Forecasting and Traffic Operations Analysis Framework Document

This document defines the methodology and assumptions that will be used in the traffic forecasting and traffic operations analysis efforts for the Benning Road Reconstruction and Streetcar Project. The project focuses on two components—the Benning Road streetcar extension (Environmental Assessment [EA] alignment) from Oklahoma Avenue NE to East Capitol Street NE and the redesign of the DC-295 and Benning Road interchange. At a high level, the forecasting and traffic operations analysis framework consists of the following key assumptions:

- Framework document consensus
- Study area boundary
- Forecasting and analysis scenarios
- Data collection and processing
- Existing volumes and balancing
    - Peak hour and peak period
- Travel demand forecasting
    - Metropolitan Washington Council of Governments (MWCOG) regional travel demand model
    - VISUM subarea model
    - Origin-destination (O-D) development
    - Traffic forecasting and volume post-processing
- VISSIM microsimulation analysis
    - Simulation and analysis period
    - Model development
    - Model calibration

FRAMEWORK DOCUMENT CONSENSUS

This framework document defines the proposed methodology for modeling/analysis and the assumptions required to develop traffic volumes, growth rates and future forecast volumes, and O-D trip tables; develop and validate an MWCOG project-focused travel demand model and VISUM subarea model; develop and calibrate a VISSIM model for analysis; and report analysis results. The document shall be reviewed and agreed upon with the District Department of Transportation (DDOT) and other stakeholders deemed appropriate by DDOT before the start of the traffic forecasting and analysis effort.

STUDY AREA BOUNDARY

The following provides a description of the study area boundary:

- **Base Scenario**: Benning Road NE Streetcar EA alignment from 26th Street NE to East Capitol Street SE (shown in **Figure 1**). The base scenario will address the transit and traffic operations resulting from the design of the proposed streetcar extension and reconstruction of Benning Road, including pedestrian and bicycle facilities.
- **Interchange Modification Report (IMR) Scenario**: Base scenario plus Anacostia Freeway (DC-295) and Benning Road NE interchange access modification and includes both the upstream and downstream interchanges (East Capitol Street SE and Nannie Helen Burroughs Avenue NE) (shown in **Figure 2**). The

IMR scenario will address the impact to transit and traffic operations resulting from the potential interchange modification and change of access at the Benning Road/DC-295 interchange.

The base scenario follows the proposed EA alignment and the adjacent intersections on Minnesota Avenue NE, which are included due to the proximity of the Minnesota Avenue Metrorail station to the Benning Road corridor. **Figure 1** shows the base scenario study intersections.

The DDOT Policy for New or Modified Access to the District of Columbia Interstate and Freeway System and Federal Highway Administration (FHWA) policy were referenced to develop the study area for the IMR scenario. FHWA policy requires that the analysis include at least the adjacent interchanges on either side of the proposed change of access location to analyze the operational impact on the mainline interstate between the proposed new/modified access and adjacent existing interchanges. DDOT policy requires that the analysis of change in access include traffic operations analyses of the DC Interstate and Freeway System mainline for:

- At least one mile in each direction of the proposed access
- At least two interchanges on either side of the proposed access
- Or at least through the next major system interchange (e.g., per Exhibit 1 of the DDOT Policy manual, East Capitol Street is defined as a system interchange and there is no system interchange on DC-295 north of Benning Road)

DDOT policy requires that the analyses include two adjacent major signalized intersections on the crossing arterials on either side the interchange ramp terminals.

After reviewing these policies, the study team determined that the study area boundary included in the project scope satisfies the FHWA policy for one adjacent interchange on either side of the proposed change in access to the DC Interstate and Freeway System. Although the study limit does not meet one of the DDOT policy requirements (e.g., at least two interchanges on either side), it is deemed sufficient for understanding the impact between the change in access location and the adjacent interchanges. **Figure 2** shows the full study area for the streetcar and IMR scenario.

Figure 1. Base Scenario Study Intersections

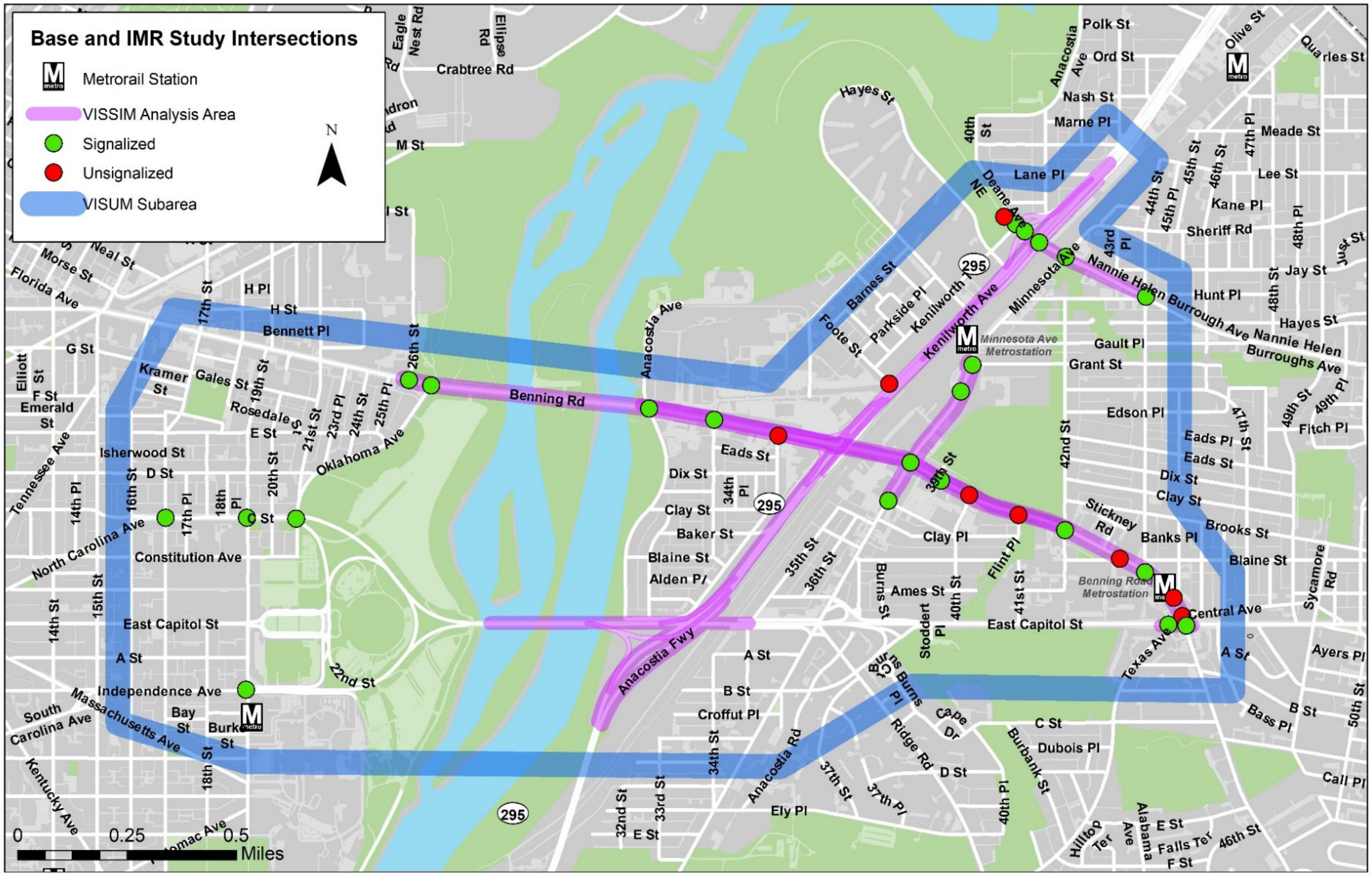

Figure 2. Benning Road Streetcar and IMR Study Area

FORECASTING AND ANALYSIS SCENARIOS

The existing conditions are established for April 2019, when traffic data was collected from the field. The future scenarios include 2025 and 2045 horizon years. A combination of future scenarios with either the streetcar project alone or interchange project alone was proposed for forecasting and analysis to understand the independent impact of the proposed streetcar extension and DC-295/Benning Road interchange modification, respectively. **Table 1** shows the combination of future scenarios considering the streetcar and interchange projects separately.

Table 1. Forecasting and Analysis Scenarios

Analysis	Benning Road Streetcar	DC-295 Interchange
Existing (2019)	1. Existing Conditions for April 2019 (Benning Road/Minnesota Avenue Construction)	
No Build 2025	5. 2025 Baseline (without both Streetcar and Interchange)	6. 2025 Baseline + Streetcar (without Interchange)
Build 2025	6. 2025 Baseline + Streetcar (without Interchange)	7. 2025 Baseline + Streetcar + Interchange
No Build 2045	2. 2045 Baseline (without both Streetcar and Interchange)	3. 2045 Baseline + Streetcar (without Interchange)
Build 2045	3. 2045 Baseline + Streetcar (without Interchange)	4. 2045 Baseline + Streetcar + Interchange

Note: additional scenarios proposed by DDOT are highlighted in orange and yellow cells.

DATA COLLECTION AND PROCESSING

The summary of data collection and data processing results will be provided in the existing conditions report. A summary of traffic count data and the development of the existing (2019) peak hour volumes is provided in **Attachment A** and will be agreed upon by DDOT prior to the start of traffic forecasting and analysis. The data to be used for traffic forecasting and analysis include the following:

- Traffic volumes (intersections, freeway/arterial mainlines, ramps)
- StreetLight O-D data
- Travel time data (field collected and Google Crowdsource data)
- Observed queue data
- Multimodal data (pedestrian/bicycle volumes, transit operations)

EXISTING VOLUMES AND BALANCING

A network peak representative hour (herein referred to as the "network peak hour") was determined for the AM peak (7:45 AM to 8:45 AM) and PM peak (5:00 PM to 6:00 PM). During these periods, the key corridors of the network experience the worst traffic operations conditions, which is characterized by demand exceeding available capacity, constrained or even decreased throughput volumes, and plateauing of the travel time along that corridor. In addition to vehicular throughput, the magnitude of pedestrian and bicyclist activities was assessed at the intersections adjacent to Metrorail stations or existing streetcar stops. The methodology and detailed data to support the network peak hour development is provided in **Attachment A – Existing Peak Hour Volumes Development Summary.** The network peak hour provides a basis upon which volume balancing will be conducted and O-D routes will be developed.

The objective of volume balancing is to remove discrepancies between separate count locations to define consistent volumes throughout the network for traffic simulation and analysis purposes. The primary criterion for this procedure is to minimize the adjustments to the original volumes, specifically minimizing the number of vehicles removed from the network. The daily, AM peak hour, and PM peak hour traffic volumes for this project were balanced in the sequence shown in **Figure 3**. First, the ramps and weaving segment at the Benning Road interchange were balanced. Next, the north- and southbound DC-295 were balanced, holding the Benning Road interchange ramp volumes constant. The arterials within the study area were balanced holding the corresponding balanced ramp volumes from DC-295 constant. The balanced volumes were then rounded to the nearest five vehicles.

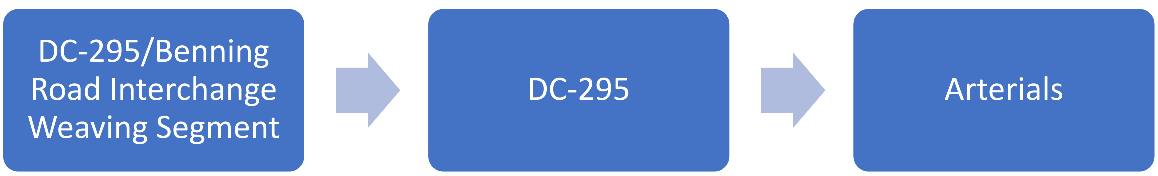

Figure 3. Volume Balancing Sequence

The intersection volumes were balanced by holding constant the approach and departure volumes controlled by freeway on- and off-ramps. The intersection turning movements at these locations were adjusted in accordance with the turning movement proportions defined by the original intersection counts. The remainder of the intersections were balanced using a strategy that minimized the difference between balanced and unbalanced volumes. A conservative approach was taken to minimize the instances where the balanced volumes were less than the unbalanced traffic counts. The intersection with the maximum total volume was held constant in both AM and PM peak hours, which produced the minimum network-wide difference between balanced and unbalanced volumes. Ultimately, some intersections show balancing differences greater than 5 percent. This difference is caused by (i) inherent noise in the traffic count data caused by corridor congestion and (ii) the practice of balancing intersection turning movement counts (TMCs) collected for one representative day with corresponding freeway ramp volumes collected for three consecutive days. The balanced traffic volumes along with the differences in comparison to the unbalanced counts are provided in **Attachment B – Existing Conditions Volumes**.

TRAVEL DEMAND FORECASTING

MWCOG Regional Travel Demand Model and VISUM Subarea Model

The overall travel demand forecasting process is summarized as follow. The process uses the most currently adopted version of the MWCOG travel demand model (Version 2.3.75) and extracts a subarea model in VISUM (Version 18). At a high level, the MWCOG model is the source of traffic analysis zone

(TAZ) land use inputs, growth rates, and a seeding O-D trip table that will be refined in VISUM. The MWCOG model is calibrated to reflect travel conditions at a regional level. As such, the MWCOG model will be validated to daily volumes using cut lines as opposed to roadway links following the requirements outlined in the *FHWA Travel Model Validation and Reasonability Checking Manual Second Edition*. To enhance the traffic forecasting accuracy using the MWCOG model, VISUM is used as a supplemental tool to assign traffic and develop forecasts with greater detail of the TAZs and street network. VISUM is used for subarea model development and validation, evaluating traffic diversion, and forecasting future volumes. The subarea model will be used for existing (2019) and future year (2025 and 2045) No Build and Build scenarios.

A subarea model from the MWCOG model will be extracted that encompasses the major roadway network surrounding the study area (see **Figure 2**). The subarea model will be imported into VISUM, at which point the network, TAZ structure, and peak period trip tables will be refined. The TAZs and associated trips will be split to provide a greater level of detail and more accurate trip loading and assignment to the network. Data such as population and employment will be used as the basis for proportioning trips into subdivided TAZs.

O-D Development

An Origin-Destination Matrix Estimation (ODME) process in VISUM will be completed on peak period and peak hour trip tables. This process will adjust the trip tables in such a way that the resulting traffic assignment on the validated VISUM network closely matches the observed traffic counts at the VISSIM model area intersections. A network peak hour and peak period will be established based on the methodology described in **Attachment A** and the balanced peak hour and peak period volumes will serve as the target of the ODME process. The corrected peak hour trip tables will be the basis of the vehicle routing used in the VISSIM analysis. StreetLight Data also will be used to assist with the development of traffic routing under the existing conditions.

Future Traffic Forecasting

The balanced existing volumes described in the previous section represent April 2019 conditions during which construction activities took place at the intersection of Benning Road NE and Minnesota Avenue NE. The balanced volumes for several movements at this intersection are significantly lower than those observed in 2017 or 2018 timeframe. As such, the study team determined that the balanced volumes are not fully representative of the typical demand conditions at the Benning Road NE and Minnesota Avenue NE intersection and typical baseline volumes should be developed for the forecasting purposes using a combination of DDOT existing AM/PM peak hour Synchro models and 2018/2019 traffic counts. Following the conservative approach agreed upon by DDOT during the traffic assumptions meeting dated July 16, 2019, the study team will include the Synchro model volumes where Synchro approach volumes are significantly larger than 2018/2019 counts and rebalance the 2018/2019 counts to develop typical baseline volumes. The following assumptions were agreed upon by the study team to carry out the baseline volume development:

- The study team will limit this process to the AM/PM Synchro models without investigating other recent traffic counts
- The study team will note and justify locations where Synchro volumes will supersede 2018/2019 counts

The future (2025 and 2045) peak hour volumes will be determined by applying growth rates obtained from the MWCOG model to the 2019 baseline peak hour volumes. The growth rates will be refined as needed using supplemental data on development from DDOT as well as based on traffic assignment results from the VISUM subarea model. The traffic assignment results will be post-processed according to the industry-standard National Cooperative Highway Research Program (NCHRP) Report 765 methodology to obtain the final future traffic forecasts. The output of this process is peak hour link and turning volumes, which will be used to develop peak period volumes for VISSIM simulation and traffic analysis. Adjustment factors will be applied to the peak period volumes to obtain future average weekday daily volumes.

VISSIM MULTIMODAL MICROSIMULATION ANALYSIS

VISSIM (Version 11) will be used for evaluating multimodal traffic operations, streetcar operations, and queuing impacts at the study intersections and ramps within the VISSIM network limits. The VISSIM analysis corridors and intersections are shown in **Figure 2** with the exception that the two signalized intersections adjacent to the DC-295/East Capitol Street NE interchange—C Street NE/21st Street NE and Independence Avenue SE/19th Street NE—are excluded from the VISSIM models due to the numerous ingress/egress points between the freeway ramp access and these intersections. Traffic forecasting will be conducted for these two intersections using Synchro. The VISSIM analysis scenarios include existing (2019) and the future scenarios that are outlined in **Table 1**.

Analysis Peak Period and Peak Hours

A network peak period and network peak hour (representative hour) were determined for AM and PM separately using the traffic count data as well as the travel time data for the Benning Road corridor. A four-hour simulation period is proposed, with a one-hour seeding period, two peak period hours (that span the network peak hour), and one shoulder hour. **Table 2** shows the proposed AM and PM simulation periods as well as the network peak hour in relation to the simulation period and analysis period. Details regarding the network peak hour development and volume balancing are provided in **Attachment A**.

Table 2: Simulation and Analysis Time Key

Time of Day	MOE	Period	Routing	Demand Inputs	Simulation Beginning Time (15-minute)	VISSIM Simulation Time
AM	No MOEs Generated	Seeding	One set of O-D routes based on the network peak hour*	Distributed by 15-minute interval	**6:00**	**0**
					6:15	900
					6:30	1800
					6:45	2700
	MOE Analysis Period	Peak Period			**7:00**	**3600**
					7:15	4500
					7:30	5400
					7:45	6300
					8:00	**7200**
					8:15	8100
					8:30	9000
					8:45	9900
		Shoulder			**9:00**	**10800**
					9:15	11700
					9:30	12600
					9:45	13500
PM	No MOEs Generated	Seeding	One set of O-D routes based on the network peak hour*	Distributed by 15-minute interval	**15:30**	**0**
					15:45	900
					16:00	1800
					16:15	2700
	MOE Analysis Period	Peak Period			**16:30**	**3600**
					16:45	4500
					17:00	5400
					17:15	6300
					17:30	**7200**
					17:45	8100
					18:00	9000
					18:15	9900
		Shoulder			**18:30**	**10800**
					18:45	11700
					19:00	12600
					19:15	13500

*Network peak hours (representative hours) for AM and PM period are highlighted in orange.

VISSIM Model Development

VISSIM network geometry will be developed using current aerial imagery of the study area and will be confirmed through field observations. Model development will include the following elements:

- Vehicle inputs coded in 15-minute intervals at entry approaches to the model network based on count data to reflect variations in traffic volumes and localized peaking pattern across the simulation period (Table 2)
- Vehicle routes as continuous O-Ds through the network (e.g., end-to-end routes), based on the VISUM traffic assignment validated against balanced peak hour traffic volumes
- Traffic yield behavior (e.g., priority rules and/or conflict areas)
- Link and approach speed
- Ring-barrier controllers (RBCs) for signal controllers to model existing signal operations for the streetcar and other modes; the future streetcar signal operations will be modeled based on the proposed signal strategies, including transit signal priority (TSP)
- Signal phasing/splits and pedestrian interval (e.g., crossing and clearance time) will be maintained according to the signal timing plan provided by DDOT
- Heavy vehicle percentage based on existing count data
- Pedestrian activities at the study intersections
- Transit operations (bus routes, stops, and dwell time) for Washington Metropolitan Area Transit Authority (WMATA) Metrobus and other operators in the study area

Existing signal timings provided by DDOT will be used for the existing conditions models. Splits and offsets will be optimized to future traffic volumes and proposed streetcar operations following DDOT signal practices and recommendations from other studies.

VISSIM Model Calibration

The VISSIM existing models will be calibrated following the criteria and thresholds derived from the FHWA Traffic Analysis Toolbox Volume III, 2014. Traffic throughput volumes, travel time, and queue lengths will be used as calibration measures for arterials and intersections. Queue calibration is not defined in the FHWA guidance; as such, the Virginia Department of Transportation's (VDOT) *Traffic Operations and Safety Analysis Manual* (TOSAM) was referenced for appropriate queue calibration. Traffic throughput volumes, speeds, and travel times will be used as calibration measures for freeway and ramp segments. **Table 3** provides the calibration measures and targets. The critical locations for queue calibration are identified in **Table 4**.

The April 2019 (Benning Road NE/Minnesota Avenue NE construction) remains the existing (2019) conditions upon which the existing VISSIM model will be calibrated using the observed data. To meet the calibration thresholds, it is necessary to use the 2019 traffic volume data that will match the queuing, travel time, and throughput data collected in the field during this time period. However, the study team understands DDOT's concerns about the calibrated behavior at the intersection of Benning Road NE and Minnesota Avenue NE may not be appropriate for a future scenario after the completion of the construction. As such, the following approaches will be considered and evaluated during the VISSIM model calibration:

- Focus more on systemwide measures, such as Benning Road corridor travel times
- Calibrate the model without adjusting driving behavior if possible, particularly link behavior that affects saturation flow rate, at the Benning Road NE/Minnesota Avenue NE intersection
- Apply link behavior calibrated at other segments of the Benning Road, which would serve as a typical Benning Road corridor behavior, to the Benning Road NE/Minnesota Avenue NE intersection

- Potentially remove link behavior calibration at the Benning Road NE/Minnesota Avenue NE intersection in the future scenario models if deemed appropriate by DDOT
- The study team plans to engage with DDOT during the process to achieve a balanced calibration for the purpose of applying the model for future alternative evaluation.

Table 3: Calibration Criteria and Acceptance Targets

Simulated Measure	Calibration Threshold	Calibration Period
Simulated Traffic Volume – Individual Links (vehicles per hour) • For mainline and interchange ramps, difference targets must be met for a minimum of 85% of mainline segments and ramps • At intersections, difference targets must be met for a minimum of 85% of approaches for the study intersections	Within ± 100 vph for <700 vph Within ± 15% for ≥700 vph and <2,700 vph Within ± 400 for ≥2,700 vph	Peak Hour
Simulated Traffic Volume – Sum of All Link Flows	Within 5% of sum of all link counts	Peak Hour
Simulated Traffic Volume – **GEH Statistic** • For intersection approaches, freeway mainline and interchange ramps, GEH statistic target must be met for a minimum of 85% of all links	< 5 for individual link flows < 4 for sum of all link flows	Peak Hour
Simulated Average Link Speed (miles per hour)	Verifying model speed heat map against INRIX or Google 15-minute average speed data for study corridor segments during the entire peak period and shoulder period (a percent difference map will be accompanied to aid the verification)	Peak Period + Shoulder Period
Simulated Travel Time (seconds)	Within ± 15% for average observed travel times of Benning Road and DC-295 study corridors The observed travel times include field travel time run data supplemented by Google travel time data collected over the month of April 2019.	Peak Period
Bottleneck and Queue Impact Verification • Bottleneck locations • Queuing impact at the identified critical locations that consist of ramps and intersection approaches (**Table 4**)	Verifying bottleneck locations using model speed heat map against INRIX or Google speed data as well as field-observed conditions Verifying model queues against observed data to verify queues that have the potential of impacting: • Spillover to an adjacent intersection • Spillover from a turn lane • The mainline in the case of a signal or junction at the end of a ramp terminal The observed queue data includes field observation of queue length by movement in 15-minute interval at the critical locations.	Peak Period + Shoulder Period

Table 4. Critical Locations for Bottleneck and Queue Verification

Intersection /Ramp/Mainline	Location
Intersection	All approaches at Benning Road NE/Minnesota Avenue NE
Intersection	All approaches at Benning Road NE/East Capitol Street NE
Intersection	Westbound left turn at Benning Road NE/Oklahoma Avenue NE
Mainline	All merge and weave areas on DC-295 at the study area interchanges
Mainline	AM/PM: Southbound DC-295 freeway basic segments throughout study area PM: Northbound DC-295 freeway basic segments throughout study area
Ramp	All ramps associated with the DC-295/Benning Road interchange

VISSIM model calibration will be achieved by adjusting specific parameters to achieve target traffic volumes, speed, travel time, and queue lengths. The primary parameters that will be adjusted include:

- Driver behavior
- Lane-change distance
- Free-flow speeds
- Traffic demand volume distribution (15-minute interval)
- Replicating external congestions at network termini using INRIX speed data

External congestion that impacts operations within the VISSIM study area exists on DC-295 external to the study area. Time-dependent speed reductions based on probe data from INRIX at the edge of the VISSIM network will be used to replicate the extent and duration of reduced speeds in these locations.

The VDOT Sample Size Determination Tool will be used to determine the appropriate number of microsimulation runs needed for the AM and PM VISSIM models. This tool uses a statistical process to ensure that an appropriate number from runs are performed at a 95th percentile confidence level. Volume and travel time measures of effectiveness (MOEs) will be used to determine number of runs:

- Travel time on the Benning Road and DC-295 routes used for calibration
- Total throughput volume at the Benning Road NE and Minnesota Avenue NE intersection
- Total throughput volume on DC-295 mainline between Benning Road NE and East Capitol Street NE

Accepted and agreed upon by DDOT:

DDOT- Robyn Jackson	**DDOT- Zuxuan Deng**	**DDOT- Yi Zhao**
______________________________	______________________________	______________________
Signature	Signature	Signature
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