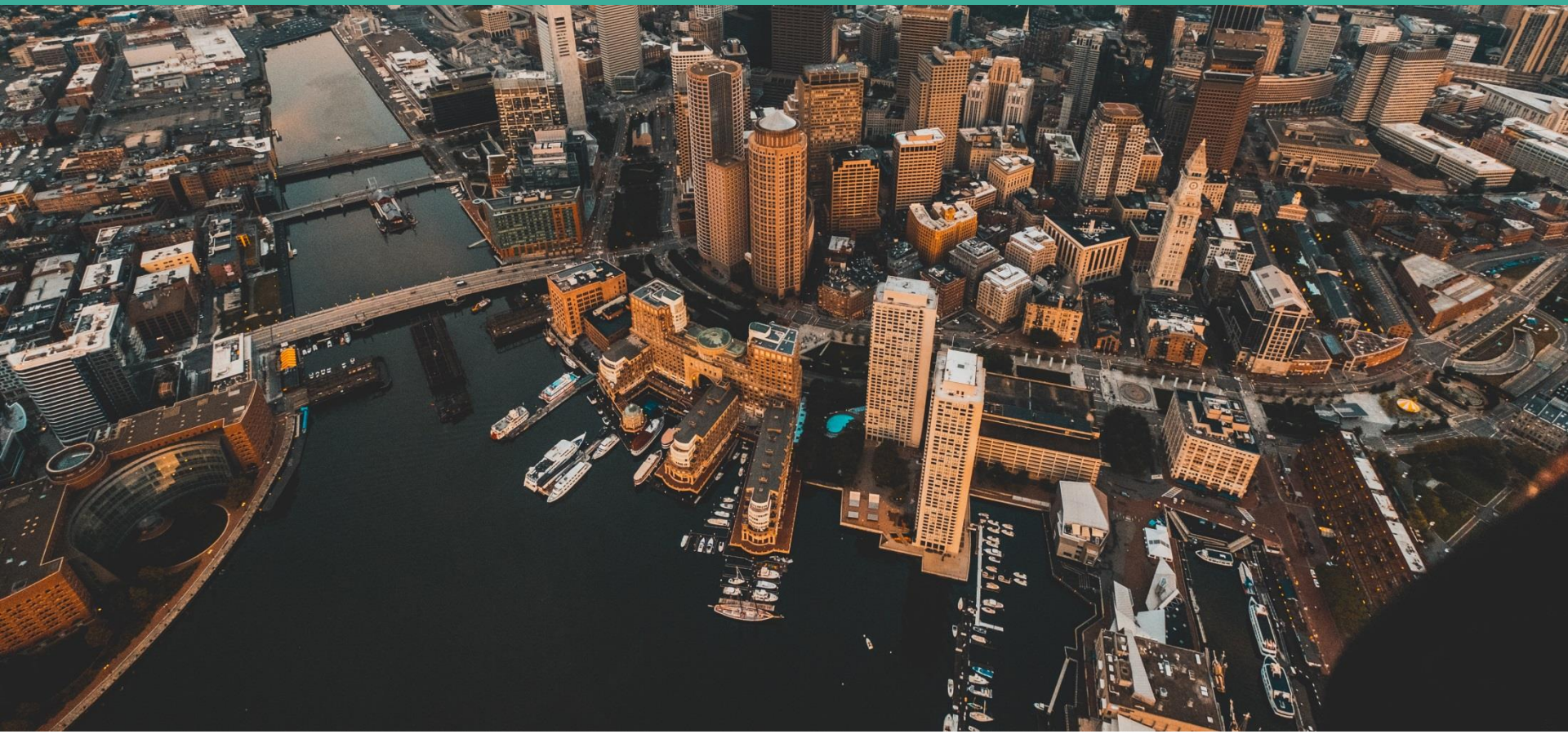
North South Rail Link Feasibility Reassessment

December 10, 2018



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Meeting Purpose

Conclude the Feasibility Reassessment process by:

- Summarizing and responding to general public comments received
- Presenting detailed cost methodology
- Presenting proposed preferred alignment whose right of way MassDOT will use to inform future decision-making through the normal project development process

BACKGROUND

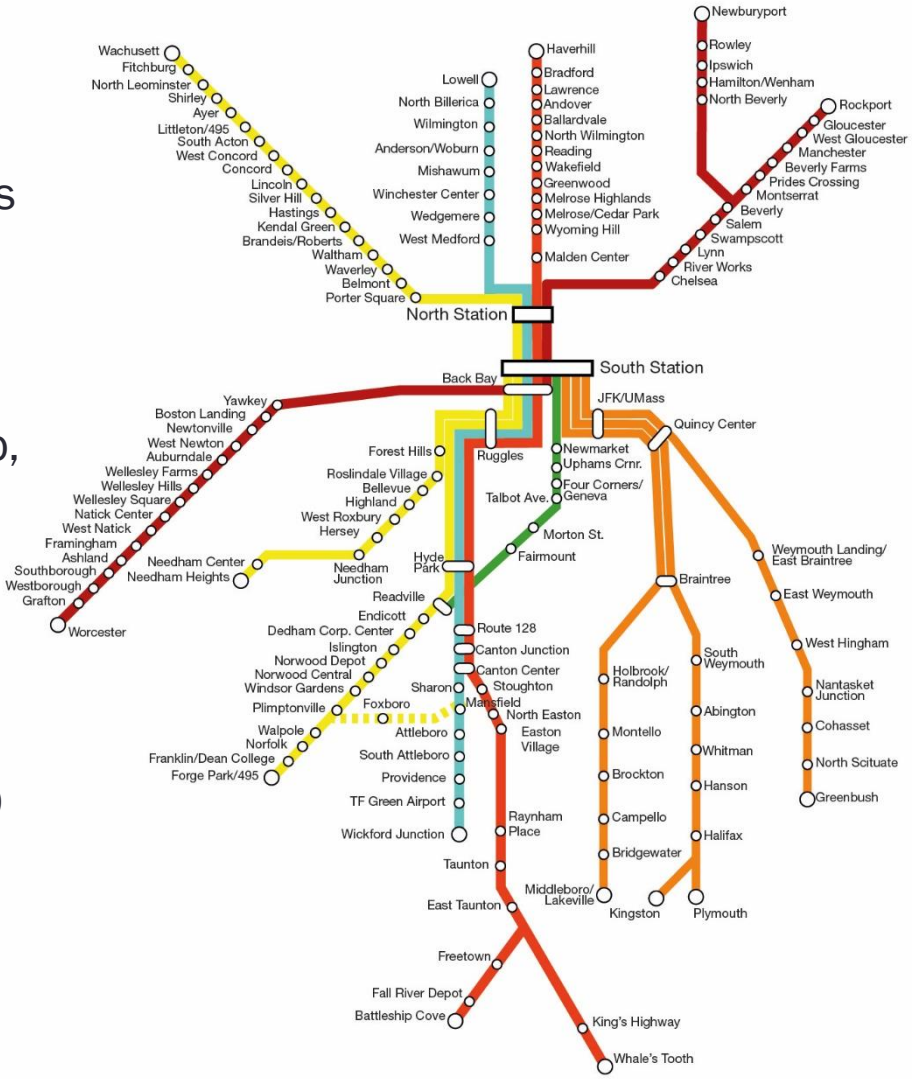
NSRL Feasibility Reassessment Update

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)

Project Status

- Draft report released in September
- Public comment period ended October 19
- 75 comments received
- Final report in January



RESPONSE TO PUBLIC COMMENTS

Major Themes of Comments

- Benefits
- Electrification
- Capacity/Service
- Forecasts
- South Station Expansion
- Cost

Benefits

The project looked at costs in isolation from benefits; only 4% of project budget was for benefits

- CTPS had a budget of $250k exclusively focused on measuring benefits – total share of overall cost dedicated to benefits was closer to 20%
- Some benefits (such as increased tourism or potential for value capture at all commuter rail stations resulting from the project) are impossible to project and quantify with any confidence
- The assessment of benefits presented a more comprehensive approach than what it is typically required by the Federal Transit Administration which focuses on mobility/environmental impacts only

Electrification

Lack of full system electrification means that some benefits were not realized; NSRL should not have to bear the costs for electrification

- MassDOT did not want to burden the cost of the NSRL with sytemwide electrification
- MassDOT and the MBTA are looking at electrification as part of the ongoing Rail Vision process
- In the study of any MBTA/MassDOT expansion project, costs and benefits are evaluated relative to a No Build, defined as the existing system plus any currently committed service or infrastructure investments. There is not currently a funded commitment to electrify the MBTA commuter rail system

Capacity/Service

MassDOT tested an unrealistic level of all day peak service which required costly upstream improvements; improvements which should not be added to NSRL costs

- The NSRL Working Group requested MassDOT to study maximum use of the infrastructure all day
- MassDOT will model a more optimal service plan as part of the MBTA Rail Vision
- Most upstream investments were necessary to maximize throughput during the peak periods and only represented 10% of project costs
- In the study of any MBTA/MassDOT expansion project, costs and benefits are evaluated relative to a No Build, defined as the existing system plus any currently committed service or infrastructure investments. There is not currently a funded commitment to increase service levels or make system wide capacity improvements

Forecasts

The CTPS travel demand model is static and only considers today's trip making behavior, not new trips that might be induced by the project

- The model is the federally approved tool to project ridership on projects seeking federal funding support
- Accurately predicting shifts in population and employment with land use decisions controlled by 175 local governments is challenging and beyond the scope of this project
- As part of the MBTA Rail Vision process a dynamic model will be used to identify the relative attractiveness of communities for development as a result of investments, and the CTPS model will include updated population/employment projections.
- MassDOT took the atypical approach of not constraining parking capacity to available supply

South Station Expansion

MassDOT spent more money on the South Station Expansion study; MassDOT should not build South Station Expansion

- In 2009, the Commonwealth received a $32.5 million grant from the Federal Railroad Administration to complete design and environmental review for South Station Expansion; the NSRL has not received federal funds and does not currently have a federal sponsor
- There is not currently funding in MassDOT or MBTA fiscally constrained capital plans for South Station Expansion
- The South Station Expansion project depends upon the relocation of the United States Postal Service Annex
- South Station Expansion has been designed to not preclude NSRL

COST METHODOLOGY

Cost Estimating Methodology

MassDOT's NSRL cost estimate was informed by a wealth of information on other major tunnel and infrastructure project:

- Arup's tunneling experts
- Use of international best practices to assign accuracy ranges and contingencies
- 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
- Benchmarks (note: diameters vary on all projects listed below):
  - London Cross Rail (UK) → Similar scope (TBM / diameter, constructability)
  - M-30 tunnel (Spain) → Similar scope (TBM / diameter)
  - CHSRL (California) → Similar scope (TBM /SEM and 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

Cost Estimating Methodology

Direct Costs Analysis:

- Tunneling, stations, portal works, trackwork, electrification

Indirect Costs (25% for civil works; 40% for tunneling works)

- Contractor's general conditions (mobilization, demobilization, site set-up, on-site supervision staff, small tools, site office supplies, health safety and sanitary on-site costs)

Contractor's Contingency (10%)

- What a contractor would price for uncertainty in labor rates, commodity volatility, and potential schedule delays for scope they cannot control

Cost Estimating Methodology

Overhead & Profit (12%)

- Contractor's home office costs and profit

Design & Engineering costs (9%)

Costs to detail the engineering design and to reach final design and construction drawings

Soft Costs (15%)

- Owner's costs: agency involvement, design QA/QC, construction monitoring and Project/Construction management, Environmental fees, legal fees and others

Risk Contingency (20% for civil works; 40% for tunneling works)

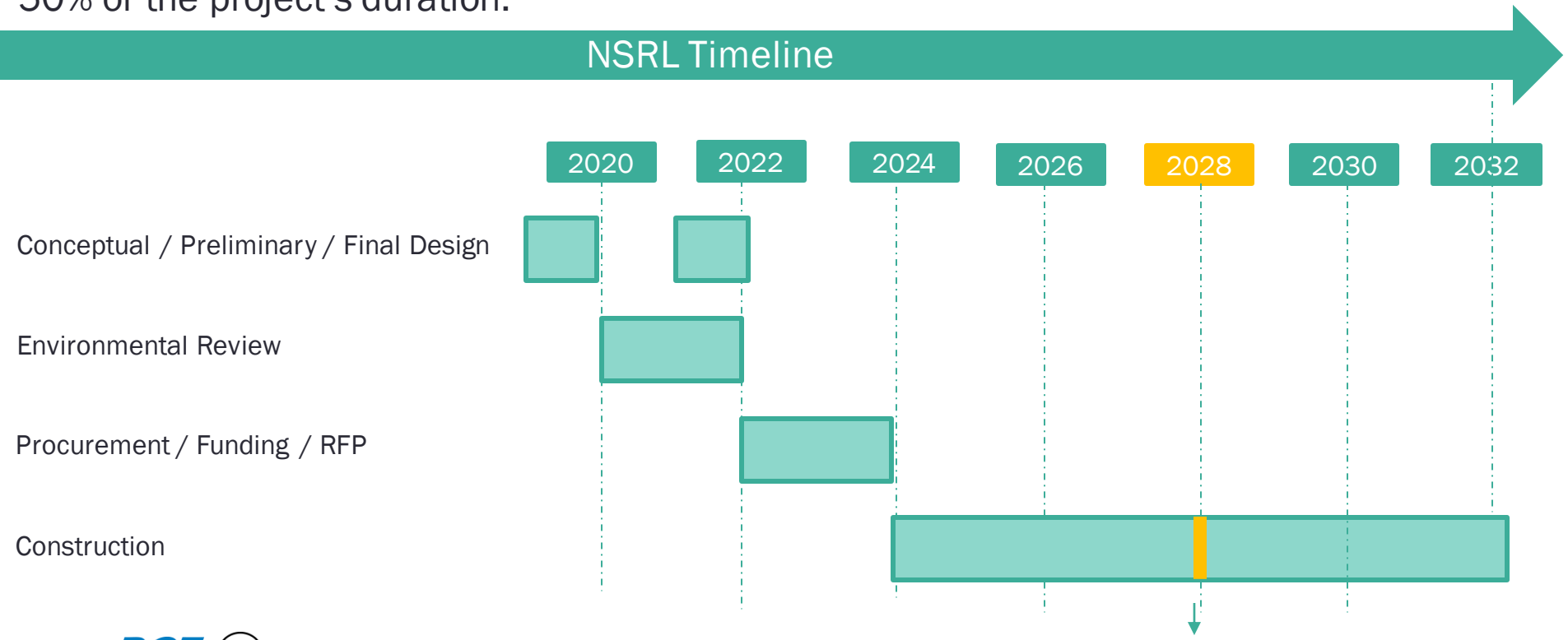
- Owner's Risk Contingency: meant to capture known unknowns and potential risks for: procurement, economic risk, change order management risk, contract administration risks, construction risk

Cost Estimating Methodology

Escalation (3.5%)

- Included to obtain the total project costs at a specific point in the future

Midpoint of construction: 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.



Cost Estimates – NSRL Tunnel Only (2018 USD)

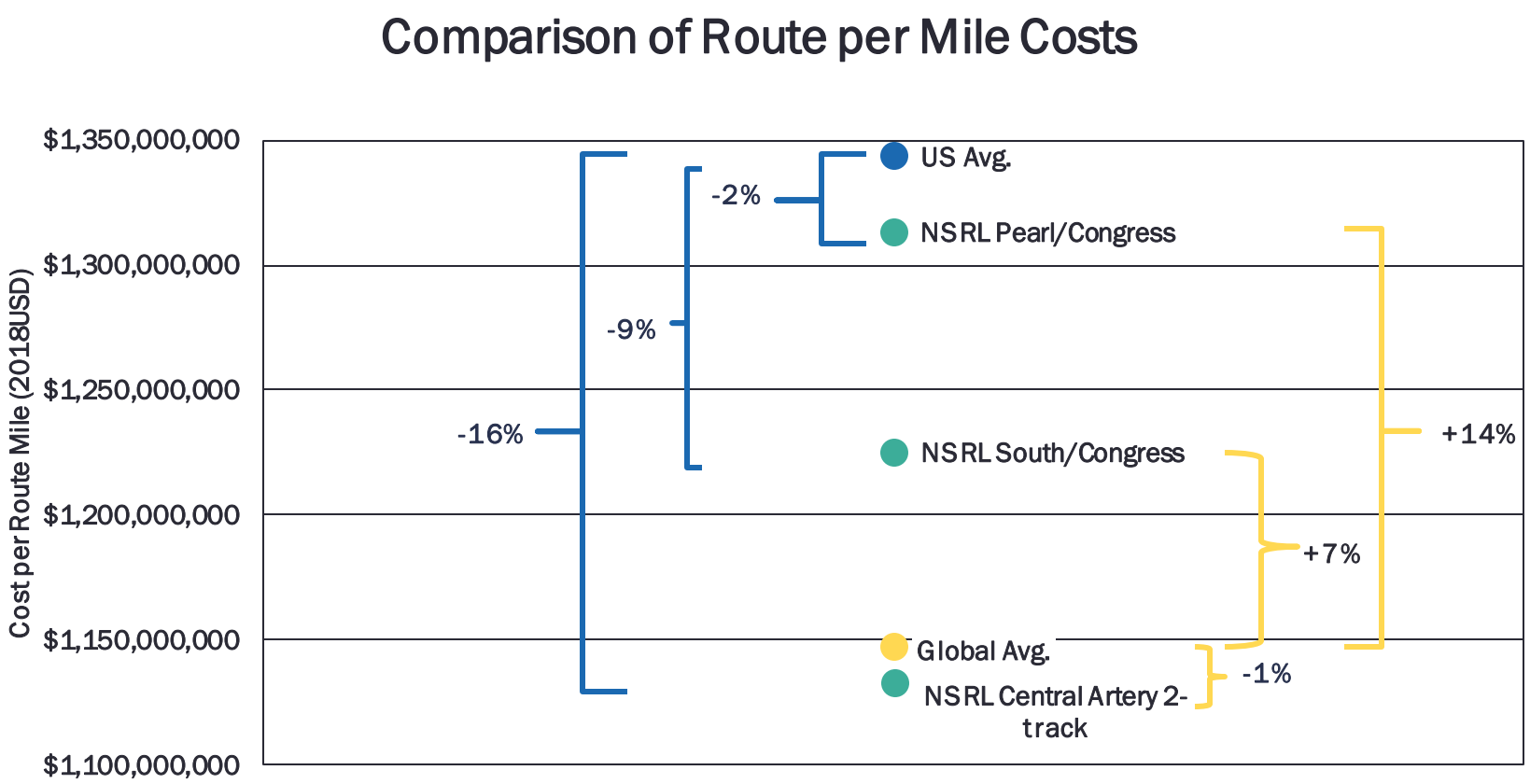
	Central Artery 2 - track	South Congress	Pearl / Congress	Central Artery 4 - Track
Tunneling Works	$3,035,000,000	$4,039,000,000	$3,577,000,000	$7,216,000,000
Stations	$990,000,000	$587,000,000	$1,874,000,000	$2,988,000,000
Trackwork/Civils	$140,000,000	$123,000,000	$134,000,000	$277,000,000
Portals	$1,221,000,000	$1,221,000,000	$1,221,000,000	$1,255,000,000
Electrification Back Bay Portal to Chelsea, W. Medford, and Malden	$364,000,000	$354,000,000	$361,000,000	$455,000,000
Layover Facilities	$75,000,000	$75,000,000	$75,000,000	$75,000,000
Allowances	$323,000,000	$360,000,000	$374,000,000	$335,000,000
Total 2018USD	**$6,148,000,000**	**$6,760,000,000**	**$7,617,000,000**	**$12,600,000,000**
Total 2028USD	***$8,629,000,000***	***$9,493,000,000***	***$10,701,000,000***	***$17,730,000,000***

2018 USD rounded to the nearest Million escalated using a 3.5% annual rate to midpoint of construction (approx. 2028)

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

Comparing the NSRL Tunnel Costs to Other Projects



Comparing the NSRL Tunnel Costs to other projects in the US

Project	LA Regional Connector	LA Purple Line Extension PH. 1	LA Purple Line Extension PH. 2	San Francisco Central Subway	NY Second Ave. Subway PH 1	NSRL 2 Track Midpoint
Alignment Length (miles)	1.9	3.92	2.59	1.7	2	5.49
Tunnel Diameter	22ft	19.10ft	19.10ft	20.7ft	19.75ft	51.5ft
Tunnel Quantity	2	2	2	2	2	1
Cross Section Excavation Area (ft2)	760	573	573	673	613	2,083
Cost	$1.7bn	$3.1bn	$2.5bn	$1.6bn	$4.4bn	$6.7bn
Year	2014	2015	2018	2010	2017	2018
Cost (Boston - 2018)	$2.1bn	$3.5bn	$2.6bn	$1.9bn	$5.1bn	$6.7bn
Cost per Route Mile	**$1.1bn**	**$0.9bn**	**$1bn**	**$1.1bn**	**$2.6**	**$1.2bn**

All project costs adjusted by location factor to Boston, and adjusted to 2018 USD

Average $ / mile other projects: $1.3bn / mile

$ / mile NSRL 2 Track Midpoint: $1.2bn / mile

NSRL Tunnels have on average 2 – 3 times the cross sectional area of other projects in the US

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Comparing the NSRL Tunnel Costs to London's Crossrail

- Crossrail project current estimated costs: $23bn USD with a total tunneling length of 25.5miles. This yields a $0.9bn/mile for a 20.3ft diameter tunnel.
- NSRL project costs yield a $1.2bn/mile average cost for tunnels which have cross sectional areas 2x or 3x larger than Crossrail.
- Larger excavation area corresponds to higher excavation costs per mile.

Project	NSRL Central Artery 2-Track	NSRL South Congress	NSRL Pearl Congress	Crossrail
Alignment Length (route miles)	5.40	5.49	5.77	12.8
Tunnel Diameter	41.5ft	51.5ft	29ft	20.3ft
Tunnel Quantity	1	1	2	2
Cross Section Excavation Area (ft2)	1,352	2,083	1,321	673
Cost per Route Mile	$1.1bn	$1.2bn	$1.3bn	$0.9

All project costs adjusted by location factor to Boston, and adjusted to 2018 USD

Comparing the NSRL Tunnel Costs to 2017 Harvard Study

- Inputs of Harvard KSG Study are based on the 2003 MassDOT Study's publicly available information.

Project	NSRL Central Artery 2-Track	Harvard KSG Study
Alignment Length 2 Track (miles)	5.40	2.788
Alignment Length 4 Track (miles)	6.62	2.95
Portal Location	Back Bay	South Portal
Alignment Grade	2.75%	3%
Excavation Method	TBM, Mined, Retained Cut	TBM

- The NSRL project has very complex station work (mined excavation, or water works in the Fort Point Channel). This might not be fully captured in KSG Study, resulting in station costs off by a factor of approximately 3 for the Central Artery Alignment.

Harvard KSG: $1.083bn / mile

NSRL Central Artery 2-Track : $1.13bn / mile

PREFERRED ALIGNMENT

to inform future decision-making through the normal project development process

Alternatives Studied

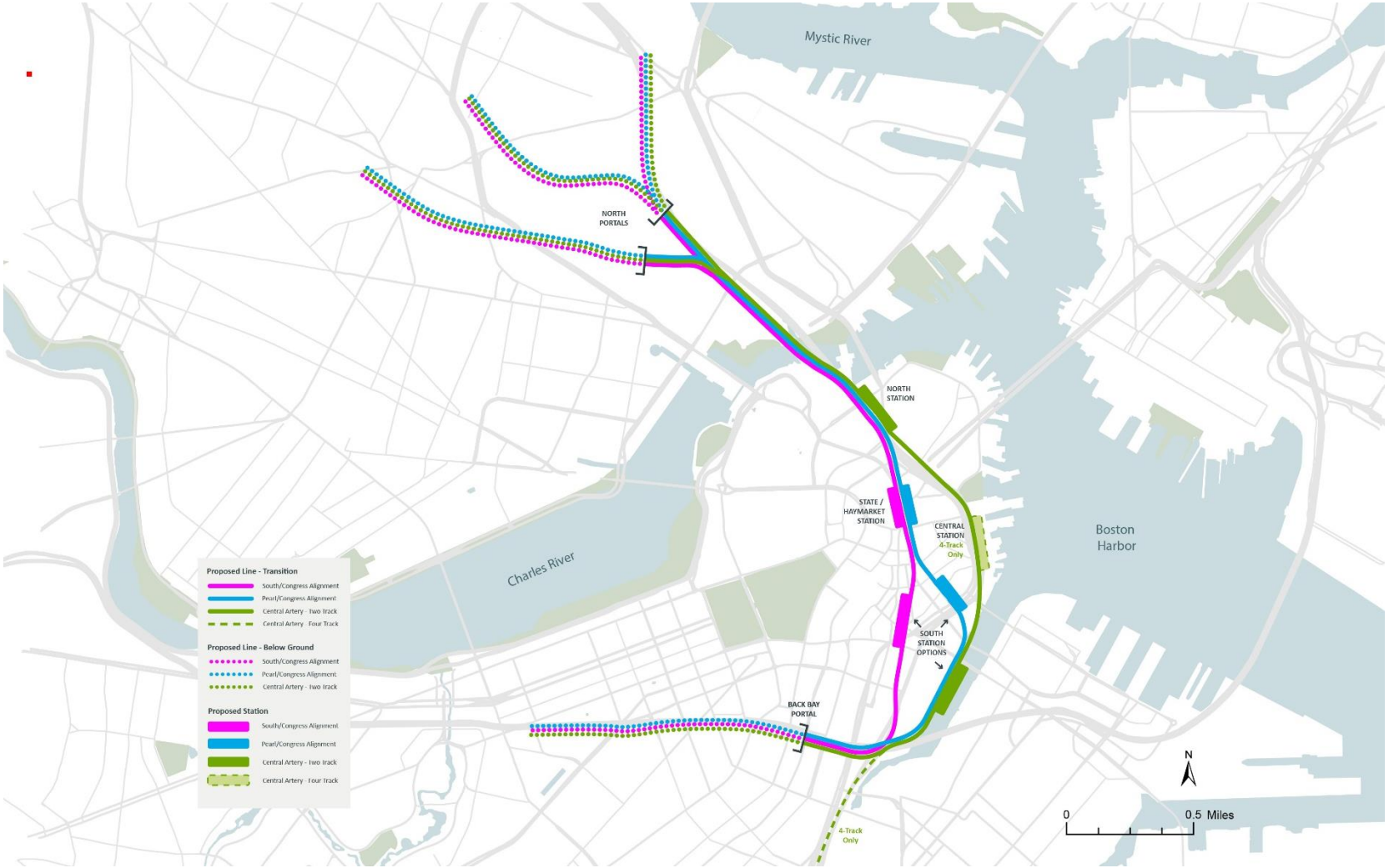
2-Track Alignment Alternatives

Tunnel Alignment	Tunnel Design	Alternative Tunnel Design
Central Artery – 2 Tracks	41-foot bored tunnel; mined stations	51-foot bored tunnel; stations within tunnel bore
Pearl/Congress – 2 Tracks	29-foot bored tunnel; mined stations	None
South/Congress – 2 Tracks	51-foot bored tunnel; stations within tunnel bore	41-foot bored tunnel; mined stations

4-Track Alignment Alternative

Tunnel Alignment	Tunnel Design	Alternative Tunnel Design
Central Artery – 4 Tracks	41-foot bored tunnel; mined stations	None

Alternatives Studied



Evaluation Objectives

Based on the Guiding Principles adopted for the feasibility reassessment, MassDOT evaluated the NSRL alignments in three broad categories:

Economy

- Estimated construction cost
- Total commuter rail weekday riders
- User benefit (downtown catchment areas)
- Risks – permitting, construction, and operations
- Potential for phasing

Environment

- Construction impacts
- Resilience in disasters and events
- Increased impacts of commuter rail operations

Equity

- Low-income households served
- Crowding reductions on MBTA bus and subway lines in low-income areas

First Step Evaluation: 2-track vs. 4-track

2-Track

	Criteria	Score	Weight	Tot.
Economy	Estimated Construction Cost	4	10	40
Economy	Total CR Commuter Rail Weekday Riders	4	4	16
Equity	Low-income households served	2	2	4
Equity	Reduced crowding on MBTA bus and subway lines in low-income areas	1	4	4
TOTAL – 2- Track				64

4-Track

	Criteria	Score	Weight	Tot.
Economy	Estimated Construction Cost	2	10	20
Economy	Total CR Commuter Rail Weekday Riders	4.5	4	18
Equity	Low-income households served	3	2	6
Equity	Reduced crowding on MBTA bus and subway lines in low-income areas	2	4	8
TOTAL – 4- Track				52

NOTE: All scores on a 1 – 5 point system. Each criterion weighted 1 – 10 based on relative importance.

First Step Evaluation : 2-track vs. 4-track

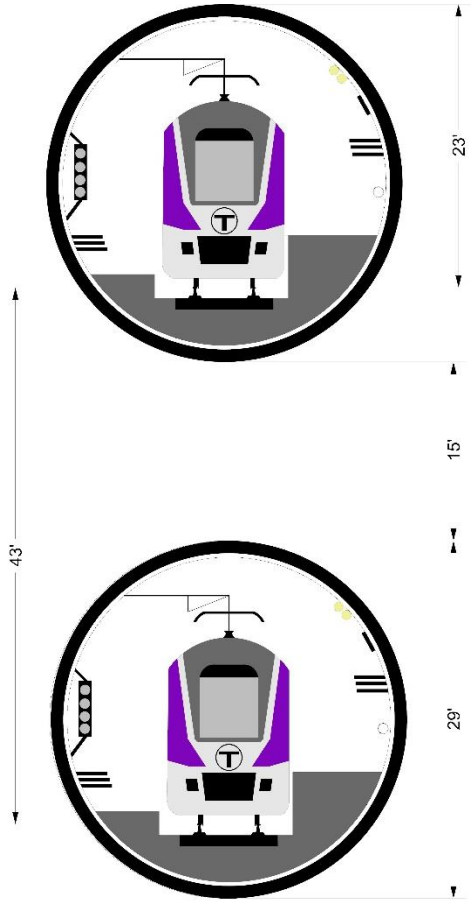
Alignment	Total Score
2-track	64
~~4-track~~	~~52~~

Comparing the two scores above, the recommendation is to advance a 2-Track alternative:

- While the 4-Track alternative slightly improves access to low-income households served (because of connecting the Fairmount Line) and results in slightly less crowding on MBTA bus and subway lines (because of its slightly greater coverage in the bus and subway service area) over the 2-Track alternative, the 2-Track alternative has a higher score because of its lower overall cost.

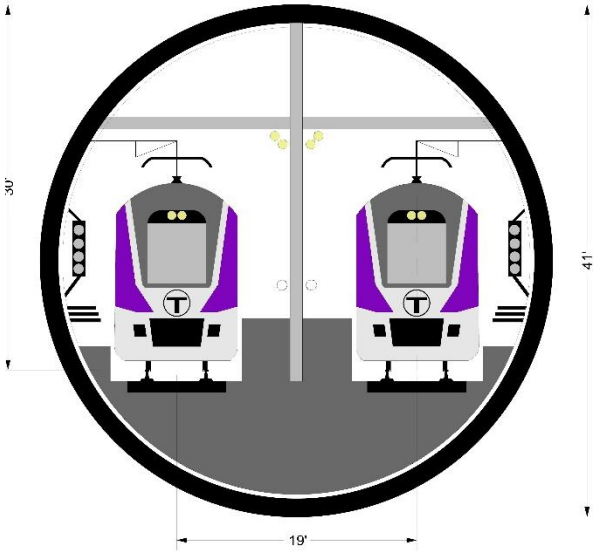
Second Step Evaluation: Construction Technology

29-Foot-Diameter



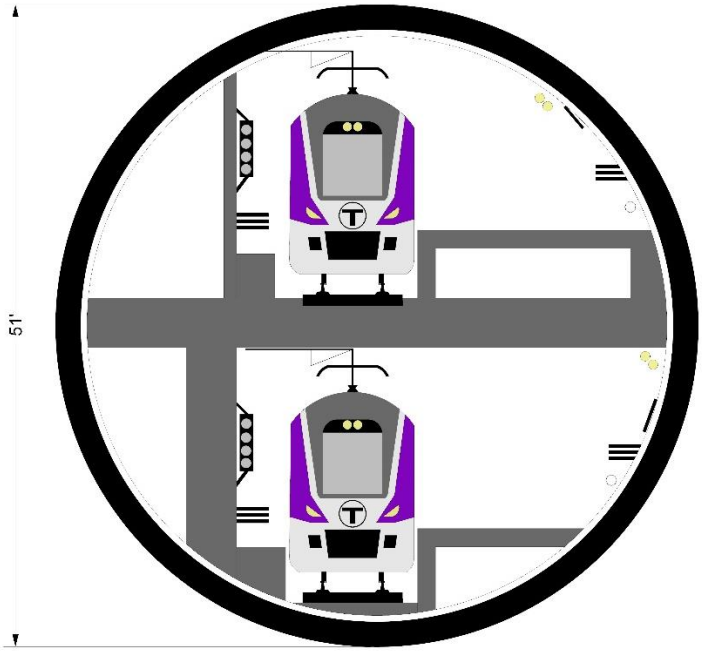
~1,300 sq ft Total Area

41-Foot-Diameter



~1,300 sq ft Total Area

51-Foot-Diameter



~2,000 sq ft Total Area

Second Step Evaluation: Construction Technology

		29-Foot-Diameter Bore			41-Foot-Diameter			51-Foot-Diameter		
	Criteria	Score	Weight	Total	Score	Weight	Total	Score	Weight	Total
Economy	Est. Constr. Cost	4	10	40	5	10	50	4.5	10	45
	Risks	1	2	2	1	2	2	3	2	6
	Potential for Phasing	1	2	2	1	2	2	1	2	2
Environment	Constr. impacts	1	2	2	1	2	2	3	2	6
	Resilience	1	4	4	1	4	4	1	4	4
TOTAL – 29-Foot-Diameter Bore				50	41-Foot		60	51-Foot		63

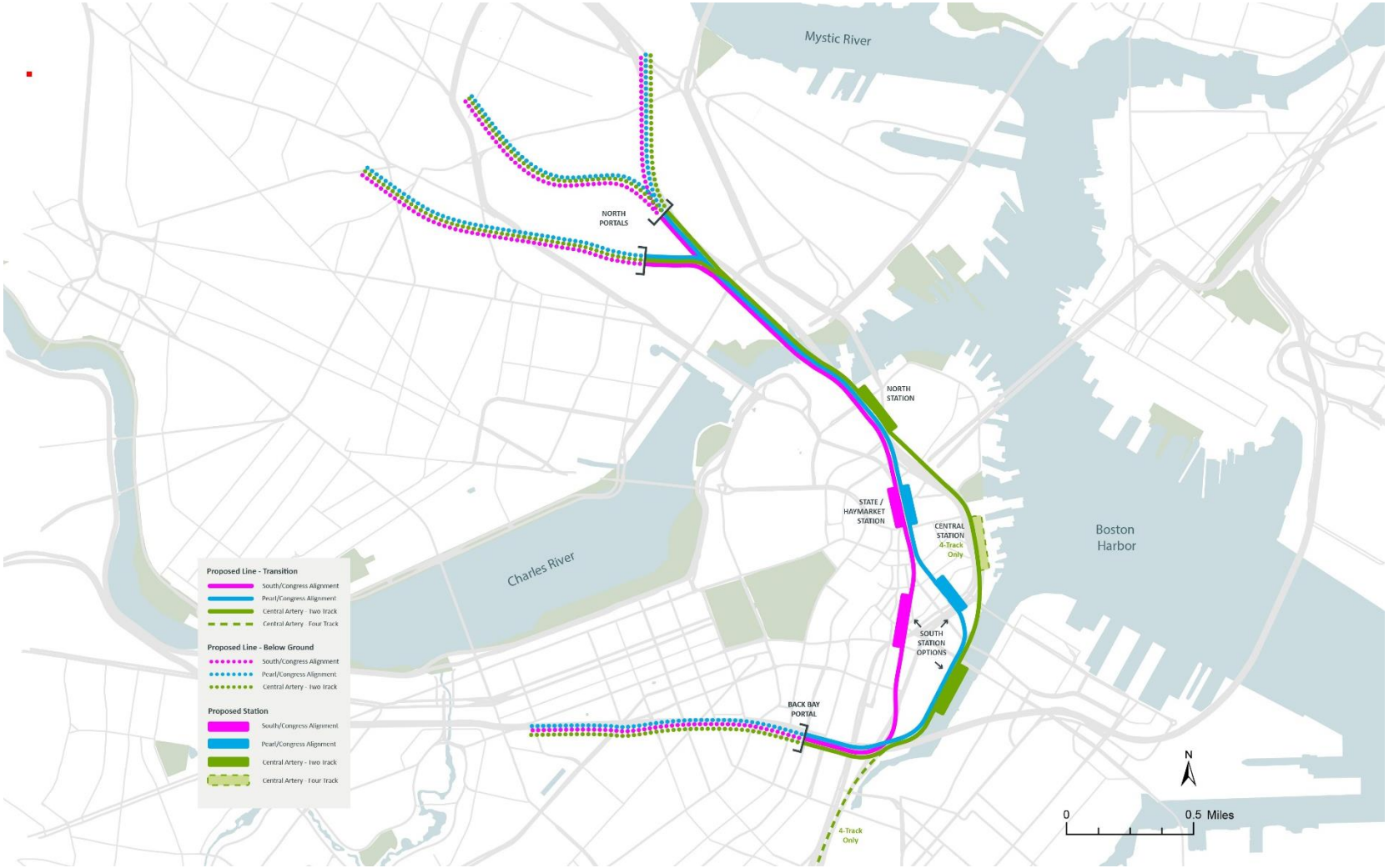
Second Step Evaluation: Construction Technology

Construction Technology	Total Score
~~29-Foot-Diameter Bore~~	~~50~~
41-Foot-Diameter Bore	60
51-Foot-Diameter Bore	63

Comparing the scores above, the 51-foot-diameter tunnel is the highest rated (however, in any environmental document, the 41-foot-diameter tunnel should be considered as an alternative):

- The main tie-breaking benefit of 51-foot-diameter tunnel is its reduced impacts on the street rights-of-way and other construction impacts and risk, which have high value in Boston. A downside of the 51-foot-diameter tunnel, aside from the higher cost, is that stations can be less appealing due to the constrained nature of constructing them within the tunnel diameter.

Third Step Evaluation: Alignment



Third Step Evaluation: Alignment

		Central Artery			South/Congress		
	Criteria	Score	Weight	Total	Score	Weight	Total
Economy	User Benefit (Downtown Catchment Areas)	2	8	16	3	8	24
	Risks – Permitting, Construction Risk, and Operations Risk	1	4	4	3	4	12
	Potential for Phasing	1	2	2	2	2	4
Environment	Construction impacts	1	1	1	2	1	2
	Resilience in disasters and events	1	1	1	1	1	1
	Increased impacts of Commuter Rail operations	2	1	2	2	1	2
Equity	Low-income households served	2	2	4	2	2	4
	Reduced crowding on MBTA bus and subway lines in low-income areas	2	1	2	3	1	3
TOTAL – Central Artery Alignment				32	South/Congress		52

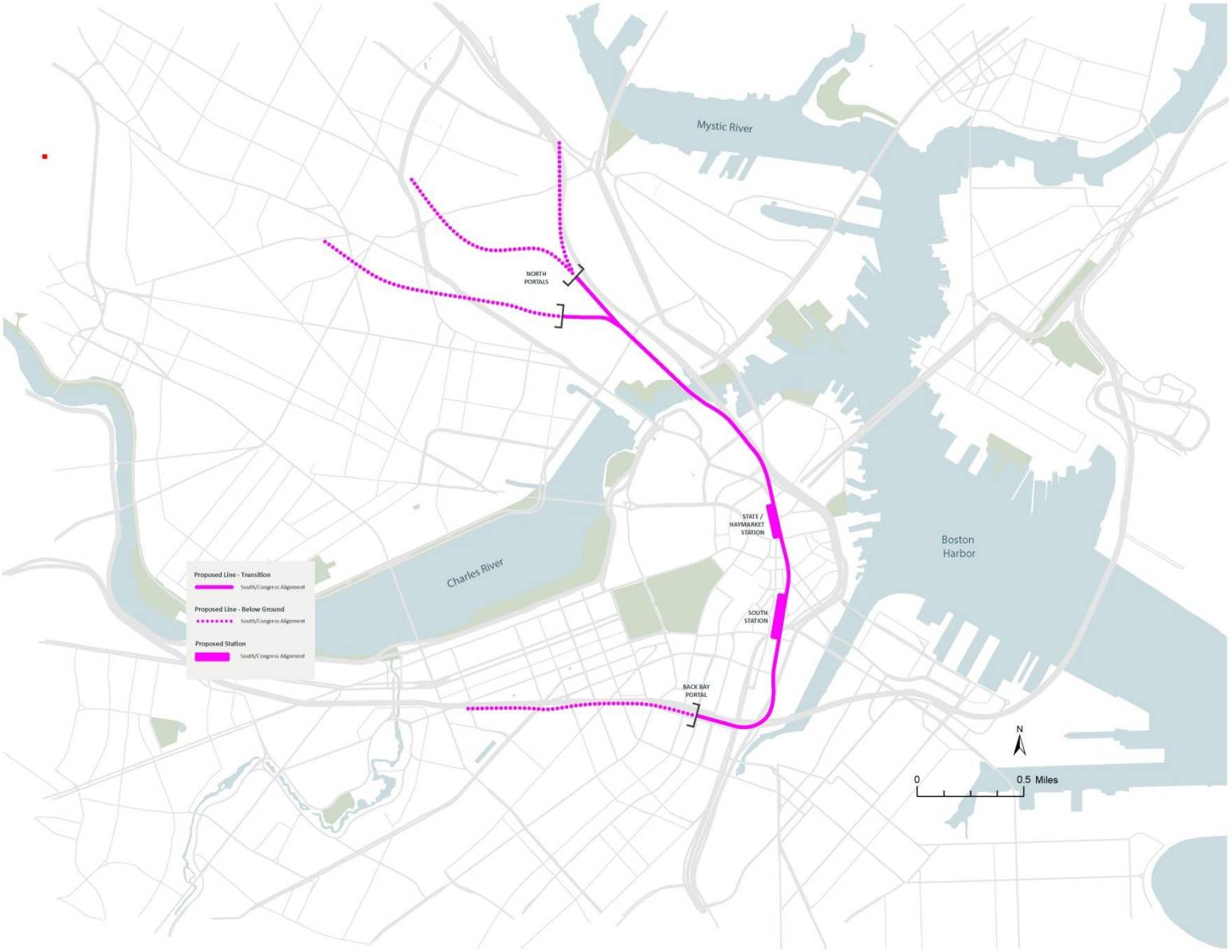
Recommendation

✓ South/Congress, using the 51-foot-diameter bored tunnel

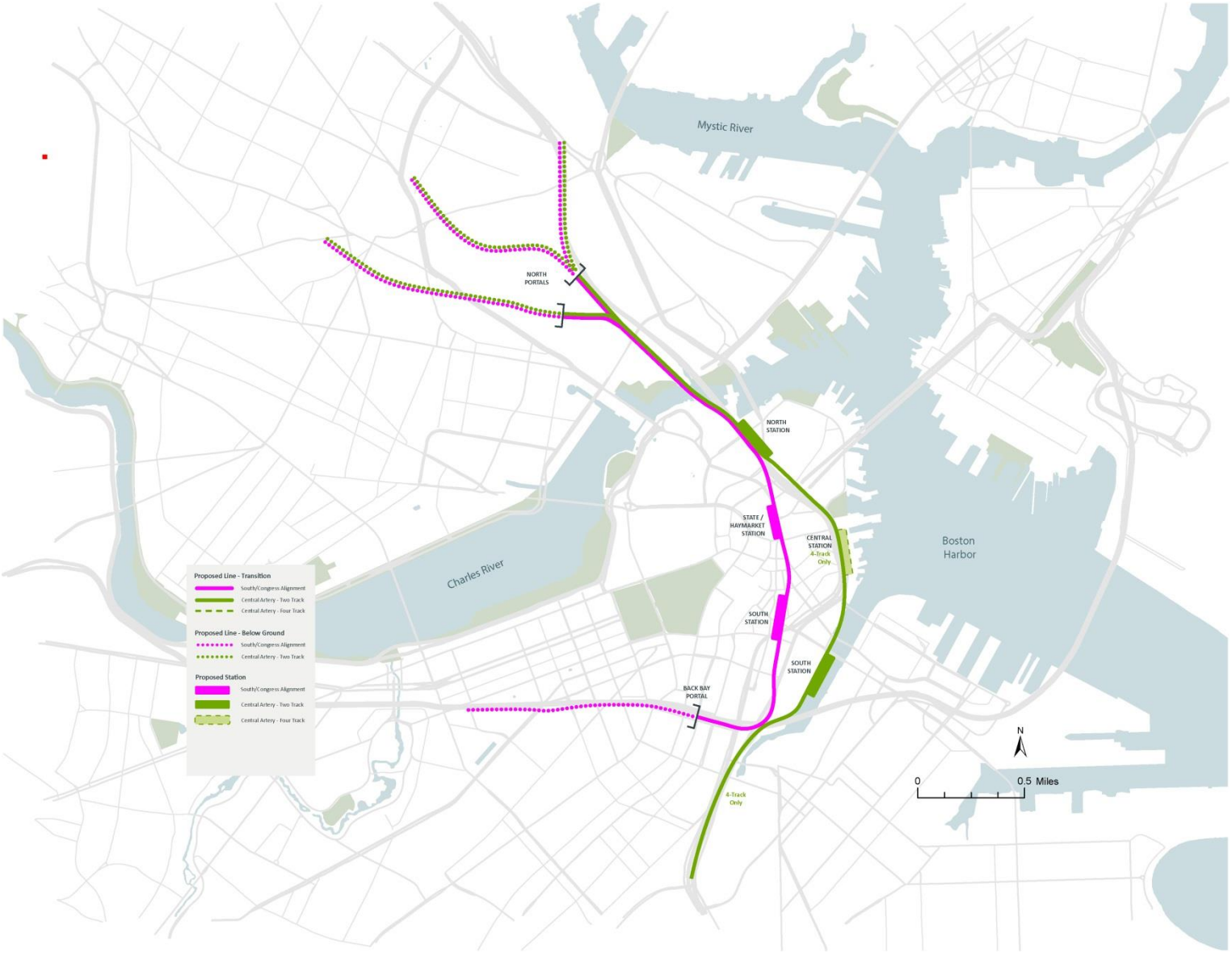
This alignment has the following advantages:

- More downtown Boston jobs are within easy walking distance of the alignment.
- South Station (tunnel tracks) is closer to existing commuters' jobs, compared to the Central Artery alignment.
- It has a State-Haymarket station that connects to the Blue, Green and Orange lines at one station, saving the cost of an additional station to make these connections.
- There is less permitting risk, as Fort Point Channel construction (which requires additional permits) is avoided in favor of a more inland route.
- It has slightly better resilience due to a more inland location that is further from sea level rise (not represented in the scoring, as in 50 years all locations are problematic).
- There is better potential for eventually creating a four-track system.

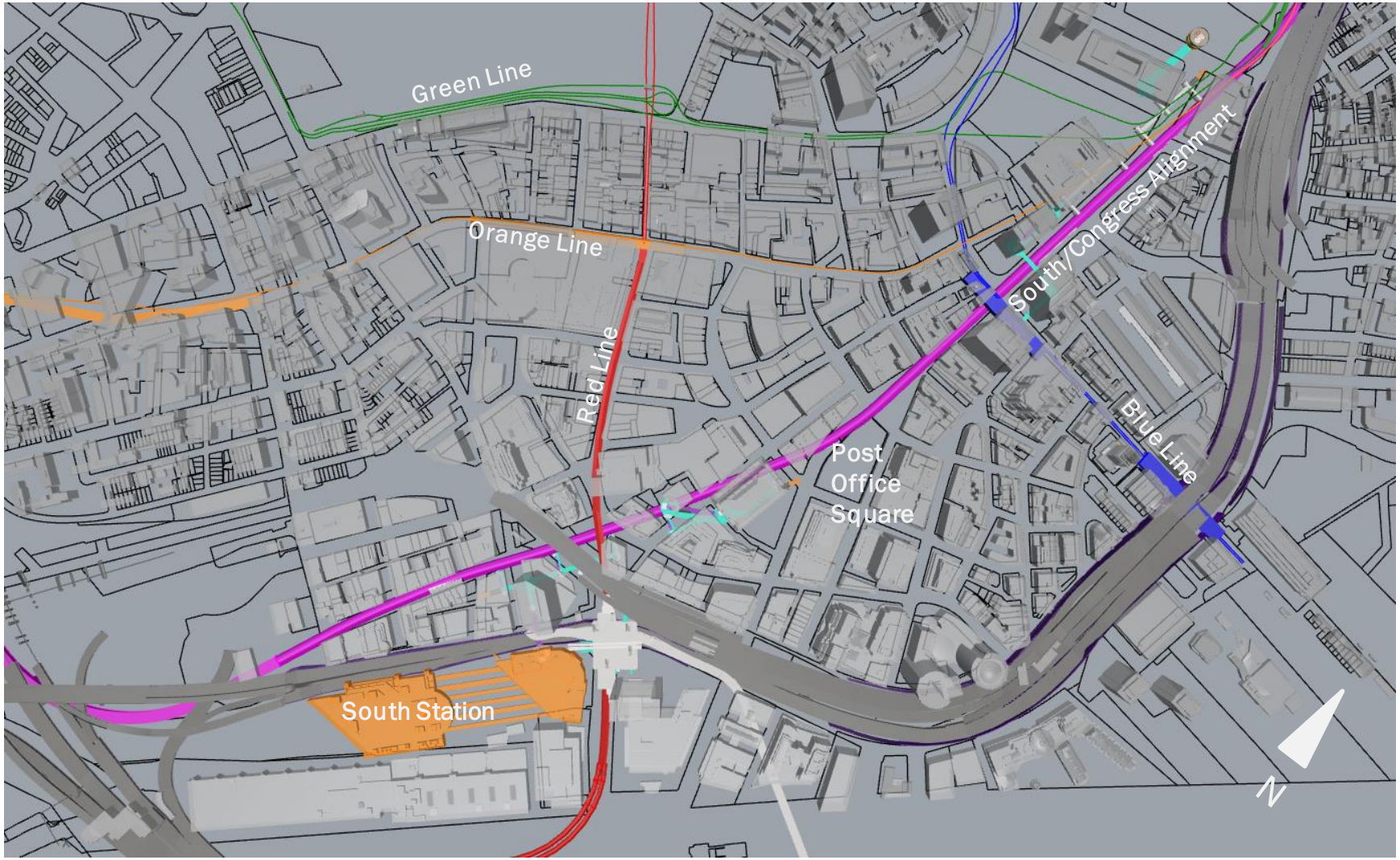
Alignment Recommendation – South/Congress √



Preferred Alignment and Potential Phasing



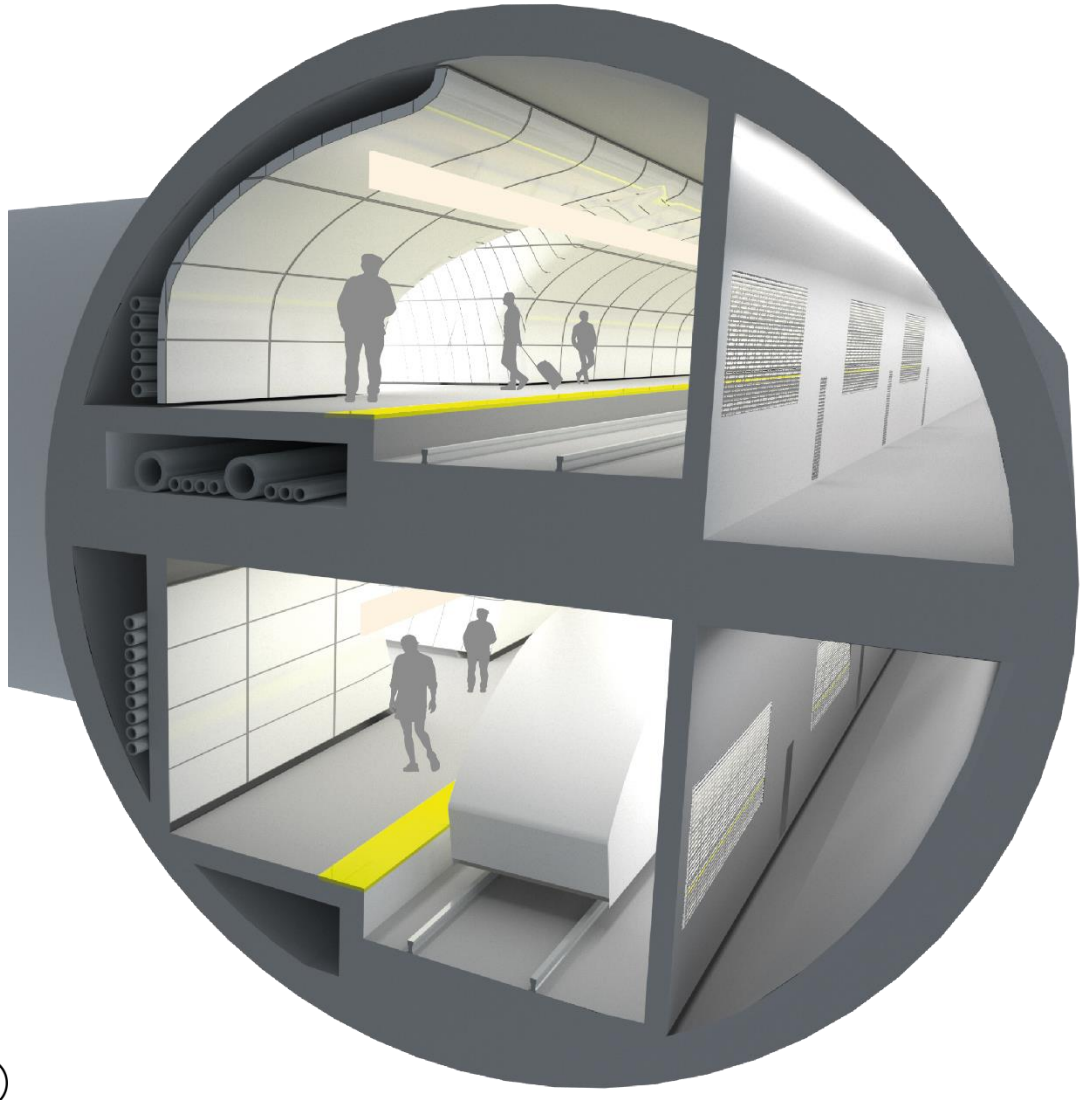
South/Congress Alignment - Overview



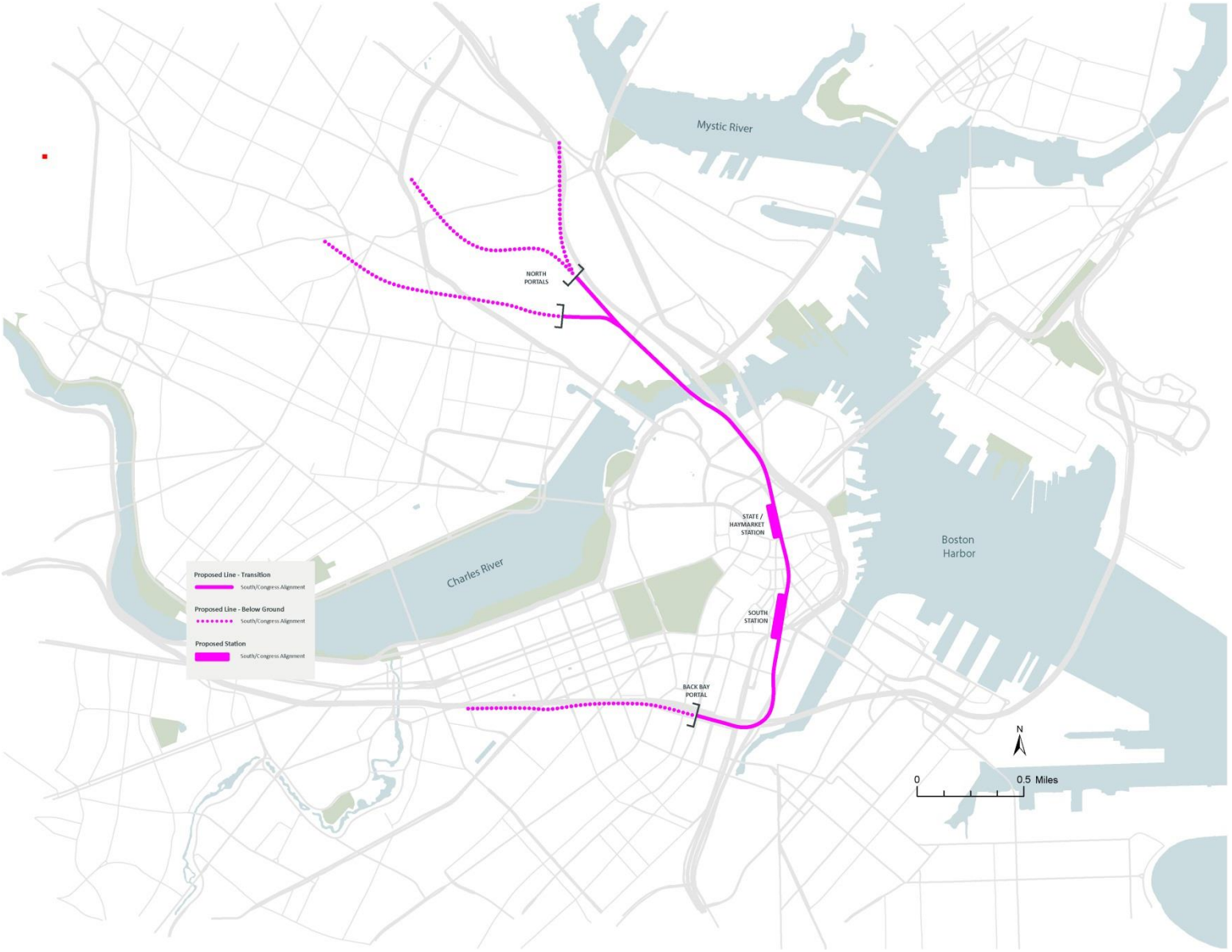
Alignment Detail

Alignment Detail

Alignment – Cross-Section



Alignment Recommendation – South/Congress √



Next Steps

To complete the Feasibility Reassessment:

- Draft preferred alignment chapter will be posted on website by tomorrow
- Public comments on preferred alignment welcome until **December 21** (email: Scott.Hamwey@state.ma.us)
- Final report posted to the website in January 2019
- This concludes the Feasibility Reassessment process

After the Feasibility Reassessment:

- Final preferred alignment will inform future MassDOT decision-making through the normal project development process
- MBTA Rail Vision will model a more optimal service plan for the NSRL as part of at least one alternative