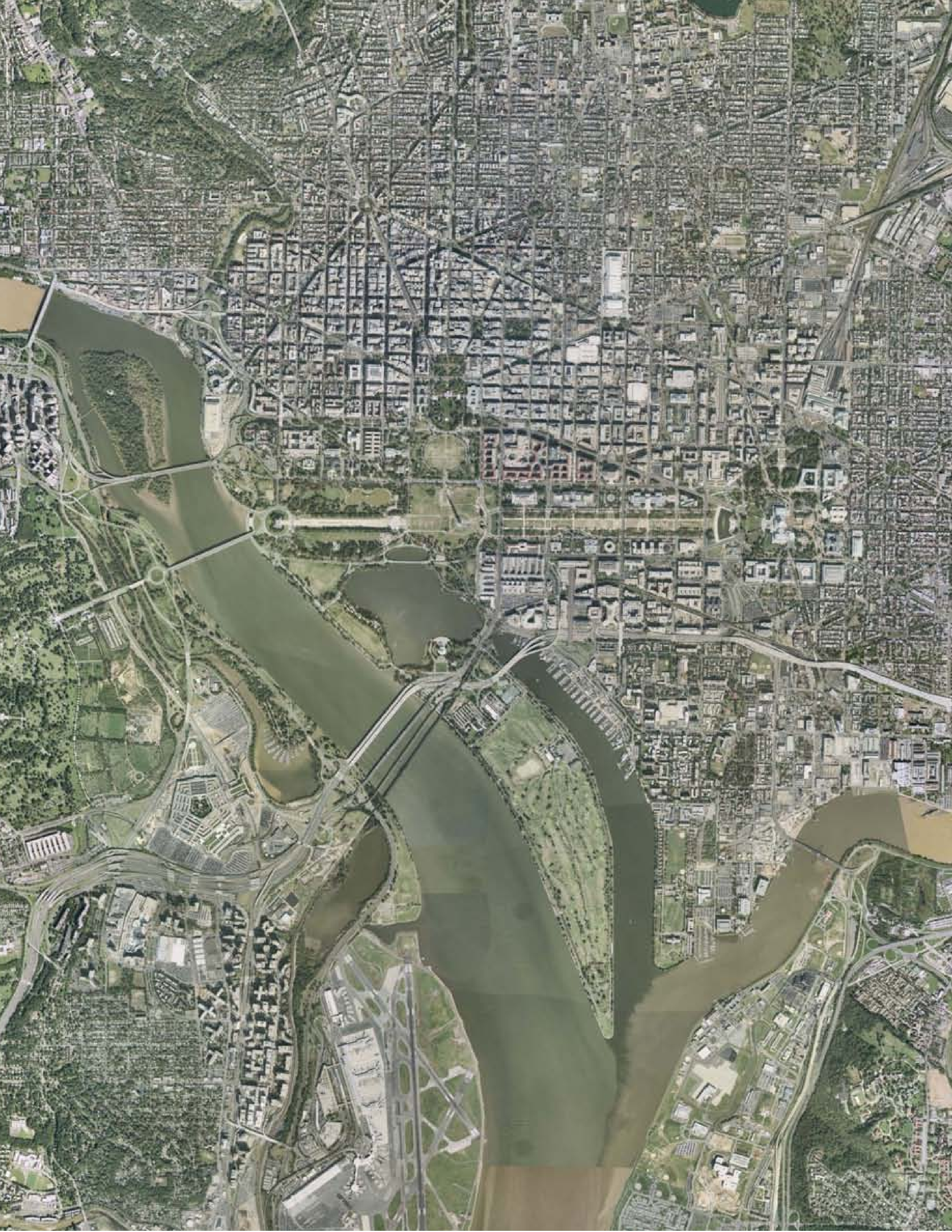
White House Area Transportation Study

Technical Appendix

June 2011



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Project Summary

Study Purpose and Overview

The 2003 Omnibus Appropriations Act (P.L. 108-7) directs the Federal Highway Administration (FHWA), in consultation with the National Capital Planning Commission (NCPC), to study ways "to address traffic problems in the immediate vicinity of the White House, including an engineering design to alleviate congestion resulting from street closures in that area."

Streets were closed and traffic was restricted around the White House, the Capitol, and the State Department following the 1995 Murrah Federal building bombing and the September 11, 2001 tragedies. The largest and most significant closures are to Pennsylvania Avenue and E Street adjacent to the White House between 15th and 17th Streets. The removal of these two crosstown arterial segments increases congestion throughout downtown and makes travel less reliable.

Figure 1: White House security perimeter and street closings

East-west vehicular travel is blocked for almost two-thirds of a mile across the heart of downtown Washington. The closures strain a downtown transportation system operating near the limits of its capacity. Travel conditions in the future are expected to deteriorate as downtown employment, commercial activity, and residential population grow.

Study Participants

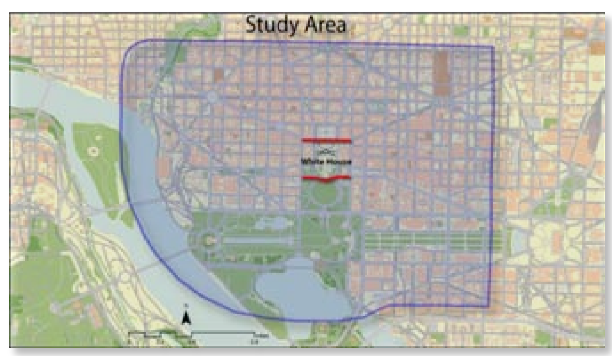
To conduct the study, FHWA established a working partnership among local and Federal agencies with jurisdiction in the affected area. Cooperating agencies included the NCPC, National Park Service (NPS), District of Columbia Department of Transportation (DDOT), District of Columbia Office of Planning (DCOP), U.S. Secret Service (USSS), Washington Metropolitan Area Transit Authority (WMATA), and Metropolitan Washington Council of Governments (MWCOG).

The study evaluates the overall health and resiliency of the downtown transportation system and reports on an array of potential actions to compensate for the closures and the new discontinuities they introduce in the downtown street grid. Some actions would repair and reinforce the street grid while others are aimed at operating the remaining system more effectively. Street and transit improvements are considered. The study focuses on how each action would improve travel across a variety of modes. Since the interrelationship between modes is central to the study, the effects of proposed actions are reported with respect to all downtown travelers.

Closure Impacts

Downtown Washington is home to 633,000 workers and 47,000 residents. Roughly 1.5 million trips are made to, from, or through the study area on a typical workday. A third of these trips (about 525,000) cross 16th Street and President's Park between M Street and Constitution Avenue.

Figure 2: Study area around street closures



Downtown streets are heavily traveled especially during peak periods and the early evening hours. The transportation system (including transit and non-transit modes) experiences substantial daily congestion. Travel conditions can be unreliable and there is little redundancy in the major routes to and across downtown.

Travelers Adapted

The closure of Pennsylvania Avenue and E Street increased downtown congestion, increased travel times, and made travel conditions less reliable for people in motorized vehicles, including buses and commercial vehicles. Travelers have adapted to the closures by finding new routes or avoiding the area altogether. Buses have been routed away from the White House and bus riders must walk further to President's Park and adjacent areas. Commercial and delivery vehicles have found new paths and in some cases modified their service schedules and fleet requirements.

On the whole, the closures are detrimental to daily travelers using the street system. Motor vehicle and Metrobus travel is slower, less direct, and less comprehensible to the casual traveler. Local residents, workers, and businesses bear the majority of these costs. Travel times are longer and congestion is more intense and extends over a longer period of time each day.

Fragmented Street Grid

Most downtown street grids would readily absorb such closures. An interconnected street network offers numerous paths to and from travel destinations. But downtown Washington's street system is not typical; it is highly fragmented. Only a handful of streets run continuously across downtown. The remaining streets are broken into interrupted segments. Washington's grid offers few crosstown routes and there is little system redundancy or resiliency. This amplifies the closure impacts.

The largest closure impact is on the trip times of travelers who begin and end their trip on either side of President's Park —commercial vehicles, taxis, personal vehicles, and buses. A person traveling between the eastern and western portions of downtown has seen his or her trip grow by up to 12 minutes.

The remaining travelers in the study area have a smaller but still measurable increase of about one to two minutes. Some travelers benefit by the closures. Certain street segments, such as Pennsylvania Avenue, are less traveled and offer time savings along either side of President's Park.

The new traffic patterns congest external approaches, exacerbate bottleneck locations, and reduce overall accessibility to people and places. Many travelers have re-oriented their trips into downtown. There is more travel at the periphery of downtown and in adjacent residential neighborhoods.

Transit Travelers

The closures both help and hinder transit patrons. Buses travel more slowly due to increased congestion and delays. Paradoxically, the closures benefit some crosstown bus riders. Buses have been re-routed to the north into areas with higher commercial and employment densities. The new routes are closer to more origins and destinations. Areas adjacent to President's Park have become somewhat less accessible by bus. Metrobus ridership has not been affected by the closures. The effect on the reminder of downtown transit (Metrorail and commuter bus) users has been relatively small. Overall Metrorail ridership has not measurably changed due to the closures.

The number of commuters traveling to downtown has decreased slightly according to long term monitoring by the National Capital Region Transportation Planning Board. There are fewer workers carpooling to downtown. Many carpoolers have switched to Metrorail. Metrorail ridership increases are also attributable to the completion of the Green Line and the expansion of public and private transit benefit programs.

Travel Times

Travelers adapted to the closures, but they paid a price. Based on model estimates, people in the downtown core near the White House spend an extra 6,600 hours a day in travel. An extra 4,000 hours a day are spent traveling across the 16^{th} Street screenline drawn along 16th street from M Street to Constitution Avenue. Overall travel times for trucks and automobiles rose by 4.4 percent.

By 2020 greater downtown Washington is expected to gain 85,000 new workers and 95,000 new residents. Travel demand will grow, causing longer peak travel periods and increased congestion. Planned transportation improvements (outlined in the region's long range transportation plan) will not keep pace with the growth. More bus riders and motorists will sit through multiple signal cycles to clear an intersection. Traffic queues will grow longer and delays will increase. The fragmented street grid will approach the limits of its ability to carry the demand. Normal day-to-day travel variances or temporary street closures would not be readily accommodated.

Mitigation Strategies

The White House Area Transportation Study considers a variety of alternatives and evaluates their potential to alleviate congestion and compensate for discontinuities in the downtown street grid by restoring lost mobility and accessibility.

Mitigation strategies broadly fall into two categories. The first category aims to repair and reinforce the street grid near the White House. Alternatives range from the re-opening of E Street to the construction of a tunnel connecting the E Street Expressway to the eastern portion of downtown.

The second category evaluates the potential for transit and traffic operational improvements to use the streets more efficiently. Traffic management, traffic operations, DC Circulator bus improvements, and K Street busway proposals are considered to gauge how effectively they would improve person mobility across downtown.

Transportation Impacts and Benefits

Alternative mitigation strategies are evaluated on their potential to improve mobility, accessibility, and reliability in a safe, cost-efficient manner with as little effect as possible on the built and natural environment. The study reports how person movements are affected. The time and trouble people have moving through the downtown network is tracked, evaluated, and compared. Person-based mobility and network-based reliability are the primary transportation considerations.

Safety and accessibility are also key factors. The study considers how alternatives might affect historic settings, the extent to which they are consistent with local plans and policies, and how their effectiveness compares to their cost. Alternatives must be consistent with security needs that led to the closures.

Restoring the Street Grid

Alternatives that repair and reinforce the street grid have the potential to largely mitigate the closure effects. These alternatives could reduce travel time, lower idling time at traffic signals, redirect traffic that shifted to surrounding neighborhoods in response to the closures, increase accessibility, and increase resiliency.

Alternatives Designed to Repair and Reinforce the Street Grid

- Re-open E Street
- Convert one-way streets to two-way streets
- E Street park deck
- Short E Street tunnel
- Pennsylvania Avenue tunnel
- Long E Street tunnel

The long E Street tunnel option does the best job of fully mitigating the closures. However, the associated costs of this alternative are high. It would entail large-scale disruption in an historic area during construction. Capital costs for a long tunnel range from half a billion to more than a billion dollars. In addition, tunneling or decking streets in the downtown core is not consistent with current District goals to maintain street-level activity and to prioritize efforts to convert motor vehicle trips to transit or non-motorized trips.

Unlike the long E Street tunnel, the remaining options do a relatively poor job of mitigating the street closures and their benefits are not commensurate with their costs. The status of E Street's closure is based upon security evaluations made periodically by the Department of Homeland Security. If the threat environment changes and E Street were to be re-opened, it would require widening for vehicular safety reasons and improved geometrics at its intersection with 17th Street in order to afford minor relief to downtown travelers.

Transit and Traffic Operations

The study also considers the extent to which operating the transportation system more efficiently could offset some of the closure impacts. Transit and traffic operations improvements are not a substitute for re-opening streets because they cannot restore the directness, simplicity, and flexibility of an uninterrupted grid. Their primary benefit lies in addressing the additional congestion and unreliability that has grown across the system following the street closures. They have the potential to help accommodate employment and population growth.

Alternatives Designed to Improve Transit Operations

- Expanded DC Circulator system (9 routes)
- K Street busway
- K Street busway with passing lanes
- K Street busway with passing lanes, expanded DC Circulator routes, and free fares
- K Street busway with streetcars, expanded circulator routes, and free fares
- K Street busway with streetcars, expanded DC Circulator routes, and free fares on the K Street busway

Some downtown bus riders experienced benefit following the closures because buses were re-routed into denser commercial districts north of the Pennsylvania Avenue. Other bus riders suffered from additional street congestion which caused minor additional delays following the street closures.

The expansion of the DC Circulator system (outlined later in this appendix) would benefit bus riders north and west of downtown, from the U Street area through Adams Morgan, DuPont Circle, and Foggy Bottom. Overall screenline volumes would fall slightly due to a shift in bus ridership to the north of M Street. There would be no significant changes in congestion, delays, and queuing on the rest of the street system. Expanding local surface transit is a priority for the District and meets District goals to foster sustainable transportation.

The reconfiguration of K Street with a dedicated busway is designed to facilitate faster and more reliable east-west bus service. Operational challenges within the busway (caused by bus bunching at stops and intersections) and congestion approaching the busway (due to the loss of capacity on K street and congestion on cross-street approaches) translate into slightly longer travel times for bus riders crossing the 16th Street screenline. There would be small benefits to riders north of the study area. Measureable benefits to users of the busway would not extend south toward the area of the street closures, which would remain less accessible by transit.

Construction of the K Street busway as a stand-alone action would create additional congestion on the remainder of the downtown surface transportation network. The physical footprint of the busway would reduce K Street's capacity for other vehicular traffic (fewer lanes would be allocated to delivery vehicles, taxis, private vehicles, and other motorized modes) and alter its functionality. Traffic would shift onto streets already taxed by the closures. The remaining network cannot adequately absorb the displaced traffic.

This finding is a direct reflection of the street network's lack of resiliency and adaptability following the closures. Queues, delays, and cycle failures (waiting through more than one traffic signal cycle to clear an intersection) would increase. Every hour of travel time savings accruing to bus riders throughout the day would be offset by two to fourteen hours of additional delay to other vehicular traffic (drivers and passengers) on the remaining study area street system and reflects the lack of resiliency on the remaining street system. The net overall number of person-hours of travel across all modes on the downtown transportation network would rise by up to 3,750 hours per day.

From a policy standpoint, the District accepts the tradeoff of transit improvements for more congestion. According to the District of Columbia Office of Planning, the Washington metropolitan region has the second highest rate of transit ridership in the nation (after New York). Mode shares for walk, bicycle, and transit trips have increased in the District in the past decade. The District Department of Transportation has adopted policies to accelerate this trend in its 2010 Action Agenda. This includes policies to, "prioritize expansion and enhancement of transit services" and to, "promote travel modes that are more space-efficient" than the private automobile.

Alternatives Designed to Improve Traffic Operations

- Traffic operations improvements
- Traffic management improvements

Operational improvements are designed to make existing facilities perform more efficiently by implementing relatively low cost adjustments. Examples of transit operational improvements could include relocating bus stops, changing fare collection methods, adjusting or coordinating service schedules, and implementing signal preemption systems.

Traffic operational improvements typically focus on traffic signal timing plans or bottleneck capacity enhancements. Adjustments to signal timing often provide additional green time to alleviate congestion and provided better coordination from one signal to another to minimize traffic signal delays. Relatively minor geometric improvements at bottleneck locations can also significantly improve system throughput and performance.

Traffic operations improvements could relieve some of the conditions caused by the closures by reducing travel times, queues, cycle failures, and delays across the system. The number of east-west travelers on transit would remain the same, while the number of people in other vehicles (all vehicular non-transit modes) would rise, bringing more people into the downtown core. The total number of motor vehicles traveling downtown would rise commensurately. About 60 percent of the travelers displaced by the closures would return. Overall travel speeds would rise, cycle failures would drop substantially, and there would be a marked reduction in travel under congested conditions (defined in this study as travel times that are three times longer than free flowing conditions).

Person hours of travel would improve on par with the benefit from re-opening E Street and Pennsylvania Avenue. Person hours of travel on buses represent some of that improvement, but the vast majority of benefit would accrue to the 800,000 vehicular trips in the study area during a typical weekday.

Favored Travel Paths

The operations alternative designates L and M Streets as motorized vehicle thoroughfares around downtown to the north, complemented by Virginia and Constitution Avenues to the south. Successful implementation would require the elimination of bottlenecks at various locations near Mount Vernon Square, Foggy Bottom, and at other locations around the Federal core. Such actions are generally at odds with existing local policies, which aim to provide mobility first to transit patrons, pedestrians, and bicyclists. The operations alternatives would not be effective without these spot improvements.

Management Option

A peer review group convened by the study noted that the provision of favored vehicular travel paths around downtown's commercial district would lower traffic volumes on H and I Streets and create an opportunity to improve the pedestrian focus and local flavor of the commercial core. The traffic management alternative entails maintaining the favored paths around the core while returning H Street to a two-way configuration and converting I Street to a two-way two-lane local street with wide sidewalks for pedestrians. The traffic management approach supports the favored travel paths by favoring signal progression and green times for north-south streets, while providing no incentive for motorized travel on H, I, and K Streets.

Traffic management would reduce rather than increase the number of vehicles crossing the 16th Street screenline. The reduction in east-west capacity benefits north-south travel through the heart of downtown. The number of cycle failures and travel under congestion would improve, but not to the extent of the operations alternative. The net person hours of travel benefit would remain near the level of the operations alternative.

Combination Alternatives

Alternatives Combining Transit and Traffic Operations

- K Street transitway with passing lane and traffic operations improvements
- K Street transitway and traffic management improvements

The relatively small benefits attributable to the busway (compared to the larger benefits associated with the traffic operations and the traffic management alternatives) led the study team to evaluate the extent to which a combination of strategies could offset the additional network delays imposed by the K Street busway. Traffic operations improvements used in combination with the busway with passing lane option would reduce, but not eliminate, additional delays to bus riders across the 16^{th} Street screenline. Over 80 percent of person hour travel savings generated by the traffic operations alternative would be maintained if traffic operations improvements were combined with a K Street busway with passing lanes.

Traffic operations actions restore some network resiliency and offset some of the consequences of diverting vehicular traffic away from K Street. About 40 percent of east-west travelers displaced across the 16^{th} Street screenline would be restored by the combination of traffic operations improvements and a two-lane busway with passing lanes.

The combination of the two-lane K Street busway and traffic management strategies would degrade travel conditions across the screenline. More travelers would be displaced from the screenline and the study area. Person hours of travel across the screenline would increase and the total hours of travel in transit would rise. The downtown street network is not resilient enough to accommodate the travel displacements from K Street and transform the orientation of H and I Streets to serve only local traffic.

Conclusions

The closure of Pennsylvania Avenue and E Street has measurably reduced the quality and reliability of travel on downtown streets. Additional street disruptions, restrictions, or reconfigurations could not be readily accommodated. With the anticipated population and employment growth in the core area, future travel using the existing network is expected to become more congested, unreliable, and unstable.

A busway in the median of K Street NW would slightly increase the travel times of bus riders crossing downtown in the vicinity of the White House. The busway's physical footprint would reduce K Street's capacity and shift some traffic onto adjacent streets, which could not readily absorb the additional demand. Bus travel times across the 16^{th} Street screenline would increase.

The closures left fewer crosstown travel paths on an already fragmented street grid. The introduction of premium bus service across the downtown core would be more readily accommodated by improving the resiliency and reliability of the remaining street network. The provision of crosstown oriented vehicular travel paths would provide benefits to a wide cross-section of downtown travelers, including bus patrons. While the operations options would not eliminate the physical disruptions of the street closures, they would offset many of the travel problems caused by the closures. The operations alternatives provide flexibility for implementing transit improvements in the future.

1 Project Background

The Federal Highway Administration (FHWA), in cooperation with other federal and local agencies, is evaluating a broad range of alternatives to alleviate congestion and improve traffic flow in the immediate vicinity of the White House. More specifically, the White House Area Transportation Study addresses discontinuities and deficiencies in the street network (serving pedestrians, bicycles, and vehicular traffic) that contribute to less direct and more circuitous circulation, reduced access, and increased congestion in downtown Washington.

1.1 Purpose of the Study

The 2003 Omnibus Appropriations Act (P.L. 108-7) directs FHWA, in consultation with the National Capital Planning Commission (NCPC), to study ways to alleviate congestion resulting from street closures and traffic restrictions in the vicinity of the White House as a result of the April 19, 1995, and September 11, 2001, tragedies. The purpose of this study is to provide information on the benefits, costs, and effects of alternative approaches to congestion relief.

Figure 3: White House security perimeter and street closures

1.2 Study Participants

This study follows earlier efforts that led to a temporary restoration of E Street traffic and re-opened Pennsylvania Avenue to non-vehicular traffic. FHWA has been working in cooperation with the NCPC, National Park Service (NPS), District of Columbia Department of Transportation (DDOT), District of Columbia Office of Planning (DCOP), U.S. Secret Service (USSS), Washington Metropolitan Area Transit Authority (WMATA), Metropolitan Washington Council of Governments (MWCOG) to identify potential improvements. A working group of staff from these agencies was formed and monthly meetings were held to apprise them of progress, review results, and gather input. A steering committee of executive leadership was also established. The steering committee met periodically at key points throughout the study.

1.2.1 Future Actions

Decisions on further development and implementation of any major alternative will occur after completion of this study and will be made jointly by federal and local officials. The FHWA does not anticipate taking an immediate action or deciding upon an immediate action as a result of this study.

1.3 Mitigation Alternatives and Strategies

The study examines a broad array of alternatives, ranging from short-term and low-cost transportation system management actions (such as re-timing traffic signals) to major capital improvements (such as a tunnel under

President's Park). The study focuses on actions that have the potential to compensate for the loss of surface streets, alleviate congestion in the area, and address restrictions on the movement of people and goods put in place since 1995.

This study addresses the issues at a planning level of detail. If a major capital improvement was pursued, it would need to be added to the Constrained Long-Range Plan for the metropolitan Washington area and evaluated in accordance with the requirements of the National Environmental Policy Act (NEPA) (including the preparation of an environmental assessment or environmental impact statement, if necessary). Some improvements identified through the study might not require a NEPA analysis and could be advanced for consideration by local implementing agencies.

This project was implemented in two major phases. The first phase considered mitigation strategies designed to repair or reinforce the street grid near the White House. The alternatives ranged from re-opening E Street to a long tunnel that connected the existing E Street Expressway tunnel to 12th and 14th Streets on the east side of President's Park. In addition to estimating the transportation benefits, this phase assessed how alternatives would likely affect the immediate area during and after construction. Order of magnitude capital cost estimates were also prepared for the tunnel alternatives.

The second phase of the project considered what could be done if a physical re-connection of the street grid was not pursued. This phase evaluates the potential for transit and traffic operations alternatives to alleviate deteriorated travel conditions resulting from the E Street and Pennsylvania Avenue closures. Traffic management and traffic operations alternatives are considered separately and in combination with a variety of transit management and operations improvements. Transit alternatives include DC Circulator bus improvements, K Street busway proposals, and free fare zones. The busway designs include two-lane busways, busways with passing lanes, and streetcars. A free fare zone on the K Street busway is included in two of the alternatives.

Total downtown person movements by auto, truck, bus, and Metrorail are considered. Data necessary for the direct simulation of bicycle and pedestrian modes were not available. The ability to collect the necessary data was beyond the study cost and timeframe. Non-motorized travel shares were estimated and used throughout the analysis process. Non-motorized travel estimates were used in the travel simulation but non-motorized modes were not directly simulated and model outputs were not generated.

1.3.1 The Transportation Problem

The street closures near the White House have had several detrimental effects on travel in the immediate area. The closures of Pennsylvania Avenue and E Street displaced about 72,000 persons making trips per day. Major crosstown bus lines were re-routed to H, I, and K Streets. Motorists were forced to find other routes. Local streets, which primarily served curbside business access, were recast as thoroughfares. Vehicle accessibility between downtown and points west declined. The loss in capacity and system continuity caused by the street closures has led to increases in:

- Congestion on parallel streets
- Vehicular travel times across the study area
- Turning movements to circumnavigate the closures
- Conflicts between motorized and non-motorized traffic
- Fuel consumption

Double-parked vehicles, loading/unloading during peak traffic periods, and temporary occupation of sidewalks and curbside lanes by construction projects exacerbate conditions. In all, travel is slower, less direct, more circuitous, and less comprehensible to the casual traveler. Local residents, workers, and businesses bear the majority of these costs. Consequently, a range of strategies is considered to address the conditions created by the street closings. The study identifies a variety of potential alternatives—across modes and at varying levels of investment and implementation timeframes—and answers questions about the costs and benefits arising from those alternatives.

1.3.2 Environmental Considerations

Some long-term and major improvements to the transportation system, such as a tunnel, have the potential to adversely affect the built and natural environment. Direct effects include disruption of traffic, increased noise, increased vehicle emissions, reduced visual quality, and other effects on communities, parklands, historic resources, and other land uses located in the area.

The study area is in a developed urban setting where the existing landscape has been shaped by considerable manmade intervention, so effects on the natural environment would be minimal. The study area includes numerous monuments, memorials, National Historic Register sites, and nationally significant parkland. Consequently, the study identifies alternative transportation improvements that avoid or minimize disruptions to these resources to the extent possible, determines whether any consequences appear to be unavoidable, and broadly describes what actions could be taken to mitigate any effects that are integral to an alternative.

1.3.3 Other Considerations

The sensitive nature of the area serves to shape the development and evaluation of alternatives. Special care is given to craft alternatives that can be adapted to complement the urban design goals associated with the Monumental Core. Alternatives should, to the extent possible, enhance the area's setting, complement District planning initiatives and objectives, enhance the area's business and commercial life, and meet the operational and security needs of the White House. Alternatives should also improve circulation, thereby enhancing roadway and transit operations. The needs of downtown travelers, including residents, workers, visitors, and business travelers, are of specific concern.

1.4 Evaluation Goals and Objectives

The overall goal legislated by Congress is to "alleviate congestion resulting from the street closures" and "address traffic problems in the immediate vicinity of the White House." The primary study objective is to identify methods to eliminate or minimize the negative travel effects of the street closures. Given the transportation problem, the sensitive nature of the study area, environmental concerns, and the other considerations outlined above, the study provides a broad range of information for consideration by decision makers and the public about how well each alternative achieves the overall study objective. This information is organized into several evaluation categories in order to quantify the performance of each alternative from each perspective. This section outlines the goals and objectives that each evaluation category is intended to address.

1.4.1 Mobility Measures

Mobility measures are used to quantify travel conditions and constraints that affect people's activities and choices. They document the performance of the transportation system by time of day and mode of travel. They also document the ability of people to move and circulate freely across a variety of modes. Mobility measures reflect the quantity and quality of travel undertaken by people. In this case, the quality of travel is represented as travel time or delay.

- The evaluation goal is to alleviate congestion and address traffic problems in the vicinity of the White House.
- The evaluation objective is to minimize travel delay, queues, and circuitous travel in the vicinity of the White House.

1.4.2 Accessibility Measures

Accessibility measures are used to evaluate the extent to which people can reach places to carry out social and economic activities. In general, more accessibility is considered better. Accessibility is measured as the time and cost required to reach a variety of destinations, or conversely, how many destinations could be reached in a given amount of time and cost.

- The evaluation goal is to restore the accessibility that was lost as a result of the street closures.
- The evaluation objective is to reduce the travel time for trips that were made more difficult by the street closures.

1.4.3 Reliability Measures

Reliability measures are used to quantify the stability and dependability of the transportation system. They account for day-to-day variations and periodic or episodic events. People value highway and transit travel options with predictable travel time from day to day.

- The evaluation goal is to improve the travel time reliability in the vicinity of the White House.
- The evaluation objective is to reduce the likelihood that the system will break down as a result of small changes in travel demand, traffic incidents, or street closures related to special events.

1.4.4 Safety Measures

For the most part, safety issues associated with transportation systems are related to vehicle and pedestrian incidents. Incident rates are correlated with traffic congestion, speed fluctuations, turning movements, and conflicts. Actions that minimize these characteristics have the potential to make the transportation system safer.

- The evaluation goal is to improve the safety of transportation in the vicinity of the White House.
- The evaluation objective is to minimize traffic factors that contribute to accidents, such as congestion, speed fluctuations, turning movements, and vehicle conflicts.

1.4.5 Environmental Impacts

Action and inaction can affect the built and natural environment. The study area encompasses important historic sites, parks, and cultural resources. The evaluation determines the extent to which implementation of a given strategy could be accomplished with minimal effect on the built and natural environment.

- The evaluation goal is to avoid effects on historic sites, parks, and cultural resources.
- The evaluation objective is to minimize effects if historic sites, parks, and cultural resources cannot be avoided.

1.4.6 Consistency with Plans and Policies

The alternative should be consistent with local and regional plans and federal policies and regulations. A number of federal, regional, and local agencies have jurisdiction over various components of the study area or the planning process. Appropriate actions will need to be taken by each agency for a given alternative to be considered for implementation.

- The evaluation goal is to be consistent with federal, regional, and local plans and policies.
- The evaluation objective is to determine the extent to which the mitigation strategies are compatible with the plans and policies of the affected agencies.

1.4.7 Capital/Operating Cost-Effectiveness

The capital and operating costs associated with a given alternative are weighed against the benefits derived from that alternative. If all other considerations are equal, strategies that cost less per unit of benefit are generally preferred.

- The evaluation goal is to show cost-effectiveness.
- The evaluation objective is to determine the capital and operating costs in relation to the benefits received by individuals and businesses affected by the street closures.

1.4.8 Security

Streets were closed and traffic was restricted in the vicinity of the White House for reasons of national security. Alternatives must meet the operational and security needs of the White House and President's Park. A secondary security consideration is how effectively an alternative supports emergency response and evacuation plans for downtown Washington, D.C.

- The evaluation goal is to ensure the operational and security needs of the White House and President's Park.
- The evaluation objective is to select a strategy that minimizes security risks.

1.4.9 Evaluation Differences between Phase One and Phase Two

As mentioned earlier, the project was executed in two phases. The first phase focused on options designed to physically re-connect the street grid. Numerous large scale infrastructure options were identified and evaluated. The study goals and objectives outlined above were developed at the outset of the phase-one study to be responsive to the nature of the options under consideration. The second phase evaluated the potential for transit and traffic operations alternatives to alleviate deteriorated travel conditions resulting from the closure of E Street and Pennsylvania Avenue. The focus of the second phase was on how one or more combinations of generally small scale and lower cost operational strategies could improve downtown travel conditions and mitigate the mobility and accessibility impacts of the closures. The primary measures for evaluating effectiveness revolved around overall person mobility and accessibility. Measures regarding environmental impacts, capital and operating costs, consistency with plans and policies, and security, were less relevant to phase two alternatives. This phase considered the effectiveness of each transit and traffic operations alternative in improving person throughput across the 16th Street screenline, increasing the average speed of person travel, reducing the traffic control delays people experience, reducing the number of people traveling under congested conditions, and reducing the overall amount of time people spend traveling.

1.5 Study Methodology

The Transportation Analysis and Simulation System (TRANSIMS) is a set of advanced travel modeling tools originally developed by the Los Alamos National Laboratory in a research partnership with the US Department of Transportation and the Environmental Protection Agency. It is a multimodal model that represents the movement of people through the transportation system as they go about their daily activities. The routing and network simulation tools from TRANSIMS and related dynamic assignment methodologies are key components used for this study.

Travel estimates for the study are based on the Metropolitan Washington Council of Governments (MWCOG) regional travel demand model and the Washington Metropolitan Area Transit Authority (WMATA) model. The models encompass 22 counties in three states plus the District. They contain approximately 2,200 traffic analysis zones, 8,500 nodes, 11,500 roadway links, and 1,750 transit lines, processing over 22 million daily person trips.

The WMATA model (based on the MWCOG model) focuses on transit mode choice and routing at a higher level of detail than the MWCOG model provides. Much of this additional detail relates to Metrorail station access, park-and-ride considerations, and the distribution of transit trips within downtown.

The study requires a greater level of detail for subarea and project level planning than the regional models provide. To this end, the study integrates the regional models with a detailed simulation model of traffic and transit operations in a subarea that comprises much of the District's and Arlington's high density business areas. This arrangement reflects the significance of the downtown travel network on regional transportation. It reflects the effect of other regional transportation improvements on the downtown core, and the effects of downtown travel conditions on the rest of the region.

The study network includes all of the regional roadways and transit services in the MWCOG and WMATA models, but expands the level of detail in and around downtown to include all local streets and traffic controls. Signal timing plans, lane configurations, turning restrictions by time of day, curbside parking and parking restrictions, delivery and loading zones, bus stop locations, and metrorail station entrances are incorporated into the networks. Transit routes are coded in detail, with fares and schedules specified throughout the day. Bus, commuter bus, and rail are represented, along with a streetcar mode in the transitway. Transfers are coordinated. Boarding, alighting, and dwell times at Metrorail stations and bus stops are included.

Land use underlying the network is represented in similar detail. Commercial and residential activity is coded along every block. Each block face is linked to a walk network and all trips begin and end with walking.

Travel paths are built along the full regional and detailed core network for all 22 million daily trips in the region and the 10 million daily trips within the beltway. The beltway is the boundary used to model auto travel that has the option to pass through the study area. Trips that pass through the detailed subarea are fully microsimulated. All vehicular travel (and related person travel) in the simulation area is captured on a second-by-second basis throughout the 24-hour period of a day. All other person travel is modeled at a one minute resolution.

The model utilizes a dynamic assignment approach to loading travel on the network. A network router finds paths for travelers through the network based on expected travel times. Travelers and vehicles are then microsimulated as they move through the transportation system. The microsimulator evaluates travel demand across all modes, tracking transit loading and unloading, traffic controls, vehicle interactions, and the rise and fall of congestion over the course of a full day.

Congestion and delay from the microsimulation are used iteratively as part of the routing process. For each iteration, travel times for the network router are updated, new travel paths are built to adjust for simulated congestion, and travelers consider switching paths. After about 100 iterations, travel times and paths stabilize and the vast majority of travelers cannot improve their travel time by changing paths or modes. (Travelers who can improve travel times by switching to transit, or walking instead of using a bus or car, are allowed to do so.) Travel benefits and disbenefits for each project alternative are estimated by comparing the total amount of time each person spends traveling in an alternative compared to a base case. Two base cases were considered by the study—an all-open (pre-closure) scenario and a do-nothing scenario with the street closures.

Extensive data collection, field verification, and peer reviews were employed to calibrate and validate the model. In addition to matching existing conditions, a model back-cast was performed to simulate pre-closure conditions to evaluate and confirm the model's predictive capabilities. Finally, model forecasts under a full range of network scenarios were utilized to develop the study's findings.

2 Existing Conditions

2.1 The Study Context

The White House lies at the heart of Washington. A symbol of democracy and freedom throughout the world, Lafayette Square, President's Park, and the Executive Office of the President complex extends more than half a mile from Constitution Avenue to H Street, encompassing nearly 82 acres of land.

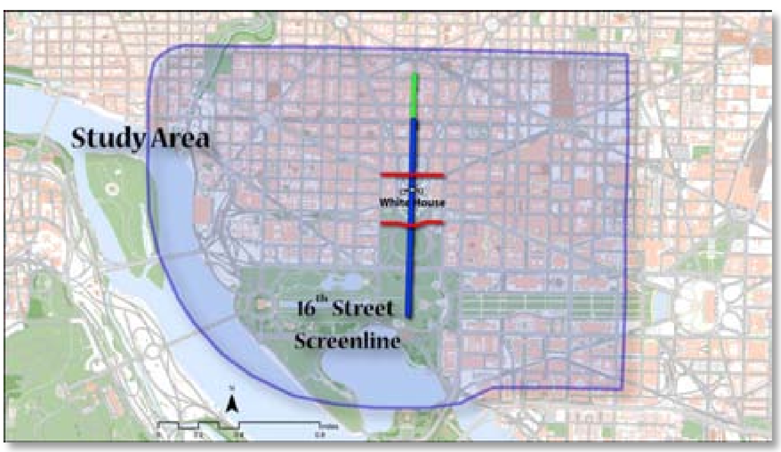
The White House serves many roles. As the home and office of the President, it is the center of the Executive branch, the venue for official presidential functions, and the residence of the first family. As a building, it stands as the ceremonial centerpiece of the nation. It is a cherished visitor destination, a place where citizens converge to exercise their right to freedom of expression, and a focal point of popular public celebration. The White House also lies at the heart of a working capital, a vibrant center of political, economic, and cultural activity.

The capital plan of Pierre L'Enfant sought to integrate the Federal Government with the local city. The ceremonial, symbolic, and functional roles of government are meant to intersect with the commercial and residential life of the metropolis. Today, downtown Washington is home to 633,000 workers and 47,000 residents and is projected to gain an additional 85,000 workers and 95,000 residents.

Washington is a dense and mature city and its transportation system reflects this stature. More than 2 million people (10 percent of total trips in the region) travel into or through the study area each workday. More than 550,000 people a day travel east-west across the area between K Street and Constitution Avenue. About 65 percent of this travel is by transit, 33 percent by automobile, and 2 percent by bicycle or on foot. Of the transit share, 89 percent use Metrorail and 11 percent use local or express bus routes.

In 1995, after the Oklahoma City bombing, and again in 2001, after the attacks of 9/11, several travel restrictions were imposed in the area, most notably the closing of streets adjacent to the White House. These closings strain the transportation system, which is operating near the limits of its capacity.

Figure 4: Study area and 16th Street screenline



2.2 What Happened

The first challenge for this study is to describe what has happened as a result of closing E Street and Pennsylvania Avenue between 15th and 17th Streets. How many people are affected and where do they go? How do these changes affect other travelers and businesses in downtown?

To help answer these questions, travel simulation models compare existing travel conditions to the conditions estimated from the hypothetical scenario that both E Street and Pennsylvania Avenue are re-opened to traffic (i.e., the All-Open scenario). This analysis tracks how each traveler in greater downtown Washington was affected by the street closures on a typical workday in 2005.

2.2.1 Mobility: Displaced Travelers

The closures of Pennsylvania Avenue and E Street displace approximately 72,000 people a day from E Street and Pennsylvania Avenue. About half of these people use the adjacent routes of Constitution Avenue and H, I, and K Streets. The other half disperse onto other streets and into neighborhoods. Approximately 100 travelers change from automobile to transit.

Figure 5: Closures displaced travelers onto adjacent street

Figure 6: Traffic increased on neighborhood streets

2.2.2 Mobility: Increased Travel Time

The overall average travel time increase for daily travelers affected by the closures was about 1 minute. When multiplied by the 200,000 vehicles that travel across downtown near the White House during a typical weekday, this small effect adds up to 3,300 hours of additional delay each day.

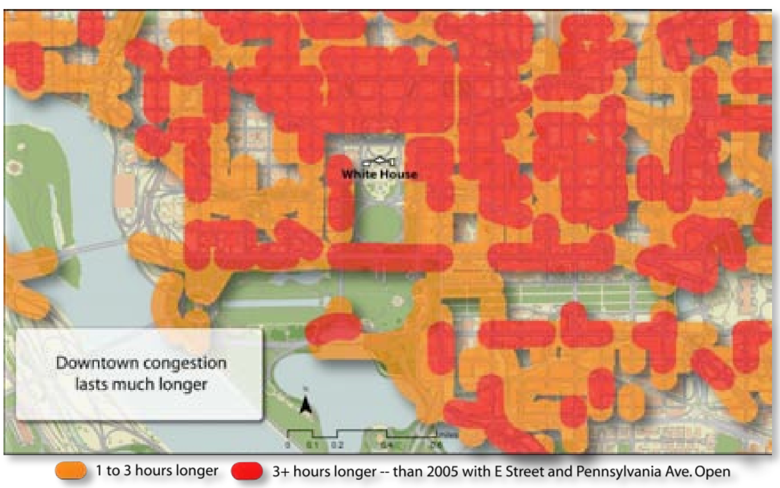
The effects are not uniform. The closures inconvenience some travelers with additional travel times of up to 12 minutes. Other travelers benefit from the displaced travel and some travel times decreased by up to 5 minutes. The winners and losers average out to a small effect. In other words, the large effects on some travelers are lost among the majority of trips with small effects. The travelers most affected are those making crosstown trips between the east and west sides of downtown. There are far more losers than winners.

Figure 7: Travel times increased for crosstown travelers

2.2.3 Mobility: Increased Congestion

The analysis also shows that traffic congestion is more severe and lasts longer. More streets in downtown have higher occupancy levels during the peak periods. Almost every street experiences congested conditions for additional hours of the day. Increases in congestion duration of 3 to 4 hours are typical. Most of these increases are during the middle of the day.

Figure 8: The hours of congestion increased



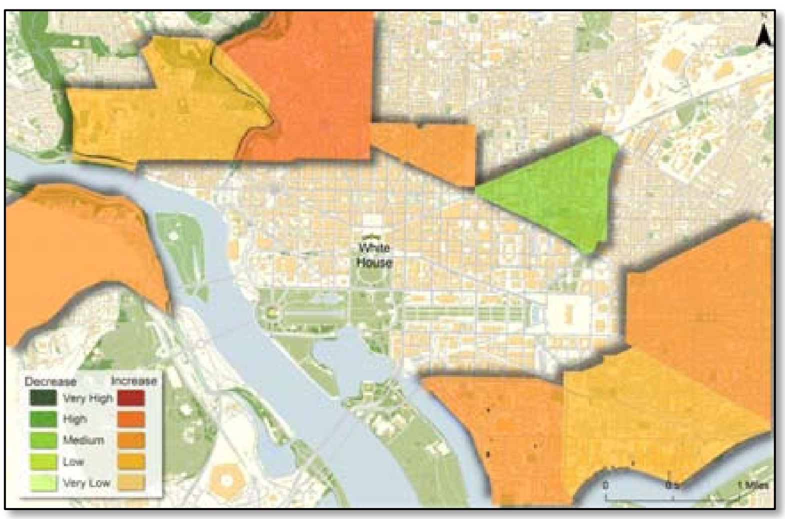
Travelers must also wait longer at traffic signals. As the following graphic demonstrates, some intersections experienced fewer cycle failures, but most intersections have more cycle failures. A cycle failure means the vehicle is unable to move through the intersection when the signal turns green and therefore needs to wait for the next green.

Figure 9: Number of cycle failures increased

2.2.4 Mobility: Increased Neighborhood Traffic

Many of the vehicles displaced from E Street and Pennsylvania Avenue use nearby streets, which in turn makes the nearby streets more congested and less attractive to the vehicles that originally used these facilities. The ripple effect disperses the traffic further into the surrounding neighborhoods. The affected areas include much of D.C. and parts of Arlington, VA. There are approximately 5 percent fewer vehicle miles of travel (VMT) in the White House study area as a result of these phenomena. Conversely, there is a proportionate gain in VMT on neighborhood streets.

Figure 10: Neighborhood traffic increased



2.2.5 Accessibility: Disconnected Street Grid

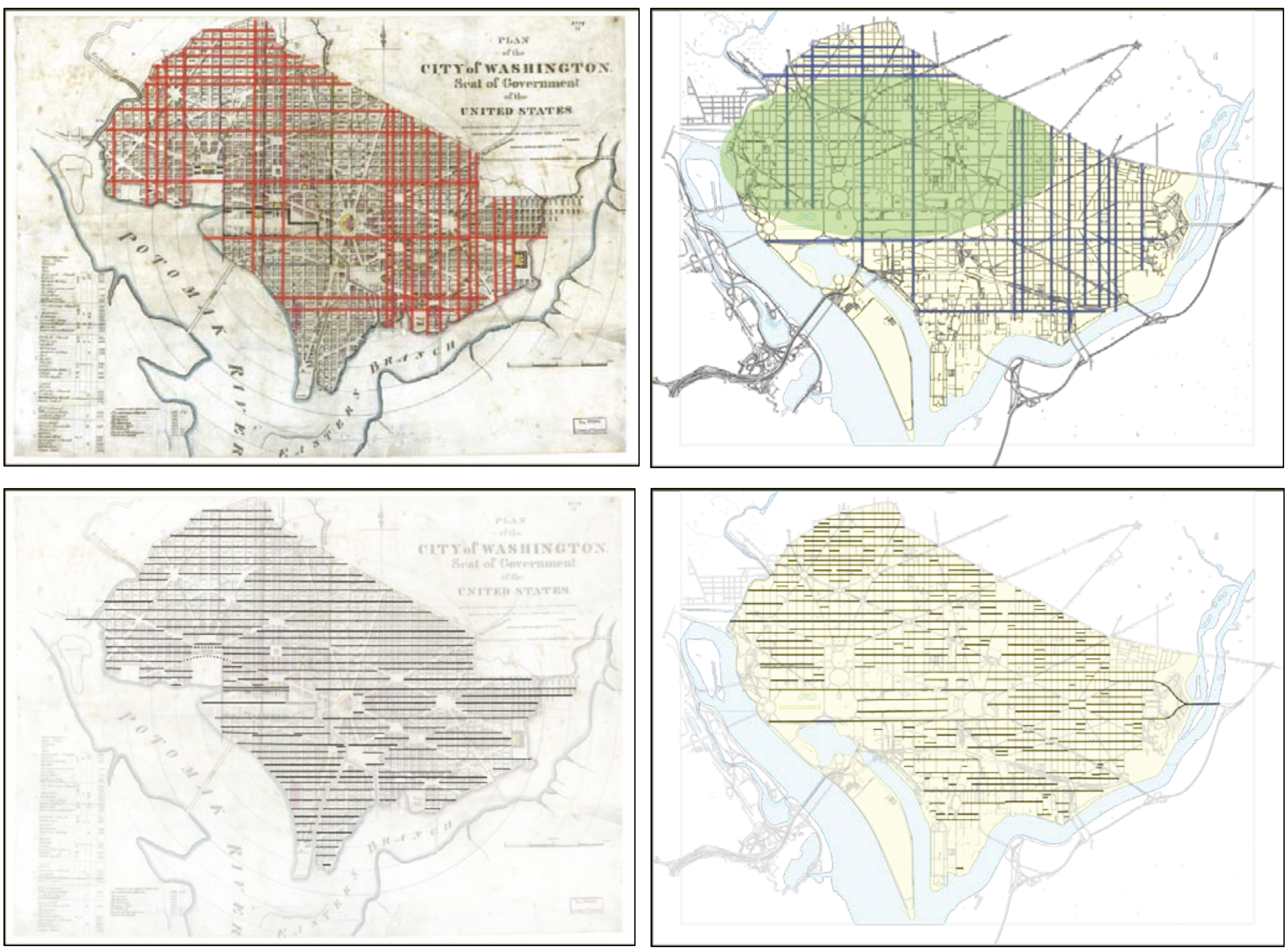
Downtown Washington's street system is based on a 1791 design by Major Pierre Charles L'Enfant. The most striking feature of L'Enfant's plan is his use of diagonal avenues radiating across the city. These symbolic avenues were designed to provide a direct line of travel between the city's most important places. L'Enfant deftly integrated the city's government, commercial, and residential neighborhoods by underlaying the symbolic avenues with a network of commercial and residential streets.

The grid contained many streets running uninterrupted across the length and breadth of downtown, highlighted in Figure 11. These provided a mobility function unavailable along the avenues, which were interspersed with public squares meant to be filled with public buildings, monuments, fountains, and people. The regular spacing of the uninterrupted streets suggests an attention to the importance of movement and mobility across the new city. The remaining streets were relatively continuous, but interruptions at the grand avenues and public squares were not uncommon. The bottom half of Figure 11 provides a schematic overlay of the east-west streets.

Many of the streets designed to serve through movements have been severed over the years. The street grid is fragmented and fragile. The figure below shows the extent of east-west street discontinuities.

The travel inconveniences precipitated by the closures are partially attributable to the nature of the city's downtown streets. Numerous discontinuities have been introduced into the street grid since the L'Enfant plan was adopted at the turn of the nineteenth century. The fragmented street system has lost some of the redundancy needed to make it strong. Each time a street is closed, the remaining streets carry higher loads, are subject to greater stresses, and are more prone to periodic failure.

Figure 11: L'Enfant planned streets and current street system



2.2.6 Accessibility: Reduced Accessibility

The travel time increases and the discontinuous street grid results in decreased accessibility to people and places. This means that fewer household and employment sites can be reached in a given amount of travel time. As the following graphic demonstrates, this result is not uniform. Certain interchanges are less accessible while others are more accessible. The physical barrier created by the closures makes it more difficult to travel across downtown. If, however, the origin and destination are on the same side of downtown, the trip time may be reduced. Because fewer vehicles are able to make east-west movements, there are fewer delays on the east or west side of downtown.

Figure 12: Overall accessibility reduced

2.2.7 Accessibility: Less Intuitive Travel Paths

The discontinuous street grid also makes travel less intuitive for occasional users and visitors. Planning a path through downtown is difficult. Tourists and out-of-town visitors find the street system confusing to navigate.

2.2.8 Reliability: Reduced Resiliency

The fragmented and fragile street grid also makes the system less resilient. Roadways are more susceptible to normal traffic variations and incidents. It also creates problems for the multitude of special events that take place in the nation's capital. When streets are closed for a World Bank meeting or a parade, for example, there are relatively few alternate routes to absorb the traffic. The system breaks down and cascading queues form at bottleneck locations.

2.3 Summary of Findings

The effects of closing E Street and Pennsylvania Avenue are relatively small in the context of total travel in downtown Washington, but they are measurable. Businesses, residents, and travelers have adapted, but they all pay a price. The reduction of travel near the White House is particularly viewed unfavorably by downtown businesses.

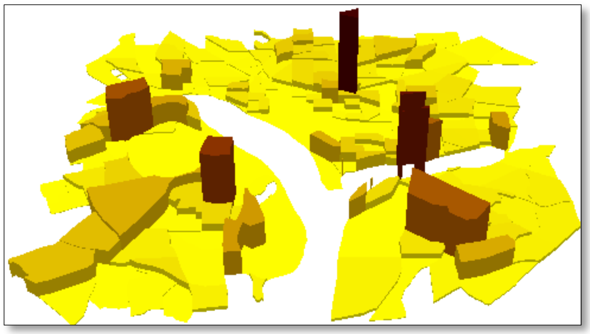
The street closures are detrimental to most travelers in downtown. Fewer people are traveling downtown, yet travel times are longer and congestion is more intense and lasts more hours of the day. Some crosstown trips are much longer while a few travelers have less travel time. Congestion and the discontinuity of the street grid provide fewer opportunities to travel through downtown. Many travelers have re-oriented their trips to the core, causing more congestion on already strained facilities, exacerbating bottleneck locations, and reducing overall accessibility to people and places. More of this travel has been pushed to the peripheries of downtown and into residential neighborhoods.

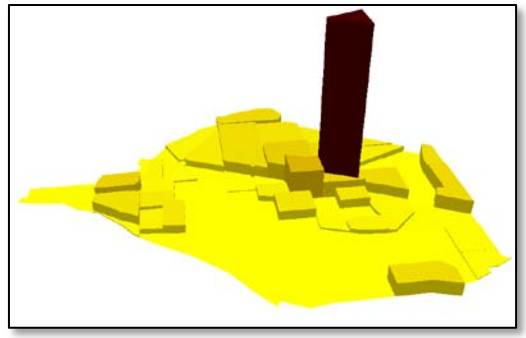
From the perspective of transit, there is no change to Metrorail ridership and only a small change in total transit usage (100 riders per day). Bus travel times are not measurably affected even though buses are experiencing more congested conditions. Buses were already traveling at low speeds with frequent stops, which made the effect less noticeable. The bus routes relocated as a result of the closures are shifted into areas of higher commercial and employment density, benefiting riders by getting them closer to their origins and destinations. As a result, the closures resulted in a net overall benefit to bus riders. Areas adjacent to President's Park, however, are less accessible to bus transit.

3 Conditions in the Year 2020

The population in the Washington region is projected to increase by 1.25 million by the year 2020 with downtown expected to increase by 95,000 residents or 16.5 percent. The figures below show the relative degree of growth. The figure on the left shows growth in the region's inner core. The figure to the right focuses in on growth in the project study area. Higher and darker columns represent higher residential growth, which is generally concentrated at the periphery of downtown Washington.

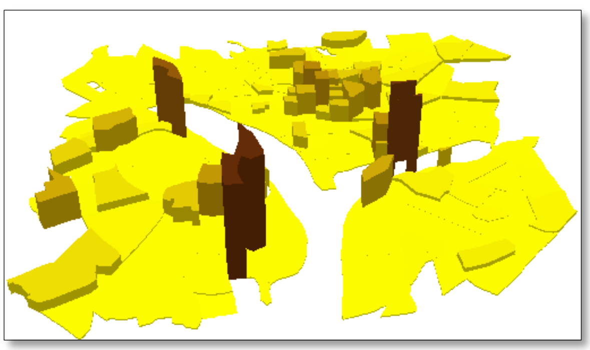
Figure 13: Population growth between 2005 and 2020

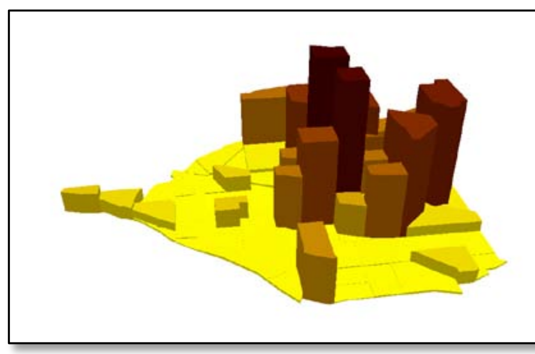




Regional employment is projected to increase by almost a million jobs by the year 2020 with downtown expected to increase by 85,000 jobs or 11.4 percent. High employment growth is projected at the periphery and within downtown.

Figure 14: Employment growth between 2005 and 2020



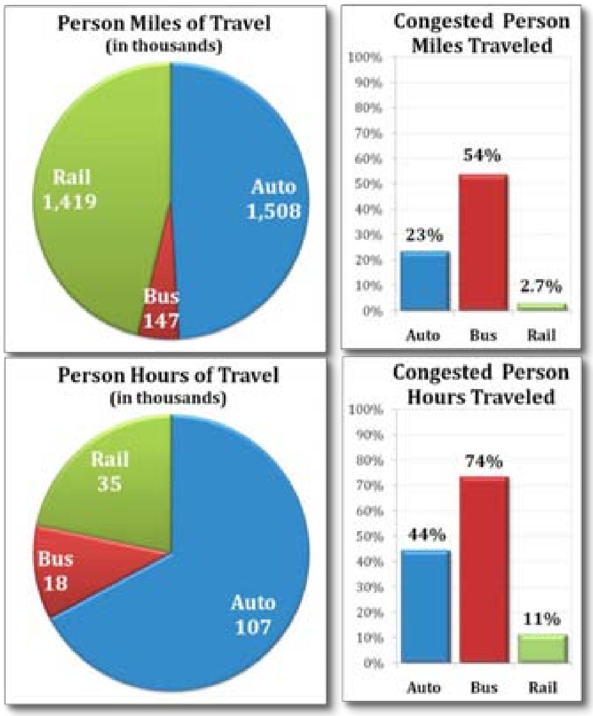


The increase in population and employment in the region will result in a substantial increase in demand for existing roads and transit facilities. Travel conditions downtown and around the White House are expected to deteriorate further.

3.1 What Will Happen If We Do Nothing?

As depicted in the following charts, the person-miles of travel in the White House study area in the year 2020 under the do-nothing scenario are equally divided between auto and transit modes. The vast majority of the transit trips are made by Metrorail. The person-hours of travel are, of course, distributed considerably differently. Approximately 60 percent of the person-hours of travel are in automobiles and less than 20 percent of the person-hours are by Metrorail. In other words, the average Metrorail speed is about twice the average auto speed, which is more than twice the average bus speed.

Figure 15: Study area person travel by mode in 2020



The bar charts to the right of each distribution depict the percentage of travel in each mode that is made in congested conditions. In this case, congested condition means that the travel time is more than three times the free flow travel time. About a quarter of the person-miles made in automobiles are in congested conditions, half of the person-miles made by bus are congested, and 3 percent of the person-miles made on Metrorail are significantly delayed. On the other hand, about 44 percent of the person-hours made in automobiles are under congested conditions, 74 percent of the person-hours in buses are congested, and 11 percent of the person-hours made by Metrorail are congested. Metrorail conditions in context are somewhat idealized, as train outages are not modeled.

More than two-thirds of travelers across the 16th Street screenline are carried by transit. Metrorail carries the vast majority of transit riders (334,000 by Metrorail and 41,000 by bus).

Figure 16: Study area and 16th Street screenline

3.1.1 Auto and Truck Performance Measures

The change in key performance measures between 2005 and 2020 are listed in the following table. The overall person miles of travel by autos and trucks increases by 44,000 miles per day or 3.0 percent. The person hours of travel increases by 7.3 percent due to an 11.8 percent increase in person hours of delay. This results in a 4.0 percent drop in average travel speed. The 35.4 percent increase in cycle failures points to increased congestion as the roadway system approaches capacity.

Table 1: Change in auto/truck travel between 2005 and 2020

Study Area -- All Day	Persons in Autos and Trucks		
	2005	2020	Change
Person Miles of Travel	1,463,000	1,507,000	3.0%
Person Hours of Travel	99,500	106,500	7.3%
Person Hours of Delay	55,500	62,000	11.8%
Number of Cycle Failures	75,000	101,500	35.4%
Average Miles Per Hour	14.7	14.1	-4.0%
Percent PMT Congested	21.8	23.2	6.1%
Percent PHT Congested	41.3	44.3	7.3%
Percent Time Congested	23.9	27.5	14.7%

The table also highlights the amount of travel that is made under congested conditions. Congested travel in this case is defined as travel times that are three times the free flow travel time. The congested person miles of travel increases by 6.1 percent and the congested person hours of travel increases by 7.3 percent.

Percent of time congested represents the portion of a 24 hour day that experiences congested conditions. It can be thought of as the duration of congestion. In this case the hours of congestion increases by 14.7 percent or an average of 51 minutes for each roadway segment in the study area.

3.1.2 Bus Performance Measures

The change in performance measures between 2005 and 2020 for bus passengers are summarized below. The overall person miles of travel in buses does not change significantly, but the number of person hours and hours of delay increase substantially. The person hours of travel increases by 8.7 percent and the person hours of delay increases by 13.0 percent resulting in a decrease in average travel speeds of 7.5 percent.

Since transit travel is much more peak period oriented than general auto travel, it is not surprising that the percentage of bus passengers that travel in congested conditions is significantly higher than auto and truck travelers. What is somewhat surprising is that the percent change in congested travel between 2005 and 2020 for bus travelers is much higher than auto and truck travelers. In other words, the rate of increase in congestion for bus travelers is higher than auto travelers.

Table 2: Change in bus travel between 2005 and 2020

Study Area -- All Day	Persons in Buses		
	2005	2020	Change
Person Miles of Travel	146,000	147,000	0.5%
Person Hours of Travel	16,000	17,500	8.7%
Person Hours of Delay	11,000	12,500	13.0%
Number of Cycle Failures	12,500	14,000	10.7%
Average Miles Per Hour	9.1	8.4	-7.5%
Percent PMT Congested	45.4	53.6	18.1%
Percent PHT Congested	66.4	73.6	10.8%
Percent Time Congested	39.6	45.5	14.8%

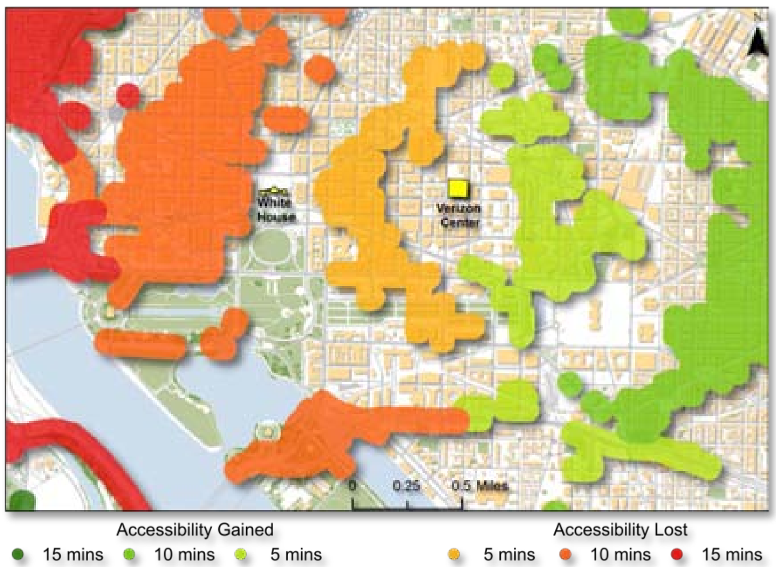
3.2 Summary of Findings

The growth in population and employment expected in downtown by the year 2020 will generate additional demand for transportation services. The simulation of this future condition leads to the following findings.

3.2.1 Mobility: Increased Travel Time

In 2020, travel times are expected to increase by 4.0 percent for autos and trucks and 7.5 percent for bus passengers. This means that fewer people and places can be reached in a given amount of travel time. The following graphic shows the change in areas that can be reached in 5, 10, and 15 minutes from the Verizon Center at 5 p.m. using an automobile.

Figure 17: Change in accessibility from the Verizon Center



3.2.2 Mobility: Increased Congestion

Congested hours of travel are expected to increase by 7.3 percent for autos and 10.8 percent for bus passengers. The duration of congestion and the frequency of cycle failures are expected to increase for auto travelers (14.7 percent and 35.4 percent, respectively).

3.2.3 Mobility: Metrorail Capacity Constraints

The 2020 Metrorail plan includes the Silver line to Dulles International Airport and the associated routing changes to the Blue and Orange lines to maximize throughput in the Rosslyn to Foggy Bottom tunnel. Even with minimum headways and eight car trains, the Metrorail system has capacity constraints in the year 2020 that will limit its ability to absorb additional transit trips destined for downtown Washington. This means that Metrorail riders will be forced to travel under full train loads for longer portions of the day and that many travelers will find they are unable to board one or more trains, causing additional platform overcrowding and safety concerns.

3.2.4 Reliability: Reduced Resiliency

The committed long-range plan network is able to absorb most of the 2020 demand without excessive congestion. The network is, however, highly sensitive to relatively small increases in demand or capacity reductions. This means that the 2020 do-nothing system is near capacity and highly susceptible to surges in demand, traffic accidents, and street closures for special events.

4 Alternatives Designed to Repair and Reinforce the Street Grid

The closures of E Street and Pennsylvania Avenue to vehicular traffic create a significant barrier to east-west travel through downtown. This led the study team to consider ways to mitigate the effects through strategies designed to repair or reinforce the street grid in the vicinity of the White House. These alternatives range from re-opening E Street to a long tunnel that connects the existing E Street tunnel to 12th and 14th Streets on the east side of President's Park.

4.1 Mitigation Alternatives and Strategies

Six alternatives are evaluated and compared to the existing conditions (i.e., Do Nothing) and the hypothetical scenario where E Street and Pennsylvania Avenue are re-opened by the year 2020. The "all open" scenario serves as the benchmark for evaluating how much of the consequences of the street closures is mitigated by each alternative.

4.1.1 Re-Open E Street

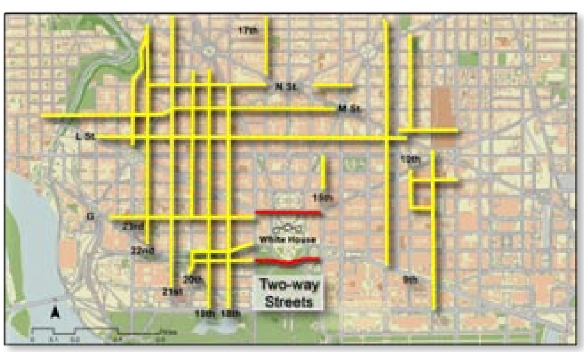
Federal and local agencies took steps to formally close Pennsylvania Avenue to vehicular traffic in the late 1990s. This alternative evaluates the potential scenario that E Street is eventually re-opened with two lanes in each direction between 15th and 17th Streets. For this scenario to become a reality, security and threat levels would need to significantly improve. The United States Secret Service issued a Federal Register notice for the permanent closure of E Street in the spring of 2011, following the conclusion of this study.

Figure 18: Re-Open E Street alternative

4.1.2 Two-Way Streets

The two-way streets alternative proposed by DDOT converts many of the one-way streets in downtown into two-way streets to emphasize local circulation and create more of a neighborhood feel and functionality.

Figure 19: Two-Way Street alternative



4.1.3 E Street Park Deck

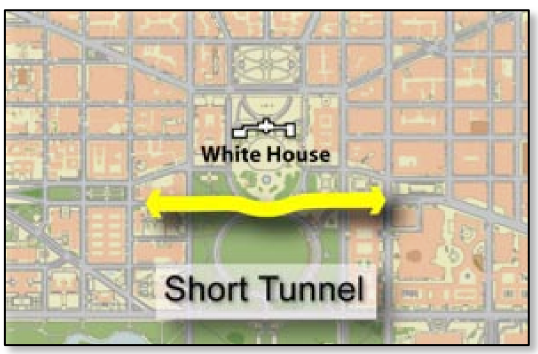
DDOT also proposed a park deck concept on E Street in President's Park. This alternative includes a shallow cut with a security cover near the White House and at-grade signalized intersections at 15th and 17th Streets. It would have one general-purpose lane in each direction and a center-reversible bus lane.

Figure 20: E Street Park Deck alternative

4.1.4 Short E Street Tunnel

The fourth alternative is a short two-lane tunnel under E Street with portals on E Street between 17th and 18th Streets and 14th and 15th Streets. The portals would provide two travel lanes exiting the tunnel for merging the traffic with the surface street.

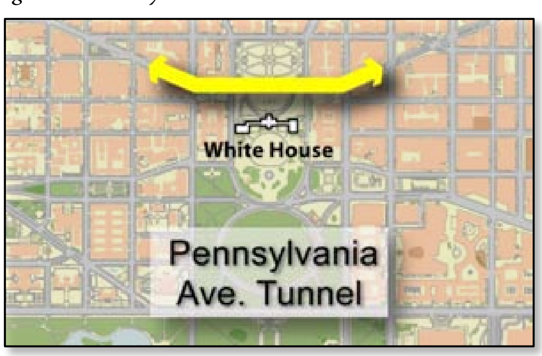
Figure 21: Short E Street Tunnel alternative



4.1.5 Pennsylvania Avenue Tunnel

Another alternative evaluated the effects of a two-lane tunnel under Pennsylvania Avenue with portals on New York Avenue between 14th and 15th Streets and Pennsylvania Avenue between 17th and 18th Streets.

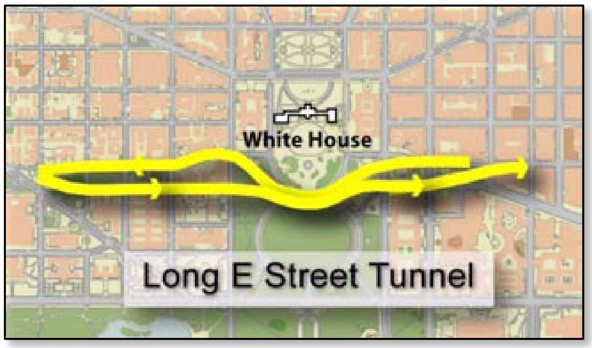
Figure 22: Pennsylvania Avenue Tunnel alternative



4.1.6 Long E Street Tunnel

The final alternative is called the long E Street tunnel. This option includes separate two-lane tunnels for each direction of travel. Each tunnel would connect with the existing E Street tunnel at 21st Street and continue under President's Park to 12th Street. Intermediate portals are included between 18th and 19th Streets and 14th and 15th Streets. An additional variation to this alternative moves the eastern terminus to 15th Street. This alternative would provide direct linkages to other facilities on the regional roadway transportation network.

Figure 23: Long E Street Tunnel alternative



4.2 Transportation Findings—How Well Do the Alternatives Perform?

4.2.1 Mobility: Relieve Adjacent Streets

The following graphics demonstrate how the alternatives change the distribution of traffic volumes in downtown. The relative effectiveness of each alternative is shown in Figure 20. The green bands show where the alternative has less volume than the do-nothing condition and the red bands show where traffic volumes increase. The E Street/tunnel-related alternatives shift considerable traffic away from Constitution Avenue and back onto E Street. The long E Street tunnel attracts more than twice as much traffic as the park deck or the re-opened E Street alternatives. This alternative also provides relief to streets as far north as M Street.

The two-way streets alternative shows a very different result. Obviously streets that were originally one-way now show traffic in both directions. The more important observation, however, is that the total volume of traffic in downtown is significantly less. This is largely due to increased congestion levels and reduced capacity. The network simply cannot accommodate as much traffic as the do-nothing alternative. This reduces the overall demand for travel to downtown and pushes trips further out into the neighborhoods.

An alternative's effectiveness at repairing and reinforcing the street grid is measured in large part by the extent to which it increases person throughput while at the same time reducing congestion and overall person hours of travel. The long E Street tunnel substantially compensates for the loss of E Street and Pennsylvania Avenue. Except for the two-way streets alternative, all other strategies relieve no more than about half the closure effects. The two-way streets alternative decreases person throughput and increases person hours of travel throughout the study area. The closure of Pennsylvania Avenue and E Street magnifies the impacts.

Figure 24: Changes in daily traffic volumes by alternative

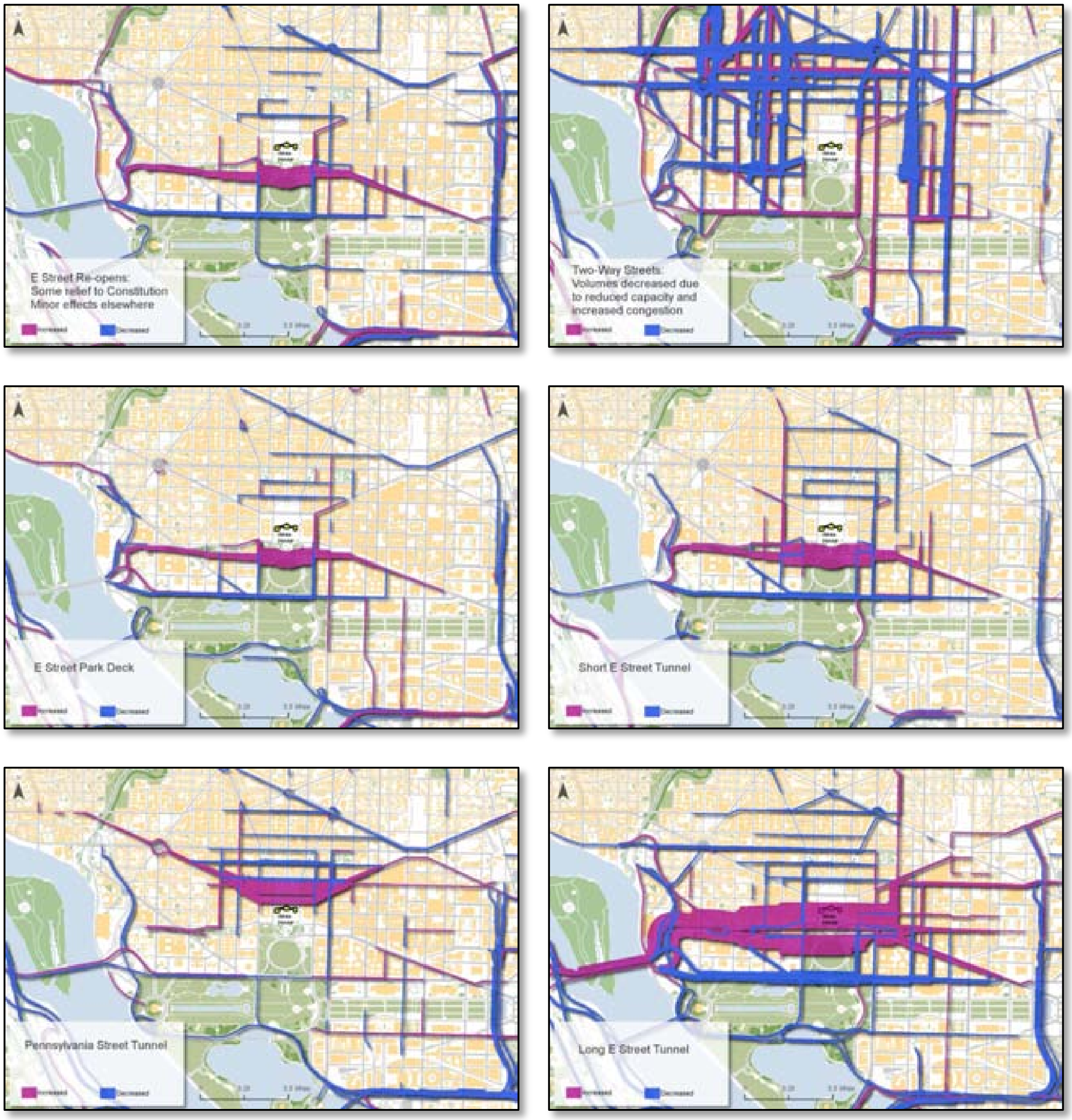
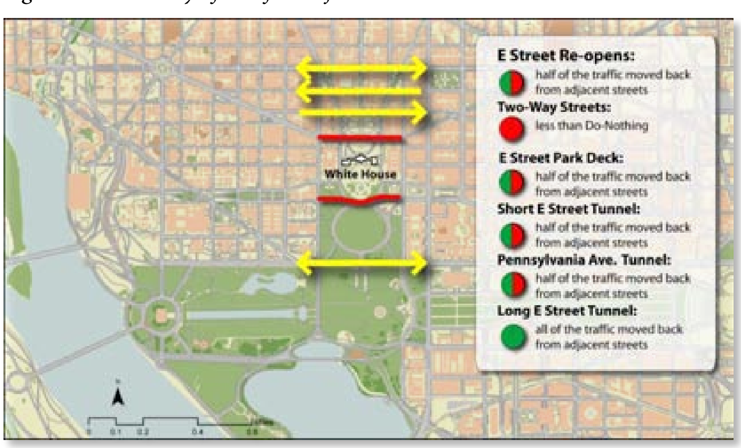


Figure 25: Summary of relief to adjacent streets



4.2.2 Mobility: Reduce Travel Time

The following table shows the effect of each alternative on cumulative travel times in the downtown area. The all-open scenario has 2,000 fewer hours of travel time each day than the do-nothing alternative. With the exception of the two-way streets alternative, all alternatives are able to recover at least 75 percent of the time lost due to the closures. The long E Street tunnel saves 5,900 hours per day, which is almost three times the loss resulting from the closures.

Table 3: Daily travel time savings by alternative

2020 Alternatives vs. Do-Nothing Alternative	Time Savings (hours/day)
All-Open Scenario	2,000
Re-Open E Street	1,800
E Street Park Deck	1,500
Short E Street Tunnel	1,590
Long E Street Tunnel	5,900
Pennsylvania Ave. Tunnel	1,730
Two-Way Streets	(1,730)

4.2.3 Mobility: Reduce Congestion

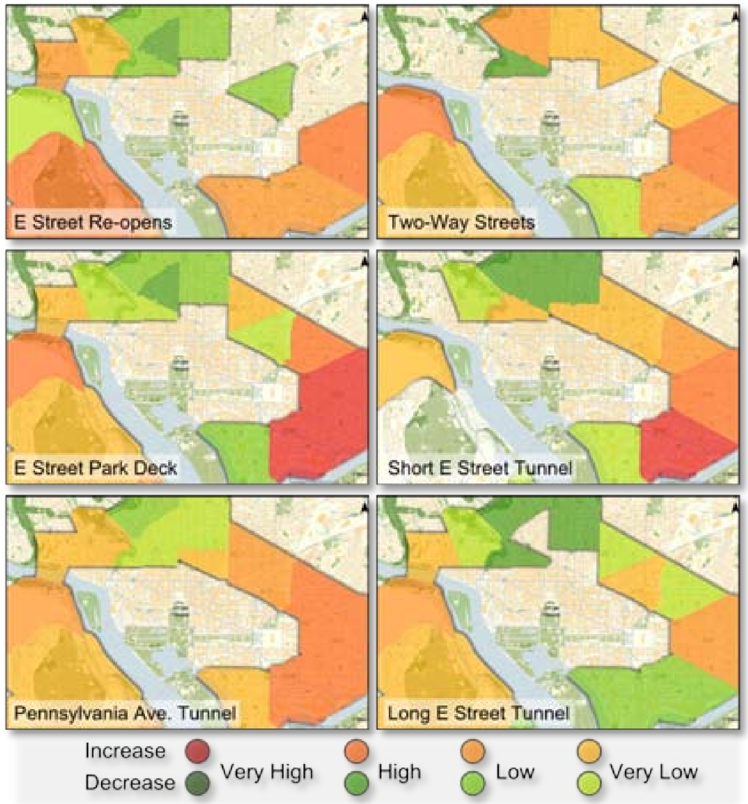
With the exception of the two-way streets alternative, the number of cycle failures is reduced by all of the proposed improvements. Most of the reductions are south of E Street. All of the alternatives also show some improvements along K Street. The long E Street tunnel reduces cycle failures as far north as M Street. In all cases, cycle failures and congestion increase in the immediate vicinity of the alternative portals.

Figure 26: Change in daily cycle failures by alternative

4.2.4 Mobility: Reduce Neighborhood Traffic

The alternatives reduce traffic in some neighborhoods and increase traffic in other neighborhoods. Most of the reductions are in the neighborhoods directly north of the White House. The increases tend to be in the Capitol Hill area. The long E Street tunnel alternative does the most to reduce neighborhood traffic without increasing traffic in other neighborhoods.

Figure 27: Neighborhood traffic changes by alternative



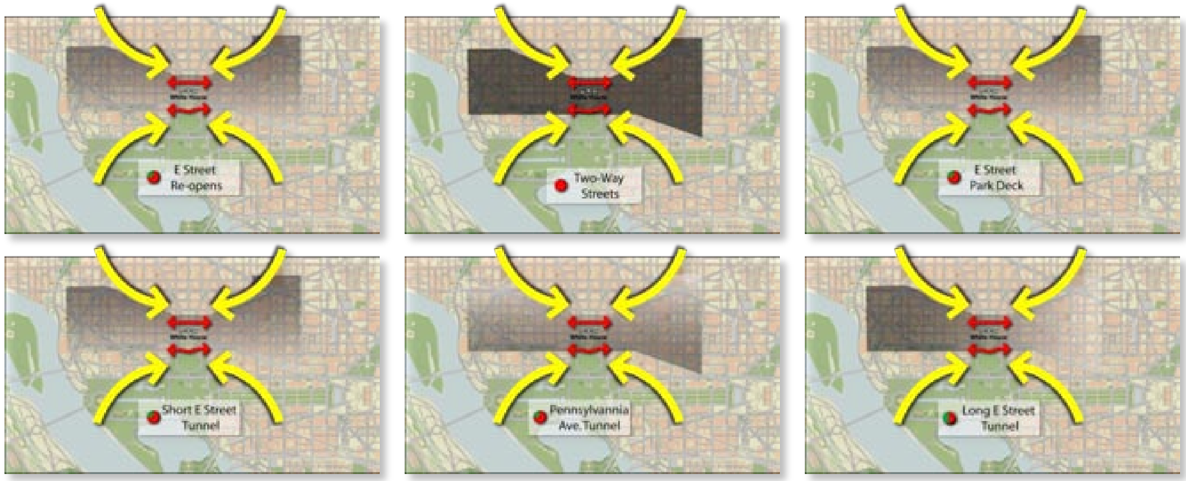
4.2.5 Mobility: Benefit Transit and Pedestrian Travel

With the exception of the reversible bus lane included in the E Street park deck alternative, none of these alternatives provide direct benefits to transit and pedestrian travel. They do, however, provide indirect benefits by reducing automobile traffic on Constitution Avenue and H, I, and K Streets. In addition, the long E Street tunnel eliminates a significant number of street-level vehicle-pedestrian conflicts between 15th and 20th Streets, but increases the number of conflicts with north-south movements at 12th and 14th Streets. Slower vehicular speeds associated with the two-way streets alternative have the potential to reduce the severity of pedestrian-vehicular accidents.

4.2.6 Accessibility: Reconnect Street Grid

Most of the alternatives reconnect the east and west sides of downtown in the vicinity of the White House. One way to measure the relative effectiveness of this reconnection is to compare the change in vehicle miles or vehicle hours of travel on the east-west streets on both sides of the White House security perimeter. Most of the alternatives increase travel hours across downtown near the White House. The two-way streets alternative creates the most hours of travel in this area. The increased hours are the result of excessive congestion rather than increased throughput. This alternative accommodates fewer trips with much longer travel times. It does, however, provide more direct access to neighborhoods and businesses in areas north and west of the White House.

Figure 28: Change in hours of travel near the closed streets; shading darkens as hours of travel increases



4.2.7 Accessibility: Increase Accessibility

Accessibility is measured by the number of people who can reach a destination within a given time budget. Accessibility to the study area within a 15 minute travel time budget was evaluated. With the exception of the two-way streets, each alternative provides additional access to people and places in downtown. The following graphics show the additional areas that can be reached within 15 minutes from the Verizon Center to the west side of downtown or from F Street and 20th Street to the east side of downtown at 5 p.m. The directness of travel within downtown is improved under the two-way streets alternative but the amount of time required to travel exceeds the potential time savings of more direct connections.

Figure 29: Typical accessibility change for a 15-minute trip

4.2.8 Accessibility: More Intuitive Travel Paths

Each of the alternatives restores connections between major streets and provides more intuitive travel paths. The two-way streets alternative also removes the complexity of navigating a network of one-way streets within downtown and provides more direct paths to a wide variety of origins and destinations.

The following graphics, however, show there is significant difference between the alternatives from the perspective of regional connectivity. The dark blue areas on the map highlight the limited access facilities that provide regional access to downtown. The graphic on top shows that the E Street park deck, the short E Street tunnel, and the Pennsylvania Avenue tunnel alternatives do not connect to the regional facilities while the long E Street tunnel shown in the bottom graphic provides a direct extension of the regional network into the heart of downtown.

Figure 30: Connections to regional facilities

4.2.9 Reliability: Improve Resilience

The resilience of the downtown transportation system reflects its ability to operate when a facility is temporarily unavailable (e.g., during a street or rail station closure) or when travel demand is unusually high (e.g., travel associated with cultural and sporting events). Most of the alternatives provide additional connectivity for east-west travel. Most alternatives also provide at least two lanes of additional roadway capacity. The long E Street tunnel provides four lanes of additional capacity and seven additional access points to regional facilities.

The 2020 traffic simulations suggest that the street grid in downtown Washington will operate very close to capacity. Small increases in demand or relatively minor reductions in roadway capacity can result in cascading queues that cause system gridlock. The alternatives that add capacity make it possible for the system to absorb additional growth in demand. The two-way streets alternative, on the other hand, is capacity constrained and therefore limits the overall demand the system can accommodate.

4.3 Non-Transportation Considerations

An analysis of the how the proposed alternatives affect the study area was conducted. Because this study is an initial assessment of alternative feasibility, a comprehensive environmental analysis was not included in the scope of work. This project focused on a preliminary assessment of how the alternatives could affect the built environment and its cultural and historic resources. Safety, security, and order of magnitude capital and operating costs were also considered.

4.3.1 Safety: Improve Safety

The safety performance measure focuses on traffic and pedestrian accidents and emergency evacuation considerations. Safety is improved by reducing vehicle-pedestrian conflicts, reducing vehicle turning movements, reducing congested travel conditions, and providing additional travel path options. Most of the alternatives reduce traffic congestion and provide additional travel paths. The tunnel alternatives also separate automobiles from pedestrians at a number of critical locations throughout the city. These include the Metrorail stations on I Street and the tourist areas around President's Park and the National Mall. Longer tunnels are more effective at separating automobiles from pedestrians in these areas than shorter tunnels. In addition, the areas around the tunnel portals have increased safety concerns that need to be carefully mitigated. The long tunnel has more portal locations than the other tunnels, but the traffic volume entering or exiting the portals is often less intense due to its ability to disperse traffic more evenly.

Reduced vehicular speeds under the two-way streets alternative have the potential to reduce the severity of crashes. On the other hand, the number of vehicular conflicts and potential interactions would rise due to the introduction of two-way traffic.

4.3.2 Environmental Impacts: Minimize Environmental Consequences

The environmental consequences for most of the alternatives can be distinguished between temporary effects during construction and lasting effects after construction is complete. The E Street tunnels have significant construction consequences within President's Park including the removal of several mature trees and the temporary relocation of the Butt-Millet monument and the Zero Mile marker. The long E Street tunnel also requires the temporary relocation of the First Division Monument and Sherman Square. After construction the E Street park deck alternative removes park land from President's Park and obstructs views of the Ellipse and the White House lawn from along most of E Street.

Because the tunnels need to be constructed by digging down through the city streets, there is significant disruption of traffic and building access. Underground utilities, storm sewers, and high-security conduits complicate construction and add to the effects and costs. In addition, the short E Street tunnel permanently affects the American Red Cross complex and access to the Corcoran Gallery. The long E Street tunnel also affects Edward J. Kelly Park, Walt Whitman Park, General Rawlins Park, Pershing Park, and Freedom Plaza. Construction of the Pennsylvania Avenue tunnel also affects the front entrance to the White House and has construction challenges as it crosses over the Metrorail Red line tunnel.

In response to concerns about the effects of the tunnel portals on streetscape aesthetics and pedestrian movements, graphical depictions of the portal locations were developed to visualize the results. Images from these depictions follow. They help to demonstrate what the tunnels would look like from various perspectives and vantage points.

Figure 31: Visual effects of tunnel portals

4.3.3 Consistency with Plans and Policies: Consistent with Plans and Policies

Plans and policies within the region often differ from year to year and agency to agency. One primary criterion, however, is consistency with the L'Enfant plan for Washington, D.C. From this perspective, the proposed alternatives fit within the L'Enfant plan for downtown. This was observed in the Comprehensive Design Plan and Final Environmental Impact Statement for the White House and President's Park (National Park Service, 1999) which concluded that, "Tunneling E Street would support the objectives of many (local) plans and enhance the historic landscape, other cultural resources, and the pedestrian experience."

The cooperating agencies are focusing improvements to the downtown transportation system to enhance transit and non-motorized mobility and accessibility. A transit first policy has been the mainstay of District of Columbia plans and programs for many years. A written policy regarding the operation of the traffic signal system is being developed by the District of Columbia.

4.3.4 Construction, Operation, and Maintenance Costs

Order of magnitude capital cost estimates were prepared for each of the tunnel alternatives based on 13 general cost categories:

- Roadway
- Utility Relocation
- Restoration
- Tunnel Hardening
- Relocate and Replace Monuments
- Contingencies
- White House Security Premium
- Maintenance of Traffic
- Tunnel Structure
- Earthwork
- Systems
- Right of Way
- Professional Services

The White House Security Premium reflects the fact that construction work in high security area is significantly more expensive than work in other areas. Based on past experience, the Secret Service suggested a 40 percent increase in construction costs within the White House Security Perimeter to account for the extra time and cost associated with security clearances, the inspection of all vehicles entering and exiting the area, and the special handling required for high security conduits.

An optimistic and conservative estimate was prepared for each category based on the range of unknowns or assumptions included in the analysis. These ranges are shown in the following table.

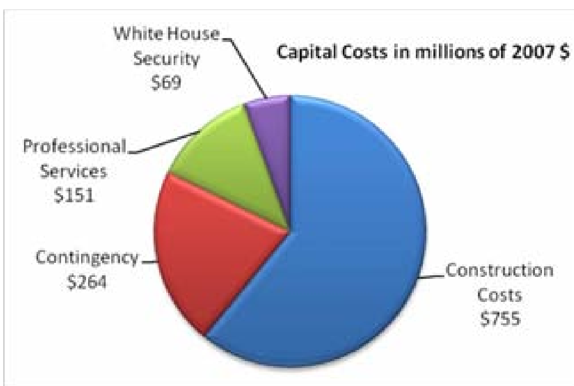
Table 4: Estimated range of capital costs

Capital Costs in 2007 $	Capital Cost Range	Cost per Linear Foot
	(millions)	(thousands)
E Street Park Deck	$82 to $146	$97 to $172
Short E Street Tunnel	$167 to $283	$78 to $131
Pennsylvania Ave. Tunnel	$171 to $292	$76 to $129
Long E Street Tunnel	$726 to $1,239	$64 to $108
15th Street Option	$516 to $840	$69 to $112

The cost estimates range from a low of $82 million for the E Street park deck to a high of $1.2 billion for the long E Street tunnel. When these values are divided by the length of the tunnel the costs range from a low of $64,000 per linear foot for the long E Street tunnel to a high of $172,000 per linear foot for the E Street park deck.

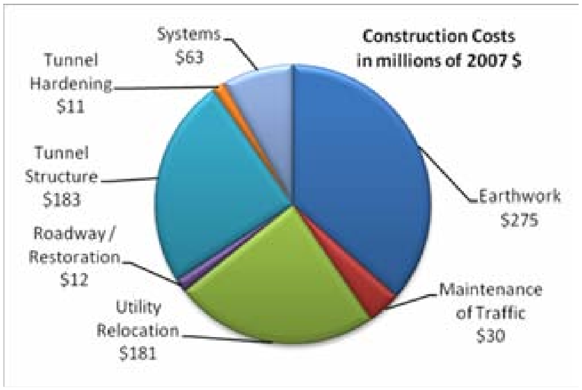
The breakdown of the conservative long E Street tunnel costs by construction and non-construction categories shows that only 60 percent of the total cost is directly related to construction.

Figure 32: Long E Street tunnel primary cost components



The breakdown of the construction costs shows that earthwork, tunnel structures, and utility relocation are the primary cost components.

Figure 33: Long E Street tunnel construction cost distribution



4.3.5 Security: Maintain White House Security

The primary reason for closing E Street and Pennsylvania Avenue is to protect the President from potential terrorist attacks. E Street is considered a temporary closure, however this study assumes the threat level will not subside enough in the foreseeable future to warrant re-opening E Street to traffic. Tunnels could be made secure through the use of appropriate materials and construction methods.

Today primary vehicle access to the White House is through security checkpoints on E Street at the entrances to President's Park. As such, all of the alternatives must provide access and space for White House security processing. This complicates the intersection movements and right-of-way required by the E Street park deck alternative at 15th and 17th Streets. Separate signal phases are needed to safely control traffic into and out of the White House access lanes. These lanes also require expanding the E Street right-of-way into President's Park.

4.4 Summary of Findings

The travel disruptions caused by the closures could largely be mitigated by restoring and reinforcing the street grid. A long tunnel connecting the east side of downtown to the E Street Expressway would reverse most of the closure results (as measured by its ability to restore accessibility, mobility, and reliability in a safe manner); the other alternatives do not do as good a job. However, all of the tunnel alternatives would affect the nature of the area during and after construction. Tunnels are also expensive to construct and maintain.

Figure 34: 16th Street screenline traffic volumes

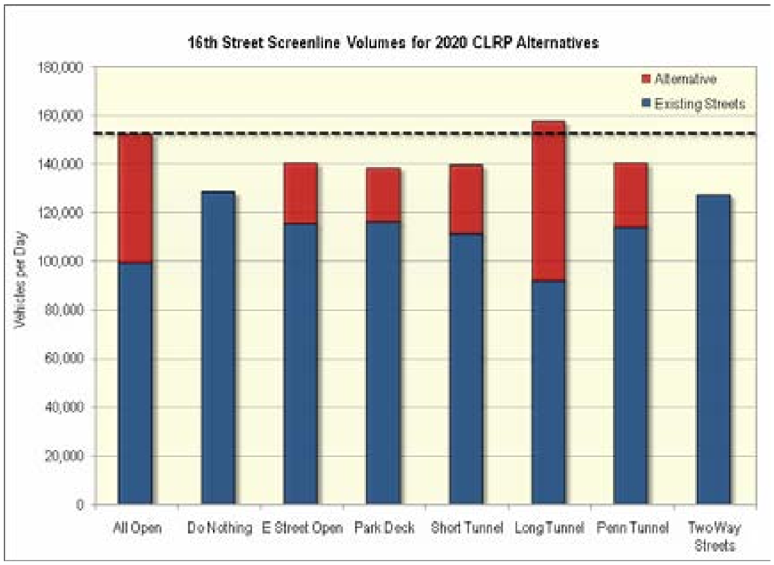
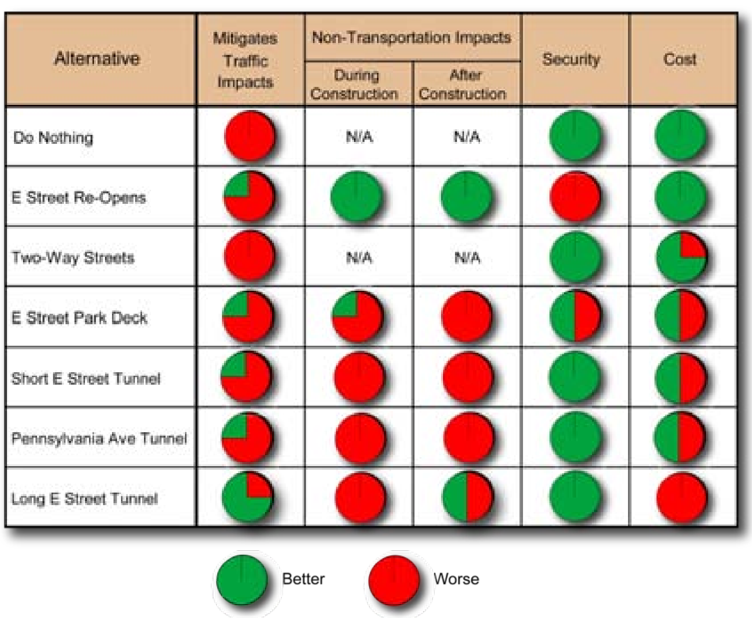


Figure 35: Alternative evaluation summary



5 Alternatives Designed to Improve Operations

Given the high cost and environmental consequences of the tunnel alternatives, the project Steering Committee recommended considering the potential for transit and traffic operations alternatives to alleviate at least a portion of the effects of closing E Street and Pennsylvania Avenue. An expert panel was consulted to identify traffic management and operational alternatives that might be considered. DDOT proposed a number of transit improvements to the DC Circulator bus system and a dedicated busway down the center of K Street between Mount Vernon Square and Washington Circle. These alternatives focus on moving people—not just vehicles—within downtown Washington.

5.1 Traffic Operations Strategies

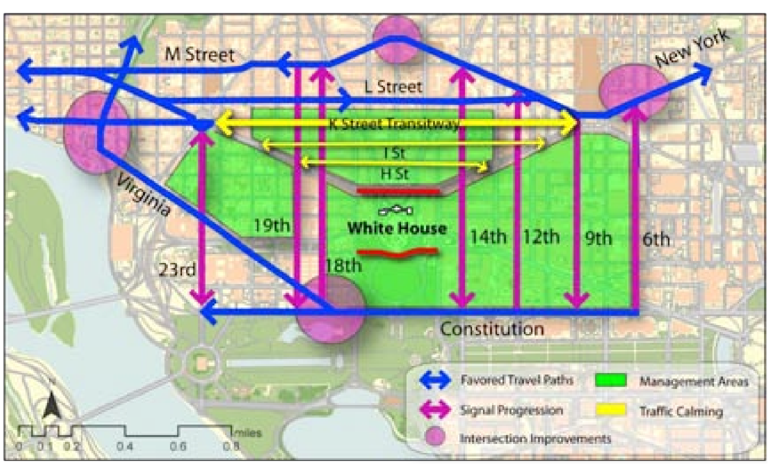
An expert panel was convened in December 2008 to observe traffic conditions in downtown Washington and identify traffic operations strategies to target traffic problems. The panel members found that driving speeds were slower in Washington, D.C. than other major cities such as Chicago or New York. The group was uniform in its professional assessment that the system they observed worked inefficiently. The system raises travel and activity costs and stress levels for all who use motorized surface transportation in the city. This is not limited to automobiles. Bus patrons suffer. Delivery times and commercial transaction costs rise. The overall cost of conducting business in the city is higher than necessary.

5.1.1 Mitigate Closure Effects

As a way of mitigating the physical discontinuity between the east side of downtown with the west side and Georgetown, the panel suggested focusing on favored travel paths through downtown. These paths could be signed appropriately and given travel time incentives by coordinating the signals on each street and at critical turning movements along the path. Favored travel paths would be reinforced by much slower travel on other crosstown streets.

One travel path that addresses congestion caused by the street closures combines Virginia and Constitution Avenues. The success of this strategy depends on key changes to critical intersections. The intersection of Virginia Avenue and Constitution Avenue would need to be reconfigured to provide additional through lane capacity westbound on Virginia Avenue and a significant redesign of the eastbound connection to Constitution Avenue near 18th Street. The other major change would involve the connections between Virginia Avenue and the Whitehurst Freeway and Rock Creek Parkway.

Figure 36: Traffic Management alternative



A complementary travel path lies further north along L and M Streets. L Street is one-way eastbound and M Street one-way westbound. The travel paths start in Georgetown on M Street and split at Pennsylvania Avenue to proceed eastbound on L Street.

The eastbound recommendation is to continue on L Street to Massachusetts Avenue and then split at 9th Street to continue south into the east side of downtown or continue on to Mount Vernon Place to New York Avenue. The westbound path would require operational improvements at the intersection of New York Avenue, 6th Street, and L Street. L Street would be reconfigured as one-way westbound under the Convention Center to Massachusetts Avenue. Alternatively or in addition, the New York Avenue to Massachusetts Avenue connection at Mount Vernon Square would be improved. The path would then follow Massachusetts Avenue to Thomas Circle where it would connect with M Street to continue westbound. Thomas Circle would need to be modified to provide sufficient capacity and throughput between Massachusetts Avenue and M Street.

This strategy also designates several north-south streets between Constitution Avenue and M Street as "primary access" facilities. The favored northbound streets would be 23rd, 18th, 14th, 12th, and 6th Streets and the favored southbound streets would be 23rd, 19th, 14th, and 9th Streets. Favoring these streets means that greater efforts would be made to minimize double parking and other lane blockage events. Traffic signals would be progressed to minimize stopping. Double turn lanes and significant green splits would be required at Constitution Avenue.

5.1.2 Pedestrian Focus

Favored automobile travel paths around the downtown core on Virginia and Constitution Avenues and L and M Streets would lower automobile traffic on H, I, and K Streets. This makes the operations on K Street more conducive to a busway and provides opportunities for better pedestrian focus on I Street. The panel does not believe I Street could move mixed traffic more effectively given its heavy curbside activity requirements. There are too many double-parked service vehicles and pedestrian conflicts around Metrorail stations to make this desirable.

The recommendation is to turn I Street into a pedestrian/service-friendly street by reducing the number of travel lanes to one in each direction, significantly widening the sidewalks for pedestrians, and adding special pull-out locations for service vehicles. This would be complemented by returning H Street to a two-way configuration with two lanes in each direction and appropriate connections to the two-way section of H Street east of 13th Street.

5.1.3 Signage and Curbside Access

The panel believes downtown suffers from too much traffic control "pollution." There are too many signs that are typically ignored by commercial and private vehicles. Most of the parking signs could be removed and/or replaced by painted curbs (used by other jurisdictions but not by the District) and consolidated parking payment systems. Removing the clutter would make the area more attractive and increase the probability that important traffic control signs would be obeyed.

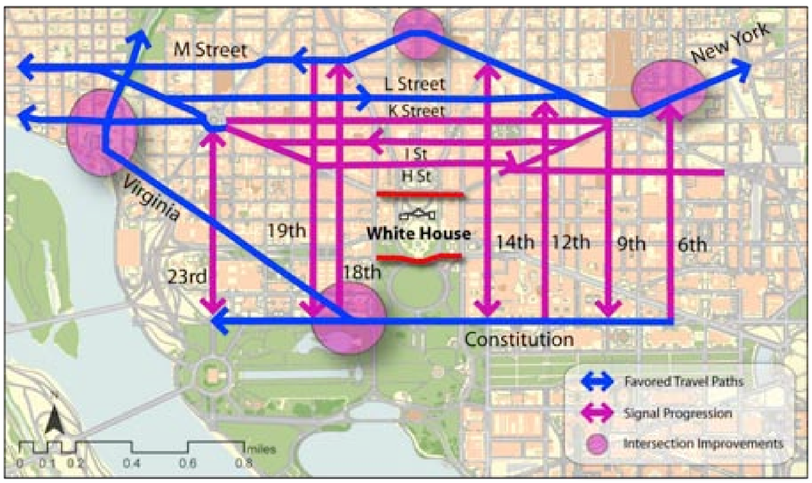
5.1.4 K Street Busway

The panel believes the reconfiguration of K Street with a center lane busway would not improve traffic operations. Reducing capacity in a network that already operates at the limits of capacity would lead to deteriorated conditions on the rest of the network. They note that permitting bus routes to turn in to and out of the busway at numerous locations would be a major operational challenge. It would be far more desirable to avoid turning movements to and from the busway between Mount Vernon Square and Washington Circle. If this is not practical, turns should be limited to one or two locations where there is adequate space to provide a designated turn pocket with a demand actuated signal phase. Left turns would also need to be prohibited along this stretch of K Street.

5.1.5 Other Possibilities

The system-wide retiming of traffic signals typically reduces traffic times by 5 percent to 10 percent. During peak periods simultaneous greens may be more effective than signal progression. In a saturated network like downtown D.C., the traffic gaps needed for effective signal progression do not exist. When every block is congested, a coordinated system of simultaneous greens permits the traffic to move as a large platoon with improved throughput.

Figure 37: Traffic Operations alternative



Peak period parking restrictions are a major problem in D.C. Even with rigorous enforcement, it typically takes more than half an hour to clear parked cars from travel lanes. One option might be to start the PM peak parking restriction at 3 p.m. or 3:30 p.m. rather than 4 p.m. Because 4 p.m. to 5 p.m. is a high traffic hour in downtown, clearing out the parked vehicles before 4 p.m. is important for the traffic operations of the entire peak period. Such actions should be evaluated by local authorities to identify potential impacts on parking demand, loss of parking revenue, and on businesses and loading.

5.1.6 Conclusions

The panel shares the study team's assessment that the obvious and practical actions to mitigate the street closures were undertaken following the closures of Pennsylvania Avenue and E Street in 1995. Few opportunities exist for major improvements that address the closures today. The panel also noted that many of the key strategies, such as the conversion of H and I Streets to a one-way pair, have not been particularly effective due to the competition between curbside access, throughput, and non-motorized traffic demands. The peer panel members believe that a great deal could be done to alleviate systemic downtown delays. Poor signal timing, phasing, and progression in combination with lane blockages cause unnecessarily low travel speeds and high transaction costs in downtown Washington.

The group notes that somewhat paradoxically, street capacity in parts of downtown could be further reduced to improve pedestrian circulation and curbside loading if favored automobile paths are provided to move crosstown traffic effectively. The existing network and its operation force a mix of crosstown and local travelers onto the same streets. They compete for space that cannot meet all of the demands placed upon the system. The designation of local crosstown routes could alleviate some of this problem.

5.2 Transit Strategies

The District of Columbia has been planning and implementing new transit services in and around downtown for many years. These services are designed to improve local circulation opportunities for D.C. residents and complement the Metrobus and Metrorail routes that provide regional access to the urban core.

For the purposes of this study, two classes of transit improvements are considered. The first focuses on expanding the DC Circulator system. The other focuses on busway options on K Street between Mount Vernon Square and Washington Circle.

5.2.1 Expanded DC Circulator Routes

The DC Circulator service plan for the year 2020 includes the two routes implemented in 2005 plus two additional routes serving northwest and southeast:

- Convention Center to S.W. Waterfront
- Georgetown to Union Station (K Street)
- U Street and Adams Morgan
- Union Station to S.E. M Street
  (Additional service expansion was identified after the study was conducted)

Figure 38: DC Circulator 2020 service plan

The National Park Service plans to supplement the Tour Mobile buses on the Mall with two fixed circulation routes identified as the Red and Blue routes. This study assumes the combination of these six routes represents the committed DC Circulator system. As such, these routes are included in all of the transit and traffic operations alternatives.

Figure 39: National Park Service routes

The expanded circulator alternative adds three new routes to the committed system to improve transit connectivity between the east and west sides of downtown. They also provide options for regional Metrorail users to access downtown tourist sites, neighborhoods, and businesses without using the most congested segments of the Metrorail system.

The expanded DC Circulator routes include:

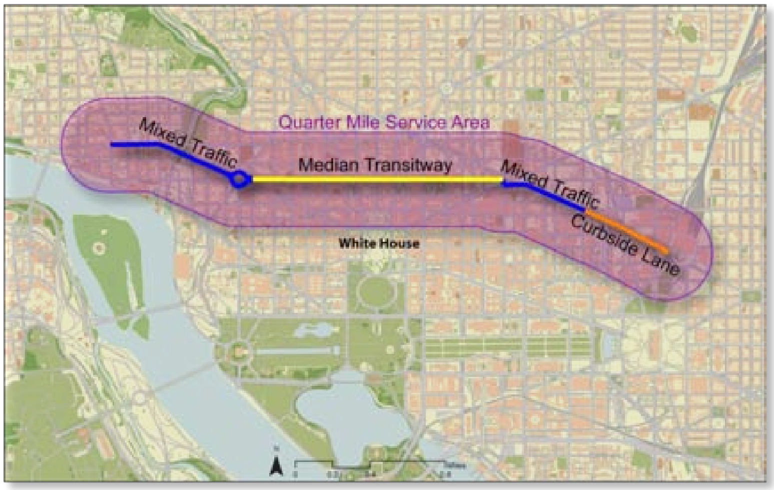
- Convention Center to U Street to DuPont Circle to Washington Circle (brown)
- Arlington Cemetery to 23rd Street to K Street to Convention Center (yellow)
- Rosslyn to Constitution Avenue to 18th/19th Streets to H/I Streets to Union Station (green)

Figure 40: Expanded DC Circulator routes

5.2.2 K Street Busway

The District of Columbia is pursuing the implementation of a busway in the center of a reconfigured K Street between Mount Vernon Square and Washington Circle. The fundamental design involves reconstructing K Street to remove the frontage roads and reconfiguring the entire cross-section to provide for a two-directional busway with stations in the center of the street and two or three travel lanes for automobiles and bicycles on either side. This busway would initially be a busway that could accommodate streetcars at some point in the future.

Figure 41: K Street busway corridor



This study evaluates a number of combinations of busway, expanded DC Circulator, and operational options in an effort to identify the range of benefits that might be expected. These combinations include:

- K Street Busway
- K Street Busway with Traffic Management
- K Street Busway with Passing Lanes
- K Street Busway with Passing Lanes and Traffic Operations
- K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on K Street
- K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on K Street

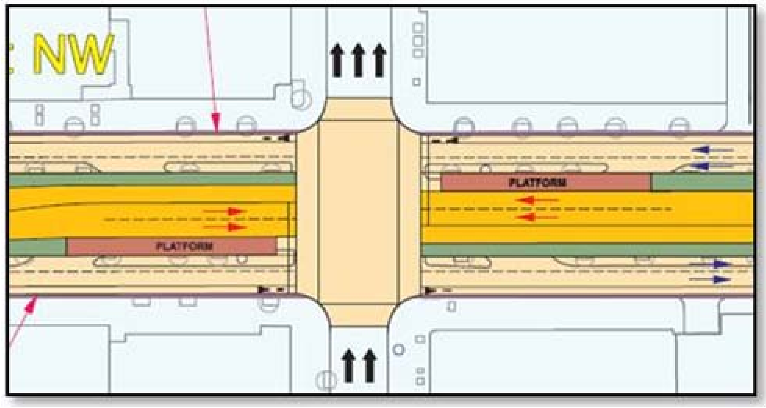
The basic busway design provides one lane in each direction with 90-foot-long station platforms that permit two buses to load and unload passengers at the same time. Bus routes from all parts of the region would use the busway to avoid delays from automobile traffic on K Street and other parallel streets. The traffic signals on K Street would also be timed to minimize bus delays at intersections.

Given all of the bus routes expected to use the busway, a bus could serve each station in each direction every 90 seconds. At stops where a significant number of riders board and/or alight from the bus, the bus could easily wait from 30 to 60 seconds to process passengers. The combined effect of frequent service, required dwell times, and traffic signal delays is likely to result in vehicle bunching and congestion-related delays on the busway.

<u>Passing Lanes</u>

Several strategies are being considered to improve performance and reduce busway delays. One strategy, identified as "with passing lanes" in the description of several alternatives, is depicted in the following graphic. The station platform is lengthened to 140 feet to serve three buses at the same time and a passing lane is added at stations to provide an opportunity for a bus to pass a slower bus, skip certain stops, or make a turn at the intersection.

Figure 42: Busway passing lanes



<u>Free Fare Zone</u>

Another strategy designed to increase ridership and reduce busway congestion is to designate the busway itself as a free fare zone. In other words, anyone boarding a bus at a K Street busway station would not pay a fare. This would permit riders to board the vehicles more quickly using the front and back doors.

If the lost revenue becomes a significant problem, similar performance gains could be achieved by placing fare machines at the stations and requiring all passengers to have a valid ticket before boarding the bus. Roving conductors would randomly check buses to ensure the passengers have valid tickets and issue fines to violators.

5.3 Transportation Findings

The transportation findings are evaluated from two perspectives. The first perspective is the alternative's effectiveness in mitigating the impacts of closing E Street and Pennsylvania Avenue (as mandated by the study's authorizing legislation). The second perspective evaluates the benefits of each alternative relative to existing conditions—or more precisely, doing nothing beyond the improvements with committed funding between now and the year 2020.

5.3.1 Evaluating Mitigation Benefits

To evaluate how well a given alternative mitigates the closing of E Street and Pennsylvania Avenue, a hypothetical simulation was performed that restores the transportation system near the White House to pre-closure conditions. This involves:

- Opening E Street and Pennsylvania Avenue between 15th and 17th Streets
- Opening the State Place connection between E Street and New York Avenue
- Reconfiguring H Street as a two-way roadway between Pennsylvania Avenue and New York Avenue
- Changing the direction of traffic flow on I Street between Pennsylvania Avenue and New York Avenue
- Restoring approximately 30 bus routes to the alignments they used prior to the street changes

This simulation is called the "all open" scenario. It restores the White House area to 1994 conditions, but includes all of the other changes in the regional long-range plan for the year 2020. This makes the all-open scenario consistent and equivalent to the transit and traffic operations alternatives outside of the immediate vicinity of the White House.

The objective of the all-open scenario is to estimate traffic and transit conditions in the year 2020 assuming E Street and Pennsylvania Avenue were open to traffic. Comparing the performance measures of each of the transit and traffic operations alternatives to the all-open scenario facilitates the assessment of the effectiveness of the alternative in mitigating the closure results.

5.3.2 Mobility: 16th Street Screenline

Closing E Street and Pennsylvania Avenue near the White House forced about 72,000 travelers a day to find new ways of crossing downtown. Many of the travelers use parallel streets. The person volume estimates in the following table capture the ability of a given alternative to restore crosstown movements between the east and west sides of downtown. The table reports the number of people crossing 16th Street between Constitution Avenue and M Street during a typical workday in the year 2020 using all modes of transportation—autos, trucks, buses, and Metrorail.

Key Findings

- East-West streets carry 30%-50% more traffic as a result of the closures.
- The only alternatives that improve both transit and auto throughput include traffic operations improvements.
- All other alternatives reduce total person volumes crossing the 16th Street screenline.

<u>All Open</u>

A review of the person movements estimated for the all-open scenario shows that a total of 570,350 people a day cross the 16th Street screenline. This includes 199,050 persons (35 percent) in autos or trucks, 40,100 people (7 percent) in buses, and 331,150 people (58 percent) on Metrorail. The mitigation objective in this case is to restore as much of the 570,350 person trips a day crossing 16th Street as possible without regard to the travel mode used. A secondary objective is to relieve congestion on the streets adjacent to the closures.

<u>Do Nothing</u>

Compared to the all-open scenario, doing nothing accommodates 559,100 people across the 16th Street screenline. This is 11,250 (2.0 percent) less than the all-open scenario. Auto travel is 15,050 (7.6 percent) less while transit travel is 3,850 (1.0 percent) more. The effect on specific streets is more significant. Constitution Avenue carries 50 percent, L Street 44 percent, M Street 34 percent, and K Street 28 percent more traffic.

<u>Expanded DC Circulator</u>

Implementing the expanded DC Circulator bus routes decreases the overall throughput slightly (0.3 percent) compared to doing nothing. The increase in bus crossings is 3.4 percent due to the additional service on H, I and K Streets. This increases the congestion on these streets which diverts additional auto and truck traffic.

Metrorail ridership decreases by 1,850 riders (0.6 percent) per day. The expanded circulator routes enable Metrorail riders to exit the system at U Street, DuPont Circle, Rosslyn, or Arlington Cemetery stations and complete their trip by bus rather than transferring between Metrorail lines at Metro Center or Gallery Place.

<u>Traffic Management</u>

From the perspective of total person movements across the 16th Street screenline, the traffic management strategy carried 1.3 percent fewer people across the screenline due to shifts in auto traffic on screenline roadways. These changes are fully consistent with the traffic management objective of reducing traffic on H, I, and K Streets and focusing traffic onto Constitution Avenue and L and M Streets. Motorized traffic on H, I, and K Streets drops by 33,800 persons per day, almost 40 percent from the do-nothing alternative. Constitution Avenue and L and M

Streets carry 26,250 (28 percent) more people. The improvements made to Constitution Avenue and L and M Streets are not sufficient to absorb all of the traffic displaced by reducing auto capacity on H, I, and K Streets. The remaining streets would operate under severe congestion throughout the day. The high traffic volumes would not be conducive to the desired pedestrian experience in the monumental core.

Traffic Operations

The traffic operations alternative restores 82 percent of the 16th Street person movements that were displaced by the closures. It achieves this result by improving auto and transit travel conditions. The signal timing improvements enable the existing facilities to support 5 percent more traffic than the do-nothing alternative. These increases are achieved by distributing the traffic more proportionately across the screenline. This results in a 25 percent reduction of auto traffic on K Street, restoring K Street to its per-closure conditions and making it more attractive to bus travelers.

K Street Busway

The K Street busway alternative lowers the total person movements crossing the 16th Street screenline by 1.3 percent. The total transit persons increase by 1,150 riders per day and the total auto persons decrease by 8,350 per day. The auto decrease is the result of a 47 percent reduction in auto throughput on K Street that cannot be fully absorbed by the adjacent streets.

The busway attracts 40 percent more transit trips to K Street. Most of this increase is from existing transit riders who change routes. Of the 8,900 additional transit riders on the busway, 4,000 use Metrorail and 3,100 use bus routes on other streets in the do-nothing alternative.

K Street Busway with Traffic Management

Adding traffic management strategies to the K Street busway reduces the total, auto, or transit throughput slightly. The most significant change is the distribution of auto traffic on screenline facilities. The auto traffic on H, I, and K Streets decreases by 38 percent while the traffic on Constitution Avenue and L and M Streets increases by 30 percent.

K Street Busway with Passing Lanes

Adding passing lanes to the K Street busway at stations and intersections increases transit ridership on the busway by 2,800 riders per day or 9 percent. The reduced auto capacity on K Street diverts 4,800 auto persons (20 percent) to other facilities. Only 3,400 of these auto trips can be accommodated on the adjacent streets in the 16th Street screenline. The net result of adding passing lanes is an additional 450 persons per day crossing the 16th Street screenline.

Table 5: 16th Street screenline daily person volumes by mode and facility

2020 Daily Person Volume Crossing the 16th Street Screenline by Mode and Facility											
Mode & Facility	All Open	Existing K-Street				Reconfigured K-Street with Transitway					
		Do Nothing	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
In Transit Vehicles											
Constitution Avenue	3,300	3,050	2,750	3,050	3,050	2,950	2,950	2,900	2,900	2,600	2,600
Pennsylvania Avenue	7,400										
H Street	5,250	4,850	5,850	4,900	4,950	2,450	2,450	2,500	2,550	3,200	3,050
I Street	1,650	10,850	11,950	10,850	10,950	7,750	7,700	7,650	7,700	8,350	8,400
K Street	21,200	20,900	20,450	20,900	21,000	29,550	29,500	33,100	33,300	37,700	35,800
L Street						2,550	2,550	2,500	2,550	2,400	2,400
MetroRail (Orange/Blue)	176,350	178,850	177,600	178,850	178,850	178,150	178,200	177,100	177,000	173,400	173,850
MetroRail (Red Line)	155,150	155,550	154,950	155,600	155,550	152,050	152,000	151,900	151,950	149,200	148,900
Bus Total	***38,750***	***39,650***	***41,000***	***39,700***	***39,950***	***45,250***	***45,150***	***48,650***	***49,000***	***54,200***	***52,300***
MetroRail Total	***331,500***	***334,450***	***332,550***	***334,450***	***334,400***	***330,200***	***330,200***	***329,000***	***328,950***	***322,650***	***322,800***
Total Transit Persons	**370,300**	**374,100**	**373,600**	**374,150**	**374,350**	**375,450**	**375,350**	**377,650**	**377,950**	**376,850**	**375,100**
In Autos or Trucks											
Constitution Avenue	40,600	60,900	61,250	76,450	69,650	64,350	81,200	65,900	68,850	64,800	65,100
E Street	24,050										
Pennsylvania Avenue	30,150										
H Street	26,900	25,750	25,450	11,500	30,000	29,450	14,100	29,600	36,750	29,100	29,650
I Street	20,250	21,700	21,550	9,150	28,150	24,300	13,400	25,200	31,550	24,600	24,400
K Street	34,650	44,200	43,000	37,200	33,250	23,600	20,100	18,800	13,750	18,600	22,150
L Street	16,100	23,100	23,150	28,800	22,200	24,200	33,200	23,350	21,750	23,200	24,900
M Street	6,200	8,300	8,250	13,300	9,700	9,650	12,950	11,300	12,600	11,150	10,100
Total in Autos+Trucks	**199,050**	**184,000**	**182,800**	**176,550**	**193,100**	**175,650**	**175,000**	**174,250**	**185,400**	**171,500**	**176,400**
Using All Modes											
Constitution Avenue	43,900	63,950	64,000	79,500	72,700	67,300	84,150	68,800	71,750	67,400	67,700
E Street	24,050										
Pennsylvania Avenue	37,550										
H Street	32,150	30,600	31,300	16,400	34,950	31,900	16,550	32,100	39,300	32,300	32,700
I Street	21,900	32,550	33,500	20,000	39,100	32,050	21,100	32,850	39,250	32,950	32,800
K Street	55,850	65,100	63,450	58,100	54,250	53,150	49,600	51,900	47,050	56,300	57,950
L Street	16,100	23,100	23,150	28,800	22,200	24,200	33,200	23,350	21,750	23,200	24,900
M Street	6,200	8,300	8,250	13,300	9,700	9,650	12,950	11,300	12,600	11,150	10,100
MetroRail (Orange/Blue)	176,350	178,850	177,600	178,850	178,850	178,150	178,200	177,100	177,000	173,400	173,850
MetroRail (Red Line)	155,150	155,550	154,950	155,600	155,550	152,050	152,000	151,900	151,950	149,200	148,900
Total Persons	**569,200**	**558,000**	**556,200**	**550,550**	**567,300**	**548,450**	**547,750**	**549,300**	**560,650**	**545,900**	**548,900**

K Street Busway with Passing Lanes and Traffic Operations

Adding traffic operations to the K Street busway with passing lanes combines the advantages of the independent strategies. This alternative is able to recover 39 percent of the reduction in 16th Street throughput caused by the street closures. This includes an overall increase in transit ridership of 7,650 riders per day over pre-closure conditions. There are 12,100 additional riders per day (51 percent) on K Street and 2,600 fewer riders per day (0.8 percent) on Metrorail.

This alternative also accommodates all of the auto person trips displaced by the busway and the busway passing lanes plus 1,400 auto travelers displaced by the closures. The 42 percent reduction in auto traffic on K Street is accommodated by a 27 percent increase in auto throughput efficiency on H and I Streets.

K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on the Busway

Adding a free fare zone to the K Street busway with passing lanes increases the transit persons served on K Street by 16,050 riders per day (74 percent) over the do-nothing condition. Much of this increase is from existing transit riders changing routes. Metrorail ridership declines by 10,900 riders per day (3.3 percent) and 3,000 riders shift from bus routes on adjacent streets to the K Street busway to take advantage of the reduced fare.

These benefits are offset by a reduction of 25,600 auto person trips (58 percent) on K Street of which only 13,100 can be accommodated on the other streets in the 16th Street screenline. The net result is 10,200 fewer persons per day crossing the 16th Street screenline compared to the do-nothing alternative.

K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on the Busway

Replacing the K Street busway with passing lanes with a streetcar improves the net throughput on the 16th Street screenline by 3,100 persons per day. This is the net result of 1,800 fewer transit riders and 4,900 more auto persons. A two-lane busway operates less efficiently without the passing lane, but this is more than offset by the travel time savings to other motorized traffic.

Compared to the do-nothing alternative, transit trips increase by 450 persons per day (0.1 percent) and auto person trips are reduced by 7,600 per day. This is an improvement over most of the other busway alternatives, but the overall effect on 16th Street throughput is still negative.

5.3.3 Mobility: Average Speed

The average daily person speeds shown in the following table provide insights into the effect of each alternative on travel within the White House area. The difference between the all-open scenario and the do-nothing simulation shows that overall average speed decreases by 2.0 percent. Speeds on east-west facilities decrease significantly (6.2 percent) while speeds on north-south facilities improve by 2.0 percent. It also shows that the closures affect auto and truck travelers more than bus passengers.

Key Findings

- East-West speeds reduced an average of 6% as a result of the closures.
- Without operational improvements, the busway becomes seriously congested and generates far fewer benefits than originally anticipated.
- Combining the busway with traffic operations improvements increases speeds for all modes and orientations.

Expanded DC Circulator

The expanded DC Circulator routes generate a small improvement (1.3 percent) in auto and transit speeds on east-west facilities.

Traffic Management

The traffic management alternative improves the overall speed well beyond (7.4 percent) the pre-closure conditions. The result is most significant (27 percent) for autos and trucks on north-south facilities. The reduced traffic volumes on H, I, and K Streets mean that more green time can be allocated to north-south movements, which in turn improves the north-south travel speeds for both autos and buses. Bus speeds on east-west facilities, however, suffer by 7.6 percent.

Traffic Operations

The traffic operations alternative focuses more on improving east-west travel than the traffic management alternatives. As such, the speed increase for east-west and north-south travel is balanced (10.0 percent vs. 10.6 percent, respectively). The benefits to auto travel is approximately three times greater than the benefits to bus travel (16.5 percent vs. 5.5 percent and 17.4 percent vs. 6.5 percent, respectively). The average speed for each mode and direction is higher than the pre-closure conditions.

K Street Busway

The K Street busway alternative reduces speeds for all modes and orientations except east-west buses. The speed improvement generated by the K Street busway is 9.6 percent. This is significantly less than the 22 mph estimate included in prior studies. A closer examination of the busway itself reveals serious operational problems at stations and intersections. During the peak periods the buses travel in platoons of five or six vehicles. Only the first two vehicles are able to discharge passengers at the station while the remaining buses wait in a queue. When the lead bus finishes processing passengers, it can often only move one bus length forward before it is stopped by the traffic signal. Without operational improvements, the busway becomes seriously congested and generated far fewer benefits than originally anticipated.

K Street Busway with Traffic Management

Adding traffic management to the busway helps improve the overall study area speeds because it provides significant improvements for north-south traffic. From the point of view of east-west auto and bus movements, travel is slower and more congested. The reduction in east-west bus speeds is 11 percent.

K Street Busway with Passing Lanes

Adding a passing lane to the busway improves east-west bus speeds by 3.4 percent and reduces east-west auto speeds by an additional 3.7 percent. The overall speed improvement generated by the K Street busway is 13 percent, but the average person speeds for all modes are still lower than the do-nothing alternative.

K Street Busway with Passing Lanes and Traffic Operations

Combining the busway with traffic operations improvements increases speeds for all modes and orientations. The overall study area improvement in auto speeds is 16 percent and the improvement in bus speeds is 7.5 percent. East-west auto travel improved by 21 percent and the K Street busway improvement is 14 percent.

K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on the Busway

Including expanded circulator routes and a free fare zone to the K Street busway adds more buses and passengers to an already heavily used facility. The net result is a 2.4 percent reduction in east-west bus speeds and a 3.8 percent increase in auto speeds. The greatest impact is on the K Street busway were speeds reduced by 5.4 percent thereby negating the benefit of adding the passing lane to the busway.

K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on the Busway

Mixing a streetcar with buses on a K Street busway results in lower average speeds for all modes and orientations. The operational problems on the busway increase by 8 percent.

Table 6: 2020 average daily speeds by mode and travel orientation

2020 Average Daily Speed (mph) by Mode and Orientation											
Mode & Orientation	All Open	Existing K-Street				Reconfigured K-Street with Transitway					
		Do Nothing	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Study Area Travel											
All Modes	19.5	19.3	19.3	21.0	21.2	19.1	19.5	18.6	20.7	18.7	18.5
Autos & Trucks	14.4	14.1	14.2	16.0	16.2	14.0	14.7	13.6	15.8	13.8	13.7
Buses	8.5	8.4	8.4	8.6	9.0	8.3	7.9	8.3	8.9	8.3	8.1
Metro Rail*	41.0	40.9	40.9	40.9	40.9	40.9	40.9	40.9	41.0	41.0	41.0
East-West Travel											
All Modes	17.9	17.2	17.3	17.8	19.0	17.1	16.6	16.6	18.6	16.7	16.3
Autos & Trucks	11.8	11.0	11.2	11.8	12.9	10.9	10.9	10.5	12.7	10.9	10.7
Buses	8.2	7.8	7.9	7.2	8.2	7.8	7.0	8.0	8.3	7.8	7.5
K Street Transitway	7.2	6.7	6.8	6.4	7.2	7.4	7.3	7.6	7.7	7.2	6.8
North-South Travel											
All Modes	15.5	15.7	15.7	18.0	17.3	15.1	16.6	14.8	16.6	14.7	14.8
Autos & Trucks	9.7	9.9	9.9	12.3	11.6	9.5	11.2	9.3	11.0	9.3	9.3
Buses	7.1	7.4	7.4	8.2	7.8	7.1	7.7	6.9	7.6	7.1	7.1

* MetroRail represents idealized speeds under optimal conditions

5.3.4 Mobility: Cycle Failures

Cycle failures are a useful way of quantifying the overall level of congestion on the network. When people in autos or buses are required to wait for an additional signal cycle to clear the intersection, considerable time is wasted and the perception of congestion increases significantly. The objective is to reduce the number of cycle failures in total and the severity of cycle failures at specific locations.

Key Findings

- The closures increased east-west cycle failures by 55 percent for auto travelers and 33 percent for bus travelers.
- Traffic management improves north-south travel by making east-west travel more difficult.
- The K Street busway increases the number of cycle failures for all travelers.
- Implementing a busway and managing traffic on H, I, and K Streets results in a very fragile system that can quickly collapse.
- Combining the busway with traffic operations reduces total cycle failures.

Closing E Street and Pennsylvania Avenue significantly increased the number of cycle failures for people traveling in autos and buses. The overall increase for the study area was 19 percent. Bus riders experience a 21 percent increase. East-west automobile travelers experience the greatest change with a 55 percent increase followed by east-west bus riders with a 33 percent increase. Bus riders also experience a 23 percent increase in cycle failures for north-south travel.

Expanded DC Circulator

The expanded DC Circulator routes reduce overall cycle failures by 5 percent. East-west auto travelers experience the greatest benefit (14 percent). Cycle failures are reduced for bus travelers because more of the trips are able to use routes that avoided the congested areas of downtown.

Traffic Management

The overall effect of traffic management is to reduce the number of cycle failures in the study area by 30 percent. This is an improvement over the pre-closure conditions, but the benefits are not uniformly distributed. North-south auto travelers have 48 percent fewer cycle failures while east-west bus riders have 46 percent more cycle failures. The net result is a 58 percent increase in cycle failures for all east-west travel over the all-open conditions.

Traffic Operations

Traffic operations reduces cycle failures for auto and bus travelers by 39 percent over the do-nothing alternative and provides a 28 percent improvement over the pre-closure conditions. Because east-west travel was given priority in the operational improvements, the largest benefits are experienced by auto and bus riders making east-west movements (57 percent and 49 percent, respectively).

K Street Busway

The busway alternative increases the number of cycle failures across the board. By far the largest effect is the 210 percent increase in cycle failures for bus travelers making east-west movements. The K Street busway results reinforce the earlier observation that the busway has serious operational problems that cause buses to be delayed on links for multiple signal cycles waiting to process passengers at the stations.

K Street Busway with Traffic Management

Unfortunately, adding traffic management to the busway alternative only serves to increase the number of cycle failures. Cycle failures more than double as a result of this strategy. The huge increase in east-west cycle failures points to a serious roadway capacity problem that affects both autos and buses. This suggests that implementing a busway and managing traffic on H, I, and K Streets will result in a very fragile system that will quickly collapse under any additional stress.

K Street Busway with Passing Lanes

Adding passing lanes to the busway reduces cycle failures on the K Street busway by 54 percent for an overall reduction of 40 percent for east-west bus travel. This is more than offset by an 85 percent increase in cycle failures for east-west auto travel. There are also increases for north-south auto and bus travel (39 percent and 70 percent, respectively).

Table 7: 2020 daily cycle failures by mode and travel orientation

2020 Daily Cycle Failures by Mode and Orientation											
Mode & Orientation	All Open	Existing K-Street				Reconfigured K-Street with Transitway					
		Do Nothing	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Study Area Travel											
All Modes	97,650	116,050	109,850	81,250	70,550	139,900	179,750	175,800	104,900	160,200	186,300
Autos & Trucks	86,000	101,850	95,700	63,050	58,750	109,900	142,700	150,500	85,450	130,000	139,250
Buses	11,650	14,150	14,100	18,200	11,800	29,950	37,050	25,300	19,450	30,200	47,050
East-West Travel											
All Modes	23,150	34,700	30,500	36,600	15,500	50,300	74,100	65,400	27,200	50,850	75,500
Autos & Trucks	17,750	27,550	23,650	26,250	11,900	28,050	48,400	51,900	20,100	30,950	36,250
Buses	5,350	7,100	6,800	10,350	3,600	22,250	25,700	13,450	7,100	19,850	39,250
K Street Transitway	1,750	1,650	1,200	5,550	1,350	16,650	17,250	7,600	3,200	14,100	33,000
North-South Travel											
All Modes	27,750	29,850	28,700	16,650	27,550	38,050	41,550	54,650	48,100	52,650	45,400
Autos & Trucks	24,200	25,450	24,600	13,200	23,300	33,000	37,250	46,000	39,700	45,100	40,650
Buses	3,550	4,350	4,050	3,400	4,250	5,050	4,300	8,600	8,400	7,550	4,750

<u>K Street Busway with Passing Lanes and Traffic Operations</u>

Adding traffic operations to the busway reduces the total number of cycle failures in the study area below the do-nothing condition, but does not fully compensate for the increases generated by the street closures. The operational improvements reduce the cycle failures from the busway with passing lanes by 61 percent for east-west auto travelers and 47 percent for east-west bus travelers. Cycle failures on the K Street busway reduce by 58 percent. They also reduce north-south cycle failures by 12 percent.

<u>K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on the Busway</u>

Adding the expanded DC Circulator routes and the free fare zone on K Street to the busway with passing lanes increases the number of cycle failures on the K Street busway by 86 percent, but helps to reduce cycle failures for all other modes and orientations. The overall reduction is 9 percent despite an overall increase for bus travelers of 19 percent.

<u>K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on the Busway</u>

Mixing a streetcar with buses on the K Street busway only increased the number of cycle failures for all modes and orientations. The increase is more than a factor of four for east-west bus riders. Almost all of this increase is on the K Street busway. The interaction of frequent streetcars with numerous bus routes and no passing lanes leads to a highly congested busway.

5.3.5 Mobility: Congested Travel Conditions

The following table reports the percentage of the total daily person-hours of travel in a given mode that is made under congested conditions. In this case, congested conditions are defined as travel times that are three times greater than free flow travel times. This measure provides insights into how much of the travel is congested and how long the congestion lasts within and beyond the peak periods. The objective is to reduce the percentage of person-hours experiencing congested conditions.

Key Findings

- Auto travel in the vicinity of the White House is 24% more congested than overall travel in downtown.
- 84% of daily transit travel on K Street is under congested conditions.
- Traffic management or operations reduce the hours of congestion by at least 20%.
- The K Street busway increases the hours of congested travel by 4% to 6%.
- Including traffic operations with the busway mitigates all of the closure effects on hours of congested travel.

<u>All Open</u>

The overall increase in hours of congested travel due to the street closures is 3.2 percent. Autos and trucks increase by 5 percent while buses increase by less than 1 percent. The effect is significantly greater for east-west travel versus north-south travel. East-west congestion duration increases by 14.4 percent for autos and trucks and is reduced by 2.8 percent for north-south travel.

<u>Do Nothing</u>

The do-nothing congestion data show that 40 percent of the travel in all modes during a typical weekday is made in congested conditions. A far greater percentage (73 percent) of bus travel is made during congested conditions. Transit travel on K Street is 84 percent congested. The results also show that auto and truck travel in the vicinity of the White House is about 24 percent more congested than travel in the overall downtown study area.

<u>Expanded DC Circulator</u>

The expanded circulators do very little to address congestion duration. The only noticeable change is a 1.0 percent improvement in north-south bus travel and a 1.8 percent improvement in east-west auto and truck travel. It also increases transit congestion on K Street by 1.3 percent.

<u>Traffic Management</u>

The traffic management alternative shows a very significant (22 percent) reduction in the overall hours of congested travel. The largest reduction is 31 percent for autos and trucks traveling north-south, but even bus travel benefits by 10 percent to 13 percent. It does increase transit congestion on K Street by 1.1 percent.

<u>Traffic Operations</u>

The traffic operations alternative shows benefits that are comparable, but at the same time different from traffic management. The operations alternative provides greater benefits to east-west auto and truck travel (25 percent vs. 17 percent, respectively) and less benefits to north-south travel (17 percent vs. 31 percent). The operations alternative also does less to improve bus travel (7 percent vs. 12 percent), but reduces transit congestion on K Street by 2.4 percent.

<u>K Street Busway</u>

The busway alternative increases the hours of congested travel by 4 percent to 6 percent. North-south auto travel has the largest increase (6.4 percent). The only reduction in the hours of congested travel is on the K Street busway (4.5 percent).

K Street Busway with Traffic Management

Adding traffic management to the busway alternative reduces the hours of congested travel in the overall study area and results in performance comparable to the all-open scenario. This benefit is achieved, however, by a significant (22 percent) improvement to north-south auto and truck traffic and an 8 percent improvement to north-south bus travel. East-west auto and truck travel is improved by 10 percent and east-west bus travel is improved by 2.2 percent despite slightly worse conditions on the K Street busway.

K Street Busway with Passing Lanes

Adding a passing lane on the busway improves the K Street busway by 2.4 percent and benefits overall east-west bus travel. It does not, however, make all other modes and directions worse by between 2.4 and 3.4 percent.

Table 8: Percent of 2020 daily person hours of travel under congested conditions

Percent of 2020 Daily Person Hours of Travel under Congested Conditions by Mode and Orientation											
Mode & Orientation	**All Open**	**Existing K-Street**				**Reconfigured K-Street with Transitway**					
		Do Nothing	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Study Area Travel											
All Modes	39.0	40.2	40.1	31.5	32.0	41.8	38.1	43.1	34.6	42.8	43.5
Autos & Trucks	42.1	44.3	44.0	33.5	34.1	45.9	40.6	47.5	36.8	46.5	47.5
Buses	72.9	73.6	73.2	64.9	68.1	74.1	71.9	74.0	69.3	74.3	74.6
East-West Travel											
All Modes	43.4	47.9	47.5	40.8	38.4	49.8	46.8	51.0	41.5	50.7	52.3
Autos & Trucks	48.2	55.0	54.0	45.5	41.5	57.5	52.0	59.1	44.7	57.2	59.2
Buses	75.7	77.6	77.8	69.6	75.2	77.6	75.9	76.3	76.9	77.9	78.5
K Street Transitway	82.5	84.0	85.2	85.0	82.0	80.2	80.6	78.2	81.2	80.7	81.3
North-South Travel											
All Modes	50.2	48.8	48.4	34.9	41.0	52.0	42.0	53.3	44.3	53.2	53.1
Autos & Trucks	56.1	54.7	54.2	37.7	45.5	58.2	45.6	59.6	49.2	59.4	59.6
Buses	79.3	78.5	77.7	68.6	72.6	80.2	73.4	80.6	74.0	79.5	79.9

K Street Busway with Passing Lanes and Traffic Operations

Including traffic operations with the busway mitigates all of the closure effects and has some additional benefits. The overall benefit is 14 percent for all modes, 17 percent for autos and trucks, and 6 percent for buses. This is an 11 percent improvement over the all-open scenario. East-west travel for all modes is 4 percent better than the all-open scenario.

K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on the Busway

Replacing traffic operations with expanded DC Circulator routes and free fares on K Street slightly improves the overall performance. The hours of congested travel for east-west autos reduces by 3.2 percent, but the congestion on the K Street busway increases by 3.2 percent.

K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on the Busway

Replacing the busway with a streetcar increases the hours of congestion for all modes and directions. The most significant effect is a 5 percent increase in the hours of congestion for east-west travel.

5.3.6 Mobility: Travel Benefits

Travel benefits are a way of measuring the effects of changes in highway and transit service on all travelers within a given area. The concept is based on travel impedance, which weights different types of travel in different ways. These weights attempt to capture the value individual travelers place on time, cost, and various transportation modes. For example, the time spent walking or waiting at a transit stop is weighted twice as much as time spent in buses or automobiles. In other words, waiting for a bus for 10 minutes would be valued the same as riding in a bus for 20 minutes.

The total impedance of a given trip is the sum of the weighted values of in-vehicle travel time, walking time, waiting time, transfer time, fares, tolls, parking costs, fuel costs, transfer penalties, turn penalties, and rail bias factors. If the total impedance of an alternative is less than the total impedance of the do-nothing alternative, the alternative has a travel benefit. This benefit is divided by the value of in-vehicle travel time in order to express the benefits in terms most people can relate to—total hours of travel time saved.

The table below summarizes the total hours of travel benefits for different groups of travelers and travel modes. The study area and 16th Street summaries report the net benefits for travelers that travel within or pass through the designated area. The D.C. resident and K Street corridor data provides additional insights based on the origin and destination of the trip. Both the origin and destination of the trip must be within the District of Columbia to be included in the D.C. resident summary. The K Street corridor reports the benefits to trips that start and end within a quarter mile of the K Street busway alignment between Union Station and Georgetown. This corridor contains 6,100 auto and transit travelers per day.

Key Findings

- The closures increased overall study area travel time by 3,600 hours per day.
- D.C. transit travelers benefited from the closures due to more direct routes and more frequent service near K Street.
- Traffic operations improvements generate 21,800 hours of auto benefits and 350 hours of transit benefits.
- Virginia and Maryland travelers receive most of the traffic operations benefits.
- The K Street busway makes auto and truck travel worse for all summary areas.
- Combining the busway with traffic operations enhances the benefits generated by each alternative separately.

<u>Closure Effects</u>

The all-open scenario represents the benefits that would be expected if both E Street and Pennsylvania Avenue were re-opened. These values can be thought of as the effect of the closures. In the study area, the closures increased general travel time by 3,600 hours per day with 56 percent of this increase born by auto and truck travelers. On the 16th Street screenline the increase is 2,700 hours with 80 percent autos and trucks.

From the perspective of D.C. residents and K Street travelers the closures of E Street and Pennsylvania Avenue had positive and negative effects. Auto and truck travel times increased by 450 hours per day. This averages out to about 5 seconds per trip. Transit travelers benefited from the closures due to more direct transit routes and more frequent service closer to K Street. The 100 hours of benefits in the K Street corridor is equivalent to 4.0 minutes of travel time savings per traveler.

Table 9: 2020 daily person travel benefits by area and mode

2020 Daily Person Travel Benefits* over the Do Nothing Alternative by Area and Mode										
		Existing K Street			Reconfigured K-Street with Transitway					
Area and Mode	**All Open**	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Net Study Area Benefits										
Autos & Trucks	2,800	0	19,750	21,800	-950	2,200	-4,050	17,650	-3,000	-4,300
Buses & Trains	3,800	850	700	800	350	-350	500	1,450	2,350	3,000
All Modes	6,600	850	20,450	22,600	-600	1,850	-3,550	19,100	-650	-1,300
Net 16th Street Screenline Benefits										
Autos & Trucks	2,150	250	3,500	4,750	-350	-550	-1,400	3,900	-800	-1,250
Buses & Trains	1,850	400	100	500	-450	-1,050	-450	-50	750	1,000
All Modes	4,000	650	3,600	5,250	-800	-1,600	-1,850	3,850	-50	-250
Net K Street Corridor Benefits										
Autos & Trucks	20	0	-20	20	-40	-50	-40	10	-30	-50
Buses & Trains	0	10	-10	0	-10	-10	-10	-20	40	70
All Modes	20	10	-30	20	-50	-60	-50	-10	10	20
Net D.C. Resident Benefits										
Autos & Trucks	450	-50	6,250	7,800	-900	-500	-1,200	6,500	-1,250	-1,600
Buses & Trains	350	450	100	200	-700	-1,250	-700	-250	500	950
All Modes	800	400	6,350	8,000	-1,600	-1,750	-1,900	6,250	-750	-650
*Benefits are defined as a reduction in travel impedance expressed as the equivalent number of hours of in-vehicle travel time										

Expanded DC Circulator

The expanded DC Circulator routes make the system performance slightly better for highway and transit travelers crossing the 16th Street screenline. The total benefits mitigate 11 percent of the closure effects. The travel times for K Street transit travelers and D.C. auto travelers increase slightly, but the overall benefit for D.C. transit travelers is 350 hours per day.

Traffic Management

The traffic management alternative improves study area auto and truck travel by 19,750 hours and transit travel by 350 hours per day. The 16th Street screenline auto travelers experience 18 percent of these benefits while transit travel is made worse. K Street corridor and D.C. transit travelers are negatively affected by this alternative. Since D.C. residents only experience 32 percent of the study area benefits, Virginia and Maryland travelers receive most of the auto benefits.

Traffic Operations

The traffic operations alternative generates 21,800 hours of auto and truck benefits and 350 hours of transit benefits. About 22 percent of the auto benefit and 43 percent of the transit benefit are experienced by travelers crossing the 16th Street screenline. Since D.C. transit travelers loss benefits and only 36 percent of the auto benefits go to D.C. residents, Virginia and Maryland travelers receive most of the auto and transit benefits generated by the traffic operations improvements.

K Street Busway

The busway alternative makes auto and truck travel worse for all summary areas. Positive transit benefits are shown in all areas except the 16th Street screenline. Since the K Street corridor and D.C. residents experience significant transit benefits, the busway increases travel times for Virginia and Maryland transit travelers who crossing the 16th Street screenline.

The 210 hours of transit benefits provided by the busway to travelers who start and end their trip in the K Street corridor is highly significant. This represents an average savings per transit trip equal to 8 minutes of in-vehicle travel time or 16.6 percent of total travel impedance. Much of this benefit is related to reduced waiting time and more direct service.

K Street Busway with Traffic Management

Adding traffic management to the busway generates 2,200 hours of auto and truck benefits in the study area and improves auto and truck travel for D.C. residents by 400 hours. Trips crossing the 16th Street screenline and transit trips made by D.C. residents are made worse. These results reinforce the finding that combining a busway with traffic management on H, I, and K Streets creates a fragile system that has no reserve capacity to accommodate increased demand or network disruptions.

K Street Busway with Passing Lanes

K Street transit travelers are the only people who benefit from adding a passing lane to the busway. The diversion of auto traffic to other streets makes conditions worse for all other travelers. The net effect is a reduction in travel time crossing 16th Street and throughout the study area. The delays to auto travelers are increased by a factor of four over the busway without passing lanes.

K Street Busway with Passing Lanes and Traffic Operations

Combining the busway with passing lanes with traffic operations improvements enhances the benefits generated by each alternative separately. The operations improvements fully compensate for the negative effects of the busway on auto and truck travel. The auto and truck improvements also increase the transit benefits generated by the busway.

This alternative also more than mitigates the travel time reductions caused by the closures. Auto travel by D.C. residents improves by a factor of 14; auto travel in the study area improves by a factor of 9; and auto travel across the 16th Street screenline improves by 80 percent. Transit travel on the K Street corridor and by D.C. residents improves substantially as well. The only travelers who are not fully mitigated by the alternative are transit travelers from Virginia and Maryland.

K Street Busway with Passing Lanes, Expanded DC Circulator Routes, and a Free Fare Zone on the Busway

Replacing traffic operations improvements with expanded DC Circulator routes and a free fare zone on the K Street busway somewhat dampens the negative effects of the busway with passing lanes on auto and truck travel in the study area. In all cases this is compensated by substantial increases in transit benefits. The overall benefits to D.C. residents and in the K Street corridor more than compensate for the travel time lost by the street closures.

The 270 hours of transit benefits provided by the busway to travelers who start and end their trip in the K Street corridor represents an average savings per transit trip equal to 10.5 minutes of in-vehicle travel time or 21.8 percent of total travel impedance. Much of this increased benefit is related to the free fares on the K Street busway.

K Street Streetcar with Expanded DC Circulator Routes and a Free Fare Zone on the Busway

Including streetcars on the K Street busway increases transit benefits in all areas and makes auto travel worse in all areas. Most transit benefits go to D.C. residents and the largest increase in travel time of any alternative is experienced by the study area auto and truck travelers.

5.3.7 Mobility: Distribution of Benefits

The conditions experienced by individual travelers are not well described by a single average travel benefit measure. Not all travelers are affected equally by a given improvement. Travelers face various conditions depending upon when they travel, where they travel, and what mode they use. For example, most E Street travelers saw their travel time grow following the closures. People who approach downtown at its periphery were able to modify their travel route to avoid the immediate closure area, adding one to two minutes to their travel time. By contrast, people who begin and end their trip near E Street on opposite sides of the closures have seen their travel time rise by as much as fifteen minutes. The wide range of individual experiences means some people are able to adapt with a small gain in travel time while others are more noticeably inconvenienced by the closures. The degree of inconvenience is relatively high near the closure area and decreases as the area under consideration widens and off-peak travel conditions are included.

Key Findings

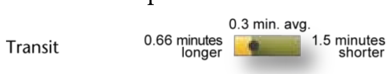
- The average travel benefit of most alternatives is relatively low.
- The range of impacts on individual travelers reveals noteworthy differences among the alternatives.
- The transit alternatives result in longer travel times for bus riders and for auto/truck transit travelers across the study screenline.
- The traffic operations alternatives reduce travel times for both auto/truck and transit travelers.
- The highest range of travel benefits is associated with operations improvements.

One way to distinguish the relative performance of alternatives with similar average values is to consider the range of individual traveler impacts. For this type of analysis it is helpful to quantify the distribution of benefits experienced by all travelers and focus on the high and low values of "most" travelers. In this case, "most" travelers is defined as 85 percent of all travelers. This means that seven and one-half percent of travelers have benefits greater than the high value and seven and one-half percent of travelers have dis-benefits lower than the low value. The majority of travelers are somewhere between the low and high value.

The results are depicted in a series of charts on the following pages for two groups of travelers: (a) travelers crossing the 16th Street screenline and (b) all travelers in the downtown study area. Transit travelers are distinguished from auto/truck travelers to discern how alternatives affect different travel modes. Two complementary charts are shown. Charts on the top show the typical range of benefits for transit patrons and auto/truck travelers. The bottom summary chart shows the total user benefit accrued for each alternative.

An example comparing pre-closure and post-closure conditions (of Pennsylvania Avenue and E Street) is highlighted below to illustrate the concept. The average travel benefit is identified as a dot. The green bar shows the range of travel time benefits (i.e., shorter travel times). The orange bar shows the range of travel time increases. The length of the bar indicates the range of impacts experienced by most travelers. A larger range means that some travelers have a much longer or shorter travel time impact than the average traveler. A smaller range indicates that few travelers experience notable differences in the length of their trip through downtown.

For example, the *average* transit patron crossing the screenline would save about one-third of a minute if the streets were open and buses traveled on their prior routes. The overall range of benefits is relatively narrow. A



high travel time savings benefit would be about 1.5 minutes; a high disbenefit would be a longer travel time of about two-thirds of a minute. These changes would affect about 41,500 transit riders, many of whom would experience very small travel time differences. The overall net daily benefit would be 1,850 hours.

Truck and automobile drivers and passengers crossing the screenline would experience a wider range of benefits if the streets were open. This reflects the relatively large impact of the street closures on trips that begin and end near Pennsylvania Avenue and E Street in the vicinity of President's Park. For example, a person traveling by taxi from one side of the closure to another might experience a twelve minute delay. When this analysis is broadened to consider all truck and automobile travelers crossing the screenline, the higher end travel time savings is reduced to about five and one-third minutes. Congestion costs to travelers who approach, but do not traverse the re-opened sections would cause some travelers to lose nearly three minutes of travel time. Many more travelers would gain time than lose time. The changes would directly benefit a majority of the 133,500 travelers who cross the screenline. The overall net daily benefit would be 2,100 hours.

The transit disbenefits from the street closures are lower than the truck/auto disbenefits because (a) rail was not directly affected by the closures; (b) buses make frequent stops and travel at lower speeds than general traffic; and (c) bus routes were rerouted closer to the core of the central employment district, resulting in shorter walking times between bus stops and bus rider origins/destinations.

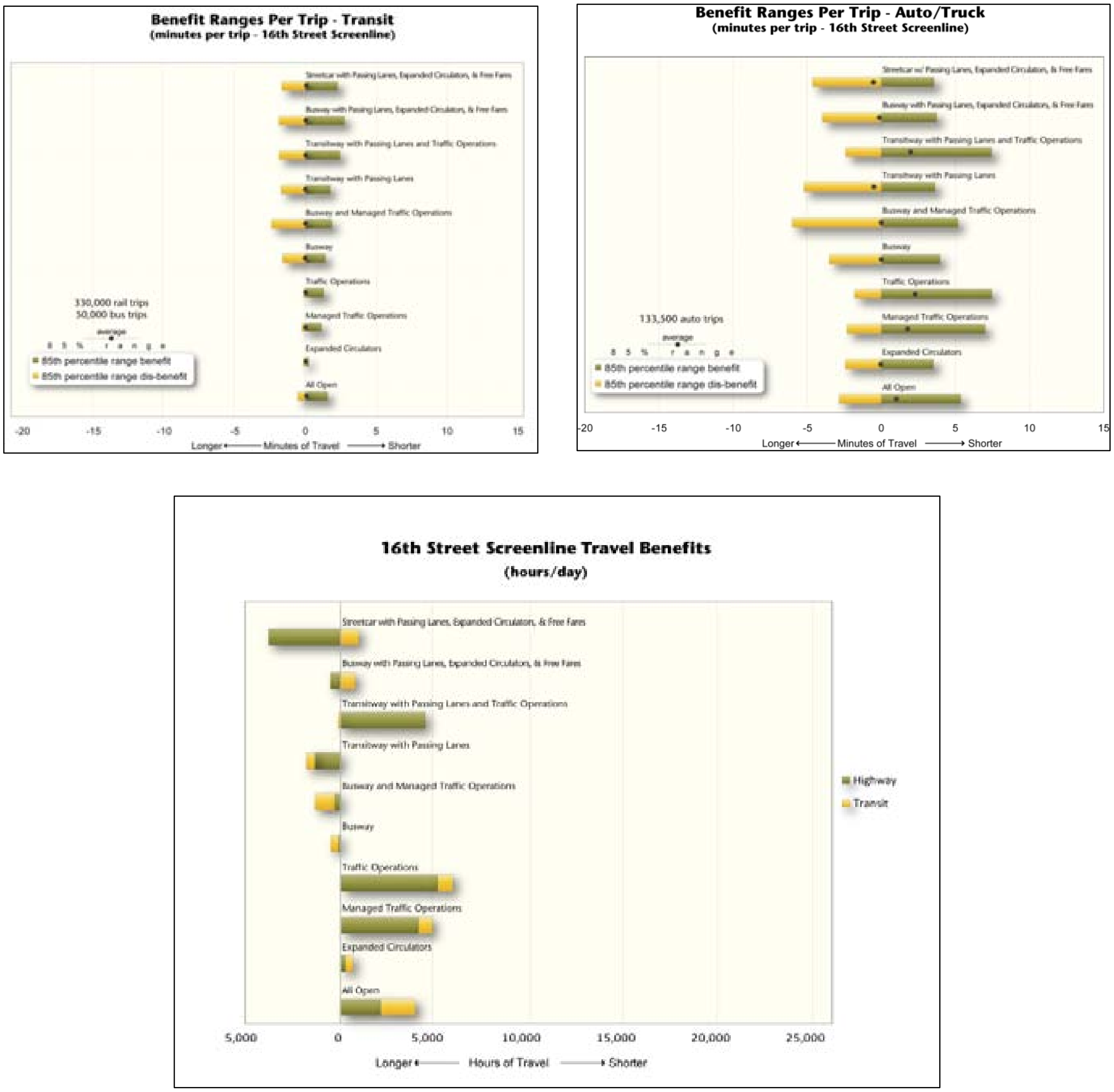
A comparison of the alternatives under consideration follows.

Travel user benefits for transit travelers crossing the 16th Street screenline are shown in Figure 43 and summarized in Table10. The average impacts are all close to zero. This is partly because Metrorail carries the vast majority of transit patrons crossing the 16th Street screenline and Metrorail travel times and costs are not affected by the proposed alternatives. People traveling by bus experience a relatively narrow range of benefits and disbenefits of about ± 3minutes. Three of the alternatives have virtually no negative impact on bus travelers while others have a range of both positive and negative impacts. The busway, busway with managed traffic operations, and busway with a three-lane cross section all result in transit traveler disbenefits. The streetcar; busway with passing lanes, free fares, and expanded circulators; traffic operations; expanded circulators alone; and traffic management alternatives all provide a travel time savings benefit. The streetcar provides about twice the benefit of traffic operations alone, due to the increased service levels associated with the streetcar operations. Combining the traffic operations alternative with the busway lessens the travel time burden on transit patrons by about 400 hours per day. The most balanced benefits are associated with the all-open or pre-closure condition.

Table 10: 2020 daily person travel benefits across the 16th Street Screenline

16th Street Screenline Travel Benefits (hours/day)			
Alternatives	Highway	Transit	Total
Busway with Traffic Operations	4,500	-50	4,450
Busway with Traffic Management	-150	-1,050	-1,200
Traffic Operations	5,250	500	5,750
Traffic Management	4,100	100	4,200
Streetcar	-1,100	1,000	-100
Busway Passing Lane, Exp. Circ, Free Fares	-550	750	200
Busway w/ Passing Lane	-1,300	-450	-1,750
K Street Busway	100	-450	-350
Expanded Circulator	300	400	700
All Open	2,100	1,850	3,950

Figure 43: Range of auto/truck traveler benefits crossing the 16th Street screenline



Truck/auto travelers crossing the 16th Street screenline are shown in Figure 43. Most of the stand alone transit alternatives impose longer travel times on truck/auto traffic. The increase is relatively small, at about one minute per trip. Overall travel times for truck/auto travel would increase between 150 and 1,300 hours per day; the majority of travelers crossing the screenline would be affected. The traffic operations alternatives benefit the average truck/auto traveler by one and a half to two minutes. Some travelers would save about seven minutes of travel time. The traffic operations alternative would provide about 5,250 hours of benefit per day to auto/truck travelers. Combining the traffic operations alternative with the busway lessens the total travel time benefit to auto/truck travelers by about 750 hours per day. This is about twice the level of benefit gained by bus riders from combining the alternatives, which suggests that improved operations would significantly improve bus travel times and reliability. The streetcar, which provides 1,000 hours of benefit to transit riders would impose 1,100 additional travel hours on general truck/auto traffic.

The greatest overall (transit and truck/auto) travel time savings are associated with the traffic operations improvements. Up to 5,750 hours per day of travel time savings could be realized.

The level of benefits accruing to travelers grows when the analysis is expanded to the entire study area because there are many more travelers in the study area than travelers who cross the 16th Street screenline. Transit benefits grow because many of the transit improvements accrue to bus passengers traveling outside the core area of the 16th Street screenline.

Travel user benefits for all travelers in the study area are summarized in Table 11and shown in Figure 44.

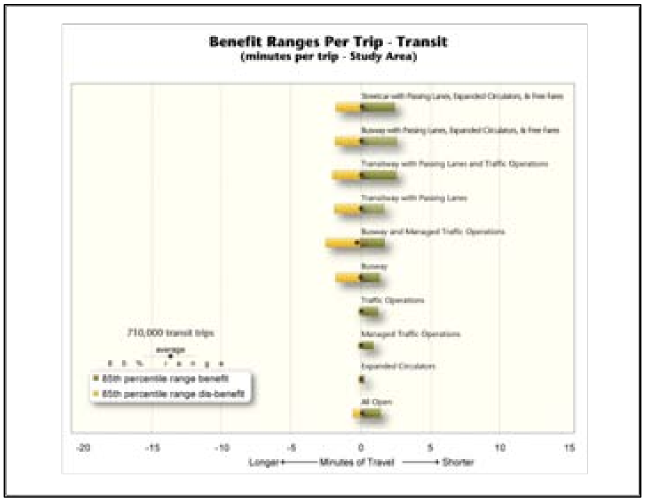
Table 11: 2020 daily person travel benefits across the study area

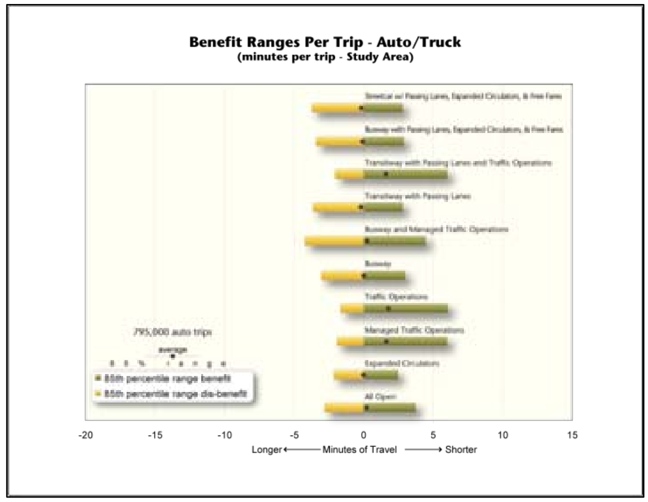
Study Area Travel Benefits (hours/day)			
Alternatives	**Highway**	**Transit**	**Total**
Busway with Traffic Operations	19,900	1,450	21,350
Busway with Traffic Management	3,150	-350	2,800
Traffic Operations	23,700	800	24,500
Traffic Management	21,950	700	22,650
Streetcar	-3,800	3,000	-800
Busway Passing Lane, Exp. Circ, Free Fares	-2,300	2,350	50
Busway w/ Passing Lane	-3,700	500	-3,200
K Street Busway	450	350	800
Expanded Circulator	100	850	950
All Open	2,800	3,800	6,600

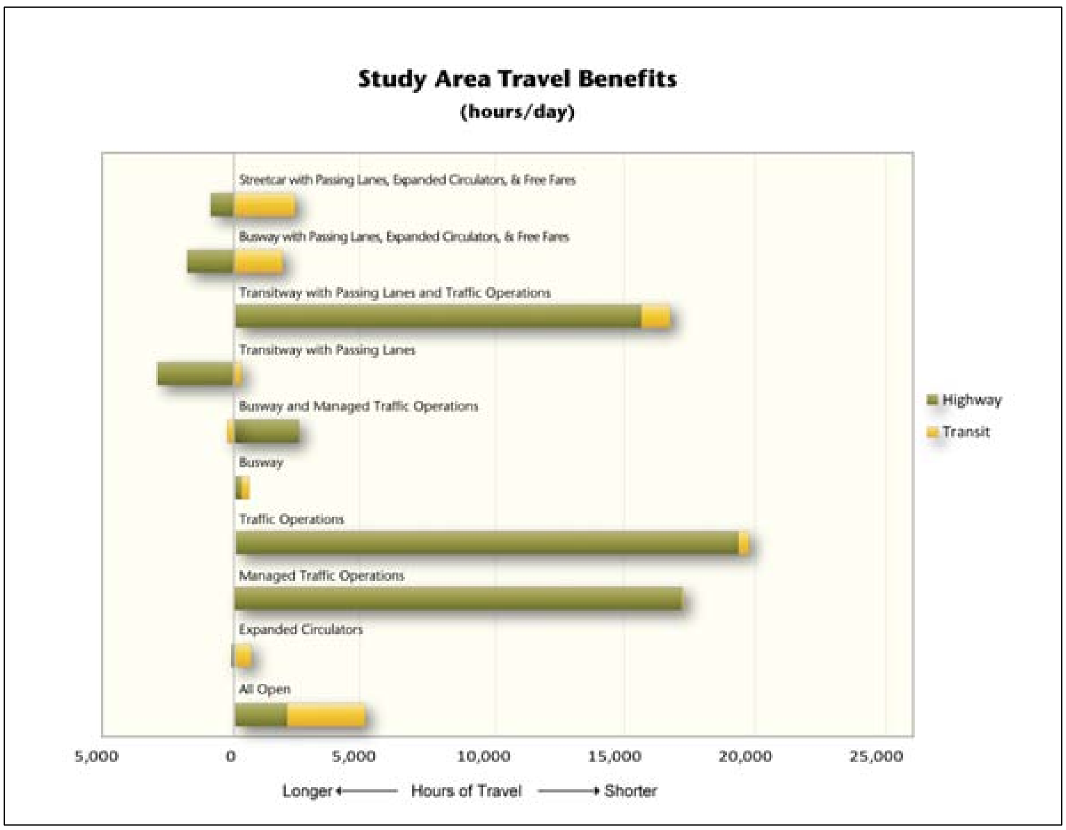
Transit travel time benefit increases are highest with the Streetcar; Busway with Passing Lane, Expanded Circulators, and Free Fares; and Busway with Traffic Operations alternatives. The remaining alternatives show smaller, more modest gains. None of the transit gains are at the level of the all-open condition, meaning the alternatives, while providing substantial benefit, do not serve to mitigate the closure actions on bus riders across the study area.

Truck/auto travel time benefits across the study area are dramatically higher. Most of the nearly 800,000 vehicular trips in the study area would benefit from the operations alternative. Up to 24,500 hours per day of travel time savings could be achieved, with most travelers averaging about two minutes of benefit. Combining the busway with traffic operations would provide over 21,000 hours of daily travel time savings. Over 90 percent of the benefit is associated with truck/auto travel.

Figure 44: Range of transit traveler benefits crossing the 16th Street screenline







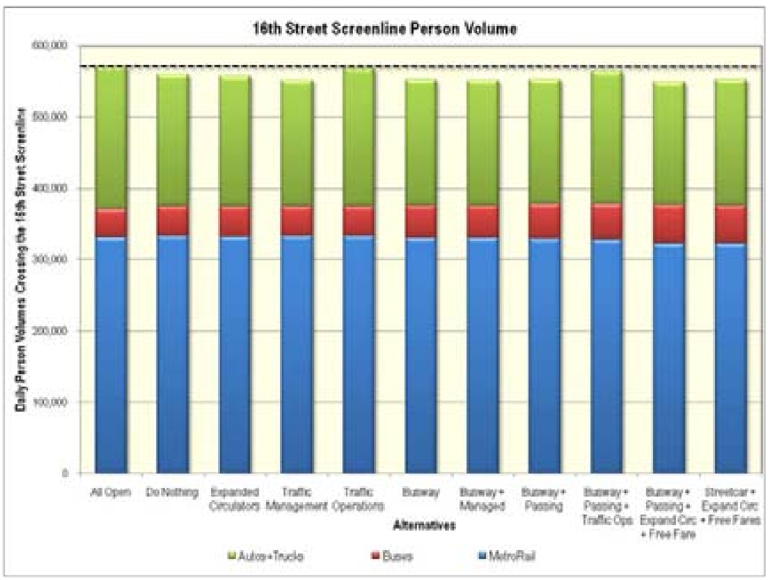
5.4 Mitigation of Effects

The transit and traffic operations alternatives provide benefits to travelers throughout downtown. These benefits may or may not mitigate the consequences of closing E Street and Pennsylvania Avenue near the White House. This section evaluates the performance of the alternatives using the mitigation objectives identified for the White House study.

5.4.1 Mobility: Relieve Adjacent Streets

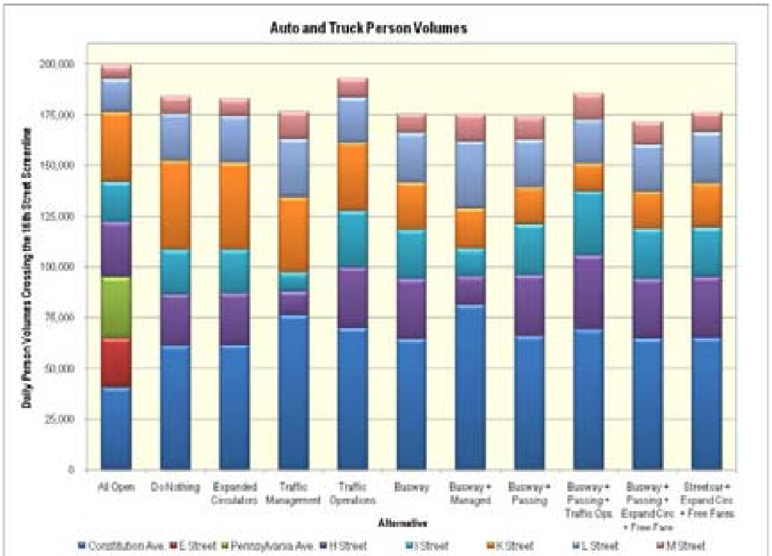
From the perspective of restoring the total person throughput across the 16th Street screenline, only the two alternatives that include traffic operations improvements mitigate a portion of the closure effects. All other alternatives make the situation worse. If only traffic operations improvements are implemented, 82 percent of the closure effect on the 16th Street screenline is mitigated. If the traffic operations improvements are added to a busway with passing lanes, 39 percent of the closure effect is mitigated.

Figure 45: 16th Street screenline daily person volumes



The distribution of auto and truck volumes on the adjacent streets within the 16th Street screenline varies considerably by alternative. The all-open scenario shows a relatively uniform distribution of traffic among all of the streets. The do nothing alternative shows significant increases on Constitution Avenue and K Street. Traffic management further increases the burden on Constitution Avenue by significantly reducing the carrying capacity of H and I Streets. The traffic operations alternative generates higher total volumes and a more balanced distribution. The busway alternatives reduce volumes on K Street and increase traffic on H, I, L, and M Streets.

Figure 46: 16th Street screenline auto and truck volumes



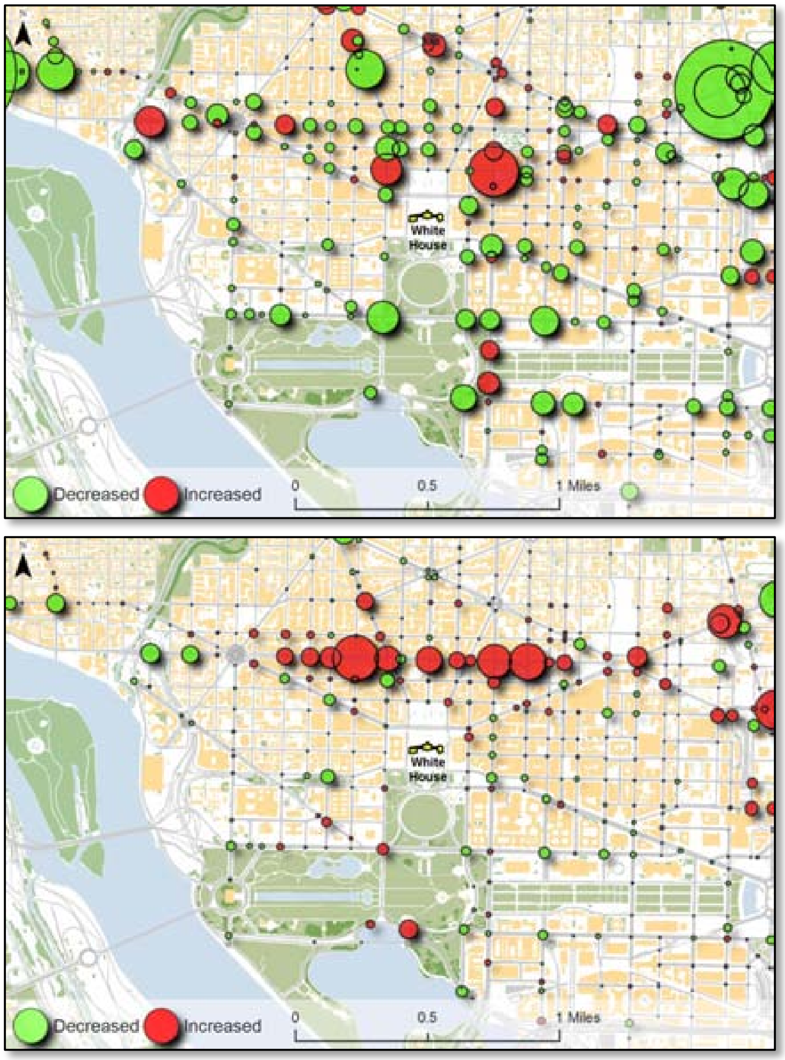
5.4.2 Mobility: Reduce Travel Time

Many of the alternatives mitigate increases in overall travel time, but relatively few alternatives help highway and transit travelers at the same time. The traffic operations alternative produces benefits that are several times greater than the travel time effects on auto and truck travelers and mitigates about 25 percent of the transit effects. Adding traffic operations to a busway alternative is necessary to mitigate the negative effects of the busway on auto travelers. It also enhances the benefits of the busway for transit travelers.

5.4.3 Mobility: Reduce Congestion

Only the alternatives that include traffic management or traffic operations mitigate the congestion consequences. From the perspective of cycle failures and the duration of congested travel conditions, most of the alternatives make congestion worse for highway and transit travelers. The traffic management alternative primarily improves north-south travel while the traffic operations alternative reduces congestion for all directions and modes of travel.

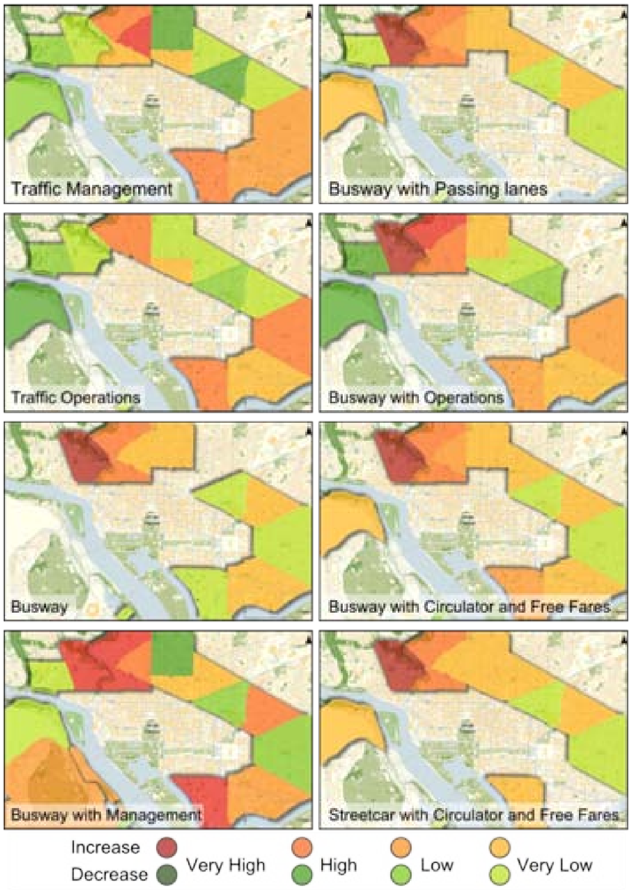
Figure 47: Change in cycle failures from do-nothing for the traffic operations alternative (top) and the K Street busway (bottom)



5.4.4 Mobility: Reduce Neighborhood Traffic

The following maps show the effect of each alternative on neighborhood traffic. The traffic management alternative reduces traffic in the northeast and northwest. The traffic operations alternative has slightly less effect on the northeast, but greater benefits for the west. The busway alternatives show improvements for the east and southeast, but increase neighborhood traffic in the northwest. Alternatives that combine a busway with traffic improvements show mixed results.

Figure 48: Changes in neighborhood traffic



5.4.5 Mobility: Benefit Transit and Pedestrian Travel

Most of the alternatives are designed to benefit transit and pedestrian travel, but relatively few actually achieve the desired goal. The K Street busway provides some travel time benefits for transit travelers along K Street if the facility is operated effectively. Unfortunately, the improvements needed for efficient operations further reduce traffic capacity, which in turn makes the streets more congested for autos and buses. The analysis demonstrates that more benefits are provided to transit travelers by improving traffic operations than by investing in a K Street busway.

5.4.6 Accessibility: Reconnect Street Grid

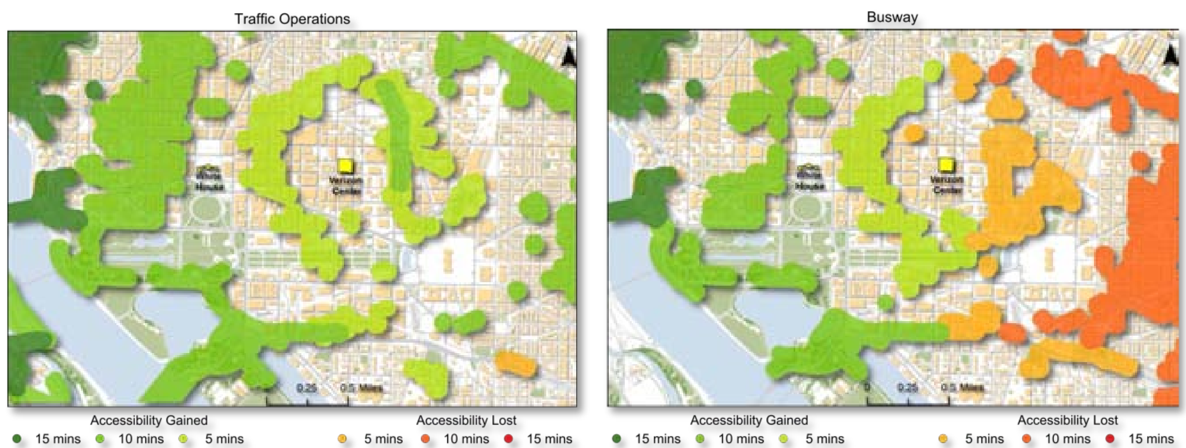
None of these alternatives do anything to reconnect the street grid. All of the busway alternatives further reduce the capacity of the street grid. The traffic management alternative also harms the street grid by reducing vehicle capacity on H, I, and K Streets.

Traffic management and traffic operations do, however, include improvements to a number of key intersections that are bottlenecks for travel into and out of downtown. Both of these alternatives also include designated routes around downtown to improve traffic circulation. By making relatively minor repairs to the street grid, the traffic operations alternative is quite effective at improving the throughput and travel times within downtown.

5.4.7 Accessibility: Increase Accessibility

Accessibility is defined as the number of people and places that can be reached in a given amount of travel time. The following graphic shows the additional areas that can be reached in 5, 10, and 15 minutes from the Verizon Center at 5 p.m. using an automobile.

Figure 49: Changes in accessibility from the Verizon Center



5.4.8 Accessibility: More Intuitive Travel Paths

One of the objectives of the traffic management and operations alternatives is to designate routes through and around downtown that are clearly marked and controlled. These alternatives also propose reductions in sign clutter to make it easier for tourists and other infrequent visitors to find the information they need to navigate effectively through downtown.

The K Street busway has the potential of making transit travel in downtown more intuitive. Tourists and infrequent travelers are more likely to use a transit system with clearly designated facilities rather than a ubiquitous but confusing set of bus routes. The DC Circulator system also benefits from a few clearly designated routes within downtown. This advantage will decrease as more routes are added.

5.4.9 Reliability: Improve Resilience

Resilience reflects the stability of the network during periods of increased travel demand or when streets are closed due to accidents or special events. The analysis shows that conditions degrade in the year 2020 if nothing is done to mitigate the closures. Additional travel demand or additional special event street closures can easily cause the network performance to collapse. If improvements are made to traffic operations, the system is able to absorb the types of capacity reductions included in the traffic management alternative (i.e., pedestrian and transit friendly improvements to H, I, and K Streets). If these improvements are not made, reducing auto capacity by introducing a K Street busway degrades the overall performance of the street system for auto and transit travelers. The only alternative with sufficient reserve capacity to absorb more than a minor fluctuation in supply or demand is the traffic operations alternative.

5.5 Summary of Findings

The overall performance of the transit and operational alternatives is summarized in the following two tables. The first table summarizes each alternative based on its ability to mitigate the consequences of the closures of E Street and Pennsylvania Avenue. In this case the performance of each alternative is compared to the performance of the all-open scenario. Green cells show performance measures that are mitigated by the alternative and red cells highlight performance measures that are not mitigated. Darker colors represent larger positive or negative differences.

The second table summarizes the performance of each alternative to the do-nothing alternative. In this case a green cell means the performance measure improved and a red cell means the performance is worse. A white cell means there is no significant difference between the alternative and the do-nothing condition.

5.5.1 All-Open Comparisons

The comparisons to the all-open scenario clearly show that the traffic management and traffic operations alternatives provide the greatest improvement in overall performance. For these alternatives all of the performance measures are significantly mitigated. Adding traffic operations improvements to the busway is the only way the busway alternatives mitigate the consequences of the closures. Without these improvements, the busway makes overall travel conditions in the study area worse. Not even traffic operations improvements, however, are able to compensate for the increased number of person cycle failures introduced by the busway.

5.5.2 Do-Nothing Comparisons

Comparisons to the do-nothing alternative show a number of performance improvements. None of the alternatives have a significant effect on the total person-miles of travel in the study area. The traffic management and traffic operations alternatives are clearly strong in all performance categories. The busway with passing lanes and traffic operations also shows positive benefits for all performance measures. The busway with traffic management shows improvements for most categories. The expanded DC Circulator alternative also has a positive effect on person cycle failures.

5.5.3 Transit-Related Findings

The introduction of a busway on K Street benefits bus travelers in the immediate vicinity of the busway, but does not extend the benefits to the areas affected by the closure of E Street and Pennsylvania Avenue. In fact, the busway makes transit travel adjacent to the White House and President's Park more difficult because many of the bus routes that originally served the White House area are re-routed onto the K Street busway.

In addition, the reconfigured K Street provides less capacity for automobile traffic, which results in increased traffic diversions to parallel streets. This increases the congestion levels and travel times on these streets, which in turn affects automobile and transit travelers on these streets. The benefits to transit travelers on K Street are more than offset by the reduction in system performance in all other areas.

The busway is less successful at addressing the effects of the closures on queues, delays, cycle failures, and person-hours of travel throughout downtown. In most cases, the busway has a negative effect on these performance measures for auto and transit travelers in the study area.

Most of these negative effects can, however, be mitigated by introducing traffic operations improvements. These improvements enable the busway and all other streets in the study area to operate more effectively. This results in greater throughput and reduced travel times.

5.5.4 Traffic Operations-Related Findings

The analysis demonstrates that there are significant opportunities to improve the efficiency of the downtown street system through traffic operational improvements. These improvements reduce travel times, queues, cycle failures, and delays in a broad area and benefit most auto and bus travelers within downtown.

The traffic management strategy generates significant benefits, but most of these benefits are realized by autos traveling north-south through downtown. Because the street closures primarily affect east-west travel, the benefits of traffic management do little to improve travel conditions for the people directly affected by the closures.

The traffic operations alternative, on the other hand, is specifically optimized to improve east-west travel and as such mitigates more of the direct consequences of the closures. The increases in east-west throughput and travel speeds benefit transit travelers in addition to autos and trucks. Less congestion on the street system means less congestion for buses in mixed traffic.

Operational efficiencies can also improve the performance of the K Street busway. Higher speeds enable H, I, L, and M Streets to accommodate more of the auto traffic, which makes it easier to optimize the busway operations on K Street.

Figure 50: Performance summary based on the all-open scenario

Percent Change in 2020 Daily Study Area Total Person Performance Statictics									
Performance Measures Compared to the All-Open Scenario	**Existing K-Street**			**Reconfigured K-Street**					
	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Miles Traveled (PMT)									
Congested Miles Traveled									
Hours Traveled (PHT)									
Congested Hours Traveled									
Cycle Failures									
Congestion Duration									
Average Speed (MPH)									

Figure 51: Performance summary based on the do-nothing alternative

Percent Change in 2020 Daily Study Area Total Person Performance Statictics									
Performance Measures Compared to the Do Nothing Scenario	**Existing K-Street**			**Reconfigured K-Street**					
	Expanded Circulators	Traffic Management	Traffic Operations	Busway	Busway with Traffic Management	Busway with Passing Lanes	Busway with Passing Lanes & Traffic Operations	Busway with Passing Lanes, Expanded Circ. & Free Fares	Streetcar with Expanded Circ. & Free Fares
Miles Traveled (PMT)									
Congested Miles Traveled									
Hours Traveled (PHT)									
Congested Hours Traveled									
Cycle Failures									
Congestion Duration									
Average Speed (MPH)									

<-----worse better ----->

6 Summary

The White House Area Transportation Study considers and evaluates a variety of potential alternatives to alleviate congestion, compensate for discontinuities in the downtown street grid, and restore congestion to pre-closure conditions in the immediate vicinity of the White House following the closures of E Street and Pennsylvania Avenue. Strategies to repair and reinforce the street grid encompass a series of individual short and long tunnel options. The United States Secret Service issued a Federal Register notice for the permanent closure of E Street in the spring of 2011. Given that the cost associated with mitigating the closure by constructing a tunnel is high, the study also evaluates transit and traffic operational improvement alternatives.

The historic and symbolic nature of the Federal core determines the type of possible actions that can be taken to improve travel conditions caused by the White House area street closures. Accordingly, the study resulted in the following findings:

- A series of short and long tunnel options all have high capital and non-capital costs from an environmental and historic perspective. Of the tunnel options, a long tunnel connecting the E Street Expressway to the eastern half of downtown could mitigate many negative travel impacts but would be very expensive and entail large-scale disruption.

- Transit operational improvements can facilitate faster and more reliable east-west bus service in and adjacent to the transitway; however, this option would not benefit riders in the vicinity of the White House closures. K Street transit improvements, as considered as part of this analysis, would create additional congestion on the remainder of the downtown surface transportation network, reduce K Street's vehicular capacity and functionality, and shift traffic onto streets already impacted by the closures.

- The adoption of traffic operations improvements could provide numerous travel time benefits and offset many of the congestion-related problems caused by the closures. The street network would regain a degree of resiliency and provide some flexibility for implementing transit improvements.

The study presents analytical information to address congestion resulting from street closures in the immediate vicinity of the White House. While the report does not provide specific recommendations to decision makers, it does contain valuable information that is necessary and appropriate for local decision makers to deliberate, develop, and implement alternatives to address the congestion issue.

7 Study Participants

7.1 Steering Committee

The steering committee assisted FHWA in the assessment transportation improvements in accordance with the request of Congress. The steering committee provided general guidance on the study scope, the performance criteria to be considered, the approach to public outreach, and the alternatives to be evaluated. In addition, the committee was consulted on the results of the transportation analysis and the content of the final report. The steering committee met periodically over the course of the study. The steering committee did not vote on or approve any specific study elements or results.

Mr. Marcel Acosta
Executive Director
National Capital Planning Commission
401 9th Street, NW
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Mr. Nat Bottigheimer
Assistant General Manager, Planning and Joint Development
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Mr. Tom Dougherty
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Mr. Terry Bellamy
Director
District of Columbia Department of Transportation
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Mr. Chris Lawson (Chair)
DC Division Administrator, FHWA
Federal Highway Administration
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Ms. Peggy O'Dell
Regional Director, National Capital Region
National Park Service
1100 Ohio Drive, SW.
Washington, DC 20242

Ms. Harriet Tregoning
Director
DC Office of Planning
1100 4th Street, SW, Suite E650
Washington, DC 20024

7.2 Working Group

The working group was represented by Federal, District, and regional agencies with jurisdiction in the Monumental Core of downtown Washington. The Federal Highway Administration chaired the group. The following agencies served on the working group: District of Columbia Department of Transportation; District of Columbia Office of Planning; National Park Service; National Capital Planning Commission; United States Secret Service; the Washington Metropolitan Area Transit Authority; and the Metropolitan Washington Council of Governments. Members of the steering committee designated the working group members. Other staff joined meetings to provide specific expertise.

The working group met monthly and assisted FHWA by providing valuable feedback throughout the course of study. The working group also provided information from prior studies, identified and supplied applicable data to support the study, and commented upon the methodologies employed in the study. The working group was consulted on the alternatives proposed for detailed evaluation, the evaluation criteria, the results of the travel analyses, and the content of the final report. The working group did not vote on or approve any specific study elements or results.

Federal Highway Administration
Fred Ducca
Brian Gardner
Michael Hicks
Sandra Jackson
Mark Kehrli
Doug Laird
Chris Lawson
Pam Stephenson

District Department of Transportation
Ramona Burns
Soumya Dey
Zach Dobelbower
Victor Ectu
Ogechi Eletmachi
Faisal Hameed
Tomika Hughey
Jeff Jennings
Douglas Noble
Kathleen Penney
Christopher Ziemann

District Office of Planning
Colleen Mitchell
Travis Parker

National Park Service
David Hayes
Susan Hinton

National Capital Planning Commission
Bill Dowd
Michael Garcia
Patrick Hart
David Levy
Michael Sherman
Tang Weihua
Ken Walton
Michael Weil

United States Secret Service
Lydia Canda
Pam Corry
Joseph DiPietro

Washington Metropolitan Area Transit Authority
Ramona Burns
Thomas Harrington
Scott Kubly
Wendy Jia

Metropolitan Washington Council of Governments
Mary Martchouk
Mark Moran

7.3 Consultant Team

A multidisciplinary team, represented by the following firms and individuals, was retained to provide expert services and support the study.

AECOM Consult
Jeffrey Bruggeman
Raymond Ellis
Hanan Kivett
Hasan El Sbayti
S. Neelisetty
Krishna Patnam
Prasanth Pulaguntla
Sashank Singuluri
David Roden
William Woodford
Michail Xyntarkis
Balaji Yelchuru

DMJM Harris
Ravi Amin
Chris Bell
Sheldon Fialkoff
Lee Farmer
Patrick Gough
Abi Lerner
Chris McGuire
Jason Mumford
Steven Shapiro

Balfour Technologies
Richard Balfour
Robert Balfour

EarthTech, Inc.
Laurent Cartayrade
Rick Sitek

Lee, Papa & Associates
Mark Papa
Gabriel Kruse

MCV Associates

BMI-SG of Vanasse Hangen Brustlin, Inc.
Charles O'Connell
Robert Gibson

Virginia Polytechnic Institute and State University
Chris Barrett
Keith Bisset
Henning Mortviet
Paula Stretz

7.4 Expert Panels

7.4.1 Model Technical Working Group

The Federal Highway Administration organized a Technical Working Group (TWG) to review and provide technical guidance on the White House Area Transportation Study. The TWG included academicians and practitioners from the public and private sector with an exceptional depth of expertise and experience in travel demand forecasting and travel simulation. They were selected for their knowledge and experience in the application and interpretation of advance travel modeling analysis tools.

Government Practitioners
Ken Cervanka, North Central Texas Council of Governments
Scott Higgins, Portland Metro

Private Sector Practitioners
Gary Davies, Urbitran
Ron Milam, Fehr & Peers

Academe
Joan Walker, University of California at Berkeley
Hani Mahmassani, Northwestern University

7.4.2 Traffic Operations Working Group

FHWA organized this working group to observe traffic conditions in downtown Washington and identify traffic operations strategies that might address traffic problems (a) observed during the field review and (b) raised by the FHWA study team on the basis of its extensive data collection, field observations, traffic modeling, and study efforts. The following served on this group:

Government Practitioners
Raj Ghaman, Federal Highway Administration
Neil Spiller, Federal Highway Administration

Private Sector Practitioners
Gary Davies, Urbitran
Fred Choa, Fehr & Peers

Academe
Hani Mahmassani, Northwestern University