

North South Rail Link Feasibility Reassessment

June 2018



Agenda

Update and present key findings on the North South Rail Link Feasibility Reassessment:

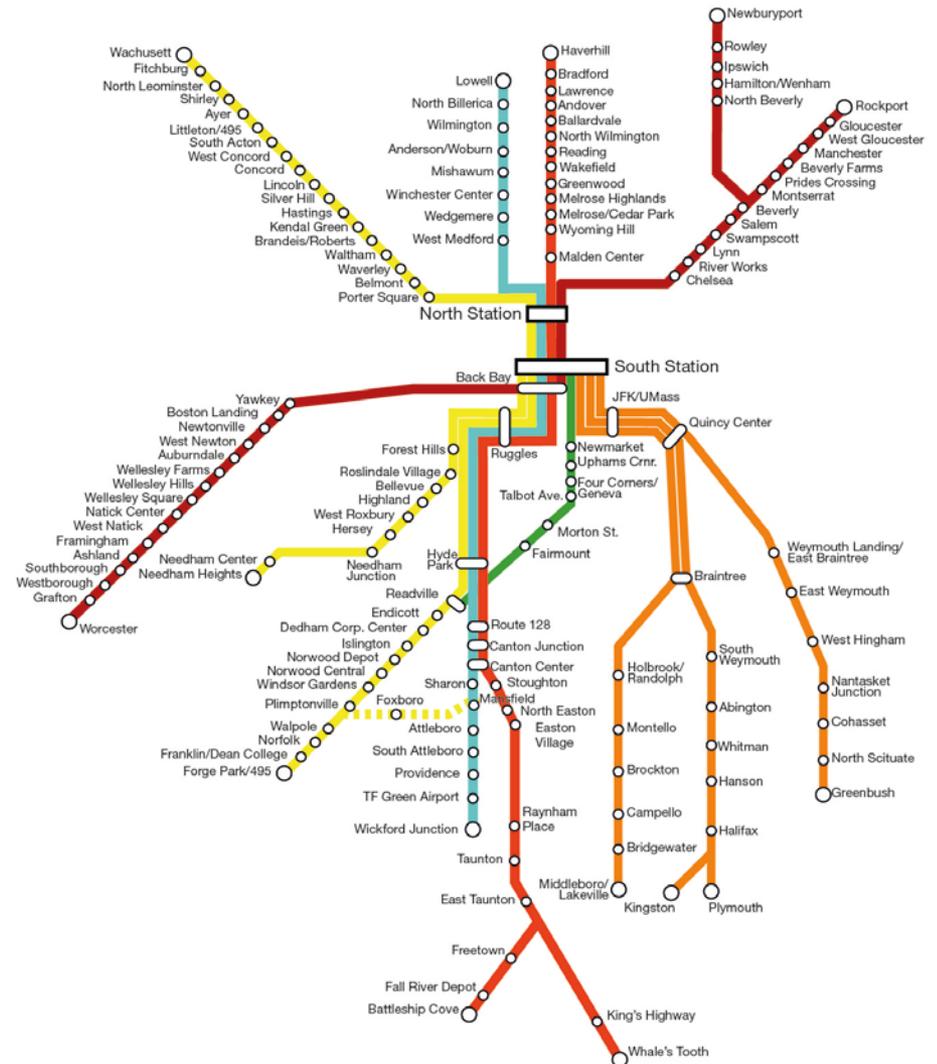
- Project Background / Scope
- Tunnel Alignments, Portals and Stations
- Service Plans
- Ridership
- Cost Estimates
- Questions

PROJECT BACKGROUND + PROJECT SCOPE

What is the North South Rail Link (NSRL)?

The North South Rail Link is a concept to connect the MBTA's north and south commuter rail networks through the construction of a rail tunnel under downtown Boston. The potential benefits of such a connection could be:

- Increase commuter rail capacity
- Improve access to employment
- Relieve rapid transit crowding
- Improve maintenance flexibility through easier access to facilities
- Reduce highway congestion and emissions
- Create redevelopment opportunities by repurposing property no longer needed for rail layover



Scope of Feasibility Reassessment

Project is charged with:

- Identifying changes in the urban form, demographics, and transportation choices since the DEIR era
- Identifying a right of way envelope
- Estimating order of magnitude cost
- Summarizing high level benefits (ridership, reductions in VMT, air quality benefits, development potential along the project corridor)

Scope does not:

- Identify potential financing options
- Evaluate impacts on development potential beyond the project corridor
- Develop a full operations simulation model
- Include a health impact assessment

Tunnel Alignments, Portals and Stations

Tunneling – TBM Technology

Given the complexities of tunneling through downtown Boston (underground utilities, existing rail and highway tunnels), the NSRL would be built by a tunnel boring machine (TBM) at a depth below these obstructions.



Photo Source: National Geographic, Tunnel Boring Machine

Tunneling – Aerial View of TBM Launch Pit

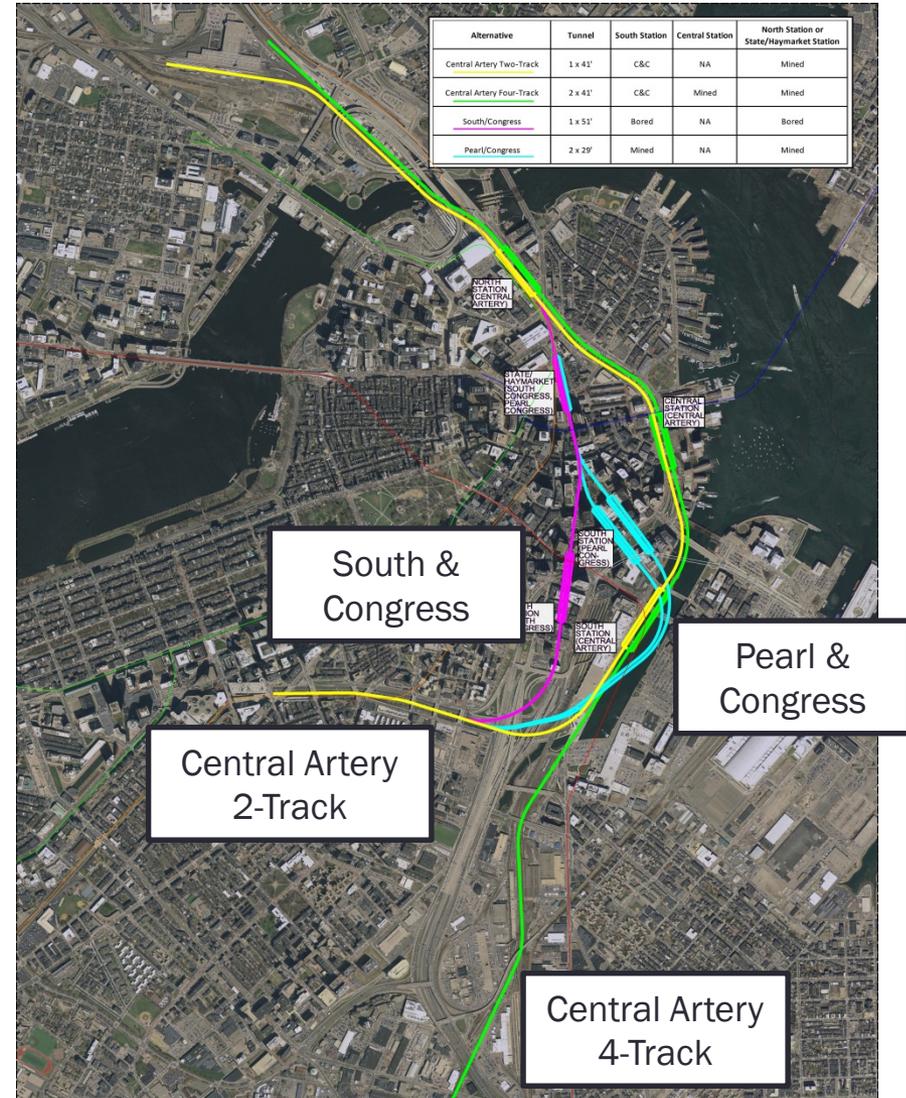


East Side Access NY

Potential Alignments

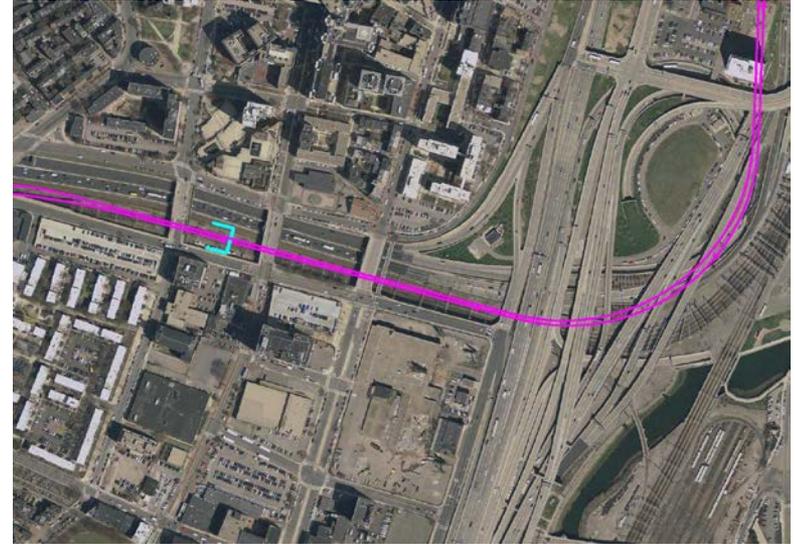
More than a dozen potential alignments were examined, with four selected as being the most viable:

- Central Artery two-track (yellow)
- Central Artery four-track (green AND yellow)
- South/Congress (pink)
- Pearl/Congress (blue)



Back Bay Portal

- Back Bay Portal utilized in all alternatives.
- **Location:** Maximum allowable 3% grade means approach to portal must begin immediately east of Back Bay station, with portal located between Shawmut Avenue and Washington Street
- **Method of Construction:** Constructed using boat sections and cut-and-cover.
- **Construction Impacts:**
 - Limited single-tracking from Back Bay into South Station
 - Temporary rerouting of some or all Amtrak, Providence, Stoughton, and Franklin Line service via the Fairmount Line into South Station (this requires electrification of the Fairmount line to allow electric Amtrak service into South Station during construction)
 - Termination of the Worcester Line and Amtrak Lakeshore Limited service west of Back Bay unless a viable rerouting (i.e. via the Grand Junction Line into North Station) is identified.



North Portals

- The North Portals are utilized in all alternatives. The TBM would be launched from these portals and driven south.
- **Location:** After passing north under the Charles River, the Fitchburg Line tracks climb to reach the surface via a portal directly south of the MBTA Boston Engine Terminal (BET) on the Cambridge/Somerville border. The other tracks (to the Lowell, Haverhill, and Newburyport/Rockport Lines) emerge from a portal due east of BET.
- **Method of Construction:** Constructed using boat sections (a U-shaped section with a continuous base slab and supporting retaining walls) and cut-and-cover.
- **Construction Impacts:** Service delays and interruptions as the north portal grade separations are constructed.

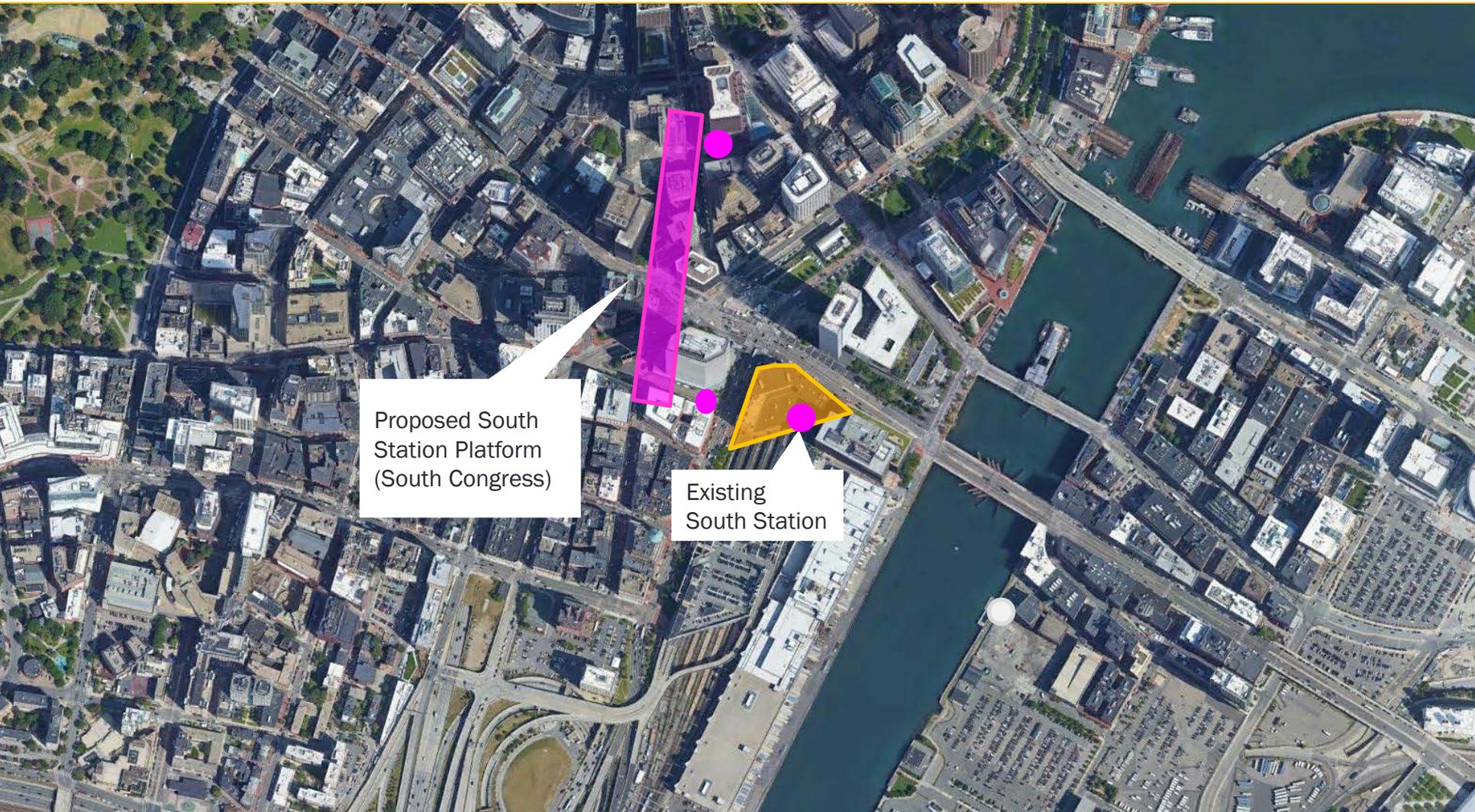


Stations Overview

- All NSRL station platforms will be underground and will not be located directly underneath North or South Station due to technical feasibility constraints. All alternatives maintain current connections into today's South Station headhouse and North Station subway station*
- The exact location of platforms will be governed by:
 - Path and depth of each tunnel alignment in relation to existing North and South Stations
 - Locations of tangent (straight) track
 - Ability to preserve connections (both to neighborhoods and other transit) available at today's North and South Stations
- While much of today's surface tracks and platforms at South Station are preserved (to serve Amtrak and MBTA lines not using the tunnel), there is the potential to shift all of North Station's commuter rail and Amtrak service below grade to the new NSRL station.

*with the exception of South Congress and Pearl Congress alignments

South Station: Platform Alternatives



Proposed South Station Platform (South Congress)

Existing South Station

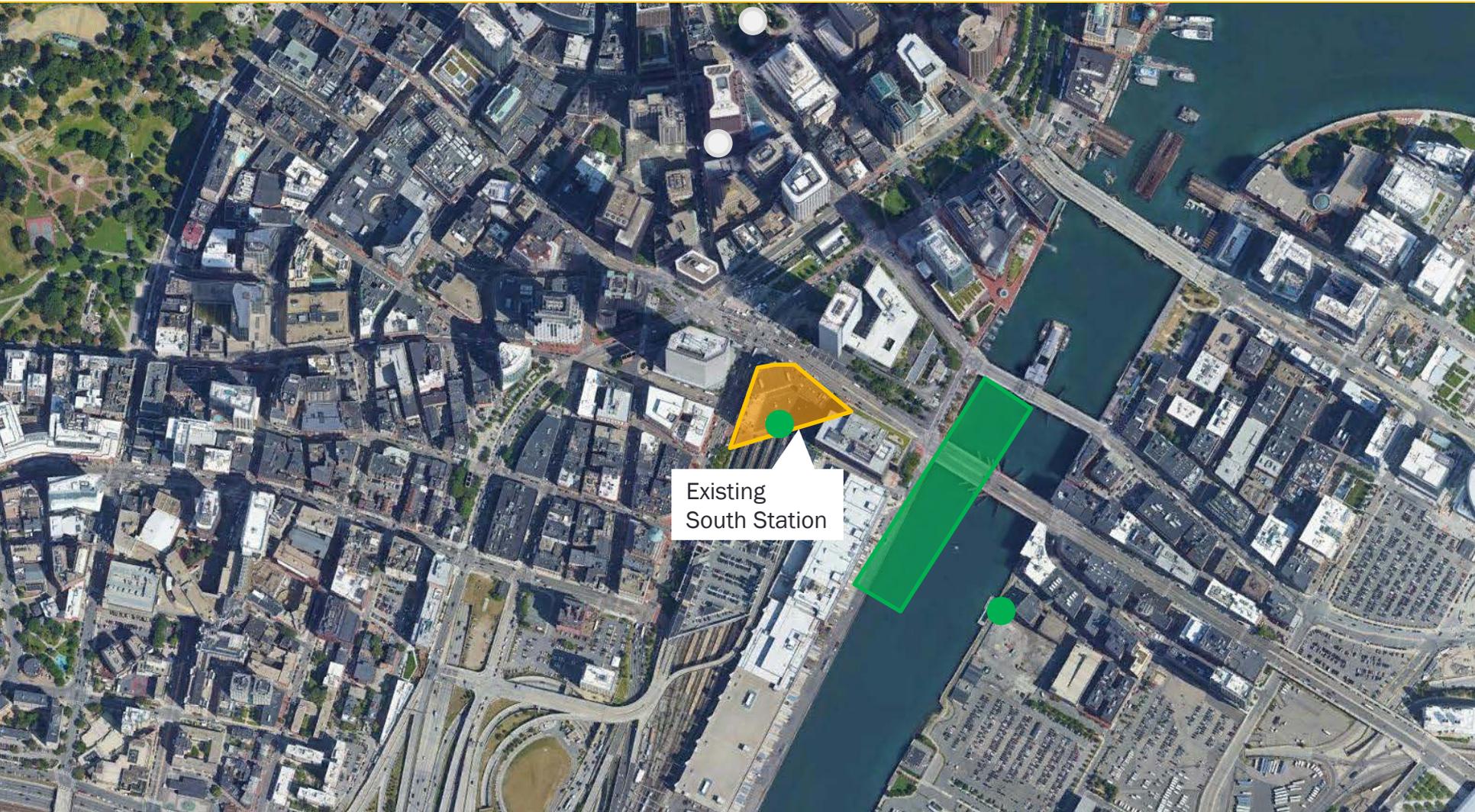
South Station: Platform Alternatives



Proposed South Station Platform (Pearl Congress)

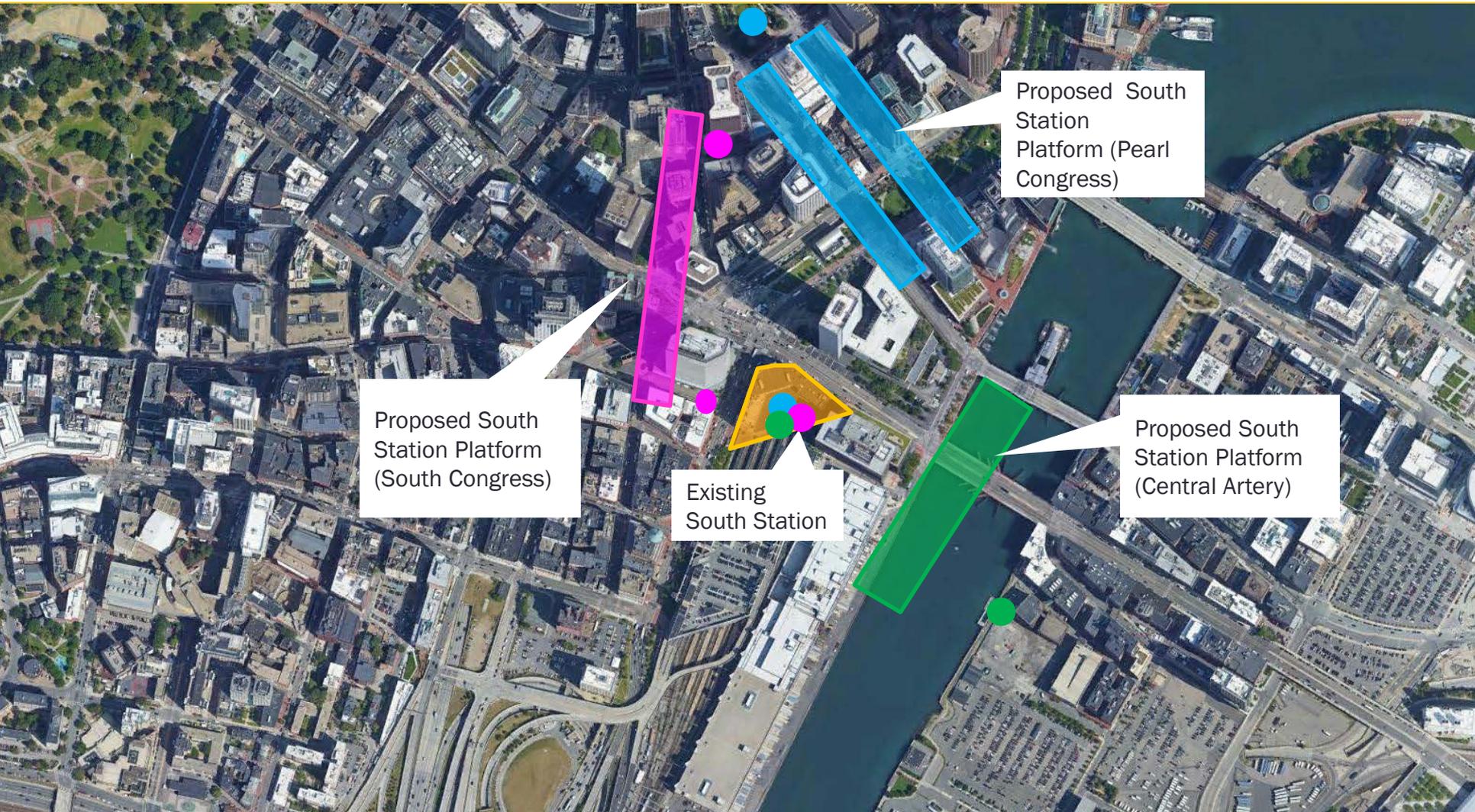
Existing South Station

South Station: Platform Alternatives



Existing
South Station

South Station: Platform Alternatives



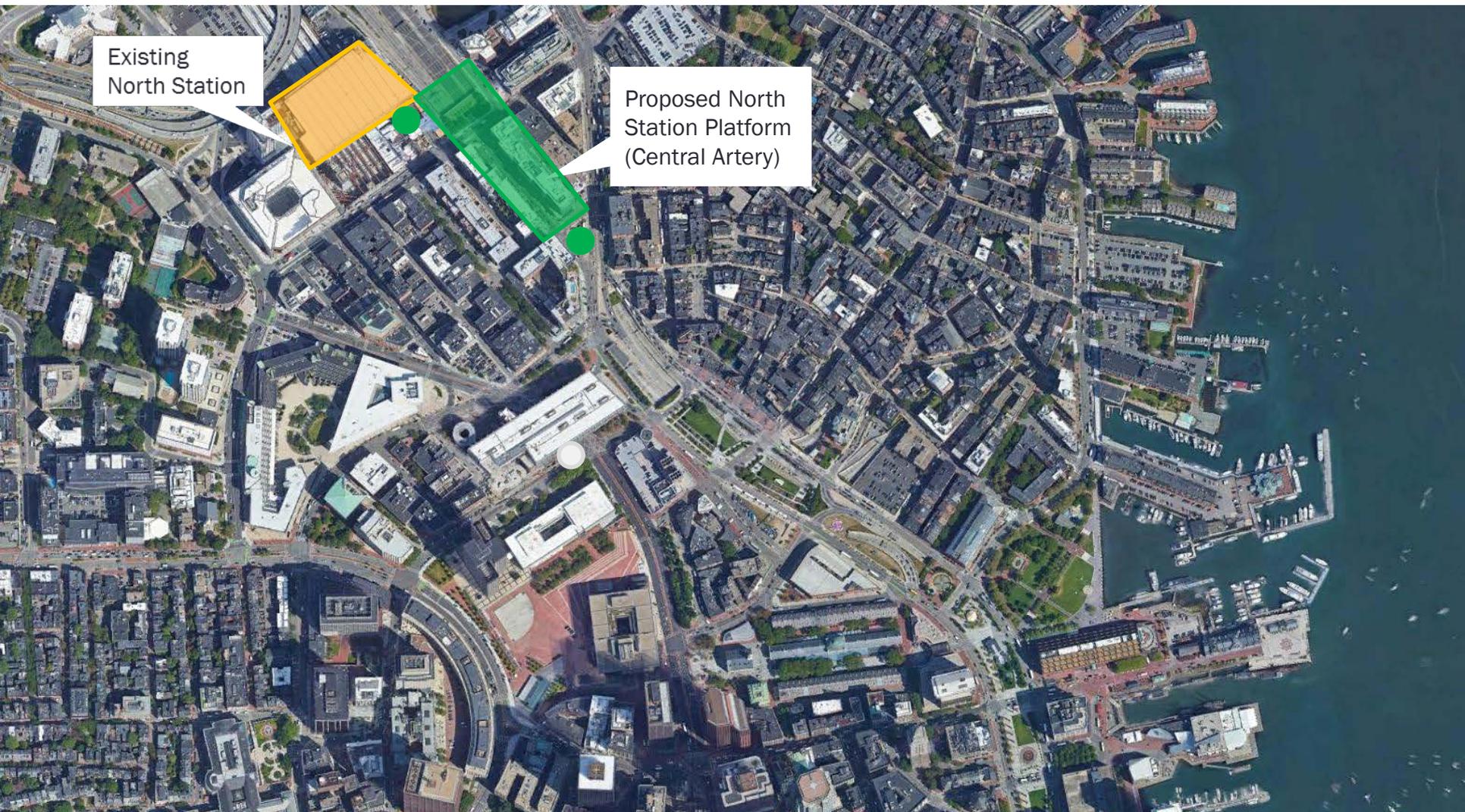
Proposed South Station Platform (South Congress)

Existing South Station

Proposed South Station Platform (Pearl Congress)

Proposed South Station Platform (Central Artery)

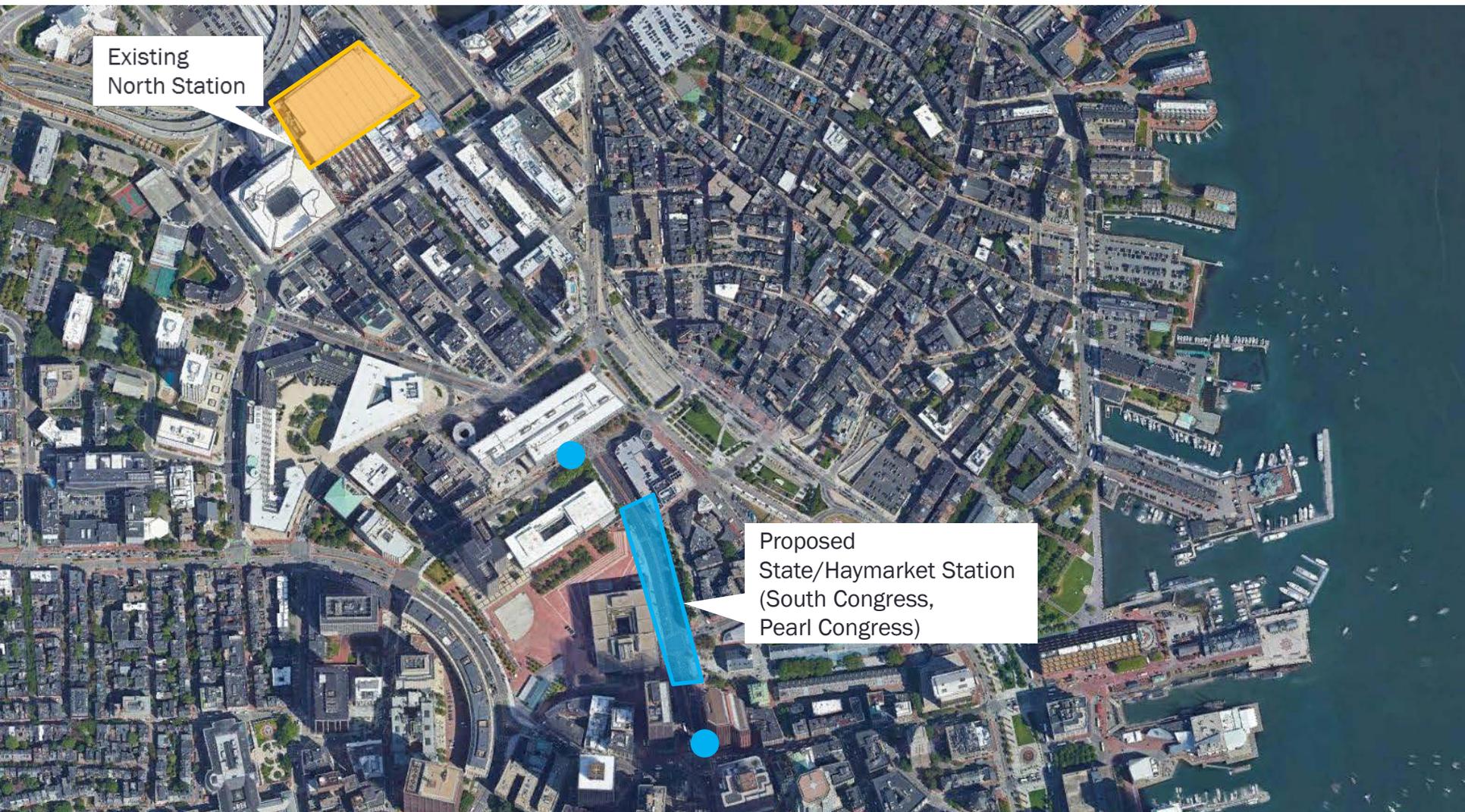
North Station: Platform Alternatives



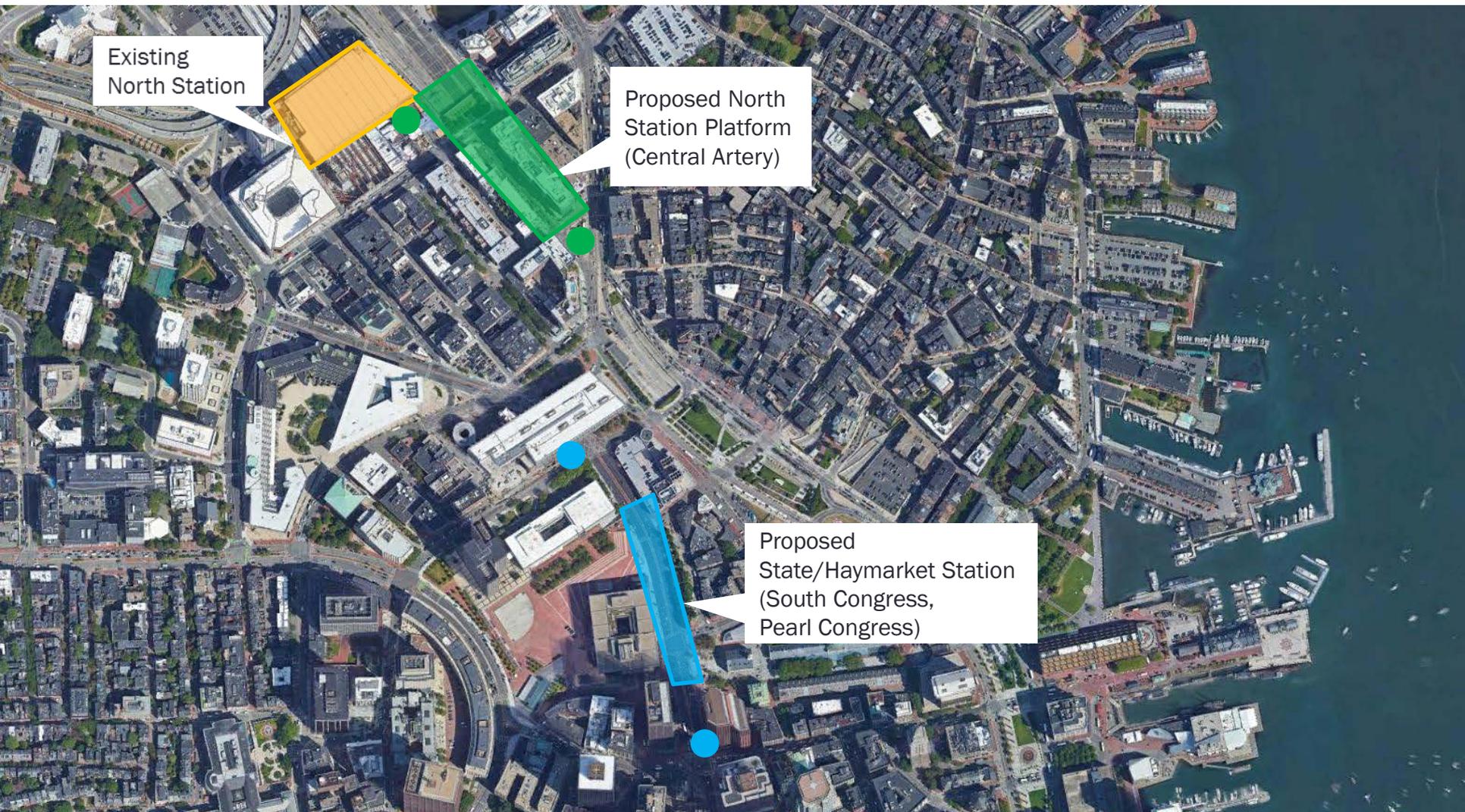
Existing
North Station

Proposed North
Station Platform
(Central Artery)

North Station: Platform Alternatives



North Station: Platform Alternatives



Existing North Station

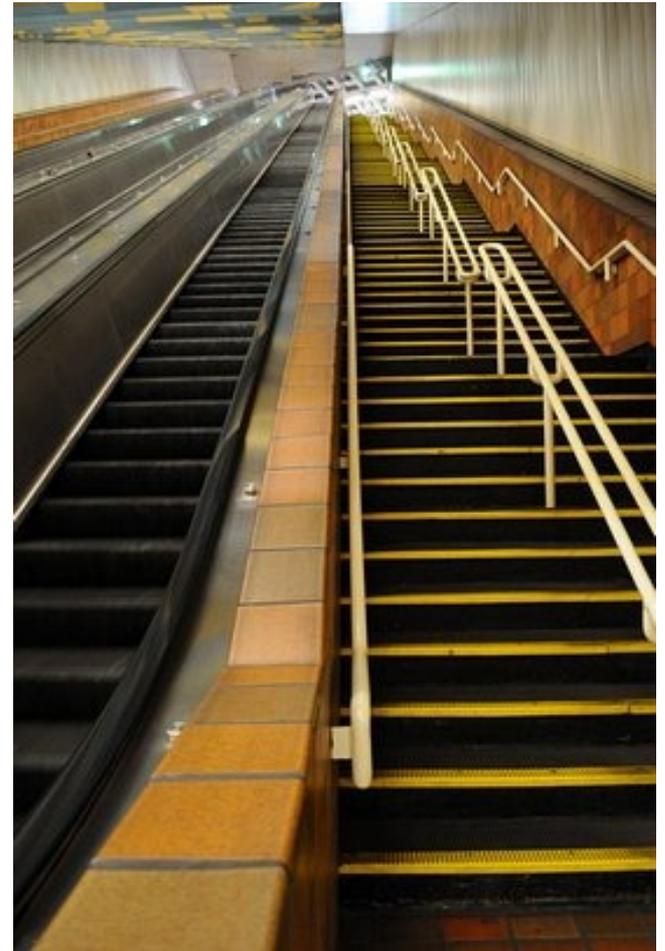
Proposed North Station Platform (Central Artery)

Proposed State/Haymarket Station (South Congress, Pearl Congress)

Station Depth Comparison

Station	Station Depth
NSRL Stations	115 - 195 feet
MBTA Aquarium	50 feet
MBTA Porter Square	105 feet
WMATA Dupont	114 feet
WMATA Bethesda	165 feet
NYC MTA 191 st Street	180 feet
Portland Washington Pk	260 feet

NOTE: We are assuming a walk time of 3-4 minutes from the underground platforms to the station entrances



Porter Square escalators/stairway

Service Plans

Service Plans

	Peak Service Levels	Off-Peak Service Levels	South Coast Rail
No Build 2040	Current service schedules	Current service schedules	South Coast line via Middleborough
South Station Expansion All-Day Peak Service (No NSRL)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	South Coast line via Stoughton (fully electrified)
NSRL Regular Service (2-track)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Hourly Service	South Coast line via Stoughton (fully electrified)
NSRL All-Day Peak Service (2-track and 4-track)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	Maximum achievable service levels (trains every 10-30 minutes, depending on the line)	South Coast line via Stoughton (fully electrified)

Note: Unlike typical ridership modeling, all service plans assume no constraints on station parking

Service Assumptions

- All trains operating through the tunnel are interlined with another line on the other side of the system
- NSRL 2 Track Tunnel can support 17 trains per hour, per direction (for context, this is more frequent service than currently provided on the Red Line); NSRL 4 Track Tunnel can support 21 trains per hour, per direction
- Passengers would be able to board and alight through all doors on a train and more quickly than is typical today, similar to rapid transit operations
- Service on the individual lines would be managed such that trains would be able to arrive precisely as scheduled for their slot to enter the tunnel and maintain the 17 trains/hour frequency
- Significant infrastructure investments beyond those necessary for the tunnel itself are made in order to meet the above assumptions.

Risks in Implementing Service Plans

The following represent some of the biggest concerns MBTA Operations has with the study's assumptions:

- No system has yet operated aspirational level of frequency with Positive Train Control
- Service disruptions on one or two tracks in the tunnel will cause ripple effects throughout the entire commuter rail system
- Assumptions about train loading/unloading time are much more aggressive than current experience
- Depth of stations is a concern during evacuation (and possible negative impact on customer experience due to longer time to exit stations)
- Rapid transit stations were not designed to accommodate transfers from commuter rail in the way they would happen now and may lack platform capacity to adequately do so
- Locations for additional layover and maintenance capacity have not been identified and are challenging to site

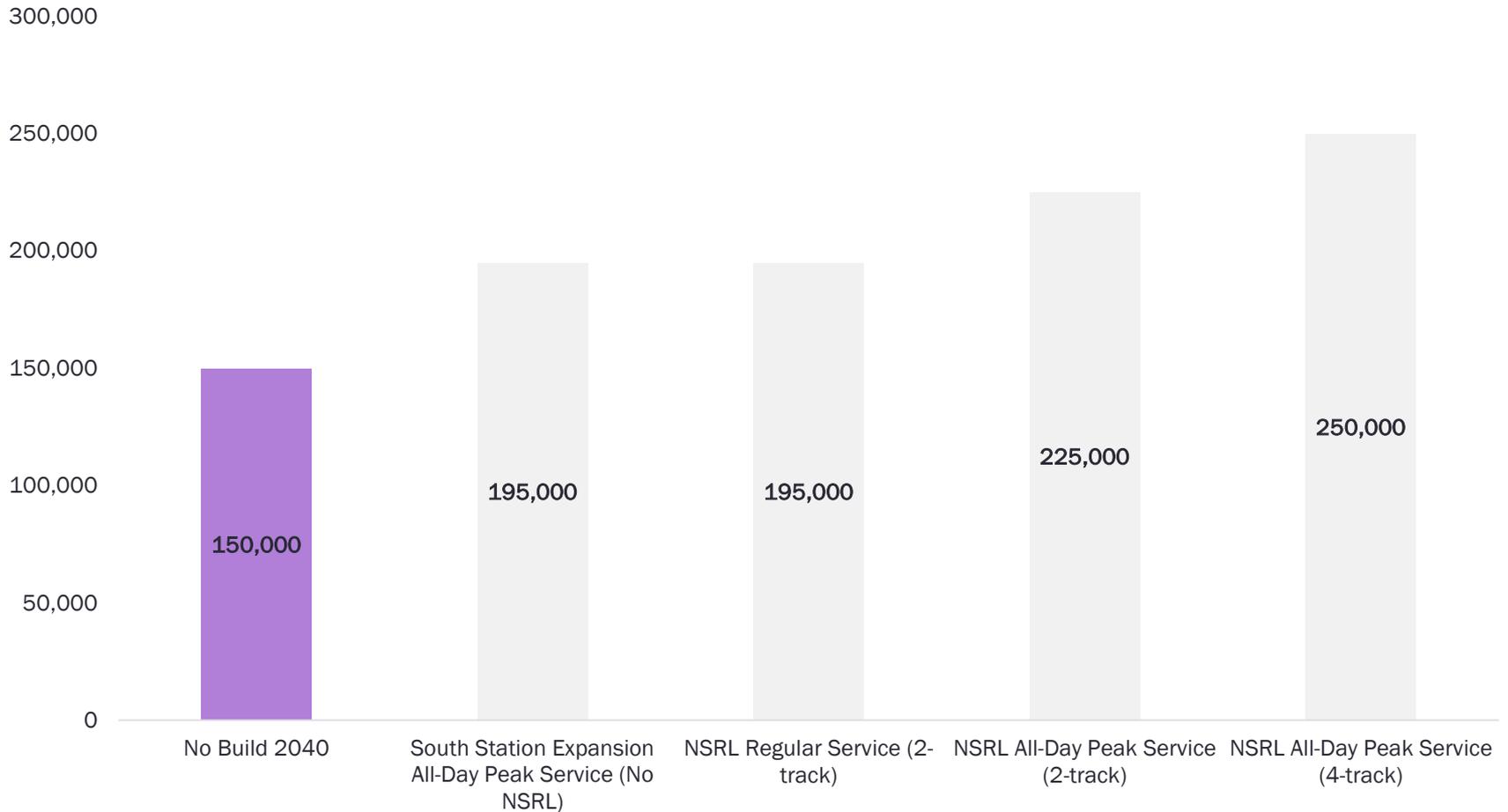
Ridership

CTPS Regional Travel Demand Model

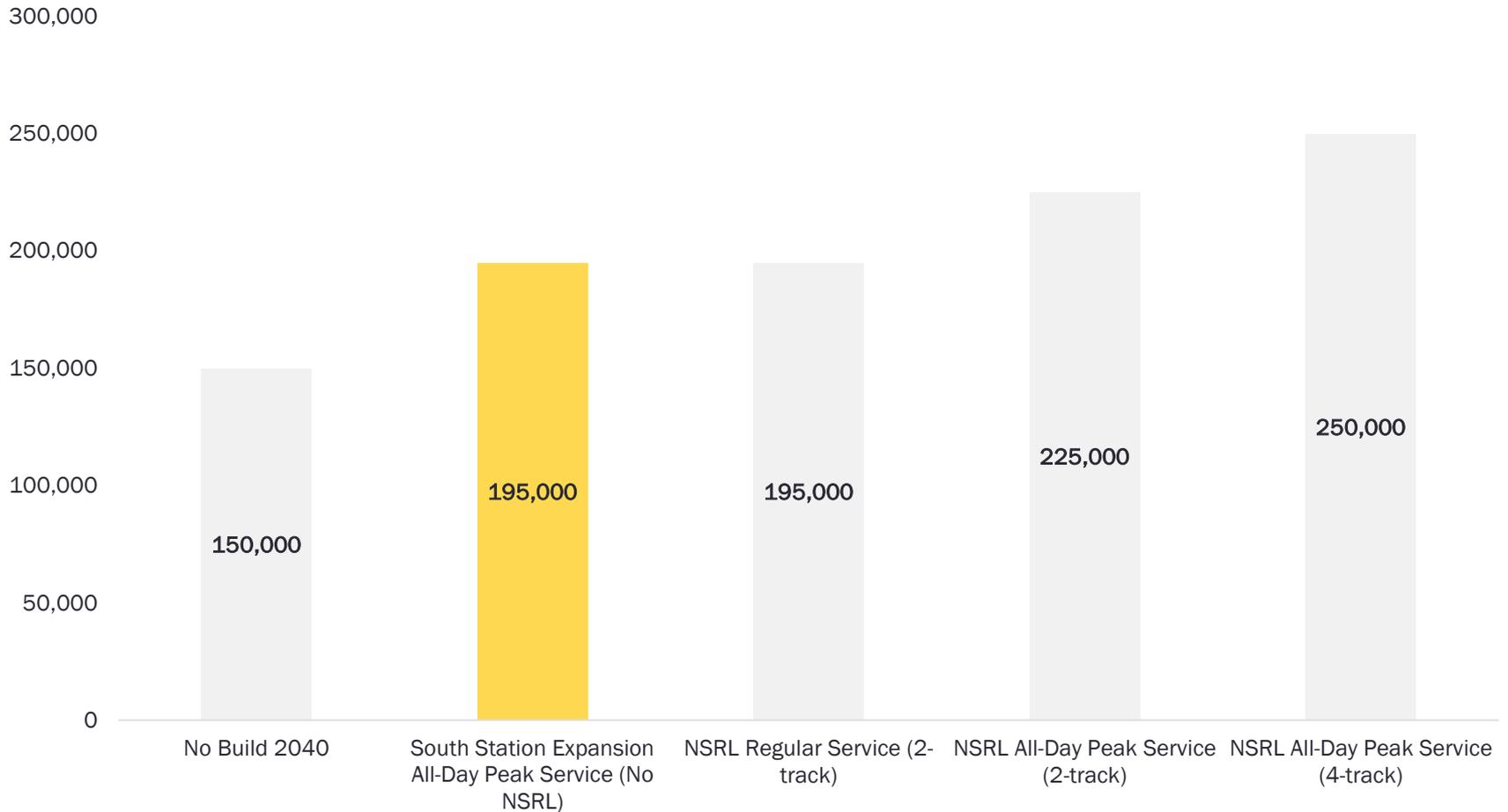
- Federally approved tool to project ridership on projects seeking federal funding support – same tool used for all major MBTA/MassDOT investments (example: GLX, South Station Expansion)
- Projects how trips are made (drive vs transit; which route or transit service) in horizon year (currently 2040)
 - Assuming future population/employment across >5,000 zones in Eastern Massachusetts, consistent with regionally adopted land use forecasts developed by MAPC
 - Model is not dynamic (transportation investments don't change land use)
- Investments (such as NSRL) are compared to a future “No Build” that doesn't include that investment, but where today's network is enhanced by other funded or otherwise committed projects in the pipeline (i.e. GLX)
- Model does not typically constrain capacity except for parking supply
 - Since model looks at a 3 hour peak period, *transit* capacity not typically an issue
- For this project, commuter rail parking was treated unconstrained in all model runs

Ridership by Alternative: No Build 2040

All Day Boardings

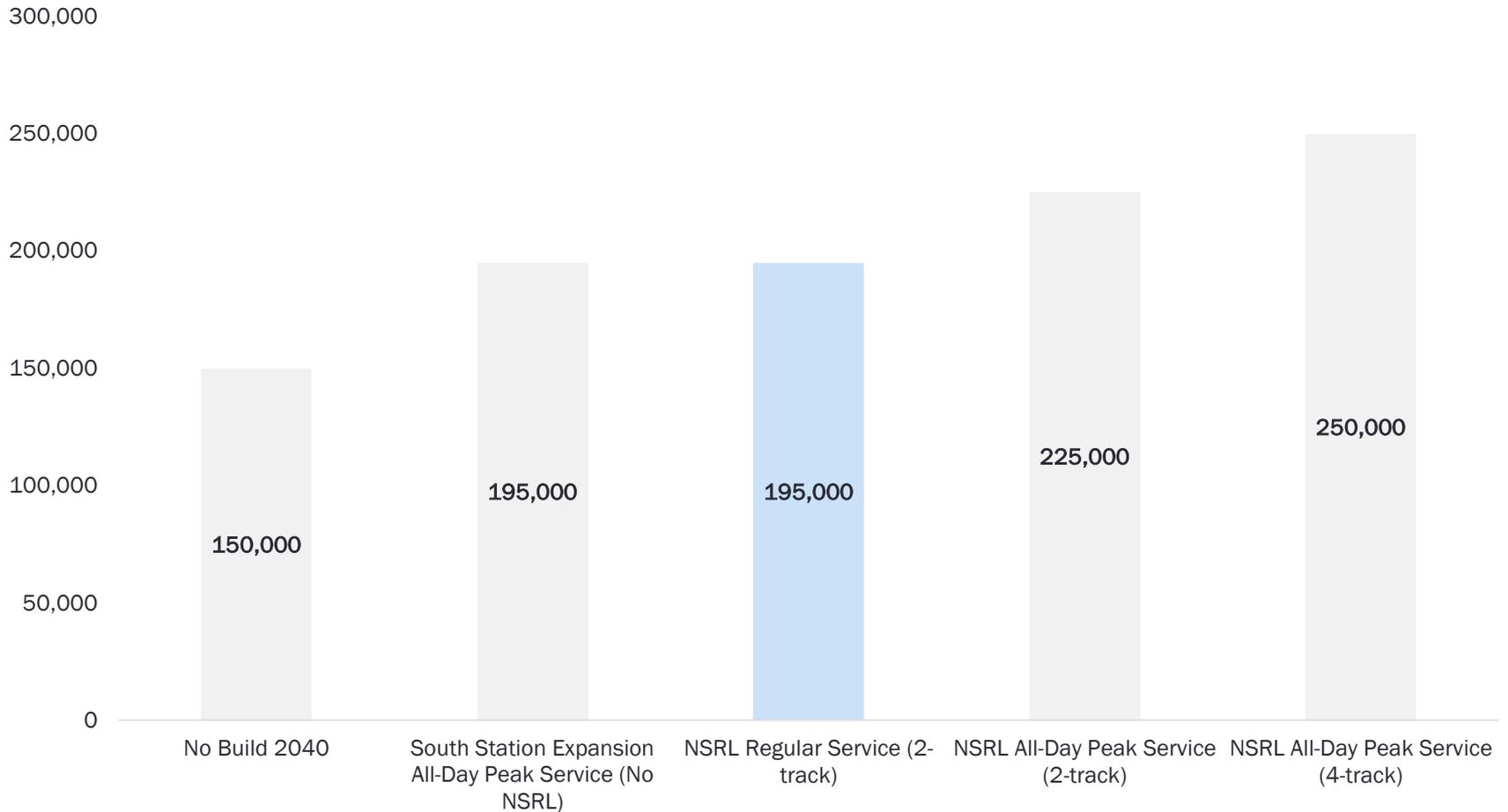


Ridership by Alternative: NSRL Regular Service (2-track) All Day Boardings

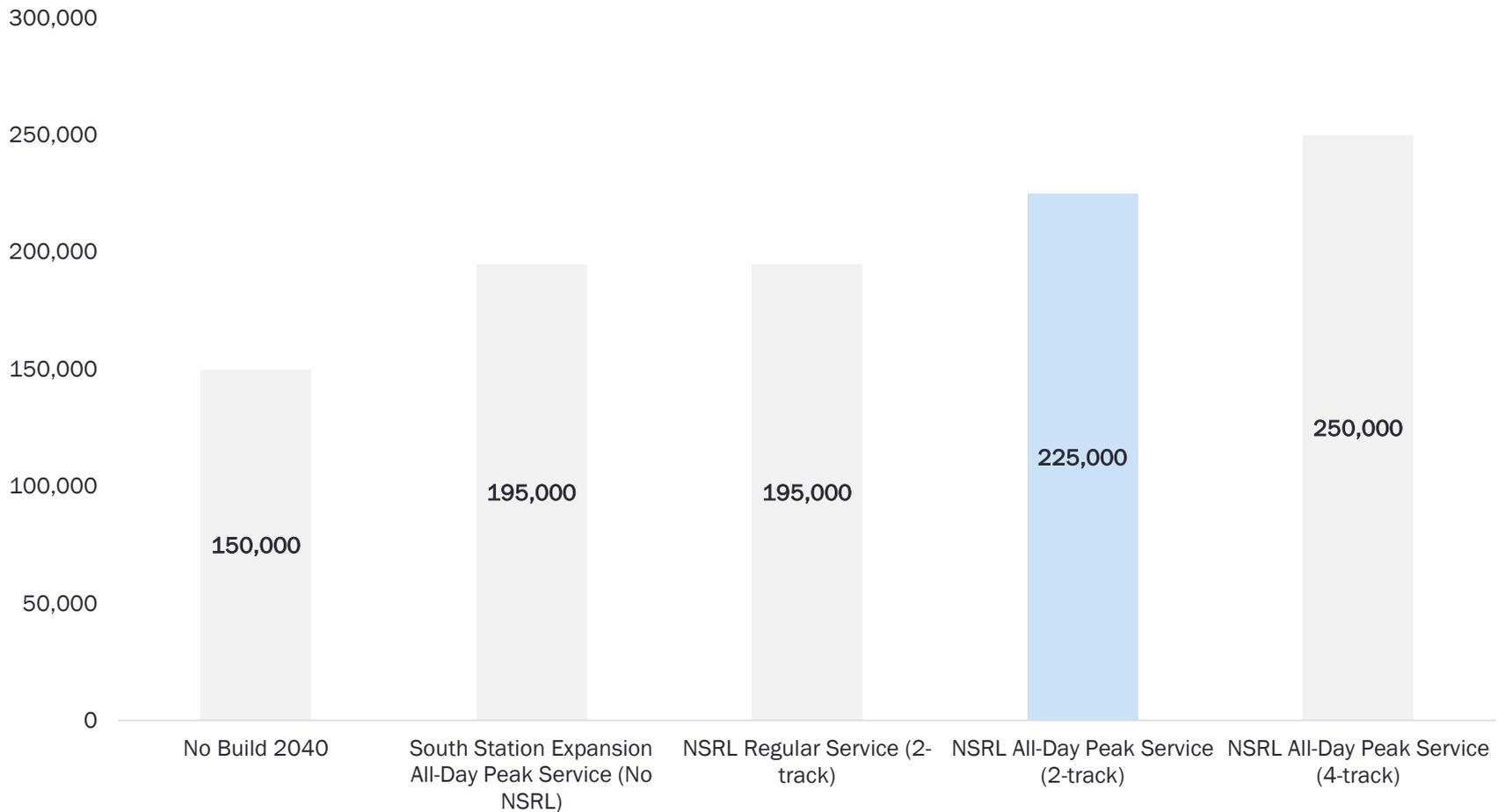


Ridership by Alternative: SSX All-Day Peak Service

All Day Boardings

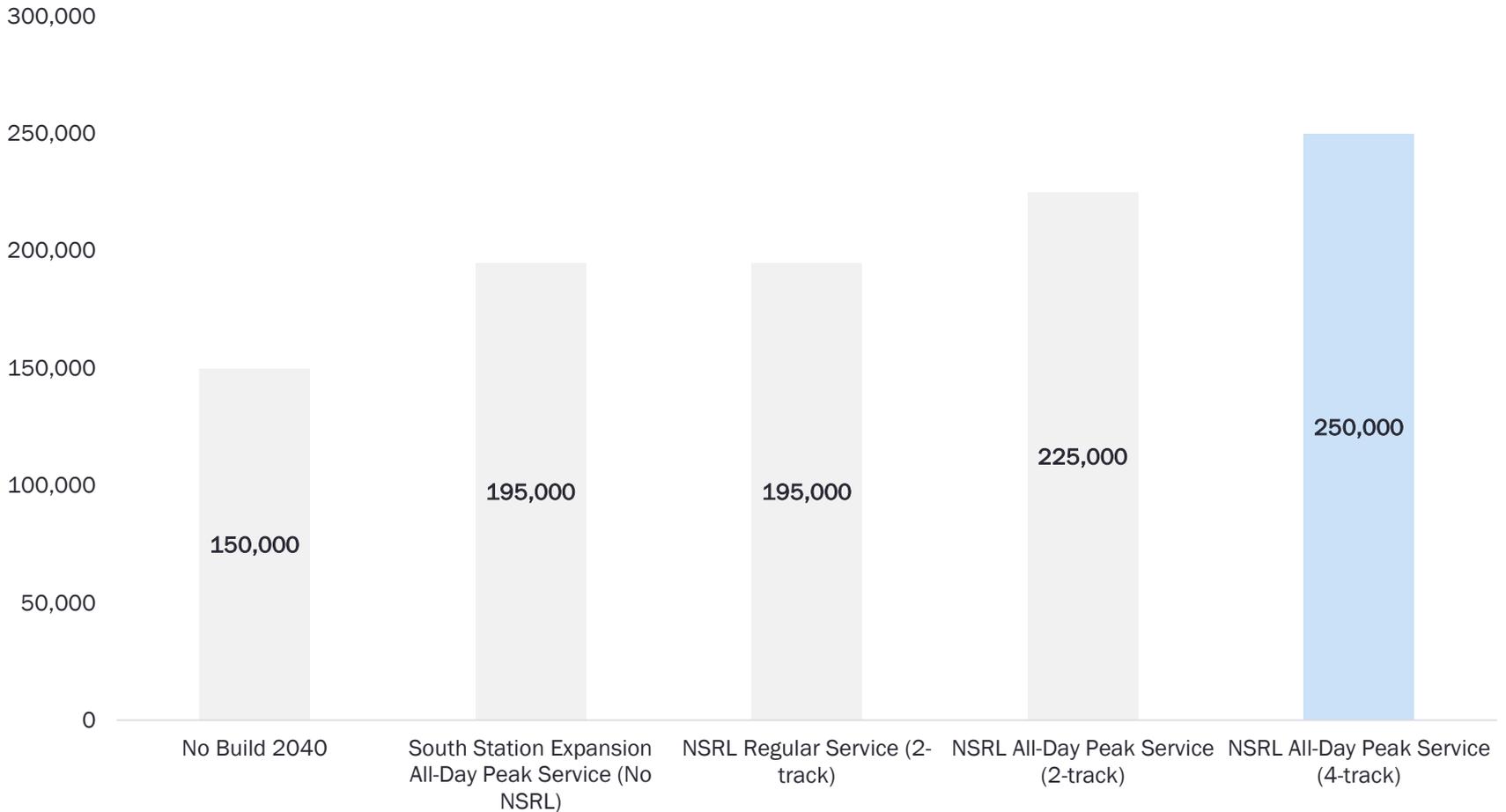


Ridership by Alternative: NSRL All-Day Peak Service (2-track All Day Boardings)



Ridership by Alternative: NSRL All-Day Peak Service (4-track)

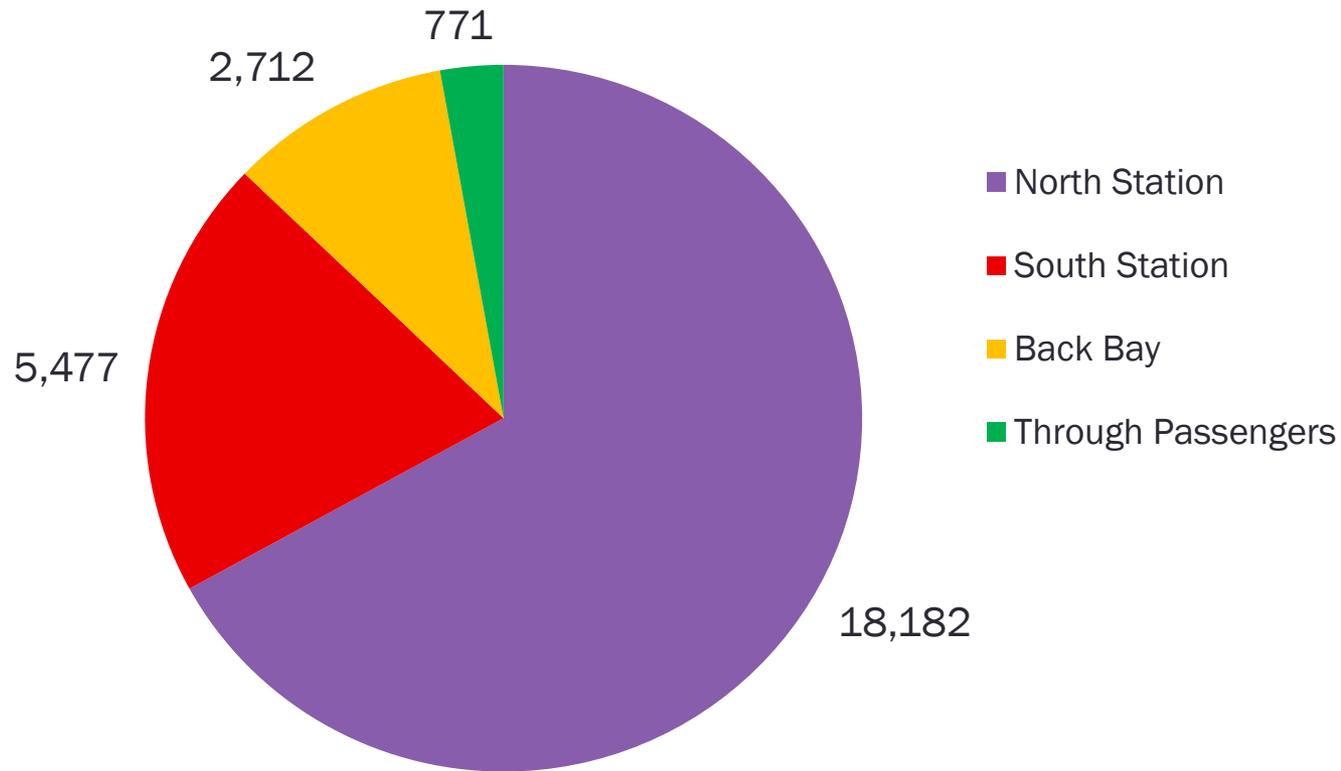
All Day Boardings



Ridership Destinations

Northside (Southbound) AM PEAK

NSRL All-Day Peak Service (2-track)



Cost Estimates

Cost Estimating Methodology

- **Escalation to midpoint of construction (2028):** Standard practice for construction costs. Aims at simplifying the cost-loading strategy of a project by assuming that 50% of the project cost will be incurred in 50% of the project's duration.
- Every cost estimate includes an annual escalation rate of **3.5%** (compounded annually)
- **Costs include:** Alignment lengths, tunnel types, station areas, trackwork, portals, and allowances
- **Allowances:** underpinning works, roadway reconstruction, and utility relocations

Total Design Build Costs: Direct Costs + Indirects + Contractor's Overhead / Profit + Design Engineering

Total Project Costs: Total Design Build Costs + Owner's Soft Costs + Project Risk Contingency + Escalation to Midpoint of Construction

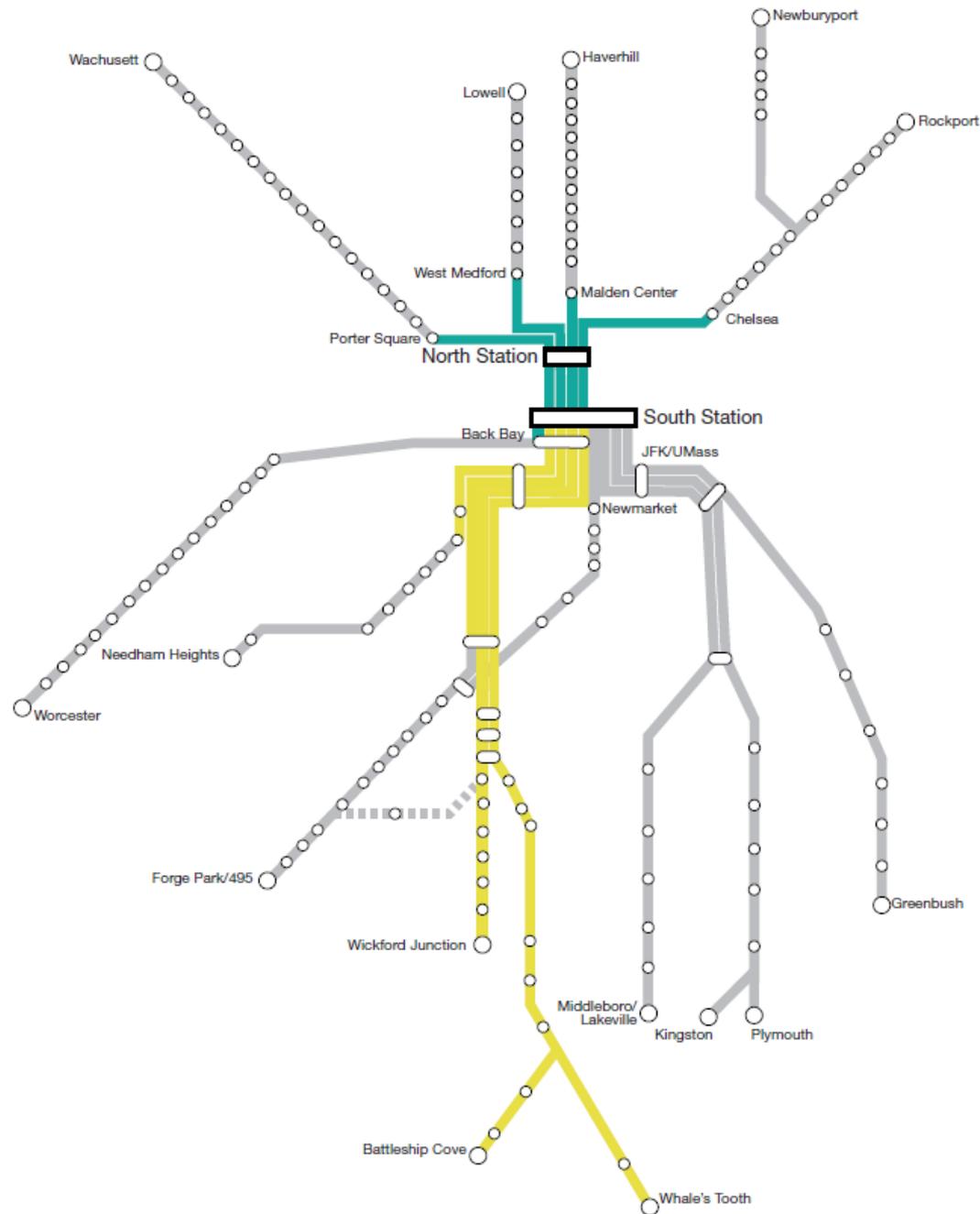
Cost Estimating Methodology

Calculation of Project Costs

- Use of Arup tunneling experts input
- Composite unit rate build-up based on construction technique which was then compared to Arup's cost databases and cost benchmarks
- Use of International Best Practices to assign accuracy ranges and contingencies (AACEi)
- Estimating mark-ups applied based on experience on other projects: Green Line Extension Project, Tappan Zee Bridge (The New NY Bridge), Texas Central Rail, Windsor Tunnel
- Use of benchmarks:
 - CHSRL (California) → Similar scope (TBM /SEM and diameter)
 - London Cross Rail (UK) → Similar scope (TBM / diameter, constructability)
 - M-30 tunnel (Spain) → Similar scope (TBM / diameter)
 - I-710 (California) → Similar scope (TBM / diameter)
 - Pannerdenschkanaal (Netherlands) → Similar scope (TBM / diameter)
 - San Francisco Central Subway → station construction type
 - Green Line Extension estimate → trackwork scope

Electrification Proposal

-  Already electrified (including SCR Phase 2)
-  Electrified as part of NSRL project



Dual Mode Locomotives + Coaches

Dual-mode locomotives are proposed for the NSRL tunnel alternatives as they are able to travel on both the electrified and non-electrified portions of the commuter rail system, switching between diesel and electric operations as appropriate



Bombardier ALP-45DP Locomotive (NJ Transit)



GE P32AC-DM Locomotive (Metro-North Railroad)

- The three 2-track alternatives involve replacing 48 diesels with dual-modes, expanding locomotive fleet with 72 dual-modes and 203 coaches
- The Central Artery 4-track alternative involves replacing 58 diesels with dual modes, expanding locomotive fleet with 72 dual-modes and 203 coaches

Other Investments Needed to Increase Service

Upstream Improvement	
Resignaling	<ul style="list-style-type: none"> 30 track miles of signaling assumed to support increased service
Double Tracking	<ul style="list-style-type: none"> Worcester, Fitchburg, Newburyport/Rockport (between McNall & Northey Point Junctions - between Swampscott and Salem stations)
Additional Platforms	<ul style="list-style-type: none"> Fitchburg, Lowell, Worcester
Grade Separation	<ul style="list-style-type: none"> Between northbound and southbound services at each tunnel portal
Turnback Crossovers	<ul style="list-style-type: none"> Fitchburg, Franklin, Fairmount
Crossing and Passing Loops	<ul style="list-style-type: none"> Needham, Old Colony (passing loop between Abington and Whitman Stations), Haverhill

Cost Estimates – Summary

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Tunneling	NA	\$8,629,000,000	\$9,493,000, 000	\$10,701,000,000	\$17,730,000,000
Vehicles	\$1,397,000,000	\$2,380,000,000	\$2,380,000,000	\$2,380,000,000	\$2,439,000,000
Upstream Investments to Support Increased Service	\$ 833,000,000	\$1,307,000,100	\$1,307,000,100	\$1,307,000,100	\$1,321,000,000
SSX*	\$2,466,000,000	NA	NA	NA	NA
Total	\$4,696,000,000	\$12,317,000,000	\$13,181,000,000	\$14,388,000,000	\$21,491,000,000

All costs escalated to midpoint of construction (2028) and rounded to the nearest Million

**includes only project elements from MassDOT's South Station Expansion Federal Environmental Filing*

NOTE: Additional Vehicles costs are part of increased service in all alternatives

Assumptions:

- Every alternative has 2 stations except for the Central Artery 4-track which has 3 stations
- All tunnel alternatives replace 66 diesel trains with dual-mode locomotive trains

Comparison of South Station Expansion Cost Estimates

Element	VJ Associates Cost Estimate: South Station Expansion	Keville Independent Cost Estimate: South Station Expansion	Arup Cost Estimate: South Station Expansion All-Day Peak Service
Dorchester Ave. including USPS Demo	\$36,700,391	\$56,623,715	\$28,000,000
South Station Headhouse	\$210,533,210	\$331,207,324	\$235,000,000
South Station Track	\$157,737,210	\$132,605,815	\$181,000,000
Layover Facilities – Widett	\$115,331,637	\$97,360,704	\$130,000,000
Layover Facilities – Readville	\$15,156,522	\$18,628,863	\$34,000,000
ROW Acquisition	\$348,308,000	\$348,308,000	\$400,000,000
Sub totals w/o contingencies	\$883,766,890	\$984,734,421	\$1,008,000,000
Contingencies	\$979,058,737	\$935,892,663	\$741,000,000
Totals in Year 2017/2018 dollars	\$1,862,825,627	\$1,920,627,084	\$1,749,000,000
Totals in Year 2028 dollars			\$2,466,000,000

NSRL Cost Comparisons

2002 MassDOT Study

Alternative	Infrastructure Cost (2002 USD)	Infrastructure Cost (2028 USD)
Two-Track (Back-Bay)/Two Station	\$ 3,368,700,000	\$ 8,240,000,000
Two-Track (South-Bay)/Two Station	\$ 3,317,100,000	\$ 8,114,000,000
Four-Track/Three Station	\$ 5,748,000,000	\$14,060,000,000

Executive Summary Table ES-7 Summary of Capital Costs (2002 Dollars) escalated to 2028 MP Construction

2017 Harvard Study

Alternative	Total Cost (2025 USD)	Total Cost (2028 USD)
Minimum (Two Track)	\$ 3,820,000,000	\$ 4,236,000,000
Maximum (Four Track)	\$ 5,940,000,000	\$ 6,586,000,000

Figure 2 and Figure 3 of NSRL White Paper_Silver_Final.PDF escalated to 2028 USD. *Note: The Harvard Study did not include cost for the tunnel boring machine launch pit and only accounted for 2.7 miles of tunneling (the MassDOT studies both accounted for 5 miles of tunneling), and no contingency for risk.*

2018 MassDOT Study

Alternative	Infrastructure Cost (2028 USD)
Central Artery Two-Track / Two Station	\$ 8,629,000,000
South Congress Alignment / Two Station	\$ 9,493,000,000
Central Artery Four Track / Three Station	\$17,730,000,000

Arup analysis (2018 Dollars) escalated to 2028 MP Construction

Operating costs - Estimates

Operating costs have been estimated for the no build (2040), South Station Expansion All-Day Peak Service (No NSRL), and the NSRL All-Day Peak Service (2-track) alternatives

	No Build 2040	South Station Expansion All-Day Peak Service	NSRL All-Day Peak Service (2-track)
Vehicle revenue miles/day	16,420	41,550	51,470
Operating expenses/year	\$400,000,000	\$775,000,000	\$929,000,000

Midpoint cost alignment, 2018 US Dollars

Next Steps

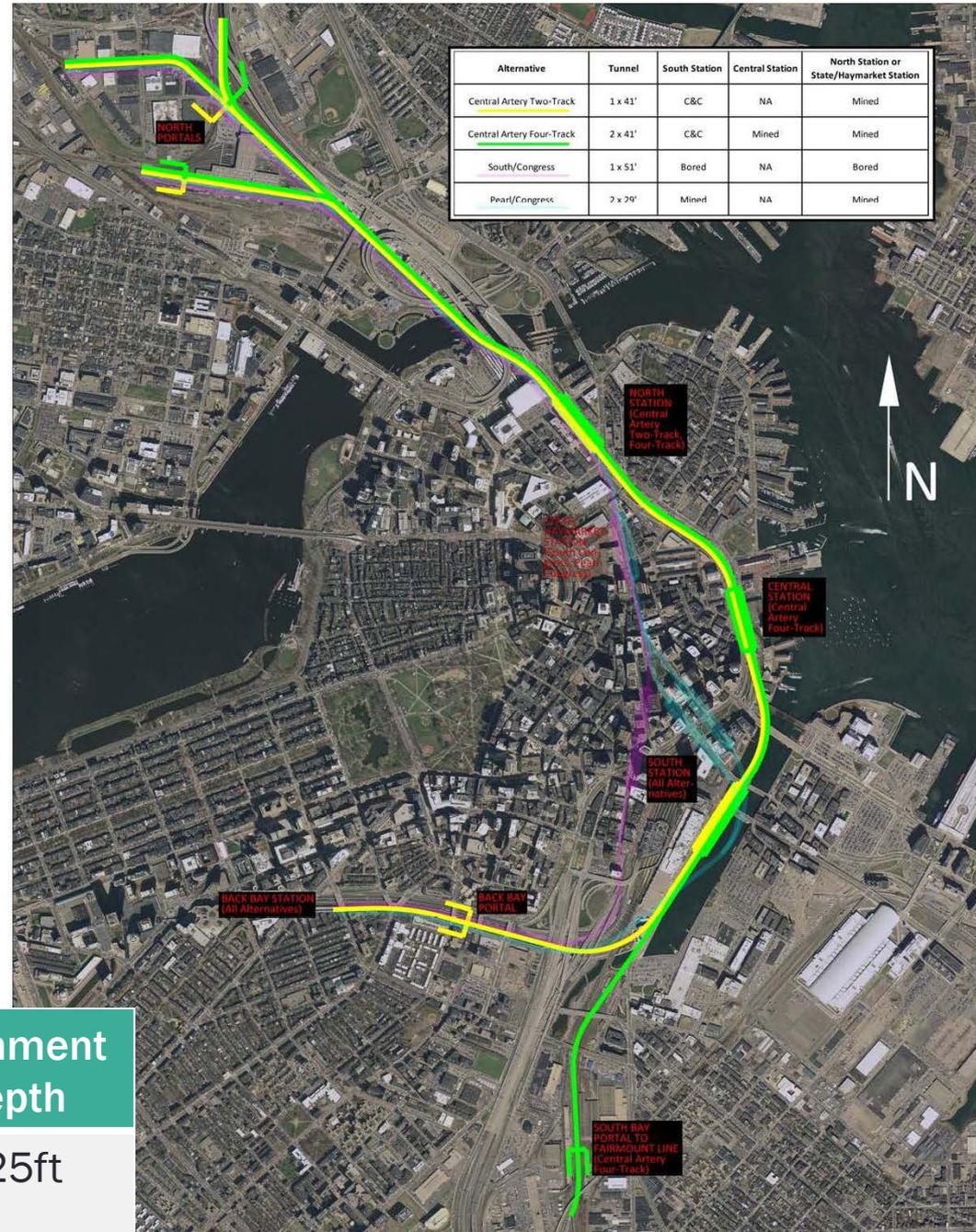
- **Public Meeting** – Thursday, June 21 – 10 Park Plaza, 2nd Floor – 5:30pm to 8:30pm
- **Release of draft NSRL Feasibility Reassessment** – Early July 2018
 - Comment Period – July/August 2018
- **Final NSRL Feasibility Reassessment Report** – Early Fall 2018
- **MBTA Rail Vision Study examining electrification and alternative service models** - Ongoing

Questions

APPENDIX

Central Artery Two-Track

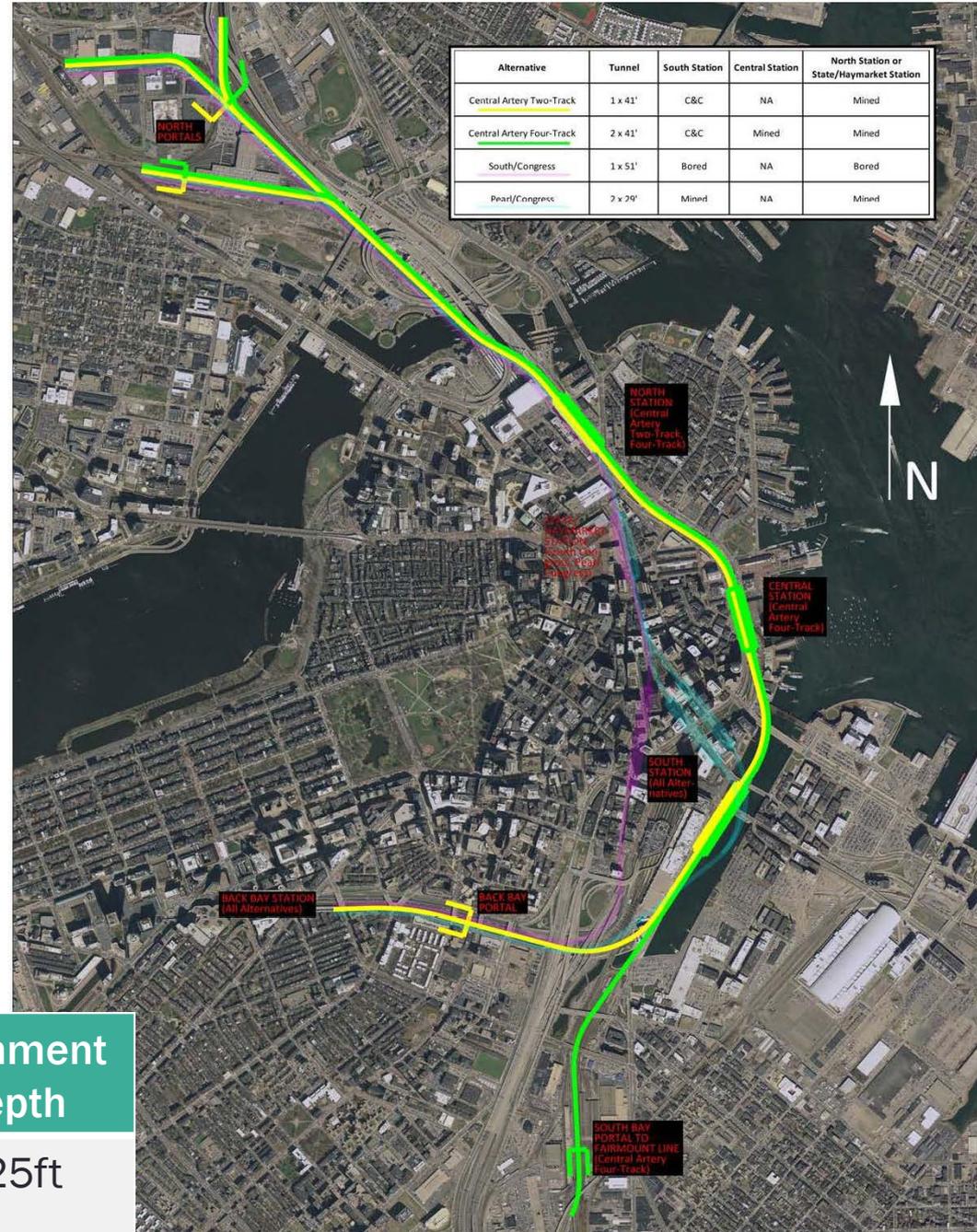
- Two stations
- Cut-and-cover construction in Fort Point Channel, mining around South Bay interchange ramps
- Alignment accommodated in a 38-foot internal diameter tunnel built using a 41-foot-diameter TBM.
- Tunnels under the Orange Line, I-90 Ramps, the Red, Silver, and Blue Lines.
- Fairmount and Old Colony Lines continue to terminate at South Station at grade



Tracks	Tunnel Diameter	Stations	Alignment Depth
2	1 x 41ft	2	125ft

Central Artery Four-Track

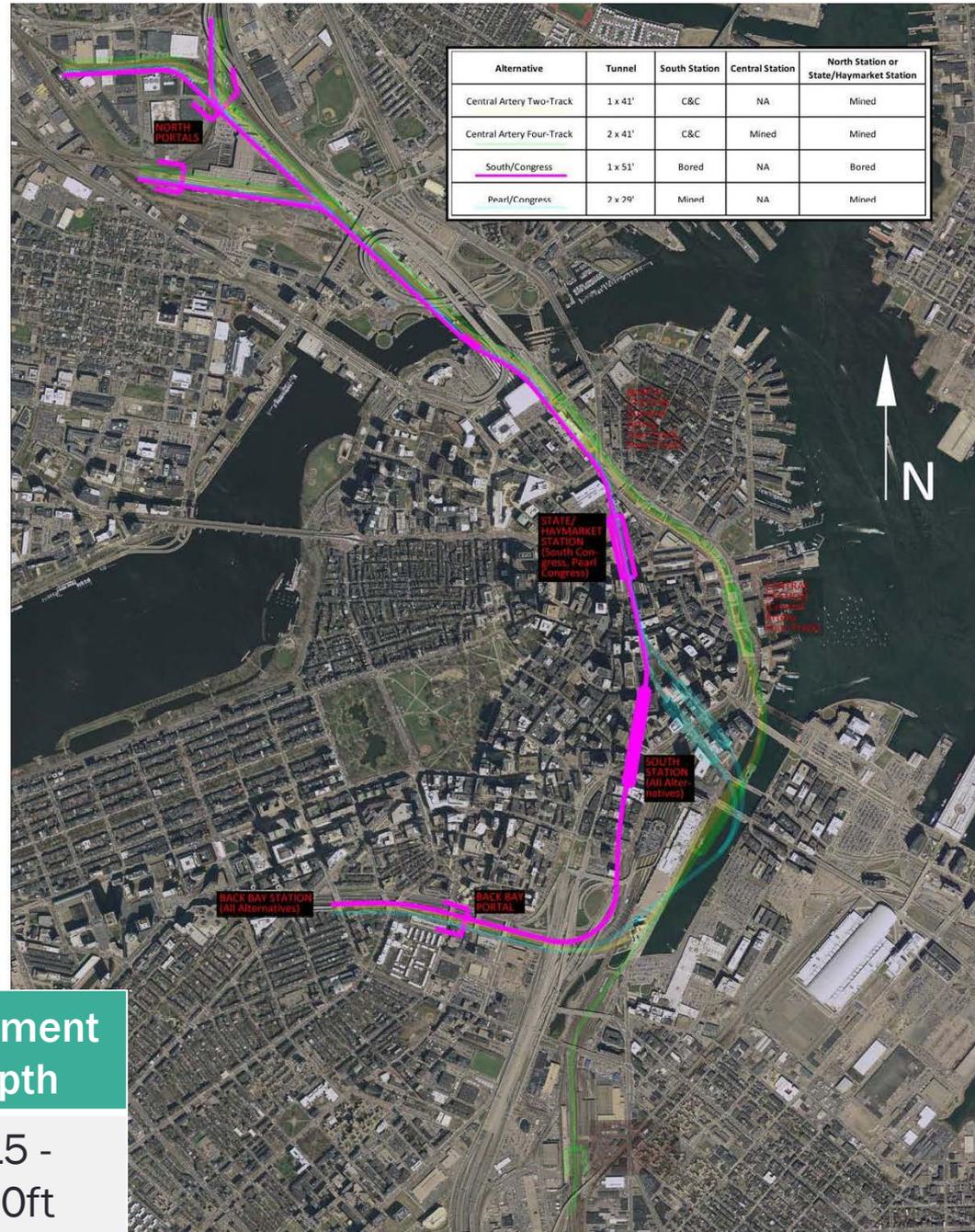
- Three stations – Includes Central Station
- Cut-and-cover construction in Fort Point Channel, mining around South Bay interchange ramps
- Uses two 41-foot TBMs to form two 38-foot internal dimension tunnels
- Tunnels under the Orange Line, I-90 Ramps, the Red, Silver and Blue Lines.
- Fairmount Line uses the tunnel. Old Colony Lines continue to terminate at South Station at grade



Tracks	Tunnel Diameter	Stations	Alignment Depth
4	2 x 41ft	3	125ft

South/Congress Alignment

- Two stations
- Single 51-foot TMB bored tunnel with stacked tracks and platforms within the tunnel bore
- Tunnels under Red, Blue, Orange and Green Lines and the southbound lanes of I-93
- Fairmount and Old Colony Lines continue to terminate at South Station at grade

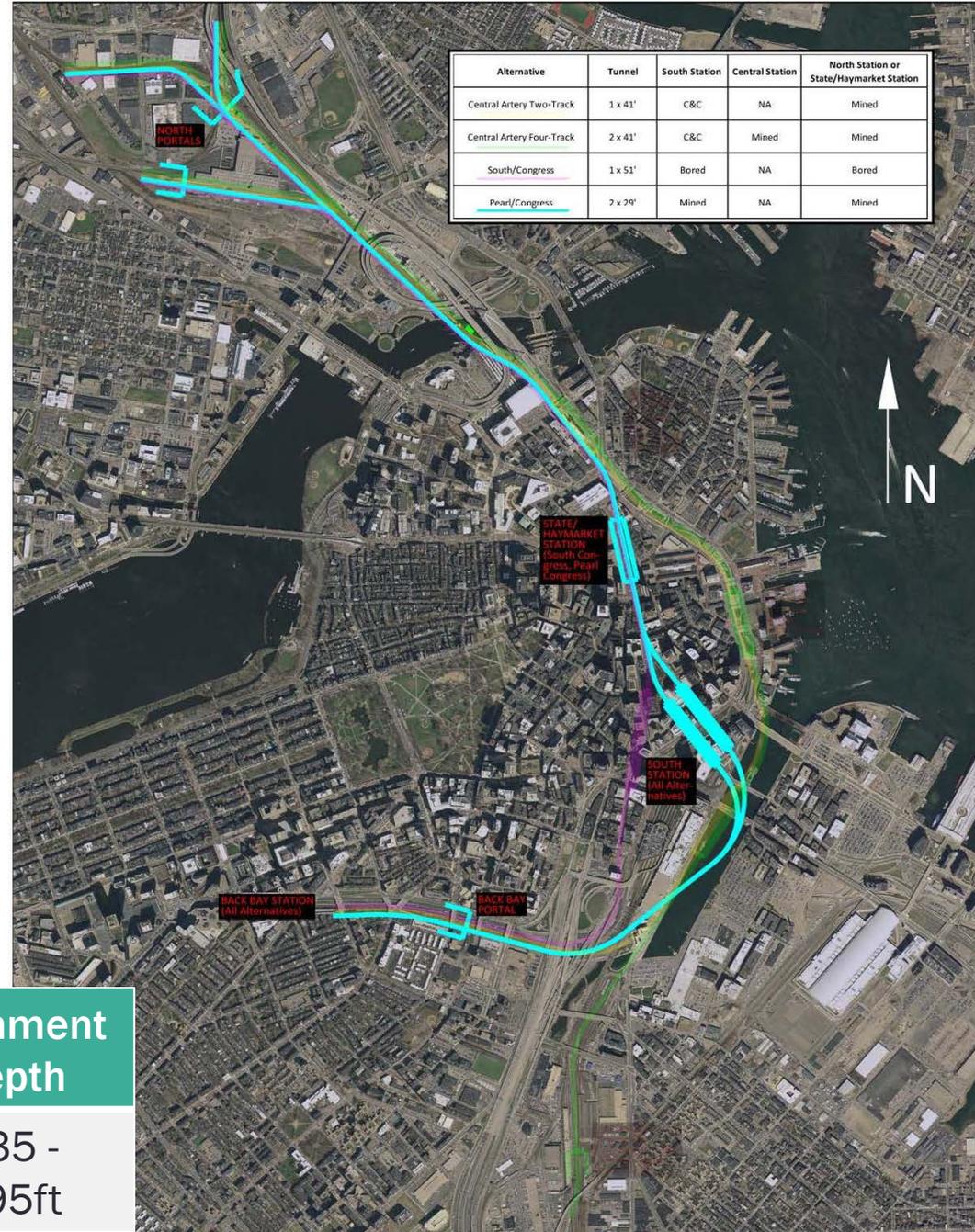


Alternative	Tunnel	South Station	Central Station	North Station or State/Haymarket Station
Central Artery Two-Track	1 x 41'	C&C	NA	Mined
Central Artery Four-Track	2 x 41'	C&C	Mined	Mined
South/Congress	1 x 51'	Bored	NA	Bored
Pearl/Congress	2 x 29'	Mined	NA	Mined

Tracks	Tunnel Diameter	Stations	Alignment Depth
2	1 x 51ft	2	115 - 130ft

Pearl/Congress Alignment

- Two stations
- Mining around South Bay interchange ramps
- Uses two 29-foot-diameter TBM bored tunnels
- Tunnels under Orange Line, I-90 Ramps, the Red and Silver Lines, I-93 northbound lanes, I-93, the Blue and Green Lines
- Fairmount and Old Colony Lines continue to terminate at South Station at grade

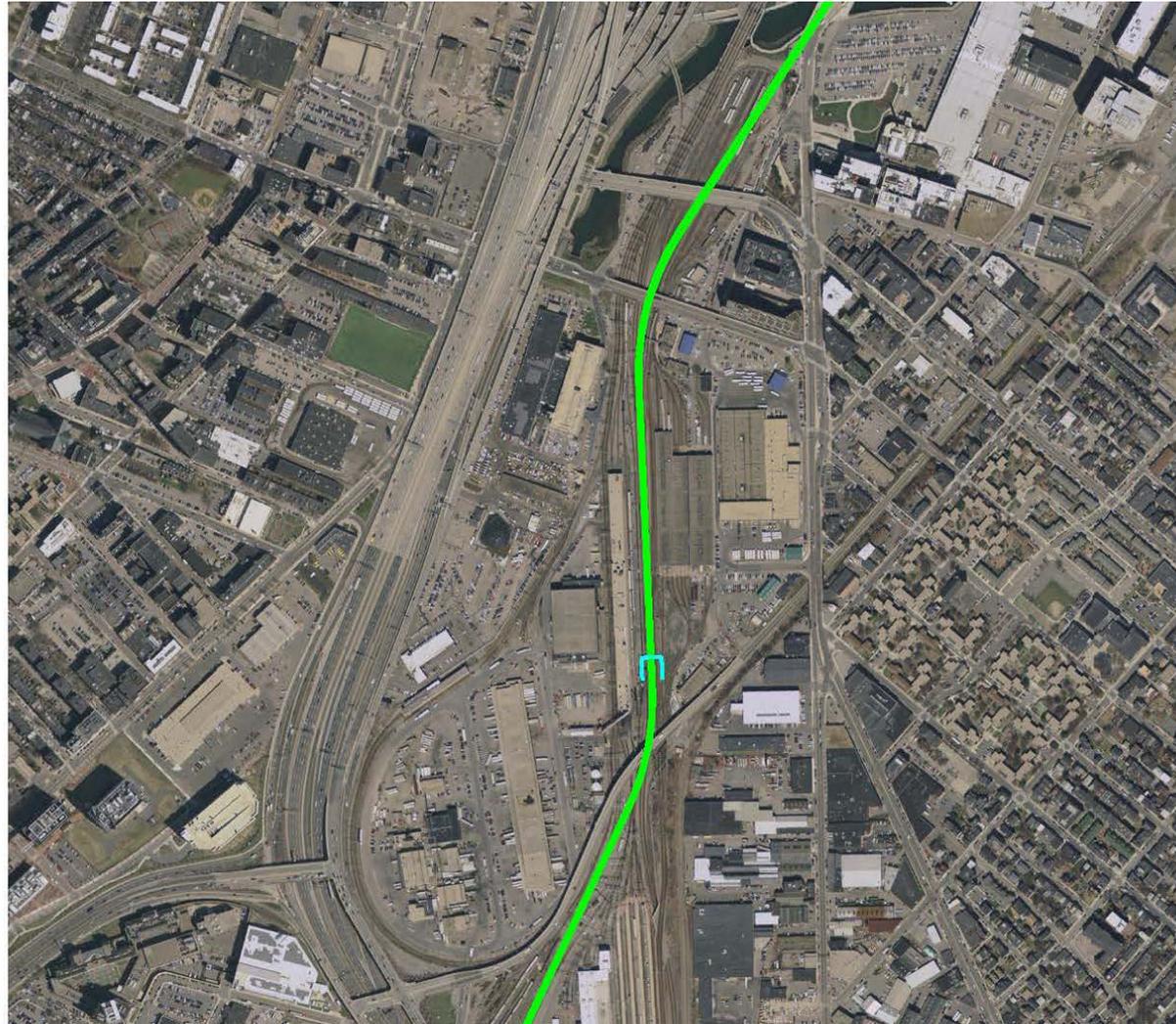


Alternative	Tunnel	South Station	Central Station	North Station or State/Haymarket Station
Central Artery Two-Track	1 x 41'	C&C	NA	Mined
Central Artery Four-Track	2 x 41'	C&C	Mined	Mined
South/Congress	1 x 51'	Bored	NA	Bored
Pearl/Congress	2 x 29'	Mined	NA	Mined

Tracks	Tunnel Diameter	Stations	Alignment Depth
2	2 x 29ft	2	135 - 195ft

South Bay Portal

- South Bay Portal only utilized in Central Artery Four-Track alternative. Necessary to accommodate Fairmount or Old Colony Lines.
- **Location:** On the Fairmount Line, just east of Widett Circle
- **Method of Construction:** Constructed using boat sections and cut-and-cover.
- **Construction Impacts:** Service delays and interruptions.



Cost Estimates – NSRL Tunnel Costs

	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Tunneling Works	\$4,282,000,000	\$5,698,000,000	\$5,046,000,000	\$10,179,000,000
Stations	\$1,396,000,000	\$827,000,000	\$2,643,000,000	\$4,214,000,000
Trackwork/Civils	\$197,000,000	\$174,000,000	\$189,000,000	\$390,000,000
Portals	\$1,723,000,000	\$1,723,000,000	\$1,723,000,000	\$1,770,000,000
Electrification Back Bay Portal to Chelsea, W. Medford, and Malden	\$469,000,000	\$456,000,000	\$466,000,000	\$598,000,000
Layover Facilities	\$106,000,000	\$106,000,000	\$106,000,000	\$106,000,000
Allowances	\$456,000,000	\$508,000,000	\$528,000,000	\$472,000,000
Total	\$8,629,000,000	\$9,493,000,000	\$10,701,000,000	\$17,730,000,000

2028 MP Construction USD rounded to the nearest Million

Assumptions:

- Every alternative has 2 stations except for the Central Artery 4-track which has 3 stations
- All tunnel alternatives replace 66 diesel trains with dual-mode locomotive trains

Cost Estimates – Vehicles

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Dual Mode Locomotives to support tunnel	\$0	\$391,000,000	\$391,000,000	\$391,000,000	\$391,000,000
Additional Dual Locomotives and Coaches to support increased service levels	\$1,397,000,000	\$1,989,000,000	\$1,989,000,000	\$1,989,000,000	\$2,048,000,000
Total	\$1,397,000,000	\$2,380,000,000	\$2,380,000,000	\$2,380,000,000	\$2,439,000,000

2028 MP Construction USD rounded to the nearest Million

Assumptions:

- Every alternative has 2 stations except for the Central Artery 4-track which has 3 stations
- All tunnel alternatives replace 66 diesel trains with dual-mode locomotive trains

Cost Estimates – Upstream Investments to Support Increased Service

	South Station Expansion All-Day Peak Service	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Layover Facilities Widett Circle (Surf. Asp.)	Included in MassDOT's SSX cost estimate	\$405,000,000	\$405,000,000	\$405,000,000	\$405,000,000
Additional Platforms	\$53,000,000	\$40,000,000	\$40,000,000	\$40,000,000	\$53,000,000
Double Track	\$298,000,000	\$376,000,000	\$376,000,000	\$376,000,000	\$376,000,000
Turnback Crossovers	\$9,000,000	\$14,000,000	\$14,000,000	\$14,000,000	\$14,000,000
Resignaling Critical Points	\$472,000,000	\$472,000,000	\$472,000,000	\$472,000,000	\$472,000,000
TOTAL	\$833,000,000	\$1,307,000,000	\$1,307,000,000	\$1,307,000,000	\$1,321,000,000

2028 MP Construction USD rounded to the nearest Million

Assumptions:

- Every alternative has two stations except for the Central Artery 4-track which has three stations
- The three 2-track alternatives involve replacing 48 diesels with dual-modes, expanding locomotive fleet with 72 dual-modes and 203 coaches
- The Central Artery 4-track alternative involves replacing 58 diesels with dual modes, expanding locomotive fleet with 72 dual-modes and 203 coaches

Operating costs - Methodology

- Train miles and hours provide the basis for the estimation of operating costs, including maintenance:
 - Distances are derived from the current MBTA Commuter Rail track network
 - Journey times are based on current schedule timings
 - Non-revenue mileage and train hours are based on assumed trainyard locations. (A high-level assessment of yard capacity has been undertaken)
 - The calculations do not allow for non-revenue moves between lines during operating hours or any additional movements required for rolling stock maintenance or refueling.
 - Mileage and hours are based on the whole consist rather than per coach.

Operating costs - Inputs

Train miles and hours per service alternative

Service Alternative	Weekday Daily Totals			
	Revenue Miles	Revenue Hours	Non-revenue Miles	Non-revenue Hours
No Build 2040	16,420	530	800	30
South Station Expansion All-Day Peak Service	41,550	1,370	1,630	60
NSRL Regular Service (2-track)	28,290	950	2,300	80
NSRL All-Day Peak Service (2-track)	51,470	1,690	2,480	80
NSRL All-Day Peak Service (4-track)	55,230	1,780	2,800	90