

***The Reduction of Run-Off Water with an Eco-Friendly Walkway***

***By***

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## **Abstract**

Water run-off can erode slopes and cause flooding in undesirable locations. The objective of this project is to reduce run-off water from hardscaping and to allow the ground to return to a more natural state. With the use of permeable pavers we achieve this landscape goal. Normal pavers or concrete displace water to an unnatural location. This can lead to the soil becoming too saturated with water and harm nearby plant life. Permeable pavers allow the water to fall through the expanded joints and continue percolating down. The use of different size rock layers allow for fast infiltration and percolation of water. LED lights were installed to compliment the walkway. Through different experiments, we conclude that permeable pavers are a success in reduction of run-off water.



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The focus for this senior project is to be environmentally friendly and to reduce the run-off water from a sloped driveway in a residential landscape. The use of permeable pavers and LED lights will be used to accomplish this landscaping goal in the construction of a 70 ft. walkway. This walkway will

complete the connection of a residential driveway to the adjacent house. Curving around the palm trees will require precision cutting. This makes the installation much more difficult compared to a straight walkway. The decision to use permeable pavers in this project has many upsides. Gaining points in Leadership in Energy & Environmental Design or (LEED) can be very beneficial.

There are many different options to choose from when constructing a walkway. A concrete pathway is a quick and permanent solution, but fails to reduce run-off. This route may lead to multiple cracks in the future and gives less detail to an area that holds potential. Gravel pathways can give a natural look. They are less expensive, but require additional maintenance and replenishment year after year. Construction with the use of permeable pavers will rule out the negative key points from other walkway options and will focus in returning the site to a pre-construction phase. (Carlsen, [The Family Handyman Magazine](#), June 1992) The goal is constructing a walkway that will last for decades without the need of major maintenance, along with reducing water run-off. In doing this, we will create an eco-friendly environment that can be enjoyed by people. The pavers can increase the value of the property, while being functional and sustainable to the surrounding environment. The placement of the LED lights along the walkway will be the final touch in illuminating the pathways design after dusk. LED lights have a

half life of a decade depending on how frequently the lights are in operation.

(Ewing Irrigation Co, Spring 2009) The LED lights will be placed alternately on the left and right side of the pavers.

The whole premise around permeable pavers is to allow the fast dispersion of water underground rather than having water runoff issues. "If the storage capacity and treatment rate available is less than the runoff volume, the excess runoff volume overflows uncontrolled to the receiving water" (James, Williams 2009). Permeable pavers are a great option to consider for water placement. For this project, a walkway will be used but if permeable pavers were installed in a driveway the effect would be greater. Permeable pavers are a combination of larger paver joints size, to ensure that a larger percent of water makes it below ground. Smaller size pea gravel will be used to catch and release the water down into the medium sized rocks. The depth of the rock layers can vary, but the deeper the layer is the better the water holding capacity. This allows the water to go back and treat the soil to its original form.

Creating walkways, driveways and roads out of permeable pavers allows for the natural flow of water to happen. This is one way to gain LEED® credits for a green building certification. Energy saving, water efficiency and CO2 emissions are all other ways to gain credit. "Developed by the U.S. Green Building Council, LEED® provides building owners and operators a concise framework for identifying and implementing practical and measurable green

building design, construction, operations and maintenance solutions” (An Introduction to LEED®, 18 Feb. 2010 ). If your business or home gets LEED ® certified, then you might be able to get a tax reduction or

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tax credit. In addition, you will save money each month on utilities. The scale is out of 100 points and there is an additional 10 points for regional areas.

Four points would be awarded for this project, which include water runoff, energy efficiency, using nearby material and using drought tolerant landscaping. Additional points can be gained such as not disturbing the nearby soil. But of course, this is just a percentage of what one needs to be certified. Choosing smarter material and how you recycle the old reduces our impact on the earth. Many large businesses such as Google and IBM already have million dollar energy saving appliances. (U.S. Green Building Council) Not only is it good for the earth, but we save money on water and energy bills.

The supplier for the euro-pavers will be Air-Vol, Block located in San Luis Obispo, Ca. Air-Vol Block was informative and helpful when I selected the materials, which included 250 sq. ft. of euro-permeable pavers, 2 pallets of pea gravel and 2 pallets of medium sized granite for the base. A big straw hat was also deemed necessary for the job at hand. Arranging for the materials to be

delivered was also an expenditure that needed to be noted. From the visit, I learned that with permeable pavers you can't put edging around the permeable pavers because of the joints size around the perimeter (Gary Abney, 2009). For edging, one would have to pour a concrete edging around the permeable pavers or install river rocks to act as the edging.

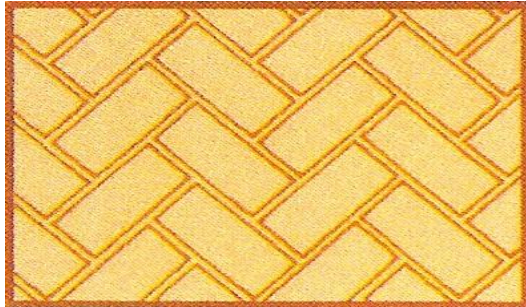
The sales associate showed us an experiment where water was flowing down and percolating onto permeable pavers in a tank. A pump was placed at the bottom of the tank and then pumped water through a PVC pipe upon the permeable pavers. The pavers were placed

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upon a 2" level pea gravel bed followed by a 4"-6" medium sized granite rock. The sprayers were placed strategically to show how rain would actually fall. There was a control valve that let the user turn it on or off. When turned to the off position, after being on for more than a minute, there was no surface water visible. The example showed proficiently how permeable pavers would actually work.

Choosing the right paver pattern to match the property's look can make it delightful to look at each day. After deciding to go with the "I" pattern, which is how the pavers are arranged, we placed the order. Choosing a certain pattern such as Herringbone or the "I" pattern will determine how many small or large pavers you will need. The key to installing the pavers is to lay down strings

to show your 90 degree angle. This will ensure you have a straight pattern without any drifting.



Herringbone Pattern



I Pattern

## Experiment

The construction of two experimental paver examples with constant water flow will show the stability and purpose of choosing permeable pavers before the actual pathway is constructed. A model construction of the pavers in a glass tank will be experiment 1. This beginning approach of the installation will provide a side view observation of the layers underneath the pavers and if they can sustain water flow based on their positioning. For example, experiment 1 will measure how fast 1 gal of water will percolate with the permeable pavers by



using 2" pea gravel and 4" granite rock. This experiment will have the pavers interlocking and will show how the different pressures of water downfall will dissipate within the gravel. Experiment 2 will be the same as Experiment 1, but it will be a sample of the pavers in the actual ground area outside. This experiment will illustrate what the pavers will actually look like in the ground once the basic layers of gravel are first installed. Experiment 2 will be very beneficial, because it will show the problematic issues that can be addressed and avoided later on during the final construction.



*Permeable vs. non-permeable*

*pavers*

## **Materials List**

*The medium sized rocks and the pea gravel were obtained from the final project materials.*

1.  $\frac{3}{4}$  PVC pipe = \$ 6
2. 7- 90 degree elbows. = \$ 6
3. "Laguna 2" pump. = \$ 42
4. Fish Tank = \$ 20
5. Flex tube= \$ 7
6. Medium sized crushed granite= \$ 80
7. Pea gravel= \$ 74
8. Permeable pavers \$ 1.50 sq. ft x 470 sq. ft = \$ 705
9. Concrete sealer = \$ 30

For the first attempt I used a flex tube that I initially thought would allow more water through. This only diminished the flow pressure, new tubing was needed. This is when I went with the  $\frac{3}{4}$ " PVC pipe. The pipe would come up and divided into 3 separate rows. Each row had  $\frac{1}{8}$ " holes drilled 1" apart. The idea is to get the most surface area coverage as possible. This will simulate rain fall. I installed a 2" collector reservoir that was to collect water from the whole length of the tank. A control valve was installed so I could cut off the water flow. There was some extra detail needed to connect the water reservoir to the pump. A special connection was made to fix the problem.

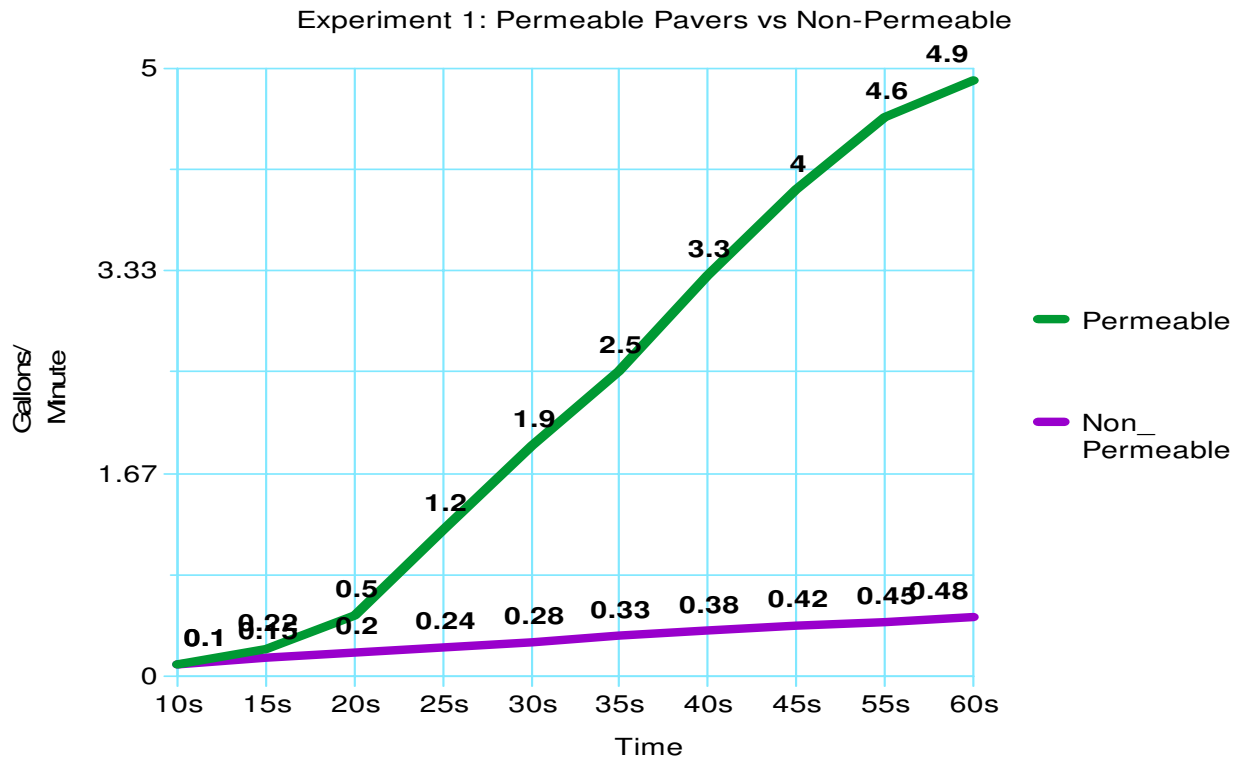
It took 5 hours to completely construct the entire experiment. I predicted the tank could handle 3.5 gallons per minute. The water replicated the actual rain water and the glass tank revealed the water flowing through the gravel layers. The result was no sign of water

accumulation for the permeable pavers. The non-permeable pavers could only withstand .5 gallons per minute. There is a 3 gallon per minute advantage when using permeable pavers. The experiment provided a better perspective of what the installation of the paver's consisted of and how it would reduce run-off.



Experiment 1 Permeable

pavers



Experiment 2 was accomplished by digging a 2' x 4' square into the ground near where the paver walkway will be put in. This will show almost identically how the pavers will look and work once installed. The materials used were the same as the ones in the walkway. The ground was compacted as much as possible using a 2"x4" board. Then a 4" layer of granite, followed by a 2" layer of pea gravel. Next came the permeable pavers and then filling in the gaps with more pea gravel. I put the hose on a low setting and measured its

output for 1 min. Once I got the correct setting I just applied it evenly over the pavers. I then measured the water output for 5 gallons a minute and ran the experiment. There was no visible sign of runoff at 5 gallons per minute.

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Experiment

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This experiment gave me a view of what the pavers actually looked like and showed the extensive work ahead of us. While providing the view of the pattern of the pavers and the detail it brought to the ground, we started to notice the pavers sloping. It wasn't extremely noticeable, but an observer would see this flaw more distinctive in a real setting. This showed me mistakes that

could be made during the construction of the pathway. I began to remove the pavers and level the gravel underneath. This took a moment to again make sure the gravel was even with the other side, which was sinking and giving the experiment area a somewhat dent. I learned by leveling the gravel that it had to be more compacted than I had it before.

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*Pre-existing Walkway*

The first step in approaching the construction of the walkway is to thoroughly measure the site. Euro pavers will be the ones of choice for this project and will not be bordered with edging. At first, I thought that all paver walkways had to have barriers, such as concrete or plastic. This edging holds and doesn't allow natural lateral movements of the pavers over the years. After

doing research, I concluded that the joint space between the permeable pavers was too large to adequately install edging. The height of the paver we are using is 3 1/8". Added to the 2" pea gravel layer and the 4" granite rock layer. Compacting the soil prior to installing the rock reduced the ground level by 1/2". Also this will help stabilize the ground and eliminate any soft spots. The final compacting also slightly reduced the final height. We want the permeable pavers to sit 1/2" above ground level. After calculating the estimated depth I needed to dig, it came out to 9 3/4 .

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## Instructions List

1. Removal of existing walkway.
2. Trenching out appropriate height.
3. Compacting the soil
4. Measuring ground height
5. Fill in with 4" crushed granite rock
6. Make rock level/compact
7. Pea gravel installation
8. Level smooth
9. Lay down string line
10. Start with full pavers
11. Cut pavers for angle change

12. Make sure "1" pattern is accurate
13. Glaze with concrete sealer
14. Fill in cracks with pea gravel
15. Installation of rock edging

We had the rocks delivered in close proximity to the job site for easier access. At this point I was trying to get the rocks as level as possible and ready for the pea gravel. A 4" layer of crushed granite was applied. A 2" layer of small pea gravel was applied next. The rocks allow the water to have enough pore space in the gravel to percolate at maximum rate. The next phase was stringing my ninety degree angle and then the installation of the permeable pavers.

Each pattern is different but following the string will ensure that you have uniformity all the way down the path. Keeping each paver parallel required time and patience but in the end I saw the difference. There was already a 3 percent grade from the east running to the west. This is necessary for the flow of ground water to disperse away, letting new water in. This factor alone saved us the time and money of having to manually dig a 2-3 percent grade. I began the



installation of the permeable pavers starting from the house working my way out. This will ensure we are starting straight and with full pavers. I laid the pavers at a 90 degree angle and used a string to check for straightness. For the curve, the pavers needed to be cut, so having a concrete saw came in handy. Just a half an inch off can be too much where I couldn't use it. I used eye protection anytime the concrete saw was in use. After laying down each paver and making sure the pattern was correct, I did a final walk around. A final compaction of the pavers was needed to eliminate any weak points underground. Filling in the edges with pea gravel made the walkway solid and aesthetically complete. Cleaning up the area and washing the equipment was also handled.

## Materials List

1. Medium sized crushed granite= \$ 80
2. Pea gravel= \$ 74
3. Permeable pavers -

$$\text{\$ } 1.50 \text{ sq. ft} \times 470 \text{ sq. ft} = \text{\$ } 705$$

4. Concrete sealer = \\$ 30

Total = 889

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## LIGHTING

- 5 LED lights @ 149 each = \\$ 745
- Timer = \\$ 8
- Junction box = \\$ 80
- 12 volt cable = \\$ 20
- Transformer= \\$ 200
- Wire connectors/silicon glue= \\$ 10

TOTAL = \\$ 1063

The supplier for the lights for this project is Ewing irrigation. L.E.D lights are said to be up to 70 % more efficient than regular 12 volt lights (An introduction to LEED 2010). Five LED lights, a timer, junction box, 12 volt cable, transformer and connectors were purchased for the project. The first to be installed was the transformer. We installed this where the electrical panel was for the house. Next came the trenching for the 12 volt wire. To optimize the digging we had to do, one wire was run from the transformer to the main LED light. From that main light the other four lights were attached. A 2' hole was dug for each light and splicing was supplemented with splicing glue. The lights were evenly placed along the walkway for maximum output. Cars backing up from the garage tend to drive close to the walkway so this was a concern for me. I didn't want a car backing up over an LED light. Careful placement was taken to insure this wouldn't happen. The total labor time mostly came from trenching and digging the 5 holes.



at Night

Maintenance is a very important part of the project that should not be forgotten. Permeable pavers will need to be maintained every couple years. With Infiltration systems, the top couple inches of the voids have a tendency to self-seal with organic matter. (Family Handyman Magazine, 1992) This reduces the drainage capacity of the permeable pavers. Regular jet-washing of permeable pavers can be used to keep joints clear. Since this project was relatively small compared to commercial projects, labor time will be minimal.



Project Completed

Upon completion of the design and construction of this project, it proved to be sustainable and appealing all in one package. The walkway expresses a European characteristic, which could remind a person of the cobble street pavers seen throughout many historic cities. This walkway differs in many modern ways that demonstrate it to be firm and smooth in pattern with avoiding any large cracks. Avoiding any cracks or uneven pavers is the major characteristic to take a close notice in fixing properly to prevent any tripping of the foot. This pathway has a solid foundation and the side support of the additional stones will enable the walkway to remain sturdy for years. All the vegetation provides a groomed, but natural appearance for future visitors who view the area from any angle of the property. The main purpose of the permeable pavers was to help extensively in reducing any runoff and allowing water to disperse evenly outside of the walkway. This will allow a natural flow of water to surround landscape. The LED lights enhance the pavers' detail when the sun goes down and provides a very elegant appearance to the residences in the background. The LED lights are sufficiently bright for giving direction down the walkway, and they also illuminate a glow that attracts a soft mood to the landscape at dusk.



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