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FINAL DELIVERABLE

Title	Waterloo Sump Pump Discharge Systems
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Community Partners	City of Manchester, Manchester Fire Department

This project was supported by the Iowa Initiative for Sustainable Communities (IISC), a community engagement program at the University of Iowa. IISC partners with rural and urban communities across the state to develop projects that university students and IISC pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

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Sump Pump Discharge System Project

City of Waterloo, IA | Final Report | December 11, 2020

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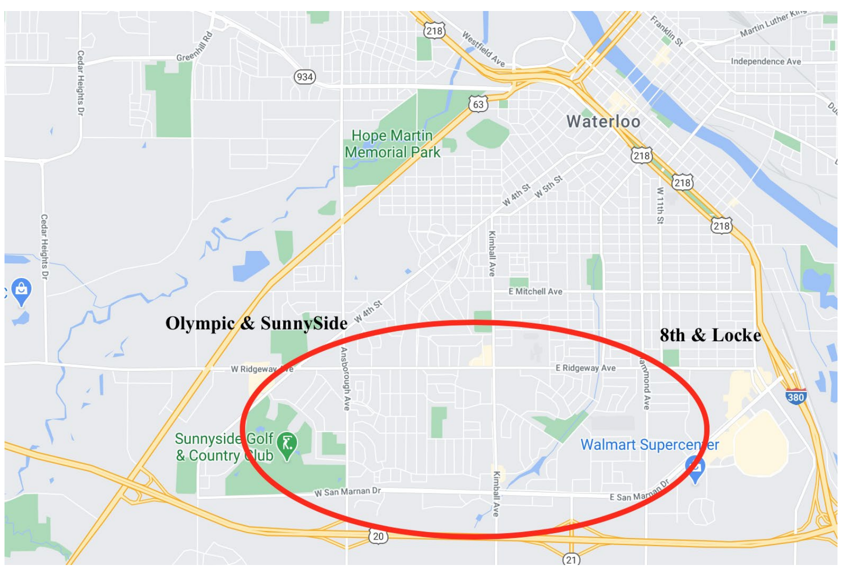
<u>Section 1: Executive Summary</u>

The City of Waterloo recently transitioned away from a combined sewer system, but problems remain from sump pump discharge entering the sanitary sewer system causing sewer overflows, basement backups, and ice & algae growth. Shown in Figure 1 is an overflowing manhole and a basement backup, which can be devastating to communities or families.

<u>Figure 1:</u> *Overflowing manhole and basement backup*

Our team devised a three part solution for the disconnection of sump pumps from the sanitary sewer system to solve problems caused by sump pump discharge around the city. The team analyzed the area circled in red shown below in Figure 2.



<u>Figure 2:</u> *Map of design area*

The three-part solution includes installing drain tile, building rain gardens, and allowing individual homeowners to route their sump pump discharge into nearby waterways. To encourage residents to participate in the solutions, it is recommended that the city begins by presenting incentives for properties to disconnect their sump pumps from the sanitary sewer and connect to appropriate outlets. As many of the areas have a large percentage of houses with access to the existing infrastructure, many properties will be able to disconnect immediately without additional infrastructure built. From then the areas we proposed solutions for will be prioritized in terms of the current number of properties able to connect to the existing storm sewer and drainage tile. The areas to implement solutions in should be prioritized using Table 1, provided below. The table is ordered by the percentage of properties able to connect immediately, therefore the city can construct solutions in areas with the lowest percentage to make the greatest impact.

Table 1: *Percentage of areas without sewer connection*

Area	Properties able to connect	Total Properties	Properties able to connect immediately
9.2	23	59	38.98%
7.1	28	71	39.44%
11	74	155	47.74%
8.1	35	70	50.00%
5.2	14	27	51.85%
12.2	12	23	52.17%
8.2	40	76	52.63%
5.1	15	28	53.57%
4.1	76	129	58.91%
3.2	63	104	60.58%
4.2	33	52	63.46%
9.1	55	84	65.48%
12.1	29	43	67.44%
7.3	18	26	69.23%
6.1	57	79	72.15%
6.2	91	123	73.98%
7.2	60	67	89.55%
2.1	84	88	95.45%
10	52	54	96.30%
3.1	40	41	97.56%
1.1	1	1	100.00%
1.2	1	1	100.00%
2.3	31	31	100.00%
2.2	46	46	100.00%

The first solution we designed is to install 6-inch perforated drain tile alongside curbs of streets where there is no existing storm sewer or drain tile. A 6” x 6” x 2” reducing “Tee” will be provided for sump pump lines from properties to be connected to the drain tile. Individual property owners will have to connect their own lines to the drainage system which will route the sump pump discharge into the storm sewer. Perforated drainage tile will be used in sections to allow the groundwater to recharge at a steady rate during dry periods and provide subgrade drainage during wet periods to extend pavement life. “Tee” and “Wye” adapters will be used to tie together additional lines, which will then transport the water to the nearest storm water outlet.

The average cost for a sub-area to install drain tile on each side of a street is estimated to be about $46,000

The second solution is for homes that are near waterways to direct their sump-pump flow into an existing waterway. To do so, residents shall connect a 2 inch pipe to their sump pump hose and direct it to the nearest waterway. This will be at the expense of each homeowner and is estimated to cost about $700 but the actual cost can vary greatly depending on the location of the sump pump in the basement and distance to the creek.

The third and final solution is to build rain gardens in yards that are isolated from the existing storm sewer system. For this to be possible, the yard must have a slope between 1-12% that goes away from the house in the backyard and a space available that is at least 10 feet away from the foundation of the home. Native plants and shrubs will be used, including Blue Grama Grass, Prairie Smoke Flowers, Prairie Blazing Star and Pale Purple Coneflower. Our design includes two rain gardens in two properties that will be built with a slope between 3-5%. One rain garden has a radius of 6 ft resulting in an area of 113 ft^2 and the other rain garden as a radius of 10 ft resulting in an area of 314 ft^2. For a home that would like to only connect their sump pump our team would recommend a rain garden between 3-5 ft in diameter at minimum. If a homeowner would like to look into connecting their downspout to the garden as well, our team would recommend a 6-10 ft diameter rain garden. The cost to install a single residential rain garden is estimated to be between $100-$1,500 depending on the type of plants used and how they are planted (i.e. planting new seeds or transplanting).

These solutions do rely on each individual property owner connecting their sump pump hose to the provided outlet. The cost of said connection is the responsibility of the property owner and for the connection to the drainage tile or rain garden is estimated to be about $266 for each property. Although again, the actual cost can vary greatly depending on the location of the sump pump in the basement and distance to the creek. However, the city can apply for grant funds to assist in the project funding for both individual and citywide funds. In addition, the city can provide incentives to ensure that these necessary connections are made.

Section 2: Organization Qualifications and Experience

UIowa StormCrew is a team of engineering students from the University of Iowa participating in our capstone design class. The team members are Tyler Ashton, Jillian Blum, Allison Cole, and Levi Runciman. Tyler Ashton is the project manager and is specializing in Environmental Engineering with a focus on Sustainability. Tyler can be reached at 515-554-1543 or tdashton@uiowa.edu**.** Jillian Blum is also specializing in Environmental Engineering with a focus on Sustainability. Allison Cole is specializing in Civil Engineering with an Environmental focus. Levi Runciman is specializing in Civil Engineering practice. Throughout the course of the project, Tyler and Jillian were responsible for leading the environmental components, specifically hydraulics and hydrology while Allison and Levi were responsible for leading the civil components, specifically structural and material estimates.

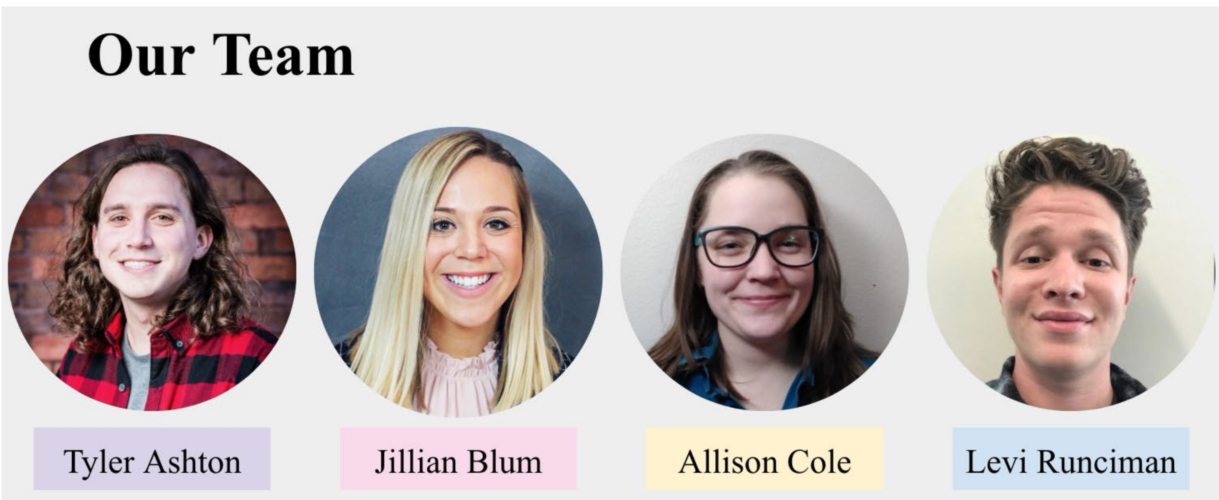


Figure 3: *UIowa STORMCREW Members*

Section 3: Design Services

The team utilized civil and environmental techniques to design a three-part solution that creates outlets for residential sump pump discharge. The solutions include infrastructure and environmental attributes that better route water through the storm water system and improve infiltration into the groundwater.

The project was initiated to solve issues of sanitary system overflows and basement backups in southern areas of Waterloo, IA, including the Olympic and Sunnyside area, as well as the 8th and Locke area. The project aims to prevent future overflows and backups from occuring by rerouting residential sump pump discharge from the sanitary sewer to other outlets. The project involves installing new drain tile, building rain gardens, and routing discharge to a nearby creek. The project will be completed with both citywide and individual property construction.

To complete the scope of services, the team followed the work plan shown in the Gantt Chart in Figure 4.

Figure 4: *Work Plan Gantt Chart*

The team began by analyzing the information obtained from the City of Waterloo to identify problem locations based on frequencies of overflow. We then came up with a set of solutions that wouldn't create other problems such as ice and algae growth or a buildup of excess water on properties. The solutions included adding storm sewer or drainage tile, building rain gardens and, bioswale, creating wet ponds, and discharging to a nearby waterway. We then met with the city of Waterloo and narrowed it down to three options: adding drainage tile, building rain gardens, and routing sump pump discharge to a nearby creek. The three potential solutions can be seen in Figure 5.

Figure 5: *Solutions to Reroute Discharge*

Once the three solutions were chosen, the team broke the larger area to be analyzed into 24 sub-areas so that the team could take a closer look at the area and provide potential solutions on a block-by-block basis. The area breakdown can be seen in Figure 6.

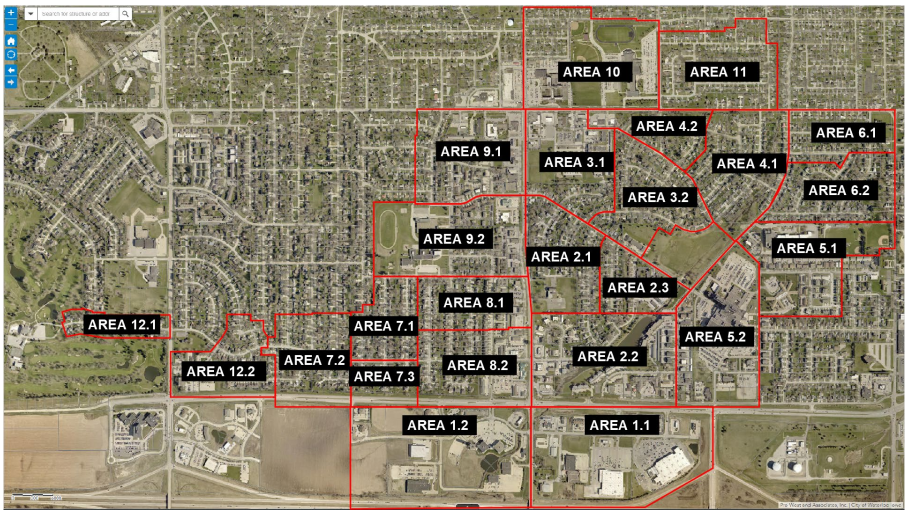


Figure 6: *Area Breakdown*

Once the large area was broken up into sub areas, we analyzed each sub-area to illustrate what solution would work best for each property. An example sub-area analysis can be seen in Figure 7, which shows area 11. The blue boxes shown represent houses that already have storm sewer or drainage tile available to connect their sump pump up to. These properties have the means to discharge their sump pump into the existing infrastructure and only need to make the connection. The green boxes shown represent houses that are good candidates to build rain gardens in their backyards due to being isolated from the existing infrastructure and having an acceptable slope to outlet water to their backyard. The pink areas shown represent houses that are near a river, creek, or other body of water that they can discharge to. Lastly, the dotted red lines represent where our team is proposing that Waterloo adds drain tile and the arrows show the direction the sump pump discharge would flow in the tile. The tile would then connect into the storm sewer already in place. The houses with green boxes and dotted red lines have the ability to use either rain gardens or drain tile depending on what the property owners choose.

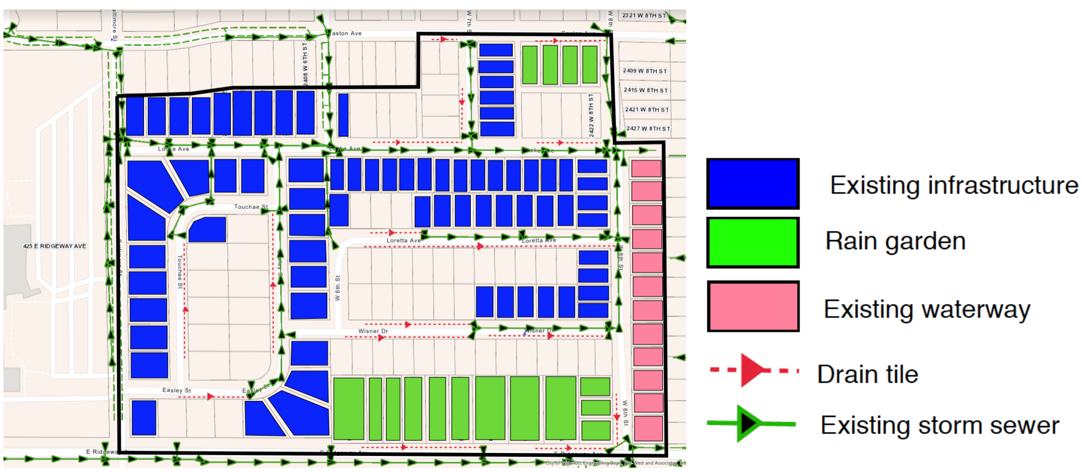


Figure 7: *Area 11 Block by Block Analysis*

Based on the ratio of residents that are able to immediately connect to existing infrastructure to total properties, the team created a priority list for the areas.

Lastly, the team developed solution designs for four representative segments that require drainage tile installations, two representative properties that have the ability to host rain gardens, and one property that is able to outlet their discharge to an existing creek. The designs are explained in further detail in Section 6.

Section 4: Constraints, Challenges, and Impacts

4.1 Constraints

The City of Waterloo has violated the Clean Water Act causing the EPA to step in. The city has signed a federal consent decree that spells out steps the city must take to create a master plan that resolves sewer overflow issues. The city is under a time constraint as they have until December 31, 2032 to make the improvements necessary under the decree. In addition to the time constraint, the consent decree requires the city to pay a total of $272,000 in settlement for the violations.

The city also has a budget constraint for the project. To keep the project within budget the team has created a solution primarily using drainage tile to reroute stormwater as it would be the most efficient and cost effective. However, in some areas it will be very difficult and resource wasting to run drainage tile to that property. Our limited options for designing this new stormwater system have forced us to choose the least expensive and easiest options all while effectively outletting the runoff.

4.2 Challenges

The choice to reroute the sump pump line into the new drainage tile system is up to each individual home in Waterloo. Gaining the cooperation of all citizens will be a difficult task to handle, as citizens may not see the benefit of the project. In addition to the cooperation of citizens, the drainage tile system itself must be designed so that it can efficiently reroute sump pump discharges from properties, all while being efficiently routed and using the least amount of material. The installation of this new drainage tile system will cause a large amount of construction work (trenching, boring, and tile installation). During this process, some roads may be forced to temporarily shut down, and people may have limited access to some properties. The installation work must be done in a way that will allow for steady traffic flows in certain areas and cause the least number of detours to be posted. In the event of a large storm during the construction period, a temporary routing system must be developed so that flooding does not occur in the area.

4.3 Societal Impact within the community and the State of Iowa

The project will pose several positive and negative social impacts on the community and the State of Iowa including discontinued sewer overflows and backup as well as issues with individual and family changes, personal and property rights, and community resources.

Implementing the potential solutions will have significant positive benefit on families and communities that are experiencing basement backup and sewer overflows. The devastating effects of increased flow from sump pump discharge will no longer occur.

However, the project may impose individual and family changes on community members because their yards are subject to change, however the possible solutions are not a health or safety risk. The project may also cause personal and property rights issues for multiple reasons. The project may put some responsibilities on the individual property owners and the owners may not want to or may not be able to comply due to financial issues or other reasons. In addition, personal and property rights become an issue if property owners try to direct their water to other properties so that they do not personally have the responsibility of fixing the problem. As an incentive, the city may increase water fees or taxes for properties that don't comply in a timely fashion. As such, the community may be upset or unable to afford these costs. Also, the implementation of some of the designs may cause temporary inaccessibility to certain areas. The community resources, population characteristics, and community and institutional structures are not expected to change.

The project aims to steer away from impacting the State of Iowa with respect to groundwater as a resource. By using perforated pipes, water will be able to infiltrate into the ground while being directed away from houses. This will help to relieve the concern of lowering the water table and will allow for the recharge of the aquifer below Waterloo and the surrounding areas.

Section 5: Alternative Solutions

Our team came up with multiple alternatives to aid in the discharge of property sump pumps. These solutions considered include a new storm sewer, added drainage tile, directing of discharge toward nearby waterways, implementation of rain gardens and/or bioswales, and the addition of wet ponds.

One of the solutions our team evaluated was the addition of a new storm sewer to neighborhoods that are not currently connected to the existing stormwater system. This solution would consist of adding a storm sewer line that properties can tap on to or route their sump pump discharge to. This solution has alternatives pertaining to the piping material and design that pose pros and cons. A new storm sewer would be an effective solution due to its durability and high life expectancy, but this solution would be the most expensive alternative and therefore was considered an invalid solution.

The second solution the team evaluated was to implement drainage tile into areas without storm sewers that do not require a full-scale sewer line implemented. This solution is possible where there are small segments of houses without storm sewer. With only a few houses routing water through drainage pipe down to storm sewers, it is possible to accommodate the water without reaching the capacity of the drainage tile. Adding drainage tile is cheaper and easier to implement than new storm sewer, however it is not as durable. In the end, this solution was considered a valid solution because of its low cost and feasibility. An illustration of how the drain tile would be laid out can be seen in Figure 8.

Figure 8: *Drainage tile layout example*

The third potential solution the team evaluated was to guide property sump pump discharge to nearby natural waterways. This would be done by extending the sump pump spout down to the water way through a by 2” PVC pipe. The pros to this solution are that it would be relatively simple and inexpensive to implement. The cons are that this solution is only possible in certain areas where a creek is nearby. Although highly unlikely, by adding an extra inlet to the creek, erosion could occur on the properties as well as downstream due to a higher flow. In addition, during heavy rain falls, the extra water to the creek could cause it to overflow. This solution was considered a valid solution because of its ability to be independently used by residents.

The fourth solution that our team evaluated is to build rain gardens and/or bioswales in areas throughout the city. A rain garden is a garden made from a blend of native shrubs, perennials, and flowers, seen in Figure 9, that can temporarily hold rainwater and allow a large percentage to be soaked into the ground. A bioswale is similar to a rain garden, however it is larger and designed to convey stormwater. Whereas rain gardens are smaller and keep the water in the place. The pros of implementing rain gardens and bioswales include that they are relatively inexpensive, easy to build, and that they provide natural aesthetics to the neighborhood. In addition, they are environmentally friendly because they allow the rainwater to infiltrate back into the ground and absorb nutrients in rainwater so the rainwater that flows out from the garden is relatively pure. The cons include the fact that they may not be as accommodating as other solutions in large storms and they can attract rodents and insects. The bioswale solution was considered invalid for the Waterloo area, as bioswales would be built on multiple properties, requiring the property owners work together to build and maintain the swales. The rain garden solution was considered a valid solution because of its ability to be used on individual properties that are isolated from existing infrastructure and unreachable by other solutions due to the slope of the isolated yards.

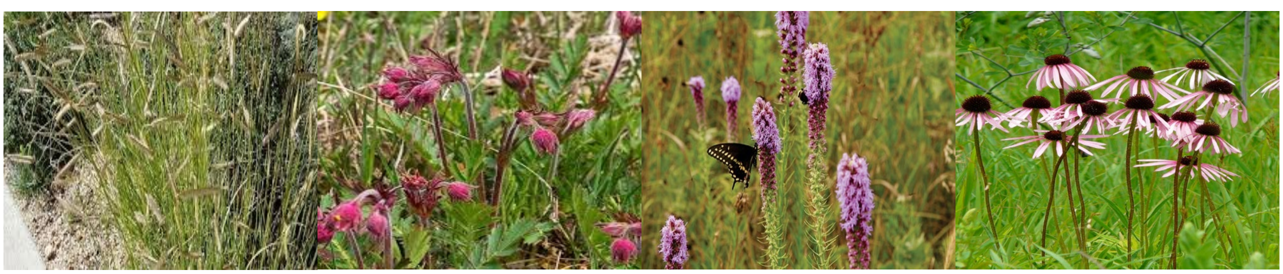


Figure 9: *Blue Grama Grass, Prairie Smoke Flowers, Prairie Blazing Star and Pale Purple Coneflower*

Section 6: Final Design Details

UIowa StormCrew designed solutions that create outlets for sump pump discharge utilizing civil and environmental techniques. The team's solutions ensure outlets that don't create other problems such as ice and algae growth or a buildup of excess water on properties. The solutions include infrastructure and environmental designs to better route water to the storm water system and improve infiltration into the groundwater.

6.1 Drain Tile

The primary design element of this project is to introduce drainage tile in areas where homes cannot discharge directly into the existing storm sewer. Drainage tile will be placed along the curb. The drainage tile will route the water down-hill by way of gravity, into the city's storm sewer or nearest acceptable outlet. Perforated 6 inch Dual-Wall HDPE drainage tile will be used for the new drain tile system. The drainage tile will be constructed with 6" to 2" tee adapters so that people can connect their sump pump hose directly to the tile. It is the responsibility of the homeowner and not that of the city to make this connection to the drainage system. Rodent guards must be installed on open outlets so that rodents don't crawl inside of a pipe and cause a backup. The design life for the drainage tile system is estimated to be 100-years however, roots and other wear may cause damage requiring city workers to repair or replace that tile.

Based off of SUDAS Chapter 2.B.3, we use a design flow of 5 gallons per minute flowing through sump pump hoses. Assuming that a drainage tile would have a minimum slope of 0.5%, a 6" drain tile at this slope can handle 75 gallons per minute. Therefore, one segment of drainage tile can accommodate the flow of at least 15 properties.

The drainage tile selected for use is a 6-inch diameter Dual-Wall HDPE perforated pipe. This product was selected for its durability and long-lasting design life. It is best to use a more expensive and more durable product now, instead of a cheaper option which is more prone to being cracked by weathering or by the infiltration of roots. Sump pump hoses from properties will be connected directly to the drainage tile by use of a 6" x 6" x 2" adapter. Tile-to-tile connections will be made by use of a 6-inch coupler in between the two drainage pipes, and sealant tape will be used to secure them together. Perforated drainage tile will be used to allow for recharging of the groundwater. The perforated tile allows some water to run out of the pipe while the majority of the water continues to flow into the storm sewers.

To estimate the quantity of the drain tile needed, the team created scaled illustrations of the drain tile to be implemented. We found that the city will need to install about 1600 linear feet of drain tile on an average street in the areas considered. See Appendix A for Drain Tile Designs.

6.2 Discharge to Creek

Houses that are nearby creeks will be permitted to discharge directly into the waterway. Based off of SUDAS Chapter 2.B, the team assumed a design flow of 5 gallons per minute flowing through sump pump hoses. The team selected that houses draining to a nearby creek extend a 2-inch pipe from their sump pump hose directly to the creek.

The pipe used to connect the resident's sump pump hose to a nearby creek will be made of polyvinyl chloride (PVC). The team chose to use polyvinyl chloride as the flows from individual houses are small enough to do so without causing extensive wear on the product. In addition, there won't be many properties discharging into the creek, flow capacity will not be an issue.

To estimate the quantity of the PVC pipe needed to connect sump pump hoses to a nearby creek, the team created a to scale illustration of the amount of pipe needed. We found that properties will need to install about 60 feet of PVC pipe per house throughout the areas considered. See Appendix B for Discharge to Creek Design.

6.3 Rain Garden

Rain gardens are proposed to be built in areas that are isolated from existing storm sewers and drainage tile by ground level elevation, however it will be up to the residents whether they want to put a rain garden in their yard or not. If a resident does not want to build a rain garden in their yard the city should run drain tile to their property if ground level slopes allow. If the ground level slopes make the drain tile option impossible, the residents should route their sump pump discharge away from their house onto their yard using a 2" PVC pipe.

Rain gardens provide an aesthetically pleasing solution to collect stormwater, while efficiently reducing the runoff from the property. In addition, rain gardens effectively filter out pollutants and allow for the recharge of groundwater. Rain gardens are eco-friendly, relatively inexpensive and easy to build. Rain gardens by themselves cannot effectively handle large storm events, but when used in combination with a drainage tile system, they will provide sufficient storage of stormwater runoff. Rain gardens will require maintenance at the time and expense of the property owners so that undesirable plants or animals don't consume the area.

Sump pump discharge for a rain garden will range from 25 to 75 cubic feet with an average depth of 4 inches (8). The rain garden design, shown in Figure 10, illustrates the 100 square foot garden shown as the green with a diameter of 6 feet and the 300 square foot garden as the circle with a diameter of 10 feet. The rain garden should be constructed a minimum of 10 feet from a building, and with a slope of 1-12% that flows away from the building (9). The site chosen for the example design has a slope ranging from 3-6% with the rain gardens about 60 feet away from the foundation of the home.

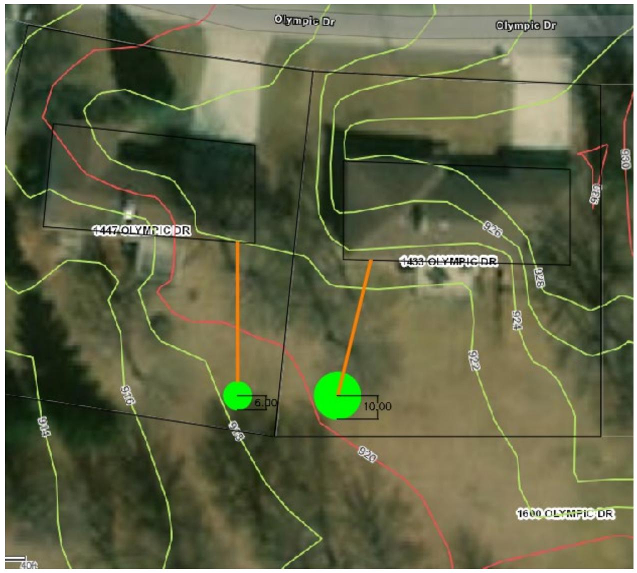


Figure 10: Example Rain Garden Geometry

The majority of the soil in the is “Tama silt loam”, according to the Iowa State University soil map, this soil is acceptable to make a rain garden on. The rain garden requires about 6 hours of full sunlight a day and isn’t an issue with our location. Plant species native to the Midwest will be used to absorb runoff and sump pump discharge. Drought resistant plants should go on the perimeter and plants that can take in more water should go in the middle to absorb more water. In addition to adding value to the home, the rain garden also provides home for wildlife and biodiversity. Specific plants can be selected based on which type of wildlife the community wants to see. A typical layout could consist of Blue Grama Grass and Prairie Smoke Flowers creating a border wall around the garden, with Prairie Blazing Star and Pale Purple Coneflower (echinacea) planted in the middle. Since water is only held for a short amount of time in a rain garden, mosquito breeding doesn’t become a prevalent issue. The rain garden also allows for the groundwater to recharge, which reduces the need for other stormwater treatment structures. The average cost of a rain garden is about $1-5 per square foot, and our designed rain gardens will be between 100 to 300 square feet, this gives a range of $100-$1,500. The large variance in the cost comes from either planting seeds or planting already grown flowers. The cost can be kept relatively low if seeds are planted instead of flowers, but this will require more maintenance and upkeep during the growth period. See Appendix C for Rain Garden Design.

Section 7: Cost Estimate

The team created an estimate for the cost of materials, labor and services, equipment, overhead costs, and profit. We assumed a contingency cost of 30% and a general condition charge of 20%. The unit costs were found from RSMeans, Menards, Lowes and ADS's websites, National Average Construction Estimates, as well as previous experience. Through analysis of the sub-areas, we were able to find the average cost of drainage tile installation to be $23 per foot. With this we can determine the average cost of all the areas to be around $895,000 using the boring method and $1,200,000 using the open cut method. Using an average length of 35 feet from house to tap, the average cost per household to make their sump-pump connection is about $320, with an installation cost of around $9 per foot of drainage tile. A cost estimate was made for tile installation with concrete removal and replacement, which effectively doubles the overall cost but is still provided as an alternative solution. The cost estimate tables can be seen below. *Note that service costs are based off of national averages, and homeowners can dig and backfill their own trenches for no additional cost. *

Table 2: *Estimated Project Cost using boring as construction method (installation cost $25.85/ft), and open cut as construction method (installation cost $35.04/ft), respectively.*

Area	Length of Tile (feet)	Cost Per Area
1.1	0	$0.00
1.2	0	$0.00
2.1	369.5	$9,551.58
2.2	0	$0.00
2.3	0	$0.00
3.1	0	$0.00
3.2	3125	$80,781.25
4.1	3295	$85,175.75
4.2	1410	$36,448.50
5.1	1810	$46,788.50
5.2	823	$21,274.55
6.1	1640	$42,394.00
6.2	1360	$35,156.00
7.1	4000	$103,400.00
7.2	730	$18,870.50
7.3	700	$18,095.00
8.1	2160	$55,836.00
8.2	2790	$72,121.50
9.1	2366	$61,161.10
9.2	2533	$65,478.05
10	130	$3,360.50
11	4050	$104,692.50
12.1	500	$12,925.00
12.2	850	$21,972.50
	Total Cost:	$895,482.78

Area	Length of Tile (feet)	Cost Per Area
1.1	0	$0.00
1.2	0	$0.00
2.1	369.5	$12,947.28
2.2	0	$0.00
2.3	0	$0.00
3.1	0	$0.00
3.2	3125	$109,500.00
4.1	3295	$115,456.80
4.2	1410	$49,406.40
5.1	1810	$63,422.40
5.2	823	$28,837.92
6.1	1640	$57,465.60
6.2	1360	$47,654.40
7.1	4000	$140,160.00
7.2	730	$25,579.20
7.3	700	$24,528.00
8.1	2160	$75,686.40
8.2	2790	$97,761.60
9.1	2366	$82,904.64
9.2	2533	$88,756.32
10	130	$4,555.20
11	4050	$141,912.00
12.1	500	$17,520.00
12.2	850	$29,784.00
	Total Cost:	$1,213,838.16

Table 3: Estimated drainage tile installation cost of the 4 streets designed using a construction method of boring (Wendy Rd, Orchard St, Barton Ave, and Wisner Dr)

Cost Estimate for Designed Drainage Tile (with Boring)			
Services	**Unit Price**	**Quantity**	**Total**
Trenching ($/ft)	$8	4,883	$39,064
Directional Boring ($/ft)	$15	1,380	$20,700
Backfill ($/ft)	$5	4,883	$24,415
Materials	**Unit Price**	**Quantity**	**Total**
6" HDPE Dual-Wall Perforated Tile ($/ft)	$3	4,883	$14,649
6" PVC Pipe ($/ft)	$5	1,380	$6,900
Tee Adapter ($/item)	$15	87	$1,305
End Cap ($/item)	$4	8	$32
Internal Coupling ($/item)	$4	213	$852
Rodent Guard ($/item)	$6	8	$48
Initial Cost			**$107,965**
General Conditions (20%)			$21,593
Contingency (30%)			$32,390
Total Cost (4 Designed Streets)			**$161,948**

Table 4: Estimated drainage tile installation cost of the 4 streets designed by concrete removal and replacement (Wendy Rd, Orchard St, Barton Ave, and Wisner Dr)

Cost Estimate for Designed Drainage Tile (with Concrete Removal)			
Services	**Unit Price**	**Quantity**	**Total**
Trenching ($/ft)	$8	6,263	$50,104
Concrete Removal ($/sq.ft)	$1	12,527	$12,527
Concrete Replacement ($/sq.ft)	$5	12,527	$62,635
Materials	**Unit Price**	**Quantity**	**Total**
6" HDPE Dual-Wall Perforated Tile ($/ft)	$3	6,263	$18,789
Tee Adapter ($/item)	$15	87	$1,305
End Cap ($/item)	$4	8	$32
Internal Coupling ($/item)	$4	213	$852
Rodent Guard ($/item)	$6	8	$48
Initial Cost			**$146,292**
General Conditions (20%)			$29,258
Contingency (30%)			$43,888
Total Cost (4 Designed Streets)			**$219,438**

Table 5: Estimated cost for house to tap connection

Estimate for Average Cost of Household Tile Connection			
Services	**Unit Price**	**Quantity**	**Total**
Trenching ($/ft)	$4	35	$140
Backfill ($/ft)	$2	35	$70
Materials	**Unit Price**	**Quantity**	**Total**
2" PVC Piping ($/ft)	$1	35	$30
6"-2" Tile Adapter	$12	1	$12
Internal Coupling ($/item)	$4	2	$8
Rodent Guard ($/item)	$6	1	$6
Total Cost (per household)			**$266**

Table 6: Estimated cost for PVC Pipe installation for house to creek discharge

Estimate for Average Cost for House to Creek Discharge			
Services	**Unit Price**	**Quantity**	**Total**
Trenching ($/ft)	$4	100	$400
Backfill ($/ft)	$2	100	$200
Materials	**Unit Price**	**Quantity**	**Total**
2" PVC Piping ($/ft)	$1	100	$85
Rodent Guard ($/item)	$6	1	$6
Total Cost (per household)			**$691**

Table 7: Estimated cost for Construction of Rain Garden

Estimate for Average Cost for Rain Garden Construction			
Services	**Unit Price**	**Quantity**	**Total**
Trenching ($/ft)	$4	35-100	$140-$400
Landscaping ($/ft^2)	$1-$5	100-300	$100-$1500
Materials	**Unit Price**	**Quantity**	**Total**
Flower Seed ($/18 oz pkg)	$18	1	$18
Transplanted Flowers	$100-$500	1	$100-$500
Total Cost (per Rain Garden)			**$358-$2418**

Section 8: Incentives, Examples, Funding

There are multiple options for incentives and funding resources the team recommends the city use to help residents to reroute their sump pump discharge. By using incentives, residents who already have access to existing storm sewer or drain tile are likely to act immediately, allowing for quicker results for the city. Further explanation of the incentives is in section 8.1. Examples of cities that have used incentives for similar projects are included in section 8.2. In addition to incentives, there are funding opportunities the city can use to help residents fund their individual projects and the city-wide project. Two examples are funding grants that can be used for this project are Community Development Blocks Grants and Hazard Mitigation Assistance Grants. These funding programs are explained in greater detail in section 8.3.

8.1 Incentives

Incentives are useful tools in achieving construction plan goals as they encourage participation from the community. Incentives to get homeowners to disconnect their sump pumps from the sanitary sewer system range from the city helping homeowners pay for various fees to charging homeowners until they disconnect from the sanitary sewer. A Low-income or senior citizen program would provide assistance for individuals that qualify. The assistance can range from partial coverage of fees or disconnecting the sump pump to full coverage. An application process, qualifications and funding will have to be determined beforehand. Stipends can be provided for homeowners or reduced fees. A rebate program would involve reimbursing the homeowner after receiving proof of disconnecting their sump pump from the sanitary sewer. A credit program would reduce the homeowners water bills for a certain amount of time (6).

Penalties, fines or increased rates are also an option. This option gets complicated because there are limited ways to legally inspect homeowners' connections without approval.

The team came up with a list of possible incentives to encourage people to disconnect their sump pumps from the sanitary sewer and discharge the stormwater legally. Based off of examples from other cities, seen in Section 8.2, we advise that the city should implement one of the following incentives.

8.2 Examples

Our team has reviewed examples of incentives that other cities have used for sump pump discharge programs. The team found that creating a rebate or a credit program for homeowners disconnecting their sump pump from the sanitary sewer is much more common than enforcing penalties and charging homeowners. This is because it is hard to legally enforce a program that charges the homeowner. In addition, it is hard to get access to people's homes without approval from the homeowner.

The first example incentive we found used by a city for a similar project was in Cedar Rapids, IA. Cedar Rapids is carrying out a pilot study for over 660 miles of sanitary sewers. In this pilot study, the city is to conduct smoke tests and provide home inspections to determine if a homeowner's sump pump is connected to the sanitary sewer system. If their sump pump is connected, the city offers to disconnect it for free (2). Although this is the most direct method for the city to fix the problem, this increases the costs for the city, as it will need to pay more than $300 for every property that they connect. Additionally, residents will need to agree to have their sump pump connections changed.

The second example incentive we found used by a city for a similar project was in Delcora, PA. In Delcora, the city mainly focuses on broken laterals, but has a sump pump inspection program as well. The city uses a variety of incentives including a low-income/senior citizen program and a penalty program for noncompliance. The low-income/senior citizen program is designed to assist residents that need to repair their private lateral but do not have the financial ability to do so. In Delcora, if a resident is over 65 years old and lives on a fixed income or meets certain qualifications, they are eligible for reimbursement of up to 50% of their repair costs. The penalty for a noncompliance program encourages a swift repair as the city will impose a fee or increase a resident's monthly bill until the repairs are made. The fees or surcharges are then refunded if the repairs are made within a specified period. (5). For the city of Waterloo to implement a similar low-income/senior citizen program, they will need to establish participation guidelines, application requirements & processing procedures, and will need a funding source as this will add over $150 per eligible resident. For the city to implement a similar penalty program for noncompliance, they will need to establish a date that disconnections from the sanitary system must be made by and will need a way to evaluate if the disconnections have been made. This program will not require additional funding or the city but may harm public relations with the residents.

The third example incentive we found used by a city for a similar project was in Des Moines, IA. In Des Moines, a Private Property Protection Program is used. The program offers a subsidy to residents to help protect their property. In Des Moines, the city will reimburse homeowners up to $1,500 to disconnect their sump pump, roof leaders from the sanitary sewer and install a backwater valve. The subsidy is paid to the property owner as a direct payment. This city has a list of terms for eligibility for the subsidy. For instance, the projects must be completed no later than June 1, 2023; it must be an existing home improvement, not new construction; and it must be done by a licensed plumber with a permit (3). For the city of Waterloo to implement a similar Private Property Protection Program, they will need to establish participation guidelines, application requirements & processing procedures, and will need a funding source as this will add up to $320 per eligible resident.

The fourth example incentive we found used by a city for a similar project was in Onondaga County, NY. In Onondaga County, the county imposed criminal penalties to homeowners who have illegal connections to the sanitary sewer. The city imposed the charges after using a Certification of Inspection or after an Affidavit had been filed with the Department of Water Environment Protection (10). For the city of Waterloo to implement similar criminal penalties for noncompliance, they will need a diagnostic video inspection or something similar to inspect what residents have unlawful connections. This program will not require additional funding for the city, but may harm public relations with the residents

The last example incentive we found used by a city for a similar project was in Carmel, IN. The city has a sump pump inspection program and a partial reimbursement credit program. The sump pump inspection program provides property owners free inspections to determine if a sump pump is connected incorrectly and to answer any questions. The partial reimbursement credit program provides credit to homeowners for disconnecting their sump pumps. The credit is given on monthly utility bills (1). To implement a similar inspection and credit programs in Waterloo, the city will need to establish participation terms and will need a diagnostic video inspection or something similar to inspect what residents have lawful connections. The city will not need an additional funding source, as this will not cost money for the city but will decrease money taken in by the city since the credit system will reduce utility fees.

8.3 Funding

Community Development Block Grants can be used to get grants for individual property owners to put the components to route their sump pump discharge to one of the three proposed solutions. Community Development Blocks Grants are administered by the Iowa Economic Development Authority with a goal of creating viable communities through decent housing, sustainable living environments, and expanding economic opportunities. These grants are specifically for people of low and moderate incomes. In order to receive the grants, the project must meet the National Objectives that are set by the U.S. Department of Housing and Urban Development. The maximum funding requests for improving water and wastewater services are based on community population. The population of Waterloo is just under 70,000 and therefore may be able to get up to $800,000 in grants, as populations greater than 15,000 can request up to $800,000 (4).

Hazard Mitigation Assistance Grants can be used to reduce or eliminate long-term risks to people and property from future disasters. The Hazard Mitigation Grant Program is funded by the Federal Emergency Management Agency (FEMA) and can be used in Waterloo to stop surcharging in extreme weather events as these events are repetitive and damaging. FEMA provides up to 75 percent of the total cost for some mitigation projects. (7).

In addition to the grant fund programs, the city of Waterloo could use sanitary funds to get the money for the disconnections. To do that, the city could put a temporary surcharge for sanitary fees for a fixed number of years to get funds to be able to construct.

Appendices

Appendix A: Drain Tile
A.1 Example Plan and Profile
A.2 Calculations
A.3 Design Specifications and Standards
A.4 Assumptions

Appendix B: Discharge to Creek
B.1 Example Plan and Profile
B.2 Calculations
B.3 Design Specifications and Standards
B.4 Assumptions

Appendix C: Rain Garden
C.1 Example Plan and Profile
C.2 Calculations
C.3 Design Specifications and Standards
C.4 Assumptions

Appendix D: Work Plan

Appendix E: References

Appendix A.1: Example Plan and Profile

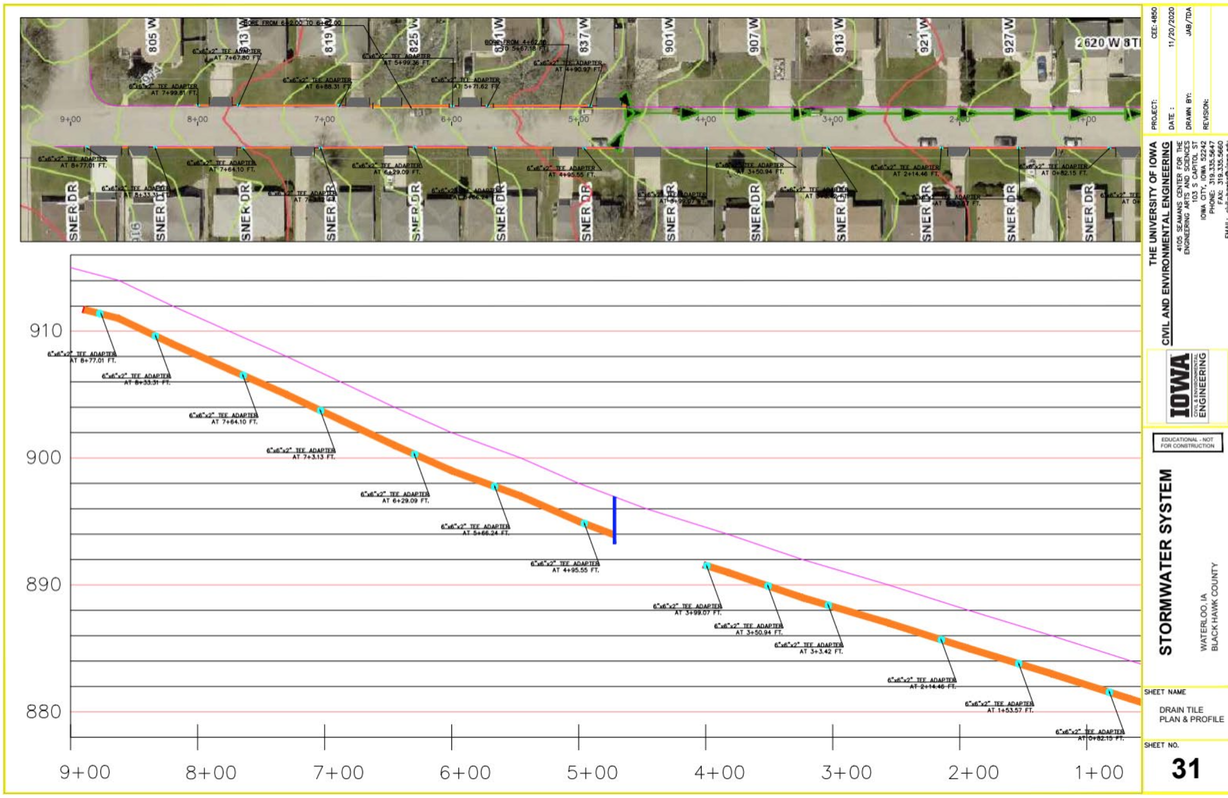


Figure 4: Plan and Profile of Wisner Road

Appendix A.2: Calculations for Drain Tile - Based off of a scaled drawing on AutoCad.

- Wendy Rd:
  - Driveway Area:
    - East side: 3280 sq ft for 13 driveways
    - West side: 2590 sq ft for 11 driveways
    - Total: 5870 sq ft for 24 driveways
  - Drain tile lengths:
    - East side: 517.90 + 554.20 = 1072.1 ft
    - West side: 480.57 + 543.39 = 1023.9 ft
    - Total: 2100 ft
  - Sump Pump Taps:
    - East Side: Need 14 taps
    - West Side: Need 14 taps
    - Total: Need 28 taps
- Wisner Dr:
  - Driveway Area:
    - North side: 542.49 sq ft for 5 driveways

        - South side: 1393.12 sq ft for 12 driveways
        - Total: 1935.61 sq ft for 17 driveways
    - Drain tile lengths:
        - North side: 340.67 ft
        - South side: 417.47 + 374.25 = 791.72 ft
        - Total: 1132.39 ft
    - Sump Pump Taps:
        - East Side: Need 6 taps
        - West Side: Need 14 taps
        - Total: Need 20 taps
- Orchard St:
    - Area:
        - East side: 991.92 sq ft for 7 driveways
        - West side: 1043.11 sq ft for 6 driveways
        - Total: 2035.00 sq ft for 13 driveways
    - Drain tile lengths:
        - East side: 481.74 + 214.78 = 696.52
        - West side: 252.38 + 359.74 = 612.12 ft
        - Total: 1308.64 ft
    - Sump Pump Taps:
        - East Side: Need 9 taps
        - West Side: Need 9 taps
        - Total: Need 18 taps
- Barton Ave:
    - Area:
        - East side: 1442.92 sq ft for 8 driveways
        - West side: 1243.83 sq ft for 10 driveways
        - Total: 2686.75 sq ft for 15 driveways
    - Drain tile lengths:
        - East side: 412.67 + 597.77 = 1010.44 ft
        - West side: 336.08 + 423.17 = 759.25 ft
        - Total: 1769.69 ft
    - Sump Pump Taps:
        - East Side: Need 10 taps
        - West Side: Need 11 taps
        - Total: Need 21 taps

Appendix A.3: Design Specifications and Standards for Drain Tile

- Designed based off of SUDAS Chapter 2.B.3.

Appendix A.4: Assumptions for Drain Tile

- Residential sump pumps have a flow of 5 gallons per minute based on SUDAS Chapter 2.B.3 so a 6” drain tile will be used to connect sump pump hoses to existing storm sewers.
- Assuming existing utilities are further than 3’ underground, they will not be in interference with the new drain tile designed.

Appendix B.1: Plan and Profile

Figure 5: Plan and Profile for discharging to nearby creek

Appendix B.2: Calculations for Discharge to Creek

- Rational method: 12-hour duration, 5-year storm
    - i = 3.44 inches
    - A = 1.88 mi^2 (design area) = 1200 acres
    - Coefficient of runoff (average) = 0.5
    - Q = CIA = (0.5)*(1200)*(3.44) = 2064 cfs

Appendix B.3: Design Specifications and Standards for Discharge to Creek

- 2" PVC pipe will be used to connect sump pump hoses to existing creeks.

Appendix B.4: Assumptions for Discharge to Creek

- Residential sump pumps have a flow of 5 gallons per minute based on SUDAS Chapter 2.B.3

Appendix C.1: Example Plan and Profile

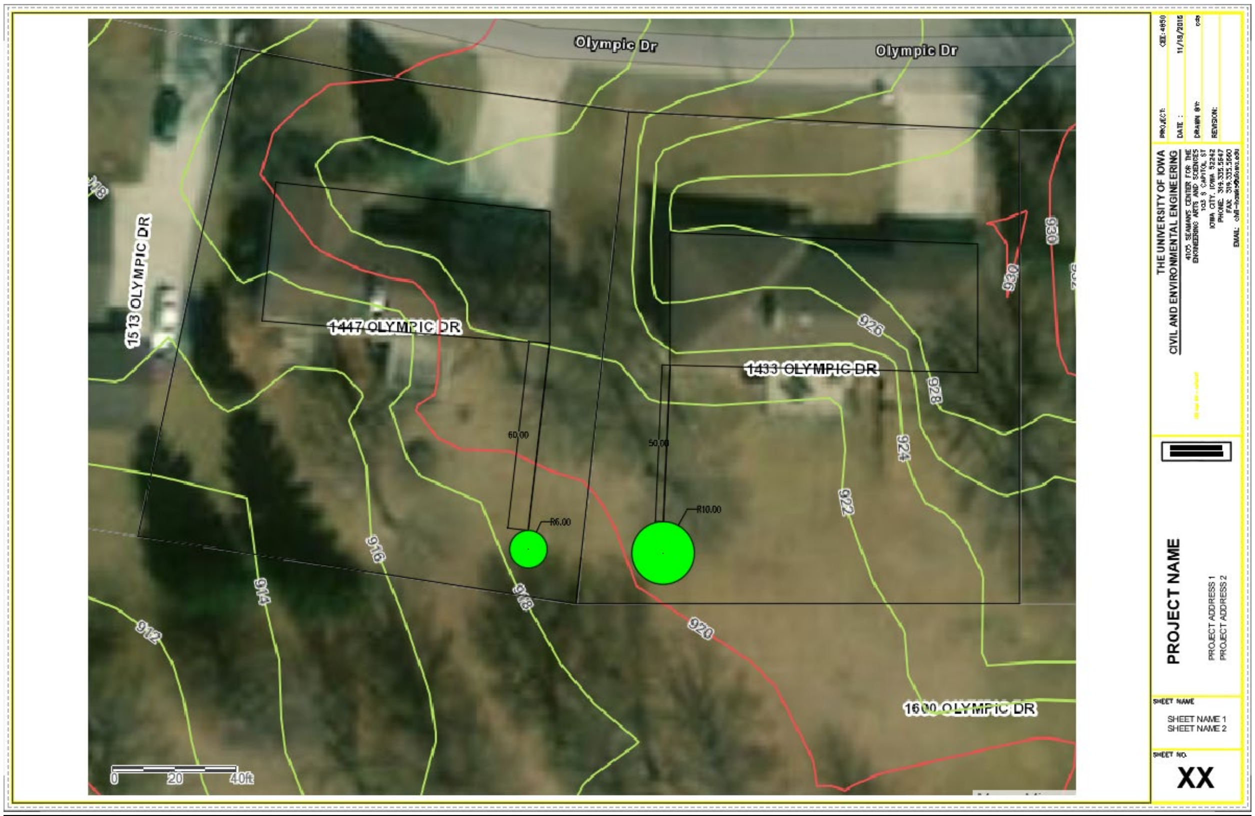


Figure 6: Plan and Profile of Rain Garden Designs

Appendix C.2: Calculations for Rain Garden

- Based on a calculation method from ILCA Sustainability Committee the sump pump design volume will be between 25 and 75 cubic feet.

Appendix C.2 Design Specifications and Standards for Rain Garden

- Located a minimum of 10 feet away from the foundation of the building so that the sump pump discharge does not infiltrate into the home's foundation.
- 2" PVC pipe will be used to connect sump pump hoses to the rain garden.

Appendix C.3 Assumptions for Rain Garden

- There are no chemicals being released from the water softener or laundry machine into the sump pump flow.

Appendix D:

References:

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