Report:
Comparing Traditional Concrete to Permeable Concrete for a Community College Pavement Application

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Background

It is well documented that storm water runoff has contributed to environmental decline in the form of stream degradation, intermittent flooding, first flush pollution in creeks, lakes and sounds, and loss of fish species\(^1,2\). The accumulation of pavement has also resulted in urban heat islands which create elevations in air temperature\(^3\), disturb urban weather patterns, and cause summer storm water to upset watersheds with their elevated temperature. The amount of imperviousness has even been quantified in relationship to watershed species decline, with 10% imperviousness -- amounting to a density of about 4 people per acre -- being the level at which streams display negative impact\(^1\).

To counteract the decline in our watersheds, a few years ago the EPA began mandating the management of storm water runoff in new construction, issuing the National Pollutant Discharge Elimination System (NPDES) Phase II requirements\(^4\). These regulations require storm water retention ponds and/or other storm water Best Management Practices (BMPs), making traditional development more expensive than in the past.

Available land is also becoming less plentiful. All of these pressures, combined with government pressure to step up the preservation of watersheds, have led to interest in development practices that are Low Impact\(^5,6\). Among these is the use of pervious pavement.

Definition of Pervious Pavement

Pervious concrete is concrete that has a low water-cement ratio and contains none or very little sand.\(^7\) It typically has a voids content of 15% to 25%, creating a structure resembling a Rice Krispies® treat and allowing as much as eight gallons of water per square foot to pass through per minute\(^8\). These drainage properties allow pervious concrete to filter storm water directly into

the ground, making the material a BMP for managing storm water runoff according to the NPDES Phase II requirements. It holds tremendous potential to scale back the negative impact that pavement has had on the environment, by eliminating storm water runoff, removing pollutants, preventing runoff damage to streams and aquatic animals, allowing watersheds to return to normal, and even by helping capture storm water for water-poor areas. Currently, though, many developers fail to see beyond initial costs of pervious implementations, and adoption has therefore been slow.

David Wu (D-OR), who chairs the Innovation and Technology Subcommittee of the U.S. House of Representatives Science and Technology Committee, recently commented on pervious concrete during a hearing on Green Transportation Infrastructure. He pointed out the tremendous benefits possible from a technology that is currently available and asked why these technologies are not being used more often. In answering his own question, Wu stated that the “biggest impediments are state and federal regulations”.

**Purpose**

While commonly used on the East Coast in hurricane communities and in areas where traffic safety is compromised by standing water, pervious pavement has not yet been widely used in the Pacific Northwest. It is relevant to look at how it compares here – in terms of up-front cost and other factors -- with traditional pavement techniques for applications such as sidewalks, driveways, and parking lots. The purpose of the current research project is to perform such a comparison.

**Scope of study**

For this research project, I am using a combination of article, book, and Internet research, and have interviewed knowledgeable engineers and concrete contractors in the field. I have collected data for traditional concrete and pervious concrete according to the following criteria:

- Cost
- Available skilled contractors, and

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Future outcomes, including:

- Durability
- Maintenance,
- Long-term savings

**Purpose of report**

In this report I present the data I have obtained by alternative (traditional concrete vs. pervious concrete), with each alternative organized by criteria. I compare the results for each alternative by criteria, and summarize the report with my recommendation for actions to take based on these findings.

Finally, I include a list of experts who contributed significant information for this report, and a list of concrete contractors who are certified (as of June 2007) by the National Ready Mix Concrete Association for installation of pervious concrete.
New Technology is Core to Bellevue’s Civic Spirit

Bellevue is a forward-thinking city. Headquarters to 13 of the state’s 100 largest public companies and nine of the largest private ones, it fosters some of the fastest-growing employers in the country\(^\text{12}\). It is the fifth largest city in the state, but does not yet have implementations of pervious concrete for storm water management\(^\text{13}\).

Bellevue is also a gem in terms of beauty. Bellevue city limits encompass a wealth of natural resources such as wetlands, lowland conifer-hardwood forest, four major stream systems, and the lakes the streams feed into. It has miles of riparian corridors and a rich diversity of plants and animals.\(^\text{14}\) In 2005, an independent environmental consultant – using data from 2003 -- reported the impact of human-induced degradation of streams and plant communities due to storm water runoff and development within riparian areas. The report concluded the city should implement specific recommendations for reducing storm water runoff.\(^\text{15}\)

As Bellevue enters a phase of unprecedented development, it is appropriate to begin using technologies which preserve the city’s unique beauty and at the same time ensure the health of the environment and the people who live and work here.

Bellevue Community College’s Unique Opportunity

Bellevue Community College, as the premier learning institution east of Lake Washington, is also in a unique position to showcase new technology. The approaches the school takes to instruction, to leadership, and to community involvement, all set an example that is far reaching. BCC students, faculty, and staff come from all walks of life and include current decision-makers and drivers of policy, as well as individuals who will be our leaders in the coming decades.

With the imminent construction of the new Science building, BCC has an opportunity to be the first in Bellevue to implement pervious concrete in sidewalks, walkways, and parking areas for the new structure. This would be as an example of smart storm water management practices for the rest of the region to evaluate and adopt. With so much current interest in this technology among engineers and policy makers, BCC can gain attention for the school by showcasing its commitment to new technology while at the same time taking steps to protect the environment. What I show with this report is whether resources exist and whether it is feasible for the school to implement a pervious solution right now.

\(^\text{13}\) Watson, R., PE, Head, Low Impact Development Program, City of Bellevue (2007, personal communication).
Traditional pavement

Below I present data for traditional pavement.

Cost

According to Chris Webb, founder of 2020 Engineering – the engineering firm for the first LEED™ Gold project in Washington State, basic installation costs for traditional concrete are $3 - $4 per square foot. He comments that conventional solid asphalt is $2 - $3 per square foot.\(^{16}\)

Both paving materials require catch basins, storm pipes, detention and treatment to meet EPA regulations, which increases the overall cost. Mr. Webb cannot predict the additional cost without first examining the site.\(^ {16}\) My best guess, after reviewing the literature, is a factor of between 10% and 20% over the total cost of conventional concrete pavements.\(^ {17}\)

The Puget Sound Partnership listed the following projects as costing $6 – $9 per square foot\(^ {18}\). Andrew Marks, Managing Director of the Puget Sound Concrete Specifications Council, remarks as follows: "these projects are small and thus have typically higher unit costs. Recent bids have been in the $4 -$6 per square foot range. Increase in project size typically results in lower unit costs. Specific project requirements and non-typical specifications tend to drive prices higher."

- Four blocks of sidewalks on N. 145th Street, Seattle
- 400 feet of sidewalks at 100th Ave., Marysville
- Six parking lots at Fort Lewis
- Sidewalk on North Street in Olympia
- Plaza at Greenwood Park, Seattle
- Alley in Bellingham
- Parking lot for Washington Aggregates & Concrete Assoc. office, Des Moines
- Nine parking spaces at Bayview Corner, Whidbey Island


\(^{19}\) Marks, A., PE. Managing Director, Puget Sound Concrete Specifications Council (2007, personal communication)
♦ For an independent contractor bid, the cost to install traditional concrete is $4.87 per square foot\textsuperscript{20,21}.

This does not include catch basins, piping, or other techniques needed to meet EPA Phase II regulations.

♦ Recent bid histories from the City of Sammamish listed bids for traditional concrete for three different street projects\textsuperscript{22}. These bids ranged from $4.22 per square foot to $6.43 per square foot.

♦ The City of Olympia performed a cost analysis of traditional and pervious concrete sidewalks. This study evaluated cost of installation, as well as cost of storm water retention and long-term maintenance. The cost of traditional concrete for sidewalks is estimated at $11.24 per square foot. This cost includes an estimate for installing a storm water retention pond system needed to meet the requirements of the \textit{2005 City of Olympia Stormwater Manual} to manage runoff from the sidewalks, which was $3,262,870. This brought the total cost of installation for traditional concrete to $5,003,000.\textsuperscript{23}

\textbf{Available skilled contractors}

I have not been able to obtain an exact number of all the concrete contractors in Washington State. One issue is that many general contractors self-perform their own work, and another is that many concrete contractors do other things than the specialty for which they are listed\textsuperscript{24}. However, it appears possible the number is a substantial one.

The Yellow Pages listed 49 pages of concrete contractors in Washington State, for a total of 486 listings\textsuperscript{25}.

The American Concrete Institute (ACI), which provides a standard certification program for the concrete industry, lists 27 individuals in Washington State who hold the ACI Concrete Flatwork Finisher & Technician certification and 43 who hold the ACI Concrete

\begin{footnotes}
\item[22] Brauns, J, PE. City of Sammamish (2007, personal communication).
\end{footnotes}
Flatwork Technician certification. A few individuals hold both certifications, so it is likely that the total number of people certified by ACI for flatwork is around 65\textsuperscript{26}.

**Future outcomes**

Future outcomes include a number of long-term issues, three of which are measured in the following summaries.

**Durability**

According to the American Concrete Pavement Association, concrete has an average life span of 30 years, adding 10% to its original strength over the life of the pavement.\textsuperscript{27}

Durability, defined by the Portland Cement Association, is the “ability of concrete to resist weathering action, chemical attack, and abrasion while maintaining its desired engineering properties.”\textsuperscript{28} Concrete is well known to be a very durable paving, and there are several types of durable concrete, each chosen as demanded by different conditions. Loss of durability has generally been ascribed to placement of pavements in locations where materials related stress is caused by the particular environment, regardless of the pavement’s original durability.\textsuperscript{29}

Roadways constructed within the last 20 years are composed of high performance grade concrete, taking environmental conditions into account (a program called Superpave) and are designed to last 75 to 100 years\textsuperscript{30}. However, even concrete roads constructed as far back as the 1950s are still in service with little or no maintenance.\textsuperscript{31}


\textsuperscript{27}Why is concrete such a great pavement choice? (n.d.) From the American Concrete Pavement Association’s Why Concrete Pavement section. Retrieved 29 July, 2007 from the American Concrete Pavement Association Web site: http://www.pavement.com/Concrete_Pavement/About_Concrete/Why_Concrete_Pavement/index.asp, para 2.


Maintenance

Traditional concrete requires very little maintenance, if any. The American Concrete Pavement Association (ACPA) states that concrete pavements are the best long-term value, “because of their longer life expectancies and minimal maintenance requirements”. 27

State highway agencies monitor the service lives of highways, with many highways lasting 25 to 40 years before resurfacing. Robert Packard, Director of Engineering and Design for the ACPA, in a summary of pavement costs and quality, points out that concrete is often selected for higher-traffic routes (as opposed to asphalt), and the pavements frequently outlast their estimated life without maintenance32.

In its evaluation of seven sidewalks, the city of Olympia calculated there would be long-term costs for maintaining traditional concrete, from the standpoint of maintaining the storm water retention pond required to meet the city’s storm water regulations. These maintenance costs were estimated at $155,610.33

Long-term savings

For traditional concrete, long term savings are usually measured compared to asphalt, which is often implemented due to a lower initial cost. The studies cited above point out that total pavement costs are less impacted by the initial cost, and more by the length of service life and maintenance required.

Maintenance costs vary depending on transportation jurisdiction and funds available, and vary from several hundred to several thousand dollars per mile annually. In California, for example, during the years studied, virtually no maintenance was performed on streets, resulting in a savings over asphalt of more than 8 to 1.32 Data from the Oklahoma Department of Transportation (DOT) shows that on U.S. 77, concrete was more than $100,000 more expensive to install than asphalt. However, maintenance costs for the 24 year period monitored after installation came to a total of only $9545, whereas an equal stretch of roadway surfaced in asphalt required $128,000 to maintain over the same period. In another survey of highway agencies, concrete was initially more expensive to install than asphalt, but proved to be $1,000 cheaper per mile per year to maintain over the long term.34

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34 Packard, RG. (1994), p 2
Pervious concrete

Below I present data for pervious pavement.

Cost:

♦ According to Chris Webb, the basic installation cost for pervious concrete is $4 - $5 per square foot.35

♦ The Puget Sound Partnership listed the following projects as costing $6 – $9 per square foot18. Again, notes Andrew Marks, “these projects are small and thus have typically higher unit costs. Recent bids have been in the $4 -$6 per square foot range. Increase in project size typically results in lower unit costs. Specific project requirements and non-typical specifications tend to drive prices higher.”36

- Four blocks of sidewalks on N. 145th Street, Seattle
- 400 feet of sidewalks at 100th Ave., Marysville
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- Sidewalk on North Street in Olympia
- Plaza at Greenwood Park, Seattle
- Alley in Bellingham
- Parking lot for Washington Aggregates & Concrete Assoc. office, Des Moines
- Nine parking spaces at Bayview Corner, Whidbey Island

♦ For an independent contractor bid, the cost to install pervious concrete is $6.26 per square foot37,38.

♦ Recent bid histories for different sidewalks within the City of Sammamish listed bids for pervious concrete at $5.25 per square foot39.

♦ The City of Olympia performed a cost analysis of traditional and pervious concrete sidewalks. This study evaluated cost of installation, as well as cost of long-term maintenance over a ten-year period. Cost of pervious concrete for sidewalks is estimated at $6.02 per square foot, for a total cost of $2,615,000.40

36 Marks, A., PE. (2007, personal communication)
At the Evergreen State College, pervious parking retrofits that were added as part of the school’s emphasis on zero discharge were described as costing “the same as, or lower than, traditional alternatives using new treatment and detention systems.” 41,42

Available skilled contractors

Bruce Chattin, Executive Director of the Washington Aggregates and Concrete Association, provided me with a list of 55 concrete contractors in Washington State currently identified as Pervious Certified Technicians by the National Ready Mix Concrete Association43.

The Technician title is awarded upon completion of a written exam. A Pervious Craftsman title is awarded to Technicians who also document 1500 hours of work experience and pass a performance exam. Applicants must already hold certification from the American Concrete Institute (ACI) in the Craftsman program (Flatwork Finisher).44

Future outcomes

Durability

According to the National Ready Mix Concrete Association, pervious concrete could provide 20 to 40 years of service with minimal maintenance45, although it is best suited for lower traffic areas such as sidewalks, parking lots, curb-side parking strips on city streets, and driveways.

There is some anecdotal evidence that pervious concrete, when placed in streets with truck traffic, experiences raveling46. However, other sources comment that knowledge of the proper cement mixture (especially water content and proper

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42Hooseim, A, PE, PMP, Assistant Director of Facilities Services for Planning and Construction, Evergreen State College (2007, personal communication)
43As cited in the NRMCA Pervious Concrete Database (June 12, 2007). Retrieved 31 July, 2007 from the National Ready Mix Concrete Association Web site: http://www.nrmca.org/certifications/pervious/certified%20personnel%20061107.pdf, p 80
curing) is key to preparing a durable surface, and that durability is not an issue.\textsuperscript{47,48}

It bears mentioning here that pervious concrete has been extensively studied with respect to freeze-thaw cycles.\textsuperscript{46,49} There is even evidence to show that pervious concrete makes for a safer roadway in winter, as the open cells of the material encourage snowmelt and draw moisture away from the surface to prevent accumulations of ice.\textsuperscript{50}

**Maintenance**

According to the National Ready Mix Concrete Association, most pervious concrete pavements need little to no surface maintenance. A key is proper site design so that surrounding landscapes do not erode and drain into the pavement surface\textsuperscript{51}.

Cleaning of the pervious pavement is usually required annually or more often; this is commonly accomplished by vacuuming. Power blowing and pressure washing are other alternatives for periodic cleaning. The NRMCA notes that maintenance practices for pervious pavements are still being developed.\textsuperscript{51}

In its planning budgets, the City of Olympia estimated its pervious sidewalks require sweeping every 6 months and pressure washing every 5 years. This maintenance cost was estimated at $147,000.\textsuperscript{52}

The EPA estimated the cost of maintenance, in the form of vacuuming and pressure washing, was approximately $200 per acre per year.\textsuperscript{53}

**Long-term savings**

According to the Center for Watershed Protection, installing traditional storm drain inlets, piping, and retention basins for storm water management can cost two to three times more than low-impact strategies such as pervious concrete for

\textsuperscript{47} Hun-Dorris, T (2005, March/April), para 16.
\textsuperscript{50} Huffman, DJ. (2007), p 5.
\textsuperscript{51} Inspection and maintenance. (n.d.) From the pervious concrete section of the National Ready Mix Concrete Association Web site: http://www.perviouspavement.org/inspection%20and%20maintenance.htm, para 4.
\textsuperscript{52} McFadden, M. (2005), p 1.
handling runoff. Projects that use pervious concrete typically don’t need sewer tie-ins, eliminating the cost of installing underground piping and storm drains.\(^{54}\)

In the Stratford Place development, Washington’s first development using pervious pavement for all hardscape (sidewalks, roads, and driveways), the installation of pervious concrete saved a total of $260,000 over conventional storm water management systems and recaptured two lots which ordinarily would have been devoted to such systems.\(^{55,56}\) This amount of savings does not include projected net revenue that will be gained from development of the additional two lots.\(^{57}\)

In another situation cited in the literature, one 12 acre development project that included an 8 acre parking lot was able to eliminate a 1.5 acre retention pond and drainage system using pervious concrete. The overall savings in this example were $400,000.\(^{58}\)

As calculated by the City of Olympia, while there were costs in maintaining pervious concrete, there were savings as well. These were calculated to be $9,000.\(^{59}\)

Long term savings can also be considered from the standpoint of effectiveness of storm water management systems; if systems are not effective at treating storm water runoff, money has been ill-spent. In a landmark evaluation of current storm water management techniques, storm water retention ponds were shown to be damaging in their ineffectiveness. For example, several watershed sites in King County downstream of the detention centers displayed hydrologic and empirical evidence of storm water impact.\(^{60}\) The same authors constructed large pervious pavement facilities to measure attributes of storm water runoff. They determined that pervious pavements were extremely effective at managing storm water and filtering impurities. Chemical analyses showed that petroleum hydrocarbons from vehicle fuel and lubricants appeared to be removed completely by infiltration; other chemicals and heavy metals all showed subdetectable or relatively low levels.


\(^{57}\) Huffman, DJ (2007), p 4.

\(^{58}\) Huffman, D. (2005), p 44.


Cost

Below I show cost in tabular form, using estimates obtained for traditional and pervious concrete, along with a chart summarizing this data.

<table>
<thead>
<tr>
<th>Table 1. Cost for Installing Traditional Concrete (per square foot)</th>
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<tbody>
<tr>
<td>Chris Webb $3 - $4*</td>
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</table>

* - Bid does not include storm water management system

Range for Traditional concrete: $3 to $11.24 per square foot.

<table>
<thead>
<tr>
<th>Table 2. Cost for Installing Pervious Concrete (per square foot)</th>
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<tbody>
<tr>
<td>Chris Webb $4 - $5</td>
</tr>
</tbody>
</table>

Range for Pervious concrete: $4 to $9 per square foot.

Fig. 1. Cost per square foot for Traditional and Pervious concrete

- Chris Webb
- Puget Sound Partnership
- Independent contractor
- City of Sammamish
- City of Olympia
Comparing the cost of traditional concrete to pervious concrete, one thing is evident:

*Traditional concrete is not clearly cheaper in terms of cost.* Quotes that were listed as lower for traditional concrete did not include the cost of storm water management, so the lower cost is a little misleading. Bids that factored in the cost of storm water management (Sammamish, Olympia, and Puget Sound Partnership) showed the same or lower cost for pervious concrete.

**Available skilled contractors**

Below is an estimate of the number of contractors available for traditional or pervious concrete installation, using ACI certification as a barometer for traditional concrete, and NRMCA certification as a barometer for pervious concrete. The estimate for total contractors comes from the Yellow Pages and is not an indication of certification.

<table>
<thead>
<tr>
<th>Table 3. Number of Concrete Contractors in Washington State</th>
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<tr>
<td><strong>Total Concrete Contractors</strong>(^{25})</td>
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<tr>
<td>486</td>
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Figure 2 summarizes this data graphically:

![Fig. 2. Number of Certified Traditional and Pervious Contractors](image-url)
While the number of certified pervious concrete contractors is a fraction of the total number of concrete contractors in the state, the number is very close to the number of concrete contractors certified to lay traditional concrete. While neither certification is required for working in the industry, they do demonstrate breadth of knowledge of the material. That the numbers are similar means there should be no bigger barrier finding a contractor to work with pervious than finding a contractor to work with traditional concrete.

Commenting on the number of contractors certified for pervious concrete, Andrew Marks, of the Concrete Specifications Council, states the following:

“The technology is mainstream enough that there is a certification program for contractors. Even though the technology is recent in the Northwest, since about 2000, there are a number of large -- and many small -- projects completed and being completed daily. There are a number of contractors who have become certified and others who have not yet become certified, but who have built successful projects.

The installation of pervious concrete is not difficult -- in fact, it is much easier to construct than conventional concrete. There are a few critical steps that must be performed correctly, but it is easy to do so, and can be performed by any competent contractor, with a little instruction or training.”

61 Marks, A., PE (2007, personal communication)
Future outcomes

Durability and Maintenance

Below is a table summarizing statements about durability and maintenance of traditional and pervious concrete.

<table>
<thead>
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<th>Table 4. Durability and Maintenance for Traditional Concrete</th>
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<td>Durability</td>
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<tr>
<td>Maintenance</td>
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<td></td>
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<tr>
<td>Maintenance of Storm water system</td>
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<table>
<thead>
<tr>
<th>Table 5. Durability and Maintenance for Pervious Concrete</th>
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<tr>
<td>Durability</td>
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<td>Maintenance</td>
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Traditional concrete does not show a clear advantage in terms of durability and maintenance. Pervious concrete is just as durable, and -- while it requires vacuuming and/or sweeping in areas where there can be build-up of soils upon the surface -- has none of the hidden maintenance costs that accompany traditional
pavement. Traditional pavement requires storm water management systems which require maintenance, the cost of which depends upon the type of system installed.

**Long term savings**

Below is a table summarizing statements about long term savings for traditional and pervious concrete.

<table>
<thead>
<tr>
<th>Table 6. Examples of Long Term Savings for Traditional and Pervious Concrete</th>
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<tbody>
<tr>
<td>Highway: $118,455 savings over asphalt$^{34}$</td>
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<tr>
<td>Highway: $1,000 per mile per year cheaper than asphalt overlay$^{34}$</td>
</tr>
<tr>
<td>Sidewalk: $9,000 savings over traditional concrete$^{59}$</td>
</tr>
</tbody>
</table>

As with durability and maintenance, *traditional concrete does not show a clear advantage in terms of long term savings*. There are significant costs associated with installing and maintaining storm water systems aside from the traditional concrete installation itself. In many cases, when a site has been well evaluated and care has been taken to design the concrete installation around the site requirements, a pervious concrete installation has a very sound advantage.
CONCLUSIONS

When traditional concrete is compared to pervious concrete across criteria of cost, availability of contractors, and future outcomes such as durability, maintenance, and long term savings, pervious concrete is clearly equal to traditional concrete where it is appropriate to be used. In many situations, it comes out ahead.

In addition, when other factors such as long-term impact on the environment are considered, pervious concrete proves superior. The infiltration properties of the material -- the ability to remove pollutants from storm water -- show far greater effectiveness than some of the most popular storm water management systems. This demonstrates that a paving system which is nearly equal in cost to traditional concrete actually pays for itself over the long term, with a more effective storm water infiltration system than commonly used traditional storm water systems. It is therefore possible to employ an environmentally sound pavement solution while saving money.
Based on the data and interviews I have obtained in this project, I recommend that Bellevue Community College talk with a pervious expert about implementing pervious concrete in sidewalk, entryway, and parking areas of the new Science building. The Science building will have a long life and it is worth implementing a solution that will have the lowest possible impact on the environment.

Pervious concrete has other important long-term effects. They include the following:\(^{62}\):

- Pervious concrete reduces urban heat island effects – thus lessening a number of the problems associated with elevated air and surface temperatures.

- Pervious concrete allows air and moisture to reach tree roots, promoting natural growth. Trees can be placed close to the edge of the concrete to reproduce a more natural environment and in return, the pavement can be kept even cooler in the summer due to shading.

- Pervious pavement is less noisy than traditional pavement, due to the open nature of the aggregate.

- Pervious pavement is safer for walkways and driveways in the winter time, as the open aggregate encourages snow to melt faster, providing better traction.

Knowing it is possible to implement an environmentally sound pavement solution without a significant increase in cost, and given both the timing of the Science building and BCC’s history of being environmentally sensitive, it makes sense to investigate pervious concrete for the current building project.

Interest in pervious concrete in Washington State is new enough that its implementation would be likely to garner significant visibility for the school.

In the process of writing this report, I spoke to many local experts and found them to be easily accessible, responsive, and thoroughly knowledgeable about designing concrete solutions. Any of these experts would be able to work with the school’s current construction contractor to provide expertise on fitting pervious concrete to the site as it is planned for traditional concrete. Since ground has just been cleared and existing pavement broken, it is an optimal time to evaluate the site without incurring any additional costs.

The Appendix provides contact information for the core group of individuals who provided data for this project, and the list of contractors certified by the NRMCA as pervious technicians.

Below is a glossary of terms that appear in this document:

**BMP:** Best Management Practice. Mitigation practice (i.e. retention pond, bio-swale, etc.) that meets U.S. Environmental Protection Agency National Pollutant Discharge Elimination System Phase II regulations. The NPDES Phase II regulations are the bare minimum that a facility must comply with; state and local regulations are often more stringent. At minimum, sites of one acre or more must have a Storm Water Pollution Prevention Plan identifying pollution mitigation as well as practices to reduce volume and discharge rates, and improve quality.

**First flush:** Delivery of a highly concentrated pollutant loading during the early stages (first 38 mm or 1.5 inches) of a rain event due to the washing effect of runoff on pollutants that have accumulated on the land.

**LID:** Low Impact Development. A development technique designed to mimic the natural flow of water on the land, where water is taken up primarily by the ground, tree leaves and roots, leaving less than 1% as runoff.

**Pervious concrete:** Concrete material that permits water to enter the ground by virtue of its porous nature or by large spaces in the material.

**Riparian areas:** Stream banks and edge areas of natural waterways such as creeks and ponds. Such areas form the transition from aquatic life to terrestrial life.

**Urban heat island effect:** A concentrated, local increase in air and surface temperature caused by the use of dark pavement materials, such as black-top asphalt and other pavements in place of natural landscape. Change in temperatures can cause other long-term effects.

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64 Huffman, D. (2005), p 49.


APPENDIX

Selected List of Experts:

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List of Certified Pervious Contractors

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