Presentation to the

Water Supply Citizens Advisory Committee

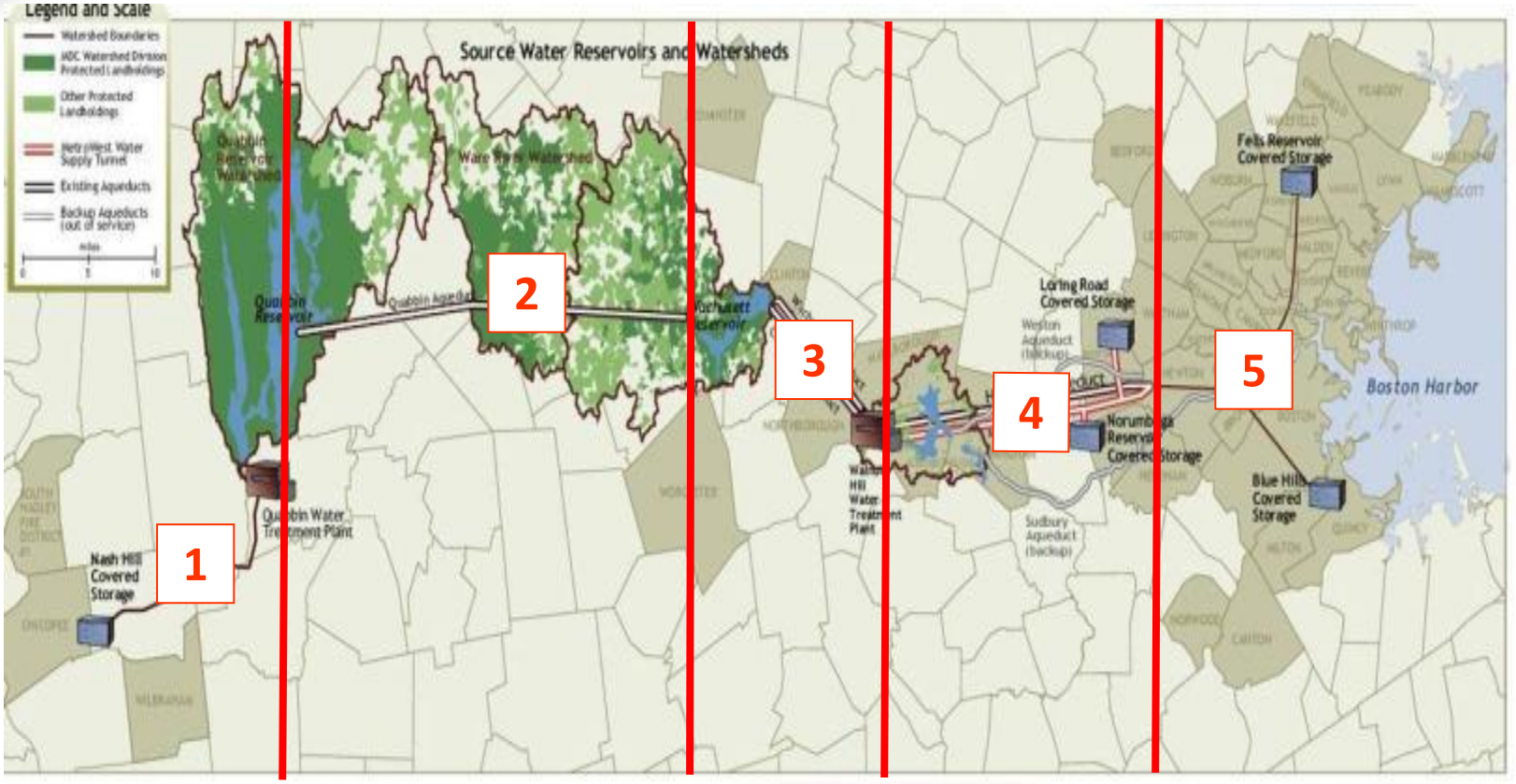
on

Metropolitan Tunnel Redundancy

October 13, 2016

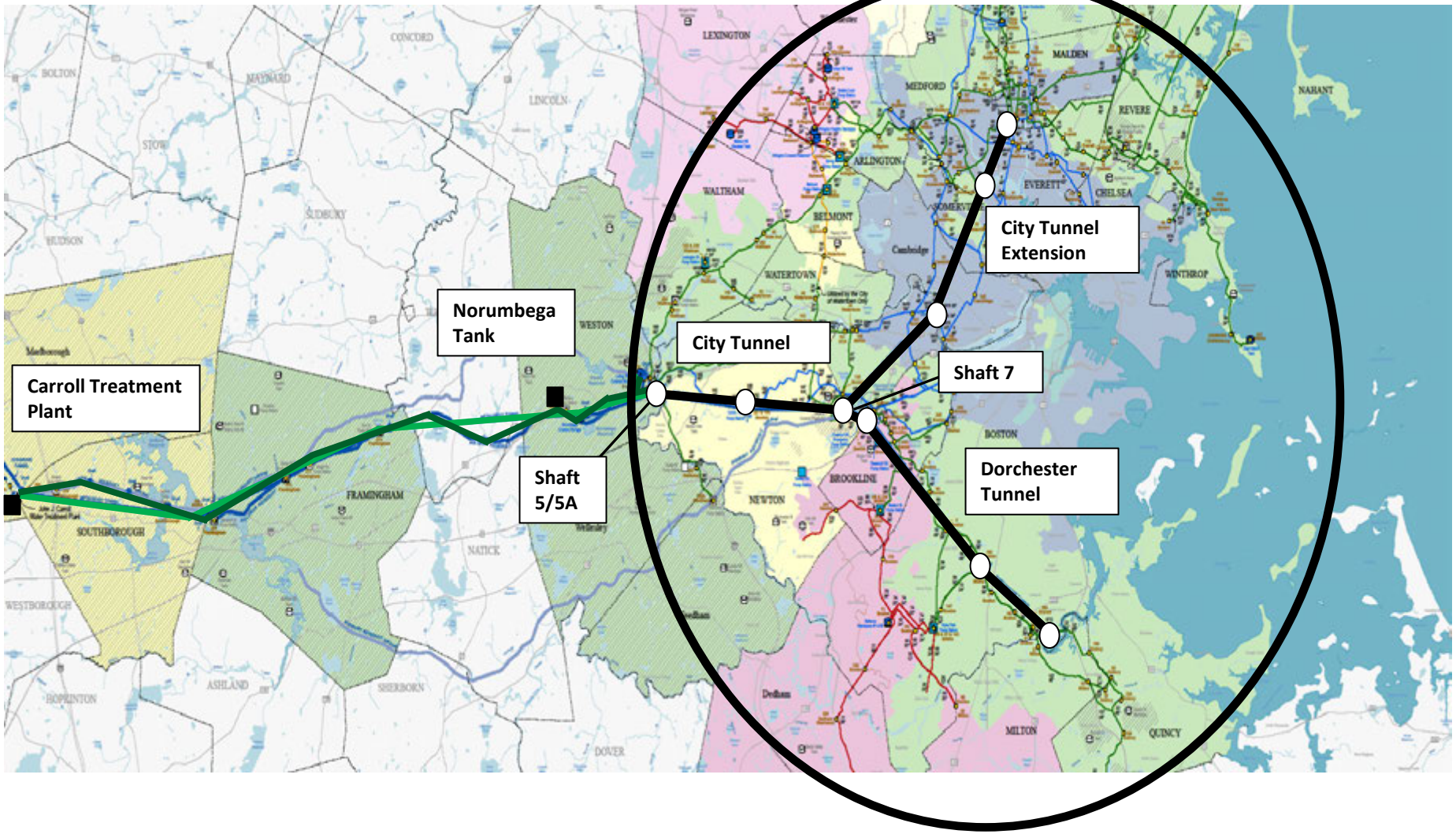
Status of Existing Transmission System Facilities

MWRA Water Transmission System

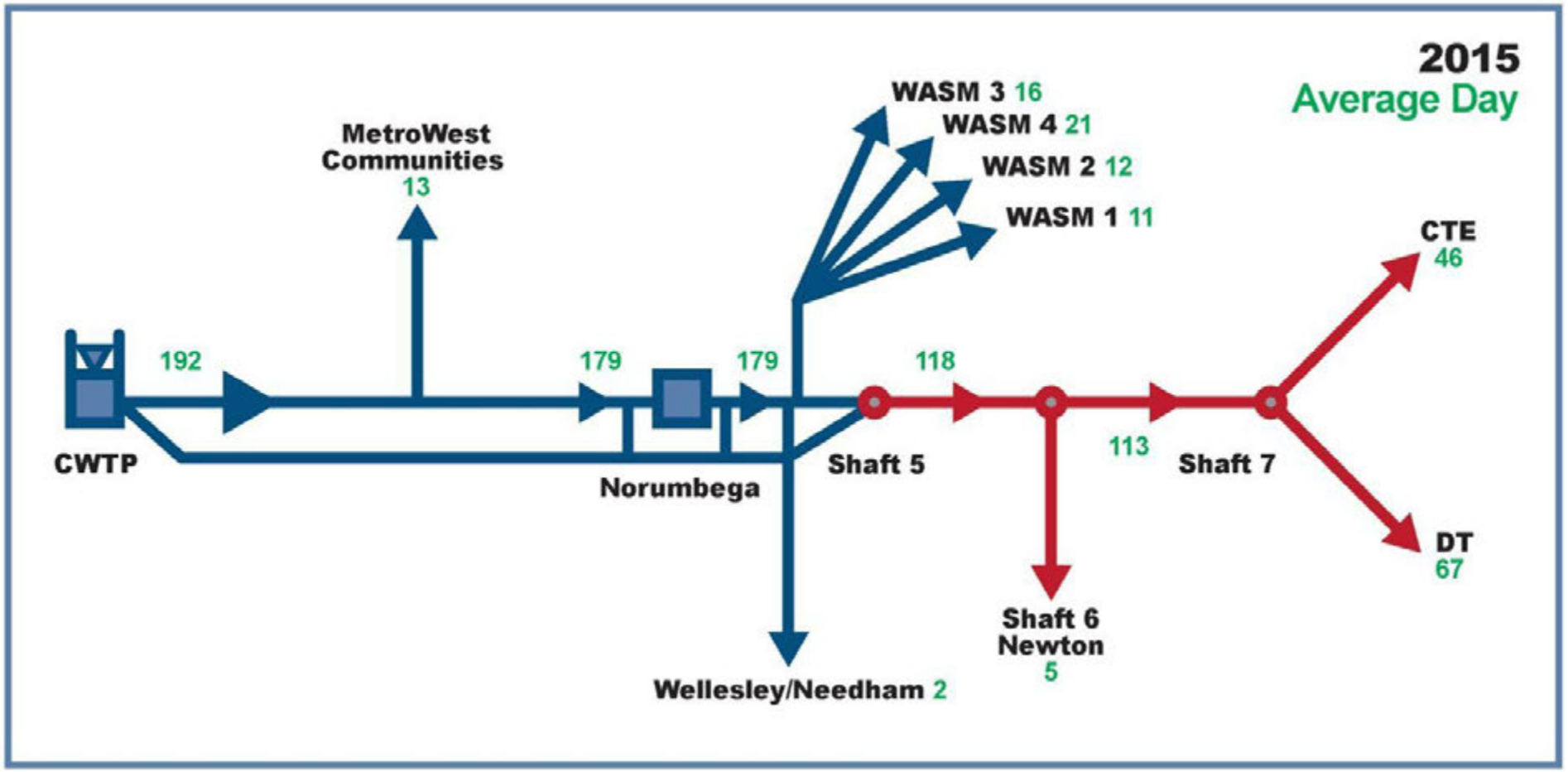


1. Chicopee Valley Aqueduct — 2007 Improvements
2. Quabbin Aqueduct — Inspection planned
3. Cosgrove Tunnel / Wachusett Aqueduct — Project underway
4. MetroWest Tunnel / Hultman Aqueduct — 2003/2013 Improvements
5. Metropolitan Tunnels — Significant Needs

Metropolitan Tunnel System



Service Provided to a Large Percentage of MWRA Customers



Approximately 60% of total system flow is carried through the Metropolitan Tunnel System

Condition of Metropolitan Tunnel System

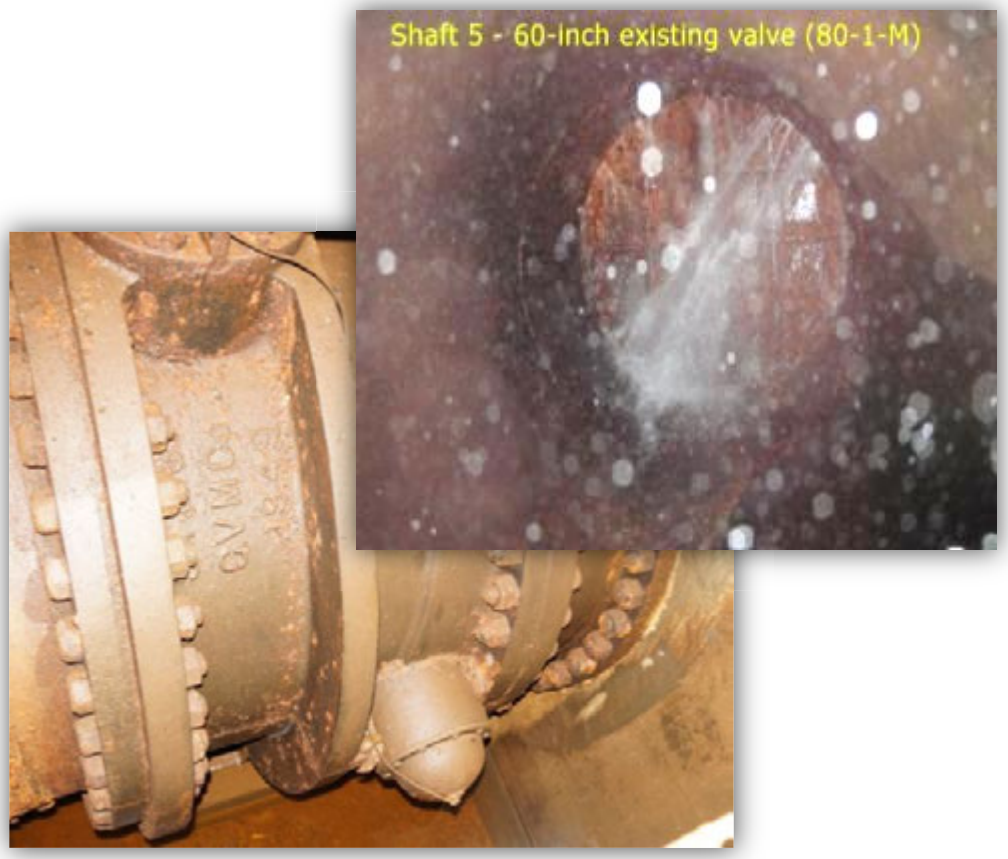
- Tunnel system:
  - Concrete-lined deep rock tunnels
  - Steel and concrete vertical shafts
  - Surface pipe, valves and appurtenances

- Little maintenance required for tunnels and shafts. **Little risk of failure**.

- Pipe, valves and appurtenances need maintenance, replacement, rehabilitation

Valve Reliability Concern

- Valves that don't work
- Valves we can't exercise



54-inch Shaft 7 Valve

Cone Valve at Shaft 7B

20-inch Shaft 7 Valve

Valve Reliability Concern

- Valves that don't work
- Valves we can't exercise

Shaft 8 PRV Chamber

Cone Valve at Shaft 7B

Gear box on valve at Shaft 8

Access Can Be Difficult

- High ground water table
- Standing water in some chambers
- Corrosion is a concern

Shaft 7C connection to Section 58

Chamber at Shaft 7C

Chamber at Shaft 7D

Appurtenances Can Be Liabilities

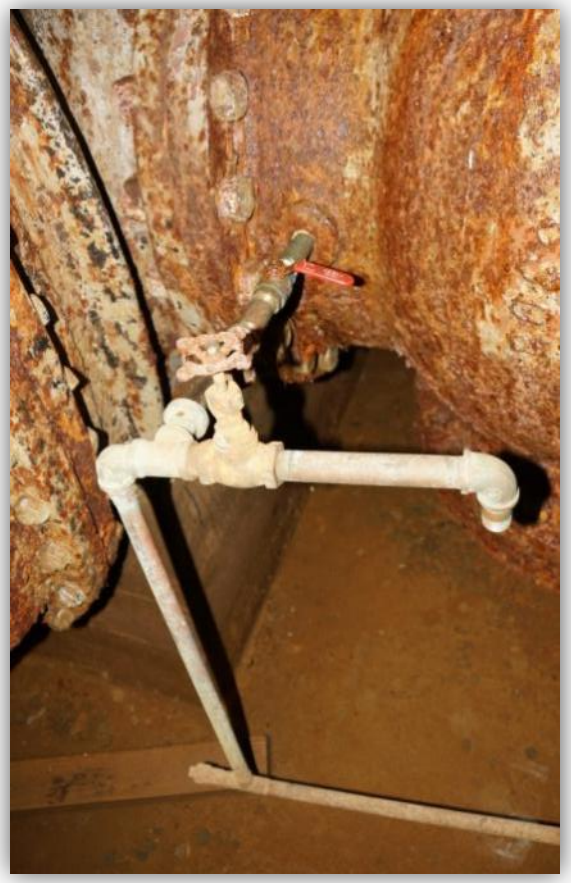
- Small pipe failures can lead to shut downs

Shaft 8 PRVs

Top of Shaft 8

Appurtenances Can Be Liabilities

- Small pipe failures can lead to shut downs



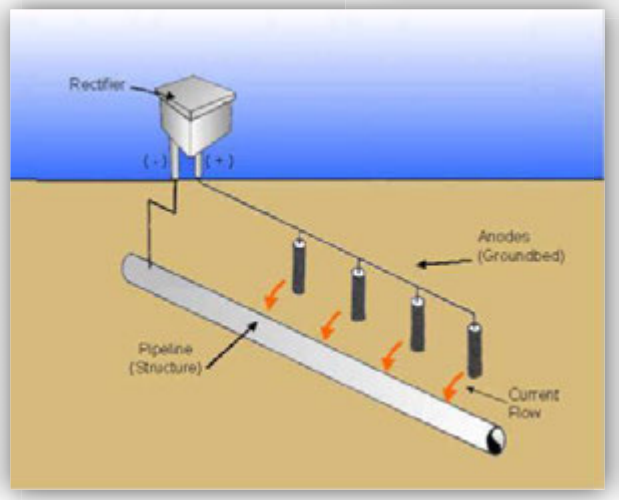
Control piping at Shaft 8

Air valve at Shaft 9A

Shaft 8 PRV Chamber

Shaft Pipeline Improvements to Reduce Risk

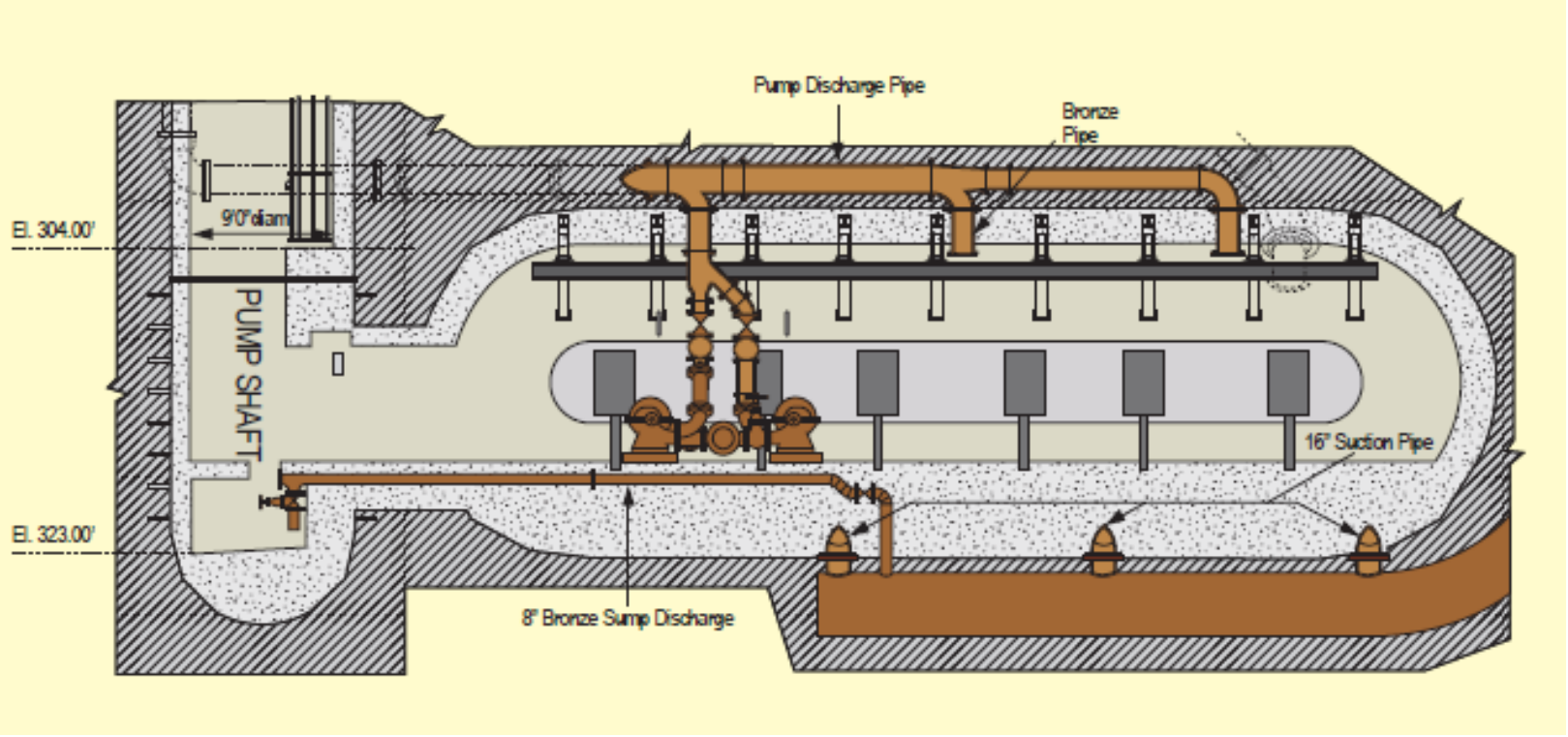
- Replace corroded bolts
- Metal thickness evaluation
- Wrap or coat pipe segments
- Replace air valves
- Cathodic protection
- Heat tracing



Location of Concern – Shaft 7

- Six 54-inch hydraulically actuated Dow Disc valves
- Junction point of all three tunnels
- Valve operability uncertain
- Small diameter piping and valves

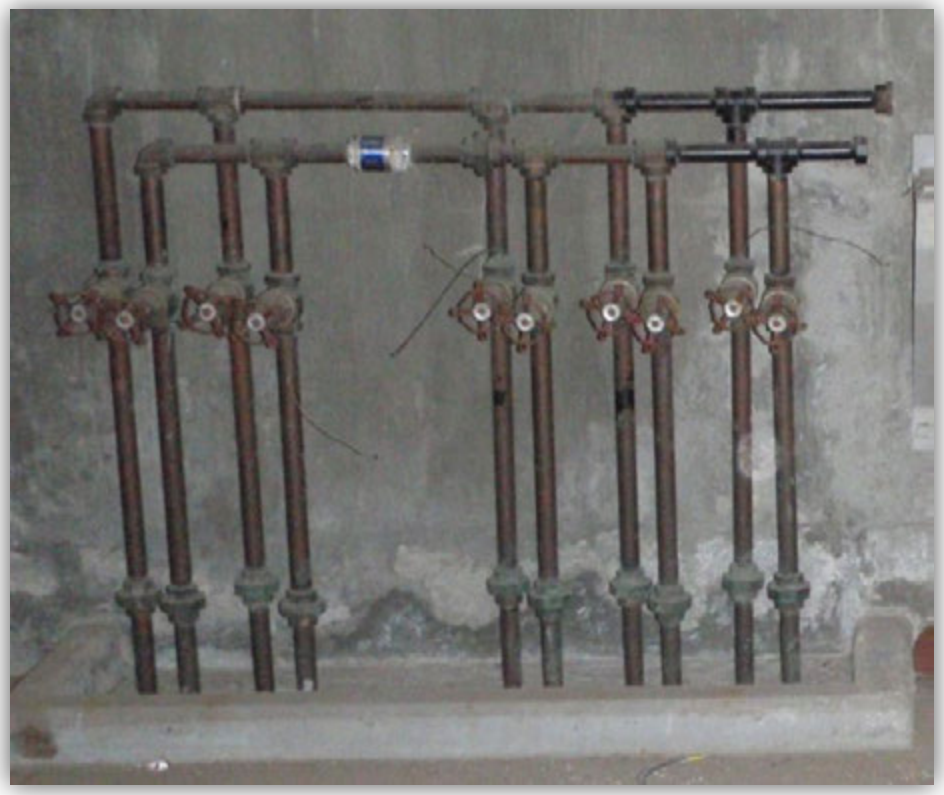
Location of Concern – Shaft 5 & 9 Pump Chambers



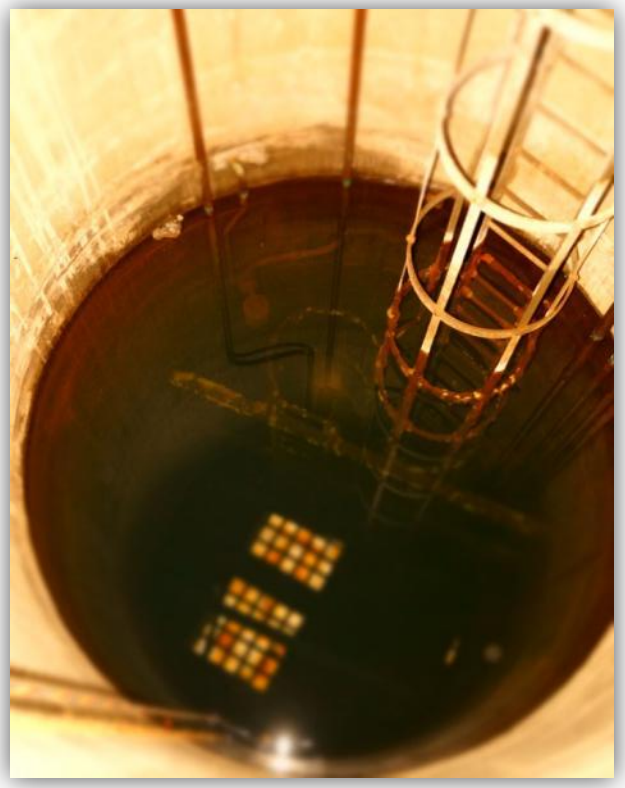
- Located at tunnel depth for the purpose of dewatering tunnels
- Access extremely difficult
- High pressure bronze pipes connect tunnel to dewatering pumps
- Smaller diameter piping from hydraulic valve actuators to surface

Shaft 9 Pump Chamber

- Shaft 9 also has a hydraulically actuated tunnel isolation valve
- Access shaft and pump chamber have been submerged for decades



Valve control piping still present in both shaft buildings



Shaft 9 access shaft is full of water

Tunnel System Shut-down Impacts

Planned Shut Down – Service to the North

- Partially supplied communities use alternate supplies
- Gillis Pump Station / Spot Pond Pump Station
- Reconfigure Northern High piping
- Pump from Open Spot Pond Reservoir (BOIL ORDER) 1-2 months at average day demand; 1-3 weeks at high day demand
- Replenish from Low Service supply lines (WATER RESTRICTIONS)

Planned Shut Down – Service to the South

- Partially supplied communities use alternate supplies
- Chestnut Hill Emergency Pump Station
- Surface Mains to Blue Hills Tanks (PRESSURE SWINGS / BREAKS)
- Pump from Chestnut Hill Reservoir (BOIL ORDER)
- Replenish from Sudbury Aqueduct

Shut Down Sometimes Unplanned

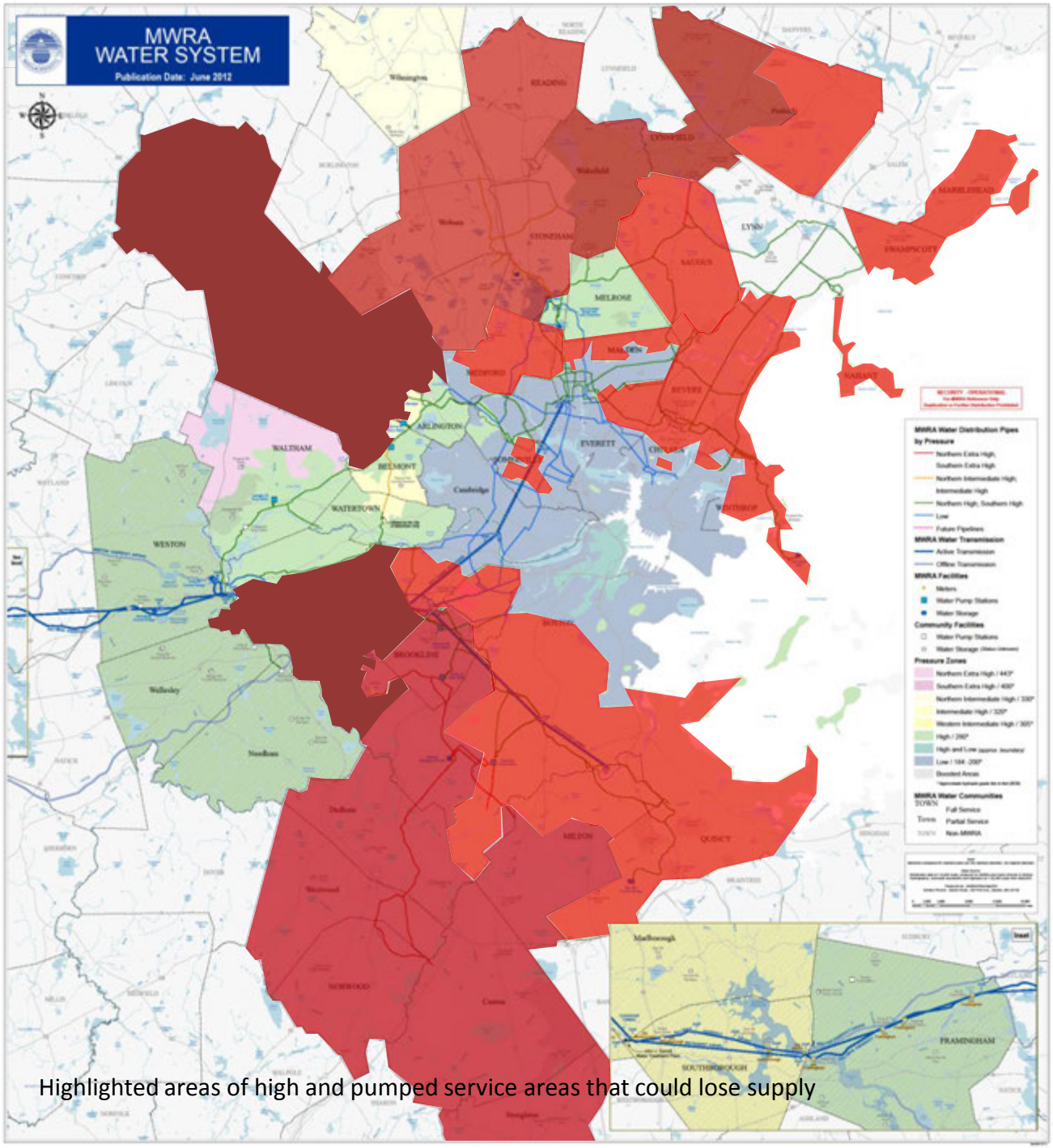
- Flooding/damage/public safety concerns
- May not have time to set up back up systems

Shut-down and Isolation Takes Time

- Extent of shut-down depends on failure
- Numerous shaft locations to isolate / multiple valves at some
- Some chambers require pumping
- Valve turn counts / time to close on the order of 45 minutes each

Wide-Spread Impact

- Sudden shut down of Metropolitan Tunnel system
- Loss of supply to high service areas
- Pumped Service Areas lose supply as tanks empty
- Whole system would be on boil order

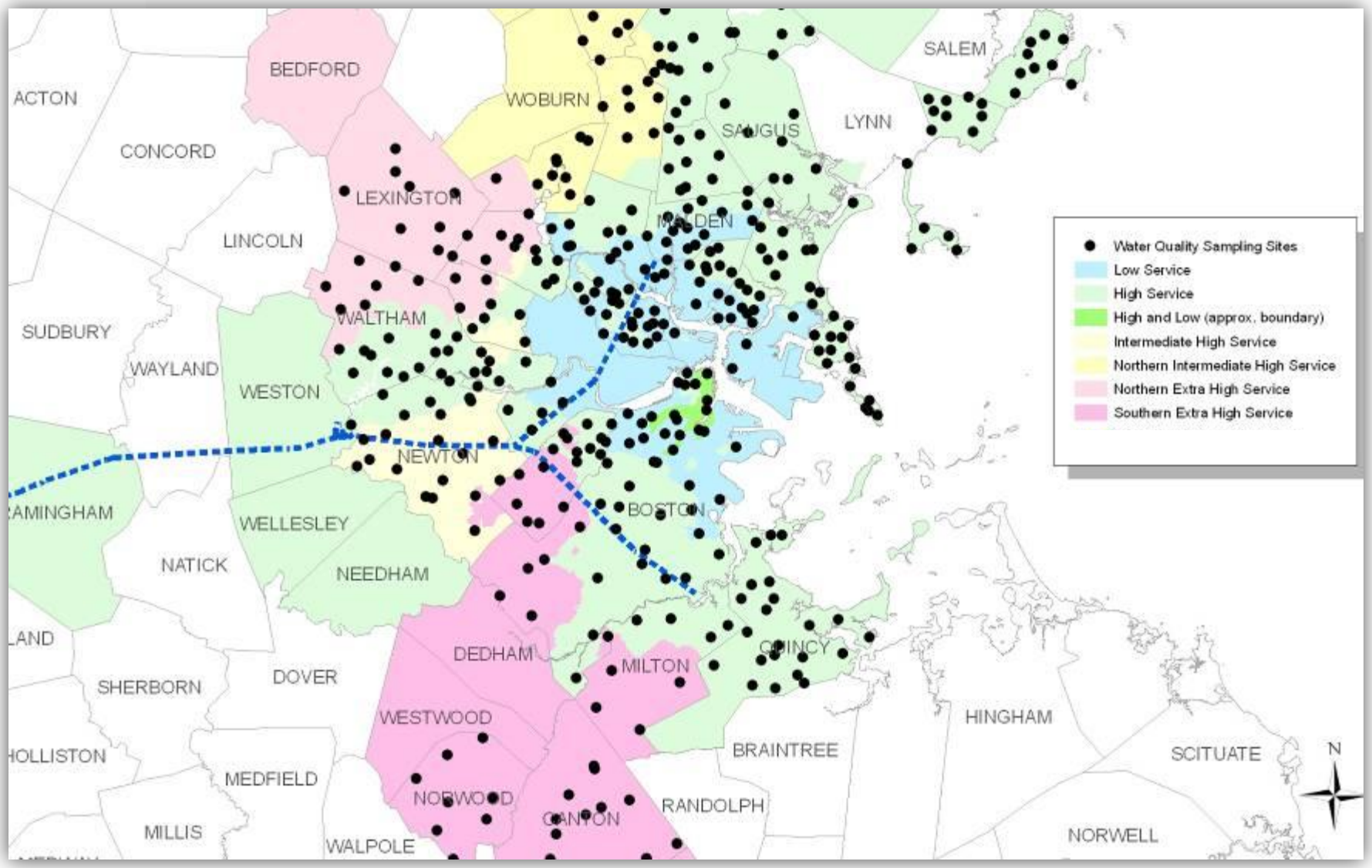


Highlighted areas of high and pumped service areas that could lose supply

Service Restoration

- Activate back-up supplies
- Large areas of MWRA and community systems will need to be refilled SLOWLY to avoid breaking lines
- Flushing to remove air pockets could take days if not weeks
- Water Quality Samples to assure public

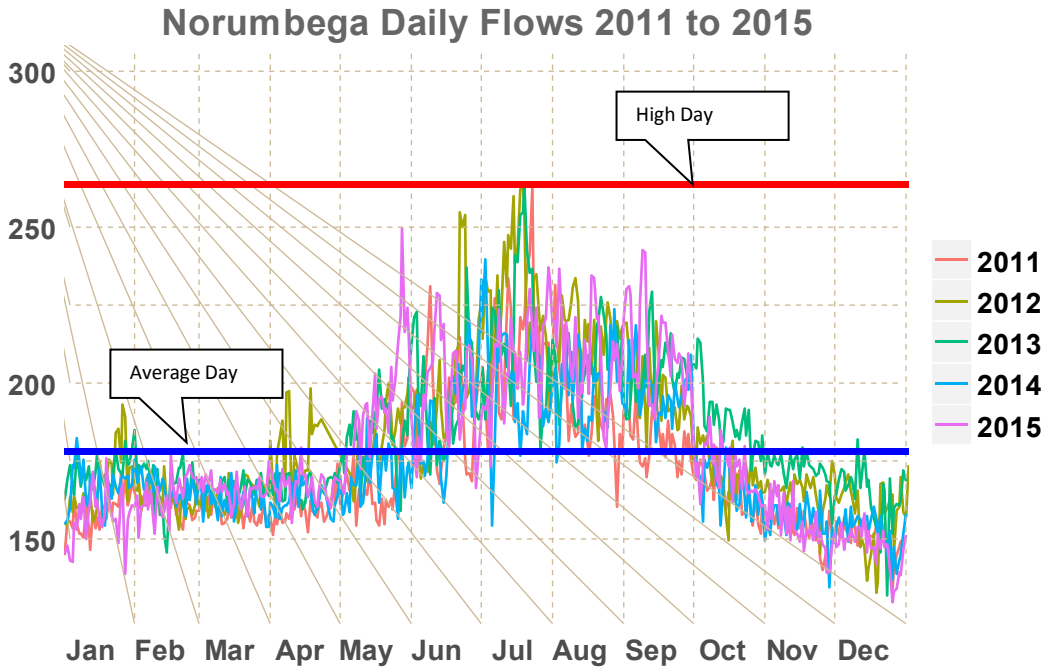
Water Quality Sample Locations



Strategic Goals for Redundancy Improvements

Water System Operating Goals

- Operating Goals:
  - Protection of Public Health
  - Providing Sanitation
  - Fire Protection
- Average day demand
- High day demand preferred
  - Longer shut downs possible



Strategic Goal for Redundancy Improvements

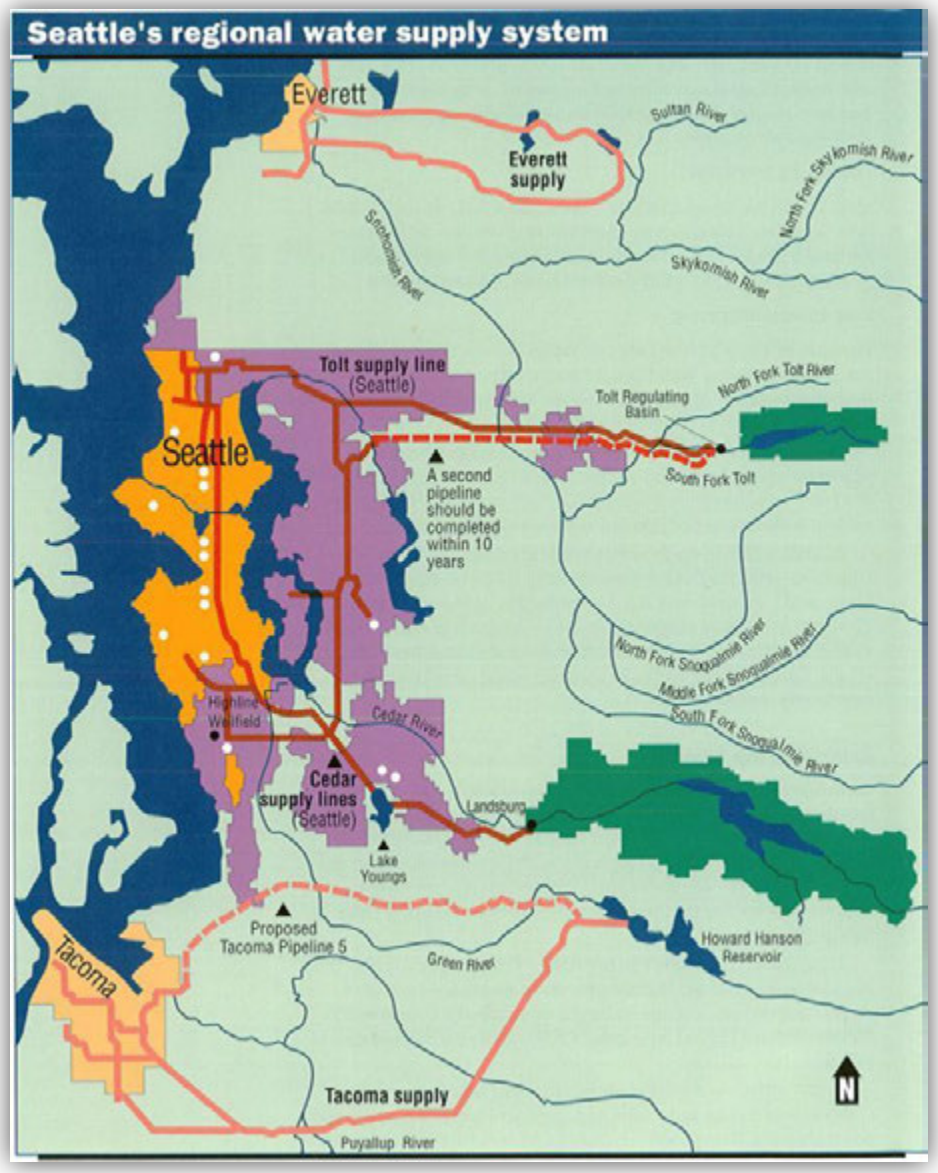
- Emergency-Only Capability
  - Utilize only if failure occurs
  - Does not allow planned maintenance
  - Decrease in level of service
  - Potential for damage to MWRA and community systems
- Planned Shut-Down Capability Preferred
  - Allows maintenance of system
  - Maintenance reduces risk of failure
  - Meet customer expectations for excellent quality water
  - Minor impact on normal service

Example Peer Organization Redundancy Programs: San Francisco

- $4.8 billion Water Supply Improvement Program
- Major Transmission and Storage Projects
- Cross Bay Tunnel
- High Day Design Enables Maintenance of Either New or Old Tunnels

Example Peer Organization Redundancy Programs: Seattle

- Two ways to convey water to all parts of their system
- Two separate supply and transmission systems
- Opposite sides of the city
- Two different feed points
- Two separate tanks
- Looped Transmission System



Example Peer Organization Redundancy Programs: New York City

- Tunnel #3 - Designed for Full Redundancy to Tunnels 1 & 2
- Stage 1 and 2 Completed – 27 miles of 24’ tunnel
- $4.7 billion through 2013

- $ 1 billion of Supply, Treatment, and Transmission projects will enable taking NYC’s largest aqueduct and supply off line for a 2.5 mile Bypass Tunnel and Repairs

Redundancy – It's Always Been a Goal for MWRA Water System

- Redundancy examples in our water system since 1800s:
  - Two basins of Chestnut Hill Reservoir
  - East and West Spot Pond Supply Mains
  - Hultman Aqueduct planned to have two barrels

Future Hultman Aqueduct connection at Shaft 4 (1940)

WASM 1 and 2 Pipe Yard (1915)

Paired Pump Stations Provide Redundancy

Brattle Court Pump Station (1907)

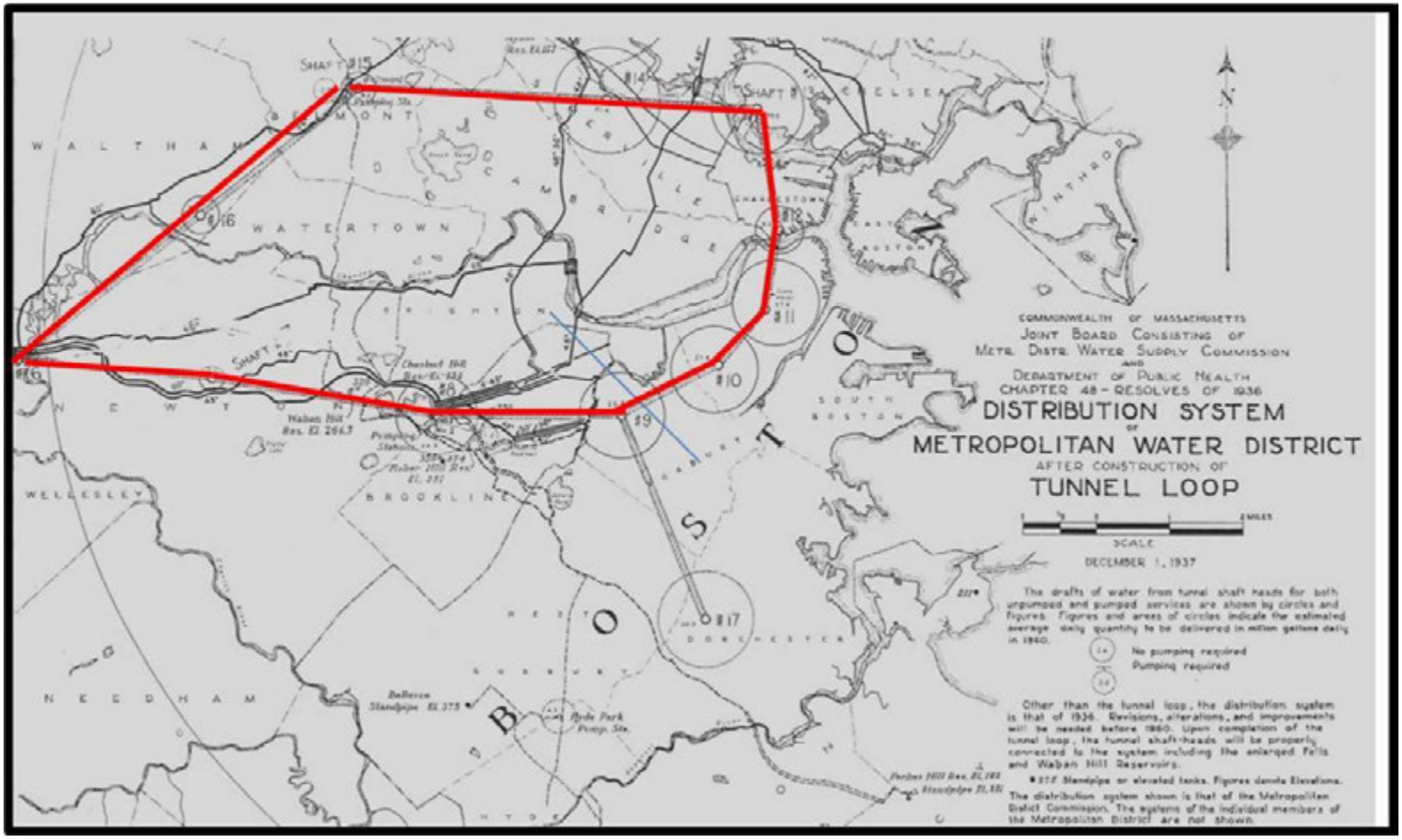
Spring Street Pump Station (1958) redundancy to Brattle Court

Gillis Pump Station (1899)

Spot Pond Pump Station (2015) redundancy to Gillis Station

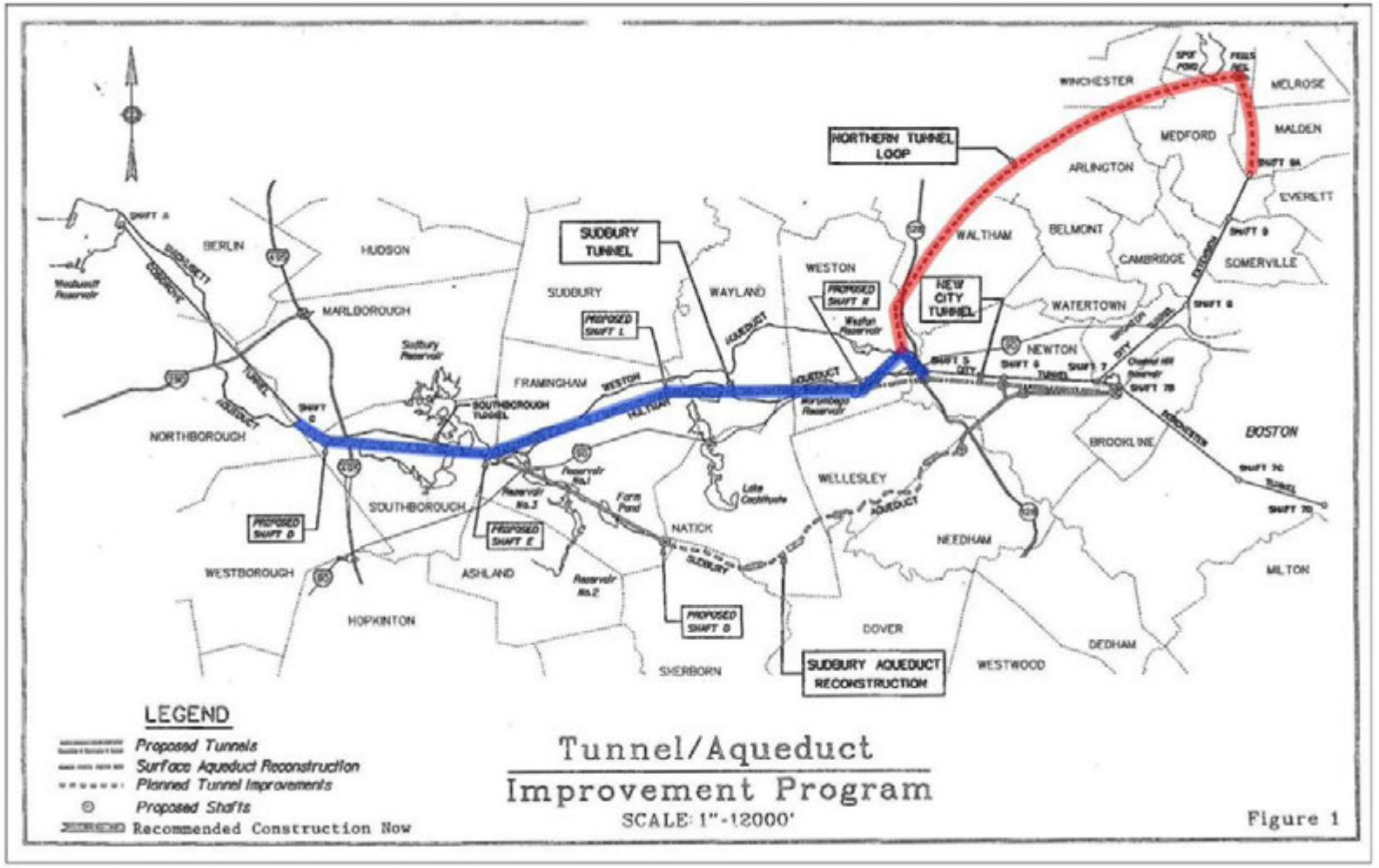
Previous Redundancy Evaluations

Original 1936 Tunnel Loop Plan

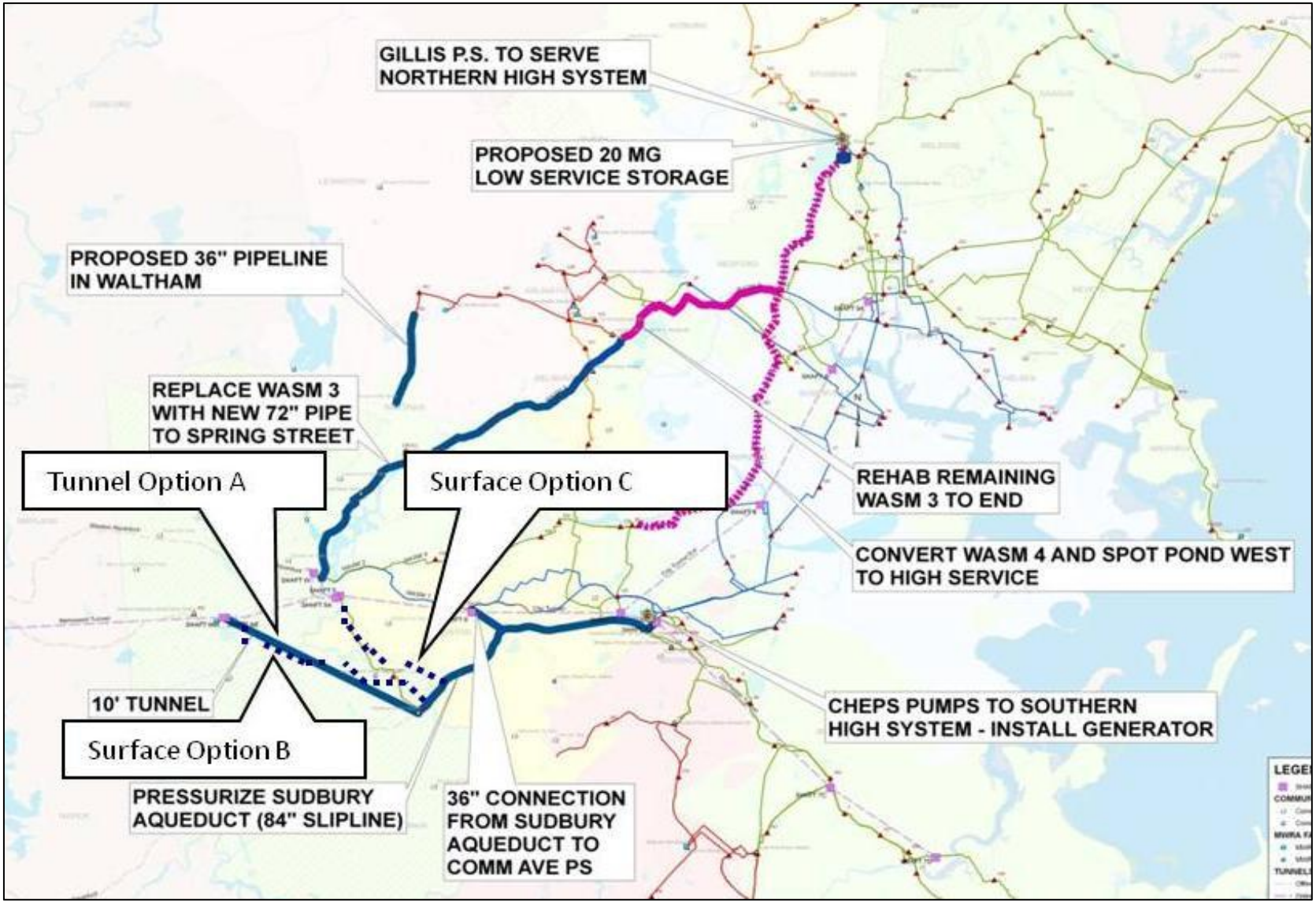


Previous Redundancy Evaluations (continued)

- 1990 Plan – MetroWest Tunnel followed by Northern Tunnel Loop



2011 Plan – Surface piping with Northern and Southern Components



Difficulties Carrying Out 2011 Plan

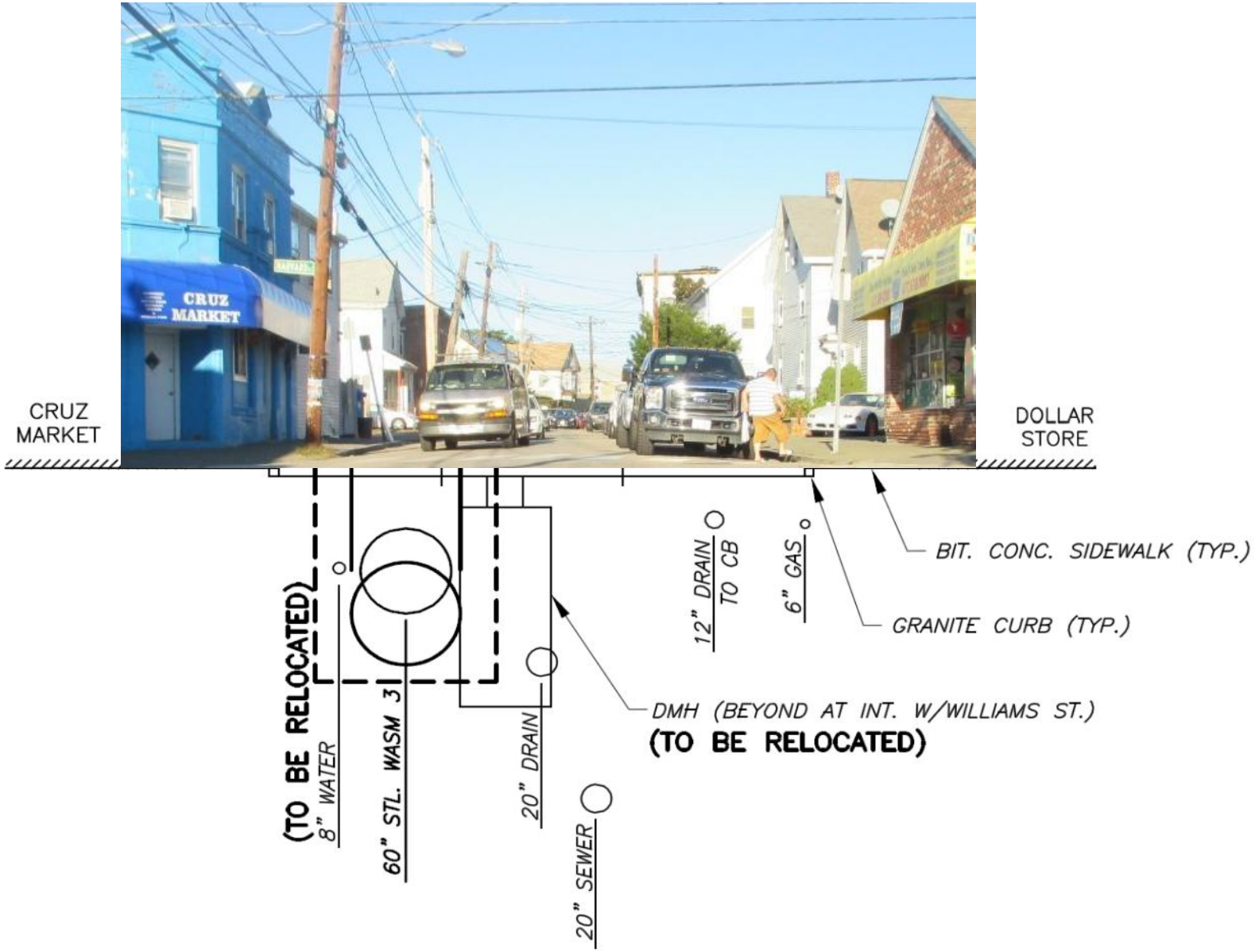
Impacts of Surface Pipeline

- Traffic
  - Street Closures & Detours
  - Congested City Streets/Gridlock
- Business Disruption
  - Access Disruption
  - Loss of Business
- Permitting & Approval
  - Multiple Environmental and Agency Permits
  - Street Opening Approvals & Fees
- Community Disruption
  - Noise
  - Dust
  - Detours
  - Long Period of Impacts Over Large Areas
  - Mitigation

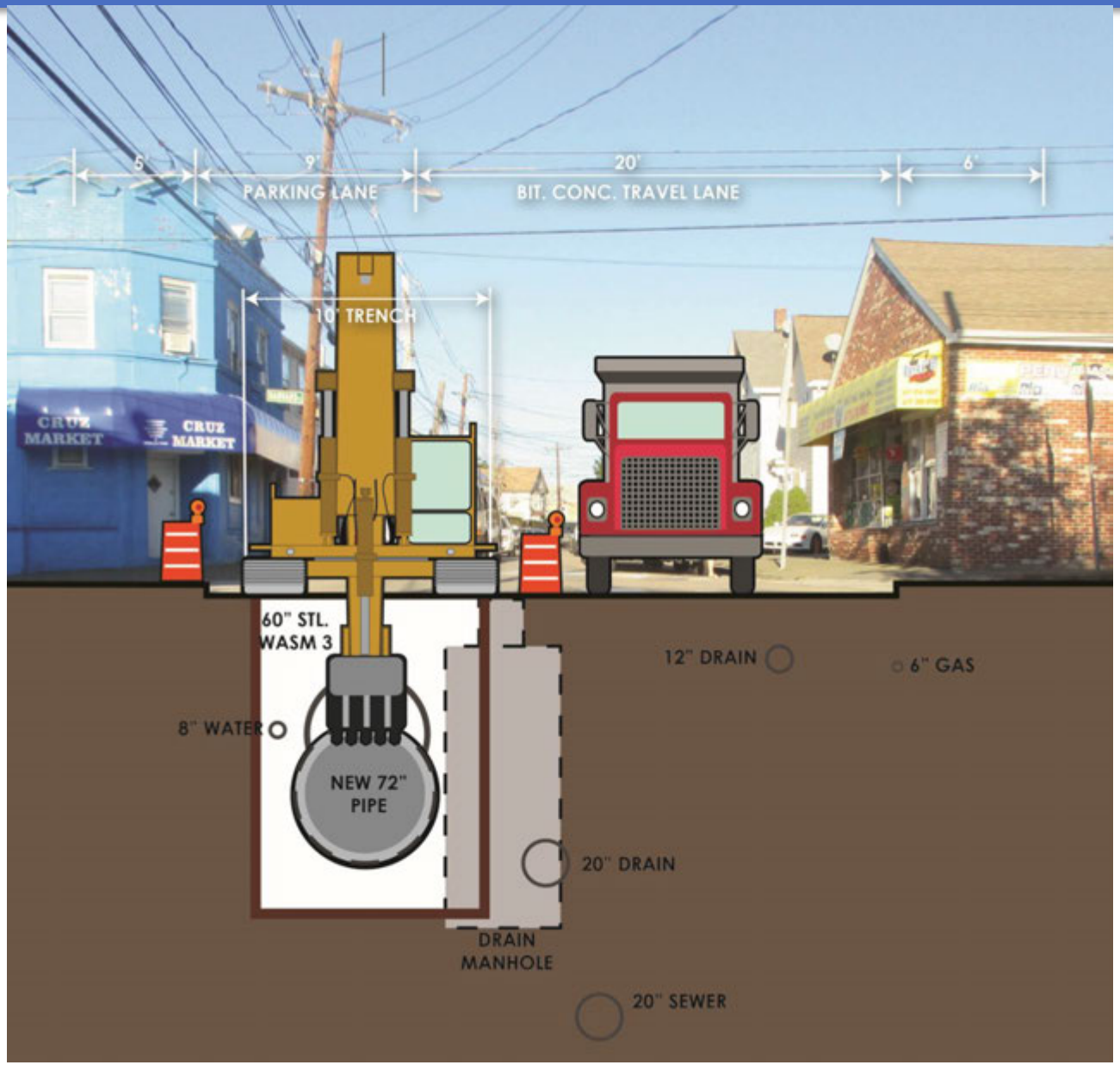
Main Street (Route 20) Waltham

Trapelo Road at Pleasant Street - Belmont

Felton Street - Waltham



Felton Street - Waltham



Construction of 72-inch Spot Pond Pipeline

Other Utilities Have Constructed Tunnels to Avoid Surface Pipe Construction Impacts

- Washington Suburban Sanitary District
  - 5.3 mile tunnel was constructed in 2015 to avoid construction impacts of a surface pipe
- East Bay Municipal Utility District (MUD)
  - 4 mile tunnel to avoid construction impacts to neighborhoods
- Metropolitan Water District of Southern California
  - 9 mile Tunnel in San Bernardino to avoid construction impacts and seismic concerns

Evaluation of Alternatives

Re-evaluation of Alternatives

- Due to the major impacts of miles of large pipe construction, additional tunnel alternatives were evaluated

- Previous and new alternatives were evaluated including pipelines, pumping and tunnels

  - 13 alternatives to the north
  - 14 alternatives to the south

Six Categories of Alternatives

North

- No new pipes - Push northern system to its limits
- Replace WASM 3 with larger pipe or construct new pipe and/or add pump station
- Construct tunnel to north

South

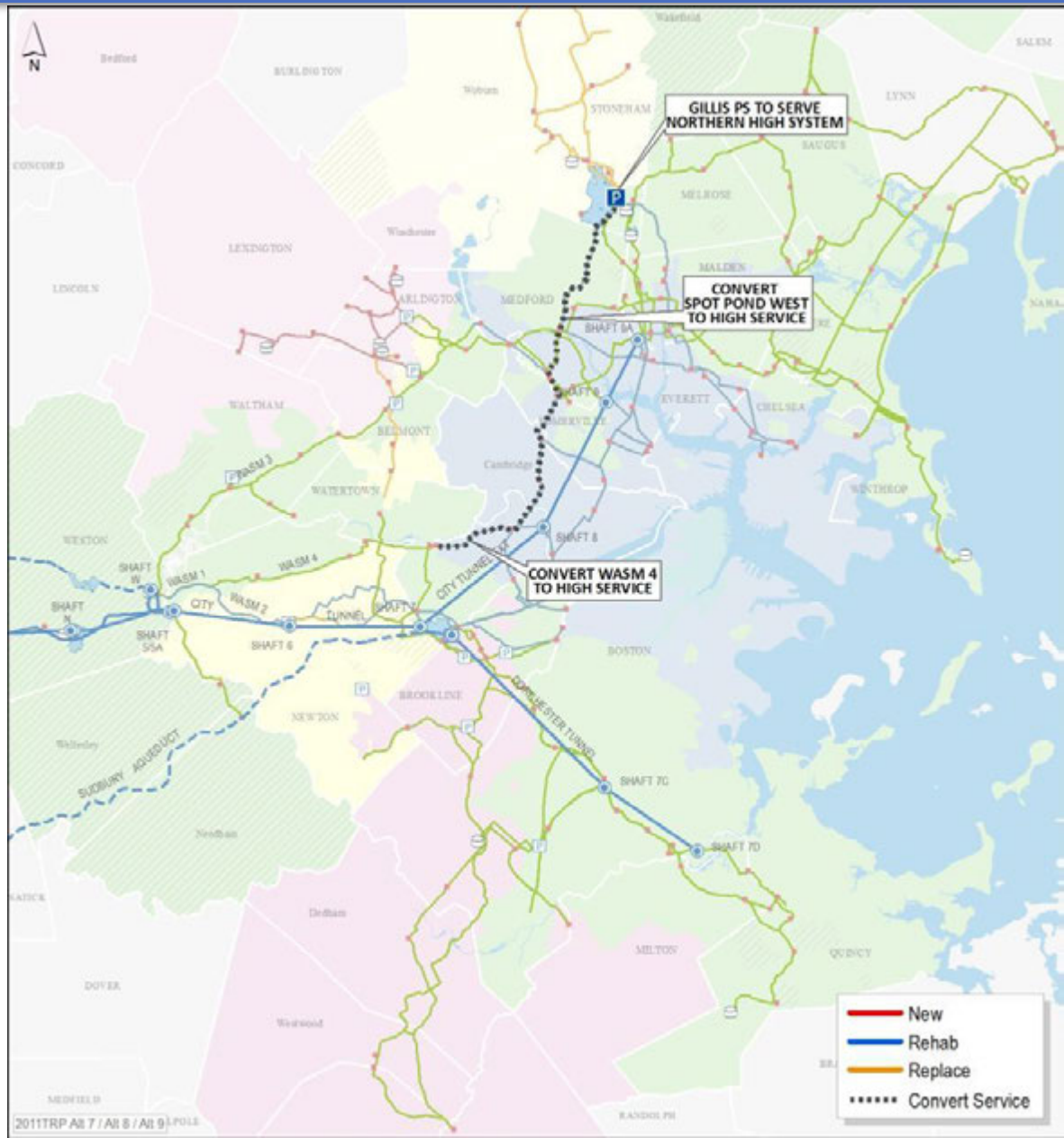
- New tunnel or pipeline from Norumbega or Shaft 5 area to Chestnut Hill and upgrade Chestnut Hill Emergency Pump Station
- New pipe to southern surface mains with or without new Pump Station
- Tunnel to Dorchester Tunnel Shaft 7C

Northern Component – Category 1 (one alternative)
Push Existing System to Its Limits

Convert part of WASM 4 and entire West Spot Pond pipeline to high service

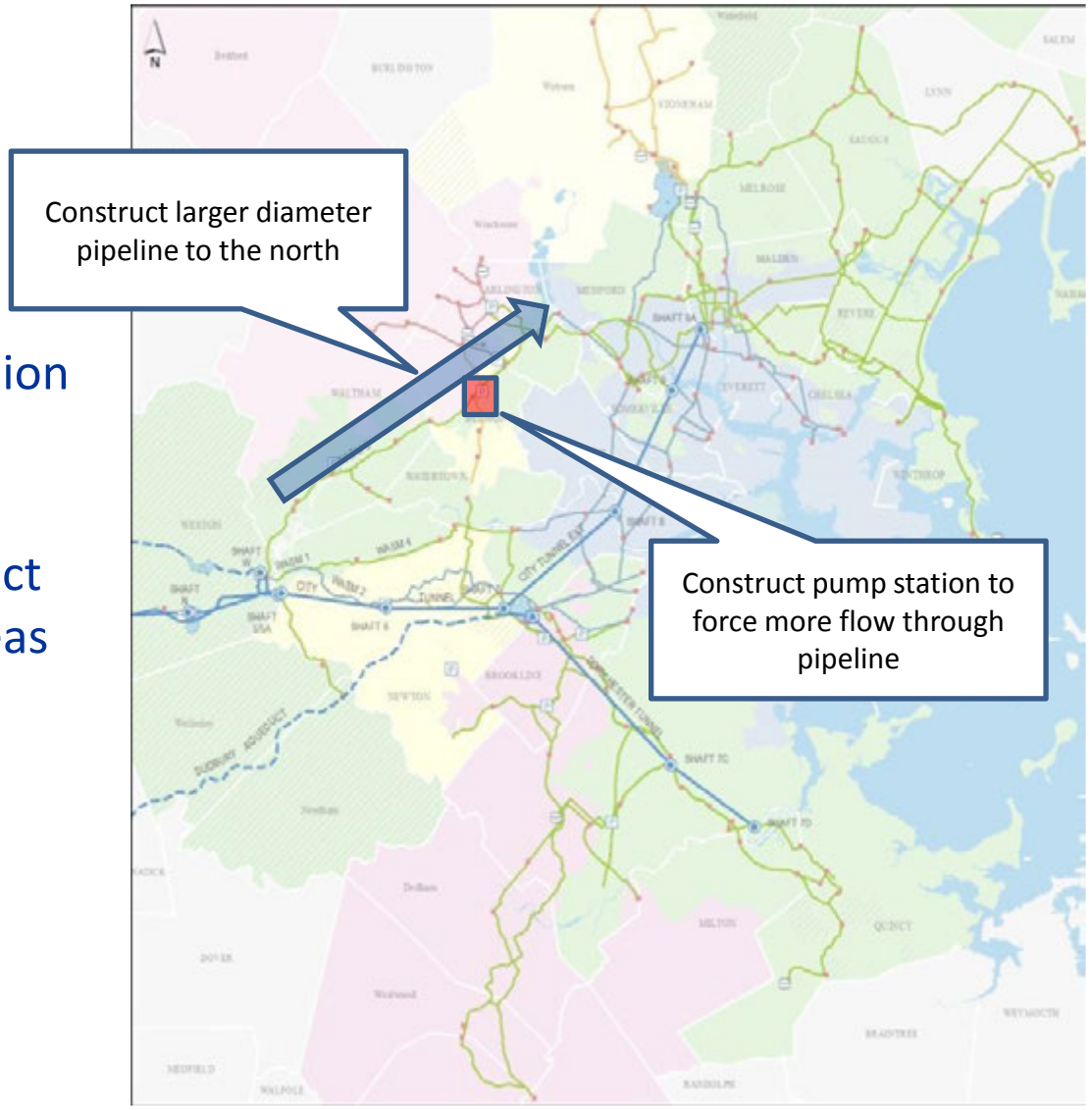
- Cost: $10 million (one alternative)
- Cannot supply summer season demands
- Not reliable for planned maintenance shut down of tunnel system
- Could be used as contingency plan for emergency use while long term solution is being implemented
- Potential pipe replacement

Cost is midpoint of construction. Does not include WASM 3 baseline work



Northern Component – Category 2
Increase Capacity to North (Larger Pipe and/or Pump Station)

- Cost: $138 million - $473 million (six alternatives)
- Large diameter pipelines are extremely difficult to construct through congested urban areas
- Pump station could cause potential pressure surges in distribution system



Cost is midpoint of construction. Does not include WASM 3 baseline work

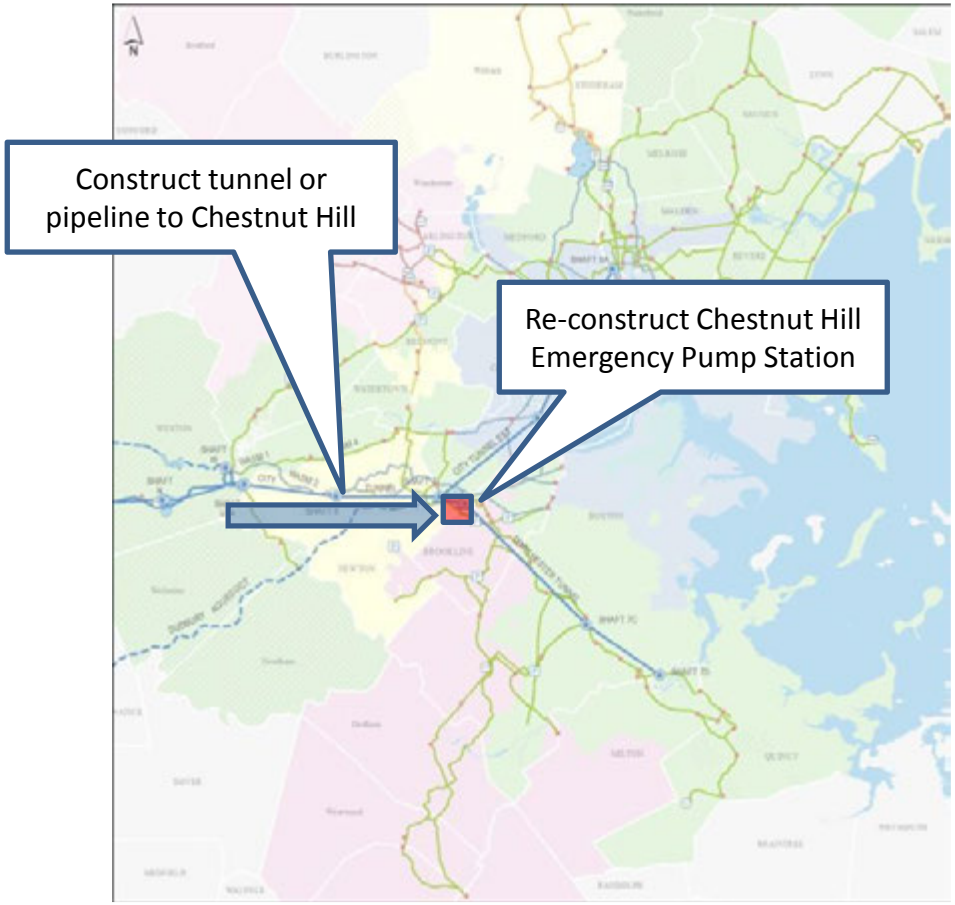
Northern Component – Category 3
Increase Capacity to North (Tunnel)

- Cost: $472 million - $1,292 million (six alternatives)
- Construction impacts would be limited to shaft construction sites and pipe connections
- Would provide redundancy to WASM 3 pipeline
- Meets redundancy goals under all demands
- Allows year round maintenance of tunnel system (in combination with a southern solution)

Cost is midpoint of construction. Does not include WASM 3 baseline work

Southern Component – Category 1
Increase Capacity to Chestnut Hill (tunnel or pipeline)

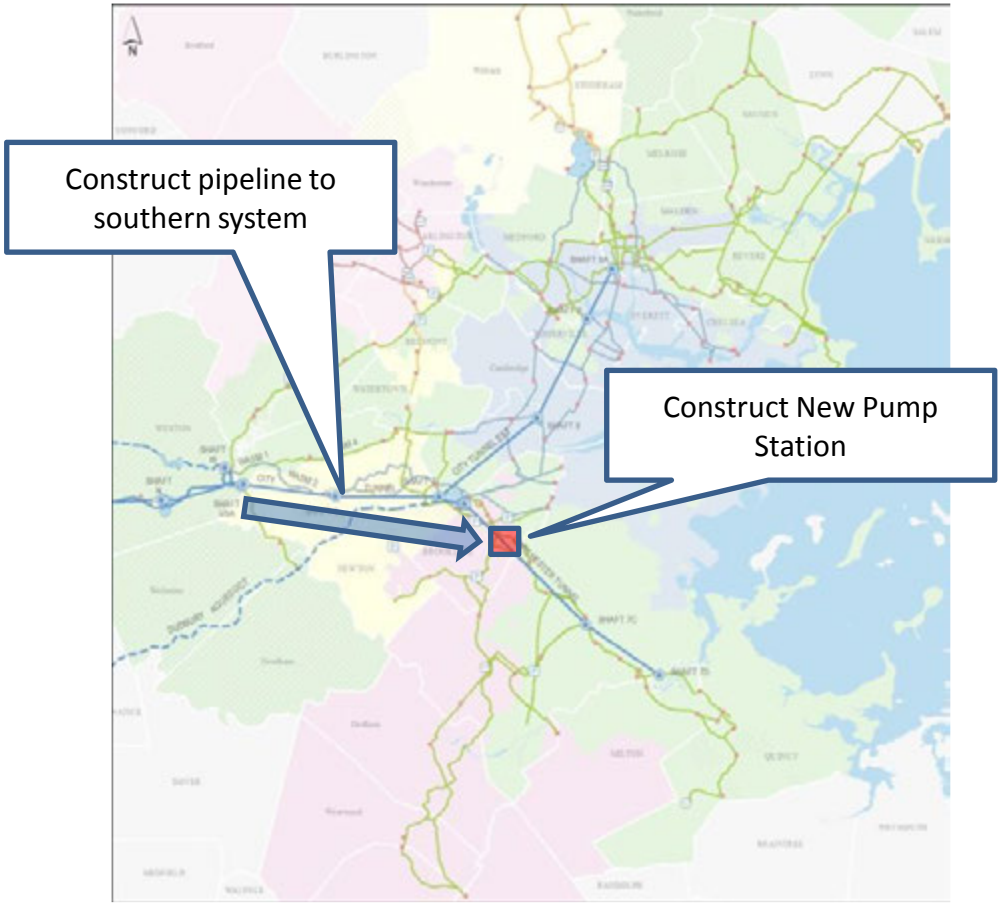
- Cost: $293 million - $629 million (nine alternatives)
- Large diameter pipelines are extremely difficult to construct through congested urban areas
- Pump station would cause higher pressures and potential surges in distribution system



Cost is midpoint of construction. Does not include WASM 3 baseline work

Southern Component – Category 2
Increase Capacity to South (pipeline with or without pump station)

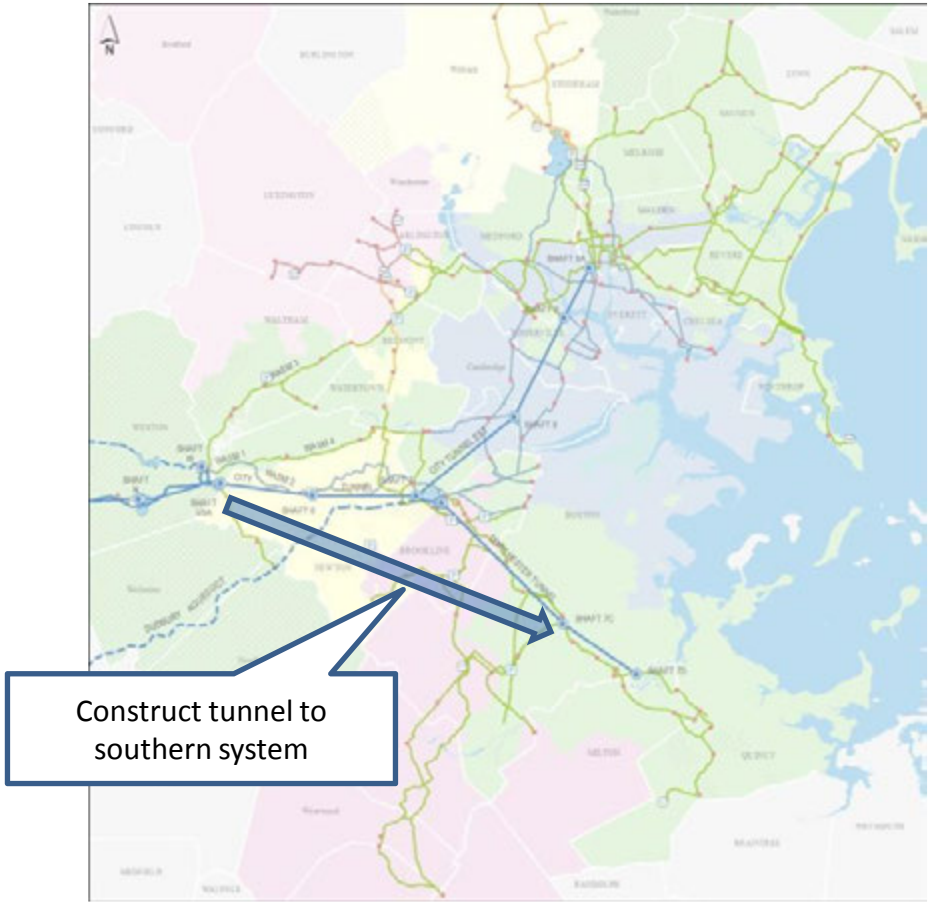
- Cost: $363 million - $390 million (two alternatives)
- Large diameter pipelines are extremely difficult to construct through congested urban areas
- Pump station would cause potential damaging pressure surges in distribution system



Cost is midpoint of construction. Does not include WASM 3 baseline work

Southern Component – Category 3
Increase Capacity to South (Tunnel)

- Cost: $716 million - $1,034 million (three alternatives)
- Construction impacts would be limited to shaft construction sites and pipe connections
- Meets redundancy goals under all demands
- Allows year round maintenance of tunnel system (in combination with a northern solution)



Cost is midpoint of construction. Does not include WASM 3 baseline work

Staff Preferred Alternative

Staff Recommendation – Interim Measures

- Take action now to reduce risk of failure/improve ability to respond:

– Tunnel-shaft pipeline improvements	$ 7.5 million
– Chestnut Hill Pump Station improvements	
• Emergency power	$ 10.9 million
• Investigate feasibility of pump output controls	$ 22.5 million
– WASM 3 rehabilitation	$104.6 million
– Commonwealth Avenue pump station low service suction capability	$ 8.0 million
– Increase PRV capacity WASM 3 and WASM 4	$ 8.7 million
– PRVs for East/West Spot Pond Supply Main community connections	$ 1.3 million
Total	$ 163.5 million

Strategic Goal for Long-Term Redundancy

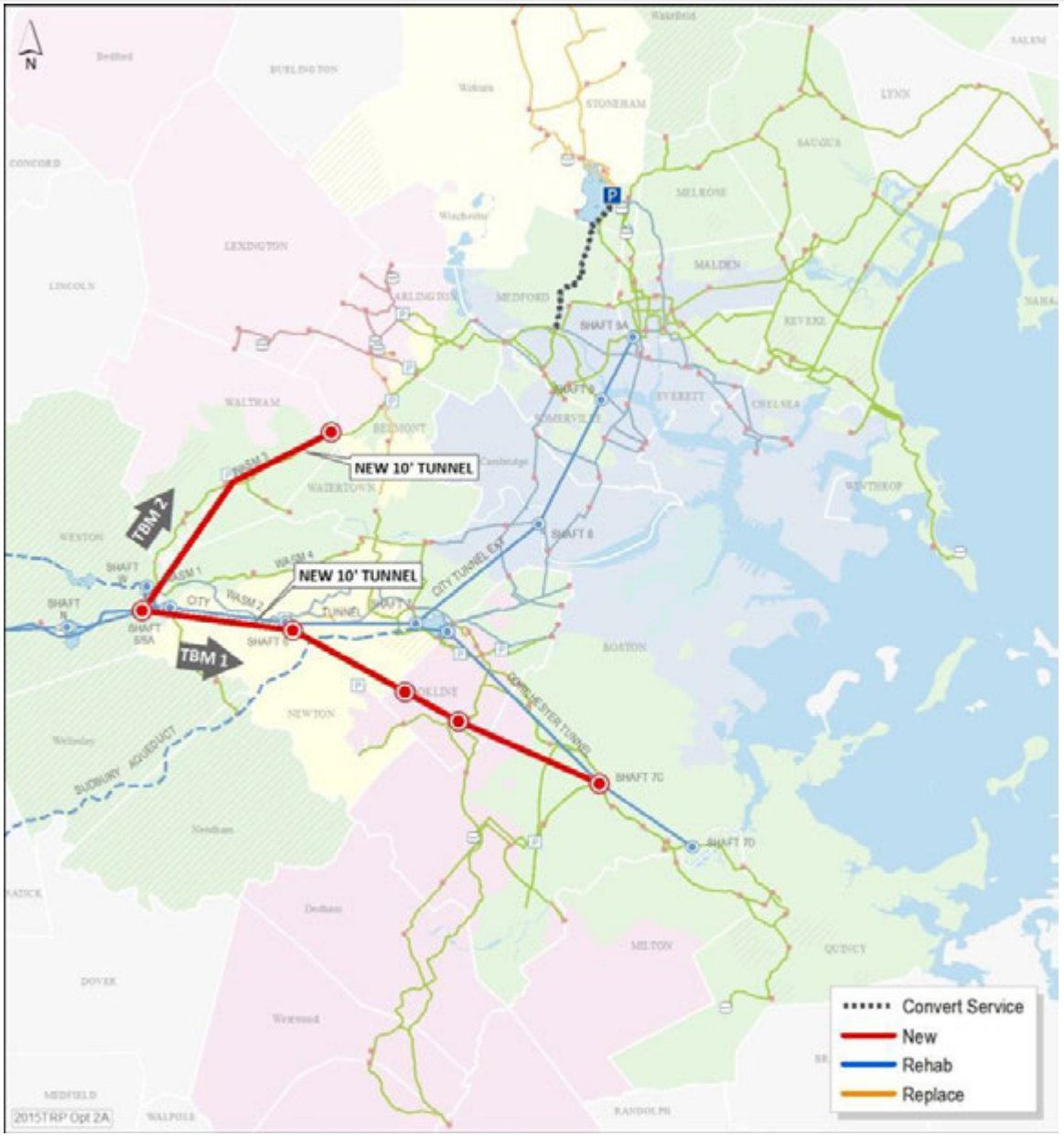
- Emergency and Planned Shut-Down Capability Preferred
  - Allows maintenance of system
  - Maintenance reduces risk of failure
  - Meet customer expectations for excellent quality water
  - Minor impact on normal service

Findings of Alternatives Analysis

- Need additional capacity to supply water to both the north and south
- Chestnut Hill Emergency Pump Station cannot reliably supply enough water to the south with the Dorchester Tunnel shut down
- Long distance large diameter surface pipelines in urban areas present significant implementation challenges

Preferred Alternative for Long-Term Redundancy

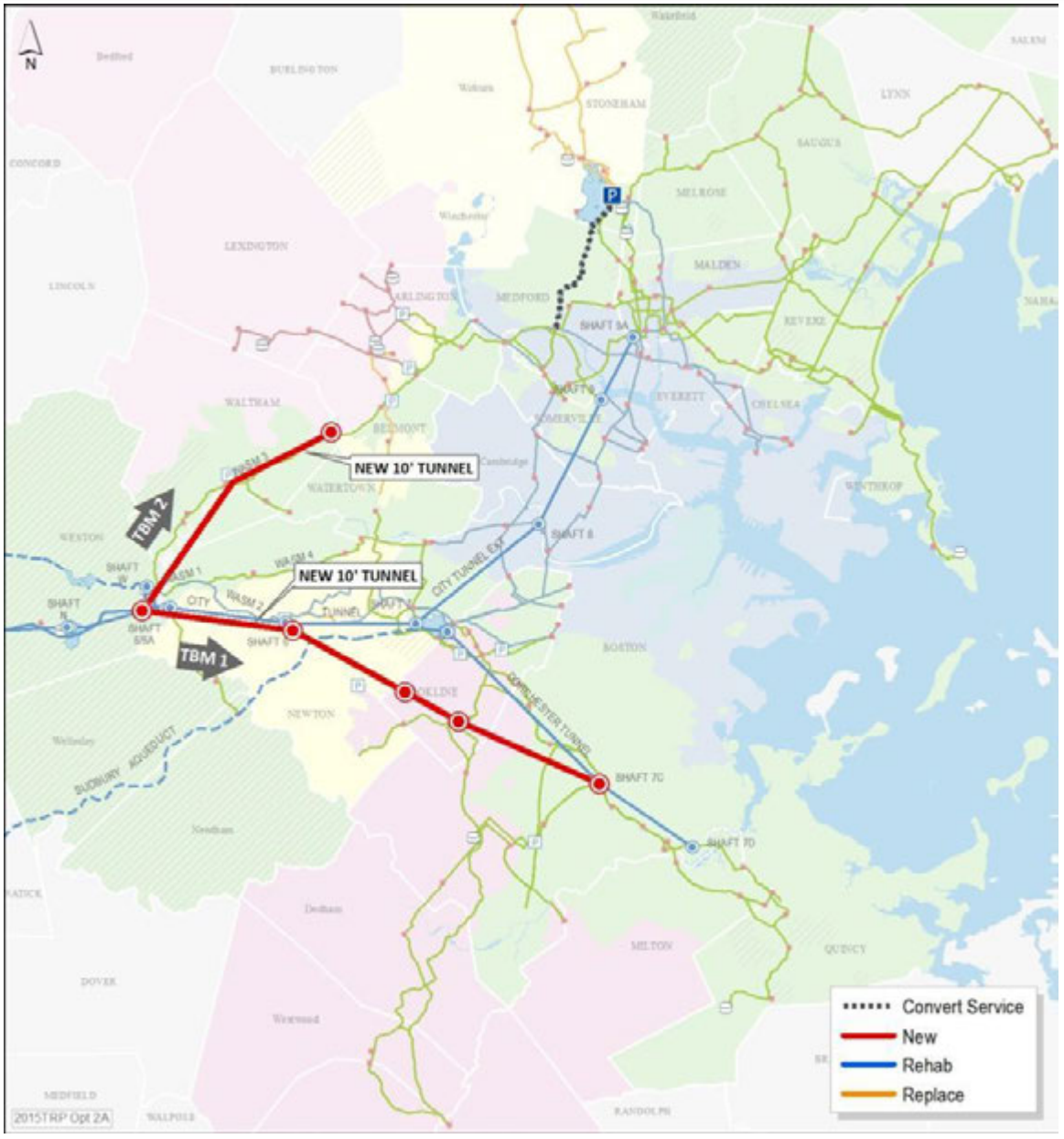
- **Two Tunnel Option Preferred**
- Time to Complete: 17 - 23 years
- Tunnels begin in the Mass Pike/Route 128 vicinity
- Northern Tunnel 4.5 miles, connects to mid-point of WASM 3 in Waltham/Belmont area.
- Southern Tunnel 9.5 miles, connects to Shaft 7C and southern surface mains



Preferred Alternative for Long-Term Redundancy

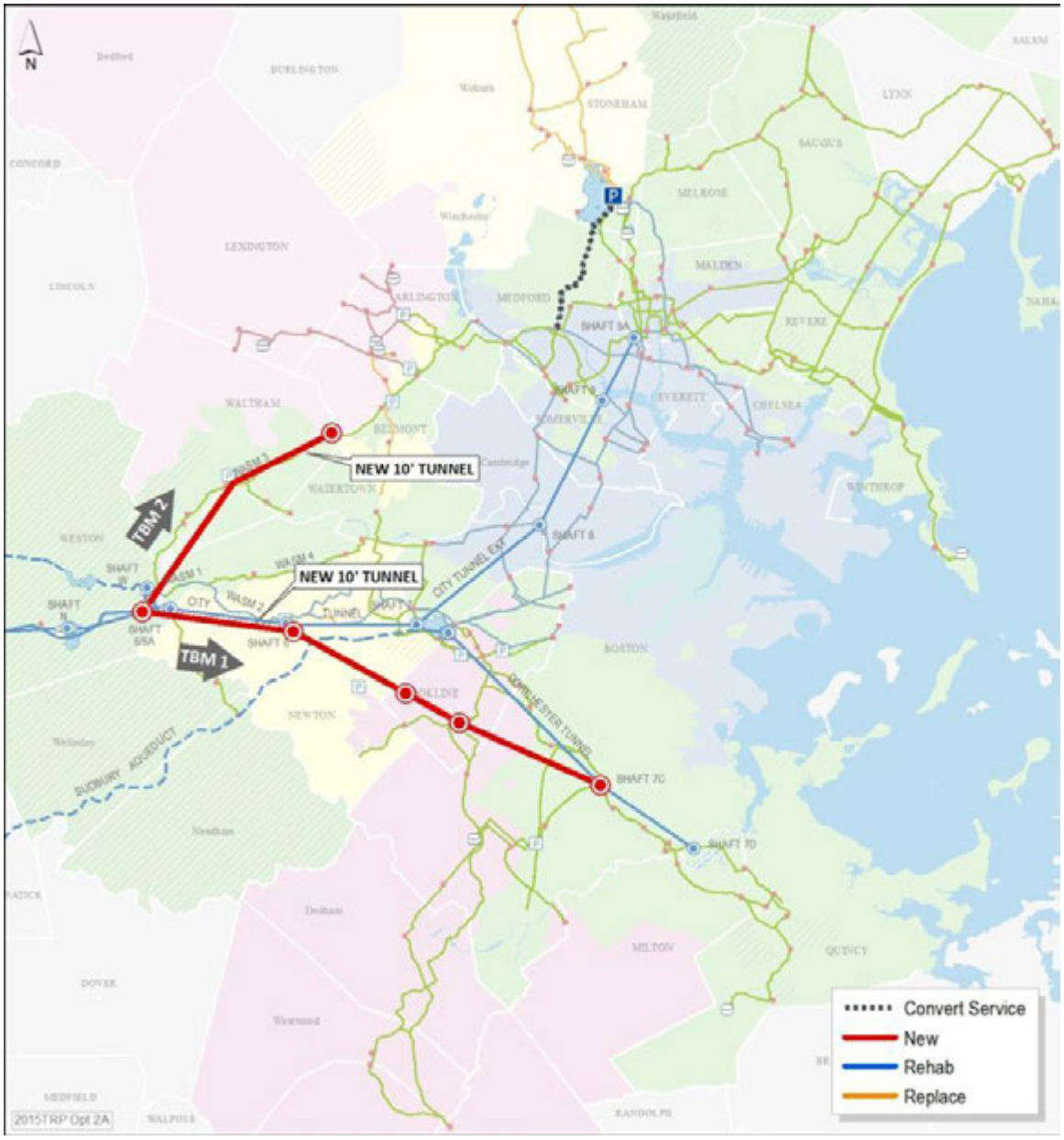
Meets Many Objectives:

- No boil order
- Flow and pressure for normal service and fire protection
- Ability to perform maintenance
- Additional benefit: Ability to meet high day demand. No seasonal restrictions.



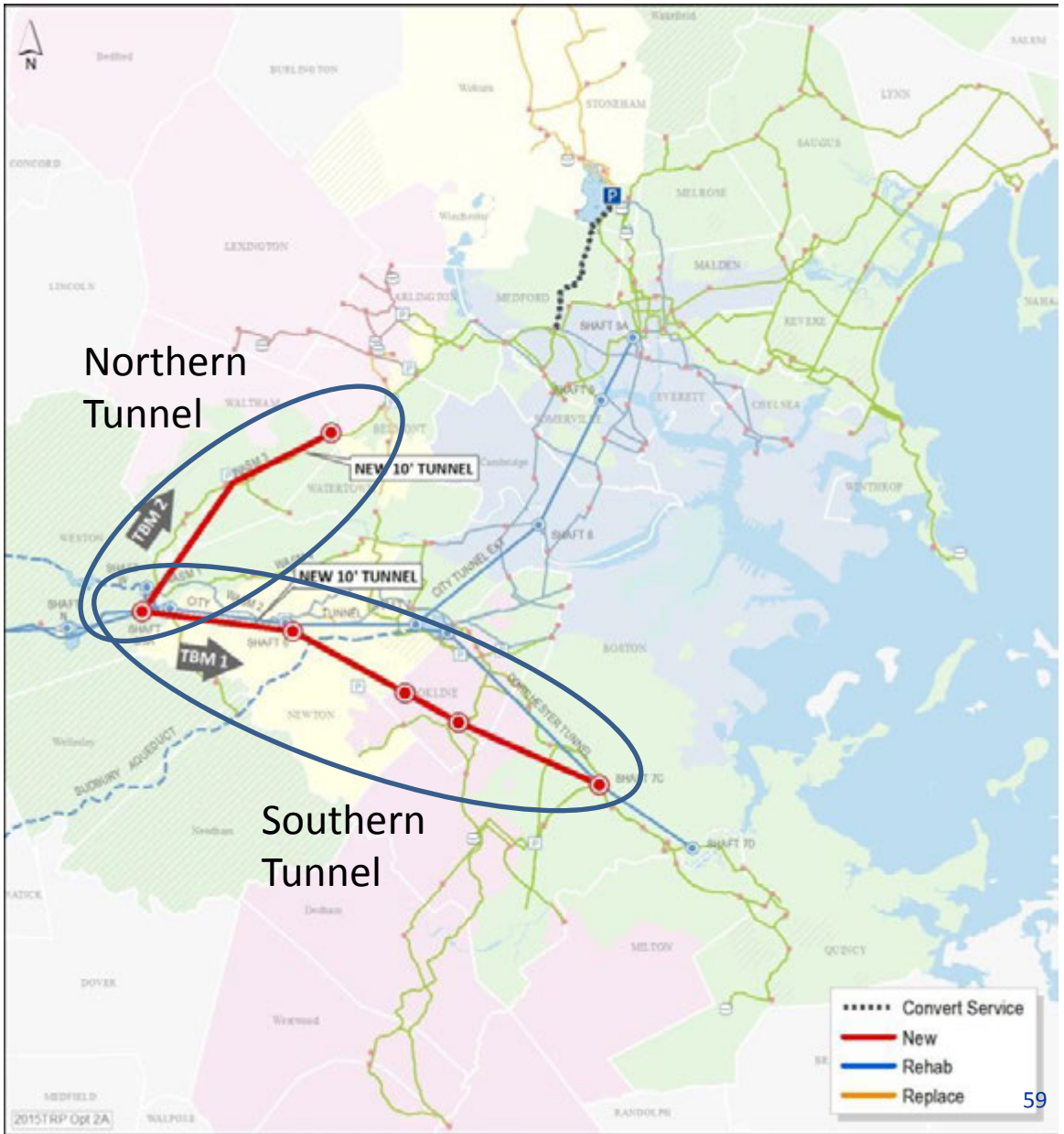
Preferred Alternative for Long-Term Redundancy

- Midpoint of Construction Cost: $1,470 -$1,700 million
- Costs include:
  - 30% contingency factor
  - 4% annual escalation
- Cost does not include baseline / interim improvement costs.



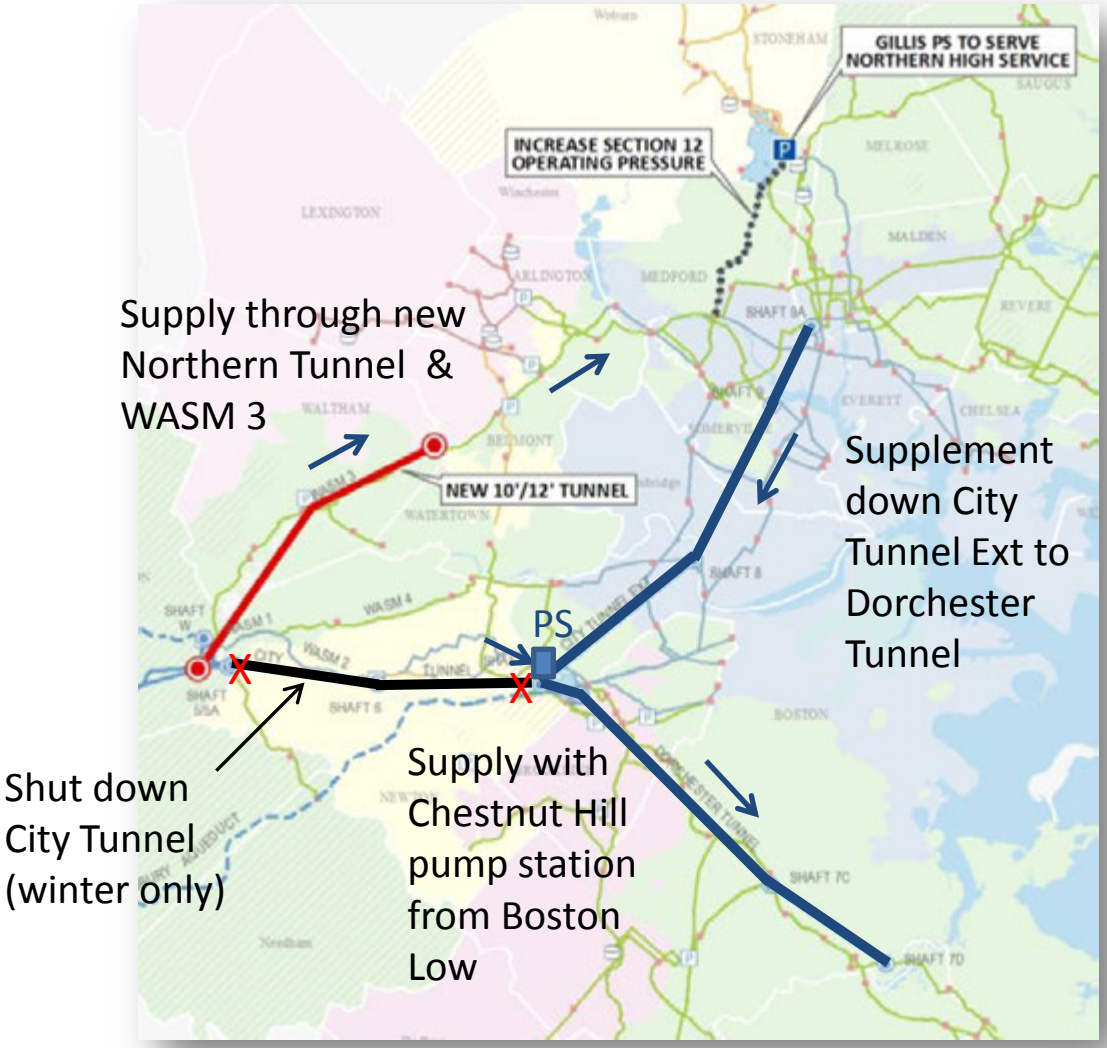
Construction in Phases Still Provides Benefit

- Could be built in phases
- Northern Tunnel
  - Redundancy for City Tunnel Extension
  - Could shut City Tunnel during periods of low demand and still feed south
- Southern Tunnel
  - Redundancy for Dorchester Tunnel
  - Eliminates reliance on the CHEPS



Phased Construction of Preferred Alternative

- If a phased approach is a goal, staff would recommend that the Northern Tunnel be constructed first
- With Northern Tunnel in place
  - test valves at Shaft 7
  - potentially address Shaft 5, Shaft 9 or Shaft 9A concerns



Meeting Summary

- MWRA Staff concluded:
  - Redundancy for Metropolitan Tunnel system is necessary for maintenance and emergency response
  - If we do nothing, failure will eventually occur
  - Extensive alternatives were identified and evaluated
  - Long distance large diameter pipeline alternatives present significant implementation challenges
  - Operational reliability problems were identified with Chestnut Hill Pump Station and other proposed pump stations
- Next Step – Bring discussion to MWRA Advisory Board meeting to allow for stakeholder input