September 28, 2020

COMMENTS ON THE DRAFT ENVIRONMENTAL IMPACT STATEMENT AND DRAFT SECTION 4(f) EVALUATION FOR WASHINGTON UNION STATION EXPANSION PROJECT (DEIS 20200120)

SUBMITTED BY

AKRIDGE

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Submitted by email to: info@WUSstationexpansion.com

Introduction

Akridge and its affiliated entities (collectively “Akridge”) appreciate the opportunity to provide comments on the Draft EIS for the Washington Union Station Expansion Project (“Expansion Project” or “SEP”). Akridge is a full-service commercial real estate firm with over four decades of experience developing and managing premier properties throughout Washington, DC. Akridge is leading the development team for Burnham Place, a proposed three-million square-foot development to be built above Union Station’s rail yard on the private air rights sold for development at Congress’ direction and owned by Akridge. The Burnham Place development will provide direct access to the expanded and improved Union Station facility. Burnham Place will represent one of the most economically catalytic project for the National Capitol Region for decades to come, and will provide a new commercial center atop an expanded multi-modal station. The Burnham Place development will feature a mix of first-class office, residential, retail, and hotel space, as well as parks and plazas. The award-winning vision matches the quality of the original, acclaimed station design by architect Daniel Burnham and ensures that Union Station continues to be a worthy gateway to the nation's capital.

As the owner of the adjacent private air rights, Akridge has been an active supporter of the plans to refurbish and expand Union Station. Modernizing train service, updating the facility, and developing a new neighborhood adjacent to a world-class transportation facility will bring significant benefits to the country, the region, and the District of Columbia. Akridge has worked alongside Amtrak, the Union Station Redevelopment Corporation, the District of Columbia government, and key stakeholders for the better part of 20 years to push for the design and implementation of an Expansion Project which will be successful for everyone. During that time, Akridge has repeatedly raised significant concerns regarding the Expansion Project that impact Burnham Place, the surrounding neighborhoods, and other stakeholders.

As discussed more fully below, several modifications to the Preferred Alternative presented in the DEIS are needed to meet FRA’s obligations under NEPA, Section 106 and Section 4(f), as well as to ensure a viable and successful design that will meet the project’s purpose and need. Akridge has spent significant time and resources to develop Alternative “A-C Modified” that would vastly improve the Expansion Project, satisfy its established objectives, and avoid undue adverse impacts to Burnham Place. Akridge believes that by making key adjustments to the Preferred Alternative, the Expansion Project can meet its purpose and need as well as the diverse goals of stakeholders, including those of Akridge.

Section I

Executive Summary

It is difficult to overstate the potential of Washington Union Station's expansion. If effectively planned, designed, funded and built, all those who live and work within or visit the National Capital Region will benefit from its implementation. Dramatic capacity increases in intercity and commuter rail growth will enhance regional mobility and open housing and job growth to more sustainable locations. Economic benefits will accrue to the District, Maryland and Virginia by leveraging existing transportation assets. Millions fewer vehicle miles traveled each year will improve air quality and reduce traffic congestion.

The Capitol Hill, Near Northeast, Union Market/Gallaudet, and NoMa neighborhoods will enjoy seamless access to a neighborhood asset—one that is treasured equally for its community impact and historic significance as it is for its efficient transportation options and high-quality passenger experience. Union Station's ambitious second redevelopment, steps from the U.S. Capitol Building, will signal to Americans and international visitors alike that our country makes bold investments in sustainable infrastructure while respecting and valuing the human experience.

It is the breadth and depth of the potential impact of the station's expansion that has led Akridge to invest 18 years in project planning, research and analysis for Burnham Place as well as Union Station. Underpinning our long term commitment is the belief that when in harmony, Burnham Place and the station expansion will be symbiotic, providing exponentially more value and benefits to all stakeholders than either project could deliver alone. In this regard, Akridge believes the public support for and successful planning of each project is fundamental to the other achieving its full potential.

At this moment within the station expansion's regulatory review, there can be two profoundly different outcomes. In one, a project plan inspires and unifies stakeholders, neighbors, approval authorities and ultimately government leaders to invest boldly in a shared vision for the station's next century. Alternatively, the regulatory process concludes with continued conflict. Stagnation follows as there is insufficient support to garner required approvals, let alone the political will to advance an uninspiring project of such enormous scale and duration.

Akridge approaches this juncture with optimism that the first path is eminently achievable. First, the foundational rationale for the station's expansion enjoys broad and vocal support. The passion with which stakeholders have expressed their views reflects a collective agreement on the project's unmatched importance. There is to date unanimous support for FRA and Amtrak's plans to reconfigure the station's tracks and platforms with new concourses and an impressive train hall positioned north of the historic building. The DEIS's detailed constructability and engineering analyses demonstrate the project's feasibility.

Burnham Place team's vision for compatible public and private projects

Alternative A-C therefore serves as an effective starting point, but for reasons discussed in these comments is not a feasible alternative. However, by making three key adjustments to the Preferred Alternative, the project can meet its Purpose and Need as well as the diverse goals of a broad group of stakeholders, including those of Akridge. These changes include:

1. **Parking**: Locate the District government's recommended 295 (or fewer) station parking spaces below the new rail concourse level in the area shown in Alternatives C and D
2. **Pick-Up and Drop-Off (PUDO)**: Alongside the (predominantly short-term) station parking below-grade, incorporate a high-capacity PUDO area including For-Hire Vehicle storage with multiple ingress and egress points
3. **Bus Facility**: Include a prominent, day-lit intercity and charter bus facility of exceptional quality with 18 slips adjacent to the Train Hall

These proposed changes, described in more detail below, are based on rigorous analysis and application of best practices in multi-modal transportation facilities. The adjustments are also informed by our engagement over several years with other stakeholders and our understanding of their concerns, goals and priorities for the station expansion including:

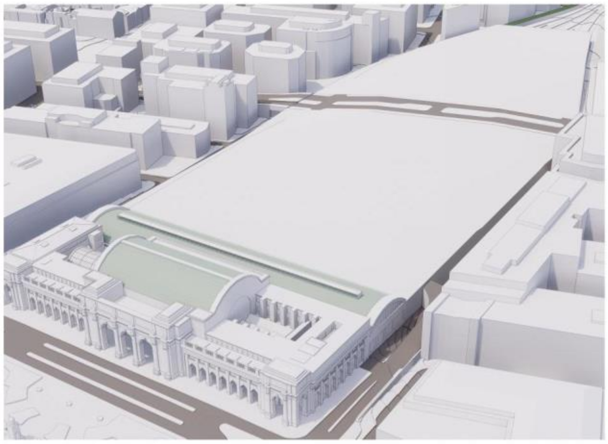
- Enhancement and preservation of key historic viewsheds and assets
- Inclusion of prominent, open spaces, such as civic plazas, parks and recreational areas
- Prioritization of pedestrian, bicycle and transit infrastructure
- Minimization of at-grade vehicular functions and congestion at the station's edges

Garage Demolition Required For Rail Growth Demands a Blank Slate Approach

The DEIS carefully and convincingly documents that in order to expand intercity and commuter rail capacity and ensure the safety, security and accessibility of the station, the existing parking garage must be demolished and the rail yard rebuilt. This requirement, reflected within all the Action Alternatives, is critically important in developing the appropriate framework in which to plan the facility's next century. No different from any other land use planning exercise, when existing improvements will be removed, the correct planning approach is to start from scratch and then determine the appropriate uses (and their scale and locations) to include. Planning for the "deck level" between the historic station and H Street should follow this approach.

This approach does not eliminate the primacy of achieving the station's key transportation goals. Nor does starting from a blank slate suggest that the existing garage property should not be utilized in service of the public interest. Rather, this framework allows planners to look 40 years ahead to predict urban transportation and design trends rather than face the burden of 40-year-old suburban planning models as a baseline condition.

EXISTING STATION CONDITIONS



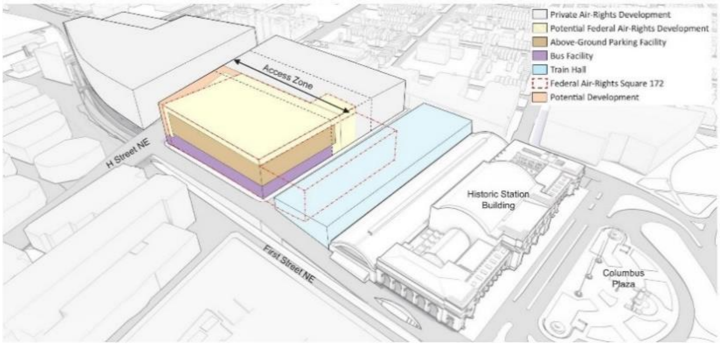
BLANK SLATE APPROACH

Problems with the Preferred Alternative

As noted previously, we believe the proposed Train Hall in Alternative A-C is approximately the right scale and optimally placed. We also agree with the inclusion of prominent pedestrian access points on both sides of H Street and at the Train Hall. However, in regards to vehicular station elements, the FRA's plan is rooted in backward rather than forward looking transportation planning principles.

A seemingly intractable challenge at many urban rail stations is how to accommodate the volume of vehicles required to serve the station's various modes. On the one hand, if potential train or bus passengers encounter an inefficient and frustrating experience arriving or departing the station by vehicle, in the future many will choose to avoid the station. However, if the streets adjacent to the station are heavily dominated by vehicles, those taking higher capacity modes such as transit, bicycle or walking will encounter unsafe conditions, similarly discouraging future station use. An unsafe and unappealing environment adjacent to the station also detracts from its historic setting and serves as a neighborhood liability rather than an asset.

We believe much of the tension surrounding the flaws in Preferred Alternative A-C involves the high demands of planning a complicated multi-modal facility in the middle of a highly constrained urban environment. This context requires a demanding assessment of the scale and collateral impacts of each of the intended uses. This assessment must not be framed by the past scale and relationship of uses, but rather start from a thorough review of current and projected demand generators and thoughtfully sized accordingly. Next, an iterative process is required to optimally locate each component.



CREDIT: DEIS Alternative A-C (Preferred Alternative), June 2020

In Preferred Alternative A-C, the parking, PUDO and bus facility components must each be right-sized and located properly in order to enable station capacity growth while facilitating, not precluding, the development of a plan that achieves the stakeholder goals listed above.

Parking

We support the DC Office of Planning (DCOP) in its recommendation and documented rationale for no more than 295 station parking spaces. Our transportation consultants conducted a station parking demand analysis in May of this year which reached a materially similar conclusion (see Appendix A). The negative impacts of including too much parking as planned in Alternative A-C are so extensive that they render the current concept infeasible:

- The proposed garage's east side hinders the creation of an adequate civic space and symmetrical backdrop behind the historic station. Its west side and associated service road prevent the creation of a greenway, new station entrances and an appropriate visual corridor along First Street NE
- If in order to facilitate a central civic space, federal air rights development is foregone along the garage's east side, the two-block long garage facade would visually harm and overwhelm that civic space
- A developable area for potential federal air rights is indicated above the garage in Alternative A-C. The feasibility of creating two stories of marketable commercial or residential space, with accessible lobby entrances, and elevators and stairs traveling through a bus and parking facility is highly doubtful and unlikely to provide economic value
- The parking levels create a substantial opportunity cost as the federally-owned property cannot be used in part for development or the creation of parks, open space and other public uses

Once right-sized, 295 predominantly short term parking spaces can fit within less than one third of the below-grade parking footprint shown in Alternatives C and D. Shifting this right-sized parking program below grade (in concert with changes to PUDO and bus facilities) will avoid all of the impacts described above, and allow the achievement of stakeholder goals for urban design, historic preservation and neighborhood integration.

We understand that USRC currently relies meaningfully on station parking garage revenues to sustain its current operations. However, we believe it is a serious mistake to continue to focus on parking as a significant revenue stream for USRC, or to let parking revenue drive critical design factors for the Expansion Project. The design, size and placement of the parking garage is a critical aspect of the Expansion Project, and should be based on how to best meet the overall purpose and need of the project for all stakeholders, not solely or even primarily on considerations of USRC revenue. Moreover, placing parking below the deck frees the federal air rights for private development, which would yield a significant and sustainable revenue stream to support USRC's important mission. Further details of the potential revenue from mixed-use development of the federal air rights are provided in Section 6D and Appendix F.

PUDO

Pick-up and drop-off activity at major transportation centers has increased dramatically within the past five years. We agree with FRA's assessment that this trend will continue to intensify, as For-Hire Vehicle (FHV) ridership replaces drive-and-park and other mode choices. The DEIS estimates that by 2040, each morning and afternoon *a vehicle will arrive or depart Union Station once each second* in order to serve projected station ridership projections. These 3,600+ trips represent a 25% higher demand than the PUDO activity at Reagan National Airport today.

With the Columbus Circle road network and PUDO lanes already beyond capacity during peak periods, it is not surprising that the DEIS projects Alternative A-C will lead to severe congestion, with vehicle queues spilling back into intersections along Massachusetts Avenue. As shown comprehensively in Appendix B2, the following fatal flaws with Alternative A-C's PUDO plan contribute to this result:

Ronald Reagan National Airport drop-off zone

- Insufficient lanes and curb frontage for FHVs to form separate queues or 're-match' with a new rider following a drop-off
- Insufficient merge and weaving areas entering and exiting PUDO facilities at Columbus Circle and the Train Hall to accommodate friends and family PUDO, taxis, multiple FHV operators, station parkers, intercity and charter buses and Burnham Place PUDO and parkers
- Inadequate space for passengers to wait and match with drivers, particularly within the second and third lanes at Columbus Circle and along First Street NE
- No off-street location for friends and family members picking up passengers to park short-term
- No staging or hold areas for high volumes of FHVs to serve surge demands when multiple Amtrak trains arrive at once

The consequences of these flaws and omissions reach beyond unacceptable traffic operations. Other outcomes and impacts include:

- Significantly compromised pedestrian and bicycle safety
- Degradation of the station's historic setting
- Passenger inconvenience and discomfort due to time spent in non-weather-protected queues or in traffic congestion
- Decreased station use as passengers make alternate travel choices
- Preclusion of high-quality civic spaces north of a new train hall

The Burnham Place team agrees with DDOT and DCOP, both of whom recommend the inclusion of a high-capacity, purpose-built, off-street PUDO facility. This facility would be in addition to other PUDO areas at Columbus Circle, the Train Hall, First Street NE and Second Street NE.

A dedicated PUDO facility could be located in a garage above the tracks, or alternatively below the rail passenger concourse level alongside station parking (as proposed in Alternatives B, C, D and E). Akridge and many other stakeholders agree that the below-grade option is the far superior choice for numerous reasons. This facility would be located directly below the new passenger rail concourse and accessed via three or more different ingress and egress points, predominantly located to the west of the station's footprint.

Benefits of a Below-Grade PUDO Facility

Concealing high-intensity vehicle functions below ground is the default choice for high-density urban land uses of all types. In the commercial core of Washington, DC it may be impossible to identify a medium- or high-density land use newly built within the last decade with significant parking at- or above-grade. The FRA recognized and validated this trend when it developed five of its six Action Alternatives to include some or all of its parking and PUDO facilities below-grade.

What is unique about planning for Union Station as compared to most other land uses is that PUDO, *not parking demand* accounts for approximately 90 percent of projected peak hour vehicle trips. Locating PUDO facilities below-grade at Union Station solves or significantly mitigates the flaws and adverse impacts described above and also includes added benefits.

1. **Comprehensive For-Hire Vehicle Operation**
    a. Off-street staging area for taxi, Uber, Lyft and other providers reduces on-street PUDO activity and serves surge PUDO demands
    b. Effective, high-volume FHV re-matching decreases overall trips, reduces circulating vehicles and neighborhood spillover
    c. High-capacity staging and pick-up below-grade reduces congestion at Columbus Circle and the required size of other PUDO facilities. A direct route below-grade from taxi staging to the first lane at Columbus Circle eliminates taxi queues on the station's East Ramp

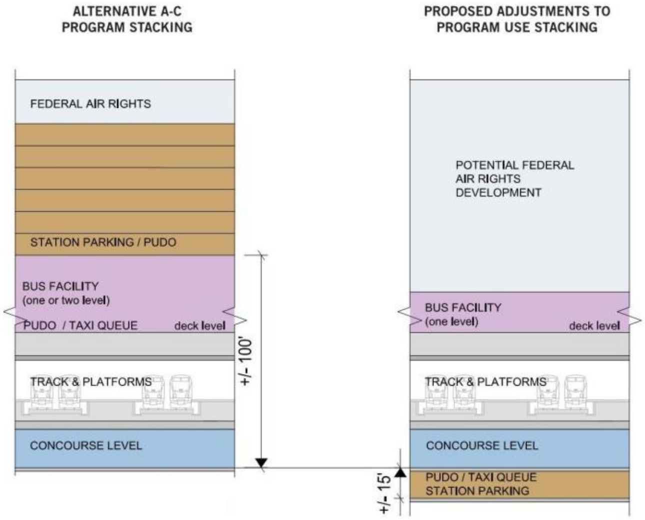
2. **Effective Off-Street Friend/Family Short-Term Waiting Area**
    a. Accommodate early-arriving drivers to free up curb space for active PUDO, decrease double-parking and circulating on adjacent streets

3. **Improved Passenger Convenience and Experience**
    a. Weather-protection improves experience, enhances safety and accelerates throughput
    b. Escalator and stair access from rail concourse directly above reduces walking distance, improves wayfinding, and decreases total trip time
    c. Locating facility egress ramps away from Columbus Circle and H Street decreases PUDO trip time to destination

4. **Efficient PUDO and Less Vehicle Congestion Yields Additional Benefits**
    a. Bicycle and pedestrian access and safety improvements at grade
    b. Improved historic setting
    c. Opportunities for multiple open spaces at station edges
    d. Less noise and lower carbon emissions

Above-Grade Garage PUDO Has Fatal Flaws

The option of locating a high-capacity PUDO facility above the bus facility is worthy of study given it is the only other location in which a dedicated PUDO area could be considered. However, there are several drawbacks to this location, some of which cannot be overcome or mitigated.



PUDO and Station Parking - Above-Grade vs Below-Grade

First, a PUDO facility within the above-grade garage would be located 100 feet above the H Street Rail Concourse and 60 feet above the main rail concourse within the Train Hall. Few rail passengers would accept this PUDO location for pick-up or drop-of when this location requires traversing six to ten stories via two or three different elevators. As train passengers will be dropped off elsewhere, drivers will then need to circulate from Columbus Circle, the Train Hall or First Street NE to the above-grade garage PUDO area to re-match for a pick-up.

Second, the proposed Alternative A-C garage includes a footprint for each parking level of approximately 115,000 square feet. This compares to 480,000 square feet available on one level below-grade. Even if right-sized station parking were included within the above-grade garage, fulfilling the PUDO functions described above would take at least three additional garage levels. This bus, parking and PUDO garage would create nearly the same adverse impacts as described in the *Parking* section above.

The Alternative A-C parking garage is accessed off a one-way PUDO road adjacent to the Train Hall. Locating PUDO within this garage would merge a thousand or more vehicles per hour onto this road, which is already overburdened by Train Hall PUDO activity and vehicles accessing private development garages. In this scenario, more than half of all PUDO trips would enter and/or exit via H Street.

Any one of these shortcomings is a significant barrier to locating a high-capacity PUDO operation in this location. Collectively, these problems demonstrate this location should not be studied further. While no traffic circulation plan will be able to meet the station's peak demands without some challenges, below-grade is the only location that can feasibly serve as a dedicated, off-street PUDO facility.

Bus Facility

Intercity and charter bus functions are pivotal transportation components within the deck level planning process for Union Station. With the existing garage slated for demolition, there is an opportunity to create one of the best bus facilities in the country—one which could provide an exceptional quality terminal for those seeking a low-cost intercity travel option and tourist groups visiting the station and nearby attractions.

Illustrative rendering created to describe a bus facility with a Neighborhood Park above and connections to PUDO and the bus lobby on the Civic Space

Bus stations are challenging to site within multi-modal facilities for many reasons:

- To safely and efficiently maneuver buses with wide turning radii and minimize back-up movements, a multi-acre footprint is often required for even a dozen slips
- Buses require tall clearance, and some carriers have plans to add even taller models to their fleets to accommodate more passengers. Facilities generally require 20 feet in height, the equivalent of roughly two levels for most other uses
- Given the two above factors, stacking two levels of bus slips requires multiple 300-foot long ramps and additional circulation space. There are few if any intercity bus stations in the U.S. that include multiple levels. The Port Authority Bus Terminal in New York City has two levels, although this station predominantly serves commuter buses, and it does not have connecting ramps between its levels
- Separating passenger waiting, queuing, boarding, and circulation areas from those where buses are actively moving is critical to maintain a safe environment
- Structural columns within a bus station must be spaced widely apart. These 'long spans' constrain proposed program areas above or below the bus level

Due to all of these challenges, if planners do not intentionally prioritize the quality of the bus passenger experience, facilities can feel uncomfortable, unpleasant and utilitarian, in sharp contrast to the gracious and uplifting feeling of a voluminous train station or airport.

Key ingredients for a World Class Bus Facility at Union Station

Burnham Place team's vision for a world class bus station

Based on research of comparable facilities and input from key project stakeholders, the Burnham Place team has identified the following essential ingredients which should guide planning for the bus facility:

1. Adjacent to historic Union Station
2. First class passenger experience
3. Direct connection to vibrant urban spaces
4. Designed to minimize neighborhood traffic, historic preservation and urban design impacts
5. Appropriately sized

Below we assess the bus facility proposed in Alternative A-C based upon these criteria.

1. Adjacent to historic Union Station

Akridge agrees with the FRA that the appropriate location for the bus facility is directly north of the Train Hall. Relatively few cities throughout the world stack intercity bus stations on top of intercity and commuter rail lines. This is in large part due to the challenges in bus facility planning cited at the outset of this section.

Burnham Place team's illustrative vision for a world-class bus facility adjacent to the historic station

Throughout the past several years, Akridge has at times advocated for evaluating the potential benefits of locating the intercity bus station elsewhere within the city with transit and highway access. We have also spent considerable resources proposing a facility which could serve as the focal point of Burnham Place's parcel north of H Street (see Appendix L Bus-North of H Street Proposal) as well as within property along First Street NE. While we still believe that each of these options is viable, we value and endorse the broad stakeholder feedback and desire to locate the facility in roughly the same location as it exists today. Further, with the adjustments described below, we believe the bus station can serve as an anchor for the open space on the deck level, activating the station environment and complementing private development.

2. First class passenger experience

Alternative A-C's bus facility falls far short of providing an inspiring and high-quality passenger experience. Its front door and lobby is along H Street NE. This location may provide visibility for those passing by in a vehicle, but few passengers will enter the facility through this lobby as PUDO is not possible at this entrance. Streetcar passengers could enter in this location, but they first must cross the driveway where buses all must exit east along H Street.

The proposed bus passenger concourse is an 'island' configuration, which means it is surrounded by bus circulation on all sides. With parking levels above and over 100 feet away from the garage edges, there is no opportunity for any natural light within this waiting and boarding area. Without a prominent pedestrian entrance or natural light and surrounded by vehicles, the proposed bus station clearly falls short of achieving this essential planning ingredient.

3. Direct connect to vibrant urban spaces

As previous described in the *Parking* and *PUDO* sections, the proposed mass of the garage and adjacent federal air rights precludes the creation of an attractive and appropriately sized civic space. However, if there *were* an attractive set of plazas and parks next to the garage, bus passengers could not directly access them. Because of its island configuration and its lack of access to the two-block long central spine from H Street NE to the Train Hall, bus passengers would have little opportunity to enjoy the open space and restaurants and amenities within this area.

Burnham Place team's vision for a world class bus station connected to vibrant urban space

4. Designed to minimize neighborhood traffic, historic preservation and urban design impacts

As stated within recent comments from DCOP and ANC 6C, it is undesirable and of great negative impact if all buses exit the bus facility to the east down H Street NE rather than to the west to North Capitol Street. Specifically:

- H Street NE is a neighborhood street and not an appropriate place to encourage high volumes of commercial vehicles
- The proposed exit ramp is positioned just west of a proposed signalized intersection which includes crosswalks for streetcar passengers—an undesirable condition
- Buses bound for points southwest via I-395 must make a U-turn on H Street or travel through neighborhood streets to reverse directions

While the *Parking* and *PUDO* sections above describe critical flaws and missed opportunities associated with an oversized garage, it is actually the dimensional footprint of the bus facility that is most directly correlated with these historic preservation and urban design flaws. While the footprint of each parking or PUDO level could theoretically be made smaller, the bus facility occupies the ‘ground’ level of the garage, and its dimensions define its deck level presence.

As proposed, the bus facility’s west edge eliminates the opportunity for a greenway. Its east edge precludes a great central civic space. Its northern extent eliminates Akridge’s ability to develop a building along H Street NE that would screen the garage. Its southern edge leaves insufficient space to create a symmetrical and high-quality backdrop for the historic building. All of these impacts can be avoided, if the bus facility is appropriately sized.

5. Appropriately sized

In station planning for most modes of travel, there are three central drivers that enable passenger growth. These include the:

- amount of tracks, slips or spaces in the station
- number of vehicles the station can process per space during peak hours
- number of passengers per vehicle

All three drivers are critically important. For example, an airport operator can increase passenger capacity by building more gates and terminal space, requiring or incentivizing faster gate turnaround times, or by increasing the number of seats per plane. Each strategy carries a different set of costs and benefits for the operator and policy makers to consider. This framework demonstrates that *the number of slips in the future Union Station Bus Facility is not the only, or potentially primary driver of its capacity*.

In fact, the DEIS demonstrates this principle in its strategy for increasing rail passenger growth. The proposed plan for all of the Action Alternatives is to *decrease* the number of active, “revenue” tracks from 20 to 19, while doubling or tripling the number of intercity and commuter rail passengers. By increasing platform and concourse space for rail passengers and improving operational infrastructure, the rail providers will serve many more trains per hour per track than they do today. Some providers will also run longer trains with higher passenger capacities, while some platforms will serve shorter trains that ‘double-berth,’ with one platformed behind another.

These plans reflect the high leverage of investments made in operational efficiency. For example, in a facility with 12 tracks (or slips), cutting just five minutes off the time it takes to process each vehicle yields the same passenger growth opportunity as adding an additional track. When space constraints or costs to expand the footprint of a facility are high (as they are within the Union Station rail terminal), it is necessary and appropriate to optimize the other two key drivers for passenger growth.

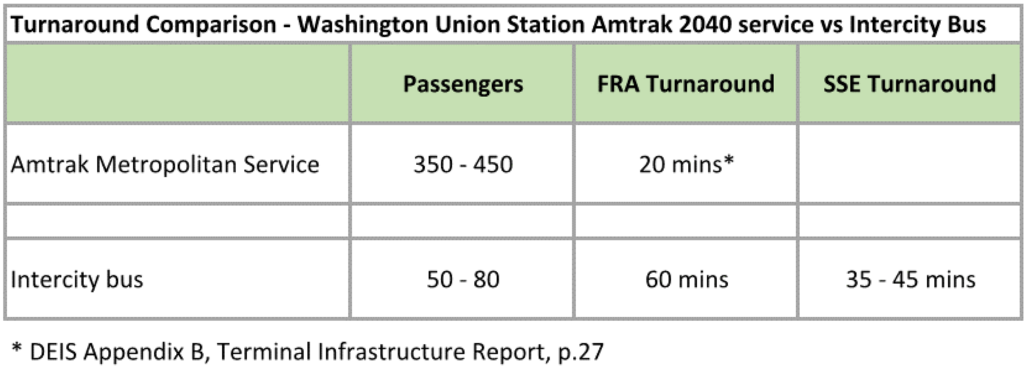
Given the essential nature and associated planning challenges with this facility, Akridge engaged Sam Schwartz Engineers (SSE), an internationally recognized bus facilities planning expert to comprehensively analyze and assess the appropriate number of slips to serve the FRA’s projected 2040 intercity and charter bus demands. Analyzing the published (as of February 2020) scheduled arrivals and departures for every bus throughout the week, and using the same passenger growth forecasts employed within the DEIS, SSE concluded that a 12-slip facility can serve in excess of 2040 projected peak demands following industry best practices (see Appendix C1). Best practices require operators to turn around buses within 35 minutes during two peak hours per week, three months of the year.

SSE also provided a conservative operational scenario which relaxes the turnaround requirement to 45 minutes. In this case, 16 slips were required to accommodate 2040 intercity and charter ridership. Per the chart below, Akridge recommends using the 16 slips indicated in the conservative scenario plus the addition of two staging spaces for a total of 18 slips as the basis for modifying Alternative A-C. An 18-slip facility compares with the 25 slips documented within the DEIS as sufficient to meet future peak demands.

Bus Facility Analysis Comparison

Category	FRA Plan - 25 slips	A-C Modified Plan
2040 intercity annual passengers	2,975,000	3,000,000
Peak hour (2 hours per week, 3 months per year) intercity <u>turnaround time:</u>	60 minutes	35 (Best Practice) to 45 minutes (Conservative)
Number of slips recommended	<u>25 total slips</u> · 13 intercity slips · 8 charter slips · 3 staging (not-active) slips · 1 DC Circulator slip	<u>18 total slips</u> · 12 to 16 shared intercity/charter slips · 2 staging (not-active) slips (DC Circulator not included)

There are two primary differences within the analyses which led to these different conclusions. First, the DEIS states that bus operators will have 60 minutes to turn around a bus. SSE's analysis, based upon charted observations and study of domestic and international facilities indicates 35 to 45 minutes as the appropriate duration for a turnaround. It is instructive to compare these turnaround times with those predicted within the DEIS for rail operations. As shown below, Amtrak plans to turn around trains with roughly five times the number of passengers in one third the amount of time.



Turnaround Comparison - Washington Union Station Amtrak 2040 service vs Intercity Bus

	Passengers	FRA Turnaround	SSE Turnaround
Amtrak Metropolitan Service	350 - 450	20 mins*	
Intercity bus	50 - 80	60 mins	35 - 45 mins

* DEIS Appendix B, Terminal Infrastructure Report, p.27

Second, FRA estimated the number of slips by applying growth factors to intercity and charter functions. FRA's conclusion that eight slips are needed to exclusively serve charter bus demand does not match their assumption (shared by SSE) that slips should be used interoperably by charters and intercity buses. Because the charter bus peak day and hour do not overlap with the intercity peak day and hour, SSE concludes that charter buses at most require three slips beyond the peak demands for intercity slip use.

For the majority of the intercity bus industry's history, station space has neither been constrained nor costly. Carriers owned standalone facilities in areas with low land costs. In other locations, such as at Union Station, an existing or 'legacy' facility built for other purposes (in this case charter/tour bus parking) contained well in excess of the space required for intercity services. In both settings, with relatively low costs per slip, there has been little motivation to invest in operational efficiencies.

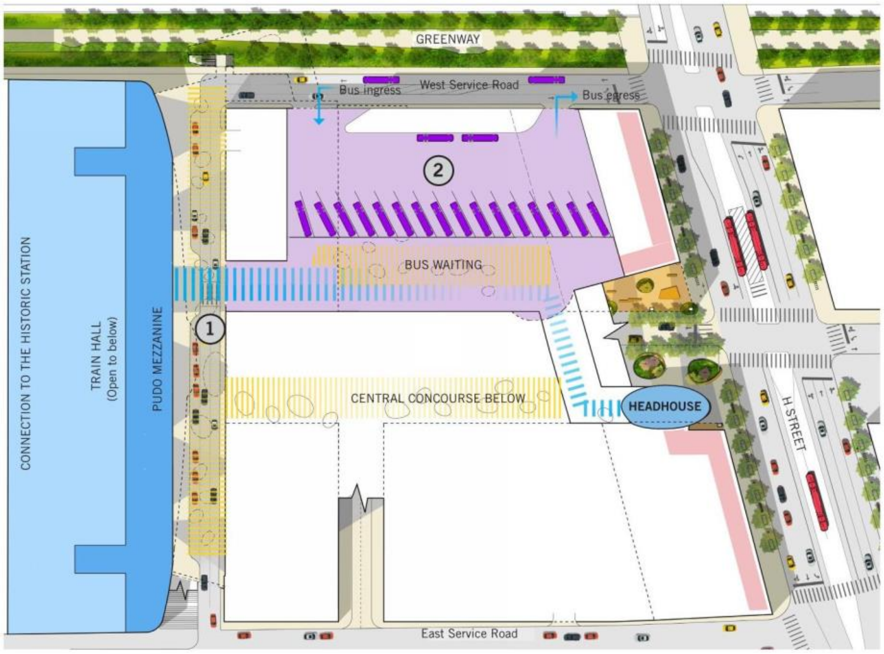
In the expanded Union Station, each bus slip will have extraordinarily high costs, so operational practices within the facility must follow the same model used for rail and PUDO, by implementing best practices. The potential costs of oversizing the bus facility are catalogued throughout this paper. These costs include the preclusion of achieving critical goals required to garner stakeholder and political support. The costs also are reflected in adverse impacts to Burnham Place, neighborhood and preservation goals. Right-sizing the facility is therefore essential to developing a station expansion vision that will be implemented.

A Vision For A Transit-Focused Mixed-Use Neighborhood: "A-C Modified"

By right-sizing and optimally locating parking, PUDO and bus facilities, an inspirational plan can effectively fulfill the station's transportation goals and requirements which achieves broad stakeholder support. In the site plan of "A-C Modified" below, a central civic space (1) of grand proportions is anchored by the Train Hall and entry plaza (2) at the south and a station headhouse at the north along H Street NE. Prominently located within the civic space is an inviting bus station entrance, which leads to a skylit bus passenger concourse. Atop the bus station is a 1 acre park (3), framed by mixed-use development and cultural uses. West of the park is an overlook (4), which connects pedestrians to the greenway.

Deck Level Plan - Civic Space/ Neighborhood Park/ Train Hall Plaza

One level beneath the plaza (see plan below) is the bus facility with direct connections to the Train Hall and headhouse. Buses circulate in and out from the West Service Road. Train Hall PUDO (which also directly connects to the bus passenger concourse) is located underneath the plaza level with large deck openings and skylights above. A below-grade PUDO facility (see Appendix B1) captures one third of peak PUDO demands, decreasing the impacts on the deck level road network shown here.



In-Deck Plan - Bus/ PUDO/ Parking

N-S Section View Looking West

A video animation which flies through this vision can be found at the following website and in the Appendix E1:

http://www.akridge.com/libvideos/burnhamplace.html

A Vision – Not A Design Proposal

To date, many stakeholders and review agencies have expressed significant frustration with the EIS process as well as the resulting Preferred Alternative. We believe a contributing factor to these reactions is the lack of comprehensible visualizations of the FRA's proposed concepts made available to the public. For a project of this scale and complexity, *illustrative* rendered perspectives and sectional views allow the viewer to grasp how its component parts fit together three dimensionally. These sorts of visual tools also can demonstrate the potential (or lack thereof) of a given planning solution to foster an inspirational urban design.

It is within this spirit that Akridge offers the A-C Modified vision. Precise building massing, architectural styles, material choices and other design related to both the station's expansion and Burnham Place will take place during later stages of project review. However, we believe the vision we have developed illustrates what is possible to achieve if the surface transportation elements of Alternative A-C are right-sized and optimally located. Further documentation in Appendix E demonstrates how such a vision is precluded without our proposed modifications.

Requested Actions

Akridge urges the FRA to take the following actions:

1. Revise Preferred Alternative A-C to include the changes described within these comments
2. Engage in further consultations with the project proponents and key stakeholders, including Akridge, to develop a revised final Preferred Alternative that optimizes and balances the comments of all stakeholders
3. Issue a revised Alternative with an opportunity for public review and comment
4. As a formal mitigation measure, establish a Technical Coordination Work Group including the project proponents and Akridge to ensure the planning of both the Expansion Project and Burnham Place are well coordinated as design moves forward. Appendix J includes a description of engineering and constructability restrictions proposed in the DEIS that if unchanged, severely harm and impact the feasibility of Burnham Place.

The viability of the station expansion depends upon these changes and this level of coordination. Akridge proposes these modifications not only because we believe they meet broad stakeholder goals, but because such modifications are also needed to meet FRA's obligations under NEPA to present feasible alternatives. The Preferred Alternative presented in the DEIS is not feasible because it contemplates the use of private air rights owned by Akridge to which access will not be available for the Expansion Project under this specific Alternative. Akridge cannot agree to transfer the acreage contemplated in Alternative A-C as proposed in the DEIS because the loss of such property (along with adjacent impacted property) would have serious adverse repercussions for the Burnham Place project. These adverse impacts to Burnham Place are outlined in Section 2 of these comments.

Akridge's vision for the A-C Modified would not only be feasible, but would also provide a win for all parties – a greatly improved Expansion Project that better meets the needs of all stakeholders, as well as ensuring that Burnham Place can be developed in a manner that will allow its benefits to be attained and harmonized with the adjacent Station. For example, shifting a right-sized parking program below grade, in concert with changes to PUDO and bus facilities, will avoid significant impacts and better allow the achievement of stakeholder goals regarding historic preservation. By reducing impacts to historic viewsheds and assets, A-C Modified will thus help FRA meet its obligations under both Section 106 and Section 4(f).

Can A-C Modified Be Implemented?

As we developed the planning framework and modifications proposed herein throughout the past year, we have heard two key areas of concern regarding the feasibility and rationale for our vision. We include those concerns and responses below.

Is below-grade construction beneath the concourse level for parking and PUDO functions feasible?

Concern With Below-Grade Parking/PUDO	Response
This strategy is more expensive than placing these functions above grade	• Additional construction costs will be more than offset by the immediate value created by viable air rights development within the federally owned property • Nowhere else in the DEIS are costs cited to justify a similar locational decision. Further, there are many examples (i.e., the size of the Train Hall), where costs are (rightly) not considered a dispositive factor • There is no other location where a dedicated PUDO facility can feasibly be located
Construction will take longer	• The DEIS indicates the construction of one level below the rail concourse will take incrementally one year longer, an increase of less than 10 percent of the total project duration • The additional construction period impacts should be measured against the permanent benefits and avoidance of adverse impacts in urban design, historic preservation and open space
There is groundwater located in this area	• This parking level will extend partially into the water table requiring additional construction scope and complexity, as documented in the DEIS • Building within the water table commonly occurs in Washington, DC and is considered routine (i.e., within buildings in the Navy Yard, the Wharf and Buzzard Point) • Adjacent private buildings west of First Street NE and east of Second Street NE extend *lower* into the water table than the one level proposed here

	• Alternative A-C already includes the construction of a network of service corridors within the same general area • Amtrak, the sponsor of the DEIS constructability studies, has stated that they prefer this below-grade location
Vehicle access to this level is constrained or insufficient	• The single point of access from K Street NE shown in several DEIS Alternatives is inadequate. Multiple or different points of access would be required • Six additional potential access points have been identified by the Burnham Place traffic engineers, and we are working with DDOT to identify the most viable and functional locations. Appendix B contains feasibility analysis on these locations

Does an 18-slip bus facility provide adequate passenger capacity and for future growth beyond 2040?

Concern With 18-Slip Bus Facility Size	**Response**
18 represents a considerable reduction in the current number of bus slips at Union Station. Will there be enough capacity to meet future demands?	• There are currently 52 slips in use at Union Station. 27 are leased exclusively by intercity bus companies. 20 are used for charter bus parking, and 5 are used for other services (See Appendix C) • The FRA in coordination with DDOT, is appropriately planning the future facility for <u>active</u> intercity and charter bus boarding and alighting <u>only</u> (plus one slip for DC Circulator staging) • The DEIS (and Burnham Place bus planning experts) assume the new facility will not include assigned or leased spaces. Today, many slips sit empty or include parked buses for four or more hours each day Slips will be used with interoperability, following best practices. • FRA assumes 60 minutes will be required to turn around arriving and departing buses at peak times. Amtrak plans to turn around 400-passenger trains within 20 minutes. • Improving operating efficiency will increase the facility's passenger capacity just as much as increasing its number of slips • With 18 slips, intercity and charter bus passenger volumes can expand well beyond the 2040 targets included in the DEIS, particularly by adding new departures outside of the two peak hours each week, increasing the average number of passengers per bus, or operating turnarounds at best practice levels

Given environmental justice and social equity concerns, it is critical to provide adequate space in the plan for a great bus facility	• As proposed in Alternative A-C, the oversized bus facility provides a second class passenger experience, with a non-daylit bus concourse isolated inside a garage • Rather than put upward pricing pressure on intercity bus fares by building an unnecessarily high-cost, oversized facility, a right-sized facility can provide an exceptional quality experience, commensurate with that enjoyed by rail passengers
Will buses 'end up back on city streets' with curbside pick-up, as occurred in some places in years past?	• DDOT policy does not and will not allow intercity bus operators to provide curbside services. • Bus companies will need to operate efficiently, like every other transportation provider at Union Station.

Conclusion

Akridge appreciates the opportunity to provide comments on the DEIS for this once in a lifetime project. As outlined in our comments, key modifications to the Preferred Alternative are needed to meet FRA's obligations under NEPA, Section 106 and Section 4(f), as well as to ensure a viable and successful design that will meet the Expansion Project's purpose and need. By right-sizing and optimally locating parking, PUDO and bus facilities, an inspirational plan can effectively fulfill the station's transportation goals, meet statutory requirements, and achieve broad stakeholder support. Akridge continues to stand ready to collaborate on an Expansion Project plan that will allow both the Expansion Project and the Burnham Place project to move forward successfully.

Burnham Place team's vision for compatible public and private projects

Section II
Impacts to Burnham Place

The DEIS assesses impacts to Burnham Place by calculating how many square feet of our deck area are consumed by the Expansion Project. This methodology is incomplete, and presents an inaccurate picture of impacts to the private development. Below we describe the process by which Akridge assesses the types and severity of impacts imposed by the Station Expansion project and whether a proposed Alternative can be compatible with Burnham Place. This multi-step approach is more valid for assessment of adverse impacts given the complex interrelationships between the two projects.

Step 1 – Identify how much and what types of property are consumed

A. Directly used for station functions – Example: the Train Hall in Alternative A-C is located in part within Burnham Place Property.
B. Indirectly impacted – Example: while a station service road is proposed directly within Burnham Place property, support structures for buildings can only be placed every 55 feet within the rail yard. Therefore, the effective amount of property consumed extends beyond the extents of that road up until the next column landing zone.

Step 2 – Assess how the consumed property and Burnham Place property that remains relate to proposed Station Expansion program elements

Example: Burnham Place property that is immediately adjacent to a congested road or parking garage is not of equivalent value to property unencumbered by such adjacency.

Step 3 – Apply Burnham Place "Design Requirements" criteria to remaining property

A. These criteria, used consistently by Akridge throughout EIS concept development, include:

    a. Adequate development opportunity
    b. Functional circulation network
    c. Strategically positioned open spaces
    d. Adequate light and air in key locations
    e. Harmonized public and private projects

Step 4 – Assess opportunity costs as compared to optimized public and private projects

Step 5 – Assess stakeholder responses, feedback and level of goal achievement

If stakeholder consensus on a project vision cannot be achieved, overall project viability is in jeopardy. Alternative E has the fewest and least severe adverse impacts on Burnham Place as compared to the other Action Alternatives. However, key stakeholders such as Amtrak, ANC 6C, historic preservation advocates and others vocally opposed this Alternative. Consequently, Akridge did not view Alternative E as a viable concept and did not support it.

Step 6 – Document construction and technical impacts

Portions of the material in the DEIS related to structural and mechanical engineering, project phasing, construction schedule, cost allocations, and other issues suffer from: a) incorrect assumptions; b) incomplete analysis; and c) engineering methods that if implemented would have devastating impacts to Burnham Place's viability. Akridge assesses and documents these impacts.

Below is a summary of where in these comments the reader can find the impacts assessed through this process.

Impact Process Category	**Location within Akridge DEIS Comments**
Step 1 – Identify how much and what types of property are consumed	• Section 6A, Property Rights
Step 2 – Assess how the consumed property and Burnham Place property that remains relate to proposed Station Expansion program elements	• Section 3, Urban Design and Planning Framework Challenges
Step 3 – Apply Burnham Place "Design Requirements" criteria to remaining property	• Section 3, Urban Design and Planning Framework Challenges Solutions • Section 4, Requirements for a Successfully Integrated Project
Step 4 – Assess opportunity costs as compared to optimized public and private projects	• Section 1, Executive Summary • Section 4, Requirements for a Successfully Integrated Project • Section 6D, Fiscal and Economic Impacts • Appendix E: Vision Framework
Step 5 – Assess stakeholder responses, feedback and level of goal achievement	• Appendix E: Vision Framework • DEIS comment submissions by other stakeholders
Step 6 – Document construction and technical impacts	• Section 6B, Technical Issues Not Thoroughly Analyzed

Section III

Preferred Alternative A-C Will Fail to Meet the Purpose and Need

A. Urban Design and Planning Framework Challenges

Developing 14-acres of air-rights above Union Station's tracks, in concert with the station's expansion, together represent an initiative of unparalleled significance in the National Capital Region. The vision for Burnham Place is a 3-million square foot mixed-use development including office, residential, hotel, retail, and cultural space, interwoven with parks, a plaza and a new circulation network – all atop a rail yard serving national and regional passenger rail. The city, region and country deserve a station district that exemplifies the best in urban, multi-modal station design, transit-oriented development, place-making, economic development, and neighborhood and historic preservation enhancement.

To be certain, much of what is proposed in Preferred Alternative A-C is important and necessary. Restructured tracks and platforms, expanded and new concourses, and important back-of-house service and mechanical areas are critical to accommodating future heavy rail growth. Akridge enthusiastically supports these proposals, even in the case of the new train hall that requires over half an acre of our air-rights property. However, the FRA's Preferred Alternative also includes program uses at the Burnham Place deck level that are not appropriately sized and located. The placement of an over-sized bus and parking facility precludes the placemaking that is fundamental to achieving a successful urban design, and the achievement of a world-class station district.

By their own admission, the FRA's planning framework does not consider urban design issues to be a key driver in evaluating and ranking alternatives. Section 4.2 of the DEIS describes how the FRA's Design Evaluation Criteria are organized into four major categories: Transportation, Experience, Urban Context, and Feasibility. Within the Evaluation Criteria, two subcategories are established – Key Drivers and Considerations. None of the Urban Context subcategories, including Heritage/Historic Fabric, Open Space, Development Opportunity/placemaking, and Community/Neighborhood, are considered Key Drivers in evaluating alternatives. To ensure a successful outcome, they must rise to the level of Key Drivers that influence the size and location of the station program. The balance of open spaces, a functional circulation network, and program uses, all influenced by historic considerations, neighborhood integration, and placemaking, are foundational to a successful urban design outcome.

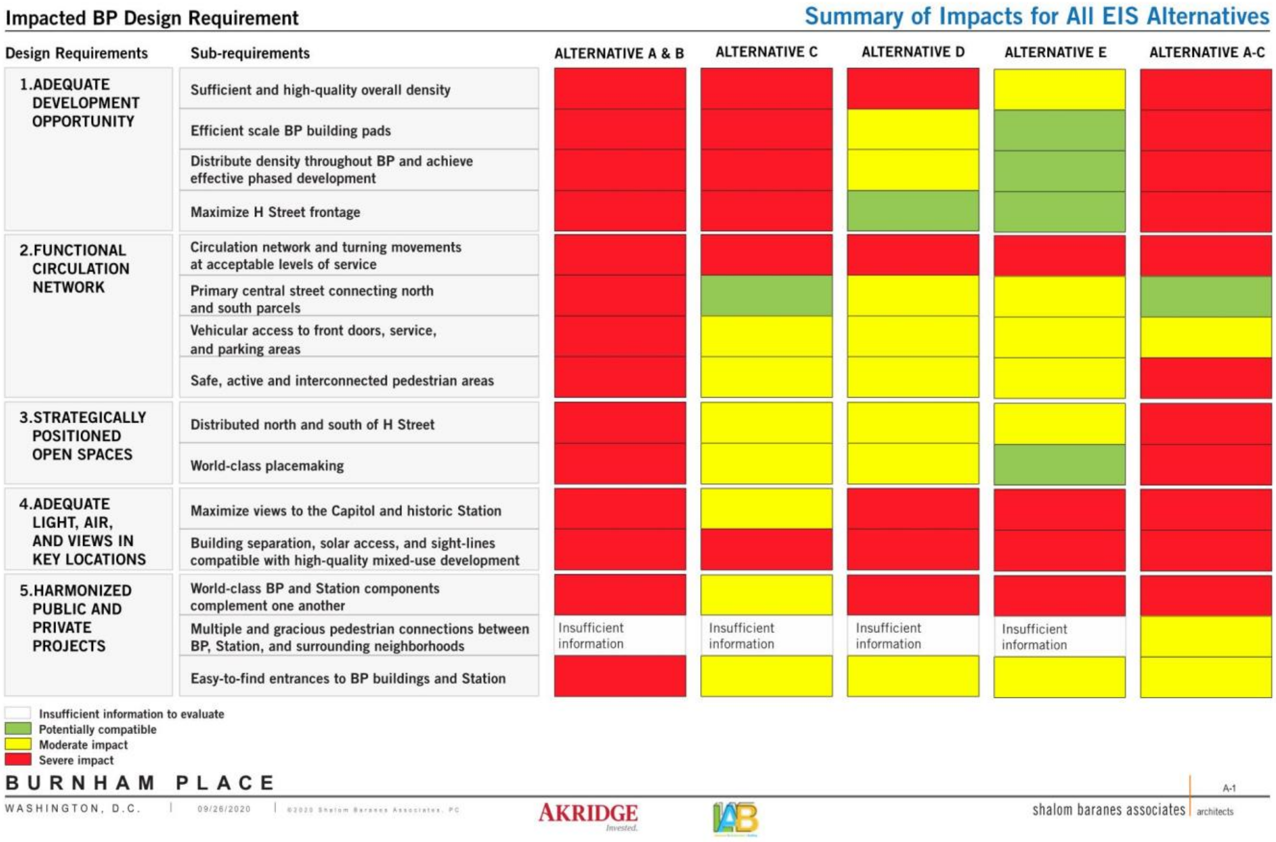
Appendix A3b of the DEIS, titled *Supporting Urban Design and Open Space Information for Concept Development*, documents urban design and open space concepts that are intended to serve as a "menu" of potential opportunities that can adapt to the emerging concepts and remain applicable and responsive to future development including Burnham Place. Important and fundamental concepts are included here, including a civic space south of H Street NE and a linear Greenway park along the western edge of the site. While the appendix acknowledges the importance of strong urban design and a network of open spaces, the Preferred Alternative precludes the successful integration of these concepts. With little consideration given to urban design and placemaking within the Preferred Alternative, the experience of all constituencies that interact with the project is diminished.

Surrounded by multiple lanes of vehicular traffic, made necessary in part due to the size of ill-conceived deck-level program uses and the placement of those uses, Alternative A-C represents an auto-dominated plan. It prioritizes pavement over people and motor vehicles over pedestrians and cyclists and does not offer a planning framework that would lead to a successful balance. Pedestrian and bicyclist circulation within and adjacent to the SEP is critically important to station users, the surrounding neighborhood, and Burnham Place, but is not considered in the DEIS. Entrances to the station, and convenient, efficient, and high-quality circulation through the station's interior spaces and concourses provide critically important pathways for surrounding commercial and residential occupants to intercity and commuter rail, Metro, and station amenities such as retail that are blocked by Alternative A-C's prioritization of vehicular traffic. The DEIS does not identify any planning or analysis of pedestrian circulation routes to, through, or around the station that recognize pedestrian safety and convenience, and opportunities for integration with the neighborhood, as stated in the project Purpose and Need.

By the same token, station retail and transportation elements will benefit from the patronage of neighborhood residents and workers, and should be designed to draw people in and through the station at all hours. This synergy will bring more revenue to WUS, which FRA identifies as key among the drivers as described further in Section 6D under Economic Analysis. Pedestrian circulation through the historic and new station buildings has not been considered in relationship to neighborhoods and Burnham Place, specifically, vertical circulation points and capacities. Burnham Place and neighborhood pedestrian circulation demand and locations are not documented, calculated, or included in the DEIS. The Greenway included in the 2012 Master Plan co-conceived by several stakeholders provided multiple opportunities to improve pedestrian facilities on the west side of the station and access to the station spaces but is not included in the DEIS.

As designed, Alternative A-C threatens Burnham Place's economic viability through density reduction, lack of urban placemaking and vehicular intensity. As early as 2017, the Burnham Place team developed and shared with the FRA and the SEP team the five essential design requirements for an EIS alternative necessary to ensure successful integration with the Burnham Place project (Appendix K). They include adequate development opportunity, functional circulation network, strategically positioned open spaces, adequate light, air, and views in key locations, and harmonized public and private projects. The five requirements, which included several subcategories within each, were conceived of as a simple and clear way for the Burnham Place team to provide the concise and effective feedback to the SEP team when it put forward preliminary alternatives. The following charts are like those presented to FRA back in 2017, but are now expanded to include Alternative A-C. They score each alternative against the five design requirements and their subcategories.

Three scoring categories were established, including potentially compatible, moderate impact, and severe impact. If there was insufficient information to provide a score, it was noted. When the Preliminary EIS Alternatives were first released, the Burnham Place team shared the scoring for Alternatives A though E soon thereafter. While Alternative E scored best from a Burnham Place perspective, Akridge did not support this alternative because it was not supported by Amtrak. After receiving this and other feedback from the Burnham Place team, the FRA put forward Alternative A-C as its Preferred Alternative. The scoring for A-C is now included on the first chart. The second chart is solely focused on Alternative A-C and provides commentary on the Burnham Place team's scoring.



Impacted BP Design Requirement

Summary of Impacts for All EIS Alternatives

Design Requirements	Sub-requirements	ALTERNATIVE A & B	ALTERNATIVE C	ALTERNATIVE D	ALTERNATIVE E	ALTERNATIVE A-C
1.ADEQUATE DEVELOPMENT OPPORTUNITY	Sufficient and high-quality overall density	🟥	🟥	🟥	🟨	🟥
	Efficient scale BP building pads	🟥	🟥	🟨	🟩	🟥
	Distribute density throughout BP and achieve effective phased development	🟥	🟥	🟨	🟩	🟥
	Maximize H Street frontage	🟥	🟥	🟩	🟩	🟥
2.FUNCTIONAL CIRCULATION NETWORK	Circulation network and turning movements at acceptable levels of service	🟥	🟥	🟥	🟥	🟥
	Primary central street connecting north and south parcels	🟥	🟩	🟨	🟨	🟩
	Vehicular access to front doors, service, and parking areas	🟥	🟨	🟨	🟨	🟨
	Safe, active and interconnected pedestrian areas	🟥	🟨	🟨	🟨	🟥
3.STRATEGICALLY POSITIONED OPEN SPACES	Distributed north and south of H Street	🟥	🟨	🟨	🟨	🟥
	World-class placemaking	🟥	🟨	🟨	🟩	🟥
4.ADEQUATE LIGHT, AIR, AND VIEWS IN KEY LOCATIONS	Maximize views to the Capitol and historic Station	🟥	🟨	🟥	🟥	🟥
	Building separation, solar access, and sight-lines compatible with high-quality mixed-use development	🟥	🟥	🟥	🟥	🟥
5.HARMONIZED PUBLIC AND PRIVATE PROJECTS	World-class BP and Station components complement one another	🟥	🟨	🟥	🟥	🟥
	Multiple and gracious pedestrian connections between BP, Station, and surrounding neighborhoods	Insufficient information	Insufficient information	Insufficient information	Insufficient information	🟨
	Easy-to-find entrances to BP buildings and Station	🟥	🟨	🟨	🟨	🟨

⬜ Insufficient information to evaluate
🟩 Potentially compatible
🟨 Moderate impact
🟥 Severe impact

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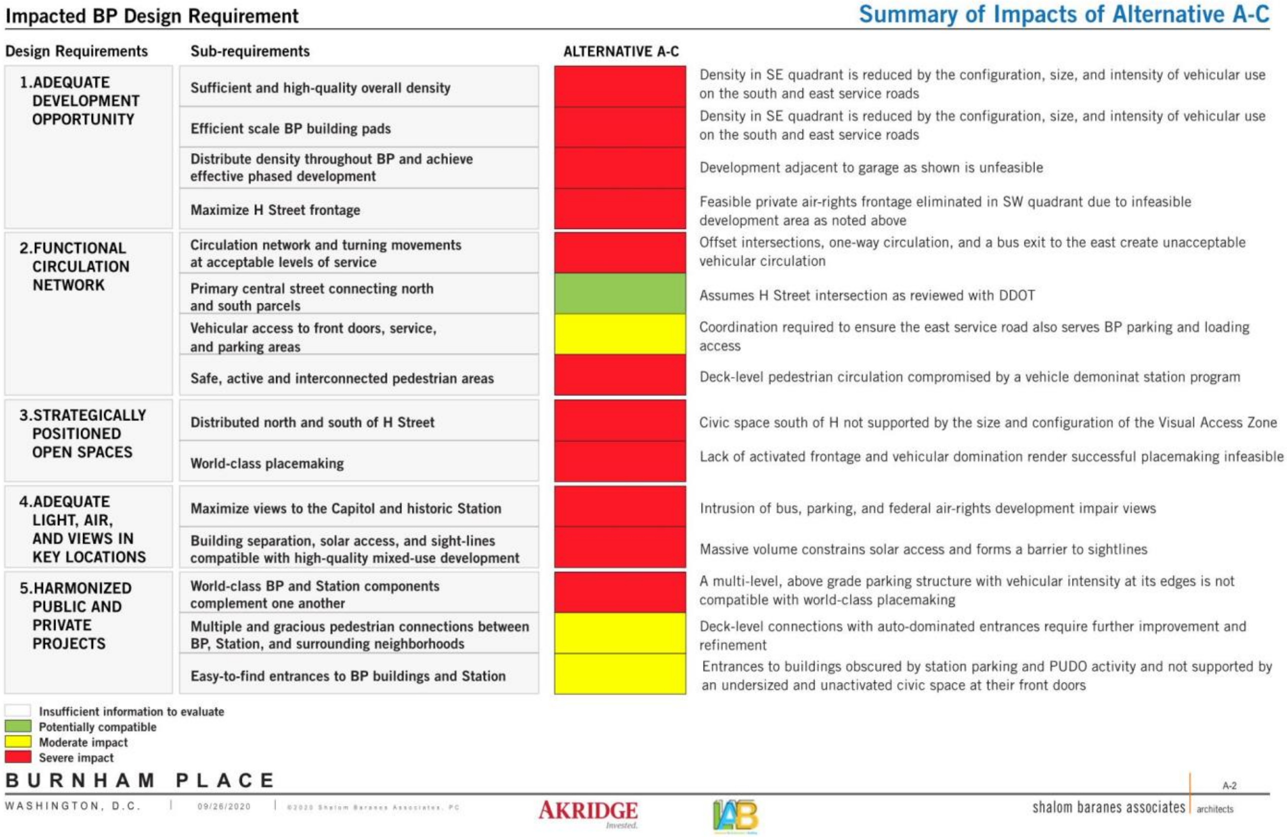

Impacted BP Design Requirement

Summary of Impacts of Alternative A-C

Design Requirements	Sub-requirements	ALTERNATIVE A-C	
1.ADEQUATE DEVELOPMENT OPPORTUNITY	Sufficient and high-quality overall density	🟥	Density in SE quadrant is reduced by the configuration, size, and intensity of vehicular use on the south and east service roads
	Efficient scale BP building pads	🟥	Density in SE quadrant is reduced by the configuration, size, and intensity of vehicular use on the south and east service roads
	Distribute density throughout BP and achieve effective phased development	🟥	Development adjacent to garage as shown is unfeasible
	Maximize H Street frontage	🟥	Feasible private air-rights frontage eliminated in SW quadrant due to infeasible development area as noted above
2.FUNCTIONAL CIRCULATION NETWORK	Circulation network and turning movements at acceptable levels of service	🟥	Offset intersections, one-way circulation, and a bus exit to the east create unacceptable vehicular circulation
	Primary central street connecting north and south parcels	🟩	Assumes H Street intersection as reviewed with DDOT
	Vehicular access to front doors, service, and parking areas	🟨	Coordination required to ensure the east service road also serves BP parking and loading access
	Safe, active and interconnected pedestrian areas	🟥	Deck-level pedestrian circulation compromised by a vehicle demoninat station program
3.STRATEGICALLY POSITIONED OPEN SPACES	Distributed north and south of H Street	🟥	Civic space south of H not supported by the size and configuration of the Visual Access Zone
	World-class placemaking	🟥	Lack of activated frontage and vehicular domination render successful placemaking infeasible
4.ADEQUATE LIGHT, AIR, AND VIEWS IN KEY LOCATIONS	Maximize views to the Capitol and historic Station	🟥	Intrusion of bus, parking, and federal air-rights development impair views
	Building separation, solar access, and sight-lines compatible with high-quality mixed-use development	🟥	Massive volume constrains solar access and forms a barrier to sightlines
5.HARMONIZED PUBLIC AND PRIVATE PROJECTS	World-class BP and Station components complement one another	🟥	A multi-level, above grade parking structure with vehicular intensity at its edges is not compatible with world-class placemaking
	Multiple and gracious pedestrian connections between BP, Station, and surrounding neighborhoods	🟨	Deck-level connections with auto-dominated entrances require further improvement and refinement
	Easy-to-find entrances to BP buildings and Station	🟨	Entrances to buildings obscured by station parking and PUDO activity and not supported by an undersized and unactivated civic space at their front doors

☐ Insufficient information to evaluate
🟩 Potentially compatible
🟨 Moderate impact
🟥 Severe impact

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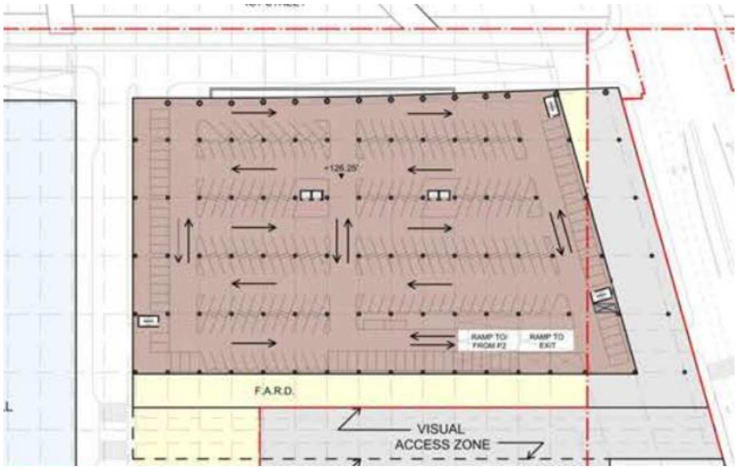
A-2

Only with modifications described in Section 4B to parking, PUDO, bus, and structure would the planning framework set the stage for a successful development opportunity and urban design. Without these changes, compatible and integrated public and private projects cannot be achieved.

If the Preferred Alternative is modified to address the flaws identified below, both the public and private projects could be successfully integrated to establish the National Capital Region's most transit-rich commercial center, with rail connections to the region's three airports as well as rail's Northeast Corridor. The two projects can catalyze tourism and reinforce Union Station as one of the world's most treasured historic resources with increased ridership and economic activity. Locally, they will eliminate barriers between neighborhoods and reknit a part of our city. The current proposal to place all transportation elements above ground leaves no occupiable space for community or people-focused programming. The domination of the parking garage gives vehicles priority, which like Director of the DC Office of Planning Trueblood stated in his testimony at the National Capital Planning Commission July 9, 2020 hearing on the DEIS, "will make high quality urban design impossible to achieve". Above grade parking, PUDO, and bus facilities eliminate the ability for an urban, vibrant, mixed-use community. Alternative A-C also adversely impacts the historic nature of WUS and precludes the celebration of the Capitol Building from several viewpoints. The total lack of green space is a significant design flaw in a neighborhood where green space is already severely lacking. Fortunately, there is still time to address these challenges. The Akridge vision for a modified A-C defines a planning framework that considers the historic and urban context, which we will detail in Section 4.

B1. Station Parking



CREDIT: DEIS Alternative A-C (Preferred Alternative), June 2020

The Union Station Expansion Project is a once in a lifetime opportunity to re-envision a pedestrian friendly, modern, urban, multimodal facility at the heart of the Nation's Capital. But that opportunity and vision is undermined by a vastly expanded parking garage that stakeholders have universally criticized as oversized An oversized garage not only decimates the possibilities for good urban design on the site, it also disrupts the progress contemplated in the SEP and the community fabric envisioned as part of this project. A parking garage does nothing for celebrating the historic WUS and the Capitol Building itself. Fortunately, there is time to correct the adverse impacts of the oversized parking garage before the EIS is finalized.

The parking analysis within the DEIS does not include in-depth research of potential parking needs in the new transit center. The DEIS does not examine DC parking policy, current parking and driving trends in the DC metropolitan region, characteristics of current or forecasted transportation modes at WUS, Amtrak demand locally or nationally, or comparative models in similar multi-modal facilities in other U.S. cities. To fill this gap, Akridge worked with SSE to study in-depth potential parking needs of the WUS transportation center, including policy, trends, and similar comparative samples.

The DEIS does not provide any analysis behind their recommendations for parking based on best practices, benchmarking, or comparisons to other urban transportation centers. Likewise, data is lacking for the following elements regarding parking:

- rental car utilization and customers served (rail passengers or other uses such as general DC residents or businesses)
- contract parking users (origin and destination of contract parking users, individual contracts versus institutional, growth or decline of contract parking, etc.)
- users who utilize the transit facility (definition of whether parking users are Amtrak, MARC, VRE, or bus riders; length of time within the facility representing single- or multi-day trips, etc.)
- Daily, weekly, and seasonal peak utilization information for the existing parking facility
- Long-term, multi-year utilization rates and characteristics for the existing parking structure
- Parking user surveys that identify reasons for using the parking garage, elasticity of demand, etc.)

The District of Columbia government has long been an advocate for the reduction of automobile reliance in the city to meet long-term sustainability goals, including in its long-range transportation plan, MoveDC. Specifically, the City is committed to "policies and incentives [that] encourage 'car-lite' living" including that 75% of all commute trips that originate in DC will be made by non-auto modes by 2040, as outlined in Table 4 of Appendix A, Parking Program. Further implementation of the parking reduction goals are set forth starting on page 5 of this same Parking Program.

In fact, Amtrak unequivocally stated they need 0 parking spaces for their riders in a January 7, 2020 memorandum, citing that less than 4% of their riders use the parking garage and this percentage decreases annually. Specifically, this memorandum states:

> *"Amtrak does not support any entity building parking...specifically to support Amtrak passengers….a majority of Amtrak and commuter rail passengers access the Station via alternate transportation modes…Planned rail infrastructure*

investments north and south of the Station and a shifting culture away from private automobile use leads Amtrak to anticipate passenger parking demand to continually decrease in the future…we do not assume that parking will increase proportionally as rail ridership increases."

Riders of other multimobility options at WUS likewise do not use on-site parking. Intercity bus riders are deterred by the higher cost of driving and parking overnight. Maryland Area Regional Commuter (MARC) and Virginia Railway Express (VRE) riders are regional commuters from their suburban or rural residences to jobs in DC and its adjacent suburbs. These riders usually park at stations near their residences and use other forms of transportation to work from WUS and so demand for parking from both MARC and VRE is 0. For more information on the downward parking trends of these riders please refer to Appendix A, Parking Program.

Likewise, the DC Office of Planning's parking analysis recommended 295 parking spaces **maximum**, stating that in other scenarios 0 parking spaces are recommended at this location. Notably, all new development projects within DC are required to include Transportation Demand Management (TDM) strategies to reduce vehicular use and encourage public transportation as well as bicycle use and walking – a trend common in all urban and urbanizing areas, including suburban development. It is therefore shocking to see not only a replacement of existing parking spaces, but a significant expansion, especially in such an urban, congested context that offers multiple public transportation options. Working with our transportation consultant, and noting no minimum parking requirement on federal property such as WUS, we concluded that in keeping with current retail practices and the programmatic retail make-up demand and support by multimodal travelers and local residents, 0 parking spaces are required to meet existing and forecasted retail demand. Likewise, the 100,000 SF of vacant office in WUS at a very transit-rich location will not require more than 62 space should it be used for office again. (Appendix A, Parking Program, pg 18) Finally, with regard to rental cars, no more than 125 parking spaces are recommended at WUS for this use.

Union Stations and other urban, multimobility hubs in other US Cities are responding to decreased parking demands and increased public transportation use in areas where land is at a premium. As seen in the table below, multimobility stations in Philadelphia, Chicago, San Francisco, and Boston all have 200 parking spaces or less – some with 0 parking spaces, as reflected by Amtrak's desire for 0 parking spaces for their riders – because they rely on the multimobility connections of multiple transportation alternatives.

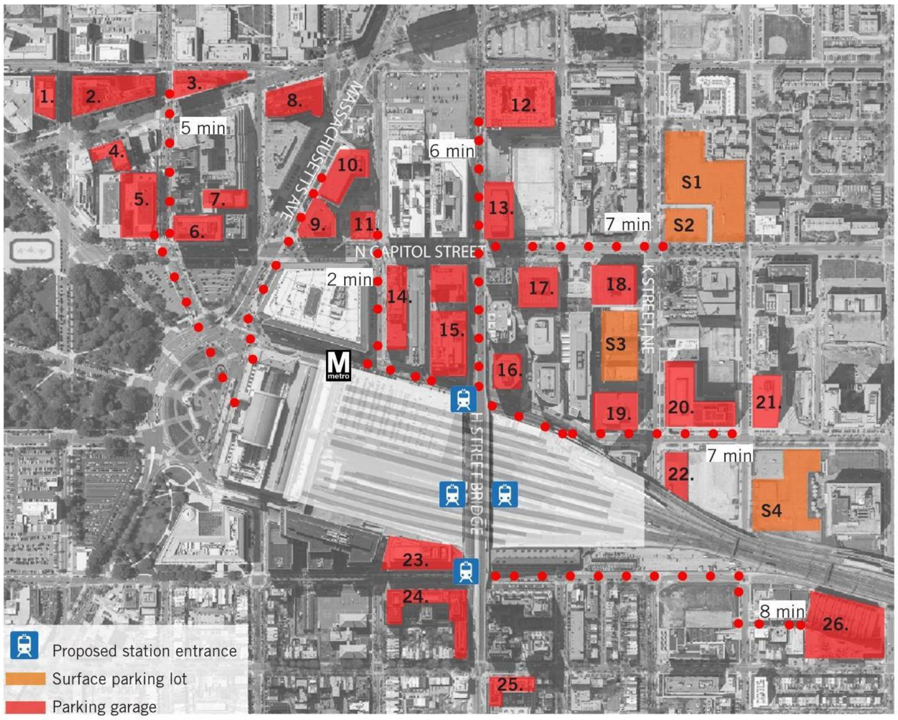
	Proposed Washington DC Union Station (FRA Preferred Alternative)	**Philadelphia 30th Street Station***	**Boston South Station***	**Denver Union Station**	**San Francisco Salesforce Center**	**Chicago Union Station**
Total Parking Spaces	1,575	106	188	0	0	0
Bike Parking	125	150	50	Not clear	130 bike racks + lockers inside	0
Direct Urban Rail Connection	Yes (Rail & Streetcar)	Yes (Rail & Streetcar)	Yes (Commuter Rail)	Yes (Light Rail, Commuter Rail)	No (planned connection to Subway)	Yes (Commuter Rail)
Direct Bus Connection	Yes (21 frequent routes)	Yes (8 frequent routes)	Yes (4 frequent routes)	Yes (9 frequent	Yes (9 frequent routes)	Yes (13 frequent

				routes)		routes)
Nearby parking (1-2 blocks away)	Yes (29 locations)	Yes (6 locations)	Yes (8 locations)	Yes (11 locations)	Yes (9 locations)	Yes (8 locations)
Amtrak Ridership (Annual)	5.8 million	4.5 million	1.6 million	143,986	NA	3.3 million

**Indicates planned develop numbers*
Source: Sam Schwartz, May 2020.

Additionally, WUS has the most access to existing parking infrastructure within close walking distance by a magnitude of two or three times other US cities' mobility stations. Our research demonstrates an average utilization rate of 72%[i] based on data from 24 of the 26 publicly available parking facilities within an 8-minute walk of the station. These garages, especially with the downward trend in parking overall, could comfortably absorb all potential WUS demand generated by office and retail uses.

Existing Public Parking Options



There are a total of **+/- 5,500** spaces within an 8 minute walk of a station entrance

1. 300 New Jersey Ave, NW - 467 spots
2. 400 New Jersey Ave, NW - 212 spots
3. 500 New Jersey Ave, NW - 80 spots
4. 415 New Jersey Ave, NW - 208 spots
5. 400 N Capitol Street, NW - 200 spots
6. 500 North Capitol Street, NW - 100 spots (est.)
7. 20 F Street, NW - 99 spots
8. 601 New Jersey Ave, NW - 230 spots
9. 1 Massachusetts Ave, NW - 100 spots (est.)
10. 25 Massachusetts Ave, NW - 125 spots
11. 660 N Capitol Street - 205 spots
12. 99 H Street, NW - 139 spots
13. 800 N Capitol Street, NW - 231 spots
14. 10 G Street, NE - 186 spots
15. 750 1st Street, NE - 231 spots
16. 810 1st Street, NE - 124 spots
17. 899 N Capitol Street, NE - 210 spots
18. 999 N Capitol Street, NE - 366 spots
19. 77 K Street, NE - 239 spots
20. 90 K Street, NE - 318 spots
21. 1100 1st Street, NE - 190 spots
22. 1001 First Street, NE - 100 spots (est.)
23. 700 2nd Street, NE - 150 spots
24. 701 2nd Street, NE - 150 spots
25. 300 H Street, NE - 100 spots (est.)
26. 1140 3rd Street, NE - 168 spots

S1. 1010 N Capitol Street, NW - 370 spots
S2. 10K Street, NW - 135 spots
S3. 15 K Street, NE - 70 spots
S4. 131 M Street, NE - 234 spots

Total: 5,737 spaces

As a result, the parking program bears little resemblance to current parking use, let alone forecasted parking use as the trend in urban, multimodal facilities has decreased over recent years. Existing intercity and commuter rail demand for parking at Union Station is extremely limited and is trending significantly downward. This is consistent across the downtown DC core, similar metropolitan areas, similar rail stations and center-city multi-modal transportation centers, as well as at major airports. Provision of a large amount of parking in the future station plan is inconsistent with the project purpose and need, DC policy and environmental sustainability goals. Proposed parking is five times more than the parking quantity recommended by DDOT and DCOP. The development of an oversized parking structure will induce demand in a place where the road network is already at gridlock during peak demand, counterintuitive especially for an area that thrives on the ability of Amtrak and bus riders to access the station with ease. This is counterproductive to Amtrak's needs and desire to grow ridership, which will only sputter if access to WUS in methods trending upward (via FHV or other PUDO and bike or Metro access) are further inconvenienced. Additionally, if the trend towards Autonomous Vehicles does indeed increase this would render the parking garage completely useless and a waste of money. Appendix A, Parking Program, pg. 14 delves deeper into this discussion.

The DEIS appears to base its determination of parking needs at WUS on past practice, rather than best practices and emerging trends. Overall, nationwide trends have seen a dramatic decrease in demand for parking and an increase in the use of For Hire Vehicles (FHV), referred to next in this Section, at urban multi-modal centers. These trends are the result of technological advancements and the introduction of new modes of micro-mobility, as well as consistent investment in high-quality public transportation infrastructure in the cities where they are observed.

Alt A-C parking plan elevates vehicles to a priority position, which is unacceptable at such a central, urban location where multimobility and climate change neutral or positive transportation elements should be prioritized. Instead of encouraging people to use public transportation, share vehicles, or bike or walk to the station, an oversized garage at this primary location adjacent to historic WUS and at the intersection of several neighborhoods has numerous, negative impacts. Directly related to this false prioritization of personal vehicles at a time when such use of this form of transportation has been trending downward for years, is circulation as it relates to vehicular access. The location of an oversized parking garage similarly impacts community and urban design by removing all opportunities for community cohesion or visual celebration of historic structures. Additionally, TVRA issues are not addressed in the DEIS and our analysis suggests that a 6 story multi-level garage would pose a significant security threat.

The Alternative A-C Parking would be one of the largest above grade parking structures within DC. The bulk and massing of this overbuilt facility obstructs visual impacts and view corridors. Additionally, vehicular circulation to and from the proposed garage is in conflict with the proposed bus and PUDO circulation.

The DEIS appears to consider the parking garage in isolation rather than in relation to other project components, resulting in a lack of integration and balance among project elements. The oversized above ground parking garage precludes other community building, revenue generating, sustainable opportunities in this context. As a direct result, the overall success of WUS, Burnham Place, and neighboring communities will be diminished.

The oversized parking garage bears no relationship to the unique historic structures around it, nor the introduction of an expanded and vibrant train hall. The oversized parking garage is not compatible with the visual access zone as defined by Alternative A-C. The view of the Capitol is not only blocked at most angles but is viewed through the frame of a large parking garage. The same is true for all southern facing views of historic WUS. Likewise, the parking garage is not compatible with the Burnham Place development. The visual access zone, pushed off center, forces the Burnham Place development to face a large, unbroken, visually unattractive façade. It cuts off or reduces the ability to have a double sided retail, which significantly reduces the economic viability of any retail development. Additionally, Alternative A-C precludes development of a successful open space south of H Street, in the heart of the combined Burnham Place and federal air rights that is a key location to connecting WUS to adjacent neighborhoods. The current design of the parking structure also precludes development of the greenway open space on the west side of the project as detailed in Section 3.

The DEIS parking analysis does not consider any of the range of impacts that the proposed parking has on other parts of the project, Burnham Place, or neighboring properties. No parking impacts on SEP and neighboring uses are analyzed, documented, or included. For example, the viewshed impacts of the proposed parking structure is not considered in the comparative analysis of the alternatives.

Cost and construction schedule are cited as reasons for selecting the garage in A-C as the preferred alternative, but information supporting this conclusion is not provided in the DEIS. In Section 4B we detail how below grade parking can be integrated with other transportation elements to reduce costs and the construction timeline. In Section IV we detail how key stakeholders will benefit from an underground, integrated parking structure, with increased revenue generation for the USRC and the station, as well as construction methods that can reduce the overall track alignment work by 50%, more than compensating for the initial time and money to move parking underground.

The DEIS analysis of parking requirements is outdated and suburban in nature, neither of which fits the current location or transportation trends that emphasize the importance of pedestrian prioritization and climate change impacts. The size and location are unfounded and will have significant adverse impacts on the neighborhood and both the SEP and BP projects. As we detail in Section III, these issues can be rectified with a right-sized, underground facility.

B2. Pick-Up and Drop-Off (PUDO) and Circulation

The way people move in and around cities has evolved since 1908 when Union Station was conceived and constructed and also since the large parking garage was built above the tracks. Moreover, pick-up and drop-off activity at major transportation centers has increased dramatically within the past five years. The DEIS projects that PUDO uses at WUS will continue to intensify, as For-Hire Vehicle (FHV) ridership replaces drive-and-park and other mode choices. The DEIS estimates that by 2040, each morning and afternoon *a vehicle will arrive or depart Union Station once each second* in order to serve station ridership projections. These 3,600+ trips represent a 25% higher demand than the PUDO activity at Reagan National Airport today. If a hub like WUS is surrounded by high-traffic streets with inefficient PUDO activity creating grid lock, then those streets will create a physical and psychological barrier around the station. A review of the DEIS traffic study for Preferred Alternative A-C indicates that the surrounding streets will degrade in level of service with longer delays and queues.

Burnham Place Consultant Team

Because future PUDO circulation is projected to comprise more than 90 percent of WUS traffic generation and could have significant impacts on Burnham Place and the station environment, Akridge asked Sam Schwartz Engineering (Sam Schwartz) to review the DEIS Preferred Alternative A-C, with a focus on PUDO operations and key concerns. The Sam Schwartz effort was based on recent PUDO trends and best practices, a review of the DEIS Preferred Alternative A-C proposal, and recommendations for design elements that should be included in the DEIS proposal to achieve the goals of the project. Sam Schwartz evaluated the basis of demand in the FRA PUDO program and the operational viability of the various facilities identified in the DEIS alternatives.

As a complement to the Sam Schwartz studies, Akridge also requested Wells + Associates (W+A) to review the DEIS traffic analysis conducted by FRA's consultant team, with a focus on the road network changes and traffic volumes associated with Alternative A-C and associated PUDO. W + A has been working with the Burnham Place team for several years to assist with trip generation forecasts for Burnham Place, multi-modal transportation analyses, and evaluation of the FRA EIS alternatives. As a local transportation consulting firm with extensive experience working in Washington, DC, W + A was tasked to help the Burnham Place team determine network impacts of the proposed PUDO program and facilities on local transportation infrastructure.

Scope and Breadth of Burnham Place Team PUDO and Circulation Studies

The DEIS identifies significant circulation problems from future station traffic in Alternative A-C: extensive traffic sharing air rights roads, separation of the air rights from the station by a major PUDO facility, requirement for a one-way circulation system at the air rights level, and significant degradations in levels of service at key intersections surrounding WUS. These problems will impact Burnham Place and degrade the environment surrounding the station, including adjacent neighborhoods. Alternative A-C relies solely on distributed, on-street PUDO lanes to accommodate the extensive pick-up and drop-off demand for the forecasted ridership growth at WUS. While distributed PUDO operations have some advantages, the DEIS does not address the impacts of relying solely on the local, Columbus Circle, and Burnham Place street network to accommodate PUDO, and potential vehicular gridlock around WUS.

Network Analysis

The effort undertaken by W + A started with analysis of the traffic and circulation elements included in the DEIS, with a focus on first evaluating and documenting issues and concerns relating to Alternative A-C. Capacity/level of service (LOS) analyses were conducted at the study intersections for Alternative A-C based on the future lane use and traffic controls and traffic forecasts shown provided by the FRA and verified by W + A. The FRA provided Synchro worksheets from the model used for the DEIS and these inputs were compared with the Synchro model prepared by W+A to ensure consistency where possible. W + A identified several discrepancies between the FRA and W+A models which raise concerns about the impacts identified in the DEIS, and suggest further study is necessary prior to completion of the FEIS:

- The FRA model did not include de facto turn lanes.
- The FRA model does not include the removal of the parking lane on the south side of K Street between North Capitol Street and 1st Street, which is used as a travel lane during the PM rush, to accommodate the proposed bicycle lanes on K Street.
- The FRA model included the right turn only bus egress as a stand-alone, signalized intersection. However, due to the proximity of the right turn egress to the Central Road, signalization as a standalone intersection is unlikely. The W+A file includes the right turn bus egress as a fifth leg to the Central Road, with its own signal phase.
- Right turn on red restrictions were not coded at several locations where No Turn on Red signs are in place.
- The number of parking maneuvers per hour were not coded in the FRA model.
- Where bus stops exist, the number of bus blockages was applied only to through movements in the FRA model and was not applied to right turn movements where a right turn lane is present.
- Bicycle volumes in the FRA model were considerably lower across the board than what was shown in counts obtained by W+A.

These issues and additional concerns with the FRA model are covered in the W + A summary of their analysis in Appendix B2. W + A verified that at least 9 of the 15 signalized study intersections are projected to operate at an overall LOS E or F. Without significant changes to Alternative A-C, there is a high probability of insurmountable congestion around all sides of WUS. This grid lock would decrease demand for Amtrak ridership, the attractiveness of commuter rail, and the optimal functioning of this multi-modal transportation center – the opposite of the goal laid out in the DEIS Purpose and Need.

Pick-up and Drop-off Facilities Analysis

Sam Schwartz evaluated each PUDO facility proposed for Alternative A-C based on the likely performance given the projected peak hour PUDO activity, considering potential queues and circulation. The analysis began with review of the FRA PUDO trip generation assumptions and then application of a queuing model to determine if the capacity of the PUDO facility would adequately meet the demands without resulting in queue spillback and the potential to affect traffic flow on the local roadways. The queuing models were used to separately evaluate the two principal ways to accommodate curbside PUDO operations: as either single server or multiple server facilities, defined as follows:

- Single server: Only one car, typically the first in queue, can load/unload at a time. Remaining vehicles in queue would wait until that car has loaded/unloaded, then the queue would move up to fill the first position, and the new car that is in the first position would load/unload.
- Multiple server: Every space along the curb could be used for loading/unloading at the same time, and the first car in does not need to be the first car out.

The queueing analysis provided a first check on the ability of the DEIS facilities to accommodate PUDO demand, which was followed by more detailed evaluation of each of the operational viability of the proposed PUDO facilities based Sam Schwartz work on similar facilities and challenges at LaGuardia Airport and Penn Station in New York, and the LAX-it PUDO facility at Los Angeles International Airport, among other relevant projects.

Finally, based on the problems in Alternative A-C, with both WUS vicinity traffic and the multiple fail-points of the PUDO facilities proposed, the Burnham Place consultant team has initiated study of potential solutions to these problems. Based on Sam Schwartz experience and the obvious conclusion that on-street PUDO facilities would not be able to accommodate the projected passenger demand, the Akridge team formulated several concepts for a centralized PUDO facility that would be able to address the deficiencies in PUDO operations that can simply not be accommodated in the spaces and streets surrounding the station. These concepts are identified in Section 4 of these comments for PUDO solutions.

Pick-up and Drop-off Impacts on Burnham Place and the WUS Vicinity

As noted in the executive summary to these comments, the Columbus Circle road network and PUDO lanes are already significantly beyond capacity during peak periods. Given the more than doubling of rail passenger activity, It is not surprising that the DEIS projects Alternative A-C will lead to severe congestion, with vehicle queues spilling back into intersections along Massachusetts Avenue and all sides of Union Station. The following fatal flaws with Alternative A-C's PUDO plan contribute to this result:

- Insufficient lanes and curb frontage for FHVs to form separate queues or 're-match' with a new rider following a drop-off
- Insufficient merge and weaving areas entering and exiting PUDO facilities at Columbus Circle and the Train Hall to accommodate friends and family PUDO, taxis, multiple FHV operators, station parkers, intercity and charter buses and Burnham Place PUDO and parkers
- Inadequate space for passengers to wait and match with drivers, particularly within the second and third lanes at Columbus Circle and along First Street NE
- No off-street location for friends and family members picking up passengers to park short-term
- No staging or hold areas for high volumes of FHVs to serve surge demands when multiple Amtrak trains arrive at once

The FRA's Preferred Alternative relies solely on on-street PUDO lanes to accommodate the extensive pick-up/drop-off operation for the station. Distributing PUDO operations around adjacent surface streets significantly increases the potential for literal gridlock around WUS. Alternative A-C fails to address the impacts associated with converting 1st Street to a one-way operation to accommodate a PUDO lane at the entrance to the H Street Concourse, and on-site circulation on the deck-level, including how the convergence of buses, parkers, and PUDO traffic will be handled both efficiently and safely at the Train Hall east-west road.

The consequences of these flaws and omissions reach beyond unacceptable traffic operations. Other outcomes and impacts include:

- Significantly compromised pedestrian and bicycle safety
- Degradation of the station's historic setting
- Passenger inconvenience and discomfort due to time spent in non-weather-protected queues or in traffic congestion
- Decreased station use as passengers make alternate travel choices
- Preclusion of high-quality civic spaces north of a new train hall

The Burnham Place team agrees with DDOT and DCOP, both of whom recommend the inclusion of a high-capacity, purpose-built, off-street PUDO facility. This facility would be in addition to other PUDO areas at Columbus Circle, the Train Hall, First Street NE and Second Street NE, and is discussed in more detail in our comments in the next section describing PUDO solutions.

Traffic Analysis Areas of Concern

Significant problems with traffic volumes and intersections serving WUS were identified both the DEIS and verified independently in the W + A Snychro modeling. In fact, because a number of key circulation details were not included in the FRA model, W + A identified several intersections and capacity issues of much greater concern than the analysis provided in the DEIS. Two of these of essential note include:

- The North Capitol Street/G Street intersection
- Columbus Circle/First Street/Massachusetts Avenue

The North Capitol Street/G Street intersection

Alternative A-C proposes a plan to convert First Street NE to one-way northbound in order to accommodate the proposed PUDO areas adjacent to the H Street Concourse entrance between G Street and I Street. As proposed, a one-way northbound configuration would allow for a pedestrian sidewalk on the west side of the street, one northbound travel lane, the PUDO lane, a median or PUDO pedestrian island, the existing cycle track, and the existing sidewalk. Based on the W + A analysis, the viability of this proposal is in serious question due to the impacts associated with eliminating southbound First Street NE traffic with the conversion of First Street NE to one-way northbound. This circulation change induces a very large volume of left-turn demand onto G Street NE, for traffic that is headed southbound on North Capitol Street, beyond the capacity of the intersection to handle, even with a potential added left turn lane.

Columbus Circle/First Street/Massachusetts Avenue

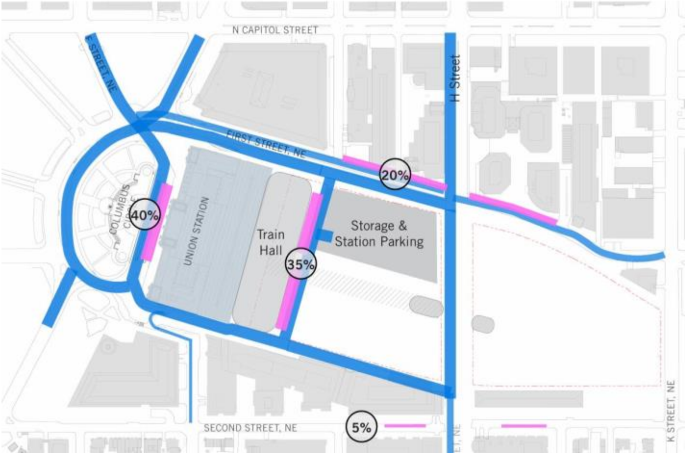
The Columbus Circle/1st Street/Massachusetts Avenue intersection serves as the entrance to the Columbus Circle PUDO area. Under the Wells model, the 95th percentile queue for the eastbound left turn movement into the PUDO area is projected to extend through the outbound side of Columbus Circle during the AM peak hour. While the W+A model shows a projected 95th percentile queue extending through and blocking the outbound side of the PUDO area, the FRA model shows the projected queue stopping just short of blocking the outbound side of the PUDO area. The reason for the discrepancy between the models is related to the phasing coded for the intersection. The W+A model uses the existing signal phasing but with optimized splits to minimize the delay and queuing. The FRA model modified the existing phasing. The validity of the phasing used in the FRA model could not be confirmed based on the information that was provided by FRA. However, the fact that the FRA model coded the eastbound left turns into the PUDO area as through movements does raise a concern.

PUDO Functionality Areas of Concern

In addition to the lack of capacity identified in the queueing analysis, the PUDO facilities proposed in Alternative A-C are unlikely to operate efficiently. Problems with the proposal for these facilities are documented in detail in the Appendix B1, PUDO Operations, and include the following:

- Long taxi queues
- Inadequate space for Friend/Family PUDO which needs longer dwell times at curbside facilities or more convenient need to park and wait or circulate around WUS and the neighborhood
- Lack of rematch strategy to be as efficient as possible within the limited amount of available space
- Rematch circulation required on station vicinity streets to link one PUDO area to another, increasing vehicular congestion
- Lack of curbside management for multiple PUDO facilities
- Gridlock and traffic spillover on 1st and 2nd Streets due to reliance on curb frontage for growing PUDO demand leads to negative impacts on adjacent local streets (a non-strategy that resembles current ad hoc operations at airports)
- Northbound First Street at K Street conversion to a one-way to accommodate a PUDO lane overloads this intersection
- Lack of study of deck-level circulation from the convergence of buses, parkers, and PUDO traffic
- Inadequate queue areas, waiting areas, and circulation space required for vehicles to find the correct entrance and exit lanes coming into and exiting the Columbus Circle location
- Lack of curbside staging areas, which the DEIS acknowledges are not accommodated.

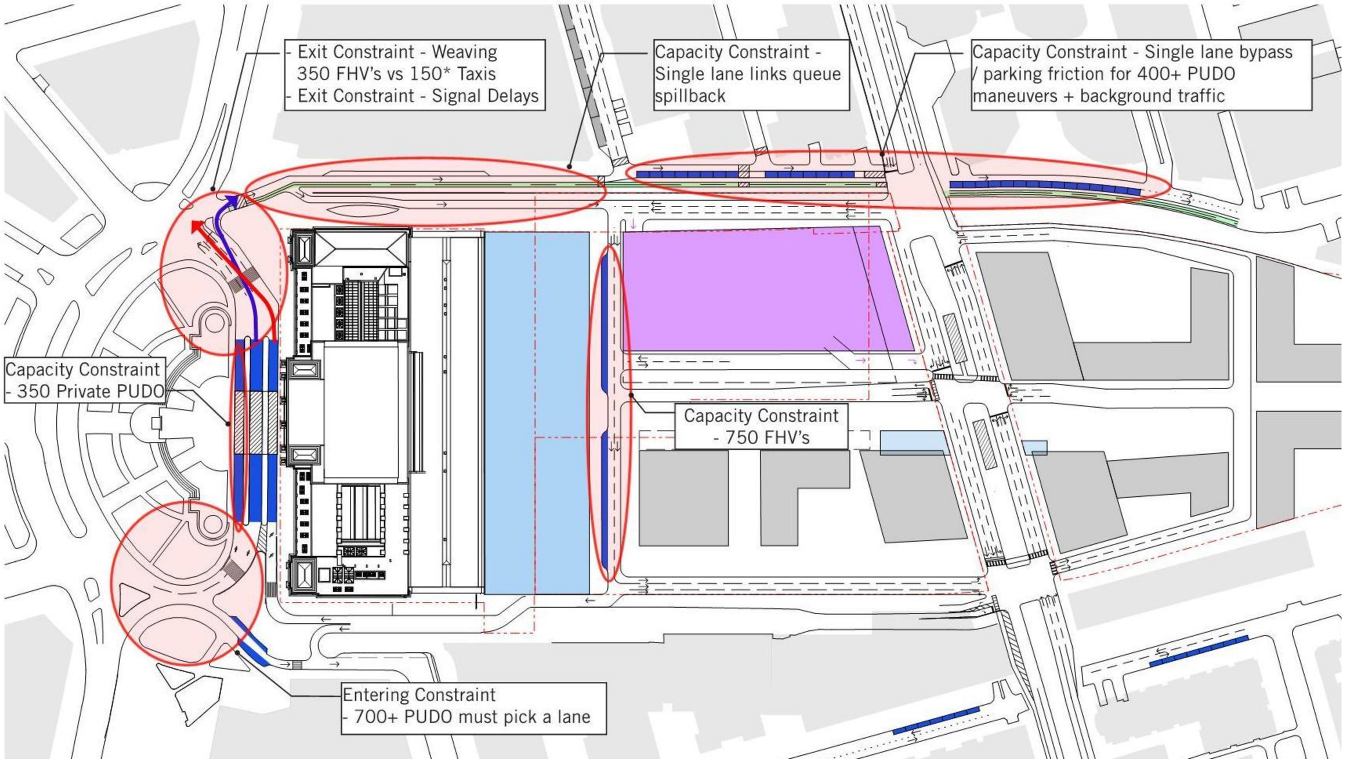
In particular, Columbus Circle, First Street, NE, and the deck level PUDO are all locations constrained by the capacity of the circulation network serving them. In addition, these locations do not allow for an organization of PUDO operations to achieve ride rematch or relinking, effective separation of pick-up and drop-off areas, or adequate circulation space. Taking an ad hoc approach to the planning of PUDO at on-street locations will further negatively impact the local road network and cause further congestion around the station and at Burnham Place.



Provision of a multiple server model, required to meet PUDO demand in Alternative A-C, demands a higher level of physical modifications and technology-enabled operations to efficiently and effectively move vehicles and their passengers to and from Union Station without gridlock during peak hours. However, the physical and space constraints at Columbus Circle, First Street NE, and the Train Hall PUDO locations will create conditions more like a single server model and likely result in indefinite queues at these location.

Circulation impacts from PUDO at the Train Hall will significantly impact Burnham Place pedestrian access to the station and critical transportation facilities including Amtrak, Metro, and the commuter railroads. The H Street level pedestrian environment will fail to realize its potential as an important urban place north of the historic station. And PUDO circulation at the east and west ramps proposed in Alternative A-C will further harm pedestrian and bicycle uses and appreciation of the historic station setting and building.

Alternative A-C Distributed PUDO

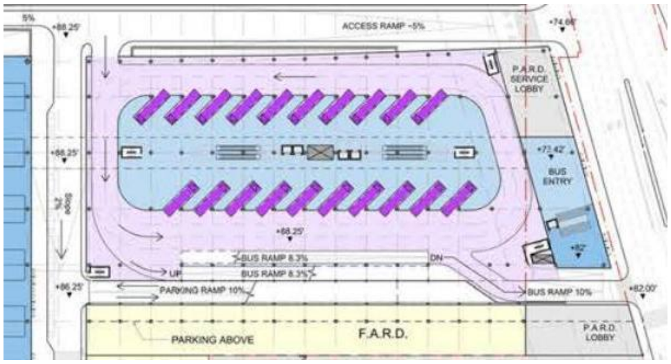


Conclusion

As proposed, Alternative A-C's reliance on the street network and curbside space immediately surrounding the station perimeter adversely impacts the valued use of these areas for pedestrian and bicycle circulation, as well as the provision of open space. The locations chosen for PUDO are thus detrimental to the promotion of transit use, by harming pedestrian and bicycle modes and increasing the demand for vehicular connections – developing a harmful feedback loop increasing the use of private vehicles and decreasing the use of transit.

A centralized PUDO facility with multiple points of ingress and egress would alleviate the reliance on on-street PUDO areas and reduce some of the burden on Columbus Circle, thereby reducing vehicular traffic immediately adjacent to the station and providing for a more pedestrian- and bicycle-friendly experience immediately surrounding the station.

B3. Bus Facility



CREDIT: DEIS Alternative A-C (Preferred Alternative), June 2020

Planning a bus facility at the historic, urban location of Washington Union Station requires balancing numerous transportation, multi-modal, circulation, and urban design requirements. Intercity and charter bus functions are a valued and important component of the SEP program. With the existing garage slated for demolition, there is an opportunity to create one of the best bus facilities in the country. To fulfill this opportunity, the WUS bus facility must a) be sufficiently (but not excessively) sized, b) provide a great passenger experience, c) complement the urban design environment and d) minimize circulation impact on pedestrians, bicyclists, local streets and adjacent projects. Preferred Alternative A-C fails to satisfy each of these objectives.

Burnham Place Consultant Team

Because of the obvious impacts the proposed Alternative A-C bus facility would impart to the character, open space, urban place-making, and vehicular circulation requirements of Burnham Place, Akridge asked Sam Schwartz Engineering (SSE), Wells + Associates, and Shalom Baranes Associates to analyze and document the impacts of the Alternative A-C bus facility. This world class consulting team did a rigorous detailed analysis of the proposed bus program for the WUS bus facility. This analysis helped inform our assessment of the current flaws with the Preferred Alternative A-C design. Our work with SSE, Wells and SBA also identified ways to elevate the bus facility and rider experience that fit with our vision of WUS and its environs as an urban, world-class, and vibrant bus facility. These solutions are described in Section 4B.

Alternative A-C Facility Programming and Design Analysis Undertaken by the Burnham Place Team

To understand the flaws with the facility Sam Schwartz undertook an extensive investigation of the existing Union Station bus facility operations and layout, including a more in-depth analysis of the bus facility capacity than included in the DEIS. The capacity analysis in the DEIS was based simply on an identification of the current number of bus slips and application of a growth factor to this number. This analysis does not capture the important issues of whether the existing facility is used efficiently, and even more importantly does not include analysis of peak day and peak hour demand. In contrast, the programming and sizing analysis undertaken by Sam Schwartz includes the following key aspects:

- Analyzed a typical weekly schedule to understand operating needs and characteristics of all existing carriers
- Analyzed and compared carrier schedules to one another and other transportation models to validate use as a baseline for growth
- Compared the analysis of existing operations against US and international best practices to develop a full understanding of the proposed framework in the DEIS proposal
- Observed and documented time needed for intercity bus loading and unloading at various high activity bus locations
- Developed an operations model to test multiple operating parameters and yield facility sizing based on specific peak hour assumptions, including “peak of the peak” and “beyond peak” scenarios

The full Sam Schwartz analysis is provided in Appendix C1 and an overview is provided here.

As a complement to the programming and capacity analysis undertaken by Sam Schwartz, Shalom Baranes Associates examined the proposed Alternative A-C bus facility from a user-experience perspective, and studied the architectural, spatial, and access elements of the facility. SBA has been involved in these key design issues for both the station project and Burnham Place since before 2010 and has worked on all transportation infrastructure elements within or adjacent to Burnham Place with the goal to coordinate and improve integration between the public and private portions of the overall project.

Flaws and Impacts with the Alternative A-C Bus Facility

As a result of this analysis, the Burnham Place team has identified a number of key issues that are significant problems with the Alternative A-C bus facility:

Size and Capacity

The FRA has taken an important initial step in identifying an intercity and charter program based on a modern operations model that uses dynamic scheduling and flexible berthing. This program identified a need for a total of 24 bus slips to fully accommodate 2040 passenger growth and demand. This approach is a critical first step to acknowledging the need to pursue a modern bus facility that is in harmony with other transportation and land uses at Union Station. Unfortunately, the bus facility proposed in the Preferred Alternative A-C was increased in size substantially above the 24-slip program established by FRA, resulting in a two-level, four story station with significant urban design and circulation impacts on Burnham Place and the surrounding neighborhoods.

As stated, the DEIS states that 24 slips are required to meet 2040 intercity and charter bus demand under an active management approach. It then adds 15 more slips "for unforeseen growth"[1] without providing criteria used to make this determination. This is particularly concerning given the Preferred Alternative's bus facility footprint can only fit 20 buses on one level, thus requiring a second level to accommodate the additional slips for the "unforeseen growth." Alternative A-C also fails to consider operational best practices that would preclude the need for additional slips.

Facility size and the appropriate number of bus slips cannot be determined without an analysis of peak hour demand. Furthermore, at WUS, peak intercity demand must be compared to peak charter demand to fully understand facility needs. Based on the information in the DEIS, intercity and charter peaks complement one another, rather than vie for the same space at the same time. As a result, the bus slip count in the DEIS is based on overall demand of a few hours each week that occur solely during a three-month peak season. All other days, hours, and times of the year will have excess capacity.

The DEIS does not provide adequate data and analysis to support the program definition of 24 intercity and charter bus berths, much less the 40 bus-berths included in Alternative A-C. Basing the overall facility size on overly-long bus dwell times of 30-minutes for a single "movement" means that a single bus which arrives and unloads passengers, then takes on new passengers will have a full hour to complete that simple operation. This assumption is the principal problem leading to the oversizing of the bus facility, and while it might serve the business interests of various private carriers using the facility for extended periods of bus parking, it is out of step with all modern transportation facilities, including the rail yard directly below the bus station. The Sam Schwartz analysis shows that a properly planned facility should utilize dwell times generally do not exceed 10 -15 minutes for passenger arrivals and 15 – 20 minutes for loading and departures.

The Alternative A-C bus facility of 40 bus slips has not been analyzed or programmatically justified. If operated with modern best practices, the 40-slip facility could generate enormous bus volumes, overwhelming the neighborhood with well more than 1000 buses per day.

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[1] USDOT-FRA. (June 2020). Draft Environmental Impact Statement for Washington Union Station Expansion Project – Appendix A4, Section 6-6, p. 35, Retrieved June 24, 2020. https://railroads.dot.gov/environmental-reviews/washington-union-station-expansion-project/draft-environmental-impact.

Alternative A-C's oversized bus facility is in part based on faulty assumptions regarding the demand for charter bus slips. Charter buses are largely tied to just three months of a peak season that coincides with cherry blossom season and spring break visits. The DEIS proposes 8 slips be committed to charter bus activity 24 hours a day, every day of the year. The Sam Schwartz analysis shows how charter bus demand can be dynamically managed to accommodate peak of the peak charter demand during the few hours per week, three months of the year needed.

Passenger Experience

Existing Bus Facility, Union Station

The Alternative A-C design places the bus passenger waiting area on a "parking lot island", surrounded on all sides by a bus parking slips. The A-C passenger waiting area has no access to natural light or fresh air and no access to quality public space. The A-C design has no prominent entrance, no quality outdoor urban space nearby and, given that it is surrounded on all sides by busses, creates inherent pedestrian and accessibility conflicts. Clearly, the bus passenger experience was not a priority consideration in the planning of the Alternative A-C bus facility. We believe the WUS bus facility should be a first-class facility, connected to world-class public spaces, with natural light and prominent accessibility. Consideration of the actual intercity bus passenger experience should be a top priority in assessing the success of the intercity Bus facility at WUS.

Urban Design Impacts

The Alternative A-C bus facility is a massive footprint of exclusive vehicular use, with no people-oriented or activated spaces on its east, west, and south perimeter frontages. The lack of pedestrian-oriented uses at ground level impacts and diminishes the quality of the pedestrian experience at the Train Hall and west side of the overall SEP. The layout of the facility proposed in Alternative A-C is configured such that the important frontages of the facility on its south, east, and west facades are all dedicated to vehicular activity, with the pedestrian uses of the facility occurring on the interior and surrounded by bus circulation. This arrangement of the facility, with vehicular functions fronting on adjacent streets, sidewalks, and public space (on three of its four sides) significantly impacts adjacent uses including the train hall on the south and Burnham Place on the east. It is not possible to create a pedestrian-oriented experience at the ground level when the interior use is completely dedicated to vehicular circulation in lieu of interesting and activated spaces such as retail or restaurants.

The proposed bus facility is of such excessive scale that it prevents the development of meaningful open space on its east side, even if the majority of that open space is located on the Burnham Place site. The facility size and footprint eliminate the possibility for realization of a greenway on the west side of the site, a key feature of Amtrak's 2012 vision and plan. Moreover, the provision of an excessive bus program is inconsistent with the project purpose and need, negatively impacting urban design, vehicular circulation, environmental sustainability, and multi-modal uses at Union Station.

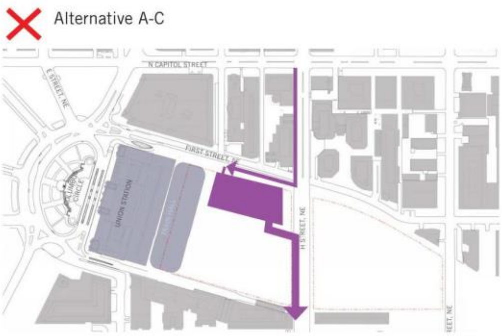
The lack of pedestrian-oriented, active uses at the ground floor of the bus/parking facility (as well as upper floors) severely impacts and diminishes the value of any Burnham Place open space, street-level environment, and buildings facing the garage that are developed on the BP property.

The large footprint and height of the proposed Alternative A-C bus facility are not compatible with the proposed Federal Air Rights development opportunities identified in the concept drawings and descriptions. The potential for adding occupiable residential, office, or other space on the east side of the bus garage is negligible, given the very narrow footprint identified in the FRA. In addition, this area noted for developing a Federal Air Rights project that connects to the H Street deck level lies entirely within the "visual access zone" identified in Alternative A-C, which is an important view corridor from H Street to the north face of the historic station. Together, the visual access zone and the garage footprint make realization of any federal air rights development in the area identified on the east side of the garage essentially infeasible.

The footprint indicated in Alternative A-C for private air rights development on the north side of the bus garage/parking facility is proposed to be modified from the existing private air rights ownership. The alternative indicates that the Station Expansion Project utilizes more than half of the ground floor of any future Burnham Place building on this parcel, takes away prime retail frontage and space for a building lobby facing the Burnham Place Central Road and H Street, and leaves an overall building dimension too narrow, extremely inefficient, and realistically un-developable due to the difficulties in placing building cores, egress stairs, and other technical elements. (Addressed further in Section 6B, Technical Impacts).

Vehicular Circulation

The location of the bus facility and its vehicular access and egress have significant circulation impacts on Burnham Place and the surrounding area. Circulation impacts from the bus facility will harm other transportation modes, place-making, economic potential, and urban design.



The bus facility location requires that all buses leaving the facility turn right onto H Street which has significant impacts at the intersection of H Street and the future Central Road to Burnham Place. This exit would create conflicts between both H Street vehicular and pedestrian circulation and would require a "5th leg" in the intersection signal timing, making all circulation less efficient and less safe. While the DEIS states that approximately 40% of bus movements are headed west from the station, all bus movements would be forced east on H Street, unnecessarily adding more bus traffic to the residential neighborhoods east of the station and ultimately requiring the use of neighborhood side streets to reverse direction and head west.

Circulation requirements for bus movements, in combination with usage of the west service road for PUDO and parking access have not been defined or demonstrated. The number of lanes and lane widths to accommodate bus movements and vehicle queueing are not provided, making the bus proposal impossible to evaluate.

Circulation from the bus facility with buses exiting at H Street and all buses turning east at the central street has significant negative impacts at the main and most important entrance to Burnham Place, harming convenience and practicality of access to Burnham Place, wayfinding, and perception of the Burnham Place project.

Conclusion

The proposed Alternative A-C bus program and facility size are over-sized, present an unacceptable passenger terminal experience, prevent realization of essential urban planning priorities, and unnecessarily directs bus traffic on to neighborhood streets. The Alternative A-C plan is out of step with best practices at modern and comparable facilities in the U.S. and Europe. Based on the in-depth analysis of potential bus program and facility needs in the new transit center, the Burnham Place team's analysis shows that best practices, trends in bus facility operations and design, and comparisons to similar bus facilities in other U.S. and European cities, all point to a reconsideration of the Alternative A-C bus proposal. As inventoried at the outset of this section, the goals for a worthy WUS bus facility are fully achievable (as described in section III) and should not be compromised.

Section IV

Modifying Alternative A-C to Achieve a Balanced Vision

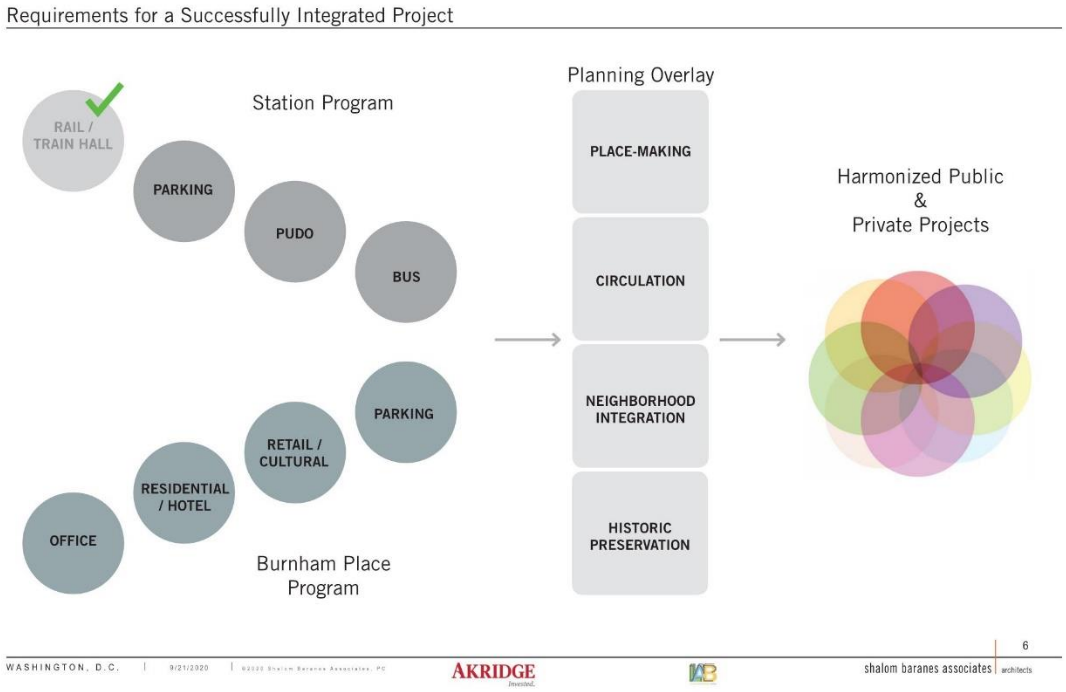
A. Requirements for a Successfully Integrated Project

AN ALTERNATIVE VISION FOR A TRANSIT-ORIENTED, MIXED-USE NEIGHBORHOOD

The city, region and country deserve a station district that exemplifies the best in urban, multi-modal station design, transit-oriented development, placemaking, economic development, and neighborhood and historic preservation enhancement.

This vision does not emerge when the baseline starting point is a comparison to existing conditions, a massive bus and parking facility that looms over the tracks, Burnham Wall and historic station headhouse. The existing bus and parking facility must be demolished to enable the reconfiguration of the station's tracks and platforms and unlock future rail growth capacity, but this should not be the starting point to envision a successful planning framework.

When we instead start with a blank slate, a strong planning framework emerges through an iterative design process that looks to balance and integrate all key urban design drivers. An initial step is to identify those drivers, which include the important station program elements of the train hall, bus, parking, and PUDO. These elements are not exclusive -- they are shaped by planning overlays of functional circulation, placemaking, neighborhood integration, and historic preservation. Through the iterative process, program uses are right-sized, their locations are optimized, and harmonized public and private projects emerge.



Requirements for a Successfully Integrated Project

The Akridge Vision is a 3-million square foot mixed-use development including office, residential, hotel, retail, and cultural space, interwoven with parks, plaza, and a new circulation network – all atop a rail yard serving national and regional passenger rail. The development is part of a revived station district that seamlessly integrates with new station elements, a world-class train hall and H Street headhouses, and a modern, efficient, and light-filled bus facility. The balance of transportation program, open spaces, circulation, historic considerations, neighborhood integration, and placemaking, are foundational to the Akridge vision for a A-C Modified.

Open Space Network

Linked open spaces connect new buildings to each other, to Union Station, and to adjacent neighborhoods.

Burnham Place team's vision for compatible public and private projects

1. Civic Space

A Civic Space south of H Street is centered on the historic Union Station enables views from the new train hall and embraces and frames the buildings around it. Transportation entrances are once again celebrated with architectural elements to create a world-class north entrance to Union Station, a modern and light-filled bus facility, and a convenient head house entrance on H Street. These entrances are supported by other active ground floor uses, that could include a variety of retail, office, hotel, or residential. The 125’ by 600’ dimensions of the overall space provide a civic and ceremonial scale that allow for a variety of landscape and hardscape environments to connect visitors to their place. Lawn panels, tree bosques, and café seating patios are some of the outdoor amenities that could be provided. Paved pedestrian circulation connects pedestrians to their next spot, whether transportation entrances and other walking routes weave through the spaces. A low intensity vehicular road, providing access to building entrances, traverses a portion of the space. The design of the road uses custom pavers and roll-over curbs to deemphasize the low-speed vehicular path and prioritize pedestrians.

2. Neighborhood Park

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A neighborhood park, built above the bus facility and adjacent to the civic space, provides a unique outdoor environment for the station district and a destination for individuals and families living in Capitol Hill, NoMa and beyond. It is an opportunity to locate the unexpected – an amphitheater built above the bus entrance, a naturalized playground to splash in water and scramble on rocks, and a connection across a bridge to a platform with views to NoMa, the historic station, and of the Capitol Building.

The neighborhood park above the bus facility is about ten feet above the adjacent civic space and gives gracious ceiling height to bus passenger waiting areas below. A combination of stairs, ramps, and landscape features create an easy and gradual ascent from the civic space up to the Neighborhood Park. Large skylights within the park transmit light down to the bus facility below.

3. Greenway

A linear park called the Greenway is a crucial extension of the Metropolitan Branch Trail (MBT), a regional pedestrian and bicycle path that extends north to Silver Spring, Maryland. Currently, the elevated trail at the NoMa-Gallaudet Metrorail station needs to drop precipitously down to street grade where it shares public street right-of-way to extend south to front of the historic station. Part of that path moves along the particularly tight and constrained First Street NE, adjacent to Burnham Wall. The Greenway provides a route to keep the Trail elevated until it connects back to grade at the southwest corner of the historic station. Connections to the network of open spaces within the air-rights development would come through a combination of ramps and stairs.

The width of the Greenway can accommodate pedestrians, bicyclists, landscaping, and unique experiences along its length, that could include the reuse of a historic train platform canopy that was once part of the Metrorail's Red Line rail yard. A pedestrian entrance to the new train hall off the Greenway provides further activation of the amenity. The High Line in New York City demonstrates the design potential of this space.

4. North Park

2012 Amtrak / Akridge Master Plan

A central open space is important to placemaking and organizing surrounding mixed-use buildings in this portion of the air-rights development. H Street NE will front office buildings and ground floor retail along the North Park with a station head house on that side of H Street. In contrast to the central Civic Space south of H Street, North Park's character transitions from commercial to residential, all while remaining publicly accessible. Retail intensity diminishes to the north and is replaced by residential lobbies and amenity frontage.

The North Park would directly connect to the Civic Space and Greenway. Crosswalks on either side of the intersection of H Street and the central road would link North Park to the Civic Space.

Functional Circulation Network

The circulation network is, like the open space network, another important planning layer that drives location and layout in a successful urban environment. A functional circulation network is comprised of pedestrian, bicycle, and vehicular circulation, prioritized as appropriate for each publicly accessible space.

1. Pedestrian Circulation

The varied spaces within the open space network, Civic Space, Neighborhood Park, Greenway, and North Park, prioritize pedestrians. Only the central Civic Space and North Park permit vehicular access to the front entrances of the air-rights development, but it is not an intense or encouraged activity. Within the Civic Space, the landscape and hardscape design offer pedestrian direct movement between transportation entrances so as to quickly catch a train, bus, or streetcar. A more casual design allows for meandering through a rich variety of landscape experiences for those with more time.

The Neighborhood Park is a place of discovery. Access to it is gained by ascending either stairs, accessible ramps, or a combination of the two. Once atop the park, a variety of areas and experiences are walkable, and could include an amphitheater, lawn panels, and play areas. The Neighborhood Park also extends to the Overlook that provides stair access down to the Greenway.

The Greenway, an extension of the MBT, provides a linear walking path between Columbus Circle and the NoMa-Galludet Metrorail station, instead of the vehicle centric proposal of Alternative A-C. Opportunities to make vertical connections up to the Greenway Overlook, H Street, and North Park are possible with modifications to A-C outlined later in this section. With this linear park in lieu of the service drive proposed in Alternative A-C, the west and south sides of the historic station offer a more pedestrian-friendly environment.

North Park, like the Civic Space, permits vehicular access but promotes pedestrian circulation as it moves from , to H Street and the North Head House towards a more intense landscape environment and access to residential buildings at the north end of Burnham Place.

While all the open spaces are individually pedestrian friendly and accessible, they collectively form an interconnected network of complementary, linked, and landscaped spaces with multiple points of access and cross flow.

2. Bicycle Circulation

Bicycle circulation is another important ingredient in creating a functional circulation network. The Greenway as an extension of the MBT is a critical segment to an 8-mile regional bicycle trail that extends to Silver Spring, Maryland. The MBT on the Greenways would be elevated and shared with pedestrians instead of its current position that shares the First Street, NE right of way with vehicles. This is enabled with a shift of the west service road east without a connection to Columbus Circle.

Bicycle access into and through the Civic Space and North Park is also promoted. Routes to all transportation entrances, which have adjacent bike racks, are accommodated. We envision a Capital Bikeshare station in the Civic Space.

3. Vehicular Circulation

Necessary vehicular intensity associated with PUDO, bus facility, parking and loading is managed along the edges of air-right development to instead prioritize pedestrians at the Civic Space and North Park. A service road rings the air-rights development along the north and south, where it intersects with H Street on the east and west edges at a lower elevation than the intersection of the central road at the apex of H Street NE, which makes the service road level ideal for parking and loading uses.

South of H Street, where the intensity of station-related vehicular circulation within the air-rights occurs, the service road loop serves transportation in addition to air rights uses. In contrast to the Alternative A-C, ingress and egress are consolidated to the southwest service road in Modified A-C. This arrangement permits buses to egress to the west and away from the Capitol Hill neighborhood to the east.

A high-capacity, centralized PUDO facility below the new rail concourse level moves many PUDO activities off H Street and creates the a pedestrian Neighborhood Park with natural light instead of 1,575-space parking facility as proposed in Alternative A-C.

Circulation solutions are detailed more fully in the subsections below.

Architecture

Only in combination and coordination with a rich variety of neighborhood-connecting open spaces and a functional circulation network can the location and layout of this important architectural program be determined. High-quality architecture is important and will be designed at a later date. Our renderings are but one way to envision a vibrant and active Union Station and Burnham Place.

Transportation Elements

Transportation entrances are the iconic objects that feature prominently in the Civic. An important entrance to a world-class train hall with the historic station's main vault visible beyond is a central focus at the south end of the space. The H Street Headhouse, provides prominent and convenient access down to below-track station concourses, announces the station to H Street vehicular traffic and the H Street streetcar stop at the north end of the space. A light-filled bus lobby front the Civic Space and is visible from H Street and the historic station.

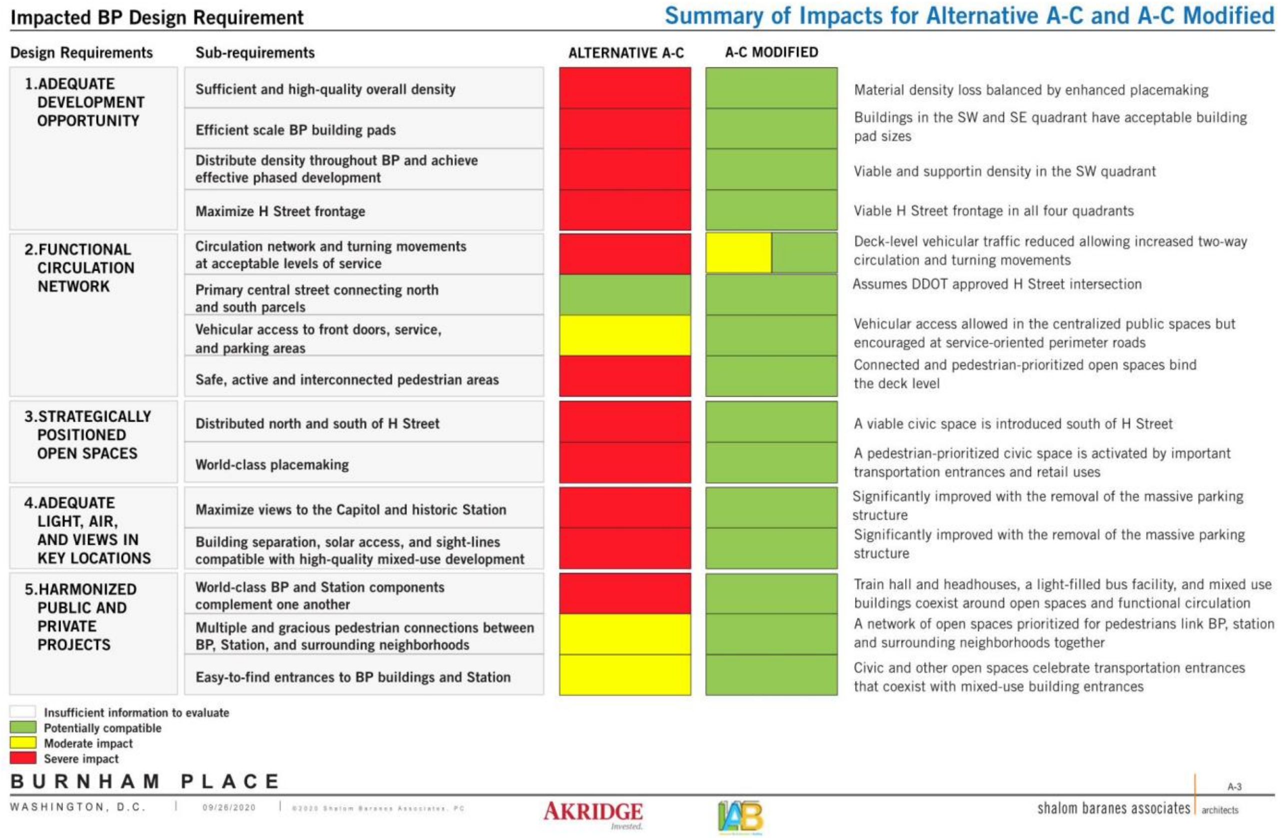
Conclusion

The adjustments to parking, PUDO and bus described in this Section will enhance the value of the private air-right development, historic interests, surrounding neighborhoods, as well as the public Expansion Project. When the public and private projects are harmonized, both projects benefit.

- A centralized, below-grade parking and PUDO operation with remote access from multiple points to the west relieves congestion directly adjacent to the historic station, making it much more accessible to pedestrians and bicyclists and respectful of the historic context.
- The network of publicly accessible, high-quality outdoor spaces, including the Civic Space, Neighborhood Park, and Greenway would all be available amenities to transit users.
- Additional opportunities to introduce natural light to transportation functions through skylights, floor openings and clerestory windows enhance user experience.
- Valuable federal air rights become available once the large volume bus and parking structure moves below grade. The value of those air rights would more than offset the construction costs of the additional below-grade level.

Going back several years, the Burnham Place team has consistently communicated to the FRA that there are five essential design requirements an EIS alternative must meet to ensure successful integration with the Burnham Place project. They include adequate development opportunity, functional circulation network, strategically positioned open spaces, adequate light, air, and views in key locations, and harmonized public and private projects. These five requirements, which included several subcategories within each, were originally conceived as a simple and clear way for the Burnham Place team to provide feedback to the FRA and the SEP team on its alternatives. This feedback was provided by scoring how each alternative meets the five design requirements.

The Burnham Place team produced the following chart which is consistent with the format of several similar charts provided to the FRA soon after the Preliminary Alternatives were first released. This new chart compares the scoring of Alternative A-C to an adjusted A-C that results once flaws are fixed, and a few key modifications are made. While Alternative A-C severely impacts and precludes the achievement of most of the essential design requirements, A-C Modified allows for potentially compatible projects.



Impacted BP Design Requirement

Summary of Impacts for Alternative A-C and A-C Modified

Design Requirements	Sub-requirements	ALTERNATIVE A-C	A-C MODIFIED	
1.ADEQUATE DEVELOPMENT OPPORTUNITY	Sufficient and high-quality overall density	🟥	🟩	Material density loss balanced by enhanced placemaking
	Efficient scale BP building pads	🟥	🟩	Buildings in the SW and SE quadrant have acceptable building pad sizes
	Distribute density throughout BP and achieve effective phased development	🟥	🟩	Viable and supportin density in the SW quadrant
	Maximize H Street frontage	🟥	🟩	Viable H Street frontage in all four quadrants
2.FUNCTIONAL CIRCULATION NETWORK	Circulation network and turning movements at acceptable levels of service	🟥	🟨🟩	Deck-level vehicular traffic reduced allowing increased two-way circulation and turning movements
	Primary central street connecting north and south parcels	🟩	🟩	Assumes DDOT approved H Street intersection
	Vehicular access to front doors, service, and parking areas	🟨	🟩	Vehicular access allowed in the centralized public spaces but encouraged at service-oriented perimeter roads
	Safe, active and interconnected pedestrian areas	🟥	🟩	Connected and pedestrian-prioritized open spaces bind the deck level
3.STRATEGICALLY POSITIONED OPEN SPACES	Distributed north and south of H Street	🟥	🟩	A viable civic space is introduced south of H Street
	World-class placemaking	🟥	🟩	A pedestrian-prioritized civic space is activated by important transportation entrances and retail uses
4.ADEQUATE LIGHT, AIR, AND VIEWS IN KEY LOCATIONS	Maximize views to the Capitol and historic Station	🟥	🟩	Significantly improved with the removal of the massive parking structure
	Building separation, solar access, and sight-lines compatible with high-quality mixed-use development	🟥	🟩	Significantly improved with the removal of the massive parking structure
5.HARMONIZED PUBLIC AND PRIVATE PROJECTS	World-class BP and Station components complement one another	🟥	🟩	Train hall and headhouses, a light-filled bus facility, and mixed use buildings coexist around open spaces and functional circulation
	Multiple and gracious pedestrian connections between BP, Station, and surrounding neighborhoods	🟨	🟩	A network of open spaces prioritized for pedestrians link BP, station and surrounding neighborhoods together
	Easy-to-find entrances to BP buildings and Station	🟨	🟩	Civic and other open spaces celebrate transportation entrances that coexist with mixed-use building entrances

⬜ Insufficient information to evaluate
🟩 Potentially compatible
🟨 Moderate impact
🟥 Severe impact

While Preferred Alternative A-C is flawed a successful planning framework is achievable with a few key modifications. The city, region and country deserve a station district that properly value the urban context.

B1. Right-Size Parking and Optimize Location and Configuration

We agree with near unanimous input from a majority of stakeholders that the final EIS decrease the amount of parking on site and place it underground. We hired SSE as transportation engineers to analyze parking demand and arrive at an estimated parking space count. They determined a range of 55-432 parking spaces will be sufficient for the uses at WUS (Appendix A, Parking Program). This is well in line with DC OP Director Andrew Trueblood's statement for no more than 295 parking spaces at this location.

Co-mingling parking and PUDO facilities organizes where vehicles can expect to enter and exit Union Station regardless of how they will circulate once inside the structure. SSE studied vehicle circulation and demand to determine which access locations would have the lowest impact to the local street network. The research, outcomes, and recommended modifications are further detailed in the PUDO and circulation portion of this section, below, and in their accompanying PUDO Paper (Appendix B).

Right-sizing parking and optimizing the configuration underground with an off-street PUDO facility and single level bus facility (described in the bus portion of this section and in the Bus Program Appendix C1 will ensure that people are the priority at this world-class, multi-modal hub and not personal vehicles.

B2. Establish a Distributed PUDO Plan, Including One High-Capacity, Below-Grade, Centralized Facility

Based on the traffic modeling studies and pick-up and drop-off analysis undertaken by the Burnham Place consultant team showing significant PUDO flaws and impacts from the PUDO facilities proposed in Alternative A-C, it is clear that a modified approach to the provision of this transportation function at Union Station is required. Based on our studies, the PUDO demand identified in the DEIS cannot be effectively met with the concept proposed in Alternative A-C for distributed facilities alone. Fortunately, the addition of a centralized, below-grade and high-efficiency facility is feasible within the station project and can significantly improve overall transportation and urban design goals for this important site.

Need for Modifications to the Alternative A-C PUDO Concept

For the overall station project to meet the Purpose and Need identified in the DEIS, pedestrian, transit, and bicycle circulation must be prioritized. Unfortunately, the vehicular circulation proposed in Alternative A-C would impact and impair these sustainable transportation modes, by surrounding all sides of the station building and local streets on the station perimeter with high levels of vehicular activity, with a corresponding reduction in pedestrian and bicycle circulation function and safety. The Burnham Place team has identified that it is not possible to meet PUDO demand without adding a centralized, high-capacity and high-efficiency PUDO facility to complement the distributed PUDO facilities proposed in Alternative A-C. Doing so will not only provide the only space capable of accommodating the essential characteristics of a well-functioning PUDO facility, but will also reduce demand at the on-grade facilities at Columbus Circle, First Street NE, and the Train Hall necessary to make these facilities functional.

The Burnham Place team is currently continuing with its studies to provide a centralized facility below-grade, directly below the rail concourses which can serve the highest levels of PUDO demand. Concealing high-intensity vehicle functions below ground is the default choice for high-density urban land uses of all types. In the commercial core of Washington, DC medium- and high-density land uses are almost always built with all significant parking below-grade. The FRA recognized and validated this trend when it developed five of its six Action Alternatives to include some or all of its parking and PUDO facilities off-street and below the new concourses proposed at WUS.

What is unique about planning for Union Station as compared to most other current land uses in DC is that PUDO, *not parking demand* accounts for approximately 90 percent of projected peak hour vehicle trips. Locating PUDO facilities below-grade at Union Station solves or significantly mitigates the flaws and adverse impacts identified in the discussion of PUDO and circulation flaws earlier in these comments.

Characteristics and Functions of a Centralized PUDO Facility

A centralized, high-capacity facility is the only way that the multiple program needs of a high-efficiency PUDO facility can be met, by providing a large and contiguous space on one level to accommodate consolidated Friend/Family pick-up and drop-off, as well as the same for FHV. DC policy and sustainability goals to reduce VMT and the overall number of vehicular trips to and from the station require a maximum degree of “rematch” to pair a new passenger with a For-hire Vehicle that has previously completed a passenger drop-off at the station. Just as important, with the large amount of Friend/Family PUDO identified in the FRA proposal for Alternative A-C, there is an equally important requirement for Friend/Family waiting areas to accommodate early vehicular arrivals to pick-up passengers. Friend/Family pick-up is substantially less efficient that FHV pick-up functions, as each passenger must match with a specific arriving vehicle, rather than match with one of many vehicles in an FHV queue.

Best practices and lessons learned from design of high volume PUDO facilities at passenger terminals show a path to address critical facility needs in order to achieve system functionality. Pick-up and drop-off zones are only as efficient as the weakest link in the system. Therefore, the relationship, capacity, and operation of all components must be considered.

Distributed and Centralized PUDO Facilities in A-C Modified

The Burnham Place team agrees with FRA and DDOT that some amount of PUDO should appropriately be placed at Columbus Circle, First and Second Streets NE, and at the Train Hall. However, the FRA model shows that demand overwhelms the practical capacities of these locations, given their physical constraints and the limited areas within the access roads leading to them. These distributed and on-street locations must be supplemented by a centralized and high-capacity below-grade facility. This strategy has the following benefits:

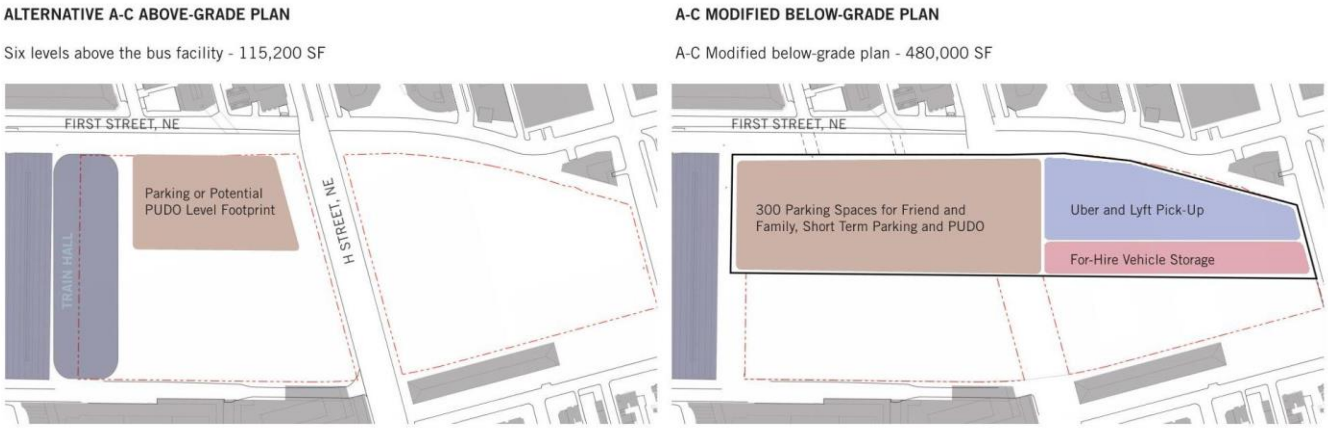
1. **Comprehensive For-Hire Vehicle Operation**
   a. Off-street staging area for taxi, Uber, Lyft and other providers reduces on-street PUDO activity and serves surge PUDO demands
   b. Effective, high-volume FHV re-matching decreases overall trips, reduces circulating vehicles and neighborhood spillover
   c. High-capacity staging and pick-up below-grade reduces congestion at Columbus Circle and the required size of other PUDO facilities. A direct route below-grade from taxi staging to the first lane at Columbus Circle eliminates taxi queues on the station's East Ramp
2. **Effective Off-Street Friend/Family Short-Term Waiting Area**
   a. Accommodate early-arriving drivers to free up curb space for active PUDO, decrease double-parking and circulating on adjacent streets
3. **Improved Passenger Convenience and Experience**
   a. Weather-protection improves experience, enhances safety and accelerates throughput
   b. Escalator and stair access from rail concourse directly above reduces walking distance, improves wayfinding, and decreases total trip time
   c. Locating facility egress ramps away from Columbus Circle and H Street decreases PUDO trip time to destination
4. **Efficient PUDO and Less Vehicle Congestion Yields Additional Benefits**
   a. Bicycle and pedestrian access and safety improvements at grade
   b. Improved historic setting
   c. Opportunities for multiple open spaces at station edges
   d. Less noise and lower carbon emissions

Providing a centralized PUDO facility at WUS in addition to other distributed PUDO locations, is a solution developed through extensive research of best layout and management practices at other transportation facilities. This proposal for a better-functioning set of PUDO facilities in A-C modified is informed by careful consideration of the station's urban context – a context that includes a significant historic structure in an important civic setting. The adjacency of Union Station to established and emerging neighborhoods, the District's mode share policy goals, and opportunities for high-quality placemaking surround the station, all point to the need to remove vehicles from neighborhood streets and minimize vehicle trips. Without a centralized PUDO facility, the DEIS proposal would not meet key elements of the stated purpose and need of the project, including facilitating intermodal travel, providing a positive customer experience, enhancing integration with adjacent neighborhoods, and supporting continued preservation of the historic station building.

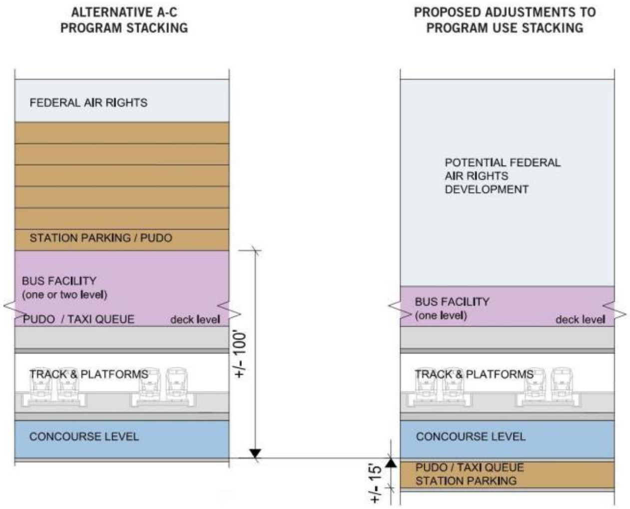
While a dedicated PUDO facility could conceivably be located in a garage above the tracks, Akridge and many other stakeholders agree that a below-grade option is the far superior choice for numerous reasons. This facility would be located directly below the new passenger rail concourse and accessed via three or more different ingress and egress points, providing the most convenient and time-saving location for access by rail passengers. A below-grade solution is the only location in the Expansion Project that is large enough to accommodate the facility size required to accomplish this task.

Above-Grade Garage PUDO Has Fatal Flaws

The option of locating a high-capacity PUDO facility above the bus facility is worthy of study given it is the only other location in which a dedicated PUDO area could be considered. However, there are several drawbacks to this location, some of which cannot be overcome or mitigated. Principal among these drawbacks is the fact that the needed program cannot be accommodated on a single level of an above-grade garage, instead requiring multiple levels to achieve the same functionality of the A-C Modified below-grade facility. Providing the full program on multiple levels leads to significant and possibly fatal operational difficulties. The proposed Alternative A-C garage includes a footprint for each parking level of approximately 115,000 square feet. This compares to 480,000 square feet available on one level below-grade. Even if right-sized station parking were included within the above-grade garage, fulfilling the PUDO functions described above would take at least three additional garage levels. This bus, parking and PUDO garage would create nearly the same adverse impacts as described in the *Parking* section above.



A PUDO facility within the above-grade garage would be located 100 feet above the H Street Rail Concourse and 60 feet above the main rail concourse within the Train Hall. Few rail passengers would accept this PUDO location for pick-up or drop-of when this location requires traversing six to ten stories via two or three different elevators. As train passengers will be dropped off elsewhere, drivers will then need to circulate from Columbus Circle, the Train Hall or First Street NE to the above-grade garage PUDO area to re-match for a pick-up.



PUDO and Station Parking - Above-Grade vs Below-Grade

In addition, concentration of additional PUDO traffic adjacent the Train Hall PUDO facility and dependent on H Street access would only worsen the circulation problems already inherent in the DEIS Alternative A-C. The Alternative A-C parking garage is accessed off a one-way PUDO road adjacent to the Train Hall. Locating PUDO within this garage would merge a thousand or more vehicles per hour onto this road, which is already overburdened by Train Hall PUDO activity and vehicles accessing private development garages. In this scenario, more than half of all PUDO trips would enter and/or exit via H Street.

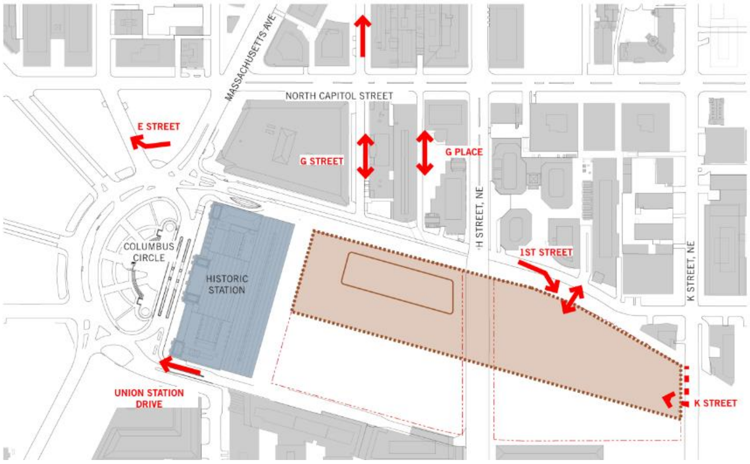
Any one of these shortcomings is a significant barrier to locating a high-capacity PUDO operation in this location. Collectively, these problems demonstrate this location should not be studied further. While no traffic circulation plan will be able to meet the station's peak demands without some challenges, below-grade is the only location that can feasibly serve as a dedicated, off-street PUDO facility.

A-C Modified Circulation Network

The Burnham Place team is carrying forward with on-going studies to identify access points to the below-grade facility proposed in A-C Modified. Sam Schwartz and W + A have begun detailed studies of options for effectively distributing demand amongst the various facilities in addition to developing concepts for access points and ramps to connect the below-grade facility to the street network.

The high-efficiency, off-street, central PUDO facility in our proposed A-C Modified has the capacity to handle one third or more of total PUDO demand. This below-grade and centralized facility in A-C Modified will relieve the on-street PUDO locations at First Street NE, the Train Hall, and Columbus Circle, and could potentially reduce PUDO volumes at these locations to approximately one-half of the volumes included in the DEIS Alternative A-C. Without such reduction in demand, the at-grade locations in the DEIS cannot be made to function given their physical constraints and the high demand forecasted.

Below-Grade Access Opportunities



Potential connection points and ramps are illustrated in the adjacent diagram. These are under review by our team to determine a set of access elements that provide the best balance of circulation demand on the local street network relative to demand sources and network capacity. In general, these access points provide the opportunity for quicker and more efficient passenger access to the station, while at the same time helping to remove traffic from streets immediately adjacent to high-volume pedestrian areas. Detailed studies for a number of ramps and access points under consideration are included in Appendix B3, Below-grade Access Ramps.

The PUDO changes recommended here will allow corresponding changes in the circulation system around the station, including circulation at the H Street level that can help to better balance area traffic and eliminate key bottlenecks arising out of the circulation plan in the DEIS Alternative A-C. These circulation changes are critical in order to reduce the extent and quantities of private and commercial vehicles adjacent to the station and on nearby streets.

Conclusion

A centralized, high-capacity, underground PUDO facility proximate to the highest demand of PUDO riders will positively impact circulation around WUS and adjacent neighborhoods, other PUDO facilities and the street network around them, pedestrian and bicyclist safety and experience. The modification will compliment and celebrate the historic WUS and provide space for a vibrant, people-oriented environment that is economically sustainable to all stakeholders. A-C Modified utilizes the on-street PUDO facilities proposed by FRA, but also adds a high-capacity, high-throughput below-grade PUDO facility. The A-C Modified plan will better meet station and public goals as indicated in the exhibit below.

Key Ingredients for a PUDO facility

	FRA'S A-C PLAN	A-C MODIFIED PLAN
Passenger Convenience	✗	✓
Vehicular Access (separation between FHV and F&F)	✗	✓
Re-match within the facility	✗	✓
Columbus Circle Taxi Queue	✗	✓
Capacity	✗	✓

B3. Create a First-Class and Right-Sized Bus Facility

"This is a generational opportunity to create an exceptional station plan that exemplifies the best in urban, multimodal station design, place-making, economic development, and neighborhood enhancement."
– Councilmember Charles Allen, Ward 6

Intercity bus service can provide a flexible, economical, and efficient mode of transportation for the public. The opportunity to provide a high-quality bus facility at WUS can enhance intercity transportation options at Union Station and create an urban transportation hub with complementary intercity services including rail and bus. The challenge in providing a well-programmed and designed bus facility is to balance its size, quality, location, and access with other transportation functions and land uses at WUS. Akridge asked SSE, an internationally recognized bus facilities planning expert, to find the balance between a right-sized bus facility design and program that provides a substantially enhanced opportunity for high quality terminal and passenger experiences at Union Station.

Modifications to Bus System Creates Efficiency, Equity, and Success for All Stakeholders

As discussed in Section 3B of our comments above, the bus facility proposed in Alternative A-C suffers from a number of program and design problems that prevent the facility from meeting the Project Purpose and Need. Fortunately, there is still time to make changes to the bus program such that it will successfully "achieve compliance with the Americans with Disabilities Act of 1990 (ADA) and emergency egress requirements; facilitate intermodal travel; provide a positive customer experience; enhance integration with the adjacent neighborhoods, businesses, and planned land uses; sustain WUS's economic viability; and support continue preservation and use of the Historic Station building."

For the past five years Akridge has worked with internationally recognized engineers, planners, and consultants to research, analyze, and develop recommendations for a modern bus facility that will live up to its potential as a world-class, urban, multimodal station. The new bus facility at Washington Union Station should be celebrated on a national, and even, international scale. Our proposed modifications to Alternative A-C focus on a right-sized, thoughtfully designed and managed bus facility that connects seamlessly with other transportation elements at WUS, as well as the new Burnham Place neighborhood.

Best practices have guided our research and analysis for modifications to the Alternative A-C bus facility. The Burnham Place team collected a large amount of data on intercity bus usage patterns and demands, both at WUS and other stations in the US and Europe, to develop an understanding of what a first-class bus facility and program can be at a 2040 Washington Union Station (see Appendix C2, Response to August 26, 2020 Greyhound Letter for extensive bus related research). Best Practices for modern transportation elements focus both on efficiency and equity that enhance the bus rider's experience. The extensive research undertaken by Sam Schwartz provides significant and compelling analysis for more correctly sizing the WUS bus facility program. As shown in the referenced report and discussed elsewhere in these comments, the data verify that an actively managed 14-18-slip facility (12 to 16 slips plus 2 staging spaces) will more than meet the 2040 daily, weekly, and hourly peak demand identified in the DEIS.

Illustrative rendering created to describe a bus facility with a Neighborhood Park above and connections to PUDO and the bus lobby on the Civic Space

With a few key modifications to the Alternative A-C concepts, the bus facility can take full advantage of best practices to create a seamless experience for intercity bus riders. The facility can be fully integrated with the open space, retail, and urban design features of the SEP and Burnham Place. In fact, these modifications will better avail bus riders to the vibrant retail opportunities and open spaces in the overall project.

First, key ingredients

In order to achieve the goals of the WUS Project Purpose and Need, the Burnham Place Team developed a framework for the key ingredients critical to achieving a world-class bus terminal at WUS. In addition to meeting 2040 passenger capacity, these ingredients are: 1) adjacency to historic Union Station, 2) a first class passenger experience, 3) direct connection to vibrant urban space, 4) minimize neighborhood traffic impacts, and 5) size to fit within the surrounding context.

Using the recommended bus slip count to meet 2040 passenger demand developed by SSE Schwartz, described below, our team examined multiple plans that would provide the most connectivity for bus riders to other station elements and transportation connections. With a focus on a high-quality passenger experience, our team envisions public spaces within the bus facility that are safe and comfortable, with dedicated space for bus riders to queue and board buses, but also ample seating, space to charge devices, use the restroom, or even grab a coffee before boarding a bus. Just as importantly, the passenger areas include direct daylight, and as envisioned in Alternative A-C Modified, are situated directly below a neighborhood park. The passenger spaces envisioned in this plan can be easily accessed from the Train Hall, central concourse, and Metro, and also have a direct entrance from the center of the most active and vibrant spot within the air rights development at H Street. Bus passengers arriving at or departing from WUS are directly connected to the great urban spaces in and around Union Station.

With parking and PUDO located below grade, the station's intercity and charter bus terminal has the opportunity to serve as a pivotal, activating element, with an entrance prominently featured in a civic space between H Street and the new train hall in the location shown in the Preferred Alternative. In this location, a bus facility can efficiently meet forecasted ridership and be configured to enhance passenger experience, with ample natural light and architectural identity.

To efficiently serve forecasted bus ridership growth in an efficient footprint that allows integration with viable development in a compelling urban design, a new bus facility of appropriate size and layout should be incorporated into the Preferred Alternative.

Second, right-size the bus facility:

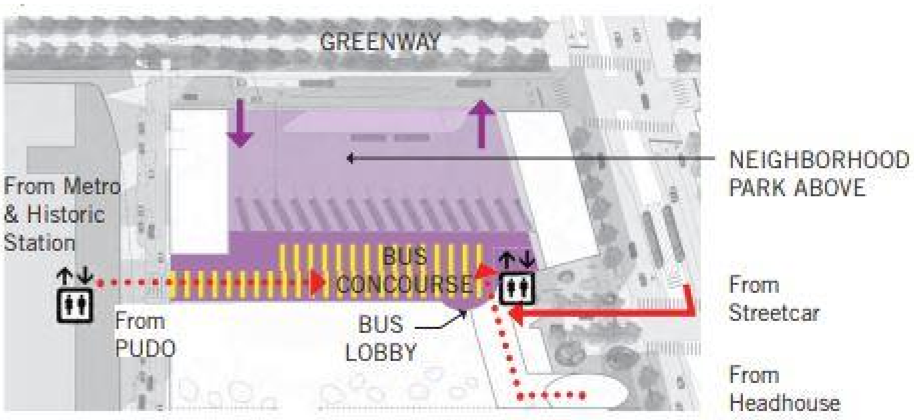
By utilizing proven, modern methods and technologies to meet high demand in an urban setting that is low on space but high on congestion, SSE has identified 14-18 bus slips (which include 2 staging slips) as fully capable of meeting peak bus passenger demand at WUS in 2040. This is accomplished through the incorporation of several key strategies: 1) active terminal management, 2) berth time slot assignment, 3) station schedule planning, and 4) dynamic berth scheduling. The DEIS does in fact recommend this type of approach for WUS:

In Alternative A-C and all Action Alternatives, the capacity of the bus facility would be optimized by using an "active management" approach. "Active management," or "dynamic management," is an approach used in the United Kingdom and New Zealand to more dynamically allocate bus slips to providers and decrease turn times for buses. As part of this active management approach, a thirty-minute time limit on bus operations has the potential to reduce the number of slips needed to manage daily peak demand by increasing the throughput of each slip. This approach is consistent with planning to improve the efficiency of rail operations for 2040.In this approach as described in the DEIS, buses could not stay at a slip for more than 30 minutes during the peak hours of operation. This quicker turnaround would allow the bus facility to process more buses with a smaller number of slips than would be the case in the No-Action Alternative and in existing operational conditions, where there are no limits on bus layovers. (Appendix C-3 p. 5-58/Appendix A5e p. 1).

The SSE analysis included in Appendix C1 documents all existing intercity bus movements at WUS and the slip utilization of the carriers operating there. This analysis is more in-depth than the review of bus capacity provided in the DEIS, as it shows bus service patterns across the entirety of a typical week, including all hours of the day, peak and off-peak. Existing intercity bus service at Union Station is heavily oriented toward weekend peak hours, with two hours on a typical Sunday accommodating the highest peaks of the entire week. During mid-week, intercity demand is significantly reduced, and averages approximately 250 bus movements per day, compared to the 310 buses movements per day on weekends. Charter bus service is also heavily oriented to seasonal and weekly peaks. The SSE analysis documents that charter bus demand at Union Station is highest during late March through mid-June, three months of the year, and also shows higher demand mid-week than on weekends. With charter bus demand highest during mid-week periods, and intercity demand peaking on weekends, the two different programs can fit together well in the new facility.

The 16 to 18 slip facility proposed in the Burnham Place team A-C Modified is very similar to the FRA bus program of 24 slips for charter and intercity buses identified in the DEIS. The primary difference between the program proposed here and the FRA DEIS bus program is in the amount of dwell time allowed for bus movements at the peak hour. The table below compares the DEIS Alternative bus slip count against the assumptions, analysis, and outcomes of our proposed Modifications:

Category	DEIS Plan – 25 Slips	A-C Modified Plan
2040 Intercity Annual Passengers	2,975,000	3,000,000
2040 Intercity Passenger Growth Projected Over Current	19%	19%
2040 Charter Passenger Growth	51%	51%
Peak Hour (2 hours/week, 4 months/year) Turnaround Time	60 minutes	35 (Best Practice) to 45 minutes (Conservative)
Turnaround Time Rationale	Bus Company Input	Field Study Measurements for Boarding and Alighting Times; Study of U.S. and International Best Practices.
Active Management Operation	Partial	Yes
Number of Recommended Berths	<u>25 Total Slips</u> • 13 intercity slips • 8 charter slips • 3 staging (non-active) • 1 DC Circulator	<u>18 Total Slips</u> • 12 to 16 shared intercity/ charter slips • 2 staging (non-active) (DC Circulator not included)
Study Methodology for Facility Sizing	Apply growth factors to existing actively used slips	Model peak hour movements based on growth factors applied to scheduled departures and arrivals for all carriers'

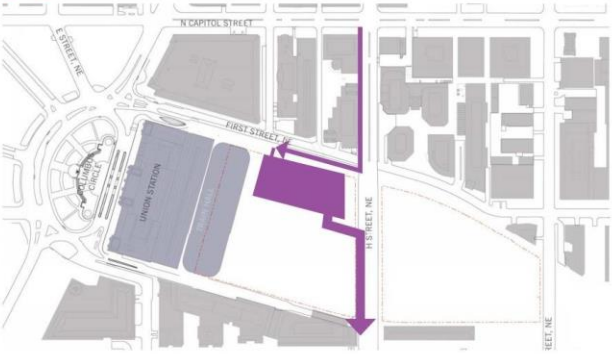


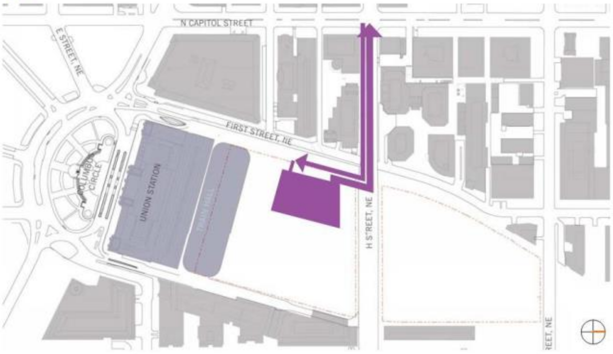
Third, circulation:

In developing a bus facility program with 16 to 18 slips the overall facility can be better placed on the site available within the federal property ownership, and bus circulation to and from the facility can be substantially improved. Because the footprint of the facility in Alternative A-C is so large it requires a one-way exit to H Street for all buses, sending them across the principal entry to Burnham Place and directly into the low-density, historic neighborhood east of the station. In addition to the noise and traffic impacts of the

Alternative A-C on Burnham Place and the residential neighborhood, there is a significant safety concern in both the vehicular operations at the Burnham Place central road and pedestrian crosswalk to the streetcar platform inherent in Alternative A-C. In contrast, the A-C Modified concept proposed here allows all buses to both access and exit the facility from both the east and the west. This is a critical change that substantially reduces bus circulation impacts on both Burnham Place and the surrounding neighborhoods. The A-C Modified concept is able to better distribute and balance bus circulation on the street network around the station, and would also be beneficial to carriers serving the station, allowing the choice of more direct departing routes according to destination, and providing resiliency in allowing alternate routing options on the local road network.

The Alternative A-C bus facility also impacts the configuration and operations of the west service road intersection with H Street. The large footprint of the bus facility and its placement require that the west service road be located directly above the Metro R.O.W. and have an offset intersection with across H Street with the west service road in the north parcel of Burnham Place. With the DEIS traffic analysis showing significant concerns with the level of service at this intersection, its offset configuration should be corrected, which is made possible with the Burnham Place team A-C modified proposal.


✗ Alternative A-C

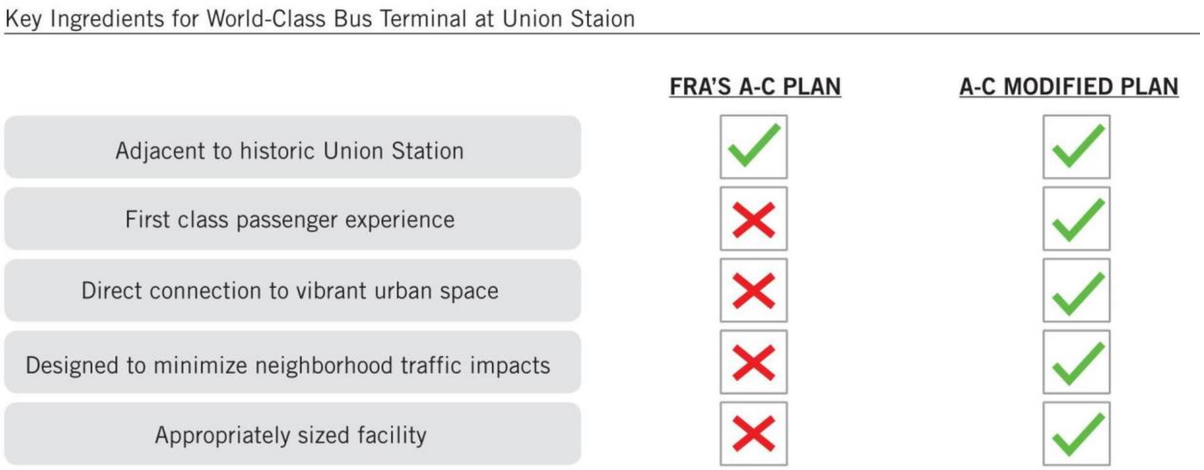

✓ A-C Modified

Conclusion

Based on the current distribution of bus movements through 2040, a twelve-berth terminal can comfortably accommodate more than 3 million annual passengers.

The Burnham Place team has studied the existing and future WUS bus program in depth, with more detailed analysis and more complete data than provided in the DEIS and determined that a 14 to 18-slip facility is more than adequate to meet the 2040 intercity and charter demand identified in the DEIS. A facility of this size would provide excess capacity even on a peak-day/peak-hour, and during off-peak times has up to six or more extra slips available for layovers and schedule perturbations during daytime hours. This facility allows bus dwell times of 35 to 45 minutes during peak hour periods for a bus that arrives and departs with passengers, far in excess of the time needed for passenger alighting and boarding, and far exceeding the time allotted to an entire passenger train in Amtrak's peak hour operating plan.

The Washington Union Station Expansion Project must provide an integrated and balanced approach for all transportation and land use elements to fully realize the potential of the project. Planning a right-sized bus facility has enormous benefits for the overall project and for bus passengers. Achieving the requirements for a bus facility at Union Station that meets passenger demand and provides a world-class experience can only be realized with a facility size and program that fits on the site. Oversizing the facility is detrimental not only to Burnham Place, the station project and other transportation modes , but to the bus facility itself, as excessive program and scale are uneconomical and as seen in the analysis here, does not allow creation of the kind of high-quality bus passenger experience needed at Union Station. As seen in the chart below, the A-C Modified plan for the bus facility not only meets future capacity, but also the remaining essential criteria needed for success.



Key Ingredients for World-Class Bus Terminal at Union Staion

	FRA'S A-C PLAN	A-C MODIFIED PLAN
Adjacent to historic Union Station	✓	✓
First class passenger experience	✗	✓
Direct connection to vibrant urban space	✗	✓
Designed to minimize neighborhood traffic impacts	✗	✓
Appropriately sized facility	✗	✓

Section V

Process and Akridge Role

For five and a half years, Akridge has participated in what was originally scoped as the creation of a "Master Development Plan" for the station's expansion, which was to include the infrastructure to create overbuild decking atop a rebuilt rail yard. Since that time, the original scope of planning and design work has shifted with various entities playing a variety of roles.

The FRA assumed the role as lead agency on the EIS. As Burnham Place is a private development requiring no federal approvals or funding, it is not subject to National Environmental Policy Act (NEPA) requirements (but is subject to local permitting and other approval procedures). Six months into the planning effort, it was established that Akridge's project would therefore be treated as a separate, private project *for purposes of regulatory review*. Akridge continued efforts to collaborate and coordinate with FRA, USRC and Amtrak on a wide range of important planning matters given the close relationships between the projects.

We worked together through workshops and information sharing on disciplines such as: civil, structural, mechanical, geotechnical and rail engineering. The Burnham Place team worked with the FRA and their consultant team on constructability and phasing, H Street Bridge planning and Threat, Vulnerability and Risk Assessments.

On many of these topics, the teams made substantial progress and found mutually beneficial or satisfactory solutions for each of the two projects. In other areas, we advanced concepts to conclusions where competing interests or lack of time led to unresolved or conflicting findings. However, within the areas that mattered most to the viability and success of Burnham Place, Akridge was never able to see our clearly-stated project requirements validated, understood and reflected within the FRA's station concept deliverables.

Station program elements, Burnham Place buildings, open spaces and pedestrian and vehicular circulation form the backbone of the station expansion and Burnham Place at the deck level. Over the past five and a half years, our design team made many presentations and submitted written materials which articulated the goals and design requirements necessary to create a successful version of Burnham Place. We jointly attended a series of workshops held by FRA's consultants on placemaking, urban and landscape design. Many of the findings from these efforts are included in the DEIS appendixes.

Once the FRA started to generate concept plans, it became clear that this work was largely for naught. Time and again, no matter how many meetings we participated in, and how often and how directly we communicated the adverse impacts of a given station concept on Burnham Place, the majority of our concerns were largely ignored within the formulation of the next round of concepts.

We provided detailed assessments and impact analyses for proposed station concepts. We suggested specific and multiple ways in which concepts could be changed to fulfill the public project's Purpose and Need but avoid needless and substantial harm to the potential of Burnham Place or preclude the achievement of other stakeholder goals.

In short, Akridge was an active participant in the early stages of the EIS process, but our presence did not impact its outcome on matters of greatest importance. We believe that ultimately, FRA reduced down the breadth and complexity of our feedback on design requirements and impacts to mean simply that we wanted the station expansion project to avoid use of our property to the greatest extent possible. This result was never our stated goal, nor is it even achieved within Alternative A-C. Rather, Akridge is willing to allow reasonable use of its air rights as long as any such intrusions do not interfere with our ability to develop a successful Burnham Place project.

In short, as shown through our actions and comments, Akridge *is* willing to allow use of portions of Burnham Place property in order to create an optimal, balanced and harmonized set of projects. Since the development of the 2012 Master Plan, we have indicated a willingness to forego some degree of development to provide extensive skylighting to a below-track concourse. We have supported an East-West Train Hall, partially within our property. We spent over a year developing a concept to site a bus facility within our parcel north of H Street, which would have served as the focal point for half of our development. In each of these examples, we were willing to advance of a given concept, provided that our overall design requirements could be met. The variety of ideas that we have put forth over the years shows our flexibility as well as openness to accept feedback on which of our concepts enjoy important stakeholder support.

In these comments, we provide a proposed set of modifications to Alternative A-C that we are confident can fulfill the station expansion's transportation functions, better align with important stakeholder priorities and also will allow Akridge to fulfill its essential requirements for a successful Burnham Place project. NEPA requires FRA to consider input from all stakeholders, and as the developer of the private air rights, Akridge is a key stakeholder in this process. Moreover, as outlined in our comments, the modifications we propose would improve the project overall and benefit all stakeholders. Thus, we are not asking FRA to listen exclusively to us, but to the chorus of stakeholders that share Akridge's concerns with the preferred alternative as proposed. The vision we put forward does not comprise "Akridge changes," adjustments for the sole benefit of the private development. Rather, these proposed changes are largely consistent with the views of, and reflect input and comments from, ANC 6C, DDOT, DCOP, NCPC, DC Council, SHPO, CFA, Congresswoman Eleanor Holmes Norton, the Federal City Council, National Trust for Historic Preservation, Capitol Hill Restoration Society, and of course feedback we have heard from Amtrak, USRC and FRA themselves over many years.

Akridge is ready to fully engage with the FRA and any and all parties who would like to come together to find common ground and create a vision with the broadest backing possible. The Section 106 consultation process and NEPA policy encourage this sort of collaboration.

As a locally- based private sector organization with nearly 20 years of history on this project, we have unmatched experience, access to resources and expertise and extraordinary motivation to reach a successful FEIS—one that creates a successful station project that can be approved, funded and built. We urge the FRA to provide us not only a seat at the table, but an openness to assess and incorporate what our ideas have to offer.

Section VI

Other Impacts

A. Property Rights

It is well settled that "[a]n agency's discussion of alternatives must be bound by some notion of 'feasibility.'" *Navajo Nation v. U.S. Forest Service*, 408 F. Supp. 2d 866 (D. Ariz. 2006). "An alternative that does not accomplish the purpose of the project in question" because the alternative cannot be accomplished is "unreasonable and does not require detailed attention in the FEIS." *City of Bridgeton v. FAA*, 212 F.3d 448 (8th Cir. 2000); *Missouri Mining, Inc. v. I.C.C.*, 33 F.3d 980 (8th Cir. 1994) (finding that rail alternative was not reasonable and need not be considered in the EIS because the project proponent did "not own and has no right to use" the alternative rail line).

Unfortunately, none of the alternatives as offered by FRA in the DEIS are feasible because each alternative, including preferred alternative A-C, contemplates the use of a substantial acreage of air rights owned by Akridge and those contemplated uses will have serious adverse impacts to Burnham Place. In other words, Akridge cannot agree to transfer the acreage contemplated in the alternatives as proposed in the DEIS because the loss of such substantial acreage would have serious adverse repercussions for its BP project as detailed above.

Further, while the DEIS assumes that Akridge's air rights property can be taken through eminent domain if it cannot be procured through negotiation, that assumption is incorrect. The Expansion Project proponents lack the legal capacity to take any of Akridge's air rights acreage through any existing eminent domain statute. Congress expressly directed Amtrak's sale of the air rights to a private entity by statute in 1997, and expressly precluded Amtrak ownership of the air rights by providing for the loss of funding were Amtrak ownership to be perpetuated. By directing the sale of the air rights to a private entity and disabling Amtrak's ownership, Congress effectively determined that the air rights cannot later be taken back, and certainly not taken as proposed here in a way that impairs private development. This legal infirmity on the eminent domain point, as well as related reasons why the proponents cannot take the Akridge air rights, are more fully spelled out in the attached letter from Akridge's counsel to FRA, found at Appendix D.

Because Akridge's air rights cannot be negotiated away to the severe detriment of the BP project, and cannot be taken without Akridge's consent, the assumption that a significant portion of those air rights are available to be developed as part of the alternatives addressed in the DEIS is unfounded. Accordingly, none of the alternatives, with the exception of the no-action alternative, are feasible as proposed in the DEIS. Akridge has made its position on this matter known to FRA and the proponents over the past several years, and inquired as to the basis on which its property might be taken. However, it never received a clear answer and no answer is provided in the DEIS.

Nonetheless, in these comments Akridge offers a modification of Alternative A-C that is feasible because it minimizes the intrusion on Akridge's air rights and maximizes the value of developable property immediately adjacent to the Expansion Project. See section 4 of these comments. The relatively small portions of the Akridge air rights that would be needed for the A-C Modified are portions that Akridge would negotiate to transfer in return for appropriate compensation. As described elsewhere in these comments, we believe the modified Alternative A-C would not only be feasible, but would also provide a win for all parties – a greatly improved Expansion Project that better meets the needs of all stakeholders, as well as ensuring that BP could be developed in a manner that will allow its benefits to be attained and harmonized with the adjacent Station.

B. Technical Issues Not Thoroughly Analyzed

The interrelationship between the adjacent SEP and BP projects, and the fact that they will necessarily share certain structural and other elements makes it imperative that the Expansion Project proponents coordinate with Akridge technical experts in the design, engineering and construction phases as the projects move forward. For that reason, in this section of its Comments, Akridge urges that the Final EIS include among the required mitigation measures a new mitigation measure that requires the SEP proponents to appoint a committee of design and other technical experts to work with Akridge's design and technical experts pursuant to an agreement to be negotiated between the parties to address issues of common concern to both projects, to ensure that the design of one project does not impair the other project and to identify areas where both projects can benefit from developing shared infrastructure elements and thereby increasing efficiencies and reducing costs for both. We note in this regard that the DEIS already imposes in Chapter 7 a variety of mitigation measures requiring coordination by proponents with agencies such as WMATA and DDOT, as well as with private entities such as Gallaudet University. The mitigation measure proposed here is consistent with these other measures and will help to ensure that the SEP is best coordinated with its immediate neighbor and more generally with the neighborhood.

Akridge recognizes that the kinds of technical issues identified in this section of its Comments cannot be fully assessed or resolved at this stage of the process. In fact, it is difficult for Akridge to determine if certain technical components and concepts for the SEP that are documented in the DEIS might be considered essential project elements or whether they might instead constitute interim solutions, "placeholders," or non-critical items. Accordingly, Akridge's goal here is not to offer specific solutions to the issues raised as it is premature to engage in that type of dialogue in the context of DEIS comments. Rather, Akridge here offers examples of some key issues that will need to be resolved through the coordinated process it proposes in the mitigation measure described above.

One of the key drivers identified in the DEIS as a reason for the selection of A-C as the Preferred Alternative is the criteria that the alternative "minimize impacts on the private air rights" (Chapter 3, Section 3.1.9.3). However, we note in this section a number of technical elements within Alternative A-C that do not "minimize impacts" on Akridge's development of its private air rights. In fact, many of the technical elements proposed for the public project could impart significant adverse impacts on Burnham Place. Again, we note these elements not to offer specific solutions at this time, but as examples of issues that are best addressed through future joint consultation. We also recognize that some technical solutions may ultimately be required or needed for the combined public and private projects that will incur impacts on the private air rights. We believe these will need to be coordinated in the design phase of the project after completion of the FEIS, and that the FEIS must not unduly constrain the development of efficient, economical, and capable technical solutions in the next phase of design. The technical challenges to Burnham Place identified herein are not meant to be comprehensive, given the limited information and review time available, as well as the fact that technologies will evolve to the betterment of both projects. Instead, we request a collaborative process for the future resolution of technical issues like those listed below in order to benefit both interrelated projects.

Examples of Key Areas Where Future Cooperation Will be Essential

We appreciate that the DEIS identifies the “scope of work in relationship to [Burnham Place]” (Appendix A3d_ pg. D-04), specifically:

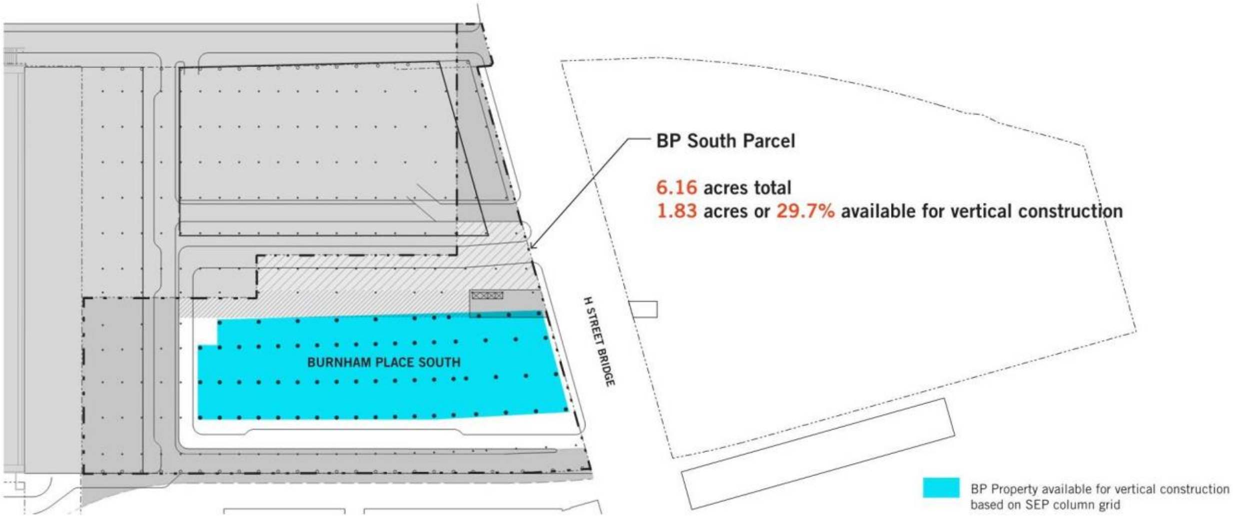
“The platforms and tracks are located below the air rights for a future private development, referred to as Burnham Place (BP). SEP is intended to not preclude this development.

“The project therefore, includes engineering systems to support the Concepts, such as the following:

1. Vertical structures and foundations, coordinated with the platforms and tracks, which also supports the platforms and floors below.
2. Track and platform ventilation, as a consequence of the deck above. Note that the fan associated plants will need to be coordinated with the buildings above.
3. Life safety systems, as a consequence of the deck above.
4. Generators, providing backup power to the systems listed above and below as a consequence of the deck above.
5. To support WUS chillers, cooling towers would be accommodated in an external location, currently proposed to be accommodated at deck level.
6. Routes for utility services would be coordinated with the tracks and platforms.”

Of these systems identified in Appendix3d of the DEIS, we were not able to find any specific information in the DEIS regarding referenced life safety systems, generators, or WUS chillers (items 3, 4, and 5) and how they might be coordinated with Burnham Place or whether they might incur impacts on the private air rights development. Thus, we do not provide comments here regarding these elements, but do discuss potential impacts from vertical structures and foundations; track and platform ventilation; and utility services routes (items 1, 2, and 6). In addition, comments on coordination of both the SEP and Burnham Place with the H Street Bridge reconstruction, and on SEP documentation of USN zoning are provided in this section.

1. Structural Systems/Vertical Structures and Foundations



Practical vertical construction is available in 29.7% of Burnham Place South Parcel once site considerations such as structural systems, station functions, road network and light access zone are factored.

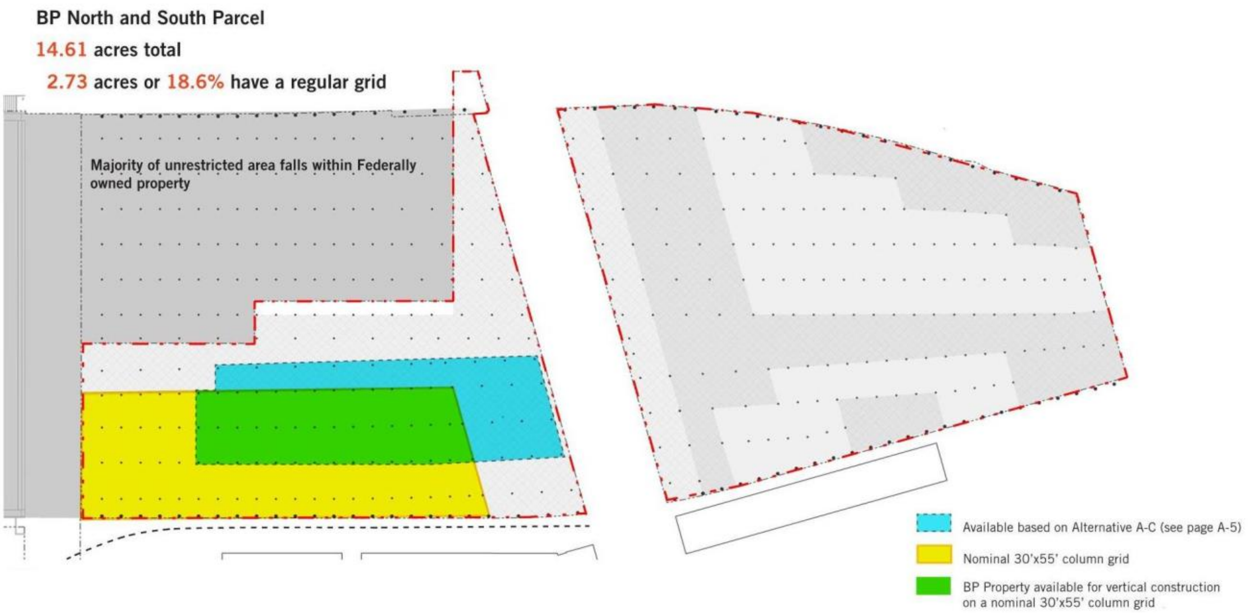
Potentially significant impacts to Burnham Place from the structural systems identified for the SEP include the following listed below:

a) Drilled shaft sizes and depths

Burnham Place column loads will vary based on building use, configuration, height, and transfer system employed. Appendix A3d indicates that some foundations will be shared between the Station Expansion Project and Burnham Place, and yet in Appendix A8 a methodology is presented for “Removal of Air-Rights Development Deck Costs” that indicates the foundations, support columns, and deck supporting Burnham Place can be entirely separated from the station project. Impacts to Burnham Place from the plans presented for drilled shaft sizes, locations, and depths might include increases in construction costs or extension of construction schedules to accommodate station elements in the size and placement of drilled shafts supporting the air rights. It is not possible to assess these impacts at this level of the SEP concept development documented in the DEIS. Coordination is required regarding drilled shaft sizes shown in Appendix A5b, Figure 46, as they could have impacts on Burnham Place cost and schedule and overall feasibility.

b) Structural Grid

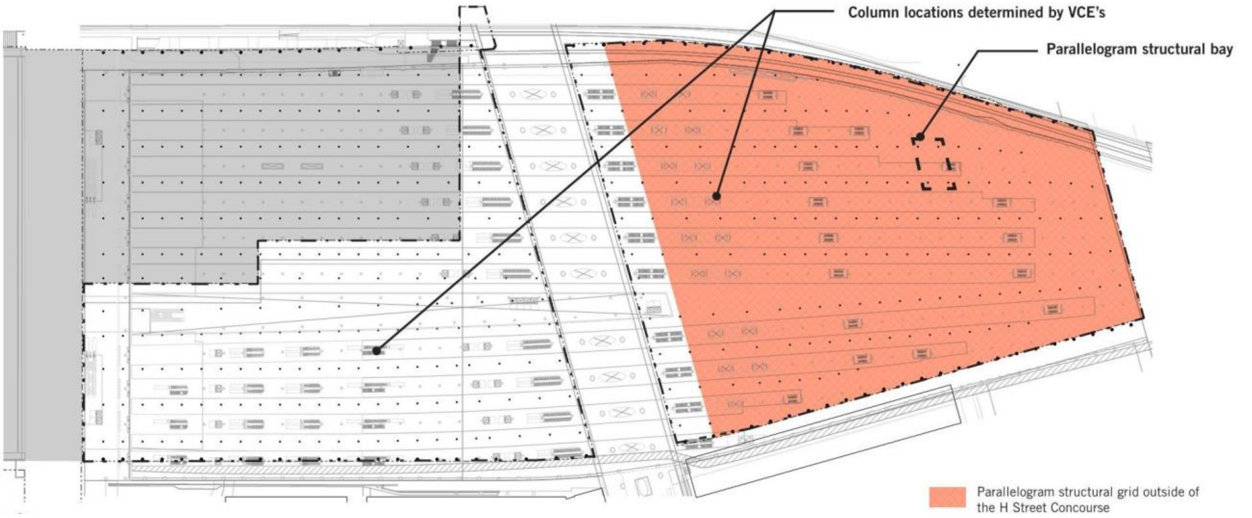
The structural grid required for the track and platform plan in Alternative A-C is a very significant determinant of Burnham Place structural design and costs. This grid will significantly impact building footprints within Burnham Place and the locations of buildings, open spaces, and the Burnham Place street network. The column grid in Appendix A5a, Drawing No. 026: Station Main/Platform Level Plan – ALT A-C, shows areas with long-span column configuration and a parallelogram grid north of the H Street Concourse that require coordination with Burnham Place team to ensure design impacts do not negatively impact floor plates of the buildings above.



+BVAreas where impacts are not imposed on BP property by long-span structure or column bay configuration

The Burnham Place team recognizes a number of these design issues are inherent in any air rights project located above a railroad terminal, however, there are also many individual details of the structural grid that can be coordinated to minimize impacts on both the public and private projects. The structural grid proposed in Alternative A-C places restrictions on the Burnham Place development within all quadrants of the air rights space that may be unnecessary in many areas. These restrictions include:

- North of H Street (outside of the H Street concourse) column grid shown for Alternative A-C depicts a parallelogram layout for the structural system instead of a regular rectangular grid with 90-degree angles. This type of grid yields inefficient building configurations and will require costly structural transfer solutions.
- To create efficient Burnham Place buildings, expensive structural transfers would likely be needed in many areas to redistribute building structural loads when not directly above the SEP support columns below.



The Burnham Place teams supports the inclusion of a relatively regular 30-foot column spacing along the platforms in the north-south direction shown in Alternative A-C. This bay spacing can be practically applied to residential, hotel, and office building types, as well as parking and helps to distribute structural loads while building a degree of resiliency in the structural system. However, the grid on both sides of the H Street Bridge is illustrated with longer north-south spans, and we are not yet able to determine potential impacts of this longer north-south spacing on Burnham Place building program or structural design and costs and will need to collaborate closely with the SEP team to ensure our development rights are not encroached upon.

c) Horizontal structural spans between columns (long-span areas)

Numerous long-span areas within the grid where there are insufficient column landing areas, similarly impact Burnham Place in the following ways:

- Greatly reduce the amount of buildable area above the deck;
- Render some building programs infeasible due to structural challenges or TVRA restrictions;
- Increase the weight of structural members in areas above tracks beyond what can be hoisted by construction equipment that will fit within the footprint of a work zone; and/or
- Increase construction costs.

▨ Station structure that exceeds a nominal 30'x55' bay size (note that as compared to typical DC construction, a 30'x 55' bay size is already a long-span in the east-west direction)

d) Structural Component Types and Design Characteristics Including the Air Rights Deck

The structural design components shown in the DEIS Appendix A5c, Figure B-4, and Appendix A5b, Figures 24 – 27, for the private air rights would impose significant impacts on Burnham Place in many areas of the air rights project. Burnham Place will likely require different structural systems in different areas of the project that adapt to specific structural and other project constraints. The Burnham Place team shared preliminary structural design parameters and concepts with the SEP consultants and the FRA in 2017 (submitted on November 15, 2017: "17-1115 Podium Structural Systems"), that outline a structural approach for Burnham Place based on efficiency and system performance. Further coordination on these issues between the project teams will be essential.

e) Design Criteria

Current structural design criteria in Appendix A3d, p. D-05refer to a Basis of Design document that is not included in the DEIS, and therefore the impacts on Burnham Place cannot be determined. The DEIS states:

"The Draft Basis of Design, which encompasses the Structural Engineering, Mechanical, Electrical and Plumbing (MEP), Fire Engineering, has been submitted as a separate document and contains information on the following:

1. Codes and standards
2. Owner requirements
3. Design parameters
4. Resilience
5. Existing conditions "

Akridge is aware from previous discussions with FRA during their development of the SEP that certain design criteria utilized in the formulation of the project concepts could have significant impacts on Burnham Place. These impacts include the exclusion of the use of precast structural systems and limitations on allowances in load reductions for multi-story buildings. We are not able to evaluate these potential impacts at this conceptual stage but assume that practical solutions to critical design criteria can be developed cooperatively in later phases of the project that are beneficial to both the SEP and Burnham Place. The Final EIS must be formulated in such a way so as not to preclude optimal structural solutions for both projects in the design efforts to follow completion of the FEIS, including with respect to structural design criteria and specific structural solutions.

f) Risk Assessment

The following information related to project risk is included in Appendix A-8, p. D-05:

> "A threat and vulnerability risk assessment (TVRA) is underway, which has informed the planning and structural design scenarios in particular. Due to the sensitive nature of the methodology and findings, its content is not summarized in this report …..Other outcomes of the TVRA will affect other planning aspects of the SEP and will be coordinated in the subsequent phases of design."

In addition, the DEIS provides the following guidance for risk (Appendix A3d, p. D-22):

> **"Approach to TVRA Requirements**
>
> TVRA establishes the guidelines and criteria to which SEP and BP must conform. In subsequent stages of design, SEP and BP must either design for threat-independent progressive collapse (element loss) or alternatively, harden the structure against the design threat where more feasible."

In 2018 Akridge completed a Burnham Place Risk Assessment Report, prepared by Thornton Tomasetti, and a "BPRA Considerations for Program Stacking" study, and shared these documents with FRA. Joint efforts for risk management for both the SEP and the Burnham Place projects will be required as part of SEP mitigation after completion of the Final EIS. While it is not clear how the results of any risk analysis undertaken by the SEP consultant team were utilized in formulating the DEIS Preferred Alternative A-C, several elements of the proposal are of concern to the Burnham Place team, and will need to be coordinated as design progresses, with potential changes to program locations and technical components required. Overall, impacts to Burnham Place from the design standards proposed in the FRA risk assessment cannot be evaluated from the information included in the DEIS or previously shared with the Burnham Place team. However, having invested considerable time in developing our own risk assessment, and with an understanding of how to understand and evaluate the relative risks for both the SEP and Burnham Place projects, the Burnham Place team has identified a number of pro-active and practical approaches to manage the risks that the SEP elements can pose to Burnham Place, and that Burnham Place structures can pose to the SEP. These solutions should be pursued jointly in an integrated design effort that involve both the SEP and Burnham Place upon completion of the Final EIS, which must be formulated in such a way so as not to preclude optimal solutions for both projects.

2. MEP Systems/Track and Platform Ventilation

The DEIS identifies a number of track and platform ventilation issues and concepts that are particularly important to Burnham Place. These issues include fan plant locations and sizes, as well as SEP concepts for fresh air makeup supplying the rail terminal. We are not able to evaluate the impacts of the ventilation concepts included in the DEIS on Burnham Place, nor comment extensively on them here, due to the fact that the information included in the DEIS is extremely conceptual and does not include any detailed explanations of system sizing, ducting, air requirements, access, or other issues.

The DEIS Appendix A3d, page D-35notes the following:

> "Exhaust fans, rated for high temperature air would generally be located in fan plant rooms above the tracks, coordinated with BP. "

The Burnham Place team agrees that coordination will be required upon completion of the Final EIS. At the same time, some of the specificity for the fan plant locations currently illustrated in the DEIS drawings (Appendix A5a, Figure D-26, Horizontal Fan Plant Integration) would have significant impacts on Burnham Place. It is unclear at this level of project development if alternative solutions for track and platform ventilation that would be less impactful to Burnham Place are possible, and whether they would also provide necessary and high-quality service to the rail terminal. Thus, because of the conceptual nature of the materials included in the DEIS, track and platform ventilation and fan plant solutions should be pursued jointly in an integrated design effort involving both the SEP and Burnham Place teams. Once completed, the Final EIS must be formulated in such a way so as not to preclude optimal solutions for either project.

3. Utility Services

The DEIS (Appendix A5c, Figure B-19) illustrates a number of utility locations to serve Burnham Place without the inclusion of additional information about the adequacy of these locations for size, access, or phasing relative to Burnham Place utility requirements. During the course of the SEP and DEIS development, the Burnham Place team requested clarification from the FRA about multiple issues related to the sizes, locations, and design restrictions or parameters that might have been defined for the locations specified in the DEIS Alternative A-C drawings for Burnham Place utility connections. Our team did not receive sufficient information from the FRA to be able to evaluate the adequacy or feasibility of the utility connection locations shown in the DEIS. We are also not able to evaluate any potential impacts to Burnham Place that might be a result of the preliminary utility indications and information included in the DEIS. However, the mitigation we have proposed to require coordination after the Final EIS is complete can be relied upon to address this issue. We request now, however, that the Final EIS not include language or illustrations that limit the ability to reach solutions for Burnham Place utilities that are practical and economical for both projects.

Please also refer to comments related to Burnham Place utility connections in our comments on "H Street Bridge Construction" directly below.

4. H Street Bridge Construction

On-going work on the H Street Bridge replacement has included both the Burnham Place and SEP consultant teams working with DDOT since 2018. This has included detailed design work to identify the appropriate bridge profile and locations for intersections connecting the SEP and Burnham Place to the bridge. Akridge has also engaged extensively with DDOT to explore the provision of utility routes to serve Burnham Place from within the public bridge and adjacent street rights-of-way. While we have not been able to find general or specific references to this work in the DEIS, we note here that a number of design details and concepts for Alternative A-C documented in the DEIS are in conflict with bridge design coordinated with DDOT.

Circulation System Intersections at H Street

Akridge and the SEP team submitted a joint memo to DDOT on October 25, 2018 (see Appendix I. Intersection Analysis "H Street Bridge Join SEP Akridge Needs 20181025") that describes appropriate design parameters for intersections at the H Street Bridge that serve Burnham Place and the Station Expansion Project. This memo documented intersection locations and configuration options at the east and west service roads likely to serve both projects, as well as the central road primarily serving Burnham Place. In spite of the design configurations outlined in the memo, Alternative A-C shows intersection configurations at the west service road and the central road that are in conflict with the guidance given to DDOT, which have negative impacts on Burnham Place circulation and urban design.

The proposed west service road shown in this memo to DDOT was aligned north and south across H Street to ensure efficient operations of the intersection and flexibility in vehicular circulation. However, the preferred Alternative A-C (Appendix C3, Page 5-189) has an offset intersection at the west service road that assumes one-way circulation routes north and south of H Street. This offset intersection and one-way circulation system would have significant limiting impacts on Burnham Place feasibility.

In addition to the proposed Alternative A-C west service road, the proposed configuration of the bus circulation has significant impacts on the operations and safety of the central road and H Street intersection. Alternative A-C's proposed bus facility exit connects directly to H Street and is immediately adjacent to the H Street/central road intersection is operationally impractical and would likely require the intersection to be treated and signalized as a "five-leg" configuration. Pedestrian safety would be compromised here, which is especially significant given this intersection includes the primary crosswalk that connects the streetcar platform to the bus facility and Burnham Place south of H Street. Way-finding for Burnham Place visitors, residents, retail patrons, and office tenants would be significantly impacted. Vehicular entry to Burnham Place would be congested with large buses that block sightlines and would likely create circulation hazards at many hours of the day, especially at peak hour periods when most impactful to Burnham Place and Union Station riders. The proposed bus circulation requires all buses to exit the bus facility headed east, even those buses that have routes and destinations that would favor a westbound departure from the station. These buses would likely turn around in adjacent residential neighborhoods and increase projected congestion issues as discussed further in the bus section of these comments.

Streetcar Location

The platform for the DC Streetcar depicted on the plan in DEIS Appendix A5a, Drawing No. 021, is in conflict with the location determined for the Burnham Place central road. This central road was determined jointly between DDOT, Akridge and the SEP consultant team. The platform location is also not consistent with the location for the streetcar station/terminal planned for the H Street Bridge determined by the DDOT bridge and streetcar design teams. As depicted in Drawing No. 021, the platform would prevent through movement between the north and south portions of Burnham Place, as well as northbound left turn movements from the central road headed westbound. The design for the H Street configuration showing streetcar and intersection parameters is shown in the illustration above.

Burnham Place Utility Connections within the H Street Bridge

As noted, the Burnham Place team has worked with DDOT since approximately 2018 to formulate concepts and locations for the provision of basic utilities serving Burnham Place, and utilizing portions of the H Street Bridge structure and right-of-way. It is conceivable that many of the utilities required to serve Burnham Place can be most efficiently and appropriately located underneath the bridge, especially in portions of the bridge structure located above First and Second Streets NE, and at the eastern and western edges of the H Street Concourse planned in the SEP Alternative A-C. Some of these utility locations may be in addition to areas for utility connections that are illustrated in the SEP drawings included in the DEIS, Appendix A5c, Figure B-19.

Please also see our comments related to Burnham Place utility connections in our comments on “Utility Services” included above.

5. Zoning Assumptions

Appendix A5b, Section A-2.6 of the DEIS includes a zoning envelope diagram that contains inaccuracies regarding zoning permitted heights and setbacks from the south end of the Union Station North (USN) zone boundary line. The DEIS diagram describes a graduated height increase from that south boundary line as you move north along the centerline of the historic station in 200’ plan increments. The USN zoning regulations (DCMR Title 11, Subtitle K, Section 305.1) specifies a 150’ increment. The north-east corner of the USN zone district is similar to the far south bonus. USN zoning allows a 90’ building height, with a height bonus to 110’ permitted through design review and approval from the DC Zoning Commission.

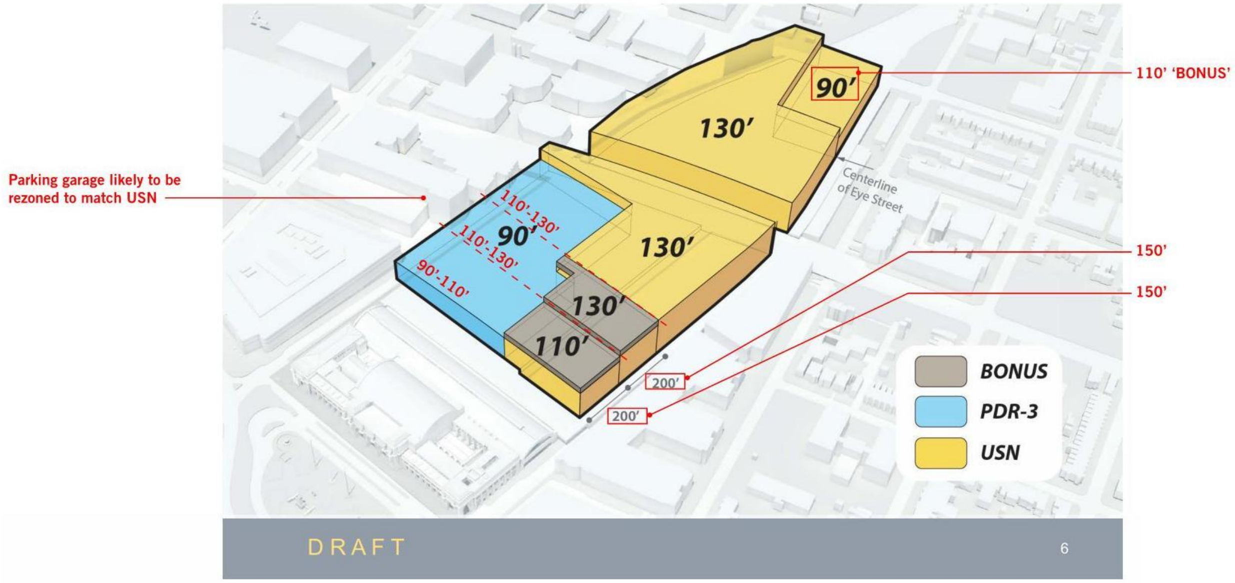


Image submitted on August 22, 2017 in the document titled “Analysis of Preliminary Alternative Impacts on BP”

C. Construction Methods Not Considered

The material in the DEIS related to phasing, construction schedule, cost allocations, and other issues include incorrect assumptions and are incomplete in its analysis, and should therefore not be codified in the Final Environmental Impact Statement without further analysis of alternate approaches to phasing or construction techniques.

The December 2018 Constructability Report by AECOM included in the DEIS Appendix A8 provides extensive information, analysis, and findings for construction techniques, schedules, and costs, which at a macro-level scale, are useful for identifying critical construction issues and are foundational studies necessary for assessing some of the environmental impacts of the project. In other words, while the work contained in the DEIS may be sufficient for evaluation of certain project impacts, it is not complete or detailed enough to determine the costs, schedule, or phasing of the Preferred Alternative A-C, or any final preferred alternative that might be developed for the FEIS. Because of the schedule length, phasing definition, and construction techniques specified in the DEIS, the impacts of adopting these approaches and concepts for construction and phasing could result in the entire air rights project being infeasible.

Key impacts include the following:

- The current phasing sequence from east to west across the rail yard is time consuming and does not provide any buildable area for Burnham Place until the completion of Phase 3, following 8 years 4 months from the start of construction. It is not feasible for Burnham Place to fund construction of the air rights deck, intermittently, across this extended period of time, prior to commencing any construction on occupiable buildings that are a part of our project.
- The estimates included in the "Removal of Air Rights Development Deck Costs" on page 2 of 17, and in Attachment 2 "ROM Cost Estimate for Alternative A-C with Private Air-rights Deck removed" in Appendix A8 do not include sufficient detail and backup for evaluation of total costs and cost allocations. For each of the DEIS alternatives in Appendix A8, the "Hard Cost Exclusions" provided in the Rough Order of Magnitude cost estimates state that for Burnham Place "Cost-sharing on structure & systems may be future decisions" and we agree that these must be future decisions.
- Figure 2a.1 on page 4 of Attachment 2, Appendix A8, shows many columns and conditions that are incorrectly assigned to the private air rights development, including columns supporting the tracks south of H Street, the perimeter foundations and walls around the entire project north of H Street, and columns and structure defining the central concourse. Akridge was not consulted in the development of the estimates for removal of the air rights deck, and notes that there are many additional costs assigned to the private air rights development based on assumptions regarding structural and MEP systems that are conjectural and without input from Akridge. In addition, the cost estimate for removing the air rights construction does not take into account costs for platform canopies, catenary support, and other elements that would have to be constructed if the air rights project is removed. For all of these reasons the DEIS is flawed in the assignment of costs to the air rights, and the FEIS should make clear that determination of construction phasing, techniques, and costs for both the SEP and the private air rights would appropriately follow completion of the FEIS, and not be in any way tied to or dependent on the information contained in the DEIS or FEIS.
- Top-down construction, or a hybrid between top-down and conventional construction (hybrid), are not included in the DEIS. Akridge has worked extensively with Amtrak on multiple concepts for both open cut excavation and top-down excavation over the course of the project. Both concepts have advantages and disadvantages, but both top-down and hybrid construction have been shown to offer schedule and cost savings in many instances. This work is not included in the DEIS, and similar to the issue noted directly above, its exclusion should not be considered a determination of construction method required for the project, as doing so would have significant and potentially unsolvable impacts on the private air rights development.
- There are other areas within Appendix A-8 that carry assumptions regarding structural and MEP systems, air rights utilities, and fire protection that have not been coordinated with the private air rights project and which, as noted directly above, could have significant and potentially unsolvable impacts on the private air rights. We have covered a number of these in our comments on the technical details and do not include them here.

Alternative Construction Approaches

There are a number of significant areas of study that the Burnham Place team has undertaken on our own and with Amtrak, to explore alternative construction phasing and techniques. Two significant efforts coordinated with Amtrak include: 1) West-to-East Phasing and 2) Single Phase Construction. Both areas of study were coordinated with Amtrak and their consultant in charge of the Terminal Infrastructure and Construction Feasibility efforts, AECOM. Ultimately, the Burnham Place consultant team found that a single-phase concept for construction, proceeding from west to east, has the potential to dramatically reduce the overall project construction duration from 12 to 7 years and deliver the most important project amenities at earlier dates. An overview of the analysis and animation of the West-to-East, Single Phase Construction are found in Appendix H.

Our studies utilized information from several drafts of Appendix B – Washington Union Station Terminal Infrastructure EIS Report prepared by AECOM during the project development, from which we were able to re-envision the FRA's proposed construction schedule with a simplification of key construction steps and operations, and utilization of information on schedules and costs, equipment specifications, site utilization, rates of production, temporary conditions, staging, and station operations developed by AECOM.

The Akridge team initially found that reversing the phasing sequence of the station project, starting on the west and working towards the east, provides a more efficient and effective method for construction staging that reduces schedule and costs, as well as manages construction risks. We shared these studies with Amtrak and AECOM team authors who reviewed our analysis and findings. In their analysis AECOM was able to confirm there are a number of potential and substantial benefits to the overall project that could be gained by reversing the phasing sequence from an east to west direction to an alternate approach beginning on the west and proceeding to the east (our understanding of possible Amtrak concerns with west to east phasing is that this sequence may be more difficult to construct changes to the tracks north of K Street, leading into the terminal). However, west-to-east phasing would deliver the high-value components of the project earlier in the schedule, including the First Street NE Concourse, MARC stub-end tracks, and Amtrak Acela and NEC-serving tracks at the stub-end of the yard. Passenger connections to the historic station building through the new concourses and to Metro would be delivered at the beginning of the project, rather than at the middle and end. The west-to-east phasing sequence wass shown to provide more tracks in revenue service throughout the construction duration than east-to-west in our joint work with Amtrak. Details are set forth in Appendix H1.

In a subsequent study that built upon the west-to-east phasing concept, Akridge consultants devised a single-phase construction approach that provides a linear and uninterrupted construction sequence for the most time-consuming construction activities in the project: excavation and drilled shafts. This single-phase construction approach provides all the advantages of west-to-east phasing and in addition reduces the overall construction duration by five to six years. Together, west-to-east sequencing and single-phase construction can be easily applied an Alternative A-C Modified concept.

The key concepts for single-phase construction are:

1. Eliminate idle periods between phases for critical path construction items.
2. Maximize number of drill rigs in operation at all times for drilled shaft production.
3. Devise "assembly line" construction concept to achieve continuous production of all project components: demolition, excavation, drilled shafts, etc.
4. Utilize Burnham Place deck for construction staging and lay-down, materials delivery, crane operations, slurry operation, and concrete deliveries.
5. Employ West to East phasing with top-down construction, but remove spoils to the side (laterally), not up through rail platforms.
6. Build First Street Concourse at beginning of construction, simultaneously with construction of Platform 1/2 above, providing egress and passenger connections to station.
7. Build H Street Concourse incrementally to serve each platform as it goes into use.
8. Begin air rights building construction when adequate deck space is available for both Terminal and Burnham Place construction.

Using this approach, the overall project schedule can be cut almost in half by condensing a multi-phased schedule into a single-phase approach, which will result in a significant cost savings from efficiency of construction operations and reduced escalation costs.

The construction sequencing utilized in the DEIS for Preferred Alternative A-C is a multi-phased approach that starts and stops the individual construction operations at each phase, which results in a reduced construction schedule. The DEIS proposes four phases, each with the same 23 construction steps, however, there is no overlap between phases, even though the areas of each phase are immediately adjacent to one another. So once a construction step in a single phase is complete, it stops and demobilizes, only to require remobilization once the next phase commences.

Contrast to this the single-phase concept, which eliminates almost all down-time for each of the individual construction operations and ensures that the critical path operations of excavation and drilled shafts can proceed without stopping. In essence, all nine major construction operations are proceeding simultaneously across the project and throughout its duration, eliminating the inefficiencies and schedule consequences of down-time.

The start and stop, four phase construction approach defined in the DEIS not only results in a lengthy construction schedule but also creates numerous potential risks and delays due to the fact that this specialized equipment is expensive and rare, and therefore is likely at any of these downtimes between phases to be tied up in use on other similar, specialized infrastructure work. In addition to the risk of schedule delays due to unavailable, specialized and necessary equipment, a prolonged, multi-phased construction approach risks losing specialized and necessary labor. Construction teams that operate this equipment will likely travel to other jobs nationally during the DEIS proposed downtime and will be difficult to regroup as a trained team at WUS for each subsequent phase of work. This will further prolong schedule, increase costs, and add to unknown delays that further exacerbate both schedule and costs. The unknown risk of further delays inherent to the DEIS proposed multiple phased construction will also impact the future Burnham Place development at a significant cost.

A single phase approach that doesn’t stop digging until the digging is done takes full advantage of specialized equipment and labor teams, cutting the construction timeframe by up to HALF and reducing costs for both the SEP and for Burnham Place. In the single-phase approach, specialized construction equipment is used continually on site, construction crews are trained once and able to improve efficiency as the project proceeds, and significant demobilization and remobilization effort and cost are eliminated along with risk they will be unavailable when needed. Conceivably, construction schedules could reduce further without the extra lag to demobilize/re-mobilize and the natural efficiencies that come with the same construction crew that work together over a four-year period and become more experienced, and faster, in their trade. The aggregated reduction of the overall construction timeframe would result in significant savings to schedule and budget.

Our team has undertaken extensive work to prove the feasibility of west-to-east versus east-to-west construction phasing, along with the added concepts of a single-phase approach. Akridge recommends that the FEIS allow for further study of these alternative construction methodologies and phasing sequences that could dramatically reduce schedule, costs, risks, and negative impacts for the Station Expansion Project, Burnham Place and adjacent neighborhoods. The potential savings inherent in single-phase, west-to-east sequencing is significant and without these savings, the viability of Burnham Place is threatened. The concepts briefly described here are well-developed and have real potential to achieve vast improvements in project costs and schedule, and moreover can facilitate the earlier generation of additional revenue for Amtrak, USRC, the District of Columbia on an earlier timetable, even further improving project economics. Therefor we urge FRA to keep multiple construction options open and recognize that close coordination between Akridge, Amtrak, and the FRA after completion of the DEIS will be needed to improve project costs and schedules. As the DEIS currently stands, the construction phasing and cost analysis included within it is insufficient to be used as criteria for selection of a preferred alternative, and if not explored further would have significant impacts on the viability of Burnham Place.

D. Fiscal Impacts and Economic Viability

If thoughtfully planned, designed and funded, the economic development potential surrounding the Washington Union Station expansion (SEP) is enormous. In addition to significant increases in intercity and commuter rail capacity, the SEP has the potential to leverage its important location by integrating neighborhoods, creating great urban places and facilitating an impactful economic engine for District and Washington region. As required by the new rail program in all of the Action Alternatives, the current parking garage will be demolished. This creates a blank slate for the valuable federally owned air-rights consumed by the current garage. Unfortunately, FRA's Preferred Alternative A-C creates an over-sized parking and bus facility which, again, consumes most of the federally owned air-rights property. Alternative A-C severely under-utilizes the federally owned air-rights property foregoes significant economic opportunity through pursuit of an outdated, suburban design program. There are numerous social, economic and environmental benefits from moving this parking underground and freeing up more of the Federal air-rights for additional private development. If developed properly, these air-rights would add valuable public and private spaces to the SEP and surrounding neighborhood, unlocking meaningful economic benefits to the District and the federal government in the process.

Akridge engaged Shalom Baranes Associates (SBA) and RCLCo to prepare an economic impact analysis to demonstrate the important economic potential of a more thoughtfully planned Expansion Project. SBA is a Washington, D.C. architectural firm with an acclaimed reputation for its expertise in residential, commercial, institutional, and governmental design. SBA's specialties include architecture, project management, historic preservation, and master planning. RCLCo is a national leader in providing thoughtful real estate economic analysis and consulting, leveraging over 50 years of experience covering thousands of public and private projects. RCLCo has specific expertise in performing public and private fiscal impact analysis and has been engaged in project evaluations in the District for more than decade.

RCLCo's Fiscal and Economic Impact Analysis (Appendix F) assumed the following (all consistent with the A-C Modified plan presented elsewhere in these comments):

- Below-grade parking and PUDO facility, and single level bus facility created space for the above ground A-C Modified vision as described in Section 4 of these comments.

- Specifically, the economic benefits of building pads buildable up to 546,000 SF of private development and complementary pedestrian focused community park and circulation spaces.

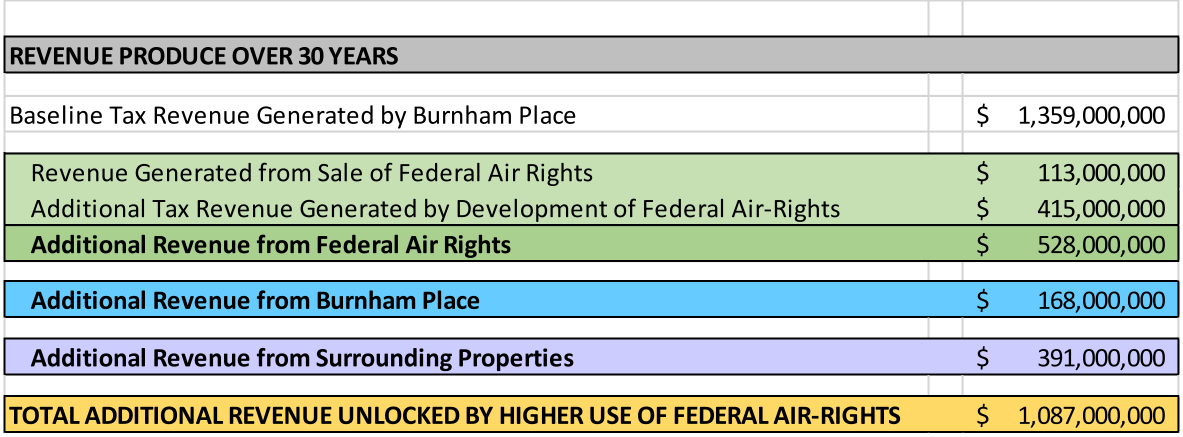
- Vibrant, mixed-use development opens up value for the Federal air-rights parcel, generates additional District tax revenue, and boosts economic value to nearby properties.

RCLCo determined that over a 30 year period, from the start of construction, more than $1 Billion is generated by the improvements from A-C Modified in addition to the projected $1.36 Billion projected baseline tax revenue generated by Burnham Place alone. It should be noted that this is a representative development plan for the Federal air-rights parcel and was conceived to be in alignment with current Union Station North zoning guidelines (the Federal air-rights parcel is currently not zoned) and in alignment with what we believe can be reasonably approved through the various approval authorities.

The findings are as follows:

- The creation of a vibrant, pedestrian-focused environment atop the federal air rights parcel would yield immediate and direct financial benefits, which could help USRCS preserve, maintain, and operate Washington Union Station. Underground parking produces an opportunity for the federal government to sell these air rights, potentially worth up to **$113 million** based on the amount of supportable development.
- The federal air-rights parcel has the potential to yield significant fiscal benefits to the District. The placement of transportation elements below the deck frees the federal property for private development, which could contribute an additional **$415 million** in revenues to the District's General Fund in the 30 years following the start of above-grade construction. This includes income tax from initial construction jobs and, once the buildings are occupied, office and retail employees as well as increased real estate taxes; sales and meals taxes; and other miscellaneous sources like personal property taxes and corporate franchise income taxes.

- Good urban design of the federal air rights parcel will impact not only the property value and prestige of WUS, but also the value of Burnham Place, of which the District also has a financial stake in, to generate additional tax revenues estimated to be approximately **$168 million** over 30 years to include income tax from construction, office, retail workers; real property tax; and tax revenues from sales on-site.
- Neighboring properties within the WUS "influence area", specifically, NoMa and Capitol Hill are severely lacking in open space with access to natural light and air (see image of public parks in vicinity around Union Station). RCLCo estimates that this transit-rich, high quality, critical connection to NoMa and Capitol Hill will increase surrounding property tax revenue by **$14 million** a year.



REVENUE PRODUCE OVER 30 YEARS		
Baseline Tax Revenue Generated by Burnham Place	$	1,359,000,000
Revenue Generated from Sale of Federal Air Rights	$	113,000,000
Additional Tax Revenue Generated by Development of Federal Air-Rights	$	415,000,000
Additional Revenue from Federal Air Rights	$	528,000,000
Additional Revenue from Burnham Place	$	168,000,000
Additional Revenue from Surrounding Properties	$	391,000,000
TOTAL ADDITIONAL REVENUE UNLOCKED BY HIGHER USE OF FEDERAL AIR-RIGHTS	$	1,087,000,000

The Federal air-rights parcel at WUS has the potential to yield significant fiscal benefits to the Federal government, the greater Washington region, the District, and surrounding properties. The Preferred Alternative A-C forecloses this potential with a large and imposing parking garage. Alternative A-C is detrimental to the viability of Burnham Place and downgrades the experience of visitors and residents the surrounding neighborhood. These social, environmental, and fiscal impacts will be felt for generations to come. The placement of the parking and PUDO facility below the new Concourse frees the Federal property for private development and civic uses, creating the strong economic engine necessary to support a successful Station Expansion Project.

Section VI

Conclusion

Akridge appreciates the opportunity to provide comments on the DEIS for Washington Union Station's expansion. As outlined above, key modifications to the Preferred Alternative presented in the DEIS are needed to meet FRA's obligations under NEPA, Section 106 and Section 4(f), as well as to ensure a viable and successful design that will meet the Expansion Project's purpose and need. Akridge has worked hard to develop Alternative "A-C Modified" which would vastly improve the Expansion Project and avoid undue impacts to surrounding neighborhoods and other development. Akridge believes that by making key adjustments to the Preferred Alternative, the Expansion Project can meet its purpose and need as well as the diverse goals of stakeholders, including those of Akridge. Akridge continues to stand ready to collaborate on an Expansion Project plan that will allow both the Expansion Project and the Burnham Place project to move forward successfully.

About the Burnham Place Team

Owner/Developer

Akridge is a comprehensive real estate services company that has invested in the Washington Metropolitan area for over four decades. It provides acquisitions, design and construction management, development, finance and asset management, leasing, and property management services. For over forty-five years, the company has acquired, developed, or entitled more than 20.6 million square feet of office, industrial flex, residential, retail, and entertainment space. Akridge has another 10 million square feet in its active pipeline, currently manages approximately 3.3 million square feet, and has a portfolio with an estimated value of over $2.1 billion. Notable projects include the 1- million-square-foot Gallery Place, the internationally recognized Homer Building, and the 3-million-square-foot Burnham Place air rights development project at Union Station.

Architect & Master Planner

Shalom Baranes Associates (SBA) is a Washington, DC architectural firm with an acclaimed reputation for its expertise in residential, commercial, institutional, and governmental design. SBA provides full architectural services for a clientele that includes both private and public sector groups. Notable specialties include architecture, master planning, historic preservation, and project management. SBA is recognized for its command design issues specific to the unique Washington, DC regulatory and urban contexts. The firm is equally acknowledged for its ability to synthesize coherent, practical solutions from complex programs. SBA excels in developing innovative designs that respect the surrounding fabric while presenting a fresh and dynamic vision that is appropriate to the urban context.

Lead Transportation and Urban Design Consultant

Laboratory for Architecture & Building (LAB) was established in 1999 and has completed a broad range of projects, including urban design, master planning, interiors, renovations, and new buildings. LAB's projects serve their immediate users and communities and respond sustainably to their environment through sound construction and careful planning, notable for their response to context, environment, and program. LAB's master planning and urban design work is forward-looking and broad in scope and includes significant local and regional transportation, commercial, and urban design projects.

Transportation Planner and Traffic Engineer

Sam Schwartz Engineering (SSE) is a leader in full-service consulting, design, operations, and program management services for public and private clients. With 25 years of experience working on transit and rail projects for public agencies and commercial businesses, SSE understands the need for cost effective solutions for complex challenges. SSE has built its team approach and project strategy around the recognition that success requires a thorough knowledge of transit and rail systems and processes as well as objective analysis capabilities and tools. Transit services include, but are not limited to, multi-modal transportation planning, engineering, operations, fare collection systems and policy, and conceptual facility design.

Transportation Planner and Traffic Engineer

Wells + Associates (W+A) has been providing professional transportation engineering and planning services for over 30 years in the Washington, DC metropolitan area, including hundreds of traffic studies for projects in the District of Columbia. Since its founding in 1991, W+A has established itself as a leader in the transportation industry by continually evolving as the transportation industry has evolved. Our team is intimately familiar the latest data, methods, and software required to analyze the needs of complex projects. And, because of our extensive experience in the District of Columbia, DDOT's guidelines and policies are well ingrained. W + A has a proven track record of work that has withstood the scrutiny of review agencies, citizens' groups, and the like on highly visible projects.

APPENDIX

APPENDIX A

PARKING PROGRAM OPERATIONS

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September 23, 2020

David Tuchmann
Vice President, Development
Akridge
601 Thirteenth Street, NW Suite 300 North
Washington, DC 20005

RE: Union Station Parking White Paper

Dear Mr. Tuchmann,

In early 2020, Akridge commissioned Sam Schwartz Engineering, DPC, (Sam Schwartz) to prepare a white paper to summarize best practices in parking management, technology, and operations at urban, multimodal transit hubs and document recommendations for the future parking supply for the proposed Union Station redevelopment. This effort was in response to growing concerns regarding FRA's proposal to provide over 1,500 parking spaces at Union Station, which we conclude is an extreme excess given the proposed uses and operations at Union Station and its location within an urban environment.

The research, analysis, and recommendations resulted in the subsequent white paper, which was finalized in May 2020. We concluded that many comparable transit hubs around the country provide limited or no on-site parking and that parking demands are generally decreasing due to trends in increased for-hire-vehicle (FHV) use and increased implementation of shared parking and Travel Demand Management (TDM) strategies. Additionally, future trends projected for automated vehicles and execution of policies and programs to minimize automobile reliance as part of the Move DC plan, indicate further reduction in future parking demands around Union Station. Therefore, we conclude that approximately 55 to 432 parking spaces should be provided, which is a substantial reduction compared to the FRA proposal.

Our findings and recommendations align with those included in a memo released on June 3, 2020, by the DC's Office of Planning and Department of Transportation assessing the parking needs for this site, which recommended a total of 295 parking spaces. As the findings and recommendations from our May 2020 white paper are aligned with those of the DC Office of Planning, Department of Transportation, and key stakeholders, it has been determined that there is not a need to update the associated analysis.

Sincerely,

Mike Flynn
Principal + Director of City Strategies

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Washington Union Station Parking Program Operations

White Paper and Research Findings
May 5, 2020

Introduction

Transportation hubs, such as intermodal stations and bus depots, are the essential connection points within our mobility network—creating a concentrated place of human activity, commerce, and transportation options. Like people, these places come in different shapes and sizes, offering a range of economic and mobility opportunity, including shops, restaurants, theaters, residences, and offices that are accessible by rail, bus, bike, walking, car, or even a skateboard or electric scooter—to name a few. With these fundamental elements in mind, transportation hubs are transforming from traditional transit centers into places of civic and social engagement.

While the primary function of a transportation hub, like Washington Union Station (WUS), is to serve multiple transportation modes and businesses, a careful balance of transportation resources must be considered to achieve a high degree of accessibility and opportunity for all patrons, particularly as our mobility ecosystem continues to change as more transportation choices emerge.

With several Environmental Impact Statement (EIS) Alternatives currently in development for the Washington Union Station Expansion Project (SEP), Akridge asked Sam Schwartz Engineers to analyze and provide recommendations related to the station parking, passenger pick-up and drop-off, and intercity and charter bus programs.

This paper provides an in-depth review of current trends and best practices related to travel activity, parking behavior, parking infrastructure, and related development patterns urban transportation centers. Specifically, we analyze potential parking requirements for rail and bus passengers, and for office and retail uses contained within the station.

The paper is organized into the following sections:

1. Peer Parking Management Assessment
2. Best Practices and Emerging Trends
3. Washington, DC Union Station Application and Evaluation; and
4. Conclusions and Recommendations

Chapter 1: Peer Parking Management Assessment

While Union Station is one-of-a-kind, other comparable transportation hubs in an urban context exist throughout the country that have similar issues balancing the needs of rail, bus, bicycle, pedestrian users, and vehicle parking demand. Accordingly, the following stations were examined as part of this study:

- Philadelphia 30th Street Station
- Boston South Station
- Denver Union Station
- San Francisco Salesforce Center
- Chicago Union Station

Parking Supply

A summary of station parking, rail transit, local bus connections, and vicinity parking for these stations, as outlined in available planning documents, is provided in **Table 1**.

Table 1: Peer Transportation Center Analysis

	Proposed Washington DC Union Station (FRA Preferred Alternative)	Philadelphia 30th Street Station*	Boston South Station*	Denver Union Station	San Francisco Salesforce Center	Chicago Union Station
Total Parking Spaces	1,575	106	188	0	0	0
Bike Parking	125	150	50	Not clear	130 bike racks + lockers inside	0
Direct Urban Rail Connection	Yes (Rail & Streetcar)	Yes (Rail & Streetcar)	Yes (Commuter Rail)	Yes (Light Rail, Commuter Rail)	No (planned connection to Subway)	Yes (Commuter Rail)
Direct Bus Connection	Yes (21 frequent routes)	Yes (8 frequent routes)	Yes (4 frequent routes)	Yes (9 frequent routes)	Yes (9 frequent routes)	Yes (13 frequent routes)
Nearby parking (1-2 blocks away)	Yes (29 locations)	Yes (6 locations)	Yes (8 locations)	Yes (11 locations)	Yes (9 locations)	Yes (8 locations)
Amtrak Ridership (Annual)	5.8 million	4.5 million	1.6 million	143,986	NA	3.3 million

**Indicates planned develop numbers*
Source: Sam Schwartz, May 2020.

Overall, this demonstrates that comparable stations provide similar multimodal services to their patrons, including direct urban rail, direct bus connections, and bicycle parking, as Union Station currently provides. Each of the examined comparable stations currently or plans to include between 0 and 188 parking spaces, in accordance with their long-term plans. Denver Union Station and Chicago Union Station operators inform incoming users that they do not provide parking, but that parking can be accessed at garages and surface lots surrounding the station. Like WUS, Chicago's Union Station is undergoing a large expansion and redevelopment. Unlike WUS, Chicago's adopted 2040 master planning document does not include dedicated rail passenger parking. In 2019, a 700-space Amtrak-owned parking garage adjacent to the station was demolished to construct a combination of office, retail, and residential transit-oriented development. Boston's South Station is executing a major Air Rights project that will bring three new buildings and add 106,000 square feet to the existing 205,165 commercial space at the station today. The Salesforce Transit Center in San Francisco is projected to decrease parking demand around the station and likewise does not provide any new parking.[1] The intercity rail stations at Denver, San Francisco, Chicago, and Philadelphia all include major retail programs, similar to the potential future retail program for WUS, with no dedicated retail or passenger parking.

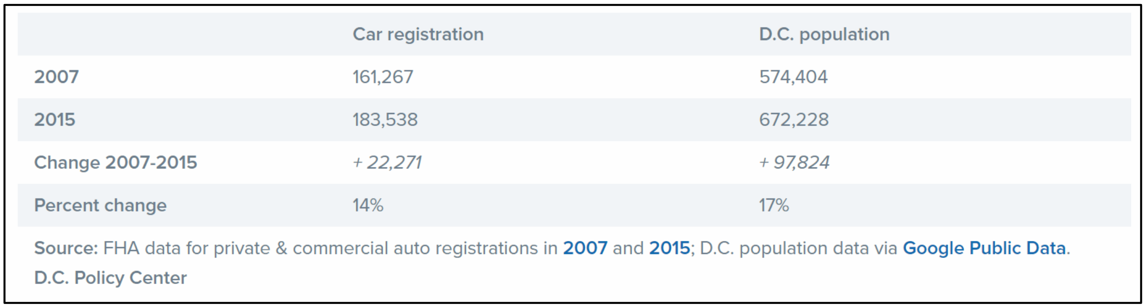
Chapter 2: Best Practices & Emerging Trends

Determination of parking needs at WUS must be based on overall best practices and emerging trends, rather than past practice. Overall, nationwide trends have seen a dramatic decrease in demand for parking and an increase in the use of For Hire Vehicles or FHV at urban multi-modal centers. These trends are the result of technological advancements and the introduction of new modes of micro-mobility, as well as consistent investment in high-quality public transportation infrastructure in the cities where they are observed.

A. Parking Management and Policy Initiatives in Washington, DC

As of 2007, the ratio between the number of car registrations and residents was 0.28. Between 2007 and 2015, the population of Washington, DC saw a 17% increase (97,800 people) and car registrations went up by 22,300, a 14% increase, as seen in **Table 2**. This is a ratio of 0.23 registrations per new resident. While a portion of this lower registration rate could be due to an increase in the population's share of people below driving age, an 18% drop in registration rates demonstrates a meaningful mode shift trend in Washington, DC.

Table 2: City's Population Growth in Comparison to Car Registrations



	Car registration	D.C. population
2007	161,267	574,404
2015	183,538	672,228
Change 2007-2015	*+ 22,271*	*+ 97,824*
Percent change	14%	17%

Source: FHA data for private & commercial auto registrations in **2007** and **2015**; D.C. population data via **Google Public Data**.
D.C. Policy Center

As the Nation's Capital and one of the largest cities in the country, the District of Columbia government has played a role in advocating for reducing the City's parking footprint and meeting long-term sustainability goals. The City has also made commitments to reduce its automobile reliance in its long-range transportation plan, MoveDC. Specifically, the plan defined a goal to "develop policies and

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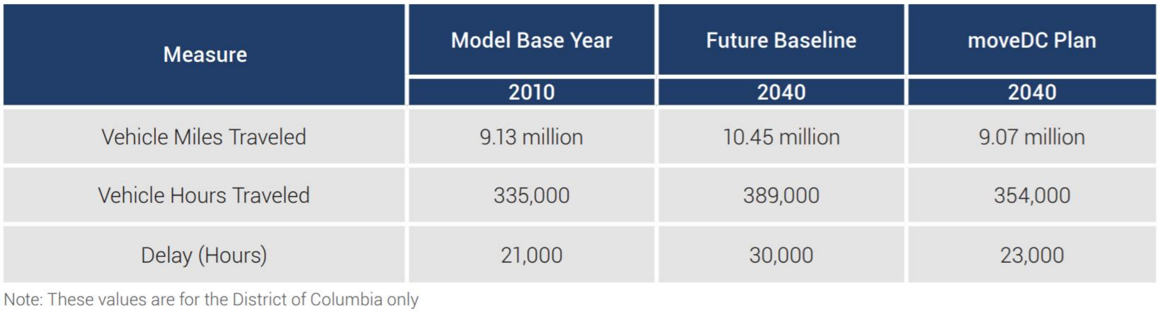
[1] Salesforce Transit Center EIS

incentives to encourage 'car-lite' living that includes a commitment that 75% of all commute trips that originate in DC will be made by non-auto modes by 2040. **Table 3** outlines the City's goals of reducing the number of vehicle miles traveled and vehicle hours traveled through 2040[i].

Table 3: MoveDC Sustainability Goals Summary



Measure	Model Base Year	Future Baseline	moveDC Plan
	2010	2040	2040
Vehicle Miles Traveled	9.13 million	10.45 million	9.07 million
Vehicle Hours Traveled	335,000	389,000	354,000
Delay (Hours)	21,000	30,000	23,000

Note: These values are for the District of Columbia only

Source: MoveDC

Further implementation of the parking reduction goals stated in MoveDC has been achieved through parking management policies throughout the city. The Union Station North (USN) Zone district, in which the Burnham Place development is located, has no minimum parking requirements, and several other zones are granted the allowance of a 50% reduction in minimum parking requirements within a half mile of a Metrorail station.

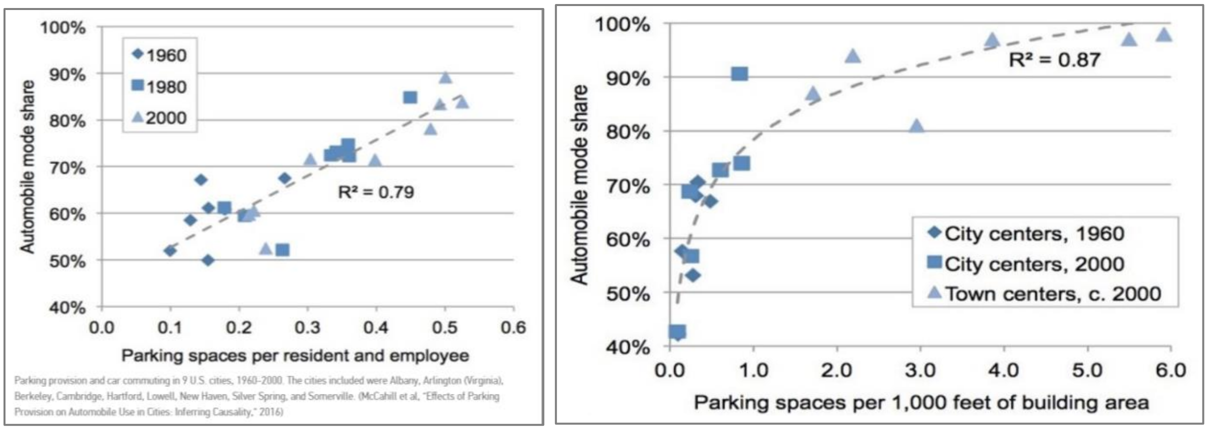
The adoption of Transportation Demand Management (TDM) initiatives plays a key role in supplementing parking reduction initiatives and sustainability goals through providing users with reliable, predictable, and comfortable mobility options. TDM refers to policies, physical amenities, programs, tools, and services that support the use of sustainable modes. TDM works with the existing transportation system to expand and support mobility options that accommodate future growth while meeting larger local and regional goals. Supporting bicycling, walking, using transit, sharing rides and micro-mobility services, and carpooling makes it easier for all users to reduce reliance on driving alone, and provides larger environmental benefits through lower emissions, health benefits through increased safety, and community benefits through active public spaces and streets.

Within Washington DC, projects are required to implement TDM strategies to reduce vehicle traffic and parking demand on a project-by-project basis during development review. In some cases, the City's Zoning Commission or Board of Zoning Adjustment conditions project approvals on parking maximums in addition to or in instead of parking minimums.

B. Parking Trends

Parking is what is known in economics as a complementary good[ii]. This means that the building of parking induces more people to drive because they are likely able to park their car more easily and typically at a lower cost than they otherwise would have been able to. One study, as shown in **Figure 1**, statistically analyzed the historical relationship between parking availability and rates of driving from 1960 to 2000. It found that as cities provided more parking spaces, the share of automobile (car) commuting increases proportionally[iii]. Similarly, as parking spots per building area increased, the mode share for driving increased. This is commonly known as an "induced demand" factor; providing more ample, available, free (or lower cost) parking leads to increased driving behavior, which then contributes to other factors, such as traffic congestion and negative safety and environmental effects. Conversely, providing fewer parking spaces or more manageable parking that is priced based on market rates can encourage less driving and parking, and shifts towards other sustainable modes, or sharing of resources (e.g., carshare, carpooling, or ride-matching, etc.)

Figure 1: Induced Parking Demand



Parking provision and car commuting in 9 U.S. cities, 1960-2000. The cities included were Albany, Arlington (Virginia), Berkeley, Cambridge, Hartford, Lowell, New Haven, Silver Spring, and Somerville. (McCahill et al, "Effects of Parking Provision on Automobile Use in Cities: Inferring Causality," 2016)

As many indicators have demonstrated that parking demand is declining, cities have begun to alter their parking development policies to reflect this shift. Cities throughout the country, including Buffalo, San Francisco, and Minneapolis, have eliminated minimum parking requirements from their zoning codes, citywide.

The abolishment of parking minimum requirements is particularly prevalent in Transit Oriented Development (TOD) areas, in which the land uses adjacent to transportation stations or facilities is surrounded by dense, mixed-use development. Demographic shifts towards cities[iv], the onset of FHV services, a decline in teenagers getting drivers licenses[v], and initiatives to cut greenhouse gas emissions[vi] have led cities to rethink their parking and development policies.

Shared Parking

Like many finite resources, parking demand experiences fluctuations throughout any given day. While garages and lots may be fully utilized during specific times, many parking facilities are completely empty during other times. Accordingly, distinct but complementary patterns form and offer an opportunity for project sponsors to optimize their parking lots and garages among multiple land uses such that the relative time periods of high or low demand can offset each other. In this way, multiple uses contained in one mixed-use development can "share" the same parking spaces but use them at different times of the day.

Shared parking policies are becoming a requirement in cities across the country, unlocking more valuable land uses, while accommodating essential parking demands and promoting travel by more sustainable modes of transportation (e.g., mass transit, biking, walking, etc.). For this reason, shared parking goes "hand-in-glove" with mixed-use, walkable, compact development similar to future development plans in and adjacent to WUS.

The business of parking operations has been declining. A recent study estimated that about one quarter of all ride-hailing trips would have otherwise consumed a parking space[vii]. Therefore, as people use FHVs more frequently, fewer parking spaces will be required. One study analyzed the sale of parking structures in 10 of the top 15 Metropolitan Statistical Areas in the U.S. and attributed these recent transactions to owner uncertainty about the future profitability of the parking industry[viii].

Similar to public transit, the demand for FHV services is driven by regional land use and population density. Demand for FHVs is observed where congestion is high, and transit options are strong. WUS is no exception and has a unique opportunity to be proactive and forward thinking in incorporating FHVs into the future design. Travelers are shifting away from rental cars in favor of using FHVs as well. Many business and leisure travelers would prefer to avoid renting a car and having to search for parking, unless they are forced to. Depending upon the number of driving trips a traveler plans to take once at a destination, FHVs can provide a more cost effective and time-saving strategy for travelers. Ride hailing and its relationship to pick-up and drop-off (PUDO) at WUS is discussed in a separate paper.

C. Automated Vehicles

The implications of autonomous vehicles (AVs) on parking could be significant. First, within parking garages, AVs may be able to be parked closer together because passengers will no longer need room to open their doors or require additional space for maneuverability (and account for human error). Passengers can exit before the car is physically parked, allowing parking garages to meet their capacity needs with a substantially smaller footprint.

There may also be less of a need for parking as shared vehicles typically stand in between pick-up and drop-off locations, as opposed to parking long-term. To further this point, AVs may not require parking or the need to park at all, especially in area where there is a constant flow of demand for pick-up/drop-off, such as WUS.

From a business and consumer perspective, AVs could represent 15% of global auto sales in the next 10 years, with widespread adoption in the next 20 to 30 years, according to reports[ix]. Various business models indicate that an AV future could represent one that drastically reduces the need to own a vehicle. Therefore, AV adoption could play a major role in the shared economy, pushing for an owner-less, subscription-based business model that allows individuals to simply pay per trip, be it an AV passenger car, shuttle, or articulated bus.

Chapter 3: Washington DC Union Station Application & Evaluation

Using the research gathered on peer transportation centers, best practices, and national expertise in the fields of parking programming the above information was applied to the WUS proposed expansion. A summary of the recommended station parking program is provided below.

A. Parking Program

Transportation Center

Union Station is, first and foremost, a confluence of transportation options and resources in one central area. Pedestrian safety and comfort are key to creating a successful mixed-use transit center. To achieve this at Union Station, a higher density and mixture of land uses within and adjacent to the station with limited parking should be prioritized. This model of development has seen success in comparable transportation centers outlined above and will be used to guide parking recommendations for the transportation functions and other land uses within Union Station. Overall, based on standard metrics, projected ridership, modal splits, and rail and bus passenger characteristics, the transportation parking demand at Union Station, both today and well into the future, is very limited.

As those traveling the greatest distance to and from Union Station, Amtrak users are most likely to generate parking demand at and surrounding Union Station. However, Amtrak has been witnessing a dramatic reduction in that parking generation within their stations and has been working through strategies to minimize their parking footprint. Specific to Union Station, a memorandum released by Amtrak on January 7, 2020 stated the following:

“Amtrak does not support any entity building parking...specifically to support Amtrak passengers….a majority of Amtrak and commuter rail passengers access the Station via alternate transportation modes…Planned rail infrastructure investments north and south of the Station and a shifting culture away from private automobile use leads Amtrak to anticipate passenger parking demand to continually decrease in the future…we do not assume that parking will increase proportionally as rail ridership increases.”

Based on 2017 survey data, Amtrak estimated that approximately 600 to 700 passengers (8% of those boarding Amtrak daily at Union Station) were using station parking. A 2019 study reported that number dropping to 4%, meaning there was an approximate 50% decline in parking demand over a two-year period[2]. It is further worth noting that this current mode split reflects conditions where demand is arguably induced by an abundant parking supply. Average daily Amtrak boardings are projected to be 16,000 in 2040 at WUS. If there is no further decline in the percentage of those parking at WUS, parking demand generated would be up to approximately 640 spaces (4% of 16,000).

However, based on 1) Amtrak’s stated policies and survey data trends; 2) national trends which show dramatic shifts from private car parking to FHV trips; and 3) a recommendation to encourage a further shift in mode, we recommend a maximum future target of 2% (320 spaces) for a mode split for Amtrak passengers who drive and park. As previously discussed, providing convenient and readily available parking induces the demand for spaces and will continue to do so if large amounts of parking continue to be provided on site. To limit induced parking demand patterns, it is recommended that 50% or more (160 spaces) of anticipated Amtrak parking demand be accommodated within the 5,500 spaces contained within nearby publicly available parking facilities (see discussion of Vicinity Parking Supply and **Figure 3**). The small portion of Amtrak riders who prioritize parking in close proximity to their ultimate destination or have physical limitations, would be able to access the remaining spaces within the station at a premium, to ensure they are accessible to users who require convenience. Accordingly, it is recommended that **0 to 160 spaces** for Amtrak services at Union Station is appropriate for study.

Another potential generator of parking demand at Union Station is intercity bus service, as passengers are traveling a greater distance to and from the station. However, the higher cost of driving and parking overnight within the station is likely a major deterrent for intercity bus users. For example, if the cost of a bus ticket from Washington, DC (departing from Union Station) to New York City is between $5 and $40 roundtrip, while the cost of parking a vehicle over 27 hours at Union Station is $48, with a $24 daily rate

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[2] Amtrak notes in the same memo that in the most recent survey of passengers in December 2019, 4% of riders from Union Station drove and parked.

charge after 26 hours, it would likely cost more to store a vehicle at Union Station than use its intercity bus services. For this reason, it is highly unlikely that this transportation mode would generate parking demand within Union Station's parking facility or at surrounding garages. Thus, we recommend that **0 spaces** be constructed for intercity bus services at Union Station.

Maryland Area Regional Commuter (MARC) and Virginia Railway Express (VRE) are regional commuter rail services that by and large transport workers from their residences in more suburban and rural locations to jobs in Washington and its adjacent suburbs. While VRE has reported a growing parking demand for their existing supply of 10,756 spaces, there is no current or planned parking provided for the Union Station site as VRE passengers are walking or using other modes to travel from Union Station to their ultimate destination. Similarly, MARC has seen increased parking demand and has constructed or has plans to add parking capacity at the Aberdeen, Halethorpe, Odenton, Bowie, State, and Seabrook station, but have indicated no need to construct parking at Union Station[x]. Accordingly, **0 spaces** are needed for the regional rail function at Union Station.

Other modes of transportation at Union Station include Metrobus, Metrorail, and other services whose passengers depend on the low cost and direct proximity to their ultimate destination provided by these modes. For example, traveling from Union Station to the Virginia Square Metro Station (in Arlington, VA) costs approximately $3.10. The rate to park at Union Station for two to ten hours is $20[xi]. Local bus passengers have similar characteristics; a national study completed by the Transportation Research Board (TRB) found that 75% to 80% of North American transit passengers walk one-quarter mile or less to bus stops, negating the need to drive or park at local bus stops[xii]. Accordingly, **0 spaces** are needed for these functions at Union Station.

Furthermore, the majority of peer transportation centers examined in Chapter 1 provide no parking spaces on-site (Chicago, Denver, and San Francisco Salesforce Center), demonstrating that the provision of parking at urban rail stations is not required for success. **Table 4** summarizes the analysis provided above by mode.

Table 4: Estimated Parking Generation – Transportation Center Land Use

	Recommended Parking Supply
Amtrak	0- 160
Intercity Bus	0
MARC/VRE	0
Metrorail, Streetcar and Metrobus	0
Total	**0-160**

Source: Sam Schwartz, May 2020.

Retail Space

To accommodate the growth of transit users, nearby residents, employees and visitors to Union Station, it is likely that new retail space will be added to the existing 206,000 square feet. As indicated in various planning documents produced through the WUS EIS process, it is assumed that approximately 60,000 to 80,000 square feet of additional retail space will be constructed in the new station program. Thus, for purposes of this analysis a total of approximately 250,000 to 300,000 square feet of current and future retail space is estimated.

Union Station is federally owned, and therefore, not bound to a minimum parking requirement. Similarly, the adjacent land is located within the Union Station North (USN) Zone District which is also not subject to minimum parking requirements. However, a review of required parking in other zones in the District that would permit the same type and density of development was conducted by Wells and Associates and found a minimum retail parking requirement of 1.33 spaces per 1,000 square feet is required in excess of 3,000 sf, with an allowance for a 50% reduction for sites within ½ mile of a Metro Station. Application of this standard to the Union Station retail would require 166 to 200 total spaces to serve current and future retail space.

It is worthy to note that this estimate of retail parking demand is for retail space built near transit service, as opposed to retail space built within a multi-modal transportation center. Therefore the 166 to 200 spaces represent the absolute highest number of spaces needed on site. Union Station's existing retail space was created in the 1980s as a shopping and entertainment destination, generating new trips from patrons in nearby suburbs and the surrounding region. However, as rail passenger populations have grown, and the neighborhood surrounding Union Station has substantially increased in density, retail space today serves travelers using MARC, VRE, Metrorail, Metrobus, Amtrak, intercity bus, and other regional or intercity transportation passengers who are already present, or residents and employees in the adjacent neighborhoods who are also within walking distance of the station. This transformation is evident in the retail programming within the building as well. For example, the West Hall was recently converted from specialty retailers to "fast casual" food purveyors, and the lower level movie theaters have been converted to a large, national-chain drugstore. This neighborhood- and passenger-oriented environment has altered the customer base of the station's retail space from those making separate trips to travelers using the station and employees or residents walking to and from the station, significantly reducing, if not eliminating, the need for retail parking on-site. **Given these factors, it is recommended that 0 spaces be designated for retail use at Union Station.**

Office

The historic Union Station building includes 110,000 square feet of office space, which was last occupied by Amtrak's corporate offices, and has been vacant since 2017. It is possible this space could be converted to other uses, such as a hotel, but for this analysis we assumed this space will be fully occupied with office uses in the future development, which generally entails a relatively higher demand for parking than other uses. While office uses typically generate some parking demand, employees in the station will have access to the commuter rail and transit modes at the station and have the opportunity to park in one of the adjacent parking facilities.

Like the retail land use, there is no minimum parking requirement associated with office space located on federal land. However, a review of required parking in other zones was conducted by Wells and Associates. Wells identified that District Department of Transportation (DDOT) preferred Vehicle Parking Rates vary depending on distance from Metrorail. DDOT's preferred parking ratio for office land uses within ¼ mile of Metrorail is 0.4 spaces per 1,000 square feet (1 space per 2,500 SF). At this ratio, approximately 44 spaces would be required for the 110,000 sf of office space in Union Station. Additionally, in analyzing an appropriate ratio for parking spaces associated with office uses in the Burnham Place project, Wells completed market research of the parking ratios of 29 office buildings within close proximity to Metrorail stations in downtown Washington, DC. Wells and Associates found that the average ratio within these buildings is 1 space per 1,500 SF. Given the very high transit-rich location, Wells recommended 1 space per 1,785 SF for Burnham Place office uses. Applying this same ratio to the station's office space would require 62 spaces. **Given these factors, it is recommended that 0 to 62 spaces be designated for office use at Union Station.**

Rental Car

Rental car services at Union Station provide a valuable means of transportation for those traveling to/from areas without transit access. As stated by the Federal Railroad Administration (FRA), the original car rental program included 75 spaces, but has expanded beyond the mezzanine level to use two bays on the second level of the garage.

The car rental industry is in a transformative state. While the healthy American economy has contributed to an increase in the number of global travelers (and potential car renters) there has been a drop in the share of ground transportation costs dedicated to rental cars among business travelers and an increase in the number of emerging technology competitors, and shifting transportation preferences which limit confidence in the industry's certainty. Peer-to-peer car sharing services in which car owners rent out their vehicles to individuals has surged; between 2017 and 2019, peer-based car sharing grew by 80% with membership more than doubling during the same time period[xiii]. Additionally, several technology investments are giving customers the ability to book or alter their reservations remotely, allowing companies to track passenger delays in real time, and expediting pick-up and drop-off procedures, all of which decrease the amount of time rental vehicles are idling or parked and increasing the efficiency of the parking footprint required for rental car companies.

These technologies also offer rental car companies the opportunity to rethink their business structure. For example, real time data tracking capabilities could allow car rental companies to operate their business—or a portion of it—at a nearby site, or allow the facility to be designed with minimal storage on-site and utilize off-site garages for larger storage. This would be aligned with transportation planning principles in that it would de-prioritize auto-based uses, bringing cars into the station on an as-needed basis. Similarly, more closely tracking customer locations, durations, and motivations would allow rental car companies to determine an appropriate size for station users within Union Station and identify an off-site facility that meets the needs of residents of adjacent neighborhoods. Limiting the footprint of rental car operations within Union Station would minimize conflicts with station pedestrians while freeing up premium, high-cost space for more desirable uses. Furthermore, in planning the rental car program at Union Station, it is also important to consider whether the current operation serves rail passengers, or functions as a general rental car facility for the surrounding neighborhood and DC businesses. If the operation is serving a significant number of non-station users, it may not be efficient to locate the facility within high-value station spaces, and unnecessarily add to vehicular traffic adjacent to the station. This consideration indicates that DC government should evaluate its policy objectives for a centralized car rental facility independently of the station use.

Due to the volatile future associated with the rental car industry as stated above and consistent with the transportation planning principles noted throughout this report, it is recommended that a rental car program of 0 to 125 spaces be considered for WUS. If the rental car program is not included directly on site, it should be located in very close proximity to the station. It is also recommended that whatever space is dedicated to this use, if included within the station and not at an adjacent site, be located and configured such that it can be converted to flex space, FHV pick-up/drop, cell phone waiting areas or other shared parking opportunities in the long-term.

Table 5 summarizes the land use and parking program recommended for the expansion of Union Station, with the minimum and maximum ranges discussed in detail above.

Table 5: Minimum and Maximum Parking Recommendation Summary

Land Use	Recommended On Site Supply Range	
	Min	Max
Transportation Center		160
Retail		200
Office		62
Rental Car		125
Shared priority spaces		-
Total (rounded)	**55**	**550**

Source: Sam Schwartz, May 2020.

While a minimum parking supply of 0 is stated in **Table 5** for each individual land use, it is recognized that WUS users—of all land uses—may be physically limited or under extreme time constraints and may have different needs in accessing WUS. Accordingly, it is recommended that a minimum number of spaces be considered for these users or that readily/easily accessible valet services be provided on-site. It is recommended that a 10% minimum of the total potential supply be provided for shared priority spaces. This number would include the minimum 44 spaces recommended by Wells and Associates for the office land use, as well as 11 additional spaces for ADA and any other users[3].

Vicinity Parking Supply

As seen at several of Unions Station's peer transportation centers, parking demand can often be accommodated by adjacent facilities. To better understand how this practice could be applied to Union Station, an analysis of parking facilities within an 8-minute walk of the station was completed, which can be seen in **Figure 2.**

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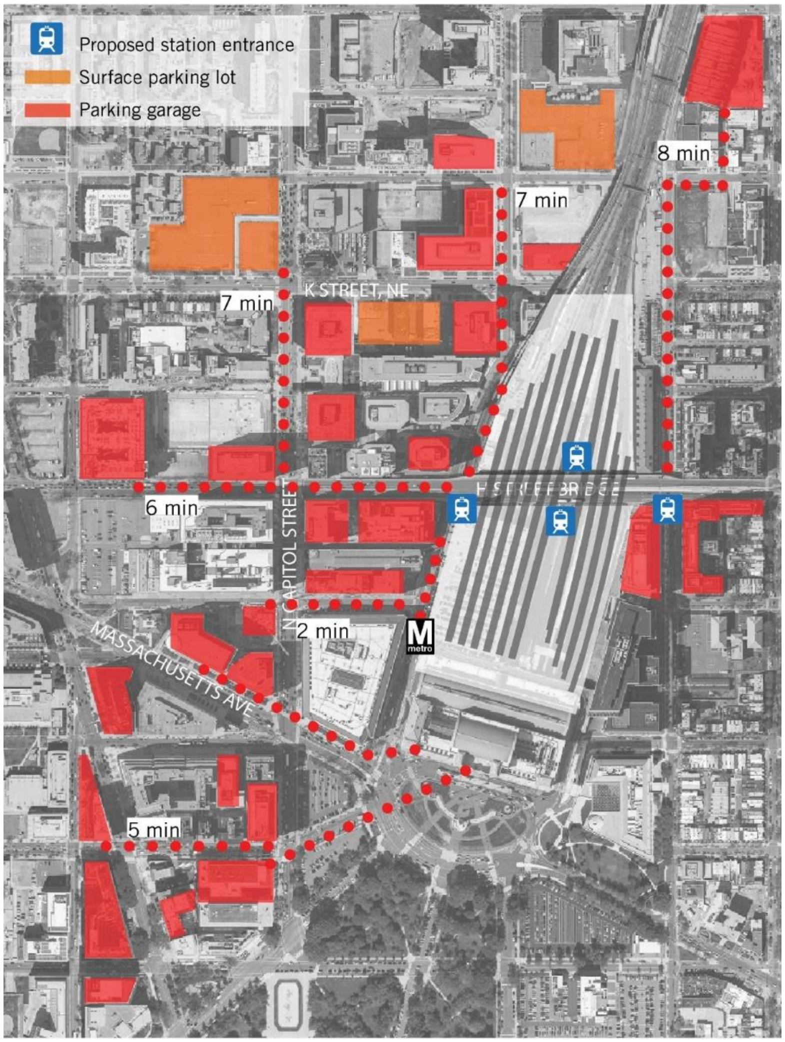
[3] The 2010 ADA Standards for Accessible Design states that for facilities between 500 to 1000 spaces, 2% of the total parking provided be ADA accessible. With approximately 550 spaces, this would translate into approximately 11 spaces.

Figure 2: Parking Facilities Within an 8-Minute Walk of Union Station



Source: Shalom Baranes Associates, May 2020.

Of the 26 publicly available parking facilities within an 8-minute walk of the station, inventory data was identified for 24 and estimates were made for the remaining two facilities. Approximately 5,500 spaces were recorded within these facilities[4] and utilization data during peak times (10am to 1pm) was found for six, with an average utilization rate of 72%[xiv], meaning that a minimum of 559 vacant spaces within two blocks of Union station at any given time which would comfortably absorb the approximately 300 spaces of potential demand generated by the transportation center, office, and retail land uses as an average of the recommendations stated in **Table 5**, and the analysis above.

However, it is probable that there are significantly more vacant spaces within the remaining 20 facilities in which parking utilization data was not available. If a 72% parking demand rate was applied to the 5,337-space inventory, approximately 1,512 spaces would be unused, providing even more options for Union Station parkers. A table summarizing these findings can be found in the *Appendix.*

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[4] Inventory data was derived from parkopedia.com

It is also worth noting that technology advancements in the parking industry have propelled efficiencies that optimize the parking footprint. App-based services including Parkopedia, SpotHero, ParqEx, and other digital reservation services connect drivers to parking facilities they would otherwise not be aware of or have access to, further expanding the number of convenient and cost competitive spaces Union Station customers, employees, and visitors can access.

Shared Parking Analysis

Shared parking is a national best practice that captures the fluctuating demand of complementary land uses served by the same parking supply. The traditional method to estimate future parking demand (outlined **Table 5**) is based on stand-alone land uses. This methodology neglects to account for the effects of 1) transportation demand management (TDM) which motivates users to use accessible transportation modes adjacent to a site and 2) users accessing multiple land uses in a single trip (captive market rate) on sites such as WUS. Therefore, this traditional method does not accurately forecast the demand based on the contextual characteristics of this site.

To more efficiently understand the benefits of these factors among WUS's various land uses and associated parking demands, a shared parking analysis was performed for the maximum development and parking generation at Union Station, as seen in **Figure 3**. For the purposes of this analysis, the maximum number of spaces recommended for each land use shown in **Table 5** were used. After accounting for Union Station's dense, mixed use, transit accessible characteristics through the TDM and captive market factors, the shared parking analysis was applied and illustrates the parking demand across multiple land uses on an hourly basis, demonstrating how—when shared—the ultimate supply needed would be lower than if the maximum number of spaces were supplied for each individual land use. The peak on-site parking demand is approximately 367 spaces occurring at 12:00pm on a weekday.

To provide incoming parkers with enough space to circulate and locate available spaces, it is an industry standard to provide an additional 15% supply, meaning that up to **432 shared spaces** would satisfy the parking demand of these land uses[5]. Considering that the maximum standalone parking demand would be around 550 spaces, this indicates that pursuing shared parking could reduce the parking footprint by approximately 120 spaces[6]. A detailed summary of the shared parking methodology can be found in the *Appendix.*

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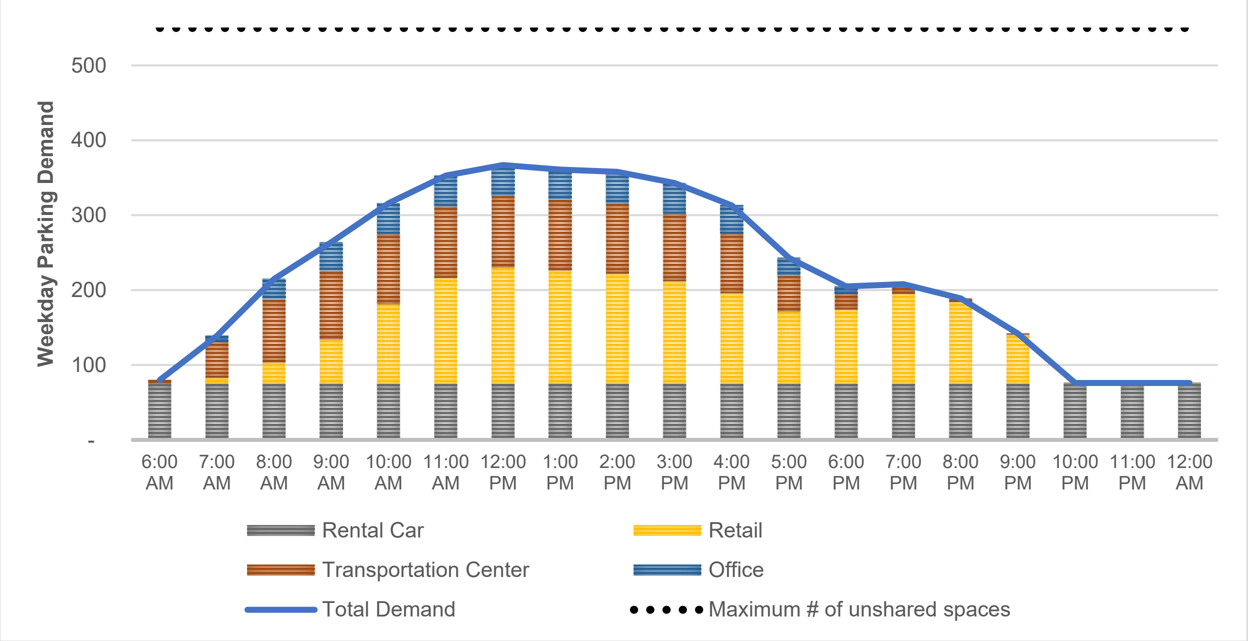
[5] Peak demand of 367 / .85 = 432 total needed supply

[6] 550 maximum supply – 432 shared parking supply = 118 difference

Figure 3: Shared Parking Supply Versus Demand by Land Use



Source: Sam Schwartz, May 2020.

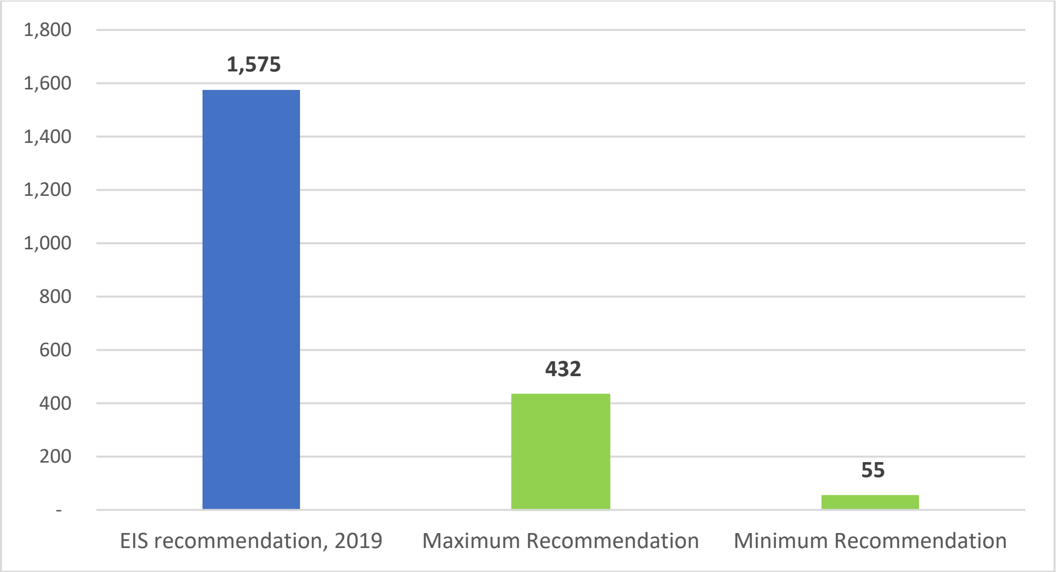
Conclusions & Recommendations

The proposal to construct a parking supply of 1,575 spaces is excessive for an urban transportation station in a city such as Washington, DC, with a high population density and one of the highest percentages of transit usage in the United States. Washington, DC is actively executing policies and programs to minimize its overall parking footprint while promoting initiatives for sustainable growth and development across the city, and Union Station should be a key part of these efforts. Transportation Demand Management initiatives to supplement these efforts are outlined in the *Appendix.*

Given the high density of development and activity continuing to occur at Washington DC's Union Station, it is critical to 'right-size' the parking supply and footprint to a size that is in accordance with current parking needs while considering the long-term future of parking in Union Station's urban context. Urban rail stations are successful when there is a high capacity for pedestrians, bicycles, rail systems (Metro), streetcar, and urban bus systems that can be easily and conveniently accessed on foot. Large swaths of private vehicle parking and street space dominated by vehicles can be counterproductive as this separates land uses, increases the time it takes to walk to, from, and within a station, and can place unnecessary financial burdens on project sponsors who are responsible for covering construction costs. Urban rail stations are also significant economic assets that work in conjunction with high-density office, hotel, retail, and commercial development immediately surrounding the station, and pedestrian connections to surrounding land uses are critical and must not be compromised by station-generated traffic.

As detailed in this paper and summarized in **Figure 4**, our research and analysis guides our recommendation to construct **a minimum of approximately 55 and maximum of approximately 432 spaces** at Union Station.

Figure 4: Recommendations Summary



Source: Sam Schwartz, May 2020.

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[i] http://www.wemovedc.org/

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[x] Schoenbaum. Greater Greater Washington. MARC plan calls for new stations, more service. September 2013

[xi] Union Station Parking Garage. Standard Parking Rates. March 2020. www.unionstationdc.com/parking

[xii] Rowe, Daniel, Chrtine Bae, and Qing Shen. Evaluating the Impact of Transit Service on Parking Demand and Requirements. Journal of the Transportation Research Board Volume: 2245 issue: 1. January 2011

[xiii] Greenblatt, Jeffery and Susan Shaheen. Automated Vehicles, On-Demand Mobility, and Environmental Impacts. July 2015

[xiv] Inventory data was gathered using Parkopedia. Utilization estimates were determined through contacting facility operators to identify the percentage occupancy of the facility during the average peak demand period (9:30am – 12:30pm)

About the authors

Sam Schwartz has been at the forefront of transportation planning in an era of transformation, working with communities to offer more mobility choices that allow greater access to economic opportunity, build social capital, increase affordability, and help create places that are enjoyable, attractive, and safe.

Our parking/curbside management and emerging mobility work draws on decades of experience integrating traffic engineering, transit planning and data analytics. Layered on top of this, Sam Schwartz has had their finger on the pulse of emerging trends, travel behavior and technology, as well as evolving data management strategies since Transportation Network Companies (TNCs) and micromobility providers began arriving in cities across the U.S. Our experience includes the development of Seattle's *New Mobility Playbook*, which is considered to be the foundation of how cities across the U.S. implement actionable and regulatory policies to integrate shared mobility and technology into an existing transportation system. As an out-growth of the identified pilots in this playbook, Sam Schwartz then worked with King County Metro and Ford Smart Mobility to pilot a first/last-mile microtransit service to park and ride locations. In Oakland, CA, Sam Schwartz collaborated with their growing Department of Transportation to develop their Transportation Strategy and implement a renowned, dynamic on-street metered parking program to help bolster economic activity and opportunity.

Appendix

Shared Parking Analysis

The shared parking analysis was performed using specific site and data from national industry-wide resources, including the Institute of Transportation Engineers and the Urban Land Institute. These principles are applied to Union Station to promote the transit-oriented nature of this site as high density, mixed-use development continues to occur.

The shared parking analysis assumes 300,000 square feet of retail space, 75 rental car spaces, 110,000 square feet of office space, and 65,000 boardings per day.

The parking demand methodology also incorporates specific reduction factors to account for the environmental setting and transportation resources provided within and adjacent to the site. These assumptions are defined below.

- *Captive market effect.* An estimate of the percentage of parkers at a given land use who are already counted as being parked at another on-site land use. For example, when employees of one land use walk to a nearby food court, there is not an additional parking space required. Internal capture rates for commercial land uses reported a captive market effect of up to 32 % reduction[i]. However, the captive market effect is typically lower when buildings are separated by parking and located further from one another, resulting in more people driving and re-parking when traveling to different locations. This captive rate is lower still when less transit and/or TDM is incorporated on site: when transit is not available and programs encouraging people to use transit are not present, they are more likely to drive, park, and re-park when traveling from place to place. Due to the shared use nature of this site, a captive market rate of 20% for commercial and residential land uses was assumed.

- *TDM adjustment factor***.** TDM is the application of strategies and policies to reduce travel demand or redistribute the demand over space and time, reducing peak rates. TDM has been a successful tool to reduce parking demand in cities, campuses, and individual sites throughout the country through encouraging the use of public transit, active transportation, or shared modes. TDM programs and policies can reduce the parking demand on any given site by up to 40% depending on the site's existing conditions, the effectiveness of the implementation, and the alternative modes currently available[ii]. Due to the many transit options available at Union Station, the pedestrian environment, and the planned mixed-use, high-density characteristics of this site, a TDM reduction factor of 15% was applied to this site.

Both the captive market effect, the TDM adjustment factor, and an office employee parking share were applied to each land uses peak demand period using the formula below. While the TDM and captive market effects were described in the previous memo, the employee parking demand is defined as the average share of peak parking demand consumed by employees as opposed to visitors on site for non-office land uses. For this analysis, a factor of 20% was used for commercial/retail and restaurant uses.

Calibrated peak demand = (1 - captive market effect) * ((1 – TDM impact) * office employee parking share * peak demand + (1 - captive market effect) * (1-office employee parking share) * peak demand)

Each of these land uses experiences a peak in their parking demand at different times throughout the day, as seen in **Table A1**. Our model is guided by the Urban Land Institute's *Shared Parking Manual* (2005), as well as data from sites examined in our previous studies and additional resources including the Victory Transportation Policy Institute (VTPI) and the High Cost of Free Parking (Shoup, 2005).

Table A1: Hourly Parking Demand by Land Use

	Office	Commercial/ Retail	Transportation Center
6AM	-	-	5%
7AM	19%	5%	50%
8AM	64%	18%	88%
9AM	91%	38%	96%
10AM	99%	68%	98%
11AM	99%	91%	100%
12PM	98%	100%	100%
1PM	96%	97%	99%
2PM	100%	95%	98%
3PM	99%	88%	94%
4PM	90%	78%	83%
5PM	58%	62%	50%
6PM	25%	64%	22%
7PM	-	77%	13%
8PM	-	70%	5%
9PM	-	42%	2%
10PM	-	-	1%
11PM	-	-	1%
12AM	-	-	1%

Source: Sam Schwartz

The calibrated peak parking demand for each of the proposed land uses was applied to the land uses hourly parking demand per the hourly parking demand factors stated above using the below formula.

Hourly demand = Parking demand reduction rate * hourly demand by land use

In applying the captive market and TDM reduction factors as described (in detail) in the memorandum, the adjusted total peak parking demand is estimated to be 740 occupied parking spaces.

This analysis uses a computer model developed by *Sam Schwartz* to provide a data-driven parking demand projection for new development with consideration of the following:

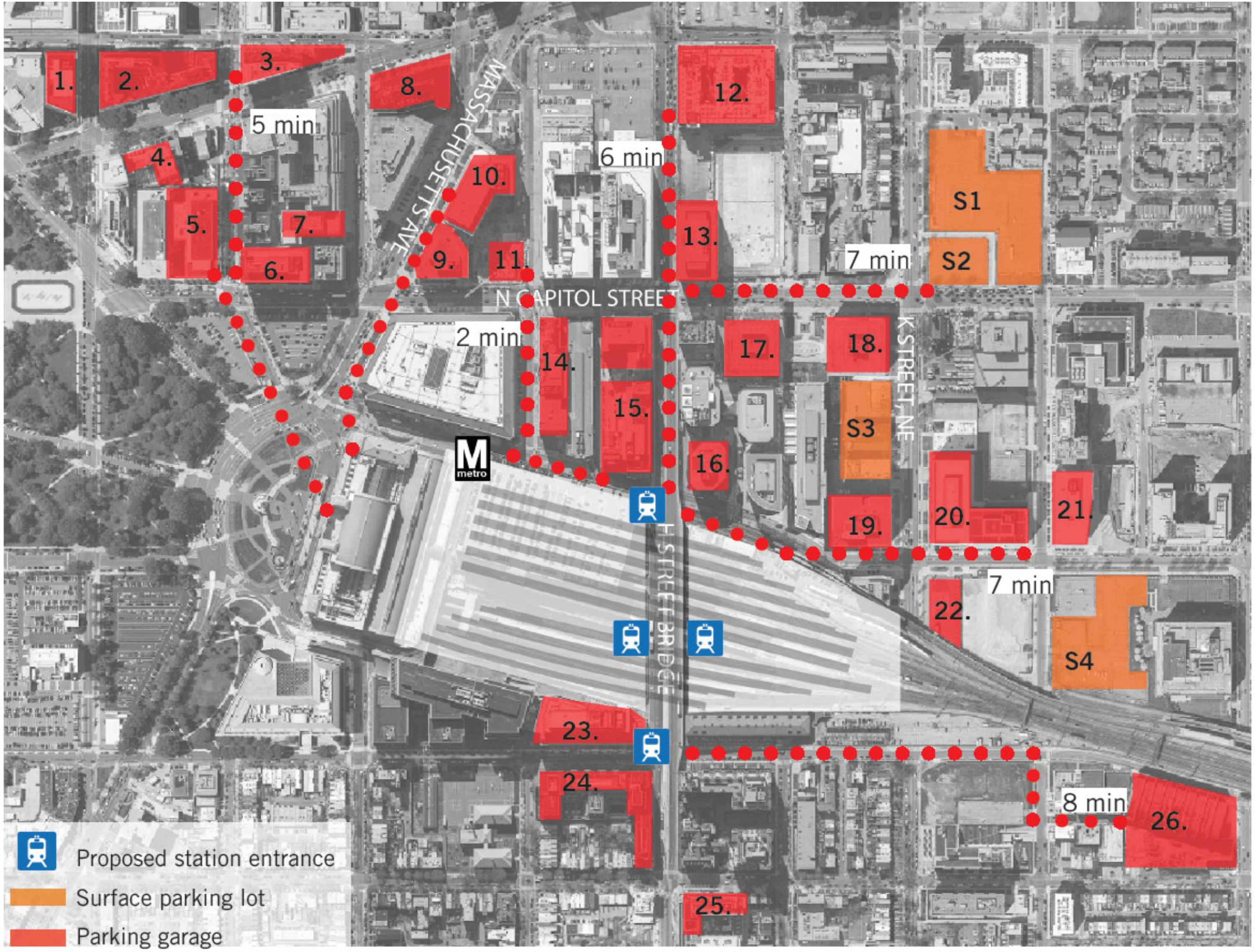
- Varied demand that exists among adjacent land uses;
- The propensity for drivers to park once and walk to multiple nearby destinations; and,
- Reductions in single-occupancy vehicles (SOVs) in conjunction with TDM measures.

Through implementing this tool, the quantity of parking spaces necessary to support a development without inconveniencing residents and visitors can typically be reduced. There are many potential benefits to being able to reduce the quantity of parking necessary to support a development, including but not limited to the following:

- Environmental benefits: potential for less stormwater runoff, less concrete production resulting in fewer greenhouse gas emissions from cement creation, smaller urban “heat island” effect of asphalt, etc.
- Economic benefits: land can be used for economically efficient activities resulting in increased property tax revenues, and the cost of overbuilding parking may not need to be passed on to tenants or site patrons.
- Security benefits: oversized parking lots can sometimes be difficult to patrol or even be local crime hotspots.
- Health benefits: walkable activity centers encourage walking instead of driving unnecessary short distances from one parking lot to another one close by.
- Aesthetic benefits: parking lots/garages are often an “eye sore”.

The tool works by using the number of units or square feet of the land uses associated with a new development as an input, calculating the parking needs based on the ITE Parking Generation publication, and identifying periods of peak and non-peak demand based on ULI’s published hourly parking demand patterns and other site characteristics to qualitatively assess the site’s contextual factors that may influence true parking demand.

Figure A1: Parking Facilities Within an 8-Minute Walk of Union Station



Source: Sam Schwartz

Figure A2: Parking Facility details Within an 8-Minute Walk of Union

Map ID	Owner/Operator	Location	Capacity	Hours	Daily Rate	Utilization Rate	# of used spaces	# of available spaces
S1 + S2	Franklin Parking, LLC	10 K St NW	505	M-Su 530am - 7pm	$9.00	25%	126	379
S3	U-Street Parking, Inc.	15 K St NE	70	M-Su 6am-7pm	$10.00	0%	0	NA
18	SP Plus Corporation / Atlantic Parking	999 N Capitol St NE	366	M-F 7am-7pm	$21.00	0%	0	NA
19	Imperial Parking (U.S.), LLC	77 K St NE	239	M-Fri 530am-7pm	$17.00	0%	0	NA
17	SP Plus Corporation	899 N Capitol St NE	210	M-F 7am-7pm	$21.00	0%	0	NA
15	SP Plus Corporation	750 1st St NE	231	M-F 7am-7pm	$20.00	85%	196	35
10	SP Plus Corporation	25 Massachusetts Ave NW	125	M-Fri 6am-8pm	$22.00	75%	94	31
11	Colonial Parking, Inc	660 N Capitol St NW	205	M-F 6am-9pm	$22.00	75%	154	51
8	Imperial Parking (U.S.), LLC	601 New Jersey Ave NW	230	M-F 7am-7pm	$22.00	0%	0	NA
7	Colonial Parking, Inc.	21 F St NW	99	M-F 7am-7pm	$0.00	0%	0	NA
3	Colonial Parking, Inc.	500 New Jersey Ave NW	80	M-F 7am-7pm	$20.00	0%	0	NA
5	Colonial Parking, Inc.	400 N Capitol St NW	200	M-Su 6am-12am	$22.00	80%	160	40
4	SP Plus Corporation	415 New Jersey Ave NW	208	M-Su All Day	$28.00	0%	0	NA
2	SP Plus Corporation	400 New Jersey Ave NW	212	M-Su All Day	$62.00	0%	0	NA
1	SP Plus Corporation	300 New Jersey Ave NW	467	M-F 6am-10pm	$26.00	0%	0	NA
24	One Parking, LLC	1140 3rd St NE	168	M-W 6am-10pm; Th-F 6am-12am	$16.00	0%	0	NA
21	Parking Management Inc	1100 1st Street, NE	190	M-F 6am-7pm	$13.00	0%	0	NA
20	Colonial Parking Inc	749 90 K St NE	318	M-F 6am-7pm	$17.00	0%	0	NA
12	Atlantic Service Group	99 H St NW	139	M-Sun 6am-12am	$20.00	0%	0	NA
13	LAZ Parking Limited	800 N Capitol St NW	231	M-F 6am-8pm	$18.00	0%	0	NA
16	SP Plus Corporation	810 1st St NE	124	M-F 7am-7pm	$20.00	0%	0	NA
14	SP Plus Corporation	10 G Street NE	186	M-F 7am-7pm	$20.00	0%	0	NA
22	Nation Parking	700 2nd St NE	150	Mon-Sun all day	$15.00	0%	0	NA
23	LAZ Parking Limited	701 2nd Street NE	150	M-F 7am-7pm	$15.00	0%	0	NA
S4	Parking Management Inc	131 M St NE	234	M-F 6am-7pm	$13.00	90%	211	23
Total			**5337**		**$19.50**	**72%**	**941**	**559**

Source: Sam Schwartz

APPENDIX B

PICK-UP AND DROP-OFF OPERATIONS AND TRAFFIC ASSESSMENT

APPENDIX B1

PICK-UP AND DROP-OFF OPERATIONS

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Schwartz

Washington Union Station Pick-up and Drop-off Operations

Research Findings and Independent Analysis of the Draft Environmental Impact Statement (DEIS) and Draft Section 4(f) Evaluation for the Washington Union Station (WUS) Expansion Project

September 2020

Introduction/ Executive Summary

The Federal Railroad Administration (FRA) released the Washington Union Station (WUS) Expansion Project Draft Environmental Impact Statement (DEIS) for public review and comment on June 4, 2020. The WUS Expansion Project, which plans for intercity and commuter rail ridership increases of 140% added passengers through 2040,[1] presents a unique opportunity to address current operational issues and implement design elements that will result in a world-class facility reflective of future conditions and responsive to changes in how people travel and interact with the public realm.

The context of cities has changed substantially since the layout of WUS was last reconceived. Planners and engineers now recognize the futility of continuing to create unlimited capacity for automobiles, and the role that induced demand plays in determining transportation outcomes. We know that trip choices in urban environments with multiple modes respond to the options that are provided. Our understanding of the physical ramifications of street design and traffic has also changed – the relationship between car traffic and pedestrian safety, walkability, and sense of place is better understood now than in the past.

From a transportation standpoint, the key to an effective transit hub is access. Access is a function of the different transportation options provided: the number of transportation choices and their respective cost, convenience, comfort, and safety. Once a major piece of infrastructure like a transit hub has been built it can be difficult to change those elements. Signature transit hubs in major cities are not redeveloped often; this typically occurs every three or four generations or more.

It is therefore critical to plan and design proactively for desired outcomes. Large-scale projects like the WUS redevelopment shape customer access choices through their design. Looking at recent trends in the greater Washington, DC, region, total drive alone mode share (including transportation network companies (TNCs) like Uber and Lyft) has decreased by 12.8% (from 66.9% to 58.3%) from 2007 to 2019, while transit share has increased by 36% (from 17.7% to 24.1%).[2] In its MoveDC plan, the City has set a goal of 75% of trips being made by non-automobile modes compared to about 60% in 2010.[3]

WUS can support and respond to these changes by providing the best possible facilities for multiple modes of access. Different modes have different needs and can be seen as a hierarchy. For walking and biking, safe, direct, comfortable routes are key to maximizing the number of people who choose those modes. This requires ensuring that the streets around WUS minimize car traffic and loading activity and accommodate wide, physically protected sidewalks, bikeways, and pedestrian crossings. Compared to those walking and bicycling, those arriving by car (whether for-hire vehicle or personal automobile) can

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[1] USDOT-FRA. (June 2020). Draft Environmental Impact Statement for Washington Union Station Expansion Project – Table ES-2. https://railroads.dot.gov/environmental-reviews/washington-union-station-expansion-project/draft-environmental-impact

[2] https://www.mwcog.org/file.aspx?&A=1AAuS26tuk0qvTVF52Q7%2bD87I582VWw4yNkHhrI8JrM%3d

[3] http://wemovedc.org/resources/Final/Part%201_Strategic_Multimodal_Plan/Strategic_Multimodal_Plan.pdf

more easily drive a little out of their way to a central pick-up/drop-off (PUDO) facility, with minimal impact on their trip convenience or cost.

If, on the other hand, a hub like WUS is surrounded by high-traffic streets with constant PUDO activity and double parking, then those streets will create a physical and psychological barrier around the station that hampers its potential as an economic, civic, and cultural hub for our nation's capital. A review of the DEIS traffic study indicates that the surrounding streets will degrade in level of service with longer delays and queues. This will be exacerbated with the proposed amount of PUDO activity at several key locations. Interventions such as a below-grade PUDO facility will help alleviate congestion and improve the public realm at the surface level while also improving the customer and service provider's experience.

With this urban planning context in mind, Sam Schwartz Engineering (Sam Schwartz) reviewed the DEIS Preferred Alternative A-C with a focus on PUDO operations and identified key concerns. Notably, the DEIS Preferred Alternative A-C does not account for recent PUDO trends and best practices. Specifically, it does not include a centralized PUDO facility, which is proven to provide significant benefits including:

- more efficient PUDO operations;
- accommodation of Friend/Family PUDO;
- reduction of vehicular circulation around the station and within the surrounding neighborhoods;
- reduced demands for on-street PUDO, allowing for improved and increased pedestrian and bicycle facilities, more seamless integration of WUS into the surrounding community, and respect for the historic setting and WUS building; and
- a positive customer experience by providing PUDO operations in close proximity to other transit modes in a covered area that provides protection during inclement weather.

Providing a centralized PUDO facility at WUS in addition to other distributed PUDO locations is a solution developed through extensive research of best layout and management practices at other transportation facilities. It is informed by careful consideration of the station's urban context – a context that includes a significant historic structure in an important civic setting; adjacency to established and emerging neighborhoods; the District's mode share policy goals; and the opportunity for placemaking. Without a centralized PUDO facility, the DEIS proposal would not meet key elements of the stated purpose and need of the project (Section ES.6), including facilitating intermodal travel, providing a positive customer experience, enhancing integration with adjacent neighborhoods, and supporting continued preservation of the historic station building.

This memorandum provides a summary of recent PUDO trends and best practices, a review of the DEIS Preferred Alternative A-C proposal, and recommendations for design elements that should be included in the DEIS proposal to achieve the goals of the project.[4] The intent is to develop an optimized solution that balances the needs of all stakeholders and meets the goals of the DEIS. It recommends that a centralized below-grade PUDO facility be considered as part of the overall PUDO operations plan.

The paper is organized into the following sections:

1. PUDO Facility Best Practices
2. DEIS Proposed PUDO Operations
  2.1. Performance and Operational Evaluation of DEIS PUDO Proposal
3. Modified A-C PUDO Proposal

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[4] In this memorandum, the term PUDO is defined to include both Friend/Family and for-hire vehicle (FHV) activity such as Lyft, Uber, traditional taxis, and limousines. The DEIS defines PUDO as Friend/Family activity only, and separately defines FHV as Lyft, Uber, traditional taxis, and limousines. Unless otherwise noted, all references in this paper to DEIS PUDO are in reference to Preferred Alternative A-C.

1. PUDO Facility Best Practices

The following is a brief overview of best practices and lessons learned from design of high volume PUDO facilities such as passenger terminals. A detailed discussion of other best practices can be found in Appendix A.

- System Functionality – The pick-up/drop-off zones are only as efficient as the weakest link. Therefore, the relationship, capacity, and operation of the entry and exit zones may be the limiting factor to overall throughput and efficiency. When developing and assessing solutions, all three parts of the system should be considered.
    - Flexibility – The design and operations should provide as much flexibility as possible. Flexibility addresses factors such as changes in pick-up vs drop-off demands, private (Friend/Family) versus commercial (FHV) operations, even changes in FHV provider demands or service types (e.g. luxury service or shared rides). All of these reflect different operating characteristics such as dwell times, customer expectations, or pedestrian queues.
    - Management – Along with flexibility is the need to manage the various system zones (entry, PUDO, exit) to optimize performance. Space allocations can be shifted during peak periods to account for higher distribution of drop-offs, pick-ups, or rematch opportunities. At higher volume locations, staff are often needed to manage entering and exiting traffic, find available spaces, enforce excessive dwelling, and inform passengers or manage pedestrian queues. Without the physical management, chaos and compromised efficiencies can arise and become ubiquitous during peaks.

- Staging Areas – Staging areas, often referred to as “hold lots” for FHVs or “cell phone lots” for Friend/Family, provide space for demand queues or early arrivals respectively. Without staging areas, the local roads and curbside can experience cruising and excessive curb demands that have negative impacts on areawide congestion. Staging areas should be located proximate to the service areas to maximize use and minimize traffic impacts.

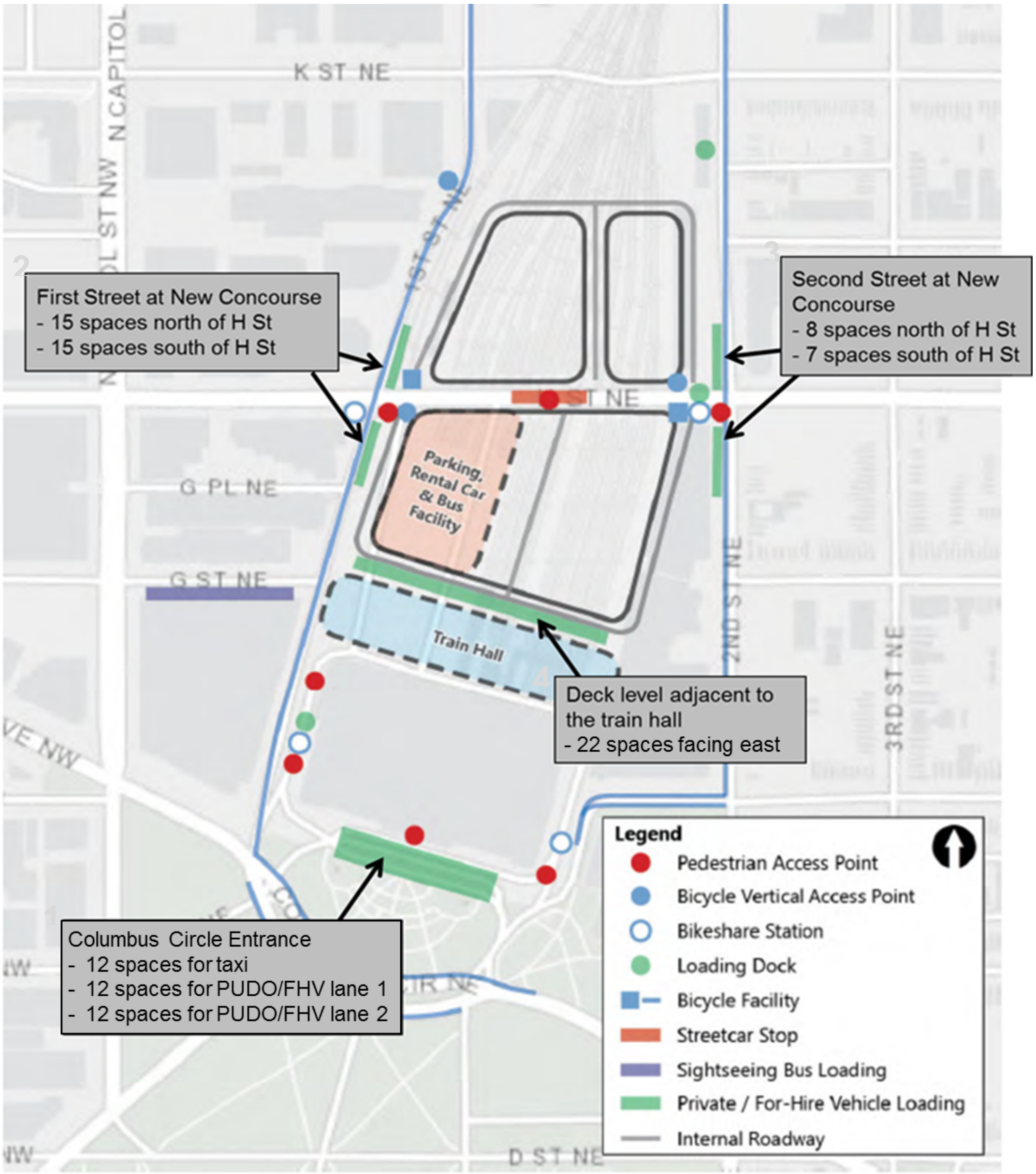
- Rematch – Allowing for vehicles that have just dropped off to quickly “rematch” to a pick-up can reduce circulation and driver dwell times. Physical designs that link drop-off areas to pick-up areas help facilitate this motion. In this context rematch refers only to getting another ride before leaving the site; however, depending on future operations, it could also refer to skipping a “virtual queue” as is done in many airport contexts with hold lots.

- Special considerations – Local context is another important consideration in the design and operation of PUDO facilities. For example, historic and/or neighborhood impacts are of greater concern in a setting such as WUS than at a stadium, airport, or other low-density commercial/industrial area.

2. DEIS Proposed PUDO Operations

The overall approach to PUDO in the DEIS proposal is to distribute operations at four facilities around WUS. **Figure 1** summarizes the location of the four proposed PUDO facilities along Columbus Circle, 1st Street, 2nd Street, and at the deck level.

Figure 1: DEIS Proposed PUDO Locations[5]



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[5] Graphic was created based on Figure 5-20 of the Draft Environmental Impact Statement. Total PUDO spaces available at Location 4, Train Hall, are shown to comprise 17 total spaces per Drawing 021 in Appendix A5a. Elsewhere, the Train Hall is described as having 550' of linear frontage available, yielding 22 spaces.

Summary of DEIS PUDO Facilities

A description of each of the four PUDO facilities is provided based on available information in the DEIS. This memo evaluates each facility[6] based on the likely performance given the projected peak hour PUDO activity, considering potential queues and circulation. A review of the traffic flows associated with the proposed PUDO facilities conducted separately finds significant problems with traffic volumes and intersections serving WUS in the FRA DEIS Alternative A-C. In addition, the analysis provided here also identifies significant concerns about the operational feasibility of PUDO circulation at three of the four facilities included in the FRA proposal *(note: the Burnham Place consultant team is performing independent traffic analyses to assess and compare the projected traffic conditions with and without a below-grade PUDO facility as of this writing).*

General Concerns:

Lack of staging areas: The DEIS acknowledges that extended standing on the curbside is not accommodated. A parking facility capable of accommodating short-term parking that would meet this need is provided in all alternatives, however no details are included. Curbside capacity analysis in the DEIS assumed average dwell times of 60 seconds for pick-ups and 15 seconds for drop-offs. However, this does not account for early arrivals of Friend/Family, nor queues for FHVs. Analyses and models are typically limited in their ability to account for the extra time finding a space, or friction leaving spaces during peak periods. It does not seem reasonable to assume that staging areas can be identified near the four proposed PUDO service locations. A single location, such as one of the WUS garage decks, would likely cause excessive traffic congestion and inefficient use and circulation.

Distribution of spaces vs. demand: The four proposed PUDO locations are shown on **Figure 1** and the number of spaces based on information presented in the DEIS and Sam Schwartz assumptions (where detailed information is not provided in the DEIS) are summarized in **Table 1**. As shown in **Table 1**, the number of spaces proposed in the DEIS that would be provided at each PUDO facility does not align with the projected demand for each facility. In some cases, like at the 1st and 2nd Street facilities, providing a greater number of spaces than the percentage of operations expected to use each facility could provide potential benefits, as these facilities are on city streets and additional space for PUDO may reduce the likelihood of double parking or impacts to traffic flow, or reduce the need for active management of those facilities. As seen in **Table 1**, the number of PUDO spaces available at Columbus Circle and the deck level are proportionally lower than the overall number of spaces required per FRA demand allocation. The potential problem is that if the number of spaces provided does not align with demand projections, it may result in issues of queue spillback, especially at Columbus Circle, which is already observed to operate poorly under current conditions.

Rematch: The DEIS trip generation and assignments assumed an FHV rematch of 50%, which is accounted for through recirculation between different pick-up and drop-off facilities. FHV drivers would be expected to sometimes combine pick-ups and drop-offs at the same location and sometimes circulate from a drop-off to a pick-up. Drop-off and pick-up may occur on the H Street level and drop-offs on the H Street level would also be able to recirculate to the front of the station. Similar links would occur between the front and First Street and between First Street and a below-ground facility with access from K Street, if provided."[7] Distributed on-street PUDO locations provide taxis the operational flexibility to drop-off and pick-up either at the same location or nearby, however TNCs are limited to the providers' applications and algorithms which do not always provide an immediate rematch. Centralized PUDO facilities provide

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[6] PUDO facilities for the DEIS's preferred alternative are described on page 3-87 of the DEIS.
[7] Email from David Valenstein (FRA) to Matt Klein (Akridge), August 26, 2020. Subject: Washington Union Station Expansion Project - Request for Technical Data.

higher opportunities for increased efficiency of rematched pick-ups due to higher concentration of turnover.

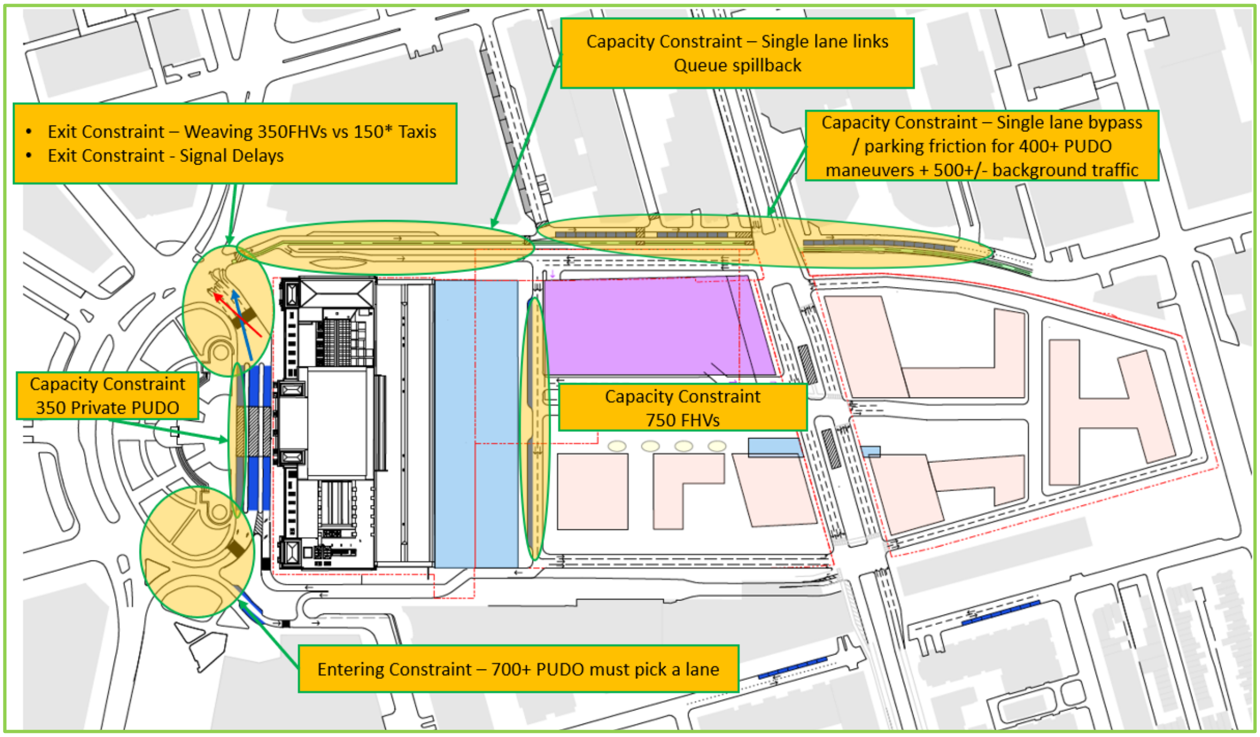
Table 1: DEIS PUDO Facility Summary

PUDO Location	**Total Spaces**	**% of Spaces**	**% of PUDO Operations** (Projected by FRA)
Columbus Circle	36*	37%	40%
Deck Level	17*	17%	35%
1st Street	30	31%	20%
2nd Street	15	15%	5%
Total	**98**	**100%**	**100%**

Note: the total number of spaces at Columbus Circle and the Deck Level are not specifically included in the DEIS. At these locations we estimated the spaces available based on the length of curb space available, as described in the following sections.

The major concerns with each proposed PUDO location are discussed below and illustrated in **Figure 2**.

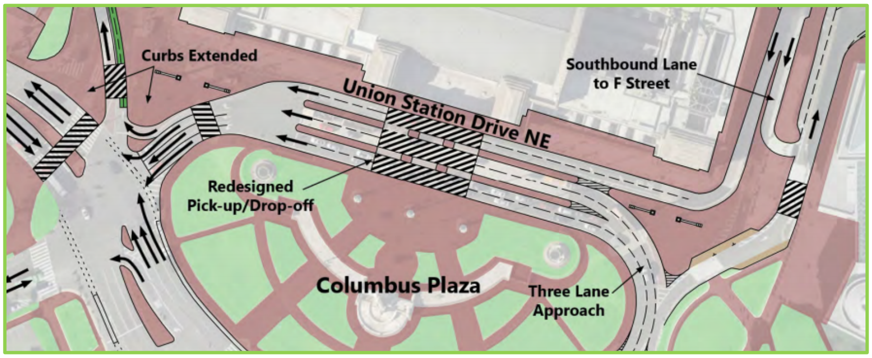
Figure 2: Concerns with DEIS Proposed PUDO Locations



PUDO Location 1: Columbus Circle

The DEIS design of the Columbus Circle PUDO facility is similar to current conditions, with the exception being that tourist and hop-on/hop-off buses would be removed from the middle two lanes, making the entire Columbus Circle facility available exclusively for PUDO functions. There would continue to be three parallel roads in front of the historic station entrance, each with two travel lanes, as shown on **Figure 3**. FRA provided the following description of operations for the three roads.[8] The right lane of each road would provide loading and unloading access and the left lane would facilitate passing. The northern roadway (closest to Union Station) would continue to be dedicated for taxis only, and taxis would continue to have separate access from the roadway that wraps around the station from the deck level. While the DEIS describes the taxi area as containing 24 spaces, we estimate that there would only be 12 functional spaces, with two rows of six spaces and each row loading and departing in unison. The remaining two roadways would accommodate PUDO, each with another 12 functional spaces.

Figure 3: DEIS Proposed Design for Columbus Circle PUDO Facility



Source: Section 106 Consulting Parties Meeting #8

There are concerns with all three components of the Alternative A-C PUDO at Columbus Circle (entry, service, and exit), and in addition, impacts on pedestrian activity, as follows:

- Entry – Notwithstanding the capacity constraints at the signalized intersection, the entry must accommodate an estimated 700+ vehicles sorting themselves between the middle aisle for FHVs and the outer aisle for Friend/Family. This weaving condition occurs over approximately 200 feet along a horizontal curve. Sorting and weaving cause slower than usual approach speeds and restricts capacity. Aggressive signing is likely not an option to help mitigate due to the historic preservation issues.
- Service – The outer aisle is estimated to provide service for approximately 350 Friend/Family vehicles during the peak hour. This is projected to be above the capacity for 12 spaces allotted to service the demands.
- Exit – The exit is projected to be the major constraint to efficient operations. The design will result in weaving caused by the taxis exiting onto Massachusetts Avenue crossing in front of the FHVs who have dropped off passengers in the middle lane and are destined for the proposed button-hook ramp to 1st Street. The queue of vehicles from the signal, particularly taxis, will block free-flow movement to 1st Street and thus restrict the volume trying to exit from other PUDO lanes.

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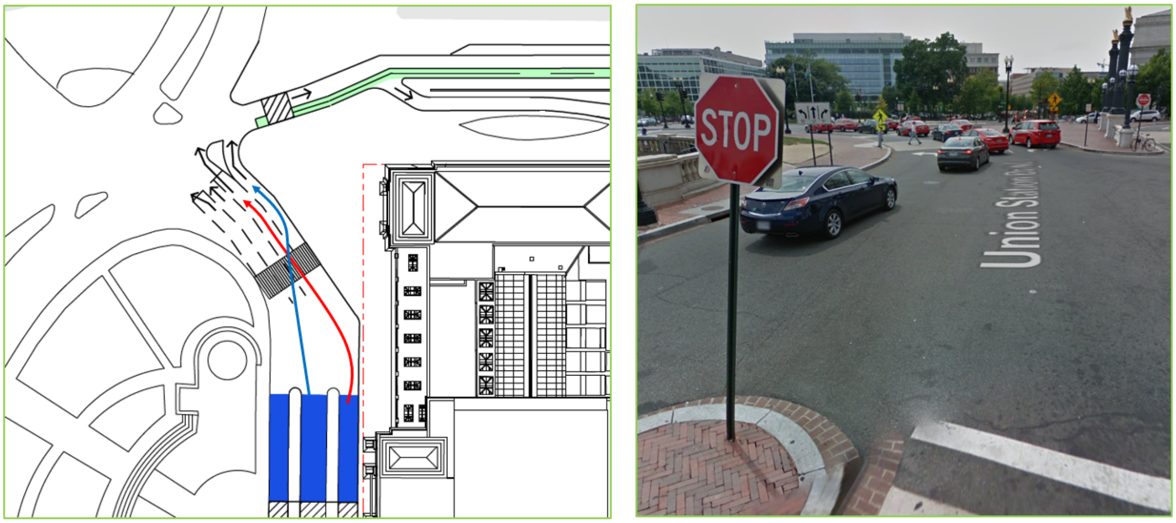
[8] Email from David Valenstein (FRA) to Matt Klein (Akridge), August 26, 2020. Subject: Washington Union Station Expansion Project - Request for Technical Data.

Figure 4 illustrates the existing queue of taxis at this location. This queue will also likely block the crosswalk shown in the DEIS plan depicted in **Figure 4**.

- Pedestrian Activity – Increased pedestrian activity in the future will also cause increased conflicts at the crosswalks. This will also cause increased crowding on the narrow islands as passengers wait, embark, and alight from their rides.

Figure 4: Proposed and existing operations at exit to Columbus Circle



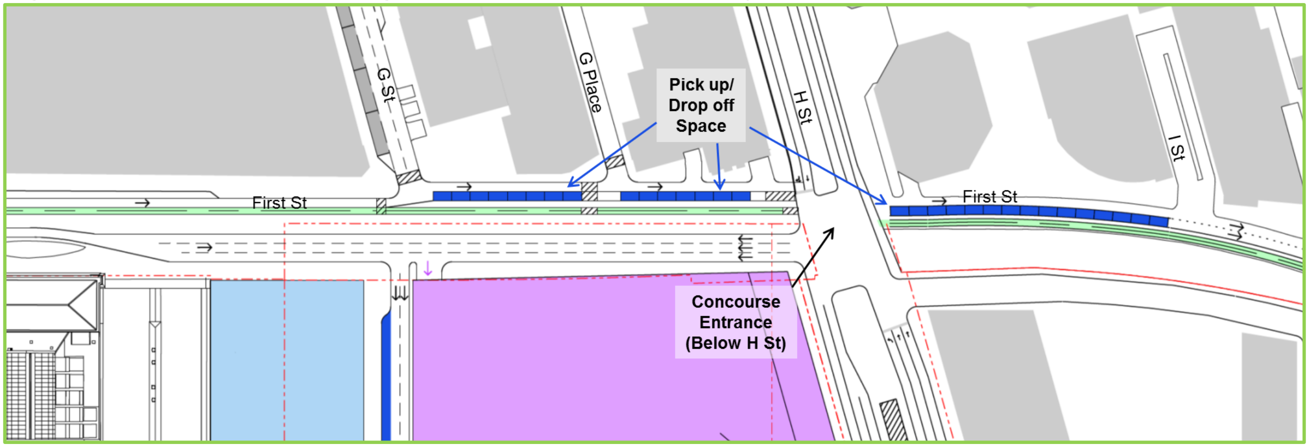
PUDO Location 2: First Street, NE

The DEIS design of the 1st Street PUDO facility would create 30 spaces for PUDO operations along the east side of 1st Street near the new H Street Concourse entrance. It is assumed that both pick-up and drop-off activity would be accommodated at this facility. The DEIS design indicates that 1st Street would operate with one northbound travel lane, the PUDO lane, and a cycle track between the PUDO lane and the sidewalk, as shown on **Figure 5**. The PUDO lane and the travel lane both appear to be 11 feet wide. Similar to the description for the Columbus Circle facility, no information is given in the DEIS for how this facility would operate or be configured to meet the variations in use and demand.

Concerns with the 1st Street operation include the following:

- While 30 spaces are provided to service an estimated peak demand of 400+ pick-ups and drop-offs, the single through lane is projected to be constrained by the 400 vehicles looking for a space and maneuvering in/out of these spaces.
- In addition, there are an estimated 500+ vehicles that constitute background traffic not associated with PUDO. The activity of 900+ vehicles would occur on one travel lane past the PUDO spaces. The background traffic may also include a high percentage of buses due to the proposed bus facility on G Street. All this activity will be difficult, at best, to manage with one travel lane.
- The single lane leading from Massachusetts Avenue/Columbus Circle is also projected to experience queues that may reach Columbus Circle during peak periods.

Figure 5: DEIS Proposed Design for 1st Street PUDO Facility



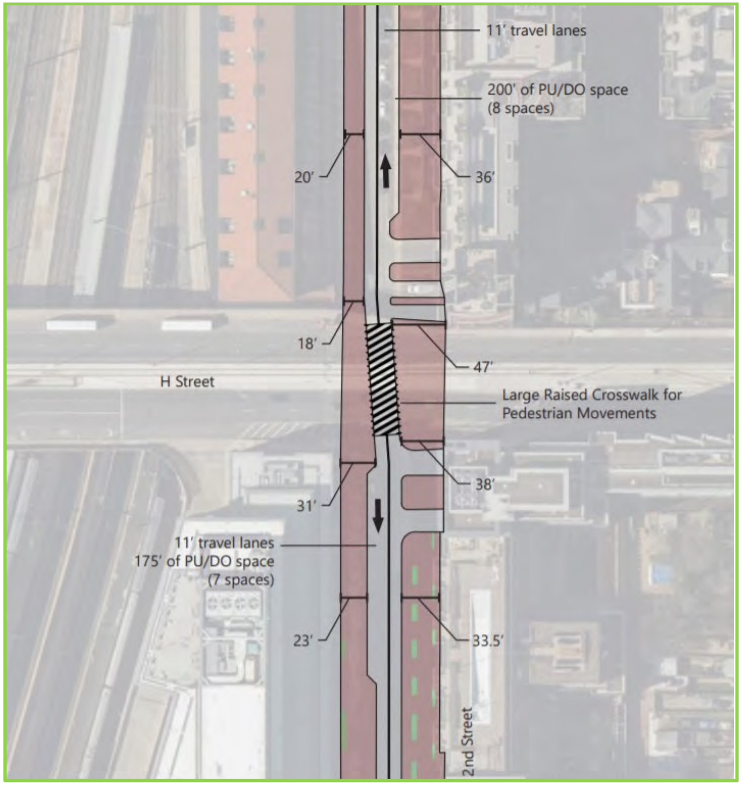
Source: Based on DEIS circulation plans

PUDO Location 3: 2nd Street

The DEIS design of the 2nd Street PUDO facility would create 15 spaces for PUDO operations along either side of 2nd Street near the new H Street Concourse entrance, as shown on **Figure 6**. 2nd Street would be a two-way street with one 11 foot travel lane in each direction. Seven PUDO spaces would be located on southbound 2nd Street, south of H Street, and eight PUDO spaces would be located on northbound 2nd Street, north of H Street. Each PUDO area was analyzed separately. The PUDO lanes appear to be 8 feet wide. It is assumed that both pick-up and drop-off activity would be accommodated at this facility.

The number of spaces provided, along with the low volumes estimated to use this PUDO location and relatively low background volumes do not appear to cause a concern at this location.

Figure 6: DEIS Proposed Design for 2nd Street PUDO Facility



Source: Section 106 Consulting Parties Meeting #8

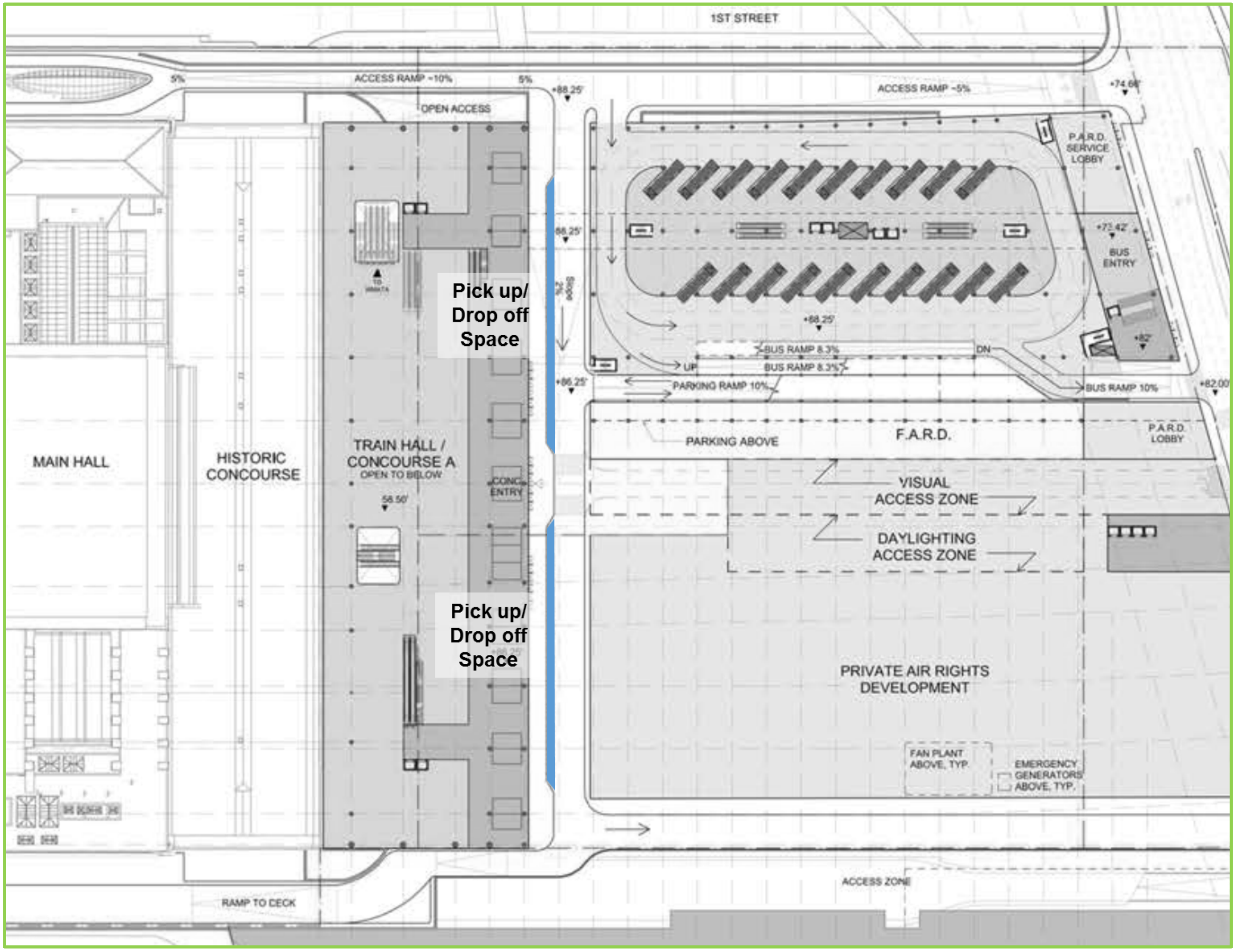
PUDO Location 4: Deck-Level

The DEIS does not provide details about the design of the deck-level PUDO facility at the Train Hall, shown in **Figure 7**; however, our analysis is based on a review of the DEIS circulation plan and drawings. The 428 feet length of curb space shown in the DEIS drawings shows that this facility would have a capacity of approximately 17 curbside spaces for PUDO operations.

However, similar to the descriptions for the other PUDO facilities, no information is given regarding the planned operations including potential separation of pick-up and drop-off zones or accommodation of Friend/Family demands. As shown below in the capacity analysis comparing single- and multi-server FHV PUDO operations in Table 2, even a multi-server operation at the Train Hall requires 21 spaces to meet the peak hour demand identified in the DEIS. In practice, this operation cannot be accommodated at the Train Hall in the 17 spaces available. In addition, the DEIS does not provide any information for planned or expected traffic flows at the deck-level facility, including queueing areas, merging of northbound and southbound traffic on the east service road, access to and egress from the proposed parking structure, and coordination of station traffic with Burnham Place circulation.

The demands estimated for the deck-level PUDO are approximately 750 peak-hour vehicles, accommodated in the 17 spaces. Additional station traffic to/from the garage would add to the congestion on the PUDO frontage road along the face of the Train Hall. Servicing 750 vehicles would assume an extremely efficient operation of the 17 spaces, with less than 2 minutes for each space to turnover. As discussed in the subsequent section of this document, we believe a minimum of 2 minutes reflects a closer estimation of turnover time. This accounts for searching for a space, matching with passengers, and friction departing the space; not to mention early Friend/Family arrivals who will try to occupy a space until addressed by enforcement. If demand is not accommodated, queues could impact the entry intersection to the Train Hall PUDO as well as spill back towards H Street and down the ramp towards Columbus Circle. Under the DEIS plan, this deck-level road is also assumed to continue to be used as taxi staging/queuing for the Columbus Circle taxi stand. These queues will restrict the exiting capacity of the PUDO operations. Some of these issues could perhaps be addressed by the addition of more traffic lanes in front of the Train Hall, but this solution is not illustrated in the DEIS and would have significant impacts on Burnham Place and pedestrian access to the Train Hall.

Figure 7: DEIS Proposed Design for Deck-Level PUDO Facility



Source: Washington Union Station Expansion Project DEIS.

2.1 Performance and Operational Evaluation of DEIS PUDO Proposal

Sam Schwartz undertook a queueing analysis of the operation of each PUDO facility in Alternative A-C, to determine if the capacity of the PUDO facility would adequately meet demand without resulting in queue spillback and the potential to affect local roadway traffic flow. Details of the queuing analysis can be found in Appendix B. This analysis provides a preliminary check on the operation assuming ideal conditions, which as noted here are very unlikely to be achieved for the proposed PUDO facilities given their configuration, access, and operational constraints.

Based on projections in the DEIS and as shown on **Table 2**, if the DEIS-proposed PUDO facilities were to operate as single-server systems (note: see Appendix B for definition of single and multiple server systems), arrival rates would exceed service rates such that queues would grow indefinitely, with the exception of the 2nd Street PUDO facility, which is expected to accommodate lower demand. If the DEIS-proposed PUDO facilities were to operate as multiple-server systems, the total number of spaces provided at each facility would theoretically accommodate the 95th percentile queues during the AM and PM peak hours.

Table 2: DEIS-Proposed PUDO Facilities - Queue Analysis

Note: PUDO volume is measured in units of transactions, not vehicle trips.

		AM Peak Hour Volume			**PM Peak Hour Volume**		
		FHV	F/F	Total	FHV	F/F	Total
		1,285	842	2,127	1,379	770	2,149
Single Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	654	Indefinite Queue	40%	724	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	Indefinite Queue	(1)	135	Indefinite Queue
Deck Level	17	35%	745	Indefinite Queue	35%	752	Indefinite Queue
First St	30	20%	425	Indefinite Queue	20%	430	Indefinite Queue
Second St NB	8	3%	53	24	3%	54	28
Second St SB	7	3%	53	24	3%	54	28
Multiple Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	654	17	40%	724	18
Columbus Circle Taxi	12	(1)	197	6	(1)	135	5
Deck Level	17	35%	745	20	35%	752	21
First St	30	20%	425	12	20%	430	12
Second St NB	8	3%	53	3	3%	54	3
Second St SB	7	3%	53	3	3%	54	3

(1) Taxi volumes at Columbus Circle are taken from previous counts provided in the FRA DEIS and are not projections. Taxi volumes are included within the total of 40% noted for Columbus Circle FHV/F/F.

The queuing analysis uses the same assumptions as the DEIS for demand volumes and dwell times (i.e. 60 seconds for pick-ups and drop-offs). However, we believe the DEIS assumptions do not reflect the likely operations of the proposed PUDO facilities, and the actual demands will be higher while the capacities will be lower due to several factors:

- Capacities – Capacities are expected to be lower due to factors including time to find an open space, time to match passengers to vehicles, friction departing a space (especially at locations with only one passing lane), and early arrivals. For comparison purposes, the most efficient airport PUDO operations observed by Sam Schwartz using the passenger identification number (PIN) system is closer to 3 minutes per transaction during peak conditions.
- Demands – The DEIS does not account for several trip generators including Burnham Place, and Union Station retail/tourism.

Note that the queuing model is a high-level planning tool to determine base operating conditions of the PUDO locations. It does not account for real world considerations in demands and operations that will typically negatively impact operations. These other considerations that will influence actual operations include, but are not limited to:

- Mix of user types (Uber/Lyft, other TNCs, shared rides such as UberPool, black cars, etc.). Where possible, separate zones or curbsides should be identified for each of these users. Multiple-server operations can still function without separate zones/curbs for the various users, however the efficiency of operations will be compromised. Furthermore, implementation of PIN operations cannot be considered when different users are sharing spaces.
- Arrivals or schedule delays. If several Friend/Family users arrive just five minutes early and enforcement does not request the vehicles to move within 1-2 minutes, then the available capacity is compromised. It is not unusual for Friend/Family users to arrive well in advance of a scheduled train arrival, or for a train to be delayed, requiring correspondingly longer dwell times for portions of this demand type.

3. Modified A-C PUDO Proposal

Because of the impacts of the pick-up and drop-off activities on Burnham Place and the station environment proposed in Alternative A-C, Akridge asked Sam Schwartz to evaluate the potential benefits that the addition of a centralized PUDO facility could provide to the Station Expansion Plan. The Modified A-C proposal introduced here includes a centralized PUDO facility at WUS in addition to the other distributed PUDO locations identified in the DEIS. Not only does this concept provide increased capacity in general, it provides an opportunity to implement a design that facilitates efficient and flexible operations, as well as reduces PUDO activity at the surface and deck levels.

Two facility concepts were developed that alleviate the surface conditions described in the prior sections of this memorandum. They illustrate the feasibility of a below-grade PUDO and determine the amount of demand that could be accommodated. A below-grade facility would be on one level, directly below the concourse. This provides convenient access for users of the PUDO facility, with escalators, elevators, and stairs for vertical circulation. Both concept alternatives are estimated to accommodate up to one-third or more of total estimated PUDO demands. While the actual PUDO spaces provided could potentially accommodate greater volumes, access points from the local street network could potentially be limiting factors for the ultimate capacity of the below-grade facility. It is further noted here that the two alternatives described below illustrate the types of operational and physical arrangements needed to efficiently accommodate the overall PUDO demand in the DEIS program for WUS. Sam Schwartz has been involved in the design and operational observation of these facilities at LaGuardia and LAX airports.

Especially important to note is the fact that the kind of operational efficiencies and multi-program functionalities provided by these facility concepts may not be achievable within the public and private street rights-of-way proposed in the DEIS Alternative A-C.

The components of each alternative include:

- Ramp connections to surface streets,
- Station parking (per District of Columbia Office of Planning capacity recommendations),
- PUDO facilities for Friend/Family including short term parking for early arrivals as well as curb space for pick-ups and drop-offs,
- PUDO facilities for FHVs including queuing space to accommodate either traditional match operations, or higher efficiency PIN system operations; separate drop-off zones are also provided with ability for rematch options to seamlessly join the service queue,
- Taxi hold area and ramp to Columbus Circle.

Alternative 1 consolidates FHV pick-ups into parallel aisles in the center of the garage. With five drive aisles, the facility is expected to provide 72 pick-up spots for TNCs and taxis (~2160 vehicles/hr). Zones are named in the graphic below for illustrative purposes but could be reconfigured as passenger mode share and demand preferences change. The facility also includes a drop-off curb allowing FHVs entering from G Street to drop passengers near elevators to the main concourse and then wrap around for a quick rematch – all within the underground facility. Empty FHVs could enter from a new First Street or K Street ramp and queue in the northern area of the facility.

Private vehicle pick-up/drop-off is also provided next to the FHV facility, including up to 30 short-term parking spaces as well as 16 PUDO spaces. Spaces would work for both pick-ups and drop-offs and allow for short term dwelling, alleviating pressure on surface streets. Three hundred parking spaces are also provided, split with roughly 170 at the southern end and 130 at the northern end.

Alternative 2 features many of the same elements as Alternative 1, with operational and geometric modifications. In Alternative 2, the FHV pick-up/drop-off facility is consolidated with vehicle queuing in one "nested" area at the northern end. This allows for all FHV activity to remain relatively separate from private vehicles and general parking. The alternative provides 35 spaces for FHV pick-up (~1050 vehicles/hr). FHV drop-offs would enter separately with private vehicles from G Street and utilize a drop-off curb along the north eastern section of the parking zone, then join the FHV queue for pick-ups.

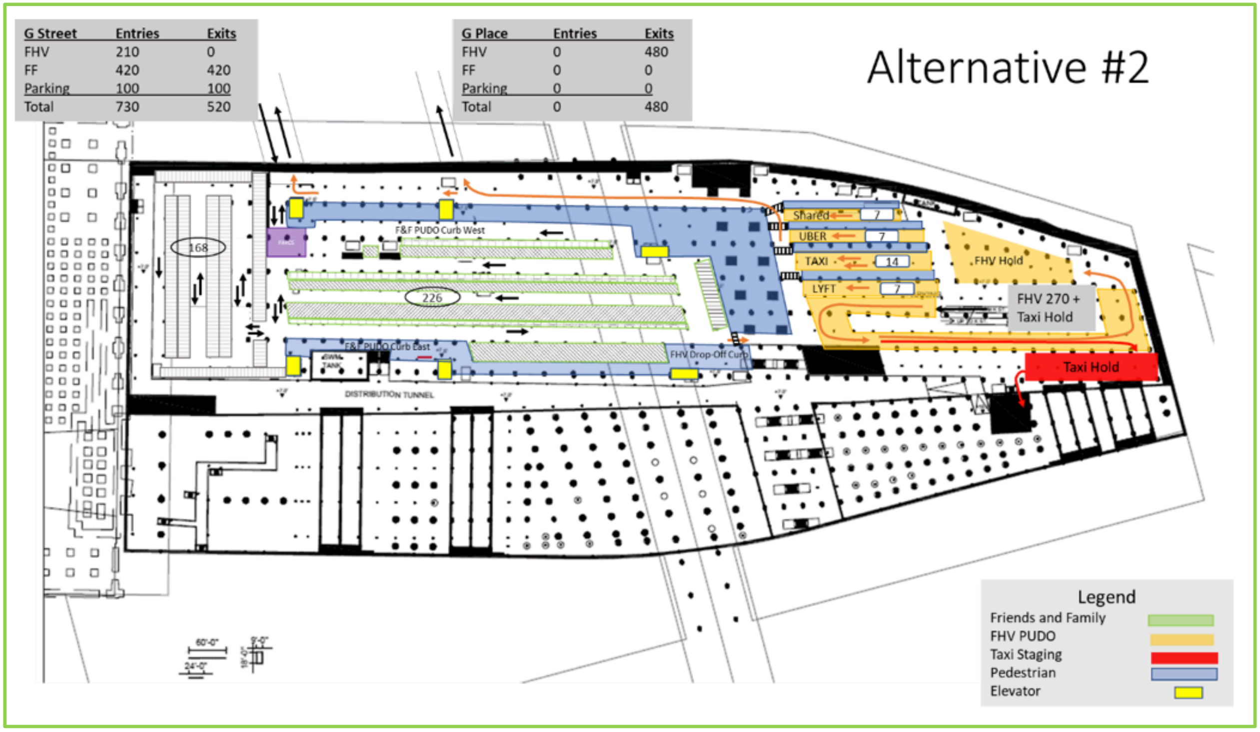
The southern half of the facility is dedicated to private vehicle pick-up/drop-off and general parking. Combined, the facility provides almost 400 spaces for these functions in a nested facility. There are also linear curbs for quick drop-offs and pick-ups which do not require short term parking.

Figure 8: Modified A-C Below-Grade PUDO Proposal, Alternative 1

G Street	Entries	Exits
FHV	210	0
FF	420	420
Parking	100	50
Total	730	470

G Place	Entries	Exits
FHV	0	480
FF	0	0
Parking	0	50
Total	0	530

Figure 9: Modified A-C Below-Grade PUDO Proposal, Alternative 2



G Street	Entries	Exits
FHV	210	0
FF	420	420
Parking	100	100
Total	730	520

G Place	Entries	Exits
FHV	0	480
FF	0	0
Parking	0	0
Total	0	480

3.1 Performance and Operational Evaluation of the Modified A-C Proposal

Sam Schwartz undertook a queueing analysis for concepts utilizing both the distributed and centralized PUDO locations described here, which include the addition of the proposed below-grade PUDO facility. This analysis has made some modifications to assumptions used in the DEIS proposal queuing analysis:

- Operations: Both single and multiple server operations were analyzed. For both analyses, the 95th percentile queue results are documented, which represent the number of curb spaces that would be needed to accommodate queues 95% of the time. The analyses were performed for only the evening (PM) peak hour.

- Dwell Times: Dwell times are consistent with the DEIS proposal queuing analysis, using 60-seconds for all activity. This does not include the need for short term parking for early Friend/Family arrivals. The analysis does not distinguish between drop-offs and pick-ups, which is a limitation of the results. Pick-up and drop-off activities usually have varying dwell times; in this queuing analysis, pick-up and drop-off trips were each assumed to have a dwell time of 60 seconds.

- Volume Inputs: The volume inputs are more conservative and reflect inclusion of additional PUDO activity not included in the DEIS consisting of Burnham Place and Union Station tourism and retail demand, as shown in **Table 3**, highlighted. The FRA projections do not include these trip generators and thus underestimate total demand. The new volumes added here make up about 15% of the total one-way trips.

- Volume Distribution - To alleviate pressure on surface streets (described previously), this scenario includes a new, centralized below-grade PUDO facility. Passenger volumes are redistributed as a result, and also include and accommodate the additional volumes described above. To support the queuing analysis, PUDO demand projections were allocated among the specific PUDO facility locations. The following assumptions were used for the two new demand generators that FRA did not consider: Burnham Place PUDO was allocated 100% to the air rights level. Pick-ups from Union Station retail/tourism were assumed to occur below concourse (65%) and at Columbus Circle (35%), while drop-offs to Union Station retail/tourism were assumed to occur at Columbus Circle (80%) and below concourse (20%). The complete distribution of PUDO activity assumed between the facilities is documented in **Table 6** in Section 6 of this paper.

The queue analysis for the Modified A-C proposal is summarized in **Table 4** below. Each of the locations would experience demands greater than the designed capacity under the single server operation assumption, except for the 2nd Street PUDO facility. Under multiple server operations, the system is projected to operate much more efficiently. Each location is projected to provide sufficient space to accommodate demands, however the Deck Level PUDO location would still be close to capacity (demand for 15 spaces during the PM peak with a supply of 17 spaces) and potentially experience backups during portions of the peak periods. A slight redistribution of demand could mitigate this condition.

Table 3: PUDO/FHV Volume Projections, PM Peak

	Hybrid Projections				
Mode/Land Use	**FHV/Taxi Travel Requests**	**Private PUDO Travel Requests**	**Riders**	**One-Way Vehicle Trips (No Rematch)**	**One-Way Vehicle Trips (Post Rematch)**
Amtrak	1,001	559	1,872	3,119	2,619
MARC	107	60	200	334	280
VRE	8	5	15	25	21
Intercity Bus	125	70	233	389	327
WMATA Metrorail	135	75	252	420	353
Federal Air Rights	3	2	6	10	8
Burnham Place	144	106	300	500	428
Union Station Retail/Tourism	81	60	168	280	240

Total	1,603	936	3,046	5,077	4,276

Note: Rows highlighted in yellow indicate demand generators that our analysis includes but FRA analysis did not include (these are Burnham Place and Union Station Tourism and Retail/Tourism). Non-highlighted rows are per the DEIS Alternative A-C data.

Table 4: Modified A-C Proposed PUDO Facilities - Queue Analysis

Note: PUDO volume is measured in units of transactions, not vehicle trips.

		AM Peak Hour Volume			**PM Peak Hour Volume**		
		FHV	F/F	Total	FHV	F/F	Total
		1,510	1,008	2,517	1,603	936	2,539
Single Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	31%	591	Indefinite Queue	30%	632	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	Indefinite Queue	(1)	135	Indefinite Queue
Deck Level	17	18%	453	Indefinite Queue	22%	562	Indefinite Queue
First St	30	6%	155	Indefinite Queue	6%	148	Indefinite Queue
Second St NB	8	1%	19	2	1%	18	2
Second St SB	7	1%	19	2	1%	18	2
Below-grade F/F (2)	30	17%	430	Indefinite Queue	15%	371	Indefinite Queue
Below-grade FHVs/Taxis (2)	72	26%	652	Indefinite Queue	26%	654	Indefinite Queue
Multiple Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/PUDO	24	31%	591	15	30%	632	16
Columbus Circle Taxi	12	(1)	197	6	(1)	135	5
Deck Level	17	18%	453	12	22%	562	15
First St	30	6%	155	5	6%	148	5
Second St NB	8	1%	19	1	1%	18	1
Second St SB	7	1%	19	1	1%	18	1
Below-grade F/F (2)	30	17%	430	12	15%	371	11
Below-grade FHVs/Taxis (2)	72	26%	652	17	26%	654	17

(1) Taxi volumes at Columbus Circle are taken from previous counts provided in the FRA DEIS and are not projections.

(2) Spaces reflect proposed Alternative 1.

4. DEIS and Modified A-C PUDO Proposal Comparison

Performance of all PUDO facilities with the addition of the below-grade PUDO would be significantly better than the PUDO facilities proposed by FRA's DEIS, based on queue modeling under multi-server conditions.[9] The facilities would see an equal or smaller share of PUDO spaces occupied during 95th percentile activity conditions. Even with greater demand and longer dwell times assumed for the Modified A-C PUDO proposal in the Sam Schwartz modeling, adequate capacity is available and fewer spaces are required to meet demand at all locations, including Columbus Circle, 1st Street, and the Train Hall. By contrast, the PUDO facilities proposed in the DEIS Alternative A-C require more spaces than the Modified A-C PUDO proposal, using model inputs with lower demand and shorter dwell times. Under ideal multi-server conditions, the FRA proposal would have higher peak occupancy, which translates into a **higher likelihood of queue spillback and associated congestion** when conditions are not ideal.[10] Moreover, as seen in the bottom two rows of **Table 4**, the below-grade facility has the potential for a substantial amount of additional capacity within the facility, although utilization of the full additional capacity could likely be limited by the capacity of the local street network at access points to the facility.

The FRA PUDO proposal also could contribute in the following ways to vehicular congestion around WUS:

- At the Columbus Circle facility, taxi operational problems that currently exist are not addressed by the FRA plan. Long taxi queues currently extend beyond the frontage and onto the circulation roadway due to a greater supply of taxis waiting to pick-up passengers than passengers waiting to be picked up and/or inefficient loading operations. Without addressing this, **the proposed deck-level PUDO facility could be blocked and rendered unusable by taxi queues.** In contrast, the Modified A-C PUDO proposal would allow some taxi activity to move to a new below-grade facility.

- The exit to the Columbus Circle facility could also become a bottleneck if the FRA plan does not include intersection and signal design changes. At this location, taxis look to exit onto Massachusetts Avenue while PUDO trips look to access 1st Street or the circulation road/deck-level facility. **This creates a weaving pattern could lead to vehicular conflicts and delays exiting the PUDO facility.** The Modified A-C PUDO proposal would reduce this issue by allowing a significant amount of demand to shift to a new below-grade facility.

- The on-street PUDO facilities on 1st and 2nd Streets under the FRA plan could lead to impacts on the adjacent travel lanes. Based on observations at airports and other taxi stands at major transit hubs, it is not uncommon to observe double parked vehicles or drivers that do not pull-in perfectly to the curbside spaces, sticking out and partially blocking the adjacent lane. The FRA plan does not include measures to mitigate this possibility, leading to a **risk that on-street PUDO facilities could sometimes block circulation of the adjacent through lanes**. The Modified A-C PUDO proposal would reduce this risk by allowing a significant amount of demand to shift to a new below-grade facility.

The Modified A-C Proposal would also produce a significantly improved pedestrian experience outside the station compared with the FRA's DEIS proposal. We estimate that the proposed below-grade facility

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[9] Note that, under a single-server model that mimics a breakdown in PUDO management, both PUDO facility plans would see indefinite queues. This indicates that managing PUDO will be important under both FRA and Modified A-C Proposal designs.

[10] Note that the Modified A-C Proposal analysis assumes a greater level of PUDO demand than FRA indicated, which makes this comparison conservative regarding their performance differences.

would attract roughly 700 PUDO vehicle trips in the PM peak hour that otherwise would be circling the station on surface streets. Without this below-grade centralized facility, the FRA's proposal would produce **more vehicular congestion around the station, potentially generating more pedestrian-vehicle conflicts, more difficult pedestrian crossings of adjacent streets, and a degraded experience of the station**. In addition, the proposal includes short-term parking for early arrivals which the DEIS identified, but includes within a parking facility that is difficult to access and remotely located away from passenger areas, limiting its attractiveness compared to the below-grade facility. **The Modified A-C Proposal would not only reduce traffic "cruising" on surface streets, but alleviate neighborhood curbside utilization.**

Successful operation of PUDO at WUS will require active management strategies to ensure optimal multi-server operations. Unfortunately, the FRA's plan fails to address several critical operational issues that could control whether the proposal can successfully meet its objectives:

- The DEIS proposal does not specify a strategy to accommodate Friend/Family PUDO operations. Those drivers tend to arrive a few minutes before their passengers arrive. If drivers need to wait 5+ minutes for their passenger and these vehicles park in the PUDO facilities or double park adjacent to the PUDO facilities, **they may disrupt operations of the PUDO facility itself and/or traffic operations in the adjacent travel lanes**. Enforcement will be required to direct waiting vehicles to the parking facility, which will essentially generate an increased number of trips on the local street network.

- The DEIS proposal does not present a strategy for rematching FHV trips in order to achieve the 50% rematching target that is assumed. In general, pick-ups and drop-offs should be possible at all PUDO facilities to maximize the chance for rematching of trips with reduced recirculation, and pick-ups should be located downstream of drop-offs. A greater amount of space would be needed at the on-street, curb-side facilities in Alternative A-C to account for longer dwell times as drivers wait for a pick-up trip, as well as including designated spaces for Friend/Family. If rematching cannot be accommodated in an efficient manner, **it will generate increased vehicular congestion as FHVs circulate between PUDO facilities searching for a rematch trip.** While it is common to allow PUDO facilities to operate unmanaged, the Modified A-C PUDO proposal would include active management strategies to optimize rematching.

- The DEIS proposal does not specify any curbside management strategies that would enable successful multiple-server operations. At large PUDO facilities, these measures typically include signage, staffing, enforcement, and management of TNCs such as Lyft and Uber via mobile app. Signage will help drivers and passengers identify their physical location and provide directions to ideal (underutilized) spaces. Denoting specific areas for different service providers (e.g. Lyft vs. Uber) through floor decals, paint treatment, and large signage can reduce confusion; these strategies have been successfully implemented at both LGA and LAX. While these strategies may be less crucial at smaller facilities, given the size of the PUDO facilities included in the DEIS proposal, signage and enforcement may be the most appropriate measures at the 1st and 2nd Street facilities; and staffing and management of the TNC providers may be more feasible at the Columbus Circle and deck-level facilities. There may be challenges associated with implementing some of these strategies, especially at Columbus Circle, due to limited ability to introduce new signage and pavement markings within the historic setting at WUS. Therefore, a more robust staffing plan may be needed at the Columbus Circle facility in lieu of other curbside management strategies. **However, the physical limitations of the PUDO locations proposed in Alternative A-C would be difficult to overcome even with aggressive management strategies.**

Most notably, while the DEIS proposal does provide additional PUDO facilities beyond Columbus Circle in an attempt to accommodate future demand, these PUDO facilities would primarily operate along designated curb frontages distributed around the station, including two street-level frontages on 1st and 2nd streets. This approach mimics typical operations at airports, where curb frontage is more plentiful and can be separated from through traffic by physical barriers, and pedestrian and bicycle circulation is not of primary concern. WUS, however, is an urban, multi-modal facility located within an historic building. Curb frontage is limited, and roadway and sidewalk space are in high demand by pedestrians and cyclists.

Increased traffic along the WUS frontages also detracts from views to the historic station and other productive uses along its perimeter, including retail and open space. While on-street PUDO facilities are critical to accommodate typical commuter and traveler desires to be dropped off directly near their destinations, the DEIS proposal does not provide solutions to address PUDO operations that would maximize benefits to all users at and around WUS, including train riders, pedestrians, cyclists, drivers, and the surrounding neighborhoods.

Even at airports, several of which have similar hourly PUDO demands compared to the 2040 WUS projections,[11] the design of PUDO operations is shifting from the typical use of curbside frontage for pick-up and drop-off to the use of centralized PUDO facilities for pick-up operations to address increased PUDO demands and congestion due to recirculation. Thus, to address some of the key concerns noted above as well as provide other operational and passenger benefits, we recommend that the DEIS proposal be revised to include a centralized PUDO facility. This aligns with the findings of the working group for the DEIS in which the D.C. Office of Planning (DCOP) and the District Department of Transportation (DDOT) indicated that they support including a high-capacity, centralized PUDO facility along with other distributed PUDO facilities.[12]

4.1 Review of Distributed PUDO With and Without a Centralized Facility

Distributed PUDO facilities are often spread out over various locations to accommodate passenger demands, i.e., PUDO facilities located at different on-street frontages around a transit hub or along curb frontages at multiple terminals at an airport. Distributed PUDO facilities tend to be smaller and follow less-efficient linear configurations. However, in principle distributed PUDO facilities can also use more efficient rectangular configurations. These facilities may or may not operate with several of the curbside management strategies described previously – signage, pavement markings, staffing, and enforcement – but unlike centralized PUDO facilities, they are generally not designed to manage PUDO operations for maximum efficiency and effectiveness, such as PIN operations. Centralized PUDO facilities at transit hubs or airports are typically located proximate to key PUDO demand generators and are designed to consolidate a large portion of PUDO operations in one location. By consolidating operations, higher PUDO demand can be served from one location and opportunities to improve efficiencies are created.

There are advantages and disadvantages of distributed PUDO operations with and without centralized facilities. Nationally, airports serve as good examples of successful and unsuccessful PUDO operations due to the concentration and volume of PUDO activity, and many airports struggle to accommodate PUDO operations as the use of FHVs has surged. Specifically, pick-ups (except taxis) have traditionally been accommodated in an unstructured fashion along terminal frontages. PUDO activity and associated

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[11] Peak hour PUDO demands for FHV pick-ups trips at LGA (Terminal B) are between 600-800 vehicles, at LAX (entire airport) are between 1,800-2,000 vehicles, and at DCA (including taxi) are 500-600 vehicles. At WUS, the projected PM peak hour demand is approximately 800-900 vehicles. These demands are based on peak hour FHV pick-ups.

[12] DEIS Appendix A-6, Section 2.2.3.6

circulation have sometimes resulted in severe congestion around terminal roadways, and onto nearby city streets, at airports such as Los Angeles (LAX) and New York-LaGuardia (LGA). As part of their redevelopment programs, both airports moved FHV pick-ups (Uber/Lyft/limos) off the terminal frontages. In 2018, LGA moved its FHV (except taxi) pick-ups to the Terminal B parking garage (serving Terminal B, only), and in 2019, LAX moved all FHV (including taxi) pick-ups (airport-wide) to the LAX-it facility. Both the Terminal B garage and the LAX-it facility are located on-site at the airports, but at locations separate from the terminal frontages; approximately a 5 to 20-minute walk from the terminals (shuttles are provided at LAX where the walking distance is greater). While walking times may increase in these examples, this is offset with shorter waiting time for a vehicle and less traffic congestion when leaving the facility. These facilities were designed and located to provide circulation benefits at the airports without sacrificing customer convenience.

The centralized pick-up facilities at LGA and LAX allow for more efficient traffic operations, including the use of PIN technology, described in great detail below, by service providers (Uber/Lyft), which substantively reduces dwell times up to 50%. Centralized operations also reduce congestion on nearby roadways because its structure minimizes vehicle recirculation. Because drivers know to find pick-up trips within the centralized facilities at LGA and LAX, rematching trips are made more efficiently, rather than drivers circulating at the airport in search for a rematch trip.

While the centralized facilities provide many benefits, they can require ongoing management of the ingress/egress operations, just as the distributed PUDO facilities in the DEIS proposal will require curbside management. For centralized facilities, operations management is needed particularly when opening, as drivers become accustomed to the new operations. At LAX, the entrance and exit driveways experienced significant congestion initially, but adding a second ingress and egress point improved this significantly. Ongoing management within centralized facilities addresses issues such as pedestrian and vehicle conflicts, driveway merges, and distributed curb and queuing capacity.

Sam Schwartz recommends the future design at WUS include a hybrid solution of distributed and centralized PUDO operations. Distributed PUDO facilities recognize the fact that any station entrance that is near a public street creates a demand for passenger drop-off, where riders desire to exit their vehicle immediately once they've reached the station. It is thus necessary to provide on-street PUDO facilities to manage locations where drop-off activity naturally occurs and minimize disruption to local traffic, and to recognize that drop-off activity is more difficult to manage than pick-up functions, especially Friend/Family drop-off. However, the addition of a centralized PUDO facility at WUS is needed to allow for more efficient PUDO operations, reduce congestion, provide opportunities for pedestrian and bicycle improvements at street level, and accommodate Friend/Family PUDO demand, which in some cases may see dwell times of 5 minutes or more. Specifically, our recommendation is to provide the centralized PUDO facility below-grade to provide PUDO operations in proximity to key station generators, including Amtrak, MARC, and VRE. The location of the PUDO facility will help generate a high volume of passengers, which, in turn, will attract a high volume of PUDO drivers. A below-grade facility would have easy access for PUDO passengers by connecting primarily via vertical elements from the track level.

In fact, four of the DEIS alternatives include a centralized, below-grade PUDO facility. Alternatives B, C, D, and E all include a below-grade PUDO facility; Alternatives B and E include a relatively small below-grade PUDO facility identified to accommodate 20 percent of total FHV pick-up demand.

Advantages and disadvantages of providing only distributed PUDO facilities versus a combination of distributed and centralized facilities at WUS are summarized in **Table 5**. With the addition of a centralized PUDO facility, WUS would be able to better serve its passengers, provide improved on-street operations, and better meet the purpose and need of the overall project.

Table 5: Benefits of Providing Distributed PUDO with and without a Centralized Facility

PUDO Facility Benefits	Distributed Only	Distributed Plus Centralized Facility
Multiple PUDO locations allow customer access closest to their origin or destination, assuming capacity at each PUDO facility is able to meet demand.	X	X
PUDO trips distributed around Union Station.	X	X
Reduced vehicle circulation provides more space for pedestrian and bicycle amenities and better integrates WUS into urban fabric.		X
Efficient operations in high volume scenarios through multiple server layout and operation.		X
Efficient operations in high volume scenarios through the use of modern PIN technology.		X
Primary PUDO facility located in close proximity to high demand generators (Amtrak, MARC, VRE) reduces walking distances and improves the passenger experience.		X
Increased likelihood of passenger pick-up or trip rematch if majority of FHV are centralized in one location closest to the majority of passenger demand.		X
Ability to accommodate staging/short-term parking for friend/family waiting for passengers (5+ minutes) versus increased circulation, double parking, or other disruptions to traffic flow.		X

5. Review of Below-Grade Versus Above-Grade PUDO Facilities

At Washington Union Station, two locations are potentially available for placement of a centralized PUDO facility, either below-grade, underneath the rail concourses, or above-grade in a structure at the air rights level. The placement of a centralized PUDO facility below-grade or above-grade is an important design choice. As shown in **Figures 8 and 9** above, a one-level below-grade facility can be developed directly underneath the passenger concourses, and meet the multiple operational and program needs for both Friend/Family and FHV PUDO. A below-concourse facility has further advantages as well:

- Customers may naturally prefer a downward progression from tracks to concourse to PUDO (Paths that involve backtracking will be viewed unfavorably).
- Below-grade space is generally less valuable; using it for PUDO also frees up surface/above grade space for commercial/community uses.
- Underground PUDO can reduce negative visual impacts of PUDO facilities. This is similar to the idea of putting parking underground to avoid the sight of a large garage.
- Underground PUDO provides better climate control/shielded from elements, as passengers stay inside a building during their transfer.

A properly-sized facility located above grade would need to occupy multiple levels of a garage structure to achieve the same program as a single-level below-grade facility, simply because the footprint available is only about one-quarter the size of the below-grade footprint. Thus, a below-grade facility also has advantages over an above-grade facility that would require use of multiple, above-track levels. A PUDO facility that utilizes the garage would have the following disadvantages:

- Places more traffic along two entry points to the deck/garage level in the Alternative A-C plan that are already identified to experience congestion, be over-capacity, and mixed with many other users (e.g. buses, PUDO at deck-level, general parking, taxis, Burnham Place traffic).
- Several levels would need to be traversed for passengers to/from the concourse level, versus only one level for the underground facility.
- Due to the limited footprint of the garage, the PUDO facility would need to be several levels to accommodate the same demands and design elements as the underground PUDO.
- The garage does not align with as many vertical circulation (elevators) access points.
- The choice of using stairs is minimized due to the larger number of levels/stairs required to climb/descend. Almost all users would be waiting and loading the elevators, which are less efficient in moving large numbers of people.

For these reasons a below-grade PUDO facility location offers clear advantages to placement above the railroad within the garage structure proposed in Alternative A-C.

6. Recommendations

We believe the DEIS proposal, which is limited to distributed PUDO operations, would pose numerous deficiencies for WUS as an urban, multi-modal transit hub that seeks to facilitate intermodal travel, provide a positive customer experience, enhance integration with adjacent neighborhoods and land uses, and support continued preservation of the historic station building. To achieve these goals and take advantage of the expansion project as an opportunity to address current operational issues and implement design elements that will result in a world-class facility that is reflective of future conditions, we recommend that a centralized PUDO facility be considered as part of the overall PUDO operations plan. A centralized PUDO facility could be located on-site and below-grade to provide maximum benefits to WUS passengers.

A detailed review of the uses and access points within WUS was conducted to identify where within the station the centralized PUDO facility would be best suited. By considering where passengers would connect to each mode within the station, as well as all uses at the station, including Burnham Place and Union Station – both of which were not considered in the DEIS analyses – a below-grade facility was determined to be the ideal location for a centralized PUDO facility. Located below-grade, adjacent to key vertical elements within the station with connections at the track level, passengers traveling from heavy PUDO generators including Amtrak, MARC/VRE, and the bus facility would be able to easily connect to the PUDO facility without long horizontal or vertical walking distances.

Likewise, depending on the placement of access ramps, vehicles would be able to enter and exit the facility with minimal circulation needed on the local street network near the station. At a minimum, there would be reduced cruising and curbside impacts, which is significant in and of itself.

Based on a careful analysis of the proximity of each passenger population to the location of each PUDO facility, the PUDO distribution within WUS is summarized in **Table 6**, which illustrates that over a third of PUDO trips could reasonably be assumed to use a below-grade PUDO facility. This aligns with the operational capacity of the proposed below-grade PUDO facility as previously described.

Table 6: Estimated PUDO Distribution at WUS, PM Peak

Mode/Land Use	Arrivals or Departures	Share of PUDO Activity	Allocation of Each Mode/Land Use's Activity			
			Below Concourse	Columbus Circle	Air Rights Level	1st and 2nd Streets
Amtrak	Arrive by DO	30.7%	25%	55%	10%	10%
	Depart by PU	30.7%	75%	10%	5%	10%
MARC/VRE	Arrive by DO	7.0%	25%	55%	10%	10%
	Depart by PU	0.1%	75%	10%	5%	10%
Metro	Arrive by DO	3.7%	45%	45%	5%	5%
	Depart by PU	4.6%	75%	20%	0%	5%
Intercity Bus	Arrive by DO	2.7%	5%	15%	80%	
	Depart by PU	5.0%	5%	5%	90%	
Union Station	Arrive by DO	2.8%	20%	80%		
	Depart by PU	2.8%	65%	35%		
Burnham Place & Federal Air Rights	Arrive by DO	4.9%			100%	
	Depart by PU	4.9%			100%	
Overall Demand Distribution (Hybrid Projections)			40%	30%	22%	7%

Source: Sam Schwartz Engineering, July 2020

7. Conclusion

The WUS Expansion Project is an opportunity to create a world-class facility for our nation's capital. Built in 1908 and redeveloped in the 1980's, the planned expansion project for 2040 will be only the second major redevelopment of the station over a 130-year period. With the expectation that the station, when complete, will need to function for another 50+ years, it is critical that it be designed in consideration of its urban context, in response to changes in how people travel and interact with the public realm, and following best practices in place at other transportation facilities.

While distributed PUDO is important, the addition of a centralized, below-grade PUDO facility is essential to the success of the WUS Expansion Project. Without a centralized facility, automobile domination in and around the station will be intensified at the expense of historic preservation, pedestrians/bicyclists, and urban design/placemaking. It is necessary to prioritize walking and biking with safe, direct, comfortable routes, and this requires ensuring that key streets around WUS minimize car traffic and loading activity and accommodate wide, physically protected sidewalks, bikeways, and pedestrian crossings.

Including a high-capacity centralized PUDO facility at WUS (along with additional distributed facilities) is a solution that is informed by careful consideration of the station's urban context – a context that includes a significant historic structure in an important setting; adjacency to established and emerging neighborhoods; and opportunity for placemaking – and is vital for the project to meet its intended purpose and need.

The addition of a centralized, below-grade PUDO facility would address specific issues identified with the DEIS proposal:

- Successful rematching without increased circulation: a centralized, below-grade PUDO facility will be able to process high volumes of PUDO trips and will be in proximity to high PUDO demand generators within WUS. Based on a review of the station layout, as shown in **Table 5**, we expect that over one-third of WUS passengers would use the below-grade PUDO facility. Rematched trips will be highly probable, which should reduce the number of circulating drivers. Reduced traffic congestion around the station perimeter would provide an opportunity to improve the efficiency and safety of pedestrian, bicycle, streetcar, Metro and bus users.

- Reduced taxi queues at Columbus Circle PUDO facility: a centralized PUDO facility will enable the creation of a driver staging area for PUDO and taxi vehicles. The staging area will allow drivers to queue off-street as they wait for passengers and can be designed to provide a direct link to the Columbus Circle PUDO facility, thereby eliminating taxi queues on the east ramp and corresponding impacts on the operation of the deck-level PUDO facility at the Train Hall.

- Reduced demands on limited curb frontage around WUS: there is limited curb frontage around WUS, and the DEIS proposal to provide only on-street PUDO facilities will increase stresses on the existing infrastructure, affect views of the historic station building, and limit opportunities for improved pedestrian and bike amenities. A centralized, below-grade PUDO facility will reduce the on-street PUDO demands, create opportunities to provide pedestrian and bicycle amenities, and support continued preservation of the station building.

- Accommodate Friend/Family demands: a centralized, below-grade PUDO facility will provide space to accommodate Friend/Family demands. These drivers are likely to arrive early and need a place to wait for 5+ minutes to meet arriving passengers. Without a dedicated Friend/Family waiting area, drivers may double park on-street and/or circulate around WUS and in adjacent neighborhoods while waiting, both of which would negatively impact traffic flow on local streets.

A centralized, below-grade PUDO facility will provide additional benefits and enable implementation of best practices that will support the world-class PUDO operations at WUS:

- Weather protection: a centralized, below-grade PUDO facility will improve the customer experience by providing shelter from inclement weather. Weather-protected facilities also operate more efficiently during all conditions, and provide more dependable and predictable service.

- Shorter walking distances: a centralized, below-grade PUDO facility would have direct access via vertical circulation elements to Amtrak, MARC, and VRE. Being located in close proximity to the rail passengers, which are identified as the largest generators for PUDO trips, will reduce walking distances and travel distances and therefore provide an improved customer experience.

- Efficient PUDO operations: implementation of a PIN system, which can significantly reduce dwell times and therefore increase operational efficiencies, is most successful in high-volume PUDO facilities that rely on a steady pool of drivers available nearby and consistent demand. A centralized, below-grade PUDO facility would create the infrastructure necessary to provide both the supply of drivers and passenger demands needed. This would improve the economic performance of the station by reducing passenger time needed to arrive and depart the transportation functions within the station.

- <u>Potential reduction in size of distributed PUDO facilities</u>: with the addition of a centralized, below-grade PUDO facility, the demand for use at the distributed PUDO facilities will still exist but will be reduced compared to the DEIS proposal. Facility size, particularly the 1st and 2nd Street facilities, could then be reduced, allowing for additional pedestrian and bicycle amenities.

Appendices

Appendix A

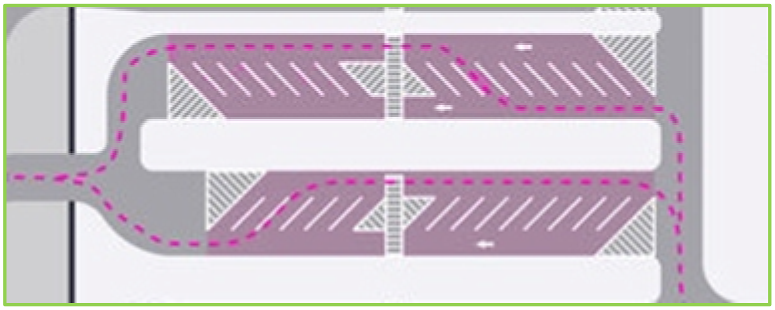
PUDO Facility Best Practices

Based on a review of other facilities that have been shifting their PUDO operations to centralized facilities, the following section provides several best practices that can be applied at WUS. A centralized PUDO facility at WUS, in addition to distributed options, would be best suited to accommodate future demands if it can provide some or all of these design elements and operational features.

Pick-Up Zone Design Concepts

Centralized PUDO facilities can be configured for high-capacity and high-throughput operations. **Figure A1** illustrates a pick-up zone concept used at Boston's Logan Airport that relies on pull-through lanes. In the Logan configuration, 30 vehicles can be parked or actively loading/unloading simultaneously, without any one vehicle blocking another. No reverse movements are required. This layout can be equally effective for taxis, TNCs and Friend/Family pick-ups. This layout clusters many vehicle loading spaces close together and requires that the customer share space with vehicles although this configuration can be modified to be ADA compliant and better support the needs of people with disabilities who require adjacent spaces to be free to facilitate customer loading.

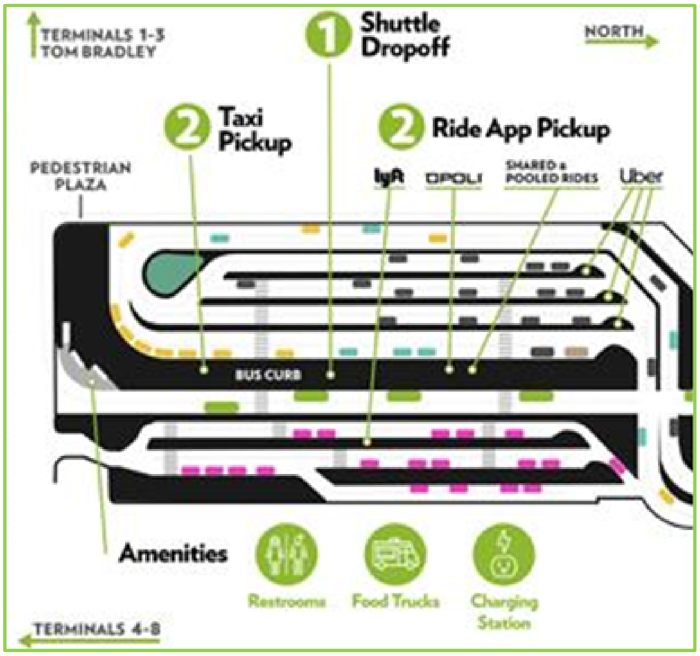
Figure A1: Logan Pull-Through Configuration



Source: https://www.lyft.com/blog/posts/your-boston-logan-international-airport-rides-are-changing

Figure A2 illustrates the multi-island linear boarding area design that is used at LAX. Typically, FHV boarding areas are separated by service provider; providing at least one area for each of the main TNCs and one for standard taxis is common. Designated areas are an important component for TNC contract agreements. The LAX model segregates the two main TNC providers and provides ample waiting space and amenities for waiting customers (including shade structures). The design uses a PIN system (described below) for TNCs during periods of high demand. It includes many pedestrian crossings but is heavily dependent on security staff to ensure safe passage.

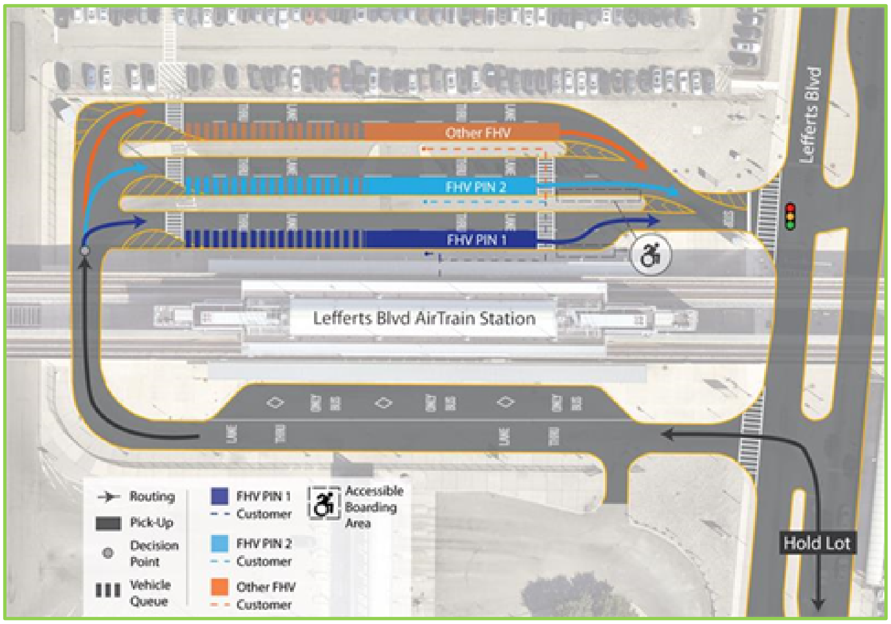
Figure A2: LAX-it Multi-Island Linear Boarding Area Design



Source: FlyLAX.com, 2020.

Figure A3 shows a conceptual design for a boarding location at a transit terminal at a large airport. This design includes two pick-up areas for FHVs that utilize PIN systems and a separate area for other providers. This concept also features designated pick-up locations for customers with disabilities.

Figure A3: Multi-Island Linear Boarding Area Design at JFK Airport



Source: Sam Schwartz, February 2020.

FHV PIN Systems

In the last few years, TNCs have introduced a pick-up mechanism similar to a typical taxi stand, also known as a “PIN” system. The PIN system uses a first-in-first-out approach to passenger-driver pairing, using a physical queue of drivers and passengers. Passengers still request rides through the mobile app, but rather than being paired with a driver via the app, they are provided an alphanumerical PIN and directed to a physical queue of waiting passengers. A TNC staffer then directs them to the first available vehicle. Before entering the vehicle, the passenger gives the PIN to the driver, who then completes the match and is provided with the passenger’s trip information. While requiring more resources (i.e. staffing, dedicated space), the PIN system has been shown to increase overall throughput of pick-up operations, simplify the passenger experience, and decrease driver waiting time. The PIN system relies on a steady pool of drivers available nearby and consistently high demand. It does not work well when demand is low, and TNCs have been known to turn off their PIN systems during lower activity periods. In July 2019, VHB collected dwell time data at LaGuardia Terminal B parking garage before and after the implementation of Lyft FastMatch (PIN system); this showed an average dwell time of 2:00 minutes for normal matching, and 0:47 minutes using a PIN system. Due to the steady flow of traffic at WUS and the high efficiency of the PIN system, this technology brings a unique opportunity to WUS within a centralized PUDO facility.

Driver Staging/Matching

In high-activity areas, TNCs may introduce another operational challenge – driver staging in close proximity to the desired pick-up zone. During low-activity times, drivers will wait nearby hoping to receive a ride request. At some locations, TNCs geofence areas where drivers are allowed to wait for rides. When they enter the geographic area, they are added to a virtual queue which helps keep track of priority when distributing ride requests to nearby drivers. Often these geofences are paired with physical parking lots to allow drivers to wait. However, the effectiveness of driver geofences has been questioned, as they may still allow drivers to wait in nearby neighborhoods and create negative community impacts. For this reason, keeping driver staging on-site or in a designated facility nearby is the optimal solution.

For any PUDO system to work, wayfinding is critical for both drivers and riders. In-app directions should match physical signage for both parties. Passenger confusion is common when exiting facilities, so additional signage should be provided to continually guide passengers to the desired location. Signage should also address other modes such as taxis and Friend/Family pick-ups, providing a comprehensive message to all users.

Friend/Family Pick-Ups

It is important that WUS PUDO facilities accommodate a limited amount of Friend/Family pick-up activity. Friend/Family pick-ups are likely to arrive before passengers as arrivals based on train schedules that may on occasion experience delays. This challenge is addressed at some airports by providing designated cellphone lots, or short-term parking lots where people can wait before picking up passengers. In theory, cell phone lots reduce congestion at arrival sections by preventing cars from continuously circling around the terminal or waiting on the sides of adjacent roads to avoid paying parking fees. Once the passenger reaches the station and is ready to be picked up, they will call the person waiting in the cellphone lot.

Most intermodal rail stations do not have the nearby space to support these facilities. As a result, Friend/Family pick-up activity happens in an ad hoc manner, with waiting vehicles potentially double-parking, or circling the station until their contact arrives. To reduce the traffic impacts of this behavior, on-street metered parking, or short-term garage space may be reserved. A centralized PUDO facility can be compatible with a separate short-term parking facility for Friend/Family pick-up. This facility can include free cellphone lot parking, or parking priced similar to near-by short-term parking resources to prevent inappropriate use. These spaces should be time limited to 15+/- minutes to ensure that vehicles are not excessively loitering and would require active management by station staff during peak demand periods.

Appendix B

Queuing Model

The operation of each PUDO facility was reviewed based on a queuing analysis, to determine if the capacity of the PUDO facility would adequately meet the demands without resulting in queue spillback and the potential to affect traffic flow on the local roadways.

Queuing Models: Two ways to model curb operations are as single servers or multiple servers, as illustrated in **Figures B1 and B2** below:

- Single server: Only one car, typically the first in queue, can load/unload at a time. Remaining vehicles in queue would wait until that car has loaded/unloaded, then the queue would move up to fill the first position, and the new car that is in the first position would load/unload.
- Multiple server: Every space along the curb could be used for loading/unloading at the same time, and the first car in does not need to be the first car out.

Figure B1: Single Server Operations

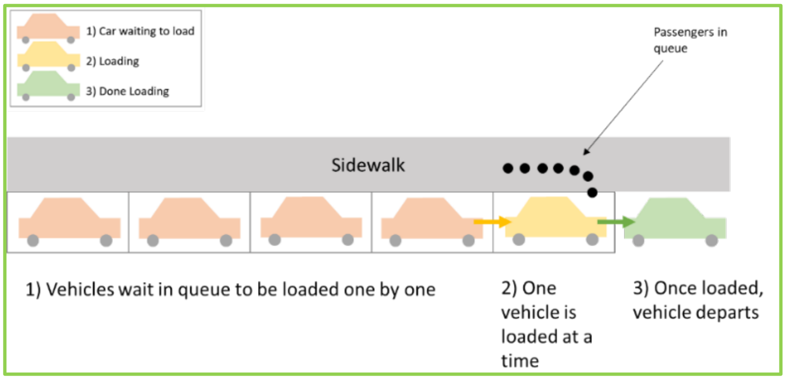
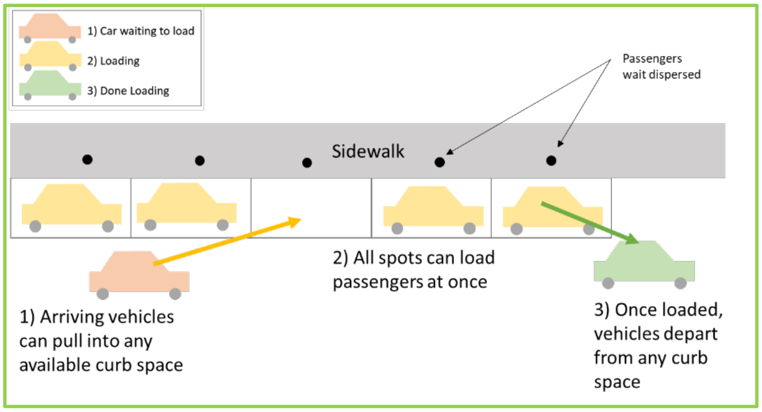


Figure B2: Multiple Server Operations



Queuing models are analysis tools that estimate the number of spaces needed to accommodate expected queues. The models consider single or multiple server conditions, and both are based on several inputs, including **demand** – the number of vehicles expected to arrive and depart over a specified time period, usually an hour, and **dwell time** – the length of time a vehicle is expected to be at the curb. Typically, demand over an hour is not evenly spaced, so queuing models are also probabilistic in nature, meaning that they account for some variation in demand over the hour. While queuing models provide estimates for determining the number of spaces needed to accommodate expected queues, they are primarily mathematical models and do not account for all elements of actual operations. For example, the models assume that demand and supply are aligned – i.e., that the number of cars arriving to pick-up passengers matches the number of passengers waiting to be picked up. The taxi queues observed at Columbus Circle reflect that there may be more taxis waiting to pick someone up than passengers waiting to be picked up and/or, at other times, that current operations are slow and inefficient; these conditions are not captured by the queuing models. The queuing models also don't capture potential operational issues, such as drivers who don't pull completely to the curb or who double park, which has implications for general traffic circulation. For the purpose of this memo, the review of each PUDO facility is based on an analysis of potential queues based on the queuing model results, as well as experience and observations of actual operations at other similar facilities.

- Operations: The DEIS does not provide detail on how each of the PUDO facilities will be operated, so both single and multiple server operations were analyzed. For both analyses, the 95th percentile queue results are documented, which represent the number of curb spaces that would be needed to accommodate queues 95% of the time. The analyses were performed for both the morning (AM) and evening (PM) peak hours.

- Volume Inputs: The inputs for the queuing analyses are based on the DEIS Preferred Alternative A-C estimates, as shown in **Table B1**, distributed to each facility based on the percentages in **Table 1**, and consider a 50% rematching[13] rate for FHV trips, as assumed in the DEIS (50% of trips dropping-off would get a subsequent pick-up trip without leaving WUS; similarly 50% of pick-up trips would be from a prior drop-off). PUDO trips completed by Friend/Family have a rematching rate of 0%. The volumes provided in the DEIS do not distinguish between drop-offs and pick-ups, which is a limitation in the queuing model results that are provided. Pick-up and drop-off activity usually have varying dwell times; in this queuing analysis, pick-up and drop-off trips were each assumed to have a dwell time of 60 seconds, explained further below.

- Dwell Times: The DEIS provides dwell time estimates and assumptions, summarized in **Table B2**. This includes an incomplete set of observed values, but ultimately the DEIS analysis assumes a 60 second dwell time across the board. The methodology to determine the dwell times is unclear. In some cases, dwell time may represent the time it takes for a passenger to enter or exit a vehicle (the time from the door opening to the door closing), but this does not capture the time it takes for a vehicle to maneuver into and out of a pick-up spot. The time for vehicular maneuvers and passenger loading/unloading together represents the time when a curb space cannot be used by another vehicle, which is more relevant for the queuing analyses. Since it is not clear what the dwell times provided in the DEIS represent, the queuing analysis for this memo conservatively assumes a 60-second average dwell time for all modes. It is the professional judgement of the Sam Schwartz engineering team that this is an appropriate assumption based on our previous experience at comparable sites (it does not include the need for short term parking for early arrivals). In an email transmitted to Akridge on August 26, 2020, the FRA stated that dwell times of 60 seconds were used for pick-up activities and 15 seconds were used for drop-offs, but did not clarify further any of the other aspects of their methodology noted above. In contrast to the 15-second drop-off dwell time noted by FRA on August 26, Sam Schwartz utilized a 60-second assumption for drop-offs in this analysis, which is closer to times required.

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[13] We define 'rematching' as the linking of a drop-off and a pick-up to be completed by the same vehicle. Note that the term may be used differently in airport contexts.

Table B1: DEIS PUDO Facility Trip Estimates (After Rematching), Alternative A-C

	Trip Estimates (After Rematching)
AM Peak Hour FHV Trips	1928
PM Peak Hour FHV Trips	2068
AM Peak Hour Friend/Family Trips	1684
PM Peak Hour Friend/Family Trips	1540

Source: DEIS pages 5-185 and 5-187

Table B2: DEIS Dwell Time Values

Mode	**Observed AM Peak Dwell Time**	**Observed PM Peak Dwell Time**	**FRA Assumed Dwell Time**
Taxi FHV	31 sec	21 sec	60 sec
Non-Taxi FHV	-	-	60 sec
Friend/Family PUDO	-	62.3 sec	60 sec

Source: DEIS pages 286 (4-29) and 2893 (65)

Based on projections in the DEIS and as shown on **Table B3**, if the DEIS-proposed PUDO facilities were to operate as single-server systems, the arrival rates would exceed the service rates such that queues would grow indefinitely, with the exception of the 2nd Street PUDO facility, which is expected to accommodate lower demands. If the DEIS-proposed PUDO facilities were to operate as multiple-server systems, the total number of spaces provided at each facility would theoretically accommodate the 95th percentile queues during the AM and PM peak hours.

Table B3: DEIS-Proposed PUDO Facilities - Queue Analysis

Note: PUDO volume is measured in units of transactions, not vehicle trips.

		AM Peak Hour Volume			**PM Peak Hour Volume**		
		FHV	F/F	Total	FHV	F/F	Total
		1,285	842	2,127	1,379	770	2,149
Single Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	654	Indefinite Queue	40%	724	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	Indefinite Queue	(1)	135	Indefinite Queue
Deck Level	17	35%	745	Indefinite Queue	35%	752	Indefinite Queue
First St	30	20%	425	Indefinite Queue	20%	430	Indefinite Queue
Second St NB	8	3%	53	24	3%	54	28
Second St SB	7	3%	53	24	3%	54	28
Multiple Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	654	17	40%	724	18
Columbus Circle Taxi	12	(1)	197	6	(1)	135	5
Deck Level	17	35%	745	20	35%	752	21
First St	30	20%	425	12	20%	430	12
Second St NB	8	3%	53	3	3%	54	3
Second St SB	7	3%	53	3	3%	54	3

(1) Taxi volumes at Columbus Circle are taken from previous counts provided in the FRA DEIS and are not projections. Taxi volumes are included within the total of 40% noted for Columbus Circle FHV/F/F.

Appendix C: Sensitivity Testing

The sensitivity testing shown in **Table C1** and **Table C2** assumes conservative demand inputs (i.e. including Union Station retail and tourism and future Burnham Place development) as well as conservative dwell times (i.e. 120 seconds for pick-ups instead of 60 seconds). As seen in **Table C2,** the Columbus Circle and Train Hall PUDO facilities show potential fail utilizing the alternate set of assumptions noted, whereas potential extra capacity exists at the 1st Street NE, 2nd Street NE, and below-grade PUDO facilities.

Table C1: DEIS-Proposed PUDO Facilities - Queue Analysis
Note: PUDO volume is measured in units of transactions, not vehicle trips.

		AM Peak Hour Volume			PM Peak Hour Volume		
		FHV	F/F	Total	FHV	F/F	Total
		1,510	1,008	2,517	1,603	936	2,539
Single Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	810	Indefinite Queue	40%	880	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	Indefinite Queue	(1)	135	Indefinite Queue
Deck Level	17	35%	881	Indefinite Queue	35%	889	Indefinite Queue
First St	30	20%	503	Indefinite Queue	20%	508	Indefinite Queue
Second St NB	8	3%	63	Indefinite Queue	3%	63	Indefinite Queue
Second St SB	7	3%	63	Indefinite Queue	3%	63	Indefinite Queue
Multiple Server Model							
		AM Peak Hour			**PM Peak Hour**		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	40%	810	Indefinite Queue	40%	880	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	11	(1)	135	8
Deck Level	17	35%	881	Indefinite Queue	35%	889	Indefinite Queue
First St	30	20%	503	24	20%	508	24
Second St NB	8	3%	63	5	3%	63	5
Second St SB	7	3%	63	5	3%	63	5

(1) Taxi volumes at Columbus Circle are taken from previous counts provided in the FRA DEIS and are not projections.
(2) Spaces reflect proposed Alternative 1.

Table C2: Modified A-C Proposed PUDO Facilities - Queue Analysis

Note: PUDO volume is measured in units of transactions, not vehicle trips.

		AM Peak Hour Volume			PM Peak Hour Volume		
		FHV	F/F	Total	FHV	F/F	Total
		1,510	1,008	2,517	1,603	936	2,539
Single Server Model							
		AM Peak Hour			PM Peak Hour		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	31%	591	Indefinite Queue	30%	632	Indefinite Queue
Columbus Circle Taxi	12	(1)	197	Indefinite Queue	(1)	135	Indefinite Queue
Deck Level	17	18%	453	Indefinite Queue	22%	562	Indefinite Queue
First St	30	6%	155	Indefinite Queue	6%	148	Indefinite Queue
Second St NB	8	1%	19	6	1%	18	5
Second St SB	7	1%	19	6	1%	18	5
Below-grade F/F (2)	30	17%	430	Indefinite Queue	15%	371	Indefinite Queue
Below-grade FHVs/Taxis (2)	72	26%	652	Indefinite Queue	26%	654	Indefinite Queue
Multiple Server Model							
		AM Peak Hour			PM Peak Hour		
Location	**Planned Spaces**	**Volume %**	**Volume**	**Spaces in use, 95th %**	**Volume %**	**Volume**	**Spaces in use, 95th %**
Columbus Circle FHV/F/F	24	31%	591	32	30%	632	40
Columbus Circle Taxi	12	(1)	197	11	(1)	135	8
Deck Level	17	18%	453	37	22%	562	Indefinite Queue
First St	30	6%	155	9	6%	148	9
Second St NB	8	1%	19	2	1%	18	2
Second St SB	7	1%	19	2	1%	18	2
Below-grade F/F (2)	30	17%	430	21	15%	371	18
Below-grade FHVs/Taxis (2)	72	26%	652	30	26%	654	30

(1) Taxi volumes at Columbus Circle are taken from previous counts provided in the FRA DEIS and are not projections.

(2) Spaces reflect proposed Alternative 1.

APPENDIX B2

TRAFFIC ASSESEMENT

WELLS + ASSOCIATES

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MEMORANDUM

TO: David Tuchmann, Akridge
Kevin Dunmire, Akridge
Michelle Chang, Akridge

FROM: Jami L. Milanovich, PE

RE: Union Station Redevelopment
Traffic Assessment

DATE: September 28, 2020

INTRODUCTION

As requested, Wells + Associates (W+A) has conducted a review of the traffic analysis conducted by the Federal Railway Administration's (FRA's) consultant team in conjunction with the preparation of the *Draft Environmental Impact Statement* (DEIS) for the Union Station Expansion project.

W+A's review of the traffic analysis associated with the DEIS was limited to the review of Preferred Alternative A-C. Alternative A-C includes the following components:

- three new signalized intersections on H Street with the west road being one-way southbound (inbound), the east road being one-way northbound (outbound), and a signalized egress for buses;[1]
- an east-west Train Hall;
- an above-grade parking structure housing 1,600 spaces with access to/from H Street via the two new signalized intersections;
- a two-level bus facility with ingress via the signalized West Road/H Street intersection and right-only egress onto H Street;
- on-street pick-up/drop-off (PUDO) areas located at Columbus Circle, 1st Street, 2nd Street, and at the deck level on the north side of the Train Hall;
- conversion of 1st Street to one-way northbound from Massachusetts Avenue to K Street to better accommodate the proposed PUDO lanes on 1st Street; and
- 280,000 SF of retail space and 297,400 SF of support area for Amtrak operations.

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[1] Preferred Alternative A-C includes three signalized intersections on H Street that would serve Union Station traffic. A fourth signalized intersection (known as the central road) would serve the private air rights development.

This memo summarizes the methodology used in the review and evaluation of Alternative A-C, results of the W+A evaluation, and key areas of concern stemming from the evaluation. A summary of the results is provided at the end of this document and notes significant concerns with a number of key elements in the Preferred Alternative A-C circulation concept.

METHODOLOGY

Upon request from Akridge, FRA provided traffic forecasts for the year 2040 developed by their consultant and Synchro worksheets from the future conditions model of Alternative A-C, in an email transmittal on August 26, 2020. In order to conduct a detailed review of Alternative A-C, W+A recreated the Synchro model using the data provided by FRA.

Study Area

The study area was based on those intersections that potentially would be most affected by the redevelopment of Union Station. A subset of the study area evaluated in the DEIS was considered for this analysis, analyzing the most critical intersections relative to the FRA proposal for pick-up and drop-off facilities. The following intersections were selected for detailed analysis:

- North Capitol Street/K Street (#1),[2]
- K Street/1st Street (#2),
- K Street/2nd Street (#3),
- North Capitol Street/H Street (#5),
- H Street/West Road (#6),
- H Street/East Road (#8),
- North Capitol Street/G Street (#10),
- G Street/1st Street (#11),
- North Capitol Street/Massachusetts Avenue (#13),
- 1st Street/Massachusetts Avenue/E Street/Columbus Circle (#14),
- Columbus Circle/Louisiana Avenue (#15),
- Columbus Circle/Delaware Avenue (#16),
- Columbus Circle/1st Street/Massachusetts Avenue (#17),

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[2] The number listed in parenthesis corresponds to the intersection number in the DEIS. Intersections #91 and 92 were not evaluated in the DEIS.

- North Capitol Street/E Street (#19),
- H Street/Central Road (#35),
- North Capitol Street/G Place (#91), and
- G Place/1st Street (#92).

Road Network Changes Associated with Alternative A-C

Under FRA's Preferred Alternative A-C, three new intersections would be created on H Street. The west road would operate one-way southbound and would provide access to the proposed Union Station parking, the proposed bus facility, and the deck-level PUDO area adjacent to the Train Hall. The east road would operate one-way northbound and would provide egress from the proposed parking and PUDO area adjacent to the Train Hall. Bus egress would be provided via a right turn only onto H Street between the east road and the west road.

On-street PUDO areas also would be provided on 1st Street northbound and on 2nd Street northbound and southbound. Columbus Circle would continue to be used for PUDO operations.

1st Street, south of G Street, would be converted from one-way southbound to one-way northbound. As such, 1st Street would provide access to the parking facility and the deck-level PUDO from the south by means of an access road on the west side of the station similar to the vehicular access in existence today in the same location. Between G and K Streets, 1st Street would be converted from two-way operation, to one-way northbound.

Lane use and traffic controls under FRA's Preferred Alternative A-C are shown on Figures 1A and 1B.

Traffic Volumes

Future 2040 traffic volumes under FRA's Preferred Alternative A-C were obtained from FRA and are shown on Figures 2A and 2B. Traffic volumes for intersections not analyzed in the DEIS were derived as follows:

- North Capitol Street/G Place (#91) – through volumes on North Capitol Street were derived from adjacent intersections at H Street and G Street. Traffic volumes for turning movements were obtained from AM and PM peak period counts conducted in May 2018.
- G Place/1st Street (#92) – traffic volumes were derived from adjacent intersections at G Street/1st Street and North Capitol Street/G Place.

Traffic Signal Timings

Traffic signal timings were obtained from DDOT and initially used in the Synchro model. Intersection splits then were optimized on an intersection-by-intersection basis to better accommodate the projected 2040 traffic volumes.

RESULTS

Capacity Analysis

Capacity/level of service (LOS) analyses were conducted at the study intersections under Preferred Alternative A-C based on the future lane use and traffic controls shown on Figures 1A and 1B, future traffic forecasts shown on Figures 2A and 2B, and the optimized traffic signal timings. FRA provided Synchro worksheets from the model used for the DEIS. The inputs were compared with the Synchro model prepared by W+A to ensure consistency where possible. The following discrepancies between the FRA and W+A models are noted:

- The FRA model did not make adjustments for de facto turn lanes. De facto turn lanes occur when two or more through lanes are present along with a heavy turning movement. Synchro flags a de facto turn lane when the volume of turns would account for 85 percent of the capacity of an exclusive turn lane. According to the Synchro User Guide and in accordance with industry standards, when a de facto lane is flagged, it should be recoded as an exclusive turn lane rather than a shared through/turn lane. If the de facto lane is not recoded as an exclusive turn lane, the actual delay to the turning vehicles could be masked by the delay for the entire approach. The following movements were flagged as de facto turn lanes by Synchro and coded as exclusive turn lanes in the W+A model, in accordance with industry standard practice:
    - North Capitol Street/H Street – Southbound left during the PM peak hour;
    - North Capitol Street/G Street – Southbound left during the AM peak hour;
    - North Capitol Street/Massachusetts Avenue – Eastbound left during the AM peak hour; and
    - North Capitol Street/Massachusetts Avenue – Southbound left during the AM peak hour.
- The FRA model does not include the removal of the parking lane on the south side of K Street within the study area, which is used as a travel lane during the PM rush, to accommodate the proposed bicycle lanes on K Street.
- The North Capitol Street/Massachusetts Avenue/F Street and H Street/Central Road/Bus Egress intersections were coded as four-legged intersections in the FRA model rather than

five-legged intersections. At the North Capitol Street/Massachusetts Avenue/F Street intersection, the volumes entering the intersections via the fifth leg (F Street) were coded on the adjacent approach; however, the impact of the signal timings associated with the fifth leg potentially was not accounted for, which could explain some minor discrepancies in results. At the H Street/Central Road/Bus Egress intersection, the Bus Egress was coded as a separate, stand-alone signalized intersection. Given the close proximity of the Bus Egress to the central road, it is unrealistic to signalize it separately from the signalized central road intersection. In the W+A model, the Bus Egress was included as a fifth leg of the H Street/Central Road intersection, which accounts for some of the discrepancy in the results at the intersection.

- In the FRA model, right turn on red restrictions were not coded at several locations where No Turn on Red signs are in place.
- For intersections where on-street parking is present, the number of parking maneuvers per hour was not coded in the FRA model. As a result, the reduction in capacity associated with cars entering and exiting parking spaces was not taken into account in the FRA model.
- Where bus stops exist, the number of bus blockages was applied only to through movements in the FRA model and was not applied to right turn movements where a right turn lane is present.
- Bicycle volumes in the FRA model were considerably lower across the board than what was shown in counts obtained by W+A. While this could be attributable to the time of year counts were conducted, the higher bicycle volumes were used in the W+A model.
- Cycle lengths and phasing were confirmed to be consistent between the FRA and W+A models (with the exception of Intersection #17 – Columbus Circle/1st Street/ Massachusetts Avenue); however, the splits (the proportion of green, yellow, and red time assigned to each phase) are difficult to compare explicitly based on the Synchro worksheets provided. Some discrepancies in results could be attributable to differences in splits assigned at each intersection.

Also of note, the FRA models did not include any movement that is permitted only by buses and/or taxis (e.g. the westbound and southbound left turns at the North Capitol Street/H Street intersection during the AM peak hour and the westbound left turn at the North Capitol Street/Massachusetts Avenue/F Street intersection). Since the W+A models used the forecasts developed by FRA, the movements also were not coded in the W+A model for Alternative A-C.

The Synchro model level of service results under Preferred Alternative A-C are summarized in Table 1. For comparative purposes, the results from FRA's model are provided in Table 1 alongside the results from the W+A model.

Table 1
Level of Service Summary①

Approach	Alternative A-C – FRA Results				Alternative A-C – W+A Results			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
1. N Capital Street/K Street – Signalized								
EB	D	46.9	E	70.7	E	55.1	F	203.2
WB	F	265.2	F	268.5	F	320.8	F	404.7
NB`	F	275.3	D	34.5	F	215.1	D	39.4
SB	F	372.7	F	560.3	F	342.8	F	518.0
Overall	**F**	**281.4**	F	**235.6**	**F**	**278.9**	**F**	**297.4**
2. K Street/First Street – Signalized								
EB	D	52.9	F	216.1	C	31.8	F	301.0
WB	F	193.3	F	146.5	F	310.6	C	28.0
NB	F	247.3	F	367.0	F	482.2	F	656.3
SB	B	12.3	B	18.8	E	61.1	F	123.6
Overall	**F**	**170.6**	**F**	**248.0**	**F**	**290.9**	**F**	**374.5**
3. K Street/2nd Street – Signalized								
EB	C	29.8	A	9.3	A	5.9	F	100.1
WB	E	59.4	B	12.9	F	412.1	F	221.5
NB	F	106.5	D	51.5	F	319.5	F	205.6
SB	B	19.6	C	26.8	C	25.9	C	34.8
Overall	**E**	**56.0**	**B**	**16.9**	**F**	**260.2**	**F**	**132.2**
5. N Capital Street/H Street – Signalized								
EB	E	61.7	E	73.2	D	43.3	D	45.1
WB	F	421.0	F	973.2	F	333.0	F	582.5
NB	F	157.0	F	111.0	F	128.5	E	70.1
SB	F	235.7	F	587.2	F	174.9	F	314.1
Overall	**F**	**247.4**	**F**	**452.5**	**F**	**192.1**	**F**	**264.1**
6. H Street/West Road – Signalized								
EB	C	30.8	D	45.4	D	42.7	B	14.5
WB	C	25.6	C	27.7	B	13.3	B	18.0
NB	NA	NA	NA	NA	A	0.0	A	0.0
SB	D	40.6	D	42.1	D	37.4	D	45.3
Overall	**C**	**27.8**	**D**	**37.6**	**C**	**24.8**	**B**	**18.3**

① **Capacity analysis based on Highway Capacity Manual 2000 methodology, using Synchro 10.**
② **The FRA model's configuration was not supported by HCM methodologies; therefore, results were not produced.**
③ **Intersection not analyzed in DEIS.**

Table 1
Level of Service Summary①

Approach	Alternative A-C – FRA Results				Alternative A-C – W+A Results			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
8. H Street/East Road – Signalized								
EB	D	35.2	B	16.3	F	164.2	C	34.1
WB	F	262.3	B	15.4	F	139.6	B	18.0
NB	D	49.4	E	57.3	F	115.0	D	47.9
SB	NA	NA	NA	NA	A	0.0	A	0.0
NW	E	57.3	E	56.6	D	48.4	B	10.6
Overall	**F**	**182.9**	**C**	**24.5**	**F**	**141.4**	**C**	**31.9**
10. N Capital Street/G Street – Signalized								
WB	D	42.7	C	22.3	C	30.7	C	30.4
NB	B	15.3	A	4.8	A	7.8	A	6.4
SB	D	42.1	F	149.0	F	898.5	F	326.0
Overall	**C**	**29.8**	**E**	**67.6**	**F**	**478.2**	**F**	**145.4**
11. G Street/1st Street – Unsignalized								
EB	②	②	②	②	F	149.5	C	20.2
NB	②	②	②	②	A	3.3	A	3.5
13. N Capital Street/F Street/Massachusetts Avenue – Signalized								
EB	E	79.7	E	68.6	F	152.6	E	79.3
WB	D	51.4	E	55.6	E	73.9	E	59.0
NB	F	94.0	E	68.9	E	74.7	E	76.4
SB	F	97.9	C	32.8	E	73.5	F	101.9
NE	C	25.7	C	28.8	C	30.7	C	30.1
Overall	**F**	**80.0**	**E**	**57.3**	**F**	**87.8**	**E**	**77.6**
14. Columbus Circle/E Street/Massachusetts Avenue/First Street – Signalized								
EB	D	35.1	C	31.9	C	30.5	F	119.1
WB	D	54.2	D	35.0	C	29.0	C	21.1
NB	C	23.5	A	9.0	C	31.8	B	17.4
SB	D	43.5	D	44.1	D	47.9	C	32.0
SW	NA	NA	NA	NA	NA	NA	NA	NA
Overall	**D**	**37.1**	**C**	**28.3**	**C**	**34.6**	**D**	**35.1**
15. Columbus Circle/Louisiana Avenue - Signalized								
EB	E	59.8	C	29.1	E	58.0	E	63.2
WB	A	9.1	B	14.9	C	27.6	B	19.0
NB	C	20.9	D	51.1	C	30.3	C	24.2
Overall	**C**	**31.1**	**C**	**29.1**	**D**	**39.8**	**C**	**0.7**
16. Columbus Circle/Delaware Avenue – Signalized								
EB	A	2.8	A	1.5	A	7.1	A	6.7
WB	NA	NA	NA	NA	A	0.6	A	2.0
NB	D	35.5	D	36.7	C	25.2	C	25.5
Overall	**A**	**3.1**	**A**	**2.2**	**A**	**4.4**	**A**	**5.4**

① **Capacity analysis based on Highway Capacity Manual 2000 methodology, using Synchro 10.**
② **The FRA model's configuration was not supported by HCM methodologies; therefore, results were not produced.**
③ **Intersection not analyzed in DEIS.**

Table 1 (continued)
Level of Service Summary①

Approach	Alternative A-C – FRA Results				Alternative A-C – W+A Results			
	AM Peak Hour		PM Peak Hour		AM Peak Hour		PM Peak Hour	
	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
17. Columbus Circle/First Street/Massachusetts Avenue – Signalized								
EB	E	73.4	B	16.4	F	240.8	D	36.0
WB	F	182.0	D	35.1	F	349.6	F	110.7
NB	D	42.6	D	42.8	C	29.5	C	30.2
Overall	**F**	**125.9**	**C**	**24.5**	**F**	**288.9**	**E**	**63.5**
19. N Capital Street/E Street – Signalized								
EB	D	35.1	C	31.9	E	56.4	D	41.8
WB	D	54.2	D	35.0	E	70.9	D	51.5
NB	C	23.5	A	9.0	C	27.4	C	25.6
SB	D	43.5	D	44.1	C	28.9	B	15.9
Overall	**D**	**37.1**	**C**	**28.3**	**D**	**40.0**	**C**	**31.2**
35. H Street/Bus Exit/Central Road – Signalized								
EB	B	17.9	B	13.2	F	90.3	B	16.0
WB	F	108.3	B	18.3	F	87.7	B	11.4
NB	D	41.3	D	53.1	D	44.2	F	192.4
SB	D	39.8	C	34.6	D	38.3	D	39.5
NE	NA	NA	NA	NA	E	77.3	F	107.7
Overall	**E**	**79.6**	**B**	**19.9**	**F**	**85.7**	**C**	**34.3**
91. N Capital Street/G Place – Signalized								
NB	③	③	③	③	A	1.6	A	1.0
SB	③	③	③	③	A	8.0	A	3.3
Overall	③	③	③	③	**A**	**5.5**	**A**	**2.1**
92. 1st Street/G Place – Unsignalized								
EB	③	③	③	③	E	44.8	B	14.9
NB	③	③	③	③	A	0.0	A	0.0

① **Capacity analysis based on Highway Capacity Manual 2000 methodology, using Synchro 10.**
② **The FRA model's configuration was not supported by HCM methodologies; therefore, results were not produced.**
③ **Intersection not analyzed in DEIS.**

As shown in Table 1, under Alternative A-C conditions, nine of the 15 signalized study intersections are projected to operate at an ***overall*** LOS E or LOS F, including the following intersections:

- North Capitol Street/K Street (AM and PM peak hours),
- K Street/1st Street (AM and PM peak hours),
- K Street/2nd Street (AM and PM peak hours),
- North Capitol Street/H Street (AM and PM peak hours),
- H Street/East Road (AM peak hour),
- North Capitol Street/G Street (AM and PM peak hours),

- North Capitol Street/Massachusetts Avenue/F Street (AM and PM peak hours),
- Columbus Circle/1st Street/Massachusetts Avenue (AM and PM peak hours), and
- H Street/Central Road (AM peak hour).

Synchro worksheets for Alternative A-C are included in Attachment A.

Queue Analysis

The 95th percentile queues under Preferred Alternative A-C resulting from the W+A Synchro model, are summarized in Table 2.

Table 2
95th Percentile Queue Summary

Lane Group	Available Storage	AM Peak Hour	PM Peak Hour
1. N Capital Street/K Street - Signalized			
EBL	120	#205	#353
EBT	520	218	#1047
EBR	95	107	55
WBL	150	230	#353
WBT	790	#1798	#1529
WBR	75	126	155
NBLTR	345	m#278	m234
SBLTR	350	#831	#890
2. K Street/First Street - Signalized			
EBL	150	#115	56
EBTR	790	213	#1275
WBT	580	m331	m214
WBR	580	m0	m0
NBL	110	#602	#1020
NBT/NBTR	1000	79	#364
SBL	200	36	61
SBR	200	#143	#200
3. K Street/2nd Street - Signalized			
EBLT	580	79	m126
EBR	580	m4	m0
WBLTR	360	#1204	#402
NBLTR	350	#497	#421
SBLTR	630	217	181

– 95th percentile volume exceeds capacity; queue may be longer.
m – Volume for 95th percentile queue is metered by upstream signal.

Table 2 (continued)
95th Percentile Queue Summary

Lane Group	Available Storage	AM Peak Hour	PM Peak Hour
5. N Capital Street/H Street - Signalized			
EBL	785	#194	#214
EBTR	785	#584	#706
WBTR	635	m#1204	#2054
NBLTR	150	#413	#415
SBTR	315	m195	m147
6. H Street/West Road – Signalized			
EBT	600	m309	m384
EBR	50	m131	m68
WBL	240	m26	m#167
WBT	240	m107	m374
SBL	150	30	104
SBTR	500	0	151
8. H Street/East Road – Signalized			
EBL	235	m#321	m30
EBTR	235	62	#712
WBT/WBTR	520	#1122	297
WBR	520	6	8
NBL	150	#477	#527
NBTR	500	125	154
NWR	100	0	0
10. N Capital Street/G Street – Signalized			
WBLTR	450	41	33
NBLTR	400	m84	m93
SBL	165	m#1021	#602
SBTR	165	67	26
11. G Street/1st Street – Unsignalized			
EBLT		954	176
NBLT		2	2
13. N Capital Street/F Street NW/Massachusetts Avenue – Signalized			
EBLTR	900	#499	#461
WBT	325	327	161
WBR	260	#465	#226
NBTR	330	m#473	#493
SBLT	415	#644	324
SBR	415	m#187	#191
NER	680	93	126

– 95th percentile volume exceeds capacity; queue may be longer.
m – Volume for 95th percentile queue is metered by upstream signal.

Table 2 (continued)
95th Percentile Queue Summary

Lane Group	Available Storage	AM Peak Hour	PM Peak Hour
14. Columbus Circle/E Street/Massachusetts Avenue/First Street – Signalized			
EBL	180	m3	m2
EBR	570	m34	m112
WBL	40	243	212
WBT	145	226	229
WBR	270	347	209
NBL	75	239	#122
NBTR	225	258	124
SBLTR	330	m170	m193
15. Columbus Circle/Louisiana Avenue – Signalized			
EBT	75	285	355
EBR	100	m#203	162
WBLT	95	116	8
NBR	425	#469	277
16. Columbus Circle/Delaware Avenue – Signalized			
EBT	130	114	109
EBR	130	m0	m1
WBT	100	m3	m14
NBR	265	2	13
17. Columbus Circle/First Street/Massachusetts Avenue – Signalized			
EBL	120	#630	#373
EBT	120	31	42
EBR	120	0	m0
WBTR	600	#980	#546
NBLTR	275	38	51
19. N Capital Street/E Street – Signalized			
EBL	105	#188	#219
EBT	275	144	232
EBR	200	0	26
WBL	200	m90	m#138
WBT	200	#443	#297
WBR	95	m0	m4
NBLTR	130	360	296
SBLTR	325	m#120	m224
# – 95th percentile volume exceeds capacity; queue may be longer. m – Volume for 95th percentile queue is metered by upstream signal.			

Table 2 (continued)
95th Percentile Queue Summary

Lane Group	Available Storage	AM Peak Hour	PM Peak Hour
35. H Street/Bus Exit/Central Road – Signalized			
EBL	240	#275	m27
EBTR	240	72	m263
WBL	235	m9	m37
WBTR	235	m199	m451
NBL	500	99	#400
NBTR	500	0	48
SBL	150	44	63
SBTR	500	7	40
NER		#125	#155
91. N Capital Street/G Place – Signalized			
NBTR	165	31	10
SBLT	150	m43	m37
92. 1st Street/G Place – Unsignalized			
EBL	500	100	10
NBLT	170	0	0

As shown in Table 2, each study intersection is projected to have lane groups with 95th percentile queues exceeding the available storage during both the AM and PM peak hours, with the following exceptions:

- Columbus Circle and Delaware Avenue,
- North Capitol Street/G Place, and
- G Place/1st Street.

Queue reports are provided in Attachment A.

KEY AREAS OF CONCERN

North Capitol Street/G Street (#10)

Under the W+A model, the southbound approach is projected to operate at a LOS F with nearly 900 seconds of delay per vehicle, and the 95th percentile queue is projected to be over 1,000 feet in the AM peak hour. The W+A model shows a far more significant impact than the FRA model. A detailed investigation into the reasons for the excessive delay and queuing reveals the following factors:

1. The southbound left turn volume is projected to be 612 vehicles per hour during the AM peak hour. The high volume is a result of southbound 1st Street traffic rerouted to the North Capitol Street/G Street intersection. As shown on Figure 3, 12 curb cuts (serving both parking garages and loading berths) are located on 1st Street between K Street and G Street. With the conversion of this portion of 1st Street from two-way operation to one-way northbound operation, a significant volume of traffic would need to reroute to G Street in order to access the curb cuts. G Street is the first opportunity south of K Street to provide eastbound access to 1st Street. As a result, a significant volume of southbound left turns would be expected and is captured in FRA's 2040 forecasts.
2. As a rule of thumb, when left turn volumes exceed 300 per hour, dual left turn lanes should be considered. The FRA forecasts project over 600 southbound left turns. It is unrealistic to think that 600 left turns per hour could be made from a shared left/through lane or even a single left turn lane without significant delays and queues.

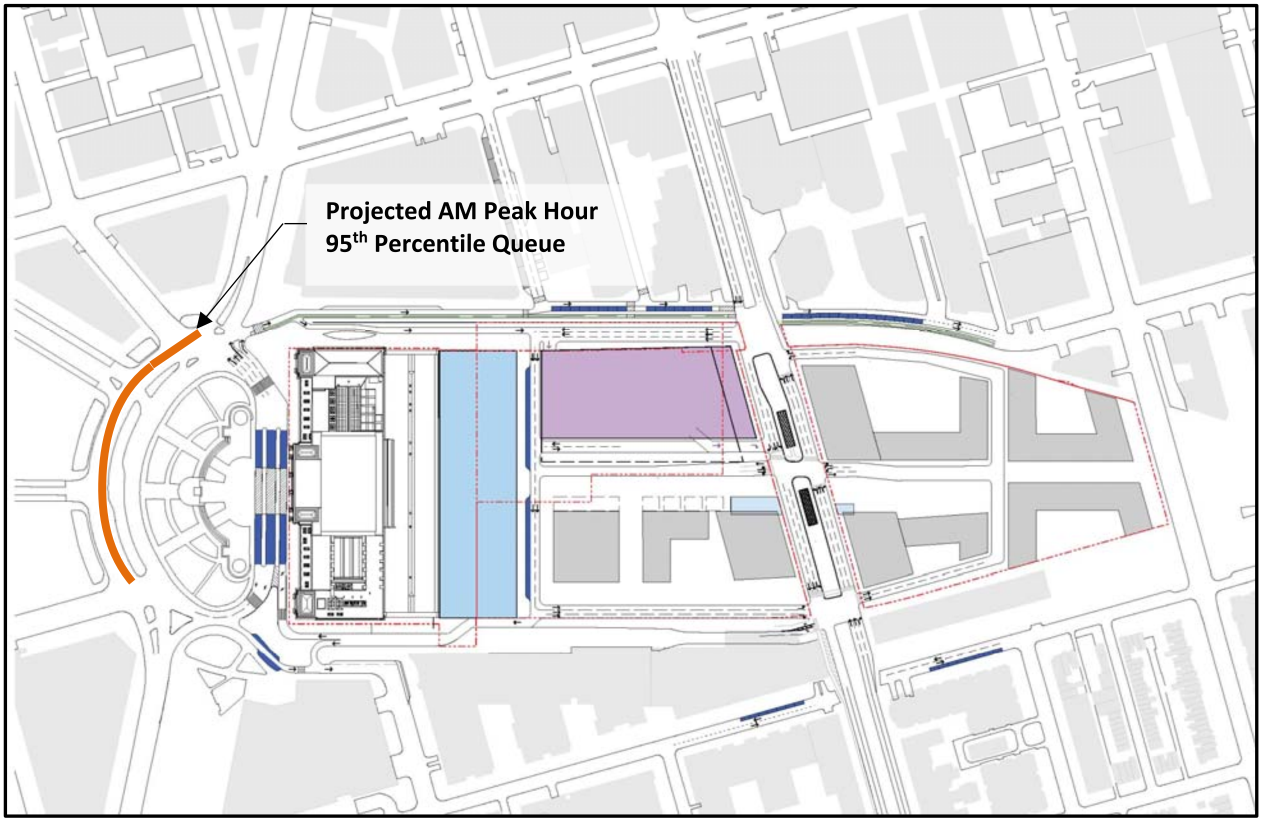
Because the FRA model did not code that de facto southbound left turn lane as an exclusive left turn lane at the North Capitol Street/G Street intersection, as prescribed by standard industry practice, the delay associated with the high left turn volume was masked because it was averaged into the overall delay for the approach.

FRA's plans to convert 1st Street to one-way northbound provide some benefit with respect to accommodating the proposed PUDO areas along 1st Street between G Street and K Street. As proposed, a one-way northbound configuration would allow for the following components from west to east: sidewalk, one northbound travel lane, PUDO lane, median, cycle track, and sidewalk. However, a closer review of the impacts associated with rerouting southbound 1st Street traffic suggests that conversion of 1st Street to one-way northbound operation has significant operational impacts on North Capitol Street during both peak hours, but especially during the AM peak hour.

Columbus Circle/1st Street/Massachusetts Avenue (#17)

The Columbus Circle/1st Street/Massachusetts Avenue intersection serves as the entrance to the Columbus Circle PUDO area. Under the W+A model, the 95th percentile queue for the eastbound left turn movement into the PUDO area is projected to extend through the outbound side of Columbus Circle during the AM peak hour, as shown on Exhibit 1.

Exhibit 1
Queues on Columbus Circle



While the W+A model shows a projected 95th percentile queue extending through and blocking the outbound side of the PUDO area, the FRA model shows the projected queue stopping just short of blocking the outbound side of the PUDO area. The reason for the discrepancy between the models is related to the phasing coded for the intersection. The W+A model uses the existing signal phasing but with optimized splits to minimize the delay and queuing. The FRA model modified the existing phasing. The validity of the phasing used in the FRA model could not be confirmed based on the information that was provided by FRA. However, the fact that the FRA model coded the eastbound left turns into the PUDO area as through movements does raise a concern. The HCM methodology that Synchro utilizes treats left turns differently than through movements. Specifically, left turn movements have a lower capacity than through movements. As a result, coding left turn movements as through movements provides for a better level of service, lower delay, and shorter queues than would result for a left turn movement. While we acknowledge that the left turn movement at this intersection is a more gradual left turn than at a typical intersection, it is clearly a left turn and not a through movement, as the FRA model would suggest.

Furthermore, the queues predicted by the Synchro model assume that the process rate for the PUDO facility does not inhibit the flow of traffic through the intersection and into the PUDO area. In other words, the queue predicted by the Synchro model is the result of the queues that would result solely from the traffic signal at the Columbus Circle/1st Street/Massachusetts Avenue intersection. If the egress from the PUDO area is blocked, no additional traffic will be able to enter the PUDO area, further extending the eastbound queues and causing gridlock within the PUDO area.

H Street/Central Road/Bus Egress (#35)

The FRA model analyzed the right turn bus egress on H Street as a stand-alone, signalized intersection. However, given the proximity of the bus egress to the central road, two separate traffic signals (one for the bus egress and one for the central road) is not feasible. The W+A model incorporated the bus egress as a fifth leg at the H Street/Central Road intersection, which resulted in an overall LOS F during the AM peak hour. A significant increase in delay (compared to the FRA model) was projected for the northbound, central road, approach; however, the overall level of service during the PM peak hour was projected to be acceptable at a LOS C.

Preferred Alternative A-C also requires all buses to turn right onto H Street when leaving the site, which would require deviation from current routes. No further information regarding modified routes was provided. Details of the modified routes should be provided, and any impacts associated with the rerouting of the buses should be addressed.

West Road/East-West Road

The intersection of the west road with the east-west road adjacent to the Train Hall is projected to experience a high volume of traffic through the intersection: 1,100 AM peak hour trips and 900 PM peak hour trips.

In addition to the high volume of traffic through the intersection, the entrance to the bus facility is located immediately adjacent to and within the functional area[3] of the intersection. According

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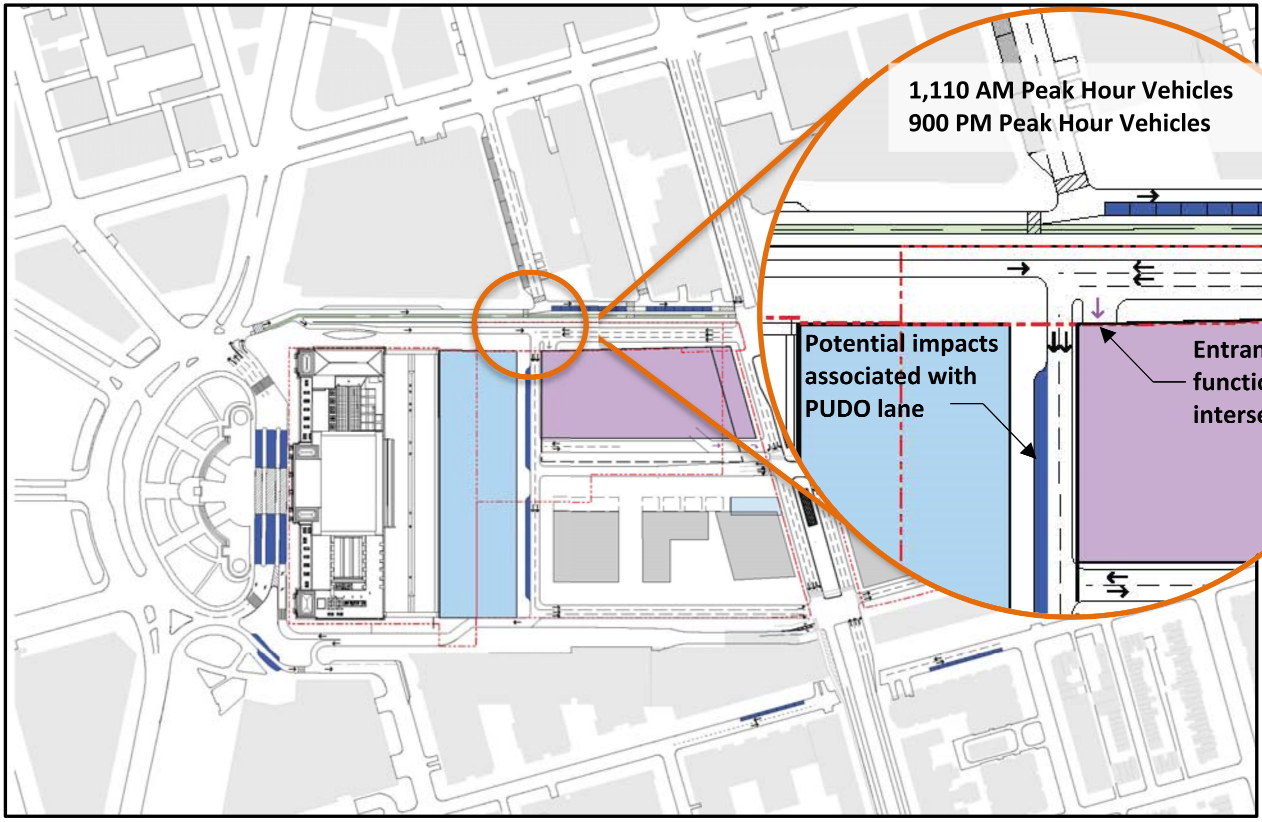
[3] According to the American Association of State Highway Transportation Officials (AASHTO), the upstream functional area of an intersection is influenced by 1) distance traveled during perception-reaction time, 2) deceleration distance while the driver maneuvers to a stop, and 3) the amount of queuing at the intersection. The downstream functional area varies by jurisdiction, but according to the Transportation Research Board, stopping sight distance can be one factor in determining the downstream functional area.

to the Federal Highway Administration's *Access Management in the Vicinity of Intersections*, limiting driveways within the functional areas of intersections improves safety.

Additionally, the impacts associated with PUDO traffic entering and exiting the traffic stream along the east-west road in proximity to the intersection is of concern. The number of vehicles entering and exiting the PUDO lane along the east-west road is expected to be higher than a conventional on-street parking lane, and the impact of the PUDO area on the operation of the intersection is highly dependent on the management of the PUDO area. Any traffic stopped in the travel lane waiting to enter the PUDO area, or any vehicles that do not pull the entire way into the PUDO lane and partially block the travel lane, would have a substantial impact on the operation of the intersection and could pose a potential safety concern since vehicles turning from the west road onto the east-west road would not be expecting stopped vehicles in the travel lane.

Exhibit 2 shows the layout of the intersection and highlights the areas of concern.

Exhibit 2
Intersection Configuration at West Road/East-West Road



1st Street, 2nd Street, and East-West Road PUDO Areas

Because of limitations associated with the Synchro model, the impact of the PUDO areas on adjacent travel lanes cannot be fully evaluated. The Highway Capacity Manual methodologies employed by Synchro take into account the loss of capacity at signalized intersections for lanes that are adjacent to on-street parking lanes. The number of parking maneuvers per hour reduces the amount of traffic that can be processed through the signal in the travel lane adjacent to the parking lane. A similar reduction in capacity could be expected for travel lanes adjacent to the PUDO areas on 1st Street, 2nd Street, and the east-west road. The impact on capacity could be exacerbated because the number of maneuvers into and out of the PUDO lanes would be significantly higher than a typical parking lane, and depending on the effectiveness of the management of the PUDO lane, PUDO traffic could spill out into the travel lane causing gridlock.

CONCLUSIONS

The redevelopment and expansion of Union Station presents a unique opportunity to create an exceptional urban multi-modal transportation hub that integrates with the surrounding neighborhood.

FRA's Preferred Alternative relies solely on on-street PUDO lanes to accommodate the extensive pick-up/drop-off operation for the station. While distributing PUDO operations provides some advantages, the proposed plan fails to address several key issues, including:

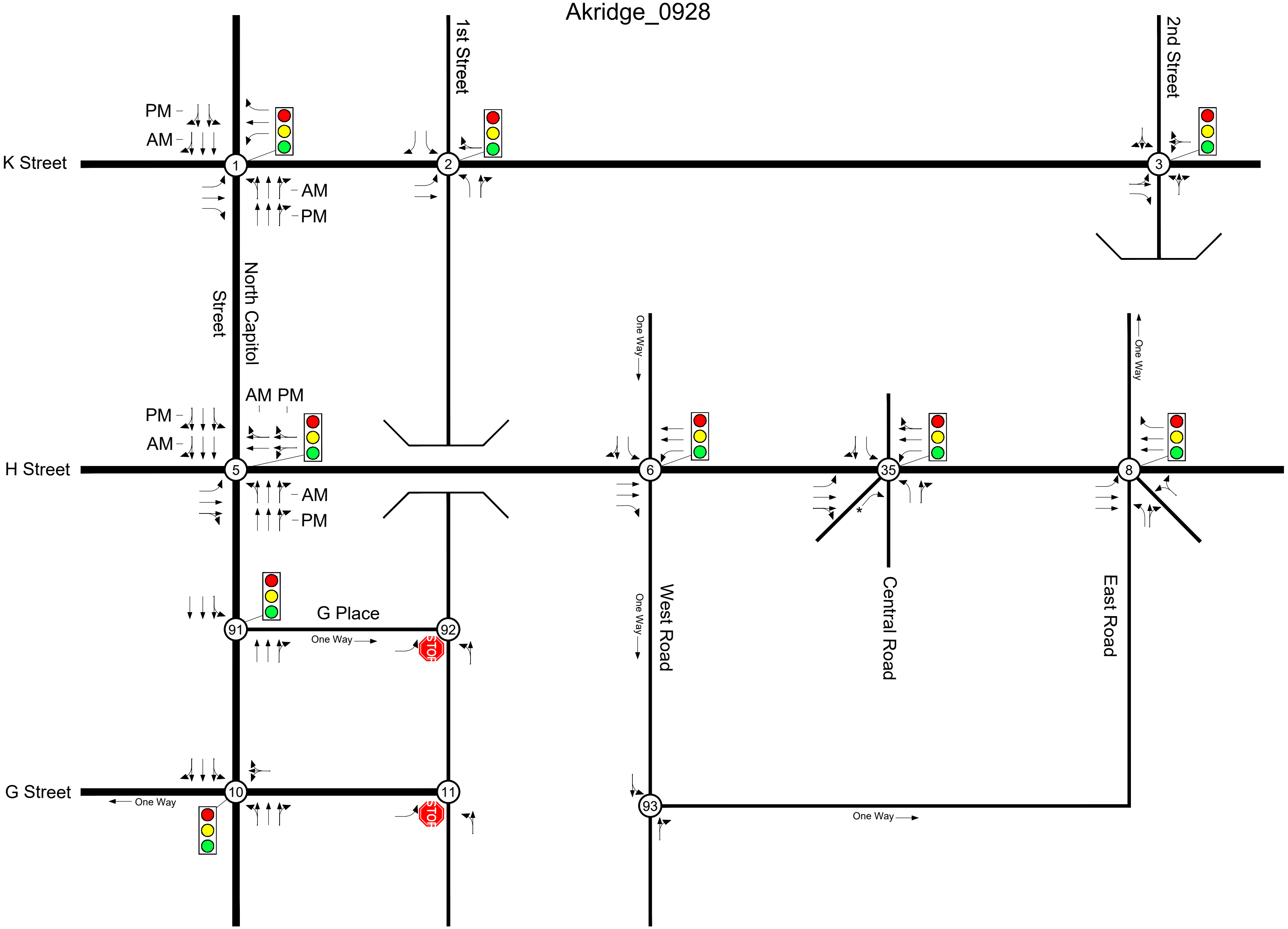
- FRA's model fails to adequately address concerns related to the gridlock at Columbus Circle. Preferred Alternative A-C relies on Columbus Circle to accommodate 40 percent of future PUDO traffic. Under current conditions, Columbus Circle fails to adequately accommodate existing traffic volumes. According to FRA's forecasts, under Preferred Alternative A-C, the volume of traffic utilizing the Columbus Circle PUDO area is projected to increase by 139 percent during the AM peak hour and 77 percent during the PM peak hour. Despite this significant increase in volume, Preferred Alternative A-C fails to identify improvements to adequately ensure gridlock will not occur.
- Preferred Alternative A-C relies on 1st Street to accommodate 20 percent of PUDO traffic. In order to accommodate the 1st Street PUDO operation, Preferred Alternative A-C would convert 1st Street to one-way northbound. However, the plan to convert 1st Street fails to address the impacts associated with the conversion. 1st Street currently provides access to 12 garages and loading berths, and as a result, carries a significant volume of southbound traffic, particularly during the commuter peak hours. By converting 1st Street to one-way northbound, all southbound traffic on 1st Street will need to be rerouted. Since most, if not all, of the southbound traffic is destined to the garages and loading berths located along 1st Street, southbound traffic would be rerouted to North

Capitol Street. Since G Street is the first eastbound connection between North Capitol Street and 1st Street, a significant volume of traffic would be rerouted to the southbound left turn movement at the North Capitol Street/G Street intersection.

- Preferred Alternative A-C relies on a significant portion of PUDO traffic using lay-by lanes on 1st Street, and to a lesser extent, 2nd Street. The plan fails to provide a detailed transportation management plan that identifies measures to ensure the on-street PUDO lanes will not spill out onto adjacent travel lanes creating gridlock on 1st and 2nd Streets. Without such a plan and active, on-going management of the PUDO areas, PUDO traffic would spill into the adjacent, travel lane causing gridlock. This is of particular concern on 1st Street, where: (1) a high volume of PUDO traffic is projected, (2) only one travel lane is proposed, (3) an increase in bus traffic is anticipated due to the relocation of charter bus activities on G Street, and (4) access must be maintained to 12 curb cuts serving parking and loading facilities. Once PUDO traffic spills into the adjacent travel lane, through traffic on 1st Street would be blocked since there is not a second lane to bypass spillover from the PUDO lane.
- The DEIS fails to analyze on-site circulation on the deck-level, including how the convergence of buses, parkers, and PUDO traffic will be handled both efficiently and safely. The intersection of the west road and the east-west road north of the Train Hall was not even analyzed in the DEIS. While movements at the intersection are theoretically limited to northbound right turn movements and southbound left turn movements (since the east-west road is proposed to be one-way eastbound), the presence of the bus entrance within the functional area of the intersection and the presence of the PUDO area along the east-west road immediately east of the intersection, pose potential operational and safety concerns at the intersection that must be addressed.

A centralized PUDO facility with multiple points of ingress and egress would alleviate the reliance on on-street PUDO areas and reduce some of the burden on Columbus Circle, thereby reducing vehicular traffic immediately adjacent to the station and providing for a more pedestrian- and bicycle-friendly experience immediately surrounding the station.

FIGURES



*Buses only

A, B - Intersections not analyzed in DEIS

Figure 1A

FRA Alternative A-C Lane Use and Traffic Control

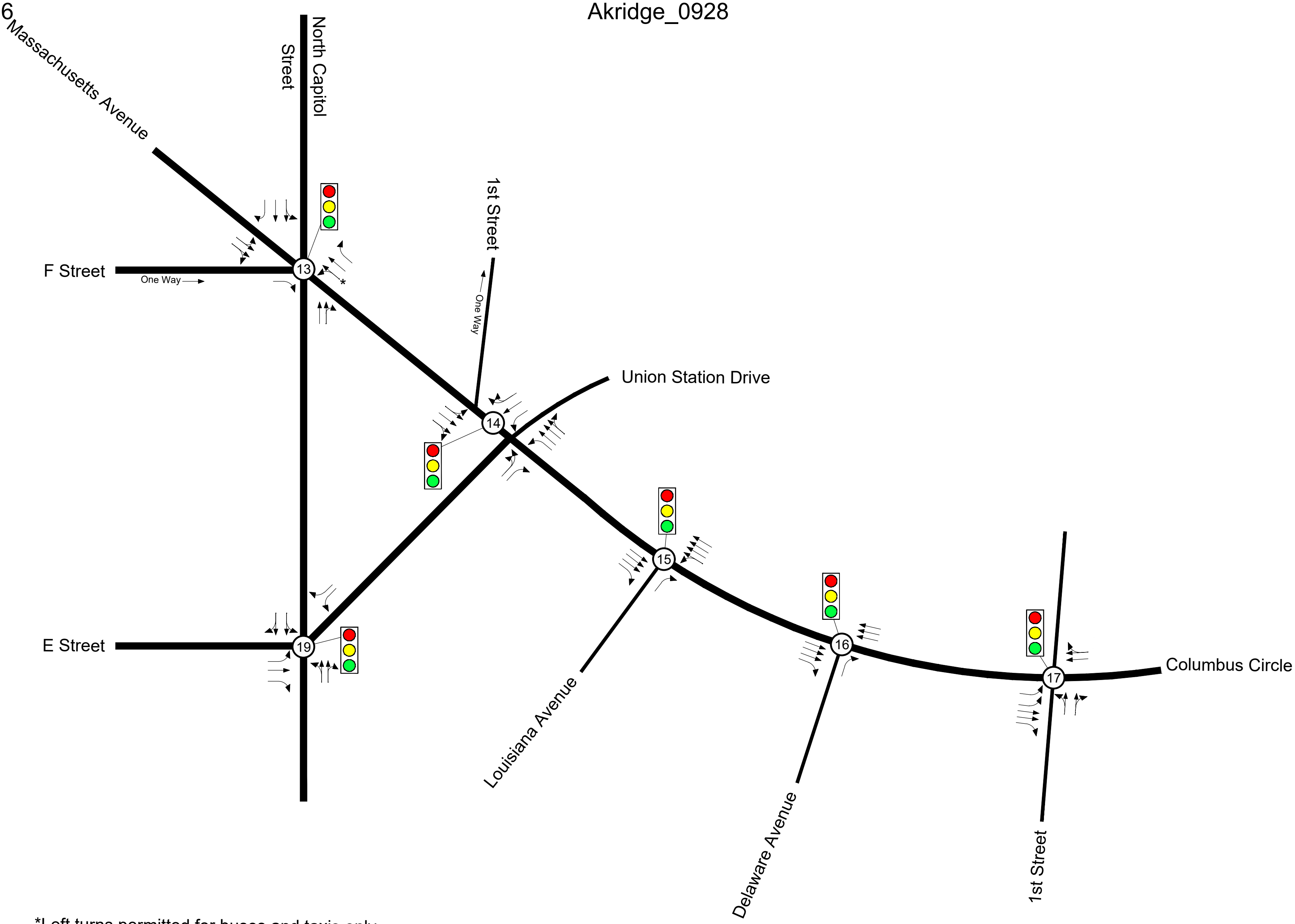
← Represents One Travel Lane

🚦 Signalized Intersection

🛑 Stop Sign

NORTH

Burnham Place
Washington, DC



*Left turns permitted for buses and taxis only.

Figure 1B

FRA Alternative A-C Lane Use and Traffic Control

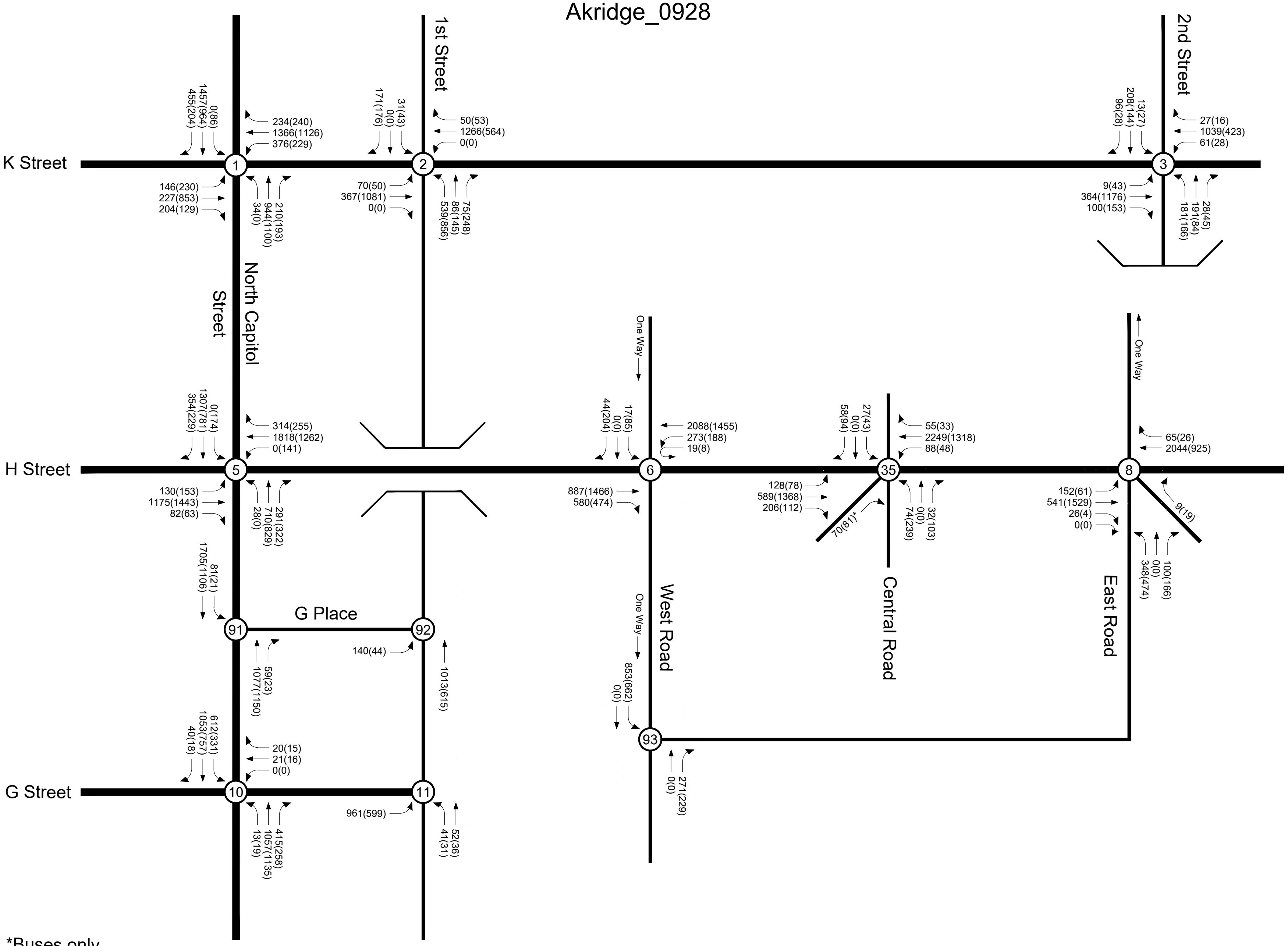
← Represents One Travel Lane

🚦 Signalized Intersection

NORTH

Burnham Place
Washington, DC

Akridge_0928



*Buses only

Intersections 91, 92, 93 not analyzed in DEIS

Figure 2A

FRA Alternative A-C Traffic Volumes

Burnham Place
Washington, DC

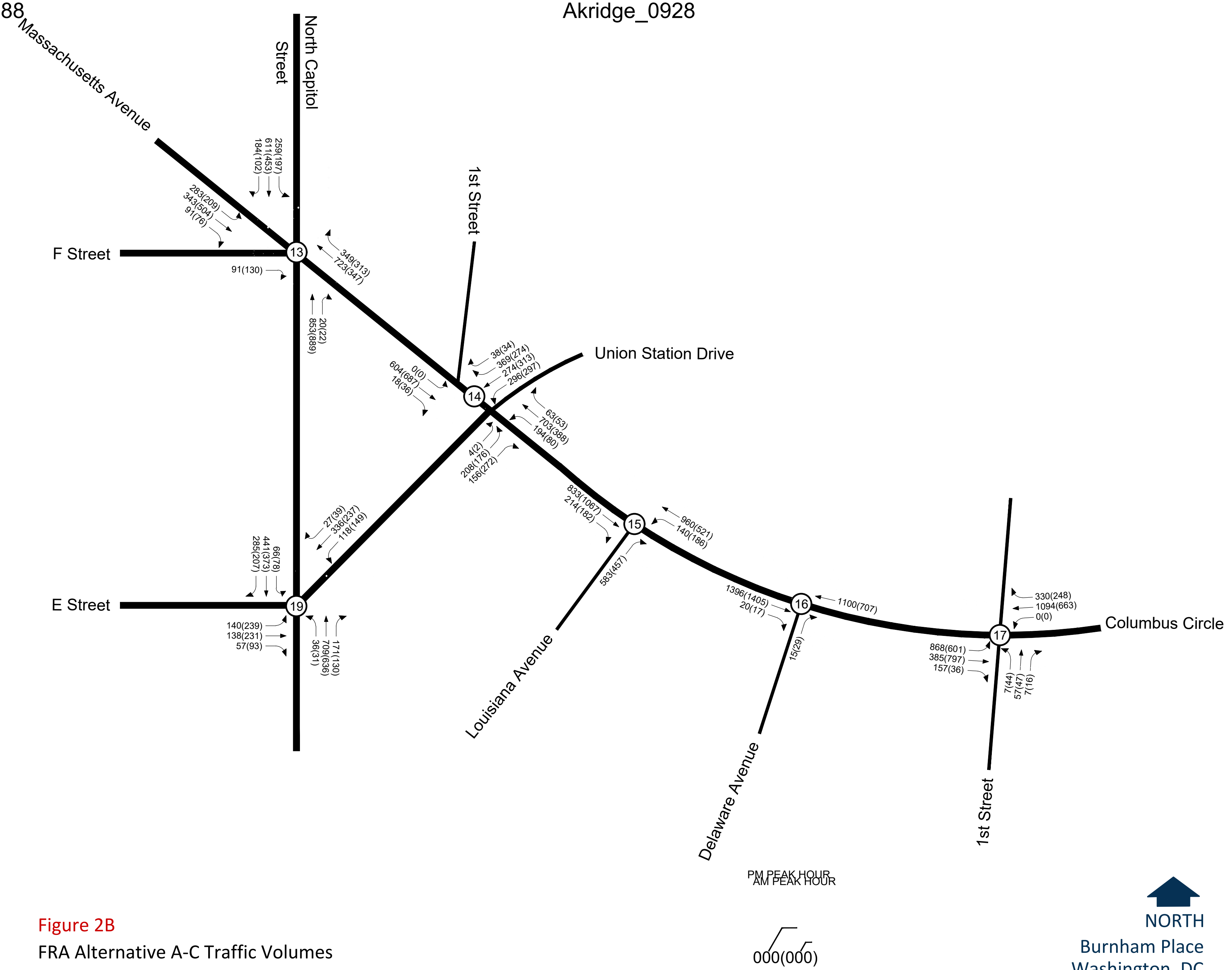


Figure 2B

FRA Alternative A-C Traffic Volumes

Burnham Place
Washington, DC

Figure 3

First Street NE

K Street NE to Massachusetts Avenue NW

a. Parking garage entrance 110 ft south of K Street

j. Loading dock entrance 245 ft north of G Place

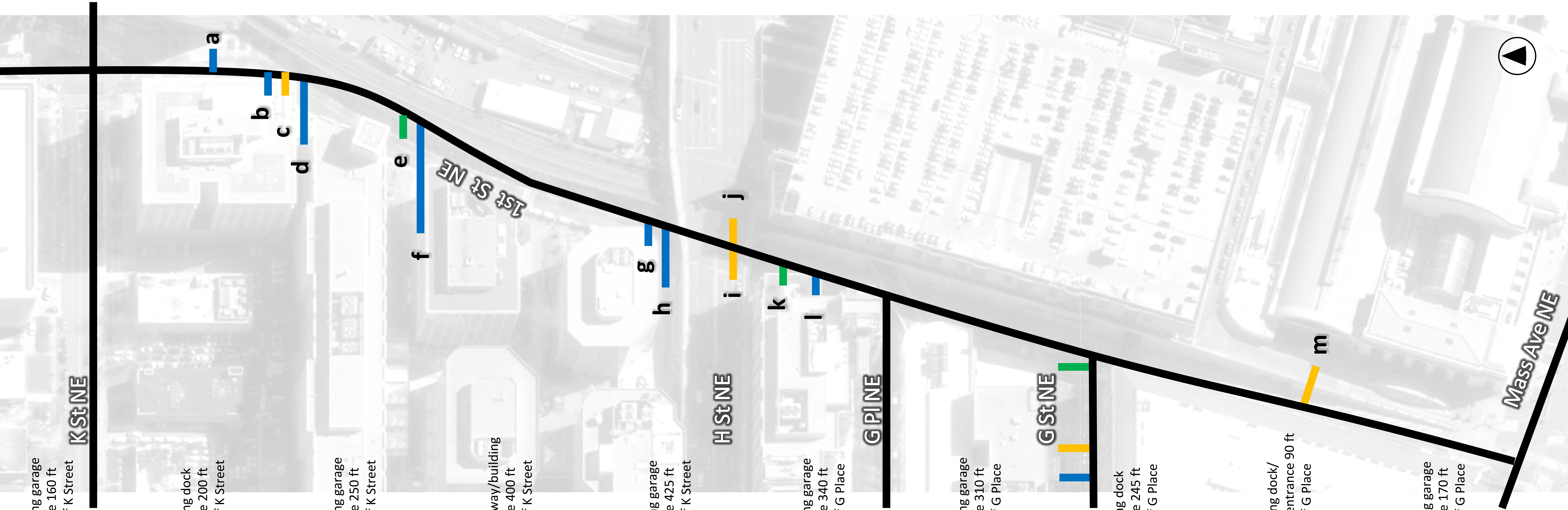
m. Loading dock entrance 350 ft north of Massachusetts Avenue

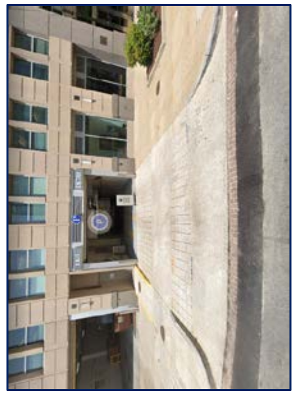
Legend

🟦 Parking Garage

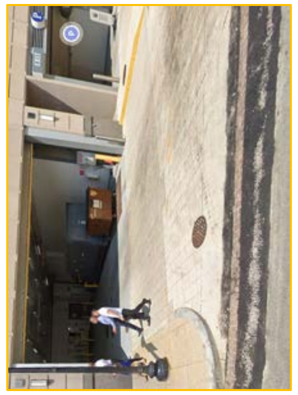
🟨 Loading Dock

🟩 Other

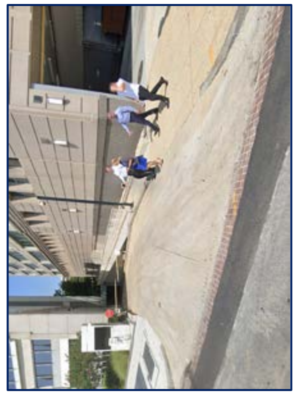




b. Parking garage entrance 160 ft south of K Street



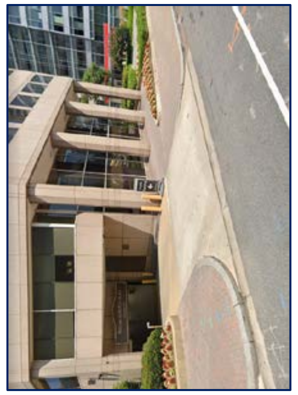
c. Loading dock entrance 200 ft south of K Street



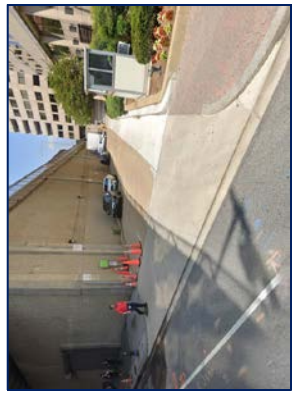
d. Parking garage entrance 250 ft south of K Street

e. Driveway/building entrance 400 ft south of K Street

f. Parking garage entrance 425 ft south of K Street

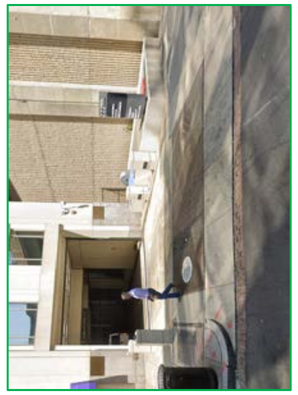


g. Parking garage entrance 340 ft north of G Place

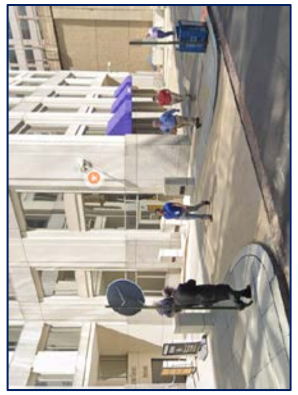


h. Parking garage entrance 310 ft north of G Place

i. Loading dock entrance 245 ft north of G Place



k. Loading dock/ garage entrance 90 ft north of G Place



l. Parking garage entrance 170 ft north of G Place

ATTACHMENT A
ALTERNATIVE A-C
Synchro Worksheets
(from W+A Model)

Queues

1: N. Capital Street & K Street NW/K Street NE

Total Future FRA A-C AM

	↗	→	↘	↙	←	↖	↑	↓
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBT	SBT
Lane Group Flow (vph)	151	234	210	388	1408	241	1224	1971
v/c Ratio	1.03	0.55	0.52	0.74	1.93	0.43	1.35	1.64
Control Delay	112.7	36.8	15.0	23.1	448.0	13.3	196.4	320.0
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	112.7	36.8	15.0	23.1	448.0	13.3	196.4	320.0
Queue Length 50th (ft)	~67	136	31	150	~1537	60	~406	~732
Queue Length 95th (ft)	#205	218	107	230	#1798	126	m#278	#831
Internal Link Dist (ft)		453			799		724	149
Turn Bay Length (ft)	120		95	150		75		
Base Capacity (vph)	146	427	401	527	728	556	906	1200
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.03	0.55	0.52	0.74	1.93	0.43	1.35	1.64

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
1: N. Capital Street & K Street NW/K Street NE

Total Future FRA A-C AM

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		↰↑↱			↰↑↱	
Traffic Volume (vph)	146	227	204	376	1366	234	34	944	210	0	1457	455
Future Volume (vph)	146	227	204	376	1366	234	34	944	210	0	1457	455
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	10	10	10	10	10
Grade (%)		-1%			1%			1%			-1%	
Total Lost time (s)	3.0	4.0	4.0	3.0	4.0	4.0		4.0			4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00		0.91			0.91	
Frpb, ped/bikes	1.00	1.00	0.88	1.00	1.00	0.84		0.95			0.87	
Flpb, ped/bikes	1.00	1.00	1.00	0.97	1.00	1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85		0.97			0.96	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00		1.00			1.00	
Satd. Flow (prot)	1424	1342	941	1337	1512	1049		3848			3512	
Flt Permitted	0.11	1.00	1.00	0.45	1.00	1.00		0.69			1.00	
Satd. Flow (perm)	171	1342	941	631	1512	1049		2676			3512	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	151	234	210	388	1408	241	35	973	216	0	1502	469
RTOR Reduction (vph)	0	0	102	0	0	51	0	30	0	0	51	0
Lane Group Flow (vph)	151	234	108	388	1408	190	0	1194	0	0	1920	0
Confl. Peds. (#/hr)	89		74	74		89	224		92	92		224
Confl. Bikes (#/hr)			8			68						1
Heavy Vehicles (%)	7%	4%	10%	10%	5%	7%	7%	4%	4%	2%	4%	5%
Bus Blockages (#/hr)	0	0	2	0	0	2	0	0	0	4	4	4
Parking (#/hr)		6	6									
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	Perm	NA			NA	
Protected Phases	7	4		3	8			2			6	
Permitted Phases	4		4	8		8	2			6		
Actuated Green, G (s)	38.0	33.0	33.0	61.0	51.0	51.0		34.0			34.0	
Effective Green, g (s)	42.0	35.0	35.0	63.0	53.0	53.0		36.0			36.0	
Actuated g/C Ratio	0.38	0.32	0.32	0.57	0.48	0.48		0.33			0.33	
Clearance Time (s)	5.0	6.0	6.0	5.0	6.0	6.0		6.0			6.0	
Lane Grp Cap (vph)	145	427	299	521	728	505		875			1149	
v/s Ratio Prot	c0.07	0.17		0.17	c0.93						c0.55	
v/s Ratio Perm	0.33		0.12	0.26		0.18		0.45				
v/c Ratio	1.04	0.55	0.36	0.74	1.93	0.38		1.36			1.67	
Uniform Delay, d1	30.2	31.0	28.9	15.0	28.5	18.0		37.0			37.0	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00		1.36			1.00	
Incremental Delay, d2	86.1	5.0	3.4	9.3	425.4	2.1		164.6			305.8	
Delay (s)	116.3	36.0	32.3	24.3	453.9	20.2		215.1			342.8	
Level of Service	F	D	C	C	F	C		F			F	
Approach Delay (s)		55.1			320.8			215.1			342.8	
Approach LOS		E			F			F			F	

Intersection Summary			
HCM 2000 Control Delay	278.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.75		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	153.5%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

2: First Street NE & K Street NE

	↗	→	←	↖	↰	↑	↘	↙
Lane Group	EBL	EBT	WBT	WBR	NBL	NBT	SBL	SBR
Lane Group Flow (vph)	71	371	1279	51	544	163	31	173
v/c Ratio	0.92	0.58	1.66	0.09	1.81	0.32	0.20	0.87
Control Delay	111.9	19.2	320.7	0.9	397.6	12.9	27.6	50.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	111.9	19.2	320.7	0.9	397.6	12.9	27.6	50.8
Queue Length 50th (ft)	31	126	~942	0	~415	33	12	15
Queue Length 95th (ft)	#115	213	m331	m0	#602	79	36	#143
Internal Link Dist (ft)		799	544			209		
Turn Bay Length (ft)	100				110			200
Base Capacity (vph)	77	641	771	557	301	508	157	198
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.92	0.58	1.66	0.09	1.81	0.32	0.20	0.87

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

2: First Street NE & K Street NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↱			↑	↱	↰	↱		↰		↱
Traffic Volume (vph)	70	367	0	0	1266	50	539	86	75	31	0	171
Future Volume (vph)	70	367	0	0	1266	50	539	86	75	31	0	171
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	12	12	12	10	10	10	10	10	10
Grade (%)		1%			1%			1%			1%	
Total Lost time (s)	4.0	4.0			4.0	4.0	3.0	4.0		4.0		4.0
Lane Util. Factor	1.00	1.00			1.00	1.00	1.00	1.00		1.00		1.00
Frpb, ped/bikes	1.00	1.00			1.00	0.72	1.00	0.92		1.00		0.35
Flpb, ped/bikes	1.00	1.00			1.00	1.00	0.44	1.00		0.87		1.00
Frt	1.00	1.00			1.00	0.85	1.00	0.93		1.00		0.85
Flt Protected	0.95	1.00			1.00	1.00	0.95	1.00		0.95		1.00
Satd. Flow (prot)	1465	1316			1582	1000	632	1252		914		386
Flt Permitted	0.10	1.00			1.00	1.00	0.95	1.00		0.65		1.00
Satd. Flow (perm)	158	1316			1582	1000	632	1252		629		386
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	71	371	0	0	1279	51	544	87	76	31	0	173
RTOR Reduction (vph)	0	0	0	0	0	26	0	39	0	0	0	102
Lane Group Flow (vph)	71	371	0	0	1279	25	544	124	0	31	0	71
Confl. Peds. (#/hr)	96		105	105		96	454		129	129		454
Confl. Bikes (#/hr)			7			11			4			66
Heavy Vehicles (%)	3%	5%	3%	4%	5%	2%	5%	7%	10%	25%	3%	7%
Bus Blockages (#/hr)	0	0	0	0	6	6	0	0	0	0	0	0
Parking (#/hr)		6	6							6	6	6
Turn Type	Perm	NA			NA	Perm	pm+pt	NA		Perm		Perm
Protected Phases		2			6		7	4				
Permitted Phases	2					6	4			8		8
Actuated Green, G (s)	37.0	37.0			37.0	37.0	28.0	28.0		18.0		18.0
Effective Green, g (s)	39.0	39.0			39.0	39.0	30.0	30.0		20.0		20.0
Actuated g/C Ratio	0.49	0.49			0.49	0.49	0.38	0.38		0.25		0.25
Clearance Time (s)	6.0	6.0			6.0	6.0	5.0	6.0		6.0		6.0
Lane Grp Cap (vph)	77	641			771	487	237	469		157		96
v/s Ratio Prot		0.28			c0.81		c0.20	0.10				
v/s Ratio Perm	0.45					0.02	0.66			0.05		0.18
v/c Ratio	0.92	0.58			1.66	0.05	2.30	0.26		0.20		0.74
Uniform Delay, d1	19.1	14.6			20.5	10.8	25.0	17.3		23.7		27.6
Progression Factor	1.00	1.00			1.24	1.00	1.00	1.00		1.00		1.00
Incremental Delay, d2	82.5	3.8			297.0	0.0	596.1	1.4		2.8		39.8
Delay (s)	101.6	18.4			322.5	10.8	621.1	18.7		26.5		67.4
Level of Service	F	B			F	B	F	B		C		E
Approach Delay (s)		31.8			310.6			482.2			61.1	
Approach LOS		C			F			F			E	

Intersection Summary			
HCM 2000 Control Delay	290.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.05		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	138.6%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

3: 2nd Street NE & K Street NE

Total Future FRA A-C AM

	→	↘	←	↑	↓
Lane Group	EBT	EBR	WBT	NBT	SBT
Lane Group Flow (vph)	406	109	1224	435	344
v/c Ratio	0.47	0.19	1.86	1.61	0.63
Control Delay	7.2	1.0	413.1	315.2	24.9
Queue Delay	0.0	0.0	0.0	0.0	0.0
Total Delay	7.2	1.0	413.1	315.2	24.9
Queue Length 50th (ft)	53	0	~960	~319	126
Queue Length 95th (ft)	79	m4	#1204	#497	217
Internal Link Dist (ft)	544		358	330	19
Turn Bay Length (ft)					
Base Capacity (vph)	864	575	658	270	542
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	0.47	0.19	1.86	1.61	0.63

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
3: 2nd Street NE & K Street NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰	↱		✥			✥			✥	
Traffic Volume (vph)	9	364	100	61	1039	27	181	191	28	13	208	96
Future Volume (vph)	9	364	100	61	1039	27	181	191	28	13	208	96
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	10	10	10	10	10	10	10	10	10
Grade (%)		-2%			-4%			-4%			-1%	
Total Lost time (s)		3.0	3.0		3.0			4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00			1.00			1.00	
Frpb, ped/bikes		1.00	0.71		0.99			0.99			0.97	
Flpb, ped/bikes		1.00	1.00		0.99			0.98			1.00	
Frt		1.00	0.85		1.00			0.99			0.96	
Flt Protected		1.00	1.00		1.00			0.98			1.00	
Satd. Flow (prot)		1659	977		1274			1189			1424	
Flt Permitted		0.97	1.00		0.96			0.59			0.98	
Satd. Flow (perm)		1609	977		1224			714			1394	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	10	396	109	66	1129	29	197	208	30	14	226	104
RTOR Reduction (vph)	0	0	50	0	1	0	0	3	0	0	19	0
Lane Group Flow (vph)	0	406	59	0	1223	0	0	432	0	0	325	0
Confl. Peds. (#/hr)	58		77	77		58	70		32	32		70
Confl. Bikes (#/hr)						14			17			14
Heavy Vehicles (%)	2%	4%	6%	2%	8%	2%	3%	23%	2%	25%	4%	2%
Bus Blockages (#/hr)	0	0	0	4	4	4	0	0	0	0	0	0
Parking (#/hr)				6	6	6	6	6	6			
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			4			8	
Permitted Phases	2		2	6			4			8		
Actuated Green, G (s)		41.0	41.0		41.0			28.0			28.0	
Effective Green, g (s)		43.0	43.0		43.0			30.0			30.0	
Actuated g/C Ratio		0.54	0.54		0.54			0.38			0.38	
Clearance Time (s)		5.0	5.0		5.0			6.0			6.0	
Lane Grp Cap (vph)		864	525		657			267			522	
v/s Ratio Prot												
v/s Ratio Perm		0.25	0.06		c1.00			c0.60			0.23	
v/c Ratio		0.47	0.11		1.86			1.62			0.62	
Uniform Delay, d1		11.4	9.1		18.5			25.0			20.4	
Progression Factor		0.47	0.16		1.00			1.00			1.00	
Incremental Delay, d2		1.6	0.4		393.6			294.5			5.5	
Delay (s)		7.0	1.9		412.1			319.5			25.9	
Level of Service		A	A		F			F			C	
Approach Delay (s)		5.9			412.1			319.5			25.9	
Approach LOS		A			F			F			C	

Intersection Summary			
HCM 2000 Control Delay	260.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.76		
Actuated Cycle Length (s)	80.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	146.9%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

5: N. Capital Street & H Street NW/H Street NE

Total Future FRA A-C AM

	↗	→	←	↑	↓
Lane Group	EBL	EBT	WBT	NBT	SBT
Lane Group Flow (vph)	133	1283	2175	1050	1695
v/c Ratio	1.06	0.91	1.64	1.18	1.33
Control Delay	122.4	32.9	319.6	125.9	174.3
Queue Delay	0.0	2.5	0.0	0.0	0.0
Total Delay	122.4	35.4	319.6	125.9	174.4
Queue Length 50th (ft)	~67	405	~1215	~325	~554
Queue Length 95th (ft)	#194	#584	m#1204	#413	m195
Internal Link Dist (ft)		456	821	157	724
Turn Bay Length (ft)					
Base Capacity (vph)	126	1407	1326	890	1277
Starvation Cap Reductn	0	0	0	0	0
Spillback Cap Reductn	0	59	0	0	9
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.06	0.95	1.64	1.18	1.34

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
5: N. Capital Street & H Street NW/H Street NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱			↑↱			↰↑↱			↑↑↱	
Traffic Volume (vph)	130	1175	82	0	1818	314	28	710	291	0	1307	354
Future Volume (vph)	130	1175	82	0	1818	314	28	710	291	0	1307	354
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	11	11	11	11	10	10	10	10	10	11
Grade (%)		-1%			-7%			1%			-1%	
Total Lost time (s)	3.0	3.0			4.0			4.0			4.0	
Lane Util. Factor	1.00	0.95			0.95			0.91			0.91	
Frpb, ped/bikes	1.00	0.97			0.95			0.91			0.93	
Flpb, ped/bikes	1.00	1.00			1.00			1.00			1.00	
Frt	1.00	0.99			0.98			0.96			0.97	
Flt Protected	0.95	1.00			1.00			1.00			1.00	
Satd. Flow (prot)	1231	2499			2860			3531			3699	
Flt Permitted	0.08	1.00			1.00			0.73			1.00	
Satd. Flow (perm)	102	2499			2860			2577			3699	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	133	1199	84	0	1855	320	29	724	297	0	1334	361
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	133	1283	0	0	2175	0	0	1050	0	0	1695	0
Confl. Peds. (#/hr)	331		161	161		331	318		302	302		318
Confl. Bikes (#/hr)			4			1			3			7
Heavy Vehicles (%)	6%	9%	4%	31%	6%	4%	36%	4%	8%	12%	7%	2%
Bus Blockages (#/hr)	4	4	4	0	0	0	4	4	4	4	4	4
Parking (#/hr)	6	6	6									
Turn Type	D.P+P	NA			NA		Perm	NA			NA	
Protected Phases	7	7 8			8			2			6	
Permitted Phases	8						2					
Actuated Green, G (s)	54.0	59.0			49.0			36.0			36.0	
Effective Green, g (s)	58.0	61.0			51.0			38.0			38.0	
Actuated g/C Ratio	0.53	0.55			0.46			0.35			0.35	
Clearance Time (s)	5.0				6.0			6.0			6.0	
Lane Grp Cap (vph)	125	1385			1326			890			1277	
v/s Ratio Prot	c0.07	0.51			c0.76						c0.46	
v/s Ratio Perm	0.49							0.41				
v/c Ratio	1.06	0.93			1.64			1.18			1.33	
Uniform Delay, d1	29.8	22.4			29.5			36.0			36.0	
Progression Factor	1.00	1.00			1.49			1.02			0.75	
Incremental Delay, d2	98.7	12.0			289.0			91.7			147.8	
Delay (s)	128.5	34.4			333.0			128.5			174.9	
Level of Service	F	C			F			F			F	
Approach Delay (s)		43.3			333.0			128.5			174.9	
Approach LOS		D			F			F			F	

Intersection Summary			
HCM 2000 Control Delay	192.1	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.46		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	134.6%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

c Critical Lane Group

Queues

6: West Road & H Street NE

	→	↘	↙	←	↘	↓
Lane Group	EBT	EBR	WBL	WBT	SBL	SBT
Lane Group Flow (vph)	905	592	279	2131	17	45
v/c Ratio	0.61	0.67	0.62	1.01	0.07	0.13
Control Delay	20.3	7.7	9.1	15.6	38.3	0.8
Queue Delay	0.0	0.0	0.6	35.2	0.0	0.0
Total Delay	20.3	7.7	9.7	50.8	38.3	0.8
Queue Length 50th (ft)	303	196	30	~133	10	0
Queue Length 95th (ft)	m309	m131	m26	m107	30	0
Internal Link Dist (ft)	821			250		125
Turn Bay Length (ft)						
Base Capacity (vph)	1475	879	447	2113	245	343
Starvation Cap Reductn	0	0	32	267	0	0
Spillback Cap Reductn	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.61	0.67	0.67	1.15	0.07	0.13

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
6: West Road & H Street NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑	↱	↰	↑↑					↰	↱	
Traffic Volume (vph)	0	887	580	273	2088	0	0	0	0	17	0	44
Future Volume (vph)	0	887	580	273	2088	0	0	0	0	17	0	44
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	10	10	12	10	10	12	10	12	10	12	12
Grade (%)		7%			-7%			-5%			0%	
Total Lost time (s)		5.0	5.0	5.0	5.0					5.0	5.0	
Lane Util. Factor		0.95	1.00	1.00	0.95					1.00	1.00	
Frpb, ped/bikes		1.00	0.91	1.00	1.00					1.00	0.98	
Flpb, ped/bikes		1.00	1.00	1.00	1.00					0.91	1.00	
Frt		1.00	0.85	1.00	1.00					1.00	0.85	
Flt Protected		1.00	1.00	0.95	1.00					0.95	1.00	
Satd. Flow (prot)		2660	1111	1645	2906					1350	1399	
Flt Permitted		1.00	1.00	0.23	1.00					0.95	1.00	
Satd. Flow (perm)		2660	1111	400	2906					1350	1399	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	0	905	592	279	2131	0	0	0	0	17	0	45
RTOR Reduction (vph)	0	0	264	0	0	0	0	0	0	0	37	0
Lane Group Flow (vph)	0	905	328	279	2131	0	0	0	0	17	8	0
Confl. Peds. (#/hr)			23	23						50		
Confl. Bikes (#/hr)			5			5			5			5
Heavy Vehicles (%)	2%	10%	7%	2%	8%	6%	2%	2%	2%	2%	2%	2%
Turn Type		NA	Perm	pm+pt	NA					Perm	NA	
Protected Phases		4		3	8						6	
Permitted Phases			4	8						6		
Actuated Green, G (s)		59.0	59.0	78.0	78.0					18.0	18.0	
Effective Green, g (s)		61.0	61.0	80.0	80.0					20.0	20.0	
Actuated g/C Ratio		0.55	0.55	0.73	0.73					0.18	0.18	
Clearance Time (s)		7.0	7.0	7.0	7.0					7.0	7.0	
Lane Grp Cap (vph)		1475	616	449	2113					245	254	
v/s Ratio Prot		0.34		0.08	c0.73						0.01	
v/s Ratio Perm			0.30	0.37						c0.01		
v/c Ratio		0.61	0.53	0.62	1.01					0.07	0.03	
Uniform Delay, d1		16.5	15.5	7.8	15.0					37.3	37.0	
Progression Factor		1.17	4.93	1.63	0.35					1.00	1.00	
Incremental Delay, d2		0.6	1.0	0.6	8.1					0.5	0.2	
Delay (s)		19.9	77.4	13.4	13.3					37.8	37.3	
Level of Service		B	E	B	B					D	D	
Approach Delay (s)		42.7			13.3			0.0			37.4	
Approach LOS		D			B			A			D	

Intersection Summary			
HCM 2000 Control Delay	24.8	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.86		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	78.3%	ICU Level of Service	D
Analysis Period (min)	15		

c Critical Lane Group

Queues

8: East Road & Driveway & H Street NE

Total Future FRA A-C AM

	↗	→	←	↖	↖	↑	↱
Lane Group	EBL	EBT	WBT	WBR	NBL	NBT	NWR2
Lane Group Flow (vph)	157	585	2107	67	359	103	9
v/c Ratio	2.53	0.34	1.26	0.08	1.13	0.53	0.02
Control Delay	746.1	3.3	145.4	0.6	131.0	50.3	0.1
Queue Delay	0.0	0.3	0.0	0.0	4.8	0.0	0.0
Total Delay	746.1	3.6	145.4	0.6	135.8	50.3	0.1
Queue Length 50th (ft)	~186	0	~984	0	~294	66	0
Queue Length 95th (ft)	m#321	62	#1122	6	#477	125	0
Internal Link Dist (ft)		242	401			217	
Turn Bay Length (ft)							
Base Capacity (vph)	62	1716	1673	877	318	196	450
Starvation Cap Reductn	0	546	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	98	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	2.53	0.50	1.26	0.08	1.63	0.53	0.02

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
8: East Road & Driveway & H Street NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR2	WBT	WBR	NBL	NBT	NBR	NWR2
Lane Configurations	↰	↑↱		↑↑	↱	↰	↱		↱
Traffic Volume (vph)	152	541	26	2044	65	348	0	100	9
Future Volume (vph)	152	541	26	2044	65	348	0	100	9
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	10	10	10	12	12	10	13	12
Grade (%)		-3%		5%			0%		
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0		5.0
Lane Util. Factor	1.00	0.95		0.95	1.00	1.00	1.00		1.00
Frt	1.00	0.99		1.00	0.85	1.00	0.85		0.86
Flt Protected	0.95	1.00		1.00	1.00	0.95	1.00		1.00
Satd. Flow (prot)	1617	2788		2789	1389	1593	983		1450
Flt Permitted	0.06	1.00		1.00	1.00	0.95	1.00		1.00
Satd. Flow (perm)	103	2788		2789	1389	1593	983		1450
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	157	558	27	2107	67	359	0	103	9
RTOR Reduction (vph)	0	44	0	0	27	0	0	0	8
Lane Group Flow (vph)	157	541	0	2107	40	359	103	0	1
Heavy Vehicles (%)	2%	10%	2%	6%	2%	2%	2%	38%	2%
Turn Type	Perm	NA		NA	Perm	pm+pt	NA		Perm
Protected Phases		4		8		5	2		
Permitted Phases	4				8	2			9
Actuated Green, G (s)	64.0	64.0		64.0	64.0	20.0	20.0		5.0
Effective Green, g (s)	66.0	66.0		66.0	66.0	22.0	22.0		7.0
Actuated g/C Ratio	0.60	0.60		0.60	0.60	0.20	0.20		0.06
Clearance Time (s)	7.0	7.0		7.0	7.0	7.0	7.0		7.0
Lane Grp Cap (vph)	61	1672		1673	833	318	196		92
v/s Ratio Prot		0.19		0.76		c0.23	0.10		
v/s Ratio Perm	c1.52				0.03				c0.00
v/c Ratio	2.57	0.32		1.26	0.05	1.13	0.53		0.01
Uniform Delay, d1	22.0	10.9		22.0	9.1	44.0	39.3		48.2
Progression Factor	0.59	0.31		1.00	1.00	1.00	1.00		1.00
Incremental Delay, d2	748.7	0.5		121.7	0.1	90.0	9.7		0.1
Delay (s)	761.7	3.9		143.7	9.2	134.0	49.1		48.4
Level of Service	F	A		F	A	F	D		D
Approach Delay (s)		164.2		139.6			115.0		
Approach LOS		F		F			F		

Intersection Summary			
HCM 2000 Control Delay	141.4	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.07		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	106.1%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Queues

10: N. Capital Street & G Street NW

	←	↑	↘	↓
Lane Group	WBT	NBT	SBL	SBT
Lane Group Flow (vph)	43	1547	638	1139
v/c Ratio	0.11	0.76	6.51	0.67
Control Delay	19.6	7.1	2499.5	3.5
Queue Delay	0.0	0.2	0.0	1.9
Total Delay	19.6	7.3	2499.5	5.4
Queue Length 50th (ft)	12	104	~823	6
Queue Length 95th (ft)	41	m84	m#1021	67
Internal Link Dist (ft)	638	441		149
Turn Bay Length (ft)				
Base Capacity (vph)	408	2027	98	1703
Starvation Cap Reductn	0	92	0	388
Spillback Cap Reductn	0	0	0	44
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.11	0.80	6.51	0.87

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

10: N. Capital Street & G Street NW

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations					↰↑↱			↰↑↑↱		↰	↑↑↱	
Traffic Volume (vph)	0	0	0	0	21	20	13	1057	415	612	1053	40
Future Volume (vph)	0	0	0	0	21	20	13	1057	415	612	1053	40
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	16	16	16	10	10	10	10	10	10
Grade (%)		0%			-1%			-3%			-1%	
Total Lost time (s)					4.0			3.0		3.0	3.0	
Lane Util. Factor					1.00			0.91		1.00	0.95	
Frpb, ped/bikes					0.84			0.86		1.00	0.98	
Flpb, ped/bikes					1.00			1.00		1.00	1.00	
Frt					0.93			0.96		1.00	0.99	
Flt Protected					1.00			1.00		0.95	1.00	
Satd. Flow (prot)					1493			3439		1291	2753	
Flt Permitted					1.00			0.92		0.12	1.00	
Satd. Flow (perm)					1493			3179		159	2753	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	0	0	0	0	22	21	14	1101	432	638	1097	42
RTOR Reduction (vph)	0	0	0	0	15	0	0	63	0	0	2	0
Lane Group Flow (vph)	0	0	0	0	28	0	0	1484	0	638	1137	0
Confl. Peds. (#/hr)	227		19	19		227	113		137	137		113
Confl. Bikes (#/hr)			5			16			7			8
Heavy Vehicles (%)	0%	0%	0%	3%	2%	4%	17%	6%	4%	18%	8%	17%
Turn Type					NA		Perm	NA		Perm	NA	
Protected Phases					4			2			6	
Permitted Phases				4			2			6		
Actuated Green, G (s)					27.0			66.0		66.0	66.0	
Effective Green, g (s)					29.0			68.0		68.0	68.0	
Actuated g/C Ratio					0.26			0.62		0.62	0.62	
Clearance Time (s)					6.0			5.0		5.0	5.0	
Lane Grp Cap (vph)					393			1965		98	1701	
v/s Ratio Prot					c0.02						0.41	
v/s Ratio Perm								0.47		c4.00		
v/c Ratio					0.07			0.76		6.51	0.67	
Uniform Delay, d1					30.4			15.0		21.0	13.7	
Progression Factor					1.00			0.50		0.23	0.17	
Incremental Delay, d2					0.3			0.3		2491.5	1.2	
Delay (s)					30.7			7.8		2496.3	3.5	
Level of Service					C			A		F	A	
Approach Delay (s)		0.0			30.7			7.8			898.5	
Approach LOS		A			C			A			F	

Intersection Summary			
HCM 2000 Control Delay	478.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	4.48		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	102.0%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
11: 1st Street & G Street NW

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰			↰↑		
Traffic Volume (veh/h)	961	0	41	52	0	0
Future Volume (Veh/h)	961	0	41	52	0	0
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	1045	0	45	57	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	147	0	0			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	147	0	0			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	0	100	97			
cM capacity (veh/h)	822	1085	1623			

Direction, Lane #	EB 1	NB 1
Volume Total	1045	102
Volume Left	1045	45
Volume Right	0	0
cSH	822	1623
Volume to Capacity	1.27	0.03
Queue Length 95th (ft)	954	2
Control Delay (s)	149.5	3.3
Lane LOS	F	A
Approach Delay (s)	149.5	3.3
Approach LOS	F	

Intersection Summary			
Average Delay	136.5		
Intersection Capacity Utilization	71.4%	ICU Level of Service	C
Analysis Period (min)	15		

Queues

13: F Street NW & N. Capital Street & Massachusetts Avenue NW/Massachusetts Avenue NE

Total Future FRA A-C AM

	↗	→	←	↖	↑	↘	↓	↙	↗
Lane Group	EBL	EBT	WBT	WBR	NBT	SBL	SBT	SBR	NER
Lane Group Flow (vph)	286	438	730	353	882	262	617	186	92
v/c Ratio	1.55	0.94	0.78	1.11	1.06	1.34	0.95	0.81	0.25
Control Delay	304.9	60.8	52.2	116.0	74.6	201.6	37.9	36.6	31.3
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	304.9	60.8	52.2	116.0	74.6	201.6	37.9	36.6	31.3
Queue Length 50th (ft)	~226	290	268	~214	~350	~193	261	57	49
Queue Length 95th (ft)	#399	#499	327	#465	m#473	#361	#644	m#187	93
Internal Link Dist (ft)		767	422		407		441		
Turn Bay Length (ft)									
Base Capacity (vph)	184	467	933	318	832	196	648	231	374
Starvation Cap Reductn	0	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.55	0.94	0.78	1.11	1.06	1.34	0.95	0.81	0.25

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
13: F Street NW & N. Capital Street & Massachusetts Avenue NW/Massachusetts Avenue NE

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	NER
Lane Configurations	↰	↱		↑↑	↱	↑↱		↰	↑	↱	↱
Traffic Volume (vph)	283	343	91	723	349	853	20	259	611	184	91
Future Volume (vph)	283	343	91	723	349	853	20	259	611	184	91
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	11	11	11	13	10	10	10	12
Grade (%)		2%		-4%		0%			3%		
Total Lost time (s)	5.0	5.0		4.0	5.0	5.0		5.0	5.0	5.0	4.0
Lane Util. Factor	1.00	1.00		0.95	1.00	0.95		1.00	1.00	1.00	1.00
Frpb, ped/bikes	1.00	0.92		1.00	0.59	0.99		1.00	1.00	0.49	1.00
Flpb, ped/bikes	0.98	1.00		1.00	1.00	1.00		0.99	1.00	1.00	1.00
Frt	1.00	0.97		1.00	0.85	1.00		1.00	1.00	0.85	0.86
Flt Protected	0.95	1.00		1.00	1.00	1.00		0.95	1.00	1.00	1.00
Satd. Flow (prot)	1236	1117		3110	811	2856		1365	1487	530	1249
Flt Permitted	0.20	1.00		1.00	1.00	1.00		0.13	1.00	1.00	1.00
Satd. Flow (perm)	264	1117		3110	811	2856		186	1487	530	1249
Peak-hour factor, PHF	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99	0.99
Adj. Flow (vph)	286	346	92	730	353	862	20	262	617	186	92
RTOR Reduction (vph)	0	0	0	0	0	1	0	0	0	0	0
Lane Group Flow (vph)	286	438	0	730	353	881	0	262	617	186	92
Confl. Peds. (#/hr)	645		619		645		645	645		264	
Confl. Bikes (#/hr)			5		5		5			5	
Heavy Vehicles (%)	4%	11%	2%	3%	5%	7%	78%	7%	4%	21%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	4	4	4	0
Parking (#/hr)	6	6	6								6
Turn Type	pm+pt	NA		NA	pm+ov	NA		pm+pt	NA	Perm	Perm
Protected Phases	1	6		2	7	8		7	4		
Permitted Phases	6				2			4		4	2
Actuated Green, G (s)	44.0	44.0		31.0	40.0	30.0		46.0	46.0	46.0	31.0
Effective Green, g (s)	46.0	46.0		33.0	44.0	32.0		48.0	48.0	48.0	33.0
Actuated g/C Ratio	0.42	0.42		0.30	0.40	0.29		0.44	0.44	0.44	0.30
Clearance Time (s)	7.0	7.0		6.0	7.0	7.0		7.0	7.0	7.0	6.0
Lane Grp Cap (vph)	189	467		933	324	830		199	648	231	374
v/s Ratio Prot	c0.12	0.39		0.23	0.11	0.31		c0.13	0.41		
v/s Ratio Perm	c0.51				0.33			c0.44		0.35	0.07
v/c Ratio	1.51	0.94		0.78	1.09	1.06		1.32	0.95	0.81	0.25
Uniform Delay, d1	39.2	30.6		35.2	33.0	39.0		41.1	29.9	26.9	29.1
Progression Factor	1.00	1.00		1.30	1.41	0.85		0.62	0.49	0.52	1.00
Incremental Delay, d2	256.3	28.7		5.8	73.2	41.8		166.2	20.7	19.4	1.6
Delay (s)	295.5	59.3		51.6	119.8	74.7		191.7	35.4	33.5	30.7
Level of Service	F	E		D	F	E		F	D	C	C
Approach Delay (s)		152.6		73.9		74.7			73.5		
Approach LOS		F		E		E			E		

Intersection Summary			
HCM 2000 Control Delay	87.8	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.46		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	23.0
Intersection Capacity Utilization	100.5%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Queues

14: Columbus Circle NE & E Street NE & Massachusetts Avenue NE & First Street NE

Total Future FRA A-C AM

	↗	↘	↙	←	↖	↖	↑	↓
Lane Group	EBL	EBR	WBL	WBT	WBR	NBL	NBT	SBT
Lane Group Flow (vph)	4	170	322	298	401	211	764	677
v/c Ratio	0.03	0.40	0.48	0.44	0.69	0.64	0.39	0.73
Control Delay	23.2	7.0	25.7	25.9	34.3	36.9	30.9	48.0
Queue Delay	0.0	12.0	64.8	0.0	0.0	70.8	57.0	55.8
Total Delay	23.2	19.0	90.4	25.9	34.3	107.7	87.9	103.8
Queue Length 50th (ft)	2	15	160	149	229	145	213	176
Queue Length 95th (ft)	m3	m34	243	226	347	239	258	m170
Internal Link Dist (ft)				62			84	422
Turn Bay Length (ft)	105							
Base Capacity (vph)	140	423	671	682	580	328	1959	932
Starvation Cap Reductn	0	0	0	0	0	202	1576	0
Spillback Cap Reductn	0	223	472	0	0	0	0	553
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.03	0.85	1.62	0.44	0.69	1.67	1.99	1.79

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

14: Columbus Circle NE & E Street NE & Massachusetts Avenue NE & First Street NE

Total Future FRA A-C AM

Movement	EBL2	EBL	EBR	WBL	WBT	WBR	WBR2	NBL	NBT	SBT	SBR
Lane Configurations		↰	↱	↰	↑	↱	↱	↰	↑↑↱	↰↑↱	
Traffic Volume (vph)	4	0	156	296	274	369	0	194	703	604	18
Future Volume (vph)	4	0	156	296	274	369	0	194	703	604	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	12	12	12	14	11	11	10	10
Grade (%)					1%				2%	0%	
Total Lost time (s)		5.0	5.0	3.0	5.0	5.0		3.0	5.0	5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00	1.00		1.00	0.91	0.91	
Frpb, ped/bikes		1.00	0.98	1.00	1.00	1.00		1.00	1.00	0.98	
Flpb, ped/bikes		0.64	1.00	0.99	1.00	1.00		1.00	1.00	1.00	
Frt		1.00	0.85	1.00	1.00	0.85		1.00	1.00	1.00	
Flt Protected		0.95	1.00	0.95	1.00	1.00		0.95	1.00	1.00	
Satd. Flow (prot)		941	1201	1567	1668	1418		1388	3919	3929	
Flt Permitted		0.58	1.00	0.95	1.00	1.00		0.95	1.00	1.00	
Satd. Flow (perm)		572	1201	1567	1668	1418		1388	3919	3929	
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	4	0	170	322	298	401	0	211	764	657	20
RTOR Reduction (vph)	0	0	128	0	0	0	0	0	0	3	0
Lane Group Flow (vph)	0	4	42	322	298	401	0	211	764	674	0
Confl. Peds. (#/hr)	1415		4	4		1415	9	359			259
Confl. Bikes (#/hr)			3			27					14
Heavy Vehicles (%)	2%	2%	9%	2%	2%	2%	2%	12%	14%	5%	75%
Bus Blockages (#/hr)	4	4	4	0	0	0	0	0	0	10	10
Turn Type	Perm	Perm	Perm	pm+pt	NA	Prot	Free	Prot	NA	NA	
Protected Phases				7	4	4		5	2	6	
Permitted Phases	8	8	8	4			Free				
Actuated Green, G (s)		25.0	25.0	43.0	43.0	43.0		24.0	53.0	24.0	
Effective Green, g (s)		27.0	27.0	45.0	45.0	45.0		26.0	55.0	26.0	
Actuated g/C Ratio		0.25	0.25	0.41	0.41	0.41		0.24	0.50	0.24	
Clearance Time (s)		7.0	7.0	5.0	7.0	7.0		5.0	7.0	7.0	
Lane Grp Cap (vph)		140	294	641	682	580		328	1959	928	
v/s Ratio Prot				0.07	0.18	c0.28		c0.15	0.19	c0.17	
v/s Ratio Perm		0.01	0.03	0.14							
v/c Ratio		0.03	0.14	0.50	0.44	0.69		0.64	0.39	0.73	
Uniform Delay, d1		31.5	32.4	24.2	23.4	26.8		37.8	17.1	38.7	
Progression Factor		0.72	0.92	1.00	1.00	1.00		0.76	1.76	1.21	
Incremental Delay, d2		0.3	0.7	2.8	2.0	6.6		7.6	0.5	1.2	
Delay (s)		22.9	30.7	27.0	25.4	33.4		36.2	30.6	47.9	
Level of Service		C	C	C	C	C		D	C	D	
Approach Delay (s)					29.0				31.8	47.9	
Approach LOS					C				C	D	

Intersection Summary			
HCM 2000 Control Delay	34.6	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.72		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	18.0
Intersection Capacity Utilization	83.6%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Louisiana Avenue NE & Columbus Circle NE

Total Future FRA A-C AM

	→	↘	←	↗
Lane Group	EBT	EBR	WBT	NBR
Lane Group Flow (vph)	868	223	1146	607
v/c Ratio	0.72	0.80	0.60	0.86
Control Delay	45.8	47.8	21.5	32.6
Queue Delay	53.4	59.0	5.3	0.6
Total Delay	99.2	106.8	26.8	33.2
Queue Length 50th (ft)	237	110	89	249
Queue Length 95th (ft)	285	m#203	116	#469
Internal Link Dist (ft)	84		133	
Turn Bay Length (ft)		98		
Base Capacity (vph)	1211	280	1900	707
Starvation Cap Reductn	694	87	163	0
Spillback Cap Reductn	0	0	681	12
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	1.68	1.16	0.94	0.87

Intersection Summary

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
15: Louisiana Avenue NE & Columbus Circle NE

Total Future FRA A-C AM

	→	↘	↙	←	↖	↗
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑↑	↱		↰↑↑↑		↱
Traffic Volume (vph)	833	214	140	960	0	583
Future Volume (vph)	833	214	140	960	0	583
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	11	16	16
Grade (%)	0%			1%	0%	
Total Lost time (s)	4.0	4.0		4.0		4.0
Lane Util. Factor	0.91	1.00		0.86		1.00
Frpb, ped/bikes	1.00	0.46		1.00		0.86
Flpb, ped/bikes	1.00	1.00		0.99		1.00
Frt	1.00	0.85		1.00		0.86
Flt Protected	1.00	1.00		0.99		1.00
Satd. Flow (prot)	4298	595		5226		1213
Flt Permitted	1.00	1.00		0.72		1.00
Satd. Flow (perm)	4298	595		3791		1213
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	868	223	146	1000	0	607
RTOR Reduction (vph)	0	113	0	0	0	30
Lane Group Flow (vph)	868	110	0	1146	0	577
Confl. Peds. (#/hr)		240	240			250
Confl. Bikes (#/hr)		28				3
Heavy Vehicles (%)	5%	8%	10%	6%	0%	3%
Parking (#/hr)					6	6
Turn Type	NA	Perm	Prot	NA		pm+ov
Protected Phases	6		7	2 7		7
Permitted Phases		6				8
Actuated Green, G (s)	29.0	29.0		55.0		59.0
Effective Green, g (s)	31.0	31.0		59.0		63.0
Actuated g/C Ratio	0.28	0.28		0.54		0.57
Clearance Time (s)	6.0	6.0				6.0
Lane Grp Cap (vph)	1211	167		2398		694
v/s Ratio Prot	c0.20			0.12		c0.21
v/s Ratio Perm		0.19		0.13		0.26
v/c Ratio	0.72	0.66		0.48		0.83
Uniform Delay, d1	35.5	34.9		15.9		19.2
Progression Factor	1.20	2.63		1.70		1.00
Incremental Delay, d2	2.9	15.1		0.6		11.1
Delay (s)	45.5	106.8		27.6		30.3
Level of Service	D	F		C		C
Approach Delay (s)	58.0			27.6	30.3	
Approach LOS	E			C	C	

Intersection Summary			
HCM 2000 Control Delay	39.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	74.2%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Delaware Avenue NE & Columbus Circle NE

	→	↘	←	↗
Lane Group	EBT	EBR	WBT	NBR
Lane Group Flow (vph)	1439	21	1134	15
v/c Ratio	0.62	0.04	0.48	0.06
Control Delay	7.3	0.8	0.6	0.7
Queue Delay	1.6	0.0	4.5	0.0
Total Delay	8.9	0.8	5.1	0.7
Queue Length 50th (ft)	98	0	6	0
Queue Length 95th (ft)	114	m0	m3	2
Internal Link Dist (ft)	133		201	
Turn Bay Length (ft)				
Base Capacity (vph)	2339	588	2339	265
Starvation Cap Reductn	669	0	1113	0
Spillback Cap Reductn	485	0	7	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.86	0.04	0.92	0.06

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
16: Delaware Avenue NE & Columbus Circle NE

Total Future FRA A-C AM

	→	↘	↙	←	↖	↗
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑↑	↱		↑↑↑		↱
Traffic Volume (vph)	1396	20	0	1100	0	15
Future Volume (vph)	1396	20	0	1100	0	15
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	12	9
Total Lost time (s)	4.0	4.0		4.0		5.0
Lane Util. Factor	0.91	1.00		0.91		1.00
Frpb, ped/bikes	1.00	0.78		1.00		0.64
Flpb, ped/bikes	1.00	1.00		1.00		1.00
Frt	1.00	0.85		1.00		0.86
Flt Protected	1.00	1.00		1.00		1.00
Satd. Flow (prot)	4150	1027		4150		724
Flt Permitted	1.00	1.00		1.00		1.00
Satd. Flow (perm)	4150	1027		4150		724
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	1439	21	0	1134	0	15
RTOR Reduction (vph)	0	9	0	0	0	10
Lane Group Flow (vph)	1439	12	0	1134	0	5
Confl. Peds. (#/hr)		67	67			606
Confl. Bikes (#/hr)		2				
Heavy Vehicles (%)	5%	2%	0%	5%	0%	2%
Bus Blockages (#/hr)	0	2	0	0	0	0
Parking (#/hr)					6	6
Turn Type	NA	Perm		NA		Perm
Protected Phases	2			6		
Permitted Phases		2				8
Actuated Green, G (s)	60.0	60.0		60.0		34.0
Effective Green, g (s)	62.0	62.0		62.0		36.0
Actuated g/C Ratio	0.56	0.56		0.56		0.33
Clearance Time (s)	6.0	6.0		6.0		7.0
Lane Grp Cap (vph)	2339	578		2339		236
v/s Ratio Prot	c0.35			0.27		
v/s Ratio Perm		0.01				c0.01
v/c Ratio	0.62	0.02		0.48		0.02
Uniform Delay, d1	16.0	10.6		14.4		25.1
Progression Factor	0.40	0.18		0.04		1.00
Incremental Delay, d2	0.7	0.0		0.1		0.2
Delay (s)	7.2	1.9		0.6		25.2
Level of Service	A	A		A		C
Approach Delay (s)	7.1			0.6	25.2	
Approach LOS	A			A	C	

Intersection Summary			
HCM 2000 Control Delay	4.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.40		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	65.8%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

17: First Street NE & Columbus Circle NE & Massachusetts Avenue NE

	↗	→	↘	←	↑
Lane Group	EBL	EBT	EBR	WBT	NBT
Lane Group Flow (vph)	943	418	171	1548	78
v/c Ratio	1.80	0.26	0.23	1.67	0.11
Control Delay	387.9	4.1	1.0	333.2	26.8
Queue Delay	0.0	0.3	0.5	0.0	0.0
Total Delay	387.9	4.4	1.5	333.2	26.8
Queue Length 50th (ft)	~498	13	0	~839	19
Queue Length 95th (ft)	#630	31	0	#980	38
Internal Link Dist (ft)		201		659	319
Turn Bay Length (ft)	120				
Base Capacity (vph)	524	1597	736	926	695
Starvation Cap Reductn	0	615	284	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.80	0.43	0.38	1.67	0.11

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis
17: First Street NE & Columbus Circle NE & Massachusetts Avenue NE

Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰↰	↑↑	↱		↑↱			↰↑↱				
Traffic Volume (vph)	868	385	157	0	1094	330	7	57	7	0	0	0
Future Volume (vph)	868	385	157	0	1094	330	7	57	7	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)	5.0	5.0	5.0		4.0			6.0				
Lane Util. Factor	0.97	0.95	1.00		0.95			0.95				
Frpb, ped/bikes	1.00	1.00	0.85		0.92			0.99				
Flpb, ped/bikes	1.00	1.00	1.00		1.00			0.97				
Frt	1.00	1.00	0.85		0.97			0.98				
Flt Protected	0.95	1.00	1.00		1.00			0.99				
Satd. Flow (prot)	2884	2834	1175		2419			2445				
Flt Permitted	0.95	1.00	1.00		1.00			0.99				
Satd. Flow (perm)	2884	2834	1175		2419			2445				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	943	418	171	0	1189	359	8	62	8	0	0	0
RTOR Reduction (vph)	0	0	75	0	26	0	0	6	0	0	0	0
Lane Group Flow (vph)	943	418	96	0	1522	0	0	72	0	0	0	0
Confl. Peds. (#/hr)	122		48			143	322		103			
Confl. Bikes (#/hr)			7			75			3			23
Heavy Vehicles (%)	2%	7%	2%	5%	5%	5%	50%	4%	2%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	4	4	0	0	0	0	0	0
Parking (#/hr)					1	1	6	6	6			
Turn Type	Prot	NA	Perm		NA		Perm	NA				
Protected Phases	5	2			6			8				
Permitted Phases			2				8					
Actuated Green, G (s)	18.0	60.0	60.0		39.0			29.0				
Effective Green, g (s)	20.0	62.0	62.0		41.0			31.0				
Actuated g/C Ratio	0.18	0.56	0.56		0.37			0.28				
Clearance Time (s)	7.0	7.0	7.0		6.0			8.0				
Lane Grp Cap (vph)	524	1597	662		901			689				
v/s Ratio Prot	c0.33	0.15			c0.63							
v/s Ratio Perm			0.08					0.03				
v/c Ratio	1.80	0.26	0.15		1.69			0.10				
Uniform Delay, d1	45.0	12.3	11.4		34.5			29.2				
Progression Factor	0.51	0.31	0.24		1.00			1.00				
Incremental Delay, d2	366.1	0.3	0.4		315.1			0.3				
Delay (s)	388.8	4.1	3.1		349.6			29.5				
Level of Service	F	A	A		F			C				
Approach Delay (s)		240.8			349.6			29.5			0.0	
Approach LOS		F			F			C			A	

Intersection Summary			
HCM 2000 Control Delay	288.9	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.17		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	111.1%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

19: N. Capital Street & E Street NW/E Street NE

Total Future FRA A-C AM

Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBT	SBT
Lane Group Flow (vph)	143	141	58	120	343	28	934	808
v/c Ratio	0.92	0.41	0.23	0.46	1.00	0.16	0.80	0.95
Control Delay	94.2	37.9	2.2	37.1	86.5	1.7	27.2	27.5
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	94.2	37.9	2.2	37.1	86.5	1.7	27.2	27.5
Queue Length 50th (ft)	72	82	0	53	~254	0	264	89
Queue Length 95th (ft)	#188	144	0	m90	#443	m0	360	m#120
Internal Link Dist (ft)		251			383		191	407
Turn Bay Length (ft)	180		40	145		75		
Base Capacity (vph)	156	343	250	259	342	177	1170	853
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.92	0.41	0.23	0.46	1.00	0.16	0.80	0.95

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
19: N. Capital Street & E Street NW/E Street NE
Total Future FRA A-C AM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		↰↑↑↱			↰↑↑↱	
Traffic Volume (vph)	140	138	57	118	336	27	36	709	171	66	441	285
Future Volume (vph)	140	138	57	118	336	27	36	709	171	66	441	285
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	8	10	10	8	11	11	11	11	11	11
Grade (%)		5%			-4%			0%			0%	
Total Lost time (s)	3.0	4.0	4.0	3.0	4.0	4.0		4.0			4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00		0.95			0.95	
Frpb, ped/bikes	1.00	1.00	0.59	1.00	1.00	0.46		0.88			0.73	
Flpb, ped/bikes	0.95	1.00	1.00	0.82	1.00	1.00		0.99			0.99	
Frt	1.00	1.00	0.85	1.00	1.00	0.85		0.97			0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00		1.00			1.00	
Satd. Flow (prot)	1196	1302	616	1166	1299	339		2502			2040	
Flt Permitted	0.27	1.00	1.00	0.60	1.00	1.00		0.89			0.74	
Satd. Flow (perm)	336	1302	616	737	1299	339		2225			1509	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	143	141	58	120	343	28	37	723	174	67	450	291
RTOR Reduction (vph)	0	0	43	0	0	21	0	18	0	0	71	0
Lane Group Flow (vph)	143	141	15	120	343	7	0	916	0	0	737	0
Confl. Peds. (#/hr)	826		455	455		826	605		417	417		605
Confl. Bikes (#/hr)			6			93			7			2
Heavy Vehicles (%)	18%	4%	2%	9%	9%	50%	3%	6%	11%	5%	5%	4%
Bus Blockages (#/hr)	0	0	0	0	0	4	0	0	0	0	0	0
Parking (#/hr)		6	6		6	6						
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	Perm	NA		Perm	NA	
Protected Phases	3	8		7	4			2			6	
Permitted Phases	8		8	4		4	2			6		
Actuated Green, G (s)	32.0	27.0	27.0	32.0	27.0	27.0		55.0			55.0	
Effective Green, g (s)	36.0	29.0	29.0	36.0	29.0	29.0		57.0			57.0	
Actuated g/C Ratio	0.33	0.26	0.26	0.33	0.26	0.26		0.52			0.52	
Clearance Time (s)	5.0	6.0	6.0	5.0	6.0	6.0		6.0			6.0	
Lane Grp Cap (vph)	164	343	162	268	342	89		1152			781	
v/s Ratio Prot	c0.06	0.11		0.03	c0.26							
v/s Ratio Perm	0.23		0.02	0.12		0.02		0.41			c0.49	
v/c Ratio	0.87	0.41	0.09	0.45	1.00	0.08		0.80			0.94	
Uniform Delay, d1	42.5	33.4	30.6	31.5	40.5	30.5		21.7			25.0	
Progression Factor	1.00	1.00	1.00	1.09	0.97	1.00		1.00			0.63	
Incremental Delay, d2	42.9	3.6	1.2	4.6	45.8	1.6		5.7			13.2	
Delay (s)	85.4	37.1	31.7	38.8	85.2	32.1		27.4			28.9	
Level of Service	F	D	C	D	F	C		C			C	
Approach Delay (s)		56.4			70.9			27.4			28.9	
Approach LOS		E			E			C			C	

Intersection Summary			
HCM 2000 Control Delay	40.0	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.94		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	101.9%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

Queues

35: Bus Exit & Central Road & H Street NE

Total Future FRA A-C AM

Lane Group	EBL	EBT	WBL2	WBT	NBL	NBT	SBL	SBT	NER
Lane Group Flow (vph)	135	837	93	2425	78	35	28	61	74
v/c Ratio	2.21	0.50	0.28	1.18	0.43	0.09	0.15	0.20	0.67
Control Delay	607.5	5.9	4.4	96.7	48.4	0.4	40.4	2.6	78.6
Queue Delay	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Total Delay	607.5	6.1	4.4	96.8	48.4	0.4	40.4	2.6	78.6
Queue Length 50th (ft)	~158	47	11	~1076	49	0	17	0	52
Queue Length 95th (ft)	#275	72	m9	m199	99	0	44	7	#125
Internal Link Dist (ft)		250		242		229		147	
Turn Bay Length (ft)									
Base Capacity (vph)	61	1665	330	2048	181	391	183	305	110
Starvation Cap Reductn	0	169	0	111	0	0	0	0	0
Spillback Cap Reductn	0	0	0	62	0	0	0	2	0
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	2.21	0.56	0.28	1.25	0.43	0.09	0.15	0.20	0.67

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
35: Bus Exit & Central Road & H Street NE

Movement	EBL	EBT	EBR	WBL2	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR2
Lane Configurations	↰	↑↱		↰	↑↱		↰	↱		↰	↱	
Traffic Volume (vph)	128	589	206	88	2249	55	74	0	32	27	0	58
Future Volume (vph)	128	589	206	88	2249	55	74	0	32	27	0	58
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	10	10	10	10	10	10	10	10	10
Total Lost time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.97		1.00	1.00		1.00	0.85		1.00	0.89	
Flpb, ped/bikes	1.00	1.00		0.98	1.00		0.92	1.00		0.87	1.00	
Frt	1.00	0.96		1.00	1.00		1.00	0.85		1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1593	2775		1452	2815		1322	1012		1307	1188	
Flt Permitted	0.06	1.00		0.30	1.00		0.72	1.00		0.73	1.00	
Satd. Flow (perm)	102	2775		455	2815		998	1012		1010	1188	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.92	0.95	0.95	0.95
Adj. Flow (vph)	135	620	217	93	2367	58	78	0	35	28	0	61
RTOR Reduction (vph)	0	0	0	0	2	0	0	29	0	0	50	0
Lane Group Flow (vph)	135	837	0	93	2423	0	78	6	0	28	11	0
Confl. Peds. (#/hr)	50		33	33		50	50		74	74		50
Confl. Bikes (#/hr)			5			5			5			5
Heavy Vehicles (%)	2%	10%	6%	2%	7%	2%	5%	14%	14%	1%	2%	2%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	64.0	64.0		78.0	78.0		18.0	18.0		18.0	18.0	
Effective Green, g (s)	66.0	66.0		80.0	80.0		20.0	20.0		20.0	20.0	
Actuated g/C Ratio	0.60	0.60		0.73	0.73		0.18	0.18		0.18	0.18	
Clearance Time (s)	7.0	7.0		7.0	7.0		7.0	7.0		7.0	7.0	
Lane Grp Cap (vph)	61	1665		330	2047		181	184		183	216	
v/s Ratio Prot		0.30			c0.86			0.01			0.01	
v/s Ratio Perm	c1.33			0.20			c0.08			0.03		
v/c Ratio	2.21	0.50		0.28	1.18		0.43	0.03		0.15	0.05	
Uniform Delay, d1	22.0	12.6		5.1	15.0		39.9	37.1		37.9	37.2	
Progression Factor	1.20	0.39		0.75	0.51		1.00	1.00		1.00	1.00	
Incremental Delay, d2	587.2	0.9		0.2	83.2		7.3	0.4		1.8	0.5	
Delay (s)	613.7	5.9		4.0	90.9		47.3	37.4		39.6	37.6	
Level of Service	F	A		A	F		D	D		D	D	
Approach Delay (s)		90.3			87.7			44.2			38.3	
Approach LOS		F			F			D			D	

Intersection Summary			
HCM 2000 Control Delay	85.7	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.80		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	106.9%	ICU Level of Service	G
Analysis Period (min)	15		
c Critical Lane Group			

	↗
Movement	NER
Lane Configurations	↱
Traffic Volume (vph)	70
Future Volume (vph)	70
Ideal Flow (vphpl)	1900
Lane Width	10
Total Lost time (s)	5.0
Lane Util. Factor	1.00
Frpb, ped/bikes	1.00
Flpb, ped/bikes	1.00
Frt	0.86
Flt Protected	1.00
Satd. Flow (prot)	1353
Flt Permitted	1.00
Satd. Flow (perm)	1353
Peak-hour factor, PHF	0.95
Adj. Flow (vph)	74
RTOR Reduction (vph)	0
Lane Group Flow (vph)	74
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	2%
Turn Type	Perm
Protected Phases	
Permitted Phases	3
Actuated Green, G (s)	7.0
Effective Green, g (s)	9.0
Actuated g/C Ratio	0.08
Clearance Time (s)	7.0
Lane Grp Cap (vph)	110
v/s Ratio Prot	
v/s Ratio Perm	0.05
v/c Ratio	0.67
Uniform Delay, d1	49.1
Progression Factor	1.00
Incremental Delay, d2	28.2
Delay (s)	77.3
Level of Service	E
Approach Delay (s)	
Approach LOS	
Intersection Summary	

Queues

91: N. Capital Street & G Place NW

Total Future FRA A-C AM

	↑	↓
Lane Group	NBT	SBT
Lane Group Flow (vph)	1221	1920
v/c Ratio	0.43	0.81
Control Delay	1.6	8.4
Queue Delay	0.4	47.3
Total Delay	2.0	55.7
Queue Length 50th (ft)	17	116
Queue Length 95th (ft)	31	m43
Internal Link Dist (ft)	149	157
Turn Bay Length (ft)		
Base Capacity (vph)	2869	2359
Starvation Cap Reductn	955	702
Spillback Cap Reductn	942	14
Storage Cap Reductn	0	0
Reduced v/c Ratio	0.64	1.16

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
91: N. Capital Street & G Place NW

	↙	↖	↑	↗	↘	↓
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			↑↑↱			↰↑↑
Traffic Volume (vph)	0	0	1077	59	81	1705
Future Volume (vph)	0	0	1077	59	81	1705
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	12	12	11	11	11	11
Total Lost time (s)			3.0			3.0
Lane Util. Factor			0.91			0.91
Frpb, ped/bikes			0.97			1.00
Flpb, ped/bikes			1.00			1.00
Frt			0.99			1.00
Flt Protected			1.00			1.00
Satd. Flow (prot)			3989			4219
Flt Permitted			1.00			0.78
Satd. Flow (perm)			3989			3287
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	0	0	1158	63	87	1833
RTOR Reduction (vph)	0	0	5	0	0	0
Lane Group Flow (vph)	0	0	1216	0	0	1920
Confl. Peds. (#/hr)	12	69		232	232	
Confl. Bikes (#/hr)				2		
Heavy Vehicles (%)	0%	0%	9%	0%	1%	6%
Bus Blockages (#/hr)	0	0	0	0	4	4
Turn Type			NA		Perm	NA
Protected Phases			2			2
Permitted Phases					2	
Actuated Green, G (s)			77.0			77.0
Effective Green, g (s)			79.0			79.0
Actuated g/C Ratio			0.72			0.72
Clearance Time (s)			5.0			5.0
Lane Grp Cap (vph)			2864			2360
v/s Ratio Prot			0.30			
v/s Ratio Perm						c0.58
v/c Ratio			0.42			0.81
Uniform Delay, d1			6.3			10.5
Progression Factor			0.20			0.67
Incremental Delay, d2			0.3			1.0
Delay (s)			1.6			8.0
Level of Service			A			A
Approach Delay (s)	0.0		1.6			8.0
Approach LOS	A		A			A

Intersection Summary			
HCM 2000 Control Delay	5.5	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.64		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	85.8%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
92: 1st Street & G Place NW

	↗	↘	↖	↑	↓	↙
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰			↰↑		
Traffic Volume (veh/h)	140	0	0	1013	0	0
Future Volume (Veh/h)	140	0	0	1013	0	0
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	152	0	0	1101	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	1101	0	0			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1101	0	0			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	35	100	100			
cM capacity (veh/h)	235	1085	1623			

Direction, Lane #	EB 1	NB 1
Volume Total	152	1101
Volume Left	152	0
Volume Right	0	0
cSH	235	1623
Volume to Capacity	0.65	0.00
Queue Length 95th (ft)	100	0
Control Delay (s)	44.8	0.0
Lane LOS	E	
Approach Delay (s)	44.8	0.0
Approach LOS	E	

Intersection Summary			
Average Delay	5.4		
Intersection Capacity Utilization	74.5%	ICU Level of Service	D
Analysis Period (min)	15		

HCM Unsignalized Intersection Capacity Analysis
93: West Road & Internal Drive

Total Future FRA A-C AM

	↙	↖	↑	↗	↘	↓
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			↱			↰
Traffic Volume (veh/h)	0	0	0	271	853	0
Future Volume (Veh/h)	0	0	0	271	853	0
Sign Control	Stop		Free			Free
Grade	0%		-5%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	0	295	927	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						468
pX, platoon unblocked	0.97					
vC, conflicting volume	2002	148			295	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	2018	148			295	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			27	
cM capacity (veh/h)	17	899			1266	

Direction, Lane #	NB 1	SB 1
Volume Total	295	927
Volume Left	0	927
Volume Right	295	0
cSH	1700	1266
Volume to Capacity	0.17	0.73
Queue Length 95th (ft)	0	176
Control Delay (s)	0.0	15.2
Lane LOS		C
Approach Delay (s)	0.0	15.2
Approach LOS		

Intersection Summary			
Average Delay	11.5		
Intersection Capacity Utilization	77.8%	ICU Level of Service	D
Analysis Period (min)	15		

Queues

1: N. Capital Street & K Street NW/K Street NE

Total Future FRA A-C PM

	↗	→	↘	↙	←	↖	↑	↓
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBT	SBT
Lane Group Flow (vph)	235	870	132	234	1149	245	1319	1280
v/c Ratio	1.57	1.35	0.27	1.57	2.03	0.53	0.89	2.04
Control Delay	307.2	197.1	8.2	309.0	492.5	18.7	38.7	496.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	307.2	197.1	8.2	309.0	492.5	18.7	38.7	496.9
Queue Length 50th (ft)	~194	~807	14	~194	~1275	74	279	~752
Queue Length 95th (ft)	#353	#1047	55	#353	#1529	155	m234	#890
Internal Link Dist (ft)		453			799		724	149
Turn Bay Length (ft)	110		95	125		75		
Base Capacity (vph)	150	644	482	149	566	459	1479	627
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.57	1.35	0.27	1.57	2.03	0.53	0.89	2.04

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

1: N. Capital Street & K Street NW/K Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		↑↑↱			↰↑↱	
Traffic Volume (vph)	230	853	129	229	1126	240	0	1100	193	86	964	204
Future Volume (vph)	230	853	129	229	1126	240	0	1100	193	86	964	204
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	10	10	10	10	10	10
Grade (%)		-1%			1%			1%			-1%	
Total Lost time (s)	3.0	4.0	4.0	3.0	4.0	4.0		4.0			4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00		0.91			0.95	
Frpb, ped/bikes	1.00	1.00	0.77	1.00	1.00	0.84		0.92			0.94	
Flpb, ped/bikes	1.00	1.00	1.00	1.00	1.00	1.00		1.00			1.00	
Frt	1.00	1.00	0.85	1.00	1.00	0.85		0.98			0.98	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00		1.00			1.00	
Satd. Flow (prot)	1465	1542	1017	1451	1354	960		3725			2657	
Flt Permitted	0.09	1.00	1.00	0.09	1.00	1.00		1.00			0.59	
Satd. Flow (perm)	134	1542	1017	133	1354	960		3725			1569	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	235	870	132	234	1149	245	0	1122	197	88	984	208
RTOR Reduction (vph)	0	0	58	0	0	58	0	23	0	0	15	0
Lane Group Flow (vph)	235	870	74	234	1149	187	0	1296	0	0	1265	0
Confl. Peds. (#/hr)	95		139	139		95	128		207	207		128
Confl. Bikes (#/hr)			71			34			5			4
Heavy Vehicles (%)	4%	4%	2%	4%	2%	2%	2%	4%	9%	2%	4%	3%
Bus Blockages (#/hr)	0	0	2	0	0	2	0	0	0	4	4	4
Parking (#/hr)					6	6						
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm		NA		Perm	NA	
Protected Phases	7	4		3	8			2			6	
Permitted Phases	4		4	8		8				6		
Actuated Green, G (s)	49.0	44.0	44.0	49.0	44.0	44.0		41.0			41.0	
Effective Green, g (s)	53.0	46.0	46.0	53.0	46.0	46.0		43.0			43.0	
Actuated g/C Ratio	0.48	0.42	0.42	0.48	0.42	0.42		0.39			0.39	
Clearance Time (s)	5.0	6.0	6.0	5.0	6.0	6.0		6.0			6.0	
Lane Grp Cap (vph)	149	644	425	147	566	401		1456			613	
v/s Ratio Prot	0.10	0.56		c0.10	c0.85			0.35				
v/s Ratio Perm	0.66		0.07	0.66		0.20					c0.81	
v/c Ratio	1.58	1.35	0.18	1.59	2.03	0.47		0.89			2.06	
Uniform Delay, d1	28.0	32.0	20.1	27.9	32.0	23.1		31.3			33.5	
Progression Factor	1.00	1.00	1.00	1.00	1.00	1.00		1.23			1.00	
Incremental Delay, d2	289.4	168.0	0.9	296.0	469.7	3.9		0.9			484.5	
Delay (s)	317.3	200.0	21.0	323.8	501.7	27.0		39.4			518.0	
Level of Service	F	F	C	F	F	C		D			F	
Approach Delay (s)		203.2			404.7			39.4			518.0	
Approach LOS		F			F			D			F	

Intersection Summary			
HCM 2000 Control Delay	297.4	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.99		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	163.6%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

2: First Street NE & K Street NE

Lane Group	EBL	EBT	WBT	WBR	NBL	NBT	SBL	SBR
Lane Group Flow (vph)	52	1114	581	55	882	405	44	181
v/c Ratio	0.35	1.62	0.82	0.12	1.93	0.78	0.38	1.01
Control Delay	26.2	311.0	27.4	0.5	449.5	33.9	45.6	90.4
Queue Delay	0.0	1.2	0.0	0.0	0.0	0.1	0.0	0.0
Total Delay	26.2	312.2	27.4	0.5	449.5	34.0	45.6	90.4
Queue Length 50th (ft)	21	~1028	304	0	~780	195	24	~56
Queue Length 95th (ft)	56	#1275	m214	m0	#1020	#364	61	#200
Internal Link Dist (ft)		799	544			209		
Turn Bay Length (ft)	100				110			200
Base Capacity (vph)	150	687	711	472	456	518	116	179
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	108	0	0	0	2	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.35	1.92	0.82	0.12	1.93	0.78	0.38	1.01

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
2: First Street NE & K Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱			↑	↱	↰	↑↱		↰		↱
Traffic Volume (vph)	50	1081	0	0	564	53	856	145	248	43	0	176
Future Volume (vph)	50	1081	0	0	564	53	856	145	248	43	0	176
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	12	12	12	10	10	10	10	10	10
Grade (%)		1%			1%			1%			1%	
Total Lost time (s)	4.0	4.0			4.0	4.0	3.0	4.0		4.0		4.0
Lane Util. Factor	1.00	1.00			1.00	1.00	1.00	1.00		1.00		1.00
Frpb, ped/bikes	1.00	1.00			1.00	0.66	1.00	0.80		1.00		0.40
Flpb, ped/bikes	1.00	1.00			1.00	1.00	0.46	1.00		0.83		1.00
Frt	1.00	1.00			1.00	0.85	1.00	0.91		1.00		0.85
Flt Protected	0.95	1.00			1.00	1.00	0.95	1.00		0.95		1.00
Satd. Flow (prot)	1410	1527			1582	917	666	1127		1056		459
Flt Permitted	0.23	1.00			1.00	1.00	0.95	1.00		0.52		1.00
Satd. Flow (perm)	335	1527			1582	917	666	1127		583		459
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	52	1114	0	0	581	55	882	149	256	44	0	181
RTOR Reduction (vph)	0	0	0	0	0	30	0	23	0	0	0	87
Lane Group Flow (vph)	52	1114	0	0	581	25	882	382	0	44	0	94
Confl. Peds. (#/hr)	97		125	125		97	333		191	191		333
Confl. Bikes (#/hr)			34			1			40			10
Heavy Vehicles (%)	7%	4%	11%	10%	5%	2%	3%	2%	2%	3%	2%	2%
Bus Blockages (#/hr)	0	0	0	0	6	6	0	0	0	0	0	0
Parking (#/hr)										6	6	6
Turn Type	Perm	NA			NA	Perm	pm+pt	NA		Perm		Perm
Protected Phases		2			6		7	4				
Permitted Phases	2					6	4			8		8
Actuated Green, G (s)	43.0	43.0			43.0	43.0	42.0	42.0		18.0		18.0
Effective Green, g (s)	45.0	45.0			45.0	45.0	44.0	44.0		20.0		20.0
Actuated g/C Ratio	0.45	0.45			0.45	0.45	0.44	0.44		0.20		0.20
Clearance Time (s)	6.0	6.0			6.0	6.0	5.0	6.0		6.0		6.0
Lane Grp Cap (vph)	150	687			711	412	293	495		116		91
v/s Ratio Prot		c0.73			0.37		c0.63	0.34				
v/s Ratio Perm	0.16					0.03	0.69			0.08		0.20
v/c Ratio	0.35	1.62			0.82	0.06	3.01	0.77		0.38		1.03
Uniform Delay, d1	17.9	27.5			23.9	15.5	28.0	23.7		34.6		40.0
Progression Factor	1.00	1.00			1.05	3.03	1.00	1.00		1.00		1.00
Incremental Delay, d2	6.2	286.4			1.0	0.0	913.7	11.1		9.2		103.0
Delay (s)	24.2	313.9			26.2	47.2	941.7	34.8		43.8		143.0
Level of Service	C	F			C	D	F	C		D		F
Approach Delay (s)		301.0			28.0			656.3			123.6	
Approach LOS		F			C			F			F	

Intersection Summary			
HCM 2000 Control Delay	374.5	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.42		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	122.6%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

3: 2nd Street NE & K Street NE

Total Future FRA A-C PM

	→	↘	←	↑	↓
Lane Group	EBT	EBR	WBT	NBT	SBT
Lane Group Flow (vph)	1270	159	487	308	207
v/c Ratio	1.23	0.21	1.42	1.31	0.53
Control Delay	120.2	0.1	226.7	195.8	34.5
Queue Delay	0.6	0.0	0.0	0.0	0.0
Total Delay	120.7	0.1	226.7	195.8	34.5
Queue Length 50th (ft)	~1037	0	~423	~251	106
Queue Length 95th (ft)	m126	m0	#402	#421	181
Internal Link Dist (ft)	544		358	330	19
Turn Bay Length (ft)					
Base Capacity (vph)	1029	744	343	236	390
Starvation Cap Reductn	114	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.39	0.21	1.42	1.31	0.53

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
3: 2nd Street NE & K Street NE

Total Future FRA A-C PM

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↰	↱		✥			✥			✥	
Traffic Volume (vph)	43	1176	153	28	423	16	166	84	45	27	144	28
Future Volume (vph)	43	1176	153	28	423	16	166	84	45	27	144	28
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	10	10	10	10	10	10	10	10	10
Grade (%)		-2%			-4%			-4%			-1%	
Total Lost time (s)		3.0	3.0		3.0			4.0			4.0	
Lane Util. Factor		1.00	1.00		1.00			1.00			1.00	
Frpb, ped/bikes		1.00	0.76		0.99			0.96			0.99	
Flpb, ped/bikes		1.00	1.00		1.00			0.98			0.99	
Frt		1.00	0.85		1.00			0.98			0.98	
Flt Protected		1.00	1.00		1.00			0.97			0.99	
Satd. Flow (prot)		1656	1086		1302			1244			1414	
Flt Permitted		0.97	1.00		0.41			0.62			0.93	
Satd. Flow (perm)		1610	1086		536			793			1327	
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	45	1225	159	29	441	17	173	88	47	28	150	29
RTOR Reduction (vph)	0	0	50	0	1	0	0	6	0	0	6	0
Lane Group Flow (vph)	0	1270	109	0	486	0	0	302	0	0	201	0
Confl. Peds. (#/hr)	31		48	48		31	31		84	84		31
Confl. Bikes (#/hr)			10			7			19			5
Heavy Vehicles (%)	3%	4%	3%	2%	6%	2%	2%	4%	2%	17%	7%	6%
Bus Blockages (#/hr)	0	0	0	4	4	4	0	0	0	0	0	0
Parking (#/hr)				6	6	6	6	6	6			
Turn Type	Perm	NA	Perm	Perm	NA		Perm	NA		Perm	NA	
Protected Phases		2			6			4			8	
Permitted Phases	2		2	6			4			8		
Actuated Green, G (s)		62.0	62.0		62.0			27.0			27.0	
Effective Green, g (s)		64.0	64.0		64.0			29.0			29.0	
Actuated g/C Ratio		0.64	0.64		0.64			0.29			0.29	
Clearance Time (s)		5.0	5.0		5.0			6.0			6.0	
Lane Grp Cap (vph)		1030	695		343			229			384	
v/s Ratio Prot												
v/s Ratio Perm		0.79	0.10		c0.91			c0.38			0.15	
v/c Ratio		1.23	0.16		1.42			1.32			0.52	
Uniform Delay, d1		18.0	7.2		18.0			35.5			29.7	
Progression Factor		0.38	0.01		1.00			1.00			1.00	
Incremental Delay, d2		105.7	0.0		203.5			170.1			5.0	
Delay (s)		112.6	0.1		221.5			205.6			34.8	
Level of Service		F	A		F			F			C	
Approach Delay (s)		100.1			221.5			205.6			34.8	
Approach LOS		F			F			F			C	

Intersection Summary			
HCM 2000 Control Delay	132.2	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	1.38		
Actuated Cycle Length (s)	100.0	Sum of lost time (s)	7.0
Intersection Capacity Utilization	127.8%	ICU Level of Service	H
Analysis Period (min)	15		

c Critical Lane Group

Queues

5: N. Capital Street & H Street NW/H Street NE

	↗	→	↙	←	↑	↘	↓
Lane Group	EBL	EBT	WBL	WBT	NBT	SBL	SBT
Lane Group Flow (vph)	158	1553	145	1564	1187	179	1041
v/c Ratio	1.05	0.95	2.74	2.18	1.04	3.44	1.29
Control Delay	114.5	35.0	826.8	551.8	70.3	1119.0	166.9
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	114.5	35.0	826.8	551.8	70.3	1119.0	166.9
Queue Length 50th (ft)	~79	505	~173	~1777	~320	~225	~487
Queue Length 95th (ft)	#214	#706	m#226	#2054	#415	m#124	m147
Internal Link Dist (ft)		456		821	157		724
Turn Bay Length (ft)							
Base Capacity (vph)	150	1640	53	719	1142	52	804
Starvation Cap Reductn	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	1.05	0.95	2.74	2.18	1.04	3.44	1.29

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
5: N. Capital Street & H Street NW/H Street NE

Total Future FRA A-C PM

	↗	→	↘	↙	←	↖	↖	↑	↗	↘	↓	↙
Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑↱		↰	↱			↑↑↱		↰	↑↱	
Traffic Volume (vph)	153	1443	63	141	1262	255	0	829	322	174	781	229
Future Volume (vph)	153	1443	63	141	1262	255	0	829	322	174	781	229
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	11	11	11	11	10	10	10	10	10	11
Grade (%)		-1%			-7%			1%			-1%	
Total Lost time (s)	3.0	3.0		4.0	4.0			4.0		4.0	4.0	
Lane Util. Factor	1.00	0.95		1.00	1.00			0.91		1.00	0.95	
Frpb, ped/bikes	1.00	0.98		1.00	0.95			0.90		1.00	0.88	
Flpb, ped/bikes	1.00	1.00		1.00	1.00			1.00		0.96	1.00	
Frt	1.00	0.99		1.00	0.97			0.96		1.00	0.97	
Flt Protected	0.95	1.00		0.95	1.00			1.00		0.95	1.00	
Satd. Flow (prot)	1470	2820		1270	1492			3492		1358	2457	
Flt Permitted	0.08	1.00		0.08	1.00			1.00		0.11	1.00	
Satd. Flow (perm)	117	2820		111	1492			3492		159	2457	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	158	1488	65	145	1301	263	0	855	332	179	805	236
RTOR Reduction (vph)	0	0	0	0	0	0	0	0	0	0	0	0
Lane Group Flow (vph)	158	1553	0	145	1564	0	0	1187	0	179	1041	0
Confl. Peds. (#/hr)	292		170	170		292	281		391	391		281
Confl. Bikes (#/hr)			5			3			9			11
Heavy Vehicles (%)	2%	4%	15%	28%	6%	4%	2%	5%	11%	6%	5%	2%
Bus Blockages (#/hr)	4	4	4	0	0	0	4	4	4	4	4	4
Turn Type	D.P+P	NA		Perm	NA			NA		Perm	NA	
Protected Phases	7	7 8			8			2			6	
Permitted Phases	8			8						6		
Actuated Green, G (s)	56.0	61.0		51.0	51.0			34.0		34.0	34.0	
Effective Green, g (s)	60.0	63.0		53.0	53.0			36.0		36.0	36.0	
Actuated g/C Ratio	0.55	0.57		0.48	0.48			0.33		0.33	0.33	
Clearance Time (s)	5.0			6.0	6.0			6.0		6.0	6.0	
Lane Grp Cap (vph)	149	1615		53	718			1142		52	804	
v/s Ratio Prot	c0.07	0.55			1.05			0.34			0.42	
v/s Ratio Perm	0.51			c1.30						c1.13		
v/c Ratio	1.06	0.96		2.74	2.18			1.04		3.44	1.29	
Uniform Delay, d1	30.5	22.3		28.5	28.5			37.0		37.0	37.0	
Progression Factor	1.00	1.00		0.93	0.92			0.91		1.04	1.03	
Incremental Delay, d2	90.7	15.0		809.4	532.7			36.3		1103.4	133.5	
Delay (s)	121.2	37.3		835.8	559.1			70.1		1142.0	171.8	
Level of Service	F	D		F	F			E		F	F	
Approach Delay (s)		45.1			582.5			70.1			314.1	
Approach LOS		D			F			E			F	

Intersection Summary			
HCM 2000 Control Delay	264.1	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.83		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	154.3%	ICU Level of Service	H
Analysis Period (min)	15		
c Critical Lane Group			

Queues

6: West Road & H Street NE

Total Future FRA A-C PM

	→	↘	↙	←	↘	↓
Lane Group	EBT	EBR	WBL	WBT	SBL	SBT
Lane Group Flow (vph)	1543	499	198	1532	89	215
v/c Ratio	0.96	0.73	0.82	0.85	0.31	0.62
Control Delay	17.7	6.6	51.0	13.2	42.4	28.7
Queue Delay	0.0	0.0	0.0	0.0	0.6	0.0
Total Delay	17.7	6.6	51.0	13.2	43.0	28.7
Queue Length 50th (ft)	426	64	86	505	55	68
Queue Length 95th (ft)	m384	m68	m#167	m374	104	151
Internal Link Dist (ft)	821			250		125
Turn Bay Length (ft)		50	190			
Base Capacity (vph)	1611	687	240	1811	289	348
Starvation Cap Reductn	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	58	0
Storage Cap Reductn	0	0	0	0	0	0
Reduced v/c Ratio	0.96	0.73	0.82	0.85	0.39	0.62

Intersection Summary

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

6: West Road & H Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↑↑	↱	↰	↑↑					↰	↱	
Traffic Volume (vph)	0	1466	474	188	1455	0	0	0	0	85	0	204
Future Volume (vph)	0	1466	474	188	1455	0	0	0	0	85	0	204
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	10	10	12	12	12	12	12	12
Grade (%)		7%			-7%			-5%			0%	
Total Lost time (s)		5.0	5.0	5.0	5.0					5.0	5.0	
Lane Util. Factor		0.95	1.00	1.00	0.95					1.00	1.00	
Frpb, ped/bikes		1.00	0.89	1.00	1.00					1.00	1.00	
Flpb, ped/bikes		1.00	1.00	1.00	1.00					1.00	1.00	
Frt		1.00	0.85	1.00	1.00					1.00	0.85	
Flt Protected		1.00	1.00	0.95	1.00					0.95	1.00	
Satd. Flow (prot)		2814	1096	1538	2491					1593	1425	
Flt Permitted		1.00	1.00	0.07	1.00					0.95	1.00	
Satd. Flow (perm)		2814	1096	116	2491					1593	1425	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	0	1543	499	198	1532	0	0	0	0	89	0	215
RTOR Reduction (vph)	0	0	60	0	0	0	0	0	0	0	89	0
Lane Group Flow (vph)	0	1543	439	198	1532	0	0	0	0	89	126	0
Confl. Peds. (#/hr)			31	38								
Heavy Vehicles (%)	2%	4%	6%	2%	26%	9%	2%	2%	2%	2%	2%	2%
Turn Type		NA	Perm	pm+pt	NA					Perm	NA	
Protected Phases		4		3	8						6	
Permitted Phases			4	8						6		
Actuated Green, G (s)		61.0	61.0	78.0	78.0					18.0	18.0	
Effective Green, g (s)		63.0	63.0	80.0	80.0					20.0	20.0	
Actuated g/C Ratio		0.57	0.57	0.73	0.73					0.18	0.18	
Clearance Time (s)		7.0	7.0	7.0	7.0					7.0	7.0	
Lane Grp Cap (vph)		1611	627	239	1811					289	259	
v/s Ratio Prot		c0.55		0.09	c0.62						c0.09	
v/s Ratio Perm			0.40	0.51						0.06		
v/c Ratio		0.96	0.70	0.83	0.85					0.31	0.49	
Uniform Delay, d1		22.2	16.8	29.7	10.6					39.0	40.4	
Progression Factor		0.65	0.47	1.41	0.87					1.00	1.00	
Incremental Delay, d2		2.1	0.6	18.3	3.2					2.7	6.4	
Delay (s)		16.4	8.6	60.2	12.5					41.7	46.8	
Level of Service		B	A	E	B					D	D	
Approach Delay (s)		14.5			18.0			0.0			45.3	
Approach LOS		B			B			A			D	

Intersection Summary			
HCM 2000 Control Delay	18.3	HCM 2000 Level of Service	B
HCM 2000 Volume to Capacity ratio	0.87		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	83.1%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues

8: East Road & Driveway & H Street NE

Lane Group	EBL	EBT	WBT	WBR	NBL	NBT	NWR2
Lane Group Flow (vph)	64	1597	964	27	494	173	20
v/c Ratio	0.29	0.96	0.63	0.04	0.90	0.39	0.02
Control Delay	19.5	34.6	18.6	2.1	55.3	30.4	0.1
Queue Delay	0.0	28.9	0.7	0.0	0.0	0.0	0.0
Total Delay	19.5	63.5	19.2	2.1	55.3	30.4	0.1
Queue Length 50th (ft)	24	335	229	0	328	92	0
Queue Length 95th (ft)	m30	#712	297	8	#527	154	0
Internal Link Dist (ft)		242	401			217	
Turn Bay Length (ft)	210						
Base Capacity (vph)	221	1670	1528	748	550	448	1067
Starvation Cap Reductn	0	171	0	0	0	0	0
Spillback Cap Reductn	0	0	244	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0
Reduced v/c Ratio	0.29	1.07	0.75	0.04	0.90	0.39	0.02

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
8: East Road & Driveway & H Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR2	WBT	WBR	NBL	NBT	NBR	NWR2
Lane Configurations	↰	↑↱		↑↑	↱	↰	↱		↱
Traffic Volume (vph)	61	1529	4	925	26	474	0	166	19
Future Volume (vph)	61	1529	4	925	26	474	0	166	19
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	10	10	10	10	12	12	13	12
Grade (%)		-3%		5%			0%		
Total Lost time (s)	5.0	5.0		5.0	5.0	5.0	5.0		5.0
Lane Util. Factor	1.00	0.95		0.95	1.00	1.00	1.00		1.00
Frt	1.00	1.00		1.00	0.85	1.00	0.85		0.86
Flt Protected	0.95	1.00		1.00	1.00	0.95	1.00		1.00
Satd. Flow (prot)	1617	2930		2712	1297	1593	1298		1450
Flt Permitted	0.23	1.00		1.00	1.00	0.95	1.00		1.00
Satd. Flow (perm)	393	2930		2712	1297	1593	1298		1450
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	64	1593	4	964	27	494	0	173	20
RTOR Reduction (vph)	0	17	0	0	12	0	0	0	9
Lane Group Flow (vph)	64	1580	0	964	15	494	173	0	11
Heavy Vehicles (%)	2%	5%	2%	9%	2%	2%	2%	12%	2%
Turn Type	Perm	NA		NA	Perm	pm+pt	NA		Perm
Protected Phases		4		8		5	2		
Permitted Phases	4				8	2			8
Actuated Green, G (s)	60.0	60.0		60.0	60.0	36.0	36.0		60.0
Effective Green, g (s)	62.0	62.0		62.0	62.0	38.0	38.0		62.0
Actuated g/C Ratio	0.56	0.56		0.56	0.56	0.35	0.35		0.56
Clearance Time (s)	7.0	7.0		7.0	7.0	7.0	7.0		7.0
Lane Grp Cap (vph)	221	1651		1528	731	550	448		817
v/s Ratio Prot		c0.54		0.36		c0.31	0.13		
v/s Ratio Perm	0.16				0.01				0.01
v/c Ratio	0.29	0.96		0.63	0.02	0.90	0.39		0.01
Uniform Delay, d1	12.5	22.7		16.3	10.6	34.2	27.2		10.6
Progression Factor	1.28	1.12		1.00	1.00	1.00	1.00		1.00
Incremental Delay, d2	1.9	9.4		2.0	0.1	20.1	2.5		0.0
Delay (s)	18.0	34.7		18.2	10.6	54.2	29.7		10.6
Level of Service	B	C		B	B	D	C		B
Approach Delay (s)		34.1		18.0			47.9		
Approach LOS		C		B			D		

Intersection Summary			
HCM 2000 Control Delay	31.9	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.93		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	10.0
Intersection Capacity Utilization	84.6%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

Queues

10: N. Capital Street & G Street NW

Total Future FRA A-C PM

	←	↑	↘	↓
Lane Group	WBT	NBT	SBL	SBT
Lane Group Flow (vph)	31	1456	341	799
v/c Ratio	0.07	0.69	3.31	0.46
Control Delay	20.1	6.1	1076.2	3.8
Queue Delay	0.0	0.2	0.0	0.1
Total Delay	20.1	6.3	1076.2	3.9
Queue Length 50th (ft)	8	96	~421	22
Queue Length 95th (ft)	33	m93	#602	26
Internal Link Dist (ft)	619	441		149
Turn Bay Length (ft)				
Base Capacity (vph)	415	2101	103	1736
Starvation Cap Reductn	0	119	0	202
Spillback Cap Reductn	0	0	0	0
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.07	0.73	3.31	0.52

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

10: N. Capital Street & G Street NW

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations					✥			↰↑↱		↰	↑↱	
Traffic Volume (vph)	0	0	0	0	16	15	19	1135	258	331	757	18
Future Volume (vph)	0	0	0	0	16	15	19	1135	258	331	757	18
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	16	16	16	10	10	10	10	10	10
Grade (%)		0%			-1%			-3%			-1%	
Total Lost time (s)					4.0			3.0		3.0	3.0	
Lane Util. Factor					1.00			0.91		1.00	0.95	
Frpb, ped/bikes					0.86			0.90		1.00	0.99	
Flpb, ped/bikes					1.00			1.00		0.96	1.00	
Frt					0.93			0.97		1.00	1.00	
Flt Protected					1.00			1.00		0.95	1.00	
Satd. Flow (prot)					1536			3627		1195	2807	
Flt Permitted					1.00			0.92		0.13	1.00	
Satd. Flow (perm)					1536			3346		168	2807	
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	0	0	0	0	16	15	20	1170	266	341	780	19
RTOR Reduction (vph)	0	0	0	0	11	0	0	32	0	0	2	0
Lane Group Flow (vph)	0	0	0	0	20	0	0	1424	0	341	797	0
Confl. Peds. (#/hr)	195		59	59		195	123		161	161		123
Confl. Bikes (#/hr)			9			5			10			7
Heavy Vehicles (%)	0%	0%	0%	2%	2%	2%	12%	7%	6%	23%	7%	6%
Turn Type					NA		Perm	NA		Perm	NA	
Protected Phases					4			2			6	
Permitted Phases				4			2			6		
Actuated Green, G (s)					27.0			66.0		66.0	66.0	
Effective Green, g (s)					29.0			68.0		68.0	68.0	
Actuated g/C Ratio					0.26			0.62		0.62	0.62	
Clearance Time (s)					6.0			5.0		5.0	5.0	
Lane Grp Cap (vph)					404			2068		103	1735	
v/s Ratio Prot					c0.01						0.28	
v/s Ratio Perm								0.43		c2.03		
v/c Ratio					0.05			0.69		3.31	0.46	
Uniform Delay, d1					30.2			14.0		21.0	11.2	
Progression Factor					1.00			0.42		0.92	0.26	
Incremental Delay, d2					0.2			0.5		1061.8	0.8	
Delay (s)					30.4			6.4		1081.1	3.8	
Level of Service					C			A		F	A	
Approach Delay (s)		0.0			30.4			6.4			326.0	
Approach LOS		A			C			A			F	

Intersection Summary			
HCM 2000 Control Delay	145.4	HCM 2000 Level of Service	F
HCM 2000 Volume to Capacity ratio	2.27		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	11.0
Intersection Capacity Utilization	85.7%	ICU Level of Service	E
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
11: 1st Street & G Street NW

Total Future FRA A-C PM

	↗	↘	↖	↑	↓	↙
Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰			⬑		
Traffic Volume (veh/h)	599	0	31	36	0	0
Future Volume (Veh/h)	599	0	31	36	0	0
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	651	0	34	39	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	107	0	0			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	107	0	0			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	25	100	98			
cM capacity (veh/h)	872	1085	1623			

Direction, Lane #	EB 1	NB 1
Volume Total	651	73
Volume Left	651	34
Volume Right	0	0
cSH	872	1623
Volume to Capacity	0.75	0.02
Queue Length 95th (ft)	176	2
Control Delay (s)	20.2	3.5
Lane LOS	C	A
Approach Delay (s)	20.2	3.5
Approach LOS	C	

Intersection Summary			
Average Delay	18.5		
Intersection Capacity Utilization	47.6%	ICU Level of Service	A
Analysis Period (min)	15		

Queues

13: F Street NW & N. Capital Street & Massachusetts Avenue NW/Massachusetts Avenue NE

Total Future FRA A-0 PM

	→	←	↖	↑	↘	↓	↙	↗
Lane Group	EBT	WBT	WBR	NBT	SBL	SBT	SBR	NER
Lane Group Flow (vph)	822	361	326	949	205	472	106	135
v/c Ratio	1.06	0.35	0.84	1.01	1.40	0.73	1.07	0.33
Control Delay	82.0	41.0	47.4	75.6	247.7	33.4	140.2	30.8
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	82.0	41.0	47.4	75.6	247.7	33.4	140.2	30.8
Queue Length 50th (ft)	~280	124	132	~353	~143	240	~78	72
Queue Length 95th (ft)	#461	161	#226	#493	#291	324	#191	126
Internal Link Dist (ft)	767	422		407		441		
Turn Bay Length (ft)								
Base Capacity (vph)	776	1017	386	938	146	648	99	408
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	1.06	0.35	0.84	1.01	1.40	0.73	1.07	0.33

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

HCM Signalized Intersection Capacity Analysis

13: F Street NW & N. Capital Street & Massachusetts Avenue NW/Massachusetts Avenue NE

Total Future FRA A-1 PM

Movement	EBL	EBT	EBR	WBT	WBR	NBT	NBR	SBL	SBT	SBR	NER
Lane Configurations		↰↑↱		↑↑	↱	↑↱		↰	↑	↱	↱
Traffic Volume (vph)	209	504	76	347	313	889	22	197	453	102	130
Future Volume (vph)	209	504	76	347	313	889	22	197	453	102	130
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	11	11	11	13	10	10	10	12
Grade (%)		2%		-4%		0%			3%		
Total Lost time (s)		5.0		4.0	5.0	5.0		5.0	5.0	5.0	4.0
Lane Util. Factor		0.95		0.95	1.00	0.95		1.00	1.00	1.00	1.00
Frpb, ped/bikes		0.96		1.00	0.56	0.99		1.00	1.00	0.20	1.00
Flpb, ped/bikes		0.97		1.00	1.00	1.00		1.00	1.00	1.00	1.00
Frt		0.99		1.00	0.85	1.00		1.00	1.00	0.85	0.86
Flt Protected		0.99		1.00	1.00	1.00		0.95	1.00	1.00	1.00
Satd. Flow (prot)		2421		3110	769	2945		1355	1517	234	1249
Flt Permitted		0.70		1.00	1.00	1.00		0.12	1.00	1.00	1.00
Satd. Flow (perm)		1721		3110	769	2945		174	1517	234	1249
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	218	525	79	361	326	926	23	205	472	106	135
RTOR Reduction (vph)	0	0	0	0	91	1	0	0	0	0	0
Lane Group Flow (vph)	0	822	0	361	235	948	0	205	472	106	135
Confl. Peds. (#/hr)	212		766		212		450	450		1030	
Confl. Bikes (#/hr)			5		5		10			10	
Heavy Vehicles (%)	12%	2%	7%	3%	5%	4%	60%	8%	2%	14%	2%
Bus Blockages (#/hr)	0	0	0	0	0	0	0	4	4	4	0
Parking (#/hr)	6	6	6								6
Turn Type	pm+pt	NA		NA	pm+ov	NA		pm+pt	NA	Perm	Perm
Protected Phases	1	6		2	7	8		7	4		
Permitted Phases	6				2			4		4	2
Actuated Green, G (s)		45.0		34.0	39.0	33.0		45.0	45.0	45.0	34.0
Effective Green, g (s)		47.0		36.0	43.0	35.0		47.0	47.0	47.0	36.0
Actuated g/C Ratio		0.43		0.33	0.39	0.32		0.43	0.43	0.43	0.33
Clearance Time (s)		7.0		6.0	7.0	7.0		7.0	7.0	7.0	6.0
Lane Grp Cap (vph)		779		1017	300	937		149	648	99	408
v/s Ratio Prot		c0.07		0.12	0.05	0.32		0.09	0.31		
v/s Ratio Perm		c0.38			0.26			c0.50		c0.45	0.11
v/c Ratio		1.06		0.35	0.78	1.01		1.38	0.73	1.07	0.33
Uniform Delay, d1		31.5		28.2	29.4	37.5		42.5	26.2	31.5	27.9
Progression Factor		1.00		1.41	2.09	1.29		0.96	1.00	0.97	1.00
Incremental Delay, d2		47.8		0.9	17.8	27.9		202.5	6.4	106.3	2.2
Delay (s)		79.3		40.6	79.3	76.4		243.4	32.5	136.9	30.1
Level of Service		E		D	E	E		F	C	F	C
Approach Delay (s)		79.3		59.0		76.4			101.9		
Approach LOS		E		E		E			F		

Intersection Summary			
HCM 2000 Control Delay	77.6	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	1.27		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	23.0
Intersection Capacity Utilization	103.9%	ICU Level of Service	G
Analysis Period (min)	15		

c Critical Lane Group

c Critical Lane Group

Queues

14: Columbus Circle NE & E Street NE & Massachusetts Avenue NE & First Street NE

	↗	↘	↙	←	↖	↖	↑	↓
Lane Group	EBL	EBR	WBL	WBT	WBR	NBL	NBT	SBT
Lane Group Flow (vph)	2	292	319	337	295	86	417	778
v/c Ratio	0.01	0.55	0.42	0.43	0.44	0.63	0.22	0.64
Control Delay	43.5	18.1	20.1	21.3	21.9	38.5	13.6	31.9
Queue Delay	0.0	63.8	66.2	0.0	0.0	10.9	8.6	57.4
Total Delay	43.5	81.9	86.2	21.3	21.9	49.4	22.2	89.3
Queue Length 50th (ft)	1	70	139	152	135	47	84	206
Queue Length 95th (ft)	m2	m112	212	229	209	#122	124	m193
Internal Link Dist (ft)				62			84	422
Turn Bay Length (ft)	115							
Base Capacity (vph)	139	532	762	788	670	137	1874	1224
Starvation Cap Reductn	0	0	0	0	0	30	1410	0
Spillback Cap Reductn	0	327	577	0	0	0	0	875
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.01	1.42	1.72	0.43	0.44	0.80	0.90	2.23

Intersection Summary

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
14: Columbus Circle NE & E Street NE & Massachusetts Avenue NE & First Street NE

Total Future FRA A-C PM

	↗	↗	↘	↙	←	↖	↰	↖	↑	↓	↙
Movement	EBL2	EBL	EBR	WBL	WBT	WBR	WBR2	NBL	NBT	SBT	SBR
Lane Configurations		↰↰	↱	↰	↑	↱	↱	↰	↑↑↱	↑↑↱	
Traffic Volume (vph)	2	0	272	297	313	274	0	80	388	687	36
Future Volume (vph)	2	0	272	297	313	274	0	80	388	687	36
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	12	12	12	14	11	11	10	10
Grade (%)					1%				2%	0%	
Total Lost time (s)		5.0	5.0	3.0	5.0	5.0		3.0	5.0	5.0	
Lane Util. Factor		1.00	1.00	1.00	1.00	1.00		1.00	0.91	0.91	
Frpb, ped/bikes		1.00	1.00	1.00	1.00	1.00		1.00	1.00	0.97	
Flpb, ped/bikes		0.66	1.00	1.00	1.00	1.00		1.00	1.00	1.00	
Frt		1.00	0.85	1.00	1.00	0.85		1.00	1.00	0.99	
Flt Protected		0.95	1.00	0.95	1.00	1.00		0.95	1.00	1.00	
Satd. Flow (prot)		968	1271	1554	1668	1418		1376	4296	3945	
Flt Permitted		0.56	1.00	0.95	1.00	1.00		0.95	1.00	1.00	
Satd. Flow (perm)		568	1271	1554	1668	1418		1376	4296	3945	
Peak-hour factor, PHF	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93	0.93
Adj. Flow (vph)	2	0	292	319	337	295	0	86	417	739	39
RTOR Reduction (vph)	0	0	220	0	0	0	0	0	0	6	0
Lane Group Flow (vph)	0	2	72	319	337	295	0	86	417	772	0
Confl. Peds. (#/hr)	1093					1093	7	296			296
Confl. Bikes (#/hr)			2								11
Heavy Vehicles (%)	2%	2%	5%	4%	2%	2%	2%	13%	4%	3%	47%
Bus Blockages (#/hr)	4	4	4	0	0	0	0	0	0	8	8
Turn Type	Perm	Perm	Prot	pm+pt	NA	Prot	Perm	Prot	NA	NA	
Protected Phases			8	7	4	4		5	2	6	
Permitted Phases	8	8		4			4				
Actuated Green, G (s)		25.0	25.0	50.0	50.0	50.0		9.0	46.0	32.0	
Effective Green, g (s)		27.0	27.0	52.0	52.0	52.0		11.0	48.0	34.0	
Actuated g/C Ratio		0.25	0.25	0.47	0.47	0.47		0.10	0.44	0.31	
Clearance Time (s)		7.0	7.0	5.0	7.0	7.0		5.0	7.0	7.0	
Lane Grp Cap (vph)		139	311	734	788	670		137	1874	1219	
v/s Ratio Prot			0.06	0.09	0.20	c0.21		c0.06	0.10	c0.20	
v/s Ratio Perm		0.00		0.12							
v/c Ratio		0.01	0.23	0.43	0.43	0.44		0.63	0.22	0.63	
Uniform Delay, d1		31.4	33.2	19.2	19.2	19.3		47.5	19.4	32.6	
Progression Factor		1.36	3.57	1.00	1.00	1.00		0.36	0.68	0.97	
Incremental Delay, d2		0.1	1.3	1.9	1.7	2.1		19.5	0.3	0.2	
Delay (s)		43.0	119.6	21.1	20.9	21.4		36.6	13.5	32.0	
Level of Service		D	F	C	C	C		D	B	C	
Approach Delay (s)					21.1				17.4	32.0	
Approach LOS					C				B	C	

Intersection Summary			
HCM 2000 Control Delay	35.1	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.55		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	74.3%	ICU Level of Service	D
Analysis Period (min)	15		
c Critical Lane Group			

Queues

15: Louisiana Avenue NE & Columbus Circle NE

	→	↘	↙	←	↗
Lane Group	EBT	EBR	WBL	WBT	NBR
Lane Group Flow (vph)	1111	190	194	543	476
v/c Ratio	0.82	0.62	0.57	0.23	0.72
Control Delay	61.1	42.3	68.9	1.4	24.2
Queue Delay	52.2	31.6	5.6	0.1	0.1
Total Delay	113.3	73.9	74.5	1.5	24.2
Queue Length 50th (ft)	304	82	123	5	176
Queue Length 95th (ft)	355	162	186	8	277
Internal Link Dist (ft)	84			133	
Turn Bay Length (ft)		98	95		
Base Capacity (vph)	1354	307	338	2361	659
Starvation Cap Reductn	803	116	93	776	0
Spillback Cap Reductn	0	0	0	276	4
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	2.02	0.99	0.79	0.34	0.73

Intersection Summary

15: Louisiana Avenue NE & Columbus Circle NE

Total Future FRA A-C PM

	→	↘	↙	←	↖	↗
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑↑	↱	↰	↑↑↑		↱
Traffic Volume (vph)	1067	182	186	521	0	457
Future Volume (vph)	1067	182	186	521	0	457
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	11	11	11	11	16	16
Grade (%)	0%			1%	0%	
Total Lost time (s)	4.0	4.0	4.0	4.0		4.0
Lane Util. Factor	0.91	1.00	1.00	0.91		1.00
Frpb, ped/bikes	1.00	0.60	1.00	1.00		0.84
Flpb, ped/bikes	1.00	1.00	1.00	1.00		1.00
Frt	1.00	0.85	1.00	1.00		0.86
Flt Protected	1.00	1.00	0.95	1.00		1.00
Satd. Flow (prot)	4381	751	1488	4402		1186
Flt Permitted	1.00	1.00	0.95	1.00		1.00
Satd. Flow (perm)	4381	751	1488	4402		1186
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	1111	190	194	543	0	476
RTOR Reduction (vph)	0	75	0	0	0	30
Lane Group Flow (vph)	1111	115	194	543	0	446
Confl. Peds. (#/hr)		134	134			272
Confl. Bikes (#/hr)		76				
Heavy Vehicles (%)	3%	13%	5%	2%	0%	3%
Parking (#/hr)					6	6
Turn Type	NA	Perm	Prot	NA		pm+ov
Protected Phases	6		7	2 7		7
Permitted Phases		6				8
Actuated Green, G (s)	32.0	32.0	23.0	55.0		56.0
Effective Green, g (s)	34.0	34.0	25.0	59.0		60.0
Actuated g/C Ratio	0.31	0.31	0.23	0.54		0.55
Clearance Time (s)	6.0	6.0	6.0			6.0
Lane Grp Cap (vph)	1354	232	338	2361		646
v/s Ratio Prot	c0.25		0.13	0.12		c0.16
v/s Ratio Perm		0.15				0.22
v/c Ratio	0.82	0.49	0.57	0.23		0.69
Uniform Delay, d1	35.2	31.0	37.8	13.5		18.2
Progression Factor	1.59	2.33	1.61	0.11		1.00
Incremental Delay, d2	4.8	6.1	6.7	0.2		6.0
Delay (s)	60.6	78.4	67.6	1.7		24.2
Level of Service	E	E	E	A		C
Approach Delay (s)	63.2			19.0	24.2	
Approach LOS	E			B	C	

Intersection Summary			
HCM 2000 Control Delay	42.8	HCM 2000 Level of Service	D
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	16.0
Intersection Capacity Utilization	69.5%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues

16: Delaware Avenue NE & Columbus Circle NE

	→	↘	←	↗
Lane Group	EBT	EBR	WBT	NBR
Lane Group Flow (vph)	1464	18	736	30
v/c Ratio	0.61	0.03	0.31	0.11
Control Delay	6.8	1.1	2.0	4.3
Queue Delay	1.0	0.0	0.6	0.0
Total Delay	7.8	1.1	2.6	4.3
Queue Length 50th (ft)	95	0	15	0
Queue Length 95th (ft)	109	m1	m14	13
Internal Link Dist (ft)	133		201	
Turn Bay Length (ft)				
Base Capacity (vph)	2384	690	2407	274
Starvation Cap Reductn	607	0	1203	0
Spillback Cap Reductn	169	0	114	1
Storage Cap Reductn	0	0	0	0
Reduced v/c Ratio	0.82	0.03	0.61	0.11

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
16: Delaware Avenue NE & Columbus Circle NE

Total Future FRA A-C PM

	→	↘	↙	←	↖	↗
Movement	EBT	EBR	WBL	WBT	NBL	NBR
Lane Configurations	↑↑↑	↱		↑↑↑		↱
Traffic Volume (vph)	1405	17	0	707	0	29
Future Volume (vph)	1405	17	0	707	0	29
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	10	10	10	10	12	9
Total Lost time (s)	4.0	4.0		4.0		5.0
Lane Util. Factor	0.91	1.00		0.91		1.00
Frpb, ped/bikes	1.00	0.92		1.00		0.65
Flpb, ped/bikes	1.00	1.00		1.00		1.00
Frt	1.00	0.85		1.00		0.86
Flt Protected	1.00	1.00		1.00		1.00
Satd. Flow (prot)	4230	1212		4272		739
Flt Permitted	1.00	1.00		1.00		1.00
Satd. Flow (perm)	4230	1212		4272		739
Peak-hour factor, PHF	0.96	0.96	0.96	0.96	0.96	0.96
Adj. Flow (vph)	1464	18	0	736	0	30
RTOR Reduction (vph)	0	8	0	0	0	20
Lane Group Flow (vph)	1464	10	0	736	0	10
Confl. Peds. (#/hr)		9				530
Confl. Bikes (#/hr)		54				4
Heavy Vehicles (%)	3%	2%	2%	2%	0%	2%
Bus Blockages (#/hr)	0	2	0	0	0	0
Parking (#/hr)					6	6
Turn Type	NA	Perm		NA		Perm
Protected Phases	2			6		
Permitted Phases		2				8
Actuated Green, G (s)	60.0	60.0		60.0		34.0
Effective Green, g (s)	62.0	62.0		62.0		36.0
Actuated g/C Ratio	0.56	0.56		0.56		0.33
Clearance Time (s)	6.0	6.0		6.0		7.0
Lane Grp Cap (vph)	2384	683		2407		241
v/s Ratio Prot	c0.35			0.17		
v/s Ratio Perm		0.01				c0.01
v/c Ratio	0.61	0.01		0.31		0.04
Uniform Delay, d1	16.0	10.6		12.7		25.2
Progression Factor	0.38	0.22		0.15		1.00
Incremental Delay, d2	0.7	0.0		0.0		0.3
Delay (s)	6.7	2.3		2.0		25.5
Level of Service	A	A		A		C
Approach Delay (s)	6.7			2.0	25.5	
Approach LOS	A			A	C	

Intersection Summary			
HCM 2000 Control Delay	5.4	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.41		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	13.0
Intersection Capacity Utilization	66.0%	ICU Level of Service	C
Analysis Period (min)	15		
c Critical Lane Group			

Queues
17: First Street NE & Columbus Circle NE & Massachusetts Avenue NE

Total Future FRA A-C PM

	↗	→	↘	←	↑
Lane Group	EBL	EBT	EBR	WBT	NBT
Lane Group Flow (vph)	653	866	39	991	116
v/c Ratio	1.09	0.52	0.06	1.13	0.17
Control Delay	83.9	3.4	0.2	105.1	26.2
Queue Delay	2.8	0.2	0.0	0.0	0.0
Total Delay	86.7	3.6	0.2	105.1	26.2
Queue Length 50th (ft)	~255	10	0	~414	27
Queue Length 95th (ft)	#373	42	m0	#546	51
Internal Link Dist (ft)		201		659	319
Turn Bay Length (ft)	120				
Base Capacity (vph)	597	1659	606	878	669
Starvation Cap Reductn	25	197	0	0	0
Spillback Cap Reductn	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0
Reduced v/c Ratio	1.14	0.59	0.06	1.13	0.17

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.

95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

17: First Street NE & Columbus Circle NE & Massachusetts Avenue NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (vph)	601	797	36	0	663	248	44	47	16	0	0	0
Future Volume (vph)	601	797	36	0	663	248	44	47	16	0	0	0
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	11	10	10	10	10	10	10	10	10	10
Total Lost time (s)	5.0	5.0	5.0		4.0			6.0				
Lane Util. Factor	0.97	0.95	1.00		0.95			0.95				
Frpb, ped/bikes	1.00	1.00	0.73		0.94			0.98				
Flpb, ped/bikes	1.00	1.00	1.00		1.00			0.93				
Frt	1.00	1.00	0.85		0.96			0.98				
Flt Protected	0.95	1.00	1.00		1.00			0.98				
Satd. Flow (prot)	2856	2944	1008		2442			2331				
Flt Permitted	0.95	1.00	1.00		1.00			0.98				
Satd. Flow (perm)	2856	2944	1008		2442			2331				
Peak-hour factor, PHF	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92
Adj. Flow (vph)	653	866	39	0	721	270	48	51	17	0	0	0
RTOR Reduction (vph)	0	0	17	0	35	0	0	12	0	0	0	0
Lane Group Flow (vph)	653	866	22	0	956	0	0	104	0	0	0	0
Confl. Peds. (#/hr)	63		91			93	144		110	110		144
Confl. Bikes (#/hr)			29			15			12			1
Heavy Vehicles (%)	3%	3%	2%	0%	5%	6%	2%	12%	2%	0%	0%	0%
Bus Blockages (#/hr)	0	0	0	0	4	4	0	0	0	0	0	0
Parking (#/hr)					1	1	6	6	6			
Turn Type	Prot	NA	Perm		NA		Perm	NA				
Protected Phases	5	2			6			8				
Permitted Phases			2				8					
Actuated Green, G (s)	21.0	60.0	60.0		36.0			29.0				
Effective Green, g (s)	23.0	62.0	62.0		38.0			31.0				
Actuated g/C Ratio	0.21	0.56	0.56		0.35			0.28				
Clearance Time (s)	7.0	7.0	7.0		6.0			8.0				
Lane Grp Cap (vph)	597	1659	568		843			656				
v/s Ratio Prot	c0.23	0.29			c0.39							
v/s Ratio Perm			0.02					0.04				
v/c Ratio	1.09	0.52	0.04		1.13			0.16				
Uniform Delay, d1	43.5	14.8	10.7		36.0			29.7				
Progression Factor	0.43	0.16	1.00		1.00			1.00				
Incremental Delay, d2	61.9	1.0	0.1		74.7			0.5				
Delay (s)	80.7	3.3	10.8		110.7			30.2				
Level of Service	F	A	B		F			C				
Approach Delay (s)		36.0			110.7			30.2			0.0	
Approach LOS		D			F			C			A	

Intersection Summary			
HCM 2000 Control Delay	63.5	HCM 2000 Level of Service	E
HCM 2000 Volume to Capacity ratio	0.79		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	86.5%	ICU Level of Service	E
Analysis Period (min)	15		
c Critical Lane Group			

Queues
19: N. Capital Street & E Street NW/E Street NE

Total Future FRA A-C PM

	↗	→	↘	↙	←	↖	↑	↓
Lane Group	EBL	EBT	EBR	WBL	WBT	WBR	NBT	SBT
Lane Group Flow (vph)	244	236	95	152	242	40	814	672
v/c Ratio	0.75	0.62	0.34	0.66	0.78	0.16	0.70	0.76
Control Delay	50.0	42.0	6.5	40.9	57.9	1.9	25.3	14.7
Queue Delay	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Total Delay	50.0	42.0	6.5	40.9	57.9	1.9	25.3	14.7
Queue Length 50th (ft)	123	144	0	78	176	0	221	180
Queue Length 95th (ft)	#219	232	26	m#138	#297	m4	296	m224
Internal Link Dist (ft)		251			383		191	407
Turn Bay Length (ft)	180		40	145		75		
Base Capacity (vph)	326	382	281	232	309	249	1168	889
Starvation Cap Reductn	0	0	0	0	0	0	0	0
Spillback Cap Reductn	0	0	0	0	0	0	0	0
Storage Cap Reductn	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.75	0.62	0.34	0.66	0.78	0.16	0.70	0.76

Intersection Summary

\# 95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis
19: N. Capital Street & E Street NW/E Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations	↰	↑	↱	↰	↑	↱		↰↑↱			↰↑↱	
Traffic Volume (vph)	239	231	93	149	237	39	31	636	130	78	373	207
Future Volume (vph)	239	231	93	149	237	39	31	636	130	78	373	207
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	10	10	8	10	10	8	11	11	11	11	11	11
Grade (%)		5%			-4%			0%			0%	
Total Lost time (s)	3.0	4.0	4.0	3.0	4.0	4.0		4.0			4.0	
Lane Util. Factor	1.00	1.00	1.00	1.00	1.00	1.00		0.95			0.95	
Frpb, ped/bikes	1.00	1.00	0.66	1.00	1.00	0.64		0.93			0.86	
Flpb, ped/bikes	0.93	1.00	1.00	0.93	1.00	1.00		1.00			0.99	
Frt	1.00	1.00	0.85	1.00	1.00	0.85		0.98			0.95	
Flt Protected	0.95	1.00	1.00	0.95	1.00	1.00		1.00			0.99	
Satd. Flow (prot)	1318	1314	677	1359	1362	490		2649			2481	
Flt Permitted	0.42	1.00	1.00	0.42	1.00	1.00		0.90			0.70	
Satd. Flow (perm)	576	1314	677	603	1362	490		2398			1747	
Peak-hour factor, PHF	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98	0.98
Adj. Flow (vph)	244	236	95	152	242	40	32	649	133	80	381	211
RTOR Reduction (vph)	0	0	67	0	0	31	0	15	0	0	48	0
Lane Group Flow (vph)	244	236	28	152	242	9	0	799	0	0	624	0
Confl. Peds. (#/hr)	317		194	194		317	148		164	164		148
Confl. Bikes (#/hr)			66			11			5			13
Heavy Vehicles (%)	4%	3%	4%	6%	4%	46%	2%	4%	20%	2%	2%	2%
Parking (#/hr)		6	6		6	6						
Turn Type	pm+pt	NA	Perm	pm+pt	NA	Perm	Perm	NA		Perm	NA	
Protected Phases	3	8		7	4			2			6	
Permitted Phases	8		8	4		4	2			6		
Actuated Green, G (s)	42.0	30.0	30.0	29.0	23.0	23.0		51.0			51.0	
Effective Green, g (s)	44.0	32.0	32.0	33.0	25.0	25.0		53.0			53.0	
Actuated g/C Ratio	0.40	0.29	0.29	0.30	0.23	0.23		0.48			0.48	
Clearance Time (s)	5.0	6.0	6.0	5.0	6.0	6.0		6.0			6.0	
Lane Grp Cap (vph)	331	382	196	235	309	111		1155			841	
v/s Ratio Prot	c0.10	0.18		0.05	c0.18							
v/s Ratio Perm	0.19		0.04	0.15		0.02		0.33			c0.36	
v/c Ratio	0.74	0.62	0.14	0.65	0.78	0.08		0.69			0.74	
Uniform Delay, d1	33.3	33.7	28.8	39.4	40.0	33.5		22.2			23.0	
Progression Factor	1.00	1.00	1.00	0.91	1.02	1.00		1.00			0.49	
Incremental Delay, d2	13.7	7.3	1.5	11.6	16.1	1.3		3.4			4.5	
Delay (s)	47.0	41.0	30.3	47.6	56.7	34.7		25.6			15.9	
Level of Service	D	D	C	D	E	C		C			B	
Approach Delay (s)		41.8			51.5			25.6			15.9	
Approach LOS		D			D			C			B	

Intersection Summary

HCM 2000 Control Delay	31.2	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.74		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	15.0
Intersection Capacity Utilization	93.8%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

Queues

35: Bus Exit & Central Road & H Street NE

Total Future FRA A-C PM

	↗	→	↙	←	↖	↑	↘	↓	↗
Lane Group	EBL	EBT	WBL2	WBT	NBL	NBT	SBL	SBT	NER
Lane Group Flow (vph)	82	1558	51	1422	252	108	45	99	85
v/c Ratio	0.57	0.84	0.47	0.68	1.41	0.37	0.27	0.32	0.86
Control Delay	21.6	16.3	21.2	11.5	248.6	11.3	43.7	9.3	109.3
Queue Delay	0.0	4.0	0.0	1.9	0.0	87.2	673.8	0.1	210.7
Total Delay	21.6	20.3	21.2	13.4	248.6	98.5	717.5	9.4	320.0
Queue Length 50th (ft)	23	235	18	360	~239	0	28	0	60
Queue Length 95th (ft)	m27	m263	m37	m451	#400	48	63	40	#155
Internal Link Dist (ft)		250		242		229		147	
Turn Bay Length (ft)									
Base Capacity (vph)	144	1849	109	2092	179	289	168	305	99
Starvation Cap Reductn	0	218	0	481	0	0	0	0	0
Spillback Cap Reductn	0	138	0	221	0	219	168	8	93
Storage Cap Reductn	0	0	0	0	0	0	0	0	0
Reduced v/c Ratio	0.57	0.96	0.47	0.88	1.41	1.54	45.00	0.33	14.17

Intersection Summary

~ Volume exceeds capacity, queue is theoretically infinite.
Queue shown is maximum after two cycles.
95th percentile volume exceeds capacity, queue may be longer.
Queue shown is maximum after two cycles.
m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

35: Bus Exit & Central Road & H Street NE

Total Future FRA A-C PM

Movement	EBL	EBT	EBR	WBL2	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR2
Lane Configurations	↰	↑↱		↰	↑↱		↰	↱		↰	↱	
Traffic Volume (vph)	78	1368	112	48	1318	33	239	0	103	43	0	94
Future Volume (vph)	78	1368	112	48	1318	33	239	0	103	43	0	94
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900	1900
Lane Width	12	12	12	10	10	10	10	10	10	10	10	10
Grade (%)		-3%			5%			0%			0%	
Total Lost time (s)	5.0	5.0		5.0	5.0		5.0	5.0		5.0	5.0	
Lane Util. Factor	1.00	0.95		1.00	0.95		1.00	1.00		1.00	1.00	
Frpb, ped/bikes	1.00	0.99		1.00	1.00		1.00	0.86		1.00	0.89	
Flpb, ped/bikes	1.00	1.00		1.00	1.00		0.92	1.00		0.89	1.00	
Frt	1.00	0.99		1.00	1.00		1.00	0.85		1.00	0.85	
Flt Protected	0.95	1.00		0.95	1.00		0.95	1.00		0.95	1.00	
Satd. Flow (prot)	1617	3081		1449	2876		1369	1100		1328	1188	
Flt Permitted	0.14	1.00		0.10	1.00		0.68	1.00		0.66	1.00	
Satd. Flow (perm)	240	3081		150	2876		986	1100		925	1188	
Peak-hour factor, PHF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Adj. Flow (vph)	82	1440	118	51	1387	35	252	0	108	45	0	99
RTOR Reduction (vph)	0	0	0	0	2	0	0	88	0	0	81	0
Lane Group Flow (vph)	82	1558	0	51	1420	0	252	20	0	45	18	0
Confl. Peds. (#/hr)			36	63		50	50		69	69		50
Confl. Bikes (#/hr)			5			5			5			5
Heavy Vehicles (%)	2%	5%	2%	2%	2%	2%	2%	9%	6%	2%	2%	2%
Turn Type	Perm	NA		Perm	NA		Perm	NA		Perm	NA	
Protected Phases		4			8			2			6	
Permitted Phases	4			8			2			6		
Actuated Green, G (s)	64.0	64.0		78.0	78.0		18.0	18.0		18.0	18.0	
Effective Green, g (s)	66.0	66.0		80.0	80.0		20.0	20.0		20.0	20.0	
Actuated g/C Ratio	0.60	0.60		0.73	0.73		0.18	0.18		0.18	0.18	
Clearance Time (s)	7.0	7.0		7.0	7.0		7.0	7.0		7.0	7.0	
Lane Grp Cap (vph)	144	1848		109	2091		179	200		168	216	
v/s Ratio Prot		c0.51			c0.49			0.02			0.02	
v/s Ratio Perm	0.34			0.34			c0.26			0.05		
v/c Ratio	0.57	0.84		0.47	0.68		1.41	0.10		0.27	0.08	
Uniform Delay, d1	13.4	17.8		6.2	8.1		45.0	37.5		38.7	37.4	
Progression Factor	0.90	0.78		1.25	1.24		1.00	1.00		1.00	1.00	
Incremental Delay, d2	6.2	2.0		9.6	1.2		213.4	1.0		3.9	0.8	
Delay (s)	18.2	15.9		17.3	11.2		258.4	38.5		42.6	38.1	
Level of Service	B	B		B	B		F	D		D	D	
Approach Delay (s)		16.0			11.4			192.4			39.5	
Approach LOS		B			B			F			D	

Intersection Summary			
HCM 2000 Control Delay	34.3	HCM 2000 Level of Service	C
HCM 2000 Volume to Capacity ratio	0.98		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	17.0
Intersection Capacity Utilization	98.4%	ICU Level of Service	F
Analysis Period (min)	15		

c Critical Lane Group

	↗
Movement	NER
Lane Configurations	↱
Traffic Volume (vph)	81
Future Volume (vph)	81
Ideal Flow (vphpl)	1900
Lane Width	10
Grade (%)	
Total Lost time (s)	5.0
Lane Util. Factor	1.00
Frpb, ped/bikes	1.00
Flpb, ped/bikes	1.00
Frt	0.86
Flt Protected	1.00
Satd. Flow (prot)	1211
Flt Permitted	1.00
Satd. Flow (perm)	1211
Peak-hour factor, PHF	0.95
Adj. Flow (vph)	85
RTOR Reduction (vph)	0
Lane Group Flow (vph)	85
Confl. Peds. (#/hr)	
Confl. Bikes (#/hr)	
Heavy Vehicles (%)	14%
Turn Type	Perm
Protected Phases	
Permitted Phases	3
Actuated Green, G (s)	7.0
Effective Green, g (s)	9.0
Actuated g/C Ratio	0.08
Clearance Time (s)	7.0
Lane Grp Cap (vph)	99
v/s Ratio Prot	
v/s Ratio Perm	0.07
v/c Ratio	0.86
Uniform Delay, d1	49.9
Progression Factor	1.00
Incremental Delay, d2	57.8
Delay (s)	107.7
Level of Service	F
Approach Delay (s)	
Approach LOS	

Intersection Summary

Queues

91: N. Capital Street & G Place NW

Total Future FRA A-C PM

Lane Group	NBT	SBT
Lane Group Flow (vph)	1210	1162
v/c Ratio	0.44	0.47
Control Delay	1.0	3.3
Queue Delay	0.5	3.1
Total Delay	1.5	6.4
Queue Length 50th (ft)	9	50
Queue Length 95th (ft)	10	m37
Internal Link Dist (ft)	149	157
Turn Bay Length (ft)		
Base Capacity (vph)	2745	2460
Starvation Cap Reductn	811	1159
Spillback Cap Reductn	957	0
Storage Cap Reductn	0	0
Reduced v/c Ratio	0.68	0.89

Intersection Summary

m Volume for 95th percentile queue is metered by upstream signal.

HCM Signalized Intersection Capacity Analysis

91: N. Capital Street & G Place NW

	↙	↖	↑	↗	↘	↓
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			↑↑↱			↰↑↑
Traffic Volume (vph)	0	0	1150	23	21	1106
Future Volume (vph)	0	0	1150	23	21	1106
Ideal Flow (vphpl)	1900	1900	1900	1900	1900	1900
Lane Width	12	12	11	11	11	11
Total Lost time (s)			3.0			3.0
Lane Util. Factor			0.91			0.91
Frpb, ped/bikes			0.99			1.00
Flpb, ped/bikes			1.00			1.00
Frt			1.00			1.00
Flt Protected			1.00			1.00
Satd. Flow (prot)			4078			4078
Flt Permitted			1.00			0.90
Satd. Flow (perm)			4078			3656
Peak-hour factor, PHF	0.97	0.97	0.97	0.97	0.97	0.97
Adj. Flow (vph)	0	0	1186	24	22	1140
RTOR Reduction (vph)	0	0	2	0	0	0
Lane Group Flow (vph)	0	0	1208	0	0	1162
Confl. Peds. (#/hr)	25	45		275	275	
Confl. Bikes (#/hr)				13		
Heavy Vehicles (%)	0%	0%	9%	0%	0%	10%
Bus Blockages (#/hr)	0	0	0	0	4	4
Turn Type			NA		Perm	NA
Protected Phases			2			2
Permitted Phases					2	
Actuated Green, G (s)			72.0			72.0
Effective Green, g (s)			74.0			74.0
Actuated g/C Ratio			0.67			0.67
Clearance Time (s)			5.0			5.0
Lane Grp Cap (vph)			2743			2459
v/s Ratio Prot			0.30			
v/s Ratio Perm						c0.32
v/c Ratio			0.44			0.47
Uniform Delay, d1			8.4			8.6
Progression Factor			0.08			0.38
Incremental Delay, d2			0.4			0.1
Delay (s)			1.0			3.3
Level of Service			A			A
Approach Delay (s)	0.0		1.0			3.3
Approach LOS	A		A			A

Intersection Summary			
HCM 2000 Control Delay	2.1	HCM 2000 Level of Service	A
HCM 2000 Volume to Capacity ratio	0.35		
Actuated Cycle Length (s)	110.0	Sum of lost time (s)	9.0
Intersection Capacity Utilization	58.0%	ICU Level of Service	B
Analysis Period (min)	15		

c Critical Lane Group

HCM Unsignalized Intersection Capacity Analysis
92: 1st Street & G Place NW

Total Future FRA A-C PM

Movement	EBL	EBR	NBL	NBT	SBT	SBR
Lane Configurations	↰			↰↑		
Traffic Volume (veh/h)	44	0	0	635	0	0
Future Volume (Veh/h)	44	0	0	635	0	0
Sign Control	Stop			Free	Free	
Grade	0%			0%	0%	
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	48	0	0	690	0	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type				None	None	
Median storage veh)						
Upstream signal (ft)						
pX, platoon unblocked						
vC, conflicting volume	690	0	0			
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	690	0	0			
tC, single (s)	6.4	6.2	4.1			
tC, 2 stage (s)						
tF (s)	3.5	3.3	2.2			
p0 queue free %	88	100	100			
cM capacity (veh/h)	411	1085	1623			

Direction, Lane #	EB 1	NB 1
Volume Total	48	690
Volume Left	48	0
Volume Right	0	0
cSH	411	1623
Volume to Capacity	0.12	0.00
Queue Length 95th (ft)	10	0
Control Delay (s)	14.9	0.0
Lane LOS	B	
Approach Delay (s)	14.9	0.0
Approach LOS	B	

Intersection Summary			
Average Delay	1.0		
Intersection Capacity Utilization	47.1%	ICU Level of Service	A
Analysis Period (min)	15		

	↙	↖	↑	↗	↘	↓
Movement	WBL	WBR	NBT	NBR	SBL	SBT
Lane Configurations			↱			↰
Traffic Volume (veh/h)	0	0	0	229	662	0
Future Volume (Veh/h)	0	0	0	229	662	0
Sign Control	Stop		Free			Free
Grade	0%		-5%			0%
Peak Hour Factor	0.92	0.92	0.92	0.92	0.92	0.92
Hourly flow rate (vph)	0	0	0	249	720	0
Pedestrians						
Lane Width (ft)						
Walking Speed (ft/s)						
Percent Blockage						
Right turn flare (veh)						
Median type			None			None
Median storage veh)						
Upstream signal (ft)						528
pX, platoon unblocked	1.00					
vC, conflicting volume	1564	124			249	
vC1, stage 1 conf vol						
vC2, stage 2 conf vol						
vCu, unblocked vol	1565	124			249	
tC, single (s)	6.4	6.2			4.1	
tC, 2 stage (s)						
tF (s)	3.5	3.3			2.2	
p0 queue free %	100	100			45	
cM capacity (veh/h)	55	926			1317	

Direction, Lane #	NB 1	SB 1
Volume Total	249	720
Volume Left	0	720
Volume Right	249	0
cSH	1700	1317
Volume to Capacity	0.15	0.55
Queue Length 95th (ft)	0	86
Control Delay (s)	0.0	11.0
Lane LOS		B
Approach Delay (s)	0.0	11.0
Approach LOS		

Intersection Summary			
Average Delay	8.2		
Intersection Capacity Utilization	63.2%	ICU Level of Service	B
Analysis Period (min)	15		