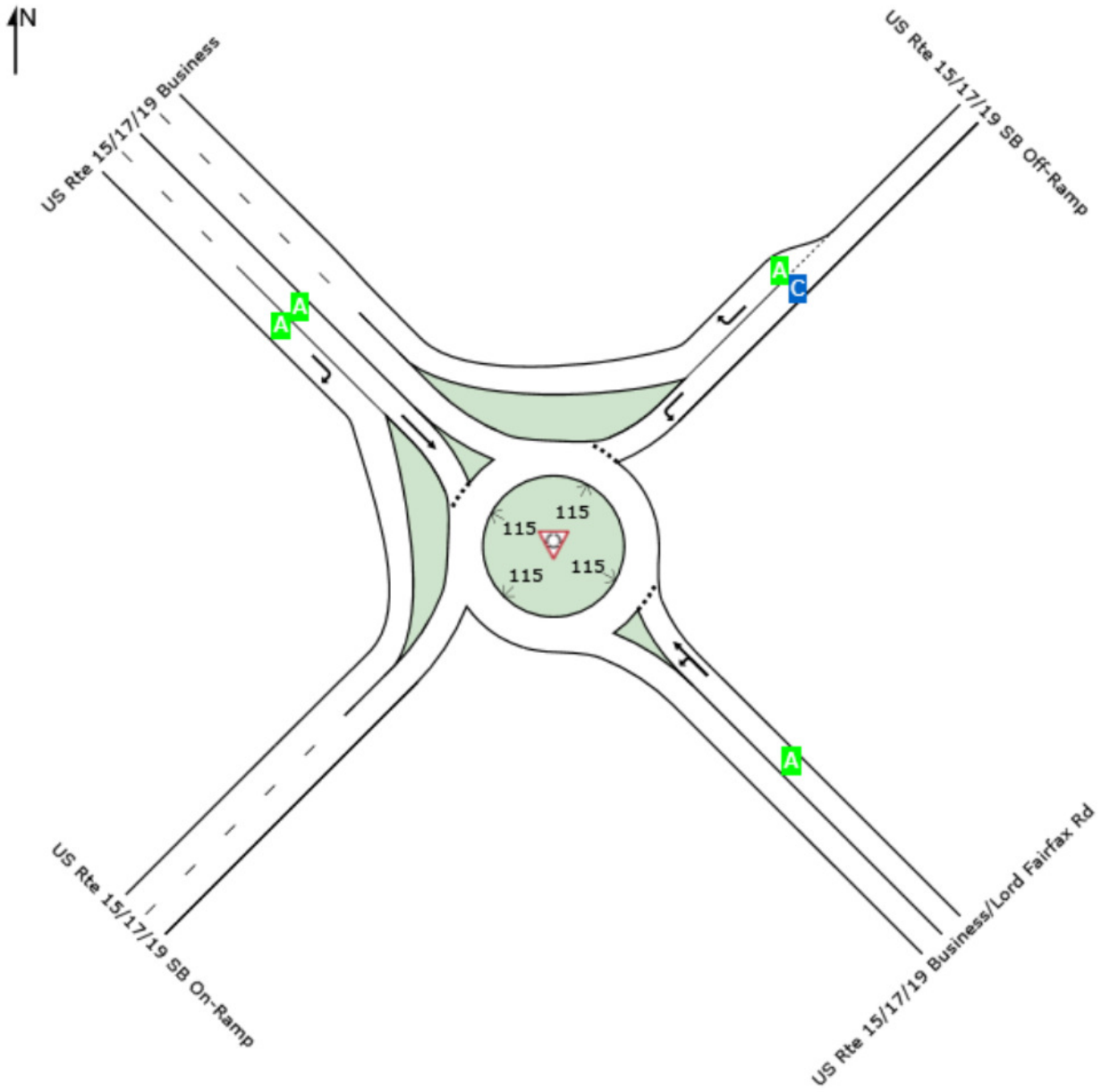
Lane Level of Service

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

All Movement Classes

	Southeast	Northeast	Northwest	Intersection
LOS	A	B	A	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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LANE LEVEL OF SERVICE

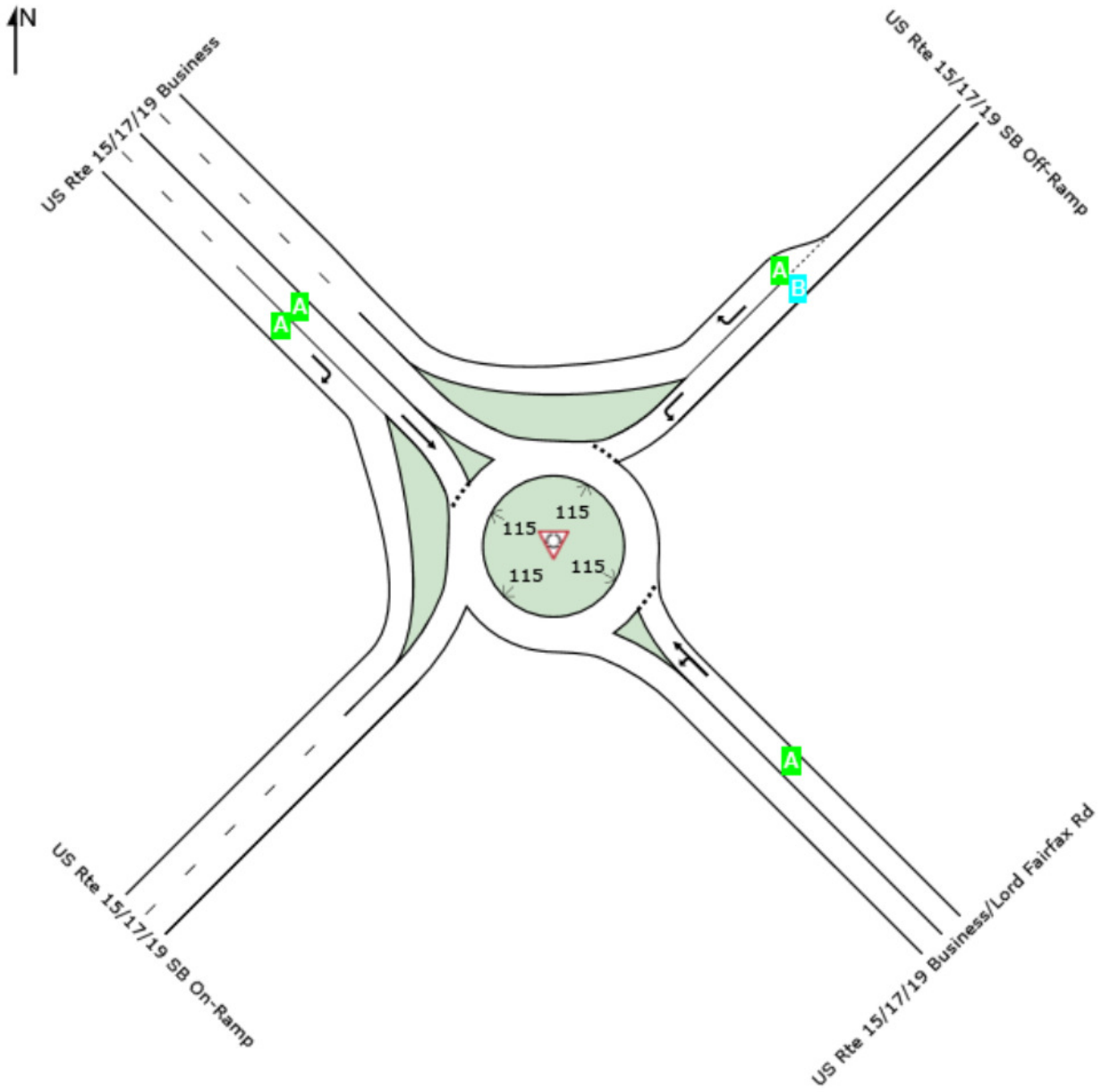
Lane Level of Service

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

All Movement Classes

	Southeast	Northeast	Northwest	Intersection
LOS	A	A	A	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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LANE LEVEL OF SERVICE

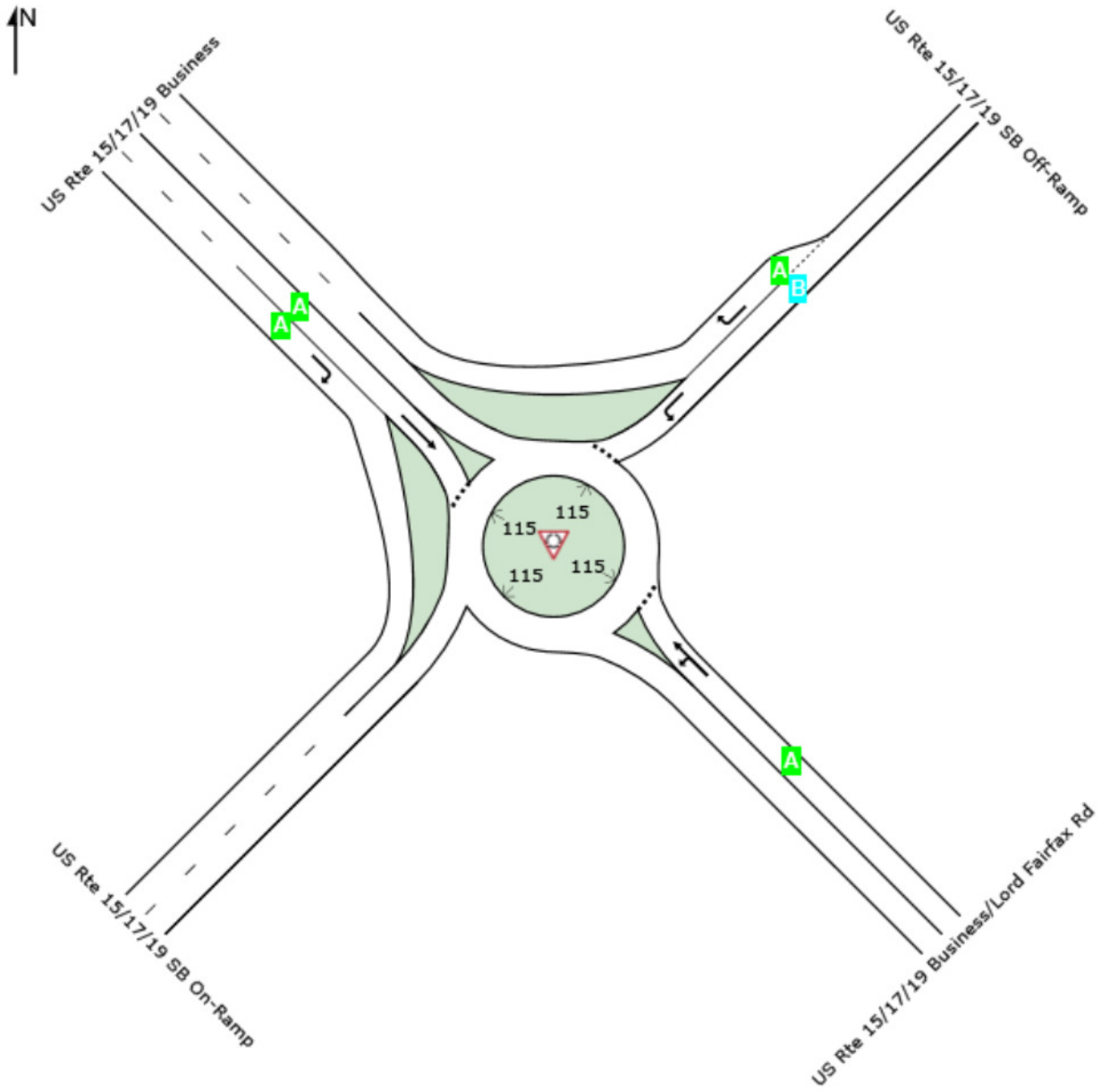
Lane Level of Service

Site: SAT Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
Roundabout

All Movement Classes

	Southeast	Northeast	Northwest	Intersection
LOS	A	A	A	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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MOVEMENT SUMMARY

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
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
SouthEast: US Rte 15/17/19 Business/Lord Fairfax Rd											
3x	L2	39	60.0	0.629	11.9	LOS B	0.0	0.0	0.00	0.36	36.6
8x	T1	816	20.0	0.629	3.8	LOS A	0.0	0.0	0.00	0.36	38.4
Approach		855	21.8	0.629	4.2	LOS A	0.0	0.0	0.00	0.36	38.3
NorthEast: US Rte 15/17/19 SB Off-Ramp											
1x	L2	198	17.0	0.397	22.8	LOS C	2.8	79.0	0.89	1.01	25.0
16x	R2	93	1.0	0.059	2.9	LOS A	0.0	0.0	0.00	0.42	36.5
Approach		291	11.9	0.397	16.5	LOS B	2.8	79.0	0.61	0.82	27.6
NorthWest: US Rte 15/17/19 Business											
4x	T1	227	10.0	0.234	5.3	LOS A	1.5	40.1	0.56	0.54	36.4
14x	R2	221	12.0	0.154	3.4	LOS A	0.0	0.0	0.00	0.43	37.2
Approach		448	11.0	0.234	4.3	LOS A	1.5	40.1	0.28	0.48	36.8
All Vehicles		1594	17.0	0.629	6.5	LOS A	2.8	79.0	0.19	0.48	36.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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MOVEMENT SUMMARY

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
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
SouthEast: US Rte 15/17/19 Business/Lord Fairfax Rd											
3x	L2	82	2.0	0.346	10.0	LOS A	0.0	0.0	0.00	0.41	38.4
8x	T1	479	2.0	0.346	3.4	LOS A	0.0	0.0	0.00	0.41	38.2
Approach		561	2.0	0.346	4.4	LOS A	0.0	0.0	0.00	0.41	38.2
NorthEast: US Rte 15/17/19 SB Off-Ramp											
1x	L2	127	2.0	0.139	12.8	LOS B	0.8	19.9	0.62	0.74	30.8
16x	R2	145	5.0	0.096	2.9	LOS A	0.0	0.0	0.00	0.42	36.3
Approach		273	3.6	0.139	7.5	LOS A	0.8	19.9	0.29	0.57	33.4
NorthWest: US Rte 15/17/19 Business											
4x	T1	245	2.0	0.210	4.6	LOS A	1.3	32.0	0.44	0.46	37.0
14x	R2	860	3.0	0.551	3.5	LOS A	0.0	0.0	0.00	0.43	37.3
Approach		1105	2.8	0.551	3.7	LOS A	1.3	32.0	0.10	0.43	37.3
All Vehicles		1939	2.7	0.551	4.4	LOS A	1.3	32.0	0.10	0.45	37.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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MOVEMENT SUMMARY

Site: SAT Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Northwestern Roundabout
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
SouthEast: US Rte 15/17/19 Business/Lord Fairfax Rd											
3x	L2	61	3.0	0.493	10.0	LOS A	0.0	0.0	0.00	0.38	38.6
8x	T1	732	3.0	0.493	3.5	LOS A	0.0	0.0	0.00	0.38	38.4
Approach		792	3.0	0.493	4.0	LOS A	0.0	0.0	0.00	0.38	38.4
NorthEast: US Rte 15/17/19 SB Off-Ramp											
1x	L2	142	12.0	0.215	16.1	LOS B	1.3	34.9	0.76	0.85	28.5
16x	R2	168	3.0	0.109	2.9	LOS A	0.0	0.0	0.00	0.42	36.4
Approach		311	7.1	0.215	9.0	LOS A	1.3	34.9	0.35	0.62	32.1
NorthWest: US Rte 15/17/19 Business											
4x	T1	278	5.0	0.250	4.7	LOS A	1.6	41.4	0.48	0.48	36.8
14x	R2	503	2.0	0.319	3.4	LOS A	0.0	0.0	0.00	0.43	37.4
Approach		782	3.1	0.319	3.9	LOS A	1.6	41.4	0.17	0.45	37.2
All Vehicles		1885	3.7	0.493	4.7	LOS A	1.6	41.4	0.13	0.45	37.1

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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INTERSECTION SUMMARY

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	34.3	mph	34.3	mph
Travel Distance (Total)	951.1	veh-mi/h	1141.4	pers-mi/h
Travel Time (Total)	27.7	veh-h/h	33.3	pers-h/h
Demand Flows (Total)	1463	veh/h	1756	pers/h
Percent Heavy Vehicles (Demand)	9.2	%		
Degree of Saturation	0.677			
Practical Spare Capacity	25.6	%		
Effective Intersection Capacity	2162	veh/h		
Control Delay (Total)	4.63	veh-h/h	5.56	pers-h/h
Control Delay (Average)	11.4	sec	11.4	sec
Control Delay (Worst Lane)	17.9	sec		
Control Delay (Worst Movement)	21.3	sec	21.3	sec
Geometric Delay (Average)	6.9	sec		
Stop-Line Delay (Average)	4.5	sec		
Idling Time (Average)	0.9	sec		
Intersection Level of Service (LOS)	LOS B			
95% Back of Queue - Vehicles (Worst Lane)	7.4	veh		
95% Back of Queue - Distance (Worst Lane)	190.0	ft		
Queue Storage Ratio (Worst Lane)	0.16			
Total Effective Stops	1064	veh/h	1277	pers/h
Effective Stop Rate	0.73	per veh	0.73	per pers
Proportion Queued	0.67		0.67	
Performance Index	52.4		52.4	
Cost (Total)	521.64	$/h	521.64	$/h
Fuel Consumption (Total)	56.5	gal/h		
Carbon Dioxide (Total)	512.8	kg/h		
Hydrocarbons (Total)	0.042	kg/h		
Carbon Monoxide (Total)	0.529	kg/h		
NOx (Total)	1.709	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	702,316	veh/y	842,779	pers/y
Delay	2,223	veh-h/y	2,667	pers-h/y
Effective Stops	510,744	veh/y	612,893	pers/y
Travel Distance	456,551	veh-mi/y	547,862	pers-mi/y
Travel Time	13,313	veh-h/y	15,975	pers-h/y
Cost	250,390	$/y	250,390	$/y
Fuel Consumption	27,140	gal/y		
Carbon Dioxide	246,140	kg/y		
Hydrocarbons	20	kg/y		
Carbon Monoxide	254	kg/y		
NOx	821	kg/y		

INTERSECTION SUMMARY

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	35.9	mph	35.9	mph
Travel Distance (Total)	721.7	veh-mi/h	866.0	pers-mi/h
Travel Time (Total)	20.1	veh-h/h	24.2	pers-h/h
Demand Flows (Total)	1120	veh/h	1344	pers/h
Percent Heavy Vehicles (Demand)	2.6	%		
Degree of Saturation	0.414			
Practical Spare Capacity	105.5	%		
Effective Intersection Capacity	2708	veh/h		
Control Delay (Total)	2.35	veh-h/h	2.82	pers-h/h
Control Delay (Average)	7.5	sec	7.5	sec
Control Delay (Worst Lane)	11.4	sec		
Control Delay (Worst Movement)	11.8	sec	11.8	sec
Geometric Delay (Average)	5.9	sec		
Stop-Line Delay (Average)	1.7	sec		
Idling Time (Average)	0.1	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	2.9	veh		
95% Back of Queue - Distance (Worst Lane)	73.5	ft		
Queue Storage Ratio (Worst Lane)	0.06			
Total Effective Stops	651	veh/h	781	pers/h
Effective Stop Rate	0.58	per veh	0.58	per pers
Proportion Queued	0.51		0.51	
Performance Index	34.0		34.0	
Cost (Total)	317.15	$/h	317.15	$/h
Fuel Consumption (Total)	31.8	gal/h		
Carbon Dioxide (Total)	284.9	kg/h		
Hydrocarbons (Total)	0.026	kg/h		
Carbon Monoxide (Total)	0.343	kg/h		
NOx (Total)	0.431	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	537,500	veh/y	645,000	pers/y
Delay	1,127	veh-h/y	1,352	pers-h/y
Effective Stops	312,500	veh/y	375,000	pers/y
Travel Distance	346,396	veh-mi/y	415,675	pers-mi/y
Travel Time	9,661	veh-h/y	11,593	pers-h/y
Cost	152,230	$/y	152,230	$/y
Fuel Consumption	15,277	gal/y		
Carbon Dioxide	136,749	kg/y		
Hydrocarbons	12	kg/y		
Carbon Monoxide	165	kg/y		
NOx	207	kg/y		

INTERSECTION SUMMARY

Site: Sat Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

Intersection Performance - Hourly Values				
Performance Measure	**Vehicles**		**Persons**	
Travel Speed (Average)	34.9	mph	34.9	mph
Travel Distance (Total)	943.6	veh-mi/h	1132.3	pers-mi/h
Travel Time (Total)	27.1	veh-h/h	32.5	pers-h/h
Demand Flows (Total)	1460	veh/h	1752	pers/h
Percent Heavy Vehicles (Demand)	3.8	%		
Degree of Saturation	0.574			
Practical Spare Capacity	48.0	%		
Effective Intersection Capacity	2542	veh/h		
Control Delay (Total)	3.88	veh-h/h	4.66	pers-h/h
Control Delay (Average)	9.6	sec	9.6	sec
Control Delay (Worst Lane)	13.3	sec		
Control Delay (Worst Movement)	17.3	sec	17.3	sec
Geometric Delay (Average)	6.4	sec		
Stop-Line Delay (Average)	3.2	sec		
Idling Time (Average)	0.5	sec		
Intersection Level of Service (LOS)	LOS A			
95% Back of Queue - Vehicles (Worst Lane)	5.3	veh		
95% Back of Queue - Distance (Worst Lane)	135.5	ft		
Queue Storage Ratio (Worst Lane)	0.11			
Total Effective Stops	1010	veh/h	1211	pers/h
Effective Stop Rate	0.69	per veh	0.69	per pers
Proportion Queued	0.62		0.62	
Performance Index	49.7		49.7	
Cost (Total)	450.62	$/h	450.62	$/h
Fuel Consumption (Total)	45.1	gal/h		
Carbon Dioxide (Total)	405.0	kg/h		
Hydrocarbons (Total)	0.036	kg/h		
Carbon Monoxide (Total)	0.472	kg/h		
NOx (Total)	0.754	kg/h		

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
Intersection LOS value for Vehicles is based on average delay for all vehicle movements.
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

Intersection Performance - Annual Values				
Performance Measure	**Vehicles**		**Persons**	
Demand Flows (Total)	700,696	veh/y	840,835	pers/y
Delay	1,865	veh-h/y	2,238	pers-h/y
Effective Stops	484,563	veh/y	581,476	pers/y
Travel Distance	452,936	veh-mi/y	543,523	pers-mi/y
Travel Time	12,985	veh-h/y	15,582	pers-h/y
Cost	216,297	$/y	216,297	$/y
Fuel Consumption	21,669	gal/y		
Carbon Dioxide	194,389	kg/y		
Hydrocarbons	17	kg/y		
Carbon Monoxide	226	kg/y		
NOx	362	kg/y		

LANE LEVEL OF SERVICE

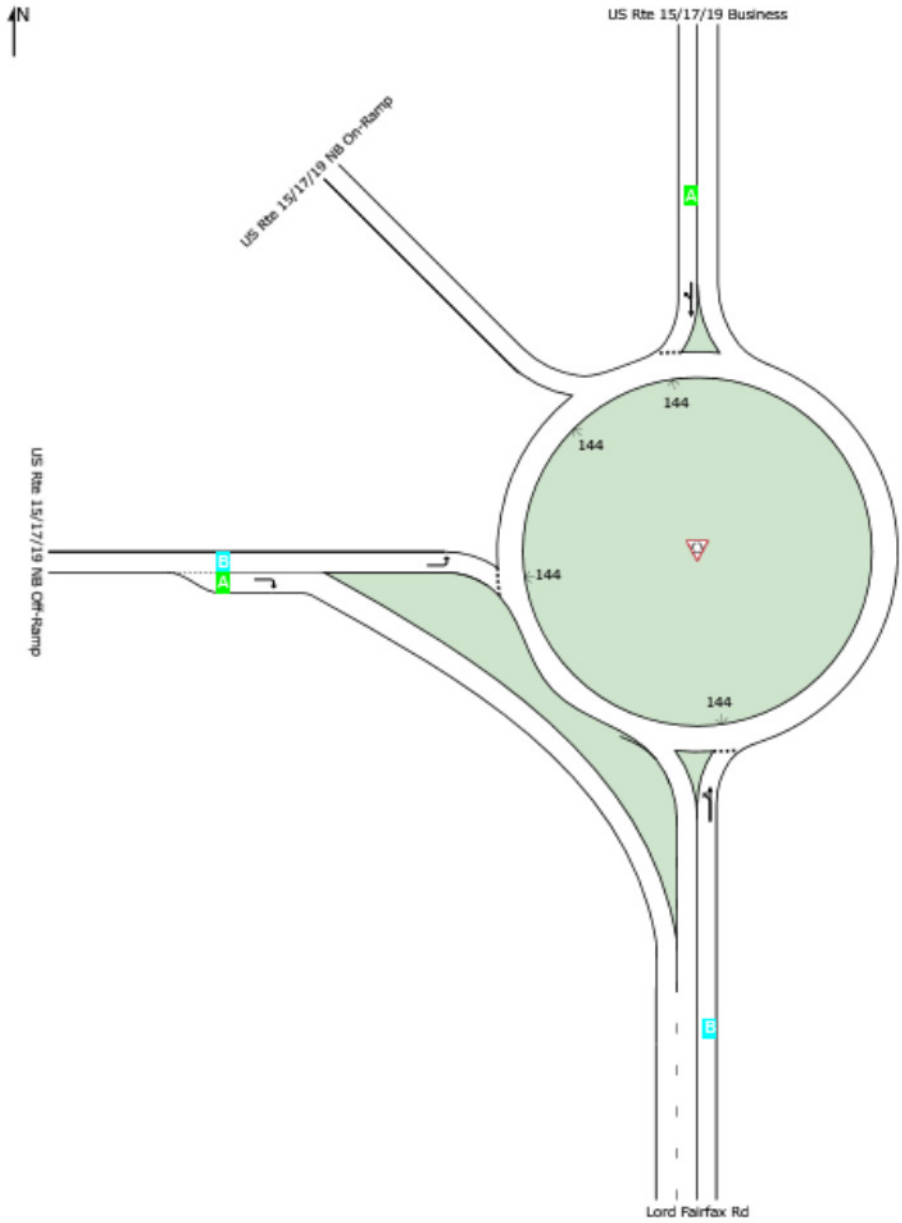
Lane Level of Service

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	B	A	B	B



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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LANE LEVEL OF SERVICE

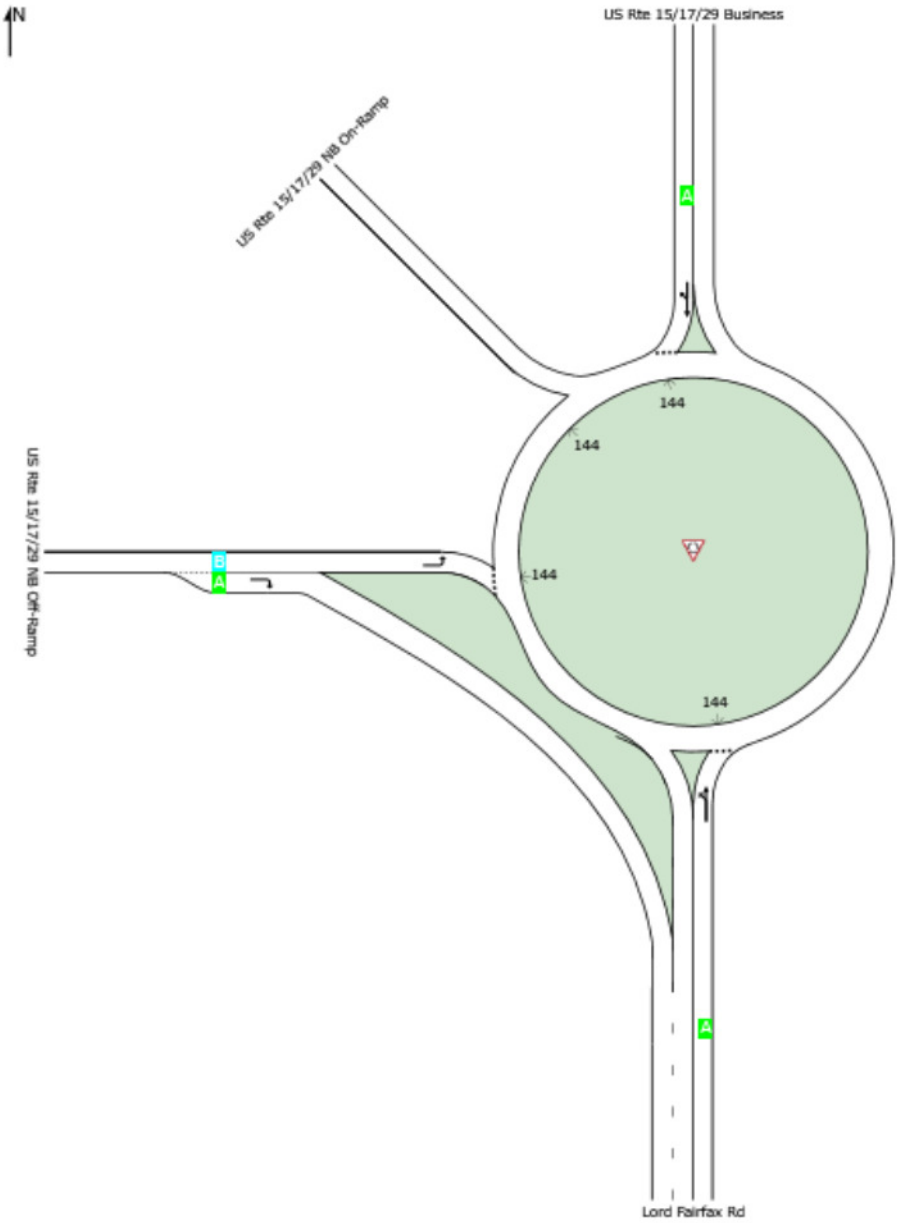
Lane Level of Service

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	A	A	B	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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LANE LEVEL OF SERVICE

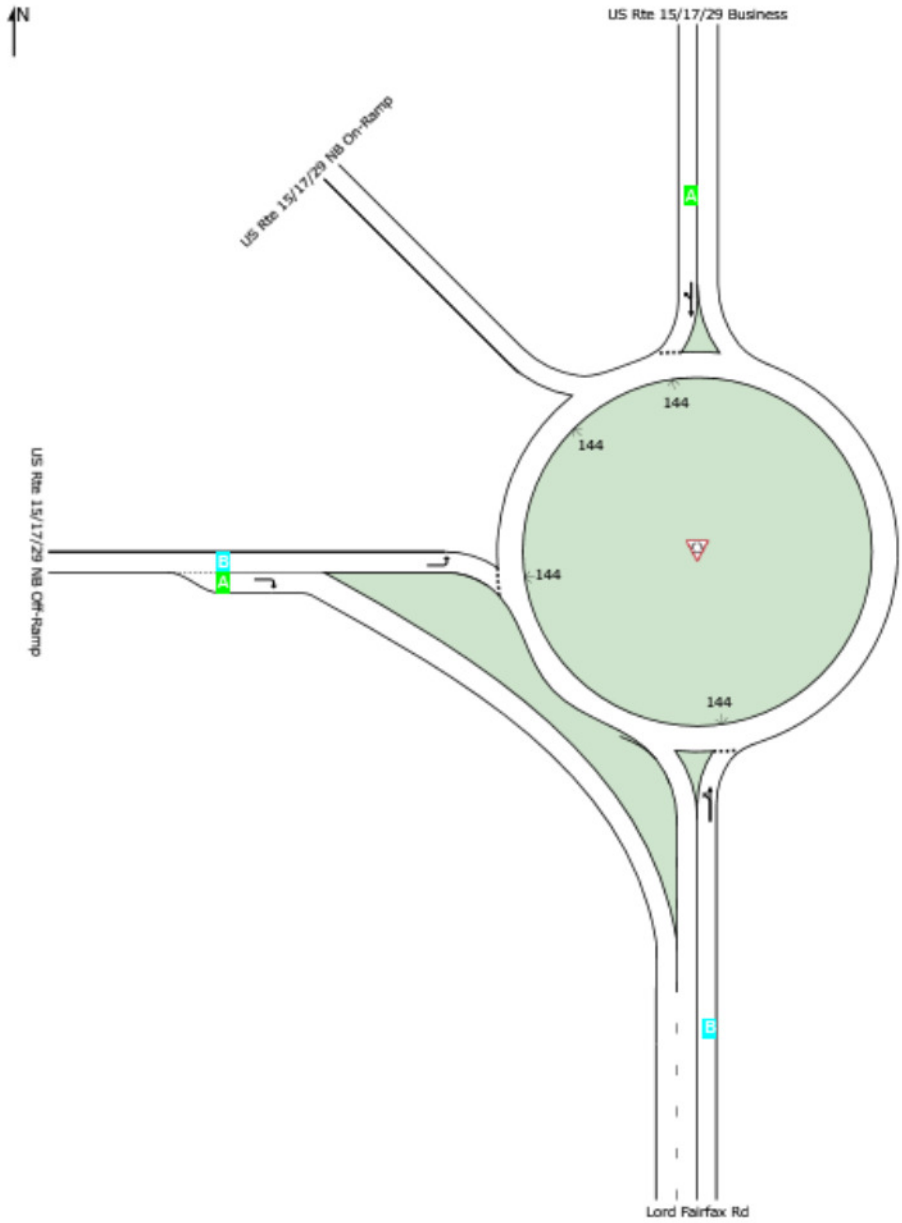
Lane Level of Service

Site: Sat Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
Roundabout

All Movement Classes

	South	North	West	Intersection
LOS	B	A	B	A



Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.

Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.

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MOVEMENT SUMMARY

Site: AM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
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: Lord Fairfax Rd											
3a	L1	88	16.0	0.538	21.3	LOS C	4.3	124.3	0.94	1.06	31.0
8	T1	136	20.0	0.538	15.7	LOS B	4.3	124.3	0.94	1.06	31.4
Approach		224	18.4	0.538	17.9	LOS B	4.3	124.3	0.94	1.06	31.3
North: US Rte 15/17/19 Business											
4	T1	344	10.0	0.390	3.8	LOS A	3.2	88.3	0.45	0.41	37.7
14b	R3	81	17.0	0.390	4.9	LOS A	3.2	88.3	0.45	0.41	35.4
Approach		425	11.3	0.390	4.0	LOS A	3.2	88.3	0.45	0.41	37.3
West: US Rte 15/17/19 NB Off-Ramp											
5	L2	719	4.0	0.677	14.8	LOS B	7.4	190.0	0.80	0.85	33.4
12	R2	95	18.0	0.067	3.2	LOS A	0.0	0.0	0.00	0.39	37.6
Approach		814	5.6	0.677	13.5	LOS B	7.4	190.0	0.71	0.80	33.8
All Vehicles		1463	9.2	0.677	11.4	LOS B	7.4	190.0	0.67	0.73	34.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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MOVEMENT SUMMARY

Site: PM Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
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: Lord Fairfax Rd											
3a	L1	140	2.0	0.414	11.8	LOS B	2.9	73.5	0.67	0.67	35.7
8	T1	222	2.0	0.414	5.8	LOS A	2.9	73.5	0.67	0.67	35.9
Approach		361	2.0	0.414	8.1	LOS A	2.9	73.5	0.67	0.67	35.8
North: US Rte 15/17/29 Business											
4	T1	234	2.0	0.331	3.9	LOS A	2.4	61.5	0.45	0.45	37.8
14b	R3	134	3.0	0.331	4.7	LOS A	2.4	61.5	0.45	0.45	35.7
Approach		369	2.4	0.331	4.2	LOS A	2.4	61.5	0.45	0.45	37.1
West: US Rte 15/17/29 NB Off-Ramp											
5	L2	333	3.0	0.274	11.4	LOS B	1.7	44.7	0.47	0.66	34.5
12	R2	56	5.0	0.036	3.1	LOS A	0.0	0.0	0.00	0.39	37.8
Approach		390	3.3	0.274	10.2	LOS B	1.7	44.7	0.41	0.62	34.9
All Vehicles		1120	2.6	0.414	7.5	LOS A	2.9	73.5	0.51	0.58	35.9

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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MOVEMENT SUMMARY

Site: Sat Peak [ATC 001 - Modified Barbell Interchange Concept]

US Rte 15/17/29 Business Interchange - Southeastern Roundabout
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: Lord Fairfax Rd											
3a	L1	151	7.0	0.574	17.3	LOS B	5.3	135.5	0.89	0.99	33.4
8	T1	229	2.0	0.574	10.7	LOS B	5.3	135.5	0.89	0.99	33.7
Approach		380	4.0	0.574	13.3	LOS B	5.3	135.5	0.89	0.99	33.6
North: US Rte 15/17/29 Business											
4	T1	266	5.0	0.404	4.2	LOS A	3.2	84.4	0.54	0.49	37.5
14b	R3	157	6.0	0.404	5.0	LOS A	3.2	84.4	0.54	0.49	35.4
Approach		423	5.4	0.404	4.5	LOS A	3.2	84.4	0.54	0.49	36.7
West: US Rte 15/17/29 NB Off-Ramp											
5	L2	562	2.0	0.468	11.9	LOS B	3.6	92.2	0.61	0.70	34.1
12	R2	95	6.0	0.060	3.2	LOS A	0.0	0.0	0.00	0.39	37.8
Approach		657	2.6	0.468	10.7	LOS B	3.6	92.2	0.52	0.65	34.6
All Vehicles		1460	3.8	0.574	9.6	LOS A	5.3	135.5	0.62	0.69	34.9

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Signalised Intersections.
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 6).
Roundabout Capacity Model: SIDRA Standard.
SIDRA Standard Delay Model is used. Control Delay includes Geometric Delay.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

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Kaufell, William

From: Ahmad, Aliya <aahmad@Dewberry.com>
Sent: Wednesday, June 06, 2018 12:34 PM
To: Kaufell, William
Cc: Kaczmarek, Carl; Curtis, Andrew; Beck, Jeremy
Subject: RE: Warrenton Files for Noise Study

Bill,

Please see the information below:

Bypass:

- Bus: 1%
- 2 Axle Truck: 1%
- 3+ Axle Truck: 1%
- 1 Trailer Truck: 6%
- 2 Trailer Truck: 0%

Business:

- Bus: 1%
- 2 Axle Truck: 1%
- 3+ Axle Truck: 0%
- 1 Trailer Truck: 1%
- 2 Trailer Truck: 0%

Let me know if you have any other questions.

Thanks,
Aliya

Aliya Ahmad
Transportation Services
Dewberry
8403 Arlington Boulevard
Fairfax, VA 22031
703.206.0833
703.849.0537 (fax)
www.dewberry.com

US 15/17/29 ATC 1 Traffic Calcluations

Interchange On/Off Ramps

	AM	PM	Sat			AM	PM	Sat	Speed
	276	259	287	**Car**	97%	268	251	278	40
SB Off Ramp D Seg 1	276	259	287	**MT**	1%	3	3	3	40
	276	259	287	**HT**	1%	3	3	3	40
	276	259	287	**Bus**	1%	3	3	3	40
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	88	138	155	**Car**	97%	85	134	150	40
SB Off Ramp D Seg 2	88	138	155	**MT**	1%	1	1	2	40
	88	138	155	**HT**	1%	1	1	2	40
	88	138	155	**Bus**	1%	1	1	2	40
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	188	121	131	**Car**	97%	182	117	127	40
Ramp D Spur	188	121	131	**MT**	1%	2	1	1	40
	188	121	131	**HT**	1%	2	1	1	40
	188	121	131	**Bus**	1%	2	1	1	40
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	37	78	56	**Car**	97%	36	76	54	35
SB On Ramp C SB On Ramp	37	78	56	**MT**	1%	0	1	1	35
	37	78	56	**HT**	1%	0	1	1	35
	37	78	56	**Bus**	1%	0	1	1	35
						AM	**PM**	**Sat**	**Speed**
	210	817	463	**Car**	97%	204	792	449	35
Ramp G SB On Ramp	210	817	463	**MT**	1%	2	8	5	35
	210	817	463	**HT**	1%	2	8	5	35
	210	817	463	**Bus**	1%	2	8	5	35
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	773	375	605	**Car**	97%	750	364	587	40
NB Off Ramp F	773	375	605	**MT**	1%	8	4	6	40
	773	375	605	**HT**	1%	8	4	6	40
	773	375	605	**Bus**	1%	8	4	6	40
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	
	161	264	283	**Car**	97%	156	256	275	25
NB On Ramp B	161	264	283	**MT**	1%	2	3	3	25
	161	264	283	**HT**	1%	2	3	3	25
	161	264	283	**Bus**	1%	2	3	3	25
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	685	323	522	**Car**	97%	664	313	506	35
Ramp F Spur NB Off for Circle	685	323	522	**MT**	1%	7	3	5	35
	685	323	522	**HT**	1%	7	3	5	35
	685	323	522	**Bus**	1%	7	3	5	35

	AM	PM	Sat			AM	PM	Sat	Speed
	89	51	82	Car	97%	86	49	80	35
Ramp F to EB Lord Fairfax	89	51	82	MT	1%	1	1	1	35
	89	51	82	HT	1%	1	1	1	35
	89	51	82	Bus	1%	1	1	1	35
	AM	PM	Sat			AM	PM	Sat	Speed
	327	225	245	Car	97%	317	218	238	35
EB Circle to Lord Fairfax SB	327	225	245	MT	1%	3	2	2	35
	327	225	245	HT	1%	3	2	2	35
	327	225	245	Bus	1%	3	2	2	35
	AM	PM	Sat			AM	PM	Sat	Speed
	84	134	139	Car	97%	81	130	135	35
	84	134	139	MT	1%	1	1	1	35
E Circle N leg	84	134	139	HT	1%	1	1	1	35
	84	134	139	Bus	1%	1	1	1	35

Bypass Southbound

									Each Lane			
	AM	PM	Sat			AM	PM	Sat	AM	PM	Sat	Speed
	1337	2551	2317	Car	91%	1217	2321	2108	608	1161	1054	55
15-17-29_SB_Inner Ln North of Int	1337	2551	2317	MT	1%	13	26	23	7	13	12	55
	1337	2551	2317	HT	7%	94	179	162	47	89	81	55
	1337	2551	2317	Bus	1%	13	26	23	7	13	12	55
	AM	PM	Sat			AM	PM	Sat	AM	PM	Sat	Speed
	1061	2292	2030	Car	91%	966	2086	1847	483	1043	924	55
15-17-29_SB_Outer Ln- bwtn Interch	1061	2292	2030	MT	1%	11	23	20	5	11	10	55
	1061	2292	2030	HT	7%	74	160	142	37	80	71	55
	1061	2292	2030	Bus	1%	11	23	20	5	11	10	55
	AM	PM	Sat			AM	PM	Sat	AM	PM	Sat	Speed
	1308	3188	2549	Car	91%	1190	2901	2320	595	1451	1160	55
15-17-29_SB_Inner Ln-2 Sth of Interch	1308	3188	2549	MT	1%	13	32	25	7	16	13	55
	1308	3188	2549	HT	7%	92	223	178	46	112	89	55
	1308	3188	2549	Bus	1%	13	32	25	7	16	13	55

Bypass Northbound

									Each Lane			
	AM	PM	Sat			AM	PM	Sat	AM	PM	Sat	Speed
	2245	1905	2145	Car	91%	2043	1734	1952	1021	867	976	55
15-17-29_NB_Inner Ln North of Int	2245	1905	2145	MT	1%	22	19	21	11	10	11	55
	2245	1905	2145	HT	7%	157	133	150	79	67	75	55
	2245	1905	2145	Bus	1%	22	19	21	11	10	11	55

	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**AM**	**PM**	**Sat**	**Speed**
	1472	1530	1540	**Car**	91%	1340	1392	1401	670	696	701	55
15-17-29_NB_Outer Ln- bwtn Interch	1472	1530	1540	**MT**	1%	15	15	15	7	8	8	55
	1472	1530	1540	**HT**	7%	103	107	108	52	54	54	55
	1472	1530	1540	**Bus**	1%	15	15	15	7	8	8	55
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**AM**	**PM**	**Sat**	**Speed**
	2857	2016	2466	**Car**	91%	2600	1835	2244	1300	917	1122	55
15-17-29_NB_Inner Ln-2 Sth of Interch	2857	2016	2466	**MT**	1%	29	20	25	14	10	12	55
	2857	2016	2466	**HT**	7%	200	141	173	100	71	86	55
	2857	2016	2466	**Bus**	1%	29	20	25	14	10	12	55
US 15/17/29 Business									**Each Lane**			
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**AM**	**PM**	**Sat**	**Speed**
	863	593	828	**Car**	97%	837	575	803	419	288	402	45
Bus-15-17-29_WB_west of Interc	863	593	828	**MT**	1%	9	6	8	4	3	4	45
	863	593	828	**HT**	1%	9	6	8	4	3	4	45
	863	593	828	**Bus**	1%	9	6	8	4	3	4	45
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**AM**	**PM**	**Sat**	**Speed**
	426	1050	722	**Car**	97%	413	1019	700	207	509	350	45 > 35
Bus-15-17-29_EB_OuterLn_west of interch	426	1050	722	**MT**	1%	4	11	7	2	5	4	45 > 35
	426	1050	722	**HT**	1%	4	11	7	2	5	4	45 > 35
	426	1050	722	**Bus**	1%	4	11	7	2	5	4	45 > 35
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**				**Speed**
	216	233	258	**Car**	97%	210	226	250				35 >45
EB Bus 15/17/29 App NW Circle	216	233	258	**MT**	1%	2	2	3				35 >45
	216	233	258	**HT**	1%	2	2	3				35 >45
	216	233	258	**Bus**	1%	2	2	3				35 >45
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**				**Speed**
	775	455	673	**Car**	97%	752	441	653				*35*
NB 15/17/29 Bus depart NW circle 1	775	455	673	**MT**	1%	8	5	7				*35*
	775	455	673	**HT**	1%	8	5	7				*35*
	775	455	673	**Bus**	1%	8	5	7				*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**				**Speed**
	404	354	389	**Car**	97%	392	343	377				*35*
SB Bus 15/17/29 Depart NW Circle	404	354	389	**MT**	1%	4	4	4				*35*
	404	354	389	**HT**	1%	4	4	4				*35*
	404	354	389	**Bus**	1%	4	4	4				*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**				**Speed**
	812	533	729	**Car**	97%	788	517	707				*35*
NB Bus 15/17/29 Depart E Circle	812	533	729	**MT**	1%	8	5	7				*35*
	812	533	729	**HT**	1%	8	5	7				*35*

	812	533	729	**Bus**	1%	8	5	7	*35*

Lord Fairfax Rd

	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	213	347	350	**Car**	97%	207	337	340	*35*
Lord Fairfax NB (turkey > Circle)-2	213	347	350	**MT**	1%	2	3	4	*35*
	213	347	350	**HT**	1%	2	3	4	*35*
	213	347	350	**Bus**	1%	2	3	4	*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	417	279	396	**Car**	97%	404	271	384	*25*
Lord Fairfax SB (Ramp F to turkey r)	417	279	396	**MT**	1%	4	3	4	*25*
	417	279	396	**HT**	1%	4	3	4	*25*
	417	279	396	**Bus**	1%	4	3	4	*25*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
Turkey_Run_Dr_SB-Roadway117	11	7	4	**Car**	100%	11	7	4	*25*
				MT	0%	0	0	0	*25*
				HT	0%	0	0	0	*25*
				Bus	0%	0	0	0	*25*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
Turkey_Run_Dr_NB-2-	3	8	11	**Car**	100%	3	8	11	*10*
				MT	0%	0	0	0	*10*
				HT	0%	0	0	0	10
				Bus	0%	0	0	0	10
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	15	9	16	**Car**	99%	15	9	16	*35*
park n rid in and ou	15	9	16	**MT**	1%	0	0	0	*35*
	15	9	16	**HT**	0%	0	0	0	*35*
	15	9	16	**Bus**	1%	0	0	0	*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	403	269	314	**Car**	97%	391	261	305	*35*
Lord_Fairfax_Rd_SB- Turkey > Traveler	403	269	314	**MT**	1%	4	3	3	*35*
	403	269	314	**HT**	1%	4	3	3	*35*
	403	269	314	**Bus**	1%	4	3	3	*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	200	332	340	**Car**	97%	194	322	330	*35*
Lord_Fairfax_Rd_NB-travelers > Turkey	200	332	340	**MT**	1%	2	3	3	*35*
	200	332	340	**HT**	1%	2	3	3	*35*
	200	332	340	**Bus**	1%	2	3	3	*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**	**Speed**
	402	260	311	**Car**	97%	390	252	302	*35*
Lord_Fairfax_Rd_SB- Travelers > Colleg	402	260	311	**MT**	1%	4	3	3	*35*
	402	260	311	**HT**	1%	4	3	3	*35*
	402	260	311	**Bus**	1%	4	3	3	*35*

	AM	PM	Sat			AM	PM	Sat		Speed
	196	321	333	**Car**	97%	190	311	323		*35*
Lord_Fairfax_Rd_NB-College > Traveler	196	321	333	**MT**	1%	2	3	3		*35*
	196	321	333	**HT**	1%	2	3	3		*35*
	196	321	333	**Bus**	1%	2	3	3		*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	138	148	277	**Car**	97%	134	144	269		*35*
Lord_Fairfax_Rd_NB to College	138	148	277	**MT**	1%	1	1	3		*35*
	138	148	277	**HT**	1%	1	1	3		*35*
	138	148	277	**Bus**	1%	1	1	3		*35*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	182	104	263	**Car**	97%	177	101	255		*30*
Lord_Fairfax_Rd_SB- from College	182	104	263	**MT**	1%	2	1	3		*30*
	182	104	263	**HT**	1%	2	1	3		*30*
	182	104	263	**Bus**	1%	2	1	3		*30*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	220	156	48	**Car**	97%	213	151	47		*30*
College_St_EB	220	156	48	**MT**	1%	2	2	0		*30*
	220	156	48	**HT**	1%	2	2	0		*30*
	220	156	48	**Bus**	1%	2	2	0		*30*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	60	173	56	**Car**	97%	58	168	54		*30*
College_St_WB	60	173	56	**MT**	1%	1	2	1		*30*
	60	173	56	**HT**	1%	1	2	1		*30*
	60	173	56	**Bus**	1%	1	2	1		*30*
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	2	9	3	**Car**	97%	2	9	3		25
Traveler's_Way_EB				**MT**	1%	0	0	0		
		9		**HT**	1%	0	0	0		
				Bus	1%	0	0	0		
	AM	**PM**	**Sat**			**AM**	**PM**	**Sat**		**Speed**
	4	11	7	**Car**	97%	4	11	7		25
Traveler's_Way_WB				**MT**	1%	0	0	0		
				HT	1%	0	0	0		
				Bus	1%	0	0	0		

APPENDIX C

Warrenton Southern Interchange US 15/17/29
State Project 0029-030-121, P101, R201, C501, B616
Federal Project No.: STP-032-7 (032)
Design Build Contract ID Number: C00077384DB100

AM, PM and Saturday Peak - Loudest Hour Results

Receptor	Saturday Peak	AM Peak	PM Peak	Loudest Hour
A-001	**61.2**	60.9	61.0	Saturday
A-002	**59.1**	58.9	58.7	Saturday
B-001	**62.8**	62.4	62.6	Saturday
B-002	**59.1**	58.5	58.9	Saturday
B-003	**65.3**	64.9	65.1	Saturday
B-004	**68.0**	67.8	67.7	Saturday
B-005	62.4	61.2	**62.5**	PM
B-006	63.2	61.7	**63.4**	PM
B-007	**61.9**	60.9	61.8	Saturday
B-008	**58.8**	58.7	58.2	Saturday
B-009	**48.9**	48.4	48.4	Saturday
B-010	**56.0**	55.6	55.4	Saturday
B-011	**54.0**	53.5	53.7	Saturday
B-012	**54.4**	53.8	54.2	Saturday
B-013	**52.8**	51.9	52.7	Saturday
B-014	**52.2**	51.3	**52.2**	Sat/PM
B-015	**54.8**	54.0	**54.8**	Sat/PM
C-001	63.1	**62.4**	63.2	AM
C-002	**58.6**	57.7	58.6	Sat/PM
C-003	59.5	58.7	**59.6**	PM
C-004	58.5	57.7	**58.7**	PM
D-001	76.2	74.3	**76.8**	PM

APPENDIX D

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219-2000

Gregory A. Whirley
Commissioner

July 11, 2018

MEMORANDUM

TO: Ross Hudnall, VDOT Senior Highway Noise Specialist

FROM: Bill Kaufell Skelly and Loy, Noise Consultant

SUBJECT: State Project No. 0029-030-121, P101, R201, C501, B616
Federal Project No. STP-032-7 (032)
Design Build Contract ID No. C00077384DB100
Warrenton Southern Interchange US 15/17/29

The 2009 General Assembly passed Chapter 120 (HB 2577, as amended by HB2025), which amends the Code of Virginia by adding in Article 15 of Chapter 1 of Title 33.1 a section numbered 33.1-223.2:21, relating to highway noise abatement.

House Bill 2025 States: Requires that whenever the Commonwealth Transportation Board or the Department plan for or undertake any highway construction or improvement project and such project includes or may include the requirement for the mitigation of traffic noise impacts, first consideration should be given to the use of noise reducing design and low noise pavement materials and techniques in lieu of construction of noise walls or sound barriers. Vegetative screening, such as the planting of appropriate conifers, in such a design would be utilized to act as a visual screen if visual screening is required.

In an effort to honor the intent of HB 2025 we are asking for your input (per Chapter VI of Materials Division's Manual of Instruction and Section 2B-3 Determination of Roadway Design of the VDOT Road Design manual (pages 2B-5 and 2B-6)). As part of the Noise Technical Report and technical files, we are seeking your professional opinion by providing comments for the project noted above. Please distribute this memorandum to the appropriate District staff and combine all responses into one response.

Should you have any questions, please contact me at (804) 371-6768. Thank you for your time and consideration regarding this request.

Comment: Is noise reducing design feasible in lieu of construction of noise walls or sound barriers? For example, the roadway alignment can be shifted away from noise sensitive receptors or the roadway can be placed in deep cut (Location & Design to address)

Response: The roadway design was modified from a diamond interchange in preliminary design, to a dual roundabout interchange for the design build contract. The redesign of the interchange has reduced the number of noise impacts from 7 residential units to 2.

Comment: Can the project support the use of low noise pavement in lieu of construction of noise walls or sound barriers? (Materials Division to address)

Response: The Virginia Department of Transportation is not authorized by the Federal Highway Administration to use "quiet pavement" at this time as a form of noise mitigation. Upon completion of the Quiet Pavement Pilot Program and approval from FHWA, the use of "quiet pavement" will be given additional consideration.

Comment: Can landscaping be utilized to act as a visual screen if visual screening is required? (Location & Design to address)

Response: Possibly, if deemed necessary landscaping could be used as a visual screening in areas where it can be placed outside of the clear zone, where it will not decrease sight distance, and where it won't require additional right of way. There is existing vegetation between the roadway network and the residential receptors.

Note: Please provide the name of each responder.

APPENDIX E

Warrenton Southern Interchange US 15/17/29
State Project 0029-030-121, P101, R201, C501, B616
Federal Project No.: STP-032-7 (032)
Design Build Contract ID Number: C00077384DB100

VDOT Highway Traffic Noise Abatement
Warranted, Feasible, and Reasonable Worksheet

Note: Not all questions apply depending on the design phase which may cause differing answers between preliminary and final design phase. Answers to the questions may change depending on the design phase of the project.

Date:	7/13/18
Project No. and UPC:	State Project No. 0029-030-121, P101, R201, C501, B616 Federal Project No.: STP-032-7 (032) Design Build Contract ID No. C00077384DB100
County:	Fauquier
District:	
Barrier System ID:	CNE B
Community Name and/or CNE#	CNE B
Noise Abatement Category(s)	B
Design phase:	Final design

	Warranted	
1	Community Documentation (if applicable)	
a.	Date community was permitted. (Per 23CFR 772 this is the date the building permit was issued).	NA
b.	Date of approval for the Categorical Exclusion (CE), Record of Decision (ROD), or Finding of No Significant Impact (FONSI):	NA
c.	Does the date in 1.a precede the date in 1.b? If yes, proceed to Warranted Item 2. If no, consideration of noise abatement is not warranted. Proceed to "Decision" block and answer "no" to warranted question. As the reason for this decision, state that "Community was permitted after the date of approval of CE, ROD, or FONSI, as appropriate."	No
2	Criteria requiring consideration of noise abatement	
a.	Project causes design year noise levels to approach or exceed the Noise Abatement Criteria?	Yes
b.	Project causes a substantial noise increase of 10 dB(A) or more?	No

	Feasibility	
1	Impacted receptor units	
a.	Number of impacted receptor units:	1
b.	Number of impacted receptor units receiving 5 dB(A) or more insertion loss (IL):	1
c.	Percentage of impacted receptor units receiving 5 dB(A) or more IL	100%
d.	Is the percentage 50 or greater?	Yes
2	Will placement of the noise barrier cause engineering or safety conflicts, e.g drainage issues or site distance issues?	No
3	Will placement of the noise barrier restrict access to vehicular or pedestrian travel?	No
4	Will placement of the noise barrier conflict with existing utility locations?	No

	Reasonableness	
1	**Surface Area (Square foot)-Benefit Factors**	
a.	Surface Area (Total square foot) of the proposed noise barrier. (ft^2)	4,587 SF
b.	Impacted noise sensitive receptor(s) receiving 5 dB(A) IL or more.	1
c.	Non-impacted noise sensitive receptor(s) receiving 5 dB(A) IL or more.	1
d.	Total number of benefited receptors.	2
e.	Surface Area per benefited receptor unit. (ft^2/BR)	2,294 SF/BR
f.	Is (1e) less than or equal to the maximum square feet per benefited receptor (MaxSF/BR) value of 1600?	No
g.	Does the barrier provide an IL of at least 7 dB(A) for at least one impacted receptor in the design year?	Yes
2	**Additional Noise Barrier Details**	
a.	Length of the proposed noise barrier. (ft)	467 ft
b.	Height range of the proposed noise barrier. (ft)	9-10
c.	Average height of the proposed noise barrier. (ft)	9.8 ft
d.	Cost per square foot. ($/$ft^2$)	$42/SF
e.	Total Barrier Cost ($)	$192,654
f.	Barrier Material	NA
3	**Community Desires Related to the Barrier**	
	Do at least 50 percent of the benefited receptor unit owner(s) and renters desire the noise barrier? If yes, continue to "decision" block. If no, the barrier can be considered not to be reasonable. Proceed to “decision” block and answer “no” to reasonableness question. As the reason for this decision, state that “The majority of the impacted receptor unit owners do not desire the barrier.”	

Decision	
Is the Noise Barrier(s) WARRANTED?	Yes
Is the Noise Barrier(s) FEASIBLE?	Yes
Is the Noise Barrier(s) REASONABLE?	No

Additional Reasons for Decision:

VDOT Highway Traffic Noise Abatement
Warranted, Feasible, and Reasonable Worksheet

Note: Not all questions apply depending on the design phase which may cause differing answers between preliminary and final design phase. Answers to the questions may change depending on the design phase of the project.

Date:	7/13/18
Project No. and UPC:	State Project No. 0029-030-121, P101, R201, C501, B616 Federal Project No.: STP-032-7 (032) Design Build Contract ID No. C00077384DB100
County:	Fauquier
District:	
Barrier System ID:	CNE D
Community Name and/or CNE#	CNE D
Noise Abatement Category(s)	B
Design phase:	Final design

	Warranted	
1	Community Documentation (if applicable)	
a.	Date community was permitted. (Per 23CFR 772 this is the date the building permit was issued).	NA
b.	Date of approval for the Categorical Exclusion (CE), Record of Decision (ROD), or Finding of No Significant Impact (FONSI):	NA
c.	Does the date in 1.a precede the date in 1.b? If yes, proceed to Warranted Item 2. If no, consideration of noise abatement is not warranted. Proceed to "Decision" block and answer "no" to warranted question. As the reason for this decision, state that "Community was permitted after the date of approval of CE, ROD, or FONSI, as appropriate."	No
2	Criteria requiring consideration of noise abatement	
a.	Project causes design year noise levels to approach or exceed the Noise Abatement Criteria?	Yes
b.	Project causes a substantial noise increase of 10 dB(A) or more?	No

	Feasibility	
1	Impacted receptor units	
a.	Number of impacted receptor units:	1
b.	Number of impacted receptor units receiving 5 dB(A) or more insertion loss (IL):	0
c.	Percentage of impacted receptor units receiving 5 dB(A) or more IL	0%
d.	Is the percentage 50 or greater?	No
2	Will placement of the noise barrier cause engineering or safety conflicts, e.g drainage issues or site distance issues?	No
3	Will placement of the noise barrier restrict access to vehicular or pedestrian travel?	No
4	Will placement of the noise barrier conflict with existing utility locations?	No

Reasonableness

1 **Surface Area (Square foot)-Benefit Factors**

a.	Surface Area (Total square foot) of the proposed noise barrier. (ft^2)	NA
b.	Impacted noise sensitive receptor(s) receiving 5 dB(A) IL or more.	NA
c.	Non-impacted noise sensitive receptor(s) receiving 5 dB(A) IL or more.	NA
d.	Total number of benefited receptors.	NA
e.	Surface Area per benefited receptor unit. (ft^2/BR)	NA
f.	Is (1e) less than or equal to the maximum square feet per benefited receptor (MaxSF/BR) value of 1600?	NA
g.	Does the barrier provide an IL of at least 7 dB(A) for at least one impacted receptor in the design year?	NA

2 **Additional Noise Barrier Details**

a.	Length of the proposed noise barrier. (ft)	NA
b.	Height range of the proposed noise barrier. (ft)	NA
c.	Average height of the proposed noise barrier. (ft)	NA
d.	Cost per square foot. ($/$ft^2$)	NA
e.	Total Barrier Cost ($)	NA
f.	Barrier Material	NA

3 **Community Desires Related to the Barrier**

Do at least 50 percent of the benefited receptor unit owner(s) and renters desire the noise barrier? If yes, continue to "decision" block. If no, the barrier can be considered not to be reasonable. Proceed to “decision” block and answer “no” to reasonableness question. As the reason for this decision, state that “The majority of the impacted receptor unit owners do not desire the barrier.”

Decision

Is the Noise Barrier(s) WARRANTED?	Yes
Is the Noise Barrier(s) FEASIBLE?	No
Is the Noise Barrier(s) REASONABLE?	NA

Additional Reasons for Decision:

The impact occurs at a single residence that has direct driveway access to the Bypass. A noise wall is not feasible in this location.

APPENDIX F

Warrenton Southern Interchange US 15/17/29
State Project 0029-030-121, P101, R201, C501, B616
Federal Project No.: STP-032-7 (032)
Design Build Contract ID Number: C00077384DB100

TNM FILES CAN BE DOWNLOADED FROM S&Ls ftp SITE ADDRESS BELOW

http://www.skellyloy-gis.com/downloads/Warenton_Interchange_TNM_Files7_13_18.zip

TNM File Naming/Runs

Validation	**Description**
Validation_hmmh\15-17-29_Val_M1	Validation model for M1
Validation_hmmh\15-17-29_Val_M2	Validation model for M2
Validation_hmmh\15-17-29_Val_M3	Validation model for M3
Validation_hmmh\15-17-29_Val_M4	Validation model for M4

2017 Existing Conditions	**Description**
Existing_hmmh\15-17-29_Exst_AM_r1	2017 Existing Conditions AM PEAK
Existing_hmmh\15-17-29_Exst_PM_r1	2017 Existing Conditions PM PEAK
Existing_hmmh\15-17-29_Exst_SAT_r1	2017 Existing Conditions Saturday PEAK

2040 Design Year Conditions	**Description**
Build\SL_ATC01_Build_AM	2040 Build with ATC01 Design AM PEAK
Build\SL_ATC01_Build_PM	2040 Build with ATC01 Design PM PEAK
Build\SL_ATC01_Build_Sat	2040 Build with ATC01 Design Saturday PEAK

2040 Mitigation	**Description**
Mitigation\ATC1_MitB2	2040 w/ ATC01 Design and Noise Wall (Saturday PEAK)

Miscellaneous	**Description**
Contours\SL_ATC1_Sat_Contours	2040 Build w/ ATC01 Design (Saturday PEAK) with receptor set used to assist in contour placement