

Boston Groundwater Trust (BGwT)

Wood Piles & Groundwater

The Important Relationship



Who we created us?



- *BGwT was established by the Boston City Council in 1986*
- *Trustees are appointed by the Mayor*
- *Funded by the City of Boston*



What we do....



- *Maintain and monitor a network of over 800 groundwater observation wells*
- *Review well readings and identify problem areas*
- *Work with City & State agencies to remedy problems*

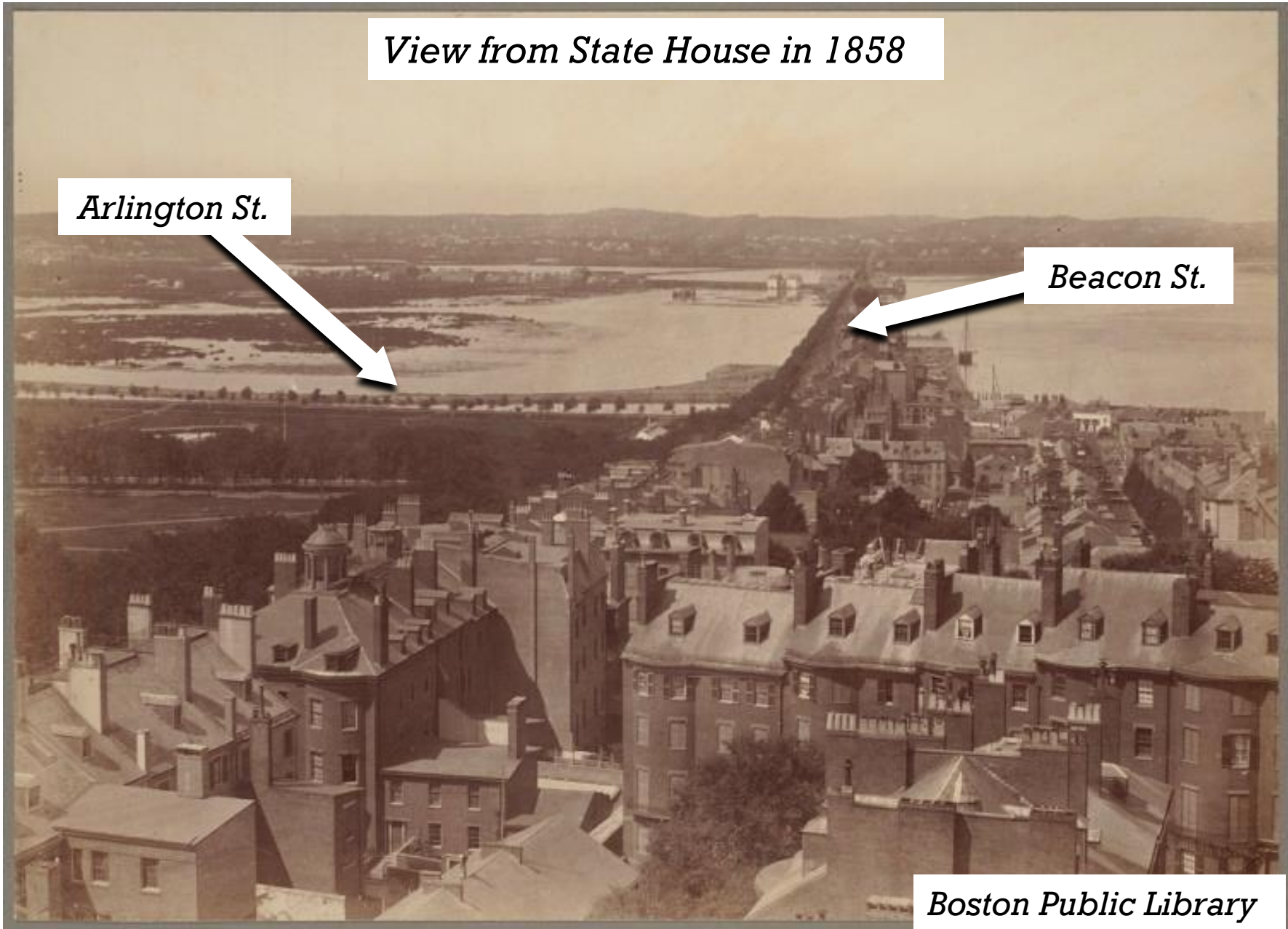


What did Boston look like prior to filling?

View from State House in 1858

Arlington St.

Beacon St.



Boston Public Library

What did Boston look like during filling?

6 days a week, 24 hours a day, it took 30 years to fill Back Bay and Fenway.

Three 35-car trains arrived every 45 minutes.

*Rate of filling was approximately **2,500 cu.yd./day**.*

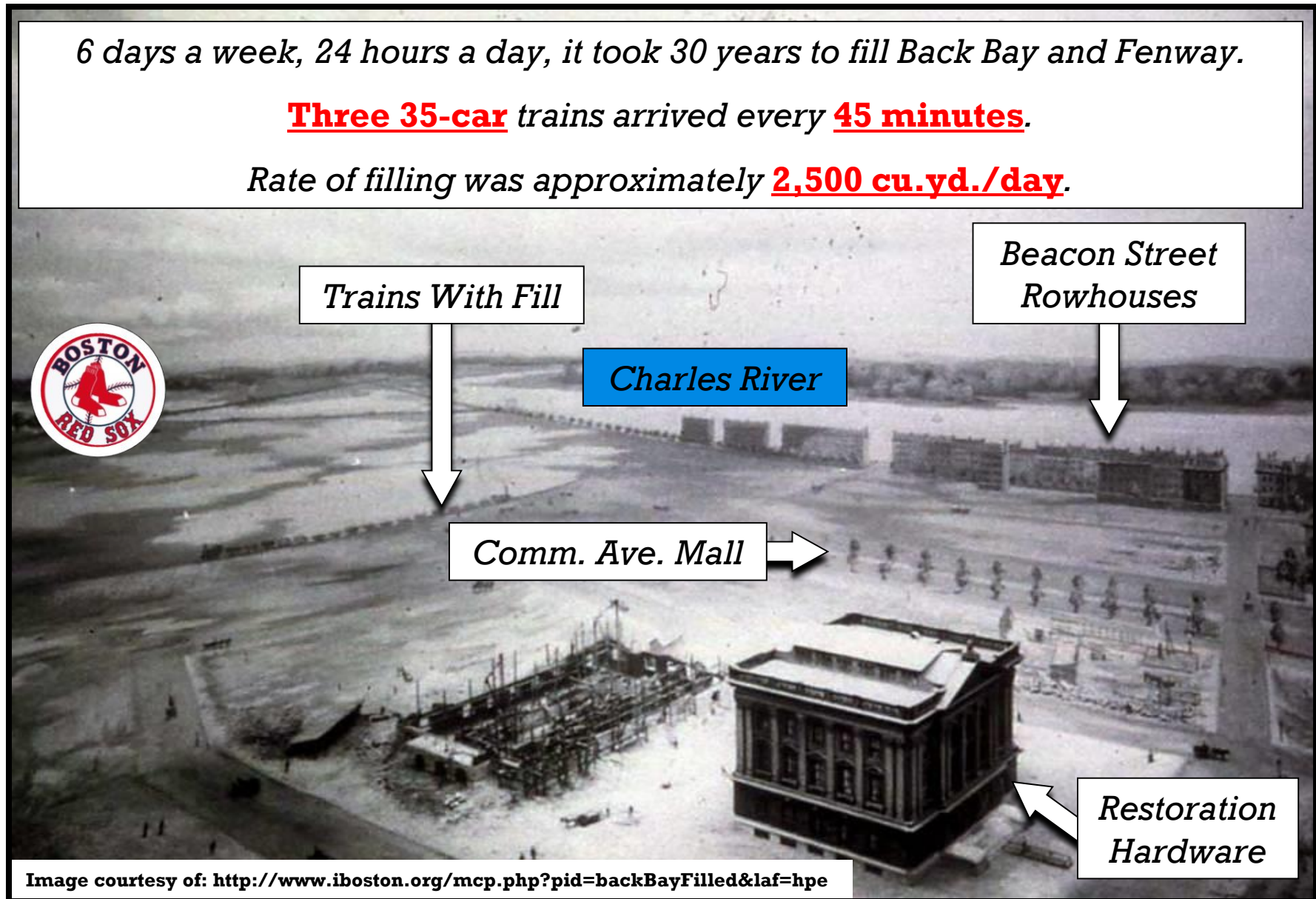
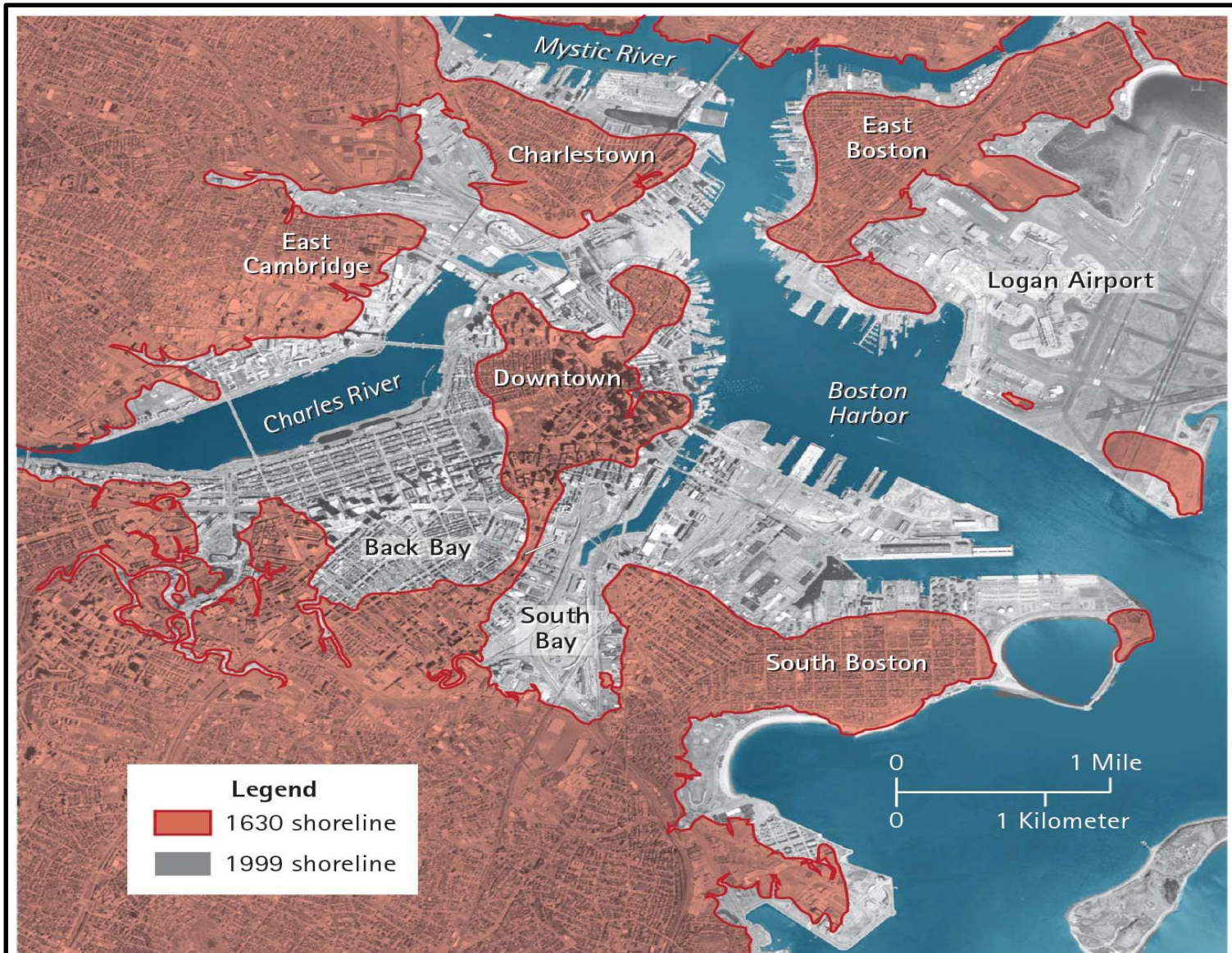


Image courtesy of: <http://www.iboston.org/mcp.php?pid=backBayFilled&laf=hpe>

Boston Today



NEWEA
WORKING FOR WATER QUALITY



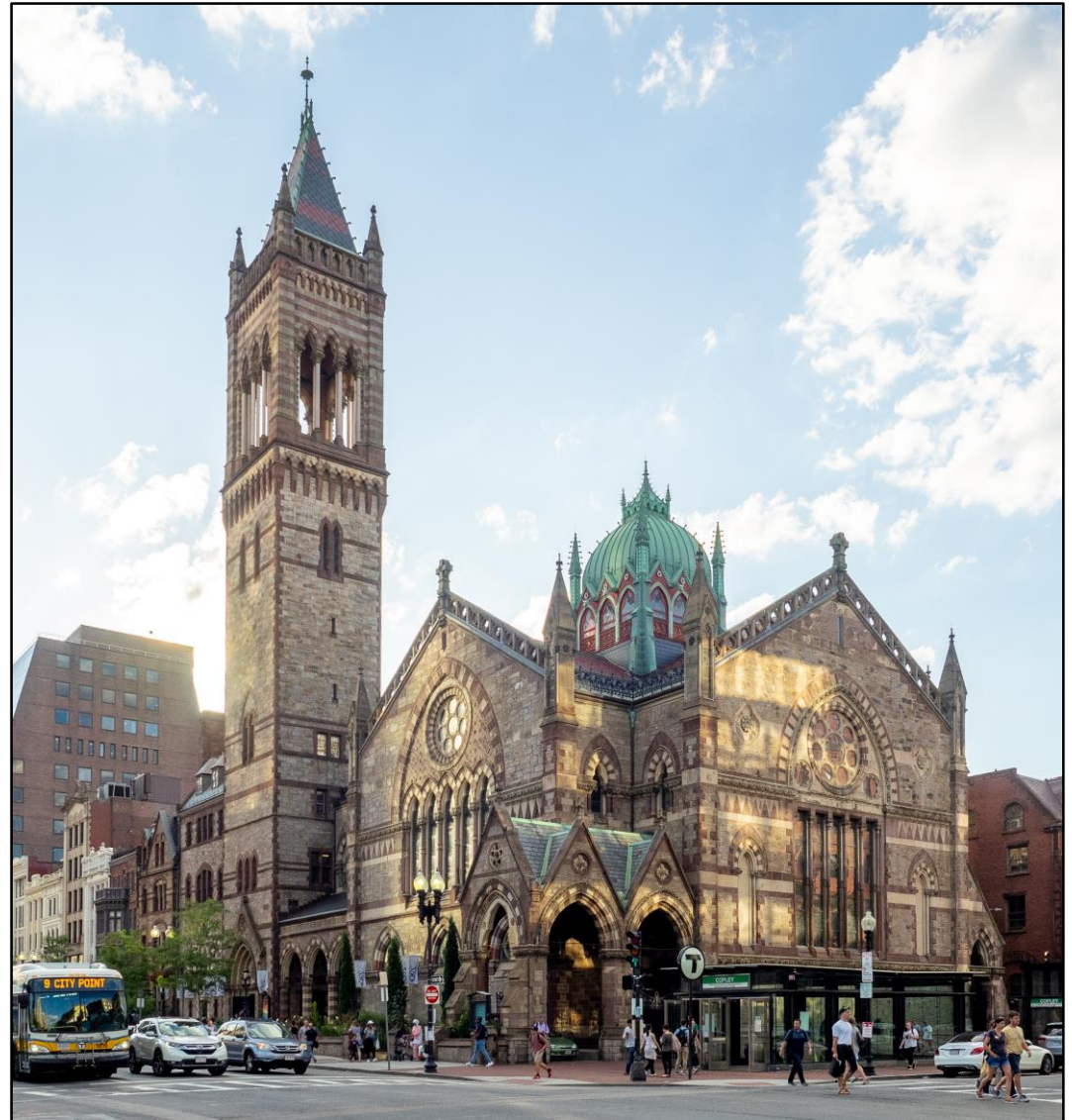
Source: Adapted from Weiskel, Peter K., Lora K. Barlow, and Tomas W. Smieszek. *Water Resources and the Urban Environment, Lower Charles River Watershed, Massachusetts, 1630–2005*. U.S. Department of the Interior, United States Geological Survey, in cooperation with the U.S. Environmental Protection Agency and the Massachusetts Department of Environmental Protection (2005), Circular 1280, Figure 9, p16.

Not just rowhouses....

Trinity Church, Back Bay



Old South Church, Back Bay



Not just rowhouses....



NEWEA
WORKING FOR WATER QUALITY

Lenox Hotel, Back Bay



BPL, McKim Building, Back Bay



Not just rowhouses....

Custom House Tower, Waterfront



Christian Science Mother Church, Fenway



Why were we established?

Is the Back Bay Sinking?

Beacon Hill Buildings Called 'Unsafe' From Water Table Damage

70 house foundations crumbling due to water problems

BEACON HILL'S CRACKING UP

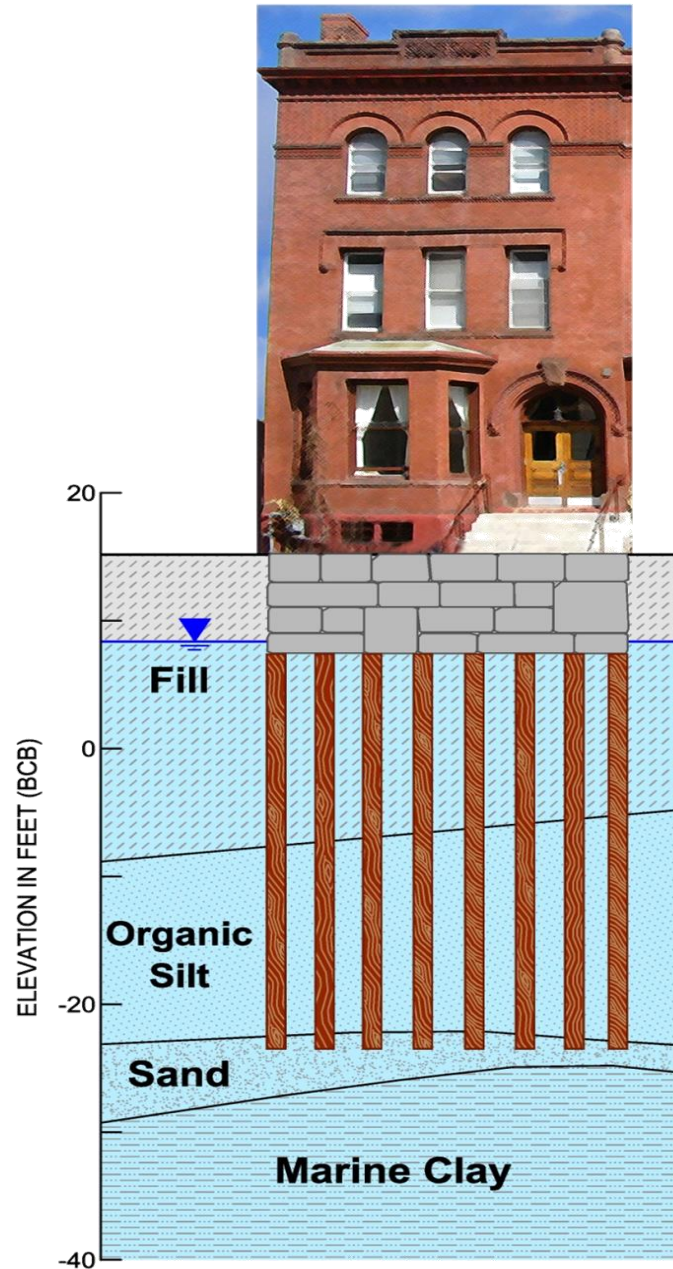
Sinking feeling hits owners of elegant homes on Beacon Hill

Rotting pilings unsettle Beacon Hill

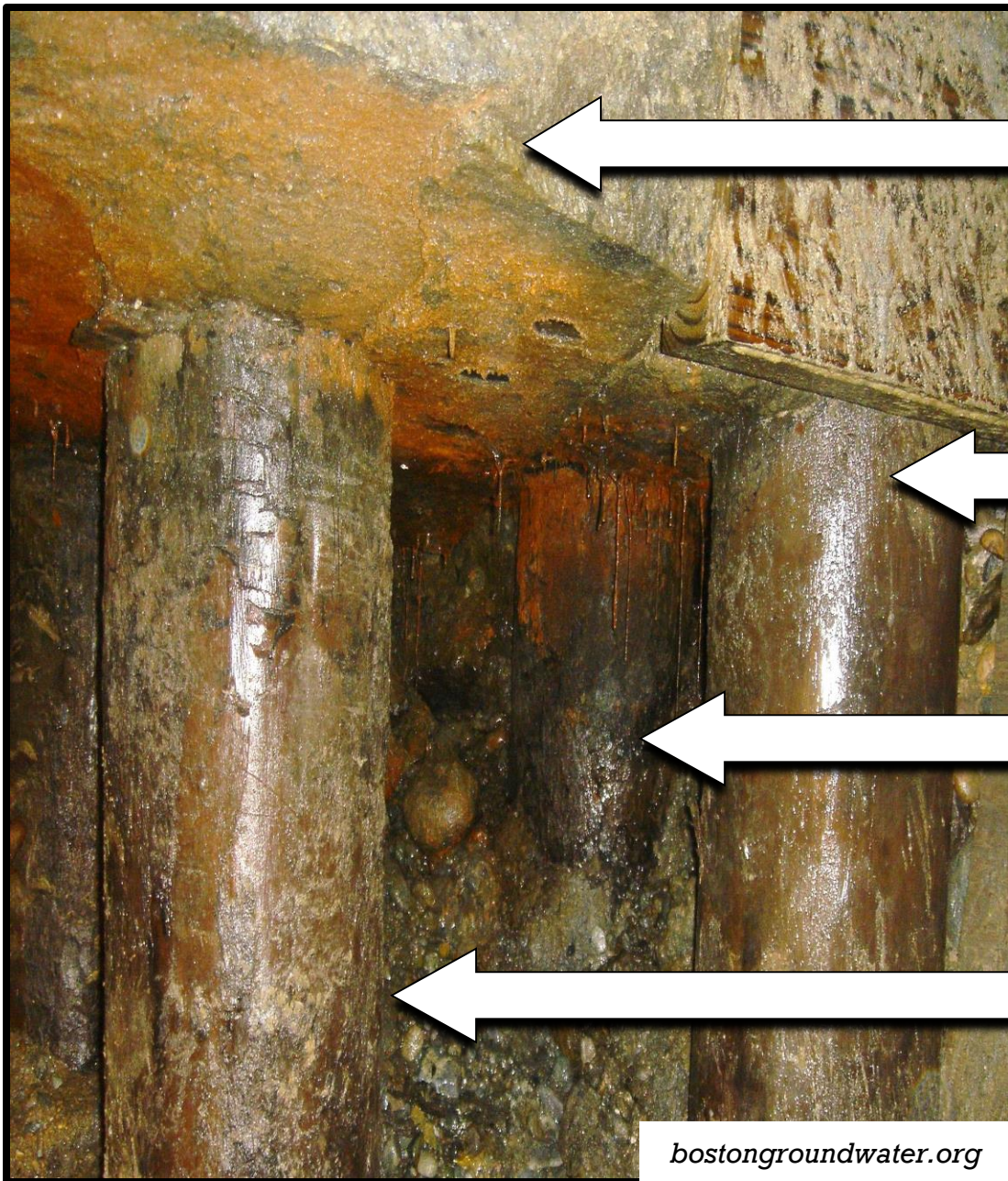
Boston's Beacon Hill on shaky ground

Owners rush to save expensive, century-old homes as foundations collapse

Typical Rowhouse: Ideal Conditions



Sound Wood Piles



Granite Pile Cap



Sound Wood Pile

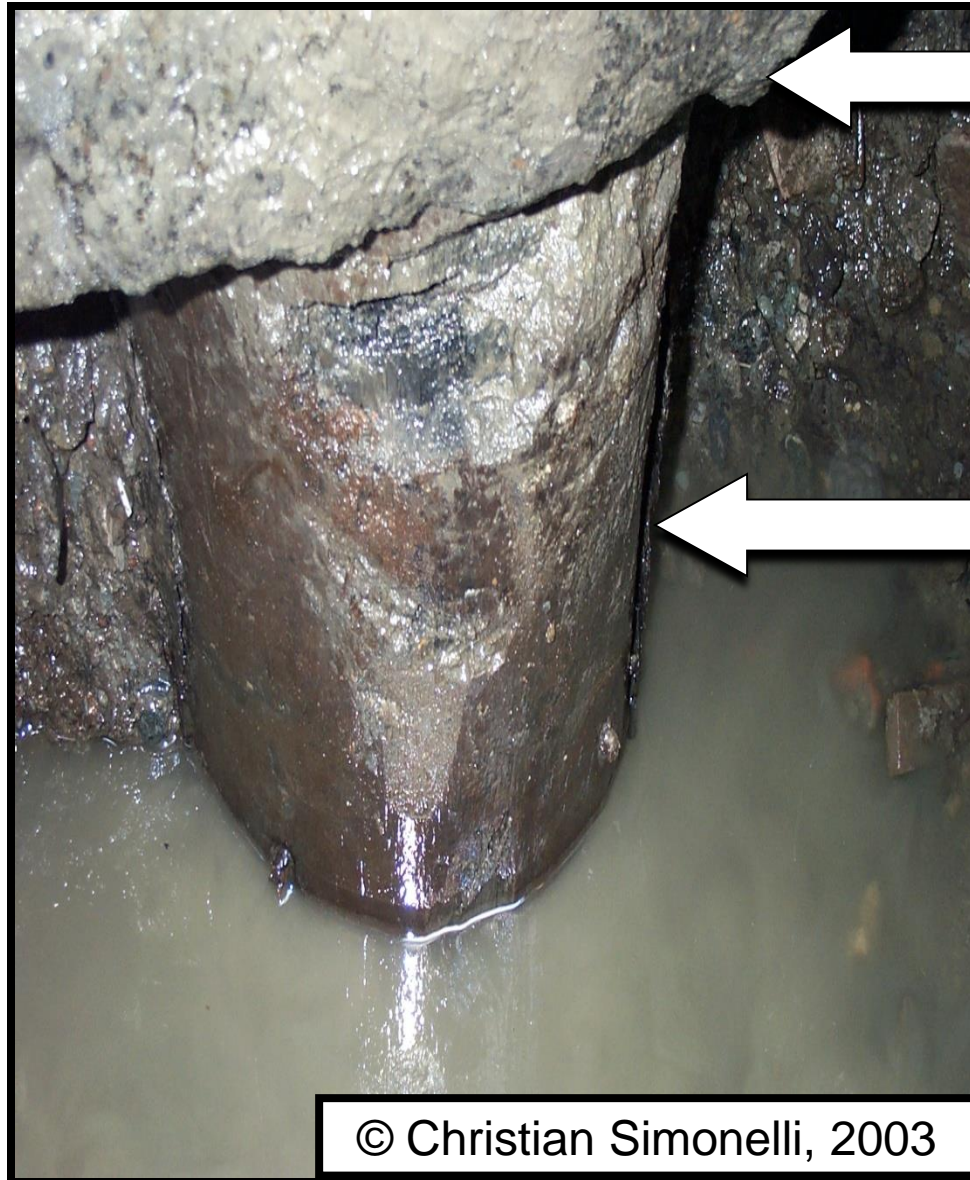


Sound Wood Pile



Sound Wood Pile

Sound Wood Pile

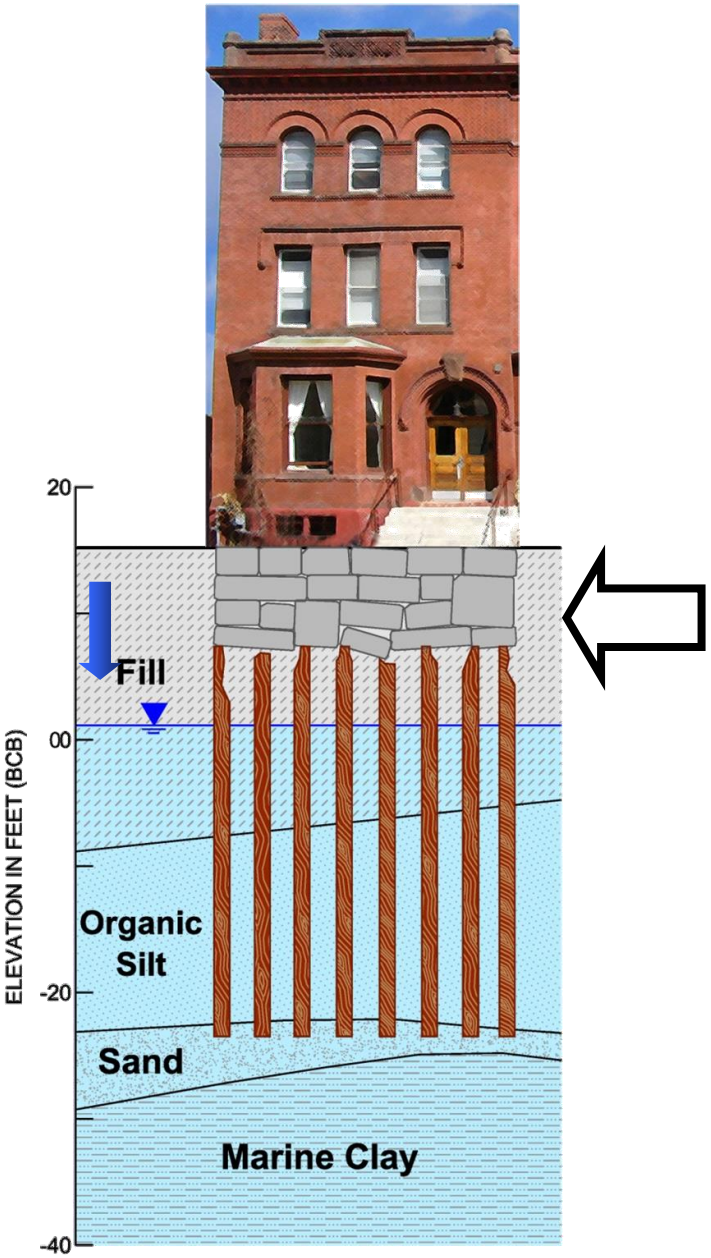


Granite Pile Cap

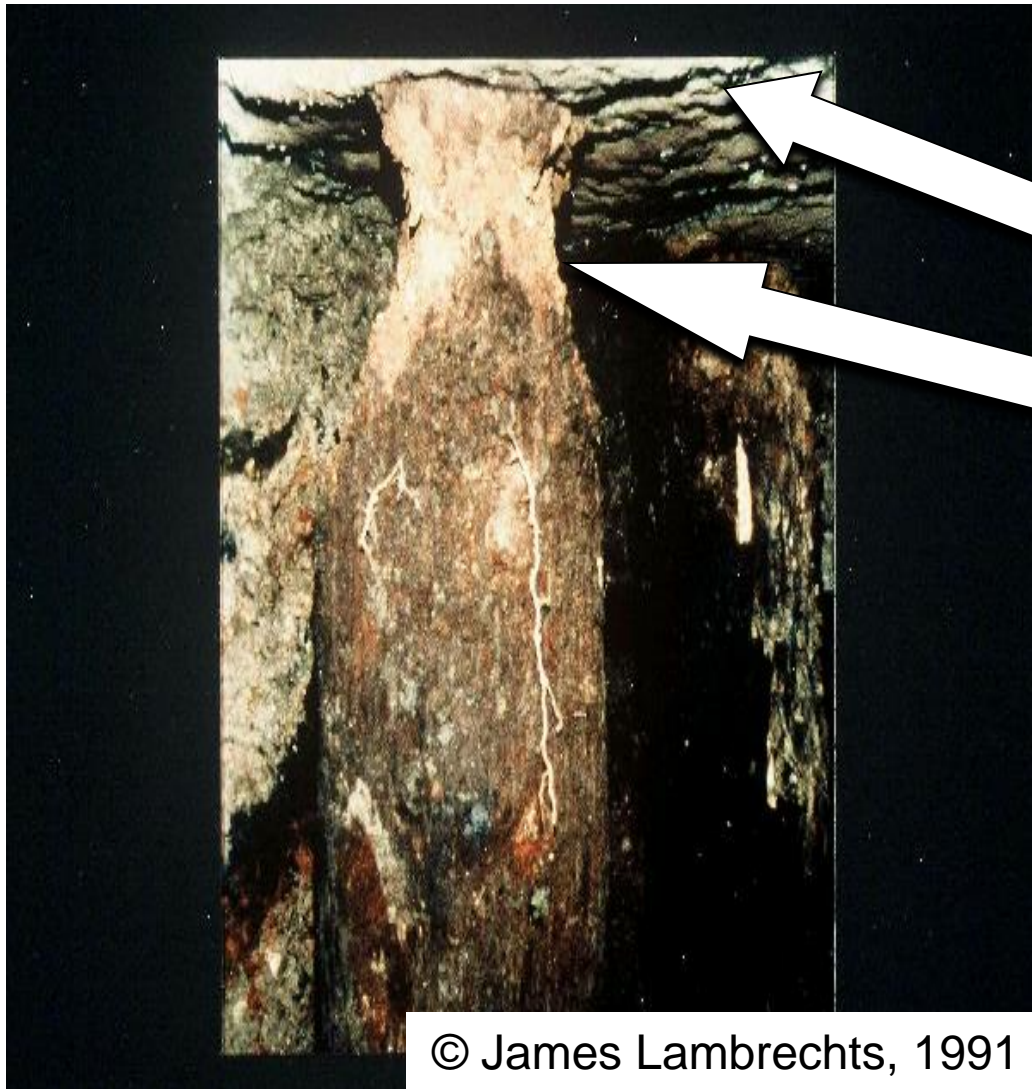
Good Wood Pile

© Christian Simonelli, 2003

Typical Rowhouse: Problematic Conditions



Rotted Wood Pile



Granite Pile Cap

*Bad
(partially rotted)
Wood Pile*

© James Lambrechts, 1991

Rotted Wood Piles



Rotted Wood Piles



NEWEA
WORKING FOR WATER QUALITY



bostongroundwater.org

Signs of settlement



Signs of settlement

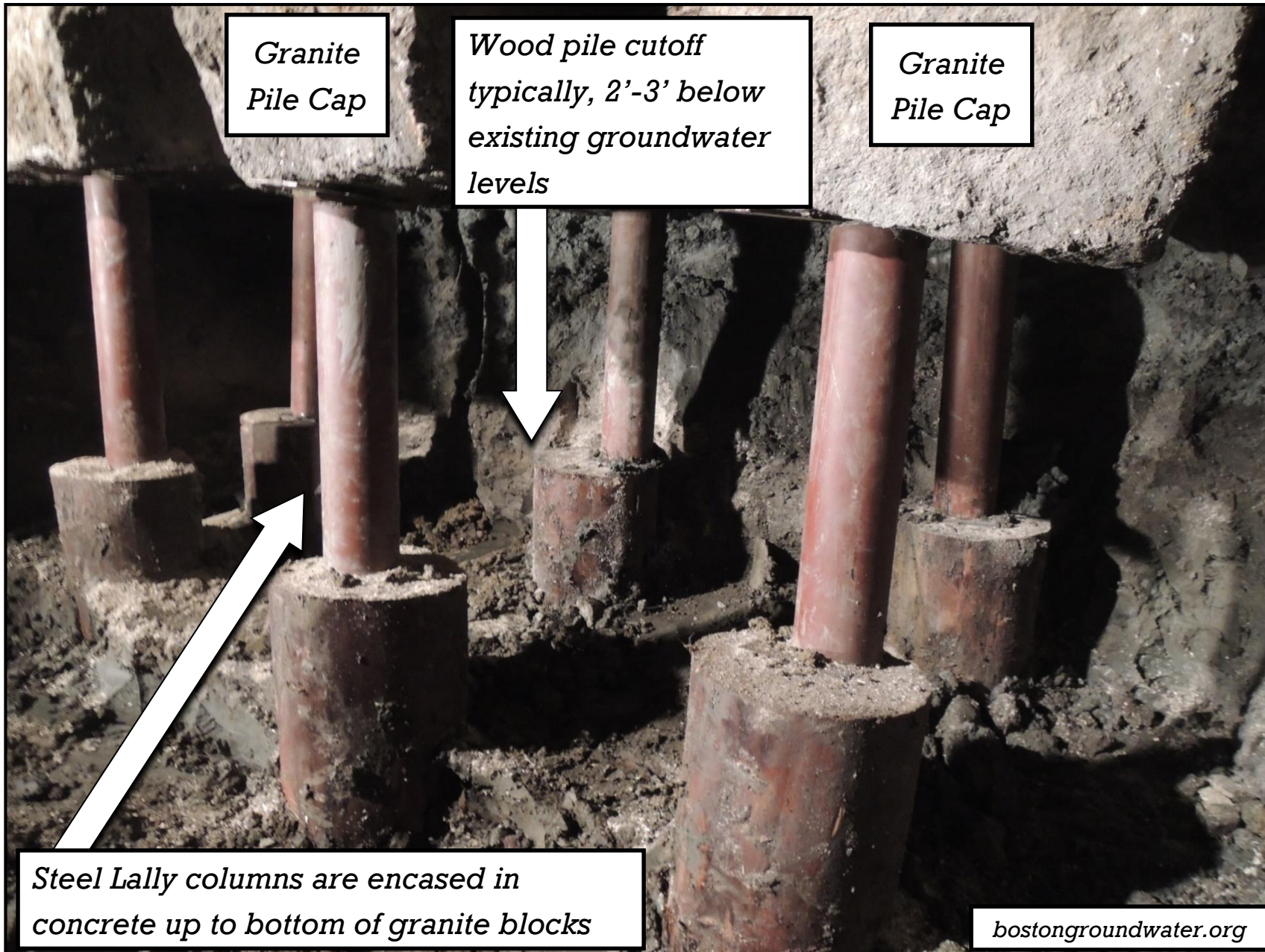


What's the fix?



NEWEA
WORKING FOR WATER QUALITY

Underpinning: Cut and Cap

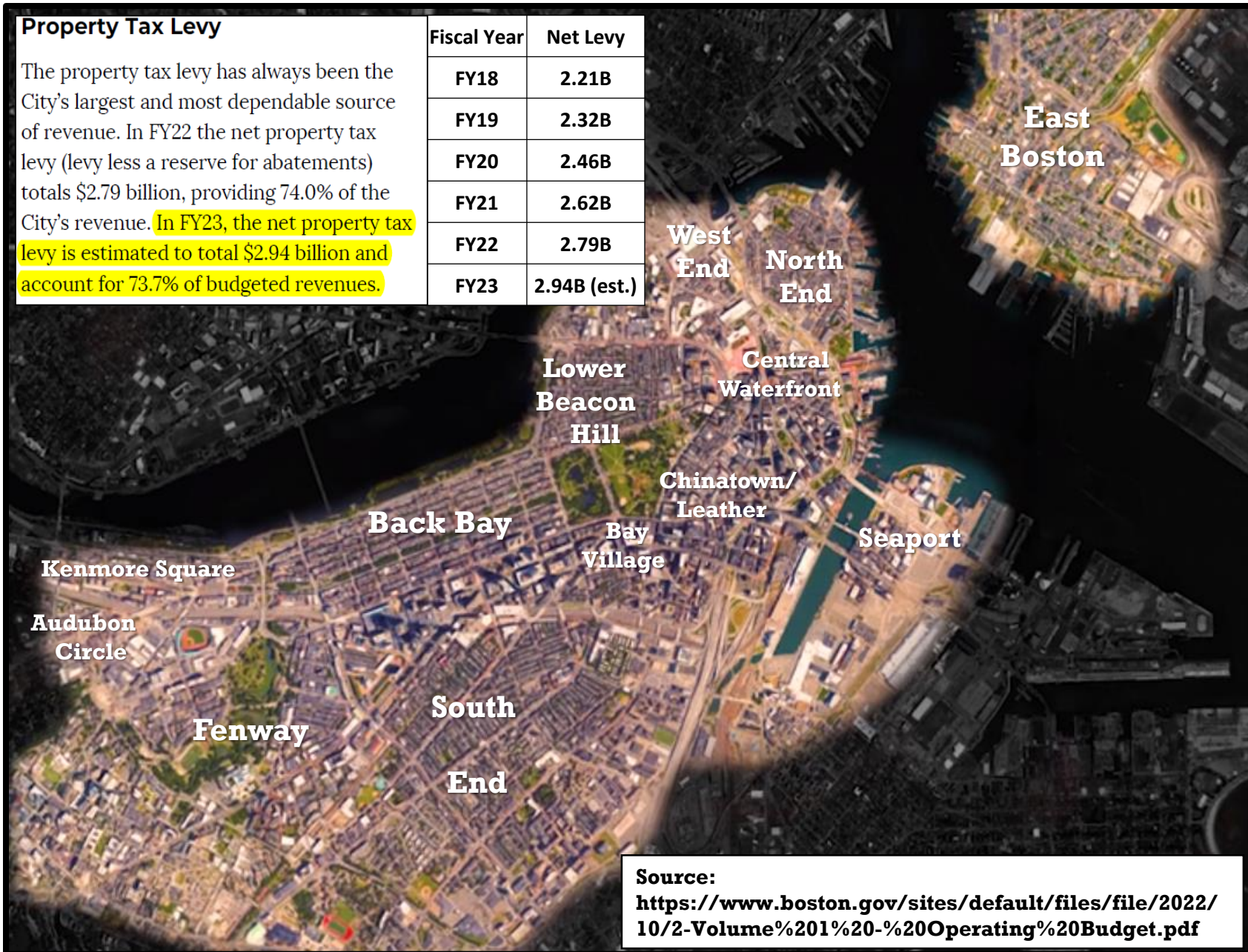


What is at risk?

Property Tax Levy

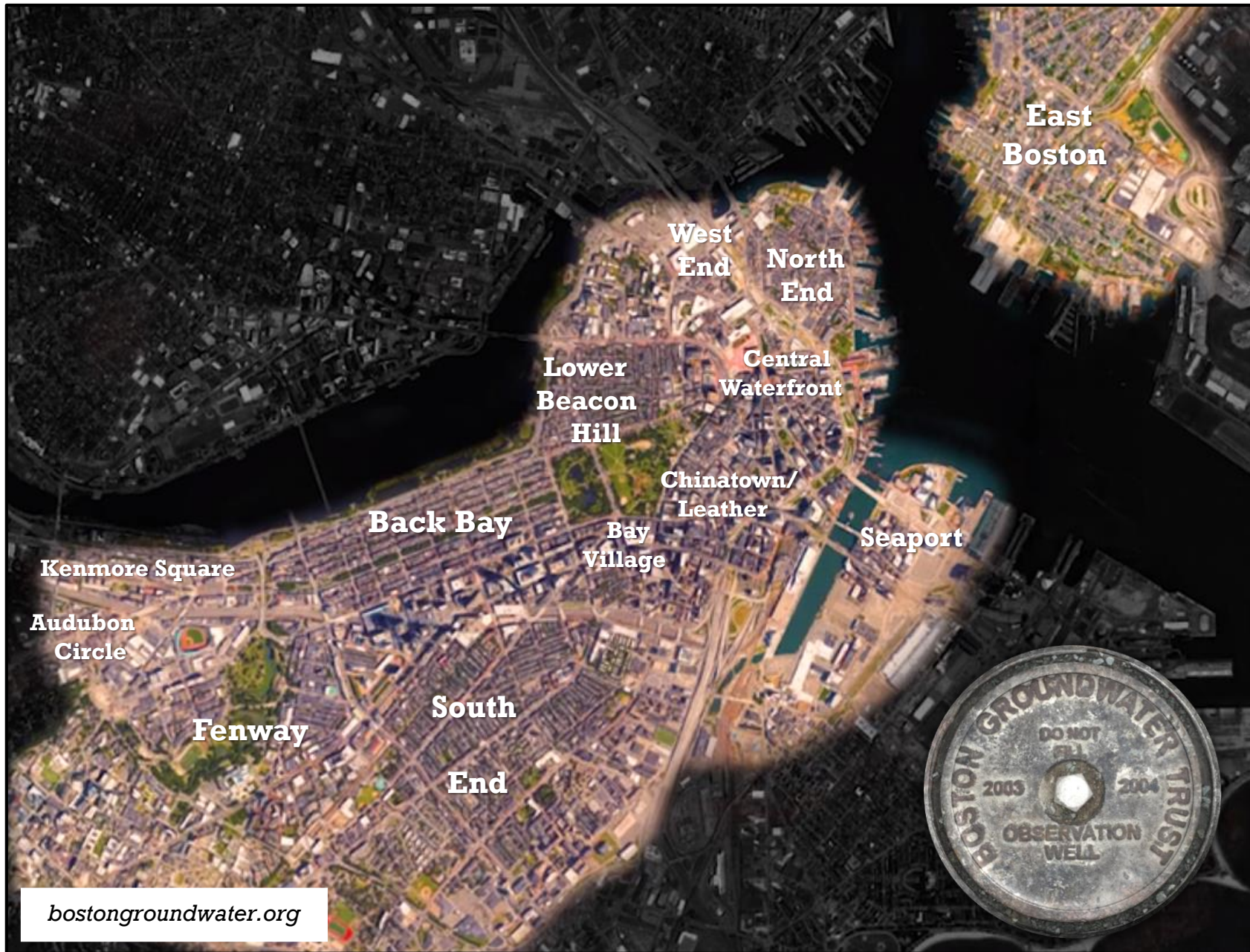
The property tax levy has always been the City's largest and most dependable source of revenue. In FY22 the net property tax levy (levy less a reserve for abatements) totals \$2.79 billion, providing 74.0% of the City's revenue. In FY23, the net property tax levy is estimated to total \$2.94 billion and account for 73.7% of budgeted revenues.

Fiscal Year	Net Levy
FY18	2.21B
FY19	2.32B
FY20	2.46B
FY21	2.62B
FY22	2.79B
FY23	2.94B (est.)



Source:
<https://www.boston.gov/sites/default/files/file/2022/10/2-Volume%201%20-%20Operating%20Budget.pdf>

Monitoring Area



bostongroundwater.org

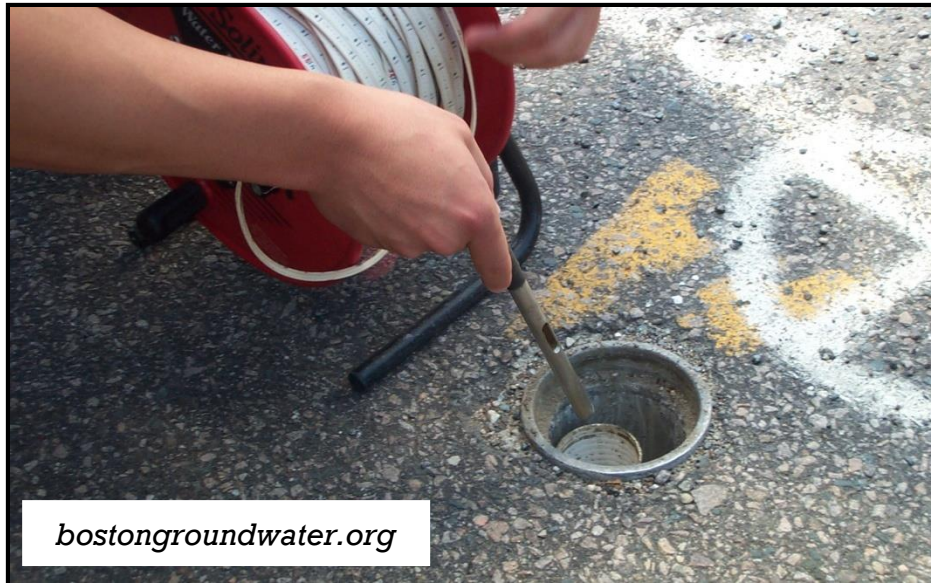
How does BGwT monitor levels?

- *A network of approx. 800 observation wells throughout the filled land areas of the city*

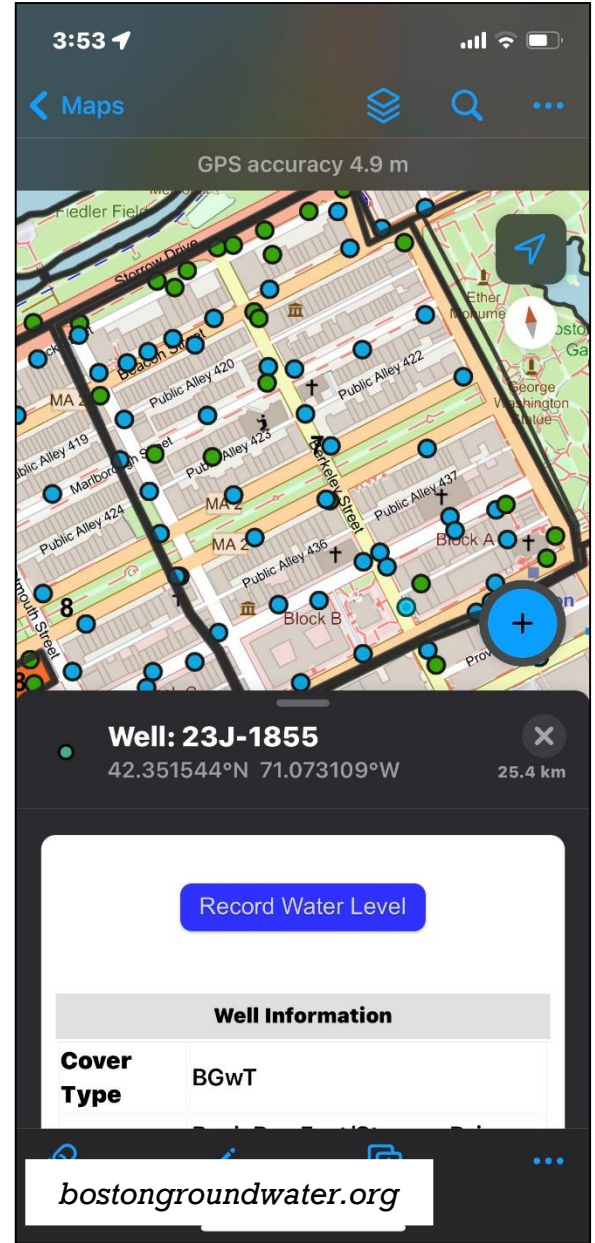
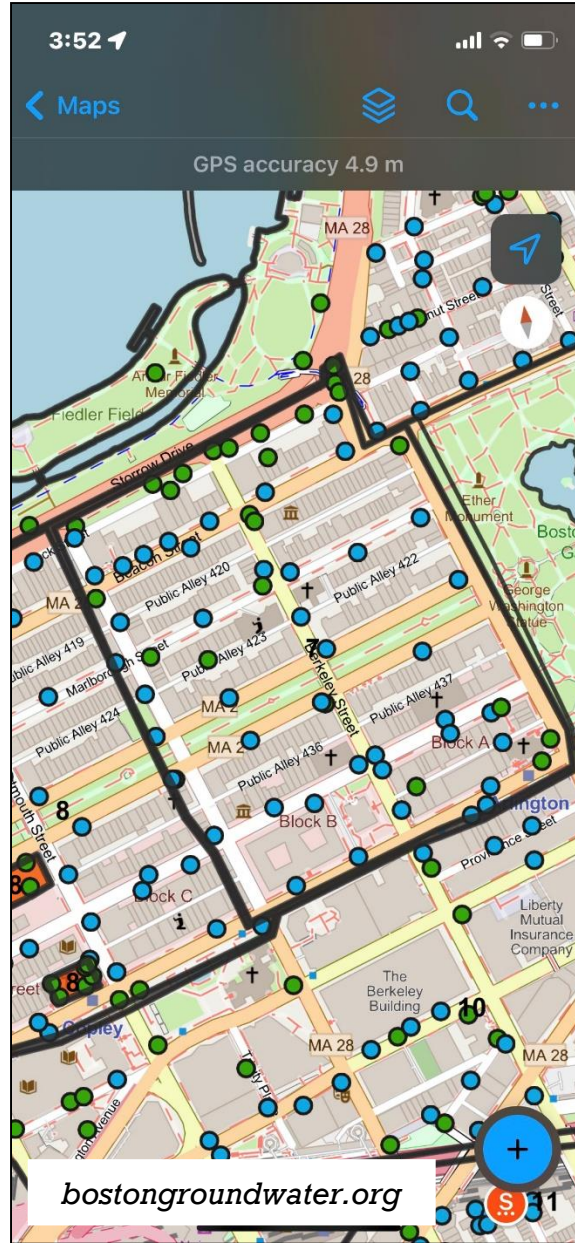
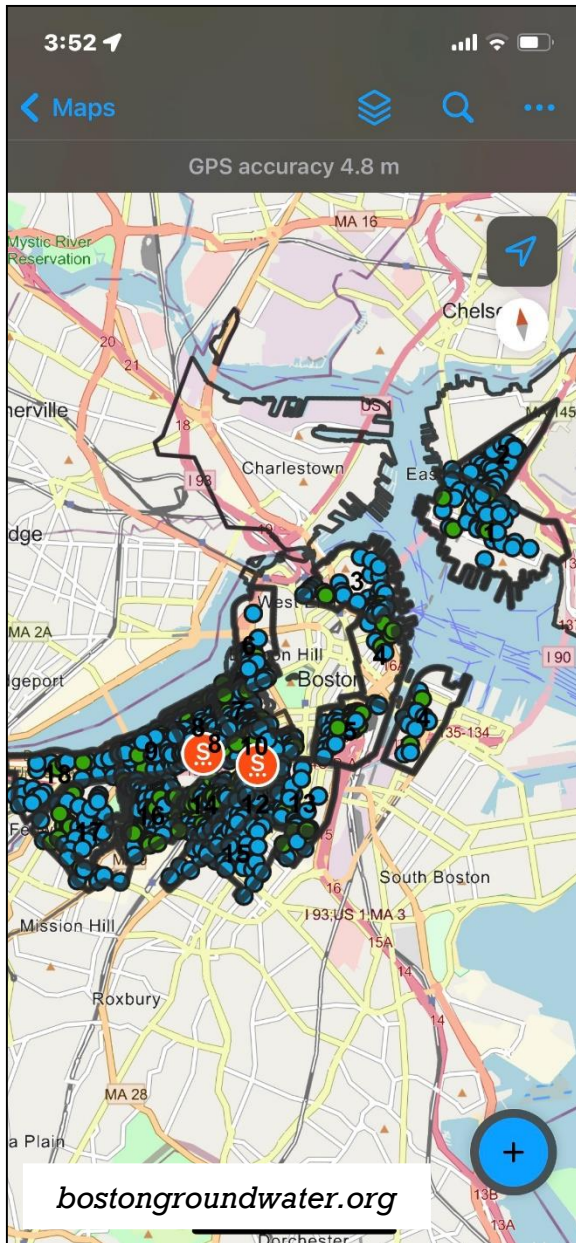


Measuring an OW

- *Pipe is placed in the fill to measure levels*
- *Use a water level indicator as shown below*



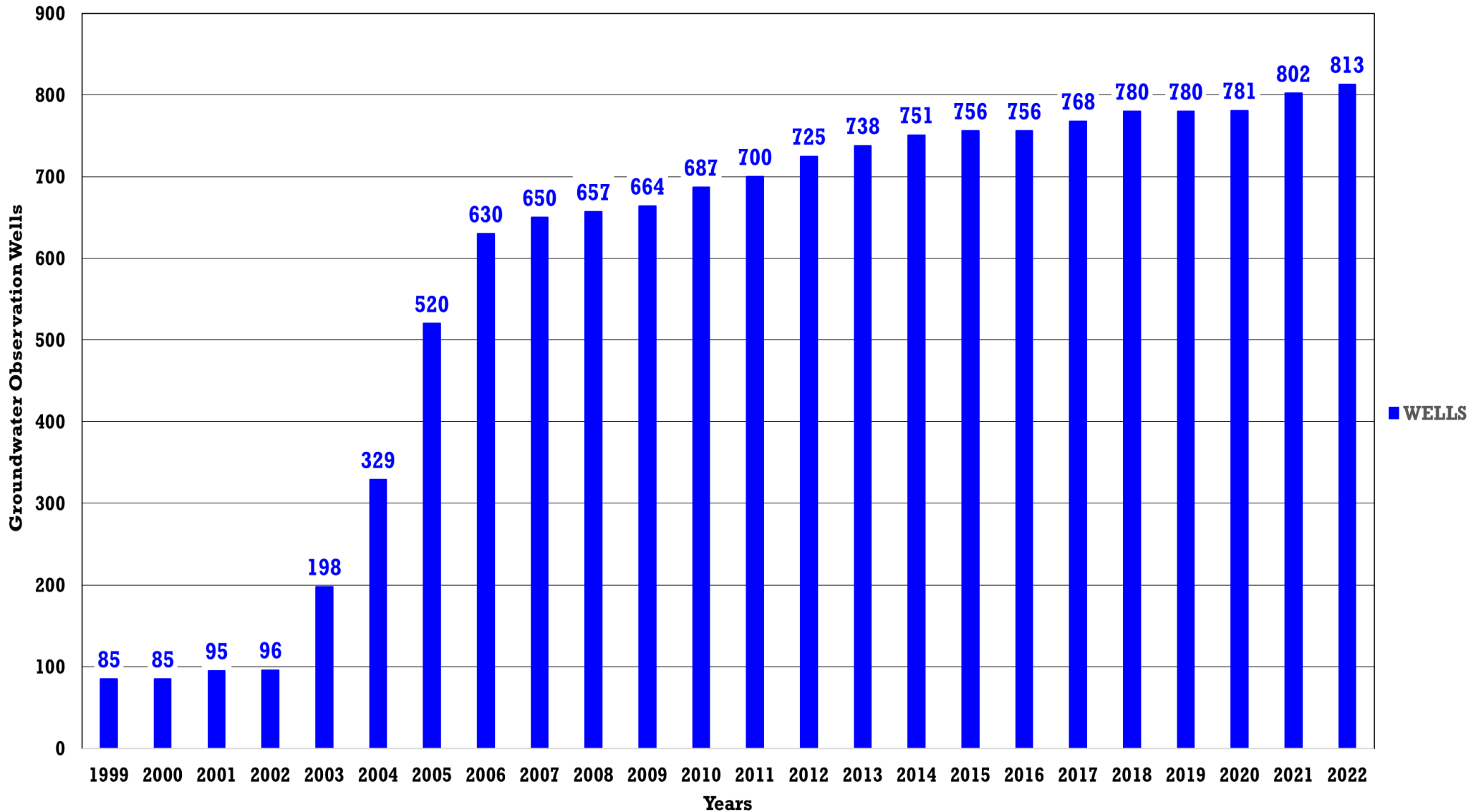
Observation Well App



Well network since 1999



Boston Groundwater Trust (BGwT): Groundwater Observation Well Network Over the Years



Observation Well & Building Foundation Information Center



BOSTON GROUNDWATER TRUST (BGwT) OBSERVATION WELL AND BUILDING FOUNDATION INFORMATION CENTER

Select well on map to view latest and historical readings.

Well #22H-2792

Corner of Peterborough St. and Park Drive, adjacent to 15 Peterborough St.

Elevations referenced to Boston City Base Datum (ft.)

Date	Elev. (ft) ¹
12/30/22	7.70
11/04/22	7.22
08/29/22	7.10
07/14/22	7.15
06/06/22	7.35
04/26/22	7.70
02/24/22	7.80
12/04/21	7.25
10/14/21	7.60
08/29/21	7.40
06/23/21	7.50
04/20/21	7.70
03/04/21	7.67
12/09/20	7.84
11/05/20	7.29
10/01/20	6.83
09/10/20	6.81
08/11/20	6.92
07/02/20	7.21
03/21/20	7.16
01/24/20	*
11/30/19	7.38
09/29/19	6.95
08/21/19	7.25
06/09/19	7.45
05/26/19	7.62
04/23/19	7.80

DOWNLOAD WELL DATA



Location Information for: 22H-2792
 Address: Corner of Peterborough St. and Park Drive, adjacent to 15 Peterborough St.
 Approx. Rim Elevation (ft.): 17
 Installation Date: 5/17/2005

Well Status

- Active
- Decommissioned

Foundation Type

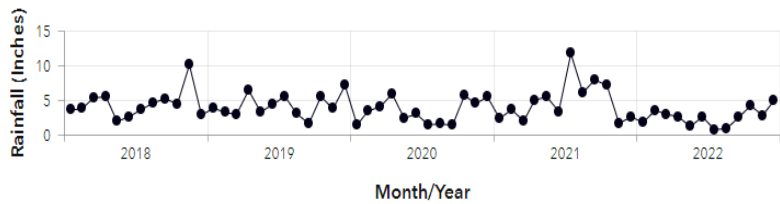
- Wood
- Other
- Earth
- Concrete & Steel

Underpinned Buildings

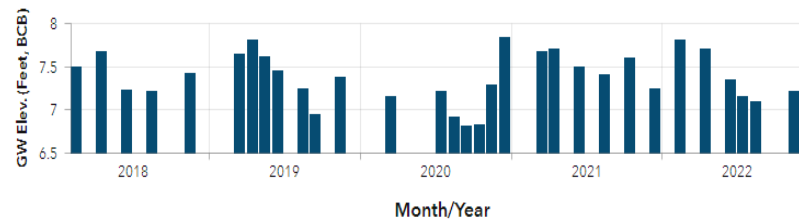


- Address: 11 Park Drive
- FoundationType: Wood
- Cutoff Elevation: 5'
- Underpinned:
- Foundation Comments: Wood Pilings
- Additional Comments:

Boston Rainfall Levels
 Data Courtesy of [Boston Water & Sewer Commission](#)



Selected Well Readings By Month Over a Five-Year Period



Why 800+ Wells?

- *Not all buildings constructed at the same time with the same pile cut off elevations*
- *Variability throughout the City, throughout the same block*



Pile Cut-off Elevations

THE BUILDING LAW OF THE CITY OF BOSTON.

BEING ACTS OF 1907, CHAPTER 550, AS AMENDED,
ALSO GENERAL AND SPECIAL ACTS RELATING
TO BUILDINGS AND THEIR MAINTENANCE,
USE AND OCCUPANCY.



CITY OF BOSTON
BUILDING DEPARTMENT
Room 901, City Hall Annex
1919

PAR. 17.— The distance between **wooden piles** shall be not less than twenty-four inches on centres. The tops of all wooden piles shall be cut at an **elevation** not higher than **grade 5.00**, except that the commissioner may in his discretion permit a higher point of cut off, but not exceeding **grade 9.00** in localities where the level of the ground water fluctuates with the tidal variations.

PAR. 18.— Wooden piles may be driven to a depth not exceeding ten feet below the ground surface by means of properly designed followers: *provided*, that such followers are constructed of steel or iron, and are equipped with a

Pile Cut-off Elevations



JOURNAL OF THE BOSTON SOCIETY OF CIVIL ENGINEERS Volume 57 JANUARY 1970

BACK BAY BOSTON PART 1

By: HARL P. ALDRICH, JR.,* Member Number 1

It was common practice in Boston to cut off wood piles at the average tide level, El. 5 Boston City Base, with entire safety. After the Back Bay was filled and through the remainder of the nineteenth century, the ground water level in the Back Bay was approximately El. 8 and as a result many buildings were constructed on piling cut off above El. 5.

Although there was ample evidence by 1914 that sewers and drains in the Back Bay were affecting the ground water table, Worcester (18,p.6) felt that El. 5 was too low and suggested a cutoff as high as El. 8. Wisely, most engineers at the time disagreed with him, believing that El. 5 or 6 should be maintained. Frederick P. Stearns (18, p.20 I) reasoned that with the presence of an increasing number of floor drains and decreased infiltration of surface water as the land was built upon, " ... piles to support important structures should be cut off below rather than above grade 5."

In final discussions, Worcester (18, p.415) challenged his fellow engineers to cite a case where rotted piles had been found below El. 8. Although no examples were forthcoming, he changed his recommendation to El. 6. In 1931, following the discovery of rotted wood piles below the Boston Public Library, the BSCE Committee on Boston Subsoils (14,p.244) was of the opinion that untreated wood piles should be cut off not higher than El. 3 in the Back Bay.

Pile Cut-off Elevations



Plans must be filed and approved by this Department before a permit for erection will be granted. No. 324

RECEIVED 1897. MAY 23

Application for Permit to Build.
(1st and 2d CLASS BUILDING.)

Boston, *May 23* 1897.

To THE BUILDING COMMISSIONER:

The undersigned hereby applies for a permit to build, according to the following specifications:

- Location, No. *Blackwood St.*
- Nearest cross street? *St. Botolph St. Ward 10*
- Name of Owner? *Samuel Mason* Address
- Builder? " " " "
- Architect? " " " "
- Purpose of building? *Apartment* Stores?
- How many families? *8*
- How near the line of the street? *10* Width of street? *50*
- Will the building be erected on solid or filling land? *filled* If in block, how many? *4*
- Size of building, No. of feet front? *29* No. of feet rear, *20* No. of feet deep, *10*
- No. of stories in height, *4* No. of feet in height from sidewalk to highest point of roof, *28*
- Number of feet in height from level of sidewalk to highest point of roof? *28*
- Number of feet in height from sidewalk to eaves? *28*
- Will foundation be laid on earth, rock or piles? *piles* Material of foundation, *stone*
- External walls, 1st, *12* 2d, *12* 3d, *12* 4th, *12* 5th, 6th, 7th, 8th, 9th, 10th, Party walls, 1st, *12* 2d, *12* 3d, *12* 4th, *12* 5th, 6th, 7th, 8th, 9th, 10th, Are the party walls solid or vaulted? *solid* External walls? *solid*
- What will be the materials of front? *brick*
- Will the roof be flat, pitch, mansard or hip? *flat* Material of roofing? *Compo*
- What will be the material of cornice? *Copper*
- What will be means of access to roof? *stairs*
- Length of piles? *20*
- Number of rows? *2*
- Distance on centres? *3*
- Diameter top? *10* Bottom? *7*
- How capped? *granite*
- Piles cut off at what grade? *5'* Grade of basement? *1'*
- Are there any hoist ways or elevators? *Yes* How protected? *stone way*
- How is the building heated? *steam* Thickness of shell of flue? *lined*
- Floors, how fastened? *balustrade*
- Fire stops to be provided? *Yes*
- Means of extinguishing fire? *Yes*
- Size of floor timbers? *2 x 12* Span? Distance O. C.?
- " headers and trimmers? *4 x 12* " " "
- " rafters? *2 x 12* " " "
- Stairways enclosed in brick walls? *Yes*
- Thickness of such walls? *12 x 8*
- Stairway halls, how finished? *plastered* Estimated cost?

If the building is to be occupied for a Tenement or Lodging House or Family Hotel, give the following particulars:-

- What is the height of cellar? *7*
- What will be the height of ceiling on first story, *10* second, *9'* third, *9* fourth, *9* fifth, sixth, seventh, eighth, ninth, tenth.
- Is the cellar to be occupied for a dwelling?
- Distance from surrounding buildings? front, *st*; side, *adj*; side, *RR*; rear, *st*.
- If there is a building already erected on the front or rear of lot, give height?
- State how many means of egress are to be provided, *2*
- Style of egress? *one door in base*
- Size of lot, No of feet front, ; feet rear, ; feet deep,

Name, *Samuel Mason*
Address, *276 Massachusetts St.*

Plans submitted? Received by?

13. Will foundation be laid on earth, rock or piles? *piles* Material of foundation, *stone*

14. External walls, 1st, *12* 2d, *12* 3d, *12* 4th, *12* 5th, 6th, 7th, 8th, 9th, 10th, Party walls, 1st, *12* 2d, *12* 3d, *12* 4th, *12* 5th, 6th, 7th, 8th, 9th, 10th, Are the party walls solid or vaulted? *solid* External walls? *solid*

15. What will be the materials of front? *brick*

16. Will the roof be flat, pitch, mansard or hip? *flat* Material of roofing? *Compo*

17. What will be the material of cornice? *Copper*

18. What will be means of access to roof? *stairs*

19. Length of piles? *20*

20. Number of rows? *2*

21. Distance on centres? *3*

22. Diameter top? *10* Bottom? *7*

23. How capped? *granite*

24. Piles cut off at what grade? *5'* Grade of basement? *1'*

Pile Cut-off Elevations



What do we know?

Foundation Data Totals

Number of Buildings Searched	Number of Buildings with Foundation Data	< 4'	4'-5'	5'-6'	6'-7'	> 7'	Piles	Concrete/Steel	Underpinned
8,303	1,686	20	641	101	46	16	461	274	127

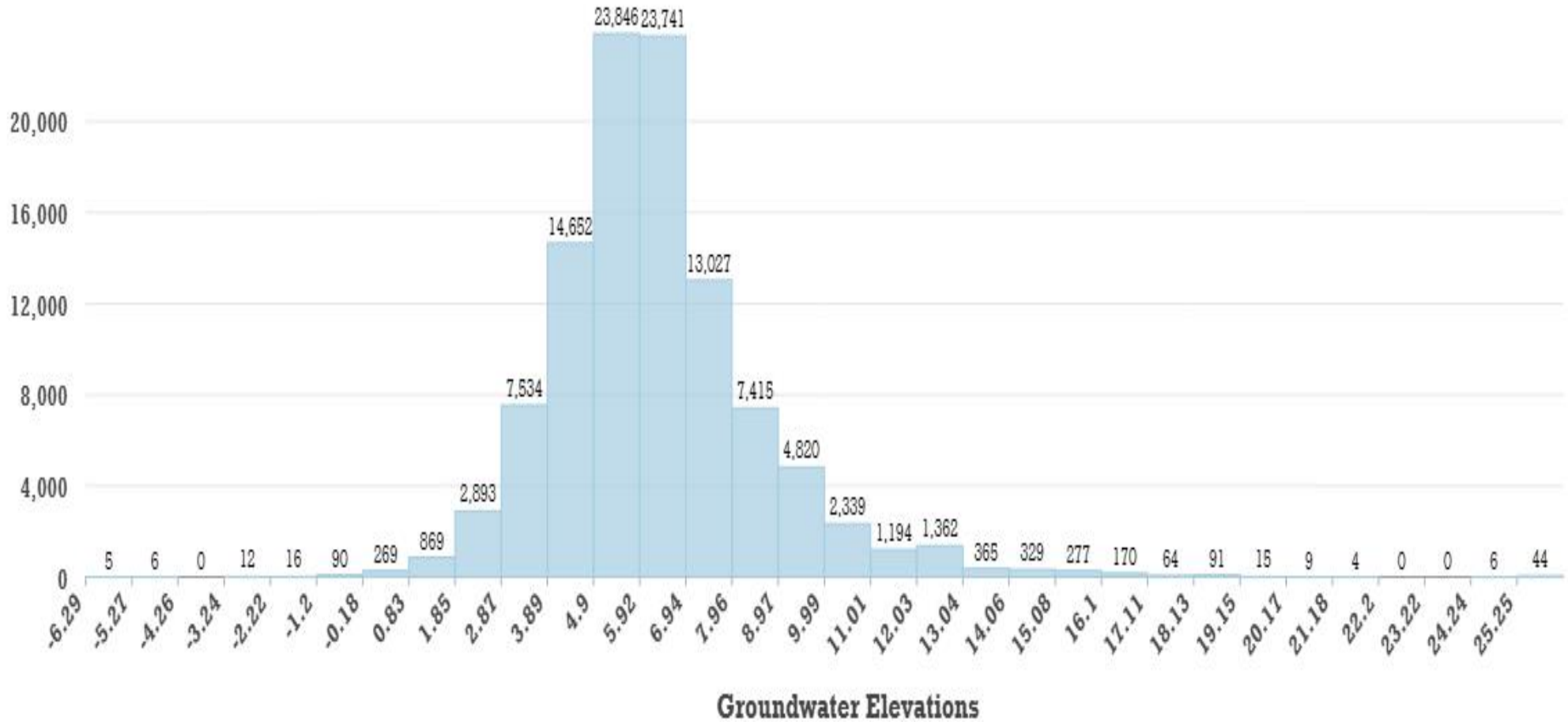
- **Foundation information for 20% of the buildings in the filled land areas of the City**
- **Majority have cutoff's between EL. 4'-5'; accounts for 38% of foundation information we do have**
- **Groundwater levels are high (above EL. 5') in most areas where we have high cutoffs**

Well Readings: 1999-2022



Distribution of Groundwater Elevations

Number of Readings 1999-2022



Information Center



BOSTON GROUNDWATER TRUST (BGwT) OBSERVATION WELL AND BUILDING FOUNDATION INFORMATION CENTER

Select well on map to view latest and historical readings.

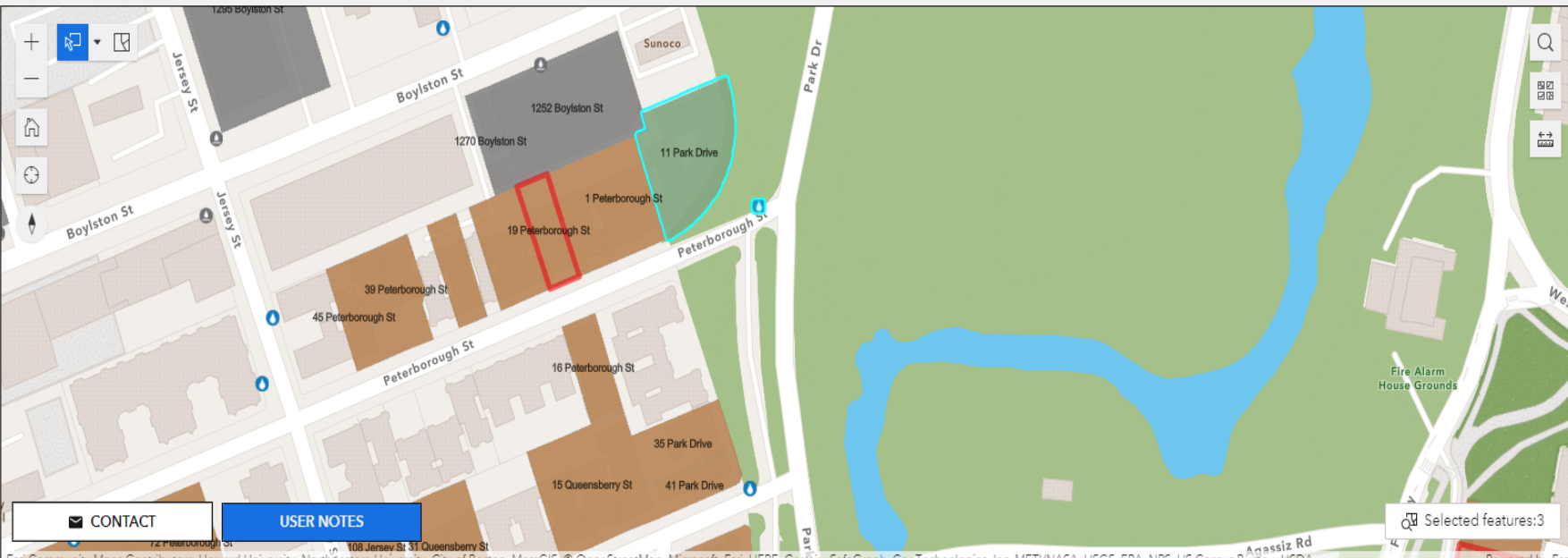
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[DOWNLOAD WELL DATA](#)



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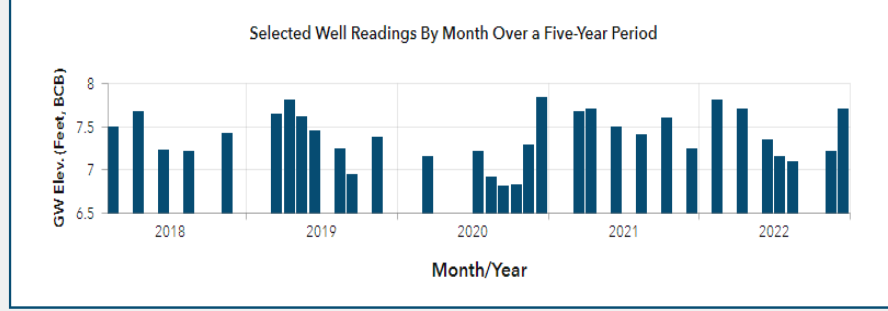
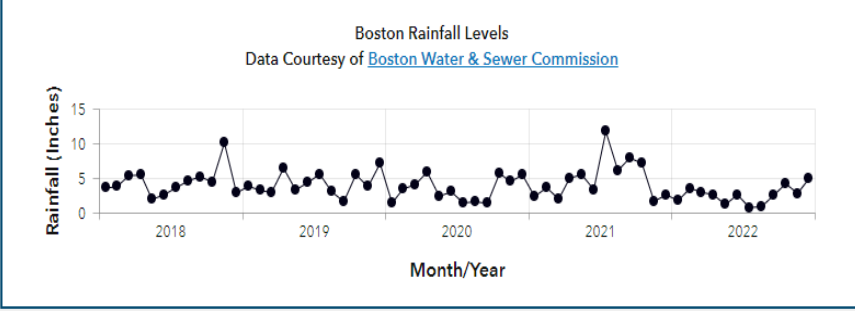
- Active
- Decommissioned

Foundation Type

- Wood
- Other
- Earth
- Concrete & Steel

Underpinned Buildings

- Address: 11 Park Drive
- FoundationType: Wood
- Cutoff Elevation: 5'
- Underpinned:
- Foundation Comments: Wood Pilings
- Additional Comments:



How do we raise and maintain GW levels?



- **Ensure that no projects negatively impact GW levels**
 - **All underground infrastructures are waterproofed**
 - **No sump pumps or underdrains**

- **Fix the leaking infrastructure**
 - **Sewers, tunnels, etc.**

- **Promote green infrastructure**
 - **Advise residents on installing recharge systems**
 - **Promote pervious pavers and porous pavement**
 - **New City standards**

Groundwater Conservation Overlay District (GCOD) Zoning



- **Raise & maintain groundwater levels**
- **Eliminate leak paths**
- **Increase amount of precipitation going into the ground**

GCOD Requirements



- **Provide recharge equal to the capture of 1” of water over the impervious area of the lot**
 - **Requires BWSC approval letter**

- **Demonstrate that project will not cause a reduction in groundwater levels on site or adjoining lots**
 - **Requires no harm letter**

Groundwater Recharge Systems

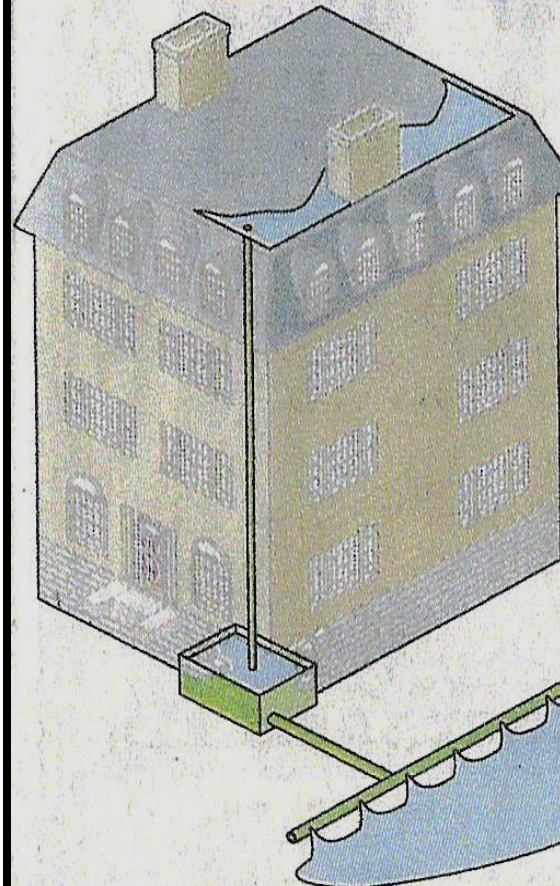
NO



YES

RECHARGING THE GROUND-WATER TABLE

Ground-water recharge systems are required for most new construction or remodel work done in the Groundwater Conservation Overlay District.



- 1 Rainwater, drained from a roof, is collected in a storage tank.
- 2 The water is carried from a perforated pipe buried below the street to replenish the ground water.

Boston Globe

Deep Excavation No Harm



NEWEA
WORKING FOR WATER QUALITY

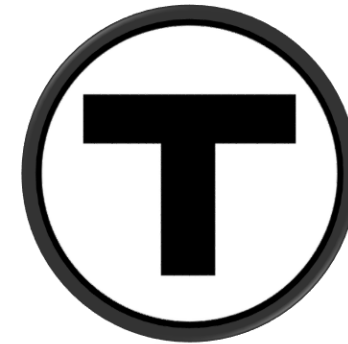


Haley & Aldrich

City/State Groundwater Working Group



Groundwater Memorandum of Understanding (MOU) signed by



- **Commitment by City & State agency leaders to participate in quarterly meetings**
- **Agencies pledged to share information, identify problem areas, explore solutions, and remediate problems that contribute to low groundwater**

Fix Infrastructure

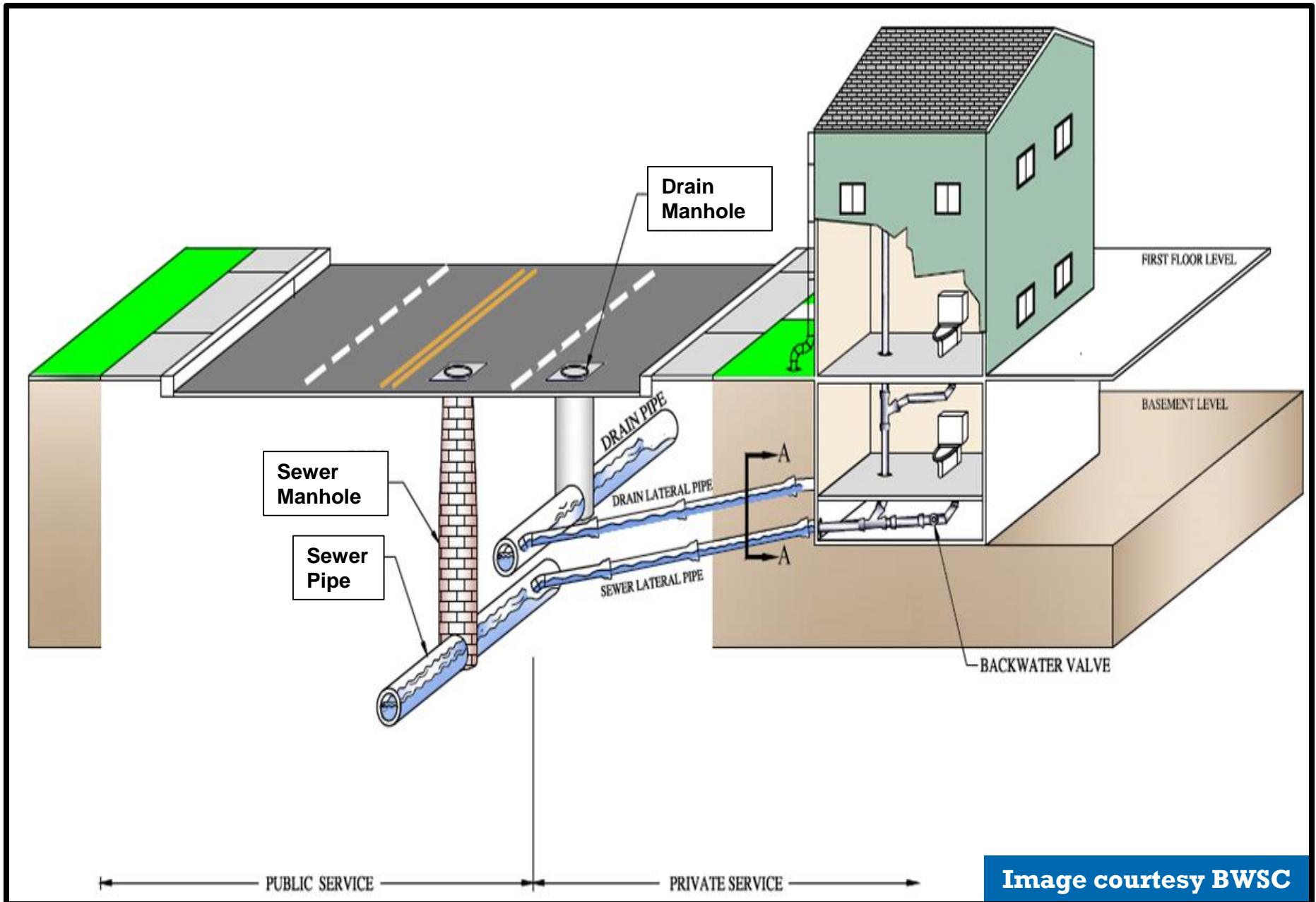
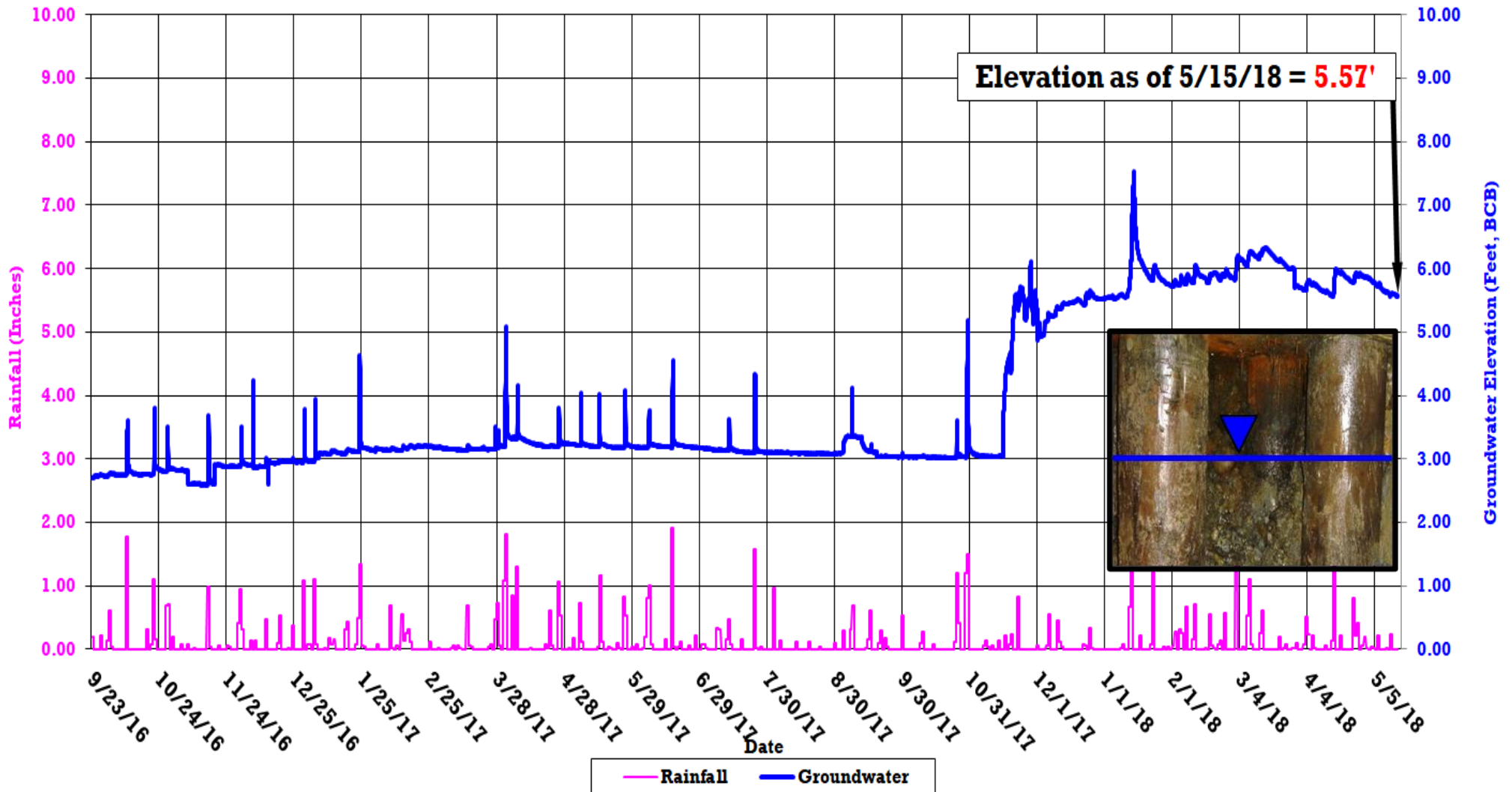


Image courtesy BWSC

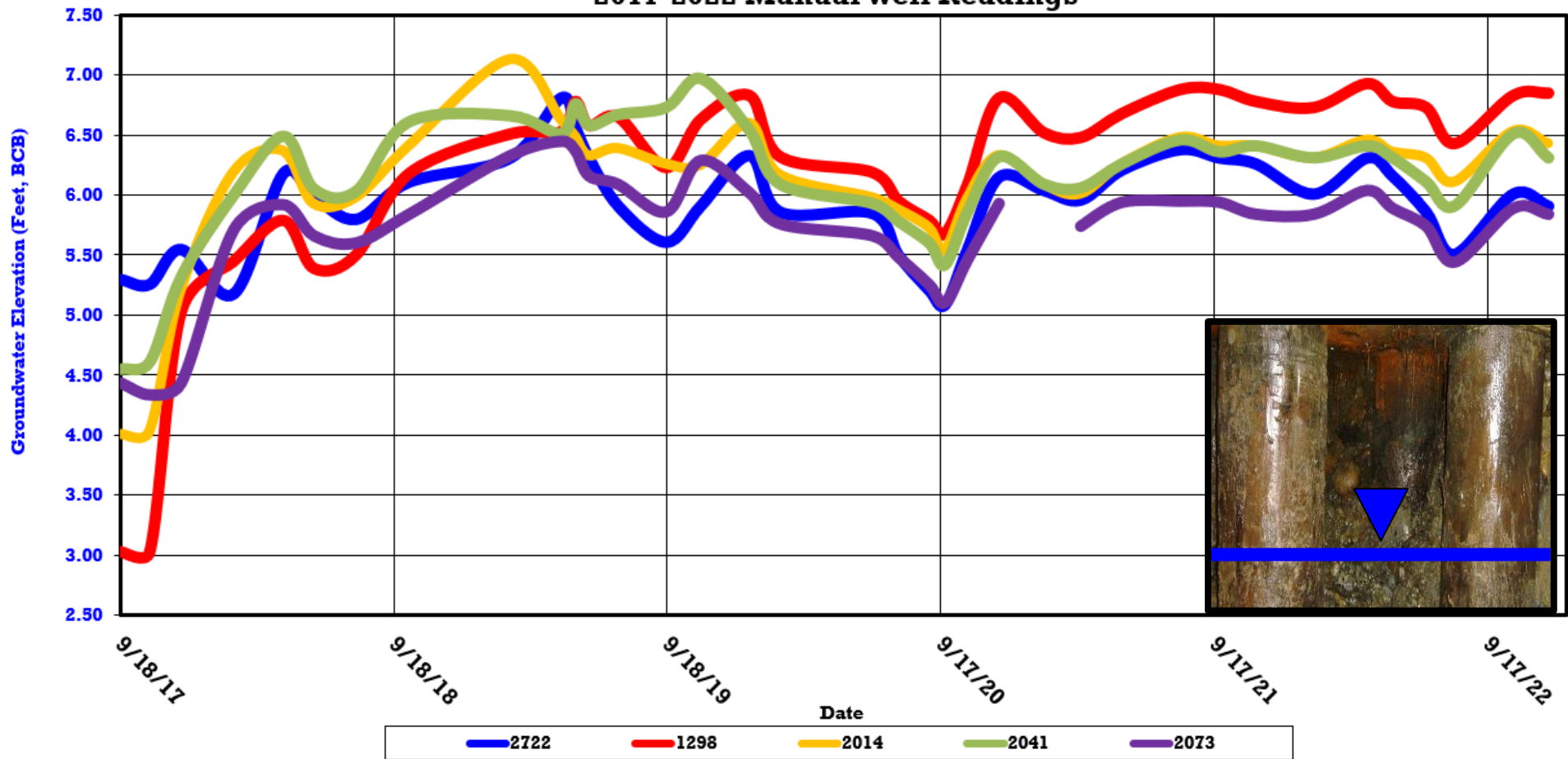
Results of Fixing a Leak

23I-1298: On Beacon St., in front of 351 Beacon St.



Results of Fixing a Leak

**Beacon Street to Commonwealth Avenue
5 Wells Along Fairfield Street
2017-2022 Manual Well Readings**

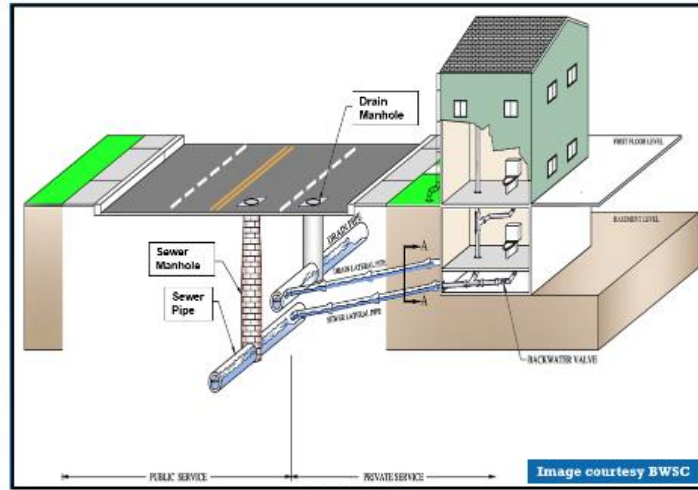


Results of Fixing a Leak


☰ **BOSTON GROUNDWATER TRUST** 🔍

GROUNDWATER & UNDERGROUND INFRASTRUCTURE

Groundwater levels can be influenced by multiple factors. Environmental factors and trends related to precipitation, seasons, and temperature. In addition, factors related to underground infrastructure. Groundwater can leak into and out of sewers, storm drains, private sewer laterals, and other below grade structures. The image below from the Boston Water & Sewer Commission (BWSC) highlights some of that infrastructure. If the infrastructure in the image below develops a leak groundwater can flow into it causing a groundwater depression in the vicinity and potentially exposing wood piles in that area to air.



Through the [City-State Groundwater Working Group](#) the Trust works with the entities who build and maintain the many sewers, drains, tunnels, manholes, and other infrastructure. The ArcGIS StoryMaps below provide a detailed approach of how low groundwater levels were identified by the Trust and how a particular entity inspected and eventually repaired that deficient infrastructure to restore groundwater levels.



Recharge Projects

BOSTON POROUS ALLEY



POROUS PAVEMENT IN BOSTON'S ALLEYWAYS ALLOWS RAINWATER TO FILTER INTO THE GROUND RATHER THAN RUN OVER PAVED SURFACES. POROUS PAVEMENT REDUCES STORMWATER POLLUTION, RECHARGES GROUNDWATER, AND HELPS PROTECT BUILDING FOUNDATIONS.



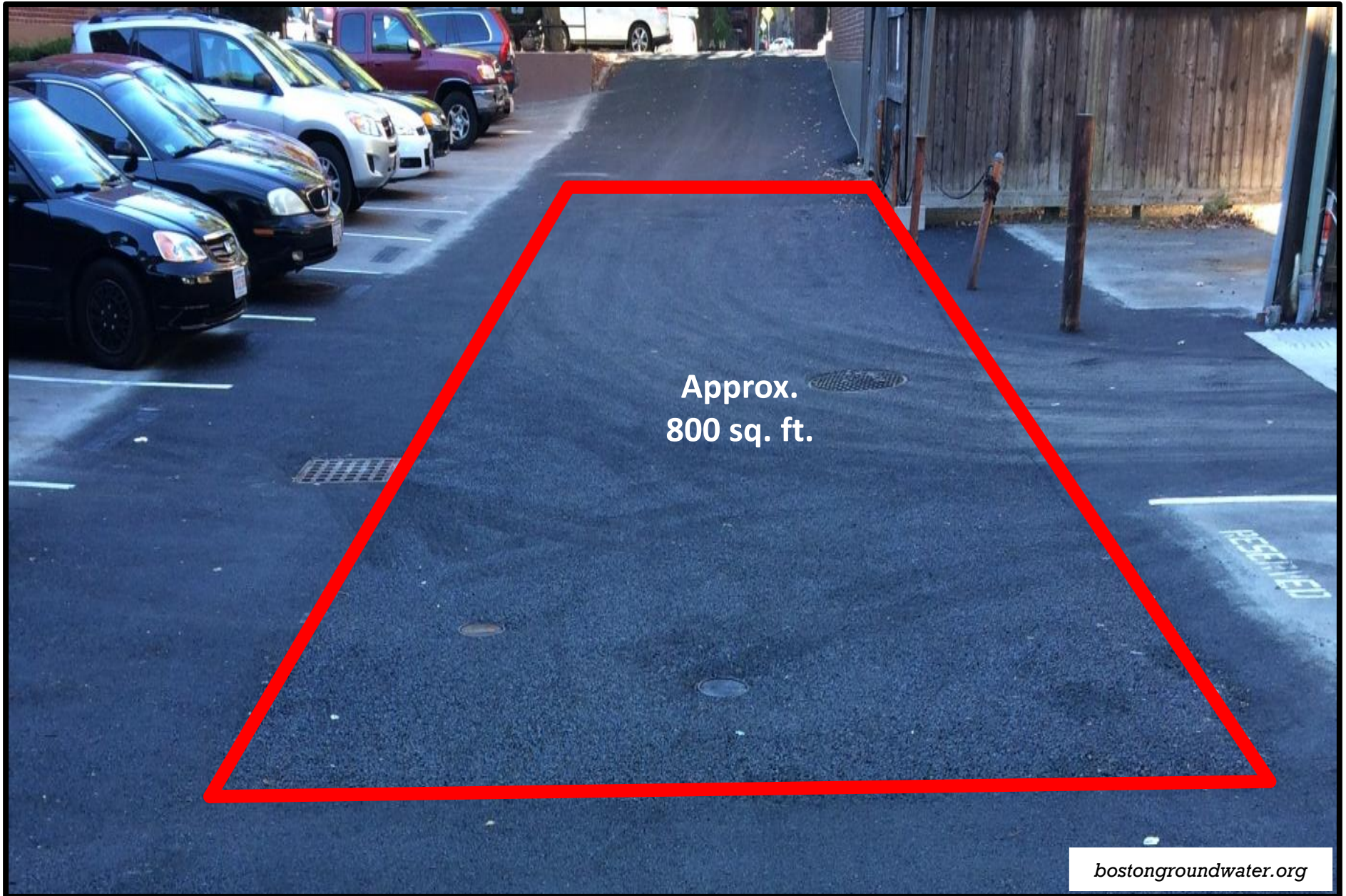
BOSTON POROUS ALLEY
When it rains, it recharges

PROJECT FUNDED BY MA DEPT. OF ENVIRONMENTAL PROTECTION & DESIGNED BY VHB

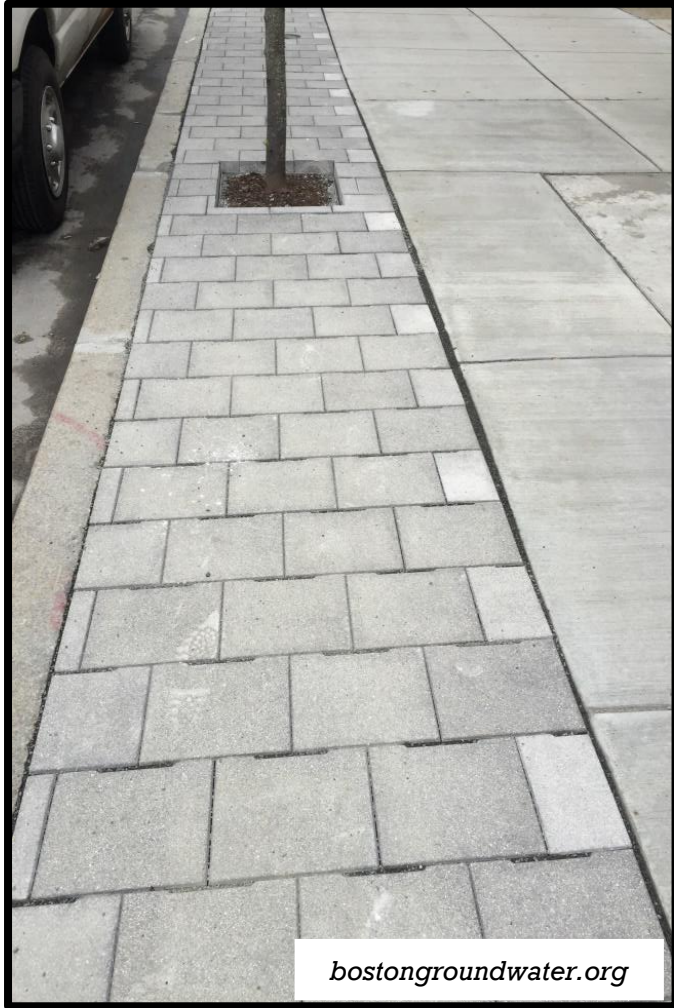


PUBLIC ALLEY #543
BOSTON PUBLIC WORKS DEPARTMENT
BOSTON GROUNDWATER TRUST
CHARLES RIVER WATERSHED ASSOCIATION

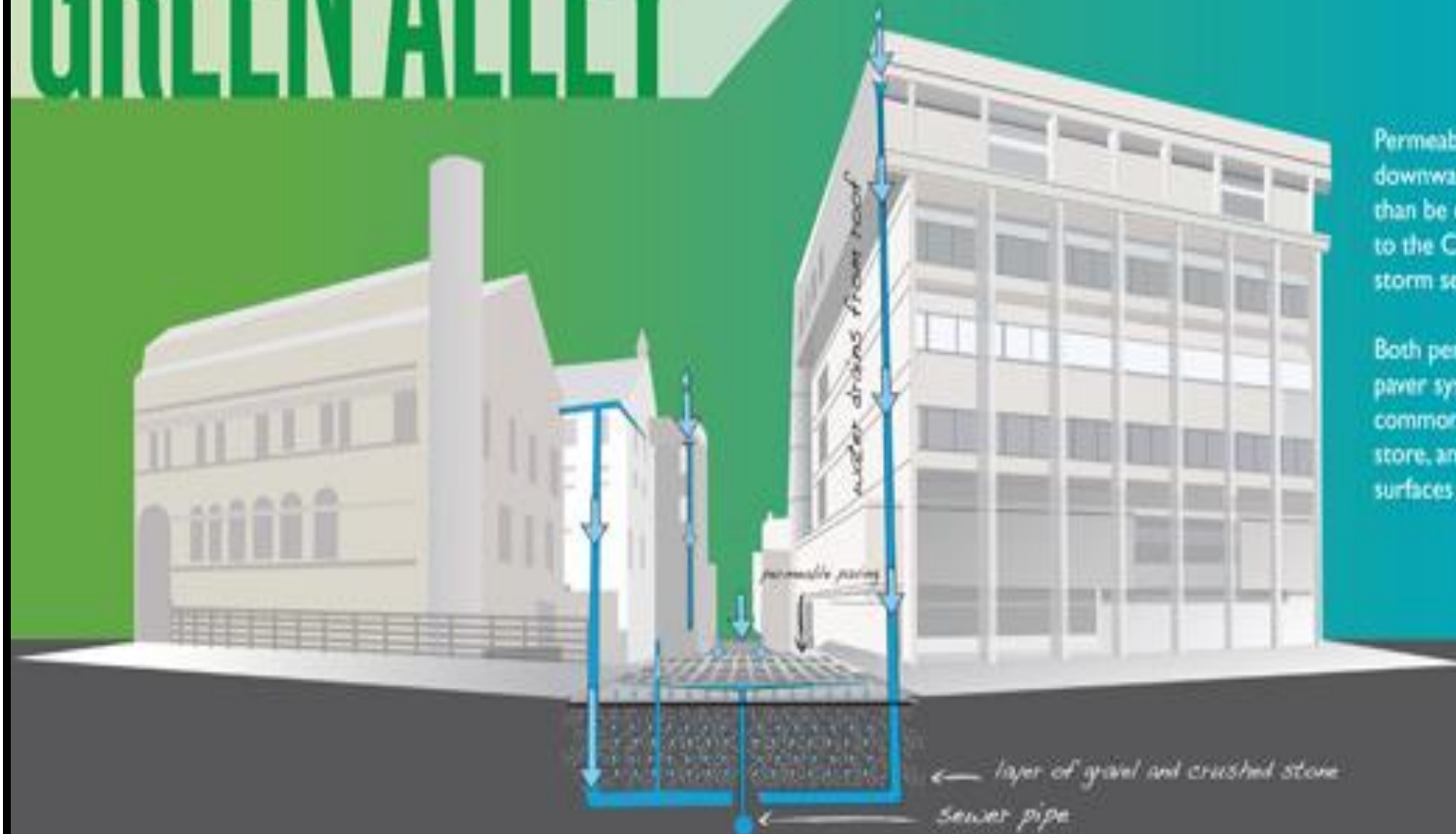
PUBLIC ALLEY 543: Pervious Asphalt



Pervious Concrete Pavers



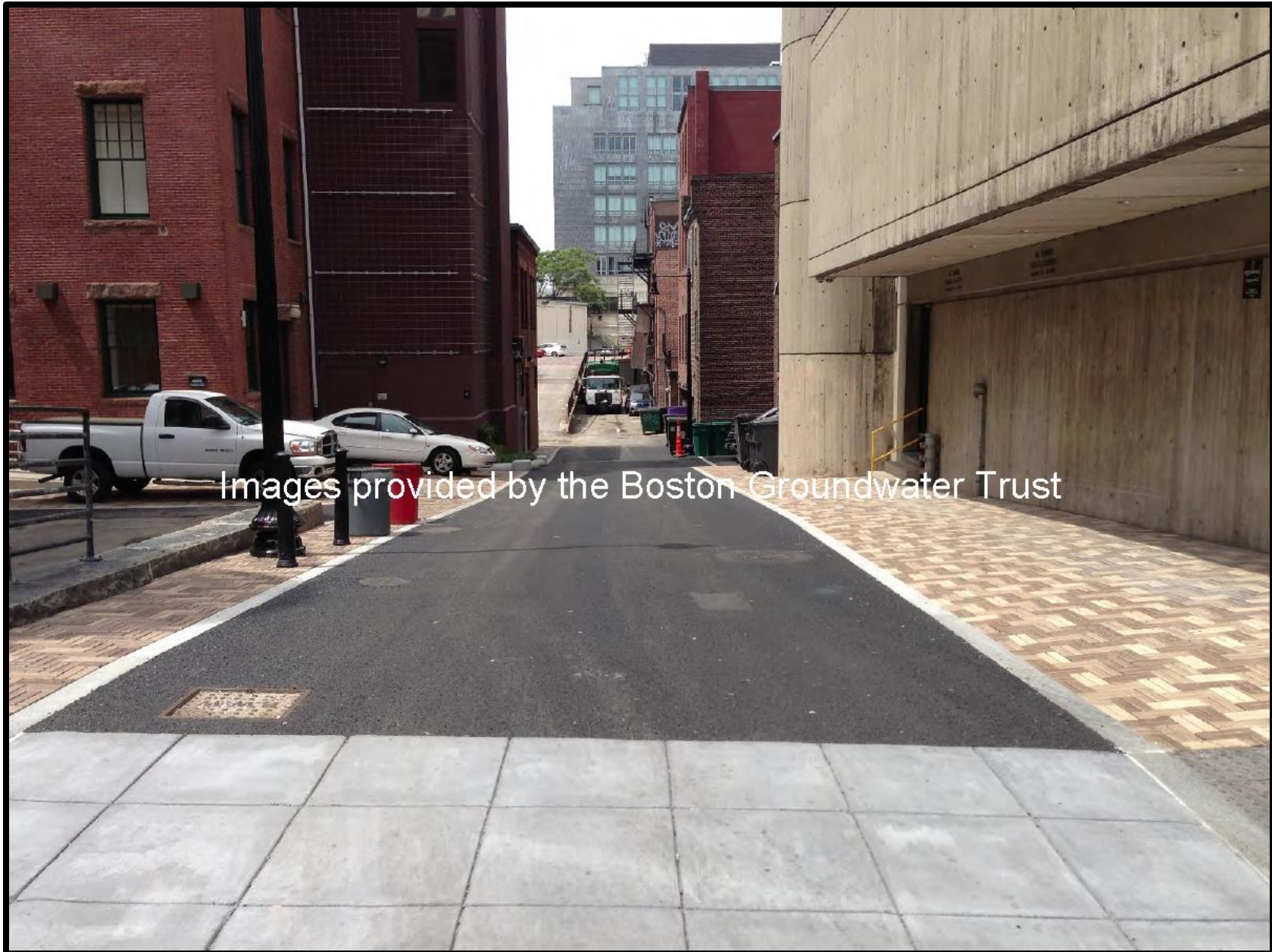
GREEN ALLEY



Permeable paving allows water to percolate downward into the earth below rather than be conveyed across a paved surface to the Charles River via a conventional storm sewer.

Both permeable asphalt and permeable unit paver systems were installed over a large common gravel bed designed to collect, store, and drain rain water from the alley surfaces and two BAC rooftops.

PUBLIC ALLEY 444: BAC Alley



East Boston: Central Square



What is Green Infrastructure?

Green infrastructure offers an alternative to traditional storm drain systems or 'grey infrastructure'. The goal of Green Infrastructure is to mimic nature to capture, clean and infiltrate the rain that falls to the ground. Green Infrastructure installations help limit the amount of stormwater entering pipes that drain to Boston Harbor.

La Infraestructura Verde ofrece una alternativa a los sistemas tradicionales de "Infraestructura Gris". Los objetivos de la Infraestructura Verde son imitar la condición natural a captura, limpia e infiltra la lluvia que cae al suelo. Las instalaciones de Infraestructura Verde ayudan a limitar la cantidad de aguas pluviales que entran a los desagües del Boston Harbor.

The Green Infrastructure demonstration project in Central Square is a collaborative effort between Boston Water and Sewer Commission, Boston Public Works, Boston Transportation and Boston Parks Departments. Central Square now has 11 Green Infrastructure features including porous pavement, infiltration trenches and tree trenches. To learn more about the program or how the Green Infrastructure works in Central Square, visit:

El proyecto de demostración de Infraestructura Verde en Central Square es un esfuerzo de colaboración entre la Comisión de Agua y Alcantarillado de Boston y la Ciudad de Boston. Central Square ahora tiene 11 características de Infraestructura Verde incluyendo pavimento poroso, zanjas de infiltración y trincheras de árboles. Para obtener más información sobre el programa o sobre cómo funciona la Infraestructura Verde en Central Square, consulte:

http://bwsc.org/GI_LID.asp

Benefits of Green Infrastructure



REDUCES STORMWATER RUNOFF AND IMPROVES WATER QUALITY



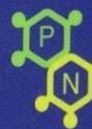
IMPROVES URBAN AIR QUALITY AND REDUCES ENERGY USE



IMPROVES HABITAT AND MITIGATES URBAN HEAT ISLAND EFFECT



INCREASES GROUNDWATER RECHARGE AND REDUCES RISK OF FLOODING



REMOVES PHOSPHORUS AND OTHER POLLUTANTS FROM RUNOFF



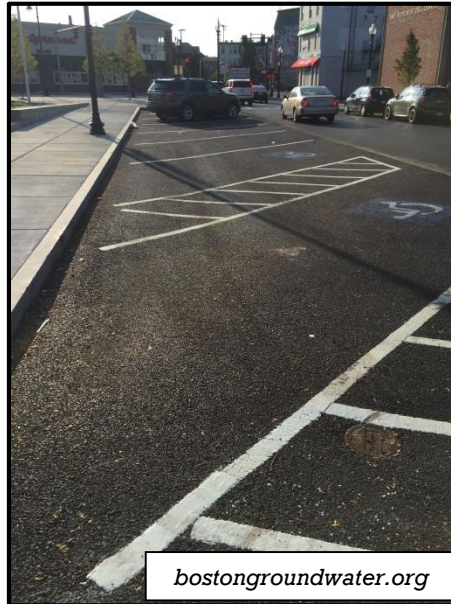
CULTIVATES PUBLIC EDUCATION OPPORTUNITIES

East Boston: Central Square

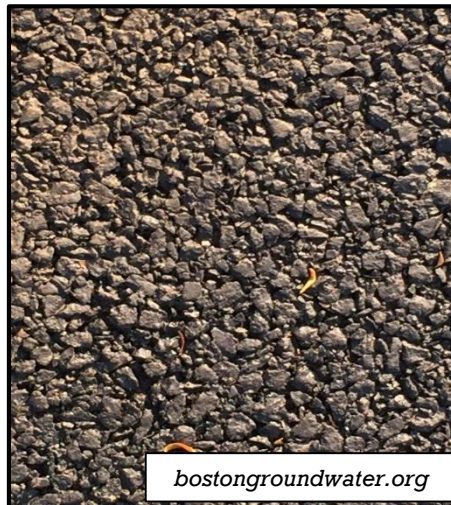
**Pervious
Concrete**



**Pervious
Pavement**



**Pervious
Pavers**



New City Standards



[HOME](#) › [LATEST CITY OF BOSTON NEWS](#) › [NEW ENVIRONMENTAL STANDARDS FOR CITY INFRASTRUCTURE ANNOUNCED](#)

NEW ENVIRONMENTAL STANDARDS FOR CITY INFRASTRUCTURE ANNOUNCED

Internal design standards will embed environmental benefits into certain future City of Boston public infrastructure.

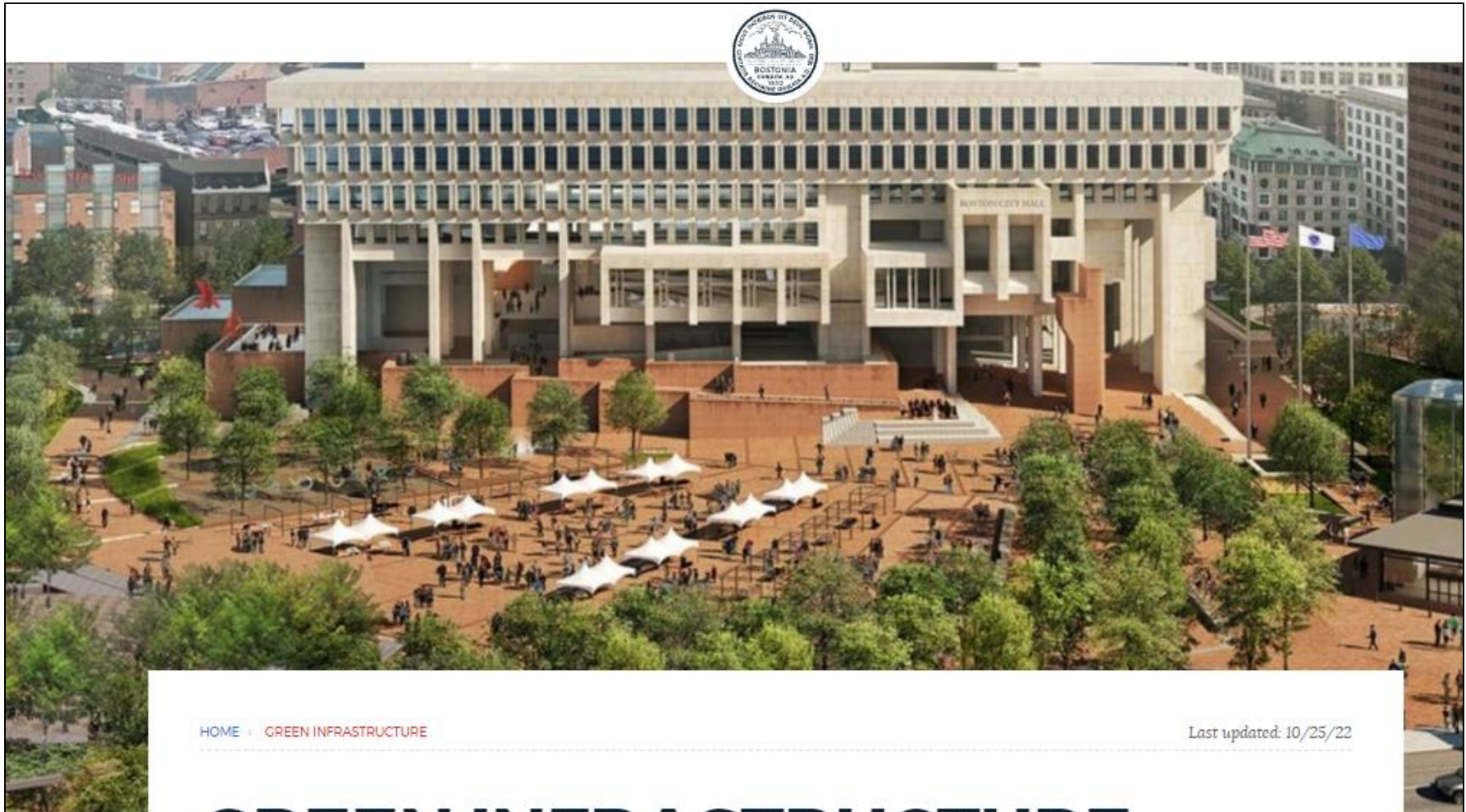
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Environment

New City Standards



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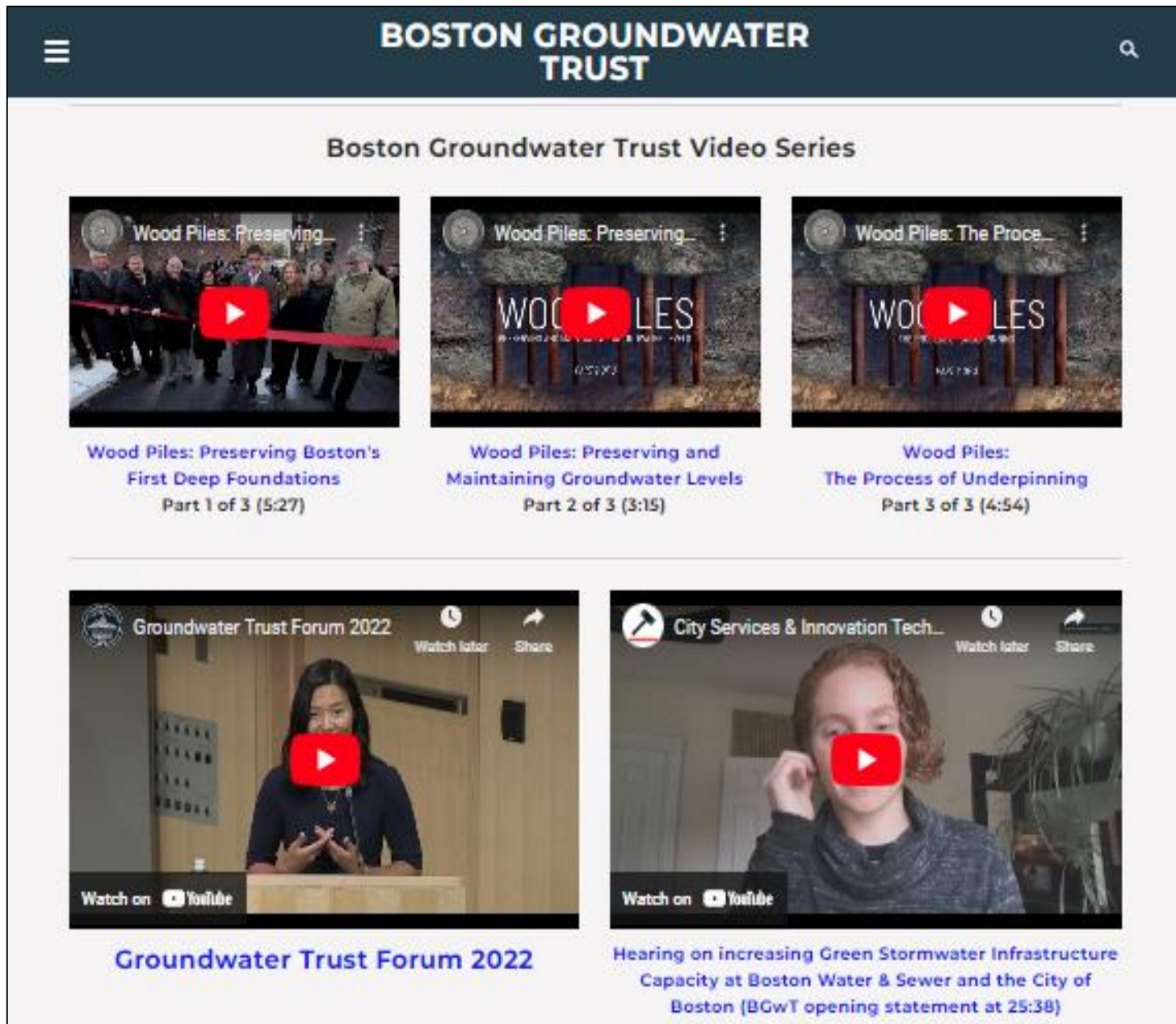
Last updated: 10/25/22

GREEN INFRASTRUCTURE

Green infrastructure is an essential part of Boston's work towards becoming a greener, more resilient and equitable city.

Remote Readers





BOSTON GROUNDWATER TRUST

Boston Groundwater Trust Video Series

Wood Piles: Preserving Boston's First Deep Foundations Part 1 of 3 (5:27)

Wood Piles: Preserving and Maintaining Groundwater Levels Part 2 of 3 (3:15)

Wood Piles: The Process of Underpinning Part 3 of 3 (4:54)

Groundwater Trust Forum 2022

Hearing on increasing Green Stormwater Infrastructure Capacity at Boston Water & Sewer and the City of Boston (BGwT opening statement at 25:38)

THANK YOU!

QUESTIONS?