14.0 Capital Cost Estimate Methodology

14.1 Purpose of the Memorandum

This memorandum documents the major assumptions that inform the conceptual capital cost estimates for the transit improvement alternatives prepared to accompany the Alternatives Analysis/Environmental Assessment (AA/EA) for the Columbia Pike Transit Initiative.

The major purpose of the preliminary capital cost estimates at this stage of project development is to inform the local capital budgeting process and assess the need for state and federal funding. The current analysis allows decision makers to anticipate capital requirements and understand the scale of potential risk as the project moves into subsequent phases of development.

14.2 Background for the Estimates

This memorandum details cost estimates for each of the study alternatives:

- **No Build Alternative** - no significant changes to the existing corridor bus network; construction of improved bus stops as part of the Arlington County Columbia Pike Super Stops program; selected improvements to the corridor roadway network in connection with the Columbia Pike Multimodal Project and other ongoing corridor projects.
- **Transportation System Management 1 (TSM 1)** - improvements in transit network connectivity to the Skyline area, purchase of standard buses in the corridor and provide vehicle wrap / branding to existing and new buses.
- **Transportation Systems Management 2 (TSM 2)** - in addition to the improvements associated with TSM 1: Procure articulated buses, provide vehicle wrap / branding to existing and new buses, contribute a percentage of construction cost to proposed Cinder Bed Road bus garage, improved bus stop amenities and off-vehicle fare collection, and a park and ride and intermodal transfer facility at Jefferson Street.
- **Streetcar Build Alternative** – modern streetcar service along an approximately 5-mile alignment between Skyline and Pentagon City with complementing bus service and off-vehicle fare collection, parking and intermodal transfer facility same as TSM 2, traction power substations along the alignment, a park-and-ride and intermodal transfer facility at Jefferson Street, and an operations and maintenance facility and supporting infrastructure.

The current estimate, based on preliminary conceptual engineering designs, is presented in the Federal Transit Administration (FTA) Standard Cost Categories format to allow refinement as design activities progress, to facilitate comparison over time and with other projects in the region, and to establish a unified basis for capital programming.

The current preliminary capital cost estimate for transit is built up independently from previous estimates for this project. A previous estimate, updated in 2007, was based on work performed during the Local Alternatives Analysis (2004-2006).

Important characteristics of the current estimate are as follows:

1. Unit prices are current for the year 2011. Costs have been escalated to the mid-point of construction, which is considered to be 2015. Based on the Engineering News Record (ENR) construction inflation rates, as well as the average inflation according to the Consumer Price Index (CPI), a constant rate of 3% per year was assumed.
2. Current estimates are based on the working draft AA/EA from November 2011 and associated general plans.
3. While the estimates are based on an increased level of engineering detail as compared with previous estimates, the current estimates reflect design work that remains conceptual in nature. Unit costs reflect local conditions and recent project experience in other U.S. cities.

Current preliminary capital cost estimates for the project are presented in **Table 14-1**.

Table 14-1: Summary of Transit Capital Cost Estimates, 2015 Dollars (Millions)

Alternative	Total Project + Contingency	Length in Miles	Cost/Mile
Transportation Systems Management Alternatives			
TSM 1	$ 4.8	5	$ 1.0
TSM 2	$ 53.2	5	$10.6
Streetcar Build Alternative			
Skyline Central Plaza Design Option	$260.8	4.96	$52.5
Skyline Route 7 Design Option	$249.8	4.93	$50.6
Jefferson Street Transit Center Design Option	$241.9	4.74	$51.1

14.3 Definitions of Alternatives for Transit Capital Cost Estimates

14.3.1 No Build Alternative

The No Build Alternative would undertake very little construction with minor improvements to existing services and structures along the route. Assumptions include:

- Continued current services of Metrobus 16 Line and coordinated Arlington Transit (ART) services;
- Ongoing roadway construction projects;
- Continued Metrobus service by 40-foot compressed natural gas (CNG) buses with a capacity of 41 seated and 20 standing passengers. Also continued ART bus service with 31- and 35-foot CNG buses with capacity for 25 seated/18 standing and 30 seated/19 standing passengers, respectively;
- Programmed bus stop upgrades along Columbia Pike in connection with the Arlington County Columbia Pike Super Stops program to include improved shelters and waiting areas, raised curbs for nearly level boarding, and real-time passenger information;
- Continued on-board fare collection; and
- Maintain existing 28-space park-and-ride at Columbia Pike and Four Mile Run Drive.

14.3.2 TSM 1 Alternative

The TSM 1 Alternative includes minor improvements to routes in the corridor. The scope of this option assumes:

- Same transit routes and vehicles as the No Build Alternative, but the network will be enhanced to provide improved services to the Skyline area;
- Consolidation of stops to ¼ to ½ mile along entire study corridor – by others;
- Street improvements will include those from the No Build Alternative – by others;
- Park-and-ride facilities will be the same as No Build Alternative – by others;
- Procurement of 40 ft. buses;
- Provide vehicle wrap / branding to existing and new buses used on the corridor; and
- Continued on-board fare collection.

14.3.3 TSM 2 Alternative

The TSM 2 Alternative includes the elements associated with TSM 1, with a few more additions. The scope of this option assumes:

- Procure 60-foot articulated buses on several routes (16G, 16H, with a capacity of 60 passengers seated and 30 standing. Network will be enhanced to provide improved services to the Skyline area;
- Provide vehicle wrap / branding to existing and new buses used on the corridor;
- Contribute a percentage of the cost to construct the proposed Cinder Bed Road bus garage.
- Consolidated stops as in TSM 1, but outfitted with ticket vending machines for off-vehicle fare collection with proof of payment;
- Construction of park-and-ride and intermodal transfer facility at Jefferson Street; and
- Street improvements required to achieve Multimodal Project cross-section will include re-setting curbs and medians to accommodate vehicular left turns, pedestrian movements, etc. – by others.

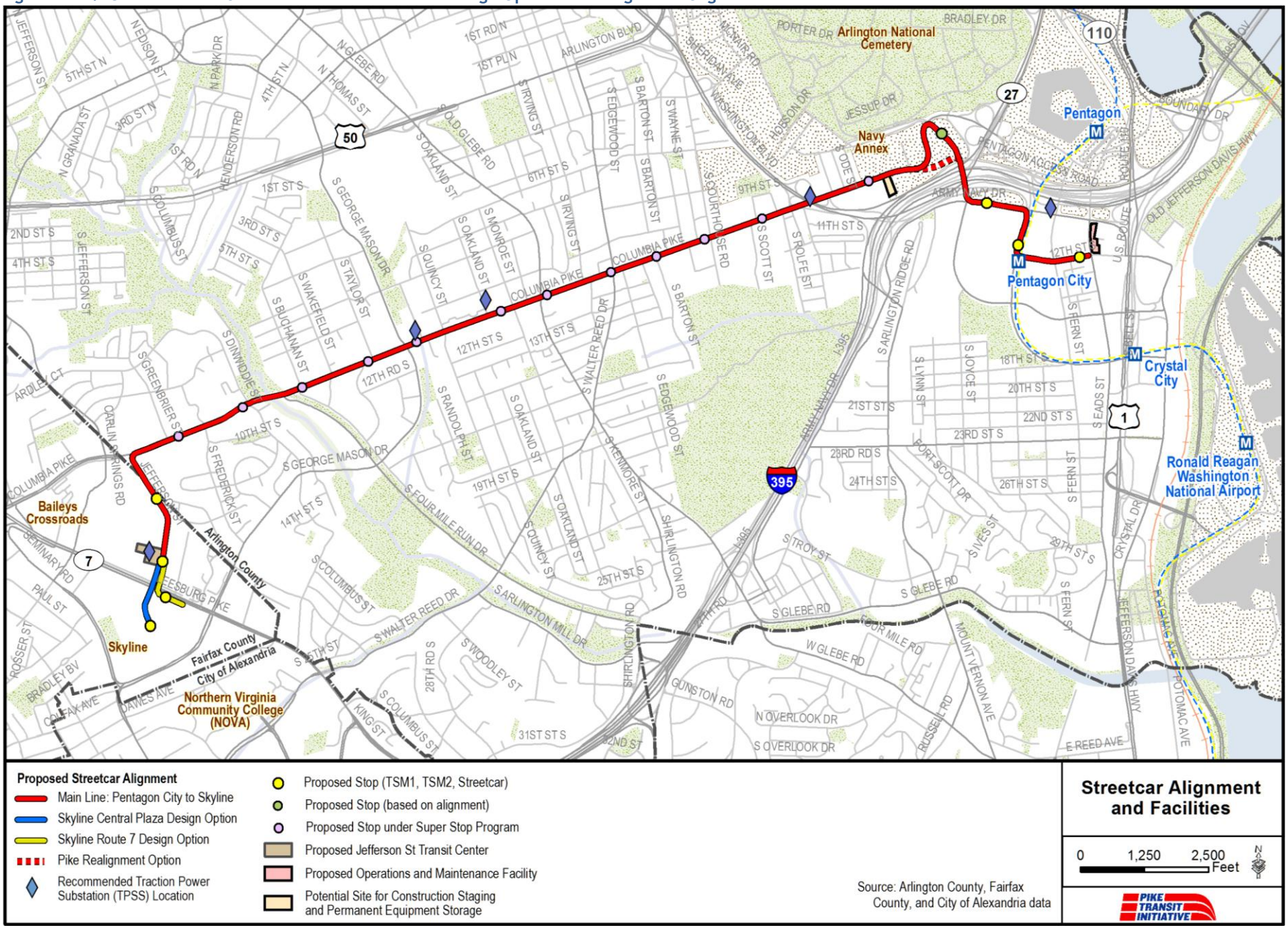
14.3.4 Streetcar Build Alternative

The Streetcar Build Alternative would require the most changes to the existing infrastructure and thus the greatest capital investment. A map of the proposed streetcar alignment, including the three design options, is illustrated in **Figure 14-1**.

The Streetcar Build Alternative includes:

- Streetcar service along a 5-mile alignment between Skyline and Pentagon City with complementary bus network;
- Fleet of 13 transit vehicles, consisting of 66-foot electric trams/modern streetcar vehicles;
- Stops outfitted with ticket vending machines for off-vehicle fare collection with proof of payment;
- Operations and maintenance (O&M) facility (or “shop”);
- General guideway infrastructure; track slab, traction power, etc.; and
- Construction of park-and-ride and intermodal transfer facility at Jefferson Street.

Figure 14-1: Columbia Pike Streetcar Build Alternative Design Options and Alignment Segments



Design Options

The Streetcar Build Alternative includes three main design options. Each design option consists of a combination of a mainline alignment segment (same for all design options), O&M facility (same for all design options), and western terminus alignment segment (specific to each design option) as follows:

- **Mainline Segment** – Consists of the 4.71 mile segment extending from the intersection of 12th Street South and South Eads Street in the Pentagon City area to the east, to the intersection of South Jefferson Street and Leesburg Pike (Route 7) intersection to the west. Segment includes 18 stops.
- **Pentagon City O&M Facility** – The maintenance facility is located on a property parcel at the corner of 12th Street South, and South Eads Street. As this is the eastern terminal for the Mainline segment there is no yard lead alignment length associated with this facility. The site is 1.5 acres in area and the facility would be capable of storing 13 streetcar vehicles.
- **Skyline Central Plaza Design Option Terminus Segment** – Consists of a 0.23 mile alignment which extends the mainline west (geographically south), across Leesburg Pike (Route 7), and into the Skyline plaza. Once inside the plaza, the alignment turns geographically east, and terminates at a streetcar stop located between the One and Two Skyline buildings to the south, and the sports and health club and Target store to the north.
- **Skyline Route 7 Design Option Terminus Segment** – Consists of a 0.20 mile alignment, which extends the mainline west (geographically south), across Leesburg Pike (Route 7), where it then turns geographically east, parallels Route 7 locating between Route 7 and the Target parking lot, and terminates at a streetcar stop adjacent to the Target parking lot.
- **Jefferson Street Transit Center Design Option Terminus Segment** – This option essentially duplicates the west end of the Mainline alignment. However, this option introduces a terminus streetcar stop at the existing stop R. The stop location and traffic operations require that the guideway be exclusive in this location, which requires moving the South Jefferson Street west curb line west to shift traffic lanes.

Components included in Capital Cost Estimates

FTAs Standard Cost Categories (SCC) included in the cost estimates for each alternative are shown in **Table 14-2**. Development of capital costs for the design options included the following components in each:

- **Skyline Central Plaza Option** – Includes Mainline and western terminus alignment segments and O&M Facility.
  - Total alignment length = 4.96 miles
  - Total stops constructed = 6
- **Skyline Central Route 7 Option** – Includes Mainline and western terminus alignment segments and O&M Facility.
  - Total alignment length = 4.93 miles
  - Total stops constructed = 6
- **Jefferson Street Transit Center Design Option** – Includes Mainline and western terminus alignment segments and O&M Facility.
  - Total alignment length = 4.74 miles
  - Total stops constructed = 5
  - Design Option also includes re-construction of South Jefferson Pike at terminus station for purposes of establishing exclusive guideway.

Table 14-2: Categories Included in Estimate by Alternative

SCC Number and Description		Alternatives			
		No Build	TSM		Streetcar Build
			1	2	
10	Guideway & Track Elements				X
20	Stations, Stops Terminals, Intermodal	X		X	X
30	Support Facilities: Yards, Shops, Administrative Buildings			X	X
40	Sitework & Special Conditions				X
50	Systems				X
60	ROW, Land, Existing Improvements			X	X
70	Vehicles		X	X	X
80	Professional Services			X	X
90	Unallocated Contingency	X	X	X	X

14.4 Basis of Estimate for Transportation System Management Alternatives

Because the TSM alternatives include minimal investments in the corridor, the SCCs considered are limited, as previously seen in **Table 14-2**. The assumptions made for the applicable categories are discussed here, and are assumed to be the same for both of the TSM options unless otherwise noted.

- Guideway and Track Elements – There are not cost items for this category for TSM 1 and TSM 2.
- Stations, Stops, Terminals, and Intermodal – There are no cost items for this category for TSM 1. TSM 2 includes construction of improved stops with shelters, passenger information, etc. at six locations along the study corridor. The Super Stops program will construct fifteen additional stops to be included as part of the No Build Alternative. TSM 2 includes allowance for off-vehicle fare collection at all corridor stops, and includes an estimate for the construction of an intermodal transfer facility at Jefferson Street with 200 park and ride spaces. All new stops under TSM 2 will be built according to the dimensions of 12 feet by 75 feet but will be modified where physical constraints exist.
- Support Facilities – There are no cost items for this category for TSM 1. The bus fleet purchased for TSM 2 will be maintained at the proposed Cinder Bed Road bus facility which is being constructed to accommodate articulated buses. TSM 2 includes capital cost to the Cinder Bed Road garage project, for purposes of storing and maintaining buses purchased in TSM 2 at that facility. Increased non-revenue costs for travel to and from Cinder Bed Road are included in the project O&M cost estimate.
- Site Work and Special Conditions – There are not cost items for this category for TSM 1 and TSM 2. Note that there is site work included with Jefferson Street Transit center included in category 20.
- 50. Systems – There are not cost items for this category for TSM 1 and TSM 2.
- Right-of-Way, Land, Existing Improvements – There are no cost items for this category for TSM 1. TSM 2 assumes right-of-way (ROW) purchased for the intermodal transfer facility at Jefferson Street.
- Vehicles – Five 40-foot standard buses were included in TSM 1. Eighteen 60-foot articulated buses were included in TSM 2. TSM 1 and TSM 2 include vehicle wrap / branding for existing and new buses to be used on the corridor.
- Professional Services – All soft costs are identified by line item to allow for adjustment of specific percentages per the direction of the project sponsors, as appropriate. No professional services costs were applied to TSM 1. For TSM 2, professional service costs were applied to Category 20, Stations, Stops, Terminals, and Intermodal only.
- Contingency – All contingencies are identified by line item to allow for adjustment of specific percentages per the direction of the project sponsors, as appropriate.
- Finance Charges – None assumed in this estimate.

14.4.1 Basis of Estimate for Streetcar Build Alternative

All SCC were used for the Streetcar Build Alternatives. **Table 14-3** provides cost data for each Design Option by category.

A description of the elements which include the majority of costs for the Streetcar Build Alternative is listed below, segregated by category:

Guideway and Track Elements

The majority of the alignment is within travel lanes along existing streets and is made up of embedded track. The typical steel-reinforced concrete track slab is 15 inches deep, two mats of reinforcement, Tee-rail running rail with rail boot, ties/leveling beam, and fasteners. The unit price used for trackwork is an average per route feet. Guideway track section assumed to be embedded in-street with a typical depth of 18 inches is shown in **Figure 14-2**. However a 3-foot excavation may be necessary in some locations if substandard subsurface conditions are discovered during subsequent design efforts. One mitigation technique for substandard conditions would be to increase the excavation depth to 3 feet and build up the section with engineered fill material. This is illustrated in **Figure 14-3**. Note that at the current level of design, subsurface investigation was not performed, and guideway costs are based on the section illustrated in **Figure 14-2**.

14.5 Basis of Transit Capital Cost Estimates

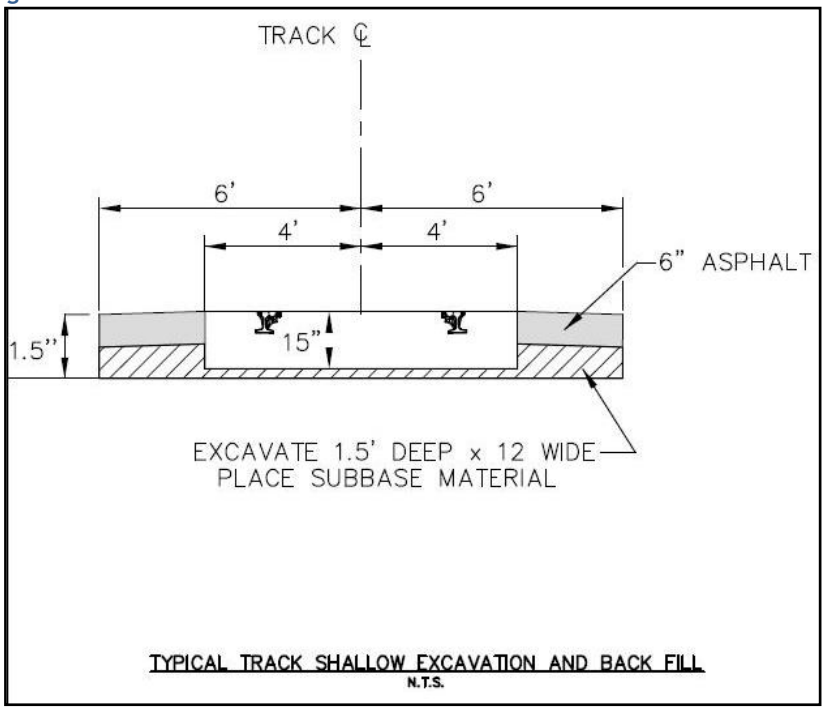
The capital costs estimates are broken down into sections dictated by the SCC for capital projects. These SCCs allow all projects seeking federal funds to be estimated and reported in a consistent format.

To present a realistic estimate of capital costs, the scope of each alternative has been defined as comprehensively as possible given the conceptual state of design at this stage of project development. **Table 14-2** shows which categories were included in the estimates for each of the project alternatives. Sections 14.2 and 14.4.1 summarize key assumptions for the overall estimates of the alternatives by cost category. These assumptions constitute the “basis” of the cost estimate.

Table 14-3: Cost Estimates for Streetcar Build Alternative Design Options, Escalated to 2015 Dollars and Including Allocated and Unallocated Contingency

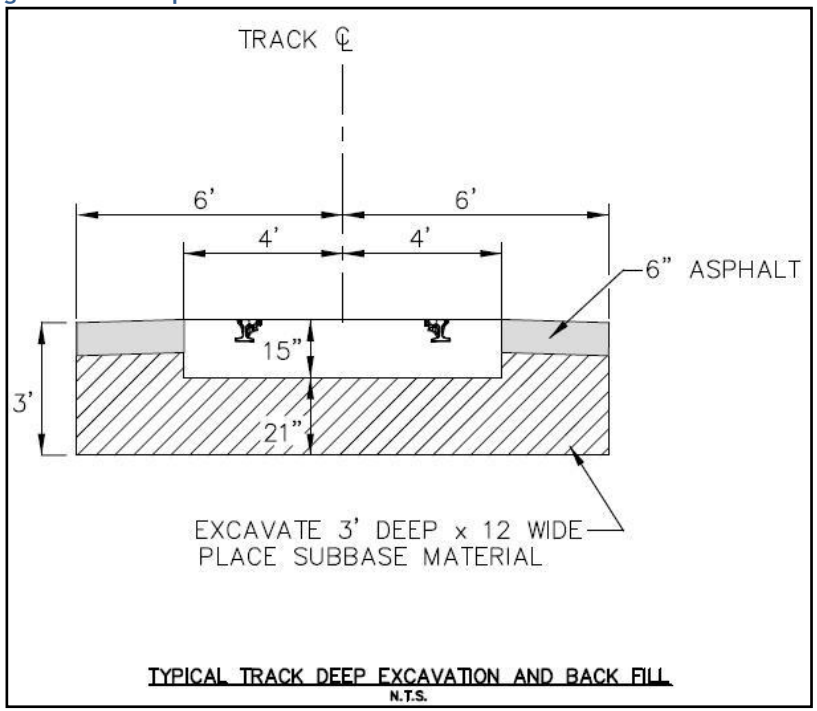
Cat. No.	Standard Cost Categories (SCC)	Skyline Central Plaza Design Option	Skyline Route 7 Design Option	Jefferson Street Transit Center Design Option
10	Guideway & Track Elements	$49,743,307	$42,127,189	$37,523,301
20	Stations, Stops, Terminals, Intermodal	$6,579,261	$6,579,261	$6,119,652
30	Support Facilities: Yards, Shops, Admin. Bldgs	$16,325,802	$16,325,802	$16,325,802
40	Sitework & Special Conditions	$18,780,560	$18,686,543	$18,905,204
50	Systems	$33,735,417	$33,497,243	$33,073,942
	Construction Subtotal (Sum Categories 10 - 50)	$125,164,346	$117,216,038	$111,947,901
60	Row, Land, Existing Improvements	$13,721,311	$14,078,590	$13,756,518
70	Vehicles	$58,503,609	$58,503,609	$58,503,609
80	Professional Services (Calc. On Subtotal 10 - 50)	$37,814,425	$35,465,141	$33,892,336
90	Unallocated Contingency (Calculated On Subtotal Cat. 10 - 80)	$25,560,228	$24,520,751	$23,814,954
	Total	$260,763,919	$249,784,128	$241,915,317

Figure 14-2: Shallow Excavation Cross Section



Source:

Figure 14-3: Deep Excavation Cross Section



Source:

Four Mile Run Bridge: Based on a review of the typical cross section in conjunction with the design criteria for a minimum of an 11 inch deck, reuse of the existing precast concrete beams with a modified deck was determined to be not feasible. The minimum existing structural deck thickness is on the order of 7 inche minimum for support of the vehicular loadings. The existing bridge structure can be seen below in **Figure 14-4**. An alternate structural configuration has been developed which utilizes structural light weight precast pre-stressed adjacent concrete box beams with an 11 inch light weight cast-in-place non composite concrete deck. The cross-section of the proposed structure can be seen in **Figure 14-5**. The Inekon Tram would be utilized as the design vehicle in accordance with the WMATA Design Criteria. Conceptual design indicates that existing pier columns would require modification to accommodate the additional loading.

Skyline: The Skyline Central Plaza Design Option would bring the streetcar through the existing Skyline Place office complex on the top of an existing elevated parking garage deck and the entrance and exit ramps. The proposed streetcar alignment runs within the Skyline facility between Skyline buildings One, Two and Three to the south, and the Target store to the north. Based on the preliminary analysis, the existing parking garage decks have been designed to accommodate an HS-20 vehicular load; however, additive effects of impact, rocking, and hunting of the streetcar have not been included. It is anticipated that the deck elevation (height) or profile grade will need to increase to meet the requirements of the proposed track slab. It is also anticipated that the structure will need to be strengthened to achieve loading requirements associated with the vehicle dynamic loading criteria. While the parking garage deck appears to be potentially viable as an alternative route for the proposed streetcar, the effects of strengthening the structure on the below grade parking structure and above/at grade facilities must be analyzed to determine operating impacts to the existing facility. Further evaluation and testing is needed to determine the actual capacity and possible retrofit/strengthening action plans.

Stations, Stops, Terminals, and Intermodal

The preliminary estimates assume a typical streetcar stop platform schematic assuming simple low-level platforms (10-inch height above top of rail) with shelters, seating, lighting, ticket vending machines, and passenger information kiosks. The typical stop along Columbia Pike (implemented under Super Stops program) is 120 feet long and 12 feet wide which can simultaneously accommodate both a streetcar vehicle and a bus. All work associated with stops along Columbia Pike is included in the No Build Alternative. Stops not on Columbia Pike are 75 feet long which accommodate a single streetcar vehicle. Along the mainline, there are 18 stations (A – R), as illustrated in **Table 14-4**. All except for five stations are curbside. Streetcar stop S is located in the Skyline area, and is included in the Skyline terminus design options. This SCC category also includes the intermodal transit facility at Jefferson Street, which includes 200 parking spaces. Some demolition, clearing, grading, and realignment will be needed for the Jefferson Street Transit Center.

Figure 14-4: Existing Typical Bridge Section

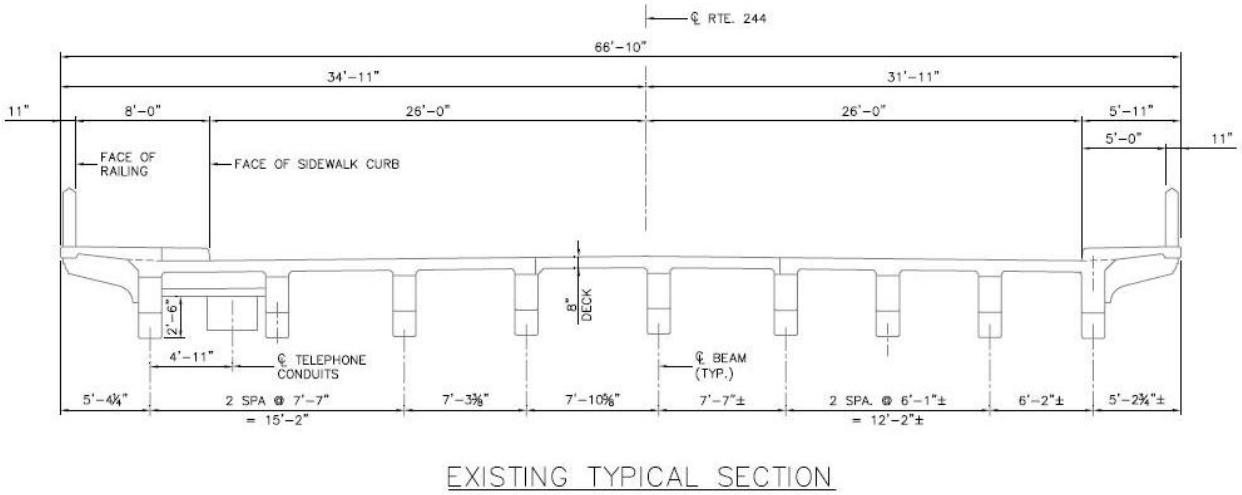


Figure 14-5: Proposed Typical Bridge Section

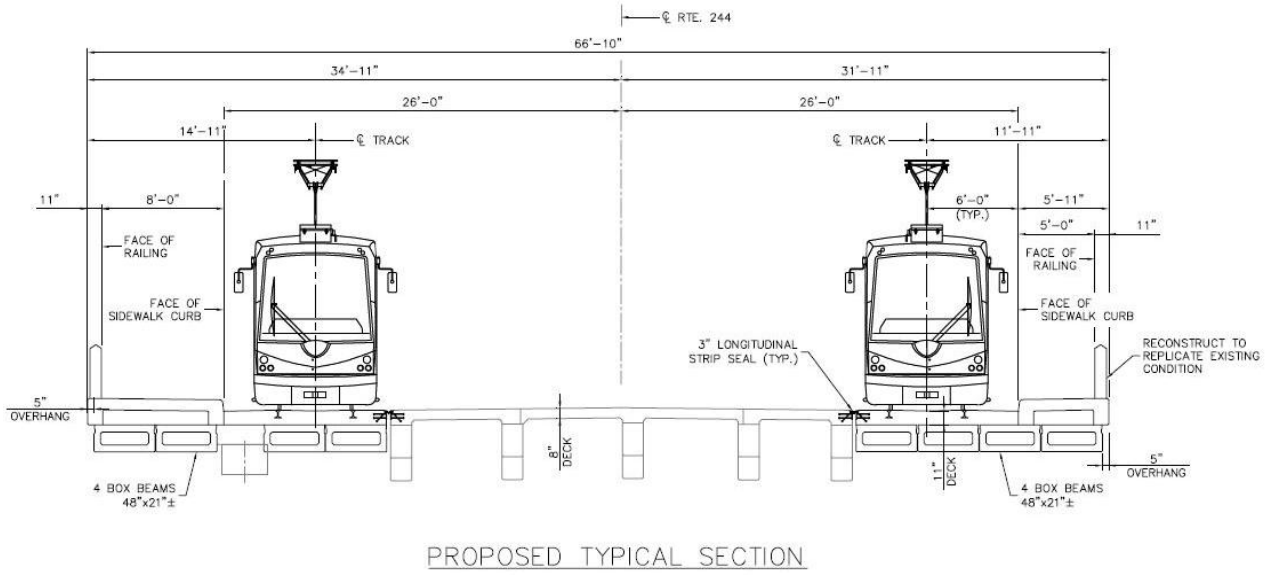


Table 14-4: Streetcar Build Station Information

		Constructed Under		Platform	
Stop Letter/Name		No Build Alternative	Streetcar Build Alternative	Center	Side
A	12th Street South		x	x	
B	S Hayes Street		x	x	
C	Army Navy Drive		x		x
D	Joyce Street		x	x	
E	Oak Street/Nash Street/Navy Annex	x			x
F	Scott Street	x			x
G	S. Courthouse Street	x			x
H	Barton Street	x			x
I	Walter Reed Drive	x			x
J	S. Glebe Road	x			x
K	S. Monroe	x			x
L	George Mason Drive	x			x
M	S. Thomas St.	x			x
N	S. Buchanan/ S. Four Mile Run	x			x
O	S. Dinwiddie Street	x			x
P	Greenbrier Street	x			x
Q	Jefferson Street - Goodwin House		x	x	
R	Jefferson Street near Leesburg Pike*		x	x	
S	Skyline Complex**		**		**

* Stop R is accounted for in Mainline Alignment Segment. It is the terminal stop for the Jefferson Street Transit Center Design Option, which does not include a Stop S.
**For the terminal Stop S, the Skyline Central Plaza Option has a single one-sided platform, and the Skyline Route 7 Design Option has a center platform.

Support Facilities: Yards, Shops, Administration Buildings

Vehicle storage and maintenance facility requirements vary greatly from system to system, depending on factors such as existing facility capacity, operational requirements, number of vehicles, ridership, etc. In the Columbia Pike project, space for storage and maintenance is constrained by the limited available land in the corridor. Elements of the Pentagon shop comprise the following:

- Site – 1.5 acres;
- Storage for 13 vehicles within facility property;
- Administration Building – 7,000 square feet;
- Maintenance Building – 12,000 square feet;
- Vehicle Storage Building – 16,000 square feet; and
- Associated Civil, Track and Systems work.

Site Work and Special Conditions

Included in this estimate are utilities, demolition, environmental mediation, mobilization, roadway changes, and temporary maintenance of traffic.

Utilities: Findings for this preliminary analysis are based on analysis along the entire transit alignment, where underground utility concentration and potential impacts were rated according to three levels of utility disturbance Minimal, Moderate, and Major. For overhead utilities, a quantity estimate was performed to document potential utility disturbance. Potential utility impacts have been identified through the influence of WMATA design criteria. Impacts to utility services during construction, relocations, and reinforcements will be minimized by careful design and where possible, routing service onto temporary lines while utilities are being relocated, or by installing new utility infrastructure and aligning new connections to minimize service disruptions before disconnecting the conflicting utility for removal. Where cost effective, utilities will be left in place and reinforced to protect against impacts from loading and vibrations during streetcar construction and operations.

In general, overhead utility lines in the vicinity of the project alignment are not at a height that would conflict with the proposed streetcar catenary system. Along Columbia Pike it is assumed that remaining overhead utilities between Greenbrier Street and Jefferson Street will be undergrounded as part of Arlington County's current utility undergrounding initiative. More detailed engineering under the forthcoming preliminary engineering phase of the project will determine which utilities will be impacted and how these will need to be addressed via relocation or undergrounding. Overhead utilities, such as utility poles, and traffic signal masts, have been evaluated. Utility poles are the overhead potential impacts, but exist along a relatively small portion of the streetcar alignment.

Potential impacts by the streetcar alignment exist in the Pentagon City area of Arlington County, as well as at the Baileys Crossroads and Skyline areas of Fairfax County.

- Minimal Utility Disturbance – A minimal utility disturbance segment has zero to two longitudinal utility lines along the shared transit lanes, and zero to seven manholes, inlets, and other structures per segment.
- Moderate Utility Disturbance – A moderate utility disturbance segment has three to five longitudinal utility lines along the shared transit lanes, and eight to fourteen manholes, inlets and other structures per segment.
- Major Utility Disturbance – A major utility disturbance segment has more than five longitudinal utility lines along the shared transit lanes, and more than 14 manholes, inlets and other structures per segment.

Drainage: Drainage design assumptions include transverse track drains at regular intervals to move surface water from the guideway. The estimates also include an allowance for some subsurface drainage paralleling the corridor; however, it is not included for a majority of the alignment.

Mobilization: Assumed as (nominally) three percent of the construction subtotal.

Roadway: Roadway vertical realignment, which includes reconstructing and repaving 500 feet of roadway and streetscape along Jefferson Street, and new curb/gutter and landscaping along Jefferson Street are assumed.

Systems

Assumed systems costs for streetcar include traction power substations, overhead contact system, a basic communications system, and a fare collection system.

Traction Power: This estimate assumes an overhead contact system that uses a single trolley wire (no messenger wire) suspended along two sets of catenary poles (the majority of the route is curb-running alignment) and related infrastructure and accessories. The cost estimate assumes a duct bank with parallel feeder lines. Traction power substations are assumed to be spaced at approximately one-mile intervals along the alignment. The assumption to use a "feeder" rather than "feederless" system is informed by the hub-and-spoke configuration of power utility service in the project corridor. The estimates include an allowance for connection to Dominion Power substations.

Communications: The estimate assumes line-of-sight operation. It is assumed the system will include a fiber communication line to serve fare collection and data displays/announcements at stations, and safety and security equipment along the transit line. Within Arlington County, this includes communication line to connect the stop facilities to existing Arlington County Communication line. Within Fairfax County, this includes installing a dedicated communication line parallel to the guideway.

Traffic Control: Seven (7) new traffic signals and two (2) signal controller changes with addition of streetcar signals, and one (1) signal controller change are assumed as part of the streetcar improvements. The estimates include allowances for signal modifications and phase changes to facilitate transit

signal priority, and assume that the communications duct bank will carry required lines and conduit. Lane markings are also included in the estimate.

Right-of-Way, Land, Existing Improvements

The preliminary assessment of ROW needs can be seen in the AA/EA; these findings are incorporated into the current preliminary capital cost estimates. At this stage of design, the area of ROW need includes the following:

- Allowance for streetcar stop facilities not on Columbia Pike
- Allowance for South Jefferson Street Transit Center
- Allowance for Traction Power Substations
- Allowance for Maintenance Facility

ROW impacts are calculated based on the square footage of each parcel needed for the project, and then escalated to represent the cost that the project sponsor can be expected to pay for the purchase of that land, associated legal fees, and other fees in the land acquisition process. Along the mainline, 20-40 parcels were impacted and the average value of these parcels was applied to all.

Vehicles

The streetcar vehicle is assumed to be the Inekon tram, the same vehicle purchased for the DC Streetcar Project. Vehicle fleet sizes are taken from a recent operations analysis that used estimates of peak hourly passenger demand while also maintaining the current bus headways. For revenue vehicles a spare ratio of 20 percent is assumed. One maintenance and tow non-revenue vehicle, and spare parts are included; however, spare parts for use beyond the revenue service date are not included. Unit costs represent typical experience for recent U.S. streetcar vehicle procurements.

Professional Services

All soft costs are identified by line item to allow for adjustment of specific percentages per the direction of the project sponsors, as appropriate. As a percentage of the project capital cost, soft costs are approximately 31 percent.

Contingency

All allocated contingencies are identified by line item to allow for adjustment of specific percentages per the direction of the project sponsors, as appropriate. Unallocated contingency is assumed at 15%. The resulting overall contingency is 25-30 percent of total project costs.

14.6 Utility of Estimates

The process of cost estimation is used in an effort to approximate, with the highest degree of likelihood at the given time, the quantity and cost of materials and labor for a project. Estimates are typically updated throughout a project's planning stages in order to understand how much capital needs to be secured, as well as how all stakeholders can expect to be impacted. Estimates at this stage in the design process provide a reasonable expectation for project budgeting. As the design continues to become more detailed, the estimates will also be expected to narrow in on a more precise price.

14.6.1 General Assumptions and Limitations

Preparation of cost estimates at this early stage of project development brings with it several challenges, among which are the questions of whether the current economic conditions, construction industry configuration, and building technologies will apply to a project implemented years in the future. In general, the estimating process has assumed that future conditions will be predictably similar to historical trends. Specific assumptions are as follows:

- Unit costs originate with historic bid data and from current engineers' estimates on other projects;
- Construction markets are assumed to be operating at reasonable levels, therefore no premium specifically related to labor costs is included, and adequate experienced contractors and craft labor are assumed available;
- Construction technology is assumed to be similar to that used today, therefore productivity rates are in keeping with those currently seen in the industry;
- Compatible trade agreements exist in the region, and no strike impacts will be experienced by the project;
- Normal weather patterns are assumed, therefore weather conditions will have no major impacts to construction schedule and costs; and
- Cooperation between stakeholders and construction contractors.

A recurring issue in the estimation of capital costs during the conceptual phase of a project is the evaluation and treatment of uncertainty. Uncertainty can result from a "difference" between the estimated cost of a project as defined during the concept phase and the actual cost of the project that is ultimately implemented. Four potential sources of uncertainty are generally recognized:

- **Changes in project scope** – during the alternatives analysis and NEPA phases of any significant transportation project, preliminary decisions on project scope are made on such issues as the extent of the proposed alignments, the number and locations of stations and facilities, and other significant issues. As a project progresses through the various stages of implementation many of the original project scope definitions that formed the basis of the cost estimate will be updated or revised.
- **Changes in design or operating standards** – similar to the broader uncertainties on project scope but generally more specific in nature, changes in transportation technology or operating rules during later phases of project development can lead to changes in project cost. A potentially large source of uncertainty within this category relates to the degree to which geotechnical conditions are understood.
- **Incorrect unit cost/quantity assumptions** – a variety of potential problems exist in the assumptions used in selecting unit cost or unit

quantities. Issues that can affect the accuracy of unit costs include local demand for construction labor and its impact on wage rates, bid climate during the construction period and fluctuations in basic material prices. Errors in quantity assumptions are often related to changes in design standards as discussed above.

- **Unforeseen issues in implementation** – perhaps one of the largest sources of uncertainty is the difficulty to anticipate issues that will only be uncovered in later stages of project development. Areas that can be most susceptible are utility relocations, hazardous materials, and soil conditions.

14.6.2 Approach to Data Sources

A significant and ongoing part of the conceptual planning process has been the development of concept designs, typical cross-sections, and other facility elements for the proposed alignment options. To begin to estimate the costs of these elements, they are compared to experience from other projects at differing levels of detail. It is useful to define the methods of applying historical data to current projects as "bottom-up" and "top-down" approaches, as described below. Both approaches make use of typical facility costs, where units of consistent dimension and cost may be summed together across the extent of the project, and non-typical facility costs, where sub-elements must be combined to form a quantifiable unit for costing.

For the cost estimates prepared for the Columbia Pike project, a blend of bottom-up and top-down approaches has been used, making the best use of available unit cost data and data from completed projects.

Bottom-up Approach

The majority of composite unit costs used for the Columbia Pike Transit Initiative capital cost estimates are developed based on a "bottom up" approach. In this approach, the cost of major work elements, as generally defined by typical sections, is determined by totaling the cost of their component parts on a per unit basis. Sufficient engineering data is required to reasonably define the scope of work and quantities represented by each typical section. Unit prices are developed and combined with the estimated quantities to determine the costs for each major category of work.

The advantage of this approach is the ability to adjust costs for minor changes of scope, as well as the higher confidence level inherent in a bottom up estimate. The disadvantage is that at the conceptual level of planning, the level of engineering detail available is typically not sufficient to warrant itemizing each feature to the degree desirable for a complete bottom up estimate. In general, this approach is used here for the following cost categories: guideway, maintenance facilities, systems, and right of way.

Top-down Approach

In this method, an order-of-magnitude cost is determined, usually derived from data from similar projects, and this cost is used directly, as a percentage of the overall construction project, or converted to some unit of measure (such as route feet) and applied as a unit cost.

This method is faster than the bottom up approach; and for conceptual planning purposes it can be sufficiently accurate. The disadvantage is that site-specific elements of the source project are not identical to elements of the alternative being evaluated. A greater emphasis has been placed on the top down approach to estimate costs for the following categories: stations, site work and special conditions, vehicles, and soft costs.

14.6.3 Accuracy of Cost Estimates

The estimating methods described above represent professionally accepted standards for preparing capital cost estimates to a level of accuracy that is consistent with the level of project definition. Accuracy is traditionally expressed as a +/- percentage range around the point estimate that has been produced and is greatest in the early stage of project definition and progressively decreases as project progress.

For example, for typical transportation projects, the expected accuracy range of an estimate prepared from final design documents is approximately +10/-5 percent. For projects at the General Plan stage (15 percent plus design), which is generally accepted to be at the point where the majority of major construction items can be quantified, the accuracy range could be expected to be about +20/-15 percent.

The cost estimates summarized as part of this memorandum are based on a level of design detail appropriate to the AA/E phase of FTA New Starts/Small Starts project development, which is prior to Preliminary Engineering. One of the primary techniques used to address uncertainties inherent in the estimating process at this stage is the application of appropriate design allowances or contingencies. As a project progresses through subsequent phases, the level of detail in the design will increase and the design allowances will decrease proportionally.

14.7 Conclusions and Next Steps

The current preliminary transit capital cost estimates will be further refined in subsequent stages of project planning and engineering design as project elements are developed in greater detail and a preferred alignment option is chosen. The format of these estimates, making use of FTA Standard Cost Categories with clearly documented assumptions, lends itself to updates throughout the project development process.

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