Groundwater Decline and the Preservation of Property in Boston

by

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Bachelor of Business Administration
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Submitted to the Department of Urban Studies and Planning in partial fulfillment of the requirements for the degree of

Master in City Planning
at the
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Abstract

There is a slow-motion disaster underway below the city of Boston. The levels of groundwater have been steadily decreasing over the past eighty years and the structural integrity of the city's older buildings is in jeopardy. Buildings located on Boston's made land that were constructed prior to 1900 were supported with wood pilings. Wood pilings remain strong so long as they are submerged in groundwater. When exposed to air, the wood decays and buildings can eventually collapse. Repairing rotted wood pilings is a substantial financial burden and is currently shouldered entirely by homeowners. State and local governments ignored the city's pilings problem for decades, but in the last eighteen months the city's groundwater issues have surfaced prominently on political agendas. The city, state and community members are now working collaboratively to implement solutions that will increase the level of groundwater throughout the city, and a window of opportunity has opened in which lasting policies can be passed that protect buildings from further damage.

The solutions to the city's groundwater problem are theoretically simple: more water must enter the ground and stay there, and rotted pilings must be repaired. However, in addressing this challenge, some very difficult obstacles to planning must be overcome. The piling decay and mitigation efforts all occur below ground thus are unseen. The effects of lowered groundwater levels have been stretched out over decades and residents and politicians have frequently underestimated the problem. Most importantly, the key stakeholders all have strong disincentives to address the issue of rotted pilings. This thesis examines the relationship between groundwater and pilings and addresses how three key stakeholder groups – the city, state, and community organizations – can pool their resources to prevent further damage to pilings and permanently increase groundwater levels in the city.

Table of Contents

Introduction

On April 5, 2005, all 500 seats in the Rabb Auditorium of the Boston Public Library were filled with residents who had come to learn about how groundwater levels affect their homes. As local experts explained the causes and consequences of reduced groundwater levels, members of the Groundwater Emergency Taskforce circulated through the audience distributing "Stop the Rot" buttons. Audience members were engaged, asked informed questions, and volunteered to take action to promote safe groundwater levels. The meeting marked an important turning point – groundwater was exposed as a serious civic problem that mattered to residents and voters. The message was not lost on the three politicians sitting in the front row - Byron Rushing, State Representative; James Hunt III, Mayoral Cabinet member and Chief for Environmental and Energy Services; and Bo Holland, special advisor to the mayor.

Figure 1: Groundwater awarness buttons created and distributed by the Boston Groundwater Emergency Taskfoce

The past year since the meeting has been marked with a flurry of political activity targeted at raising groundwater levels in Boston. Following the Groundwater Educational Forum, a Memorandum of Understanding was signed by a various state and city agencies that signaled a collective commitment to increase groundwater levels; the City of Boston amended its zoning provisions through the passage of Article 32, the Groundwater Conservation Overlay District; the Boston Groundwater Trust, a municipal entity, was fully funded for the first time since its creation; and dozens of news articles have been published to document these advancements.

Groundwater has re-surfaced as a prominent issue for the City of Boston. Flowing invisibly beneath the city streets, groundwater plays a crucial role in maintaining the stability of much of the Boston's historic built fabric. Most large structures built on fill before 1900 – including buildings over three stories tall, homes, bridges, churches, and institutional buildings – are supported by wood pilings. When originally built, the pilings were submerged in groundwater. If groundwater levels drop, the wooden pilings become exposed to air and rot. Buildings with rotten pilings become structurally unsound and are either condemned or underpinned.

Falling groundwater levels threaten both the physical and metaphorical foundations of the city. Neighborhoods such as the South End and Back Bay that are comprised of rows of historic brownstones define the character and image of the city, and it is precisely these buildings that are at risk of being condemned or destroyed due to structural instability. The majority of the city of Boston is exposed to the risk of rotted pilings, including buildings in the Back Bay, Beacon Hill, South End, Bay Village, North End, Fort Point Channel, South Boston, Chinatown, and Fenway.

Rotted pilings threaten the economic stability of the city as well. The uncertainty of the underlying condition of pilings threatens to negatively impact property values and has already cut into the sale price of homes in affected areas. Buyers are currently inquiring about the conditions of pilings, requesting test pits be dug prior to purchase, and, if rotted pilings are discovered, have demanded a full underpinning before purchasing a home. If property values fall due to uncertainty over pilings, then the tax base will be reduced and will negatively impact the overall economy of the city.

Any response to the problem of groundwater decline is expensive. Repairing rotted pilings costs hundreds of thousands of dollars per structure. Restoring groundwater levels requires large scale investment to fix leaks in sewer lines and walls of basements, subway tunnels, and highway underpasses. Allowing the status quo to continue threatens the structural integrity of homes throughout Boston.

City residents first became aware of the threat of rotten pilings in the 1930s, but only recently has this problem begun to be addressed. For many years, the magnitude of the problem and expense of any potential solution prevented city and state officials from openly discussing groundwater issues. The threat of liability halted participation in mitigation efforts because agencies feared that addressing the problem would serve as an admission of fault.

Although large and complex, the problems associated with falling levels of groundwater in Boston are solvable. If all of the leaks in the sewer lines were fixed or if all of the wooden piles were underpinned then the threat of structural instability due to lowered groundwater levels would be eliminated. Are these solutions pipe dreams? Perhaps, but such ideals provide important goals towards which policy solutions should aim.

This thesis examines the issue of groundwater declines and associated damage to pilings in Boston in order to suggest a more comprehensive response to mitigating structural risks. I sought to answer the following questions:

- What have been the causes and consequences of pilings damage in Boston?
- How can lowered groundwater levels be more effectively addressed by state and city policy?
- Can targeted interventions by neighborhood groups help mitigate pilings damage?
- Can existing financing tools be used to fund the repair of damaged pilings?

Chapter One examines the causes and effects of lowered groundwater levels in Boston by mapping the problem, its sources, and the historical occurrences of piling-related damage. By understanding the places and people that groundwater levels affect, a tailored community response can be created that cuts across neighborhood lines and unites residents that share the common goal of restoring the structural stability of their buildings.

Chapter Two assesses city and state strategies that aim to restore groundwater levels. Local response to the problem of rotted pilings has to date focused singularly on restoring groundwater levels either by fixing leaks or by promoting recharge. Substantial progress is being made gradually with leaks; this chapter provides recommendations for increasing groundwater recharge.

Chapter Three focuses on the repair of pilings as a means of mitigating the structural uncertainties in Boston. One of key messages of this report is that underpinning pilings is the most certain and stable way to address structural challenges of the city, yet policymakers and local residents seem to avoid addressing the pilings and choose to focus their attention exclusively on groundwater. This chapter considers the history of protection of pilings in Boston and proposes actions that make underpinning a more financially feasible response to the groundwater challenge.

Chapter Four considers how community organizing can be most effectively harnessed in order to protect structures at risk of pilings rot. The groundwater issue has been on the radar of some neighborhood groups longer than others, and neighborhood coalitions have effectively raised political awareness surrounding the pilings issue. What can neighborhood groups learn from one another, and what more could community organizations do in order to prevent further lowering of groundwater levels and to assist structures that have already sustained pilings damage?

Chapter Five summarizes the findings of the previous chapters and recommends strategies that city, state, and community stakeholders can follow in order to better mitigate damages associated with rotting pilings. The chapter then reflects upon Boston's structural challenges and frames the problems from the perspective of some classic planning challenges.

1. Problems Underlying the City

"Isaura, city of the thousand wells, is said to rise over a deep, subterranean lake. On all sides, wherever the inhabitants dig long vertical holes in the ground, they succeed in drawing up water, as far as the city extends, and no farther. Its green border repeats the dark outline of the buried lake; an invisible landscape conditions the visible one; everything that moves in the sunlight is driven by the lapping wave enclosed beneath the rock's calcareous sky." [1] - *Italo Calvino*

1.1 Introduction

Changes in the groundwater flows in Boston are creating real and immediate dangers for the built environment above. A substantial percentage of Boston's older buildings are supported by wood pilings, and when groundwater levels drop the timber pilings quickly rot. Pilings deterioration has been occurring for decades and the damage has only gotten worse. Like the mythical city Isaura, the visible fabric of Boston is directly affected by the invisible activity below the ground's surface.

Groundwater level and pilings maintenance remained low on political and community radars for decades for multiple reasons. First, groundwater is easy to ignore – it flows unseen, and is difficult to map with any real accuracy. Second, repeated attempts to attach legal liability for causing groundwater levels to fall have been stymied. The complex underground web of activity in Boston makes drawing a causal relationship between groundwater level reductions and their sources nearly impossible. Third, as a property owner, it is easier – and far less expensive – to be complacent than proactive. The risk of damage due to lowered groundwater levels is ever-present, but the actual occurrences of damage are isolated, rare, and difficult to predict. Finally, for many years nobody has wanted to admit any responsibility for causing groundwater levels to fall for fear of being shouldered with the entire cost of remediation the problem. Combined, these conditions have allowed pilings rot to continue and the risk of damage has spread across the city.

This chapter explains the nature of the pilings problem in Boston, why groundwater levels have fallen, and who is affected. Awareness about pilings damage is increasing amongst politicians, community groups, and the real estate market as a whole, and it is important that the sources and consequences of the problem are accurately understood so that informed policy decisions can be made.

1.2 Boston's Unique Subterranean Challenge

A unique combination of forces comes together in Boston to create a structural challenge that is unlike anywhere else in the United States. While other cities have experienced lowered groundwater levels and pilings damage, no other city has extent of filled land or quantity of wood-pile structures that characterize Boston. Unlike other older American cities, a large part of Boston's historic fabric survived urban renewal so the city has the great fortune of retaining a significant stock of older buildings that must be preserved. This section traces the history of land-making in Boston and reviews the physical properties of wood pilings in order to explain the subsurface conditions that underlie the structural challenges of the city.

1.2.1 Land-making

Boston embarked upon an aggressive growth strategy between 1794 and 1890 that expanded all neighborhoods in the city, including the central waterfront, Bulfinch Triangle, West End, Flats of Beacon Hill, Back Bay, South Cove, South Bay, South Boston, Dorchester, East Boston, and Charlestown. Land making in Boston has enabled the growth of the original 783 acre Shawmut Peninsula[2] to the contemporary Boston, which is comprised of over 5,250 acres of filled land.[3] Figure 1 shows the history of land-making in the city.

Land-making coincided with advancements in structural engineering and transportation that expanded type of materials that could be used to fill the new land. The first railroad in the United States was built in 1804 order to transport gravel taken from the southwest side of Mount Vernon for the filling of the Beacon Hill Flats.[4] Railroad technology later enabled the filling of the Back

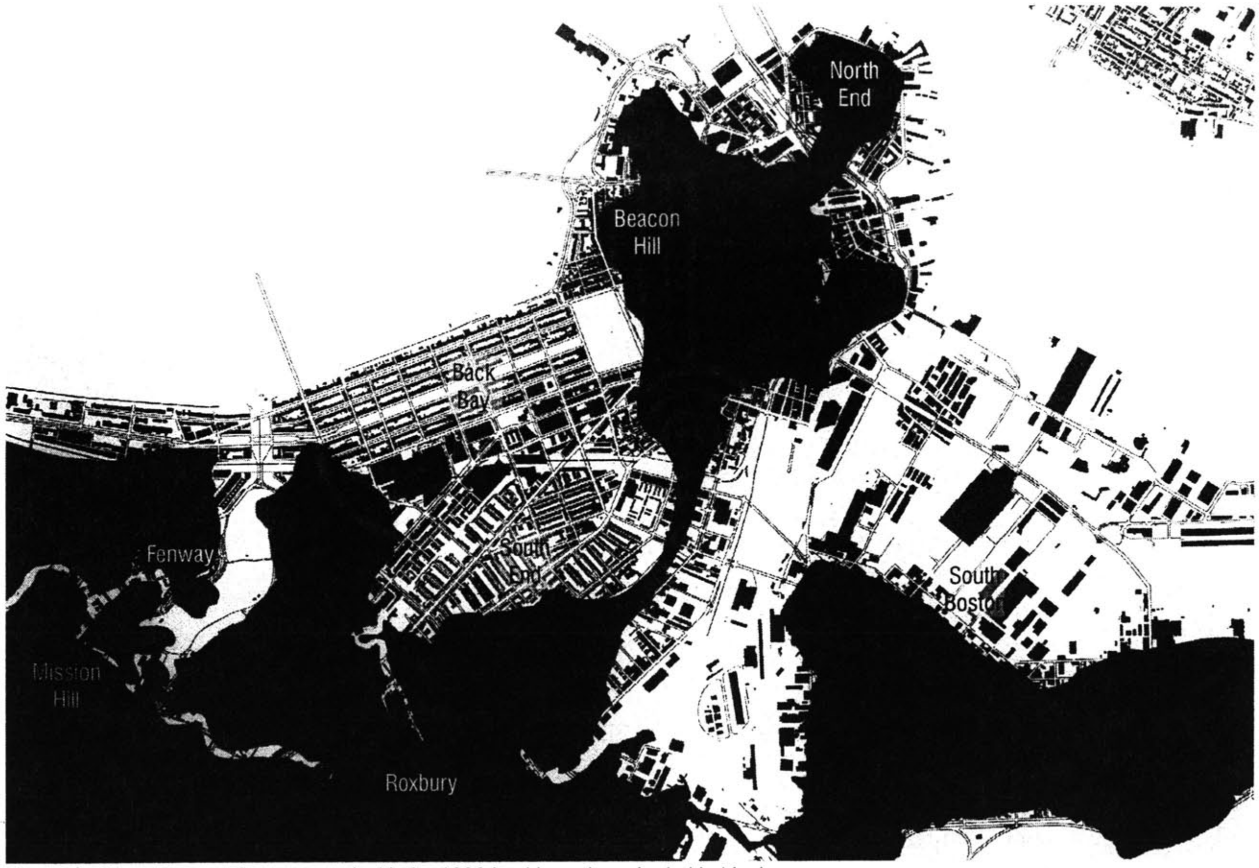


Figure 2: City of Boston figure ground with the 1630 land boundary shaded in black

Bay between 1858 and 1880. Trains arrived to Boston from Needham hourly and around the clock carrying the soil, sand, and rock that was used to fill Back Bay.

Buildings built on filled land before 1900 used wood pilings for structural support. Piles were driven through the softer fill into a hard layer of clay or soil below. The quality of the soil around the piles is one of the key factors that determine the length of time a wood pile remains preserved once it is exposed to air. The fill consists of primarily gravel and dirt, dredged earth, mud from the tidal flats, and garbage.[5] Cambridge slate underlies most of the Boston area, including the original Boston peninsula, Back Bay, East Boston, Cambridge, Watertown, and Somerville.

1.2.2 About Wood Pilings

Wood pilings remain strong so long as they remain submerged in water; European cathedrals are supported by wood pilings that were driven hundreds of years ago. The piles – often tree trunks of pine or spruce trees – were typically 25-30 feet long and were driven through the fill layer into a harder, more stable layer of sand, clay, or gravel beneath. Piles were spaced two to three feet apart and were conventionally cut off at an elevation of five feet above Boston City Base.[6] Boston City Base is the mean low tide level and is conventionally used as the zero-point against which groundwater and pile cut-off elevations are measured.[7] In the early 1900s the average water table elevation in the Back Bay was eight feet, leaving a three-foot buffer of groundwater above the tops of most pilings.

Wood pilings that are exposed to air feed subterranean parasites and rapidly disintegrate. Certain substances within the wood are food to fungi, and air and moisture cause fungi to grow and spread on exposed timber.[8] Fungi is the most aggressive cause of pilings deterioration, however pilings exposed to air are also vulnerable to termites and wharf borers, a winged beetle that attacks wood that is above the surface of the water. Once wood has been exposed to air, the amount of time that the piles can remain structurally viable is brief and ranges from three to twenty years. The lifespan of the wood piling depends on a variety of factors including type of wood, when the tree was cut, and conditions of the surrounding soils. A fully decayed pile has the consistency of mulch.

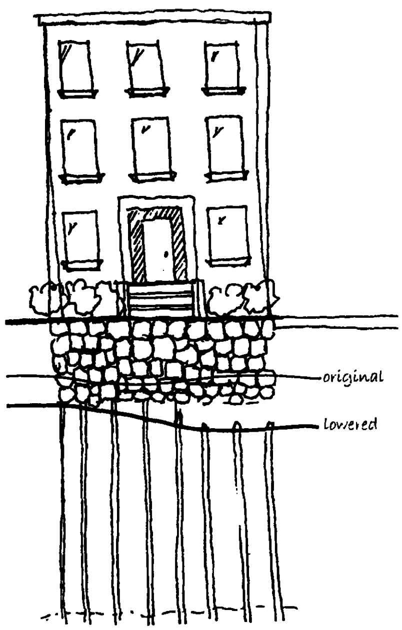


Figure 3: When the water table drops, tops of pilings that are exposed to air rot and decay.

Buildings typically include redundant pilings and can tolerate some decay. However, in the absence of intervention, pilings will continue to rot and eventually the building will settle onto the soil below the rotted pilings. Civil engineers inspect buildings with suspect pilings and condemn structures that have substantial changes in their method of support.[9]

Lowered groundwater levels have left the tops of many pilings throughout the city exposed to air. The most recent well readings indicate that groundwater levels in 146 of the 571 wells were below five feet.[10] This alarming statistic indicates that, within the monitoring area, roughly one fourth of wood pilings are exposed to air.

The only way to determine whether the pilings under a building have rotted is to dig a test pit, a procedure that costs several thousand dollars. Test pits are dug by hand because the exact location of pilings is not known. The exposed wood pile is then tested to determine the degree of rot. A variety of tests can be used to test the rot in a piling. The screwdriver test involves sticking a screwdriver into the pile in order to measure how far the tool can be driven. More technical analysis involves removing larger pieces of wood and evaluating the discoloration in order to assess the degree of decomposition. Wood pieces can also be sent to a lab for a more technical determination of structural stability.

One of the significant challenges with respect to lowered groundwater levels is that the elevation of the tops of pilings is unknown for large areas of the city. Traditionally, pilings were cut off and capped at five feet above Boston City Base. After the Back Bay was filled, the average mean low tide in the area rose to eight feet, and many developers felt that the five foot cut-off for wood pilings was excessively conservative. The higher water table prompted some engineers to advocate for a pilings cut-off standard of eight feet.[11] Fortunately, cooler heads prevailed and most pilings were cut at an elevation between five and six feet. However, pile cut-off elevations were ultimately at the discretion of the developer and vary from building to building.

1.3 Tracking Sources of Groundwater Loss

Boston loses 102.5 billion gallons of groundwater annually.[12] The only city in the United States that wastes a greater volume of groundwater than Boston is the sprawling metropolis of Atlanta. Aging infrastructure, underground construction, and impervious development are the principal sources for lowered groundwater levels in the city. Each year, the city of Boston loses a volume of groundwater that is equivalent to one year and eighty-nine days of water that is produced for the entire MWRA Waterworks System[13], which equals one fourth of the total capacity of the Quabbin Reservoir.[14]

The city's groundwater loss is attributed primarily to leaks in aging sewers, basements, underpasses, and subway tunnels. When not leaking, these deep underground structures obstruct water flow and act as dams against groundwater movement. Impervious surface paving prevents stormwater recharge and further reduces groundwater levels throughout the city.

In 1984, the Boston Redevelopment Authority commissioned Boston geotechnical engineering firm Haley & Aldrich to investigate the causes and consequences of development upon groundwater levels in the city. This section summarizes the findings of the 1985 Report on Groundwater in Back Bay, a subsequent technical essay on Back Bay groundwater levels, and a comprehensive study of basements in Back Bay in order to explain the primary causes of lowered groundwater levels and map the interventions that block groundwater flows throughout the city.

1.3.1 Leaks

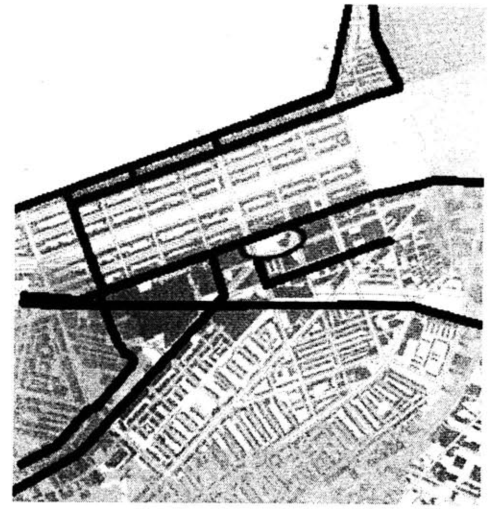


Figure 4: Boston's Back Bay is surrounded by infrastructure that drains away the local groundwater supply.. Copley Square is circled for reference.

Groundwater loss in Boston can be largely attributed to groundwater leaking into sewers, basements, tunnels, and underpasses. Groundwater that leaks into basements and tunnels also enters the sewer lines through pumps. Groundwater that is diverted into the sewer system either through pumps or cracks in the sewer pipes is treated at the Deer Island Sewage Treatment Plant and released into the Massachusetts Bay. Once sent to Deer Island, that water is lost; it does not return to its source.

Sewers

Cracks and leaks in the sewer lines are the most prevalent cause of lowered groundwater levels in Boston. Boston's sewer system originated in the nineteenth century and gaps in aging pipes allow groundwater to leak into the sewer system. In some instances, pronounced groundwater drawdown is observed in the area of a sewer main and fixing the sewer pipe restores the water level. In the 1930s the Saint James Avenue Sewer in Back Bay was found to be responsible for dangerous levels of groundwater drawdown around Trinity Church. Analysis of groundwater contours around Copley Square indicated that the St. James Avenue Sewer was the source of drawdown, so a partial dam was constructed in the sewer and water levels in the observation wells rose immediately. [15] However; causation of groundwater drawdown is extremely difficult to determine. Frequently sewers are patched in areas where groundwater levels are low and there is no effect on the level of the water table in the area.

The West Side Interceptor is one of the larger sewer lines in Boston and has been suspected of draining away substantial quantities of groundwater. The West Side Interceptor was built between 1877 and 1884 and runs along Charles Street, Beacon Street, and southwest towards Fenway. The large sewer pipe was installed in order to collect the outflow from the combined sewers in the northerly section of Back Bay that had formerly discharged into the Charles River.[16] Recognizing the high level of groundwater infiltration into the West Side Interceptor, the Boston Water and Sewer Commission is beginning a three-year, $2.6 million project to re-line the pipes during the summer of 2006.[17]

In the last ten years, the Boston Water and Sewer Commission (BWSC) and Massachusetts Water Resource Authority (MWRA) have made several important enhancements to the water and sewer lines in order to prevent leaks. In 1988, the sewer system was expanded through the construction of the Boston Main Interceptor and the new East Side Interceptor, which replaced deteriorated portions of the original system and increased the capacity of the sewer system. The new interceptors caused a reduction in the amount of groundwater leaking into the sewer system. In 2004, the MWRA completed the MeteroWest Water Supply Tunnel and also began an aggressive initiative to replace or line all unlined pipes in its 300-mile network. By fixing the leaks in the water supply network, the MWRA has improved the quality of water in the city, and has also eliminated important, albeit inadvertent, source of groundwater recharge.

Subways

The Huntington Avenue Subway, Boylston Street Subway, other subway tunnels and T-stations are responsible for lowering of groundwater levels in Back Bay. Construction of both the Huntington Avenue and Boylston Street Subways required prolonged dewatering, for which underdrain pipes were installed. These underdrains are believed to collect and divert groundwater that leaks into the structures.[18] The Back Bay MBTA station and leaks at the interchange of Massachusetts Turnpike and the Orange Line tunnel near the Back Bay Station are suspected to have caused significant drawdown around St. Charles Street in the South End. In 2004, the MBTA agreed to build a recharge tank under St. Charles Street and pay for one year of recharge.[19] Groundwater on St. Charles has largely returned to adequate levels, however levels in much of the neighborhood remain low.

Roads

Leaks into walls and floors of underpasses are a significant cause of groundwater lowering in Boston. The Storrow Drive Underpass is the roadway most notorious for its leaks, and the Massachusetts Turnpike Extension has also been investigated for lowering groundwater levels. In 1985 Storrow Drive was believed to be pumping 20,000 gallons of water per day from several wet wells.[20] The effects on groundwater levels of new construction, including the Big Dig and proposed renovations to the Storrow Drive tunnel, remain to be seen.

Basements

Basements cause localized lowering of groundwater by either damming the flow of water or, when leaks exist, draining water into sewer lines through pumps. Sump pumps are commonly used by homeowners to prevent basement flooding. These pumps are installed below the foundation and lower the surrounding groundwater to the level of the pump. Deep basements and parking lots of commercial buildings create proportionately greater loss of groundwater through leaks and damming effects. For example the Fleet Center pumps 120 gallons of water per minute.[21]

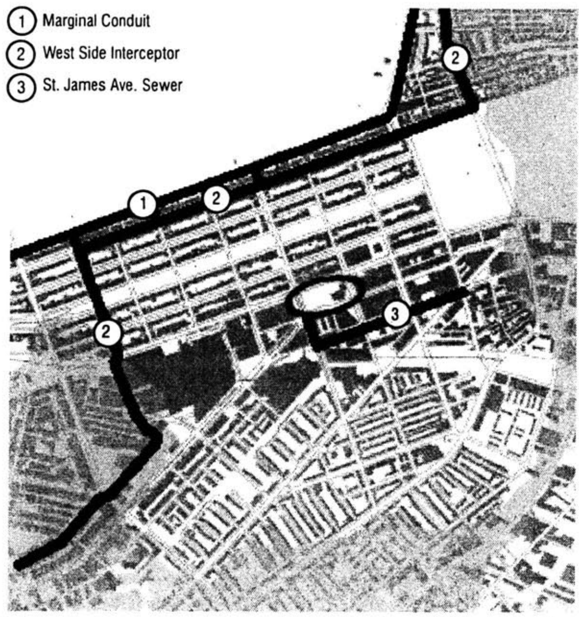


Figure 5: Sewers have been responsible for draining groundwater through leaks and cracks and lowering groundwater levels in Back Bay.

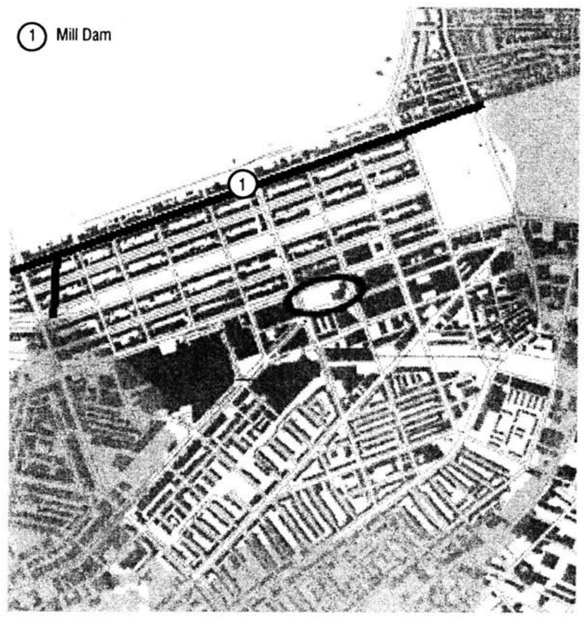


Figure 6: Constructed between 1818-21, Mill Dam blocked off water from the Charles River and enabled the filling of the Back Bay.

Until recently, residential buildings could construct basements in districts with low groundwater levels without attaining approval by special permit. One Marlborough Street resident went so far as to dig a basement that was deep enough to allow their children to dunk on their new, regulation-height basketball hoop.[22] Because basements were built as-of-right, the total number and location of basements is not known, therefore the net effect of basements on groundwater lowering cannot be determined.

1.3.2 Dams

If underground construction had never been developed in Boston then groundwater levels would be uniform throughout the city and the water table elevation would be roughly eight feet, well above the cut-off height of the pilings. However, groundwater levels vary significantly from block to block and often fluctuate as well. A significant source for this unnatural variability in groundwater levels are underground developments – basements, underpasses, tunnels, and dams – that impede the flow of groundwater. Specifically, Mill Dam, West Side Interceptor, and Boston Marginal Conduit act as dams that block the flow of water from the Charles River Basin into Back Bay. [23]

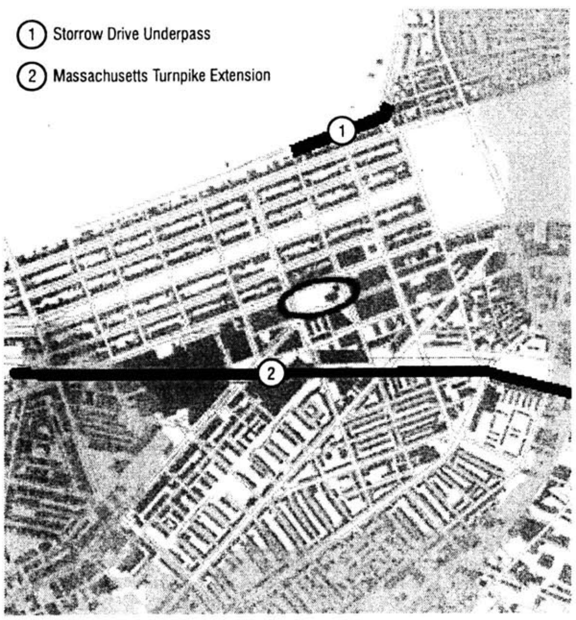


Figure 7: Highway underpasses act as both dams and drains, blocking groundwater flows when solid and leaking ground-water through cracks in walls tunnel walls

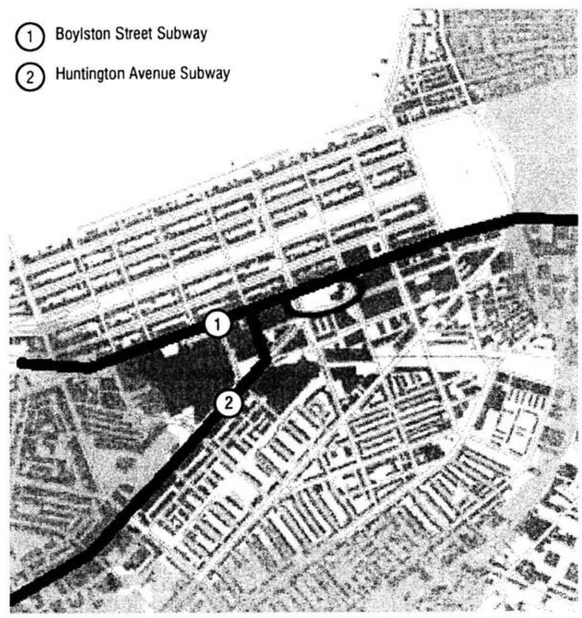


Figure 8: Subways, like underpasses, block and divert groundwater flows. The amount of groundwater draining into subway tunnels is unknown.

Mill Dam

The Mill Dam blocks water from the Charles River from recharging the Back Bay. Built between 1818 and 1821, The Mill Dam stretched for a mile and a half across the Back Bay and connected Boston to Brookline along the present-day site of Beacon Street. Mills were located on Gravelly Point and were powered by tidal activity of the river. Upon the dam's completion, project surveyor John Hales stated that the "Great Dam" was "composed of solid materials and made water tight".[24] Completion of the Mill Dam spurred more land filling to the north and south of the new dam project and the land between the Mill Dam and the original Boston Neck eventually became Back Bay, Bay Village, the South End. After the Mill Dam was constructed, water levels in the receiving basin dropped below mean tide (eight feet above Boston City Base).

Marginal Conduit

The Marginal Conduit has been the cause of catastrophic lowering of groundwater in the Beacon Hill Flats. Constructed in 1910 as part of the Charles River Dam project, the Marginal Conduit was designed to catch overflow from the West Side Interceptor and Stony Brook. In later years, pipes were placed beneath the Marginal Conduit in order to reduce the dam effect and carry groundwater from one side of the structure to the other. Subsequent groundwater drops in the areas indicate that the siphons have been unsuccessful in their efforts to stem the fall of groundwater in the area.

1.3.3 Failure to Recharge

Groundwater is replenished by stormwater draining into the ground. Within Boston, roads, buildings, sidewalks, parking lots, and other impervious surfaces block recharge and drain stormwater away. James Lambrechts, technical advisor to the Boston Groundwater Trust, estimates that only five percent of the surface area of the city is pervious.[25] Adding to the problem are unnecessary obstructions such as downspouts, which channel rainwater from the roof directly into the sewer system.

Recharge basins are an effective means of maintaining safe groundwater levels at impervious sites. Three separate recharge systems in Copley Square keep the pilings of Trinity Church and the Boston Public Library submerged. Trinity Church installed conductors that collect water from the roof gutters and channel it into a brick lined pit in the basement, the Boston Public Library installed a recharge system along Dartmouth Street in the mid 1950s, and Sasaki redesign of Copley Square in 1968 included a recharge basin below the plaza.[26] In the South End, a recharge tank was installed on St. Charles Street that maintains groundwater levels for nearby homes. There are currently only a handful of examples of recharge systems in the city, however recently implemented zoning changes will increase residential use of recharge systems.

1.4 History of groundwater-related damage in Boston

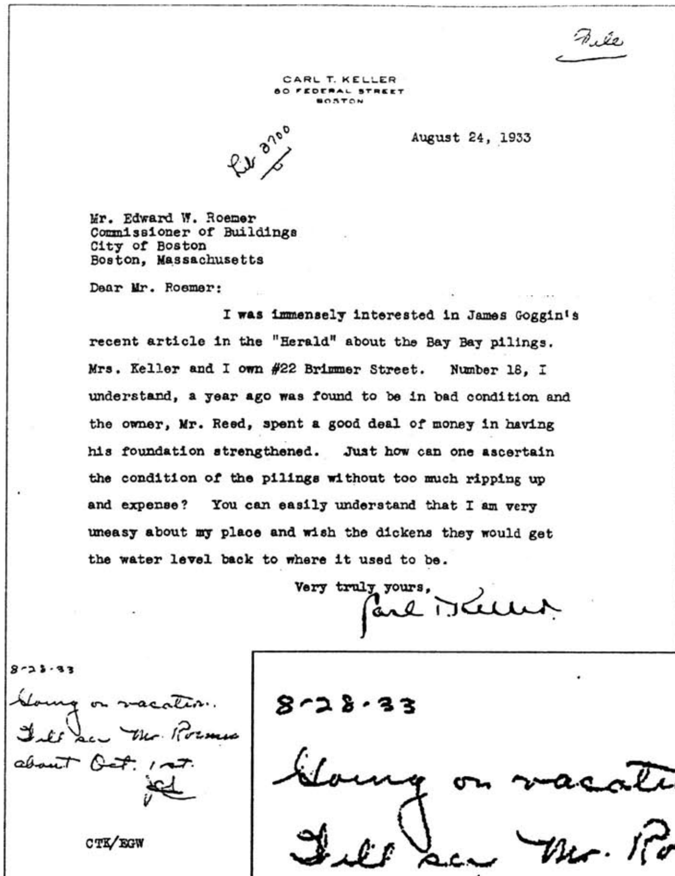
Records of pilings-related damage are largely incomplete and most accounts are anecdotal. Long-time residents of the Beacon Hill, Back Bay, the South End, Bay Village, and the Fenway can each tell a story about a neighbor who experienced the agony of underpinning or, worse, condemnation. However, property-owners are frequently reluctant to discuss groundwater or pilings for reasons of denial and desire to protect property values. Newspapers reported on the most severe pilings stories, but only during the periods of time when groundwater issues were important to the city. The Boston Inspectional Services Department houses records of cut-off heights of pilings and permit applications for underpinnings. However, many of the records about pilings are incomplete therefore the risk of damage remains unknown.

This section compiles anecdotal information, newspaper articles, reports, and a sampling of inspectional service data to document some of the pilings failures to date. Although largely incomplete, these stories demonstrate that pilings damage is not localized to any one neighborhood, but spread across the city and across all socioeconomic, race, class, and income divisions.

The city of Boston has been aware of pilings damage for almost eighty years. The 1930s were marked by several notable incidents of pilings damage, including the discovery of severe rot in more than forty percent of the pilings in the Boston Public Library.[27] The library initiated an intensive reconstruction effort for its sinking foundation. The cost of the underpinning in 1930 was $200,000[28], which is the equivalent of $2.3 million today. Discovery of pilings rot below the Boston Public Library triggered concern for neighboring Trinity Church, which subsequently investigated its pilings, found they were solid, and implemented a permanent recharge system on site.

In addition to the Boston Public Library, several residential buildings were found to have rotted pilings during the 1930s. Oxford Place in Chinatown was condemned due to rotted pilings. Brimmer Street in the Flat of Beacon Hill found its first incidents of rotted pilings in 1936, and there would soon be many more.

On August 24, 1933, Carl Keller, a resident of the Beacon Hill Flats, wrote a letter to the City of Boston commissioner of Buildings (see Figure 9). His letter expressed concern and outrage over the lowered groundwater levels and confusion as to how to protect his property from harm. In response, the commissioner scribbled across the bottom of the note "Going on Vacation."[29] In fact, the city remained on vacation with respect to groundwater issues for almost fifty years until the mid-1980s when a new series of piling-related failures prompted city officials to pay attention again.


File

CARL T. KELLER
60 FEDERAL STREET
BOSTON

August 24, 1933

Mr. Edward W. Roemer
Commissioner of Buildings
City of Boston
Boston, Massachusetts

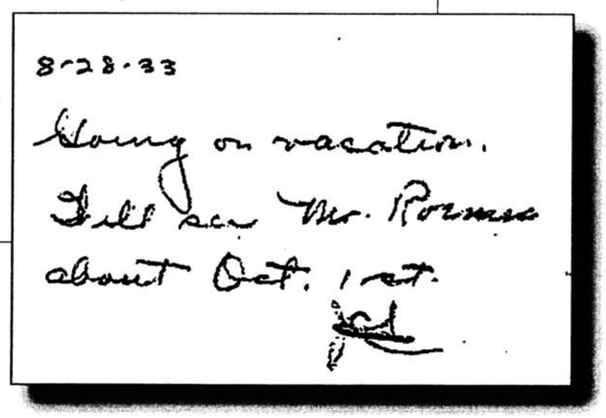
Dear Mr. Roemer:

I was immensely interested in James Goggin's recent article in the "Herald" about the Bay Bay pilings. Mrs. Keller and I own #22 Brimmer Street. Number 18, I understand, a year ago was found to be in bad condition and the owner, Mr. Reed, spent a good deal of money in having his foundation strengthened. Just how can one ascertain the condition of the pilings without too much ripping up and expense? You can easily understand that I am very uneasy about my place and wish the dickens they would get the water level back to where it used to be.

Very truly yours,
Carl T. Keller

8-28-33
Going on vacation.
Will see Mr. Roemer
about Oct. 1st.

CTK/EGW


8-28-33
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Will see Mr. Roemer
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Figure 9: Letter from Beacon Hill resident Carl Keller to the City of Boston, 24 August 1933

In 1980, the pilings of four residential buildings on Belvidere Street that were owned by the Christian Science Church were found to be rotted beyond repair. The residents of all thirty-two units were forced to leave and plans were made to fix the pilings and convert the building to luxury housing.[30] Instead, the building was torn down and today is a surface parking lot.[31] Five buildings on Hudson Street in Chinatown were condemned and demolished due to rotted pilings between 1988 and 1989.[32] In 1986, residents of a townhouse in Otis Place in the Flat of Beacon Hill awoke to find that their house had collapsed six inches overnight. Between 1985 and 1989, geotechnical consulting firm Haley & Aldrich reinforced more than 50 pilings in the Back Bay.[33]

The problems of pilings damage continue today. This year, twenty condominium owners in the North End each paid $50 thousand in order to underpin the pilings below their building. The expense was too much for some and owners were forced to sell their homes at a reduced price. Anecdotal stories of rotted pilings have prompted the Boston Groundwater Trust to expand its well network into potentially affected areas within East Boston.

1.5 Conclusions

The risk of structural damage due to lowered groundwater level affects the city as a whole, and specifically targets those neighborhoods that make Boston a unique built environment and define the image of the city. The problem can remain invisible for years and is easy to ignore, but it must be addressed. The character of the city, along with the financial holdings of thousands of Bostonians, is linked to the structural preservation of homes that rest on wood pilings. There are only two ways to maintain the stability of structures that are supported on wooden pilings: (1) keep the wood piles submerged in water, and (2) reinforce the pilings. The following chapters consider both strategies in order to create more comprehensive approach to structural preservation in Boston.

2. Maintaining Groundwater at Safe Levels

"In Groundwater We Trust" – Slogan from Boston Groundwater Trust T-shirts

2.1 Introduction

Following decades of denial, local and state governments have finally acknowledged that lowered groundwater levels pose serious threats to the City of Boston. The mayor, state agencies, and various local government officials have stated publicly that groundwater levels are low and political response is required.1 Words are being mirrored with actions, and federal, state, and local agencies have contributed money and resources toward improving groundwater levels. In past years, state and local entities were so fearful of liability that groundwater discussions could only be held through lawyers. Today, the city's groundwater problems have become part of the public's consciousness and can no longer be ignored.

Groundwater levels will increase only if a two-pronged effort to stop leaks and increase recharge is advanced. Recharge alone is insufficient for increasing groundwater to a level that will preserve wood pilings. Even if all stormwater reentered the ground, leaky sewers and other infrastructure would drain away a substantial amount of the groundwater and the tops of some pilings would remain exposed. Nonetheless, the present rate of water capture in Boston is too low and recharge is a worthy pursuit.

This chapter considers the strategies and policies that have been adopted in order to increase recharge in Boston and examines how these policies can be made more effective.

2.2 Recharge Efforts to Date

Within Boston stat e and local government agencies have joined forces in order to raise the water table in Boston. The two city entities that are currently address groundwater issues are the City of Boston and the Boston Groundwater Trust, and various state agencies are actively involved in groundwater issues, including Boston Water and Sewer Commission, Massachusetts Water Resources Authority, MBTA, and Massachusetts Turnpike Authority. Within the city government, groundwater issues have escalated to the cabinet level. James Hunt III, Chief for Environmental and Energy, is directly responsible for addressing groundwater and acts as a liaison between city and state stakeholders responsible for creating groundwater problems.

2.2.1 City Efforts

Boston Groundwater Trust

In 1986 the City of Boston created the Boston Groundwater Trust, a quasi-governmental municipal entity that has been entrusted with promoting "the public health, safety, convenience, and welfare by monitoring groundwater levels and making recommendations to raise, restore, or protect the water table in areas where it is low to protect wood pile and other types of foundations of buildings".[2] The Boston Groundwater Trust was the City's first official response to preventing groundwater-related disasters and was formed soon after a consortium of Beacon Hill Flats residents sued Boston Water and Sewer Commission and the Massachusetts Water Resource Authority. The case settled out of court and the Groundwater Trust remained as the city agency dedicated to addressing groundwater issues. The Trust is a municipal entity, funded largely by the city, and managed by twelve trustees who are appointed by the mayor. As an entity of the city, the power granted to the Groundwater Trust can be taken away as easily as it was given. In 1993, Boston Mayor Thomas Flynn chose not to appoint new Trustees to the Groundwater Trust, and the Trust went dormant until 1999 when Mayor Thomas Menino reinstated funding for the organization and appointed new trustees.

Today, the Boston Groundwater Trust monitors more than 600 wells throughout the city, maintains a database of groundwater levels for each well, analyzes composite well readings to find hot spots (areas where groundwater levels are dangerously or abnormally low), and works with the city, state, and other governmental agencies to promote activities that restore or maintain groundwater at safe levels. The Trust employs two full-time staff, has a technical advisory committee comprised of local civil and geotechnical engineers, and maintains a permanent office space in Back Bay.

Monitoring Wells

Boston's streetscape is dotted with hundreds of six-inch cast iron discs that hide a network of monitoring wells that track the levels of groundwater throughout the city. These inconspicuous interventions are monitored regularly and serve as a warning system when groundwater levels become dangerously low. As a whole, the well network tells the story of groundwater flows throughout the city – information which is critical to creating a strategy for mitigating damage from lowered groundwater levels.


Figure 10: Boston Groundwater Trust Well Cover

The first monitoring wells were installed between 1936 and 1940 by the Works Progress Administration (WPA) following the discovery of dangerously low groundwater levels around the Boston Public Library. The WPA installed 1296 wells and took over 95,000 readings during the four year project period.[3] Tragically, a fire at Boston City Hall destroyed the records of these readings.[4] The well infrastructure laid by the WPA has been important in tracking groundwater levels in the city at multiple points in time. In 1967 and 1968, the USGS used the WPA wells to monitor groundwater levels in order to understand the impact of the proposed Inner Belt expressway.[5] Fewer than half of the WPA wells were useable at the time of the USGS study. When the Boston Groundwater Trust was formed in 1986, ownership of the WPA wells was granted to the Trust. In 1999, the Groundwater Trust began to uncover the WPA wells that could still be used, which numbered roughly 150. These wells formed the base of the Boston Groundwater Trust's monitoring network until 2003, when a Commonwealth Environmental Bond Bill infused the Groundwater Trust with $1.6 million dollars, which financed the digging of 500 new wells.[6] Today, the Boston Groundwater Trust monitors 671 groundwater wells throughout the city and plans to increase the number of dry wells in the city to over 800 by the end of the year. Once complete, this extensive monitoring well network will be able to measure the ebbs and flows of groundwater in Back Bay, Beacon Hill, Bay Village, Chinatown, the South End, the North End, East Boston, and the Fenway.

Well readings are taken every six weeks by an undergraduate co-op student at

Wentworth Institute of Technology. Each well reading captures the date, time, and water level at the time of reading. The Boston Groundwater Trust maintains a database that tracks the water level readings for each well since 1999. A history of water elevations for each well is shown on an interactive map that is hosted on the Boston Groundwater Trust website.[7]

Groundwater Conservation Overlay District

On February 15, 2006 the City of Boston Zoning Commission added Article 32, the Groundwater Conservation Overlay District (GCOD), to its zoning code. This new article adds a recharge requirement to certain types of developments within the overlay district boundary. The GCOD became the twelfth category of overlay districts that regulate development within the City of Boston.[8]

The GCOD applies to any projects that result in new paving or the erection or extension of any structure; excavation of more than seven feet above Boston City Base; or substantial rehabilitation of a structure (alterations or repairs that cost more than half of the value of the building). Any of these projects would require relief from existing zoning and must be approved by either the Zoning Board of Appeals or the Commission of Inspectional Services. In order to receive a building permit, the applicant must demonstrate that the new project will capture a specified amount of rainwater (a volume of rainfall equivalent to one inch for each square inch of the lot to be occupied by the proposed project) and that the project will avoid any negative impact to groundwater levels on site or on adjacent lots.[9] If the criteria established in Article 32 are not met, then a building or use permit will not be issued for the project. It is important to note that the Article 32 promotes recharge, therefore the policy prevents pilings from further damage but does not correct for damage that has already occurred.

Boundaries of the new GCOD and associated study areas can be seen in Figure 11. The area includes Back Bay, parts of Beacon Hill, Chinatown, the South End, the Fenway, Bay Village, the Leather District, and the area around Boston University. The Commission has also designated several study areas – areas for which there is less data about the level of groundwater. Anecdotal evidence has been reported that indicates that pilings have rotted in East Boston, the North End, and South Boston. These study areas are being monitored through new test wells that will be installed by the Boston Groundwater Trust by the end of this year. If testing indicates that the GCOD boundaries need to be expanded to include study areas, the BRA must recommend new additions, then the Boston Zoning Commission decides whether to accept the BRA's recommendations.

Figure 11: Groundwater Conservation Overlay District boundary

Any project that is subject to the provisions of Article 32 must be certified by a licensed engineer in order to demonstrate that the project meets the water capture requirements of the new Groundwater Conservation Overlay District. The Inspectional Services Department reviews and approves projects that propose only new paving. Projects that involve excavation, extension, or substantial rehabilitation create a larger potential impact for neighboring properties, therefore approval must be granted by the Zoning Board of Appeals. Projects that come before the Zoning Board of Appeals are discussed in a public hearing, to which community members and abutting property owners are invited, then reviewed by the Boston Groundwater Trust and Boston Redevelopment Authority. Final approval or disapproval is granted by the Zoning Board of Appeals.

Overlay districts are a commonly-used tool for protecting the availability and purity of shared groundwater resources. An overlay district is applied to a contiguous area and adds an additional layer of restrictions to the existing zoning regulation in order to promote a special purpose. Groundwater overlay districts are used in

Minnesota; Cape Cod; Broward County, Florida; Spokane County, Washington; and Crystal Lake, Illinois in order to protect the quality of groundwater locally.

2.2.2 City-State Working Group

The past two years have been marked by increased cooperation and collaboration between city and state agencies in order to address the problems associated with lowered levels of groundwater. A Memorandum of Understanding signed in September 2005 formalized a commitment of the various agencies toward a common goal – solving for the lowered water table. The MOU was signed by the City of Boston, Boston Groundwater Trust, Boston Water and Sewer Commission, MBTA, Massachusetts Turnpike Authority (MTA), Massachusetts Water Resources Authority, and the State of Massachusetts. Following the MOU, each organization has demonstrated its increased commitment to protecting groundwater resources in Boston. Many of these organizations have already committed funding for the Boston Groundwater Trust, including the City of Boston ($155,000), Executive Office of Environmental Affairs ($50,000), and Boston Water and Sewer Commission ($25,000). James Hunt III, chief of energy and environment for the City of Boston and a member of the Mayor's Cabinet, convened the signatory organizations and with one mission in mind. "Our number one priority [with respect to groundwater] is to plug leaks," comments Hunt.[10]

MOU signatory groups have increased their commitment to maintaining safe groundwater levels. This year the MBTA acknowledged for the first time that it bears some responsibility for the city's groundwater problems and created a line item in its annual budget to mend subway infrastructure that contributes to lowered levels of groundwater. The Boston Water and Sewer Commission has sealed leaking sewer mains; diligently investigated their infrastructure in areas where groundwater is abnormally low; and effectively mitigated hot spots, such as the area around St. Charles Street in the South End, where the BWSC pumped 22,000 gallons of water a day from a near-by fire hydrant to recharge groundwater levels.[11] Likewise, the MTA has inspected areas of the Turnpike near Chinatown where abnormally low groundwater levels have been observed.

In spite of these advancements, there is still much room for improvement. The recent contributions made by key agencies begin to look paltry when compared to the magnitude of the problem. For example, from its annual budget of $1.125 billion, the MBTA allocated $3 million to the groundwater restoration effort. Relative to the $52.3 million[12] that the MBTA will spend in 2005 for infrastructure improvements, this nod to groundwater protection hardly seems significant. The 2002 Environmental Bond Bill raised $707 million, of which a mere $1.6 million was allocated to groundwater-related causes, a sum that would be adequate to underpin five homes. Although groundwater has become an issue, the money trail suggests that its priority remains low.

Boston Water and Sewer Commission (BWSC)

The Boston Water and Sewer Commission, a city agency with a high degree of autonomy, is investing heavily in capital improvements that will reduce infiltration and prevent groundwater lowering. The agency has done more than any other state agency to respond to decreased groundwater levels. Each month, the Boston Water and Sewer Commission uses the data collected by the Groundwater Trust to create contour maps of the groundwater hydrology throughout the city. Based on these maps, the BWSC and the Groundwater Trust determine hot spot areas and potential sources of drawdown. If the cause of the drawdown is suspected to be a Boston Water and Sewer Commission pipe, then the BWSC will fix its leak. The St. James Avenue sewer in Back Bay was recently repaired following a series of low groundwater reading by the Boston Groundwater Trust.

2.3 Improving Policies to Increase Recharge

2.3.1 Citywide Solutions

Long-term Planning

Members of the city-state working group are fixing leaks in sewers, tunnels, and underpasses as they are discovered. This ad hoc approach to the problem makes budgeting, prioritizing, and planning impossible. Signatories to the MOU should create a citywide strategy for addressing risks associated with groundwater loss. As part of the long range planning, agencies would have to determine how much it would cost to fix leaks in infrastructure and/or to underpin all pilings and quantify the risk associated with structural instability caused by groundwater decline. Quantifying costs and risks will make for better policy and will help homeowners make better decisions about recharge and underpinning.

Mapping

Millions of dollars have been spent digging wells into the ground – now a much smaller investment needs to be made in order compile the data into useful information. The Groundwater Trust has amassed vast quantities of raw data from well readings. Well reading data is publicly available and sorted by well, however individual well readings only indicate groundwater levels at points. In order for all of this data to have a real impact, the water level between the points needs to be extrapolated into a full contour map of groundwater flows in the city. This mapping is already done on a monthly basis by the Boston Water and Sewer Commission. The contents of these maps are closely guarded by the Boston Groundwater Trust and Boston Water and Sewer. If the maps were made publicly available, community groups could take a more active and informed role in the defense against groundwater drawdown in their neighborhood.

Several layers of information should be included on maps that are released to the public, including groundwater contours, locations of sewers and deep basements, well locations, and groundwater depths. If all of this information is presented in a graphically coherent fashion, then there are multiple active residents within each neighborhood who possess professional expertise that would enable them to accurately interpret the maps. Better mapping would reduce the need to dig costly test pits and provide critical feedback about the effects of recharge systems (or other interventions) that are implemented locally. With the recently-implemented Groundwater Conservation Overlay District, information gained from well reading has become more important than ever. The city and stakeholders need to understand how the newly mandated levels of recharge affect groundwater levels locally.

High tech well readers

The Boston Groundwater Trust should keep abreast of emerging technologies in compatible fields in order to automate readings in more wells. For example, the MIT Department of Civil Engineering and Media Lab have produced a remote sensing device that reads the water level in sewers in order to detect Combined Sewer Overflow (CSO) events. The technology involves a pressure transducer, which measures the weight of the water above the chip, and communicates via microchip to a receiver that is located 100m away on a stationary object such as a lamppost. The receiver communicates with the central database via Bluetooth technology. The microchip can transmit the data in real time and, if each well had a sensor, the underlying hydrology of much of Boston could be mapped in real time as well.[13] This technology could readily be made available for under $200 per well.[14]

The Boston Groundwater Trust has purchased twenty-five data loggers, which use a pressure transducer to monitor the level of groundwater every hour. The data loggers are used to monitor wells in hot spots in order to develop a better understanding of groundwater activity in the most sensitive locations.

Each unit cost $1,000 and the purchase was funded by a grant from the City.

Strengthening the Groundwater Conservation Overlay District

Article 32 has limited applicability and is but one piece of a larger strategy aimed at increasing recharge levels in designated areas of Boston. The Groundwater Conservation Overlay District alone will not increase groundwater to levels adequate for protecting pilings. Development proposals that are subject to the overlay district criteria are infrequent. The area within the overlay district is almost fully developed and there are limited opportunities to increase impervious surface area. The "substantial rehabilitation" criterion of the code is only met if renovations are proposed that are valued at greater than half of the value of the building. Given current property values, the cost of renovation would have to equal at least $200 thousand in most cases in order to meet Article 32 standards.

The stated purpose of the Groundwater Conservation Overlay District is to "prevent the deterioration of and, where necessary, promote the restoration of, groundwater levels in the city of Boston; (b) protect and enhance the historic neighborhoods and structures, and otherwise conserve the value of its land and buildings; (c) reduce surface water runoff and water pollution; and (d) maintain public safety". [15] For these goals to be met, the overlay district must be applied to more projects, create more stringent recharge requirements, and be incorporated into a more comprehensive effort to increase recharge levels. The following actions could improve the effectiveness of the new zoning article:

- Standardize storage requirements – Article 32 requires that new development include a water storage system that can capture a volume of rainfall equivalent to one inch across the area of new impervious surface, or equivalent to the one inch of rainfall over the entire building area for substantial rehabilitation projects. However, neither the BRA, nor the Boston Groundwater Trust, nor the City of Boston, nor the Inspectional Services Department has established specifications for storage or recharge systems or strategies that will comply with the new zoning. "We want to see what the engineers come up with," said Elliot Laffer, Executive Director of the Boston Groundwater Trust.[16]

  By leaving the definition of compliance for the market to decide, the city is missing an opportunity to add teeth – higher levels of enforceability and rigor

– to the overlay district. As written, the overlay requirements are too loose. Applicants need only demonstrate that adequate amounts of rainwater will be stored, not recharged, below ground. Property owner may utilize the storage system of their choosing. The city could mandate a higher level of recharge if it specified the types of systems that are permissible to use as holding tanks or performance standards for recharge that the holding tanks must meet.

- Reduce threshold – Apply the Article 32 requirements to any project seeking a building permit. The parts of the city that are most threatened by lowered groundwater levels are also some of the densest, most built-out neighborhoods in the city. The GCOD requirements kick in when a property-owner expands the building's footprint or digs underground. However, many of the structures in affected neighborhoods are already fully built-out. If the GCOD requirements were imposed upon every developer seeking a building permit, then recharge goals could be met more quickly.

GCOD boundary lines should include all filled areas of land on which buildings supported by wood pilings stand – The intent of the overlay district is to protect buildings on wood pilings from future lowering of the water table. To achieve this end, any filled land on which buildings with wood pilings are still standing should be included within the boundary of the overlay district, even if well readings indicated that groundwater heights are adequate today. Rotted pilings are known to exist in neighborhoods outside of the GCOD, including the North End and East Boston. This empirical evidence should provide enough proof to merit extending the overlay district into a neighborhood. Local officials insist that groundwater levels must be monitored and understood before extending overlay district protections to a neighborhood. However, new construction could always cause groundwater to fall in the future and additional data will not change the need to protect susceptible areas that have been excluded from the district.

<u>Article 80</u>

Any new development project that is over 20,000 square feet in gross floor area must conform to the development requirements of Article 80 of the Boston zoning code. The projects that fall under the Article 80 umbrella are of a scale that can significantly affect groundwater levels for surrounding properties. Article 80 outlines four types of development reviews: small project review for developments between 20,000-50,000 square feet, large project review, for developments greater than 50,000 square feet; Planned Area Development Review, and Institutional Master Plan Review.

Projects that undergo Article 80 review today must estimate their effects on surrounding groundwater levels as a part of the permitting process. However, this requirement is enforced by convention not code and this informal policy could change at a whim. Groundwater protection should be codified built into Article 80 review so that development permits are conditioned upon implementation of recharge systems and evidence that the new project will not negatively impact surrounding groundwater levels. Projects affect groundwater levels in proportion to their scale. Large developments should be held to the same standards or higher as is required for residential building through Article 32, the Groundwater Conservation Overlay District.

2.3.2 Point Interventions

Individual property owners have little control over sewer leaks but some ability to increase recharge in their own neighborhoods. Currently in Boston, only five percent of water that falls from the sky returns to the earth. Channeling rainwater from roofs into the ground would capture thirty percent of the rainwater for recharge. If parking lots were repaved with pervious materials then half of the rainwater would recharge the ground.[17] Small, incremental improvements in stormwater recharge systems could protect buildings around Boston from future reductions in the level of the water table.

Neighborhoods in Boston with the most severe groundwater problems waste their most important source of recharge, stormwater, by connecting drainpipes to sewer lines through downspouts. The most recent capital improvement program of the Boston Water and Sewer Commission includes a $2.25 million project that, over the next three years, will disconnect downspouts from sewers in Jamaica Plain, Dorchester, Neponset, Ward Street, Allston-Brighton, West Roxbury, and Hyde Park.[18] BWSC has disconnected 1,400 downspouts since 1994.[19] It is unclear why Boston neighborhoods with low groundwater have not been included in this project. In the next capital budget plan, neighborhoods with low groundwater levels and little pervious space should be included in the downspout removal program.

2.4 Negative Impacts of Recharge

Promoting recharge could be problematic for property-owners of buildings with basements that are prone to flooding. Leaking basements pose a problem for many property owners in the city, and the source of these leaks is often groundwater entering through cracks in the basement walls. In a letter to the BRA dated October 28, 2005, Elliott Laffer, director of the Boston Groundwater Trust, expressed his concern for promoting recharge in areas that need groundwater levels to remain depressed, such as low basements.[20] Recharge around these properties will exacerbate the leak issue and owners of garden apartments will object vociferously to proposed new development that will increase recharge levels.

If recharge increases before leaks are fixed, then the sewer system will be taxed by the additional groundwater that will be pumped through its system. Fixing the leaks in sewers and other subterranean structures will require much time, money, and inter-agency cooperation. The Boston Water and Sewer Commission should be consulted in devising recharge strategies to ensure that the sewer system can handle the increased capacity.

2.5 Conclusion

City and state agencies have made dramatic and commendable efforts over the past year and a half to address local groundwater issues cooperatively. Public agencies have taken a large step in acknowledging their infrastructure projects have caused reduced groundwater levels, and there are now concerted efforts being made to fix leaks and reduce infiltration and inflow of groundwater into sewers and tunnels. Large and small scale projects that increase recharge are being simultaneously pursued. The politicization of the boundary lines for the new Groundwater Conservation Overlay District has caused this small-scale and highly incremental recharge project to receive a disproportionate amount of local attention. Boston loses massive quantities of groundwater to infiltration into subterranean infrastructure. The city and state should remain focused on their efforts to plug leaks underground.

3. Working from the Bottom Up: Protecting Boston's Pilings

"It's a muddy, inconvenient, low-tech mess" – Susan Scott, South End resident and groundwater activist, referring to the underpinning process

3.1 Introduction

With so much focus on groundwater, it is easy to forget that the real sources of structural instability in Boston are the wood pilings. Wood pilings are a great area of mystery – their cut-off heights are frequently unknown and the physical condition of the pilings can only be determined by visual inspection, which involves digging a test pit. Moreover, the patterns of cut-off elevations of wood pilings can be even more quirky than the flows of groundwater. Some developers left the piling lines blank on the permit form, others may have been inaccurate in their estimation of the cut-off elevations, and sometimes piling cut-off height can vary beneath a single structure. On Beacon Street, there is one home that is supported by pilings that are cut off at four different heights.[1] Without understanding the structural condition of the pilings, any groundwater management strategy – including the most aggressive recharge strategy – is little more than a guessing game. This is the dirty little secret that everybody involved with groundwater in Boston knows but nobody wants to talk about.

There are properties around the city with rotted pilings waiting to be discovered, and as the city and state make incremental steps toward increasing levels of recharge, pilings already exposed to air will continue to decay. Lowered groundwater levels are not the fault of the property owners, but these residents are shouldered with the full burden of financing - up front and in full - underpinning once their pilings rot. This chapter considers rotted pilings in greater depth in order to understand how property owners of buildings with rotted pilings can be better incorporated into the city, state, and community groundwater strategies.

3.2 Demystifying the Pilings Problem

3.2.1 Why nobody wants to talk about pilings

All stakeholders involved in the groundwater issues have a disincentive to address pilings. Property owners frequently prefer the risk of not knowing about the conditions of their pilings to the potential burden of underpinning, which is both an expensive and inconvenient undertaking. If pilings are rotted, then underpinning is the only solution for maintaining the structural integrity of a building. Moreover, homeowners who have dug test pits must disclose their findings prior to selling their home. Several Back Bay and South End residents conveyed anecdotes of neighbors who were forced to reduce the sale price of their home by $200 to $300 thousand in order to compensate for the cost of underpinning. There are strong psychological factors that prevent homeowners from fully absorbing the risk associated with groundwater loss. Individuals who are directly exposed to high levels of risk tend to assume that the hazards are trivial. Further, the uncertainty surrounding the magnitude of pilings damage leads property owners to excessively discount their risk exposure.[2]

State and city agencies responsible for reducing groundwater levels have agreed to address sources of drawdown, but will never volunteer to talk about the option of paying for underpinning. Financing pilings' underpinnings would put these agencies in a bottomless pit of liability – once one underpinning is financed, the agencies would then be responsible for the cost of past, present, and future underpinnings, which could cost billions of dollars. Their strategy of silence about the pilings has worked to date. Property owners have lost or settled every legal claim brought against city and state agencies to extract damages for the cost of underpinning. Predicting groundwater flows is an uncertain science and causation is virtually impossible to prove. Moreover, even if causation was determined, property owners would have to prove that agencies were negligent in their development of infrastructure and knew that groundwater infiltration would result from their projects. Many of the causes of drawdown were installed decades ago and the statute of limitations on legal action has passed.

The Boston Groundwater Trust does not have the funding or the mandate to help mitigate the problem of rotted wood pilings. As its name suggest, the Boston Groundwater Trust deals with groundwater. By charter, the organization is limited to installing monitoring wells, tracking groundwater levels, and participating in city-state efforts to address groundwater.

Neighborhood groups such as Citywide GET are the most appropriate agency to focus on pilings repair because they have the least to lose by raising pilings issues. Citywide GET is reluctant to endorse any pilings program in which property owners must pay for pilings repair. They fear that if private residents show willingness to pay for pilings damage, then the burden of liability will be lifted from those agencies that caused the groundwater to fall and the pilings to rot. This argument is unfounded. Based on case precedent, there is no reason to believe the agencies that have caused groundwater levels to fall will ever pay for repairing pilings damages.

3.2.2 About Underpinning

Reinforcing the pilings with steel and concrete ("underpinning") serves as a permanent solution to preserving the structural foundation of buildings. Steel-reinforced pilings will provide sound structural support for the expected life of the buildings so long as groundwater levels do not fall below the underpinned section of the piles. Underpinning pilings provides additional benefits of earthquake protection and structure stability irrespective of the city's groundwater levels. Local civil engineer and groundwater expert Jim Lambrechts believes that by replacing the top three to four feet of pilings, the underpinning structure will remain sound through the life of the building.[3]

Underpinning is a low-tech, messy, and expensive solution. Current rates for underpinning a structure range from $250 to $500 thousand, depending on the size of the structure, number of pilings, and amount of rotted wood. Pits must be hand dug below the building, then the rotted sections of piling are cut off and reinforced with steel and poured concrete. The reinforced pilings are joined by a single concrete slab which creates a uniform, single foundation for the house. Wood piles were capped in pairs using a granite stone, so each house was supported by detached stones beneath. The uniform concrete foundation prevents incremental settling that occurs when groundwater drops or earthquakes hit. In highly built-out areas, there is no room to store the construction materials and excavation debris associated with underpinning.

3.2.3 Pilings Rot: The Case of Brimmer Street

Physical damage from rotted pilings seems rare, but once discovered, rot can blight an entire street. Brimmer Street provides the most dramatic (and legendary) tale of a street doomed by rotted pilings. To date, thirty-four out of the forty-eight structures along Brimmer Street that were built on wood pilings have been underpinned. Ten buildings on the street have wood pilings that have yet to be underpinned. The underpinning began in 1936 when two buildings at the far ends of the street – 8 and 70 Brimmer Street – were underpinned. The subsequent piling repairs along Brimmer Street have demonstrated why underpinning is such an onerous and politically thorny solution to the piling rot problem.

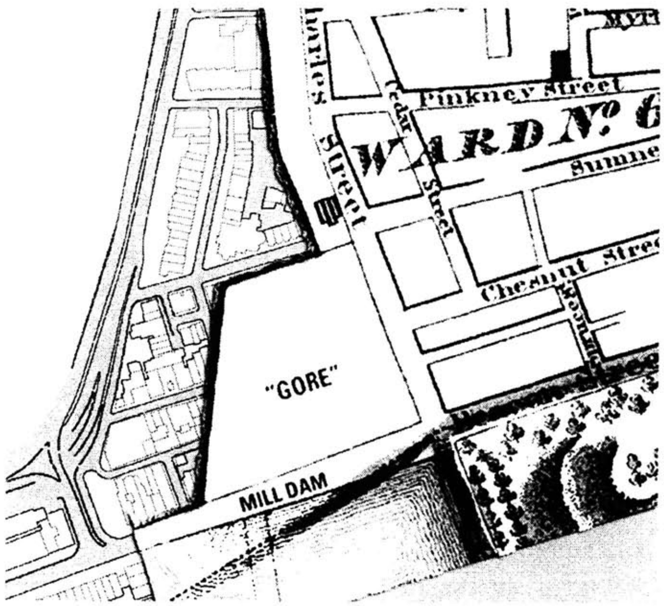


Figure 12: 1826 map of the Beacon Hill Flat overlayed upon the present-day figure ground of the neighborhood. The edge of the "gore" runs along Brimmer Street

Brimmer Street is located within the Beacon Hill Flat, a neighborhood that was filled between 1803 and 1870.[4] The Flat was filled in three phases; from 1803 to 1807, Mount Vernon was cut down in order to fill the land that became Charles Street. In 1818, construction of the Mill Dam (at the location of Beacon Street today) created speculative interest in filling a "gore" to the north of the dam and west of Beacon Hill. To facilitate the filling of this new section of the Beacon Hill Flat, a sea wall was built along the water-side of Brimmer Street in 1821. The sea wall and all of the building subsequently constructed on the gore were built upon wood pilings. On Brimmer Street, the first structures were built in the late 1870s and a second phase of development occurred along the street in the early 1910s.

In the mid 1980s, houses along Brimmer Street between Mt. Vernon and Pinckney Street began to show serious signs of rotted pilings. Large cracks appeared in walls, floors were uneven, doors were misaligned in their frames, and the walls popped and cracked throughout the night. David Kubiak lived on 31 Brimmer Street at the time and vividly recalls the night in which he was startled awake in the wee hours of the morning when settlement caused a four foot section of crown molding to fall off of his ceiling and land a few feet away from the head of his bed.[5] Between 1984 and 1989, sixteen structures on Brimmer Street were underpinned.[6]

Groundwater levels can be hyper-local. In some instances drawdown is so localized that one house will have exposed pilings and its neighbor's pilings will still be submerged. Even within the gore of the Beacon Hill Flat, none of the structures on Lime Street, which runs perpendicular to Brimmer Street, have been underpinned. The localized damage on Brimmer Street can be traced to leaks in the Marginal Conduit. When the new Charles River Dam was built in the 1970s, it blocked the tidal flows of the Charles River. Prior to the new Charles River Dam, water would flow into the Marginal Conduit during high tide and leak through cracks into the ground, providing an important source of recharge for Brimmer Street. When the new dam was built, the Marginal Conduit was rerouted to a pumping station that kept the pipes empty, ending an inadvertent source of recharge and causing groundwater levels on Brimmer Street to drop.[7]

In dense neighborhoods such as Beacon Hill and the South End, pilings damage in one building frequently indicates damage in adjacent structures. This condition creates collective neighborhood pressure to not investigate pilings because rarely can property owners underpin their building without affecting the building next door. Underpinning often involves restoring the pilings below the party wall shared with neighbors. Long form permits issued for structural changes for properties on Brimmer Street often specified that neighboring party walls had to be repaired in addition to the repair of pilings for the structure for which the permit was issued. Moreover, if the pilings in the party wall have rotted, then the pilings of the adjacent property are almost certainly damaged and the neighbors will then have to incur the expense of underpinning their homes. On Brimmer Street,

Figure 13: The shaded structures along Brimmer Street were underpinned between 1930 to 2006.

shared party walls resulted in several structures that were underpinned at once. Figure 13 illustrates the history of underpinning along Brimmer Street. The row of black houses were all underpinned between 1980 to 1989. The other shaded structures were underpinned between 1930 to 1979 and 1990 to 2005.

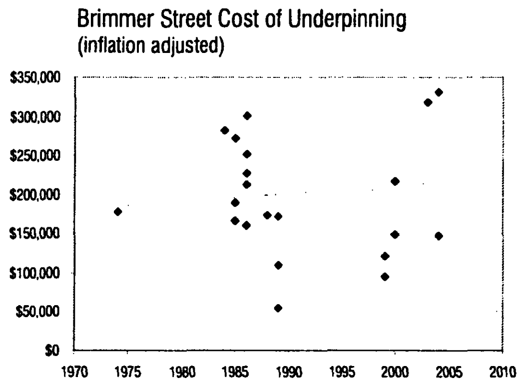


Figure 14: This scatter plot indicates that cost of underpinning has remained fairly even since 1975.

The building permit records for Brimmer Street demonstrate that underpinning is expensive but the cost remains relatively constant over time. In 1936, 70 Brimmer Street was the first house on the street to be underpinned at a cost of $500. By 2003, the cost of underpinning the house across the street at 71 Brimmer had risen to $300,000. Adjusted for inflation, the underpinning expense appears to be fairly constant over time (see Figure 14). The consistent pricing of underpinning is in line with the manual nature of the process.

Brimmer Street serves as an important reminder that while large-scale damage from pilings rot is relatively rare, once the rot sets in, damage can impact a relatively large area quickly and at great expense.

3.3 Policy Tools that Fund Underpinning

The horrors of underpinning that plagued Brimmer Street await an unknown number of property owners in Boston. Property owners are fully responsible for paying for repairs to damages that they did not cause and cannot control. Individual property owners are powerless in restoring groundwater levels around their property. This situation is inherently unjust and in many cases is debilitating for city residents. The costs of underpinning have caused residents to move, sell their homes at a reduced rate, and take out second mortgages. This problem that is shifted to homeowners is rooted in the activities of state and local agencies. As such, the city and the state have an obligation to pursue legislation that eases the financial burden of paying for pilings repair. Financing tools that assist homeowners with wastewater management problems serve as good models for future mechanisms to assist homeowners in paying for underpinning. The following pages provide policy mechanisms that keep the costs of underpinning manageable.

Betterment Tax

Chapter 80 of the Massachusetts General Law states that property owners that benefit from public investments can be charged a proportionate tax that captures their gain from the improvement. Betterment taxes can be used in one of two ways to finance the preservation of groundwater levels in Boston. First, Chapter 83, Section 15 of the Massachusetts General Laws states that cities may spread the cost of sewer assessments uniformly across all of the property owners within a territory. This idea can be applied to fixing leaky sewers throughout the Boston area in order to increase groundwater levels. In this application, the beneficiaries of this policy would be all of the households in Boston served by the Boston Water and Sewer Commission, and costs could be spread amongst the households over a 20-year period.

Betterment taxes can also be used to serve as long term financing for a state-run pilings-replacement program. In this case, property owners would be charged the cost of replacing their pilings over a twenty-year term (the length of time over which benefits subject to betterment assessments may be taxed). The betterment assessments currently used to fund on-site sewage disposal systems serves as a model for a betterment-financed pilings replacement program.

Betterment agreements are currently used to fund the cost of repairing, replacing, or upgrading on-site sewage disposal systems. The betterment is a financial agreement between a homeowner and the community. Communities provide long-term low cost financing to homeowners for projects that are eligible for funding through betterment agreements. Before a betterment agreement can be implemented, the homeowners that have applied for the betterment must be pre-approved. Improvements paid for by betterment agreements belong to the property owner, and repayment is charged on the real estate tax bill. If homeowners default then the community can obtain a "municipal lien" on the home.

Low Interest Loans

Pilings replacement and recharge basins could be funded through low interest, long term loans that are backed by the state. The model for applying for state funds, selecting projects, establishing repayment plans, and collecting payments has already been established by the Massachusetts Department of Environmental Protection

(MassDEP). MassDEP runs the State Revolving Loan Fund, which finances wastewater treatment facilities, wastewater conveyance systems, and construction that reduces inflow and infiltration of groundwater into sewer pipes. If the State Revolving Loan Fund model was replicated in order to finance pilings replacements, then all of the buildings in Boston that require underpinning at a given time could be tracked collectively and underpinning could be prioritized and achieved systematically.

Other agencies are also using low interest loans in order to help municipalities implement infrastructure improvements that are in line with the mission of the agency. For example, the Massachusetts Water Resources Authority lends $25 million annually[8] as part of a program that provides interest-free loans to water system communities. Loans are used to improve local pipes in order to improve water quality within the entire system. MWRA also provides expert contractors to ensure that the best distribution systems are implemented.

3.4 Conclusion

Fixing the pilings is critical to maintaining the structural stability of buildings in Boston. Underpinning will keep the structure physically sound for the remaining life of the building and provide greater protection against earthquakes. Financing is the major obstacle to replacing pilings, however there are several funding tools that are used for sewer projects that provide financing models that could be used to create large scale underpinning programs. Neighborhood organizations should take the lead on organizing underpinning financing efforts because every other stakeholder group gains to lose by making too big of an issue over rotted pilings. As such, it is up to the neighborhood groups to organize and lobby state and local governments to approve new programs that fund underpinnings and remove the financial burdens from homeowners.

4. Neighborhood Response

"You have our attention. Keep it!" - State Representative Byron Rushing, April 5, 2005 following the Groundwater Educational Forum[1]

4.1 Introduction

Overwhelming neighborhood response served as the impetus for the most recent and comprehensive city and state response to groundwater restoration. Continued neighborhood action and growing involvement is necessary to keep groundwater on local agendas and to promote more effective remediation strategies. Although the scale of the problem is too large to be solved by citizen action alone, continued community pressure and activism is essential for keeping groundwater issue alive and important to local politicians, and for escalating the problem to state and even federal levels.

This chapter addresses how property owners and concerned citizens can mobilize to mitigate issues of lowered groundwater levels in their neighborhoods and throughout the city. Community activism is too frequently seen as an antithesis to government; I suggest that neighborhoods should organize and work with the city as part of a larger strategy for reducing the risk of structural damage due to pilings rot.

4.2 Assessing the Role of Neighborhood Organizations

Civic organization about pilings protection in Boston is rooted within neighborhood groups. Early organizing efforts responded to projects that were believed to be responsible for significant draw-downs of groundwater at specific points. As the monitoring well network grew, a finer-grained understanding of groundwater conditions developed. Correlations could clearly be seen between projects that were suspected of draining away groundwater and severely low groundwater levels. Also, the well readings made clear that the problem of low groundwater affected the entire city, not just distinct neighborhoods.

This section outlines the history of civic involvement in groundwater issues and considers what more community groups can do to protect pilings, how neighborhood groups could work together, what neighborhoods could learn from each other, and the limits of community organizing with respect to addressing the groundwater challenge.

4.2.1 History of Civic Involvement with Groundwater

Civic involvement continues to increase in conjunction with the growth of the monitoring well network. The earliest wells were located in the South End, Back Bay, Beacon Hill, Fenway, and Chinatown. In response to a known threat, neighborhood members from each of these districts organized in various ways to combat lowered groundwater levels. The city is now expanding its focus on groundwater issues and will monitor water levels in the North End, East Boston, and South Boston. The communities in these districts are less versed in addressing groundwater problems and can learn much from the past twenty years of experience from the other neighborhood groups.

Neighborhood Association of the Back Bay (NABB)

The Neighborhood Association of the Back Bay, the first neighborhood group to formally address its local groundwater challenges, formed its groundwater committee in 2002[2] in order to address groundwater issues that were suspected to be caused by the Storrow Drive Underpass. NABB's groundwater committee benefited from strong leadership and a high political profile. Martha Walz spearheaded the committee and re-enlivened the groundwater issue in the Back Bay. Ms. Walz moved from chairing NABB to the state legislature where she has created a Groundwater Caucus and remains committed to advocating for better groundwater management in Boston. Today, NABB lobbies state and city agencies on behalf of property owners and advocates for more wells in Back Bay.

Ellis South End Neighborhood Association

Groundwater advocacy in the South End began with the Ellis South End Neighborhood Association. Unlike the Back Bay, which has one community organization that advocates for the entire neighborhood, the South End has thirteen neighborhood associations representing districts within the South End. Ellis South End Neighborhood Organization's groundwater committee was formed in order to address pilings damage on St. Charles Street and Chandler Street caused by nearby leaks in the MBTA Orange line subway and highway tunnel connections.

Citywide Groundwater Emergency Taskforce (Citywide GET)

In 2002, Ellis and the Neighborhood Association of the Back Bay combined the forces of their groundwater committees to create Citywide GET. Today Citywide GET has a mailing list of 600 people and is endorsed by the neighborhood associations of the Back Bay, South End, St. Botolph's, and Bay Village. Citywide GET is focused on mobilizing community action in order to force the city, state, and responsible agencies to repair damages associated with reduced groundwater levels. "This is a constituency-building problem, not a technical problem," says Joan Lancourt, Citywide GET community organizer, groundwater advocate, and Back Bay Resident.[3] Citywide GET has done more than any other neighborhood association to educate residents about groundwater problems, including organizing the 2005 Groundwater Educational Forum. Citywide GET has also written and posted on its website a citizens guide to pilings protection, which includes a technical explanation of why pilings rot and resources for residents concerned about the pilings beneath their homes.

There are several neighborhoods with suspected pilings problems that are conspicuously missing from Citywide GET's member list. These neighborhoods include the North End, East Boston, Chinatown, Fort Point Channel, and South Boston. Citywide GET has reached out to these neighborhoods and is expanding its educational efforts into many of these areas. In the past six months, leaders from Citywide GET have presented in educational forums for the North End, East Boston, and Fort Point Channel.

Boston Groundwater Trust

The Board of Trustees of the Boston Groundwater Trust is comprised of twelve people, eight of which are members of neighborhoods associations in areas affected by lowered groundwater levels. The Boston Back Bay Association, the Neighborhood Association of the Back Bay, Fenway Community Development Corporation, Beacon Hill Civic Association, Chinatown Neighborhood Council, and Ellis Neighborhood Association are each represented on the Groundwater Trust. Eleven of the twelve trustees are appointed by the mayor. As a quasi-governmental agency, the Groundwater Trust works with other political entities and is bound to its charter, which limits the organization to monitoring groundwater levels and working with other signatories to the Groundwater MOU to restore the water table throughout the city.

North End

For many years, North End residents believed that their proximity to the harbor kept them safe from pilings damage due to lowered groundwater levels. This belief was shattered this year when the pilings of a 23-unit condominium building on Fulton Street were found to be rotted. The building is currently being underpinned at a cost of $2 million, which was split amongst the owners.[4] On average, each owner paid $50 thousand, and many had to take out loans, second mortgages, and in at least one instance, sell at a reduced cost. Luckily for the North End, its first incident of pilings damage coincides with increased city-wide attention to groundwater issues. The North End is now working with experienced local groundwater activists from Citywide GET to formulate the neighborhood's educational campaign and to unite neighborhood interests and promote a city-wide strategy for addressing groundwater problems.

East Boston

Groundwater is currently emerging as an issue in East Boston. The first public meeting was held on April 10, 2006 in order to educate local residents about the causes and harms associated with lowered groundwater levels in the city. The Boston Groundwater Trust is expanding its well network into East Boston and will complete installation by the end of the year.

East Boston has been reluctant to join Citywide GET, although the East Boston neighborhood has the most to gain from the groundwater policies that have already been advanced. For example, if the boundaries of the Groundwater Conservation Overlay District were expanded to include East Boston, the new zoning article would have a far greater impact than it could have in Back Bay, Beacon Hill, or the South End because East Boston still has open space onto which buildings can expand. Community organizing in East Boston is an important vehicle for adjusting the overlay district boundaries.

4.2.2 Future Challenges for Neighborhood Organizations

As more wells are installed around the city and evidence of lowered groundwater levels increases, the scope of the groundwater challenge will grow. More neighborhoods will have to follow the lead of Citywide GET and create programs that educate residents and induce politicians to include their neighborhood in existing groundwater remediation programs. Moreover, community activists will have to decide what the next step on their agenda will be. Citywide GET's efforts to put groundwater on the agenda of the city and the state have been an undisputable success. What challenges will community organization need to overcome in order to remain effective?

Short term challenges

- *Capacity building* – As volunteer organizations, Citywide GET and all groundwater committees of neighborhood groups are limited by the time and energy of their members. Citywide GET is currently the most experienced and well-versed organization adept at generating community interest about groundwater issues. However, the organization is already facing and will continue to experience growth issues.

- *Keeping politicians' feet to the fire* – Neighborhood groups must continue to exert pressure on politicians to keep Boston's groundwater problems high on their agenda. Now is a time of heightened cooperation and collaboration amongst the various political stakeholders, however their commitments and dedication are tenuous. The Memorandum of Understanding will keep the parties on task so long as the political will is behind it, but a MOU is not a law and does not create an agency with any granted or implied power. The Groundwater Trust, which was fully funded last year and is enjoying great city support at present, has a tenuous source of power. Funding has been cut in the past and the organization can be (and has been) entirely eliminated at the will of the mayor. Since there is no internal entity driving political stakeholders forward, the community must remain active and continue to exert pressure upon state and local authorities so that groundwater remains a high priority issue, new solutions are passed, and existing remedies are enforced with the highest degree of rigor.

- *Moving forward* – Citywide GET is currently moving in many different directions, including educating other Boston neighborhoods about pilings, advocating for a right to groundwater, and maintaining pressure on political officials. In reality, neighborhood organizations are limited in their capacity to mitigate a problem of this scale and Citywide GET should work with other neighborhood organizations to assess their abilities and create a strategy that maximizes the capacity of community organizing.

Long Term Goals

- *Changing from neighborhood-based to a city-wide advocacy* - As the scope of the problem grows, the demand to create a citywide strategy, as opposed to a neighborhood-based solution, will become more pronounced. With no formal policies in place, the best neighborhood strategy currently is to squeak louder than all other neighborhoods. As a result, policies addressing groundwater to date have been ad hoc and neighborhood specific. The overlay district boundaries reflect the neighborhood boundaries. Leaks are fixed as new hotspots emerge. While some neighborhoods have captured the attention of politicians, other neighborhoods with significant pilings challenges but no local advocates, such as Chinatown, have been markedly underserved. In the interest of building capacity, neighborhood organizations from across the city should work together to advocate for a citywide, long-term plan for addressing groundwater.

4.3 Areas of Expansion for Neighborhood Action

Neighborhood groups have two important roles in mitigating the groundwater problems in Boston: 1) exerting pressure on politicians to make sure that this issue remains relevant; and 2) creating solutions to help affected homeowners address the problem. Citywide GET and other neighborhood groups are currently pursuing a strategy in which community participants establish cooperative relationships with political agencies, which is in strong opposition to the adversarial, litigious stance taken by communities in the 1980's. The current approach of the neighborhood groups is correct and has proven effective for promoting groundwater recharge policies, however leaves property owners with damaged pilings with no recourse.

4.3.1 Why neighborhood groups should sponsor piling remediation programs

Neighborhood organizations should pursue a two-pronged strategy of advancing solutions for rotted pilings while advocating for prevention through groundwater recharge. These strategies are compatible and address the structural challenges of Boston comprehensively. Moreover, actively addressing the rotted pilings puts the issue on the table. At present, there is a strong disincentive for everybody involved – property owners, agencies, the city, and the state – to not talk about pilings. If this situation continues and nobody takes on the pilings-repair issue, then homeowners will continue shouldering the costs of repairs.

It is within the mission and mandate of a neighborhood organization to pool its resources, help neighbors in need, and make an issue out of the already-rotted pilings in the city. Neighborhood groups are the best organization to address strategies that assist with pilings repair because collective organizations have little to lose by addressing pilings. Unlike home owners, concerned with property value, and state and local agencies, who are concerned with legal liability and cost, neighborhood groups risk nothing by finding ways to help homeowners deal with the expense of underpinning if their pilings have already rotted. This section examines ways in which neighborhood groups can expand their mission in order to address the problem of currently rotted pilings.

4.3.2 How Collective Action can Address Rotted Pilings

Education – The educational program currently presented by Citywide GET and other neighborhood organizations to interested community members needs to expand beyond an explanation of the political events surrounding groundwater. Education should include an explanation of the underpinning process that includes costs, an explanation of the procedure, and personal accounts from homeowners that have gone through the underpinning process.

Community Participation – A collective community effort can be made to investigate the pilings data for individual home, blocks, and the entire neighborhood. The Boston Inspectional Services department has building permit records that indicate the cut-off heights of pilings beneath many buildings in the city. The permit records are incomplete; some developers did not complete the form, and all permits from buildings constructed before 1872 were destroyed in the Great Fire. Nonetheless, many records remain that indicate cut-off heights of pilings and with research, this gaping hole in groundwater strategy can be better understood. The Boston Groundwater Trust has reviewed many of these records and compiled a listing of the piling cut-off heights of many of the structures in the city, however their records are incomplete. In my search of the Inspectional Service Department records, I found many structures with pilings elevations records that were not listed in the Groundwater Trust's database. There is much more data left to be discovered about piling cut-off elevations throughout the city.

Groundwater wells measure the height of the groundwater, but little is currently known about the cut-off heights of pilings throughout the city. By organizing committees or school projects, a collective research effort can be made to complete the understanding of the pilings cut-off elevations within a neighborhood in order to effectively evaluate the well readings.

Lobbying strategy to pressure state and city to addressing pilings – Citywide GET and other neighborhood groups need to lobby the city and state to create programs that mitigate the debilitating expense of underpinning a home. More effort should be made by community organizations to research legislative tools that could be used to finance pilings replacement. Programs can include low interest loans, bonds for underpinning, betterment taxes, and an expanded overlay district that includes all buildings supported by wood pilings. Other policy changes include revisions to the state building code to require recharge and legislation modeled after Title V that requires homeowners to dig a test pit and underpin if necessary before selling their home. Neighborhood groups can work with public policy graduate programs at local universities to explore these tools and create a lobbying strategy for the community.

4.3.3 Clarifying messages presented to communities

Citywide GET, the Boston Groundwater Trust, City of Boston, Boston Water and Sewer Commission, and Massachusetts Turnpike Authority are currently working hard and in good faith to pursue policies that prevent groundwater loss. Their efforts need to be lauded. Instead, inconsistent messages at community meetings create suspicion and confusion amongst local residents. The organizations need to work together to create a clear and consistent message. The following strategies could help clarify the public message presented in educational forums:

- Clarify how well reading data informs prevention strategy - The validity of well readings is called into question multiple times during the course of an information session. Residents are told that groundwater levels are hyper-local and can vary by as much as six feet across one city block. Within the same presentation, maps are shown that indicate that wells are often spaced more than a block apart. Based on this information, audience members are led to believe that the density of wells is too low to give a meaningful image of the hydrology of the city. Residents of neighborhoods outside of the overlay district study area are told that more wells are being installed, but they are not told how the well readings will inform the decision to expand overlay district boundaries.

- *Clarify how the overlay district and other proposed policies will affect groundwater and pilings*

– Community advocacy groups are currently presenting an incomplete message with respect to the overlay district and pilings protection. Their strong promotion of the groundwater conservation overlay district and city-state working group gives a false sense that the policies that have been passed to date will protect homeowners from piling rot in the future. The political efforts are moving in the right direction with respect to groundwater but improvement is incremental and slow. Recharge will not solve for rot until sewer leaks are all fixed, and many more pilings will rot before this happens. Property owners need to understand this condition. Residents living within the overlay district should not be lulled into a false sense of security, and those living outside the district should understand the limitations of the policy so that they can evaluate how much time and energy they want to expend in order to become part of the district.

4.4 Conclusions

Neighborhood organizing cannot solve the pilings problem in Boston, however it can exert pressure to pass policies that mitigate damage. Citywide GET and other concerned residents have effectively persuaded the city and state to implement policies that address groundwater and recharge. Now is the time for neighborhood organizations to step back, assess the problem as a whole, and determine the next phase in their strategy. The issue of already-rotted pilings is currently being ignored, and if neighborhood groups do not address this problem, nobody will. A neighborhood organization strategy that includes treatment of rotted pilings creates a more complete response to the problem and a more comprehensive explanation of the structural challenge facing the city.

5. Conclusions

5.1 Overview

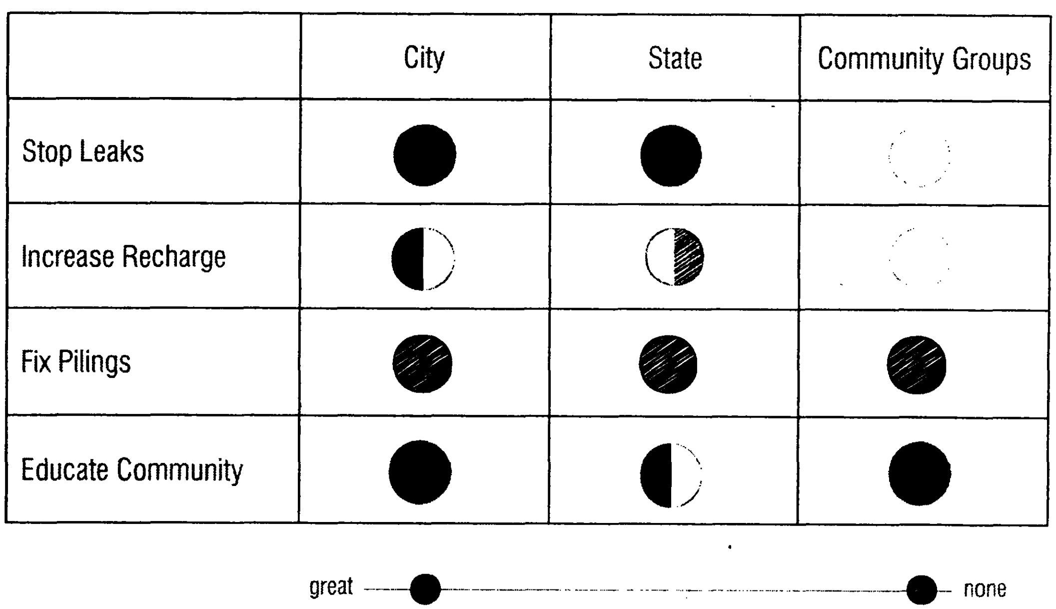
The groundwater problem in Boston is a crisis slow-motion, but actions are underway that have the potential to avert further disaster. The City of Boston, public agencies, State, and community leaders are dedicated to working together to create and implement solutions and for the first time in the city's history, progress can be seen. The political groundwork has been laid on which to address the problem and members of the city-state working group are meeting regularly in order to keep the issue alive and gradually implement solutions. High-level politicians within the state and city have adopted the issue as a personal cause. In the past year and a half, legislation has been advanced in the form of an overlay district that will increase recharge within affected neighborhoods in the city; education initiatives are underway in multiple neighborhoods in order to make residents aware of the challenges associated with lowered groundwater levels; and physical infrastructure has been improved in order to mitigate further groundwater loss.

Substantial progress has been made over the past year and a half, but the groundwater problem that is one hundred years in the making will take many more years to resolve. Any solution requires a three-pronged approach that stops leaks, increases recharge, and repairs pilings. Policy makers and groundwater activists have implemented policies that focus strongly on fixing leaks and incremental systems of recharge. Mechanisms for implementing large-scale recharge systems or repairing damaged pilings remain off of the table. As the level of the water table is incrementally restored through recharge systems and the repair of leaking pipes and tunnels, pilings will continue to rot. Property owners will have to self-finance ongoing underpinning efforts unless pilings restoration is raised as an issue on par with groundwater.

Individual property owners are the parties most affected by lowered groundwater levels and are also most removed from the solution. This is a collective problem but the effects are highly individual. If policies are implemented that protect individual homeowners from rot or from the debilitating costs of underpinning then the Boston's groundwater problem will be solved. This chapter assesses current policies that address groundwater and provides recommendations for how key stakeholders can strengthen their efforts to mitigate pilings damage in the city.

5.1.1 Pilings Protection Report Card

The problem of rotted pilings in Boston has a very simple conceptual solution: water needs to get into the ground and stay there, pilings that have rotted need to be repaired, and residents need to be educated about the structural challenges to their property so that community pressure upon politicians remains strong. Success in efforts to protect pilings from further rot can be measured by four metrics: (1) stopping leaks; (2) recharging groundwater; (3) repairing pilings; and (4) educating the community. The following section evaluates local response to date according to each of these metric, and the remainder of the chapter provides recommendations for how stakeholders can improve their efforts to create a more successful response to the city's piling and groundwater challenge.



(1) Stopping Leaks

Local response to the problem of rotted pilings has focused heavily on finding sources of groundwater drawdown and repairing leaks as they are found. The present efforts to stop the leaks within the city's vast sewer network are right on target and need to continue. Other agencies with leaking infrastructure, such as the MBTA, should follow the lead of the Boston Water and Sewer Commission and work toward reducing groundwater infiltration into tunnels and basements.

(2) Increasing Recharge

Boston needs to pursue an aggressive recharge strategy in order to counteract the vast expanse of impervious surface that keeps water from entering the ground. Recharge will increase in small, incremental steps due to the recently-implemented Groundwater Conservation Overlay District. The city could increase the level of groundwater recharge substantially by requiring that projects demonstrate a higher level of recharge as part of the to the Article 80 development review.

(3) Pilings

Rotted pilings are at the heart of the city's groundwater problem, yet nobody wants to talk about underpinning because repairing pilings is perceived as a last resort solution. Somebody needs to bite the bullet and put pilings on the table. While groundwater levels are gradually restored, more pilings will rot and individual homeowners will again be stuck covering the exorbitant costs of repair. Citywide GET has nothing to lose by raising the pilings issue and has the clout to affect change in this area. If neighborhood groups do not make an issue out of funding pilings replacement programs, nobody will.

(4) Local Knowledge

Community organizing has effectively educated residents in the Back Bay, South End, and Beacon Hill about the dangerous effects lowered groundwater levels can have on wood pilings supporting structures throughout the city. Unfortunately, residents of neighborhoods where this issue is beginning to emerge, such as the North End, Fort Point Channel, and East Boston, are less informed about the causes and consequences of pilings rot. Citywide GET, Boston Groundwater Trust, the City of Boston, and other MOU signatories have been conducting educational seminars in affected neighborhoods in order to promote local understanding and community action. These efforts are commendable and need to continue.

5.2 Neighborhood Organizations / Citywide GET

5.2.1 Strategy

Community groups have a limited but important role to play in creating solutions for the groundwater challenges in the city. Citywide GET and each neighborhood organization are comprised of local volunteers and are limited by the capacity of their members. Neighborhood groups should assess how their efforts could be most influential and engage in activities that maximize their ability to prevent further rot and help property owners of structures that are supported by wood pilings.

Neighborhood organizing has already proven extremely capable of influencing policy. Community activists have been effective in lobbying state and local politicians to raise the level of awareness about groundwater protection and their efforts help keep Boston groundwater at a prominent position on political agendas. Neighborhood groups have also successfully coordinated education sessions to inform residents of affected areas of the threats associated with lowered groundwater and the initiatives underway to address the issue. Community groups could do much more in terms of creating tools to help residents finance underpinning for rotted pilings.

Citywide GET is currently expending much energy lobbying for the re-drawing of the boundaries of the Groundwater Conservation Overlay District. While this issue is important on principle, the overlay district will not promote enough recharge to restore the water table to a level that is higher than the wooden pilings. Community groups would provide a much greater service to homeowners by discovering creative mechanisms for financing underpinning. The following goals should inform neighborhood group's strategy with respect to groundwater advocacy:

- Maintain pressure on politicians to raise water table and address damaged pilings
- Educate local property owners about effects of lowered water table on wood pilings
- Find financial mechanisms that help property owners manage costs of underpinning
- Bridge across neighborhood lines to create a stronger city-wide coalition

5.2.2 Obstacles to success

1. *Capacity* – Citywide GET needs to increase its capacity so that it can move beyond organizing meetings and lobby politicians, expand into new neighborhoods, and advance strategies that address damaged pilings. Citywide GET has been highly effective in raising groundwater issues to the consciousness of Back

Bay and South End residents; however residents of neighborhoods such as the North End and East Boston, where pilings are beginning to emerge, are not aware of the relationship between groundwater levels and structural stability. Neighborhood groups of districts affected by lowered groundwater levels need to increase their own involvement in groundwater activism and increase local awareness about the effects of groundwater loss. Citywide GET could then grow its capacity by training local leaders in underserved neighborhoods.

2. *Information gaps* – Neighborhood groups do not have the information required in order to help property owners protect themselves from costly underpinning and test pit digs. All of the required data is publicly available and waiting to be compiled in a format that can be used by the community to effectuate positive change. The following pieces of information should be collected and made publicly available:

    a. Maps – The subsurface conditions of groundwater, sewers, basements, tunnels, and other below-ground infrastructure are stored in separate locations and sometimes only exist in the minds and memories of local engineers who have become familiar with groundwater issues. This information should be compiled and made publicly available to the extent that security permits. Groundwater contour lines, sewer locations, basements footprints and depths, and locations of homes with wood pilings should each be layers on a map. Combined, this information provides a much more complete description of groundwater activity than the current maps use, which show well reading elevation at discrete points where the groundwater wells are located.

    b. Pilings Cut-off Data – The cut-off elevations of pilings remains in large part a mystery for homeowners, community groups, and policy makers. The Boston Groundwater Trust database of available cut-off elevations is largely incomplete; the permit records of the Boston Inspectional Services Department contain cut-off records that are not included in the database. These records need to be more thoroughly researched in order to create as complete an understanding as possible of the risk associate with lowered groundwater levels in various parts of Boston. Neighborhoods groups can work with schools and property owners to compile the pilings cut-off levels within their communities.

c. Financial tools – Community groups do not have the capacity to launch financing programs that can help remediate a problem that is as large in scale and cost as would be necessary to underpin all of the rotted pilings in Boston. However it is within the mandate and mission of neighborhood organizations to put the issue of funding underpinning on the table. If community groups don't address the problem of paying for underpinning then nobody will, and the cost of the problem will continue to be born by individual property owners. Community groups can combine their research on piling cut-off data and complete mapping information to work with banks and engineers to create a more informed risk profile of the city's pilings problem.

5.2.3 Opportunities for success

1. *Political Connections* – Community activists committed to groundwater issues are small in number but highly effective due to a combination of strong organization, dedication, and political connections. Citywide GET prepared for a year to coordinate the April 2005 meeting at the Boston Public Library, and the event proved to be a watershed moment that triggered a coordinated city and state response to lowered groundwater levels in the city. The members of Citywide GET and other neighborhood organizations are property owners and long-term residents of Boston, and frequently have direct access to influential politicians. State representative Martha Walz was a member of the Neighborhood Association of the Back Bay groundwater committee before she became a member of the state legislature, and continues to advocate for responsible groundwater policy today.

2. *Technical capacity* – Charting groundwater flows does not require high degrees of scientific understanding, and if neighborhood groups were given complete mapping information then there would be somebody involved with the organization that would possess the expertise required to act as a technical advisor for community action.

3. *Vested interest* – Volunteers who work with Citywide GET and other neighborhood organizations are also property owners whose homes and savings are on the line and at risk of loss due to actions outside of their control. This vested interest should keep local residents engaged in pursuing the goals of Citywide GET and other local groundwater activities.

4. *Timeliness* – Boston's groundwater problems have captured local attention and interested parties are working independently on creative approaches to the problem. For example, Ferdi Hellweger, assistant professor in the Center for Urban Environmental Studies at Northeastern University, has created a negotiation game that has been modified for all education levels, ranging from graduate students to kindergarteners, in which individuals adopt the roles of key stakeholders in order to collaboratively create solutions Boston's groundwater problems. Initiatives such as this should be brought under a single umbrella of a unified community organization.

5.3 Boston Groundwater Trust

5.3.1 Strategy

Within the city's big, messy, expanding groundwater problem, the Boston Groundwater Trust (BGwT) is lucky to have a defined role: monitoring groundwater wells and serving as an information broker. The 671 wells monitored by the Groundwater Trust are the city's early warning system for groundwater draw-downs, and the BGwT records are the primary source of data used to develop and prioritize groundwater mitigation strategies. The BGwT will complete its well installation project this summer, after which the monitoring network will be complete. Once the data collection network is complete, the BGwT needs to find a way to more effectively convey information in a visual format to be used by the city, state, public agencies, and the public at large.

There are currently only a handful of people in the city who have a complete understanding of the history of Boston's groundwater activity, fill patterns, incidents of rotted pilings, and locations of subterranean infrastructure such as sewers and basements. The technical advisory committee of the BGwT is comprised of five individuals with decades of collective expertise with local groundwater and geotechnical issues. Mapping data will take the relevant knowledge out of the heads of the experts and put it down on paper so that there is a physical record of groundwater activities in the city and so that more people can access information to help devise creative approaches to the solution. The knowledge that is stored within the BGwT should be more widely disseminated so that local residents can access information that enables them to understand and evaluate the groundwater conditions within their neighborhood.

5.3.2 Obstacles for Success

The Boston Groundwater Trust and city agencies are currently reluctant to make maps publicly available and accessible because it is unclear how and by whom the maps will be used. Local officials frequently express concern that sharing too much mapped information with the public will result in misguided, alarmist reactions. This concern is unfounded – neighborhood groups have demonstrated a desire to work with politicians and have largely abandoned antagonistic, litigious stance taken by residents twenty years ago. Politicians should reciprocate by providing residents with the information that they need to know about their property in order to best protect themselves (and the city) from further pilings damage. The mapping information is available now – the Boston Water and Sewer Commission creates contour maps of groundwater elevations in the city based on monitoring well readings provided by the Boston Groundwater Trust, and the Massachusetts Water Resources Authority has maps of all of the sewer locations in the city. Homeowners should be able to access mapping information that has been funded by their tax dollars and is directly relevant to their financial interests.

5.3.3 Opportunities for Success

The Boston Groundwater Trust's completion of its well network this summer will mark a moment of opportunity during which the organization can expand its mission from data collection to information production. Although the notion of mapping will spark controversy with city and public agencies, the Groundwater Trust currently has the financial and political capital to complete the mapping project. BGwT currently enjoys a high level political support, collaborative relationships with agencies that collect other relevant mapping data, and is fully funded.

5.4 City-State Working Group Members

5.4.1 Strategy

The Memorandum of Understanding signed by the members of the City-State Working Group marks an important shift toward cooperation amongst the key stakeholders whose activities affect groundwater levels in Boston. Policies have already been passed that will incrementally increase groundwater levels in the city, and agencies are working together to implement recharge systems and prevent further groundwater loss. The following strategies should inform the agenda of the members of the City-State Working Group:

- *Fix Leaks* – Leaks into sewer lines, basements, and tunnels remain the most significant cause of lowered groundwater levels in the city. Recharge or underpinning programs will not be able to mitigate groundwater loss until the leaks are sealed. The Boston

Water and Sewer Commission has mapped groundwater contour lines and searched for leaks in places where low groundwater levels correspond to sewer locations. Their vigilance and open communications with the Boston Groundwater Trust and the City serves as a model for cooperation to which all other MOU signatories should strive.

- *Create a recharge policy with teeth* – The Groundwater Conservation Overlay District is an important first step toward creating a zoning policy that promotes recharge. The approach of the GCOD is reasonable and its requirements should apply to all districts on filled land in which buildings supported by wood piles still stand. The recharge systems implemented as a result of the GCOD will predominantly affect residential buildings, therefore recharge systems will be introduced incrementally and at a small scale. Extending the GCOD requirements to Article 80 projects would implement more substantial recharge systems throughout the city.

  For reasons of fairness and recharge efficiency, groundwater recharge requirements should be codified into Article 80. A recharge strategy that is implemented through the GCOD and not Article 80 places the burden of mitigating groundwater drawdown fully on the shoulders of the homeowner. Through GCOD, the private citizen must yet again fund groundwater solutions for a problem that they did not cause. Large projects have a much greater impact on groundwater levels, either through their basements or through increased impervious surface area due to the large building footprint. Local officials are currently using Article 80 review as an opportunity to mandate greater groundwater protection, but unlike the GCOD, Article 80 does not mandate a specific amount of recharge. Codifying recharge requirements would provide long term groundwater protection and improve transparency in the development process.

- Create financing tools for repairing pilings – Only the City-State working group has the organizational capacity and access to funds to be able to create an underpinning financing program. There are several funding programs, including betterment assessments and low-interest loans, which are used to compensate for the repair of private septic systems and could serve as models for a new underpinning financing program.

5.4.2 Obstacles to Success

1. *Time* – MOU signatories have to maintain a long-term engagement in groundwater issues for the proposed solutions to stick. Recharge will take years even if all

proposed improvements are made aggressively and immediately. Installing recharge basins and repairing leaks in sewers and tunnels will be a slow, incremental process. As these improvements are gradually made, pilings will continue to rot.

2. *Politics* – Codifying recharge requirements into Article 80 will provide the city with the largest and most productive recharge system. However, this proposal will add to the logistical complexity and cost of new development in Boston. Will the City go up against developers and revise Article 80 to force all institutional projects or developments larger than 20,000 square feet or to implement recharge systems as part of large new projects? The city has already codified groundwater monitoring as part of Article 80 review and in some cases has negotiated mandatory installation of recharge basins as well. Recharge is currently made a requirement for Article 80 projects because groundwater is an important issue within local government today, but will the City be willing to codify this policy and impose new development requirements into perpetuity?

3. *Money* – Financing private septic improvements requires a much smaller amount of investment than financing underpinning. The order of magnitude between the cost of repairing a septic system as compared to underpinning a home is substantial; the former costs roughly $3000 and the latter costs about $300,000. Can the funding tools that MWRA and MassDEP use to help finance septic repairs scale up?

5.4.3 Opportunities for Success

The heightened level of cooperation between state and city agencies creates an unprecedented moment of opportunity to push forward large-scale solutions that make a real difference to the levels of groundwater in the city. Boston Water and Sewer Commission's aggressive efforts to repair leaks will, if continued, play a substantial role in keeping groundwater at its source underground. Now is the time for equally aggressive recharge and underpinning programs to be negotiated. This is a complicated solution that must be addressed directly and aggressively. The path of least resistance is too costly to consider, and groundwater will not recharge without substantial state, city, and private intervention.

5.5 Reflections

Urban planning is a process of discovery and problems are always more complicated than they appear. Discourse about the built environment is rife with euphemisms, jargon, (mis)perceptions, and hidden agendas that can mask the true nature of the challenges at hand. Like all great planning problems, the true complexity of the Boston's groundwater problem is not readily visible and emerges only after one begins to investigate beneath the surface, both literally and figuratively. Boston's pilings challenge cannot be solved simply by treating the component parts that are responsible for decay – groundwater, wood, and aerobic bacteria. To address the problem of rotted pilings, local actors must take on highly complex planning challenges – engendering collective action, mediating state and local divisions of power, repairing aging infrastructure, creating long-term solutions for short-term attention spans, and avoiding the real threat of high-stakes litigation. This section considers the groundwater problem through the lens of these classic planning challenges in order show how more general approaches to such planning challenges can be applied to Boston's groundwater problem, and to demonstrate how city, state, and community groups have effectively responded to some of these difficult issues.

5.5.1 Collective Action

A collective action problem is one in which the interests of the collective are met by each individual member acting cooperatively, but members considering their own self-interest are better off not cooperating. In large groups, if the any member's contribution is non-essential to the success of the collective goal, then there is an incentive for those members to free-ride. Collective action problems are most frequently overcome through incentives that encourage cooperation.

There are several different collectives that must act in unison in order to address Boston's groundwater problem. All of the stakeholders – the city, state, residents, MBTA, MTA, MWRA, BWSC, and other agencies responsible for lowering groundwater levels – can be considered one collective. The most efficient and economical solution to the groundwater problem involves each agent solving for the level of groundwater loss in the city for which they are responsible. However, groundwater is difficult to trace and some agencies know that they direct causation can never be proven between their activities and lowered groundwater levels, therefore there is a built-in incentive to free-ride and expect others to solve for the problem. This attitude has resulted in property owners paying for repairs to piling damaged as a result of infrastructure developed and owned by the city, state, and federal governments.

Defining the collective and determining what will motivate like groups to act is a critical component of the solution to the groundwater problem. For example, the community is considered a single stakeholder but in reality this is as disjointed a group as any. The community is currently galvanized according to neighborhood affiliations, and even within neighborhoods there is not a collective. Renters perceive this problem differently from property owners; owners of basement apartments have different interests than their neighbors in the penthouse; and owners of structures built on fill are less sympathetic to this issue than their neighbors whose houses rest on piles.

Is there a motivating force that is compelling enough to spur collective action amongst neighborhoods groups in Boston? In neighborhoods such as Back Bay, the South End, and Beacon Hill Flats, where virtually all homes rest on piles and home prices are amongst the highest in the country, protection of property value has provided the impetus for collective community action. Neighborhoods such as the North End, in which most houses rest on original land, will have a more difficult time rallying community support. Nonetheless, all owners of structures supported by wood piles share the interest of protecting their property and their investment, which provides a motivating force which should be strong enough to unite a critical mass of community members across neighborhood lines.

5.5.2 Jurisdictional Conflicts

The problem of creating a coordinated solution to the city's groundwater problem addresses the classic challenge of coordinating independent agencies within a system of decentralized power. The Commonwealth of Massachusetts has dispersed its governing authority amongst various independent agencies tasked with the responsibility of providing various public services, including transportation infrastructure, transit, and water and sewer services. These authorities are independent agencies – their funding comes from bonds and rate payments, the state has no control over their operations, and heads of each authority are appointed, not democratically elected. Moreover, each agency has a very specific task, and frequently does not perceive groundwater to be part of their mission. Solving the groundwater problem requires unifying independent authorities with disparate interests and priorities around an issue that requires long-term attention and demonstrates no visible results. This is a true challenge.

The city's groundwater problem is exemplary of the classic dilemma associated with decentralization of government power. Public authorities can complete large-scale projects more quickly and efficiently than the state would be able to do on its own. These agencies are not held to the stringent procedural requirements with which the government must comply and task-driven authorities develop an expertise on a single topic. However, delegating government services to public authorities create planning that is fragmented along functional lines. When the provision of government services becomes too fragmented and power decentralized, no central authority is left to pull the pieces together and create policies for issues that cut across functional lines.

In the case of Boston, the various public authorities that affect groundwater levels in the city are independent entities of the state. MWRA, MBTA, BWSC, and MTA are chartered agencies that derived their power from the state but act independently. Each of these agencies is self-sufficient financially and is led by a political appointee who is not subject to public oversight via democratic elections. The agencies all have passed policies and made decisions about infrastructure that affect groundwater levels, but since groundwater is not the focus of their mission, the peripheral effects of their actions remained unaddressed for many years.

Although the City of Boston has no jurisdictional authority over public authorities, Boston's Cabinet Chief of Environmental and Energy Services, James Hunt III, has united these independent entities through the Memorandum of Understanding (MOU). Through the MOU, the City of Boston, State of Massachusetts, and the public authorities have promised to share information, work cooperatively, and fix infrastructure that is responsible for groundwater depletion. The MOU demonstrates that negotiation can be an effective tool use to unite disparate public authorities toward a goal that is not directly within their stated mission. However the MOU as a promise is only as strong as the commitment of the agency leaders. Groundwater is an important topic today therefore agencies such as the City of Boston, BWSC, and Boston Groundwater Trust, remain active in remediating causes of groundwater loss. However, if support for this issue wanes then the MOU does not legally bind public authorities to act in any sort of way, therefore the continued commitment to the minimization of groundwater loss is tenuous.

5.5.3 Planning for future disaster

Local governments have historically failed to plan for disasters for a host of reasons. The cost of future risk is difficult to comprehend and easy to discount. City budgets are tight and planning for future disaster draws funds away from programs with immediate and perceptible effects. Most importantly, planning for disaster is incredibly complex and requires interagency governmental cooperation along with involvement from the private sector and local community. In spite of these challenges, planning for disaster is always good policy. When disaster hits, local governments are most frequently left with task of financing repairs. These events can be catastrophic for the communities experiencing them but they are too small to qualify for federal disaster relief. In 1999, $26 billion of damage befell cities in the United States as a result of localized natural disasters[1], and the cost of damages continues to increase.

In responding to its groundwater challenge, Boston has gone through all of the motions typical to disaster planning on the local level. The city has addressed some of the classic questions associated with planning for disasters: Who should be responsible and for what? What level of harm should policies solve for? At what expense is disaster planning being conducted? Answers to these questions have varied over time; during the past eighty years, the city has denied the problem, allowed development that magnified groundwater loss, established an authority to study the problem, and is now working collaboratively with various governmental entities and community members to mitigate the problem.

Planning for long-term problems is an inherent challenge of disaster planning, and in Boston the challenge is magnified by the nebulous impact of the disaster. Unlike natural disasters such as floods and earthquakes, for which mental images of the disaster are known, rotted pilings pose a far more nebulous risk. The threats to the city lie below ground, are invisible to the eye, and impacts occur in a piecemeal fashion over time. The effects of mitigation are imperceptible as well – nobody notices when a house does not fall. Moreover, Boston's groundwater crisis threatens property values, not lives, which places the groundwater challenge in a different category of problems than natural disasters and terrorism. However, it is important to remember that rotting pilings could contribute to a large-scale structural catastrophe in the event of an earthquake in Boston.

Before the City of Boston can fully address the challenge of rotted pilings, it must first understand the risks – how many people are subject to harm, how many structures could be damaged, and what is the likelihood that impacts will occur?[2] Once the risks are known and quantified, planning needs to happen in an integrated fashion so that all stakeholders cooperate to create solution. If all affected parties do not work together, then the activities of one agency threaten to undermine the work of another. For example, policies that promote recharge will be ineffectual unless leaks in sewer lines are repaired. A policy that promotes underpinning will quickly become obsolete if groundwater levels continue to fall. Recent and intense political pressure has prompted the City of Boston and other agencies to implement policies that promote better groundwater management. First phase mitigation efforts have been implemented in the form of an overlay district and the city-state working group. The challenge for the city is to maintain and expand the initiatives underway. Continued community involvement is critical to keeping political leaders engaged in this issue.

Conversations about Boston's groundwater problem once resembled observing a slow motion car crash – everybody knew that something bad was about to happen but no entity felt responsible to stop the problem on its own. In the past eighteen months, the City, State, public authorities, and community members have united to launch multifaceted approaches toward mitigating the potential disaster associated with rotted pilings. For the first time in eighty years, resolving the problem of rotted pilings is a viable possibility. The new policies that promote increased groundwater levels are an important first step to mitigating the harm associated with rotted pilings. The level of political commitment and community involvement must remain at its current high level so that policies can be properly expanded, long-term solutions are implemented, and funding is procured for maintaining the structural stability of wood pilings throughout the city.

Appendices

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Figure Annotations

Figure 1 – "Stop the Rot" button courtesy of the Citywide Groundwater Emergency Taskforce

Figure 2 – Boston figure ground and the 1630 land boundary of the city based on mapping data stored on the BostonAtlas.

Figure 4-8 – Locations of the sewers, dams, highways, and subways based on findings reported in Harl Aldrich and James Lambrechts 1986 report, "Back Bay Boston Park II: Groundwater Levels."

Figure 9 – Letter from Carl Keller is kept in the records of Boston Inspectional Services

Figure 11 – City of Boston. Boston Zoning Code and Enabling Act Volume 1 Article 32: Boston Groundwater Conservation Overlay District.

Figure 12 – Boston 1826 map can be found in Nancy Seasholes' *Gaining Ground,* p. 141.

Figure 13-14 – Underpinning data for Brimmer Street based on Boston Inspectional Services Department permit records.

Interviews

13 March 2006 – Charles Harvey, Associate Professor, MIT Department of Civil and Environmental Engineering

14 March 2006 – Elliott Laffer, Executive Director, Boston Groundwater Trust

16 March 2006 – Andrew Whittle, Professor, MIT Department of Civil and Environmental Engineering

16 March 2006 – Terry Szold, Adjunct Associate Professor, MIT Department of Urban Studies and Planning

20 March 2006 – Langley Keyes - Ford Professor and associate Department Head, MIT Department of Urban Studies and Planning

21 March 2006 – Herman Karl, Lecturer, MIT Department of Urban Studies and Planning

22 March 2006 – James Hunt III, City of Boston Chief for Environmental and Energy Services

29 March 2006 – Rick Shaklik, Boston Redevelopment Authority Deputy Director for Zoning

31 March 2006 – Gordon Richardson, Chair, Citywide Groundwater Emergency Taskforce

31 March 2006 – James Lambrechts, Assistant Professor, Wentworth Institute of Technology Department of Civil, Construction, and Environment

27 April 2006 – Gerald Frug, Professor, Harvard Law School

29 April 2006 – Susan Scott, Citywide Groundwater Emergency Taskforce

29 April 2006 – Joan Lancourt, Citywide Groundwater Emergency Taskforce

1 May 2006 – David Koubiak, North End Resident

Meetings

22 March 2006 – Boston Groundwater Trust Board of Trustees Meeting

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