MIAMI RIVER

TUNNEL FEASIBILITY STUDY

Miami River Tunnel Feasibility Study

Miami-Dade TPO GPC VI-6

Prepared by:

ATKINS

August 2017

TPO

Miami-Dade Transportation Planning Organization

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CALTRAN ENGINEERING GROUP, INC.

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Miami River Tunnel Feasibility Study

1.0 Introduction

This report documents the investigation of the feasibility of constructing a tunnel facility connecting Brickell Avenue and Biscayne Boulevard under the Miami River in Downtown Miami. This section of the report introduces the background for this study, describes the study area, and summarizes the report organization.

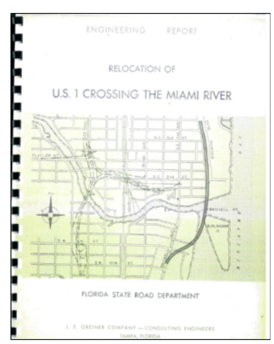
1.1 Study Background

There have been considerable concerns expressed in recent times over continuing and mounting congestion near the existing Brickell Avenue bridge crossing over the Miami River in Downtown Miami. The recurring surface street congestion associated with the bridge openings has led to extensive deliberations on this topic involving several governmental entities and agencies as well as stakeholder interests. This coordination is seeking short-term betterment of traffic operations in conjunction with vessel movements along the river, in relation to published Federal bridge curfew regulations governing the opening of the bridges for marine traffic.

The Miami-Dade Transportation Planning Organization commissioned this study of a tunnel facility under the Miami River from a long-term solution perspective to examine the feasibility of a tunnel facility under the Miami River in the vicinity of Brickell Avenue and Biscayne Boulevard. The intent of such a tunnel would be to provide relief to the volume of traffic using the Brickell Avenue bridge, and to lessen the severity of congestion near the bridge. The traffic movements through the tunnel would be unimpeded by marine navigation.

The specific focus of the study was to identify alternatives that were technically feasible in regard to geometric alignment and construction method. While the study touches upon environmental and traffic circulation elements associated with a tunnel in this area, those elements were limited in their scope. The primary mission was to develop conceptual tunnel configurations that could be implemented, and that could be further investigated in subsequent more detailed studies.

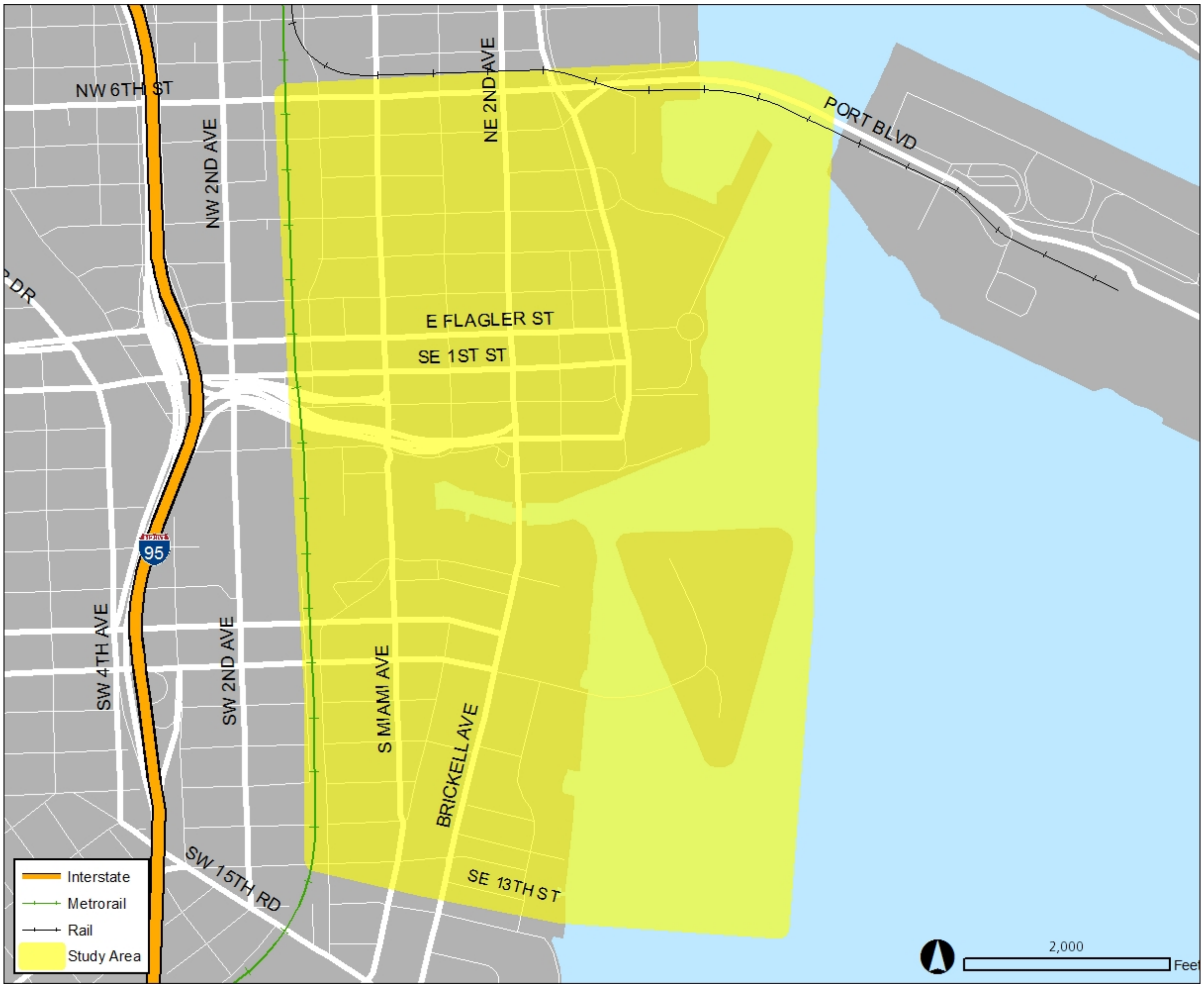
As a frame of reference, in 1964 the Florida Department of Transportation conducted a study of both bridge and tunnel options connecting Biscayne Boulevard to Brickell Avenue. The 1964 construction cost estimate for the high-level bascule bridge was $4.8 million with right-of-way cost of $3.5 million, for a total capital cost of $8.3 million. For the tunnel option, the construction cost estimate was $16.4 million, with right-of-way cost of $4.3 million, for a total capital cost of $20.7 million.



1.2 Study Area

The project study area is bounded on the north by NE 6th Street, on the west by the Metrorail line, on the south by SE 13th Street, and on the east by Biscayne Bay. The targeted alignment for a tunnel was a connection between the Brickell Avenue and Biscayne Boulevard corridors, but the study area was defined to encompass a larger influence area. A project location map is depicted in **Figure 1-1**.

Figure 1-1 Study Area Map



1.3 Study Organization

This report is organized into five sections, summarized as follows:

Section 1. Introduction: Describes the study background and study area.

Section 2. Existing Conditions: Details current conditions within the study area.

Section 3. Conceptual Facility Planning Factors: Covers the facility design criteria, typical sections, construction technologies and other related elements of a tunnel facility.

Section 4. Alternatives Analysis: Identifies and evaluates alternatives, discusses related features of a tunnel and its implementation, and describes the preferred alternative.

Section 5. Findings: Summarizes the findings and observations of the study analyses.

2.0 Existing Conditions

Cataloguing the existing conditions provides the context of the study, setting the foundation for the feasibility analysis. Described in this section are general corridor characteristics, cultural features, natural and biological features, roadway characteristics, and bridge characteristics.

2.1 Corridor Characteristics

The study area setting is likely the most complex within the state of Florida for developing a major infrastructure project. The study area is characterized by a set of very distinguishing characteristics, including:

- The epicenter of Florida high-rise development with announced projects topping 80 stories, with the most expensive riverside properties topping $100 million per acre ($230/square foot).
- Dozens of high rise projects in the development pipeline: just completed, under construction, in planning, or proposed.
- A dramatic transformation of Downtown Miami and Brickell from an employment destination to a mixed use, live/work/play environment with a large residential population supported by shopping, dining, and recreational outlets.

At the same time, the study area is denoted by other features that complicate the development of a major infrastructure project such as the proposed tunnel project, including:

- Congested street environment.
- Several sensitive land use sites including parks, historic sites, public walkways.
- Limited width street rights-of-way.
- Property access points for high-density land developments.

These circumstances contribute to a number of challenges to constructing major infrastructure projects, such as:

- Maintenance of traffic during construction.
- Mitigation of construction disruption.
- Constrained setting for construction in terms of working area, staging area, and construction site access and egress for workers, materials, and waste products.
- Avoidance of right-of-way impacts to sensitive or expensive properties.

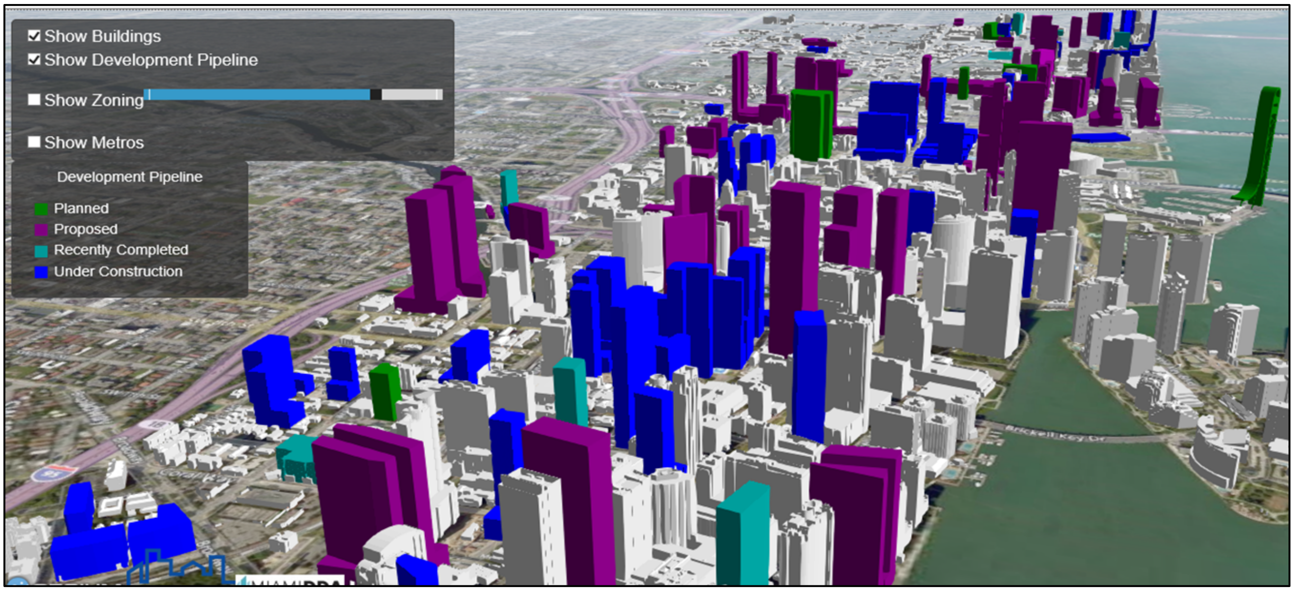
Figures 2-1, 2-2, and 2-3 illustrate the high-density and constrained right-of-way setting of the study area.

Figure 2-1 Representative High-Rise Projects in the Study Area

Figure 2-2 View of the Miami River Mouth

Source: GoogleEarth

Figure 2-3 Development Pipeline



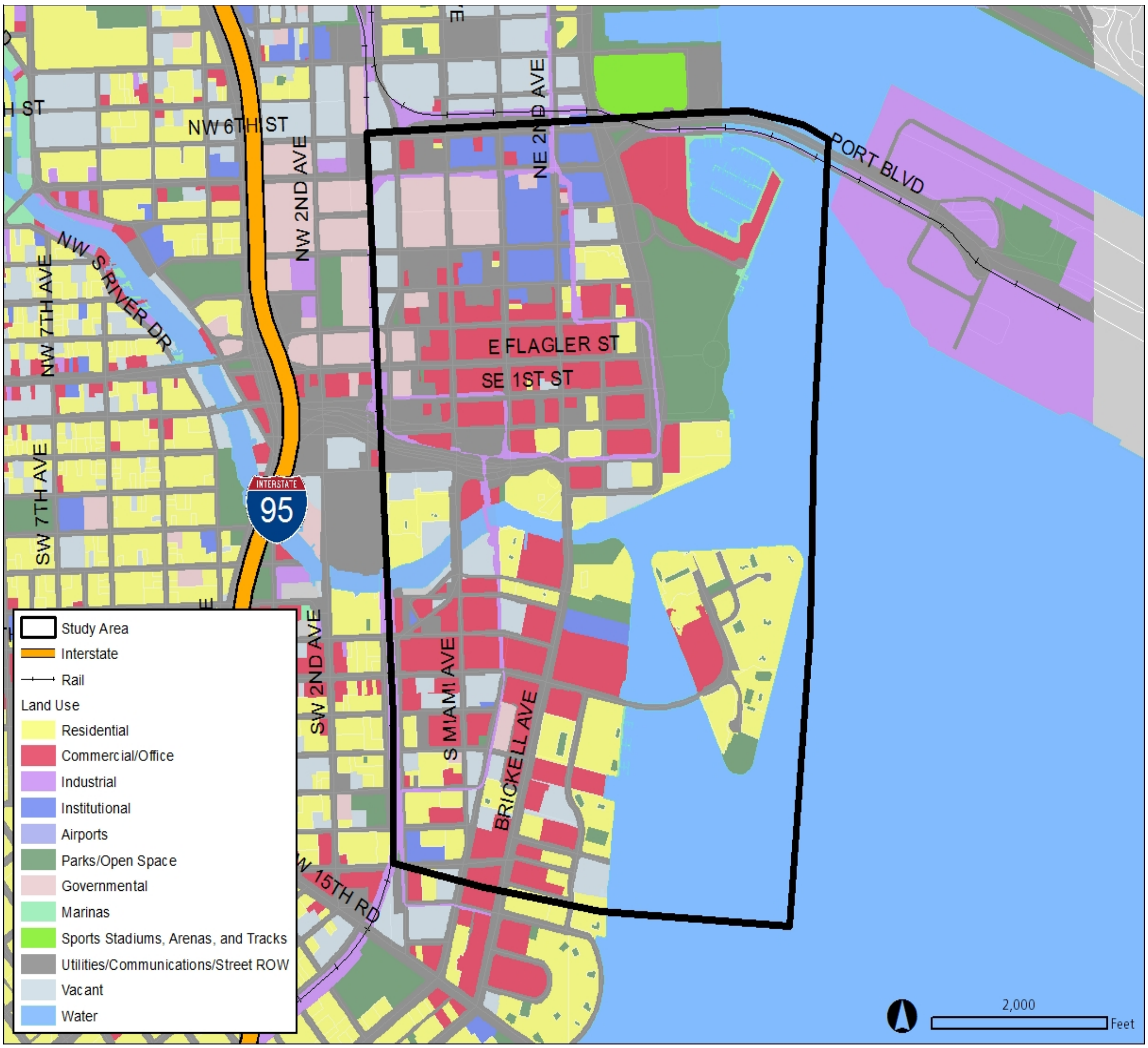
Source: Downtown Development Authority

2.1.1 Land Use Data

Existing Land Use

Figure 2-4 displays the generalized land use map for the study area. There is a high concentration of Commercial/ Office land uses (red) in the study area. Brickell Key is almost entirely residential (yellow). The land use north of the Miami River is more diverse with a mix of residential, commercial/ office, institutional (dark blue), governmental (pink) and parks/open space.

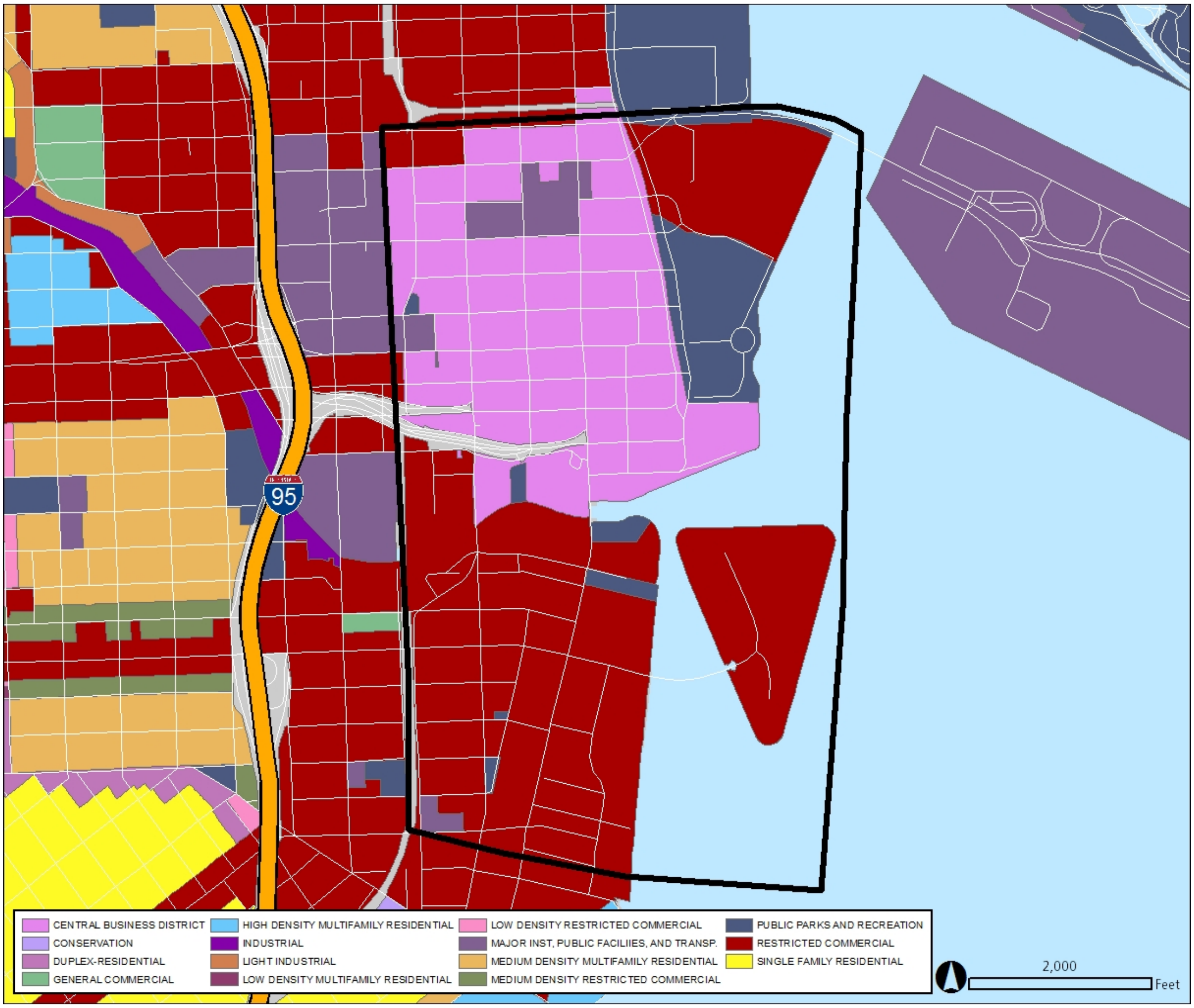
Figure 2-4 Existing Land Use



Future Land Use

Figure 2-5 displays the municipal future land use designations for the study area. The future land use north of the Miami River is predominately low-density restricted commercial. The future land use south of the Miami River is almost entirely restricted commercial. Other common future land uses designation are public parks and recreation.

Figure 2-5 Future Land Use



2.1.2 Cultural and Community Features

Social and Economic Features

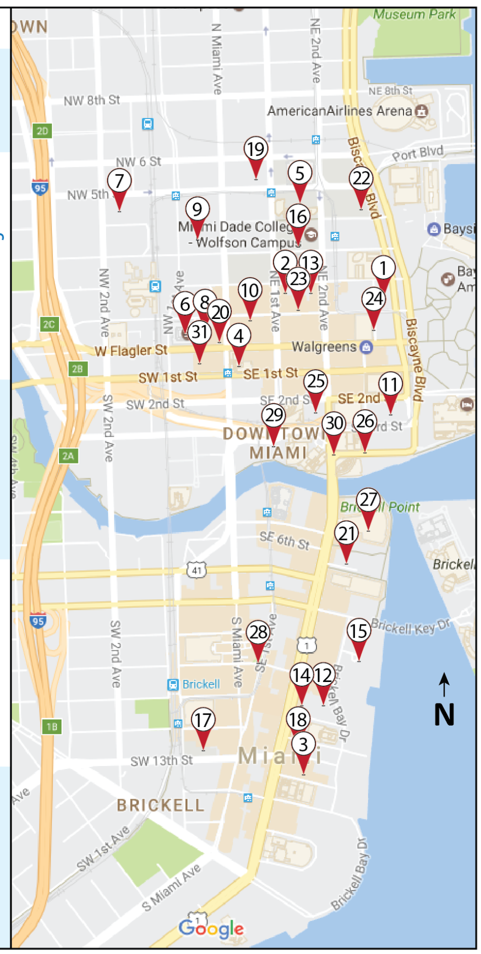
The Florida Department of Transportation (FDOT) Efficient Transportation Decision Making (ETDM) Environmental Screening Tool (EST) *Sociocultural Data Report (2017)* (SDR) was used for demographic data collection. The SDR uses the US Census 2015 American Community Survey (ACS) data and reflects the approximation of the population within the study area of the project's alignment intersecting Census Block Groups. A Census Block Group is a geographical unit used by the US Census Bureau which is between the Census Tract and the Census Block. It is the smallest geographical unit for which the Bureau publishes sample data, i.e., data which is only collected from a fraction of all households.

Community Services

Community services typically serve the needs of the surrounding area and provide a focal point for adjacent neighborhoods and communities. **Figure 2-6** displays the community services in the study area, including churches, schools, community centers, and public facilities.

Figure 2-6 Community Services

Name	Address	
1 French American Chamber of Commerce	100 Biscayne Blvd.	Community Centers
2 Gesu Senior Center	118 NE 2nd St.	
3 Shiseido Latin American Corporation	1221 Brickell Ave.	
4 Women of Tomorrow Mentor & Scholarship Program	22 E Flagler Street	
5 Miami Fire Department and Rescue Station 1	144 NE 5th St.	Governement Buildings
6 Miami-Dade County Circuit Courthouse	73 W Flagler St.	
7 Miami-Dade County Family Court – L. E. Thomas Courthouse	401 NW 2nd Ave.	
8 Miami-Dade County Parking Violation Bureau	22 NW 1st St.	
9 US District Court Clerk	400 N Miami Ave.	
10 US Post Office	36 NE 1st St.	
11 US Post Office	200 S Biscayne Blvd.	
12 US Post Office	1101 Brickell Ave.	
13 Florida Center for Theological Studies	111 NE 1st St.	Schools
14 Florida International University – The Metropolitan Center	1101 Brickell Ave.	
15 Iberoamerican Business University	825 Brickell Bay Dr., Apt. 843	
16 Miami-Dade College	300 NE 2nd Ave.	
17 Southside Elementary School	45 SW 13th St.	
18 Strayer University Brickell Campus	1201 Brickell Ave.	
19 Central Baptist Church – Christ Fellowship Downtown	500 NE 1st Ave.	Churches
20 First Church of Christ, Scientist	15 W. Flagler St.	
21 First Presbyterian Church of Miami	609 Brickell Ave.	
22 First United Methodist Church of Miami	400 Biscayne Blvd.	
23 Gesu Catholic Church	118 NE 2nd St.	
24 Masjid Al-Fayza of Miami	36 NE 3rd Ave.	
25 Pursuit Miami Church Downtown	200 SE 2nd Ave.	
26 Bayfront Park	301 S. Biscayne Blvd.	Public Parks
27 Brickell Park	501 Brickell Ave.	
28 Brickell Plaza Mini Park (Allen Morris Brickell Park)	SE 10th Street & SE 1st Ave.	
29 Fort Dallas Mini Park	64 SE 4th St.- (Butler Building)	
30 Miami River Walk	SE 2nd Ave. to Brickell Bridge	
31 Paul Walker Mini Park/Latin Gourmet Cafeteria	46 West Flagler St.	



Age and Disability

The median age is 34 and persons age 65 and over comprise 4.25% of the population. There are 427 persons (2.6%) between the ages of 20 and 64 that have a disability.

Population Trends

Based on the SDR population data, the study area growth has been substantial in the past few decades, with a population of 4,049 people in 1990 expanding to 21,661 people in 2015. In 2015, the total number of households in the study area was 10,839 with 1.69 persons per household.

Demographics

Table 2-1 compares the race composition for the study area with Miami-Dade County. The project area has a higher white population and lower Hispanic or Latino and Black or African-American population than the rest of the county.

Table 2-1 Study Area Demographics

Demographic	Study Area	Miami-Dade County
White Alone (Race)	86.20%	75.75%
Black or African-American Alone (Race)	7.18%	18.64%
Asian Alone	2.43%	1.59%
“Other”* (Race)	4.19%	4.02%
Hispanic or Latino of Any Race (Ethnic Group)	49.95%	65.62%

Source: United States Census Bureau (2015 US Census ACS)

* “Other” includes American Indian or Alaska Native Alone, Native Hawaiian & Other Pacific Islander Alone, Some Other Race Alone, and Claimed 2 or More Races.

Housing

As **Table 2-2** outlines, housing trends are different than in the County with a lower percentage of owner-occupied dwelling units and a much higher median housing value.

Table 2-2 Study Area House Trends

Housing Trends	500-foot Project Buffer Area	Duval County
Number of housing units	17,962	391,719
Primary Type of Home	Multi- family homes (98%)	Single family homes (51%)
Owner occupied units	16%	45%
Renter occupied units	44%	39%
Vacant Units	40%	16%
Median housing value	$366,400	$144,000
Homes without a vehicle	871 (4%)	94,281 (9%)

Language

Within the study area are 468 (2.31%) that speak English “not at all” and 834 people (4.12%) that speak English “not well”. Based on US DOT Policy Guidance, the FDOT has identified four factors to help determine if Limited English Proficiency (LEP) services would be required as listed in the FDOT Project development and Environment (PD&E) Manual, Part 1, Chapter 11, Section 11.1.2.2 Based on a review of these factors and the fact that LEP population accounts for 6.43% of the population for this project, LEP services will be required.

Age and Disability

The median age is 34 and persons age 65 and over comprise 4.25% of the population. There are 427 persons (2.6%) between the ages of 20 and 64 that have a disability.

Income

The median household income for Miami-Dade County is $43,129. The income in the study area is much higher with a median household income of $72,232. There are 12.91% households below poverty level and 0.40% households with public assistance within the study area.

2.1.3 Economic Elements

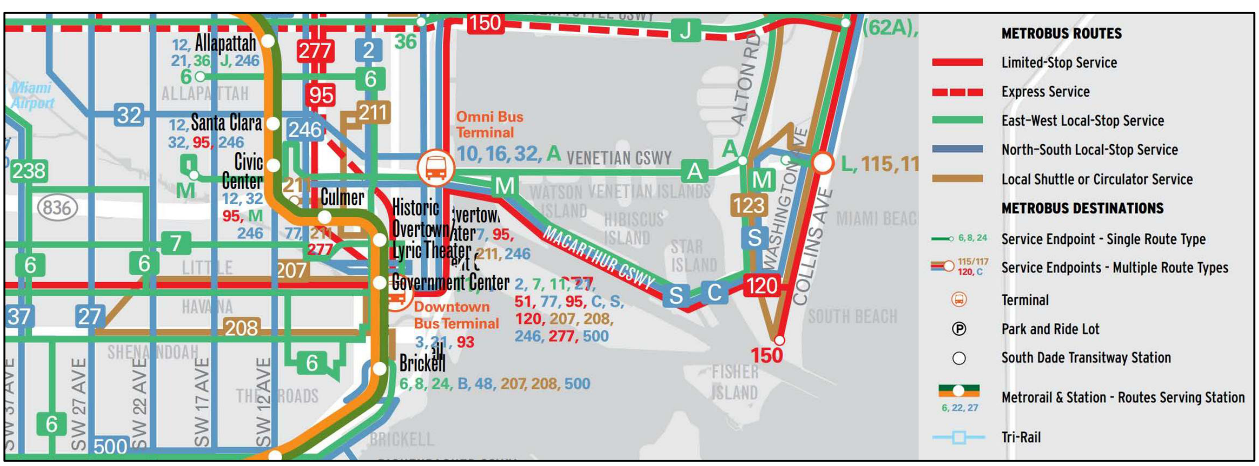
There are 14 Developments of Regional Impact (DRIs) and no Planned Unit Developments (PUDs) within the study area. The project is within the Miami-Dade County Florida Empowerment Zone and Enterprise Zone – Miami-Dade County (EX-1301). Communities selected as Empowerment Zones promote economic development in their distressed communities. An Enterprise Zone is a specific geographic area targeted for economic revitalizing. Enterprise Zones encourage economic growth and investment in distressed areas by offering tax advantages and incentives to businesses locating within the zone boundaries.

2.1.4 Mobility Elements

Transit

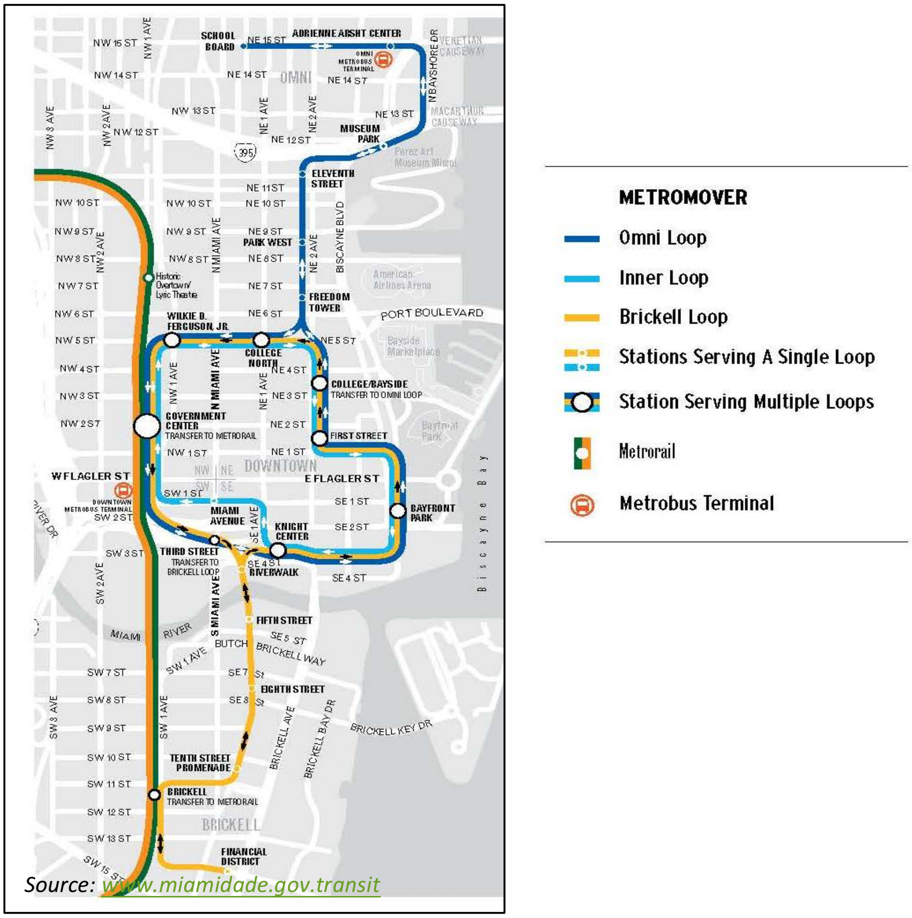
Miami-Dade County residents and visitors have several transit options in the study area including: bus, enhanced bus, express bus, Metromover, and Metrorail. Within the study area, there are 9 intermodal terminal facilities, 21 fixed guideway transit network Stations, and 65 bus transit routes as shown in **Figures 2-7 and 2-8**. Per the *2040 Southeast Florida Regional Transportation Plan Regional Transit System Master Plan,* "the use of public transit in the Southeast Florida region is the greatest in Miami-Dade County at five percent and the highest number of those in the workforce walking to work is also in Miami-Dade County, where the numbers reach two percent." There are no County bus routes which traverse the Brickell Avenue bridge. However, the City of Miami Trolley Biscayne Route (**Figure 2.9**) crosses the Brickell Avenue bridge.

Figure 2-7 Miami-Dade County Transit System Metrobus and Metrorail Map



Source: www.maimidade.gov.transit

Figure 2-8 Miami-Dade County Transit System Metromover Map



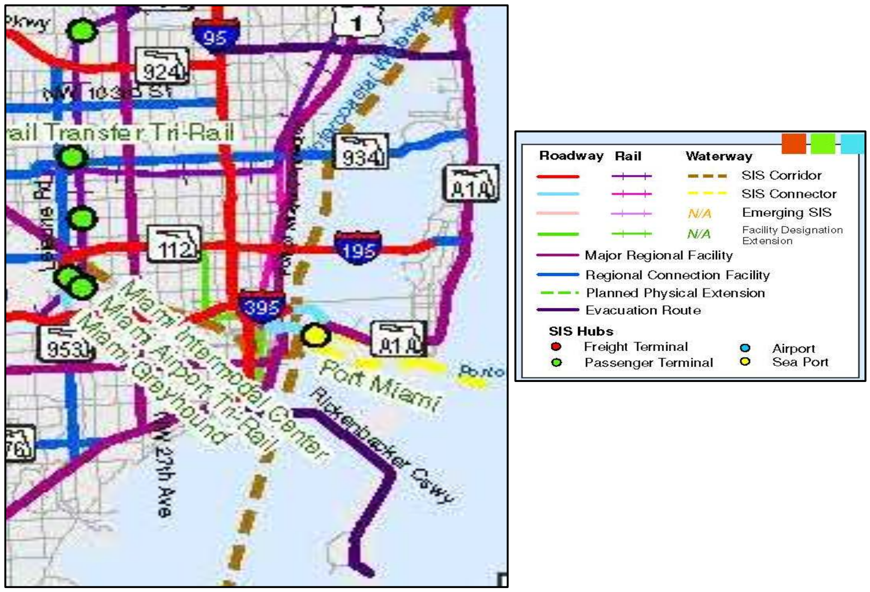
Source: www.miamidade.gov.transit

Figure 2-9 City of Miami Trolley – Biscayne Route

Regional Transportation Network

The 2040 Regional Corridor Network identifies corridors that support regional travel of people and goods for stronger regional planning. **Figure 2-10** shows the regional facilities that are with the study area including the roadways, rail, Strategic Intermodal System (SIS) connector (Intracoastal Waterway), and seaport (PortMiami).

Figure 2-10 2035 Regional Transportation Network



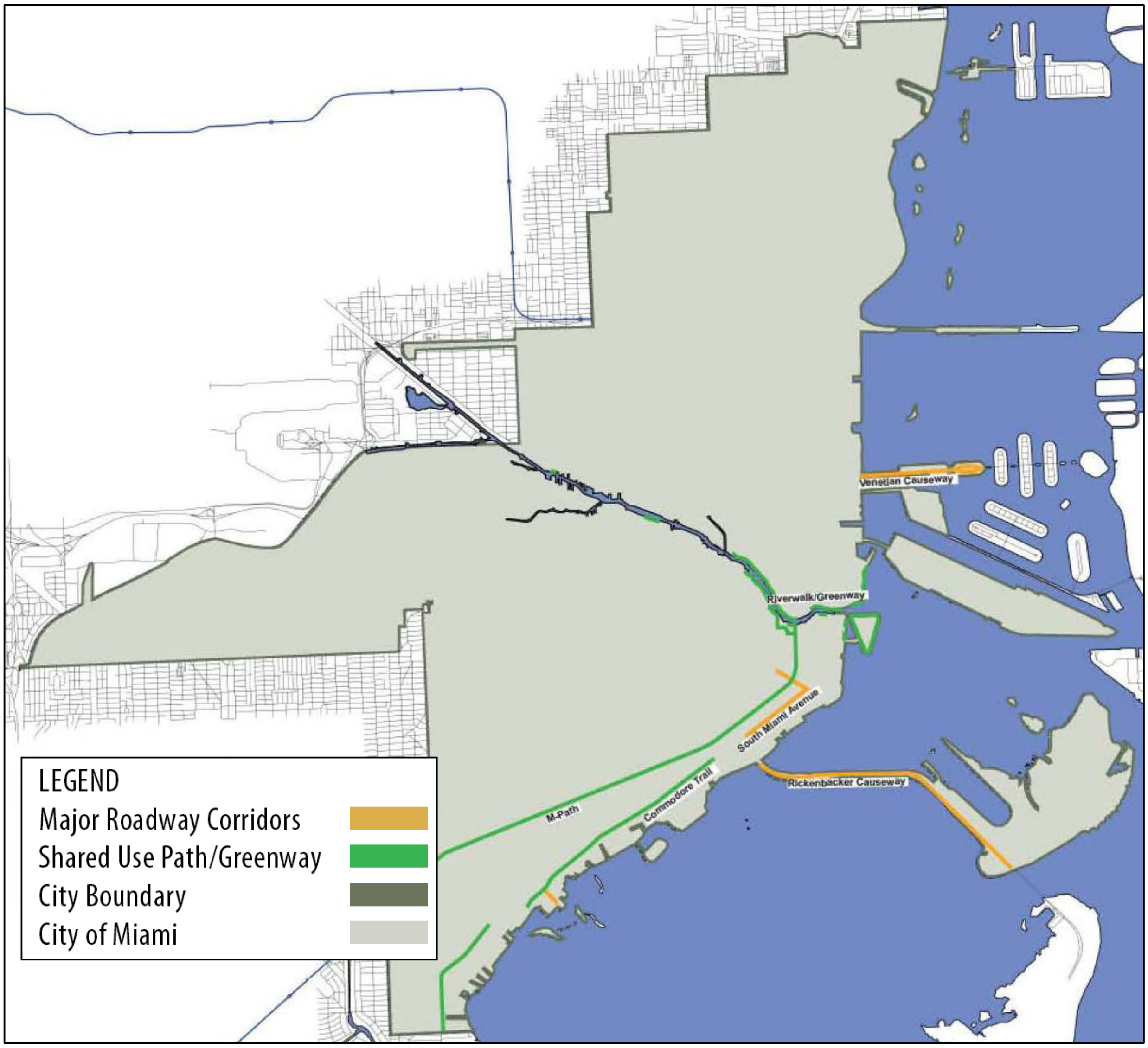
Freight

This project will support movement of goods from the Port of Miami which is located just outside of the study area. The *Miami-Dade 2040 Long Range Transportation Plan* (LRTP) states "The established and expanding freight transportation system, serves as the cornerstone of the region's economy, providing access to Florida's largest consumption market, as well as connecting the region to the global economy through major sea and air gateways. Miami-Dade County is home to a multi-cultural community with an economy dominated by tourism, international trade, agriculture and mining, and natural resources. Miami-Dade County has an extensive freight system encompassing all major modes of transportation. These modes work to complement one another to ensure a smooth flow of goods throughout the county, the region, the state, and the country. The freight infrastructure is undergoing significant improvements and expansion to position the region for future growth."

Bicycle and Pedestrian Routes

The *City of Miami 2030 Bicycle Master Plan* states "The Plan identified that most of the existing corridors within the city are primarily designed for automobile use. Very few bicycle facilities exist within the Downtown area, which makes for an unsafe environment for bicyclists along these corridors. **Figure 2-11** reveals the lack of bicycle facilities, parking, and the unbalanced geographical distribution of what has been implemented." The M-Path and Miami River Greenway Trails depicted on the map are described in detail in Section 2.2 Recreational Facilities.

Figure 2-11 Existing Bikeway Network



2.1.5 Potential Displacements

The proposed project corridor traverses through downtown Miami with Commercial and Services; High-Density Multi-Family; Institutional; Office; and Parks, Preserves and Conservation Areas land uses. Most of the homes in the area are high-density residential in high rise dwelling units. The *Miami-Dade 2040 LRTP* states "Substantial household growth is predicted to continue in Downtown Miami. The substantial supply of new condominium units is increasingly being brought to market as rental stock, generating a highly competitive rental market that translates into greater affordability and choice attractive to the substantial downtown employment base."

2.1.6 Farmlands

The project is located in the Miami urbanized area. It has been determined that there are no farmlands as defined by *7 Code of Federal Regulations (CFR) 658* in the project area. Therefore, the provisions of the Farmland Protection Policy Act of 1984 do not apply to this project.

2.2 Cultural Features

2.2.1 Historic and Archeological Sites

The EST GIS analysis identified 12 archaeological sites, three historic bridges, nine resource groups, and 289 historic structures within the study area.

Archeological Sites

Of the twelve archaeological sites, nine have not been evaluated for National Register of Historic Places (NRHP) eligibility by the State Historic Preservation Officer (SHPO). Two of the sites, Granada (8DA11) and SE 2nd St. Midden (8DA6328) have been determined eligible for listing in the NRHP by the SHPO. One site, the Miami Circle at Brickell Point (8DA12), is listed in the NRHP and has been designated a National Historic Landmark (NHL). The property containing the Miami Circle at Brickell Point (8DA12) was purchased by the State of Florida and is operated as a park managed by the City of Miami.

Historic Bridges

There are three historic bridges within the study area: South Miami Ave. Bridge (8DA1087), Brickell Ave. Bridge (8DA5098), and Port of Miami Bascule Bridge (8DA12620). The three bridges have not been evaluated for NRHP eligibility by the SHPO.

Resource Groups

Of the nine resource groups, six are historic linear resources, two are historic districts, and one is an archaeological district. There is one historic railroad, the FEC Railroad (8DA10107), which has been determined eligible for listing in the NRHP by the SHPO. There are five historic roads: Biscayne Blvd. (8DA6901), Brickell Ave. (8DA10073), Flagler St. (8DA10448), SW 1st St. (8DA10509), and Calle Ocho (8DA4586). All five of the roads have been determined ineligible for listing in the NRHP by the SHPO; however, Brickell Ave. and Calle Ocho have been designated as State Historic Highways (SHH). Of the two historic districts, the Downtown Miami Commercial Historic District (8DA5126) has been determined eligible for listing in the NRHP by the SHPO and the Downtown Miami Historic District (8DA10001) is listed on the NRHP. The single archaeological district, the Brickell Resource Group (8DA5360), has been determined eligible for listing in the NRHP by the SHPO. The Downtown Miami Historic District (8DA10001) is composed of 60 contributing buildings, some of which are individually listed in the NRHP.

Historic Structures

Of the 289 historic structures, 54 have been determined ineligible for listing in the NRHP by the SHPO. A total of 58 have been determined eligible or potentially eligible for listing in the NRHP by the SHPO, of which 23 are individually listed in the NRHP. The remaining 177 have not been evaluated by the SHPO, although many are contributing resources within the NRHP-listed Downtown Miami Historic District (8DA10001).

Cultural Resource Surveys

There have been 31 previous cultural resource surveys conducted within the study area. Fifteen of those surveys were conducted by the FDOT for various transportation projects. The remaining surveys include those conducted for city and county-wide assessments, communication tower projects, and private development projects. According to the EST GIS, there are some parcels with pre-1970 construction dates located within the study area that have not been recorded; however, there does not appear to be a significant number of historic resources that have not been recorded. Overall, the project will require extensive involvement with both historic and archaeological sites.

2.2.2 Recreational Facilities

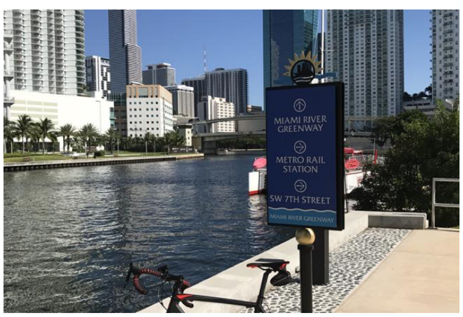
The project study area has numerous park and recreational facilities as mentioned under the Community Services section. The area parks include:

- Brickell Park
- Brickell Plaza Mini Park (Allen Morris Brickell Park)
- Fort Dallas Mini Park
- Miami River Walk
- Bayfront Park
- Paul Walker Mini Park/Latin Gourmet Cafeteria

Trails and Greenways

Trails within the study area include the M-Path and Miami River Greenway. The M-Path is a 9.4 mile paved multi-use trail which opened in 1983, and is part of the Miami-Dade Transit (MDT) system. The trail follows the MDT right-of-way under the elevated Metrorail guideways. The M-Path is one of Florida's oldest rail trails built atop a portion of the Florida East Coast Railway (FEC). The trail end points are SW 1st Avenue and the Miami River (Downtown Miami), and Dadeland Mall at US 1 and SW 88th St. (South Miami).

M-Path
Source: TrailLink.com



Miami River Greenway
Source: TrailLink.com

Based on information from the *Miami River Greenway Action Plan*, the Miami River Greenway is an urban greenway project located along both banks of the Miami River. The plan is for it to eventually form an uninterrupted walkway from the mouth of the river in Downtown Miami to the Dolphin Expressway near the Civic Center area, and in the long term all the way to Miami International Airport. On the north bank the walkway is currently known as the Miami Riverwalk which currently extends beyond the river through Bayfront Park along Biscayne Bay where it is known as the Bay Walk. Plans are to extend this as far north and south as the Julia Tuttle and Rickenbacker Causeways, respectively. A map of these trails is shown in Figure 2.7 in the previous Mobility Section.

2.2.3 Section 4(f) Resources

In addition to the resources listed in the recreation and historic and archeological features sections, there are two National Parks projects; Miami River Bicycle Trail and Bayfront Park II. These projects were constructed with funding in part from US Department of Interior (DOI) National Park Service (NPS) Land and Water Conservation Fund (LWCF) and are therefore also Section 6(f) historic resources. Additional coordination will be necessary if these facilities are affected. Avoidance and/or minimization of impacts to these public resources is suggested.

2.3 Natural and Biological Features

2.3.1 Natural Features

Natural features include wetlands, water quality and surface waters, floodplains, aquatic preserve/outstanding Florida waters, and coastal zones.

Wetlands

Based on data from the National Wetlands Inventory (NWI), within the project study area there are 198.26 acres (27.58%) of marine wetlands and 11.85 acres (1.65%) of estuarine wetlands. Impacts to NWI wetlands and other aquatic habitats may be subject to regulation under Section 404 of the Clean Water Act, or other State/Federal statutes.

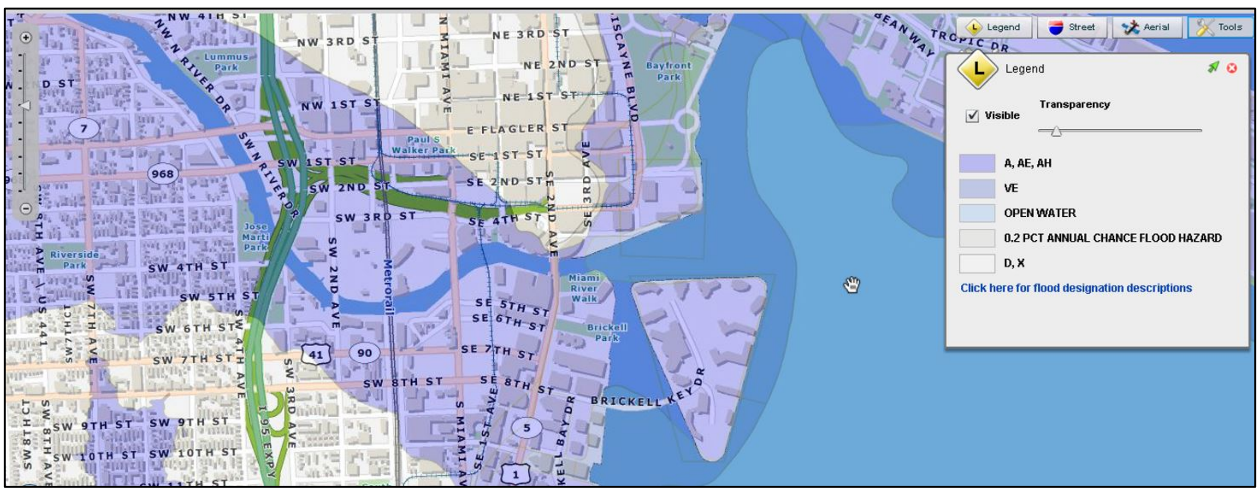
Water Quality and Surface Waters

The project study area is within the Biscayne Bay Aquatic Preserve which is an Outstanding Florida Waters (OFW). There are three waterbodies within the study area; C-6/Miami River (Lower Segment), Direct Runoff to the Bay, and PortMiami. Each of these are Verified Impaired Florida Waters.

Floodplains

Within the study area, Special Flood Hazard Areas are identified as Zone AE with 2,740.13 acres (84.53%) and Zone VE with 77.27 acres (2.38%) and D-FIRM 100-year Flood Plain are identified as Flood Zone AE with 371.04 acres (51.62%) and Zone VE with 123.47 acres (17.18%). **Figure 2-12** displays the flood zones.

Figure 2-12 Flood Zones



Aquatic Preserve/Outstanding Florida Waters

Aquatic Preserves are designated as such, to maintain an area in an essentially natural or existing condition so that their aesthetic, biological, and scientific values may endure for the enjoyment of future generations (*Section 258.36, F.S.*). OFW's are designated and specially protected because of their natural attributes. (*Section 403.061, F.S.*). Based on a review of the project, Biscayne Bay Aquatic Preserve has been identified within the project study area as an OFW, and its limits include the Miami River.

Coastal Zone Consistency

It will be determined in future phases, through the Advance Notification process, whether this project is consistent with the Florida Coastal Zone Management Plan (FCMP).

2.3.2 Biological Features

Biological features include wildlife and their habitat along with essential fish habitat.

Wildlife and Habitat

Based on review of the ETDM EST GIS analysis there are no Florida Natural Areas Inventory (FNIA) Element Occurrences or Florida Fish and Wildlife Conservation Commission (FWC) wildlife observations. A review of the US Fish and Wildlife Services (USFWS) website was conducted and an Information for Planning and Consultation (IPAC) Report was produced for the project study area. Protected species identified in this report are listed in the appendix.

The project study area is also within the American Crocodile, Piping Plover, and West Indian Manatee Consultation Areas. Additionally, there is critical habitat for the West Indian Manatee and FWC State Manatee Protection Zones. Rare and imperil fish identified in this area include the Mountain Mullet found in the Cutler Drain Canal and the Mangrove Rivulus (waterbody not named).

Essential Fish Habitat

There is Essential Fish Habitat (EFH) within the project study area. As mentioned previous, Biscayne Bay is an Aquatic Preserve and there are Johnson Critical Seagrass Critical Habitat in Northern Biscayne Bay. The ETDM EST GIS analysis identified Seagrass Beds of 38.79 acres (5.4%) of continuous and 43.08 acres (5.99%) of discontinuous seagrasses and two types of Environmentally Sensitive Shorelines totaling over 21,000 feet; 8B: Sheltered Solid Man-made Structures and 8C: Sheltered RipRap. There are also Sovereign Submerged Lands.

2.3.3 Physical Environmental Features

Contamination

Atkins performed a preliminary review of potential contamination sites along the project corridor. The review included an evaluation of database records compiled by the United States Environmental Protection Agency (U.S. EPA), the Florida Department of Environmental Protection (FDEP), and the Miami-Dade County Department of Regulatory and Economic Resources, Division of Environmental Resources Management (DERM). Environmental Data Management (EDM) Inc. of Largo, Florida conducted a database search of potential hazardous materials and petroleum sites within one-eighth mile (660 feet) of the proposed project corridor. The EDM Report is provided in the appendix. In summary, the EDM Report identified 79 potential contamination sites along the Miami River Tunnel project corridor. Of these, 14 sites were likely to be considered Medium- or High-ranked potential contamination sites, pending further research. The remaining 65 potential contamination sites were likely to be ranked as Low, pending further research. The Brownfields Areas, located along the project corridor north of 5th Street SW, would also be likely Medium-ranked potential contamination sites.

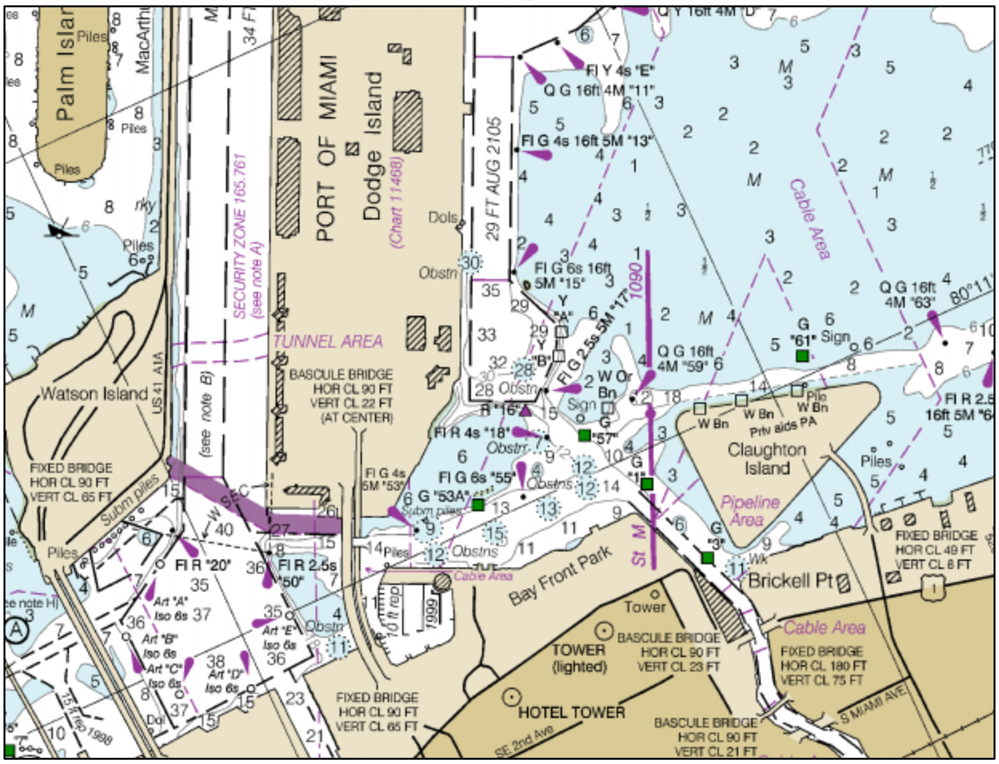
Noise and Vibration

Traffic noise will need to be considered for the entire project limits with attention to the areas in proximity to the tunnel openings if sensitive receptors are nearby. If tunnel openings need to be modeled for traffic noise, guidance provided in the Transportation Research Board's (TRB) National Cooperative Highway Research Program (NCHRP) Report 791, *Supplemental Guidance on the Application of FHWA's Traffic Noise Model (TNM)* (2014) should be utilized. This guidance offers specific methods for modeling tunnel openings for traffic noise on highway projects. Construction vibration will also need to be considered in regard to the methods to be used for tunnel construction.

Navigation

The two navigable waterways in the study area are the Miami River and Atlantic Intercostal Waterway. **Figure 2-13** displays the navigation chart of the study area vicinity. The Miami River was dredged approximately 10 years ago to its Federally authorized channel depth of –15 feet mean low water (MLW). The US Army Corps of Engineers requires a minimum of 14 feet of clearance from the floor of the river to other infrastructure such as utilities, or in this case, a tunnel.

Figure 2-13 Navigation Chart



Air Quality

This project is in an area which has been designated as attainment for all the air quality standards under the criteria provided in the Clean Air Act Amendments (CAAA) of 1990. Therefore, air quality conformity does not apply. The intent of the project is to reduce congestion in the vicinity of the Brickell Avenue bridge, so it is anticipated that the project would have a beneficial effect on air quality.

Global Climate Change

The issue of global climate change is an important national and global concern that is being addressed in several ways by Federal and State government. The transportation sector is the second largest source of total Green House Gases (GHG) in the United States, and the greatest source of carbon dioxide (CO_2) emissions – the predominant GHG. In 2004, the transportation sector was responsible for approximately 31 percent of all CO_2 emissions in the United States. The principal anthropogenic (human-made) source of carbon emissions is the combustion of fossil fuels, which account for approximately 80 percent of anthropogenic emissions of carbon worldwide. Almost all (98 percent) transportation-sector emissions result from the consumption of petroleum products such as gasoline, diesel fuel, and aviation fuel.

The transportation sector is a substantial contributor to GHG emissions in Florida, accounting for about 46 percent of CO_2 emissions in Florida. The transportation sector's GHG emissions in Florida are dominated by personal vehicle travel in cars and light trucks, which account for almost two-thirds of these emissions. Other trucks account for an additional 4 percent of CO_2 emissions.

Strategies are being developed and/or implemented at the Federal and State level to address transportation GHG. Former Governor Crist established the Action Team on Energy and Climate Change by signing *Executive Order 07-128*, "Florida Governor's Action Team on Energy and Climate Change," on July 13, 2007. A Florida climate change Action Plan is being developed that would include strategies to reduce emissions, including recommendations for proposed legislation for consideration by the Florida Legislature.

Key Florida strategies for reducing transportation's contribution to GHG emissions include:

- Reducing the rate of fuel consumption by enhancing vehicle efficiency;
- Reducing congestion and delay on the transportation system;
- Reducing the carbon content of fuel, so that fewer emissions are generated for each gallon of fuel consumed;
- Reducing the growth rate in travel by managing travel demand; and
- Expanding options for travel by means other than single-occupant vehicles, and changing land use patterns.

2.4 Roadway Characteristics

This section provides details on the roadway features within the project area. Details include a narrative description and examples of typical sections, functional classification, and other existing roadway conditions such as drainage, signalization, and lighting.

2.4.1 Description of Roadways

A summary of the roadway characteristics is displayed in **Table 2-3.** Further roadway descriptors and typical sections are summarized in this section.

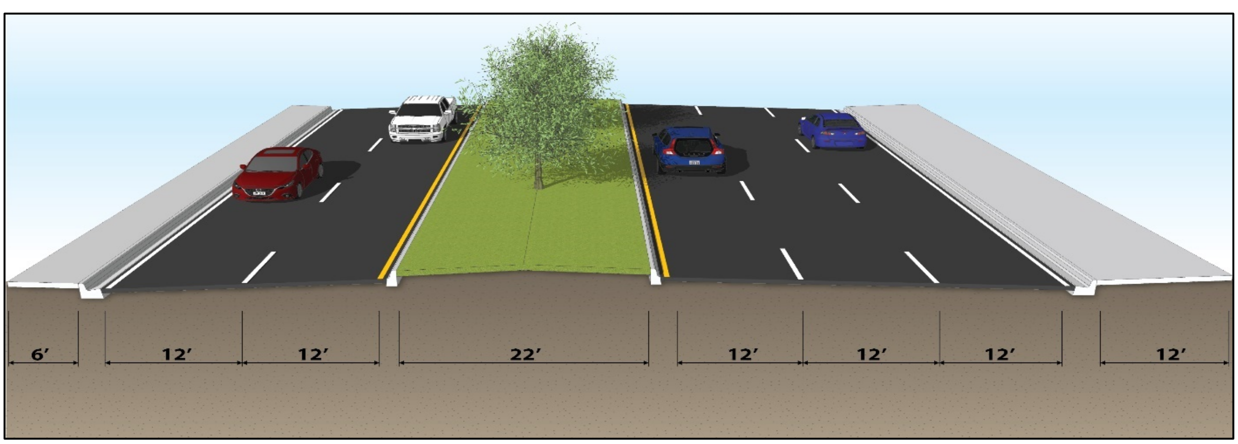
Table 2-3 Roadway Characteristics

Roadway	ROW (feet)	Number of Lanes	Direction	Road Ownership
Brickell Avenue South of SE 10th Street	94	4	NB and SB	FDOT
Brickell Avenue South of SE 8th Street	100	5	NB and SB	City of Miami
Brickell Avenue North of Biscayne Boulevard Way	70	3	SB	FDOT
Biscayne Boulevard North of NE 2nd Street	200	8	NB and SB	FDOT
Biscayne Boulevard Way	50	3	EB	FDOT
SE 3rd Street	100	3	EB	City of Miami
SE 2nd Street, from SE 2nd Ave. to Biscayne Blvd.	100	3	WB	FDOT
SE 7th Street, from S. Miami Ave. to Brickell Ave.	70	3	EB	FDOT
SE 8th Street, from S. Miami Ave. to Brickell Ave.	70	3	WB	FDOT

Brickell Avenue South of 8th Street

Brickell Avenue south of SE 8th Street is a bi-directional roadway with three northbound lanes and two southbound lanes spanning 100 feet of right-of-way. A 22-foot landscaped median and sidewalks are included within this right-of-way. **Figure 2-14** displays a typical roadway cross-section for Brickell Avenue south of SE 8th Street.

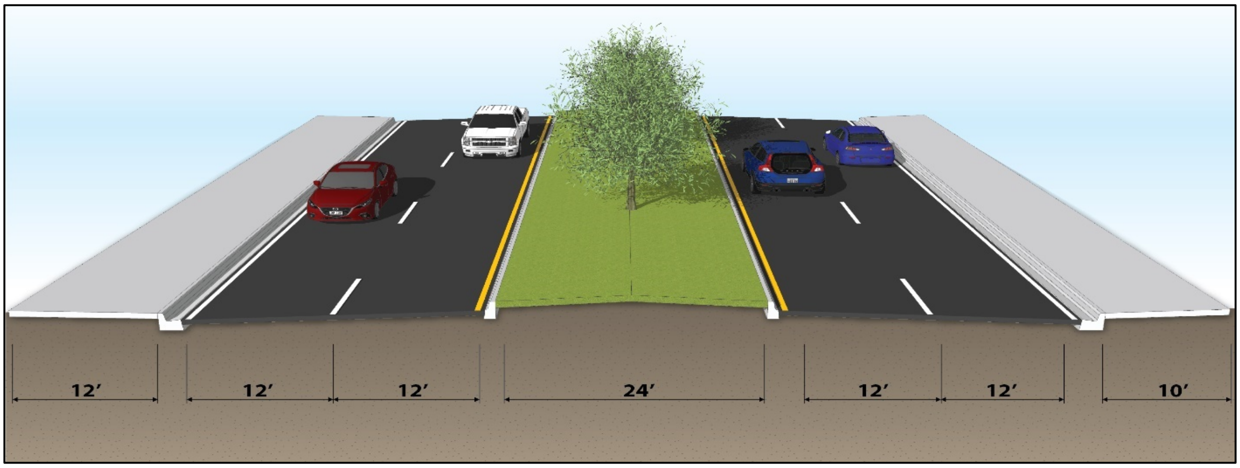
Figure 2-14 Brickell Avenue South of SE 8th Street



Brickell Avenue South of SE 10th Street

Brickell Avenue south of SE 10th Street is a bi-directional roadway with two lanes in both directions, and 94 feet of right-of-way. Within this right-of-way is a 24-foot median and 10- to 12-foot sidewalks on both sides. **Figure 2-15** depicts a typical roadway cross section.

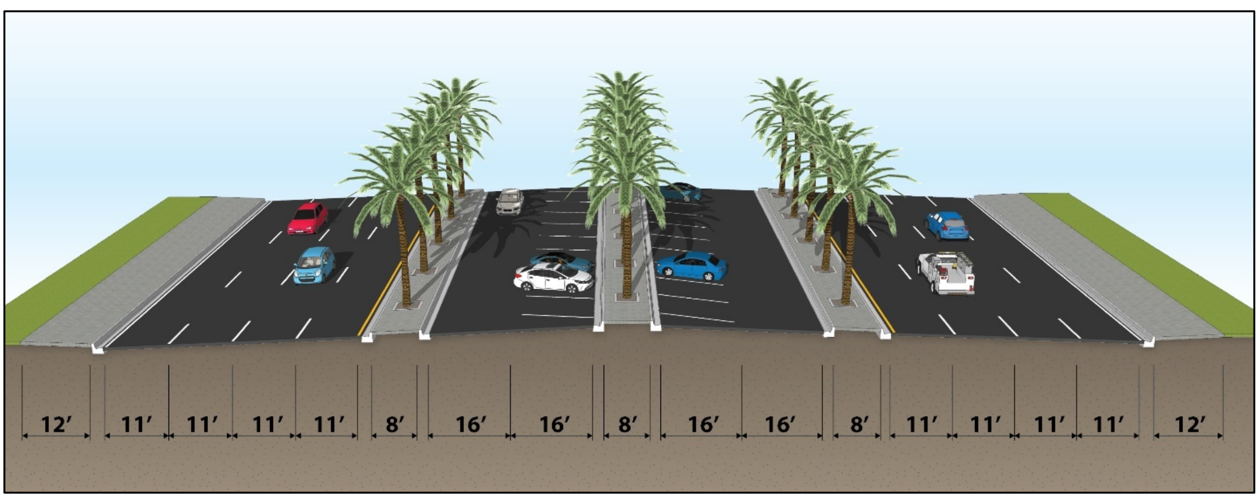
Figure 2-15 Brickell Avenue South of SE 10th Street



Biscayne Boulevard North NE 2nd Street

Biscayne Boulevard north of NE 2nd street is a bi-directional roadway with eight 11 foot through lanes. The 200 feet of right of way includes angled parking in the median and 12-foot wide sidewalks. **Figure 2-16** depicts the roadway cross-section. Biscayne Boulevard is posted for 30 mph.

Figure 2-16 Biscayne Boulevard North of NE 2nd Street



Biscayne Boulevard Way

Biscayne Boulevard Way is a one-way eastbound road which parallels the river and walkway. Vehicles traveling from Brickell Avenue over the Miami River bascule bridge into Downtown Miami will use this roadway. The road includes sidewalks and three 11-foot through lanes that lead into northbound Biscayne Boulevard with various downtown attractions such as Museum Park.

SE 3rd Street

SE 3rd Street is a one way eastbound road that leads into Downtown Miami from I-95. This road includes sidewalks, a Metromover guideway bisecting the street, and three 11-foot through lanes within a 100-foot right-of-way.

SE 2nd Street from SE 2nd Avenue to Biscayne Boulevard

SE 2nd Street between SE 2nd Avenue and Biscayne Boulevard is a one-way westbound road with three 11-foot lanes and a right-of-way width of 100 feet. This road is used to exit Downtown Miami via I-95 or enter Brickell Avenue using the Miami River bascule bridge.

SW 7th Street and SW 8th Street from Brickell Avenue to Miami Avenue

SW 7th Street and SW 8th Street function as an east-west one-way pair. SW 7th Street from Brickell Avenue to Miami Avenue has a 70-foot right-of-way with three 11-foot lanes westbound, with on-street parking on both sides of the street. SW 8th Street from Brickell Avenue to Miami Avenue has a 70-foot right-of-way, with three 11-foot lanes eastbound, and on-street parking on both sides of the street.

2.4.2 Functional Classification

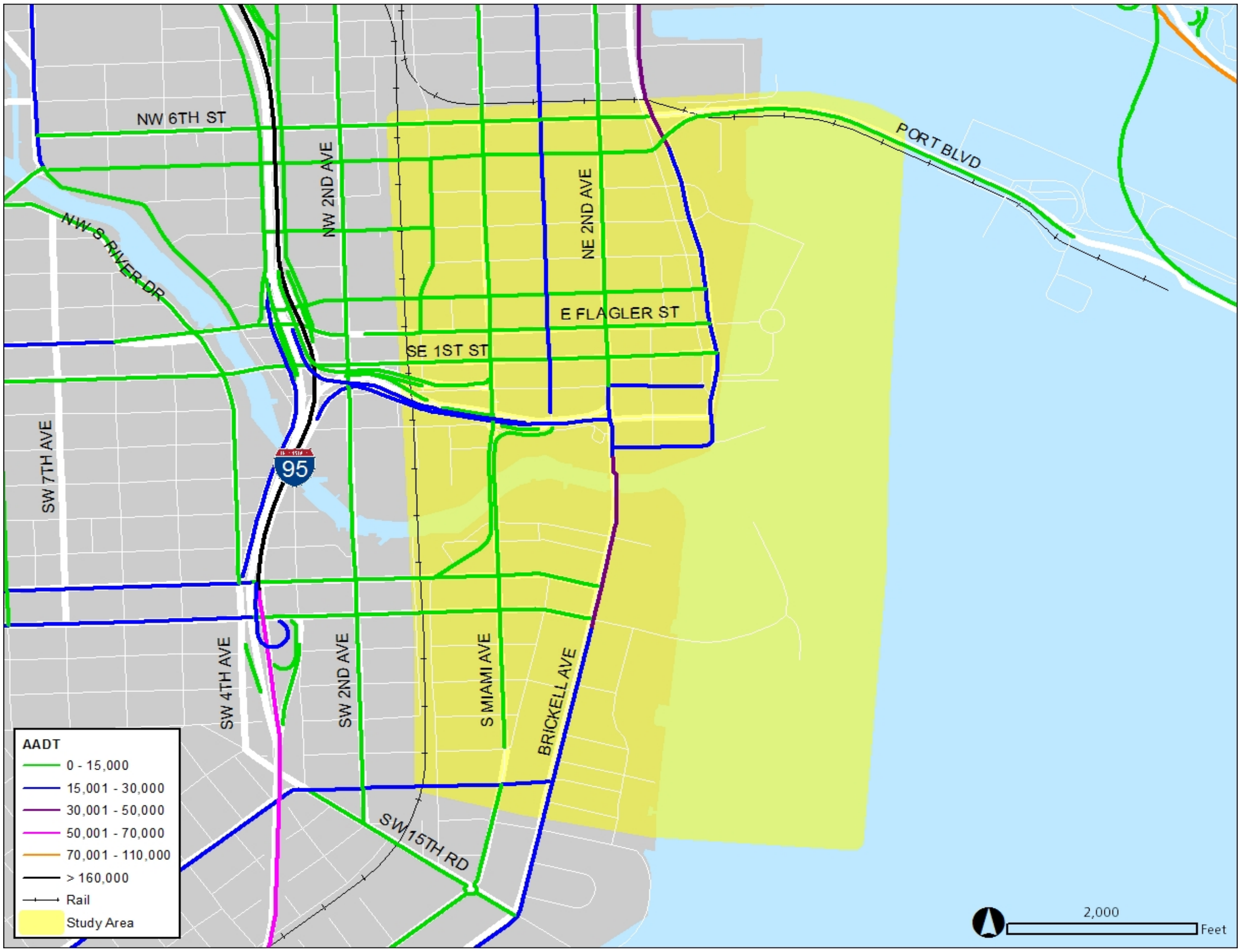
The functional classification of a road is the class or group of roads to which the road belongs. As defined by the FHA, the three main functional classes are arterial, collector, and local. Moreover, FDOT identifies roads classified as principal or minor arterial urban roadways typical for freight traffic. The FDOT functional classification of the roadways within and around the study area are displayed in **Figure 2-17.** The roadways displayed in green (minor arterial urban), red (principal arterial, other, urban), or blue (principal arterial interstate, urban) on the map are the roadways typical for freight traffic that traverse through the study area.

Figure 2-17 FDOT Functional Classification

2.4.3 Existing Traffic

The Average Annual Daily Traffic (AADT) of a roadway is a general measure of how busy a road is based on the average volume of the roadway. The most recent FDOT AADT results (2016) for the study area for are displayed in **Figure 2-18**. The roadways shown in green or blue have the lower volumes, whereas the shown in pink or black have the higher volumes.

Figure 2-18 Annual Average Daily Traffic (AADT), 2016



2.4.4 Right-of-Way

The existing right-of-way locations near and around the study area are depicted in **Figure 2-19.**

Figure 2-19 Right-of-Way

2.4.5 Drainage

The existing drainage within the project area is handled primarily by curb inlets that collect the roadway stormwater runoff and a closed pipe system that conveys the untreated stormwater directly to the Miami River. Runoff from the existing Brickell Avenue bridge and approaches falls through the grating of the lift spans or sheet flows to scuppers located along the outside edges of pavement and discharges directly to the Miami River. The project area is located entirely within the tidal Biscayne Bay drainage basin.

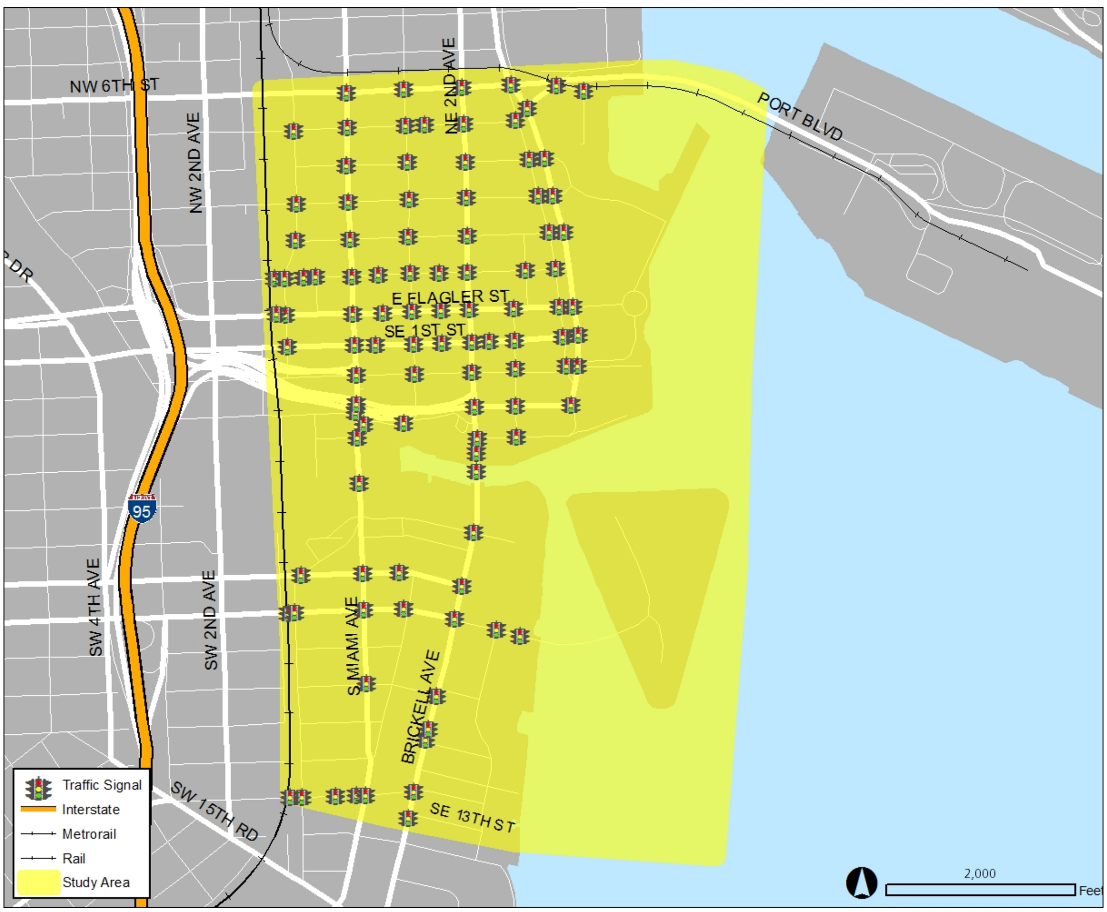
2.4.6 Lighting

Most roadway lighting within the study area consists of single fixture poles maintained by Florida Power & Light and Miami-Dade County.

2.4.7 Traffic Signals

There are approximately 100 signalized intersections within the study area. **Figure 2-20** depicts the locations of the traffic signals.

Figure 2-20 Traffic Signal Locations



2.4.8 Utilities

The existing utilities along the corridor include American Traffic Solutions, AT&T, Comcast, Miami Dade County Public Works and Traffic, Fiberlight, FDOT District 6 ITS, FPL, Fibernet, FPL Trans., Hotwire, Level 3, MCI, Miami Dade Water and Sewer, TECO, CenturyLink, XO Communications, AT&T Distributions, Central Support Facility, Zayo Group, and Miami Dade Enterprise Technology Services Department. Existing utilities within the project area are summarized in **Table 2-4**.

Table 2-4 Existing Utility Owners

Utility Owners	Utility Type
American Traffic solutions	Communications
AT&T	Communications/Fiber Optic
Comcast	CATV & Fiber Optic
Miami Dade County Public Works and Traffic	Traffic/Street Lights
Fiberlight	Fiber Optics
FDOT D6 ITS	Fiber Optics
FPL	Electric
Fibernet	Fiber Optics
FPL Trans.	Electric
Hotwire	Fiber Optics, Telephone, CATV, COAX
Level 3	Fiber Optics
MCI	Communications/Fiber Optic
Miami Dade Water and Sewer	Water & Sewer
TECO	Gas
CenturyLink	Fiber Optics
XO Communications	Telecommunications
AT&T Distribution	Telephone
Central Support Facility	Chill Water & Electrical
Zayo Group	Fiber Optics
Miami Dade Enterprise Technology services Dept.	Fiber Optics

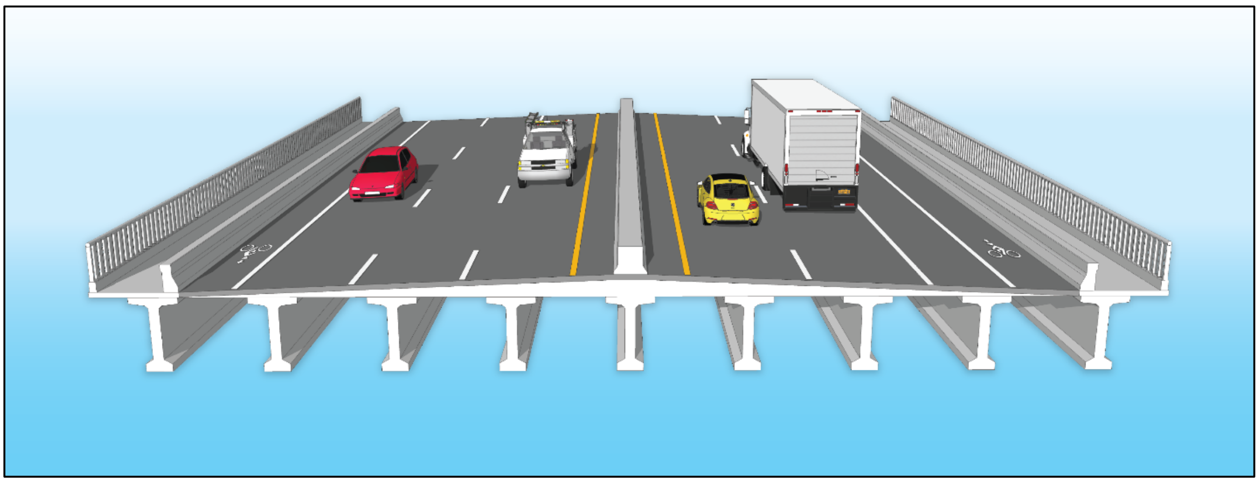
2.5 Existing Brickell Avenue Bridge

The original Brickell Avenue Bridge was built in 1929, and replaced in 1995 by the Florida DOT. This section provides details on the current bridge facility, bridge traffic volume, and bridge openings.

2.5.1 Bridge Facility

The Brickell Avenue Bridge was widened by one additional northbound lane in 2006 to reduce the traffic bottleneck through downtown. Presently, that northbound lane is striped for a bicycle lane and buffer. There are also barrier-protected pedestrian walkways on both sides of the bridge. With the 1995 reconstruction, the bridge was reconfigured to 6% grades on both sides to provide a higher river clearance when closed. There are approach roadway segments on both sides of the river channel on fill with retaining walls. The bridge approach structures are 118 feet long supported on 48-inch drilled shafts taken down to -45 feet below grade, and 50 feet long. The bridge bascule piers on both sides are 34-feet long and supported on 30-inch square piles. There are a pair of bascule leaves each 57.5 feet long for a combined length of 115 feet over the river channel. **Figure 2-21** displays a typical section of the Brickell Avenue Bridge.

Figure 2-21 Brickell Avenue Bridge Typical Section



2.5.2 Bridge Traffic Volume

According to the bridge plans for the 1995 replacement project, the average daily traffic on the Brickell Avenue bridge was 36,000. The Florida DOT Traffic Online website provides the following additional Average Annual Daily Traffic (AADT) volumes:

2016	37,000	**2011**	36,500
2015	36,500	**2010**	36,500
2014	34,000	**2005**	34,000
2013	36,500	**2001**	36,000
2012	34,000		

It is seen that the AADT volumes have been consistently in the 34,000 to 37,000 vehicles per day range for years. This is likely indicative of the capacity of the roadway network near the bridge being reached under peak hour demand when the bridge is locked down, and with some traffic equilibrium being reached with the nearby Miami Avenue bridge given downtown travel patterns and relative level of service between the two bridges.

2.5.3 Bridge Openings

The Brickell Avenue bascule bridge opens its leaves according to Federally prescribed operation regulations noted below, for vessels whose air draft exceeds the bridge clearance under tidally influenced water elevations, typically with a two-foot clearance margin. The bridge was required to open 4,990 times in 2010, according to a cited reference. According to bridge tender records reviewed for the Miami River Freight Improvement Study being prepared by the Florida DOT presently for the Brickell Avenue bridge for the one-year period of July 2015 to June 2016, the bridge was opened 5,928 times. Note that bridge tender data includes only those vessel movements requiring the opening of a lift bridge, and not total vessel movements including those that do not require a bridge opening. This recent data is an increase over the 2010 figure of nearly 1,000 openings in approximately five years, or an increase of 18.8% overall, or about 3.5% growth per year compounded. A portion of this is likely due to lowered marine traffic during the Great Depression years.

Bridge tender data includes only those vessel movements requiring the opening of a lift bridge. Data for this review was based on the average number of times the bridge was opened in two hour intervals per month. This is intended to provide the reader with an understanding of the vessel movement by month that will affect local road network vehicle traffic patterns.

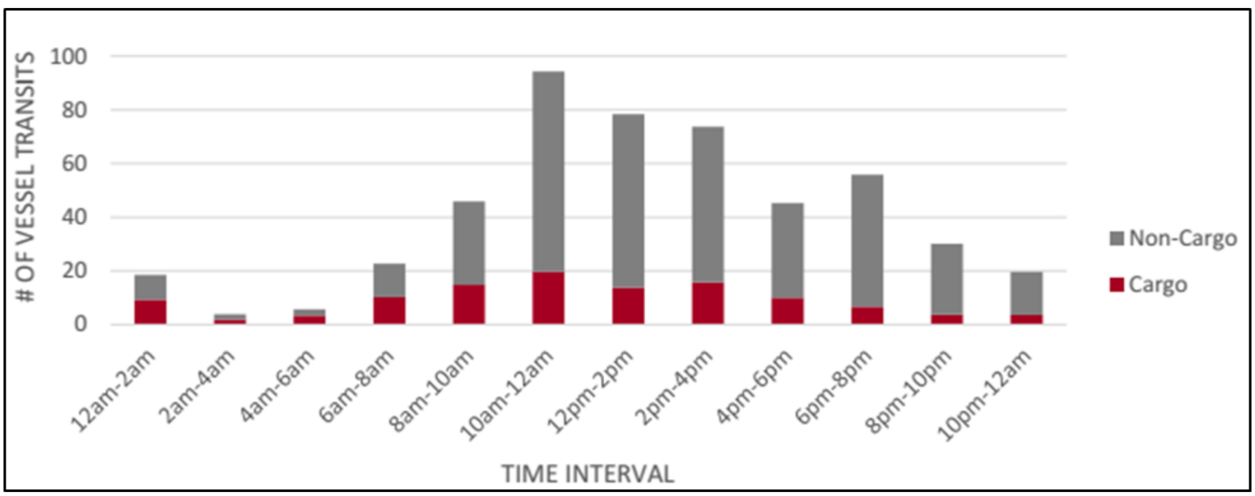
Bridge Opening Curfew

A bridge opening curfew is in place during high traffic hours relating to morning commutes, lunch hours, and evening commutes for vehicular traffic. Curfews are only in place for recreational vessels; however, recreational vessels are known to 'piggyback' on cargo vessels when required to transit up or down the river as needed through curfew hours.

Bridge Vessel Movements

On average a total of 494 vessels move past the Brickell Avenue Bridge each month, approximately 114 are cargo vessels or tugs and 380 of which are recreational vessels. **Figure 2-22** provides the average cargo vessel and non-cargo vessel transits per month in two-hour intervals across the 24-hour day, for those vessels requiring the lift bridge to open. Overall, vessel movements are heavier during business hours and commuting hours, where approximately 75% of cargo vessel transits occur between 6am and 6 PM on average and approximately 73% of recreation vessel transits occur in the same time period.

Figure 2-22 Brickell Avenue Bridge Vessel Movements by Daily Period, July 2015 – June 2016



Federal Regulations on Bridge Openings

Below is the published federal regulation governing the opening of lift bridges on the Miami River:

> *Code of Federal Regulations – Title 33, Chapter 1, Subchapter J, Part 117 – Drawbridge Operation Regulations:*
>
> **§117.305 Miami River.**
>
> **(a)** ***General.*** **Public vessels of the United States, tugs, tugs with tows, and vessels in a situation where a delay would endanger life or property shall, upon proper signal, be passed through the draw of each bridge listed in this section at any time.**
>
> (b) The draws of the S.W. First Street Bridge, mile 0.9, up to and including the N.W. 27th Avenue Bridge, mile 3.7 at Miami, shall open on signal; except that, from 7:35 a.m. to 8:59 a.m. and 4:45 p.m. to 5:59 p.m., Monday through Friday, except Federal holidays, the draws need not open for the passage of vessels.
>
> (c) The draws of the Miami Avenue Bridge, mile 0.3, and the S.W. Second Avenue Bridge, mile 0.5, at Miami, shall open on signal; except that, from 7:35 a.m. to 8:59 a.m., 12:05 p.m. to 12:59 p.m. and 4:35 p.m. to 5:59 p.m., Monday through Friday, except Federal holidays, the draws need not open for the passage of vessels.
>
> **(d) The draw of the Brickell Avenue Bridge, mile 0.1, at Miami, shall open on signal; except that, from 7 a.m. to 7 p.m., Monday through Friday except Federal holidays, the draw need open only on the hour and half-hour. From 7:35 a.m. to 8:59 a.m., 12:05 p.m. to 12:59 p.m. and 4:35 p.m. to 5:59 p.m., Monday through Friday except Federal holidays, the draw need not open for the passage of vessels.**

2.5.4 Geotechnical Data

The subsurface conditions along the various study corridors are expected to be consistent with those found at the Brickell Avenue Bridge, the Metrorail and Metromover crossings of the Miami River, and the PortMiami Tunnel. These conditions must be considered to establish the feasibility of construction methods for the tunnel. The soils stratigraphy follows a generally expected geologic profile consisting of the following formations:

- **Pamlico Formation:** The Pamlico formation is the uppermost geologic strata along the tunnel alignments. This formation is generally 8 to 12 feet thick and composed of loose to medium fine sands with limestone fragments.

- **Miami Limestone Formation:** The Miami Limestone formation is composed of soft to medium hardness oolitic limestone. This limestone, underling the Pamlico Layer, extends to depths of about 25 to 50 feet below ground surface. It is characterized by high porosity and permeability.

- **Fort Thompson Formation:** The Fort Thompson formation is composed of sandy limestone to sandstone. This formation underlies the Miami Limestone formation, and extends down to depths of approximately 110 feet below the ground surface. It is characterized by high porosity and permeability.

- **Tamiami Formation:** The Tamiami Formation is composed of calcareous sandstones and sandy limestones. This limestone underlies the Fort Thompson Formation and can be found at depths of 110 to 120 feet below ground surface. This formation is characterized by high permeability; however, this formation may be layered with impermeable clay-rich layers that will not transport large amounts of groundwater.

The available borings show that these formations are not continuous and are interspersed with sand layers, which may have been old solution holes in the limestone. The underlying sand and porous limestone formations are highly permeable and must be considered when evaluating construction methods for the tunnel.

Several of the proposed tunnel alignments traverse under the approach spans of the Brickell Avenue bridge, and close to several Metromover piers along Biscayne Boulevard. The Brickell Avenue approach spans are founded on non post-grouted drilled shafts, and the Metromover piers in this area are founded on augercast piles. Both of these deep foundation systems achieve their load carrying resistance through side friction. The conceptual profiles of the tunnel achieve a minimum of 10 feet of clearance from the top of tunnel excavation to the as-built plan drilled shaft/augercast pile tip elevations. It is expected that this separation will have minimal effect on the resistance of these foundations.

3.0 Conceptual Facility Planning Factors

3.1 Roadway Design Criteria

The roadway design criteria used in the preliminary design of the project are those for federally-funded urbanized area facilities with a design speed of 35 mph. **Table 3-1** summarizes the applicable major roadway design criteria for the proposed project. The design criteria are in conformance with the following specifications:

- American Association of State Highway and Transportation Officials (AASHTO), A Policy on Geometric Design of Highway and Streets, 2011 Fourth Edition.
- FHWA, Manual on Uniform Traffic Control Devices, 2009 Edition.
- FDOT, Standard Specifications for Road and Bridge Construction, 2017.
- FDOT, Roadway and Traffic Design Standards, January 2017.
- FDOT, Roadway Plans Preparation Manual, 2017.

It is assumed that neither pedestrian nor bicycle movements would be allowed within the tunnel, but cross-section of the tunnel would include emergency walkways. Additionally, as for the PortMiami tunnel, movements of vehicles with hazardous cargos or oversize and overweight loads, would be prohibited from transit through the tunnel.

Table 3-1 Roadway Design Criteria

Criteria	AASHTO		FDOT PPM V-I		Comments
	Value	Reference	Value	Reference	
Classification	Urban Arterial	Pg. 1-10	Urban Arterial	AASHTO	-
Min. D_5	35 MPH	Sect. 6.3.1	40-60 MPH	Tbl. 1.9.1	Current posted signs are 30 MPH with 35 MPH design speed for flexibility.
Min. Lane Widths	24' (2 lanes)	Sect. 4.16.4	11'	Tbl. 2.1.1	-
Cross Slope	0.015 - 0.04	Pg. 4-5	0.02-0.04	Tbl. 2.1.5	-
Horizontal Clearance (EOP to Wall)	1.5' (raised) 2.5' (desirable)	Pg. 4-53	-	-	Not found in PPM V-I
Shoulder Width (recommended)	5' inside 10' outside	Pg. 4-53	8' inside 10' outside	Tbl. 2.3.2	-
e_{max}	0.06	Pg. 3-31	0.05	Ch. 2.9	-
R_{min}	340'	Tbl. 3-7	358'	Tbl. 2.9.2	-
R_{min}(NC)	-	-	1,146'	Tbl. 2.9.2	-
Min. Vertical Grade	0.30%	Pg. 3-119	0.30%	Tbl. 2.6.4	-
Max. Vertical Grade	7%	Tbl. 7-4	7%	Tbl. 2.6.1	-
K - Crest	29	Tbl. 3-34	47	Tbl. 2.8.5	-
K - Sag	49	Tbl. 3-36	49	Tbl. 2.8.6	-
Min. Vertical Curve Length	3V=105'	Pg. 3-153	3V=105'	Tbl. 2.8.6	-
Max. Grade Change w/o Curve	-	-	0.8	Tbl. 2.6.2	Not found in AASHTO
Vertical Clearance	14' (16' desirable)	Fig. 4-14	16.5'	Fig. 2.10.3	-
Sight Distance	250'	Tbl. 3-1	250'	Tbl. 2.7.1	-

3.2 Roadway Typical Section Analysis

The development of alignment alternatives for this study was undertaken with several key assumptions:

- Provide an alignment connection between Biscayne Boulevard and Brickell Avenue: While there are several dominant travel patterns in the study area, the movement between Biscayne Boulevard and Brickell Avenue is one of them.

- Provide two two-lane roadways: Given the continuing growth of Downtown Miami as an emerging global center as the primary regional employment hub and with an evolving live/work/play environment, it is anticipated that the four-lane facility is needed to meaningfully address growing cross-river travel demand. Also, as discussed later, a four-lane facility is more efficient in terms of its typical section.

- Avoid any right-of-way encroachments: Property in Downtown Miami is very expensive and encroachment would dramatically increase project cost. Most development is high-rise with building footprints relatively close to the property lines. A recent land sale on the Miami River was for $100 million/acre ($2,300/square foot).

- Retain the existing Brickell Bridge in operation: This is a key assumption. While only the City of Miami operates its Biscayne Trolley Route over the bridge, it is heavily used by pedestrians and bicyclists.

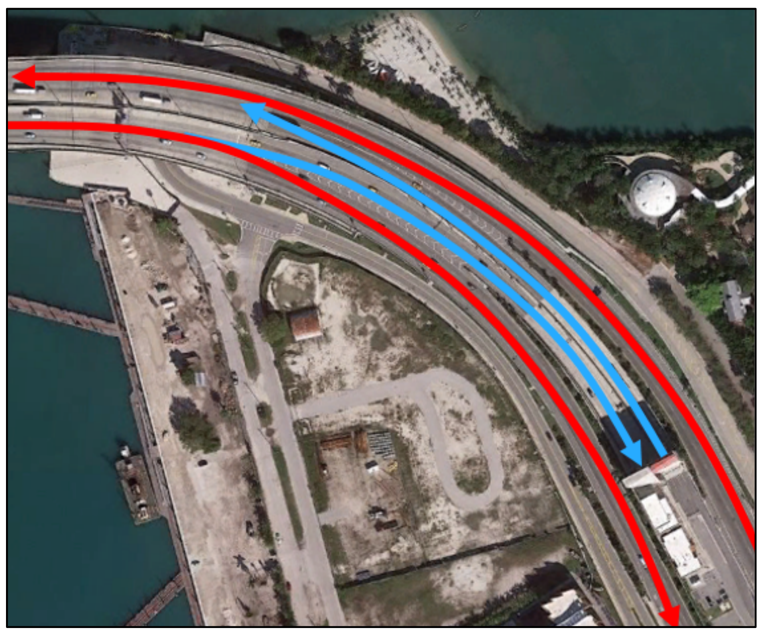
3.2.1 Design Challenges

Development of a tunnel facility also brings with it certain conceptual design challenges. The first of these is that the tunnel will have U-shaped portal roadway sections open to the sky with flanking vertical walls. The length of these sections is approximately two city blocks long, meaning that an intermediate street will be cut off as shown in **Figure 3-1**.

The second challenge is the insertion of the tunnel roadway into an existing roadway. A presumption in this study is that a large share of existing traffic will be diverted into the tunnel, thus relieving the surface street of traffic volume and subsequently reducing the number of travel lanes required. Nevertheless, the typical section of a tunnel consumes more width than adjacent surface street travel lanes, which is an issue in a constrained right-of-way setting. **Figure 3-2** illustrates a relatively unconstrained example for the PortMiami tunnel portals which were inserted into the center of the MacArthur Causeway on Watson Island by relocating the causeway directional roadways outward to allow for the four-lane tunnel roadway. Brickell Avenue with its 100-foot right-of-way presents a much more confined situation.

Figure 3-2 Typical Tunnel Portal

Figure 3-1 PortMiami Tunnel North Portal



3.2.2 Design Typical Sections

Roadway design criteria were applied to develop roadway typical sections. These typical sections were then compared to the Brickell Avenue setting to test compatibility, as Biscayne Boulevard has a much wider typical section. One of the core assumptions of the study was that a four-lane tunnel facility would be needed. As a test, a two-lane typical section was developed along with a four-lane typical section, first for rectangular, single-cell tunnel chamber. Those typical sections are shown in **Figures 3-3 and 3-4**.

Rectangular Sections, 2 and 4 Lanes

It is seen that the two-lane section because of wider lane and shoulder requirements has a section width of 57.5 feet, about 80% of the width compared to the four-lane section width of 73.5 feet. If both sections included center median or New Jersey barrier separations, the dimensions would be slightly greater. While a two-lane section is not proposed for the tunnel, this comparison shows that a four-lane section is more efficient in terms of the space required.

Figure 3-3 Typical Section, 2-Lanes

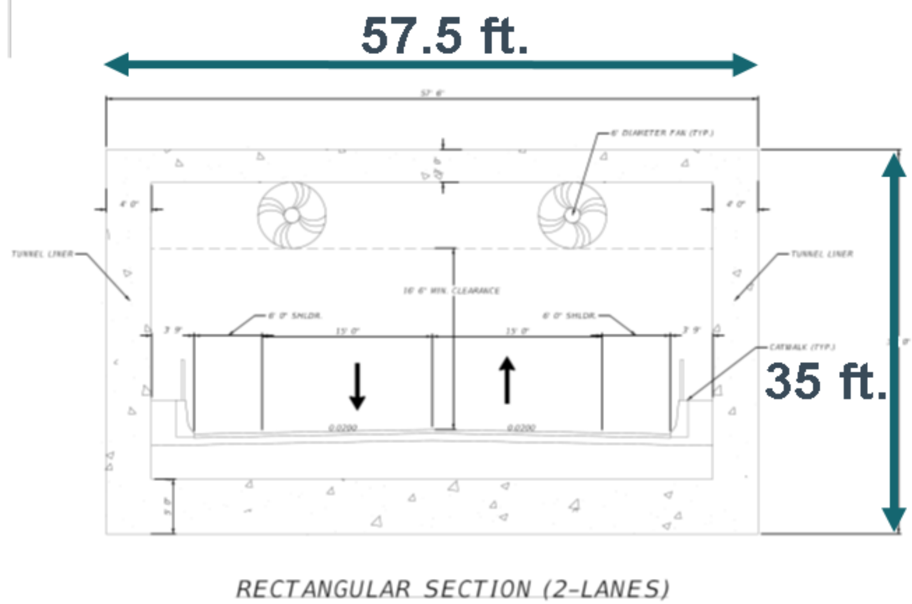
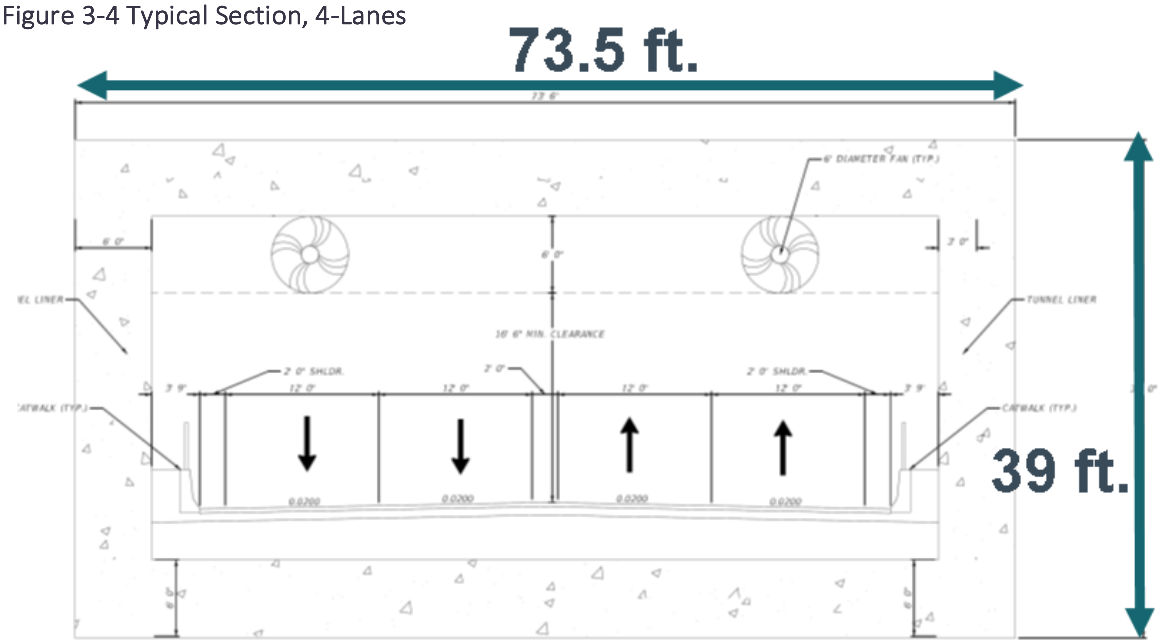


Figure 3-4 Typical Section, 4-Lanes



Rectangular Section, Stacked

The four-lane typical section was then compared to the width of Brickell Avenue (approximately 100 feet). Biscayne Boulevard is much wider at 200 feet and does not pose the same constraint. A four-lane single-cell tunnel section with a nominal width of 76 feet with a center barrier would leave a 12-foot margin on either side (which would not accommodate a sidewalk and travel lane), and would place the construction zone relatively close to high-rise building foundations. Consequently, a rectangular two-cell tunnel section with two directional roadways in a stacked configuration was developed. This section has a width of 44.5 feet and a height of 65 feet, as shown in **Figure 3-5**.

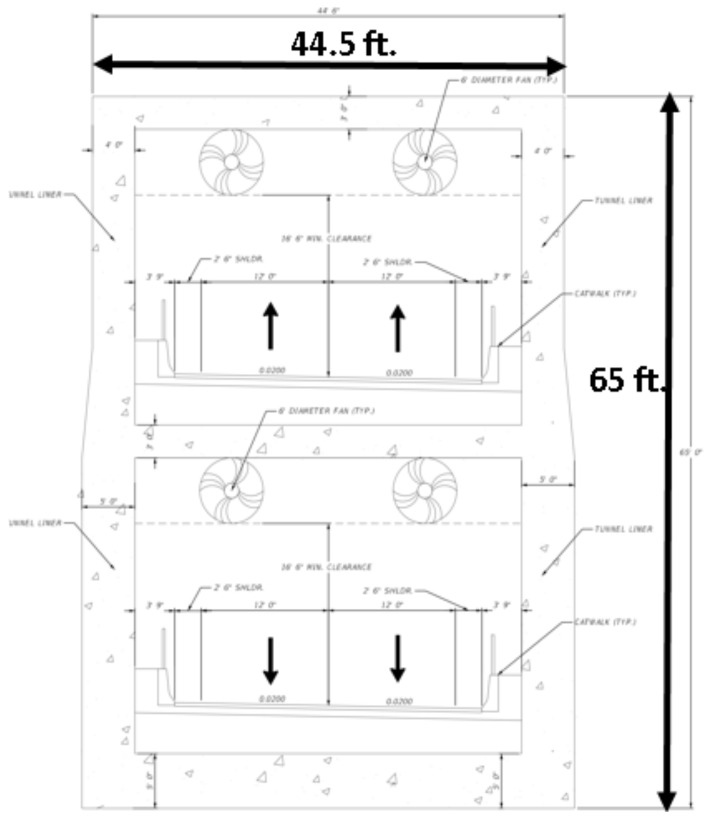


Figure 3-5 Rectangular 2-Cell Tunnel, 4-Lanes, Stacked

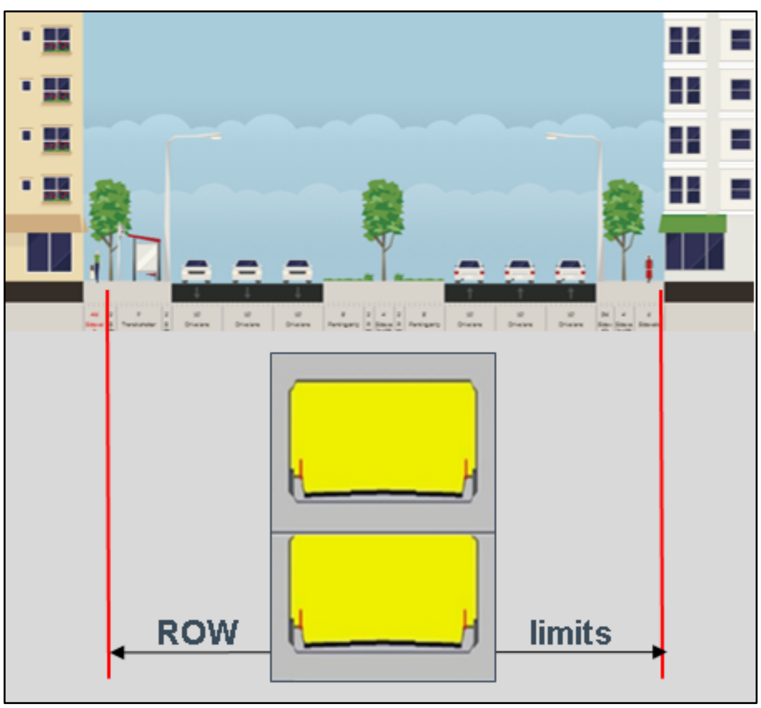


Figure 3-6 Stacked 4-Lanes, Under Brickell Avenue

Figure 3-6 illustrates the stacked 4-lane typical section in relation to the Brickell Avenue right-of-way setting. It is seen that the stacking and provides more lateral space from buildings and for traffic maintenance as well as working room for construction.

Twin Bored Tunnel Configuration

A bored tunnel configuration was also tested. **Figure 3-7** illustrates the typical section for a pair of bored tunnel sections, which is very similar to that for the PortMiami bored tunnel. It is seen that this section is 94 feet in width, in comparison to the approximate 100 feet of width for the Brickell Avenue roadway. **Figure 3-8** shows the existing PortMiami tunnel roadway with essentially the same cross-section, and **Figure 3-9** displays a rendering of the tunnels under Brickell Avenue. However, given the lateral spread of its dimensions, the side-by-side twin tunnel bores as utilized for the PortMiami tunnel with minimum lateral width constraints will not be feasible for this project.

Figure 3-7 Twin Bored Tunnel Cells, 4-Lanes

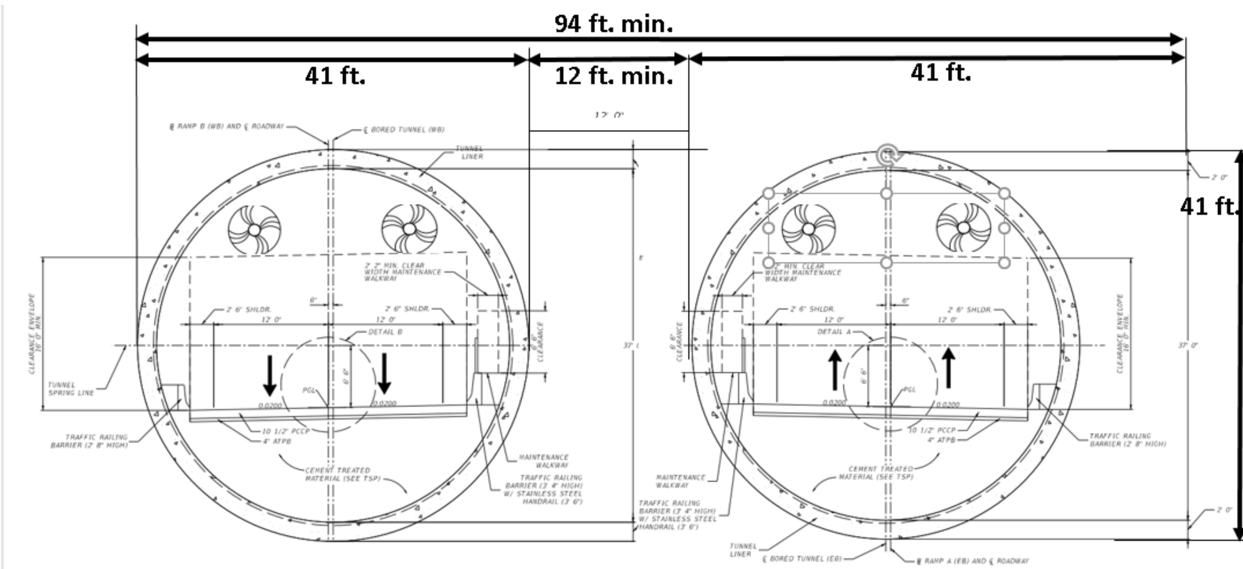
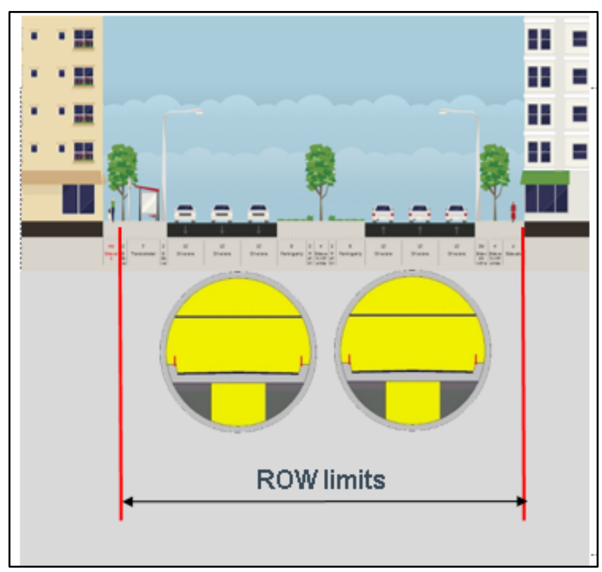


Figure 3-8 PortMiami Tunnel Roadway

Figure 3-9 Twin Bored Tunnels Under Brickell Ave.



Stacked Bored Tunnel Configuration

In response to twin bored tunnels not being feasible, further review led to the concept of stacking the tunnel bores. This concept is illustrated in **Figures 3-10 and 3-11**.

Figure 3-10 Stacked Bored Tunnels, 4 Lanes

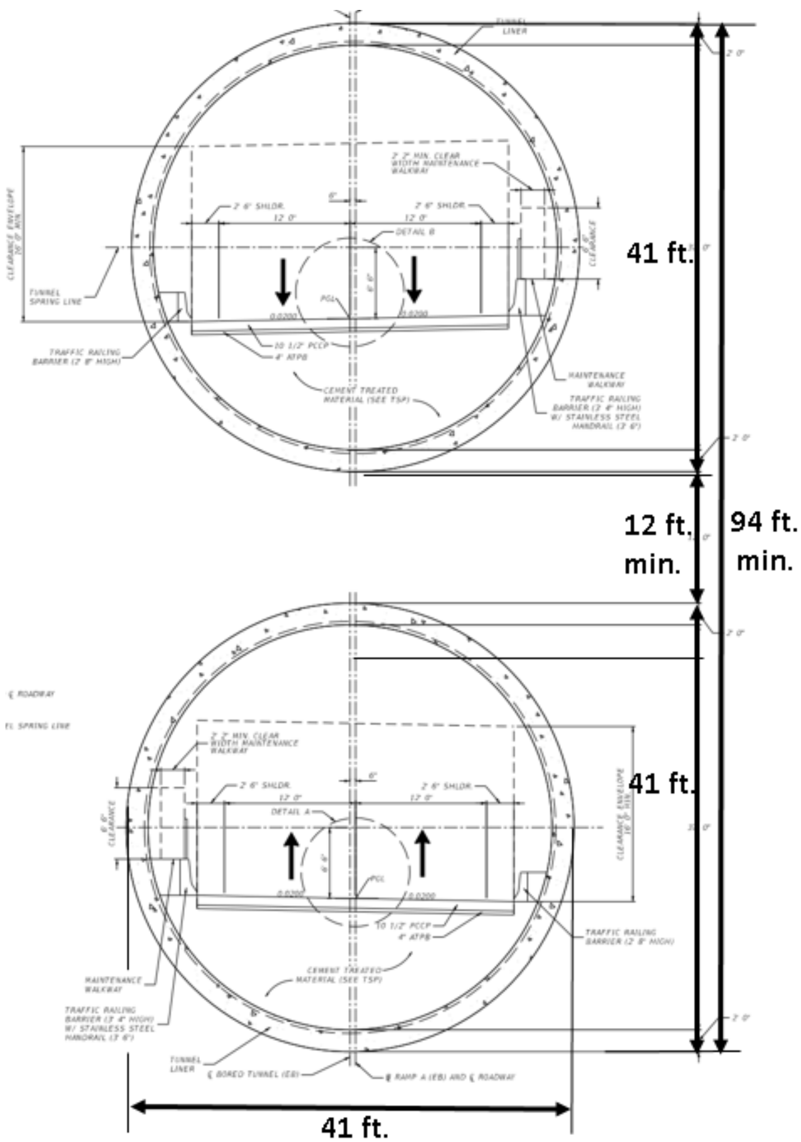
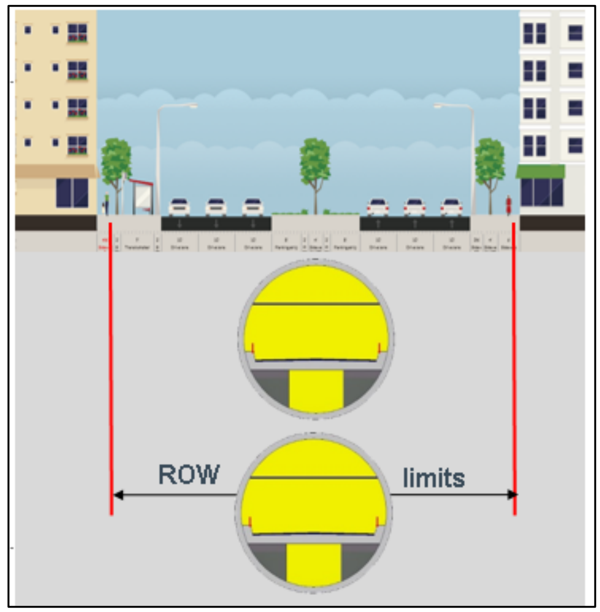


Figure 3-11 Stacked Tunnel Section Under Brickell Avenue



3.3 Tunnel Construction Technologies

The subsurface conditions in the area are considered soft ground. Appropriate methods of soft ground tunnel construction include: (1) cut-and-cover construction, (2) immersed tube tunnel construction, (3) bored tunnel using a tunnel boring machine or using traditional mining techniques, and (4) mined tunnel using the sequential excavation method. The following sections describe the feasibility of each construction method.

3.3.1 Cut-and-Cover Construction

Cut-and-cover construction methodology provides a means to allow construction of the tunnel within an open dewatered pit, like that shown in **Figure 3-12**. The tunnel shell would consist of conventional reinforced cast-in-place concrete, cast in dry conditions. Due to limited space within the corridor right-of-way, the open pit would be bounded by walls to allow a vertical faced excavation, thereby minimizing the footprint of construction and allowing local access traffic to be maintained within the corridor. The walls will be subjected to significant hydrostatic pressures due to the permeability of the sand and limerock that will be encountered.

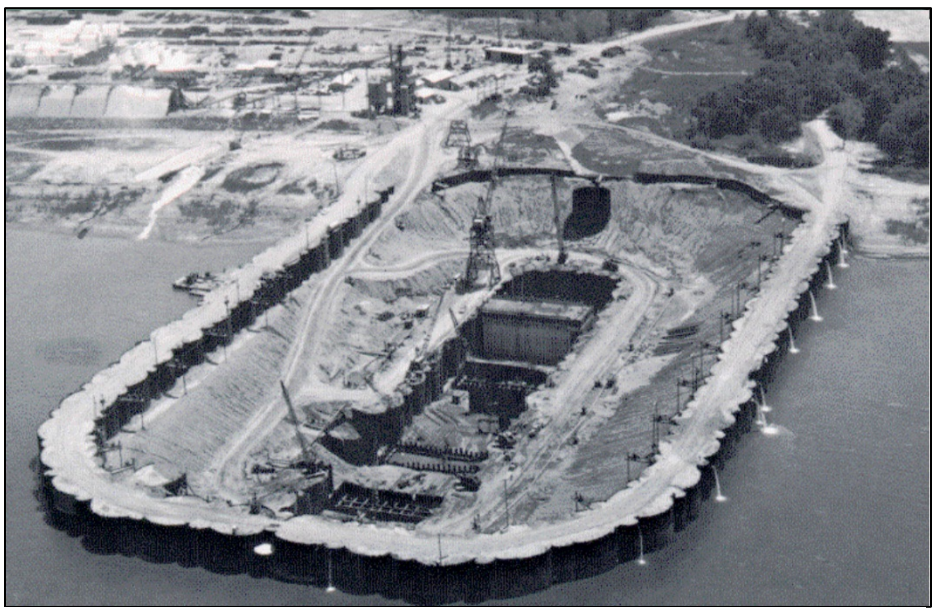


Figure 3-12 Cut and Cover Construction

Typical wall types include steel sheet piles and/or secant pile walls, both of which are installed prior to pit excavation. The steel sheet pile wall system will typically be shored, either with prestressed soil anchors engaging the soil/rock behind the wall, or by a strut system installed between the opposing walls. This shoring minimizes the settlement that can occur behind the wall by reducing the outward deflection of the wall. The feasibility of prestressed soil anchors would be dependent on the required anchor length and the distance between the wall and the right-of-way limit.

The highly porous soil/limerock in the area will require a seal in the base of the pit to counteract the increasing hydrostatic uplift forces as the pit is dewatered. The seal consists of concrete with a buoyant weight that resists the upward hydrostatic pressure. Generally, the pit is excavated to the proposed grade prior to dewatering. The seal is then cast underwater using the tremie method. Vertical soil anchors may be installed in the limerock to help resist this upward pressure, thereby reducing the thickness of the tremie seal.

Practical excavation depths of approximately 50 feet can be achieved using the cut-and-cover method. Cut-and cover construction on this project will be limited to the area at the ends of the tunnels only where the profile depth is shallow, for the following reasons:

1. The area outside the tunnel portals will remain as an open section. Therefore, this construction technique is appropriate, similar to that shown in **Figure 3-13**.
2. The typical side-by-side roadway typical section does not provide sufficient lateral separation to the right-of-way limits to allow for travel lanes on Brickell Avenue to remain in the portal area, and also places construction closer to adjacent buildings increasing the possibility of ground settlement.
3. The proposed alignment profiles are significantly deeper than the 50-foot practical limit of this method within bodies of water.
4. The deeper alignment sections, as discussed in the next section of the report, extend under existing bridges and close to right-of-way lines near existing and proposed tall buildings.
5. Maintenance of Miami River shipping commerce prevents a protracted closure that would be required for this method to be used in the Miami River.

In conclusion, the cut-and-cover construction is not considered feasible for construction of the roadway approaches to the tunnel and the tunnel portals.

Figure 3-13 US 1 Kinney Tunnel Portal in Fort Lauderdale

3.3.2 Immersed Tube Tunnel Construction

The immersed tube methodology for tunnel construction provides a means to construct the main shell of the tunnel off-site. Tunnel sections are pre-fabricated with end bulkheads, sealing them from water intrusion and allowing them to float. Immersed tube tunnel sections are typically about 300 feet in length. They are floated to the project site, as shown in **Figure 3-14.** Once properly positioned, the sections are lowered into a dredged trench to achieve the desired profile of the roadway within the tunnel, as shown in **Figure 3-15.** Once immersed, they are connected together, and the bulkheads are removed to form a continuous tunnel.

Figure 3-14 Immersed Tube Tunnel Section Being Transported to Site

Figure 3-15 Positioning and Final Placement of Immersed Tube Section

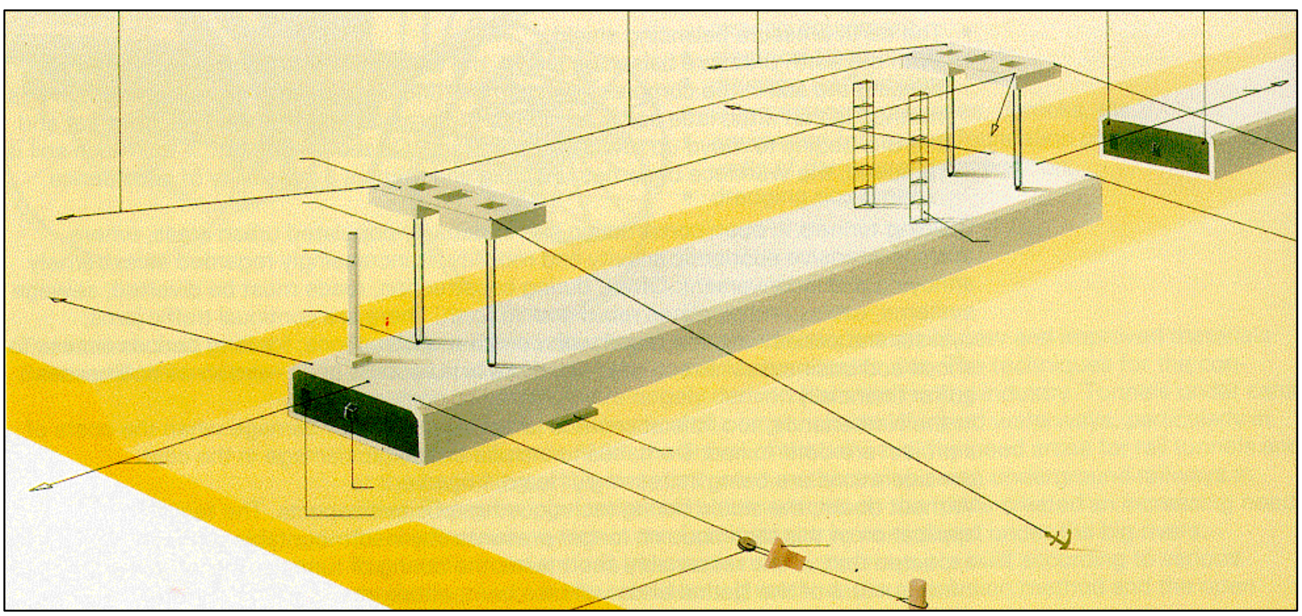
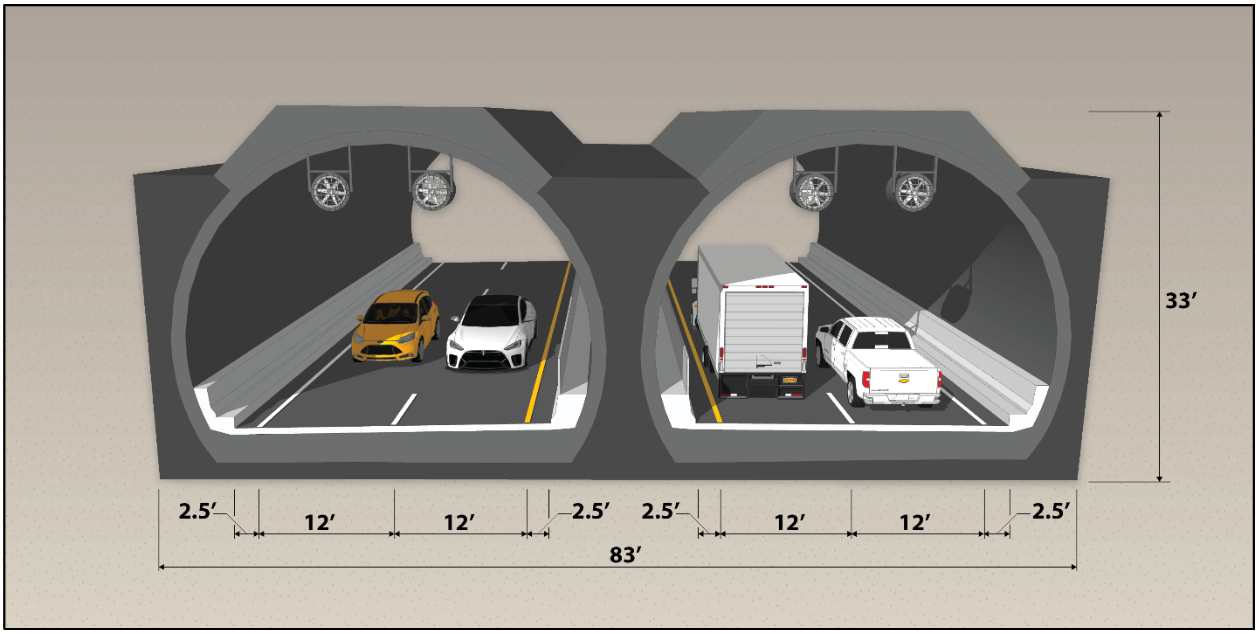


Figure 3-16 shows a representation of an immersed tube section, which typically have the directional roadways in a side-by-side configuration. As will be discussed later, the width of Brickell Avenue does not accommodate the width of this typical section while maintaining traffic lanes on Brickell Avenue.

Figure 3-16 Immersed Tube Section



The immersed tube tunnel methodology is not considered a feasible alternative for this project for the following reasons:

1. Immersed tube tunnel construction is effective for tunnel sections under water bodies. Most of the proposed alignments, as discussed in the next section of the report, have significant lengths that are inland from available water bodies. Dredging channel trenches inland to utilize this technology is impractical.
2. The tunnel sections in the Miami River are expected to be very deep for reasons discussed in the next section of the report. Excavation of a deep trench will have an impact on the stability of sea walls/bulkheads lining the Miami River.
3. The tunnel alignment may have curvatures that do not lend themselves to the immersed tube tunnel method due to difficulties in balancing asymmetrical tunnel sections for transport and for positioning within the excavated trench.
4. Dredging of a deep trench in the Miami River and the time required to position and ballast multiple sections will result in lengthy closures of the Miami River, and have a major impact to Miami River commerce and navigation.
5. Immersed tube tunnel construction was originally proposed for the Port Miami tunnel, but was found not to be permittable by the Florida Department of Environmental Protection (FDEP). FDEP was concerned with the pollution of the waterway and adjacent protected waters of Biscayne Bay from turbidity resulting from underwater excavation. A change in this position is not expected.

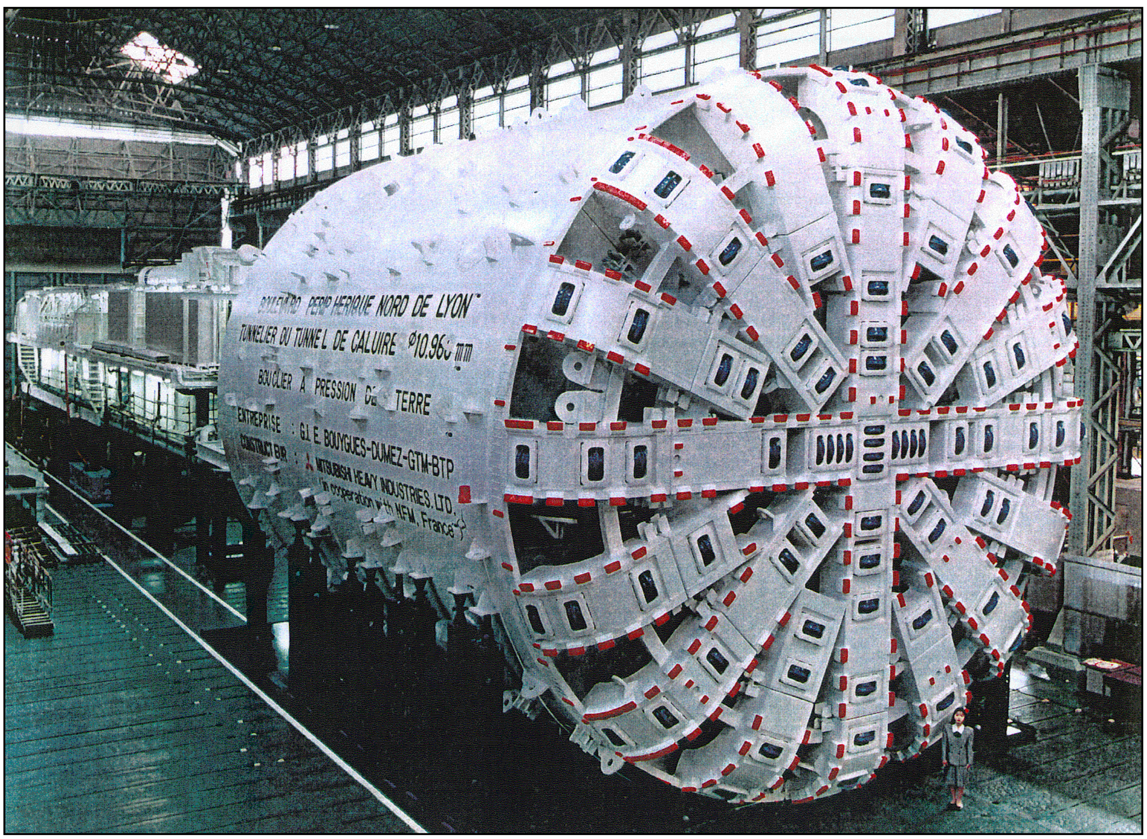
In conclusion, the immersed tube construction is dropped from consideration for the construction of a tunnel under the Miami River.

3.3.3 Bored Tunnel Construction

The bored tunnel methodology for tunnel construction excavates the earth along the alignment of the tunnel while permanent facing supporting the excavation is installed behind the excavating machinery. Shielding is provided for temporary support of the excavation while the permanent facing is placed. Bored tunnels are typically circular in shape, with precast concrete segments placed to form an annual ring within the excavation. The area between the outside of the facing panels and the exposed face of the excavation is grouted to provide a uniform pressure around the ring to keep it in compression with minimum bending within the panels.

Bored tunnels can either be drilled or mined. A tunnel boring machine (TBM), as shown in **Figure 3-17**, is an example of a drilled application where a rotating disk with cutter heads excavates the material in front of the bore. Traditional mining techniques can also be used to excavate this material. To minimize impacts at the surface and maximize the benefits from an investment in the TBM, it is desirable to extend the bored tunnel section to its maximum limits.

Figure 3-17 Tunnel Boring Machine



The stability and consistency of the materials at the face of the excavation are of extreme importance to the success of tunnel boring. The materials that will be encountered in this project are highly permeable that will allow water to freely percolate through the sides and face of the excavation. Sand seams also exist that form areas of surface inconsistency that can cause damage to a TBM. Grouting and/or freezing in advance of the excavation will be required to provide cutting surface stability for the TBM, and prevent water intrusion for the mining option. Advances in technology have occurred that satisfactorily address these issues. The PortMiami tunnel is an example of successfully meeting these challenges in similar soil characteristics as would be found on this project.

Tunnel boring also requires a boring pit to accommodate assembly and launch of the TBM into a bore alignment. For the PortMiami tunnel (see **Figure 3-18**), a boring pit of 100 feet in width, over 400 feet in length, and 40 feet deep at the boring face was needed. This area is needed to assemble the boring machine and trailing support gear (total of 428 feet).

Figure 3-18 Breakthrough of First of Two PortMiami Tunnel Bores

Large bore tunnels of the diameter required for the Miami River tunnel have not been constructed with TBMs at as small of a turning radius as proposed in this alignment. However, with advances in technology, it is believed that the issues related to this radius can be resolved, making a TBM feasible for this project.

Figures 3-19 and 3-20 depict the bored tunnel configurations of side-by-side and stacked as previously discussed.

Figure 3-19 Bored Tunnel Side-by Side

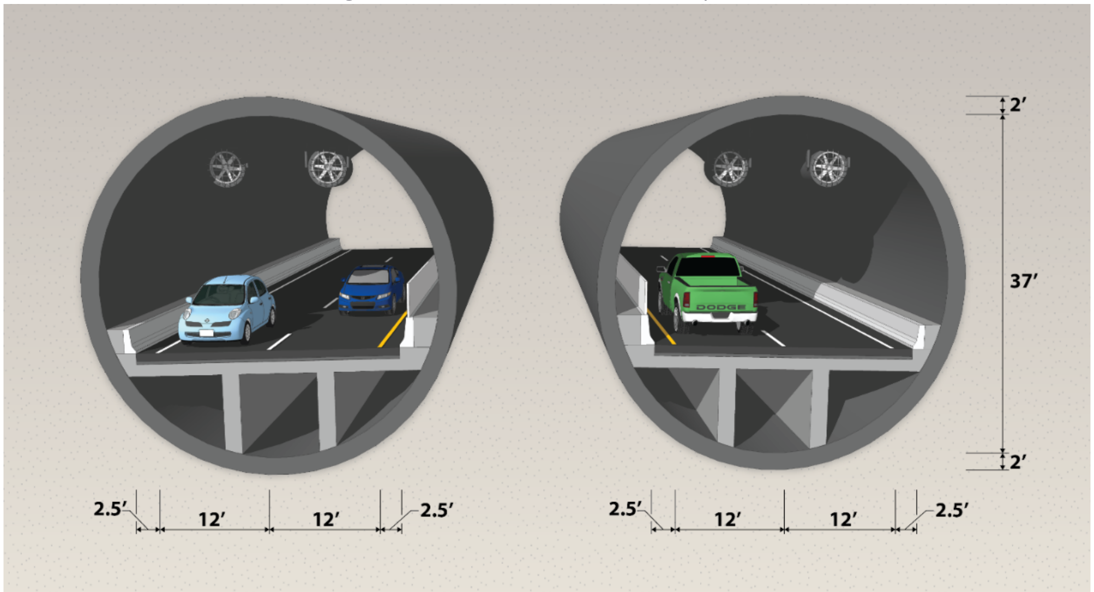
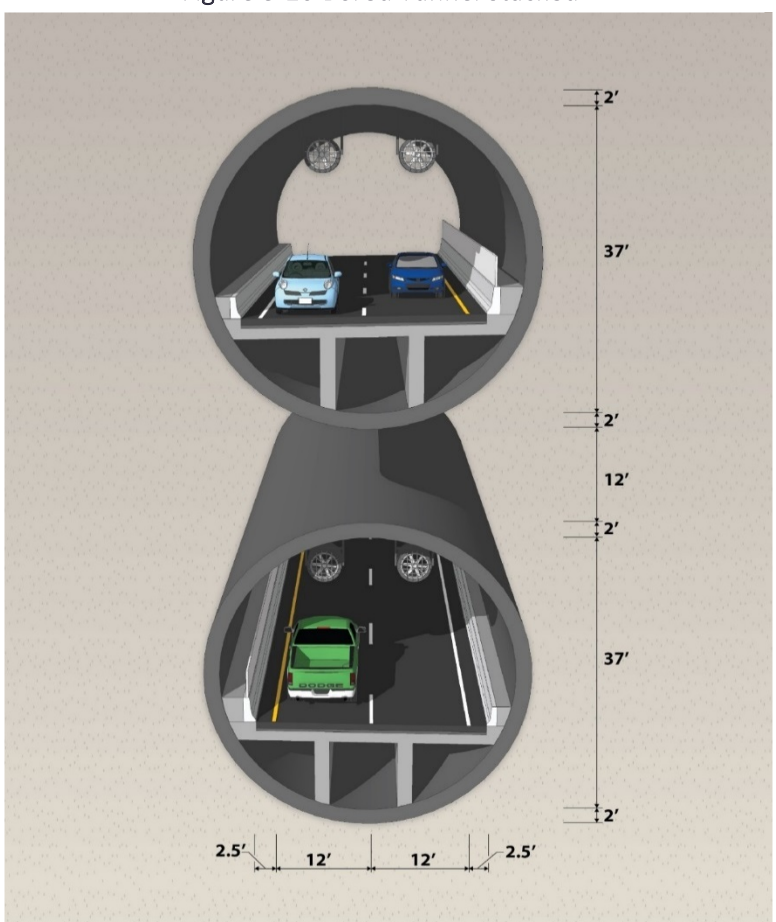


Figure 3-20 Bored Tunnel Stacked



3.3.4 Sequential Excavation Method

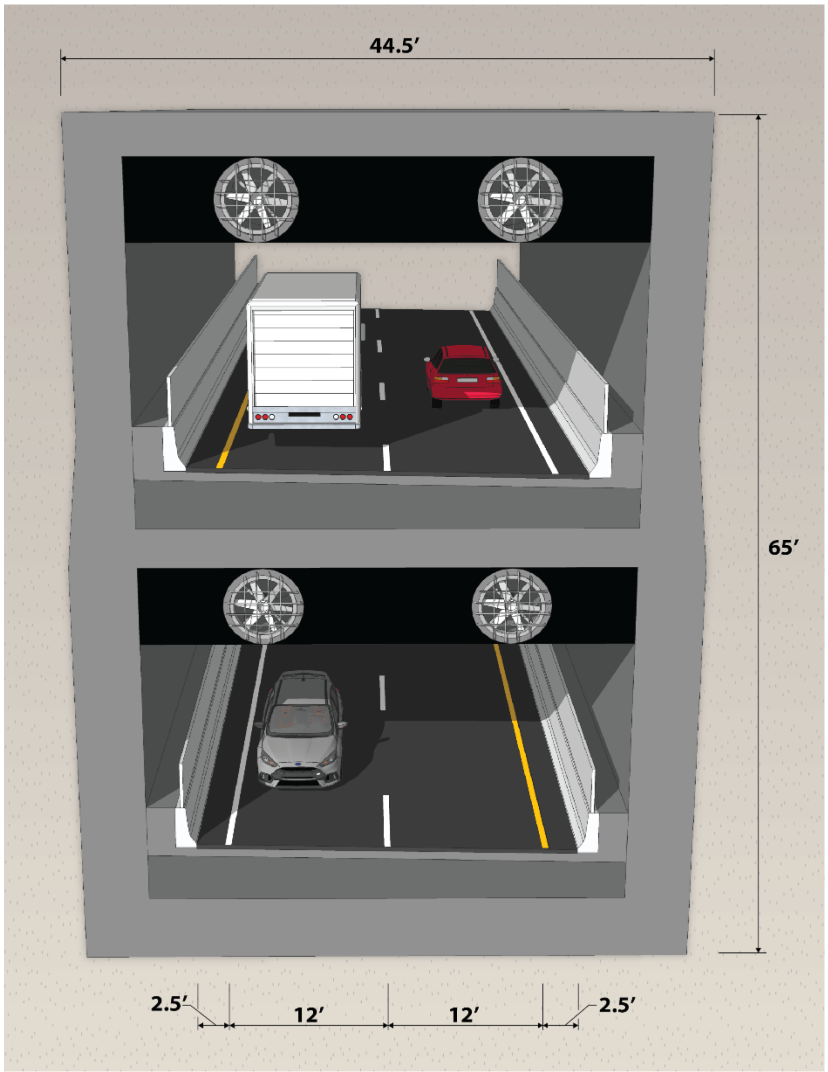
The Sequential Excavation Method (SEM) for tunnel construction utilizes the self-supporting capability of the ground to an optimum, maximizing economy in ground support. In this method, a series of smaller tunnels, commonly referred to as drifts, are advanced to form a load-carrying arch. Grouting and/or freezing in advance of the excavation would most likely be required to prevent water intrusion for the mining operation. The arch is reinforced with shotcrete in combination with steel reinforcement or mesh, arched steel lattice girders, and/or grouting. This method allows for the construction of tunnels with complex geometry and/or changes in section, as the method is not dependent on an annular ring for strength. More efficient concrete sections can also be utilized. **Figure 3-21** illustrates tunnel mining in the 2nd Avenue Subway transit tunnel project in New York City with favorable rock formations.

Figure 3-21 Tunnel Mining in the 2nd Avenue Subway Project

Limiting settlement with this construction method will be essential since the tunnel alignment is located near existing buildings, bridges, and the Metromover. These settlements can be controlled using shorter drifts and rapid completion of the tunnel arch support. Monitoring of the behavior/movement of the excavation is essential for the performance of this method, such that adjustments to the number of drifts and drift lengths can be made during construction.

Figure 3-22 illustrates a rectangular stacked tunnel section that would result from this tunnel construction method.

Figure 3-22 Mined Tunnel Configuration



In conclusion, the sequential excavation method for tunnel construction is considered feasible for the construction of the tunnel under the Miami River.

3.4 Ventilation, Drainage and Systems

3.4.1 Ventilation

Ventilation is generally required in road tunnels to provide a safe environment for motorists. This objective can be achieved by the following:

- Preventing the dangerous accumulation of vehicle-emitted pollutants (i.e., carbon monoxide, CO and oxides of nitrogen, NO)
- Maintaining visibility in the tunnel by preventing the accumulation of haze- producing pollutants
- Providing life/safety support during a vehicle fire incident in a tunnel.

Tunnel ventilation schemes are categorized as either natural or mechanical systems. Natural systems rely on the piston-effect of moving vehicles, external wind, and temperature and pressure differentials between the portals to produce airflow through the tunnel. Mechanical systems use fans to produce airflow. Mechanical systems can be further classified as longitudinal, semi-transverse, or transverse systems. During normal tunnel operations, the tunnel length, the traffic density, and the direction of traffic movement (i.e., uni-directional vs. bi-directional) are some of the key factors in determining whether the ventilation requirements can be achieved by passive means (e.g., the piston action airflow generated by the moving vehicles) or whether mechanical ventilation is required.

However, a mechanical ventilation system is a requirement by the National Fire Protection Association (NFPA) for tunnels exceeding 800 feet in length. A jet fan longitudinal ventilation approach would be the least costly method for ventilating the tunnel. No parallel ducts, fan structure, air intakes of exhaust stacks are required. While the jet fan system requires increased headroom for the roadway, the absence of dedicated supply and exhaust ducts and the need for ventilation building renders this system less costly than other ventilation systems.

It is anticipated that jet fans would be adequate for this tunnel facility as the length of tunnel sections should be in the range of the 4,200-foot twin tunnels at PortMiami.

3.4.2 Drainage

Local, State, and Federal Requirements

The South Florida Water Management District (SFWMD) and the Miami-Dade County Department of Environmental Resources Management (DERM) have established stormwater quality and quantity requirements for all new projects. In most cases, DERM criteria, encouraging full on-site retention of the first inch of runoff, which is more stringent and should be the controlling criteria used for the project. Standards set by Miami-Miami-Dade County are in most cases more stringent than those of State agencies and must therefore be followed.

The EPA also requires a National Pollutant Discharge Elimination System (NPDES) permit for most construction projects. Preliminary coordination with this agency indicates that Miami-Dade County would have jurisdiction for this project.

There are no water quality or discharge rate control criteria applicable to this project. This project is located in the Biscayne Bay area, which is a tidal area. According to the FDOT Drainage Manual, Volume 1, Section 5.3.1.4.1, projects located within tidal areas are not subject to any discharge control requirements.

Local Implementation

In order to satisfy stormwater quality requirements, most projects within Miami-Dade County utilize a system of subsurface drainage with emergency overflow to nearby water bodies. Along the coast, the predominant subsurface drainage method is by drainage wells.

Recommended Drainage Inlets

The roadway would have a cross slope with the low point of the cross slope on the interior side of each roadway. It is recommended that drain inlets, at approximately 200-foot spacing, be provided in the tunnel with embedded drain pipe in concrete slab. Drain inlets shall be located outside of traffic lanes. Embedded drain piping would be a minimum of 12-inches in diameter. At the low point of the tunnel, the 12-inch diameter embedded drain pipe would empty into a settling chamber.

Recommended Pump Stations and Trench Drains

Three pump stations are recommended for the tunnel drainage system: one portal pump station at each end of the tunnel and one mid-channel station at the low point of the tunnel.

The mid-channel pump station would consist of a settling chamber, a wet well and a pump room common to both roadway cells. A minimum of two pumps would be provided. Each pump would be sized to handle a maximum anticipated fire water flow rate that assumes a maximum water inflow rate during fire-fighting operations. In addition, a jockey pump is proposed to handle low flows.

The pumps would be provided with an alternator and local level controls. The pump discharge would be carried by an embedded pipe to a holding tank where treatment of the discharge can occur before outfall to the local sewer system. The storage capacity of the drainage pump station shall be sized for a minimum of 10-minutes water inflow at the anticipated design flow rate.

The stormwater flows entering the portal areas would be calculated on the basis of a 100-year storm. A trench drain would be provided across the roadway at each portal to capture the stormwater entering the portals. The trench drains would be designed to eliminate any carryover of stormwater into the tunnel. Since these trench drains would be below the water table and sea level, pumping the stormwater would be necessary.

The portal pump stations would consist of a settling chamber, a wet well and a pump room common to both roadway cells also. Two pumps would be provided at each of the two portal stations. Each pump would be sized for the maximum flow entering the trench drains. A jockey pump would be provided for small loads. The portal pumps would be provided with an alternator and local level controls similar to those for the mid- channel pumps. The pump discharge from each portal station would be discharged to the stormwater drainage system at approved locations.

3.5 Tunnel Infrastructure and Control Systems

The tunnel facility will require a comprehensive set of supporting infrastructure and control systems to provide for facility management, operations, and incident response. These systems will include the following elements:

- Drainage system and pump stations
- Lighting
- Information and messaging signs
- Ventilation
- Fire suppression and smoke removal
- Operations video and monitoring system
- Vehicle emissions monitoring

These systems are typically monitored and managed from a central tunnel control center staffed with personnel to oversee operations and participate in traffic management and response to hazardous situations and incidents. The control center would typically be sited in a building sited along the project corridor. However, there may be an opportunity to house these functions with the PortMiami tunnel control center, assuming that space could be constructed for the requirements of the second tunnel and that a contractual arrangement could be struck.

As for the PortMiami tunnel, a traffic operations response team including tow trucks would need to be situated in the vicinity of the project in order to address traffic crashes or other vehicle breakdowns.

3.6 Portal Closure Options

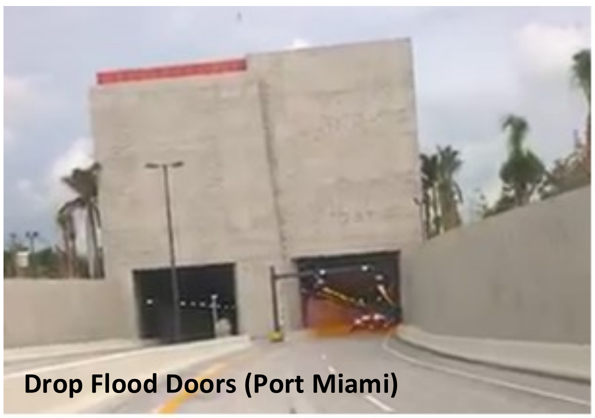
Surface street elevations in the study area range from 8 to 10 feet above sea level, making the tunnel subject to flooding during storm surge events. Methods for sealing the tunnel entrances will need to be considered to protect the tunnel. Flooding of the tunnel should be avoided through all reasonable means available. Hurricane flooding can be prevented by (1) raising the portals and roadway elevations above the flood stages, (2) designing flood gates to cover the portal openings, or (3) a combination of both these methods.

For the PortMiami tunnel, given the relatively open conditions at both ends, the original approach was to profile the tunnel approach roadways to a height sufficient to exceed the critical overtopping elevation and to protect the approach roadway from flooding with side berms or walls.

Recent hurricanes in South Florida as well as New Orleans demonstrated the damage that flooding can do in low lying areas. Flooding of the tunnel is to be avoided through all reasonable means available, due to the immense damage that would be incurred to the tunnel. The most likely threat of tunnel flooding from any source in the project location is posed by hurricanes. Floodwaters from hurricanes are dependent on several variables including wind speed, direction and forward speed of the hurricane, and the topographic features at specific locations. Because of the limitations of historical data on hurricanes, it is difficult to predict their recurrence flood intervals. The current methodology to compute recurrent flood intervals involves the use of numeric storm surge models and historic meteorological data. Tunnel flooding would need to be precluded for a major hurricane such as Category 5; therefore, a critical storm flood elevation assuming worst case conditions should be used for preliminary design purposes.

At the time of the original PortMiami Tunnel planning in the 1990s, the critical water overtopping level was +23 feet, accounting for the maximum-of-maximum storm surge scenarios plus additional wave action. Subsequently, for various reasons, it was determined by the concessionaire selected to build and operate the tunnel that the required flood protection would be provided by flood gates. That critical elevation is impractical for tunnel portals on Brickell Avenue and Biscayne Boulevard, so it is expected that portal gates of some sort would be incorporated into the final facility design. **Figure 3-23** depicts the 50-ton vertical drop flood gates included in the PortMiami tunnel design, swing gates and sliding gates, as well as inflatable tunnel plugs being considered for New York transit tunnels in the aftermath of Tropical Storm Sandy. Drop or swing flood gates seem the most likely prospects to address flood control for this project setting.

Figure 3-23 Tunnel Portal Closure Options



3.7 Recommended Tunnel Construction Methodologies

For the proposed Miami River Tunnel, the following tunnel construction methods are recommended and are reflected in the remaining sections of this report.

- **Bored Tunnel Method:** This is the technology utilized successfully for the PortMiami tunnel.
- **Sequential Excavation Method:** This tunnel is considered feasible for this corridor based on consultation from tunnel engineering resources and input from contracting firms.

There have been significant advances in recent years in the methods and machinery applied to tunnel projects. The single-bore 53-foot diameter tunnel boring machine in operation in Seattle is one of the largest to date. Contractors have devised improved processes to construct tunnels using mining techniques supplemented by grouting, soil freezing, tiebacks and other approaches. It is anticipated that these advancements and innovations would be in play should this project advance to actual implementation.

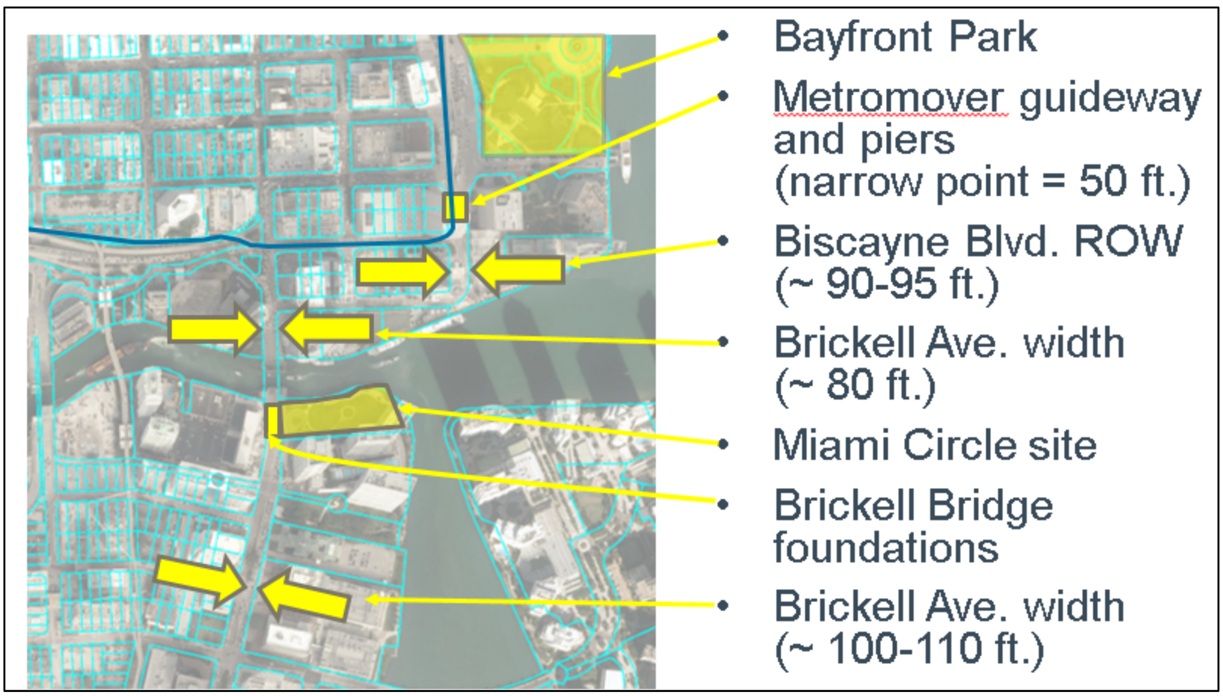
4.0 Alternatives Analysis

As noted in Section 3.2, the prime objective of this study was to investigate and identify technically feasible tunnel alignments consisting of two travel lanes in each direction across the Miami River connecting Biscayne Boulevard and Brickell Avenue. These feasible alignments could then be examined in greater detail in a subsequent and more comprehensive Project Development and Environmental (PD&E) Study per standard Florida DOT protocols. The alignments needed to avoid right-of-way encroachments due to the high cost of land in Downtown Miami as well as potential adverse effects on property improvements ranging into the hundreds of millions of dollars in value. A final key goal was to retain the existing Brickell Bridge in operation during and after the construction of the tunnel. This section of the report presents the following: the process of alignment definition and review, and identification of technically feasible alignments that might be advanced through further study.

4.1 Initial Considerations

Development of the preliminary alternatives was focused on locations east of the Metromover corridor. The corridor characteristics compiled in Section 2 were reviewed to inform this process, as well as the design criteria and related considerations described in Section 3. Coupled with field review, several key conditions were identified as influencers on the development of potential alignments across the river. **Figure 4-1** summarizes key constraints on alignment configuration that were identified.

Figure 4-1 Alignment Constraints



The alignment constraints are further described as follows:

- Brickell Avenue right-of-way south of the Miami River: While the right-of-way width varies slightly, it is generally in the range of 100 feet wide, with four to six travel lanes, a median with left turn lanes at certain locations, and occasional right turn lanes. As noted in the last section, inserting a four-lane tunnel section into this street configuration is problematic. The proposed stacking of directional tunnel roadways consumes less of the Brickell Avenue width, and also separates the directional tunnel portals over a longer section of the street, facilitating the splicing of the existing street and proposed tunnel roadways. However, the width of Brickell Avenue is still a significant constraint for the construction of boring pits for launching tunnel bores and for receiving the boring machine as it exits a bore.

- Brickell Avenue right-of-way north of the Miami River: Just north of the Brickell Avenue bridge and Biscayne Boulevard Way, the street right-of-way is 80 feet in width, which is constraining for the reasons described immediately above.

- Biscayne Boulevard at the Miami River: The lower section of Biscayne Boulevard between Biscayne Boulevard Way and SE 2nd Street has a right-of-way width of approximately 95 feet. As before for Brickell Avenue, this width is a geometric constraint. This situation is further complicated by the Metromover alignment which enters Biscayne Boulevard from SE 3rd Street and swings northward into the center of the boulevard, as discussed next.

- Metromover Alignment on Biscayne Boulevard: The Metromover guideway enters from SE 3rd Street and occupies the center of Biscayne Boulevard. In the block of Biscayne Boulevard between SE 3rd Street and SE 2nd Street, the distance between the eastern property line and the guideway support columns is approximately 45 feet. This distance does not accommodate even the narrower stacked tunnel section. Consequently, it was determined that the tunnel profile will need to pass under the footings for the Metromover guideway by at least 15 feet. This downward adjustment will push the tunnel portal locations further north along Biscayne Boulevard.

- Brickell Avenue bridge foundations: The south approach of the Brickell Avenue bridge consists of a fill section contained by retaining walls, an approach span supported on pile foundations, and a bascule element which operates the lift spans of the bridge. Since it is desired to maintain the bridge in operation, including during construction of a tunnel, it presents a particular constraint of a tunnel alignment in both the horizontal and vertical alignments.

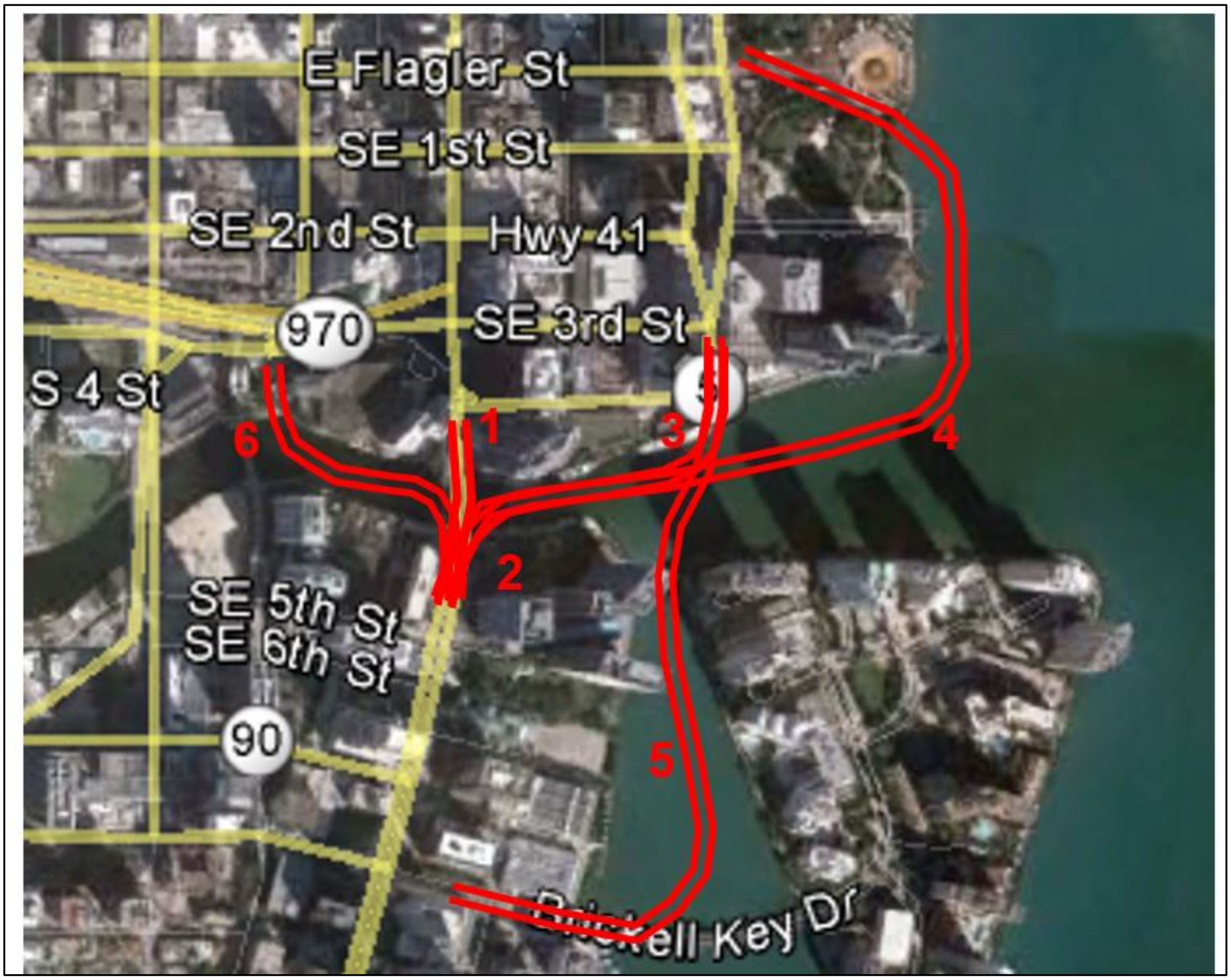
- Bayfront Park: As a public park of the City of Miami, operated through the Bayfront Park Management Trust, any encroachment into the park will require various reviews and approvals.

- Miami Circle Site: This historic site located on the south bank of the Miami River east of Brickell Avenue is protected by virtue of several status designations. Any encroachment will need to be carefully considered and would be subject to several governmental consultations, as is discussed further at a later point in this section of the report.

4.2 Crossing Location Screening

While the focus was on connecting the Brickell Avenue and Biscayne Boulevard corridors, all possible crossing locations within the study area east of the Metromover were initially identified. These six potential locations are presented in **Figure 4-2.** These locations were reviewed for suitability for further development as an alignment concept for the proposed tunnel, including preliminary profiles. This review is summarized in this section. Based on this screening, Alternatives 1 and 2 are retained for further consideration.

Figure 4-2 Potential River Crossing Locations



Alternative 1: Reverse Curve Alignment Connecting Brickell Avenue to Biscayne Boulevard

- **Description:** Connects from Brickell Avenue under the river mouth and bay under Bayfront Park to Biscayne Boulevard
- **Advantages:** Provides a relatively direct connection between Brickell Avenue and Biscayne Boulevard
- **Disadvantages:**
  - Requires staggered portals further from the river and stacked tunnel section on both sides of the river
  - Has a reverse curve alignment, though would be within design criteria
  - Length will be more costly
  - Will pass under west corner of the Miami Circle site
- **Fatal Flaws:** None
- **Disposition:** Retained for further consideration

Alternative 2: Brickell Avenue to Biscayne Boulevard Under Bayfront Park

- **Description:** Connects from Brickell Avenue under the river mouth and bay under Bayfront Park to Biscayne Boulevard
- **Advantages:** Most of alignment on north side of the river would be shallower if foundations in Bayfront Park are not problematic
- **Disadvantages:**
  - Requires staggered portals and stacked tunnel section south of the river
  - Length would be much longer, significantly affect cost
  - Requires clearances to tunnel under Bayfront Park
- **Fatal Flaws:** None, except for cost
- **Disposition:** Retained for further consideration

Alternative 3: Shallow Alignment Under the Existing Brickell Avenue Bridge

- **Description:** Connects from Brickell Avenue north towards SE 2nd Avenue
- **Advantages:**
  - Profile may be able to interface with the SE 7th/8th Streets couplet
  - Shallower alignment would be shorter and less expensive
- **Disadvantages:**
  - Does not preserve the existing Brickell Avenue bridge
  - Brickell Avenue traffic would be rerouted during the term of construction
  - Right-of-way and other constraints north of the river preclude connections to Biscayne Boulevard, as well as to the I-95 Connector ramps
- **Fatal Flaws:** Brickell Avenue bridge does not remain in place
- **Disposition:** Dropped from further consideration

Alternative 4: Deep Alignment Under the Existing Brickell Avenue Bridge

- **Description:** Connects from Brickell Avenue north towards SE 2nd Avenue
- **Advantages:** Would preserve the existing Brickell Avenue bridge
- **Disadvantages:**
  - Would require deeper stacked tunnel configuration which has one tunnel profile much deeper and more difficult to connect
  - Right-of-way, profile, and other constraints north of the river preclude connections to Biscayne Boulevard, as well as to the I-95 Connector ramps
- **Fatal Flaws:** Portal connections on the north side of the river
- **Disposition:** Dropped from further consideration

Alternative 5: Brickell Key Drive at Brickell Avenue to Biscayne Boulevard

- **Description:** Connects from Brickell Avenue by way of Brickell Key Drive and northward to south end of Biscayne Boulevard
- **Advantages:**
  - Allows Brickell Avenue bridge to remain in place
  - Profile may be able to interface with the SE 7th/8th Streets couplet
  - Shallower alignment would be shorter and less expensive
- **Disadvantages:**
  - Insufficient landward room along Brickell Key Drive for staggered portals with a stacked tunnel configuration
  - Insufficient street width on Brickell Key Drive for a four-lane side-by-side roadway portal
  - Requires a deep tunnel profile given the width of Biscayne Boulevard and presence of Metromover guideway north of the river
- **Fatal Flaws:** Brickell Key Drive segment does not accommodate tunnel portals
- **Disposition:** Dropped from further consideration

Alternative 6: Reverse Curve Alignment Connecting Brickell Avenue to NE 1st Street:

- **Description:** Connects from Brickell Avenue north towards NE 1st Avenue
- **Advantages:**
  - Profile may be able to interface with the SE 7th/8th Streets couplet
  - Shallower alignment would be shorter and less expensive
- **Disadvantages:**
  - Shallow tunnel profile would not preserve the existing Brickell Avenue bridge
  - Deep tunnel profile to preserve bridge would preclude connections to street system north of the river.
  - Would pass under Fort Dallas Park historic site
  - Brickell Avenue traffic would be rerouted during the term of construction
  - Right-of-way and other constraints north of the river preclude reasonable connections to Biscayne Boulevard, as well as to the I-95 Connector ramps
- **Fatal Flaws:**
  - Horizontal curvatures are too severe
  - Brickell Bridge likely to be affected
- **Disposition:** Dropped from further consideration

4.3 No-Build Alternative

In addition to the Build Alternatives, a No-Build Alternative was considered. This option would not entail the development of additional cross-river capacity in the form of a tunnel. However, this option could embrace of variety of action items that have been developed in dialogue between the involved stakeholders in downtown traffic congestion, Brickell Avenue bridge operations, and Miami River marine operations. These alternatives include pedestrian gates on the lift bridge, "white glove" downtown ambassadors to guide pedestrian movements, refinements to bridge opening management within published Federal regulations on bridge opening curfews, and other traffic operations related improvements. This option would embrace the objective of trying to optimize bridge area traffic operations on a short-term basis, but would not provide a long-term capacity increase.

4.4 Alternative 1: Reverse Curve Alignment

The reverse curve alignment connecting Brickell Avenue to Biscayne Boulevard ('Alignment 1') is the most direct connection between Brickell Avenue and Biscayne Boulevards. This alternative is presented with the cross-section for the bored tunnel excavation technology with a corresponding stacked twin bore cross section and is referred to as Alternative 1A. The mined tunnel alignment profile would be somewhat similar. It has the following general characteristics:

- General Description
    - Two stacked bored tunnels, separation at the portals of 12 feet, but increased along the tunnel length
    - Deeper tunnel bore is considered to be southbound, and shallower tunnel bore is northbound
    - Both tunnel bore profiles are lower than would otherwise occur, because they are profiled to pass under the Metromover foundations on Biscayne Boulevard between SE 3rd Street and SE 2nd Street, and under a corner of the south approach span to the Brickell Avenue bridge
    - This alternative passes under the northwest corner of the Miami Circle site, though it is well below surface grade

    - Southbound tunnel:
        - North portal section open roadway begins just south of NE 4th Street and ends just north of NE 2nd Street, where the southbound tunnel section begins.
        - Tunnel section runs from just north of NE 2nd Street at Biscayne Boulevard south to a point 230 feet south of SE 10th Street on Brickell Avenue
        - South portal open roadway section begins at a point 230 feet south of SE 10th Street on Brickell Avenue and ends just south of SE 12th Street
        - Dimensions
            - North portal: 590 feet
            - Tunnel: 5,310 feet
            - South portal: 590 feet
            - TOTAL 6,490 feet

- Northbound tunnel:
  - South portal open roadway section begins just north of NE 10th Street on Brickell Avenue and ends just south of SE 8th Street, where the northbound tunnel section begins.
  - Tunnel section runs from just south of SE 8th Street to Flagler Street on Biscayne Boulevard
  - North portal open roadway section begins at Flagler Street and ends at a point 200 feet north of NE 1st Street on Biscayne Boulevard
  - Dimensions
    - South portal: 564 feet
    - Tunnel: 3,622 feet
    - North portal: 564 feet
    - TOTAL 4,750 feet

- The combined bi-directional length of this alternative, including both portal sections is 11,240 feet, or 2.128 miles. This is about the same as the combined total length of the PortMiami tunnel bores and approaches.

Figure 4-3 presents the plan view of this alternative, while **Figures 4-4** to **4-6** depict the profiles of the directional roadways. While both the tunnel boring machine and sequential excavation methods of tunneling are both considered feasible, this alternative is presented with the tunnel boring machine alignment profile configuration. This alternative has a maximum depth below grade of approximately 150 feet. In comparison, the PortMiami tunnel has a maximum depth below grade of 120 feet.

Figure 4-3 Build Alternative 1A – Plan View

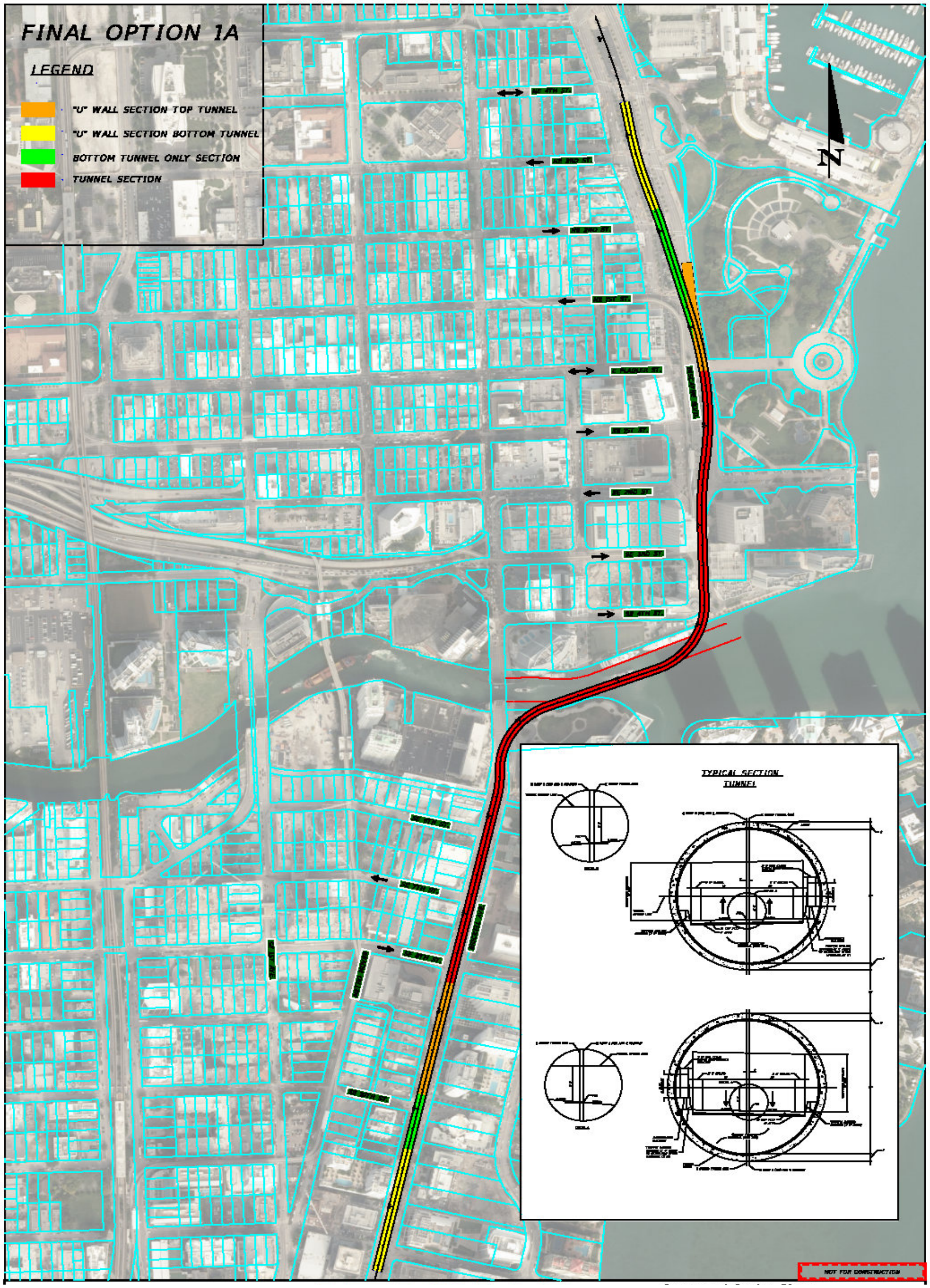


Figure 4-4 Build Alternative 1A – Profile (Section 1)

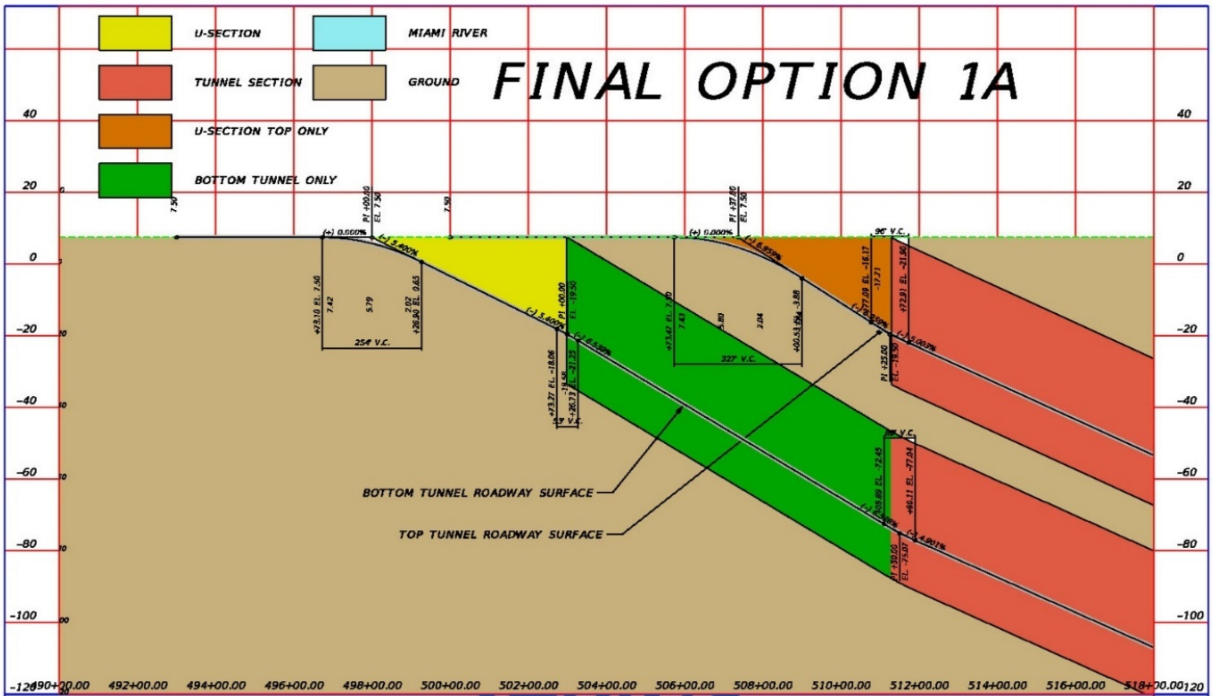


Figure 4-5 Build Alternative 1A – Profile (Section 2)

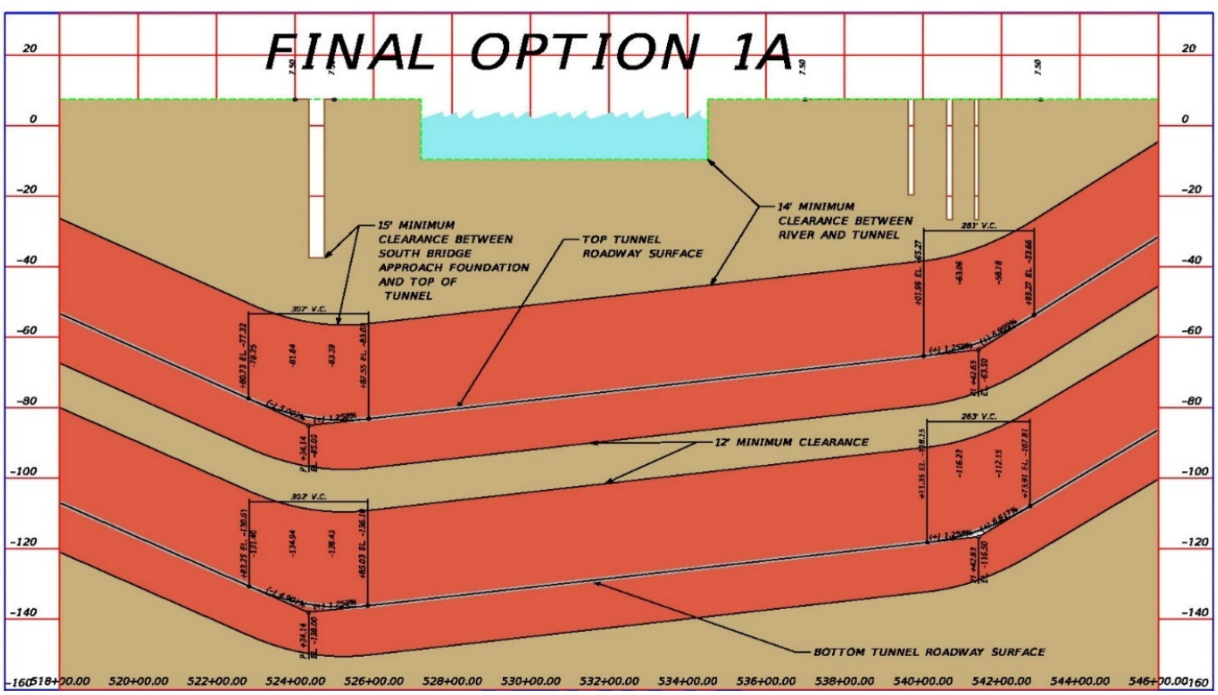
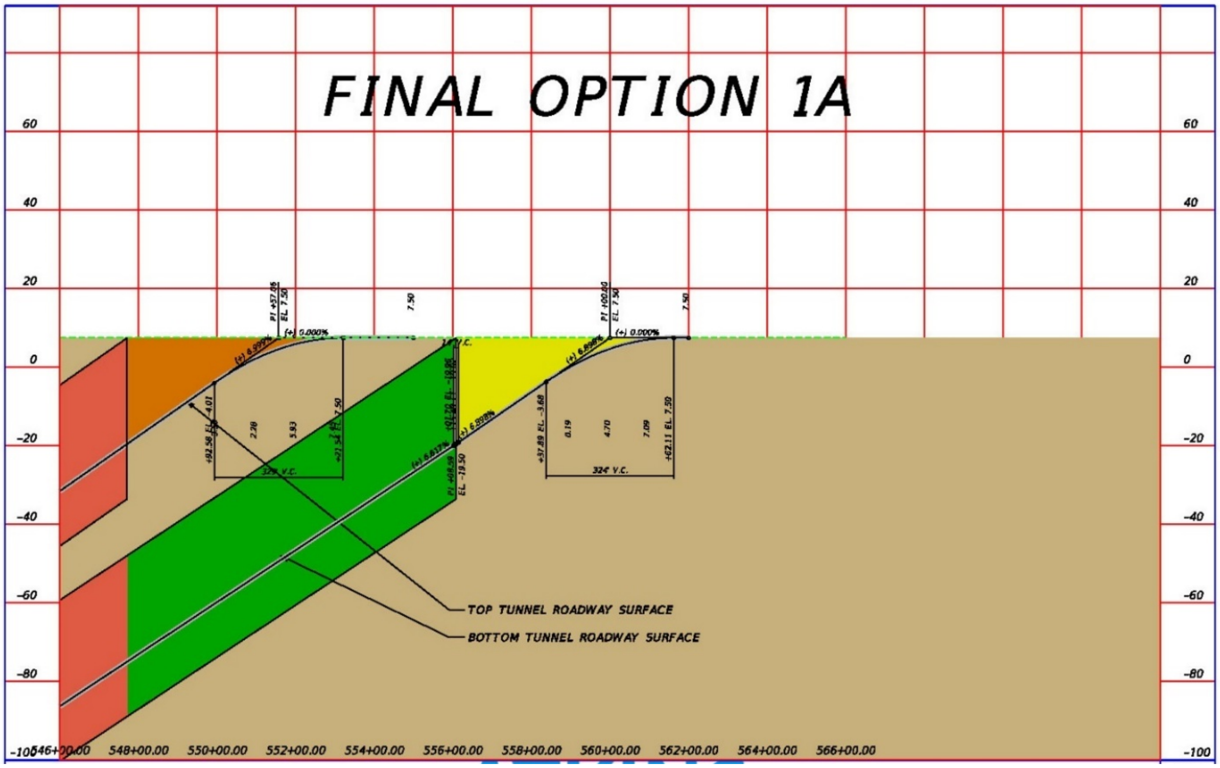


Figure 4-6 Build Alternative 1A – Profile (Section 3)



4.5 Alternative 2: Brickell Avenue to Biscayne Boulevard Under Bayfront Park

The second alternative alignment traverses from Brickell Avenue under the Miami River mouth and under Bayfront Park to link with Biscayne Boulevard ('Alternative 2'). This alternative is presented with the cross-section for the mining tunnel excavation alternative with a corresponding stacked rectangular cross section and is referred to as Alternative 2B. The bored tunnel alignment profile would be somewhat similar. Alternative 2 has the following characteristics:

- General Description
    - Two rectangular cells in a stacked configuration denote this alternative, but these are transitioned to a side-by-side configuration under Bayfront Park so that they enter Biscayne Boulevard as a four-lane section in the median of the street
    - The deeper tunnel bore is considered to be southbound, and the shallower tunnel bore is northbound
    - Both tunnel bore profiles are lower than would otherwise occur south of the Miami River because they are profiled to pass under a corner of the south approach span to the Brickell Avenue bridge
    - This alternative passes under the northwest corner of the Miami Circle site, though it is well below surface grade
    - This alternative passes under a narrow swath of private property at the foot of Biscayne Boulevard where it almost meets the Miami River

- Southbound tunnel:
    - South portal open roadway section begins just south of NE 4th Street on Biscayne Boulevard and ends just north of NE 2nd Street, where the southbound tunnel section begins
    - Tunnel section runs from just north of NE 2nd Street at Biscayne Boulevard south to a point 230 feet south of SE 10th Street on Brickell Avenue
    - North portal open roadway section begins at a point 230 feet south of SE 10th Street on Brickell Avenue and ends just south of SE 12th Street
    - Dimensions:
        - North portal: 632 feet
        - Tunnel: 6,190 feet
        - South portal: 632 feet
        - TOTAL 7,454 feet

- Northbound tunnel:
    - South portal open roadway section begins just north of NE 10th Street on Brickell Avenue and ends just south of SE 8th Street, where the northbound tunnel section begins
    - Tunnel section runs from just south of SE 8th Street to just north of NE 2nd Street on Biscayne Boulevard
    - North portal open roadway section begins just north of NE 2nd Street on Biscayne Boulevard and ends just south of NE 4th Street
    - Dimensions:
        - South portal: 710 feet
        - Tunnel: 5,092 feet
        - North portal: 710 feet
        - TOTAL 6,512 feet

- The combined bi-directional length of this alternative, including both portal sections is 13,966 feet, or 2.645 miles. This is about ½-mile longer than the combined total length of the PortMiami tunnel bores and approaches.

Figure 4-7 presents the plan view of this alternative, while **Figures 4-8** to **4-10** depict the profiles of the directional roadways. While both the tunnel boring machine and sequential excavation (mined) methods of tunneling are both considered feasible, this alternative is presented with the mined methodology alignment profile configuration. This alternative has a maximum depth below grade of approximately 120 feet. In comparison, the PortMiami tunnel also has a maximum depth below grade of 120 feet.

Figure 4-7 Build Alternative 2B - Plan

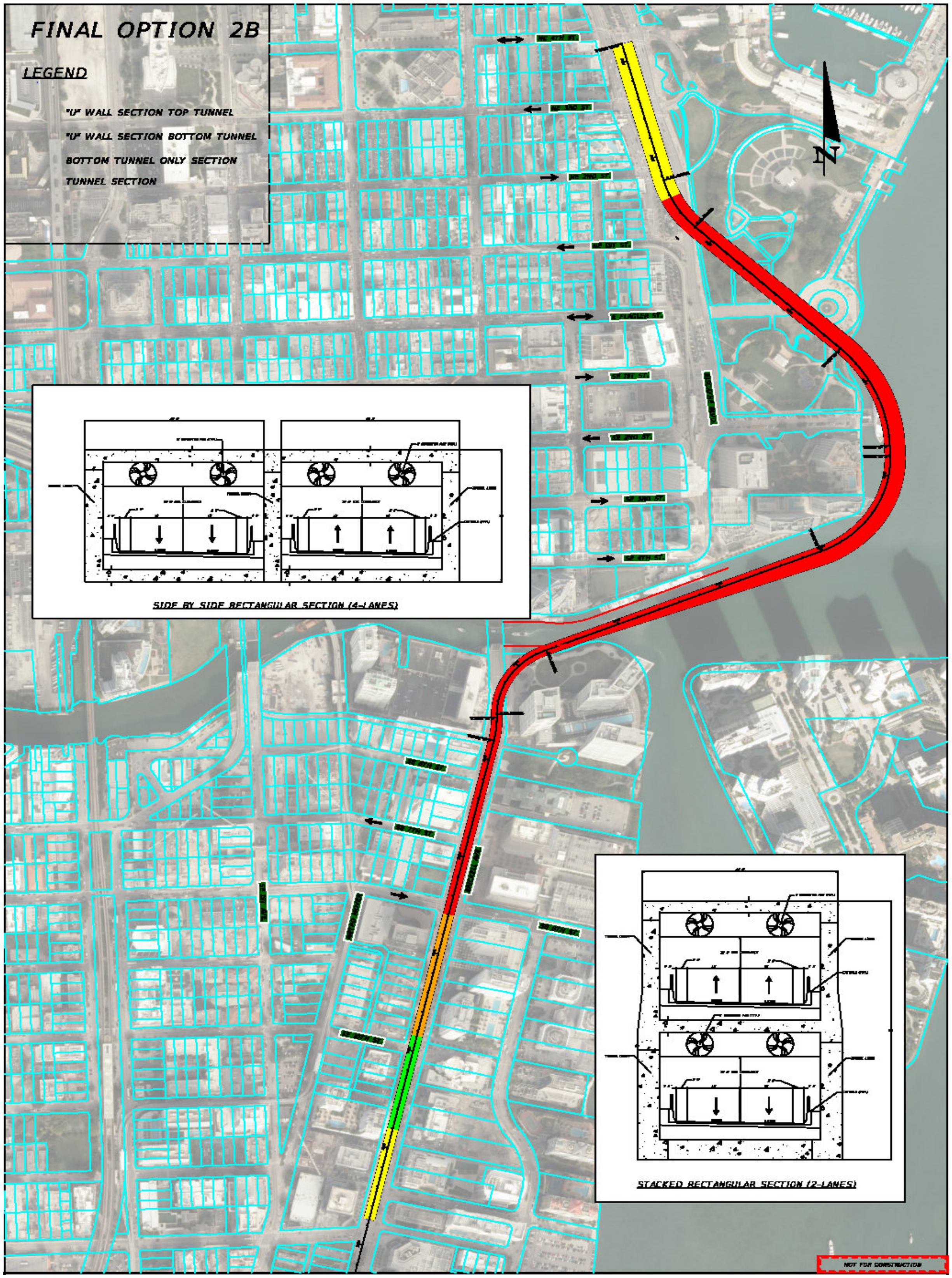


Figure 4-8 Build Alternative 2B – Profile (Section 1)

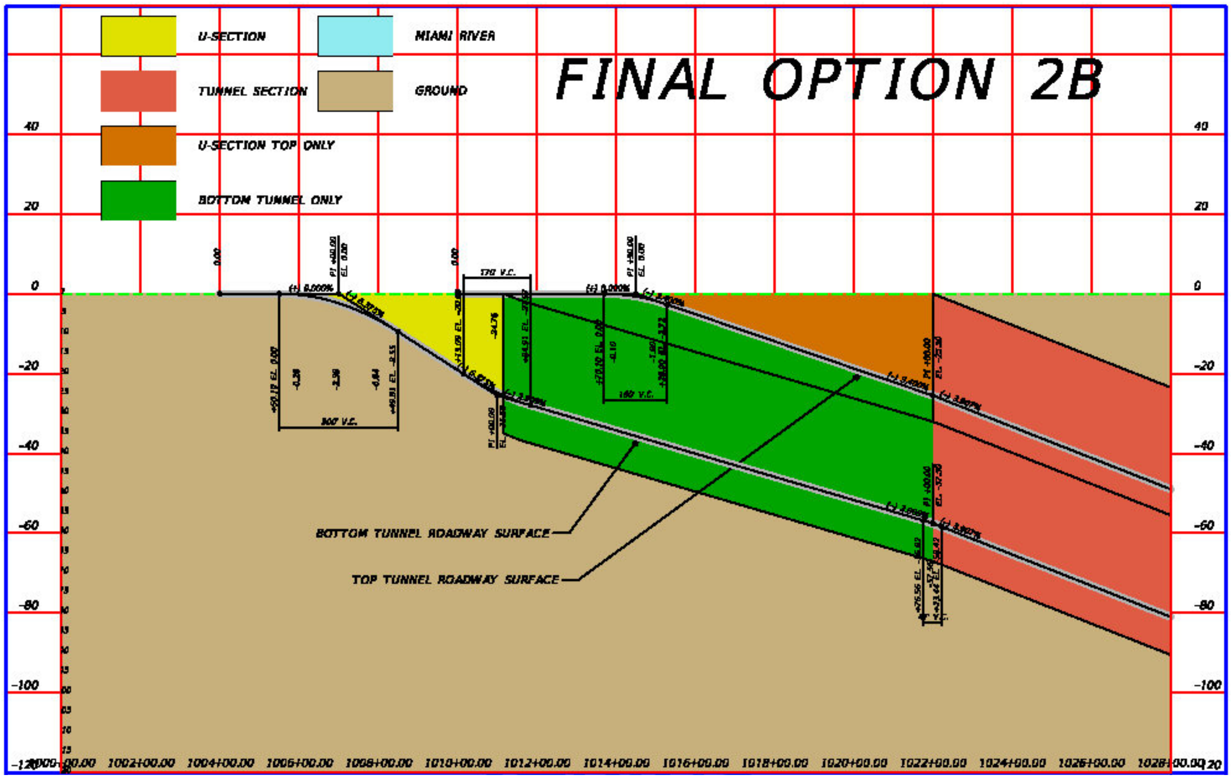


Figure 4-9 Build Alternative 2B – Profile (Section 2)

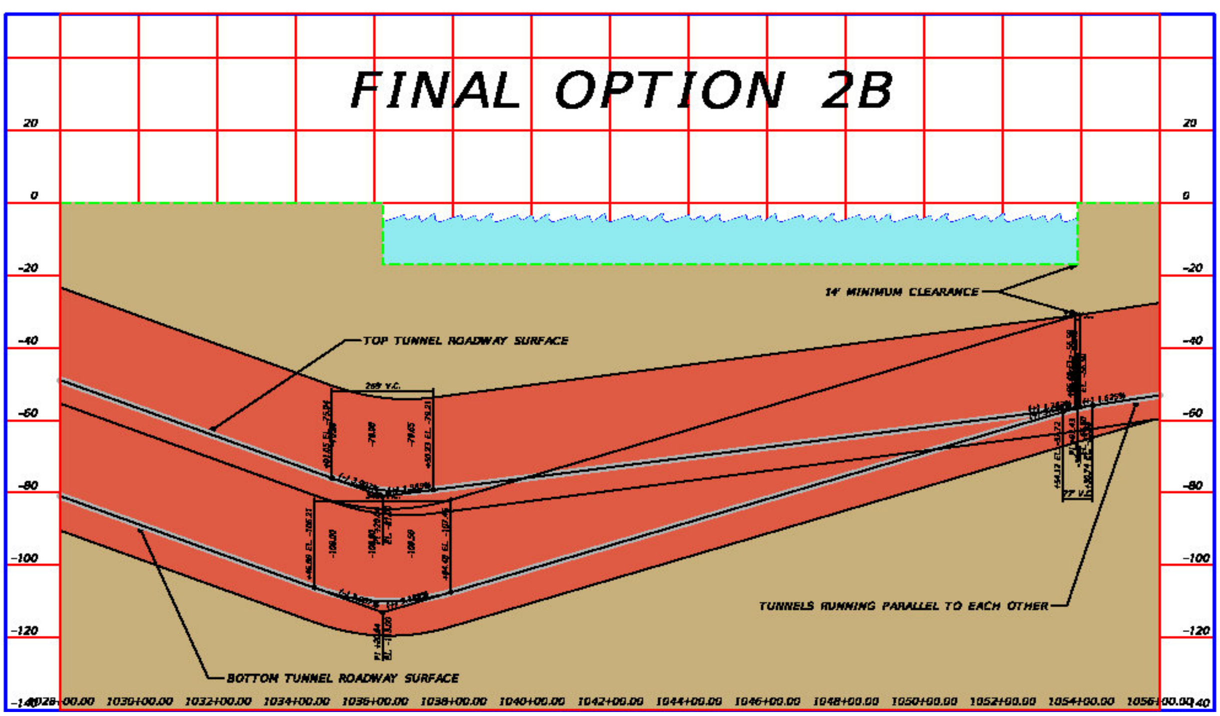
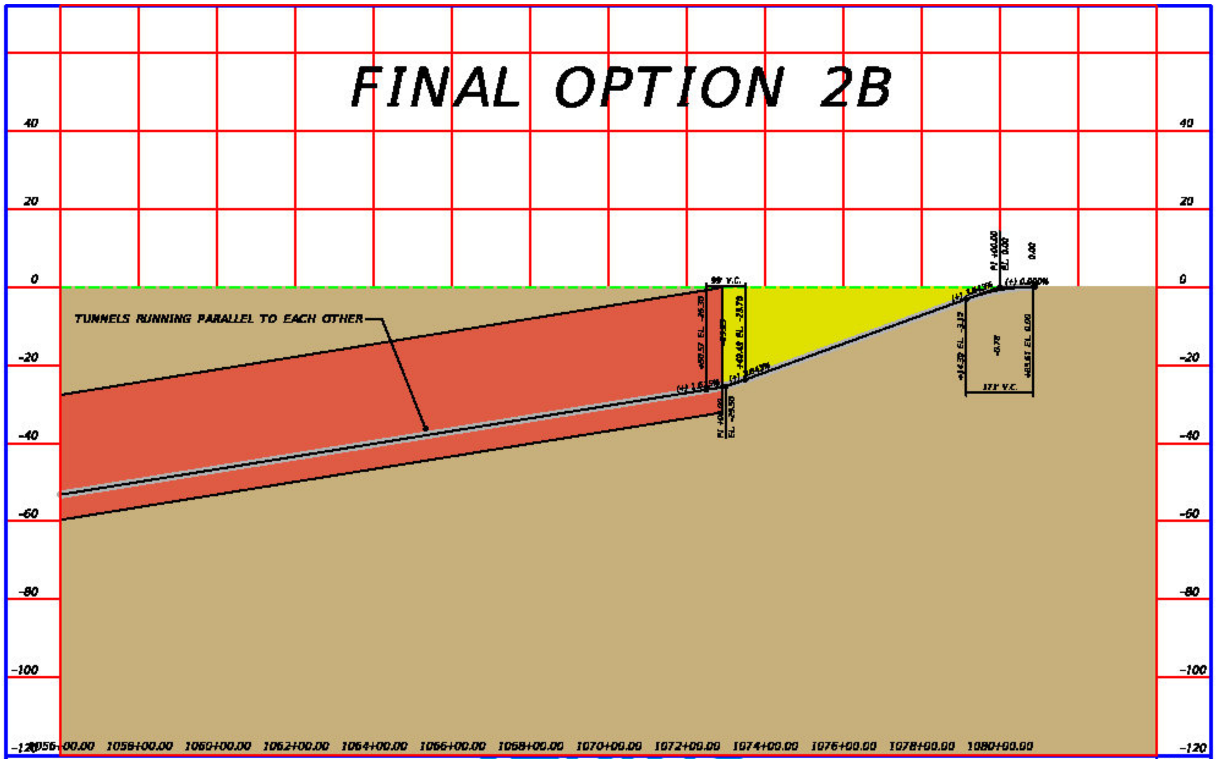


Figure 4-10 Build Alternative 2B – Profile (Section 3)



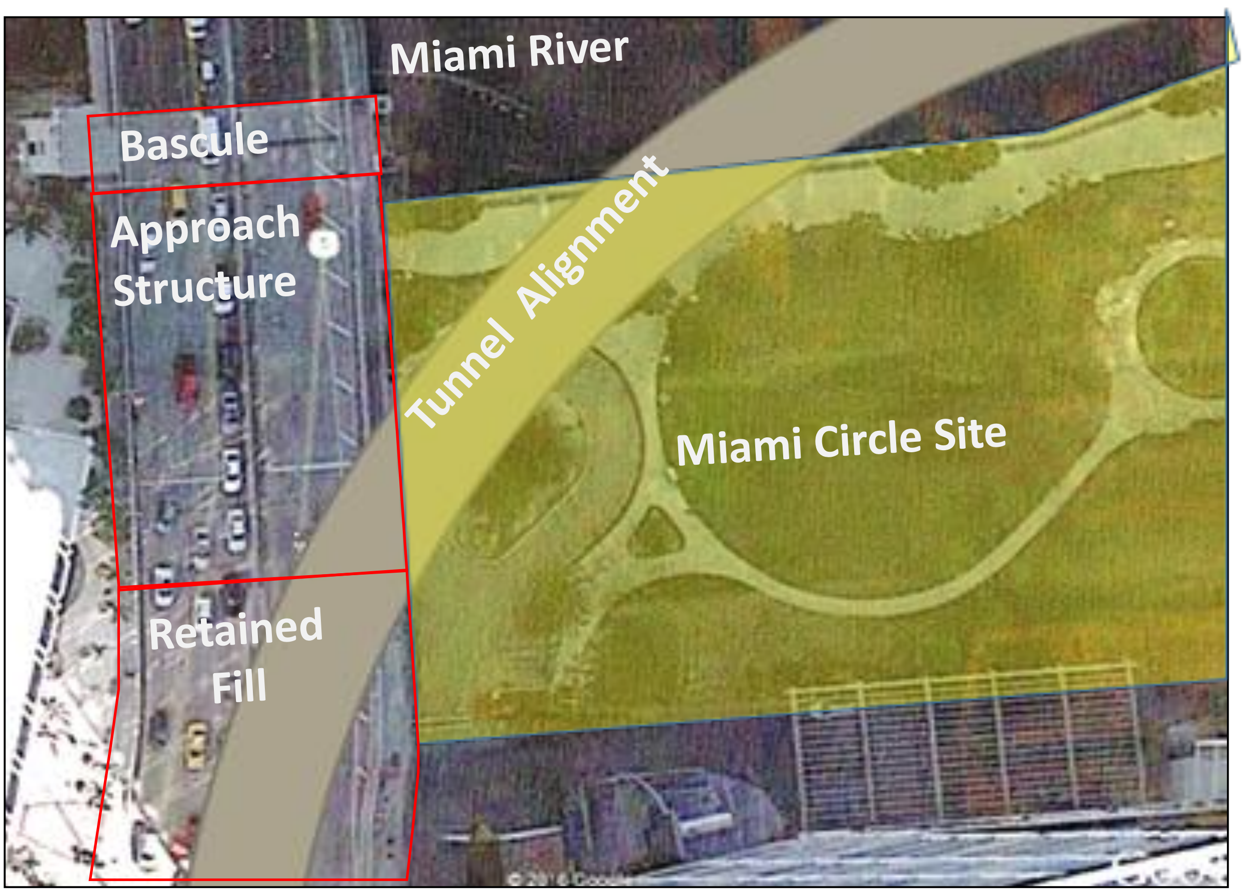
4.6 Alternative Details

4.6.1 Miami Circle Site

The Miami Circle site, also known as the Brickell Point site, was listed in the National Register of Historic Places in 2001 and designated a National Historic Landmark in 2009. The site is believed to be the southern part of the pre-Columbian village of Tequesta that used to exist on both the north and south banks of the Miami River. It is thought that the circular formation of holes that have been cut out of the oolitic limestone bedrock represents the footprint of a structure such as a council house, a chief 's house, or a temple. There are also various unique features at this site. There is an intended marking of the cardinal points. A series of holes forms an east-west line with a carving of a human-like eye at the circle's eastern point that might have some association with the equinox and solstice. Other directions were indicated with distinctive cuts or rocks set in the holes. Artifacts recovered, including the remains of a fully articulated shark, a complete sea turtle carapace, and non-local basaltic axes, indicate the site may have had ceremonial importance to the Tequesta. The Miami Circle is the only complete cut-in-rock prehistoric structural footprint discovered in eastern North America. Due to the importance of this discovery, the State purchased the property in 1999.

The Alternative 1 and Alternative 2 tunnel alignments both are positioned underneath Brickell Avenue, and are proposed to turn to the east as they approach the Brickell Avenue bridge to proceed easterly under the Miami River a short distance before turning northward under Biscayne Boulevard. To execute the northbound-to-eastbound turn at the river, the alignment would pass under the northwest corner of the Miami Circle site as shown in **Figure 4-11**.

Figure 4-11 Miami Circle Site



The figure illustrates that the tunnel alignment would pass under the improved end of the site where there is a street cul-de-sac and riverside walkways. In this area, the top of the upper Alternative 1 tunnel bore is approximately 50-60 feet below the ground level elevation of the improved corner of the site. This is considered to be a relatively minimal type of encroachment that would have no material effect upon the historic site. Regardless, research indicates that several governmental agency consultations would likely be necessary to obtain clearances for this encroachment. These would include:

- State Historic Preservation Office & Advisory Council on Historic Preservation:
    - Provide evidence of no adverse effect on the resource
    - Execute an Interagency Memorandum of Understanding committing to measures to prevent harm to the resource

- Section 4(f) review:
    - Make a confirmation of Section 4(f) status
    - Perform a determination of the extent of any taking
    - Assess subsurface rights in relation to encroachment

- Natural Resource land designation due to P2000 funding:
    - Demonstrate that there is no other practical and prudent alternative, and that all steps to minimize impacts have been taken
    - Payment of funds, land, or services necessary to offset the actual adverse impacts reasonably expected to be caused by the construction, operation, and maintenance of encroaching facility

Completion of these actions is considered feasible given the nature of the proposed encroachment. However, additional research and early consultation is recommended in order to properly resolve the open topics in a timely manner.

For both Alternatives 1 and 2, **Figure 4-11** also illustrates the extent of the conflict with the approach structure of the Brickell Avenue bridge. The approach structure is supported by pile foundations which extend to -45 feet. The tunnel has been profiled to avoid these pile tips by at least 15 feet of clearance.

4.6.2 South End of Biscayne Boulevard

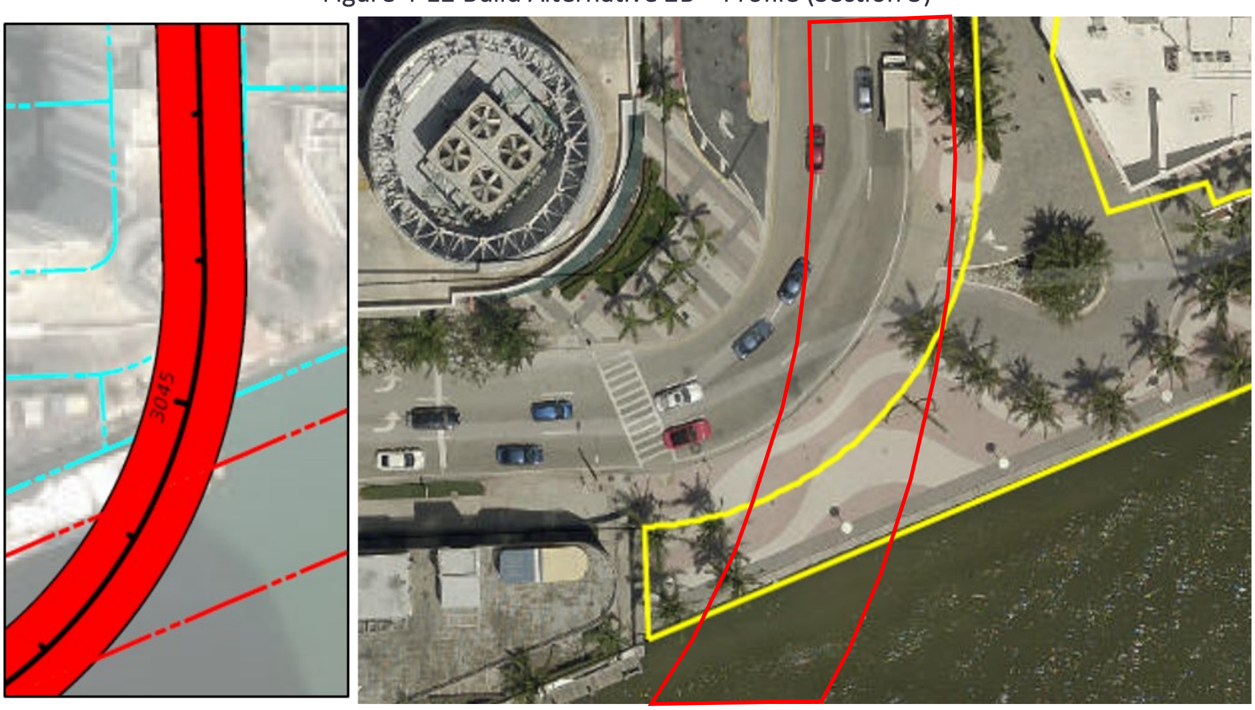
Alternative 1 enters the south end of Biscayne Boulevard across a narrow strip of privately owned land. This land appears to be dedicated for use as part of the Riverwalk corridor, and is otherwise not a buildable area. At this point the upper tunnel bore is approximately 45 below surface grade and will have no effect at street level. It is presumed that an amicable arrangement for tunnel passage in this area can be struck. **Figure 4-12** shows the layout of the tunnel in relation to property boundaries.

4.6.3 Brickell Avenue Status

Brickell Avenue is designated as a State Historic Highway per Senate Bill 138, per the following language:

> *Section 26. (1) That portion of Brickell Avenue situated within the corporate limits of the City of Miami and lying between S.E. 25th Street and the south shoreline of the Miami River is designated as a state historic road. No state funds shall be expended by any public body or agency to alter its location whether by extension of its boundaries or the extension of the name Brickell Avenue.(2) Nothing in this section shall be construed to prevent the ordinary maintenance and repair of that portion of Brickell Avenue situated within the corporate limits of the City of Miami and lying between S.E. 25th Street and the south shore line of the Miami River, provided the location of the historic road is preserved; to prevent the removal or replacement of any landscaping, including any hammock, banyan, or mahogany trees located on either side of the paved surface of the road or in the central media of the road; to prevent any work that is necessary for the public health or safety as determined by the agency having jurisdiction over that portion of Brickell Avenue described in subsection (1); to prevent the removal of invasive plant species on the roadway or right-of-way; to prevent such action deemed necessary to clear or maintain the road subsequent to a natural disaster such as a hurricane; to limit widening or physical changes to Brickell Avenue to improve vehicular or pedestrian movement; or to limit the commercial development adjacent to the roadway. The term "ordinary maintenance" means those activities necessary to preserve the existing traffic patterns and to accommodate the volume of traffic operating on that portion of Brickell Avenue described in subsection (1) as of July 1, 2007. However, the preservation of that portion of Brickell Avenue described in subsection (1) takes priority over considerations of traffic management, and the public safety shall not be construed to require alterations in that portion of Brickell Avenue described in subsection (1) or its landscaping when alternative means of promoting safety, including more restrictive regulations, are available.*

Figure 4-12 Build Alternative 2B – Profile (Section 3)



It is also appropriate to note that while Brickell Avenue from I-95 northward to the Miami River was previously entirely under the jurisdiction of the Florida DOT, the portion of the street south of SE 8th Avenue was transferred back to the City of Miami at the City's request. So it is noted that a portion of the proposed tunnel alternative alignments do not fall within a street under Florida DOT responsibility. For Alternative 1, that is a length of 1,520 feet of the overall alternative length of 6,492 feet, or about 23.5% of that alternative's length.

4.6.4 Portal Connections to Existing Streets

For Alternative 1, a review of tunnel portal connections with Biscayne Boulevard and Brickell Avenue was made. While there are alternative geometry layouts to accomplish these merge and diverge elements, those developed are reasonable and can be refined should the project move forward.

Figure 4-13 shows the northbound merge of the upper tunnel bore. This merge was proposed to occur on the east side of Biscayne Boulevard in an area where there are no intersecting streets or driveway along the east curb, and NE 2nd Street is one-way eastbound.

Figure 4-14 shows the southbound diverge movement into the lower tunnel bore occurring south of NE 4th Avenue. The proposed tunnel portal consumes the median area currently used for parking although there are remaining areas available for landscaping. Alternatively, the portal could be tucked in closer to southbound Biscayne Boulevard to reduce impact to the median area.

Figure 4-13 North Portal Layout for Alternative 1 Northbound

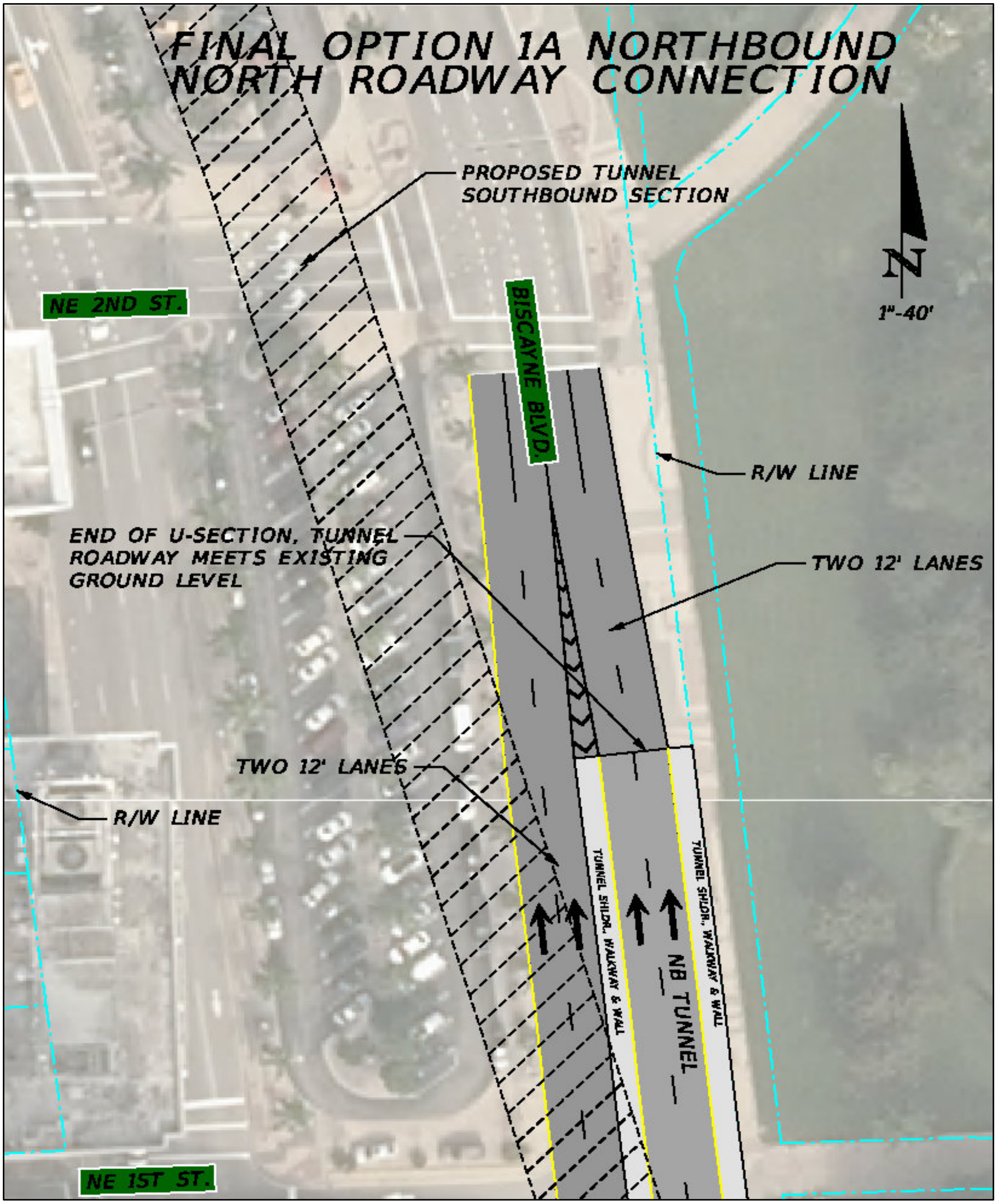


Figure 4-14 North Portal Layout for Alternative 1 Southbound

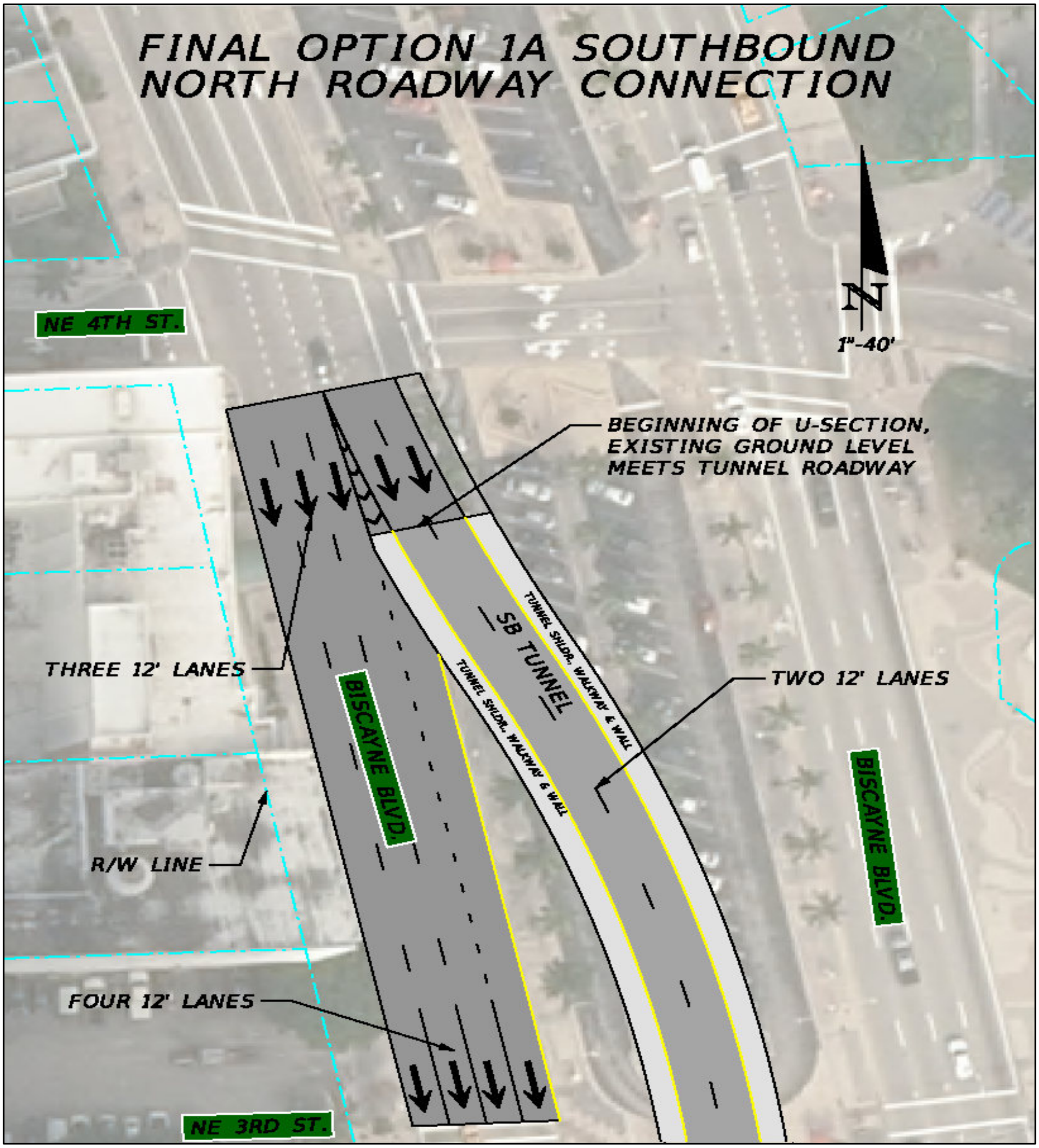
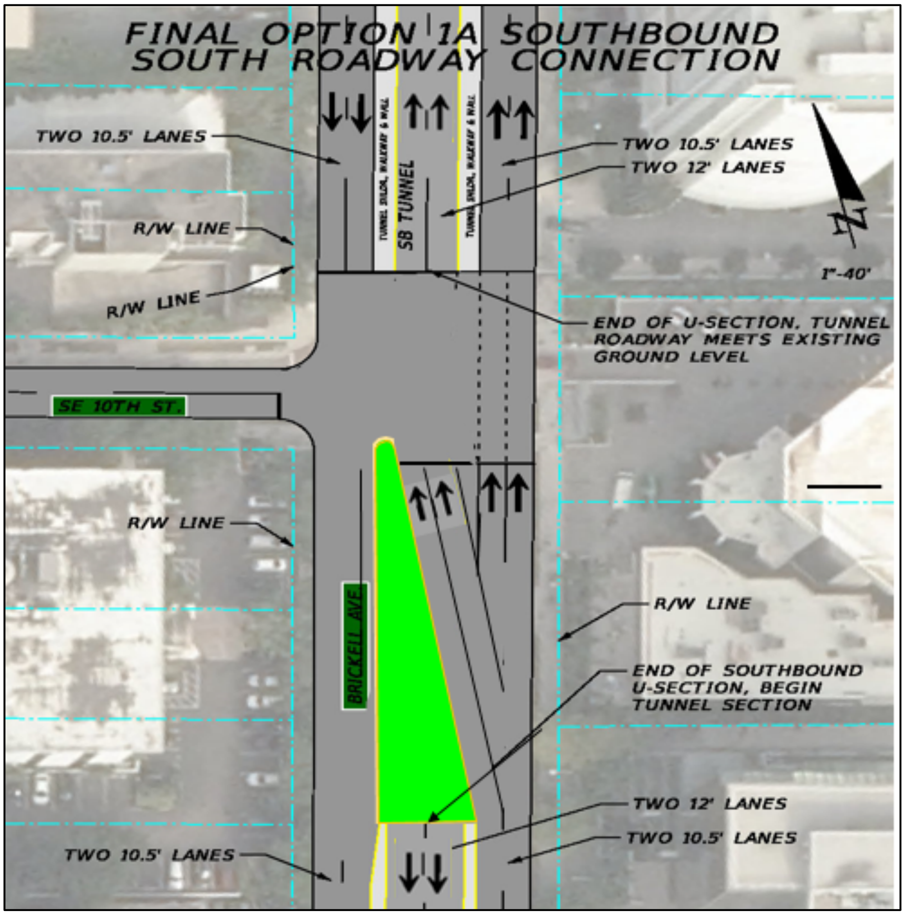


Figure 4-15 shows the southbound merge movement from the lower tunnel bore occurring at SE 10th Street on Brickell Avenue and the northbound portal entering the tunnel. The proposed tunnel portal consumes the median area currently used for parking although there are remaining areas available for landscaping. Alternatively, the portal could be tucked in closer to southbound Biscayne Boulevard to reduce impact to the median area.

Figure 4-15 South Portal Layout for Alternative 1 NB and SB



4.6.5 Compatibility with Biscayne Boulevard and the Biscayne Green Project

The Downtown Development Authority has been studying Biscayne Boulevard in the Downtown Miami area south of I-395 with a vision to create a Grand Promenade. The concept has evolved to become the Biscayne Green with further refined design concepts. In January 2017, a portion of the median was temporarily converted into a "Green" setting as a demonstration of the overall concept. The Florida DOT has recently approved funding for a lane elimination study which has long been a component of the improvement vision. Elements of this concept have variously included:

- Removing parking from the center median in the area between SE 2nd Street and NE 5th Street and creating a landscaped park-like setting
- Removal of Biscayne Boulevard traffic lanes
- Possible alignment for the Beach Corridor SMART Plan premium transit project linking downtown to Miami Beach along MacArthur Causeway

Figures 4-16, 4-17, and 4-18 illustrate the location and design concepts for this improvement project.

Figure 4-16 Biscayne Boulevard Grand Pedestrian Promenade Image 1

Figure 4-18 Biscayne Boulevard Grand Pedestrian Promenade Image 2

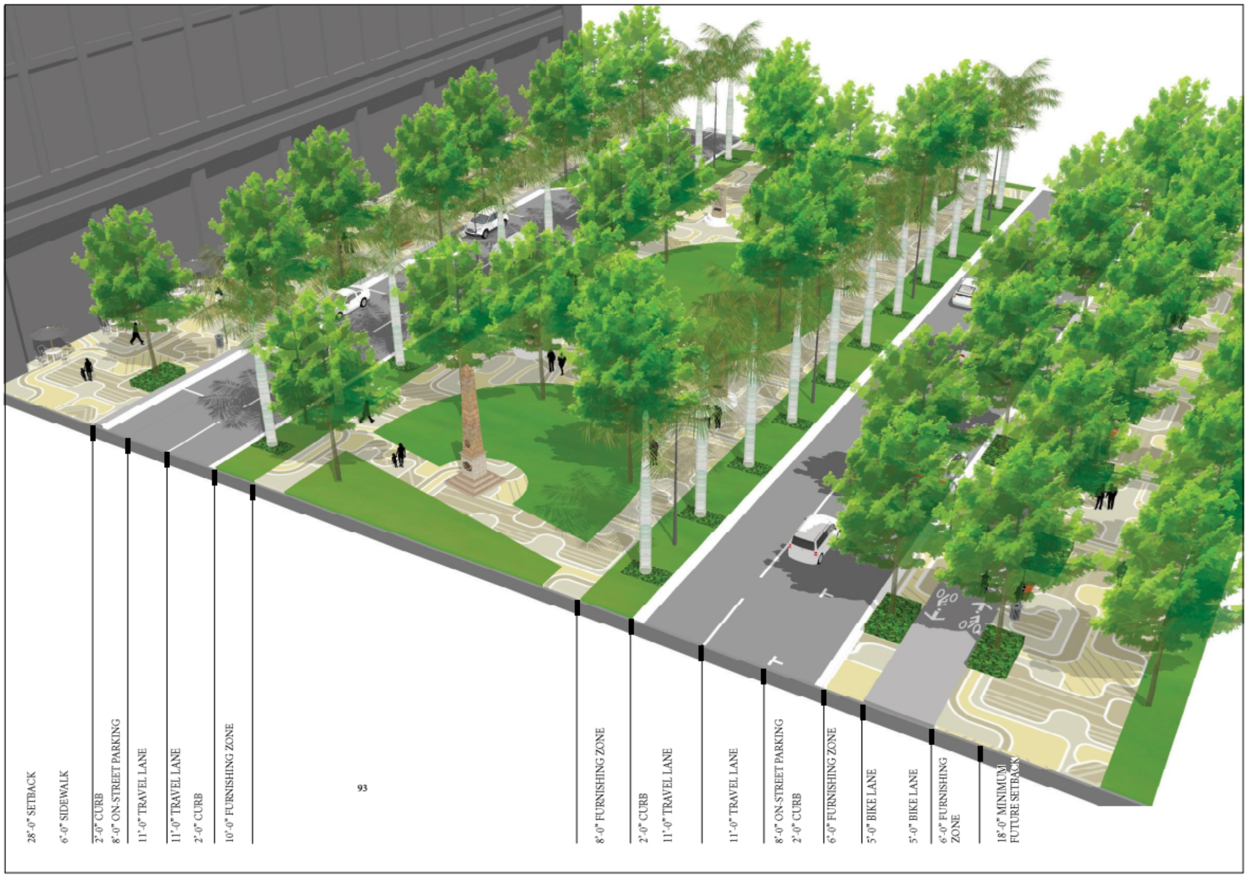


Figure 4-17 Biscayne Boulevard Grand Pedestrian Promenade Image 3

The proposed tunnel portals would affect the Biscayne Green concept in terms of their footprint and the number of lanes on Biscayne Boulevard, but it is considered that the design concept could be adjusted to accommodate the tunnel portals. For Alternative 1, the northbound portal is located between Flagler Street and NE 2nd Street and would preclude pedestrian movements from Bayfront Park at NE 1st Street. Its southbound portal would lie from NE 4th Street southward to NE 2nd Street and would eliminate both pedestrian and vehicular movements across the median at NE 3rd Street which flows one-way westbound. **Figure 4-14** previously showed an alignment for a southbound entry portal which fell in the median of Biscayne Boulevard between NE 4th and 2nd Streets, but this footprint could be reconfigured closer to the remaining southbound Biscayne Boulevard travel lanes so that the portal only marginally encroaches into the median area.

For Alternative 2, the portal concept shown in **Figure 4-7** occupies the median area, and would disrupt two blocks of the Biscayne Green concept. However, that layout can be adjusted to split the northbound and southbound portals to the edges of the median to minimize encroachment into the median. As for the southbound portal of Alternative 1, Alternative 2 northern portals would preclude pedestrian and vehicular movements across the median at NE 3rd Street due to the depressed open portal roadways.

While the northern tunnel portals of either alternative would alter the Biscayne Green layout as originally conceived, it appears that reasonable accommodations can be made for the tunnel portals. A detailed resolution is not possible in this study, and there remain several open variables as to the outcome of the lane reduction study and the accommodation of a potential transit guideway in order to integrate tunnel portals into the proposed Biscayne Boulevard corridor improvement concept.

4.6.6 Project Staging and Disposal Sites

While this conceptual study cannot anticipate project construction conditions years into the future, it is still considered useful to discuss possible staging sites for the project and disposal sites for the spoil materials.

Staging Areas

The tunnel project will require substantial staging areas which may be close or distant from the project site depending on the nature of the materials. For example, supplies and equipment related to the tunnel boring machine will need to be proximate to the project site, while tunnel liner concrete segments could be produced offsite and trucked in on a just-in-time basis. In the constrained setting of Downtown Miami, staging sites will be scarce. Some possible options include the following:

- Parcel B (4 acres) located east of the American Airlines Arena, planned to be developed as a park, but currently vacant
- Marine slip between the American Airlines Arena and Bicentennial Park is 9 acres in size. The width of the slip could be covered by beams and planking supported midspans by temporary piles or possible barges secured together
- Vacant sites pending development in either Downtown Miami or Brickell
- Vacant sites on the fringe of Downtown Miami such as the Resort World holdings on the old Miami Herald site
- Virginia Key in designated areas
- Acquisition of sufficient land that could be reverted to redevelopment once construction is completed.

- Development of a "barge raft" or floating concrete chamber platform, of sufficient size and anchored adjacent to a bulkhead for land access. These are in application, but the question is the relative cost in relation to other options.

Another component of the construction staging is employee parking. It is anticipated that a project of this scale will require several hundred workers, many of them directly onsite. Options to address site access workers could include remote parking sites with shuttle buses, leasing of underused parking spaces in proximity to the project, and encouraging the use of Metrorail, Metromover, and Metrobus for access to the site.

Spoil Materials

It is estimated that approximately 600,000 cubic yards of rock and soil would be removed from the tunnel project for Alternative 1 with bored tunnels. This material would be transported from both ends of the tunnel corridor one or more disposal sites. Some of the material excavated could be clean, crushed rock, which could be reused beneficially at other locations, subject to testing for contamination. Reuse opportunities for quality uncontaminated rock could include filling rock mining pits in west Miami-Dade County, development site raising, building artificial offshore reefs, reinforcing bulkheads, construction of berms, or use in road paving materials, depending on the consistency of the spoils materials. The project development team should would work with federal, state, and local agencies to identify reuse and disposal opportunities. Materials excavated from soil and loose material portions of the project are more likely to be contaminated because they are typically nearer the surface, where contaminants from previous or current industrial uses can collect or be carried by groundwater.

Numerous factors would affect the selection of the ultimate destination of the tunnel excavation spoil materials. The crushed rock could be used at numerous different locations, particularly since it would be removed over a period of almost two years. A spoils management plan should be developed to address the ultimate management of the project's spoils. The spoils management plan will need to be consistent with federal and state requirements for solid and hazardous waste management

At this early stage, the final destination for the spoils materials cannot yet be determined. Depending on the location of the use or disposal, they may be transported by local trucks, by drayage to rail cars, or by barge to coastal or offshore destinations.

4.7 Potential Tunnel Traffic Demand

A limited analysis of travel demand patterns as influenced by the presence of the tunnel facility was performed using the latest version of the regional travel demand model (SERPM 7.062) for 2040 conditions. This analysis tested several tunnel portal connection locations along Brickell Avenue and Biscayne Boulevard. The key observations noted are as follows:

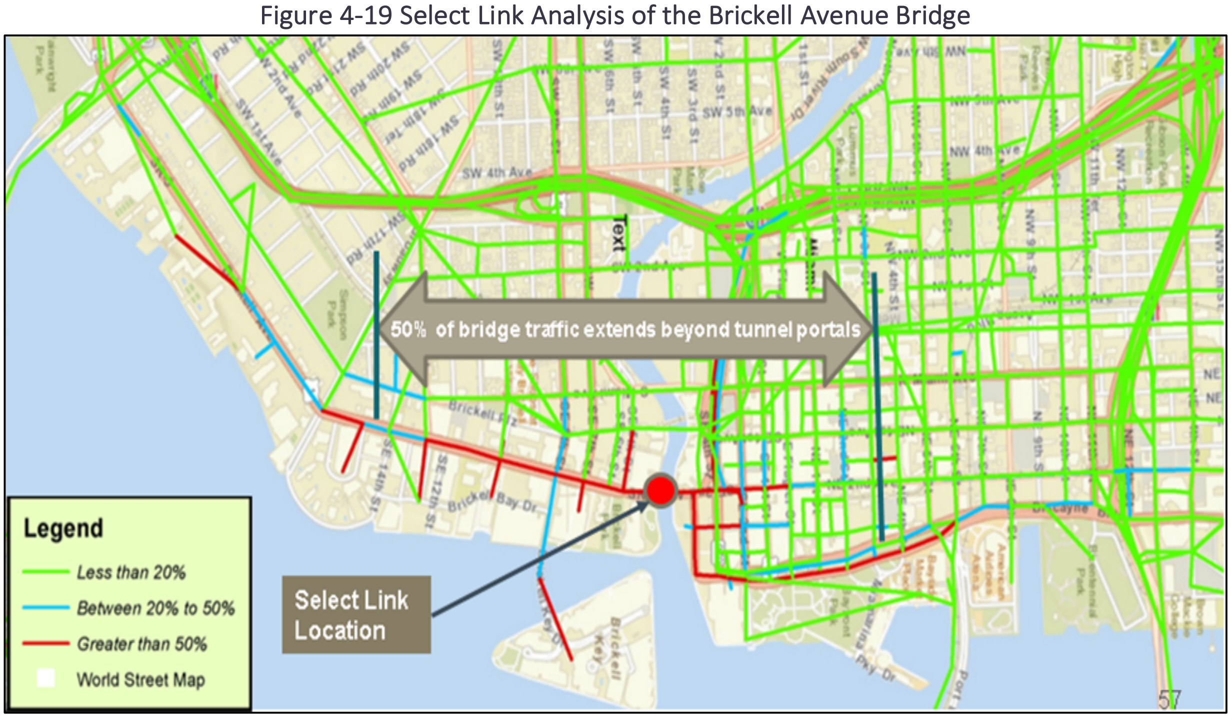
- The 2040 No-Build scenario shows the Brickell Avenue bridge with a daily traffic volume of 36,100 similar to recent daily volumes. There is directionality favoring the southbound over the northbound, similar also to recent counts.
- With Alternative 1 portal locations as described, the resulting 2040 daily volumes are:
    - Brickell Avenue bridge: 18,900 vehicles, a 17,200 vehicle reduction (-48%)
    - Miami River tunnel: 43,600 vehicles

- This indicates that the tunnel as Alternative 1 is attracting 26,400 other trips from other pathways. According to documentation, there is a reduction in traffic using the SW 2nd Avenue bridge by 4,300 vehicles compared to the No-Build condition, and by 5,000 vehicles on the Miami Avenue bridge.
- Volumes increase on Biscayne Boulevard north of the portals by approximately 21,800 vehicles, and on Brickell Avenue south of the portals by about 14,600 vehicles.
- The tunnel itself exhibits significant directionality between the two roadways, expected because portal locations are not symmetrical and thus cause different diversions, and because of the directionality and circuitry involved with Brickell Avenue bridge access north of the river. Northbound volumes are about twice those of southbound, in part owing to its portal locations being closer to the river and intercepting more traffic.

4.7.1 Select Link Analysis

These figures, though preliminary, demonstrate the traffic diversion capacity of the tunnel to divert half the Brickell Avenue bridge traffic to the tunnel route. **Figure 4-19** presents a "select link" analysis which depicts travel patterns of Brickell Avenue bridge users. The "select link" output function shows for the selected link – the one including the existing bridge – the orientation of those trips across the network. The diagram shows that for those trips crossing the bridge, they constitute 50% or more of the traffic on segments of Biscayne Boulevard as far north as Port Boulevard, and on segments of Brickell Avenue as far south as SW 15th Road. In addition, the diagram shows that the 20% share threshold of bridge trips on road segments extends as far south as Rickenbacker Causeway, as far north at I-395, and as far west as I-95 via the downtown connector ramps. Thus, the market for a tunnel is not just short trips in the immediate vicinity of the bridge.

Figure 4-19 Select Link Analysis of the Brickell Avenue Bridge



4.7.2 Tolling Potential

A cursory review of the possibility of tolling was conducted. Tolling is typically utilized when there is a need to underwrite the capital cost of the facility. Tolls can also be used to cover the ongoing operations and maintenance of a facility. It should be noted that these uses relate to the use of "net" tolls after the cost of toll collection. Generally, the introduction of tolling to a roadway facility will diminish the number of users and thus the revenue generated. The user response to a toll is captured within an "elasticity" measure which gauges the rate of diversion in response to a given tolling level. That rate is typically a function of the time saved on the tolled facility in relation to other routing options and the user's perceived value of time.

No direct tolling analysis was conducted in this study, but a somewhat similar and recent case study was identified in Seattle. The Alaskan Way viaduct on the city waterfront is being replaced by a 2.2-mile long tunnel and short connecting road segments. For that project, a very detailed tolling analysis was performed looking at variable tolling scenarios including peak-hour premium tolls, varying base toll levels, peak-hour only tolling, premium tolling for trucks, and tolling on weekdays only or all seven days of a week (Alaskan Way Viaduct Replacement Program Advisory Committee on Tolling and Traffic Management – Advisory Recommendations for Tolling the SR 99 Tunnel, Washington State Department of Transportation, March 2014).

A review of this document and its findings for the degree of traffic diversion under seven tolling scenarios and permutations was distilled into a high-level and simplified measure of the rate of trip diversion from the tunnel based on the tolling cost per mile of facility. From this review a ratio of 0.7% traffic diversion per 1-cent per mile of tolling cost was derived. For this Miami River tunnel project, Alternative A with a bidirectional average length of just over one mile, applying this factor to various tolls would yield the following traffic diversions:

Tolling Level	Traffic Diversion
• 25¢ one-way toll	16%
• 50¢ one-way toll	32%
• 75¢ one-way toll	48%

Applying tolls and traffic diversion to the average daily traffic estimate, allowing 15% deduction for toll collection cost, and annualizing yields an estimated $2-4 million per year for tolls of 25¢ to 50¢. This revenue would be only a small fraction of the funds need to be retiring debt service on a construction finance instrument. Thus, tolling on this facility where there are alternative travel paths will not be able to recoup amortized capital costs. However, tolling ultimately could be used to defray a large portion of capital and operating costs, if toll diversion response locally were similar to the above figures.

4.8 Conceptual Cost Estimates

Given the conceptual level of project definition and study resources, an in-depth buildup cost analysis was not possible. However, a comparative cost analysis was performed in relation to the capital costs for the PortMiami tunnel project.

4.8.1 Approach

The capital cost for the PortMiami tunnel was $607 million with a 2010 cost basis. The roadway improvements included with the tunnel project included the relocation of MacArthur Causeway, the addition of two interior lanes on the MacArthur Causeway bridge over the Intracoastal Waterway, and roadway circulation improvements along the PortMiami portals of the tunnel. It is not anticipated that this scale of ancillary roadway improvements would be required for the Miami River tunnel, so the base cost for the PortMiami tunnel was adjusted downward to $585 million. The length of the pair of tunnel bores for the PortMiami tunnel is 4,200 feet, which yields a cost of $139,286/lineal foot (LF)of twin bore, or $69,643/LF of single tunnel bore. These unit costs were escalated to 2017 on the basis of 3.25% per year escalation compounded, yielding values of $174,107 and $87,054, respectively. Finally, a complexity factor of 15% was applied to account for the more constrained conditions in the Downtown Miami setting, yielding slightly rounded cost values of $200,000/LF of twin tunnel bore and $100,000/LF of single tunnel bore. These values were applied to the tunnel lengths of alternatives to derive a conceptual level of cost.

Because of the lack of alignment specific geotechnical information and the lack of tunnel mining experience locally for the scale of this project, a premium of 20% was applied to tunnel mining alternatives; while tunnel mining avoids the cost of a tunnel boring machine in the range of $55-60 million, and contractor contacts suggested that the project cost could be less, there is no demonstrable information to that effect locally, so a more conservative estimate is made, based on literature research which suggests that tunnel mining could be more expensive that tunnel boring depending upon circumstances.

4.8.2 Estimate Inclusions

With the approach taken, the cost estimation process includes the labor and materials associated with:

- All construction elements and systems intrinsic to the PortMiami tunnel project.
- Mobilization, utilities, maintenance of traffic, and similar costs.
- Boring machine fabrication, shipping, assembly, operations, disassembly, return shipping.
- Tunnel liners, tunnel finish out, tunnel systems.
- Tunnel excavation spoil disposal.
- Ancillary roadway improvements.
- Control center building.

4.8.3 Estimate Exclusions

The cost estimation process excludes cost associated with:

- Right-of-way
- Environmental mitigation
- Spoil contamination remediation
- Extraordinary spoil disposal costs
- Extraordinary utility relocations
- Financing costs related to loans and paybacks

4.8.4 Additive Costs

There are several additive costs for front end work to further plan the facility, conduct the detailed alternatives analysis

- Preliminary studies (PD&E, geotechnical, cultural resources, ROW elements)
- Final design and engineering
- Construction oversight
- Legal, permitting, procurement

4.8.5 Total Estimated Conceptual Cost

Table 4-1 presents the estimated conceptual costs for several final alternatives, including:

- Alternative 1A: Reverse Curve Alignment – Bored Tunnel
- Alternative 1B: Reverse Curve Alignment- Mined Tunnel
- Alternative 2A: Brickell Avenue to Biscayne Boulevard Under Bayfront Park – Bored Tunnel
- Alternative 2B: Brickell Avenue to Biscayne Boulevard Under Bayfront Park – Mined Tunnel

The actual project configuration, cost, and duration may vary depending on final project scope, final design, construction sequencing, and production rates. Costs shown are in 2017 dollars.

Table 4-1 Conceptual Costs

Alternative	1A	1B	2A	2B
Technology	Bored	Mined	Bored	Mined
Configuration	Circular Stacked	Rectangular Stacked	Circular Stacked	Rectangular Stacked
2017 Base Capital Cost	**$894.2**	**$1,050.7**	**$1,129.5**	**$1,327.1**
Additive Costs				
Preliminary Studies (PD&E, geotechnical, etc.) at 4%	$40.00	$40.00	$40.00	$40.00
Final Design at 10%	$89.4	$105.1	$112.9	$132.7
Construction Oversight at 12%	$107.3	$126.1	$135.5	$159.3
Other (legal, permitting, procurement, etc.) at 0.5%	$8.9	$10.5	$11.3	$13.3
Subtotal - Additives	**$245.7**	**$281.7**	**$299.8**	**$345.2**
Grand Total	***$1,139.9***	***$1,332.3***	***$1,429.2***	***$1,672.4***

NOTE: Excludes right-of-way, environmental mitigation, spoil contamination remediation, extraordinary spoil disposal costs, extraordinary utility relocations, and financing costs related to loans and paybacks.

4.8.6 Operations and Maintenance Costs

An important element of the investment in a tunnel facility is the recognition that such infrastructure requires multiple systems components for traffic and incident monitoring, emergency communications, incident management, messaging, drainage and pumps, ventilation for air quality, fire suppression, portal flood protection, lighting, and others. These systems are managed at an operations control center housing administrative and operations staff, including incident response staff. There are also utility costs for electricity to power lighting and ventilation systems, video monitoring, the ITS information system, and other elements. In addition, there are routine and periodic maintenance activities as well as certain facility and equipment repair and renewal aspects that are included.

The cost of providing for the operations and maintenance functions are a necessary and ongoing feature of keeping the tunnel in a good state of repair and readiness to address vehicle breakdowns, traffic incidents and crashes, and other emergency conditions for the safety and security of tunnel users.

Based on a review of the literature and information for the PortMiami tunnel, it is estimated that the annual operations and maintenance cost for the proposed tunnel in the Alternative 1 configuration would be in the range of $4-6 million per year in 2017 dollars.

4.9 Alternatives Comparison

Table 4-2 presents a comparison of the final alternatives considered. Five evaluation categories were identified, each with multiple criteria relating to the evaluation category. Evaluation categories were weighted in terms of relative consequence to alternative suitability. Each criterion was scored on a 5-step scale of 0 to 4, with 4 representing very good satisfaction of a criterion, and 0 representing weak satisfaction of a criterion. The resulting scores indicate that Alternative 1A: Reverse Curve Alignment – Bored Tunnel best addresses the purpose of the project with the lowest cost.

While Alternative 2 in either form avoids certain issues with reduced proximity to buildings along Biscayne Boulevard, its increased length translates into nearly $300 million in additional cost, and with a horizontal alignment that introduces additional length of roadway curvatures. Its advantages are outweighed by the cost differential.

Mining alternatives due to the costing approach receive a lower overall score. However, it is recommended that as the tunnel project advances, that the procurement vehicle could incorporate the mining alternative as a construction method to ascertain contractor insight and innovation as to the cost-effectiveness of that method in the study area setting, given new or improved techniques that may be available at the time of procurement.

Table 4-2 Alternative Comparison

EVALUATION CRITERIA	MEASURE	Option 1A Reverse Curve Alignment [Bored Tunnel]	Option 1B Reverse Curve Alignment [Mined Tunnel]	Option 2A Brickell Avenue to Biscayne Boulevard Under Bayfront Park [Bored Tunnel]	Option 2B Brickell Avenue to Biscayne Boulevard Under Bayfront Park [Mined Tunnel]
Transportation					
Portal Connections	Workability of portal connections to surface streets	◕	◕	◕	◕
Existing Brickell Bridge	Preserves existing bridge	●	●	●	●
Directness	Provides a direct alignment	●	●	◑	◑
Subtotal		11	11	9	9
Weighted Subtotal	3.00	33	33	27	27
Planning					
Traffic Volumes at River Crossing	Reduces traffic volumes at existing bridge	●	●	●	●
Subtotal		4	4	4	4
Weighted Subtotal	1.50	6	6	6	6
Social/Environmental Impacts					
Cultural/Historic Resource Impacts	Avoids impacts to ultural/historic resources	◑	◑	◔	◔
Noise and Vibration	Relative level of noise and vibration potential	◕	◕	●	●
Subtotal		5	5	5	5
Weighted Subtotal	0.75	3.75	3.75	3.75	3.75
Site Characteristics					
Street Disturbance	Extent of street disruption during construction	◕	◕	◕	◕
Utilities	Extent of utility conflicts	◕	◕	◕	◕
Subtotal		6	6	6	6
Weighted Subtotal	0.75	4.5	4.5	4.5	4.5
Conceptual Costs					
Construction Cost	Consruction cost relative to lowest cost	●	◕	◕	◑
Ground Settlement	Potential for issues and costs associated with ground settlement	◕	◕	●	●
Potential Right-of-Way Issues	Extent of problematic right-of-way issues	◕	◕	◑	◑
Subtotal		10	9	9	8
Weighted Subtotal	4.00	40	36	36	32
Total		36	35	33	32
Weighted Total	10.00	87.25	83.25	77.25	73.25

● Fully addresses the measure, or is the best alternative relative to the criteria.

◕ Largely addresses the measure, or is an acceptable but not a preferred alternative relative to the criteria.

◑ Partially addresses the measure, or is an acceptable but not a preferred alternative relative to the criteria.

◔ Somewhat addresses the measure, or not a preferred alternative relative to the criteria.

○ Fails to address the measure, or the alternative is lowest ranked relative to the criteria.

5.0 Implementation Elements

This section of the report addresses several project development elements related to the ultimate implementation of the proposed project.

5.1 Agency Coordination, Consultation, and Permitting

A project of this complexity would necessarily involve dozens of agencies and jurisdictions in relation to coordination and agreements, as well as consultation and permitting to satisfy regulatory requirements. Coordinating transportation agency partners will most likely include the Florida DOT, Miami-Dade County, and the City of Miami.

5.1.1 Key Project Coordination

Key aspects of the project which would require significant coordination and further development over the planning and project development phase would include but not be limited to:

- Addressing right-of-way encroachments at the following locations at the Miami Circle site and Biscayne Boulevard at the Miami River
- Coordination of north portal configurations with Biscayne Boulevard planning projects
- Tunnel spoil disposal sites and truck access routing
- Corridor and remote staging sites for construction materials and employee parking
- Maintenance of traffic plans for temporary and long-term traffic detours and possible permanent traffic flow changes
- Noise and vibration monitoring program
- Construction settlement plan
- Construction staging
- Community outreach strategy during construction
- Advance permit coordination and agency consultation

5.1.2 Project Coordination Agencies

Likely agencies to be involved in project coordination and consultation would include, but not limited to:

- United States Army Corps of Engineers
- United States Coast Guard
- National Marine Fisheries Service
- United States Fish and Wildlife Services
- Florida Department of Environmental Protection
    - Biscayne Bay Aquatic Preserve
    - Florida Fish and Wildlife Conservation Commission
- Miami Dade County RER Class I Permit
    - In the event of barges and/or any waterborne construction activities.
- City of Miami Historic Preservation (Brickell Avenue historic road designation)
- Miami Circle Site
    - State Historic Preservation Office & Advisory Council on Historic Preservation
    - Section 4(f) review
    - Florida Department of State: Natural Resource land designation due to P2000 funding

5.2 Traffic Control Plan

It is understood that a project of this scale will have significant impacts to the infrastructure of the roadway network in and around the limits of the project. It is essential for final project limits to be based on detailed conceptual traffic control and construction analysis to achieve the following:

- Implement the project
- Minimize potential conflicts between projects
- Implement other possible permanent network changes to address shifts in travel patterns in response to the new network capacity represented by the tunnel

Additionally, during construction adjustments in traffic circulation around construction zones must be accommodated. Detours would be kept to a minimum. Roadway access will be maintained and construction of temporary alternative routes will be accommodated wherever possible. As noted, it may be appropriate to implement portions of permanent network adjustments as part of construction phase accommodations.

Finally, a traffic control plan would be developed and implemented in consultation with local jurisdictions, FDOT and the City of Miami. Measures to be considered for implementation in the Traffic Control Plan would include, but not be limited to:

- Careful coordination of the phasing of the individual construction projects that are currently underway within the project area
- Advance public notification to motorists of the nature, extent, and duration of any street closing and possible detour routes, if needed
- Detour signing placed in advance at strategic locations to notify motorists of alternate routing.
- Use of ITS, warning signs, and markings

5.3 Implementation Timetable

The development of this project, if advanced, could occur in several ways. The traditional approach would be a sequenced progression of project development activities, with basic steps and timelines as follows:

PHASE	**DURATION**
• PD&E Study/EIS (1)	3 – 4 years
• Final Design	2 – 2-1/2 years
• ROW clearance (if required)	2 – 3 years
• Construction	4 – 4-1/2 years
• Identification of funding sources For construction and operations	To be determined

(1) Project Development and Environmental Study & Environmental Impact Study

These phases can be fast-tracked to some extent to reduce overall duration. An alternative approach would be some form of public-private partnership (P3) ranging from a design-build procurement to a full concession agreement as was struck for the PortMiami tunnel implementation. Often a long-term P3 procurement can accelerate portions of the project development process, though as explained further in Section 5, requires a strategy for debt retirement, and may likely have a higher total project financial cost for this reason.

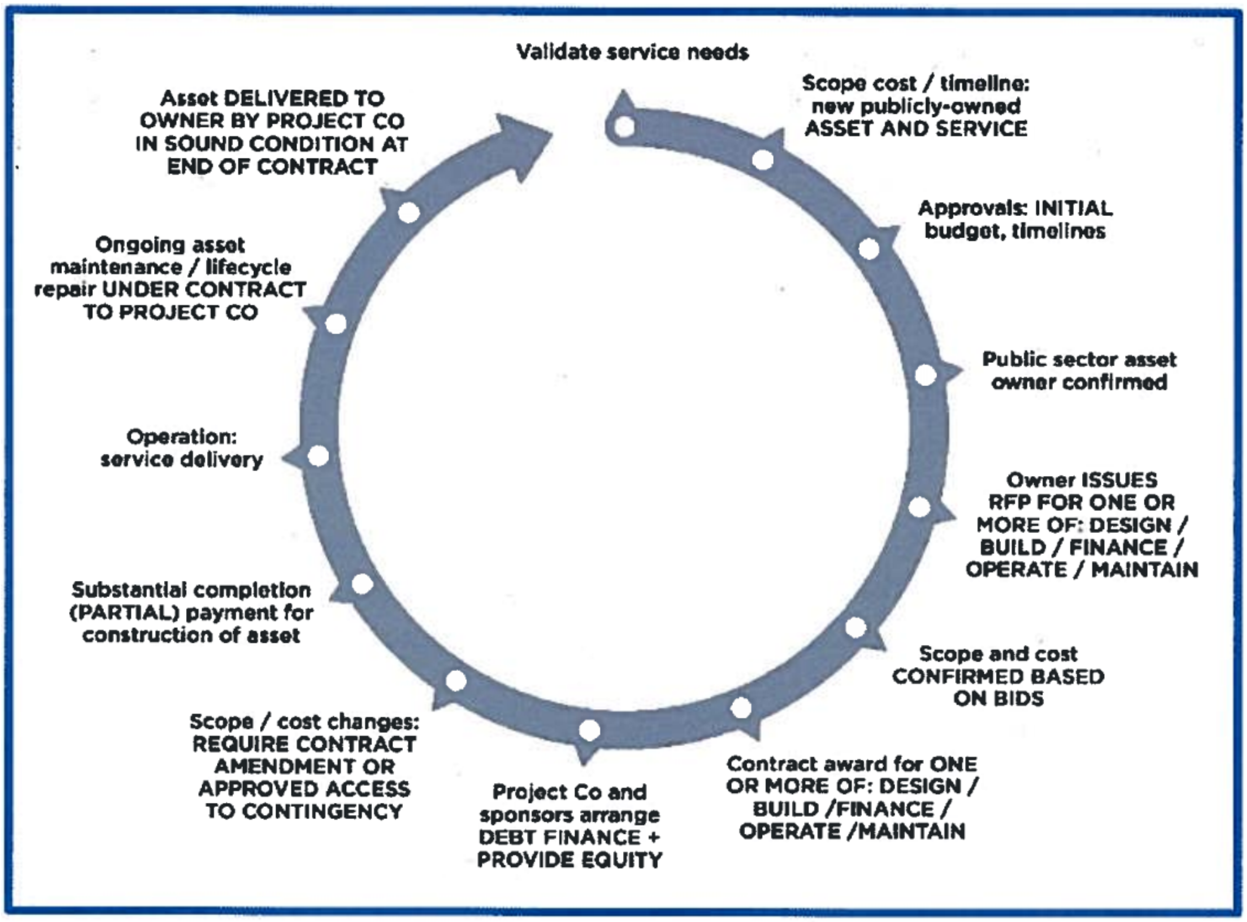
5.4 Funding and Finance

The proposed Miami River tunnel project, as defined, is on the scale of the PortMiami tunnel completed and opened to traffic in 2014, though slightly longer in overall length, and in a more complex and constrained physical setting. The future implementation of this project, if advanced, could proceed in one of two general ways.

5.4.1 Traditional Infrastructure Procurement

The first approach is the traditional infrastructure project development where the necessary set of steps is accomplished in a more or less sequential manner, led by a public jurisdiction. The recent Miami-Dade TPO publication (Public-Private Partnership (P3) Reference Guide, 2016) provides very useful reference material contrasting traditional versus the alternative approach through some form of public-private partnership (P3). **Figure 5-** illustrates the traditional method of project development steps.

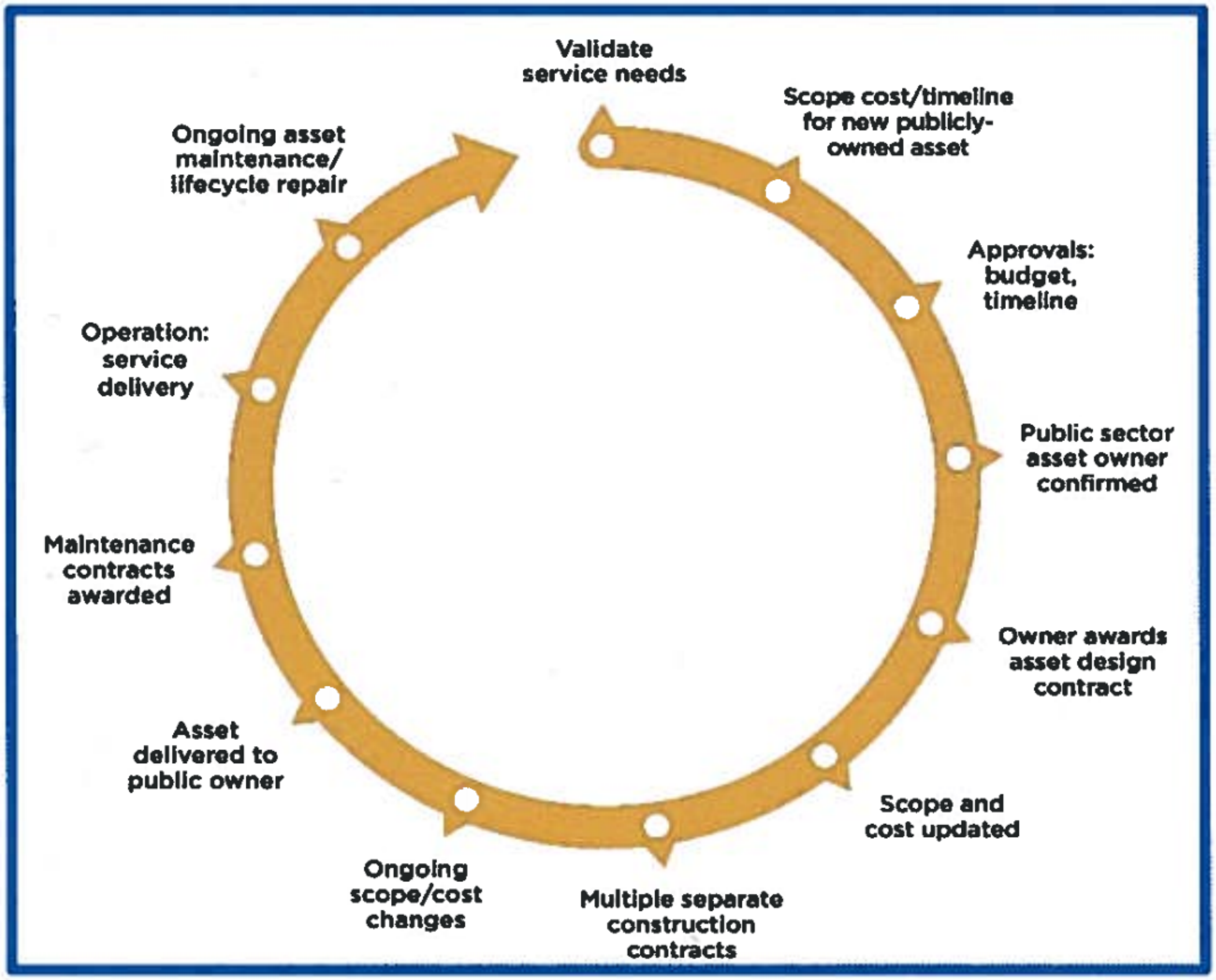
Figure 5-1 Traditional Infrastructure Procurement Process



5.4.2 P3 Infrastructure Procurement

In contrast, there is the P3 infrastructure process, a version of which was selected to implement the PortMiami tunnel project a few years ago. **Figure 5** illustrates the general steps in deploying this methodology.

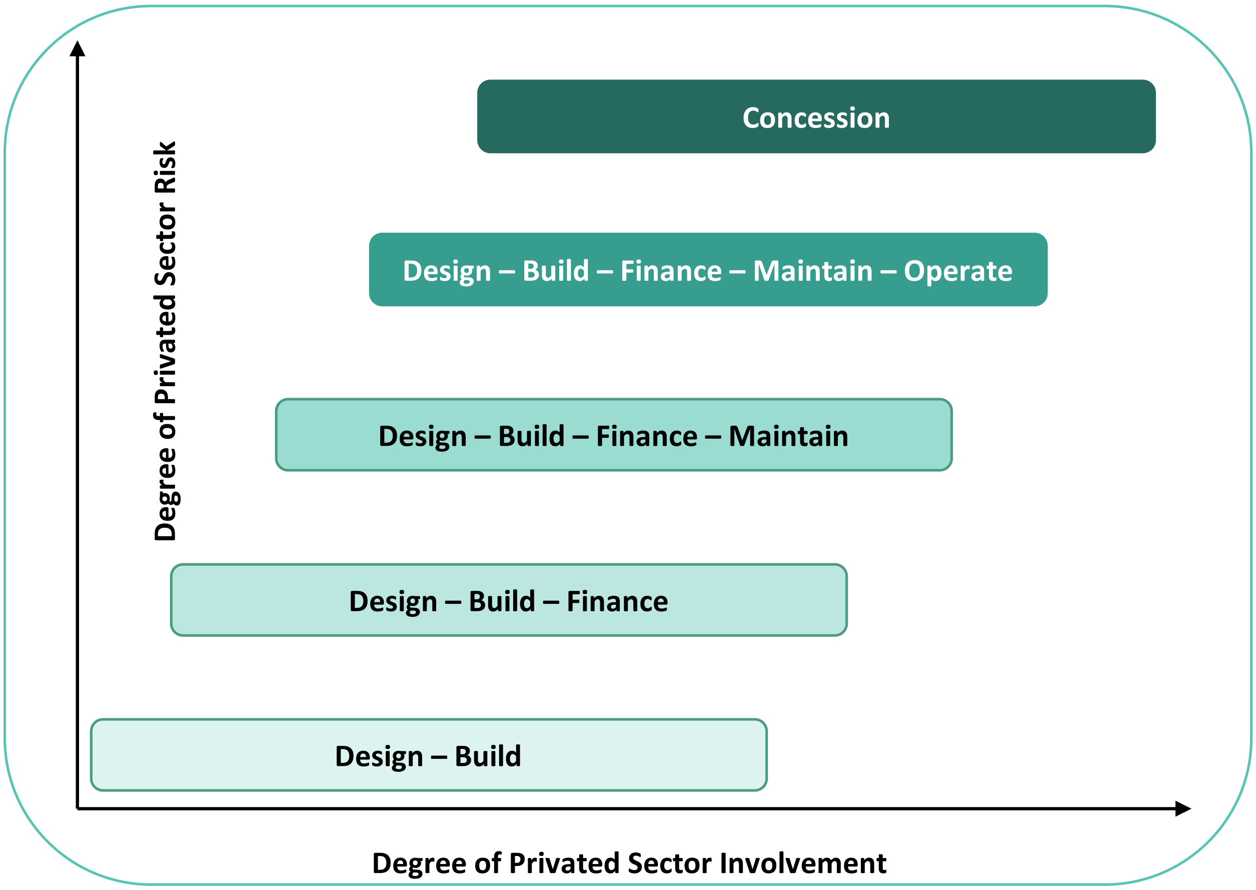
Figure 5-2 P3 Infrastructure Procurement Process



P3 Procurement Levels

There are several different levels of P3 procurement integration of private sector involvement with the traditional project development process, covering the basic steps of designing, building, financing, maintaining, operating, or a full turnkey package of a concession agreement. Error! Reference source not found. illustrates these several levels, with the notation that the PortMiami tunnel was implemented through a concession agreement.

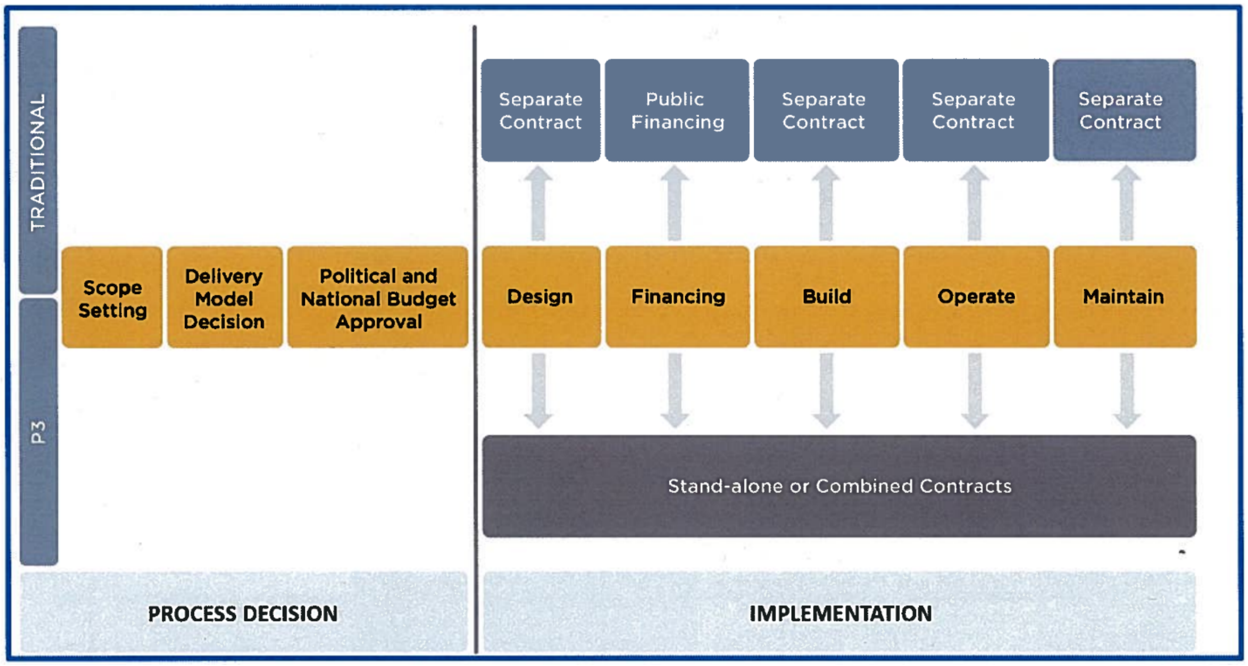
Figure 5-3 P3 Procurement Levels



Traditional and P3 Comparison

Figure 5-4 contrasts the distinctions between these two project implementation approaches through the several project development phases. Not addressed in this flow diagram is the decision on how early to engage the private sector in the project planning and development process. For the PortMiami tunnel project, the corridor planning and alignment development steps occurred much earlier, with approved environmental documents on hand. The selected concessionaire updated those documents and prepared the final design plans. The planning baton could be passed to the private sector earlier in the process, though integrated public agency involvement would be critical.

Figure 5-1 Comparison of Traditional and P3 Approaches



The P3 process if well-conceived, planned, and executed, can accelerate the pace of project development and implementation, and can incentivize the identification of more cost-effective project solutions and construction strategies by shifting certain risks to the concessionaire. However, besides the deployment of an optimal technical solution to the project, it is vital to consider the project sources of funds and financing strategy. If the project is financed with private sector capital equity or some form of loans or bonds, these will translate into cash flow commitments offsetting potential initial capital cost savings. It is important to perform a Value-for-Money analysis to identify and contrast the financial commitments of alternative project funding/financing strategies.

In the TPO publication cited above, it is noted that the Miami-Dade County Board of Commissioners created a P3 Task Force to advise the County on the use of P3's. The final report of this body issued in April 2016 articulated a more detailed set of implementation steps from generalized P3 process steps that represent a thoughtful and robust approach to protect public interests, ensure a worthwhile project, demonstrate and define key project components, and define a well-managed oversight and implementation to ensure project success in all dimensions. The PortMiami tunnel project is considered successful in delivering the promised project on schedule and on budget.

PortMiami Tunnel Financing Strategy

Financing sources for the PortMiami tunnel project included a $341 million TIFIA loan; $341.5 million in short-term commercial bank debt (provided by a "club" of 10 banks); and $80 in equity from the partners in the concession. The TIFIA loan is backed by the availability payments due to the concessionaire from the Florida DOT. Under the concession agreement, the Florida DOT also provided the concessionaire a total of $100 million in milestone payments during the construction period between 2010 and 2013, and provided a $350 million final acceptance payment upon construction completion. This is to be followed by 30 years of availability payments during the operating period, totaling $32.479 million annual (in 2009 $), with adjustments for inflation. Deductions will be made from this amount if the operation of the facility does not meet prescribed performance standards.

Total capital operating costs over the life of the concession through 2045 are projected to be $2.65 billion (in year-of-expenditure dollars). Funding for these lifetime expenditures came from $221 million in Federal-aid highway funds; $1.89 billion in State funds; and $528 million in county and city funds. https://www.transportation.gov/policy-initiatives/build-america/port-miami-tunnel-miami-fl

Relative to the financing, many P3 projects involve projected toll revenues. These can be rolled in as an element of project financing, or as for the I-595 privatization project, toll revenues were excluded from the project financing by the Florida DOT as a risk management decision. In the case of the proposed Miami River tunnel project, as discussed in Section 4 of this report, toll revenues may provide a slice of project funding for capital or ongoing operations and maintenance costs. However, capital cost recovery through tolling as applied for conventional toll roads is impractical in this case as total capital cost recovery would result in tolls so high that traffic demand would be diluted to minimal levels and traffic relief role of the project would be subverted.

5.5 Construction Phasing Strategy

A construction sequence for Alternative 1 was defined at a conceptual level as a prospective program for the significant elements of the tunnel construction program, based in part on experience from the recent PortMiami tunnel project, and is divided into four onsite phases. These phases do not include tunnel boring machine fabrication and delivery (Phase 0), which could require 12-15 months for fabrication, partial assembly, and shipping from Europe (as was the case for the PortMiami tunnel boring machine). The tunnel manufacturing and subsequent four onsite phases are summarized in **Figure 5-2** below, and described across **Figures 5-6 to 5-9**.

Figure 5-2 Tunnel Construction Phasing and Timelines

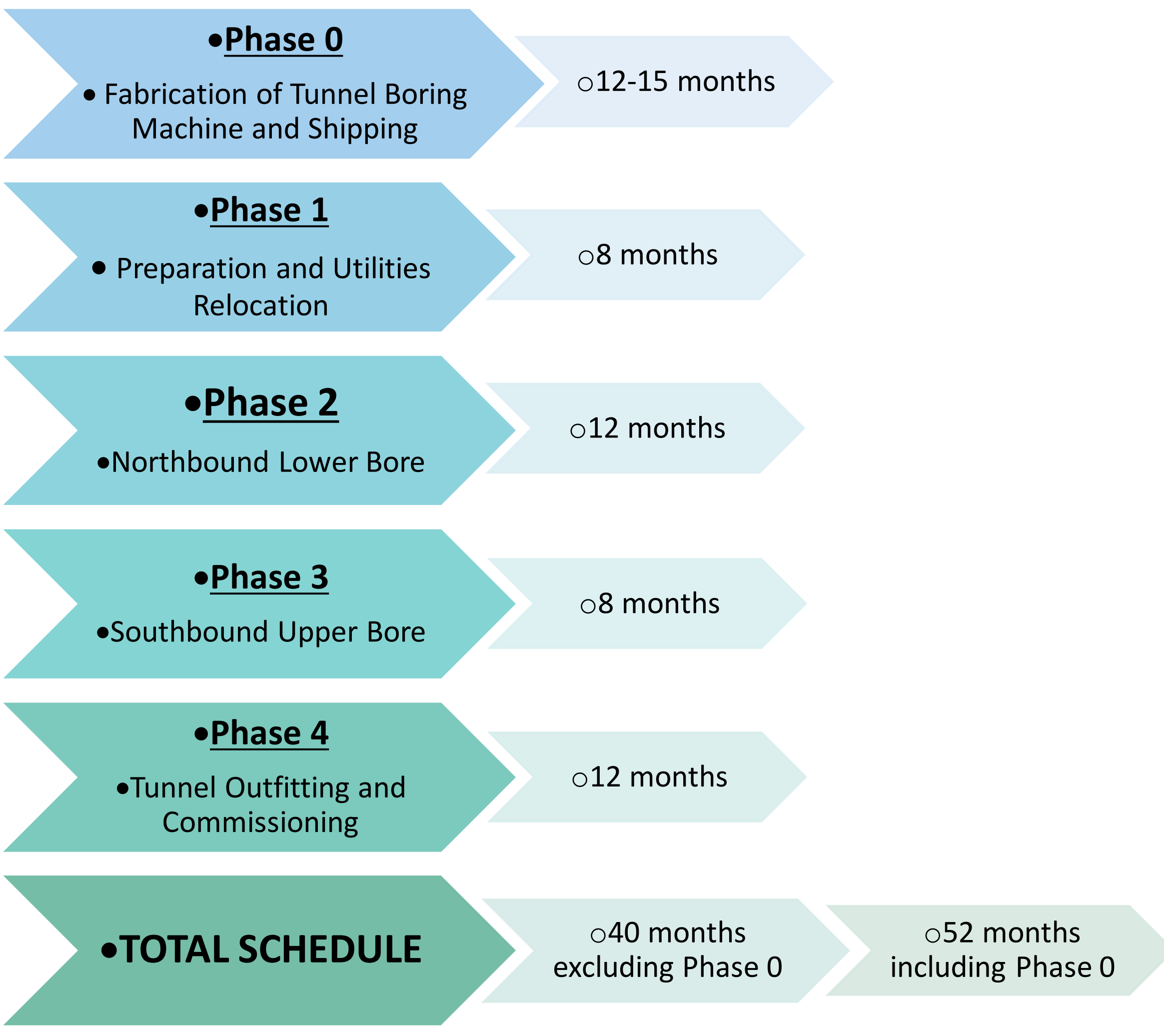
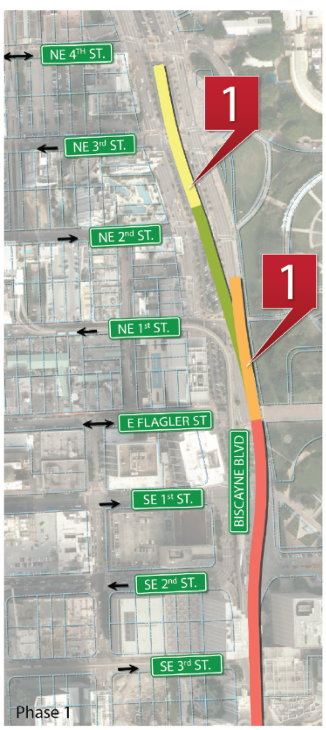


Figure 5-3 Construction Staging Phase 1

Phase 1 – Preparation and Utilities Relocation (8 months)

South Portals

1. Perform utilities relocations in vicinity of both south portal areas. Execute required maintenance of traffic plan.
2. Receive tunnel boring machine elements at off site staging location.



North Portals

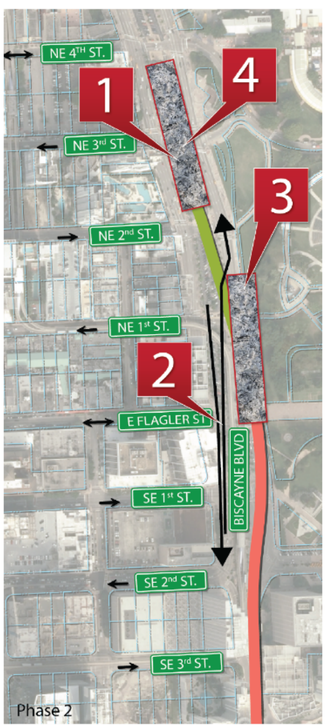
1. Perform utilities relocations in vicinity of both north portal areas. Execute required maintenance of traffic plan.

Figure 5-4 Construction Staging Phase 2

Phase 2 – Northbound Lower Bore (12 months)

South Portals

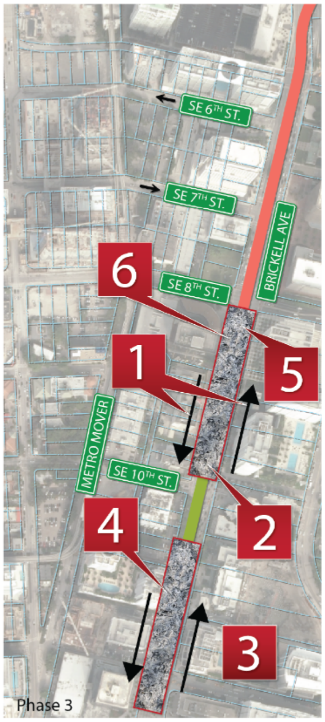
1. Narrow Brickell Ave. to 1-lane each way around boring pit, and implement construction area detour plan.
2. Prepare boring pit for lower tunnel bore in center of street in area of SE 10th St. to SE 12th St.
3. Begin lower tunnel bore (northbound).
4. Begin lower tunnel bore finish-out work as tunnel boring progresses.



North Portals

1. Prepare boring pit for lower bore in median of Biscayne Blvd. in area of NE 2nd St. to NE 4th St.
2. Reroute northbound traffic on Biscayne Blvd. to west side of upper tunnel boring pit; relocate SB access to Chopin Plaza west of Metromover and implement construction area detour plan.
3. Prepare boring pit for upper tunnel bore in area of Flagler St. to NE 1st St.
4. Complete northbound lower tunnel bore approximately 9 months after initiation.

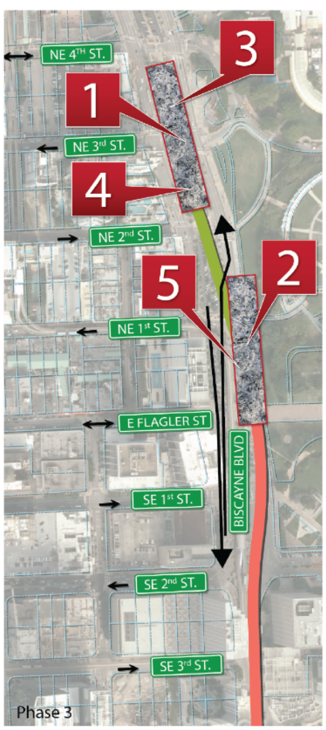
Figure 5-5 Construction Staging Phase 3



Phase 3 – Southbound Lower Bore (8 months)

South Portals

1. Narrow Brickell Ave. to 1-lane each way around upper tunnel boring pit.
2. Prepare boring pit for upper tunnel bore in area of SE 8th St. to SE 10th St.
3. Continue lower tunnel bore finish-out work as tunnel boring progresses.
4. Complete construction of lower tunnel bore portal approach walls and paving.
5. Complete southbound upper tunnel bore approximately 6 months after initiation. Complete construction of upper tunnel bore portal approach, walls and paving. Complete complete reconstruction of Brickell Ave. roadway.
6. Disassemble tunnel boring machine and transport parts offside.



North Portals

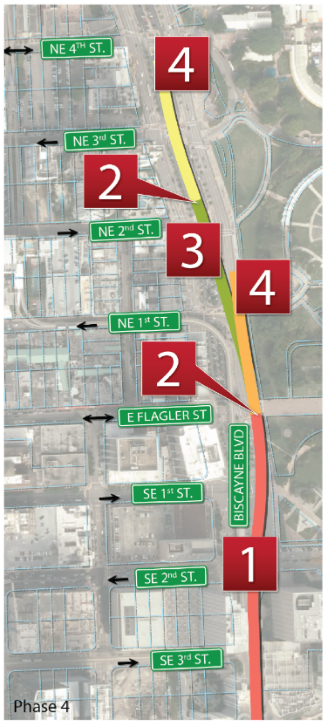
1. Partially disassemble tunnel boring machine in lower tunnel boring pit (northbound bore), relocate to upper tunnel boring pit, and reassemble.
2. Begin boring upper tunnel bore (southbound).
3. Complete construction of lower tunnel bore portal approach walls and paving.
4. Continue and complete lower tunnel bore finish-out work.
5. Complete construction of upper tunnel bore portal approach walls and paving. Continue upper tunnel bore finish-out work as tunnel boring progresses.
6. Complete reconstruction of Biscayne Blvd. roadways.

Figure 5-6 Construction Staging Phase 4

Phase 4 – Tunnel Outfitting/Commissioning (12 months)

Both Tunnel Bores

1. Continue installation of all tunnel systems, including control center.
2. Complete installation of portal gates.
3. Perform testing and commissioning protocols.
4. Open tunnel to traffic operations.



5.6 Conclusion and Next Steps

The potential impact of the Miami River tunnel studied in this report is significant in terms of relief to surface street congestion in the vicinity of the Brickell Avenue bridge, especially when exacerbated by bridge openings for marine traffic in the river. Limited travel demand modeling suggests that the tunnel will attract sufficient traffic to justify a four-lane facility and that traffic crossing the existing bridge will be significantly diminished. These benefits would be accrued only with a significant investment in the capital cost and ongoing operations cost of the tunnel facility. Relatively short vehicular trips between lower Downtown and northern Brickell will likely remain bridge users given the locations of the tunnel portals as necessitated by existing foundation conditions at the bridge and along Metromover on Biscayne Boulevard. The tunnel as proposed would also trigger some shifts in travel movement patterns across the lower section of Downtown Miami and in the Brickell District. These shifts need to be identified and analyzed further as part of any further planning and development of this proposed project.

The purpose of this study was mainly to identify technically feasible alignments as a basis for considering pursuit of further project development activities. The project with its location within the dense urban setting is in significant contrast to the recently executed PortMiami tunnel. However, that completed project is very instructive to the advancement of this new tunnel proposal. The implementation of the 2nd Avenue transit subway project in New York City is also informative for its execution of a major twin-tube underground transportation project within the constrained setting of an urban street with approximately the same right-of-way width as Brickell Avenue.

The next steps identified for the development of this tunnel corridor are incorporation into the currently adopted Miami-Dade TPO Long Range Transportation Plan as an unfunded project, and pursuit of funds for further corridor study and analysis within the adopted 5-year Transportation Improvement Program. Such studies can undertake more detailed analysis of various facets of tunnel planning and design, as well as construction, identified in this study and will like identify possible technical and cost-effective refinements leading to an improved project definition. Should the project be advanced, it would capture the intent of the tunnel and bridge options first identified in the 1966 study sponsored by the Florida DOT to connect Biscayne Boulevard with Brickell Avenue.

6.0 Appendices

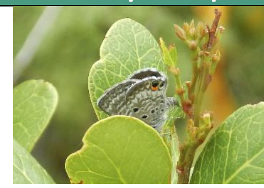
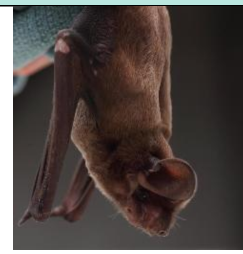
The following appendices are included in this section:

Appendix A: Protected Species

Common Name	Scientific Name	Status	Species photograph
Birds			
Bachman's Warbler	*Vermivora bachmanii*	Endangered	No photo available.
Cape Sable Seaside Sparrow	*Ammodramus maritimus mirabilis*	Endangered	
Everglade Snail Kite	*Rostrhamus sociabilis plumbeus*	Endangered	
Florida Grasshopper Sparrow	*Ammodramus savannarum floridanus*	Endangered	
Florida Scrub-jay	*Aphelocoma coerulescens*	Threatened	
Ivory-billed Woodpecker	*Campephilus principalis*	Endangered	No photo available.
Kirtland's Warbler	*Campephilus principalis*	Endangered	
Piping Plover	*Charadrius melodus*	Threatened	

Common Name	Scientific Name	Status	Species photograph
Birds			
Red Knot	*Calidris canutus rufa*	Threatened	
Red-cockaded Woodpecker	*Picoides borealis*	Endangered	
Wood Stork	*Mycteria americana*	Threatened	
Corals			
Elkhorn Coral	*Acropora palmata*	Threatened	No photo available.
Staghorn Coral	*Acropora cervicornis*	Threatened	
Ferns and Allies			
Florida Bristle Fern	*Trichomanes punctatum ssp. floridanum*	Endangered	No photo available.
Fishes			
Atlantic Sturgeon (gulf Subspecies)	*Acipenser oxyrinchus (=oxyrhynchus) desotoi*	Threatened	
Smalltooth Sawfish	*Pristis pectinata*	Endangered	

Common Name	Scientific Name	Status	Species photograph
Flowering Plants			
Beach Jacquemontia	*Jacquemontia reclinata*	Endangered	No photo available.
Blodgett's Silverbush	*Argythamnia blodgettii*	Threatened	No photo available.
Cape Sable Thoroughwort	*Chromolaena frustrata*	Endangered	No photo available.
Carter's Mustard	*Warea carteri*	Endangered	No photo available.
Carter's Small-flowered Flax	*Linum carteri*	Endangered	No photo available.
Crenulate Lead-plant	*Amorpha crenulata*	Endangered	No photo available.
Deltoid Spurge	*Chamaesyce deltoidea ssp. deltoidea*	Endangered	No photo available.
Everglades Bully	*Sideroxylon reclinatum ssp. austrofloridense*	Proposed Threatened	No photo available.
Florida Brickell-bush	*Brickellia mosieri*	Endangered	No photo available.
Florida Pineland Crabgrass	*Digitaria pauciflora*	Proposed Threatened	No photo available.
Florida Prairie-clover	*Dalea carthagenensis floridana*	Endangered	No photo available.
Florida Semaphore Cactus	*Consolea corallicola*	Endangered	No photo available.
Garber's Spurge	*Chamaesyce garberi*	Threatened	No photo available.
Johnson's Seagrass	*Halophila johnsonii*	Threatened	No photo available.
Okeechobee Gourd	*Cucurbita okeechobeensis ssp. okeechobeensis*	Endangered	No photo available.
Pineland Sandmat	*Chamaesyce deltoidea pinetorum*	Proposed Threatened	No photo available.
Sand Flax	*Linum arenicola*	Endangered	No photo available.
Small's Milkpea	*Galactia smallii*	Endangered	No photo available.
Insects			
Bartram's Hairstreak Butterfly	*Strymon acis bartrami*	Endangered	No photo available.
Florida Leafwing Butterfly	*Anaea troglodyta floridalis*	Endangered	No photo available.

Common Name	Scientific Name	Status	Species photograph
Miami Blue Butterfly	*Cyclargus (=Hemiargus) thomasi bethunebakeri*	Endangered	
Schaus Swallowtail Butterfly	*Heraclides aristodemus ponceanus*	Endangered	No photo available.
Mammals			
Florida Bonneted Bat	*Eumops floridanus*	Endangered	
Florida Panther	*Puma (=Felis) concolor coryi*	Endangered	
Puma (=mountain Lion)	*Puma (=Felis) concolor (all subsp. except coryi)*	Similarity of Appearance (SAT) -Threatened	
West Indian Manatee	*Trichechus manatus*	Threatened	
Reptiles			
American Alligator	*Alligator mississippiensis*	SAT - Threatened	

Common Name	Scientific Name	Status	Species photograph
Reptiles			
American Crocodile	*Crocodylus acutus*	Threatened	
Eastern Indigo Snake	*Drymarchon corais couperi*	Threatened	
Hawksbill Sea Turtle	*Eretmochelys imbricata*	Endangered	
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	
Loggerhead Sea Turtle	*Caretta*	Threatened	
Snails			
Stock Island Tree Snail	*Orthalicus reses (not incl. nesodryas)*	Threatened	No photo available.

Source: FWS IPaC

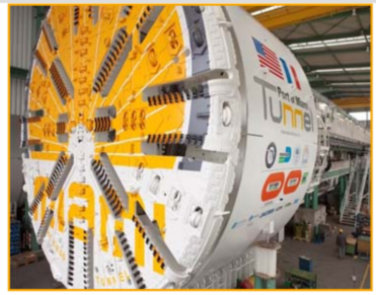
Appendix B: PortMiami Tunnel Boring Machine Fact Sheet

Port of Miami Tunnel

A public-private partnership project by

TUNNEL BORING MACHINE (TBM) & TUNNELING FACT SHEET

OVERVIEW



MAT Concessionaire's design-build contractor, Bouygues Civil Works Florida (BCWF), excavated twin tunnels, connecting Watson Island and Dodge Island in the City of Miami, using a Tunnel Boring Machine (TBM) specifically designed for the Port of Miami Tunnel's geology. The TBM was built by Herrenknecht in Germany. The construction of the Port of Miami Tunnel project broke ground in May 2010 and is scheduled to be completed in May 2014.

TBM PRODUCTION:

Production of the TBM parts ran from March through October 2010. Assembly commenced in October 2010 and was completed in April 2011.

TBM TESTING/COMMISSIONING IN GERMANY:

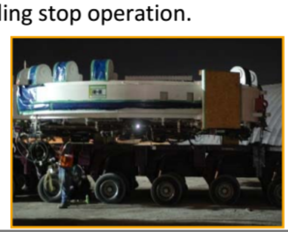
Fully assembled, the TBM's testing and commissioning was successfully completed on April 15, 2011.

SHIPMENT:

Disassembly and packaging of the fully commissioned TBM pieces ran between April and May 2011. The packaged TBM was driven on special trucks from the Herrenkencht plant to the Port of Kehl in Germany. Cranes lifted the TBM pieces onto river barges bound for Port Rotterdam in Holland, where it was loaded onto the Combi Dock I. The ocean carrier's self-contained cranes lifted the TBM's 19 heavy haul pieces onboard and the ship commenced its transatlantic voyage to Miami on June 8, 2011.

TBM ARRIVAL IN THE USA:

The Combi Dock I ship arrived at PortMiami on June 23, 2011. The TBM arrived in pieces (75 regular cargo, 20 containers and 19 heavy haul pieces). The regular cargo and container pieces were delivered via trucks from PortMiami to the median of the MacArthur Causeway on Watson Island. The 19 heavy haul pieces were lifted by the ship's cranes onto barges. The barges delivered the pieces to Watson Island. From the barges, each piece was loaded onto a special roll-on/roll-off vehicle that delivered the pieces one by one to the MacArthur Causeway median during a very successful five-night rolling stop operation.



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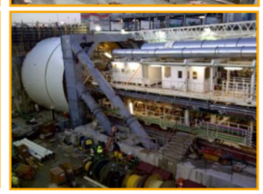
TUNNEL BORING MACHINE (TBM) & TUNNELING FACT SHEET

PRE-ASSEMBLY:

The pre-assembly of some of the TBM pieces (such as the cutterhead and tailskin) began the week of July 5, 2011, after all of its pieces were at the staging site in the median.

REASSEMBLY OF THE TBM IN THE LAUNCHING PIT:

The launching pit for the TBM is approximately 400 feet long, 100 feet wide and 40 feet deep. Assembly of the TBM began on August 10, 2011, when the first piece was lowered into the pit from the staging area in the median. That was one of the six pieces of the TBM shield. Piece by piece, one per day, the head of the TBM began to take shape inside the launching pit, while the TBM's six gantries (tail) were also assembled in the work zone. On September 1, 2011, the cutter head of the TBM was lowered into the pit.



FULLY ASSEMBLED:

The TBM consists of a cutter head with an outside diameter of ***42.3 feet*** (as high as a 4 story building) and a ***361 foot*** long trailing support gear made up of 6 gantries. The total length of the TBM is ***428.5 feet*** long (more than a football field).

TBM NAME:

The South Florida Girl Scouts Troops named our TBM ***"Harriet"***, after the American History Icon Harriet Tubman. Born a slave, this African-American abolitionist and humanitarian escaped slavery and led several rescue missions through a network of secret passages and safe houses known as *The Underground Railroad*. At its height during the 1850s-1860s, the *Underground Railroad Movement* freed more than 100,000 slaves and became a staple of America's history. With our TBM going underground to make history for South Florida, Harriet is a fitting name for this Florida mining marvel.

TBM LAUNCH:

Harriet launched from her home in the Watson Island pit on November 11, 2011, boring the first tunnel towards Dodge Island.

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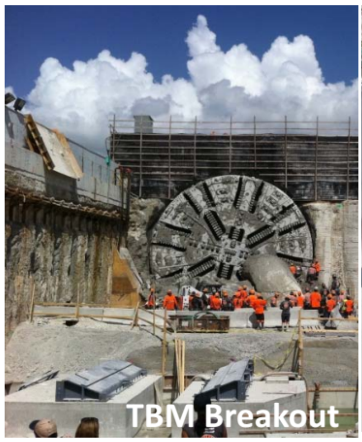
TUNNEL BORING MACHINE (TBM) & TUNNELING FACT SHEET

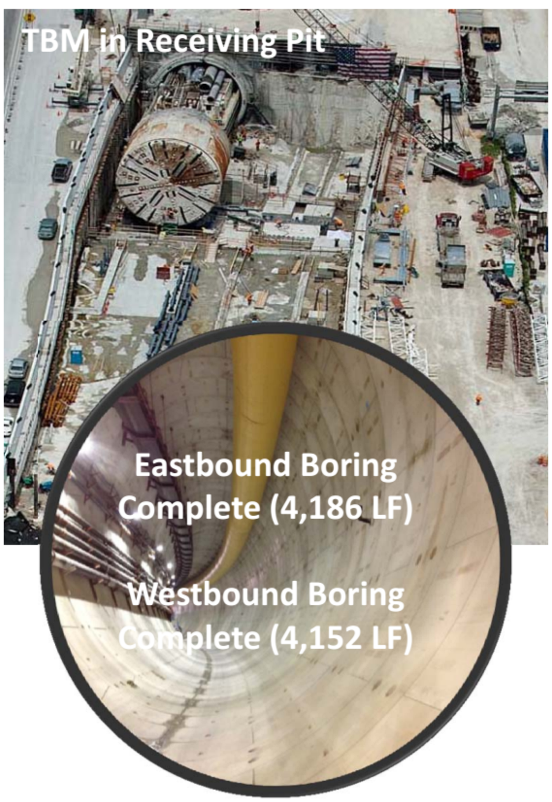
TBM BREAKOUT – EASTBOUND TUNNNEL & TURN AROUND:

PAGE THREE

Harriet emerged on Dodge Island on July 31, 2012. She was then disassembled, turned around and reassembled. The westbound tunnel mining began on October 29, 2012, and was completed on May 6, 2013.


TBM Breakout


TBM on Turnaround Table


TBM in Receiving Pit

Eastbound Boring Complete (4,186 LF)

Westbound Boring Complete (4,152 LF)


TBM Rotation


TBM Placement for Westbound Boring

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TUNNEL BORING MACHINE (TBM) & TUNNELING FACT SHEET

PAGE FOUR

TUNNELING PROCESS:

Tunneling occurs when the cutter head rotates as a cutting wheel boring out the underground area, while the trailing gear contains the electrical, mechanical, guidance systems and additional support equipment. Excavated material is carried back through the trailing gear on an enclosed conveyor belt or pumped through pipes and deposited outside the tunnel entrance, or portal. It is moved off-site to be used as fill material and is disposed in a manner consistent with applicable environmental rules and regulations. As the TBM moves forward it also erects precast concrete liners (known as segments) that become the finished wall of the tunnel. Once the liners are in place, grout is pumped into the space between it and the excavated area to fill any voids or gaps. The TBM then pushes off from the finished ring to move forward and the process begins again.

FEEDING THE TBM:

It took a total of approximately 12,000 segments to create the lining of the two tunnels. The segments were made at the Cemex concrete plant in Sweetwater specifically for this project. Each segment weighed 12.2 metric tons; 5'7" wide; 14'6" long; and 2' thick. The segments were placed on special trucks and were rolled directly into the tunnel. It took 8 segments to construct each ring and the TBM constructed approximately 3-6 rings per day. It took approximately 1500 rings to line both tunnels. Each ring installation took approximately 60 to 75 minutes to put in place.

TUNNELING OPERATIONS:

During the tunneling operations, there were approximately 12 to 16 persons working in the TBM, as well as 12 to 14 persons on the surface of the machine. The TBM worked 24 hours per day; 20 hours alternating between excavating and ring installation and 4 hours stopped for maintenance.

FOR MORE INFORMATION CONTACT:

Public Information Specialist, Liz Fernandez 786.502.0704 or liz.fernandez@stantec.com or visit the project website at: www.portofmiamitunnel.com

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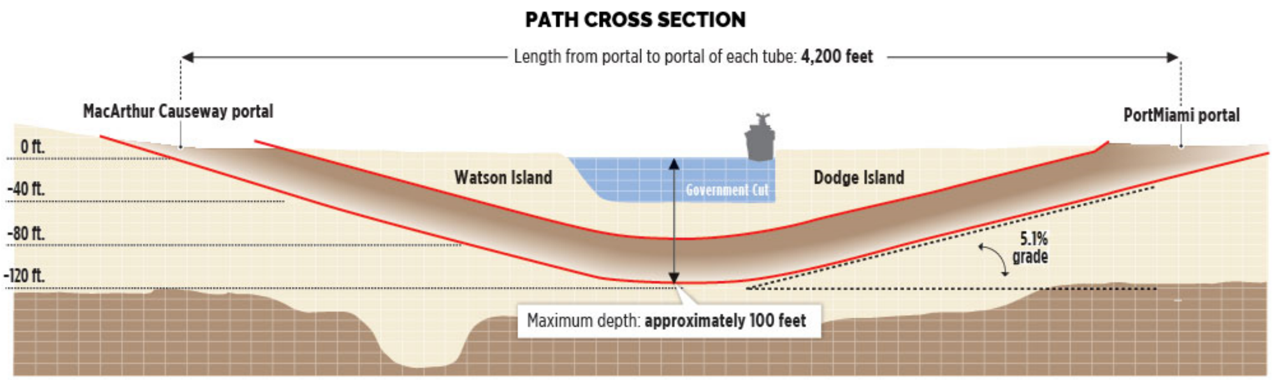


SOURCE Miami Access Tunnel Concessionaire GRAPHICS BY Marco Ruiz

Second Avenue Subway

The Metropolitan Transportation Authority (MTA) and MTA New York City Transit have begun the final planning and environmental analysis for a full-length Second Avenue Subway, from 125th Street to the Financial District in Lower Manhattan. Our goal is to initiate construction by the end of 2004.

The Second Avenue Subway will reduce overcrowding and delays on the Lexington Avenue Line and improve access to mass transit for commuters and residents of the far East Side of Manhattan.

Construction

Three main techniques will be used for tunnel and station construction depending on geological conditions and on specific facilities that could be needed at street level, such as station entrances and vent shafts. The three construction methods are tunnel boring, cut-and-cover and mining.

Tunnel Boring Machines

Tunnel Boring

Much of the Second Avenue Subway will be built using tunnel boring technology, in which a powerful circular cutting machine drills a tunnel in rock or soil with minimal disruption to the street (①). The excavated material is then taken to street level and removed by truck (②). Tunneling will be done through bedrock wherever possible, which is quicker and more cost effective than mining or cut-and-cover.

There are two types of boring machines: the Tunnel Boring Machine (TBM), used in rock, and the Earth Pressure Balance Machine (EPBM), typically used in soil. A TBM is likely to be used between approximately 6th Street and 92nd Street, where the bedrock is close to the surface. An EPBM may be used in soil south of 6th Street, because the bedrock is relatively deep.

The actual tunnel construction will occur without many street disruptions. However, the street will be excavated and significant street disruptions will occur where the TBM is inserted into and removed from the ground, where excavated material is removed, and where stations and support facilities, such as vent shafts, are located.

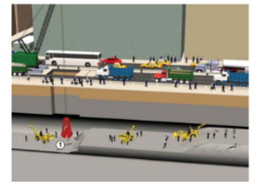
Cut-and-Cover

Most of New York City's subway system was built using the cut-and-cover technique. With this method, a trench is cut in the street, the soil is supported by vertical walls and a frame is built to support concrete or metal street decking (①). The decking allows the street to remain open to traffic and pedestrians while excavation and construction continue in the tunnel below.

Cut-and-Cover at Times Square

Cut-and-cover is likely to be used at many station locations, at other places where access to the street is required, and for sections of the alignment where the tunnel will be very close to the surface, such as the section between the existing tunnel segments, which were built in the 1970s. Through the "cut" in the street, excavated material can be removed and equipment can enter or exit the tunnel (②).

Mining



The third technique to be used to build the subway tunnels is mining. The primary method of mining in rock is drill and blast. This procedure involves drilling many small holes within a rock area and then placing small amounts of explosives in each hole. Under carefully controlled and monitored conditions, explosives are then detonated sequentially for short intervals, breaking the rock while spreading the release of energy from the explosives over a longer period, lessening potential ground vibration at nearby structures. When mining is done in soil, the drill and blast method is not required. Soil and rock will be excavated and removed by backhoes, bulldozers, and a clamshell shovel suspended by a crane (①).

Mining will be used on portions of the tunnel too short to make tunnel boring cost effective, and on curved portions of the tunnel that are too constrained for a TBM. Some stations will be excavated from below street level, and the street will be penetrated to build station entrances and venting. Additionally, an access shaft is needed to remove excavated materials and to bring in or remove equipment from the tunnel.

Removal and Reuse of Excavated Material

Cranes, small rail cars and conveyors will be used to bring excavated rock and debris to the street level. At the surface, material will be transferred either directly to a barge or to trucks. Trucks will then transport loads out of the city or bring the excavated material to a barge for removal. Two barge facilities are being proposed: one located near the line's north end, the other at the south end.

Most of the excavated material will be clean crushed rock that can be used for such projects as filling abandoned mines, building artificial reefs, reinforcing bulkheads or paving roads.

Metropolitan Transportation Authority

Traffic Mitigation

A key aspect of construction is to develop a plan that will allow the city to continue to function normally during construction. Every effort will be made to minimize disruptions to pedestrian and vehicular traffic.

In general, the project will not require closing of entire streets. During construction, at least two lanes will remain open to traffic. Efforts will be made to maintain access to businesses and residences.

Building and Infrastructure Protection

Structural and ground improvement techniques will be used to minimize ground settlements, and to preserve the structural integrity of various facilities, including utility lines, buildings, tunnels and ramps.

Underpinning is a structural process that includes the use of drilled or jacked supporting piles to provide temporary support or reinforcement to protect existing structures. Ground freezing and grouting are typical soil improvement options used to control ground settlement and distortion.

Construction Compliance and Green Design

All work will comply with applicable federal, state and city codes and regulations, with the goal of achieving the highest degree of public safety.

The Second Avenue Subway project will include design elements that foster the prevention of pollution and minimization of waste. Wherever possible, the project will use technologies to minimize adverse environmental impacts and incorporate sustainable design principles, including energy efficiency, enhanced environmental quality and material conservation.

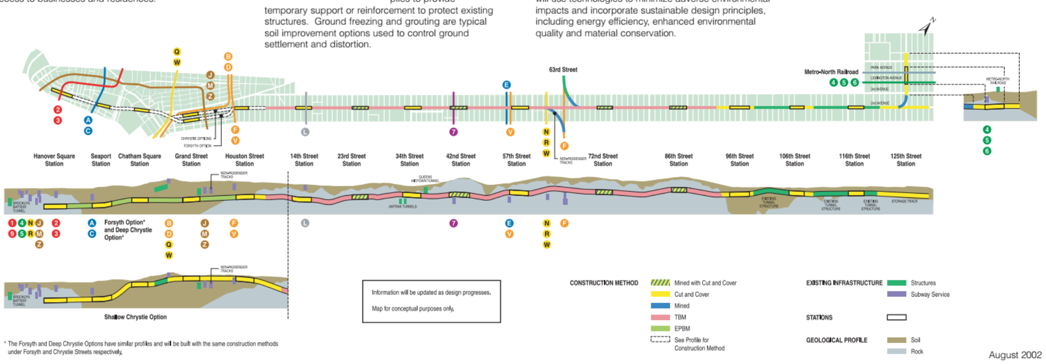
Second Avenue Subway

Stay Involved

Stay informed of upcoming meetings and receive the latest information on the project.

MTA New York City Transit
Second Avenue Subway Project
130 Livingston Street, Third Floor
Brooklyn, NY 11201

Web site: http://www.mta.info/planning/sas
E-Mail: secondavenuesubway@nyct.com
Telephone Hotline: (718) 694-5164



* The Forsyth and Deep Chrystie Options have similar profiles and will be built with the same construction methods under Forsyth and Chrystie Streets respectively.

August 2002

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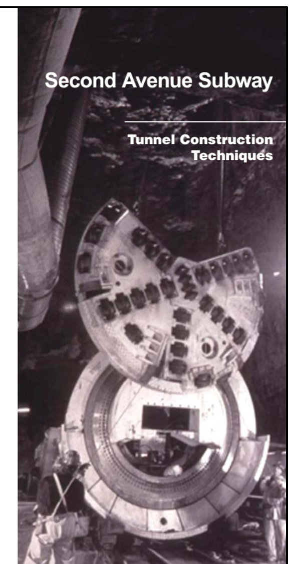
New York City Transit
Second Avenue Subway Project
130 Livingston Street, Third Floor
Brooklyn, NY 11201



Second Avenue Subway

Tunnel Construction Techniques

Metropolitan Transportation Authority