TIER ONE EVALUATION REPORT

Miami-Dade County
Department of Transportation and Public Works
Beach Corridor Rapid Transit Project

Bus Rapid Transit (BRT)
Aerial Cable Transit (ACT)
Monorail
Autonomous Vehicles
Automated Guideway Transit (AGT)
Light Rail Transit (LRT)/Streetcar
Heavy Rail Transit (HRT)

CIP Project Number: 153 | ETDM Number : 14257 | November 2017
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MIAMI-DADE COUNTY

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1 EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Miami-Dade County Department of Transportation and Public Works (DTPW) is conducting a Project Development and Environment (PD&E) study for the Beach corridor in collaboration with the Federal Transit Administration (FTA) and Florida Department of Transportation (FDOT). This Tier One Evaluation considered six alternative technologies to provide rapid-transit connections between the Midtown Miami/Design District, Downtown Miami, and Miami Beach (**Figure 1.1**). The Tier One Evaluation studies a connection to Fifth Street/Alton Road in Miami Beach. A subsequent Tier Two study will feature an expanded study area to include additional destinations in Miami Beach, including the Washington Avenue and Alton Road corridors between Fifth Street and the Miami Beach Convention Center. DTPW identified the following transit technologies (modes) for consideration in the Beach Corridor Rapid Transit Project Tier One Evaluation:

- Automated guideway transit (Metromover)
- Streetcar/light rail transit
- Heavy rail transit (Metrorail)
- Bus rapid transit
- Aerial cable transit
- Monorail
- Automated transit systems

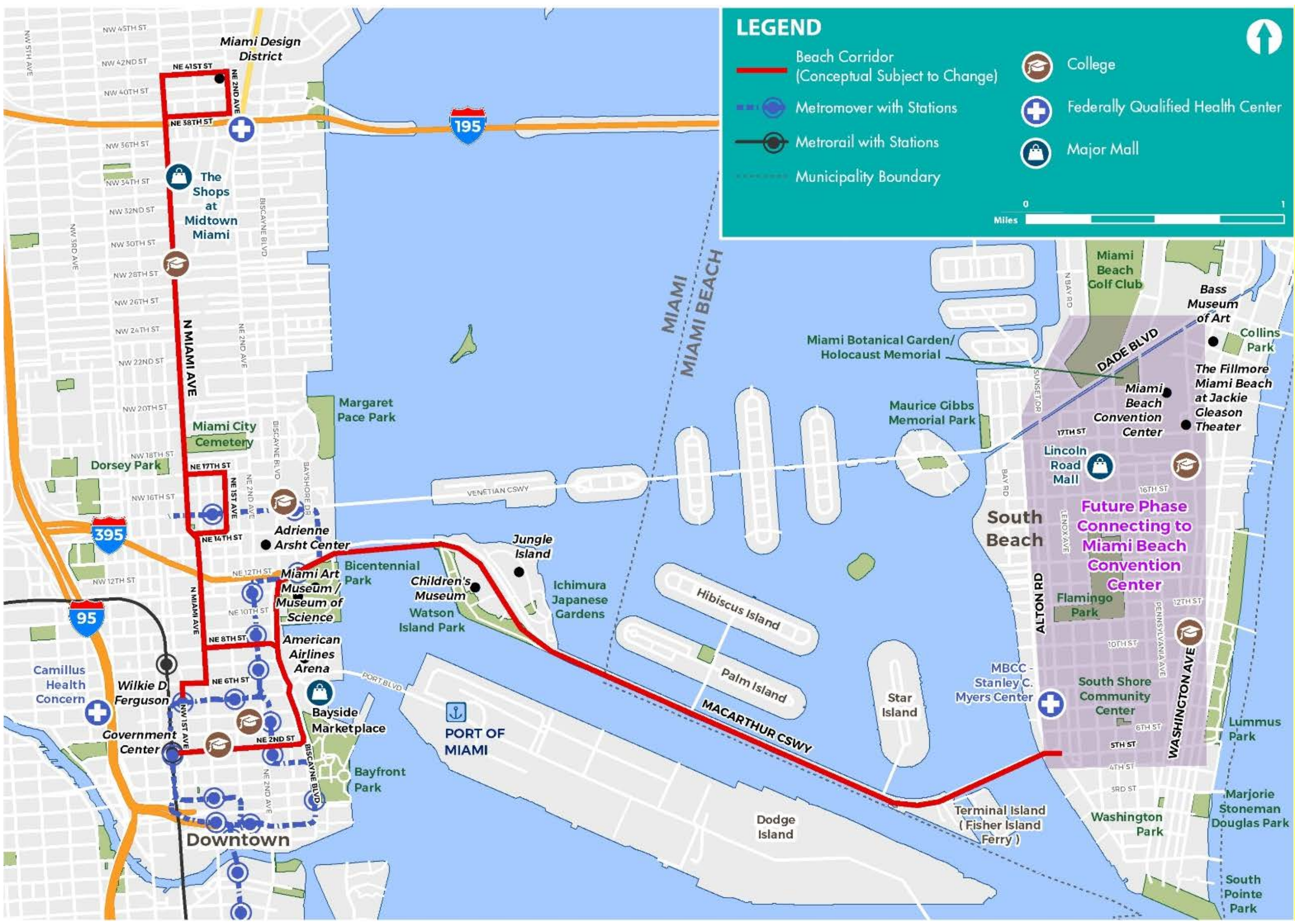

Figure 1.1 | Study Area

The Tier One Evaluation included a summary of these transit technologies and modes, the development of representative alignments, public involvement (as summarized in Appendix B), and the evaluation of the potential modes with respect to transit performance, economic and community development, environmental effects, and cost/feasibility. Based on the results of the evaluation, four transit modes are recommended to advance for further analysis in Tier Two: automated people mover (Metromover expansion), bus rapid transit/express bus, monorail, and streetcar/light rail transit.

1.2 OVERVIEW OF THE CORRIDOR

The Beach corridor traverses an area that is at the epicenter of population and economic growth within Miami-Dade County. The central business district (CBD) area and Miami Beach have undergone rapid population and employment increases over the past decade, a trend that is projected to continue over the next 20 years. The population densities in the study area are among the highest in the nation, with Downtown Miami (CBD) at 17,800 persons per square mile and Miami Beach at 11,500 persons per square mile, per the 2010 U.S. Census. Downtown Miami saw a dramatic 172 percent increase in population density over the last decade.

Due to the region's appealing qualities, such as its temperate climate; attractive beaches; and convenient access to the Caribbean and Latin America, South Florida, and Miami-Dade County, it has become an important tourist destination for both national and international visitors. The county hosts millions of annual visitors and seasonal residents. Visitors typically access the study area via tour bus, taxi, or rental car.

Miami Beach and Downtown Miami are the two most popular locations for overnight stays, lodging 60 percent of all 2012 visitors with approximately 5.8 million and 2.4 million overnight guests, respectively. Additionally, four of the six most-visited attractions are in close proximity to the Beach corridor, including South Beach, the beaches, Lincoln Road, and Downtown Miami. The study area also contains PortMiami. In 2013, 4.1 million cruise ship passengers used the port, up from 3.4 million in 2000. This high rate of tourism generates additional demand for travel, produces additional trips within the area, and contributes to traffic and subsequently roadway congestion. The 2012 Visitor Industry Overview, a survey that reached 13.4 percent of all visitors that year, listed traffic congestion as the top negative aspect of trips to greater Miami. Traffic congestion has been the top-ranked problem in each of the last five annual surveys.

The project corridor includes three distinct segments of travel demand and origin/destination pairs: an east–west connection between Miami Beach and downtown Miami (approximately 5 miles), and a north–south connection between the Design District/Midtown and downtown Miami (approximately 3 miles); as well as Design District/Midtown to Miami Beach (approximately 8 miles).

In the east–west segment, I-195 is operating at capacity and I-395 is experiencing traffic volumes that exceed its capacity by more than 50 percent. Existing bus transit service in the east–west corridor serves more than 17,000 riders per day, with the two most frequent routes at 72 percent and 89 percent of their existing capacity, respectively.

The north–south segment is served by several local streets, operating at between 50 and 90 percent of capacity. The most frequent bus service in the north–south segment operates at 87 percent capacity, while Metromover operates at 85 percent capacity.

The 8-mile project corridor is further characterized by the following:

- Mixed-use development, including areas of high residential and employment density
- A diverse population with a higher-than-countywide minority percentage and a lower median household income than county and national levels
- Limited transportation pathways, with high average daily traffic volumes and congestion on the expressways and major roadways
- Historic, cultural, and recreational resources
- Wetlands and critical habitats for protected species
- Land uses sensitive to noise and vibration effects
- Special Flood Hazard Area (SFHA) designation for nearly 50 percent of the corridor
- A navigable waterway (the Atlantic Intracoastal Waterway)

1.3 PURPOSE, GOALS, AND CRITERIA

A draft purpose and need statement was developed to guide this Tier One Evaluation, including the identification of project goals and evaluation criteria. The draft statement of purpose and need will be further refined as the project development process progresses.

The purpose of the project is to increase the person-throughput to the Beach corridor's major origins and destinations via a rapid transit technology. Project goals include the following:

- Connect to and provide direct, convenient, and comfortable rapid-transit service to serve existing and future planned land uses
- Provide enhanced interconnections with Metrorail, Tri-Rail, Brightline, Metromover, and Metrobus routes; Broward County Transit (BCT) bus routes; Miami and Miami Beach circulators; jitneys; shuttles; taxis; Transportation Network Companies (TNCs); and/or other supporting transportation services
- Promote pedestrian- and bicycle-friendly solutions in the corridors of the study area

The technology characteristics of each transit mode were considered in the context of representative alignments, allowing for evaluation against the following criteria:

1.3.1 Transit Performance Criteria

- Interoperability and modal integration: The compatibility of the proposed mode with other existing and proposed transit modes, including the availability of one-seat rides between significant origins and destinations, the number of transfers required for trips between significant origins and destinations, and the horizontal and vertical separation between modes at significant transfer points.
  - *Interoperability:* The ability to operate contiguously as an extension of an existing technology/mode, offering one-seat rides, economies of scale in operations and maintenance, and the potential for a shared fleet/operations and maintenance facility.
  - *Modal integration:* Because there are several existing modes in operation in Miami, and because of limitations on the transit mode options that the City of Miami Beach is willing to consider, the Beach Corridor Rapid Transit Project will feature some transfers between modes for many of the possible trip origins and destinations. The quality of these intermodal connections in terms of ease and location of transfer will influence the ridership of both the selected beach corridor technology and the overall transit system ridership.
- Operational speed and reliability: The average operating speed of the mode on the representative alignment and the proportion of trips that are likely to achieve the scheduled times and/or headways. Average operating speed is influenced by factors such as the maximum operating speed of the vehicle technology; curves, grades and stop spacing in the transit alignment; and traffic congestion for those modes that operate at-grade on arterial streets.
- Resiliency: Considering the effects of climate change, including sea level rise and the frequency and severity of weather events, the relative resiliency of the mode to changing climatic conditions. The resiliency of the alternative technologies and modes is considered with respect to how quickly they could be expected to return to service after a storm/flood event.
- Passenger capacity: Capacity of the mode to serve the projected passenger demand in the corridor.
- Vehicle reliability and safety: Reliability and safety record of the technology/mode.
- Passenger amenities: Air-conditioning, ride comfort, passenger information systems, and other passenger amenities available as a proven feature of the technology.

1.3.2 Economic and Community Development Criteria

- Scale/urban fit: The relationship of the infrastructure required by the transit mode to the scale of the pedestrian and built environments, and the ability to fit the infrastructure into existing rights-of-way.
- Transit-oriented development (TOD) compatibility: The ability of the mode to support or catalyze TOD at station areas, as influenced by the capacity of the mode and the compatibility of the mode with the scale of the built environment at station areas.
- Pedestrian/bicycle access: The positive or negative contribution of the mode to pedestrian and bicycle access in the corridor. This includes impacts of the infrastructure to pedestrian and bicycle facilities, as well as the potential for passengers to bring bikes onto the transit mode.

1.3.3 Environmental Effects Criteria

- Natural Resources Impacts
  - Wetland and other surface waters
  - Protected species and habitat
  - Coastal
  - Floodplain
- Socioeconomic Impacts
  - Social/economic

- Mobility
- Relocation potential
- Cultural
- Historic/archaeological resources
- Recreational facilities
- Visual and aesthetic

- Physical Impacts
  - Contamination
  - Noise and vibration
  - Air quality

1.3.4 Cost and Feasibility Criteria

- Constructablity: The ability to construct the project in the proposed corridor within the typical range of cost for the mode; cost-effectiveness to be considered as part of the Tier Two Evaluation.
- Operating cost: The ability to provide transit service of sufficient capacity to serve projected demand within the typical range of cost for the mode; cost-effectiveness to be considered as part of Tier Two Evaluation.
- Eligibility for funding: The ability to meet required and desirable characteristics for federal funding, including the Americans with Disabilities Act (ADA), Buy America, and service-proven technology.

1.4 SUMMARY OF TRANSIT TECHNOLOGIES AND MODES

The summary of transit technologies and modes (Figure 1.2) included the following topics:

- Technological Features: A summary of technological features including the size and capacity of the transit vehicles, propulsion systems, guideway characteristics (such as elevated or at-grade), and the minimum turning radius and maximum grade capabilities of the vehicles. Unique characteristics such as battery technologies, passenger amenities, and safety were also addressed as applicable.
- Modal Application: A summary of the typical application of the technology regarding stop spacing, average operating speed, and total length.
- Alignment and Station Locations: A representative potential alignment and station locations that would be feasible for the beach corridor were identified.
- Key Constraints, and Cost and Feasibility Issues: For each mode and alignment, any constraints that are significant to either the cost to build and operate the system or the feasibility of effective operations were identified.

	Automated Guideway Transit	Light Rail Transit			Heavy Rail Transit	Bus Rapid Transit		Aerial Cable Transit		Monorail	ATS
		Streetcar	Tram	Light Rail		Arterial BRT	Busway BRT	Gondola	Aerial Tram		
Typical Application											
Line Length	2-5 miles	2-5 miles	6-15 miles	15-30 miles	20-40 miles	10-20 miles	10-50 miles	1-3 miles	.5-1 miles	15-20 miles	TBD
Stop Spacing	.50 miles	.25 miles	.25-.50 miles	.50 miles	.25-2 miles	.50 miles	.75 miles	.50 miles	.50 miles	.50 miles	TBD
Transit Right-of-Way[1]	Exclusive	Mixed	Semi-Exclusive	Semi-Exclusive to Exclusive	Exclusive	Semi-Exclusive & Mixed	Exclusive	Exclusive	Exclusive	Exclusive	Semi-Exclusive & Mixed
Average Operating Speed	20 mph	10 mph	20 mph	35 mph	45 mph	20 mph	35 mph	15 mph	18 mph	35 mph	20 mph
Peak Service Frequency	2-6 mins.	10-15 mins.	6 mins.	6-10 mins.	2-10 mins.	10-12 mins.	8-12 mins.	15-60 secs.	4-15 mins.	4-10 mins.	4 mins.
Capital Cost/Mile	$100 Million	$40 Million	$60 Million	$75 Million	$200 Million	$10 Million	$25 Million	$55 Million	$60 Million	$110 Million	$10 Million
Technological Features & Requirements											
Vehicle Length (Single Car)	42′	66′ to 82′	120′ to 155′	82′ to 92′	70′ to 350′	60′	60′	15′	25′	42′	TBD
Passenger Capacity Per Car/Train	50/200	120/car	265 to 340/car	225 car/ 900 train	170/850	100	100	6-15	50-100	85/350	TBD
Minimum Turning Radius	98′	82′	82′	82′	90′	42′	42′	N/A	N/A	98′	TBD
Maximum Grade	10%	9%	7%	7%	6%	10%	10%	30%	30%	10%	TBD
Propulsion System[2]	AC Third Rail	DC OCS or OESS	DC OCS, OESS or APS	DC OCS	DC Third Rail	Diesel, CNG, Battery, DC OCS	Diesel, CNG, Battery	Haul Cable	Haul Cable	DC Third Rail	TBD
Level Boarding	✓	Optional	✓	✓	✓	Optional	Optional	✓	✓	✓	TBD
Low Floor	100%	50%-100%	100%	50%-100%	100%	0%-50%	0%-50%	100%	100%	100%	TBD
Representative System	Metromover	Seattle Streetcar	Team de Bordeaux	MAX (Portland)	Metrorail	Healthline (Cleveland)	RIT Curitiba (BR)	La Paz, Bolivia	Roosevelt Island, NY	Las Vegas, NV	N/A

Transit Right of Way[1]
Transit Right-of-Way: Operating environment of the mode, which may include mixed traffic (lane shared with general trafffic), semi-exclusive (separate lane, stopping at intersections), exclusive (grade-separated), or a combination of these operating environments.

Propulsion System[2]
Propulsion System: OCS=Overhead Contact System; OESS=On-Board Energy Storage System (Batteries or Supercapacitors); APS=Embedded powerrail.

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Figure 1.2 | Mode and Technology Characteristics

1.5 ALTERNATIVES EVALUATION

The following transit modes are recommended for further evaluation because the Tier One Evaluation shows that these modes have the potential to meet the project goals of providing direct, convenient and comfortable rapid-transit service, providing enhanced intermodal connections, and promoting pedestrian- and bicycle-friendly solutions in the corridor.

- Automated guideway transit (Metromover expansion)
- Monorail
- Bus rapid transit/Express bus
- Light rail transit/streetcar

The potential to meet the project goals with these transit modes is demonstrated in the evaluation of these modes regarding transit performance, economic and community development benefits, environmental effects, and cost and feasibility, as shown in **Figure 1.3.**

The following modes are recommended to advance to Tier Two Evaluation:

- **Monorail** is a technology capable of operating at high speeds, with vehicles that provide high passenger capacity. As an elevated mode, monorail is reliable (does not get stuck in traffic) and is resilient in the face of climate change impacts (particularly flooding). The scale and urban fit of this elevated mode, and the feasibility or impact of providing safety walkways on the guideway, are potential concerns that will be further evaluated in Tier Two.
- **AGT** is an existing technology operating in Miami; an extension of the Metromover would provide the opportunity for one-seat rides or cross-platform transfers from any of the locations currently served by Metromover, as well as an easy transfer from Metrorail at Government Center. As compared with monorail, AGT operates at lower speeds and with smaller vehicles. Similar to monorail, AGT is reliable (does not get stuck in traffic) and is resilient in the face of climate change impacts (particularly flooding). The scale and urban fit of this elevated mode is a potential concern that will be further evaluated in Tier Two.
- **Light Rail Transit** is a flexible technology that can operate at lower speeds in mixed traffic on city streets, or at higher speeds on an exclusive guideway. Light rail is offered in a range of sizes and capacities, branded as streetcar, tram or LRT service. Off-wire technologies that allow LRT to operate without overhead wires make it compatible in urban settings where views and aesthetics are important considerations.
- **Bus Rapid Transit** provides passenger amenities similar to rail transit service and, like LRT, is a flexible technology that can operate at lower speeds in mixed traffic on city streets, or at higher speeds in dedicated lanes. Bus rapid transit carries fewer passengers per vehicle than rail transit modes. A variation of the bus mode in the form of Express Bus will also be evaluated in Tier 2.

The Tier One evaluation demonstrated that the recommended modes differ in their suitability to sub-areas of the study corridor. Four distinct segments were identified for consideration in Tier Two, with approximate study area boundaries indicated in **1.4** and **1.5**:

- Design District
- Downtown Miami
- Bay Crossing
- Miami Beach.

The recommended Tier Two study areas for alignment alternatives by mode, as shown in the figures, are:

- **Monorail:** Recommended for study of alignment alternatives in the Design District, Downtown Miami, and Bay Crossing segments.
- **Metromover:** Recommended for study of alignment alternatives in all segments (Design District, Downtown Miami, Bay Crossing and Miami Beach).
- **BRT/Express Bus:** Recommended for study of BRT and/or Express Bus from Downtown to Convention Center (with a repurposed typical section along the Causeway and a dedicated lane in Miami Beach) and Express Bus along a freeway loop alignment using **I**-95, **I**-195, **I**-395 in Miami and 5th street, Washington and Alton Roads in the Miami Beach segment.
- **LRT/Streetcar:** Recommended for study of alignment alternatives in the Design District, Bay Crossing, and Miami Beach segments.

For each of these study area segments and modes, the Tier Two evaluation will consider additional alignment alternatives and will not be limited to the representative alignments that were developed for Tier One evaluation.

As part of the Tier Two Evaluation, DTPW will develop detailed cost and ridership estimates, as well as conceptual engineering that may refine some of the transit performance evaluation, to allow for a comparison of these options regarding cost-effectiveness and other capital investment criteria, such as mobility improvement, congestion relief, land use, economic development, and environmental benefits such as greenhouse gas reductions.

The following modes are not recommended for further evaluation:

- Aerial Cable Transit: This mode is not recommended because of significant flaws regarding transit performance (lack of modal integration, low speed, insufficient capacity, and safety concerns) and environmental effects (impacts to views).
- Heavy Rail Transit: This mode is not recommended because of significant flaws regarding environmental effects (impacts to historic properties) and cost/feasibility (construction cost expected to be above the typical range for this mode).
- Automated Transit Systems: This mode is not recommended as a stand-alone modal option because of a significant flaw regarding transit performance (insufficient capacity). However, in the Tier Two Evaluation of bus rapid transit, opportunities to adapt elements of automated transit systems to bus rapid transit will be considered.

	Automated Guideway Transit	Ligh Rail Transit/ Streetcar	Heavy Rail Transit	Bus Rapid Transit	Aerial Cable Transit	Monorail	ATS
Transit Performance Criteria							
Interoperability/Modal Integration	●	◑	●	◑	○	◔	◑
Operational Speed & Reliability	◕	◑	●	◑	◑	●	◑
Resiliency	●	◔	●	◑	◕	●	◑
Passenger Capacity	◑	◕	●	◑	◔	●	◔
Vehicle Reliability & Safety	●	●	●	●	◔	●	◕
Passenger Amenities	◕	●	●	◑	○	●	◑
Economic & Community Development Criteria							
Scale/Urban Fit	◔	●	○	◑	○	○	◕
TOD Compatibility	◑	●	◕	◑	○	◕	◔
Ped/Bike Access	◑	◕	◑	◑	○	◑	○
Environmental Effects Criteria							
Natural Resources	◑	◕	◕	○	◕	◕	○
Socio Economic Impacts	◕	◔	◕	◔	◑	◕	◔
Physical Impacts	◑	◕	●	◔	○	◔	○
Cost & Feasibility Criteria							
Constructability	◑	◔	●	◔	◕	●	○
Operating Cost	◑	◑	●	◑	●	◑	◔
Eligibility for Funding	●	●	◕	●	○	●	◑

LEGEND

Lowest Benefit ○ ◔ ◑ ◕ ● Most Benefit

Lowest Impact/Cost ○ ◔ ◑ ◕ ● Highest Impact/Cost

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Figure 1.3 | Evaluation Matrix

Figure 1.4 | Tier Two Alignment Study Areas—Design District Segment & Downtown Miami Segment

Figure 1.5 | Tier Two Alignment Study Areas—Bay Crossing Segment & Miami Beach Segment

2 OVERVIEW OF THE CORRIDOR

This section provides an overview of existing conditions in the corridor including the following:

- Land use, population, and employment
- Environmental conditions
- Traffic conditions and travel demand
- Existing structures crossing Biscayne Bay

2.1 LAND USE, POPULATION, AND EMPLOYMENT

The Beach Corridor Rapid Transit Project is proposed for a corridor of approximately 8 miles in length. The study area extends approximately 0.5 miles on each side of the corridor, or roughly 8 square miles. For purposes of initial travel shed evaluation, the corridor is centered on Miami Avenue and MacArthur Causeway, and reflects the typical half-mile walking distance to transit service. The travel corridor extends from Miami Avenue/41st Street in the Miami Midtown/Design District, through Downtown Miami, to Miami Beach via the MacArthur Causeway, and ends at 5th Street/Alton Road. **Figure** 2.1 illustrates the traffic analysis zones (TAZs) included in the regional travel demand model that define the study corridor, for which there are land use, population, and employment data. The corridor study area comprises all or portions of 104 TAZs.

Figure 2.1 | Beach Corridor Rapid Transit Project Study Area and TAZs

Figure 2.2 illustrates the land uses in the corridor study area. As shown, there is a wide mix of land uses in the corridor, including residential areas in Midtown Miami and South Miami Beach; retail, office, and public areas distributed throughout the corridor but particularly focused in Downtown Miami; and industrial areas in the middle of the Miami Avenue segment between 14th and 30th streets. The residential areas represent the population centers, and the retail, office, public, and industrial areas represent significant employment centers as described below.

Figure 2.2 | Corridor Land Use

Figure 2.3 illustrates the population locations and densities (persons per acre) in the corridor, based on 2010 census data, and Figure 2.4 illustrates the distribution of employment by TAZ in the study area. Approximately 90,000 persons live within the corridor, and there are approximately 150,000 jobs within the corridor. As shown on the maps, there are several areas with high population densities and others with high employment concentrations. Combined, the population and employment data facilitate analysis of various travel markets as well as potential alignments of enhanced transit to serve the primary origins and destinations (or trip-producers and attractions), particularly the largest category of home-to-work commuter trips during morning and afternoon peak hours.

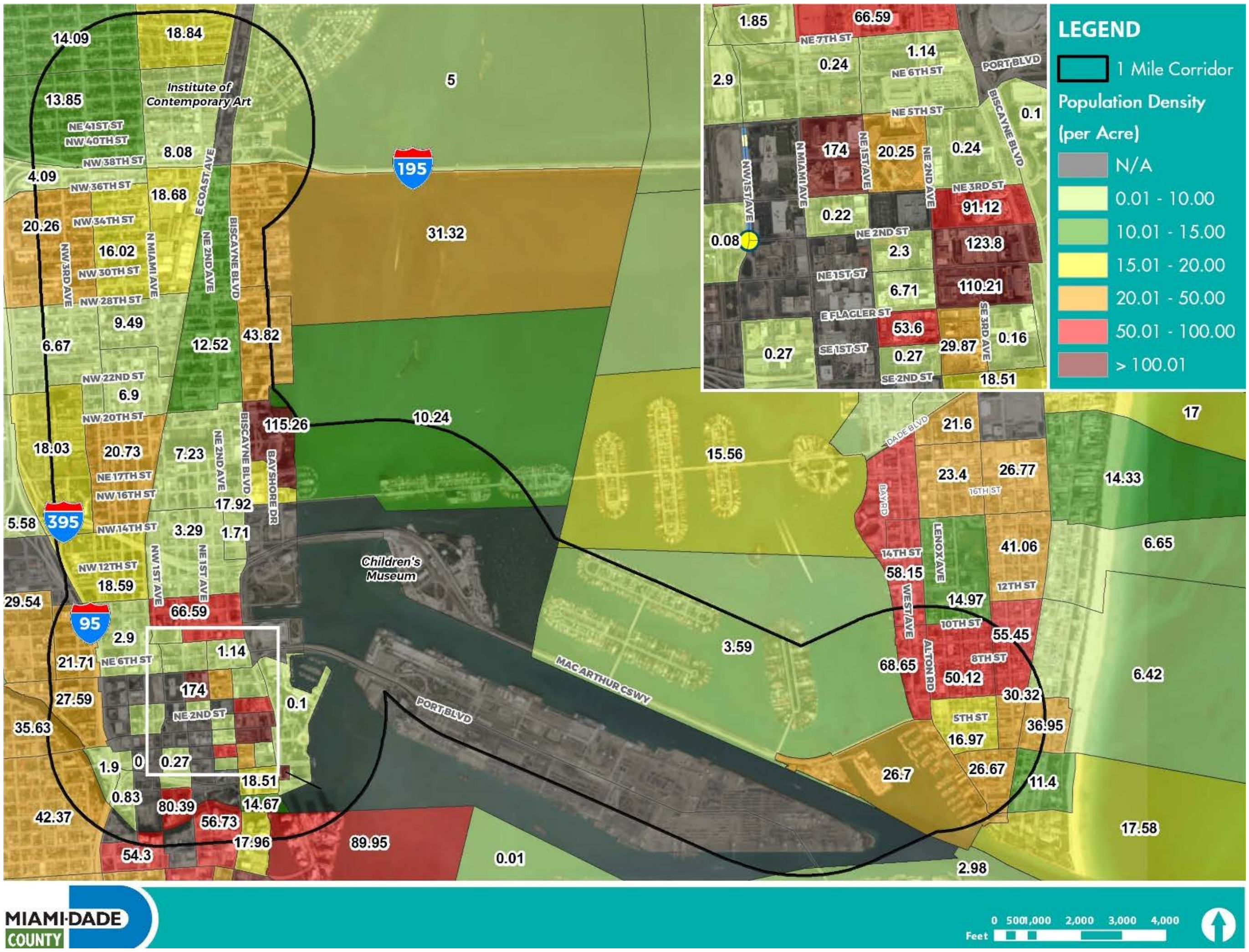


Figure 2.3 | Corridor Population Densities

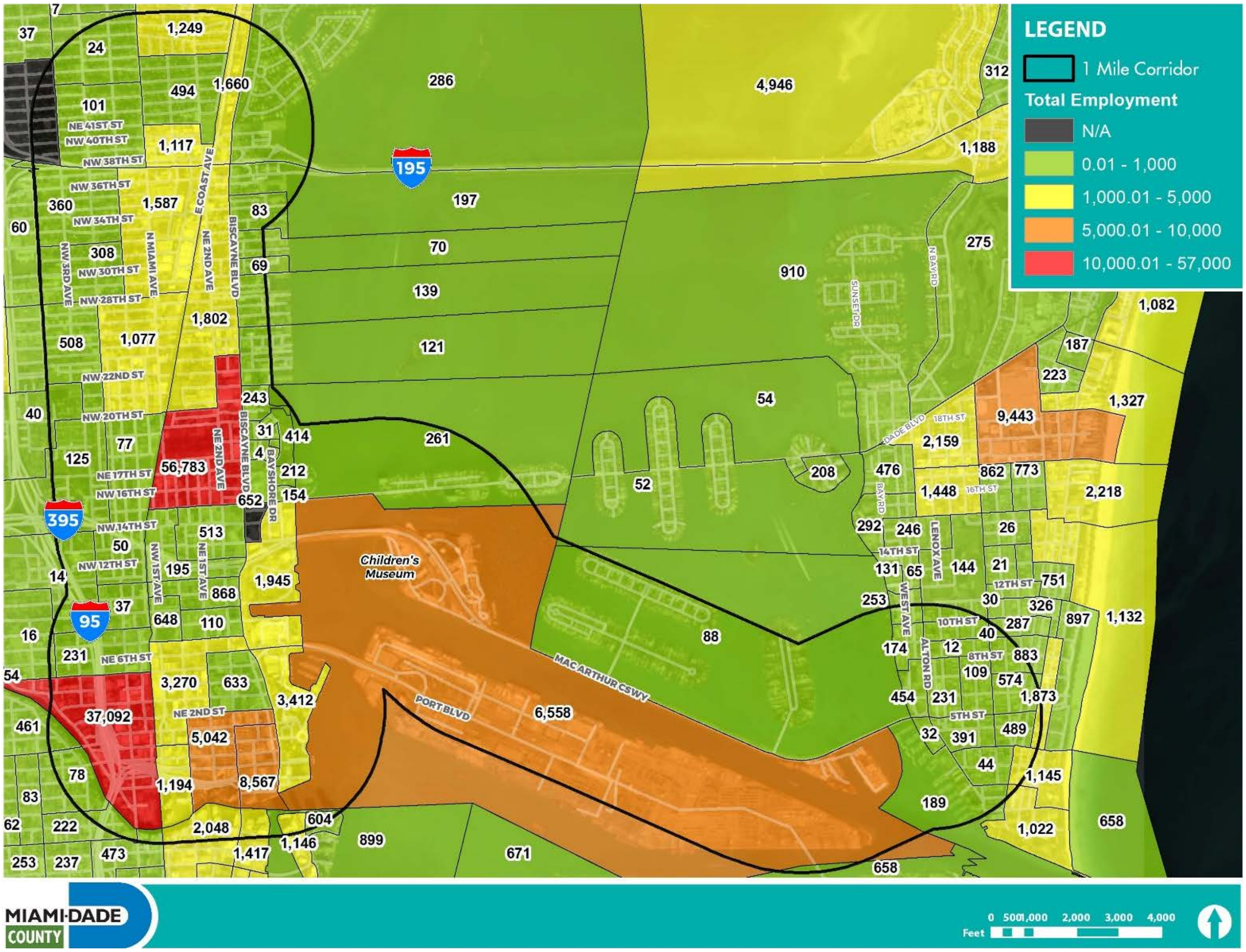


Figure 2.4 | Corridor Employment

2.2 ENVIRONMENTAL CONDITIONS

FDOT conducted a screening of the project using the Efficient Transportation Decision Making (ETDM) Environmental Screening Tool (EST) with a buffer of 200 feet. A supplemental desktop study of environmental resources, and evaluation of potential effects on those resources, was conducted as part of the Tier One analysis. Buffers for this additional analysis were expanded for some environmental resources as appropriate. The following describes the findings of the desktop study and the buffers used. The results of the evaluation of the degree of potential impact by alternative are provided in the evaluation matrix included in Section 5.

2.2.1 Social and Economic

A 500-foot buffer was used for the demographic and income screening criteria. A 200-foot buffer for the proposed corridor was used for the screening of other social and economic data.

2.2.1.1 Socioeconomic

The project traverses two Miami-Dade County census-designated places (Miami Beach and Miami). Seven Developments of Regional Impact (DRI) and four brownfield sites are present along the project corridor. The Miami-Dade County Enterprise Zone, which encompasses a U.S. Housing and Urban Development (HUD) Empowerment Zone (the Miami-Dade County Empowerment Zones), also spans portions of the project corridor. A 200-foot buffer was selected to evaluate community features and to identify the community facilities that would be directly and physically impacted by the proposed improvements.

Community features reported within the 200-foot buffer of the project corridor include the following: four civic centers, two community centers, 19 cultural centers, five government buildings, four health care facilities, 11 homeowner and condominium associations, seven group care facilities, two laser facilities, three local Florida park and recreational facility boundaries (two are national parks), five religious centers, 17 schools, one social service facility, three existing recreational trails, one fire station, and one Florida Site File cemetery.

A 500-foot buffer was selected to evaluate the project's potential impact to disadvantaged populations residing within the project area. Comparing the area of the project corridor with the demographic characteristics for Miami-Dade County, a 500-foot buffer contains a higher percentage of minorities, a lower percentage of individuals age 65 and over, and a lower median household income of $36,660 compared to $43,129 for the county and $50,157 nationally (Figure 2.5.). Additionally, 24.62 percent, or 1,958 persons, within the census block groups within 500 feet of the corridor "speak English less than well." This percentage is lower than the percentage for Miami-Dade County (34.5 percent).

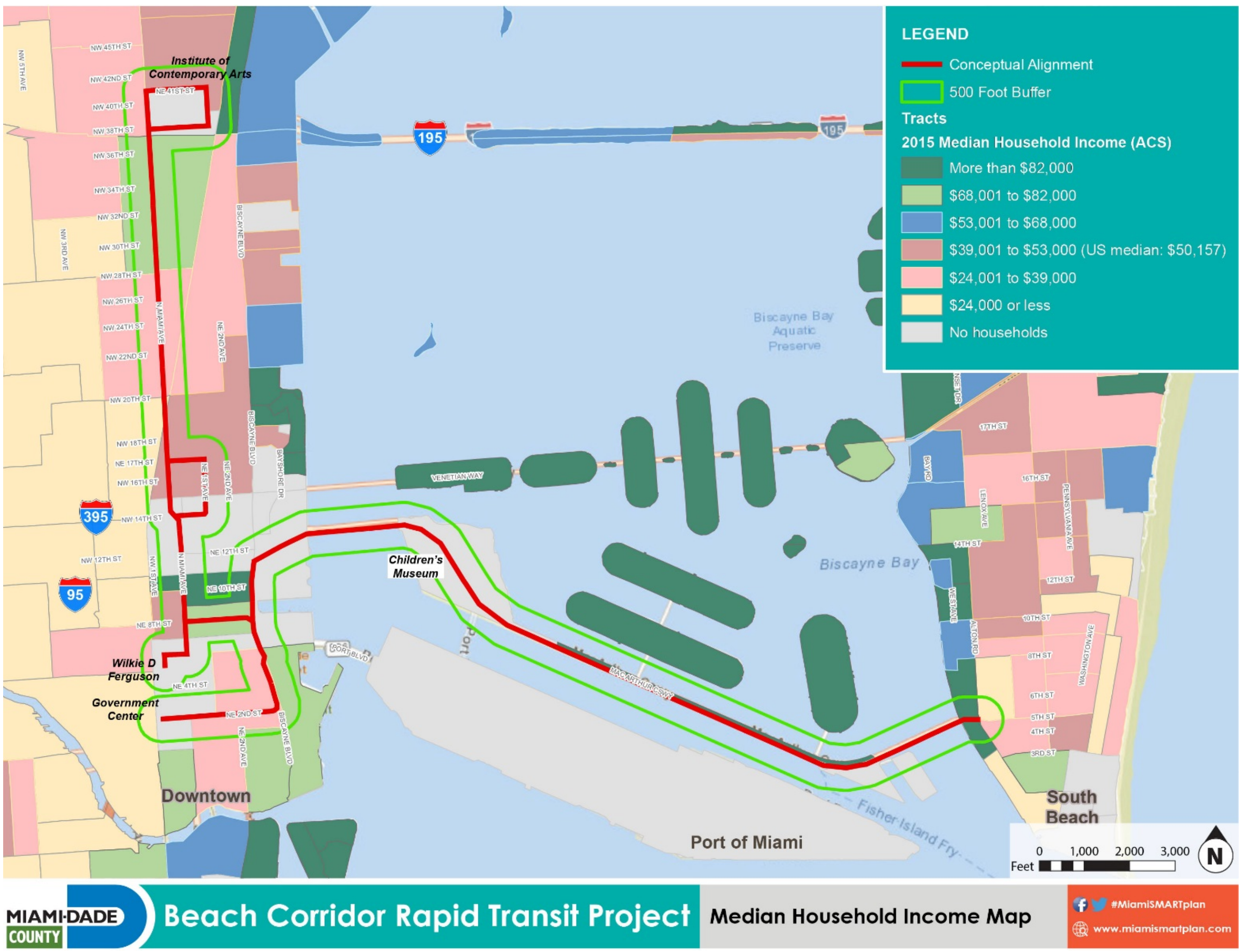


Figure 2.5 | Median Household Income

2.2.1.2 Mobility

The project encompasses the I-395/MacArthur Causeway/SR A1A corridor. I-395/MacArthur Causeway/SR A1A connects the southern end of Miami Beach to the central core of Miami, providing important linkages to I-95, SR 836/Dolphin Expressway, Miami International Airport, and PortMiami and cruise terminals. Routes C, M, and S, as well as Route 120 (Beach Max, providing limited-stop service), are operated by DTPW and use significant portions of the project, including I-395/MacArthur Causeway/SR A1A, and SR 5/US 1/Biscayne Boulevard.

The Downtown Miami portion of the project is anchored by North Miami Avenue, a north–south arterial connecting Downtown Miami at the southern end with the Little Haiti neighborhood at the northern end. This arterial is important because it provides a parallel facility to I-95, linking I-395 and I-195 and providing greater accessibility to the Downtown Miami core.

The Metromover operates within 200 feet of the project corridor. The project additionally occurs within two Transportation Disadvantaged Service Provider Areas (Miami-Dade Transit Agency and Logisticare Solutions, LLC) and is within the vicinity of three transit stations, multiple existing recreational trails, 16 FDOT Roadway Characteristics Inventory (RCI) bridges, 21 facility crossings and the navigable Atlantic Intracoastal Waterway.

2.2.1.3 Relocation Potential

The area surrounding the project corridor is composed primarily of public/semi-public and retail/office activities, industrial land uses, notable vacant land (nonresidential and residential), and residential uses. Given the fact that right-of-way availability along the project is limited due to the surrounding urban environment and access to proximate businesses, the project will be designed to avoid and minimize relocation.

2.2.2 Cultural

For this evaluation, a 200-foot buffer for the screening of cultural data in the vicinity of the proposed corridor was included.

2.2.2.1 Historic/Archaeological

The following historic and archaeological resources are reported within 200 feet of the project corridor (Figure 2.6):

- Historic Standing Structures: 144 total. Eight eligible for the National Register of Historic Places (NRHP), 55 ineligible for the NRHP, 79 not evaluated by the State Historic Preservation Office (SHPO), and two with potential to be eligible.
- Historic Bridges: Two total. Both ineligible for the NRHP.
- Historic Cemeteries: One total. Eligible for the NRHP.
- Resource Groups: Four total. Two eligible for the NRHP, one ineligible for the NRHP, one not evaluated by the SHPO.

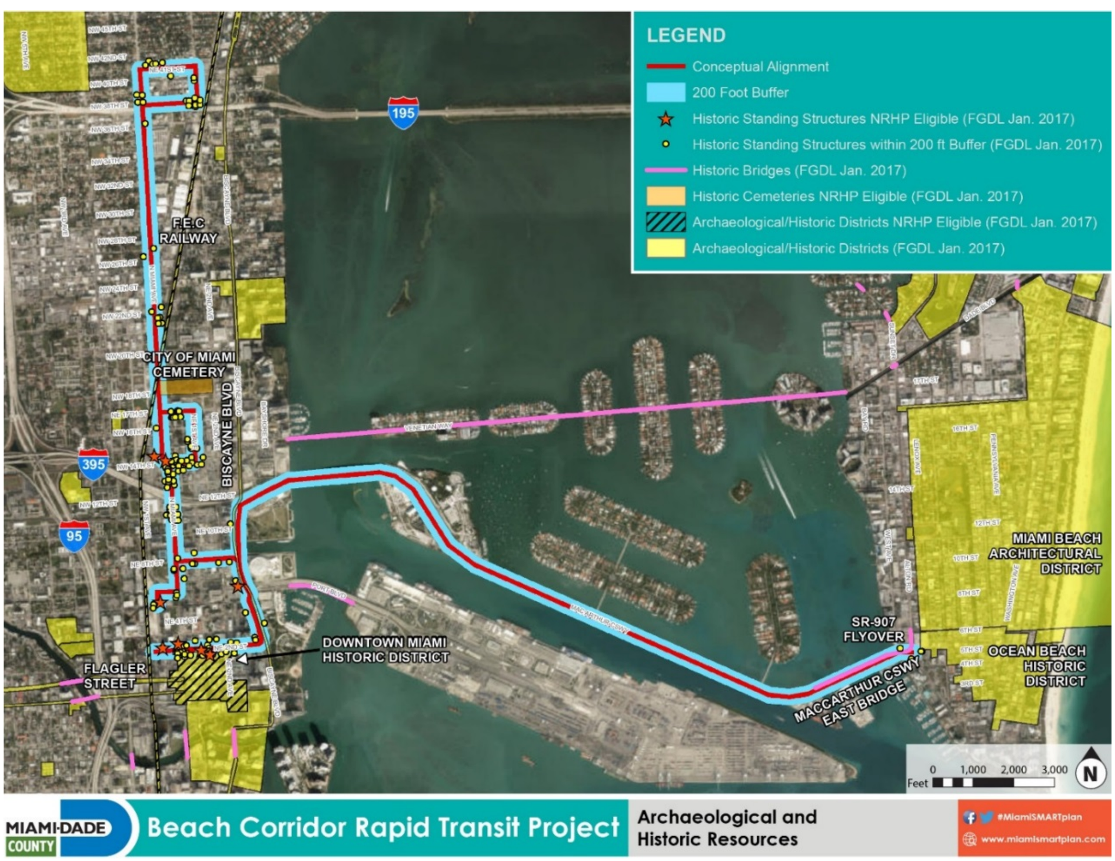


Figure 2.6 | Archaeological and Historic Resources

2.2.2.2 Recreational Sites

The following recreation areas/features are reported within the 200-foot buffer of the project: four park and recreational facility boundaries (two are National Park Projects); three existing recreational trails; two Office of Greenways and Trails (OGT) multiuse trail opportunity and hiking trail priorities, including two of the same trails identified as part of the Shared-Use Nonmotorized (SUN) trail network in Florida (All Aboard Florida rail-with-trail corridor and East Coast Greenway–Dade corridor); a third OGT multiuse trail opportunity (Baywalk trail corridor); one related OGT paddling trail opportunity; and the navigable Atlantic Intracoastal Waterway.

2.2.3 Natural

2.2.3.1 Wetlands and Other Surface Waters

Per review of the latest Florida Fish and Wildlife Conservation Commission (FWC) Geographic Information Services (GIS) data set for submerged aquatic vegetation (seagrass) coverage, 9.2 acres of discontinuous seagrass beds lie within 200 feet of the project corridor (Figure 2.7). These seagrass beds, located at the eastern end of the project, are associated with Biscayne Bay and occur around I-395/MacArthur Causeway/SR A1A. Seagrass is also designated by the National Oceanic and Atmospheric Administration (NOAA) as an Essential Fish Habitat (EFH) for several federally managed fish species and their prey.

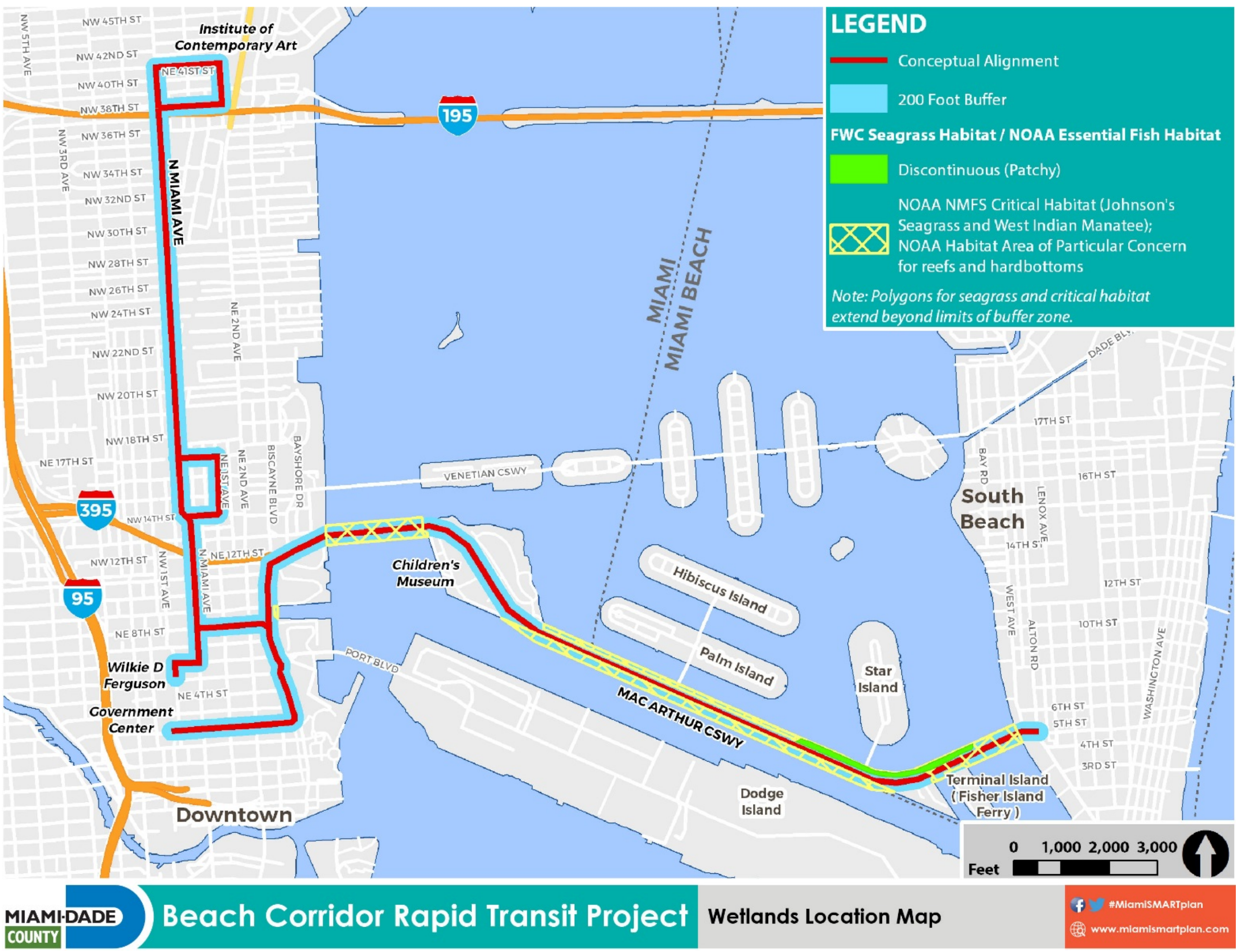


Figure 2.7 | Wetlands Locations

2.2.3.2 Protected Species and Habitat

The 200-foot project buffer zone occurs within the South Florida Ecosystem Management Area (Lower East Coast Management Area). The buffer zone falls entirely within the U.S. Fish and Wildlife Service (USFWS) Consultation Areas (CA) for the West Indian manatee, piping plover, American crocodile, and Atlantic Coast plants, while the western portion of buffer zone falls within the CA of the Florida bonneted bat (Figure 2.8).

All open-water portions of the buffer zone fall within NOAA Critical Habitat Zones for the West Indian manatee and Johnson's seagrass, and a NOAA Habitat Area of Particular Concern for reefs and hardbottoms.

Additional federally-listed species that may potentially be present within the buffer include the Eastern indigo snake and sea turtles.

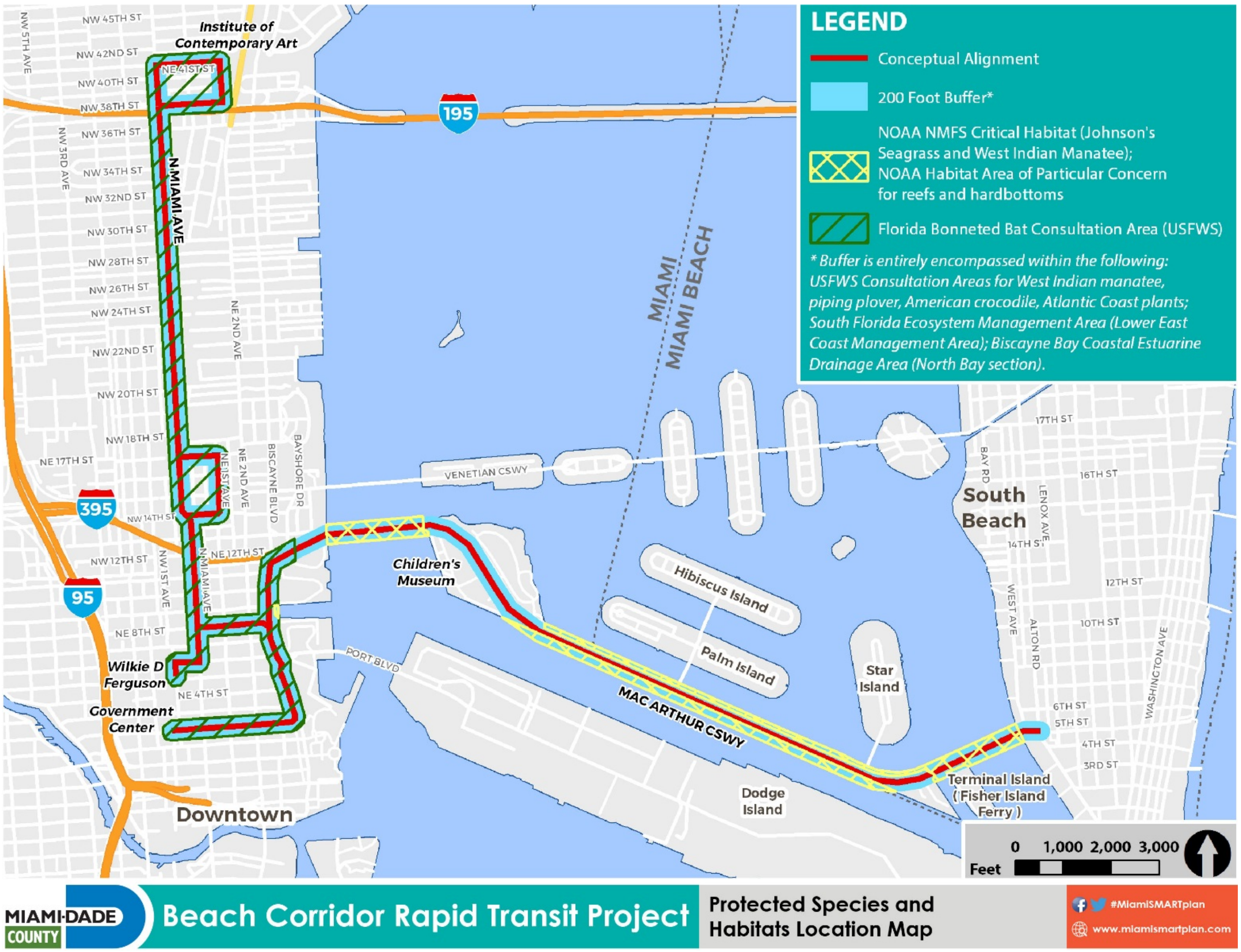


Figure 2.8 | Protected Species and Habitats Locations

2.2.3.3 Coastal

The 200-foot project buffer zone falls within the Biscayne Bay Coastal Estuarine Drainage Area (in the North Bay section). In addition, more than 20,000 linear feet of environmentally-sensitive shoreline and 9.2 acres of seagrass beds/EFH are located within the buffer zone (seagrass coverage described above).

2.2.3.4 Floodplain

Flood hazard areas identified on Florida Emergency Management Agency (FEMA) flood insurance rate maps are identified as Special Flood Hazard Areas (SFHAs), which are defined as areas that will be inundated by a flood event having a 1 percent chance of being equaled or exceeded in any given year. The 1-percent-annual-chance flood is also referred to as the base flood or 100-year flood. FEMA floodplain data was evaluated for the project using a 200-foot buffer of the project area. According to FEMA floodplain data, 199 acres, or 49 percent of the project buffer, are located within SFHA Flood Zone AE (Figure 2.9). FEMA defines Flood Zone AE as areas subject to inundation by the 1-percent-annual-chance flood event determined by detailed methods. The remaining area is identified to be outside of the SFHAs and at a higher than the elevation of 0.2-percent-annual-chance flood.

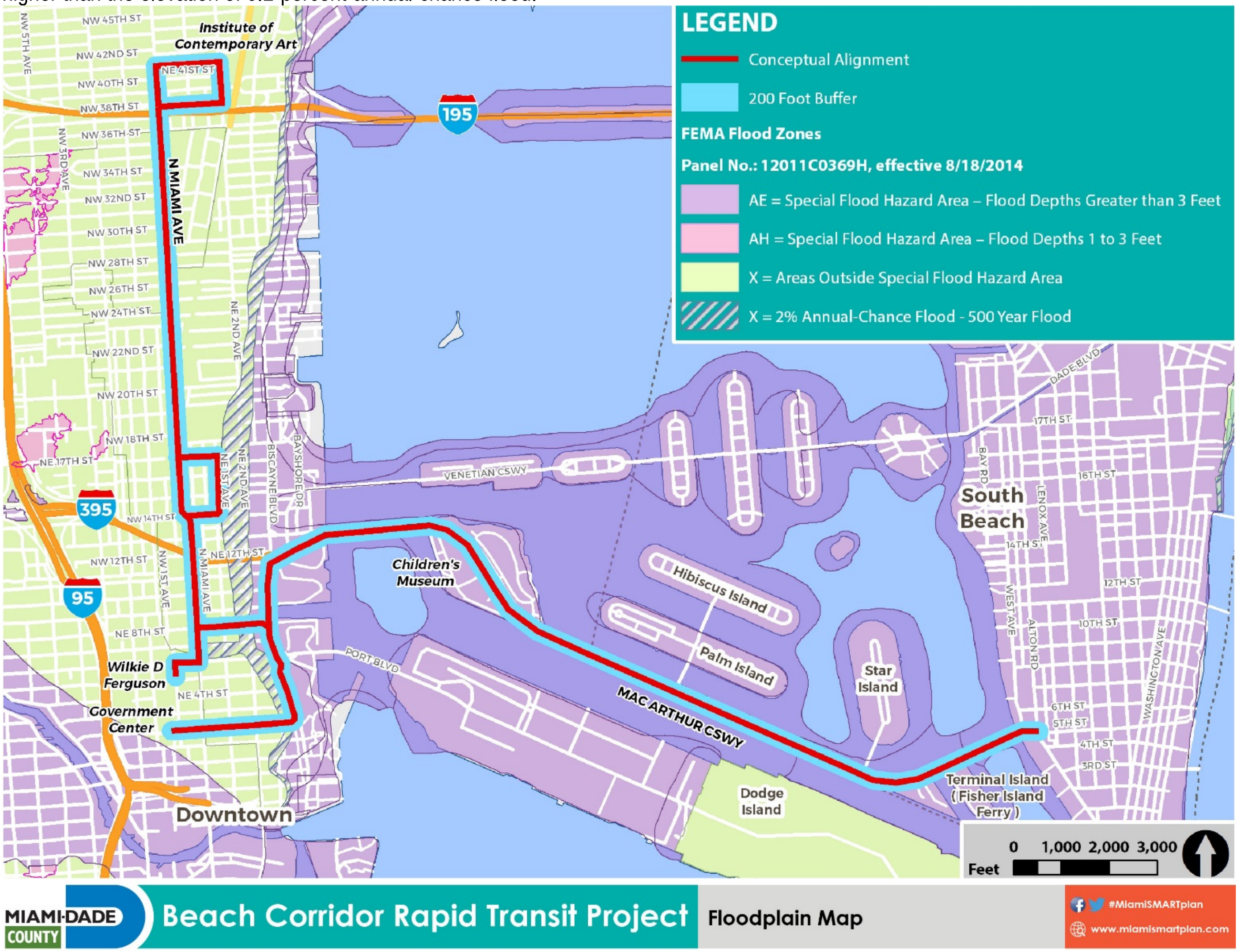


Figure 2.9 | Floodplains

2.2.4 Physical

2.2.4.1 Noise

The project is located within two Miami-Dade County census-designated places (Miami Beach and Miami). Seven DRIs and 29 acres (2.87 percent) of residential uses are also present within a 200-foot buffer surrounding the project corridor. The primary sources of existing noise along the proposed project corridor are local traffic on surface roads, as well as, noise from the existing Metromover and Metrorail transit operations.

Other community features within the 200-foot buffer of the project corridor that may be sensitive to noise and vibration effects include the following: four civic centers, two community centers, 19 cultural centers, five government buildings, four health care facilities, 11 homeowner and condominium associations, seven group care facilities, two laser facilities, three park and recreational facility boundaries, five religious centers, 17 schools, one social service facility, three existing recreational trails, three OGT multiuse trail opportunity and hiking trail priorities, two related OGT paddling trail opportunities, and several archaeological and historic resources.

The Tier One comparative evaluation of noise impacts of transit technologies is presented in Appendix C.

2.2.4.2 Air Quality

The project is located within the Southeast Florida air shed. However, the metadata states that the information is based on 1990 data. As such, current information published on the U.S. Environmental Protection Agency (USEPA) website was consulted for the project. The current data (June 2017) indicates that the project is not located within a USEPA-designated Air Quality Maintenance or Non-Attainment Area for any of the six pollutants (nitrogen oxides, ozone, carbon monoxide, lead, sulfur dioxide, and small particulate matter) specified by the USEPA in National Ambient Air Quality Standards.

2.2.4.3 Contamination

Three buffers were used for the review of contaminated sites: 500 feet for contaminated sites; 1,000 feet for non-landfill solid waste sites; and 0.5 miles for National Priority List (NPL) and Comprehensive Environmental Response, Compensation, and Liability (CERCLA) Superfund sites. The 500-foot buffer of the project corridor contains four brownfield sites and 29 contaminated sites regulated by Miami-Dade Department of Environmental Resources Management (DERM) or Florida Department of Environmental Protection (FDEP), including petroleum, dry cleaner, and other waste cleanup categories (**Figure 2.10**). Additionally, three non-landfill solid waste sites are located within 1,000 feet of the project corridor. No NPL or Superfund sites are present within 0.5 miles of the project corridor.

2.2.4.4 Navigation

The project corridor crosses the Atlantic Intracoastal Waterway, a navigable waterway.

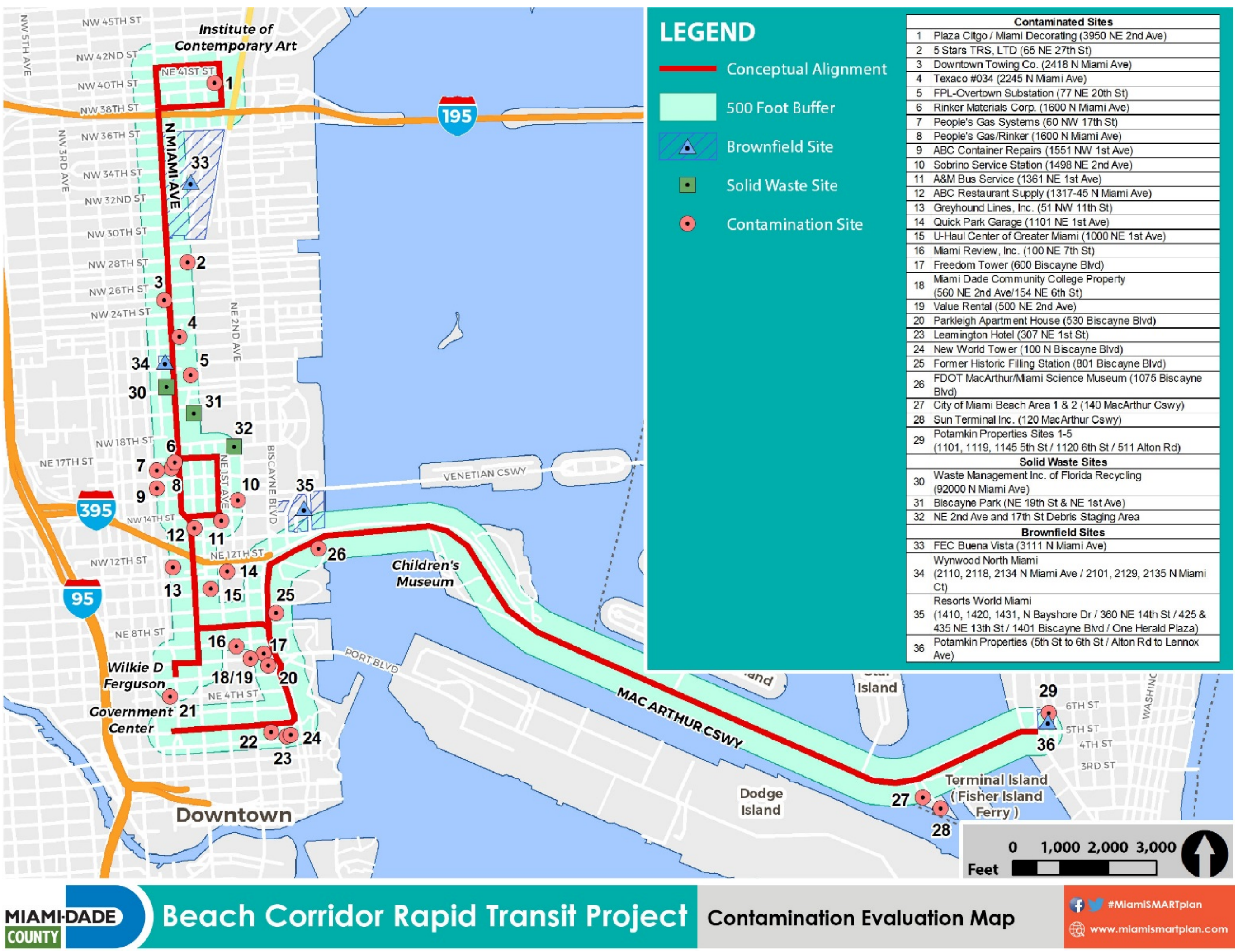


Figure 2.10 | Contamination Evaluation

2.3 TRANSIT CONDITIONS, TRAFFIC CONDITIONS, AND TRAVEL DEMAND

Downtown Miami and South Miami Beach (South Beach) are two major activity centers in Miami-Dade County. Over the past decades, these two areas have experienced significant growth in population, employment, and tourism. The significant growth, projected to continue in the coming decades, will generate travel demand that can no longer be met by the current roadway and transit network. To improve transportation between the Design District, Downtown Miami, and Miami Beach, the Strategic Miami Area Rapid Transit (SMART) Plan identified the need to analyze the feasibility of a fixed-guideway transit connection.

The project study area serves two distinct travel markets: an east–west connection between Miami Beach and Downtown Miami (approximately 5 miles), and a north–south connection between the Design District/Midtown and Downtown Miami (approximately 3 miles).

This analysis evaluates existing transit and traffic conditions in these two travel markets separately.

2.3.1 Transit Conditions

2.3.1.1 East–West Connection

The east–west corridor connecting Downtown Miami with Miami Beach along the MacArthur Causeway is served by five bus routes: routes C/103, M/113, S/119, and 120 operate on the MacArthur Causeway; and route A/101 follows the Venetian Causeway (Table 2.1).

Peak-hour headways for these routes range from 12 minutes to 45 minutes, resulting in 440 daily bus trips running in the corridor carrying about 17,500 passengers on a typical weekday. It typically takes at least 30 minutes to travel from Downtown Miami to Miami Beach by transit during peak hours, which is about twice as long as by driving.

Table 2.1 | East–West Transit Services

Route	Peak-Hour Headway	Ridership Per Day	Buses Per Day	Capacity	Capacity Consumption
A/101	30	70	28	1,680	4%
C/103	20	2,500	103	6,180	40%
M/113	45	700	19	1,140	61%
S/119	12	8,600	161	9,660	89%
120	12	5,600	129	7,740	72%
Total		17,470	440	26,400	53%

Source: Miami-Dade Department of Transportation and Public Works, May 2017.

The final column in the table above indicates an estimate of the service consumption, or ratio of riders to seats provided. Route S/119, with 12-minute peak headways, is a highly productive route, operating close to capacity. For the corridor as a whole this ratio is lower, but still relatively high compared with the system overall.

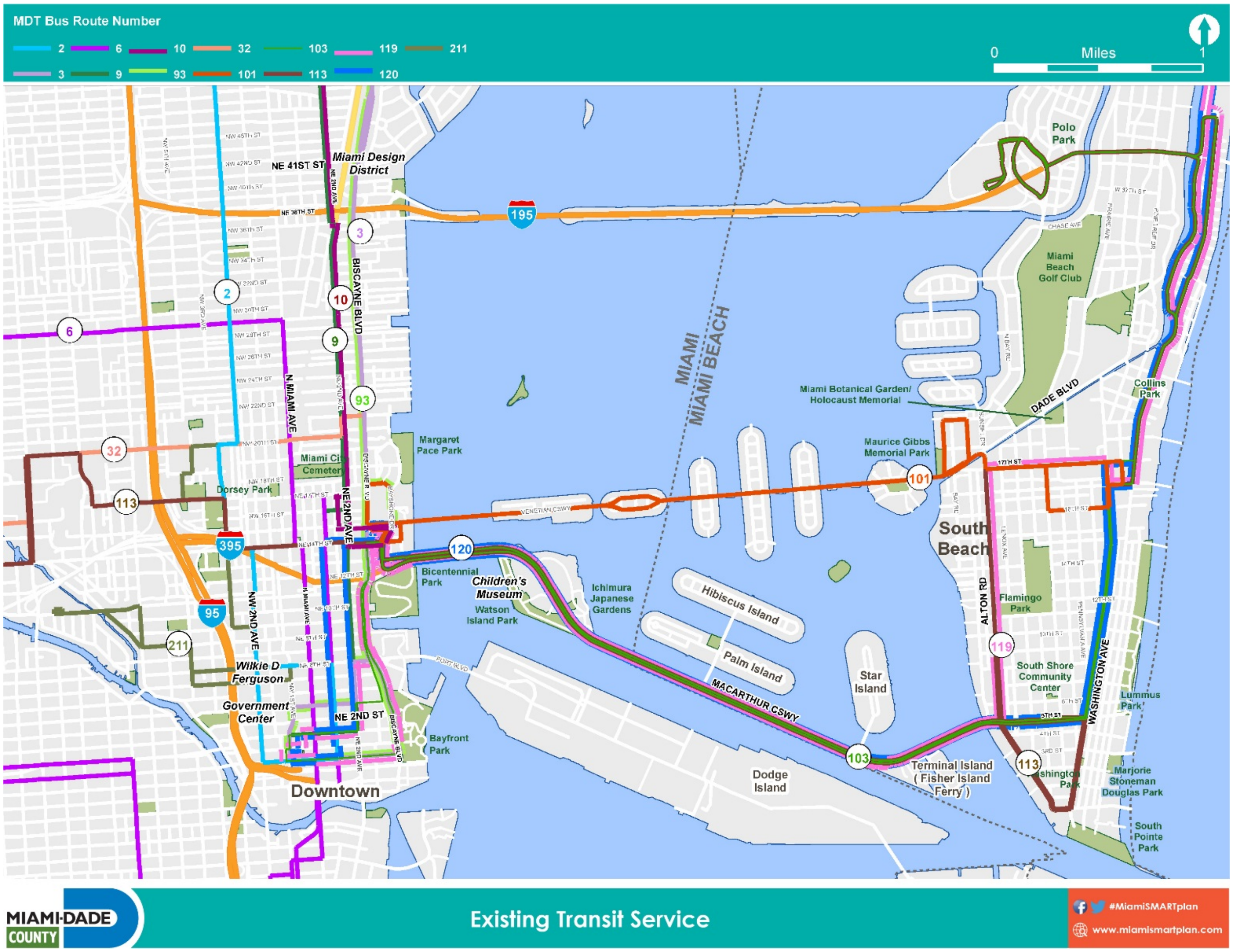


Figure 2.11 | Existing Transit Service

2.3.1.2 North–South Connection

The north–south connection between the Design District/Midtown and Downtown Miami is served by eight bus routes operating on NW Third Avenue, NW Second Avenue, NW First Avenue, North Miami Avenue, NE Second Avenue, and Biscayne Boulevard, providing peak-hour headways ranging from 15 to 60 minutes (Table 2.2). On a typical weekday, approximately 614 buses provide service in this corridor, carrying about 23,700 passengers. It takes at least 20 minutes to travel from the Design District/Midtown to Downtown Miami by transit during peak hours, which is about twice the time to travel by car.

The southern portion of this corridor is also served by Metromover, which consists of the following three loops:

- Outer/Omni Loop connects Adrienne Arsht Center and the Omni neighborhood with Downtown Miami with 5-minute peak-period headways
- Inner/Downtown Loop serves Downtown Miami central business district with 1.5-minute peak-period headways
- Outer/Brickell Loop connects Downtown Miami with the Brickell area to the south with 5-minute peak-period headways

The Outer/Omni Loop of Metromover runs parallel with NE Second Avenue between NE 15th Street in the Omni neighborhood and NE First Street in Downtown Miami, and provides transfer access to Inner/Downtown Loop and Outer/Brickell Loop in Downtown Miami, as well as to Metrorail at the Government Center and Brickell stations. The average weekday ridership of Metromover is about 29,000 passengers.

Table 2.2 | North–South Transit Services					
Route	Peak-hour headway	Ridership per day	Buses per day	Capacity	Capacity consumption
2	20	2,500	96	5,760	43%
3	20	6,000	125	7,500	80%
6	60	500	20	1,200	42%
9	12	5,900	113	6,780	87%
10	30	2,500	67	4,020	62%
32	30	2,700	64	3,840	70%
93	15	3,500	89	5,340	66%
211	45	90	16	960	9%
Total Bus		23,690	590	35,400	57%
Metromover	1.5 –- 5	29,300	360	34,560	85%
Source: Miami-Dade Department of Transportation and Public Works, May 2017.					

The final column in the table above indicates an estimate of the service consumption, or ratio of riders to seats provided. Routes 3 (Biscayne Boulevard) and 9 (NE Second Avenue) are highly productive routes, while Route 211 (Overtown circulator) sees very low ridership.

2.3.2 Traffic Conditions

2.3.2.1 East–West Connection

The major roadway serving this corridor is the MacArthur Causeway, a six-lane highway that connects to I-395 and crosses Biscayne Bay alongside PortMiami on Dodge Island and the main channel used by cruise ships. As the major connection between Downtown Miami and South Beach, MacArthur Causeway carries more than 97,000 vehicles per day, exceeding the design capacity by more than 50 percent and resulting in severe congestion in both directions during peak hours and on weekends. Despite this constraint, traffic has grown 4 percent in the past five years.

Venetian Way/NE 15th Street is a two-lane roadway built on the Venetian Causeway connecting Downtown Miami and the city center of Miami Beach, and serving several residential communities on the islands in between. Located about 1 mile north of MacArthur Causeway, Venetian Way also serves as an alternative road for people traveling between Downtown Miami and Miami Beach. The annual average daily traffic (AADT) on Venetian Way has increased about 44 percent over the past five years alone.

I-195 is a six-lane highway connecting I-95 with the Miami Design District and the Bayshore and Mid-Beach areas in Miami Beach. The AADT on I-195 has grown 14 percent from 101,200 in 2011 to 115,400 in 2016. The volume to capacity (V/C) ratio for this roadway is 0.99.

Table 2.3 | East–West Traffic Conditions					
Route	Lanes	AADT 2011	AADT 2016	Growth	V/C Ratio
I-195	6	101,200	115,400	14%	0.99
Venetian Causeway	2	2,700	3,900	44%	0.37
MacArthur Causeway/I-395	6	93,300	97,100	4%	1.62
Total		197,200	216,400	10%	
Source: Florida Traffic Information, 2016.					

2.3.2.2 North–South Connection

NW Second Avenue is a two-lane arterial running through Downtown Miami and Wynwood. The AADT on NW Second Avenue was about 9,100 in 2016, which has grown by 25 percent since 2011.

Miami Avenue is the main north–south street running through Brickell, Downtown Miami, and the Design District/Midtown. It is a two-way, four-lane road from NE 17th Street to the Design District, and a one-way southbound road from NE 17th Street to Downtown Miami, with three lanes on the segment between NE 17th Street and NE Fifth Street, and two lanes south of NE Fifth Street. (Note that traffic data for Miami Avenue does not reflect changes to the configuration of the street after the 2011 counts as well as diversion to avoid construction impacts in the corridor; the Tier Two evaluation will feature additional traffic counts to provide a more detailed analysis of Miami Avenue traffic conditions and travel demand.)

NE Second Avenue is a four-lane arterial connecting Downtown Miami and the Design District, transitioning to a three-lane road north of 36th Street. Traffic on NE Second Avenue has increased significantly over the past five years. There are about 11,600 vehicles on NE Second Avenue per day in 2016, a growth of 29 percent since 2011.

Biscayne Boulevard is a six-lane arterial running north–south alongside Biscayne Bay, providing access to many major activity centers in Downtown Miami, including Museum Park, American Airlines Arena, and PortMiami. The AADT on Biscayne Boulevard was about 39,000 in 2016, which has grown by 47 percent since 2011.

Table 2.4 | North–South Traffic Conditions

Route	Lanes	AADT 2011	AADT 2016	Growth	V/C Ratio
NW 2nd Ave.	2	7,300	9,100	25%	0.87
Miami Ave.*	4*	31,500	13,400	-57%*	0.59
NE 2nd Ave. (N of 41st St.)	3	9,000	11,600	29%	0.79
Biscayne Blvd.	6	26,500	39,000	47%	0.77
Total		74,300	73,100	-2%	

** - No count available for the 2-lane segment of Miami Avenue.*
Source: Florida Traffic Information, 2016.

The final column in Table 2.4 above provides a volume-to-capacity (V/C) ratio based on daily traffic volumes and service volume thresholds for a facility of that type. As indicated, NW Second Avenue is operating closest to capacity, with the other roadways operating at between 60 percent and 80 percent of capacity over a 24-hour period.

2.3.3 Intersection Conditions

Using Highway Capacity Software (HCS), a peak-hour intersection level of service (LOS) analysis was conducted for three intersections along the study-area roadways for which traffic counts were available from DTPW. The results are shown in Table 2.5 and Table 2.6. These roads are generally operating below capacity conditions, with conditions approaching capacity as one moves south closer to Downtown Miami (20th Street).

The intersection of NE Second Avenue and 41st Street is a T-intersection and is currently unsignalized, however it was analyzed as though a signal were installed since that will be required for premium transit operations. During p.m. peak hours, the overall LOS of the intersection is at LOS A, however, the eastbound approach is at LOS C with about a 28-second delay per vehicle.

The intersection of Miami Avenue and 29th Street operates at LOS C during both a.m. and p.m. peak hours with about a 24- to 25-second delay per vehicle. The southbound traffic experiences the longest delay during a.m. peak hours, while the northbound traffic has the longest delay during p.m. peak hours, reflecting peak flows southbound into downtown in the a.m. and northbound in the p.m.

The intersection of Miami Avenue and 20th Street operates at LOS D in a.m. peak hours and LOS E in p.m. peak hours. The eastbound approach experiences the most delay, operating at LOS F with about a 121-second delay per vehicle during the a.m. peak hour and a 95-second delay per vehicle during p.m. peak.

Table 2.5 | Intersection Delay and LOS — A.M. Peak

	Intersection		Approach							
			Eastbound		Westbound		Northbound		Southbound	
	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
NE 2nd Ave. and 41st St.	No traffic count available									

Miami Ave. and 29th St.	24.9	C	13.8	B	13.2	B	19.3	B	33	C
Miami Ave. and 20th St.	54.8	D	121	F	54.9	D	9.2	A	24.4	C
Note: Delay in seconds.										

Table 2.6 | Intersection Delay and LOS — P.M. Peak										
	Intersection		Approach							
	Delay	LOS	Eastbound		Westbound		Northbound		Southbound	
			Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS
NE 2nd Ave. and 41 St.	8.7	A	28.4	C	N/A	N/A	8.1	A	6.9	A
Miami Ave. and 29th St.	23.6	C	15.3	B	14.2	B	32.5	C	21.0	C
Miami Ave. and 20th St.	61.8	E	94.9	F	50.5	D	50.0	D	59.3	E
Note: Delay in seconds.										

2.3.4 Findings

The study area contains some of the highest-density activity centers in South Florida and experiences very high traffic volumes and highly congested traffic conditions for much of the typical weekday, with even greater congestion on weekends on some roadways. Both Miami and Miami Beach are in the midst of building booms, with dozens of high-rise projects under construction currently, and many more planned as residents and businesses continue to relocate to this area.

Both east–west and north–south connections are totally constrained. As travel demand increases in the region and the study area, traffic will quickly reach gridlock conditions unless additional travel capacity is provided via transit investments that can make better use of the existing road capacity, or by adding new transit guideway capacity.

2.4 EXISTING STRUCTURES

Existing structures in the corridor that cross Biscayne Bay are key considerations in the evaluation of potential transit technologies and modes. The bridge crossings on the MacArthur Causeway consist of three structures. Bridge Nos. 870771 and 870772, which were completed in 1996 and 1995 respectively, were originally designed as three-lane bridges carrying westbound (WB) and eastbound (EB) traffic respectively over Biscayne Bay. Both bridges underwent superstructure and substructure widening in 2013 to add an additional lane of traffic to bring them to their current-day configuration of four traffic lanes in each direction. The third structure is Bridge No. 870077, designed in 1956, as a six-lane highway carrying both WB and EB traffic over the east channel of MacArthur Causeway.

2.4.1 Bridge No. 870771 (WB MacArthur Causeway) and No. 870772 (EB MacArthur Causeway)

The overall lengths of the WB and EB bridges are 2,467 feet, 8 5/8 inches and 2,454 feet, 0 inches respectively. The WB bridge superstructure consists of two, three-span continuous deck units and three, four-span continuous deck units, whereas the EB bridge superstructure consists of three, three-span continuous deck units, two, four-span continuous deck units, and a single simple span unit. Both bridges use post-tensioned Florida Bulb-T 72 beams. The end bents are founded on 42-inch drilled shafts and the piers on either 48-inch or 84-inch drilled shafts.

In 2013 these bridges were widened to the inside within the original median gap of 30 feet, 4 inches (see Figure 2.12). Single piers were constructed to accommodate the widening of both bridges. Exterior substructure and superstructure widening was also done on spans 15-18 for the EB bridge. The operational and inventory load rating of the EB bridge is 1.32 and 1.02 respectively. The sufficiency rating for the WB and EB bridges is 84 and 85 respectively.

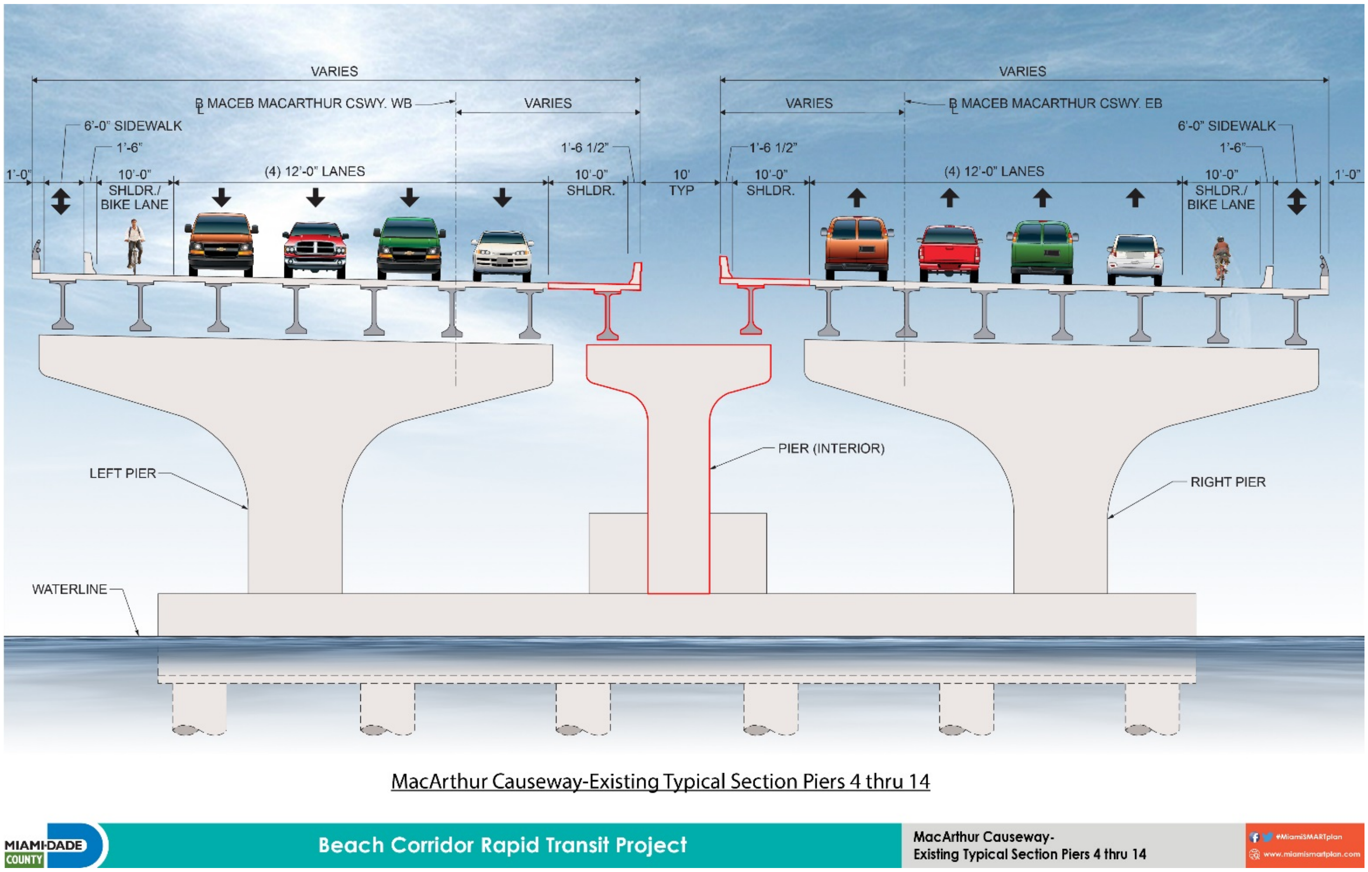


Figure 2.12 | MacArthur Causeway Existing Typical Section (Bridge No. 870771 and No. 870772)

2.4.2 Bridge No. 870077 (WB and EB MacArthur Causeway over East Channel)

The overall length of this bridge is 2,155 feet, 0 inches. The bridge superstructure consists of 15 spans of 45 feet, 19 spans of 65 feet, two spans of 70 feet, and a single 105-foot span. The bridge uses AASHTO Type II beams. The end bents and piers are founded on 20-inch precast concrete piles.

In 1978, the bridge underwent several repair procedures, including cleaning and resealing joints with elastomeric compression seals, repairing spalls with epoxy mortar, constructing steel saddle-beam supports on Pier 26, painting structural steel and shoe assemblies, and installing guardrails. The sufficiency rating for the bridge is 72.

2.4.3 Options to Accommodate Future Transit Crossing Biscayne Bay

In lieu of repurposing lanes on the existing bridges, the alternatives to accommodate a future mode of transit on these bridges are either to widen the EB bridges (bridge widening to the south) or to construct a new bridge to the south of the EB bridges.

Widening was assumed to be feasible only for the EB bridges/widening to the south because:

- Due to the reconstruction of I-395 with a signature bridge, in the planning phase a transit corridor was provided for a future transit extension to/from Miami Beach. The corridor is located directly south of I-395, thus eliminating the option of utilizing the north side of I-395 as a viable transit route.
- The optimal location for a transit transfer station with metromover could occur at the existing Museum Station. Utilizing a transit alignment north of the Causeway bridge would not allow access to the Museum Station.

The widening alternative not only will have to account for construction of foundation and substructure in very close proximity to the existing structures, but also for vessel-impact loads on the new and existing foundations. In addition, the existing superstructure and substructure must be evaluated to account for the effects of the selected transit alternative. Widening also will conflict with the existing pedestrian ramp at the east end of the bridge that leads to Parrot Jungle Trail. In lieu of the issue associated with the widening of existing structure, constructing a new bridge for transit would be a more feasible solution.

The Tier One evaluation included preliminary evaluation of the potential for a new center-running guideway structure using the existing median of the bridge, rather than widening the existing bridge or constructing a new transit bridge. The technical feasibility of a median option will be evaluated further in Tier Two; the Tier One evaluation assumes the need to widen or construct a new structure, based on the following considerations:

- The space between bridges 870771 and 870772 is 10'-5" for the majority of the structures, but this gap reduces to roughly 3 ft. by the end of bridge at Span 18. In addition, FDOT District 6's Design-Build project (Contract Number E-6J53) proposes inside widening of the first 2 units (7 spans) of the EB Bridge (870772) that will significantly reduce the gap between the bridges. There is no gap between the EB and WB travel lanes on Bridge 870077.
- Reverse curves would be required at each end of the bridge that could negatively affect the ride of the vehicle.
- There may be adequate space for a 9' diameter hammer-head pier to fit between the structures to accommodate rail on an elevated guideway that is cantilevered over the existing travel lanes; see Figure 2.11 illustrating the 10' existing clearance between the left and right piers. New piers may be required in the Bay to support the guideway structure, and long bridge spans over the eastbound travel lanes would be required for transitions to and from the center median, meaning there may not be a significant cost, schedule or environmental permitting advantage for a center median guideway structure.
- Tier two will feature further evaluation of the potential to support a new guideway structure on the existing bridge foundations.

2.5 EXISTING UTILITIES

The following activities were undertaken to identify public- and privately-owned utilities within a 200-foot buffer of the study corridors:

- Sunshine State One Call (Sunshine811®) design tickets issued in June 2017 listed 29 utility agencies/owners (UAOs) with facilities within the study limits. (Table 2.7, and Figures 2.13 and 2.14).
- UAOs were contacted for information relating to the size, type, and location of their facilities within the limits of the study.
- Field surveys were conducted along each study alignment.
- Roadway and structures as-built plans were reviewed.
- Utility work schedules (UWS), relocation plans, and coordination reports for the I-395 design-build project (FDOT FPID 251688-1-56-01) were reviewed to identify potential relocations associated with the planned improvements.
- Information was obtained for the following Miami-Dade County Water and Sewer Department (MDWAS) utility improvement projects identified on the MDC GISWeb:
  - Project ID 10666: The CL-1 Downtown Transmission Force Main (FM) Extension project is currently under design-build construction and involves the installation of a 48-inch force main along North Miami Avenue from NW Eighth Street to NW 36th Street, and along NE 36th Street from North Miami Avenue to NE Second Avenue, as well as installation of a 12-inch water main.
  - Project ID 13494: This project is in design, with anticipated construction completion in 2019 for a new, second, reinforcing 42-inch FM from NE Fourth Avenue and 62nd Street to N Miami Avenue and 36th Street, and an upgraded 48-inch FM (Project ID 10666) at North Miami Avenue and 36th Street.

The locations of existing major utilities are summarized in Table 2.7, and Figures 2.13 and 2.14. The utility information collected for the Tier One analysis of the Beach corridor rapid transit alternatives is considered Levels C and D. For the purpose of this Tier One feasibility study, "major" utilities were defined as the following:

- Gas lines with a diameter of 4 inches or greater
- Water and sewer pipes with a diameter of 4 inches or greater
- Buried distribution and subaqueous electric duct banks
- Aerial and buried electric transmission lines
- High-capacity fiber-optic cables and fiber-optic duct banks

The location, size, and type of utilities within the project limits will be confirmed through additional coordination with UAOs and utility surveys as technologies, alignments, and station locations are evaluated and refined.

Table 2.7 | Utility Agencies/Owners and Utility Locations

	Utility Agency/Owner (UAO) | Contact Person	Utility Type	Utility Locations[1]												
			MacArthur Cswy.	Biscayne Blvd	NE 2nd St	NW 1st Ave	NE 5th St	NE 8t St	N Miami Ave	NE 17th St	NE 13th St	NE 1st Ave	NE 41st St	NE 38th St	NE 2nd Ave
1	A T & T/ Distribution | Steve Lowe	Tel, FOC	●	●	●	●	●	●	●	●	●	●	●	●	●
2	AT&T Corporation (Transmission)[2] | Greg Jacobson	HC FOC		●	●	●	●	●	●						
3	American Traffic Solutions | Santiago Martinez	ITS							●					●	
4	Atlantic Broadband | Edwin Zambrana	FOC	●		●	●	●	●	●	●	●	●			
5	Centurylink | Allen Aten	FOC, CATV			●	●	●	●	●	●			●	●	●
6	City of Miami Beach Utilities | Ashok Verma	W, S, RCW	●												
7	Comcast Cable | Leonard Maxwell-Newbald	CATV, FOC	●	●	●	●	●	●	●	●	●	●	●	●	●
8	Crown Castle Ng | Randy Oliver	FOC							●						
9	Miami-Dade County Traffic[3] |	ITS	●	●	●	●	●	●	●	●	●	●	●	●	●
10	FDOT District 6 ITS | Thomas Miller	ITS	●	●	●	●	●	●	●		●	●		●	●
11	Fiberlight | Jacob Marroney	FOC		●	●	●	●	●	●						
12	Fibernet Direct (formerly FPL Fibernet) | Danny Haskett	FOC		●	●	●	●	●	●			●		●	●
13	Florida Gas Transmission | Joseph E. Sanchez	Gas	●						●	●		●			
14	Florida Power & Light – Distribution | Edgar Aguilara	Electric	●	●	●	●	●	●	●	●	●	●	●	●	●
15	Florida Power & Light - Subaqueous | Joel Bray	Electric	●												
16	Florida Power & Light--Transmission | George Beck	Electric	●	●	●	●	●	●	●	●	●	●			
17	Hotwire Communications | Phil Gallub	FOC	●	●	●	●		●	●	●			●	●	●
18	Intermetro Fiber | William Valentine	FOC			●	●	●		●						
19	Level 3 Communications | Jorge Pelaez	FOC		●	●	●	●	●	●	●			●	●	●
20	MCI Communications | Dean Boyers	Electric	●	●	●	●	●	●	●		●	●		●	●
21	Miami-Dade County Central Support[3] | Milton Hernandez	Chilled W	●	●	●	●	●	●	●		●				
22	Miami- Dade Enterprise Technology | Frank Dopico	ITS	●	●	●	●	●	●	●						
23	Miami-Dade County Water & Sewer | Patrick Chong	W, S	●	●	●	●	●	●	●	●	●	●	●	●	●
24	Sprint | Mark Caldwell	FOC						●	●	●			●	●	●
25	Strome Networks | Kristin Zaky	FOC						●	●						
26	Teco Peoples Gas | Alex Roche	Gas	●	●	●	●	●	●	●	●	●	●	●	●	●
27	Windstream Communications | Douglas Pickle	Tel, FOC				●	●	●	●	●	●	●	●	●	●
28	X O Communications | Anthony Kowaleski	FOC		●	●	●	●	●	●						

(1) Facility located within 200-foot buffer of corridor, per Sunshine State One-Call® design tickets, issued in June 2017.
(2) Includes PortMiami (Teleport Communications America) facilities

Table 2.7 | Utility Agencies/Owners and Utility Locations

	Utility Agency/Owner (UAO) | Contact Person	Utility Type	Utility Locations[1]												
			MacArthur Cswy.	Biscayne Blvd	NE 2nd St	NW 1st Ave	NE 5th St	NE 8t St	N Miami Ave	NE 17th St	NE 13th St	NE 1st Ave	NE 41st St	NE 38th St	NE 2nd Ave

[3] Includes Miami-Dade County chilled water and associated power facilities

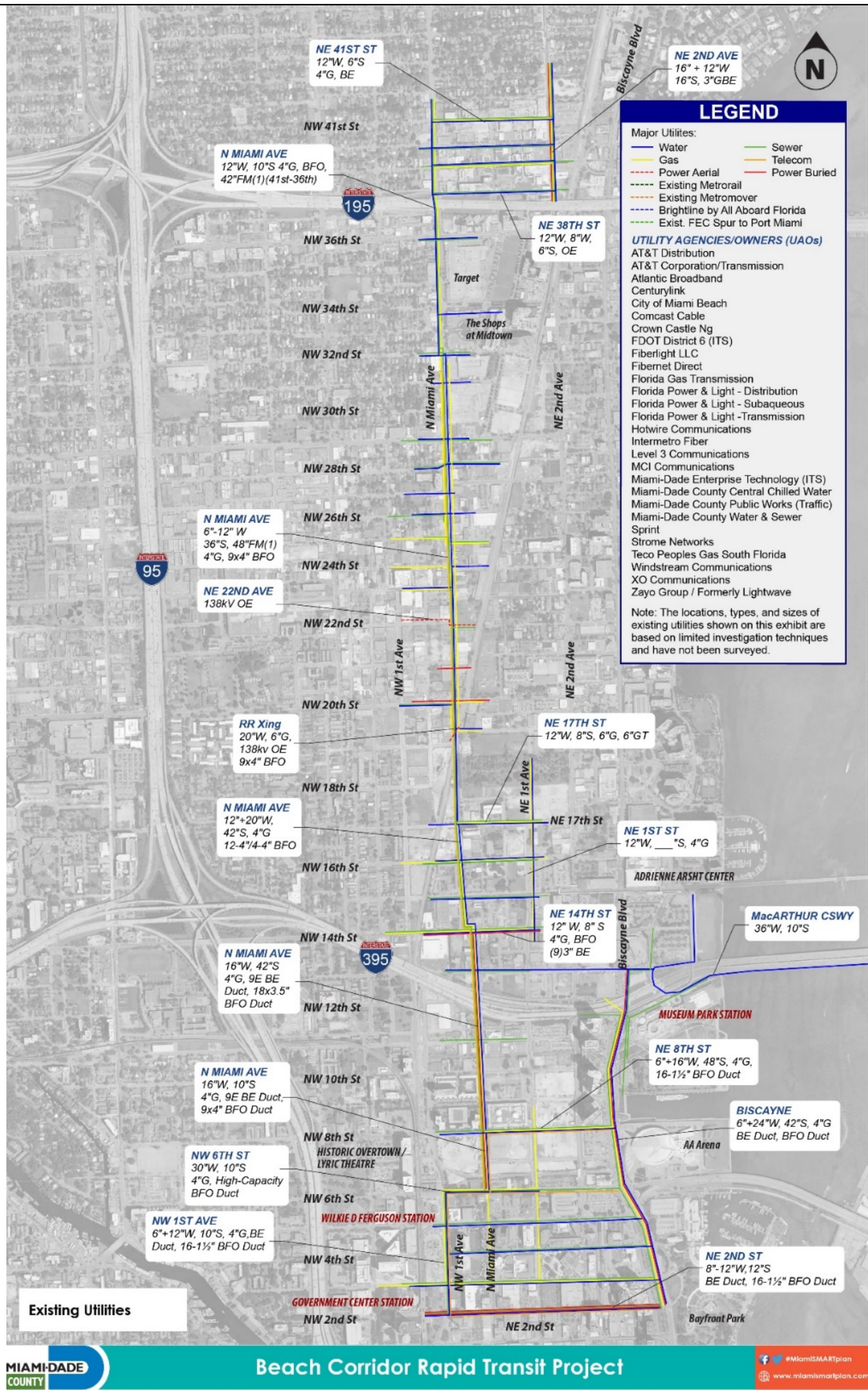


Figure 2.13 | Existing Utilities – Miami

Figure 2.14 | Existing Utilities – Bay Crossing and Miami Beach

3 PURPOSE, GOALS, AND EVALUATION CRITERIA

A draft purpose and need statement was developed to guide this Tier One Evaluation, including the identification of project goals and evaluation criteria. The statement will be further refined as the project development process progresses.

3.1 PROJECT CORRIDOR

The Miami-Dade County DTPW is conducting a PD&E study for the Beach corridor in collaboration with the FTA and FDOT. The study areas is shown below in **Figure 3.1**:

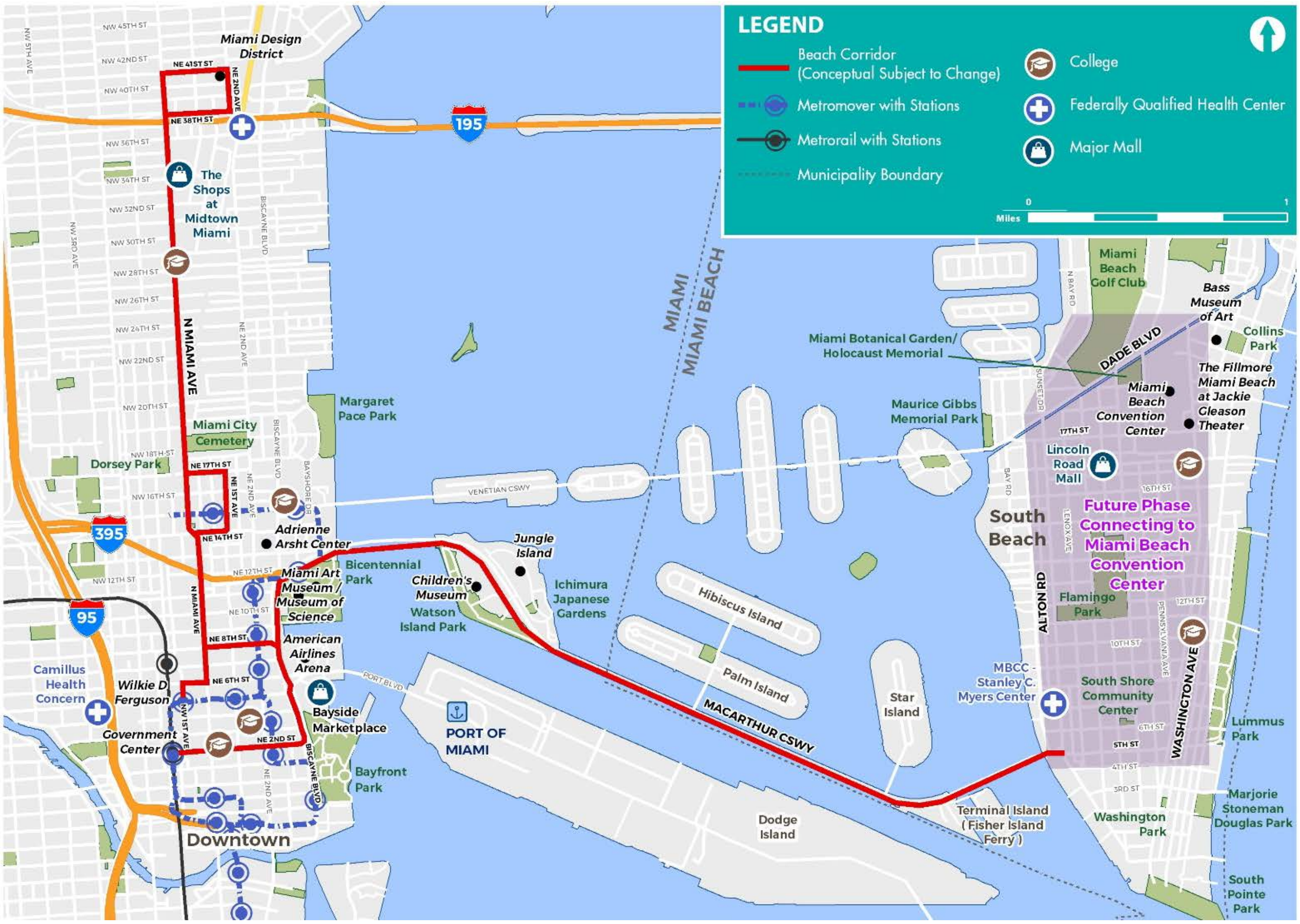


Figure 3.1 | Study Area

3.2 PROJECT PURPOSE

The purpose of the project is to increase the person-throughput to the Beach corridor's major origins and destinations via rapid-transit technology.

3.3 PROJECT NEED

The Beach corridor traverses an area which is at the epicenter of population and economic growth within Miami-Dade County. The central business district (CBD) area and Miami Beach within the county have undergone rapid population and employment increases over the past decade, a pattern that is projected to continue over the next 20 years. The population densities in the study area are among the highest in the nation, with Downtown Miami (CBD) at 17,800 persons per square mile and Miami Beach at 11,500 persons per square mile, per the 2010 U.S. Census. Downtown Miami saw a dramatic 172 percent increase in population density over the last decade.

Due to the region's appealing qualities, including its temperate climate, attractive beaches, and convenient access to the Caribbean and Latin America, Miami-Dade County has become an important tourist destination for both national and international visitors and hosts millions of annual visitors and seasonal residents. Visitors typically access the study area via tour bus, taxi, or rental car.

Miami Beach and Downtown Miami are the two most popular locations for overnight stays, lodging 60 percent of all 2012 visitors with approximately 5.8 million and 2.4 million overnight guests, respectively. Additionally, four of the six most-visited attractions are in close proximity to the beach corridor, including South Beach, the beaches, Lincoln Road, and Downtown Miami. The study area also contains PortMiami. In 2013, 4.1 million cruise ship passengers used the port, up from 3.4 million in 2000. This high rate of tourism generates additional demand for travel, produces additional trips within the area, and contributes to traffic and subsequently roadway congestion. The 2012 Visitor Industry Overview, a survey that reached 13.4 percent of all visitors that year, listed traffic congestion as the top negative aspect of trips to greater Miami. Traffic congestion has been the top-ranked problem in each of the last five annual surveys.

The project corridor includes two distinct travel markets: an east–west connection between Miami Beach and Downtown Miami (approximately 5 miles), and a north–south connection between the Design District/Midtown and Downtown Miami (approximately 3 miles).

In the east–west corridor, I-195 is operating at capacity and I-395 is experiencing traffic volumes that exceed its capacity by more than 50 percent. Existing bus transit service in the east–west corridor serves more than 17,000 riders per day, with the two most frequent routes at 72 percent and 89 percent of their existing capacity, respectively.

The north–south corridor is served by several local streets, operating at between 60 and 90 percent of capacity. The most frequent bus service in the north–south corridor operates at 87 percent capacity, while Metromover operates at 85 percent capacity. Currently, in the peak periods, transit travel times along the north–south and east–west corridors are more than double the automobile travel times. Average automobile volumes in the corridors serving the study area range from 39,000 along arterial roadways to 97,000 along I-395.

The upsurge in tourism, residential growth, and economic redevelopment in the study area have all generated additional demand for travel. Yet, the study area's growth and development is constrained by its natural geographic boundaries that significantly limit the availability of land for additional roadways and parking.

To retain and continue to attract such growth, more core capacity is needed to maintain mobility essential to sustainable growth.

3.4 PROJECT GOALS

The draft project purpose and need serves as the basis for project goals and evaluation criteria relating to the following:

- Connect to and provide direct, convenient, and comfortable rapid transit service to serve existing and future planned land uses
- Provide enhanced interconnections with Metrorail, Tri-Rail, Brightline, Metromover, Metrobus routes, Broward County Transit (BCT) bus routes, Miami and Miami Beach circulators, jitneys, shuttles, taxis, Transportation Network Companies (TNCs), and/or other supporting transportation services
- Promote pedestrian- and bicycle-friendly solutions in the corridors of the study area

3.5 TECHNOLOGIES CONSIDERED IN TIER ONE EVALUATION

DTPW identified the following transit technologies (modes) for consideration in the Beach Corridor Rapid Transit Project Tier One Evaluation:

- Automated guideway transit
- Streetcar/light rail transit
- Heavy/third rail transit
- Bus rapid transit
- Aerial cable transit
- Monorail
- Autonomous/connected vehicle transit

3.6 EVALUATION OF TECHNOLOGY/MODAL CHARACTERISTICS

The first step in the Tier One Evaluation was to identify the following key characteristics of technology/mode:

3.6.1 Typical Application of the Technology

- Line length: The typical length of individual lines in a system using the specified technology.
- Stop spacing: The typical distance between stops that is characteristic of the specified technology and mode
- Transit right-of-way: The operating environment of the mode, which may include mixed traffic (lane shared with general traffic), semi-exclusive (separate lane, stopping at intersections), exclusive (grade-separated), or a combination of these operating environments.
- The average operating speed typically achieved. Each technology has a maximum operating speed, but the average operating speed is influenced by constraints within the alignment such as grades, curves, deceleration and acceleration upon entering and exiting stations, stop spacing and, for modes operating at-grade and in mixed flow, traffic conditions and congestion.
- Peak service frequency
- Capital cost/mile
- Operating cost/mile

3.6.2 Technological Features and Requirements

- Vehicle length (single car)
- Passenger capacity per car/train: most rail vehicle technologies allow for "coupling" of train cars into "train sets." Additionally, light rail vehicles are offered as "articulated' cars of varying lengths, made up of multiple sections.
- Minimum turning radius: the tightest turn that a given transit technology is capable of making.
- Maximum grade: the steepest grade that a given transit technology is capable of climbing.
- Propulsion system: the power source and type of motor used to move the transit vehicle.
- Level boarding: The vehicle floor level at entry is level with the passenger platform.
- Low floor: The percentage of total vehicle floor area that is at the same level as the boarding level.

3.7 REPRESENTATIVE ALIGNMENT DEVELOPMENT AND SCREENING

To support the Tier One Evaluation of transit technologies/modes, alignment alternatives by mode were developed and screened to allow the evaluation of a representative alignment for each mode, including the identification of study area segments and, as applicable, operational concepts for serving the major origin and destination pairs.

The initial development and screening asked the following questions regarding the representative alignment:

- Is it duplicative of existing premium transit?
- Is it near existing transit to allow for integration?
- Is it serving existing/future land use, particularly mixed-use/high-density?
- Is it maximizing accessibility from surrounding areas?
- Can it incentivize redevelopment, increase densities, or lead to land-use changes?
- Is it efficient in terms of operations (ability to provide service to Midtown without having to go all the way to the beach and back)?
- Can the proposed alignment for premium transit fit within existing rights-of-way?
- Can we optimize existing rights-of-way (potential use of existing publicly owned lands)?
- Can we minimize construction costs and impacts by limiting the number of Florida East Coast (FEC) railway crossings, I-95/I-395/I-195 crossings, and Metrorail/Metromover crossings?
- Can we minimize potential impacts to major utilities?
- Can we minimize potential impacts to historic and environmental features?

The purpose of the representative alignments is to provide enough specificity about the application of each mode to the corridor to allow for a comparative evaluation of the modes. For those modes advancing to Tier Two, additional alignment alternatives will be developed in an effort to minimize costs and impacts, to improve performance, and to respond to additional public and agency feedback. The alignment alternatives study areas for Tier Two evaluation are discussed further in Section 5, Alternatives Evaluation.

3.8 TIER ONE EVALUATION CRITERIA FOR MODES AND REPRESENTATIVE ALIGNMENTS

The technology characteristics of each transit mode were considered in the context of the representative alignments, allowing for evaluation of the following criteria:

3.8.1 Transit Performance Criteria

- Interoperability and modal integration: The compatibility of the proposed mode with other existing and proposed transit modes, including the availability of one-seat rides between significant origins and destinations, the number of transfers required for trips between significant origins and destinations, and the horizontal and vertical separation between modes at significant transfer points.
  - Interoperability: The ability to operate contiguously as an extension of an existing technology/mode, offering one-seat rides, economies of scale in operations and maintenance, and the potential for a shared fleet/operations and maintenance facility.
  - Modal integration: Because there are several existing modes in operation in Miami, and because of limitations on the transit mode options that the City of Miami Beach is willing to consider, the Beach Corridor Rapid Transit Project will feature some transfers between modes for many of the possible trip origins and destinations. The quality of these intermodal connections in terms of the ease and location of transfer will influence the ridership of both the selected beach corridor technology and the overall transit system ridership.
- Operational speed and reliability: The average operating speed of the mode on the representative alignment, and the proportion of trips that are likely to achieve the scheduled times and/or headways.
- Resiliency: Considering the effects of climate change, including sea level rise and the increased frequency and severity of weather events, the relative resiliency of the mode to changing climatic conditions.
- Passenger capacity: The number of passengers that the mode can accommodate with a given service plan, as determined by the passenger capacity of vehicle technology, the average operating speed of the mode given the representative alignment, and the number of vehicle trips that will be required to meet the service plan. Adjustments to the operating plan to meet passenger demand will be considered in the Tier Two evaluation.
- Vehicle reliability and safety.
- Passenger amenities: Air-conditioning, ride comfort, passenger information systems, etc.

3.8.2 Technological Features and Requirements

- Scale/urban fit: The relationship of the infrastructure required by the transit mode to the scale of the pedestrian environment and the built environment, and the ability to fit the infrastructure into existing rights-of-way.
- TOD compatibility: The ability of the mode to support or catalyze TOD at station areas as influenced by the cumulative effects of the capacity of the mode and the compatibility of the mode with the scale of the built environment at station areas.
- Pedestrian/bicycle access: The positive or negative contribution of the mode to pedestrian and bicycle access in the corridor. This includes impacts of the infrastructure to pedestrian and bicycle facilities, as well as the potential for passengers to bring bikes onto the transit mode.

3.8.3 Environmental Effects Criteria

- Natural resources impacts
  - Wetland and other surface waters
  - Protected species and habitat
  - Coastal
  - Floodplain
- Socioeconomic impacts
  - Social/economic
  - Mobility
  - Relocation potential
  - Cultural
  - Historic/archaeological resources
  - Recreational facilities
  - Visual and aesthetic

- Physical impacts
  - Contamination
  - Noise and vibration
  - Air quality

3.8.4 Technological Features and Requirements

- Constructability: The ability to construct the project within the typical range of cost for the mode; cost-effectiveness to be considered as part of Tier Two Evaluation. This criterion addresses constraints and characteristics of the corridor which would influence the capital cost of a given transit mode as applied to this corridor.
- Operating cost: The ability to provide transit service of sufficient capacity to serve projected demand within the typical range of cost for the mode; cost-effectiveness to be considered as part of Tier Two Evaluation. This criterion considers the frequency of service that would be required for a given transit mode to provide sufficient capacity in this corridor.
- Eligibility for funding: The ability to meet required and desirable characteristics for federal funding, including ADA, Buy America, and service-proven technology.

4 SUMMARY OF TRANSIT TECHNOLOGIES AND MODES

4.1 INTRODUCTION

This section provides summary information about each transit technology/mode that is considered in the Tier One Evaluation, including the following topics:

- Technological features: Size and capacity of the transit vehicles, propulsion systems, guideway characteristics (such as elevated or at-grade), and the minimum turning radius and maximum grade capabilities of the vehicles. Unique characteristics such as battery technologies, passenger amenities, and safety are also addressed as applicable.
- Modal application: The typical application of the technology with respect to stop spacing, average operating speed, and total length.
- Alignment and station locations: A representative potential alignment and station locations that would be feasible for the beach corridor are identified, including a minimum operable segment that connects from Downtown Miami to Fifth Street and Alton Road in Miami Beach.
- Key constraints, and cost and feasibility issues: For each mode and alignment, any constraints that are significant to either the cost to build and operate the system or the feasibility of effective operations.
- The characteristics of the transit technologies/modes are summarized in Figure 4.1 and described below. Transit modes are evaluated in Section 5, Alternatives Evaluation.

4.2 AERIAL CABLE TRANSIT (AERIAL TRAM/GONDOLA)

4.2.1 Technology and Modal Characteristics

Technological Features: Aerial cable transit (ACT) is a technology that uses tensioned cables to support and propel suspended passenger cabins. On-board rechargeable batteries provide power for equipment such as lighting and doors. Air-conditioning is typically not provided, although there are systems in development that provide air-conditioning for short distances or durations (less than 5 minutes).

There are two types of ACT systems: detachable gondolas and fixed aerial trams. Gondolas feature small passenger cabins ranging from 8- to 35-passenger capacity depending on the number of cables used to support the cabin. Multiple closely-spaced gondolas travel in a loop, allowing for headways as short as 15 seconds. The maximum capacity of a gondola system is 5,000 passengers per hour per direction (assuming a tri-cable gondola with 35-passenger cabins operating at 15-second headways). Gondolas do not come to a complete stop at stations—passengers board slowly moving vehicles (50 feet per minute). To meet ADA, attendants are required at each station to assist passengers and, if necessary, stop the vehicles during boarding.

Aerial trams operate like elevators, traveling back and forth along the same cable. They feature larger passenger cabins than gondola systems (up to 200 passengers), but headways are limited by the end-to-end travel time, and therefore capacity is lower (500 to 1,500 passengers per hour per direction).

Modal Application: Aerial trams are typically implemented to make short-distance connections (1 mile or less) without intermediate stops to address issues such as steep grades or water crossings. Gondola systems can accommodate more station stops and have been implemented for lines of up to 6 miles.

Examples: The Portland Aerial Tram carries passengers from Portland's South Waterfront area to Oregon Health and Sciences University (OHSU), which includes a hospital/medical center. The tram alignment is 3,300 feet and rises 500 feet from the South Waterfront to OHSU. The tram cabins can accommodate up to 78 passengers and travel at up to 22 miles per hour, though they slow to a near stop at the midway point as they move through a

The Portland Aerial Tram connects the South Waterfront area to the OHSU medical campus.

	Automated Guideway Transit	Light Rail Transit			Heavy Rail Transit	Bus Rapid Transit		Aerial Cable Transit		Monorail	ATS
		Streetcar	Tram	Light Rail		Arterial BRT	Busway BRT	Gondola	Aerial Tram		
Typical Application											
Line Length	2-5 miles	2-5 miles	6-15 miles	15-30 miles	20-40 miles	10-20 miles	10-50 miles	1-3 miles	.5-1 miles	15-20 miles	TBD
Stop Spacing	.50 miles	.25 miles	.25-.50 miles	.50 miles	.25-2 miles	.50 miles	.75 miles	.50 miles	.50 miles	.50 miles	TBD
Transit Right-of-Way[1]	Exclusive	Mixed	Semi-Exclusive	Semi-Exclusive to Exclusive	Exclusive	Semi-Exclusive & Mixed	Exclusive	Exclusive	Exclusive	Exclusive	Semi-Exclusive & Mixed
Average Operating Speed	20 mph	10 mph	20 mph	35 mph	45 mph	20 mph	35 mph	15 mph	18 mph	35 mph	20 mph
Peak Service Frequency	2-6 mins.	10-15 mins.	6 mins.	6-10 mins.	2-10 mins.	10-12 mins.	8-12 mins.	15-60 secs.	4-15 mins.	4-10 mins.	4 mins.
Capital Cost/Mile	$100 Million	$40 Million	$60 Million	$75 Million	$200 Million	$10 Million	$25 Million	$55 Million	$60 Million	$110 Million	$10 Million
Technological Features & Requirements											
Vehicle Length (Single Car)	42′	66′ to 82′	120′ to 155′	82′ to 92′	70′ to 350′	60′	60′	15′	25′	42′	TBD
Passenger Capacity Per Car/Train	50/200	120/car	265 to 340/car	225 car/ 900 train	170/850	100	100	6-15	50-100	85/350	TBD
Minimum Turning Radius	98′	82′	82′	82′	90′	42′	42′	N/A	N/A	98′	TBD
Maximum Grade	10%	9%	7%	7%	6%	10%	10%	30%	30%	10%	TBD
Propulsion System[2]	AC Third Rail	DC OCS or OESS	DC OCS, OESS or APS	DC OCS	DC Third Rail	Diesel, CNG, Battery, DC OCS	Diesel, CNG, Battery	Haul Cable	Haul Cable	DC Third Rail	TBD
Level Boarding	✓	Optional	✓	✓	✓	Optional	Optional	✓	✓	✓	TBD
Low Floor	100%	50%-100%	100%	50%-100%	100%	0%-50%	0%-50%	100%	100%	100%	TBD
Representative System	Metromover	Seattle Streetcar	Team de Bordeaux	MAX (Portland)	Metrorail	Healthline (Cleveland)	RIT Curitiba (BR)	La Paz, Bolivia	Roosevelt Island, NY	Las Vegas, NV	N/A

Transit Right of Way[1]
Transit Right-of-Way: Operating environment of the mode, which may include mixed traffic (lane shared with general trafffic), semi-exclusive (separate lane, stopping at intersections), exclusive (grade-separated), or a combination of these operating environments.

Propulsion System[2]
Propulsion System: OCS=Overhead Contact System; OESS=On-Board Energy Storage System (Batteries or Supercapacitors); APS=Embedded powerrail.

MIAMI-DADE COUNTY
Beach Corridor Rapid Transit Project
Mode & Technolgy Characteristics
#MiamiSMARTplan
www.miamismartplan.com

Figure 4.1 | Mode and Technology Characteristics

Figure 4.2a | Aerial Cable Transit Representative Alignment – Miami

Figure 4.2b | Aerial Cable Transit Representative Alignment – Biscayne Bay/Miami Beach

support tower. With two trams in operation and an end-to-end travel time of 4 minutes, the typical headway is approximately 6 minutes. The cost to construct the tram was $57 million (in 2006 dollars). The round-trip fare is $4.70, but annual passes are available for $100, and annual/monthly passes for Portland light rail, bus, and streetcar are accepted as free transfers. As a result, the cost for daily riders is much lower than the cost for tourists or infrequent users.

4.2.2 Representative Alignment

As shown in Figures 4.2a and 4.2 b, the representative alignment for Tier One Evaluation includes a station north of I-395, which would provide access to the Metromover at Museum Park via a pedestrian bridge, and an alignment that generally follows MacArthur Causeway, including a Watson Island stop.

4.2.3 Key Constraints and Cost/Feasibility Issues

Geometric Constraints: Because ACT runs on suspended cables, the horizontal alignment must be straight between each station. Without the flexibility to make turns that follow roadways in an urbanized area with high-rise buildings, the technology is limited to the minimum operable segment with one station at each side of Biscayne Bay and an intermediate station at Watson Island. ACT does not appear to be a feasible technology to provide circulation to and within the Miami Design District and Downtown Miami.

Operational Constraints: With a maximum operating speed in the 15–20 miles per hour range, the travel time across the bay would be approximately 15 minutes, which is comparable to current travel times by bus transit. The capacity of the system, which could be in the range of 1,000–4,000 passengers per hour per direction, may not be sufficient to accommodate demand in the corridor.

4.3 AUTOMATED GUIDEWAY TRANSIT (METROMOVER EXTENSION)

4.3.1 Technology and Modal Characteristics

Technological features: Automated guideway transit (AGT) is a fully-automated transportation system with driverless vehicles operating on fixed guideways and exclusive rights-of-way (elevated in urban areas or in tunnels at airports). AGT trains operate on a two-rail guideway system with either rubber tires on concrete or steel guideway or steel wheels on steel rail.

Typically, AGTs, regardless of the technology or manufacturer, are defined by the following characteristics:

- Driverless/fully automated
- Operate on fixed guideway (usually elevated)
- Vehicles have rubber tires on concrete or steel surface

Miami currently has an AGT system in place, which is known as the Metromover. The existing vehicles have an overall body length of 39 feet, 8 inches, and body width of 9 feet, 4 inches. The minimum turning radius of the CX100 vehicle is 75 feet, and the maximum grade is 10 percent. The maximum operating speed is 25 miles per hour, but newer vehicles are expected to be able to achieve speeds of 35 miles per hour. In Downtown Miami, curves and stop spacing limit the Metromover to average operating speeds of 10 miles per hour, but AGT would be able to travel at or near the maximum operating speed for the bay crossing segment of the alignment.

Modal Application: Because the maximum operating speed of an AGT is lower than that of other rail modes operating on exclusive guideways, it is typically applied to relatively short corridors of 2–5 miles in length, with stop spacing of 0.25–0.5 miles.

Examples: Miami's Metromover is an automated, driverless, rubber-tired people-mover system located in the highly urbanized area of Downtown Miami. The original Metromover vehicle was the C100 vehicle, named because of its nominal capacity of 100 passengers. This specific AGT system design has been owned by multiple companies, and the name evolved to be the CX-100 vehicle, and then the Innovia vehicle for later versions. Currently, the Metromover vehicle design is owned and manufactured by Bombardier.

The Metromover system is a fully elevated AGT that spans an approximate system length of 4.4 miles with stations typically located every three city blocks. There are 21 stations extending from SW 14th Street in the Brickell financial district to the school board at NW 15th Street. Service on the Brickell and Omni loops is in a counterclockwise direction, while the service on the downtown loops is in a clockwise direction. Connections to Metrorail are provided at the Government Center and Brickell stations. The Third Street station is a transfer station for transfers between the Omni and Brickell loops, while the Arena/State Plaza station is a transfer station between all three loops. There are two stations (Fifth Street and Riverwalk) located immediately on either side of the Miami River that are approximately 70 feet above grade due to navigational clearance requirements over the Miami River.

The CX-100 vehicles can reach a maximum speed of approximately 32 miles per hour, but because the stations are closely spaced and there are numerous turns in the downtown alignment, the average operating speed of the system is 10 miles per hour.

4.3.2 Representative AGT Alignment

For the purposes of Tier One Evaluation of this technology, the AGT mode is assumed to follow the alignment shown in Figures 4.3a and 4.3b. This alignment connects to the existing Metromover system at three locations: the vicinity of the Wilkie D Ferguson, Jr., station (enabling connection to the Government Center station for transfer to Metrorail, bus, and the upcoming Brightline rail system), the Museum Park station, and between the First Street and College Bayside stations. The Metromover extension would be a spur of the existing Omni Loop east of the Museum Park station, which would then follow the MacArthur Causeway alignment to Miami Beach, and the westbound route would rejoin the Omni Loop east of the Arsht Center station.

The potential alignment traversing Biscayne Bay may utilize separate bridge structures (parallel to the existing bridges carrying I-395/MacArthur Causeway vehicular traffic) and generally follow a path on the south side of the existing Interstate. An additional alignment option can be considered at Watson Island in concert with a future proposed development, as shown in the figure.

Figure 4.3a | Metromover Extension Representative Alignment – Miami

Figure 4.3b | Metromover Extension Representative Alignment – Biscayne Bay/Miami Beach

4.3.3 Key Constraints and Cost/Feasibility Issues

Geometric Constraints: The Metromover's relatively small minimum turning radius and grade-separated nature allows this technology to navigate within the geometric constraints of the existing built environment, thus minimizing the need to acquire rights-of-way. It is possible that some existing on-street parking along N Miami Avenue, NW Fifth Street, and NE Second Avenue may be removed to accommodate the support structure of the elevated guideway system. Crossings with the planned reconstruction of the I-395 viaduct through the downtown area should be evaluated and will be further analyzed during the Tier Two phase.

Profile Constraints: Elevated guideway structures would be able to cross over existing structures or limited-access roadways.

Operational Constraints: Operating on a grade-separated guideway allows this technology to perform at consistent speeds and on a reliable schedule.

4.4 BUS RAPID TRANSIT

4.4.1 Technology and Modal Characteristics

Technological Features: Bus rapid transit (BRT) typically features 60-foot articulated buses, raised platforms at stations for near-level boarding, station amenities such as off-board fare payment and real-time arrival information, and some level of priority for operations, such as bus-only lanes and transit signal priority. Some BRT projects feature a "busway," with exclusive, grade-separated operations. Some BRT vehicles feature left-sided doors to accommodate center-running alignments and center-platform stations. BRT vehicles may be traditional diesel-powered buses, or may be powered with compressed natural gas (CNG), or battery-electric propulsion systems. The bus batteries can be charged during short station stops (station charging) or during longer layovers at terminus stations/maintenance facilities (depot charging). New technologies in development in China combine many of the characteristics of rail vehicles into a rubber-tired vehicle that offers passenger capacity, ease of access and ride comfort similar to rail vehicles without the expense of track installation (trackless train technology). If this technology becomes viable, it could likely be implemented at a cost closer to that of BRT than that of LRT.

Battery-powered buses and charging facilities.

Omnitrans sbX E Street BRT Vehicles, San Bernardino, California.

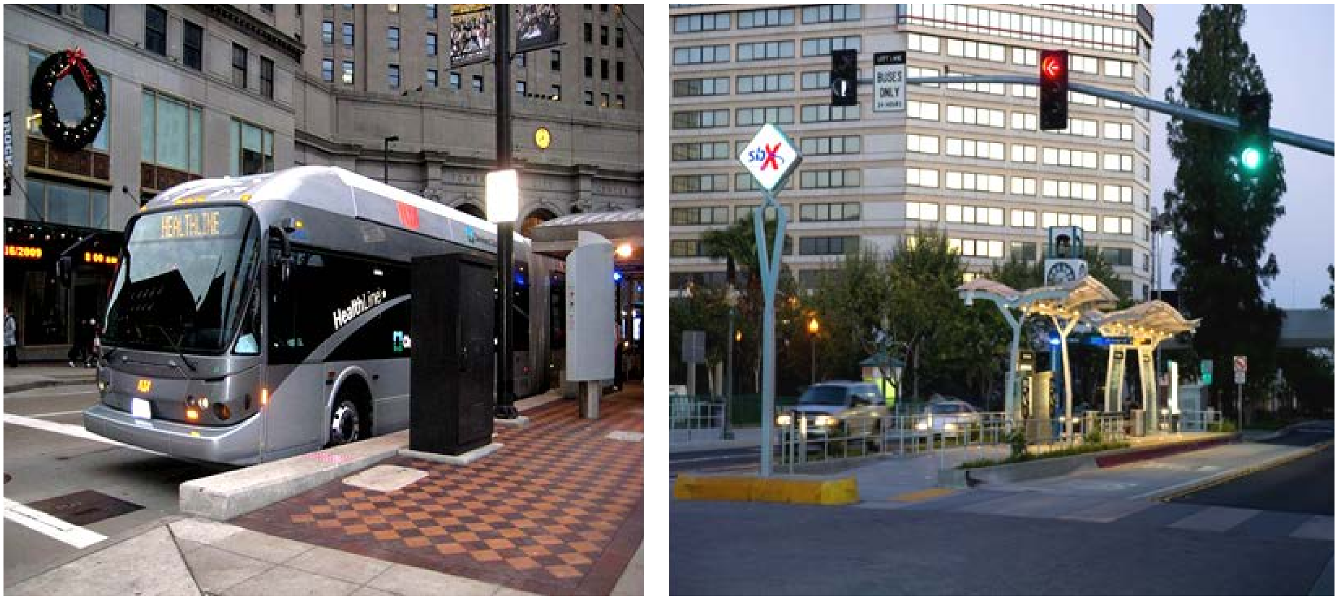
CRRC Corporation of China is developing a bus that offers a rail-like experience.

BRT stations range from simple platforms at sidewalk level with shelter/canopy structures and amenities such as off-board fare collection and real-time arrival information, to grade-separated structures similar to light rail stations, providing in-line stops in a highway right-of-way.

Modal Application: BRT typically employs low-floor, 60-foot articulated buses for easier access and higher capacity, operating with limited stops and enhanced stations (typically spaced 0.5–1 mile apart), faster operating speed due to transit signal priority (TSP) at intersections, and frequent headways (typically 5–10 minutes during peak hours). These capital investment elements ensure faster operating speeds, greater reliability of service, and increased convenience and passenger amenities.

Examples: Within the range of approaches and capital improvements, BRT can include buses using dedicated lanes (such as the Omnitrans sbX E Street BRT corridor in San Bernardino, California,); exclusive busways (such as the 19.8-mile South Miami-Dade Busway); shared high-occupancy vehicle (HOV) lanes for Express bus operations; or improved bus service in mixed-traffic flow on city streets.

South Miami-Dade Busway.



Cleveland Euclid Corridor HealthLine BRT (left) and Omnitrans sbX E Street BRT (right).

4.4.2 Representative BRT Alignment

As shown in Figures 4.4a and 4.4b, the representative BRT alignment developed for Tier One evaluation was assumed to operate on surface streets in the Midtown Miami/Design District and Downtown Miami, and in an exclusive busway on MacArthur Causeway, making 12 station stops for an average spacing of approximately 0.65 miles. The representative alignment assumes side alignment/stops, but center-running/center-platform configurations may be feasible for some segments of the alignment, which can be evaluated in Tier Two. Additional alignment considerations for Tier Two are discussed in Section 5.

The southbound/eastbound BRT route from the Institute of Contemporary Art in Midtown Miami to 5th Street/Alton Road in Miami Beach would depart from the Institute station at NE 2nd Avenue and travel south, turn right (west) onto NE 40th Street, then turn left (south) onto Miami Avenue, and continue to the 34th Street station (The Shops at Midtown Miami). The route would continue south on Miami Avenue to the 27th Street station, continue south to the 17th Street station, continue south to the 9th Street station, and then the route would turn right (west) on NW 6th Street to the NW 6th Street/Miami station. The route would continue west and then turn left (south) onto NW 1st Avenue to the NW 2nd Street station (Government Center and Metromover/Metrorail stations). The route would turn left (east) on NW 2nd Street and continue to the NE 2nd Avenue station (First Street Metromover station). The route would turn left (north) on Biscayne Blvd. and continue to the Biscayne Blvd./Port Blvd. station, then continue north and turn right (east) onto the on-ramp for the MacArthur Causeway, with a stop at Bayshore Drive and the on-ramp (Museum Park Metromover station). The route would continue east on MacArthur Causeway to the Miami Children's Museum station on Watson Island, and then continue east on the Causeway to the terminal station at 5th Street and Alton Road in Miami Beach. The 7.56-mile eastbound alignment includes a total of 12 stations with average spacing of 0.63 mile.

The westbound/northbound BRT route from the 5th Street/Alton Road station in Miami Beach to the Institute of Contemporary Art in Midtown Miami would depart from the 5th/Alton station, travel west on the MacArthur Causeway, and continue west to the Miami Children's Museum station on Watson Island. The route would continue west to the Biscayne off-ramp and the Biscayne/NE 13th Street station. The route would turn left (south) on Biscayne Blvd. and continue south to the 5th Street/Biscayne station (opposite the NB Biscayne/Port Blvd. station). The route would turn right (west) on NE 1st Street and continue to the NE 1st Street/NE 3rd Avenue station (near First Street Metromover station), then turn right (north) on NW 1st Avenue and continue to the NW 1st Avenue/NW 2nd Street station (Government Center and Metromover/Metrorail stations). The route would continue north on NW 1st Avenue and turn right (east) on NW 5th Street, continue east to the NE 5th Street/NE 1st Avenue station (College North Metromover station), then turn left (north) on NE 1st Avenue. The route would continue north on NE 1st Avenue to the NE 1st Street/NE 9th Street station, then turn left (west) on NE 17th Street, then turn right (north) to the 17th

Street station on Miami Avenue. The route would continue north on Miami Avenue to the 27th Street station, then on to the 34th Street station (The Shops at Midtown Miami), then turn right (east) on NE 41st Street, then turn right (south) on NE 2nd Avenue, and terminate at the Institute of Contemporary Art station. The 8.01-mile westbound alignment includes a total of 12 stations with average spacing of 0.67 mile.

Figure 4.4a | BRT Representative Alignment – Miami

Figure 4.4b | BRT Representative Alignment – Biscayne Bay/Miami Beach

4.4.3 Key constraints and Cost/Feasibility Issues

The representative alignment roadways are congested, especially in the urban core areas, which could limit the speed and reliability of service. Converting general-purpose lanes to transit-only lanes may be feasible for portions of the alignment, which will improve speed and reliability. These opportunities will be evaluated in Tier Two.

4.5 HEAVY RAIL TRANSIT (METRORAIL EXTENSION)

4.5.1 Technology and Modal Characteristics

Technological features: The heavy rail transit (HRT) options in this study will connect to the existing Metrorail system that is operated by DTPW. The existing system consists of two lines (Green and Orange) and includes 23 stations and a little more than 24 miles of track. Through the downtown area, the system is entirely aerial, on a dedicated, grade-separated right-of-way. Station platforms are typically 456 feet in length, with track alignments that allow for expansion to an ultimate length of 616 feet. The 456-foot length allows for operations of a six-car train, and ultimately an eight-car train. Currently, operations include both four-car and six-car trains.

The vehicles are 75 feet long (coupler-to-coupler) and 10 feet, 3 inches wide over the door threshold. Seating capacity is approximately 76, with "crush loading" of approximately 250 passengers per car. A four-car trainset could carry 304 seated passengers and 1,000 total passengers. The vehicles are propelled by AC propulsion equipment, powered by a 750-volt AC contact rail system.

Although the vehicles can traverse a curve with a radius as small as 250 feet (low-speed yard operations), the mainline design criteria specify a desired minimum radius of 1,000 feet (with smaller values requiring DTPW approval). It is anticipated that the future east–west corridor extension may involve a mainline radius of 350 feet. The design criteria indicate a maximum desired grade of 3 percent, but will allow 4 percent with DTPW approval.

Miami's elevated Metrorail HRT

Modal Application: HRT offers very high capacity with high speed and reliability, and therefore is typically applied to routes that serve high-density origins and destinations and may include both short and long trip lengths. HRT is typically implemented as a subway in dense urban areas, transitioning to elevated or fully exclusive at-grade alignments outside of the center city.

Stations on HRT alignments are typically spaced at 1-mile intervals on average. Frequently, the spacing of downtown stations is closer, and those further from the CBD are spaced a little farther apart, with the existing DTPW lines being no exception.

Although the vehicles and most horizontal curves are designed for a maximum operating speed of 70 miles per hour, DTPW limits operations to 58 miles per hour (which is the next-lower speed setting on the automatic train operations controller). When station stops and other restrictions are included, the average speed on the existing system drops to somewhere near 27–31 miles per hour.

Examples: The heavy rail options in this study will connect to the existing Metrorail system that is operated by DTPW. Similar HRT systems operate in many other cities, including Washington, D.C.; Baltimore, Maryland; Dallas, Texas; and San Francisco, California.

4.5.2 Representative HRT Alignment

A representative alignment for extension of Metrorail is shown in Figures 4.5a and 4.5b. The eastern extension that eventually crosses the bay connects to the existing system, with No. 15 turnouts just south of the existing Overtown/Arena Rail station. The alignment turns east and traverses NW and NE Second streets until it turns north along Biscayne Boulevard/US 1, then crosses the bay on a new structure immediately south of MacArthur Causeway/SR A1A, terminating in Miami Beach along Fifth Street/SR A1A. The large turning radius requirments for Metrorail limit the alignment options. Therefore, there would be separate spurs for connections to the Design District and to Miami Beach, and many origin-destination pairs would require transfers and out-of-drection travel.

The northern extension connects to the existing system on the east–west tangent (north of NW 11th Street) between the existing Culmer and Overtown/Arena Rail stations. The connections are made with No. 15 turnouts, and could not be made closer to the Overton/Arena station because of inadequate tangent lengths. The alignment goes east along NW 11th Street, and then turns north along N Miami Avenue.

Figure 4.5a | Metrorail Extension Representative Alignment – Miami

Figure 4.5b | Metrorail Extension Representative Alignment – Biscayne Bay/Miami Beach

4.5.3 Key Constraints and Cost/Feasibility Issues

Within the City of Miami area, there are several large buildings that conflict with the proposed alignment, even when using radii that are less than desired. Therefore, a Metrorail extension to serve the Beach corridor would have very high costs for property acquisition and significant impacts to economic development. A tunnel alignment could be considered, but similar impacts would result from the need to construct large tunnel portals and to purchase and clear private parcels for the approach segments for transitions from elevated to subway line segments. In a National Environmental Policy Act (NEPA) environmental process, the availability of reasonable alternatives to a Metrorail extension, and the degree of environmental/social impacts would make it unlikely that a Metrorail extension for the beach corridor could be approved and survive legal challenges.

The representative alignment would require two or three routes to provide service on the existing Metrorail routing, the Midtown/Design District route, and the direct connection to Miami Beach. The introduction of additional routes would adversely affect the frequency of service on the system. When two routes share a common section of track, the frequency of service within the common area is a combination of that of the two separate routes. For example, if each route has 10-minute headways, then the common portion will have 5-minute headways.

4.6 LIGHT RAIL/TRAM/STREETCAR

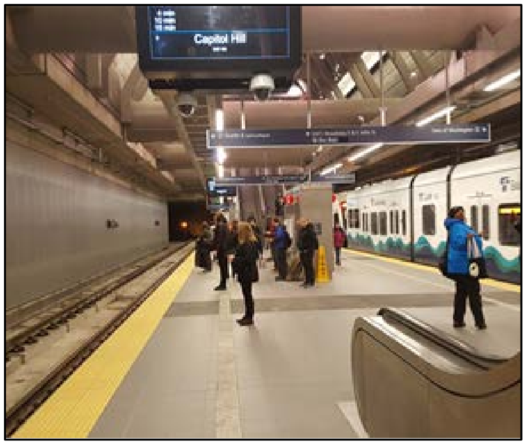
4.6.1 Technology and Modal Characteristics

Technological Features: Light rail vehicle (LRV) technology features railcars that operate on steel wheels/rails with electric propulsion, level boarding, air-conditioning, passenger information systems, and double-leaf doors. LRVs range from 8–10 feet in width and from 66-foot, three-section, single-unit trains (modern streetcar) to 400-foot, four-car trainsets (light rail transit or LRT) in length. Trams, as implemented in Europe, are typically five- to seven-section, single-unit trains ranging from 98–155 feet in length. LRVs also vary in their minimum turning radius and maximum grade capabilities and can be powered via an overhead contact, battery power, or embedded third-rail power system (the latter limited to trams comprised of at least five sections because of requirements for the length of the train). Streetcars and trams are now offered with a variety of off-wire technologies, allowing them to operate off-wire in some segments with power supplied via on-board rechargeable batteries or in-ground power systems. The off-wire capability can be applied to avoid overhead obstacles such as low-clearance bridges, or in areas where overhead wires are not locally acceptable for visual/aesthetic reasons. These vehicles offer “hybrid” operation, so they can operate with power from an overhead wire in segments where off-wire is not required. The battery-drive systems have significant range (for example, streetcars in Seattle travel off-wire for 3 miles on each round trip). The in-ground systems have unlimited range but require a somewhat longer, tram-style vehicle to provide adequate spacing of the in-ground electrical relays. This allows the power system to be safely turned on while the train passes over the power source and off when the train is not present.

Modal Application: Modern streetcars are typically operated in mixed-traffic flow at low speeds with relatively close stop spacing, with lines of up to 5 miles in length. Modern trams are typically operated in a mix of dedicated surface lanes and exclusive lanes at-grade, with varied stop spacing (tighter at the most central urban locations) and lines of 5–15 miles in length. LRT systems are typically operated in a mix of dedicated lanes and fully grade-separated guideways (elevated or subway), operating at high speeds over lines of 15–50 miles in length. Most of these differences in the typical modal application of the different LRV types are not mandated by the type of vehicle, so there is flexibility to customize the application of any of the modes to the needs of a given community and alignment, as noted in the examples below.

Examples:

- LRT
  - o Seattle's Link light rail system operates primarily in tunnels and on elevated guideways, with a 3-mile, at-grade section that operates in an exclusive median with signal pre-emption at intersections. This system also features 400-foot platforms that can accommodate four-car trainsets. These features make it very similar to heavy rail in speed, reliability, capacity, and construction cost.



Link light rail arriving at a tunnel station in Seattle.

  - o Portland's MAX light rail system features a broad range of applications, from tunnels and elevated guideways to at-grade operations through downtown Portland. The MAX platforms are shorter for a better fit with urban settings, which limits the operation to two-car trainsets.

Two-car MAX light rail train operating at-grade in downtown Portland.

- Tram
  - The Tramway de Bordeaux in Bordeaux, France, uses trains with five to seven sections for greater capacity than streetcars, and uses a ground-level power supply to provide for off-wire operation through historic city center.

Off-wire operation of the Tramway de Bordeaux allows integration of the tram into the historic city center.

The Tramway de Bordeaux features an in-ground power-supply that is activated only when the tram is passing over the power rails.

- Streetcar
  - The Seattle Streetcar uses rechargeable batteries to power the streetcars through a 3-mile off-wire segment. These three-section streetcars operate primarily in mixed flow with general purpose traffic, but approximately 1 mile of the system operates in exclusive transit-only lanes that are shared with buses.

The Seattle Streetcar operating on battery power to avoid conflicts with the existing overhead trolley bus system.

4.6.2 Representative LRT Alignment

The representative alignment developed for Tier One evaluation, as shown in Figures 4.6a and 4.6b, would operate in an exclusive right-of-way, primarily on a new structure along the south side of MacArthur Causeway, and in a combination of mixed-flow and semi-exclusive lanes at-grade in Downtown Miami and Midtown/Design District. The alignment includes a Downtown Miami loop route, as well as a route that would continue north through Midtown/Design District before returning to Downtown Miami and the bay crossing. This would allow for operation of two routes—one of which would bet through-routed to Miami Beach, and the other that would return to the Design District via the downtown loop. The representative alignment assumes vehicles with off-wire capability for segments that cross beneath I-395, I-195, and certain downtown roadways.

The representative alignment assumes a three-section, 75-foot streetcar vehicle with 80-foot platforms, but could be adjusted to five-section, 98-foot tram technology; the type of off-wire technology and the length of the vehicle will be determined after Tier One. Additionally, after Tier One, side- and center-alignment options will be revisited and optimized. Additional alignment considerations for Tier Two are discussed in Section 5.

Figure 4.6a | Light Rail Transit Representative Alignment – Miami

Figure 4.6b | Light Rail Transit Representative Alignment – Biscayne Bay/Miami Beach

4.6.3 Key Constraints and Cost/Feasibility Issues

Geometric Constraints: This technology is one of the most flexible in its ability to conform to existing geometric constraints because of the tighter turning radii available with the tram and streetcar sub-technologies of LRT.

Profile Constraints: This technology is also flexible in terms of profile. It can operate at-grade through surface street intersection and transition onto elevated guideway structures as needed to cross over existing structures or limited access roadways.

Operational Constraints: This technology option would operate at-grade in Downtown Miami, which will limit speed and reliability due to congestion in the urban core. There may be opportunities to mitigate this limitation through the use of dedicated lanes and signal priority. Without dedicated lanes and signal priority, the surface street portion of the alignment will likely operate at average speeds of about 10 miles per hour; with dedicated lanes and priority, the average operating speed could be improved to about 15 miles per hour. In exclusive guideway across the bay, the average operating speed would be approximately 35 miles per hour.

4.7 MONORAIL

4.7.1 Monorail Technology and Modal Characteristics

Technological Features: Straddle monorail technology features railcars that operate on concrete beam guideways, with rubber drive wheels that run on the top of the beam and guide wheels running along the two sides. Traction power is supplied by a trolley wire mounted on the sides of the guideway beam, and electricity is picked up by shoes on the vehicle. Monorail vehicles are 10 feet wide and roughly 35–45 feet long (can vary by manufacturer), and may be operated in two- to eight-car trainsets. Monorails have a minimum turning radius of 130–150 feet and can handle grades as steep as 10 percent.

Modal Application: Monorails are operated on an exclusive guideway separated from vehicular traffic, typically via elevated structure supported by columns. The average length of a monorail system is about 10 miles with an average station spacing of 0.5–1 mile. Typical monorail systems are automated and operate at a top speed of 55 miles per hour.

Examples:

The Seattle monorail guideway in downtown Seattle.

Passengers wait to board the Seattle monorail.

4.7.2 Representative Monorail Alignment

As shown in Figures 4.7a and 4.7b, the representative alignment developed for Tier One evaluation would begin in the Design District and follow N Miami Avenue to the downtown area, where it would use NW First Ave, NE Second Street, and Biscayne Boulevard to make stops at locations such as Government Center, Bayfront Park, AA Arena, and Museum Park. The alignment would then cross the bay by following alongside MacArthur Causeway to the south, stopping at Watson Island, and Fifth Street and Alton Road. Additional alignment considerations for Tier Two are discussed in Section 5.

Figure 4.7a | Monorail Representative Alignment – Miami

Figure 4.7b | Monorail Representative Alignment – Biscayne Bay/Miami Beach

4.7.3 Key Constraints and Cost/Feasibility Issues

Geometric constraints: In the downtown area, the alignment must traverse some areas where right-of-way is tight, requiring curves that push the limits of what the infrastructure/vehicles can handle. Further engineering needs to be done to minimize impacts.

Operational constraints: The smaller-radius curves in the downtown area will impact the speed of the vehicles, creating a longer transit time through downtown and limiting the speed advantage that monorail technology has over AGT technology.

Safety requirements: National fire/life safety guidelines recommend a walkway located along one side or in the center of an aerial structure to provide an alternative means of moving passengers from the vehicle to a point of safety (i.e., the next station). If such a walkway is required for a new monorail system, the walkway would impact cost, environmental impact, and the ability to design a system that will fit within the constraints of the built environment. As part of the Tier Two evaluation, the safety issues and possible requirement for a walkway will be reviewed in detail with the Federal Transit Administration and local agencies.

4.8 CONNECTED/AUTONOMOUS VEHICLES–AUTOMATED TRANSIT SYSTEMS

4.8.1 Technology and Modal Characteristics

Technological Features: Autonomous vehicle technology uses advanced control systems and sensory information to navigate without human input. Connected vehicle technology incorporates information transmitted by other vehicles and by traffic signals. The combination of these technologies could allow vehicles to operate more efficiently on existing roadways, yielding higher capacity and higher average operating speeds. Together, autonomous and connected vehicle technology could be applied to vans or buses to create automated transit systems (ATS).

Modal Application: For the Tier One Evaluation, application of ATS to the Beach corridor is assumed to be a variation of the BRT mode, with the added characteristics of autonomous and connected vehicle features that may allow for more frequent and reliable service.

Examples: Currently, apart from fixed-guideway, automated-guideway transit systems, no fully autonomous transit operation exists. However, some transit operators are beginning to incorporate driver-assistive ATS technology into conventional transit vehicles for BRT operations in Minneapolis, Minnesota, and Eugene, Oregon. The Jacksonville Transit Authority is planning for conversion of the Jacksonville Skyway into the "Ultimate Urban Circulator," which would run automated shuttles on the elevated guideway system, rather than vehicles on tracks. This will allow for some future extensions to be at-grade, rather than limiting extensions to additional elevated segments.

There have been several demonstrations or pilots of fully autonomous transit vehicles, primarily in western Europe. Such demonstrations use small, electric, low-floor transit vehicles with capacities of up to 15 passengers and operating speeds of up to about 20 miles per hour. These projects suggest that the opening stages of functional autonomous transit will utilize small, electric vehicles on geofenced shuttle or circulator routes operating on exclusive right-of-way.

At the time of this report, no major high-occupancy bus manufacturer has a fully autonomous vehicle in production, and only one (Nova Bus/Volvo) offers driver-assistive technology on its vehicles. Mercedes-Benz is actively developing a semi-autonomous bus based on sensors now deployed on its Actros truck platform, and an electric bus manufacturer (Proterra) has partnered with the University of Nevada-Reno to pilot self-driving technology in Reno, Nevada.

Oklahoma City recently conducted an Autonomous Streetcar Study and recommend a pilot project that would introduce one driverless streetcar into operation on the new streetcar line that is scheduled to open in late 2018; the target date for implementation of the pilot project is 2021.

4.8.2 Example ATS Vehicles Currently Developed

4.8.3 Representative ATS Alignment

The ATS mode is assumed to follow the same alignment as the BRT option described in section 4.4.

4.8.4 Key Constraints and Cost/Feasibility Issues

Operational Constraints: ATS would realize siimilar average operating speeds and travel times as BRT (Table 4.1) when operating along the same routes with similar station spacing.

5 ALTERNATIVES EVALUATION

5.1 INTRODUCTION

The following transit modes are recommended for further evaluation because the Tier One Evaluation shows that these modes have the potential to meet the project goals of providing direct, convenient, and comfortable rapid-transit service, enhanced intermodal connections, and pedestrian- and bicycle-friendly solutions in the corridor.

- Monorail
- Automated guideway transit (AGT/Metromover expansion)
- Bus rapid transit (BRT)/Express Bus, including the potential to incorporate automated transit system (ATS) technologies
- Light rail transit/streetcar (LRT)

The potential to meet the project goals with these transit modes is demonstrated in the evaluation of these modes regarding transit performance; economic and community development benefits; environmental effects; and cost and feasibility; as shown in Figure 5.1 and described below. Based on the results oft of the Tier One evaluation, technologies that require at-grade operations or dedicated lanes in the urban congested core of Downtown Miami (LRT and BRT), will not be considered in Tier Two within those subareas. Bus technology applications will be limited to express bus alignments along the major expressways serving the study area and a potential for crossing the Bay area using a repurposed typical section for MacArthur Causeway.

The Tier One evaluation demonstrated that the recommended modes differ in their suitability to sub-areas of the study corridor. Four distinct segments were identified for consideration in Tier Two, with approximate study area boundaries indicated in Figures 5.2 and 5.3:

- Design District
- Downtown Miami
- Bay Crossing
- Miami Beach.

5.1.1 Recommended Tier Two Study Areas

The recommended Tier Two study areas for alignment alternatives by mode, as shown in Figures 5.2 and 5.3, are:

- Monorail: Recommended for study of alignment alternatives in the Design District, Downtown Miami, and Bay Crossing segments.
- Metromover: Recommended for study of alignment alternatives in all segments (Design District, Downtown Miami, Bay Crossing and Miami Beach).
- BRT/Express Bus: Recommended for BRT and/or Express Bus study from Downtown to Convention Center (with a repurposed typical section along the Causeway and a dedicated lane in Miami Beach) and Express Bus along a freeway loop alignment using I-95, I-195, I-395 in Miami and 5th street, Washington and Alton Roads in the Miami Beach segment.
- LRT/Streetcar: Recommended for study of alignment alternatives in the Design District, Bay Crossing, and Miami Beach segments.

For each of these study area segments and modes, the Tier Two evaluation will consider additional alignment alternatives and will not be limited to the representative alignments that were developed for Tier One evaluation. Alignment segments that have been demonstrated in Tier One to have significant flaws (including at-grade LRT and BRT alignments in the Downtown Miami segment) will not be advanced in Tier Two.

	Automated Guideway Transit	Ligh Rail Transit/ Streetcar	Heavy Rail Transit	Bus Rapid Transit	Aerial Cable Transit	Monorail	ATS
Transit Performance Criteria							
Interoperability/Modal Integration	●	◑	●	◑	○	◔	◑
Operational Speed & Reliability	◕	◑	●	◑	◑	●	◑
Resiliency	●	◔	●	◑	◕	●	◑
Passenger Capacity	◑	◕	●	◑	◔	●	◔
Vehicle Reliability & Safety	●	●	●	●	◔	●	◕
Passenger Amenities	◕	●	●	◑	○	●	◑
Economic & Community Development Criteria							
Scale/Urban Fit	◔	●	○	◑	○	○	◕
TOD Compatibility	◑	●	◕	◑	○	◕	◔
Ped/Bike Access	◑	◕	◑	◑	○	◑	○
Environmental Effects Criteria							
Natural Resources	◑	◕	◕	○	◕	◕	○
Socio Economic Impacts	◕	◔	◕	◔	◑	◕	◔
Physical Impacts	◑	◕	●	◔	○	◔	○
Cost & Feasibility Criteria							
Constructability	◑	◔	●	◔	◕	●	○
Operating Cost	◑	◑	●	◑	●	◑	◔
Eligibility for Funding	●	●	◕	●	○	●	◑

LEGEND

Lowest Benefit ○ ◔ ◑ ◕ ● Most Benefit

Lowest Impact/Cost ○ ◔ ◑ ◕ ● Highest Impact/Cost

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Figure 5.1 | Evaluation Matrix

Figure 5.2 | Tier Two Alignment Study Areas—Design District Segment & Downtown Miami Segment

Figure 5.3 | Tier Two Alignment Study Areas—Bay Crossing Segment & Miami Beach Segment

5.2 MONORAIL

5.2.1 Transit Performance Criteria

Interoperability and Modal Integration: A monorail system would provide one-seat rides from Fifth Street and Alton Road in Miami Beach to destinations in Downtown Miami and the Design District. An elevated station at Museum Park would allow for an easy transfer to Metromover. The representative alignment developed for Tier One analysis assumes that connecting service on Metrorail would require either a second transfer (from Metromover) at Government Center station, or a walk of approximately 200 feet. In Tier Two, options that may provide a more direct connection to Metrorail will be analyzed. A monorail system would not extend an existing mode of transit, and it is unlikely that a monorail extension beyond 5th Street/Alton Road in Miami Beach would be feasible given existing historic resource areas.

Operational Speed and Reliability: As a grade-separated system operating on an exclusive, elevated guideway, monorail would provide fast, reliable travel times and headways with a significant travel-time advantage over existing modes of travel.

Resiliency: As an elevated mode with a power-supply system integrated into the guideway structure, monorail is expected to perform well with respect to resiliency issues such as flooding and high winds.

Passenger Capacity: Monorail is a high-capacity system. Based on the service plan shown in Appendix A, the peak hour passenger capacity per direction would be approximately 1,600 passengers, and daily capacity would be in the range of 35,000.

Vehicle Reliability and Safety: Monorail is a proven technology that operates safely and reliably.

Passenger Amenities: Monorail provides excellent ride comfort and a 100 percent low-floor vehicle.

5.2.2 Economic and Community Development Criteria

Scale/Urban Fit: Monorail transit requires large support columns for elevated guideway structures that may be considered out of scale with the urbanized settings of the Beach corridor and could impact the existing roadway and pedestrian environment. Figure 5.4 presents a plan view of a monorail station if constructed within a 70’ street right-of-way. Figures 5.5 and 5.6, respectively, present typical sections of monorail transit on N Miami Avenue and on I-395/MacArthur Causeway.

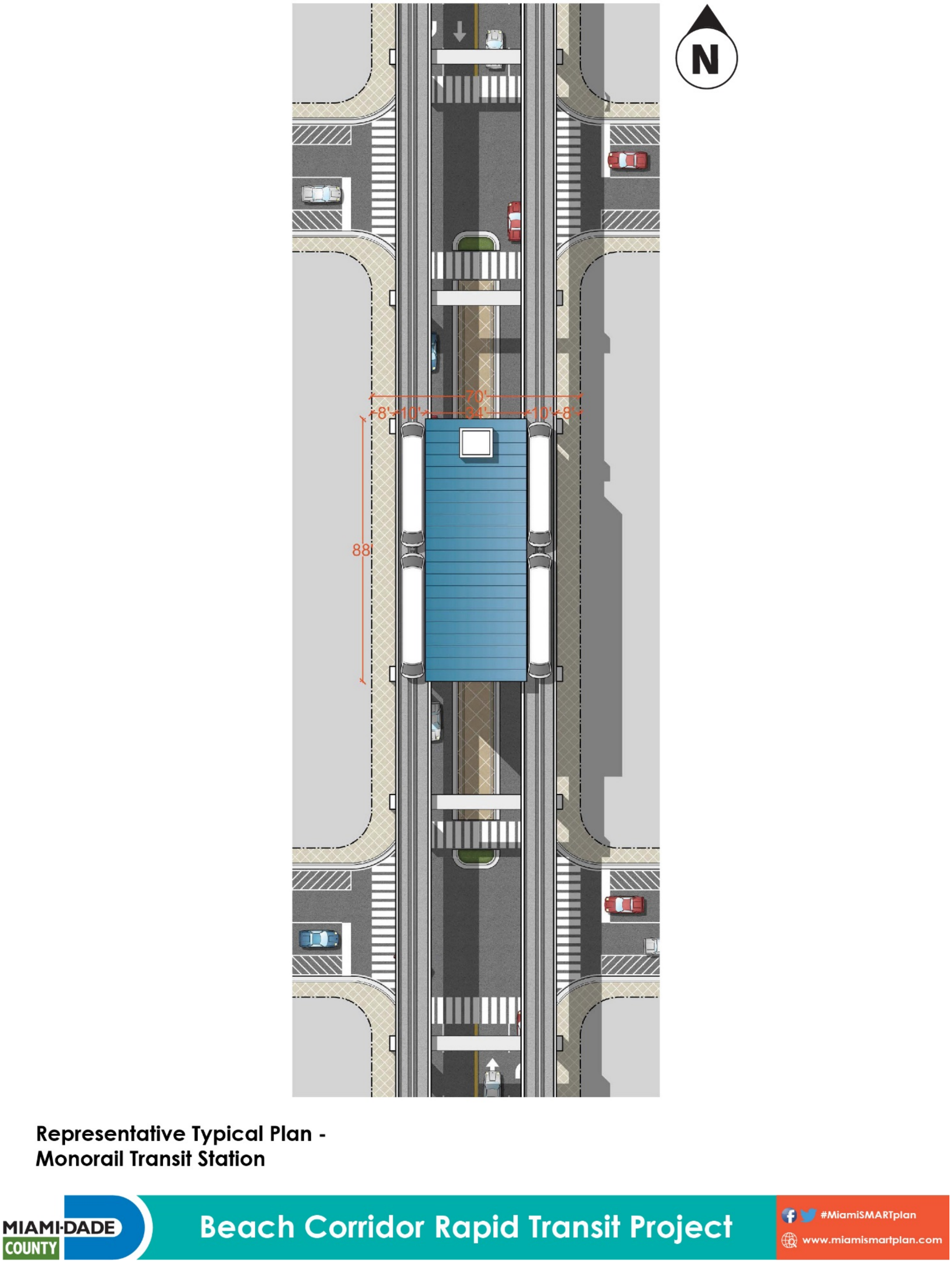

Figure 5.4 | Proposed Typical Plan – Monorail Transit Station

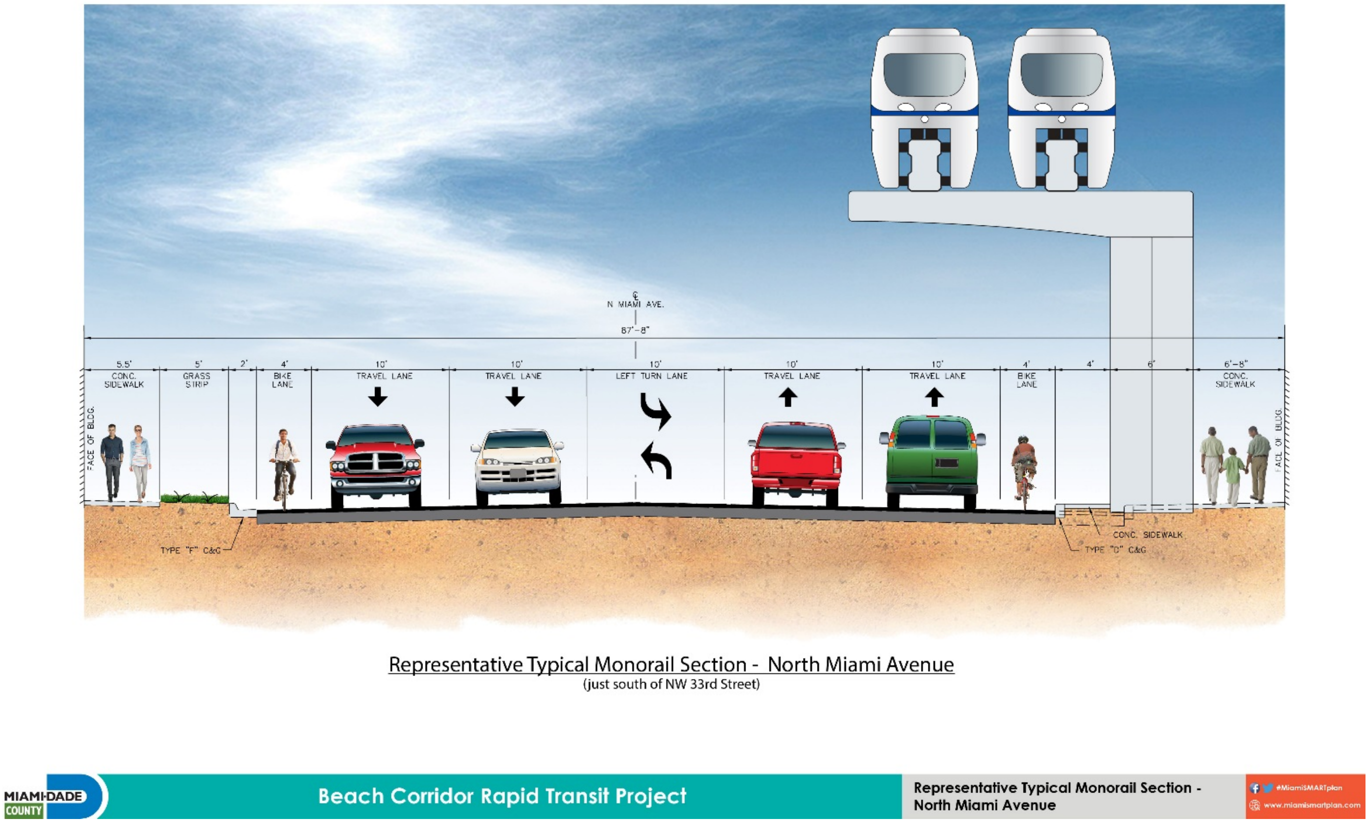

Figure 5.5 | Representative Typical Monorail Section – N Miami Avenue

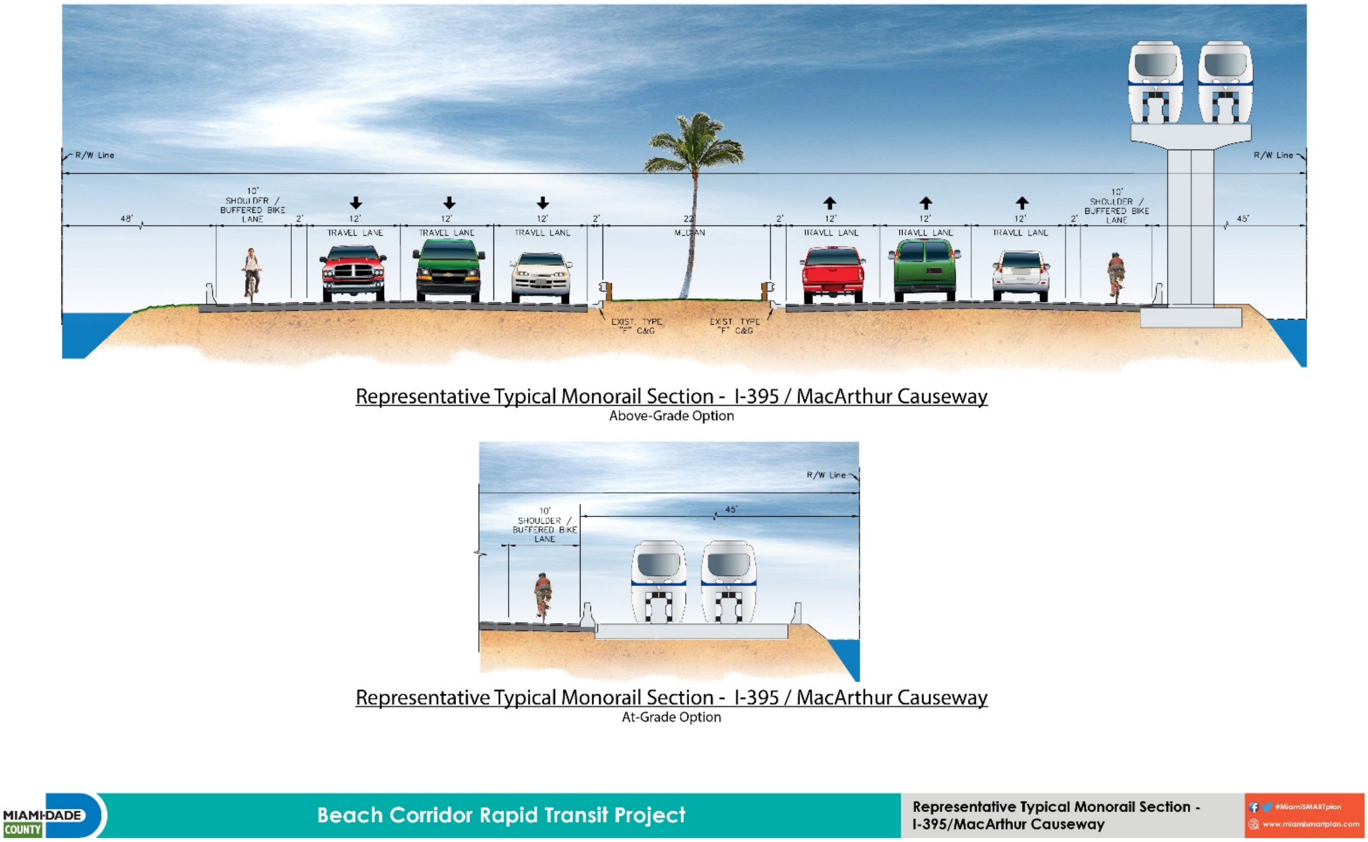

Figure 5.6 | Representative Typical Monorail Section – N Miami Avenue

TOD Compatibility: Monorail has the potential to facilitate TOD by providing a high-capacity, high-ridership mode of transit with recognizable stations. In some areas, the visual impact of the monorail infrastructure might detract from the TOD opportunities.

Pedestrian/Bicycle Access: Monorail stations and vehicles are accessible for people with bicycles and could accommodate bicycles on board (either by installing bike racks or allowing passengers with bikes to hold them upright during travel). The guideway support columns may have some adverse impacts to pedestrian and bicycle facilities. As compared with an at-grade mode, elevated stations are not as convenient for pedestrians, requiring use of escalators and elevators which may experience reliability issues.

5.2.3 Environmental Effects Criteria

Social and Economic: Monorail would be elevated throughout much of the corridor. Access and lack of connectivity with other modes of transit (e.g., Metromover) may limit use by some of the population of the area. However, this mode of transit is fast and reliable, with high-capacity, which is a benefit for residents and visitors.

Cultural: Construction within the existing right-of-way reduces impacts to historic/archaeological resources and other community services and resources. However, construction of the piers for an elevated structure may cause vibrations that could potentially affect historic structures. This would be evaluated during Tier 2.

Natural: If no construction work is performed within Biscayne Bay, impacts to wetlands (seagrass) and marine protected species would be minimal. An elevated monorail also has less impact to the floodplain than at-grade alternatives.

Physical: Physical impacts from noise are less with monorail than with other forms of transit. The Downtown Miami area of the project has several potential contamination sites, which would need to be evaluated in the Tier 2 analysis.

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5.2.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment, inclusive of a maintenance facility and vehicles, is in the range of $900 Million (M) to $1.1 Billion (B). The cost-effectiveness of the mode will be evaluated in the Tier Two Evaluation, which will also feature consideration of additional alignment alternatives.

Operating Cost: The estimated annual operations and maintenance cost of the monorail mode, based on a service plan assuming 5-minute peak headways as shown in *Appendix A*, is $18 million.

Eligibility for Funding: Monorail is a service-proven technology, ADA-compliant, and available as Buy America compliant.

5.2.5 Tier Two Alignments

Tier Two evaluation will consider monorail alignments within the Design District, Downtown Miami and Bay Crossing segments within the study areas shown in Figures 5.2 and 5.3.

5.3 AUTOMATED GUIDEWAY TRANSIT (METROMOVER EXPANSION)

5.3.1 Transit Performance Criteria

Interoperability and Modal Integration: An extension of the AGT/Metromover system would provide the best opportunity for interoperability with existing transit. An extended Metromover would provide one-seat rides from Fifth Street and Alton Road in Miami Beach to destinations in downtown served by the existing Metromover stations at Museum Park, 11th Street, Park West, Freedom Tower, College North, Wilkie D. Ferguson, Government Center, First Street, and College Bayside, and to new stations on a Metromover extension to the Midtown/Design District area (Figure 5.7). Additionally, this mode would provide for easy transfers at Government Center to reach destinations served by Metrorail (including Miami International Airport) and the Metromover Brickell Loop.

Operational Speed and Reliability: As a grade-separated system operating on an exclusive, elevated guideway, the Metromover would provide reliable travel times and headways. Average operating speed on the existing system is relatively slow (10 miles per hour) due to stop spacing and curves, but the bay-crossing segment of the system would operate at or near the top speed of the vehicles (approximately 30 miles per hour), resulting in a crossing time of approximately 7 minutes that would provide a significant travel-time advantage over existing peak-period options.

Resiliency: As an elevated mode with a power-supply system integrated into the guideway structure, AGT is expected to perform well with respect to resiliency issues such as flooding and high winds.

Passenger Capacity: The existing Metromover platforms would constrain the system to two-car trains. Based on the service plan shown in *Appendix A*, the peak-hour passenger capacity per direction would be approximately 500 passengers, and daily capacity would be in the range of 12,000. AGT systems often operate with very frequent service to provide passenger capacity to meet demand; potential service plan modifications to provide additional capacity will be considered in the Tier Two evaluation.

Vehicle Reliability and Safety: AGT is a proven technology that operates safely and reliably.

Passenger Amenities: AGT provides excellent ride comfort and a 100 percent low-floor vehicle, and the system is familiar to travelers around the world, as it is ubiquitous in airports. However, they are mostly used for shorter trips, where standing during the ride is less of a concern.

5.3.2 Economic and Community Development Criteria

Scale/urban fit: As an elevated transit mode, the Metromover has some negative impacts within urban areas, such as Downtown Miami and the Design District, in terms of both visual impact and impacts to existing roadway and pedestrian infrastructure where support columns and station entries would be placed. The relatively tight turning radii that AGTs can accomplish allow them to follow existing rights-of-way without requiring extensive property acquisition and demolition of existing buildings. Figure 5.8 presents a plan view of a Metromover station if constructed within a 70-foot street right-of-way. Figures 5.9 and 5.10, respectively, present the existing North Miami Avenue roadway cross-section and the potential cross-section after construction of a Metromover extension. Figures 5.11and 5.12, respectively, present the existing I-395/MacArthur Causeway roadway cross-section and the potential cross-section after construction of a Metromover extension.

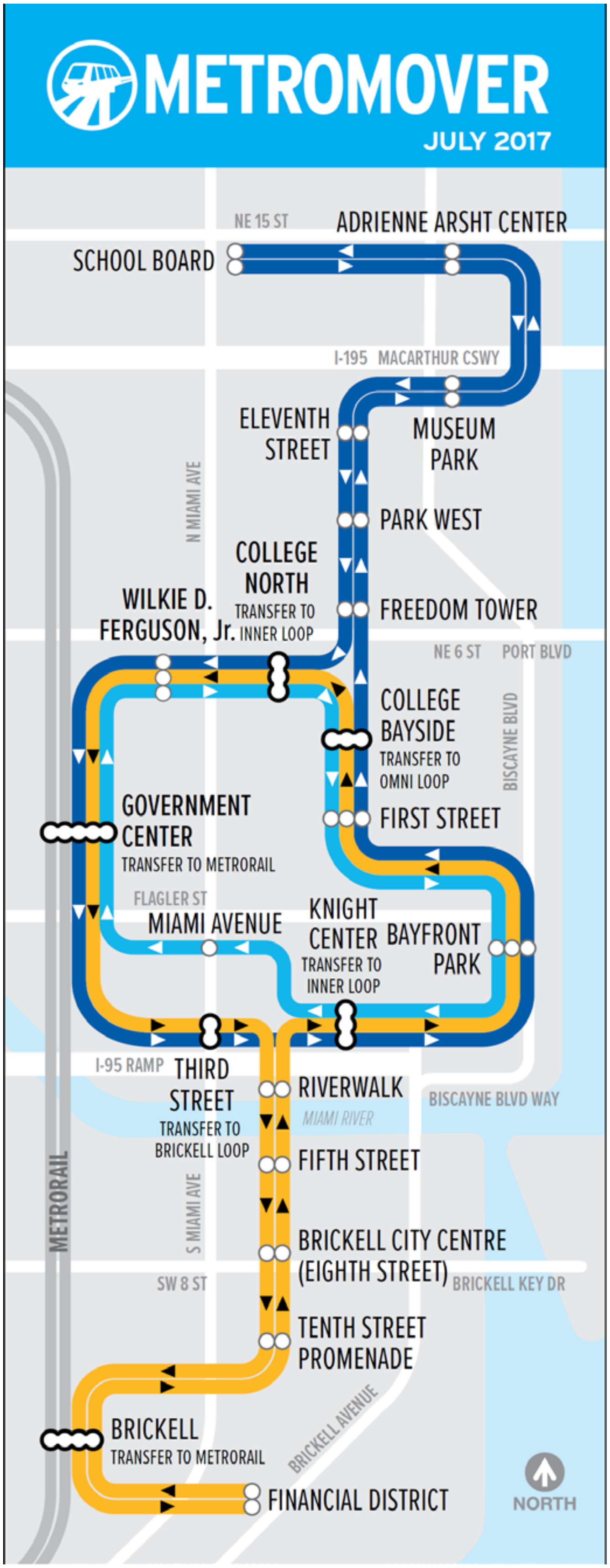
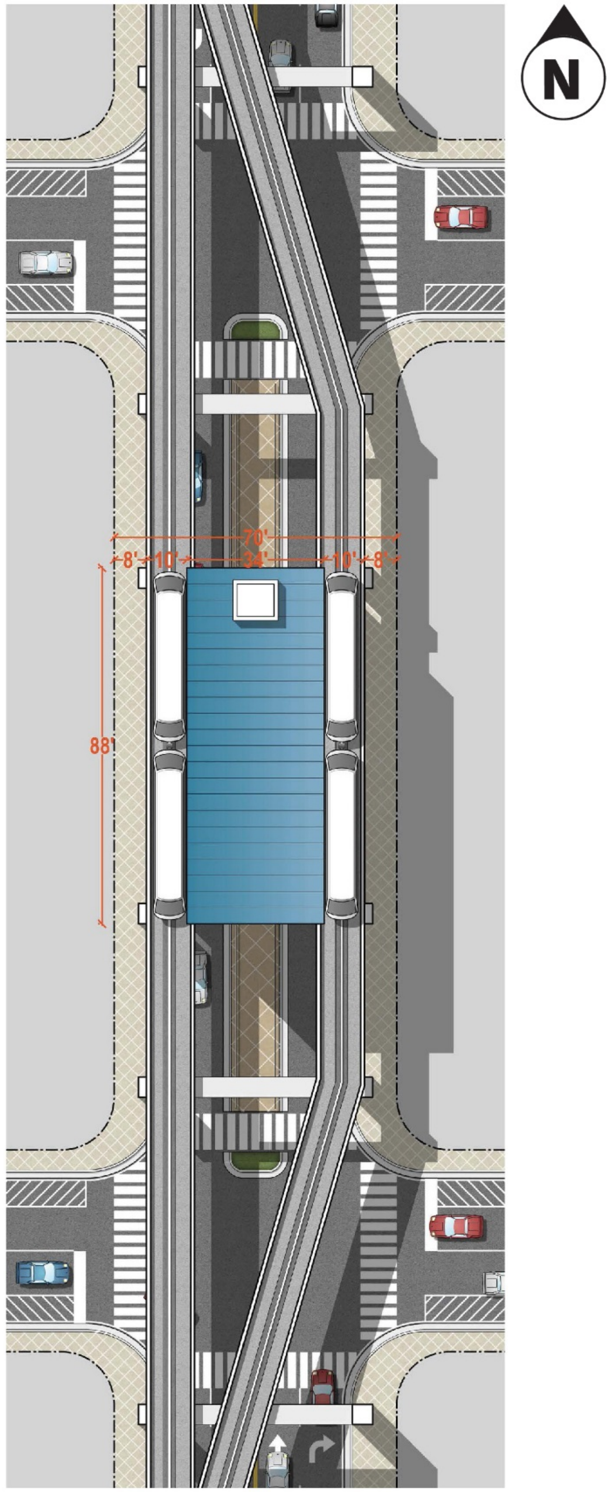


Figure 5.7 | Existing Metromover System Map



Representative Typical Plan -
Metromover Station in 70' Right-of-Way

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Figure 5.8 | Representative Typical Plan – Metromover in 70-Foot ROW

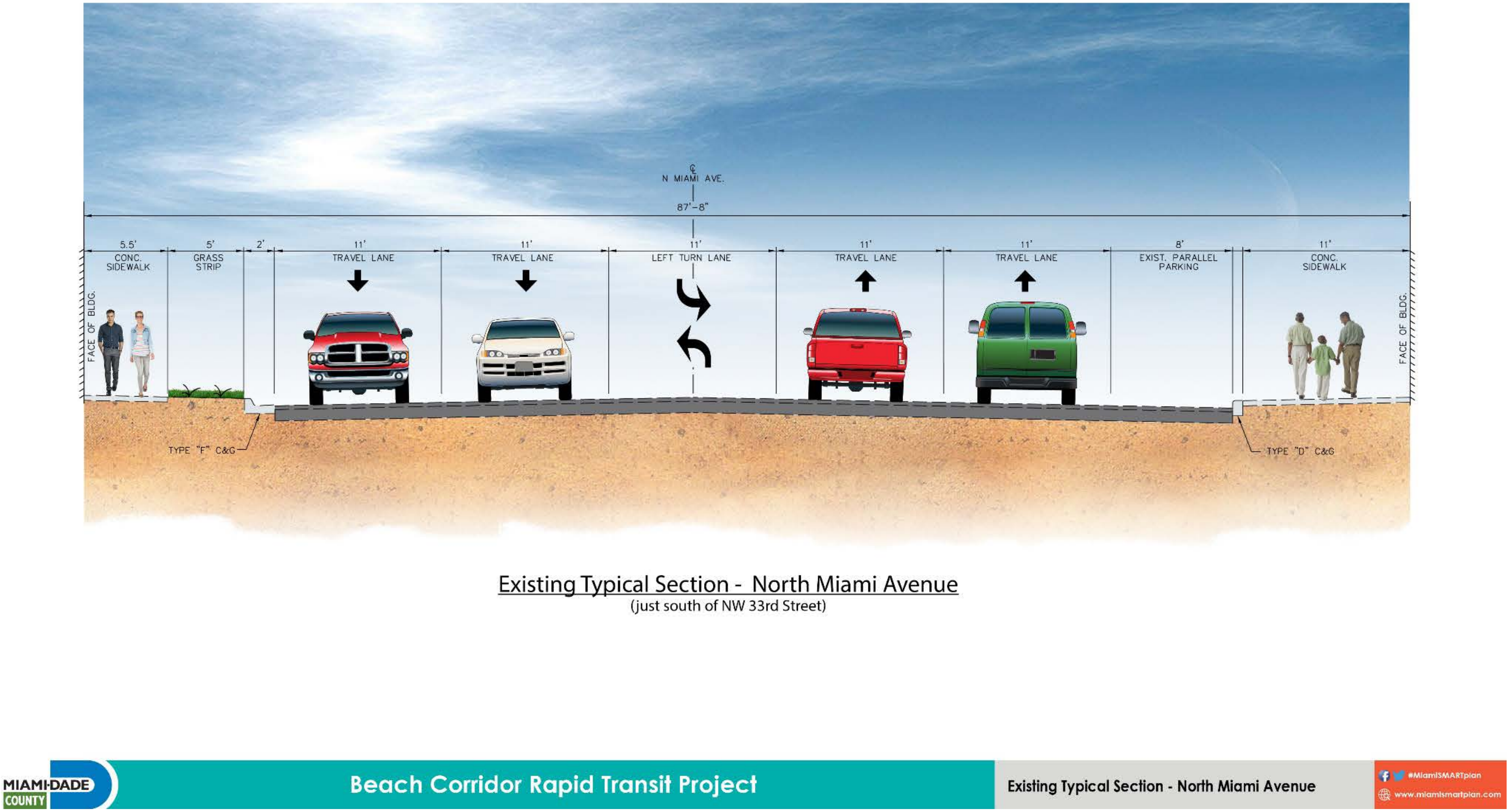


Figure 5.9 | Existing Typical Section – N Miami Avenue

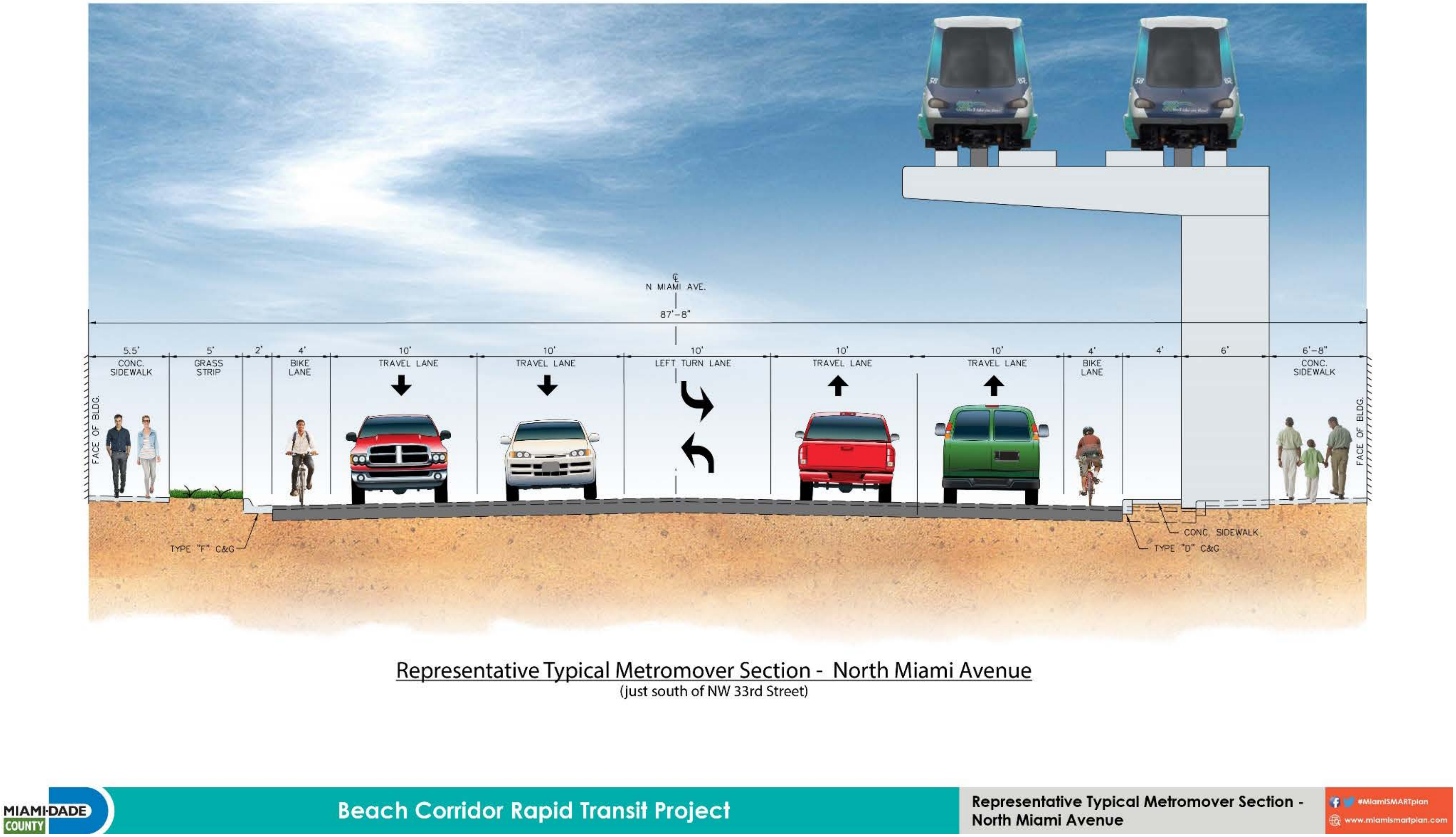
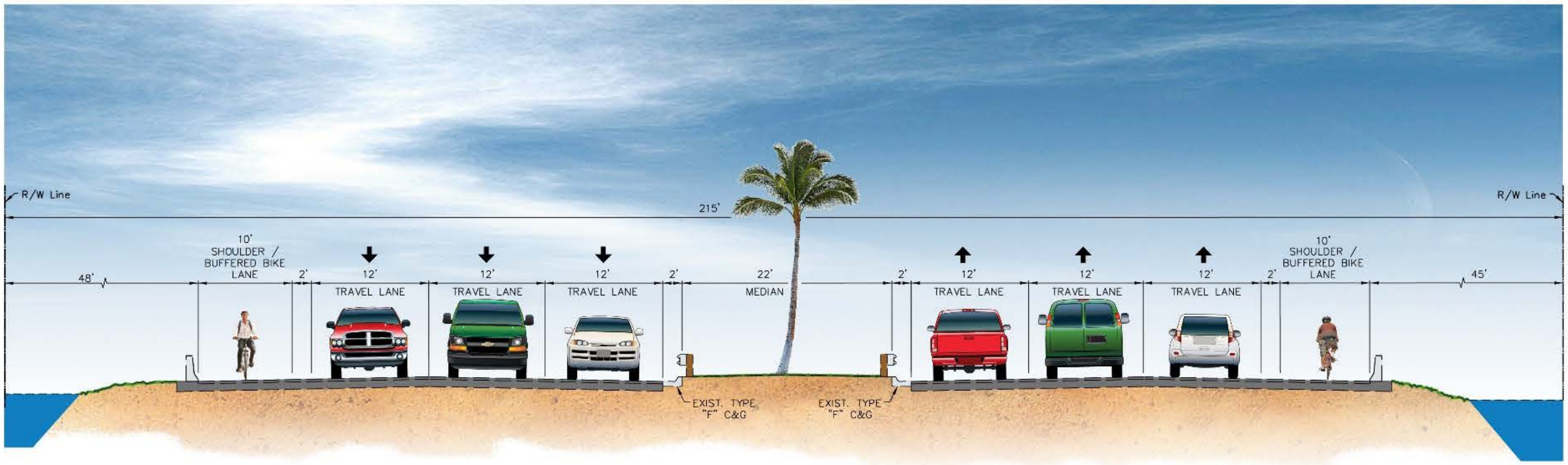


Figure 5.10 |Representative Typical Metromover Section – N Miami Avenue



Existing Typical Section - I-395 / MacArthur Causeway

MIAMI-DADE COUNTY

Beach Corridor Rapid Transit Project

Existing Typical Section - I-395/MacArthur Causeway

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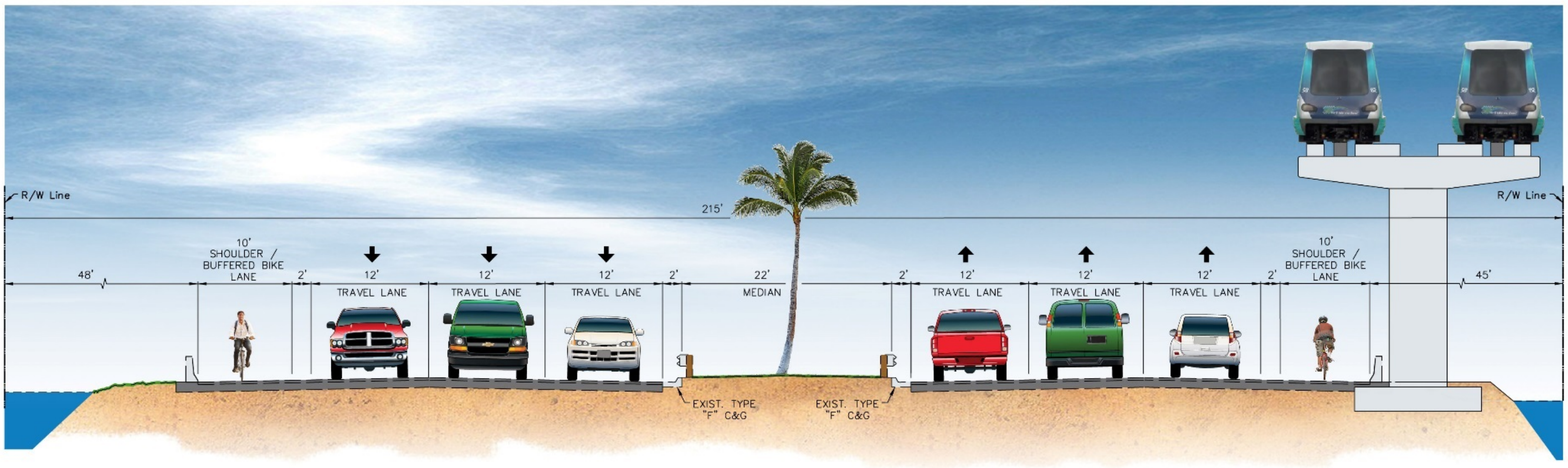
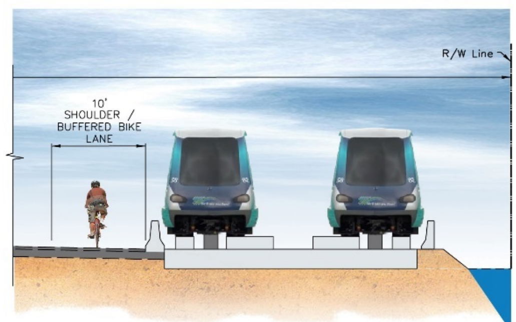
Figure 5.11 | Existing Typical Section – I-395/MacArthur Causeway



Representative Typical Metromover Section - I-395 / MacArthur Causeway
Above-Grade Option



Representative Typical Metromover Section - I-395 / MacArthur Causeway
At-Grade Option

MIAMI-DADE COUNTY | Beach Corridor Rapid Transit Project | Representative Typical Metromover Section - I-395/MacArthur Causeway | #MiamiSMARTplan www.miamismartplan.com

Figure 5.12 | Representative Typical Metromover Section – I-395/MacArthur Causeway

TOD Compatibility: The Metromover has potential to facilitate TOD by providing a high-capacity, high-ridership mode of transit with recognizable stations. In some areas, however, the visual impact of the Metromover infrastructure might detract from the TOD opportunities.

Pedestrian/Bicycle Access: Metromover stations and vehicles are accessible for people with bicycles and could accommodate bicycles on board (either by installing bike racks or allowing passengers with bikes to hold them upright during travel). The guideway support columns may have some adverse impacts to pedestrian and bicycle facilities. As compared with an at-grade mode, elevated stations are not as convenient for pedestrians, requiring the use of escalators and elevators that may experience reliability issues.

5.3.3 Environmental Effects Criteria

Social and Economic: The Metromover has the highest rating for the mobility of residents and visitors because it would be integrated with existing transit systems and accessibility would not be affected by distance.

Cultural: Construction within the existing right-of-way reduces impacts to historic/archaeological resources and other community services and resources. However, construction of the piers for an elevated structure may cause vibrations that could potentially affect historic structures. The potential effects will be evaluated during Tier 2.

Natural: The Metromover is similar to the monorail in natural impacts because it will be constructed within existing right-of-way; impacts to wetlands (seagrass) and protected species will be minimal and the impacts to the floodplain are less than BRT and LRT.

Physical: The noise levels of the Metromover is similar to other forms of transit and will therefore result in equivalent noise impacts along the corridor. The Downtown Miami area of the project has several potential contamination sites, which would need to be evaluated in the Tier 2 analysis.

5.3.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment, inclusive of maintenance facility expansion and vehicles, is in the range of $900 M to $1.1 B, which is within the range of typical cost per mile for this mode. The cost-effectiveness of the mode will be evaluated in the Tier Two Evaluation.

Operating Cost: The estimated annual operations and maintenance cost of the Metromover extension, based on a service plan assuming 4-minute peak headways as shown in Appendix *A*, is $17 million. The cost-effectiveness of the mode will be evaluated in the Tier Two Evaluation, which will also feature consideration of additional alignment alternatives.

Eligibility for Funding: The Metromover is a service-proven technology, ADA-compliant, and available as Buy America compliant.

5.3.5 Tier Two Alignments

Tier Two evaluation will consider Metromover alignments within the Design District, Downtown Miami, Bay Crossing and Miami Beach segments within the study areas shown in Figures 5.2 and 5.3.

5.4 BUS RAPID TRANSIT (BRT)

5.4.1 Transit Performance Criteria

Interoperability and Modal Integration: BRT would not extend an existing mode, but would have the potential to be extended along dedicated lanes in Miami Beach. BRT would provide easy transfers to numerous existing bus routes, and in Miami Beach could provide an easy transfer to another mode such as LRT, or be extended to reach additional Miami Beach destinations. BRT would offer a transfer to Metrorail and Metromover at Government Center, however the distance between the BRT and Metrorail/Metromover platforms would be approximately 200 feet, which would be less convenient and desirable to passengers than the Metromover-to-Metrorail transfer. Local commuters and some tourists might find this transfer acceptable, but some airport-bound travelers would likely be discouraged by this transfer and choose other travel options.

Operational Speed and Reliability: BRT would operate at-grade in a combination of mixed-flow and semi-exclusive (dedicated transit lane) operations.

Resiliency: As an at-grade mode, BRT has vulnerability to flooding. If an advanced technology such as an automated guidance system with sensors in the roadways were implemented with BRT, this could be another vulnerability to flood. BRT is not expected to be vulnerable to high winds (other than during a storm event).

Passenger Capacity: Based on the service plan shown in *Appendix A*, the peak-hour passenger capacity per direction would be approximately 700 passengers, and daily capacity would be in the range of 15,000.

Vehicle Reliability and Safety: BRT is a safe and reliable mode.

Passenger Amenities: BRT is comfortable for seated passengers, but the ride quality for standing passengers is not comparable to the ride quality of the rail transit modes.

5.4.2 Economic and Community Development Criteria

Scale/Urban Fit: BRT would operate within existing roadways and would be compatible with the scale of the neighborhoods along the Beach corridor. Figures 5.13 and 5.14 present plan views of side-platform and center-platform BRT stations if constructed within a 70' street right-of-way. Figures 5.15 and 5.16 present potential roadway cross-sections after construction of BRT.

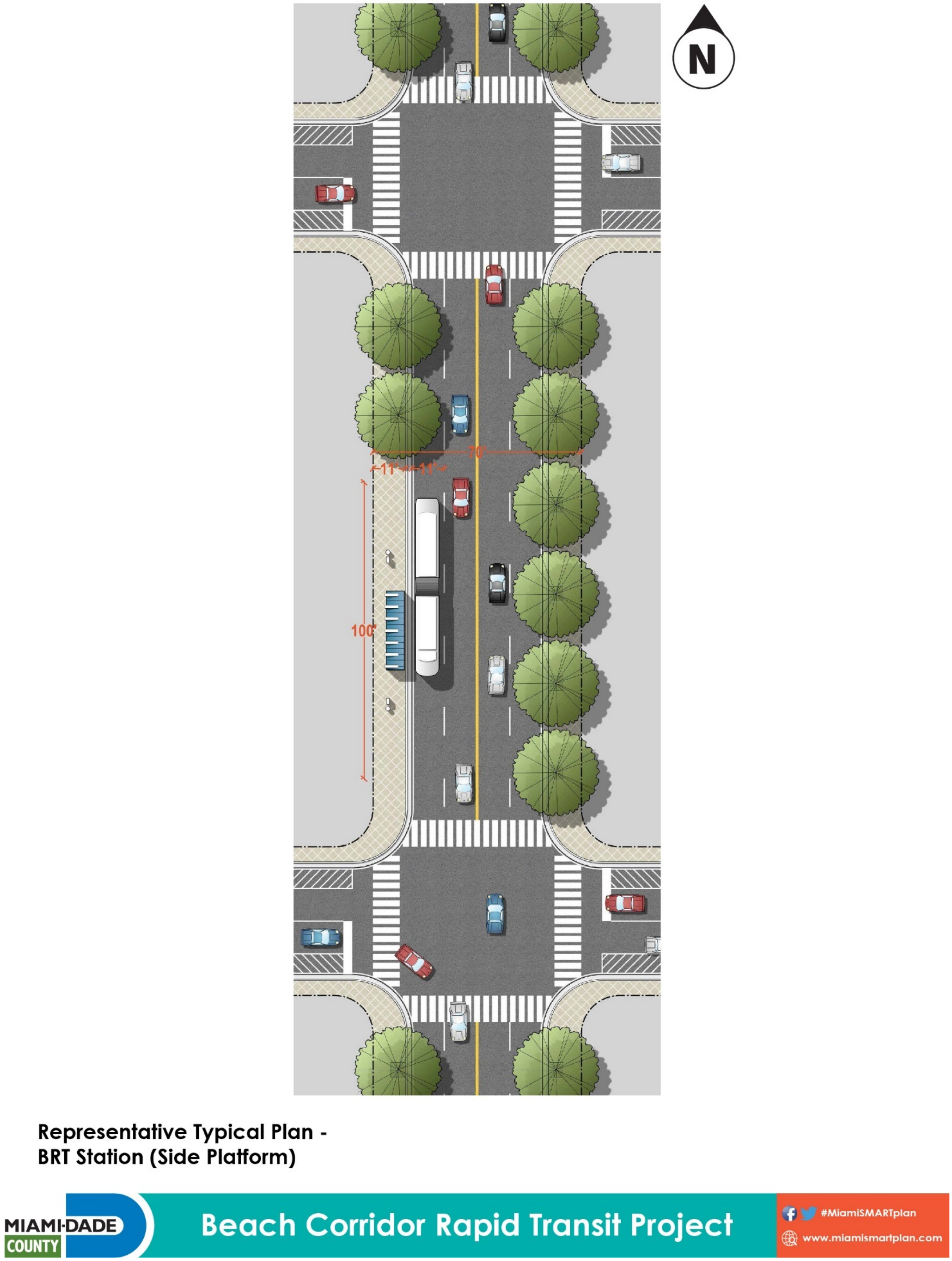


Figure 5.13 | Representative Typical Plan – BRT Station (Side Platform)

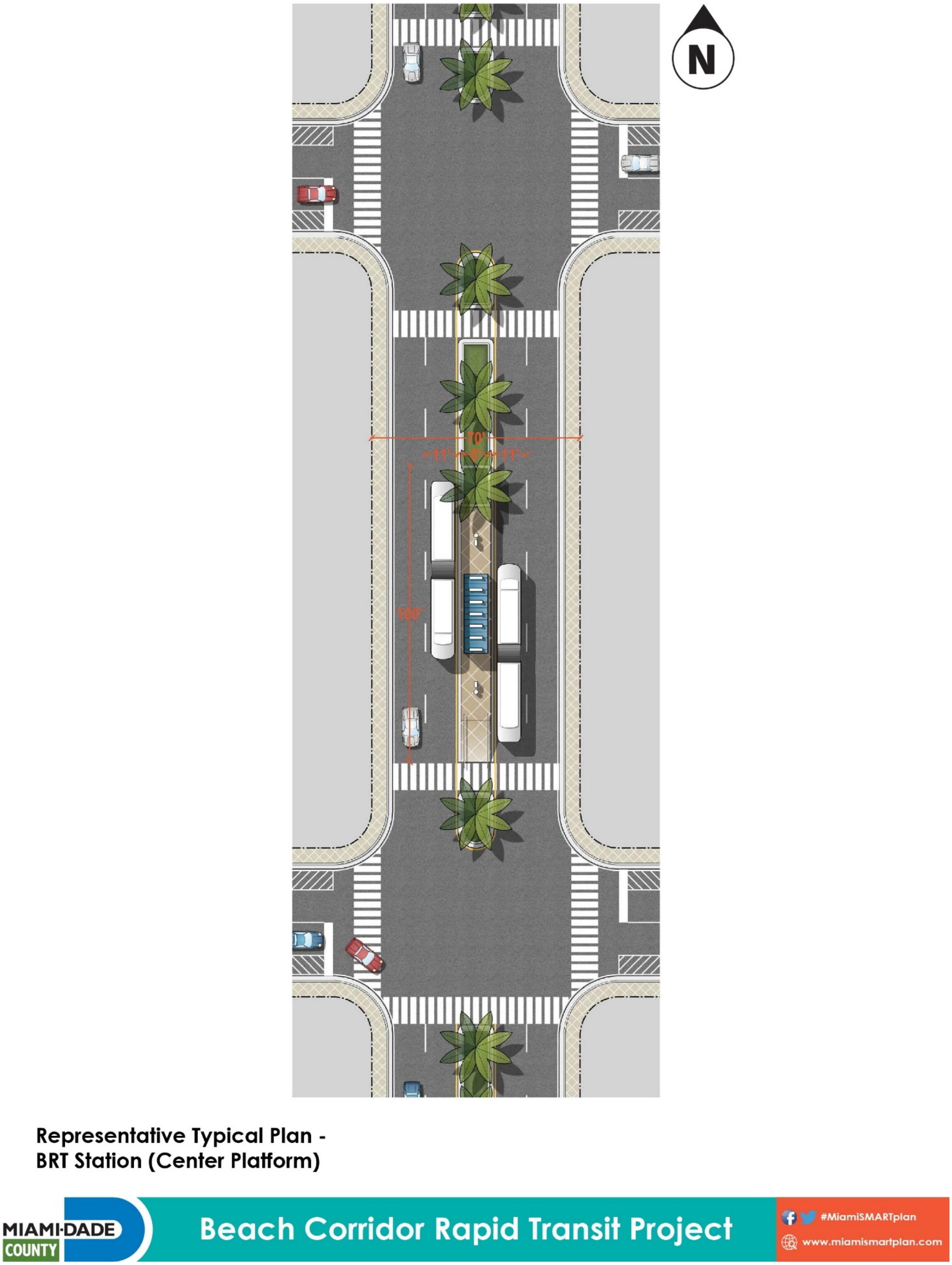


Figure 5.14 | Representative Typical Plan – BRT Station (Center Platform)

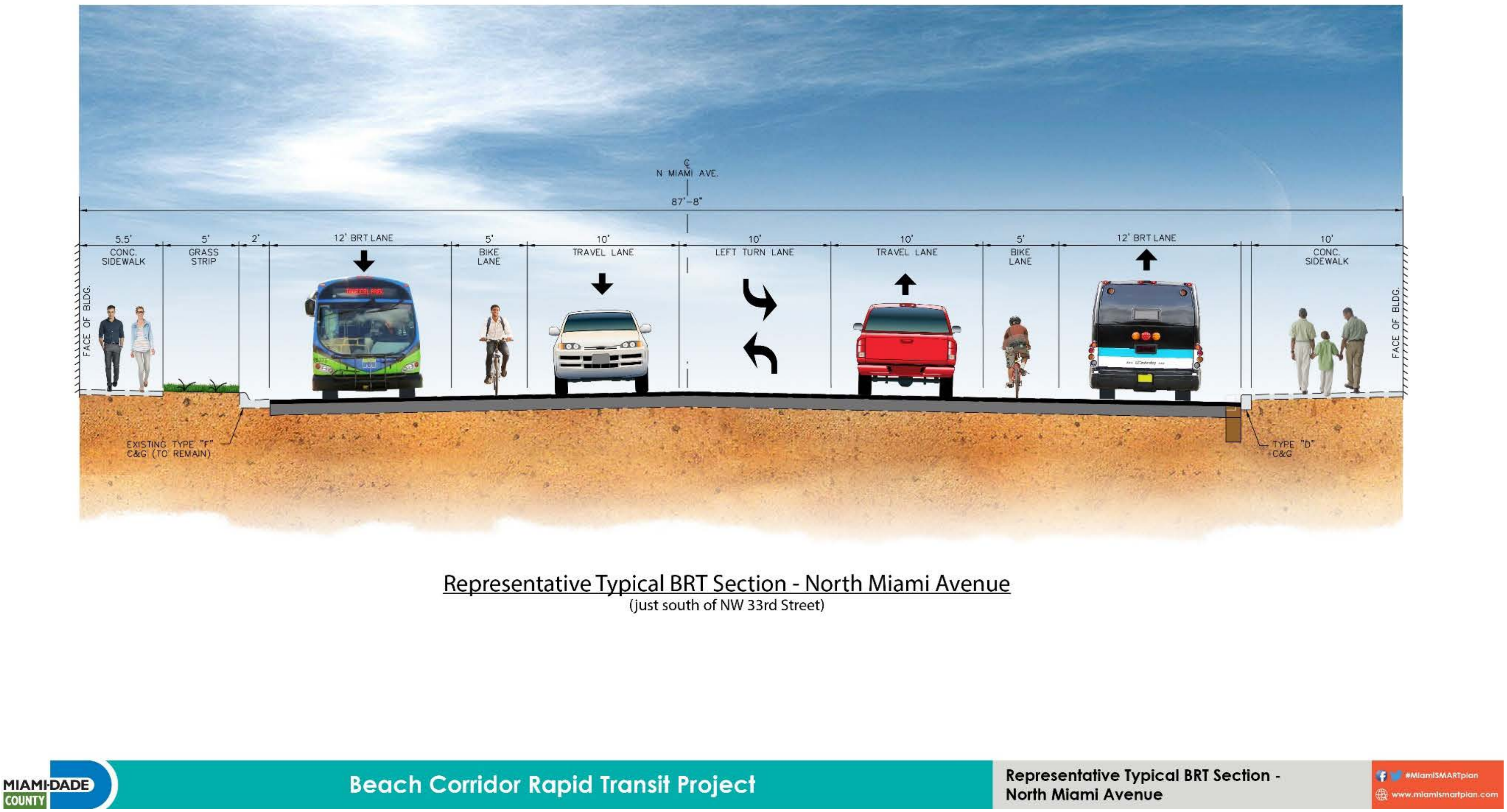


Figure 5.15 | Representative Typical BRT Section – N Miami Avenue

Figure 5.16 | Representative Typical BRT Section – I-395/MacArthur Causeway

TOD Compatibility: BRT has some potential to serve as a catalyst for TOD, particularly if it is implemented with features that make the stations and dedicated lane segments recognizable and attractive features of the urban environment. Typically, the development community does not respond to bus transit in the same way it responds to rail transit, but there are examples of BRT systems, such as the "Healthline" BRT system in Cleveland, Ohio, that have spurred TOD.

Pedestrian/Bicycle Access: BRT infrastructure is not expected to have adverse impact on pedestrian and bicycle facilities. It may be feasible to accommodate people with bikes on the BRT vehicles, depending on the design of the vehicle. Exterior bike racks would likely not be included, because the process of loading and unloading the bikes would delay the service.

5.4.3 Environmental Effects Criteria

Social and Economic: The advantage of BRT is that it provides accessibility to other bus transit routes as well as other modes of transportation and government/employment centers.; however, the distance between the BRT and Metrorail/Metromover stations may limit accessibility for some travelers. In addition, because some of the operation would be in mixed-flow lanes, the level-of-service (travel times) may be reduced, thereby reducing mobility of travelers.

Cultural: Construction within the existing right-of-way reduces impacts to historic/archaeological resources and other community services and resources. Effects to historic resources and recreational areas will be evaluated during Tier 2.

Natural: Construction of BRT lanes within existing right of way would have limited impact to natural resources; i.e., wetlands (seagrass) and protected species. However, the increase of at-grade pavement increases impacts to the floodplain.

Physical: BRT would increase traffic at ground level and, potentially, increase noise levels. The Downtown Miami area of the project has several potential contamination sites, which would need to be evaluated in the Tier 2 analysis.

5.4.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment, including vehicles, is in the range of $300 M to $400 M. This assumes that a to provide exclusive bay-crossing lanes is within the range of typical cost per mile for BRT projects that incorporate exclusive guideways. See section 5.4.5 below for discussion of the assumptions to be carried forward into Tier Two evaluation.

Operating Cost: The annual operating and maintenance cost of this mode, based on the service plan assuming 5-minute peak headways as shown in Appendix A, is $11 million. The cost-effectiveness of the mode will be evaluated in the Tier Two Evaluation, which will feature express bus options along expressways and a BRT connection only from downtown to Miami Beach Convention Center.

Eligibility for Funding: BRT is a service-proven technology, ADA-compliant, and available as Buy America compliant.

5.4.5 Tier Two Alignments

Tier Two evaluation will include a BRT and/or Express Bus study from Downtown Miami to Convention Center (with a repurposed typical section along the Causeway and a dedicated lane in Miami Beach) and Express Bus along a freeway loop alignment using I-95, I-195, I-395 in Miami and 5th street, Washington and Alton Roads in the Miami Beach segment. The evaluation of a BRT option that uses existing right-of-way across Biscayne Bay rather than a widened bridge with an exclusive guideway will ensure that the Tier Two evaluation includes a low-cost rapid transit option.

5.5 LIGHT RAIL TRANSIT (LRT/TRAM/STREETCAR)

5.5.1 Transit Performance Criteria

Interoperability and Modal Integration: LRT would not extend an existing mode, but would have the potential to be extended in Miami Beach. An LRT mode would provide a one-seat ride between the origins and destinations along the alignment including the Design District, and Fifth Street/Alton Road in Miami Beach, and could be integrated into a future LRT/streetcar system as currently proposed in Miami Beach. The representative LRT alignment is elevated at the Museum Park station, allowing for an easy transfer to Metromover. Connecting service on

Metrorail would require either a second transfer (from Metromover) at Government Center station, or a walk of approximately 200 feet. LRT also would provide for easy at-grade transfers to numerous existing bus routes.

Operational Speed and Reliability: The LRT mode would provide a fast and reliable bay crossing and could be accessed via Metromover from numerous origins along the Metromover system for a fully grade-separated, reliable trip. For trips continuing on the LRT mode into the Design District, operations will be similar to those of BRT — faster than existing bus service, but subject to traffic congestion or accidents at intersections that would impact reliability.

Resiliency: As an at-grade mode, LRT has vulnerability to flooding. Additionally, traditional overhead power supply systems for light rail/streetcar systems present vulnerability to high winds. Off-wire technologies may mitigate this vulnerability.

Passenger Capacity: There is a range of vehicle sizes and configurations available with the LRT family of modes, including the three-section modern streetcar used in new streetcar systems in the United States and the five-section tram that is common in European light rail systems. Either is feasible for the Beach corridor and would provide a range of approximately 120–265 passengers per train. Based on the service plan shown in *Appendix A* and the assumption of a five-section tram, the peak-hour passenger capacity per direction would be approximately 1,300 passengers, and daily capacity would be in the range of 29,000.

Vehicle Reliability and Safety: LRT vehicles and systems are safe and reliable.

Passenger Amenities: LRT vehicles can be provided as 100 percent low-floor with level boarding and provide excellent ride quality for both seated and standing passengers.

5.5.2 Economic and Community Development Criteria

Scale/Urban Fit: LRT, in a tram or modern streetcar configuration, fits easily within existing roadways and the scale of urbanized neighborhoods. Most streetcar and tram systems are considered enhancements to their urban settings. Figures 5.17 and 5.18 present plan views of side-platform and center-platform LRT stations if constructed within a 70' street right-of-way. Figure 5.19 presents a potential North Miami Avenue roadway cross-section after construction of LRT. Figure 5.20 presents a potential I-395/MacArthur Causeway cross-section after construction of LRT.

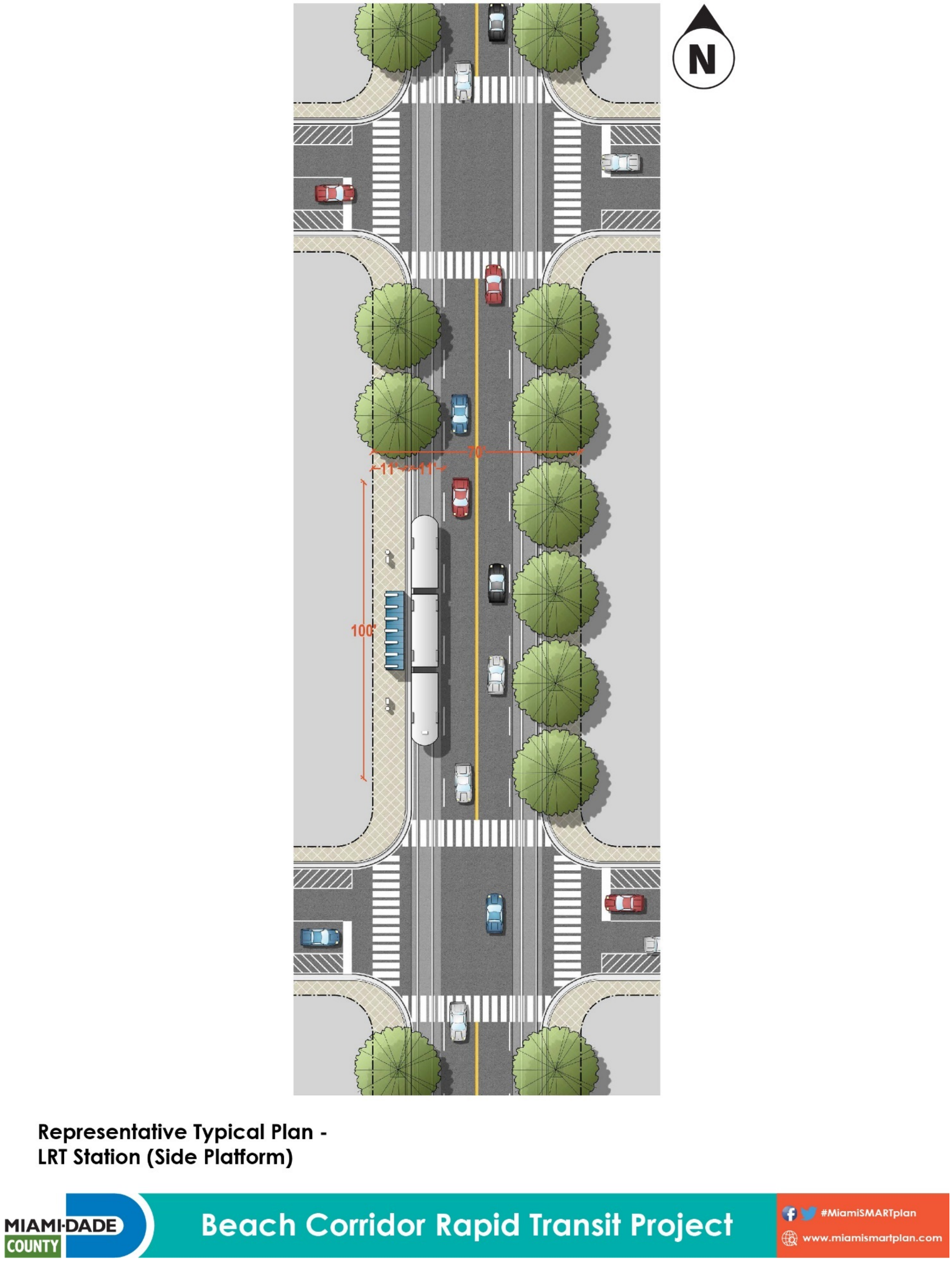


Figure 5.17 | Representative Typical Plan – LRT Station (Side Platform)

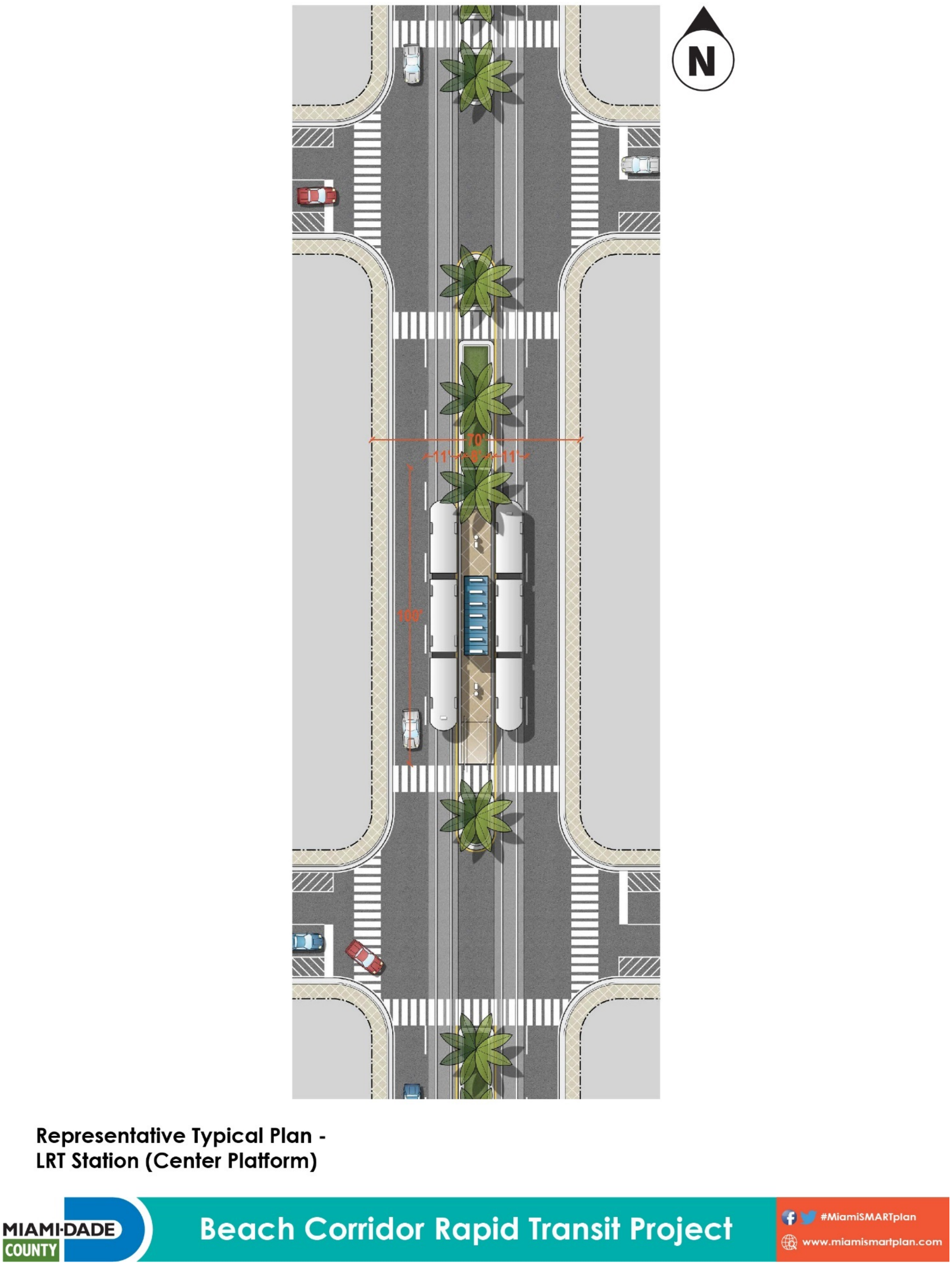


Figure 5.18 | Representative Typical Plan – LRT Station (Center Platform)

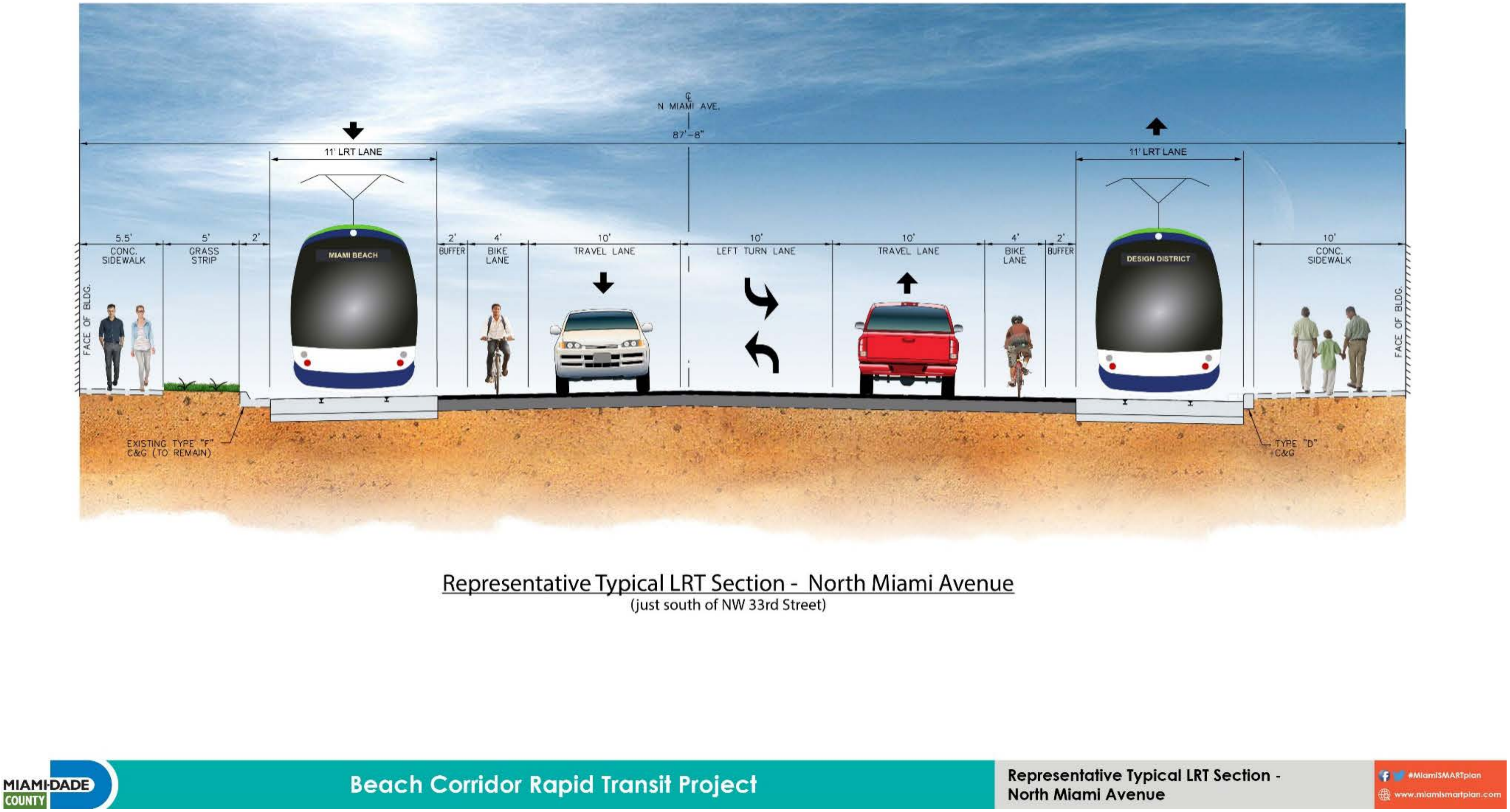


Figure 5.19 | Representative Typical LRT Section – N Miami Avenue

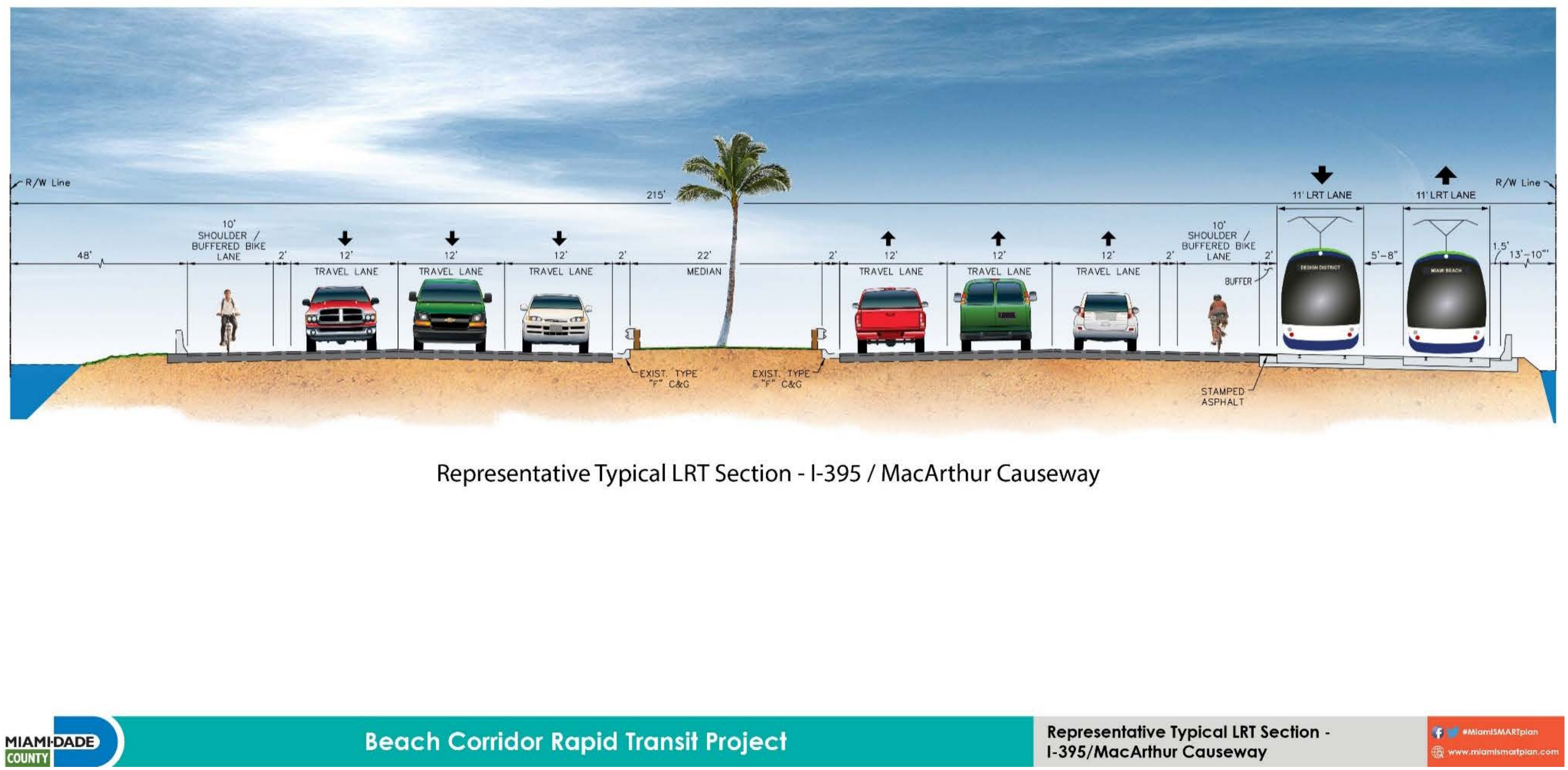


Figure 5.20 | Representative Typical Section – I-395/MacArthur Causeway

TOD Compatibility: LRT, including trams and modern streetcars, have a demonstrated ability to catalyze economic development.

Pedestrian/Bicycle Access: LRT stations and vehicles are accessible for people with bicycles and could accommodate bicycles on board (either by installing bike racks or allowing passengers with bikes to hold them upright during travel). LRT tracks can be a hazard for cyclists, but there are a variety of design solutions that can provide a safe travel pathway for cyclists.

5.5.3 Environmental Effects Criteria

Social and Economic: LRT would also provide for easy transfers to existing bus transit routes. Similar to BRT and the monorail, the distance between the LRT and Metrorail/Metromover stations may limit accessibility for some travelers. Part of travel on the LRT across MacArthur Causeway would be fast and reliable. Sections in mixed-flow lanes in Downtown Miami and the Design District would be subject to traffic and congestion. (An exclusive LRT travel lane will not be designated in the Downtown Miami segment.) In addition, at-grade rail service can cause conflicts with pedestrians and cyclists in all segments of the study area.

Cultural: Construction within the existing right-of-way reduces impacts to historic/archaeological resources and other community services and resources. Effects to historic resources and recreational areas will be evaluated during Tier 2.

Natural: Construction of LRT lanes within existing right of way would have limited impact to natural resources; i.e., wetlands (seagrass) and protected species. However, the increase of at-grade pavement increases impacts to the floodplain.

Physical: LRT would increase traffic at ground level and, potentially, increase noise levels. The Downtown Miami area of the project has several potential contamination sites, which would need to be evaluated in the Tier 2 analysis. An exclusive LRT travel lane will not be designated in the Downtown Miami segment.

5.5.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment, inclusive of a maintenance facility and vehicles, is in the range of $700 M to $800 M, which is within the range of typical cost per mile for this mode. The cost-effectiveness of the mode will be evaluated in the Tier Two Evaluation, which will also consider additional alignment alternatives and will limit this mode to the Design District, Bay Crossing and Miami Beach segments.

Operating Cost: The estimated annual operations and maintenance cost of the representative light rail/streetcar mode, based on a service plan assuming 5-minute peak headways as shown in *Appendix A*, is $17 million. The alignment and operating plan will be refined in the Tier Two Evaluation.

Eligibility for Funding: LRT is a service-proven technology, ADA-compliant, and available as Buy America compliant.

5.5.5 Tier Two Alignments

Tier Two evaluation will consider LRT alignments within the Design District, Bay Crossing and Miami Beach segments. The Downtown Miami segment will not advance for further evaluation of a street-running LRT mode, given the existing congestion that would make fast and reliable operations, by way of an exclusive transit lane, in this segment, infeasible. Tier Two alignments will include additional analysis of the potential for elevated segments or exclusive transit lanes to optimize speed, reliability, and ridership potential (such as for the connection between the Design District and Bay Crossing segments, or for an elevated segment to connect LRT to Metromover in Downtown Miami).

5.6 ALTERNATIVES NOT RECOMMENDED FOR FURTHER EVALUATION

The following alternatives are not recommended for further evaluation, either because they are not expected to be able to meet the project goals or because there are significant cost and feasibility issues associated with the application of the mode to the Beach corridor:

- Aerial cable transit
- Heavy rail transit
- Automated transit system (as a stand-alone technology; advanced to Tier Two as applied to a BRT system)

These transit modes are not considered suitable for the Beach corridor because of significant flaws regarding transit performance, economic and community development benefits, environmental effects, or cost and feasibility, as shown in Figure 5.1 and described below.

5.7 AERIAL CABLE TRANSIT (ACT)

5.7.1 Transit Performance Criteria

Interoperability and Modal Integration: An aerial tram or gondola system would not extend any of the existing modes operating in Miami. Trips between most origins and destinations in the Beach corridor would require at least one transfer, and most trips would require more than one transfer because of the limited portion of the corridor that could feasibly be served by ACT.

Operational Speed and Reliability: Travel on an aerial tram or gondola would be reliable, but would offer the lowest average operating speed across the bay of the modes under consideration, because of the technological limitations of the mode.

Passenger Capacity: An aerial tram may not offer sufficient capacity to meet the potential ridership demand in the Beach corridor; a gondola system with very frequent service might offer sufficient capacity. Based on the service plan shown in *Appendix A*, the peak-hour passenger capacity per direction of an aerial tram would be approximately 240 passengers, and daily capacity would be in the range of 5,000.

Resiliency: As an elevated mode, ACT is not vulnerable to flooding. However, most ACT systems are required to suspend operations during high winds.

Vehicle Reliability and Safety: ACT has a good safety record. However, crossing Biscayne Bay would present unique challenges in terms of the ability to evacuate passengers in the event of a malfunction. The iconic nature of the bay location may also make ACT in this location more vulnerable to threats than other transit modes.

Passenger Amenities: Although industry representatives claim that aerial trams or gondolas can now be provided with air-conditioning, there is no system in service that provides air-conditioning for a 15-minute trip. Without climate control, travel in an aerial tram or gondola in Miami would be uncomfortable for much of the calendar year.

5.7.2 Economic and Community Development Criteria

Scale/Urban Fit: ACT would require very large towers at the termini in Downtown Miami and Miami Beach, which would limit the siting options for the terminal stations and make it difficult to achieve a good fit with the adjacent urban settings.

TOD Compatibility: Because of the limitations described in Section 4, the ACT mode would serve only three station locations, which limits its potential to catalyze economic development.

Pedestrian/Bicycle Access: ACT stations and vehicles are accessible for people with bicycles and could accommodate bicycles on board (either by installing bike racks or allowing passengers with bikes to hold them upright during travel). An operating policy accommodating bicycles would be more likely for an aerial tram system than for a gondola system (because of the small size of the gondolas). ACT infrastructure is not expected to have any adverse impacts to pedestrian or bicycle facilities.

5.7.3 Environmental Effects Criteria

Social and Economic: ACT would require travelers to transfer between modes of transportation modes because ACT is not feasible throughout the corridor. Also, ACT has the lowest operating speed of any of the alternatives and would not have climate control. Therefore, ACT would not meet the socioeconomic need for mobility in the corridor.

Cultural: ACT is not feasible in several sections of the corridor, therefore, its effect on cultural resources is unknown.

Natural: The ACT would require large towers to operate, which may require additional right-of-way and impact natural resources in Biscayne Bay.

Physical: The Downtown Miami area of the project has several potential contamination sites, which would need to be evaluated in the Tier 2 analysis.

5.7.4 Cost and Feasibility Criteria

- Constructability: The estimated capital cost of this mode, assuming an aerial tram with characteristics similar to the Portland Aerial Tram, is in the range of $500 M to $600 M.
- Operating Cost: The estimated annual operations and maintenance cost of this mode, based on the service plan assuming 6 minute peak headways as shown in Appendix A, is $13 million.
- Eligibility for Funding: To be implemented in the beach corridor, ACT would require a climate-control system that is not yet service-proven, which could be a concern for potential funding partners.

5.8 HEAVY RAIL TRANSIT (HRT)

5.8.1 Transit performance criteria

Interoperability and Modal Integration: An extension of the Metrorail system would provide one-seat rides from Fifth Street/Alton Road in Miami Beach to destinations in downtown already served by existing Metrorail stations. Transfers would be required for service from the Midtown/Design District area. Additionally, this mode would provide for easy transfers at Government Center to reach destinations served by Metromover. In Miami Beach, there is potential for an easy transfer from a Metrorail station at Fifth Street/Alton Road to an at-grade premium transit service such as LRT/streetcar.

Operational Speed and Reliability: As a grade-separated system operating on an exclusive, elevated guideway, Metrorail would provide fast, reliable travel times and headways with a significant travel-time advantage over other modes of travel.

Resiliency: As an elevated mode with a power-supply system integrated into the guideway structure, Metrorail is expected to perform well with respect to resiliency issues such as flooding and high winds.

Passenger Capacity: Metrorail is a very high-capacity system. Based on the service plan shown in *Appendix A*, the peak-hour passenger capacity per direction would be approximately 2,700 passengers, and daily capacity would be in the range of 60,000.

Vehicle Reliability and Safety: Heavy rail is a proven technology that operates safely and reliably.

Passenger Amenities: Heavy rail provides excellent ride comfort and a 100 percent low-floor vehicle.

5.8.2 Economic and Community Development Criteria

Scale/Urban Fit: HRT requires large support columns for elevated guideway structures, or large tunnel portals for subway alignments, which are out of scale with the urbanized settings of the Beach corridor and would impact the existing roadway and pedestrian environment. Figure 5.19 presents a plan view of a Metrorail station if constructed within a 70’ street right-of-way.

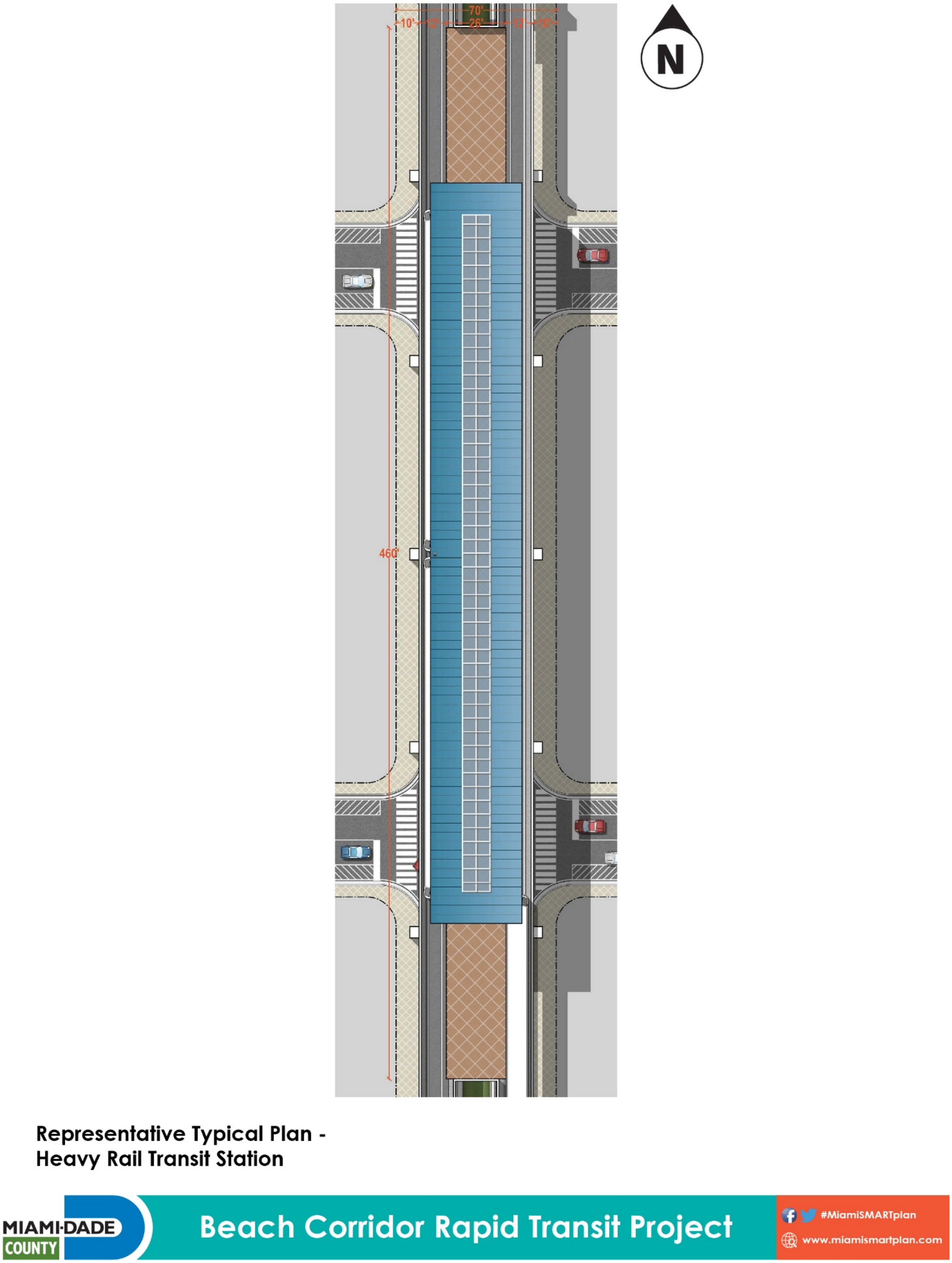


Figure 5.21 | Representative Typical Plan – Heavy Rail Transit Station

TOD Compatibility: Metrorail has potential to facilitate TOD by providing a high-capacity, high-ridership mode of transit with recognizable stations. In some areas, the visual impact of the infrastructure might detract from the TOD opportunities.

Pedestrian/Bicycle Access: Metrorail stations and vehicles are accessible for people with bicycles and could accommodate bicycles on board (either by installing bike racks or allowing passengers with bikes to hold them upright during travel). The guideway support columns may have some adverse impacts to pedestrian and bicycle facilities. As compared with an at-grade mode, elevated stations are not as convenient for pedestrians, requiring use of escalators and elevators which may experience reliability issues.

5.8.3 Environmental Effects Criteria

Social and Economic: In terms of mobility, heavy rail is fast, reliable, accommodates high-capacity travel and is easily accessible.

Cultural: Construction of heavy rail would require large support columns and, potentially additional right-of-way. Therefore, historic/archaeological sites or other community resources could be impacted by the project.

Natural: Construction of heavy rail would likely impact natural resources in Biscayne Bay due to the need for additional right-of-way.

Physical: Heavy rail generates high levels of noise and vibration, which would impact residents and visitors, community and cultural facilities and wildlife in the area. The alignment would also likely impact contaminated properties.

5.8.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment is in the range of $1.7 B to $2 B. This is outside the range of typical cost per mile for this mode because of the extensive acquisition of developed land, demolition, and site work that would be required to extend Metrorail in the study area.

Operating Cost: The estimated annual operations and maintenance cost of the heavy rail mode, based on a service plan assuming 8-minute peak headways as shown in *Appendix A*, is $22 million.

Eligibility for Funding: Heavy rail transit is a service-proven technology, ADA-compliant, and available as Buy America compliant.

5.9 AUTOMATED TRANSIT SYSTEMS (ATS)

5.9.1 Transit Performance Criteria

Interoperability and Modal Integration: ATS operating on the representative alignment developed for the BRT mode would provide a one-seat ride between the origins and destinations along the alignment including the Design District, Downtown Miami, and Fifth Street/Alton Road in Miami Beach. ATS would provide for easy transfers to numerous existing bus routes, and in Miami Beach could provide an easy transfer to another mode such as LRT, or could be extended to reach additional Miami Beach destinations. ATS would offer a transfer to Metrorail and Metromover at Government Center. However, the distance between the ATS and Metrorail/Metromover platforms would be approximately 200 feet, which will be less convenient and desirable to passengers than the Metromover-to-Metrorail transfer. Local commuters and some tourists might find this transfer acceptable, but some airport-bound travelers would likely be discouraged by this transfer and choose other travel options.

Operational Speed and Reliability: ATS would operate at-grade in a combination of mixed-flow and semi-exclusive (dedicated transit lane) operations. ATS would offer a significant travel-time advantage over existing bus service, but travel at speeds roughly comparable to auto travel times. Additionally, the at-grade operations would limit the reliability of the service, as it could be impacted by traffic congestion or accidents at intersections, even where a dedicated lane and transit signal priority may be provided. Options to maximize speed and reliability in conjunction with BRT will be evaluated as part of the Tier Two Evaluation.

Resiliency: As an at-grade mode, ATS would be vulnerable to flooding.

Passenger Capacity: ATS is initially expected to be provided in small vehicles, which may limit the capacity. Therefore, the mode is not expected to be able to meet the travel demand in the corridor. Based on the service plan shown in *Appendix A*, the peak-hour passenger capacity per direction would be approximately 130 passengers, and daily capacity would be in the range of 3,000.

Vehicle Reliability and Safety: ATS is anticipated to offer safety advantages over vehicles operated by humans, but the actual performance is unknown.

Passenger Amenities: ATS is initially expected to be provided in small vehicles that may not offer the ride quality or ease of entry and exit that larger transit vehicles provide.

5.9.2 Economic and Community Development Criteria

Scale/Urban Fit: ATS would operate within existing roadways and would be compatible with the scale of the neighborhoods along the Beach corridor.

TOD Compatibility: There is no experience with ATS related to TOD.

Pedestrian/Bicycle Access: ATS is initially expected to be provided in small vehicles that would not accommodate bicycles.

5.9.3 Environmental Effects Criteria

Social and Economic: ACT would provide for easy transfers to existing bus transit routes. Similar to other modes of transit, the distance between the ACT and Metrorail/Metromover stations may limit accessibility for some travelers. Part of travel would be fast and reliable; however, sections in mixed-flow lanes would be subject to traffic and congestion, slowing travel times. In addition, this mode of transit does not meet the capacity needs of the corridor.

Cultural: Construction within the existing right-of-way reduces impacts to historic/archaeological resources and other community services and resources.

Natural: Construction within existing right of way would have limited impact to natural resources; i.e., wetlands (seagrass) and protected species. However, the increase of at-grade pavement increases impacts to the floodplain.

Physical: Noise and contamination impacts are expected to be comparable to other modes of transit.

5.9.4 Cost and Feasibility Criteria

Constructability: The estimated capital cost of the representative alignment, inclusive of vehicles, is in the range of $8 to $10 million.

Operating Cost: The estimated annual operations and maintenance cost of the ATS mode, based on a service plan assuming 5-minute peak headways as shown in *Appendix A,* is $11 million.

Eligibility for Funding: ATS is a new technology and may not be a good stand-alone candidate for traditional transit capital funding sources.

APPENDIX A | TRANSIT OPERATIONS AND MAINTENANCE (O&M) COST ESTIMATION

Transit Operations and Maintenance (O&M) Cost Estimation

Following Federal Transit Administration (FTA) requirements and general industry practice, a simplified cost allocation model was developed to estimate operations and maintenance (O&M) cost for the Beach Corridor alternatives based on four cost categories:

- Vehicle operations ($/ vehicle or train revenue hours)
- Vehicle maintenance ($/ vehicle revenue miles)
- Non-vehicle maintenance ($/ directional route miles)
- General administration ($/ peak vehicles)

The unit costs for these four categories were developed separately by technology. Heavy rail, Automated People Mover (Metromover), and BRT were established using historical average unit costs computed from operating and service data of Miami's Metrorail, Metromover, and regular and commuting bus service in the National Transit Database (NTD). Monorail was developed using unit costs of Metromover. LRT/Streetcar, and Aerial Cable Car were developed using national average costs from 2006 to 2015 in NTD. Costs were inflated to 2017 dollars using Consumer Price Index (CPI) data from the Bureau of Labor Statistics (BLS). Figure A-1 summarizes the unit costs of all seven modes/technologies from the O&M model.

Figure A-1 | Operations and Maintenance (O&M) Unit Cost by Technology

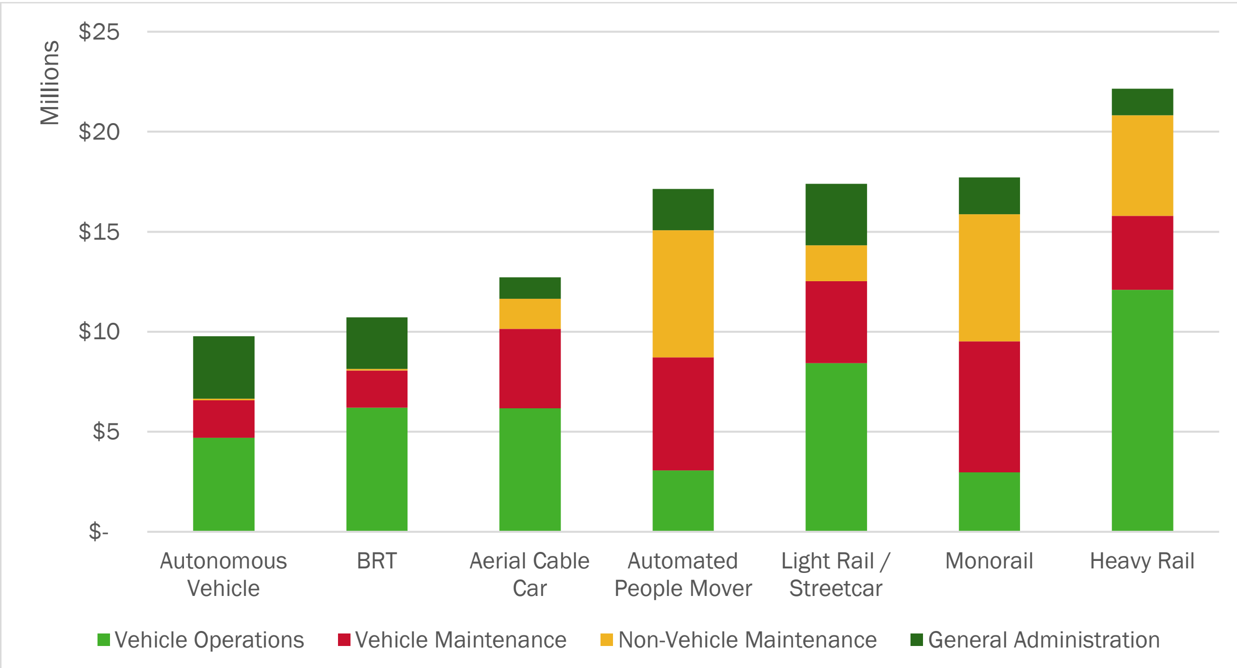
Source: NTD, M-D DTPW, 2006-2015.

Note: Train revenue hours were used as the vehicle operation cost factor for rail modes. Autonomous vehicle was assumed to have 60% unit cost for vehicle operations and the same unit costs for vehicle maintenance, non-vehicle maintenance, and general administration as BRT. The unit costs of "Light Rail / Streetcar" were average unit costs of all light rails and streetcars in NTD. Monorail was developed using unit costs of Metromover.

In terms of vehicle operations, heavy rail has the highest cost per train revenue hour and autonomous vehicles and automated people mover have the lowest unit costs. Aerial cable car's unit costs for vehicle maintenance are significantly higher than other technologies. Automated people mover has the highest non-vehicle maintenance unit cost, followed by heavy rail and aerial cable car. The unit costs of general administration are relatively similar for all seven technologies.

The O&M costs were then calculated using a service plan with headways of five minutes during peak hours and 10 minutes during off-peak hours (slightly longer headways for heavy rail and aerial cable car.) The results are illustrated in Figure A-2.

Figure A-2 | Operations and Maintenance (O&M) Cost by Technology



BRT and autonomous vehicle are estimated to have the lowest O & M cost, which are around 10 million dollars per year. Due to technology and engineering limitations, aerial cable car will only be feasible from approximately the Museum Park Metromover Station to 5th Street & Alton Road. The O&M cost for this 3.5-mile representative aerial cable car alignment is approximately $13 million. Automated people mover, light rail/streetcar, and monorail O&M expenses are estimated at approximately $17 million annually. Heavy Rail O&M expenses are estimated at approximately $22 million annually, mostly as a result of high vehicle operation expense.

Detailed tables of the service plan and O&M cost model results can be found in Table A-1 and Table A-2 respectively.

Table A-1 | Service Plan

Time Period	Early Morning		AM Peak		Midday		PM Peak		Evening		Late Night	
	5:00 AM	7:00 AM	7:00 AM	9:00 AM	9:00 AM	4:00 PM	4:00 PM	6:00 PM	6:00 PM	9:00 PM	9:00 PM	11:00 PM
Weekdays Headways (min)												
Heavy Rail	10		8		10		8		10		20	
Monorail	10		5		10		5		10		20	
BRT	10		5		10		5		10		20	
Light Rail / Streetcar	10		5		10		5		10		20	
Autonomous Vehicle	10		5		10		5		10		20	
Automated People Mover	10		5		10		5		10		20	
Aerial Cable Car	12		6		12		6		12		20	
Weekends Headways (min)												
Heavy Rail	20		20		10		10		10		20	
Monorail	20		20		10		10		10		20	
BRT	20		20		10		10		10		20	
Streetcar	20		20		10		10		10		20	
Autonomous Vehicle	20		20		10		10		10		20	
Automated People Mover	20		20		10		10		10		20	
Aerial Cable Car	20		20		12		12		12		20	

Table A-2 | Operations and Maintenance Cost Model

	Autonomous Vehicle	BRT	Aerial Cable Car[1]	Automated People Mover	Light Rail / Streetcar	Monorail[2]	Heavy Rail
Unit Cost							
Vehicle Operations Cost / Vehicle or train Revenue Hours	$74.76	$124.60	$284.57	$85.76	$172.57	$85.76	$483.56
Vehicle Maintenance / Vehicle Revenue Miles	$2.48	$2.48	$14.06	$7.53	$5.26	$7.53	$2.46
Non-Vehicle Maintenance / Directional Route Miles	$6,288	$6,288	$431,814	$609,026	$172,227	$609,026	$481,407
General Administration / Peak Vehicles	$184,402	$184,402	$179,380	$205,375	$236,513	$205,375	$132,870
Service Statistics							
Annual Vehicle or Train Revenue Hours	62,898	49,860	21,696	35,778	48,816	34,734	25,032
Annual Vehicle Revenue Miles	754,776	747,900	282,048	751,338	781,056	868,350	1,501,920
Directional Route Miles	11.77	11.77	3.50	10.43	10.43	10.43	10.43
Peak Vehicles	17	14	6	10	13	9	10
O & M Cost							
Vehicle Operations	$4,702,192	$6,212,473	$6,173,990	$3,068,281	$8,424,317	$2,978,748	$12,104,483
Vehicle Maintenance	$1,870,380	$1,853,340	$3,964,571	$5,657,102	$4,108,547	$6,538,129	$3,692,685
Non-Vehicle Maintenance	$73,989	$73,989	$1,511,350	$6,353,120	$1,796,607	$6,353,120	$5,021,844
General Administration	$3,134,831	$2,581,626	$1,076,280	$2,053,754	$3,074,675	$1,848,378	$1,328,697
Total	$9,781,392	$10,721,428	$12,726,191	$17,132,257	$17,404,147	$17,718,376	$22,147,709

[1] ACT cost was developed for the representative alignment from approximately the Museum Park Metromover Station to 5th Street & Alton Road.
[1] Monorail was developed using unit costs of Metromover.

[1] Cost was developed for the representative alignment from approximately the Museum Park Metromover Station to 5th Street & Alton Road.
[2] Monorail was developed using unit costs of Metromover.

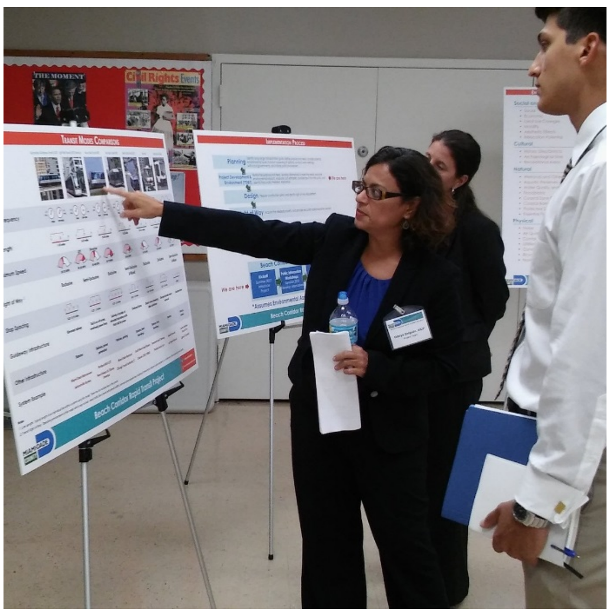
Table A-3 | Travel Time by Mode and Segment

			Heavy Rail Transit	Monorail	BRT	LRT / Streetcar	Autonomous Vehicle	Automated People Mover	Aerial Cable Car
Southbound/Eastbound		Distance (mi	Travel Time (min:sec)						
	Total	**7.6**	**15:35**	**18:02**	**29:44**	**28:04**	**37:49**	**21:10**	**35:04**
	Design District - Downtown Miami Travel Tim	4.2	10:55	11:55	18:34	17:10	23:13	13:29	22:19
	Downtown Miami - Miami Beach Travel Time	3.3	04:40	06:07	11:11	10:54	14:36	07:40	12:45
Westbound/Northbound		Distance (mi	Travel Time (min:sec)						
	Total	**8.5**	**16:28**	**19:22**	**32:23**	**30:43**	**41:21**	**22:56**	**38:01**
	Miami Beach-Downtown Miami Travel Time	3.3	04:40	06:07	11:10	10:54	14:35	07:40	12:45
	Downtown Miami- Design District Travel Tim	5.1	11:48	13:15	21:13	19:50	26:46	15:15	25:16
	Avg One-Way Travel Time (min)		**16.02**	**18.70**	**31.06**	**29.40**	**39.59**	**22.04**	**36.54**

APPENDIX B | PUBLIC INVOLVEMENT

The Beach Corridor Rapid Transit Project Tier One public involvement effort included one agency/elected official kickoff meeting, two public kickoff meetings, several one-on-one meetings with elected officials, the City of Miami and the City of Miami Beach. Meeting announcements were mailed to nearby property owners, placed in the *Miami Herald* and *el Nuevo Herald*, posted on social media and hundreds were distributed by hand at transit hubs and posted on buses and municipal trolleys.

The kickoff meetings were held in an open-house format followed by a formal presentation and comment period. There were 176 total attendees. Attendees were provided with a project fact sheet, speaker card for verbal comment, comment card for written comment, and a survey of public transit modes and preferences. Comments received were largely in support of providing additional public transit services and delivering improvements quickly. Residents urged that more be done in the short term to improve access to Miami Beach from the mainland while we consider long-term solutions. Current inadequate transit options for people who work on the Beach contribute to lack of parking for residents. Several meeting attendees recommended that a direct connection to Miami International Airport should be included. Attendees suggested using data from previous studies of the same area to expedite the process. They also expressed concerned about the study limits and terminus of the corridor, because they stated that Fifth Street and Alton Road in Miami Beach is not a desired destination for anyone visiting Miami Beach. Subsequent presentations to stakeholders included comments on studying different north south alignments in comparison to Miami Avenue (NE 2nd Avenue and Biscayne Boulevard in Design district segment and NW 2nd Avenue in Downtown Miami segment). As a result of input received, the Tier 2 evaluation will be expanded to included alignments to the Miami Beach Convention Center.



APPENDIX C | NOISE IMPACT ANALYSIS

An operational noise assessment was conducted for each mode and representative alignment considered in the Tier One evaluation, using the FTA guidelines spreadsheet and procedures. Aerial Cable Transit was excluded from the analysis, based on literature review indicating this mode would not be expected to cause noise impacts. Project-related noise levels and noise impact distance were calculated using FTA reference sound levels for each transit technology. These noise impacts distances were used for the rank order rating assessment and were also used to show noise impact buffers on corridor figures for each technology.

Table C-1 shows the existing noise level, predicted distance for moderate and severe noise impacts due to each mass transits technology, and the rank order assigned to determine potential for noise impact for each technology.

Table C-1 | Operational Noise Impacts

Alignment Section	Land Use	Rail Technology Type	Speed, mph^	Existing Noise Level L_{dn}, dBA	Mod. Impact Noise Level, dBA	Sev. Impact Noise Level, dBA	Mod. Impact Distance, ft*	Sev. Impact Distance, ft*	Mod. Impact Rank Order	Sev. Impact Rank Order
Design District	Residential	Metromover	20	75	65	73	13	4	4	4
MacArthur Causeway	Residential	Metromover	30	61	58	64	64	27	4	3
Design District	Residential	Monorail	25	75	65	73	3	1	2	2
MacArthur Causeway	Residential	Monorail	45	61	58	64	19	8	2	2
Design District	Residential	Metrorail	30	75	65	73	55	16	6	6
MacArthur Causeway	Residential	Metrorail	55	61	58	64	340	145	6	6
Design District	Residential	LRT/Streetcar**	15	75	65	73	14	4	5	4
MacArthur Causeway	Residential	LRT/Streetcar**	45	61	58	64	170	73	5	5
Design District	Residential	BRT	15	75	65	73	5	1	3	2
MacArthur Causeway	Residential	BRT	45	61	58	64	62	27	3	3

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