metro

NoMa Pedestrian Tunnel Feasibility Study

Engineering Assessment Report

December 17, 2015

Submitted to:
Washington Metropolitan Area Transit Authority

Prepared by:
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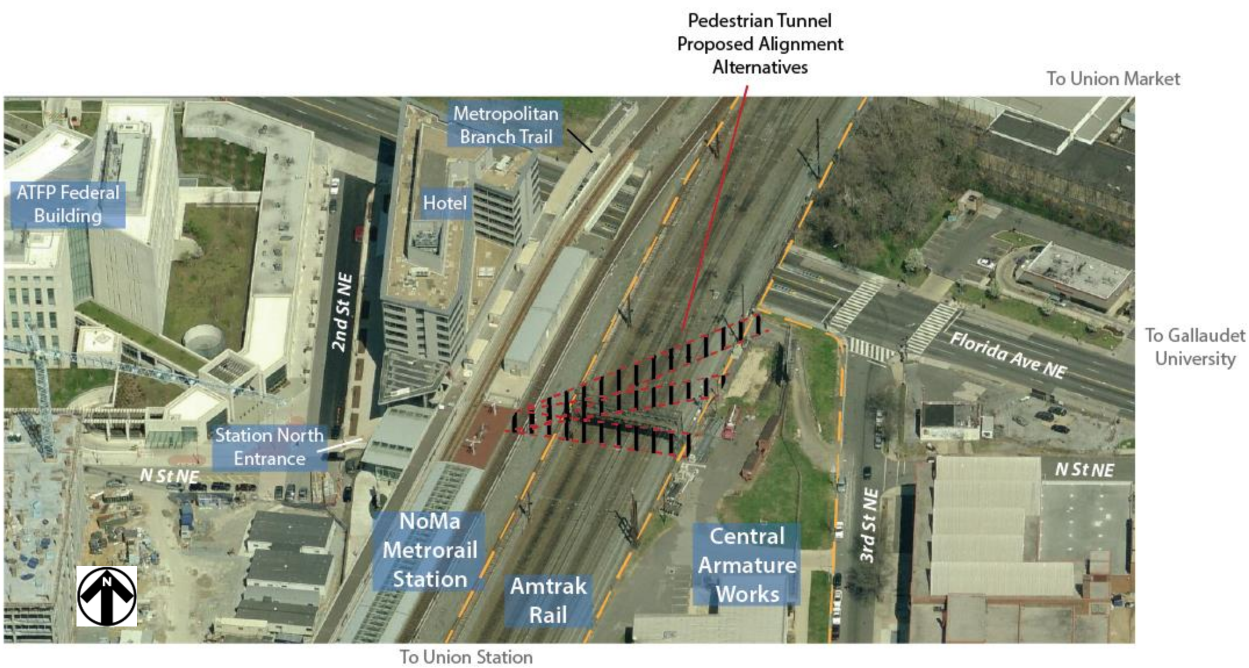
Executive Summary

The Washington Metropolitan Area Transit Authority (WMATA) conducted a study to determine the feasibility of the construction of a new pedestrian tunnel in response to the growth the NoMa neighborhood is experiencing, particularly east of the Northeast Corridor. AECOM has assessed the engineering needs and applicable codes for construction of this tunnel to link the existing NoMa-Gallaudet University Metrorail station on the west, to the neighborhood to the east, and has determined that tunnel construction is feasible.

Currently, there are six Amtrak rail tracks adjacent to the east of NoMa-Gallaudet University Metrorail station. The station is served by two rail tracks on either side of a central platform. At the present time, there is no direct route for pedestrian access between the station and the neighborhood and ongoing redevelopment to the east of the rail tracks. The proposed facility will provide a safe, and ADA accessible, connection to the station, as well as a more direct route to Gallaudet University.

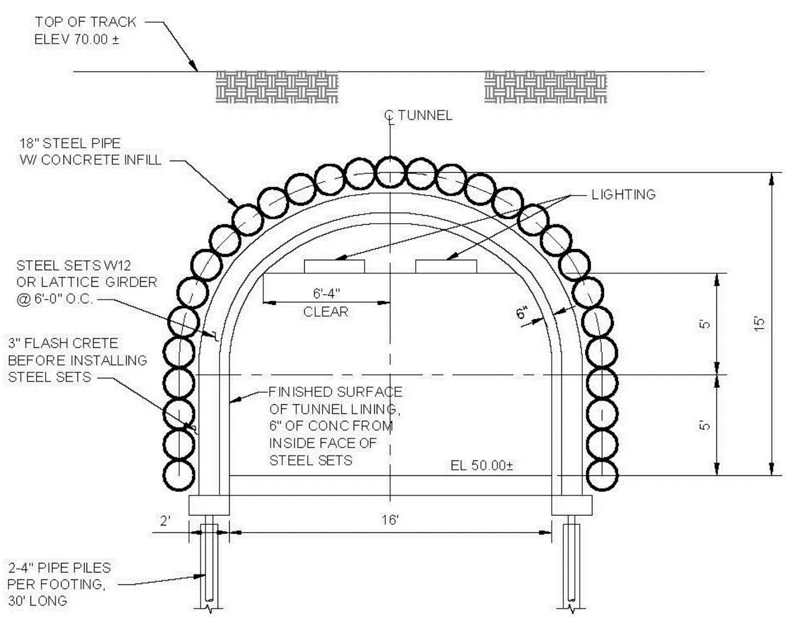


The study kicked-off with a meeting on December 10, 2014 to discuss tunnel requirements, constraints, and design guidelines with WMATA, the consultant team from AECOM and other stakeholders including DDOT, ANC 6C, NoMa BID, and Gallaudet University. Data was collected from stakeholders and compiled into an existing conditions report. The stakeholders attended a site visit on January 21, 2015 to review existing conditions, requirements, possible alignments, and major constraints. WMATA, DDOT, Amtrak, Gallaudet University, Trammell Crow (developer for the adjacent private property to the east), NoMa BID, ANC 6C, and the consultant team attended the site visit. Concept designs were developed for various alignments and different tunnel entrance locations. Due to railroad operational concerns, open-cut construction was not considered for the new pedestrian tunnel. The following tunnel construction methods were considered:

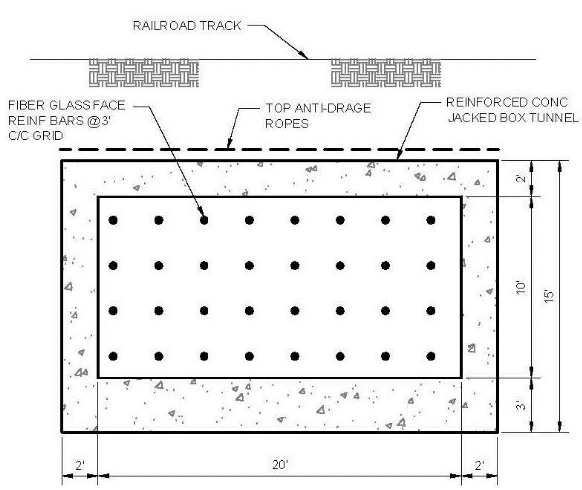
- Arch and Flat Roof Pipe Tunneling
- Jacked Box Technique
- Sequential Excavation Method (SEM)

This study determined that a pedestrian tunnel can be constructed beneath the railroad tracks and provide direct east-west access via connection to the existing mezzanine level. Arch Pipe Tunneling and the Jacked Box technique are considered the most feasible tunneling methodologies and are discussed in detail in this engineering assessment. Illustrations of these two methods are shown below.

Typical Pipe Arch Roof Tunnel Section



Typical Jacked Box Tunnel Section



Due to clearance requirements beneath the existing track, the tunneling methods resulted in differing vertical alignments and cross sections. Initial concept sketches for six alignments were presented and discussed with stakeholders at a meeting on April 27, 2014, and resulted in the selection of three alignments for further analysis. Following the meeting, Trammell Crow evaluated the alignments and provided a concept sketch for their site which incorporated a slightly modified version of one of the alignments. The modifications were incorporated into the concept designs and assessment.

Three primary alignments were reviewed and include the performance of an engineering analysis and consideration of the primary constraints including the proposed neighborhood redevelopment, the active railroad tracks, the vicinity of Gallaudet University, and the safety for all Metrorail users. However, although tunneling is feasible, tradeoffs exist between options in terms of tunnel size, construction schedule and cost, and impacts to the station and adjacent properties and facilities.

The project construction cost, not including environmental analysis, engineering and public involvement, is estimated to be between $16.6 million and $23.7 million depending on the tunneling method and alignment used. It is recommended that the project be advanced to preliminary engineering, including geotechnical, utility and site investigation, and further coordination with stakeholders, to analyze the complex and detailed engineering required to select a preferred alignment and tunneling method, and develop a biddable and constructible design that will bring this project to reality, improve access to the Metro station and serve as a catalyst for continued area growth.

1 Introduction

The Washington Metropolitan Area Transit Authority (WMATA) and Washington, DC (the District) are exploring the feasibility of a pedestrian tunnel beneath the existing Amtrak railroad to provide ADA compliant access to the NoMa Metrorail Station to the west and support the neighborhood redevelopment from the east along 3rd Street, NE. This final report includes an analysis of the existing site and subsurface conditions, an engineering assessment which evaluates feasible pedestrian tunnel alignments and specific tunneling method options, a discussion of the challenges associated with implementing and constructing a tunnel, and provides order of magnitude construction cost estimates.

1.1 Approach and Scope of Report

This final report describes the application of several methods of tunnel construction methodology for the excavation of the proposed pedestrian tunnel beneath six (6) existing Amtrak railroad tracks along the rail corridor adjacent to the NoMa Metrorail Station, as well as two active Metro tracks which service the station. The scope of the study is to analyze the constructability and construction costs associated with these methods in order to determine which alignment and tunneling method will meet WMATA and the District's objectives with no disruption to Amtrak railroad service and minimal disruption to station operations.

Based on review of as-built drawings, available information, coordination with stakeholders, and customary engineering practice, this assessment considered, but was not limited to, the following:

- Structural/Tunneling practices and concerns
- Geotechnical
- Site Conditions
- Mechanical and Electrical
- Architecture
- Amtrak and Metro infrastructure and guidelines
- Stakeholder needs and requirements
- Fire and Life Safety
- Accessibility

The purpose of this final report and engineering assessment is to present a description and comparison of tunnel options including the technical feasibility, railroad impacts and order of magnitude costs and schedule. The content presented herein reflects the latest proposed alignments and design concepts at the time of preparation of this report, and may require revision should any of this information change.

This Final Report and Engineering Assessment is organized as follows:

- Section 2 – Existing Station Site, Utilities, and Subsurface Conditions
- Section 3 – Alignment Development Process
- Section 4 – Tunneling Methods
- Section 5 – Tunnel Lining Design and Construction Evaluation

- Section 6 – Accessibility Codes and Standards
- Section 7 – Architectural and Finish Treatment
- Section 8 – Mechanical and Electrical
- Section 9 – Fire Protection and Fire Life Safety
- Section 10 – Tunnel Construction Estimate and Schedule
- Section 11 – Federal Environmental Documentation Requirements
- Section 12 – Conclusion

2 Existing Station Site, Utilities, and Subsurface Conditions

This section describes the existing station site, utilities, and subsurface conditions in order to identify the physical constraints and challenges associated with the proposed construction of the pedestrian tunnel beneath the Amtrak railroad tracks. The existing station area and site conditions are outlined below, and are further documented in the Existing Conditions Memorandum included in Appendix E.

2.1 Existing NoMa Station

2.1.1 Station Layout

The NoMa Station, which opened in 2004, is located between M Street NE and Florida Avenue NE and between 3rd Street NE and 2nd Street NE. The NoMa Station is divided into two levels. Riders access the station and pay on the first level. The platform is on the second level which riders access by using an escalator, staircase, or elevator. There are two entrances to the station, one at the south end, on M Street NE, between 1st Street NE and 3rd Street NE, and one at the corner of N Street NE and 2nd Street NE.

The NoMa Station is a center platform station; the inbound and outbound Metrorail Red Line utilizes the tracks that run on both sides of the passenger platform to stop at the NoMa Station. The commuter trains (such as MARC, VRE, and Amtrak) use the tracks adjacent to the NoMa Station, east of the passenger platform, to access Union Station and the nearby rail yard.

2.1.2 Station Structural Design

The station has a hybrid structural configuration, where the outbound track is on an embankment supported by a cantilever cast-in-place concrete retaining wall, and the inbound track is on a precast concrete box girder guideway. The station platform is comprised of twin longitudinal box girders with an adjoining slab. The platform box girders are supported by transverse precast prestressed concrete cross girders that rest on the embankment retaining wall at one end and the guideway columns at the other end. The Metropolitan Branch Trail (MBT), located to the west of the inbound track, is comprised of a track-level precast concrete box girder viaduct supported on concrete columns.

The vertical stem of the embankment retaining wall is 3’-9” thick. The wall has a spread-footing foundation with a 5’-9” heel extending behind the wall and 16’-0” toe extending in front of the wall, under the ground level floor of the station. The back side of the embankment retaining wall has a Miradrain drainboard and an 8-inch underdrain at approximately floor level of the station. Further behind the retaining wall was a temporary support-of-excavation wall that may still have in-place components. Near track level there is a variable-elevation electrical ductbank running longitudinally behind the wall. Typical guideway and MBT viaduct column spacing is 66'-8". This spacing also defines locations of transverse girders that support the platform.

North of the ground level service rooms between column lines 10 and 11 (just north of the Florida Avenue entrance pavilion), the embankment retaining wall is comprised of a mechanically stabilized earth (MSE) wall. Also between column lines 10 and 11, there is about 16 feet of unoccupied wall space between the Florida Avenue entrance pavilion and the service rooms. Track-level service rooms at north and south ends of the station are supported on the embankment by cast-in-place concrete slabs and foundation walls with spread footings.

2.1.3 Station System Design

The NoMa Station obtains power from two 13.8kV electrical feeders from PEPCO, which originate in the AC Switchboard Room, which is located in the North Service Rooms on the platform level. Fire sprinklers provide fire protection in required areas of the station. Electrical and mechanical rooms within the station have various combinations of exhaust, heating and air conditioning which are controlled by the automated energy management system (AEMS). Control and monitoring of systems are provided through the data transmissions system (DTS). The outbound track bed within the NoMa Station limits contains ductbanks for power, communication, contact rail heating, traction power, and grounding.

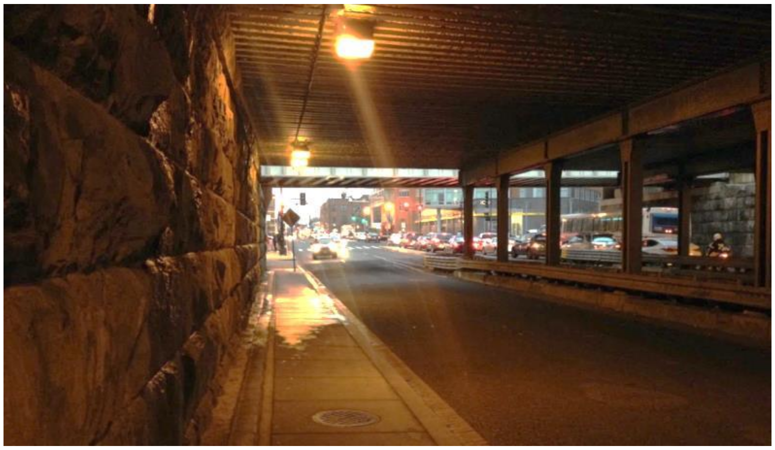
2.2 Multimodal Access

When accessing the NoMa Station, 81% of the passengers walk, 9% of the passengers take the bus, 9% of the passengers take a car, and 1% of the passengers use a bicycle. Pedestrians arrive from all areas around the NoMa Station, including the business and residential developments east of the station, and Union Market and Gallaudet University east of the station. The pedestrian pathways from east of the Amtrak rail to the south entrance provide a more desirable pathway due to the wide sidewalks and well-lit areas. Figure 1 shows the narrow sidewalks on Florida Avenue pedestrians use to get from the northeast side of the railroad facilities to the northwest entrance. It is expected that the pedestrians gravitate towards the south entrance to avoid the narrow sidewalk adjacent to the travel lane.

In addition, the station can be accessed from:

- Metro Bus routes X3, 90, 92, and 93, which stop on Florida Avenue between 3rd Street NE and 4th Street NE and then walking to the Metro entrance;
- The Metropolitan Branch Trail, which has an access ramp outside the south entrance and access stairs at the northwest entrance. A Capital Bike Share station located just outside the south entrance on M Street NE; and
- Driving and parking in a nearby lot.

Figure 1: Narrow Sidewalk along Florida Avenue



2.3 Existing Transportation Network

The existing transportation network in the study area includes a mix of pedestrian, bicycle, rail (Metrorail, commuter rail, and Amtrak), Metrobus, and automobile infrastructure and service. The non-automobile mode share in NoMa is approximately 35 percent. While the study area itself has between 20 and 40 percent of households with zero cars, areas to the east and north of the study area have between 40 and 60 percent of households with zero cars.

2.3.1 Pedestrians and Bicycles

2.3.1.1 Network

Sidewalks exist on both sides of nearly every street within the study area, except for 3rd Street NE between Florida Avenue and M Street NE. At these two locations, sidewalk exists on only one side of the street. There is a staircase entrance near the entrance at the intersection of N Street NE and 2nd Street NE. Bicycle lanes can be found on 1st Street NE and 4th Street NE. The study area is also served by a multi-use trail, the Metropolitan Branch Trail, which runs from Union Station to Silver Spring, Maryland on a combination of off-street and on-street facilities. The segment that runs through the study area is an off-street facility that runs from Union Station to Franklin Street NE, approximately 2.5 miles.

2.3.1.2 Pedestrian Volumes

According to the NoMa BID, volumes average around 92,000 pedestrians on the streets of the NoMa BID on weekdays. The intersections with the highest volumes are found on the western side of the study area, with the intersection of 1st Street NE and N Street NE having high volumes both in the AM and PM peak. East of the Metrorail Red line, the intersection at 3rd Street NE and M Street NE has the highest volume.

2.3.1.3 Pedestrian/Bicycle Network Deficiencies

The low pedestrian volumes at the Florida Avenue intersections at 2nd Street NE and 3rd Street NE may be related to deficiencies in the east-west connections in the pedestrian and bicycle network within the study area. In the vicinity of the NoMa Station, bicycle level of service (LOS) on Florida Avenue is an E, while nearby north-south streets are D or better. LOS, established by the *Highway Capacity Manual*, assigns a letter grade to the relative traffic flow; A is the best grade with free flowing traffic and F is the worst grade with unstable flowing traffic. The *New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study* (2010) also identified east-west connections to the NoMa Station to be hindered.

The *New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study* (2010) also identified deficient pedestrian spaces, using criteria including: proximity of pedestrian activities to roadway, sidewalk gaps, sidewalk width, presence of planting strips and street trees, traffic volume, and posted speed limits. Along principle arterials and collector streets in the study area, no street has both high-pedestrian activity and highly-rated pedestrian deficiency. However, the highest rated streets for pedestrian activity and deficiency within the study area are found to the east of the Metrorail Red line and freight and passenger railroad facilities. Higher levels of pedestrian activity and deficiency are found to the north and west of the study area.

The levels of pedestrian activity and deficiency are only partially reflected in the safety of intersections in the study area. Between 2010 and 2012, more bicycle and pedestrian crashes occurred on the west side of the study area, predominately at the intersection of New York Avenue and Florida Avenue and the intersection of 1^{st} Street NE and N Street NE. On the east side of the corridor, pedestrian and bicycle crashes are predominately clustered at the intersection of 3^{rd} Street NE and Florida Avenue, which is also the location of the only pair of bus stops in the study area.

2.3.2 Metrorail Ridership

The ridership at the NoMa Station has increased faster than predicted. In 2008 the Metrorail Station Access & Capacity Study predicted the average weekday ridership at the NoMa Station to increase from 2,177 boardings in 2005 to 3,919 boardings in 2030, an 80% increase over 25 years.

New York Avenue and Florida Avenue serve as the principle arterial streets within the study area and each carry 56,800 and 22,100 vehicles per day respectively. 1^{st} Street NE, 4^{th} Street NE, and M Street NE serve as collector streets in the study area, while all other streets in the study area serve local traffic.

Florida Avenue is considered a high frequency crash corridor by DDOT, as it had 1,361 total collisions between 2010 and 2012. Within the study area, the most dangerous intersection is at New York Avenue and Florida Avenue, where 160 crashes occurred between 2010 and 2012. Of all the intersections in the District of Columbia, the New York Avenue and Florida Avenue intersection ranked fifth for crash frequency from 2010 to 2012, third for crash severity cost in 2012, and was the 15^{th} most hazardous intersection between 2010 and 2012, according to DDOT.

Additionally, the intersection at 1^{st} Street NE and M Street NE was included in DDOT's ranking of dangerous intersections, as the 12^{th} highest crash rate (2.85 crashes per million vehicles) in the District from 2010 to 2012. However, earlier data from 2005 to 2007 shows that the 1^{st} Street NE and M Street NE intersection crash rates have not always been as high and several other intersections, including 1^{st}

Street NE and New York Avenue, 3rd Street NE and Florida Avenue, and 1st Street NE and N Street NE, have historically had higher crash rates.

2.3.3 Metrobus

The study area is served by four Metrobus lines: X3 and the 90s line (90, 92, and 93) as well as the other Metrobus routes that serve the NoMa neighborhood, many of which travel along North Capitol Street west of the study area and K Street NE south of the study area. Within the study area, there is only one pair of bus stops, found at the intersection of 3rd Street NE and Florida Avenue.

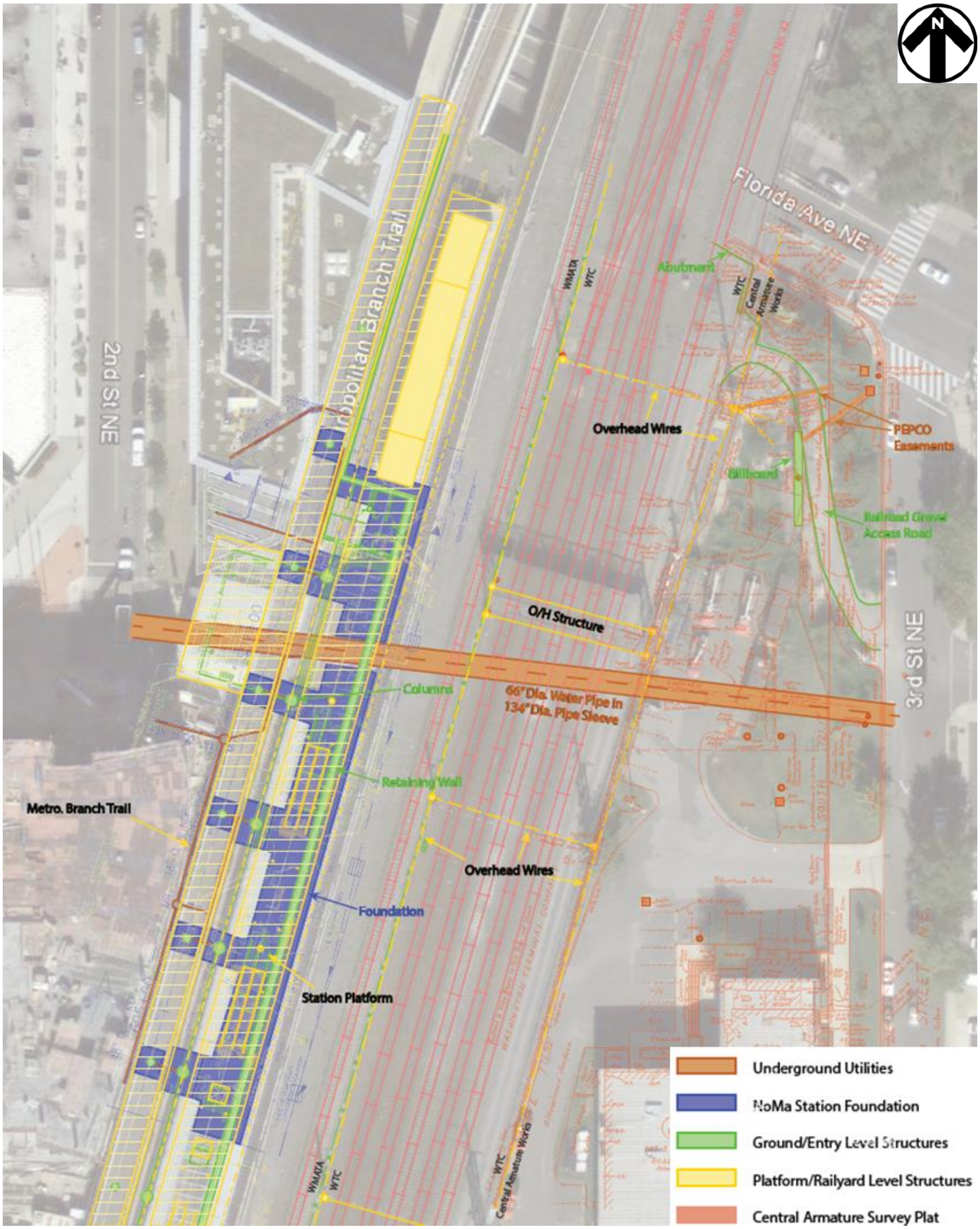
The 90s line (90, 92, and 93) provides higher frequency service to the study area, with buses arriving every seven minutes during weekday peak service and 15 minutes during weekday off-peak service. X-3 provides service during peak hours and only in the peak direction, with 15 minute headways westbound in the morning peak and 30 minute headways eastbound in the afternoon peak.

The 90s line carries the most Metrobus passengers through the study area, with a weekday average of 12,266 riders. X3 carries fewer riders: 1,502 on the average weekday. The westbound stop at the Florida Avenue and 3rd Street NE intersection contributes more than 600 average daily boardings to the ridership averages of these two routes, while the eastbound stop contributes between 151 and 300 average daily boardings.

2.4 Site Easement

The NoMa Station is located west of and beneath the passenger and freight rail tracks, stretching from M Street NE to Florida Avenue, between 2nd Street NE and 3rd Street NE. Two bridges, one over M Street NE and one over Florida Avenue, support the Metrorail tracks in the vicinity of the station. The elevated Metropolitan Branch Trail runs parallel to the tracks on the west side of the station. There is a 66” water main pipe with a 134” sleeve running east to west, passing only a few feet under the station’s foundation but is buried approximately 20 feet under the existing ground line east of the station. Figure 2 shows that there is a gravel access road connecting the tracks to 3rd Street NE between Florida Avenue and N Street NE. There is a Pepco easement near the gravel access road. A billboard is present, adjacent to the gravel access road. There are also overhead wires, over the railroad tracks. Other easements, recorded and unrecorded, may be present on the site but records could not be found.

Figure 2: NoMa Station Site Layout



2.5 Existing Land Uses

2.5.1 Development

Property in the study area is currently used largely for commercial uses, especially office. Prior to 2005, over 6 million square feet of office space and over 200,000 square feet of retail space existed in the NoMa neighborhood. Since 2005, office and retail space has doubled, while over 3,800 residential units and about 600 hotel rooms have also been added to the area. provides details on where these developments have occurred, as well as the locations of planned developments in the area.

Northeast of the NoMa Station, an area that has been historically used for wholesale food operations has recently seen more retail uses introduced, specifically at the Union Market building. At Union Market, along with several other properties nearby, planned unit development (PUD) for additional retail and residential units is either active or has been submitted for review.

2.5.2 Residential

Currently, the NoMa neighborhood (in the NoMa BID) has about 3.8 million square feet of residential space, most of which has been developed since 2005. The construction of additional residential units is expected to continue over the near-term, with an additional 1.9 million square feet of residential space to be added over the next five years.

2.5.3 Office

Office space makes up the greatest amount of land use in the NoMa neighborhood, with about 13 million square feet. Over the next five years, another 3.6 million square feet of office space are planned or proposed to be added.

2.5.4 Retail

Retail uses make up the smallest amount of land uses, with around 380,000 square feet. Aside from the development at Union Market, the greatest amount of retail is located near the NoMa Station, west of the Red Metrorail line between M St and N St. Over the next five years, additional retail space is expected to be constructed, nearly doubling the existing retail space.

2.6 Zoning

All of the study area around the NoMa Station falls under one of three commercial zoning designations: C-3-C, C-M-1, and C-M-3. Table 1 describes the acceptable uses in each zoning district.

The study area falls within two districts used to finance neighborhood improvements: the New York Avenue Metro Area Special Assessment District and the NoMa Business Improvement District. The New York Avenue Metro Area Special Assessment District was created in 2001 to fund the construction of the NoMa Station through public-private partnership, with private funding coming through an additional property tax on non-residential properties in the district. The NoMa Business Improvement District was created in 2006 and funds beautification projects, street ambassadors, marketing, urban planning, economic development, and other improvements in the neighborhood through additional taxes on properties in the district.

Figure 3: NoMa Development Map, NOMABID.ORG (2014)

DEVELOPMENT SUMMARY

Type	Office (SF)	Retail (SF)	Residential (units)	Hotel (rooms)	Total (SF)	% of Total
Delivered Before 2005	6,243,000	234,350	-	-	6,477,350	19%
Commercial Delivered 2005 – April 2014	6,508,258	331,426	-	-	6,839,684	20%
Residential	-	-	3,836	-	3,836,000*	11%
Hotel	-	_	-	622	435,400	1%
Planned	9,324,197	548,349	6,247	886	16,739,746	49%
TOTAL	22,075,455	1,114,125	10,083	1,508	34,328,180	

* Estimate

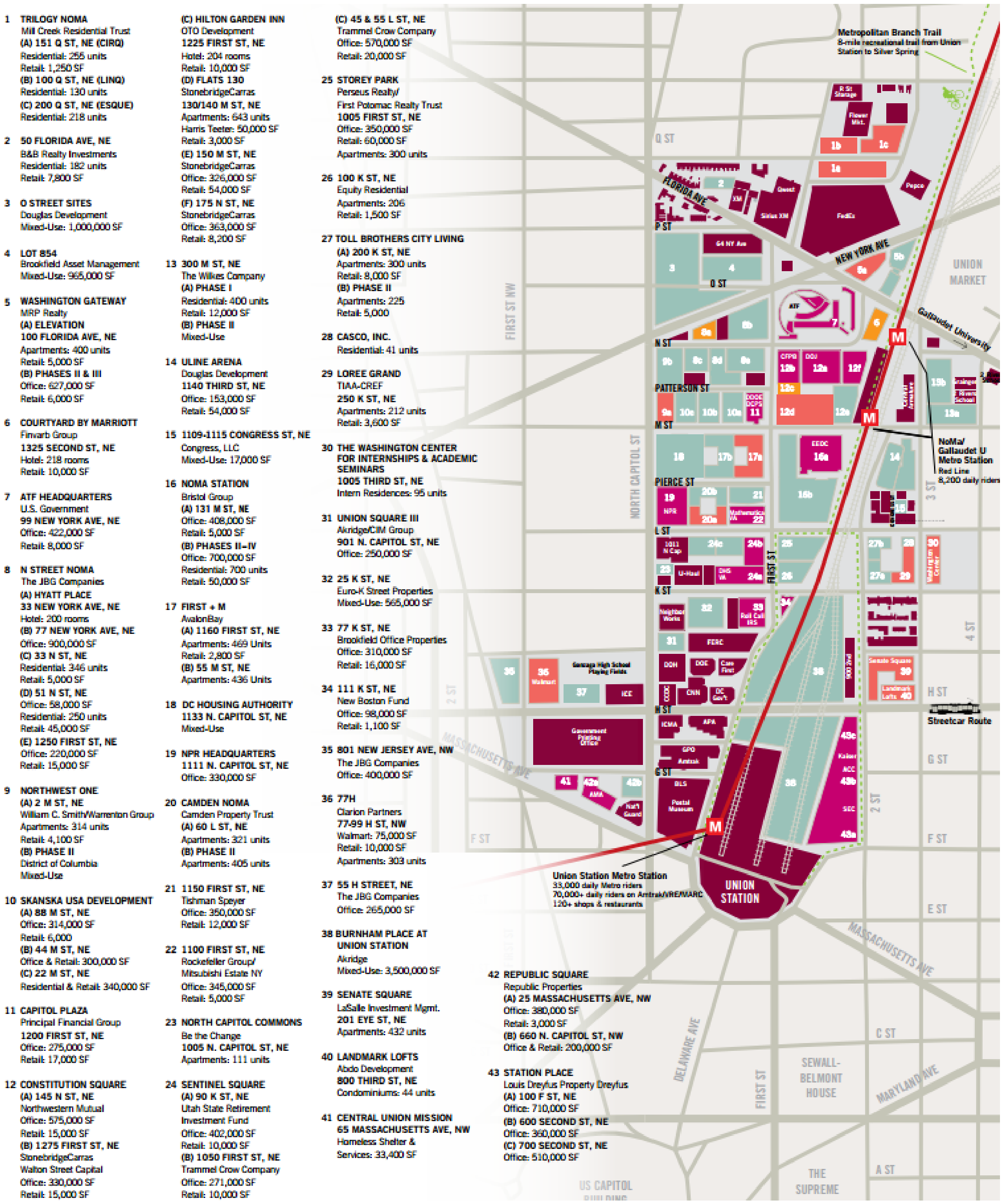


Table 1: Study Area Zoning Designations

Zoning Designation	Description
C-3-C	Permits matter-of-right development for major business and employment centers of medium/high density development, including office, retail, housing, and mixed uses to a maximum lot occupancy of 100%, a maximum FAR of 6.5 for residential and for other permitted uses, and a maximum height of ninety (90) feet. Rear yard requirements are twelve (12) feet; one family detached dwellings and one family semi-detached dwellings side yard requirements are eight (8) feet.
C-M-1	Permits development of low bulk commercial and light manufacturing uses to a maximum FAR of 3.0, and a maximum height of three (3) stories/forty (40) feet with standards of external effects and new residential prohibited. A rear yard of not less than twelve (12) feet shall be provided for each structure located in an Industrial District. No side yard shall be required on a lot in an Industrial District, except where a side lot line of the lot abuts a Residence District. Such side yard shall be no less than eight (8) feet.
C-M-3	Permits development of high bulk commercial and light manufacturing uses to a maximum FAR of 6.0, and a maximum height of ninety (90) feet with standards of external effects and new residential prohibited. A rear yard of not less than twelve (12) feet shall be provided for each structure located in an Industrial District. No side yard shall be required on a lot in an Industrial District, except where a side lot line of the lot abuts a Residence District. Such side yard shall be no less than eight (8) feet
TDR	Transferable Development Rights - A large portion of NoMa is designated as a “Transferable Development Rights Receiving Zone” (TDR), developers are able to utilize development rights purchased from other locations in the city.

Source: DC Office of Zoning

2.7 Utilities

To accommodate the proposed tunnel, it is important that existing utilities are identified and accounted for early in the design. Being located in a fully developed and urbanized location, numerous existing utilities, both aerial and subsurface, are found within the project limits. Existing information on utilities in the entire study area, bounded by the western limits of the Noma Metrorail Station, the northern curbline of Florida Ave NE, the eastern curbline of 3rd St NE and M St NE, was evaluated. This inventory of existing surface and subsurface utilities was performed using available documentation and observation. Topographical survey and/or geophysical prospecting techniques were not employed at this time, but are strongly recommended for design activities; it is believed that some of the utility documentation collected previously was based on physical determination, as it is possible that not all utilities within the project area are accurately represented or located, including any undisclosed government utilities. In addition, any recent or ongoing utility relocation work by utility companies may not be included in this discussion.

Based on available documents provided by DDOT and WMATA, utilities that may be encountered include those listed in Table 2.

The various tunnel alignments attempt to reduce impact to major utilities while maximizing effective interface with the terrain and existing and proposed structures.

This inventory of existing utilities is limited, and as such, all utilities may not be accurately accounted. It is recommended that coordination with facility owners occur as the design advances, and that a subsurface utility exploration (SUE) program be implemented.

Table 2: Existing Utilities

Utility Type	Utility Owner	Description
Gas	Washington Gas	Available records do not indicate any Washington Gas facilities in the vicinity of the proposed tunnel. However, facilities are located in the adjacent streets, and service is provided to the NoMa Station.
Water	DC Water (WASA)	Underground distribution lines and service connections are at various locations. Pipe size varies from 3" to 66". The 66" main is encased in 132" tunnel, crossing between 2nd and 3rd Streets at N Street. Fire hydrants are located around the project area.
Electric	Potomac Electric and Power Company (PEPCO), Washington Metropolitan Transportation Authority (WMATA)	Aerial – Overhead wires mounted typically to wooden poles are found along east side of tracks; size and type unknown. Subsurface – Underground facilities throughout project area. Extensive underground transmission and distribution facilities, including traction power and track heating, and station electric/lighting. There is an electrical ductbank located beneath the eastern WMATA track, along the length of station.
Telephone	Verizon Communications	Aerial – Overhead wires mounted typically to wooden poles are found along east side of tracks; size and type unknown. Subsurface – Unknown, no lines appear in materials.
Communication/ CATV	Washington Metropolitan Transportation Authority (WMATA)	Aerial – Overhead communication wires mounted typically to wooden poles are observed throughout the project area along both sides of the roadways; size and type unknown. Subsurface – Underground train communication cable/conduit within the project area.
Street Lighting	District Department of Transportation	Street lighting is throughout the project limits including bridge mounted lights. Luminaires are acorn (2nd Street) and cobra-head style (3rd Street) mounted on aluminum poles.
Traffic Signals/ Enforcement	District Department of Transportation and Metropolitan Police Department	DDOT standard traffic signals, control cabinets, and cameras and devices are around the project and are typically surface mounted on a standalone pole or foundation. DDOT cameras are typically for traffic surveillance while the MPD owned facilities are for red light and speed enforcement. Underground facilities including manholes, hand holes, and conduit are also present to services the aboveground equipment. Size and location of underground facilities are unknown.
Sanitary Sewer	DC Water (WASA)	Sanitary lines of various sizes run along M Street and Florida Ave. Station cleaner room includes sanitary sewer drain to M Street.
Storm Drainage	DC Water (WASA)	Storm runoff on ground surface is conveyed by gutters to catch basins; size and location of drainage piping varies. Existing underground storage system west of tracks and treatment structure (between M and N Streets). Tracks are drained by PVC pipes and small grate inlets. Retaining walls include underdrains.
Rail	Washington Metropolitan Transportation Authority (WMATA)	Project is adjacent to WMATA facilities. As such, underground utilities may be present. Project crosses beneath and over existing rail facilities.

2.8 Subsurface Conditions

The proposed NoMa pedestrian tunnel will be located beneath the live railroad tracks with the finished tunnel floor at elevation varying from +47 to +53 feet, depending on the proposed alignments, and clear tunnel height of 10 feet and 5.5 feet clearance requirement between the railroad tracks and the top of the tunnel. The geologic conditions at the proposed tunnel location are interpreted based on the geotechnical data from Borings NY-17U and NY-18A and the Geotechnical Engineering Report for Glenmont Route, New York Avenue Station in 2001 (provides information in the vicinity of the existing station) ; the geologic section of B&O Route, Station 102+50 to 115+00 dated March 12, 1969; and initial geotechnical findings in the vicinity of the eastern end of the tunnel to include Borings B4, B5, B8, and B9 recently drilled in 2015 which were provided by the developer of the Central Armature Works site Trammell Crow (additional information regarding geotechnical data to the east of the tracks is available upon request to Trammell Crow).

The subsurface conditions consist of approximately 15 feet of fill overlying 5 feet of silty sands of the Terrace deposits, which is underlain by clays and sands of the Potomac group. The embankment fill was placed in the early 1900's to provide grade separation with the cross streets and was unlikely be compacted in accordance with the current railroad standards. Fill generally consists of interlayers of medium stiff to stiff clay/low plasticity silt with Standard Penetration Test (SPT) values ranging from 6 to 17 and loose to medium dense silty/clayey sands, with SPT values ranging from 7 to 17. The Terrace deposits include interlayers of medium stiff to stiff low plasticity silts/clays with SPT values ranging from 6 to 18 and loose to medium dense silty/clayey sands, with SPT values ranging from 9 to 26. The clays and sands of the Potomac group consists of stiff to very stiff low plasticity silts/clays with SPT values ranging from 10 to 25 and medium dense to very dense silty/clayey sands, with SPT values ranging from 15 to 60. The groundwater shown on the geologic section in 1967 and measured in the recent borings ranges approximately from Elev. 22 to 40 feet, which is well below the invert of the proposed tunnel.

It is anticipated that the proposed pedestrian tunnel will be excavated above the groundwater table. Depending on the proposed tunnel height, the upper half of the tunnel may be excavated in the old track embankment fill and the bottom half may be excavated in the Terrace and Potomac deposits. In an open-face tunnel excavation, the fill materials and Terrace soils may exhibit cohesive-running or slow raveling. Because of the uncertainty associated with the old track embankment fill materials, a soil investigation and lab testing program should be performed during the preliminary engineering phase to obtain more reliable soil properties to help characterize ground condition along the selected tunnel alignment.

As the proposed tunnel will be excavated beneath live railroad tracks, ground settlement must be effectively controlled and limited to allowable values. The conceptual design layout will focus on providing an effective control of face stability during excavation and a comprehensive monitoring program to control ground loss and ground surface settlement. Pre-support and/or ground improvement may be required to minimize ground settlement. The geotechnical review focused on the area closest to the station and it is anticipated that the ground in the area of the station is similar.

The support of excavation wall, consisting of sheet piling and tie-back tendons, installed during the construction of the NoMa station, remains in place. The means of addressing this obstruction must be considered in the design system and construction methods.

2.9 Railroad

The proposed pedestrian tunnel will be located beneath the live railroad tracks of Amtrak and WMATA. Both sets of tracks support passenger rail traffic only, as there is no freight service at this location. All trains traveling north from Union Station and all trains heading south to Union Station pass by the NoMa Gallaudet University Metro Station. Non-Metro trains run on Amtrak's Northeast Corridor, and are powered by a combination of diesel engines and electrified overhead catenary structures.

Design and construction beneath these railroad tracks must be in accordance with the WMATA Adjacent Construction Project Manual, and all applicable standards of Amtrak and the American Railway Engineering Manual (AREMA), including loading requirements as detailed under Appendix C, and providing a minimum clearance of 5.5 feet, between the bottom of each respective rail, and the top of the tunnel.

Additionally, the proposed construction concepts must readily accommodate, or provide for the modification of, the existing Amtrak signal bridge, located over the Amtrak tracks, and in line with the existing station entrance.

Amtrak and other stakeholders are currently undertaking modifications at Washington Union Station – the Terminal, Ivy City Yard – that may require modifications to the Northeast Corridor signals and track between K and C Interlockings, which govern rail movements through the various junctions and crossovers near the proposed tunnel location. The proposed pedestrian tunnel will be in the vicinity of the Home Signal for C Interlocking. As the potential future Amtrak signal bridge configuration is not yet known, the prudent concept for the pedestrian tunnel will account for the need to shore/underpin the foundation area beneath the existing signal bridge footings. The relocation of the signal bridge would only be possible with extreme adjustments by Amtrak and would affect train throughput to and from the Terminal and the Ivy City Yard with negative effects on the ability to stage trains.

3 Alignment Development Process

This section describes the tunnel alignment development process including an initial universe of alignments, stakeholder coordination, and preliminary screening criteria.

3.1 General Arrangement for Proposed Tunnel, Tunnel Alignment and Profile

The proposed pedestrian tunnel will connect from a portal on the 3rd Street, NE side of the tracks to the existing NoMa station at a level beneath the tracks in line with the existing station mezzanine. The pedestrian tunnel shall provide an open, well lighted concept, and a straight-line alignment between portals for safety and accessibility. The materials for the finished tunnel surfaces were selected to support this open and light concept, and are further detailed in Section 7.2.

Initially, six tunnel alignments were evaluated with respect to the site conditions including, but not limited to, the surrounding topography, utilities, and potential railroad impacts (see Figure 4). The proposed pedestrian tunnel alignments range in length from approximately 145 feet to 230 feet. Through further analysis and discussion with stakeholders several of the alignments were determined to have significant disadvantages and three alignments were selected for further assessment and cost estimating. The assessment of the alignments is shown in Table 3.

Major considerations which informed the development and evaluation of the alignments include:

- Preferred tunnel width is 20 feet based on stakeholder preferences and accessibility considerations
- The existing 132 inch diameter tunnel housing a 66 inch diameter water main shall remain in its current location, as shown in Figure 4.
- A minimum cover between the top of tunnel and top of railroad tie for the Amtrak and WMATA tracks is approximately five feet six inches.
- The proposed grade for the pedestrian tunnel finish floor is expected to be a maximum of 3% from the 3rd Street NE side portal to the station. A low point pump station will be required to drain the tunnel section in the event of flooding conditions.
- The proposed tunnel must be designed to accommodate support of the Amtrak signal bridge (shown in Figure 1) by providing either ground modifications or being laid out to provide structural support for the concentrated signal bridge load. Alternatively, new straddle type foundation could be constructed to bridge the tunnel alignment, and transfer load to deep side foundations.
- Tunnel entrance at 3rd Street NE will require transition sections from the covered tunnel portal locations to the existing grades. The structure will consist of a transition or “U” structure section to grade. Landscaping, fencing and appropriate barriers would be installed.
- Tunnel Ventilation will not be required based on current National Fire Protection Association (NFPA) requirements since the tunnel is less than the 800-foot minimum length.
- The preferred temporary construction area may be located in areas adjacent to 3rd Street NE. It is expected that the temporary construction area would need to be an area at least 100 feet wide by 200 feet long or about ½ acre.
- The WMATA Metrorail and platform are integrated into the station foundation. The pedestrian tunnel will exit through the existing station retaining wall.
- Ownership, security, and hours of operation for the tunnel.

Each tunnel alignment and tunneling method was reviewed with respect to its ability to create an ADA accessible pathway between the station’s existing finished floor elevation of 52 feet, and the eastern site, while maintaining the required 5.5 feet clearance beneath the eastern WMATA track at an elevation of 72 feet, and the existing Amtrak rail tracks, at elevations ranging between approximately 69 feet and 71 feet. The necessary clearance beneath the tracks, and the finished floor elevation of the existing station, were the constraints which most directly defined slope of the tunnel, and therefore the eastern tunnel inverts, which ranged in elevation from 45 feet to 53 feet, locating between 9 feet and 21 feet below the existing site elevations at each respective outfall. These relationships are further detailed on the tunnel profiles in Appendix A.

The various tunnel alignments were presented to and discussed with stakeholders ranging from NoMa Business Improvement District, the property owner and future developer of the Central Armature Works (CAW) site at the east portal of the proposed tunnel, Amtrak, Gallaudet University, District of Columbia Office of Planning, and various WMATA offices. The six initial options shown on Figure 4, and detailed in Table 3 were evaluated for feasibility and function. Alignments 2A and 2C were eliminated due to their extended tunnel length and the depth required to tunnel beneath 3rd Street, NE Alignment 4 was eliminated from consideration due to its impacts on Metro station access during construction.

This resulted in three remaining alignments for further concept development and engineering assessment. Engineering analysis also considered various tunneling methods for each of the alignments. Further discussion of tunneling methods is in Section 4 of this report.

3.2 Selected Alignments

Alignments were analyzed with respect to the existing conditions, including the WMATA station and Amtrak facilities, the impact to the proposed future neighborhood redevelopment, such as the anticipated tunnel outfall invert, and necessary means of vertical circulation, based upon surrounding site grades.

3.2.1 Alignment 1

This alignment creates a small entry plaza between the tunnel and the existing sidewalk at Florida Avenue, NE. This option results in a minimal impact on the developable footprint. However, proximity of the tunnel to Florida Avenue, NE would require major lane closures and disruption of traffic during construction.

3.2.2 Alignment 2B

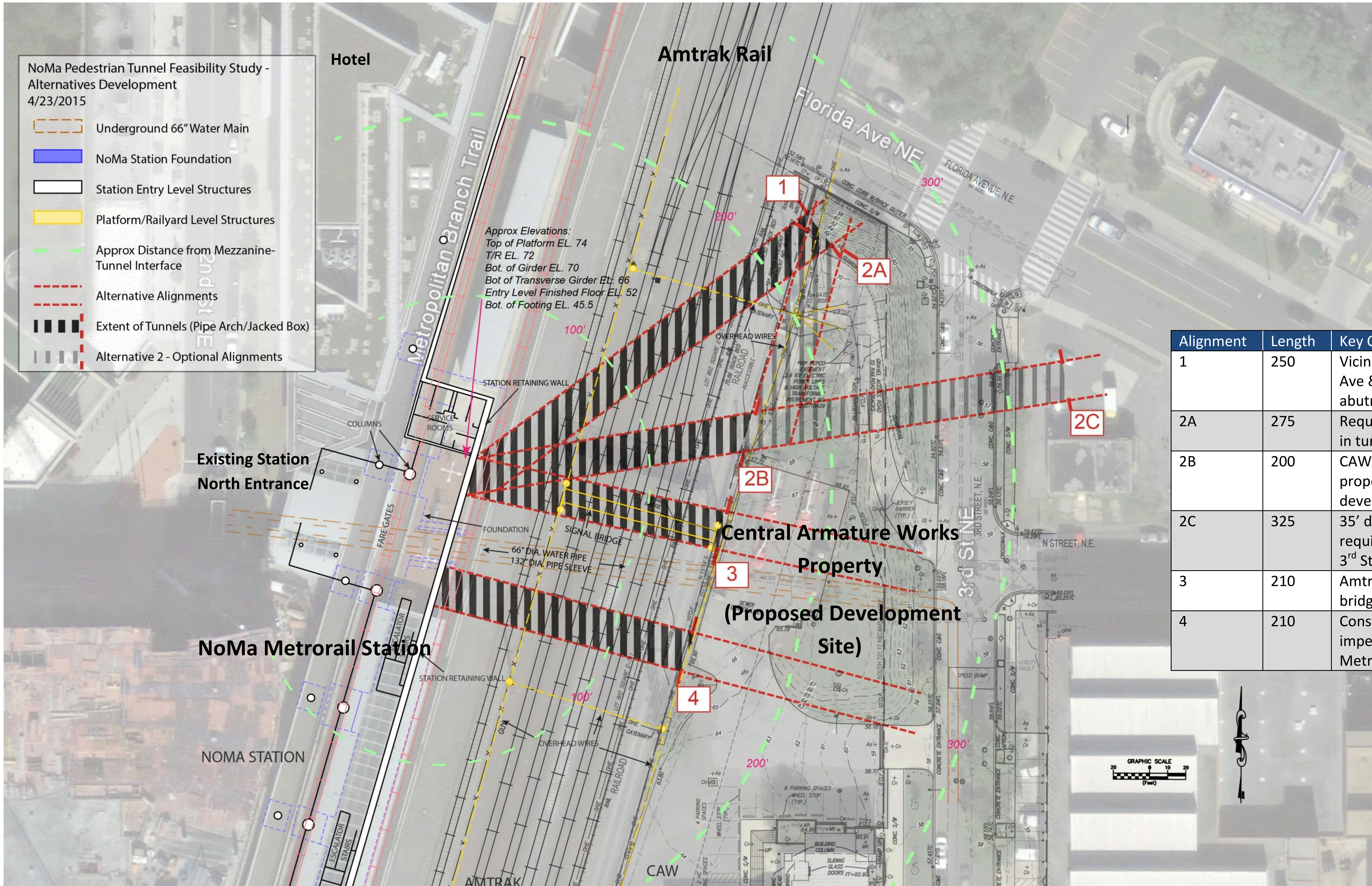
This alignment has the opportunity to integrate into the adjacent development at grade, but also results in a more significant elevation grade change. This alignment attempts to avoid the signal bridge over the Amtrak property.

3.2.3 Alignment 3A (slightly modified Alignment 3)

In coordination with the CAW development team, a new alignment, 3A, (minor horizontal adjustment of initial Alignment 3 and lowered east portal to 47-foot elevation) was determined to have the greatest feasibility and integration with the proposed development. Alignment 3A represents a logical location for the tunnel because it is on axis with the adjacent urban street network and provides a tunnel opening that integrates with current development plans. This alignment however, is located beneath an Amtrak signal bridge, and represents the most significant elevation change between the pedestrian tunnel entrance and grade, which can be seen on sheets A-8 and A-10 of Appendix A.

Figure 4: Initial Pedestrian Tunnel Alignments

To Union Market



To Gallaudet University

Alignment	Length	Key Conflicts
1	250	Vicinity to Florida Ave & rail bridge abutment
2A	275	Requires a change in tunnel direction
2B	200	CAW site proposed development
2C	325	35' depth required to clear 3rd St utilities.
3	210	Amtrak signal bridge
4	210	Construction area impedes existing Metro access

To Union Station

Figure 5: Initial Pedestrian Tunnel Alignments Profile Sketches

See Appendix A for more detailed profile sketches

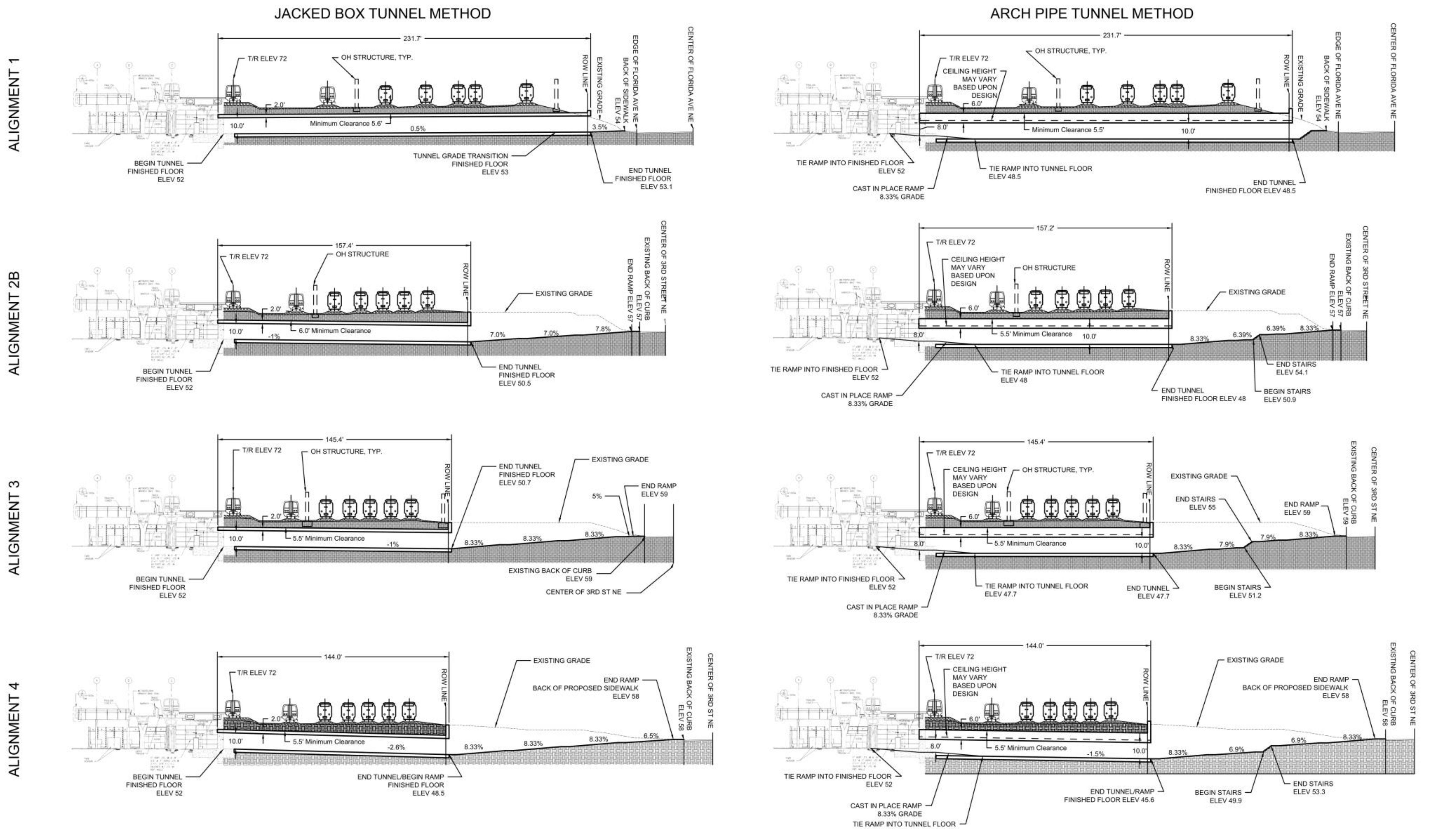


Table 3: Initial Alignment Review Matrix

	Alignments	1	2			3	4
	Alternate Eastern Entrance		**2A**	**2B**	**2C**		
Physical Characteristics	Length (ft) (total / to CAW property)	250 / 232	275 / 157	200 / 157	325 / 157	210 / 145	210 / 144
	Maximum Width (ft)	20+	20+	20+	20+	20+	20
	Floor to Ceiling Height (ft)	8 - 10	8 - 10	8 - 10	8 - 10	8 - 10	8 - 10
	Stairs Required (Not considering CAW site - pending development)	N	N	N	Y - 35 ft depth to clear utilities under 3rd St	N	N
	Continuous Straight Tunnel (Y/N)	Y	N	Y	Y	Y	Y
Physical Constraints	Vicinity of OHE Poles, Foundations, and UG utilities	N	Y- Immediate Vicinity (OHE)	Y-Adjacent (Signal Bridge)	Y- Immediate Vicinity (Water and Sewer under 3rd St)	Y-Immediate Vicinity (Signal Bridge)	N
	Proximity to 66" Water Main	N	N	N	N	Y-Immediately Adjacent	Y-Adjacent
	Vicinity of Billboard Foundation			Y-Adjacent	Y-Adjacent		
	Impact on CAW Site Development Plans	Coordination will be less extensive with this option because the tunnel east entrance is located on the periphery of the development site.	Depends on how close future building plans are to the edge of Amtrak ROW.	East tunnel entrance is within the proposed building footprint of the development site.	Tunnel will be beneath proposed building footprint so coordination with building foundation design will be a significant constraint.	East tunnel entrance is within the proposed building footprint of the development site. However, the location provides a feasible location within the development site.	East tunnel entrance is within the proposed building footprint of the development site.
Constructability Issues	[1] - Minimal construction issues [2] - Issues can be overcome through design and construction techniques [3] - Complex construction issues that may be difficult to overcome	[3] Will require set-up of construction equipment on Florida Avenue and create complex traffic issues.	[2] Reasonable set-up area. May create conflicts with future property development.	[1] Reasonable set-up area likely available. Preferred tunnel length.	[3] Difficult tunnel length. Construction set-up and staging will be very difficult. A portion is beneath the water table.	[2] Constructability will depend on ability to relocate signal bridge for rail.	[3] Likely creates issues for Metro access during construction.
East-West Access Improvement	Directness of east-west connectivity and potential to separate from paid area	[LOW] Minimal improvements to east-west connectivity. Potential to separate from paid area.	[LOW] Improves access east-west.	[MEDIUM] Improves access east-west. Potential to separate from paid area.	[LOW] Significant vertical changes in elevation. Potential to separate from paid area.	[HIGH] Improves access east-west. Potential to separate from paid area.	[HIGH] Shortest distance. No potential to separate from paid area .
Selection	Justification for selection or elimination from further consideration	**Selected** for further analysis because of the minimal impact to the CAW Site Development Plans.	**Eliminated** from further consideration due to extended length and not a continuous straight tunnel.	**Selected** for further analysis because of the minimal impact to the Amtrak Signal Bridge.	**Eliminated** from further consideration due to extended tunnel length and the depth required to tunnel beneath 3rd Street.	**Selected** because of the short tunnel length (perpendicular to existing rail) and integrates best with CAW Site Development Plans. Further analysis resulted in a modification of this alignment (3A) as explained in section 3.2.3	**Eliminated** from further consideration due to its impacts on Metro station access during construction.

Legend: Minor Issues (yellow) Major Issues (red)

4 Tunneling Methods

Due to the location of the Northeast Corridor tracks directly adjacent to the NoMa Metrorail Station, cut-and-cover was eliminated as a means of construction for the pedestrian tunnel. Therefore, the following tunneling methods beneath the railroad were evaluated as part of this study:

- Pipe Arch/Pipe Flat Roof Tunnel – Consists of installing a series of pipes around the perimeter of the proposed tunnel (arch or flat roof configuration) to provide temporary support and protect the adjacent existing structures during the tunnel excavation.
- Jacked Box Tunnel – Consists of horizontally thrusting a box structure forward into the ground using open shield and jacking technology, then excavating from inside of the tunnel box structure.
- Sequential Excavation Method (SEM) with soil stabilization ground improvement using ground/soil stabilization techniques – Consists of sequentially excavating the ground while providing initial ground support via a shotcrete liner, steel arches (lattice girders), reinforced forepoling, and face stability ground reinforcement, as needed. The permanent concrete tunnel lining is then cast-in-place.

The following qualitative factors were assessed for each of these tunneling methods:

- Technical feasibility
- Constructability and staging requirements
- Alignment for the new tunnel and connection to existing Station
- Potential impacts to railroad and adjacent structures
- Environmental impact
- Order of magnitude construction costs
- Construction Schedule
- Impact to the existing right-of-way and utilities
- Local/regional/national contractor availability

During the Preliminary Design phase of the project, additional detailed engineering analysis of the selected method will be necessary to ensure tunneling will be performed in such a way that above railroad track elevations will not be displaced, including determining an appropriate method of providing anti-drag resistance to be implemented.

4.1 Pipe Arch/Flat Roof Tunneling Method

The Pipe Arch/Flat Roof tunneling method consists of installing a series of pipes around the perimeter of the proposed tunnel to provide temporary support and protect the adjacent existing structures during the tunnel excavation (See Figure 6, Figure 7 and Figure 8). The pipe arch and flat roof tunneling methods are similar in construction and design but each has some advantages over the other. The major advantage of the flat roof tunnel method is a better utilization of the space inside the tunnel. However, a flat roof tunnel typically requires a heavier lining section than the arch roof tunnel because of its uneven load distribution. The arch tunnel section typically requires a lighter tunnel lining section;

however, the utilization of the tunnel space is somewhat restricted by its arch shape, which impacts the depth of the tunnel invert elevation to maintain minimum clearance (5.5 feet) from the track above. Because of this arch shape, the arch roof tunnel can provide a maximum clear pedestrian tunnel width of approximately 16 feet, rather than the preferred 20 feet.

Both pipe arch roof and flat roof methods involve the use of pipe jacking or auger drilling to install a series of steel pipes and supporting structural steel frame supported on a pile foundation system. The final section of the tunnel structure uses cast-in-place reinforced concrete tunnel lining. The pipe piles are reinforced with steel members or reinforcing wide flange steel sections and encased in concrete. The structural steel frames will be placed approximately at six-foot centers. Excavation of each six-foot segment is performed with general mining equipment. A pipe pile foundation is placed to support the steel frames. Both methods will maintain a minimum 5.5 feet of overburden above the tunnel crown and below the railroad tracks. The cross section of the concept pipe arch and flat roof tunnel is shown Figure 6 and Figure 7.

An overview of the design and construction procedure for the Pipe Roof Tunnel includes the following items:

- Design pipe flat/arch tunnel per design criteria outlined in Section 5.4 of the report.
- Evaluate potential impacts of tunnel construction on adjacent structures, buildings and railroad
- Design and install an Instrumentation and Monitoring program to monitor the Amtrak and Metro Railroad tracks and adjacent structures as needed
- Evaluate potential impacts on adjacent structures and railroad during construction to determine any need for protection
- Install entry pit and head wall to the bottom of tunnel excavation level
- Through the portal headwall install drilled pipes to create a roof supported underpass beneath railroad tracks. Pipes may be interlocked to create the pipe arch roof and the fiber glass rods installed to provide face support during open face excavation.
- Excavate soil beneath pipe sections for approximately six feet, as shown in Figure 8.
- Install pipe piles for foundation support of structural steel frames
- Place concrete foundation at pile locations
- Install structural steel frame supported on pile supported foundation
- Excavate next segment at approximately six-foot sections using a conventional mining equipment
- Continue until excavation of tunnel is complete
- Construct final cast-in-place reinforced concrete tunnel box liner
- Prepare and remove existing foundation wall to allow an open passage into the station level
- Connect to existing station ensuring waterproofing details
- Apply tunnel finishes

Figure 6: Typical Pipe Flat Roof Tunnel Section

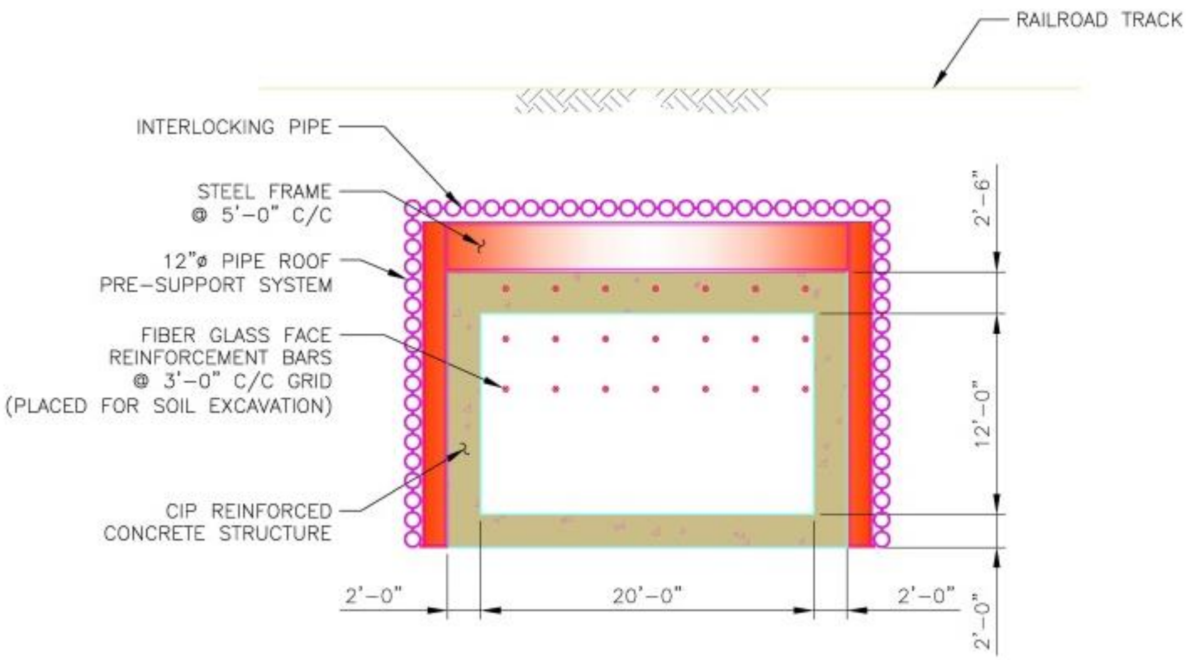


Figure 7: Typical Longitudinal Section of the Pipe Arch/Flat Tunnel

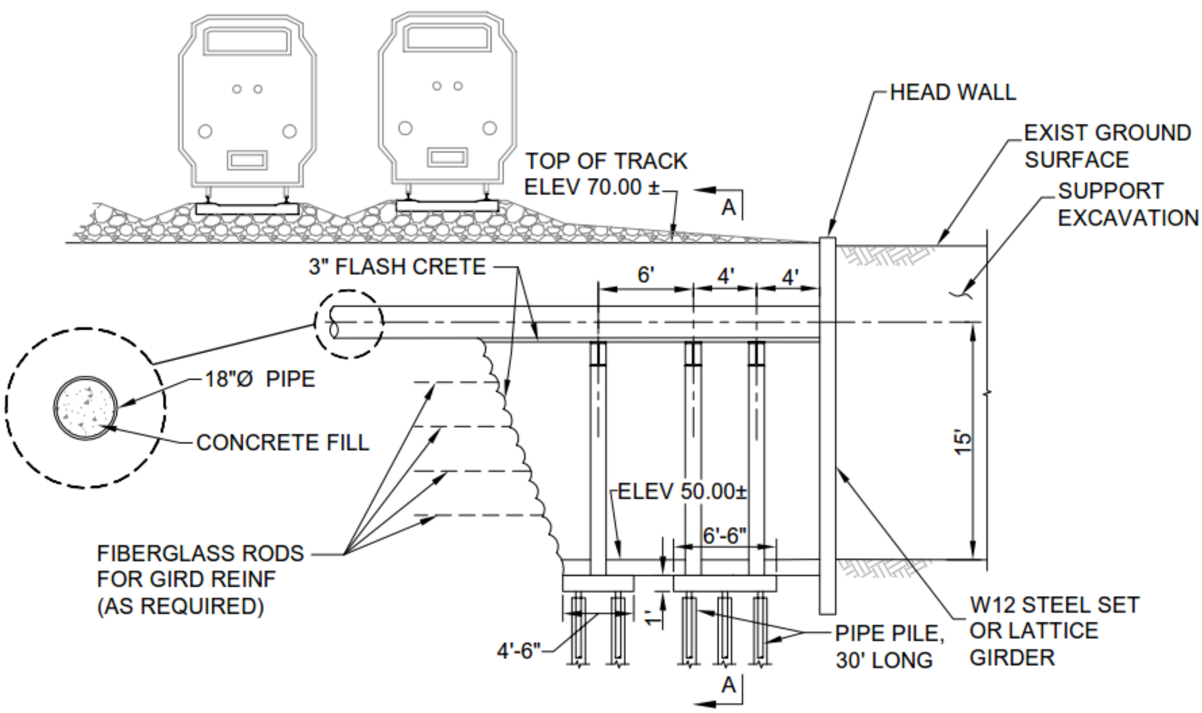
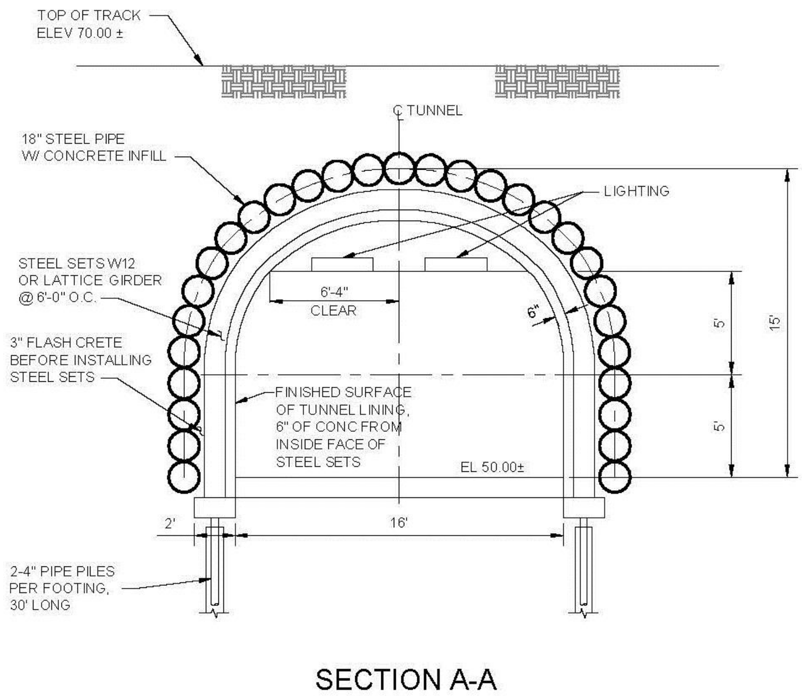


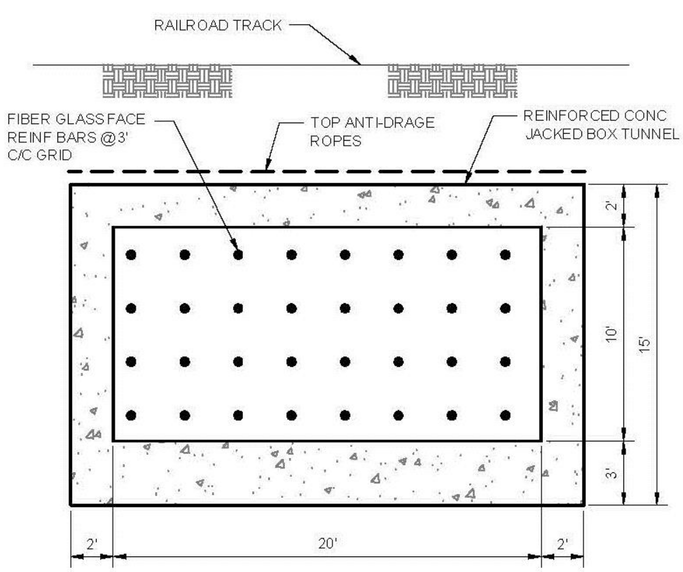
Figure 8: Typical Pipe Arch Roof Tunnel Section A-A



4.2 Jacked Box Tunneling Method

Jacking a box tunnel beneath the existing Amtrak Railroad with approximately 5.5 feet of cover involves the advancement of a site cast-in-place or pre-cast reinforced concrete rectangular or other shaped section using high capacity hydraulic jacks (A potential concern with pre-cast elements will be delivering the sections by truck, as they may be too large for easy delivery; generally, site cast will be preferred). The structure to be installed is constructed at an area adjacent to the tunnel drive, in a pre-excavated launch pit or area. The box structure is then horizontally thrust forward into the ground beneath the railroad using open shield and jacking technology. Excavation then occurs from inside of the tunnel box structure. Typical section is shown in Figure 9.

Figure 9: Typical Jacked Box Tunnel Section



An overview of the design and construction procedure for the Jacked Box Tunnel includes the following main items:

- Establish design criteria for structural, geotechnical and tunneling
- Structural design of jacked box, design box shield, determine need for compartmentalization or full open face jacking, determine need for excavation cubicles and breasting plates, design jacking mechanism/dead-man, drag ropes/sheets
- Evaluation of potential impacts of tunnel construction on adjacent structures, buildings and railroad
- Design and install Instrumentation and Monitoring program to monitor the impacts on the adjacent structures and railroad tracks
- Construct a launch or jacking area and prepare a head wall at the entry portal
- Construct the reinforced concrete box to be jacked on a prepared base
- Prepare the horizontal hydraulic jacks and deadman support
- Install anti-drag system
- Insert fiber glass face reinforcement through the head wall
- Initiate tunnel jacking operation
- Remove the head wall as jack box interfaces with the head wall
- Excavation the soil face using conventional method for three feet with fiber glass rods providing tunnel face support. Shotcrete could be utilized if needed.
- Prepare the base of the structure
- Jack box sections approximately three feet into face of tunnel
- Continue procedure until jacked box section arrives at the face of station foundation wall beyond the railroad
- Prepare and remove existing foundation wall to allow an open passage into the station level
- Apply tunnel finishes

4.3 Sequential Excavation Method (SEM)

SEM (also referred to as NATM – New Austrian Tunneling Method) constitutes a method where the surrounding rock or soil formations of a tunnel are integrated into an overall horseshoe shaped ring-like support structure. Figure 10 shows a typical SEM tunnel section. With this method, the tunnel is sequentially excavated and the excavation sequences can be varied. The initial ground support is provided by initial shotcrete liner, steel arches (lattice girders), reinforced forepoling and face stability ground reinforcement, as needed. The permanent tunnel lining would be a cast-in-place reinforced concrete tunnel providing a clear pedestrian tunnel width of approximately 16 feet and clear height of 10 feet.

The SEM construction process includes the following:

- Install headwall and the support of excavation system
- Provide grouted forepoling and face stability grouting from the headwall prior to excavation
- Remove segments of headwall portion at tunnel face and perform excavation process

- Remove headwall and excavation top heading followed by bench heading sequentially as shown in Figure 11
- Provide lattice girders and initial shotcrete liner sections after excavation to provide temporary support
- Provide waterproofing and cast-in-place concrete final liner
- Apply tunnel finishes

After review of the SEM, it was determined that although the method is technically feasible, the SEM construction beneath the several Amtrak and Metro lines would expose these facility owners to unnecessary high risks. These include:

- Potential excessive and uncontrollable ground settlement (without a grouting program from the track surface) may cause undue disruption to service.
- Forepoling pipes used to reinforce the tunnel crown may interfere and protrude into the railroad clearance zone (i.e. 5.5 feet cover above tunnel crown).

With the above potential risks, and the fact that the SEM construction does not offer a substantial reduction in construction cost or schedule compared to other tunneling methods previously mentioned, this tunneling method was eliminated from further consideration. No further details of cost and schedule of this tunneling method are included in the report.

Figure 10: Typical SEM Cross Section

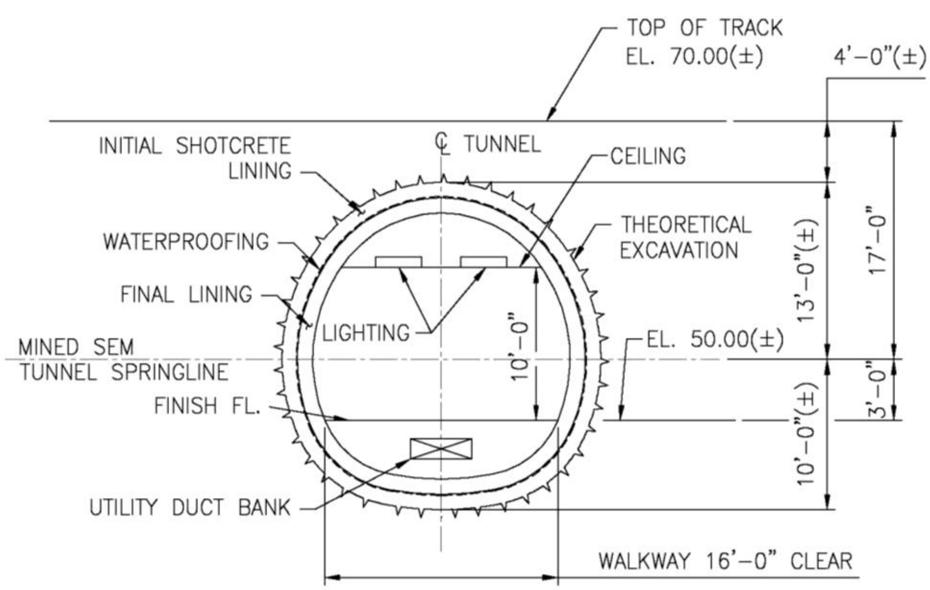
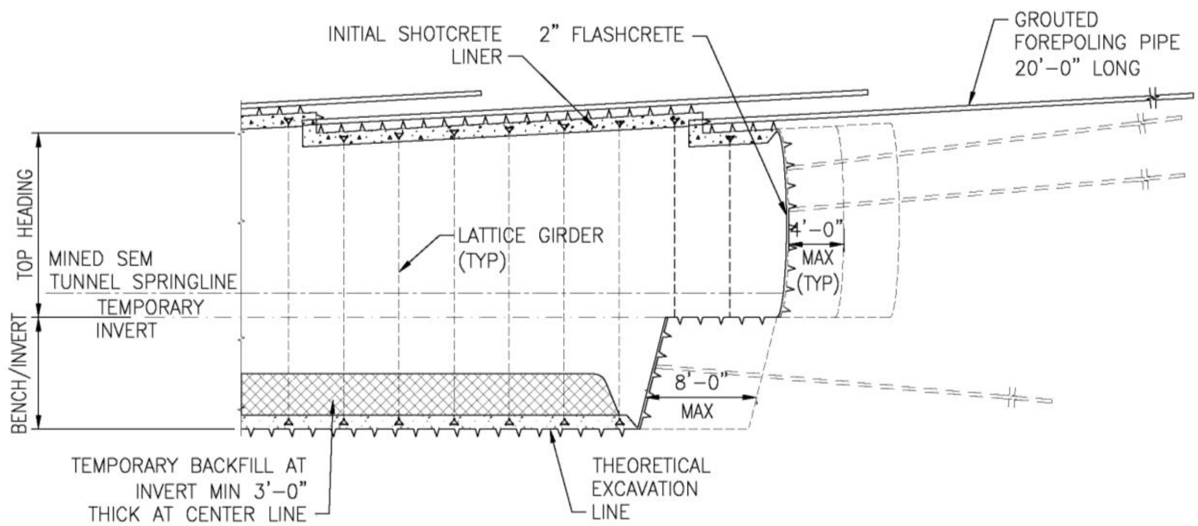


Figure 11: Typical SEM Longitudinal Section and Construction Sequence



5 Tunnel Lining Design and Construction Evaluation

In this feasibility study, a typical section of pipe arch roof tunnel and jacked box tunnel were evaluated to estimate the approximate structural requirements for these types of tunnels and provide input for the rough order or magnitude (ROM) cost estimates. The design of pipe flat roof tunnel would be similar to that of the pipe arch roof tunnel; hence, it was not evaluated as a separate case. The following sections discuss the structural design approach, loading conditions, and assumptions used in this feasibility study.

5.1 Design Codes, Manuals, Standards and Reports

Because this pedestrian tunnel will be located beneath active railroad facilities, the design is based on the 2013 American Railway Engineering Manual (AREMA).

5.2 Design Assumptions

The following design assumptions were used in the analysis:

- Ground cover over pipe arch/flat roof and jacked box tunnels is 5.5 feet below the track bed
- Preferred tunnel width is 20 feet based on stakeholder preferences and accessibility considerations
- Uniformly-distributed gravity loads were used
- For the pipe arch/flat roof tunnel, frames and excavation were spaced 6 foot on center. A typical frame was analyzed with tributary loads over 6-foot spacing. For jacked box tunnel, a typical one foot wide tunnel section was used in the analysis.
- The overhead structure foundation will exert additional loads on localized areas of the tunnel roof. This localized load is expected to be minimal and was not included in the design loads for

the typical section of tunnel design at this feasibility stage. Overhead structure loadings will be evaluated during the Preliminary Design phases of the project based on the selected alignment.

- The penetration of the station wall was determined to be feasible, via generally similar means for each tunneling method. Additional detailed engineering work regarding the wall's penetration and means of retaining the wall's structural integrity will be required during the Preliminary Design phase of the project.
- The phreatic groundwater level is below the invert of the proposed tunnel section, therefore a fully wrapped structure will not be necessary for water tightness. Preliminary Design should evaluate the appropriate means of providing water tightness at the roof of the tunnel, connection points, and joints.

5.3 Design Loads

The loads considered in this analysis include dead load, earth loads, live load, water load, impact load, and seismic load, and were calculated in accordance with AREMA standards. These loads were considered for each alignment and tunneling method, and are detailed in Appendix D.

5.4 Tunnel Lining Design Approach

This section briefly discusses the structural analysis of the pipe arch roof and jacked box tunnels performed for this feasibility study. It also discusses in detail the basis of assessing the feasibility of the jacked box tunnel application as this appears to be a viable method for the subject project. As noted throughout the report, further engineering analysis and evaluation will be required during the Preliminary Engineering phase of the project to confirm the applicability of these tunneling methods and the required structural tunnel lining.

5.4.1 Pipe Arch Roof Tunnel

A typical section of one-foot wide was analyzed using SAP2000 and the anticipated loads discussed in Section 5.3. The proposed arch pipe roof tunnel cross section will be 16 feet wide by 10 feet high clear as shown in the Figure 8. The preferred 20 foot width could not be attained using this tunnel method. Due to its arch shape, a wider structure becomes taller, which resulted in tunnel slopes which were not in accordance with ADA requirements. The design of the pipe arch roof tunnel at this stage includes the following:

5.4.1.1 Design of Steel Sets

The tunnel lining will consist of steel sets used for temporary support during tunnel excavation and a concrete/shotcrete wall to be placed between the steel sets to provide additional long-term structural capacity. Two loading conditions need to be considered for the steel sets: short-term loading during construction and long-term loading. At this feasibility stage, the steel sets were only evaluated for the short-term condition, where the concrete/shotcrete is not yet installed. Load sharing between steel sets and the concrete/shotcrete wall will need to be evaluated for the long-term loading condition.

The steel sets were assumed to be 6 feet on center and analyzed with a 2-D frame modeled for the above estimated loads. The soil reaction was modeled as compression-only springs, having stiffness of

50 kcf. The steel set structural capacity was checked following the guideline provided in AREMA, Chapter 15 – Steel Structures. A W12x96 would be required for the support set.

The vertical load at each leg of the steel set was supported using a micropile foundation to minimize settlement. The design of micropile foundation is based on the guidelines provided in FHWA NHI-05-039 Micropile Design and Construction Manual.

5.4.1.2 Design of Arch Pipes

The arch pipes were assumed to be simply supported by the steel sets with a typical span of six feet and supported by the ground in the unexcavated section of the tunnel. The last span adjacent to the existing station wall would be a cantilever section during the excavation period, until the last steel set is installed. The pipe was analyzed as a multiple span, simply supported beam using SAP2000. It was determined that steel pipes of 18” OD, and 3/8” wall thickness, with in-filled concrete, would be required to support the anticipated loads.

5.4.2 Jacked Box Tunnel

This section discusses the structural analysis of the jacked tunnel structure and other components of a jacked tunnel system.

5.4.2.1 Box Tunnel Design

The proposed jacked box tunnel concept is shown in Figure 9. The cross section provides 20 feet wide and 10 feet high clear distances, 2 feet thick roof slab and side walls, and 3 feet thick base slab to provide room for jacking operations. At this feasibility level, the jacked box tunnel was analyzed for the long-term loading condition only. During construction, the jacked box will be subjected to additional loads from the jacking system. It is anticipated that these temporary loads can be adequately handled with additional reinforcement at localized areas where the loads are applied. The design of these details will be addressed during the preliminary engineering and final design phases.

A typical section of one-foot wide was analyzed using SAP2000 and the anticipated loads discussed in Section 5.3. The soil reaction was modeled as compression-only springs having stiffness of 120 kcf for springs supporting base slab and 50 kcf for springs on the side walls. Base slab springs at the corners are two times stiffer than the springs at the middle of the base slab. It was determined that the proposed thicknesses of tunnel slabs and wall are adequate.

5.4.2.2 Tunnel Jacking Process and Components

Jacked Tunnel Components

The components making up the jacked tunnel scheme are as follows:

- Casting / thrust pit
- Jacking base
- Jacked units
- Intermediate Jacking Stations (IJS) as needed
- Rear jacking station

- Mining shield to allow for safe excavation and ground treatment (as needed) during jacking
- Shield entry through thrust pit head wall
- Jacking process – forces and components
- Alignment control
- Drag sheets/ropes anchorages
- Reception works and shield removal
- Monitoring of ground movements and railroad resurfacing

Jacked Tunnel Construction Sequence

Construction of a jacked box tunnel consists of three main stages that are briefly discussed in the following sections. These construction stages are schematically shown in Figure 12.

Stage 1 – Casting of Jack Box

Stage 1 provides casting of the concrete boxes to be jacked into place. This includes the head wall and pit preparation, jacking drive resistance slab, the shield on the lead section of jacked box and placement and setup of the jacking frame.

The complete concrete box will be cast on the jacking base and meet the required design strength prior to the start of jacking operation.

In order to ensure continuity of railroad operations, excavation is generally not permitted within 12 feet of the centerline of the nearest track, and clearances of greater than 18 feet are generally preferred. These requirements must be taken into account in setting the thrust pit headwall positions and excavation required on the reception side. Special consideration will be used at the reception location to include the impacts to the existing retaining wall and structure.

The overall jacked tunnel lengths may be divided into a number of unit lengths to include practical IJS and rear jack arrangements. The breakdown of units will be determined during preliminary engineering. It is essential to distribute the jacking reactions without lifting off the jacking base at its front end due to the eccentricity of the IJS jacks, compared to the single tier of rear jacks.

The thrust pit will be sized to allow adequate working space and install rear jacks. Side guides and a bond breaker will be used to allow smooth jacking and maintain alignment during entry through the headwall. A load transfer mechanism will be designed to transfer jacking forces to the soil.

The head wall will be skewed to allow progressive shield entry. Ground treatment will be evaluated during preliminary design. Once units are sufficiently advanced, sheet anchorages are installed behind rear unit.

The need, application and requirements for IJS's will be determined during preliminary design. This analysis will consider the stresses on drag sheets (ropes), capacity of jacking system, and control steerage ability.

Stage 2 – Jacking Box

The concrete box will be advanced into ground as the jacks apply pressure to the frame and advancing the tunnel box. The jacking frame will reach the limit of throw and additional jacking blocks are installed. After a new set of jacking blocks are installed, the push continues to complete another advancement of the box. As the jacked box is moved forward, the tunnel face will be continuously excavated using conventional excavation equipment. The face stability will be checked and maintained throughout the operation to provide safety for workers and minimize impacts on adjacent structures. The excavation cycles are repeated until the jacked box reaches the desired position.

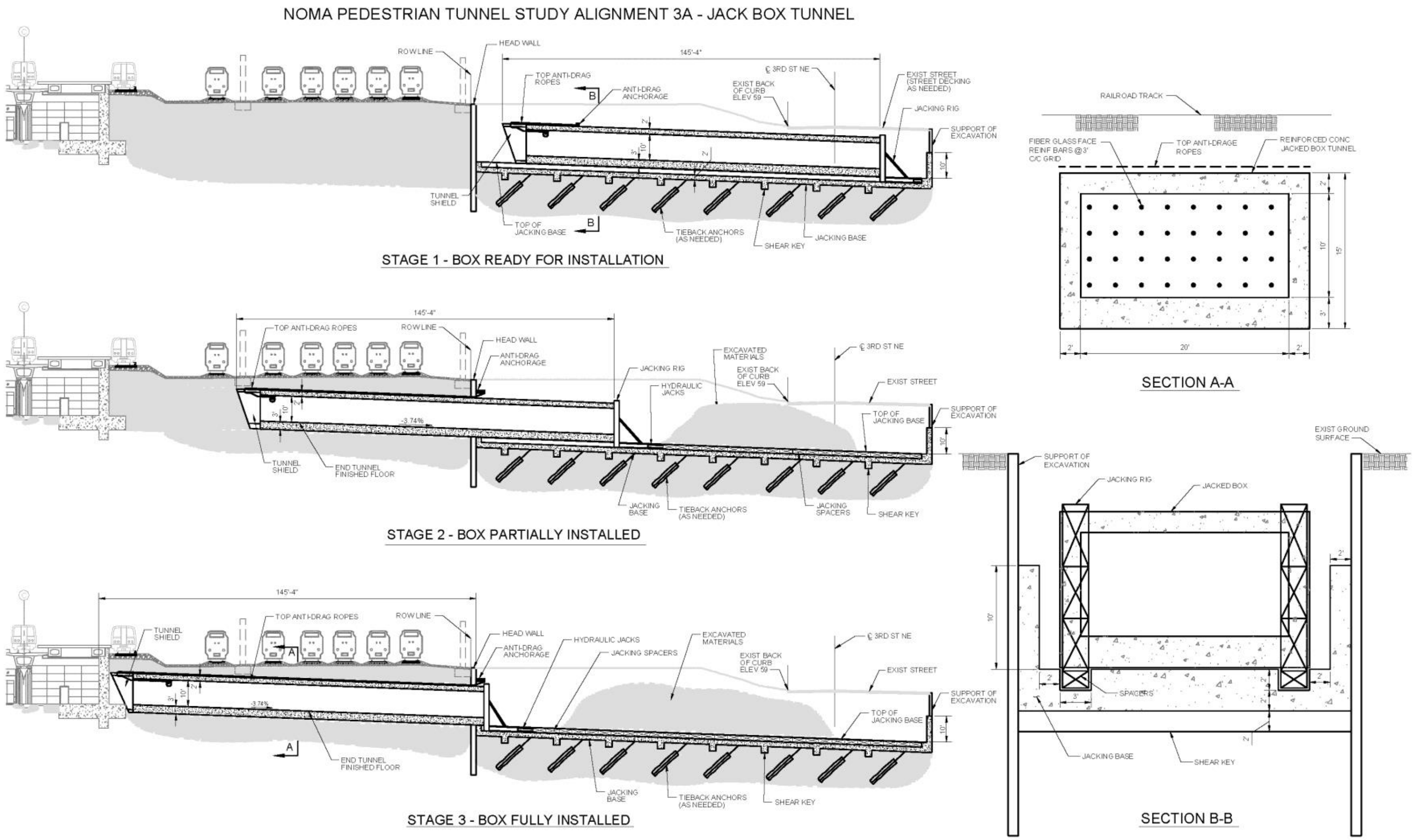
It is critical to ensure the unit begins the jacking process on the correct alignment. For the feasibility analysis and proposal IJS's were not included. IJS are important in maintaining the ability to "steer" the units through the ground. The need for these stations will be determined during the preliminary design. For the feasibility analysis, the unit is considered as a single unit, driven in a straight alignment approximately 100 feet in length, which is acceptable as a single unit driven from jacks at the back face.

A detailed understanding of the ground conditions, and jacking system (including number of jacks, their location and applied pressure), are critical to control of the drive. Subsurface conditions for application of the jacked tunnel construction are favorable. Refer to the Geotechnical Technical Memo for description of exiting ground conditions.

Stage 3 – Final Position of Jacked Box

Once the jacked box reaches the final position, the shield will be removed or incorporated into the final structure of the jacked box. The structural connection between the jacked box and the existing station structure will be constructed and the architectural finishes will be applied

Figure 12: Construction Sequence of Jacked Box Tunnel



5.4.2.3 Thrust Pit Wall and Base Design

Thrust Pit Layout

Thrust pit layout will include adequate space for placement of jacked boxes, construction of a backstop jacking restricting structure, and installation of jacking mechanism. The headwall wall will be constructed on a 15 degree skew to the face of the shield to allow gradual entrance through the headwall into the ground. The following minimum thrust pit layouts were considered:

- Minimum distance between the sides of jacked tunnel box and support of excavation is four feet
- Clearance between the rear of the last cast section and inside back wall is eight feet, to allow for placement of jacks. A dead man wall of four feet is expected beyond the clearance line.
- Shield and headwall clearance is two feet
- A screed finish is laid to the top of the jacking slab to proposed profile and alignment
- The need and use of guide walls will be evaluated during the preliminary design phase and minor adjustments will be made accordingly

Safety Clearances and Protection

In order to ensure safe operations for both contractor and railroad operations, the appropriate clearances must be maintained throughout the duration of the project. Any work performed within the Amtrak right of way, within less than 25 feet from the centerline of track, or with the potential to impact rail operations, will require railroad flagging services. This will be an additional project expense. Thrust pits are generally required to be located at least 18 feet from the centerline of the nearest track, but with appropriate justification, may be considered as close as 12 feet from the centerline of the nearest track. Amtrak may elect to require the pit be located entirely off of Amtrak property. Railroad safety clearance, as dictated by Amtrak, must be maintained, and thrust pit layout will conform to the clearance distances.

Vertically Retained Earth Support System

The need and extent of a vertical support of excavation system will be evaluated in preliminary design. The cost estimate will include a nominal cost for pit support of excavation.

Thrust Pit Base Design

Thrust pit base provides the mechanism to construct the jacked boxes, a launching slab and jacking resistance link to resist jacking forces. The analytical model of the base slab will use a 3D finite element mesh. Resistance to the jacking loads will be mobilized from the following areas:

- Skin friction between soil interface below the slab
- Skin friction between thrust pit walls and soil (if walls are used)
- Resistance at the pit rear support wall

5.4.2.4 Tunnel Jacking Shield

General

Railroad and worker safety at the face of excavation is dependent on ensuring face stability during the mining process.

Face Stability

Cell dividers and breasting plates are used in difficult ground conditions to maintain face stability; however, they are not expected to be required to control face stability at this location. The needs for additional face stability will be evaluated during the preliminary design phase.

Geometry

Dimensions and reinforcement will be evaluated during preliminary design. It is anticipated that a separate cast-in-place shield with a slight hood at the roof level will be used.

Design Loadings

Design loadings for the feasibility sizing of members will consider vertical loads from ground and railroads above and lateral load from normal static ground pressures, as discussed in Section 5.3. Ground water is not expected in the drive locations. During the preliminary engineering phase, the design will evaluate further loadings due to upward steering, special forepoling/arching loads to shield, jacking forces at rear of the unit, and IJS's transferred loads if needed. These loadings are not expected to impact the conceptual design provided in the feasibility report.

5.4.2.5 Drag Sheets and perimeter Friction Reduction

Drag sheet designs will be included in the preliminary engineering phase. The drag sheet design will include the following: drag reducing measures; drag sheet design requirements; drag sheet anchorage; lubrication systems, etc.

5.4.2.6 Jacking Force Requirements

Jacking Operation

The tunnel units are advanced into the ground by jacks mounted at the rear of the unit. The rear jacks will react against a thrust block through a series of concrete packers. To simplify analysis during this feasibility study, the jacked section will be considered a single unit. Multiple tunnel units will be evaluated with IJS installed. The use of several units can reduce the construction staging area length, footprint of jacking slab, and realize other advantages which will be evaluated during preliminary design.

Assessment of Jacking Resistance

The jacking resistance includes the friction between the drag sheets and the roof, the soil drag on the roof (not covered by drag sheets), soil drag on the sides, soil drag on the base in contact with the soil, and shield end resistance. The jacking resistance will be calculated for values of soil friction/adhesion compatible with expected stoppage between jacking cycles. The breakout resistance will also be included; however, in this application no breakout will be required.

For the feasibility design, only basic jacking resistance has been calculated. The soil is not expected to create horizontal squeezing resistance. The in-situ vertical ground pressure prior to jacking, and the displacement of the soil due to the jacking affects, may cause minor heave and settlements which will be assessed in preliminary design.

Major loads contributing to the jacking resistance include:

- Unit base slab to soil resistance – The soil conditions are in a mostly sand and gravel mixture and the base will remain in contact with the soil
- Roof resistance under drag sheets – Assume resistance beneath drag sheets of total vertical pressure X coefficient of friction (0.22), excluding railroad live loads

- Wall resistance – angle of friction between the structure and soil for granular soils
- Nominal jacking resistance of 400psf was used for this feasibility evaluation
- Shield end reaction – the face area in contact with the soil, assuming a two foot maximum penetration of the shield, beyond the mined face. Breasting plates are not expected to be needed in this design because of the favorable ground conditions. Consider end bearing of shield on soil plus embedment adhesion
- The soil strength sensitivity does not vary largely to develop maximum jacking resistance, and the resistance variation is not great where the assumption of cohesive or non-cohesive ground is used in this design and the average strengths of soil were used

Face Stability

Control of face stability within the units, as jacked into place, is critical to ensure that the ground surface settlement is kept within acceptable limits and to maintain safety at the face during excavation.

For the feasibility analysis, face reinforcement consisting of fiberglass rods were used. A refined evaluation will be included in the preliminary design.

Assessment of Number of Jacks

The number of jacks required for the factored jacking load is derived from the jack capacity when operating at the rated pressure of 10,000psi (for this feasibility study) and since the jacking forces are reduced upon movement, jacks will normally operate at lower pressures.

Factors of Safety are applied to the calculated jacking resistance to include the following:

- Variations in soil strata and strength
- Possible obstruction encounters increasing shield pressure
- Adverse effects on ground treatment on soil properties
- Vertical or horizontal steerage (to maintain direction control or correct a misalignment)
- Leading single unit FOS = 2.0

Steerage is achieved by switching off some of the jacks on one side or top or bottom and increasing the jack pressure on others.

5.4.2.7 Rear Jack Reaction System

The reaction to the jacking force is resisted through an upstand beam, or dead man, at the back of the launch base. The resistance to the force is developed through the jacking. The ultimate reaction force for design is total jack capacity time an additional FOS = 1.1 for robustness. Key features of the rear jacking arrangement include:

- Capacity of each of the rear jacks will be determined in preliminary design. Two hundred ton capacity was used to determine a cost basis for the jacked tunnel option.
- Group jacks to each side for maximum steerage and to ensure the center zone is free for access
- Size each packer consistent with the number and locations of jacks

6 Accessibility Codes and Standards

This section identifies the applicable codes and standards associated with the design of a pedestrian tunnel, and provides an analysis of the various access issues associated with the various tunnel design options proposed herein.

It is expected that the developer for the area in the vicinity of the east entrance would have the ability to tie into the proposed pedestrian tunnel. This non-system occupancy would require special consideration beyond the NFPA 130 Standard and are not depicted at the conceptual level.

6.1 List of Codes and Standards

- Federal Standards: Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines, 2004 edition, (ADAAG) as adopted by the USDOT in November 2006
- Federal Standards for Accessible Means of Egress: the 2004 ADAAG references the 2000 ICC/IBC and the 2003 ICC/IBC for accessible means of egress
- District of Columbia Provisions: Chapter 11 of the D.C. Uniform Construction Code, 2013 edition which reference ICC A117.1, Accessible and Usable Buildings and Facilities.
- District of Columbia Provisions for Accessible Means of Egress: Section 1007 of the DC Construction Code, 2013 edition.
- Gallaudet University: DeafSpace Design Guidelines - Volume 1

6.2 Accessibility Criteria

The section identifies the specific ADAAG criteria application to the pedestrian tunnel and its entrance conditions.

6.2.1 Site Accessibility/ East Entrance

One or more of the accessible elements listed below must be provided for the east portal pedestrian tunnel entrance, based on the options discussed in Section 6.3 under *Site Specific Conditions*:

- An accessible ramp, complying with the requirements of ADAAG Section 405, shall provide site accessibility from the public way on Florida Avenue or 3rd Street, to the east entrance portal of the pedestrian tunnel
- An accessible stair, complying with the requirements of ADAAG Section 504, shall provide site accessibility from the public way on Florida Avenue or 3rd Street, to the east entrance portal of the pedestrian tunnel
- An accessible elevator, complying with the requirements of ADAAG Section 407, shall provide site accessibility from the public way on 3rd Street, to the east entrance portal of the pedestrian tunnel

6.2.2 Station Entrance/ West Entrance

The connection to the NoMa Metro Station on the west end of the pedestrian tunnel shall provide a second accessible entrance to the tunnel. One or more of the below accessible elements must be provided, based on the options discussed under *Site Specific Conditions*:

- An accessible ramp, complying with the requirements of ADAAG Section 405, shall provide accessibility from the existing NoMa Metro Station, to the west entrance portal of the pedestrian tunnel

- An accessible walking surface, complying with the requirements of ADAAG Section 403, shall provide accessibility from the existing NoMa Metro Station, to the west entrance portal of the pedestrian tunnel

6.2.3 Pedestrian Tunnel Walking Surface

These accessible elements must be provided for the pedestrian tunnel:

- An accessible route complying with the requirements of ADAAG Section 402 shall provide accessibility through the entire length of the pedestrian tunnel.
- An accessible walking surface complying with the requirements of ADAAG Section 403 shall provide accessibility through the entire length of the pedestrian tunnel.

6.3 Site Specific Conditions

This section describes the specific conditions created by the pedestrian tunnel as a result of the various tunneling options.

6.3.1 Site Accessibility (East Side)

The elevation at the station mezzanine differs from the existing grade on the east side of the Amtrak tracks; therefore, a change in level must occur at the east pedestrian tunnel entrance. The level of elevation change is dependent on both the alignment and tunneling method selected. While there are many solutions to this issue, the following discussion and supporting graphics illustrate one potential solution at each condition. In many cases, the solutions could be interchangeable between tunnel options with few changes (such as a longer ramp). Elevators are introduced below as an option for consideration because the arch pipe construction method creates an excessive elevation change not easily navigated with ramps. While elevator use increases costs, it reduces the footprint needed (as compared to excessive ramps) and provides a better accessible connection to the pedestrian tunnel and station. It should be noted that the solution chosen has a direct impact on the developable footprint of the adjacent Central Armature Works site, as depicted by the green area in Figure 13 and Figure 14.

Timing is a key driver for the construction of this pedestrian tunnel. For Alignment 1, the pedestrian tunnel's eastern entrance would be at the periphery of the adjacent site, so if the tunnel is installed prior to the development of the adjacent site, it is not anticipated that the future adjacent construction will substantially impact its operation. For Alignments 2B and 3A, the pedestrian tunnel's eastern entrance would be located in the center of the adjacent site, potentially resulting in greater impacts to the tunnel's operation. Alignments 2B and 3A could be built in the following sequences:

- Tunnel opens and is then closed to the public during construction – Tunnel originally opens with temporary entry elements. Once construction of the proposed adjacent development begins, the contractor will close the entrance and rebuild a new entrance in its final condition. The developer will be responsible for design and construction of the entrance.
- Tunnel opens and remains open – Tunnel remains open during construction of the proposed adjacent development, and contractor is responsible for patron safety during construction.

- Tunnel opens after construction – No temporary entry is built and pedestrian tunnel is not used until after the site is developed.

Providing equal access for all patrons is always a priority, but special consideration should be given to access for deaf patrons, due to the station's proximity to Gallaudet University. The DeafSpace Guidelines, Volume 1 should be used as a guideline when designing a space that functions appropriately. Care should be taken to apply the guidelines while not inadvertently altering the ability of the space to function as a transportation facility. This is however only the beginning of what should become an interactive process to engage the eventual users of this space, throughout the design process. The following are primary considerations and an example of how the criteria may be applied in this condition, as the project advances into the design phase:

- Space and Proximity – Care should be given for how patrons understand their surroundings with respect to distance and surroundings.

  Specific applications include developing strategies to open the space to create feelings of security, providing sufficient tunnel width to allow for small gather spaces throughout the tunnel, and maintaining unobstructed views to the tunnel entrances.

- Sensory Reach – Care should be given to open up spaces to allow for a greater range of multi-sensory perception.

  Specific applications include developing strategies that create clear understanding of path of travel, the use of transparent materials to enhance visual connection between spaces, and logically locating patron elements to enhance understanding of the space.

- Mobility and Proximity – Care should be given to creating spaces that are easily traversable and allow for the continued ability to communicate throughout.

  Specific applications include developing strategies that provide soft intersections at the pedestrian tunnel ends, establishing a preferred width to accommodate interaction along the length of the tunnel, and locating vertical circulation elements to provide clear uninterrupted pathways.

- Light and Color – Care should be given to all pedestrian tunnel users for adequate lighting and the appropriate use of color as it has a profound impact on the overall quality of the space.

  Specific applications include developing lighting strategies that provide adequate lighting to read facial expressions, the use of diffuse lighting on surfaces to reduce the silhouette effect, and the use of lighting to orient patrons in the space by highlighting vertical circulation elements.

- Acoustics and Electromagnetic Interference – Care should be given to appropriately designing spaces to reduce the interference caused by background noise.

  Specific applications include developing acoustic strategies to reduce the amount of background noise generated by multiple patrons in the tunnel at one time, adequately separating equipment spaces, and the correct installation of equipment to reduce unnecessary vibration.

Figure 13: Jacked Box Site Plans

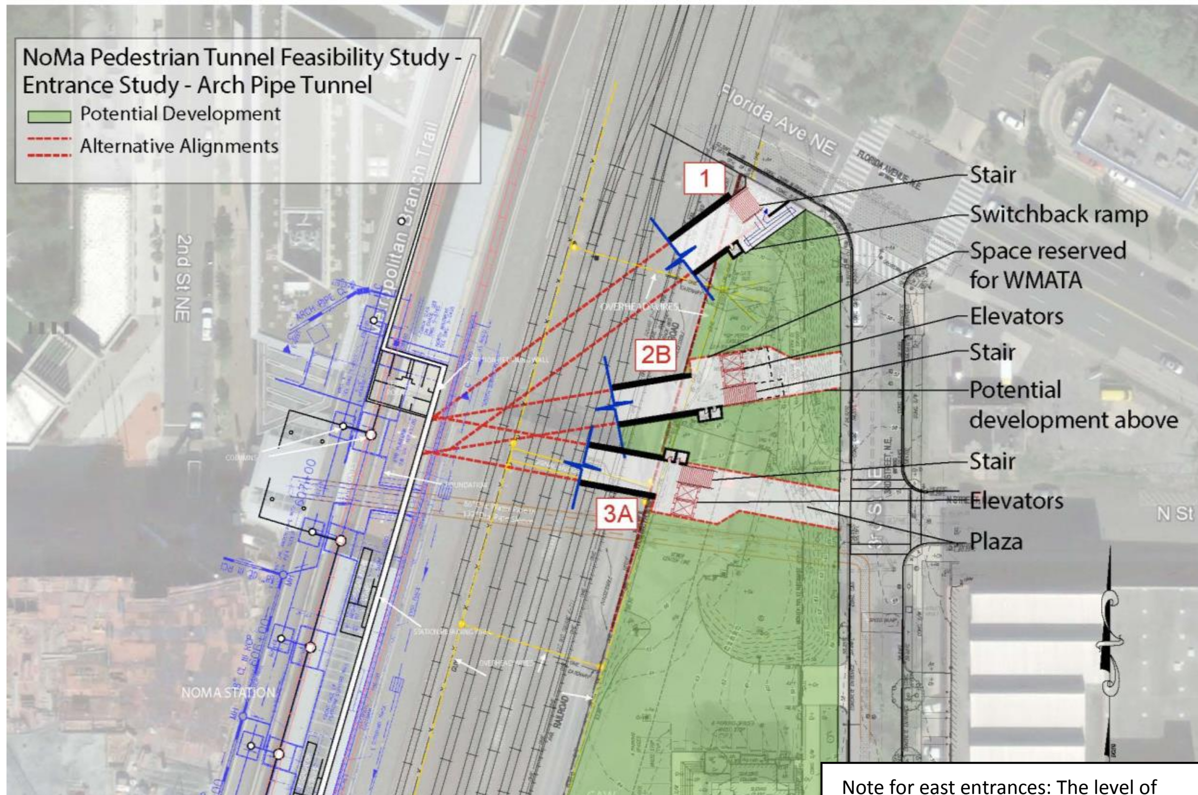
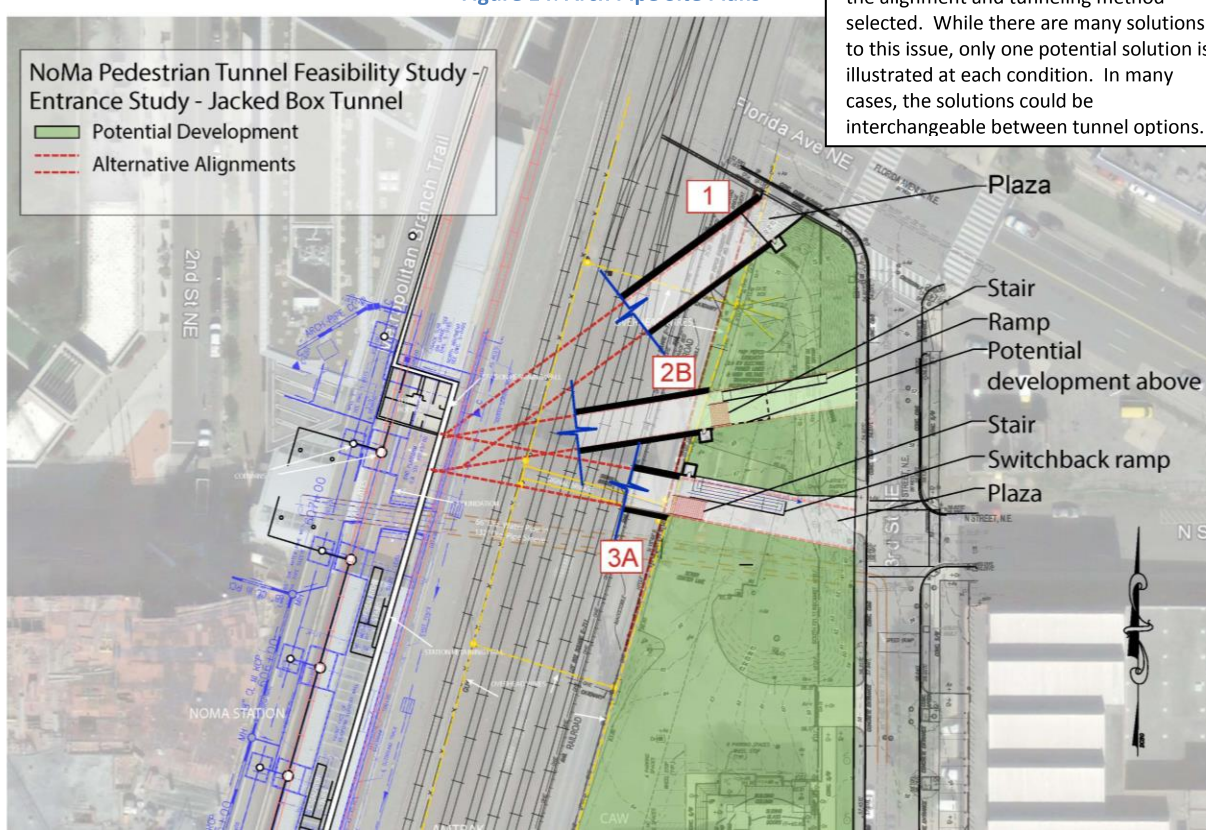


Figure 14: Arch Pipe Site Plans



Note for east entrances: The level of elevation change is dependent on both the alignment and tunneling method selected. While there are many solutions to this issue, only one potential solution is illustrated at each condition. In many cases, the solutions could be interchangeable between tunnel options.

Alignment	Jacked Box Tunnel	Arch/Flat Roof Pipe Tunnel
1	This option creates a small entry plaza between the tunnel and the existing sidewalk. This tunnel method results in a minimal elevation change between the pedestrian tunnel finish floor and the existing sidewalk. As a result, the plaza can simply slope up to the existing sidewalk without the need for additional stairs, ramps, or elevators. This option results in a minimal impact on the developable footprint.	This option also creates a small entry plaza between the tunnel and the existing sidewalk. This tunnel method results in a more significant elevation change, as compared to the jacked box option, and therefore requires the use of stairs and a ramp. Because the elevation change is still minimal, the use of an elevator is not recommended for consideration. This option uses a switchback ramp to provide access for non-ambulatory patrons which has a direct impact on the adjacent developable footprint.
2B	This alignment option has the opportunity to integrate into the adjacent development at grade, but also results in a more significant elevation grade change. To ensure a favorable situation that meets WMATA's needs, space should be preserved at the tunnel entrance for vertical circulation and the corresponding circulation needs. This option illustrates the use of a ramp and stairs to traverse the elevation change and the space identified for WMATA use needed, at a minimum, to ensure functionality of the vertical circulation elements. The use of a ramp impacts the adjacent development. Coordination with the developer will be important to ensure a solution that works for both WMATA and the developer.	This tunnel option results in a more significant elevation grade as compared to the jacked box tunnel method. As a result, this option illustrates the use of an elevator and stair as a ramp would continue to increase the amount of disturbance on the adjacent development. To again ensure a favorable situation that meets WMATA's needs, space should be preserved at the tunnel entrance for vertical circulation and the corresponding circulation needs. The space illustrated preserves minimal space needed to ensure functionality of the vertical circulation elements. Coordination with the developer will again be important to ensure a solution that works for both WMATA and the developer.
3A	The alignment 3A option represents a logical location for the tunnel because it is on axis with the adjacent urban street network and provides a tunnel opening that integrates with current development plans. This alignment also represents the most significant elevation change between the pedestrian tunnel entrance and grade. This entrance option illustrates the use of a ramp and stair, for patrons to traverse the elevation change as an interim solution. (The use of an elevator may also be warranted similar to the Arch Pipe entrance concept discussed below.) The remaining space at grade could be used to create a plaza that connects into the existing urban street network. This also creates a logical break in the adjacent development although the developer may still have the opportunity to build over the plaza space. Tunnel Alignment 3 is also the preferred option by the developer. The scheme illustrated would be a temporary condition with the developer building the final condition as the site is developed.	This tunnel method at tunnel alignment 3A represents the most significant elevation change between the pedestrian tunnel entrance and grade. As a result, this entrance option illustrates the use of an elevator and stair for patrons to traverse the elevation change. (The use of a ramp may also be feasible similar to the Jacked Box entrance concept discussed above) The remaining space at grade could again be used to create a plaza, in the interim condition that connects into the existing urban street network, which also creates a logical break in the adjacent development. The scheme illustrated would be a temporary condition, with the developer building the final condition as the site is developed.

6.3.2 Station Entrance (West Side)

This section discusses design options at the west side where the pedestrian tunnel connects into the existing station.

6.3.2.1 Description

All tunnel alignment schemes interface with the existing station in a similar location which forms an opening through the station's east wall, between column line 10 and the wall forming the north limits of the public mezzanine. While there are a variety of options between the interface of the station and the new tunnel, two primary options are described below.

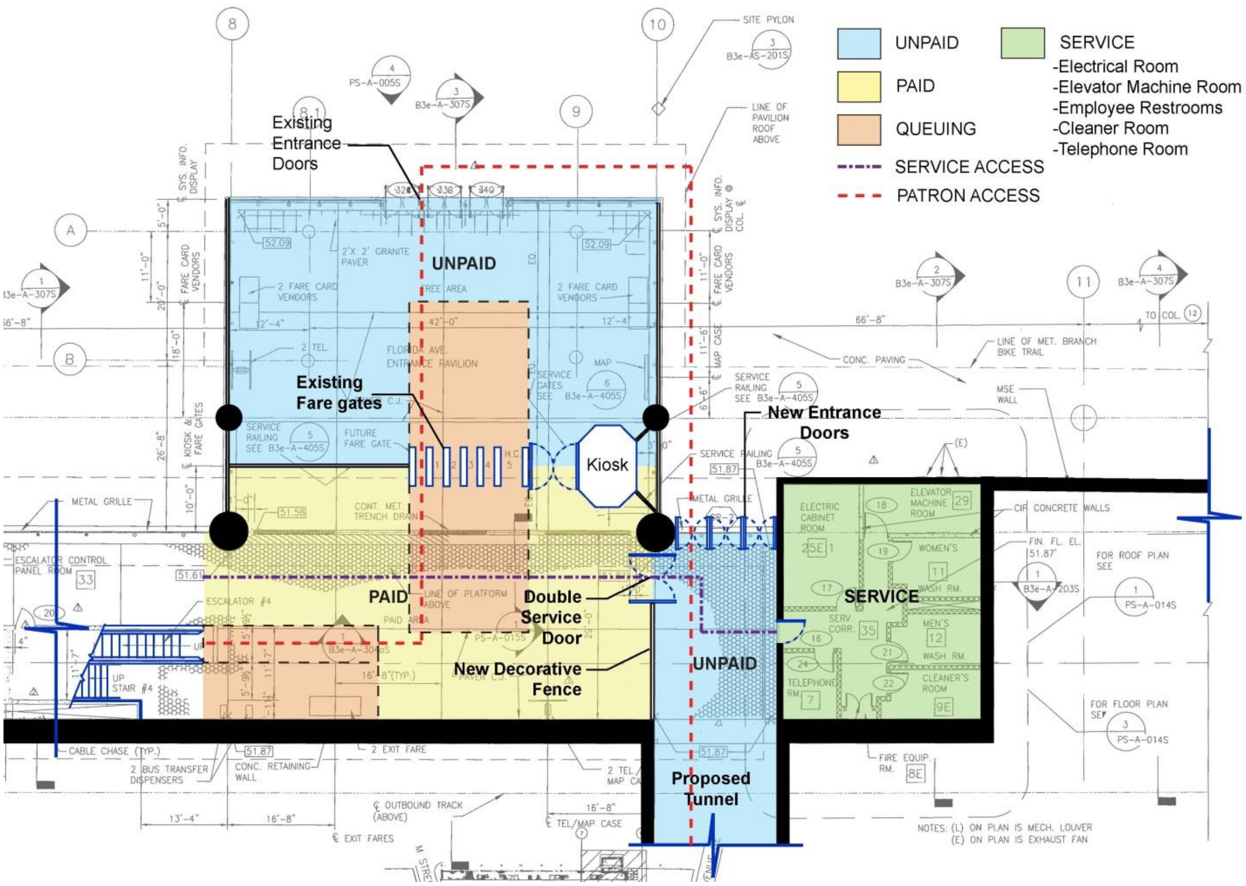
Both options provide for potential 24-7 tunnel access, separating the tunnel from the paid area, however the pass-through creates a more definitive barrier. Providing 24-7 tunnel access presents significant security issues during times that the station is closed. Coordination between Metro Transit Police Department, Metropolitan Police Department and any private security employed by the adjacent development, will be necessary to ensure adequate security.

6.3.2.2 Option 1: Pass-through

This option defines the interface between the proposed pedestrian tunnel and the existing NoMa Metro Station as simply a pass through, connecting the urban street network on both sides of the Amtrak tracks. To achieve this option a new barrier must be installed along column line 10 that separates the paid area of the station and the pedestrian tunnel. This barrier could either be a wall or a fence. A decorative fence is the preferred approach so the station manager can provide monitoring to the pedestrian tunnel. A key controlled double service door through the barrier will provide direct access for WMATA personnel and equipment from the service rooms to the station. New entry doors or roll-down gates for user egress from the tunnel are also provided.

While this option provides an improved connection between both sides of the track, it creates a negative situation for the existing station. First, this option is focused solely on connecting the opposite sides of the tracks. Station users are required to pass through the entire length of the pedestrian tunnel and continue to walk roughly 60 feet around to the existing entrance. Second, this option effectively splits the station into two parts, by creating a divide between the station and its service spaces which include an electrical room, elevator machine room, employee restrooms, a cleaner's room, and the station telephone room.

Figure 15: Pass-through



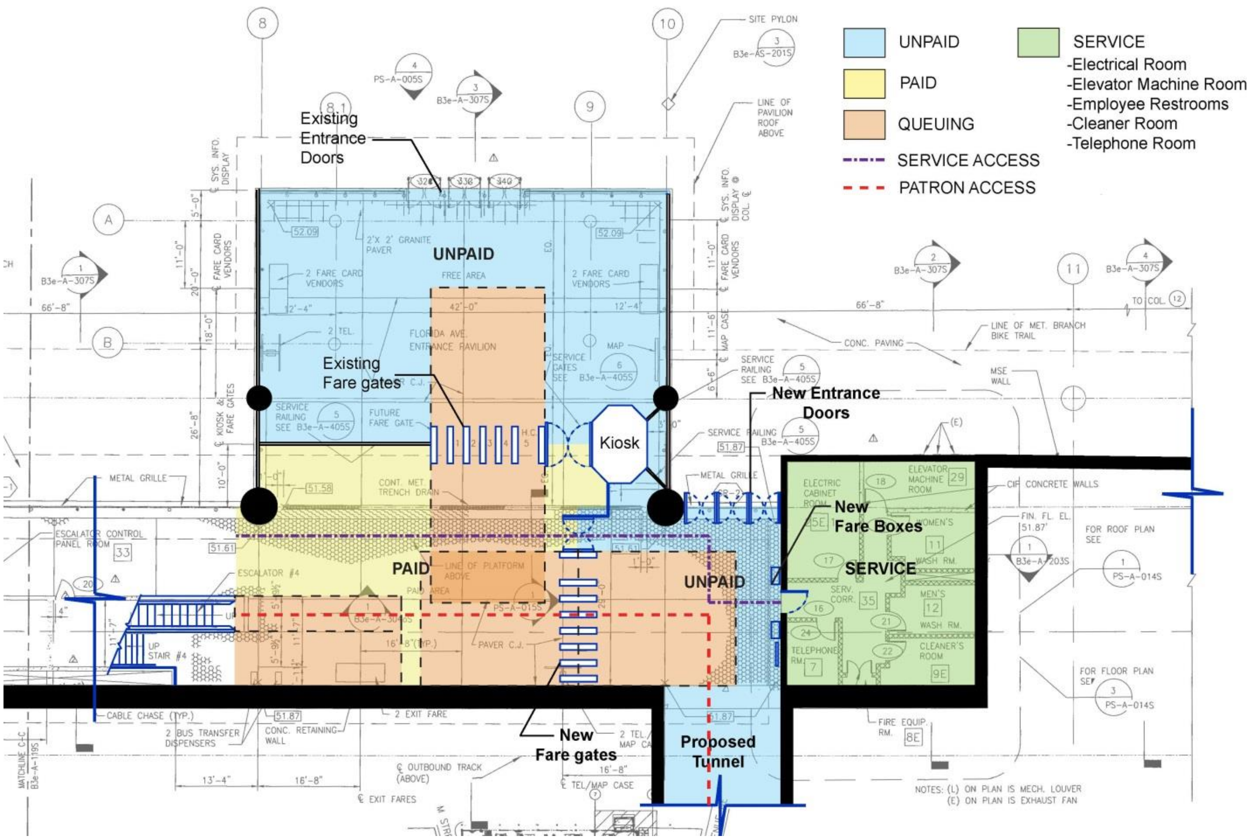
6.3.2.3 Option 2: Station Entrance

This option takes advantage of the situation that the pedestrian tunnel creates, by making it not only a pass-through tunnel, but also a new entrance into the station. To achieve this option a new set of faregates, service doors, and entry doors must be installed.

The new faregates must be installed just south of the tunnel entryway while still providing access to the station manager kiosk. The existing length of the paid area allows enough space for the installation of new faregates, which includes 25 feet on both sides of the faregate for queuing, in accordance with WMATA's design criteria. This option also includes a service door so maintenance personnel do not need to exit the station, which creates a more ideal and efficient operation for maintenance staff. New entry doors are also included as well, for users who want to connect to the urban street network.

This option's primary advantage is that it provides multiple functions: One, a pedestrian tunnel pass-through, and secondly, anew station entrance. As a result, station operations are minimally impacted and station users originating from east of the tracks have a direct connection to the station.

Figure 16: Station Entrance



6.3.2.4 *Arch Pipe Construction Type*

If the arch pipe construction type is chosen then a ramp must be provided at the interface opening between the existing station and the pedestrian tunnel due to the elevation change between the existing station and proposed pedestrian tunnel. The Arch Pipe tunnel creates a deeper overall section as described earlier in this report. The ramp would measure roughly 75 feet in length (includes bottom, intermediate, and top landing) at a maximum slope of 1:12. Handrails would be provided on both sides of the ramp. Though this ramp can be constructed to meet ADA criteria, it is not preferred to include the ramp if there is another option.

7 Architectural and Finish Treatment

This section discusses main themes to consider when designing a pedestrian tunnel and also proposes two basic finish schemes.

7.1 Basic Architectural Approach

The addition of this passageway and resultant entrance creates a new connection to the east side which provides increased connectivity to the adjacent neighborhoods and proposed development. The primary architectural objective is to create a scheme that encourages pedestrian connectivity, patron safety, and where the lighting, finishes, and supporting building systems are integrated into the final product. The following is a brief discussion of elements for further consideration:

7.1.1 Safety

Safety is not an element to be added to the design, but instead to be considered in all design decisions. Per WMATA Manual of Design Criteria, Section 3 and industry best practices, the passageway tunnel should be located to maximize the station manager's visibility. This includes ensuring sight angles are aligned so the station manager can monitor the tunnel. Other strategies include avoiding recesses along the length of the tunnel, strategically locating various elements programmed for the tunnel (such as farecard vendors), and using transparent surfaces where applicable to minimize areas where potential lawbreakers can hide. The use of "highly transparent glazing" is also documented in the DeafSpace Design Guidelines as a positive for opening up and linking spaces within a building to maintain visual connection.

Active strategies for encouraging safety include provisions for CCTV cameras and emergency phone locations.

Lighting, discussed in the next section, is also used to create a safe environment.

7.1.2 Lighting

The goal of an effective lighting scheme is to enhance safety, clearly articulate the functionality of the space, and enhance the architecture of the space. An effective lighting scheme enhances visual acuity of the space, which results in a better functioning space for patron use. A well-lit space creates the perception of a safer space, as people are less likely to cause trouble in an environment where they are easily identifiable. This in turn creates a space that is not just perceived as safer, but is actually safer as well. The lighting strategy should take into account the various elements within the space, and provide higher light levels at decision points, such as vertical circulation elements and entrances. The lighting scheme should be developed with and enhance the architecture of the space, instead of competing with it. Average illumination levels proposed for the passageway are 10 foot candles (FC) for the tunnel portion of the passageway, and 25 – 30 FC at vertical circulation elements.

Lighting should also take into account the DeafSpace Design Guidelines. Maintaining visual connection between people interacting in a space is a primary goal of the guidelines whether this is to enhance communication through signing or simply to read cultural and facial expressions. Maintaining illumination levels to preserve this interaction is important within this space.

7.1.3 Acoustics

Acoustics should be considered during the design phase. Selection of materials to absorb sound, and thus reduce echo, should be taken into account. While many materials, such as wall panels and floor surfaces, will most likely be hard in nature, the tunnel ceiling is a primary opportunity for acoustic treatment.

7.1.4 Signage

Provisions should be made for signage locations within the tunnel. Primary locations include ceiling-hung and wall-mounted locations. These locations should be included in the architectural concept to avoid the cluttered look created by adding signage after the design has been completed.

7.1.5 Integrate Systems Components

To the greatest extent practicable, building systems should be integrated into the architectural concept. Including a hung ceiling in the cross section for the passageway will provide the opportunity to hide cabling, conduit and piping as needed. Another strategy to hide these elements is to create a cavity wall along the passageway walls.

The closure gate at the passageway entrances are another opportunity for integration. If practical, the closure gate should be hidden from view when not in use.

7.1.6 Passageway Size

The section summarizes preferred passageway size.

7.1.7 Width

The passageway should be sized to accommodate the future demand of the space. For this study, a 20 foot clear width was chosen based on stakeholder preferences and accessibility considerations. The jacked box tunnel is able to provide this clear width, however the arch pipe tunnel can provide no greater than 16 feet clear width, due to the shape of the structure, and the vertical constraints. Future analysis including pedestrian modeling should be completed during the design process to confirm the width needed. At 16 feet clear the design meets the required ADA widths, and has sufficient space for vertical circulation elements at the east entrance.

7.1.8 Height

The height of the space should be sufficient to accommodate both a 10 foot clear height from finished floor to hung ceiling and space for building systems in a plenum above the hung ceiling. Providing 10-foot clear reduces the ability of patrons to harm the space, but also allows for the ability to hang elements as necessary. Proposed clearance for a hung object from the ceiling such as signage is 8 feet. The need for signage greater than 2 feet in height is not anticipated, however should be considered during Preliminary Design.

7.2 General Finish Strategy

There are two proposed conceptual finish options for the pedestrian tunnel summarized in Table 4. Each scheme relates to the potential function the new pedestrian tunnel will eventually serve. As the design progresses, the tunnel owner will need to make selections on finishes proposed.

7.2.1 Finish Option 1: Passageway Architecture

This option realizes the pedestrian tunnel function as a passageway connecting the urban street network on either side of the existing Amtrak tracks. The finishes proposed here reflect the standard WMATA palette.

7.2.2 Finish Option 2: Station Architecture

This option realizes the pedestrian tunnel function as a new station entrance. The finishes proposed here reflect the current palette of the NoMa station and seek to extend the same finish philosophy into the new station entrance.

Table 4: Architectural Finishing Options

	Option 1 Passageway Architecture	Option 2 Station Architecture	Notes
Surface	Finishes	Finishes	
Ceiling	Perf. Aluminum Ceiling Panel	Perf. Aluminum Ceiling Panel	Perforate Panel according to Acoustical Needs
Floor	Quarry Paver Tile	Granite Paver	
Wall	Metal Panel or Precast Panel	Concrete Wall	Joints to match station (Vert = 8'-4", Horiz = 3'
Lights	Wall Mounted Lighting	Recessed Lighting	Fixture to match station.
Handrails	Stainless Steel	Stainless Steel	Stainless Steel to match existing station

7.3 Section Considerations

Figure 17 illustrates a cavity wall configuration for the passageway. This configuration results in the ability to hide building systems behind the finish wall, and also protects the wall from potential water leakage through the tunnel wall. Use of this configuration would result in a loss of approximately 2 feet of the clear width. If this strategy is used, care should be taken to design the finish wall for inspection.

Figure 17: Jacked Tunnel Box with Cavity Wall Section

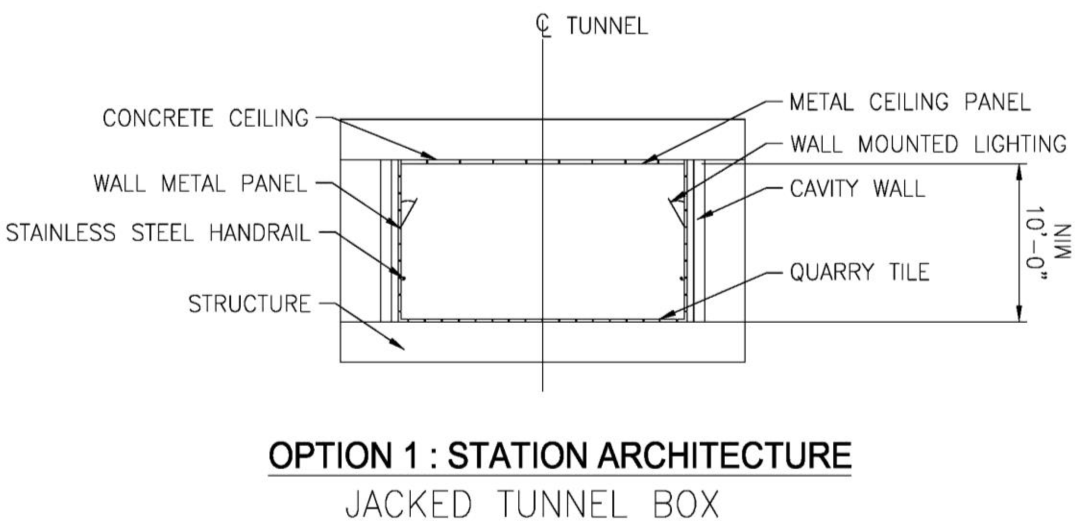
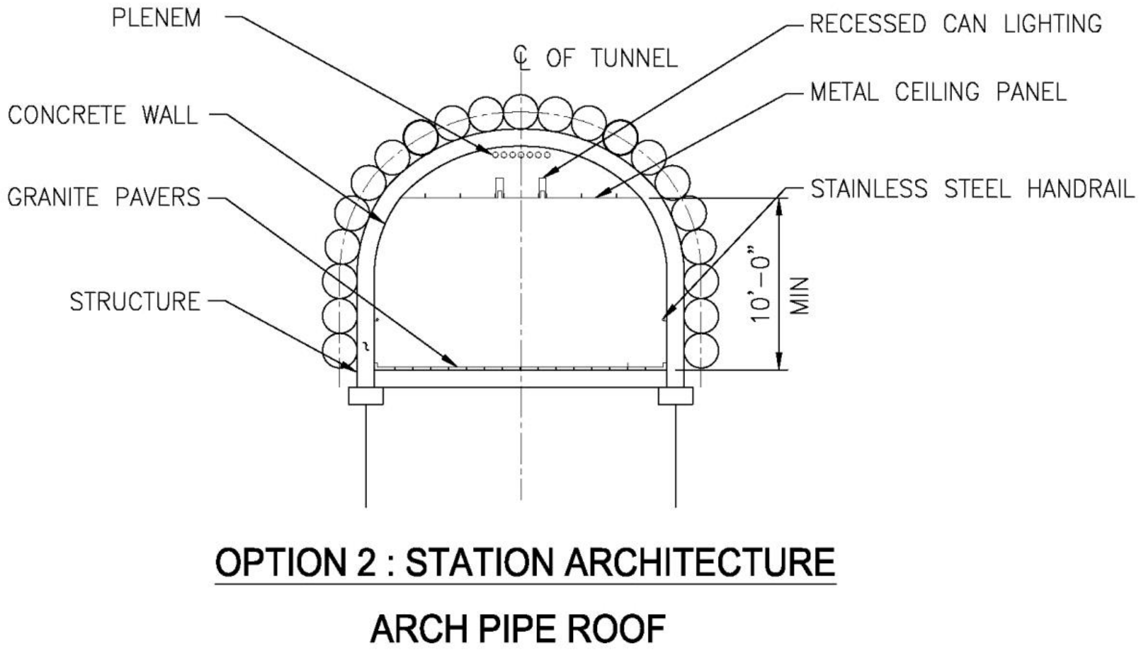


Figure 18 illustrates a hung ceiling configuration for the passageway. This configuration results in the ability to hide building systems above the finish ceiling and also to recess lighting elements. If this strategy is used, care should be taken to account of water leakage from the tunnel ceiling above.

Figure 18: Arch Pipe Roof with Hung Ceiling Section



It should be noted that finishes shown in Figure 17 and Figure 18 are not mutually exclusive and are interchangeable (to a certain degree) with the Option 1 and Option 2 finish options including light fixtures selected, the decision to expose the structure above or install ceiling panels, and the decision to expose the walls or install wall panels. These sections are shown to illustrate differing options for the relationship of finishes within the passageway tunnel.

7.4 General Finish Attribute Considerations

There are many considerations that influence the selection of materials. Some of these considerations include:

- Finishes used in a high pedestrian use environment, should be durable and long-lasting
- Provisions for encouraging maintenance, and specifying anti-graffiti strategies where appropriate
- Finishes should be noncombustible and provide low flame spread
- Floor finishes should be nonslip, with a high coefficient of friction
- Wall finishes should be impact and wear resistant
- Exterior finish elements should be weather resistant while maintaining their appearance despite direct sunlight
- Special consideration should be given to the light reflectance levels of finishes as they will have a direct impact on the lighting strategy developed for the passageway

The above discussion should not be seen as all inclusive, but instead a summary of the primary considerations. Further review and consideration should be given to the WMATA Manual of Design

Criteria and DeafSpace Design Guidelines to ensure a space that functions according to WMATA's needs and also serves the needs of the patrons using this new entrance.

8 Mechanical and Electrical

The proposed pedestrian tunnel will provide additional access to the NoMa Metro Station and as such is considered an integral part of the station. National Fire Protection Association (NFPA) 130 Standard for Fixed Guideway Transit and Passenger Rail Systems and the WMATA Manual of Design Criteria define the mechanical and electrical requirements for the proposed pedestrian tunnel.

The major mechanical and electrical components of the tunnel include:

- Power distribution
- Lighting
- HVAC
- Elevator
- Drainage

8.1 List of Codes and Standards

- NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems 2014 Edition: Chapter 5.
- NFPA 70 – National Electrical Code.
- District of Columbia Building Code, 2013 Edition.
- WMATA Manual of Design Criteria, Sections 13 and 14.
- Current version of the International Mechanical Code.

8.2 Power Distribution

Power will be required for tunnel lighting, ventilation, temporary elevator, drainage, and convenience outlets for facility maintenance. The power requirements for the mechanical and electrical systems in the tunnel will be in the order 50 to 60kVA (including elevator) and should preferably be fed from the existing NoMa Station power distribution system at 277/480V and 120/208V, 3 phase, 4 wire. The availability of spare capacity at the existing power and lighting circuit breaker panels remains to be determined. If an elevator is utilized to reduce the circulation footprint, a new 208/120V 3 phase, 4 wire electrical panel will be required in the proposed elevator room. Electrical circuits would be installed in conduit which would be embedded or concealed.

8.3 Lighting

As indicated in Section7.1.2, the average illumination levels required for the passageway are 10 foot candles for the tunnel portion of the passageway, and 25 – 30 foot candles at vertical circulation elements. This can be accomplished with recessed light fixtures installed into the tunnel ceiling. Energy efficient and low maintenance LED light sources should be considered in the design. Half of the lights will provide emergency lighting as discussed later in Section 9.3.

8.4 HVAC

The WMATA Manual of Design Criteria does not require passageways to be heated. The existing NoMa Metro Station entrance area is not air conditioned; therefore, the connecting pedestrian tunnel is not required to be air conditioned. Normal tunnel ventilation will depend on gravity ventilation. Emergency ventilation is discussed in Section 9.2.

8.5 Elevator

A temporary elevator is proposed at the east entrance portal of the pedestrian tunnel, until the developer buildout of the Central Armature Works site is completed, to provide site accessibility from 3rd Street. As the elevator may be removed upon the developer buildout, the need for its construction is dependent on the phasing of the pedestrian tunnel, with respect to the developer buildout. The elevator requires an elevator room for mechanical and electrical equipment. Intrusion detection with notification at the station kiosk will be required for the elevator room door.

8.6 Drainage

Drainage of the tunnel and elevator machine room will be required. A pumping station will be required at the low end of the tunnel. The drainage system and pump capacity will be provided in accordance with the WMATA Design Criteria, Section 14.8, and will be further designed during the preliminary engineering phase.

8.7 Security Gate

A security gate may be required at the east entrance portal to prevent access during nonrevenue hours. If a gate is determined to be necessary, it will require electrical power and local controls for gate operation in accordance with WMATA Design Criteria.

9 Fire Protection and Fire Life Safety

The east entrance to the tunnel is considered temporary until the developer build out is completed. The temporary access will need to comply with all Codes and Standards. It is expected that the developer will be required to follow the WMATA adjacent construction requirements for the area in the vicinity of the east entrance. Issues that would need to be addressed by the developer would include fire separation, security during nonrevenue hours and elevator replacement.

The proposed pedestrian tunnel will provide an additional access point to the NoMa Metro Station, and as such is considered an integral part of the station. Therefore, the requirements of NFPA 130 and the WMATA Manual of Design Criteria define the fire protection and fire life safety requirements for the proposed pedestrian tunnel. The egress requirements are addressed in Section 6.

The major Fire Protection and Fire Life Safety aspects of the tunnel include:

- Emergency Ventilation
- Emergency Lighting

- Fire Alarm
- Fire Protection
- Communication
- Command Center

9.1 List of Codes and Standards

- NFPA 130 – Standard for Fixed Guideway Transit and Passenger Rail Systems 2014 Edition: Chapter 4 and Chapter 5.
- NFPA 70 – National Electrical Code.
- District of Columbia Building Code (DCBC), 2013 Edition.
- WMATA Manual of Design Criteria, Sections 13 and 14.
- Current version of the International Mechanical Code.

The pedestrian tunnel is defined as an addition to the existing NoMa Metro Station as defined by DCBC § 202 and must comply with DCBC § 3411 accessibility requirements. As an addition, the building Use and Occupancy classifications do not change.

WMATA design criteria requires the use of NFPA 130 for station entrances and therefore NFPA 130 should be used in conjunction with the DCBC.

- Construction Type – Construction types for the pedestrian tunnel must conform to DCBC Table 503. Fire resistance ratings for building elements must conform to DCBC Table 601 and NFPA 130 5.2.2.
- Interior finishes – All pedestrian tunnel finishes must comply with NFPA 130 §5.9.
- Fire Separations - Rated separations in the pedestrian tunnel must meet the requirements of NFPA 130 § 5.2.3. The east pedestrian tunnel entrance interface with future development will need to comply with NFPA 130 § 5.2.3.5. Fire separations between ancillary occupancies in adjacent facilities to the pedestrian tunnel should meet the requirements of DCBC Table 508.4.

9.2 Emergency Ventilation

The proposed tunnel is not in an enclosed system station and its underground length is less than 1000 feet; therefore, a mechanical emergency ventilation system is not required by NFPA 130. An engineering analysis should be considered during preliminary engineering.

9.3 Emergency Lighting

Half of the pedestrian tunnel lights are required to be emergency lights designed in accordance with WMATA Design Criteria. Emergency lights should be independently fed from an emergency power source. Since the power requirement for the emergency lighting is relatively small, they should be fed from the existing NoMa Metro Station Emergency Power system.

9.4 Fire Alarm

Fire detection and alarm is required in the tunnel and elevator room. It should be interconnected with the existing NoMa Metro Station Fire alarm system.

9.5 Fire Protection

NoMa Metro Station has an existing dry stand pipe. This standpipe can be extended to provide the required fire protection coverage for the proposed pedestrian tunnel approximately 300 feet in length.

9.6 Communication

The proposed pedestrian tunnel should include signage, passenger information display system (PIDS), public address system, emergency telephone, and CCTV. All of these systems are present at the existing NoMa Metro Station and should be extended to the proposed pedestrian tunnel in accordance with WMATA Manual of Design Criteria.

Modifications to the existing station kiosk would be required to accommodate the proposed elevator, CCTV cameras, intrusion detection, fire detection, and communication equipment.

9.7 Fire and Smoke Separations

The tunnel is considered a public area and connects to the public area of the existing NoMa Metro Station so a fire separation is not required between these areas. The new elevator machine room is considered non-public space and a two hour fire separation is required between these areas.

9.8 Command Center

The tunnel emergency operations should be covered by the NoMa Metro Station existing Command Center.

10 Tunnel Construction Estimate and Schedule

10.1 Tunnel Construction Estimate

The tunnel construction cost estimate is a “bottom-up” estimate including time, labor and materials. This estimate includes contractor’s costs and profit, mobilization and demobilization, station demolition, identified utility relocations, tunnel construction and concrete, geotechnical instrumentation and monitoring for tunneling and railroad, and tunnel finishes including lighting, wall finishes, retaining structures and landscaping. Estimate assumes a Design-Bid-Build project delivery and maintaining operation of the station facility during construction; however, the estimate does not include soft costs for professional services such as NEPA documentation, engineering and public outreach.

The detailed tunnel construction cost estimate was performed for a tunnel length of 145 feet (Option 3A) for the Pipe Arch Roof tunneling method with a tunnel finish dimension of 175 square feet. The estimate for the Pipe Flat Roof tunneling method with a tunnel finish dimension of 240 square feet was prorated from the arch pipe estimate. The overall construction methods are similar. The estimate for the Jacked Box tunnel was provided by JackedStructures, a consultant specializing in this tunneling methodology. It should be noted that the width of the Arch Pipe Tunnel is only 16 feet wide, compared to 20-feet wide for both the Pipe Flat Roof and Jacked Box.

Alignment 3A includes additional costs for the reconstruction of the Amtrak signal bridge in the immediate vicinity of the existing signal bridge, and would require several weekend localized track outages to construct the new signal bridge and cut in all the circuitry. Reconstruction of this signal bridge is anticipated cost approximately three million dollars. Alternatively, modified foundations could be incorporated to avoid reconstruction, which reduce this cost to approximately five hundred thousand dollars.

Order of magnitude construction costs range from $20.5 million dollars to $27.8 million dollars depending on alignment and tunnel methodology. Table 5 below details the cost estimates for the different options.

Table 5: Order of Magnitude Construction Cost Estimates

	Jacked Box Tunnel			Pipe Flat Roof			Arch Pipe Tunnel		
Item	**Option 1**	**Option 2B**	**Option 3A**	**Option 1**	**Option 2B**	**Option 3A**	**Option 1**	**Option 2B**	**Option 3A**
Contractor On Site Construction Costs	$ 1,988,287	$ 1,723,182	$ 1,590,630	$ 1,988,287	$ 1,723,182	$ 1,590,630	$ 1,988,287	$ 1,723,182	$ 1,590,630
Utility Relocation	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238	$ 1,085,238
Headwall & SOE	$ 286,108	$ 286,108	$ 286,108	$ 253,222	$ 253,222	$ 253,222	$ 190,739	$ 190,739	$ 190,739
Station Demo	$ 435,740	$ 435,740	$ 435,740	$ 435,740	$ 435,740	$ 435,740	$ 328,860	$ 328,860	$ 328,860
Tunnel Excavation & Concrete	$ 11,668,206	$ 8,423,875	$ 7,399,350	$ 14,004,440	$ 10,110,522	$ 8,880,864	$ 10,529,907	$ 7,602,080	$ 6,677,502
Geotechnical I & M	$ 680,740	$ 680,740	$ 680,740	$ 680,740	$ 680,740	$ 680,740	$ 511,377	$ 511,377	$ 511,377
Railroad Flagman	$ 98,658	$ 98,658	$ 98,658	$ 554,129	$ 554,129	$ 554,129	$ 416,008	$ 416,008	$ 416,008
Total Tunnel Costs	**$ 16,242,977**	**$ 12,733,542**	**$ 11,576,464**	**$ 19,001,796**	**$ 14,842,774**	**$ 13,480,563**	**$ 15,050,417**	**$ 11,857,484**	**$ 10,800,354**
Tunnel Finishes	**$ 3,956,020**	**$ 3,739,276**	**$ 3,689,700**	**$ 3,956,020**	**$ 3,739,276**	**$ 3,689,700**	**$ 3,927,424**	**$ 3,710,223**	**$ 3,634,536**
Landscaping	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**	**$ 500,000**
Signal Bridge (New Bridge, down Track)	**$ -**	**$ -**	**$ 3,000,000**	**$ -**	**$ -**	**$ 3,000,000**	**$ -**	**$ -**	**$ 3,000,000**
Signal Bridge (Temporary Support)	**$ -**	**$ 500,000**	**$ -**	**$ -**	**$ 500,000**	**$ -**	**$ -**	**$ 500,000**	**$ -**
Wing Wall SOE	**$ 200,000**	**$ -**	**$ -**	**$ 200,000**	**$ -**	**$ -**	**$ 200,000**	**$ -**	**$ -**
Construction Total	**$ 20,900,000**	**$ 17,500,000**	**$ 18,800,000**	**$ 23,700,000**	**$ 19,600,000**	**$ 20,700,000**	**$ 19,700,000**	**$ 16,600,000**	**$ 18,000,000**
Design Services (estimated 17% of construction cost)	**$ 3,553,000**	**$ 2,975,000**	**$ 3,196,000**	**$ 4,029,000**	**$ 3,332,000**	**$ 3,519,000**	**$ 3,349,000**	**$ 2,822,000**	**$ 3,060,000**
Total	**$ 24,453,000**	**$ 20,475,000**	**$ 21,996,000**	**$ 27,729,000**	**$ 22,932,000**	**$ 24,219,000**	**$ 23,049,000**	**$ 19,422,000**	**$ 21,060,000**

Cost Estimating Assumptions:

Cost of Arch Pipe Tunnel is for 16 foot width instead of 20 foot, due to engineering constraints

Estimates are prepared using current dollars (2015)

Assumes cooperation between stakeholders

No escalation is included

Includes base construction, tax, contractor mark-up, subcontractor mark-up, and contingency

Estimate assumes a Design-Bid-Build project delivery

Design services estimates consider unknown site conditions, extensive subsurface utility exploration, coordination with various stakeholders, public meetings, and NEPA activities

Estimate assumes maintaining operation of the station facility during construction

10.2 Tunnel Construction Schedule

The tunnel construction schedule is subject to numerous variables and constraints. Duration for tunnel construction only, will vary based upon the selected alignment/tunnel length, tunneling method, construction lay-down area available, phasing plan with developer's construction in the vicinity of the east portal, and geotechnical conditions beneath the railroad to name a few. Given these variables, it is anticipated that tunnel construction, not including interior and site finishing, will last approximately 8 to 14 months; additional time may be required for phasing in conjunction with developer's construction. Additional elements included in the concept designs (e.g., relocation of the Amtrak signal bridge, station mezzanine reconfiguration, temporary east side elevators, and finish works) may feasibly be constructed within an additional 4 to 6 months depending on the final selection of a tunnel alignment. The overall feasible range of construction time is from 12 to 20 months. Refinement and selection of preferred alignment and tunneling method, along with coordinating a phasing plan with the adjacent developer and preliminary engineering, will make it possible to determine a more precise construction schedule. This schedule estimate does not include pre-construction activities, such as preliminary engineering, stakeholder coordination, determination of owner, final engineering, and permitting.

11 Federal Environmental Documentation Requirements

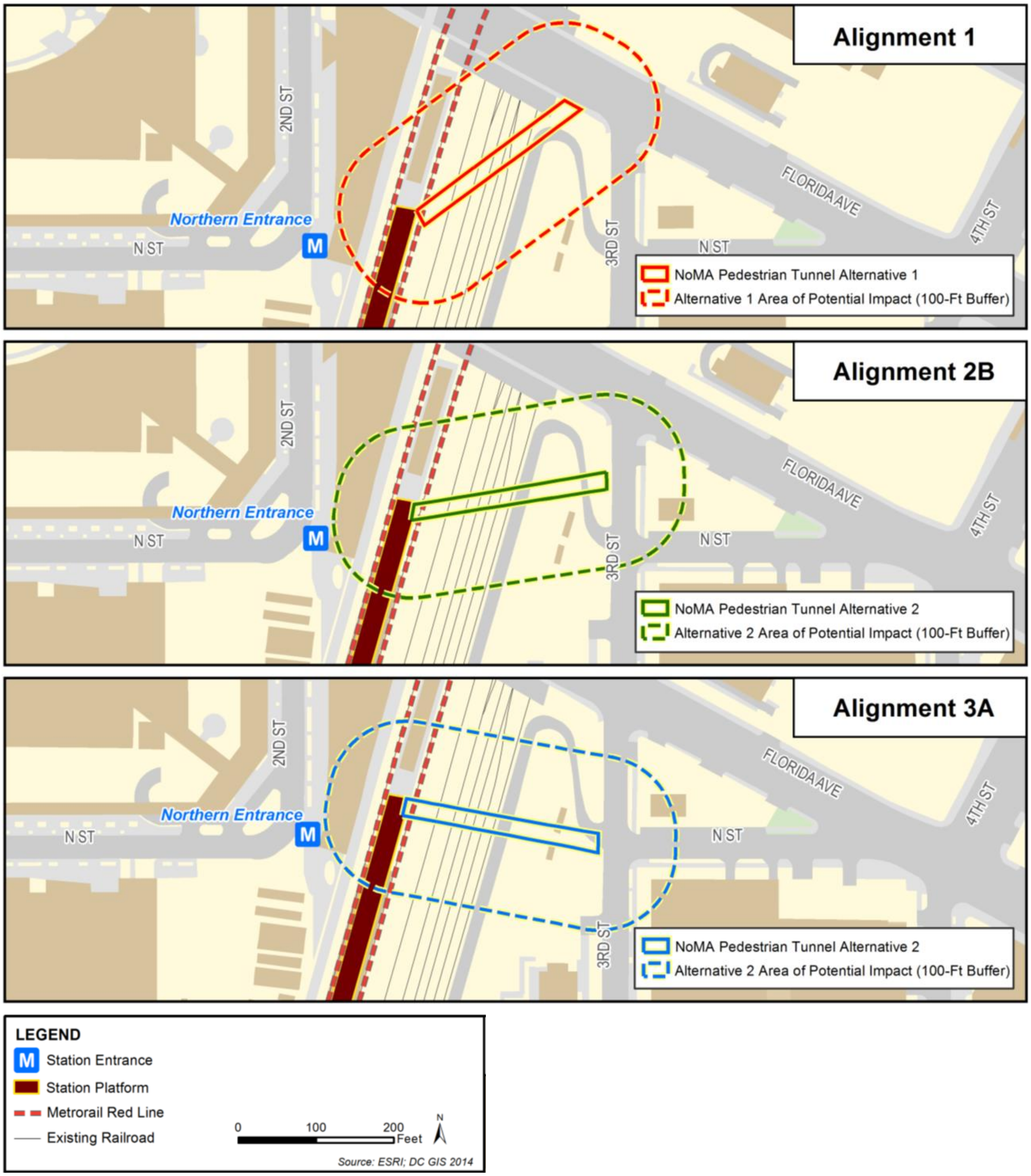
In order to advance the proposed pedestrian tunnel improvements using federal funds, the appropriate level of federal environmental review must be undertaken. Under NEPA, there are three possible classes of action that determine the documentation required. Class I actions are those which are likely to significantly affect the environment, and require preparation of an Environmental Impact Statement (EIS). Class II actions are those which do not individually or cumulatively have significant environmental impacts. For these actions, a Categorical Exclusion (CE) would be issued. Projects qualifying for CEs can either be listed in regulations (23 CFR771.118 for FTA projects) or agreed to by the federal agency. Class III actions are those where the significance of the environmental impact is not clear. These actions require the preparation of an Environmental Assessment (EA), which can result either in a Finding of No Significant Impact (FONSI), or in an identification of potentially significant impacts, in which case an EIS is required.

11.1 Methodology

The environmental scan was conducted using available Geographic Information System (GIS) data provided by the District of Columbia, as well as web-based inventory tools for each resource area. The environmental scan considered all resources that lie within the project study area. Unless otherwise specified, the study area is defined as a ¼-mile buffer from the NoMa-Gallaudet University Metrorail station, as shown in Figure 19. For some resources, such as hazardous and contaminated material, a 100-foot buffer was used, as shown in Figure 20.

Figure 19: Quarter-Mile Study Area

Figure 20: 100-Foot Buffer Study Area



11.2 Preliminary Environmental Scan Findings

Table 6 provides a summary of the preliminary environmental scan findings for each alignment. This environmental scan covers resource areas typically analyzed in compliance with NEPA, other state and federal laws, and WMATA Compact policies.

Table 6: Preliminary Environmental Scan Findings

Resource	Alignment	Preliminary Findings
Land Use & Zoning	1, 2B and 3A	Mixed-use squares in the NoMa area have unique characteristics that allow for a balance of industrial, residential, and office uses. DC's Future Land Use Map shows much of the project study area east of the railroad tracks as "Mixed Use Production Distribution Repair/Residential." The intent of this designation is not to blend industrial uses with housing, but rather retain viable industrial activities until market conditions support their conversion to live/work space, housing, artist studios, and similar uses. The area west and inclusive of the railroad tracks is zoned C-3-C (permits matter-of-right development for major business and employment centers of medium/high density development) and is part of the North Capitol TDR Zone. The area east of the tracks is zoned C-M-3 (permits development of high bulk commercial and light manufacturing uses). There are currently no zoning regulations regarding enclosed pedestrian space criteria for C-3-C or C-M-3.
Consistency with Local Plans	1, 2B and 3A	The proposed project is consistent with local area plans which envision NoMa as a "vibrant, diverse and highly pedestrian-oriented mixed-use neighborhood, defined by its unique industrial heritage, linked to its surrounding neighborhoods, built with enduring character, and strengthening central Washington with long term economic viability and environmental sustainability" (NoMa Vision Plan and Development Strategy, DCOP, October 2006). Other plans include: NoMa Neighborhood Access Study and Transportation Management Plan (DDOT, 2010), NoMa Connected Public Realm Design Plan (NoMa BID, 2012), and the Comprehensive Plan for the National Capital: Central Washington Area Element (DCOP, 2006).
Neighborhoods & Community Facilities	1, 2B and 3A	The proposed project is unlikely to create barriers between neighborhoods or prevent access to community resources.

Resource	Alignment	Preliminary Findings
		The project study area is comprised mostly of the NoMa/Near Northeast neighborhood in Ward 6, and parts of Ivy City, Eckington, and Truxton Circle in Ward 5. Community facilities within the project study area include: Union Market, Two Rivers Public Charter Schools (4th Street Elementary & Middle Schools), the Metropolitan Police Department (Prostitution Unit and/or SOD Tactical Branch), Upon This Rock Tabernacle, and Greater Pleasant Grove Baptist Church. Gallaudet University is located east of the project study area, but located outside of the ¼-mile boundary. Major employers within the project study area include: USDOJ's Bureau of Alcohol, Tobacco, Firearms and Explosives Headquarters (approximately 4800 employees), other USDOJ offices located at Constitutional Square (approximately 2000 employees), DC Public Schools Central Office, and the District Department of the Environment.
Environmental Justice	1, 2B and 3A	Based on the US Census Bureau's ACS 5-Year Estimates (2009-2013), minority and low-income populations exist within the ¼-mile study area. The proposed project is not anticipated to have disproportionately high or adverse impacts on environmental justice populations; however, as the study progresses, further study will be required. The project should engage these populations at all stages of project development.
Public Parklands	1, 2B and 3A	No public parks or parklands are located within the project study area. Brentwood Park is located nearby, but outside of the ¼-mile study area. The proposed project would not affect access to this park and would require no additional right-of-way in the vicinity of this resource. The Metropolitan Branch Trail runs parallel to the inbound Metro tracks (elevated, off-street) in the project study area. The trail is an important transportation route for pedestrian and bicyclists, providing connections to homes, work, and play. The trail is operated by DDOT and is not anticipated to be affected by the proposed project.
Historic & Cultural Resources	1, 2B and 3A	Impacts to historic and cultural resources are unlikely, though further study will be required. There are two

Resource	Alignment	Preliminary Findings
		known designated historic structures within the project study area: 1) Woodward & Lothrop Service Warehouse located at 131 M Street NE and 2) M.J. Uline Ice Company and Arena (Washington Coliseum) located at 1132, 1140 & 1146 3rd Street NE. Both structures are listed in the DC Inventory of Historic Sites and the National Register. The presence of archeological resources within the project study area will require further study. Given the previous disturbance in the area where any of the alignments would be constructed, the potential for archeological resources is assumed to be low, because the site would be excavated through fill.
Property Acquisition & Displacements	1, 2B and 3A	The proposed project would not require property acquisition or displacement. The developer of the parcel directly east of the tracks (the Central Armature Works site) is a vested stakeholder in the project. An access easement or MOU is likely needed for the proposed pedestrian tunnel to traverse underneath the railroad tracks. Further study and coordination will be required.
Traffic	1, 2B and 3A	Impacts related to traffic would likely occur during construction, depending on the alignment chosen and construction staging (see Construction Impacts section below). Impacts to rail, vehicular, pedestrian, or bicycle traffic should be avoided or minimized to the greatest extent possible. The proposed project is anticipated to improve pedestrian safety and east-west connectivity in the study area.
Hazardous & Contaminated Materials	1, 2B and 3A	Preliminary research indicates the presence of several hazardous waste facilities within the project study area: Sunoco Service Station (101 New York Ave NE), Central Armature Works (1200 3rd Street NE), W.W. Grainger (311 N Street NE), and Saba Cab Company (1232 4th Street NE). Further study will be required.
Air Quality	1, 2B and 3A	The proposed project is located in the Washington, DC Metropolitan Region which is a non-attainment area for ground level ozone and $PM_{2.5}$ criteria pollutants. However, the proposed project is not anticipated to affect regional air quality in any measurable or substantial way.

Resource	Alignment	Preliminary Findings
Noise & Vibration	1, 2B and 3A	Considering the project is located in an urban environment with existing industrial, transit, and rail uses, the proposed project is not likely to increase ambient noise or vibration levels above existing conditions. Residential and institutional receptors are located within the project study area, but are not adjacent to any of the proposed alignments. Noise and vibration levels from construction activities related to the proposed project, although temporary, could create a nuisance at nearby locations. Best management practices would be employed to minimize temporary effects.
Water Resources	1, 2B and 3A	A review of available mapping did not identify any streams, wetlands or floodplains within the project study area; therefore, impacts to water resources are not anticipated as a result of the proposed project.
Threatened & Endangered Species	1, 2B and 3A	No impacts to federally-protected species habitat are anticipated as a result of the proposed project. However, USFWS IPaC search results indicate the presence of a threatened species in the project study area—the Northern Long-eared Bat (Myotis septentrionalis). The potential for northern long-eared bat is very low, because the construction work is all underground and no trees would be affected. This will be confirmed through discussions with FTA and FWS.
Utilities	1, 2B and 3A	Being located in a fully developed and urbanized location, numerous existing utilities, both aerial and subsurface, are found within the project area. Available utilities data indicates a 66” water main encased in a 134” diameter concrete pipe sleeve which lies just beneath the northwest entrance to the station and continues east to the intersection of 3rd Street and N Street NE. Data regarding foundations for rail related structures and geotechnical data east of the station and west of 3rd Street were not available at the time of this scan. Modification or relocation of utilities is likely to occur as a result of the proposed project.
Construction Impacts	1	Construction staging for Alignment 1 would require closing Florida Avenue, which would be a major disruption to traffic and the local community since Florida Avenue is a principal arterial route with an ADT volume of 27,000.

Resource	Alignment	Preliminary Findings
		Minimal disruptions to passenger service along the Amtrak corridor and minimal disruptions to WMATA station operations are anticipated. However, tunneling beneath active rail presents the possibility of track settlement, which would require resurfacing to restore the tracks. Noise and vibration levels from construction activities related to the proposed project, although temporary, could create a nuisance at nearby locations. Best management practices would be employed to minimize temporary effects.
	2B and 3A	Construction would be staged on the east side of the railroad tracks in areas adjacent to 3rd Street NE. Minimal disruptions to passenger services along the Amtrak corridor are anticipated due to the necessary modifications to the signal bridge. Minimal disruptions to WMATA station operations are also anticipated. Additionally, tunneling beneath active rail presents the possibility of track settlement, which would require resurfacing to restore the tracks. Noise and vibration levels from construction activities related to the proposed project, although temporary, could create a nuisance at nearby locations. Best management practices would be employed to minimize temporary effects.

11.3 Findings and Next Steps

In general, the proposed pedestrian tunnel appears to present very few adverse impacts to either the human or natural environment. However, as planning for the project progresses, more detailed analysis is warranted to ascertain the extent and potential severity of impacts identified in this preliminary environmental scan.

As a result of the findings here within, the following subject areas raise the greatest potential for concern:

- *Potential Construction Impacts*. Depending on the alignment chosen, construction staging could adversely impact traffic. Impacts to rail, vehicular, pedestrian, or bicycle traffic should be avoided or minimized to the greatest extent possible.
- *Potential for Hazardous Materials*. Numerous potential and known hazardous materials were identified. A combined Phase I/Phase II Environmental Site Assessment is recommended as the project moves forward.
- *Potential for Utilities Modifications*. A better understanding of utilities within and planned for the proposed project site is needed to help shape the design of the project as well as to understand potential impacts to existing and planned utilities. Mitigation of utilities impacts will be challenging as the project moves forward.

The findings in this document are preliminary and intended for use by the project team. As the project advances, this document will serve as an aid for the responsible agencies as they oversee environmental documentation and other planning and design activities. The next step in this study is to coordinate with FTA to make the Class of Action determination should federal funding be identified for the proposed project. Based on the environmental scan findings, the likely class of action would be an undocumented Categorical Exclusion; subject to concurrence by FTA.

12 Conclusion

AECOM has assessed the engineering needs and applicable codes for construction of a pedestrian tunnel in response to the tremendous growth the NoMa neighborhood is experiencing, especially east of the Northeast Corridor, and has determined that such a facility is feasible.

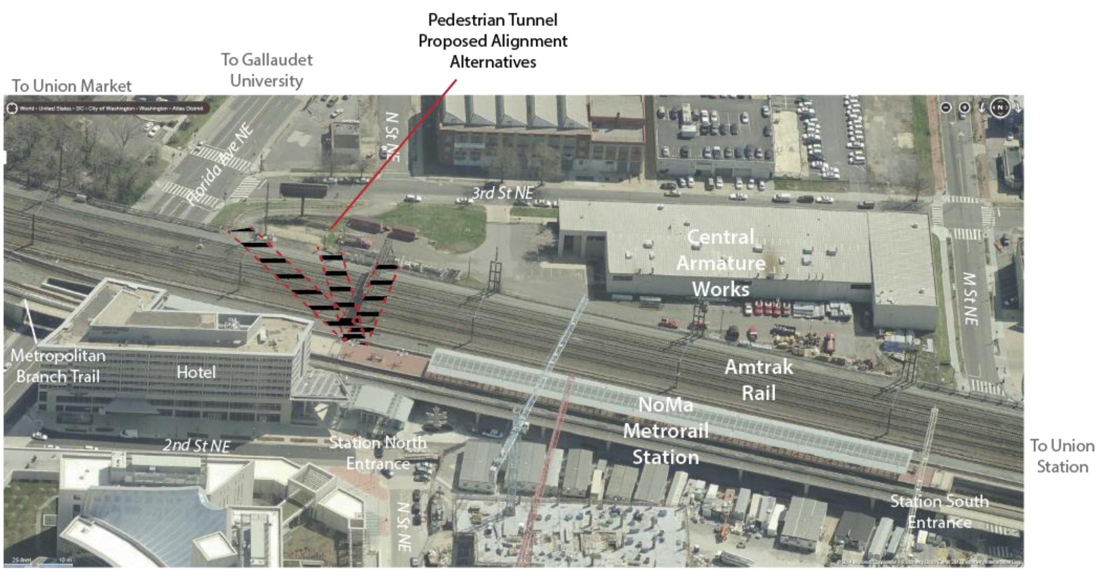
To provide safe and efficient access to the NoMa-Gallaudet Metro Station, WMATA and the District undertook this study to determine the feasibility of providing a dedicated pedestrian tunnel to provide direct access from the east to the station mezzanine on the west. Analysis was based on data collected, and through close coordination with WMATA and stakeholders and the design goals and constraints collectively vetted. This initial process developed numerous alignments and options that were then narrowed down to three alignment options for engineering assessment. Throughout this process, safety of all tunnel users, WMATA station staff, and of rail users was paramount. Likewise, ensuring accessibility for all tunnel users was equally important.

Figure 21: View of Proposed Tunnel from Station Mezzanine

Upon review of several tunneling methodologies, coupled with differing alignments responding to site constraints (both existing and proposed), several pedestrian tunnel options are feasible. However, although feasible, tradeoffs exist between options in terms of cost, construction duration, tunnel size provided, and impacts to the station and/or adjacent properties, railways and roadways. Please refer to Table 7 for a matrix discussing these variables.

As discussed, three alignments were selected for analysis from an original list of six initial options. Alignment 1 departs the station in a northeast direction diagonally towards Florida Avenue, NE, daylighting between the existing railroad bridge and 3rd Street, NE, This is the longest of the three alignments, has the least opportunity to connect with proposed developer plans and the most opportunity to disrupt traffic along Florida Avenue, NE. Alignment 2B departs on a slight diagonal and offers opportunity to integrate with the proposed development and potentially avoids the existing Amtrak signal bridge. Alignment 3A is the shortest of the alignments presented and offers the greatest feasibility and integration with the proposed development and existing street network; however, this alignment is in conflict with the existing signal bridge.

Figure 22: Proposed Tunnel Alignments



Three tunnel construction methods were considered: Arch and Flat Roof Pipe Tunneling, Jacked Box and Sequential Excavation Method (SEM). Open-cut construction was not considered due to railroad operational considerations. After review of the SEM, it was determined that although the method is technically feasible, the SEM construction would expose the rail facilities above to unnecessary high risks including ground settlement and protrusions into the railroad clearance zone. Therefore, this tunneling method was eliminated from further consideration. Arch Roof Pipe Tunneling and Jacked Box are considered the most feasible construction methods for this site.

This study has determined that multiple tunnel alignments are feasible via two tunneling methods. These methods and alignments each present their own unique qualities, which are detailed in Table 7. Therefore, further stakeholder input and environmental analysis is required to select a preferred alignment and tunneling method and finalize discussion of tunnel ownership. Similarly, going forward, complex and detailed engineering is required to develop a design that is biddable and constructible to realize the gains that this tunnel will provide.

Figure 23: Proposed Tunnel Entrance to Station Mezzanine

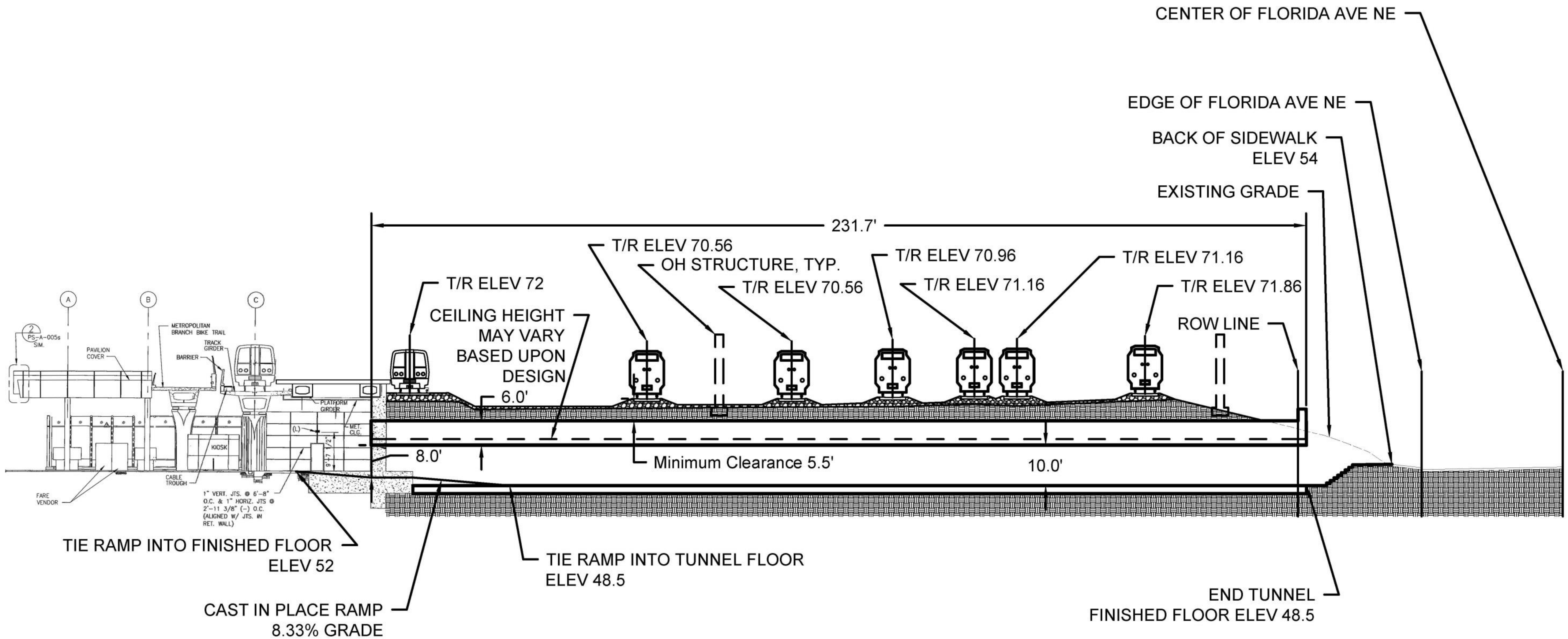
Table 7: Preferred Alignments Evaluation Matrix

		Alignments	1		2B		3A	
		Method	Jacked Box	Arch Pipe	Jacked Box	Arch Pipe	Jacked Box	Arch Pipe
Description	Physical Characteristics	Length (ft) (total / tunnel portion only)	255 / 231		250 / 157		250 / 145	
		Maximum Width (ft)	20	16	20	16	20	16
		Floor to Ceiling Height (ft)	10	8-10	10	8-10	10	8-10
		Vertical Circulation Requirements	No need for stairs, ramps, or elevators	Requires stairs and ramps	Requires stairs and ramps	Requires stairs and elevators	Requires stairs, ramps, or elevators	Requires stairs, ramps, or elevators
		Continuous Straight Tunnel (Y/N)	Y		Y		Y	
	Physical Constraints	Vicinity of OHE Poles, Foundations, and UG utilities	N		Y-Adjacent (Signal Bridge)		Y-Immediate Vicinity (Signal Bridge)	
		Proximity to 66" Water Main	N		N		Y-10 ft clearance from water main	
Evaluation Factors	Constructability Issues	[1] - Minimal construction issues [2] - Issues can be overcome through design and construction techniques [3] - Complex construction issues that may be difficult to overcome	[3] Will require set-up of construction equipment on Florida Avenue and create complex traffic issues.		[1] Reasonable set-up area likely available. Preferred tunnel length.		[2] Constructability will depend on ability to relocate signal bridge for rail.	
	Integration with Station Mezzanine	Angle and elevation of tunnel in relation to the existing station mezzanine	Tunnel at an approximately 45 degree horizontal angle to mezzanine retaining wall	Requires lowering a portion of mezzanine floor to ramp down to tunnel floor elevation	Angle of tunnel provides direct line of site from station manager kiosk	Requires lowering a portion of mezzanine floor to ramp down to tunnel floor elevation	Tunnel perpendicular to mezzanine retaining wall	Requires lowering a portion of mezzanine floor to ramp down to tunnel floor elevation
	East-West Access Improvement	Directness of east-west connectivity	Minimal improvements to east-west connectivity		Improves access east-west		Improves access east-west. Integrates with existing street grid.	
	Integration with/Impact to CAW Site Development	Site development construction (phasing)	No impact		Impacts to construction phasing		Minimum impact to potential development	
		Impacts to Development footprint	Minimal overlap on the periphery of development footprint		Potentially conflicts with hotel core, service access, hotel entrance, and hotel/retail space layout		Potentially integrates with hotel/retail space layout	
		Integration with Development	Activate north park at Florida Ave; does not direct public to primary retail on 3rd St		Directs public to primary retail on 3rd St		Directs public to primary retail on 3rd St; Allows for service access corridor	
	Preliminary Cost Estimate (Order of Magnitude)		$24.5M	$23.0M*	$20.5M	$19.4M*	$22.0M	$21.0M*

Legend: Minor Issues (yellow) Major Issues (red)

*** Cost of arch pipe tunnel is for 16 foot width instead of 20 foot due to engineering constraints**

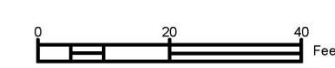
Appendix A: Tunnel Profiles

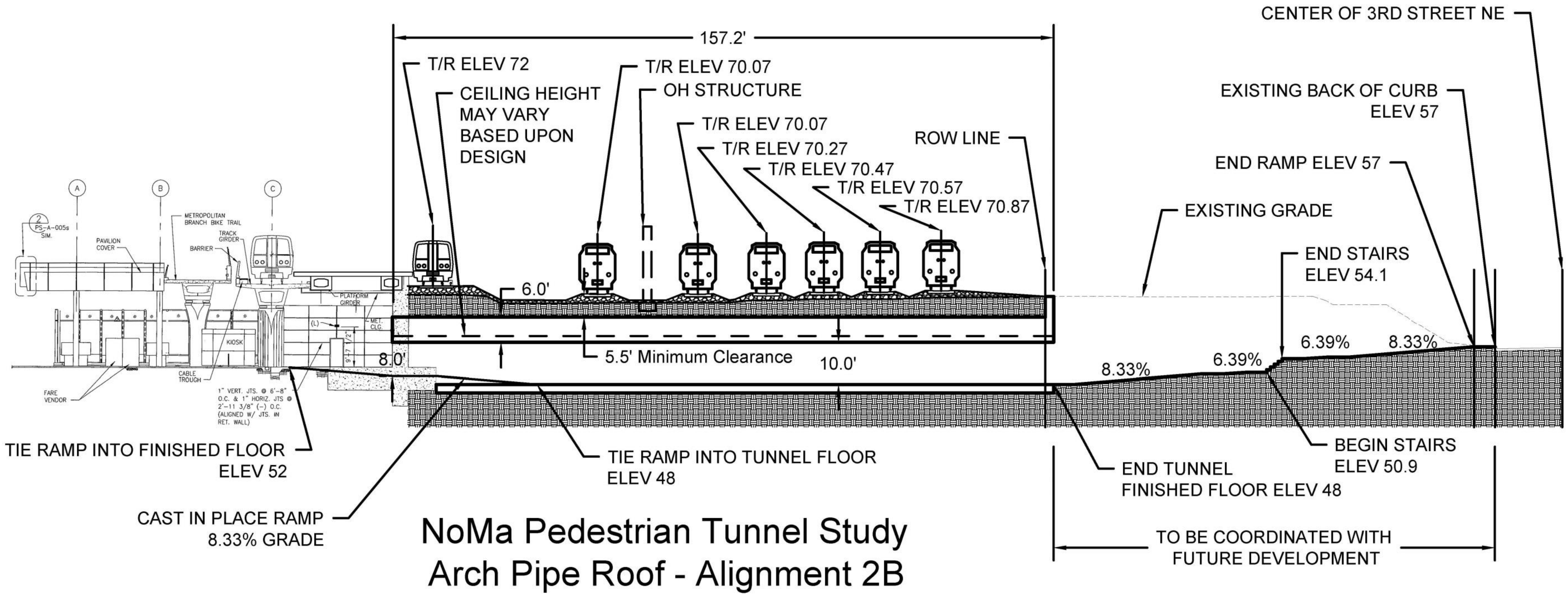


NoMa Pedestrian Tunnel Study
Arch Pipe Roof - Alignment 1

NOTES:

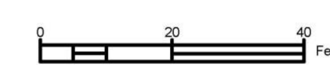
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 1, ARTICLE 5.1.6.2
3. SIZE AND LOCATION OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS THE PROPOSED ALIGNMENT IS NOT PERPENDICULAR TO THE TRACKS, AND NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES

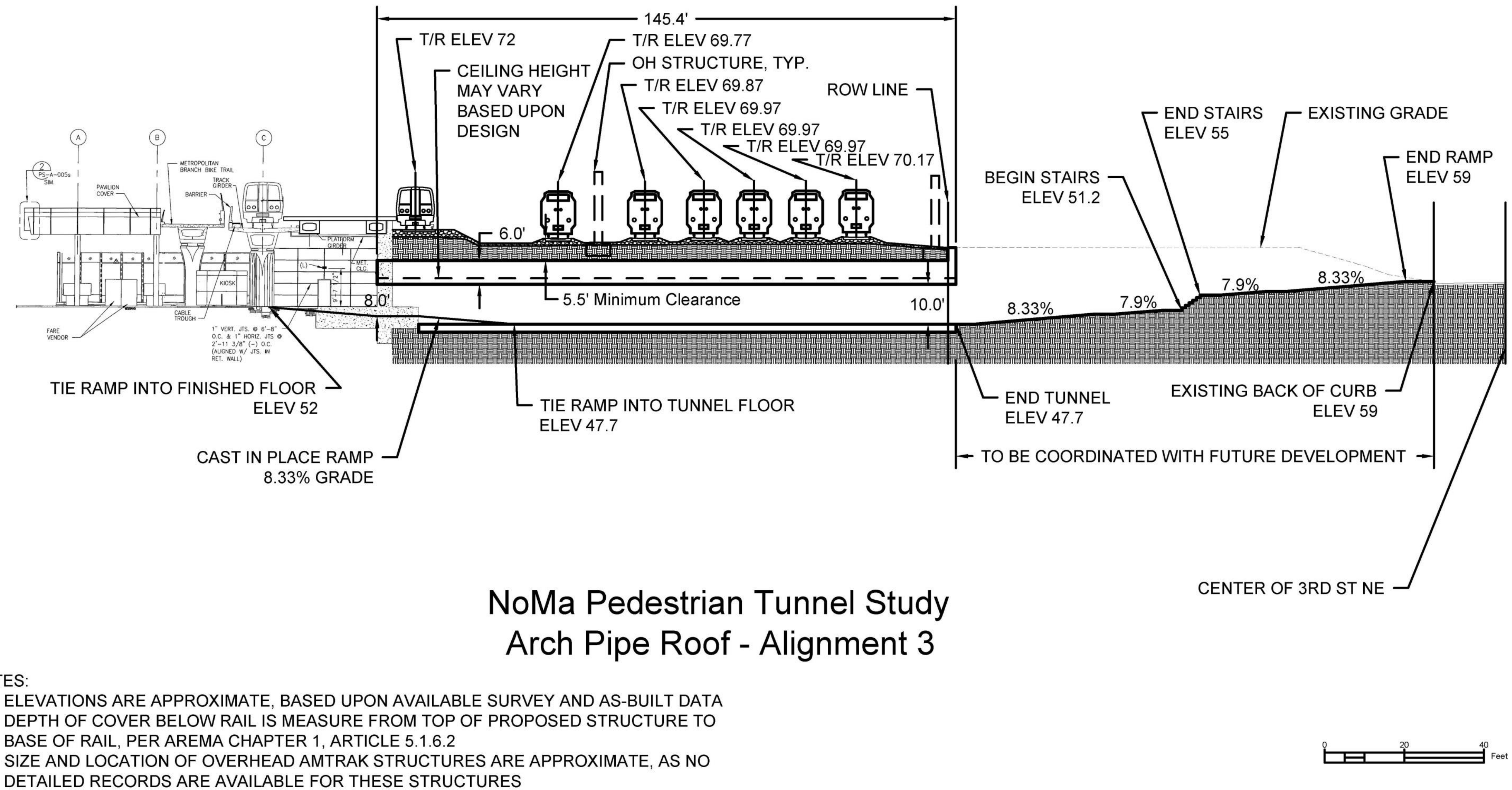




NoMa Pedestrian Tunnel Study
Arch Pipe Roof - Alignment 2B

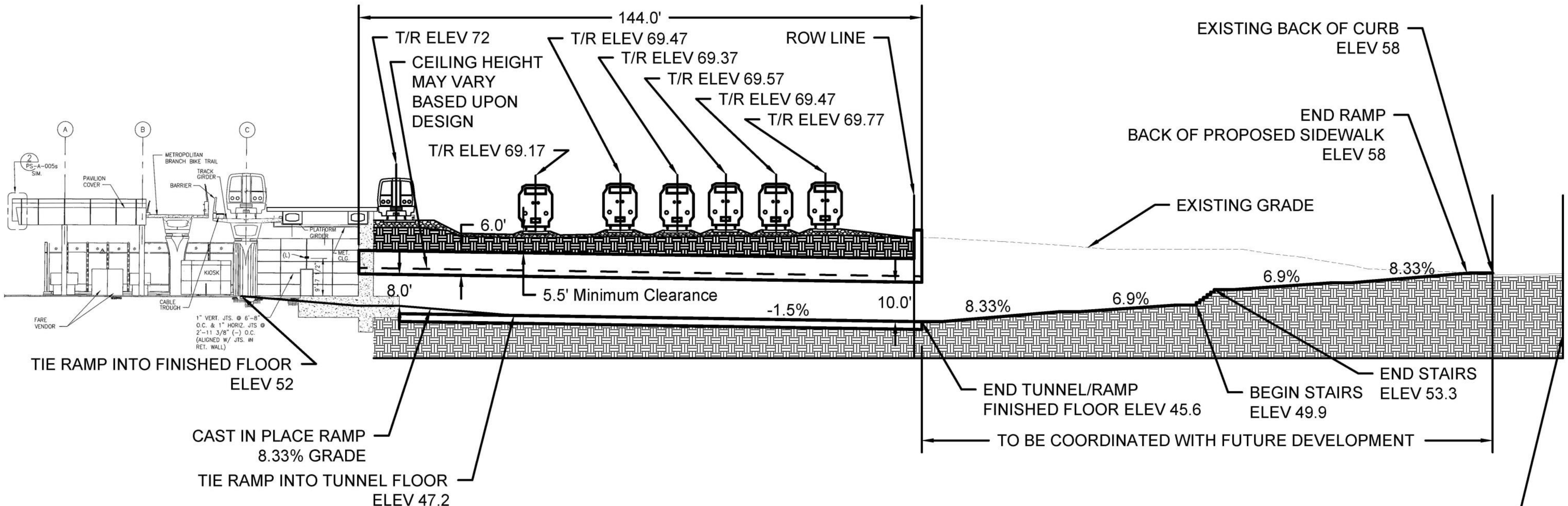
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 1, ARTICLE 5.1.6.2
3. SIZE AND LOCATION OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS THE PROPOSED ALIGNMENT IS NOT PERPENDICULAR TO THE TRACKS, AND NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES





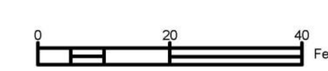
NoMa Pedestrian Tunnel Study
Arch Pipe Roof - Alignment 3

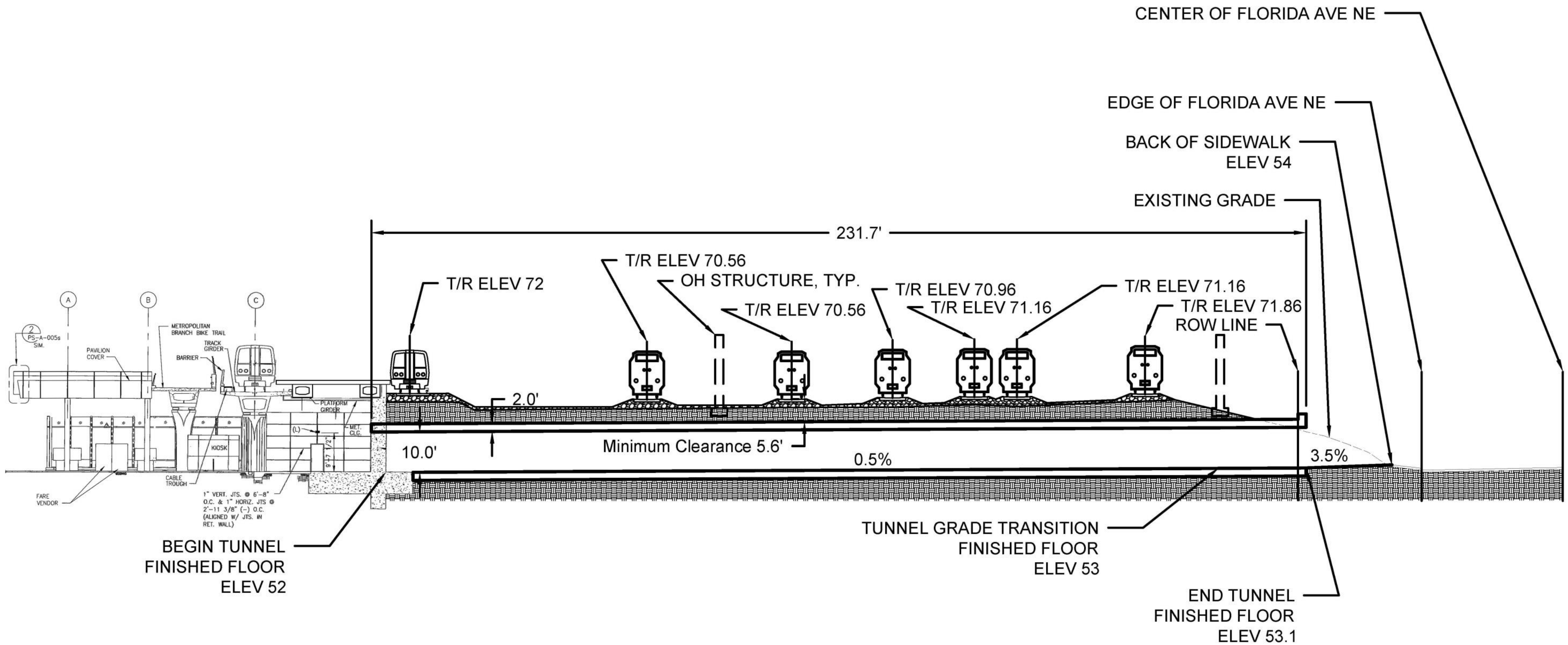
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 1, ARTICLE 5.1.6.2
3. SIZE AND LOCATION OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES



NoMa Pedestrian Tunnel Study
Arch Pipe Roof - Alignment 4

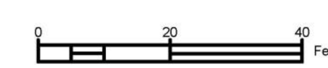
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 1, ARTICLE 5.1.6.2

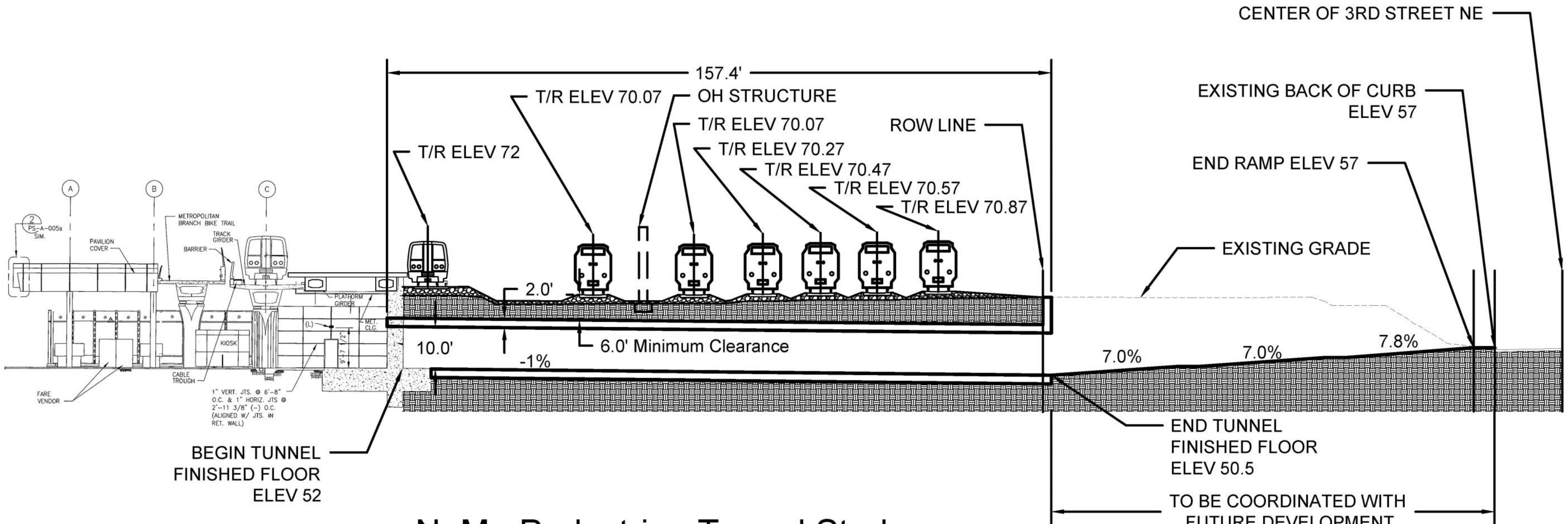




NoMa Pedestrian Tunnel Study
Jacked Box - Alignment 1

NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 8, ARTICLE 16.1.1
3. SIZE AND LOCATION OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS THE PROPOSED ALIGNMENT IS NOT PERPENDICULAR TO THE TRACKS, AND NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES

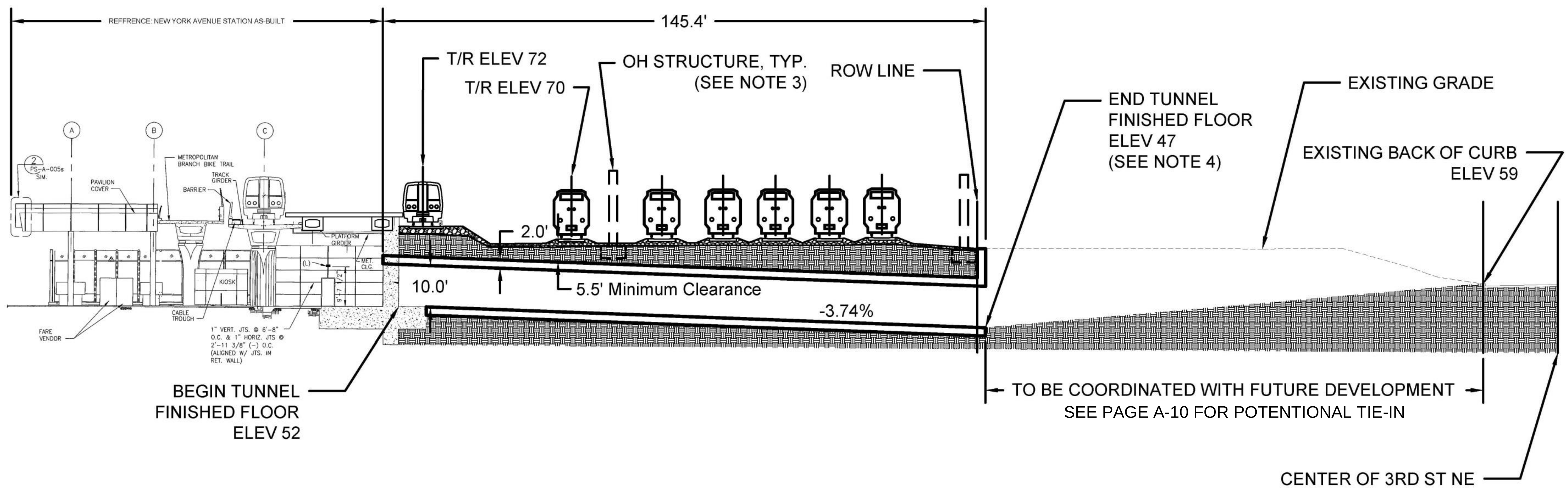




NoMa Pedestrian Tunnel Study
Jacked Box - Alignment 2B

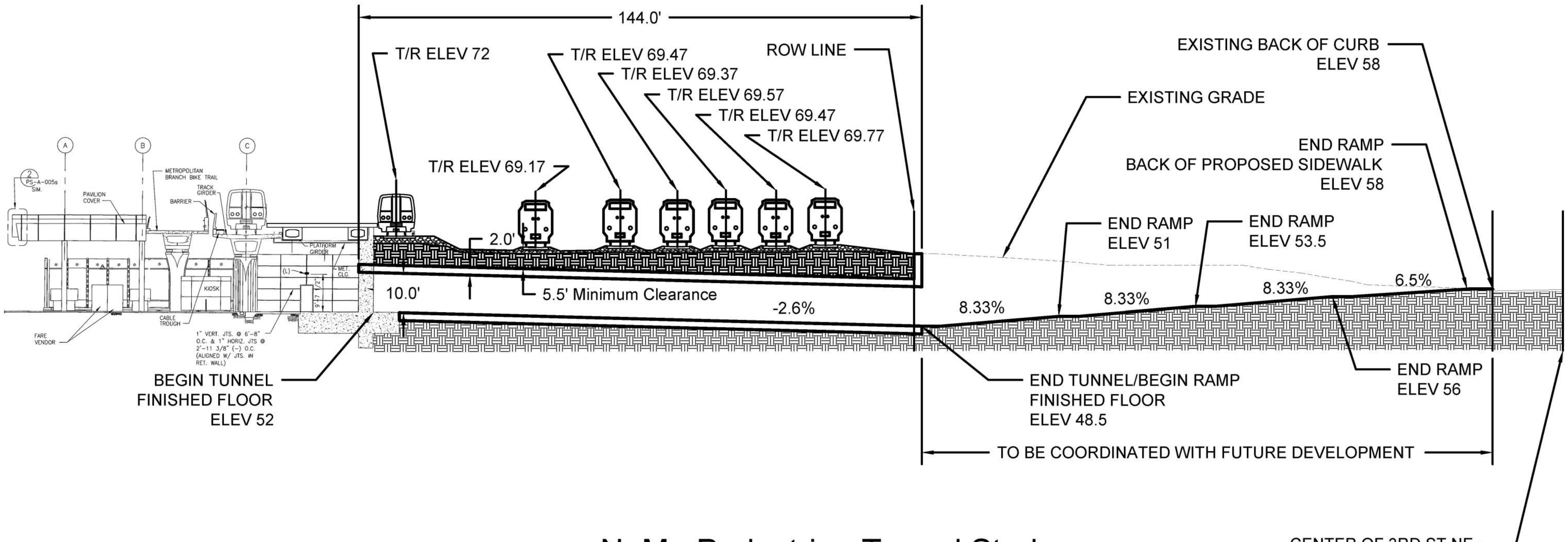
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 8, ARTICLE 16.1.1
3. SIZE AND LOCATION OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS THE PROPOSED ALIGNMENT IS NOT PERPENDICULAR TO THE TRACKS, AND NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES

0 20 40 Feet



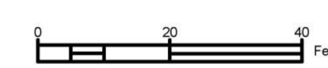
NoMa Pedestrian Tunnel Study
Jacked Box - Alignment 3A

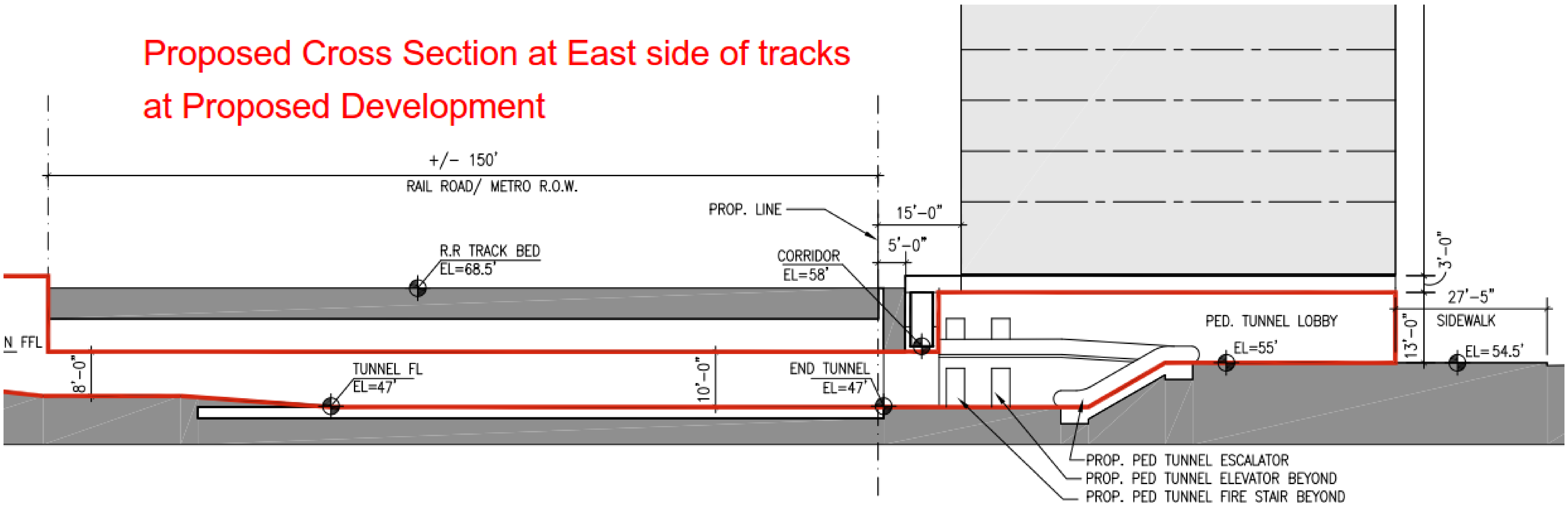
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 8, ARTICLE 16.1.1
3. SIZE OF OVERHEAD AMTRAK STRUCTURES ARE APPROXIMATE, AS NO DETAILED RECORDS ARE AVAILABLE FOR THESE STRUCTURES
4. TUNNEL FINISHED FLOOR ELEVATION CORRESPONDS WITH C.A.W PLANNING CONCEPT OPTION 3A SECTION C-C



NoMa Pedestrian Tunnel Study
Jacked Box - Alignment 4

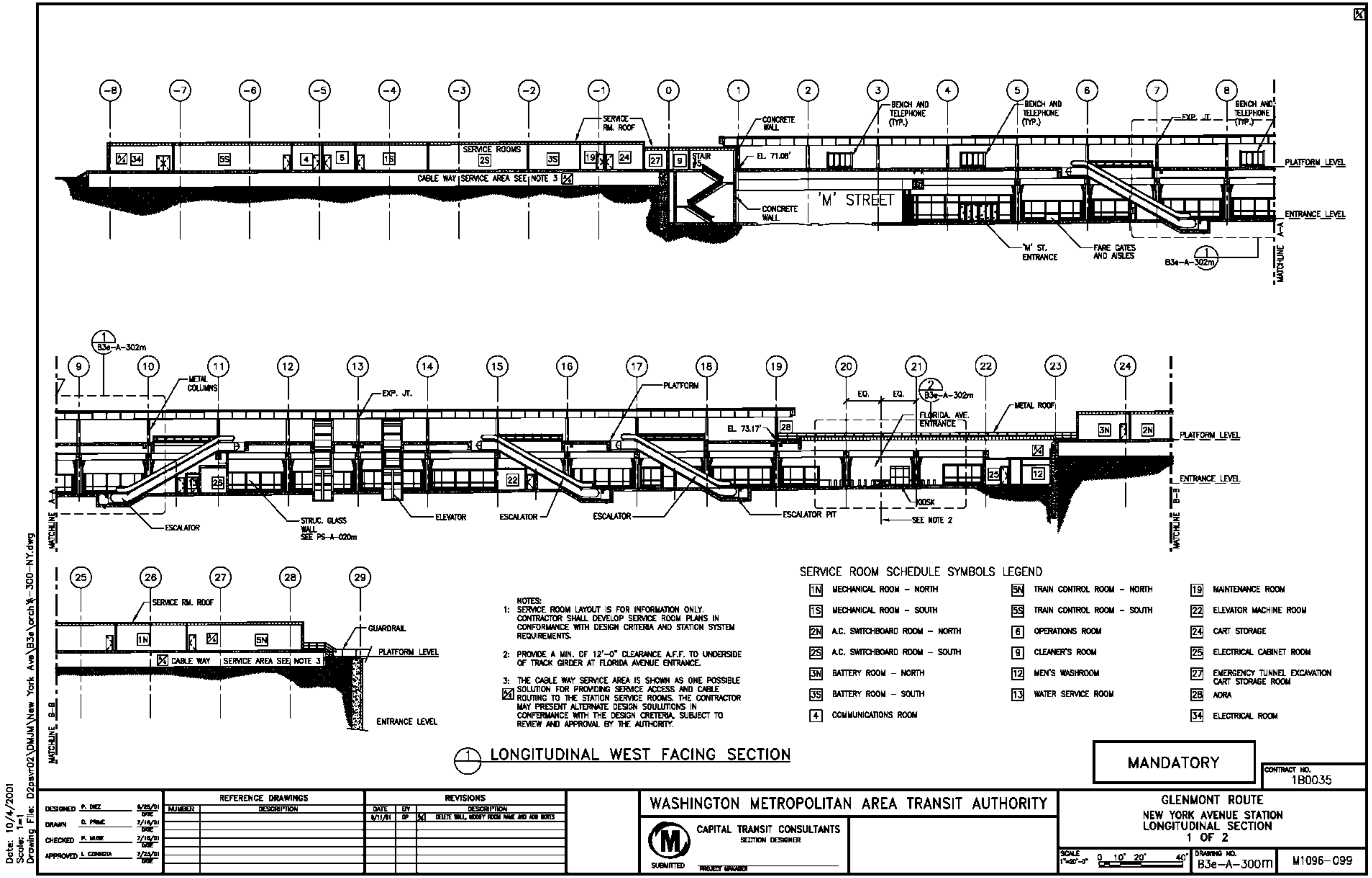
NOTES:
1. ELEVATIONS ARE APPROXIMATE, BASED UPON AVAILABLE SURVEY AND AS-BUILT DATA
2. DEPTH OF COVER BELOW RAIL IS MEASURE FROM TOP OF PROPOSED STRUCTURE TO BASE OF RAIL, PER AREMA CHAPTER 8, ARTICLE 16.1.1

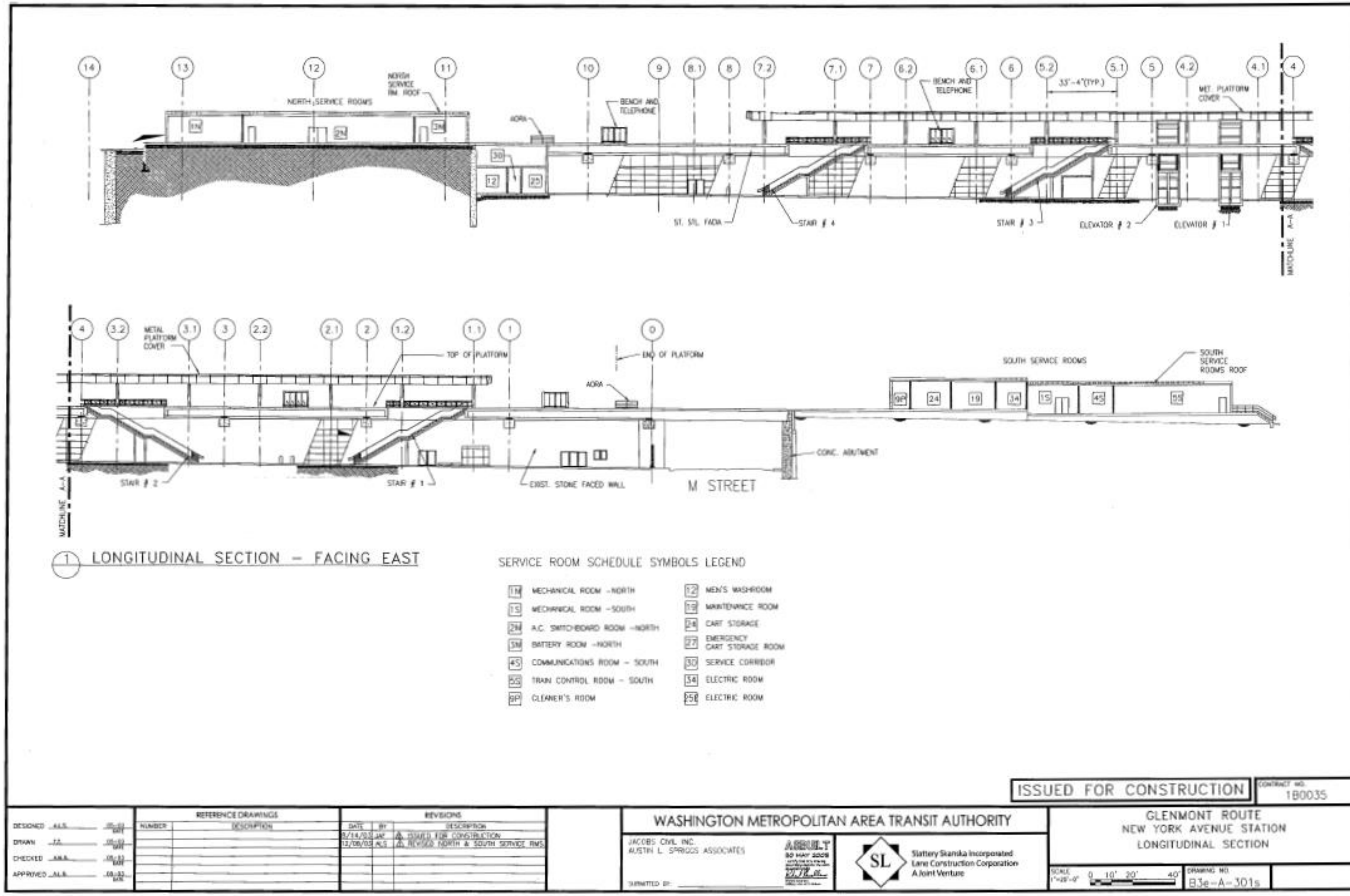


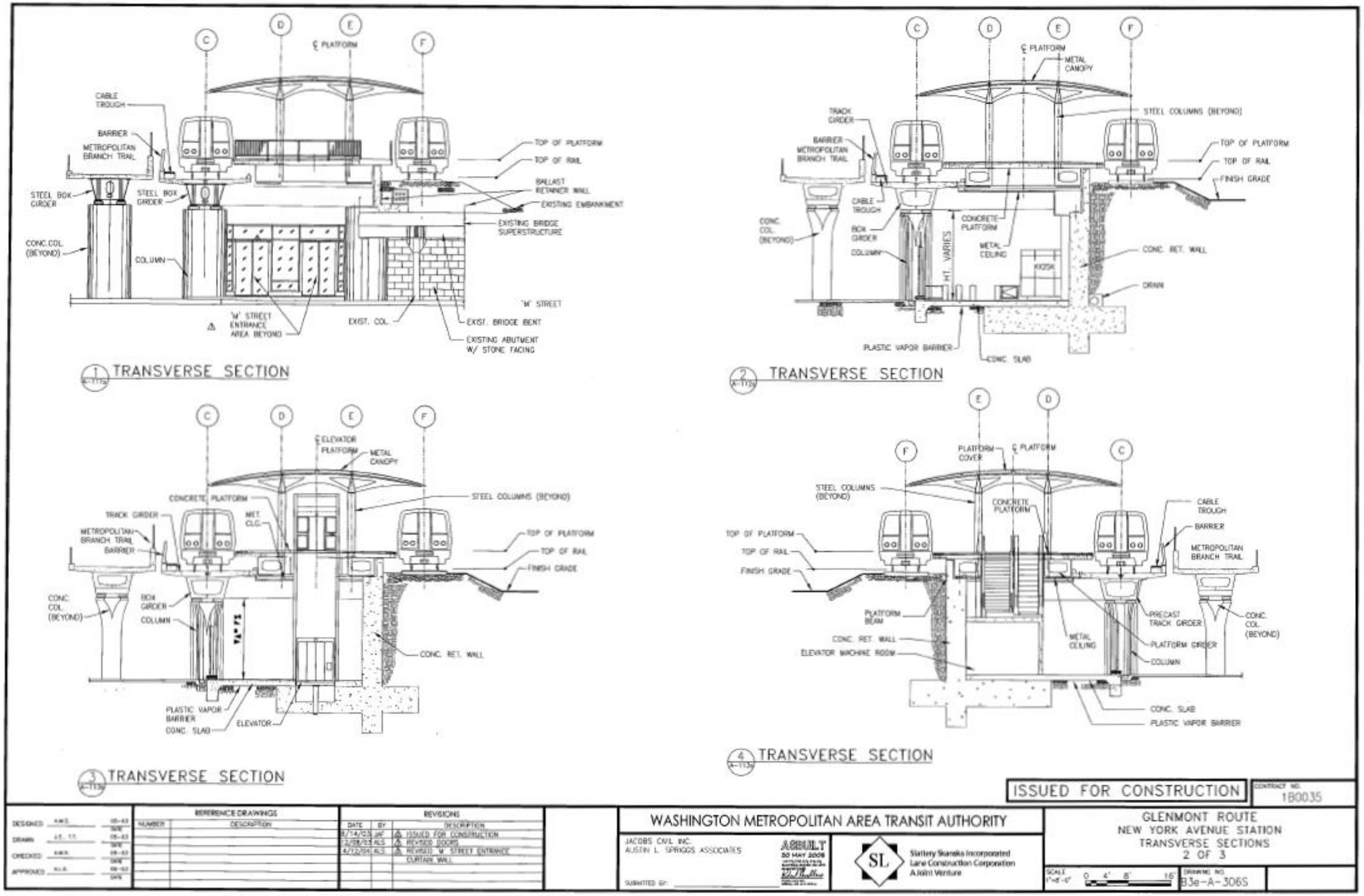


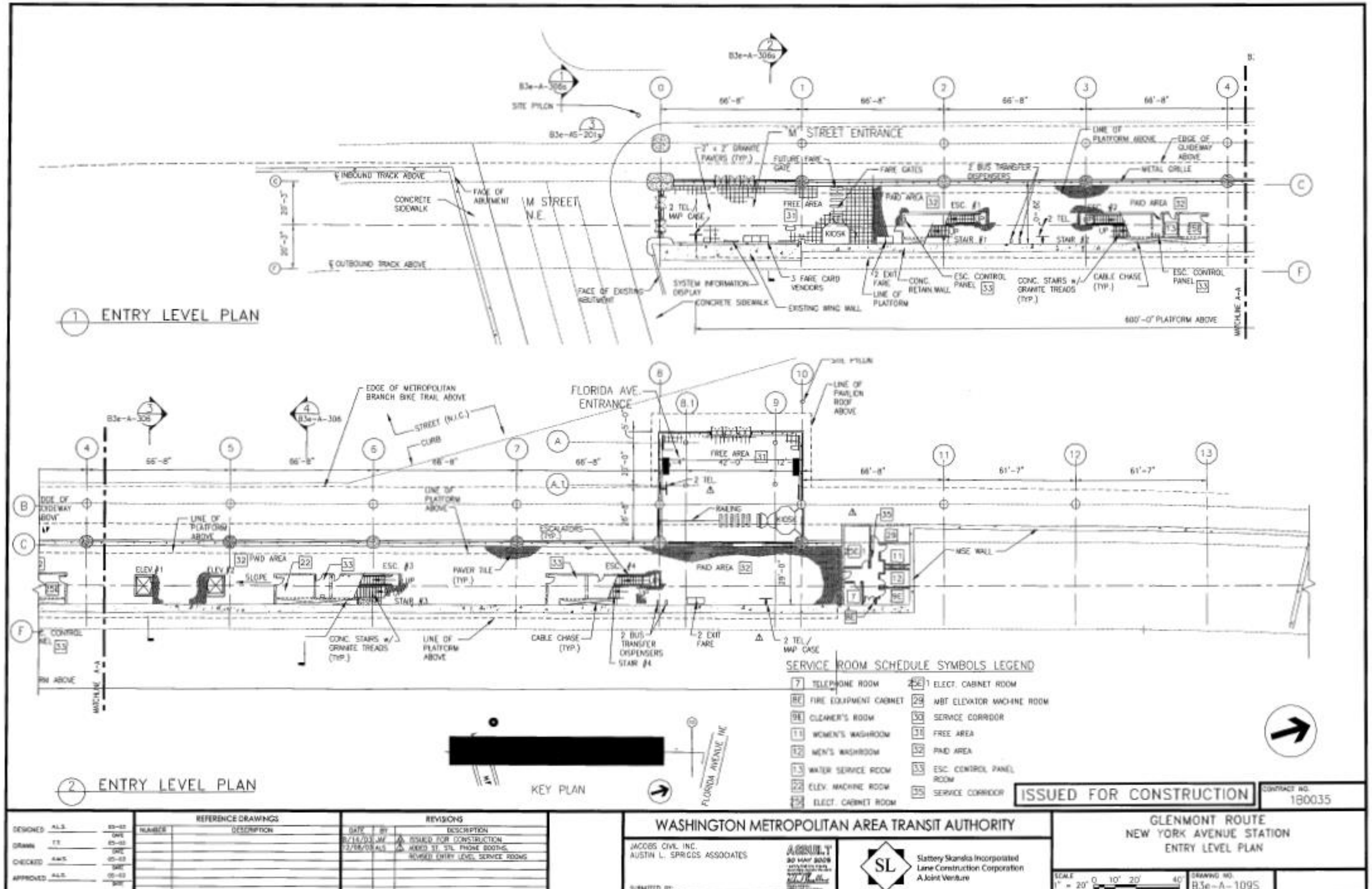
Courtesy of Trammell Crow

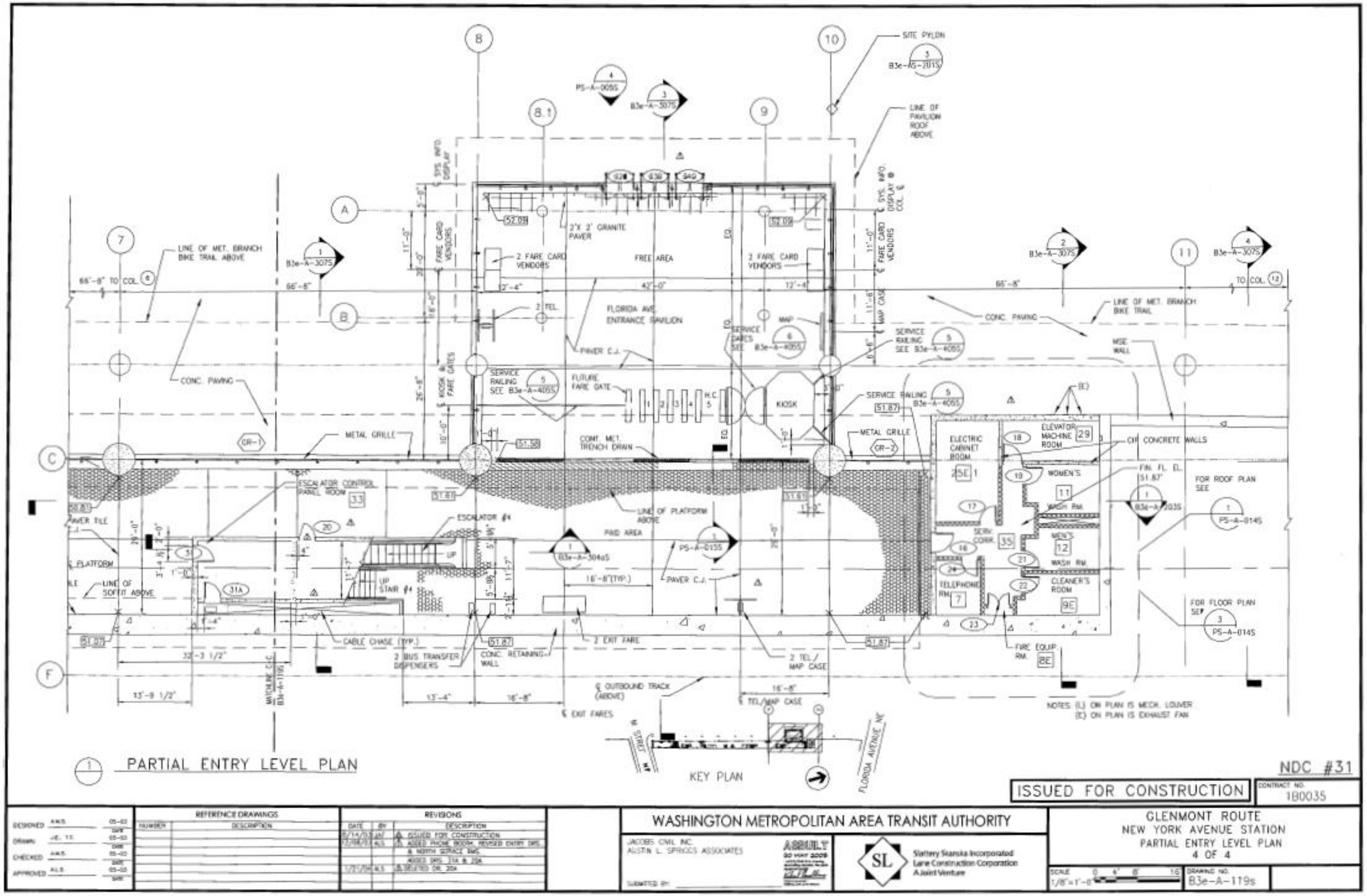
Appendix B: WMATA Station As-Builts

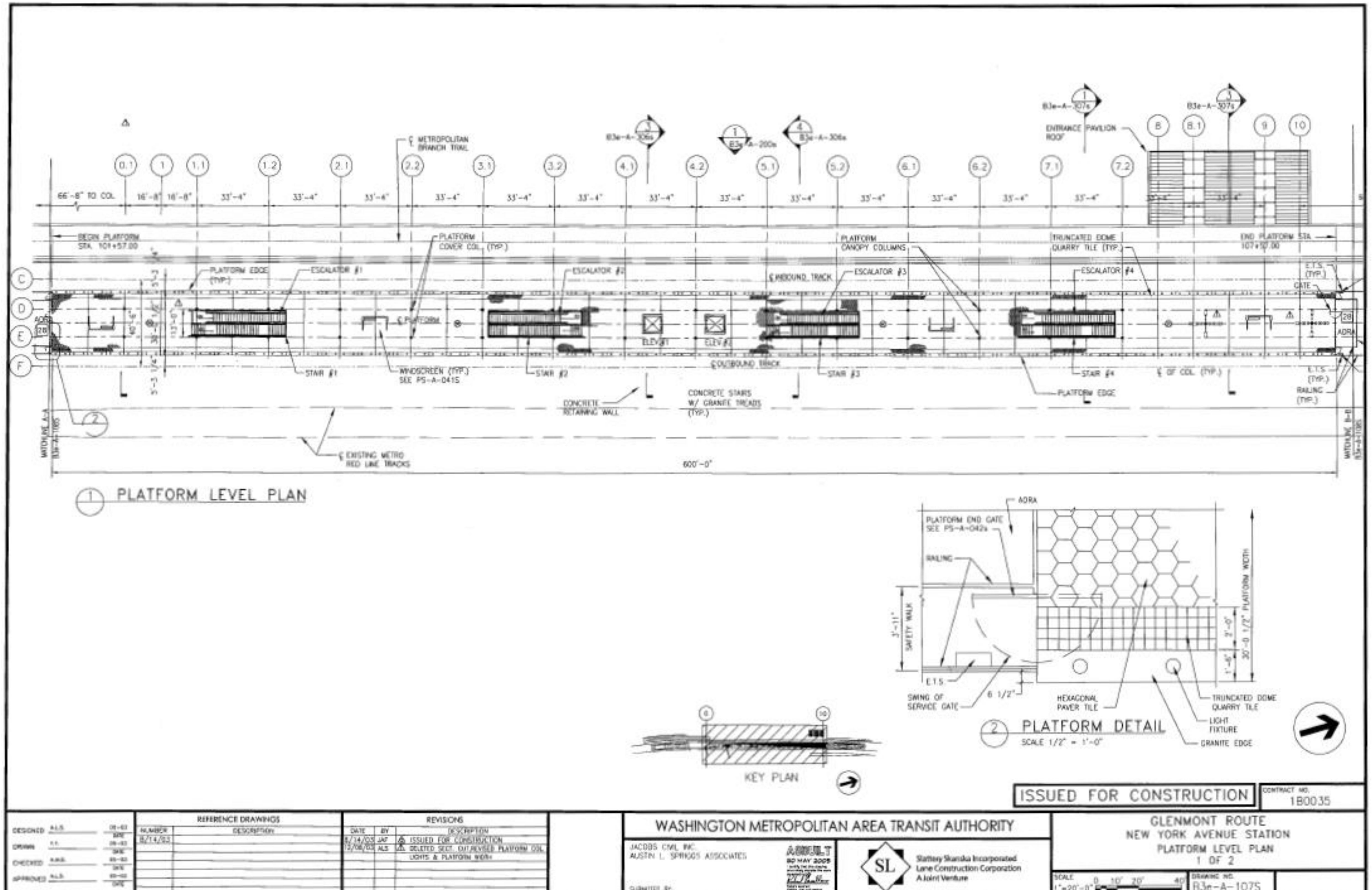

SERVICE RM. ROOF
CONCRETE WALL
BENCH AND TELEPHONE (TYP.)
EXP. JT.
SERVICE ROOMS
STAIR
EL. 71.08'
CABLE WAY SERVICE AREA SEE NOTE 3
PLATFORM LEVEL
'M' STREET
ENTRANCE LEVEL
'M' ST. ENTRANCE
FARE GATES AND AISLES
B3e-A-302m
MATCHLINE A-A
METAL COLUMNS
PLATFORM
EQ.
FLORIDA AVE. ENTRANCE
METAL ROOF
EL. 73.17'
ESCALATOR
STRUC. GLASS WALL SEE PS-A-020m
ELEVATOR
ESCALATOR PIT
KIOSK
SEE NOTE 2
MATCHLINE B-B
GUARDRAIL
NOTES:
1: SERVICE ROOM LAYOUT IS FOR INFORMATION ONLY. CONTRACTOR SHALL DEVELOP SERVICE ROOM PLANS IN CONFORMANCE WITH DESIGN CRITERIA AND STATION SYSTEM REQUIREMENTS.
2: PROVIDE A MIN. OF 12'-0" CLEARANCE A.F.F. TO UNDERSIDE OF TRACK GIRDER AT FLORIDA AVENUE ENTRANCE.
3: THE CABLE WAY SERVICE AREA IS SHOWN AS ONE POSSIBLE SOLUTION FOR PROVIDING SERVICE ACCESS AND CABLE ROUTING TO THE STATION SERVICE ROOMS. THE CONTRACTOR MAY PRESENT ALTERNATE DESIGN SOULUTIONS IN CONFERMANCE WITH THE DESIGN CRETERIA, SUBJECT TO REVIEW AND APPROVAL BY THE AUTHORITY.
SERVICE ROOM SCHEDULE SYMBOLS LEGEND
1N MECHANICAL ROOM - NORTH
1S MECHANICAL ROOM - SOUTH
2N A.C. SWITCHBOARD ROOM - NORTH
2S A.C. SWITCHBOARD ROOM - SOUTH
3N BATTERY ROOM - NORTH
3S BATTERY ROOM - SOUTH
4 COMMUNICATIONS ROOM
5N TRAIN CONTROL ROOM - NORTH
5S TRAIN CONTROL ROOM - SOUTH
6 OPERATIONS ROOM
9 CLEANER'S ROOM
12 MEN'S WASHROOM
13 WATER SERVICE ROOM
19 MAINTENANCE ROOM
22 ELEVATOR MACHINE ROOM
24 CART STORAGE
25 ELECTRICAL CABINET ROOM
27 EMERGENCY TUNNEL EXCAVATION CART STORAGE ROOM
28 AORA
34 ELECTRICAL ROOM
1 LONGITUDINAL WEST FACING SECTION
MANDATORY
CONTRACT NO. 1B0035
Date: 10/4/2001
Scale: 1=1
Drawing File: D2psvr02\DMJM\New York Ave\B3e\arch\A-300-NY.dwg
DESIGNED
DRAWN
CHECKED
APPROVED
REFERENCE DRAWINGS
NUMBER
DESCRIPTION
REVISIONS
DATE
BY
DESCRIPTION
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
CAPITAL TRANSIT CONSULTANTS
SECTION DESIGNER
SUBMITTED
PROJECT MANAGER
GLENMONT ROUTE
NEW YORK AVENUE STATION
LONGITUDINAL SECTION
1 OF 2
SCALE 1"=20'-0"
DRAWING NO. B3e-A-300m
M1096-099

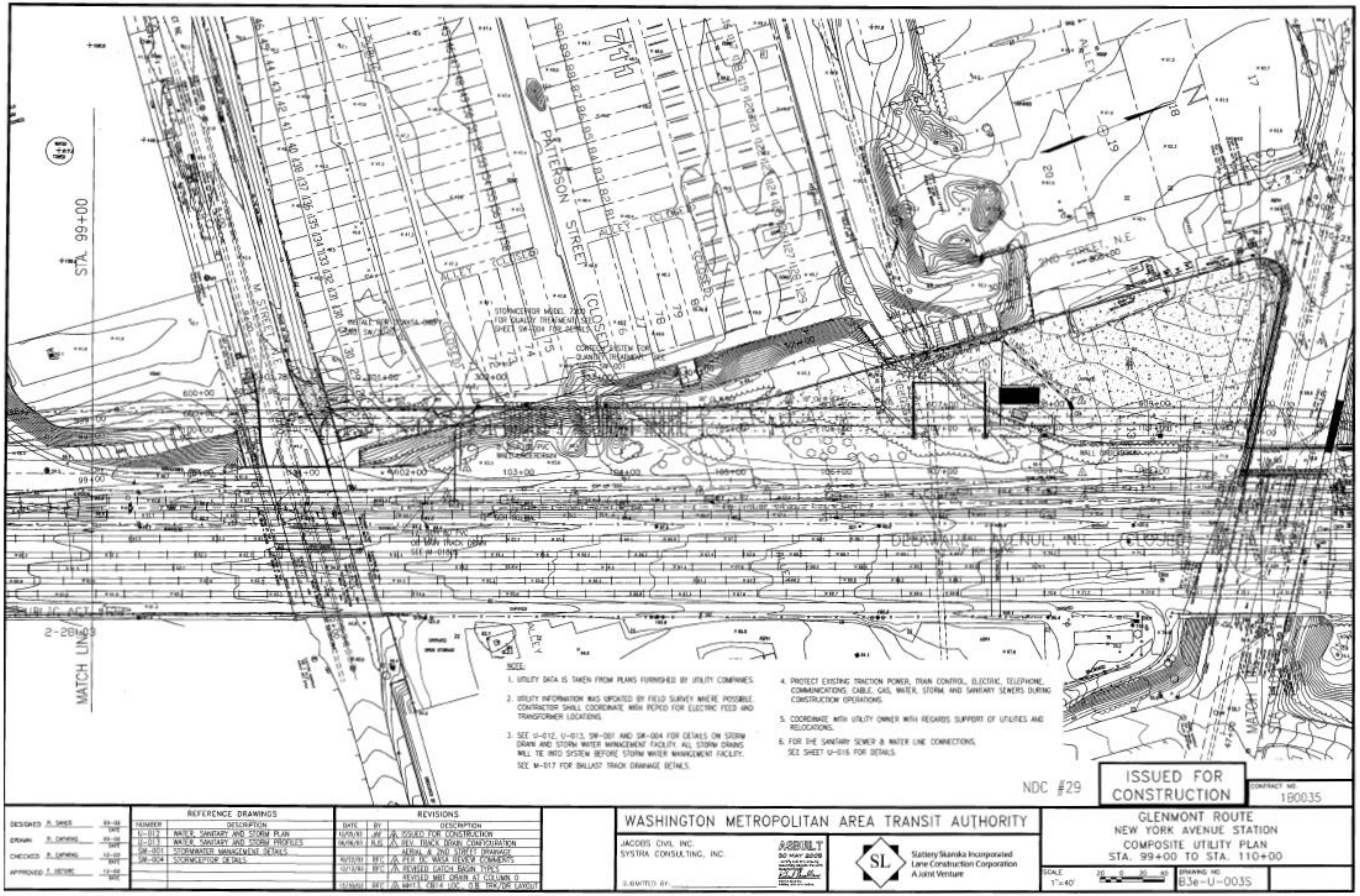

NORTH SERVICE ROOMS
NORTH SERVICE RM. ROOF
BENCH AND TELEPHONE
ST. STL. FACIA
STAIR # 4
STAIR # 3
ELEVATOR # 2
ELEVATOR # 1
MET. PLATFORM COVER
33'-4"(TYP.)
MATCHLINE A-A
METAL PLATFORM COVER
TOP OF PLATFORM
END OF PLATFORM
SOUTH SERVICE ROOMS
SOUTH SERVICE ROOMS ROOF
CONC. ABUTMENT
STAIR # 2
STAIR # 1
EXIST. STONE FACED WALL
M STREET
LONGITUDINAL SECTION – FACING EAST
SERVICE ROOM SCHEDULE SYMBOLS LEGEND
1N MECHANICAL ROOM –NORTH
1S MECHANICAL ROOM –SOUTH
2N A.C. SWITCHBOARD ROOM –NORTH
3N BATTERY ROOM –NORTH
4S COMMUNICATIONS ROOM – SOUTH
5S TRAIN CONTROL ROOM – SOUTH
9P CLEANER'S ROOM
12 MEN'S WASHROOM
19 MAINTENANCE ROOM
24 CART STORAGE
27 EMERGENCY CART STORAGE ROOM
30 SERVICE CORRIDOR
34 ELECTRIC ROOM
25E ELECTRIC ROOM
ISSUED FOR CONSTRUCTION
CONTRACT NO. 1B0035
REFERENCE DRAWINGS
REVISIONS
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
JACOBS CIVIL INC.
AUSTIN L. SPRIGGS ASSOCIATES
ASBUILT
30 MAY 2005
Slattery Skanska Incorporated
Lane Construction Corporation
A Joint Venture
GLENMONT ROUTE
NEW YORK AVENUE STATION
LONGITUDINAL SECTION
SCALE 1"=20'-0"
DRAWING NO. B3e-A-301s

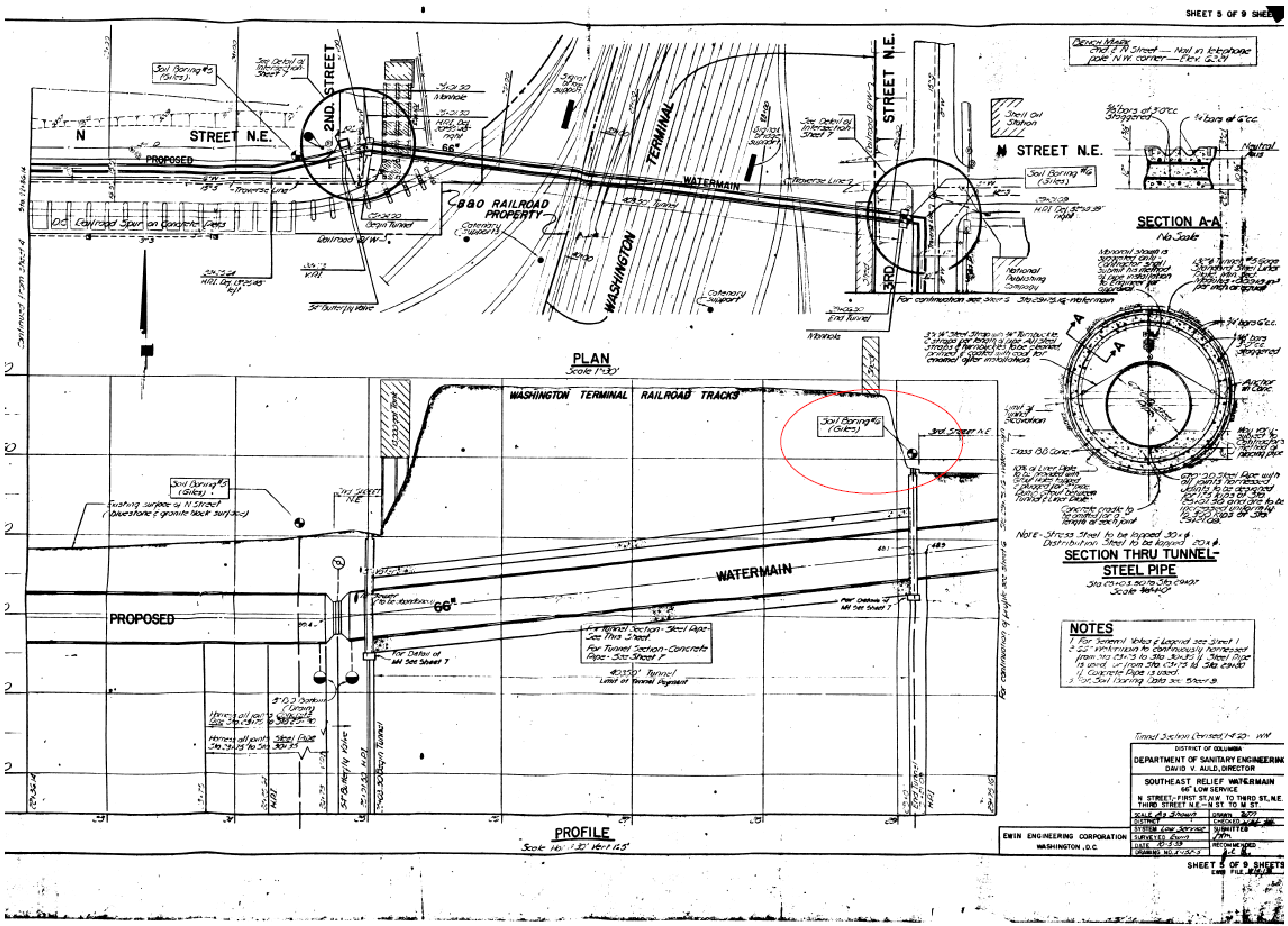

1 TRANSVERSE SECTION
CABLE TROUGH
BARRIER
METROPOLITAN BRANCH TRAIL
STEEL BOX GIRDER
CONC.COL. (BEYOND)
COLUMN
TOP OF PLATFORM
TOP OF RAIL
BALLAST RETAINER WALL
EXISTING EMBANKMENT
EXISTING BRIDGE SUPERSTRUCTURE
'M' STREET
'M' STREET ENTRANCE AREA BEYOND
EXIST. COL.
EXIST. BRIDGE BENT
EXISTING ABUTMENT W/ STONE FACING
2 TRANSVERSE SECTION
℄ PLATFORM
METAL CANOPY
STEEL COLUMNS (BEYOND)
TRACK GIRDER
CONCRETE PLATFORM
METAL CEILING
HT. VARIES
KIOSK
CONC. RET. WALL
DRAIN
FINISH GRADE
PLASTIC VAPOR BARRIER
CONC. SLAB
3 TRANSVERSE SECTION
℄ ELEVATOR PLATFORM
ELEVATOR
4 TRANSVERSE SECTION
PLATFORM COVER
PLATFORM BEAM
ELEVATOR MACHINE ROOM
PRECAST TRACK GIRDER
PLATFORM GIRDER
ISSUED FOR CONSTRUCTION
1B0035
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
JACOBS CIVIL INC.
AUSTIN L. SPRIGGS ASSOCIATES
ASBUILT
30 MAY 2005
Slattery Skanska Incorporated
Lane Construction Corporation
A Joint Venture
GLENMONT ROUTE
NEW YORK AVENUE STATION
TRANSVERSE SECTIONS
2 OF 3
B3e-A-306S
REFERENCE DRAWINGS
REVISIONS
ISSUED FOR CONSTRUCTION
REVISED DOORS
REVISED 'M' STREET ENTRANCE CURTAIN WALL

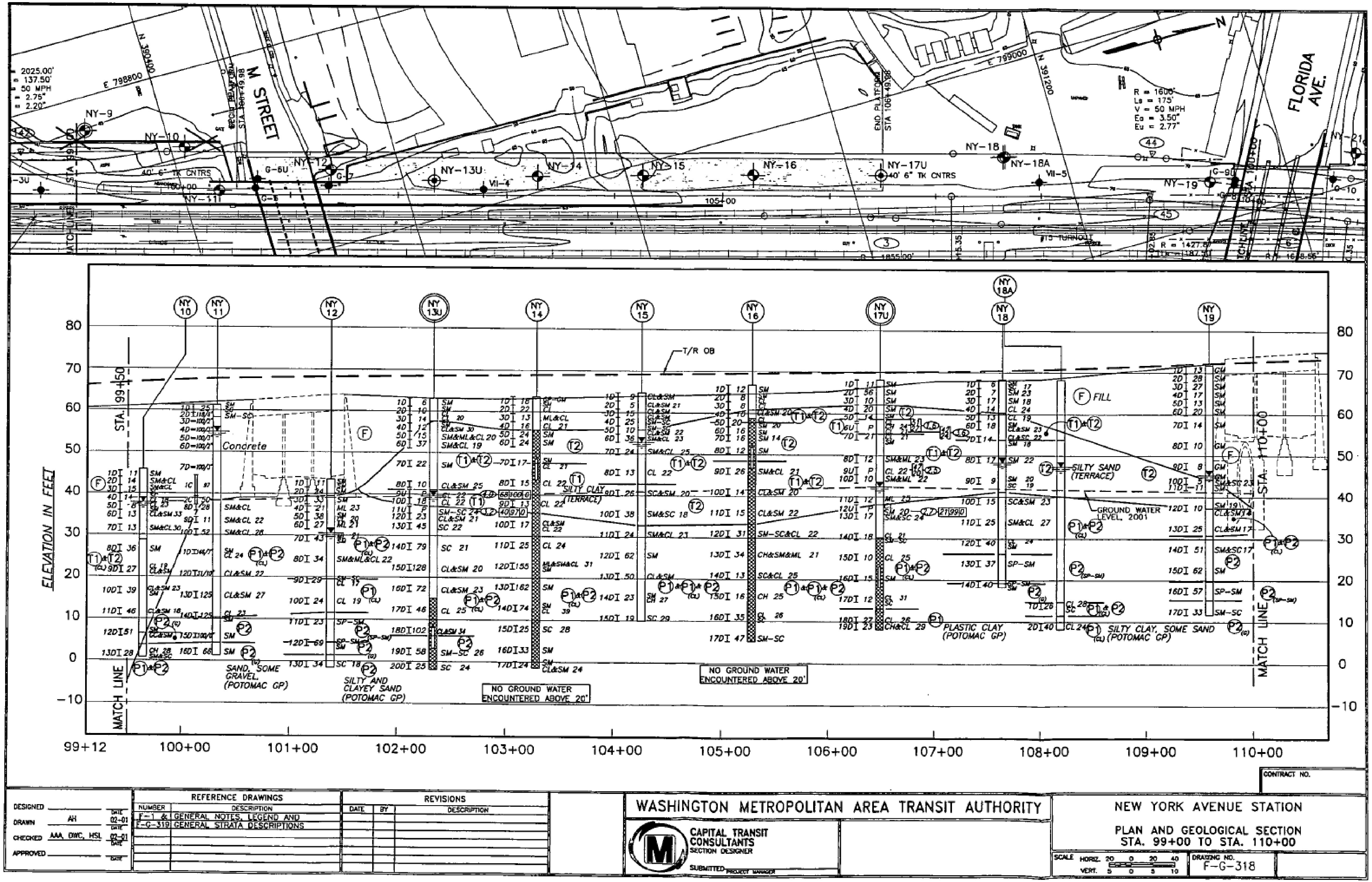

"M" STREET ENTRANCE
M STREET N.E.
1 ENTRY LEVEL PLAN
FLORIDA AVE. ENTRANCE
EDGE OF METROPOLITAN BRANCH BIKE TRAIL ABOVE
2 ENTRY LEVEL PLAN
[redacted]
KEY PLAN
FLORIDA AVENUE NE
SERVICE ROOM SCHEDULE SYMBOLS LEGEND
7 TELEPHONE ROOM
8E FIRE EQUIPMENT CABINET
9E CLEANER'S ROOM
11 WOMEN'S WASHROOM
12 MEN'S WASHROOM
13 WATER SERVICE ROOM
22 ELEV. MACHINE ROOM
25 ELECT. CABINET ROOM
29 MBT ELEVATOR MACHINE ROOM
30 SERVICE CORRIDOR
31 FREE AREA
32 PAID AREA
33 ESC. CONTROL PANEL ROOM
35 SERVICE CORRIDOR
ISSUED FOR CONSTRUCTION
CONTRACT NO. 1B0035
REFERENCE DRAWINGS
REVISIONS
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
JACOBS CIVIL INC.
AUSTIN L. SPRIGGS ASSOCIATES
ASBUILT
Slattery Skanska Incorporated
Lane Construction Corporation
A Joint Venture
GLENMONT ROUTE
NEW YORK AVENUE STATION
ENTRY LEVEL PLAN
SCALE 1" = 20'
DRAWING NO. B3e-A-109S


PARTIAL ENTRY LEVEL PLAN
KEY PLAN
FLORIDA AVE ENTRANCE PAVILION
FREE AREA
PAID AREA
KIOSK
ELECTRIC CABINET ROOM
ELEVATOR MACHINE ROOM
WOMEN'S WASH RM.
MEN'S WASH RM.
CLEANER'S ROOM
TELEPHONE RM.
FIRE EQUIP. RM.
ESCALATOR CONTROL PANEL ROOM
NOTES: (L) ON PLAN IS MECH. LOUVER
(E) ON PLAN IS EXHAUST FAN
NDC #31
ISSUED FOR CONSTRUCTION
CONTRACT NO. 1B0035
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
JACOBS CIVIL INC.
AUSTIN L. SPRIGGS ASSOCIATES
Slattery Skanska Incorporated
Lane Construction Corporation
A Joint Venture
GLENMONT ROUTE
NEW YORK AVENUE STATION
PARTIAL ENTRY LEVEL PLAN
4 OF 4
SCALE 1/8"=1'-0"
DRAWING NO. B3e-A-119s
REFERENCE DRAWINGS
REVISIONS


PLATFORM LEVEL PLAN
PLATFORM DETAIL
SCALE 1/2" = 1'-0"
KEY PLAN
ISSUED FOR CONSTRUCTION
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
GLENMONT ROUTE
NEW YORK AVENUE STATION
PLATFORM LEVEL PLAN
1 OF 2
B3e-A-107S


STA. 99+00
MATCH LINE
PATTERSON STREET
M STREET
2ND STREET, N.E.
DELAWARE AVENUE, N.E. (CLOSED)
NOTE:
1. UTILITY DATA IS TAKEN FROM PLANS FURNISHED BY UTILITY COMPANIES.
2. UTILITY INFORMATION WAS UPDATED BY FIELD SURVEY WHERE POSSIBLE. CONTRACTOR SHALL COORDINATE WITH PEPCO FOR ELECTRIC FEED AND TRANSFORMER LOCATIONS.
3. SEE U-012, U-013, SW-001 AND SW-004 FOR DETAILS ON STORM DRAIN AND STORM WATER MANAGEMENT FACILITY. ALL STORM DRAINS WILL TIE INTO SYSTEM BEFORE STORM WATER MANAGEMENT FACILITY. SEE M-017 FOR BALLAST TRACK DRAINAGE DETAILS.
4. PROTECT EXISTING TRACTION POWER, TRAIN CONTROL, ELECTRIC, TELEPHONE, COMMUNICATIONS, CABLE, GAS, WATER, STORM AND SANITARY SEWERS DURING CONSTRUCTION OPERATIONS.
5. COORDINATE WITH UTILITY OWNER WITH REGARDS SUPPORT OF UTILITIES AND RELOCATIONS.
6. FOR THE SANITARY SEWER & WATER LINE CONNECTIONS, SEE SHEET U-016 FOR DETAILS.
NDC #29
ISSUED FOR CONSTRUCTION
CONTRACT NO. 1B0035
REFERENCE DRAWINGS
REVISIONS
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
JACOBS CIVIL INC.
SYSTRA CONSULTING, INC.
ASBUILT
30 MAY 2008
Slattery Skanska Incorporated
Lane Construction Corporation
A Joint Venture
GLENMONT ROUTE
NEW YORK AVENUE STATION
COMPOSITE UTILITY PLAN
STA. 99+00 TO STA. 110+00
SCALE 1"=40'
DRAWING NO. B3e-U-003S


SHEET 5 OF 9 SHEETS
N STREET N.E.
2ND. STREET
3RD. STREET N.E.
WASHINGTON TERMINAL
WATERMAIN
B&O RAILROAD PROPERTY
PLAN
Scale 1"=30'
SECTION A-A
No Scale
SECTION THRU TUNNEL-STEEL PIPE
WASHINGTON TERMINAL RAILROAD TRACKS
Soil Boring #5 (Giles)
Soil Boring #6 (Giles)
PROPOSED
66"
WATERMAIN
PROFILE
NOTES
DISTRICT OF COLUMBIA
DEPARTMENT OF SANITARY ENGINEERING
DAVID V. AULD, DIRECTOR
SOUTHEAST RELIEF WATERMAIN
66" LOW SERVICE
N STREET - FIRST ST. N.W. TO THIRD ST. N.E.
THIRD STREET N.E. - N ST. TO M ST.
EWIN ENGINEERING CORPORATION
WASHINGTON, D.C.


M STREET
FLORIDA AVE.
NY-9
NY-10
NY-12
NY-13U
NY-14
NY-15
NY-16
NY-17U
NY-18
NY-18A
NY-19
ELEVATION IN FEET
MATCH LINE
STA. 99+50
STA. 110+00
T/R OB
Concrete
FILL
SILTY SAND (TERRACE)
GROUND WATER LEVEL, 2001
PLASTIC CLAY (POTOMAC GP)
SILTY CLAY, SOME SAND (POTOMAC GP)
SAND, SOME GRAVEL (POTOMAC GP)
SILTY AND CLAYEY SAND (POTOMAC GP)
NO GROUND WATER ENCOUNTERED ABOVE 20'
99+12
100+00
101+00
102+00
103+00
104+00
105+00
106+00
107+00
108+00
109+00
110+00
REFERENCE DRAWINGS
F-1 & GENERAL NOTES, LEGEND AND
F-G-319 GENERAL STRATA DESCRIPTIONS
REVISIONS
WASHINGTON METROPOLITAN AREA TRANSIT AUTHORITY
CAPITAL TRANSIT CONSULTANTS
SECTION DESIGNER
NEW YORK AVENUE STATION
PLAN AND GEOLOGICAL SECTION
STA. 99+00 TO STA. 110+00
DRAWING NO. F-G-318

Appendix C: Design Loads

1 Design Loads

The loads considered in this analysis include dead load, earth loads, live load, water load, impact load, and seismic loads as specified in AREMA manual. The estimation of these loads is discussed in the following sections.

1.1 Dead Load (D)

1. Self-weight of the arch pipe roof and jacked box tunnel is calculated based on unit weights of concrete and
2. Arch pipe, 18 inch diameter, heavy wall steel pipe with reinforced concrete infill and an average of 4 inches of protective shotcrete, as needed.

$$D = (70+265)/1.5 + 150*4/12= 423 \text{ psf}$$

3. Jacked box tunnel, 2.0 foot thick roof:

$$D = 2.0*150 = 300 \text{ psf}$$

1.2 Earth Loads

Earth loads on the proposed tunnel lining include vertical and lateral earth loads. These loads are estimated for the proposed alignment 3A.

1.2.1 Vertical Earth Load (EV)

Vertical earth loads were calculated based on a total unit weight of 120 pcf, per AREMA. The overburden uniform vertical loads (soil + live + impact) on the tunnel roof would be more critical for the ground cover of 5.5 feet (per AREMA Figure 8-16-1). The vertical earth load in this analysis is calculated based on 5.5 feet of soil cover.

$$EV = 5.5*120 = 660 \text{ psf}$$

1.2.2 Later Earth Load (OH)

The lateral earth pressure coefficients for both pipe arch roof and jacked box tunnels will be between active and at-rest earth pressure because of ground relaxation during tunnel excavation. For this feasibility study, at-rest earth pressure is conservatively used for both types of structures and friction angle of 33 degrees was used for the sandy silt / clayey sands at the tunnel elevation.

$$K_o = 1-\sin\phi = 0.45.$$

1.3 Hydrostatic Pressure (WA)

Hydrostatic pressure is not included since the expected groundwater elevation is well below tunnel invert.

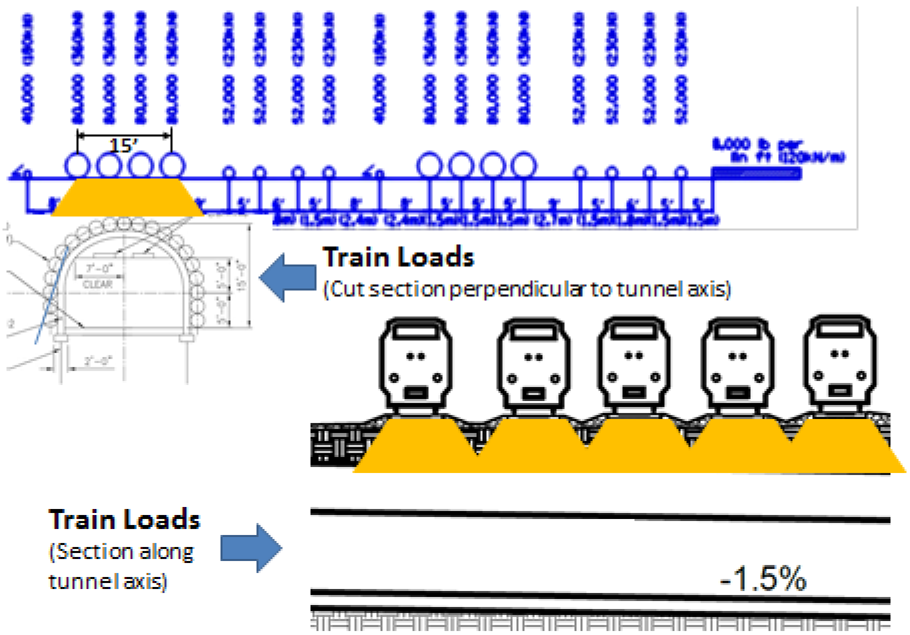
1.4 Train Live Load (LL)

Train live load is calculated following the guidelines provided in AREMA, Chapter 8, as detailed further below.

1.4.1 Vertical Live Load

The live loads applied on the tunnel lining are derived from the train loads specified in AREMA Chapter 8-Reinforced Concrete Design, Part 2, Section 2.2.2 Design Loads and Part 16 Design and Construction of Reinforced Concrete Box Culverts. Vertical live load is estimated based on the Cooper E-80 load as specified in AREMA Section 2.2.2 Design Loads.

Figure 1: Cooper E-80 Loading Distribution



The train load at the arch pipe tunnel roof is assumed to be uniformly distributed. The live load from a single train is calculated based on the load distribution zone shown AREMA Figure 8-16-2 as below:

$$\text{Train } LL_{vert1} = 4*80/((8.5+5.5)*(15+3+5.5)) = 0.97 \text{ ksf}$$

As shown in Figure 2, the load distribution zones of two adjacent trains locally overlap, so the live load on the typical tunnel cross section will be higher than the live load from a single train. At this feasibility study level, this increase is approximated by a 30% increase of the live load, which results in the total train load used in the analysis:

$$\text{Train (2 adjacent trains passing) } LL_{vert} = 1.26 \text{ ksf}$$

Figure 2: Distribution of Railroad Loading

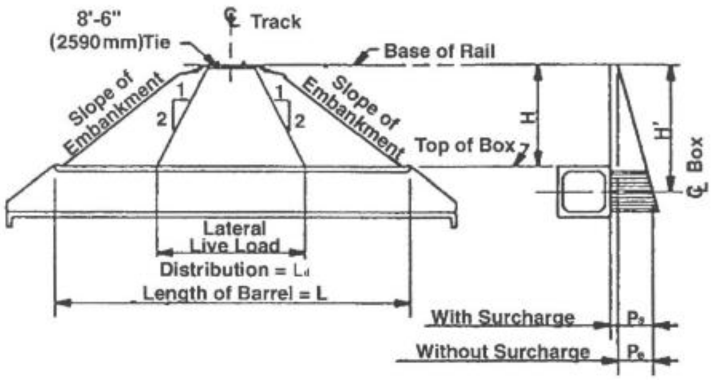


Figure 8-16-2. Distribution of Loads

1.4.2 Lateral Live Load

The lateral live load is estimated based on the vertical live load, and the lateral earth pressure coefficient:

$$LL_{lat} = 0.45*1.26 = 0.57 \text{ ksf}$$

1.4.3 Impact Load

Vertical train impact load is calculated following AREMA Chapter 8, Section 2.2.3. Per AREMA Chapter 8, Section 16.4.4, no impact is added to the lateral forces on the side of the box. The vertical impact load at the top of rail is calculated as below.

I = Live load x 225/sqrt(span)/100

I = 1.26 x 225/sqrt(16)/100 = 0.7 ksf

Per AREMA Figure 8-16-1, impact load decreases with depth, and approaches zero at depth of 10 feet below the base of rail. For the tunnel roof at a depth of 5.5 feet below the base of rail, the impact load is approximately half of the value calculated at top of rail.

I = 0.35 ksf

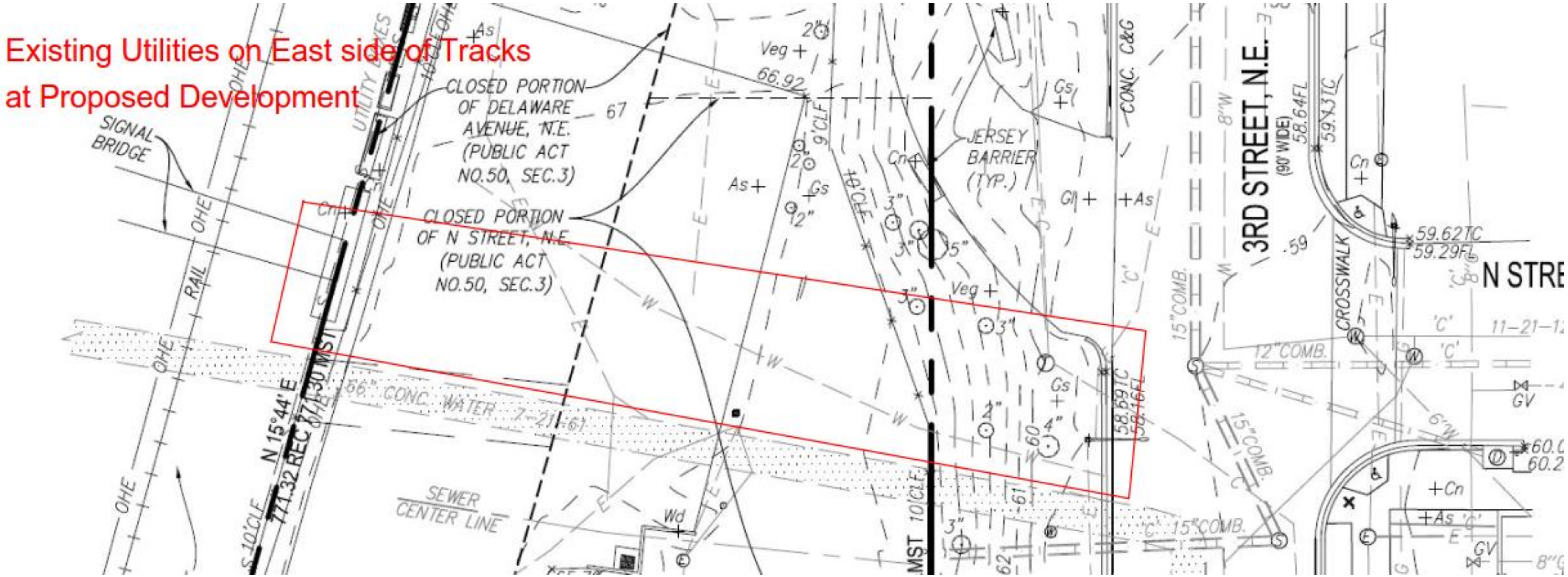
1.4.4 Longitudinal Train Forces

Longitudinal train forces and other forces are not required to be accounted for, for box culverts, as specified in AREMA, Chapter 8, Section 16.4.5. Longitudinal train forces are not considered in this feasibility study. Longitudinal train forces will be evaluated at the Preliminary Design Phase to ensure minimal impact.

1.5 Seismic Loads

Seismic loads were not evaluated at this stage since the anticipated ground motions in the project area are relatively low and our previous experience indicates that the seismic load case would not govern the tunnel lining design. This should be confirmed during the Preliminary Design phase.

Appendix D: East Side Utility Plans



Courtesy of Trammell Crow

Appendix E:
Existing Conditions Memorandum

NoMa Pedestrian Tunnel Feasibility Study

Existing Conditions Report

February 2015

Submitted to:
Washington Metropolitan Area
Transit Authority

Prepared by:
AECOM

Table of Contents

Appendices

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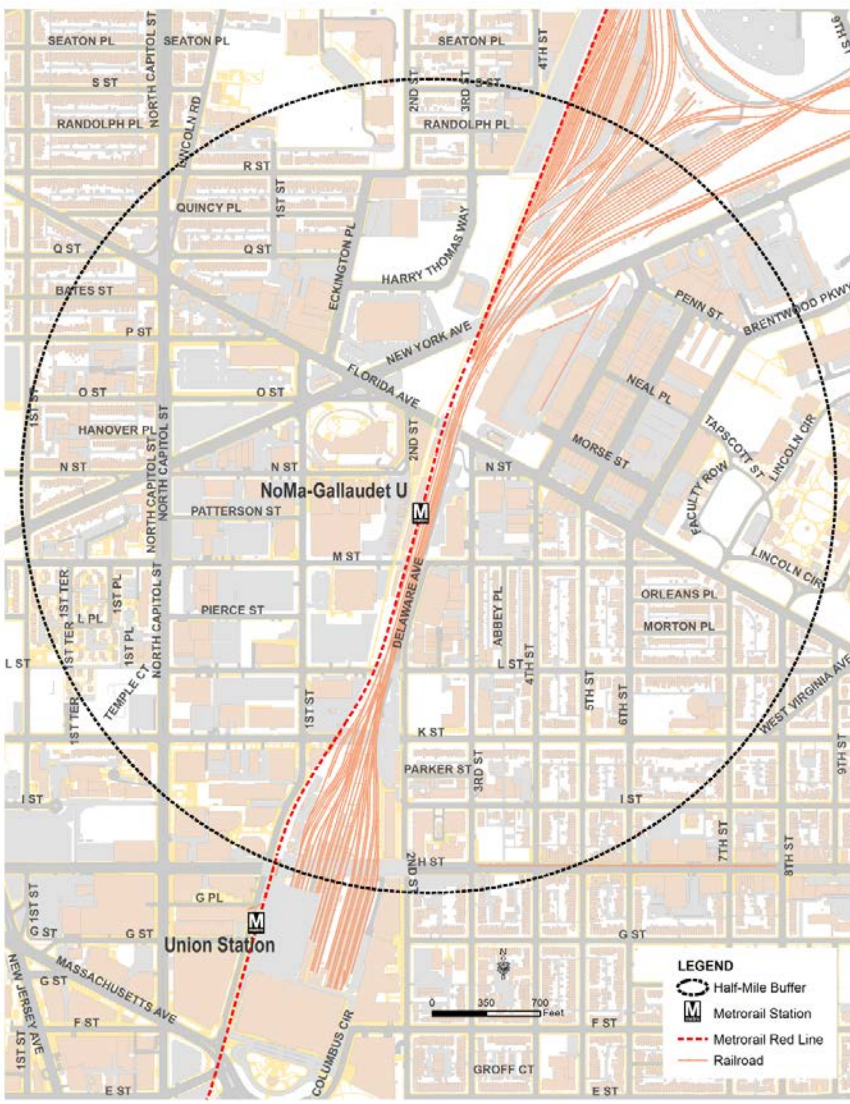
1. Introduction

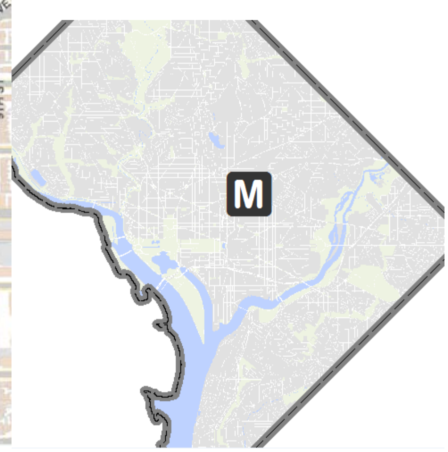
This report provides an overview of existing conditions in the vicinity of the NoMa-Gallaudet University Metrorail station. The report is a component of the NoMa Pedestrian Tunnel Feasibility Study being conducted by the Washington Metropolitan Transit Authority (WMATA) to determine the challenges associated with designing, permitting, and constructing an ADA compliant pedestrian tunnel at the NoMa-Gallaudet University Metrorail station. This tunnel, beginning at the NoMa-Gallaudet station and terminating near the intersection of 3rd Street Northeast and N Street Northeast, would provide additional access to accommodate the ridership growth attributed to development in the area east of the Union Station rail yard.

Figure 1 provides the approximate ½ mile radius boundary of the study area for the NoMa Pedestrian Tunnel Feasibility Study and the overview of existing conditions found in this report.

Figure 1: NoMa Metro Station Study Area



Key Map



The report will identify and review:

- Previous Studies
- Existing Land Uses, including development, zoning, assessment and improvement districts, and cultural resources
- Existing Transportation Network, including Metrorail, roadway traffic, Metrobus service, pedestrian and bicycle infrastructure, and passenger and freight rail operations
- Existing Utilities, Station Structure, Topography, Drainage and Subsurface geotechnical soils information
- Proposed changes to land uses found in previous plans and studies
- Proposed improvements to the transportation network found in previous plans and studies
- Current and future access deficiencies at the NoMa-Gallaudet University Metrorail station

1.1 Material Reviewed

Existing conditions were determined by a variety of sources, including previous plans and studies, GIS files, engineering drawings, and aerial photos. Several visits to the study area were made to obtain digital photographs. A site visit was made on January 21, 2015 along with stakeholders from Washington Metropolitan Area Transit Authority (WMATA), District Department of Transportation (DDOT), Amtrak, Gallaudet University, Advisory Neighborhood Commission 6C06, NoMa Business Improvement District, and local developers.

A list of materials reviewed and their sources is included in **Table 3** in **Appendix B**. **Figure 8** in **Appendix A** identifies additional plans and studies that have been undertaken in the study area.

2. Existing NoMa Station

2.1 Station Layout

The NoMa-Gallaudet University Metrorail station, which opened in 2004, is located between M Street Northeast and Florida Avenue Northeast and between 3rd Street Northeast and 2nd Street Northeast (see **Figure 2**).

2.1.1 Station Circulation

The NoMa Station is divided into two levels. Riders access the station and pay on the first level, as seen in **Figure 3**. The platform is on the second level which pedestrians access by using an escalator, stair case, or elevator, as seen in **Figure 3**. There are two main entrances to the station, one at the south end, on M Street Northeast, between 1st Street Northeast and 3rd Street Northeast, and one at the corner of N Street Northeast and 2nd Street Northeast, as seen in **Figure 2**. The cross sections for the northwest entrance and the south entrance are seen in **Figure 9** and **Figure 10** respectively, in **Appendix A**. **Table 4** in **Appendix B** quantifies the NoMa Metro station access options.

The NoMa Station is a center platform station; the inbound and outbound Metrorail Red Line utilizes the tracks that run on both sides of the passenger platform to stop at the NoMa station, as seen in the cross section in **Figure 10** in **Appendix A**. The commuter trains (such as MARC, VRE, and Amtrak) use the tracks adjacent to the NoMa station, east of the passenger platform, to access Union Station and the nearby rail yard, as seen in **Figure 2**.

The Metropolitan Branch Trail (MBT), which stretches from Union Station in Northeast DC to Springfield, Maryland, passes through the NoMa station, and provides access to the Metro stop. The MBT is elevated and is located west of the inbound tracks.

Figure 2: Existing NoMa Metro Station Entrance Locations

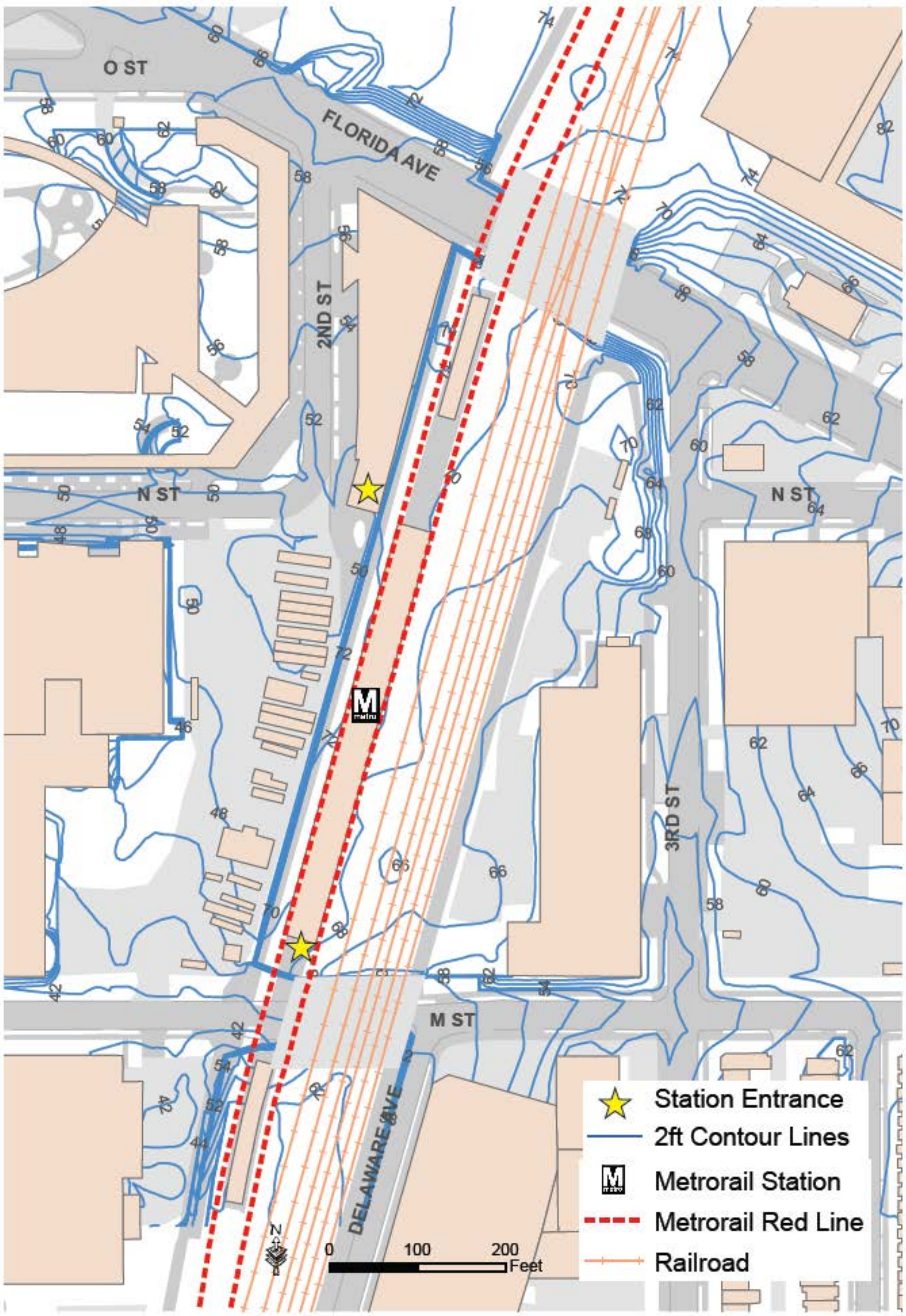
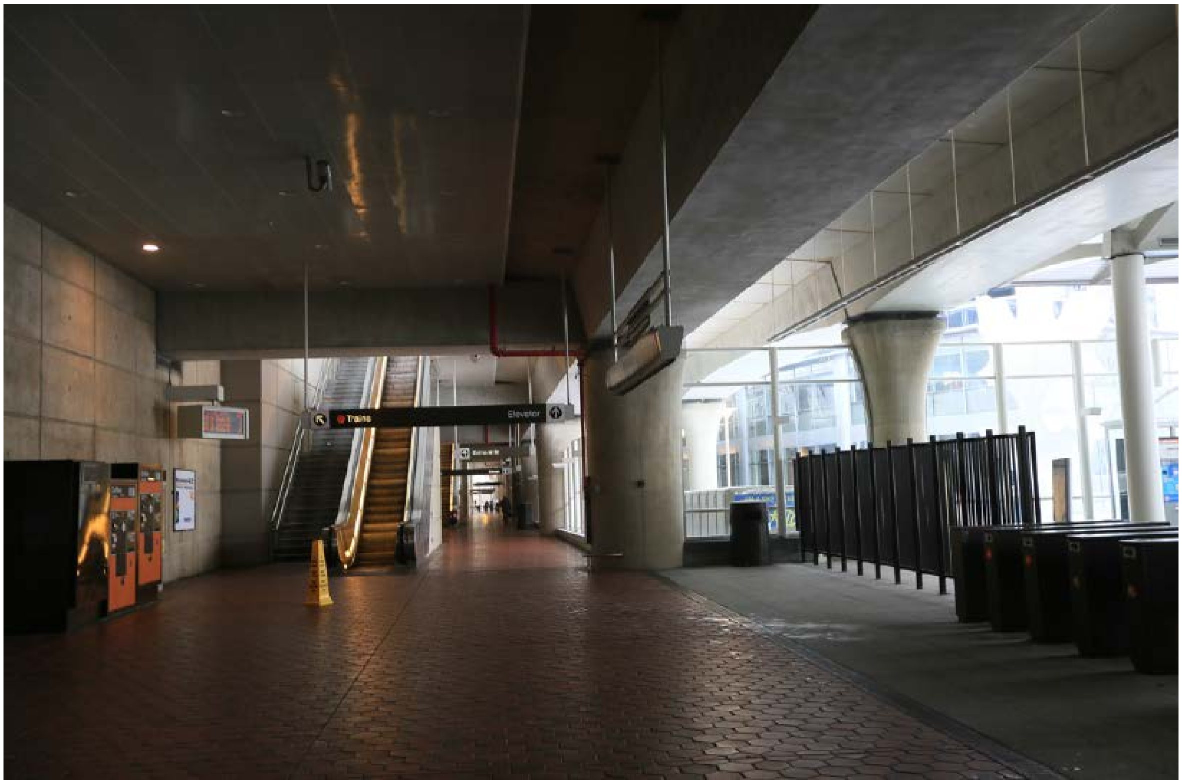


Figure 3: Pedestrian Access into NoMa Station



2.1.2 Station Structural Design

The NoMa station has two levels, one at ground level and one at track level. The station has a hybrid structural configuration, where the outbound track is on an embankment supported by a cantilever cast-in-place concrete retaining wall, and the inbound track is on a precast concrete box girder guideway. The station platform is comprised of twin longitudinal box girders with an adjoining slab. The platform box girders are supported by transverse precast prestressed concrete cross girders that rest on the embankment retaining wall at one end and the guideway columns at the other end. **Figure 11** in **Appendix A** shows the location of the station platform and concrete columns relative to the façade of the Metro station. The Metropolitan Branch Trail (MBT), located to the west of the inbound track, is comprised of a track-level precast concrete box girder viaduct supported on concrete columns.

The vertical stem of the embankment retaining wall is 3’-9” thick. The wall has a spread-footing foundation with a 5’-9” heel extending behind the wall and 16’-0” toe extending in front of the wall, under the ground level floor of the station. The back side of the embankment retaining wall has a Miradrain drainboard and an 8-inch underdrain at approximately floor level of the station. Further behind the retaining wall was a temporary support-of-excavation wall that may still have in-place components. Near track level there is a variable-elevation electrical ductbank running longitudinally behind the wall. Typical guideway and MBT viaduct column spacing is 66’-8”. This spacing also defines locations of transverse girders that support the platform.

North of the ground level service rooms between column lines 10 and 11 (just north of the Florida Avenue entrance pavilion), the embankment retaining wall is comprised of a mechanically stabilized earth (MSE) wall. Also between column lines 10 and 11, there is about 16 feet of unoccupied wall space between the Florida Avenue entrance pavilion and the service rooms. Track-level service rooms at north and south ends of the station are supported on the embankment by cast-in-place concrete slabs and foundation walls with spread footings.

A typical structural and station section is seen in **Figure 13** in **Appendix A.**

2.1.3 Station System Design

The NoMa station obtains power from two 13.8kV electrical feeders from PEPCO, which originate in the AC Switchboard Room, which is located in the North Service Rooms on the platform level. Fire sprinklers provide fire protection in required areas of the station. Electrical and mechanical rooms within the station have various combinations of exhaust, heating and air conditioning which are controlled by the automated energy management system (AEMS). Control and monitoring of systems are provided through the data transmissions system (DTS). The outbound track bed within the NoMa station limits contains ductbanks for power, communication, contact rail heating, traction power, and grounding.

2.2 Pedestrian Access

Pedestrians arrive from all areas around the NoMa Station, including the business and residential developments east of the station, and Union Market and Gallaudet University east of the station. Qualitative observations indicate the majority of pedestrians arriving from east of the station use the southern entrance because of the wide sidewalk and well lit area. **Figure 4** shows the wide sidewalks on M Street Northeast in front of the south entrance to the NoMa Metro Station. **Figure 5** shows the narrow sidewalks on Florida Avenue pedestrians use to get from the northeast side of the railroad facilities to the northwest entrance. It is expected that the pedestrians gravitate towards the south entrance to avoid the narrow sidewalk adjacent to the travel lane.

Figure 4: Wide Sidewalks in front of NoMa Metro Station South Entrance

Figure 5: Narrow Sidewalk along Florida Avenue

The station can be accessed from:

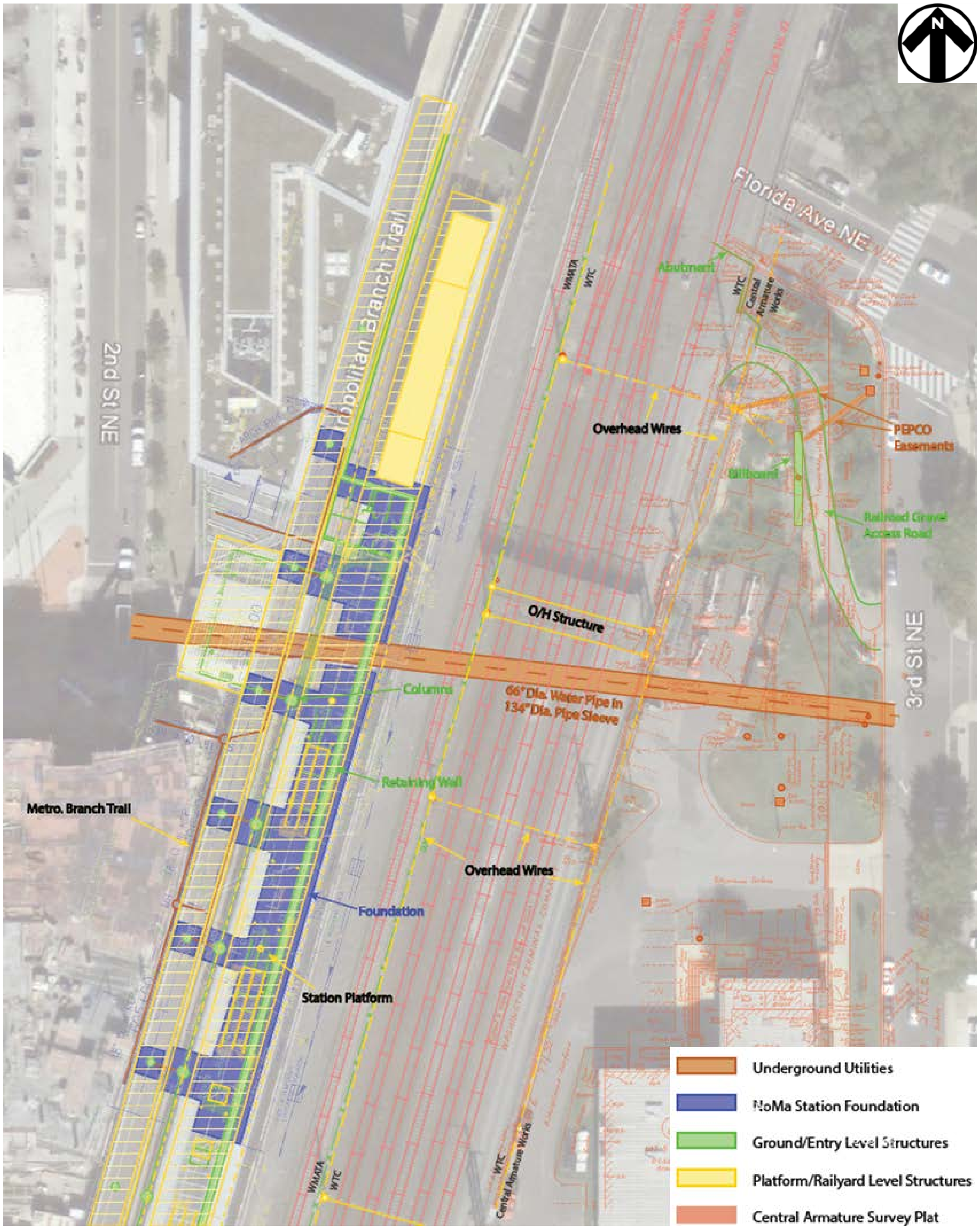
- Metro Bus routes X3, 90, 92, and 93, which stop on Florida Avenue between 3rd Street Northeast and 4th Street Northeast and then walking to the Metro entrance;
- The Metropolitan Branch Trail, which has an access ramp outside the south entrance and access stairs at the northwest entrance; and
- Driving and parking in a nearby lot.

There is also a Capital Bike Share station located just outside the south entrance on M Street Northeast, see **Figure 23** in **Appendix A**. When accessing the NoMa station, 81% of the passengers walk, 9% of the passengers take the bus, 9% of the passengers take a car, and 1% of the passengers use a bicycle, see **Figure 12** in **Appendix A**. Projected modal splits for arriving pedestrians could not be found in any of the reviewed studies.

2.3 Site Easement

The NoMa-Gallaudet University Metrorail station is located west of the passenger and freight rail tracks, stretching from M Street Northeast to Florida Avenue, between 2nd Street Northeast and 3rd Street Northeast. Two bridges, one over M Street Northeast and one over Florida Avenue, support the Metrorail tracks in the vicinity of the station. The elevated Metropolitan Branch Trail runs parallel to the tracks on the west side of the station. There is a 66" water main pipe with a 134" sleeve running east to west, passing only a few feet under the station's foundation but is buried approximately 20 feet under the existing ground line east of the station (see **Figure 6** and **Figure 14** in **Appendix A**). **Figure 6** shows that there is a gravel access road connecting the tracks to 3rd Street Northeast between Florida Avenue and N Street Northeast. There is a Pepco easement near the gravel access road. A billboard is present, adjacent to the gravel access road. There are also overhead wires, over the railroad tracks. Other easements, recorded and unrecorded, may be present on the site but records could not be found.

Figure 6: NoMa Metro Station Site Layout



3. Existing Land Uses

3.1 Development

Property in the study area is currently used largely for commercial uses, especially office. Prior to 2005, over 6 million square feet of office space and over 200,000 square feet of retail space existed in the NoMa neighborhood. Since 2005, office and retail space has doubled, while over 3,800 residential units and about 600 hotel rooms have also been added to the area. **Figure 7** provides details on where these developments have occurred, as well as the locations of planned developments in the area.

Figure 7: NoMa Development Map, NOMABID.ORG (2014)

DEVELOPMENT SUMMARY

Type	Office (SF)	Retail (SF)	Residential (units)	Hotel (rooms)	Total (SF)	% of Total
Delivered Before 2005	6,243,000	234,350	-	-	6,477,350	19%
Commercial Delivered 2005 – April 2014	6,508,258	331,426	-	-	6,839,684	20%
Residential	-	-	3,836	-	3,836,000*	11%
Hotel	-	_	-	622	435,400	1%
Planned	9,324,197	548,349	6,247	886	16,739,746	49%
TOTAL	22,075,455	1,114,125	10,083	1,508	34,328,180	

* Estimate

1 TRILOGY NOMA
Mill Creek Residential Trust
(A) 151 Q ST, NE (CIRQ)
Residential: 255 units
Retail: 1,250 SF
(B) 100 Q ST, NE (LINQ)
Residential: 130 units
(C) 200 Q ST, NE (ESQUE)
Residential: 218 units

2 50 FLORIDA AVE, NE
B&B Realty Investments
Residential: 182 units
Retail: 7,800 SF

3 O STREET SITES
Douglas Development
Mixed-Use: 1,000,000 SF

4 LOT 854
Brookfield Asset Management
Mixed-Use: 965,000 SF

5 WASHINGTON GATEWAY
MRP Realty
(A) ELEVATION
100 FLORIDA AVE, NE
Apartments: 400 units
Retail: 5,000 SF
(B) PHASES II & III
Office: 627,000 SF
Retail: 6,000 SF

6 COURTYARD BY MARRIOTT
Finvarb Group
1325 SECOND ST, NE
Hotel: 218 rooms
Retail: 10,000 SF

7 ATF HEADQUARTERS
U.S. Government
99 NEW YORK AVE, NE
Office: 422,000 SF
Retail: 8,000 SF

8 N STREET NOMA
The JBG Companies
(A) HYATT PLACE
33 NEW YORK AVE, NE
Hotel: 200 rooms
(B) 77 NEW YORK AVE, NE
Office: 900,000 SF
(C) 33 N ST, NE
Residential: 346 units
Retail: 5,000 SF
(D) 51 N ST, NE
Office: 58,000 SF
Residential: 250 units
Retail: 45,000 SF
(E) 1250 FIRST ST, NE
Office: 220,000 SF
Retail: 15,000 SF

9 NORTHWEST ONE
(A) 2 M ST, NE
William C. Smith/Warrenton Group
Apartments: 314 units
Retail: 4,100 SF
(B) PHASE II
District of Columbia
Mixed-Use

10 SKANSKA USA DEVELOPMENT
(A) 88 M ST, NE
Office: 314,000 SF
Retail: 6,000
(B) 44 M ST, NE
Office & Retail: 300,000 SF
(C) 22 M ST, NE
Residential & Retail: 340,000 SF

11 CAPITOL PLAZA
Principal Financial Group
1200 FIRST ST, NE
Office: 275,000 SF
Retail: 17,000 SF

12 CONSTITUTION SQUARE
(A) 145 N ST, NE
Northwestern Mutual
Office: 575,000 SF
Retail: 15,000 SF
(B) 1275 FIRST ST, NE
StonebridgeCarras
Walton Street Capital
Office: 330,000 SF
Retail: 15,000 SF
(C) HILTON GARDEN INN
OTO Development
1225 FIRST ST, NE
Hotel: 204 rooms
Retail: 10,000 SF
(D) FLATS 130
StonebridgeCarras
130/140 M ST, NE
Apartments: 643 units
Harris Teeter: 50,000 SF
Retail: 3,000 SF
(E) 150 M ST, NE
StonebridgeCarras
Office: 326,000 SF
Retail: 54,000 SF
(F) 175 N ST, NE
StonebridgeCarras
Office: 363,000 SF
Retail: 8,200 SF

13 300 M ST, NE
The Wilkes Company
(A) PHASE I
Residential: 400 units
Retail: 12,000 SF
(B) PHASE II
Mixed-Use

14 ULINE ARENA
Douglas Development
1140 THIRD ST, NE
Office: 153,000 SF
Retail: 54,000 SF

15 1109-1115 CONGRESS ST, NE
Congress, LLC
Mixed-Use: 17,000 SF

16 NOMA STATION
Bristol Group
(A) 131 M ST, NE
Office: 408,000 SF
Retail: 5,000 SF
(B) PHASES II–IV
Office: 700,000 SF
Residential: 700 units
Retail: 50,000 SF

17 FIRST + M
AvalonBay
(A) 1160 FIRST ST, NE
Apartments: 469 Units
Retail: 2,800 SF
(B) 55 M ST, NE
Apartments: 436 Units

18 DC HOUSING AUTHORITY
1133 N. CAPITOL ST, NE
Mixed-Use

19 NPR HEADQUARTERS
1111 N. CAPITOL ST, NE
Office: 330,000 SF

20 CAMDEN NOMA
Camden Property Trust
(A) 60 L ST, NE
Apartments: 321 units
(B) PHASE II
Apartments: 405 units

21 1150 FIRST ST, NE
Tishman Speyer
Office: 350,000 SF
Retail: 12,000 SF

22 1100 FIRST ST, NE
Rockefeller Group/
Mitsubishi Estate NY
Office: 345,000 SF
Retail: 5,000 SF

23 NORTH CAPITOL COMMONS
Be the Change
1005 N. CAPITOL ST, NE
Apartments: 111 units

24 SENTINEL SQUARE
(A) 90 K ST, NE
Utah State Retirement
Investment Fund
Office: 402,000 SF
Retail: 10,000 SF
(B) 1050 FIRST ST, NE
Trammel Crow Company
Office: 271,000 SF
Retail: 10,000 SF
(C) 45 & 55 L ST, NE
Trammel Crow Company
Office: 570,000 SF
Retail: 20,000 SF

25 STOREY PARK
Perseus Realty/
First Potomac Realty Trust
1005 FIRST ST, NE
Office: 350,000 SF
Retail: 60,000 SF
Apartments: 300 units

26 100 K ST, NE
Equity Residential
Apartments: 206
Retail: 1,500 SF

27 TOLL BROTHERS CITY LIVING
(A) 200 K ST, NE
Apartments: 300 units
Retail: 8,000 SF
(B) PHASE II
Apartments: 225
Retail: 5,000

28 CASCO, INC.
Residential: 41 units

29 LOREE GRAND
TIAA-CREF
250 K ST, NE
Apartments: 212 units
Retail: 3,600 SF

30 THE WASHINGTON CENTER FOR INTERNSHIPS & ACADEMIC SEMINARS
1005 THIRD ST, NE
Intern Residences: 95 units

31 UNION SQUARE III
Akridge/CIM Group
901 N. CAPITOL ST, NE
Office: 250,000 SF

32 25 K ST, NE
Euro-K Street Properties
Mixed-Use: 565,000 SF

33 77 K ST, NE
Brookfield Office Properties
Office: 310,000 SF
Retail: 16,000 SF

34 111 K ST, NE
New Boston Fund
Office: 98,000 SF
Retail: 1,100 SF

35 801 NEW JERSEY AVE, NW
The JBG Companies
Office: 400,000 SF

36 77H
Clarion Partners
77-99 H ST, NW
Walmart: 75,000 SF
Retail: 10,000 SF
Apartments: 303 units

37 55 H STREET, NE
The JBG Companies
Office: 265,000 SF

38 BURNHAM PLACE AT UNION STATION
Akridge
Mixed-Use: 3,500,000 SF

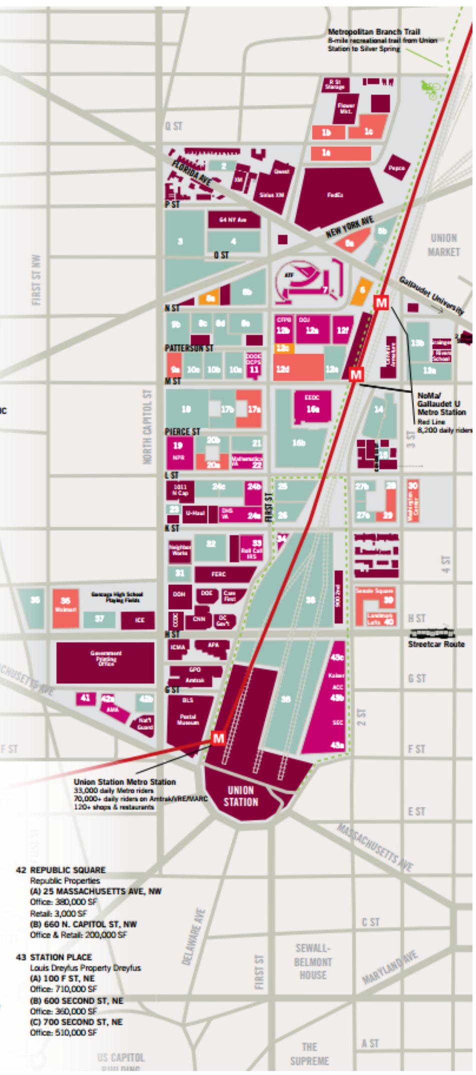
39 SENATE SQUARE
LaSalle Investment Mgmt.
201 EYE ST, NE
Apartments: 432 units

40 LANDMARK LOFTS
Abdo Development
800 THIRD ST, NE
Condominiums: 44 units

41 CENTRAL UNION MISSION
65 MASSACHUSETTS AVE, NW
Homeless Shelter &
Services: 33,400 SF

42 REPUBLIC SQUARE
Republic Properties
(A) 25 MASSACHUSETTS AVE, NW
Office: 380,000 SF
Retail: 3,000 SF
(B) 660 N. CAPITOL ST, NW
Office & Retail: 200,000 SF

43 STATION PLACE
Louis Dreyfus Property Dreyfus
(A) 100 F ST, NE
Office: 710,000 SF
(B) 600 SECOND ST, NE
Office: 360,000 SF
(C) 700 SECOND ST, NE
Office: 510,000 SF



Northeast of the NoMa-Gallaudet University Metrorail station, an area that has been historically used for wholesale food operations has recently seen more retail uses introduced, specifically at the Union Market building. At Union Market, along with several other properties nearby, planned unit development (PUD) for additional retail and residential units is either active or has been submitted for review.

3.1.1 Residential

Currently, the NoMa neighborhood has about 3.8 million square feet of residential space, most of which has been developed since 2005. The construction of additional residential units is expected to continue over the near-term, with an additional 1.9 million square feet of residential space to be added over the next five years. A map of the existing property owners can be seen in **Figure 54** in **Appendix A**.

3.1.2 Office

Office space makes up the greatest amount of land use in the NoMa neighborhood, with about 13 million square feet. Over the next five years, another 3.6 million square feet of office space are planned or proposed to be added.

3.1.3 Retail

Retail uses make up the smallest amount of land uses, with around 380,000 square feet. Aside from the development at Union Market, the greatest amount of retail is located near the NoMa-Gallaudet University Metrorail station, west of the Red Metrorail line between M St and N St. Over the next five years, additional retail space is expected to be constructed, nearly doubling the existing retail space.

3.2 Zoning

All of the study area around the NoMa-Gallaudet University Metrorail station falls under one of three commercial zoning designations: C-3-C, C-M-1, and C-M-3. **Figure 16** in **Appendix A** displays the boundaries of these zoning designations in the study area and **Table 1** describes the acceptable uses in each zoning district.

Table 1: Study Area Zoning Designations

Zoning Designation	Description
C-3-C	Permits matter-of-right development for major business and employment centers of medium/high density development, including office, retail, housing, and mixed uses to a maximum lot occupancy of 100%, a maximum FAR of 6.5 for residential and for other permitted uses, and a maximum height of ninety (90) feet. Rear yard requirements are twelve (12) feet; one family detached dwellings and one family semi-detached dwellings side yard requirements are eight (8) feet.
C-M-1	Permits development of low bulk commercial and light manufacturing uses to a maximum FAR of 3.0, and a maximum height of three (3) stories/forty (40) feet with standards of external effects and new residential prohibited. A rear yard of not less than twelve (12) feet shall be provided for each structure located in an Industrial District. No side yard shall be required on a lot in an Industrial District, except where a side lot line of the lot abuts a Residence District. Such side yard shall be no less than eight (8) feet.
C-M-3	Permits development of high bulk commercial and light manufacturing uses to a maximum FAR of 6.0, and a maximum height of ninety (90) feet with standards of external effects and new residential prohibited. A rear yard of not less than twelve (12) feet shall be provided for each structure located in an Industrial District. No side yard shall be required on a lot in an Industrial District, except where a side lot line of the lot abuts a Residence District. Such side yard shall be no less than eight (8) feet

Source: DC Office of Zoning

The study area falls within two districts used to finance neighborhood improvements: the New York Avenue Metro Area Special Assessment District and the NoMa Business Improvement District. The New York Avenue Metro Area Special Assessment District was created in 2001 to fund the construction of the NoMa-Gallaudet University Metrorail station through public-private partnership, with private funding coming through an additional property tax on non-residential properties in the district. The NoMa Business Improvement District was created in 2006 and funds beautification projects, street ambassadors, marketing, urban planning, economic development, and other improvements in the neighborhood through additional taxes on properties in the district. **Figure 17** in **Appendix A** shows the boundaries of these districts in relation to the study area.

3.3 Cultural Resources

3.3.1 Schools

One school exists within the study area, Two Rivers Public Charter School, which serves preschool through 8th grade students. Gallaudet University is slightly east of the study area and is specifically aimed to educate deaf and hard of hearing students. **Figure 18** in **Appendix A** shows the locations of these two schools in relation to the study area.

3.3.2 Parks

No parks or public open space currently exist within the study area. **Figure 19** in **Appendix A** shows the nearest parklands to the study area.

3.3.3 Historic Resources

Two sites in the study area are included in the National Register of Historic Places: the Woodward & Lothrop Service Warehouse on M St west of the Red Metrorail line and the Uline Ice Company Plant and Arena Complex on M St east of the Red Metrorail line. Both sites are also included under the District of Columbia Inventory of Historic Sites. **Figure 20** in **Appendix A** shows the location of these two historic sites, as well as the locations of other sites that are eligible for designation as a historic site.

3.3.4 Places of Worship

There are six places of worship is within the boundaries of the study area. **Figure 21** in **Appendix A** shows the location of this place of worship, as well as the locations of places of worship near the study area.

4. Existing Transportation Network

The existing transportation network in the study area includes a mix of pedestrian, bicycle, rail (Metrorail, commuter rail, and Amtrak), Metrobus, and automobile infrastructure and service. The non-automobile mode share in NoMa is approximately 35 percent (see **Figure 22** in **Appendix A**). While the study area itself has between 20 and 40 percent of households with zero cars, areas to the east and north of the study area have between 40 and 60 percent of households with zero cars, as seen in **Figure 23** in **Appendix A**.

4.1 Metrorail Ridership

The ridership at the NoMa Metro station has increased faster than predicted. In 2008 the Metrorail Station Access & Capacity Study predicted the average weekday ridership at the NoMa Metro Station to increase from 2,177 boardings in 2005 to 3,919 boardings in 2030, an 80% increase over 25 years (see **Table 5** in **Appendix B**). However, the average weekday boarding passengers, shown in **Table 6** in **Appendix B**, increased from 2,177 passengers in 2005 to 8,412 boarding passengers in 2014, a 286% increase over 10 years, 115% greater than the predicted 2030 average weekly ridership.

4.2 Automobile/Roadway Traffic

New York Avenue and Florida Avenue serve as the principle arterial streets within the study area and each carry 56,800 and 22,100 vehicles per day respectively. 1st Street Northeast, 4th Street Northeast, and M Street Northeast serve as collector streets in the study area, while all other streets in the study area serve local traffic. **Figure 24** in **Appendix A** shows the locations of arterials and collectors within ½ mile of the NoMa-Gallaudet University Metrorail station entrances. **Table 7** in **Appendix B** and **Figure 25** in **Appendix A** show traffic volumes in the study area.

Florida Avenue is considered a high frequency crash corridor by DDOT, as it had 1,361 total collisions between 2010 and 2012. Within the study area, the most dangerous intersection is at New York Avenue and Florida Avenue, where 160 crashes occurred between 2010 and 2012. Of all the intersections in the District of Columbia, the New York Avenue and Florida Avenue intersection ranked fifth for crash frequency from 2010 to 2012, third for crash severity cost in 2012, and was the 15th most hazardous intersection between 2010 and 2012, according to DDOT. **Figure 26** in **Appendix A** shows the history of crashes in intersections between 2010 and 2012 along the Florida Avenue corridor.

Additionally, the intersection at 1st Street Northeast and M Street Northeast was included in DDOT's ranking of dangerous intersections, as the 12th highest crash rate (2.85 crashes per million vehicles) in the District from 2010 to 2012. However, earlier data from 2005 to 2007 (see **Figure 27** in **Appendix A**) shows that the 1st Street Northeast and M Street Northeast intersection crash rates have not always been as high and several other intersections, including 1st Street Northeast and New York Avenue, 3rd Street Northeast and Florida Avenue, and 1st Street Northeast and N Street Northeast, have historically had higher crash rates.

4.3 Metrobus

The study area is served by four Metrobus lines: X3 and the 90s line (90, 92, and 93). **Figure 28** in **Appendix A** shows these routes, as well as the other Metrobus routes that serve the NoMa neighborhood, many of which travel along North Capitol Street west of the study area and K Street Northeast south of the study area. Within the study area, there is only one pair of bus stops, found at the intersection of 3rd Street Northeast and Florida Avenue.

Table 8 in **Appendix B** shows the headways of the Metrobus routes in the NoMa neighborhood, with the routes within the study area highlighted in yellow. The 90s line (90, 92, and 93) provides higher frequency service to the study area, with buses arriving every seven minutes during weekday peak service and 15 minutes during weekday off-peak service. X-3 provides service during peak hours and only in the peak direction, with 15 minute headways westbound in the morning peak and 30 minute headways eastbound in the afternoon peak.

The 90s line carries the most Metrobus passengers through the study area, with a weekday average of 12,266 riders. X3, which only runs during weekday peak hours in the peak direction, carries fewer riders: 1,502 on the average weekday. The westbound stop at the Florida Avenue and 3rd Street Northeast intersection contributes more than 600 average daily boardings to the ridership averages of these two routes, while the eastbound stop contributes between 151 and 300 average daily boardings, as seen in **Figure 29** in **Appendix A**.

4.4 Pedestrians and Bicycles

4.4.1 Network

Sidewalks exist on both sides of nearly every street within the study area, except for 3rd Street Northeast between Florida Avenue and M Street Northeast and N Street Northeast between 3rd Street Northeast and Florida Avenue, see **Figure 30** in **Appendix A**. At these two locations, sidewalk exists on only one side of the street. There is a staircase entrance near the entrance at the intersection of N Street Northeast and 2nd Street Northeast. Bicycle lanes can be found on 1st Street Northeast and 4th Street Northeast, see **Figure 31** in **Appendix A**. The study area is also served by a multi-use trail, the Metropolitan Branch Trail, which runs from Union Station to Silver Spring, Maryland on a combination of off-street and on-street facilities. The segment that runs through the study area is an off-street facility that runs uninterrupted from Union Station to Franklin Street Northeast, approximately 2.5 miles.

4.4.2 Pedestrian Volumes

The intersections with the highest volumes are found on the western side of the study area, with the intersection of 1st Street Northeast and N Street Northeast having high volumes both in the AM and PM peak, see **Figure 32** in **Appendix A**. East of the Red Metrorail line, the intersection at 3rd Street Northeast and M Street Northeast has the highest volume.

4.5 Pedestrian/Bicycle Network Deficiencies

The low pedestrian volumes at the Florida Avenue intersections at 2nd Street Northeast and 3rd Street Northeast may be related to deficiencies in the east-west connections in the pedestrian and bicycle network within the study area. In the vicinity of the NoMa Metro station, **Figure 33** in **Appendix A** shows that the bicycle level of service (LOS) on Florida Avenue is an E, while nearby north-south streets are D or better. LOS, established by the *Highway Capacity Manual*, assigns a letter grade to the relative traffic flow; A is the best grade with free flowing traffic and F is the worst grade with unstable flowing traffic. The *New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study* (2010) also identified east-west connections to the NoMa-Gallaudet Station to be hindered, see **Figure 34** in **Appendix A**.

The *New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study* (2010) also identified deficient pedestrian spaces, using criteria including: proximity of pedestrian activities to roadway, sidewalk gaps, sidewalk width, presence of planting strips and street trees, traffic volume, and posted speed limits. Along principle arterials and collector streets in the study area, no street has both high-pedestrian activity and highly-rated pedestrian deficiency, see **Figure 35** in **Appendix A**. However, the highest rated streets for pedestrian activity and deficiency within the study area are found to the east of the Red Metrorail line and freight and passenger railroad facilities. Higher levels of pedestrian activity and deficiency are found to the north and west of the study area.

The levels of pedestrian activity and deficiency are only partial reflected in the safety of intersections in the study area. Between 2010 and 2012, more bicycle and pedestrian crashes occurred on the west side of the study area, predominately at the intersection of New York Avenue and Florida Avenue and the intersection of 1st Street Northeast and N Street Northeast, see **Figure 36** in **Appendix A**. On the east side of the corridor, pedestrian and bicycle crashes are predominately clustered at the intersection of 3rd Street Northeast and Florida Avenue, which is also the location of the only pair of bus stops in the study area.

4.6 Passenger Rail

All trains traveling north from Union Station and all trains heading south to Union Station pass by the NoMa Gallaudet University Metro Station. Non-Metro trains run on the Northeast Corridor. No freight trains pass through the study area. Trains on the Northeast Corridor are powered by a combination of diesel engines and electrified overhead catenary structures.

4.6.1 Train Track Locations

The non-Metro tracks are located to the east of the Metro tracks and are located between 2nd Street Northeast and 3rd Street Northeast; all tracks run parallel to one another.

4.6.2 Track Utilization

At Washington Union Station, 128 revenue trains arrive and depart daily, as seen in **Figure 37** in **Appendix A**. The track usage at Washington Union Station (WUS) is broken down in **Figure 42** in **Appendix A**. The current arrival and departure times at WUS are shown in **Figure 39** in **Appendix A** and **Figure 40** in **Appendix A**. Note that two MARC trains have a layover in the West Yard, located to the north of the NoMa Station.

5. Existing Utilities and Drainage

5.1 Utilities

Being located in a fully developed and urbanized location, numerous existing utilities, both aerial and subsurface, are found within the project limits. This inventory of existing surface and subsurface utilities (recorded in **Table 2**) was performed using available documentation and observation. Note that the data reviewed contained discrepancies so not all utilities within the project area are accurately represented and located, including any undisclosed government utilities and any recent utility relocation work. Underground electric, telephone, and communication facilities are assumed to be contained within ductwork.

Table 2: Existing Utilities

Utility Type	Utility Owner	Description
Gas	Washington Gas	Unknown—no gas appears on materials.
Water	DC Water (WASA)	Underground distribution lines and service connections; size and locations vary from 3" to 66" (66" main is encased in 134" tunnel, crossing between 2nd and 3rd Street Northeast at N Street Northeast, see **Figure 51**). Fire hydrants are located around area.
Electric	Potomac Electric and Power Company (PEPCO), Washington Metropolitan Transportation Authority (WMATA)	Aerial – Overhead wires mounted typically to wooden poles are found along east side of tracks; size and type unknown. Subsurface – Underground facilities throughout project area. Extensive underground transmission and distribution facilities, including traction power and track heating, and station electric/lighting.
Telephone	Verizon Communications	Aerial – Overhead wires mounted typically to wooden poles are found along east side of tracks; size and type unknown. Subsurface – Unknown, no lines appear in materials.
Communication/ CATV	Washington Metropolitan Transportation Authority (WMATA)	Aerial – Overhead communication wires mounted typically to wooden poles are observed throughout the project area along both sides of the roadways; size and type unknown. Subsurface – Underground train communication cable/conduit within the project area.
Street Lighting	District Department of Transportation	Street lighting is throughout the project limits including bridge mounted lights. Luminaires are acorn (2nd Street Northeast) and cobra-head style (3rd Street Northeast) mounted on aluminum poles.
Traffic Signals/ Enforcement	District Department of Transportation and Metropolitan Police Department	DDOT standard traffic signals, control cabinets, and cameras and devices are around the project and are typically surface mounted on a standalone pole or foundation. DDOT cameras are typically for traffic surveillance while the MPD owned facilities are for red light and speed enforcement. Underground facilities including manholes, hand holes, and conduit are also present to services the aboveground equipment. Size and location of underground facilities are unknown.
Sanitary Sewer	DC Water (WASA)	Sanitary lines of various sizes run along M Street Northeast and Florida Ave. Station cleaner room includes sanitary sewer drain to M Street Northeast.
Storm Drainage	DC Water (WASA)	Storm runoff on ground surface is conveyed by gutters to catch basins; size and location of drainage piping varies. Existing underground storage system west of tracks and treatment structure (between M and N Street Northeast). Tracks are drained by PVC pipes and small grate inlets. Retaining walls include underdrains.
Rail	Washington Metropolitan Transportation Authority (WMATA)	Project is adjacent to WMATA facilities. As such, underground utilities may be present. Project crosses beneath and over existing rail facilities.

5.2 Drainage

5.2.1 Site Drainage

Site **Survey plat, Lot 8 , Square 747** (**Figure 55** in **Appendix A**) shows 2 catchbasins along M Street Northeast, 1 catchbasin at south end of 3rd Street Northeast, and 1 catchbasin along Florida Avenue. No pipes are shown on the survey. The outbound tracks appear to have 12” perforated PVC drains with cleanouts in the track bed and above the ducts. The PVC drains outlet approximately 4 feet below the finished grade. The at-grade typical sections show ditches and inlets on both sides of tracks. However, the ditch and inlet line work and related details are clouded out and crossed out on the plans so information was lost in the review. The Noma Station appears to have a multiple-barrel Contech 60-66” diameter underground SWM storage system and a Stormceptor. The drainage network appears to tie into the existing 36”x54” drainage structure at the center of M Street Northeast.

5.2.2 Metro Station Drainage

The **Metro as-built** plans (see **Figure 56** through **Figure 63** in **Appendix C**) show a canopy roof with scupper and drainspouts approximately every 65 feet. The escalators and elevators have sump pits for drainage and are expected to outlet to the sanitary sewer. It is assumed that the sump pits also have pumps to ensure the pits properly drain. The ballast drain plans show 8” PVC drain pipes extending under the floor at finish grade, tying into the 12” PVC outlet drains. The platform support wall detail sheet shows underdrain for the platform support wall along the top of the footings and outlets at finished grade, located approximately at station 102+45. The elevated track support details show scupper grates for the central drainage slot and 4” PVC drainpipes.

5.3 Site Topography

The NoMa Metro Station sits approximately at elevation 70 feet as seen in **Figure 2**. East of the NoMa station, the area slopes towards 3rd Street Northeast; 3rd Street Northeast slopes north towards Florida Avenue. East of the NoMa station, the grade gently slopes east until 3rd Street Northeast where the elevation steeply drops approximately 10 feet. West of the NoMa station, the elevation steeply drops approximately 20 feet (before 2nd Street Northeast) and then gently slopes to the southwest.

5.4 Subsurface Geotechnical Soils Information

The geologic conditions at the NoMa Metro station are interpreted based on the geotechnical data presented in the Geotechnical Engineering Report for Glenmount Route, NoMa-Gallaudet University Metrorail station and from Borings NY-17U and NY-18A drilled in the vicinity of the proposed tunnel, see **Figure 64** in **Appendix C**, Geotechnical Plan and Borings.

The subsurface conditions in the vicinity of these borings consist of approximately seven feet of fill overlying 20 feet of clays and sands of the Terrace deposits, which is underlain by clays and sands of the Potomac group. Fill generally consists of interlayers of stiff clay and medium dense silty/clayey sands, with SPT values ranging from 6 to 17. The Terrace deposits include of interlayers of stiff silty clays and medium dense silty/clayey sands, with SPT values ranging from 9 to 21. The clays and sands of the Potomac group consists of very stiff silty clays and medium dense to very dense silty/clayey sands, with SPT values ranging from 10 to 40. The groundwater elevation measured in the borings at the time of investigation ranges approximately from Elev. 42 to 48 feet. The soil and groundwater data obtained from the boring currently drilled for this project will confirm the above interpreted geologic conditions.

An existing geotechnical engineering report generated in July 2001 for construction of the new NoMa Metro station is available and can be used as the basis of ground assessment for tunneling. Specifically Borings number 14 through 18 and test results for those boring are located on the station side of the tracks. Additional borings are being taken along on the 3rd Street Northeast area for future development. These borings will be included in the review when received. Geotechnical data beneath the non-Metro rails has not been found at the time of this report. Since trains have operated in this area for decades, it is likely that surface ground may have local contamination.

Records appear to indicate that the local area is not within the 100-year flood zone.

6. Previously Proposed Land Uses

6.1 Residential

Planned residential uses in NoMa will include a mix of apartments, condominiums, and townhouses. Currently, ground-floor residences are not found in NoMa, but exist to the northwest and southeast of the study area. As development occurs, ground-floor residences are expected to be added to east-west streets where smaller right-of-way may not be conducive to commuter and retail traffic, as seen in **Figure 41** in **Appendix A**. This strategy is intended to provide connections to surrounding residential neighborhood and complement plans for retail development.

6.2 Retail

Retail development in the study area is planned for 1st Street Northeast, M Street Northeast, 3rd Street Northeast (between Florida Avenue and M Street), N Street Northeast (east of the Red Metrorail line and railroad tracks and facilities), and 4th Street Northeast (between Florida Avenue and M Street Northeast). As seen in **Figure 42** in **Appendix A**, the highest priorities for retail development are located adjacent to the M Street Northeast entrance to the NoMa-Gallaudet University Metrorail station and at the intersection of 1st Street Northeast and M Street Northeast. These priorities are intended to emphasize east-west connections to the redevelopment opportunities at Uline Arena and the Florida Avenue Market, both of which are expected to serve as major neighborhood destinations.

6.3 Open Space

Aside from the Metropolitan Branch Trail, the study area currently has no public open space. In large part, plans for open space in NoMa are reliant on connections and improvements to the Metropolitan Branch Trail, as well as landscaped streets (see **Figure 43** in **Appendix A** and **Figure 44** in **Appendix A**). The *NoMa Public Realm Design Plan* (2012) has also proposed a park within the study area at the intersection of 3rd Street Northeast and N Street Northeast, as seen in **Figure 45** in **Appendix A**.

7. Previously Proposed Transportation Network Improvements

Roadway, transit, and pedestrian and bicycle improvements have already been proposed for the NoMa Metro Station because of the growing popularity of the area surrounding the NoMa Metro station. As discussed in section 5.1, the average weekly ridership is increasing faster than expected in 2008 due in part to the development of the surrounding area.

7.1 Roadway Improvements

Roadway improvements in the study area include a mix of new roads, conversion of one-way streets to two-way, a road diet on Florida Avenue, and various intersection improvements. In the *NoMA Vision Plan and Development Strategy* (2006), the new roads in the study area include an extension of 2nd Street Northeast from N Street Northeast to L Street Northeast, extension of Patterson Street from 1st Street Northeast to the planned 2nd Street Northeast extension, and an alleyway from N Street Northeast to M Street Northeast between 3rd Street Northeast and 4th Street Northeast (see **Figure 46** in **Appendix A**). While not including the Patterson Street extension and the new alleyway, the *NoMa Neighborhood Access and Transportation Management Plan* (2010) also recommends the extension of 2nd Street Northeast, though only between N Street Northeast and M Street Northeast, where it would serve as a pedestrian priority street (see **Figure 47** in **Appendix A**).

As seen in **Figure 47** in **Appendix A**, only one conversion of a one-way street to two-way traffic is recommended within the study area, found on 4th Street Northeast. A pair of conversions from two-way traffic to one-way streets is recommended for L Street Northeast and K Street Northeast. Several other conversions are recommended near the study area, including on segments of M Street Northeast that fall outside of the study area boundary, Patterson Street, and Pierce Street.

A road diet is planned for Florida Avenue along the eastbound lanes from 2nd Street Northeast to Gallaudet University, as seen in **Figure 48** in **Appendix A**. The additional space from removing one eastbound lane would be used to create wider sidewalks. Along with the intersection realignment at Florida Avenue and New York Avenue (see **Figure 46** in **Appendix A**), a realignment is proposed for the intersection of N Street Northeast and Florida Avenue, as shown in **Figure 49** in **Appendix A**. Additionally, new traffic signals are recommended at the intersections of 1st Street Northeast and N Street Northeast (which would include east, west, and southbound left-turn phasing), 3rd Street Northeast and M Street Northeast (which would include eastbound left-turn phasing) and Florida Avenue and 2nd Street Northeast. The existing traffic signal at 1st Street Northeast and M Street Northeast is recommended to be modified to include left-turn phasing for east, west, and southbound turns, following the conversion of the segment of M Street Northeast west of 1st Street Northeast to a two-way street. Prohibitions against right turns at red lights are proposed for 3rd Street Northeast and Florida Avenue for northbound traffic on 3rd Street Northeast, due to the poor sight distance through the Florida Avenue underpass.

7.2 Transit

The *NoMA Vision Plan and Development Strategy* proposes a modification to Metrobus service that would bring the D1, D3, D4 line to the study area to serve a new pair of bus stops at the NoMa-Gallaudet University Metrorail station entrance at M Street Northeast (see **Figure 50** in **Appendix A**). The route of this proposed modification, as well as a proposed new DC Circulator route that would connect NoMa to the Nationals Stadium and Waterfront area, relies on the extension of 2nd Street Northeast from N Street Northeast to L Street Northeast.

The *NoMa Neighborhood Access and Transportation Management Plan* also proposes additional DC Circulator routes, as seen in **Figure 51** in **Appendix A**. These new routes could either be an extension of the existing Union Station to Navy Yard route (like the route proposed in *NoMA Vision Plan and Development Strategy*) or an entirely separate route. By connecting to both Union Station and NoMa-Gallaudet University Metrorail station, the proposed DC Circulator routes could provide access to rail service, support local commercial destinations, and provide a cost savings to businesses in the area that are currently running private employee shuttles.

7.3 Pedestrians and Bicycles

Improvements proposed within the study area that are exclusively for pedestrians are the addition of sidewalk along the southbound lanes of 3rd Street Northeast between Florida Avenue and M Street Northeast and the widening of sidewalk as a result of the road diet on Florida Avenue between 2nd Street Northeast and Gallaudet University (see **Figure 48** in **Appendix A** and **Figure 49** in **Appendix A**).

Proposals for bicycle facilities address needs of both travel and parking. New bicycle lane proposals include either a shared use path or bicycle lane (see **Figure 52** in **Appendix A** and **Figure 53** in **Appendix A**) on M Street Northeast, a cycle track or bicycle lanes on L Street Northeast, bicycle lanes on N Street Northeast west of NoMa-Gallaudet University Metrorail station, and a combination of protected cycle track and unprotected bicycle lanes on 1st Street Northeast. A ramp to the Metropolitan Branch Trail would connect to the proposed bicycle lanes or cycle track on L Street Northeast. Covered bicycle parking facilities are recommended at both entrances to the NoMa-Gallaudet University Metrorail station. The addition of a bike sharing location at the NoMa-Gallaudet University Metrorail station, proposed in the *NoMa Neighborhood Access and Transportation Management Plan*, has already occurred, as well as a Capital Bikeshare location at the intersection of 1st Street Northeast and M Street Northeast.

8. Conclusions

The NoMa-Gallaudet University Metrorail station, which opened in 2004, is heavily utilized and ridership has grown faster than expected, attributed to the rapid development in the neighborhood. Pedestrians arrive at the station predominately by walking. The station has two entrances, northwest and south, with the south entrance receiving noticeably more traffic. Pedestrian and bicycle connections to the east and particularly northeast of the station are negatively affected by higher level of vehicle traffic on Florida Ave, narrow sidewalks, and poor sidewalk lighting. The majority of the development surrounding the NoMa Metro Station has occurred west of the tracks; most of the development has been either residential, office, or retail. Existing plans call for additional large developments to the east of the station. The existing transportation network is constantly being updated to accommodate projected passenger growth and east-west connections will likely increase in priority.

The station has a hybrid structural configuration, where the outbound track is on an embankment supported by a cantilever cast-in-place concrete retaining wall, and the inbound track is on a precast concrete box girder guideway. The inbound and outbound tracks are slightly higher (varies) than the adjacent tracks to the east. The girders supporting the inbound track are at a minimum of 12 feet (varies) above the ground level. The ground level of the station consist of entrances and fare boxes at the northwest and south ends of the station and are connected by a 29 foot wide corridor that runs the length of the station. Main structural elements relevant to this study include: the 3’-9” thick embankment retaining wall beneath the outbound track; the spread-footing foundation for the wall; columns spaced 66’-8” to support the inbound track and the Metropolitan Branch Trail. Structural elements, in addition to columns, which impacting direct access to the retaining wall near the northwest entrance include service rooms to the north and vertical circulation to the south.

Available utilities data indicates a 66” water main encased in a 134” diameter concrete pipe sleeve which lies just beneath the northwest entrance to the station and continues east to the intersection of 3rd Street and N Street. Data regarding foundations for rail related structures and geotechnical data east of the station and west of 3rd Street were not available at the time of this report.

Appendix A: Figures

Figure 8: Recent Studies and Previously Proposed Infrastructure Projects, Recommended New Roads, Signals, and Two-Way Streets, NoMA Vision Plan and Development Strategy (2006), p. 3.15

Figure 9: Northwest Entrance Section

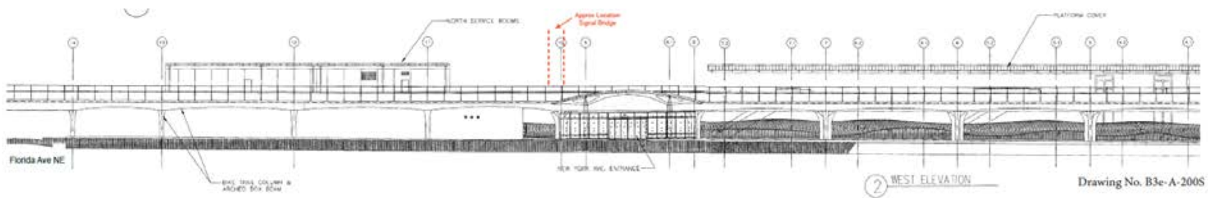


Figure 10: South Entrance Cross Section & Platform Location

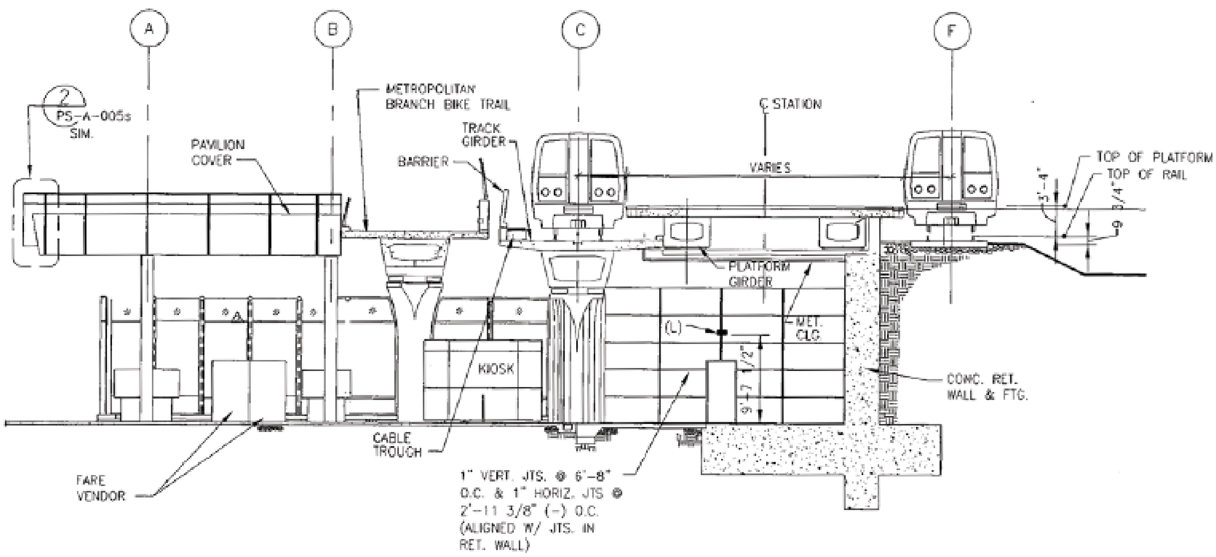


Figure 11: Location of concrete columns and station platform

Figure 12: Existing Access Mode Shares (2007), New York Avenue-Gallaudet University Station Access Improvement Study, p. 11

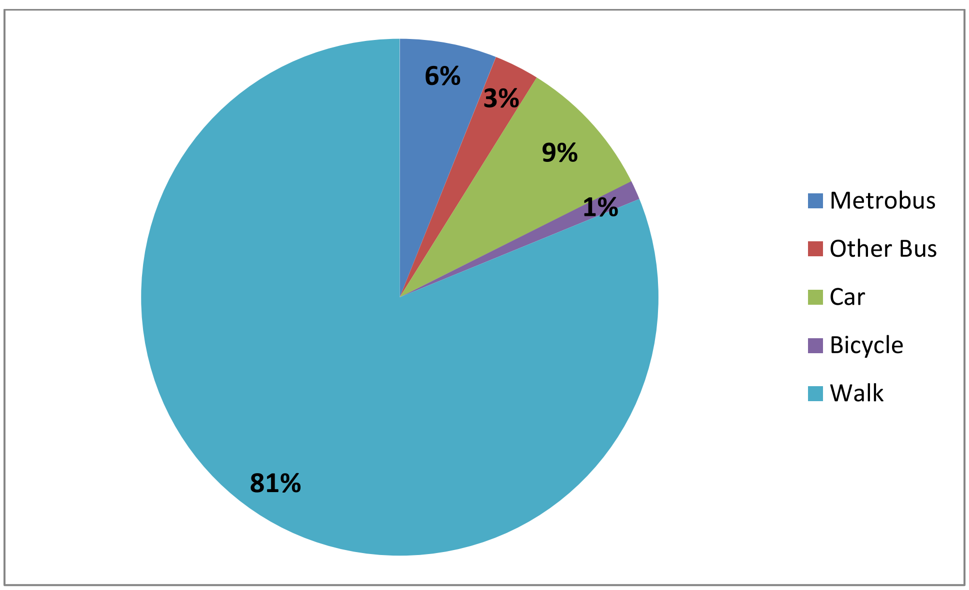


Figure 13: Typical Structural and Station Section

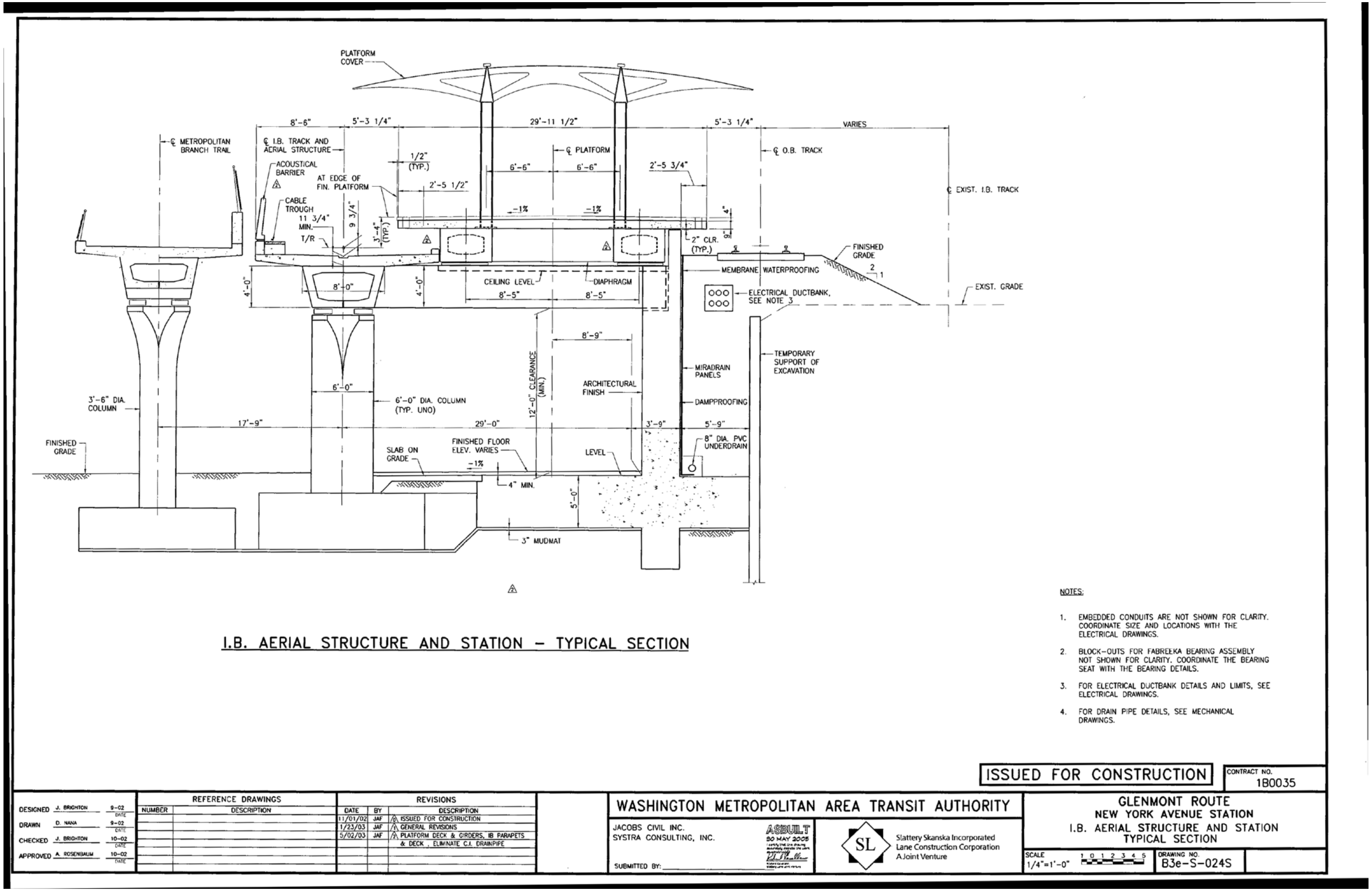


Figure 14: Existing Water Pipe Profile

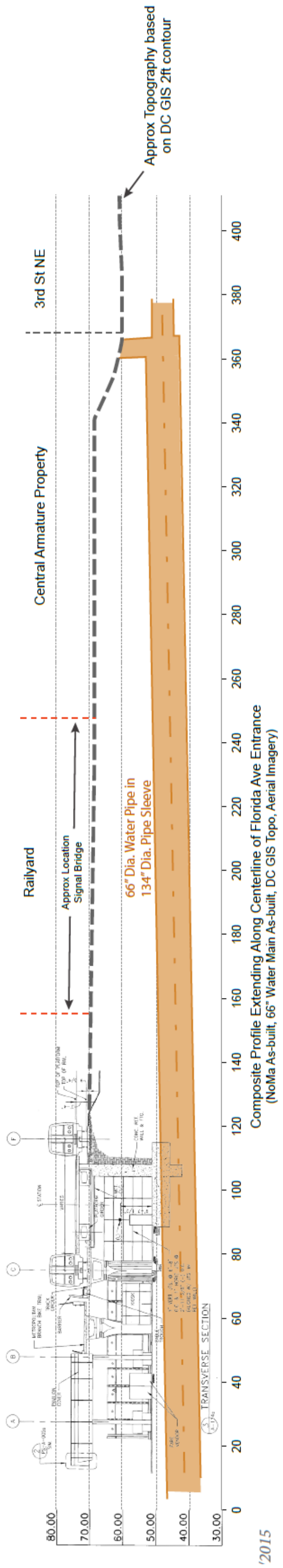


Figure 15: Development Map, NoMA Vision Plan and Development Strategy (2006), p. 3.5

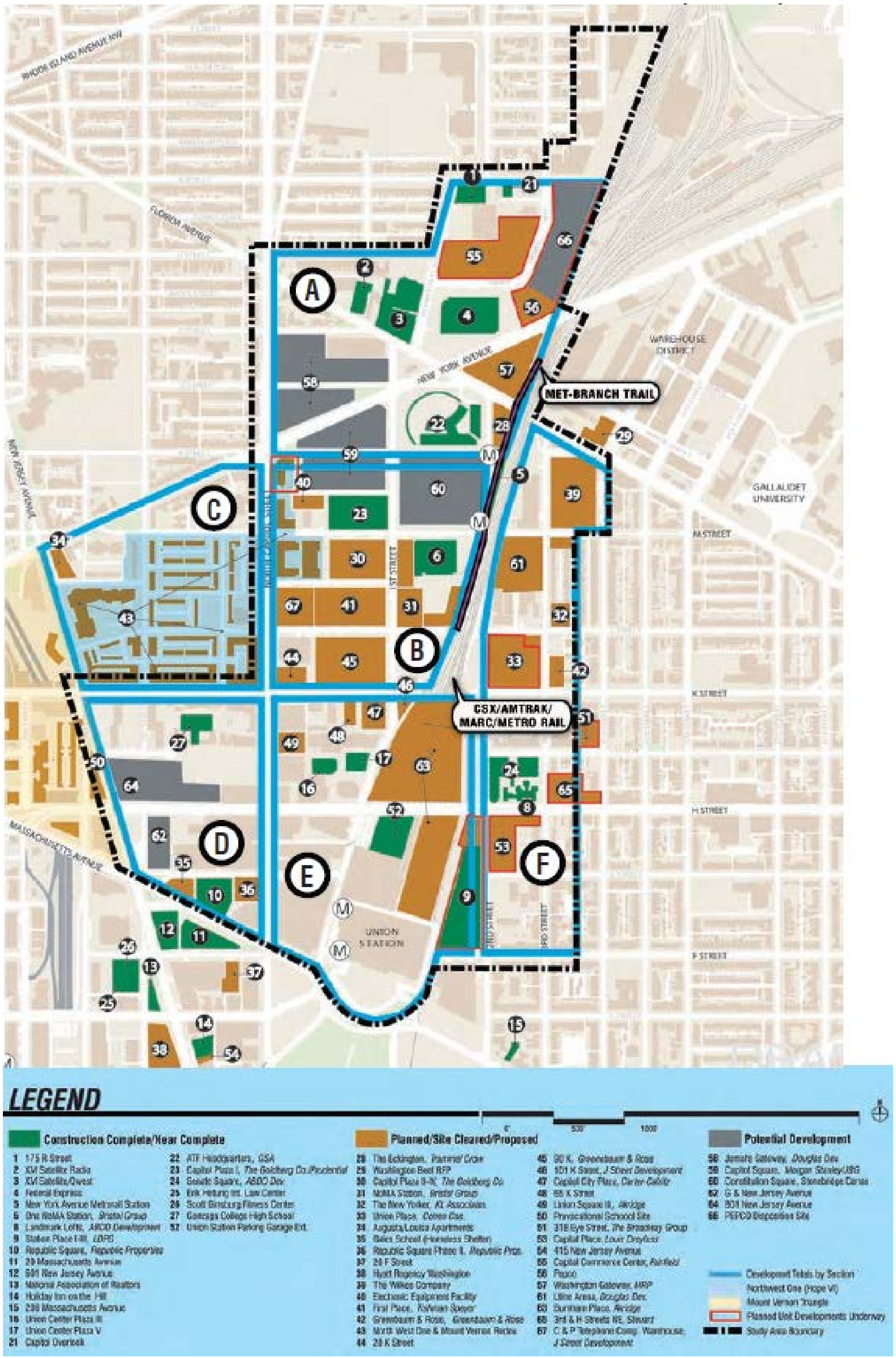


Figure 16: Existing Zoning, NoMA Vision Plan and Development Strategy (2006)

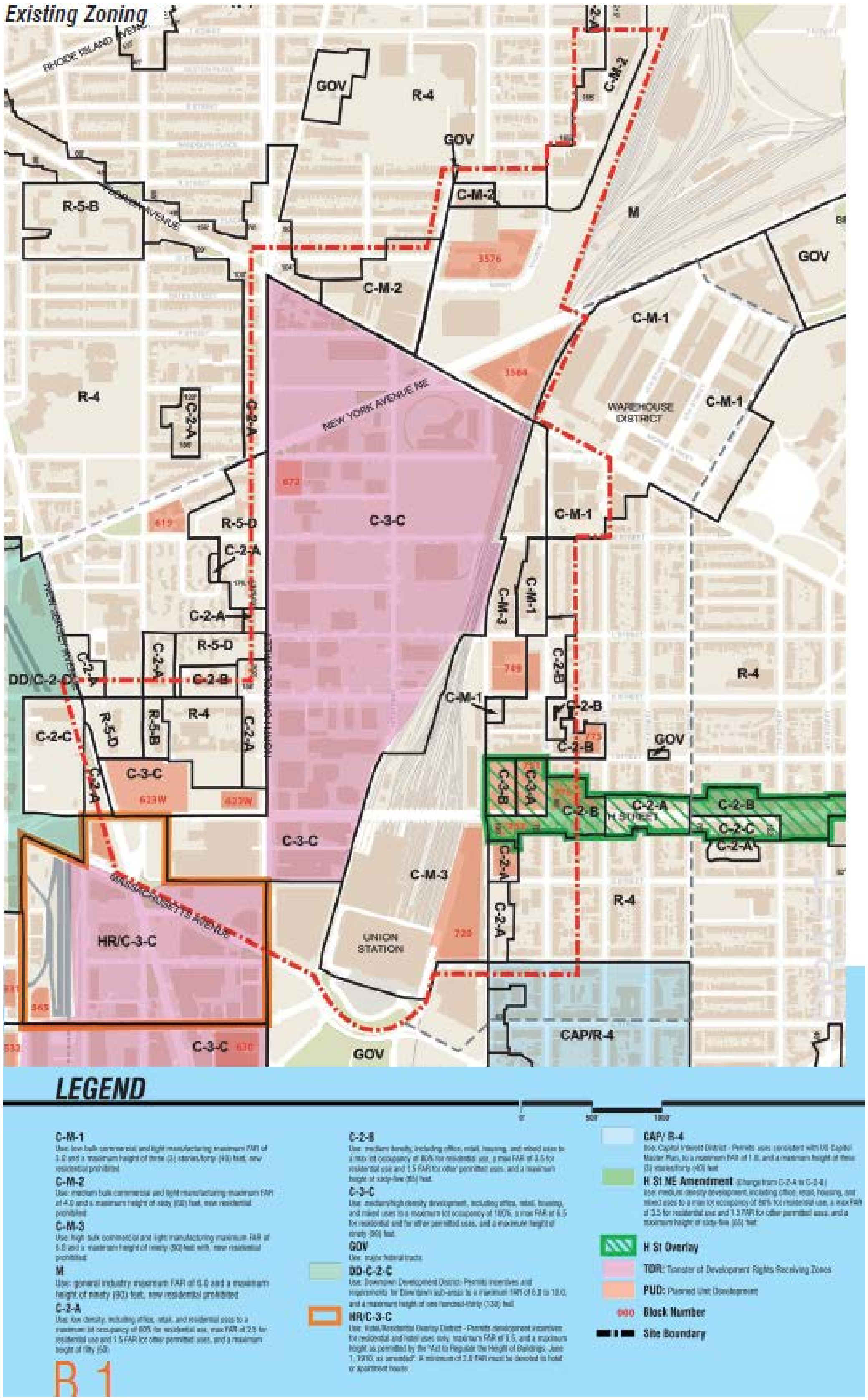


Figure 17: NY Avenue Metro Area Assessment Boundaries, NoMA Vision Plan and Development Strategy (2006)

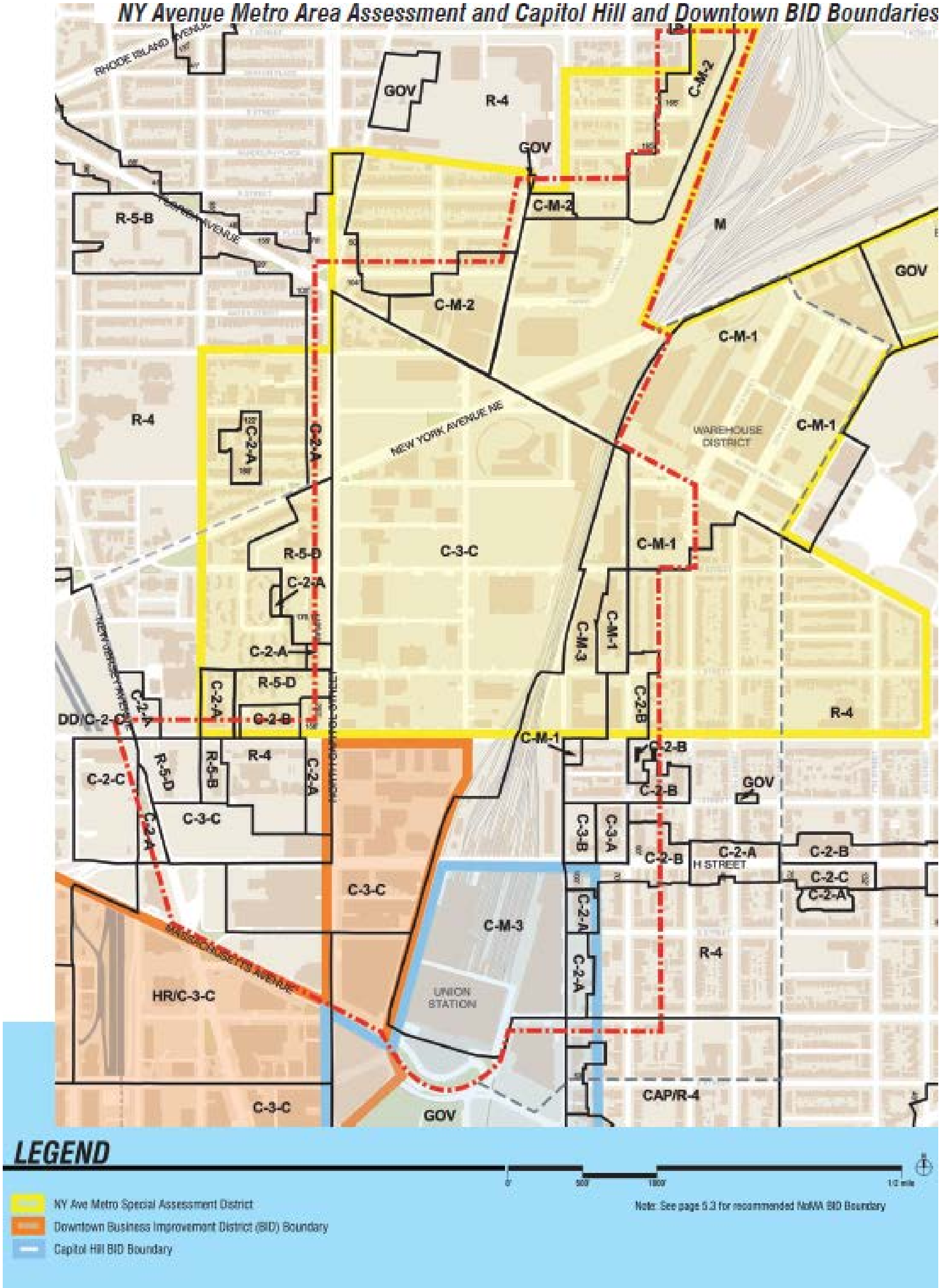


Figure 18: Schools, DC Atlas Plus

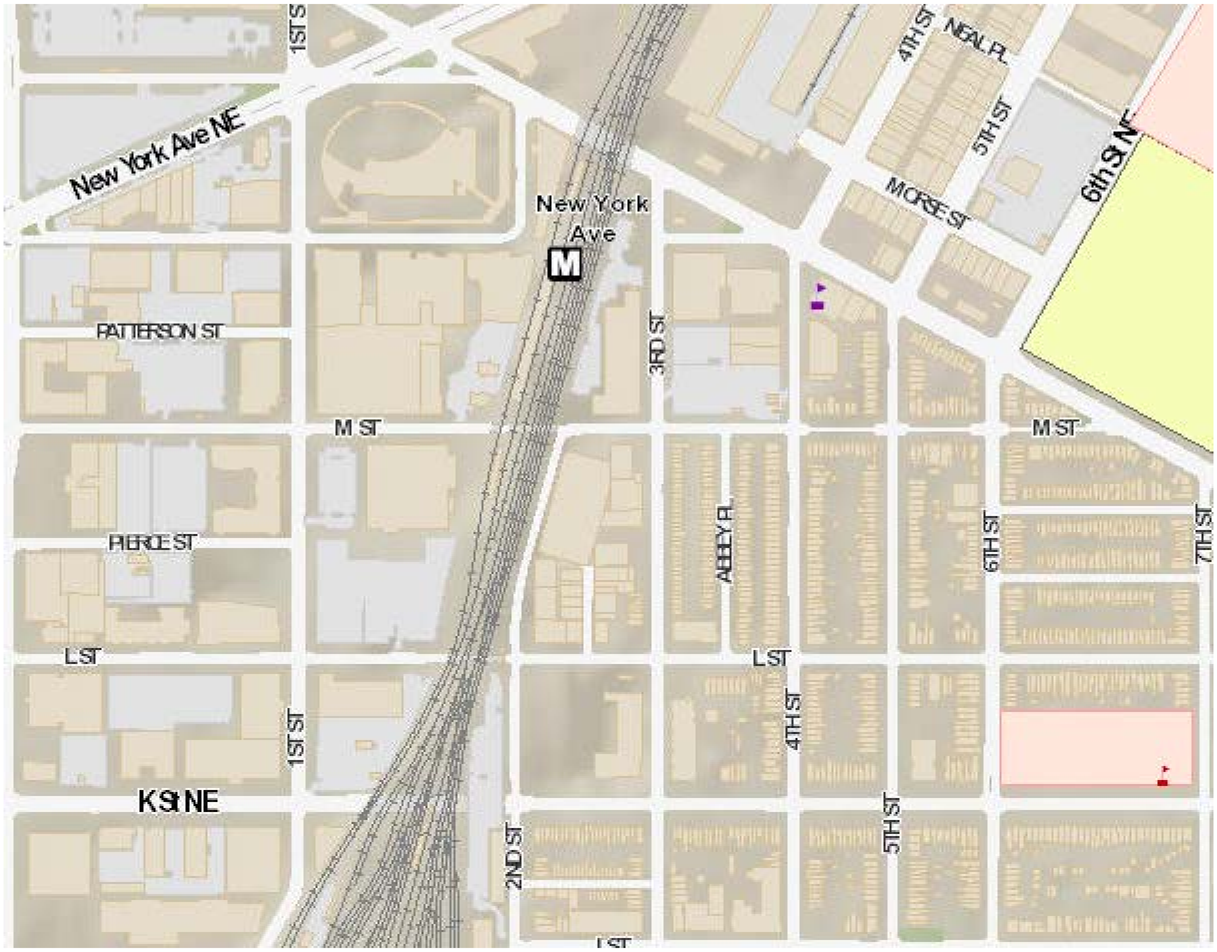


Figure 19: Existing Open Space, NoMA Vision Plan and Development Strategy (2006), p. 3.20

Figure 20: Historic Resources, NoMA Vision Plan and Development Strategy (2006), p. 3.29

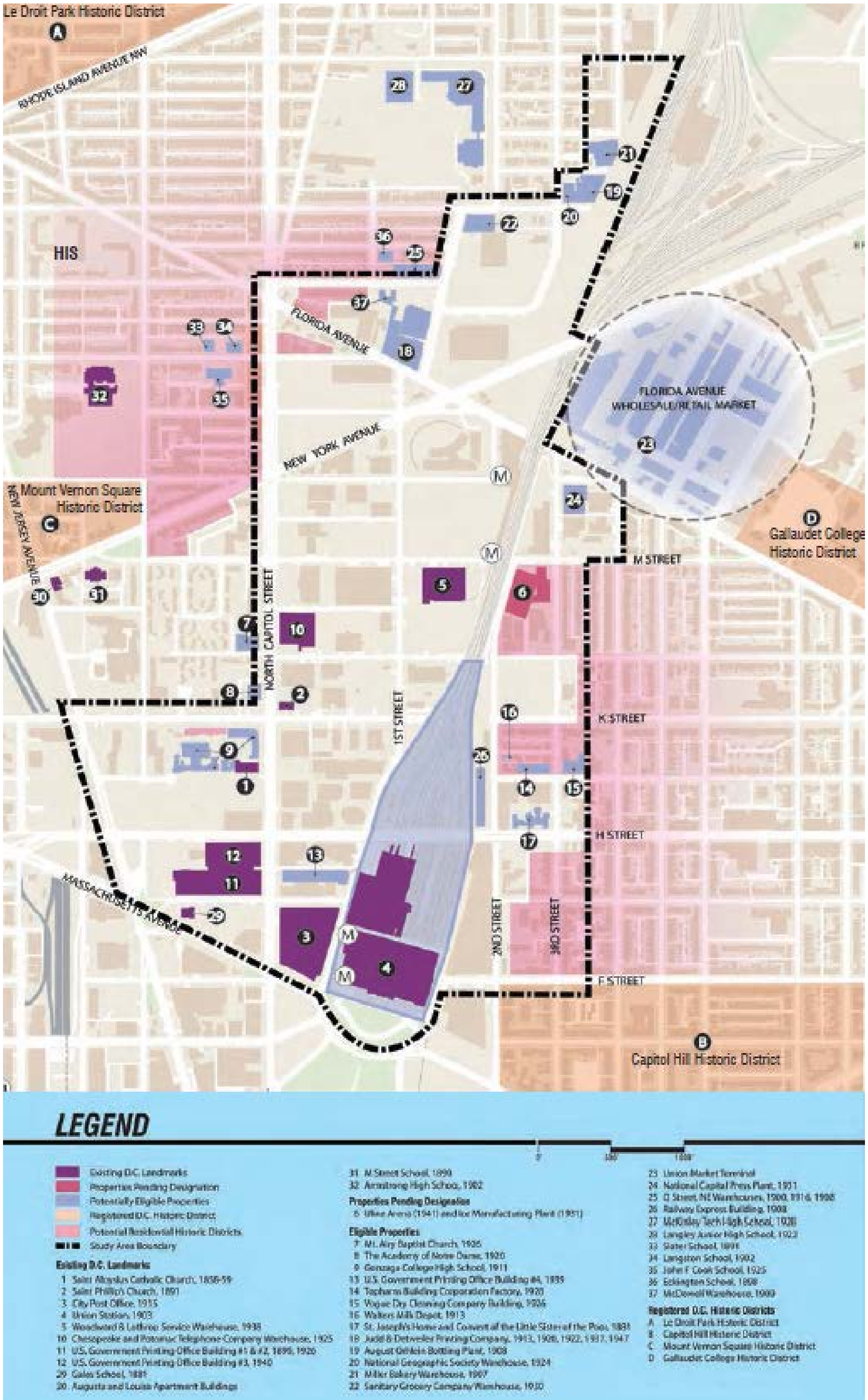


Figure 21: Places of Worship, DC Atlas Plus

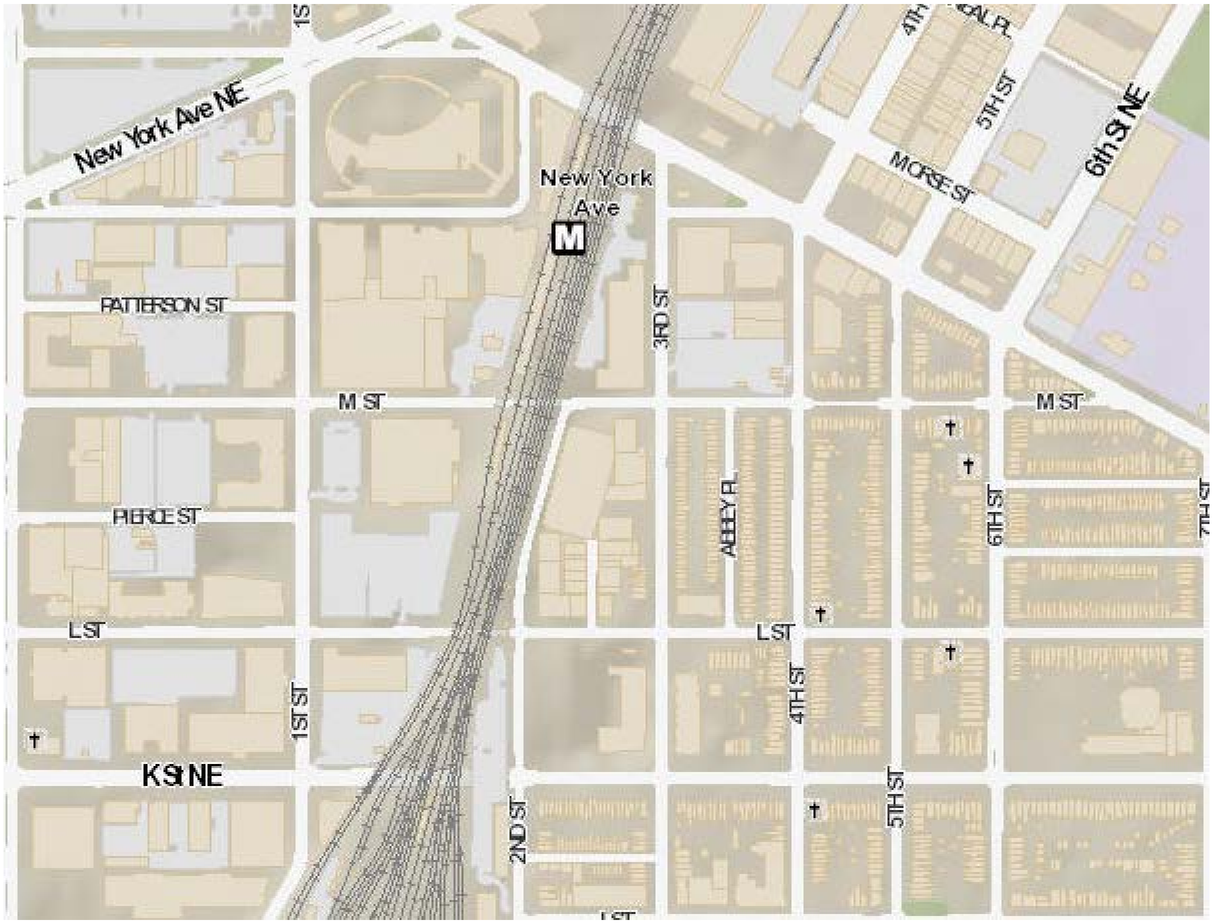


Figure 22: NoMA Mode Split, Gateway Market Transportation Impact Study (2013), Appendix G

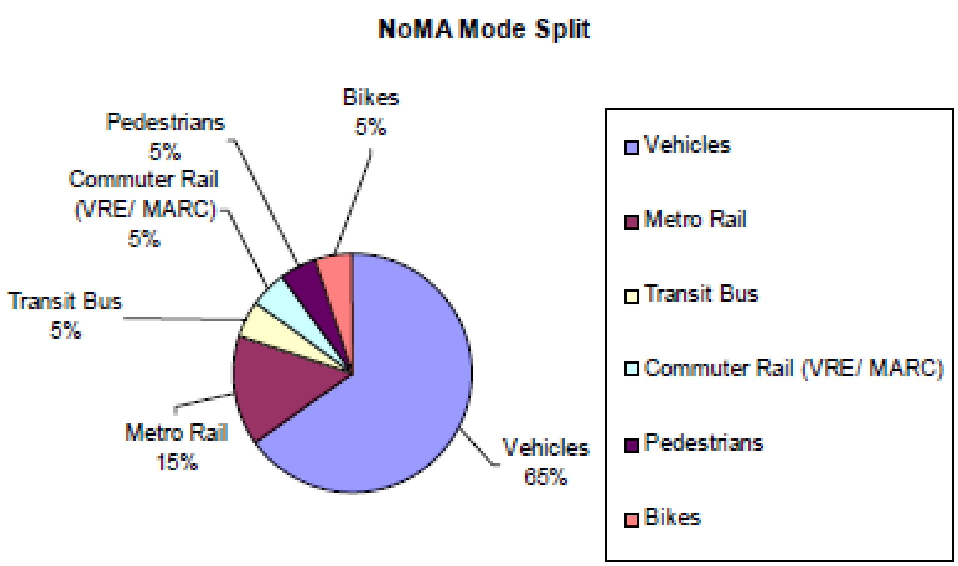


Figure 23: Zero Car Households, Florida Avenue Multimodal Transportation Study Public Meeting slides (2013), Slide 8

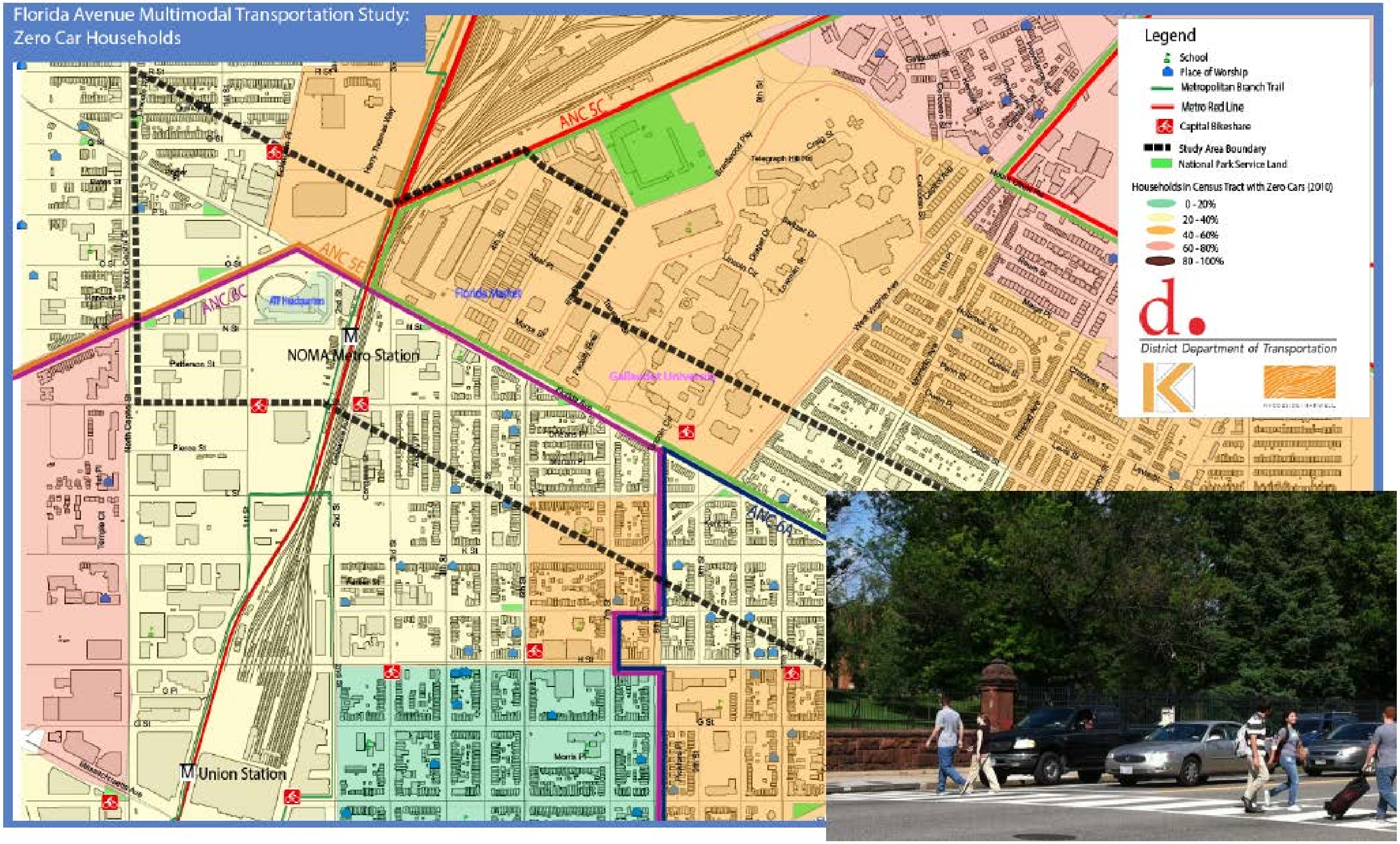


Figure 24: Roadway Classifications, New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study (2010), p. 21

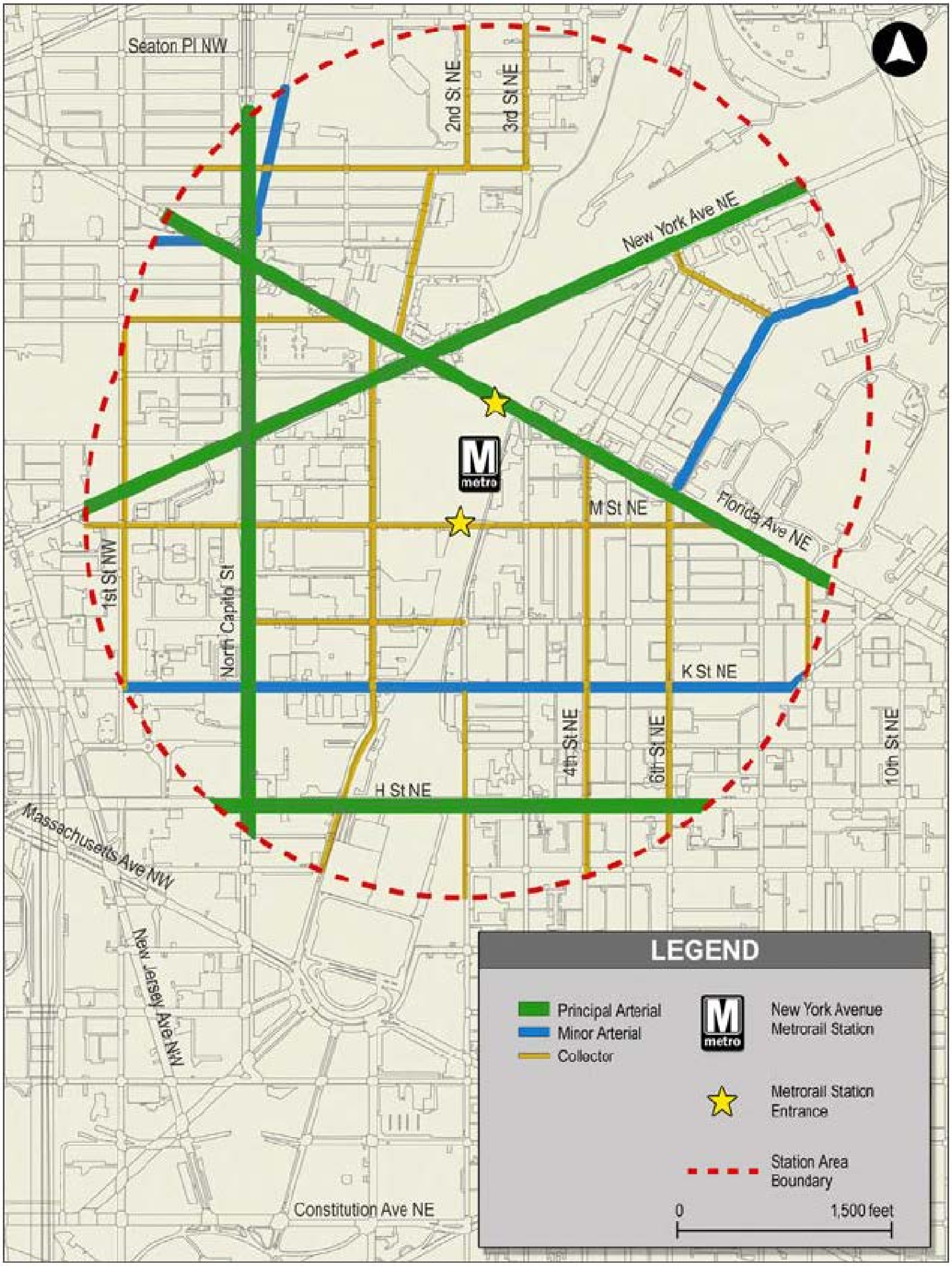


Figure 25: 2012 Traffic Volumes (in thousands), DDOT

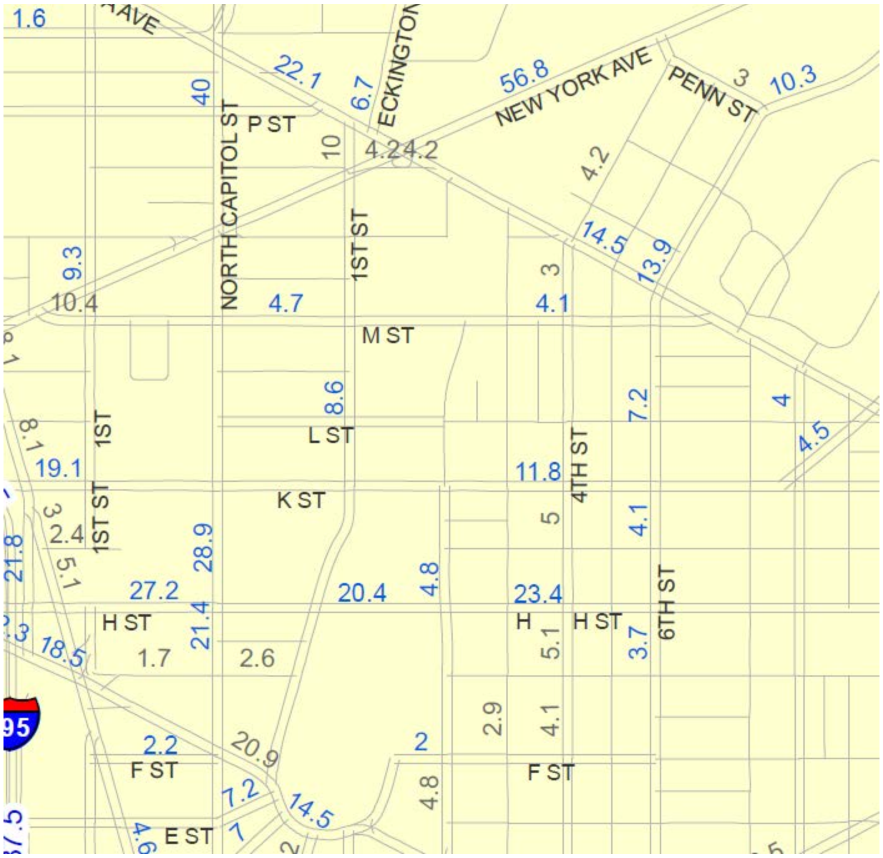


Figure 26: Intersection Crash History (2010-2012), Florida Avenue Multimodal Transportation Study Public Meeting slides, Slide 10

Figure 27: Intersection Crashes and Crash Rates (2005-2007), NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

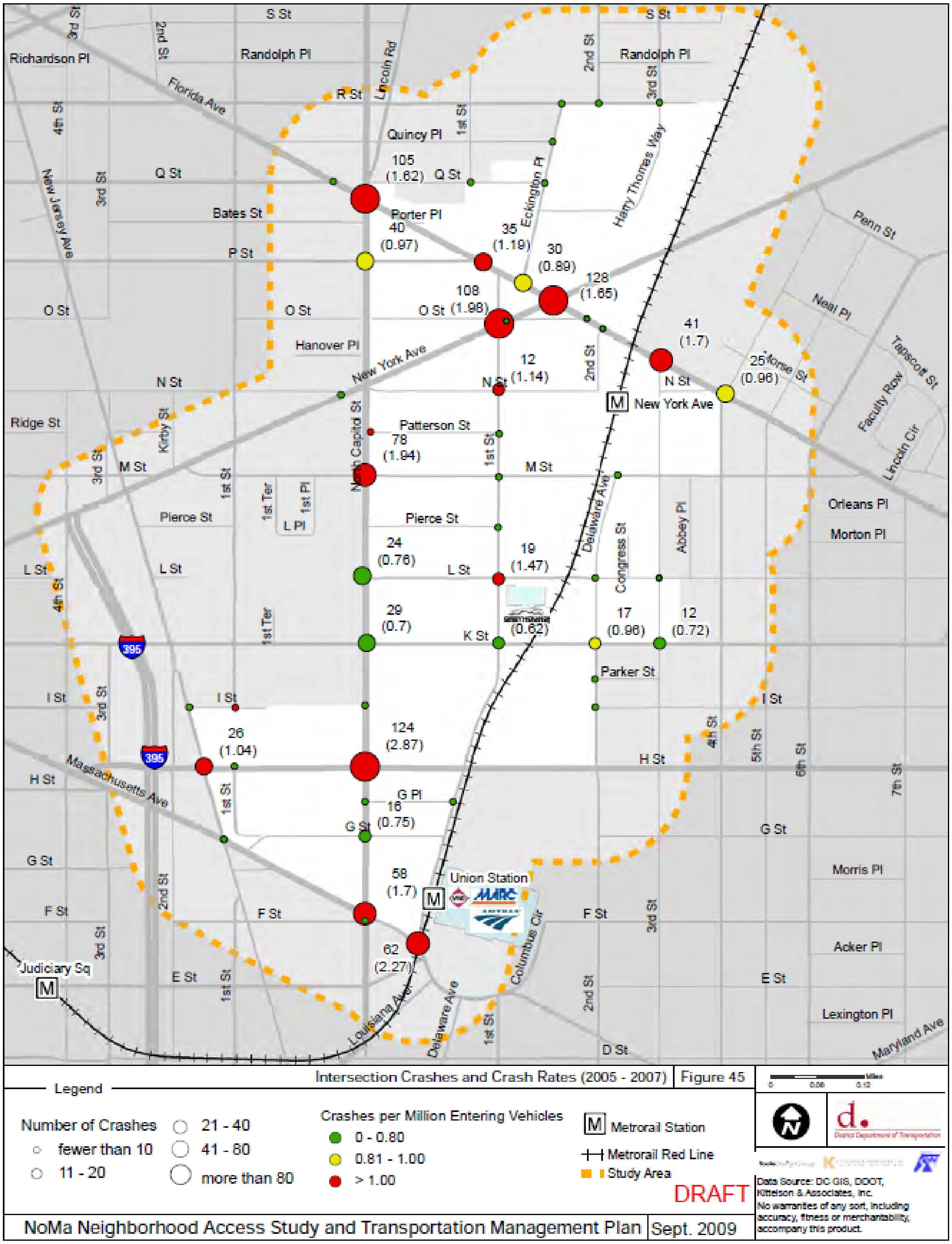


Figure 28: Local Transit Routes, NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

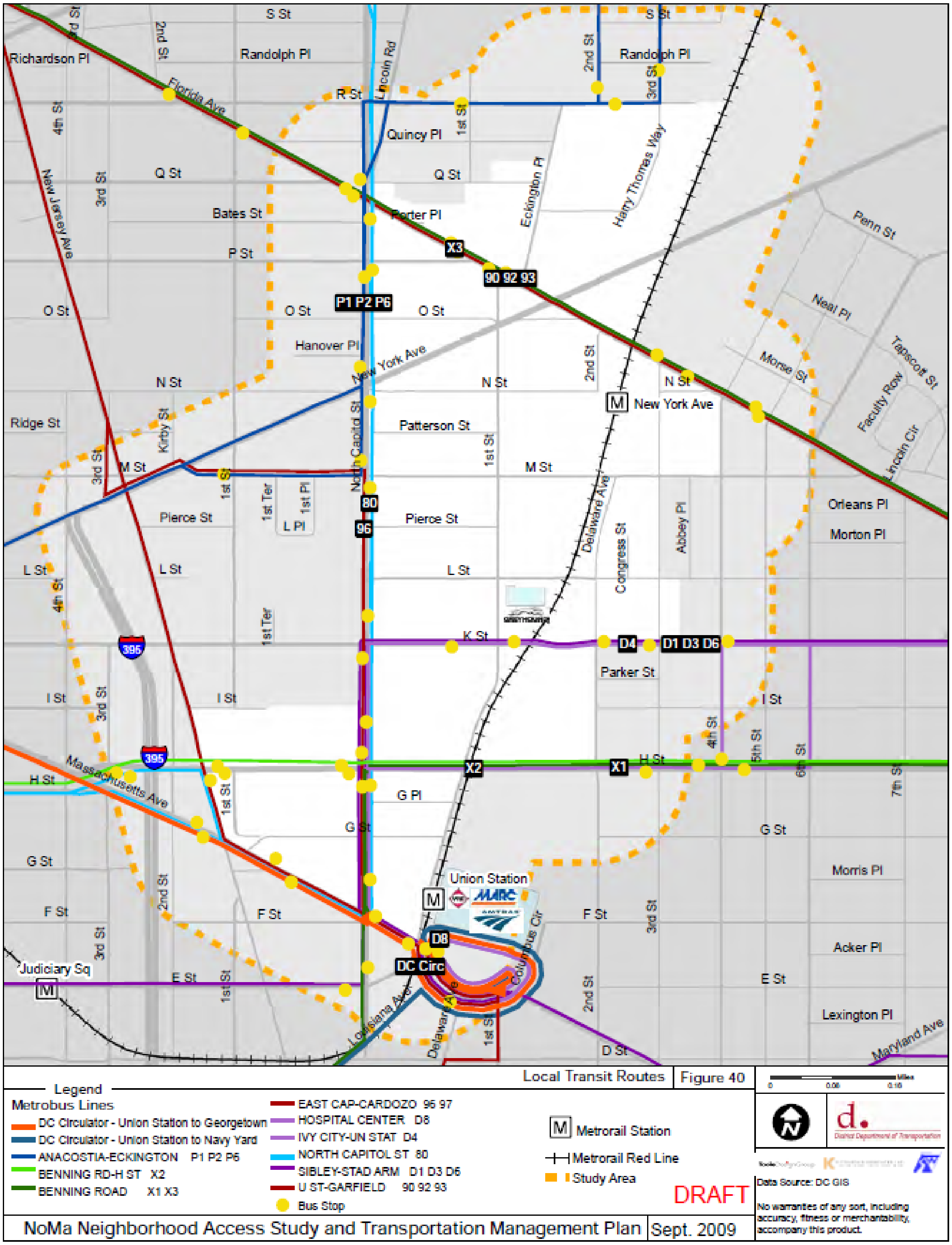


Figure 29: Total Daily Boardings (Metrobus), NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

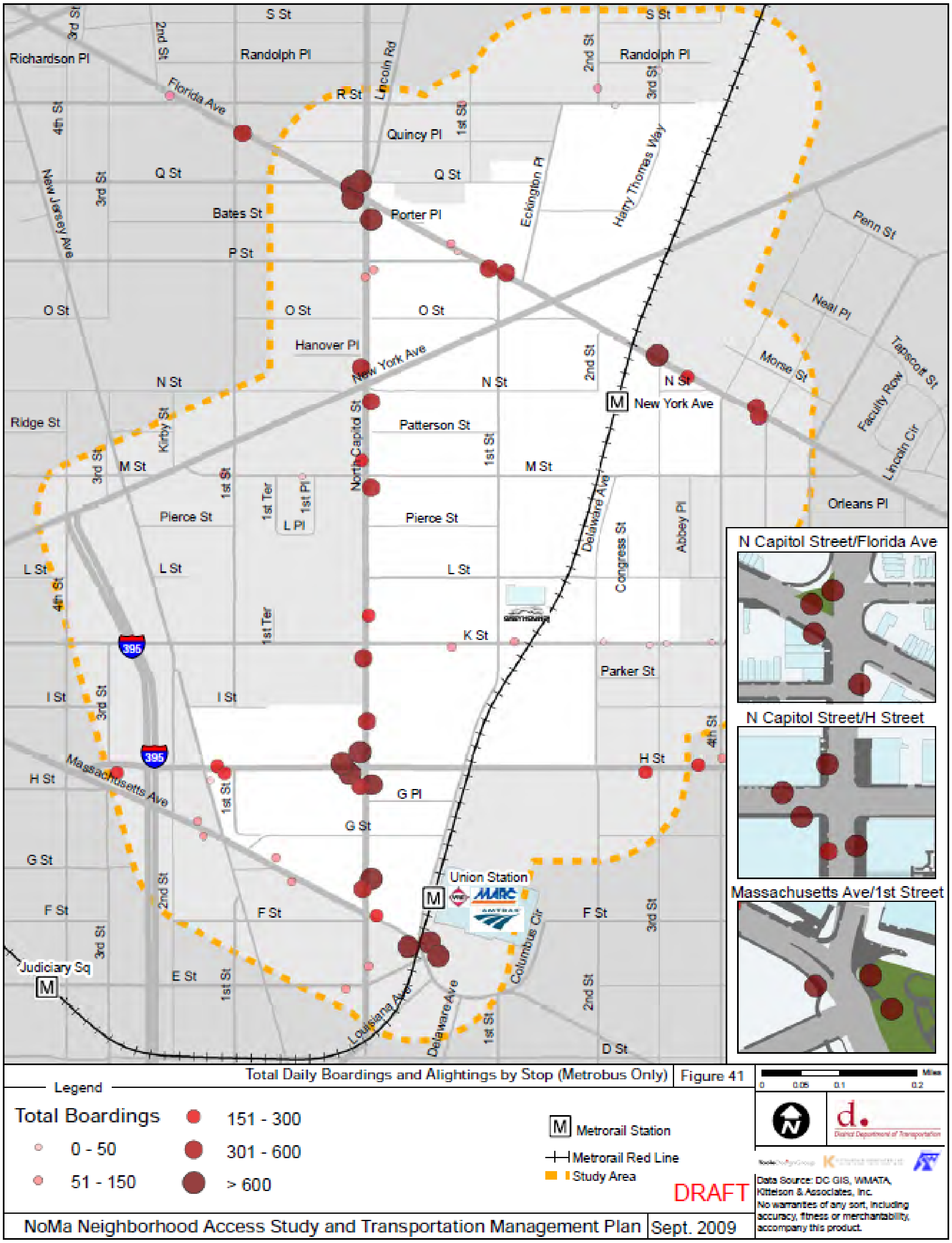


Figure 30: Existing Pedestrian Facilities, NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

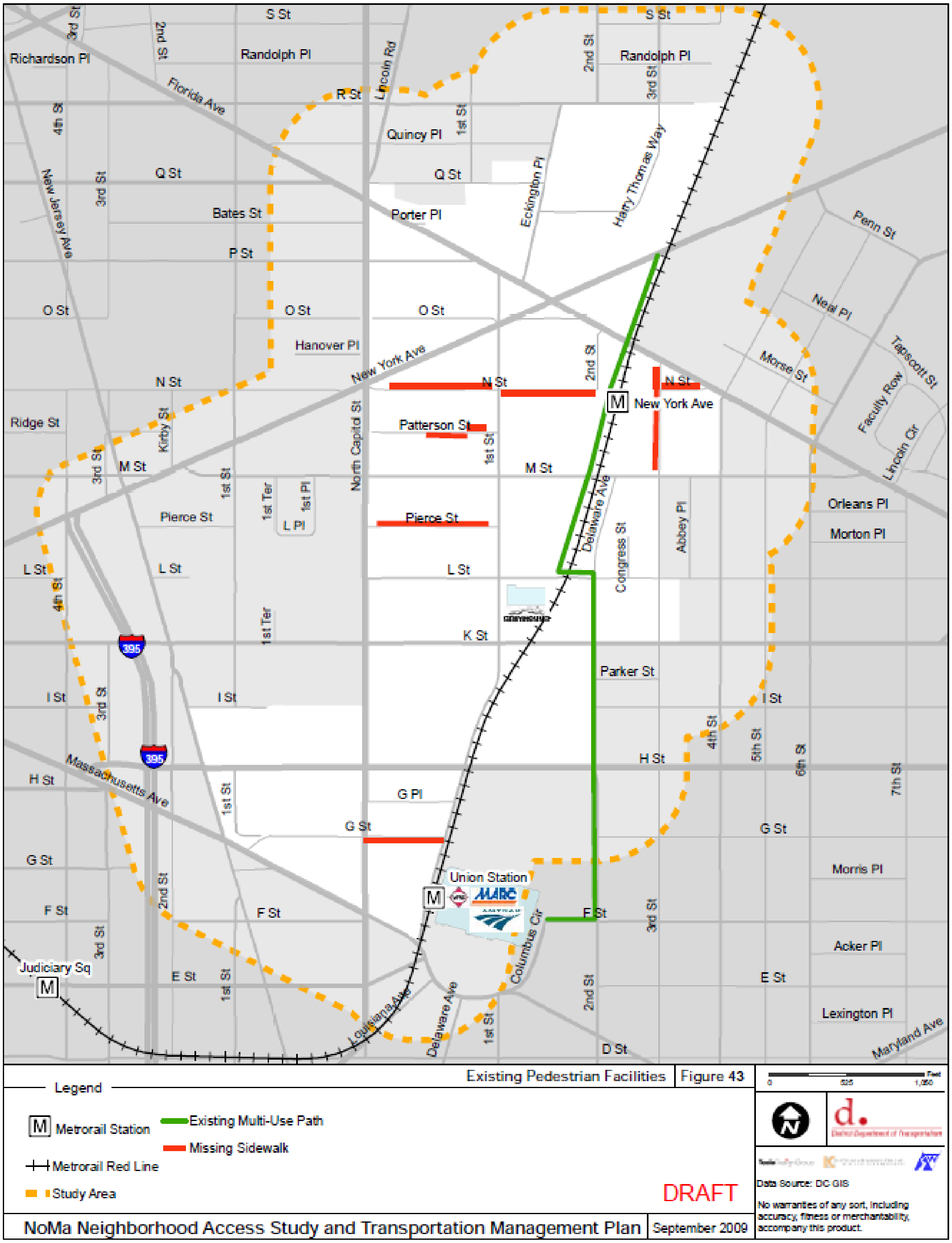


Figure 31: Existing Bicycle Facilities, NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

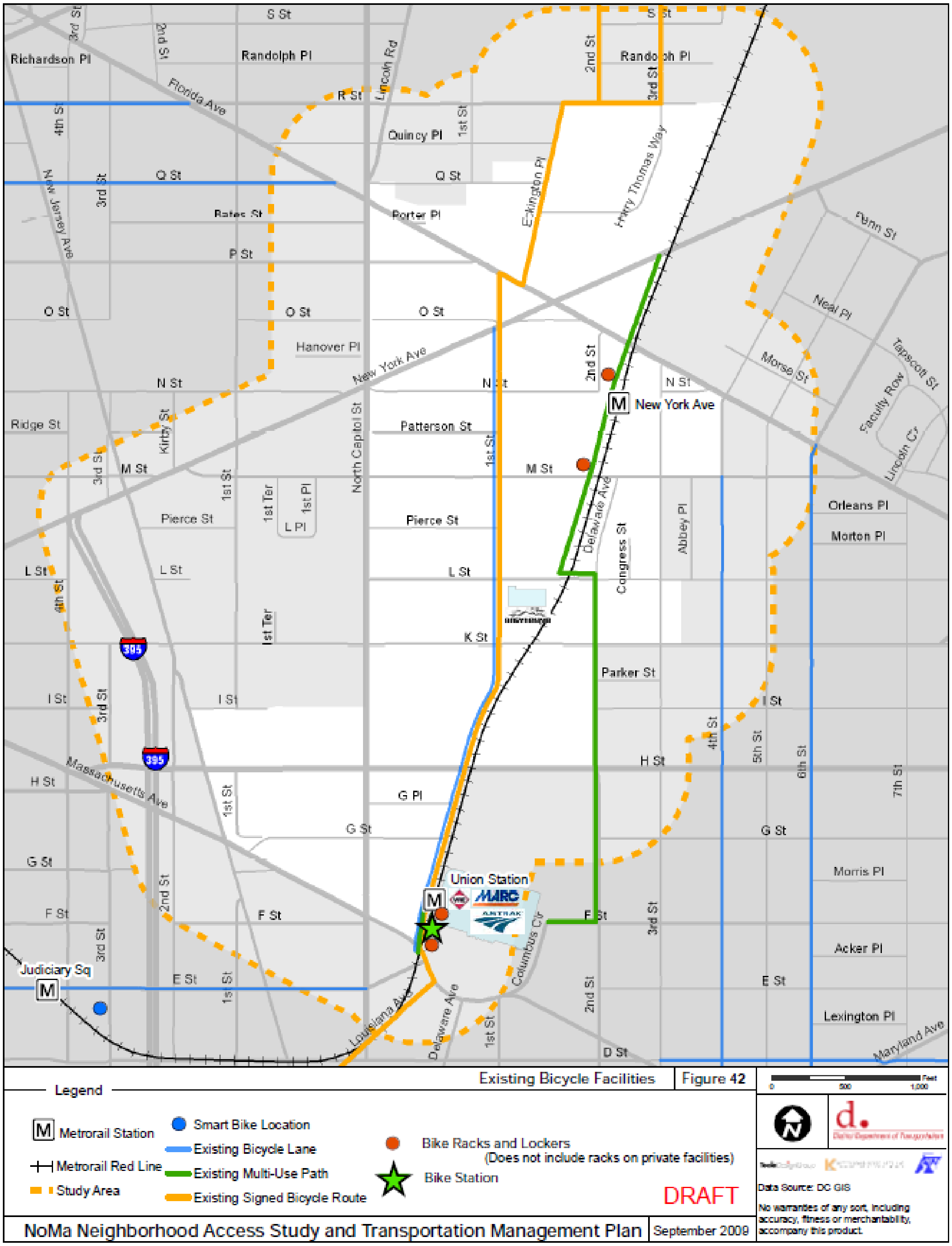


Figure 32: AM and PM Pedestrian Volumes, NoMa Neighborhood Access and Transportation Management Plan (2010), Appendix G

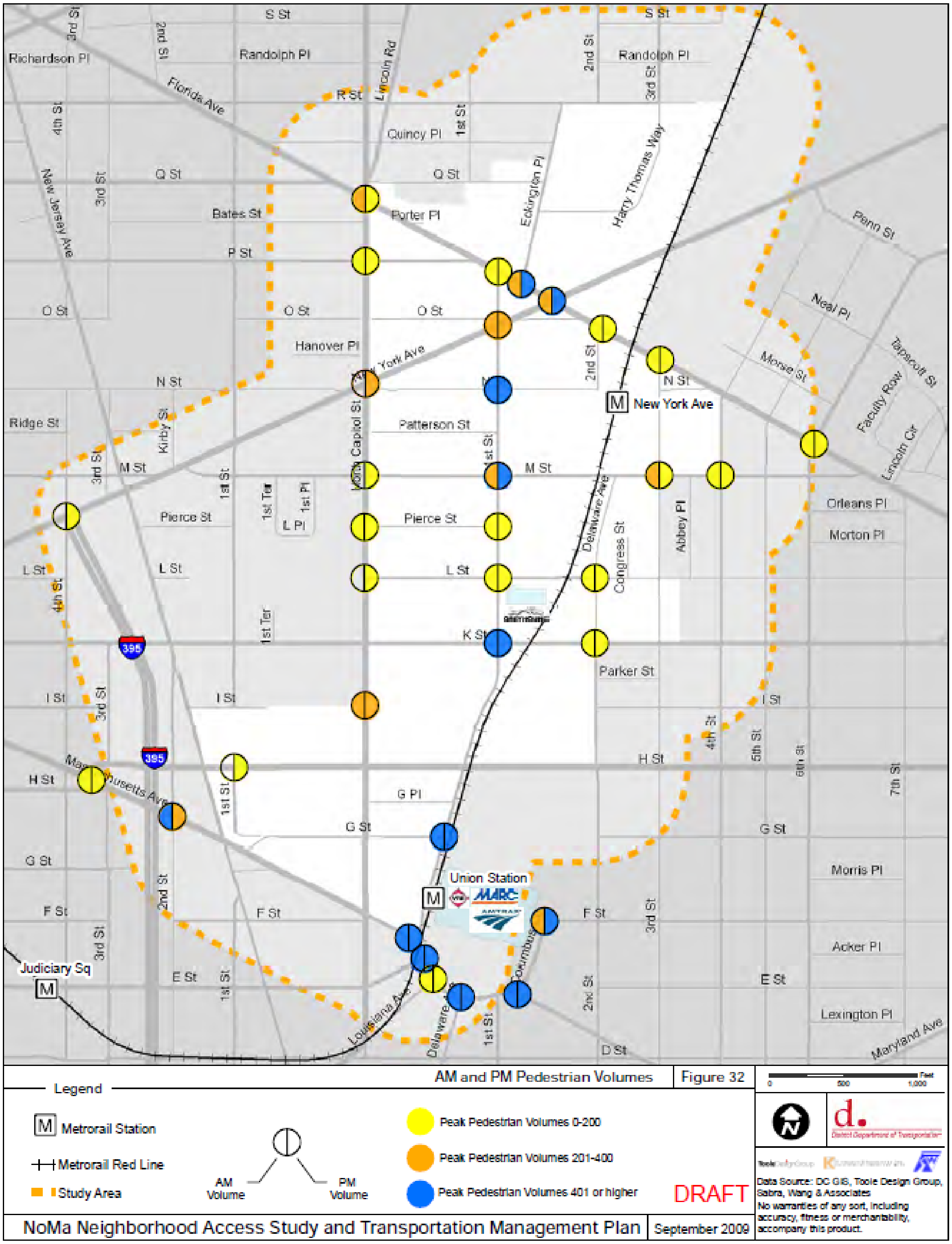


Figure 33: Bicycle Levels of Service, Gateway Market Transportation Impact Study (2013), p. 7

Roadway	Bicycle LOS
Florida Avenue	E
New York Avenue	E
2nd Street	N/A
3rd Street	N/A
N Street	N/A
4th Street (between Morse and Florida)	A
4th Street (south of Florida Avenue)	C
4th Street (north of Morse Street)	N/A
5th Street	N/A
6th Street (north of Florida Avenue)	B
6th Street (south of Florida Avenue)	D
Morse Street	N/A

Figure 34: Existing Pedestrian Barriers, NoMA Vision Plan and Development Strategy (2006), p. 3.22

Figure 35: High Pedestrian Activity/Deficiency Roadways, New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study (2010), p. 15

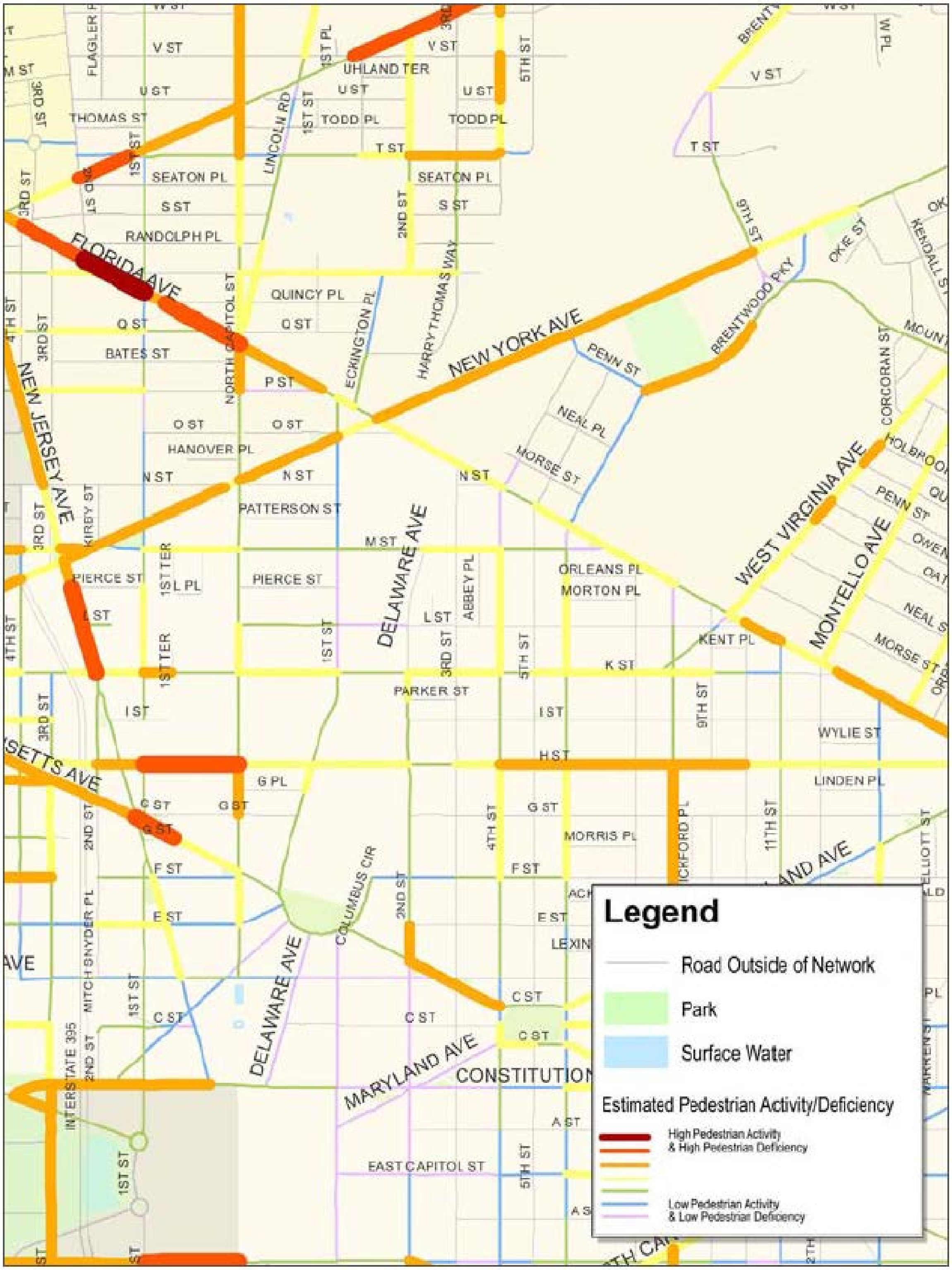


Figure 36: Bicycle and Pedestrian Crashes (2010-2012), Florida Avenue Multimodal Transportation Study Public Meeting slides, Slide 9

Figure 37: Existing Track Usage

West Side Stub End Tracks					
Track	**Length (ft)**	**Cars**	**Platform**	**Electrified**	**Services**
7	640	6	Low		MARC (All Lines)
8	1,171	13			MARC (All Lines)
9	1,327	15	High		MARC (All Lines)
10	984	11		X	MARC (All Lines)
11	984	11	High	X	MARC (All Lines)
12	1,071	12		X	MARC (All Lines)
13	1,170	13	High	X	AMTRAK (NE Regional)
14	1,260	14		X	AMTRAK (NE Regional)
15	1,000	11	Low	X	MARC (All lines) / AMTRAK (NE Regional, Long-Distance)
16	1,576	18		X	MARC (All lines) / AMTRAK (NE Regional, Long-Distance)
17	1,350	15	High	X	AMTRAK (Acela Express, NE Regional)
18	1,111	12		X	AMTRAK (Acela Express, NE Regional)
19	1,030	11	High	X	AMTRAK (Acela Express, NE Regional)
20	1,028	11		X	AMTRAK (Acela Express, NE Regional)
East Side Run-Through Tracks					
Track	**Length (ft)**	**Cars**	**Platform**		**Services**
21	NA	NA	-		-
22	1,620	18		X	-
23	1,675	19	Low	X	VRE (Manassas & Fredericksburg) / AMTRAK (NE Regional, Long-Distance)
24	1,663	19		X	VRE (Manassas & Fredericksburg) / AMTRAK (NE Regional, Long-Distance)
25	1,860	21	Low	X	VRE (Manassas & Fredericksburg) / AMTRAK (NE Regional, Long-Distance)
26	1,883	21		X	AMTRAK (NE Regional,Long Distance)
27	771	8	Low	X	VRE (Manassas) / MARC (Penn Line)
28	778	9		X	VRE (Manassas)
29	728	8	-	X	-
30	728	8		X	-

Figure 38: Existing Union Station Operating Plan, WUS Master Plan Phase 1 Rail Improvements Feasibility Study (2014)

Service Provider	Arrivals	Departures
MARC Brunswick	12	12
MARC Camden	9	10
MARC Penn	30	29
VRE	15	15
Amtrak Regional	33	33
Amtrak Long Distance	14	14
Amtrak Acela	15	15
Total Current	**128**	**128**

Figure 39: Existing MARC Train Layovers at Union Station, WUS Master Plan Phase 1 Rail Improvements Feasibility Study (2014)

Train Inbound #	Arrival Time	Train Outbound #	Departure Time	Length (ft)	Track	Storage Location
890	6:47 AM	895	6:30 PM	324	8 to 30 to 8	Platform
407	6:50 AM	442	5:50 PM	577	12	West Yard
511	7:24 AM	436	5:10 PM	662	14	Platform
874	7:31 AM	877	4:55 PM	579	8 to 15	West Yard
892	7:46 AM	893	5:15 PM	425	9	Platform
415	7:56 AM	426	3:23 PM	580	28	Platform
847	7:59 AM	422	1:20 PM	410	15	Platform
876	8:03 AM	875	4:25 PM	494	7	Platform
878	8:30 AM	424	2:20 PM	494	15	Platform
419	8:41 AM	538	5:20 PM	665	16	Platform
421	9:04 AM	532	4:25 PM	662	16	Platform
523	10:00 AM	430	4:20 PM	579	12	Platform
425	10:35 AM	873	3:35 PM	410	12	Platform
429	12:35 PM	428	4:10 PM	563	14	Platform

Figure 40: Existing Acela Turns at Union Station, WUS Master Plan Phase 1 Rail Improvements Feasibility Study (2014)

Train Inbound #	Arrival Time	Train Outbound #	Departure Time	Length (ft)	Track
2117	2:47 AM	2122	5:00 PM	802	20
2103	8:48 AM	2110	11:00 AM	802	20
2107	9:47 AM	2164	12:00 PM	802	17
2109	10:48 AM	2166	1:00 PM	802	19
2151	11:47 AM	2168	2:00 PM	802	20
2153	12:42 PM	2170	3:00 PM	802	17
2155	1:47 PM	2172	4:00 PM	802	19

Figure 41: Recommended Ground-Floor Residential Plan, NoMA Vision Plan and Development Strategy (2006), p. 3.11

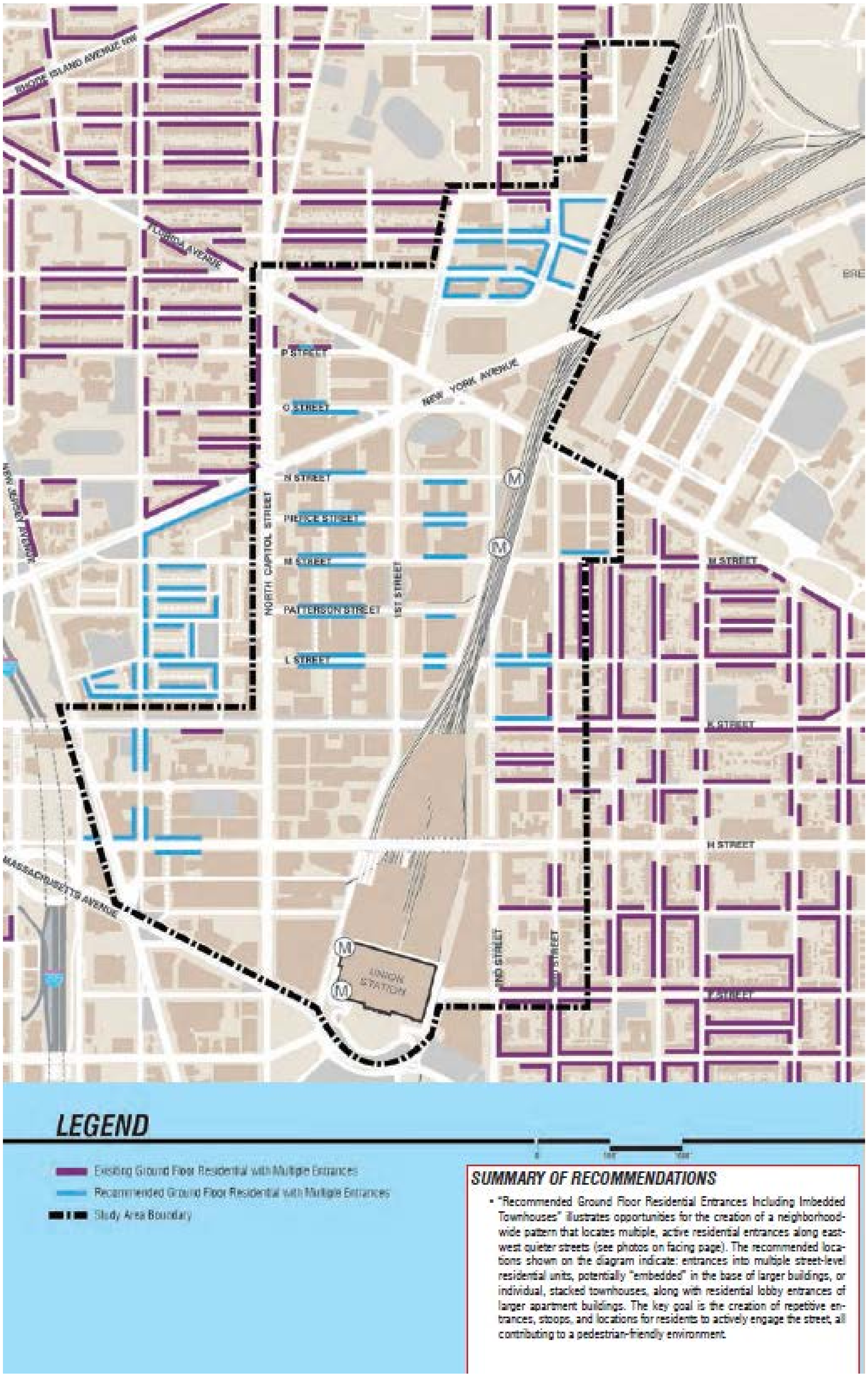


Figure 42: Recommended Retail Plan, NoMA Vision Plan and Development Strategy (2006), p. 3.9

Figure 43: Recommended Open Space, NoMA Vision Plan and Development Strategy (2006), p. 3.21

Figure 44: Public Realm Framework, NoMa Public Realm Design Plan (2012), p. 5

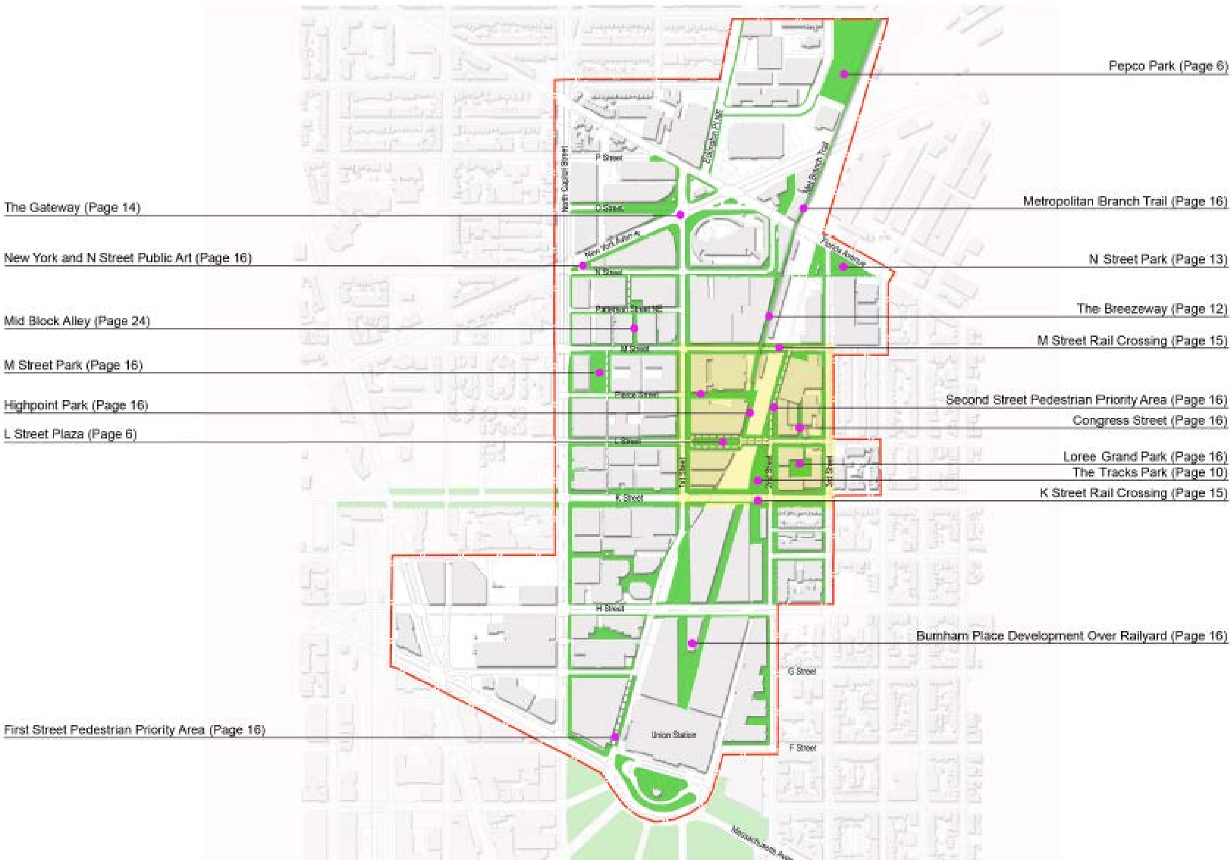


Figure 45: Proposed N Street Northeast Park, NoMa Public Realm Design Plan (2012), p. 13

View from the N Street and Florida Avenue intersection looking west

Figure 46: Recommended New Roads, Signals, and Two-Way Streets, NoMA Vision Plan and Development Strategy (2006), p. 3.13

Figure 47: Travel Direction Changes, Roadway Extensions, and Other Improvements, NoMa Neighborhood Access and Transportation Management Plan (2010), p. 50

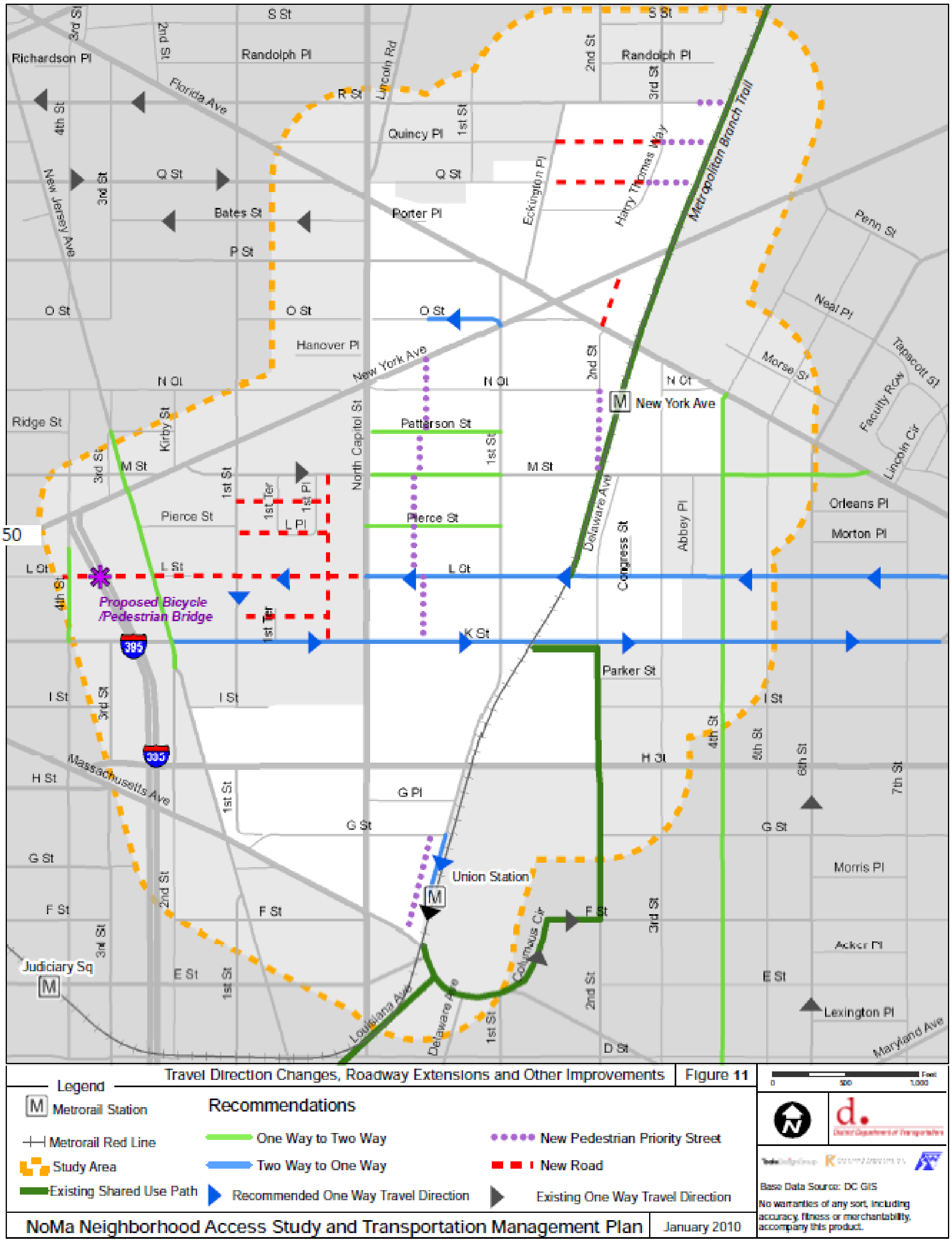


Figure 48: Proposed Lane Reduction on Florida Avenue, NoMa Neighborhood Access and Transportation Management Plan (2010), p. 45

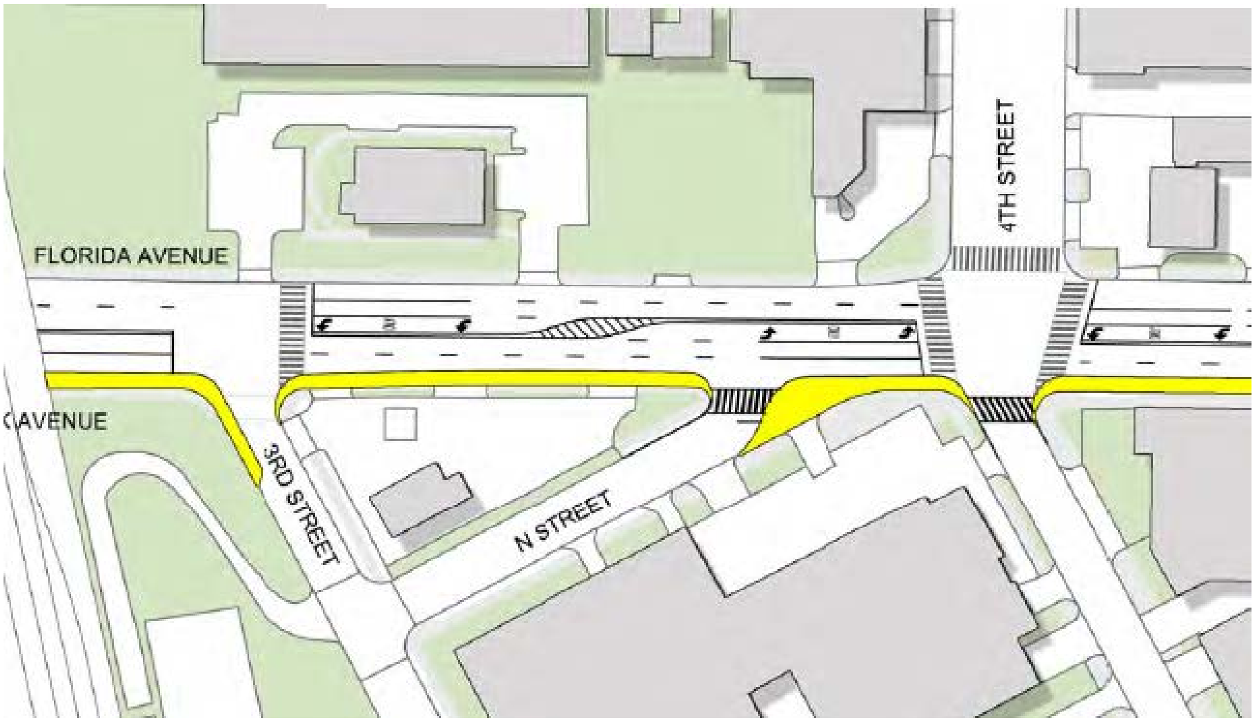


Figure 49: Intersection Recommendations (West), NoMa Neighborhood Access and Transportation Management Plan (2010), p. 36

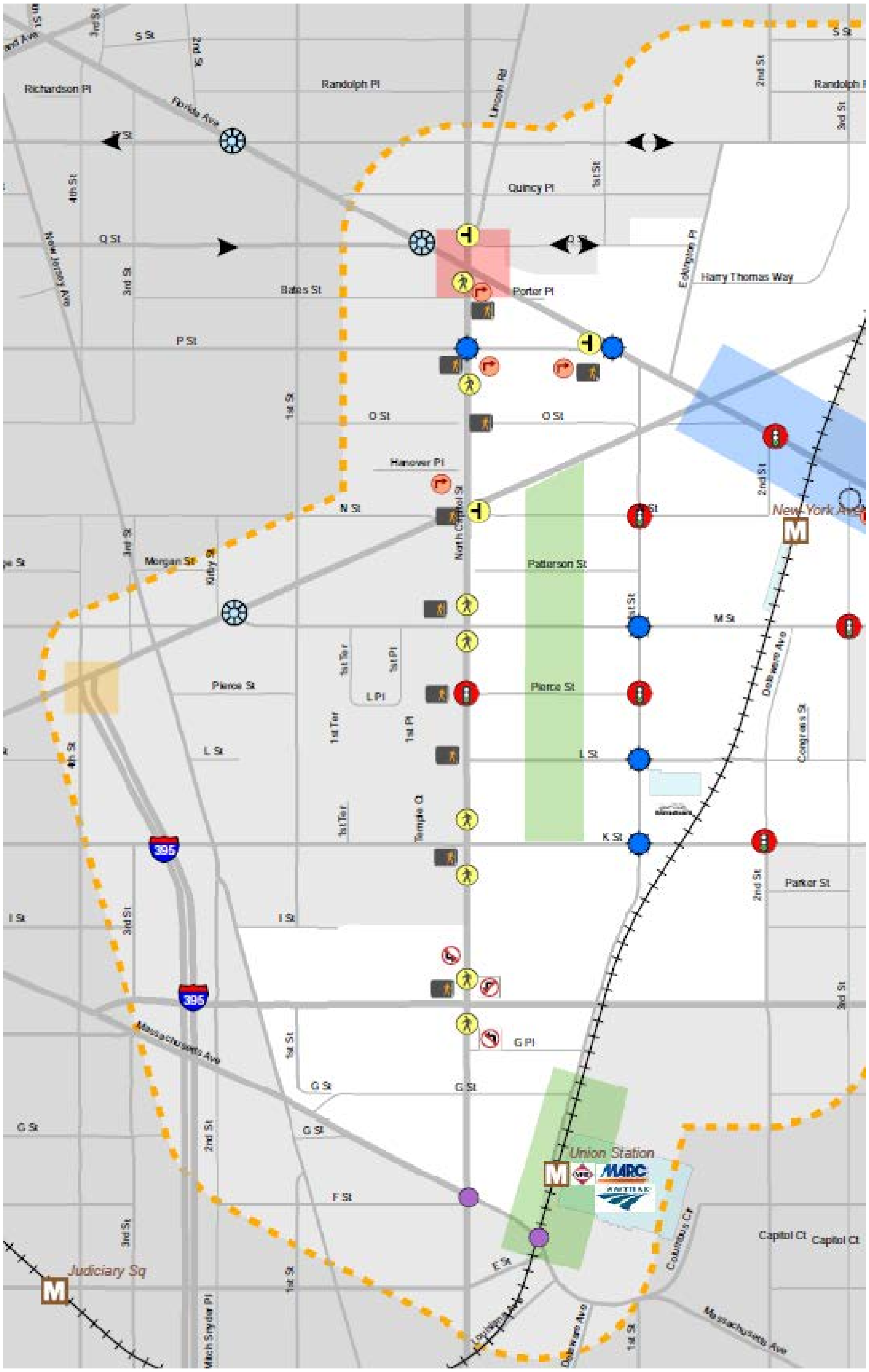


Figure 50: Recommended Metrobus Route Alteration and Future Metrobus Stops, Recommended New Roads, Signals, and Two-Way Streets, NoMA Vision Plan and Development Strategy (2006), p. 3.17

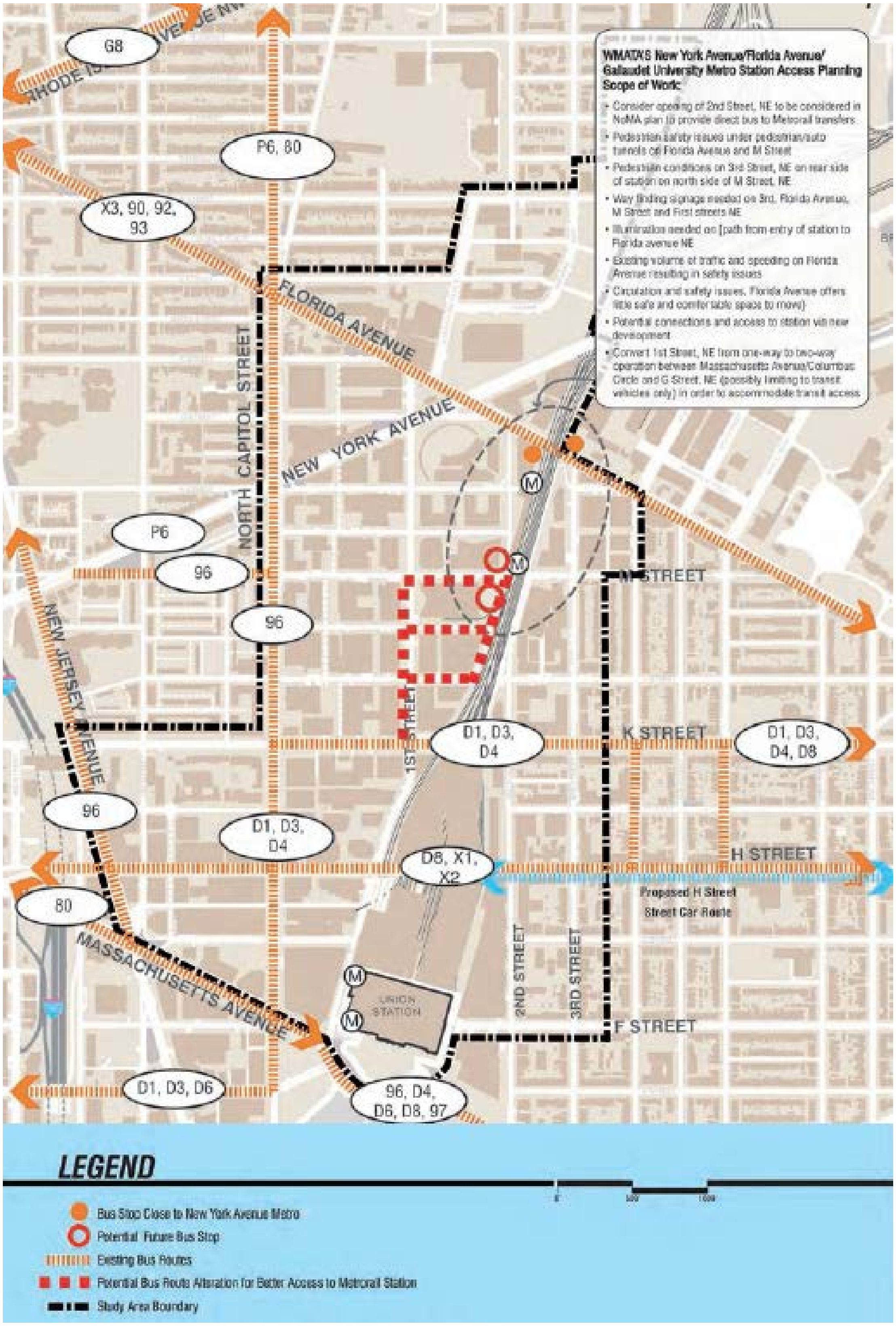


Figure 51: Proposed NoMa Circulator Routes, NoMa Neighborhood Access and Transportation Management Plan (2010), p. 51

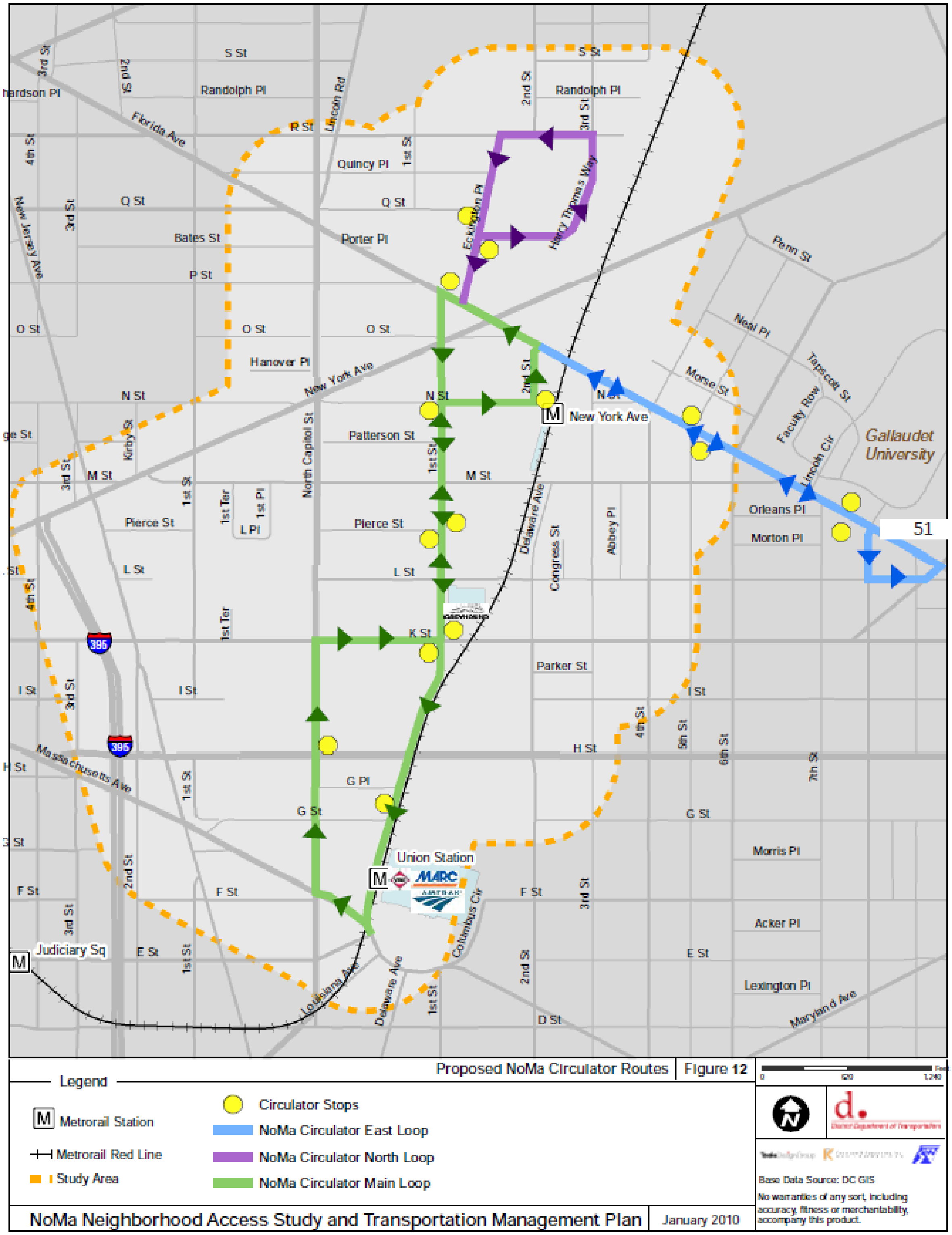


Figure 52: Bicycle Facility Recommendations (East), NoMa Neighborhood Access and Transportation Management Plan (2010), p. 41

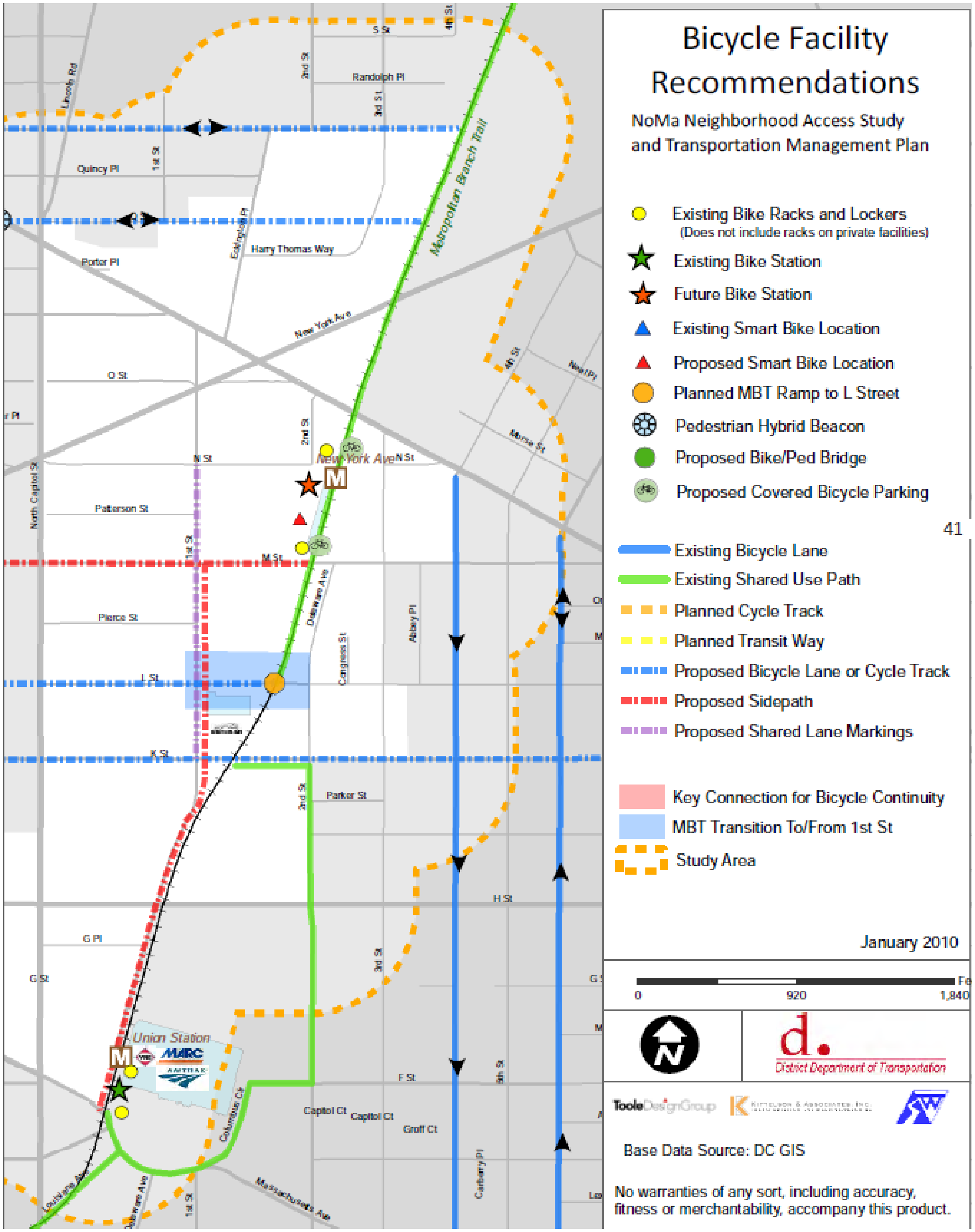


Figure 53: Recommended Bicycle Infrastructure, NoMa Public Realm Design Plan (2012), p. 17

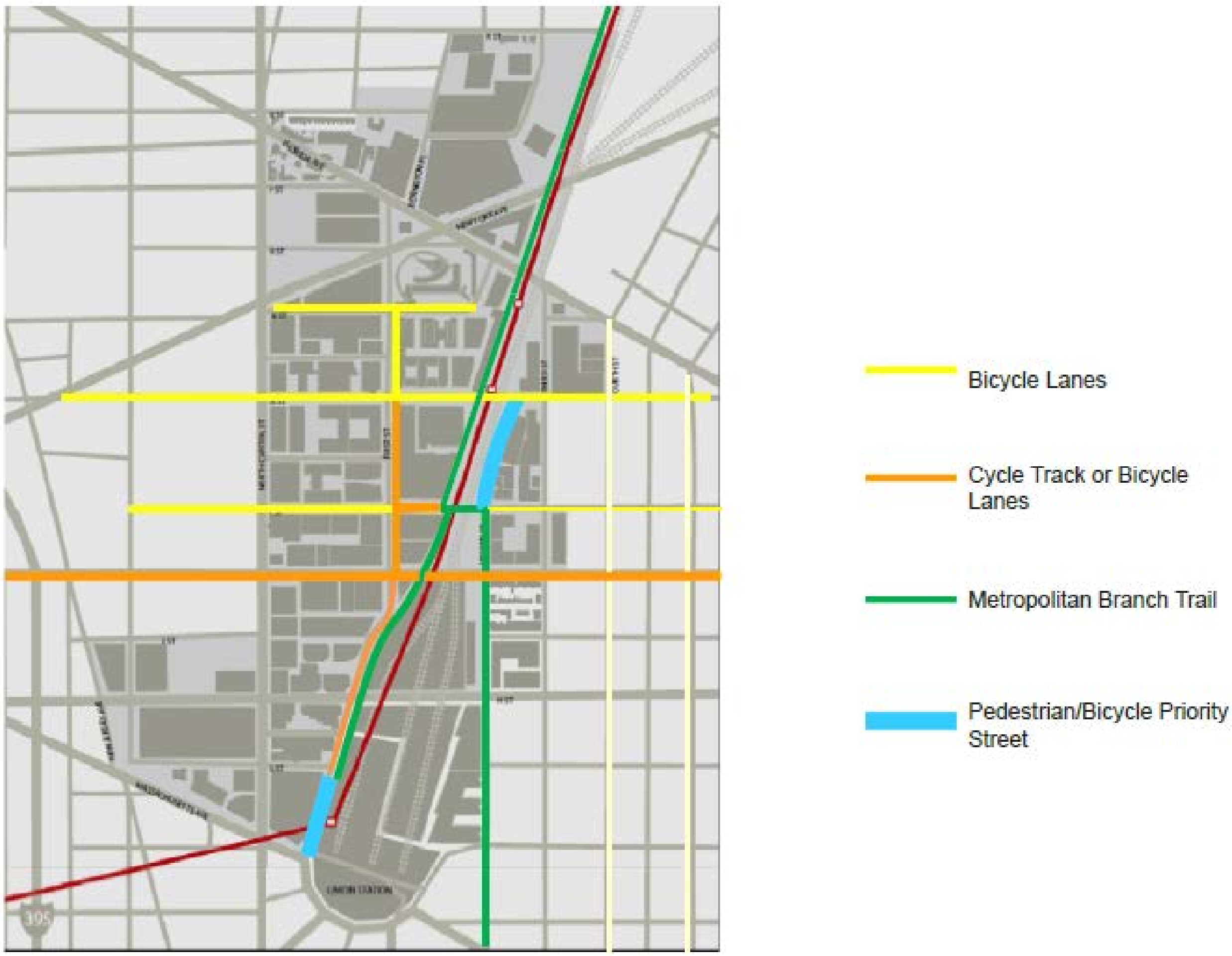


Figure 54: NoMa Station Vicinity Parcel Boundaries (Aerial)

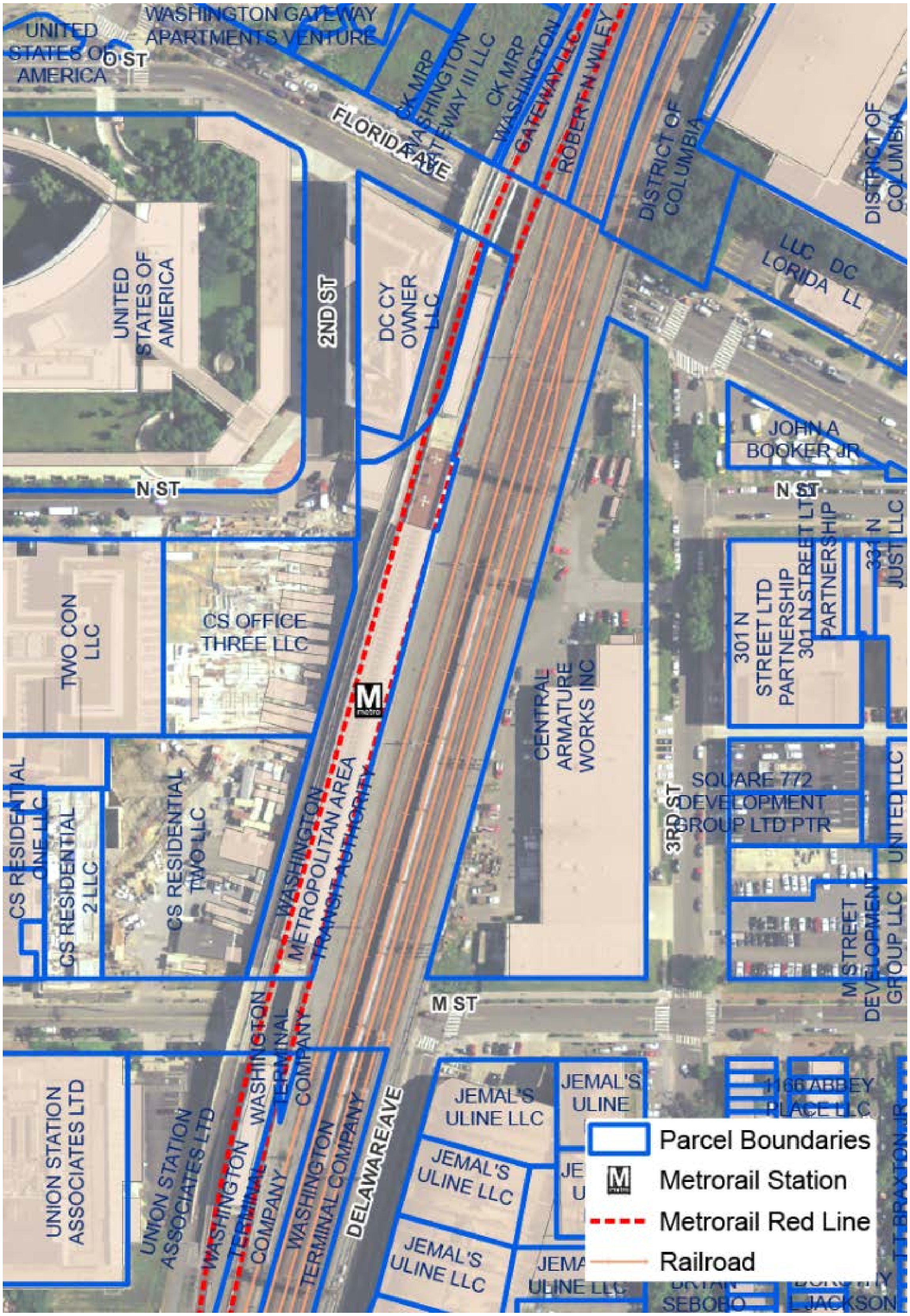
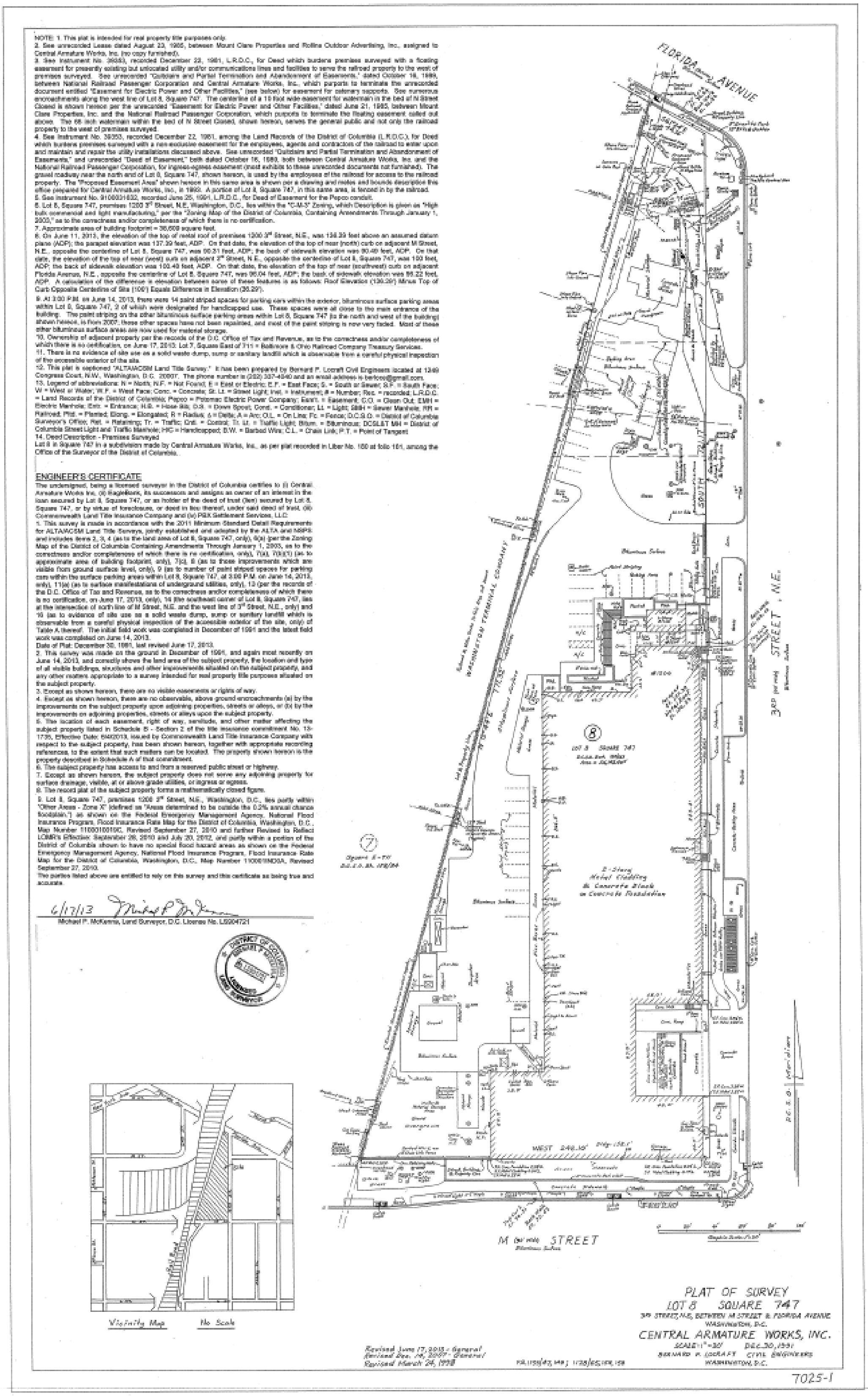


Figure 55: Site Survey Plat



Appendix B: Tables

Table 3: Previous Plans and Studies Reviewed

Name of Plan/Study	Year	Developed By	Description
NoMa Vision Plan and Development Strategy	2006	District of Columbia Office of Planning	• Serves as Small Area Plan for NoMa. • Provides revitalization strategy for area facing a major increase in development. • Recommends underpass improvements, connection of bus services to Metrorail station, reconstruction of 1st Street Northeast, extension of 2nd Street Northeast, signalization improvements, mixed land uses, and curb cut restrictions.
NoMa Neighborhood Access and Transportation Management Plan	2010	District Department of Transportation (DDOT)	• Provides strategies for managing congestion and mitigating potential conflicts between multimodal users resulting from expected growth and changing transportation needs in NoMa. • Recommends modified signal phasing, widened sidewalks, additional bicycle parking, improved connections to the Metropolitan Branch Trail, intersection realignments, extending the DC Circulator system, and pedestrian and bicycle infrastructure improvements for east/west streets.
New York Ave-Florida Ave-Gallaudet University Station Access Improvement Study	2010	Washington Metropolitan Area Transit Authority (WMATA)	• Identifies access needs and deficiencies to define ways to improve accessibility for pedestrians and bicyclists. • Recommends improved sidewalks, bicycle facilities, lighting, repaired embankment walls, wayfinding, and transit-oriented development.
NoMa Public Realm Design Plan	2012	NoMa Business Improvement District	• Recognizes park space as need for NoMa visitors and residents and uninviting east/west streets as a weakness. • Recommends new park space on N St between 3rd Street Northeast and Florida Avenue, artistic enhancements and bicycle infrastructure for railroad underpasses on east/west streets, and the addition of street plantings and enhanced lighting.
Gateway Market Transportation Impact Study	2013	District Department of Transportation (DDOT)	• Reviews possible transportation impacts of a Planned Unit Development (PUD) at the intersection of Florida Avenue and 4th Street Northeast. • Recommends transportation demand management strategies and improvements for promoting pedestrian and bicycle trips to minimize additional vehicular trips generated from PUD.
Florida Avenue Multimodal Transportation Study	Ongoing	District Department of Transportation (DDOT)	• Currently studying Florida Avenue Corridor from New York Avenue to H Street Northeast to improve safety and mobility and balance needs of all modes in the corridor. • Alternatives being evaluated include widened sidewalks, street trees, bicycle lanes or cycle tracks, improved lighting, and simplified intersections.
DC Atlas Plus	2015	District of Columbia Office of the Chief Technology	• Online mapping tool

		Officer (OCTO)	
DC Municipal Regulations, Title 11: Zoning	2015	District of Columbia Office of Documents and Administrative Issuances	• Zoning regulations for the District of Columbia
WUS Master Plan Phase 1 Rail Improvements Feasibility Study	2014	Amtrak	• Reviews existing conditions at Union Station to determine feasibility of implementation of Phase 1 improvements identified in the 2012 Union Station Master Plan. • Provides information on existing operating plans and track assignments for MARC, VRE, and Amtrak passenger rail services at Union Station.
2012 Traffic Volumes	2012	District Department of Transportation (DDOT)	• Traffic count data collected through the Highway Performance Monitoring System. • Counts are collected on a three-year cycle and converted to Annual Average Daily Traffic (AADT).
Metro 2014 10-Year Historical Ridership	2014	Washington Metropolitan Area Transit Authority (WMATA)	• Average weekday passenger boardings at Metrorail stations. • Located at: http://www.wmata.com/pdfs/planning/2014%2010%20Year%20Historical%20Rail%20Ridership.pdf
Metrorail Station Access & Capacity Study	2008	Washington Metropolitan Area Transit Authority (WMATA)	• Provides estimates for growth in Metrorail station boardings through 2030 and identifies issues related to station access and circulation. • Forecasts 80.2% ridership growth at New York Ave-Florida Ave-Gallaudet University station and recommends general improvements to bicycle and pedestrian access.
Aerial Photos	2014	Bing	• Aerial photography and mapping provided by Microsoft.
DeafSpace Design Guidelines	2010	Gallaudet University	• Design guidelines for an update to the Gallaudet Ten Year Facilities Master Plan. • Reviews how space, mobility, light and color, and acoustics and electromagnetic interference can be used to extend sensory reach and encourage social connections for deaf or hard of hearing individuals.
Geotechnical Engineering Report: Glenmount Route, New York Avenue Station	2001	Washington Metropolitan Area Transit Authority (WMATA)	• Provides subsurface conditions and geotechnical recommendations for the NoMa-Gallaudet University Metrorail station prior to its construction.
Success Built on Transit	2014	NoMa Business Improvement District	• An advertising supplement in the Washington Business Journal that documents economic development in the NoMa BID and success of the public-private partnership to develop the NoMa-Gallaudet University Metro station.
NoMa-Gallaudet University Metrorail station As Built Plans	2005	Washington Metropolitan Area Transit Authority (WMATA)	• Plans and drawings of the NoMa-Gallaudet Metrorail Station.

Table 4: NoMa Metro Station Access Options

Facility/Amenity	Quantity
Station Entrance	North entrance: 200 Florida Avenue, NE (corner of 2nd and N Streets, NE) South entrance: M Street, NE between 1st Street and Delaware Avenue, NE
Bicycle/Pedestrian Trail	1 (part of Metropolitan Branch Trail)
Bicycle Storage	13 inverted U-type racks; 28 lockers
Elevators	3 (2 from platform to mezzanine; 1 from Metropolitan Branch Trail to north entrance)
Escalators	4 (2 per entrance)
Staircases	4 (2 per entrance)
Fare Gates	8 (5 at north entrance; 3 at south entrance)
Fare Vending Machines	7 (4 at north entrance; 3 at south entrance)
Exit Fare Vending Machine	4 (2 per entrance)

Table 5: Stations with Highest Forecasted Development

STATION NAME	HH Growth change 05-30	Job Growth change 05-30	Forecasted Ridership Growth	Land for More Parking?[13]	Bike Needs	Walk Needs
College Park-U of MD	153.9%	66.3%	47.1%	No	Bike racks	
Judiciary Square	131.9%	34.2%	27.2%	No		
Shady Grove	113.6%	59.0%	45.5%	Yes	Bike route	Sidewalks
Union Station	93.6%	33.7%	12.9%	No		
Navy Yard	87.2%	61.3%	80.2%	No	Bike route	
Federal Triangle	84.5%	20.7%	20.2%	No		
Brookland-CUA	84.4%	7.4%	14.4%	No		Sidewalks
Branch Ave	83.5%	233.9%	18.3%	Yes	Bike route	Sidewalks
Gallery Pl-Chinatown	80.1%	31.8%	92.0%	No	Bike racks	
New York Ave-Florida Ave-Gallaudet U	75.2%	45.5%	80.2%	No		
Arlington Cemetery	74.7%	28.3%	-15.9%	No		
Silver Spring	74.3%	15.1%	21.8%	No	Bike racks/lockers	
Anacostia	74.1%	11.1%	38.9%	No		Sidewalks, crossing
King Street	71.6%	58.0%	24.3%	No	Bike racks	
Greenbelt	69.0%	48.7%	-2.1%	Yes		Sidewalks, crossing
White Flint	64.8%	36.6%	157.7%	No		
Van Dorn Street	63.0%	50.7%	53.9%	No	Bike racks	Sidewalks, crossing
Crystal City	57.0%	65.2%	29.4%	No		
Waterfront-SEU	56.6%	36.9%	11.4%	No	Bike racks	
Clarendon	56.6%	39.1%	77.3%	No	Bike racks/lockers	
Largo Town Center	56.5%	221.5%	40.5%	Yes		Sidewalks
Mt Vernon Sq 7th St-Convention Center	56.2%	55.4%	121.0%	No	Bike racks	
Eisenhower Avenue	52.4%	68.0%	345.8%	No		Sidewalks, crossing
New Carrollton	47.8%	59.3%	15.5%	Yes	Bike route	
Ronald Reagan Washington National Airport	47.1%	58.9%	437.4%	No		
West Falls Church-VT/UVA	20.8%	76.9%	-50.5%	No		Sidewalks, crossing

Sources: WMATA, MWCOG, AECOM Consult, PB

Table 6: Average Weekday Boardings (Metro 2014 10-Year Historical Ridership)

Metrorail Average Weekday Passenger Boardings

Station	2005**	2006**	2007**	2008**	2009**	2010**	2011***	2012***	2013***	2014***
Morgan Blvd	-	-	-	-	-	-	1,736	2,290	1,929	2,036
Mt Vernon Sq-UDC	3,358	3,615	3,633	3,990	3,634	3,888	3,813	4,263	4,293	4,541
Nat'l Airport (Regan)	6,024	6,220	6,458	6,344	6,349	6,414	6,739	6,341	6,561	6,732
Navy Yard	3,048	3,238	4,243	9,768	9,113	9,156	8,249	9,884	9,229	10,514
Naylor Road	3,194	3,402	3,325	3,260	3,144	3,165	3,047	3,175	3,100	3,035
New Carrollton	9,091	10,006	10,436	10,625	10,118	10,287	9,940	9,839	9,242	9,098
New York Avenue	2,177	2,945	3,489	4,603	5,229	5,673	7,461	8,019	8,456	8,412
Pentagon	15,171	15,893	15,968	16,055	16,318	16,726	16,999	17,114	16,324	15,853
Pentagon City	15,783	16,176	16,339	16,803	16,503	17,197	17,023	16,382	15,589	15,623
Potomac Ave.	3,421	3,651	3,583	3,824	4,098	4,144	4,050	3,978	3,869	3,834
Prince George's Plaza	4,637	4,872	4,903	5,034	5,093	5,309	5,374	5,336	5,120	5,133
Rhode Island Ave.	5,491	5,757	6,046	6,144	6,121	5,651	5,227	5,645	5,896	6,070
Rockville	4,237	4,365	4,572	4,736	4,880	4,927	4,812	4,834	4,900	4,769
Rosslyn	16,224	16,770	15,462	17,760	16,941	18,122	17,158	16,718	15,632	15,460
Shady Grove	13,360	13,894	14,439	14,390	14,107	13,945	13,856	13,870	13,444	13,308
Shaw-Howard Univ	3,450	3,679	3,804	4,029	4,256	4,290	4,439	4,696	4,751	5,044
Silver Spring	13,078	14,032	14,777	15,155	14,077	13,421	13,471	13,621	13,057	13,195
Smithsonian	12,234	12,465	11,597	12,027	12,764	12,895	12,603	11,946	10,786	10,911
Southern Avenue	5,916	6,278	6,356	6,537	6,263	5,931	5,776	5,909	5,523	5,349
Spring Hill	-	-	-	-	-	-	-	-	-	-
Stadium-Armory	5,608	5,341	5,329	3,235	3,062	3,559	3,077	3,069	2,873	3,022
Suitland	6,039	6,214	6,510	6,631	6,453	6,668	6,417	6,396	5,924	5,677
Takoma	6,201	6,362	6,466	6,664	6,811	6,685	6,488	6,143	5,823	5,813
Tenleytown	6,687	7,563	7,493	7,401	7,290	7,091	6,677	7,220	7,074	6,736
Twinbrook	4,531	4,763	4,805	4,943	4,628	4,587	4,773	4,632	4,569	4,470
Tysons Corner	-	-	-	-	-	-	-	-	-	-
U Street-Cardozo	4,790	5,406	5,934	6,567	7,115	7,183	7,048	7,238	7,501	7,968
Union Station	31,864	32,596	32,935	34,383	34,465	32,745	33,697	33,250	32,975	32,465
Van Dorn Street	3,679	3,835	3,825	3,828	3,689	3,792	3,653	3,587	3,380	3,374
Van Ness-UDC	7,094	7,462	7,730	7,648	7,276	7,155	7,559	6,699	6,414	6,505
Vienna	12,832	13,177	13,143	13,642	13,759	13,967	13,682	13,773	13,141	12,947
Virginia Square-GMU	3,289	3,608	3,886	4,016	4,067	4,103	3,953	3,733	3,695	3,721
Waterfront	3,146	3,163	3,201	3,175	3,067	3,974	4,236	4,536	4,347	4,024
West Falls Church	9,649	10,124	10,290	10,748	10,499	10,836	10,740	10,891	10,369	10,597
West Hyattsville	3,415	3,656	3,839	3,925	3,694	3,809	3,855	3,951	3,905	3,995
Wheaton	4,468	4,887	4,874	4,754	4,653	4,543	4,472	4,374	4,094	4,227
White Flint	3,682	3,714	4,010	4,097	4,096	4,210	4,266	4,151	3,951	3,889
Wiehle-Reston East	-	-	-	-	-	-	-	-	-	-
Woodley Park-Zoo	7,566	8,077	8,471	8,726	8,292	7,607	7,864	7,915	7,734	7,240
	686,185	713,703	724,667	750,431	746,017	748,929	743,962	744,918	725,770	721,804

All Daily Passenger Boardings were taken in May unless noted otherwise.
**** Average weekday ridership computed by EDADS Editing System**
***** Average weekday ridership computed by Crystal ReportsSystem**

Table 7: Study Area Roadway Volumes

Road Name	Functional Classification	ADT (vpd) in Thousands
Florida Avenue	Principle Arterial	22.1
New York Avenue	Principle Arterial	56.8
1st Street Northeast	Collector	8.6
4th Street Northeast	Collector	3.0
M Street Northeast	Collector	4.1

Table 8: Bus Headways in NoMa Neighborhood

Route	Direction	Weekday		Saturday	Sunday
		Peak	Off-Peak		
80	Northbound	10	15	30	30
80	Southbound	10	15	30	30
90-92-93	Northbound	7	15	10-20	10-20
90-92-93	Southbound	7	15	10-20	10-20
96-97	Westbound	10	25	30	30
96-97	Eastbound	10	25	30	30
D1	Westbound	30	-	30	-
D1	Eastbound	10	-	20	-
D3	Westbound	25	-	35	-
D3	Eastbound	30	-	30	-
D4	Westbound	20	30	30	30
D4	Eastbound	20	30	30	30
D6	Westbound	10	20	30	35
D6	Eastbound	10	20	30	35
D8	Northbound	12	30	25	30
D8	Southbound	15	30	20	30
DC Circulator (Union Station to Georgetown)	Westbound	10	10	10	10
DC Circulator (Union Station to Georgetown)	Eastbound	10	10	10	10
DC Circulator (Union Station to Navy Yard)	Northbound	10	10	10	10
DC Circulator (Union Station to Navy Yard)	Southbound	10	10	10	10
P6	Northbound	15	30	30	30
P6	Southbound	15	30	30	30
X1-X3	Westbound	15	-	-	-
X1-X3	Eastbound	30	-	-	-
X2	Westbound	8	15	10-15	10-15
X2	Eastbound	8	15	10-15	10-15

Appendix C: WMATA Station As-Builts

Figure 56: Station Longitudinal Section (West Facing), Drawing B3w-A-300m, New York Avenue Station As-built, 2005

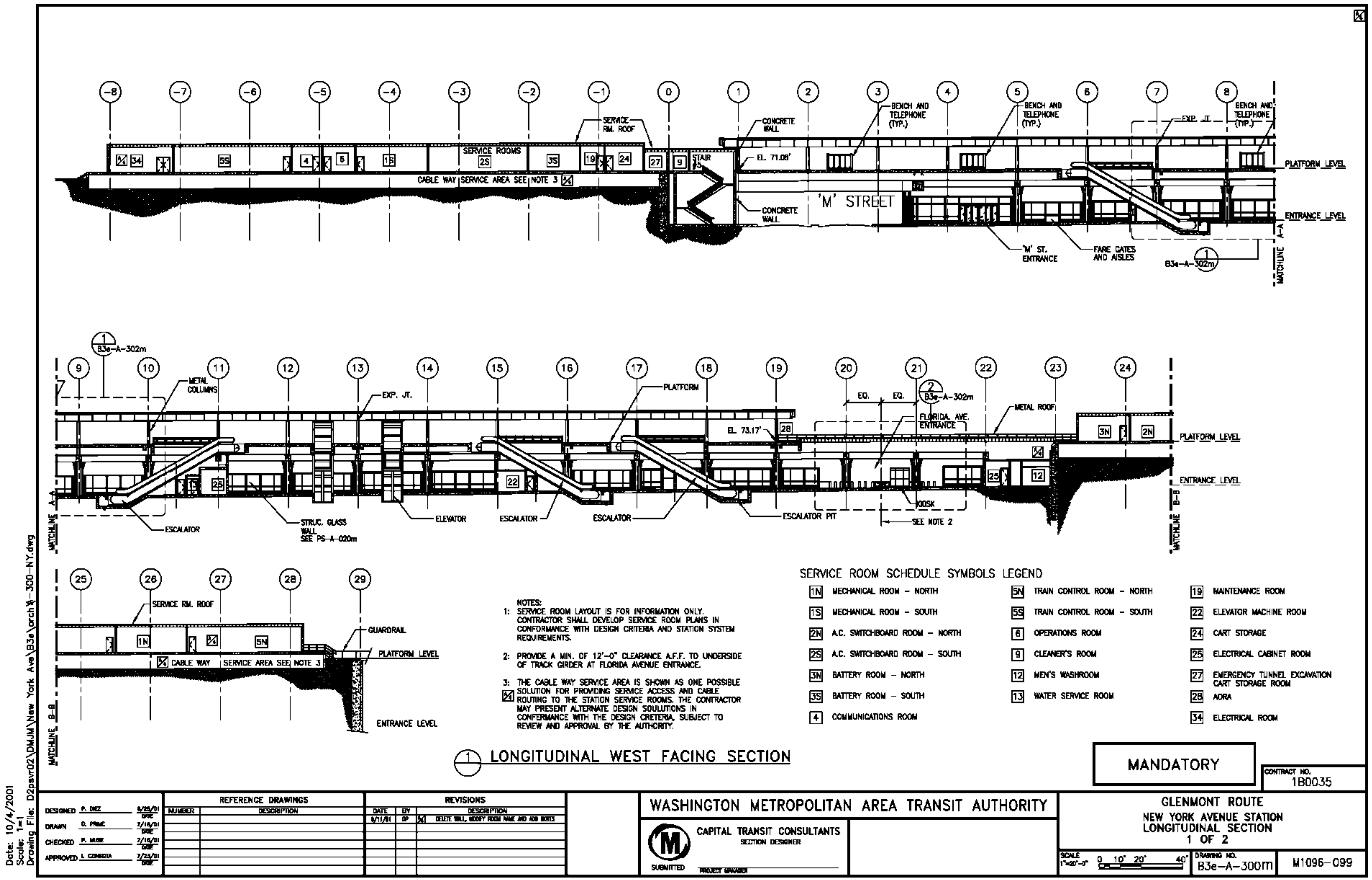


Figure 57: Station Longitudinal Section (East Facing), Drawing B3e-A-301s, New York Avenue Station As-built, 2005

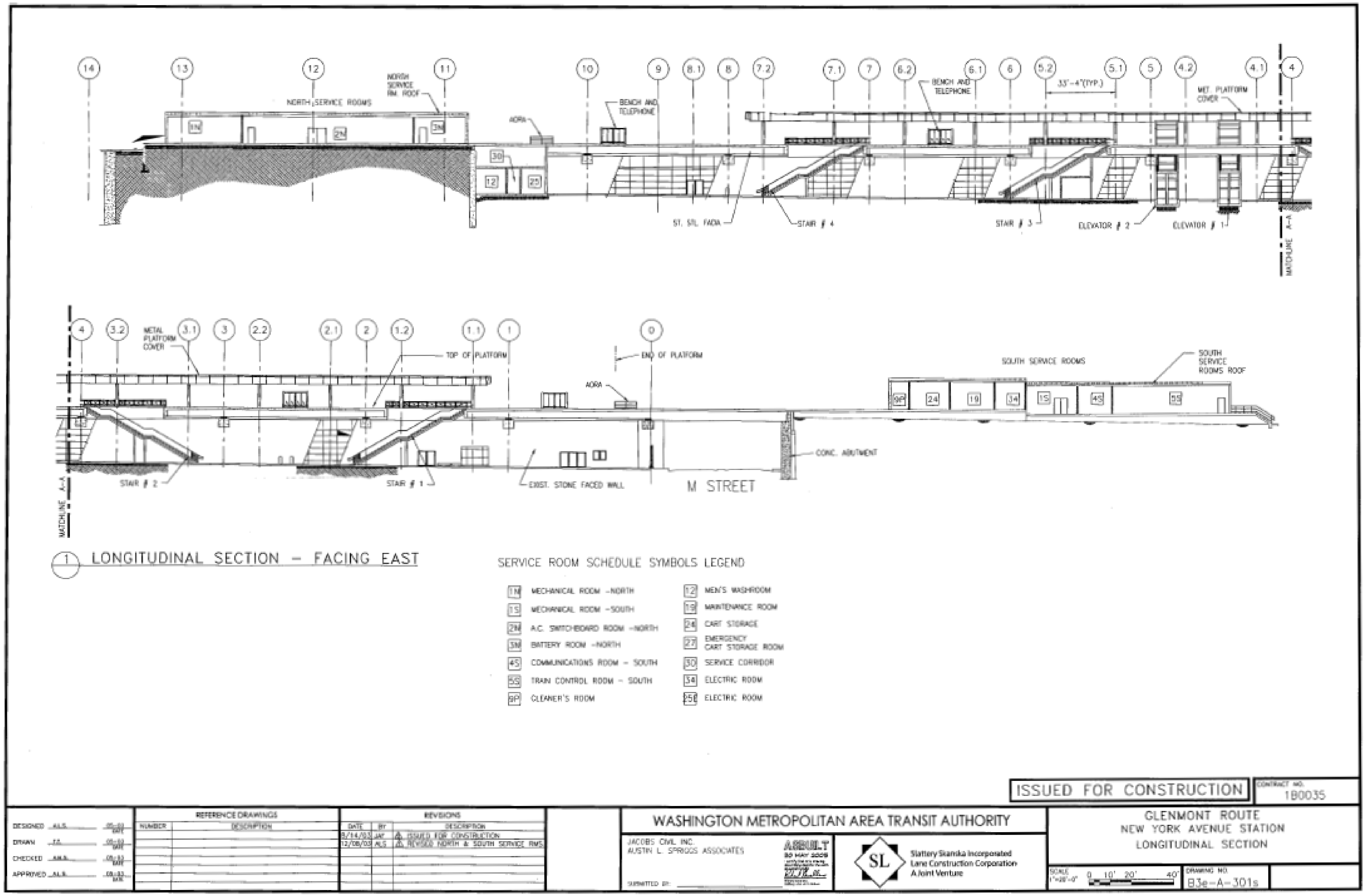


Figure 58: Transverse Sections, Drawing B3e-A-306S, New York Avenue Station As-built, 2005

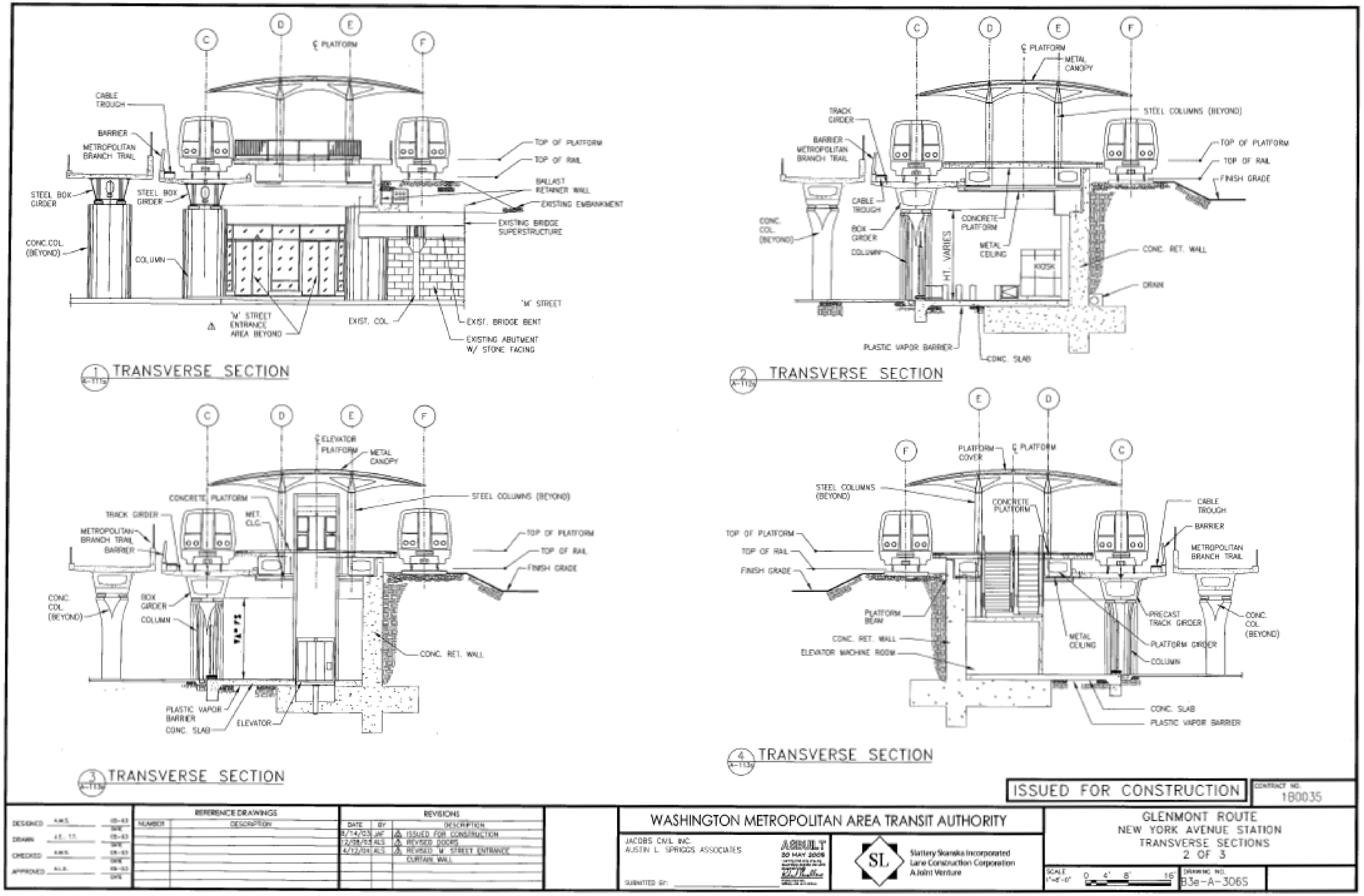
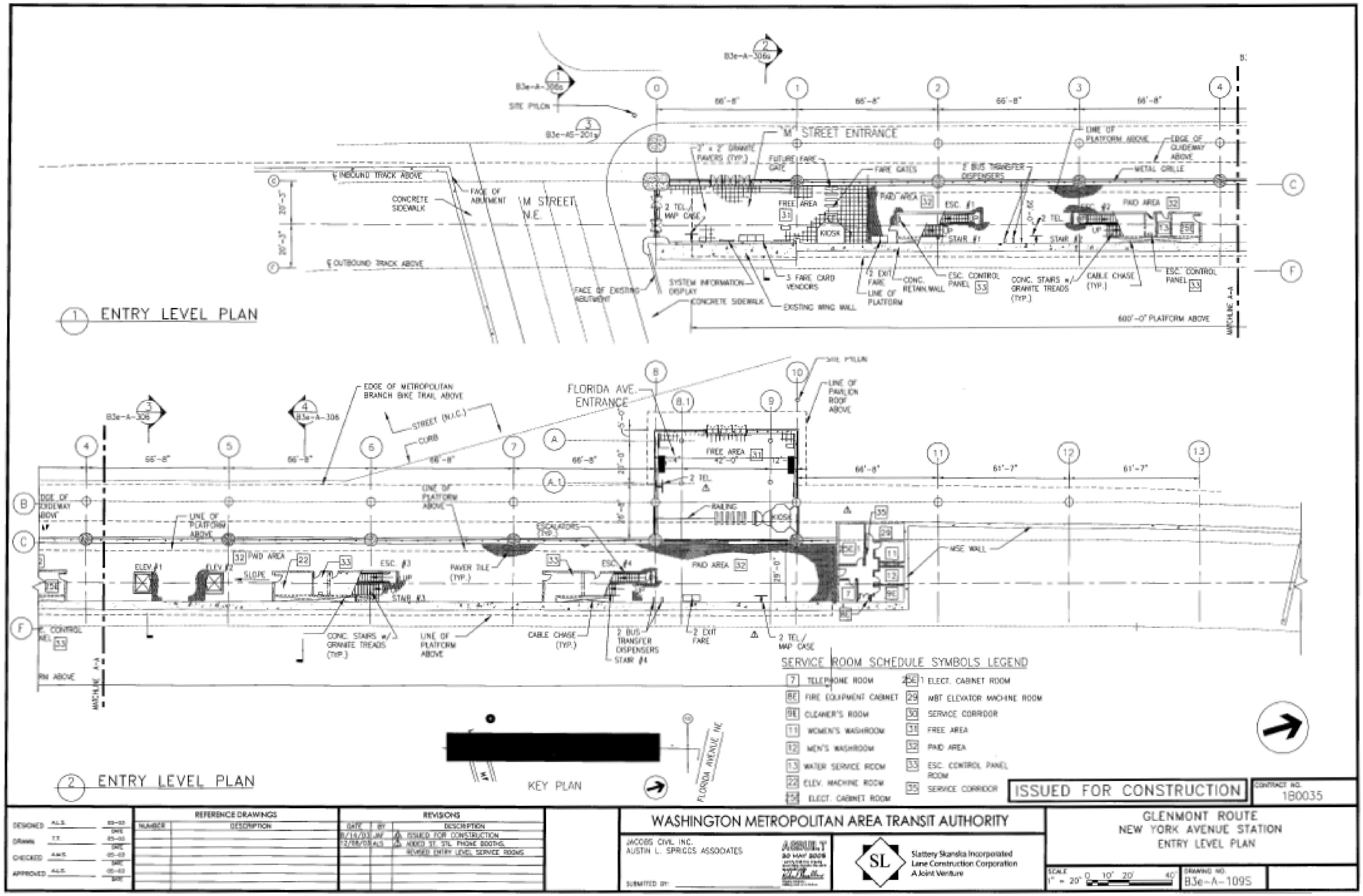


Figure 59: Entry Level Plan, Drawing B3e-A-109S, New York Avenue Station As-built, 2005



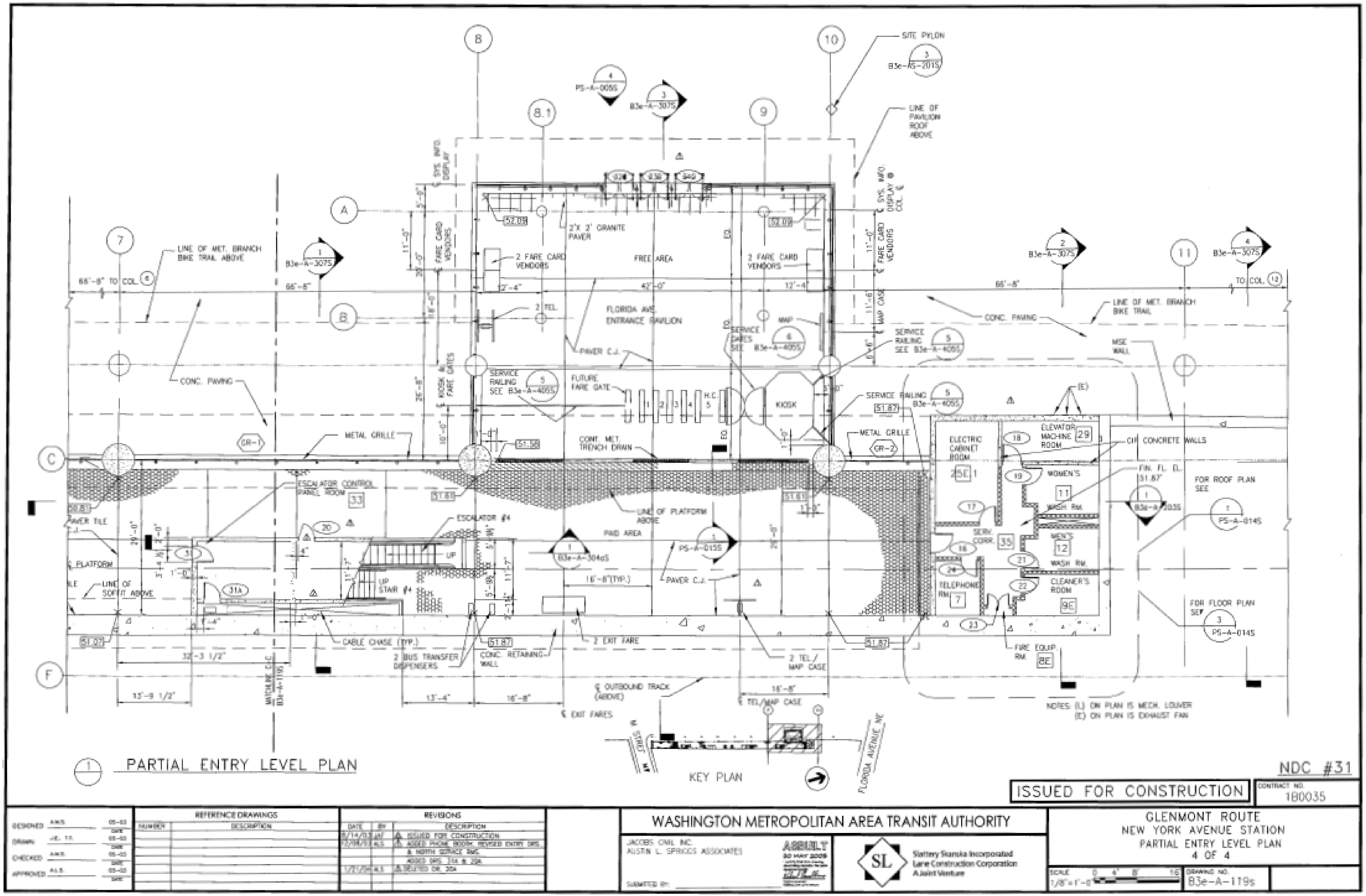


Figure 60: Partial Entry Level Plan (Florida Avenue Entrance), Drawing B3e-A-119S, New York Avenue Station As-built, 2005

Figure 61: Platform Level Plan, Drawing B3e-A-107S, New York Avenue Station As-built, 2005

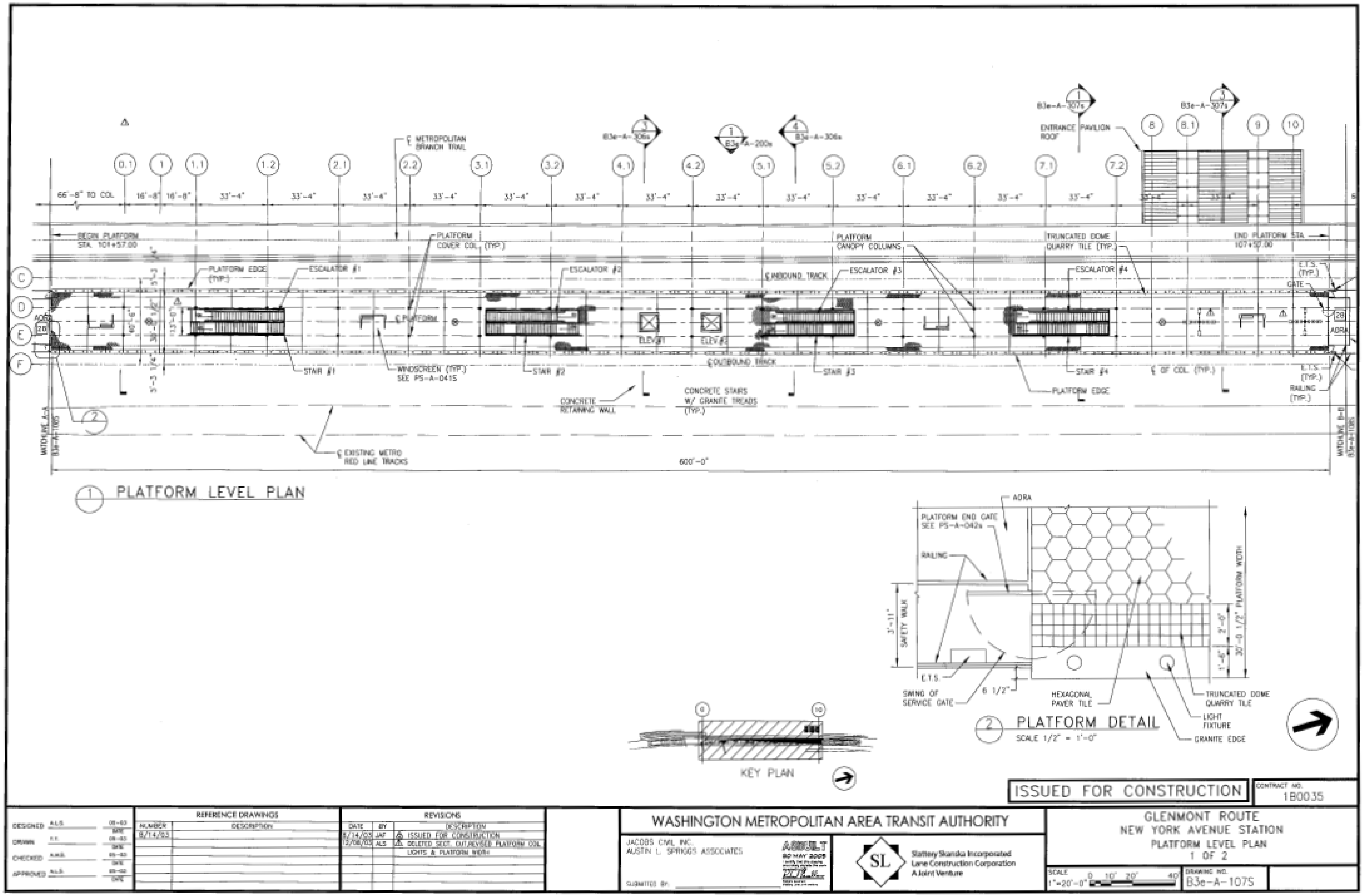


Figure 62: Composite Utility Plan, Drawing B3e-U-003S, New York Avenue Station As-built, 2005

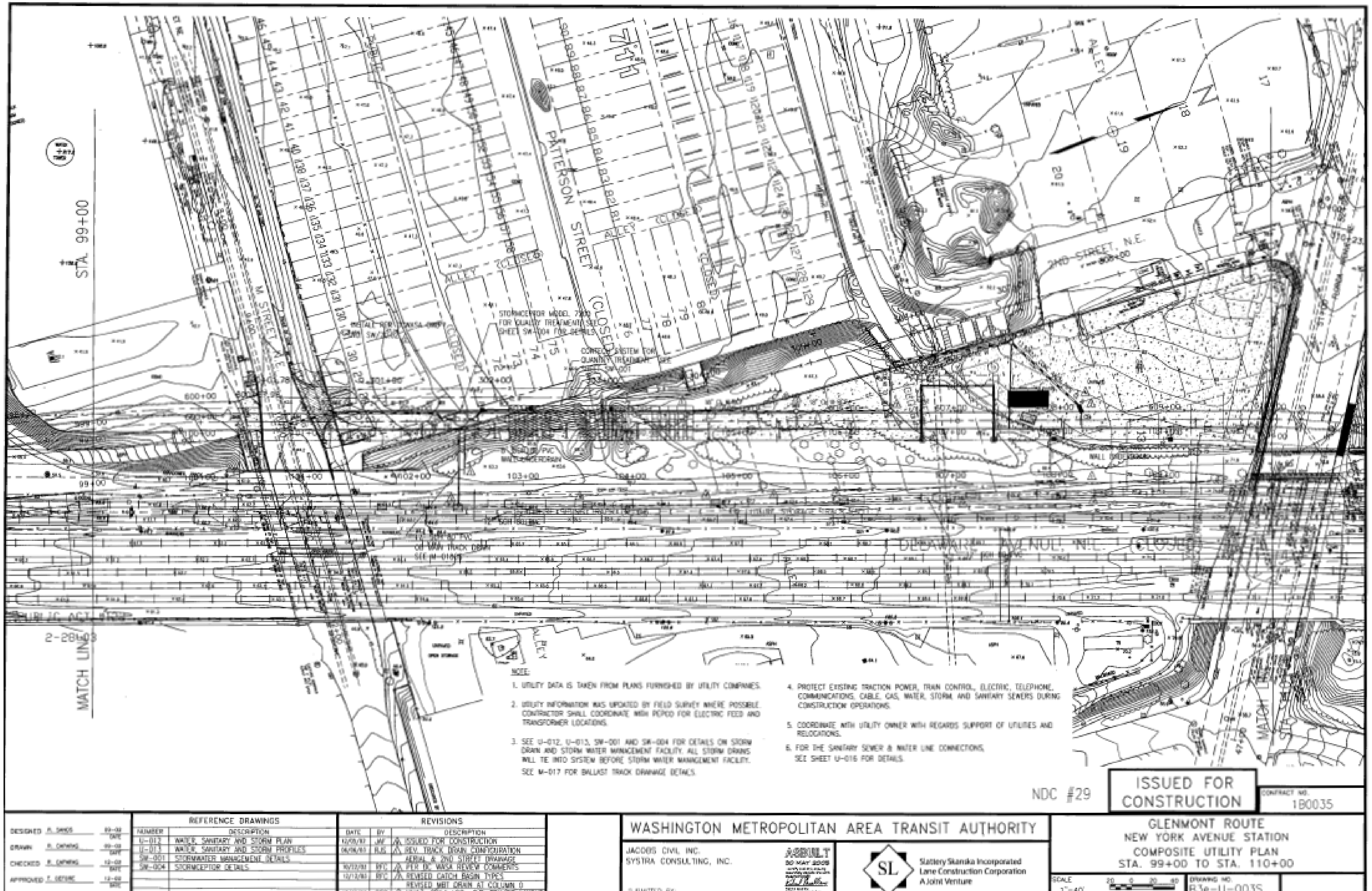


Figure 63: Southeast Relief Watermain, Sheet 5 of 9, District of Columbia Department of Sanitary Engineering, 1960

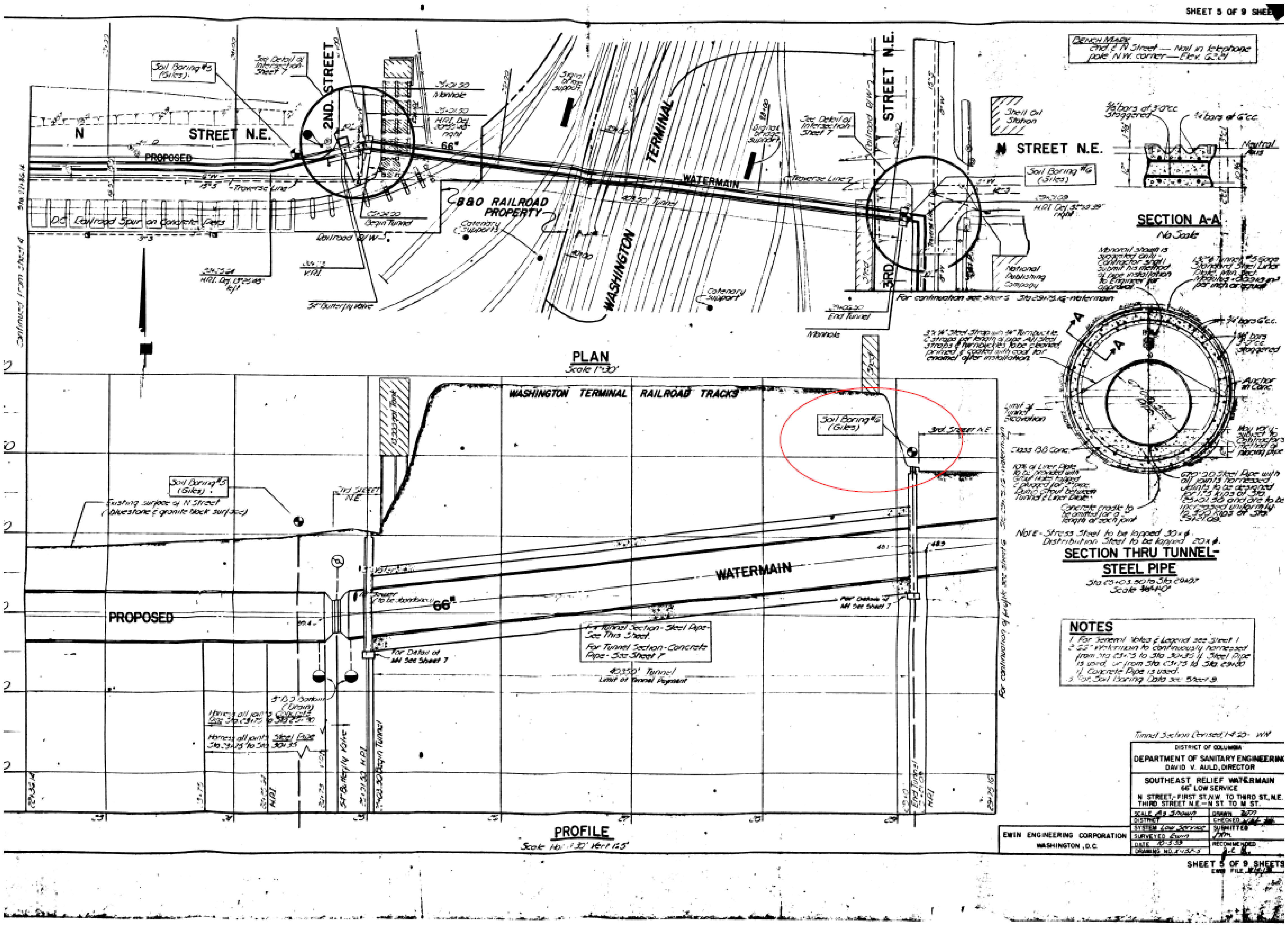


Figure 64: Geotechnical Plan and Borings, 1B0035 Geotechnical Engineering Report, p. 22