Review of the Tunnel Crossing of the New River in Fort Lauderdale, FL

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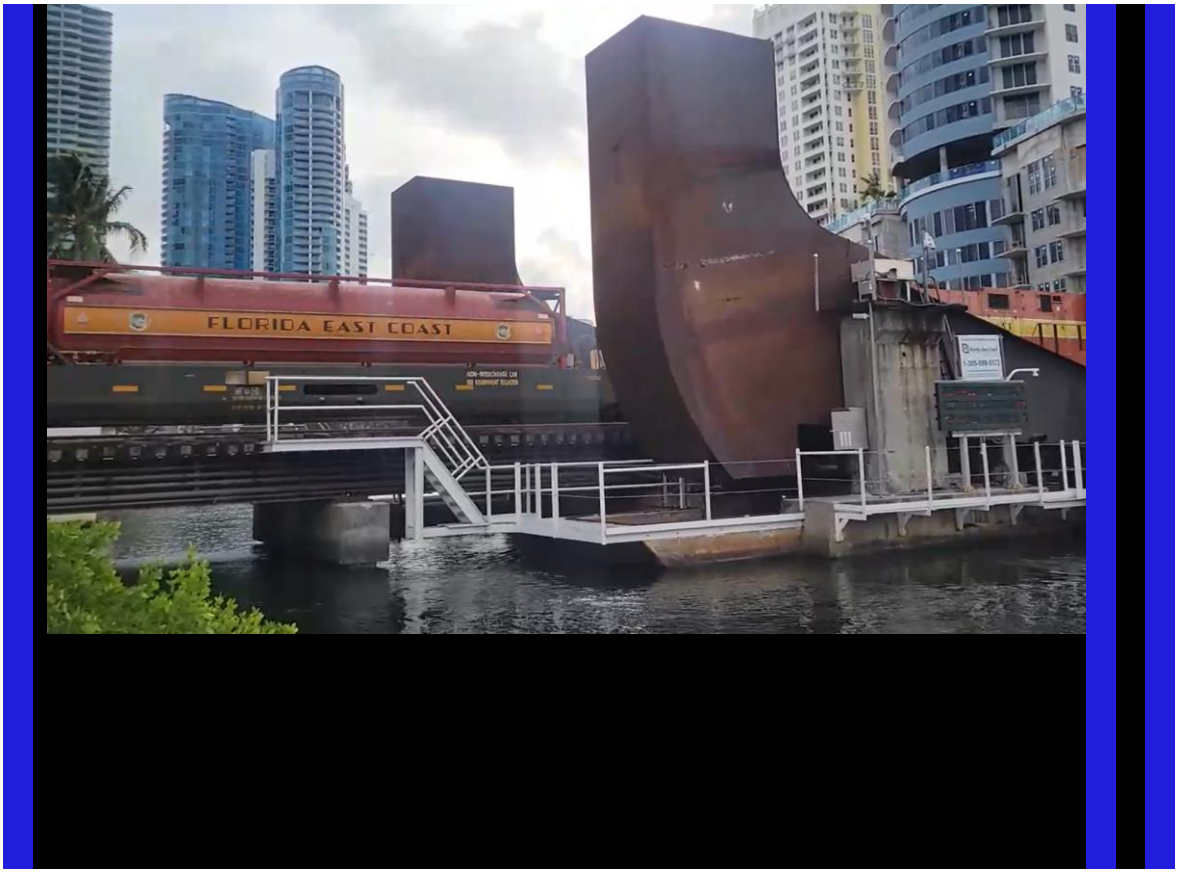

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Project no:	D3864500
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Client:	Broward County
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1. Executive Summary

Jacobs reviewed a tunnel conceptual design for new passenger rail service across the New River on the Florida East Coast Railway (FECR) corridor. The conceptual design was prepared by a third-party consultant for the City of Fort Lauderdale. The focus of the review was on key technical, financial, environmental, and other aspects of the tunnel concept, and it was performed using federal and state guidelines for cost estimating and feasibility determination; industry standards for tunnel and passenger rail design; and Jacobs's expertise on previous projects, including the Port of Miami Tunnel.

The tunnel option developed by the City Consultant includes un underground passenger station, which is long enough to serve commuter rail passengers only and not Brightline. Therefore, Brightline would not use this tunnel option, and they will continue to operate on the existing bridge. The report and conceptual design developed by the City Consultant is a tunnel alignment concept only, which from a tunneling perspective, the report has fatal flaws and is lacking the following key technical and financial aspects:

Geotechnical and Geological Conditions

Whether local or regional, geological conditions are crucial for a tunnel project's feasibility and may impact technical, financial, risk, construction cost, and environmental aspects.

- The report does not have any geotechnical discussions or assumptions, which are the most important factors to determine feasibility and cost estimate of any tunnelling project.
- There is no discussion about any specific type of tunnel boring machine (TBM). The depth of the tunnel below groundwater level and the river crossing indicates a closed face TBM is required.
- Because of the shallow tunnel cover proposed by the City Consultant and with high sandy content ground, it is likely that a slurry TBM suitable for a sandy ground will be mandated. This will increase the cost of the TBM, and it will require a staging area for a slurry de-sanding plant. All these costs are not included in the City Consultant's estimate.
- There is no discussion regarding the type of Support of Excavation (SOE) for the U-wall, cut-and-cover tunnel, and TBM launching and receiving pits. The proposed tunnel (and its alignment) is not constructible within the existing railroad right-of-way due to the required dimensions of the SOE along the proposed tunnel portal locations.
- Geological stability will be required as surface subsidence is expected during tunnel excavation directly below the existing tracks; this presents a significant life/safety risk to the railroad operation and surrounding buildings. Associated cost needs to be included in the site/civil category.
- Excavation of the underground Station will take place in soil of very loose to loose type with high groundwater table, which has significant risk of losing ground stability. A significant amount of ground improvement such as ground freezing will be required.
- The access tunnel that connects the shaft and the underground station has the potential issue of buoyancy and requires tie-downs both during temporary and permanent conditions. The height of the access tunnel/cavern is about 50 feet, its cover is only about 20 feet, and the groundwater table is near the ground surface.
- The settlement induced by the SEM station construction with shallow cover in loose sandy material will significantly impact the existing railway, which has very limited displacement tolerances.

Mitigation measures to address this issue may be costly and should be accounted for in the overall project cost estimation.

- U-wall and cut-and-cover tunnel constructions in South Florida require a special construction technique to avoid buoyancy during construction, in temporary, and in permanent conditions. Tie-downs have been successfully implemented to prevent buoyancy issues in South Florida. This type of construction will cost more than that for traditional U-wall and cut-and-cover tunnel construction without tie-backs.

Fire / Life / Safety (FLS)

There is no space proofing discussion for both the tunnel and the station, such that the proposed dimensions can be verified; no discussions for tunnel cross passages; no details on means of egress during an emergency event, nor discussions on the tunnel ventilation scheme and air quality at the station are provided. The report does not discuss tunnel drainage and pumps (portal trench drains and low point pump station) either.

The ventilation system will require fans and large ducts to circulate air in the tunnel and at the station. The Station design should also have at least two egress shafts to the surface; only one egress shaft is shown in the City Consultant's report. In addition, the underground station will not replace the existing Brightline station, but a connection between the 2 stations is expected. Such connection to the Brightline station was not provided on the sketches and cross-sections by the City Consultant. These items will require space that will likely impact the size of tunnel, and which should be reflected on the cost estimate.

Track Vertical and Horizontal Alignment

A review of the vertical and horizontal alignment as it relates to the TBM excavation, track transition, and existing bridge pilings was performed.

- In the City Consultant's report identifies the tightest curve with a radius of 1,100 ft allowing normal operating speed of 45 MPH. However, for TBM construction and muck disposal using conveyor belt, the desired minimum radius is 1,200 ft to have proper space for the conveyor belt mucking system. This may result in a longer tunnel.
- The transition from the underground track to the surface track on the North end of the alignment has some unrealistic horizontal curves. Based on design standards from the AREMA Manual, to achieve these vertical and horizontal transitions, the track will need to be longer, which will lengthen the tunnel. In addition, these transitions will also be difficult for TBM excavation.
- The proposed tunnel vertical alignment is aggressive to minimize tunnel cover and to achieve a shorter tunnel length. To validate that the proposed tunnel alignment is feasible, in addition to geotechnical and geological analysis, river bathymetry and scour assessments for the tunnel under the New River will be required.

Cost Estimate Contingency Assumptions

The cost contingency used by the City Consultant does not follow the recommendations from the Federal Transit Administration (FTA) Oversight Procedure 40 – Risk and Contingency Review. According to the FTA, a contingency of 33% corresponds to a project that has been advanced to 30% design. The City Consultant tunnel design is conceptual at best and is more representative of 15% design or less. Therefore, following the FTA recommendation the appropriate contingency that should be applied at this level is 40%-45%. The same contingency should be applied for the Operations and Maintenance (O&M),

and the Cyclical Replacement cost. The total capital cost estimated by the City Consultant is $888M with a 33% contingency, but with a 43% contingency the cost estimate increases by $812,000 to $996M.

The most significant cost variance is in Category 40. Sitework where items related to the type of excavation (TBM), geotechnical and geological considerations and fire/life/safety should be considered.

Description	Jacobs Estimate 1.146-mi Tunnel (2024$)	City Consultant Estimate 1.146-mi Tunnel (2024)
10 - GUIDEWAY & TRACK ELEMENTS	347,622,590.00	247,208,757.00
20 - STATIONS, STOPS, TERMINALS, INTERMODEL	217,360,000.00	304,624,744.00
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS		
40 SITEWORK & SPECIAL CONDITIONS	193,185,000.00	13,191,496.00
50 - SYSTEMS	30,640,000.00	14,509,688.00
Construction Subtotal (SCC 10-50)	**788,807,590.00**	**579,534,685.00**
60 - RIGHT OF WAY	1,300,000.00	1,300,000.00
80 - PROFESSIONAL SERVICES (APPLIES TO CATS.10-50)	260,306,504.70	115,906,937.00
Subtotal (SCC 10-80)	**1,050,414,094.70**	**696,741,622.00**
ALLOCATED CONTINGENCY	315,124,228.41	191,246,446.00
UNALLOCATED CONTINGENCY	136,553,832.31	
Bid Total	**1,502,092,155.42**	**887,988,068.00**

Figure E-1. Capital Cost Estimate Comparison

The City Consultant did not apply the contingency percentage to the Professional Services Cost Category nor to the Right-of-Way Purchase Cost Category, which increases their cost by an additional $100M. The City Consultant also did not include capital costs related to passenger connection to the Brightline Station or a connection to the east side of the tracks., which and could increase the cost by $100M. The cost of the Brightline connection plus the increase due to a 43% Contingency applied to the City Consultant's cost estimate increases the total cost to $1.09B.

Operations & Maintenance and Cyclical Replacement Cost

The O&M and Cyclical Replacement cost estimate Jacobs calculated for the 1.146-mile tunnel totals $15M per year including a 43% contingency vs. $1.9M per year with a 30% contingency calculated by the City Consultant. The most significant differences are in the Annual Cyclical Replacement Cost of the power, fans, and ventilation systems. City Consultant lacks the passenger station, railroad structures and system O&M cost. In addition, the annualized Cyclical Replacement cost estimate does not appear to have been calculated using a compounded escalation rate.

O&M + Cyclical Replacement Cost	Jacobs	City Consultant
Annual O&M + Cyclical Cost	$15,195,890.59	$1,886,040.00
Annual O&M	$2,079,792	$1,482,000.00
Annual Cyclical	$13,116,098.59	$404,040.00
Future Cumulative Cost at 50 years	$1,990,631,275.95	$195,740,776.00
Annualized 50-yr Cumulative Cost	**$15,188,516.64**	**$2,309,741.16**

Figure E-2. O&M and Cyclical Replacement Cost Comparison

2. Introduction

Broward County engaged Jacobs to review a tunnel conceptual design for new passenger rail service across the New River on the Florida East Coast Railway (FECR) corridor. The conceptual design was prepared by a third-party consultant for the City of Fort Lauderdale. Jacobs' review of this concept is to focus on key technical, financial, environmental, and other aspects of the tunnel concept. The findings of the review of the tunnel conceptual design alternative are presented in the sections below.

2.1. Background

In early 2023 the City of Fort Lauderdale and Broward County collaboratively engaged a consultant (the "Whitehouse Group") through the Broward Metropolitan Planning Organization (MPO), to conduct a joint study of previously developed alternatives for passenger rail to cross the New River on the FECR corridor. The alternatives previously developed included three (3) bridges and one (1) tunnel, and they were performed under the Florida Department of Transportation District 4. Jacobs performed the study of the FDOT tunnel alternative as part of the Whitehouse Group team.

On August 18, 2023, the Whitehouse Group delivered to the City of Fort Lauderdale and Broward County the results of the study. As the Whitehouse Group study wrapped up in late 2023, the City of Fort Lauderdale separately contracted another consultant, BDO ("City Consultant") to explore new tunnel design alternatives that might reduce the cost, lower right-of-way impacts, and otherwise improve the feasibility of a tunnel alternative. The City Consultant's design alternative was completed in April 2024.

The review Jacobs performed of the City's Consultant tunnel option was focused on two tasks: one focused on the technical aspects of the conceptual design, and the other focused on the capital and operations and maintenance cost estimates review.

2.2. Documentation Reviewed

- New River Crossing Report, Report on Tunnel Alternative, April 2024, BDO. Commission Memorandum 24-062
- Subsurface Exploration Report No. J-21116.001, City of Fort Lauderdale, Quest Engineering (August 11, 2021)
- Report of Subsurface Exploration and Geotechnical Engineering Study, Proposed 42-Level Society Las Olas Phase II, Fort Lauderdale, Florida 33301, NV5 Project No.: 17126; dated October 29, 2021

Additional documents used for reference:

- American Railway Engineering and Maintenance-of-Way Association 2023 Manual
- Assessment of Alternatives for Enabling Commuter Rail to Cross the New River on the FEC Corridor, Technical Memorandum No. 3 Capital Costs (August 2023, Whitehouse Group)
- Assessment of Alternatives for Enabling Commuter Rail to Cross the New River on the FEC Corridor, Technical Memorandum No. 4 Operating and Maintenance (August 2023, Whitehouse Group)
- Transit Corridor & Project Evaluation (TCPE) Guidance Florida Department of Transportation, June 2024.

2.3. Assumptions

The opinion and findings provided in the technical memorandum are based on the following assumptions:

- City Consultant's documents have an accurate tunnel alignment.
- The design of the alignment does not require validation.
- A geotechnical analysis for this project alignment has not been performed yet.
- Dimensions are approximate. The quality of the graphics provided in the City Consultant's report was low, which made certain notes and dimensions difficult to read.
- The depth of the review is representative of the limited time and budget provided.
- Construction experience from the Port Miami Tunnel (POMT), Miami, FL is applicable to this project.
- Construction experience of the Okeechobee Road Depressed Section in Hialeah, Dade-County, FL, which is in South Florida, and its Support of Excavation (SOE) aspects are applicable to this project.
- The disclaimers included in the City Consultant's report are not applicable since the report is a public record for the City of Fort Lauderdale.

3. Task 1—Technical Review of New Tunnel Alternative

The technical review of the conceptual design document prepared by the City Consultant included main design assumptions, completeness, horizontal and vertical alignment, FLS, station design, impact to freight traffic and constructability.

In the introduction of the City Consultant's report, it is stated that the "… *tunnel is viable and fiscally feasible by providing a shorter tunnel alternative with a lower cost compared to previous studies that rendered the tunnel concept more challenging due to the high cost*." It is Jacobs' opinion after review of this tunnel alternative that it is not a viable and fiscally feasible option at this stage. This option lacks engineering justification and misses many critical components, such as FLS and other required operations for an underground rail tunnel. The discussion included in Sections 3 and 4 of this Technical Memorandum provides the basis of our opinion.

The dimensions of the conceptual tunnel provided by the City Consultant are as follows:

Table 1. City Consultant's Tunnel Dimensions	
Tunnel Length:	1.146 miles
Max. Tunnel Slope:	4%
Max. Depth:	55 feet Below Mean Sea Level
No. of Tunnels:	2
Single Tunnel Min. Dimensions:	21.9 feet x 24.5 feet (Rectangular)
Single Tunnel Max. Dimensions:	26 feet Diameter (Circular)
Station Platform Length & Width:	500 feet X 34 feet

3.1. Validation of Major Assumptions

Agreement of access/use by FEC

- Achieving an agreement to access the FEC right-of-way will be key to this project. The tight confines of the corridor and the size of the temporary and permanent underground works will make this project technically complex for operational logistics and access adjacent to the operating tracks and roadways. It will also require relocation of existing signal houses and providing temporary facilities, such as utilities, pedestrian and vehicular access.
- The City Consultant is proposing the tunnel alignment to the East and West of the existing tracks so as not to impact the current operations. Achieving "No Impact" cannot be assumed because the work will be at minimal clearance from an active main track which will require operating slower trains and full-time railroad flagmen, therefore, the costs should include a premium for delays to the work based on train traffic, especially the fast Brightline trains.

Tunneling Design

- The report does not have any geotechnical discussions or assumptions, which are the most important factors to determine feasibility and cost estimate of any tunnelling project.
- There is no discussion about any specific type of tunnel boring machine (TBM). The type of TBM utilized for this tunnel construction ties in with tunnel construction means and methods and

ground support requirements. The depth of the tunnel below groundwater level and the river crossing indicates a closed face TBM is required.

- There is no discussion regarding the type of Support of Excavation (SOE) for the U-wall, cut-and-cover tunnel, and TBM launching and receiving pits. The proposed tunnel (and its alignment) is not constructible within the existing railroad right-of-way as a result of the required dimensions of the mentioned SOE along the proposed tunnel portal locations.

Station Design

- The conceptual level of tunnel and underground station do not provide enough space for installation of all systems engineering, FLS, and egress.

Project Cost:

- Due to the lack of a feasible tunneling and underground station concept, the proposed capital cost can be mis-leading.

3.2. Completeness Review

To complete a feasibility study for a tunnel option the following important aspects need to be investigated due to the likelihood they will affect project cost and construction risks:

- Geotechnical, geological, and hydrological information: The investigation can drastically affect the feasibility and cost of the project.
- Topography of the portal areas and pre-construction survey of structures around the tunnel.
- River bathymetry and scour assessments for the tunnel underpass.
- For underground stations means of egress, cross passages, FLS, and space proofing.
- Vertical and horizontal alignment for constructability and revenue operations.
- Detailed easement and property availability for construction and construction staging.
- Utility investigation for relocation, expansion and new utilities required.
- Environmental assessment of the area related to contamination.

After reviewing the City's Consultant report, it was determined that the tunnel alignment is a concept at most and has no engineering justifications for its feasibility because it is lacking details related to the important aspects listed above. **From the tunneling perspective the report is lacking the following components to achieve the purpose of the project:**

- Discussion of Geological Conditions: whether it is local or regional, which is crucial for the feasibility of a tunnel project. Knowing whether the geological conditions are local or regional is crucial for the feasibility of a tunnel project. Any geotechnical and geological risk mitigation would require additional construction contingency if not addressed or mitigated.

- Discussion on Support of Excavation (SOE): Conceptual level of SOE scheme for U-wall, cut-and-cover tunnel, and tunnel boring machine (TBM) launching and receiving pits. Fatal flaws for SOE construction are to be discussed in the sections below.

- Discussion on Fire / Life / Safety (FLS) for tunnel and underground station operations. Space proofing, details for tunnel cross passages, means of egress during an emergency event; air quality and ventilation scheme in the tunnel and in the station; and tunnel drainage and pumps (portal trench drains and low point pump station) were provided in the City Consultant report.

- The tunnel is proposed to be excavated with less than 15 feet of cover. A detailed bathymetric and geotechnical assessment should be conducted to confirm the viability of the tunnel under-passing the New River with such limited cover / overburden.
- System components: no track, signal, communication (related fire/life/safety), SCADA were provided or discussed.
- Tunnel Control Center: no discussion on location, easement, hardware, and software.
- Tunnel alignment study including vertical and horizontal transitions for TBM and track.
- Preliminary construction risk assessment of the existing structures that will be interfering with the tunnel alignment and excavation activities.

In summary, these major components will impact constructability and cost.

3.3. Vertical and Horizontal Alignment - Tunnel

A review of the tunnel horizontal alignment was made, particularly as it related to impact on existing bridge pilings and possible need to adjust alignment in ways that would cause tunnel alignment to go outside FECR right of way.

3.3.1 Horizontal Curves

In the City Consultant's report "the tightest curve has a radius of 1,100 ft allowing normal operating speed with suitable track superelevation and providing train speed of 45 MPH." However, for TBM construction and muck disposal using conveyor belt, the desired minimum radius is 1,200 ft to have proper space for the conveyor belt mucking system. This may result in a longer tunnel.

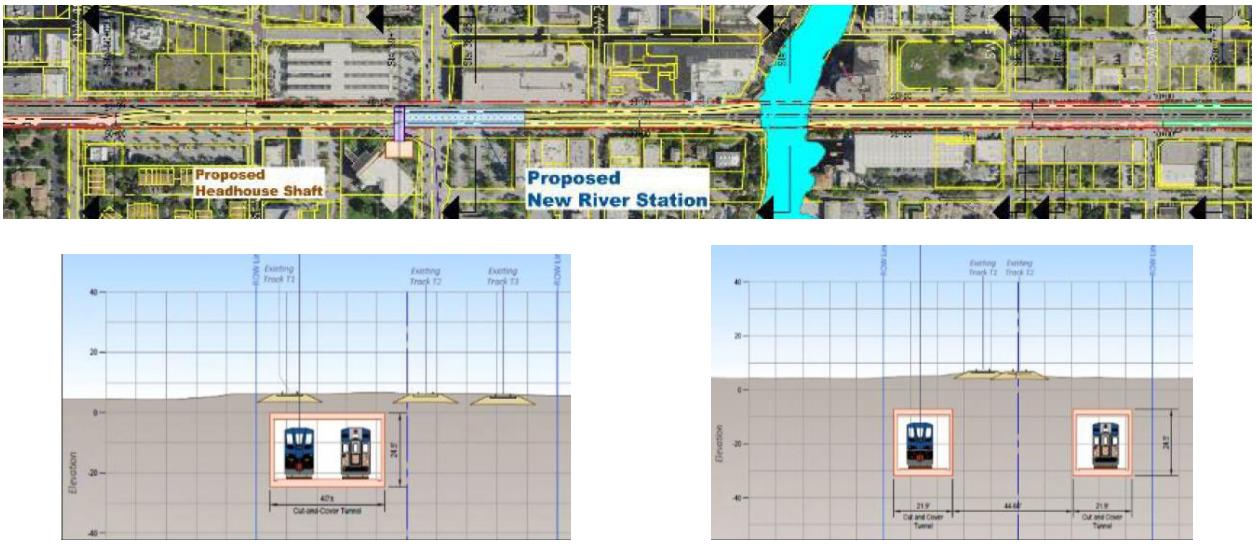


Figure 1. Transition from Tunnel Approach to Cut-and-Cover on North and South Ends

3.3.2 Transition Between Cut-and-Cover and TBM Tunnel Sections

The transition between the cut-and-cover and TBM tunnel sections needs to be clarified. The required bellmouth structure may interfere with the existing railway construction sequence. Refer to **Figure 1** for Transition From Tunnel Approach to Cut-and-Cover on North and South Ends.

3.3.3 TBM Portal Excavation Outside of the FEC Right-of-Way (ROW)

The proposed tunnel is not constructable, within the existing railroad ROW along the proposed alignment as explained below.

South Portal

Two TBM receiving pits were proposed at the South portal, as shown in **Figure 2** below from the City Consultant's report, Stage 6 Portal Construction.

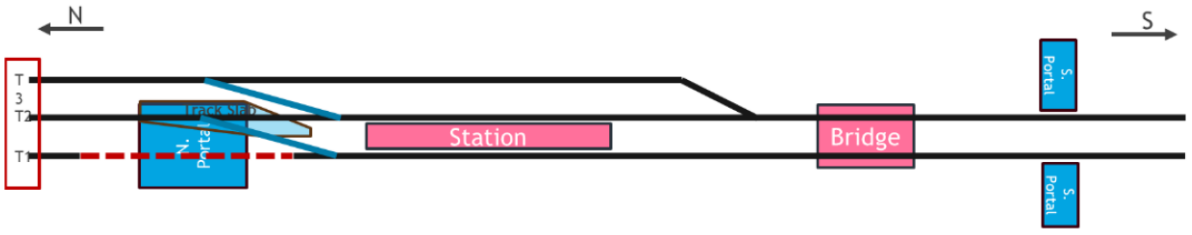


Figure 2. City Consultant's STAGE 6 – PORTAL CONSTRUCTION

The proposed excavated outside tunnel diameter is 28 feet. To receive the TBM, the receiving pit is approximately 44 feet wide, which includes 28 feet tunnel outside diameter, 5 feet either side clearance of the tunnel (i.e., 10 feet total), and the 3 feet width of the SOE on either side of the pit (6 feet total).

The railroad easement is about 100 feet wide. To construct two TBM receiving pits, each at least 44 feet wide, during live tracks is not feasible, as shown in **Figure 3**.

The distance between the west easement limit to the edge of the southbound track is about 35 feet, which is smaller than the required width of a 44-foot-wide TBM receiving pit. This will require single tracking operations for FEC and Brightline during the construction of the west side South portal.

Figure 3. South Portal, near SW 5th Street

The Figure 4 below shows a typical TBM Break-in/Break-out SOE scheme utilized for the (POMT). The overall width of this section including the CSM wall is about 110 feet.

Figure 4. Port Miami Tunnel (POMT) TBM Break-in Support of Excavation With Secant Pile And Cutter Soil Mixing Wall

North Portal

One combined TBM launching and receiving pit was proposed at the North portal, as previously shown on Figure 2. The construction of this TBM launching and receiving pit is unfeasible for the following reasons:

- Constructing the receiving pit west of Track 1 will require significant encroachment on adjacent property, since minimum space exists between Track 1 and the ROW.
- Minimum combined TBM launching and receiving pit is about 82 feet, which includes the two TBM outside diameter (28 feet each), pillar between two tunnels (10 feet, which needs extensive ground improvement to keep tunnel stability during construction), 3 feet SOE wall on each side (6 feet total), and 5 feet clearance each side of the SOE.
- The TBM launching and receiving pit will encroach not just Track 2, but also Track 3.

Refer to Figure 5 for North Portal clearances.

Figure 5. Proposed North Portal location between NW 4th and NW 5th Streets

3.3.4 Transition from Underground Track to Surface Track

The transition from the underground track to the surface track on the North end of the alignment has some unrealistic horizontal curves. As shown in **Figure 6** without a geometric layout, the total tunnel length of the proposed scheme cannot be verified because of the several horizonal and vertical curves. The actual tunnel length could be longer than that proposed in order to accommodate the minimum geometry for the curves. In addition, the two "S" curves shown on the north bound underground track will be difficult for TBM excavation. These "S" curves also need to follow railroad operational and safety requirements.

The plan for the northern segment of the tunnel depicted, shown to be SEM and Cut & Cover, does not match the profile. The plan shows it on the West side of the ROW, yet the Cross Section shows it on the East side of the ROW. Refer to section 3.4.2 for discussion related to railroad vertical and horizontal curves.

Figure 6. City Consultant's Stage 10 Complete Horizontal Tunnel Alignment

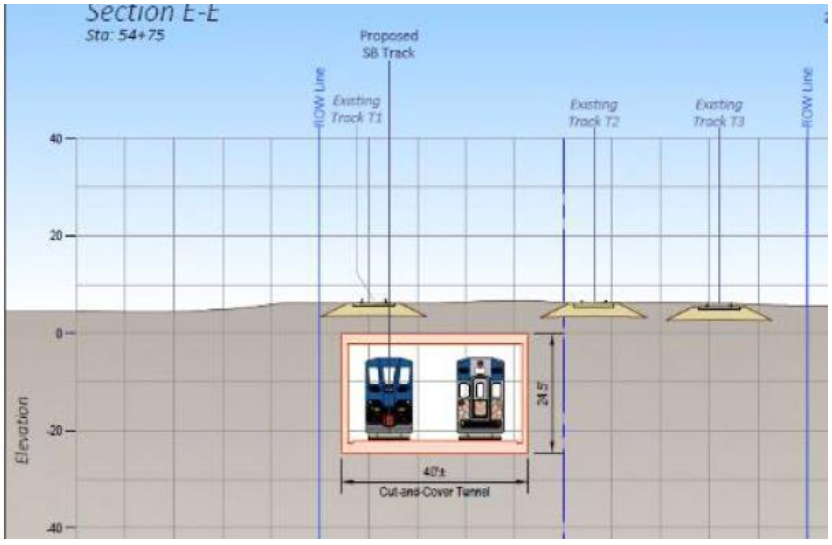


Figure 7. City Consultant's Profile Does not match Plan

3.3.5 Installation of Track Slab Under Track 2

As mentioned earlier, the TBM launching and receiving pit dimension will encroach on Track 2 and Track 3 due to the total dimension and clearance required. The proposed surface track slab as part of the future cut-and-cover tunnel roof structure is not desirable. As shown on **Figure 8** below, the proposed Stage 3

from the City Consultant's construction sequencing solution will be difficult to achieve, or unfeasible from structural and waterproofing perspectives. In addition, all the edges of the "slab" are cold joints, where waterproofing detail requires special attention for its long-term performance.

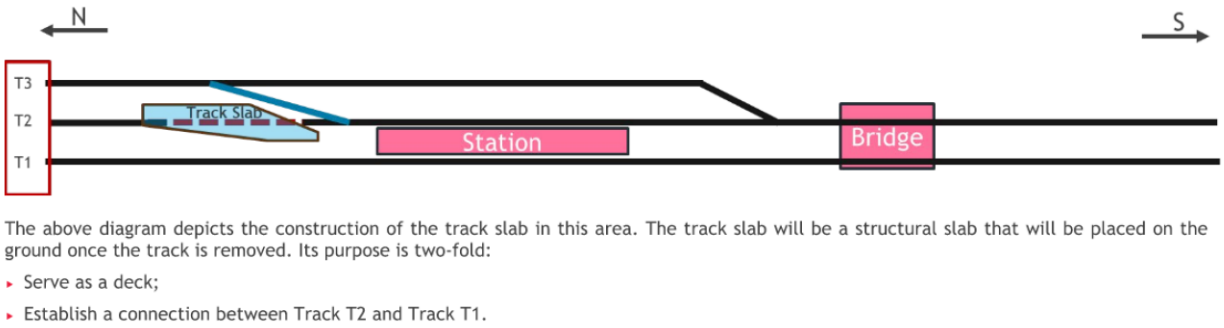


Figure 8. City Consultant's Stage 3 Track Slab under Track 2

3.3.6 Bridge Foundation Clearance

In the City Consultant's report, Figure 15 illustrates two clearances. The first is the horizontal clearance between the bored tunnel and existing pile foundations. The second is the vertical clearance below the New River channel bottom. Proximity to the existing pile foundations would likely have an adverse impact on the capacity of the exterior piles. The tunnel would also intersect any batter piles installed parallel to the river. Batter piles are not shown, but assumed to be present as they are typically used on movable railroad bridges.

Additionally, the tunnel is located approximately 15 feet below the New River channel bottom. Given the horizontal proximity of the tunnel to the bridge foundation, the effects of bridge scour will likely adversely impact the channel bottom. The existing scour depth is typically shown in the Bridge Hydraulic Sheet (plans) and/or included in the Bridge Hydraulic Report. Scour values from 10-20 feet would not be unexpected (-30 feet), exposing the top of the tunnel and adversely impacting scour conditions and bridge stability.

3.3.7 Access Shaft to Station

The proposed underground station to serve the commuter rail passengers is located south of the existing Brightline station, underneath Broward Blvd. The proposed station's access shaft will be located from the vacant lot of the existing Juvenile Justice Department's building, as shown in **Figure 9**.

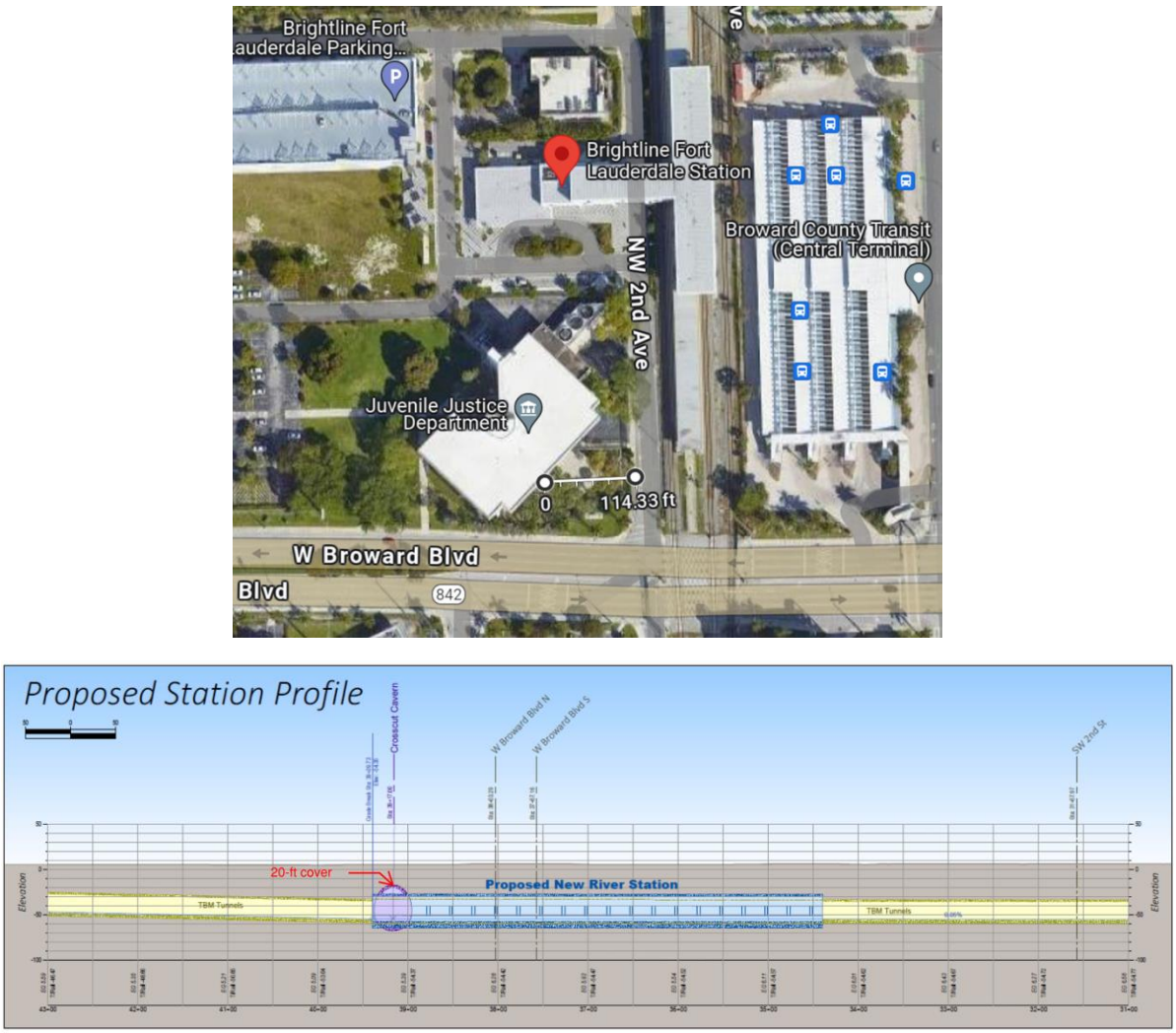


Figure 9. City Consultant's Prosed Underground Access/Exit Shaft at Station Location

The size of the lot for an access/exit shaft is small from a construction perspective. The shaft has to house all underground systems operation and ventilation equipment in addition to passenger circulation. In addition, the station requires at least two underground egresses to the surface; only one is provided. An additional means of egress will be required for emergency exit and access purposes.

3.3.8 Other Risks

Tunnel construction along live track requires significant geological and geotechnical assessments to maintain tunnel and railroad track stability during construction, but also to ensure FLS of railroad operations and buildings along the proposed alignment. The City Consultant report is optimistic about this subject without justification.

3.4. Vertical and Horizontal Alignment - Track

A review of the tunnel vertical alignment was made, particularly as it related to the proposed tunnel depth, gradients, and track transitions, and whether closure of streets may be required to ensure safe sight distance or traffic flow.

3.4.1. Transition North of the Underground Station

The proposed alignment requires a short distance of a 4% grade over 600 feet on the south side of the tunnel, exceeding Brightline's preferred maximum grade of 3%. The City Consultant states that it is acceptable for passenger trains to exceed the 3% grade for a short distance. This steep grade this close to a station is not desirable from a train operations perspective. While a short 4% grade located in a running section can benefit from the momentum head generated by a moving train, a train departing the station will be at lower speeds and could have issues surmounting the grade.

As shown in **Figure 10** the transition to and from north of the station with a vertical slope of 2.19% combined with a horizontal curve is unfeasible, and to accommodate it may require a longer tunnel. Section 3.7.1 of the AREMA Manual provides details related to Compensated Gradients, where a curve on a slope needs to be compensated 0.04% per degree of curve, to account for the added resistance of a train on a curve. Therefore, reducing the slope could be used on a tangent section of track.

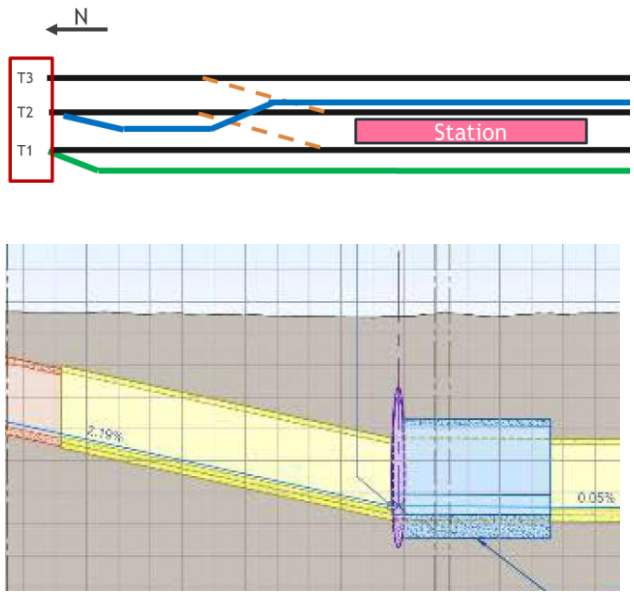


Figure 10. City Consultant's Proposed Underground Station Plan and Profile

3.4.2. Alignment over the River

Looking at the overall tunnel profile, the profile does not show vertical curves necessary to join each of the tunnel segments. A review of the proposed design was performed in comparison to what the AREMA Manual of Engineering (2023) Commuter and Intercity Rail Systems applicable sections recommend. A summary of the findings related to the Vertical and Horizontal are as follows:

- Section 3.5.8.1 Vertical Curves has a formula to calculate the minimum curve length. The impact of this is either holding the vertical point of intersection (VPI) and increasing the length of the tunnel, or impacting the grade crossings and in the case of the station, shifting the platform location south. Alternatively, hold the end points of the vertical alignment, which is controlled by existing roadway crossings (NW 6th Street on the northern limit and SW 7th Street on the southern limit), thereby increasing the grades beyond allowable. The length of vertical curves (LVC) varies based on assumed design speed, therefore, a LVC (50 mph) is 400 feet.

- Section 3.5.8.2 Grades: notes that 3-4% grade is the upper limit of allowable intercity or commuter rail service for short distances, whereas 2-3% grades are recommended.
- Section 3.5.8.5 Compensated Grades: the recommended practice is to utilize compensated grades where horizontal and vertical curve coexist.
- Grades increase substantially as illustrated below, and they exceed allowable. Refer to **Figure 11** for the verified slopes holding the reports portal location. A longer tunnel is required to reduce the maximum grades to acceptable values

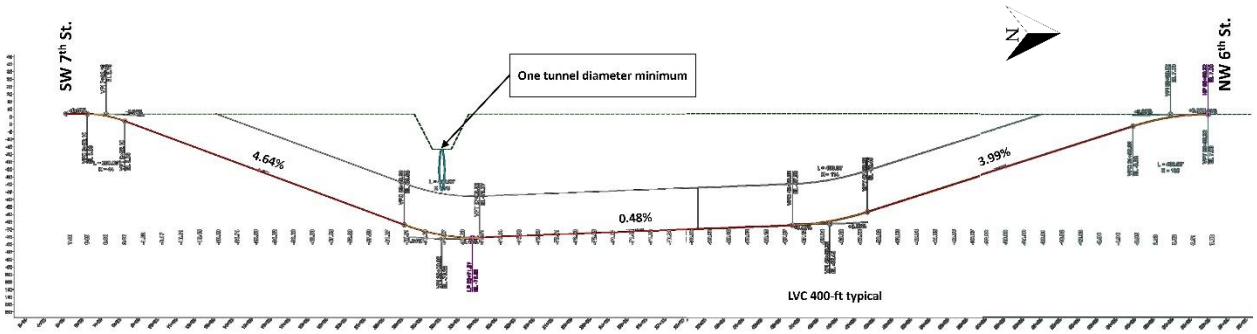


Figure 11. Jacobs Verified Tunnel Vertical Slopes

3.4.3. Other Risks

In general, the vertical alignment in the City Consultant's report is aggressive without justification or looking into geological/geotechnical/hydrogeological information to determine its feasibility. Significant contingency should have been taken at this draft concept level, which is not properly addressed in the report. The lack of geotechnical discussion and the lack of discussion of the construction issues for underground structures in this S. Florida area present a major risk and fatal flaw in planning an underground infrastructure at this magnitude. Section 3.7 of this Technical Memorandum presents more details related to ground stability and risks associated with the underground structure construction proposed or not discussed/understood in the City Consultant's report.

3.5. Fire Life and Safety (FLS)

3.5.1. TBM Tunnel, Cross Passages, Ventilation, and Emergency Access Shaft

A FLS preliminary assessment should be provided to identify the minimum number and the position of cross passages, ventilation, and emergency access shafts and position of (if any).

The tunnel will be excavated through loose soil with low overburden and potentially high ground water levels. The construction of cross passages may require extensive ground improvement measures that can increase cost, and could potentially induce significant settlement. For example, the POMT required freezing the ground and water to -22 degrees Fahrenheit to stabilize the ground enough to safely construct cross passages.

3.5.2. Underground Station

A preliminary fire, life, and safety assessment should be provided to identify the required dimensions for the station, platforms, emergency exits, safe areas, ventilation shafts, etc. In particular, Jacobs noted the following:

- The station length has been reduced from 1,200 feet (with a 1,000-foot platform) in the FDOT study to 450 - 500 feet.
- Tunnel Length: Station exit (Sta. 39+00) to South portal (Sta. 10+00) exceeds National Fire Protection Association (NFPA) Standard 130 maximum distance between exits of 2,500 feet. Furthermore, the station's conceptual design does not comply with NFPA 101 which requires a minimum of two means of egress be provided within a building or structure.
- Station Depth: As proposed, the station is located with 30 feet of cover, under Broward Blvd. The station depicts a single crosscut cavern passage and mezzanine level. The mezzanine would be built above the tunnel, reducing the cover by at least 10 feet. However, NFPA Standard 130 Standard for Fixed Guideway Transit and Passenger Rail Systems requires an analysis of emergency egress which will have significant impacts on egress locations and ventilation requirements. Likely, this will require an additional access location, typically both ends of the station with associated ventilation equipment.
- A FLS analysis is required to identify the minimum number of exits, which will impact the ground surface area and overall station construction cost.

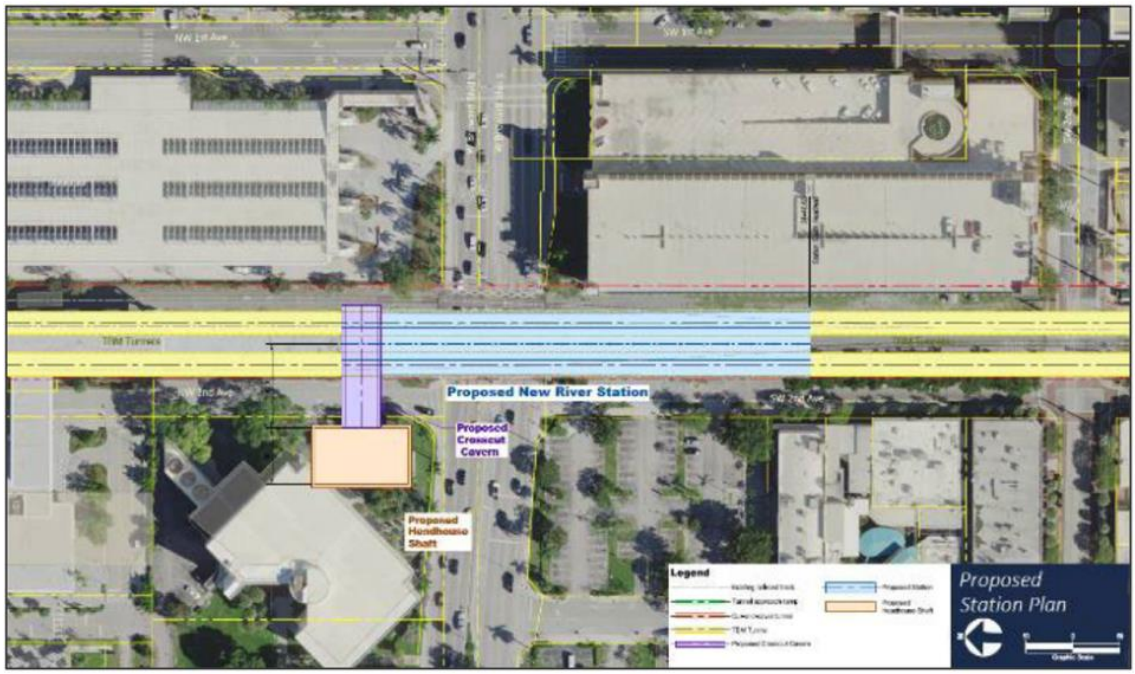


Figure 12. City Consultant Underground Station Plan View

3.6. Resiliency considerations

The City Consultant report includes the use of flood gates as a resilience solution against flooding. This is an important solution to include for any tunnel. However, gates or some flood protection measure will also need to be installed at the station access on surface (shaft). Operationally, the City Consultant's report implies that when flood gates are shut surface tracks aboveground are still operational for freight and Brightline service only, not commuter.

Providing flood gates is a necessary solution; however, details about how the flood gates will be operated during a power outage along with other resilience solutions need to be considered. The following questions may assist:

- Who will have the ability to open and close the gates?
- How will the gates be opened and closed: remotely? by hand with field personnel?
- Does back up power need to be included in the design to operate the flood gates?
- Does the entity responsible for opening and closing the gates need special hardware and software, and a back-up location to remotely access the gate controls?
- Is there back-up power for tunnel and railroad operations during an outage?
- Is there back-up for railroad communications systems during an outage from a tower, wayside signal, or back office?

Other solutions to manage extreme heat and humidity, carbon reduction initiatives, pandemics, natural disasters, terrorist incidents, and catastrophic incidents should be included in future designs of any New River crossing to harden the system. These considerations will have an impact on capital and operating cost.

3.7. Geological Stability in the Area and Risks to Surrounding Buildings

No geotechnical, geological and hydrogeologic information was discussed in the City Consultant report. This presents a major risk for underground structure constructions.

In accordance with Jacob's experience with the report previously completed under the Whitehouse Group, and a report released by Quest on August 11, 2021, South Florida is generally underlain by limestone with varying degrees of weathering. In some areas, the limestone appears and behaves as a solid rock mass, while in other areas, the limestone appears and behaves as a soil.

According to the Quest report valuable insights into the local subsurface conditions at two distinct locations, the New River underpass, and the Fort Lauderdale Brightline Station, were obtained through the analysis of two boreholes: Borehole B6 and Borehole B7, respectively.

Borehole B6 is the most likely representative of the ground conditions at the New River underpass. The results of the boring indicate that the ground is mostly soil, with a small layer (about 10 feet) of weak limestone rock at the tunnel crown. The limestone rock has an RQD (Rock Quality Designation) of 45-49%, which indicates that it is weak and fractured. The weak rock could potentially influence the tunnel excavation. The geological profile under New River is shown in **Figure 13**.

It is concluded that the City Consultant's tunnel option will encounter mix-face tunneling condition (some portions in soft ground and some portions in rock). For example, since the proposed tunnel is very shallow, its crown will be exposed to sandy material.

Groundwater table presents a risk to underground constructions. In accordance with NV5, the groundwater table is near the exiting ground surface along tunnel alignment, ranges from -1.5 to +2.5 1988 North American Vertical Datum (NAVD).

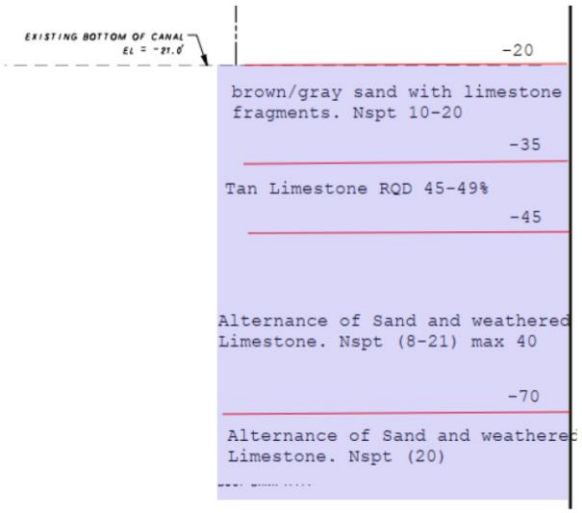


Figure 13. Geological profile under New River (Quest)

3.7.1. Support of Excavation (SOE) for U-Wall, Cut-and-Cover Tunnel, and TBM Launching and Receiving Pits

Temporary SOE structures are required to facilitate the construction of the project. The SOE has to provide a dry construction environment to protect the construction equipment and construction personnel. Since the groundwater table is high in the region and to prevent the buoyancy impact both in temporary and permanent conditions, tie-downs (or ground anchors) are typically employed in the South Florida region, and in combination with a unique excavation scheme described below. This scheme has been used for the SOE of POMT in Miami, FL and the Okeechobee Road depressed section in Hialeah, Dade-County, FL. The construction sequence of this scheme is as follows:

1. Construct groundwater cut-off wall around the SOE.
2. Construct tie-downs (or ground anchors) in wet condition (groundwater infiltration at the bottom of the SOE).
3. Excavate and remove the soil/muck in the SOE in wet condition, from surface around the SOE or using barges inside the SOE. Refer to **Figures 14 and 15**.

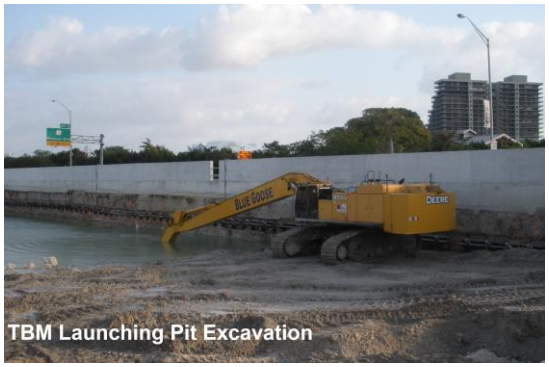


Figure 14. Excavate and remove the soil/muck

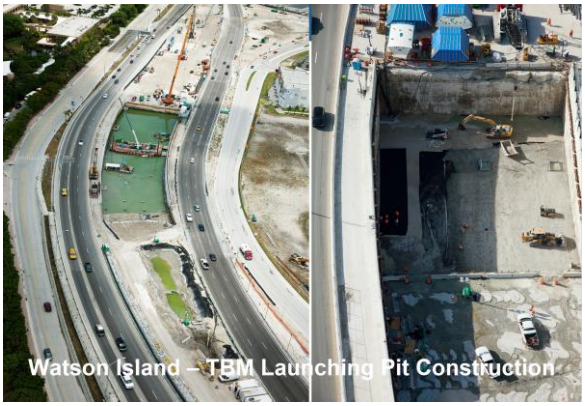


Figure 15. POMT SOE construction

4. Tremie-seal the bottom of the SOE. See **Figures 16 and 17.**
5. Dewater the water in the SOE. See **Figure 18.**

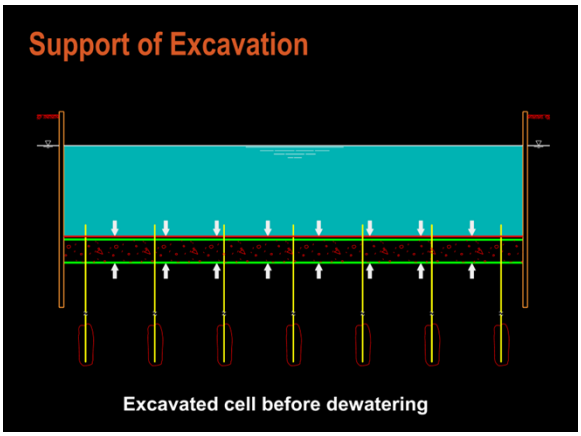


Figure 16. SOE Construction Okeechobee Road depressed section

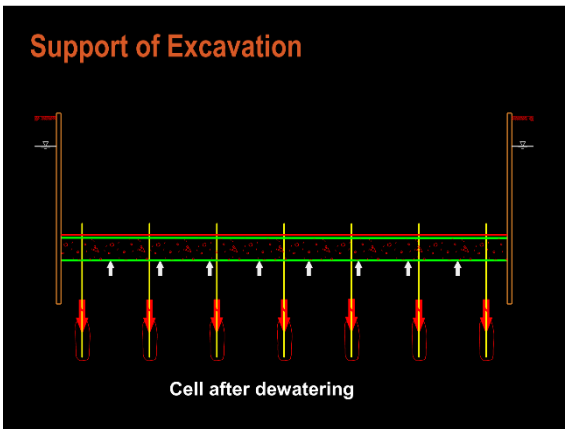


Figure 17. SOE Construction Okeechobee Road depressed section (tie down)

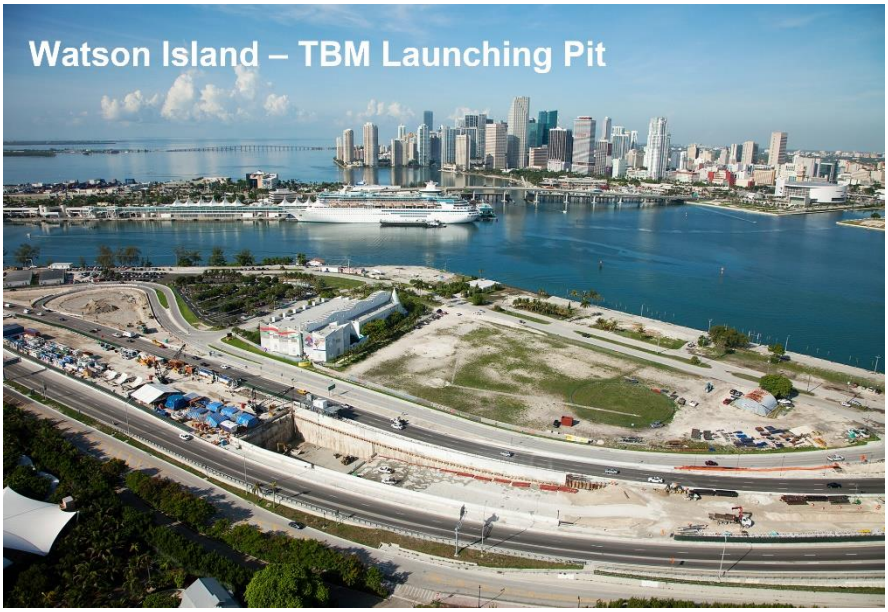


Figure 18. Port Miami Tunnel TBM Launching Pit after dewatering

6. Specific plugs to prevent water infiltration into the SOEs during TBM break-in and break-out will be needed as well. Typically, overlapped secant piles with water-stop rings are installed to facilitate TBM break-in break-out operation. See **Figure 19** for the POMT TBM launching pit with secant pile plug and Cutter Soil Mixing (CSM) to prevent groundwater inflow during TBM break-in.

Figure 19. Port Miami Tunnel TBM Launching Pit with Secant Pile and CSM

The City Consultant may have under-estimated the effort for SOE construction for this specific geology in the region; no description was mentioned about construction means and methods and risk mitigation for the SOEs for the U-walls and cut-and-cover tunnels.

3.7.2. Tunnel Boring Machine and its Logistics

As the tunnel excavation will be in mixed-ground condition (high sandy content), a closed face TBM will be required. An Earth Pressure Balance Machine was employed for the POMT project; however, its earth pressure muck disposal mechanism is unable to convey the mixed fragments (soil and limestone mix) from tunnel excavation. A modified mucking mechanism, similar to that of a slurry machine's, was then implemented (called water control). Because of the low tunnel cover proposed by the City Consultant and with high sandy content ground, it is likely that a slurry TBM should be mandated. This mandate will increase the procurement cost of the Slurry TBM, suitable for sandy ground, and its required staging area for a slurry de-sanding plant. All these costs are not included in the City Consultant's estimate.

3.7.3. Station

The station construction implies significant settlement risks in areas that were not impacted in the FDOT study (e.g., the Park Garage). The station has been relocated to the south of the existing Brightline station, where it will probably be excavated in loose ground conditions with limited overburden. The geotechnical conditions may necessitate extensive ground improvement measures for stabilization. The station construction cost should be re-evaluated accordingly.

Figure 20 provides a bird's view of the underground station. Construction of the underground station and its access tunnel (leading to the shaft) will be in sand with NSPT (Standard Penetration Test blow-count

number) from 0 to 10 (Quest Borehole B7 – sand layer from ground surface to Elevation -60), which indicates very loose to loose and low strength material (note – NSPT number and its relative Density relationship: 0-4, Very Loose; 4-10, Loose; 10-30, Medium; 30-50, Dense; over 50, Very Dense).

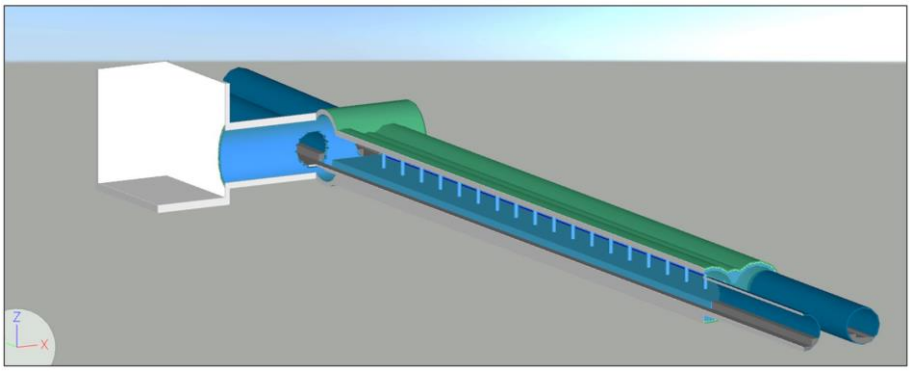


Figure 20. City Consultant's Bird's Eye View of Access shaft, Access tunnel/cavern, and Underground Station

Underground construction in this type of very loose to loose ground with high groundwater table has significant risk of losing ground stability during excavation. A significant amount of ground improvement (such as ground freezing) will be required.

The access tunnel that connects the shaft and the underground station has the potential of buoyancy issues and requires tie-downs both during temporary and permanent conditions. The height of the access tunnel/cavern is about 50 feet, and its cover is about 20 feet only, with the groundwater table is near the ground surface.

- The proposed location of the construction shaft appears to have a considerable impact on the Juvenile Justice Department building, potentially interfering with the current operations or future use of this building.
- An assessment should be conducted to verify if the proposed dimensions of the shaft and crossover are sufficient to facilitate the excavation of the challenging station construction.
- A suitable work site area needs to be identified and evaluated to ensure adequate space is available for the station construction activities.
- The settlement induced by the SEM station construction with shallow cover in loose sandy material will significantly impact the existing railway, which has very limited displacement tolerances. Mitigation measures to address this issue may be costly and should be accounted for in the overall project cost estimation.

To address the unknown soil conditions at this level, significant contingencies should be assumed as part of the cost estimate. The City Consultant has included a contingency amount of $191M for the entire tunnel project. For the POMT project had $150M contingency fund set up by the Procuring Authority to mitigate the risk associated with unforeseen ground conditions, and it was jointly funded by the Procuring Authority and the Miami-Dade County. This indicates that the contingency for estimated at this level of conceptual design is low.

3.7.4. Tunnel

The tunnel is proposed to be excavated with less than 15 feet of cover (see **Figure 21**). A detailed bathymetric and geotechnical assessment should be conducted to confirm the viability of the tunnel under passing the New River with such limited overburden. A detailed tunnel buoyancy calculation should be performed to ensure the tunnel's stability under the river.

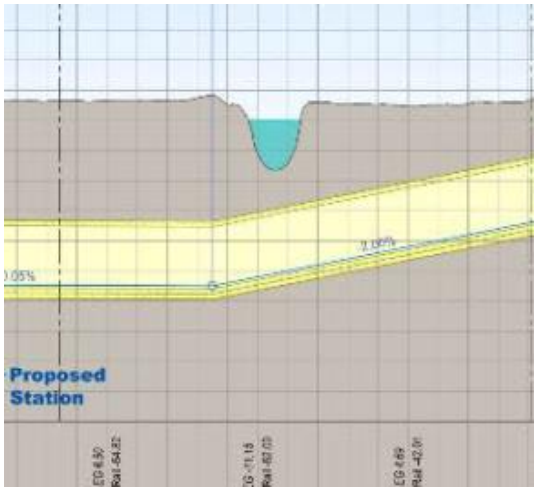


Figure 21. City Consultant's Profile

The City Consultant's proposed alignment will have a different approach than the previous solution developed by FDOT (see **Figure 22**). It will rise immediately after crossing the river, which will result in a shorter tunnel length. However, this approach may cause settlement impacts in different areas than what was initially anticipated and assessed in the FDOT tunnel alternative. If a decision is made to further pursue an adjusted tunnel alternative, a detailed easement study and settlement analysis needs to be conducted.

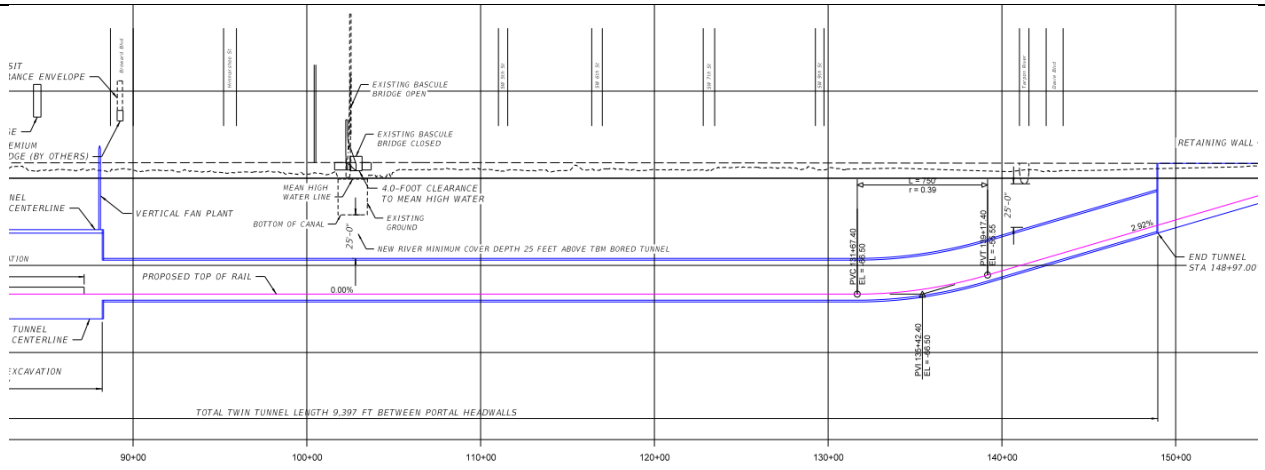


Figure 22. FDOT Tunnel Alternative

3.8. Environmental and Traffic Impact Associated with Excavated Material Handling

The City Consultant's report mentions that City-owned property can be temporarily used as a staging area for excavated material. The report also states traffic disruption "from over 10,000 dump truck movements near the tunnel portals, need to be addressed." Therefore, cost allowances were assumed in the City Consultant's cost estimate to address items such as traffic impact.

However, the tunnel will result in about double truckloads of material that must be transported. Assuming a cost allowance may be appropriate during the conceptual design stage, but it does not consider the cumulative impact on traffic due to streets that will be closed for excavation of the tunnel.

POMT operated two hundred trucks daily carrying spoils to the landfill on Virginia Key as part of the landfill closure. As the tunnels are different sized, a proportional amount of traffic impacts can be expected (27 vs 41 ~ 75 trucks), assuming similar distance to spoil location.

3.9. Station Design Considerations

The City Consultant station design was reviewed for consideration of both inter-city and commuter rail service at or near the current Brightline station in downtown Fort Lauderdale without disrupting the operations or station pilings. The station access location is planned to be at the future Governmental Center site, at the NW corner of Broward Blvd and the FEC crossing. The report states that the passenger station will complement the Brightline station; however, details for this connection are not provided, only a few sentences explaining that there will be a connection via an underground mezzanine under Broward Blvd.

The station platform slope proposed is 0.05%, which is acceptable. The station is planned to be constructed using SEM. Significant geological issues are discussed in Section 3.7.2 of this Technical Memorandum.

The length of the proposed platform for the Commuter Rail is estimated at 500 ft and does not accommodate Brightline service or minimum platform requirements (850 feet). A larger platform length required for Brightline is not included in the design, but an added cost estimate is provided.

According to AREMA "Platform lengths are based upon car length (nominally 85 feet), times the number of cars with a margin of 40 feet for braking." Five hundred feet will allow a trainset that has a locomotive and 3 cars and 1 cab car (assuming push-pull operations). Although the 500 feet platform provides enough space for a trainset, a more detailed analysis and design needs to consider the type of structures and facilities that will be available at the station, and which may require the platform to be longer.

3.10. Potential impacts to current and future freight and intercity passenger rail services.

The City Consultant's report attempts to provide an option that will not operationally impact FECR and Brightline. However, this does not seem feasible with the tunnel option as the following operational conflicts will need to be addressed:

- The first section ramp approaching the south end will impact the existing signal houses at SW 7th, 6th, and 5th Streets, along with Florida Power & Light lines on the west side of the tracks.

- At NW 4th Street where the open cut section starts south of the road right ROW there will be a conflict with the Brightline station platform that extends from NW 4th Street all the way to the station platform. This means that there will be no access to the platform during construction. See **Figure 23.**

Figure 23. Brightline Station Platform Intersection with NW 4th Street

- NW 4th Street will be closed during construction due to open cut, adding to the traffic congestion that will have to be routed around the excavation and the construction traffic.

- Operationally special trackwork, such as new crossovers and turnouts, is not provided in the City Consultant's report. Currently there is a turnout north of Sunrise Blvd from Track 3 to Track 2 (North Bound direction); two crossovers South of SE 23rd Street between Tracks 1 and 2; a turnout from Track 2 to Track 3 South of Broward Blvd.; and there are no crossovers south of the River until you get to SW 33rd Street, which is just North of I-595. The location of these crossovers and turnouts do not provide flexibility for track outages and mechanical issues that may take place during and after construction.

4. Task 2—Cost Estimate Review for New Tunnel Alternative.

Jacobs reviewed the City Consultant's preliminary capital and operating & maintenance cost estimates. A summary of the length and costs of the City Consultant tunnel vs. the one reviewed under the Whitehouse Group study, is presented below.

	City Consultant Tunnel Alternative	Whitehouse Group (Jacobs)
Length	1.146 Miles	1.80 Miles
Capital Cost	$888M (FY 2023)	$2.6B (2023)
Operations and Maintenance Cost (Per year)	~$1.5M	$4.326M

4.1 Review of Capital Cost Estimate

The City Consultant provided a cost estimate following the FTA Standard Cost Categories, which includes construction cost, ROW acquisition, soft cost, and contingency. A review of each cost category is discussed in this section. The 2023 Level 4 Capital Cost estimate is $888M, and the cost based on the year of expenditure will be $1,040M.

FTA Work Elements *(Amount as stated)*	Level 4 Cost Estimates
10.00 Guideway and Track Elements (Tunnel)	$ 247,208,757
20.00 Stations, Stops & Terminals	$ 304,624,744
40.00 Site Work & Special Conditions	$ 13,191,496
50.00 Railroad System - Underground Segment	$ 14,509,688
60.00 ROW	$ 1,300,000
80.00 Professional Services	$ 115,906,937
90.00 Contingency	$ 191,246,446
Total Capital Cost (2023 Dollars)	**$ 887,988,068**

Figure 24. City Consultant Capital Cost Breakdown & Comparison

To understand the differences and similarities of the Whitehouse (Jacobs) cost estimate developed in 2023, some of the quantities were reduced based on the length reduction of the proposed tunnel, using a factor of 33.36%.

This base cost estimate does not include any cost for the connection to the Brightline station, a connection to the bus terminal, nor any expansion or replacement of a Brightline station.

10.00 Guideway and Track Elements

To review the City Consultant's cost estimate, the Whitehouse Group (Jacobs) estimate for this cost category was modified to reflect 1030 Track Feet (TF) of retained cut (SCC 10.08), 1,400 TF of Cut and Cover Tunnel (SCC 10.06) and 3,600 TF of TBM tunneling (10.07) based on the new tunnel length. The City Consultant identifies that this Cost Category is for the tunnel only as it identifies the name if the category with a "(Tunnel)," and this leads to believe that the cost presented excludes cost for the actual guideway (rail and ties). The cost presented appear more comparable to the cost in 10.07 for tunnel only; indicating that preparation, cut & cover, and retaining walls and trackwork have not been included.

20.00 Stations, Stops & Terminals

The previous station alternative had a platform area that is 1000 feet X 35 feet, approximately 70 feet-75 feet below ground. The City Consultant is proposing a station platform that is narrower (34 feet), but it is half the length (500 feet) and 20 feet shallower. Half the length of the station platform does not translate into half the cost to build the station.

However, both stations propose to have mid-point landing at the mezzanine, and they include escalator/elevator access. Jacobs station cost estimate has is lower than the City Consultant's, however significant site work is expected for the building's ventilation and mezzanine. No cost was included for passenger connections to Brightline or to the east side of the tracks. Cost difference in this category about $67M.

In addition, the City Consultant is showing a summary of the FTA Work Types in comparison to the previous cost estimate updated by Jacobs for the Whitehouse Group. The Whitehouse (Jacobs) cost for this category is shown incorrectly in the City Consultant's table of comparison; the correct cost is $303M, not $202M.

40.00 Site Work and Utilities

The estimate for this cost category is extremely low, especially given that there will be a need for temporary facilities and possible relocation of power and signals. More details about the breakdown this cost estimate are needed, but preliminary indications are the contractor's general conditions and indirect costs have been omitted, leaving a gap of nearly $180 million.

50.00 Systems

The estimate for this cost category is extremely low and does not appear to have included railroad signals and communications systems, security, fire, and life safety. With an equivalent amount from the Jacobs estimate for this category there is still a variance of $16M of lower cost on the City Consultants estimate.

60.00 Right of Way

Capital cost for this category was not part of the Whitehouse Group (Jacobs) cost estimate. The City Consultant is not expecting major land acquisition. However, a $1.3M budget was provided to account for ROW acquisition and leases. This assumption and the amount budgeted are not feasible given the discussion of clearances and space needed for the TBM provided in Sections 3.3 and 3.4 of this Technical Memorandum. However, for this exercise Jacobs assumed the same amount for the capital cost estimate.

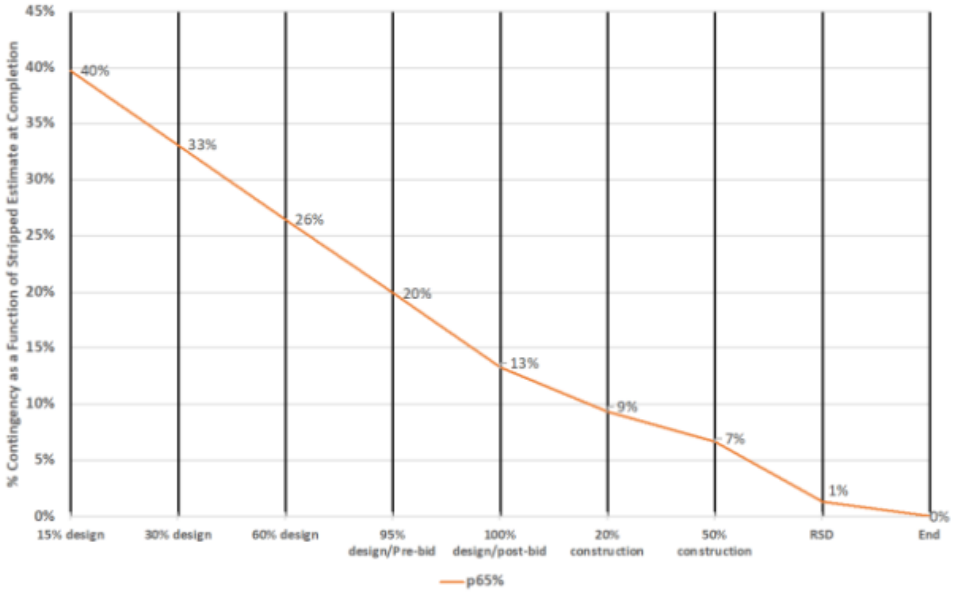
80.00 Professional Services

The estimate for this category is based on assumed percentages applied to the construction capital cost. A comparison of agency costs on similar projects suggests that the 20% of SCC 10-50 used here is low by

almost half. Costs in this category can range from 28-45%. Jacobs estimated this cost category at 33% of the Construction cost vs. 17% used by the City Consultant.

90.00 Contingency

The City Consultant used 33% contingency for this cost estimate. This percentage is lower than the recommendation on FTA's Oversight Procedure 40 – Risk and Contingency Review for this level of design, which ranges between 40%-45% contingency for a project that has 15% design or less (refer to **Figure 25**). During the review performed by Jacobs, under the Whitehouse Group, it was understood that the goal was to support the 'alternative studies' and identify a tunnel estimation for comparison with the bridge solutions. During the estimation performed under the Whitehouse Group, and while preparing a capital cost estimate for this Technical Memorandum Jacobs applied an Allocated and Unallocated contingency of 30% and 13% respectively, which together adds up to 43%. This percentage follows the FTA recommendations, and it was applied to all Cost Categories, including Professional Services.



Source: US DOT Federal Transit Administration, TPM-20 Office of Capital Project Management Project Management Oversight, Oversight Procedure 40 - Risk and Contingency Review Figure M-1 FTA Top-Down Model Nominal Contingency Levels (P65) by Project Phase

Figure 25. FTA OP 40 Contingency Level by Project Phase

In the City Consultant's cost estimate of this version of the tunnel the contingency has been reduced from 43% previously used by Jacobs estimated at $783M, to 33% estimated at $116M. Even with the reduced tunnel length, reducing the contingency to 33% and following the FTA s and FRA's project development guidance implies that the feasibility study should have progressed to the next level of design and investigation, involving a more detailed engineering study and more detailed information. Utilizing 33% contingency at this level of design is not appropriate because it corresponds to a project that has been advanced to 30% design. In addition, the City Consultant did not apply the contingency percentage to the Professional Services Cost Category nor to the Right-of-Way Purchase Cost Category. For a side-by-side comparison of the Jacobs cost estimates to the City Consultant refer to **Table 3.**

Description	Jacobs Estimate 1.8-mi Tunnel (2023$)	Jacobs Estimate 1.146-mi Tunnel (2024$)	City Consultant Estimate 1.146-mi Tunnel (2024)	Variance ($)
10 - GUIDEWAY & TRACK ELEMENTS	705,451,260.00	347,622,590.00	247,208,757.00	-100,413,833.00
20 - STATIONS, STOPS, TERMINALS, INTERMODEL	303,260,000.00	217,360,000.00	304,624,744.00	87,264,744.00
30 SUPPORT FACILITIES: YARDS, SHOPS, ADMIN. BLDGS				0.00
40 SITEWORK & SPECIAL CONDITIONS	274,169,150.00	193,185,000.00	13,191,496.00	-179,993,504.00
50 - SYSTEMS	85,460,000.00	30,640,000.00	14,509,688.00	-16,130,312.00
Construction Subtotal (SCC 10-50)	1,370,400,000.00	788,807,590.00	579,534,685.00	-209,272,905.00
60 - RIGHT OF WAY		1,300,000.00	1,300,000.00	0.00
80 - PROFESSIONAL SERVICES (APPLIES TO CATS.10-50)	452,100,000.00	260,306,504.70	115,906,937.00	-144,399,567.70
PROJECT DEVELOPMENT	82,200,000.00	47,328,455.40	2%	
ENGINEERING	137,000,000.00	78,880,759.00	6%	
PROJECT MANAGEMENT AND DESIGN COORDINATION	109,600,000.00	63,104,607.20	3%	
CONSTRUCTION ADMINISTRATION & MANAGEMENT	68,500,000.00	39,440,379.50	3%	
PROFESSIONAL LIABILITY AND OTHER NON-CONST	13,700,000.00	7,888,075.90	2%	
LEGAL; PERMITS; REVIEW FEES BY OTHER AGENCIES	13,700,000.00	7,888,075.90	1%	
SURVEYS, TESTING, INVESTIGATION, INSPECTIONS	13,700,000.00	7,888,075.90		
START UP	13,700,000.00	7,888,075.90		
Subtotal (SCC 10-80)	1,822,500,000.00	1,050,414,094.70	696,741,622.00	-353,672,472.70
ALLOCATED CONTINGENCY	546,600,000.00	315,124,228.41	191,246,446.00	
UNALLOCATED CONTINGENCY	236,900,000.00	136,553,832.31		
Bid Total	2,606,000,000.00	1,502,092,155.42	887,988,068.00	

Table 3. Jacobs Cost Comparison with City Consultants Cost

Additional cost items not included in the City Consultant's total have been provided, and they are related to the station's passenger connection to the Brightline station and access to the east side of the tracks (the BCT Bus Terminal), and tide gates. According to the City Consultant these costs could increase the estimate by $100M. Jacobs did not include these additional capital costs either. However, tide gates are included in the Jacobs O&M and Cyclical Replacement cost.

4.2 Review of Operations and Maintenance Cost Estimate

The City Consultant's report provided a total yearly Operations and Maintenance (O&M) cost estimate of $1.886M including a yearly Lifecycle (Cyclical Replacement) cost of $250,800. The yearly cost includes a 30% contingency.

The City Consultant claims that the O&M cost, which does not include the Station, railroad systems, railroad track and railroad vehicles, is in line with previous studies. This is an incorrect statement; the previous O&M cost estimate developed by Jacobs only excluded the O&M cost of rail vehicles. The O&M cost estimate provided by the City Consultant does not include all the infrastructure that requires maintenance as part of the tunnel.

Category *(Amount as stated)*	Per Annum Cost
Labor	$ 900,000
Utility Expenses (Power Supply)	$ 240,000
Replacement Cost (Lifecycle)	$ 250,800
Miscellaneous	$ 60,000
Contingency	$ 435,240
O&M Cost	**$ 1,886,040**

Table 6: O&M Costs (Annual)

Forecast Period	Cumulative O&M Cost	Present Value (Today's Dollar Value)
50 Year Forecast	$195,740,776	$99,735,368
75 Year Forecast	$395,260,708	$147,800,235
125 Year Forecast	$1,259,619,767	$240,468,584

Figure 26. City Consultant's Operations & Maintenance Cost Summary

Tunnel Maintenance Items	
	Total
Tunnel- 50 Year Operations and Expense Maintenance Costs	$1,454,400
10yr Tunnel Cyclic Capital in Year of Expenditure $ (YoE $)	
25 yr. Cyclical Tunnel	
15 yr. Cyclical Tunnel	
Track, signals & Communications Operations & Maintenance	$1,523,696
20 yr. Cyclical Track	
20 yr. Cyclical Signals & Communications	
Station O&M Cost	$333,695
25 yr Cyclical Station Elevators	
20 year Cyclical Station	
Sub-Total	$3,311,791
Allocated Contingency (30%)	$993,537
Unallocated Contingency (10%)	$331,179
Total in YoE $	$4,636,508
Low range Accuracy (30%)	$3,245,555.4
High range Accuracy (50%)	$6,954,761.5
Total O&M Cost Only	$3,311,791
Sub-total plus Allocated + Unallocated Contingency (40%)	$4,636,508
Total Cyclical Cost only	$0
Sub-total plus Allocated + Unallocated Contingency (40%)	$0
Total in YoE $	$4,636,508
50 Yrs Cumulative (2023 Dollars)	$585,344,910.45
Average Cyclical 2023 Dollars:	$20,617,342.75
Average Annual O&M (2023 Dollars) =	$4,326,281.86
Average Annual O&M & Cyclical (2023 Dollars) =	$24,943,624.61

Figure 27. Jacobs Previously Developed O&M Estimate

4.3 Tunnel O&M Cost Comparison

Table 4 provides a comparison of the Jacobs O&M tunnel individual items vs. the City Consultant's estimate. This table excludes cyclical replacement cost.

TABLE 4. O&M Tunnel Systems	Annual Jacobs Operations Estimate	Annual City Consultant Operations Estimate
Items		
Power System	$144,000	$240,000
Ventilation Control/Monitoring System	$788,400	$0
Labor Cost	$0	$900,000
Inspections	$375,000	$0
Lighting	$65,000	$0
Drainage	$22,000	$0
Tide Gates	$60,000	$0
Miscellaneous	$0	$60,000
Total Per Year (w/o contingency)	$1,454,400	$1,200,000
Total Per Year (w/ contingency)	$2,079,792	$1,560,000

When applying the reduction factor to some of the items on the Jacobs 2023 O&M cost estimate to achieve an equivalent tunnel length, the updated O&M cost total is only reduced in the cyclical cost of the waterproofing /concrete rehab line item since most of the costs estimated are not length dependent. Ventilation control and monitoring systems have a large portion of the cost regardless of tunnel length. Tide gate costs do not change with tunnel length, and drainage may be affected by tunnel length but will have minimal impact. It is important to note that this cost comparison is for the tunnel O&M only, and does NOT include any other civil structures, railroad tracks, passenger station or systems. The annual O&M costs presented on Table 4 are in present value, with the Jacobs contingency of 43% versus the City Consultant providing a 30% contingency.

4.4 O&M Cyclical Cost Comparison

The City Consultant provides an estimate of items that require cyclical replacement for the tunnel's life. **Table 5** provides a comparison of the Jacobs Cyclical tunnel cost estimates vs. the City Consultant's:

TABLE 5. Cyclical Cost Tunnel Systems	Jacobs		City Consultant	
	Life Expectancy	Cyclical Cost Estimate	Life Expectancy	Cyclical Cost Estimate
Items				
Ventilation System	25	$1,000,000	20	$4,400,000
Fans	25	$11,200,000	-	-
Power System	25	$24,000,000	20	$220,000
Ventilation Control/Monitoring System	15	$1,000,000	-	-
Fire/Life Safety	10	$1,500,000	-	-
Waterproofing/Concrete Rehab	10	$605,088	-	-
Inspections	2	$0	-	-
Lighting	25	$960,000	-	-
Drainage	25	$800,000	-	-
Tide Gates	50	$1,000,000	-	-
Pumps	-	-	15	$132,000
Blue Light Stations	-	-	20	$220,000
Miscellaneous	-	-	1	$60,000
Total Per Year (w/o contingency)		$42,065,088		$5,032,000
Annualized Cost w/ contingency		$13,116,098.59		$ 404,040.00

Some of important items missing on the City Consultant's Cyclical Replacement Cost estimate are as follows:

- The cost of the ventilation, fans and monitoring system is greatly underestimated.
- Flood gates: although a cost estimated was provided at $450K per flood gate, this was not included in the O&M cyclical replacement. With 4 gates, an additional $1.8M for capital cost and replacement should be added.
- The cost of power substations is low, and there is no information related to the number of power sub stations.

- There is no cost for tunnel drainage and concrete water proofing.
- The City Consultant's report does not mention the tunnel control building needed and its hardware and software basic requirements.
- Blue light stations will be part of the FLS system.
- Traction power is not required. The current assumption is that passenger rail vehicles will utilize diesel multiple units or locomotive for operations.

The table below provides a comparison of the City Consultant's O&M and Cyclical Replacement costs, annualized and cumulative over 50 years using the values provided in Tables 4 and 5.

Table 6. Annualized and Cumulative O&M + Cyclical Replacement Cost	Jacobs	City Consultant
Items		
Annual O&M + Cyclical Cost	$15,195,890.59	$1,886,040.00
Annual O&M	$2,079,792	$1,482,000.00
Annual Cyclical	$13,116,098.59	$404,040.00
Compounded Escalation Rate Used	3.50%	2%
Future Value of Annual Cost Factor	130.998	103.784*
Future Cumulative Cost at 50 years	$1,990,631,275.95	$195,740,776.00
Annual Value of Future Cost Factor	0.00763	0.0118
Annualized 50-yr Cumulative Cost	$15,188,516.64	$2,309,741.16

** Estimated by Jacobs*

The City Consultant's total Cyclical Replacement cost ($5,032,000) was averaged over each item's life expectancy without any annualization factors, with an average annual cost of $1,450,800. This cost is unrealistic and cannot be used to project an O&M budget.

The City Consultant does provide a projected 50-year cumulative O&M cost that includes Cyclical Replacement cost and contingency for a total of $195,740,776 using a 2% compounded escalation rate. Although this number could not be verified **Table 6** provides an estimated Future Value of Annual Cost Factor of 103.784 assumed to verify the City Consultant's estimate.

To calculate the Cumulative O&M and Cyclical Replacement costs the consultant used a 2% compounded escalation rate vs. 3.5% used by Jacobs. A 3.5% escalation rate is more in line with the multipliers provided by the Florida Department of Transportation Work Program Highway Construction Cost Inflation Factors for years 2 through 36, which vary between 2.9% and 3.3%. Using 3.5% is closer to the inflation trend projected to 50 years. Using a 2% compounded escalation rate is not a realistic representation of current inflation rates.

And lastly, the City Consultant utilized a 30% contingency, where Jacobs used 43% to be consistent with the FTA contingency guideline utilized for the Capital Cost estimate.

5. Conclusion

After reviewing the City Consultant's report, it is concluded that major components of the proposed tunnel alternative have not been identified or developed enough to conclude that this tunnel option is feasible. Among the components that have not been identified or developed enough are geotechnical and geological conditions, hydrogeological conditions, FLS, track vertical and horizontal alignment, and cost estimate contingency assumptions. All these components may have an impact on the length of the tunnel, which will have an impact on the constructability, capital, and O&M cost.

Geotechnical and geological conditions will greatly impact the type of excavation, TBM used, and support of excavation needed for this project. Additional ROW may also be needed due to staging and TBM portal size. FLS equipment and space proofing is required for the tunnel and the station design. Vertical and horizontal alignment of the track inside the tunnel cannot be attained without increasing its length. This alignment will also be difficult for the TBM to maneuver. And lastly the cost estimates provided by the City Consultant are missing basic tunnel and railroad systems and do not include an appropriate contingency for the level of design completed to date.

Based on the design aspects that Jacobs has raised in this technical memorandum, this tunnel option cannot be deemed technically or financially feasible at the level of design provided by the City Consultant.