

## Introduction

We were tasked with mitigating the runoff from  $\frac{1}{4}$ ", 1", 2" and 4" rain storms in nine watersheds on the St. Paul campus using a variety of options including rain gardens, underground storage, green roofs, permeable pavement, and planting trees. I immediately did some extremely impressive high-level calculations and determined that rain gardens were by far the most cost-efficient method of collecting runoff, and I largely succeeded in mitigating even the largest storms using only rain gardens.

In the following sections I will outline my process. For the sake of brevity, and because all other solutions are very similar to the solution for the 4" rainfall, I will focus primarily on the placement of rain gardens to capture a 4" rainfall event. Please see Table 1 (attached) for my complete calculations. Note that it shows the cumulative area of the raingardens and their mitigation effect. Sometimes the surface area exceeds the 15% greenspace limit, but if you subtract the area of raingardens found in parking lots, the number will be under the threshold. Also note that I did not attach the table that is found in the project write up because I found it very confusing. Sorry. Did you want a table like that for each rainfall amount? If the same rain garden exists in each event, does it get a new number each time? Do I give that sink a rainfall mitigation in each rainfall, or just one? What if it is in the same general location but changes shape and position? What if it is in one solution but not another? I was also confused about the runoff amounts you wanted added to the grates. Because I did raingardens, the result of the model is the same as the unmitigated, and the runoff is calculated manually later. Is the number I should be entering a zero, or the same as the unmitigated runoff? I chose to put a zero, except in the single instance where underground storage was needed.

All my rain garden calculations are based on a layer I made that can be found in the QuarterInch geodatabase. I made all the watersheds into polygons, then erased the impervious surfaces and the buildings from that layer. Because we were allowed to build new sinks in areas with trees, I did not subtract the canopy layer. I found 15% of this layer, and that is the available space I had to build my raingardens in green space. Additionally, I was able to use up to 50% of a given parking lot. Rain gardens are shown in the pink polygons on the screenshots below.

## Results

*Gym, PPID 1*



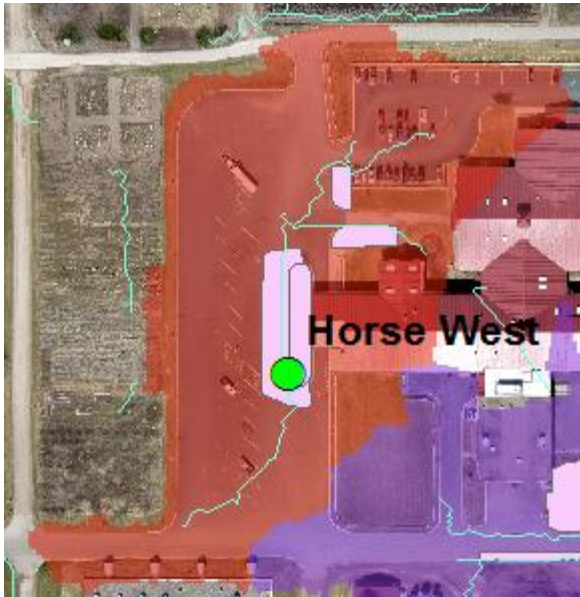
The gym watershed was mitigated by essentially turning the garden that is already there into a rain garden. The location was ideal because it was a large green space that was right next to the drain, meaning that I did not have to worry about being too far upstream and not collecting enough runoff with my rain gardens. This watershed was also easy in that the watershed had a lot of greenspace, and I only had to use about 9% of the allotted 15% for the 4" rainfall.

*Cargill, PPID 2*



This watershed was trickier, in that I had to be conscious of where the water was coming from. There was not a lot of greenspace or parking lots around the final pour point, so I had to get most of the water from upstream locations. The large rain garden to the north should cover the flow from the parking lot and open area above it, while the two gardens to the south can handle the flow from other areas. In this solution I had 400 square meters of greenspace still available to turn into rain gardens.

#### *Horse West PPID3*



This was a fairly simple one as well. There was a lot of open green space near the pour point which absorbed most of the water in most solutions. For the four inch, I used 519 of the 674 available square meters for raingardens, and used an additional 518 in my parking lot. The large parking lot meant that I was nowhere near the 50% threshold, and by using more raingarden in the lot instead of maxing out my greenspace, I ensured that the area around the pour point had adequate volume. The parking lot retains most of its original functionality, and the raingarden does not impede driving too much. The covered entrance is still useable, and while the parking spaces are not accessible from one side anymore, the longer spaces are ideal for the horse

trailers like that one seen in the image. This watershed really showed the offset between the impermeable shapefile and the image, and I chose to draw my raingardens based on the image. Otherwise the parking lot layer covers about half of that median space.

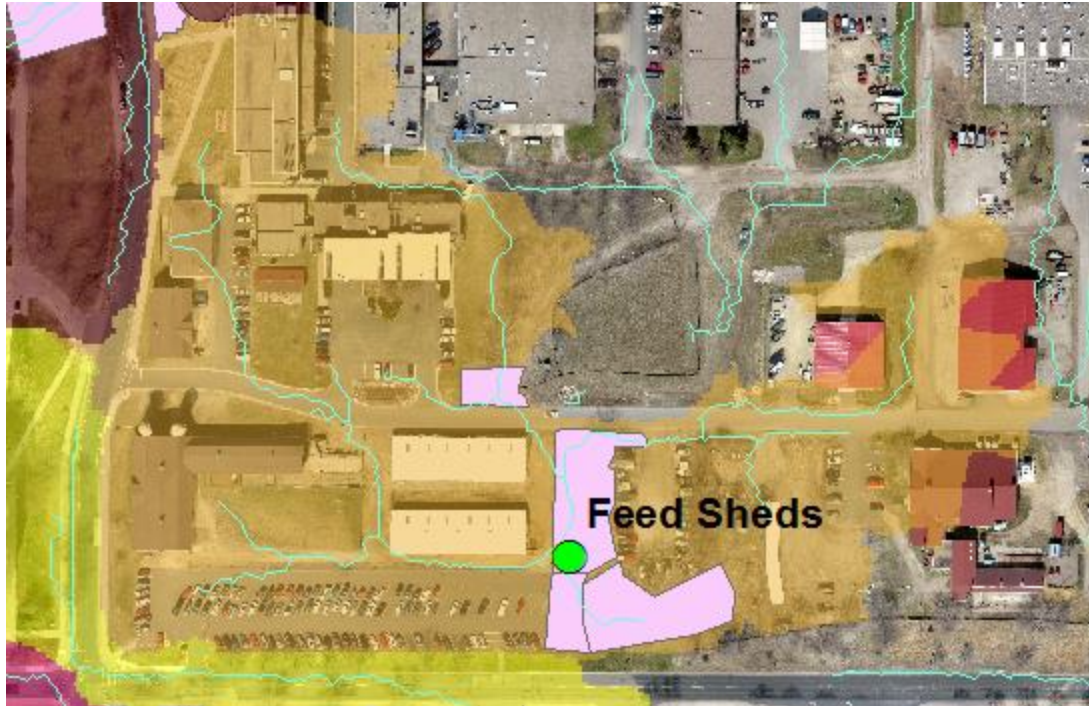
#### *Horse South PPID 4*





I thought this was the hardest watershed to make raingardens for. Was I liberal in my definition of a parking lot? Maybe. Do I strongly disagree with the area to the south being called impervious surface? Yes. Is all the water contained in the gardens? Yes. Does the parking lot still give ample space for drivers? Yes. Considering the area around the pour point is a giant dirt pile, I don't think these people would mind the rain garden along the edge of their lot. In fact, I think they will thank me for this very cost efficient method of runoff mitigation. I used every available inch of greenspace in this, and the rest was covered in the parking lot.

*Feed Sheds (PPID 5)*



This was another easy solution. I had a lot of green space around the pour point, and used all of the 15% allotted for rain gardens. I then connected the gardens via a new sink in the parking lot, which did not take up anywhere close to 50% of that lot.

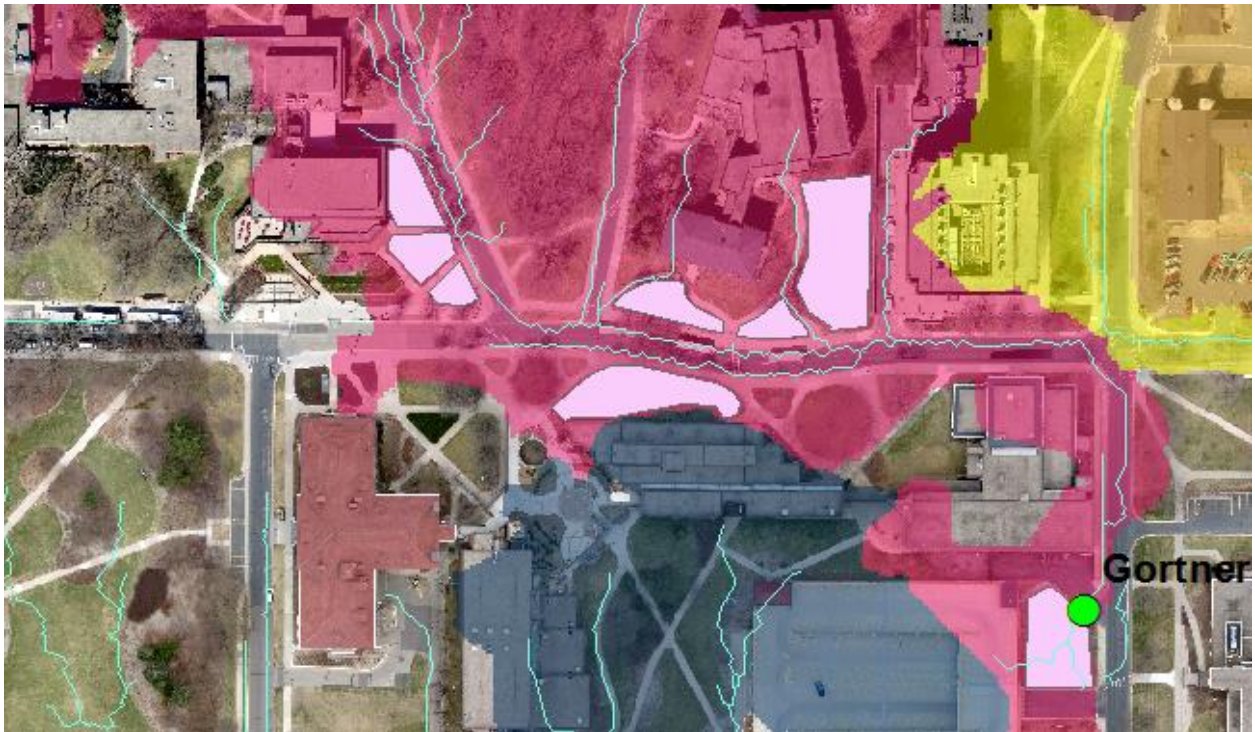
CEC (PPID 6)



Yet another easy solution. Luckily the large area of greenspace is only ~8 meters from the pourpoint, making it well within the 10 meter limit. With some sloping or a pipe this is an easy solution for even a 4" rainfall, and I still have over 100 square meters of greenspace before my 15% limit is reached.



*Gortner (PPID 7)*



Gortner was a huge watershed, but that meant it also had a lot of greenspace. I placed the raingardens in areas well downstream from everything. While the three on the west of this image won't hold all the water coming from the north, flow can be directed to any of the 4 gardens that line the road and anything else can be held by the large garden at the pour point. I did not have to use any parking spaces for this, and was still 800 square meters of greenspace under my quota.

*Pomeroy (PPID 8)*



The lack of greenspace made this one hard, and it was the only watershed that required underground storage. I really wanted to put a rain garden on the top of the parking ramp, but felt that may not have gone over too well. After converting 15% of the greenspace and the only area of the parking lot that was feasible, I was left with 420.6 cubic meters of runoff in a 4" storm. This had to be stored in underground tanks, which is a costly option.

#### *Vet School (PPID 9)*



This watershed also proved to be difficult due to the lack of greenspace. I focused most of the greenspace on making two very large sinks at the very downstream end of the flow, and put most of the parking lot sinks into the middle lot, which receives a lot of runoff from the lot and the building. There may be some opposition to the loss of parking spaces, but less than 50% of the lot was used, and those people will just have to pay the school hundreds of dollars a term to park in lots halfway across campus just like the rest of us. Even though I took up parking spaces and one side of what looked like a ramp, the other side of the ramp is still open, and I don't believe I blocked any doorways or made part of the lot too narrow for a car.

#### **Conclusion**

I think the very lax restrictions on raingardens made the rainfall mitigation pretty easy. If the gardens were shallower, or if we were not allowed to put them where trees are, or if less greenspace was available, it would have been much harder. However, as it stands this process was essentially a math problem, and because rain gardens were by far the most cost efficient method, they were the only thing I used with the exception of one underground storage tank. For this reason, all my databases are almost identical, with the "Solutions" feature dataset being the only change. See the attached Table 2 for my costs, but because I only used raingardens I think I completed the assignment as cheaply as possible. The only way I could have been more effective was if some of the rain gardens (the ones with a negative number in the last column of Table 1) did not hold more than the total runoff, but an extra 0.1 cubic meters is negligible when it comes to cost.



