



Implementation of  
Permeable Pavement  
within the City of Oshkosh, WI

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# Executive Summary:

Stormwater management has become an increasing issue for cities across the country. The purpose of this paper is to identify stormwater management issues within the City of Oshkosh, and to provide a recommended ordinance to help address these issues. The Oshkosh Sustainability Advisory Board has asked us to identify best management practices for stormwater management issues in parking lots. Different techniques of best management practices include bioswales, retention ponds, buffer zones and permeable pavements. This paper specifically focuses on permeable pavements and why they should be considered a best management practice, as well as explaining how they work. Supporting evidence coupled with case studies will be examined and compared to Oshkosh stakeholders. In addition, a cost benefit analysis of permeable pavements is included while considering Oshkosh parking lots. To combat issues associated with stormwater management we proposed an ordinance requiring the use of permeable pavements that we strongly urge the City of Oshkosh to implement.

# Introduction/Background:

Stormwater management is something that every city across the United States has to think about. We have moved to an urbanized lifestyle and in doing so have put stress on ground water recharge and stormwater management. Cities across the globe have laid down impervious concrete and asphalts that hurt the groundwater system. Rain is unable to soak into the ground because of impervious zones which can lead to floods and property damage. Impervious surfaces have not only impacted recharge rates but they have also increased runoff. In addition, during large rain events water runs into the sewer systems at rates that are too fast. In result, the excess water can lead to downstream flooding, bank erosion, high turbidity, and habitat destruction. This is why green infrastructure regarding rainwater recharge is important to understand and utilize. After talking with Public Works Director James Rabe there are several infrastructure issues regarding Oshkosh sewers. One of the main problems for Oshkosh is flooding basements due to stormwater infiltration to sanitary sewer systems. “There are several sources of clear water inflow and infiltration into the sanitary sewer system” (Rabe, personal communication, April 2018). “Mr.” Rabe mentioned that there is leaky sewer systems and manholes that contributed to clean water infiltration. In addition he was seeing private properties installing sump pumps and foundation drains installed incorrectly. These are all issues that Oshkosh faces when it comes to stormwater management. Luckily there are ways to relieve stress on the sewer systems through safe permeable surfaces. Oshkosh has shown some initiative by using permeable pavements on city projects. Some private businesses have followed and started using them as well. Permeable pavements can limit the amount of rainwater that enters the sewer

system and recharge groundwater reserves. Innovation and implementation of permeable pavement practices in parking lots across Oshkosh could save the city some money and reduce problems regarding the sewer system and treatment process.

## Permeable Pavement Information:

When determining if the city of Oshkosh, WI should promote and continue the implementation of permeable pavement, we must fully understand what permeable pavement is. In comparison to common asphalt and concrete pavement we normally see throughout the city, permeable pavement differs because it allows for the infiltration of water. Instead of rainfall running off of the pavement directly into the sewer systems, the porosity of permeable pavement allows the water to filter through the pavement, eliminating runoff issues such as erosion and water pollution (USGS, n.d.). The filtration of the water through the pavement allows for pollutants and harmful contaminants to be filtered out in a natural way, before the water reaches the underlying soils. This allows the rainfall to be cleaned before reaching the soils or waterbodies (Clark et al., 2008).

There are many types of permeable pavement but the most common types are permeable pavers, porous concrete, and porous asphalt. All three act in similar ways, allowing for the infiltration of rainfall. Permeable pavers refer to unit blocks or pavers that allow water to flow in between them, through underlying filtration layers. Porous asphalt and porous concrete are designed in similar fashion, with underlying layers, but differ in that they have a top layer of poured asphalt or concrete. In general, all three of these permeable pavements try to achieve the

same objective. They all aim to allow rainfall to pass directly through them, filtering out contaminants, then being released back into the soils.

When determining which permeable pavement best suits the city of Oshkosh, we believe that the pavement method should be site dependent. This means that all three methods can be used in areas that best suit them. For instance, a small business may want their walkways to be done in permeable pavers, whereas a large company may want their entire parking lot done in porous asphalt. By allowing the individual consumer to choose which permeable pavement they want, they will be allowed more flexibility.

## Costs:

Finding a specific cost for permeable pavement surfaces depend on many factors including soil type, the size gradient of rock underneath the pavement, the surface itself, and maintenance cost. Although all these factors seem daunting, many studies have shown that these surfaces are worth the investment in the long run. We strongly believe that these surfaces are more than a paved area. They are an investment that can benefit everyone in the community of Oshkosh. Not only will these surfaces benefit our community, we may also see reduced costs in other areas. The price of permeable pavement seems to fluctuate by site making it hard to put an exact number for any surfacing project. According to a study carried out at the University of California Davis, prices were found to range from approximately one dollar to roughly eleven dollars per square foot (Terhell et al, 2015). This data was split up into three different surfacing techniques: porous asphalt, pervious concrete, and concrete pavers. Porous asphalt cost 1.11 dollars per square foot. Pervious concrete cost 6.66 dollars per square foot. Lastly, concrete

pavers were the most expensive option at about 11.10 dollars per square foot. This study provides costs for construction and maintenance costs for a half acre parking lot. We recognize that this is a large parking surface, but it provides some numbers for both areas of cost. Also, these costs are accrued over a 25 year period. After summing costs of installation and maintenance, they found that the total cost of a permeable surface parking lot totalled out to \$306,706.62. The standard asphalt total cost came out to \$371,356.28 (Terhell et al, 2015). Costs for each type of pavement were broken down even further and can be observed in Figure 1 at the end of the report. Some important permeable pavement sections include: vacuum sweeping, restoring permeability, and refreshing the base. Standard pavements also have some important areas such as: crack sealing, sealcoating, stripping, patching, and lastly resurfacing (Terhell et al, 2015). Each type of surface accrues cost that the other does not. Figure 1 reveals that seal coating and replacing a surface increases the cost of a standard pavement over a 25 year period. In this case, maintenance of a permeable surface is also given. The research group estimated that over a 25 year period, a permeable pavement would require vacuum sweeping to occur 25 times at a cost of \$400.00 per sweep (Terhell et al, 2015). According to the Missouri Department of Transportation we found that the average price of a street sweeper is approximately \$258,221 (Missouri Department of Transportation Bid Tabulation of Request 3-080213 Street Sweepers, 2009). This average was found by taking the price of similar trucks from three different companies. Now this may seem like a large sum of money, but when compared to the cost of maintaining a standard surface it is minimal. Standard pavements require sealcoating and crack sealing which are costly. These stem from the freeze thaw action that occurs regularly in a standard pavement. Because of the high infiltration rate of permeable surfaces, water will hardly

ever, if at all, freeze in the permeable surface causing cracks to form. Over the twenty five year period the standard pavement would require cracks to be sealed 25 times and sealcoating would occur five times. At a cost of \$250.00 dollars per cracking sealing and \$20,000 per seal coat, the standard pavement acquires a cost of \$110,000 over the 25 year period (Terhell et al, 2015).

Among other costs included in Figure 1, it is obvious in this situation that permeable pavements will be cost effective in the long run. Not only did they give an approximation for cost, but they also provided a life span for each type of surface. Porous asphalt was found to have 17.5 years of life span, whereas pervious concrete had a longer life span of about 25 years. Lastly, concrete pavers are the most expensive option with the longest life span ranging from 25-30 years (Terhell et al, 2015). Dave Buch, President of PaveDrain, stated that his company has installed paver block surfaces over a decade ago that are still running smooth today without any repairs needed (Buch, pers comm, 2018). One thing to note about the cost of these surfaces is the fact that the cost is very site dependent. Soil types and size of rock grade in the underground chamber will be two main factors in the final cost of permeable pavements. One essential tool for choosing pavement surfaces is cost because it is usually the driving force in decision making. We believe that these surfaces will be worth the cost for the city and all residents going into the future.

## Benefits:

Although the cost of implementing these types of surfaces may seem expensive, they offer benefits to water quality, water runoff, and reduce the need for some other best management practices. Porous surfaces provide benefits in three different ways: environmental benefits, economic benefits, and social benefits. The environmental benefits of these systems are



well documented and have been proven to reduce pollution from chemicals found on most parking lot surfaces. A study carried out in 2008 by the University of New Hampshire had proven that porous pavements can be beneficial in a cold weather climate. New Hampshire is a great location because they normally have six months a year of subfreezing weather (Roseen, 2012). The study area was also large scale, a nine acre parking lot, unlike most studies or installations that remain small. At the end of this study, phosphorus levels fell but only partially (42 percent efficiency) and saw almost a complete removal of total suspended solids and zinc (Roseen, 2012). They did mention that nitrates and chlorides saw around zero change in reduction. This is typical for any water management system that is not a vegetated filtration system (Roseen, 2012). It is also important to note that these pavements can reduce peak water flows that runoff from impervious pavements. Over the five year study period from 2004-2008, peak flows were reduced by 90 percent (Roseen, 2012). Our group has encountered many questions in relation to the performance of these pavements in a cold weather climate. We believe that this is a misconception among many people who have questions about these systems. Research has found that these pavements perform well in a cold weather climate. We have found that places like Calgary, Canada, Burnsville, Minnesota, and the University of New Hampshire have implemented these pavements and reported that they work well through winter months. Research done by the University of New Hampshire revealed that even under significant frost penetration (71 cm), the pavements performed at a high rate and the pavement showed zero signs of structural damage (Roseen, 2012). Another report carried out by the University of California Davis provided results on the performance of these surfaces in relation to mean water runoff reduction. This would be very beneficial to the city of Oshkosh in hopes of reducing basement

flooding and other water runoff issues. UC Davis found that all surfaces performed extremely well when compared to standard pavements. All pervious pavements saw a reduction in runoff by approximately 98%. Regular asphalt or concrete surfaces saw a runoff reduction of only 32%. Knappenberger et. al., 2017, stated that, “Time-series analysis showed that peak flow mitigation of stormwater was considerably superior with permeable pavements in comparison with impervious pavement surfaces” (Knappenberger et al, 2017) These standard pavements have no benefits outside of runoff reduction whereas permeable pavements provide high quality infiltration rates. These high quality infiltration rates help to increase stormwater outflow. Throughout a study at Washington State University from 2011-2015, researchers found that 99.5% of storm water infiltrated through the surface year round (Knappenberger et al, 2017). By increasing infiltration rates within the City of Oshkosh, the amount of flooding within residential basements and streets should decrease.

Permeable pavements also have an added benefit of an economic savings in the long run. As we discussed in the previous section, porous pavements have lower maintenance costs over a 25 year period. They also provide more opportunities for savings by reducing the amount of spending on other best management practices. This would include, but not limited to, retention ponds, drainage basins, catch basins, and other biofilters. Figure 2 at the end of the report gives a more detailed looked at the cost savings porous pavements provide when used over other best management practices.

## Recommended Ordinance:

The City of Oshkosh currently has a Stormwater Management section in the City of Oshkosh municipal codes. Within these ordinances, Citywide Stormwater Management Plan and Ordinance Development touch on best management practices (BMP) during construction and post-construction. These BMPs include but are not limited to retention ponds, catch basins, bioswales, filtration strips and permeable pavements. Although barely mentioned, these BMPs need to be expanded on within the ordinances. We recommend adding Article VII, titled Best Management Practices, in the Stormwater Management section. Within this new article, we want to focus attention on permeable pavement in parking lots. Our proposal seeks to address many of the challenges that come with stormwater management by requiring some permeable surface coverage in new parking lots that are built over the minimum parking requirements.

In our recommended ordinance, any newly constructed off-street parking area, designed to accommodate five or more vehicles shall comply with the permeable surface requirements set forth. Also, any parking lots that are going to be reconstructed or added too will require permeable pavement. Any off-street parking area that exceeds the minimum parking requirements must implement permeable surfaces in at least 20% of the total area. We would like these areas to be focused on sections of parking lots that are low lying, or in areas where runoff will travel the most. These areas will allow for the best infiltration of runoff.

## Stakeholders:

### PaveDrain - Doug Buch (President of PaveDrain)

One of the key, primary stakeholders that has played a crucial role in the implementation of permeable pavers throughout most of Midwestern U.S. has been PaveDrain. PaveDrain is a permeable pavement company based out of Milwaukee, WI who have already finished projects within the city of Oshkosh. They have worked on the Downtown Oshkosh YMCA, the Oshkosh Fire Station #16, the Oshkosh Senior Center, and the Bucks Minor League Herd Arena.

To understand PaveDrain's thoughts on Oshkosh's implementation and promotion of permeable pavement, we decided to interview the president of PaveDrain, Doug Buch. After finishing our interview with Mr. Buch, it was apparent to us that he had a true passion for sustainability and permeable pavement. He emphasized how not only the PaveDrain block allows for better infiltration of stormwater but also how the filtered water that passes through becomes incredibly cleaner. This clean water could then be either allowed to infiltrate into the groundwater or can be collected and used for drinking water, watering crops, and everything in between. The PaveDrain system also helps to eliminate unnecessary stormwater infrastructure costs such as detention ponds and basins. Mr. Buch clearly emphasized how the PaveDrain system is "green" infrastructure that helps to reduce the amount of "gray" infrastructure. By implementing permeable pavers such as the PaveDrain, areas reduce runoff issues that are common with impervious surfaces like asphalt and concrete.

One of the biggest concerns about implementing permeable pavement within Oshkosh is the maintenance required. When interviewing, Mr. Buch we plainly asked what his thoughts were on maintenance in regards to permeable pavement like his PaveDrain system. He made it clear that maintenance heavily relies on where the permeable pavement is implemented. For instance, city streets collect the most amount of debris and degradation in comparison to swimming pool decks or walkways. He stated that a city street with a 20:1 run on ratio (20 square feet of impervious surface running into 1 square feet of PaveDrain) will probably need to be cleaned 2-4 times a year. But, areas with little traffic and pressure may never need to be maintained. In regards to maintenance of parking lots, he claimed it should only need to be cleaned every 4-5 years. Although the amount of maintenance required is very site dependent, Mr. Buch claimed that projects that have been finished over a decade ago are still going strong. We also asked him how well the PaveDrain blocks handle winter weather. He claimed that the blocks handle the snow and ice very well and reduce the need for deicing road salts. He did however mention that the blocks can become scraped and damaged by steel snow plows but the blocks will never be removed or flipped out like some other smaller permeable pavers.

Another key factor in regards to the implementation of permeable pavers like the PaveDrain is cost. According to Mr. Buch, installation of the PaveDrain blocks average \$11.00 - \$13.00 per square foot. These costs include the placement of the blocks, shipment of product to jobsite, filter layers, and complete installation. These prices are quite a bit higher than other permeable pavement options. When it comes to continuing the installation and promotion of permeable pavements within Oshkosh, we believe the biggest concern and hurdle is going to be the costs. It is going to be very important to emphasize how installing permeable pavers will

overall reduce costs of other stormwater management practices as well as runoff and erosion issues. As stated earlier, Mr. Buch believes that permeable pavers allows for the reduction of excess costs for stormwater infrastructure.

Towards the end of our interview with Mr. Buch, we asked him what his thoughts were on how willing and open most companies and businesses were to implementing eco-friendly and sustainable practices like permeable pavement. He said that although the trend is on the incline for environmental consciousness, some businesses, especially in the civil engineering community, have needed extra guidance and influencing in regards to “green technologies”. He did however say that the City of Oshkosh is already heavily devoted to “green technologies” and the promotion of sustainable practices. Mr. Buch provided great insight into the permeable pavement industry. His perspectives helped our group understand where someone directly associated with permeable pavement lies in regards to the promotion of permeable pavement within Oshkosh.

## Omni Associates (Civil Engineer) - Robert Givens

After running into a roadblock with contacting a contracting company we were referred to Mr. Givens as another possible stakeholder. Mr. Givens is a Civil Engineer for Omni Associates. Talking to him gave our group the chance to discuss barriers for permeable surfaces with someone who had managed projects pertaining to large scale implementation of permeable surfaces. He discussed with us how municipalities and private sector organizations face different barriers and reasons for the use of permeable surfaces. Some of his large scale work has been

done within Oshkosh where he helped design and implement over a mile of porous surface at the EAA sight in Oshkosh.

Most of the questions directed toward Givens related to the benefits related these surfaces when compared to other water management practices. When asked about whether or not porous surfaces are worth the initial increased cost he stressed that those decisions should be made based on how valuable the land is. He talked about situations like if parking lots cannot afford to lose space for retention ponds or bio swales, they would implement permeable surfaces. If that land is more valuable as a parking lot you would use porous pavement to put that water retention underground. He also addressed the idea that porous surfaces cannot withstand the weather in the midwest. He had told me that the weather is not a large factor in the performance of these products. It is very very unlikely that frost-thaw action will cause structural damage to the surface. The layer of porous rock holds air and when the surface is placed over this rock layer a natural insulation is created. This is what helps to keep water flowing through the surface so ponding does not occur.

The other half of the questions were directed around some of the barriers and obstacles that come with permeable surfaces. First, Givens stated the increase in cost is one of the largest factors in choosing other stormwater management practices. Again, he reiterated that the price is worth it if an individual thinks the land is valuable enough for the use of these surfaces. He also talked about how maintenance can be tedious and the labor intensive installation processes. Although installation is becoming slightly less of a problem because of automated installation, these are focused on small scale projects. Lastly, clogging is a major fear for porous surfaces. Landscaping adjacent to these surfaces needs to be watched closely. Clean up must be perfect or

dirt from landscaping could clog the surface. Sanding areas for traction during the winter is not allowed because of the high risk of clogging. One benefit is the reduction of sand and salt on these surfaces, which could cut down runoff of those substances. We also asked Mr. Givens if permeable surfaces have issues with snow plows. He had said that these surfaces are very similar to a regular pavement so fear of breaking it with a snow plow is virtually impossible. Out of the three types of porous surfaces, permeable pavers are the only type that may chip from plowing, but that is also very unlikely.

## Poblocki Paving - Dan Van Bommel

Poblocki Paving is a paving company based out of the Milwaukee and Madison area. They perform paving jobs ranging from standard asphalt and concrete as well as porous asphalt and permeable pavers. Poblocki Paving made a name for themselves when they implemented underground stormwater harvesting systems that collected rainfall in three large tanks. Over 145,000 gallons of water can be stored in these tanks, where it can then be used for paving operations. Poblocki Paving also has experience installing porous asphalt and pavers like the PaveDrain block systems. Dan stated that Poblocki Paving is one of the largest installers of PaveDrain within Wisconsin.

When asking Dan what his thoughts were on permeable pavement, he stated that from his experience permeable pavement works but has some downsides. He mentioned how some owners neglect the permeable pavement and do not maintain them correctly. When this happens the pavement can become clogged and start to buckle under the misuse. Also, he found that on rare occasions the PaveDrain blocks have a hard time handling the ice during winters, whereas



porous asphalt handled it well. Although the PaveDrain struggles sometimes with the winter weather, it is important to understand it handles the weather better than impervious concrete or asphalt. Therefore, PaveDrain still remains the viable option in terms of water infiltration during the majority of the year.

When concluding the interview with Dan, we asked him whether he thinks permeable pavement is a viable option within Oshkosh. He stated that he is a big advocate for permeable pavement but wants us to understand some of the downsides. Initial costs can dissuade some businesses from wanting permeable pavement and the lack of maintenance once installed seem to be the biggest issues. If we can address these issues within Oshkosh, permeable pavement will generally help in the reduction of runoff and increase filtration rates of rainfall. Dan provided great insight into the paving industry and his support for permeable pavement demonstrates how effective it can be. Making sure businesses and owners know the end game cost benefits of permeable pavement is key. Along with this, it is important to make sure they are educated on maintaining these permeable pavements so that clogging and other issues are avoided.

## Private Citizen - Misty McPhee

One secondary stakeholder that we interviewed was Misty McPhee, a private resident of the City of Oshkosh. We felt getting a private citizens perspective would be beneficial for our recommendation of using more permeable surfaces in Oshkosh. As someone who lives in Oshkosh, she would be directly and indirectly affected by the implementation of more permeable surfaces. We interviewed her in hopes of seeing how citizens perceive permeable pavements.

During the interview, we asked if she had ever considered using permeable surfaces on her own property. She informed us that she does have plans to use them during the construction of her new house. Permeable pavement surfaces typically come at a higher price than your standard pavements. However, Misty told us that she is willing to pay more for permeable surfaces because she cares. To her, paying more for permeable pavement may come with a short term cost but the long term benefits are huge and really do benefit the community as a whole. Even though not all citizens may be willing to make this financial commitment, this shows there are people out there willing to take on that extra cost because they know how beneficial permeable pavement surfaces can be.

There are incentives that the City of Oshkosh has that encourages the use of permeable pavement surfaces. Oshkosh has a permeable pavement credit policy that rewards citizens for implementing them and reducing stormwater flows and pollution. Misty was not aware of this credit policy and she felt the city could do more to promote it. She did however acknowledge that part of the responsibility falls on the citizen to be informed. We mostly talked about the use of permeable surfaces on residential properties but did also discuss how businesses play a role in using these surfaces as well.

We were curious what citizens of the city expected from the businesses that are located in Oshkosh. We asked if businesses that call Oshkosh “home” have an obligation to the city and its people to implement permeable surfaces for the greater good? She said that she believes they do, especially the businesses located along the river. She felt that a lot of them were here because of the river and because of that they have a responsibility to keep the river clean. Overall, Misty felt that the implementation of permeable pavements within Oshkosh parking lots is a great idea.

## Private Citizen - Anonymous

Another secondary stakeholder that was interviewed was a private landowner who wished to remain anonymous. We wanted to get multiple private citizens in an attempt to strengthen our argument for the use of permeable pavements in the City of Oshkosh. This individual is someone yet again that would be directly affected by the use of permeable pavements. This private citizen had a slightly different opinion of permeable pavements than our other citizen interview which we believe is important because there are obviously going to be varying opinions on this topic.

During the interview we asked if she had ever considered using permeable surfaces on her own property. It turns out she was not familiar with the topic of permeable pavements at all, so we took it upon ourselves to explain what they are and purposes they serve. We informed her that permeable pavement surfaces typically come at a higher price than your standard pavement. Once we told her this she was quick to shoot down the idea of ever using permeable surfaces on her own property. We informed her of the benefits that come with permeable surfaces but she had no interest in paying more upfront.

In this interview we once again brought up the City of Oshkosh's incentive program for permeable surfaces. Oshkosh has a permeable pavement credit policy that rewards citizens for implementing them and reducing stormwater flows and pollution. This private citizen was not aware of the policy which was not surprising since she was already unfamiliar with permeable

pavement surfaces. After realizing she was not interested in the use of permeable surfaces on her residential property, we wanted to see how she felt about businesses implementing them more.

We asked her the same question regarding permeable pavement use by business as we did our other private citizen. We asked if businesses that call Oshkosh “home” have an obligation to the city and its people to implement permeable surfaces for the greater good? She said that if businesses really wanted to boost their public relations, then implementing permeable surfaces could be a good way to do that. She felt that it could show the businesses are also thinking about the citizens of Oshkosh and not just themselves. However, she left us with saying that even though implementing more permeable surfaces could be a good thing, she doesn't feel like businesses should have to do this and that it should be their choice.

## University of Wisconsin Oshkosh Grounds

### Manager - Lisa Mick

We chose to interview Lisa Mick as one of our stakeholders because of her role as the Grounds Manager for University of Wisconsin Oshkosh. The University prides itself on its efforts to promote sustainability and eco-friendly practices, making it a good candidate for the exploration of porous pavements. Being able to discuss some questions related to porous pavements with the Grounds Manager gave us a perspective of a state run organization and not a “for profit” business. The first question that I had asked Lisa Mick was, what was the major barrier for the University to use porous pavements as part of sustainability plans? Mick had said that cost was the main factor for porous pavements for campus structures. This drew a follow up

question on how this barrier could be overcome. Mick had stated that the school budget would need a major overhaul. Although the University has its hands tied financially, it may be able to provide another form of aid to porous pavements.

Lisa Mick had discussed how education would be an integral factor for the adoption of new technologies like green infrastructure and porous pavements. Education will be beneficial for the green infrastructure movement. It gives people the chance to make their own informed decisions without having the city enforce laws or penalties to private residents who do not meet city standards for water run off. Mick had stated that older generations are more reluctant to new ideas because they simply may not know about them. Public education would give residents the chance to get detailed explanations about the upside to green infrastructure such as porous pavements, bioswales, or rain gardens. She believes that most people want to do what is right for the earth, “I think that people want to do what is right and best for this earth but don't necessarily want to spend hours researching how to do it” (Mick, pers comm., 2018).

The big takeaway from this interview was the importance of education as a tool for the advancement of green infrastructures as a means to reduce water runoff and point source pollution. With cost being a major barrier, education may be a cost effective way justify use of green infrastructures in the future. This could also get more private residents to use some of these techniques on their own properties. This could bring new businesses to the area to accommodate the need for alternative building practices. Along with this, building the relationship between private residents and the city in their efforts to adopt more eco-friendly practices is crucial. Our group believes that a culture for sustainability should be created and facilitated by the city. The

key to long term sustainability within Oshkosh, depends on public education and understanding the benefits proper adoption of new practices can be going into the future.

## Director of Public Works - James Rabe

James Rabe is the director of Public Works in Oshkosh and was able to shed some light on the issues regarding stormwater management in Oshkosh. After asking if Oshkosh has any issues regarding stormwater infiltration or inflow he said yes, there are several issues. He mentioned that the sewer systems in Oshkosh have been taking on too much water which has damaged the system leading to leaks. In result, Oshkosh has seen property damages from flooding and basement damage. After identifying the problem, we asked him about how open Oshkosh is to adopting green infrastructure. James seemed pleased with how Oshkosh has used permeable pavement in new parking lot projects. He mentioned that the senior center parking lot reconstruction used PaveDrain's block system. Since then Oshkosh has used PaveDrain on three other separate projects. Afterwards, the downtown YMCA and the new Milwaukee Herd arena in Oshkosh decided to construct their parking lots with stormwater management in mind. James also mentioned that adding a permeable system takes some land surveying and each site can change. In addition, Oshkosh has clay soils which is not as permeable as normal soils. This can possibly bring up issues within these permeable systems. James believes that Oshkosh can serve as a platform in using these new technologies and that others will jump on board. After talking about some of the logistics, we talked with him about how he would convince people that green technology is an investment that would see return. Rabe stated, "Leading by example and

showing how it can be done” was crucial for others learning (Rabe, pers comm., 2018). More specifically, he talked about educating them on when and where these types of practices can be utilized. The city buildings using permeable pavements have opened the door to more collaboration. James mentioned that the Engineering division started working with the EAA in order to educate themselves on stormwater management. He also mentioned that the EAA had an interesting permeable concrete storage system that could see future use. On top of that, the city has used some of EAA’s information to implement where they see fit. After talking with James Rabe, we gave him a chance to voice his opinion on why people don’t want to implement green technologies besides the cost. He believes the biggest issue is the knowledge or lack thereof. “Even if you have a perfectly designed system, if the end user (property owner) does not have the desire, willingness, or knowledge on how to properly operate and maintain the systems, they will fail” (Rabe, pers comm., 2018). Time has become so important in our world today and efforts to understand and utilize these practices are not out there yet. The city of Oshkosh moving forward will continue to use them when they can, but it's up to citizens to do some research.

## John Flannigan Private Snow Removal

John Flannigan is the founder of a private snow removal service called the Grounds Guys of Appleton and Oshkosh. They service all types of properties including condos, retirement homes and commercial lots. John was unfamiliar with permeable pavements and as far as he knew did not plow any lots with permeable pavements. When I asked him about permeable pavements he did not follow and asked me what they were. After explaining what they were, he

understood and had heard of the concept before. He was very interested in learning what they were and imagined that if he were to come across permeable pavements he would find a way to plow the lot. In addition to plowing in the winter, John leads a team in garbage pick up, pot watering and mulching for the city. He has come across many bioswales and green practices within parking lots. John is also a homeowner in Oshkosh and when I asked him about stormwater management he knew some basic information about the cities ordinances on stormwater management. In order to make permeable pavements a more viable option, an education program and outreach to citizens and workers would be largely beneficial. John agreed and was very interested in learning how permeable pavements could maximize space and fix the parking issue in Oshkosh. John agreed that there was parking issues in Oshkosh and was more interested in how permeable pavements could increase lot size because stormwater can infiltrate the ground with permeable pavements. Implementing permeable pavements would count towards the city ordinance of pervious surfaces and increase lot sizes for business and events. He believed that this would benefit the citizens of Oshkosh.

## Benchmarking/Case Studies:

### Calgary, Alberta, Canada:

Calgary, a city populating over 1,200,000 people within the providence of Alberta, Canada, has done a lot in regards to permeable pavement. Calgary has seen a major rise in population over the last couple decades and because of this the city recognized it's need for better stormwater management. Within the last decade, Calgary has implemented a Low Impact



Development (LID) protocol. This development plan promotes the use of stormwater management practices such as permeable pavement (Vanderstoop, 2007). Along with the development plan, Calgary has design guidelines provided by a consulting engineering company, Tetra Tech Inc. This company provided Calgary with guidelines on how permeable pavement can be implemented within the city (Tetra Tech, 2015). A similar development plan was completed for the City of Oshkosh by Earth Tech AECOM in 2008 (Earth Tech AECOM, 2008). This guideline for a citywide stormwater management plan and ordinance development discusses possible use of BMPs, including permeable pavements, within the City of Oshkosh.

Although this city has a population well above Oshkosh, it is important to see how other cities in similar climates act on permeable pavement. As stated earlier, one of the biggest questions when determining if permeable pavement is a viable option within Oshkosh is whether the pavement can handle the large amount of snowfall and winter weather. Both Calgary and Oshkosh lie within similar latitudes and receive similar amounts of snow and rainfall. They both also have four seasons. Oshkosh receives about 30 inches of rain per year and about 36 inches of snowfall (Oshkosh, Wisconsin - Climate, n.d.). In comparison, Calgary receives about 13 inches of rain per year and about 50 inches of snowfall (Pelmorex Inc. n.d.). Calgary has taken the initiative to implement permeable pavement within its city to better address its stormwater issues. Oshkosh should take a similar approach and promote the use of permeable pavement.

# Minneapolis, Minnesota

Minneapolis is a large city that has a very similar climate to that of Oshkosh. Much like Calgary, we wanted to show that there are other places with similar climates as Oshkosh's that are taking initiative when it comes to implementing permeable surfaces. However, just because they are hopping on board now does not mean that they have always supported the use of permeable surfaces. In fact, up until 2010 the City of Minneapolis did not mention permeable surfaces in their ordinance and they even went as far as to not allow them at all. Permeable surfaces were not permitted to be used on residential or non-residential parking surfaces.

Then in 2010 city officials amended Title 20, Chapter 541 of the Minneapolis Code of Ordinances relating to Zoning Code: Off-Street Parking and Loading. This amendment now allows citizens and businesses to use permeable pavement at their discretion as long as they are capable of carrying a wheel load of 4,000 pounds (Gordon, 2010). Some of the materials to be used listed in the ordinance are pervious asphalt, pervious concrete, and permeable pavers among others. In this ordinance it is also mandatory that these permeable surfaces be installed and maintained per industry and city standards (Gordon, 2010). Minneapolis is a great example of a city that saw an opportunity to bring best management practices into their ordinances. It would be a good idea for the City of Oshkosh to follow in their footsteps and mention permeable surfaces by name in their ordinance.

# Madison, Wisconsin Permeable Paver Test Plot Project

The permeable paver project at the Sycamore Dog Park in Madison, Wisconsin is a great example of a small scale implementation project for permeable pavements. This park had engineers implement best management practices in order to learn more about permeable pavements. At this project site, the researchers set up three plots of land next to each other, all using different parking materials. The three materials used were permeable asphalt, porous concrete and permeable pavers. Each system was set up with a collection system designed to account for inflow, outflow, and overflow. In addition, the engineers decided to specifically look at total suspended solids and salt. Salt pollution is a challenge in Wisconsin because of the climate creating icy roads. One of the lead engineers working on the permeable surfaces project had this to say, “Permeable pavers can significantly reduce the amount of salt that ends up in the water supply – some say by up to 70%.” (Bannerman, 2014). This study is currently underway and are waiting for 21 storm events in order to receive sufficient data. This project has led the way to new innovative ideas and technology used for stormwater management. The Wisconsin DNR has been changing the regulations on permeable pavements consistently and use this test site to determine new regulations. Madison attracts people to permeable pavements by making parking space a premium. In addition, other BMPs like retention and detention ponds can be a potential liability where children and parents are present. Making permeable pavers the new norm is something they hope to accomplish because it could increase the amount of parking stalls throughout the city. They believe that permeable pavements can increase parking and

ground water recharge. A diagram showing more information regarding this study can be found in (Figure 3) at the end of this paper.

## Burnsville, Minnesota

Burnsville is a city located in Central Minnesota that provided a great opportunity to see what another city is doing to overcome their stormwater management issues. Burnsville is similar in size to the City of Oshkosh by size and population. This made it more feasible to investigate how they plan to overcome water management issues. They also face some similar water quality and water runoff related issues and have used many different solutions to fix their problems. The city relies on their four core strategies to combat water quality and filtration issues. These four strategies aim to improve water quality and infiltration, sustainable groundwater use, maintenance of stormwater management systems, and stewardship and education. This city also has several riverways, ponds, and lakes just like the City of Oshkosh. The City of Burnsville states an entire plan for each strategy. Each strategy is broken down to provide a description of the activity that will be initiated, what department will lead the projects, estimated implementation and annual costs, and the potential benefits. We believe that this can be very beneficial to the City Oshkosh as a guideline moving forward to implement more sustainable practices. Burnsville plans to implement a strategy to set new lawn design standards to require restoration of soil permeability after construction activity (Burnsvilles Sustainability guide, 2007). This project would be lead by the planning and natural resources department and has potential benefits of reducing flooding, reducing the reliance on sewer systems, and

protecting water quality (Burnsville Sustainability Guide, 2007). One of Burnsville's strategies to combat groundwater supply is to retrofit city-owned sprinkler systems with rain sensors. This would cost the City roughly 50 - 100 dollars per sprinkler and this aims to reduce water use and water pumping (Burnsville Sustainability Guide, 2007). One of the most important areas for both Oshkosh and Burnsville to create a sustainable culture is educating the local citizens. The City of Burnsville has several great ideas pertaining to education. We recommend that we follow up on some of these education strategies. Two ideas that we believe would be successful in Oshkosh would be to start an educational bulletin and provide educational demonstrations at city facilities. If you would like to refer to the Burnsville Sustainability Guide we will provide a link within the citation section of this report. Moving forward with plans like these we recommend that The City of Oshkosh pursues as many funding grants as possible to carry out some of these programs.

## Significance for Sustainability:

The recommended ordinance should help the city of Oshkosh address all three pillars of sustainability: environment, economy, society. The city has already dedicated itself to becoming more sustainable and the implementation of permeable pavement within parking lots will only help in the continuation of Oshkosh becoming more environmentally friendly. By requiring newly constructed parking lots to have a specific amount of permeable pavement, these parking lots will help in the reduction of runoff and filter out pollutants. This will help the city address some of its environmental issues like runoff and erosion. Along with addressing environmental issues, permeable pavement will help Oshkosh decrease costs in other stormwater mitigation construction such as detention ponds, bioswales, and retention basins. Although the initial

installation costs of permeable pavement is generally higher than poured asphalt and concrete, in the long run the city will save because it will not have to put as much money into erosion control, runoff issues, and sewer system failures. Not only will the city address environmental and economic issues, the implementation of permeable pavement will also benefit the community of Oshkosh and its citizens. The permeable pavement will reduce the flooding issues we see so often within Oshkosh. Basement and street flooding are known issues within Oshkosh, and permeable pavement will help mitigate some of these excess runoff issues.

## Summary:

Stormwater management has become an issue for Oshkosh in all three categories of sustainability. The first negative issue Oshkosh faces is the environmental impact of stormwater runoff. Impervious pavements have caused high volumes of runoffs that impact our water systems. Because Oshkosh is surrounded by rivers and one of the biggest inland lakes, stormwater management needs to change. The next focal point is the social pillar, where we are seeing stormwater volume become an issue for our sewer systems. As discussed earlier, Oshkosh's sewer systems are having a difficult time keeping up with rain events. This can lead to many issues including flooded basements, parks and streets. The final point to focus on is the economic pillar. By implementing more permeable pavement within Oshkosh, stormwater runoff would decrease in these areas. This would then lead to an increase in property values, cleaner lakes and rivers, and decreased floodings.. Permeable pavements are an investment designed to impact all three pillars for a more sustainable city. Oshkosh has already implemented some permeable pavements using PaveDrain, showing that stormwater management is a focal point for

the city. Our recommendation of requiring parking lots to use 20% permeable pavements will have the best results for stormwater management. Permeable pavements ensure environmental stability and water quality by letting stormwater filter naturally through the soil to recharge groundwater. Allowing stormwater to recharge groundwater means less stress on sewer systems and less flooding. As presented, permeable pavements are an investment that will be cost effective within 20 years. Space is incredibly important in today's world and permeable pavements can maximize the value of a parking lot. Implementing permeable pavements reduces extra space needed for other BMPs such as detention ponds and catch basins. Permeable pavement is the future of stormwater management and can help the City of Oshkosh reach its runoff issues.

## Figures:

Figure 1:

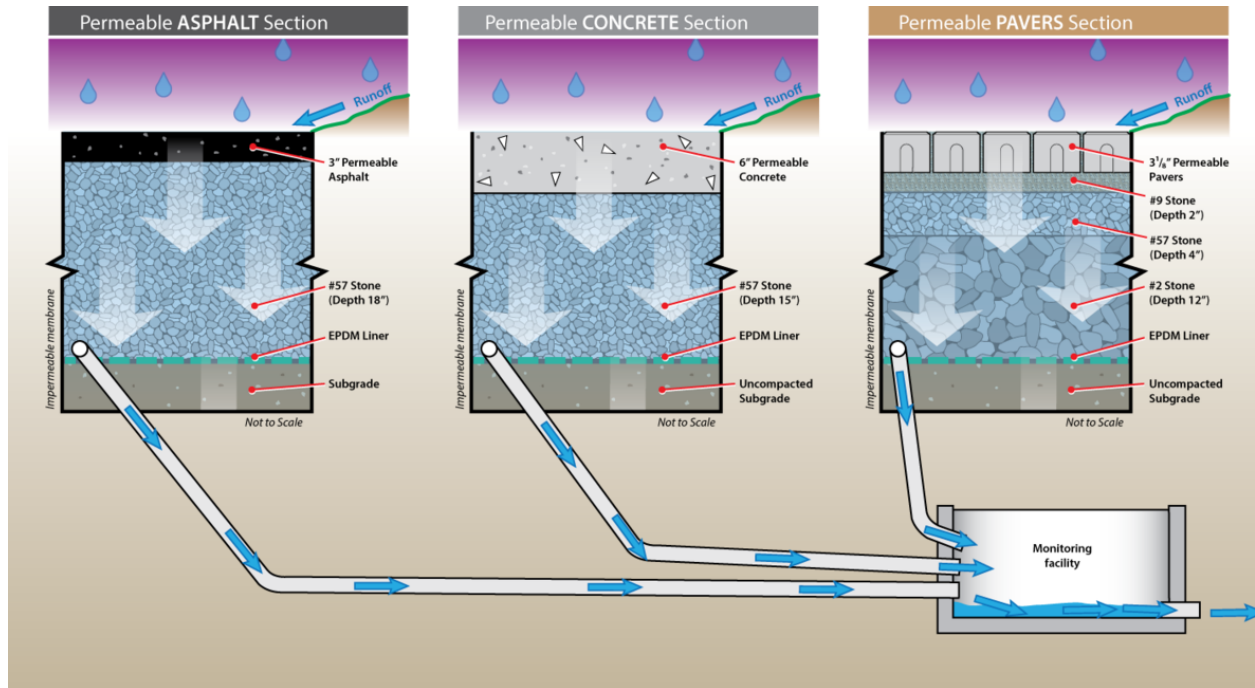
BMP PRACTICE	AVG CONSTRUCTION COST		Annual Cost	
	2007	2015	2007	2015
Wet Basin	\$557,726.00	\$763,286.54	\$21,206.00	\$29,021.88
Multi-chambered treatment train	\$342,806.00	\$469,153.68	\$7,147.00	\$9,781.16
Oil-Water Separator	\$159,583.00	\$218,400.35	no data	no data
Delware Sand Filter	\$286,250.00	\$391,752.89	\$2,497.00	\$3,417.32
Storm-Filter	\$379,795.00	\$519,775.68	no data	no data
Austni Sand Filter-Concrete	\$301,989.00	\$413,292.80	\$2,553.00	\$3,493.96
Biofiltration Swale	\$71,913.00	\$98,417.91	\$4,124.00	\$5,643.98
Biofiltration Strip	\$78,404.00	\$107,301.29	\$671.00	\$918.31
Infiltration Trench	\$181,784.00	\$248,783.96	\$1,982.00	\$2,712.50
Extended Detention Basin	\$214,847.00	\$294,032.95	\$4,999.00	\$6,841.48
Drain Inlet Insert	\$192,923.00	\$264,028.45	\$3,728.00	\$5,102.03
Drain Inlet Insert	\$460.00	\$629.54	no data	no data
<b>Total</b>	<b>\$2,768,480.00</b>	<b>\$3,788,856.04</b>	<b>\$48,907.00</b>	<b>\$66,932.61</b>

Figure 2:

BMP PRACTICE	AVG CONSTRUCTION COST		Annual Cost	
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Figure 3:





(Mcphee, pers.comm, Date) Month Year

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