Greenland Meadows LID Case Study: Economics

UNIVERSITY OF NEW HAMPSHIRE STORMWATER CENTER

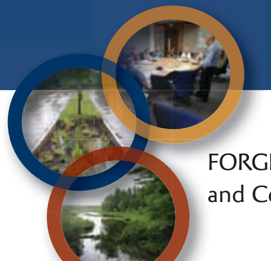
Utilizing an LID approach that featured porous asphalt and a gravel wetland, a cost-competitive drainage system was designed for a large retail development.

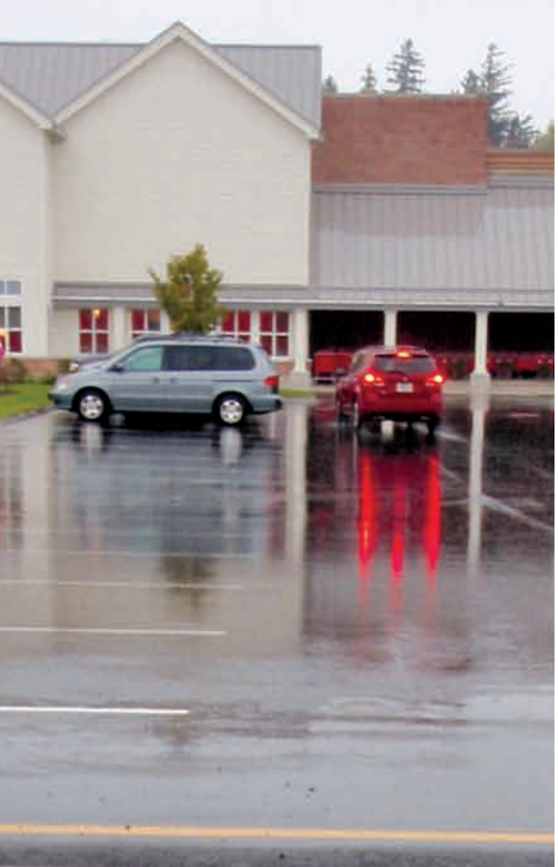
Greenland Meadows is a retail shopping center built in 2008 by Newton, Mass.-based New England Development in Greenland, N.H. The development is located on a 56-acre parcel and includes three, one-story retail buildings, paved parking areas consisting of porous asphalt and non-porous pavements, landscaping areas, a large gravel wetland, and advanced stormwater management facilities. The total impervious area of the development – mainly from rooftops and non-porous parking areas – is approximately 25.6 acres.

Framingham, Mass.-based Tetra Tech Rizzo provided all site engineering services and design work for the stormwater management system, which included two porous asphalt installations covering a total of 4.5 acres along with catch basins, a sub-surface reservoir for rooftop runoff, and a large gravel wetland for the treatment of nitrogen. The UNH Stormwater Center provided guidance and oversight with the porous asphalt installations and supporting designs.

The development at Greenland Meadows features the largest porous asphalt and gravel wetland installation in the Northeast.

This case study shows how a combination of porous asphalt and standard pavement design with a sub-surface gravel wetland was more economically feasible than a standard pavement design with a conventional sub-surface stormwater management detention system. This analysis covers some of the site-specific challenges of this development and the environmental issues that mandated the installation of its advanced LID-based stormwater management design.





ADDRESSING ENVIRONMENTAL ISSUES

During the initial planning stage, concerns arose about potential adverse water quality impacts from the project. The development would increase the amount of impervious surface on the site resulting in a higher amount of stormwater runoff compared to existing conditions. The development is located immediately adjacent to Pickering Brook, an EPA-listed impaired waterway that connects the Great Bog to the Great Bay.

Tetra Tech Rizzo worked closely with New England Development, the UNH Stormwater Center, the New Hampshire Department of Environmental Services, and the Conservation Law Foundation (CLF) on the design of this innovative stormwater management system with LID designs.

HYDROLOGIC CONSTRAINTS

Brian Potvin, P.E., director of land development with Tetra Tech Rizzo, said one of the main challenges in designing a stormwater management plan for the site was the very limited permeability of the soils. "The natural underlying soils are mainly clay in composition, which is very prohibitive towards infiltration," Potvin said. "Water did not infiltrate well during site testing and the soils were determined to not be adequate for receiving runoff." As such, Tetra Tech Rizzo focused on a stormwater management design that revolved around stormwater quantity attenuation, storage, conveyance, and treatment.

According to Austin Turner, a senior project civil engineer with Tetra Tech Rizzo, the Conservation Law Foundation feared that a conventional stormwater treatment system would not be sufficient for protecting water quality. "Since there was interest in this project from many environmental groups, especially CLF, permitting the project proved to be very challenging," Turner said. "We were held to very high standards in terms of stormwater quality because Pickering Brook and the Great Bay are such valuable natural resources."

ECONOMIC COMPARISONS

Tetra Tech Rizzo prepared two site work and stormwater management design options for the Greenland Meadows development:

Conventional: This option included standard asphalt and concrete pavement along with a traditional sub-surface stormwater detention system consisting of a gravel sub-base and stone backfill, stormwater wetland, and supporting infrastructure.

LID: This option included the use of porous asphalt and standard paving, a subsurface stone reservior for rooftop runoff, a subsurface gravel wetland, and supporting infrastructure.

The western portion of the property would receive a majority of the site's stormwater prior to discharge into Pickering Brook.

TABLE 1: Comparison of Unit Costs for Materials for Greenland Meadows Commercial Development

ITEM	CONVENTIONAL OPTION	LID OPTION	COST DIFFERENCE
Mobilization / Demolition	$555,500	$555,500	$0
Site Preparation	$167,000	$167,000	$0
Sediment / Erosion Control	$378,000	$378,000	$0
Earthwork	$2,174,500	$2,103,500	–$71,000
Paving	$1,843,500	$2,727,500	$884,000
Stormwater Management	$2,751,800	$1,008,800	–$1,743,000
Addtl Work-Related Activity (Utilities, Lighting, Water & Sanitary Sewer Service, Fencing, Landscaping, etc.)	$2,720,000	$2,720,000	$0
Project Total	**$10,590,300**	**$9,660,300**	**–$930,000**

*Costs are engineering estimates and do not represent actual contractor bids.

TABLE 2: Conventional Option Piping

	TYPE	QUANTITY	COST
Distribution	6 to 30-inch piping	9,680 linear feet	$298,340
Detention	36 and 48-inch piping	20,800 linear feet	$1,357,800

TABLE 3: LID Option Piping

	TYPE	QUANTITY	COST
Distribution	4 to 36-inch piping	19,970 linear feet	$457,780
Detention*	—	0	$0

*Costs associated with detention in the LID option were accounted for under "earthwork" in Table 1.

Table 1 compares the total construction cost estimates for the conventional and the LID option. As shown, paving costs were estimated to be considerably more expensive (by $884,000) for the LID option because of the inclusion of the porous asphalt, subbase, and subsurface reservoir. However, the LID option was also estimated to save $71,000 in earthwork costs as well as $1,743,000 in total stormwater management costs, primarily due to piping for storage. Overall, comparing the total site work and stormwater management cost estimates for each option, the LID alternative was estimated to save the developers a total of $930,000 compared to a conventional design, or about 26 percent of the overall total cost for stormwater management. **Tables 2 and 3** further break down the differences in stormwater management costs between the conventional and LID designs by comparing the total amount of piping required under each option.

Although distribution costs for the LID option were higher by $159,440, the LID option also completely removed the need to use large diameter piping for subsurface stormwater detention. The elimination of this piping amounted to a savings of $1,357,800. "The piping was replaced by the subsurface gravel reservoir beneath the porous asphalt in the LID alternative," Potvin said. "Utilizing void spaces in the porous asphalt subsurface reservoir to detain stormwater allowed us to design a system using significantly less large diameter pipe. This represented the most significant area of savings between each option."

CONSERVATIVE LID DESIGN

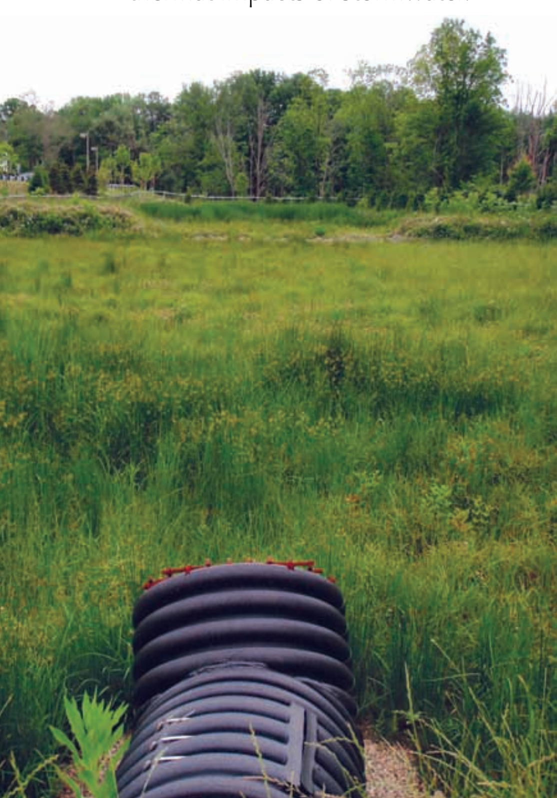
Although the developers were familiar with the benefits of porous asphalt, Potvin said they were still concerned about the possibility of the systems clogging or failing. "The developers didn't have similar projects they could reference," he said. "For this reason, they were tentative on relying on porous asphalt alone."

To resolve this uncertainty, the Tetra Tech Rizzo team equipped the porous pavement systems with relief valve designs: additional stormwater infrastructure including leaching catch basins. "This was a conservative 'belt and suspenders' approach to the porous asphalt design," Potvin said. "Although the porous pavement system is not anticipated to fail, this design and strategy provided the developers with a safety factor and insurance in the event of limited surface infiltration."

To further alleviate concerns, a combination paving approach was utilized. Porous asphalt was limited to passenger vehicle areas and installed at the far end of the front main parking area as well as in the side parking area, while standard pavement was put in near the front and more visible sections of the retail center and for the loop roads, delivery areas expected to receive truck traffic. "This way, in case there was clogging or a failure, it would be away from the front entrances and would not impair access or traffic into the stores," Potvin said.

LID SYSTEM FUNCTIONALITY

The two porous asphalt drainage systems – one in the main parking lot and one in the side parking area – serve to attenuate peak flows, while the aggregate reservoirs, installed directly below the two porous asphalt placements, serve as storage. The subbase includes the use of a filter course of medium-grained sand, which provides an additional means of stormwater treatment. Peak flow attenuation is insured by controlling the rate at which runoff exits with an outlet control structure. Nearly the entire site is routed to the gravel wetland on the west side of the site. The gravel wetland is designed as a series of flow-through treatment cells providing an anaerobic system of crushed stone with wetland soils and plants. This innovative LID design works to remove nitrogen and other pollutants as well as mitigate the thermal impacts of stormwater.



CURRENT CONDITIONS

As of 2011, and 3 years of operation, LID in a commercial setting is functioning well both from a durability and water quality perspective. Water quality monitoring indicates a very high level of treatment (see accompanying water quality fact sheet). The porous pavements continue to function well for both permeability and durability. They retain a high level of permeability in part due to a routine maintenance schedule. Pavement durability for passenger vehicles has been strong. Durability has been an issue for non-design loads. In parking areas designed for passenger vehicles only, on occasion, tractor trailers have used the paved areas for turning resulting in damaged pavement. Damage and repairs to porous pavements were managed similarly to standard pavements. The durability is consistent with the standard asphalt and concrete areas where damage is also observed from the demands of high use. The inadvertent use of porous pavements for non-design loads can be prevented by careful design including the use of tight turning radius, obstructions for large vehicles, and the posting of signs.

SUMMARY

Although the use of porous asphalt and gravel wetlands in large-scale commercial development is still a relatively new application, this case study showed how LID systems, if designed correctly and despite significant site constraints, can bring significant water quality and economic benefits. With Greenland Meadows, an advanced LID-based stormwater design was implemented given the proximity of the development to the impaired Pickering Brook waterway. In addition to helping alleviate water quality concerns, the LID option eliminated the need to install large diameter drainage infrastructure. This was estimated to result in significant cost savings in the site and stormwater management design.

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