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12/12/17

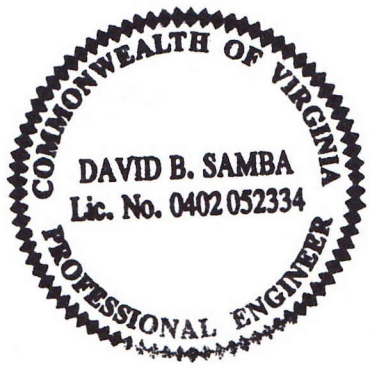
COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION

DIVISION: LOCATION AND DESIGN

REPORT COVER SHEET

Columbia Pike / Washington Boulevard Interchange Modification Report Update
March 2020
Kimley-Horn



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Project Description – Modification of Interchange of VA 244 (Columbia Pike) and VA 27 (Washington Boulevard) in Arlington County, Virginia

From: Route 110
To: Interstate 395
Project UPC No.: Pending

Columbia Pike/ Washington Boulevard

Interchange Modification Report

UPDATE

Prepared for:

Federal Highway Administration
Eastern Federal Lands Highway Division

Prepared By:

Kimley»Horn

March 2020

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Executive Summary

Introduction

Arlington National Cemetery (ANC) provides a unique setting that serves as a tribute to the service and sacrifice of our nation's veterans. Monuments and memorials throughout the 624-acre grounds commemorate individuals and significant events in our nation's history. ANC's landscape provides opportunities for family members and other guests to honor our veterans, remember their sacrifice, and explore our nation's history.

Looking to the future, and consistent with ANC's 2018 Strategic Plan, additional space is needed that is contiguous with the existing cemetery to allow ANC to maintain operations beyond the 2030s. This 49-acre expansion of ANC is the Preferred Alternative of an Environmental Assessment (EA) prepared by ANC, the U.S. Army Corps of Engineers (USACE), and their consultant team, HNTB. This ANC Southern Expansion (ANCSE) project is moving forward to provide additional burial capacity and extend the life of the cemetery, while also improving regional multimodal transportation safety and capacity within the project area.

An expansion of the cemetery is possible by realigning the east end of Columbia Pike (Virginia Route 244), modifying its intersection with S. Joyce Street, modifying its interchange with Washington Boulevard (Virginia Route 27) near the Pentagon, replacing Southgate Road with a new S. Nash Street alignment, relocating numerous utilities, and relocating ANC's operations complex to south of Columbia Pike. The Columbia Pike corridor is vitally important for Arlington County and the Washington, DC region. As stated in a letter sent by Arlington County to ANC on May 21, 2019:

> *Columbia Pike (Route 244) and the connections with Joyce Street and Washington Boulevard (Route 27) is extremely important to the Arlington County community and the regional surface transportation network. This segment of Columbia Pike provides the dominant connection for transit service to Pentagon City and is one of only two primary highway routes that service the Pentagon. This link is used by over 500 Metrobus and ART public transit trips per weekday and carries upwards of 10,000 persons per weekday. It is anticipated that both the number of daily bus operations and average daily bus transit ridership will continue to grow as both the Columbia Pike Corridor and the adjacent Pentagon City/Crystal City/Potomac Yard areas continue to develop.*
>
> *This roadway segment also provides the only direct pedestrian and bicycle connection from the Central Arlington County area south of Arlington Boulevard (Route 50) and along the Columbia Pike Corridor to the Pentagon, Pentagon City/Crystal City/Potomac Yard areas and beyond to the District of Columbia, via the Arlington Memorial Bridge. This linkage is especially important for visitors accessing the growing number of memorials located in the vicinity of the Pentagon and ANC.*

The effort to realign Columbia Pike, modify the interchange, and implement other transportation improvements is being accomplished as a Defense Access Road (DAR) project by the Federal Highway Administration (FHWA) Eastern Federal Lands Highway Division (EFLHD). This effort consists of extensive collaboration and coordination between EFLHD, ANC, USACE, and the ANCSE consultant, HNTB; the Virginia Department of Transportation (VDOT); and the Transportation Division of Arlington County's Department of Environmental Services (DES). Kimley-Horn serves as EFLHD's DAR project consultant.

Purpose and Need for Interchange Modification

The modification of the Columbia Pike/Washington Boulevard interchange in Arlington County is a project of national and regional significance. The modification will allow ANC to fulfil its southern expansion plans to support the addition of contiguous burial space on the property. The modification will allow the Pentagon Memorial Fund (PMF) to develop a Visitor Education Center (VEC) close to the Pentagon 9/11 memorial. The modification will also complement the realignment of Columbia Pike, a project oriented to enhance multimodal travel to the Pentagon and to the Arlington County neighborhoods of Columbia Pike, Pentagon City, and Crystal City, while creating additional space for ANC.

The purpose and need statement for this interchange improvement project is as follows:

> *The rapid growth in the Northern Virginia region has created a need for the modification of the interchange of Columbia Pike and Washington Boulevard within Arlington County near the Pentagon and Arlington National Cemetery. The purpose of the interchange modifications and the complimentary realignment of Columbia Pike described in this IMR are as follows*:

- To improve safety and security
- To allow for more contiguous land for Arlington National Cemetery expansion
- To improve traffic and transit operations at signalized intersections
- To provide for more efficient pedestrian and bicycle access along Columbia Pike and through its interchange with Washington Boulevard
- To improve multimodal access to regional destinations, and maintain consistency with the Arlington County Master Transportation Plan, the Columbia Pike Multimodal Street Improvements Project, ANC expansion plans, and Pentagon 9/11 Memorial plans

The preferred interchange modifications include:

- Realigning Columbia Pike between Washington Boulevard and the existing access driveway to the Air Force Memorial to have a less severe curvature and grade change
- Removing the Washington Boulevard southbound cloverleaf interchange ramps and replacing these ramps with a directional southbound off-ramp from Washington Boulevard and a directional southbound on-ramp from Columbia Pike that meet at a signalized intersection with Columbia Pike
- Modifying the northbound approach at the intersection of Columbia Pike and S. Joyce Street to have dual left-turn lanes, the westbound approach to have a single left-turn lane, and the southbound approach to be removed and relocated to as a new street (S. Nash Street)

Original IMR Process

Planning to realign Columbia Pike, modify the Columbia Pike/Washington Boulevard interchange, and expand ANC began in the early 2010s. To modify the interchange, an interchange modification report (IMR) was required by FHWA and VDOT given that any modification to the Columbia Pike/Washington Boulevard interchange could have significant impacts on the long-term operations of ANC and on the daily travel of Arlington County residents, federal government and other employees, military personnel, visitors, and commuters to and through the County, as well as along Washington Boulevard. In 2014, Arlington County evaluated options to modify the western side of the interchange. This effort recognized the importance of identifying an appropriate interchange modification design to meet the ANC goal of additional contiguous burial space and to support the related efforts of Arlington County to realign Columbia Pike, to relocate the intersection of S. Joyce Street and Columbia Pike, and to improve multimodal access along the Columbia Pike corridor.

Arlington County worked in collaboration with VDOT and ANC to identify and screen interchange alternatives. The results of this process and the evaluation of the preferred alternative were documented in the Columbia Pike/Washington Boulevard Interchange Modification Report (IMR)[1], completed in August 2017 by Kimley-Horn and conditionally approved by VDOT in 2017. The approach, assumptions, and findings of the original IMR are incorporated herein by reference.

Need for IMR Update

As part of the further development of the ANCSE and DAR projects, VDOT and Arlington County each reviewed the applicability of the original IMR as the baseline for understanding future multimodal traffic conditions. While the original IMR was conditionally approved in 2017, it was based on traffic data collected from October 2011 through October 2014; on the then current, preliminary understanding of the ANCSE development plans; and on a preliminary understanding of where the PMF VEC would be sited. The IMR was also finalized prior to decisions on major land use changes in Pentagon City on the southern edge of the IMR project area. Since the conditional approval of the 2017 IMR, many underlying assumptions that informed the evaluation of the preferred alternative have evolved, including:

1. ANCSE plans have been refined, including the relocation of the existing ANC operations complex to the south side of the realigned Columbia Pike and the construction of a parking garage to further support the southern expansion project (and to replace lost parking at the Air Force Memorial and along Southgate Road).
2. A development site for the PMF VEC has been determined and vehicular access is now desired.
3. National Landing (incorporating parts of Pentagon City, Crystal City, and Potomac Yards) was chosen as the site for Amazon's second headquarters (HQ2) campus and will bring more than 25,000 new employees to this part of Arlington County, some of whom may contribute to vehicle traffic through the subject interchange.
4. Mode split in Arlington County has continued to diversify consisting of a surge of bicycle and scooter use that has led to a reassessment of the adequacy of sidewalk and bicycle infrastructure.

Recognizing the age of the underlying traffic data and the impacts of these more recent land use and transportation changes, VDOT and Arlington County requested that the original IMR be updated and resubmitted for approval as a condition of moving forward with the ANCSE project and inherently the

[1] Columbia Pike Washington Boulevard Interchange Modification Report (IMR), August 2017, prepared by Kimley-Horn and conditionally approved by VDOT in November 2017

DAR project. In response, FHWA EFLHD, in collaboration with ANC and in close coordination with VDOT and Arlington County, initiated the Columbia Pike/Washington Boulevard IMR Update (herein, the "IMR Update") as part of the DAR project. Several coordination meetings were held with representatives of EFLHD, Arlington County, VDOT, USACE, and ANC during this process. The purpose of these meetings was to establish study methodology and review responsibilities as well as to provide general progress updates. Some of the major coordination meetings related to the IMR are identified below:

- July 17, 2019 – Update Kick-off, Scoping, and Framework Document
- August 5, 2019 – Travel Demand Forecasting Methodology
- September 9, 2019 - Arlington National Cemetery SE DAR Project – PMF VEC Design Concept Review
- September 16, 2019 – PMF VEC Trip Generation
- September 17, 2019 – Modeling Methodology for Interchange Modification Report (IMR)
- Update, Columbia Pike/Washington Blvd Interchange #1
- September 23, 2019 – Modeling Methodology for Interchange Modification Report (IMR)
- Update, Columbia Pike/Washington Blvd Interchange #2
- November 18, 2019 - Future Traffic Volumes and Analysis Results
- January 8, 2020 – Draft Submittal Comment Response Discussion

This IMR Update was prepared to address the questions posed by VDOT and Arlington County and to confirm that the previously identified preferred alternative remains appropriate to accommodate the changes in development, land use, and access. This IMR Update further interprets how the proposed alternative will perform operationally with respect to future year traffic and future year multimodal travel behaviors related to anticipated private vehicle, public transportation, pedestrian, and bicycle/scooter traffic demands, which may be generated by future land developments and future transportation infrastructure and policy changes within the defined IMR study area.

IMR Update Major Revisions

This IMR Update addresses requirements from VDOT and Arlington County as well as additional requirements from project stakeholders (as documented in an IMR framework development process in June and July 2019) by including the following revisions:

- Existing analyses based on traffic, pedestrian, transit, and bicycle counts conducted in June 2019.
- Traffic forecasting based on the latest Metropolitan Washington Council of Governments (MWCOG) Travel Demand Model (version 2.3.75) and the latest Cooperative Forecasts (Round 9.1)
- Refined forecast years (2025 and 2045)
- Updated study area safety review (based on crash data from 2014 to 2018)
- Quantitative (ISATe) crash analysis
- Removal of Synchro and HCM based analyses in favor of VISSIM analyses
- Updated signal timing at arterial intersections in the study area
- Refined preferred alternative (i.e. number of approach lanes at Columbia Pike)
- Reassignment of traffic to reflect the relocation of the ANC service complex, the development of a parking garage, the closure of Southgate Road, and the opening on Nash Street
- Inclusion of future traffic related to the development of the PMF VEC
- Inclusion of future traffic related to the development of the Amazon campus and associated area developments (i.e., the "Amazon Effect")

Operational and Safety Findings of IMR Update

Findings from the completion of this IMR Update with respect to transportation operations and safety include:

- Under existing conditions, southbound Washington Boulevard operates within acceptable ranges regarding expected travel speeds and congestion relative to the facility type, posted speed limit, and peak hour volumes.
  - Travel speeds and densities suggest that there is minimal congestion in either the AM or PM peak periods.
  - Similarly, the ramps that provide connections between southbound Washington Boulevard and Columbia Pike operate well and demonstrate no congestion or queuing that impacts Columbia Pike or Washington Boulevard.
  - The arterial street network of Columbia Pike, S. Joyce Street, and Army Navy Drive also performs well with all intersection operating at level of service (LOS) D or better.
  - These findings support the notion that the requested interchange modification is not in direct response to any known operational concerns; instead, this request is primarily driven by desired land use changes.
- The most recent five-year history of vehicle crashes demonstrates that while the number of observed crashes along Washington Boulevard does not exceed the expected crash rate for a roadway of a similar facility or functional class, there were many crashes located near the merge, diverge, and weaving areas of southbound Washington Boulevard.
- Under No-Build 2025 conditions, southbound Washington Boulevard is anticipated to operate at densities and speeds consistent with existing conditions and the arterial network generally still operates with intersections at or above LOS D, with the exception of the intersection of Columbia Pike and S. Joyce Street which is anticipated to operate at LOS E during the PM peak period. Based on the anticipated additional delays at this intersection, travel times on routes in the study area are anticipated to increase by 2 to 13 seconds during the AM peak hour and by 5 to 34 seconds during the PM peak hour when compared to existing conditions travel time on these routes.
- Under No-Build 2045 conditions, southbound Washington Boulevard is anticipated to operate at densities and speeds consistent with existing and 2025 conditions and the arterial network generally still operates with intersections at or above LOS D, with the exception of the intersection of Columbia Pike and S. Joyce Street which is anticipated to operate at LOS F during the PM peak hour, with the northbound left turn movement experiencing significant delays. Based on the additional delays at this intersection, projected travel times on routes in the study area are anticipated to increase by 2 to 45 seconds during the AM peak hour and by 3 seconds to over 5 minutes during the PM peak hour when compared to 2025 No-Build conditions travel time routes.
- Based on the latest ANCSE and DAR development plans, as part of the realignment of Columbia Pike the current VDOT driveway will be realigned to be opposite the new S. Nash Street; a new right-out driveway will be opened along eastbound Columbia Pike; and a new right-in entrance will be built along southbound S. Joyce Street.
  - It is anticipated that on a typical day the ANC operations complex site (with parking garage) will generate 139 AM peak hour vehicle trips and 168 PM peak hour vehicle trips (made up of ANC employees, AFM visitors and employees, operations complex visitors, and other parking garage users).
  - It is not anticipated that this relatively low number of trips will impact operations at the intersection of Columbia Pike and S. Joyce Street, or cause congestion along S. Joyce Street, along Columbia Pike, or on Washington Boulevard.

- Based on the latest information provided by the PMF, a right-in/right-out driveway pair will be constructed along eastbound Columbia Pike to provide access to the PMF VEC site. In addition, a right-in/right-out driveway will be built as a service entrance/exit along northbound S. Joyce Street.
  - It is anticipated that on a typical day this site will generate 60 AM peak hour vehicle trips and 68 PM peak hour vehicle trips.
  - It is not anticipated that this relatively low number of trips will impact operations at the intersection of Columbia Pike and S. Joyce Street or cause congestion at the ramps that provide connections between southbound Washington Boulevard and Columbia Pike.
- The full-build out of the Amazon campus (estimated to account for an additional 25,000 employees) could consist of approximately 4.5 million square feet of office and 123,000 square feet of retail and was forecast to generate 4,760 AM peak hour and 4,733 PM peak hour new person trips in the area.
  - Peak period trip calculations were based on the application of trip generation rates and equations contained in the Institute of Transportation Engineers *Trip Generation Manual (10th Edition) for land use code (LUC) 710 (office) and LUC 820 (retail). Trip generation rates/equations were applied to the overall square footage of each land use type to generate gross person trips.*
  - Based on the commitment of Amazon and Arlington County to pursue sustainable transportation options, a thirty percent (30%) personal vehicle mode split was the anticipated operational target for the Amazon HQ2 development. As such, applying the 30 percent factor to the person trips above resulted in a full build-out of the Amazon campus that was estimated to generate 1,399 AM peak hour vehicle trips and 1,302 PM peak hour vehicle trips.
  - An additional 12,000 employees were estimated to be added in Crystal City and Pentagon City as a result of the "Amazon Effect." Assuming a similar trip generation methodology and mode split target (given Arlington County's commitment to high-frequency transit and improved bicycle and pedestrian infrastructure), these new employees were estimated to generate approximately 828 AM peak hour and 764 PM peak hour new vehicle trips in the area.
  - Of the Amazon HQ2 and "Amazon Effect" vehicle trips quoted above, only a relatively small percentage of trips were anticipated to travel along Columbia Pike or along the Washington Boulevard corridor (compared to those trips using I-395, US Route 1, and other available routes). As a practical example, at year 2040, only 91 AM and 59 PM trips were anticipated to be added to the intersection of Columbia Pike and S. Joyce Street (which is approximately 4 percent of the additional AM peak hour Amazon-related traffic and 3 percent of the additional PM related traffic.
  - Given these findings, it is concluded that the development and build-out of Amazon will likely not significantly impact the operations of southbound Washington Boulevard or of the operations of Columbia Pike.
- Under Build 2025 conditions, southbound Washington Boulevard is anticipated to operate at densities and speeds consistent with No-Build 2025 conditions.
  - The removal of a weave area is anticipated to reduce a pocket of congestion that would otherwise be present on southbound Washington Boulevard. Compared to 2025 No-Build Conditions, the arterial network is anticipated to be significantly improved with the intersections of Columbia Pike and S. Joyce Street operating at LOS B instead of LOS E during the PM peak hour
  - Based on the anticipated reduced delays at this intersection, travel times routes in the study area are anticipated to be reduced by 2 to 50 seconds during the AM peak hour and by 1 to 112 seconds during the PM peak hour when compared to 2025 No-Build travel time routes.

- Under Build 2045 conditions, southbound Washington Boulevard is anticipated to operate at densities and speeds consistent with No-Build 2045 conditions.
  - The removal of a weave area is anticipated to a pocket of congestion that would otherwise be present on Southbound Washington Boulevard. Compared to 2045 No-Build Conditions, the arterial network is anticipated to be significantly improved with the intersections of Columbia Pike and Joyce Street operating at LOS B instead of LOS E during the PM peak hour.
  - Based on the anticipated reduced delays at this intersection, travel times routes in the study area are anticipated to reduce by 3 to 51 seconds during the AM peak hour and by 1 second to just over five minutes during the PM peak hour when compared to 2045 No-Build travel time routes.
- The results of an ISATe evaluation indicate a modified interchange may result in fewer expected crashes along southbound Washington Boulevard due to the removal of weave, merge, and diverge areas.
  - A signalized ramp terminal may result in more intersection conflict points along Columbia Pike.
  - It is anticipated that crashes at the ramp terminal would be less severe than crashes occurring under the interchange's current configuration due to the differences in vehicle operating speeds under the two scenarios.
  - It is further anticipated that the ramp terminal will be designed to maximize to the extent possible the safe movements of vehicles, pedestrians, bicycles, and other users.

Given the above findings, it has been demonstrated that the proposed interchange modifications can be implemented with minimal to no impacts to mainline operations along Washington Boulevard and with generally positive impacts to the forecasted arterial operations, even when considering the changes in study area traffic, access, and development that are the subject of this IMR Update. The interchange modifications and Columbia Pike realignment to be accomplished by the DAR project are appropriate to accommodate the potential future traffic and multimodal needs related to the Amazon HQ2 Campus, Amazon-related development in Crystal City, traffic generated by the relocated ANC operations complex, and traffic generated by the PMF VEC.

Responses to FHWA Policy on Interstate Highway Access Modifications

The 2017 IMR was developed in accordance with the applicable VDOT and FHWA interchange modification criteria. The report adhered to the regulations and guidance provided in the *August 31, 2010, FHWA Memorandum, Interstate System Access Information Guide* and addressed the eight policy points detailed in the August 27, 2009 *Policy on Access to the Interstate System.*

Since the approval of the 2017 IMR, FHWA released an updated *Policy on Access to the Interstate System (*dated May 22, 2017). The purposes of the updated policy were to eliminate duplication with other project reviews and to focus the policy on the "technical feasibility of any proposed change in access in support of FHWA's determination of safety, operational, and engineering acceptability." The new policy further stated that "consideration of social, economic, and environmental impacts and planning considerations will be addressed through the National Environmental Policy Act (NEPA) review of the project."

The responses to the previous eight policy points were documented in the 2017 IMR and are generally still valid. As part of this IMR Update, the policy statement, the two relevant policy points, and responses to those policy points are presented below.

Policy Statement: It is in the national interest to preserve and enhance the Interstate System to meet the needs of the 21st century by assuring that it provides the highest level of service in terms of safety and mobility. Full control of access along the Interstate mainline and ramps, along with control of access on the crossroad at interchanges, is critical to providing such service. Therefore, FHWA's decision to approve new or revised access points to the Interstate System under 23 U.S.C. 111 must be supported by substantiated information justifying and documenting that decision. The FHWA's decision to approve a request is dependent on the proposal satisfying and documenting the following requirements:

Policy Point 1: An operational and safety analysis has concluded that the proposed change in access does not have a significant adverse impact on the safety and operation of the Interstate facility (which includes mainline lanes, existing, new, or modified ramps, ramp intersections with crossroad) or on the local street network based on both the current and the planned future traffic projections. The analysis should, particularly in urbanized areas, include at least the first adjacent existing or proposed interchange on either side of the proposed change in access (23 CFR 625.2(a), 655.603(d) and 771.111(f)).

The crossroads and the local street network, to at least the first major intersection on either side of the proposed change in access, should be included in this analysis to the extent necessary to fully evaluate the safety and operational impacts that the proposed change in access and other transportation improvements may have on the local street network (23 CFR 625.2(a) and 655.603(d)). Requests for a proposed change in access should include a description and assessment of the impacts and ability of the proposed changes to safely and efficiently collect, distribute, and accommodate traffic on the Interstate facility, ramps, intersection of ramps with crossroad, and local street network (23 CFR 625.2(a) and 655.603(d)). Each request should also include a conceptual plan of the type and location of the signs proposed to support each design alternative (23 U.S.C. 109(d) and 23 CFR 655.603(d)).

RESPONSE:

> *The operations analyses for the preferred build alternative is discussed in* ***Section 7.2****, of the IMR update. The preferred build alternative was forecast to result in a potential improvement to operations and safety within the study area. An analysis of historic study area crashes is provided in* ***Section***

3.8. *The analysis indicated a total of 237 crashes within the study area over a five-year history and a significant number of rear-end and angle collisions.*

With the projected increase of traffic congestion under future 2025 and 2045 traffic volumes (being imposed on the existing No-Build street system) it is anticipated that peak period traffic operation will continue to degrade, and the number of crashes may increase. Without improvements, the study area network may become over capacity and oversaturated—increasing congestion and increasing the likelihood of additional rear-end and sideswipe collisions near ramp merge, diverge, and weave points. Additionally, without improvements, queue spillback from the merge point, along the ramps, and back to mainline Washington Boulevard is possible, further increasing travel risk for those merging on and off Washington Boulevard.

While the crash rates in the study area are not significantly higher than statewide crash rates for similar facilities or functional crash roads, there are several crash types (angle, same-direction sideswipe, and rear-end) that may be addressed by a reconfiguration of the merge point from Washington Boulevard to Columbia Pike.

The preferred build alternative, due to the elimination of weave, merge, and diverge movements, and the consolidation of these moments at a single, signal-controlled intersection along Columbia Pike, should enhance safety at the points of interaction between Washington Boulevard and Columbia Pike. Many of the geometric factors that contribute to potentially unsafe conditions would be removed or otherwise mitigated by the modifications associated with the preferred build alternative. The preferred build alternative also would reduce the number of conflict points at the intersection of Columbia Pike and S. Joyce Street resulting from the conversion from a 4-leg intersection to a 3-leg intersection.

It is anticipated that the severity of crashes that occur due to the interaction of the ramp terminal and the Columbia Pike arterial would be reduced. Rather than merging at speed, the westbound ramp approach would stop and enter a signalized intersection. Any crash that would occur at this location in the preferred build alternative would be the at significantly slower speeds than under the No-Build condition. This would lessen the severity of the crashes.

Further safety analysis for the preferred alternative is discussed in ***Sections 3.8 and 7.3****.*

A conceptual signing plan for the preferred concept was developed to demonstrate that the modified interchange configuration could be signed in accordance with the Manual on Uniform Traffic Control Devices (MUTCD). The conceptual signing plan is included in ***Appendix H*** *for reference.*

Policy Point 2: The proposed access connects to a public road only and will provide for all traffic movements. Less than "full interchanges" may be considered on a case-by-case basis for applications requiring special access, such as managed lanes (e.g., transit, HOVs, HOT lanes) or park and ride lots. The proposed access will be designed to meet or exceed current standards (23 CFR 625.2(a), 625.4(a)(2), and 655.603(d)). In rare instances where all basic movements are not provided by the proposed design, the report should include a full-interchange option with a comparison of the operational and safety analyses to the partial-interchange option. The report should also include the mitigation proposed to compensate for the missing movements, including wayfinding signage, impacts on local intersections, mitigation of driver expectation leading to wrong-way movements on ramps, etc. The report should describe whether future provision of a full interchange is precluded by the proposed design.

RESPONSE:

The proposed interchange modification will continue to provide for all traffic movements between Columbia Pike and Washington Boulevard. The proposed conceptual design plan is included in ***Appendix H****.*

The interchange modifications associated with the preferred build alternative are expected to meet or exceed current design standards from the VDOT Road Design Manual and AASHTO A Policy on Geometric Design of Highways and Streets (the Green Book). The design standards and criteria used for the preferred alternative are described in ***Chapter 5*** *of this IMR Update.*

Additional factors beyond the operation, safety, and engineering acceptability of the requested change will be addressed as part of a separate of related NEPA process. Of note, the ANCSE Environmental Assessment (EA) is being prepared in accordance with NEPA requirements and includes in its scope both the expansion of the cemetery and the DAR project elements. A Finding of No Significant Impacts (FONSI) is intended to be issued by ANC for the ANCSE project and a FONSI is intended to be issued by FHWA for the DAR project. The FONSI to be issues by FHWA is dependent upon an IMR accepted by the stakeholder agencies and approved by VDOT.

Columbia Pike/Washington Boulevard Interchange Modification Report (IMR)

UPDATE

1. Introduction

Arlington National Cemetery (ANC) provides a unique setting that serves as a tribute to the service and sacrifice of our nation's veterans. Monuments and memorials throughout the 624-acre grounds commemorate individuals and significant events in our nation's history. ANC's landscape provides opportunities for family members and other guests to honor our veterans, remember their sacrifice, and explore our nation's history.

Looking to the future, and consistent with ANC's 2018 Strategic Plan, additional space is needed that is contiguous with the existing cemetery to allow ANC to maintain operations beyond the 2030s. This 49-acre expansion of ANC is the Preferred Alternative of an Environmental Assessment (EA) prepared by ANC, the U.S. Army Corps of Engineers (USACE), and their consultant, HNTB. This ANC Southern Expansion (ANCSE) project is moving forward to provide additional burial capacity and extend the life of the cemetery, while also improving regional multimodal transportation safety and capacity within the project area.

An expansion of the cemetery is possible by realigning the east end of Columbia Pike, modifying its intersection with S. Joyce Street and its interchange with Washington Boulevard (Virginia Route 27) near the Pentagon, replacing Southgate Road with a new S. Nash Street alignment, and relocating numerous utilities as well as relocating ANC's operations complex to south of Columbia Pike. The effort to realign Columbia Pike, modify the interchange, and implement other transportation improvements is being accomplished as a Defense Access Road (DAR) project by the Federal Highway Administration (FHWA) Eastern Federal Lands Highway Division (EFLHD). This effort consists of extensive collaboration and coordination between EFLHD, ANC, USACE, and the ANCSE consultant, HNTB; the Virginia Department of Transportation (VDOT); and the Transportation Division of Arlington County's Department of Environmental Services (DES). Kimley-Horn serves as EFLHD's DAR project consultant.

Through ongoing discussions, the stakeholders have generally agreed that the DAR project and its associated elements would not only provide more contiguous land for ANC, but also support a new alignment of Columbia Pike that would benefit local and regional traffic and transit operations as well as provide more direct pedestrian and bicycle connections to regional trails and to destinations in the area, including the Pentagon 9/11 Memorial, the Air Force Memorial, Arlington National Cemetery, and many other destinations along Columbia Pike and in Pentagon City.

It is understood that the modification of the Columbia Pike/Washington Boulevard interchange requires the approval by VDOT of an Interchange Modification Report (IMR), completed in accordance with VDOT's Instructional and Informational Memorandum (IIM-LD-200.9), dated January 3, 2017 and that the IMR will also need to follow FHWA guidelines, including the FHWA Virginia Division's "Standard Operating Procedure (SOP) for New or Revised Interstate Access Points." This report serves as an IMR Update to the original conditionally approved Columbia Pike/Washington Boulevard IMR. It documents the update in the approach, processes, and methodology as requested by project stakeholders.

1.1. Purpose and Need for Interchange Modification

The modification of the Columbia Pike/Washington Boulevard interchange in Arlington County is a project of national and regional significance. The modification will allow ANC to fulfil its southern expansion plans to support the addition of contiguous burial space on the property. The modification will allow the Pentagon Memorial Fund (PMF) to develop a Visitor Education Center (VEC) close to the Pentagon 9/11 memorial. The modification will also complement the realignment of Columbia Pike, a project oriented to enhance multimodal travel to the Pentagon and to the Arlington County neighborhoods of Columbia Pike, Pentagon City, and Crystal City, while creating additional space for ANC.

The purpose and need statement for this interchange improvement project is as follows:

> *The rapid growth in the Northern Virginia region has created a need for interchange modification within Arlington County near the Pentagon and Arlington National Cemetery. The purpose of the interchange modifications and the complimentary realignment of Columbia Pike described in this IMR Update are as follows*:

- To improve safety and security
- To allow for more contiguous land for Arlington National Cemetery expansion
- To improve traffic and transit operations at signalized intersections
- To provide for more efficient pedestrian and bicycle access along Columbia Pike and through its interchange with Washington Boulevard
- To improve multimodal access to regional destinations, and maintain consistency with the Arlington County Master Transportation Plan, the Columbia Pike Multimodal Street Improvements Project, ANC expansion plans, and Pentagon 9/11 Memorial plans

The preferred interchange modifications include:

- Realigning Columbia Pike between Washington Boulevard and the existing access driveway to the Air Force Memorial to have a less severe curvature and grade change
- Removing the Washington Boulevard southbound cloverleaf interchange ramps and replacing these ramps with a directional southbound off-ramp from Washington Boulevard and a directional westbound on-ramp from Columbia Pike that meet at a signalized intersection with Columbia Pike
- Modifying the northbound approach at the intersection of Columbia Pike and S. Joyce Street to have dual left-turn lanes, the westbound approach to have a left-turn lane, and the southbound approach to be removed and relocated to as a new street (S. Nash Street)

1.2. Planning Context

For many years, realigning the east end of Columbia Pike has been an objective of Arlington County to benefit local and regional traffic and transit operations as well as to provide more direct pedestrian and bicycle connections to regional trails and to destinations in the area. In 2012, the County completed the *Columbia Pike Multimodal Street Improvements Transportation Study*, which recommended a consistent street cross section and a variety of multimodal improvements within the street space for all of Columbia Pike, from the Fairfax County line to the interchange with Washington Boulevard near the Pentagon.

While Arlington County was planning improvements to Columbia Pike, ANC was planning for expansion and continued operations. In 2012, ANC assumed ownership of land once occupied by the Navy Annex, formerly located on the north side of Columbia Pike between S. Oak St. and the Air Force Memorial. ANC plans to expand into this area, consistent with its 2018 update to the *Real Property Master Plan.* This plan

also includes expansion into the area currently occupied by the intersection of Columbia Pike and Southgate Road/S. Joyce Street. Thus, it is in the interest of ANC to support a realigned Columbia Pike and a modified interchange with Washington Boulevard so that the expansion of contiguous land can be maximized for ANC.

Design of the Columbia Pike Multimodal Transportation Improvements project began in 2014, to include the potential realignment of the east end of Columbia Pike, from just west of the Air Force Memorial, through the intersection with Southgate Road/S. Joyce Street, to the interchange with Washington Boulevard near the Pentagon. The design also included a modification of the west side of the interchange (conversion of the existing loop ramps to direct on/off ramps).

To modify the interchange, an IMR was required by FHWA and VDOT, given that any modification to the Columbia Pike/Washington Boulevard interchange could have significant impacts on the long-term operations of ANC and on the daily travel of Arlington County residents, federal government and other employees, military personnel, visitors, and commuters to and through the County, as well as along Washington Boulevard. In 2014, Arlington County evaluated options to modify the western side of the interchange. This effort recognized the importance of identifying an appropriate interchange modification design to meet the ANC goal of additional contiguous burial space and support the related efforts of Arlington County to realign Columbia Pike, to relocate the intersection of S. Joyce Street and Columbia Pike, and to improve multimodal access along the Columbia Pike corridor.

Working in collaboration with VDOT and ANC, Arlington County identified and screened interchange alternatives. The results of this process, and the evaluation of the preferred alternative, were documented in the Columbia Pike/Washington Boulevard Interchange Modification Reports (IMR), completed in August 2017 by Kimley-Horn and conditionally approved by VDOT in 2017. The approach, assumptions, and findings of the original IMR are incorporated herein by reference.

The Pentagon has also made strides to improve transportation and security on its property. The *Pentagon Reservation Master Plan* was updated in 2016 and documents plans for its parking and surrounding roadways. Following the terrorist attacks on September 11, 2001, the northeast quadrant of the Columbia Pike/Washington Boulevard interchange was modified to accommodate a new truck processing area and to generally improve security. The loop ramp in this location was replaced with a direct ramp. The Pentagon received approval from VDOT for this modification.

1.3. Project Location

The interchange of Columbia Pike and Washington Boulevard immediately west of the Pentagon in Arlington County is the focus of this IMR. The study area for this IMR, as shown in **Figure 1-1**, extends beyond the limits of the interchange and encompasses the following area:

- Columbia Pike: Between S. Orme Street and N. Rotary Road/S. Rotary Road
- Washington Boulevard: Between merge point of ramp from Jefferson Davis Highway (Route 110) to the Interstate 395 (I-395) overpass
- S. Joyce Street: Between Columbia Pike and just south of its intersection with Army Navy Drive
- Army Navy Drive: Between S. Joyce Street and just east of its intersection with S. Hayes Street
- Southgate Road: Between S. Oak Street and Columbia Pike
- N. Rotary Street and S. Rotary Street

Figure 1-1: IMR Study Area

The following intersections, freeways, and ramps within the study area were identified for analysis:

- Columbia Pike/S. Rotary Road
- Columbia Pike/Future ANC Driveway
- Columbia Pike/S. Joyce St
- Columbia Pike/Air Force Memorial Driveway
- Columbia Pike/VDOT Driveway
- Columbia Pike/PMF VEC Driveway
- Columbia Pike/S Orme St/Washington Boulevard (west interchange) ramps
- S. Joyce St/Army Navy Drive
- S. Joyce St/Future ANC driveway
- Army Navy Drive/Pentagon City Mall parking lot
- Army Navy Drive/S. Hayes Street
- Washington Boulevard southbound and northbound (including ramps to/from Columbia Pike and the reversible HOV/HOT lane)
- Ramp from Jefferson Davis Highway (Route 110) to Washington Boulevard southbound

The parcels immediately adjacent to the study area are generally zoned for special districts (S-3A) and varying densities of commercial (C-) or residential (R-) uses. The special district designation includes the Joint Base Fort Myer-Henderson Hall, Arlington National Cemetery, the Pentagon, the Air Force Memorial, and the Interstate Highway system. Land use is further discussed in **Chapter 8**.

1.4. Need for IMR Update

As part of the further development of the ANCSE and DAR projects, VDOT and Arlington County each reviewed the use of the original IMR as the baseline for understanding current and future multimodal traffic conditions. While the original IMR was conditionally approved in 2017, it was based on traffic data collected from October 2011 through October 2014; on the then current, preliminary understanding of the ANCSE development plans; and on only a preliminary understanding of where the PMF VEC would be sited. The IMR also was finalized prior to decision on major land use changes in Pentagon City on the southern edge of the IMR project area.

Since the conditional approval of 2017 IMR, many underlying assumptions that informed the evaluation of the preferred alternative have evolved:

1. ANCSE plans have been refined, including the relocation of the existing ANC operations complex to the south side of the realigned Columbia Pike and the construction of a parking garage to further support the southern expansion project (and to replace lost parking at the Air Force Memorial and along Southgate Road).
2. A development site for the PMF VEC has been determined and vehicular access is now desired.
3. National Landing (incorporating parts of Pentagon City, Crystal City, and Potomac Yards) was chosen as the site for Amazon's second headquarters (HQ2) campus and will bring more than 25,000 new employees to this part of Arlington County, who may contribute to vehicle traffic through the subject interchange.
4. Mode split in Arlington County has continued to diversify consisting of a surge of bicycle and scooter use that has led to a reassessment of the adequacy of sidewalk and bicycle infrastructure.

Recognizing the age of the underlying traffic data and the impacts of these land use and transportation changes, VDOT and Arlington County have both indicated that the original IMR should be updated and resubmitted for approval as a condition for moving forward with the ANCSE project and inherently the DAR project. These requests were formalized in letters from both VDOT and Arlington County written to ANC (copies provided in **Appendix A**).

In response to these letters, FHWA EFLHD in collaboration with ANC and in close coordination with VDOT and Arlington County, initiated this Columbia Pike/Washington Boulevard IMR Update (herein referred to as the "IMR Update") as part of the DAR project. Specific responses that this IMR Update is providing to the major points of the letters are summarized below.

1.4.1. Responses to VDOT and Arlington County Letters

Specific responses of this IMR Update to the major points raised in each letter are provided below:

VDOT Letter to Ms. Katharine Kelley, Superintendent, Department of the Army (April 16, 2019)

- Point 1: "We note that the traffic study … is now over three years old. It must be updated to incorporate new development planned or proposed, including the Amazon HQ2 campus and related development. This should be done with respect to housing, commuting and other socioeconomic factors."
  - ☑ The IMR Update considers the multimodal transportation impacts of 4.5 million square feet of office and 123,000 square feet of retail associated with the Amazon Campus, as well as the multimodal transportation impacts of an additional 2.6 million square feet of office in Crystal City.
  - ☑ Future traffic forecasting (growth and travel patterns) is based on the additional housing, employment, and population projections as provided by Arlington County and as updated with the consideration of Amazon HQ2 and Amazon-related development.
- Point 2: "While updating the traffic study, the traffic analysis must be updated to reflect an accurate understanding of the travel demand and forecasted multimodal transportation needs…"
  - ☑ Future traffic forecasting (growth and travel patterns) is based on the additional housing, employment, and populations projects as provided by Arlington County and as updated with the consideration of Amazon HQ2 and Amazon-related development
  - ☑ Future traffic forecasting assumed a significant mode split (70 percent non-auto) for Amazon HQ2 and Amazon-related developments. This mode split has been approved by Arlington County and accepted by VDOT during the scoping of this IMR Update.
  - ☑ The IMR Update forecasted additional pedestrian and bicycle trips at each study area intersection. Future transit (routes and headways) were developed based on a review of Arlington County's Transit Development Plan.
- Point 3: "The traffic study must also include projected traffic counts at any proposed intersections along Columbia Pike taking into consideration development south of Columbia Pike including the proposed Arlington National Cemetery maintenance facility, the Pentagon 9/11 Memorial, and the Air Force Memorial."
  - ☑ The IMR Update includes all intersections along Columbia Pike from S. Orme Street to S. Rotary Road including the following new proposed intersections: (1) S. Nash Street/VDOT Driveway, (2) right-out exit from the relocated ANC operations complex, (3) right-in/right-out driveway(s) of the PMF VEC, and (4) the new ramp terminal from Washington Boulevard.
  - ☑ The IMR Update includes a right-in entrance to the relocated ANC service complex facility along S. Joyce Street.

- ☑ The IMR Update considers a loss of parking at the Air Force Memorial and along Southgate Road (to be relocated at the ANC operations complex parking garage).

- Point 4: "The traffic study must provide additional information with respect to the proposed southern gateway to ANC, and its expected impact on traffic operations."
  - ☑ The IMR Update includes S. Nash Street which serves as the southern gateway to ANC and the relocated ANC operations complex.
- Point 5: "When VDOT approved the Interchange Modification Report (IMR) (dated November 29, 2017) prepared by Arlington County, access to the Pentagon 9/11 memorial was expected to be pedestrian only. This was a condition of VDOT approval of the IMR. Since the location of the Memorial site has changed, the approval of the IMR is no longer valid. The IMR must be updated to reflect any changes resulting from the advancement of design…"
  - ☑ The IMR Update includes right-in/right-out driveways of the PMF VEC along Columbia Pike and peak hour traffic volume projections as provided by the PMF VEC consultant team.

Arlington County Letter to Ms. Cara Sydnor, Southern Expansion Program Integrator, Arlington National Cemetery (May 21, 2019) (in reference to the ANCSE Traffic Study dated April 15, 2019 for which the original IMR was a referenced source)

- Point 1: "the current draft traffic study lacks any appropriate framing of Columbia Pike and its regional connections in the assessment"
  - ☑ The IMR Update includes greater context about the multimodal importance of Columbia Pike and Washington Boulevard.
- Point 2: "The draft traffic study is based on the outcomes of an aging IMR, which was conditionally approved by VDOT…. it does not fully address the changed conditions that we face today. It did not capture the proposed relocation of the ANC maintenance facility and its associated trips to the current proposed location, nor did it include any proposed vehicular access or estimated vehicular trips for the current proposed site of the 9/11 Memorial Visitor Center, now planned for the southwest quadrant of the interchange. It also did not reflect the more recent major land use changes that are planned in Pentagon City where a major corporation is moving forward with plans for new construction of a 4.2 million square foot office campus…"
  - ☑ The IMR Update considers the multimodal transportation impacts of 4.5 million square feet of office and 123,000 square feet of retail associated with the Amazon HQ2 campus, as well as the multimodal transportation impacts of an additional 2.6 million square feet of office in Crystal City.
  - ☑ The IMR Update includes right-in/right-out driveway(s) of the PMF VEC along Columbia Pike and peak hour traffic volume projections as provided by the PMF VEC consultant team
  - ☑ The IMR Update include S. Nash Street which serves as the Southern Gateway to ANC, the relocated ANC service complex, and traffic generation associated with the development of the parking garage.
- Point 3: "The draft traffic study uses a simple Synchro analysis that is only focused on vehicle traffic"
  - ☑ The IMR Update is based on VISSIM analyses, which consider multimodal interactions between different travel modes. Similarly, existing and potential future bicycle, pedestrian, and transit volumes are included in the analysis.

It is noted that the April 2019 draft traffic study (and corresponding traffic analysis) did in fact capture the relocation of trips from the existing maintenance site to the proposed maintenance site as a reassignment of traffic and that at the time of the April 2019 draft report, the sizing of the PMF VEC had not been

finalized and therefore no trip generation or information on size/functionality could be considered as part of the April or subsequent August analyses.

1.4.2. IMR Update Approach

It should be noted that other than updating the previous IMR to be reflective of current conditions, to include a revised vision of the future, and to be responsive to the requests of VDOT and Arlington County, all other IMR assumptions that governed the 2017 IMR are generally considered to be valid. As such, the remainder of this document follows the same general template as the 2017 IMR. Specific assumptions that are the subject of the IMR Update were defined in an IMR Framework Document, developed at the start of the IMR Update process and signed by project stakeholders (See **Appendix B**).

2. Methodology

This IMR Update was developed in accordance with the applicable VDOT and FHWA interchange modification criteria. This report adheres to the regulations and guidance provided in the August 31, 2010, FHWA Memorandum*, Interstate System Access Information Guide* and addresses the two policy points detailed in the May 2017 *Policy on Access to the Intestate System*. Additionally, this report follows the organizational structure identified in the VDOT *Instructional and Informational Memorandum 200.9*., *Development of Justification for Additional or Revised Access Points; Creation of Interchange Justification/Modification Reports.*

This IMR Update is recognized as a collaborative effort to achieve the objectives of various stakeholders that have a vested interest in improved land use and multimodal transportation operations along Columbia Pike. These stakeholders include:

- Federal Highway Administration, Eastern Federal Lands Highway Division (FHWA EFLHD)
- United States Army Core of Engineers (USACE)
- Arlington National Cemetery (ANC)
- Arlington County
- Virginia Department of Transportation (VDOT) Northern Virginia District and Central Office

2.1. Related Studies

The following studies were reviewed by the study team to understand the impacts of the proposed interchange modification on the study corridor and surrounding traffic network as well as to gather data relevant to the study corridor.

Relevant data from the studies listed below were used as appropriate to support this IMR Update:

- Columbia Pike Washington Boulevard Interchange Modification Report (IMR), prepared by Kimley-Horn, approved November 2017
- Arlington National Cemetery – Southern Expansion Traffic Technical Memorandum – Future Conditions, prepared by HNTB, dated August 2019
- Metropolitan Park 6, 7, 8 Multimodal Transportation Assessment (MMTA), prepared by Gorove Slade, submitted June 20, 2019

2.2. Key Assumptions

Key assumptions used to develop this IMR Update were discussed with, submitted to, and approved by relevant stakeholders during the framework process, which included multiple meetings to discuss traffic study-related assumptions.

2.2.1. Study Area

The existing Columbia Pike/Washington Boulevard interchange is in Arlington County, southeast of Arlington National Cemetery and immediately west of the Pentagon. The study area is as described in **Section 1.3**.

2.2.2. Analysis Tools and Assumptions

Traffic operations analysis and reporting were conducted in accordance with the methodologies outlined in VDOT's *Traffic Operations and Safety Analysis Manual (TOSAM) – Version 1.0*. It was noted that TOSAM Version 2.0 would likely be in effect prior to the delivery of the IMR Update. As such calibration and analysis conducted under this IMR Update were tailored to be aligned to the most current understanding of the anticipated TOSAM Version 2.0 changes.

VISSIM 9 was selected and approved by Arlington County and VDOT Traffic Engineering Division for the development and analysis of this IMR.

2.2.3. Projected Start Year and Design Year

The following analysis years were assumed for this study:

- Existing conditions – 2019
- Opening Year – 2025
- Design Year – 2045 (Opening Year + 20 years)

2.2.4. Traffic Data

Traffic volume data was collected to develop existing peak hour volumes in this IMR. A description of the data collection process is described in **Section 3.6**.

2.2.5. Crash Data

Crash data was obtained from VDOT for the most recent five years from January 1, 2014 to December 31, 2018. The crash data collection and analysis results are described in **Section 3.8.**

2.2.6. Peak Periods for Analysis

The weekday AM, and PM peak hours were identified as the critical periods for analysis purposes. The peak hours were determined to occur between 7:45 and 8:45 AM and between 5:00 and 6:00 PM.

2.2.7. Future Traffic Forecast

Traffic forecasts for the Opening Year (2025) and Design Year (2045) were developed using the Metropolitan Washington Council of Governments (MWCOG) Travel Demand Model Version 2.3.75 and with information obtained from related studies. The process for developing future traffic forecasts is described in **Section 6.2**.

3. Existing Conditions

3.1. Demographics

The study area is in Arlington County, Virginia. Arlington County is a member jurisdiction of the Metropolitan Washington Council of Governments (MWCOG), an independent, nonprofit association that brings area leaders together to address major regional issues in the following counties, cities, and towns:

- *Virginia:* City of Alexandria, Arlington County, City of Fairfax, Fairfax County, City of Falls Church, Loudoun County, City of Manassas, City of Manassas Park, Prince William County
- *Maryland:* Town of Bladensburg, City of Bowie, Charles County, City of College Park, City of Frederick, Frederick County, City of Gaithersburg, City of Greenbelt, Montgomery County, Prince George's County, City of Rockville, City of Takoma Park
- District of Columbia

The US Census Bureau estimated that Arlington County had a 2018 population of approximately 237,521, which represents a population growth of 14.4 percent since 2010. MWCOG projects Arlington County's population to exceed 301,200 in the year 2045.

The MWCOG member jurisdictions had a 2015 population of approximately 5,390,600. Population and employment trends within the MWCOG member jurisdictions and based on 'Round 9.1. Growth Trends to 2045' suggest that there will be a population of approximately 6,925,700 and a workforce of approximately 4,273,800, employees by 2045; a growth of 28.5 percent and 35.2 percent from 2015, respectively. Projected population and employment changes within the study area are described in **Chapter 8**. It is noted that these estimates represent forecasts prior to the consideration of the Amazon campus.

3.2. Existing Land Use

The parcels immediately adjacent to the study area are generally zoned for special districts (S-3A) and varying densities of commercial (C-) or residential (R-) uses. The special district designation includes the Joint Base Fort Myer-Henderson Hall (JBM-HH), Arlington National Cemetery (ANC), the Pentagon, the Air Force Memorial, and the interstate system. Land use is further discussed in **Chapter 8**.

3.3. Existing Roadway Network

The roadways within the study area are of varying types, ranging from interstate highways to urban local roadways as discussed below:

Harry G. Shirley Memorial Highway (I-395): I-395 is an urban interstate comprised of four to five lanes in each direction with additional feeder lanes near interchanges. It also has two limited access high occupancy toll (HOT/HOV) lanes. I-395 is the largest road entering the District of Columbia and serves as a major regional north-south commuter route between Northern Virginia and Washington, DC. I-395 connects with I-695 and I-295 in Washington, DC, and with I-495 and I-95 near Springfield, Virginia. In the study area, exit ramps from I-395 provide direct access to Columbia Pike, the Pentagon parking lots, and Hayes Street, which connects to Army Navy Drive. Near the study area, the speed limit is 55 miles per hour (mph). While I-395 is within the influence area of the interchange, the subject modifications have no direct impact on I-395. Within the study area, the annual average daily traffic (AADT) along this road is 139,000 vehicles per day (vpd) and the annual average weekday traffic (AAWDT) is 153,000 vpd, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

Columbia Pike (Route 244): Columbia Pike is classified as an urban "other" principal arterial with two lanes in each direction. It runs east-west from the Pentagon to Route 236 (Little River Turnpike) in Annandale, Virginia. Columbia Pike intersects major routes in Northern Virginia such as Lincolnia Road, Route 7, George Mason Drive, and Glebe Road. Columbia Pike is also considered the principal street in South Arlington. The speed limit is 25 mph within the study area. Within the study area, the AADT along this road is 7,900 vpd and the AAWDT is 6,800 vpd, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

Washington Boulevard (Route 27): Washington Boulevard is classified as an urban other Freeway/Expressway and is a six-lane, divided limited access road. Washington Boulevard connects major travel routes in Northern Virginia, such as the George Washington Memorial Parkway, Route 110, I-395, and US Route 50. Near the study area, the speed limit is 45 mph. In the study area, Washington Boulevard is signed as east (for vehicles traveling north through the interchange) and west (for vehicles traveling south through the interchange). Washington Boulevard is considered the mainline in this report and is referenced as northbound/southbound herein. Within the study area, the AADT along this road is 49,000 vpd west of Columbia Pike and 70,000 vpd east of Columbia Pike. The AAWDT is 53,000 vpd west of Columbia Pike and 75,000 vpd east of Columbia Pike, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

S. Joyce Street (Route 6722): S. Joyce Street is classified as an urban minor arterial road with two lanes in each direction. It provides access between Columbia Pike and Pentagon City underneath the I-395 overpass. The speed limit is 35 mph within the study area. Within the study area, the AADT along this road is 11,000 vpd and the AAWDT is 12,000 vpd, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

Army Navy Drive (Route 6605): Army Navy Drive is classified as a major collector with 2 lanes in each direction that runs east-west from 12th Street South to 25th Street South. Army Navy Drive provides connections to Crystal City and Pentagon City. Near the study area, the speed limit is 35 mph. Within the study area, the AADT along this road is 73,000 vpd and the AAWDT is 79,000 vpd, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

Southgate Road: Southgate Road is a local access road for employees and service vehicles to ANC and Joint Base Myer-Henderson Hall and provides access to residential neighborhoods west of the interchange area. Parking is available on both sides of the street. There are two access points to JBM-HH along Southgate Road. Access Point 1 (Gate 1) is located at the intersection of Southgate Road and S. Orme Street and is open 24 hours a day, seven days a week. The Marine Corps Exchange (a military commissary) is located directly past Gate 1 and is assumed to be a traffic generator. Access Point 3 (Gate 3) is located on Hobson Drive, about 600 feet east of Access Point 1. Gate 3 is open from 6:00 AM until 6:00 PM, Monday through Friday. The AADT and AAWDT was not reported for this facility.

Rotary Road: N. and S. Rotary Road are local roads that form a ring road around the Pentagon Parking Lot. S. Rotary Road provides access to the Pentagon from the Washington Boulevard/Columbia Pike interchange to the east. N. Rotary Road is located within the security stand-off zone that was established post-September 11, 2001 and is restricted to authorized-vehicles only.

S. Orme Street: S. Orme Street is a residential street between Southgate Road and Columbia Pike just northeast of the Washington Boulevard (Route 27) and Columbia Pike (Route 244) interchange and south of Arlington Cemetery. This roadway provides access to Washington Boulevard from the southern and western sides of Arlington National Cemetery's well as the limited developments that are present in that area. The AADT and AAWDT was not reported for this facility.

S. Hayes Street: S. Hayes Street is classified as a minor arterial with 3 lanes in each direction south of Army Navy Drive and the termination of both eastbound and westbound I-395 ramps into Crystal City. S. Hayes Street

runs north-south from Army Navy Drive south to S. Fern Street where it becomes 18th Street South while providing arterial access throughout the Crystal City neighborhood, particularly to the major commercial district which includes Pentagon City Mall. Within the study area, the AADT along this road is 10,000 vpd and the AAWDT is 11,000 vpd, as reported in the 2018 VDOT Daily Traffic Volume Estimates Jurisdiction Report 00.

A map of the existing lane configuration and study area AADT is provided in Figure 3-1.

3.4. Active Travel Modes

The Washington Metropolitan Area Transit Authority (WMATA) operates both Metrorail (rapid transit) and Metrobus (bus transit) service in the study area.

The Columbia Pike corridor currently has the highest number of daily bus commuters in the Commonwealth of Virginia. Ridership is expected to increase as the Amazon campus grows in neighboring Crystal City and Pentagon City. Bus stops are located along Columbia Pike, Army Navy Drive, S. Joyce Street, S. Hayes Street, and within the Pentagon property. Nearly 30 percent of residents along Columbia Pike use transit at least 3 days a week and the corridor supports more than 17,000 daily riders across 600 daily bus trips. WMATA Metrorail Yellow and Blue lines serve Crystal City, Pentagon City, and the Pentagon. The Blue line also serves Arlington National Cemetery. WMATA provides Metrobus service along many study area roads. Relevant routes operating during the AM and PM peak commuting periods include:

- Lincolnia - North Fairlington Line (7A, 7F, 7Y)
- Alexandria - Pentagon Line (10A, 10E) (2,120 average weekday passengers)
- Columbia Pike Line (16A, 16C, 16E, 16J, and 16P) (4,447 average weekday passengers)
- Columbia Pike – Pentagon City Line (16G, 16H) (4,123 average weekday passengers)

Barcroft-South Fairlington Line (22A, 22C, 22F) (1,607 average weekday passengers)

Average weekday ridership values are based on the WMATA bus ridership data viewer[2] for the year 2019.

Arlington Transit (ART) provides local bus services in the area. Relevant routes include:

- Ballston – Pentagon (ART 42) (1,046 average weekday passengers in July 2019)
- Arlington Village - Arlington View-Pentagon City (ART 74) (68 average weekday passengers in July 2019)
- Douglas Park - Nauck-Pentagon City (ART 84) (251 average weekday passengers in July 2019)
- Pentagon-Army Navy Drive-Shirlington (87, 87A, 87X) (585 average weekday passengers in July 2019)

Average weekday ridership values are based on the ART Monthly Service Performance Report[3] for the year July 2019.

The Department of Defense offers a free shuttle bus service from various location within Arlington County, the District of Columbia, and Bailey's Crossroads in Fairfax County to the Pentagon. Several shuttles use facilities within the study area in their service. A valid military or civilian contractor identification badge (Common Access Card) is always required to ride the bus.

Study area transit routes are shown in **Figure 3-2.**

[2] https://www.wmata.com/initiatives/ridership-portal/Bus-Data-Portal.cfm#main-content
[3] https://www.arlingtontransit.com/art/assets/File/2019_08_12_Report_JulyServiceEffectiveness_FINAL.pdf

Figure 3-1: Existing Study Area Lane Configurations and AADTs

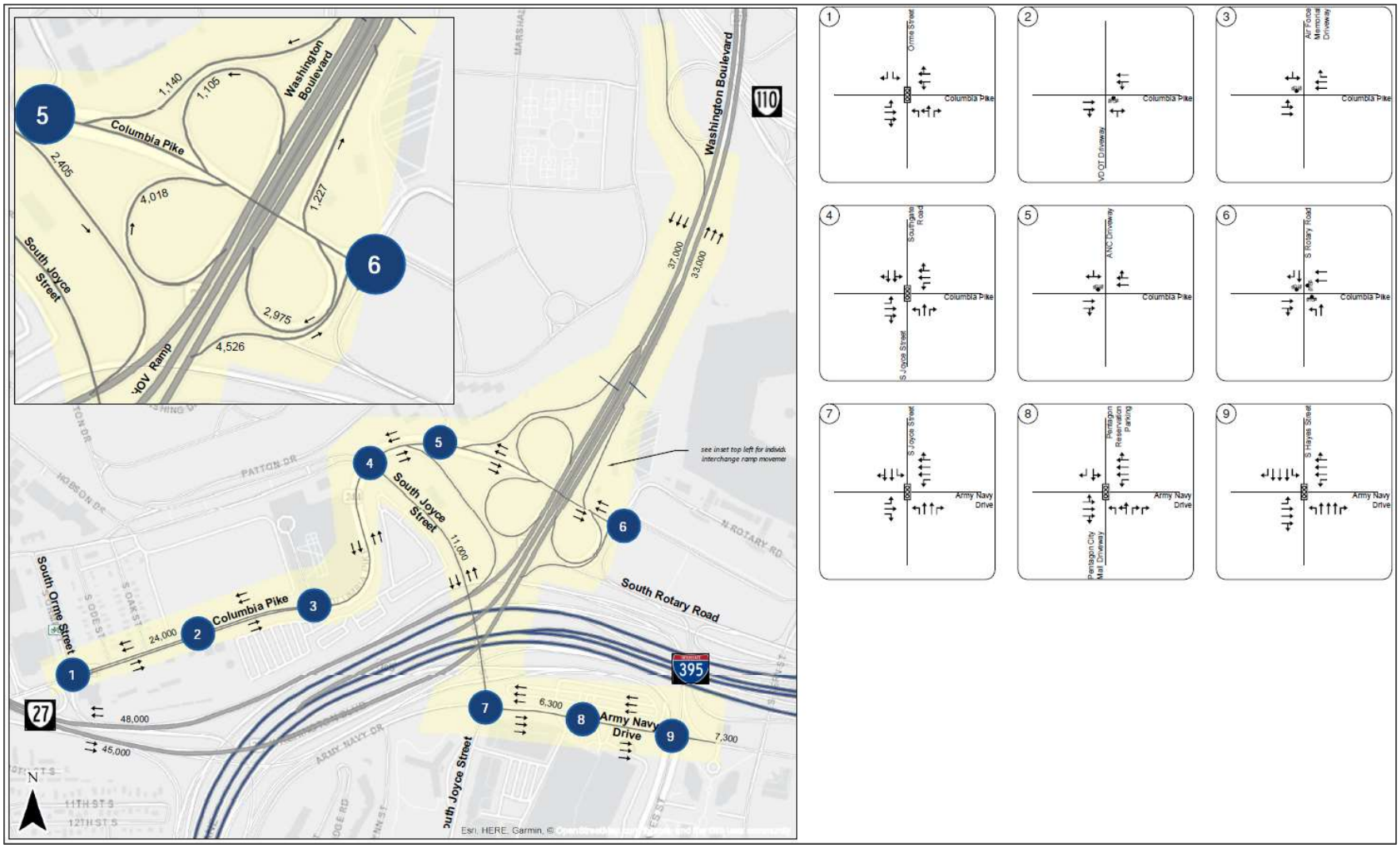
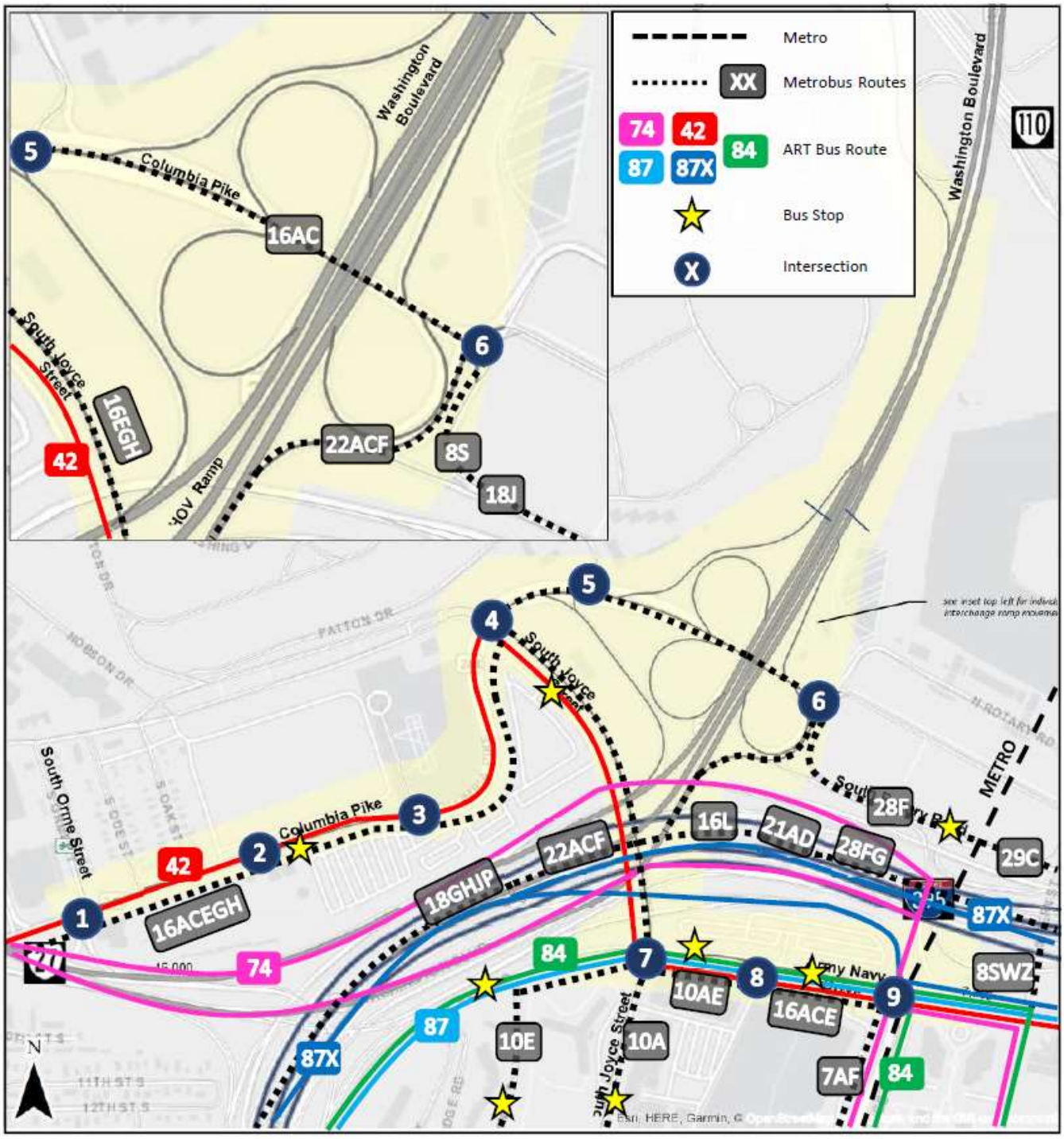


Figure 3-2: Existing Study Area Transit Routes



Sidewalks within the study area provide connections with the Pentagon and Pentagon City. These sidewalks range in width from four feet along portions of the residential streets to up to twelve feet. Crosswalks are present at many locations in the study area. However, striping is extremely faint at crosswalks along Southgate Road. Crosswalks with pedestrian-actuated signals are available at the following intersections:

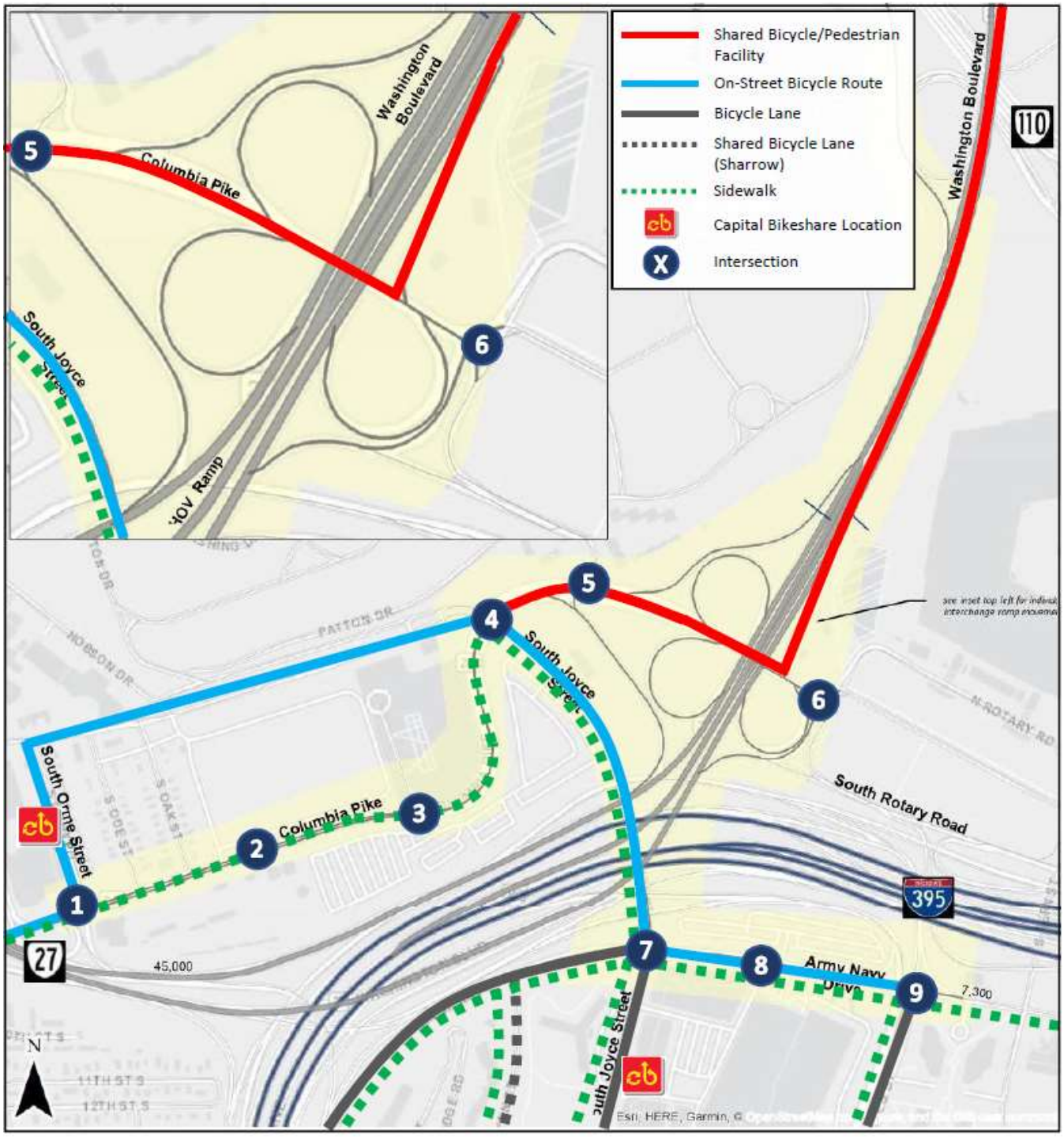
- Columbia Pike and S. Orme Street
- Columbia Pike and S. Joyce Street
- Army Navy Drive and S. Joyce Street
- Army Navy Drive and Pentagon City Mall Driveway
- Army Navy Drive and S. Hayes Street
- Army Navy Drive and S. Fern Street
- S. Joyce Street and Pentagon Row North Entrance

Based on limited visual reviews, many sidewalks and crosswalks in the study area do not appear to be in compliance with the Americans with Disabilities Act (ADA) based on width or grade.

An on-street bicycle route is sign posted along S. Orme Street from Columbia Pike to Southgate Road and continuing to S. Joyce Street. This route is part of the Arlington County bicycle network and connects with trails leading to JBM-HH, the Pentagon, ANC, the Mount Vernon Trail, and Arlington Memorial Bridge. Overall there is a mix of designated bike lanes and bicycle-friendly roads with comfort levels varying from “less comfortable” (along Army Navy Drive between S. Joyce Street and S. Eads Street) to “somewhat comfortable” (north of I-395 to Southgate Road and south of Army Navy Drive along S. Joyce Street and S. Hayes Street) and “most comfortable” (along Southgate Road, along Army Navy Drive west of S. Joyce Street, and along the Arlington Loop which is adjacent to I-395) within the study area as reported by Arlington County’s 2018 Bicycle Comfort Map. A Capital Bikeshare docking station is located on S. Orme Street in front of the Sheraton Hotel. This station has 9 bike docks and allows riders to connect with over 500 docking stations in the National Capital Region. There are additional stations on S. Joyce Street, Army Navy Drive, S. Hayes Street, and S. Rolfe Street, all less than a ½ mile away.

Pedestrian and bicycle facilities in the study area are shown in Figure 3-3.

Figure 3-3: Existing Study Area Bicycle and Pedestrian Network



3.5. Interchanges

The study area for this IMR includes the Columbia Pike/Washington Boulevard interchange located immediately west of the Pentagon. This partial cloverleaf interchange includes 3 ramps along northbound Washington Boulevard and 4 ramps along southbound Washington Boulevard, as previous depicted in **Figure 3-1.**

In the eastbound direction of Washington Boulevard, the ramps include:

- Ramp from Washington Boulevard northbound to Columbia Pike/N. Rotary Road/S, Rotary Road
- Loop ramp from Columbia Pike eastbound to Washington Boulevard northbound.
- Ramp from Columbia Pike westbound to Washington Boulevard northbound.

In the westbound direction of Washington Boulevard, the ramps include:

- Ramp from Washington Boulevard southbound to Columbia Pike westbound.
- Loop ramp from Columbia Pike westbound to Washington Boulevard southbound.
- Loop ramp from Washington Boulevard southbound to Columbia Pike eastbound.
- Ramp from eastbound Columbia Pike to southbound Washington Boulevard.

Existing geometric data associated with the ramps (i.e. acceleration/deceleration lane lengths) are detailed in **Section 3.7**.

All ramp terminal movements are continuous merge and diverge movements except for the northernmost off-ramp serving Washington Boulevard southbound traffic destined to westbound Columbia Pike, which is yield controlled at Columbia Pike, and the southernmost off-ramp serving Washington Boulevard northbound traffic destined to westbound Columbia Pike, which is stop controlled at Columbia Pike.

3.6. Traffic and Safety Data

Various data sources were used to compile the necessary inputs for the operational analyses. Traffic volumes, peak period factors, heavy vehicle percentages, acceleration/deceleration lane lengths, lane designations, turn-lane storage lengths, speed data, and crash data were all established from current data collection efforts. All relevant traffic counts used in this study are included in **Appendix C**.

3.6.1. Existing Traffic Data and Volume Balancing

Traffic Counts

Turning movement counts (TMCs) were collected in 2019 to establish existing condition for the study area. The following intersections had data collected on June 5, 2019 during the AM peak period of 5:30 to 9:30 AM and the PM peak period of 3:00 to 7:00 PM:

- S. Orme Street/Columbia Pike
- Columbia Pike/S. Joyce Street/Southgate Road
- Arlington National Cemetery Service Complex Driveway/Columbia Pike
- Columbia Pike/S. Rotary Road
- S. Joyce Street/Army Navy Drive
- Pentagon Reservation Parking/Army Navy Drive

In addition to these counts, TMC data collected in October 2018 by HNTB as part of the ANCSE Traffic Study was also considered. Those counts were taken at the following locations:

- Air Force Memorial Driveway/Columbia Pike
- Arlington National Cemetery Service Complex Driveway/Columbia Pike
- VDOT and Virginia State Police Facility Driveway/Columbia Pike

Arlington County also provided TMC data for the intersection of S. Hayes Street and Army Navy Drive between 7:00 and 11:00 AM and 3:00 and 7:00 PM during May 2018.

Directional vehicle tube counts were collected in 15-minute intervals, all day during the week of June 5 through June 11, 2019 at the following locations:

- Southbound Washington Boulevard between VA-110 & Columbia Pike
- Northbound Washington Boulevard between HOT/HOV Ramp Merge & Pentagon Lot
- Southgate Road between Hobson Drive & Columbia Pike
- S. Joyce Street south of Columbia Pike
- Columbia Pike between S. Oak Street & Air Force Memorial Drive
- Northbound Washington Boulevard I-395 off-ramp to Columbia Pike & Pentagon
- Southbound Washington Boulevard ramp onto Pentagon Mall & River entrance
- Jefferson Davis Highway ramp onto southbound Washington Boulevard
- Southbound Washington Boulevard to eastbound Columbia Pike
- Eastbound Columbia Pike ramp onto southbound Washington Boulevard
- Eastbound Columbia Pike ramp onto northbound Washington Boulevard
- Westbound Columbia Pike onto southbound Washington Boulevard
- Southbound Washington Boulevard ramp to westbound Columbia Pike
- Westbound Columbia Pike ramp onto northbound Washington Boulevard
- Northbound Washington Boulevard onto eastbound S. Rotary Road
- I-395 HOV ramp from Washington Boulevard

Collected count data included passenger vehicle, bicycle, pedestrian, and heavy vehicle movements.

Based on direction provided in the VDOT Traffic Operations and Safety Analysis Manual (TOSAM) a universal peak hour for the study area in the AM and PM peak periods was determined using the available count data. The observed individual peak hours for all intersections, ramps, and mainline count locations were recorded and network traffic volumes were analyzed to determine the maximum 1-hour traffic volumes experienced at most study area intersections and along the arterial and freeway links within the study area.

Based on an emphasis on network operations during the peak of interchange-related movements, the peak hours of analysis used in this IMR were identified as 7:45 AM to 8:45 AM and 5:00 PM to 6:00 PM. During the morning, 7:45 AM to 8:45 AM represents the hour that captures the best combination of the peak of traffic volumes in the network and the significant congestion along Washington Boulevard. During the afternoon, 5:00 PM to 6:00 PM represents the hour that captures the highest volume of overall traffic along ramps and through arterial intersections in the network.

Table 3-1 and **Table 3-2** show the AM and PM peak hour traffic volumes at each count location and the network peak hour traffic volumes. Arlington County and VDOT concurred with the resulting peak period volumes.

Following the identification of the AM and PM peak hours, intersection peak hour volumes were balanced between intersections, ramps, and the freeway mainline. In general, volume balancing was performed in accordance with VDOT TOSAM guidance, where imbalances between intersections were mitigated proportionally across all lane groups. Traffic volume balancing techniques are described below:

- The intersection of Columbia Pike and S. Joyce Street was held constant.
- Arterial intersection volumes were balanced such that differences between upstream departures and downstream arrivals were distributed proportionally based on existing counts.
- For nearly all upstream and downstream pairs, the imbalances in traffic volumes between intersections were added to the movements which had lower volumes, increasing the total study area traffic, which is a conservative approach.

Existing Heavy Vehicle Percentages

The traffic count data for arterial and freeway movements included vehicle classification breakdowns which were used to derive heavy vehicle percentages (based on FHWA Vehicle Classification 4 and higher) during the peak hours. Based on review of collected traffic counts, the heavy vehicle compositions were assumed to be two percent for all inputs expect the I-395 HOV/HOT facility. The HOV/HOT was manually assigned to be 100 percent single occupancy vehicles.

Existing Balanced AM and PM peak hour traffic volumes are provided in **Figure 3-4.**

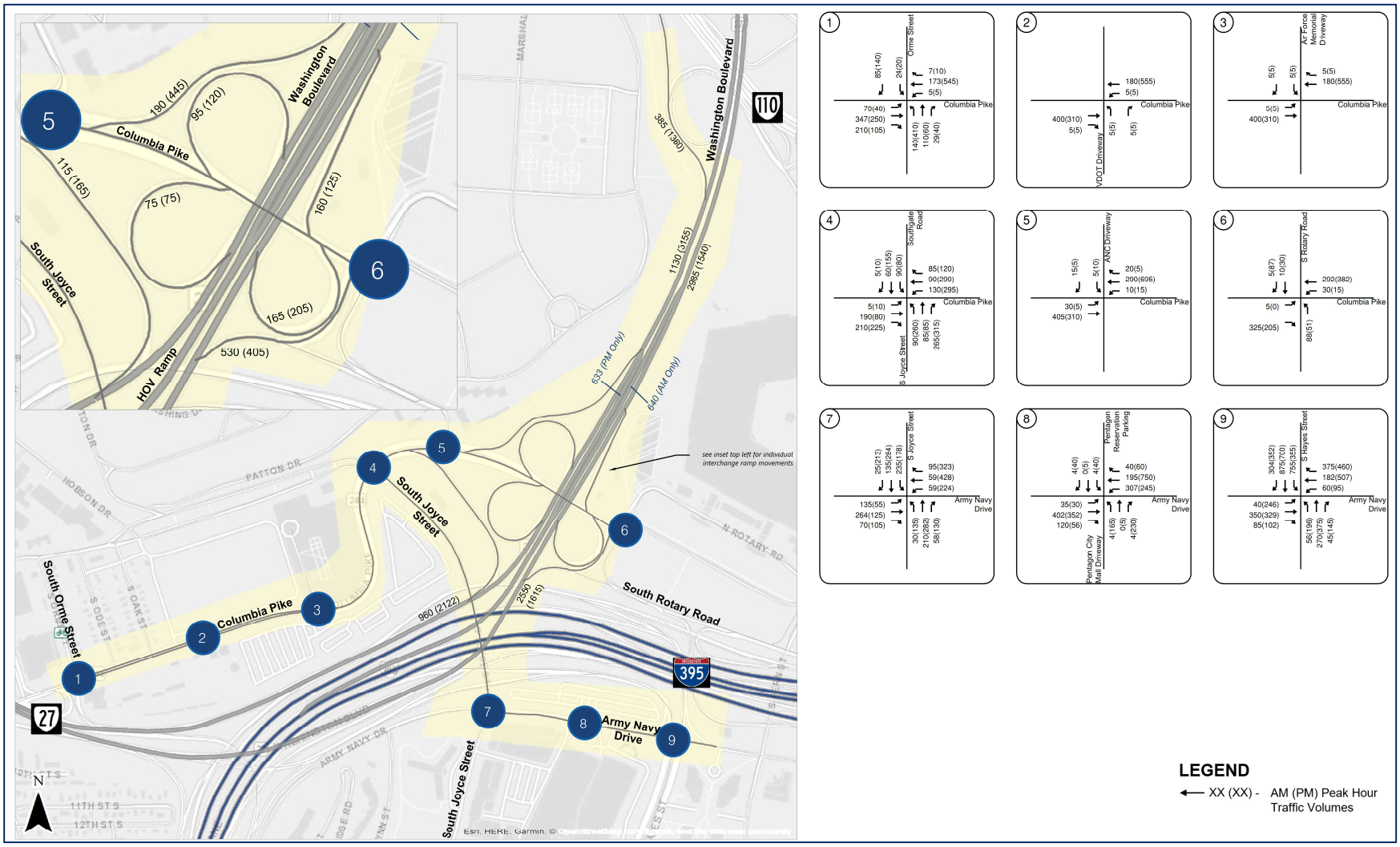
Table 3-1: AM Peak Hour Determination

Site No.	Site	Site Peak Hour (Start)	Volume During Site Peak Hour (V_S)	Volume during Network AM Peak Hour (V_N)	Relative Match (V_N/V_S)
Mainline:					
1	Southbound Washington Boulevard between VA-110 & Columbia Pike	7:15 AM	1,275	**1128**	**89%**
2	Northbound Washington Boulevard between HOV Ramp Merge & Pentagon Lot	7:00 AM	3,375	**2916**	**86%**
3	Southgate Road between Hobson Drive & Columbia Pike, Eastbound	7:30 AM	148	**137**	**93%**
4	Southgate Road between Hobson Drive & Columbia Pike, Westbound	8:00 AM	159	**159**	**100%**
5	S. Joyce Street south of Columbia Pike, Eastbound	7:15 AM	446	**444**	**99%**
6	S. Joyce Street south of Columbia Pike, Westbound	7:45 AM	390	**390**	**100%**
7	Columbia Pike between South Oak Street & Air Force Memorial Drive, Eastbound	7:45 AM	415	**415**	**100%**
8	Columbia Pike between South Oak Street & Air Force Memorial Drive, Westbound	7:45 AM	192	**192**	**100%**
9	Northbound Washington Boulevard I-395 off-ramp to Columbia Pike & Pentagon	6:45 AM	2,812	**2552**	**91%**
		Total	6,548	**6,015**	**3,784**
Ramps:					
1	Southbound Washington Boulevard ramp onto Pentagon Mall & River entrance	7:45 AM	143	**143**	**100%**
2	Jefferson Davis Highway ramp onto southbound Washington Boulevard	7:15 AM	426	**384**	**90%**
3	Southbound Washington Boulevard to eastbound Columbia Pike	6:30 AM	116	**73**	**63%**
4	Eastbound Columbia Pike Ramp onto southbound Washington Boulevard	7:30 AM	96	**94**	**98%**
5	Eastbound Columbia Pike Ramp onto northbound Washington Boulevard	8:00 AM	161	**158**	**98%**
6	Westbound Columbia Pike onto southbound Washington Boulevard	8:00 AM	128	**113**	**88%**
7	Southbound Washington Boulevard Ramp to westbound Columbia Pike	7:15 AM	194	**188**	**97%**
8	Westbound Columbia Pike ramp onto northbound Washington Boulevard	7:00 AM	206	**165**	**80%**
9	Northbound Washington Boulevard onto eastbound S. Rotary Road	8:00 AM	580	**530**	**91%**
10	I-395 HOV ramp from Washington Boulevard	8:30 AM	740	**640**	**87%**
		Total	2,790	**2,488**	**89%**
Intersections:					
1	S. Orme Street/Columbia Pike	7:45 AM	1,352	**1352**	**100%**
4	Columbia Pike/S. Joyce Street/Southgate Road	7:30 AM	1,321	**1300**	**98%**
5	Arlington National Cemetery Service Complex Driveway/Columbia Pike	7:15 AM	958	**894**	**93%**
6	Columbia Pike/S. Rotary Road	7:45 AM	706	**706**	**100%**
7	S. Joyce Street/Army Navy Drive	7:45 AM	1,415	**1415**	**100%**
8	Pentagon Reservation Parking/Army Navy Drive	8:15 AM	1,318	**1298**	**98%**
9	S. Hayes Street/Army Navy Drive	8:15 AM	3,673	**3433**	**93%**
		Total	10,743	**10,398**	**97%**

Table 3-2: PM Peak Hour Determination

Site No.	Site	Site Peak Hour (Start)	Volume During Site Peak Hour (V_S)	Volume during Network AM Peak Hour (V_N)	Relative Match (V_N/V_S)
Mainline:					
1	Southbound Washington Boulevard between VA-110 & Columbia Pike	6:00 PM	3,542	**3154**	**89%**
2	Northbound Washington Boulevard between HOV Ramp Merge & Pentagon Lot	4:45 PM	1,588	**1516**	**96%**
3	Southgate Road between Hobson Drive & Columbia Pike, Eastbound	4:00 PM	241	**219**	**91%**
4	Southgate Road between Hobson Drive & Columbia Pike, Westbound	4:00 PM	204	**67**	**33%**
5	S. Joyce Street south of Columbia Pike, Eastbound	5:15 PM	670	**666**	**99%**
6	S. Joyce Street south of Columbia Pike, Westbound	5:00 PM	662	**662**	**100%**
7	Columbia Pike between South Oak Street & Air Force Memorial Drive, Eastbound	5:15 PM	307	**301**	**98%**
8	Columbia Pike between South Oak Street & Air Force Memorial Drive, Westbound	5:00 PM	518	**518**	**100%**
9	Southbound Washington Boulevard I-395 off-ramp to Columbia Pike & Pentagon	5:15 PM	1,621	**1613**	**100%**
		Total	6,548	**6,015**	**92%**
Ramps:					
1	Southbound Washington Boulevard ramp onto Pentagon Mall & River entrance	6:15 PM	101	**84**	**83%**
2	Jefferson Davis Highway ramp onto southbound Washington Boulevard	5:30 PM	1,406	**1359**	**97%**
3	Southbound Washington Boulevard to eastbound Columbia Pike	3:45 PM	94	**77**	**82%**
4	Eastbound Columbia Pike Ramp onto southbound Washington Boulevard	4:00 PM	126	**119**	**94%**
5	Eastbound Columbia Pike Ramp onto northbound Washington Boulevard	4:45 PM	132	**124**	**94%**
6	Westbound Columbia Pike onto southbound Washington Boulevard	6:00 PM	206	**167**	**81%**
7	Southbound Washington Boulevard Ramp to westbound Columbia Pike	4:45 PM	455	**443**	**97%**
8	Westbound Columbia Pike ramp onto northbound Washington Boulevard	4:00 PM	228	**205**	**90%**
9	Northbound Washington Boulevard onto eastbound South Rotary Road	5:45 PM	475	**407**	**86%**
11	I-395 HOV ramp from Washington Boulevard	6:00 PM	1,238	**633**	**51%**
		Total	4,461	**3,618**	**81%**
Intersections:					
1	S. Orme Street/Columbia Pike	5:00 PM	1,645	**1645**	**100%**
4	Columbia Pike/S. Joyce Street/Southgate Road	5:00 PM	1,913	**1913**	**100%**
5	Arlington National Cemetery Service Complex Driveway/Columbia Pike	5:00 PM	1,215	**1215**	**100%**
6	Columbia Pike/South Rotary Road	4:30 PM	732	**711**	**97%**
7	S. Joyce Street/Army Navy Drive	5:00 PM	2,439	**2439**	**100%**
8	Pentagon Reservation Parking/Army Navy Drive	5:00 PM	2,005	**2005**	**100%**
9	S. Hayes Street/Army Navy Drive	4:00 PM	3,817	**3750**	**98%**
		Total	13,766	**13,678**	**99%**

Figure 3-4: Existing (Year 2019) AM and Peak Hour Traffic Volumes



3.6.2. Existing Geometric, Lane Designation, Travel Time, and Speed Data

Aerial photography was reviewed, and a field visit was conducted on July 25, 2019 to confirm roadway geometry and measurements including acceleration and deceleration lane lengths, storage lane lengths, and lane designations and usage in the study area.

During field visits posted speed limits were obtained for study area roads, as identified below. These speeds were used in the analysis.

- Washington Boulevard – 45 mph
- Washington Boulevard/Columbia Pike interchange ramps – ramp advisory speeds as posted; if none posted, 25 mph was used
- Rotary Road – 25 mph
- Columbia Pike – 25 mph within the study area
- S. Joyce Street – 35 mph between Columbia Pike and Army Navy Drive; 25 mph south of Army Navy Drive
- Southgate Road – 25 mph
- Army Navy Drive – 35 mph

Nine travel time routes were established and measured in the study area, with a specific emphasis on travel through arterial streets. Vehicle probe data from the Regional Integrated Transportation Information System (RITIS) were used to obtain travel speeds along Washington Boulevard. RITIS data was pulled for all Tuesdays, Wednesdays, and Thursdays from January 2019 to May 2019. RITIS data was available for all locations in the study area with the exception of S. Joyce Street mid-block.

Based on the similarity between results of travel time runs and of RITIS data, the analyses were generally calibrated based on the field observed travel time runs, as described in **Section 3.7**.

3.6.3. Crash History

The most recent available 5-year crash data (January 1, 2014 to December 31, 2018) was obtained from VDOT and used for the safety analysis and is included in **Appendix D**. A discussion and qualitative analysis of the reported crashes in the study area is contained in **Section 3.8**. Further discussion and analysis of the impacts to study area safety resulting from the proposed interchange modification, including the application of the Enhanced Intersection Safety Analysis Tool (ISATe), is found in **Section 7.4.**

3.7. Existing Operational Performance

3.7.1. Analysis Methodology and Software

Operational analyses were performed throughout the IMR study area for arterial intersections, the Washington Boulevard general purpose and HOV/HOT lanes, and the interchange ramps between Columbia Pike and Washington Boulevard. VISSIM 9 was used to analyze all study area components. For the purposes of the existing conditions, ramp (weave, merge, diverge), arterial, and freeway analyses were conducted using VISSIM software, as well as analyzing intersections.

VISSIM is a microscopic, behavior-based multi-purpose traffic simulation program. VISSIM can assess the impacts on traffic operations resulting from traffic congestion or friction at other parts of the network. This capability of the micro-simulation model was important to portray adequately the traffic operations for existing conditions as well as for future conditions. One of the key benefits of the VISSIM analysis package is the ability to visually simulate traffic operations to reveal the operational effects of various design solutions. VISSIM 9 was utilized to model arterials, freeways, and ramps in the study area and create MOEs for each. MOEs used at

intersections in the VISSIM analysis included simulated intersection delay (seconds per vehicle), simulated max queuing at intersections, and LOS equivalent. For freeways and ramps, MOEs included average speed and density for certain segments. VISSIM densities are reported in vehicles per hour per lane. Additionally, travel time segments were setup throughout the network. The travel time segments are described in **Table 3-3** and detailed in **Appendix B**.

Table 3-3: Travel Time Segments

ID	Route
1	Route A1: Eastbound Columbia Pike from S. Oak Street to southbound S. Joyce Street to eastbound Army Navy Drive, ending at S Hayes Street
2	Route A2: Westbound Army Navy Drive from S. Hayes Street to northbound S. Joyce Street to westbound Columbia Pike, ending at S Oak Street
3	Route B1: Northbound S. Joyce Street from Pentagon Row (south of Army Navy Drive) to eastbound Columbia Pike, ending at the Rotary Road in the Pentagon parking lot
4	Route B2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot southbound S. Joyce Street, ending at Pentagon Row
5	Route C1: Eastbound Columbia Pike from S. Oak Street to Rotary Road in the Pentagon parking lot
6	Route C2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot to S. Oak Street
7	Route D1: Northbound Washington Boulevard from the on-ramp from northbound I-395 through the Columbia Pike interchange to the off-ramp to southbound Route 110
8	Route D2: Southbound Washington Boulevard from the on-ramp from southbound Route 110 through the Columbia Pike interchange to the off-ramp to southbound I-395
9	Route D3: Southbound Washington Boulevard from the on-ramp from southbound Route 110 to the ramp to westbound Columbia Pike and onto westbound Columbia Pike through to S. Oak Street

VISSIM Model Calibration

The purpose of a simulation model is to investigate the impacts of a proposed improvement alternative. Calibration is the adjustment of the model parameters to improve the model's ability to reproduce observed traffic conditions. It is the required step during any traffic analysis to ensure the model can reproduce local driver behavior and traffic performance characteristics. Calibration should be done prior to evaluating different alternatives. VISSIM, like most simulation models, is designed to be flexible enough such that it can be correctly calibrated to accurately represent local conditions within an acceptable tolerance. Default software parameters are rarely suited to represent local conditions. Therefore, calibration of VISSIM model parameters Is typically required to represent the local conditions of the study area. The Existing Conditions AM and PM peak hour VISSIM models have been calibrated based on guidance and direction provided in the TOSAM. It is noted that the TOSAM is currently being updated from Version 1.0 to Version 2.0 to reflect feedback from modelers around the state with regard to recommended calibration criteria and thresholds. Based on coordination with the team assisting VDOT with the TOSAM update, and at the request of project stakeholders, the calibration criteria and thresholds for this project were modified to anticipate the changes from TOSAM Version 1.0. The models were reviewed by Arlington County and VDOT and determined to be calibrated to field conditions appropriately. Further details on the VISSIM Calibration process, including driver behavior parameters, are included in **Appendix E.**

VISSIM Model Sample Size Determination

VDOT's TOSAM provides a methodology and spreadsheet tool for determining the appropriate number of simulation runs. This methodology is based on a statistical process developed by FHWA to ensure that an appropriate number of simulation runs are performed at a 95th percentile confidence level. This process represents a standard statistical "t-Test", where the mean and standard deviation of specific MOEs are evaluated to determine whether they are within an allowable tolerance (recommended to be within 10%) of the confidence level. Upon review, no more than ten simulation runs were determined to be necessary for both the AM and PM peak hour existing conditions models. Results from VDOT's Sample Size Determination Tool are shown in the **Appendix E**.

3.7.2. VISSIM Analysis and Results

Existing conditions VISSIM results are detailed in **Table 3-4** and **Table 3-5** and shown graphically in **Figure 3-5, Figure 3-6, Figure 3-7,** and **Figure 3-8**. Intersections or movements with equivalent LOS E or F are noted. The tables are color-coded to indicate intersection performance (i.e. equivalent LOS A to C, acceptable operations as green; equivalent LOS D and E, moderate operations as yellow and orange, respectively; and equivalent LOS F, unacceptable intersection operations, as red. Speeds and densities along the freeway and ramps are discussed. The tables are color-coded to match the gradation used on the speed and density maps (i.e. low speed/high densities are coded orange to dark red and high speed/lower densities are coded yellow to light green). Existing VISSIM results area also presented in **Appendix F.** purposes. A summary comparison of all study year and analysis scenario results is included in **Section 7.5.**

Existing Arterial Delay Analysis Summary

Nearly every intersection and nearly every intersection approach operates at equivalent LOS D or better, which represent acceptable delays in Arlington County. The lone exception is the northbound approach of the intersection of S. Joyce Street and Columbia Pike which operates at equivalent LOS E.

Peak Hour Freeway and Ramp Speeds

Figure 3-5 and **Figure 3-7** illustrate freeway mainline and ramp segment speeds. During the AM peak hour, mainline congestion (speeds lower than 30 mph) can be observed along Washington Boulevard northbound. Mainline speeds above 40 mph are also observed along Washington Boulevard southbound which indicates acceptable, near free flow speeds and low congestion operations. During the PM peak hour, mainline speeds above 40 mph are also observed along both directions Washington Boulevard which indicates acceptable, near free flow speeds and low congestion operations.

Peak Hour Freeway and Ramp Density

Figure 3-6 and **Figure 3-8** illustrate freeway mainline and ramp segment densities. During the AM peak hour, mainline congestion (densities greater than 35 vehicles per mile per lane, vpmpl) can be observed along Washington Boulevard northbound. Washington Boulevard southbound and the interchange ramps operate at lower densities, which indicates acceptable, near free flow speeds and low congestion operations. During the PM peak hour, low densities are observed along both directions Washington Boulevard and the interchange ramps which indicates acceptable, near free flow speeds and low congestion operations.

It is noted that an operational improvement is not the primary focus of the proposed interchange modification. The existing interchange, based on a review of speeds and densities, appears to function well in the westbound direction). Eastbound congestion through the interchange is the result of delays that originate from outside of the study area.

Table 3-4: Existing (Year 2019) AM Peak Hour Intersection Analysis Summary

Intersection	Mvmt	Existing			
		Approach Delay	Approach Equivalent LOS	Intersection Delay	Intersection Equivalent LOS
1: Columbia Pike/Orme	NB	18.3	B	13.6	B
	SB	12.8	B		
	EB	10.9	B		
	WB	16.3	B		
2: Columbia Pike/VDOT Driveway/Nash	NB	13.0	B	0.5	A
	SB	-	-		
	EB	0.3	A		
	WB	0.3	A		
3: AF Memorial (Existing & No-Build only)	NB	12.7	B	0.7	A
	EB	0.6	A		
	WB	0.4	A		
4: Columbia Pike/Joyce	NB	19.5	B	21.7	C
	SB	32.1	C		
	EB	15.0	B		
	WB	28.3	C		
5: Columbia Pike/ANC Ops Center (Existing & No-Build only)	SB	7.8	A	0.7	A
	EB	0.3	A		
	WB	0.8	A		
6: Columbia Pike/Rotary Road	NB	12.0	B	6.4	A
	SB	10.8	B		
	EB	0.6	A		
	WB	10.7	B		
7: Army Navy/Joyce	NB	15.2	B	22.1	C
	SB	12.7	B		
	EB	30.7	C		
	WB	30.7	C		
8: Army Navy/Pentagon City Mall	NB	8.9	A	17.9	B
	SB	25.6	C		
	EB	23.6	C		
	WB	12.2	B		
9: Army Navy/S Hayes St	NB	40.4	D	30.5	C
	SB	30.4	C		
	EB	46.6	D		
	WB	12.9	B		

Table 3-5: Existing (Year 2019) PM Peak Hour Intersection Analysis Summary

Intersection	Mvmt	Existing			
		Approach Delay	Approach Equivalent LOS	Intersection Delay	Intersection Equivalent LOS
1: Columbia Pike/Orme	NB	20.0	B	16.2	B
	SB	11.2	B		
	EB	11.5	B		
	WB	17.4	B		
2: Columbia Pike/VDOT Driveway/Nash	NB	12.1	B	0.8	A
	SB	-	-		
	EB	0.2	A		
	WB	0.9	A		
3: AF Memorial (Existing & No-Build only)	NB	14.2	B	1.1	A
	EB	0.6	A		
	WB	1.2	A		
4: Columbia Pike/Joyce	NB	71.1	E	49.6	D
	SB	45.8	D		
	EB	16.8	B		
	WB	45.8	D		
5: Columbia Pike/ANC Ops Center (Existing & No-Build only)	SB	11.0	B	2.6	A
	EB	0.2	A		
	WB	3.5	A		
6: Columbia Pike/Rotary Road	NB	9.3	A	7.7	A
	SB	11.3	B		
	EB	0.6	A		
	WB	10.2	B		
7: Army Navy/Joyce	NB	16.9	B	24.8	C
	SB	16.3	B		
	EB	20.7	C		
	WB	36.3	D		
8: Army Navy/Pentagon City Mall	NB	11.2	B	21.4	C
	SB	24.4	C		
	EB	25.3	C		
	WB	23.5	C		
9: Army Navy/S Hayes St	NB	43.4	D	26.2	C
	SB	23.0	C		
	EB	19.9	B		
	WB	22.7	C		

Figure 3-5: Existing (Year 2019) VISSIM Results - AM Peak Hour Speed

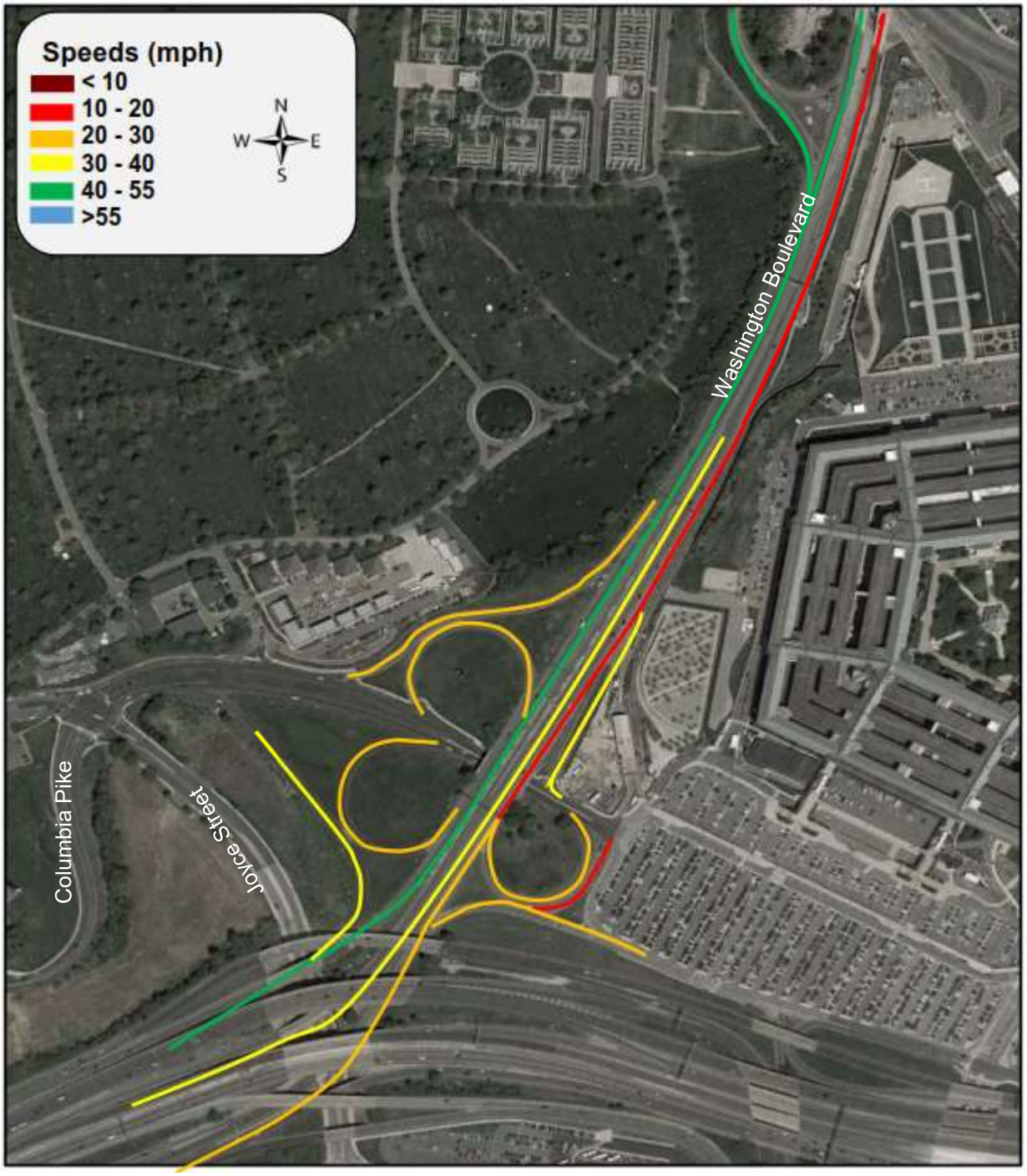


Figure 3-6: Existing (Year 2019) VISSIM Results - AM Peak Hour Density

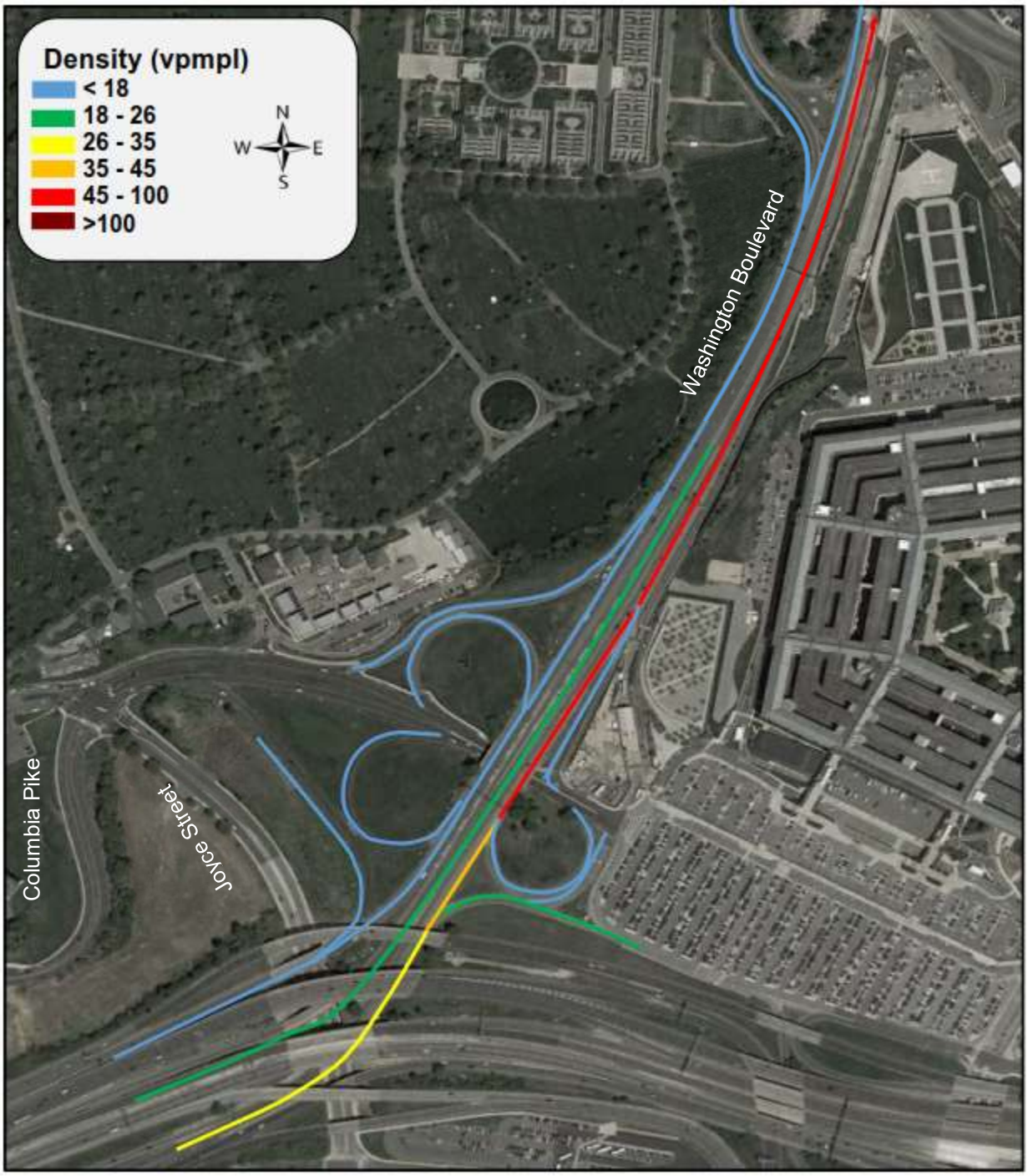


Figure 3-7: Existing (Year 2019) VISSIM Results - PM Peak Hour Speed

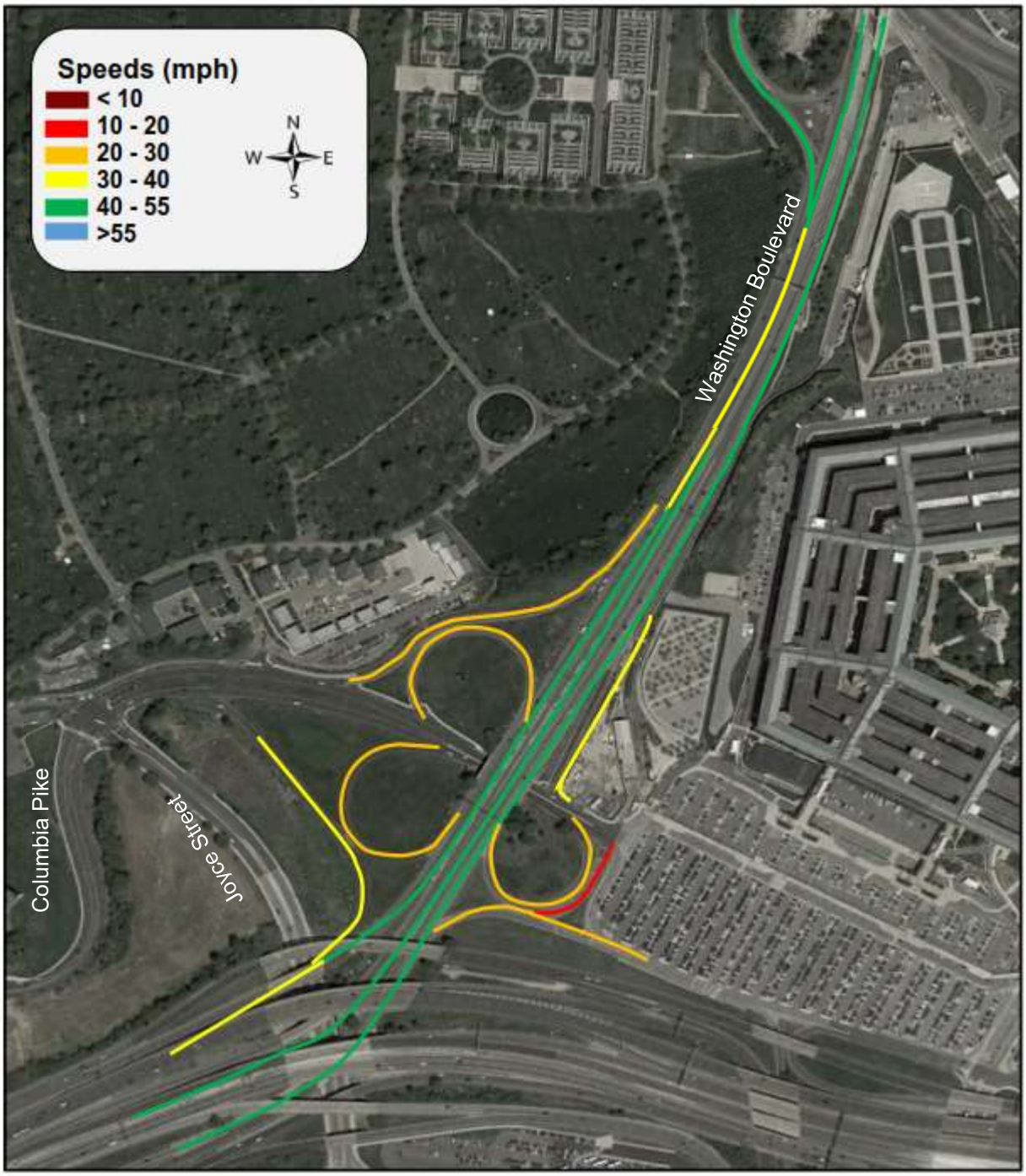
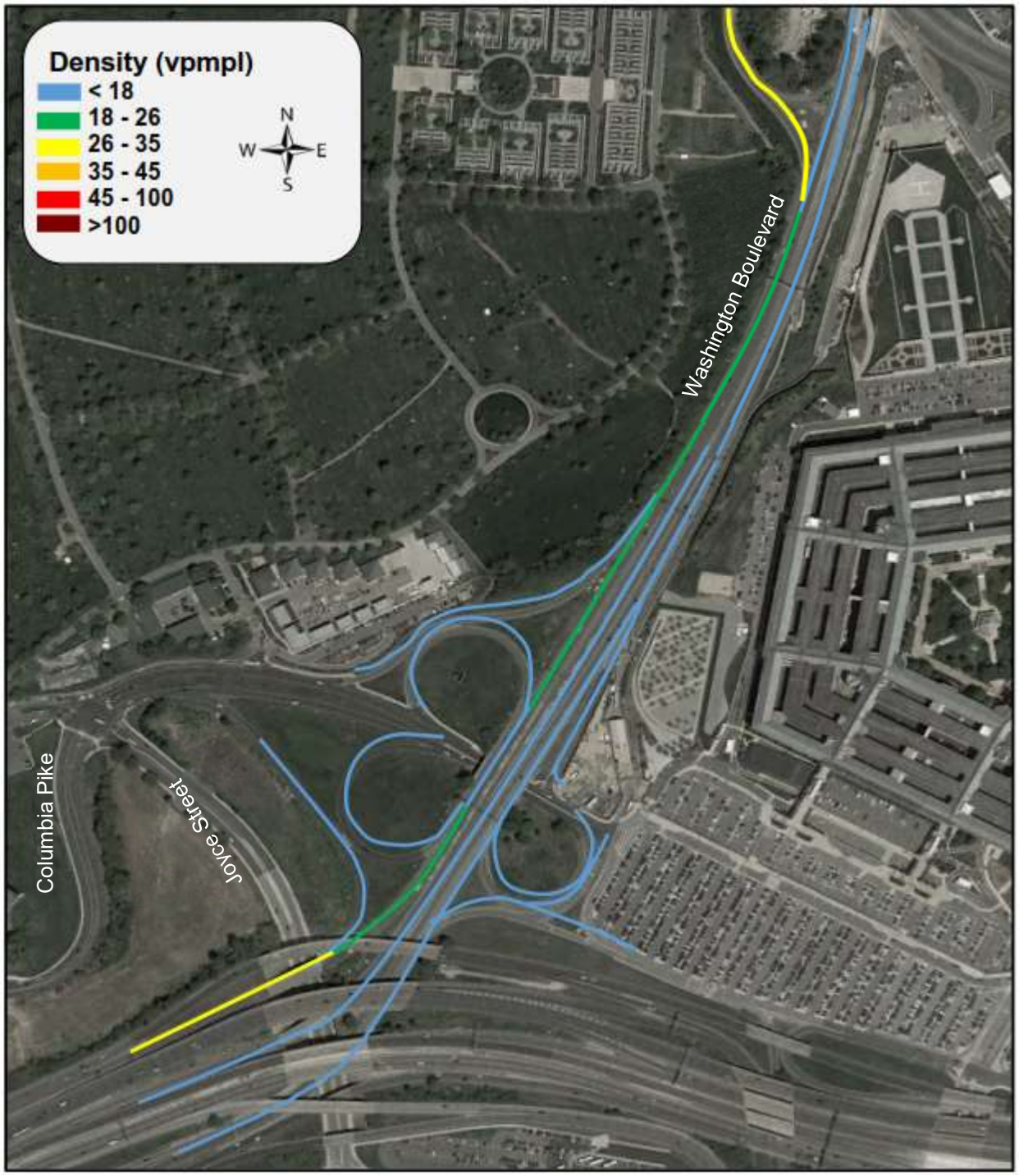


Figure 3-8: Existing (Year 2019) VISSIM Results - PM Peak Hour Density



3.8. Existing Safety Conditions

A crash analysis was conducted to review and document existing crash patterns within the study area roadway network. Five years of available crash data, from January 1, 2014 to December 31, 2018, were obtained from VDOT. The 2014 to 2018 VDOT reported crashes are shown in Figure 3-9.

A total of 237 crashes occurred within the study area during the 2014 to 2018 reporting period. Of interest were the number of crashes that occurred within the influence area of an intersection (roughly within 250 feet along each intersection approach) and the number of crashes that occurred along road segments outside of the influence areas. Nine crashes occurred in the influence area of the Columbia Pike and Orme Street intersection, two crashes occurred at the intersection of Columbia Pike and VDOT Driveway, one crash at the intersection of Columbia Pike and the Air Force Memorial Driveway, 12 crashes at the intersection of Columbia Pike and S. Joyce St/Southgate Rd, one crash at the intersection of Columbia Pike and Rotary Road, 26 crashes at the intersection of the S. Joyce Street and Army Navy Drive, eight crashes at the intersection of Army Navy Drive and the Pentagon driveway, and 95 crashes at the intersection of Army Navy Drive and Hayes Street. 13 crashes occurred along ramps or in proximity to weave, merge, and diverge points of ramps. The remaining crashes occurred along the Columbia Pike or Washington Boulevard, outside the influence areas of ramps or intersections. Of the ramp crashes, none occurred along the loop ramp from Columbia Pike westbound to Washington Boulevard southbound, none occurred along the loop ramp from Washington Boulevard southbound to Columbia Pike eastbound, and nine crashes occurred along the off-ramp from I-395 northbound to Hayes Street southbound.

3.8.1. Crashes by Severity

The most prevalent crash types in the study area were “property damage only” crashes followed by type B crashes involving injuries. There were two crashes resulting in fatalities in the study area. Four crashes at the Army Navy Drive with Joyce Street intersection, one crash at the Columbia Pike with Orme Street intersection, and one crash at the Army Navy Drive with Pentagon South Parking Lot intersection involved a pedestrian. Four of the six crashes occurred during the nighttime/evening hours, which indicates that the crashes may have resulted from lack of adequate lighting and lack of visibility.

3.8.2. Crashes by Type

Most crashes in the study area were either angle collisions (45 percent) or rear-end collisions (24 percent). This can be attributed to congestion along the roads as well as permissive turning movements at intersections. At the intersection of Army Navy Drive with S. Joyce Street more than half the reported crashes were angle collisions. At the intersection of Columbia Pike with Southgate Road a third of the reported crashes were rear-end collisions. When considering crashes along the Army Navy Drive and S. Joyce Street intersection, 54 percent of the crashes were angle collisions. The data suggest that rear-end collisions were a more prevalent crash type along segments than at intersections in the study area and that angle crashes were more prevalent at intersections.

Specific to the ramps that are the subject of this interchange modification, there were no reported collisions in our study period on the loop ramps.

Figure 3-9: Study Area Crashes, 2014-2018

3.8.3. Crash Rates

Crash rates are based on the number of crashes on the specified section of roadway, the Average Annual Daily Traffic (AADT) on the roadway, the time of analysis, and the length of the roadway section. All crash rates are expressed in terms of crashes per 100 million vehicle-miles traveled. Some sections of the study area segments have different AADTS; along these sections, a weighted average of the two AADTs was used. The weighted average was calculated for each year in the analysis period, then a five-year weighted average was used as the weighted AADT for the segment.

The total crash, injury crash, fatality crash rates for study area segments are described below. The 2018 VDOT Crash Summary Book was utilized to determine the statewide average crash rate for similar facility types (**Table 3-6**) and roads of a similar functional class (**Table 3-7**) to determine the statewide average crash rate for the different road facility segments. Relevant excerpts from the Crash Summary Book are included in **Appendix D**.

When comparing similar facilities, the calculated crash and injury rates along Columbia Pike and Washington Boulevard are lower than the statewide average for total crashes and injuries. The prevalence of crashes may be attributed to congestion and permissive or illegal turning movements at intersections and at the mall entrance. This is indicated by the amount of angle crashes and the occurrence of head-on type crashes.

Table 3-6: Segment Crash Rates (Facility Type), 2014-2018

Segment	Crashes			Injury			Fatal		
	*Total Crashes	Crash Rate	2018 Statewide Average Crash Rate**	*Total Crashes	Crash Rate	2018 Statewide Average Crash Rate**	*Total Crashes	Crash Rate	2018 Statewide Average Crash Rate**
Columbia Pike	3	21.90	142.13	1	7.30	44.64	0	0	0.99
Washington Boulevard	65	60.57	62.38	15	13.98	17.55	1	1.07	0.46
Total	68	-	-	16	-	-	1	-	-

* Total crashes along a segment also include those crashes that occur at intersections along the segment.
****Statewide Crash Rates based on Facility Type** – Rt. 27: Primary, Divided, Partial Full Control of Access; Rt. 244: Primary, Divided, No Control of Access; Army Navy Drive and S. Joyce Street: Secondary, Divided, No Control of Access

Crash Rate = Total Crashes/[(AADT) x (365) x (Length of Analysis Period (Years)) x (Section Length)]/100,000,000
Crash rates are expressed in crashes per 100 million vehicle-miles traveled
AADT – based on weighted average of VDOT reported AADTs within the segment between 2014 and 2018
Analysis Period – 5 years (January 1, 2014 to December 31, 2018
Section Length - Rt. 27: 0.84 miles, Rt. 244: 0.95 miles, Army Navy Drive:0.41 miles, S. Joyce Street: 0.61 miles

When comparing against roads of a similar functional class, the calculated total crash and injury rates only along Army Navy Drive are lower than the statewide average for total crashes and injuries. The prevalence of crashes though may be attributed to congestion and permissive or illegal turning movements at intersections and at the mall entrance. This is indicated by a large amount of angle crashes and the occurrence of head-on crashes.

Table 3-7: Segment Crash Rates (Functional Class), 2014-2018

Segment	Crashes			Injury			Fatal		
	*Total Crashes	Crash Rate	2012 Statewide Average Crash Rate**	*Total Crashes	Crash Rate	2012 Statewide Average Crash Rate**	*Total Crashes	Crash Rate	2012 Statewide Average Crash Rate**
Columbia Pike	3	21.90	172.35	1	7.30	51.78	0	0	0.77
Washington Boulevard	65	60.57	172.35	15	13.98	51.78	1	1.07	0.77
Total	68	-	-	16	-	-	1	-	-

* Total crashes along a segment include those crashes that occur at intersections along the segment.
Statewide Crash Rates based on Functional Class– Rt. 27 and Rt. 244: Primary, Urban Other Principal Arterial; Army Navy Drive and S. Joyce Street: Secondary, Urban Minor Arterial
Crash Rate = Total Crashes/[(AADT) x (365) x (Length of Analysis Period (Years)) x (Section Length)]/100,000,000
Crash rates are expressed in crashes per 100 million vehicle-miles traveled
AADT – based on weighted average of VDOT reported AADTs within the segment between 2014 and 2018
Analysis Period -5 years (January 1, 2014 to December 31, 2018)
Section Length - Rt. 27:0.84 miles, Rt 244: 0.95 miles, Army Navy Drive:0.41 miles, S. Joyce Street: 0.61 miles

3.8.4. Crash Conditions

Table 3-8, Table 3-9, Table 3-10, and Table 3-11 summarize the crash trends in the Columbia Pike/Washington Boulevard area with respect to weather, lighting, time-of-day conditions, and collision type respectively.

Table 3-8: Crash Summary – Weather Condition, 2014-2018

Intersection or Segment	Weather Condition						Total Crashes*
	Clear		Rain		Snow		
Army Navy Drive and Hayes Street	87	92%	8	8%	0	0%	95
Army Navy Drive and Joyce Street	18	69%	6	23%	2	8%	26
Army Navy Drive and Pentagon South Parking Lot	8	100%	0	0%	0	0%	8
Columbia Pike and Air Force Memorial	1	100%	0	0%	0	0%	1
Columbia Pike and Orme	4	44%	4	44%	1	11%	9
Columbia Pike and Rotary Road	1	100%	0	0%	0	0%	1
Columbia Pike and Southgate Road	12	100%	0	0%	0	0%	12
Columbia Pike and VDOT Driveway	4	100%	0	0%	0	0%	4
Columbia Pike Segment	2	67%	1	33%	0	0%	3
Ramp Influence Area	12	92%	1	8%	0	0%	13
Washington Blvd Segment	57	88%	8	12%	0	0%	65
Total	206	87%	28	12%	3	1%	237

Number of Crashes | Percentage of Crashes

Table 3-9: Crash Summary – Light Condition 2014-2018

Intersection or Segment	Light Condition						Total Crashes*
	Daylight		Dawn/Dusk		Dark		
Army Navy Drive and Hayes Street	67	71%	3	3%	25	26%	95
Army Navy Drive and Joyce Street	11	42%	2	8%	13	50%	26
Army Navy Drive and Pentagon South Parking Lot	7	88%	0	0%	1	13%	8
Columbia Pike and Air Force Memorial	0	0%	0	0%	1	100%	1
Columbia Pike and Orme	6	67%	0	0%	3	33%	9
Columbia Pike and Rotary Road	0	0%	0	0%	1	100%	1
Columbia Pike and Southgate Road	7	58%	0	0%	5	42%	12
Columbia Pike and VDOT Driveway	4	100%	0	0%		0%	4
Columbia Pike Segment	1	33%	0	0%	2	66%	3
Ramp Influence Area	12	92%	0	0%	1	8%	13
Washington Blvd Segment	36	55%	7	11%	22	34%	65
Total	151	64%	12	5%	74	31%	237

Number of Crashes | Percentage of Crashes
*Total crashes may include crashes where lighting description was not recorded at the time of the accident

Table 3-10: Crash Summary – Severity, 2014-2018

Intersection or Segment	Crash Severity										Total
	A		B		C		PDO		Fatal		
Army Navy Drive and Hayes Street	0	0%	31	33%	1	1%	63	66%	0	0%	95
Army Navy Drive and Joyce Street	0	0%	9	35%	0	0%	17	65%	0	0%	26
Army Navy Drive and Pentagon South Parking Lot	1	13%	1	13%	1	13%	5	63%	0	0%	8
Columbia Pike and Air Force Memorial	0	0%	0	0%	0	0%	0	0%	1	100%	1
Columbia Pike and Orme	0	0%	1	11%	1	11%	7	78%	0	0%	9
Columbia Pike and Rotary Road	0	0%	0	0%	0	0%	1	100%	0	0%	1
Columbia Pike and Southgate Road	1	8%	3	25%	0	0%	8	67%	0	0%	12
Columbia Pike and VDOT Driveway	0	0%	1	25%	0	0%	3	75%	0	0%	4
Columbia Pike Segment	0	0%	1	33%	0	0%	2	67%	0	0%	3
Ramp Influence Area	1	8%	2	15%	0	0%	10	77%	0	0%	13
Washington Blvd Segment	2	3%	12	18%	1	2%	49	75%	1	2%	65
Total	5	2%	61	25%	4	2%	165	70%	2	1%	237

Number of Crashes | Percentage of Crashes

Table 3-11: Crash Summary – Type, 2014-2018

Intersection or Segment	Crash Severity										Total
	Angle		Rear End		Sideswipe Same Direction		Fixed Object off Road		Other		
Army Navy Drive and Hayes Street	67	71%	8	8%	4	4%	0	0%	16	17%	95
Army Navy Drive and Joyce Street	14	54%	2	8%	1	4%	1	4%	9	35%	26
Army Navy Drive and Pentagon South Parking Lot	5	63%	1	13%	0	0%	0	0%	2	25%	8
Columbia Pike and Air Force Memorial	0	0%	0	0%	0	0%	0	0%	1	100%	1
Columbia Pike and Orme	2	22%	3	33%	0	0%	0	0%	4	44%	9
Columbia Pike and Rotary Road	0	0%	0	0%	0	0%	0	0%	1	100%	1
Columbia Pike and Southgate Road	3	25%	4	33%	2	17%	0	0%	3	25%	12
Columbia Pike and VDOT Driveway	1	25%	2	50%	0	0%	0	0%	1	25%	4
Columbia Pike Segment	0	0%	1	33%	0	0%	1	33%	2	67%	3
Ramp Influence Area	5	38%	3	23%	3	23%	0	0%	2	15%	13
Washington Blvd Segment	10	15%	32	49%	9	14%	3	5%	14	22%	65
Total	107	45%	56	24%	19	8%	13	5%	42	18%	237
Number of Crashes | Percentage of Crashes											

3.9. Environmental Constraints

At the time of the 2017 IMR, the following conditions were true:

- The 2009 FHWA *Policy on Access to the Interstate System* was in effect
- The application of federal funding for the interchange modification was an uncertainty
- The NEPA document to describe the environmental impacts of the interchange modification was in development by others.

As such, the 2017 IMR included a thorough environmental constraints review to determine if any sensitive sites were present or potentially impacted by the realignment of Columbia Pike and the Columbia Pike/Washington Boulevard interchange modifications. It was noted at the time that the review was intended to be a precursor to a more extensive examination of environmental and community impact issues that would otherwise have been accomplished through a concurrent NEPA process.

As part of this IMR Update, it is recognized that the guidance of the 2017 FHWA *Policy on Access to the Interstate System* is now in effect. This guidance specifically changed the FHWA 8-point policy to a 2-point policy focused on technical feasibility of any proposed change in access in support of FHWA's determination of safety, operational, and engineering acceptability. The new policy further stated that "consideration of social, economic, and environmental impacts and planning considerations will be addressed through the NEPA review of the project." As such, the importance of the environmental constraints review has been de-emphasized in this IMR Update. The rationale for this change is that the ANCSE EA is being done under the NEPA and includes in its scope both the expansion of the cemetery and the DAR project elements. A Finding of No Significant Impacts (FONSI) will be issued by ANC for the ANCSE project and a FONSI will be issued by FHWA for the DAR project; however, the FHWA FONSI is dependent upon an IMR accepted by the Partner Agencies and approved by VDOT [and FHWA].

As such, the environmental constraints review has been updated, but has been moved to **Appendix G** of this IMR Update to be in compliance with the recommended focus of the 2017 FHWA Policy. In the case of conflicts, the information in the ANCSE EA will supersede the information contained in **Appendix G**.

The overall findings of the environmental constraints review can be summarized as the following:

- No residential or commercial right-of-way acquisitions or relocations are currently proposed.
- There are known petroleum release cases, registered petroleum facilities, 26 cases of petroleum releases, and 6 voluntary remediation sites within ½ mile of the environment constrain area.
- Northern Virginia designated as nonattainment or maintenance areas for air quality in accordance with the Clean Air Act and Arlington County is within the Northern VA/DC/MD PM2.5 and Ozone Nonattainment Area and a carbon monoxide attainment/maintenance area.
- No forestland or Agricultural Forestal Districts; no prime farmland, unique farmland, and farmland of statewide or local importance; and no open space easements were identified within the environmental constraints area.
- The Great Falls Loop of Virginia Birding and Wildlife Trail is a driving trail leading to wildlife viewing sites throughout Virginia and is located within the existing I-395 corridor and may be protected under Section 4(f). no impacts to the trail are anticipated
- No permanent impacts are anticipated to cultural, community, or historic resources.
- Temporary construction impacts during constructed will be minimized and would be mitigated through a detailed construction phasing and maintenance of traffic plan, developed as part of the DAR project.

4. Alternatives Considered

This IMR was focused on evaluating the impacts of a realistic and implementable transportation solution that is compatible with the multimodal improvement efforts occurring along Columbia Pike and that addresses the operational needs of the area and provide useable, contiguous burial space for ANC.

4.1. No-Build Conditions

The no-build condition represents no modification of the existing interchange, no realignment of Columbia Pike, and no further southern contiguous expansion of ANC. The analysis of no-build conditions for years 2025 and 2045 were conducted for the study area network. The results of the analyses are reported in **Section 7.2.**

Due to the forecasted traffic growth within and around the study area many of the roadways within the study area will approach oversaturation and be over capacity under 2025 and 2045 conditions. The impact of this congestion along Columbia Pike will reduce the available capacity for traffic exiting the Washington Boulevard southbound mainline as the peak hour ramp volumes will approach the capacity of the interchange ramps. The increase in vehicle density along the ramps will cause queues that are anticipated to reach the mainline, degrading traffic operations along Washington Boulevard.

While Columbia Pike and Southgate Road could conceivably still be realigned in the absence of an interchange modification, the benefits to ANC would be minimal. The amount of contiguous space gained would be minimal. Even if a land exchange was brokered without the proposed improvements, ANC would be left with outparcels that would be undesirable for burial space due to the required crossing of Columbia Pike (at-grade or otherwise) and the safety and operational concerns that might entail.

As a result, this IMR presents a series of potential alternatives and evaluates a preferred alternative that is intended to simultaneously meet the ANC's land needs and address future traffic operations concerns.

4.2. Build Options

From August through October 2014, Arlington County worked with ANC and VDOT to identify potential interchange modification alternatives. The stakeholders performed a high-level screening and fatal flaw analysis of a total of nine alternatives (five developed by the County and four developed by ANC's consultant). The five alternatives developed, as originally developed and depicted by Arlington County are identified in **Figure 4-1 to Figure 4-5** and described as follows:

- Alternative 1 (ACO 1) – "Spread Diamond Interchange with traffic signal" consists of realigning the southbound Washington Boulevard to westbound Columbia Pike ramp to serve as the north leg of a signalized t-intersection with a realigned Columbia Pike. This configuration removes the ramps between Columbia Pike eastbound and Washington Boulevard southbound, between Columbia Pike westbound, and Washington Boulevard southbound, and between Washington Boulevard southbound and Columbia Pike eastbound (See **Figure 4-1**).
- Alternative 2 (ACO 2) – "Spread Diamond Interchange with roundabout" consists of realigning the southbound Washington Boulevard to westbound Columbia Pike ramp to serve as the north leg of a roundabout with a realigned Columbia Pike. This configuration removes the ramps between Columbia Pike eastbound and Washington Boulevard southbound, between Columbia Pike westbound, and Washington Boulevard southbound, and between Washington Boulevard southbound and Columbia Pike eastbound (See **Figure 4-2**).
- Alternative 3 (ACO 3) – "Tight Diamond Interchange" consists of converting the northwest and southwest quadrants of the interchange to form a tight diamond with a signalized intersection at the ramp terminals

with Columbia Pike. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-3**).

- Alternative 4 (ACO 4) – Realigned Columbia Pike without any further interchange modification (See **Figure 4-4**).
- Alternative 5 (ACO 5) – "Tighter Diamond Interchange with retaining walls" consists of converting the northwest and southwest quadrants of the interchange to form a very tight diamond (tighter than ACO 3) with a signalized intersection at the ramp terminal with Columbia Pike. The placement of the ramp terminals is such that retaining walls would likely be needed. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-5**).

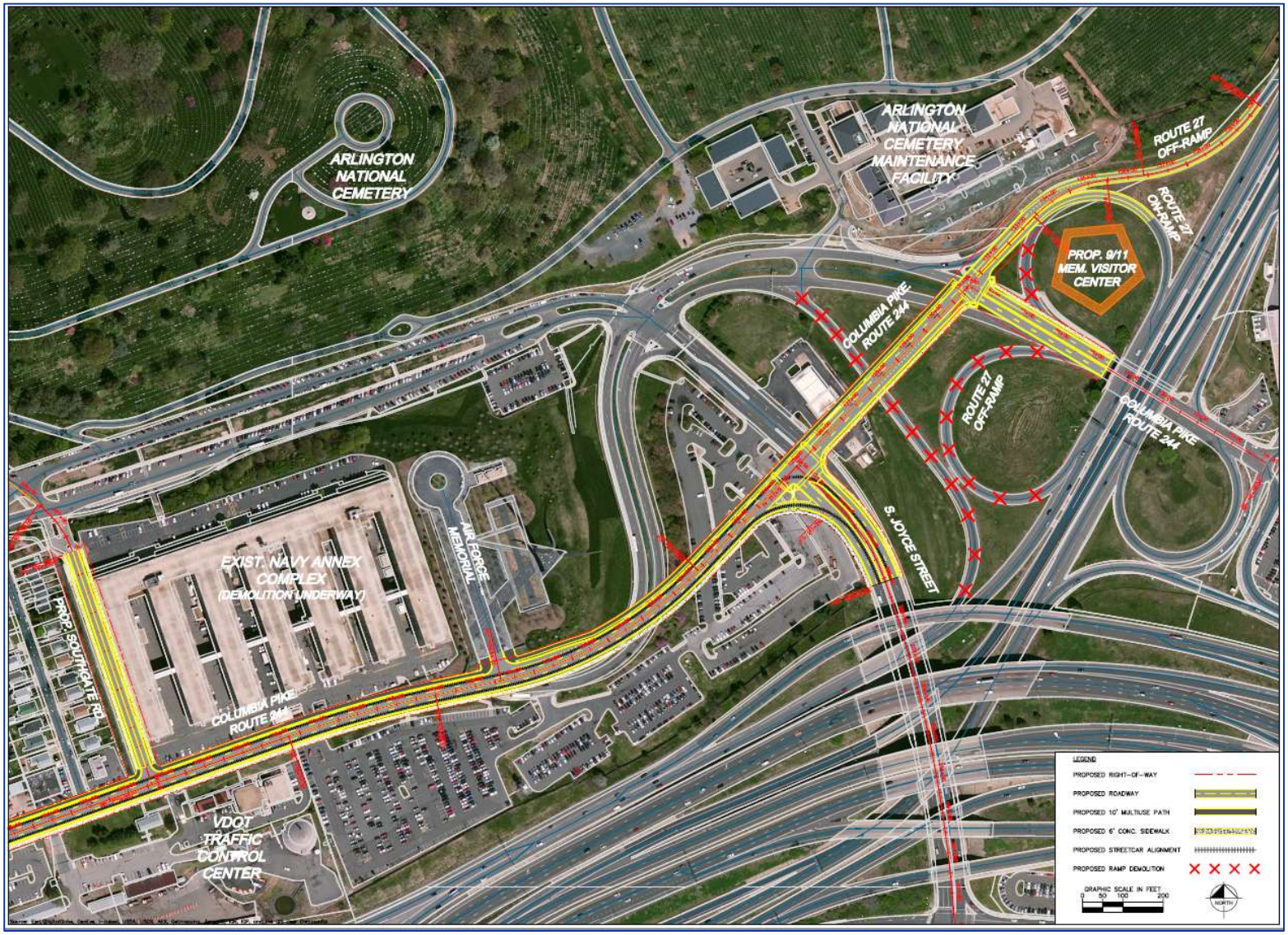
The four alternatives, as originally developed and depicted by ANC are identified in **Figure 4-6 to Figure 4-9** and described as follows:

- The common themes of the four alternatives are (1) horizontal/vertical geometry controlled by existing grade, (2) de minimis impacts to Air Force memorial, (3) maintaining approximately 2.2 acres for Pentagon 9/11 Memorial visitors center site, and (4) maintaining access to ANC maintenance facility.
- Alternative 6 (ANC 1) – "Master Plan/Tear Drop Interchange" is a refinement of the ANC Master Plan concept, modified based on additional traffic and vertical geometry data. The vertical alignment was revised to specifically reduce the amount of earthwork and profile differences along Columbia Pike. This alignment contains one ANC outparcel. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-6**).
- Alternative 7 (ANC 2) – "Braided Ramp Interchange" is a braided ramp design that is the most expensive of the 4 ANC alternatives (based on construction costs only). This alternative requires two new bridges and associated retaining walls. The intent of this alternative is to push the heavy ramp traffic away from the ANC southern expansion while realigning the Columbia Pike approach to Joyce Street. Alternative 7 has one signalized and one unsignalized intersection and it was suggested that aesthetic treatments could be provided on the bridge and retaining walls to match the I-395 Bridge. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-7**).
- Alternative 8 (ANC 3) – "No Westbound Route 27 Ramps Interchange" has the smallest footprint of all alternatives, which results in the most space for the Cemetery, and removes the southbound Washington Boulevard ramps (i.e., ramp traffic to/from westbound Route 27 would be added to the interchanges to the north and south). This alternative would require more analysis and would include a much larger study area. Further analysis of this alternative could indicate that additional improvements would be needed at the other interchanges to accommodate the added traffic. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-8**).
- Alternative 9 (ANC 4) – "Tight Diamond Interchange" is a modified version of the County's Alternative 3 (tight diamond). This alternative pushes Columbia Pike further to the south and may result in horizontal sight distance issues at the intersection with the Route 27 ramps. This configuration removes/modifies all northwest and southwest quadrant ramps (See **Figure 4-9**).

As part of the high-level screening, VDOT also prepared an independent assessment of the potential design alternatives. The results of the VDOT Assessment are illustrated in **Figure 4-10**.

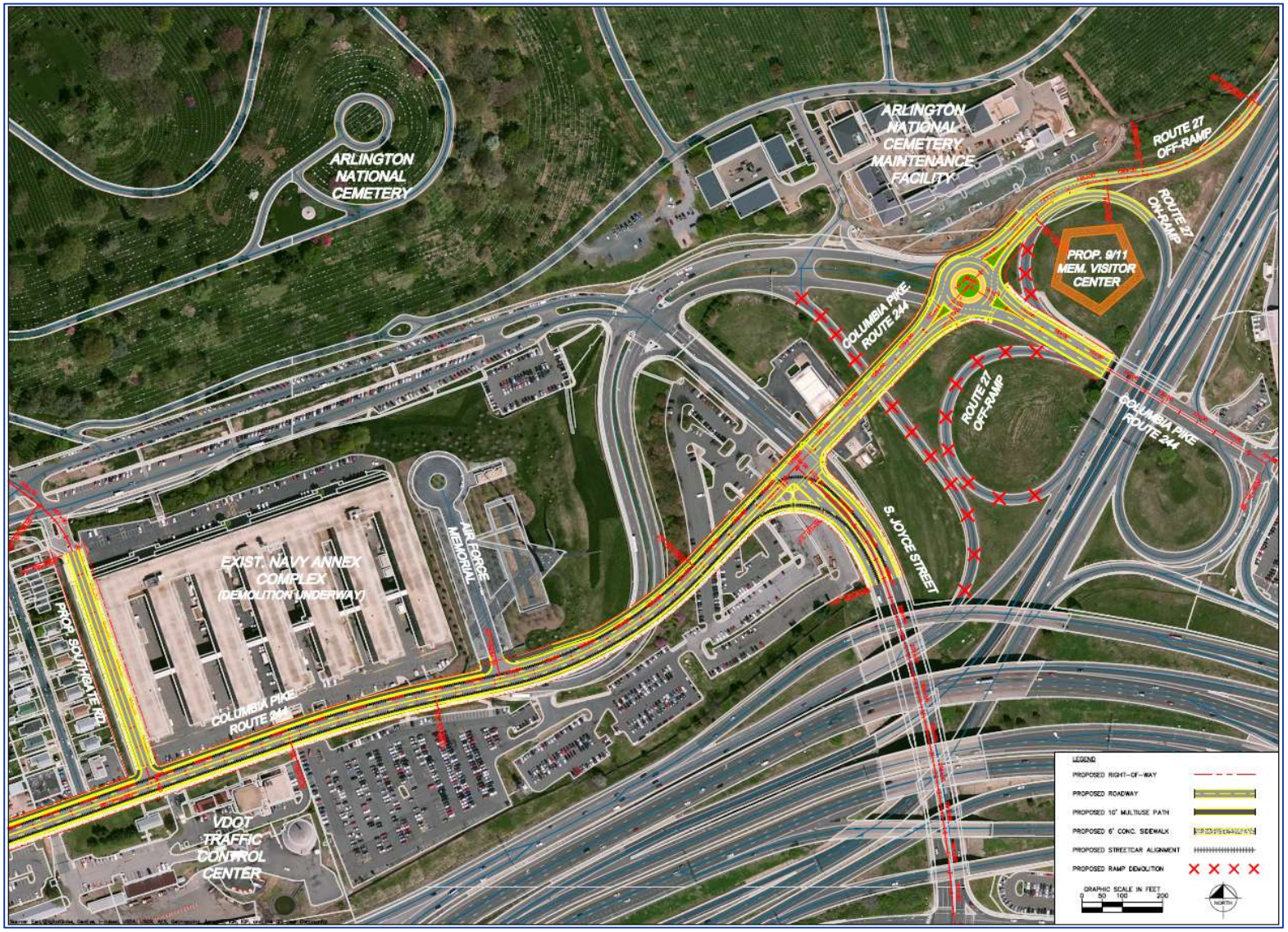
The remaining potential alternatives were screened using a set of evaluation criteria, specifically targeted to address the purpose and need of this interchange modification report. The selected high-level evaluation criteria included assessments of the impact on traffic operations, geometric considerations, land use impacts, accommodations for future transit options, multimodal connectivity, and feasibility of design and construction. The results of the high-level screening are shown in **Figure 4-11.**

Figure 4-1: Alternative 1 (ACO 1) Concept



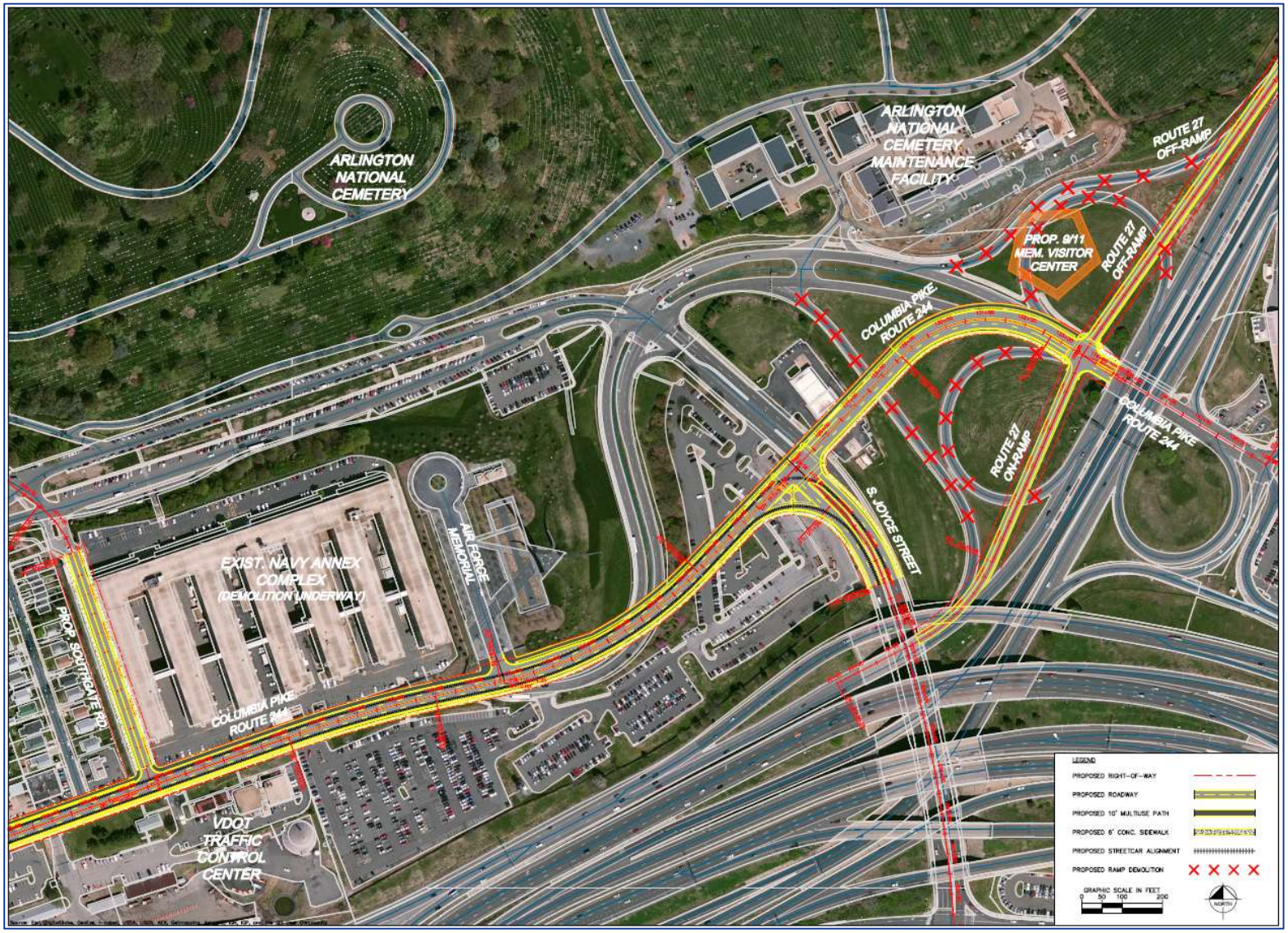
Original graphic as developed in 2014 by Kimley-Horn on behalf of Arlington County.

Figure 4-2: Alternative 2 (ACO 2) Concept



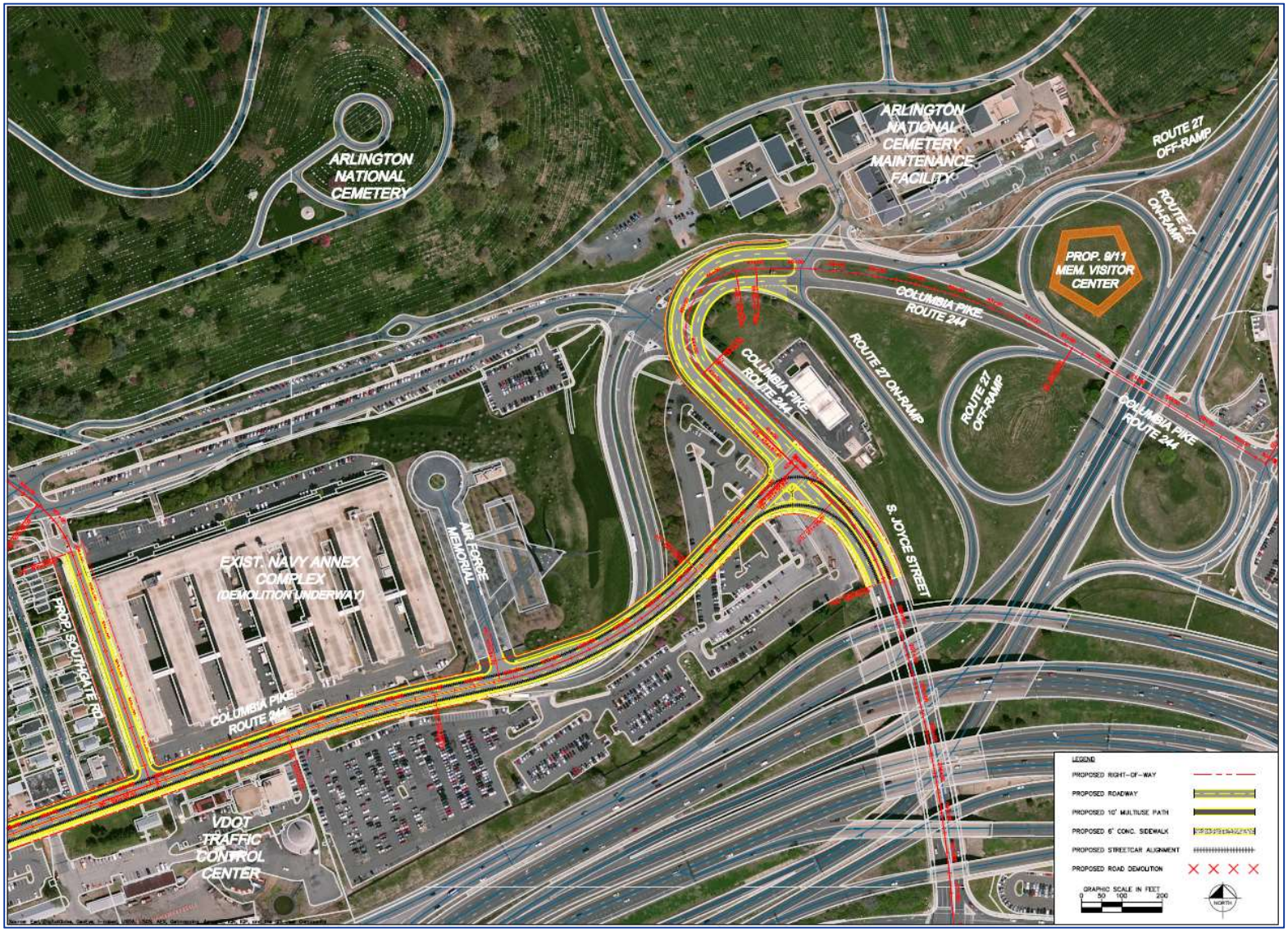
Original graphic as developed in 2014 by Kimley-Horn on behalf of Arlington County.

Figure 4-3: Alternative 3 (ACO 3) Concept



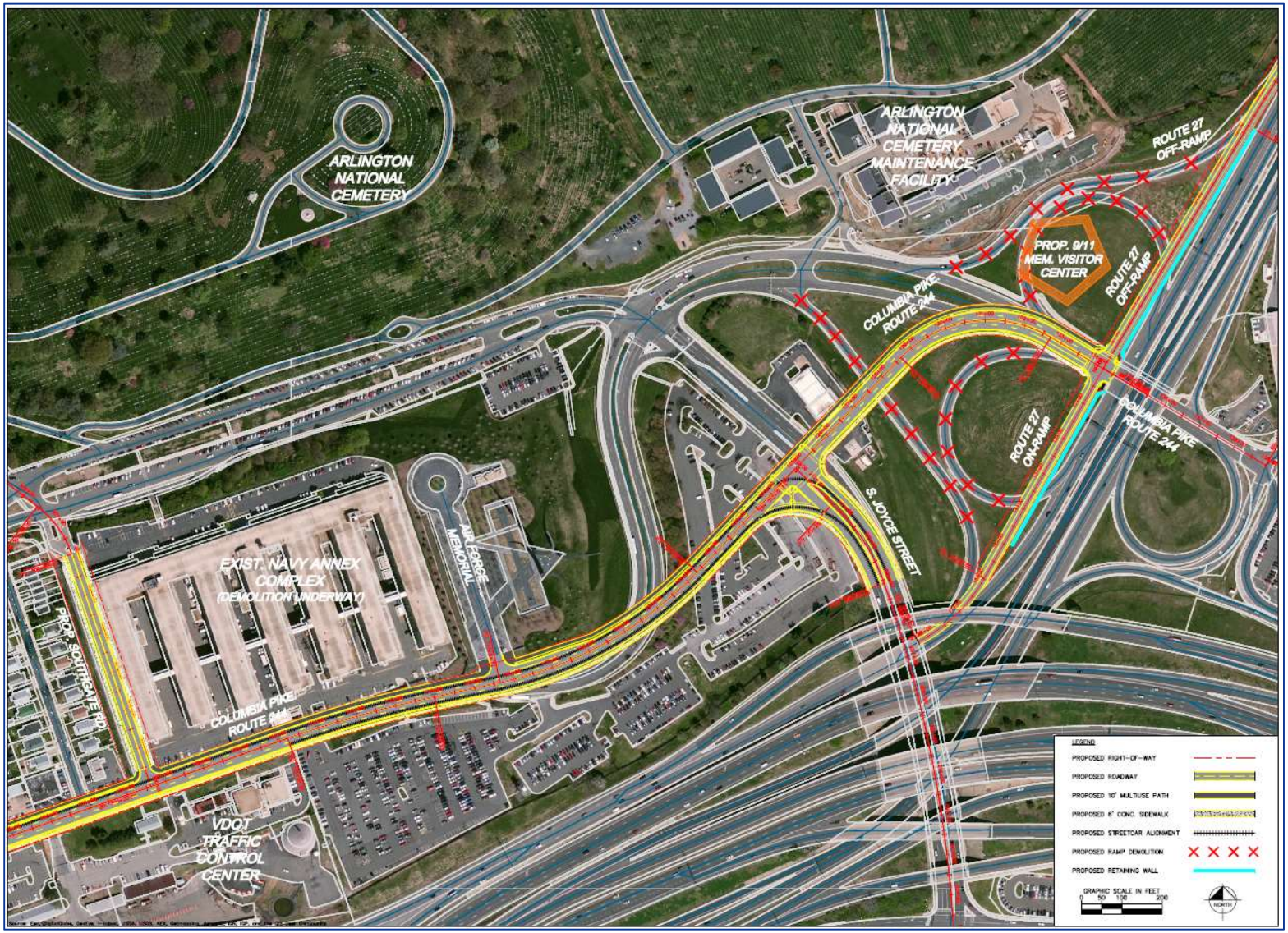
Original graphic as developed in 2014 by Kimley-Horn on behalf of Arlington County.

Figure 4-4: Alternative 4 (ACO 4) Concept



Original graphic as developed in 2014 by Kimley-Horn on behalf of Arlington County.

Figure 4-5: Alternative 5 (ACO 5) Concept

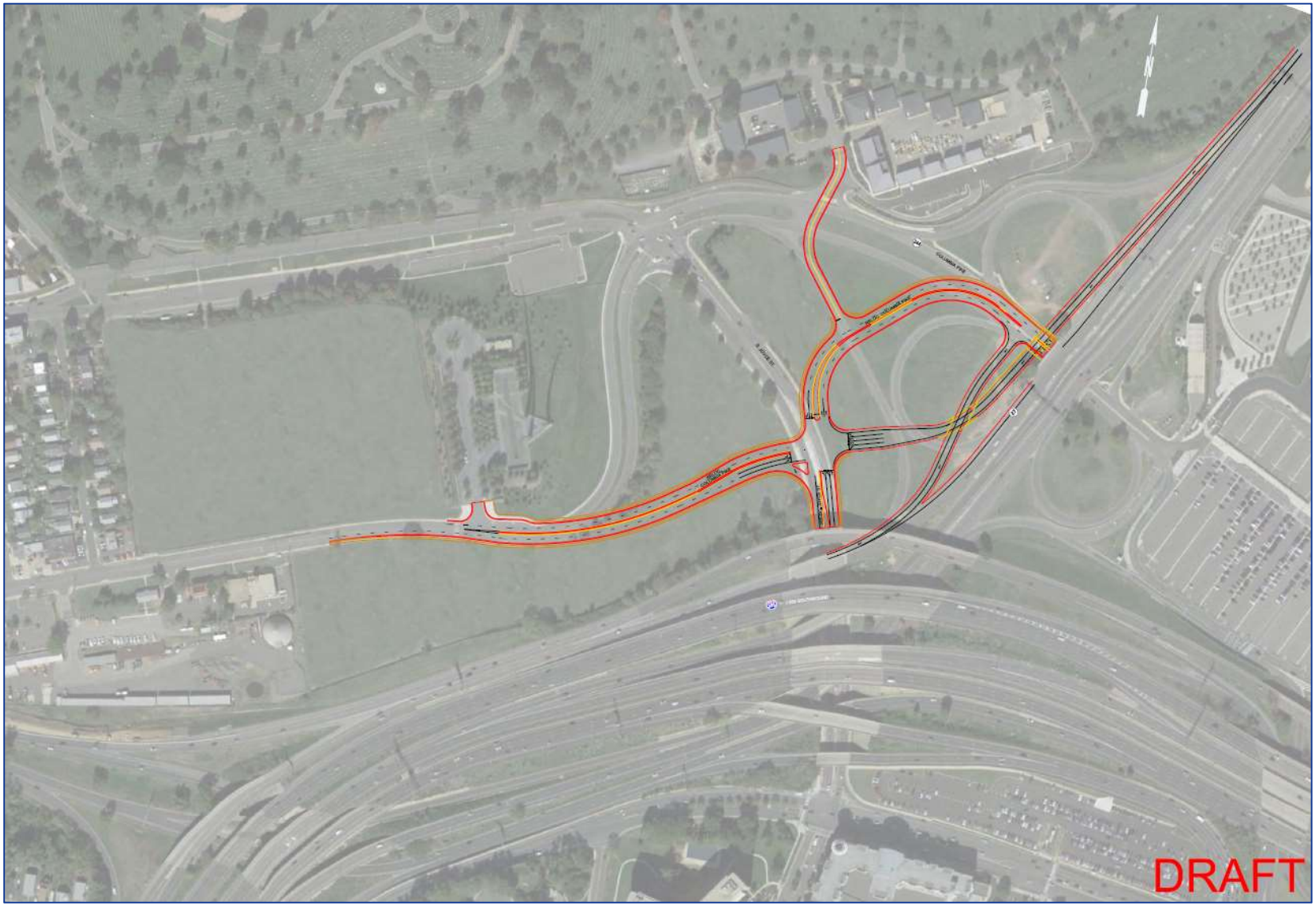


Original graphic as developed in 2014 by Kimley-Horn on behalf of Arlington County.

Figure 4-6: Alternative 6 (ANC 1) Concept

Original graphic as developed in 2014 by HNTB on behalf of ANC.

Figure 4-7: Alternative 7 (ANC 2) Concept



Original graphic as developed in 2014 by HNTB on behalf of ANC.

Figure 4-8: Alternative 8 (ANC 3) Concept

Original graphic as developed in 2014 by HNTB on behalf of ANC.

Figure 4-9: Alternative 9 (ANC 4) Concept

Original graphic as developed in 2014 by HNTB on behalf of ANC.

Figure 4-10: Fatal Flaw Analysis

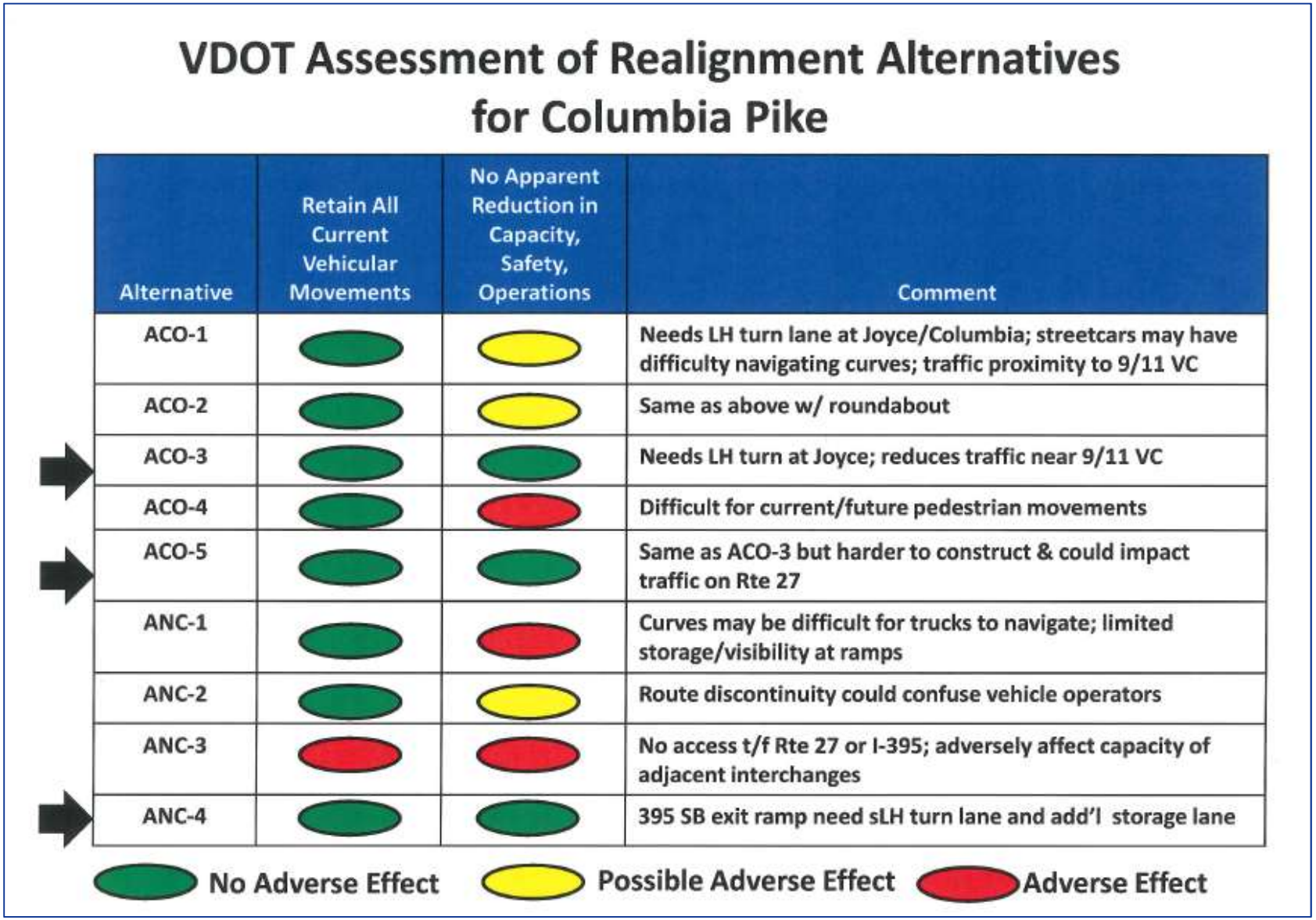


Figure 4-11: High-Level Screening of Alternative Matrix of Partial Set of Alternatives

As of September 22, 2014

High-Level Screening of Alternatives: Columbia Pike Realignment and Columbia Pike/Washington Boulevard Interchange Modification

	Traffic Operations (A)					Geometric Considerations (B)		Land Use Impacts (C)				Streetcar Accommodations (D)			Multi-modal Connectivity (E)		Feasibility (F)		
Evaluation Criteria / Alternatives	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	Interchange Operations	Columbia Pike Operations	Access Management	Multimodal Safety	I-395/Washington Blvd Mainline Ops	Potential DEs/DWs	Sight Distance	ANC Contiguous Land Expansion	Cultural/Heritage Center	9/11 Memorial Visitor's Center	Public Parking (for memorials etc.)	Streetcar Turning Radius	Streetcar Maintenance Facility	Streetcar Grade Restrictions	Along Columbia Pike	Sub-regional	Constructability	Maintainability	Delivery Schedule
ANC 1	×	○	○	●	○	×	○	○	●	●	●	●	×	●	○	●	●	●	●
ANC 2	○	○	●	○	●	○	●	○	●	●	●	●	×	●	●	●	●	○	○
ANC 4	○	○	○	●	●	●	●	●	●	●	●	●	×	●	●	●	●	●	●
ACO 3	○	○	○	●	●	●	●	○	●	●	●	●	●	●	●	●	●	●	●
No Build	○	●	●	○	●	●	●	×	●	×	●	●	●	○	●	●	N/A	●	N/A

● = CRITERIA MET, NO SIGNIFICANT ISSUES ○ = CRITERIA PARTIALLY MET, CONCERNS × = CRITERIA NOT MET, CONSTRAINTS

The results of stakeholder's consensus from the fatal flaw and screening exercises are as follows:

- ACO 1 was recommended to be dismissed from consideration due to lack of reasonable access to 9/11 Visitor Center.
- ACO 2 was recommended to be dismissed from consideration due to lack of reasonable access to 9/11 Visitor Center.
- ACO 3 was identified as the County's preferred alternative and VDOT concurred that a tight diamond is their preferred ramp configuration.
- ACO 4 was recommended to be dismissed from consideration as it did not address the purpose and needs identified in this IMR process
- ACO 5 was identified as a design variant (i.e. relative to how "tight" the diamond was) of ACO 3. It was recommended that this alternative be dismissed as a standalone concept.
- ANC 1 was recommended for further consideration although Arlington County noted concerns with the ability to accommodate future transit options along the corridor and VDOT indicated that the alternative was less desirable due to the lack of truck storage areas and the suitability of the designed curves for truck movements
- ANC 2 was recommended for further consideration although Arlington County noted concerns with the ability to accommodate future transit options and VDOT indicated concerns with the configuration disorienting drivers and being difficult to sign appropriately.
- ANC 3 was recommended to be dismissed due to the lack of connectivity between Washington Boulevard and Columbia Pike and the inconsistencies with the Pentagon Master Plan.
- ANC 4 was identified as a design variant (i.e. relative to how "tight" the diamond was) of ACO 3. It was recommended that this alternative be dismissed as a standalone concept.

4.3. Transportation System Management Options

Transportation system management options, such as HOV lanes, ITS, ramp metering and transit, are recognized traffic operation improvement and mitigation strategies currently employed in the study area or in the immediate region. It is anticipated that further transportation system management options could be implemented as interim steps to address degrading operational performance. Ramp metering and ITS deployment (dynamic message signs, for example) could be deployed individually or as part of an Integrated Corridor Management strategy to improve Washington Boulevard and I-395 operations. It is noted however that none of these options would achieve the goal of providing more contiguous burial space for ANC, which is part of the purpose and need statement.

4.4. Proposed Interchange Access

Following further stakeholder coordination and upon review of the high-level screening and fatal flaw analysis, the stakeholders generally concurred on a tight diamond concept for the interchange but differed on the preferred Columbia Pike alignment near the Air Force Memorial and the Southgate Road/S. Joyce Street intersection. Arlington County refined the tight diamond concept and produced ACO 3.3, the preferred build alternative of this IMR, which, in comparison to the original ACO 3, reduces the land area south of Columbia Pike while maintaining a usable parcel for Arlington County, minimizes impacts to the Air Force Memorial entrance, and maximizes the contiguous area north of Columbia Pike for ANC while allowing for a future transit alternative along S. Joyce Street and Columbia Pike. It is noted that based on the combined stakeholder coordination, all realistic build alternatives are variants of a tight diamond and would not result in significantly different analytical results. For that reason, only the refined ACO 3.3 design is further evaluated in this analysis.

The preferred alternative is a solution that maximizes the amount of contiguous interment space for ANC by realigning Columbia Pike, relocating Southgate Road, and modifying the northwest and southwest quadrant ramps of the interchange to form a tight diamond. Design elements include:

- Realigning Columbia Pike between Washington Boulevard and the proposed new road connection of S. Nash Street to be located east of existing S. Oak Street, along the western edge of the old Navy Annex property. At the Columbia Pike and S. Joyce Street intersection, the northbound approach of this intersection has dual left-turn lanes and the westbound approach has a single left-turn lane.
- Relocating the southbound terminus of S. Southgate Road to S. Nash Street.
- Demolishing the Washington Boulevard southbound cloverleaf interchange ramps and replacing these ramps with a directional southbound off-ramp from Washington Boulevard and a directional southbound on-ramp from Columbia Pike that meet at a signalized intersection with Columbia Pike.

It is noted that the preferred alternative has been refined since the time of the original IMR to better align with the ANCSE and DAR projects. Through close coordination between stakeholders and the design engineers for both the ANCSE and DAR projects, the alignment of Columbia Pike has been adjusted to accommodate the location of the proposed boundary wall for the Cemetery which was set previously during preliminary engineering efforts. Refining of the preferred alternative also included slight adjustments to the alignments of the on and off ramps at the Washington Boulevard interchange, which was done both to accommodate the desired boundary wall location for ANC and preliminary site layout and access to the proposed Pentagon Memorial Fund 9/11 V VEC. It is noted that the final location and configuration of the driveways serving the VEC will be subject to the review and approval of Arlington County and requires justification in an access management waiver submitted for VDOT review and approval per IIM-LD-200.9.

The off-ramp has also been modified to a three-lane approach to accommodate a single left turn lane and dual right turn lanes. The specific lane configuration and phasing at the ramp terminal will continue to be refined as part of the DAR project. To accompany the dual rights, 15’ receiving lane widths are used on westbound Columbia Pike to aid in those turning movements. Of course, this addition poses concerns for pedestrian safety, so to help mitigate that concern crossings were added on both the southern and eastern legs of the intersection providing an alternate route for pedestrians.

Along with the alignment adjustments were minor intersection updates, namely to the Columbia Pike/Joyce Street intersection. The previous iteration of the preferred alternative included a single receiving lane for left turns made from westbound Columbia Pike onto southbound S. Joyce Street. Advancing the design and testing turning movements for the design vehicle, a WB-67 in this case (used by ANC to deliver materials to the Operations Complex), it was determined that two receiving lanes are needed on S. Joyce Street in this location. In turn, this means that the previously shown free-flow add lane for right turns onto southbound S. Joyce Street from eastbound Columbia Pike has been adjusted to a yield-condition angled slip lane.

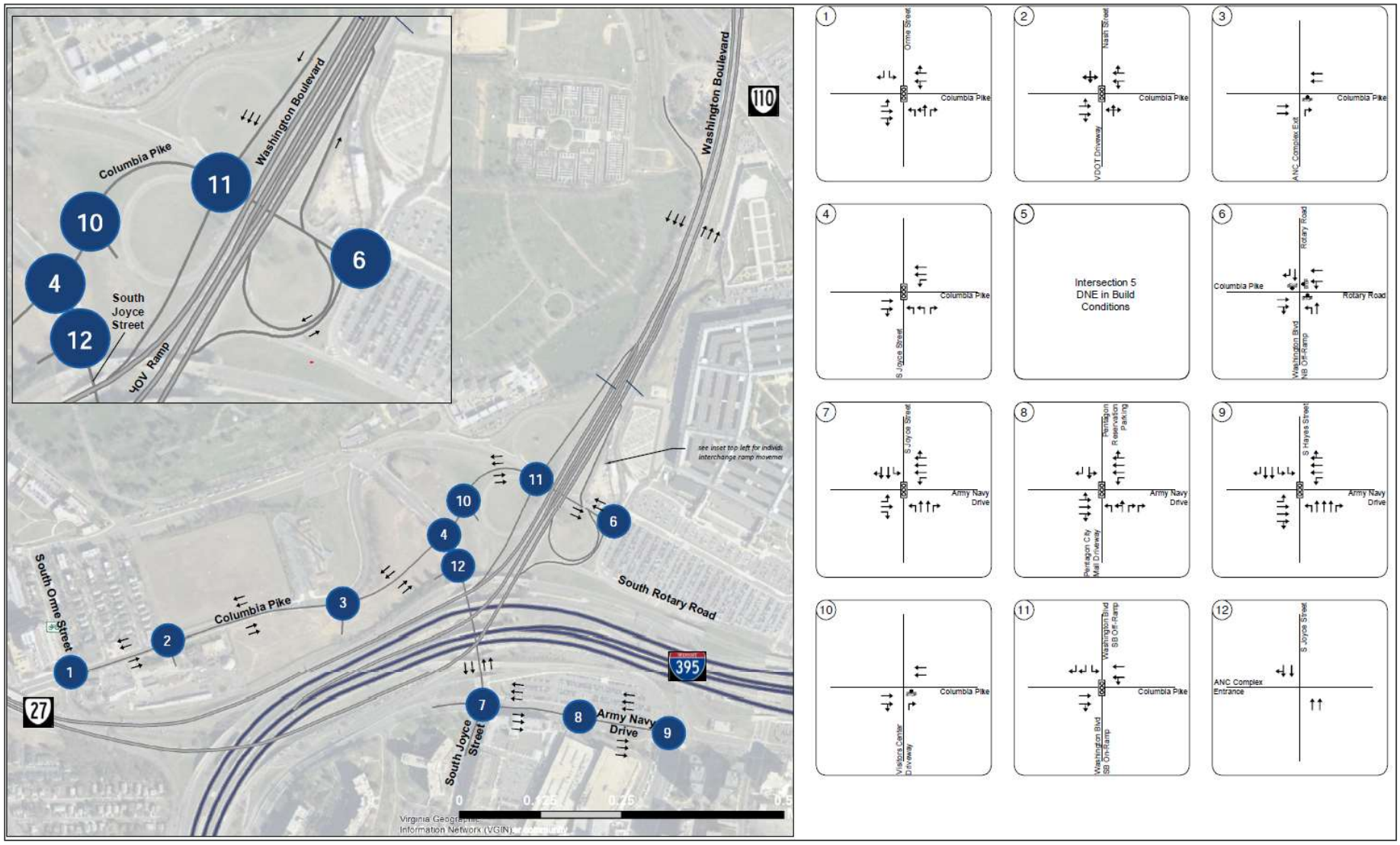
The most up to date preferred build alternative (corresponding to 40 percent preliminary plans) is shown in **Figure 4-12**.

The preferred build alternative assumes the signalization of the new ramp terminal. The overall study area analysis also assumed 1) the signalization of Columbia Pike and the new S. Nash Street, 2) modifications to the signal timing/phasing at Columbia Pike and Joyce Street, and 3) a signalized pedestrian crossing to the Air Force Memorial. It is noted that signal warrant analyses and/or signal justification reports and other required documentation will be address in later phases of the overall ANC DAR project.

The study area lane configurations associated with the build conditions is shown in **Figure 4-13**.

Figure 4-12: Preferred Build Alternative

Figure 4-13: Future Build Lane Configuration



5. Roadway Geometry

5.1. Geometric Criteria and Preferred Build Conceptual Design Plan

The design and geometric criteria for the existing network and the preferred alternative is described in the following sections. Conceptual design plans were developed in accordance with the following applicable guidelines:

- A Policy on Geometric Design of Highways and Streets (AASHTO 2018, 7th Edition)
- VDOT Road Design Manual, Volume 1 (VDOT 2019)
- VDOT Road and Bridge Standards (VDOT 2016)
- Roadside Design Guide, 3rd Edition (AASHTO 2011, 4th Edition)
- Access Management Manual, Second Edition (TRB 2014)

Design criteria and guidance from these documents were applied to roadways within the project limits based on functional classification and roadway design speeds. The proposed design assumes a WB-67 as the design vehicle to determine the design impacts of the turning radii. **Table 5-1** and **Table 5-2** summarize the AASHTO design criteria for each roadway within the project limits. **Table 5-3** and **Table 5-4** summarize the VDOT design criteria for each roadway within the project limits. It is noted that these four tables show the typical recommended design criteria from each source/agency based on the type of roadway under consideration. It is noted that there is some variance between the two sources. The design criteria used for the preferred build alternative was informed by these two sources and negotiated through careful consideration with project partners and stakeholders to align with purpose and need of the interchange modification and the many other ongoing projects in the immediate vicinity. The preferred build alternative focused on improvements along the ramps between southbound Washington Boulevard and Columbia Pike.

5.1.1. Design Waivers/Exceptions

As design has progressed, there are several design exceptions or waivers that will need to be considered as the final design process gets underway. As part of the overall project goal of multimodal mobility within and to/from the Columbia Pike corridor, Arlington County in conjunction with FHWA EFLHD, ANC, and VDOT, has proposed a shared-use path connection heading northeast from the Washington Boulevard interchange along Washington Boulevard to Route 110 be implemented as part of the DAR project and the ramp relocations. This shared-use path connection is seen as being mutually beneficial to many stakeholders and tourists and is now included in the overall design. However, physical constraints in the area of the interchange limit the space in which the shared-use path can be placed. As currently proposed, the shared-use path connection will run along the western side of the proposed off-ramp at the Washington Blvd/Columbia Pike interchange. With 16 feet available from the face of proposed curb to the boundary wall along the ANC property, the shared-use path will be protected by concrete barrier along the edge of shoulder, behind which is proposed a 2’ shoulder on either side of the 10’ paved shared use path. It is noted that if a barrier is needed, the curb would be removed, and the shoulder would be paved to the face of the safety shape per AASHTO Roadside Design Guide Chapters 5 and 10. Having a 2’ horizontal clearance to vertical obstructions instead of the 3’ horizontal clearance will require a design waiver from VDOT. If a minimum 2’ clearance on each side of the shared-use path is maintained on a barrier-separated facility, a design exception will likely not be required.

Table 5-1: AASHTO Design Criteria – Network Roadways

Criteria	Columbia Pike	Southgate Road/S. Nash Street	S. Joyce Street	Army Navy Drive	Washington Boulevard
Functional Classification	Other Principal Arterial	Local Road	Minor Arterial	Major Collector	Other Freeway
Terrain	Rolling	Rolling	Rolling	Rolling	Rolling
Design Speed	25 mph	25 mph	35 mph	40 mph	50 mph
Posted Speed	25 mph	25 mph	35 mph	35 mph	45 mph
Number of Lanes	2 each direction	1 each direction	2 each direction	2-3 each direction	2 each direction
Minimum Width, Travel Lane	12' at interchange; 11' elsewhere	10'	11'	11'	12'
Minimum Width, Vehicle/Bike	--	--	--	--	--
Paved Shoulder Widths	--	--	--	--	LT: 4' RT: 10'
Graded Shoulder Widths	--	--	--	--	LT: 4' RT: 10'
Normal Cross Slope	2%	2%	2%	2%	2%
Minimum Radius	250'	250'	533'	533'	758'
Maximum Superelevation	4%	4%	4%	4%	8%
Minimum Stopping Sight Distance	215'	215'	333'	354'	474'
Maximum Grade	9%	8%	8%	10%	5%
Minimum Median Width	10'	--	10'	18'	10'
Clear Zone	As much space as practical	--	As much space as practical	As much space as practical	20'
Minimum Vertical Clearance	16'	14'	16'	14'	16'
Sidewalk Width	5'	5'	5'	5'	--
Sidewalk Buffer Width	--	--	--	--	--
Access Management Spacing/Limits of Limited Access**	200'	200'	200'	200'	--
Ramp Terminal Spacing***	--	--	--	--	1000'/2000'

Notes:
**Denotes minimum spacing between unsignalized access points.
***Larger value is minimum for weaving areas not part of a cloverleaf interchange. Smaller value is for all other areas.

Table 5-2: AASHTO Design Criteria – Network Ramps

Criteria	Columbia Pike EB to Washington Boulevard WB	Washington Boulevard WB to Columbia Pike EB	Columbia Pike EB to Washington Boulevard NB	Washington Boulevard NB to Columbia Pike	Columbia Pike WB to Washington Boulevard NB	Columbia Pike WB to Washington Boulevard WB	Washington Boulevard WB to Columbia Pike WB
Functional Classification	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp
Terrain	Rolling	Rolling	Rolling	Rolling	Rolling	Rolling	Rolling
Number of Lanes	1	1	1	2	1	1	1
Minimum Width, Travel Lane	16'	16’	16’	28’	16'	16’	16’
Paved Shoulder Widths	LT: 2' RT: 8'	LT: 2' RT: 8'	LT: 2' RT: 8'	LT: 2' RT: 8'	LT: 2' RT: 8'	LT: 2' RT: 8'	LT: 2' RT: 8'
Graded Shoulder Widths	LT: 4' RT: 10'	LT: 4' RT: 10'	LT: 4' RT: 10'	LT: 4' RT: 10'	LT: 4' RT: 10'	LT: 4' RT: 10'	LT: 4' RT: 10'
Normal Cross Slope	2%	2%	2%	2%	2%	2%	2%
Minimum Radius	314'	214'	134'	314’	314’	214’	214’
Maximum Superelevation	8%	8%	8%	8%	8%	8%	8%
Minimum Stopping Sight Distance	237’	205'	147'	271'	250'	200’	205’
Maximum Grade	6%	7%	8%	6%	6%	7%	7%
Clear Zone	14’	14’	14’	14’	14’	14’	14’
Minimum Vertical Clearance	16'	16'	16'	16'	16'	16'	16'

Table 5-3: VDOT Design Criteria

Criteria	Columbia Pike	Southgate Road/S. Nash Street	S. Joyce Street	Army Navy Drive	Washington Boulevard
Functional Classification	Urban Other Principal Arterial	Urban Local Road	Urban Minor Arterial	Urban Major Collector	Other Freeway
VDOT Standard	GS-5	GS-8	GS-6	GS-7	GS-5
Terrain	Rolling	Rolling	Rolling	Rolling	Rolling
Design Speed*	25 mph	25 mph	40 mph	40 mph	50 mph
Posted Speed	25 mph	25 mph	35 mph	35 mph	45 mph
Number of Lanes	2 each direction	1 each direction	2 each direction	2-3 each direction	2 each direction
Minimum Width, Travel Lane	12' at interchange; 11' elsewhere	10'	11'	11'	12'
Minimum Width, Vehicle/Bike Shared Lane	--	12'	--	--	--
Paved Shoulder Widths	--	--	--	--	LT: 4' RT: 10'
Graded Shoulder Widths	--	--	--	--	LT: 12' RT: 12'
Normal Cross Slope	2%	2%	2%	2%	2%
Minimum Radius	273'	273'	593'	593'	760'
Maximum Superelevation	2%	2%	2%	2%	8%
Minimum Stopping Sight Distance	200'	200'	305'	305'	425'
Maximum Grade	9%	8%	8%	10%	5%
Minimum Median Width	15'	15'	15'	15'	10'
Clear Zone	See RDM A-28	See RDM A-28	See RDM A-28	See RDM A-28	20'
Minimum Vertical Clearance	16.5'	16.5'	16.5'	16.5'	16.5'
Sidewalk Width	5'	5'	5'	5'	--
Sidewalk Buffer Width	4'	--	--	4'	--
Access Management Spacing/Limits of Limited Access	X = 750'; Y = 1320'; M = 990'	--	--	--	--
Ramp Terminal Spacing	--	--	--	--	1000'/2000'

Table 5-4: VDOT Design Criteria – Network Ramps (Design Criteria GS-R)

Criteria	Columbia Pike EB to Washington Boulevard WB	Washington Boulevard WB to Columbia Pike EB	Columbia Pike EB to Washington Boulevard EB	Washington Boulevard EB to Columbia Pike	Columbia Pike WB to Washington Boulevard EB	Columbia Pike WB to Washington Boulevard WB	Washington Boulevard WB to Columbia Pike WB
Functional Classification	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp	Freeway Ramp
Terrain	Rolling	Rolling	Rolling	Rolling	Rolling	Rolling	Rolling
Number of Lanes	1	1	1	2	1	1	1
Minimum Width, Travel Lane	16'	16’	18’	28’	16'	16’	16’
Minimum Width, Vehicle/Bike	--	--	--	--	--	--	--
Paved Shoulder Widths	LT: 4' RT: 8'	LT: 4' RT: 8'	LT: 4' RT: 8'	LT: 4' RT: 8'	LT: 4' RT: 8'	LT: 4' RT: 8'	LT: 4' RT: 8'
Graded Shoulder Widths	LT: 6' RT: 10'	LT: 6' RT: 10'	LT: 6' RT: 10'	LT: 6' RT: 10'	LT: 6' RT: 10'	LT: 6' RT: 10'	LT: 6' RT: 10'
Normal Cross Slope	2%	2%	2%	2%	2%	2%	2%
Minimum Radius	316’	215'	135'	316’	316’	215’	215’
Maximum Superelevation	8%	8%	8%	8%	8%	8%	8%
Minimum Stopping Sight Distance	250’	200’	155’	250’	250’	200’	200’
Maximum Grade	6%	7%	7%	6%	6%	7%	7%
Clear Zone	14’	14’	14’	14’	14’	14’	14’
Minimum Vertical Clearance	16.5'	16.5'	16.5'	16.5'	16.5'	16.5'	16.5'

Along Columbia Pike, due to ROW constraints, roadway signs may need to be placed in the landscaped strip between the outside travel lane and the cycle track and pedestrian oriented signs will need to be placed between the cycle track and the sidewalk. There is no buffer between the sidewalk and the boundary fence.

Along the ramp, if a 3' horizontal clearance cannot be maintained a design expectation will be submitted to VDOT for review and approval. Should approval not be granted, any proposed signs along the ramp will be relocated to the gore side of the roadway and overhang the appropriate lane.

It is also noted that the final location and configuration of the driveways serving the PMF VEC will be subject to the review and approval of Arlington County and requires justification in an access management waiver submitted for VDOT review and approval per IIM-LD-200.9.

5.1.2. Interchange Signing and Pavement Markings

A proposed conceptual interchange signing and pavement marking plan was developed for the preferred build concept. The conceptual plan, in addition to the signing plan, is included in **Appendix H.** The plan was developed to comply with current MUTCD and VDOT standards for interstate highways and other roadways. It is noted that some of the recommended signs are larger than the signs they are replacing. Prior to final design, mounting structures should be reviewed for appropriate wind loads to determine if the structures are appropriate to accommodate the recommended signage. Similarly, placement of any new or relocated signage should be reviewed to determine if there are ROW or easement needs.

It is noted that the signing plan included in the IMR is conceptual to demonstrate that a plan for signing the change in interchange operations can be provided in a clear manner. The final signing plan would developed as part ongoing plan set design. Additional opportunities to refine the signing plan per stakeholder review and comments will occur. Once again, should it later be determined, as a result of the continued refinement of the design plan, that the 3' clearance cannot be met, an alternate location for sign placement will be proposed and/or appropriate coordination with VDOT and other stakeholders will be initiated (up to and including just faction and preparation of any necessary design exceptions or waivers).

6. Traffic Volumes

6.1. Existing Traffic Volumes

As described in **Section 3.6**, AM and PM commuter peak hours were established to be weekdays, 7:45 – 8:45 AM and 5:00 – 6:00 PM, respectively. AM and PM peak hour volumes were shown in **Figure 3-4**.

6.2. Forecasting Methodology

Existing traffic count data and the MWCOG Version 2.3.75 regional travel model was used as resources to develop future year traffic forecasts. The methodology used to develop forecasted traffic volumes is described in the following sections.

6.2.1. Review and Calibration of Unmodified MWCOG Travel Demand Model Study Area Traffic and Demographics

The latest MWCOG travel demand model version (version 2.3.75) on the 3,722-traffic analysis zone (TAZ) system was reviewed in conjunction with Round 9.1 Cooperative Forecasts (socioeconomic data) for the Existing (2019), Opening (2025), and Design (2045) model years. The MWCOG model was strategically modified to improve the accuracy and reliability of forecasts within and near the study area, specifically for the Columbia Pike and Washington Boulevard corridors and roadways connected to the corridors. Modifications to the MWCOG model are discussed in **Appendix E**.

Calibration Criteria and Thresholds

Calibration targets were developed based on guidance from the FHWA Transportation Model Improvement Program (TMIP) Travel Model Validation and Reasonableness Checking Manual and the Virginia Travel Demand Modeling Policies and Procedures Manual (VTM). Because the MWCOG/TPB Model has already been vetted through FHWA's TMIP Peer Review process, the validation process for the model is focused on the "fit" to the project study area and includes the following comparisons:

- Regional comparisons to VDOT AADTs at the daily level
- Percent difference in total volume for cutlines
- Columbia Pike and Washington Boulevard study area comparisons to field traffic counts (AM/PM periods and daily)
- R-squared between modeled volumes and counts on links
- Percent difference in total volumes across links with counts
- Percent root mean squared error (%RMSE) across all links with counts

Table 6-1 provides a listing of the agreed-upon travel demand model calibration criteria.

Table 6-1. Travel Demand Forecast Model Calibration Criteria.

Calibration Scale	Calibration Check		Calibration Threshold
Regional	% Difference in Total Volume for Cutlines	Cutline Volume	
		50,000	10%
		100,000	10%
		150,000	10%
		200,000	8%
		250,000	7%
Study Area	R-Squared between modeled volume and counts on links		0.88
	% Difference in Total Volume Across All Links		10%
	% RMSE Across All Links		25%

The following cutlines, shown in **Figure 6-1**, were used in the calibration process:

- North Cutline
  - Washington Boulevard north/east of Route 110
  - Route 110 north/west of Washington Boulevard
  - George Washington Memorial Parkway north of I-395
- South Cutline
  - I-395 south/west of Washington Boulevard
  - Arlington Ridge Road south of I-395
  - US 1 north of 23rd St
  - George Washington Memorial Parkway south of I-395 and north of National Airport
- East Cutline
  - Theodore Roosevelt Bridge (I-66)
  - Memorial Bridge
  - 14th Street Bridge (I-395/US 1)
- West Cutline
  - US 50 (Arlington Boulevard) west of Washington Boulevard
  - Columbia Pike west of Washington Boulevard
  - I-395 south/west of Washington Boulevard

Figure 6-1. Travel Demand Model Calibration Cutlines

Calibration Data

Traffic counts used for the overall study traffic operations analysis were collected on weekdays in June 2019 prior to the end of the Arlington County school year. Several of these 48-hour mainline and ramp counts were used in the travel demand model calibration process. Field-collected traffic counts were used in the link-level travel demand model calibration wherever applicable. For cutlines, VDOT's 2018 count estimates[4] were used as comparison counts.

[4] https://www.virginiadot.org/info/resources/Traffic_2018/AADT_000_Arlington_2018.pdf

6.2.2. Travel Demand Model Edits

The following edits have been applied to the MWCOG model during the calibration process:

- Ramps have been micro-coded to improve forecasts and correlation to the microsimulation process (rather than showing each interchange as a diamond per MWCOG's default interchange coding format). This includes coding interchange turn restrictions where applicable to ensure that if there are multiple ramps between facilities, traffic uses the correct ramp and does not make illegal or otherwise illogical movements. Turn restrictions were enforced at the following interchanges:
  - Columbia Pike and Washington Boulevard (east)
  - Washington Boulevard and Route 110
  - Ramps from Pentagon and Pentagon City areas to and from I-395
- Link facility types were modified to better represent study area facilities as they exist and to improve loading of trips, including the following:
- Changing the facility type for Columbia Pike from "major arterial" to "minor arterial" east of Glebe Road.
- Changing the facility type for Washington Boulevard from "major arterial" to "freeway" between US 50 and its terminus near Route 110 and George Washington Memorial Parkway.
- Changing the facility type for US 50 (Arlington Boulevard) from "major arterial" to "expressway" east of Seven Corners; this designation was further modified to "freeway" near grade-separated interchanges along US 50.
- Centroid connector locations were modified/added/removed to improve loading of trips:
- The location of the centroid for the Pentagon was shifted to the south and west from its default position to improve loading of Washington Boulevard and associated ramps at the Columbia Pike interchange.

These edits are the results of an extensive process of testing and adjusting various parameters known to impact facility loading while still maintaining the integrity of the overall model processes and procedures. Calibration documentation is provided in **Appendix I**.

6.2.3. Travel Demand Model Calibration Results

Cutline Calibration

Table 6-2 shows the calibration results for the total volume across the four cutlines. All cutlines are meeting the calibration thresholds. A table showing comparisons of individual links across each cutline is provided in the **Appendix I.**

Table 6-2. Cutline Calibration Results

Cutline	Cutline Volume (Counts)	Cutline Volume (Modeled)	% Difference	Criteria	Meets?
#1: North	187,000	183,966	-1.6%	10.0%	Yes
#2: South	378,900	396,219	4.6%	7.0%	Yes
#3: East	356,661	354,624	-0.6%	7.0%	Yes
#4: West	395,000	381,040	-3.5%	7.0%	Yes

Study Area Link Calibration

Table 6-3 provides an overview of the link-level calibration results. The thresholds are being met across all links in the study area for which comparison counts are available. A full comparison of individual link volumes is provided in the **Appendix I.**

Table 6-3. Study Area Link Volume Calibration Results

Calibration Check	Model Outputs	Threshold		Meets?	n
R-squared between modeled volumes and counts on links	0.99	>=	0.88	Yes	11
% Difference in Total Volume Across All Links	8%	<=	10%	Yes	11
% RMSE Across All Links	18%	<=	25%	Yes	11

6.2.4. No-Build Volume Development Methodology

Future No-Build AM and PM peak hour volumes in the study area were developed based on available data from Arlington County and using a methodology agreed upon by project stakeholders. The available data included a recently-completed study for one of the developments associated with the Amazon campus (Multimodal Transportation Assessment [MMTA] for Metropolitan Park 6, 7, 8; published June 20, 2019 and prepared by Gorove Slade) as well as supplementary data provided by Arlington County.

The MMTA study includes trip generation rates and assumed mode share for office and retail uses associated with the first phase of the new Amazon planned development. As part of the MMTA study, 2.1 million square feet of office and 67,000 square feet of neighborhood retail was considered for traffic analysis zone (TAZ) 1493.

For analysis purposes, Arlington County indicated another 2.4 million square feet of office and another 123,000 square feet of neighborhood retail would be added to the Amazon campus by 2045 to serve the total 25,500 new employees brought to the area. Additionally, another 2.7 million square feet of office in Crystal City would be occupied due to the "Amazon effect" creating 12,000 new jobs in Crystal City. Estimated development levels were developed assuming a 200 square foot per employee in Crystal City and 160 square feet per employee on the Amazon Campus.

To maintain consistency with this previously-completed study, future No-Build traffic volumes for this IMR update were developed as follows:

- Run 2025 and 2045 updated MWCOG model scenarios without Amazon land use in place (using the currently-adopted Round 9.1 regional socioeconomic data forecasts).

The MWCOG model network and inputs have been updated where applicable to reflect changes made during the existing conditions MWCOG model calibration process, as documented in the August 30, 2019 memorandum on travel demand model calibration.

- Use *National Cooperative Highway Research Program (NCHRP)*[5] *Report 765* methodology to grow existing AM and PM peak hour traffic volumes to 2025 and 2045 peak hour traffic volumes using MWCOG model link volume outputs. This provides background traffic volumes in the study area.
- For the approved developments associated with the Amazon campus (located in MWCOG zones 1493 and 1501), apply the trip generation rates and mode share percentages from the Metropolitan Park MMTA study to the *total* new office and retail developments approved for each of those zones. This reflects a commitment from the developers to ensure a significant non-auto mode split. Trip generation and mode split tables are provided in **Appendix J**.

[5] National Cooperative Highway Research Program (NCHRP Report 765: Analytical Travel Forecasting Approaches for Project-Level Planning and Design. NCHRP. (2013).

- Assign traffic volumes for the Amazon-associated developments to the study area network using trip distributions from MWCOG model scenarios *with* the Amazon land use in place (using modified Round 9.1 forecasts provided by Arlington County).

The trip distributions for auto trips into and out of the Amazon area were reviewed at a jurisdictional level and are provided in **Appendix J**.

The localized trip distributions for roadways within the study area were developed using select link analyses conducted for the centroid connectors into and out of zones 1493 and 1501.

- The resulting total future No-Build traffic volumes are the sum of the background traffic volumes and the Amazon-associated traffic volumes. A breakdown of these traffic volumes for both 2025 and 2045 is provided in **Appendix J**.

6.2.5. Build Volume Development Methodology

The roadway network Build condition for this IMR are not anticipated to affect the levels of background traffic in the IMR study area. Some amount of existing traffic volumes in the study area must be reassigned to account for the following changes:

- **Relocation of existing ANC Service Complex** (currently located just north of Columbia Pike between S. Joyce Street and Washington Boulevard) to a new Operations Complex with a parking garage, which will be located south of Columbia Pike between S. Orme Street and S. Joyce Street. Access to the new Operations Complex will be provided via a right-out exit along eastbound Columbia Pike and via a right-in driveway along southbound S. Joyce Street; all driveway volumes for the ANC Service Complex under No-Build conditions will be rerouted to use the Operations Complex driveway under Build conditions.

Additional traffic volume to be attracted to the relocated facility and parking garage will be as described in a traffic study prepared by HNTB (and dated August 2019).

- **Closure of Southgate Road north of Columbia Pike**; access to Fort Myer and Henderson Hall previously provided by Southgate Road will be provided by a new facility, S. Nash Street, to be constructed parallel to and east of S. Oak Street. A new signalized intersection will be provided on Columbia Pike at S. Nash Street, with the existing VDOT driveway forming a fourth leg of this intersection on the south side of Columbia Pike. Trips previously turning onto and off Southgate Road will be re-routed to use Columbia Pike and Nash Street.

The August 2019 ANCSE traffic study notes that some of the trips heading northbound on Southgate Road in the AM peak and southbound on Southgate Road in the PM peak are trips utilizing the existing curb parking spaces on Southgate Road; these trips will be removed from the Columbia Pike/Nash Street re-routing and instead re-routed to the ANC Operations Complex garage as described in the August 2019 traffic study.

- **Removal of Air Force Memorial driveway north of Columbia Pike**; trips to this driveway will be re-routed to the ANC Operations Complex garage.
- **Realignment of Washington Boulevard southbound ramps to and from Columbia Pike**; all d trips destined for Columbia Pike eastbound or westbound will exit via the existing ramp to Columbia Pike westbound, which will tie into Columbia Pike at a signal. All trips from Columbia Pike to Washington Boulevard southbound will access via this signal as well.

No changes to volumes or traffic assignment are required for trips to or from Washington Boulevard northbound.

In addition to the volume reassignment, the development of the Pentagon 9/11 Memorial VEC is contingent on the realignment of Columbia Pike and the modification of interchange ramps. As such, this development is treated as an approved and unbuilt development that is tied to the Build scenario. One right in driveway and one right in, right out driveway along Columbia Pike are considered for this development. A second, delivery only, right-in, right-out driveway is planned along northbound S. Joyce Street. The traffic volumes for this site were developed and provided by the traffic consultant for the VEC, Gorove Slade. A high-level overview of trip generation is provided below, excerpted from a memorandum[6] prepared by the PMF VEC consultant:

- The 9/11 VEC plans to be open to the public 9:00 AM to 4:00 PM. Extended hours will be available to accommodate tour groups or special events beyond the typical public hours. Evening special events, when occurring, will begin after 6:00 PM. The 9/11 VEC will be open 360 days a year, closed for New Year's Day, July 4, Labor Day, Thanksgiving Day, and Christmas Day.
- The current visitation of the 9/11 Pentagon Memorial tops 1 million visitors per year. We anticipate an annual visitorship of about 900,000 to the VEC, 55% of whom are school-age children. Similar to how visitors arrive to the memorial today, it is anticipated that 35% of visitors will arrive by Metro, 55% by bus, and 10% by private vehicle. The visitors arriving by bus will either be dropped at the VEC bus-drop entrance or the Pentagon City Fashion Mall and transfer to the local shuttle from Pentagon City to the VEC. Visitors arriving by private vehicle will be able to utilize the VEC parking area. Visitors arriving via Metro will utilize the Pentagon City Metro station and transfer to the local shuttle from Pentagon City to the VEC.
- In most cases, trip generation for a site is developed using the latest edition of the Institute of Transportation Engineers' (ITE) Trip Generation Manual; however, there is no land use comparable to the VEC represented in the ITE Trip Generation Manual. Instead, the projected number of museum visitors per day, the projected number of conference center and special event attendees, and the projected number of employees and VEC staff were used to determine the number of anticipated trips generated by the site over the course of the day and during the AM and PM peak hours.
- Therefore, two trip generation scenarios were considered. (Typical Day – Includes daytime conference without evening special events and Event Day – Includes both daytime conference with evening special events).
- Assuming an equal distribution of trips throughout the year, and 360 operating days per year, a total of 2,500 visitors are expected per day. At this time, the operating hours of the exhibit space are anticipated to be 9:00 AM to 4:00 PM. The average length of a typical visit to the museum and memorial is estimated to be approximately 90 minutes, with 45 minutes spent at the VEC and 45 minutes spent at the memorial.
- inbound and outbound percentage of trips was estimated based on operating hours of the exhibit space, and the number of people expected to be on the VEC site at a given time. The design narrative notes that the exhibit area will accommodate a maximum of 350 visitors per hour; therefore, this occupancy has been assumed in the hourly distribution of trips to the site.
- Due to the VEC opening an hour earlier than the Smithsonian museums and other museums in the DC area, and the large number of school groups anticipated, the peak occupancy for this site is anticipated to occur slightly earlier than some other comparable sites. The patterns of the

[6] Pentagon Memorial Visitor Education Center – Site Design and Transportation. Gorove Slade. October 2019.

existing Pentagon 9/11 Memorial were also considered, but since the Memorial is open 24 hours, the typical visit patterns differ from what is anticipated at the VEC.

- As noted in the design narrative, approximately 300 conference events are anticipated for the VEC site per year. Attendance at these events is anticipated to be approximately 150 - 200 people and the majority of these events are expected to occur during the day. For these events, the arrival and departure pattern of conference attendees was assumed to be generally similar to that of a typical workday. The Hourly Distribution of Entering and Exiting Vehicle Trips from ITE Trip Generation Manual for Land Use 712 (Small Office Building) was used as a basis for hourly trips in and out of the site.
- The VEC will also be available for special event use during the evening, and the team anticipates approximately 15 evening dinner events per year with 300 guests. For this use, an hourly trip distribution from the ITE Trip Generation Manual was not available, so the inbound and outbound percentage of trips was estimated based on a typical schedule of events for an evening banquet. It was assumed that arrivals would increase from 5:00 PM to 7:00 PM, with approximately 85% of arrivals occurring during this time period. It was assumed that attendees would stay for approximately 4 hours and that 80% of departures occur between 9:00 PM and 11:00 PM.
- It is anticipated that approximately 30 staff/employees will be at the site at any given time.
- The resulting peak hour trip generation is shown in Table 6-4.

Table 6-4. PMF VEC Peak hour Vehicular Trip Generation Summary

Scenario	AM Peak Period			PM Peak Period		
	In	Out	Total	In	Out	Total
Typical Day	48 veh/hr	12 veh/hr	60 veh/hr	8 veh/hr	60 veh/hr	68 veh/hr
Event Day	48 veh/hr	12 veh/hr	60 veh/hr	44 veh/hr	60 veh/hr	104 veh/hr

In addition to the previously described modifications that were made to the 2015 travel demand model, the forecast models were also reviewed to determine if there were future planned transportation improvements or network refinements that should be considered. A review of regional jurisdictional plans was performed to check for any future roadway improvement or new construction projects not yet in the MWCOG model that could impact the future year travel demand network. These plans included MWCOG's CLRP, Arlington County's Capital Improvement Plan (CIP), Arlington County's Master Transportation Plan, and VDOT's Six-Year Improvement Program (SYIP). No additional projects refinements were identified to be included in the forecast year models.

Further details about the traffic forecasting methodology are included in **Appendix J.** Arlington County and VDOT concurred on the future traffic volumes used in this analysis. The resulting 2025 and 2045 future year, no-build and build traffic volumes are shown in Figure 6-2 to Figure 6-5**.** Additional volume figures which show the individual component volume that make up the 2025 and 2045 presented herein are included in **Appendix J**.

Figure 6-2: 2025 No-Build Traffic Volumes

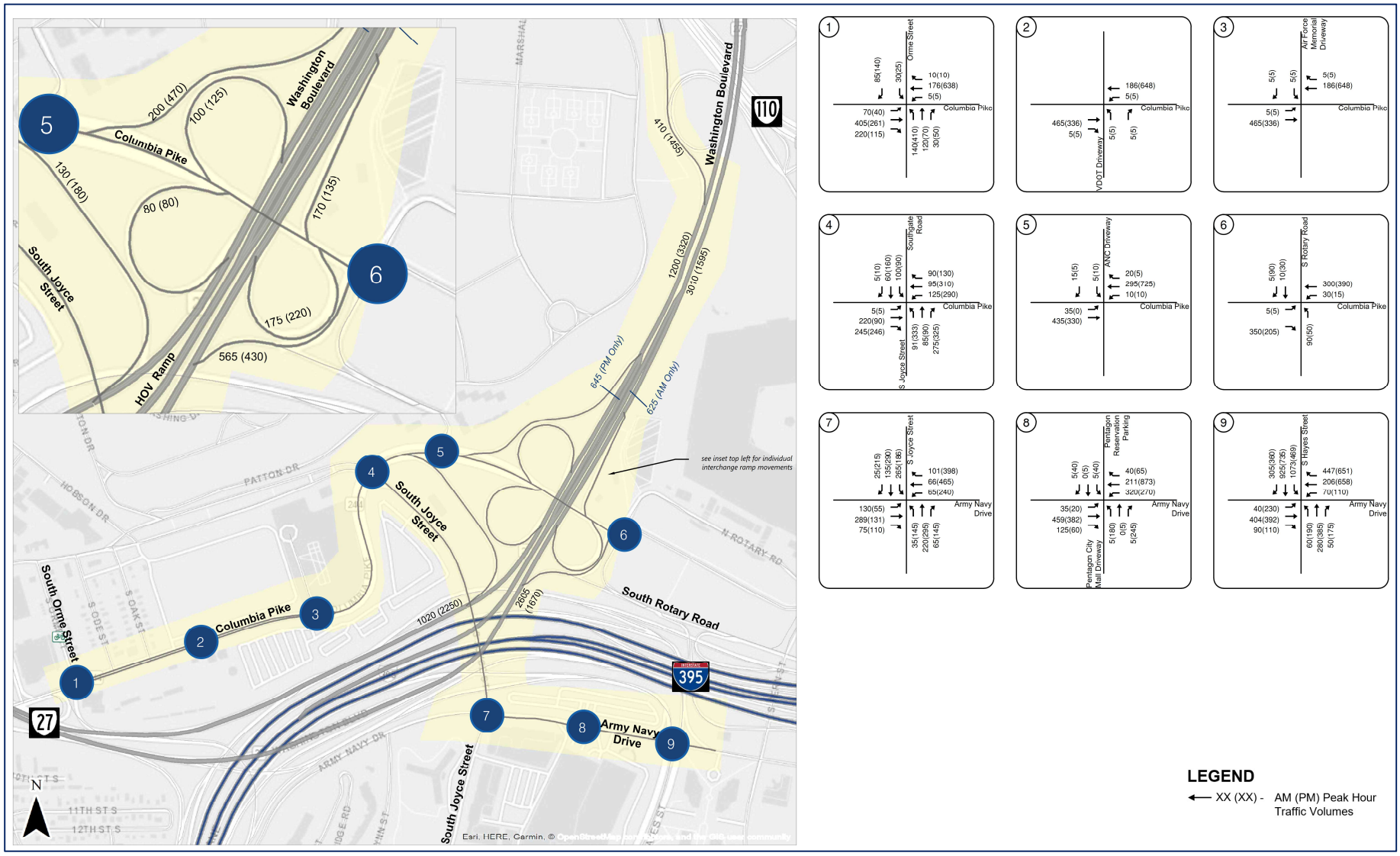


Figure 6-3: 2045 No-Build Traffic Volumes

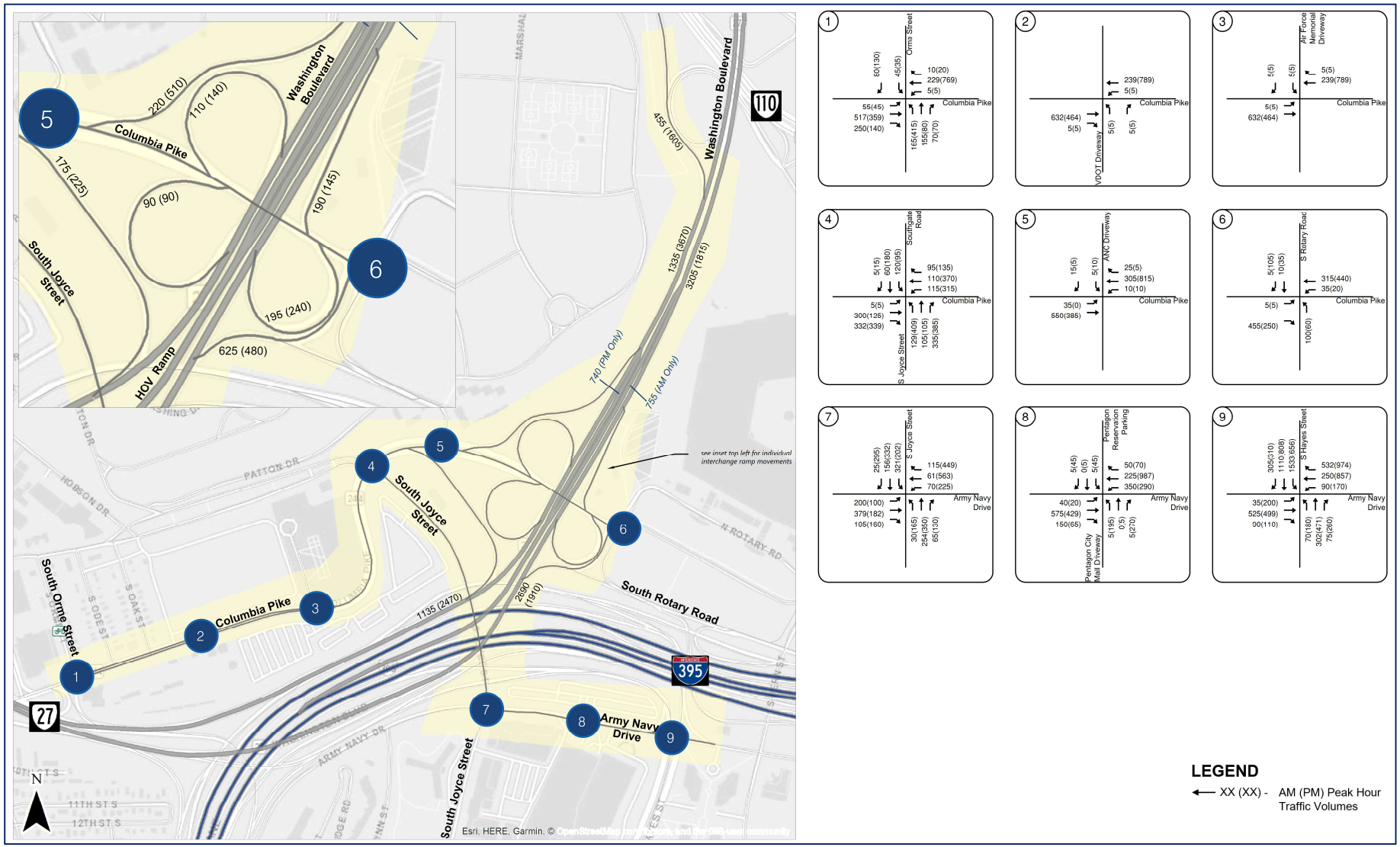


Figure 6-4: 2025 Build Traffic Volumes

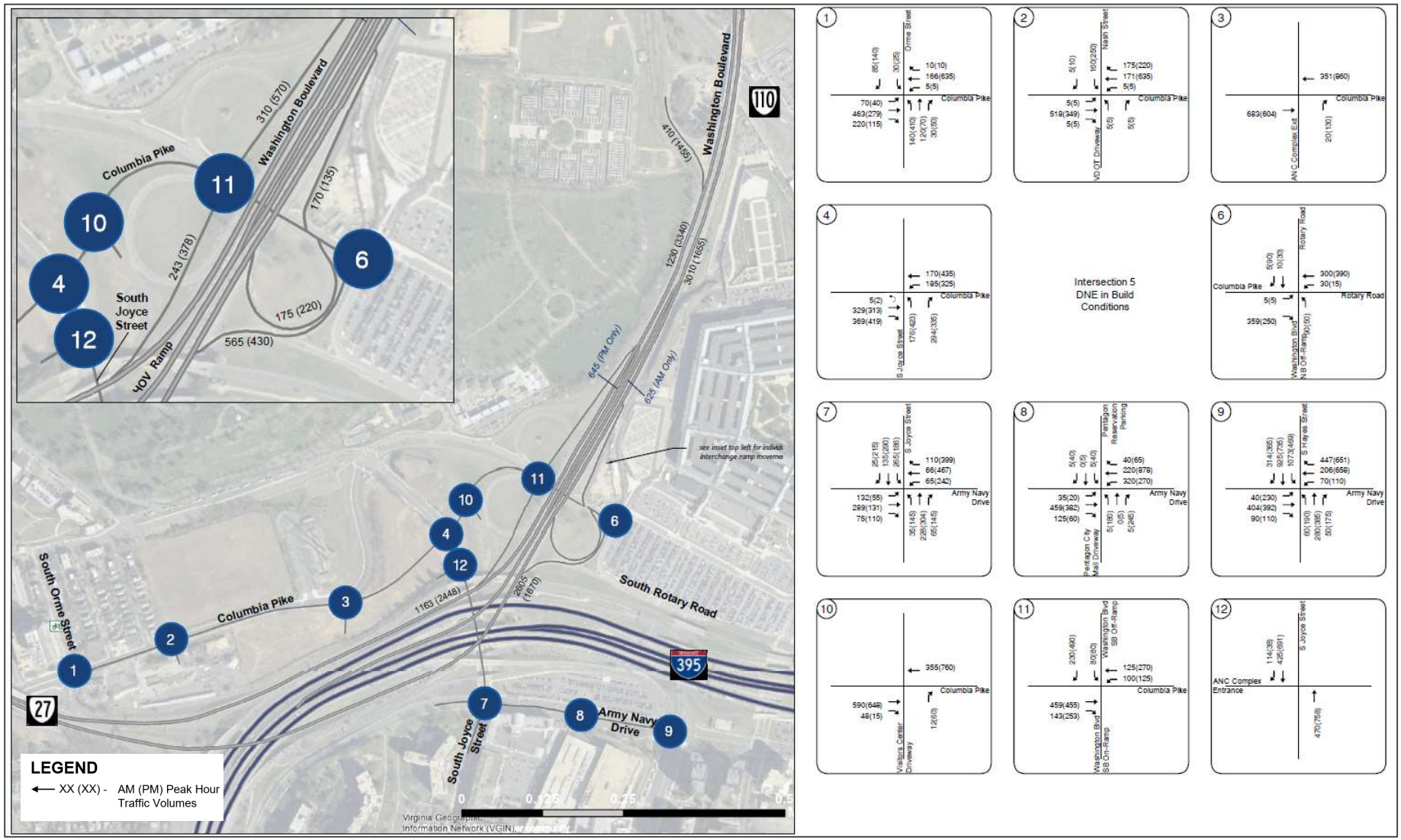
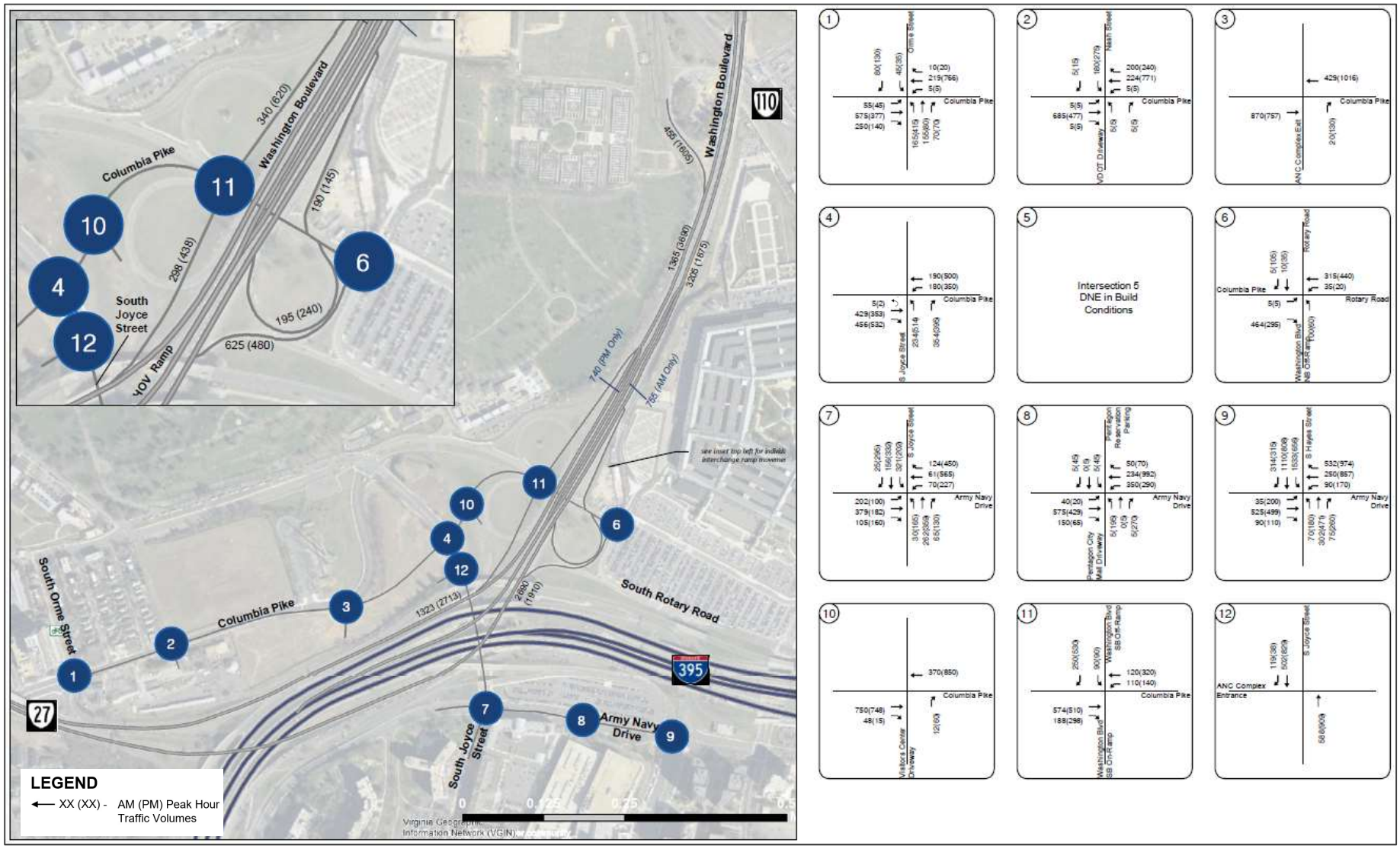


Figure 6-5: 2045 Build Traffic Volumes



7. Traffic Operations

7.1. Existing Conditions

The existing conditions operational analyses are summarized in detail in **Section 3.7**.

7.2. Future Conditions

The No-Build Conditions were analyzed for both 2025 and 2045.

In addition to the changes in land use associated with the Amazon campus, as well as the changes in land use and access assumed as part of the project Build alternative, the following background transportation improvements will be incorporated into the traffic forecasting and VISSIM models for both the 2025 and 2045 analysis years:

- Army Navy Drive Complete Streets[7]: multimodal transportation improvements along Army Navy Drive from its intersection with S. Joyce St to 12th St, including conversion of the right-most lane of traffic in each direction to a bus-only lane and construction of a cycle track on the south side of the roadway.
- I-395 Express Lanes extension[8]: additional lane and revised operations from HOV-3+ during peak periods to HOT-3+ between the Turkeycock interchange in Alexandria and S. Eads St in Arlington

The No-Build traffic models also include refinements to signal timing, phasing, coordination, and cycle lengths as appropriate and suitable for the forecasted traffic volumes. All refinements to future scenario signal timing were reviewed by Arlington County for compatibility with the traffic signal system adjacent to the study area. As a result of these refinements, certain future year traffic movements operate at improved levels of service than existing conditions, even with the increase in traffic volumes. The signal timings used in the analysis of future year conditions are just one example of timings that could be used to mitigate the impacts of future traffic growth. It is advisable to review, refresh, and develop signal timings periodically to enhance compatibility with field conditions. As a result, it is expected that the signal timings used in this study would be further vetted and refined prior to implementation in the field.

Specific improvements to the intersection of Army Navy Drive and S. Hayes Street/I-395 consists if the conversion of the southbound approach from I-395 to have two left turn lanes and two through lanes instead of a single left turn lane and three through lanes. It also consists of an increase in cycle length (by 30 and 20 seconds for the AM and PM peak periods, respectively).

No-Build and Build freeway speed and density results are provided in **Table 7-1** and **Table 7-2** and are shown in **Figure 7-1** to **Figure 7-16**. The tables are color-coded to match the gradation used on the speed and density maps (i.e. low speed/high densities are coded orange to dark red and high speed/lower densities are coded yellow to light green). No-Build and Build arterial intersection results are provided in **Table 7-3** and **Table 7-4**. The tables are color-coded to indicate intersection performance (i.e. equivalent LOS A to C, acceptable operations as green; equivalent LOS D and E, moderate operations as yellow and orange, respectively; and equivalent LOS F, unacceptable intersection operations, as red. No-Build and Build travel time results are provided in **Table 7-5** and **Table 7-6** and shown in **Figure 7-17** and **Figure 7-18**.

[7] https://projects.arlingtonva.us/projects/army-navy-drive-complete-street/
[8] http://www.virginiadot.org/projects/northernvirginia/395_express.asp

Table 7-1: AM Peak Hour Freeway and Ramps No-Build and Build Comparison

Facility	Segment	Type	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build
			Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)
Northbound Washington Boulevard	Mainline south of Columbia Pike	Diverge	29	28	28	18	18	29	31	32	48	49
	Off-ramp to Columbia Pike (EB and WB combined)	Ramp	28	28	28	28	28	18	20	19	21	21
	Off-ramp to Columbia Pike EB	Ramp	15	14	14	14	13	3	3	4	4	4
	Off-ramp to Rotary Road	Ramp	24	24	24	24	24	18	19	19	21	20
	Mainline between off-ramp to Columbia Pike and on-ramp from Columbia Pike EB	Basic	23	22	21	15	15	44	47	47	63	63
	On-ramp from Columbia Pike EB	Ramp	22	22	46	22	45	7	8	5	9	6
	Mainline between on-ramp from Columbia Pike EB and on-ramp from Columbia Pike WB	Merge	19	18	18	14	14	47	49	50	61	62
	On-ramp from Columbia Pike WB	Ramp	31	31	35	31	35	5	5	5	6	5
	Mainline between on-ramp from Columbia Pike WB and on-ramp from I-395 HOV	Merge	16	16	16	13	13	58	59	59	71	71
	Ramp from I-395 HOV NB to Washington Blvd NB	Ramp	31	31	32	25	26	20	20	20	30	29
	Mainline north of on-ramp from I-395 HOV	Basic	11	11	11	9	8	82	84	84	115	116
Southbound Washington Boulevard	Mainline north of on-ramp from Route 110 SB	Basic	49	49	48	49	48	5	5	6	6	6
	On-ramp from Route 110 SB	Ramp	48	48	48	48	48	8	9	9	9	9
	Mainline between on-ramp from Route 110 SB and off-ramps to Columbia Pike WB/I-395 HOV SB	Weave	52	52	52	52	52	5	6	6	6	6
	Ramp from Washington Blvd SB to I-395 HOV SB	Ramp	-	-	-	-	-	-	-	-	-	-

Facility	Segment	Type	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build
			Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)
	Off-ramp to Columbia Pike WB	Ramp	28	28	-	28	-	7	7	-	8	-
	Mainline between off-ramps to Columbia Pike WB/I-395 HOV SB and on-ramp from Columbia Pike WB	Basic	53	53	52	53	52	9	9	6	11	6
	On-ramp from Columbia Pike WB	Ramp	26	26	-	26	-	4	4	-	4	-
	Mainline between on-ramp from Columbia Pike WB and off-ramp to Columbia Pike EB	Weave	51	51	-	51	-	7	7	-	8	-
	Off-ramp to Columbia Pike EB	Ramp	24	24	-	23	-	3	4	-	4	-
	Mainline between off-ramp to Columbia Pike EB and on-ramp from Columbia Pike EB	Basic	52	52	53	52	53	9	10	9	11	10
	On-ramp from Columbia Pike EB	Ramp	30	30	-	30	-	4	4	-	6	-
	Mainline south of on-ramp from Columbia Pike EB	Merge	52	52	52	51	51	9	10	10	11	11
	Off-ramp to Columbia Pike	Ramp	-	-	52	-	51	-	-	6	-	7
	On-ramp from Columbia Pike	Ramp	-	-	46	-	45	-	-	5	-	6

Table 7-2: PM Peak Hour Freeway and Ramps No-Build and Build Comparison

Facility	Segment	Type	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build	Existing	2025 No-Build	2025 Build	2045 No-Build	2045 Build
			Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Speed (mph)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)	Density (veh/mi/ln)
Northbound Washington Boulevard	Mainline south of Columbia Pike	Diverge	43	43	43	43	43	12	13	13	15	15
	Off-ramp to Columbia Pike (EB and WB combined)	Ramp	29	29	29	29	29	14	15	15	16	16
	Off-ramp to Columbia Pike EB	Ramp	15	15	15	15	15	2	2	2	2	2
	Off-ramp to Rotary Road	Ramp	25	25	25	25	25	14	15	15	17	17
	Mainline between off-ramp to Columbia Pike and on-ramp from Columbia Pike EB	Basic	46	46	46	46	46	13	13	13	15	15
	On-ramp from Columbia Pike EB	Ramp	22	22	37	22	38	9	10	10	9	11
	Mainline between on-ramp from Columbia Pike EB and on-ramp from Columbia Pike WB	Merge	46	43	46	43	45	13	14	12	15	13
	On-ramp from Columbia Pike WB	Ramp	36	31	46	31	46	4	5	16	5	18
	Mainline between on-ramp from Columbia Pike WB and on-ramp from I-395 HOV	Merge	46	42	46	42	45	14	16	15	18	17
	Ramp from I-395 HOV NB to Washington Blvd NB	Ramp	-	-	-	-	-	-	-	-	-	-
	Mainline north of on-ramp from I-395 HOV	Basic	46	42	46	42	46	11	12	12	14	13
Southbound Washington Boulevard	Mainline north of on-ramp from Route 110 SB	Basic	41	42	33	41	33	14	15	19	17	21
	On-ramp from Route 110 SB	Ramp	42	46	42	46	42	32	31	35	35	38
	Mainline between on-ramp from Route 110 SB and off-ramps to Columbia Pike WB/I-395 HOV SB	Weave	31	44	43	41	42	26	18	19	22	22
	Ramp from Washington Blvd SB to I-395 HOV SB	Ramp	44	47	41	46	39	14	14	16	16	19
	Off-ramp to Columbia Pike WB	Ramp	25	26	-	22	-	17	18	-	27	-

Facility	Segment	Type	Existing Speed (mph)	2025 No-Build Speed (mph)	2025 Build Speed (mph)	2045 No-Build Speed (mph)	2045 Build Speed (mph)	Existing Density (veh/mi/ln)	2025 No-Build Density (veh/mi/ln)	2025 Build Density (veh/mi/ln)	2045 No-Build Density (veh/mi/ln)	2045 Build Density (veh/mi/ln)
	Mainline between off-ramps to Columbia Pike WB/I-395 HOV SB and on-ramp from Columbia Pike WB	Basic	43	46	45	46	44	24	24	24	26	26
	On-ramp from Columbia Pike WB	Ramp	26	26	-	26	-	5	5	-	5	-
	Mainline between on-ramp from Columbia Pike WB and off-ramp to Columbia Pike EB	Weave	44	46	-	45	-	16	17	-	19	-
	Off-ramp to Columbia Pike EB	Ramp	24	24	-	24	-	3	3	-	4	-
	Mainline between off-ramp to Columbia Pike EB and on-ramp from Columbia Pike EB	Basic	45	46	45	46	44	24	24	24	27	26
	On-ramp from Columbia Pike EB	Ramp	30	30	-	30	-	5	6	-	7	-
	Mainline south of on-ramp from Columbia Pike EB	Merge	36	36	35	35	33	29	31	32	34	37
	Off-ramp to Columbia Pike	Ramp	-	-	26	-	25	-	-	16	-	17
	On-ramp from Columbia Pike	Ramp	-	-	43	-	41	-	-	9	-	11

Figure 7-1: 2025 No-Build VISSIM Results - AM Peak Hour Speed

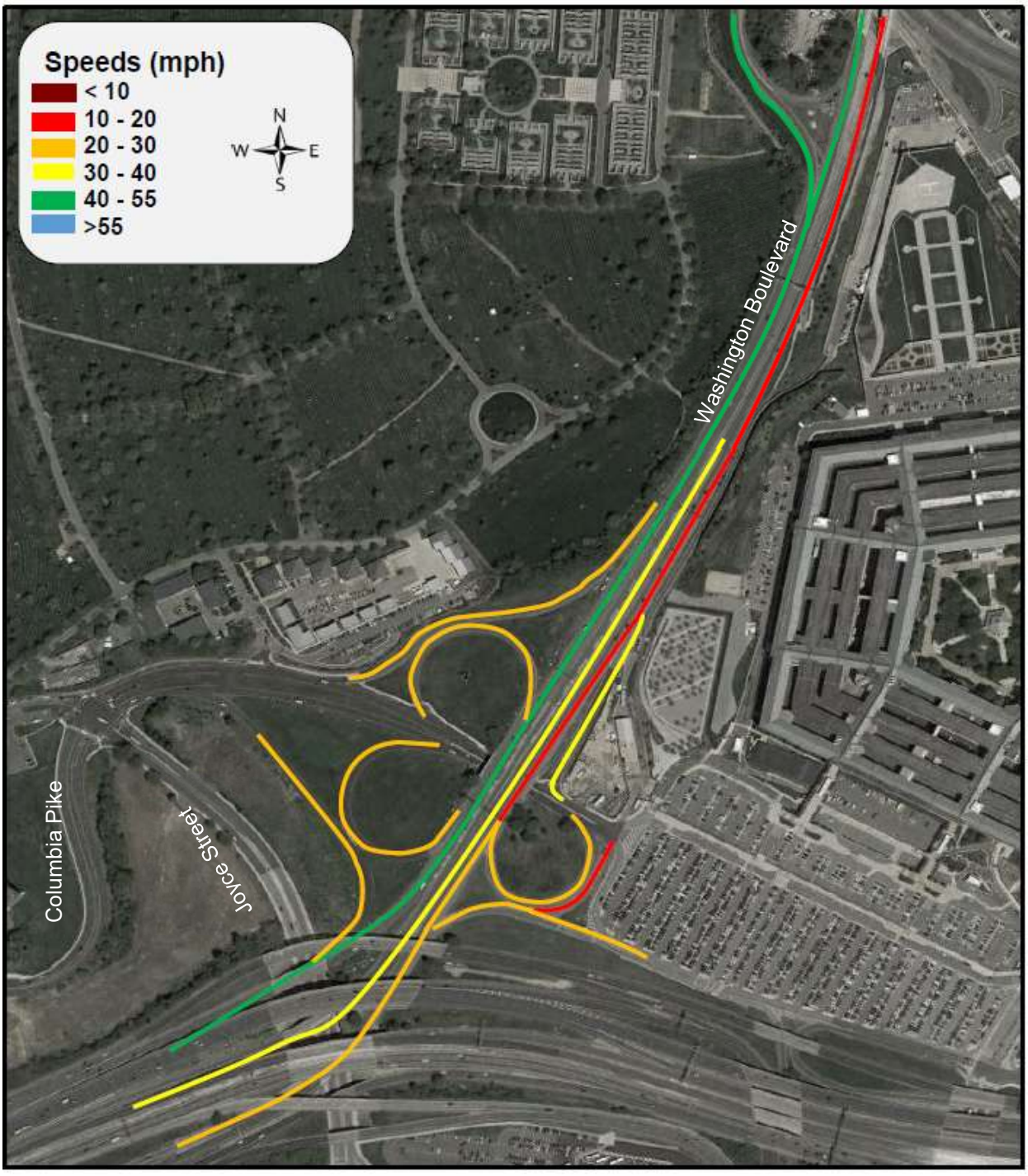


Figure 7-2: 2025 No-Build VISSIM Results - AM Peak Hour Density

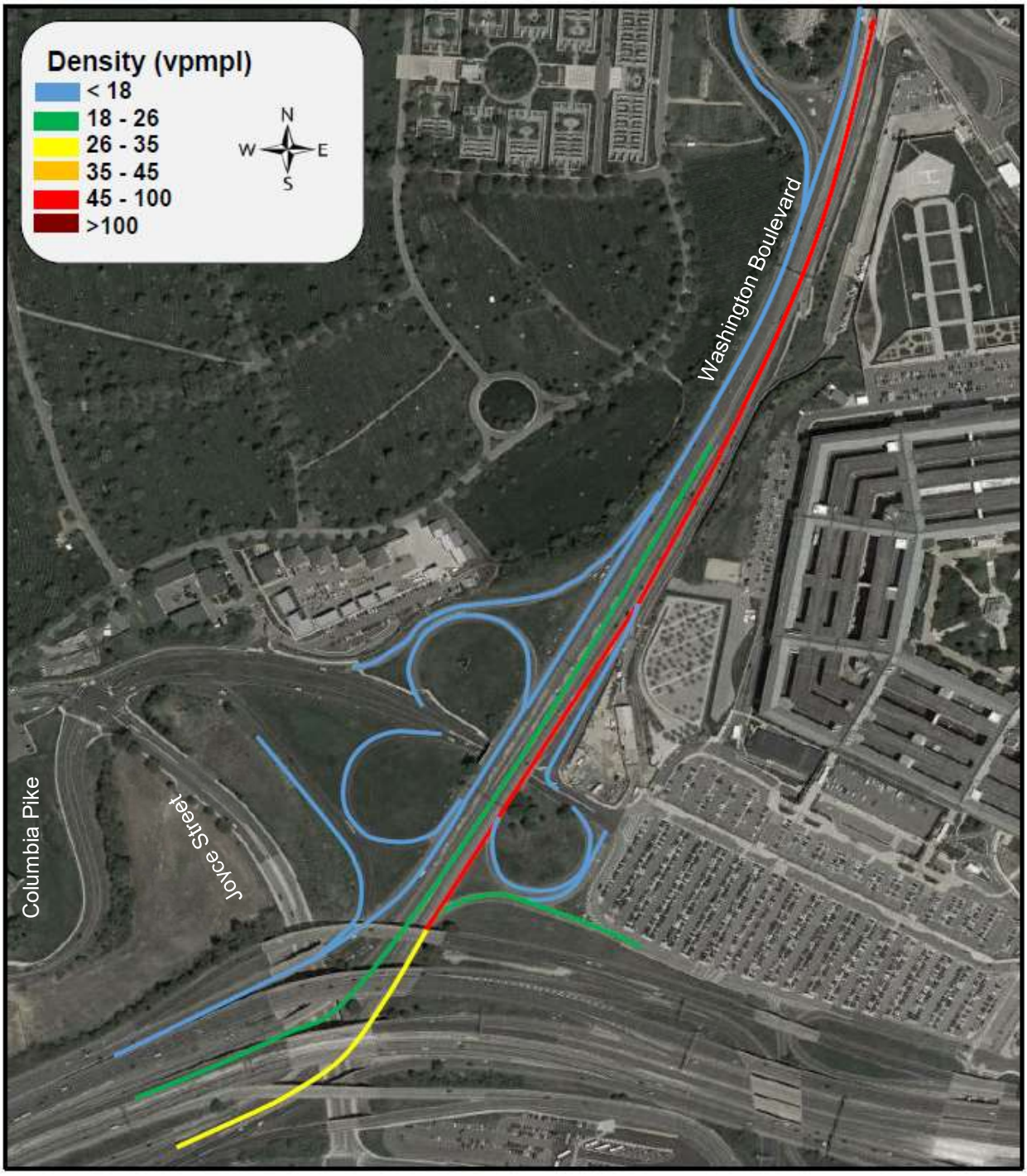


Figure 7-3: 2025 No-Build VISSIM Results - PM Peak Hour Speed

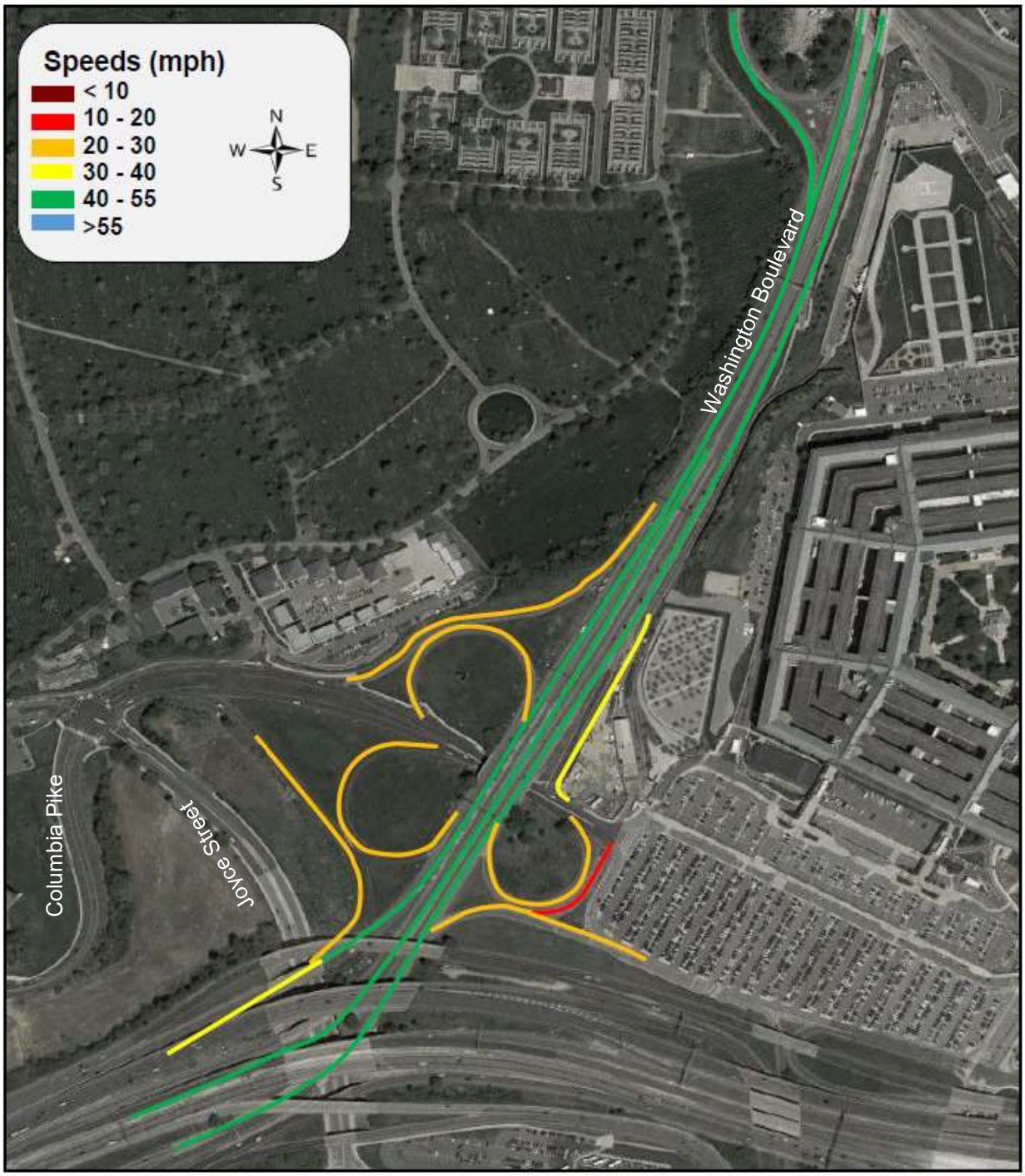


Figure 7-4: 2025 No-Build VISSIM Results - PM Peak Hour Density

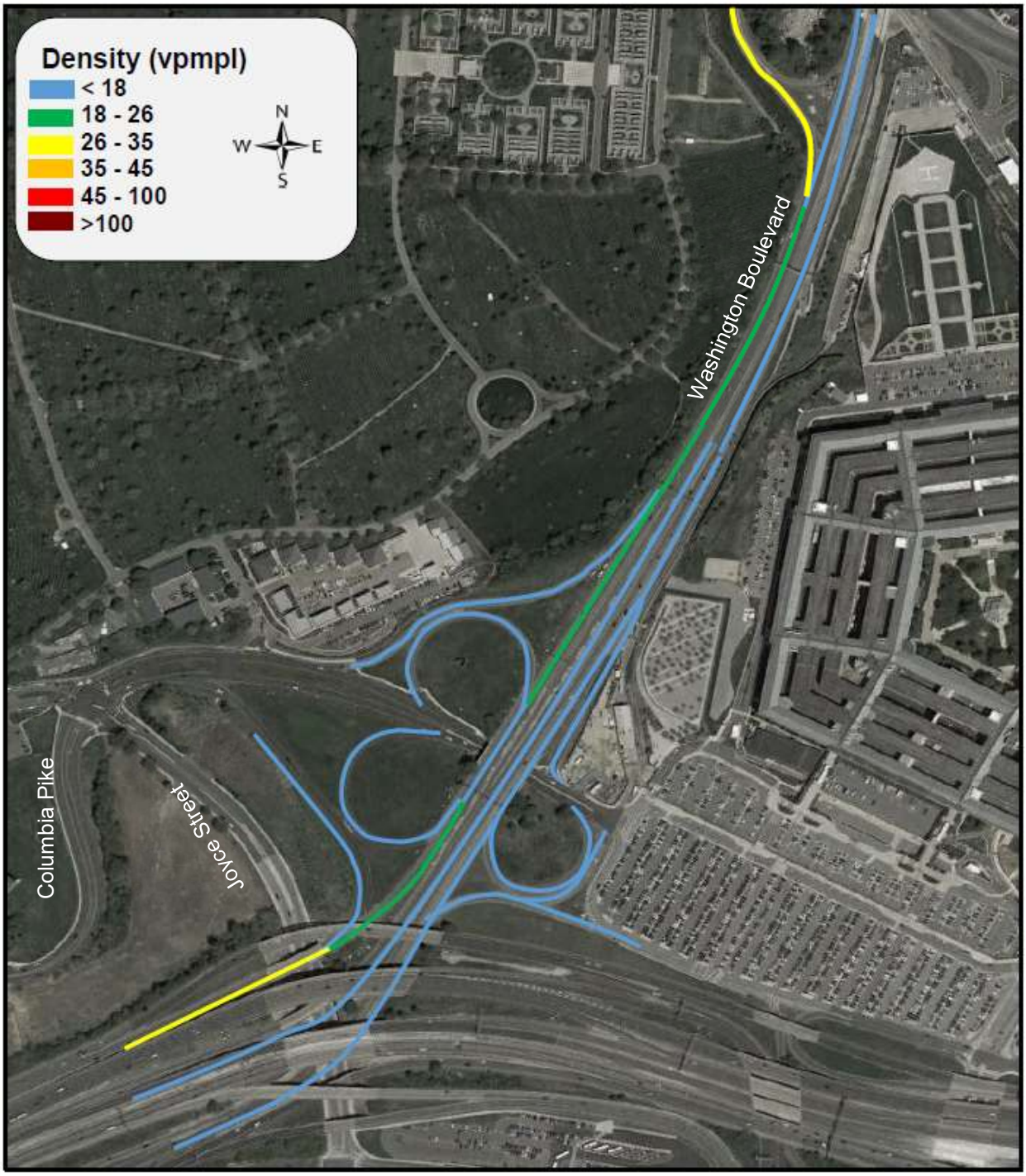


Figure 7-5: 2045 No-Build VISSIM Results - AM Peak Hour Speed

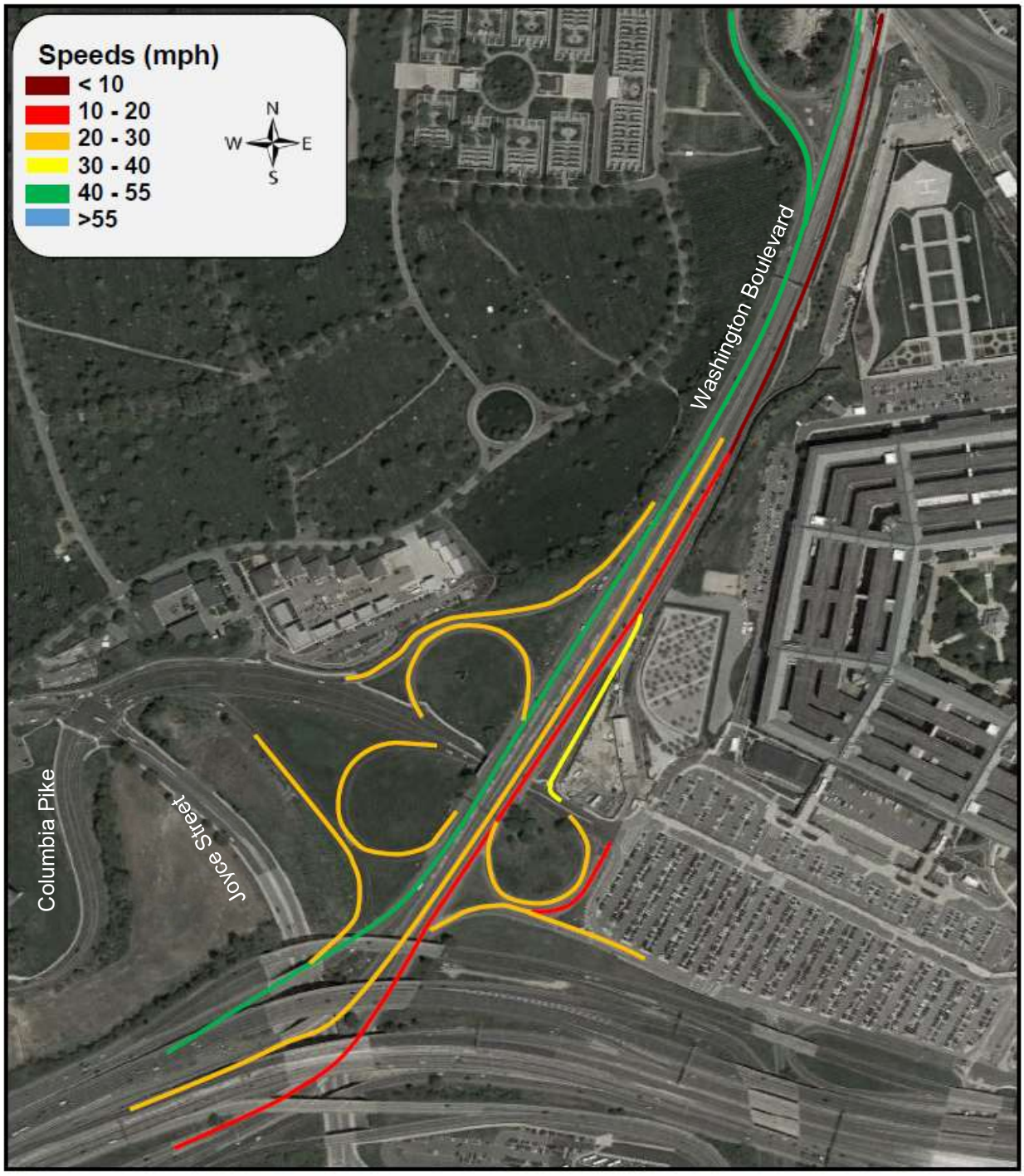


Figure 7-6: 2045 No-Build VISSIM Results - AM Peak Hour Density

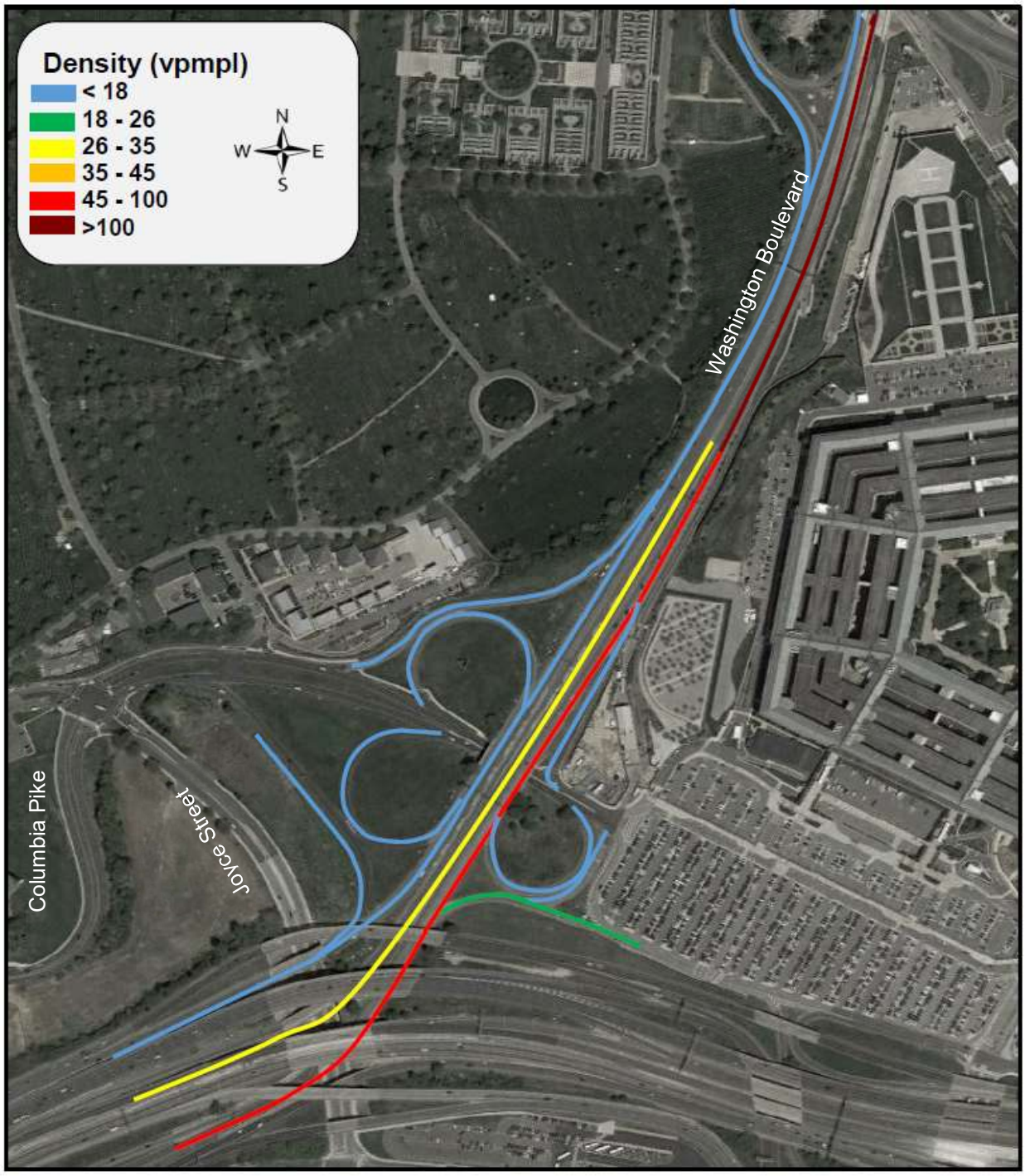


Figure 7-7: 2045 No-Build VISSIM Results - PM Peak Hour Speed

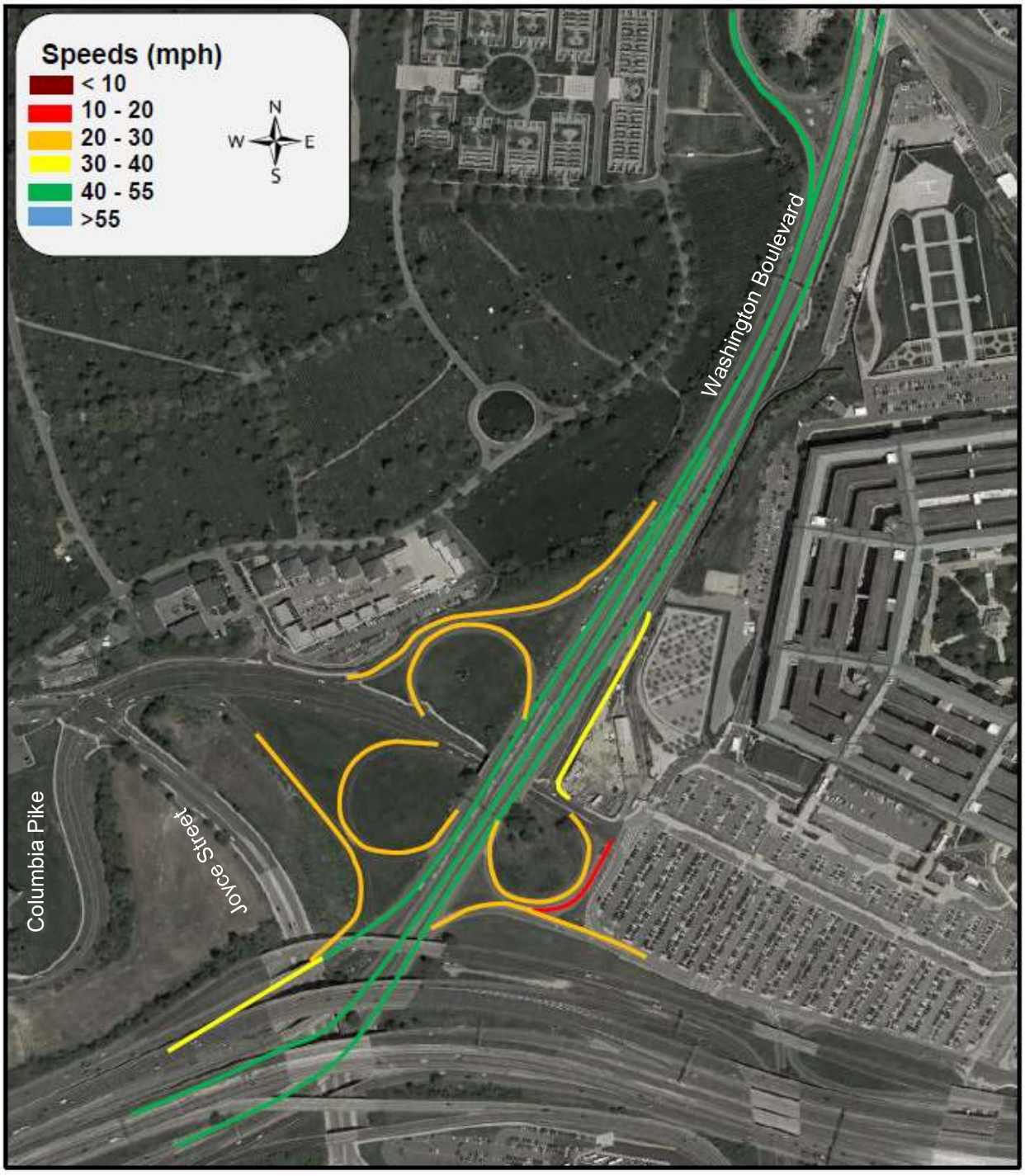


Figure 7-8: 2045 No-Build VISSIM Results - PM Peak Hour Density

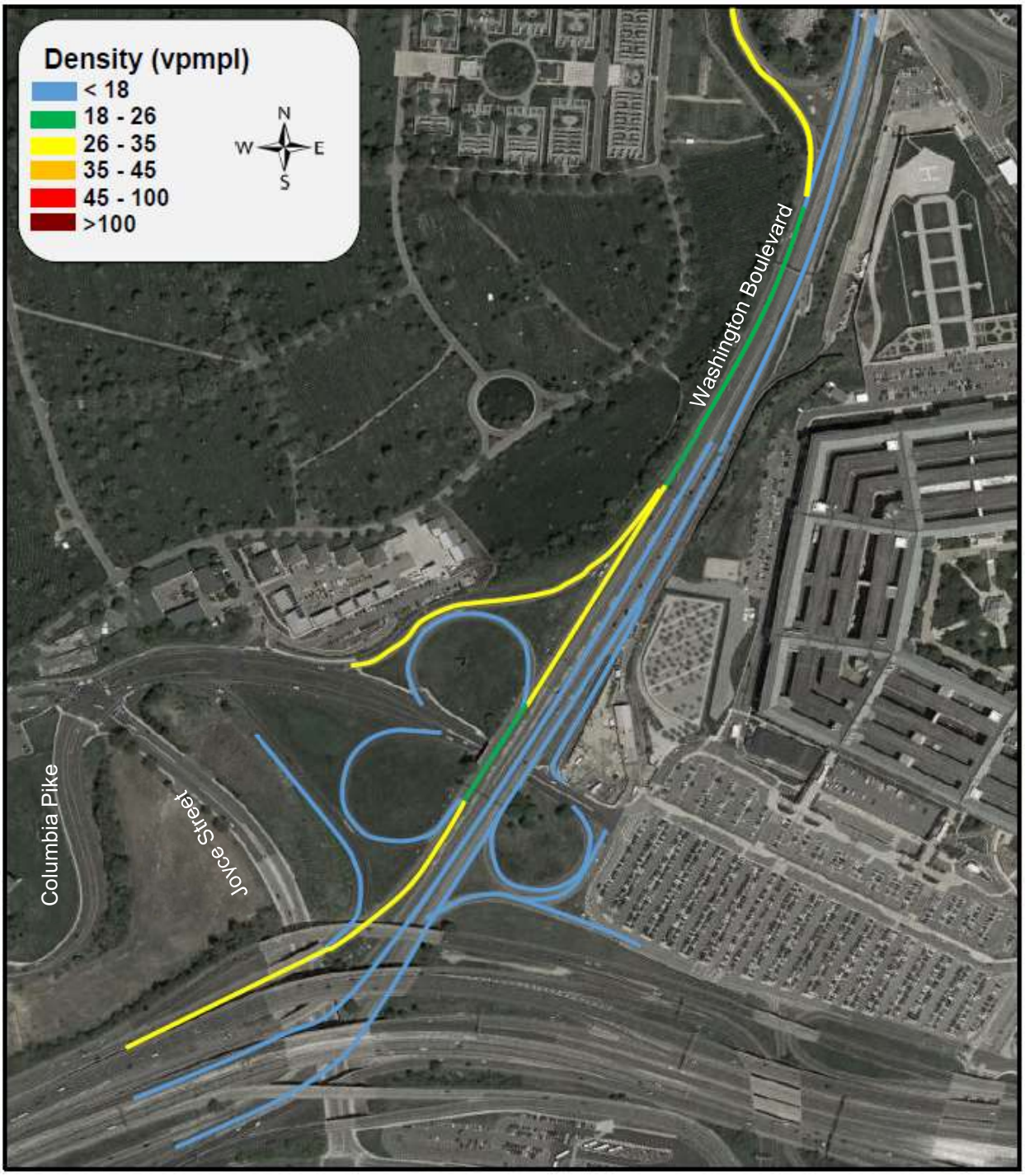


Figure 7-9: 2025 Build VISSIM Results - AM Peak Hour Speed

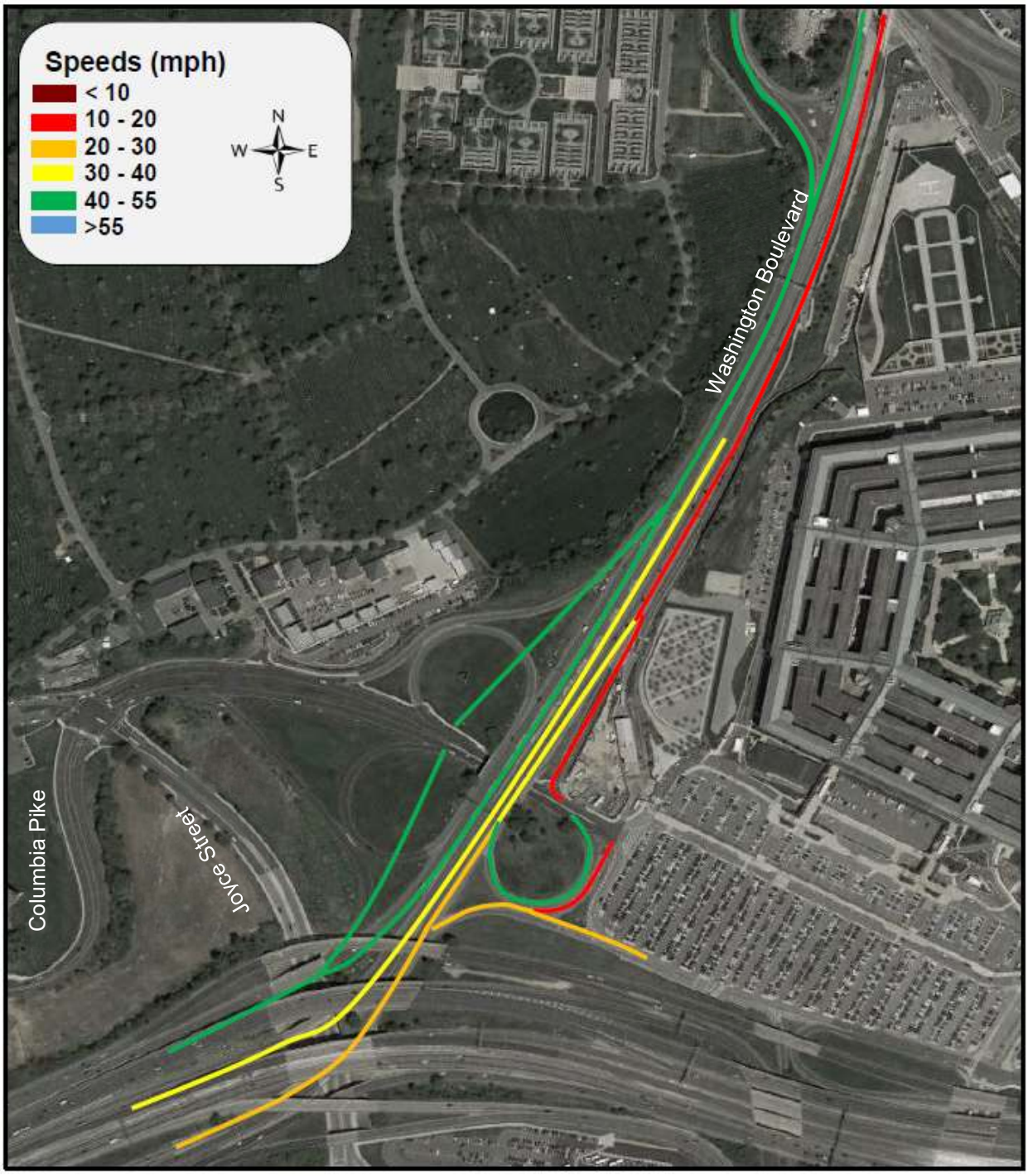


Figure 7-10: 2025 Build VISSIM Results - AM Peak Hour Density

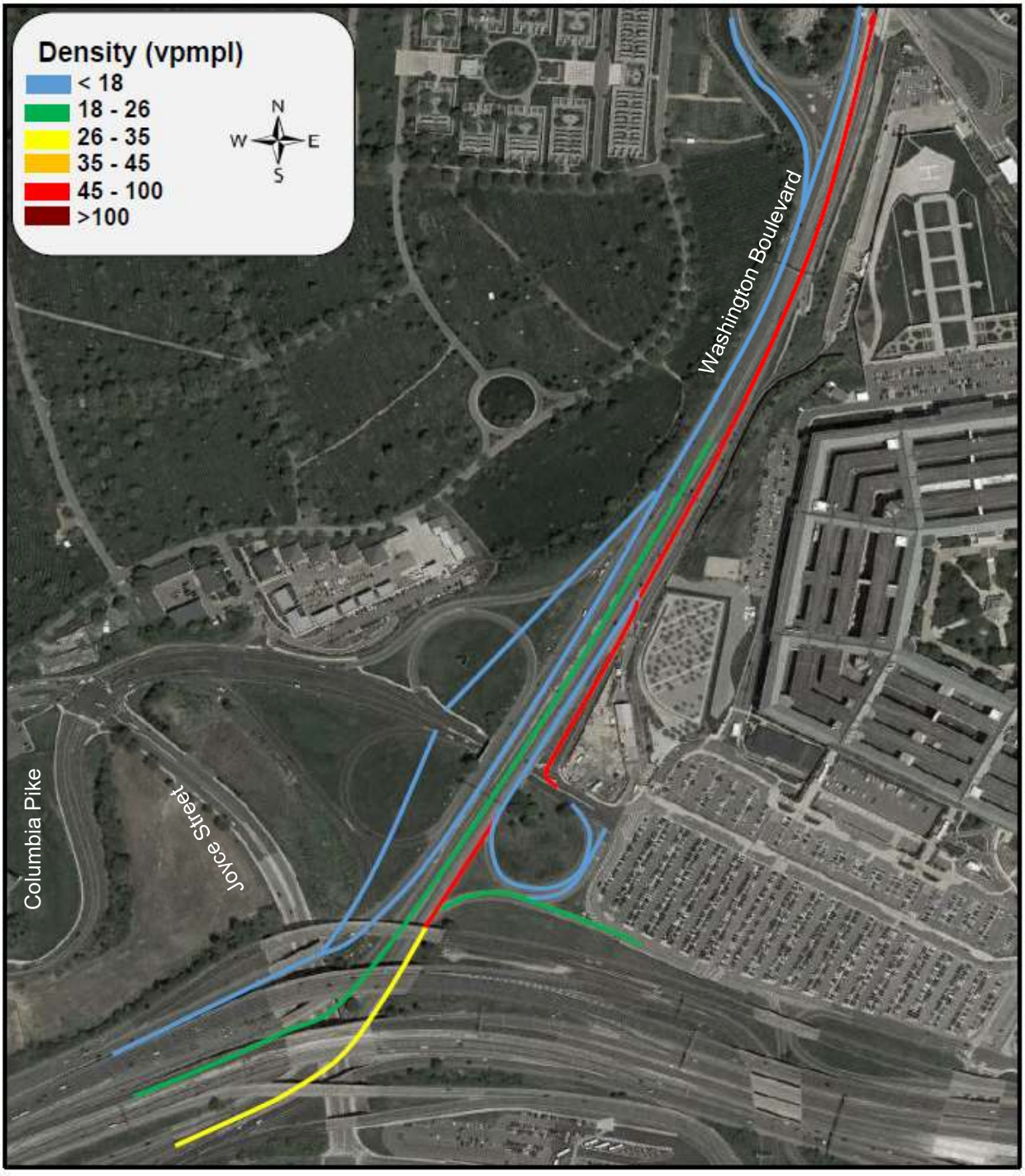


Figure 7-11: 2025 Build VISSIM Results - PM Peak Hour Speed

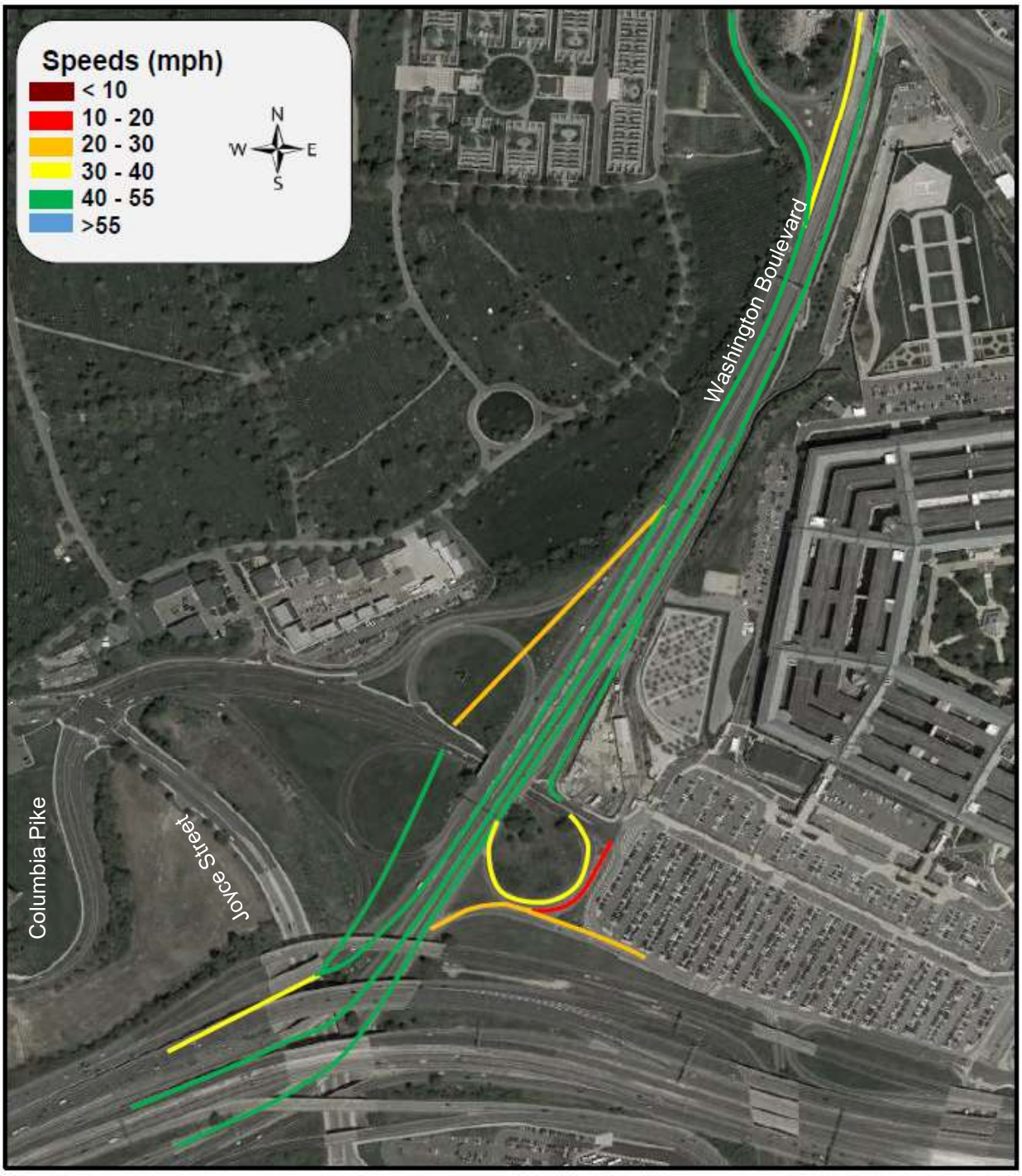


Figure 7-12: 2025 Build VISSIM Results - PM Peak Hour Density

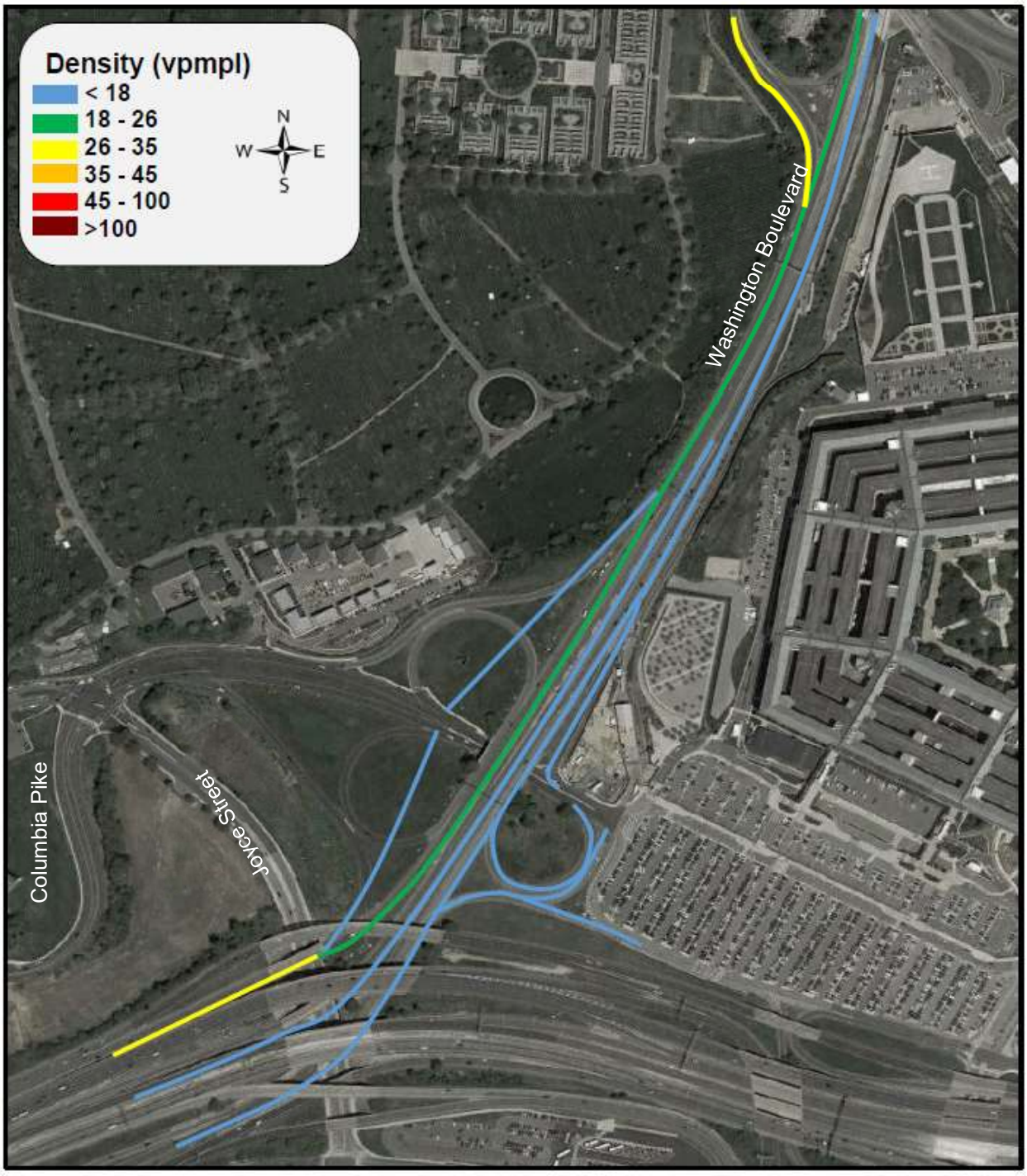


Figure 7-13: 2045 Build VISSIM Results - AM Peak Hour Speed

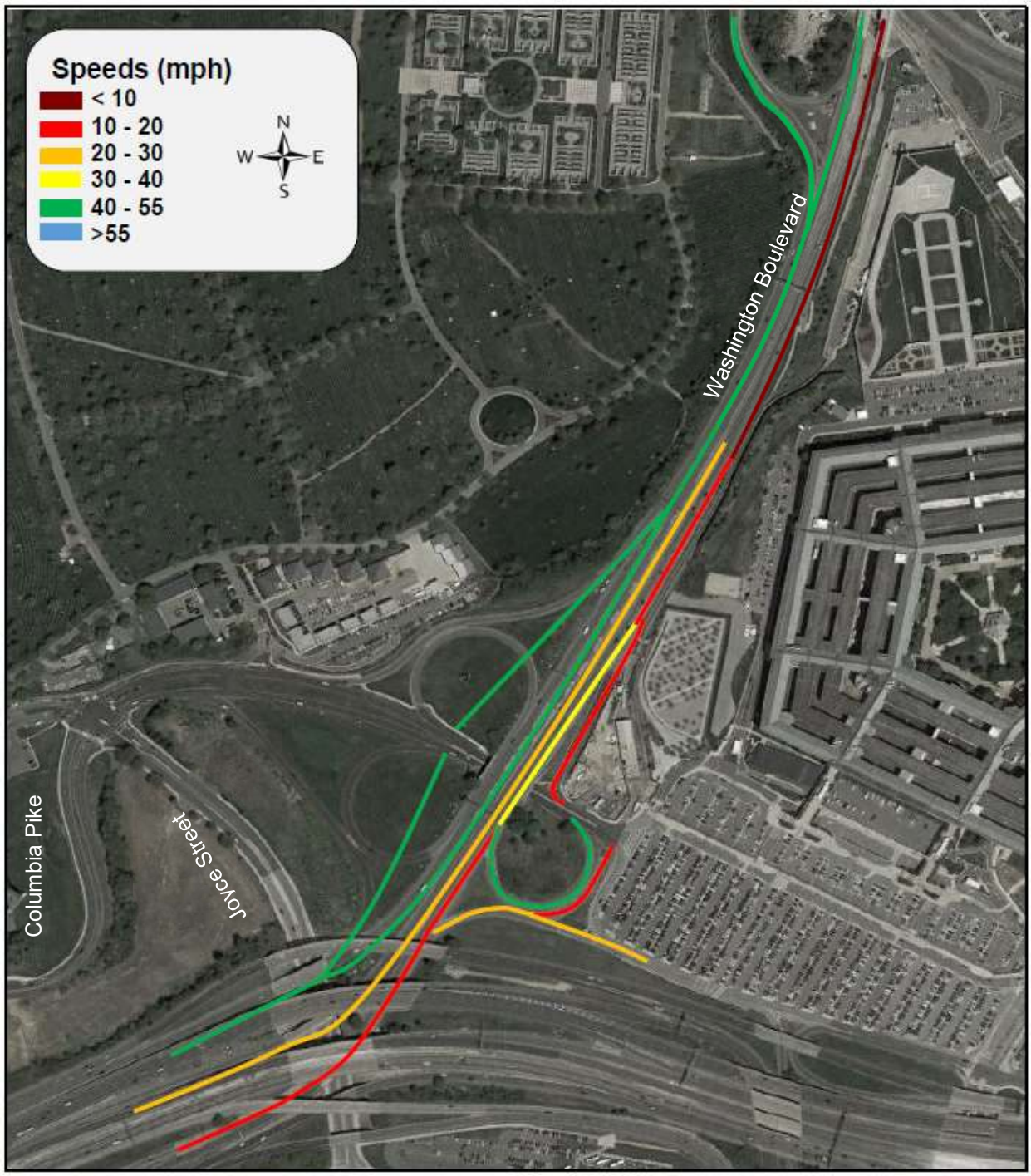


Figure 7-14: 2045 Build VISSIM Results - AM Peak Hour Density

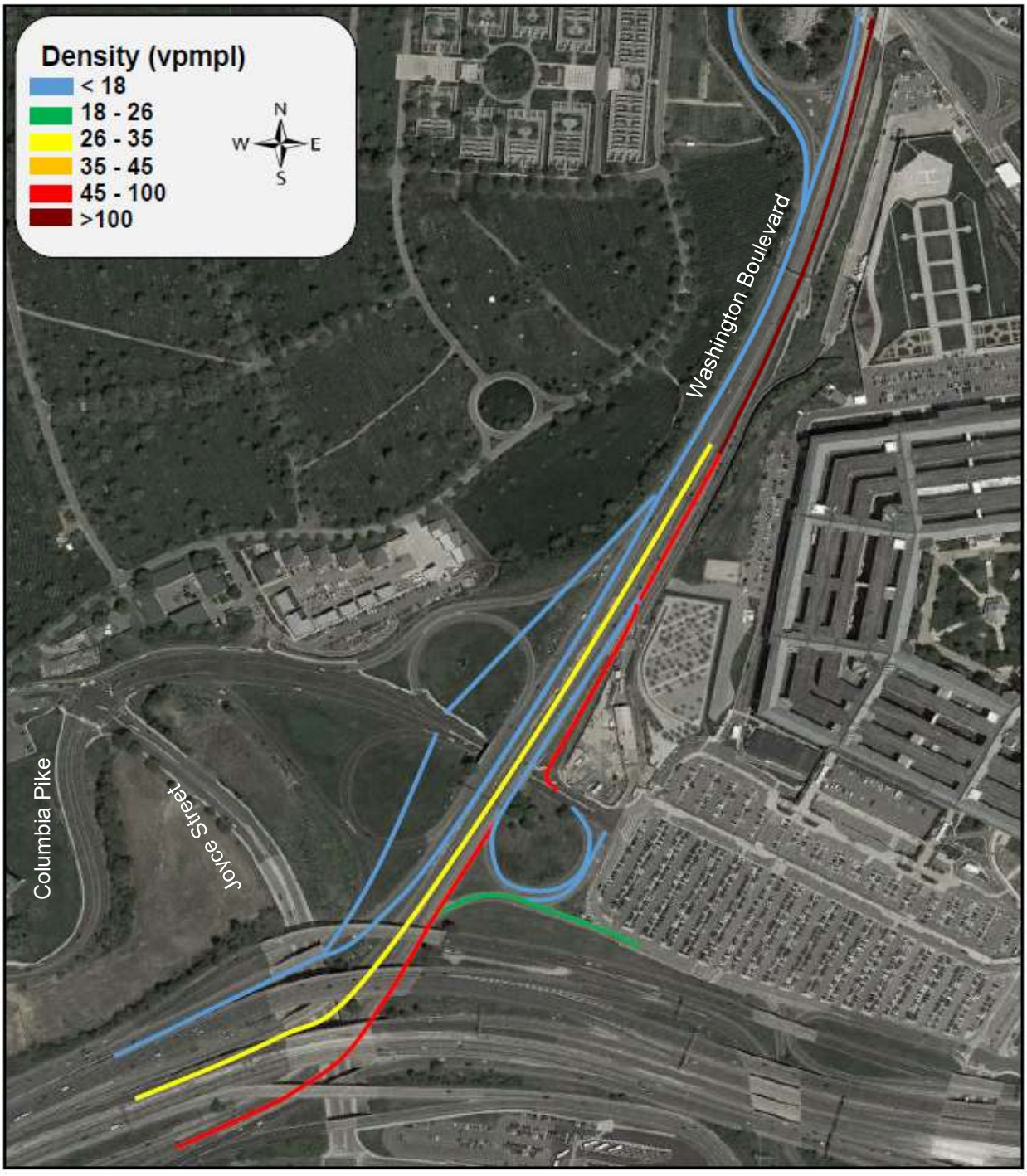


Figure 7-15: 2045 Build VISSIM Results - PM Peak Hour Speed

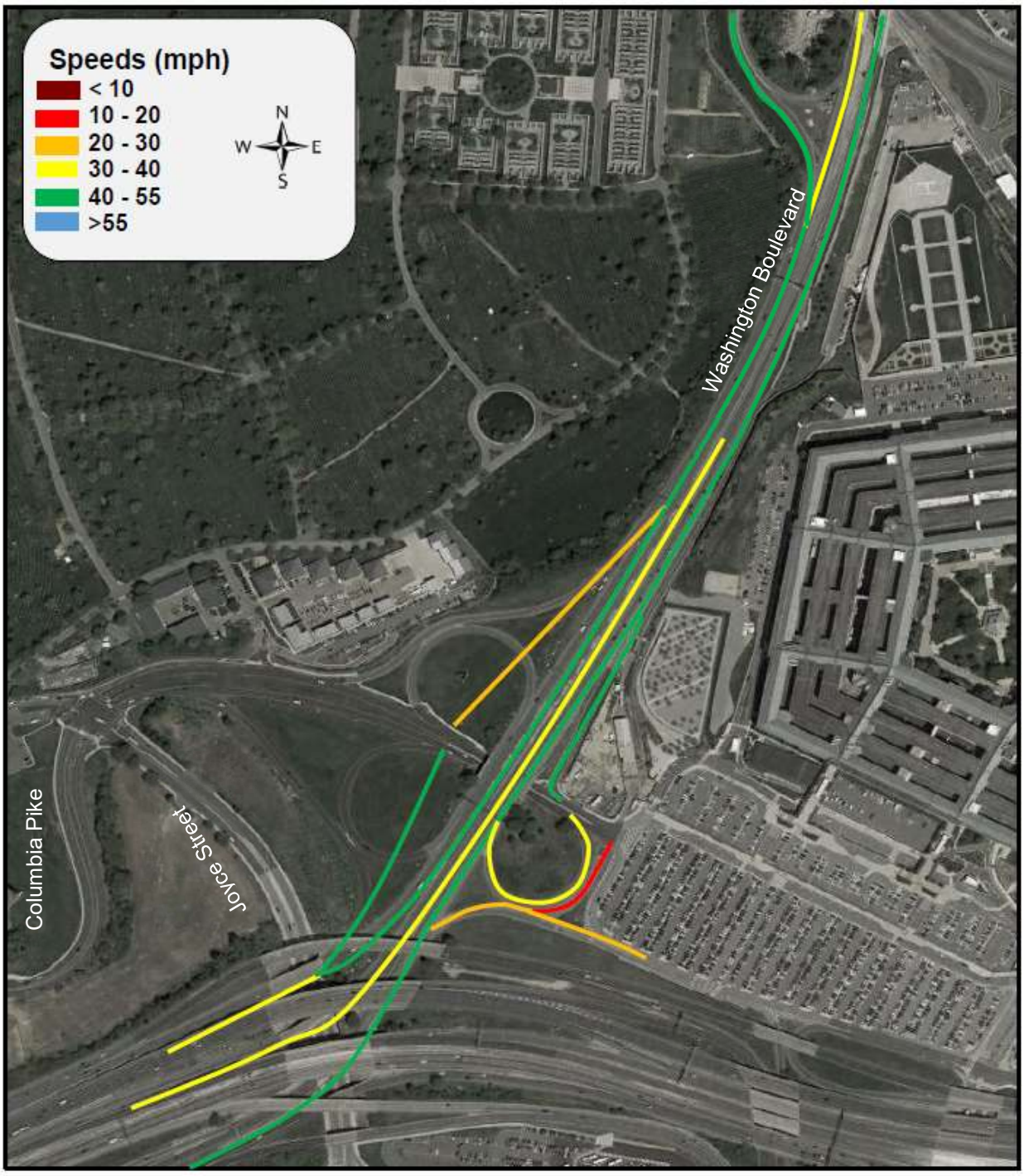


Figure 7-16: 2045 Build VISSIM Results - PM Peak Hour Density

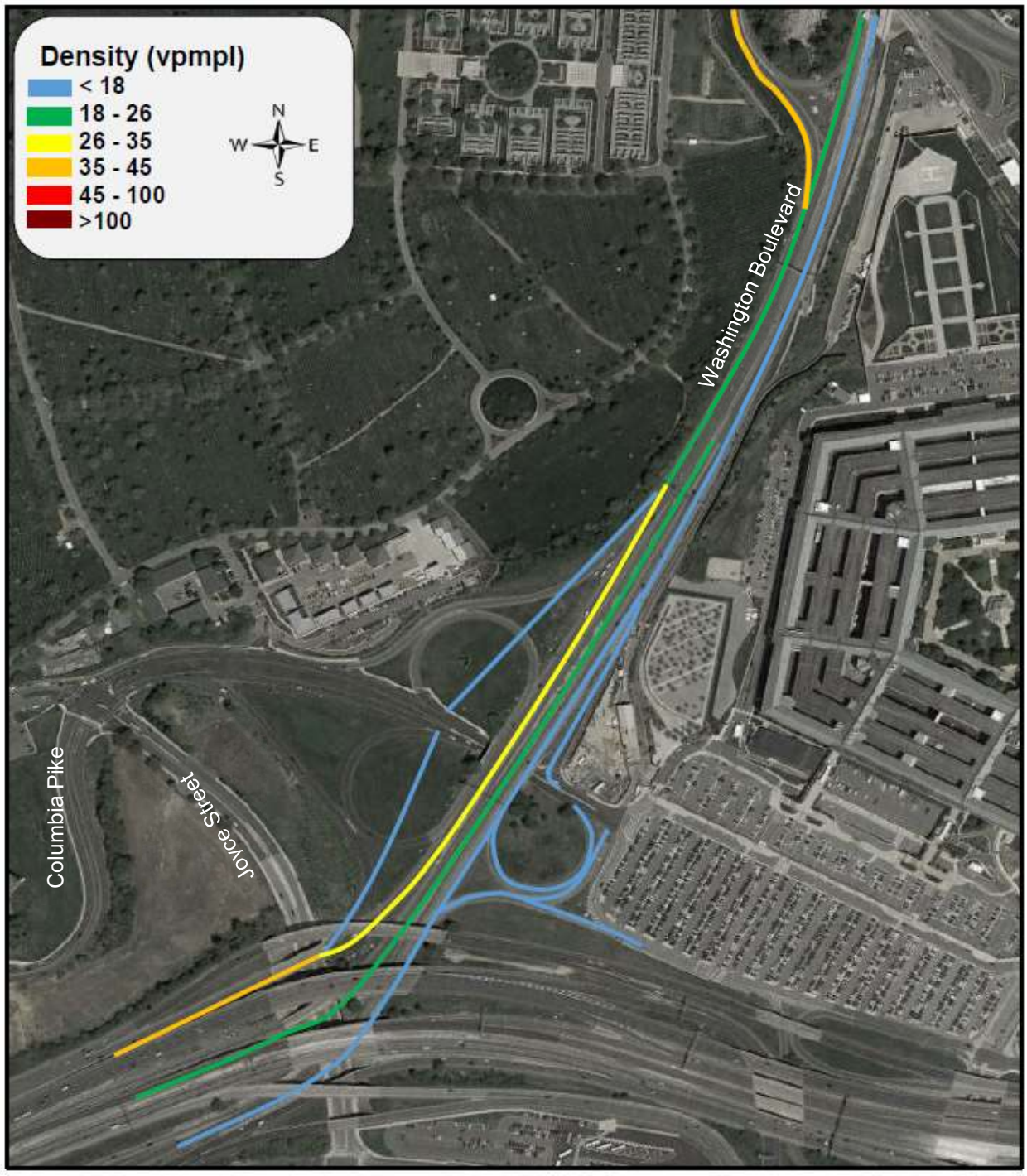


Table 7-3: AM Peak Hour Arterial Intersection No-Build and Build Comparison

		No-Build 2025				No-Build 2045				Build 2025				Build 2045			
		Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS
1: Columbia Pike/Orme	NB	19.9	B	14.9	B	21.9	C	18.4	B	37.8	D	20.1	C	25.8	C	20.2	C
	SB	13.3	B			18.6	B			19.0	B			20.1	C		
	EB	12.6	B			16.0	B			14.9	B			18.3	B		
	WB	16.8	B			20.4	C			14.5	B			18.2	B		
2: Columbia Pike/VDOT Driveway/Nash	NB	13.0	B	0.7	A	17.3	C	1.1	A	11.7	B	8.1	A	9.7	A	9.2	A
	SB	-	-			-	-			24.0	C			29.7	C		
	EB	0.6	A			1.1	A			6.3	A			6.4	A		
	WB	0.4	A			0.6	A			3.3	A			5.0	A		
3: AF Memorial (Existing & No-Build only)	NB	13.1	B	0.9	A	13.9	B	1.5	A	-	-	-	-	-	-	-	-
	EB	0.9	A			1.7	A			-	-			-	-		
	WB	0.5	A			0.7	A			-	-			-	-		
4: Columbia Pike/Joyce	NB	18.2	B	22.0	C	20.4	C	24.1	C	11.4	B	10.2	B	11.6	B	15.4	B
	SB	31.1	C			32.0	C			-	-			-	-		
	EB	17.6	B			23.3	C			10.6	B			18.0	B		
	WB	29.2	C			27.9	C			7.7	A			14.8	B		
5: Columbia Pike/ANC Ops Center (Existing & No-Build only)	SB	9.3	A	0.8	A	9.9	A	1.0	A	-	-	-	-	-	-	-	-
	EB	0.4	A			0.5	A			-	-			-	-		
	WB	0.9	A			1.3	A			-	-			-	-		
6: Columbia Pike/Rotary Road	NB	14.5	B	6.8	A	28.0	D	8.0	A	15.2	C	6.7	A	30.8	D	8.3	A
	SB	11.7	B			12.1	B			11.7	B			13.1	B		
	EB	0.8	A			0.9	A			0.4	A			0.6	A		
	WB	11.0	B			11.6	B			11.1	B			11.8	B		
7: Army Navy/Joyce	NB	17.0	B	21.9	C	19.8	B	24.0	C	15.3	B	20.6	C	18.4	B	22.1	C
	SB	13.2	B			16.7	B			9.7	A			12.0	B		
	EB	28.5	C			29.5	C			28.6	C			28.8	C		

		No-Build 2025				No-Build 2045				Build 2025				Build 2045			
		Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS
	WB	31.1	C			30.0	C			31.1	C			29.6	C		
8: Army Navy/Pentagon City Mall	NB	28.5	C	19.0	B	26.8	C	21.2	C	12.5	B	19.4	B	13.1	B	22.4	C
	SB	25.1	C			25.1	C			14.3	B			14.7	B		
	EB	25.3	C			26.6	C			27.5	C			29.2	C		
	WB	12.1	B			14.5	B			10.9	B			14.4	B		
9: Army Navy/S Hayes St	NB	41.0	D	33.1	C	55.8	E	37.0	D	36.4	D	31.4	C	48.1	D	38.1	D
	SB	35.2	D			37.7	D			32.5	C			40.1	D		
	EB	46.1	D			44.2	D			47.5	D			46.4	D		
	WB	13.0	B			19.7	B			13.4	B			19.9	B		
10: Columbia Pike/Pentagon Memorial (Build only)	NB	-	-	-	-	-	-	-	-	3.7	A	0.6	A	5.3	A	0.9	A
	SB	-	-			-	-			-	-			-	-		
	EB	-	-			-	-			0.6	A			1.1	A		
	WB	-	-			-	-			0.6	B			0.6	C		
11: Columbia Pike/Washington Blvd SB Ramps (Build only)	NB	-	-	-	-	-	-	-	-	-	-	17.0	C	-	-	24.1	C
	SB	-	-			-	-			26.8	C			26.6	C		
	EB	-	-			-	-			12.4	B			23.7	C		
	WB	-	-			-	-			15.5	B			21.6	C		

Table 7-4: PM Peak Hour Arterial Intersection No-Build and Build Comparison

		No-Build 2025				No-Build 2045				Build 2025				Build 2045			
		Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS
1: Columbia Pike/Orme	NB	21.4	C	17.4	B	24.3	C	19.2	B	36.8	D	20.4	C	36.7	D	26.0	C
	SB	12.8	B			15.1	B			15.0	B			16.4	B		
	EB	11.9	B			13.9	B			13.3	B			12.4	B		
	WB	18.8	B			20.0	C			13.4	B			30.0	C		
2: Columbia Pike/VDOT Driveway/Nash	NB	12.8	B	0.9	A	15.6	C	1.1	A	11.9	B	10.9	B	12.7	B	14.2	B
	SB	-	-			-	-			22.1	C			26.0	C		
	EB	0.3	A			0.5	A			5.1	A			7.3	A		
	WB	1.1	A			1.3	A			9.9	A			14.2	B		
3: AF Memorial (Existing & No-Build only)	NB	15.3	C	1.3	A	15.8	C	1.5	A	-	-	-	-	-	-	-	-
	EB	0.8	A			1.1	A			-	-			-	-		
	WB	1.4	A			1.6	A			-	-			-	-		
4: Columbia Pike/Joyce	NB	86.5	F	59.3	E	349.3	F	144.3	F	12.3	B	12.3	B	15.6	B	15.5	B
	SB	39.6	D			40.5	D			-	-			-	-		
	EB	19.1	B			26.2	C			14.0	B			17.6	B		
	WB	57.7	E			64.4	E			10.7	B			13.1	B		
5: Columbia Pike/ANC Ops Center (Existing & No-Build only)	SB	13.5	B	7.9	A	16.7	C	22.9	C	-	-	-	-	-	-	-	-
	EB	0.1	A			0.2	A			-	-			-	-		
	WB	11.2	B			32.5	D			-	-			-	-		
6: Columbia Pike/Rotary Road	NB	9.5	A	8.1	A	9.9	A	9.2	A	10.6	B	7.1	A	12.1	B	7.8	A
	SB	13.1	B			18.0	C			9.4	A			9.7	A		
	EB	0.6	A			0.8	A			0.3	A			0.3	A		
	WB	10.4	B			11.1	B			10.8	B			11.9	B		
7: Army Navy/Joyce	NB	21.0	C	27.3	C	37.3	D	47.6	D	21.0	C	25.5	C	26.3	C	31.9	C
	SB	17.6	B			22.8	C			11.1	B			18.3	B		
	EB	19.9	B			27.2	C			19.7	B			21.1	C		

		No-Build 2025				No-Build 2045				Build 2025				Build 2045			
		Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS	Delay	Equivalent LOS
	WB	38.5	D			82.9	F			38.9	D			48.8	D		
8: Army Navy/Pentagon City Mall	NB	49.1	D	30.1	C	81.8	F	48.8	D	16.5	B	23.9	C	19.4	B	21.0	C
	SB	25.4	C			32.7	C			23.9	C			25.5	C		
	EB	23.8	C			24.3	C			25.9	C			24.6	C		
	WB	26.2	C			47.8	D			25.7	C			19.9	B		
9: Army Navy/S Hayes St	NB	27.2	C	25.7	C	125.3	F	139.9	F	28.7	C	32.6	C	42.0	D	91.8	F
	SB	26.9	C			161.5	F			48.5	D			75.6	E		
	EB	27.6	C			28.8	C			23.9	C			31.8	C		
	WB	22.6	C			181.8	F			22.3	C			158.0	F		
10: Columbia Pike/Pentagon Memorial (Build only)	NB	-	-	-	-	-	-	-	-	4.4	A	1.6	A	4.6	A	1.8	A
	SB	-	-			-	-			-	-			-	-		
	EB	-	-			-	-			1.3	A			1.4	A		
	WB	-	-			-	-			1.6	B			1.9	B		
11: Columbia Pike/Washington Blvd SB Ramps (Build only)	NB	-	-	-	-	-	-	-	-	-	-	20.6	C	-	-	20.2	C
	SB	-	-			-	-			30.9	C			31.9	C		
	EB	-	-			-	-			16.0	B			12.2	B		
	WB	-	-			-	-			13.9	B			18.1	B		

Table 7-5: AM Peak Hour Travel Time Comparison

Segment ID	Route	Peak Period Travel Time						
		Existing VISSIM (MM:SS)	2025 No-Build VISSIM (MM:SS)	2025 Build VISSIM (MM:SS)	2045 No-Build VISSIM (MM:SS)	2045 Build VISSIM (MM:SS)	No-Build To Build Difference (MM:SS)	No-Build To Build Difference (%)
1	Route A1: Eastbound Columbia Pike from S. Oak Street to southbound S. Joyce Street to eastbound Army Navy Drive, ending at S. Hayes Street	03:14	03:20	03:00	03:35	03:15	-00:20	-10%
2	Route A2: Westbound Army Navy Drive from S. Hayes Street to northbound S. Joyce Street to westbound Columbia Pike, ending at S Oak Street	03:07	02:58	02:27	03:04	02:37	-00:27	-14%
3	Route B1: Northbound S. Joyce Street from Pentagon Row (south of Army Navy Drive) to eastbound Columbia Pike, ending at the S. Rotary Road in the Pentagon parking lot	02:15	02:15	02:13	02:20	02:08	-00:12	-9%
4	Route B2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot southbound S. Joyce Street, ending at Pentagon Row	02:41	02:50	02:00	02:47	01:56	-00:51	-32%
5	Route C1: Eastbound Columbia Pike from S. Oak Street to Rotary Road in the Pentagon parking lot	02:11	02:14	02:00	02:19	02:32	00:13	10%
6	Route C2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot to S. Oak Street	02:07	02:09	01:53	02:11	01:58	-00:13	-10%
7	Route D1: Northbound Washington Boulevard from the on-ramp from northbound I-395 through the Columbia Pike interchange to the off-ramp to southbound Route 110	02:46	02:49	02:50	03:34	03:36	00:02	1%
8	Route D2: Southbound Washington Boulevard from the on-ramp from southbound Route 110 through the Columbia Pike interchange to the off-ramp to southbound I-395	00:57	00:57	00:57	00:57	00:57	00:00	0%
9	Route D3: Southbound Washington Boulevard from the on-ramp from southbound Route 110 to the ramp to westbound Columbia Pike and onto westbound Columbia Pike through to S. Oak Street	02:43	02:41	02:30	02:43	02:40	-00:03	-2%

Figure 7-17: AM Peak Hour Travel Time No-Build and Build Comparison

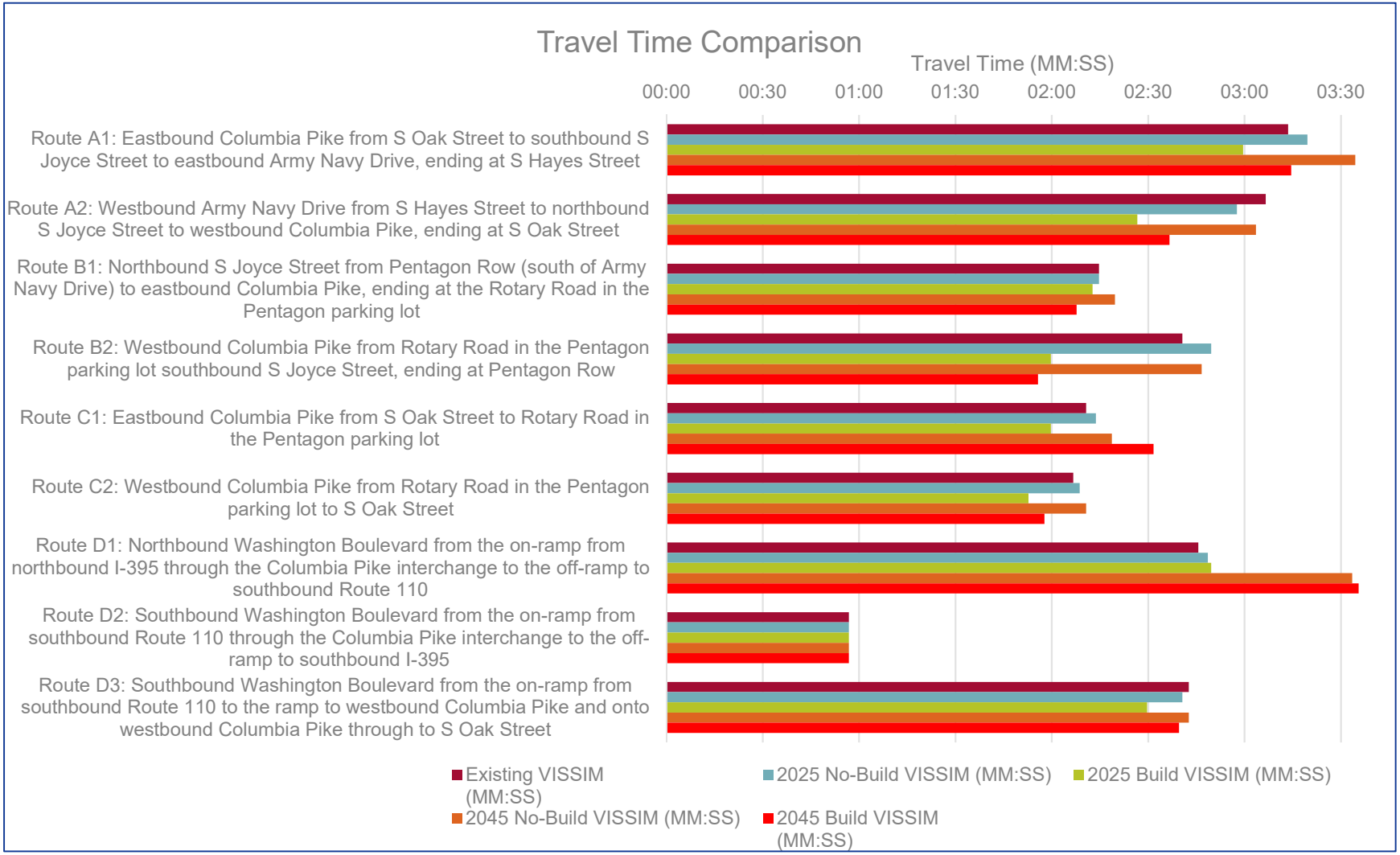
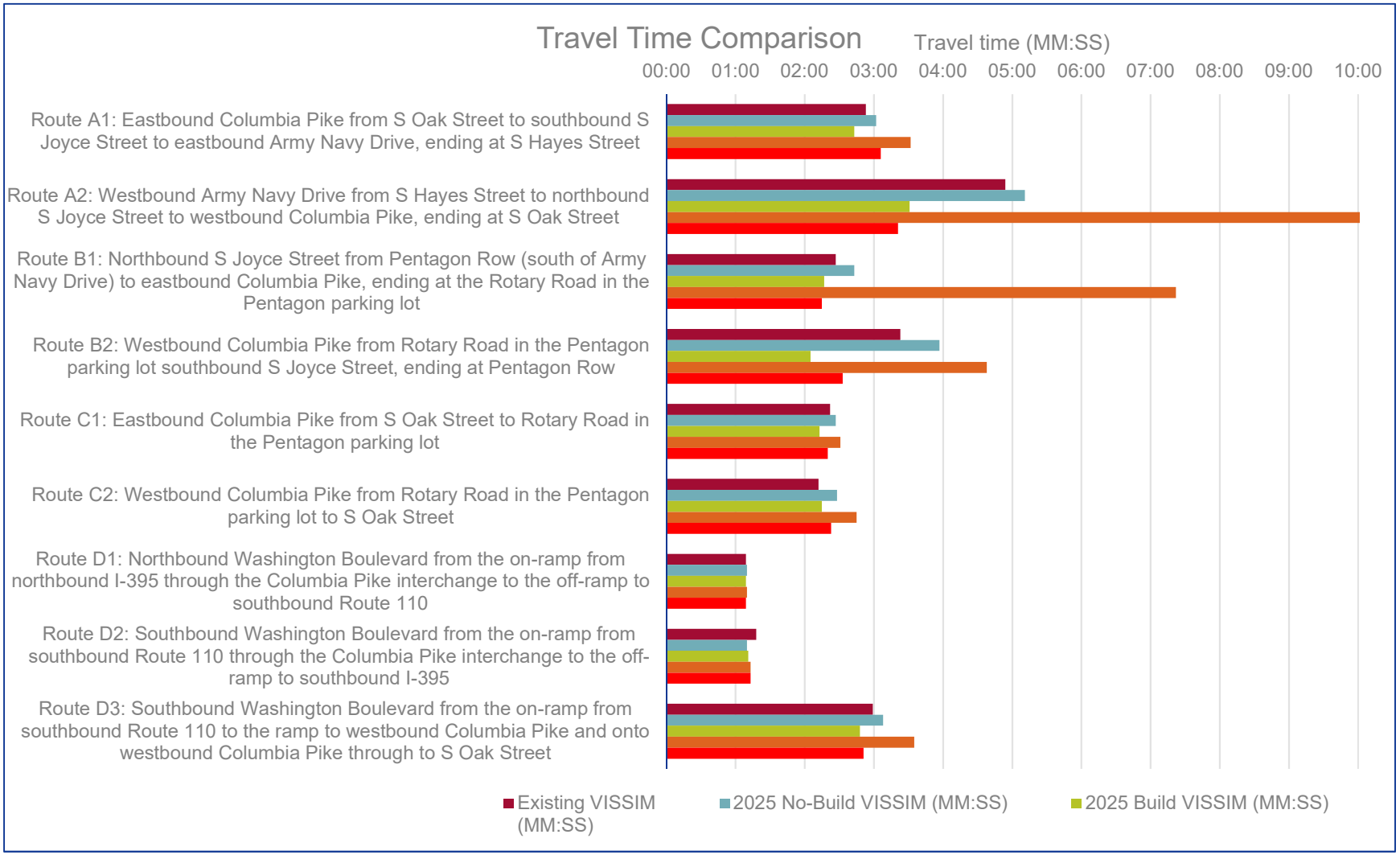


Table 7-6: PM Peak Hour Travel Time Comparison

Segment ID	Route	Peak Period Travel Time						
		Existing VISSIM (MM:SS)	2025 No-Build VISSIM (MM:SS)	2025 Build VISSIM (MM:SS)	2045 No-Build VISSIM (MM:SS)	2045 Build VISSIM (MM:SS)	No-Build To Build Difference (MM:SS)	No-Build To Build Difference (%)
1	Route A1: Eastbound Columbia Pike from S. Oak Street to southbound S. Joyce Street to eastbound Army Navy Drive, ending at S. Hayes Street	02:53	03:02	02:43	03:32	03:06	-00:26	-12%
2	Route A2: Westbound Army Navy Drive from S. Hayes Street to northbound S. Joyce Street to westbound Columbia Pike, ending at S Oak Street	04:54	05:11	03:31	10:14	03:21	-06:53	-67%
3	Route B1: Northbound S. Joyce Street from Pentagon Row (south of Army Navy Drive) to eastbound Columbia Pike, ending at the Rotary Road in the Pentagon parking lot	02:27	02:43	02:17	07:22	02:15	-05:07	-69%
4	Route B2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot southbound S. Joyce Street, ending at Pentagon Row	03:23	03:57	02:05	04:38	02:33	-02:05	-45%
5	Route C1: Eastbound Columbia Pike from S. Oak Street to Rotary Road in the Pentagon parking lot	02:22	02:27	02:13	02:31	02:20	-00:11	-7%
6	Route C2: Westbound Columbia Pike from Rotary Road in the Pentagon parking lot to S. Oak Street	02:12	02:28	02:15	02:45	02:23	-00:22	-13%
7	Route D1: Northbound Washington Boulevard from the on-ramp from northbound I-395 through the Columbia Pike interchange to the off-ramp to southbound Route 110	01:09	01:10	01:09	01:10	01:09	-00:01	-1%
8	Route D2: Southbound Washington Boulevard from the on-ramp from southbound Route 110 through the Columbia Pike interchange to the off-ramp to southbound I-395	01:18	01:10	01:11	01:13	01:13	00:00	0%
9	Route D3: Southbound Washington Boulevard from the on-ramp from southbound Route 110 to the ramp to westbound Columbia Pike and onto westbound Columbia Pike through to S. Oak Street	02:59	03:08	02:48	03:35	02:51	-00:44	-20%

Figure 7-18: PM Peak Hour Travel Time No-Build and Build Comparison



7.2.1. AM Peak Hour

- During the AM peak period, all intersections are anticipated to operate at an acceptable level of service (equivalent LOS D or better) across all scenarios, including 2045. This reflects the low traffic volumes and congestion observed today during the AM peak along arterials in the study area.
- The new signalized intersection of Columbia Pike and the Washington Boulevard southbound ramps in the Build condition is anticipated to operate at equivalent LOS C in both 2025 and 2045. Southbound off-ramp queues are forecasted to be well within the available storage provided (note: no southbound right-turn-on-red movements were allowed in order to conservatively assess intersection operations).
- AM peak hour travel times along arterial routes are forecasted to generally remain consistent or improve going from No-Build to Build conditions.
- The most significant reduction in travel time in 2045 is anticipated to be for the route along westbound Columbia Pike (starting in the Pentagon parking lot) to southbound S. Joyce Street (ending at Pentagon Row), which sees a forecasted reduction in travel time of more than 50 seconds in the Build condition (32 percent reduction) due to the realignment of Columbia Pike and improved capacity at the Columbia Pike/S. Joyce Street intersection.
- The most significant increase in travel time in 2045 is anticipated to be for the route along eastbound Columbia Pike between S. Oak Street and the Pentagon parking lot, which sees an increase in travel time of 13 seconds in the Build condition (10 percent increase). This forecasted modest increase is attributable to the new traffic signal at the southbound Washington Boulevard ramps.
- Forecasted, speeds and queuing along Washington Boulevard are consistent between No-Build and Build condition (consistent with the observed travel times in both directions).
- More significant forecasted queues are observed along northbound Washington Boulevard in 2045 as Compared to 2025 due to higher traffic volumes (reflected in longer travel times), but the queueing and travel times are consistent between No-Build and Build conditions.

7.2.2. PM Peak Hour

- During the PM peak period, forecasted traffic volumes are higher along the study area arterial network, and, as such, a deterioration in operations is anticipated in the future, especially in 2045. However, the forecasted Build condition significantly mitigates anticipated future operational issues presented in the No-Build condition, most notably at the intersection of Columbia Pike and S. Joyce Street. In the PM peak in the No-Build condition, forecasted heavy northbound left-turn volumes are constrained by permissive-only signal operations (forcing vehicles to yield to southbound through traffic coming from Southgate Road) as well as limited storage for a single-lane turn bay. This northbound left turn sees significant queue spillback along S. Joyce Street, and these queues extend to Army Navy Drive and beyond by 2045. The forecasted westbound left turn at the Columbia Pike/S. Joyce intersection is also constrained in the No-Build condition due to protected-only signal operations and limited turn bay storage.
- In the 2025 No-Build condition, this intersection is anticipated to operate at equivalent LOS E, with the northbound approach operating at equivalent LOS F due to queueing stemming from the permissive-only northbound left turn. In the 2025 Build condition, this intersection is anticipated to operate at equivalent LOS B, with low delay for the northbound and westbound approaches.
- In the 2045 No-Build condition, this intersection is anticipated to operate at equivalent LOS F, with the northbound approach seeing nearly 350 seconds of delay and queues spilling back and

affecting operations along westbound Army Navy Drive. In the Build condition, this intersection is anticipated to operate at equivalent LOS B, again with low delay for the northbound and westbound approaches.

- The new signalized intersection of Columbia Pike and the Washington Boulevard southbound ramps in the Build condition is anticipated to operate at equivalent LOS C in both 2025 and 2045. Southbound off-ramp queues are forecasted to be well within the available storage provided (note: in the analysis, no right-turn-on-red movements from the ramp terminal were allowed in order to conservatively assess intersection operations).
- The intersection of Army Navy Drive and Hayes Street is forecasted to operate at slightly improved equivalent LOS under build conditions compared to no-build conditions. This is likely due to the significant forecasted improvements at Columbia Pike and S. Joyce Street indirectly resulting in less impacts to upstream intersections.
- PM peak hour travel times are forecasted to generally remain consistent or show a significant improvement in the Build condition as compared to the No-Build condition.
- The most notable reductions in travel times are forecasted for routes utilizing the northbound approach at Columbia Pike/S. Joyce Street. Route A2 (westbound Army Navy Drive from S. Hayes Street to westbound Columbia Pike, ending at S. Oak Street) is forecasted to experience a reduction in travel time of nearly 7 minutes (67 percent) in the 2045 Build condition as compared to No-Build, while Route B1 (northbound S. Joyce Street to Pentagon parking lot) is forecasted to experience a reduction in travel time of more than 5 minutes (69 percent) in the 2045 Build condition. These improvements are attributable to the improved operations at the Columbia Pike/S. Joyce Street signal in the Build condition.
- Forecasted speeds and queuing along Washington Boulevard are generally consistent between No-Build and Build condition (consistent with the observed travel times in both directions).

7.3. Qualitative Safety Analysis

The conversion of existing roadway geometry to the preferred build alternative will result in the removal of an existing short weaving area along the Washington Boulevard mainline, the modification of a yield-controlled merge area to a fully-signalized intersection along Columbia Pike, and the conversion of a single four-legged intersection with challenging sight distances to a pair of three-legged intersections with fewer conflict points and improved geometries and sight distances. Each of these improvements may result in safety enhancements compared to the baseline conditions.

Research provided by National Cooperative Highway Research Program (NCHRP) Report 687, *Guidelines for Ramp and Interchange Spacing,* indicates that there is an inverse relationship between crash rates and auxiliary lane length. FHWA's 2013 Signalized Intersections: Informational Guide, Chapter 4 Geometric Design, found that transforming a four-legged intersection to a three-legged 't-intersection' improved safety due to a reduction in the number of potential conflict areas between vehicles from 32 to 9.

NCHRP Report 687 indicates that observable operational roadway characteristics such as vehicle density, average speed, and speed differential often relate to how safe a roadway is. High vehicle densities indicate that vehicles are traveling nearer each other, increasing the likelihood of collisions between them. High speed differentials reduce the amount of reaction time a driver has to avoid a collision. Crash types most commonly associated with multi-vehicle crashes in these situations include rear-end, sideswipe, and angle collisions.

7.3.1. Southbound Washington Boulevard

The preferred build alternative modifies the interchange of Washington Boulevard and Columbia Pike by changing the westbound ramp sequence from that of a typical cloverleaf interchange with four ramps and a weaving length of 350 feet to a sequence of two ramps and no weaving areas. NCHRP Report 687 Chapter 4.5 indicates that weaving areas between ramps with a length less than 900 feet will have a crash rate 25 percent greater than the rate for a baseline weaving area with a length of 1,600 feet.

Based on the reviewed crash history, several crashes were reported along southbound Washington Boulevard within the study area. Many of these crashes occurred in the merge and weaving area between the existing loop ramps that are proposed to be removed with the preferred build alternative. The modification of ramps along southbound Washington Boulevard will reduce the number of ramps on the roadway, increase the spacing between ramps, and remove a short-length weaving area that is susceptible to higher crash rates.

Compared to the No-Build Alternative, the removal of the weaving area may allow drivers to travel more closely to the expected speed along Washington Boulevard with fewer interruptions. This could serve to reduce rear-end type collision caused by sudden braking and congested conditions.

7.3.2. Ramp Merge Areas at Columbia Pike

The preferred build alternative modifies the existing yield-controlled ramp merge areas with a fully signalized intersection at the terminus of the Washington Boulevard southbound ramp. Replacing the existing cloverleaf interchange with a signalized intersection may reduce the potential for the types of collisions (rear-end, angle, sideswipe) that are common to merge areas. Pedestrian crossing movements at the new ramp terminal would likely be improved with appropriately located high-visibility crosswalks.

7.3.3. Columbia Pike and S. Joyce Street/Southgate Road

With the preferred alternative, there will be a reduction in the number of intersection conflict points and sight distances will be improved for all intersection approaches. This may serve to reduce the prevalence of rear-end and angle crashes that were noted in the review of crash history, particularly those involving a vehicle making a westbound left turn movement. Pedestrian crossing movements would likely be improved with appropriately located high-visibility crosswalks.

7.4. Quantitative Safety Analysis

7.4.1. ISATe Overview

The Enhanced Interchange Safety Analysis Tool (ISATe) was used to assess the safety performance across the Build and No-Build conditions in the existing, 2025, and 2045 years along southbound Washington Boulevard and the ramps connecting southbound Washington Boulevard and Columbia Pike. The ISATe study area and freeway and ramp segments are shown in **Figure 7-19**.

Traffic volumes and geometric conditions are inputs that enable the program to apply safety performance functions (SPFs) and crash modification factors (CMFs) for the estimation of both the predicted and expected yearly crash frequencies. An SPF is a statistical model used to estimate the average crash frequency for a specific site type, with specified base conditions, based on traffic volume and roadway segment length. A CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a site. The tool then uses the Empirical Bayes (EB) method, supplemented with crash data from the most recent 5 years (2014 through 2018), to convert a predictive average crash frequency to a more accurate expected average crash frequency.

Figure 7-19: ISATe Study Area (Washington Blvd/West Area Ramps) with 2014-2018 Crash Locations

7.4.2. ISATe Approach

The Build condition implements significant changes in geometry to the ramps connecting southbound Washington Boulevard and Columbia Pike within this ISATe study area. As a result, separate analyses for the No-Build and Build were generated. Additionally, although calibration will most accurately generate the number of crashes expected on a roadway, as calibration factors are not yet available for Virginia roadways, ISATe with default factors was used for a comparative evaluation of the predicted crashes between the No-Build and Build conditions.

Segmentation along southbound Washington Boulevard was developed based on gore points for entering and exiting ramps for the westbound movement and remained consistent across both models. The four existing ramps were inputs to the No-Build, using measurements based on aerial imagery from Google Maps and NearMap. Both ramps from the Build condition were inputs the Build model using measurements from the most recently developed preliminary engineering design plans.

Average Annual Daily Traffic (AADT) volumes along the freeway mainline and the ramps were based on average of three 24-hour tube counts that were collected in June 2019. For the purposes of the ISATe analysis, AADTs along the Columbia Pike arterial were based on PM peak hour traffic with an assumed K-factor of 0.10.

The Build ISATe analysis retained all 2014-2018 crash data used in the No-Build analysis as most crash locations were along Washington Boulevard. The modifications in the Build analysis are largely geometric and related to the ramps. Due to model constraints that require the latest year of analysis to be within 23 years of the first year of crash data (2014), the final year of the ISATe analysis is year 2037. AADT Volumes for year 2045 developed and applied to the 2037 year and future year results were taken from this model year. This approach was taken to ensure the inclusion of crash data from the most recent five years.

7.4.3. ISATe Results

The safety analysis results for southbound Washington Boulevard and the ramps in the No-Build condition are shown in **Table 7-7** and **Table 7-8**, respectively, and the safety analysis results for the Build condition are shown in **Table 7-9** and **Table 7-10**, respectively. The total number of crashes in **Table 7-7 and Table 7-8** represents the cumulative number of crashes occurring from 2019 to 2037 as well as the predicted number of crashes each year for 2019, 2025, and 2045. The crash distributions in **Table 7-9 and Table 7-10** demonstrate the expected severity of crashes along the full facility, from Property Damage Only (PDO), including injury levels A, B, and C, to Fatal crashes (K). **Table 7-11 and Table 7-12** show the change in results from the No-Build analysis to the Build Analysis.

Freeway Results

From the No-Build to the Build analysis, the total number of crashes along the freeway portion of the study area is estimated to decrease by nearly 15 incidents. With fewer ramps entrances and exits, from four to two, and the elimination of a weaving segment, the freeway area may experience less lane-changing and more consistent travel. The greatest estimated reduction of crashes is in the Property Damage Only category because that was initially, and remains, the category with the most incidents. The estimated reduction in single-vehicle crashes, particularly “Crashes with a fixed object”, can be attributed to a more consistent roadway as well.

Table 7-7: Total Crashes in the No-Build Analysis by Facility and by Year

Crashes by Facility Component	Nbr. Sites	Total	K	A	B	C	PDO
Freeway segments, crashes:	6	284.6	1.2	3.7	24.1	46.3	209.3
Ramp segments, crashes:	4	29.5	0.3	1.0	5.1	6.9	16.2
Crossroad ramp terminals, crashes:	0	0.0	0.0	0.0	0.0	0.0	0.0
Crashes for Entire Facility by Year	**Year**	**Total**	**K**	**A**	**B**	**C**	**PDO**
	2019	15.2	0.1	0.2	1.4	2.6	10.8
	2025	16.1	0.1	0.2	1.5	2.7	11.5
	2045	17.8	0.1	0.3	1.6	3.0	12.9

Table 7-8: No-Build Analysis Crash Distribution

Distribution of Crashes for Entire Facility							
Crash Type	Crash Type Category	Estimated Number of Crashes During the Study Period					
		Total	K	A	B	C	PDO
Multiple-Vehicle Crashes	Head-on crashes:	0.7	0.0	0.0	0.1	0.2	0.3
	Right-angle crashes:	4.3	0.0	0.1	0.4	0.8	3.1
	Rear-end crashes:	147.7	0.5	1.5	10.1	19.1	116.4
	Sideswipe crashes:	53.1	0.1	0.4	2.4	4.6	45.6
	Other multiple-vehicle crashes:	5.5	0.0	0.1	0.5	0.8	4.1
	Total multiple-vehicle crashes:	211.3	0.7	2.1	13.4	25.5	169.6
Single-Vehicle Crashes	Crashes with animal:	1.1	0.0	0.0	0.1	0.1	1.0
	Crashes with fixed object:	75.4	0.6	1.9	11.3	19.8	41.7
	Crashes with other object:	8.2	0.0	0.1	0.6	1.2	6.2
	Crashes with parked vehicle:	1.5	0.0	0.0	0.2	0.4	0.8
	Other single-vehicle crashes	16.5	0.2	0.6	3.5	6.0	6.2
	Total single-vehicle crashes:	102.7	0.9	2.6	15.8	27.6	55.9
Total crashes:		314.0	1.5	4.7	29.2	53.1	225.5

Table 7-9: Total Crashes in the Build Analysis by Facility and by Year

Crashes by Facility Component	Nbr. Sites	Total	K	A	B	C	PDO
Freeway segments, crashes:	6	269.7	1.1	3.5	22.9	44.0	198.1
Ramp segments, crashes:	2	8.7	0.1	0.2	1.0	2.2	5.2
Crossroad ramp terminals, crashes:	1	43.8	0.0	0.7	4.4	17.4	21.2
Crashes for Entire Facility by Year	**Year**	**Total**	**K**	**A**	**B**	**C**	**PDO**
	2019	15.5	0.1	0.2	1.4	3.0	10.8
	2025	16.5	0.1	0.2	1.5	3.3	11.4
	2045	18.5	0.1	0.3	1.6	3.6	12.9

Table 7-10: Build Analysis Crash Distribution

Distribution of Crashes for Entire Facility							
Crash Type	Crash Type Category	Estimated Number of Crashes During the Study Period					
		Total	K	A	B	C	PDO
Multiple-Vehicle Crashes	Head-on crashes:	1.0	0.0	0.0	0.1	0.4	0.5
	Right-angle crashes:	14.5	0.0	0.2	1.5	5.2	7.5
	Rear-end crashes:	162.4	0.5	1.8	11.8	28.1	120.2
	Sideswipe crashes:	53.4	0.1	0.4	2.3	4.9	45.7
	Other multiple-vehicle crashes:	5.6	0.0	0.1	0.4	0.9	4.2
	Total multiple-vehicle crashes:	236.9	0.6	2.5	16.2	39.5	178.2
Single-Vehicle Crashes	Crashes with animal:	1.0	0.0	0.0	0.0	0.1	0.9
	Crashes with fixed object:	61.6	0.4	1.4	8.8	17.3	33.8
	Crashes with other object:	7.8	0.0	0.1	0.6	1.2	5.9
	Crashes with parked vehicle:	1.3	0.0	0.0	0.2	0.4	0.7
	Other single-vehicle crashes	13.4	0.1	0.4	2.6	5.3	5.0
	Total single-vehicle crashes:	85.2	0.6	1.9	12.2	24.1	46.4
Total crashes:		322.1	1.2	4.4	28.4	63.6	224.5

Table 7-11: Change in Total Crashes from No-Build to Build Analysis

Crashes by Facility Component	Nbr. Sites	Total	K	A	B	C	PDO
Freeway segments, crashes:	6	-14.9	-0.1	-0.2	-1.2	-2.3	-11.2
Ramp segments, crashes:	From 4 to 2	-20.8	-0.2	-0.8	-4.1	-4.7	-11
Crossroad ramp terminals, crashes:	From 0 to 1	43.8	0	0.7	4.4	17.4	21.2
Crashes for Entire Facility by Year	**Year**	**Total**	**K**	**A**	**B**	**C**	**PDO**
	2019	0.3	0	0	0	0.4	0
	2025	0.4	0	0	0	0.6	-0.1
	2045	0.7	0	0	0	0.6	0

Table 7-12: Change in Crash Distribution from No-Build to Build Analysis

Distribution of Crashes for Entire Facility							
Crash Type	Crash Type Category	Estimated Number of Crashes During the Study Period					
		Total	K	A	B	C	PDO
Multiple-Vehicle Crashes	Head-on crashes:	0.3	0.0	0.0	0.0	0.2	0.1
	Right-angle crashes:	10.2	0.0	0.2	1.1	4.4	4.5
	Rear-end crashes:	14.7	0.0	0.3	1.7	9.0	3.8
	Sideswipe crashes:	0.3	0.0	0.0	-0.1	0.3	0.1
	Other multiple-vehicle crashes:	0.1	0.0	0.0	0.0	0.0	0.1
	Total multiple-vehicle crashes:	25.7	-0.1	0.4	2.7	13.9	8.6
Single-Vehicle Crashes	Crashes with animal:	-0.1	0.0	0.0	0.0	0.0	-0.1
	Crashes with fixed object:	-13.8	-0.2	-0.5	-2.6	-2.6	-7.9
	Crashes with other object:	-0.4	0.0	0.0	-0.1	-0.1	-0.2
	Crashes with parked vehicle:	-0.2	0.0	0.0	0.0	0.0	-0.1
	Other single-vehicle crashes	-3.1	-0.1	-0.2	-0.9	-0.8	-1.2
	Total single-vehicle crashes:	-17.5	-0.2	-0.7	-3.6	-3.5	-9.5
Total crashes:		8.1	-0.3	-0.3	-0.8	10.5	-0.9

Ramps Results

The Build scenario geometric configuration reduces the number of ramps to two on the west side of southbound Washington Boulevard and as a result the estimated total number of crashes drops by almost 21 incidents over 23 years. The limiting of merge and diverge areas as the ramps enter of exit the freeway could reduce the interactions of vehicles at differing speeds in a high-speed area, potentially lowering the likelihood of a safety incident.

Ramp Terminal Results

A signal-controlled ramp terminal is included in the Build scenario geometry which introduces 12 new conflict points and has an estimated 43.8 crashes in 23 years. This terminal is responsible for the increase in expected multiple-vehicle crashes, particularly the right-angle and rear-end type crashes that are more common in intersections. The distribution of severity of crashes at the ramp terminal is like that on other facilities with the number of Property Damage Only crashes being the highest. This location also includes a higher ratio of level “C” injury crashes but has no expected fatalities.

Summary

While there are anticipated increased in safety for the existing portions, freeway and ramp, of the study area, the new ramp terminal is related to likelihood of different crash types at the specific location. In total, the ISATe analysis predicts an estimated increase of 8 crashes over 23 years with the majority increase in level “C” injury crashes and a slight reduction of all other types of crashes, including fatal incidents. Across the entire facility in the Build condition, estimated prevalence of Property Damage Only crashes still far exceeds all other crash types, making up 70% of all incidents. The ramp terminal would likely be designed to promote safety with detailed attention to sight distances, signal phasing, lane configuration, and lane alignments, and the new ramps design will facilitate safer entrances and exits from the freeway in the westbound direction. Such improvements and a focus on multimodal operations may result in a Build condition that remains an adequately safe facility.

7.5. Operational Analysis Summary

7.5.1. Arterials

An analysis of existing conditions indicates that the arterial intersections in the study area all generally operate at acceptable LOS (D or better) during both peak hours. The exception to this is the intersection of Columbia Pike with Joyce Street/Southgate Road, which during the PM peak hour operates at LOS E. The reduced LOS of the former is the result of significant delays in the northbound S. Joyce Street and westbound Columbia Pike approaches to the intersection. Traffic volumes and challenging sight distances in the eastbound and westbound directions of Columbia Pike limit the flexibility in green time allocation and signal timing phase options that are available for implementation. The overall intersection LOS indicates that these intersections are approaching capacity and will only further degrade in LOS with the forecasted growth of traffic volumes in the absence of any improvements.

An analysis of 2025 No-Build conditions indicates that the arterial intersections in the study area will all operate at acceptable LOS D or better, with the exception of the aforementioned LOS deficiencies at the intersection of Columbia Pike with Joyce Street/Southgate Road.

An analysis of 2045 No-Build conditions indicates that the arterial intersections in the study area will all operate at acceptable LOS D or better, with the exception of the aforementioned LOS deficiencies at the intersection of Columbia Pike with S. Joyce Street/Southgate Road. By 2045, the forecasted PM peak hour traffic volumes will begin to saturate the study area and push the study area arterial intersections towards capacity. It is noted that the results at Columbia Pike are among the best results that could be achieved after exploring a menu of signal timing options including coordination, cycle length, phasing, and green time allocation. This is indicative that more substantive improvements are needed to improve the operation of the study area in general and the intersection of Columbia Pike with S. Joyce Street in particular.

An analysis of 2025 and 2045 Build conditions indicates that the arterial intersections in the study area will all operate at acceptable LOS D or better. This indicates that the combination of the proposed interchange modification, the Columbia Pike realignment, the Southgate Road relocation, and traffic signal timing modifications can greatly improve arterial operations in the study area. The analysis demonstrates that a signalized intersection at the Washington Boulevard ramp terminal and the intersection associated with the PMF VEC and the relocated service complex can be designed to integrate well within a coordinated Columbia Pike street network. While the improvements considered in the build scenario do not specifically target any of the other arterial intersections, by relieving the congestion at one of the major bottlenecks in the study area, residual improvements are observed at the other intersections. This is the result of improved progression and reduced queuing and delay along the arterial streets in the study area.

7.5.2. Mainline

For nearly all scenarios analyzed, during the AM peak hour, the southbound Washington Boulevard mainline operates with good progression (speeds greater than 40 mph, densities generally less than or around 30 vehicles per mile based on VISSIM results). It is noted that the build scenarios have negligible positive impacts on westbound AM peak period mainline operations.

For nearly all scenarios analyzed, during the AM peak hours, the Washington Boulevard northbound mainline operates with moderate to heavy congestion (reduced speeds of less than 20 mph, densities much greater than 45 vplpm based on VISSIM results). These issues are especially prevalent north of the

merge point of the ramp from Columbia Pike westbound to Washington Boulevard northbound. Speeds ahead of this merge point are well below 20 mph and densities exceed 100 vplpm. As traffic volumes reach the forecasted levels, speed and density issues become more prevalent. It is noted that the improvements associated with the Build scenarios are wholly contained on the west side of the interchange and have no direct impacts on northbound Washington Boulevard operations. It is expected that further coordination between ANC, VDOT, the County, and the Pentagon would be necessary to identify responsive and compatible improvements for the eastern side of the interchange. The identification and analysis of those potential improvements goes beyond the scope of this IMR Update.

Bottlenecks along the Washington Boulevard mainline are improved by the Build conditions; the operational improvements are likely the result of better progression and reduced queuing along westbound Columbia Pike during the PM peak hour, allowing vehicles to efficiently exit the mainline via the proposed modified ramp (as well as the removal of a weaving area).

7.5.3. Interchange Ramps

For nearly all scenarios, during the AM and PM peak hour the interchange ramps perform well when considering speeds and density. Ramp speeds generally conform to the posted ramp advisory speeds and densities are low, indicating near free flow conditions. With the preferred build alternative, along the ramp from Washington Boulevard southbound to Columbia Pike, the signalized intersection at the terminal of the ramp introduces a minor increase in density and reduction in speed due to periodic stops at red lights. No significant operational impacts are expected due to this change. The ramps will continue to operate well, and no queue spillback or other impacts are anticipated to the mainline.

8. Land Use

This chapter of the report includes a brief description of existing and planned zoning and land uses within the study area. Additional land use information for the study area can be found in **Chapter 3**.

8.1. Existing Land Use and Zoning

Figure 8-1 illustrates the current zoning within the area. Most of the study area is located within the special zoning district (S-3A) that includes Arlington National Cemetery, Air Force Memorial, and the Pentagon. The Foxcroft neighborhood, located to the north of Columbia Pike, contains parcels zoned for single-family residential, townhouse, and apartment (R-6, R2-7, RA8-18). Portions of the neighborhood are also zoned for commercial use (C-O, C-1). Nearby land uses include the Pentagon City Mall, commercial developments (C-O-2.5), apartment complexes (RA6-15), and hotels (RA-H).

8.2. Future/Potential Land Use and Development

Arlington County's General Land Use Plan (GLUP), amended in December 2018, shows planned zoning that is consistent with existing residential, commercial, and special land use in the study area. The GLUP denotes the Pentagon City Mall property and surrounding development to the south of Army Navy Drive as a "Coordinated Development District" within the County's Jefferson Davis Metro Corridor special planning area. **Figure 8-2** illustrates zoning according to the most recent GLUP. Arlington County is currently in the process of designing multimodal Streetscape improvements along Columbia Pike. The project, which extends from S. Joyce Street (within the project area) west to South Jefferson Street, will feature multimodal roadway and streetscape improvements, traffic signal upgrades, replacement of drainage and sewage infrastructure, and underground relocation of existing overhead utilities. The 2014 Pentagon Master Plan Update focused on the development of the Pentagon 9/11 Memorial and VEC, which are currently under development within the project study area. The plan update also includes projects to renovate or replace smaller exterior buildings on the campus and to reduce parking capacity by 1,295 spaces. The 2018 Arlington National Cemetery Real Property Master Plan included an expansion of the cemetery south to Interstate 395 from its current extent at Southgate Road. This additional space would be used for internment and for the needs of cemetery grounds maintenance contractors. The plan takes into consideration a potential realignment of Columbia Pike and ramps to and from southbound Washington Boulevard as detailed in this IMR Update. In October 2018, MWCOG released Round 9.1 Cooperative Forecasts with updated population and employment totals. These projected totals are shown for years 2015 and 2045 in **Table 8-1**. Between 2015 and 2044, the results suggest an average employment increase of 0.83% per year in Arlington County and 1.01% per year in the MWCOG region. Over the same time, the results suggest an average population increase of 1.04% per year in Arlington County and 0.84% per year in the MWCOG region. **Figure 8-3** and **Figure 8-4** depict the anticipated employment and population changes (pre-Amazon) as reflected in the MWCOG 9.1 Cooperative Forecast model for the areas adjacent to the study area between 2015 and 2045, respectively. Figure 8-5 and Figure 8-6 depict the anticipated employment and population changes (with Amazon) as reflected in the draft MWCOG 9.1 Cooperative Forecast developed by Arlington County.

Table 8-1: MWCOG Region Projected Growth (Round 9.1 Cooperative Forecast Data Pre-Amazon)

Year	Employment			Population		
	2015	2045	2015-2045	2015	2045	2015-2045
Arlington County	209,700	269,100	0.83%	220,900	301,200	1.04%
MWCOG Region Total	3,160,800	4,273,800	1.01%	5,390,600	6,925,700	0.84%

Figure 8-1: Zoning Map

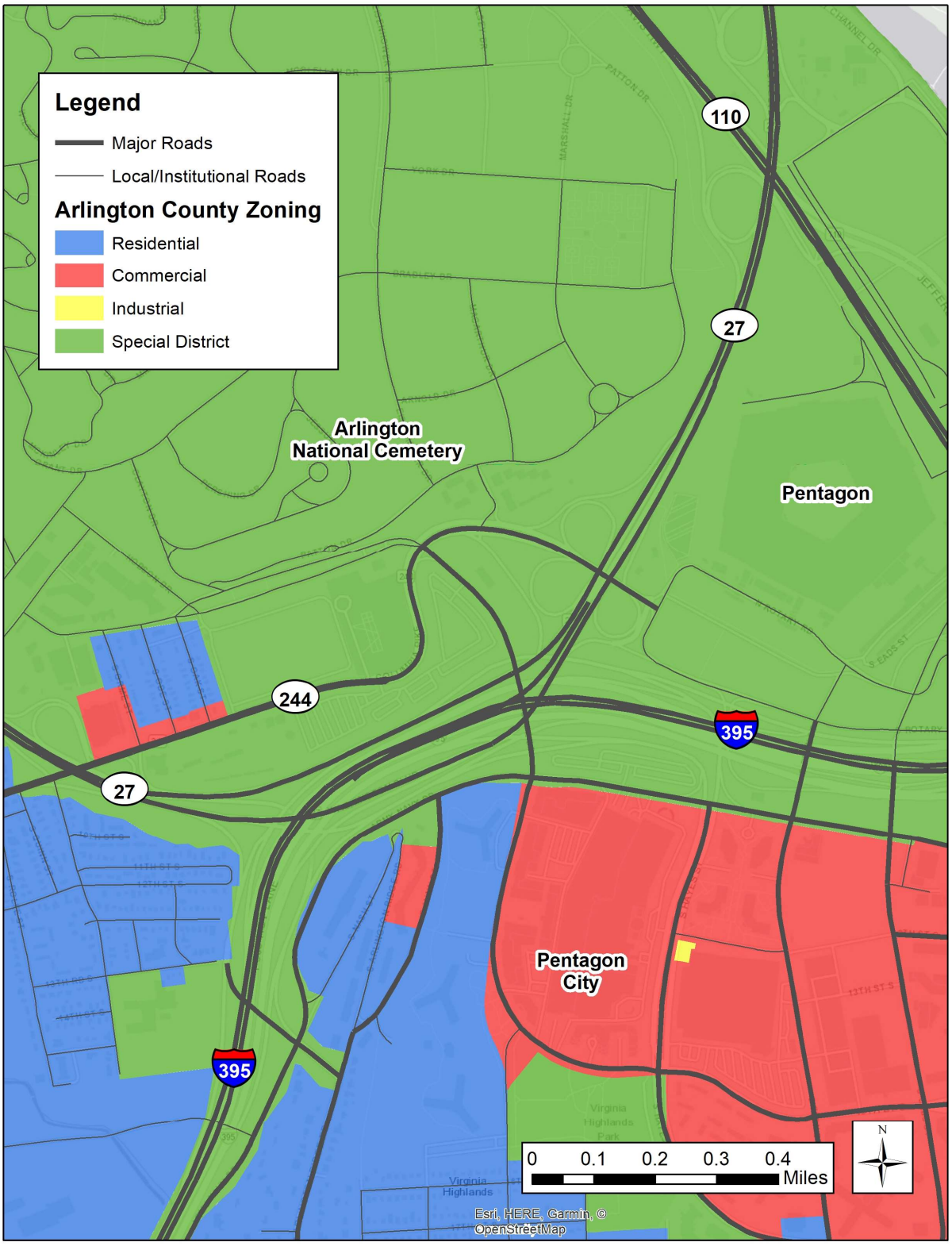


Figure 8-2: GLUP Map

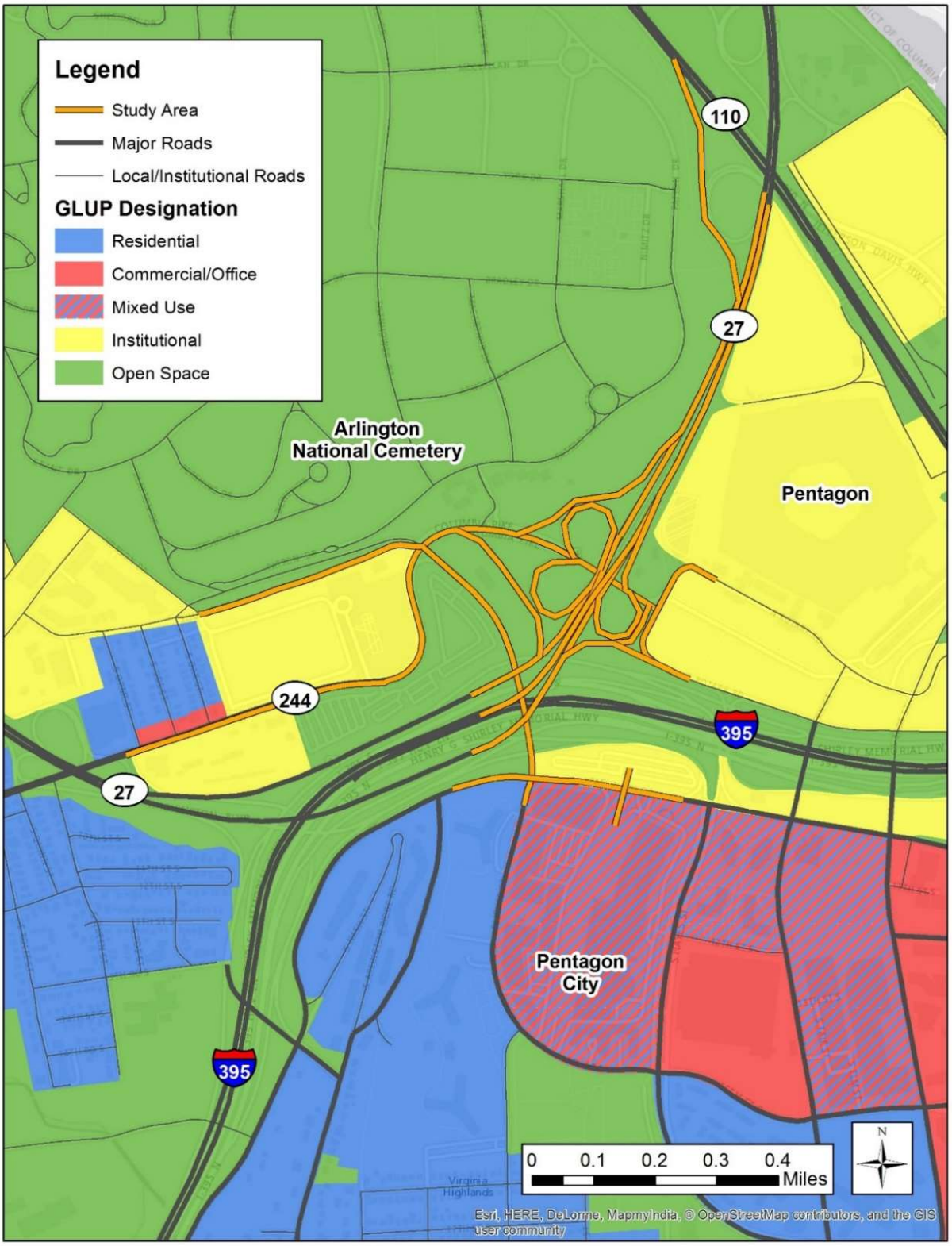


Figure 8-3: MWCOG Projected Employment Changes 2015 – 2045 (9.1 Forecasts Without Amazon)

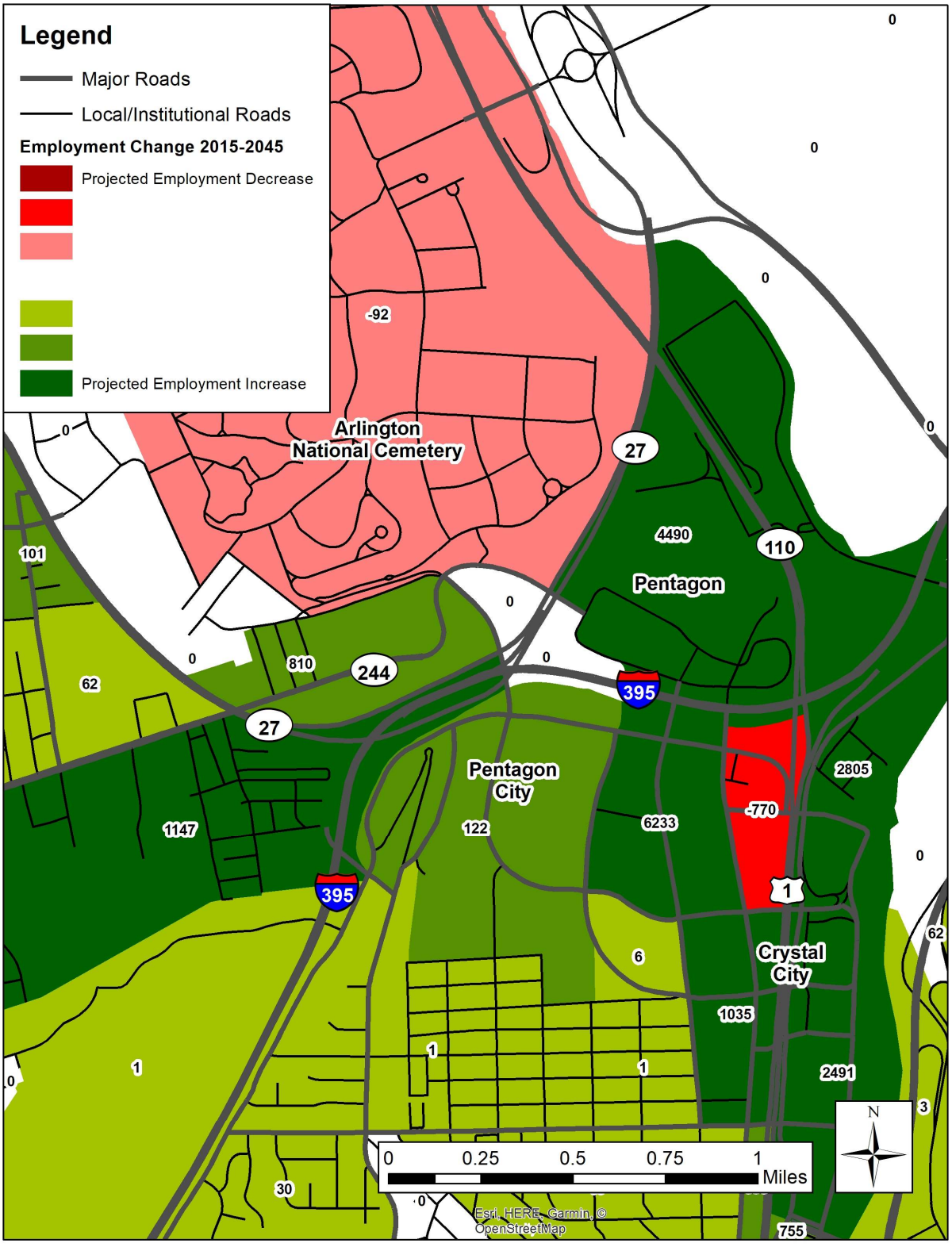


Figure 8-4: MWCOG Projected Population Changes 2015 – 2045 (9.1 Forecasts Without Amazon)

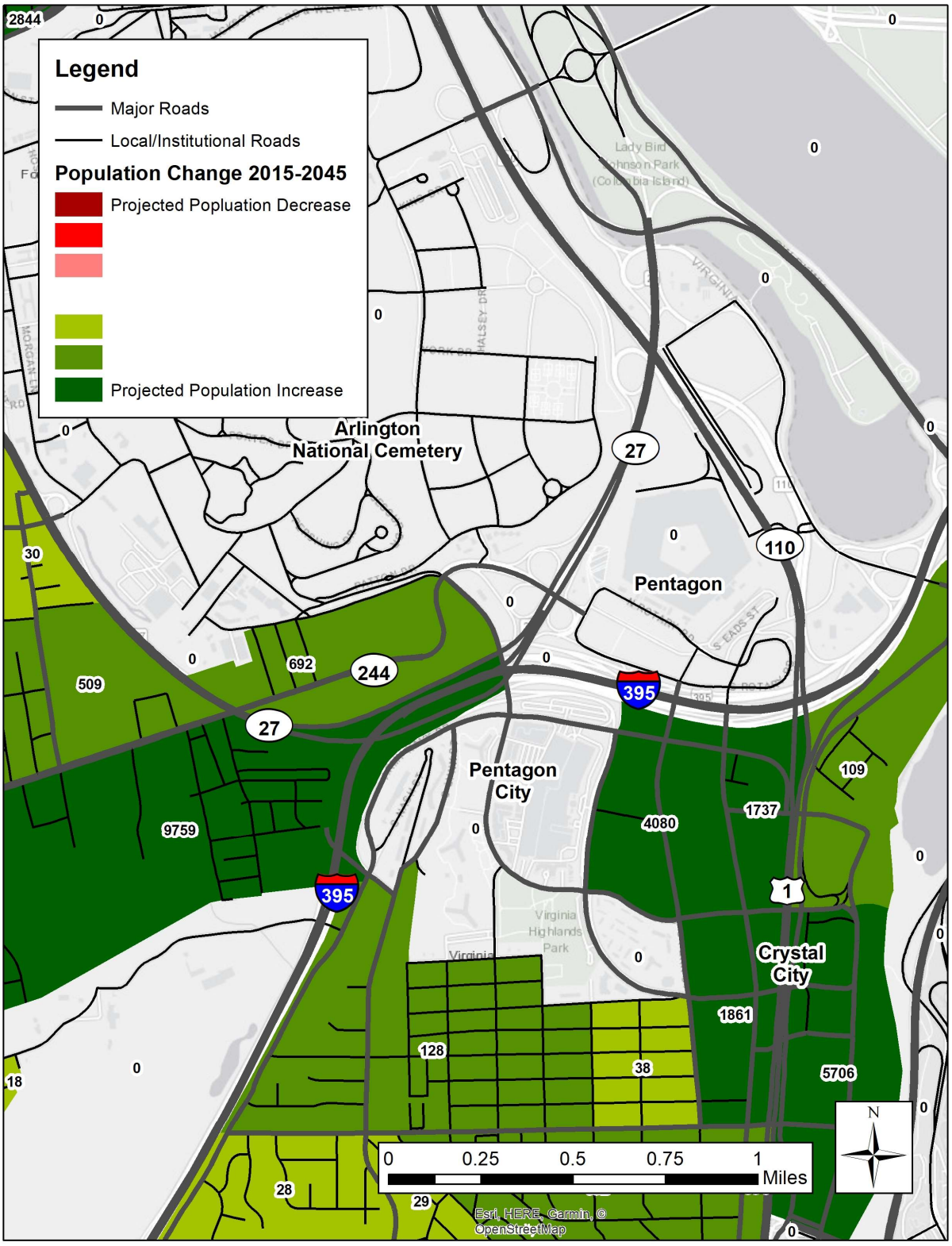


Figure 8-5: MWCOG Projected Employment Changes 2015 – 2045 (9.1 Forecasts With Amazon)

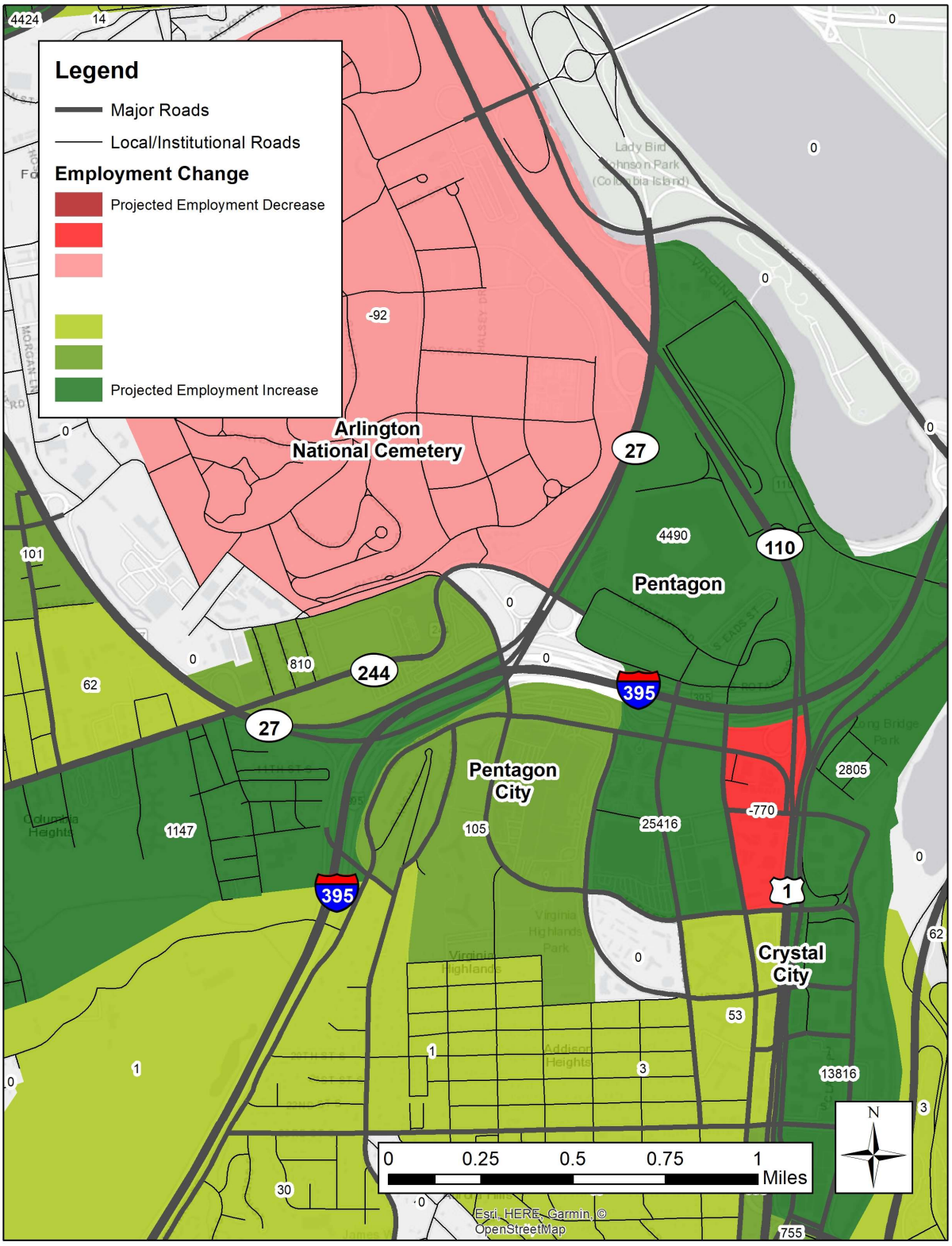
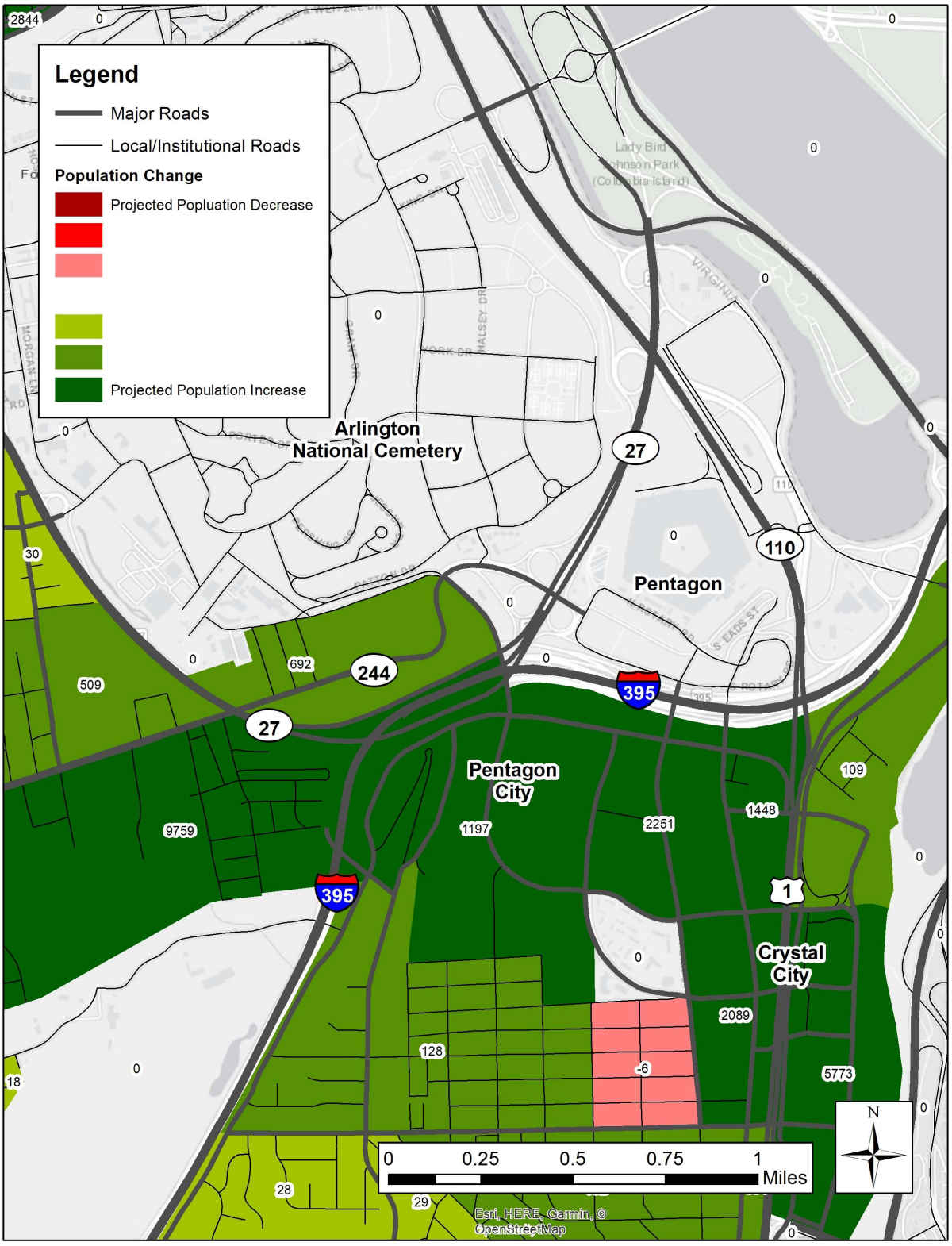


Figure 8-6: MWCOG Projected Population Changes 2015 – 2045 (9.1 Forecasts With Amazon)



9. Environmental Compliance

An existing environmental constraint review was outlined in **Chapter 3** and is included as **Appendix G**.

It is recognized that that the ANCSE EA is being done under NEPA and includes in its scope both the expansion of the cemetery and the DAR project elements. A FONSI will be issued by ANC for the ANCSE project and a FONSI will be issued by FHWA for the DAR project; however, the FHWA FONSI is dependent upon an IMR accepted by the Partner Agencies and approved by VDOT [and FHWA].

10. Conclusions

The purpose of this IMR Update has been to present a reanalysis of the conditionally approved Columbia Pike/Washington Boulevard Interchange modification report. This IMR Update was tailored to address concerns that critical assumptions had changed since the approval of the 2017 IMR. Specifically, the IMR Update addresses VDOT, Arlington County, and additional requirements from project stakeholders as indicated though the framework process by including the following revisions:

- Existing analyses based on traffic, pedestrian, transit, and bicycle counts conducted in June 2019.
- Traffic forecasting based on the latest Metropolitan Washington Council of Governments (MWCOG) Travel Demand Model (version 2.3.75) and the latest Cooperative Forecasts (Round 9.1)
- Refined forecast years (2025 and 2045)
- Updated study area safety review (based on crash data from 2014 to 2018)
- Quantitative (ISATe) crash analysis
- Removal of Synchro and HCM based analyses (in favor of VISSIM analyses)
- Updated signal timing at arterial intersections in the study area
- Refined preferred alternative (i.e. number of approach lanes at Columbia Pike)
- Reassignment of traffic to reflect the relocation of the ANC service complex, the development of a parking garage, the closure of Southgate Road, and the opening on Nash Street
- Inclusion of future traffic related to the development of the PMF VEC
- Inclusion of future traffic related to the development of the Amazon campus and associated area developments (i.e. the “Amazon Effect”)

With respect to the findings presented herein, it has been demonstrated that the interchange modifications can be implemented with minimal to no impacts to mainline operations along Washington Boulevard and with generally positive impacts to the forecasted arterial operations, even when considering the changes in study area traffic, access, and development that are the subject of this IMR Update.

The interchange modification and Columbia Pike realignment designs put forward by the DAR and ANCSE are sufficient to accommodate the potential future traffic and multimodal needs related to the Amazon Campus, Amazon-related development in Crystal City, traffic generated by the relocated service complex, and traffic generated by the PMF VEC.

These updated findings aside, the conclusions of the 2017 IMR are still valid:

A modification to the west side of the interchange creates an opportunity to expands the contiguous burial space of Arlington National Cemetery, supports the multimodal realignment and upgrade of Columbia Pike, and provides functional space for the PMF VEC.

All aspects of the interchange modification project, from inception to concept design to current refinement under the DAR process, has been deliberately prepared to respond to the purpose and need statement:

> *The rapid growth in the Northern Virginia region has created a need for the modification of the interchange of Columbia Pike and Washington Boulevard within Arlington County near the Pentagon and Arlington National Cemetery. The purpose of the interchange modifications and the complimentary realignment of Columbia Pike described in this IMR are as follows*:

- To improve safety and security
- To allow for more contiguous land for Arlington National Cemetery expansion (in concert with the previous demolition of the Navy Annex facilities)
- To improve traffic and transit operations at signalized intersections
- To provide for more efficient pedestrian and bicycle access along Columbia Pike and through its interchange with Washington Boulevard
- To improve multimodal access to regional destinations, and maintain consistency with the Arlington County Master Transportation Plan, the Columbia Pike Multimodal Street Improvements Project, ANC expansion plans, and Pentagon 9/11 Memorial plans

The preferred build alternative was developed and refined following an exhaustive and collaborative process between FHWA EFLHD, USACE, Arlington County, ANC, and VDOT. Multiple design options were considered, screened, and evaluated for consistency with the purpose and need statement and compatibility with the transportation and land use goals for the area. The preferred build alternative, a tight diamond interchange configuration represents a mutually agreeable alternative that satisfied many of the individual stakeholder goals (i.e. optimization of contiguous burial space for ANC, reservation space for PMF VEC, not precluding access to the ANC maintenance facility, realigning and upgrading Columbia Pike to improve safety and operation and introduce multimodal elements, the relocation of Southgate Road, not precluding a future transit option along Columbia Pike, and minimizing impacts to Air Force Memorial).

While the primary purpose of this IMR is not traffic operations focused, it has been demonstrated that by 2045, absent of other improvements, the arterial traffic operations in the area may degrade as traffic volumes increase. It has been further demonstrated with the preferred build alternative, in addition to the realignment of Columbia Pike and relocation of Southgate Road, the operation along Columbia Pike and the areas around the interchange could be significantly improved. Vehicle delays at intersections could be reduced, and any potential spillback of Washington Boulevard ramp traffic to the mainline can be minimized. The preferred build alternative also supports a more multimodal Columbia Pike with improved sight distances, safer pedestrian crossing experiences, road and intersection configurations that support transit movements, and a shared use path. The elimination/consolidation of ramp movements reduces higher-speed weave, merge and diverge areas, potentially improving safety of travel within and through the interchange.

It has also been demonstrated that the interchange modification and Columbia Pike realignment can be designed to applicable state and local road design requirements and that the modified interchange can be signed in a clear and concise manner that makes the best use of the existing infrastructure to provide a clear message to motorists about points of interests and route guidance. Lastly, this IMR demonstrated that the modification of the interchange and realignment of Columbia Pike can be implemented in a manner that is consistent with the surrounding land uses and that maintains the vital access to ANC and the Pentagon.

The Columbia Pike/Washington Boulevard Interchange Modification is vital to the success and transportation network integrity of this area of the County. This modification has the potential to benefit multiple stakeholders, to improve access to some of the Nation’s most important government and cultural facilities, and to improve multimodal traffic operations for motorists, pedestrians, transit riders, and bicyclists. The proposed modification has been respectfully designed to consider a balancing of many diverse and competing interests and represents a collaborative and thoughtful approach to enhance the functionality and compatibility of this vital interchange with the surrounding land uses.