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Mitigation and Beautification: Placing Rain Gardens in the KeyStone Neighborhood of Rock Island, Illinois

Rosalie K. Starenko
Augustana College - Rock Island

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MITIGATION AND BEAUTIFICATION: PLACING RAIN GARDENS IN THE KEYSTONE NEIGHBORHOOD OF ROCK ISLAND, ILLINOIS

by

Rosalie Katherine Starenko

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ABSTRACT

With new stormwater management regulations, cities are looking for strategies to reduce urban runoff, and rain gardens are one of several strategies that capture runoff and encourage infiltration and evaporation. In doing so, pollution from runoff is mitigated and combined sewer systems experience fewer overflow events. I argue as well that the implementation of rain gardens would act as a movement for neighborhood beautification. This research develops a new methodology for placing rain gardens that: 1) maximizes the aesthetic value of the gardens by favoring high-visibility locations and 2) targets locations that would best benefit from reduced stormwater runoff. The methods are developed and applied to the KeyStone neighborhood of Rock Island, Illinois.

A sample of approximately 200 parcels was taken and each parcel in the study area has been evaluated and ranked based on a set of beautification criteria focusing on areas of high-visibility and scales of "beauty." Using the US Environmental Protection Agency's National Stormwater Calculator, each parcel was again ranked according to the modeled percent change of runoff with the installation of a rain garden. The two ranks were then combined into a composite benefits score and mapped using ArcGIS software to display the parcel's potential for neighborhood beautification and runoff reduction.

INTRODUCTION

Rain gardens, also called bioretention or bioinfiltration systems/cells, are small man-made basins designed with specific soil and plant types to collect runoff from impervious surfaces through channelization, thereby mimicking the natural hydrology of the landscape through the processes of water infiltration into their soil beds and evapotranspiration through the structure of the plants in the garden's body (U.S. EPA Green Infrastructure). They are considered a component of low impact development (LID), an initiative in stormwater management by using "natural means" to combat the degrading effects of stormwater runoff (Davis 2007). In urban areas, where large amounts of impervious surfaces are present, pollutants accumulate and are channeled into water bodies rather than undergoing a natural filtration process through plants and soil. These pollutants include suspended solids, oil and grease, organic carbon, phosphorous and nitrogen nutrients, heavy metals, pesticides, and pathogens (Li and Davis 2009). Each of these pollutants has a significant effect on water quality as it enters regional watersheds via stormwater runoff. This runoff affects watersheds due to the downstream flooding, increase in stream velocity as water is channeled and runs quickly over impervious surfaces and into streams, increase in turbidity, habitat destruction, combined sewer overflows, city infrastructure damage, and contaminated bodies of water that the excess stormwater induces (U.S. EPA Stormwater Management 2012). However, it has been tested that bioretention has a remarkable effect on the filtration and infiltration of these pollutants as the water runoff is channeled into their basins (Davis 2007; Davis et al. 2009; Li and Davis 2009). This is done through adsorption, filtration, plant uptake, microbial activity, decomposition, sedimentation, and volatilization (U.S. EPA Stormwater Technology Fact Sheet 1999). The uncontrolled amounts of stormwater runoff that urban areas experience today are problematic not only for the disruption the excess water causes to an ecosystem's state of equilibrium, but for the damages, both physical and economic, encountered by urban structures and their residents.

This paper examines the development of a new methodology in rain garden placement. It was formulated to involve both qualitative and quantitative approaches to research so that elements of both physical and cultural geography might be incorporated, presenting an open-minded analysis. The purpose of this is to display the usefulness of rain gardens as a system of pollution mitigation as well as a method of neighborhood beautification in an area looking to maintain a sense of place. A map is presented displaying the most efficient locations for rain gardens in the KeyStone neighborhood of Rock Island, Illinois.

Rain gardens are important not just for environmental reasons, but for human factors as well. This is an argument specific to this study, for no known literature exists that treats rain gardens as green space to be used for neighborhood beautification. Yet, these rain gardens are gardens nonetheless, and theoretically should provide all of the same benefits as green space in an urban area.

STUDY AREA

The Quad Cities straddle the Mississippi River between Iowa and Illinois and are composed of the four cities of Davenport and Bettendorf, Iowa, and Rock Island and Moline, Illinois. Like many midwestern river cities, the Quad Cities' connected waterways, railroads, and once-thriving manufacturing plants for Farmall, International Harvester, and John Deere farming equipment have greatly influenced the area's settlement geography. Yet, its economic and physical decline due to the decentralization of wealth is displayed as another defining characteristic of the midwestern Rust Belt landscape (Tweet 1996). Norman Moline, professor emeritus of geography at Augustana College in Rock Island, claims it is for these reasons the Quad Cities are seeking identity (Tweet 1996).

In the late 1960s, the Quad Cities—Rock Island especially—began a slow and steady process of urban decline. Following the onslaught of Dutch Elm disease during the 1960s and 70s, which devastated the majority of the area's residential tree population, bare neighborhoods began to show physical signs of deterioration, for it was at this time in Rock Island's history that the farming industries began to lose economic power and eventually file for bankruptcy in the early 1980s, leaving the already sparse city behind (Tweet 1996).

In a response to the departure of a thriving urban and industrial community, some Rock Island citizens began to look at the land for a sense of identity, paying special attention to the Mississippi River that "joins" the four cities (Tweet 1996). It is this attention to natural beauty in hopes of urban renewal that made Rock Island the perfect selection for this study.

Figure 1. A row of houses line 7th Avenue, one of the busiest streets that runs through the KeyStone neighborhood in Rock Island. Historic houses showing deterioration like several of these is typical of Rock Island.

In 2014, the Rock Island Planning Commission developed a comprehensive plan with the purpose of promoting various sustainability principles, including a focus on the value of communities and neighborhoods. Among these sustainability principles was the promotion of residential rain gardens. Interest in best management practices (BMPs) for the city made the formulation of this study possible (City of Rock Island Comprehensive Plan 2014). Furthermore, the Quad Cities' landscape is intersected with numerous urban watersheds—ravines—that terminate in the Mississippi River. This makes the area an especially important location for possible stormwater management through rain garden implementation. There are currently studies being conducted by the Upper Mississippi Center (UMC) of Augustana College in Rock Island that test the water quality of these ravines. Their data is readily available and their presence in the KeyStone neighborhood displays a commitment to water resource management on the neighborhood's behalf (Augustana College).

The KeyStone neighborhood was selected as a smaller, more specific study site not only for its proximity to Augustana College, but also because of its overall interest in both environmental and community values. KeyStone is situated on the northeastern side of Rock Island, with Augustana College, the Mississippi River, and the border of the city of Moline acting as its western, northern, and eastern borders, respectively (Figure 1, Figure 2). According to a survey conducted for the 1996 KeyStone Neighborhood Plan, beautification has been a top priority for the residents (Neighborhood Plan 1996). Its accessibility to Augustana College, the presence of urban watershed no. 11, its openness to community gardening and rain gardens, and its desire for neighborhood beautification and a sense of identity have made it the best candidate for a more specific study area.

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Figure 2. The study area displaying the KeyStone Neighborhood's location in Rock Island, and Rock Island's location in Illinois.

LITERATURE REVIEW

Rain Gardens for Urban Watershed Health

One of the main incentives for installing a rain garden is for its use as a stormwater control measure (SCM) (Figure 3). Stormwater management is an increasing concern for many cities, especially those with old infrastructure systems that could be compromised. Combined sewer systems integrate both sanitary sewage and stormwater into one piping system, and after a heavy rainfall event, it is common for these systems to overflow due to the excess stormwater. When this combined sewer overflow (CSO) happens, a mixture of stormwater and sewage—untreated human feces, industrial waste, toxic materials, and debris—flow from discharge points and into watersheds, creating a major concern for water quality (National Pollutant Discharge Elimination System 2012). A study conducted in Minneapolis-St. Paul, MN analyzed the effects of rain gardens on water quality, and their results show that there exist varying effects of rain gardens on the infiltration of pollutants. Perhaps more pertinent to this study, their results show as well that the rain garden sites significantly reduced the overflow from runoff events, for the gardens captured all of the inflow which was infiltrated into the soil and evaporated or transpired through the surface vegetation (Tornes 2005).

Rain Gardens as Pollution Mitigation

Because of the extent of impervious surfaces in urbanized areas, stormwater runoff will pick up any pollutants—oils, heavy metals, fertilizers, and nutrients from fertilizers, animal waste, and household detergents—collected on these surfaces and transport them to their exit points. Nutrients, specifically nitrogen and phosphorous, target the most concern from scientists for their degrading effects in water bodies (Palmer et al. 2013). The literature suggests that bioretention cells—rain gardens—can act as a remover of these pollutants at varying levels because of their retention and infiltration characteristics.

Figure 3. A diagram showing the body and functions of a residential rain garden.
Image Source: City of Vienna, West Virginia. http://vienna-wv.com/portal/2013/07/18/what-is-a-a-rain-garden/

Bioretention cells perform particularly well at absorbing suspended solids, heavy metals, and hydrocarbons, but the levels of absorbing nutrients are highly variable (Palmer et. al 2013; Randal and Bradford 2013). However, with the proper design, it is possible for the nutrients to be retained. One study in Maryland tested the effects of pollutant removal from parking lot runoff though bioretention cells by testing and recording the amount of pollutants removed from water leaving two rain gardens. The removal rates were 47 percent for total suspended solids, 76 percent for total phosphorous, 57 percent total copper, 83 percent lead, 62 percent zinc, and 83 percent nitrate, each a significant amount (Davis 2007).

The porous sandy soils, mulch, and native vegetation (pollution and water-intolerant plants) act as the other factors in removing pollutants from infiltrating stormwater, but the overall consensus seems to be the levels of pollution mitigation is highly variable and much of the process depends on specific designs of rain gardens (DeBusk et al. 2011).

Rain Gardens as Neighborhood Beautification

Although there are no studies that we know of regarding the effect of rain gardens specifically on neighborhood beautification and revitalization, studies show that the presence of green space in urban settings is beneficial—not only for environmental quality and aesthetic reasons, but for the positive effects the vegetation has on peoples' physical and mental moods as well (Malakoff 1995; Gupta et al. 2012). At the neighborhood level, urban green spaces provide aesthetic balance and increase the environmental quality of the area by absorbing pollutants, releasing oxygen, and providing clean water and soil. The green space provides a sense of social safety, reduces crime, increases social interaction, and increases property values, therefore encouraging city dwellers to feel a sense of pride for their place of residence (Malakoff 1995; Gupta et al. 2012).

The concepts of place, sense of place, and “topophilia” are well-discussed in the field of geography. The geographer Yi-Fu Tuan defines topophilia as the coupling of sentiment with place, with images provided by surrounding environments to determine a strong feeling; it is “the affectionate bond between people and place or setting” (Tuan 1974). But how does topophilia manifest in a setting? One article claims landscape architecture can create a sense of place, with gardening at the root of the impulse to create a sense of place. The author argues that landscape architecture is an essential expression of human behavior and emotion, a way to give our world value (Crozier 2003). When one walks the streets of the KeyStone neighborhood, one does not necessarily feel expression. Rather, the feeling of suppression has made its way into the composition of the KeyStone neighborhood, as it has with other Rustbelt cities in the Midwest.

The KeyStone neighborhood, and Rock Island in general, is an area that has seen economic struggle, and green space could act as a real benefit to the neighborhood. Because there are public green spaces already present—Longview Park, Lincoln Park, Schwiebert Park—the next step in the city beautification process would be green space at the individual homeowner scale (Gupta et al. 2012). While this study is not meant to be an advocate for the installation of rain gardens in the neighborhood, it does suggest them as a possible mode of beautification and revitalization in any setting because of the sense of place that Crozier suggests gardens can encourage in the people who live among them.

Beauty and Runoff: An Integrated Approach

Studies within the last few decades have shown that a mixed-use approach to research has become “an obvious one in contemporary human geography” (Philip 1997, 273). L. J. Philip argues that researchers should forgo the present divide that separates quantitative and qualitative methodologies so that a suitable methodology might be designed for their own research projects, while Knigge and Cope write more specifically about the benefits of a combined grounded theory and visualization approach. It is within these arguments that this study fits.

Grounded theory uses the collection of qualitative data to bring about specific themes present in the data through the process of coding. Coding is what connects this qualitative approach to the quantitative measures of visualization, in which specific data are represented visually. Among a number of visualization methods is the use of GIS to display visual spatial patterns of the collected data (Knigge and Cope 2004). Knigge and Cope state that the convergence of these two research techniques, dubbed *grounded visualization*, forces the researcher to look at data from multiple angles in a reflective manner that seeks connections of all forms in the results of a study. This was tested in a case study done in Buffalo, New York that sought connections between community gardens and a sense of place in a diverse neighborhood. Their methodology, a test in progress, included four steps: exploring neighborhood census data, participant observation through neighborhood exploration, visualization—mapping connections and context—and further rounds of analysis as necessary, allowing the research to be “attuned to multiple subjectivities, truths, and, meanings” (Knigge and Cope 2004, 2035). Their initial results have encouraged them to consider “the possibility that community gardens were potential sources for political and economic empowerment…and deepened [their] focus on [the gardens'] meanings for local residents" (Knigge and Cope 2004, 2033).

METHODOLOGY

For this project, a new methodology was created to include quantitative data in measuring the percent change of infiltration on a parcel if a rain garden were installed, and include qualitative data regarding a rain garden's possible effect on the beauty of a neighborhood space. Because of the character of the study, a combination of both physical and human elements of geography was vital: not only is the science behind a rain garden important, but the feelings and perceptions that they create in the people who live around them are of equal importance. To display this theme of physical science and human behavior, a multi-tiered process was developed.

To determine which parcels to analyze out of the total 1,594 present in the study site, a stratified random sampling method was used to condense the sample size to 500 parcels, and then to 204 parcels (Table 1, Table 2). Two variables stratified the data—commercial, industrial, or residential land use, and property values of individual parcels. The goal was to include a random but representational selection of parcels from the three land-use zones, and then again for property values within the Residential Zone. Out of the total 1,594 parcels, the percentage of each zone within the study site was calculated and multiplied to 500 to produce 25 commercial parcels, 3 industrial parcels, and 472 residential parcels. To determine which 472 residential parcels to study, the value was stratified again by property value into 5 classes of equal range: $40,000 and under, $40,000-$60,000, $60,000-$80,000, $80,000-$100,000, and $100,000 and up. The percent of houses within each range was calculated and multiplied to 472 (the number of residential parcels) to produce 40 parcels with a property value at $40,000 and under, 45 at $40,000-$60,000, 172 at $60,000-$80,000, 52 at $80,000-$100,000, and 63 at $100,000 and up (Table 1).

Table 1. Quantitative data from the primary sampling process.

Zones	**Number (Out of 1594)**	**Percent**	**Number of Sampled Parcels**
Commercial	79	5%	25
Industrial	10	0.6%	3
Residential	1503	94.3%	472
Property Values	**Number (Out of 1503)**	**Percent**	**Number of Sampled Residential Parcels**
$40,000 and under	127	8.5%	40
$40,000-$60,000	145	9.6%	45
$60,000-$80,000	549	36.5%	172
$80,000-$100,000	485	32.3%	52
$100,000 and up	197	13.3%	63

Originally, the sample site was meant to encompass both the KeyStone neighborhood and urban watershed no. 11, which lies within the neighborhood's blocks. But because of time restraints, the watershed was removed from the study area, bringing the number of parcels in the site from 500 to 204, causing slight misrepresentations of equal percentages from the two stratification categories (Table 2).

Table 2. Quantitative data from the final sampling process.

Zones	**Number of Sampled Parcels (Out of 204)**	**Percent**
Commercial	11	5.4%
Industrial	3	0.1%
Residential	190	93.1%
Property Values	**Number (Out of 204)**	**Percent**
$40,000 and under	21	10.3%
$40,000-$60,000	20	9.8%
$60,000-$80,000	58	28.4%
$80,000-$100,000	68	33.3%
$100,000 and up	37	18.1%

Four teams of Upper Mississippi Center interns and Augustana College students and faculty through Augustana College and the Upper Mississippi Center (UMC) completed the fieldwork over the course of several months to rank each sampled site manually on paper from 1, “poor” to 3, “best.” The size of the parcel was considered, as well as its visibility—how well it is seen from high-traffic areas, its connection to the neighborhood—how well a rain garden would be seen from someone walking the sidewalks, and the potential impact in beautification that parcel in particular would experience from a rain garden. In this last criterion, a parcel would receive a “1” if there would be no impact, or the parcel could already be considered beautiful (Figure 4).

ADDRESS/BUILDING NAME ________________________________

Current Land Use _____

Size _____

Visibility _____

Connection to Neighborhood _____

Potential Impact _____

Average _____

Figure 4. The sheet of criteria for ranking each parcel for “beauty.”

Upon the completion of this fieldwork, the criteria in each parcel were averaged and rounded to a whole number from 1 to 3, providing an overall rank for that parcel’s particular need to be beautified by a garden.

Data was then collected using the United States Environmental Protection Agency’s National Stormwater Calculator (USEPA NSWC) to determine the infiltration rates for each sampled parcel before and after the installation of a hypothetical rain garden. Using the NSWC’s Baseline/Current Scenario model with all default options selected, the rates of infiltration, runoff, and evaporation of all stormwater on a parcel with the calculator’s provided soil, topography, and rainfall event data could be determined. The percent of impervious surface for each parcel was manually entered into the NSWC using GIS data provided by the UMC. With the real-time rates determined, called the “baseline scenario,” new rates of infiltration, runoff, and evaporation could be calculated for parcels if they were to have a rain garden, called the “current scenario.” The percent change in infiltration was calculated and entered into a spreadsheet. Where the parcel saw a change of 0-25 percent, a rank of 1 was given; a change of 26-50 percent was ranked 2; and a change of 51-100 percent was ranked 3. These numbers are arbitrary and were not based off of any data from previous studies—they are simply a way to give a value to the given data, and it was decided that any change over 50 percent is significant enough to be given the highest value.

All ranks and rates were entered into spreadsheets to view and store the data, and were then uploaded into ArcGIS Software to visually display the different ranks (Figure 5, Figure 6).

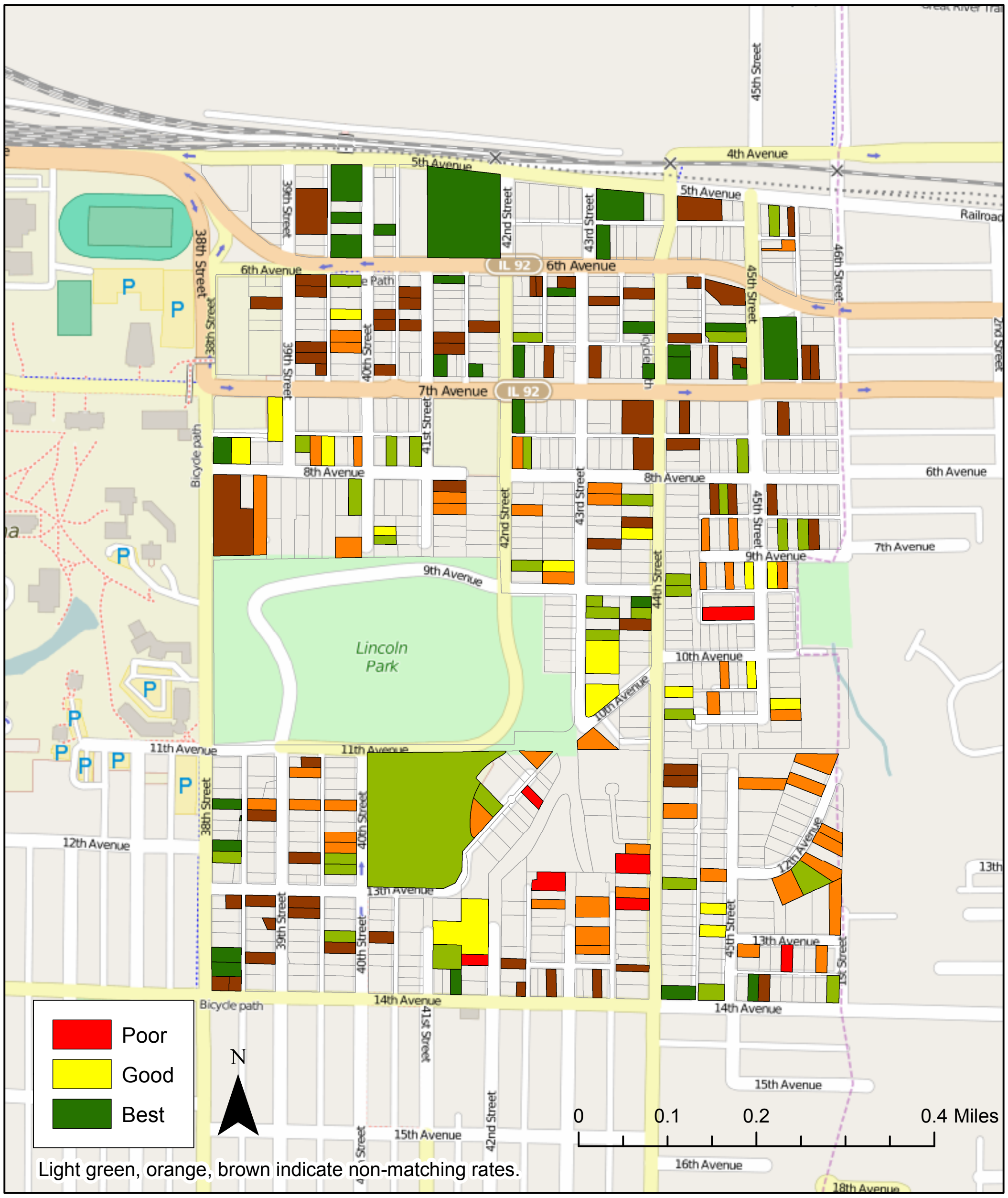
RESULTS

Each sampled parcel was ranked manually given the determined criteria for neighborhood beautification or revitalization. The same parcels were also ranked based on the percent change of stormwater infiltration before and after a hypothetical rain garden was installed on the property, modeled by the USEPA’s National Stormwater Calculator computer program (Appendix A, Appendix B).

A cartographic representation of surveyed parcels displays several clusters of data (Figure 5, Figure 6). A range of colors from brown to orange to light green are shown, indicating that these shades were not a perfect match in infiltration and beautification rates with one layer displayed at 50 percent transparency. The solid red, yellow, and green parcels indicate a perfect match, for when the transparent layer was overlaid on the other, the colors matched and therefore

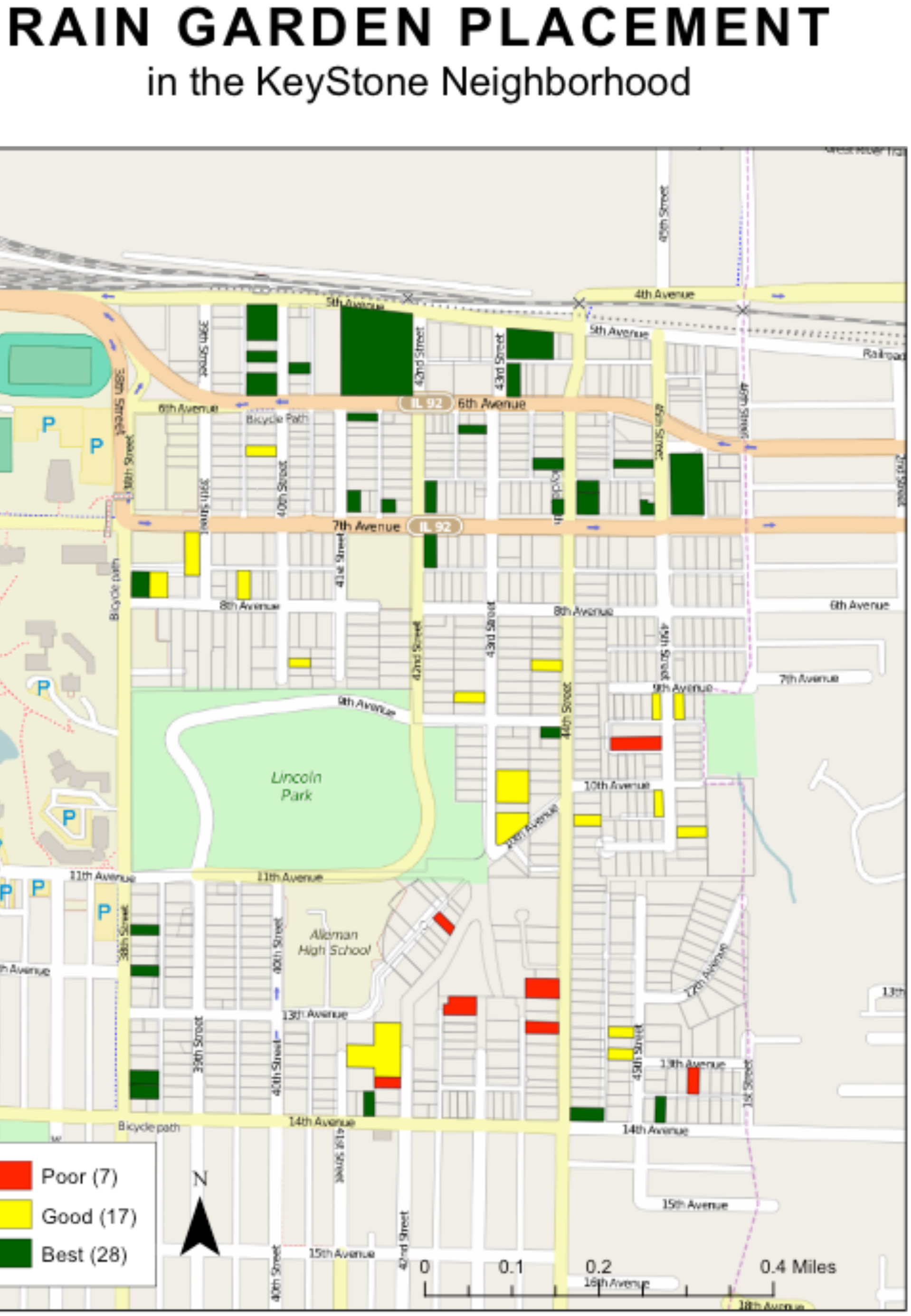
TESTED SITES

in the KeyStone Neighborhood



Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA, Rock Island County

Figure 5. A map of the study site with both Beautification and Infiltration Rate layers overlaid. Red, yellow, and green parcels indicate poor, good, and the best locations to place a rain garden considering neighborhood beautification/revitalization and good stormwater infiltration rates.



Service Layer Credits: © OpenStreetMap (and) contributors, CC-BY-SA, Rock Island County

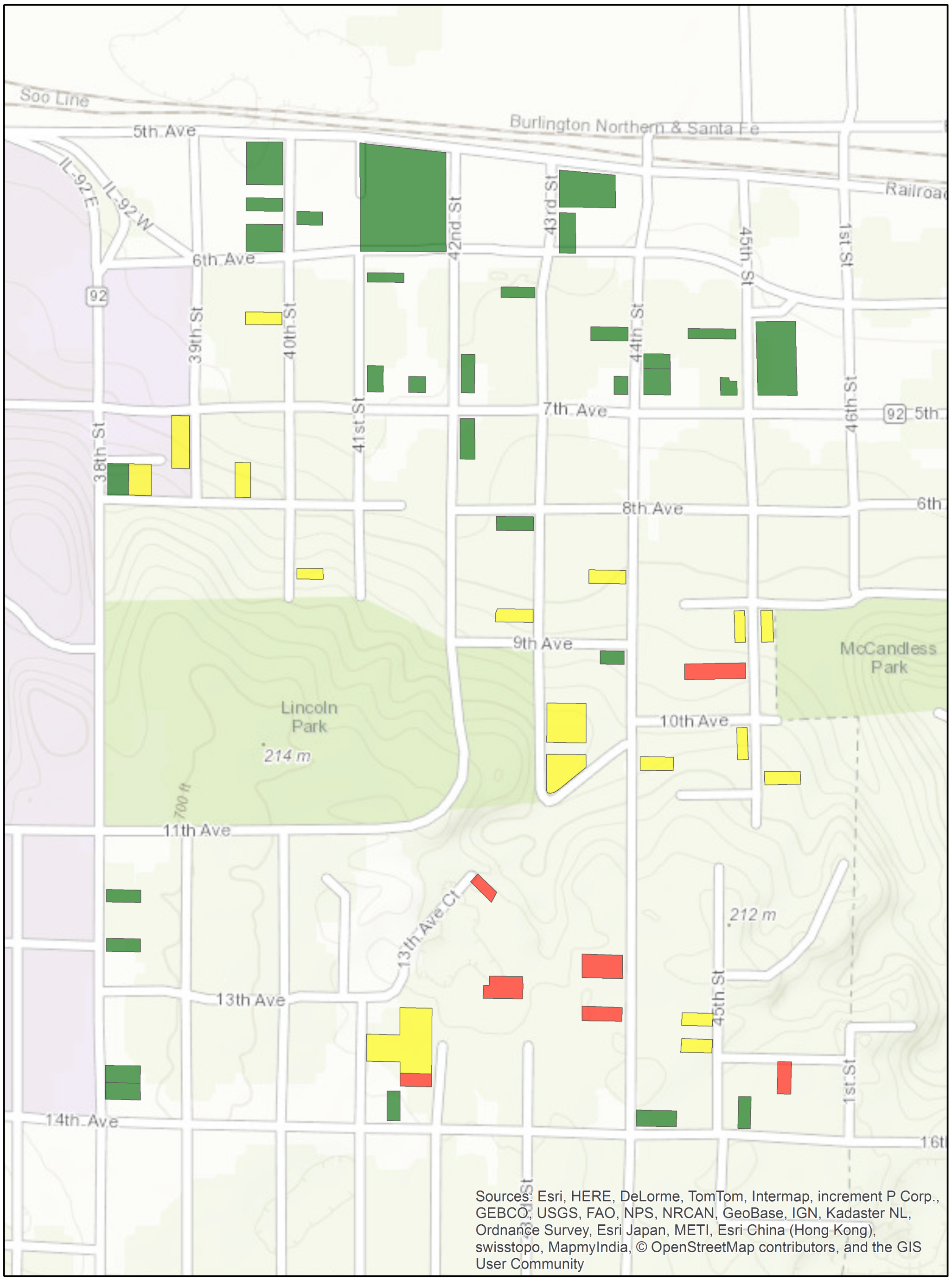
Figure 6. A map of the study area showing only the parcels that received the same rank in beautification and infiltration. These are the final sites to consider for rain gardens after having gone through the methodological process of this study.

remained the same. These were selected and made into the final map (Figure 6). This map may be presented to future parties interested in installing rain gardens in the neighborhood as a reference for poor, good, and the best parcels to place the gardens.

DISCUSSION AND CONCLUSION

It's difficult to ignore the spatial patterns that arise in these maps. There is a steady progression of color from green to yellow to red (Figure 6), with little mixing of the three. The northern section of the neighborhood has received green marks, or "best," the center section is generally ranked yellow, or "good," and although the southern part has received the most variance, it was mostly composed of parcels marked red, or "poor," for rain garden placement. This was expected due to both the socio-economic makeup and the topography of the neighborhood (Figure 7).

The Mississippi River lies on the north side of the KeyStone neighborhood, and the parcels labeled "best" for rain gardens are situated near its floodplain, the area of the neighborhood lowest in elevation. As one travels further south, the elevation rises. Halfway through KeyStone is the bluff of the river, and the southern part lies on top of the bluff. There are two reasons why these parcels are labeled best: these parcels, being at the bottom of the hill, will receive the most stormwater runoff as it flows down the bluff and into the river, making their percent change of infiltration before and after the installation of a rain garden higher than other parcels. The other reason is because of the local cultural phenomena known as "the hill." The hill is the bluff, and acts as a separator between the older, less affluent neighborhoods below the hill



Sources: Esri, HERE, DeLorme, TomTom, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community

Figure 7. A topographic map overlaid with the final parcels. One can see that the parcel rank correlates with elevation.

of Rock Island from the neighborhoods above, which are newer and house families with higher income levels. These wealthier neighborhoods are predominantly ranked “poor” among the beautification criteria, as their outward appearance is already well maintained, and they generally have smaller ranks in percent change of infiltration due to their higher elevation, making them less likely to benefit from a rain garden on their property.

Each of these patterns is well connected to the methodology of this study. It is probable that there is such a clear spatial pattern regarding the beautification ranks because of the stratification of property values when determining the sample site. In doing so, there is an equal number of parcels from each determined range creating a pattern of equality among the ranks (Table 1).

Further restrictions of this study are among the following: the limiting nature of the NSWC models, the fact that rain gardens may not have a dramatic effect on the water quality of the Mississippi River, the relative human perception of what beauty in a neighborhood looks like, the presence of multiple people determining what this beauty is at different times during the study, and the absence of a complete watershed in which the behavior of infiltration could have been monitored.

The NSWC offers two options for modeling a rain event: they are the number of years to analyze the model and event threshold. In the case of a real event, it is unlikely that the model event will occur, for the default options of the calculator were used, giving the calculator twenty years of projected data and 0.10 inches as an event threshold. Future studies might benefit from different values. Furthermore, even if the events are modeled accurately, it is possible that installing rain gardens in a watershed that drains directly into the Mississippi River will have little effect on its system, according to Dr. Norman Moline. Rain gardens would better benefit the smaller watersheds farther upstream so that the smaller stream systems will see the positive effects of less stormwater runoff, and it will be translated downstream. Directly confronting the stream of the highest order—the Mississippi River—will not manage the stormwater upstream, nor will it affect the areas downstream due to the sheer size and channelization of the river.

Concerning the beautification of the KeyStone neighborhood, determining what was beautiful in the neighborhood was a complicated process. “Beauty” is a relative term that deserves special attention. In this study, what was determined as beautiful in a parcel was a house well-maintained and a lawn well-taken care of—the conventional look of an American Dream home. Beauty in a neighborhood meant money in a neighborhood, which is a problematic assumption. Though this study was conducted to test a methodology concerning the placement of rain gardens so that they might promote neighborhood revitalization and awareness, the placement would be relative to the perceptions of the person in the field conducting the beautification criteria section of the methodology, for each person has his or her own view of what is attractive. Several student workers from Augustana College and the Upper Mississippi Center helped to determine the beautification ranks, perhaps giving a well-rounded look at the average perceptions of beauty, or perhaps the data has been skewed and was inconsistent because of the numbers of views present.

Nonetheless, the data presented in this study represents a valid proposal and argument. The idea presented by Michael Crozier that landscape architecture is at the root of a sense of place, and that a garden lies at the root of landscape architecture is particularly important. It gives the sense that rain gardens act like complex, multi-faceted beings affecting not just water quality, human perception as well.

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APPENDICES

APPENDIX A

With addresses removed to protect homeowners, this table shows the results of each parcel in the study site.

Average Percent Impervious	**Current Infiltration**	**Modeled Infiltration**	**Change**	**Infiltration Rate**	**Beautification Rate**
61.75	36	62	72.22	3	3
64	33	60	81.82	3	3
63.6	33	60	81.82	3	3
66.25	31	59	90.32	3	3
71	27	56	107.41	3	3
60.33	36	61	69.44	3	3
60	62	36	72.22	3	3
59	62	37	67.57	3	3
55.5	64	41	56.1	3	3
55.5	72	44	63.64	3	3
71.33	56	27	107.41	3	3
60.5	61	36	69.44	3	3
92.17	31	7	342.86	3	3
66.5	44	26	69.23	3	3
69	57	28	103.57	3	3
77.63	53	21	152.38	3	3
75.5	54	23	134.78	3	3
73.2	55	25	120	3	3
87.55	34	11	209.09	3	3

85.33	49	14	250	3	3
78	39	18	116.67	3	3
78.67	38	17	123.53	3	3
71.6	56	26	115.38	3	3
66.33	59	31	90.32	3	3
54.67	64	41	56.1	3	3
63.75	60	33	81.82	3	3
63.5	60	34	76.47	3	3
55	64	41	56.1	3	2
61.5	35	61	74.29	3	2
74.5	24	55	129.17	3	2
58.83	62	37	67.57	3	2
60.33	61	36	69.44	3	2
61	61	36	69.44	3	2
63	60	34	76.47	3	2
72.5	56	26	115.38	3	2
53	43	65	51.16	3	2
71.25	42	23	82.61	3	2
62	61	35	74.29	3	2
52.86	65	43	51.16	3	2
56	64	40	60	3	2
60.17	62	38	63.16	3	2
54	64	42	52.38	3	2
55.67	64	40	60	3	2
54	64	42	52.38	3	2

59.5	62	37	67.57	3	2
59	62	37	67.57	3	2
57.67	63	38	65.79	3	2
52.25	65	43	51.16	3	2
55.13	41	64	56.1	3	1
52.8	43	65	51.16	3	1
59.5	37	62	67.57	3	1
65.6	31	59	90.32	3	1
56.33	40	63	57.5	3	1
69	29	57	96.55	3	1
56.11	40	63	57.5	3	1
56.75	39	63	61.54	3	1
58.33	38	63	65.79	3	1
61.25	36	61	69.44	3	1
53	43	65	51.16	3	1
82.25	17	51	200	3	1
80.5	18	52	188.89	3	1
54.92	64	36	77.78	3	1
68.25	29	58	100	3	1
69	66	30	120	3	1
69.75	43	24	79.17	3	1
63	34	60	76.47	3	1
65	32	59	84.38	3	1
70	43	24	79.17	3	1
70	42	24	75	3	1

58	38	63	65.79	3	1
66.5	59	31	90.32	3	1
69.75	57	28	103.57	3	1
55.67	40	63	57.5	3	1
81.63	51	17	200	3	1
79.8	38	17	123.53	3	1
61.5	61	35	74.29	3	1
67.13	44	26	69.23	3	1
78.5	38	18	111.11	3	1
68.33	58	29	100	3	1
62	69	37	86.49	3	1
59.5	62	37	67.57	3	1
55.33	64	41	56.1	3	1
61.33	61	35	74.29	3	1
60	62	37	67.57	3	1
69.2	43	24	79.17	3	1
62.67	60	34	76.47	3	1
71.5	60	34	76.47	3	1
58.5	62	38	63.16	3	1
82.67	36	14	157.14	3	1
74	55	24	129.17	3	1
72.75	56	25	124	3	1
63.5	60	34	76.47	3	1
78	39	18	116.67	3	1
80.25	38	16	137.5	3	1

65.25	59	32	84.38	3	1
65.5	59	32	84.38	3	1
66.33	59	31	90.32	3	1
64.75	60	33	81.82	3	1
70	57	28	103.57	3	1
62	61	35	74.29	3	1
61.5	61	35	74.29	3	1
59.33	62	37	67.57	3	1
55.83	64	40	60	3	1
69	57	29	96.55	3	1
66	59	31	90.32	3	1
55.67	64	40	60	3	1
71.25	56	27	107.41	3	1
69.67	57	28	103.57	3	1
56.5	63	40	57.5	3	1
57.17	63	39	61.54	3	1
54.75	64	41	56.1	3	1
54.33	64	42	52.38	3	1
43.1	51	70	37.25	2	3
47.54	49	69	40.82	2	3
46.75	48	68	41.67	2	3
43	51	70	37.25	2	3
39.67	54	71	31.48	2	3
52	44	65	47.73	2	3
43	69	51	35.29	2	3

48.8	67	47	42.55	2	3
43	70	52	34.62	2	3
50	45	66	46.67	2	3
49	67	46	45.65	2	3
58.57	48	32	50	2	3
44.67	69	50	38	2	3
45.6	68	49	38.78	2	3
50.5	66	45	46.67	2	2
35	73	58	25.86	2	2
44.5	50	69	38	2	2
49	46	67	45.65	2	2
39.11	55	71	29.09	2	2
48.5	67	46	45.65	2	2
43	69	51	35.29	2	2
49.33	67	46	45.65	2	2
47.5	68	48	41.67	2	2
47.5	68	48	41.67	2	2
52	65	44	47.73	2	2
45.75	68	49	38.78	2	2
48.33	67	47	42.55	2	2
43.43	69	51	35.29	2	2
39	71	55	29.09	2	2
44.13	51	70	37.25	2	1
50.25	45	66	46.67	2	1
50.5	44	66	50	2	1

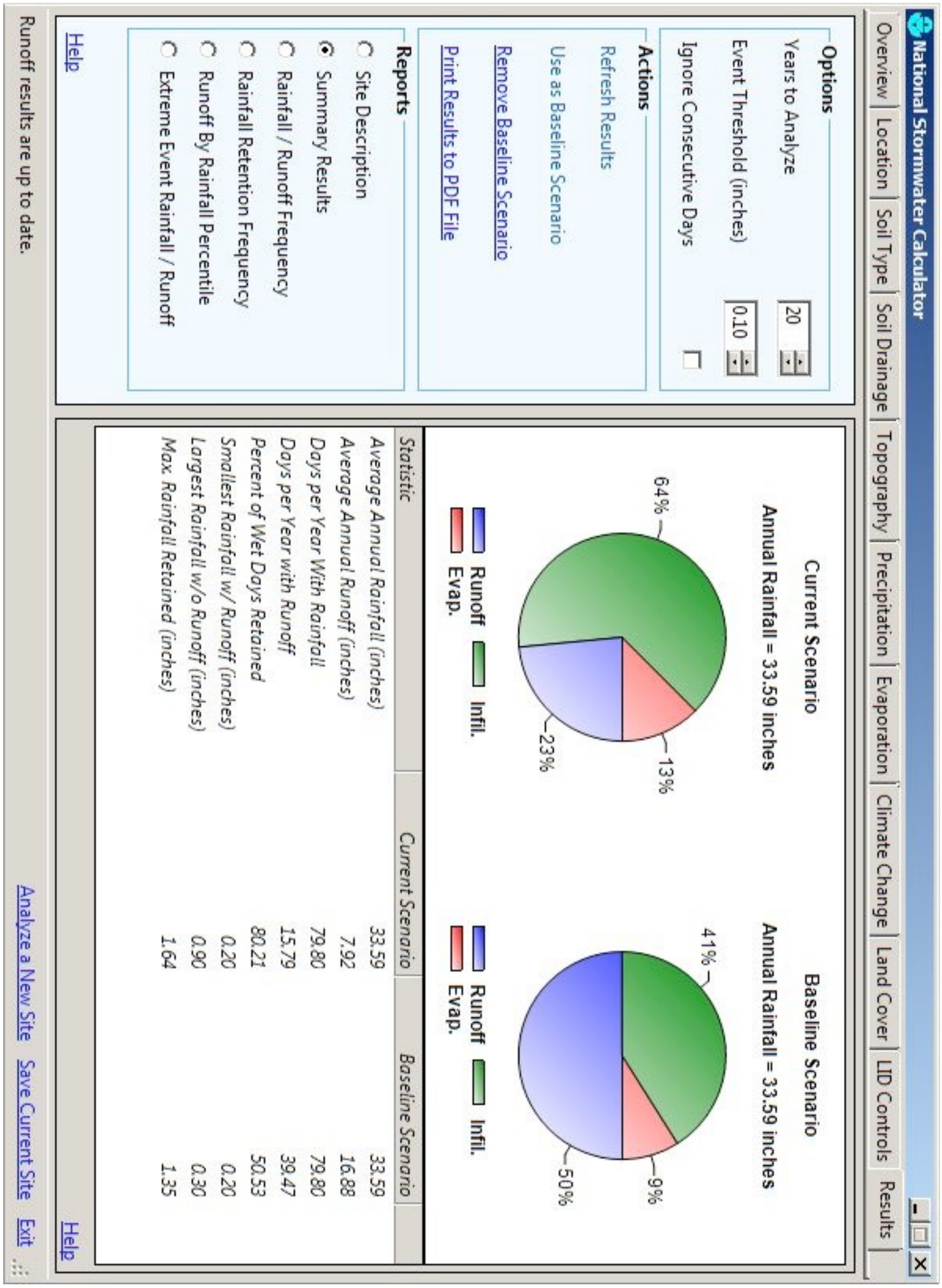
48.5	46	67	45.65	2	1
37.75	56	72	28.57	2	1
54.25	42	63	50	2	1
50.5	45	66	46.67	2	1
38	61	81	32.79	2	1
48.5	46	67	45.65	2	1
39	55	71	29.09	2	1
43.33	51	69	35.29	2	1
41	53	70	32.08	2	1
47.6	76	51	49.02	2	1
45.5	68	49	38.78	2	1
43.33	70	51	37.25	2	1
36	73	58	25.86	2	1
46	68	49	38.78	2	1
49	67	46	45.65	2	1
41	70	53	32.08	2	1
35	73	58	25.86	2	1
48.25	67	47	42.55	2	1
56.75	48	33	45.45	2	1
44.5	69	50	38	2	1
48.5	67	47	42.55	2	1
37.25	72	57	26.32	2	1
41.5	70	53	32.08	2	1
46	68	49	38.78	2	1
44.5	69	50	38	2	1

50	66	45	46.67	2	1
50	66	45	46.67	2	1
48.75	67	46	45.65	2	1
34.67	60	75	25	1	3
30	64	77	20.31	1	3
44.5	50	69	38	1	3
43	51	70	37.25	1	3
5.33	87	89	2.3	1	2
25.5	77	66	16.67	1	2
18.33	74	82	10.81	1	2
27.25	65	77	18.46	1	2
30.4	69	85	23.19	1	2
31	62	75	20.97	1	2
32	61	75	22.95	1	2
29.4	63	75	19.05	1	2
0	89	89	0	1	2
30	63	75	19.05	1	2
34.67	59	73	23.73	1	2
30	63	75	19.05	1	2
28.17	64	76	18.75	1	2
39.4	54	71	31.48	1	2
21.83	70	79	12.86	1	2
13.25	79	85	7.59	1	2
40.6	54	71	31.48	1	2
28.67	64	76	18.75	1	2

33.67	59	74	25.42	1	2
13.25	77	83	7.79	1	2
34	74	59	25.42	1	2
31.67	61	75	22.95	1	1
28	64	76	18.75	1	1
55	65	76	16.92	1	1
30.67	62	75	20.97	1	1
33.67	74	59	25.42	1	1

APPENDIX B

This image shows the final window of an analyzed example site using the EPA's National Stormwater Calculator, available at http://www.epa.gov/nrmrl/wswrd/wq/models/swc/



Options

Years to Analyze: 20

Event Threshold (inches): 0.10

Ignore Consecutive Days ☐

Actions

Refresh Results

Use as Baseline Scenario

Remove Baseline Scenario

Print Results to PDF File

Reports

- ○ Site Description
- ● Summary Results
- ○ Rainfall / Runoff Frequency
- ○ Rainfall Retention Frequency
- ○ Runoff By Rainfall Percentile
- ○ Extreme Event Rainfall / Runoff

Statistic	*Current Scenario*	*Baseline Scenario*
Average Annual Rainfall (inches)	*33.59*	*33.59*
Average Annual Runoff (inches)	*7.92*	*16.88*
Days per Year With Rainfall	*79.80*	*79.80*
Days per Year with Runoff	*15.79*	*39.47*
Percent of Wet Days Retained	*80.21*	*50.53*
Smallest Rainfall w/ Runoff (inches)	*0.20*	*0.20*
Largest Rainfall w/o Runoff (inches)	*0.90*	*0.30*
Max. Rainfall Retained (inches)	*1.64*	*1.35*

Runoff results are up to date.