Boston's Porous Alley Demonstration Project

Summary Report

April 2016

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Massachusetts Department of Environmental Protection -
Section 319 Grant Program

Project Partners:
City of Boston
Charles River Watershed Association
The Boston Groundwater Trust

Project Engineer:
Vanasse Hangen Brustlin, Inc

Like cities around the country and across the globe, Boston is planning for change. Driven by community interest in improving the urban environment, concerns about climate change, flooding and sustainability, and the need to protect water quality in the Charles River and Boston Harbor, the City of Boston recently undertook a demonstration project to explore the feasibility of using porous pavement to increase groundwater recharge and to reduce flooding and water pollution.

Boston has an unusual environmental legacy, with over half the City area built on filled land, close to sea level, protected only by low sea walls and dams. Some of the City's most historic and valuable real estate is on filled land, supported by wood pilings, and threatened by falling groundwater levels. The City also has tremendous environmental assets. The successful cleanup of the Charles River and Boston Harbor has led to economic development and improvements in quality of life. Yet the river and harbor remain at risk. Extensive urban water quality monitoring in Boston and elsewhere across the United States has shown that runoff from roadways and other paved surfaces carries high levels of pollution. Protecting the City from increased rainfall and pollution will require a wide array of approaches and technologies, with the most successful likely being those that restore environmental function, and provide multiple benefits to residents.

Porous pavement is one of the potential "tools" available in urban areas to reduce the negative impacts of urbanization on the natural environment. It has numerous potential benefits, but also poses challenges; perhaps most important, few municipal officials in the New England region have experience with the design, construction requirements, maintenance and public acceptability of porous pavement. In addition, there are few "standard designs" for porous asphalt systems, so municipalities interested in installing these systems may face an expensive planning process.

The demonstration project was designed explicitly to evaluate porous pavement, and to help the City develop a standardized methodology and conceptual design that would be useful in other areas. The project included a lengthy pre-construction evaluation and design phase, community outreach, a carefully monitored installation, and post-construction monitoring to determine efficacy. In addition, the team has worked to understand and learn throughout the project process, and to provide a forthright critique as a way to help support the City in its efforts to increase overall environmental health and sustainability.

Setting

Location

The Porous Alley demonstration project site is in the South End neighborhood of Boston, in Public Alley 543, running between Holyoke and West Canton Streets, parallel to and northwest of Columbus Avenue (see Figure A). Public Alley 543 is like many public alleys in Boston, serving the back entrances, yards and parking areas of private residences. The alley is also used for trash collection and deliveries. The City-owned area of the alley is approximately 250 feet long and 10 feet wide, paved, and set below the level of the streets around it.

Figure A: Project Location

Figure B: Existing Conditions and Ownership

Challenges and Opportunities

The project site was selected because it is in an area with multiple problems that porous pavement may improve:

- The alley is in the City's Groundwater Conservation Overlay District (GCOD), and has been identified as an area where a low water table threatens building foundations.
- Drainage from the alley flows into a combined sewer, contributing to overflows and pollution during heavy rainstorms.
- Heavy rain can lead to ponding in the alley or localized flooding.

Porous pavement, which allows rainwater to filter directly into the ground rather than run off into municipal drains, can address all of these problems. Because so much of Boston's publicly owned land consists of streets and alleys, renovating these public ways with porous pavement could be a way to address multiple problems, while maintaining their primary function of passage. However, the City has little experience with this treatment system, and City officials have questions about design, construction, cold weather performance, maintenance and cost. The Porous Alley project provides an opportunity to evaluate the effectiveness and desirability of porous pavement in an active alley.

Neighborhood

The project site is in an historic neighborhood, built on what were once tidal marshes. The area around the project site is primarily residential, dominated by Victorian style brick row houses built in the 1800's. Immediately adjacent to Public Alley 543 are two privately owned condominium buildings, and Methunion Manor, a cooperatively owned affordable housing complex (see Figure B).

Porous Pavement

There are multiple forms of porous pavement in use in the United States including porous asphalt, porous concrete, and a wide variety of porous pavers and pre-cast slabs. For this Porous Alley project, porous asphalt was selected because asphalt is the most common paving material used in Boston's streets and alleys, and is relatively low in cost compared to other porous pavements.

Porous asphalt is similar to conventional asphalt in load strength, longevity and appearance. The primary difference between conventional and porous asphalt is that when the porous asphalt mix is made, the smallest fine pieces are eliminated. These “fines” typically fill in the small spaces in conventional asphalt, forming an impermeable surface; without these, the asphalt has small openings throughout its structure that allow water to pour through. To prevent surface damage, and to allow rainwater to soak into the ground and recharge groundwater, the porous asphalt layer must have a sub-surface storage layer, which allows rainwater to slowly filter into the natural soil beneath the asphalt. Typically, coarse gravel is used to create this storage, which also provides a strong and stable support for the asphalt.

Porous Pavement and Green Alley Projects

The City of Chicago likely has the most extensive and well-known program of constructing porous alleys, with over 200 alleys “greened” using a variety of methods including porous pavement. Numerous other cities including Los Angeles and Seattle, Austin, Texas, Baltimore, Maryland and Montreal, Quebec have active alley greening programs that aim to reduce runoff, flooding and pollution while improving neighborhood quality of life.

There have been numerous installations of porous pavement in New England. The most rigorously tested and monitored sites have been constructed by or in cooperation with the University of New Hampshire’s Stormwater Center. The majority of these sites are parking lots, although they include driving corridors that carry more daily traffic than a typical Boston alley. Within Boston, the Boston Architectural College’s Green Alley project includes porous asphalt, as well as additional greening elements.

The City of Boston, in particular its Public Works, Transportation and Parks Departments, and the Boston Water and Sewer Commission, have implemented a wide variety of greening projects that include some limited porous pavement. However, this Porous Alley Demonstration Project is the first City project to implement and test the effectiveness of porous pavement in an alley.

The Demonstration Project

A successful demonstration project offers an opportunity to test, evaluate and learn about technical issues, operations, and costs, as well as the institutional and public processes for a technology or technique that is new to a municipality. Demonstration projects by their nature are often more costly and time-consuming than implementation of a standardized, accepted project.

This demonstration project was developed and implemented by a partnership that included the City of Boston Public Works Department, Charles River Watershed Association (CRWA), the Boston Groundwater Trust (BGWT), and Vanasse Hangen Brustlin, Inc. (VHB). The team coordinated with and received support from other City agencies, including Boston Water and Sewer Commission. The Project was made possible by a grant from the Massachusetts Department of Environmental Protection’s Section 319 Nonpoint Source Competitive Grants program, as well as significant funding from the City of Boston. Additional funding and in-kind support was provided by the BGWT and VHB.

Planning and Design

Because this was a demonstration project, intended to answer questions and provide direction for future projects, planning and design were more intensive than they would be for a typical construction project. The project team spent a lot of time selecting a site that was representative of many alleys, and where groundwater monitoring wells were already in place so that project benefits could be measured. The design (see Figure C) incorporated a new monitoring well in the actual subsurface storage area.

Spatial constraints, existing infrastructure and the need to include the monitoring equipment caused challenges in both the design and implementation phases. The alley has a mix of public and private property, limiting the possible project area. Steep grades from the street lead down to the alley on both sides. There were numerous utilities in the alley, some of which had to be relocated prior to construction. There is a private, unpaved dirt alley intersecting the project alley. Because of ownership issues, the City couldn't do more than provide modest protection to keep the dirt from getting onto the porous pavement. The City also had to work out an agreement with Methunion Manor, one of the abutting property owners, to allow for the use of their property for some of the construction equipment and staging.

Finally, the project team coordinated several public meetings to ensure that area residents were comfortable with and well informed about the project, and to address parking and access concerns during the construction. Hopefully, the lessons learned from this project will make it easier to plan for, work through and resolve these issues in future projects.

The final project design was a 66 foot long, 10 foot wide section of porous asphalt in the middle of the alley, with a storage area beneath it composed of coarse gravel, creating 425 cubic feet (nearly 3,200 gallons) of water storage. There is an overflow pipe (see Figure D) from the storage area into the existing sewer to prevent any possible overflow from the storage area.

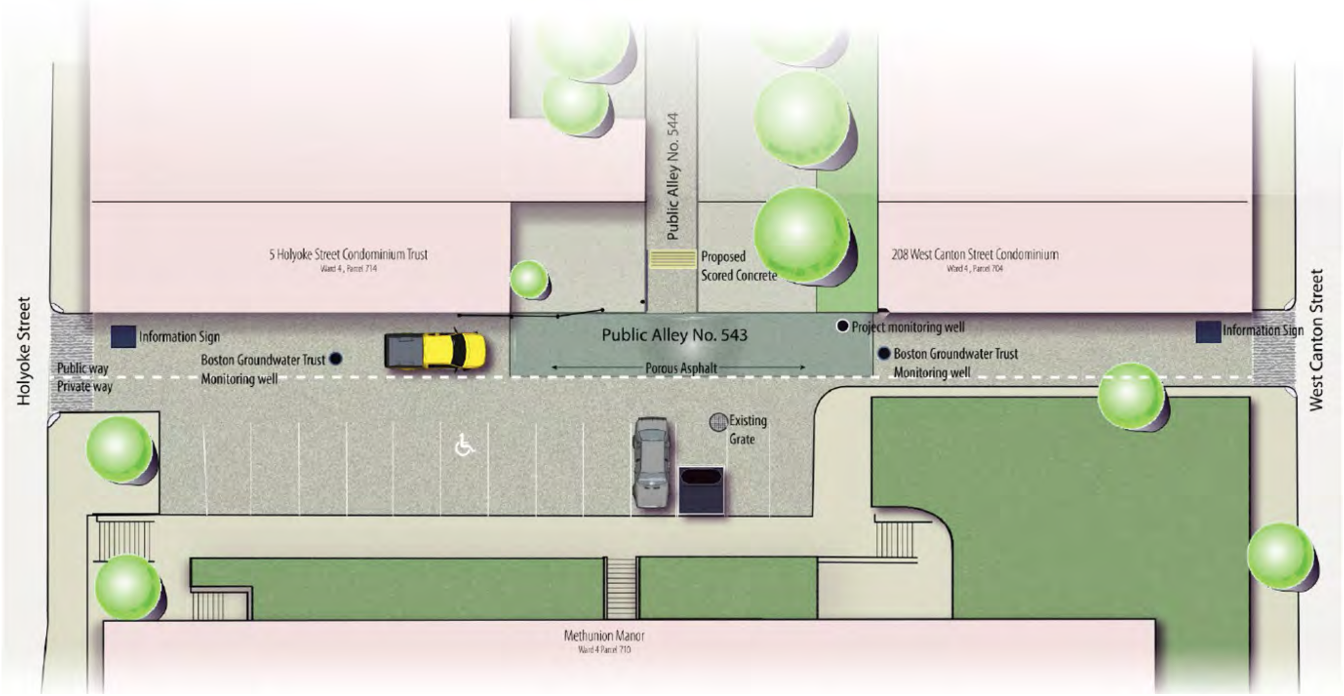

Figure C: Proposed Plan

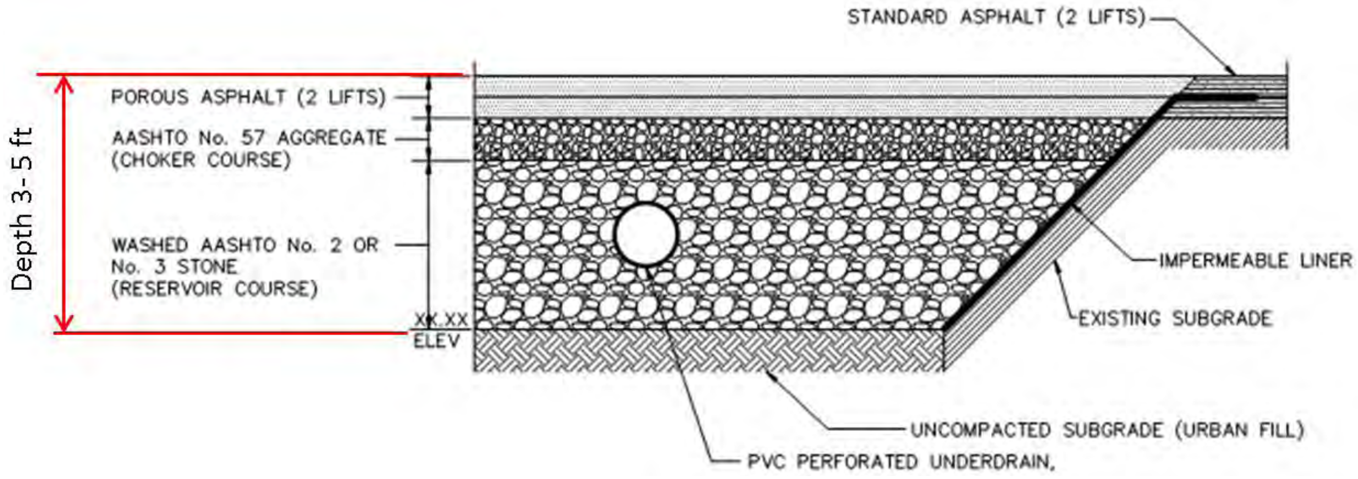

Figure D: Proposed Schematic Section

Construction

Prior to construction, on-site soil tests were conducted to be sure that underground conditions were suitable for infiltration. The results were positive, and the project was put out to bid by the City. The project construction required that the alley be closed during working hours. In addition, the team agreed that contractor experience with the installation of porous asphalt was a critical qualification and therefore it was included as a contractor requirement in the bid documents.

The actual construction (see Figure E) lasted over two weeks, although there were several delays which could be avoided in future projects. First, utilities that should have been moved before the project started were not moved; and second, there were unknown utilities underneath the roadway that were only found once the construction had started. These issues, unfortunately, are common with urban construction projects, and are certainly not unique to this demonstration project.

Figure E: Construction Process

Figure F: Alley Before and After Construction

In-field modifications to the design were needed to avoid large utilities, including a communications cable, that were found during construction and could not be moved. The subsurface storage area was shifted slightly to the west, and was built slightly shorter and wider than the original design. Nevertheless, the total volume of storage was maintained. The planned "rumble strip" that was intended to reduce tracking of sand and dirt from the adjacent private dirt alley could only be partially constructed across the edge of the alley because of property ownership concerns. Nevertheless, the project construction was successful, without significant cost overruns in spite of the delays in construction.

Maintenance

A long term maintenance and management plan has been developed for the porous alley. The goal of the plan is to minimize clogging and maintain the permeability of the pavement surface. Road sand should not be used for traction in winter, and salt should be used only as needed. Sweeping with a regenerative air street sweeper once every six months is recommended, as is periodic testing of permeability rates. Because the demonstration project was the first City project where porous asphalt was used in a public right of way, maintenance will be handled by a private contractor. However, as more rights of way are constructed with porous asphalt, the City is considering whether and how to conduct this type of maintenance with its own staff and equipment.

Monitoring and results

The monitoring program for the porous alley was designed to monitor at two areas of interest: infiltration of precipitation to the ground; and treatment of pollution.

To monitor infiltration, a 6 inch diameter well with an access cap at the surface was installed in the storage area beneath the porous asphalt. A logger was placed inside the well, which collected continuous readings of the depth of the water in the storage area measuring how much water was collecting and building up before it infiltrated into the ground below. One permanent groundwater


Figure G: CRWA Staff Monitoring Groundwater Levels and Infiltration Rate

elevation monitoring well maintained by BGWT was already in place near the east end of the alley, and a second well was installed at the west end of the alley as part of this project. The role of these monitoring wells was to observe the immediate response of the porous asphalt and storage area to rain and snow, as well as the long term benefits, if any, to increasing ambient groundwater levels in the area.

The project was also designed to learn about the positive impacts of the porous asphalt system on water quality. In Boston, nutrients and sediments are a particular concern. Data collected from other porous asphalt projects has shown that the filtration of rainwater runoff and snowmelt through porous asphalt systems helps remove pollutants.

To test whether the porous alley was improving water quality, the team designed a two phased water quality monitoring program. First, CRWA staff collected physical samples from the monitoring well during four rainstorms (see Figure G). These samples were sent to a local water quality laboratory for analysis. The second phase of monitoring, which would have collected and analyzed water quality samples from overflows from the storage system, was never implemented because the system has never overflowed.

The results of the monitoring program confirmed very high levels of infiltration to the ground (see Figure H), and measurable, but variable, water quality improvements from the filtration provided by the system. Rainwater that fell directly onto the porous asphalt, and runoff that ran onto the porous asphalt from surrounding pavement, was easily filtered into the subsurface storage area, and then rapidly filtered into the soil below. In fact the water level in the storage area rarely built up more than a few inches even after heavy rain events. The groundwater monitoring wells at either end of the alley showed increases in ambient groundwater levels during all seasons monitored (see graphs in Appendix A). The porous asphalt system is helping increase groundwater levels in the immediate area.

Water quality varied quite a bit between the sampling events, but all samples showed the system is filtering out pollutants (see Figure I). With the caveats that samples were collected using a fairly simple method, and the sample size was modest, the filtering system seems to reduce pollutants enough to

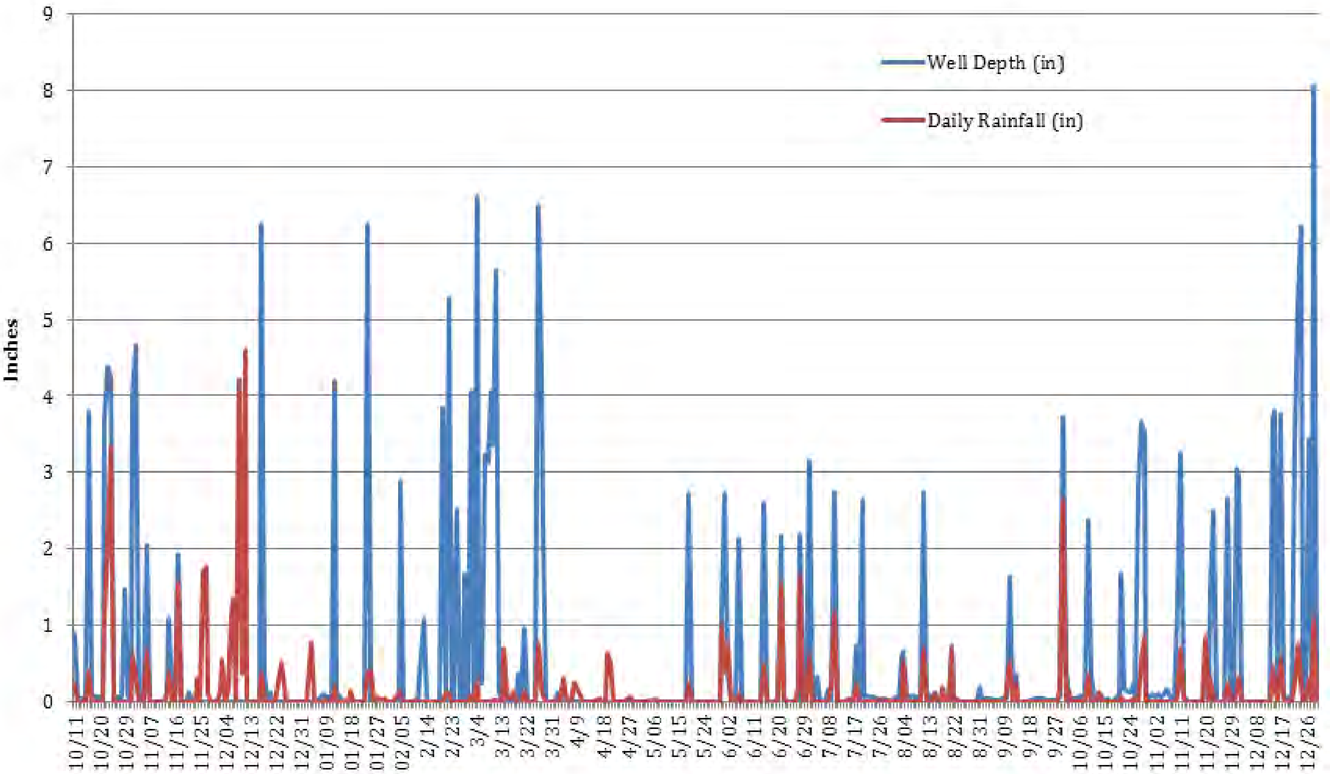

Figure H: Depth of water in Boston porous alley observation well (blue) and rainfall volume (red), October 11, 2014- December 30, 2015.

meet stormwater permit requirements, including the phosphorus TMDL for the Charles River. Because there has never been any overflow back to the sewer, and all the water that flows into the porous asphalt system filters into the ground, the system has actually removed 100% of the pollution to date.

Finally, team members periodically visited the site after construction in both wet and dry weather, observing the condition of the pavement, and its apparent permeability. A permeability test was conducted in 2015 . Nearly two years after construction, the pavement surface is in good repair, without any evident settling or cracks. The pavement is less permeable at the surface than when first

Parameter	Storm Event #1 (mg/L)*	Storm Event #2 (mg/L)	Storm Event #3 (mg/L)	Storm Event #4 (mg/L)	Porous Alley #5 (mg/L)	West Canton #5 (mg/L)	Detection Limit (mg/L)
Total Phosphorus	0.32	2.65	0.24	4.6	0.39	1.1	0.02
Total Suspended Solids	220	230	98	1200	39	180	1.0
Nitrogen, Nitrate/Nitrite	<0.10	<0.10	ND	<0.10	<0.10	0.15	0.10
Total Nitrogen	1.2	1.4	1.7	32	1.6	5.9	0.3
Total Kjeldahl Nitrogen	1.2	1.4	1.7	32	1.6	5.75	0.3

Figure I: Pollutant concentrations measured in laboratory samples installed, and some water does run over the surface of the porous asphalt. Most significantly, however, there is no evidence of overflow from the system, and rainwater does not seem to be discharging into the catch basin and storm drain located just several feet from the porous asphalt section. Even though some water runs over the permeable surface in some spots, it eventually filters through the porous asphalt and into the storage area below.

Lessons Learned

As expected, this demonstration project produced many valuable insights that will facilitate future porous pavement installations by Boston and other cities and towns in the region, as well as private developers. Lessons learned can be divided into several broad categories:

- *Planning: interdepartmental coordination*

Internal communications between different municipal departments from the earliest stages can help identify and avoid many problems that could slow the project schedule down. Utility management, relocation of parking, property agreements, and other nearby construction projects may all be handled by different departments. Ensuring that all relevant parties are aware of the project and have opportunities to provide input during design can avoid problems later.

- *Planning: community outreach*

As with any construction project, residents need to be informed about the project early enough to plan and to be prepared for construction impacts. Most concerns voiced by abutters related to parking, access and noise during construction. Concerns about long term issues such as potential leaks of groundwater into basements are legitimate, and careful planning, engineering and design, in addition to abutter outreach, is critical to minimize these risks and to address abutters’ concerns.

- *Planning: project lead*

An innovative or new project in a municipality needs a champion, someone who can coordinate with staff across departments, interface with residents, answer questions and be involved in all stages of the project. Ideally, the project lead should have enough authority and access to people in all the relevant departments to be able to break through logjams and keep the project on track when problems arise.

- *Site selection*

Although some design elements can be standardized, porous pavement installations will likely always need more site-specific analysis and planning than full-depth repaving, and certainly more than simple resurfacing projects. The project must not only address the usual construction concerns such as underground and overhead utilities, private property, and neighbors’ concerns, but also issues such as groundwater elevation, soil porosity, and potential contaminants, grades, and the need to protect adjacent structures. At some sites, an underground storage and recharge area may not be possible.

- *Construction*

The selection of a good contractor, and having independent on-site construction monitoring, are critical, especially because there are still few contractors with porous asphalt installation experience. Key points for project success include precision excavation; appropriate selection and placement of subsurface materials including stone, geosynthetics, and underdrains; and pavement grading.

- *Maintenance*

Long-term maintenance responsibilities should be reviewed and assigned before the project is constructed. There are many ways maintenance responsibilities and oversight can be planned, and it should be expected that these arrangements will change over time.

Porous asphalt: the big picture

The results of this demonstration project show that porous asphalt can be used successfully in Boston, despite freeze-thaw conditions, snow, and variable subsurface soil conditions. Porous asphalt performs well, reducing runoff and pollution, and increasing groundwater recharge. It can support traffic, including trucks, common in a Boston alley, and the residents and other users generally feel it performs exactly like conventional asphalt.

Maintenance – always one of the primary concerns with porous pavements – should not be ignored, but is a manageable issue. As vacuum or regenerative air sweepers become more commonplace, maintenance for porous asphalt will become routine, and may actually be less burdensome than for other infiltration systems such as rain gardens or subsurface chambers. Even with poor maintenance, porous asphalt systems are likely to function well. Fortunately, in other porous asphalt installations, it has been possible to restore permeability to clogged pavement through power washing and regenerative air sweeping.

The project also highlights the importance of careful construction planning and monitoring, and the need for ongoing maintenance. Although standard construction designs are increasingly available for porous asphalt installations, site specific details will always be present. Underground or overhead utilities, property lines, abutter agreements, and soil conditions are typical issues in any urban construction project has to take into consideration. Any of these issues, and many others, can cause delays. Porous asphalt projects are particularly sensitive to delays because fewer companies have porous asphalt installation experience, and the application requires a special mix that may not always be available. Installation requires careful monitoring and oversight because even minor errors in grading can lead to too much or too little flow getting to the porous area. Until porous asphalt installation becomes more common, extra time in the planning and installation stages should be anticipated.

Porous asphalt is a good choice for certain locations and situations, but may not be for others. Broadly speaking, if flood control and/or recharge are a high priority, if there is limited space available, and if subsurface conditions are appropriate, porous asphalt is likely one of the best options for managing stormwater in urban settings. It is inappropriate, however, in areas where there is a concern about polluted groundwater or soil contamination migration, where the water table is too close to the surface for effective infiltration, or when underground utilities cannot be moved or protected. An advantage is that because porous asphalt recharges everywhere below its surface, it doesn't require as much excavation depth as subsurface chambers would need to recharge the same volume. Additionally, porous asphalt performs the function of pretreatment so pretreatment systems like catch basins are not required. Further research to compare function and cost of these different systems will help cities and towns select the most cost-effective and appropriate uses.

Overall, porous asphalt is likely to have many useful applications and benefits in urban settings, including those in older cities with more severe winter conditions like Boston.

References

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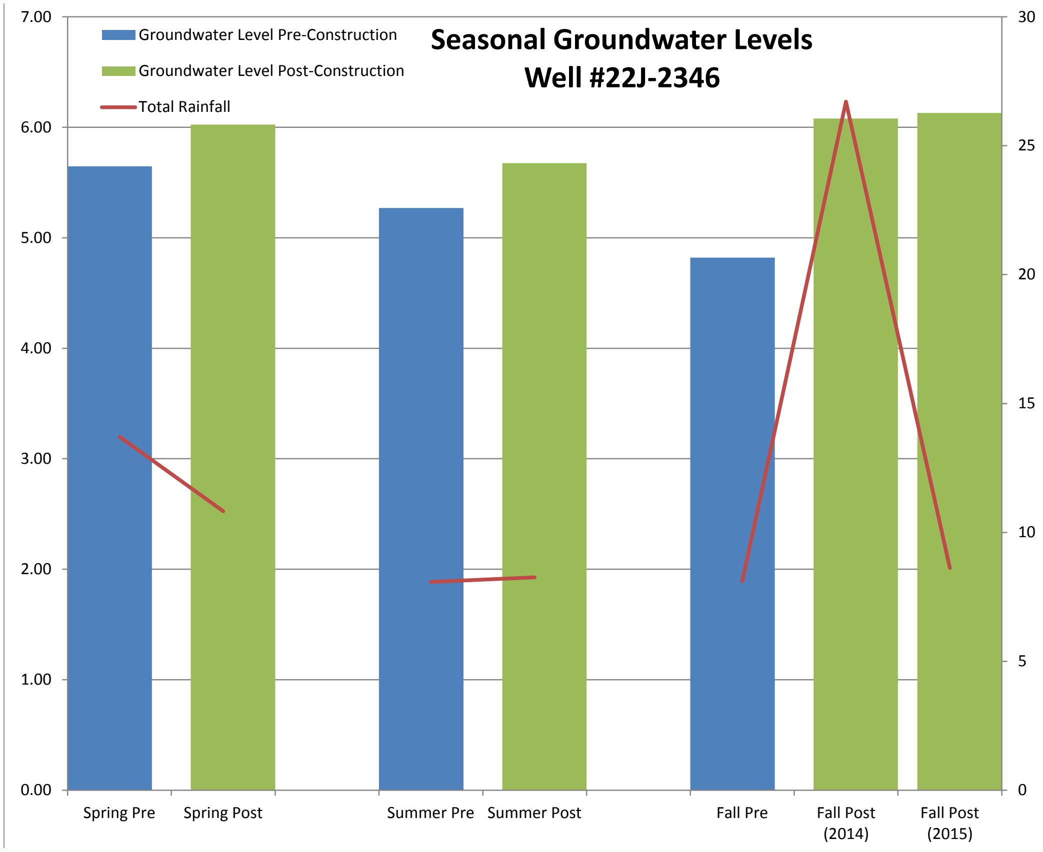
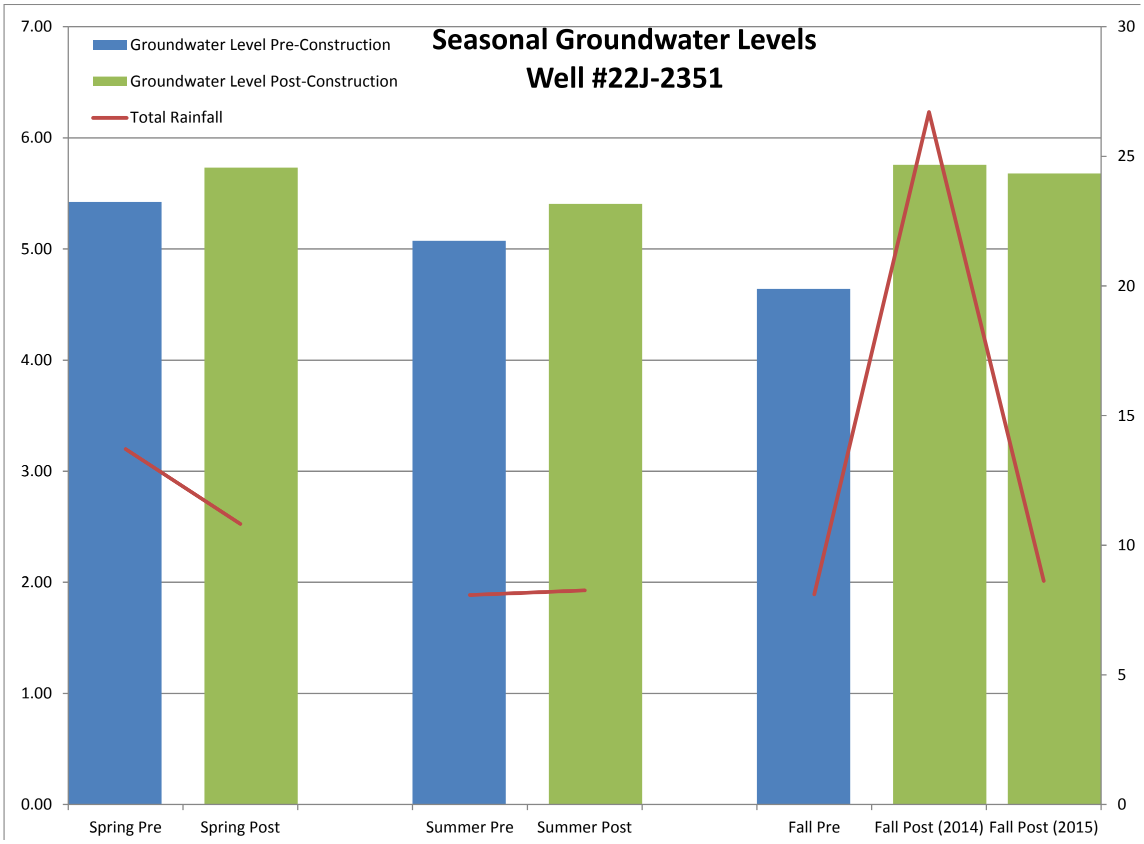
http://untappedcities.com/2013/08/07/montreals-ruelles-vertes-green-alleyways-help-the-environment-and-create-a-sense-of-community/

Appendix A


Well 22J 1671
Groundwater Level Pre-Construction
Groundwater Level Post-Construction
Total Rainfall
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
30
25
20
15
10
5
0
Spring Pre
Spring Post
Summer Pre
Summer Post
Fall Pre
Fall Post (2014)
Fall Post (2015)


Seasonal Groundwater Levels
Well #22J-2346
Groundwater Level Pre-Construction
Groundwater Level Post-Construction
Total Rainfall
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
30
25
20
15
10
5
0
Spring Pre
Spring Post
Summer Pre
Summer Post
Fall Pre
Fall Post (2014)
Fall Post (2015)



Seasonal Groundwater Levels
Well #22J-2351