Access & Opportunity

Columbia Pike Transportation

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APP Report
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This project would simply not have been possible without the guidance and support of so many. First and foremost, I want to thank the team at the Columbia Pike Revitalization Organization, specifically Kim Klingler and Amanda Lovins, for the opportunity to complete such an engaging and topical project.

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Finally, I want to thank my friends and family, whose love and support was never in question and always on my mind.

On my honor, as a student, I have neither given nor received aid on this assignment.

Brendan Novak

Cover Photo: Arlington Cinema & Drafthouse by Bekah Richards
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DISCLAIMER

The author conducted this study as a part of the program of professional education at the Frank Batten School of Leadership and Public Policy, University of Virginia. This paper is submitted in partial fulfillment of the course requirements for the Master of Public Policy degree. The judgements and conclusions are solely those of the author, and are not necessarily endorsed by the Batten School, by the University of Virginia, by the Columbia Pike Revitalization Organization, or by any other entity.

STATEMENT ON COVID-19

Extraordinary circumstances have emerged in Virginia, the United States of America, and the World. Coronavirus disease 2019 (COVID-19), has impacted every facet of life, and promises to continue disrupting the regular course of life for the foreseeable future. The health implications and the economic impact of the disease have significantly reduced vehicle traffic nationwide, and transit ridership in the Washington, D.C. metropolitan area is at a historic low. Meanwhile, the looming economic recession threatens to undermine tax revenues for state and local governments, absent significant support from the federal government. That is to say, the emergence of COVID-19, and the ongoing response by the government, has significant impacts on the assumptions and findings presented in this report. This by no means invalidates the information and recommendations contained therein, but does suggest that they should be interpreted with these everchanging circumstances in mind. My hope is that business will return to usual within a reasonable timeframe, in no small part due to the hard work and sacrifice of healthcare workers, researchers, policymakers, and our society. During this time of uncertainty, compassion, perseverance, and yes, rigorous policy analysis, have never been more important. Thank you again for reading, and above all, stay safe.

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EXECUTIVE SUMMARY

Columbia Pike is a critical corridor in the transportation network for Arlington and the broader Northern Virginia/Washington, D.C. metropolitan area. It is the busiest bus corridor in Virginia, and supports tens of thousands of vehicles daily. Its importance is only expected to grow in the coming years as the area experiences an economic boom, including the opening of Amazon's HQ2 which alone is expected to bring tens of thousands of new residents. In addition to inefficiency, the situation on the Columbia Pike corridor raises acute questions about equity. Columbia Pike is home to vibrant communities of racial minorities, recent immigrants, and low-income residents. Meanwhile, investment in public transit lags significantly behind peer corridors in the county, despite the fact that these communities rely disproportionately on public transit. *Transportation infrastructure on the Columbia Pike corridor is not optimized for current population and economic development trends, creating inefficiencies in the transportation network and imposing external costs on surrounding communities.*

The Columbia Pike Revitalization Organization is tasked with working alongside the county government, community members, and business leaders to guide investment that promotes smart, equitable growth. This paper evaluates opportunities for investment in transportation infrastructure in service of that goal. In addition to current planned investments, this paper considers two other major programs: peak hour bus rapid transit and light rail. Each option is evaluated on the criteria of net benefit, equity, and feasibility.

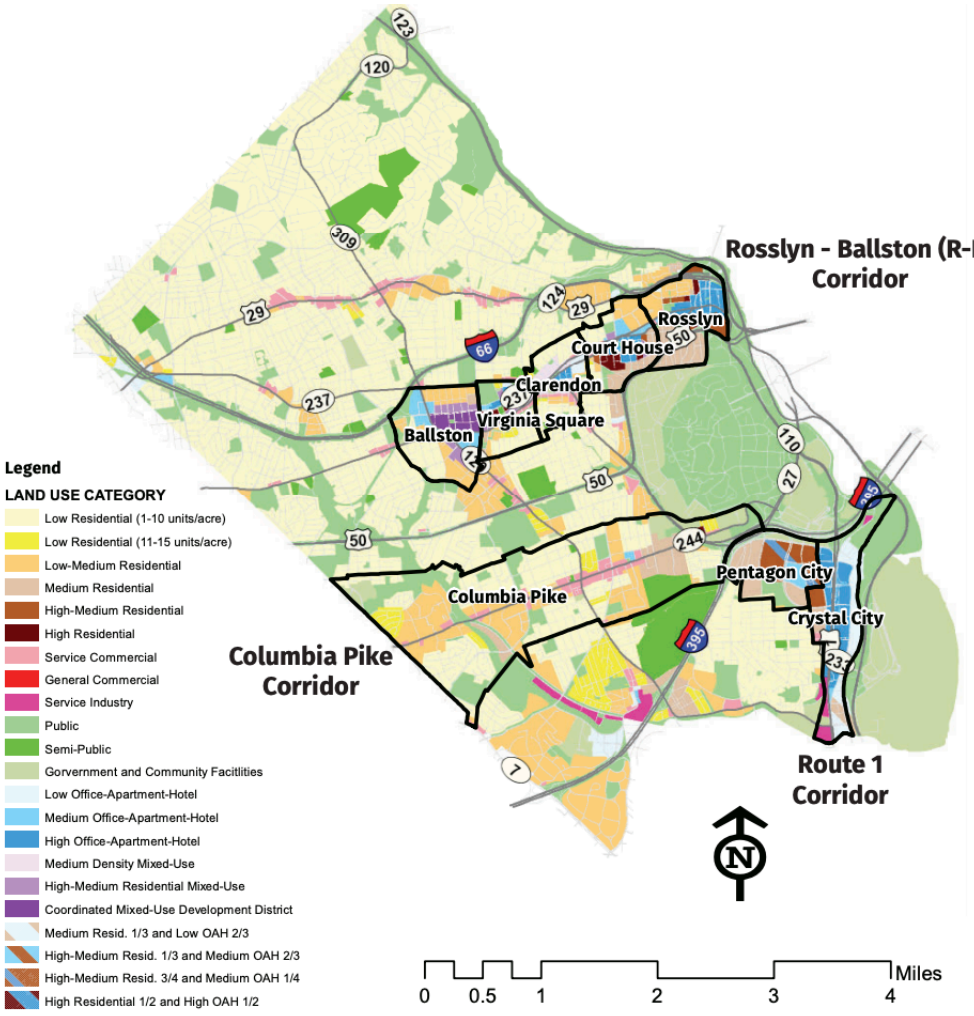
The final recommendation is to institute peak hour bus rapid transit on Columbia Pike. It provides significant benefits to transit users by reducing delays from traffic and improving reliability. It would connect residents of Columbia Pike more tightly to the broader regional transportation network, especially those with lower socioeconomic status.

BACKGROUND

Problem Statement

Transportation infrastructure on the Columbia Pike corridor in Arlington, Virginia is not optimized for current population and economic development trends, creating inefficiencies in the transportation network and imposing external costs on surrounding communities. The Columbia Pike Revitalization Organization (CPRO) is tasked with acting in conjunction with the county government to design and implement plans that foster smart growth on the Columbia Pike corridor, including transportation infrastructure.

Figure 1: Arlington County

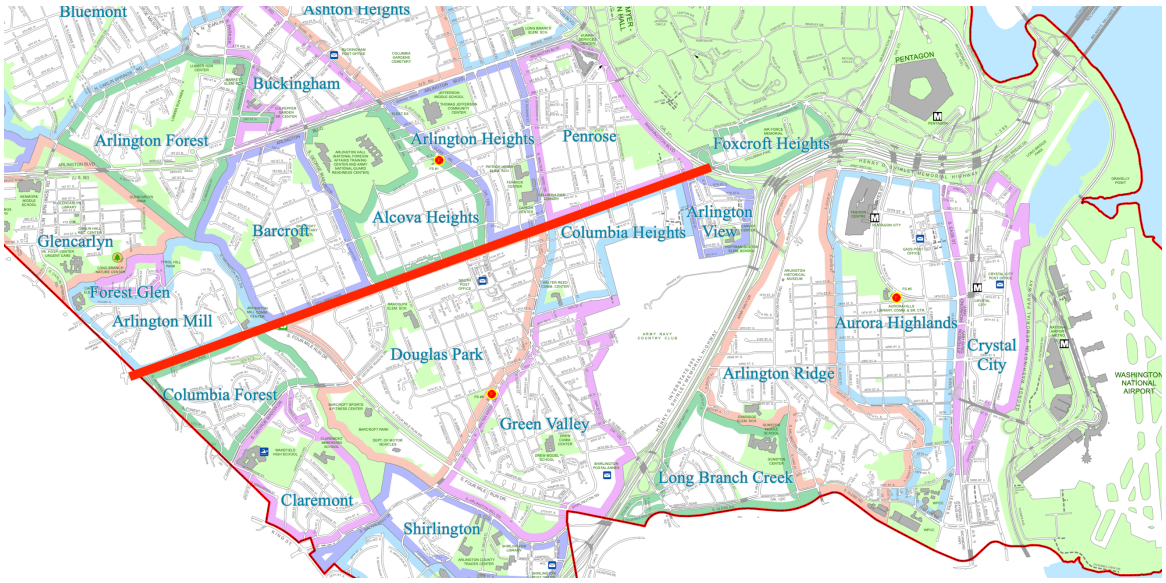


Source: https://maps.arlingtonva.us/

Brief History of Columbia Pike

Columbia Pike is among the oldest major corridors in Arlington, and one of three major planning corridors (areas designated for high-density development) in the county, along with the Rosslyn-Ballston (R-B) and Route 1 corridors. As of 2019, the corridor has a population of 39,300 residents. (Department of Community Planning, Housing, and Development Profile, 2019). The Pike is an east-west thoroughfare that has its eastern terminus near the Pentagon and runs the length of the county bisecting south Arlington, through Fairfax, and west to Annandale. The Arlington portion of the road dates back to a turnpike chartered by the federal government in 1810 that ran roughly along the same path as the modern-day Pike. It was first commercially developed in the early 1900's, when streetcar connections to other neighborhoods stimulated economic growth (Columbia Pike Development History, n.d.). In this time period, planning and development was oriented toward streetcar commuters and pedestrians. The Pike itself was characterized by a "street wall" of retail and apartments side by side, uninterrupted by parking lots (Columbia Pike History, n.d.).

Figure 2: Expanded view of Columbia Pike, in red



Source: https://maps.arlingtonva.us/

From the 1950's through the 1970's, development became more automobile-oriented, with new construction often consisting of fast food restaurants, drive through banks, and other retail with accompanying parking lots. During this time the Pike was widened to four lanes, doubling the area available for vehicle traffic (Liebertz, 2010). By the 1990's, traffic congestion on Columbia Pike reached unmanageable levels, and there was a sustained effort by county leaders and local stakeholders to implement more sustainable development of the corridor. These efforts culminated in a revitalization plan, released in 1990 and updated in the early 2000's. The revitalization plan emphasized smart growth, with dense development and transit-oriented planning. Until recently, the entirety of the road was owned and operated by the Commonwealth of Virginia. In 2010, the Commonwealth transferred ownership of the portion of the road within Arlington county to the local government, subject to a handful of binding conditions (Arlington County Board, 2010).

Scope of the problem

Vehicle traffic on the Columbia Pike imposes a litany of external costs on other travelers, surrounding communities, and the environment. Traffic congestion is a classic example of the common property resources problem: marginal public costs of consumption exceed marginal private costs, leading to the overuse of resources and socially inefficient outcomes (Brown, 1974). In other words, because drivers don't have to bear the full cost of their presence on the road to other drivers in the form of traffic, there will be too many drivers without some intervention. This issue is further compounded by the fact that it imposes costs in the form of longer travel times on public transportation riders (who have to share travel lanes with automobiles), exacerbating the under-consumption of transit which would otherwise reduce traffic congestion (Adler & Ommeren, 2016).

Aside from congestion, vehicle traffic on the Pike also contributes to air pollution. Automobiles emit a range of pollutants that impose external costs on surrounding communities and the global environment including greenhouse gases, nitrogen oxide, particulate matter, and others. These pollutants cause health problems and contribute to environmental issues such as acid rain and global climate change (EPA, n.d.). Another external cost associated with vehicle traffic is a decrease in safety for pedestrians, bikers, and other drivers due to the threat of collision (Southworth, 2005).

Dense development along the Columbia Pike corridor has led to strains on existing transit infrastructure. The corridor carries more bus riders than any other in the Commonwealth of Virginia, averaging nearly 20,000 boardings per day (Arlington Economic Development, n.d.). Meanwhile, automobile traffic averaged about 30,000 vehicles per day in 2012, though traffic has declined in recent years due to increases in transit ridership (Merchant, 2014).

Despite this trend, the decline in vehicle traffic on the Pike has lagged significantly behind that of other major corridors in Arlington. Namely, the traffic decline on the R-B corridor was more than double that on the Pike (Merchant, 2014). Further, residents of the Columbia Pike corridor are significantly more likely than residents of the R-B or Route 1 corridors to commute to work by driving alone, rather than taking public transportation or biking/walking (Department of Community Planning, Housing, and Development Profile, 2019). Much of this difference can be attributed to the degree of dense, transit-oriented development occurring along either corridor. The R-B and Route 1 corridors are characterized by their connection to heavy rail and the broader regional transit network. For example, the R-B corridor boasts four Metro stops on the Orange/Silver line and a number of parallel and intersecting bus routes. Meanwhile, despite strides in sustainable development, the Columbia Pike corridor lacks the same level of transit resources, and is characterized by mixed-traffic vehicle travel lanes that includes a network of bus lines.

Existing Transit Infrastructure

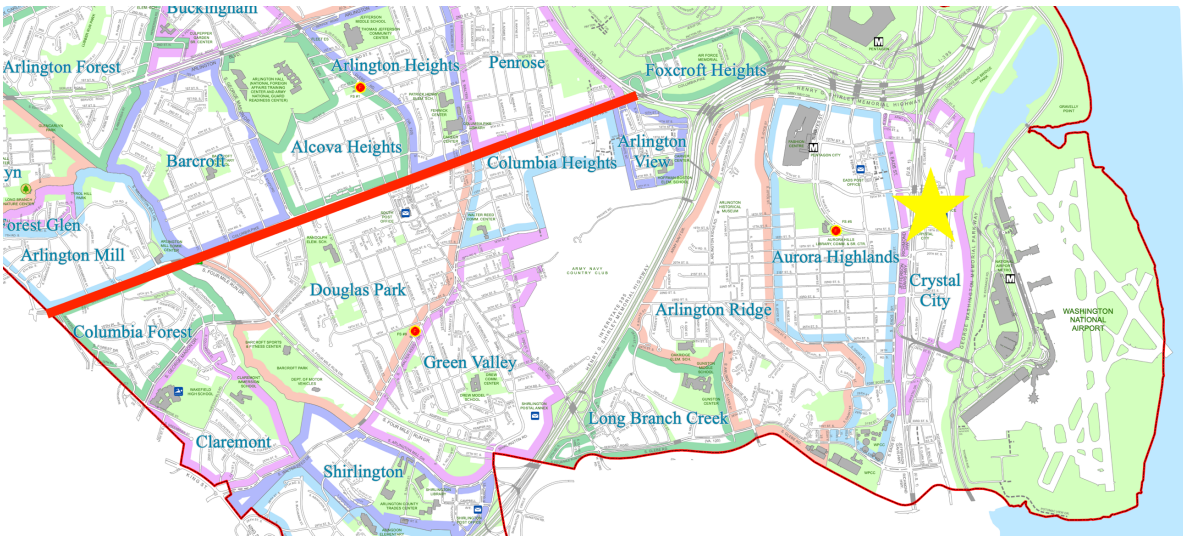
Bus Routes

Columbia Pike, as the busiest bus corridor in the Commonwealth, naturally hosts a number of bus lines. This includes service from Washington Metropolitan Area Transit Authority (WMATA) Metrobuses, as well as Arlington Transit (ART) Buses. Bus infrastructure was recently remodeled by the county and branded the Columbia Pike Premium Transit Network. This reimagining of the infrastructure includes consolidated routes, higher frequency (especially during peak hours), expanded connections to nearby residential, commercial, and transportation hubs, and improvements to boarding efficiency such as off-vehicle fare collection and improved transit stations. Most of these plans are currently in the implementation/construction phase, and are on track to be completed in the next few years (Columbia Pike Premium Transit Network, n.d).

Bike Infrastructure

Available space for traffic is scarce on Columbia Pike, and to this point the county has prioritized automobile infrastructure on the Pike proper at the expense of bike infrastructure. Instead, the county has elected to establish "bike boulevards" on parallel residential streets. Special signage, street alignments, and road markings have been installed to provide an alternate travel route for bikers (Columbia Pike Bike Boulevards, n.d.).

Figure 3: Columbia Pike in Red, with Amazon HQ 2 starred



Source: https://maps.arlingtonva.us/

Projected development trends

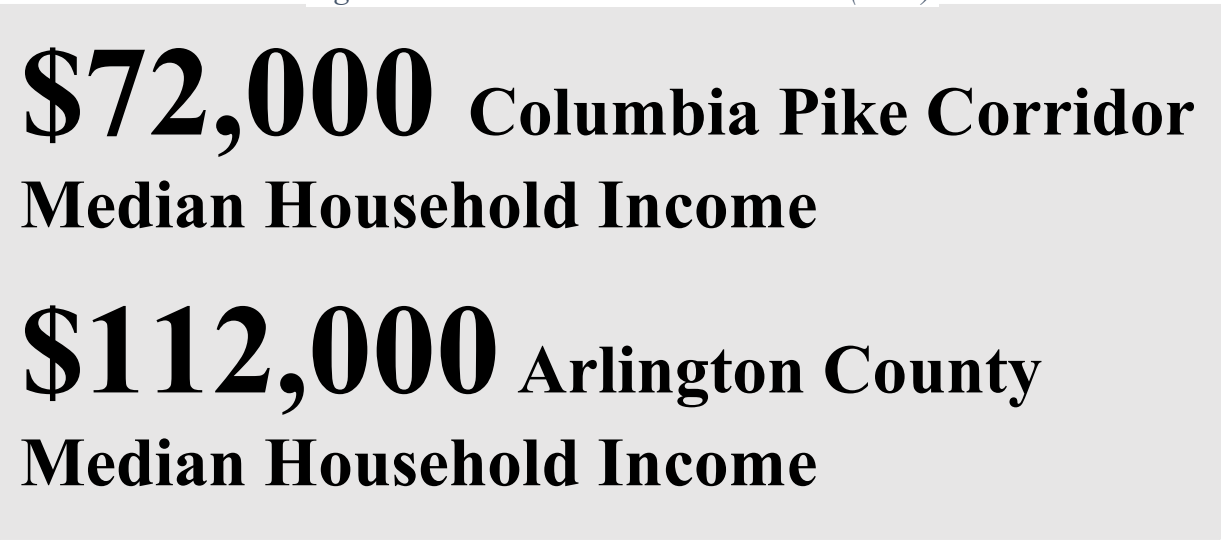
Arlington County, and the surrounding Washington, D.C. metropolitan area, has experienced an economic boom in recent years, bringing along significant population growth. Namely, since 2010 the population has grown by 9 percent, to a total of 226,000 people (Department of Community Planning, Housing, and Development Profile, 2019). These trends are expected to accelerate in the coming years, especially considering the recently announced Amazon Headquarters planned for National Landing (also known as Crystal City), a neighborhood near the Pike. Columbia Pike has changed dramatically over the last decade in response to these pressures and development plans

and is situated to bear a significant portion of the influx in stresses on the region (Virginia Population Estimates, 2019; Arlington Approves Amazon HQ2 Performance Agreement, 2019).

Equity

The Columbia Pike corridor serves as a home to large communities of historically marginalized groups, and is a majority-minority community, meaning non-White residents make up a majority of the people living in the area. The two largest non-White racial groups living in the area are Latinos (33 percent) and Blacks (16 percent). The corridor is home to about as many committed affordable housing units as the other two major commercial development corridors in Arlington combined (Department of Community Planning, Housing, and Development Profile, 2019). As a result, there are a number of low-income residents living and working on the Pike corridor.

Figure 4: Area median household income (2017)



Source: ***https://www.arlingtonva.us/profile/***

The median household income for the Columbia Pike corridor lags significantly behind that of the county: in 2017 it was $72,000 in the corridor compared to $112,000 for the county as a whole (Department of Community Planning, Housing, and Development Profile, 2019). Meanwhile, a third of households in the corridor subsist on incomes that qualify as "low-income" for households larger than or equal to one person by U.S. Department of Housing and Urban Development standards (HUD, 2019). This presents an additional need for comprehensive public transportation services in this area, as low-income people are far more likely to rely on public transportation to

get to and from work than the average resident due to the significant expense of owning and operating a personal vehicle (Center for Transit-Oriented Development, 2014).[1]

Inefficiencies

Traffic congestion

Traffic congestion is a frequently researched and generally well-understood problem in economics. It's fodder for introductory textbook examples and inquiry at the cutting edge of research alike, because it is a quintessential example of the common property resources problem. In short, the common property resources problem is a market failure that emerges when there are too many people consuming a good that cannot reasonably be made exclusive (Hardin, 1968; Thompson, 1998). In the context of Columbia Pike, the good in question is the road itself. Except in the case of toll roads or congestion pricing, drivers rarely face a direct price for using public roads. This lack of direct cost factors into decision-making when deciding to drive a car rather than use an alternative mode of transport, resulting in more drivers on the road than there would otherwise be (Arnott & Small, 1994). This generates congestion and delays for everyone on the road, especially during peak times (Arnott et al. 1993). The disconnect between the cost to drivers of driving and the costs they impose on the transportation system is at the heart of the common property resources problem. Importantly, traffic congestion is considered economically inefficient because if drivers could coordinate effectively, there would be fewer cars on the road, travel times would decline across the board, and everybody would be better off. In the absence of this collective action, there is some role for government intervention (Wade, 1987).

Altogether, traffic congestion costs the U.S. hundreds of billions of dollars each year (Sweet, 2011). With this figure in mind, it should be noted that economists have struggled to appropriately quantify the dollar cost of traffic congestion. A common quantification strategy concerns itself with productivity loss due to time wasted in sitting in traffic (Gibbons & Proctor, 1954). There are a number of ways to assign a dollar value to the time spent in traffic, but the most common involves using wages to infer how people value their time (Heckman, 1974, Boardman et al., 1997). This approach is subject to considerable debate: though most economists agree that the value of time

[1] See Appendix A for more demographic information about the Columbia Pike Corridor

should be tied to wages, there is persistent disagreement of how to appropriately convert wages to a valuation of time (Stopher, 2004).

Pollution

Vehicles emit a litany of pollutants during the course of regular operation, most of which are tied to the combustion of fossil fuels. This is problematic because, not unlike the common property resources problem, they impose costs on society that drivers do not fully consider when deciding to drive. A few of the most destructive pollutants to consider are carbon dioxide (CO2), nitrogen oxide (NOx), airborne particulates, and chemical runoff. These pollutants cause a variety of environmental and health problems including climate change, acid rain, respiratory conditions, and others (Environmental Protection Agency, n.d.). Because these costs are not fully accounted for by drivers, people choose to drive more than they should, and society as a whole would benefit if people drove less frequently (Parry & Walls, 2007). Overall, air pollution from transportation costs the U.S. hundreds of billions of dollars per year (Robinson, 2019).

An important distinction to draw is one between pollutants that create "hotspots" and those that do not. Pollutants create hotspots when concentrated emissions generate elevated hazards (Morag-Levine, 2007). For example, pollutants such as airborne particulate matter are more harmful when encountered in higher concentrations, relative to the danger from the same amount of particulate matter encountered more diffusely (Donaldson, 2003). This is in contrast to pollutants such as CO2, which is not toxic to humans (and therefore not liable to create hotspots) but still imposes costs on society by contributing to climate change and other environmental problems (Morag-Levine, 2007). This differentiation is relevant because from a political perspective, the immediate surrounding community bears a far greater share of the total external costs associated with hotspot pollution. Research suggests that hotspot pollution is more politically salient for citizens and governments because it impacts them most directly (Daley & Garand 1998; Ansari et al., 2013).

Possible Interventions

Bus infrastructure

One possible solution for the problem of excess traffic would be increased investment in bus infrastructure. In relatively dense urban areas like Columbia Pike, buses can alleviate many of the

negative externalities associated with automobiles and traffic congestion discussed above. Columbia Pike is currently served by a number of bus lines, but there are opportunities to invest in making buses a more attractive alternative to driving single occupancy vehicles. Even with relatively basic bus infrastructure, the per-passenger impact of buses on traffic congestion and pollution is significantly less than that of single occupancy vehicles by virtue of their high capacity (Cervero, 2013).

The returns to buses are compounded even more with comprehensive investments in infrastructure that prioritize efficient travel on high-traffic roads. When buses have to compete with single occupancy vehicles for scarce space on roads, as is the case currently on Columbia Pike, bus passengers are subject to the costs associated with traffic congestion, which dilutes the social benefits of bus travel. One potential intervention to address this is the establishment of dedicated bus travel lanes. Analyses show that this infrastructure investment can significantly raise bus travel speeds, with only marginally negative impacts on car travel speeds (Basso et al., 2011). This is somewhat counterintuitive: one would expect car travel speeds to decline due to scarcer road space. However, this slowing effect is mediated by the decrease in conflict with buses, which tend to stop and start frequently, as well as the removal of cars from the road if drivers choose to take transit (ibid).

Light rail

Most of the benefits to bus infrastructure hold true for light rail as well. In terms of traffic congestion alleviation, trams provide comparable benefits to buses with dedicated lanes, holding ridership constant. An important caveat is that trams have higher passenger capacity than buses, so they are able to transport more riders at any given time and are therefore more suited to higher density areas that expect high ridership (Hess et al., 2005). However, this high capacity comes at the expense of flexibility to meet fluctuations in demand along a particular route (ibid).

The pollution impacts of light rail relative to buses are highly dependent on a number of factors, particularly the source of energy used to power either mode of transportation. Trams are relatively easier to electrify than buses from an engineering perspective, so they have the potential to be low-carbon, dependent on the source of energy in the grid (Lajunen & Lipman, 2016). Even if the grid

is not completely green, electrified transport addresses urban pollution hotspots to some extent, because the power generation (and therefore pollution) is often conducted away from major population centers (Lave et al., 1995).

ALTERNATIVES

Enhanced Bus Service

In 2016 the county elected to pursue an "enhanced bus service" plan for the Columbia Pike corridor, in an effort to alleviate traffic congestion and promote dense transit-oriented development. In the intervening few years, the county has designed and implemented a number of policies to streamline existing bus service on Columbia Pike ("Columbia Pike Premium Transit Network," 2016). As such, this alternative could be viewed as "letting present trends continue" — that is, pursuing no additional policy on top of plans already in the works. In particular, improvements include the following infrastructure investments:

Figure 5: Planned transit stations for Columbia Pike

Source: https://newsroom.arlingtonva.us/release/board-approves-columbia-pike-transit-stations-contract/

Transit Stations: The county is currently in the process of constructing the first phase of 23 total transit stations on Columbia Pike (See Fig. 1). These stations are intended to replace existing bus

stops with more user-friendly and accessible infrastructure. Current bus stops on the Pike are typically bare-bones: many have benches and few have shelters for rain, wind, and sun. Every planned transit station in construction will include weather guards, real time bus arrival information, seating, and a raised platform for easier boarding ("Columbia Pike Premium Transit Network," 2016).

Off-board fare collection: The existing fare collection process involves passengers paying fare as they board, which often causes service delays, especially during peak ridership hours. Off-board fare collection systems have passengers pay their fare at a kiosk prior to boarding and carry a receipt of purchase onto the bus, which streamlines the process ("Columbia Pike Premium Transit Network," 2016).

Transit Signal Priority: Currently, buses on Columbia Pike share travel lanes with private vehicles, and a major source of bus delays in urban contexts is signalized intersections, at which buses have to wait for cross-traffic to pass. One potential response to this problem is traffic signal priority, which uses wireless connectivity to extend yellow lights and expedite red lights for buses, allowing them to move more freely through intersections ("Columbia Pike Premium Transit Network," 2016).

Evidence

Buses are able to transport people more efficiently than private single-occupancy vehicles, and generate less pollution per passenger. Improvements similar to each aspect of enhanced bus service outlined above have led to better on-time performance in other cities, more ridership, and improved customer satisfaction ("Better boarding, better buses: streamlining boarding & fares," 2017). Meanwhile, modelling and empirical research in a number of cities support the efficacy of traffic signal priority, which can lead to a modest decrease (around 10 percent) in travel times for bus riders (Hu et al, 2014).

Timeline

The timeline on this alternative is relatively short, because the implementation process has already begun for a number of infrastructure improvements. The first phase of transit stations is currently

under construction, and the county has already approved the other planned improvements. As such, certain aspects are already in the implementation phase, while the rest of the plan is set to be completed in 2026.

Bus Rapid Transit

Buses currently share travel lanes with private vehicles on Columbia Pike. This subjects them to traffic congestion and delays, which detracts from the benefits of bus travel. A potential solution to this would be implementing dedicated bus lanes on Columbia Pike during peak hours, allowing buses to travel more freely and bypass congestion. Until very recently, this was not an option due to regulations from the state level, but changes to these rules have opened the door for implementing this policy on Columbia Pike (McAffrey, 2017). Under this proposed alternative, one lane in each direction would be clearly marked as a bus only lane during certain hours. The effective hours would be staggered so the eastbound lane would be restricted in the morning (when many commute into Washington D.C./the Crystal City area) while the westbound lane would be restricted in the evening (when the balance of commuting is reversed.)

Evidence

Bus Rapid Transit (BRT), characterized by dedicated bus lanes, has been shown by a number of models to be an effective remedy for traffic congestion (citations). Because buses are able to move more freely when they don't have to compete with private vehicles, dedicated lanes significantly increase bus reliability and travel speeds, encouraging ridership and inducing demand (Cervero, 2017). Importantly, these added benefits to bus riders come at a nominal cost to drivers of private vehicles. While this is somewhat counterintuitive, this is because there are fewer cars on the road to begin with and a reduction in conflict with buses, which tend to stop and start frequently (Tao Tao & Nelson, 2011).

Timeline

Implementing BRT would not require the intensive infrastructure investment that light rail, or even the transit stations entail, but seeing as the policy is not currently being developed it would suffer a time delay with getting the ball rolling in the county government. Commissioning studies, planning, and soliciting public comments would add a front ended time commitment for

implementation. That said, once it reaches time to break ground, it could be implemented relatively quickly. The most intensive infrastructure investments would be signage, street paint, and perhaps an educational/traffic enforcement campaign.

Light Rail

Light rail, also known as trams or trolleys, could serve as a solution for the transportation needs of Columbia Pike. Like buses, trams carry significantly more people per square foot of vehicle space than single-occupancy vehicles and generate a fraction of the emissions. Pursuing this alternative would involve laying down streetcar tracks on Columbia Pike, which would be a major infrastructure investment. The trolley could run in dedicated lanes, like BRT, or it could share travel space with private vehicles, as was the case in past streetcar plan proposals for Columbia Pike. Regardless of how the lanes are allocated, this alternative would involve laying down a set of streetcar tracks in either direction, running the length of Columbia Pike in Arlington. It would also require acquiring a fleet of streetcars to run on the tracks to achieve the desired frequency.

Evidence

Depending on whether it is run in dedicated lanes or in shared travel lanes, a streetcar system would serve a similar function to BRT or enhanced bus service, respectively. The marginal returns to ridership, congestion alleviation, and pollution alleviation would therefore be determined in part by the streetcar's ability to attract riders that would otherwise not use the bus systems and elect to drive. Evidence from past studies in Arlington regarding streetcar proposals, among other research, suggests an inherently greater favorability towards streetcars, relative to buses. This is likely due in part to aesthetic preferences for trolleys as well as a general stigma against buses ("Comparative Return on Investment Study," 2014). Furthermore, streetcars have higher capacity than buses, and can carry more individual passengers at any given time (Hess et al., 2005). This is relevant looking ahead, because it allows streetcars to support denser development. Considering projected population growth trends for the corridor, density will have to be a key part of Columbia Pike's development.

Timeline

Of the three alternatives, light rail likely has the longest time horizon. This comes largely as a result of the significant physical infrastructure investments necessary to implement a streetcar system. Laying down trolley tracks is a lengthier and more complicated process than the other alternatives considered above, so policymakers would have to account for the relatively delayed rollout.

CRITERIA

Each alternative will be assessed using the following criteria. The rank order of each alternative relative to the others will be used as a rule of thumb to easily assess how they stack up to other possible interventions.

Net Benefit

As a partner to the Arlington County Government, CPRO is concerned with operating in the public interest. As such, the analysis will consider the net benefit that accrues to the county as a whole. A benefit-cost analysis will help ensure that proposed alternative is an efficient use of public funds. Alternatives will be evaluated along this criterion by subjecting each to a comprehensive benefit-cost analysis, relative to the baseline of no further action. A negative net present value suggests that the social welfare of Arlington is better off without that particular intervention. If, for any alternative, net benefit is negative, that alternative will be ruled out.

The benefit-cost analysis will use standard estimation and projection strategies to generate a rigorous estimate of expected social benefits accrued to the community as a result of the potential interventions. Monetary costs and benefits such as capital and maintenance costs will be estimated using standard plugins from the transportation literature. Non-monetary costs and benefits will be valued using the most appropriate estimation method for the particular good or service. Gross benefits and costs will be discounted to present values at a rate of 7 percent per year and subtracted from each other to determine the net benefit in a common unit of reference. More information about assumptions and the estimation process can be found in the appendix.

The benefit-cost analysis will be conducted using conservative assumptions and methodology across the board, biasing the estimate toward a negative NPV. This is done to ensure that any given alternative is viable even under low-performing outcomes. As a result, the sign (positive or negative) of the net benefit estimate will be broadly robust to changes in parameters and assumptions within the realm of possibility. In general, the methodology employed will align with standard industry practice. However, due to constraints on resources and available data, the

analysis will be necessarily assumption-dependent. Specific dollar number estimates should be taken lightly, and should be interpreted broadly.

Equity

As important as net benefit is the question of to whom these benefits accrue. Because car ownership can be prohibitively expensive, especially in urban contexts, public transportation is inherently tied to the welfare of low-income residents. Further, low-income Arlington residents are overrepresented on Columbia Pike relative to the county as a whole, meaning they are more likely to bear the external costs associated with the nearby transportation infrastructure and more likely to benefit from investment in public transportation. In order to ensure the recommended policy is fair, the extent to which the alternatives serve vulnerable populations will be considered. Any policy enacted should at the very least not harm those already structurally disadvantaged.

In order to evaluate distributional effects, the literature will be consulted in order to understand the extent to which each alternative impact particular groups, especially those considered vulnerable or disadvantaged. Close attention will be paid to low-income residents, recent immigrants, children, and the elderly.

Political Feasibility

Even the most beneficial proposed policy is meaningless if the political cost of implementation is insurmountable. The history of transportation on Columbia Pike is fraught with political battles, some of which have resulted in the cancellation of projects otherwise deemed beneficial and just. Though this criterion is the most subjective of the three, it is an important enough consideration that omission would be inappropriate. The alternatives will be evaluated using case studies and expert consultations to make the process of evaluation as rigorous as possible. In order to quantify feasibility, each alternative will be assigned a value ranging from 0 to 4, with 0 representing a policy that is completely infeasible, and 4 representing a policy that can be enacted entirely uncontroversially, without any political or institutional barriers to consider.

FINDINGS

Status Quo

Net Benefit

The status quo is used as the baseline for the cost-benefit analysis, so it by definition has no net benefit. That is, the net benefits of the other alternatives are forecast in relation to the baseline of the status quo.

Equity

The status quo is relatively inequitable. Columbia Pike is one of the region's most diverse corridors, and as such it serves many socioeconomically disadvantaged communities. Despite this fact, its public transportation infrastructure is severely lacking, especially relative to other parts of the county characterized by whiter, wealthier communities (Arlington County Projects & Planning, 2019). Nevertheless, residents have access to the bus service, and ongoing improvements should work to make the bus network more accessible. However, regardless of access, the high levels of vehicle traffic on the Pike subject the community to a number of costs (Delucci, 2008). Chief among these are the pollutants associated with vehicle traffic, such as the various chemicals emitted in car exhaust and noise pollution which has been shown to be a significant risk factor for a number of diseases.

Political Feasibility

The status quo will be implemented by default without action. As outlined above, there are a number of marginal infrastructure improvements currently under construction (Arlington County Projects and Planning, 2019). Because this package of improvements has already been approved, funded, and subjected to a community review process, political feasibility is not much of an ongoing concern.

Bus Rapid Transit

Net Benefit

BRT has a positive net benefit of about $79 million.[2] This largely comes as a result of reduced average trip and wait times for transit riders, as well as moderate increases to property values of nearby land. Meanwhile, the capital and maintenance costs of BRT are comparatively very low, relative to light rail. This is already accounted for in the analysis, but is an important consideration because, like many local governments, Arlington necessarily has limited financial resources at its disposal. Other costs include additional commute times for drivers, who will suffer increases in congestion as a result of this alternative.

Equity

BRT would be a highly equitable intervention. It would significantly increase the efficacy of the public transportation infrastructure along Columbia Pike. The increased speed, frequency, and reliability of bus service associated with BRT would improve quality of life for families on Columbia Pike (Cervero, 2013). Furthermore, it would tie Columbia Pike in more tightly with the broader regional transit network, by significantly reducing travel times to the Pentagon City Metro station. Meanwhile, this option would require significantly less construction than the light rail alternative, which would spare those living near the Pike the disruptions, potential health risks, and other costs associated with more prolonged construction projects (Delucchi, 2008).

Political Feasibility

There have been a handful of well-publicized experiments with establishing dedicated right of way for buses in the Washington, D.C. metropolitan area. Alexandria opened a set of bus lanes in 2014, and a handful of these bus lanes debuted during summer 2019 in Washington, D.C. Meanwhile, Arlington County debuted a transitway in Crystal City, along the Route 1 corridor in 2016, and recently elected to expand it (Crystal City Potomac Yard Transitway, 2016). Because there is precedent in Arlington for similar interventions, this alternative will benefit from some measure of familiarity among constituents and stakeholders. In fact, this alternative would connect to the existing BRT infrastructure in Crystal City, and could benefit from being billed as a natural

[2] See Appendix B

expansion of the project, which benefits from status quo bias and popularity among users. Using the Crystal City Busway as a proof-of-concept is especially valuable because the impacts speak for themselves: ridership on those lines during relevant hours increased as much as 50 percent (Arlington County Newsroom, 2019). That is not to say that this alternative would pass without any contention. The Crystal City Busway ultimately passed unanimously, but not without a lengthy review process and considerable changes to the initial plan. For example, concern from drivers voiced during the review process led to reductions in the restricted hours for rush-hour bus lanes (Koma, 2018).

Figure 6: The Crystal City Busway

Source: https://www.flickr.com/photos/beyonddc/25892126944/

Meanwhile, another consideration for political feasibility is the negotiation with the Virginia Government. As it stands, Arlington County is currently required by the state to keep four lanes

of traffic (two in either direction) open to cars at all times, which automatically precludes any kind of BRT, even during peak periods (McAffery, 2017). The state government under the Northam and McAuliffe administrations has signaled a willingness to loosen this restriction, but this would nevertheless require the county to strike a deal.

Light Rail

Net Benefit

Light Rail has a net benefit of about $637 million.[3] Light rail would achieve the same positive impacts to the efficiency of the transportation network, and then some due to increased capacity. Meanwhile, the boon to surrounding property values overcomes the significantly higher capital and operational price tag. Important to note is the fact that benefits in this case largely rely on increases in property value and development induced by this investment. Though this is consistent with the observed effect of similar investments in other cities across the United States, it should be noted that it is difficult to predict with certainty the exact level of appreciation and development that would occur in response to the installation of light rail infrastructure.

Equity

Light rail is a moderately equitable alternative. On the one hand, it would carry along with it many of the distributional benefits of BRT. Additionally, the increased peak capacity of light rail relative to BRT means that many of these benefits to quality of life could be shared more widely and expanded in the future. However, this would come at the cost of a period of intensive construction in the short term, to lay down tracks and install other related infrastructure. This kind of construction is known to subject nearby residents to acute health risks associated with noise, particulates, and exhaust (Gilchrist & Allouche, 2005).

Furthermore, there are typically concerns about the potential for gentrification associated with rail projects. Gentrification would be by no means inevitable, but it has been observed as an outcome from some similar light rail projects (Baker & Lee, 2019). Benefactors of gentrification tend to be second-wave business owners, and property owners, whereas renters tend to be among those hurt

[3] See Appendix B

most (Lees et al., 2013). The Columbia Pike corridor has a relatively low homeownership rate, especially compared to the county as a whole (Arlington County Projects & Planning, 2019). This high share of the population that rents would be at increased risk for displacement if any given project were to accelerate existing gentrification of the area. Implementation of the light rail alternative would require significant care from policymakers in order to ensure that the Columbia Pike community is not adversely affected.

Political Feasibility

Light Rail is a moderately feasible alternative. The Columbia Pike corridor has a fraught recent history with similar projects. In the mid-2000s, Arlington County began studying the prospect of installing a streetcar on the corridor. Following years of public comment, study, and review, the project was approved, only to be killed right before groundbreaking (Sullivan & Olivo, 2014). This reversal came largely as a result of political pushback from residents in other parts of the county who were uncomfortable with the tax burden of the project or otherwise did not see the value of a streetcar (Sullivan & Nadkarni, 2014). The political battle surrounding the streetcar has since quieted down somewhat, but there is reason to suspect that a similar planned project could face similar opposition. The feasibility of this alternative could also be undermined by the H Street streetcar, a streetcar established in Washington, D.C. that has had mixed success, with a planned expansion recently cancelled (David, 2020). Though H Street and Columbia Pike are entirely different corridors, opponents of light rail on the Pike might point to it as evidence against the proposal.

This alternative faces the same obstacles related to the lane restrictions on Columbia Pike as the BRT alternative. In order to successfully implement this alternative, the County would have to strike a deal with the Virginia Government relaxing the regulation requiring two open lanes in either direction at all times. As stated before, there is evidence that the state government under Governor Northam would be open to such an agreement.

Decision Matrix

Figure 7: Decision Matrix

Criterion	No Build	Bus Rapid Transit	Light Rail
Net Benefit	3	2	1
Equity	3	1	2
Feasibility	1	2	3

Recommendation

CPRO should promote the implementation of peak hour bus rapid transit on Columbia Pike. It provides significant net social benefits, primarily by greatly increasing the ease and speed of bus travel during the busiest times of day, while only marginally impacting the commute of drivers. This makes the transportation network operate more efficiently, and generates net positive social benefits. Importantly, these benefits are generated with relatively little capital investment, certainly compared to light rail, which is an important consideration for a county with constrained resources. Furthermore, though this intervention is expected to generate some increases to property values along the Pike, it is not as dependent on property appreciation as light rail.

From an equity perspective, BRT performs excellently at servicing the existing residents of the Columbia Pike community, particularly those at the most disadvantage. Meanwhile, it also serves to clean up the environment by taking cars off the road, which reduces health risk factors and generally makes the community more livable. Importantly, it does these things all the while being a low risk for spurring inequitable development and displacement.

Finally, BRT is a feasible alternative within a reasonable timeframe. Its low upfront capital cost will soften pushback from taxpayers, and it will likely draw support from regional transportation partners. Negotiating with the Virginia Governor's office to loosen the two-lane restriction could be a hiccup, but Governor Northam and his predecessor Governor McAuliffe have both signaled a willingness to cooperate on that particular issue. Finally, it is not mutually exclusive to eventual

investment in light rail. Following implementation of BRT, should the county desire to further invest in light rail at some point in the future, it could take advantage of the existing public transportation infrastructure associated with BRT such as signage, markings, and familiarity among the community.

IMPLEMENTATION

The following section discusses important considerations for CPRO to account for when advising the county on the implementation of peak-hour BRT.

Stakeholders

Arlington County Government

The Arlington County Board has entrusted special status to CPRO as the steward organization of the Pike, and its recommendations will therefore not be taken lightly. Nevertheless, special care should be taken care to round up supporters and persuade skeptics among county leaders. Board members such as Katie Cristol and Christian Dorsey, who have been longtime advocates for increased investment in Columbia Pike, should be consulted early to act as key allies in generating political capital. Meanwhile CPRO should work closely with other board members who have in the past been more skeptical of transportation improvements, such as Libby Garvey, in order to learn their support.

State Lawmakers

In order to legally implement the recommendation, Arlington must enter into an agreement with the Virginia government in order to amend their contract regarding the operation of Columbia Pike. In order to accomplish this, CPRO should begin early conversations with key members of the Northam administration, as well as Attorney General Herring's office. Fortunately, Governor Northam (and his predecessor Governor McAuliffe) has in the past signaled a willingness to renegotiate said contract, and over the course of his tenure has been a supporter of public transit and transit-oriented development.

Regional Transportation Partners

Bus Service on Columbia Pike is provided jointly by ART and WMATA. As CPRO and Arlington prepare to implement lane service changes in the next few years, they should work with WMATA in order to reconfigure bus routes during affected hours in order to optimize service. This process could take time but it will likely be uncontroversial, as the changes serve WMATA's goals and could ultimately cut down on their operational costs.

Community Stakeholders

Though the recommendation is minimally disruptive, both fiscally and physically, CPRO and its partners should take a proactive stance in engaging community input before rollout. In particular, CPRO can expect some opposition from local residents who are accustomed to commuting by car, and are wary of delays that they will have to endure in order to implement the recommendation. These resident's concerns are valid and CPRO should look to reassure them by pointing out the myriad benefits that will come to them and their neighbors as a result of the program. This process of grievance and reassurance should be organized into formal public comment sessions, to be held at regular intervals at times accessible to broad swaths of stakeholders.

Leveraging Past Successes

Arlington has experienced success implementing peak hour BRT in other parts of the county, such as in Crystal City. CPRO should connect early with key leaders in the rollout of that program in order to identify key takeaways from that process, and apply them to the new context. Meanwhile, CPRO can point to the resounding success of that program as reassurance for skeptical or oppositional stakeholders. Because the Crystal City busway is so effective and so popular, the recommendation could even be pitched as a natural extension, seeing as how Columbia Pike links to Crystal City through Pentagon City.

Iterative Policymaking

In the leadup to implementation, CPRO and the Arlington County Government should invest in the infrastructure necessary to collect and analyze important performance data. Collected data should include average car speed, average bus speed, average bus occupancy, and enforcement data for the bus only lanes, among other statistics. This data should be used to tweak bus service in order to better and more efficiently serve the community.

Potential Hiccups

Enforcement

A perennial issue with bus lanes, especially when they are only in effect for part of the day, is the problem of enforcement. Due either to ignorance or defiance, some motorists fail to heed the restrictions on the lane, which decreases efficacy and safety. To combat this, CPRO advocate for preemptive design tactics such as colored lanes, and automated electronic signs. Additionally, it should look to take advantage of existing intersection cameras and invest in bus-mounted cameras. For the uninformed, CPRO should conduct an informational campaign so that regular motorists understand how the changes affect them.

Publicity

Because the recommendation involves reducing the right of way by one lane in the peak direction during certain hours, there will necessarily be resulting traffic delays, at least initially. This will subside as more pike residents opt for the bus rather than driving, but the initial optics could be difficult to manage. To preempt this, CPRO should begin a community engagement program to inform people about the new service before it debuts. In many ways, the mild traffic caused by the BRT is part of internalizing the external costs of driving and inducing transit use. However, this doesn't mean that CPRO shouldn't be proactive about promoting ridership in the weeks and months leading up to rollout.

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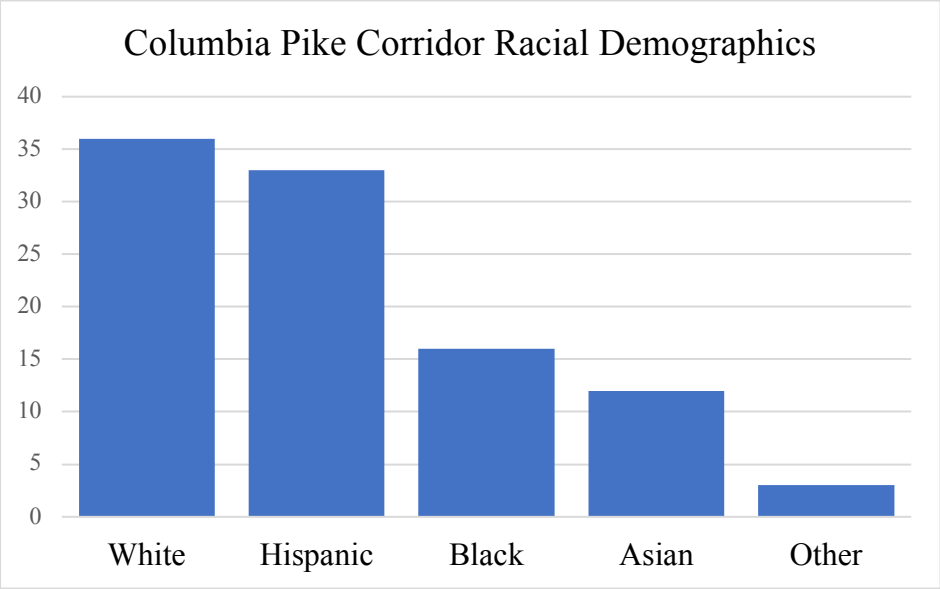
APPENDICES

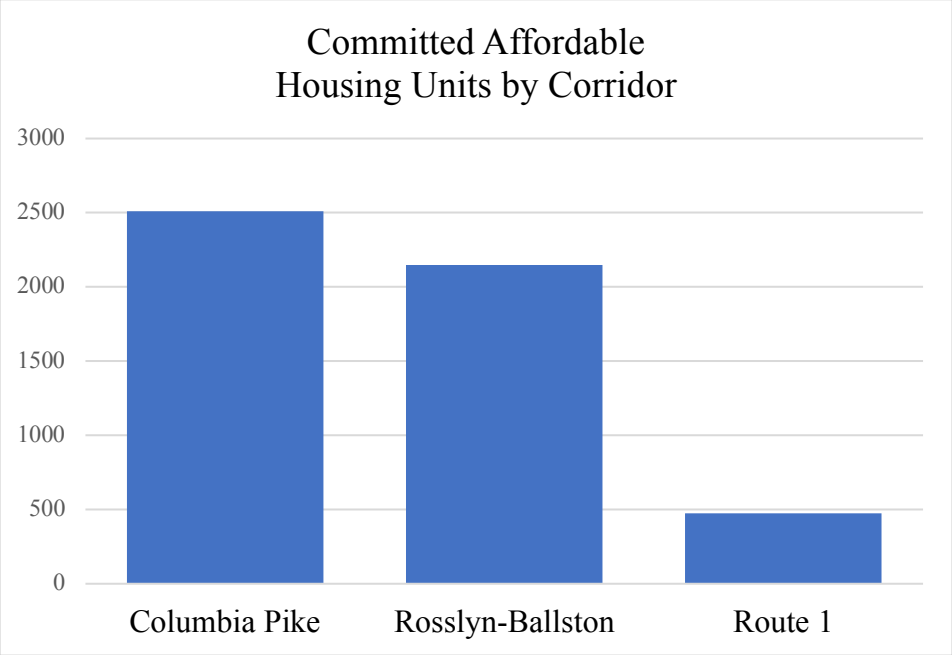
Appendix A: Demographic profile of Columbia Pike

Figure 8: Columbia Pike Corridor Racial Demographics (2011)



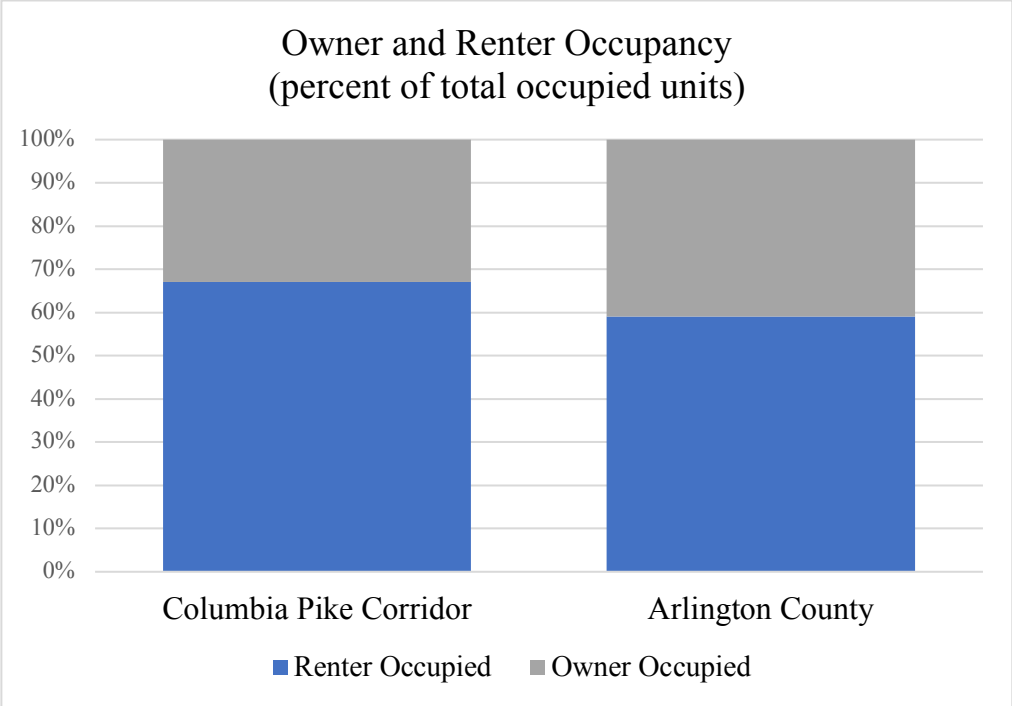
Source: Arlington Department of Community Planning, Housing and Development

Figure 9: Committed Affordable Housing Units by Corridor (2017)



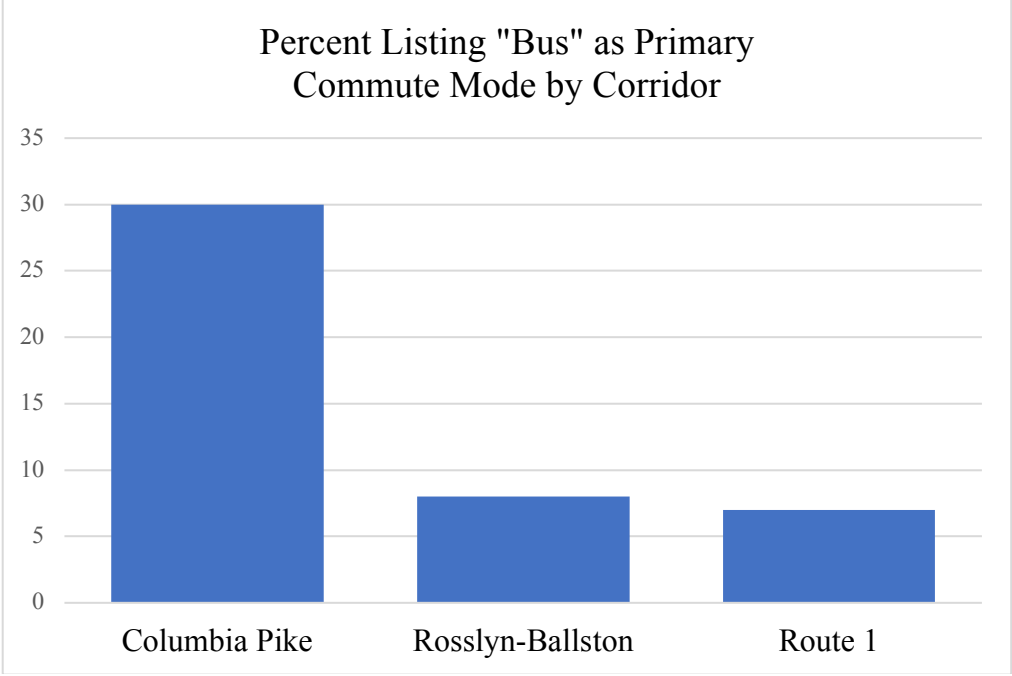
Source: https://www.arlingtonva.us/profile/

Figure 10: Owner and Renter Occupancy



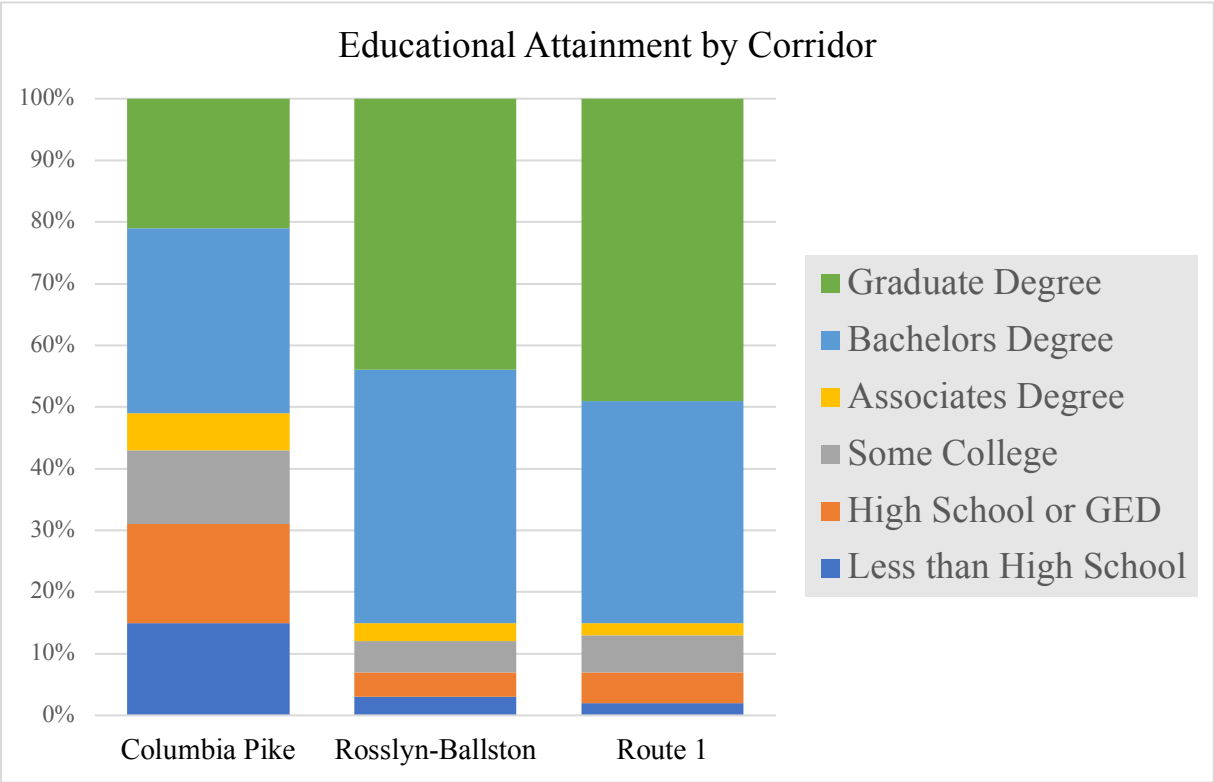
Source: https://www.arlingtonva.us/profile

Figure 11: Percent Listing "Bus" as Primary Commute Mode by Corridor (2017)



Source: https://www.arlingtonva.us/profile/

Figure 12: Educational Attainment by Corridor (2017)



Source: Source: https://www.arlingtonva.us/profile/

Appendix B: Benefit Cost Analysis

Assumptions

Assumption	Figure	Source
General Assumptions		
Discount rate (percent)	0.07	Standard Practice
Commute days in a year	245	Standard Practice
Average Regional Hourly Wage (to minutes) (2019)	0.9	Arlington County Dept. of Projects and Planning
Average car commute	30	American Community Survey
Average daily vehicle throughput	28000	Columbia Pike Revitalization Organization
Proportion of vehicle trips during peak hours	0.48	NHWA
Average vehicle occupancy	1.67	NHWA
Length of corridor (miles)	3.5	
Daily transit ridership	19000	Columbia Pike Revitalization Organization
Wage discount for driving	0.5	Standard Practice
Average bus trip time (minutes)	35	American Community Survey
Average transit wait time for relevant routes (minutes)	6	WMATA
Proportion of bus trips during peak hours	0.58	WMATA
Surrounding Land Value (USD)	$900000000	Arlington County Dept. of Projects and Planning
Bus Rapid Transit		

Capitol cost/mile (USD)	$500000	Transportation Research Board
Annual Maintenance Cost	10000	Transportation Research Board
Average car delay (percent)	0.05	Transportation Research Board
Average transit trip time reduction (percent)	0.05	Transportation Research Board
Average transit wait time reduction (percent)	0.05	Transportation Research Board
Property value premium	0.01	Literature Findings
Light Rail		
Capitol cost/mile (USD)	$150000000	Transportation Research Board
Annual Maintenance Cost (USD)	$20000	Transportation Research Board
Arlington share of capital funding	0.5	Previous Proposals
Average car delay (percent)	0.04	Transportation Research Board
Average transit trip time reduction (percent)	0.05	Transportation Research Board
Average wait time reduction (percent)	0.06	Transportation Research Board
Property value premium (percent)	0.08	Literature Findings

Summary BCA BRT

	Amount	Discounted	Calculation
Costs			
Construction capital	$1750000	None	Capital cost/mile * corridor length

Maintenance	$358913.18	7% year 1-20	Maintenance cost/mile * corridor length
Increased car travel time	$39322955.30	7% year 1-20	Expected additional time in traffic * average hourly wage
Benefits			
Decreased transit travel time	$22524688.51	7% year 1-20	Expected reduction in travel time * average hourly wage
Decreased transit wait time	$7722750.35	7% year 1-20	Expected reduction in wait time* average hourly wage
Property value premium	$90000000	None	Property value * premium

Summary BCA Light Rail

	Amount	Discounted	Calculation
Costs			
Construction capital	$75000000	None	Capital cost/mile * corridor Length
Maintenance	$741580.90	7% year 1-20	Maintenance cost/mile * corridor length
Increased car travel time	$39244466.37	7% year 1-20	Expected additional time in traffic * average hourly wage
Benefits			
Decreased transit travel time	$22524688.51	7% year 1-20	Expected reduction in travel time * average hourly wage
Decreased transit wait time	$9267300.416	7% year 1-20	Expected reduction in wait time* average hourly wage
Property value premium	$720000000	None	Property value * premium

Final BCA Summary Table

Option	NPV
BRT	$78,815,570.37
Light Rail	$636,805,941.56