Summer 2014

The Public Perception of Green Infrastructure Technologies in Omaha, Nebraska

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THE PUBLIC PERCEPTION OF GREEN INFRASTRUCTURE TECHNOLOGIES IN OMAHA, NEBRASKA

by

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AN UNDERGRADUATE THESIS

Presented to the Faculty of
The Environmental Studies Program at the University of Nebraska-Lincoln
In Partial Fulfillment of Requirements
For the Degree of Bachelor of Science

Major: Environmental Studies
With the Emphasis of: Natural Resources

Under the Supervision of Dr. Zhenghong Tang

Lincoln, Nebraska

August 13, 2014

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University of Nebraska, 2014

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Abstract

This project takes place in two neighborhoods in Omaha, Nebraska: the Saddle Hills neighborhood and the Benson neighborhood. A survey was distributed to neighborhood residents in order to gauge their understand of stormwater management and green infrastructure technologies. Currently, Omaha uses two types of stormwater/sanitary sewer systems: a combined sewer system (CSS) and a municipal separate storm sewer system (MS4). Approximately half of Omaha operates using the CSS and due to the amount of impermeable surfaces across the city when rainfall events occur the sewer treatment facility discharges untreated excess storm and sewer water into the Missouri River. According to the U.S. Environmental Protection Agency's (EPA) Combined Sewer Overflow (CSO) Control Policy implemented by the National Pollutant Discharge Elimination System (NPDES) municipalities utilizing a CSS are required by the CSO to limit overflow events to 4 annually or 85% of the CSO volume. In order to comply with the CSO Control Policy Omaha is converting the CSS to a

MS4, in addition to this Omaha is also implementing green infrastructure technologies throughout the city to retain stormwater where it originally falls for a 24-hour period in order to decrease the load rendered upon the water treatment facility. The primary research objective of the survey was to understand the current perceptions and behaviors of Omaha, Nebraska residents for stormwater and green infrastructure initiatives and to increase local and regional scientific evidence on green infrastructure practices, develop strategies to improve urban water quality and improve the effectiveness in disseminating this information to target audiences. After analysis of the surveys the conclusion was made that Omaha residents have a varied and medium level of understanding of stormwater management and green infrastructure initiatives. To resolve this issue city and industry officials should work to implement outreach and educational initiates to create a more aware public in regards to stormwater management, pollution and urban water quality.

Preface (Acknowledgements)

A special thanks to my thesis advisor Dr. Zhenghong Tang for allowing me to assist him with this UNL Urban Waters Project and teaching me about environmental planning, my thesis reader Dr. Rodrigo Cantarero teaching me in the United States and abroad the interconnected societal aspects of planning, Environmental Studies program director Dr. David Gosselin and advisor Sara Cooper ensuring preparedness and creative thinking to face future sustainability issues. Additionally, I would like to thank Yanfu Zhou, EPA technical advisor Roberta Vogel-Leutung, and Andy Szatko for their preliminary work on this project.

Introduction

Currently, Omaha, Nebraska has two types of sewer systems: a combined sewer system (CSS) and a municipal separate storm sewer system (MS4). The CSS operates as the name implies, directing stormwater runoff from streets, sidewalks, and parking lots into the same underground pipes used for sewage transportation and treatment. In the CSS, both rainwater runoff and untreated sewage are piped to a wastewater treatment facility for proper sanitation. In contrast, a MS4 has separate pipelines for stormwater runoff and sanitary sewage. The stormwater runoff is then directly discharged into nearby lakes, streams, and waterways; and the sanitary sewage is piped to a treatment facility for proper sanitation. In Omaha, Nebraska the CSS is currently being used from the Missouri River to roughly 72nd street, in what is classified as the 'older' section of Omaha.

With continued expansion of urban growth and more urban development occurring in Omaha, Nebraska the amount of impervious pavement has dramatically increased over 157 years since the city was incorporated in 1857. Now, rainfall events at a tenth (1/10") of an inch or greater causes the CSS to flood and overwhelm the wastewater treatment facility and pipes associated with the CSS, resulting in a combined sewer overflow (CSO). During a CSO the excess rainwater runoff and untreated sewage bypasses the treatment facility, resulting in the direct dumping of the rainwater runoff and untreated sewage into the Missouri River and Papillion Creek. The United States Environmental Protection Agency (EPA), through the Combined Sewer Overflow (CSO) Control Policy Act now requires municipalities with a CSS to limit their overflow events to 4 per year or mitigate 85% of the CSO volume.

President Bill Clinton's Council on Sustainable Development first coined the term *green infrastructure* in 1999 "and identified green infrastructure as one of the five strategic areas of sustainable community development" (President's Council on Sustainable Development, 1999). The President's Council on Sustainable Development defined green infrastructure as "a network

of open space, airsheds, watersheds, woodlands, wildlife habitat, parks, and other natural areas that provides many vital services that sustain life and enrich the quality of life" (President's Council on Sustainable Development, 1999). This definition of what green infrastructure is can be viewed as widely holistic by using such vague terminology, but nonetheless this definition is acceptable. The U.S. Environmental Protection Agency (EPA) defines green infrastructure as "an approach to wet weather management that is cost-effective, sustainable, and environmentally friendly…Green infrastructure management approaches and technologies infiltrate, evapotranspire, capture, and reuse storm water to maintain or restore natural hydrologies" (Allen III, 2012). The U.S. EPA definition of green infrastructure is much more narrowly defined, as well as primarily places green infrastructure emphasis at the site-scale level of development and primarily pertains to stormwater water management to increase infiltration, reduce runoff, and mitigate the potential for flooding (Allen III, 2012). Stormwater is the accumulation of precipitation from the lack of infiltration into the ground and soils by the introduction of impermeable surfaces (Parikh et. al, 2005). In urbanized areas, the increase in stormwater runoff is directly associated to the increased development of impervious surfaces, which also introduces the water to numerous sources of anthropogenic pollutants that are not found in the natural system (Parikh et. al., 2005).

This study's primary research objective is to understand the current perceptions and behaviors of Omaha, Nebraska residents for stormwater and green infrastructure initiatives (Mayer, 2012). Furthermore, this study attempts to increase local and regional scientific evidence on green infrastructure practices, develop strategies to improve urban water quality, and improve the effectiveness in disseminating this information to target audiences (Strecker, 2001).

Currently in Omaha, Nebraska most citizens are unaware of the negative effects that high amounts of stormwater runoff can have on the built environment, as well as the natural

ecosystem. In addition to being unaware of the negative effects of stormwater, Omaha citizens are also unaware of the benefits that stormwater and rainwater have by keeping that water on the site at which it originally falls upon (Allen III, 2012). Lastly, Omaha citizens are unfamiliar with the concept of green infrastructure technologies and the immense societal and ecological benefits the implementation of such technologies can bring to a community or region (Madden, 2010). Backhaus (2012) describes that the usage of green infrastructure is a "relatively recent development, with a correspondingly short record of planning experience and knowledge transfer." This further supports the notion that the general public is unaware of these technologies showing the need for enhanced education and outreach initiatives to get the public thinking about stormwater logically and creatively. Backhaus (2012) echoes the second research objective of this study stating, "closer cooperation between the planning authorities of different fields" with stakeholders throughout the implementation of green infrastructure initiatives.

Dunn (2012) suggests that one-method municipalities around the country can work to improve urban water quality "is by making green infrastructure investments." There are also added societal benefits when green infrastructure is specifically implemented in the urban poor/poverty areas (Dunn, 2012). The implementation of "decentralized storage and infiltration approaches" such as "permeable pavement, rain barrels, and cisterns to capture and reuse rainwater" can be done so relatively inexpensively and would have the greatest aesthetic impact in neighborhoods that would typically not have such green technologies (Dunn, 2012).

While the research on the performance, function, and resident attitudes of green infrastructure is limited but growing, studies in neighborhoods where green infrastructure is present shows that those residents have a "better understating of ecological systems, increased access to urban green space, [and] safe and healthier neighborhoods" (Barnhill et. al., 2012). Prior to the implementation of green infrastructure in neighborhoods residents typically are

confused by the terms "open space, green space, and green infrastructure" and the degree to which each can be beneficial to the neighborhood (Barnhill et. al., 2012). Barnhill (2012) utilized focus groups in Syracuse, New York discussing "benefits and constraints to implementation of green infrastructure" in addition to "resident's perceptions of ecosystem services, quality of life, and preferences toward implementation of green infrastructure technologies" (Barnhill et. al., 2012).

There exists significant knowledge and understanding gaps between researchers, industry, citizens, and policy makers in understanding the best methods on how to implement green infrastructure technologies and disseminate the benefits to the general public. With little knowledge about stormwater and green infrastructure Omaha citizens lack the ability to actively participate in large-scale sustainability initiatives (such as green infrastructure technologies). Stormwater educators question what approaches are most appropriate and effective when reaching out to the general public to educate them about the impacts of urban water quantity and quality related to stormwater. This study seeks to gauge the knowledge level of stormwater awareness and green infrastructure technologies of Omaha, Nebraska residents in two neighborhoods to be used to better implement green infrastructure technologies across the city of Omaha and more effectively communicate with Omaha residents.

Terminology

Combined Sewer System (CSS): a wastewater collection system which conveys sanitary wastewaters (domestic, commercial, & industrial) and stormwater through a single pipe to a publicly owned treatment works (POTW) for treatment prior to discharge to surface waters.

Discharge: When used without qualification, means the "discharge of a pollutant".

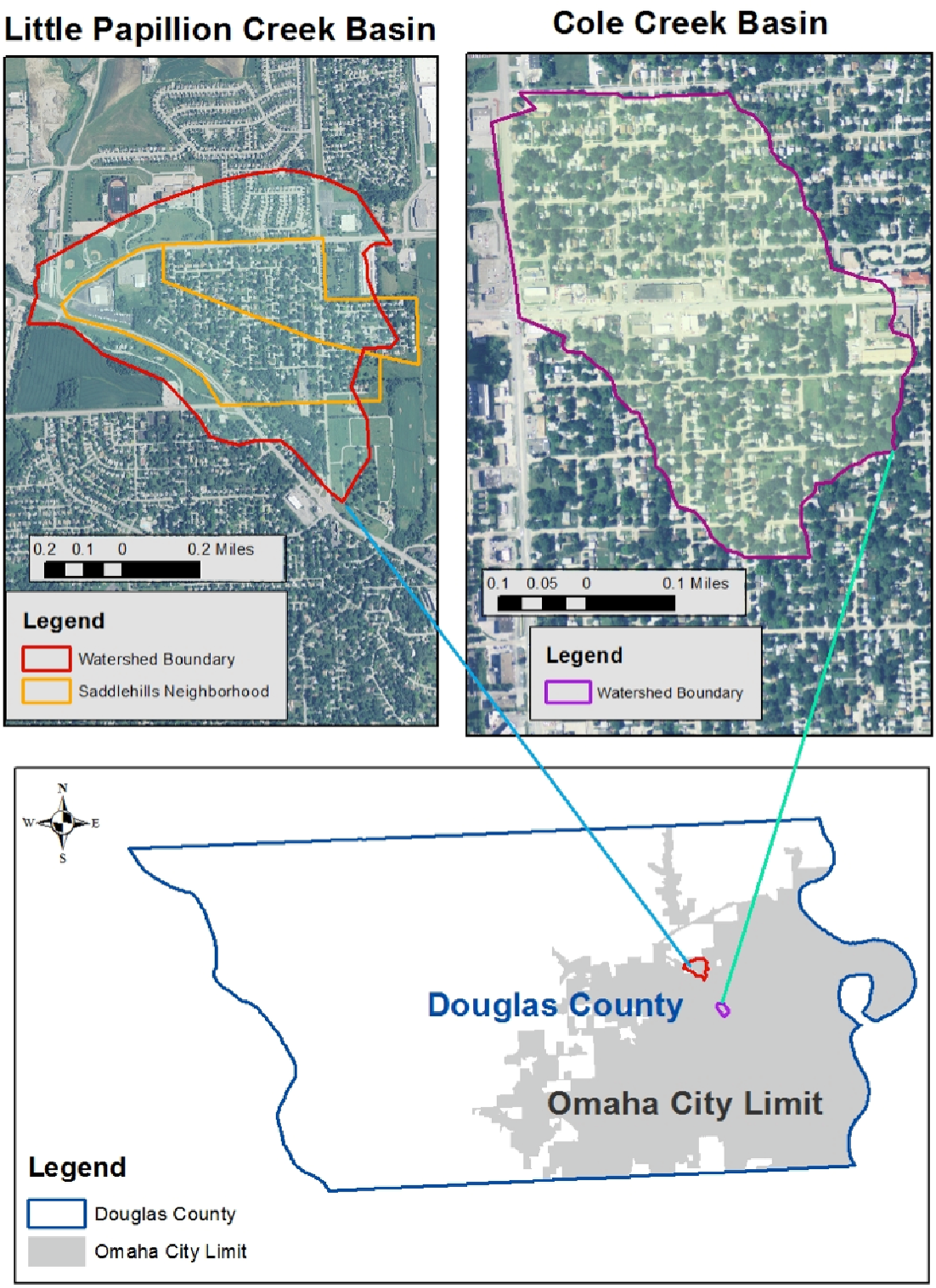
Discharge of a pollutant: Any addition of any "pollutant" or combination of pollutants to "waters of the United States" from any "point source", or any addition of any pollutant or combination of pollutants to the waters of the "contiguous zone" or the ocean from any point source other than a vessel or other floating craft which is being used as a means of transportation. This includes additions of pollutants into water of the United States from: surface runoff which is collected or channeled by man; discharges through pipes, sewers, or other conveyances, leading into privately own treatment works.

Municipal Separate Storm Sewer System (MS4): A conveyance or the system of conveyances (including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains):

i. Owned or operated by a State, city, town, borough, county, parish, district, association, or other public body (created by or pursuant to State law) having jurisdiction over disposal of sewage, industrial wastes, stormwater, or other wastes, including special districts under State law such as sewer district, flood control district or drainage district, or similar entity, or an Indian tribe or an authorized Indian tribal organization, or a designated and approved management agency under section 208 of the CWA that discharges to waters of the United States;
ii. Designed or used for collecting or conveying stormwater;
iii. Which is not a combined sewer; and
iv. Which is not part of a Publicly Owned Treatment Works as defined at 40 CFR 122.2.

Pollutant: Dredged spoil, solid waste, incinerator residue, filter backwash, sewage sludge, munitions, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial, municipal and agricultural waste discharged into water.

Stormwater: Stormwater runoff, snow melt runoff, and surface runoff and drainage.



(Project location map provided by Dr. Zhenghong Tang.)

Methods

The study will take place in two separate neighborhoods of Omaha, Nebraska. The first study area is the Little Papillion Creek Basin, also, for the case of this study, is known as the Saddle Hill neighborhood located between the streets of Blair High Road and Crown Point Avenue in Omaha, Nebraska. The area is covered by a 20-year neighborhood (named Saddle Hills) that includes a variety of ethnicities and income levels. The Saddle Hills neighborhood is approximately 60 acres in area and the entire neighborhood drains down to a single outflow at the bottom of the neighborhood. The stormwater runoff from the Saddle Hills neighborhood discharges directly into the Little Papillion Creek. This is a significant feature in choosing this neighborhood as one of the study site, because the neighborhood is a complete watershed within the proper city of Omaha, Nebraska.

The second area is the Cole Creek Basin, also, for the case of this study, is known as the Benson neighborhood located between 72nd Street on the west, 67th Street on the east, Bedford Street on the north, and Lake Street on the south. There exist a variety of land uses in the Benson neighborhood including commercial, educational, and single/multi-family housing covering an area of approximately 101 acres. Relative to the city of Omaha, the Benson neighborhood is an old neighborhood where a majority of the buildings are 50-100 years-old and high percentage minority and middle-low income households. The watershed that contains the Benson neighborhood drains directly into Cole Creek that is located northwest of the study area. Another feature that makes the Cole Creek Basin/Benson neighborhood a good location to study is that Cole Creek has significant stream bank erosion and is of high concern to the city of Omaha.

The study will take place by surveys distributed to the two study areas, aimed at an estimated 1,300 households (600 households in the Saddle Hills neighborhood and 900 households in the Benson neighborhood). The 47-question survey developed by Dr. Zhenghong

Tang will seek to obtain the level of knowledge, the current behaviors, and perception of stormwater and related issues from the two study areas (Barnhill et. al., 2012). The questions were specifically designed to assess what the residents currently knew about stormwater management practices, the role stormwater management at the site, neighborhood and watershed scale in addition to where and how stormwater pollutants originate and their effect. The survey will also attempt to identify resident's understanding of green infrastructure, the purpose of green infrastructure, and the costs and benefits associated with the implementation of green infrastructure technologies. Questions will also be written to gauge resident's understanding of scientific concepts such as the water cycle, definition of a watershed, and current policies and laws regarding what substances are and are not permissible in stormwater drains, waterways, streams, and lakes. After the residents have completed the survey, 20 strategic questions that were asked will be examined, graded and used as the main content from which analyses and summaries will be drawn. This is done so to ensure that the analysis only takes into account the survey questions of interest for this study. The survey was designed to include question that pertained to household income, property value, and education level that were not directly relevant to the objectives of this particular study.

The analysis method chosen for this study is to classify the selected 20 questions of the survey into categories congruent with their percent answered correct while using that classification to draw a descriptive summary about the two study areas. The descriptive summary drawn from the results of the selected survey questions will then be used to identify the level and type of engagement created by the city of Omaha for outreach and communication purposes to the public regarding stormwater management and green infrastructure initiatives.

Results

On August 2, 2012 a community meeting was held in the Saddle Hills neighborhood (Little Papillion Creek Basin area) to discuss Omaha's urban water quality and related projects. At the meeting there were 35 participants in attendance and as part of the meeting they were asked to complete the 20-question survey. Of the 35 participants in attendance, 23 completed surveys were collected following the conclusion of the community meeting. Thus, the sample from the Saddles Hills neighborhood equals N=23.

In September of 2012, 410 letters were mailed out to residents in the Benson neighborhood (Cole Creek Basin area) containing the 20-question survey. Of the 410 letter mailed out, 18 surveys were returned completed. Thus, the sample from the Benson neighborhood equals N=18. Combining the survey results between the two watersheds (from the Saddle Hills neighborhood and the Benson neighborhood) the overall sample total equals N=41.

Analyses of the survey results were conducted by categorizing each question based on its percent answered correctly. There were five ranges to which answers could be categorized, those being: (1) Very Well - 80% or more correct, (2) Well - 70%-80% correct, (3) Moderately - 60%-70% correct, (4) Weakly - 50%-60% correct, and (5) Very Weakly - 50% or less correct. The Saddle Hills neighborhood and the Benson neighborhood results were analyzed separately to gain the level of understanding between the two watersheds and communities in this project. The results of both neighborhoods were also combined to use a gauge the level of understanding among Omaha residents as a whole.

Survey responses from the Saddle Hills neighborhood were analyzed as:

(1) Vey Well – 80% or more correct: Q1, Q5, Q6, Q8, Q9, Q11, Q19 & Q20
(2) Well – 70%-80% correct: Q13
(3) Moderately – 60%-70% correct: Q2, Q7 & Q10
(4) Weakly – 50%-60% correct: Q3, Q4 & Q17
(5) Very Weakly – 50% or less correct: Q12, Q14, Q15, Q16 & Q18

(N=23)

Survey responses from the Benson neighborhood were alternatively only analyzed into three categories due to the smaller range of the percentage of correct answers, those being: (1) Very Well – 80% correct or more, (2) Moderately – 60%-70% correct, and (3) Weakly – 50% or less correct.

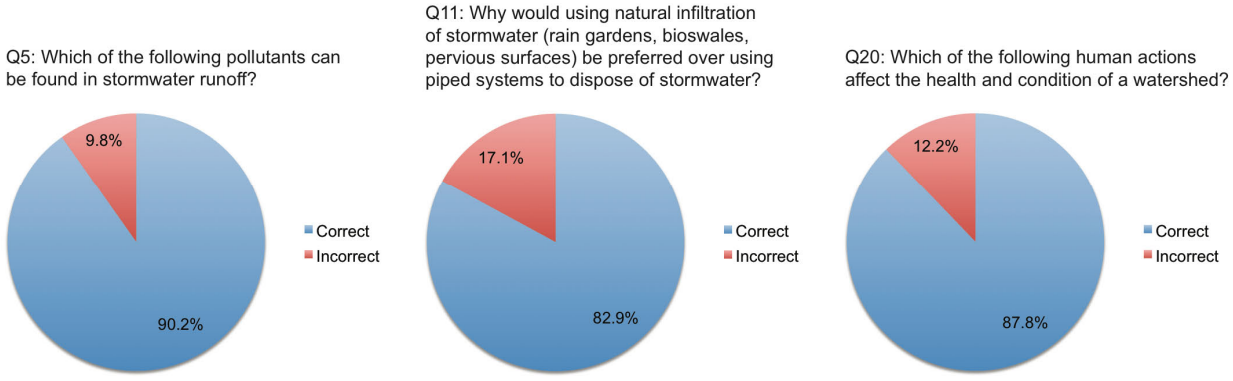
(1) Very Well – 80% correct or more: Q1, Q5, Q6, Q8, Q9, Q10, Q11 & Q20
(2) Moderately – 60%-70% correct: Q2, Q4, Q7, Q13, Q17 & Q19
(3) Weakly – 50% or less correct: Q3, Q12, Q14, Q15, Q16 & Q18
(N=18)

Combining survey responses from the Saddles Hills neighborhood and the Benson neighborhood yielded the results:

(1) Very Well – 80% correct or more: Q1, Q5, Q6, Q8, Q9, Q11 & Q20
(2) Well – 70%-80% correct: Q10 & Q19
(3) Moderately – 60%-70% correct: Q2, Q7 & Q13
(4) Weakly – 50%-60% correct: Q4 & Q17
(5) Very Weakly – 50% or less correct: Q3, Q12, Q14, Q15, Q16 & Q18

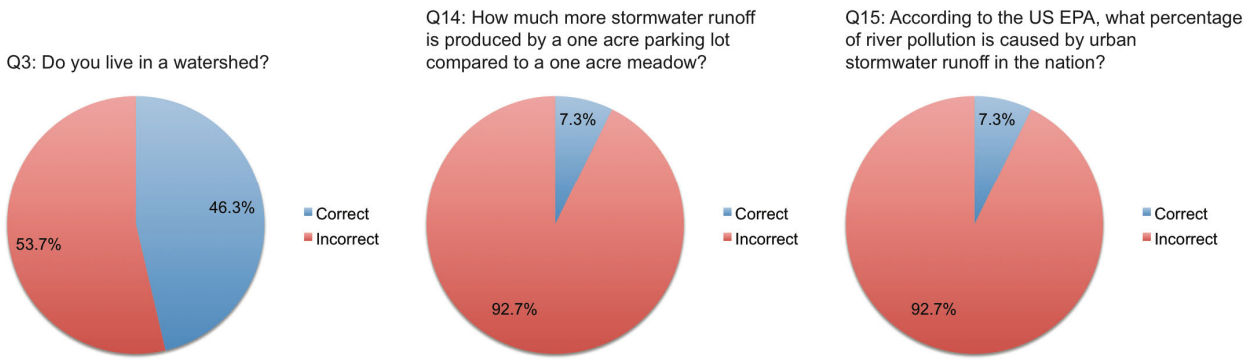
Graphs of three questions contained in the 'Very Well' and 'Very Weakly' category were created to show exact percentages of each.

Very Well Responses



(Figure 1)

Very Weakly Responses



(Figure 2)

Comparing the questions that were most commonly answered 'Very Well' to those questions that were answered 'Very Weakly' will show where the public's knowledge gap lies and provides to city and industry officials areas where greater communication can be made. The results from the surveys were similar to those hypothesized in that Omaha residents would have an understanding of some topics related to stormwater management, but other topics would not be well known about. Attached in the Appendix is a comparison between the different survey results.

Discussion

Analysis of the survey results has yielded the descriptive conclusion between the two study sites that city of Omaha residents, in general, have a varied and medium level of understanding about stormwater management and green infrastructure initiatives. In addition to having a varied and medium level understand about stormwater management and green infrastructure initiatives, residents are unaware of the negative effects high amounts of stormwater runoff has on the built environment and adjacent natural ecosystem. Furthermore, Omaha residents are very unaware of the benefits of keeping rainwater on the site where it originally falls. This study also shows that age groups, socioeconomic and education levels do not factor into resident's level of understanding these concepts; this variance is observable

between both groups. Gaining this insight about the perception Omaha residents have in regards to stormwater management and green infrastructure initiatives sets up a communication dilemma when government and industry officials attempt to design and launch stormwater management and green infrastructure initiatives in respective neighborhoods and urban watersheds. Without community backing and understanding, green infrastructure initiatives won't achieve their maximum potential water conserving benefit (McDonald et. al., 2011). For this reason a greater step must be taken to reach out to the public and neighborhood leaders to inform them about the costs of traditional (or 'grey') stormwater management and display the benefits green infrastructure as a means of stormwater management (Dietz, 2007).

Looking at the results of the 'Very Well' answered survey questions (Figure 1) the residents do understand and have knowledge about what green infrastructure is, the issues regarding pollutants, and how human influences impact the environment. Examining the results of the 'Very Weakly' answered survey questions (Figure 2) shows that residents do not visualize their place in the ecosystem and the quantity of water that enters the stormwater system. This is why the conclusion has been made that Omaha residents have a varied and medium level of understand about stormwater management and green infrastructure technologies. This level of knowledge should be enhanced to through educational efforts to show residents that stormwater in some cases is a pollutant but should be utilized as a resource. Omaha has already begun the process to educate the public by holding events such as World O! Water Festival, Under The Sink tours, and cleanup days organized by Keep Omaha Beautiful, Inc. (Environmental Quality Division, 2012).

Acting on this concern, outreach and education efforts must coincide with the development of new green infrastructure initiatives. Pre-construction and post-construction informative community demonstrations will allow city and industry officials to engage nearby

neighborhood residents with the goal of creating a proactive and knowledgeable public in regards to stormwater management efforts and related ecosystem benefits green infrastructure offers.

The U.S. Environmental Protection Agency (EPA) has described in their document titled *Getting in Step: Engaging and Involving Stakeholders in Your Watershed* a framework for community outreach that can be applied in the case for the city of Omaha and their green infrastructure initiates as part of their MS4 development. Working with neighborhood leaders, city and industry officials should work to seek out stakeholders in the adjacent communities and actively work with them to describe the changes that are planned on being made while demonstrating the benefits green infrastructure will provide. This plan requires a three-stage process: 1) Awareness Stage, 2) Education Stage, and 3) Action Stage (Tonning et. al., 2007).

Awareness Stage

The Awareness stage describes the first step that needs to take place in order to generate involvement and support of the proposed green infrastructure project. At this point it is critical to simply inform the neighborhood and surrounding residents about the issues of the CSS and its detrimental and costly effects and describe the general plan regarding the MS4 along with the implementation of green infrastructure initiatives and technologies (Tonning et. al., 2007). Literature, including background information on the issue and proposed project, as well as a map of the urban watershed delineating where rainwater naturally flows in an easy to understand fashion (Tonning et. al., 2007). Reaching out to media outlets at this point in the project, providing them with an urban watershed map, background information on the purpose of the project, a list of city and industry officials the public is able to contact with their questions and concerns, and a description of the preliminary scope of the project in addition to quotes by those involved (Tonning et. al., 2007). After assembled this information can be submitted to all local

media outlets including print, television, radio and online sources (Tonning et. al., 2007). During the Awareness stage it is also critical to give presentations to the local public about the green infrastructure project by city and industry officials.

Education Stage

Once the public has been made aware of the changes to come the Educational stage of the outreach plan is next to be implemented. During the Educational stage, more specifically researched information about the proposed green infrastructure project should be distributed to the key neighborhood stakeholder groups but together by the city and industry officials in charge of the project. Additionally, during the Education stage is when a dialog between city and industry officials and neighborhood/community stakeholders should begin to develop a sense of understanding between the two (or more parties) in regards to their "values, attitudes, [and] concerns" related to the success implementation of the green infrastructure project (Tonning et. al., 2007). Neighborhood stakeholder groups should be viewed and utilized as a critical, locally knowledgeable resource and their input should be taken seriously into the design of the green infrastructure project (Tonning et. al., 2007).

City and industry officials should continue to submit project information and progress to media outlets and community newsletters. More specific and targeted information regarding the project should be distributed to groups such as gardening associations, Boy's and Girl's Scouts, local religious institutions, local businesses, elementary and high schools (Tonning et. al., 2007). A general slide show regarding the green infrastructure project highlighting geographic regions, major stormwater management issues/concerns, types and sources of local stormwater pollutants, and the ecological/financial benefit the implementation of green infrastructure projects will provide compared to the alternative methods of management (Tonning et. al., 2007). Outreach in the form of sponsored events at the green infrastructure site would allow city and industry

officials to give tours, walkthroughs, and demonstrations that would allow the public and nearby residents to observe firsthand the scope of the project while gaining understanding of the project's purpose as a means for stormwater management throughout the watershed (Tonning et. al., 2007).

Action Stage

The Action stage of public outreach works best once the green infrastructure project has been completed and is operational. Monitoring of the completed green infrastructure site during and after rainfall events will give city and industry officials crucial feedback (Tonning et. al., 2007). Not all green infrastructure technologies are the same, additionally, not all urban watersheds are the same (nor have similar specific concerns), and thus there exists a delicate balance when choosing what green infrastructure technology to site at a specific location (Allen III, 2012). Furthermore, the reaction to different types of green infrastructure technologies is to be expected by each neighborhood and community where they are located (Barnhill et. al., 2012). Analyzing the performance of the implemented green infrastructure technology, as well as the social perception of that technology are two critical components that factor the successfulness of green infrastructure (Tonning et. al., 2007).

After the project has been completed, city and industry officials should hold a community/city-wide ribbon cutting ceremony or another major public event to showcase the project, which in-turn enhances the educational aspect of the outreach plan (Tonning et. al., 2007). Utilizing government and city officials, industry and business leaders, and academics as speakers at such an event would acknowledge the necessary collaboration needed for the successful implementation of green infrastructure technologies that are, as shown by the survey, not well known about by the public as a method for stormwater management (Tonning et. al., 2007).

(Representative Lee Terry (R-NE) speaking at the ribbon cutting ceremony at a green infrastructure site in the Benson neighborhood / Photo Credit: Matthew Spohr)

Utilizing online social media websites (Facebook, Twitter, etc.) would further allow city and industry officials implementing green infrastructure technologies another means to connect with a targeted audience and stakeholders for educational purposes. Currently, The Omaha Stormwater Program is managing an active Facebook page called 'Omaha Stormwater' where informative posts showing subscribers various green infrastructure site locations around Omaha, do's/don't of household care to minimize the level of pollutants that enter stormwater drains, and various festivals or community-wide gatherings where Omaha Stormwater has a booth set up to

interact and discuss stormwater management and green infrastructure technologies with the public.

With the combination of an active outreach plan and utilizing social media outlets, city and industry officials can connect with and educate more of the public about stormwater issues. Currently, there does exist a disconnect in the level of understand and knowledge about problematic aspects of stormwater management, but with educational campaigns, green infrastructure site visits/demonstrations, and an active social media presence The Omaha Stormwater Program can better implement their goals during their process meeting the National Pollutant Discharge Elimination System (NPDES) municipal stormwater discharge permit.

Conclusion

This study selected two neighborhoods in Omaha, Nebraska 1) Saddle Hills neighborhood and 2) Benson neighborhood. The Saddle Hills neighborhood was selected to be part of this study because the neighborhood encompasses its own complete watershed and can be used in the future for stormwater management studies dividing the neighborhood to create a controlled environment. The Benson neighborhood was chosen due to its mixed socioeconomic income levels, a variety of land-sue types in the neighborhood, and the neighborhood's stormwater discharge location has experienced severe erosion and pollution. The study consisted of a survey distributed to both neighborhoods yielding a total of 41 (N=41) completed returned surveys. The research objectives of this study were to understand the current perceptions and behaviors of Omaha, Nebraska residents for stormwater management and green infrastructure initiatives, and to increase local and regional scientific evidence on green infrastructure practices, develop strategies to improve urban water quality and improve the effectiveness in disseminating the information to target audiences (Mayer, 2012) (Strecker, 2001). Analyzing the results of the

surveys showed there exists a varied and medium level of understanding of stormwater management and green infrastructure initiates by the public.

Understanding that there is a knowledge gap between city and industry officials working to alleviate stormwater pollution and the public, working to bridge this misunderstanding can done so by creating interactive education efforts in the neighborhoods where stormwater pollution is a concern and additionally utilizing online sources such as websites and social media sites (Facebook, Twitter, etc.) to engage residents in a digital format. While the survey results showed that there does currently exist a varied and medium level of understanding of stormwater management and green infrastructure technologies by the public, moving into the future, this does not have to be the status quo. Residents are unaware of the detrimental effects of urban stormwater runoff because they are not taught to recognize rainwater as a pollutant. Building on this notion, stormwater can become a pollutant force when it is not understood and managed correctly. Installing residents with the idea that stormwater is a value resource, especially in times of drought and climate change, and should be harnessed and utilized rather than sending it down the drain will only aid urban centers financially and ecologically (Backhaus et. al., 2012).

Building off the results of the study in regards to the research objectives it is evident that much more proactive efforts need to be made to enhance the residents understanding about stormwater management and green infrastructure technologies. Knowing the current perception of residents on stormwater related issues will give those involved with future green infrastructure projects a baseline to start at and build from during their educational efforts (Barnhill et. al., 2012). Also understanding an outreach plan that gets residents excited and supportive of the proposed green infrastructure project further increases the level of success the project will obtain.

Taking into consideration this study's scope and discoveries made about the level of knowledge Omaha residents have, it would be highly beneficial to conduct a similar study after

the education, outreach, and construction of a green infrastructure project has been completed in a particular neighborhood to develop pre-project and post-project knowledge levels to gauge the successfulness in creating a more aware public. The experimentation with alternative outreach methods to increase the education of stormwater management should be considered. This could include acquiring the direct intervention of the public, schools, and local business leaders in the design and construction of green infrastructure projects as community service or community revitalization campaigns. Further studies should also seek to identify what scientific concepts the public lacks understanding of to increase support of stormwater management plans. This could include education campaigns to teach the public about ecological systems such as the water cycle, how watersheds function, and how pollutants travel through the environment. Additional studies can look at to what degree elected public officials value and place an emphasis on ecosystem system services and water conservation efforts, which has a direct result on the amount of public funding that could be made available to such projects needed to combat substandard urban water quality and quantity.

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Appendix

Table 1. A comparison between different survey results (percentages of correct responses)

Question	Saddle Hills	Benson	Overall
1. Stormwater is rain water or snowmelt that runs off surfaces such as rooftops, lawns, paved streets, graveled roads, driveways, and parking lots. A. True B. False	91.3%	100.0%	95.1%
2. Where does most of the stormwater go? A. To the sewage treatment plant B. To a separate stormwater treatment plant C. Directly into local waterways D. I'm not sure	60.9%	61.1%	61.0%
3. Do you live in a watershed? A. Yes B. No C. Don't know	56.5%	33.3%	46.3%

4. A watershed is generally defined as: A. a building that stores water B. all the land area that drains to a given point in a water body C. all the water area that drains to a given point in a landform D. a moment in time when you cross into a new area E. a new way of organizing environmental agencies	52.2%	66.7%	58.5%

5. Which of the following pollutants can be found in stormwater runoff? A. Bacteria B. Nutrients C. Heat D. Oil and Grease E. All of the Above	91.3%	88.9%	90.2%
6. All storm drains flow to a treatment plant where the stormwater is treated before it goes into a river or stream. A. True B. False	87.0%	94.4%	90.2%
7. It is best to apply lawn chemicals before a rain so that the rain can force the chemicals into the ground. A. True B. False	60.9%	61.1%	61.0%
8. The major pollution contributor to stormwater is industry. Pet waste and grass clippings don't contribute at all. A. True B. False	87.0%	100.0%	92.7%
9. Would you eat a fish that was swimming in water polluted by storm water runoff? A. Yes B. No	82.6%	94.4%	87.8%

10. Which of the following has the greatest percentage of impervious cover in suburban areas? A. Rooftops B. Lawns C. Roads, parking lots or driveways D. Vacant lots	69.6%	83.3%	75.6%
11. Why would using natural infiltration of stormwater (rain gardens, bioswales, pervious surfaces) be preferred over using a piped system to dispose of stormwater. A. Natural infiltration techniques cost less B. Natural infiltration recharges groundwater C. Natural infiltration could contaminate groundwater D. Both A & B E. I am not sure	82.6%	83.3%	82.9%
12. Recent watershed research has discovered that urban stream quality begins to sharply decline once impervious cover in a watershed exceeds: A. 10% B. 20% C. 30% D. 45% E. 75%	21.7%	5.6%	14.6%

13. How many gallons of water fall on a one-acre yard during a one-inch rainfall? A. 45,000 gallons B. 27,200 gallons C. 4 imperial gallons + one pint D. enough to flood my basement E. None	73.9%	61.1%	68.3%
14. How much more stormwater runoff is produced by a one acre parking lot compared to a one acre meadow? A. 6% B. 78% C. no difference D. 100% E. 1600%	4.3%	11.1%	7.3%
15. According to the US EPA, what percentage of river pollution is caused by urban stormwater runoff in the nation? A. virtually none, industrial pollution is the major problem B. virtually none, trees cause pollution C. 11% D. 21% E. 99%	8.7%	5.6%	7.3%

16. A single quart of motor oil dumped down a storm sewer creates an oil slick of what size? A. no slick, oil sinks to bottom B. no slick, oil travels from storm sewer to treatment plant C. 160 square feet D. 2 acres E. twice the size of the Exxon Valdz	47.8%	44.4%	46.3%
17. Which of the following statements about urban lawns is false? A. some common pesticides applied to lawns are routinely detected in urban streams B. few people take soil tests before applying fertilizers to their lawn C. atmospheric deposition supplies at least a third of the nutrients needed for a lawn D. lawns produce no runoff	52.2%	66.7%	58.5%
18. What well known American said "When the well's dry, we know the worth of water"? A. Will Rogers B. Aldo Leopold C. Chris Rock D. Ben Franklin E. Mark Twain	8.7%	38.9%	22.0%

19. Choose all of the following you have participated in over the past year: A. River clean-ups B. Adopt-a-road litter collection C. Recycling D. Volunteer water monitoring E. Storm drain marking F. Household Hazardous Waste drop-offs G. Other:	87.0%	61.1%	75.6%
20. Which of the following human actions affect the health and condition of a watershed? A. Increasing impervious surfaces through building roads, houses, and parking lots B. Removing vegetation along drainage ways and streams C. Straightening stream channels and piping stormwater directly into waterways D. All of the above	87.0%	88.9%	87.8%