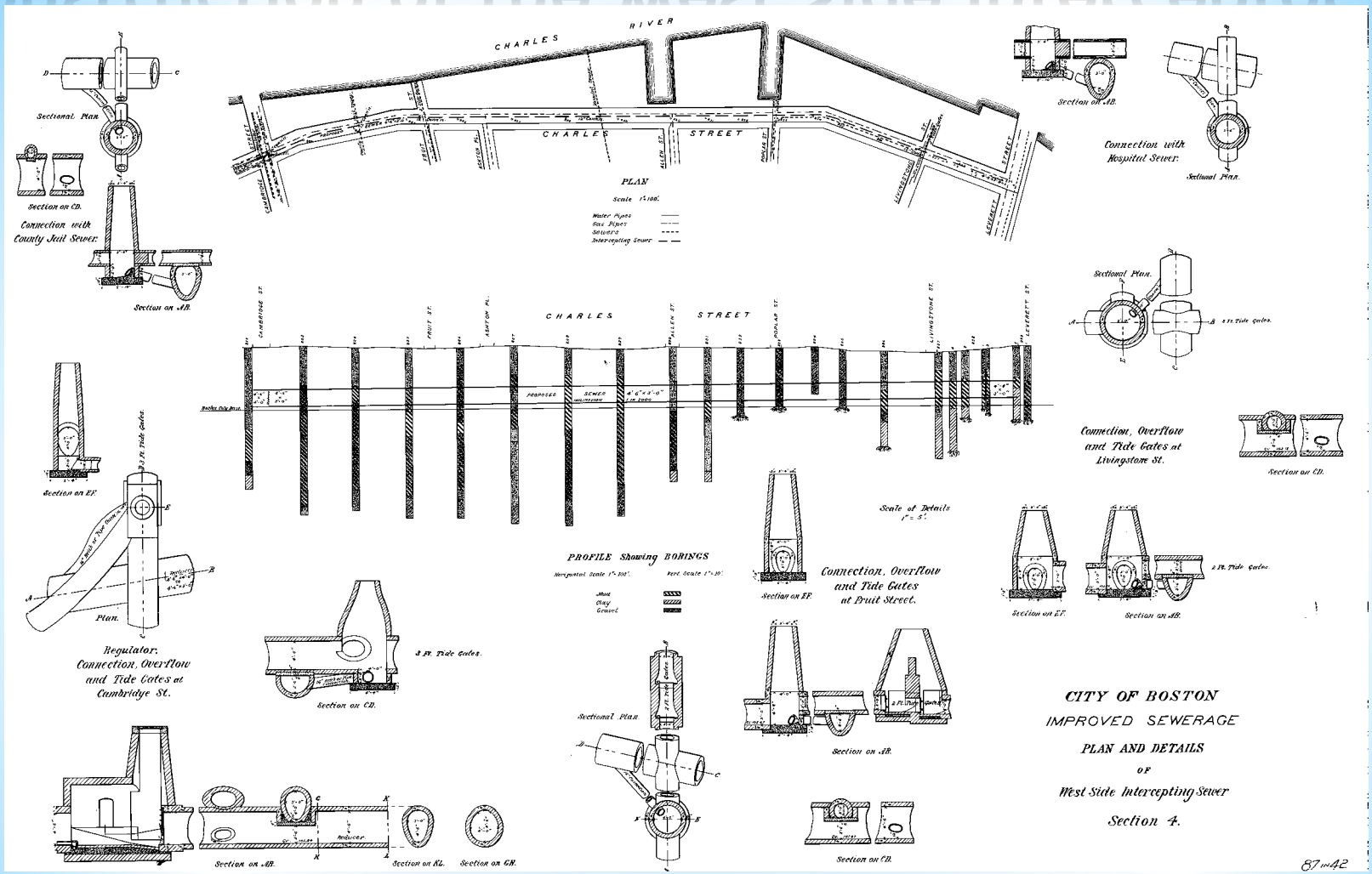
THE WEST SIDE INTERCEPTOR REHABILITATION BOSTON, MA

Construction of the West Side Interceptor



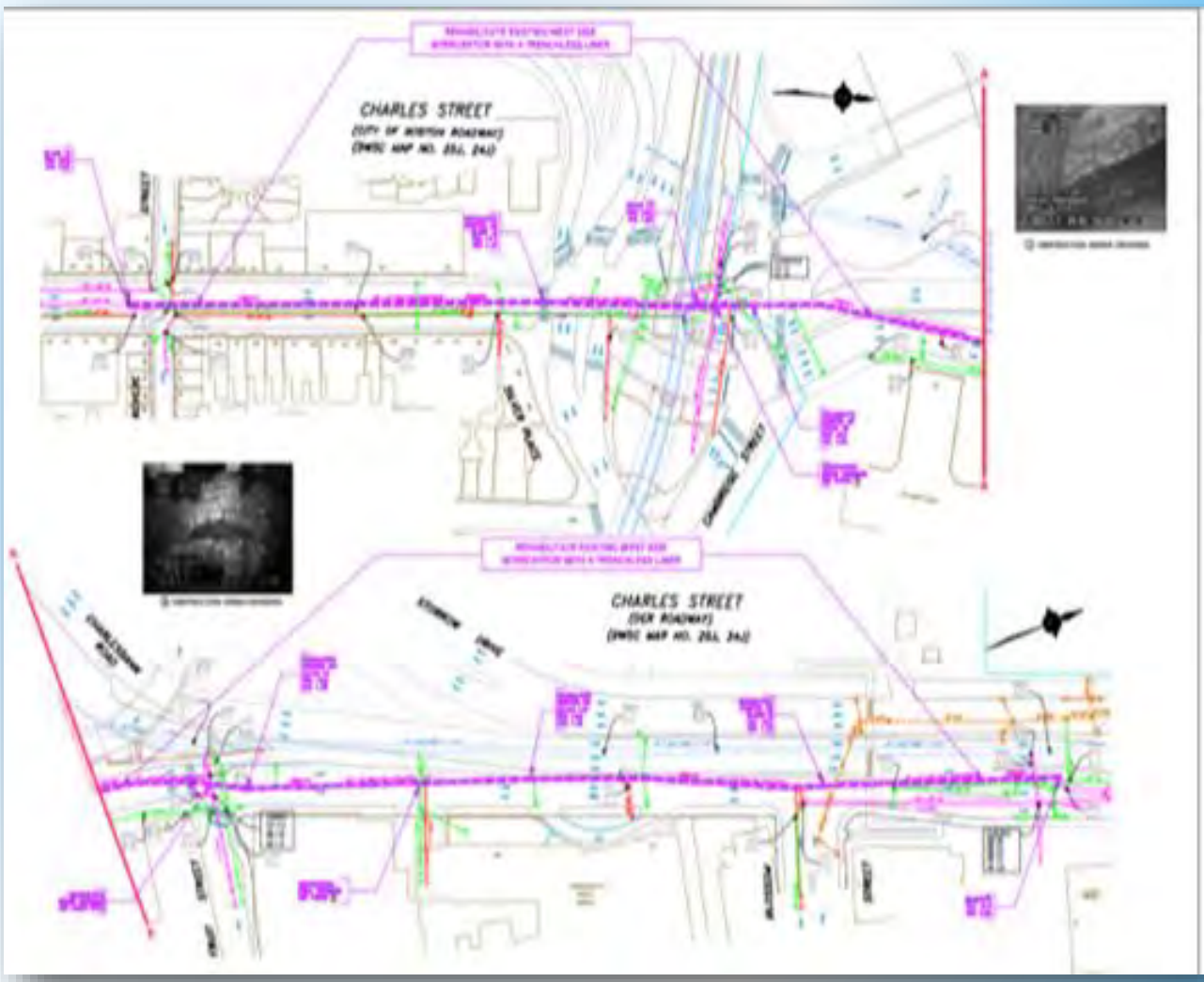
* Constructed in 1884 at a cost of $38,548.96 for 2,186’ - unit cost - $17.63 per foot

PROJECT LIMITS: Revere Street to Blossom Street

SCOPE OF WORK:

Cleaning & Lining

* 700’ of 48” x 54” brick combined sewer
* 1,450’ of 36” x 54” brick combined sewer
* Re**habilitation of Manholes**
  * 6 brick manholes
  * Depth - 17’
* Cost - $2.2 million
  * $1,000 per foot as compared to the original cost



TEAM MEMBERS

Boston Water and Sewer Commission

* Owner, Designer, and Construction Manager

General Contractor:

* RJV Construction
  * Bypass Installation
  * Access Points

Subcontractors:

* Insituform Technologies, LLC - *Resin Impregnated Liner*
* Quadex Lining Systems, LLC - *GeoKrete Geopolymer Liner*
* National Water Main Cleaning Company - *Cleaning & Inspection*
* Vortex Turnkey Solutions - *Sewer Bypass Design and Layout*

CRITICAL ABUTTERS & IMPACTS OF PROJECT

Busy, Busy, Busy …

- Massachusetts General Hospital
- Mass Eye & Ear Hospital
- Liberty Hotel – 5 Star (Previously the Suffolk County Jail)
- Access road to Storrow Drive, 6-lane highway
- Adjacent to Charles River and the Hatch Shell – home of the Fourth of July Events
- Red Line T Stop
- Closure of the Longfellow Bridge
- Restrictions: Days, nights, weekends only

PROJECT CONDITIONS

Issues Identified:

- Structural rehabilitation of **elliptical brick pipe**
- **Crack developing** in crown
- **Pipe obstructions** in the crown of the pipe
- **Pipe-size transition** mid reach
- **Maintaining flow** 24/7
- **Weather concerns** with combined system
- **Traffic impacts** and restricted hours
- **Red Sox** games
- **Hatch Shell** events – 4th of July
- **Accessing** Storrow Drive

PROJECT CONDITIONS

Due to proximity to Mass General Hospital, an extremely congested and mission critical area

- **Traffic impacts & restricted hours**
  - Initially restricted but impacting progress
- **Accessing Storrow Drive**
  - Diverting traffic around the work zone

Agencies required **Traffic plans**

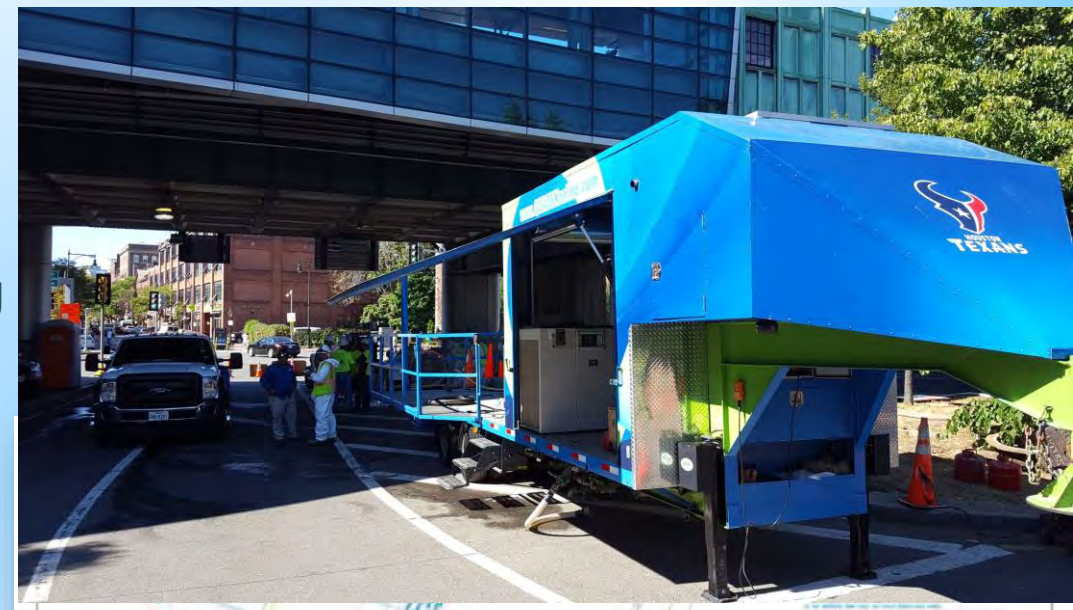
Multiple agencies - BTD, BPWD and DCR

Pedestrian traffic from MBTA Stop

Police details - State and Boston

Project Duration - 3 months

Summer 2016



PROJECT SETUP

- **Cleaning** combined sewer
- **Dye testing** to confirm active connections
- **Access** holes for sewer bypass connections
- **Coordinating** location of access points
- Set-up **primary and secondary pumps** for each service
  - Service Flows varied from 0.1 mgd to 0.5 mgd
  - Two 4” pumps – sound attenuating
- Coordinating **work zones** with deliveries to hospitals – 24/7 and tractor trailers
- Weekly project **meetings with abutters** to finalize work conditions
- 6 **Intermediate pumps** with 6” header; ~2.0 MGD dry flow
- **Overflow capacity** to Marginal conduit is 5 MGD for peak demand with a rain event

MGH Primary bypass

MGH 2nd bypass connection

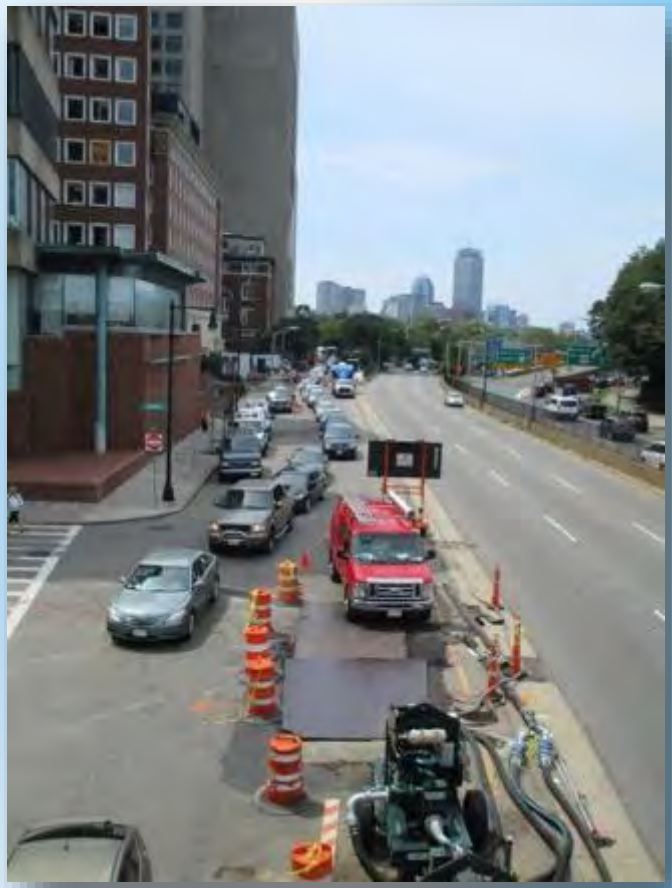
MASS EYE & EAR

SETTING UP THE PROJECT

Maintaining Blossom Street

Secondary ambulance entrance

Maintaining Charles Street



Safety and minimal, if any, disruption was always the goal!

PIPE CONDITIONS, INFILTRATION & OBSTRUCTIONS

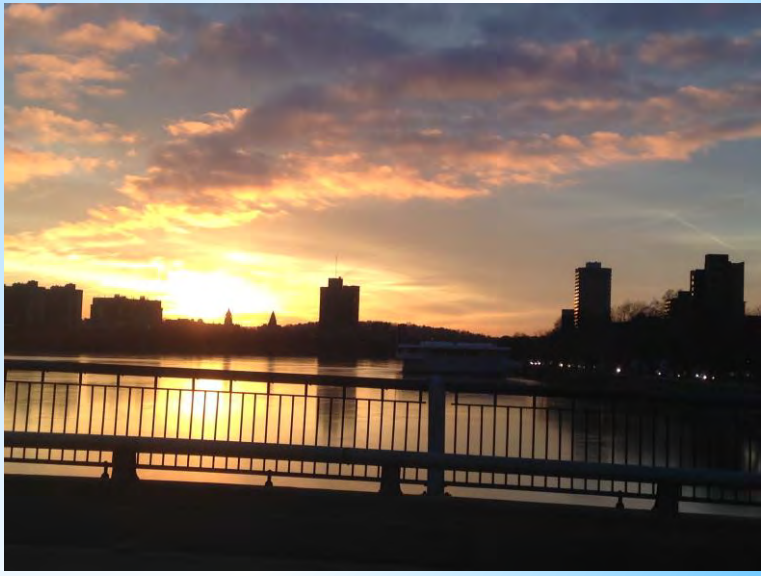
Infiltration issues throughout

Some obstructions could not be removed

Led to the selection of the Quadex Lining System featuring GeoKrete Geopolymer for unique conditions

INSTALLATION - *BACKGROUND*

- The combined sewer, known as the *West Side Interceptor*, controls flow from Beacon Hill and the West End of Boston
- Contributing flow includes the "TD Garden"
  - home of the Celtics and the Bruins
- Majority is a combined sewer system
- During major rain events the system did surcharge
- Bypassing of the base flow
- Work not allowed during rain events
  - can have unanticipated thunderstorms
- Need for multiple technologies



SCOPE OF WORK: INSITUFORM TECHNOLOGIES, LLC.

- Work was done at night and over weekends
- Congested residential area
- Inversion to completion
  - 18 hours
- Liner thickness
  - 48”x54” - 22.6 mm
  - 36”x54” – 27.6 mm
- Five inversions
- Bypass systems in place

ENGINEERING THE LINER THICKNESS

- Insituform's Criteria
  - CIPP Design per ASTM F1216
    - ✓WRc Type II Design
    - ✓300,000 psi Flexural Modulus (250,000 psi required)
    - ✓4,500 psi Flexural Strength
    - ✓3,000 psi Tensile Strength
    - ✓Soil Load – 120 pcf
    - ✓Live Load – HS-20
    - ✓Groundwater – 8'-9' above
    - ✓Factor of Safety – 2

LINER MATERIAL CONSIDERATIONS

Quadex's GeoKrete Geopolymer:

- Field friendly
- Precision mixed
- Corrosion resistant
- High strength
- Easy application
- Quick cure times
- Flexible with weather conditions

SCOPE OF WORK:
QUADEX LINING SYSTEMS, LLC.

Requirements to complete project:

- Limited working hours
- Work in hospital district
- Liner thickness
* Two runs
* Bypass systems in place

DEFINING A GEOPOLYMER

- The term *geopolymer* is typically used when describing the amorphous to crystalline reaction produced from the synthesis of alkali aluminosilicates with alkali hydroxide/ silicate solution.
- A geopolymer is formed when you combine an aluminosilicate powder with an alkaline solution.

ENGINEERING THE QUADEX LINER THICKNESS

- CIPP Design per ASTM C1216
- Liner Thickness of 36”x54” – 41mm
- Geopolymer Design tailored to project particulars using industry accepted design approaches, including:
  - ✓WRc Type II Design
  - ✓Approximate Closed Form Tunnel Design
  - ✓Three-Dimensional Finite Element Analysis
  - ✓2,500,000 psi Flexural Modulus (250,000 psi required)
  - ✓1,300 psi Flexural Strength
  - ✓Soil Load – 120 pcf
  - ✓Live Load – HS-20
  - ✓Groundwater – 10’ above
  - ✓Factor of Safety – 2

ENGINEERING THE QUADEX LINER THICKNESS

Physical Properties	ASTM Reference	Requirements
Compressive Strength	ASTM C 39 / C 109	Min. 8,000 psi @ 28 days
Flexural Strength	ASTM C 78 / C 293	Min. 800 psi @ 28 days
Density	ASTM C 138 / C 642	Dry 80 - 100 lb/ft^3 Wet 100 - 120 lb/ft^3
Chemical Resistance, Sulfuric Acid pH 1.0	ASTM C 267	Max 2% mass loss @ 8 weeks
Modulus of Elasticity	ASTM C 469	Min. 5,400,000 psi @ 28 days
Split Tensile Strength	ASTM C 496	Min. 900 psi @ 28 days
Freeze Thaw Durability	ASTM C 666	Max 0.1% Loss @ 300 cycles
Bond Strength to Concrete	ASTM C 882	Min. 3,000 psi @ 28 days
Shrinkage Test	ASTM C 1090	Max 0.02% @ 28 days
Abrasion Resistance	ASTM C 1138	Max 1.5% Weight Loss @ 6 cycles on 28 day sample
Rapid Chloride Ion Permeability	ASTM C 1202	Very Low @ 28 days

STRUCTURAL RENEWAL

Liner application at Obstruction

Manhole Rehabilitation

STRUCTURAL Quality Control

Quality Control and Testing of Quadex Liner – Required Strength of 8,000 psi

Of Massachusetts
"The Construction Testing People"

5 Richardson Lane, Stoneham, MA 02180 781-438-7755 (Voice) 781-438-6216 (Fax)

Compressive Strength Report - Concrete

Distribution Copy

Report Date	07-20-2016
Report No.	1
Job Number	19885
Project	Charles St Sewer Rehab 245 Charles St. Boston, MA
Contractor	Quadex Lining Systems
Concrete Co.	On site

ALL FIELD TESTS DONE ACCORDING TO ASTM: C-172 C-31 C-143 C-1064

ALL COMPRESSIVE STRENGTH TESTS DONE ACCORDING TO ASTM: C-39 C-1231

CLASS CONCRETE: 8000# | **No. Of Sets:** 1 | **CUBIC YARDS:**

SET 1 LOCATION: Sewerage sanitary line

Lab No.	Size (in.)	Area (sq. in.)	Condition	Date Cast	Date Tested	Age Days	Total Load (lbs.)	Unit Load (psi.)	Fracture Type
R335	4.00 x 8.00	12.57	Good	07/20/16	07/26/16	6	100,000	7,960	1
R336	4.00 x 8.00	12.57	Good	07/20/16	07/27/16	7	105,000	8,350	1
R337	4.00 x 8.00	12.57	Good	07/20/16	08/03/16	14	125,000	9,940	1
R338	4.00 x 8.00	12.57	Good	07/20/16	08/17/16	28	138,000	10,980	1
R339	4.00 x 8.00	12.57	Good	07/20/16	08/17/16	28	141,000	11,220	2
R340	4.00 x 8.00	12.57	Good	07/20/16	08/17/16	28	140,000	11,140	1

Slump (in.)	
Air Temp. (F.)	78
Conc Temp (F)	83
Truck No.	
Ticket No.	
Time	2:00
Unit Wt lbs/cu ft	
Air Content (%)	

CONCLUSION

* The geopolymer liner provided a cost effective solution to rehabilitating two difficult and distinct sections of variable size sewers in the City of Boston.
* The Insituform liner provided a complete restoration of our standard combined sewer system in tight conditions.
* Sometimes multiple technologies is the best solution.

Boston Water and Sewer Commission
980 Harrison Ave. Boston, MA 02119

COOPERSTOWN, NY
NOV 15-16
NASTT
NORTHEAST REGIONAL CHAPTER
TRENCHLESS CONFERENCE

*We believe we hit a home run on this project!