

15.0 Operations and Maintenance Cost Calculations

15.1 Introduction

Operations and Maintenance (O&M) costs were calculated for each of the four alternatives being considered in the analysis.

- No Build Alternative - bus only.
- Transportation Systems Management Alternatives (TSM 1 and TSM 2) - bus only. Two TSM alternatives were developed - differences between the alternatives are based on differences in bus run times and differences in vehicle types.
- Streetcar Build Alternative - includes the streetcar network and a background bus network. The streetcar network utilized in these cost estimates reflects service between Skyline and Pentagon City.

15.2 Cost Summary

Total operations and maintenance costs (and underlying revenue vehicle hours for streetcar and platform hours for bus) for each alternative are outlined in **Table 15-1**.

The TSM 1 and TSM 2 alternatives provide the same overall level of service. The difference in costs in **Table 15-1** relates to faster run times under the TSM 2 alternative (related predominantly to shorter dwell times associated with off-board fare collection and multiple door entry). Faster run times means fewer buses are required to provide the same level of service and therefore costs are lower.

Bus routes 16G, 16H, and 16H/ in the TSM 2 alternative use articulated buses. These articulated buses will be serviced at the Cinder Bed Road Garage resulting in longer deadhead times for these routes. As a result, the platform hour to revenue hour ratio for these bus routes 16G, 16H, and 16H/ are revised (increased) to account for increased deadhead time, see **Table 15-2B** and **Table 15-8B**.

15.3 Cost Methodology - Bus Service by Alternative

Total annual operating costs for three alternatives - No Build, TSM 1, and TSM 2 - involve only operating costs associated with bus operations. The Streetcar Build Alternative involves both bus costs and streetcar costs (discussed in Section 15.4).

Costs for each alternative are summarized in **Table 15-1**. More details on costs by route for each alternative are shown in **Tables 15-5A, 15-5B, 15-5C, and 15-5D**. Data by route for the Streetcar Build Alternative identifies those

routes that will no longer be in service under the Streetcar Build Alternative, having been replaced by the streetcar.

Bus O&M costs are calculated in a comparable manner as streetcar costs, but with one difference - the process involves multiplication of annual vehicle platform hours (rather than revenue hours) by a cost per platform vehicle hour. The cost per platform hour of \$140.83 is provided by WMATA and is used for estimating operating costs for all WMATA bus services. The cost per platform hour for ART41 incremental service is \$75.08 and is provided by Arlington County.

Platform hours include the entire time from when a bus pulls out of the garage to begin its service day to the time it pulls into the garage. Platform hours include both deadhead time and revenue time. The ratios of platform hours to revenue hours are shown in **Table 15-2A** by route. WMATA provided the operating statistics data that was used to calculate these ratios.

Platform hours for bus are calculated in the following manner:

1. Calculate Daily Revenue Hours for Each Route - The revenue hours per trip are based on the run time for each one-way trip added to a recovery time. The recovery time is assumed as 10% of the run time. Run times were taken from the timetables for those routes in which there is no change between the No Build and the three alternatives (TSM 1, TSM 2, and Streetcar Build). For those routes that change (e.g. there is a change in run time relative to the No Build because of the consolidation of stops and reduced dwell time) run times were derived from the VISSIM model runs for each alternative.
2. Translate Revenue Hours to Platform Hours - Revenue hours are translated into platform hours by applying a factor to revenue hours that takes into account different deadhead hours for different routes. The factor is based on a platform hour to revenue hour ratio for each route that is based on WMATA bus operations data. **Table 15-2A** shows the platform hour factors calculation.
3. In TSM 2 Alternative, routes 16G, 16H, and 16H/ will utilize articulated buses. Articulated buses will be stored at the maintenance facility located at Cinder Bed Road, not Four-Mile Run. This change in maintenance facility will result in additional deadhead minutes to the run times for articulated buses leading to an increase in platform hour factor for these routes in the TSM 2 Alternative. The incremental change in deadhead minutes was calculated based on existing pull-out and pull-in data for routes 16G, 16H, and 16H/ which was then applied to the Cinder Bed Road maintenance facility. The comparative platform factors are shown in **Table 15-2B**. The platform hour factors for other routes and other alternatives remain unchanged.

Table 15-1: Estimated Annual Operations and Maintenance Costs (2011 dollars)

Alternative	Revenue/Platform Hours			O&M Cost by Mode		Total O&M Cost
	Bus (Platform Hours)	Streetcar (Revenue Hours)	Total Hours	Bus	Streetcar	
No Build	102,591	N/A	102,591	\$14,447,891	\$0	\$14,447,891
TSM 1	149,501	N/A	149,501	\$20,082,255	\$0	\$20,082,255
TSM 2	142,007	N/A	142,007	\$19,026,781	\$0	\$19,026,781
Streetcar Build - Low	80,965	58,124	139,089	\$10,430,305	\$9,009,143	\$19,439,448
Streetcar Build - Mid	80,965	58,124	139,089	\$10,430,305	\$11,624,700	\$22,055,005
Streetcar Build - High	80,965	58,124	139,089	\$10,430,305	\$15,112,110	\$25,542,415

Table 15-2A: Platform Hour Factor Calculations

Route(s)	Type of Hour	Mon-Thurs Factor	Friday Factor	Saturday Factor	Sunday Factor
16A, B, D, E, J, P	Daily Platform Hours	169.60	173.67	130.07	80.43
	Daily Revenue Hours	142.55	145.75	120.08	66.87
16G, H, K	Daily Platform Hours	111.55	111.55	71.05	36.83
	Daily Revenue Hours	92.73	92.73	64.87	33.27
16F	Daily Platform Hours	38.67	38.67	No trips	No trips
	Daily Revenue Hours	29.27	29.27	N/A	N/A
16L	Daily Platform Hours	6.93	6.93	No trips	No trips
	Daily Revenue Hours	4.17	4.17	N/A	N/A
16Y	Daily Platform Hours	42.13	42.13	No trips	No trips
	Daily Revenue Hours	26.18	26.18	N/A	N/A

* See Table 15-2B for platform hour factors for routes 16G, 16H, and 16H/ in the TSM 2 Alternative.

Source: WMATA Bus Planning, December 2010.

Table 15-2B: Revised Platform Hour to Revenue Hour Factor for TSM 2 Alternative Routes with Articulated Vehicles

Route, Day	Four Mile Run Facility (standard buses)	Cinder Bed Road Garage (articulated buses)
16G, weekday	1.20	1.38
16G, Saturday	1.10	1.27
16G, Sunday	1.11	1.28
16H, weekday	1.20	1.30
16H, Saturday	1.10	1.19
16H, Sunday	1.11	1.20
16H/	1.20	1.30

- The TSM and Streetcar Build alternatives also include the incremental ART41 service. This incremental service will provide an additional four trips per hour for ART41 on all days of the week. In the TSM alternatives, the 16G route would be modified to go to the center of the Skyline complex to better serve this high-density location. As a result the route of 16G would follow the Columbia Pike alignment and would not serve the neighborhood of Columbia Heights West. The inclusion of ART41 incremental service would ensure continued service to the Columbia Heights West neighborhood in the absence of 16G. In the Streetcar Build alternative 16G is discontinued and the incremental ART41 trips through the Columbia Heights West would ensure continued service to this neighborhood.

15.4 Cost Methodology - Streetcar

Streetcar O&M costs were calculated by multiplying the total annual revenue vehicle hours of streetcar service by a range of cost per revenue hour of service. Total Streetcar revenue hours are summarized in **Table 15-3A**.

Table 15-3A: Streetcar Revenue Vehicle Hour Summary

	Daily Revenue Vehicle Hours	Annual Days of Service	Total Annual Revenue Vehicle Hours
Weekday	184.5	251	46,310
Saturday	111	58	6,438
Sunday	96	56	5,376
Total	-	365	58,124

Total annual revenue vehicle hours were calculated based on the streetcar operating plan developed as part of the project definition. The Appendix outlines detailed assumptions for each study alternative.

The steps for calculating annual streetcar revenue hours are as follows (see **Tables 15-4A, 15-4B, and 15-4C** for detail):

- Calculate round trip cycle time. This was calculated utilizing VISSIM model runs that were completed for each alternative. Round trip cycle time includes vehicle run time and recovery time at each terminal prior to the start of the next trip.
- Calculate the number of vehicles in service based on round trip cycle time and headway. The number of vehicles in service is a key driver of revenue vehicle hours. Number of vehicles in service is calculated by dividing round trip cycle time by headway.
- Calculate Daily Revenue Vehicle Hours. Daily revenue vehicle hours are calculated by multiplying the number of vehicles in service, in each time period (e.g. AM Peak) by the number of hours in that time period). Daily revenue hours by time period are then summed to get total daily revenue hours. This process is done for Weekday, Saturday, and Sunday.

- Annualize Daily Revenue Vehicle Hours (Weekday, Saturday, and Sunday). The daily revenue hours for Weekday, Saturday, and Sunday, as outlined above, are annualized by multiplying the daily revenue hours by the number of days in the year. In this instance, it was assumed there are 251 days of weekday service, 58 days of Saturday service (reflects holidays), and 56 days of Sunday service.

Streetcar Annual O&M costs were calculated by multiplying the annual revenue hours by a cost per revenue vehicle hour.

Because the definition of the streetcar network is still conceptual, a range of cost per revenue hour was used to provide a range of potential costs. The range is established by three data points as follows:

- Low Range - \$155 per revenue hour - based on approximate average for cost per revenue hour for Portland Streetcar (\$140¹ per revenue hour) and Philadelphia surface streetcar (\$154.87 per revenue hour, see **Table 15-3C**). The average of these two data points (\$147.45) is adjusted for inflation, see **Table 15-3B**.
- Mid Range - \$200 per revenue hour - based on the cost per revenue hour for New Orleans Canal Street Streetcar Line (\$185.21 per revenue hour, see **Table 15-3C**) and adjusted for inflation, see **Table 15-3B**.
- High Range - \$260 per revenue hour - based on cost per revenue hour for San Francisco MUNI surface streetcar (\$247.28 per revenue hour, see **Table 15-3C**) and adjusted for inflation, see **Table 15-3B**.

Total annual streetcar costs based on each data point within the unit cost range are shown in **Table 15-3B**.

Table 15-3C shows the cost per revenue hour for other streetcar systems in the United States, as obtained from the National Transit Database (NTD). The NTD is the mechanism by which the Federal Transit Administration collects uniform data needed to administer federal transit programs. The data collected consists of selected financial and operating data from federal grantees. The most recent available NTD data is for 2009. Data for streetcar systems is categorized within the broader light rail transit (LRT) mode; therefore NTD does not provide generalized average statistics on streetcars.

For reference, **Table 15-3D** shows the conceptual operating cost estimates prepared for the Benning Road streetcar extension in Washington DC. The DC Streetcar System Plan (October 2010) notes that unit operating costs for streetcar could, at the lower end, be comparable to unit operating costs for regional Metrobus service. The “medium” unit cost of \$216.81 is based on an average of several streetcar systems, while the high range represents an upper limit of streetcar operating experience.

¹ Portland Streetcar – The Portland Experience – Development Oriented Streetcars, pg3
<http://www.sactr.com/documents/cassresources/Gustafson%20Rick.pdf>

The detailed data underlying the calculations described in Sections 3 and 4 above are contained in Tables 15-6A through 15-9C.

Table 15-3B: Annual Streetcar Operating Costs

Cost Range	Cost/Revenue Hour, 2009*	Cost/Revenue Hour, 2011**	Recommended Cost/Revenue Hour, rounded	Annual Revenue Vehicle Hours	Total Streetcar Cost, 2011
Low	\$147.45	\$156.42	\$155.00	58,124	\$9,009,143
Mid	\$185.21	\$196.49	\$200.00	58,124	\$11,624,700
High	\$247.28	\$262.34	\$260.00	58,124	\$15,112,110

* 2009 cost as obtained from NTD, see highlighted cells in Table 15-3C.

** 2011 costs assume an annual inflation rate of 3%.

Table 15-3C: Costs per Revenue Hour for Light Rail* Systems in United States

All Systems		Eastern Systems (east of Mississippi)	
City/Metro	Costs Per Revenue Hour	City/Metro	Costs Per Revenue Hour
Boston	221.58	Boston	221.58
Philadelphia	154.87	Philadelphia	154.87
Pittsburgh	373.11	Pittsburgh	373.11
Baltimore	238.33	Baltimore	238.33
New Jersey	435.88	New Jersey	435.88
Charlotte	307.21	Charlotte	307.21
New Orleans	185.21	Average	288.50
Dallas	441.08		
Houston	211.29		
St. Louis	210.16		
Denver	123.55		
Salt Lake	109.28		
Los Angeles	389.99		
San Francisco	247.28		
San Jose	289.45		
Portland	197.15		
Seattle	211.17		
Average	255.68		

Southern Systems	
City/Metro	Costs Per Revenue Hour
Charlotte	307.21
New Orleans	185.21
Dallas	441.08
Houston	211.29
Average	286.20

Source: 2009 National Transit Database

*Streetcar systems are highlighted in the table; streetcar systems are grouped with LRT in NTD data.

**The Portland Oregon Streetcar does not report to the National Transit Database. The figure for Portland in Table 15-3C is for the Portland regional light rail system. The source of the \$140 streetcar cost is referenced in the footnote on the previous page.

Table 15-3D: Operating Costs - DC Streetcar, Benning Road Extension

Cost Range	Hours Per Year	Cost Per Hour	Inflation	FY2012	FY2016
Low	12,300	\$130.00	3%	\$799,500	\$1,799,689
High	12,300	\$300.00	3%	\$1,845,000	\$4,153,128
Medium	12,300	\$216.81	3%	\$1,333,382	\$3,001,465

Table 15-4A: Cost Calculations - Cost per Revenue Vehicle Hour - Low Range

Period	Hours in Period	Round Trip Cycle Time	Headway	Vehicles in Service	Rounded up	Hours in Period	Vehicle Hours	Cost per Hour	Total Period Cost
Weekday Cost Estimates									
AM Peak	5:30 AM - 9:30 AM	65	6	10.83	11	4	44	\$155.00	\$6,820
Mid -Day	9:30 AM - 3:00 PM	65	6	10.83	11	5.5	60.5	\$155.00	\$9,378
PM Peak	3:00 PM - 7:00 PM	65	6	10.83	11	4	44	\$155.00	\$6,820
Evening	7:00 PM - 1:00 AM	65	12	5.42	6	6	36	\$155.00	\$5,580
Total Cost per Weekday									\$28,598
Annual Weekdays									251
Annual Weekday Streetcar Cost Per Revenue Vehicle Hour									\$7,177,973
Saturday Cost Estimates									
All Day	6:30 AM - 1:00 AM	65	12	5.42	6	18.5	111	\$155.00	\$17,205
Annual Saturdays									58
Annual Saturday Streetcar Cost Per Revenue Vehicle Hour									\$997,890
Sunday Cost Estimates									
All Day	7:30 AM - 11:30 PM	65	12	5.42	6	16	96	\$155.00	\$14,880
Annual Sundays									56
Annual Sunday Streetcar Cost Per Revenue Vehicle Hour									\$833,280
Total Annual Streetcar Cost Per Revenue Vehicle Hour (Low Range)									\$9,009,143

Table 15-4B: Cost Calculations - Cost per Revenue Vehicle Hour - Mid Range

Period	Hours in Period	Round Trip Cycle Time	Headway	Vehicles in Service	Rounded up	Hours in Period	Vehicle Hours	Cost per Hour	Total Period Cost
Weekday Cost Estimates									
AM Peak	5:30 AM - 9:30 AM	65	6	10.83	11	4	44	\$200.00	\$8,800
Mid -Day	9:30 AM - 3:00 PM	65	6	10.83	11	5.5	60.5	\$200.00	\$12,100
PM Peak	3:00 PM - 7:00 PM	65	6	10.83	11	4	38.5	\$200.00	\$8,800
Evening	7:00 PM - 1:00 AM	65	12	5.42	6	6	36	\$200.00	\$7,200
Total Cost per Weekday									\$36,900
Annual Weekdays									251
Annual Weekday Streetcar Cost Per Revenue Vehicle Hour									\$9,261,900
Saturday Cost Estimates									
All Day	6:30 AM - 1:00 AM	65	12	5.42	6	18.5	111	\$200.00	\$22,200
Annual Saturdays									58
Annual Saturday Streetcar Cost Per Revenue Vehicle Hour									\$1,287,600
Sunday Cost Estimates									
All Day	7:30 AM - 11:30 PM	65	12	5.42	6	16	96	\$200.00	\$19,200
Annual Sundays									56
Annual Sunday Streetcar Cost Per Revenue Vehicle Hour									\$1,075,200
Total Annual Streetcar Cost Per Revenue Vehicle Hour (Mid Range)									\$11,624,700

Table 15-4C: Cost Calculations - Cost per Revenue Vehicle Hour - High Range

Period	Hours in Period	Round Trip Cycle Time	Headway	Vehicles in Service	Rounded up	Hours in Period	Vehicle Hours	Cost per Hour	Total Period Cost
Weekday Cost Estimates									
AM Peak	5:30 AM - 9:30 AM	65	6	10.83	11	4	44	\$260.00	\$11,440
Mid -Day	9:30 AM - 3:00 PM	65	6	10.83	11	5.5	60.5	\$260.00	\$15,730
PM Peak	3:00 PM - 7:00 PM	65	6	10.83	11	4	44	\$260.00	\$11,440
Evening	7:00 PM - 1:00 AM	65	12	5.42	6	6	36	\$260.00	\$9,360
Total Cost per Weekday									\$47,970
Annual Weekdays									251
Annual Weekday Streetcar Cost Per Revenue Vehicle Hour									
Saturday Cost Estimates									
All Day	6:30 AM - 1:00 AM	65	12	5.42	6	18.5	111	\$260.00	\$28,860
Annual Saturdays									58
Annual Saturday Streetcar Cost Per Revenue Vehicle Hour									
Sunday Cost Estimates									
All Day	7:30 AM - 11:30 PM	65	12	5.42	6	16	96	\$260.00	\$24,960
Annual Sundays									56
Annual Sunday Streetcar Cost Per Revenue Vehicle Hour									
Total Annual Streetcar Cost Per Revenue Vehicle Hour (High Range)									\$15,112,110

Table 15-5A: Annual O&M Costs - By Day and Total for No Build Alternative

Route	Cost Per Platform Hour	Annual Weekday Cost	Annual Saturday Cost	Annual Sunday Cost	Total Annual Cost
16A	\$140.83	\$1,542,085	\$0	\$0	\$1,542,085
16B (Culmore)	\$140.83	\$1,138,266	\$29,111	\$37,400.84	\$1,204,778
16B (Annandale)	\$140.83	\$0	\$579,137	\$285,901	\$865,038
16D	\$140.83	\$1,130,694	\$0	\$0	\$1,130,694
16E (Culmore)	\$140.83	\$276,784	\$66,338	\$78,218	\$421,341
16E (Annandale)	\$140.83	\$66,462	\$0	\$17,622	\$84,083
16F	\$140.83	\$776,419	\$0	\$0.00	\$776,419
16G	\$140.83	\$2,911,571	\$542,026	\$272,074	\$3,725,672
16H and 16H/	\$140.83	\$738,073	\$0	\$0	\$738,073
16J	\$140.83	\$1,762,082	\$357,010	\$0	\$2,119,092
16K	\$140.83	\$0	\$23,720	\$20,729	\$44,450
16L	\$140.83	\$214,762	NA	NA	\$214,762
16P	\$140.83	\$0	\$0	\$149,528	\$149,528
16Y	\$140.83	\$1,431,876	NA	NA	\$1,431,876
Total Cost - No Build Alternative					\$14,447,891

Table 15-5B: Annual O&M Costs - By Day and Total for TSM 1 Alternative

Route	Cost Per Platform Hour	Annual Weekday Cost	Annual Saturday Cost	Annual Sunday Cost	Total Annual Cost
16A	\$140.83	\$1,394,439	\$0	\$0	\$1,394,439
16B (Culmore)	\$140.83	\$1,000,294	\$24,846	\$38,839	\$1,063,979
16B (Annandale)	\$140.83	\$0	\$579,137	\$286,752	\$865,890
16D	\$140.83	\$1,012,913	\$0	\$0	\$1,012,913
16E (Culmore)	\$140.83	\$276,784	\$66,338	\$66,720	\$409,842
16E (Annandale)	\$140.83	\$66,462	\$0	\$14,953	\$81,415
16F	\$140.83	\$783,885	\$0	\$0	\$783,885
16G	\$140.83	\$3,675,095	\$568,478	\$479,018	\$4,722,592
16H	\$140.83	\$2,182,406	\$325,794	\$274,525	\$2,782,726
16H/	\$140.83	\$2,304,146	\$0	\$0	\$2,304,146
16J	\$140.83	\$1,489,084	\$301,698	\$0	\$1,790,782
16K	\$140.83	\$0	\$23,720	\$17,333	\$41,053
16L	\$140.83	\$214,762	NA	NA	\$214,762
16P	\$140.83	\$0	\$0	\$149,528	\$149,528
16Y	\$140.83	\$1,354,477	NA	NA	\$1,354,477
ART41*	\$75.08	\$841,207	\$137,949	\$130,669	\$1,109,826
Total Cost - TSM 1 Alternative					\$20,082,255

* Incremental service only

Table 15-5C: Annual O&M Costs - By Day and Total for TSM 2 Alternative

Route	Cost Per Platform Hour	Annual Weekday Cost	Annual Saturday Cost	Annual Sunday Cost	Total Annual Cost
16A	\$140.83	\$1,328,818	\$0	\$0	\$1,328,818
16B (Culmore)	\$140.83	\$914,062	\$21,379	\$32,798	\$968,239
16B (Annandale)	\$140.83	\$0	\$579,137	\$286,752	\$865,890
16D	\$140.83	\$989,357	\$0	\$0	\$989,357
16E (Culmore)	\$140.83	\$274,547	\$66,338	\$66,720	\$407,605
16E (Annandale)	\$140.83	\$66,462	\$0	\$14,953	\$81,415
16F	\$140.83	\$783,885	\$0	\$0	\$783,885
16G	\$140.83	\$3,633,528	\$562,069	\$473,601	\$4,669,197
16H	\$140.83	\$2,166,933	\$323,496	\$272,579	\$2,763,008
16H/	\$140.83	\$2,135,288	\$0	\$0	\$2,105,331
16J	\$140.83	\$1,389,811	\$281,585	\$0	\$1,671,397
16K	\$140.83	\$0	\$23,720	\$17,333	\$41,053
16L	\$140.83	\$214,762	NA	NA	\$214,762
16P	\$140.83	\$0	\$0	\$149,528	\$149,528
16Y	\$140.83	\$1,257,729	NA	NA	\$1,257,729
ART41*	\$75.08	\$841,207	\$137,949	\$130,669	\$1,109,826
Total Cost - TSM 2 Alternative					\$19,436,996

* Incremental service only

Table 15-5D: Annual Bus O&M Costs - By Day and Total for Streetcar Build Alternative

Route	Cost Per Platform Hour	Annual Weekday Cost	Annual Saturday Cost	Annual Sunday Cost	Total Annual Cost
16A	\$140.83	\$1,312,413	\$0	\$0	\$1,312,413
16B (Culmore)	\$140.83	\$931,308	\$23,818	\$40,884	\$996,010
16B (Annandale)	\$140.83	\$0	\$579,137	\$286,752	\$865,890
16D	\$140.83	\$989,357	\$0	\$0	\$989,357
16E (Culmore)	\$140.83	\$274,547	\$66,338	\$66,720	\$407,605
16E (Annandale)	\$140.83	\$66,462	\$0	\$14,953	\$81,415
16F	\$140.83	\$716,694	\$0	\$0	\$716,694
16G	\$140.83	\$0	\$0	\$0	\$0
16H and 16H/	\$140.83	\$0	\$0	\$0	\$0
16J	\$140.83	\$1,439,448	\$291,642	\$0	\$1,731,089
16J (PC)	\$140.83	\$595,633	\$0	\$0	\$595,633
16K	\$140.83	\$0	\$23,720	\$17,333	\$41,053
16L	\$140.83	\$214,762	NA	NA	\$214,762
16P	\$140.83	\$0	\$0	\$149,528	\$149,528
16Y	\$140.83	\$1,219,030	NA	NA	\$1,219,030
ART41*	\$75.08	\$841,207	\$137,949	\$130,669	\$1,109,826
Total Cost for Bus - Streetcar Build Alternative					\$10,430,305

* Incremental service only

Table 15-6A: Bus Service - No Build Alternative - Calculation of Revenue Vehicle Hours

Route	One Way Trips by Day*			One Way Revenue Time Per Trip			Daily Revenue Hours		
	Weekday Daily Trips	Saturday Daily Trips	Sunday Daily Trips	Weekday Revenue Hours Per Trip	Saturday Revenue Hours Per Trip	Sunday Revenue Hours Per Trip	Weekday Revenue Hours	Saturday Revenue Hours	Sunday Revenue Hours
16A	39	0	0	0.94	0.00	0.00	36.66	0.00	0.00
16B (Culmore)	41	5	8	0.66	0.66	0.49	27.06	3.30	3.95
16B (Annandale)	0	65	30	0.00	1.01	1.01	0.00	65.65	30.21
16D	28	0	0	0.96	0.00	0.00	26.88	0.00	0.00
16E (Culmore)	14	16	15	0.47	0.47	0.55	6.58	7.52	8.27
16E (Annandale)	2	0	2	0.79	0.00	0.93	1.58	0.00	1.86
16F	16	0	0	1.04	0.00	0.00	16.64	0.00	0.00
16G	156	124	63	0.44	0.49	0.49	68.64	60.33	31.08
16H and 16H/	30	0	0	0.58	0.00	0.00	17.40	0.00	0.00
16J	59	57	0	0.71	0.71	0.00	41.89	40.47	0.00
16K	0	8	6	0.00	0.33	0.39	0.00	2.64	2.37
16L	6	0	0	0.61	0.00	0.00	3.66	0.00	0.00
16P	0	0	20	0.00	0.00	0.79	0.00	0.00	15.80
16Y	34	0	0	0.74	0.00	0.00	25.16	0.00	0.00

Note: The number of trips is based on current WMATA timetables and includes both eastbound/westbound trips.

Table 15-6B: Bus Service - No Build Alternative - Calculation of Daily Platform Hours

Route	Weekday Platform Factor	Saturday Platform Factor	Sunday Platform Factor	Weekday Platform Hours	Saturday Platform Hours	Sunday Platform Hours
16A	1.19	1.08	1.20	43.63	0.00	0.00
16B (Culmore)	1.19	1.08	1.20	32.20	3.56	4.74
16B (Annandale)	1.19	1.08	1.20	0.00	70.90	36.25
16D	1.19	1.08	1.20	31.99	0.00	0.00
16E (Culmore)	1.19	1.08	1.20	7.83	8.12	9.92
16E (Annandale)	1.19	1.08	1.20	1.88	0.00	2.23
16F	1.32	NA	NA	21.96	0.00	0.00
16G	1.20	1.10	1.11	82.37	66.36	34.50
16H and 16H/	1.20	1.10	1.11	20.88	0.00	0.00
16J	1.19	1.08	1.20	49.85	43.71	0.00
16K	1.20	1.10	1.11	0.00	2.90	2.63
16L	1.66	NA	NA	6.08	0.00	0.00
16P	1.19	1.08	1.20	0.00	0.00	18.96
16Y	1.61	NA	NA	40.51	0.00	0.00

Table 15-6C: Bus Service - No Build Alternative - Calculation of Annual Platform Hours

Route	Annual Weekday Platform Hours	Annual Saturday Platform Hours	Annual Sunday Platform Hours	Total Annual Platform Hours
16A	10,950	0	0	10,950
16B (Culmore)	8,083	207	266	8,555
16B (Annandale)	0	4,112	2,030	6,142
16D	8,029	0	0	8,029
16E (Culmore)	1,965	471	555	2,992
16E (Annandale)	472	0	125	597
16F	5,513	0	0	5,513
16G	20,674	3,849	1,932	26,455
16H and 16H/	5,241	0	0	5,241
16J	12,512	2,535	0	15,047
16K	0	168	147	316
16L	1,525	0	0	1,525
16P	0	0	1,062	1,062
16Y	10,167	0	0	10,167
Total	85,132	11,342	6,117	102,591

Note: The calculations assume 251 weekdays, 58 Saturdays and 56 Sundays.

Table 15-7A: Bus Service - TSM 1 Alternative - Calculation of Daily Revenue Hours

Route	One Way Trips by Day			One Way Revenue Time Per Trip			Daily Revenue Hours		
	Weekday Daily Trips	Saturday Daily Trips	Sunday Daily Trips	Weekday Revenue Hours Per Trip	Saturday Revenue Hours Per Trip	Sunday Revenue Hours Per Trip	Weekday Revenue Hours	Saturday Revenue Hours	Sunday Revenue Hours
16A	39	0	0	0.85	0.00	0.00	33.15	0.00	0.00
16B (Culmore)	41	5	8	0.58	0.56	0.51	23.78	2.82	4.10
16B (Annandale)	0	65	30	0.00	1.01	1.01	0.00	65.65	30.30
16D	28	0	0	0.86	0.00	0.00	24.08	0.00	0.00
16E (Culmore)	14	16	15	0.47	0.47	0.47	6.58	7.52	7.05
16E (Annandale)	2	0	2	0.79	0.00	0.79	1.58	0.00	1.58
16F	16	0	0	1.05	0.00	0.00	16.80	0.00	0.00
16G	152	111	96	0.57	0.57	0.57	86.64	63.27	54.72
16H	105	74	64	0.49	0.49	0.49	51.45	36.26	31.36
16H/	97	0	0	0.56	0.56	0.56	54.32	0.00	0.00
16J	59	57	0	0.60	0.60	0.00	35.40	34.20	0.00
16K	0	8	6	0.00	0.33	0.33	0.00	2.64	1.98
16L	6	0	0	0.61	0.00	0.00	3.66	0.00	0.00
16P	0	0	20	0.00	0.00	0.79	0.00	0.00	15.80
16Y	34	0	0	0.70	0.00	0.00	23.80	0.00	0.00
ART41*	72	64	60	0.52	0.45	0.47	37.20	28.80	28.00

* Incremental service only

Table 15-7B: Bus Service - TSM 1 Alternative - Calculation of Daily Platform Hours

Route	Weekday Platform Factor	Saturday Platform Factor	Sunday Platform Factor	Weekday Platform Hours	Saturday Platform Hours	Sunday Platform Hours
16A	1.19	1.08	1.20	39.45	0.00	0.00
16B (Culmore)	1.19	1.08	1.20	28.30	3.04	4.92
16B (Annandale)	1.19	1.08	1.20	0.00	70.90	36.36
16D	1.19	1.08	1.20	28.66	0.00	0.00
16E (Culmore)	1.19	1.08	1.20	7.83	8.12	8.46
16E (Annandale)	1.19	1.08	1.20	1.88	0.00	1.90
16F	1.32	NA	NA	22.18	0.00	0.00
16G	1.20	1.10	1.11	103.97	69.60	60.74
16H	1.20	1.10	1.11	61.74	39.89	34.81
16H/	1.20	1.10	1.11	65.18	0.00	0.00
16J	1.19	1.08	1.20	42.13	36.94	0.00
16K	1.20	1.10	1.11	0.00	2.90	2.20
16L	1.66	NA	NA	6.08	0.00	0.00
16P	1.19	1.08	1.20	0.00	0.00	18.96
16Y	1.61	NA	NA	38.32	0.00	0.00
ART41*	1.20	1.10	1.11	44.64	31.68	31.08

* Incremental service only

Table 15-7C: Bus Service - TSM 1 Alternative - Calculation of Annual Platform Hours

Route	Annual Weekday Platform Hours	Annual Saturday Platform Hours	Annual Sunday Platform Hours	Total Annual Platform Hours
16A	9,902	0	0	9,902
16B (Culmore)	7,103	176	276	7,555
16B (Annandale)	0	4,112	2,036	6,148
16D	7,192	0	0	7,192
16E (Culmore)	1,965	471	474	2,910
16E (Annandale)	472	0	106	578
16F	5,566	0	0	5,566
16G	26,096	4,037	3,401	33,534
16H	15,497	2,313	1,949	19,759
16H/	16,361	0	0	16,361
16J	10,574	2,142	0	12,716
16K	0	168	123	292
16L	1,525	0	0	1,525
16P	0	0	1,062	1,062
16Y	9,618	0	0	9,618
ART41*	11,205	1,837	1,740	14,783
Total	123,075	15,258	11,168	149,501

Note: The calculations assume 251 weekdays, 58 Saturdays and 56 Sundays.

* Incremental service only

Table 15-8A: Bus Service - TSM 2 Alternative - Calculation of Daily Revenue Hours

Route	One Way Trips by Day			One Way Revenue Time Per Trip			Daily Revenue Hours		
	Weekday Daily Trips	Saturday Daily Trips	Sunday Daily Trips	Weekday Revenue Hours Per Trip	Saturday Revenue Hours Per Trip	Sunday Revenue Hours Per Trip	Weekday Revenue Hours	Saturday Revenue Hours	Sunday Revenue Hours
16A	39	0	0	0.81	0.00	0.00	31.59	0.00	0.00
16B (Culmore)	41	5	8	0.53	0.48	0.43	21.73	2.42	3.47
16B (Annandale)	0	65	30	0.00	1.01	1.01	0.00	65.65	30.30
16D	28	0	0	0.84	0.00	0.00	23.52	0.00	0.00
16E (Culmore)	14	16	15	0.47	0.47	0.47	6.53	7.52	7.05
16E (Annandale)	2	0	2	0.79	0.00	0.79	1.58	0.00	1.58
16F	16	0	0	1.05	0.00	0.00	16.80	0.00	0.00
16G	152	111	96	0.49	0.49	0.49	74.48	54.39	47.04
16H	105	74	64	0.45	0.45	0.45	47.25	33.30	28.80
16H/	97	0	0	0.48	0.00	0.00	46.56	0.00	0.00
16J	59	57	0	0.56	0.56	0.00	33.04	31.92	0.00
16K	0	8	6	0.00	0.33	0.33	0.00	2.64	1.98
16L	6	0	0	0.61	0.00	0.00	3.66	0.00	0.00
16P	0	0	20	0.00	0.00	0.79	0.00	0.00	15.80
16Y	34	0	0	0.65	0.00	0.00	22.10	0.00	0.00
ART41*	72	64	60	0.52	0.45	0.47	37.20	28.80	28.00

* Incremental service only

Table 15-8B: Bus Service - TSM 2 Alternative - Calculation of Daily Platform Hours

Route	Weekday Platform Factor	Saturday Platform Factor	Sunday Platform Factor	Weekday Platform Hours	Saturday Platform Hours	Sunday Platform Hours
16A	1.19	1.08	1.20	37.59	0.00	0.00
16B (Culmore)	1.19	1.08	1.20	25.86	2.62	4.16
16B (Annandale)	1.19	1.08	1.20	0.00	70.90	36.36
16D	1.19	1.08	1.20	27.99	0.00	0.00
16E (Culmore)	1.19	1.08	1.20	7.77	8.12	8.46
16E (Annandale)	1.19	1.08	1.20	1.88	0.00	1.90
16F	1.32	NA	NA	22.18	0.00	0.00
16G	1.38	1.27	1.28	102.79	68.81	60.05
16H	1.30	1.19	1.20	61.30	39.60	34.56
16H/	1.30	NA	NA	60.41	0.00	0.00
16J	1.19	1.08	1.20	39.32	34.47	0.00
16K	1.20	1.1	1.11	0.00	2.90	2.20
16L	1.66	NA	NA	6.08	0.00	0.00
16P	1.19	1.08	1.20	0.00	0.00	18.96
16Y	1.61	NA	NA	35.58	0.00	0.00
ART41*	1.20	1.10	1.11	44.64	31.68	31.08

* Incremental service only

Table 15-8C: Bus Service - TSM 2 Alternative - Calculation of Annual Platform Hours

Route	Annual Weekday Platform Hours	Annual Saturday Platform Hours	Annual Sunday Platform Hours	Total Annual Platform Hours
16A	9,436	0	0	9,436
16B (Culmore)	6,491	152	233	6,875
16B (Annandale)	0	4,112	2,036	6,148
16D	7,025	0	0	7,025
16E (Culmore)	1,949	471	474	2,894
16E (Annandale)	472	0	106	578
16F	5,566	0	0	5,566
16G	25,801	3,991	3,363	33,155
16H	15,387	2,297	1,936	19,619
16H/	15,162	0	0	15,162
16J	9,869	1,999	0	11,868
16K	0	168	123	292
16L	1,525	0	0	1,525
16P	0	0	1,062	1,062
16Y	8,931	0	0	8,931
ART41*	11,205	1,837	1,740	14,783
Total	118,818	15,029	11,073	144,919

Note: The calculations assume 251 weekdays, 58 Saturdays and 56 Sundays.

* Incremental service only

Table 15-9A: Bus Service - Streetcar Build Alternative - Calculation of Daily Revenue Hours

Route	One Way Trips by Day			One Way Revenue Time Per Trip			Daily Revenue Hours		
	Weekday Daily Trips	Saturday Daily Trips	Sunday Daily Trips	Weekday Revenue Hours Per Trip	Saturday Revenue Hours Per Trip	Sunday Revenue Hours Per Trip	Weekday Revenue Hours	Saturday Revenue Hours	Sunday Revenue Hours
16A	39	0	0	0.80	0.00	0.00	31.20	0.00	0.00
16B (Culmore)	41	5	8	0.54	0.54	0.54	22.14	2.70	4.32
16B (Annandale)	0	65	30	0.00	1.01	1.01	0.00	65.65	30.30
16D	28	0	0	0.84	0.00	0.00	23.52	0.00	0.00
16E (Culmore)	14	16	15	0.47	0.47	0.47	6.53	7.52	7.05
16E (Annandale)	2	0	2	0.79	0.00	0.79	1.58	0.00	1.58
16F	16	0	0	0.96	0.00	0.00	15.36	0.00	0.00
16G	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
16H and 16H/	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00
16J	59	57	0	0.58	0.00	0.00	34.22	33.06	0.00
16J (PC)	24	0	0	0.59	0.00	0.00	14.16	0.00	0.00
16K	0	8	6	0.00	0.33	0.33	0.00	2.64	1.98
16L	6	0	0	0.61	0.00	0.00	3.66	0.00	0.00
16P	0	0	20	0.00	0.00	0.79	0.00	0.00	15.80
16Y	34	0	0	0.63	0.00	0.00	21.42	0.00	0.00
ART41*	72	64	60	0.52	0.45	0.47	37.20	28.80	28.00

* Incremental service only

Table 15-9B: Bus Service - Streetcar Build Alternative - Calculation of Daily Platform Hours

Route	Weekday Platform Factor	Saturday Platform Factor	Sunday Platform Factor	Weekday Platform Hours	Saturday Platform Hours	Sunday Platform Hours
16A	1.19	1.08	1.20	37.13	0.00	0.00
16B (Culmore)	1.19	1.08	1.20	26.35	2.92	5.18
16B (Annandale)	1.19	1.08	1.20	0.00	70.90	36.36
16D	1.19	1.08	1.20	27.99	0.00	0.00
16E (Culmore)	1.19	1.08	1.20	7.77	8.12	8.46
16E (Annandale)	1.19	1.08	1.20	1.88	0.00	1.90
16F	1.32	NA	NA	20.28	0.00	0.00
16G	1.20	1.10	1.11	0.00	0.00	0.00
16H and 16H/	1.20	1.10	1.11	0.00	0.00	0.00
16J	1.19	1.08	1.20	40.72	35.70	0.00
16J (PC)	1.19	1.08	1.20	16.85	0.00	0.00
16K	1.20	1.10	1.11	0.00	2.90	2.20
16L	1.66	NA	NA	6.08	0.00	0.00
16P	1.19	1.08	1.20	0.00	0.00	18.96
16Y	1.61	NA	NA	34.49	0.00	0.00
ART41*	1.20	1.10	1.11	44.64	31.68	31.08

* Incremental service only

Table 15-9C: Bus Service - Streetcar Build Alternative - Calculation of Annual Platform Hours

Route	Annual Weekday Platform Hours	Annual Saturday Platform Hours	Annual Sunday Platform Hours	Total Annual Platform Hours
16A	9,319	0	0	9,319
16B (Culmore)	6,613	169	290	7,072
16B (Annandale)	0	4,112	2,036	6,148
16D	7,025	0	0	7,025
16E (Culmore)	1,949	471	474	2,894
16E (Annandale)	472	0	106	578
16F	5,089	0	0	5,089
16G	0	0	0	0
16H and 16H/	0	0	0	0
16J	10,221	2,071	0	12,292
16J (PC)	4,229	0	0	4,229
16K	0	168	123	292
16L	1,525	0	0	1,525
16P	0	0	1,062	1,062
16Y	8,656	0	0	8,656
ART41*	11,205	1,837	1,740	14,783
Total	66,304	8,829	5,832	80,965

Note: The calculations assume 251 weekdays, 58 Saturdays and 56 Sundays.

* Incremental service only

Attachment A: Detailed Operating Plan Assumptions

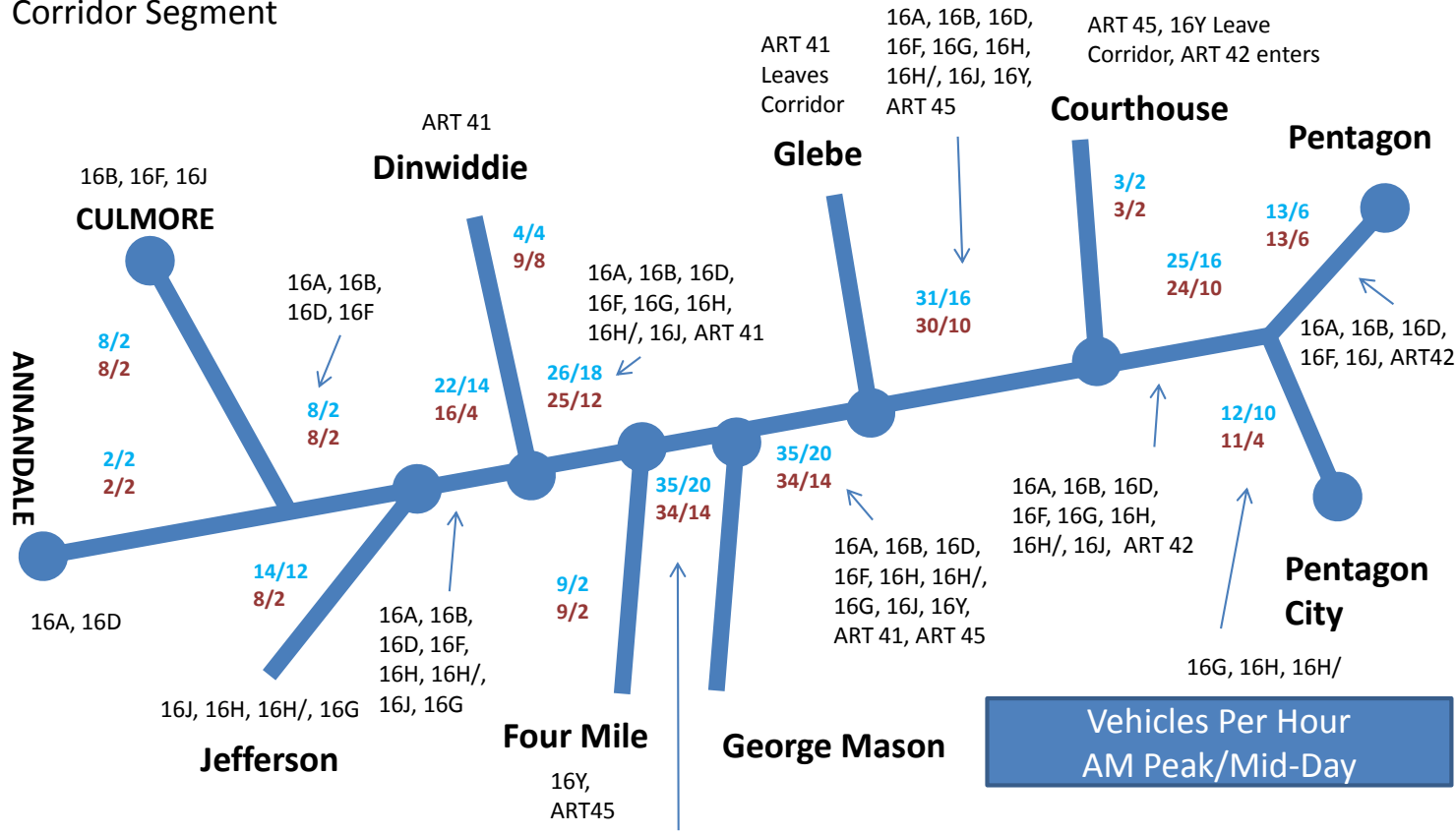
Table A1: TSM Alternatives - Bus Routes and Vehicles per Hour

Route	Terminal Points	Hours of Service	Peak Vehicles Per Hour - Eastbound	Mid-Day Vehicles Per Hour - Eastbound
Pentagon				
16A	Annandale to Pentagon Metro Station (will run as limited stop)	Weekday - all day	1	1
16B	Culmore to Pentagon Metro Station (weekend service to Annandale)	Peak period, evenings, and weekends	2	0
16D	Annandale to Pentagon Metro Station (will run as limited stop)	Weekday - all day	1	1
16E	Culmore to Pentagon Metro Station via Pentagon City	Evenings - each day	N/A	N/A
16F	Culmore to Federal Triangle via Pentagon (will remain as Limited Stop)	Peak period, peak direction	4	0
16J	Culmore to Pentagon Metro Station	All Day, Weekdays, Saturdays	2	2
16K	Columbia Heights West to Pentagon Metro Station	Weekend mornings only	N/A	N/A
16L	Annandale to Pentagon Express (via I-395)	Weekday peak period, peak direction	2	0
16P	Culmore to Pentagon Metro Station via Pentagon City	Sunday - all day	N/A	N/A
Subtotal Pentagon	(Note: 16L not included in schematic diagram Figure A1 on Page 22 - does not run on Columbia Pike)		12	4
Pentagon City				
16G*	Skyline (TSM 2)/NOVA (TSM 1) to 12 th Street South (Conference Center)	All Day, 7 days per week	5	5
16H*	Skyline (TSM 2)/NOVA (TSM 1) to Pentagon City and then to Crystal City	Weekday, All Day	3	2
16H/*	Skyline (TSM 2)/NOVA (TSM 1) to 12 th Street South (Conference Center)	Weekday, All Day	4	3
Subtotal Pentagon City			12	10
16Y	Four Mile Run Road to Farragut Square	Peak period, peak direction only	7	0

Figure A1: TSM Alternatives - Bus Routes and Number of Vehicles per Hour by Geography

TSM 1 and 2 Alternatives

Eastbound Transit Service Along Columbia Pike – Vehicles Per Hour (AM Peak/Mid-Day) by Corridor Segment



Note: 16L – Included in table totals but not included in diagram – runs to Pentagon but not via Columbia Pike

16A, 16B, 16D, 16F, 16G, 16H, 16H/, 16J, 16Y, ART 41, ART 45

TSM 1 & 2
No-Build

Table A2: TSM Service Plan Assumptions

16G	Weekday	Saturday	Sunday
Peak	6 trips per hour in the first hour of peak; 10 trips per hour in the remaining three hours of peak $(6*1) + (10*3) = 36$ trips	6 one way trips per hour all day (3 in each direction)	6 one way trips per hour all day (3 in each direction)
Midday	8 trips per hour * 5.5 hours = 44 trips	6 trips per hour * 18.5 hours = 111 trips	6 trips per hour * 16 hours = 96 trips
Late Night	6 trips per hour * 6 hours = 36 trips		
Total Trips	152	111	96

Route 16H	Weekday	Saturday	Sunday
Peak	6 trips per hour * 8 hours = 48 trips	4 one way trips per hour all day (2 in each direction)	5 one way trips per hour all day (2 in each direction)
Midday	6 trips per hour * 5.5 hours = 33 trips		
Late Night	4 trips per hour * 6 hours = 24 trips	4 trips per hour * 18.5 hours = 74 trips	4 trips per hour * 16 hours = 64 trips
Total Trips	105	74	64

16H/	Weekday	Saturday	Sunday
Peak	8 trips per hour * 8 hours = 64 trips	No trips on Saturday	No trips on Sunday
Midday	6 trips per hour * 5.5 hours = 33 trips		
Late Night	0 trips per hour * 6 hours = 24 trips		
Total Trips	97	0	0

All other routes are maintained identical to the No Build Alternative.

Table A3: 16G, 16H and 16H/ Service in TSM Alternatives - Weekday

Period	Span of Service	Hours in Period	16G			16H			16H/				
			Headway in minutes	Average Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips		
AM Peak	5:30 AM - 9:30 AM	4	5:30 AM - 6:30 AM - 10 6:30 AM - 9:30 AM - 6	9*	36	10	6	24	7.5	8	32		
Mid -Day	9:30 AM - 3:00 PM	5.5	7.5	8	44	10	6	33	10	6	33		
PM Peak	3:00 PM - 7:00 PM	4	3:00 PM - 4:00 PM - 10 4:00 PM - 7:00 PM - 6	9**	36	10	6	24	7.5	8	32		
Evening	7:00 PM - 1:00 PM	6	10	6	36	15	4	24	No trips	0			
Total Trips Per Weekday					152	Total Trips Per Weekday			105	Total Trips Per Weekday			97

*6 trips per hour 5:30 AM - 6:30 AM; 10 trips per hour 6:30 AM - 9:30 AM

**6 trips per hour 3:00 PM - 4:00 PM and then 10 trips per hour 4:00 PM - 7:00 PM

Table A4: 16G, 16H and 16H/ Service in TSM Alternatives - Saturday

Period	Span of Service	Hours in Period	16G			16H			16H/		
			Headway in minutes	Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips
All Day	6:30 AM - 1:00 AM	18.5	10	6	111	15	4	74	No trips	0	0

Table A5: 16G, 16H and 16H/ Service in TSM Alternatives - Sunday

Period	Span of Service	Hours in Period	16G			16H			16H/		
			Headway in minutes	Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips	Headway in minutes	Trips/Hour	Total Trips
All Day	7:30 AM - 11:30 PM	16	10	6	96	15	4	64	No trips	0	0

All other routes are maintained identical to the No Build Alternative.

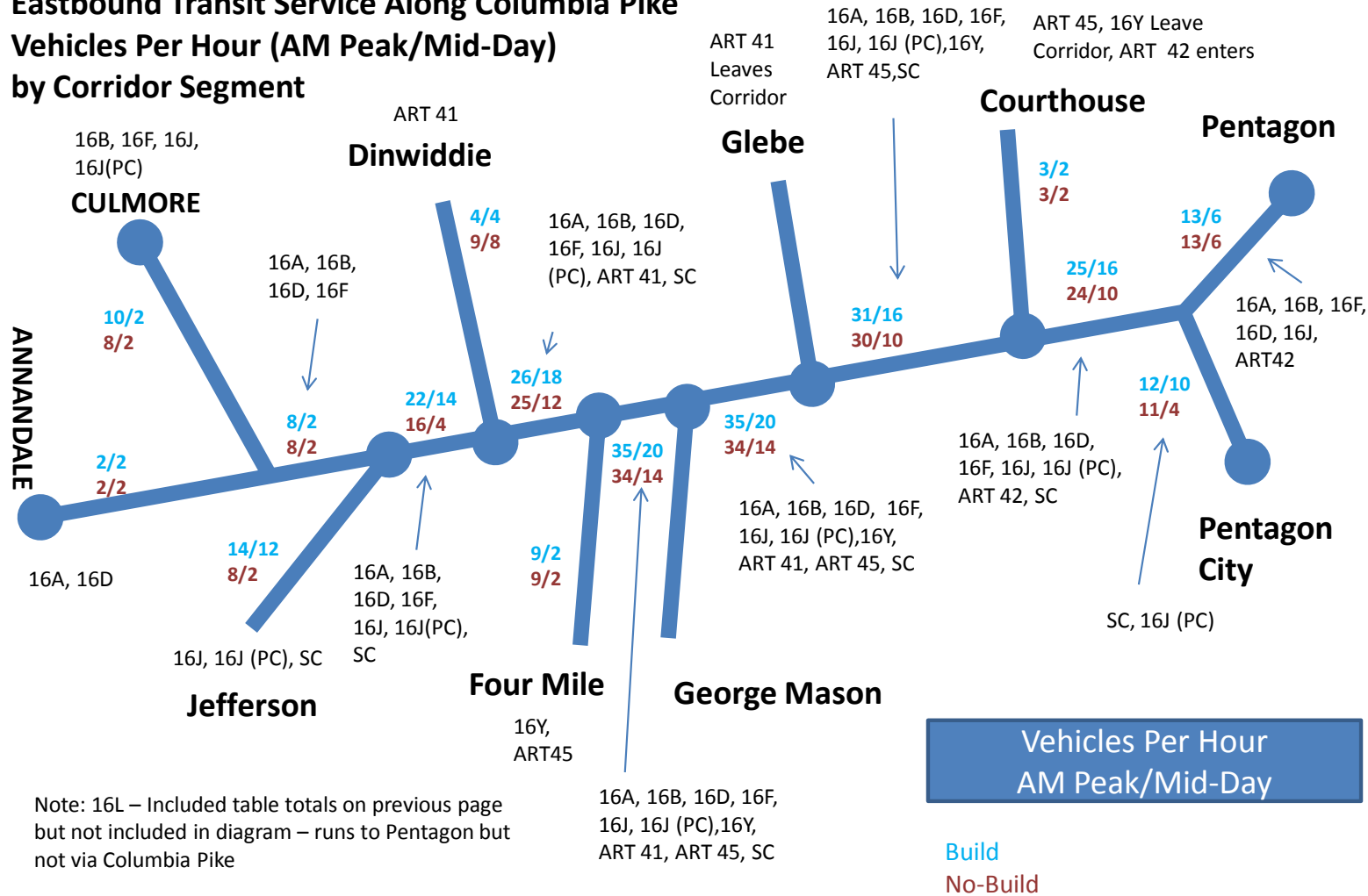
Table B1: Build Alternative - Bus Routes and Vehicles per Hour

Route	Terminal Points	Hours of Service	Peak Vehicles Per Hour - Eastbound	Mid-Day Vehicles Per Hour - Eastbound
Pentagon				
16A	Annandale to Pentagon Metro Station (will run as limited stop)	Weekday - all day	1	1
16B	Culmore to Pentagon Metro Station weekend service to Annandale)	Peak Periods, evenings and weekends	2	0
16D	Annandale to Pentagon Metro Station (will run as limited stop)	Weekday - all day	1	1
16E	Culmore to Pentagon Metro Station via Pentagon City	Evenings - each day	N/A	N/A
16F	Culmore to Federal Triangle via Pentagon - Remains Limited Stop	Peak period	4	0
16J	Culmore to Pentagon Metro Station	All Day weekdays, Saturdays	2	2
16K	Columbia Heights West to Pentagon Metro Station	Weekend mornings only	N/A	N/A
16L	Annandale to Pentagon Express (via I-395)	Weekday peak period, peak direction	2	0
16P	Culmore to Pentagon Metro Station via Pentagon City	Sunday - all day	N/A	N/A
Subtotal Pentagon	(Note: 16L not included in schematic diagram - next slide - does not run on Columbia Pike)		12	4
Pentagon City				
Streetcar	Skyline to 12 th Street South (Conference Center)	All Day, 7 days per week	10	10
16J (PC)	Culmore to Pentagon City Metro Station	Peak Period Only	2	0
16G	<i>Removed in Build</i>	<i>Removed in Build</i>	N/A	N/A
16H	<i>Removed in Build</i>	<i>Removed in Build</i>	N/A	N/A
16H/	<i>Removed in Build</i>	<i>Removed in Build</i>	N/A	N/A
Subtotal Pentagon City			12	10
16Y	Four Mile Run Road to Farragut Square	Peak period, peak direction only	7	0

In the Build Alternative, the Streetcar and 16J (PC) replace the routes 16G, 16H and 16H/. All other routes are maintained identical to the No Build Alternative. The service plan for Build Alternative is discussed in the main report under streetcar cost calculations; see Tables 4A through 4C.

Figure B2: Build Alternative - Bus Routes and Number of Vehicles per Hour by Geography

Build Alternative
Eastbound Transit Service Along Columbia Pike
Vehicles Per Hour (AM Peak/Mid-Day)
by Corridor Segment



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