Consulting

MBTA Rail Transformation

Discontinuous Electrification Analysis
Phase 1 & Phase 1a

May 2022 – Final Draft

Contents

NetworkRail

Phase 1: Providence Line

Providence Line inc. Stoughton – Service Pattern

PEAK & OFF-PEAK HOUR (REPEATING)

TYPE OF SERVICE	Wickford	Stoughton	Providence	TOTAL PEAK
FREQUENCY (Min.)	60min	30min	30min	HOUR TRAINS
Wickford Junction	●			1
TF Green	●			1
Providence	●		●	2
S.Attleboro	●		●	2
Mansfield	●		●	2
Sharon	●		●	2
Stoughton		● ●		2
Canton Center		● ●		2
Canton Junction	●	● ●	●	4
Route 128	●	● ●	●	4
Hyde Park		● ●		2
Back Bay	●	● ●	●	4
South Station	●	● ●	●	4
End to End time	96'	35'	68'	

●	Station Stop
Station	Existing Station
Station	Existing Inner Core Station
Station	Proposed New Inner Core Station
*	Based solely on speed profiling as part of energy modeling

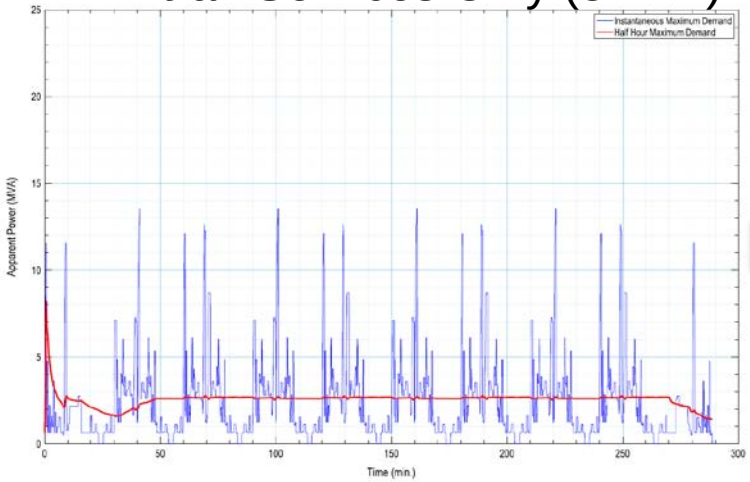
Additional Commentary:

1. Stoughton services will be 1 tph (off-peak) and 2 tph (peak)
2. All other patterns remain the same through peak and off-peak
3. Excludes South Coast Rail Full Build services (South Station - Stoughton - New Bedford - Fall River)

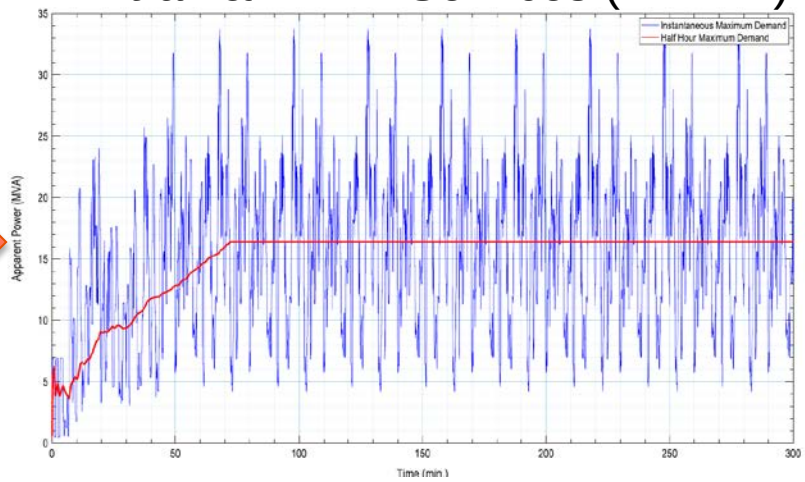
Note: Most energy-intensive Service patterns used for energy modeling

Energy Model – existing infrastructure

Sharon –
Amtrak Services Only (3MVA)



Sharon –
Amtrak & MBTA Services (17MVA)



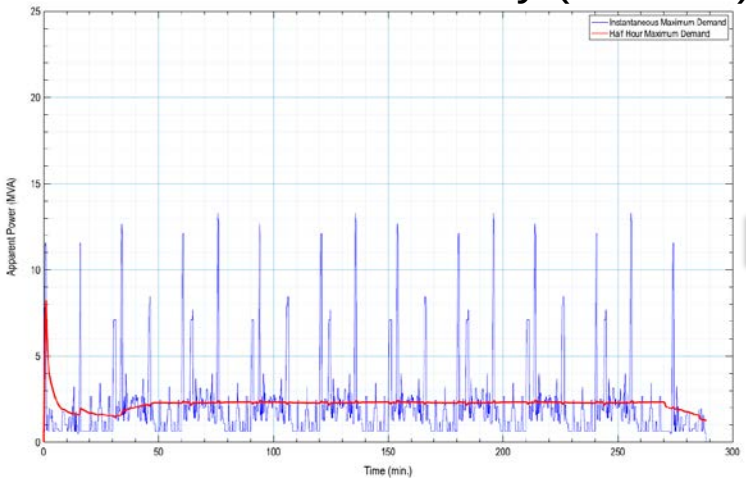
40MVA transformers at Sharon grid connection

*The energy analysis shows a **significant increase** in demand at Sharon grid connection when the MBTA services are introduced.*

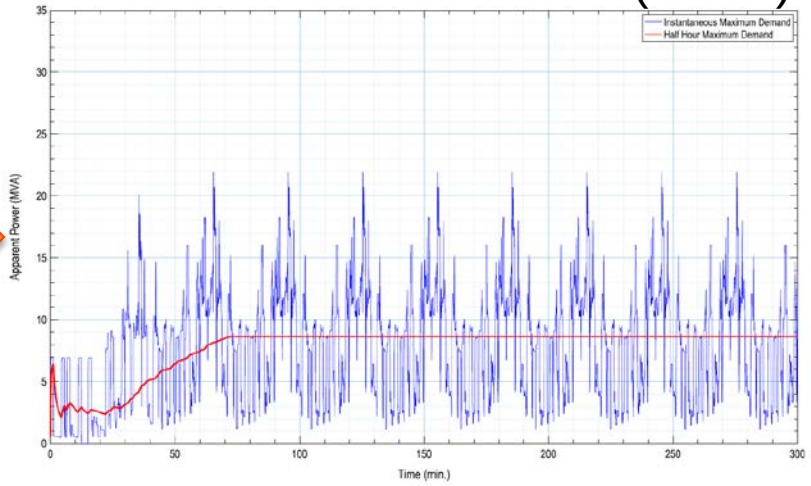
A new grid connection is recommended near south station.

Energy Model – existing infrastructure

Warwick –
Amtrak Services Only (2.5MVA)



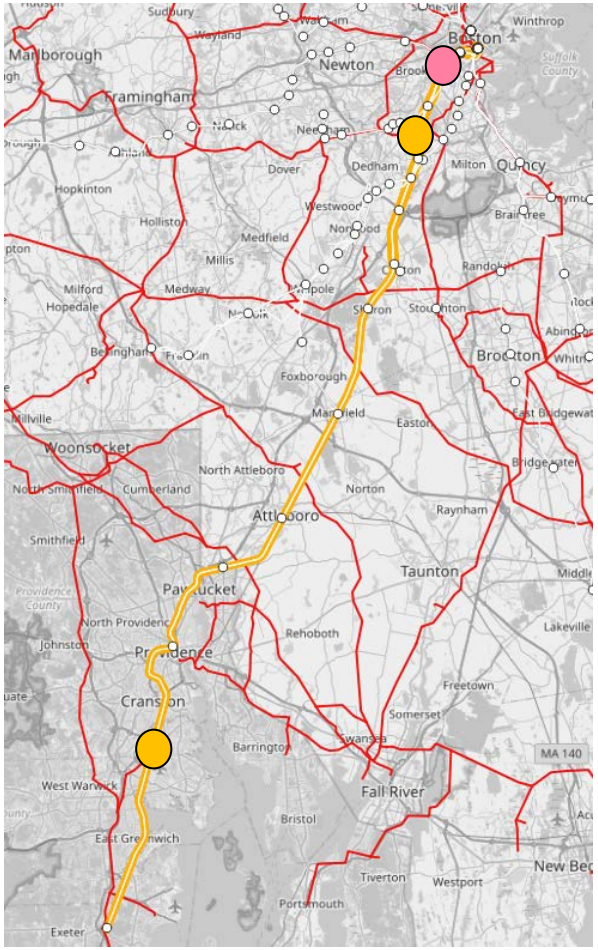
Warwick –
Amtrak & MBTA Services (9MVA)



40MVA transformers at Warwick grid connection

*The energy modelling shows a **manageable increase** in demand at Warwick grid connection when MBTA services are introduced. It is not anticipated this will cause a capacity issue at Warwick (subject to more detailed analysis).*

Providence Line: Solution Utilizing OCS



- Entire MBTA Providence Line service to run OCS
- Potential new substation at Roxbury
- Maintenance Facility at Readville Yard

Providence Line OCS (South Station – Wickford Jcn)

Existing HV Transmission Line network

Proposed Substation locations (Roxbury)

Existing Substation locations (Sharon, Warwick)

Providence Line – Capital Scope

OCS solution

- No additional OCS: Entire line is already wired
- Power System: 1 new incoming AC Feed at Roxbury, plus new Section Break at Readville
- Overline structures: 2 Bridge reconstructions & 17 Contact Wire adjustments
- Stations: 800ft Platforms lifted by 41” for level boarding. New passenger overbridge at South Attleboro
- Yards: New Electrified Yard at Readville with Maintenance Facility, plus upgrade of Pawtucket Yard for S&I

Assumptions

- AC feed location at Roxbury requires feasibility study. Upgrade to include static balancing
- ‘Minimum’ structure clearance assumed, with a Maintenance tolerance of 6”
- Readville site development can be completed in time for the new fleet
- Existing Signal System assumed to be immunized; EMC study needed for new fleet
- 4th Track through Attleboro electrified under another project
- Readville – Canton New track excluded
- Level boarding is required throughout

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Phase 1: Stoughton Line

Providence Line inc. Stoughton – Service Pattern

PEAK & OFF-PEAK HOUR (REPEATING)

TYPE OF SERVICE	Wickford	Stoughton	Providence	TOTAL PEAK
FREQUENCY (Min.)	60min	30min	30min	HOUR TRAINS
Wickford Junction	●			1
TF Green	●			1
Providence	●		●	2
S.Attleboro	●		●	2
Mansfield	●		●	2
Sharon	●		●	2
Stoughton		● ●		2
Canton Center		● ●		2
Canton Junction	●	● ●	●	4
Route 128	●	● ●	●	4
Hyde Park		● ●		2
Back Bay	●	● ●	●	4
South Station	●	● ●	●	4
End to End time	96'	35'	68'	

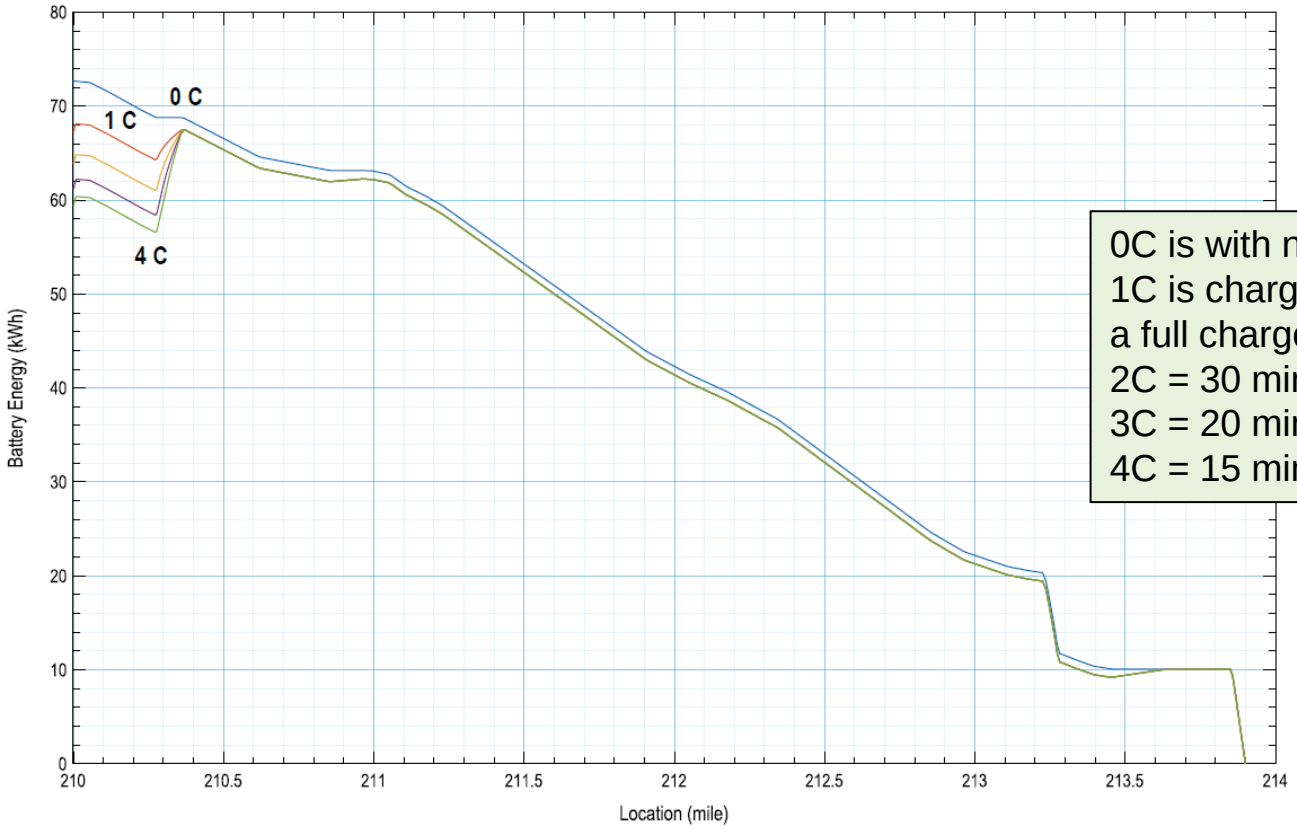
●	Station Stop
Station	Existing Station
Station	Existing Inner Core Station
Station	Proposed New Inner Core Station
*	Based solely on speed profiling as part of energy modeling

Additional Commentary:

1. Stoughton services will be 1 tph (off-peak) and 2 tph (peak)
2. All other patterns remain the same through peak and off-peak
3. Excludes South Coast Rail Full Build services (South Station - Stoughton - New Bedford - Fall River)

Note: Most energy-intensive Service patterns used for energy modeling

Energy profile for Stoughton Line

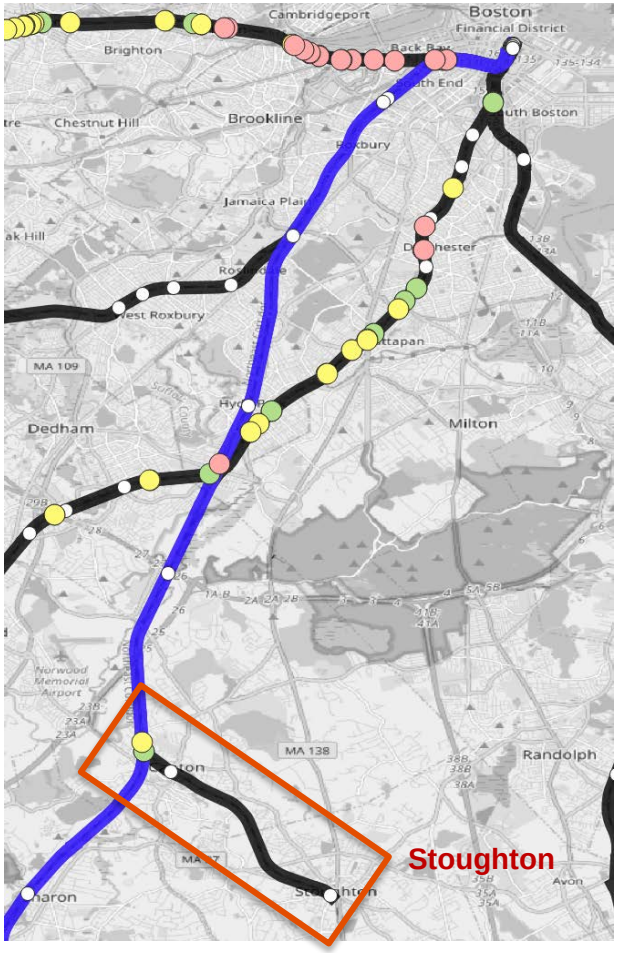


0C is with no regen
1C is charging rate equal to a full charge in 1hour
2C = 30 mins
3C = 20 mins
4C = 15 mins

Theoretically possible to run a full battery service from Canton Jct to Stoughton

Notes:
1. Energy modelling excludes Providence Line, which is assumed to be full OCS solution
2. For stopping patterns / service frequency – refer to Providence Line

Stoughton Line: Clearance issues (All)

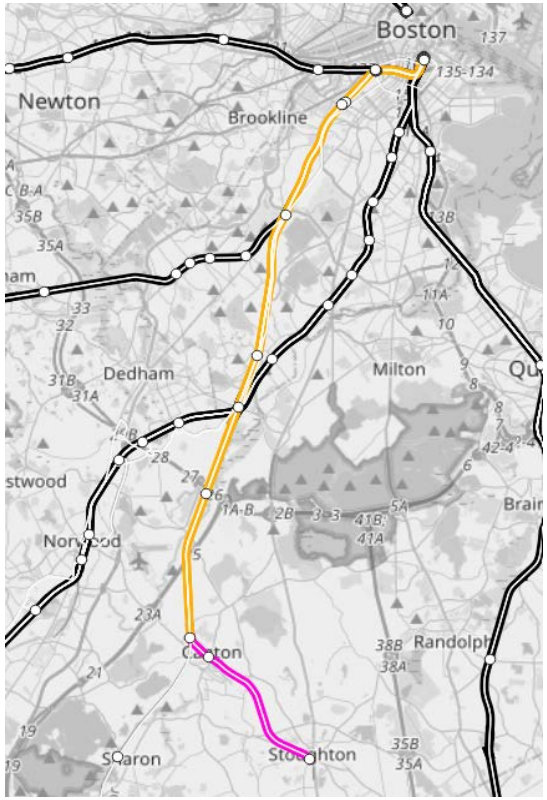


- There are 3 structures on Stoughton Line
- **No structure clearance issues identified** (based on MBTA limiting outline)

Clearances by range	Stoughton
<17.5'	0
17.5 - 19'	1
>19'	2

Discontinuous Electrification Solution

- Run on existing OCS from South Station to Canton Junction.
- Run on Battery Power from Canton Junction to Stoughton and back again.
- No additional charging locations required.
  - *Assumes that the train reaches Canton Junction with sufficient battery charge as a result of Providence Line OCS.*



Stoughton is very short and benefits from battery charging when on the Providence Line – no additional charging required

Discontinuous Electrification – Scope

Discontinuous Electrification Solution

- High level platforms at Canton Center.

Assumptions

- Platform modifications / relocation to be part of South Coast Rail (Full Build) scope, not this Program
- No prolonged / overnight stabling at Stoughton (battery depletion)

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Phase 1: Fairmount Line

Fairmount Line – Service Pattern

PEAK & OFF PEAK HOUR (REPEATING)

TYPE OF SERVICE	Fairmount	TOTAL PEAK HOUR TRAINS
FREQUENCY (Min.)	15min	
Readville	●	4
Fairmount	●	4
Blue Hill Ave	●	4
Morton St.	●	4
Talbot Ave	●	4
Four Corners/Geneva	●	4
Uphams Corner	●	4
Newmarket	●	4
South Station	●	4
End to End time	25'	
Modeled Travel Time *		

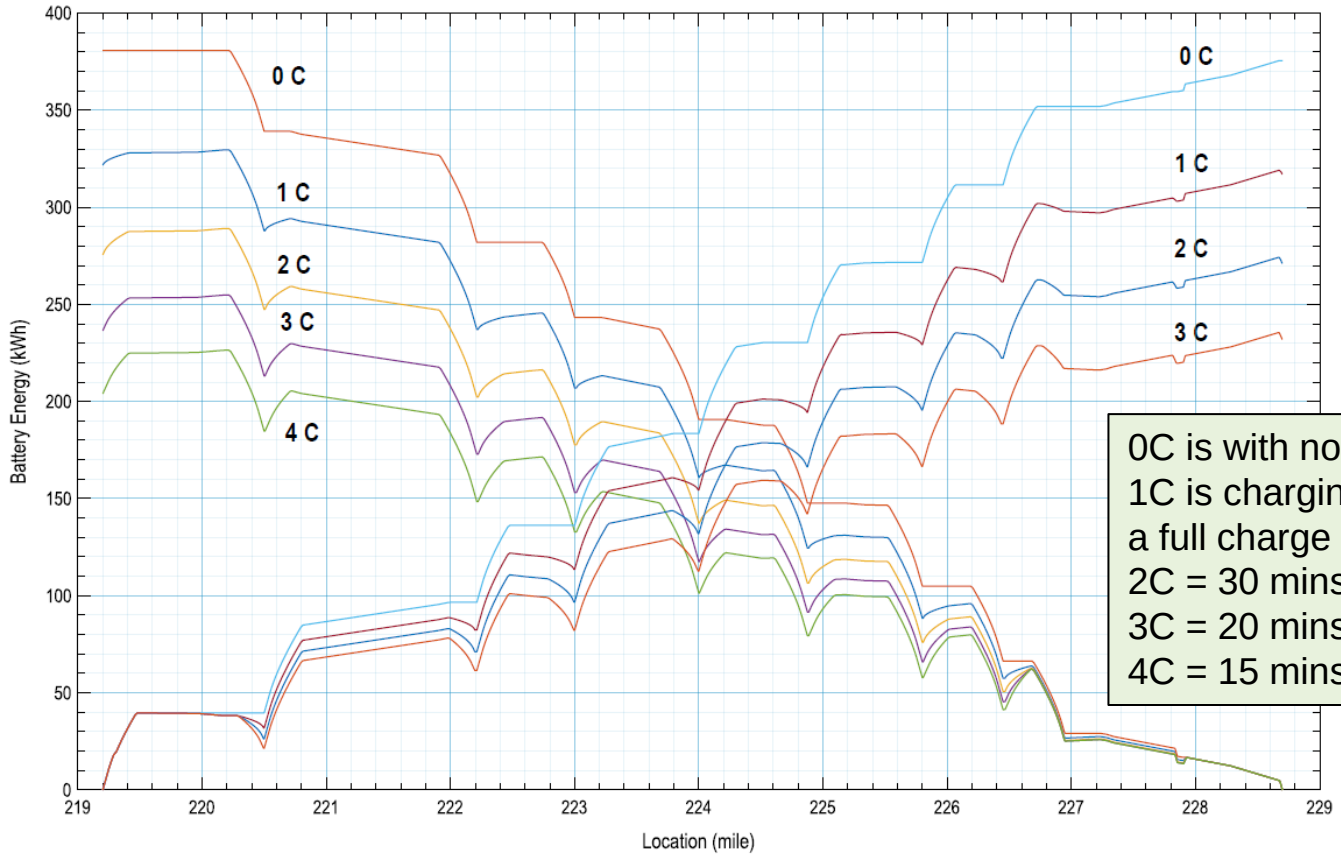
Additional Commentary

1 4 tph to Readville all-day service

●	Station Stop
Station	Existing Station
Station	Existing Inner Core Station
Station	Proposed New Inner Core Station
*	Based solely on speed profiling as part of energy modeling

Note: Most energy-intensive Service patterns used for energy modeling

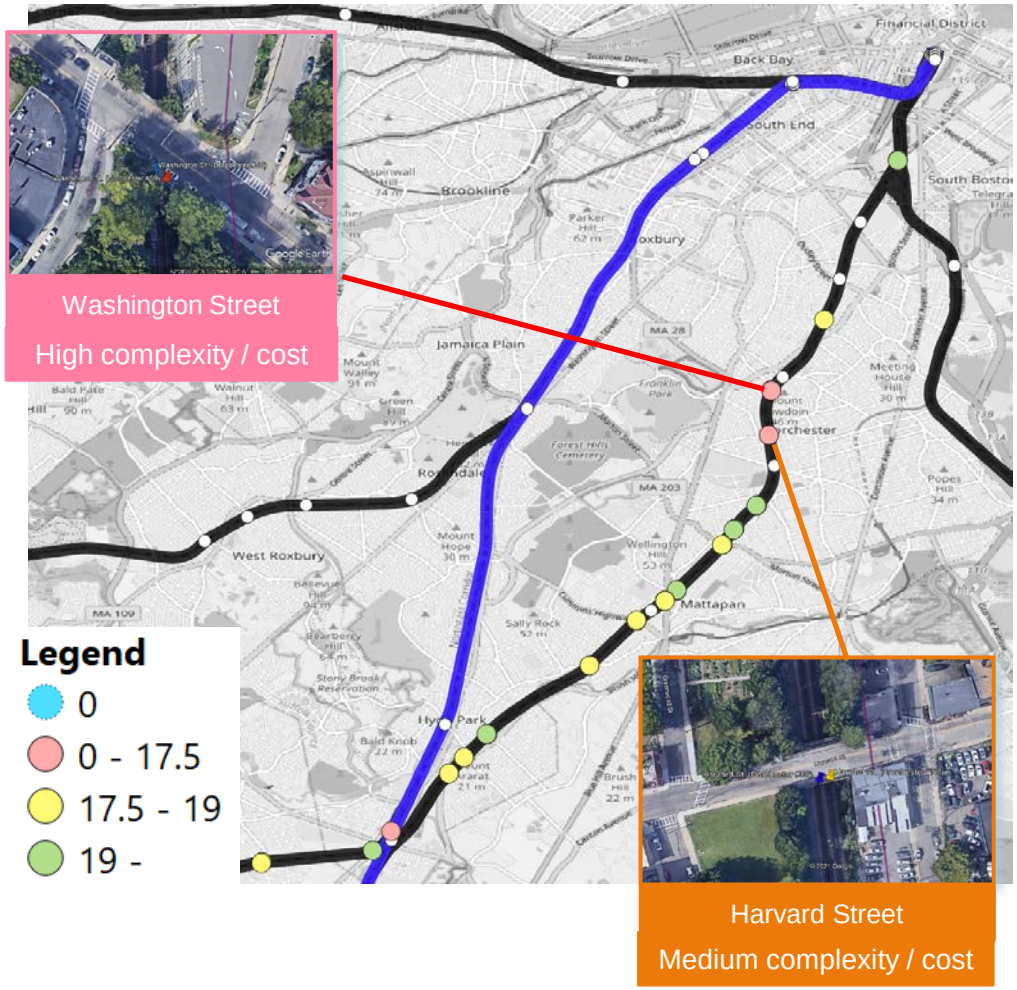
Energy profile for Fairmount Line



0C is with no regen
1C is charging rate equal to a full charge in 1hour
2C = 30 mins
3C = 20 mins
4C = 15 mins

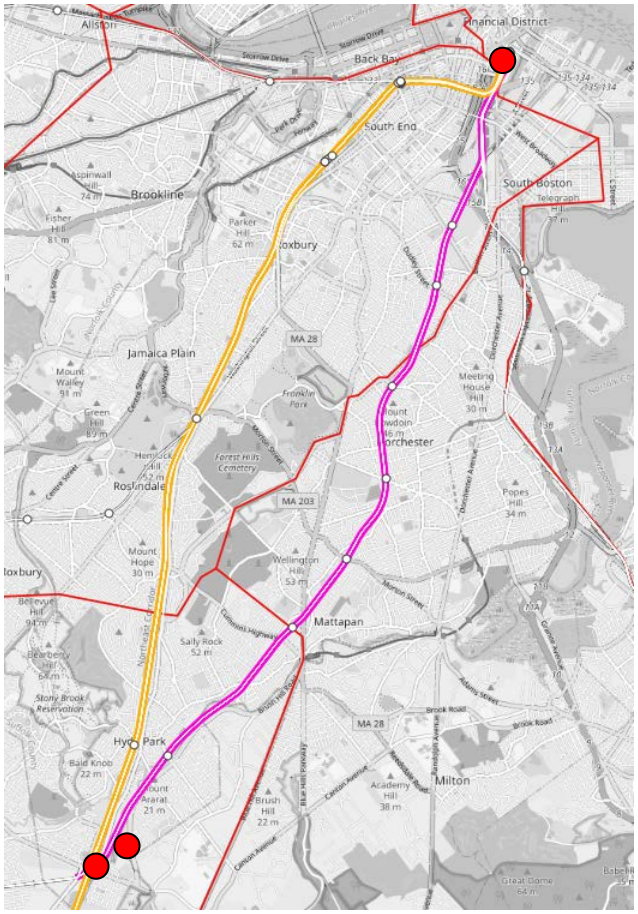
Theoretically possible to run a full battery service.

Fairmount Line: Clearance issues (All)



- Lowest bridge clearances measured at 17.3’
  - Washington St: $30m recon
  - Harvard St: $20m recon
- Avoiding OCS through the Fairmount Line will lead to significant capital savings on Structures

Discontinuous Electrification Solution



- Run on Battery Power for majority of the Fairmount Line
- Use existing 1.5 miles of OCS out of South Station to charge Train batteries, Additional charging station at Readville (OCS or rigid catenary) to be fed from Providence Line
- Additional charging facilities located within Readville Yard
- Will allow replacement of 3 Trainsets
- Discontinuous Electrification including battery replacement ~$70M-$160M cheaper than full electrification

Fairmount Line (Battery)

Providence Line (OCS)

Transmission Lines

Existing Substations

Charging Stations (South Station; Readville)

Discontinuous Electrification – Scope

Discontinuous Electrification Solution

- Power: Battery charging station at Readville (fed from upgraded Providence Line system)
- Stations: 3 Platforms upgraded to high level (Fairmount & Readville)
- 2 charging stations at Readville

Assumptions

- Existing OCS in and around South Station will provide sufficient charging opportunity
- Battery charging station at Readville can be supplied from the upgraded Providence Line system
- 1 Platform & Track at Readville sufficient for desired service levels
- Sufficient capacity at Readville for a new fleet maintenance facility

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Phase 1: Eastern Line

Eastern Line – Service Pattern

PEAK HOUR (REPEATING)

TYPE OF SERVICE	Newburyport Local	Rockport Local	TOTAL PEAK
FREQUENCY (Min.)	30min	30min	HOUR TRAINS
Rockport			2
Gloucester			2
West Gloucester			2
Manchester			2
Beverly Farms			2
Prides Crossing			2
Montserrat			2
Newburyport			4
Rowley			2
Ipswich			2
Hamilton/Wenham			2
North Beverly			2
Beverly			4
Salem			4
Swampscott			4
Lynn			4
River Works			4
Chelsea			4
North Station			4
End to End time	62'	66'	

BI-DIRECTIONAL SERVICE

OFF PEAK (REPEATING)

TYPE OF SERVICE	Newburyport Local	Beverly Local	Rockport Local	TOTAL PEAK
FREQUENCY (Min.)	60min	15min	60min	HOUR TRAINS
Rockport				2
Gloucester				2
West Gloucester				2
Manchester				2
Beverly Farms				2
Prides Crossing				2
Montserrat				2
Newburyport				4
Rowley				2
Ipswich				2
Hamilton/Wenham				2
North Beverly				2
Beverly				4
Salem				4
Swampscott				4
Lynn				4
River Works				4
Chelsea				4
North Station				4
End to End time	62'	35'	66'	

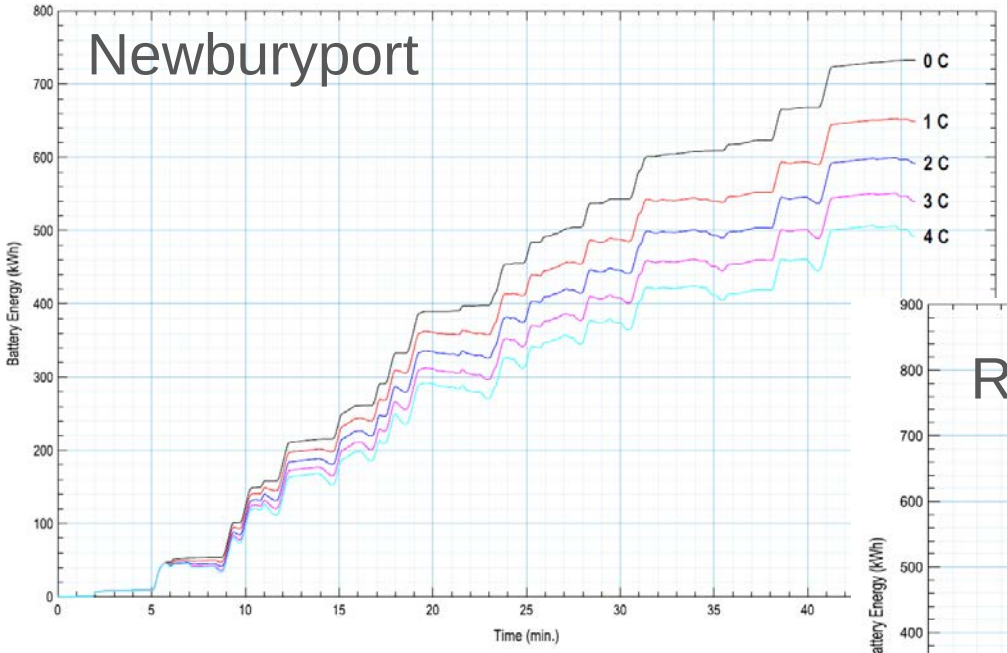
	Station Stop
Station	Existing Station
Station	Existing Inner Core Station
Station	Proposed New Inner Core Station
*	Based solely on speed profiling as part of energy modeling
Bold text	Key station
	Hourly Service

Additional Commentary:

1. 2022 Climate Bill amendment calls for construction of infill stations at Everett & Revere. These are not included on existing stopping patterns. The impact on energy needs for the local services would need to be modelled and balanced with OCS / infrastructure needs, if confirmed as a valid option.

Note: Most energy-intensive Service patterns used for energy modeling

Energy profile for Eastern Line



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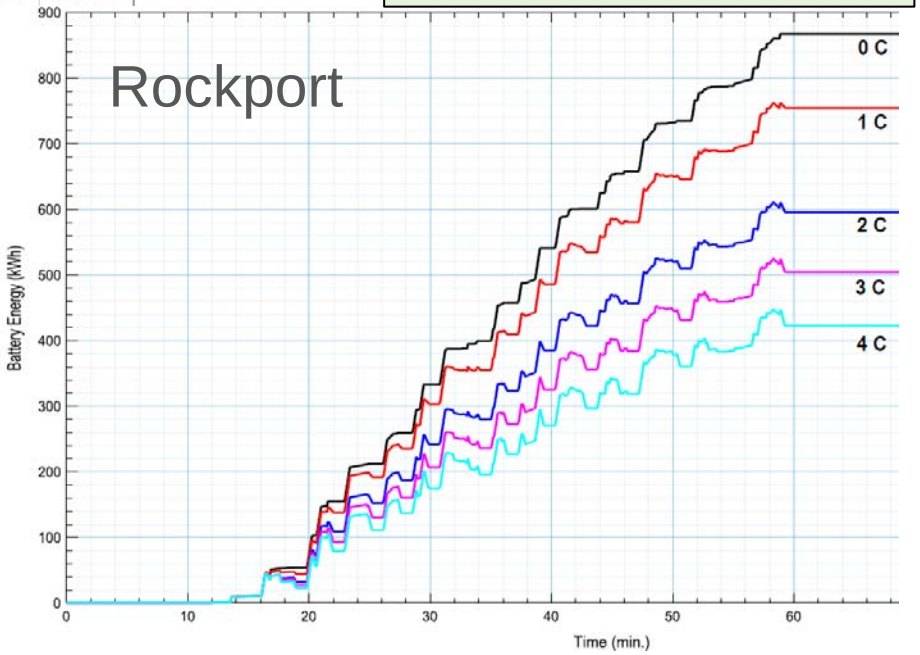
1C is charging rate equal to a full charge in 1hour
2C = 30 mins
3C = 20 mins
4C = 15 mins



Theoretically possible to run a full battery service
(assuming 2No 4 car units each with a 500kWh battery)

Eastern Line: Clearance issues (excl. Drawbridges)

Low complexity / cost | Medium complexity / cost | High complexity / cost

- Analysis based on available LiDAR data and MBTA Limiting Outline
- A number of potentially constraining structures identified
- Relative complexity of rebuilding indicated by color coding
- Potential for significant cost & disruption – but there is opportunity to 'design out'
- At least one structure rebuilt since LiDAR data was taken

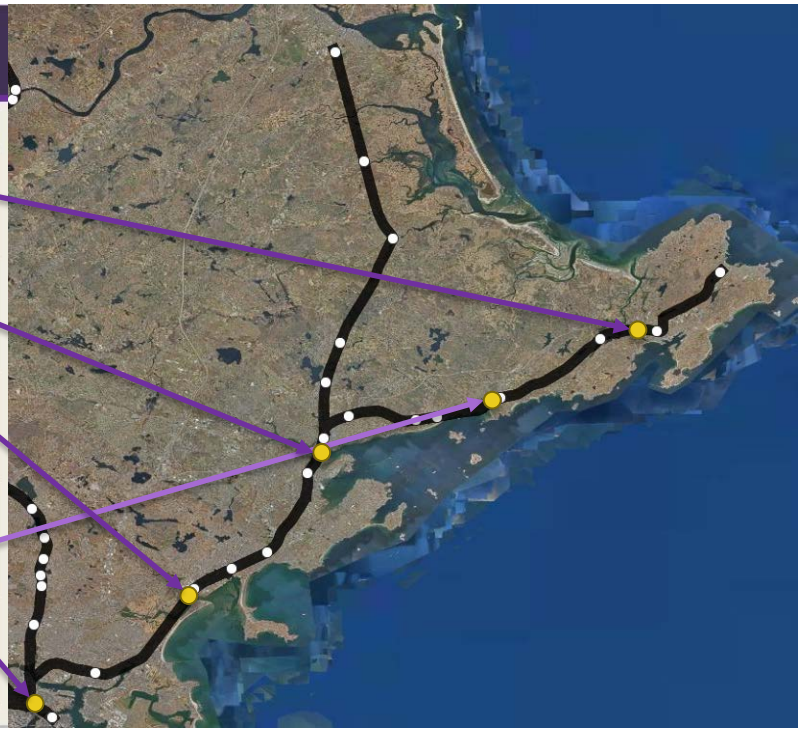
Eastern Line: Clearance issues (Drawbridges)

Systemwide Challenges (Continued)
Drawbridges

Massachusetts Bay Transportation Authority

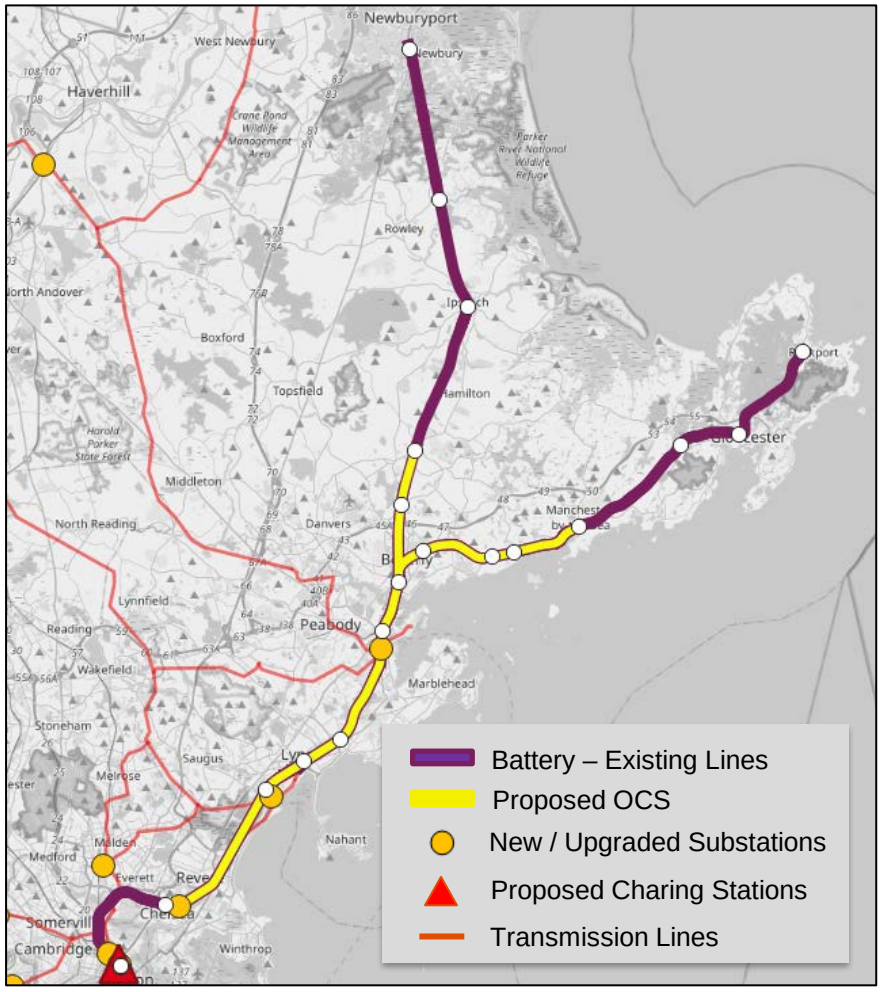
Drawbridge		Condition	Replacement Cost	Year Built
	Gloucester	Structurally Deficient – to be replaced	$60M	1911
	Beverly	Structurally Deficient – to be replaced	$56M	1885
	Saugus	Structurally Deficient – to be replaced	$60M	1911
	Manchester	Structurally Adequate	N/A	1944
	Tower A	Structurally Deficient – to be replaced	$121M	1931

45



Drawbridges have been factored into Infrastructure analysis, on the basis they are difficult / expensive to retrofit and maintain with functioning OCS

Discontinuous Electrification Solution



- Run partial OCS from Chelsea – Beverley – Manchester and Chelsea – Beverley – Hamilton & Wenham
- Run on battery for the remainder of the route
- Additional charging station at LMF and North Station
- Allows for replacement of 10 trainsets
- OCS limits designed to avoid significant constraints (costs):
  - Washington Ave. Bridge, Chelsea
  - Tower A, Manchester & Gloucester Drawbridges
- OCS limits designed to avoid complex & costly locations:
  - Saugus & Beverly Drawbridges; Salem Tunnel
- Discontinuous Electrification Solution including battery replacement ~$200M cheaper than full electrification over 30 years

Discontinuous Electrification – Scope

Discontinuous Electrification Solution

- 89.2 single track miles of new Overhead Line (entire Eastern Line)
- 2 new Substations
- 1 – 2 new Stations
- New Electrified Light Maintenance Facility (LMF) at South Salem
- Replace 9 overline structures; modify / replace 5 drawbridges
- Signal System Immunization

Assumptions

- It is feasible to wire OCS and operate / maintain it through the various drawbridges and at-grade crossings
- High level platform lengths are 500ft for bi-level and 800ft for single-level
- Single level trains – no structure clearance required with OCS
- Bi-level trains require bridge work in some areas
- One Maintenance Facility to serve the North side system. Location assumed at South Salem

NetworkRail

Phase 1a – Worcester Line

Worcester Line – Service Pattern

PEAK HOUR (REPEATING)

TYPE OF SERVICE	Express	Zonal Express	Urban Rail	TOTAL PEAK HOUR TRAINS
FREQUENCY (Min.)	Every 60 Min.	Every 30 Min.	Every 30 Min.	
Worcester	●	● ●		3
Grafton		● ●		2
Westborough		● ●		2
Southborough		● ●		2
Ashland		● ●		2
Framingham	●	● ●	● ●	5
West Natick			● ●	2
Natick Center			● ●	2
Wellesley Square			● ●	2
Wellesley Hills			● ●	2
Wellesley Farms			● ●	2
Riverside				
Auburndale			● ●	2
W. Newton			● ●	2
Newtonville			● ●	2
Boston Landing	●	● ●	● ●	5
West Station				
Landsdowne	●	● ●	● ●	5
Back Bay	●	● ●	● ●	5
South Station	●	● ●	● ●	5
End to End time	N/A	80 mins	55 mins	
Modeled Travel Time *				

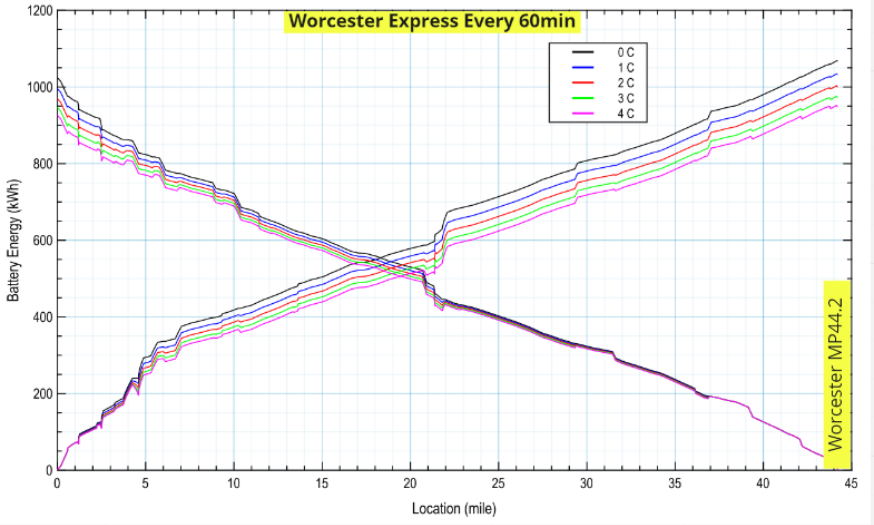
●	Station Stop
Station	Existing Station
Station	Existing Inner Core Station
Station	Proposed New Inner Core Station
*	Based solely on speed profiling as part of energy modeling
Bold text	Key station

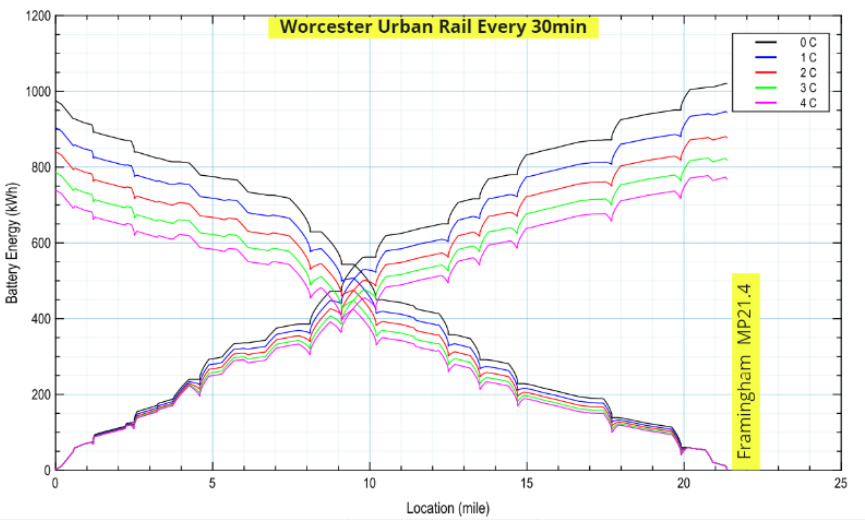
Additional Commentary:

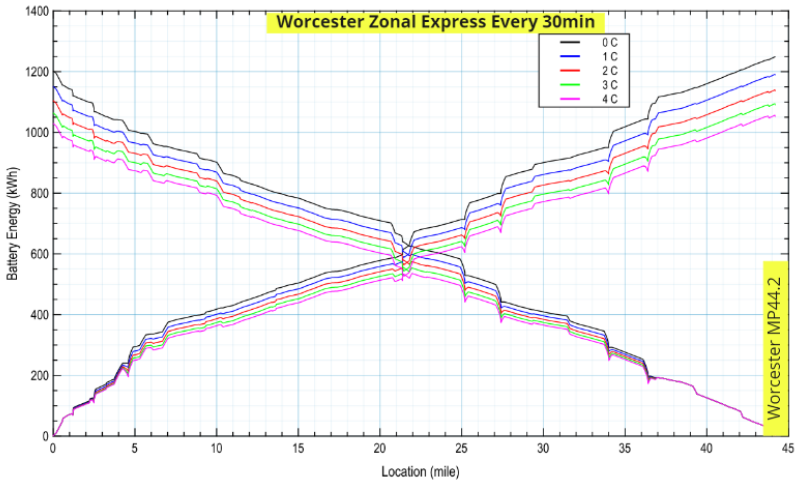
1. Intent is an all day, frequent repeating service to encourage modal shift
2. South Station - Worcester car minimum journey time is 45 mins
3. South Station - Worcester local stopping service minimum time currently 1hr 31 mins
4. South Station - Worcester local stopping service based on EMU speed profile
5. Layover facility required at Worcester
6. New Stations at Riverside & West Station not included in stopping patterns
7. All 3 Wellesley Stations included in the stopping patterns
8. Current travel times taken from current MBTA timetables
9. Zonal Express current travel time - based on current express to Natick, minus 2 mins (adjusted for construction work)
10. No off-peak services defined, but will not be any more energy intensive than the local stopping service

Note: Most energy-intensive Service patterns used for energy modeling

Energy profile for Worcester Line







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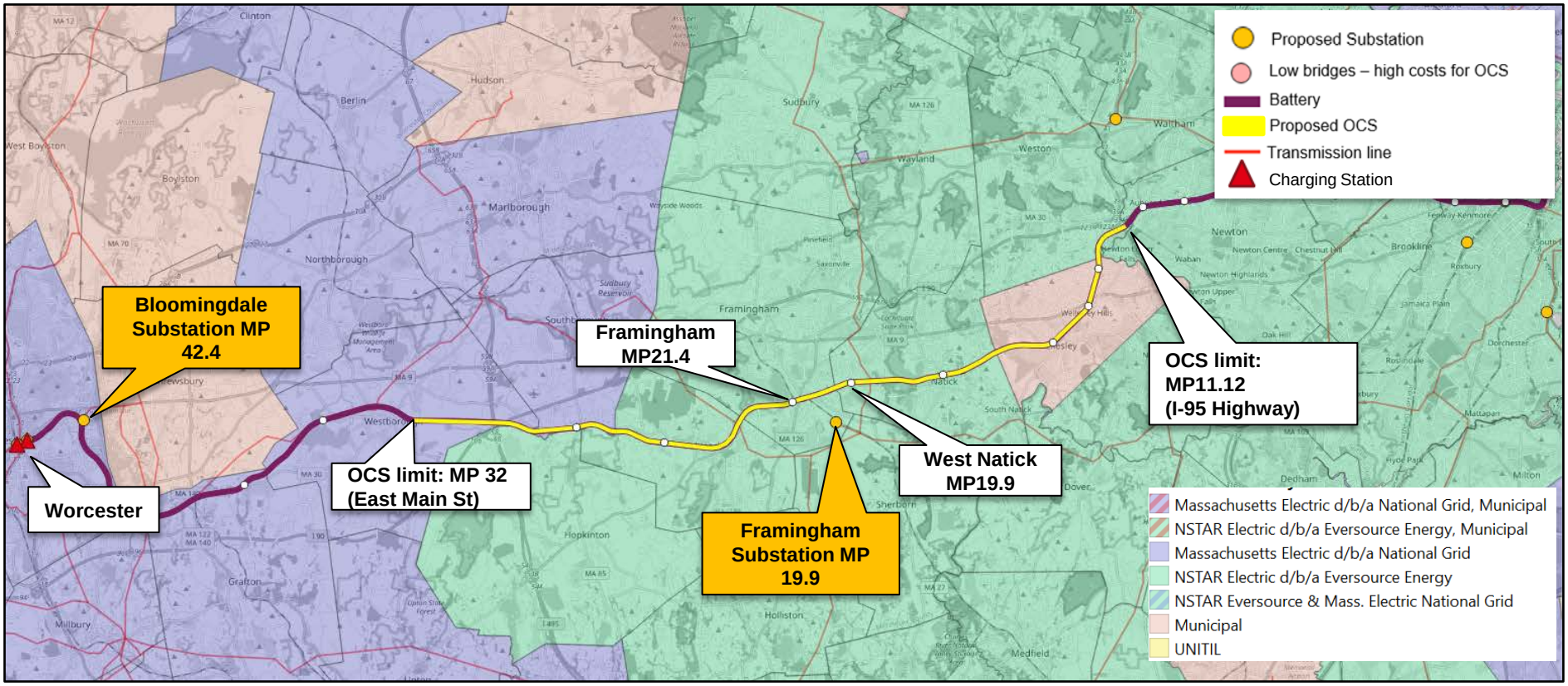
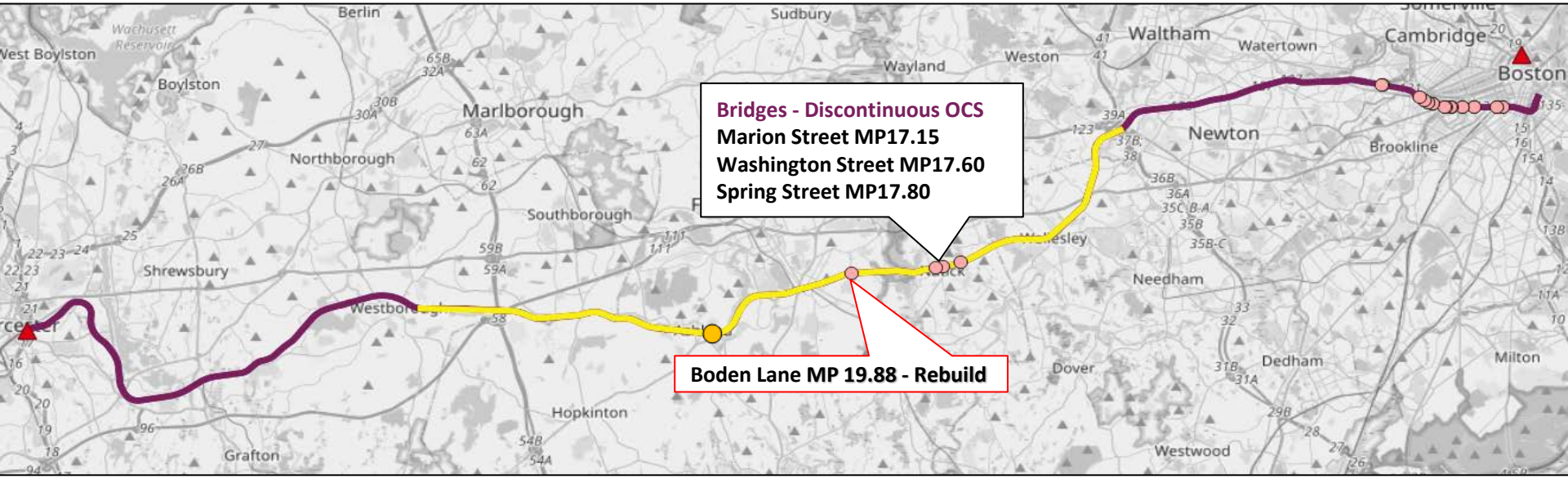
1C is charging rate equal to a full charge in 1hour
2C = 30 mins
3C = 20 mins
4C = 15 mins

Proposal and Utility Provider Coverage



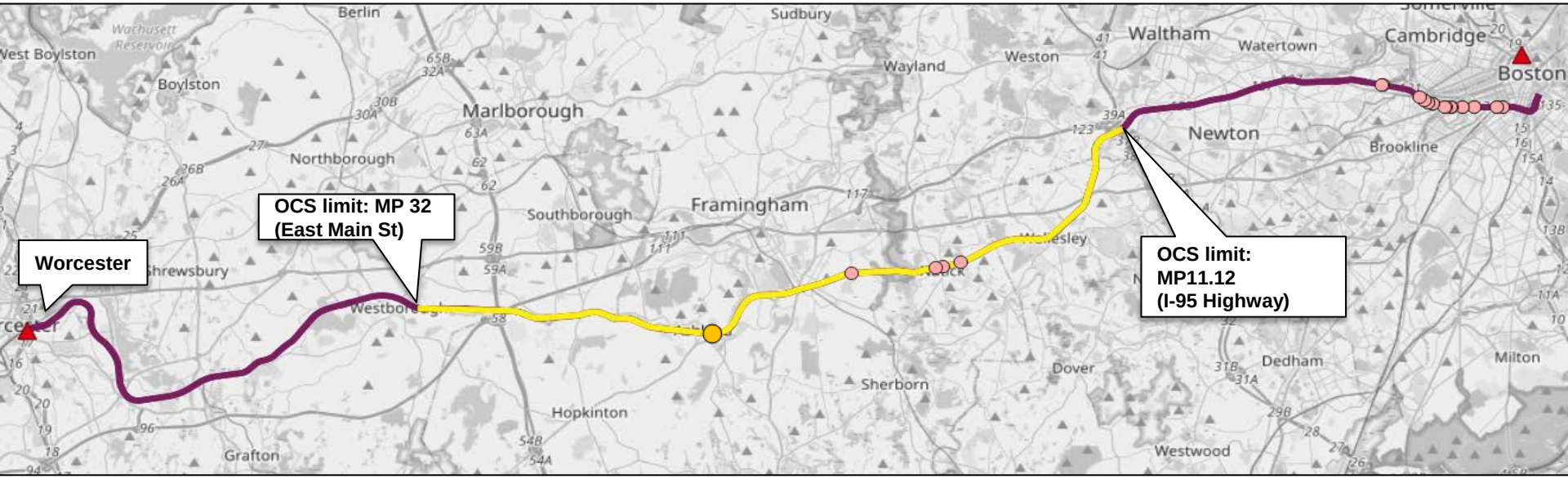
Worcester Line Clearance Issues (All)

- Proposed Substation
- Low bridges – high costs for OCS
- Battery
- Proposed OCS
- Transmission line
- Proposed Charging Station



Discontinuous Electrification Solution

- Proposed Substation
- Low bridges – high costs for OCS
- Battery
- Proposed OCS
- Transmission line
- Proposed Charging Station



Discontinuous Electrification – Scope

Discontinuous Electrification Solution

- 42 STM of discontinuous OCS
- 1 structure under proposed OCS to be rebuilt (Boden Lane MP19.88)
- 1 new substation for OCS + 1 new / upgraded substation for charging power at Worcester Station & Layover
- 1 charging facility feeding 2 lines at Worcester station (3rd line is not platformed)
- 1 charging facility (or OCS) at a suitable layover facility near Worcester Station
- 3 platform upgrades to high-level at Auburndale, West Newton & Newtonville
- Replace 1 overline structure in Natick
- Signal System Immunization

Assumptions

- New substation needed at Worcester; may be possible to Value Engineer with a shore supply at the layover and trickle charging / bulk battery storage at the station.
- Worcester triple track project will upgrade platforms to 800ft long high level at West Natick, Wellesley Square, Wellesley Hills & Wellesley Farms. Natick Centre is also being upgraded (separate project)
- Platform upgrades only required to stations that are inaccessible – partially accessible stations through mixed boarding fleet solution
- 26 overline structure interventions avoided due to discontinuous OCS
- No Maintenance Facility on the Worcester Line – to be based at Readville

NetworkRail

International Presence

Boston
London
New York
Riyadh
Sacramento
San Francisco
Sydney
Toronto
Washington