The University of Rhode Island's Permeable Parking Lots:

A Case Study of Alternative Pavement Materials

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DRAFT UPDATE

The University of Rhode Island Cooperative Extension in partnership with the Rhode Island Department of Health Source Water Protection Program

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Introduction

In an effort to promote sustainable, environmentally-sound campus development, the University of Rhode Island installed two parking lots during 2002 and 2003, using porous asphalt. Then, in the summer of 2005, the University installed a third porous asphalt parking lot. This case study describes that project, summarizes results to date, and discusses key features to be considered for future alternative pavement projects. This case study does not discuss all permeable products available, nor does it constitute an endorsement of any product. Any errors or omissions are the sole responsibility of the authors.

The First Two Parking Lots (2002-3)

Site Description

In order to accommodate the demand generated by commuting students and the newly constructed Ryan Convocation Center, the University of Rhode Island (URI) installed two parking lots at the Kingston campus during 2002 and 2003. Both parking lots have porous pavement due to the fact that they are located within the Pawcatuck sole source aquifer, within the town of South Kingstown's groundwater protection overlay district, and within the wellhead protection area (WHPA) for the University's wells. The permeable asphalt helps to control runoff of pollutants to surface waters and protects groundwater supplies.

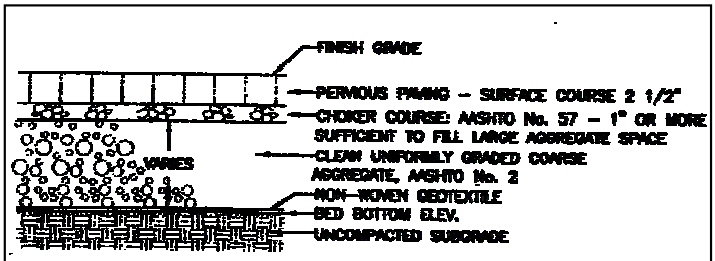
The total parking lot capacity accommodates about 1,000 passenger vehicles. The larger lot, which is 5.5 acres, holds 814 vehicles and was constructed in the fall of 2002 on an old turf farm previously utilized by the University for overflow parking. The nearby smaller lot, which is 1.47 acres, is a retrofit of an existing lot near the former Dairy Barn site and accommodates about 200 vehicles. To further alleviate campus traffic and parking demand, URI simultaneously expanded shuttle bus service to these lots and other outlying parking lots. The construction of this lot was completed in 2003. Due to concerns of potential groundwater contamination and compaction of the porous bituminous asphalt, commercial and industrial vehicles are not permitted to park in these lots.

Results of a pollution risk assessment conducted by URI Cooperative Extension, Nonpoint Education for Municipal Officials (NEMO) program, under the Rhode Island Source Water Assessment Program, estimated that the percent of impervious cover of the WHPA is very high at almost 30%. These findings supported the need for a permeable option to maintain groundwater recharge and avoid additional impacts to downstream habitat quality, already impaired by stormwater runoff. Infiltration of pollutants to groundwater was a concern, but considered to be a low overall risk based on light use of the parking lots, distance from the well, and environmental assessments by the design engineers. Monitoring wells were installed to evaluate impacts to the underlying groundwater, and the results are summarized in the *Water Quality Monitoring* section.

Additional information on the potential impacts of permeable pavements on groundwater is available in the *Porous Pavement and Groundwater Quality Technical Bulletin*.

Design Details

The porous asphalt layer in the two URI parking lots is 2.5 inches thick with a slope of less than two percent to allow for maximum seepage through the pavement and drainage to the vegetated islands. Located below the layer of porous asphalt is approximately a 1-inch layer of choker course (AASHTO No. 57), which fills the large aggregate space associated with the top of the underlying crushed stone and provides a stable surface for the overlying asphalt. Located under the choker layer is a uniformly graded, clean crushed rock (AASHTO No. 2) recharge bed with 40% void space designed to receive, temporarily store, and infiltrate the incoming rainfall and any sheet flow from the adjacent landscaped areas (**Figure 1**).



Typical Pervious Paving Recharge Bed Section – Not drawn to scale

Figure 1: A schematic diagram of the porous pavement system
Source: Beta Group, Inc., Cahill Associates, Carol R. Johnson Associates Inc., and Antonio P. Franco & Associates Electrical Engineers, 2002.

The crushed rock layer is 3 to 3.5 feet deep to protect against potential frost damage, and it is designed to store the volume of water associated with a 100-year storm (7.1 inches of rainfall). The exact depth of the crushed rock was dependent upon the composition of the underlying substrate. The parking lot was constructed as a series of trenches separated by

the vegetation islands, and some of them had to be excavated deeper than others to reach the proper base material. The crushed rock recharge bed is a critical feature in the design of porous pavements because it provides proper drainage and stability to the asphalt and a large storage area for the infiltrating water. The Environmental Protection Agency (EPA) recommends at least 4 feet separation between the bottom of the recharge bed and the bedrock or seasonally high water table as a precautionary measure to protect the underlying groundwater (EPA 1999). The maintenance of groundwater quality is a critical concern in this case, so the bottom of the recharge bed was designed to be 6.0 feet and 6.5 feet above the seasonal high groundwater table at the 800- and 200-car parking lots, respectively.

The crushed rock storage reservoir is separated from the underlying soils and adjacent subsurface materials by a layer of geotextile filter fabric. Each trench area, including the sides, was lined with the filter fabric. The purpose of this material is to prevent the movement of fine soil particles into the overlying reservoir, which could impede the infiltration of surface water into the storage bed. To ensure proper infiltration, the bottom of the recharge bed was leveled and left uncompacted so that the water could permeate throughout the entire surface. The entrance areas of the parking lots are paved with conventional bituminous asphalt because of heavier use and sediment deposition from tires as vehicles enter the lot.

Landscaped parking lot islands were designed as bioinfiltration areas throughout the parking lot to provide a secondary route of infiltration during intense rainfall and in case the pavement surface begins to clog. These islands were designed to dissipate energy, and they have 6-inch risers with cleanout and beehive overflow grates connected to pipes located below grade to distribute the collected water into the underlying storage reservoir (**Figure 2**). The 6-inch risers were sized and spaced to convey the runoff from the 100-year storm peak and distribute the water within the underlying storage bed as stand alone infiltration devices in case the pavement surface clogged over time.

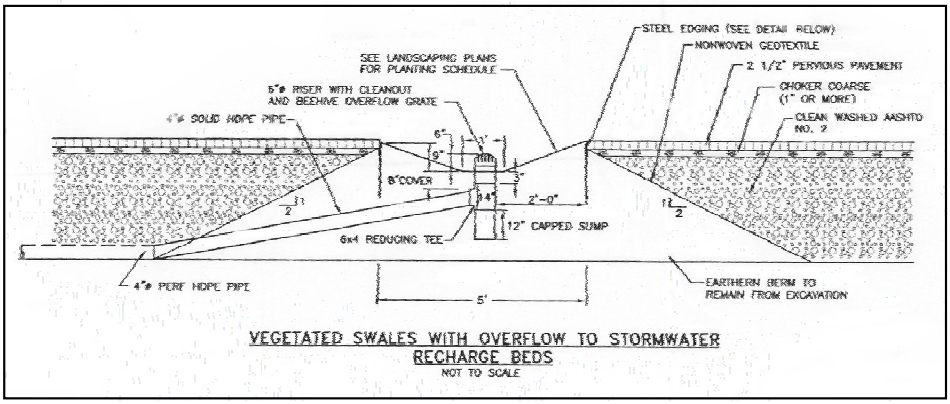


Figure 2: A diagram of the vegetated islands and 6" risers
Source: Beta Group, Inc., Cahill Associates, Carol R. Johnson Associates Inc., and Antonio P. Franco & Associates Electrical Engineers, 2002.

The outer areas of the lot are landscaped with trees, and grass is maintained around the parking lots' boundaries to keep wind blown dust from nearby agricultural activities and eroded soil from accumulating on the porous asphalt. The property along the northerly and westerly boundary of the larger parking lot is graded to prevent the runoff from flowing onto the porous asphalt. The runoff is detained in a natural depression where it is allowed to percolate into the underlying soil. An emergency spillway was designed to transmit any overflow to the recharge bed in the unlikely event that the detention area becomes clogged.

Mix Specifications

The asphalt for the two lots was provided by J.H. Lynch & Sons, Inc., and the design mix is shown below in **Figure 3**:

ATC ASSOCIATES INC.

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OCT 30 2002

J.H. Lynch & Sons, Inc.
Cumberland

HOT MIX ASPHALT PLANT TEST RESULTS

Client Name: Mr. Nick Giardino
J.H. Lynch & Sons, Inc.
50 Lynch Place
Cumberland, RI 02864

Date: October 18, 2002

Project Name: University of Rhode Island
Kingston, RI

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SUPPLIER INFORMATION

Supplier: J.H. Lynch

Location: Peacedale, RI

MIX INFORMATION

Mix Type: Pervious 3/8 Top

Asphalt Type: PG 64-28
Silicon/Anit Strip

RAP: No X Yes __ (%)

EXTRACTION TEST RESULTS (% passing by weight)

Sieve Size (mm)	Ext. #1	Ext. #2	Ext. #3	Ext. #4	Job Mix Formula
1 1/2" (37.5)					
1 (25.0)					
3/4 (19.0)					
5/8 (16.0)					
1/2 (12.5)	100	100			100
3/8 (9.5)	99	97			90-100
#4 (4.75)	38	33			30-40
8 (2.36)	9	8			10-20
16 (1.18)	5	5			5-15
30 (.600)	4	3			1 3
50 (.300)	2	2			-
100 (.150)	1.4	1.1			-
200 (.075)	1.4	.7			-
Asphalt (% by wt)	5.95	5.71			5.75-6.0
Temp. (°F)	320	315			275-325
Time	0730	1220			
Marshall No.					

REMARKS:

Respectfully submitted,

ATC Associates Inc.

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Figure 3. Design mix for 2002 parking lot.

Cost Information

The construction costs of URI's two porous parking lots were comparable to equivalent sized conventional parking lots (B. Brosnan, personal communication; R. Wilcox, personal communication; V.Wyman, personal communication). The costs of porous asphalt and conventional asphalt are approximately equal. The crushed rock, the material used for the recharge bed in the porous pavement system, usually costs more than a conventional lot's compacted subbase, but this expense is typically offset by the significant reduction in stormwater pipes and inlets (Cahill et al., 2003). The topsoil that is removed for the stone recharge bed can be used elsewhere on site for landscaping, which diminishes the need for purchasing additional soil. Furthermore, because detention basins are not required for porous parking lots, as they are for their conventional counterparts, porous pavement systems can be a viable economic option.

The construction costs for building these two porous lots totaled $3,033,700. This figure includes the costs associated with site preparation, demolition of the old Dairy Barn, all of the materials (i.e. bituminous paving, concrete for the sidewalks, curbing, and car stops, brick pavers, crushed stone for the recharge bed, timber for the guardrail), the storm drain system, lighting, emergency telephones, security cameras, post construction landscaping around the lot and within the vegetated islands, installation of monitoring wells, maintenance during construction, and inspection and testing of the lots following construction. The design fees were approximately ten percent of the aforementioned construction costs. **Therefore, the cost per parking space was approximately $3,000**. It is important to note that this particular project had site specific costs such as the demolition of the Dairy Barn, removal of stone masonry walls, and installation of emergency telephones and security cameras, which would not be encountered in all porous parking lot situations. **According to Cahill Associates, installations of porous pavement usually average between $2,200 and $2,750 per parking space for design, parking, aisles, and stormwater management (Cahill et al., 2003).**

The Parking Lot Expansion (2005)

In the summer of 2005, a new porous asphalt parking lot was constructed at URI, expanding the larger existing lot and increasing the capacity by 768 spaces from 814 to 1582. The new portion of the lot covers 5.8 acres.

Several changes were made to the design to simplify maintenance. Those changes included:

- fewer, wider infiltration islands (See **Figure 4** right.)
- curb cuts for water entry to island bioinfiltration areas
- mowed grass, not meadow grasses for islands
- fewer wheel stops, where possible, due to wheel stops being moved by cars and plowing

Figure 4. Wider infiltration islands are connected to conventional islands.

The contractor for this project was Fleet Construction Co., Inc. The asphalt was provided by their subsidiary Coventry Asphalt L.L.C, and the design mix is shown below in **Figures 5, 6 and 7**.

The construction cost for this expansion was $1,548,000, and the design cost was $140,000. The design consultant on the project was S/L/A/M and Maguire. **That brings the per-space cost for this portion of the lot to $2198. (When the cost of all three lots is considered, the per-space cost for URI's porous asphalt lots averages to $2650.)**

7-11-05 URI Blend

ACTUAL BIN PERCENTAGES

BIN #1	BIN # 2	BIN # 3	BIN # 4	BIN # 5	Asphalt	TOTAL %
12.2	81.7	0.0	0.0	0.0	6.1	100.0

BIN WEIGHT CALCULATOR

BIN # 1	BIN # 2	BIN # 3	BIN # 4	BIN # 5	Asphalt	TOTAL	% Asphalt	Total Virg. Agg.
244	1634	0	0	0	122	2000.0	6.1	1878

			Bin#4		*Bin #3*	*Bin #2*	*Fine Blend*			*Bin #1*	*Asphalt*	*BIN # 5* 3/4"	1/2"			
	Percent	**0**	**0**		**0**	**87**	**0**	**100**	**0**	**13**	**6.1**	**0**	**0**		**J.M.F**	
Metric	Sieve	1 1/2"	3/4"		1/2"	3/8"	N. Sand	W. Dust	S. Dust	Results	**Virgin**	1/2" Rap	3/4" Rap	Blend	P-401	Variance	Master Range
50 mm	2"	100.0	100		100.0	100	N/A	N/A	100	100	100.0	100	100.0	**100**	100	0.0	
	1 1/2"	100.0	100		100.0	100	N/A	N/A	100	100	100.0	100	100.0	**100**	100	0.0	
25 mm	1"	43.0	100		100.0	100	N/A	N/A	100	100	100.0	100.0	100.0	**100**	100	0.0	
19 mm	3/4"	13.0	94.0		100.0	100	N/A	N/A	100	100	100.0	100.0	100.0	**100**	100	0.0	
	5/8"																
12.5 mm	1/2"	3.0	9.0		91.0	100	100	100	100.0	100.0	100.0	96.1	90.8	**100**	100	0.0	
9.5 mm	3/8"	2.0	1.1		30.0	98.0	100.0	100	100.0	100.0	98.3	87.2	82.6	**98**	95	-3.3	
4.75 mm	#4	0.0	0.5		2.0	28.0	98.3	100.0	98.8	100.0	37.4	67.5	64.5	**37**	35	-2.4	
2.36 mm	#8	0.0	0.0		1.0	3.0	95.5	80.0	69.9	80.0	13.0	52.5	48.4	**13**	15	2.0	
	#16	0.0	0		0.9	3.0	88.0	61.0	47.5	61.0	10.5	40.8	37.1	**11**	10	-0.5	
600 mm	#30	0.0	0		0.0	2.0	64.9	43.0	33.2	43.0	7.3	29.3	27.3	**7**			
300 um	#50	0.0	0		0.0	0.0	28.2	26.0	21.4	26.0	3.4	16.4	16.6	**3**			
	#100	0.0	0		0.0	0.0	4.9	13.0	12.4	13.0	1.7	8.7	8.6	**2**			
75 um	#200	0.0	0		0.0	0.0	**1.3**	**7.0**	6.5	7.0	0.9	5.5	4.7	**1**	2	1.1	
															6.1		
						F.M	**2.2**	**3.3**									

Figure 5. Design mix for expansion of parking lot.

URI Blend Sheet

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Pervious Paving Trial Mix Test Results

Mix Delivery Temperature: 250 F +/-10
Lay Down Temperature : 245 F +/-5

Test Type

Asphalt Content (% of Weight)				
Stability (lb..)	N/A	N/A	N/A	N/A
Flow (.01in.)	N/A	N/A	N/A	N/A
V.M.A. (%)	N/A	N/A	N/A	N/A
Voids (%)	N/A	N/A	N/A	N/A
Density (p.c.f.)	N/A	N/A	N/A	N/A

Job Mix Forn	11/2"	3/4"	1/2"	3/8"	Sand	Stone Sand	Stone Dust
Blend Based	0%	0%	0	87	0	13	0

Number Of Blows: N/A

Note: All gradation results based on a WASH SIEVE ANALYZES.

Sieve Size Metric	Standard	Job Mix Formula	Master Range
25mm	1"	100%	*100*
12.5mm	1/2"	100%	*100.0%*
9.5mm	3/8"	98%	*95.0%*
4.75mm	# 4	37%	*35.0%*
2.36mm	# 8	13%	*15.0%*
1.18mm	# 16	11%	*10.0%*
75um	# 200	1%	*2.0%*
% Bitumen		6%	*6.0%*

Test	Results	Spec. Req.
Stability (lb..)	N/A	N/A
Flow (.01in.)	N/A	N/A
V.M.A. (%)	N/A	N/A
Voids (%)	N/A	N/A
Density (p.c.f.)	N/A	N/A

Date: 7/5/2005

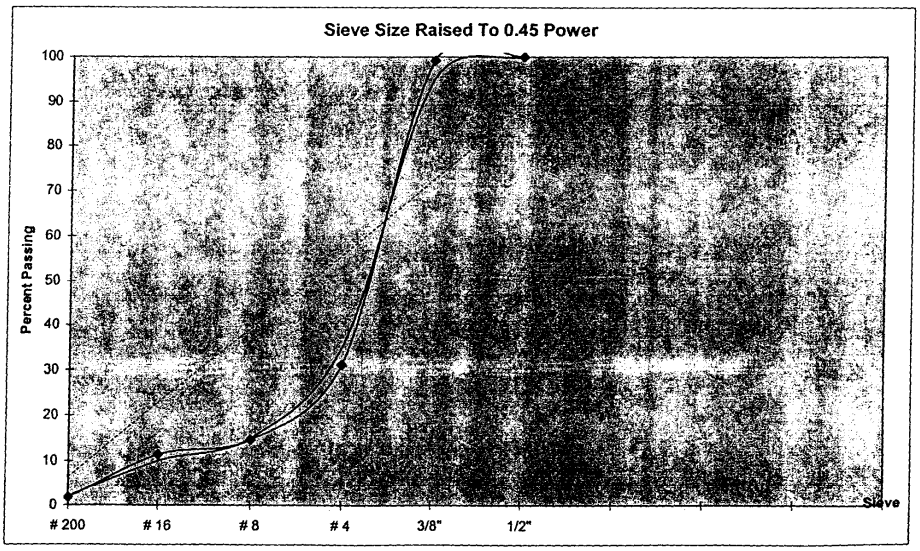
7/11/2005

Figure 6. Design mix for expansion of parking lot.

URI Blend Sheet

Plant Location	Plant Type	Aggregate Producer	Binder Supplier	Mix Type	Asphalt Grade	Anti-Stripping Agent
Coventry Massachusetts	Batch	Richman Quarry	Hudson Asphalt	Pervious Paving	64-22	see submittals

Sieve	(Series 1) %Passing	Lower Limits(Series2) %Passing	Upper Limits (Series 3) %Passing
# 200	2	2	2
# 16	11	10	10
# 8	15	15	15
# 4	31	35	35
3/8"	99	95	95
1/2"	100	100	100



Date: 7/5/2005

7/11/2005

Figure 7. Design mix for expansion of parking lot.

Observations

The University's maintenance crew started to see surface defects at the northeast corner of the larger parking lot, near the bus terminal, by the time of original publication of this document in December 2004. **Figure 8** illustrates these surface defects. They believe that it is due to outright abuse from drivers speeding out of the parking lot. According to Dan Wible of Cahill Associates, this type of unraveling, which is caused by wheels turning under a stationary vehicle, is not unique to porous parking lots.

Figure 8. Surface defects have appeared within the parking lots. The left photo shows a close-up view, while the right photo shows a particularly damaged area.

In addition, some of the wear appeared after plowing, indicating plow blades were not raised as required. University personnel have indicated that the winter maintenance contractor uses a snow pusher in order to reduce contact with the surface of the lot, but unless the pusher is raised the recommended 1", the damage is likely to continue to occur.

The winter maintenance contractor also reported experiencing a freeze on the parking lot, which did not drain until the ice melted (Dave Bascom, personal communication). This supports the findings of Boving et al. discussed in the Water Quality Monitoring section of this document, suggesting that the permeability of some areas of the parking lots has been compromised.

The sweeping contractor has reported that much debris is left in the pores of the asphalt after vacuuming. When this was reported to Cahill Associates, they recommended that sweeping followed by vacuuming would be acceptable.

Clogging of the permeable surface is visible, especially in highly trafficked areas and, to some extent, in areas where snow was stockpiled during the winter. In addition, excavation at the edge of the parking lot for construction of a new sidewalk in July 2005, revealed that the permeable asphalt layer had become tacky and soft, apparently due to separation of the binder from the aggregate. (See **Figure 9**.) This resulted in sediment collecting at the surface, at a depth of approximately 1/16" thick. This sedimentation and

tackiness is inhibiting infiltration. Cahill Associates suggested that the use of an improved mixture that includes the polymer Styrene-Butadiene-Styrene should prevent separation of the binder and eliminate tackiness. While this new porous asphalt mixture is recommended for future construction projects, it is likely that the cost of replacing the current asphalt on the parking lots would be prohibitive.

Figure 9: Clogged Layer of Porous Asphalt

If one wants to repair the surface for aesthetic reasons, areas less than 50 square feet can be patched with standard asphalt, while those greater than 50 square feet should be patched with an approved porous asphalt.

Another observation related to longer-term maintenance of the lots involved the bioretention areas. Meadow grasses planted within the depressed parking lot bioretention areas were considered too difficult to maintain properly and these were eventually mowed. The maintenance personnel have reported that cutting weed growth with line trimmers in the narrow stalls of the parking lot is tedious. The wider stalls that were constructed in the expansion of the lot are less problematic.

Water Quality Monitoring

Due to the location of these parking lots within a wellhead protection area, monitoring wells were installed by J.H. Lynch and Sons. Ten monitoring wells were installed in and adjacent to the larger parking lot, and six were installed in the smaller parking lot, as required by the Rhode Island Department of Environmental Management (RIDEM). Although the installation of these wells is mandatory, water quality sampling is not (Ray Wilcox, personal communication). To evaluate parking lot performance and potential water quality impacts, Dr. Thomas Boving, of the Geosciences Department, and Dr. Mark Stolt, of the Natural Resources Science Department, applied for and received funds from the URI Transportation Center (URITC) to monitor infiltrated stormwater directly below the porous asphalt (URITC Research Profile – Porous Pavement and Water Quality).

During the construction of the 800-vehicle lot, four paired water quality sampling stations were installed by J.H. Lynch and Sons as part of Dr. Boving's and Dr. Stolt's project. These sampling stations utilize a nested design to capture the infiltrating water at depths three and five feet below the parking lot surface. Each station is comprised of two infiltration catchment and sampling components. The catchment portion is a five cm deep stainless steel box that collects water either three or five feet below the ground surface. This water is gravity fed into an adjacent one-gallon glass bottle, which is retrieved from the surface via an eight-inch diameter PVC pipe (**Figure 10**).

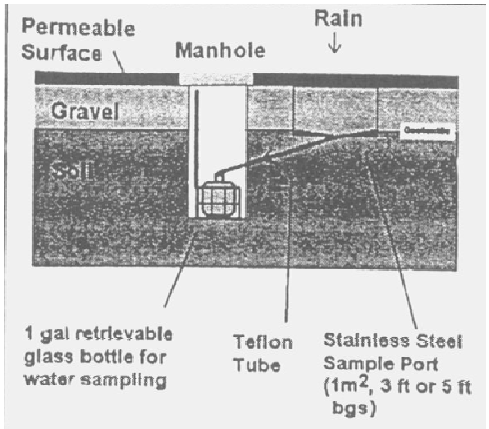


Figure 10: A schematic diagram of the water quality sampling stations
Source: Boving, 2003

The three-foot sampling station is located immediately within or at the base of the crushed rock layer, depending on the depth of the storage bed. The five-foot sampling station is buried under approximately two feet of soil below the geotextile layer. Three of these stations are located within the parking lot, and one is located adjacent to the lot to serve as a control. Of the sampling stations located in the parking lot, one is located near the entrance/exit of the lot just north of the impervious section, one is located in the east central portion of the lot, while the other is located near the northwest edge of the parking lot in an area that serves as an overflow protection (**Figure 11**).

Figure 11: A schematic diagram of the 800-vehicle parking lot and location of the groundwater monitoring wells
Source: J. Augustern, 2004

Between January 2004 and April 2005, water samples and field parameter data were collected regularly. The samples were collected within 24 hours of a major rain event. Dissolved oxygen (DO), temperature, electroconductivity, and pH were measured regularly in the field. The water samples were regularly analyzed for metals (zinc, copper, and iron), nutrients (nitrate and total phosphate). Selected samples were analyzed for bacteria (fecal coliform and *E. Coli*), polycyclic aromatic hydrocarbons (PAHs), lead, chloride, and biological oxygen demand (BOD) (Boving et al., 2007).

Between late April 2005 and June 2005, a multi-species tracer test was conducted. This was an attempt to determine if selected pollutants were being attenuated by the parking lot. Additionally, particulate samples from snow collected from piles in the parking lot were examined, and hydraulic tests of the geotextile were performed. Finally, traffic counters were used to determine typical parking lot use (Boving et al., 2007).

The results of the study showed that water was able to flow through the porous asphalt initially, but over the course of the study, the pavement became clogged by sand brought in from vehicles as they entered the parking lot. (Maintenance recommendations do not permit sanding during the winter, so the source of the sand was presumed to be external.

This was supported by high electric conductivity and chloride measurements in the winter.) Sweeping of the parking lot was not sufficient to remove the sand from the pore space. The clogging was greatest in high traffic areas and, to a lesser extent, in areas where snow was piled (Boving et al., 2007).

The monitoring failed to produce any water at the deep sample ports, and this is attributed to over-compaction of the sediment as well as the geotextile layer. The hydraulic tests of the geotextile indicated that water flowing through the porous asphalt must be flowing laterally on top of the layer until encountering a seam or hole. Boving et al. suggest that a possible source of the geotextile clogging is dust from the crushed granite rock used in the parking lot construction (Boving et al., 2007).

Areas of the parking lot that remained porous were able to remove organic and metal contaminants; the tracer test demonstrated a greater than 90% retention capacity for metals. PAHs were present at very low concentrations, and no bacteria or BOD were detected. However, nutrient (nitrate and phosphate) concentrations were found to be comparable to typical urban runoff in Rhode Island. The highest nutrient levels were measured in the spring and fall, and Boving et al. attribute that to fertilizer dust settling on the parking lot from the nearby farm land.

Maintenance Recommendations

University personnel are responsible for the maintenance of the porous parking lots. Cahill Associates state that with minimal maintenance, porous bituminous asphalt can function effectively for well over 20 years. Cahill Associates and Beta Group, Inc. provided the following maintenance recommendations to the University, detailing specific actions that should be taken to prevent clogging of the pavement, to remove snow and ice accumulation, and to repair damaged areas.

Removing Snow and Ice

- Do not apply abrasives such as sand or cinders on or adjacent to porous pavement
- Snow plowing is fine but should be done carefully (i.e. set the blade approximately 1” higher than usual)
- Salt application is not acceptable due to the close proximity of the drinking water wellfield. Environmentally benign deicers such as Ice-Ban, which is produced by Natural Solutions Corporation of Chesapeake, VA, are permissible.

Preventing Clogging of Pavement Surfaces

- Vacuum pavement at least four times per year with a commercial cleaning unit and transport the removed material to a previously designated disposal area. The use of pavement washing systems or compressed air units is not recommended.

- Maintain planted areas adjacent to pavement to prevent soil washout
  - Inspect planted areas on a semi-annual basis and remove any litter.
  - Replant and/or stabilize any bare spots or eroded away areas
  - Mow the vegetated islands and infiltration basin at least once per growing season. The grass vegetation should not be cut to a height less than four inches.
  - Immediately clean any soil deposited on pavement

- Do not allow construction staging, soil/mulch storage, etc. on unprotected pavement surface.

- Do not stockpile snow on pavement surface. Sand and grit in snow will clog pavement.

- Clean inlets draining to the subsurface bed twice per year.

Inspecting the Surface

- Inspect the porous pavement surface annually for deterioration or spalling.

Repairing Damages

- Surface should never be seal-coated.

- Damaged areas less than 50 square feet can be patched with porous or standard asphalt

- Larger areas should be patched with an approved porous asphalt

- Any required repair of drainage structures should be done promptly to ensure continued proper functioning of the system.

Additional Recommendations

Researchers also recommend the following based on their observations:

- Modify future pavement design to retain more silt or organic matter in underlying soils for increased pollutant attenuation.

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- Consider eliminating the geotextile fabric liner to avoid horizontal flow along this barrier, promote more uniform infiltration, and thereby potentially enhance pollutant attenuation. The University of New Hampshire's Stormwater Center released a document in 2007 that provides general design specifications for porous asphalt pavement and infiltration beds.

- Consider site-specific conditions in order to determine whether or not it might be necessary to have a drainage basin to prevent run-on to the porous pavement structure.

- Use an asphalt mixture that includes the polymer Styrene-Butadiene-Styrene in order to prevent separation of the binder and eliminate tackiness.

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- Stress the importance of proper maintenance to the porous function of the pavement.

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- Avoid stockpiling sediment-laden snow on the parking lot to maintain infiltration.

- In addition, design engineers have suggested adding rough material such as chatter strips to the impermeable entryways to help shake sand and salt from cars.

Availability of Porous Pavement

Porous pavement is feasible for parking lots, but it is not a viable option for smaller projects such as home driveways. This is because the design fees alone are cost prohibitive, and most contractors and batch plants do not find it worthwhile to produce such small quantities of the porous bituminous asphalt. Furthermore, porous pavement installed at private homes is often more vulnerable to poor maintenance by home owners, which in turn may lead to a shorter lifespan of the porous material. Homeowners interested in other porous driveway alternatives should refer to the manual entitled *Permeable Pavement: What's It Doing On My Street?*

Final Recommendations

The field of permeable pavement technology is continually advancing. In light of that, we recommend thorough consultations not only with the engineering firm designing the permeable feature, but also with a range of environmental consultants who have demonstrated, recent experience with permeable projects. In addition, long term performance monitoring to demonstrate effectiveness of these technologies, identify design and maintenance improvements, and to make findings widely available to designers, regulators and consumers is also critical.

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[1] Cahill Associates was an environmental engineering and planning firm used in this project.
[2] BETA Group, Inc. was an engineering firm used in this project.
[3] J.H. Lynch and Sons installed monitoring wells and water quality sampling stations for this project.

For those interested in visiting the porous asphalt parking lots, the 1400-vehicle lot is located on the northwest side of the intersection of Plains Road and West Alumni Road, and the 200-vehicle lot is located on the northern side of West Alumni Road (**Figure 12**).

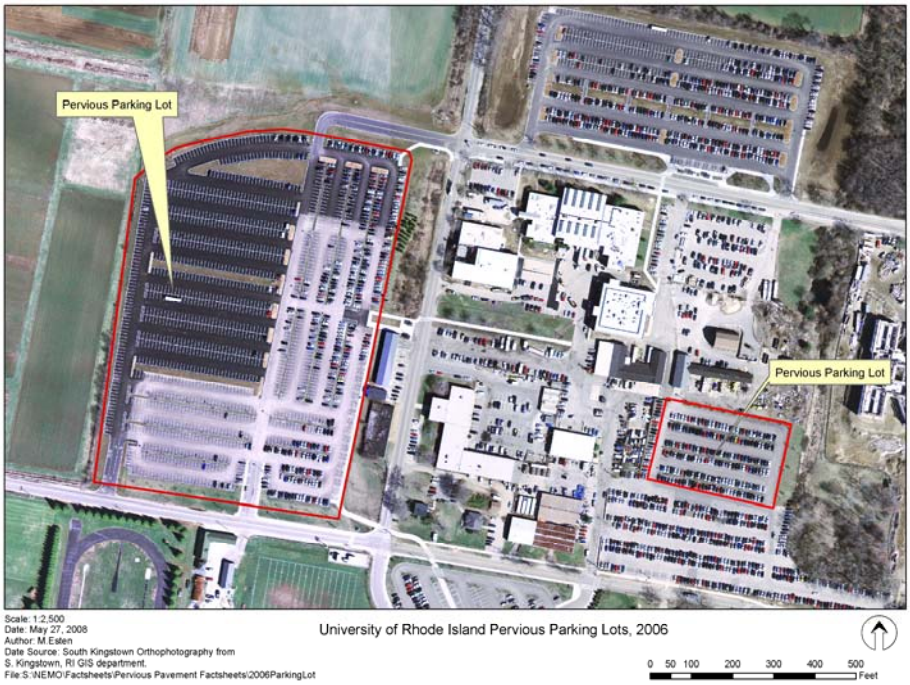

Figure 12: A map showing the location of the University of Rhode Island's porous parking lots

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