CITY OF OMAHA
NPDES PERMIT FOR THE MUNICIPAL SEPARATE STORM SEWER SYSTEM (MS4)
NE0133698
2016 ANNUAL REPORT

Submitted by:
Environmental Quality Control Division
5600 S. 10 St.
Omaha, NE 68107

April 1, 2016

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"I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering the information, the information submitted is to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for known violations. See 18 U.S.C. 1001 and 33 U.S.C 1319, and Neb. Rev. Stat. 81-1508 thru 81-1508.02."

James P Kee Jr

Signature of Authorized Representative or Cognizant Official

3/31/2017

Date

JAMES P KEE JR

Printed Name

EQCD Manager

Title

Introduction

The second Omaha Municipal Separate Storm Sewer System (MS4) National Pollutant Discharge Elimination System (NPDES) Permit (NE0133698/PCS 999428) was issued by the Nebraska Department of Environmental Quality (NDEQ) and became effective on October 1, 2008. The MS4 permit authorizes the City of Omaha to discharge storm water from all existing City of Omaha owned or operated MS4 outfalls to the Papillion Creek, the Missouri River, and their tributaries subject to the identified limitations and the Storm Water Management Plan (SWMP) as modified. The City's Environmental Quality Control Division (EQCD) oversees the administration of the permit and ensures that the City is in compliance with the permit requirements.

The MS4 permit was issued for a five-year period and expired on September 30, 2013. The NDEQ issued an administrative extension to this permit in October 2013. The MS4 permit identifies the current City of Omaha SWMP. The SWMP requires the City to submit an annual report and a semi-annual progress report to the NDEQ. In addition, reports will be made available to the public on the Omaha Stormwater Program (www.omahastormwater.org) and Papillion Creek Watershed Partnership web sites (www.papiopartnership.org).

The City of Omaha Departments that participates in meeting the MS4 permit requirements include:

- Public Works Department
  - Environmental Quality Control Division
  - Street Maintenance Division
  - Sewer Maintenance Division
  - Construction Division
  - Design Division
- Parks, Recreation and Public Property Department
  - Park Maintenance
  - Golf Operations
- Fire Department
- Law Department
- Planning Department

The City is committed to partnering with several organizations to meet the MS4 requirements in the most efficient manner possible. The major partners are listed below. The City intends to continue developing additional partnerships throughout the permit cycle to meet the permit requirements.

- Keep Omaha Beautiful (KOB)
- Papillion Creek Watershed Partnership (PCWP)
- Douglas-Sarpy County Extension Office
- Papio-Missouri River Natural Resource District (P-MRNRD)
- Natural Resource Conservation Service (NRCS)

This report satisfies the annual reporting requirement for permit year 8 and covers the calendar year from January 1, 2016 through December 31, 2016. The report is laid out as follows: the program elements are shaded, the permit requirements are underlined, and the City's description of permit compliance is in plain text.

I. Public Education & Outreach

A. Distribute informational brochures on the proper disposal of household hazardous wastes and the availability of the Household Hazardous Waste facility.

The City of Omaha contracted with Keep Omaha Beautiful, Inc. (KOB) to distribute educational information. In the annual report submitted to the City by KOB they reported distributing a total of 1,862 brochures at locations and community events throughout 2016. The 1,862 brochures that were distributed covered topics concerning household hazardous waste. Brochures were primarily provided to adult participants attending KOB's outreach events and delivered to commercial and public locations around the City. Below is a summarized list of the locations where materials were distributed.

King Science & Technology Magnet Center (3720 Florence Blvd)
Fontenelle Elementary School (3905 N 52nd St)
Roncalli Catholic High School (6401 Sorensen Pkwy)
St. Margaret Mary's Catholic School (123 N 61st St)
St. Margaret Mary's Catholic School (123 N 61st St)
Community of Grace Christian Lutheran Church (3434 N 204th St)
Columbus Park Community Center (1515 S 24th St)
Monroe Middle School (5105 Bedford Ave)
UNO College of Public Affairs & Community Service (6320 Maverick Plaza)
Rose Theater (2001 Farnam St)
UNO Community Engagement Center (6100 Dodge Street)
Sandoz Elementary (5959 Oak Hills Dr)
Rose Theater (2001 Farnam St)
Rose Theater (2001 Farnam St)
Marian High School (7400 Military Ave)
Women's Center for Advancement (222 S 29th St)
King Science & Technology Magnet Center (3720 Florence Blvd)
St. Cecilia Cathedral Grade School (3869 Webster St)
Our Lady of Lourdes School (2124 S 32nd Ave)
Belle Ryan Elementary School (1807 S 60th St)
Mercy High School (1501 S 48th St)
Dundee Elementary School (310 N 51st St)
First United Methodist Church (7020 Cass St)

St. Martin De Porres Center (2111 Emmet Street)
Spring Ridge Elementary School (17830 Shadow Ridge Dr)
Omaha Northwest High School (8204 Crown Point Ave)
Union Pacific Headquarters (1400 Douglas St)
Elmwood Park (Elmwood Park Dr. & Jones St.)
Brownell-Talbott School (400 N Happy Hollow Blvd)
Dundee Elementary School (310 N 51st St)
Gomez Heritage Elementary School (5101 S 17th St)
Durham Museum (801 S 10th St)
Omaha's Henry Doorly Zoo & Aquarium (3701 S 10th St)
Metropolitan Community College (5300 N 30th St)
Dundee Elementary School (310 N 51st St)
Lauritzen Gardens (100 Bancroft St)
Central Middle School (12801 L St)
Joslyn Elementary School (11220 Blondo St)
Benson High School (5120 Maple St)
Beals Elementary
UNMC (42nd St & Emile St)
Dundee Elementary School (310 N 51st St)
Jewish Community Center (333 S 132nd St)
Castelar Elementary School (2316 S 18th St)
YMCA Southwest Omaha Branch (13010 Atwood Ave)
Lewis & Clark Middle School (6901 Burt St)
Liberty Elementary School (2021 St Marys Ave)

UNO Community Engagement Center (6100 Dodge Street)
Immaculate Conception Church (2708 S 24th St)
Assumption-Guadalupe Parish Office (4930 S 23rd St)
Emmaus Bible Church (4501 S 23rd St)
St. Luke's Lutheran Church (2315 I St)
St. Martin of Tours Church (2324 J St)
Iglesia Cristiana Discípulos (4401 S 23rd St)
Grace Methodist Church (2418 E St)
Heartland Workers Center (4923 S 24th St)
Columbus Park Community Center (1515 S 24th St)
The Salvation Army Kroc Center (2825 Y St)
Kids Can Community Center (4860 Q St)
Justice for Our Neighbors (2414 E St)
One World Community Health Center (4920 S 30th St)
Boys & Girls Club - South Omaha Branch (5051 S 22nd St)
Downtown Omaha YMCA (430 S 20th St)
El Museo Latino (4701 S 25th St)
SAC Federal Credit Union (4704 S 24th St)

Wells Fargo Bank (4650 S 24th St)
GI Forum Omaha (2002 N St)
Whole Foods Market (10020 Regency Cir)
Bank of the West (4724 S 24th St)
Heartland Emergicare (2419 M St)
Good Life Chiropractic (2415 M St)
Supermercado Nuestra Familia (3548 Q St)
UNO Academic & Career Development Center (6100 Dodge Street)
South Omaha High Magnet School (4519 S 24th St)
St. Vincent de Paul Elementary School (14330 Eagle Run Dr)
Dundee Elementary School (310 N 51st St)
Chalco Hills Recreation Area (8901 S 154th St)
Creighton University's Harper Center (602 N 20th St)
UNO Sapp Field House (6001 Dodge St)
Castelar Elementary School (2316 S 18th St)
Durham Museum (801 S 10th St)
Lauritzen Gardens (100 Bancroft St)

In addition to the distribution of brochures, the City maintains the website www.underthesink.org that presents a variety of information about the site, materials accepted and not accepted, hours of operation, and alternative use products.

In the 2016 calendar year UnderTheSink, the household hazardous waste facility, had a total of 17,884 drop offs resulting in a total 1,103,856 lbs of material, an average of 5,519 lbs/day (of days accepting waste). A total weight of 231,024 lbs of HHW was shipped offsite by our disposal contractor. Those drop-offs and that total weight can be further broken down into:

- Recycling Totals in 2016:
  - Steel from paint and aerosol cans: 55,700 lbs
  - Latex paint used with Posi-Shell at Sarpy County Landfill: 12,540 gal
  - Oil-based paint and flammable liquids used as industrial fuel: 11,150 gal
  - Antifreeze recycled: 2,008 gal
  - Automotive batteries: 10,088 lbs
  - Fluorescent bulbs: 12,729 bulbs
- Oil Totals in 2016:
  - Collected approximately 9,450 gal from 5,665 people
  - Sold a total of 3,641 gal during the summer to Tri-State Oil Reclaimers, Inc.
  - The remaining oil, was/is being burned in the waste-oil boiler at the facility

- ReStore Totals in 2016:
  - People who took free usable items for their own use: 12,065 persons
  - Weight of non-paint items taken: 231,696 lbs
  - Gallons of free paint taken: 22,368 gal
- 9 tours were conducted in 2016.

This permit requirement continues to be met.

B. Issue public service announcements related to storm water protection on local TV, radio or print outlets, which will address TMDL pollutants of concern.

In addition to the distribution of educational brochures and public outreach events, Keep Omaha Beautiful, Inc. coordinated a number of public service announcements (PSAs) and other information regarding stormwater pollution through radio, print, and websites in 2016. In total there were 527 PSA's with the following breakdown: radio spots (502), print ads (10), websites (13), and television spots (2). Topics and events addressed by these spots included stormwater pollution prevention, proper firework disposal, World O! Water, and storm drain labeling.

This permit requirement continues to be met.

C. Continue existing drain marking program to improve public awareness concerning illegal dumping utilizing volunteer services, which will address TMDL pollutants of concern.

Keep Omaha Beautiful, Inc. coordinated neighborhood groups and scout troops in 2016 to mark and clean storm sewer inlets. In total, 1,511 inlets were cleaned and had disks placed on them. Over 373 volunteers participated, totaling 855 of community service hours. The table below is a summary of the areas where the disks were placed.

Month	General Description of Target Area	Organization	# of Drains Cleaned/ Marked	# of Volunteers
April	Laurel Avenue between N. 30th & N. 33rd St. & Arcadia Avenue between N. 30th & 33rd St.	MCC - Campus Sustainability & Planning Division	20	3
April	Saddle Hills Park & Neighborhood Area #1	Omaha Northwest High School	24	11
April	Around UNO's Mammel Hall	UNO's Office of Sustainability	6	2
April	Bent Creek / Barrington Park Area	Aldrich Elementary School - 5th Grade IB Class	15	6
May	120th & L to 144th & Q (areas surrounding the school)	Central Middle School - Various Classes	65	87
May	Lafayette Ave. from 156th to 164th St. & California St. from 156th to 164th St.	Aldrich Elementary School - Various Classes	97	6
June	S. 90th to S. 96th St from Harrison St. to Berry St.	Boy Scout Troop #462	100	14
June	170th to 180th & near Q St.	Boy Scout Troop #484	100	23
June	N. 24th St. Business District (Lothrop to Grant)	UNMC Summer Medical Students	75	40

Month	General Description of Target Area	Organization	# of Drains Cleaned/ Marked	# of Volunteers
June	Dundee/Memorial Park-Area surrounding Dundee Elementary	Dundee Elementary - Summer School Classes	143	37
July	Z St. to Drexel St. from S. 167 Ave. to S. 159th Ave.	Latter Day Saints - Omaha Congregation #1	67	11
July	Huntington Park area near 144th & Eagle Run Drive	Girl Scout Troop #42103	61	4
June	52nd & Larimore area	Latter Day Saints - Omaha Congregation #2	21	13
August	Neighborhoods from 120th to 132nd between Maple St. & Blondo St.	Eagle Scout - Cody Merrill	318	28
August	Near S. 41st Street & Saddle Hills	Local Family (Community Service Project)	50	4
September	UNO South Campus & periphery areas	UNO's Office of Civic & Social Responsibility	50	9
September	Around Hillside Elementary	UNO's 9/11 Day of Service	12	8
September	Around Western Hills Elementary	UNO's 9/11 Day of Service	18	3
September	Park St. to Seward St. from N. 85th St. to N. 87th Street	UNO's 9/11 Day of Service	37	3
September	Grant St. & Blondo St. from 61st to 69th St.	UNO's 9/11 Day of Service	25	3
September	UNO main campus and periphery	UNO's 9/11 Day of Service	30	8
September	Memorial Park neighborhood area (north of the park)	UNO's 9/11 Day of Service	30	4
September	132nd to 156th near Blondo St.	Boy Scout Troop #99	88	16
October	Saddle Hills Park & Neighborhood Area #2	Northwest High School	23	10
October	Aksarben area east of UNO's south campus	UNO Global Day of Service & Sustainability Office	21	15
October	Near Hitchcock Park	Bellevue West High School	15	5
		TOTALS	**1,511**	**373**

KOB, Inc also uses a GIS tracking system to better direct the volunteers to areas that have not been marked. Using this GIS system improves the tracking of those inlets which have been marked or need marking. The City's Sewer Maintenance Division currently estimates that within City limits, there are approximately 40,000 storm drains.

This permit requirement continues to be met.

D. Hold a Sediment and Erosion Control Seminar for the developers, builders, engineers, vendors, and graders, which will address TMDL pollutants of concern.

The City worked with the P-MRNRD, Douglas-Sarpy County Extension Office, Douglas County Environmental Services, NDEQ, and PCWP to present the annual sediment and erosion control seminar on February 5, 2016. There were 285 people that signed in at the seminar. Presentations at the event included:

- Track-out from Construction Sites
- Successful Seeding & Stabilization
- Managing Your Grading Permit: Stage Changes, Closures, & More
- City of Omaha's 2015 Compliance Issues
- NDEQ Stormwater Update
- EPA Region 7 – Latest Developments in Stormwater Regulation & Green Infrastructure

This permit requirement continues to be met.

E. Schedule outreach events with industry trade organizations to educate the regulated community regarding Omaha's Industrial Permitting Program.

EQCD presented at 19 different outreach events attended by the permitted community with a total attendance of 1,224. Previous annual reports have documented these events on a permit year basis. In order to match the rest of this annual report, which is based on a calendar year, outreach events conducted through the end of 2016 have been included in this report. Events were held throughout the State of Nebraska and at national conferences, but most were held in the Omaha area. Topics at these events cover industrial stormwater, construction stormwater, post-construction, and other topics of interest for the regulated community. Audiences varied from business owners to consultants and government staff. Throughout the year, calls are fielded to answer specific questions regarding these issues as well. The table below is a summary of events and activities conducted.

EVENT	DATE	LOCATION	ATTENDEES	COMMENTS
Soil Science Society of America Annual Conference	11/16/2015	Minneapolis, MN	25	Presentation: Rethinking Bioretention Design - Maximize in-Situ Soils, Enhance Function, & Reduce Costs
NeFSMA Annual Meeting	11/19/2015	Ashland, NE	40	Presentation on green infrastructure practices & performance observed by the City of Omaha
NPDES Permitting - City of Omaha Perspective	12/10/2015	Lamp Ryerson & Associates	50	Lunch and Learn with LRA regarding grading permitting
Annual Sediment and Erosion Control Seminar	2/5/2016	Omaha, NE	285	Annual seminar regarding erosion and sediment control
Landscape Expo Show	2/16/2016	La Vista, NE	60	Presentation to a variety of contractors (i.e. landscape) regarding stormwater and green infrastructure practices
Great Plains LID Symposium	3/7/2016	Omaha, NE	42	Half-day workshop on permeable pavement

Great Plains LID Symposium and Design Competition Awards Event	3/8/2016	Omaha, NE	138	Full day conference with three tracks presenting on many low impact development practices and stormwater topics. Design competition to design a low impact development driven project. Public presentation, scoring, and awards for competition
Great Plains Symposium tour	3/9/2016	Omaha, NE	42	Tour of multiple green infrastructure practices across Omaha, this was the second day of the Great Plains LID Symposium
2016 National Watershed & Stormwater Conference	4/12/2016	Omaha, NE	25	Hub location for the Center of Watershed Protection's national webcast conference. Local presentations given during the day.
NWEA presentation	4/20/2016	La Vista, NE	125	Presentation on stormwater management strategies & performance observed by the City of Omaha
Graham Environment Day	4/22/2016	Omaha, NE	30	Presentation on stormwater, sediment and erosion control, and sharing resources with Graham Construction field crews
USGBC Educational Lunch presentation	6/28/2016	Omaha, NE	20	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha
NeFSMA Annual Conference	7/21/2016	Kearney, NE	40	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha
NNLA Field Trip	8/5/2016	Omaha, NE	25	Tour of multiple green infrastructure practices across Omaha with Nebraska Nursery and Landscape Association
International LID Conference	8/29/2016	Portland, ME	100	Presentation on Omaha's use of green infrastructure in City parks
Green Infrastructure Tour	9/15/2016	Omaha, NE	94	Annual tour of multiple green infrastructure practices in the Omaha Metro area, in conjunction with the Extension Office and UNO
Kansas City Community Organization and EPA Tour	10/6/2016	Omaha, NE	13	Small group touring are part of an urban neighborhood (Marlborough where KC Target Green, Green Infrastructure project is located),

				where the City of KC is putting in some large GI features in parks, visiting Omaha to see examples.
Western Nursery Landscape Association Webinar	11/1/2016	Online from Omaha	20	Present webinar for the Western Nursery & Landscape Association on "Greening the Green Industry"
APWA Conference	11/2/2016	Kearney, NE	50	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha

This permit requirement continues to be met.

F. Work collaboratively with other community organizations to develop a campaign aimed at picking up pet waste which will address TMDL pollutants of concern.

The City of Omaha hired a marketing firm in 2009, MINT Design Group, to assist in the development and implementation of the pet waste campaign. Advertisements were developed and published in several area newspapers, billboard space was used, mass mailings distributed, theater advertising purchased, posters placed on litter cans, radio announcements broadcast, a television commercial produced, and other media printed. We continue to use these materials today. It was a very successful campaign and won the Silver Award in the Total Advertising Campaign category from the Eighth Annual Service Industry Advertising Awards. Additionally, EQCD attended four events that were focused on pet owners where flyers were handed out along with pet waste bag dispensers, as shown in the table below. These materials are also handed out at other outreach events such as Earth Day and home show booths.

Date	Location	Activity	Dispensers
4/16/2016	Elmwood Park	Earth Day Omaha	250
6/25/2016	Hefflinger Park	ODPA Spring Bark in the Park	150
9/24/2016	Youngman Park	Fly into Fall	42
10/2/2016	NHS	Humane Society Walk for the Animals	500

The City of Omaha has also partnered with the Omaha Dog Park Advocates by supplying Pet Waste Bag Stations and Pet Waste Bags for the two dog parks in Omaha. The Advocates keep the dispensers supplied with bags and submit a count to EQCD. A total of 48,000 bags were used during this permit year.

This permit requirement is on schedule to be met.

G. Develop materials and displays associated with BMP demonstration projects installed with Storm Water Management Program Plan funds from NDEQ.

Educational signage has been placed at the City's Under The Sink Facility, Orchard Park, and Metropolitan Community College (MCC) Fort Omaha Campus; all are accessible by the public. In 2016 signage was placed at the Creighton Prep demonstration project as part of a supplemental environmental project. The signage explains the design and function of the BMP's onsite. The green and traditional roofs at the Saddlebrook Joint Use facility have two weather monitoring stations installed. The public can view the differences between the two on two separate screens; one located in the library the other located in the stairwell outside of the indoor track. There are also webcams directed toward the green roof which will also

be displayed on the screens. We also have the weather information of the green roof available on our website www.omahastormwater.org.

In collaboration with the US EPA Office of Research and Development, USGS, the Omaha CSO Program, and the University of Nebraska Extension a kiosk was placed at the Douglas County Extension Office that shares real-time data of the Sewer Maintenance bioretention and permeable pavement demonstration project installed in 2014. In 2016 the kiosk was removed from its location at stored the EQCD offices until a program update was put onto the machine. During this time the EPA transferred ownership of the kiosk to the University of Nebraska at Omaha. The content on the kiosk is currently being updated and will be place on UNO's campus in 2017.

Three demonstration projects have taken shape during 2016. A bioswale and hydrodynamic separator were constructed at the City of Omaha's Vehicle Impound Lot, a sediment capture structure and drainage channel improvements were installed as part of the Hillsdale Channel Improvement project, and a green infrastructure classroom project at Dundee Elementary School was designed with construction planned for in 2017. Signage will be incorporated into the project at Dundee Elementary and project fact sheets developed for the other projects.

Project fact sheets continue to be developed for Omaha Stormwater Program's demonstration projects and Omaha CSO Program green infrastructure projects to share basic information on each project with the community. Currently 15 GI fact sheets have been created. These are shared with participants on tours and other outreach events.

The Omaha Stormwater Program's website, www.omahastormwater.org, features demonstration and other green infrastructure projects that the program has been involved with. Information provided includes photos, background information, and other specific information on them as they mature from year to year.

This permit requirement continues to be met.

H. Develop a City Stormwater Program Web Site, including but not limited to storm water related information and provide educational information targeted for residents, children, and industries, which will address TMDL pollutants of concern.

The City of Omaha has developed and deployed a website, www.omahastormwater.org dedicated to our Stormwater Management Program. From the website industries can access the necessary documents to apply for a permit as well as access resources to help them maintain compliance. Developers and engineers can access the necessary documents to apply for Construction and Post-Construction Stormwater permits.

Residents can access information as to how they can improve water quality by actions they take at home. Children's activities are also available on the website. There is also public information available on the demonstration projects that have been implemented in areas of the city. The public can access information related to the monitoring program. Additionally there is an online complaint or comment form available to the public.

The website was significantly updated in early 2014 to improve navigation and to increase resources and content to residents, industries, and developers. The website content continues to be updated regularly and improved for better use by the public. Facebook continues to be emphasized as a way to further enhance communication with the public. Regular status updates sharing facts on stormwater, demonstration projects,

and other related information were posted and helped to connect them to the Omaha Stormwater website. In 2016 OmahaStormwater.org had 5,572 users with 45,594 total page views. It should be noted that analytics were down for most of November and a portion of December. Omaha Stormwater Program Facebook page had 120 posts with a total reach of 189,409.

This permit requirement continues to be met.

II. Public Participation & Involvement

A. Operate a storm water hotline and web based complaint system for Watershed (general information, complaints, reports of illegal dumping, etc.)

The City of Omaha's Environmental Quality Control Division investigated 107 complaints received in the 2016 permit and calendar year. Previous annual reports have documented complaints on a permit year basis. In order to match the rest of this annual report, which is based on a calendar year, complaints received through the end of 2016 have been included in this report. Complaints ranged from excess sediment in the street to suspicious discharges. A table compiling the complaints, investigations and resolutions of these reports can be found in Attachment B.

This permit requirement continues to be met.

B. Participate in organizing to hold open houses on Papillion Creek Watershed Plan activities.

The Papillion Creek Watershed Partnership holds monthly meetings, which are open to the public, to discuss watershed and water quality policies. There were five meetings and one subcommittee meeting held in the 2016 calendar year. The following table summarizes the times and attendance for the meetings.

Date	Count	Target Market	Comments
2/25/2016	16	South Sarpy Stakeholders	Stakeholder meeting for the Water Quality Plan
4/28/2016	12	Partnership Members	Partnership Meeting
5/26/2016	15	Partnership Members	Partnership Meeting
6/23/2016	16	Partnership Members	Partnership Meeting
11/10/2016	11	Partnership Members	Partnership Meeting
12/15/2016	19	Partnership Members	Partnership Meeting

This permit requirement continues to be met.

C. Continue to implement a stream Cleanup Day. Utilize Keep Omaha Beautiful, Inc. to identify stream segments in need of cleanup and recruit volunteers from the local area, public groups, and representatives from local area business and developments.

Keep Omaha Beautiful, Inc. (KOB) organized multiple 2016 cleanup events. An official Stream Cleanup Day was not held in 2016, but numerous cleanup event were coordinated with individuals and groups. In total, there were 260 cleanups with 64 of them occurring at or near a stream, 26 at or near a lake, 164 in parks, and 6 at schools. The number of volunteers involved was 3,621, resulting in 8,365 total volunteer hours. 2,479 bags of litter were collected. 180 miles of trails were a part of these cleanups as well.

This permit requirement continues to be met.

D. Provide tours of UnderTheSink, household hazardous waste facility for schools and neighborhood organizations to learn about the proper way to manage household chemicals and about storm water treatment systems installed at the site.

A total of 9 tours were conducted at the UnderTheSink Facility in 2016. Stormwater Best Management Practices (BMPs) have also been installed at the facility along with educational signage. The BMPs were completed in the fall of 2009 and are meant to serve as a demonstration project to the public.

This permit requirement continues to be met.

E. Hold World O! Water Festival focused on elementary school aged children to celebrate Clean Water and engage in water quality related activities.

The World O! Water Festival was held on September 10, 2016 from 12 PM until 4PM at Wehrspann Lake / Chalco Hills Recreation Area. There were approximately 50 organizations that participated by handing out information, conducting an activity or providing demonstrations. 2,419 visitors attended the event. Information that was handed out included water stewardship, recycling, water quality, and water conservation. Activities included a watershed pollution demonstrative model, canoe rides, nature hikes, and science experiments. This was the 12th successful year the event was held.

This permit requirement continues to be met.

F. Participate in community organizations, conferences workshops, and web casts related to water quality and storm water management.

City of Omaha Environmental Quality Control Division conducted 32 education and outreach activities with the public, schools, and community organizations. Previous annual reports have documented complaints on a permit year basis. In order to match the rest of this annual report, which is based on a calendar year, activities through the end of 2016 have been included in this report. In addition, Keep Omaha Beautiful held 106 outreach events, for a total of 138. Total estimated participation of these events is 21,930. Topics ranged from general stormwater education to rain barrel workshops to information on green infrastructure. A summary table of education and outreach activities conducted by the City of Omaha's Stormwater Program and Keep Omaha Beautiful can be found in Attachment E.

City of Omaha EQCD staff attended or participated in 35 workshops, webcasts, or trainings in the 2016 permit year. These activities continue to further our staff's knowledge and experience on water quality and stormwater management. The following table is an accounting of the events attended.

Date	Topic	Associated Program	Attendees
10/14/2015	Safety Meeting	Good Housekeeping	11
11/12/2015	Safety Meeting	Good Housekeeping	9
1/13/2016	For Omaha Engineers	Good Housekeeping	13
1/29/2016	Nebraska H20 Program Presentation	Good Housekeeping	2
2/5/2016	Annual Sediment & Erosion Control Seminar	Combination	39
2/10/2016	February Safety Toolbox Meeting	Good Housekeeping	12
2/23/2016	GIS Training	Combination	29
3/8/2016	Great Plains LID Symposium Workshop and Kaneko	Post-Construction	15

Date	Topic	Associated Program	Attendees
3/9/2016	March Safety Toolbox Meeting	Good Housekeeping	14
4/5/2016	ASP's Clean & Green	Combination	5
4/12/2016	2016 National Watershed & Stormwater Conference	Combination	16
4/13/2016	April Safety Toolbox Meeting	Good Housekeeping	13
4/19/2016	GIS 201 - ArcGIS online	Good Housekeeping	10
4/20/2016	NWEA presentation	Post-Construction	10
5/11/2016	May Safety Toolbox Meeting	Good Housekeeping	11
6/8/2016	June Safety Toolbox Meeting	Good Housekeeping	13
7/12/2016	Construction site inspections	Construction	3
7/12/2016	City Construction Site Inspection Training	Construction	3
7/13/2016	July Safety Toolbox Meeting	Good Housekeeping	15
7/20/2016	City Construction Site Inspection Training	Construction	2
8/5/2016	Erosion Inspector Certification	Construction	1
8/5/2016	Erosion Inspector Certification	Construction	1
8/5/2016	Erosion Inspector Certification	Construction	1
8/8/2016	City Construction Site Inspection Training	Construction	5
8/10/2016	August Safety Toolbox Meeting	Good Housekeeping	13
9/15/2016	Omaha Green Infrastructure Tour	Post-Construction	7
9/21/2016	September Safety Toolbox Meeting	Good Housekeeping	12
10/12/2016	October Safety Toolbox Meeting	Good Housekeeping	7
10/12/2016	City Construction Site Inspection Training	Construction	1
11/2/2016	APWA Conference	Post-Construction	4
11/4/2016	Permix Training	Construction	1
11/9/2016	November Safety Toolbox Meeting	Good Housekeeping	11
12/14/2016	December Safety Toolbox Meeting	Good Housekeeping	16

This permit requirement continues to be met.

III. Illicit Discharge Detection & Elimination

A. Perform dry-weather inspections including Physical Characteristics Examinations of storm water outfalls 72" or greater and any outfalls with documented complaints.

The City of Omaha – EQCD staff inspected all outfalls identified the previous year as priority outfalls (those 72" or greater and/or documented illicit discharges). They also inspected all outfalls located in areas annexed by the City. EQCD Staff completed all inspections by September 30th, 2016. Any outfall with an obvious or suspicious discharge was to be reported immediately to EQCD. No new outfalls were inspected based on the previous year's inspection. No outfalls were inspected due to annexation. No suspicious discharges were found but one outfall was noted as having a potential, with two physical characteristics with low severity index numbers.

Outfall inspections were only conducted after 48 hours of dry weather. A Physical Characteristics Examination form was completed for each outfall, if flow was present sample was collected for pH testing in the field, if an illicit discharge was encountered EQCD Inspectors called supervisory staff immediately. Photographs were taken of outfalls to be kept as a record of outfall conditions during the inspection. Outfall inspections were entered into the City of Omaha's CityWorks asset management system. A total of 83 priority outfalls were inspected in 2016.

This permit requirement continues to be met.

B. Investigate and seek resolution concerning any dry weather discharges potentially impacted by sources by notifying the source that they must discontinue discharging, and initiate enforcement action consistent with adopted ordinance which will address TMDL pollutants of concern. Any source that the applicant feels constitutes and immediate health or safety threat will be reported immediately to the NDEQ.

There were no confirmed illicit discharges from an outfall inspection during the permit year 2016.

This permit requirement continues to be met.

C. Dry Weather inspection of storm water outfalls, including smaller outlets and those that discharge to lesser tributaries or other storm conduits in response to suspect conditions and / or complaints.

There were 268 potential outfalls identified by EQCD using GIS information collected by sewer maintenance in 2009. All outfalls were inspected during dry weather.

A total of 73 code enforcement actions associated with complaints were taken in 2016. 19 of those were associated with an illicit discharge. The remainder of those actions were "Requests for Voluntary Compliance". There were no fines levied or collected in 2016. A table summarizing the year's activities can be found in Attachment B.

This permit requirement continues to be met.

D. Enforce Existing City Codes prohibiting illicit discharge connections to storm sewers.

There was one instance of an illicit discharge connection in 2016. Upon discovery, the facility immediately contracted with a plumber to properly plumb the sanitary line. NDEQ was notified and the City of Omaha Pluming Department was involved to ensure compliance with City code.

This permit requirement continues to be met.

E. Maintain and prevent instances of sanitary sewer leakage into MS4 or waters of the state.

The Sewer Maintenance Division is responsible for preventing sanitary seepage into the storm sewer. They perform preventive and corrective maintenance to the system and are able to identify areas where seepage is occurring. Because of the way the MS4 system is designed, sanitary seepage to the MS4 is an extremely rare event. Storm water pipes are not located immediately below the sanitary line; they are almost always installed on the other side of the street or parallel to the sanitary line. There were no instances of sanitary seepage/leakage at two locations found in 2016. There were two instances of flow backing up and flowing out of a manhole to the storm sewer. There were fifteen instances of Sanitary Sewer Overflows that reached waters of the state. All of these instances were reported to the state under a separate NPDES Permit as a requirement to report Sanitary Sewer Overflows and Combined Sewer Overflows. The pipes were repaired and no issues occurred

This permit requirement continues to be met.

F. Maintain and update a sewer map of major storm water outfalls and identify the names of respective receiving waters.

The Sewer Maintenance Division is responsible for maintaining and updating storm sewer, in addition to sanitary and combined sewers. EQCD utilizes this information to catalogue and support inspections of outfalls. Handheld portable GPS units are used during outfall inspections to locate them, update information, and track inspections.

In 2010, EQCD staff used the current GIS data collected by sewer maintenance in 2009 to direct our inspections. Two hundred and sixty eight points were inspected resulting in additional priority outfalls being identified. We continue building on the database to better document outfall conditions so that future inspections will be comparative to the past inspections. The data helps to better direct inspections and compare the previous year's condition with the current condition of the outfalls.

The City of Omaha GIS Department maintains a layer of all known waterbodies in Douglas County.

This permit requirement continues to be met.

G. Prevent, contain and respond to spills to the MS4. Review, as necessary, interdepartmental SOP's with respects to spills, dumping and illegal disposal that impacts the MS4.

The City of Omaha's Environmental Quality Control Division worked with the Omaha Fire Department (OFD) to develop a policy dealing with spills that the OFD responds to. Previously the OFD would chemically treat a spill to aid in the breaking down of petroleum products. The revised policy requires OFD to spread fly ash over a spill to absorb any petroleum products. They then collect the material and drop it off at one of several locations throughout the City. Each location has a dedicated 55 gallon drum for storage of the waste material. OFD monitors the use of the barrels and coordinates proper disposal with a hazardous materials processing contractor.

The Omaha Fire Department's Hazardous Materials Unit responded to 533 incidents in the 2016 calendar year.

This permit requirement continues to be met.

IV. Construction Site Program

A. Maintain the construction site inspection and reporting web site and continue to make enhancements.

The City of Omaha deployed its new permit tracking and reporting system, Permix, at the beginning of April 2014. The new system integrates Grading Permits, Linear Underground Projects, Post-Construction Stormwater Management Plans and Public Improvements, under one website and database system. The individual processes are linked by a common project name and number if applicable. This allows for a more comprehensive approach to managing these activities while creating an efficient means for project Applicants to apply for permits and have plans reviewed. The system is being used by all of the communities within the Papillion Creek Watershed Partnership for Grading Permits and Post-Construction Stormwater Management Plans. Improvements to the site in 2016 include a work queue for City users, improved project list page layout, and inspection report layout.

This permit requirement continues to be met.

B. Maintain a construction site inspection program that includes procedures for reporting, resolving deficiencies, and taking appropriate enforcement action consistent with adopted ordinances.

EQCD administers the inspection program for Erosion Control, both within the City of Omaha's jurisdiction as well as the Papillion Creek Watershed Partnership's (PCWP) individual member's jurisdiction. The City's Grading Permit Program requires that the owners of active sites hire an independent inspector, a Project Inspector, to do inspections weekly and after 0.5 inches of rain. In the 2016 calendar year, reports were submitted to Permix by City Inspectors and Project Inspectors for construction sites as per the NPDES Stormwater Discharges from Construction Sites General Permit. Additionally, enforcement actions were entered by City personnel. The table below accounts for the reports submitted for sites within the City of Omaha's jurisdiction.

	City Inspection Reports	Private Inspection Reports
Phase I Sites (>5 acres)	435	4,574
Phase II Sites (<5 acres)	496	3,343
Total	931	7,917

A summary table of enforcements that were taken within the City of Omaha's jurisdiction can be found in Attachment C.

Since the Permix system was launched in April 2014, on-going training and support of the system users has been provided. This includes video tutorials on www.omahastormwater.org website, email, and phone conversations with the users. Compliance assistance and project related questions are addressed as they came up for users.

This permit requirement continues to be met.

C. Maintain regulations and design specifications for controlling erosion, sediment loss, and other TMDL pollutants of concern from construction sites that disturb areas of 1 acre or more.

The Omaha Municipal Code Section 32-101 (Grading Permit Required) requires owners/operators to obtain a grading permit on sites sufficiently large enough to require an NPDES construction general permit. On

March 10, 2003 when the NPDES Phase II regulation became effective the City began enforcing the soil erosion and sediment control measures on sites that disturbed one acre or greater in the City's jurisdictional area, which extends 3 miles beyond City limits in Douglas County. This allows the City to regulate many of the large developments (SIDs) that remain active for years and have a great potential to adversely impact water quality.

The City has incorporated the Sediment and Erosion Control Manual into the Omaha Regional Storm Water Design Manual as Chapter 9. The Omaha Regional Storm Water Design Manual was adopted by the City of Omaha in April 2006. The Omaha Regional Storm Water Design Manual was updated in 2014. Each chapter was updated with current information. Chapter 8, Stormwater Best Management Practices (BMPs), included updates to BMPs based on monitoring and performance and added new ones including permeable pavement and soil conditioning. Chapter 9, Erosion and Sediment Control, incorporated the Supplemental BMP Guide into it and updated existing BMPs. Formatting and graphics were also greatly improved with the update. Digital copies, in PDF format with links throughout, are available on our website at www.omahastormwater.org/orsdm.

This permit requirement has been met.

D. Maintain a program for performing review of Grading Permit applications to ensure compliance with applicable regulations and design specifications.

The Public Works Department, Environmental Quality Control Division, reviews the grading permit applications and the associated Storm Water Pollution Prevention Plans (SWPPP). Unless the SWPPP meets the requirements specified in the Omaha Regional Storm Water Design Manual, a grading permit will not be issued. Sites 5 acres or greater are given priority over sites less than 5 acres.

The City of Omaha issued a total of 97 permits in 2016. 33 permits were for sites greater than 5 acres 64 permits issued for sites less than 5 acres in size. During 2016, there were a total of 423 active permits, with 323 at the start of the year and 343 at the end.

This permit requirement continues to be met.

V. Post Construction Runoff Control

A. Develop a guidance document for Post Construction Storm Water Management Plan.

The City of Omaha finalized the guidance document titled *City of Omaha Post Construction Stormwater Management Planning Guidance* in July 2009. The document is available on the City's website www.omahastormwater.org and www.omahapermix.com. The guidance document incorporated minor updates in August 2015.

This permit requirement continues to be met.

B. Participate with other City Departments to prepare an Environmental Element of City of Omaha Master Plan and include applicable storm water management provisions.

The Omaha City Council voted 7-0 to adopt the Environmental Element – a comprehensive environmental vision for the city – as a component of Omaha's master plan Dec. 14, 2010.

The document, developed through a two-year process led by the City of Omaha and Omaha by Design, includes more than 600 recommendations in five sections – the natural environment, urban form and transportation, building construction, resource conservation and community health. Each goal is accompanied by a set of objectives and strategies, and a set of measurements has been developed for each of the five sections.

This permit requirement continues to be met.

C. Develop a database of existing structural BMPs (private and public) that reduce the impact of urbanization on storm water run-off and improve water quality and enhance other amenities and activities such as green space, parks and recreation, urban planning, aesthetics, and public safety.

The City of Omaha reviews proposed post construction storm water BMPs for code compliance, functionality, and manageability. Once the proposed post construction BMP passes the review and is approved, that allows construction and implementation to begin. The management plan that is submitted along with the proposed BMP is then attached to the property deed to ensure long term compliance. The City has developed a database, Permix, for tracking purposes and has integrated the Construction program, Public Improvements, and Linear Underground Projects into this database.

A database has been developed to track post construction BMPs within the City of Omaha. Information being entered includes; location, ownership, provided capacity, required capacity, contributing drainage area, type of BMP, date of installation and type of drainage area (combined sewers r separate storm sewers). Each BMP has the latitude and longitude included so that they can be easily mapped using our GIS.

This permit requirement continues to be met.

D. Inspect annually and maintain (as necessary) City owned storm water BMP structures.

All City-owned stormwater BMP structures were inspected for any major maintenance issues in early spring and in early winter of 2016. A physical characteristics examination form is completed during the inspection for structures that had flow or were wet. No basins needed a PCE form completed in 2016. Maintenance is performed by various City Departments based upon the type of activity required. Most of the City

Departments are using Cityworks to track their maintenance activities. Additionally EQCD employed three employees, one full-time and two part-time, who were dedicated to maintaining City owned stormwater BMP structures throughout the year. The table below indicates when the inspection occurred as well as any maintenance issues at that time.

SITE	INSPECTION DATES	SEDIMENT REMOVAL	TRASH REMOVAL	DEBRIS REMOVAL	MOWING
Storz Expressway (E)	6/24/2016	Yes	Yes	Yes	Yes
	12/29/2016	Yes	No	No	No
Storz Expressway (W)	6/7/2016	Yes	Yes	Yes	Yes
	12/29/2016	Yes	Yes	Yes	No
Adams Park Lagoon	Park under construction in 2016, part of the JCB & Miami Sewer Separation & Adams Park Detention Improvements; Year 1 of 2 establishment period with contractor				
Lake James Park	6/27/2016	No	No	No	No
Fontenelle Park Lagoon	6/6/2016	No	No	No	No
John J Pershing Drive 1.5	6/27/2016	No	No	Yes	Yes
	12/29/2016	No	Yes	Yes	No
Miller Park	6/27/2016	No	No	No	No
	12/29/2016	Yes	No	No	No
10th & Nicholas	5/6/2016	No	No	No	No
	12/28/2016	No	No	No	No
13th & Carter Blvd	6/24/2016	No	No	Yes	No
	12/28/2016	Yes	Yes	No	No
13 & Fowler	6/24/2016	No	No	No	No
	12/28/2016	No	Yes	Yes	No
Carter Lake	6/27/2016	No	No	No	No
	12/30/2016	Yes	No	No	No
19 & Carter Blvd	6/27/2016	No	No	Yes	No
	12/29/2016	Yes	Yes	Yes	No
18th Street E & Ave H	5/6/2016	Yes	Yes	Yes	No
	12/28/2016	Yes	Yes	Yes	No
14th & Ida St	6/27/2016	No	No	Yes	Yes
	12/29/2016	No	Yes	Yes	No
John J. Pershing No. 1	6/7/2016	No	No	Yes	Yes
	12/30/2016	No	Yes	Yes	No

SITE	INSPECTION DATES	SEDIMENT REMOVAL	TRASH REMOVAL	DEBRIS REMOVAL	MOWING
John J. Pershing No. 2	6/27/2016	No	No	No	Yes
	12/29/2016	Yes	Yes	Yes	No
Gifford Dr. No 1	5/6/2016	No	No	No	Yes
	12/28/2016	No	No	No	No
9th & Storz	6/27/2016	No	No	No	No
	12/29/2016	No	Yes	Yes	No
Westlawn Cemetery	6/6/2016	No	No	Yes	Yes
64th Street Channel	6/6/2016	No	No	Yes	Yes
Elmwood Park	6/27/2016	No	No	No	No

This permit requirement continues to be met.

E. Revise storm water BMP maintenance and inspection plan as needed.

Adams Park Lagoon has been renovated to include a screening structure to capture trash and debris and constructed wetlands as part of the JCB/Miami Sewer Separation CSO Project. The project has a total storage capacity of 77 acre-feet. The Adams Park Stormwater BMP portion of the project wrapped up construction in 2016. Incorporated into the contract for the BMP is a two year establishment period where the contractor will maintain the BMP to ensure the BMP's vegetation established fully, 2016 represents the first of those two years. Due to the active construction of the Adams Park BMP, no inspections were conducted in 2016.

Each project is inspected annually at a minimum. If maintenance that exceeds the capacity of the dedicated employees, coordination with other City divisions or outsourcing of that work is sought.

This permit requirement continues to be met.

F. Implement strategies, which include a combination of structural and or non-structural BMPs appropriate for the watershed, which will address TMDL pollutants of concern. Evaluate these strategies and implement changes as necessary to improve water quality and address TMDL pollutants of concern.

The City of Omaha continues to partner with the Omaha Public Schools to monitor four discharge points at the Saddlebrook Joint Use Facility. Only flow was monitored in 2016. The bioretention system was re-planting in the fall of 2015. Flow monitoring data remains consistent with previous years in showing reduced peak discharge rates and total volume from the green roof when compared to the traditional roof. Going forward, the City will continue to compare the performance of the traditional versus the green features in terms of volume. With all monitoring efforts, the goal is to gain a better understanding of how well BMP's can reduce pollutants of concern so as to better promote their use in new and re-development.

The City of Omaha updated their Omaha Regional Stormwater Design Manual (ORSDM) in 2014. This update included many updates to Chapter 8 Stormwater Best Management Practices to reflect current technologies, research, and field experiences.

In addition to Saddlebrook Joint Use Facility, the City of Omaha continues to actively evaluate the performance of BMPs, including past and current demonstration projects. Additional details on 2016 BMP assessments can be found in Section VIII and Attachment D.

The City of Omaha presents information about BMPs to the general public, community and trade organizations, and businesses on a regular basis. These presentations cover information the City has learned about the performance of their demonstration projects, experiences through implementation of their SWMP, and design approaches for BMPs that improve their overall effectiveness. Sharing this information will help to improve post-construction BMPs in addressing pollutants of concern. A listing of events is included in I Public Education and Outreach section e or Attachment E.

In 2016, the City of Omaha's Bioretention Manual was updated to include current design details and resources from experiences and monitoring efforts from demonstration projects and implementing the SWMP. The plant list was also updated in the back of the manual, which provides an extensive list of plants that are suitable to use in vegetation-based BMPs such as bioretention. Bioretention systems are the most common type of BMP used in the Papillion Creek Watershed Partnership (PSMP). Improving its design, construction, and maintenance will have a significant benefit in protecting water quality and addressing pollutants of concern.

This permit requirement continues to be met.

VI. Pollution Prevention/Good Housekeeping

A. Maintain Facility Runoff Control Plans (FRCP) for all City maintenance facilities to indentify BMPs implemented. Review FRCP annually and update as necessary. Inspect all facilities annually.

The City of Omaha conducted compliance inspections at City Maintenance Facilities where FRCP's had been implemented. The audits are given an overall score of Outstanding, Satisfactory, or Needs Improvement. The scores were based upon a records and site review. The inspector not only looked to see that facility inspections were being conducted but that any corrective actions that were noted had been addressed in a timely manner. 14 facilities were inspected in 2016. One facility was relocated to an expanded joint use facility at Jaynes Street. Jaynes Street will have a new hot spot conducted and will have an FRCP developed in 2017. 5 facilities received a Needs Improvement, 6 facilities received a Satisfactory, and 3 received an Outstanding rating.

The City conducted 22 additional facility inspections where no FRCP had been recommended (primarily public parks/golf courses) to perform a "Hot Spot" evaluation. None of those facilities received Needs Improvement, 14 received a Satisfactory, and 8 received an Outstanding rating. Copies of EQCD findings were forwarded to the facility and department supervisors.

This permit requirement continues to be met.

B. Inspect storm sewer conduits, channels and catch basins and remove and properly dispose of sediment and debris as needed to maintain an efficient system within permitted area.

The Sewer Maintenance Division is responsible for the inspecting, cleaning, repairing and maintaining of the storm sewer system. The Street Maintenance Division is responsible for any creek maintenance cleaning or clearing. They use the same work order tracking system to account for their activities. The table below represents both Divisions' storm sewer system activity for the permit year of 2016.

Work Order Type (Description of Work):	Storm/Storm Combined	Combined:	Task Total
Bait - (Put bait in nearest sewer entrances)	29	8	37
BU-SSO - (BU into property, City Caused, to NDEQ)	0	4	4
Bypass-SSO contained - (BP did not reach waters of State reported to NDEQ)	0	10	10
Bypass-SSO WOS - (Bypass reached waters of State, report to NDEQ)	0	1	1
Clean FE - (Clean Flared End)	12	0	12
Clean Inlet - (Clean Inlet)	1,350	26	1,376
Clean MH - (Clean Manhole)	13	39	52
Clean Storm Struct - (Clean Stormwater Structure)	2	0	2
Dye Test - (Put Dye in Structure/Cavity to find flow)	326	100	426
I-Clean - (Clean the Inlet)	3	0	3
I-Flared End - (Reset/Daylight/New Grate)	6	0	6
I-New (Install new Inlet)	1	1	2
Inlet Blown Off - (Inlet Grate was blown off but is not missing)	4	0	4
Inlet Broken - (Inlet Grate was broken and replaced)	5	0	5
Insp Structure - (Inspect Sewer Structure (ex.FE, MH, Inlet)	537	161	730

Work Order Type (Description of Work):	Storm/Storm Combined	Combined:	Task Total
I-Repair - (Seal box, reset hood, reset grate, replace aprons)	244	3	247
I-Replace - (Replace Inlet, Includes all inlet types)	42	1	43
L/S Locate - (Locate where line segment is.)	111	73	184
MH Blown Off - (Manhole was blown off but not missing)	26	17	43
MH Broken - (Manhole broken and replaced)	7	8	15
MH Locate - (Find the location of manhole)	54	65	119
MH Stolen - (Manhole cannot be found)	7	3	10
MH-Abandon - (Abandon the Manhole)	3	1	4
MH-Clean - (Clean the Manhole)	0	12	12
MH-New - (Install new Manhole)	2	0	2
MH-R/C - (Reset/Replace Ring & Cover)	33	42	75
MH-Repair - (Ex-seal riser/brick or pipe wall link, floor rehab)	16	50	66
MH-Replace - (Replace manhole and or risers)	0	1	1
Notified Utility - (Notified a utility about a problem they have)	21	16	37
O-Backfill Tamp - (Backfill a void that is not sewer related)	1	1	2
O-Ditchwork (Open ditching, culvert daylighting, etc…)	4	0	4
Odor-Business (Bad Odor in Business)	0	1	1
Odor-Inside - (Bad Odor in residence)	0	5	5
Odor-Outside - (Bad Odor outside)	8	14	22
O-Erosion Control (Replace dirt displaced by erosion)	3	0	3
O-Landscaping - (Doing any landscape work at the project area)	2	2	4
P-Abandon - (Abandon the Pipe)	2	5	7
P-Combo Repair - (Seal a Combined line)	0	7	7
Private - (Private Problem, notify owner)	25	52	77
P-Sanitary Repair - (Repair a Sanitary line)	3	9	12
P-Sanitary Replace - (Replace a Sanitary line)	0	6	6
P-Serv lat defect - (Repair/Replace the service line)	1	13	14
P-Sewer Walk - (Investigate/repair large sewers w/ walk team)	0	1	1
P-Storm Repair - (Repair a Storm line)	52	0	52
P-Storm Replace - (Replace a Storm line)	24	3	27
Street Flooding - (Storm Water is flooding the street)	11	1	12
Test Hole - (Drill Test Hole)	1	0	1
TV Assessment - (Complete PACP Assessment)	24	31	55
TV Inspection - (TV line to find defect)	121	158	311
Unscheduled Jet - (Jetting a line reactively)	55	119	174
Unscheduled Jet Vac - (Jet Vac'ing a line reactively)	40	64	104
Unscheduled Saw - (Jet Sawing a line reactively)	2	6	8
Creek Maintenance	-	-	4
Culvert Cleaning	-	-	21
Culvert Repair	-	-	2
Debris Removal	-	-	1,044
Ditch Maintenance/Cleaning	-	-	45
Storm Debris Removal - ROW	-	-	1

Work Order Type (Description of Work):	Storm/Storm Combined	Combined:	Task Total
Task Total:	3,233	1,140	5,554

This permit requirement continues to be met.

C. Training will be provided for employees to prevent pollutant runoff from municipal operations at City maintenance facilities and at field operations.

The City of Omaha employed the services of Felsburg Holt & Ullevig (FHU) in 2009 to develop a training program targeted toward municipal operations at City maintenance facilities. EQCD held 11 training sessions at municipal facilities in 2016, there were a total of 177 employees in attendance combined.

This permit requirement continues to be met.

D. Provide for street cleaning in the following areas: Residential, Business, Major Streets, Other areas in conjunction with special projects.

There are approximately 4,877 lane miles within the City of Omaha. In 2016, the City mechanically swept a total of 8,693 curb miles. The table below gives a more detailed accounting of the City's street sweeping activities. The street sweeping operation no longer allows for debris to be separated by areas of the city.

Area of City	Curb Miles Swept	Tons of Debris Removed
Business District & Major Streets	3,349	2,046
Residential Areas	5,344	5,395
Totals	8,693	7,441

This permit requirement continues to be met.

E. City staff that applies pesticides will be trained in a certification program that complies with FIFRA regulations.

The City's Environmental Quality Control Division and the Parks and Recreation Department have applicators who are required to be FIFRA certified. There are currently 29 certified applicators. All certifications are up to date and are obtained from the Douglas–Sarpy County Extension Office.

This permit requirement continues to be met.

F. The City will continue to minimize pesticide and fertilizer use on publically maintained properties.

EQCD works with the Parks Department to encourage applicators to minimize pesticide and fertilizer use on publicly maintained properties. Additionally Keep Omaha Beautiful Inc. distributed information and presented on the topic to multiple locations and events from March through September.

This permit requirement continues to be met.

VII. Industrial Facilities

On March 3rd 2016, the City of Omaha sent a letter to NDEQ to request a permit amendment to modify its Stormwater Management Plant (SWMP) program element #7 Industrial Facilities. The NDEQ approved the amendment in a letter received April 5th, 2016. The amended SWMP, letter requesting amendments and the NDEQ response letter are included in Attachment A.

A. Assess the current listing of industries and maintain a systematic process to update the current listing of "known industrial facilities" in the MS4 that are required to obtain and industrial NPDES permit for stormwater discharge.

July 18th, 2016 the NDEQ issued their new Industrial Stormwater Permit General Permit (ISW-GP), NER910000, replacing the previous permit NER900000. Omaha requested and received from the NDEQ an updated list of industries in Omaha covered under the 2011 ISW-GP and those that have sent in new their Notice of Intents (NOI) for coverage under the new permit issued in July 2016. Outreach to Omaha industries will continue in 2017 to update them of these changes and for obtaining coverage under the NDEQ ISW-GP NER910000 permit.

In 2016, the City ceased use of the CBI Systems, Inc MS4Web web-based software for tracking of permitted sites. A spreadsheet was developed to track annual inspections of permitted facilities and an Access database is utilized to organize industry information and permitting information. Going into 2017, ISW-GPs will be integrated into the CityWorks asset management system.

The City of Omaha website has a section devoted to industries and many educational and reference resources for them area available there, including ISW-GP NER910000 permit and related documents.

This permit requirement on schedule to be met.

B. Maintain and refine a process for review of SWPPPs and stormwater discharges from known industrial facilities subject to state and federal stormwater discharge regulations or those that are determined by the Permittee to have a potential for contributing a substantial pollutant loading to the MS4.

E & A Consulting Group (E&A) and Felsburg Holt & Ullevig were contracted to assist the City in inspecting industrial facilities during this permit year. A total of 24 permitted facilities from multiple sectors were inspected for compliance during the calendar year of 2016. The facilities that were inspected have City of Omaha ISW Permits and were inspected for compliance with their permit. This list of industries was selected prior to the amendment. Of the 24 inspections, 16 had obtained an Industrial Stormwater Permit with NDEQ. Based upon the list provided by NDEQ, there were 170 facilities permitted at the end of 2015 and 6 were permitted in 2016. Due to the timing of permit issuance and contracting for these inspections, inspecting 20% of NDEQ issued ISW permits was not possible in 2016.

This permit requirement continues to be met.

VIII. Storm Water Monitoring Plan

On March 3rd 2016, the City of Omaha sent a letter to NDEQ to request a permit amendment to modify its Stormwater Management Plant (SWMP) program element #8 Stormwater Monitoring Plan. The NDEQ approved the amendment in a letter received April 5th, 2016. The amended SWMP, letter requesting amendments and the NDEQ response letter are included in Attachment A.

A. The development and implementation of a BMP monitoring plan. Monitoring will be flow based monitoring to assess the performance of different BMPs.

In 2015, the City of Omaha contracted with Burns and McDonnell to develop a BMP Monitoring Plan to assess the performance of existing green infrastructure demonstration projects to further assess their benefits on water quantity and quality. In the fall of 2015, Creighton Prep and Orchard Park were the first two sites to have monitoring equipment installed. Creighton Prep has inflow and outflow area velocity sensors and samplers, pressure transducers in stilling basins to measure water movement at depth under the bioretention, and another pressure transducer in the bottom of the bioretention system to assess draw down rates for above ground ponded water. Orchard Park is utilizing a neutron probe and tubes in series around the north bioretention system to assess water movement in and around it.

In 2016 the University of Nebraska – Omaha Welcome Center's demonstration BMP was the next site to have monitoring equipment installed. Equipment was installed in late 2016 and includes two webcams to record plant growth and water ponding levels, pressure transducer in the bottom of both bioretention systems to assess draw down rates for above ground ponded water, and soil moisture and temperature sensors nested in five locations at the site. Flow is not being directly measured at this site, but the data collected will provide insights into how well water infiltrates and the systems are performing as a whole. An executive summary of monitoring data taken in 2016 was provided by Burns and McDonnell and is included in Attachment D.

Additional monitoring occurred during 2016 to assess the performance of BMPs at additional demonstration project sites. Below is a summary of those assessments in 2016.

Saddlebrook Joint Use Facility
The construction of a green roof and a bioretention garden was completed in 2009 at the Saddlebrook Joint Use Facility. The bioretention garden receives runoff from part of the parking area at the facility. Monitoring stations were also installed at the green roof discharge point, traditional roof discharge point, bioretention garden discharge point and a point of discharge from a parking area without a BMP upstream.

Flows from these areas were monitored in 2016 and no water quality sampling occurred in 2016. The bioretention underwent repairs and re-planting in the fall of 2015. Flow monitoring data remains consistent with previous years in showing reduced peak discharge rates and total volume from the green roof when compared to the traditional roof. The same is true with the bioretention system in 2016. As data is collected, the City will continue to compare the performance of the traditional versus the green features in terms of volume reduction.

Sewer Maintenance Demonstration Project

The City of Omaha is collaborating with the US EPA, USGS, University of Nebraska at Omaha, and the Omaha CSO Program on the monitoring of the Sewer Maintenance demonstration project. The monitoring effort is focused assessing the water quantity benefits associated with permeable pavement and bioretention systems through a water balance study. A weather station, inflow and outflow flumes, soil moisture sensors, and water level pressure transducers are all incorporated to monitor the total flows into and out of the systems. The monitoring project will be in place for three years with 2016 being the second year. An excerpt of preliminary 2016 water balance data is included in Attachment D. Initial data indicates that the permeable pavement and bioretention system provide significant volume and peak flow reductions. A valve that is installed on the bioretention system also provides significant benefits in the overall performance and management of the system. At the time of this annual report, USGS had not finalized analysis of the 2016 data. When completed it will be shared and included in the 2017 annual report.

Saturated Hydraulic Conductivity (Infiltration) Assessment

The City of Omaha performed an infiltration study at nine sites throughout the Omaha area in the fall of 2016. This study examined the hydraulic characteristics of both bioretention systems and rain gardens when compared to traditional turf lawns, allowing for better estimation of their infiltration capacity and overall efficiency. A Modified Philip-Dunne (MPD) infiltrometer was used to estimate infiltration rates via saturated hydraulic conductivity measurements for rain gardens, bioretention systems, and turf lawns. Across all survey sites, average measurements of saturated hydraulic conductivity in rain gardens (55.31 in/hr) and bioretention systems (23.00 in/hr) were significantly higher than those acquired over adjacent turf grasses (2.53 in/hr).

Data generated from this study provided a current assessment for the surveyed sites and will act as baseline measurements for future monitoring efforts. Measuring infiltration rates of BMPs will provide insights into the efficiency of BMPs in reducing discharges to the storm sewer system. This study highlighted the importance of obtaining quick and quantifiable measurements via MPD infiltrometers in addition to visual inspections. Furthermore, this study stressed the significance of implementing pretreatment structures within inlet areas in order to reduce sediment loading and prevent debris from reducing the structures ability to infiltrate stormwater. Future work includes continuing infiltration testing efforts at surveyed sites and additional sites to better capture spatial and temporal patterns. The full report is included in Attachment D.

This permit requirement continues to be met.

B. Partner with local organizations, such as Nebraska Watershed Network, to evaluate the results of data that they collected that could provide water quality information on stream or urban aquatic fisheries.

The City of Omaha partnered with the University of Nebraska at Omaha (UNO) on a project titled Evaluating Regional Rain Garden Environmental Conditions, Functional Attributes, and Costs/Benefits. The project came about as part of a service-learning grant UNO received to engage science teachers in Omaha Public Schools in the scientific method by doing real-life research projects. Steve Rodie, Director for the Center for Urban Sustainability at UNO, was the project lead, Rachael Burns, Horticulture teacher at Northwest High School in Omaha, was the researcher, Andy Szatko, Environmental Quality Control Technician I at the City of Omaha, provided support and equipment, and Ted Hartsig, Soil Scientist with Olsson and Associates, consulted on soil analysis. The project assesses the infiltration rates of rain gardens in the Saddle Hills Neighborhood just south of Northwest High School and part of a demonstration project by the City of Omaha Stormwater Program. Rachael Burns and Steve Rodie created a poster with their project information and results; this has been included in Attachment D.

This permit requirement continues to be met.

C. Use GIS to identify land use based on zoning and calculate pollutant loads from discharges of the MS4 based on literature values and precipitation data.

A land use map was created by the Douglas County GIS (DCGIS) Department for City of Omaha (Figure_). Land use patterns were based on current zoning procedures/practices and used to map areas within the City Limits and within the Extra Territorial Jurisdiction (ETJ). Five classifications were used to document current land use patterns including Agricultural, Commercial, Industrial, Mixed-Use, and Residential areas. Of the roughly 140 mi^2 covered by the five different classifications and represented within the City of Omaha and ETJ boundary, a little less than half of the area is represented by agricultural land use. In addition, residential use occupies 31.5 % of the total area followed by commercial, industrial, and mixed-use areas at 10.2 %, 9.5 %, and 3.1 %, respectively. A map has been included in Attachment D.

A literature review of pollutant loads for land use types has not been completed at the time of this annual report. This will be done in 2017.

Zoning by Square Mile

Omaha & ETJ		Omaha Only	
Zone	**mi^2**	**Zone**	**mi^2**
AG	64.1	AG	4.6
AV	4.3	AV	4.2
CBD	0.8	CBD	0.8
CC	5.3	CC	5
CH	0	CH	0
DR	33.3	DR	13.4
DS	0.5	DS	0.5
GC	1.3	GC	1.3
GI	10.1	GI	9.1
GO	1.4	GO	1.4
HI	2.8	HI	2.8
LC	0.2	LC	0.2
LI	0.4	LI	0.4
LO	0.3	LO	0.3
MH	0.5	MH	0.2
MU	4.3	MU	3.4
NBD	0.2	NBD	0.2
R1	3.9	R1	2.8
R2	10.6	R2	9.5
R3	11.2	R3	10.5
R4	20	R4	10.7
R4(35)	15.6	R4(35)	15.6
R5	4.6	R5	3.4
R5(35)	1.9	R5(35)	1.9
R6	3.6	R6	2.8

Omaha & ETJ		Omaha Only	
R7	3.8	R7	3.6
R8	0.6	R8	0.6
RR	1.8	RR	1.5
Total	207.4	**Total**	110.7

Land Use by Square Mile

Land Use	Omaha (mi^2)	ETJ (mi^2)	Total (mi^2)	Percent Cover (%)
Agricultural	4.6	59.5	64.1	45.6
Commercial	14	0.5	14.4	10.2
Industrial	12.3	1	13.3	9.5
Mixed	3.4	0.9	4.3	3.1
Residential	24.5	19.8	44.3	31.5

This permit requirement is on schedule to be met.

IX. Additional Permit Reporting Requirements

1. Proposed SWMP Changes and Revisions

Attachment A is the SWMP for the City of Omaha; the City was granted an administrative extension to the existing permit and operates under this SWMP. The City annexed the following unincorporated areas in August 2016, and would now be considered part of the MS4 Permit coverage area.

Area Description	Population	Sq Miles	Acres
Autumn Grove and Adjacent Area – SW 156th & Q St	1,857	0.240	153.856
Dickensons Landing/Wood Creek – S of 175th & F St	1,454	0.231	147.577
Elk Valley – SE 204th & W Dodge Rd	754	0.159	101.858
Falcon Ridge – NW 180th & Harrison St	883	0.254	162.557
High Point & Adjacent Area – 198th-204thSt, approx. 1200-1600 block	105	0.154	98.443
Pacific Ridge – NW 180th & Pacific St	267	0.057	36.240
Western Oaks & Adjacent Area – NW 160th & Harrison	732	0.126	80.422

2. Expenditures for the Storm Water Program

At the time of preparation of this annual report the City Finance Department had not finalized the accounting for 2016 expenditures, so the following figures are subject to minor revisions. A copy of the complete City of Omaha budget with past expenditures can be found at http://finance.cityofomaha.org. Stormwater management activities are embedded in variety of City programs and work groups. These activities are funded by a variety of sources including the General Fund, Sewer Revenue Funds, Stormwater Administrative Fee Fund, Street and Highway Allocations, and the Street Maintenance Fund.

As such, it is difficult to accurately compile a comprehensive financial summary of every City activity that may have impacts on stormwater. For example, the City maintains litter cans in business districts throughout the City and has a contractor scheduled to empty them on a regular basis. This activity constitutes a stormwater source control or pollution prevention program. These costs are expended from the Solid Waste budget and are not included in the figures below.

1. Administrative

The Quality Control Division of the Omaha Public Works Department has responsibility for coordinating City activities to implement the SWMP and insure that the City meets its MS4 and CSO permit requirements. The estimated MS4 administrative expenditures for 2016 and appropriated 2017 budget amounts are listed below.

Administrative	2016 Expenditures	2017 Planned
Flood Control Administration	$218,597	$368,421
Baseline/BMP Monitoring[1]	$332,694	$482,785
Sediment/Erosion Control Program	$332,694	$482,785
Industrial Program[2]	$66,539	$96,557
Public Education/Outreach	$243,975	$354,042
MS4 Planning	$133,077	$193,114
Annual Administrative Total	$1,327,576	$1,977,703

[1] Includes outfall monitoring, outfall inspections, and illicit discharge investigations

[2] Includes industrial inspections and permitting

2. Operation and Maintenance

The major MS4-related Operation and Maintenance 2016 expenditures and budgeted amounts for 2017 are listed below. These amounts were estimated by evaluating the overall activity costs in the City budget organizations and assigning a percentage for the costs attributable to storm water related activities. There are undoubtedly additional City funded expenditures that impact storm water management, and the following is a conservative estimate of total costs for the City.

Operation and Maintenance	2016 Expenditures	2017 Budgeted
Engineering Design	$449,488	$662,393
Pavement Maintenance	$576,253	$1,417,374
Creek/Open Channel Maintenance	$801,766	$743,036
Street /Right of Way Cleaning	$3,020,099	$3,188,015
OWP (debris removal)	$9,342	$16,926
Residential Street Rehabilitation	$63,396	$520,000
Bridge Maintenance and Rehab	$76,904	$72,500
Sewer Maintenance	$606,165	$652,243
Annual O&M Total	$5,603,414	$7,272,487

ATTACHMENT A

ATTACHMENT A

Stormwater Management Plan for the City of Omaha

#1: Public Education & Outreach

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
1.A	Distribute informational brochures on the proper disposal of household hazardous wastes and the availability of the Household Hazardous Waste facility.	Year 1 – 5: Print and distribute brochures. Include the following in Annual Report: the quantity of waste received at the drop-off facility; a summary list of the distribution outlets used for brochures; an estimate of the brochures distributed each year.
1.B	Issue public service announcements related to storm water protection on local TV, radio or print outlets which will address TMDL pollutants of concern.	Year 1 – 5: A summary of the activities will be included in the Annual Report.
1.C	Continue existing drain marking program to improve public awareness concerning illegal dumping utilizing volunteer services (Boy Scouts) which will address TMDL pollutants of concern.	Year 1 – 5: Mark approximately 1,000 inlets annually and include a summary in the Annual Report.
1.D	Hold a Sediment and Erosion Control Seminar for the developers, builders, engineers, vendors, and graders which will address TMDL pollutants of concern.	Year 1 – 5: Annual Sediment and Erosion Control Seminar. Include a summary of the approximate number of participants in Annual Report.
1.E	Schedule outreach events with industry trade organizations to educate the regulated community regarding Omaha's Industrial Permitting Program.	Year 1 – 2: Industrial Permit Outreach. Include a summary of the number of events and approximate number of participants in Annual Report.
1.F	Work collaboratively with other community organizations to develop a campaign aimed at picking up pet waste which will address TMDL pollutants of concern.	Year 1: Develop outreach material and partnerships. Year 2 - 5: Distribute information. Provide an estimate of number of brochures distributed and activities targeted.
1.G	Develop materials and displays associated with BMP demonstration projects installed with Stormwater Management Program Plan funds from NDEQ.	Year 1 -5: Provide a narrative and examples of materials developed in annual report.
1.H	Develop a City Stormwater Program Web Site, including but not limited to storm water related information and provide educational information targeted for residents, children, and industries which will address TMDL pollutants of concern.	Year 1-5: Develop, operate and maintain a City Stormwater Web site. Include a narrative in the Annual Report describing the functions of the website.

 # 2: Public Participation and Involvement

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
2.A	Operate a stormwater hotline and web based complaint system for Watershed (general information, complaints, reports of illegal dumping, etc.).	Years 1 - 5: Maintain system operation and include summary of received calls/emails in the Annual Report.
2.B	Participate in organizing and hold open houses on Papillion Creek Watershed Plan activities.	Years 1 - 5: A summary of activities will be included in the Annual Report.
2.C	Continue to implement a stream Cleanup Day. Utilize Keep Omaha Beautiful to identify stream segments in need of cleanup and recruit volunteers from the local area, public groups, and representatives from local area business and developments.	Years 1 – 5: Conduct one clean-up day each year. A summary of the clean-up day activities will be included in the Annual Report.
2.D	Provide tours of UndertheSink, household hazardous waste facility, for schools and neighborhood organizations to learn about the proper way to manage household chemicals and about stormwater treatment systems installed at the site.	Year 1 – 5: Provide a summary of the tours conducted on an annual basis for the annual report. Document when BMPs are installed and included in the tour.
2.E	Hold World O! Water Festival focused on elementary school aged children to celebrate Clean Water and engage in water quality related activities.	Year 1-5: Hold event annually. Report estimated number of participants in Annual Report.
2.F	Participate in community organizations, conferences, workshops, and web casts related to water quality and stormwater management.	Year 1- 5: Report number of staff attending, dates, location, and description of events.

 # 3: Illicit Discharge Detection and Elimination

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
3.A	Perform dry-weather inspections including Physical Characteristics Examinations of storm water outfalls 72" or greater and any outfalls with documented complaints.	Year 1 – 5: Inspect and record observations. Included a count of outfalls inspected in the Annual Report.
3.B	Investigate and seek resolution concerning any dry weather discharges of potentially impacted by sources by notifying the source that they must discontinue discharging, and initiate enforcement action consistent with adopted ordinance which will address TMDL pollutants of concern. Any source that the applicant feels constitutes an immediate health or safety threat will be reported immediately to the NDEQ.	Year 1 – 5: The following information will be included in the Annual Report: the number of potential process or wastewater sources found; the number of above resolved at local level; and the identity of any referred and/or unresolved discharge sources.
3.C	Dry weather inspection of storm water outfalls, including smaller outlets and those that discharge to lesser tributaries or other storm conduits, in response to suspect conditions and/or complaints.	Year 1 – 5: Inspect and record observations. Included a count for outfalls inspected in the Annual Report.
3.D	Enforce existing City codes prohibiting illicit discharge connections to storm sewers.	Year 1 -5: Summarize code violations and enforcement actions taken in annual report.
3.E	Maintain and prevent instances of sanitary sewer leakage into MS4 or waters of the state.	Year 1 -5: Summarize investigations of leakage and actions taken in Annual Report.
3.E	Maintain and update a sewer map of major storm water outfalls and identify the names of respective receiving waters.	Years 1 - 5: Map will be maintained electronically on City GIS.
3.G	Prevent, contain and respond to spills to the MS4. Review, as necessary, interdepartmental SOPs with respects to spills, dumping and illegal disposal that impacts the MS4.	Year 1-5: Summarize number of reports of spills and actions taken in Annual Report. Identify City Department SOP and review date in Annual Report.

 # 4: Construction Site Runoff Control

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
4.A	Maintain the construction site inspection and reporting web site and continue to make enhancements.	Year 1-5: Include a narrative in the annual report about major web site upgrades and the date implemented.
4.B	Maintain a construction site inspection program that includes procedures for reporting, resolving deficiencies, and taking appropriate enforcement action consistent with adopted ordinances.	Years 1-5: The Annual Report will contain the following information relative to this commitment: 1) the number of inspections conducted in each of the following size categories: < 5 acres and > 5 acres 2) the number of sites receiving enforcement actions.
4.C	Maintain regulations and design specifications for controlling erosion, sediment loss, and other TMDL pollutants of concern from construction sites that disturb areas of 1 acre or more.	Year 1 -5: Provide a narrative description of any changes implemented in the City's sediment and erosion control regulations or design specifications in the annual report.
4.D	Maintain a program for performing review of Grading Permit applications to ensure compliance with applicable regulations and design specifications.	Year 1 -5: Summarize the number of grading permit issued on an annual basis.

 # 5: Post-construction Runoff Control

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
5.A	Develop guidance document for Post-Construction Stormwater Management Plan.	Year 2: Develop guidance document for Post Construction Storm Water Management Plan Year 2-5: Revise as necessary.
5.B	Participate with other City Departments to prepare an Environmental Element of City of Omaha Master Plan and include applicable storm water management provisions.	Year 1-5: Summarize progress in annual report. Year 5: Present the Environmental Element to City Planning Board and Omaha City Council for their consideration to adopt into the Omaha Master Plan.
5.C	Develop a database of existing structural BMPs (private and public) that reduce the impact of urbanization on storm water run-off and improve water quality and enhance other amenities and activities such as green space, parks and recreation, urban planning, aesthetics, and public safety.	Year 2: Coordinate with engineering firms and the NRD to identify existing BMPs and their location. Year 3: Develop a database and GIS map of BMPs.
5.D	Inspect annually and maintain (as necessary) City owned storm water BMP structures.	Year 1 -5: List BMPs inspected and summarize maintenance activity in Annual Report.
5.E	Revise stormwater BMP maintenance and inspection plan as needed.	Year 1-5: Review maintenance plan annually and include new structures. Make revisions as necessary. Report revisions and new structures in Annual Report.
5.F	Implement strategies, which include a combination of structural and or non-structural BMPs appropriate for the watershed, which will address TMDL pollutants of concern. Evaluate these strategies and implement changes as necessary to improve water quality and address TMDL pollutants of concern.	Year 1 -5: Summarize strategies, findings, and any changes in the Annual Report.

 # 6: Pollution Prevention/Good Housekeeping for Municipal Operations

BMP #	SWMP Element Description	Measurable Commitments & Implementation Schedule
6.A	Maintain Facility Runoff Control Plans (FRCP) for all City maintenance facilities to indentify BMPs implemented. Review FRCP annually and update as necessary. Inspect all facilities annually.	Year 1 -5: Review logs of FRCP updates and inspections. Report dates in annual report.
6.B	Inspect storm sewer conduits, channels and catch basins and remove and properly dispose of sediment and debris as needed to maintain an efficient system within permitted area.	Year 1 - 5: Report maintenance activities in the Annual Report.
6.C	Training will be provided for employees to prevent pollutant runoff from municipal operations at City maintenance facilities and at field operations.	Years 1 – 5: Provide training annually for employees and include summary in Annual Report of when training was held and number of attendees.
6.D	Provide for street cleaning in the following areas: Residential Business Major Streets Other areas in conjunction with special projects	Year 1 – 5: Summarize street cleaning activities in annual report.
6.E	City staff that applies pesticides will be trained in a certification program that complies with FIFRA regulations.	Year 1 -5: Report total number of City Staff certified each year in the Annual Report.
6.F	The City will continue to minimize pesticide and fertilizer use on publically maintained properties.	Year 1 -5: Summarize efforts in Annual Reports.

 # 7: Industrial Facilities (Amended 2016)

BMP#	SWMP Element Description	Measureable Commitments & Implementation Schedule
7.A	Assess the current listing of industries and maintain a systematic process to update the current listing of "known industrial facilities" in the MS4 that are required to obtain an industrial NPDES permit for stormwater discharge.	**On-Going All years –** Maintain the process for updating industrial facilities and any additional new facilities on the list of NDEQ permitted industrial facilities.
7.B	Maintain and refine a process for review of SWPPPs and stormwater discharges from known industrial facilities subject to state and federal stormwater discharge regulations or those that are determined by the Permittee to have a potential for contributing a substantial pollutant loading to the MS4.	**On-Going All Years** – Annually inspect 20%of NDEQ permitted industrial facilities subject to state and federal stormwater discharge regulations or develop a prioritization scheme to address facilities of greatest pollution potential for targeted inspections if inspection of all known facilities is not possible based on increases to the number of known facilities.
The Permittee may conduct other activities not specifically identified in this section which contribute to the industrial and related facility program.		

#8: Storm Water Monitoring Plan (Amended 2016)

BMP#	SWMP Element Description	Measurable Commitments & Implementation Schedule
8.A	The development and implementation of a BMP monitoring plan Monitoring will be flow based monitoring to assess the performance of different BMPs Monitoring Plan: Monitoring of the BMPs is to provide more useful data than has been gathered in the past. This will provide for a more complete picture of the efficiency of various BMPs in the watershed. a. Consideration will be given to the following objectives: i. Quantify the BMPs ability to reduce discharges to the storm sewer system. ii. Evaluate if any improvements could be made to the BMP to increase the volume of water detained from the storm sewer system. b. A record of the following information: i. Narrative and quantitative data, as appropriate, for each event. ii. A narrative description of the data and duration of the events sampled (either simulated event or real event)	**On-Going All Years** – Implement annual monitoring plan
8.B	Partner with local organizations, such as Nebraska Watershed Network, to evaluate the results of data that they collected that could provide water quality information on stream or urban aquatic fisheries	**On-Going All Years** –Report the results in the annual report.
8.C	Use GIS to identify land use based on zoning and calculate pollutant loads from discharges of the MS4 based on literature values and precipitation data.	**On-Going All Years** –Report the estimate in the annual report based on literature values.
The Permittee may conduct other activities not specifically identified in this section which contribute to Monitoring Program.		

City of Omaha
Jean Stothert, Mayor

Public Works Department

Omaha/Douglas Civic Center
1819 Farnam Street, Suite 601
Omaha, Nebraska 68183-0601
(402) 444-5220
Fax (402) 444-5248

Robert G. Stubbe, P.E.
Public Works Director

March 3, 2016

Emma Trewhitt
NPDES Permits and Compliance Unit, Water Quality Division
Nebraska Department of Environmental Quality
1200 "N" Street, Suite 400
Lincoln, NE 68509

RE: City of Omaha Municipal Separate Storm Sewer System (MS4) Permit NPDES # 0133698/IIS 738817

Dear Ms. Trewhitt,

This letter is to request a permit amendment pursuant to the provision of Part VI of our MS4 permit. Omaha would like to make changes in the Stormwater Monitoring Plan (SWMP) in program elements #7 Industrial Facilities and #8 Storm Water Monitoring Plan.

1) Justification to amend Program Element #7 Industrial Facilities

At the time the SWMP was drafted, Omaha felt that it would be more effective in getting Industries to allow us to inspect their facilities if Omaha issued permits in addition to the state issued permit. However, Omaha has had limited success in getting facilities to apply for Omaha's permit and has limited ability to take enforcement action. I believe Omaha can be more effective in helping industries maintain compliance with a State issued NPDES Industrial Stormwater Permit if industries were only issued a state permit. We could avoid any potential conflicts/or confusion created by differing permit requirements, and if needed, we would request a letter from NDEQ stating that the City is required to inspect permitted facilities in the event industries denied us access to their facility.

2) Justification to amend Program Element #8 Stormwater Monitoring Plan

The MS4 post construction program element was implemented in 2008 and requires new development and re-development to implement BMPs. Numerous BMPs have been installed throughout the Papillion Creek Watershed, and the City would like to better understand the effectiveness of the control measures to meet TMDLs for the Papillion Creek System. The City believes this will be an increased level of effort in this program element, because additional sites will be added to the BMP monitoring plan.

We are asking that the SWMP be amended and replace the current SWMP#7 and #8 with the language that follows, which is the same as what was previously submitted to NDEQ in 2013 with the MS4 permit renewal application.

#7 Industrial Facilities

BMP#	SWMP Element Description	Measureable Commitments & Implementation Schedule
7.A	Assess the current listing of industries and maintain a systematic process to update the current listing of "known industrial facilities" in the MS4 that are required to obtain an industrial NPDES permit for stormwater discharge.	**On-Going All years** – Maintain the process for updating industrial facilities and any additional new facilities on the list of NDEQ permitted industrial facilities.
7.B	Maintain and refine a process for review of SWPPPs and stormwater discharges from known industrial facilities subject to state and federal stormwater discharge regulations or those that are determined by the Permittee to have a potential for contributing a substantial pollutant loading to the MS4.	**On-Going All Years** – Annually inspect 20%of NDEQ permitted industrial facilities subject to state and federal stormwater discharge regulations or develop a prioritization scheme to address facilities of greatest pollution potential for targeted inspections if inspection of all known facilities is not possible based on increases to the number of known facilities.
The Permittee may conduct other activities not specifically identified in this section which contribute to the industrial and related facility program.		

#8 Stormwater Monitoring Plan

BMP#	SWMP Element Description	Measurable Commitments & Implementation Schedule
8.A	The development and implementation of a BMP monitoring plan Monitoring will be flow based monitoring to assess the performance of different BMPs Monitoring Plan: Monitoring of the BMPs is to provide more useful data than has been gathered in the past. This will provide for a more complete picture of the efficiency of various BMPs in the watershed. a. Consideration will be given to the following objectives: i. Quantify the BMPs ability to reduce discharges to the storm sewer system. ii. Evaluate if any improvements could be made to the BMP to increase the volume of water detained from the storm sewer system. b. A record of the following information: i. Narrative and quantitative data, as appropriate, for each event. ii. A narrative description of the data and duration of the events sampled (either simulated event or real event)	**On-Going All Years** – Implement annual monitoring plan
8.B	Partner with local organizations, such as Nebraska Watershed Network, to evaluate the results of data that they collected that could provide water quality information on stream or urban aquatic fisheries	**On-Going All Years** –Report the results in the annual report.
8.C	Use GIS to identify land use based on zoning and calculate pollutant loads from discharges of the MS4 based on literature values and precipitation data.	**On-Going All Years** –Report the estimate in the annual report based on literature values.
The Permittee may conduct other activities not specifically identified in this section which contribute to Monitoring Program.		

In addition to requesting the modification, we would also like to request that we are authorized to implement this by M 1, 2016. Data from the spring rain events is very valuable in assessing BMP effectiveness since these runoff events tend to carry the heavies pollutant loads.

If you have any questions or need additional information, do not hesitate to contact me at (402)-444-3915 ext. 229 and thank you for considering the City's request.

Sincerely,

Nina Cudahy

Nina Cudahy
Environmental Quality Control Manager, City of Omaha

CC: Robert Stubbe, Omaha Public Works Director
Reuel Anderson, Supervisor, NPDES Permits and Compliance Unit, Water Quality Division

STATE OF NEBRASKA

Pete Ricketts
Governor

APR 0 5 2016

DEPARTMENT OF ENVIRONMENTAL QUALITY
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Director
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Nina Cudahy
Environmental Quality Control Manger
City of Omaha
5600 South 10th Street
Omaha, NE 68107

RE: City of Omaha MS4 Permit, Stormwater Management Plan (SWMP)
NDEQ ID: 999428
Program ID: NE0133698

Dear Ms. Cudahy:

The Department has reviewed your Notice of Intent (NOI) submitted March 7, 2013. Proposed changes to the Stormwater Management Plan (SWMP) were included. The Department agrees that monitoring Best Management Practices (BMPs) is a better use of City resources when stream sampling is being conducted by parallel programs that can share the same data. We do not object to you implementing the proposed change in the SWMP this year prior to MS4 permit reissue. If you have questions regarding this letter or your MS4 permit, please contact Emma Trewhitt at 402-471-8330.

Sincerely,

Reuel Anderson, Unit Supervisor
NPDES Permits and Compliance
402-471-1367
reuel.anderson@nebraska.gov

ec: Emma Trewhitt

ATTACHMENT B

ATTACHMENT B
COMPLAINT INVESTIGATIONS

Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
10/2/2015	4765 S 135 St, Omaha, NE 68137	No	Debris in the Street/Sewer	Request for Voluntary Compliance - Verbal
10/7/2015	3711 N 84th St, Omaha, NE 68134	Yes	Dumping	Request for Voluntary Compliance - Verbal
10/14/2015	Rabe's Meats	No	Spill	Request for Voluntary Compliance - Verbal
10/15/2015	2203 S 181st Cir, Omaha, NE 68130	No	Construction - Grading Permit	Request for Voluntary Compliance - Verbal
10/16/2015	4913 Spaulding St, Omaha, NE 68104	No	Stormwater Runoff	No Action Taken
10/21/2015	4866 O St, Omaha, NE 68117	No	Leaves in the Street	No Action Taken
10/21/2015	11057 Oakbrook Dr, Omaha, NE 68154	No	Stormwater Runoff	No Action Taken
10/21/2015	9465 Dewey Cir, Omaha, NE 68114	No	Stormwater Runoff	No Action Taken
10/22/2015	2302 S 182nd Cir & 2451 S 182nd Cir Omaha, NE 68130	No	Construction	Request for Voluntary Compliance - Verbal
10/23/2015	6001 Seward St, Omaha, NE 68104	No	Other (please specify)	No Action Taken
10/27/2015	9521 Douglas St, Omaha, NE 68114	No	Construction	Request for Voluntary Compliance - Verbal
10/29/2015	12572 Ohern St, Omaha, NE 68137	No	Leaves in the Street	Request for Voluntary Compliance - Written
11/7/2015	168th & Fort St - E & S	No	Concrete Washout/Slurry	Referred to NDOR
11/7/2015	702 N 75 St, Omaha, NE 68114	No	Debris in the Street/Sewer	Request for Voluntary Compliance - Written
11/9/2015	14023 Adams Cir, Omaha, NE 68137	No	Leaves in the Street	Request for Voluntary Compliance - Written
11/19/2015	35th & Oak St, Omaha, NE 68105	Yes	Concrete Washout/Slurry	Referred to NDEQ
11/24/2015	12572 Ohern St, Omaha, NE 68137	No	Debris in the Street	Request for Voluntary Compliance - Written
11/24/2015	702 N 75 St, Omaha, NE 68114	No	Debris in the Street	Request for Voluntary Compliance - Written
11/25/2015	7602 Pinkney St, Omaha, NE 68134	No	Leaves in the Street	Request for Voluntary Compliance - Written

ATTACHMENT B

Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
11/25/2015	123 S 68 St, Omaha, NE 68132	No	Leaves in the Street	Request for Voluntary Compliance - Written
11/27/2015	122nd & Farnam St, Omaha, NE 68154	No	Dumping	No Action Taken
11/30/2015	4205 Browne St, Omaha, NE 68111	No	Stormwater Runoff	Request for Voluntary Compliance - Verbal
11/30/2015	King Kong - 3362 S 13th St, Omaha, NE 68108	No	Spill	Request for Voluntary Compliance - Written
12/4/2015	14506 U St, Omaha, NE 68137	No	Debris in the Street	Request for Voluntary Compliance - Written
12/9/2015	552 S 22 St, Omaha, NE 68102	No	Construction	Request for Voluntary Compliance - Verbal
12/15/2015	3113 State St, Omaha, NE 68112	No	Construction	Request for Voluntary Compliance - Written
12/17/2015	807 Cole Creek Dr, Omaha, NE 68114	No	Dumping	Request for Voluntary Compliance - Verbal
12/21/2015	12235 N St, Omaha, NE 68137	No	Debris in the Street	Request for Voluntary Compliance - Verbal
1/12/2016	3018 S 32nd St, Omaha, NE 68105	No	Stormwater Runoff	Forward to Street Department
1/13/2016	10711 Mockingbird Dr, Omaha, NE 68127	No	Dumping	Request for Voluntary Compliance - Verbal
1/26/2016	3113 State St, Omaha, NE 68112	No	Construction	Request for Voluntary Compliance - Verbal
3/3/2016	6706 L St, Omaha NE, 68117	No	Wash Water	Request for Voluntary Compliance - Verbal
3/15/2016	2703 S 14 St, Omaha, NE 68108	No	Stormwater Runoff	No Action Taken
3/16/2016	101 S 204 St, Elkhorn, NE 68022	No	Stormwater Runoff	Request for Voluntary Compliance - Verbal
3/18/2016	180th & Military, approximately 2 blocks north (Omaha, NE 68007)	No	Construction	Request for Voluntary Compliance - Verbal
4/4/2016	22nd & Douglas St	Yes	Concrete Washout/Slurry	Request for Voluntary Compliance - Verbal
4/4/2016	23rd & Douglas Sts, Omaha	Yes	Concrete Washout/Slurry	Notice of Violation
4/6/2016	31st & Leavenworth, Omaha, NE 68105	No	Construction	Request for Voluntary Compliance - Verbal
4/6/2016	2713 F St, Omaha, NE 68107	No	Spill	Request for Voluntary Compliance - Verbal
4/7/2016	100th Ave & Grover St	No	Other (please specify)	Forward to Streets & Sewer Maintenance

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Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
4/13/2016	NE corner of 35th St & Dodge 3412 Dodge St	No	Construction	Request for Voluntary Compliance - Verbal
4/13/2016	8502 Mormon Bridge Rd, Omaha, NE 68152 & 4703 State St	No	Other (please specify)	Request for Voluntary Compliance - Verbal
4/19/2016	3135 S 61 Ave, Omaha, NE 68106	No	Construction	Request for Voluntary Compliance - Verbal
5/2/2016	4601 N 192 Ter Cir/ 192nd Ter Cir and Meredith/ 192nd Terrace Circle off Manderson (Indian Creek Villas)	No	Construction	Request for Voluntary Compliance - Verbal
5/5/2016	16505 Fort St, Omaha, NE 68106	No	Construction	Forwarded to NDEQ
5/9/2016	NE corner of 35th St & Dodge 3413 Dodge St	No	ID - Construction	Request for Voluntary Compliance - Verbal
5/9/2016	NE corner of 35th St & Dodge 3412 Dodge St	No	Construction	Request for Voluntary Compliance - Verbal
5/9/2016	14011 Shirley St, Omaha, NE 68144	No	Debris in the Street/Sewer	Forward to Sewer Maintenance
5/10/2016	61st & O St, Omaha, NE	No	Construction	Forward to Street Maintenance
5/12/2016	1630 N 105 St, Omaha, NE 68144	Yes	Stormwater Runoff	Request for Voluntary Compliance - Written
5/13/2016	1347 Ellison St, Omaha, NE 68110		Stormwater Runoff	Forward to Street Department
5/16/2016	180th & Military, approximately 2 blocks north	No	Construction	Request for Voluntary Compliance - Verbal
5/17/2016	3104 N 193 Ave, Elkhorn, NE 68022	No	Construction	No Action Taken
5/17/2016	15220 Military Rd (Ackerhurst Dairy Farm)	No	Construction	Request for Voluntary Compliance - Verbal
5/19/2016	1351 S 52nd Ave, Omaha, NE 68106	Yes	Concrete Washout/Slurry	Letter of Warning
5/20/2016	7917 Woolworth Ave, Omaha, NE 68124	Yes	Non-stormwater discharge	Request for Voluntary Compliance - Written
5/23/2016	4800 Poppleton, Omaha, NE 68106	No	Construction	Request for Voluntary Compliance - Verbal
5/23/2016	3904 N Branch Dr	No	Stormwater Runoff	No Action Taken
5/25/2016	Brandeis Apartments, 210 S 16 St, Omaha, NE 68102	No	Wash Water	Request for Voluntary Compliance - Verbal

ATTACHMENT B

Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
5/27/2016	South of 7440 Farnam St	No	Construction	Request for Voluntary Compliance - Verbal
5/27/2016	88th & Fort	Yes	Spill	No Action Taken
6/1/2016	18618 Leavenworth St, Elkhorn, NE 68022	No	Dumping	Request for Voluntary Compliance - Verbal
6/7/2016	252 S 199 St, Omaha, NE 68022	Yes	Dumping	Request for Voluntary Compliance - Written
6/7/2016	252 S 199 ST	No	Construction	Other
6/7/2016	7002 Q St Omaha, NE 68117	Yes	Dumping	Request for Voluntary Compliance - Verbal
6/10/2016	1114 S 55th St	No	Construction	Request for Voluntary Compliance - Verbal
6/14/2016	14067 Drexel Cir Omaha NE 68137-4040	Yes	Concrete Washout/Slurry	Letter of Warning
6/17/2016	5108 Y St	Yes	Construction	Request for Voluntary Compliance - Written
6/21/2016	17650 Wright St - Bellezza Salon	Yes	Illicit Connection	Letter of Warning
6/23/2016	SE corner of 72nd & Blondo, behind Family Dollar	No	Dumping	No Action Taken
6/24/2016	34th & Redick 3421 Redick Ave	No	Construction	Request for Voluntary Compliance - Written
7/5/2016	17008 Hawthorne Plaza, Omaha, NE 68118-2853	Yes	Spill	Request for Voluntary Compliance - Verbal
7/11/2016	1205 Drexel St, Omaha, NE 68107	No	Construction	Request for Voluntary Compliance - Verbal
7/12/2016	4906 S 235th St, Elkhorn, NE 68022	No	Construction	Request for Voluntary Compliance - Verbal
7/20/2016	51st & 52nd St on Chicago St	Yes	Construction	Request for Voluntary Compliance - Verbal
7/22/2016	14454 Tibbles St	No	Stormwater Runoff	No Action Taken
8/4/2016	156th & Maple 15505 Ruggles St, #106	Yes	Spill	Request for Voluntary Compliance - Written
8/18/2016	3336 S 66th Ave Cir, Omaha, NE 68106	No	Construction	Request for Voluntary Compliance - Verbal
8/23/2016	12228 Patrick Ave	No	Construction	Request for Voluntary Compliance - Verbal
8/24/2016	9316 Oak St	No	Stormwater Runoff	No Action Taken
8/25/2016	3452/3458 S 13th St	No	Construction	Request for Voluntary Compliance - Verbal
8/26/2016	6522 S 173rd Ave	No	Construction	Request for Voluntary Compliance - Verbal

ATTACHMENT B

Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
8/26/2016	6522 S 173rd Ave	No	Construction	Request for Voluntary Compliance - Verbal
8/26/2016	7820 Jackson St	No	Construction	No Action Taken
8/30/2016	1510 J Street	No	Stormwater Runoff	No Action Taken
9/7/2016	4610 Orchard Ave	No	Construction	No Action Taken
9/20/2016	Approximately the area at & around 2344 S 182nd Cir	Yes	Construction	Request for Voluntary Compliance - Verbal
9/21/2016	3412 Dodge St NE corner of 35th St & Dodge	Yes	Construction	Request for Voluntary Compliance - Verbal
9/22/2016	170th & I St	No	Debris in the Street/Sewer	No Action Taken
9/22/2016	524 S 90th St	No	Construction	Request for Voluntary Compliance - Verbal
9/28/2016	2712 S 17th St	No	Dumping	No Action Taken
9/28/2016	6308 S 178th St, Omaha, NE 68135	No	Dumping	Request for Voluntary Compliance - Verbal
10/3/2016	6902 N 45th St / North of 45th St & Huntington Ave, caller states it is at the dead end of 45th, 6902 N 45th St	No	Construction	Request for Voluntary Compliance - Verbal
10/3/2016	Erskine St between 55th & 58th St	No	Leak	No Action Taken
10/6/2016	NE corner of 35th St & Dodge 3412 Dodge St	No	Construction	Request for Voluntary Compliance - Written
10/11/2016	6620 N 107th; the townhome office address is 6510 N 107th Plaza	No	Construction	Request for Voluntary Compliance - Verbal
10/20/2016	129th Cir & Eagle Run Dr	Yes	Concrete Washout/Slurry	Letter of Warning
10/26/2016	8745 Raven Oaks Dr	No	Construction	Request for Voluntary Compliance - Verbal
11/1/2016	3402 Martin Ave & 3417 Martin Ave	No	Debris in the Street	Request for Voluntary Compliance - Written
11/2/2016	6008 Country Club Oaks Place	No	Construction	Request for Voluntary Compliance - Verbal
11/7/2016	1929 S 47th St	No	Debris in the Street	Request for Voluntary Compliance - Verbal
11/10/2016	1412 Howard Street	Yes	Construction	Request for Voluntary Compliance - Verbal
11/15/2016	36th St & I-80 at the South Omaha bike trail	No	Debris in the Street/Sewer	No Action Taken
11/18/2016	72nd & Redick 6406 N 72nd St	Yes	Dumping	Request for Voluntary Compliance - Verbal

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Date Received	Issue Address	Illicit Discharge	Complaint Type	Enforcement Action Taken
12/2/2016	24335 Douglas Circle; West Shores	No	Construction	No Action Taken
12/8/2016	4202 Dahlman Ave, on Dahlman	No	Leak	No Action Taken

ATTACHMENT C

Omaha Grading Permit Enforcements

Permit Number	Address	Status	Date Submitted	Action Taken
OMA-20130813-1533-1	186th & Pacific, Omaha, NE 68022	Resolved	9/1/2016	RVC
OMA-20140214-1597-2	7101 N 102nd Circle, Omaha, NE 68122	Resolved	7/8/2016	RVC
OMA-20140825-2710-GP1	168th & IDA, Omaha, NE 68007	Resolved	10/26/2016	RVC
OMA-20141219-2899-GP1	186th & Blondo Street, Omaha, NE 68022	Active	8/9/2016	Forward to NDEQ
OMA-20150527-3123-GP2	6801 S 180 Street, Omaha, NE 68135	Resolved	10/19/2016	RVC
OMA-20150625-3155-GP2	18451 California Street, Omaha, NE 68022	Resolved	7/15/2016	RVC

ATTACHMENT D

Creighton Prep

2016 Monitoring Executive Summary

Creighton Prep

The Creighton Prep site is located on the southern edge of the Creighton Preparatory High School near the intersection of Western Ave and N 72nd Street in Omaha, Nebraska. The bioretention garden was constructed in spring 2014 and designed by Lamp Rynearson & Associates. The inline bioretention garden is sized to receive the primary drainage area runoff from a 24-inch inlet pipe that has a peak discharge of approximately 23.5 cfs for a 2.1 acre drainage area. However, the bioretention basin also receives overland flow from the 7.7 acre turf sports field, showing that the garden is undersized depending on the turf grass soil conditions prior to a given rain event.

Burns & McDonnell and the City of Omaha developed a monitoring plan that outlined the equipment, placement of equipment, installation requirements, and field procedures to monitor inflow and outflow of the primary structures, ponding depth in the garden, the local water table, and collect inflow and outflow water quality samples. An area velocity meter was installed in the 24-inch inflow pipe and the 12-inch area inlet outflow pipe. The local water table beneath the bioretention basin was monitored using three shallow wells referred to as stilling wells. The ponding depth within the bioretention basin was monitored with a similar method using a pressure transducer and a stilling basin. Finally, two automated water quality samplers were installed near the inflow and outflow locations.

Monitoring activities were completed on site between July 23, 2015 and August 11, 2016: Major monitoring activities include:

- Installed three (3) Stilling Wells (By Others) – July 23, 2015
- Installed Inflow/Outflow flow meters; installed stilling basin; installed pressure transducers; installed rain gauge – August 7, 2015
- Removed equipment and winterized remaining equipment November 24, 2015
- Re-installed monitoring equipment, collected survey coordinates and elevations (By Others), and performed stilling well slug tests April 15, 2016
- Water Quality Samples Collected
    - Event 1 – April 26, 2016
    - Event 2 – May 26, 2016
    - Event 3 – June 21, 2016

The monitoring data recorded for the Creighton Prep bioretention site included rainfall, inflow and outflow discharge rates, ponding water depth, local water table, and water quality samples. During the monitoring period the overall weather conditions in Omaha, Nebraska were more wet and hotter than normal. Daily weather history and observations from the Eppley Airfield Weather Station were downloaded for comparison. An Isco 674 tipping bucket rain gauge recorded precipitation was on site, the total recorded rainfall during the 2015 and 2016 monitoring periods was approximately 17 inches and 15 inches, respectively. Isco 2150 area velocity flow meters recorded flow were on site; the largest inflow event volume event was approximately 77,000 cubic feet on August 17 & 18, 2015. A Global Water WL 16 pressure transducer within a stilling basin recorded ponding depth on site; the maximum ponding event elevation was 1139.57 feet on August 17 & 18, 2015. Global Water WL 16 pressure transducers within shallow monitoring wells recorded local water table levels on site; during the monitoring period, the well data varied greatly between wells for the same events due to varying soil permeability across the garden. Isco 6712 full-sized automated samplers collected inflow and outflow water quality samples. Analyzed sampling events occurred on April 27, 2016, May 26, 2016, and June 21, 2016.

The inflow and outflow data indicated that for the majority of events runoff from the grass turf field was significant. Therefore for the volume measured into the bioretention garden did not match the volume measured leaving the bioretention garden. The water quality data was also inconclusive with no real trends other than TSS was significantly reduced from the inflow to the outflow for the May 26, 2016 and June 21, 2016 events. The TDS also was higher in the outflow indicating that fines and organic material in the engineered soils may be washed out through the underdrain. The near surface monitoring wells had varied results with Well 3 having no response to inflow, Well 2 having some response to inflow, and Well 1 having immediate response to inflow. Overall the near surface monitoring wells indicated a local water table below the bioretention garden between elevation 1127.7 to 1129.5 feet or approximately 8 to 9 feet below the bottom of the bioretention garden.

The ponding depth data seemed to provide the most useful data for this inline bioretention garden. A measurable ponding depth was observed when rainfall depth exceeded approximately 0.1 inches or the peak rainfall intensity exceeded 2.6 inch/hour. Overall ponded water within the bioretention garden infiltrated at an average rate of approximately 1.5 inches per hour.

Orchard Park

The Orchard Park site is located on the western edge of Orchard Park near the intersection of N 66th Street and Kansas Avenue in Omaha, Nebraska. The bioretention system was constructed in 2009 and designed by Olsson & Associates. The offline bioretention garden is sized to receive the primary drainage area runoff from two street side curb-cuts which serve an approximate 1.0 acre drainage area. The bioretention basin can overflow into a nearby sewer inlet if a given rain event produces a volume greater than the design volume.

Burns & McDonnell and the City of Omaha developed a monitoring plan that outlined the equipment, placement of equipment, installation requirements, and field procedures to monitor ponding depth in the main garden basin, soil moisture in and outside the basin, and collect inflow and outflow water quality samples during a simulation event. Soil moisture was monitored using soil moisture sensors and neutron probes. The ponding depth within the bioretention basin was monitored using a pressure transducer and a stilling basin.

Monitoring activities were completed on site between September 23, 2015 and August 11, 2016: Major monitoring activities include:

- Installed stilling basin and rain gauge – September 23, 2015
- Installed fifteen (15) Aluminum Neutron Probe Tubes (By Others) – September 23, 2015
- Installed soil moisture sensors – October 2, 2015
- Conducted Simulation Event – October 19, 2015
- Removed equipment and winterized remaining equipment - November 24, 2015
- Re-installed monitoring equipment, collected survey coordinates and elevations (By Others) - April 15, 2016

The monitoring data recorded for the Orchard Park bioretention site included rainfall, ponding water depth, soil moisture, and simulation event water quality samples. During the monitoring period the overall weather conditions in Omaha, Nebraska were more wet and hotter than normal. Daily weather history and observations from the Eppley Airfield Weather Station were downloaded for comparison. A

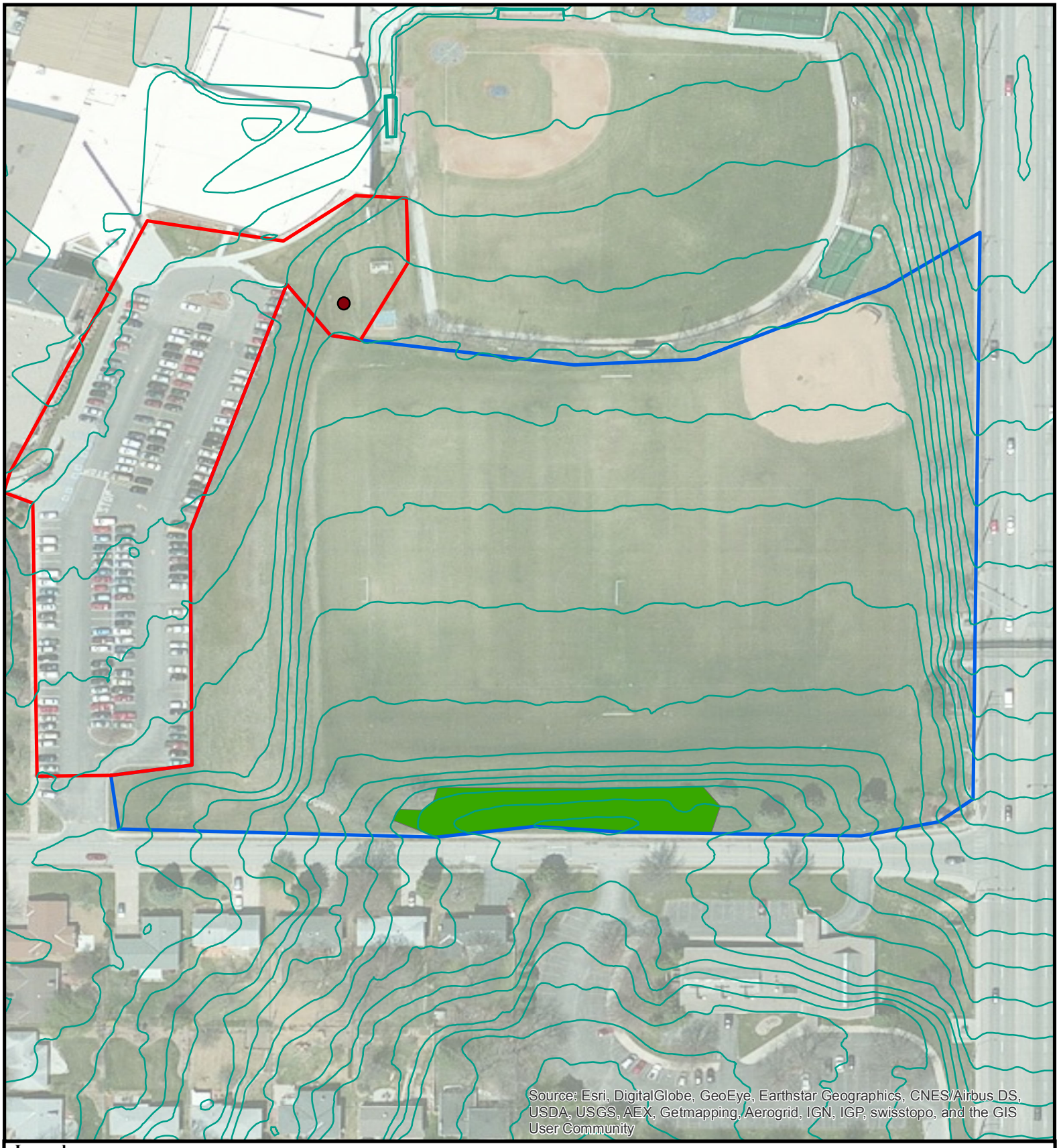
ATTACHEMENT D

Decagon Devices ECRN-100 tipping bucket rain gauge recorded precipitation on site; the total recorded rainfall during the 2015 and 2016 monitoring periods was approximately 6 inches and 22 inches, respectively. A Global Water WL 16 pressure transducer within a stilling basin recorded ponding depth within the primary bioretention cell; the maximum non-simulation event ponding event elevation was a depth of 1.39 feet on November 11, 2015. Decagon Devices GS3 soil moisture sensors were installed in and outside of the basin to record soil moisture. Soil moisture was also collected at depths of up to ten feet with a Troxler neutron probe and the installed aluminum tubes. Both methods of soil moisture collection were compared and analyzed. A simulation event was conducted to utilize the above monitoring equipment as well as the collection of water quality samples in controlled environment.

Overall the soil moisture data showed that the soils beneath and around the bioretention cell were mostly to fully saturated soils. The soil moisture sensors and neutron probe data showed some drying of the upper soils during dry periods but deeper soils were found to be very wet throughout the monitoring period. Soil moisture within the bioretention basin was found to be greater at all depths than soils outside of the bioretention basin. The soil moisture sensor data did generally agree with the neutron probe data but in general the neutron probe soil moisture was found to be lower than the soil moisture sensors. The soil moisture sensors in the upper 30 inches of soil had better response to rainfall events.

Water quality samples collected during a simulation event on October 19, 2015 were generally inconclusive. The first flush sample into the forebay was high in TSS at 3,930 mg/L with no measurable TSS in the underdrain samples which indicates 100% reduction in TSS through the bioretention basin. The TDS data showed no reduction in TDS through the forebay, bioretention basin, or underdrain samples. The highest nitrate-nitrite nitrogen and E.coli samples were recorded from the first sample collected from the underdrain after the valve was opened. Water quality samples collected in Cole Creek were also found to be high in E.coli.

The infiltration rate during the simulation event with the underdrain value closed was very low at 0.12 inches per hour. With the valve opened a quarter of a turn, the ponded water within the basin dewatered at a rate of 4.18 inches per hour.



Legend

- 2FT CONTOURS
- INFLOW AREA: 2.1 ACRES
- UNGAUGED AREA: 7.7 ACRES
- GRATE INLET
- BIORETENTION CELL

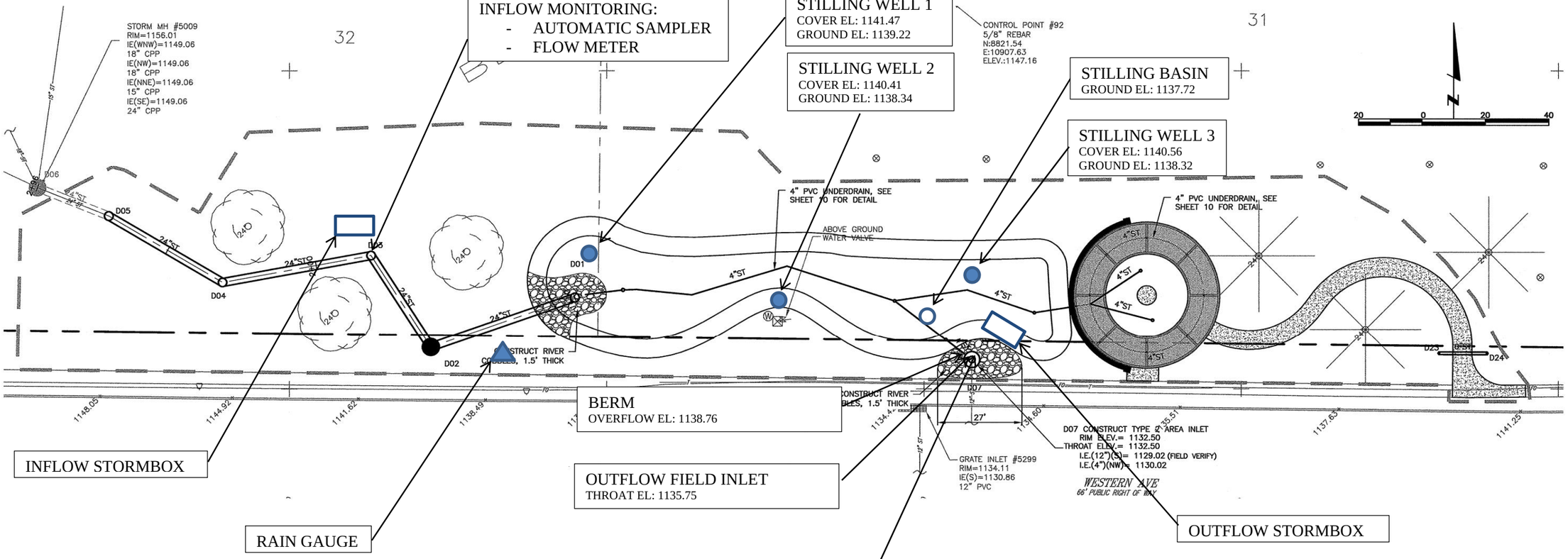
CREIGHTON PREP CONTRIBUTING AREAS
OMAHA STORMWTER PROGRAM
GREEN INFRASTRUCTRE MONITORING

N
W E
S

Feet
0 30 60 120 180 240 300

BURNS McDONNELL

OMAHA STORMWATER PROGRAM



Creighton Prep Survey Data		
Point	**Northing**	**Easting**
Stilling Basin	548407.38	2732378.86
Overflow	548392.76	2732394.11
Berm	548397.52	2732386.46
Stilling Well 1	548416.69	2732264.26
Stilling Well 2	548411.95	2732335.73
Stilling Well 3	548419.50	2732396.73

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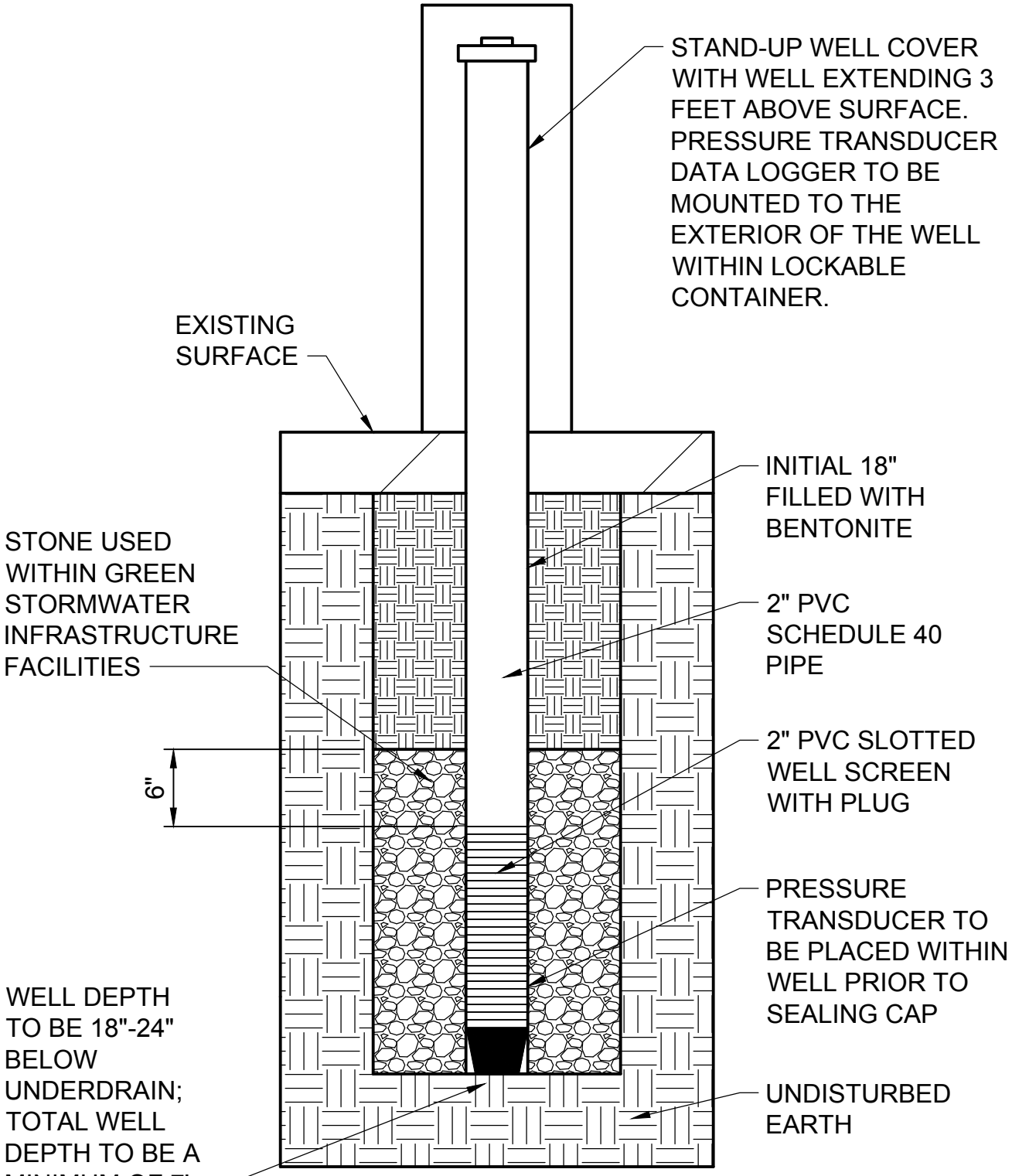
CREIGHTON PREP
SITE LAYOUT



STILLING WELL

NOT TO SCALE

OMAHA STORMWATER PROGRAM

BURNS McDONNELL

CUT SHEET
STILLING WELL

06/05/2015

Omaha GI Monitoring
Creighton Prep - Ponding Summary

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2015 Creighton Prep Ponding Analysis											
Rain Event*	5-day Prior Rainfall (in)	Event Start	Event End	Duration	Total Depth (in)	Avg Intensity (in/hr)**	Max Intensity (in/hr)**	Max Ponding (Elev. ft)	Max Ponding (in)	Max Ponding (date/time)	Notes
1	0.01	8/8/2015 3:10	8/8/2015 4:40	1:30:00	0.170	0.107	0.240	1137.83	1.32	8/8/2015 4:41	
2	0.20	8/9/2015 0:05	8/9/2015 3:10	3:05:00	1.580	0.499	3.480	1139.12	16.80	8/9/2015 0:16	
3	2.05	8/9/2015 23:45	8/10/2015 0:05	0:20:00	0.800	1.920	2.640	1139.16	17.28	8/10/2015 0:01	
4	0.02	8/17/2015 4:25	8/18/2015 12:45	32:20:00	6.000	0.185	4.800	1139.57	22.20	8/18/2015 1:06	Multiple Peaks within Storm
5	0.20	8/22/2015 17:55	8/22/2015 18:25	0:30:00	0.200	0.343	1.440	-	-	-	Data gap 8/19 - 8/28
6	0.20	8/27/2015 7:45	8/27/2015 8:00	0:15:00	0.060	0.180	0.240	-	-	-	Data gap 8/19 - 8/28
7	0.07	8/27/2015 23:55	8/28/2015 3:35	3:40:00	0.990	0.264	0.960	-	-	-	Data gap 8/19 - 8/28
8	0.00	9/6/2015 19:35	9/6/2015 19:40	0:05:00	0.030	0.180	0.240	1137.73	0.12	9/7/2015 2:00	No Significant Ponding
9	0.07	9/8/2015 3:05	9/8/2015 5:50	2:45:00	0.650	0.229	1.560	1138.82	13.20	9/8/2015 5:30	
10	0.73	9/9/2015 20:55	9/9/2015 22:15	1:20:00	0.130	0.092	0.120	1137.75	0.36	9/9/2015 22:30	
11	0.00	9/17/2015 2:30	9/17/2015 2:30	0:00:00	0.010	0.120	0.120	1137.73	0.12	9/17/2015 2:35	No Significant Ponding
12	0.01	9/18/2015 10:15	9/18/2015 10:50	0:35:00	0.070	0.105	0.240	1137.76	0.48	9/19/2015 1:20	No Significant Ponding
13	0.09	9/22/2015 16:20	9/24/2015 21:05	52:45:00	4.440	0.084	2.400	1139.02	15.60	9/23/2015 8:55	Multiple Peaks within Storm
14	1.36	9/29/2015 2:25	9/29/2015 4:40	2:15:00	0.270	0.116	0.360	1138.34	7.44	9/29/2015 4:45	
15	0.00	10/22/2015 8:45	10/22/2015 8:45	0:00:00	0.010	0.120	0.120	1137.76	0.48	10/22/2015 9:05	No Significant Ponding
16	0.05	10/23/2015 4:40	10/23/2015 18:30	13:50:00	0.280	0.020	0.480	1137.76	0.48	10/23/2015 8:30	No Significant Ponding
17	0.32	10/27/2015 13:40	10/27/2015 15:15	1:35:00	0.070	0.042	0.360	1137.77	0.60	10/27/2015 13:50	No Significant Ponding
18	0.11	10/30/2015 21:05	10/31/2015 5:50	8:45:00	0.270	0.031	0.240	1137.77	0.60	10/30/2015 21:10	No Significant Ponding
19	0.02	11/11/2015 13:45	11/11/2015 21:15	7:30:00	0.710	0.094	1.200	1138.44	8.64	11/11/2015 15:05	Multiple Peaks within Storm
20	0.06	11/16/2015 23:25	11/17/2015 9:15	9:50:00	0.550	0.055	1.080	1138.48	9.12	11/17/2015 9:10	
21	0.64	11/17/2015 22:40	11/18/2015 0:00	1:20:00	0.140	0.099	0.360	1138.00	3.36	11/17/2015 23:45	
22	0.78	11/20/2015 17:40	11/20/2015 17:40	0:00:00	0.010	0.120	0.120	1137.80	0.96	11/20/2015 21:05	

*12hr Interevent Minimum
**Intensities calculated per 5 minute intervals
Total Event Depth Less than 0.1"
"-" Data Not available
Basin Ground Elevation (ft): 1137.72

Omaha GI Monitoring
Creighton Prep - Ponding Summary

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2016 Creighton Prep Ponding Analysis											
Rain Event*	5-day Prior Rainfall (in)	Event Start	Event End	Duration	Total Depth (in)	Avg Intensity (in/hr)**	Max Intensity (in/hr)**	Max Ponding (ft)	Max Ponding (in)	Max Ponding (date/time)	Notes
1	0.14	4/18/2016 10:00	4/18/2016 11:55	1:55:00	0.220	0.110	0.240	-	-	-	Data gap 4/15 - 6/10
2	0.39	4/20/2016 4:15	4/21/2016 0:40	20:25:00	2.420	0.118	1.080	-	-	-	Data gap 4/15 - 6/10
3	2.44	4/24/2016 4:50	4/24/2016 5:00	0:10:00	0.040	0.160	0.240	-	-	-	Data gap 4/15 - 6/10
4	0.21	4/26/2016 22:30	4/26/2016 22:40	0:10:00	0.030	0.120	0.120	-	-	-	Data gap 4/15 - 6/10
5	0.29	4/27/2016 0:10	4/27/2016 18:20	18:10:00	1.760	0.096	1.080	-	-	-	Data gap 4/15 - 6/10
6	2.03	4/30/2016 2:25	4/30/2016 9:05	6:40:00	0.990	0.147	0.360	-	-	-	Data gap 4/15 - 6/10
7	0.01	5/9/2016 1:05	5/9/2016 7:20	6:15:00	1.110	0.178	1.560	-	-	-	Data gap 4/15 - 6/10
8	1.16	5/9/2016 20:15	5/9/2016 22:00	1:45:00	0.300	0.164	0.240	-	-	-	Data gap 4/15 - 6/10
9	1.49	5/11/2016 0:35	5/11/2016 8:05	7:30:00	0.970	0.128	1.560	-	-	-	Data gap 4/15 - 6/10
10	0.06	5/16/2016 11:45	5/16/2016 12:55	1:10:00	0.100	0.080	0.120	-	-	-	Data gap 4/15 - 6/10
11	0.00	5/23/2016 11:40	5/24/2016 0:55	13:15:00	0.470	0.035	1.080	-	-	-	Data gap 4/15 - 6/10
12	0.48	5/25/2016 1:45	5/25/2016 2:05	0:20:00	0.290	0.696	1.560	-	-	-	Data gap 4/15 - 6/10
13	0.84	5/26/2016 17:05	5/26/2016 20:55	3:50:00	0.260	0.066	0.720	-	-	-	Data gap 4/15 - 6/10
14	0.06	6/3/2016 19:15	6/3/2016 19:45	0:30:00	0.380	0.651	1.560	-	-	-	Data gap 4/15 - 6/10
15	0.01	6/18/2016 2:40	6/18/2016 4:45	2:05:00	0.380	0.175	0.240	1138.29	6.84	6/18/2016 4:43	
16	0.46	6/21/2016 1:45	6/21/2016 5:00	3:15:00	0.280	0.084	0.360	1138.38	7.92	6/21/2016 3:13	**4.65 in/hr Infiltration Rate**
17	0.00	6/27/2016 7:35	6/27/2016 8:00	0:25:00	0.060	0.120	0.120	1137.72	0.00	6/27/2016 7:38	No Significant Ponding
18	0.08	6/28/2016 7:55	6/28/2016 8:05	0:10:00	0.050	0.200	0.360	1137.72	0.00	6/28/2016 7:58	No Significant Ponding
19	0.14	6/29/2016 4:25	6/29/2016 5:45	1:20:00	0.740	0.522	1.560	1139.26	18.48	6/29/2016 5:08	**1.15 in/hr Infiltration Rate**
20	0.92	6/29/2016 19:05	6/29/2016 20:00	0:55:00	0.170	0.170	0.480	1139.05	15.96	6/29/2016 19:13	
21	1.12	7/2/2016 3:55	7/2/2016 18:30	14:35:00	1.940	0.132	0.600	1138.00	3.36	7/2/2016 6:02	
22	2.01	7/7/2016 1:35	7/7/2016 5:10	3:35:00	0.360	0.098	0.720	1137.88	1.92	7/7/2016 2:07	
23	0.42	7/11/2016 23:25	7/12/2016 1:25	2:00:00	0.650	0.312	0.480	1138.01	3.48	7/12/2016 0:07	
24	0.18	7/18/2016 0:25	7/18/2016 6:25	6:00:00	0.740	0.123	0.240	1138.03	3.72	7/18/2016 1:07	

*12hr Interevent Minimum

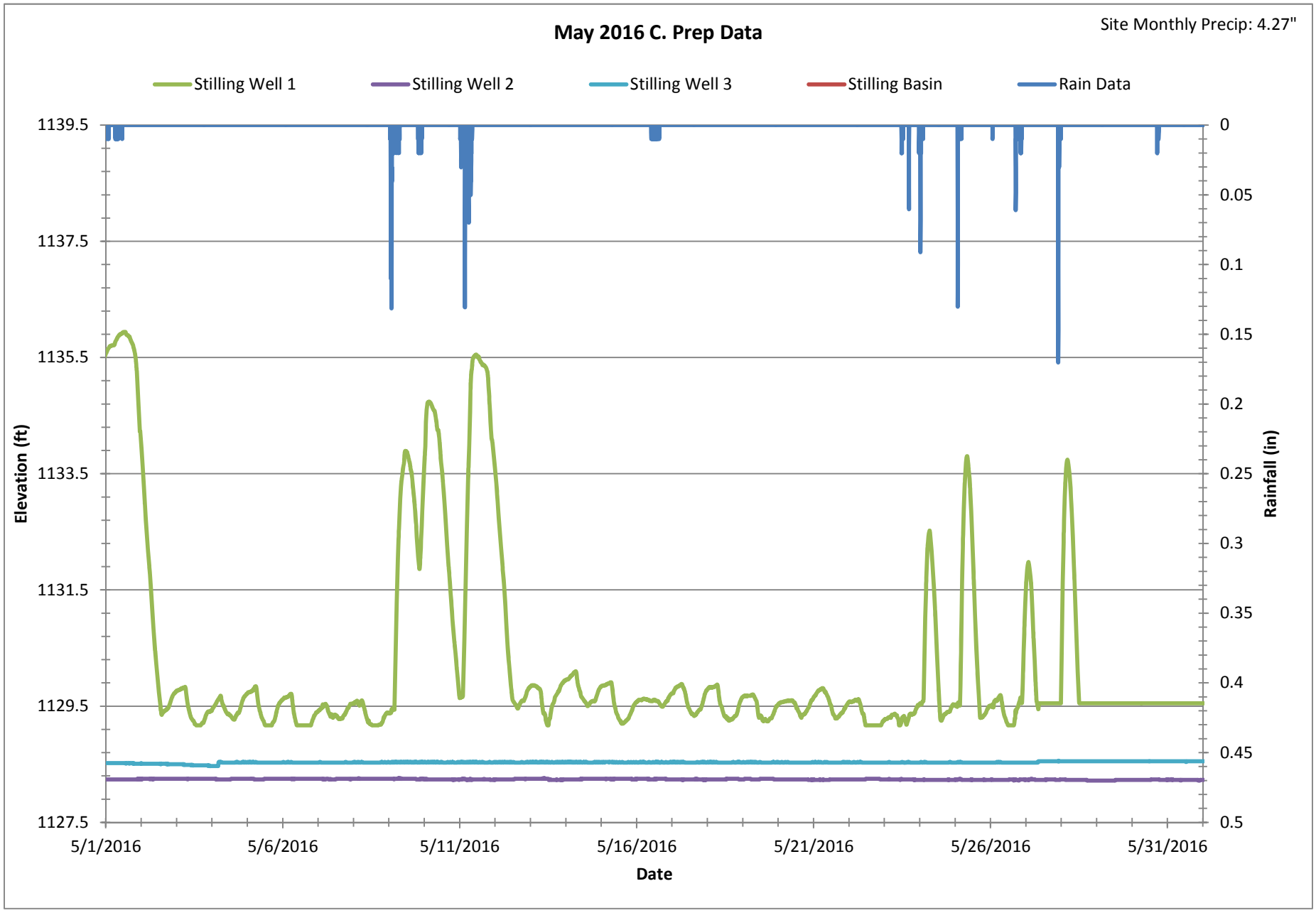
**Intensities calculated per 5 minute intervals

Total Event Depth Less than 0.1"

"-" Data Not available

Basin Ground Elevation (ft): 1137.72

Creighton Prep



Omaha Green Infrastructure Monitoring 2016
Composite Sample Table
Site: C. Prep
Date: 4/26/2016 - 4/27/2016

Event Start: 4/26/2016 20:50
Event End: 4/27/2016 5:25

Inflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	0	1-2in.	1	-
2	5	1-2in.	1	-
3	10	1-2in.	1	-
4	15	1-2in.	1	-
5	20	1-2in.	1	-
6	25	1-2in.	1	-
7	30	1-2in.	-	-
8	35	1-2in.	-	-
9	40	-	-	-
10	45	-	-	-
11	50	-	-	-
12	55	-	-	-
13	60	-	-	-
14	65	-	-	-
15	70	-	-	-
16	75	1-2in.	2	-
17	80	1-2in.	2	-
18	85	1-2in.	2	-
19	90	1-2in.	2	-
20	95	1-2in.	2	-
21	100	1-2in.	3	-
22	105	1-2in.	3	-
23	110	1-2in.	3	-
24	115	1-2in.	3	-

Outflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	0	~1/3L	1	-
2	15	~1/3L	1	-
3	30	~1/3L	1	-
4	45	~1/3L	2	-
5	60	~1/3L	2	-
6	75	~1/3L	2	-
7	90	~1/3L	2	-
8	105	~3/4L	3	-
9	120	~3/4L	3	-
10	135	~3/4L	3	-
11	150	~3/4L	3	-
12	165	~3/4L	-	-
13	180	~3/4L	-	-
14	195	~3/4L	-	-
15	210	~3/4L	-	-
16	225	~3/4L	-	-
17	240	~3/4L	-	-
18	255	~3/4L	-	-
19	270	~3/4L	-	-
20	285	~3/4L	4	1
21	300	~3/4L	4	1
22	315	~3/4L	4	1
23	330	~3/4L	4	1
24	345	~3/4L	4	1

Omaha Green Infrastructure Monitoring 2016
Water Quality Results
Site: Creighton Prep
Date: 4/26/2016 - 4/27/2016

Beginning of Event: 4/26/2016 20:50 **Rain Total:** 0.98 **Days Since Previous Rain:** 2 (.45in)
End of Event: 4/27/2016 5:25
Event Duration: 8hrs 35min (intermittent)

					Results								
Sample Label	**Time Collected**	**Time Elapsed (min)**	**Date Collected**	**Location**	**Cadmium (mg/L)**	**Zinc (mg/L)**	**TKN (mg/L)**	**Nitrate Nitrite Nitrogen (mg/L)**	**Phosphorus (mg/L)**	**TDS (mg/L)**	**TSS (mg/L)**	**pH (S.U.)**	**E. Coli (CFU/100mL)**
Incoming 1	9:26PM - 9:50PM	0 - 25	4/27/2016	Influent Sampler	<	0.007	4.02	1.33	0.28	142	57	7.17	-
Incoming 2	10:40PM - 11:00PM	75 - 95	4/27/2016	Influent Sampler	<	0.03	1.69	1.31	0.11	146	10	7.52	-
Incoming 3	11:05PM - 11:20PM	100 - 115	4/27/2016	Influent Sampler	<	0.03	1.36	1	0.08	134	13	7.35	-
Outgoing 1	10:16PM - 10:46PM	0 - 30	4/27/2016	Effluent Sampler	<	0.03	1.79	2.41	0.13	178	32	7.56	-
Outgoing 2	11:01PM - 11:46PM	45 - 90	4/27/2016	Effluent Sampler	<	0.03	1.46	1.77	0.11	166	8	7.43	-
Outgoing 3	12:00AM - 12:45AM	105 - 150	4/27/2016	Effluent Sampler	<	0.01	<	2.3	0.11	152	14	7.54	-
Outgoing 4	3:00AM - 4:00AM	285 - 345	4/27/2016	Effluent Sampler	<	<	<	0.73	0.13	86	12	7.67	-
Outgoing 5	3:00AM - 4:00AM	285 - 345	4/27/2016	Effluent Sampler	<	<	<	0.67	0.13	96	16	7.57	-

< Value below detectable limit
- Parameter not tested

Omaha Green Infrastructure Monitoring 2016
Composit Sample Table
Site: C. Prep
Date: 5/26/2016

Event Start: 5:05 PM
Event End: 9:10 PM

Inflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	0	~3/4 L	1	-
2	5	~3/4 L	2	-
3	10	~3/4 L	3	-
4	15	-	-	-
5	20	-	-	-
6	25	-	-	-
7	30	-	-	-
8	35	-	-	-
9	40	-	-	-
10	45	-	-	-
11	50	-	-	-
12	55	-	-	-
13	60	-	-	-
14	65	-	-	-
15	70	-	-	-
16	75	-	-	-
17	80	-	-	-
18	85	-	-	-
19	90	-	-	-
20	95	-	-	-
21	100	-	-	-
22	105	-	-	-
23	110	-	-	-
24	115	-	-	-

Outflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	0	~3/4 L	1	-
2	15	~3/4 L	1	-
3	30	~3/4 L	1	-
4	45	~3/4 L	2	1
5	60	~3/4 L	2	1
6	75	~3/4 L	2	1
7	90	~3/4 L	2	1
8	105	~3/4 L	3	-
9	120	~3/4 L	3	-
10	135	~3/4 L	3	-
11	150	~3/4 L	3	-
12	165	~3/4 L	-	-
13	180	~3/4 L	-	-
14	195	~3/4 L	-	-
15	210	~3/4 L	-	-
16	225	~3/4 L	-	-
17	240	~3/4 L	-	-
18	255	~3/4 L	-	-
19	270	~3/4 L	-	-
20	285	~3/4 L	4	2
21	300	~3/4 L	4	2
22	315	~3/4 L	4	2
23	330	~3/4 L	4	2
24	345	~3/4 L	4	2

Omaha Green Infrastructure Monitoring 2016
Water Quality Results
Site: Creighton Prep
Event Date: 5/26/2016

Beginning of Event: 5:05 PM **Rain Total:** 0.12 **Days Since Previous Rain:** 1
End of Event: 9:10 PM
Event Duration: 4hrs 5min (intermittent)

					Results								
Sample Label	**Time Collected**	**Time Elapsed (min)**	**Date Collected**	**Location**	**Cadmium (mg/L)**	**Zinc (mg/L)**	**TKN (mg/L)**	**Nitrate Nitrite Nitrogen (mg/L)**	**Phosphorus (mg/L)**	**TDS (mg/L)**	**TSS (mg/L)**	**pH (S.U.)**	**E. Coli (CFU/100mL)**
Incoming 1	5:11 PM	0	5/27/2016	Influent Sampler	<	0.007	1.76	0.52	0.15	72	138	8.33	-
Incoming 2	5:16 PM	5	5/27/2016	Influent Sampler	<	0.05	1.52	0.45	0.11	66	66	8.26	-
Incoming 3	5:20 PM	10	5/27/2016	Influent Sampler	<	0.03	1.25	0.47	0.07	52	24	7.62	-
Outgoing 1	5:31 PM - 6:00 PM	0 - 30	5/27/2016	Effluent Sampler	<	0.02	0.76	1.26	0.12	134	27	7.62	-
Outgoing 2	6:15 PM - 7:00 PM	45 - 90	5/27/2016	Effluent Sampler	<	0.01	0.63	1.24	0.12	154	19	7.63	-
Dup	6:15 PM - 7:00 PM	45 - 90	5/27/2016	Effluent Sampler	<	0.01	0.64	1.27	0.12	158	12	7.65	-
Outgoing 3	7:15 PM -8:00 PM	105 - 150	5/27/2016	Effluent Sampler	<	0.02	<	1.23	0.11	152	13	7.54	-
Outgoing 4	10:15 PM - 11:15 PM	285 - 345	5/27/2016	Effluent Sampler	<	0.01	<	0.52	0.09	98	7	7.63	-
Duplicate 2	10:15 PM - 11:15 PM	285 - 345	5/27/2016	Effluent Sampler	<	0.01	<	0.51	0.09	118	6	7.67	-

< Value below detectable limit
- Parameter not tested

Omaha Green Infrastructure Monitoring 2016
Composite Sample Table
Site: C. Prep
Date: 6/21/2016

Event Start: 1:52 AM
Event End: 5:25AM

Inflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	0	-	-	-
2	5	-	-	-
3	10	-	-	-
4	15	-	-	-
5	20	-	-	-
6	25	-	-	-
7	30	-	-	-
8	35	-	-	-
9	40	-	-	-
10	45	-	-	-
11	50	-	-	-
12	55	-	-	-
13	60	-	-	-
14	65	~2/3 full	1	-
15	70	~2/3 full	2	-
16	75	~2/3 full	3	1
17	80	~2/3 full	3	1
18	-	-	-	-
19	-	-	-	-
20	-	-	-	-
21	-	-	-	-
22	-	-	-	-
23	-	-	-	-
24	-	-	-	-

Outflow

Automatic Sampler Bottle #	Time Ellapsed (min)	Water Collected	Composite #	Duplicate
1	25	~2/3 full	1	-
2	40	~2/3 full	1	-
3	55	~2/3 full	1	-
4	70	~2/3 full	2	-
5	85	~2/3 full	2	-
6	100	~2/3 full	2	-
7	115	~2/3 full	2	-
8	130	~2/3 full	3	2
9	145	~2/3 full	3	2
10	160	~2/3 full	3	2
11	175	~2/3 full	3	2
12	190	~2/3 full	-	-
13	205	~2/3 full	-	-
14	220	~2/3 full	-	-
15	235	~2/3 full	-	-
16	250	~2/3 full	-	-
17	265	~2/3 full	-	-
18	280	~2/3 full	-	-
19	295	~2/3 full	-	-
20	310	~2/3 full	4	-
21	325	~2/3 full	4	-
22	340	~2/3 full	4	-
23	355	~2/3 full	4	-
24	-	-	-	-

Omaha Green Infrastructure Monitoring 2016
Water Quality Results
Site: Creighton Prep
Event Date: 6/21/2016

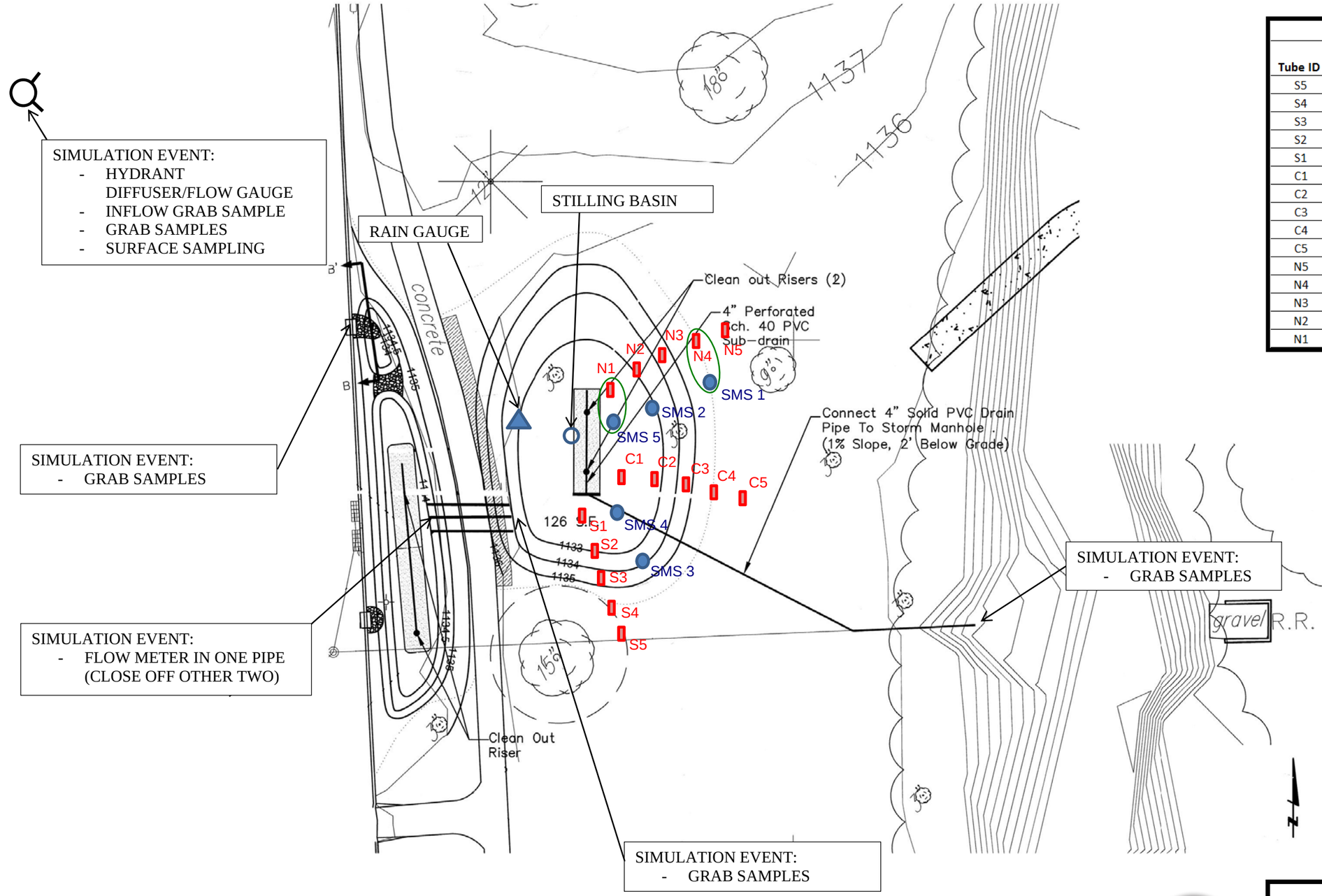
Beginning of Event: 1:45AM **Rain Total:** 0.3 **Days Since Previous Rain:** 0.5
End of Event: 5:25AM
Event Duration: 3hrs 40min (intermittent)

					Results									
Sample Label	**Time Collected**	**Time Elapsed (min)**	**Date Collected**	**Location**	**Cadmium (mg/L)**	**Zinc (mg/L)**	**TKN (mg/L)**	**Nitrate Nitrite Nitrogen (mg/L)**	**Phosphorus (mg/L)**	**TDS (mg/L)**	**TSS (mg/L)**	**pH (S.U.)**	**E. Coli (CFU/100mL)**
Incoming 1	3:00AM	65	6/21/2016	Influent Sampler	<	0.15	2.31	0.73	0.3	88	627	8.11	-
Incoming 2	3:05AM	70	6/21/2016	Influent Sampler	<	0.11	1.61	0.49	0.29	<	331	8.01	-
Incoming 3	3:10AM - 3:16 AM	75 - 80	6/21/2016	Influent Sampler	<	0.06	1.2	1	0.2	40	126	7.46	-
Dup	3:10AM - 3:16 AM	75 - 80	6/21/2016	Influent Sampler	<	0.06	1.29	2.72	0.2	40	125	7.42	-
Outgoing 1	2:16AM - 2:45AM	0 - 30	6/21/2016	Effluent Sampler	<	0.02	1.07	2.91	0.19	192	27	7.3	-
Outgoing 2	3:00AM - 3:45AM	45 - 90	6/21/2016	Effluent Sampler	<	0.03	0.91	1.87	0.18	96	36	7.38	-
Outgoing 3	4:00 - 4:45AM	105 - 150	6/21/2016	Effluent Sampler	<	0.02	0.82	1.34	0.17	114	34	7.41	-
Duplicate	4:00 - 4:45AM	105 - 150	6/21/2016	Effluent Sampler	<	0.02	0.91	1.34	0.17	140	25	7.49	-
Outgoing 4	7:00AM - 7:46AM	285 - 330	6/21/2016	Effluent Sampler	<	0.01	0.61	1.37	0.15	166	5	7.59	-

< Value below detectable limit
- Parameter not tested

Orchard Park

2016 Monitoring Executive Summary



Neutron Probe Survey Data				
Tube ID	Northing	Easting	Casing Elevation	Ground Elevation
S5	564446.03	2734966.66	1135.64	1135.73
S4	564451.22	2734964.87	1135.52	1135.59
S3	564457.16	2734962.44	1135.05	1135.20
S2	564461.74	2734960.91	1135.39	1133.89
S1	564469.46	2734958.74	1135.33	1133.17
C1	564476.79	2734965.52	1135.66	1133.12
C2	564475.31	2734973.25	1135.74	1134.39
C3	564474.52	2734979.02	1135.58	1135.58
C4	564472.82	2734984.26	1135.60	1135.56
C5	564471.82	2734988.60	1135.11	1135.28
N5	564505.01	2734985.22	1135.72	1135.48
N4	564502.90	2734980.58	1135.65	1135.89
N3	564499.93	2734975.22	1135.44	1135.29
N2	564498.15	2734970.87	1135.49	1134.27
N1	564493.67	2734965.18	1135.44	1133.22

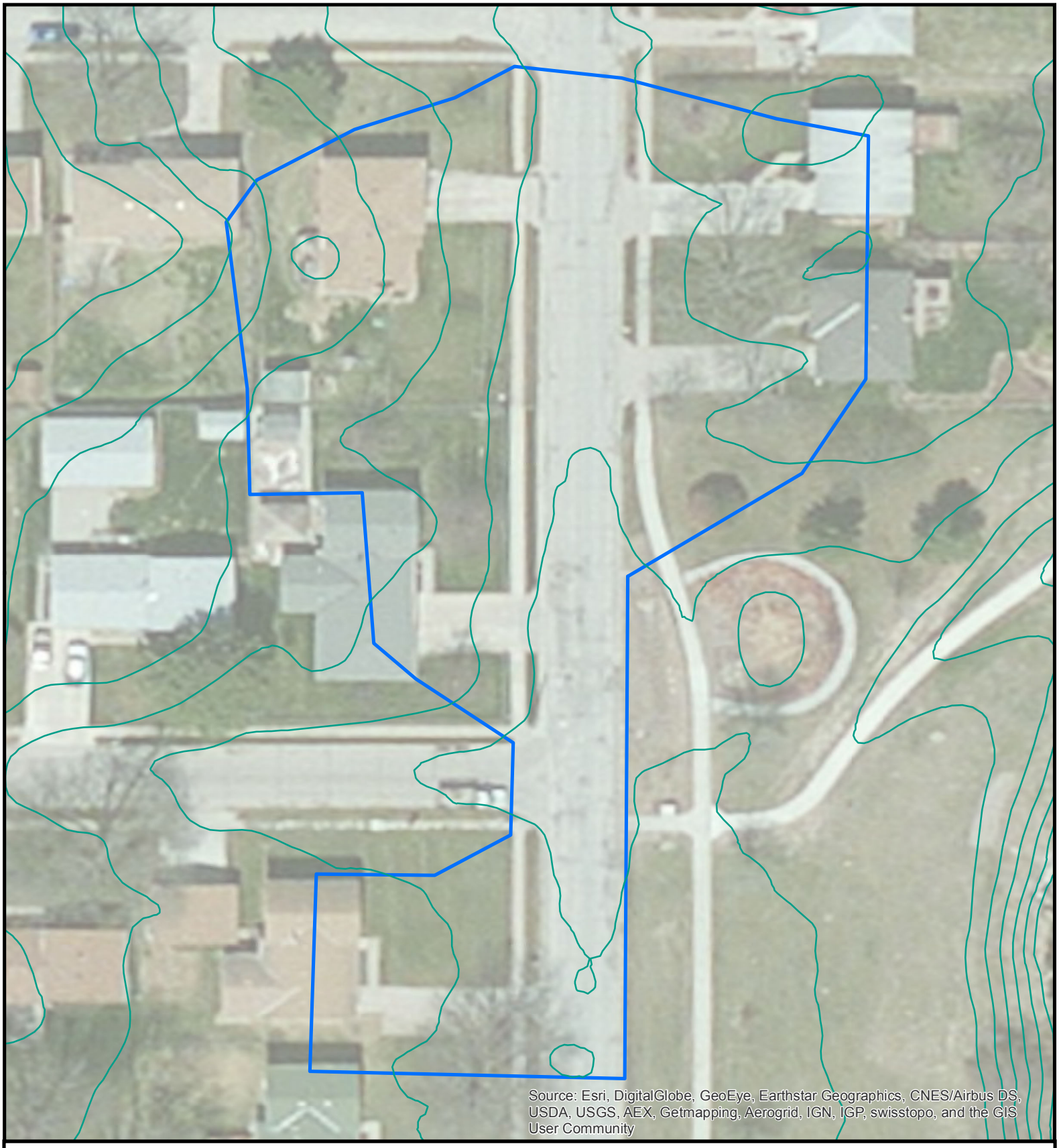
NEUTRON PROBE TUBES

SOIL MOISTURE SENSORS

SOIL MOISTURE SENSORS AND NEUTRON PROBE COMPARISONS

BURNS McDONNELL

ORCHARD PARK
SITE PLAN



Legend

2FT CONTOURS

CONTRIBUTING AREA: 1.0 ACRES

ORCHARD PARK CONTRIBUTING AREA
OMAHA STORMWTER PROGRAM
GREEN INFRASTRUCTRE MONITORING

N
W E
S

Feet

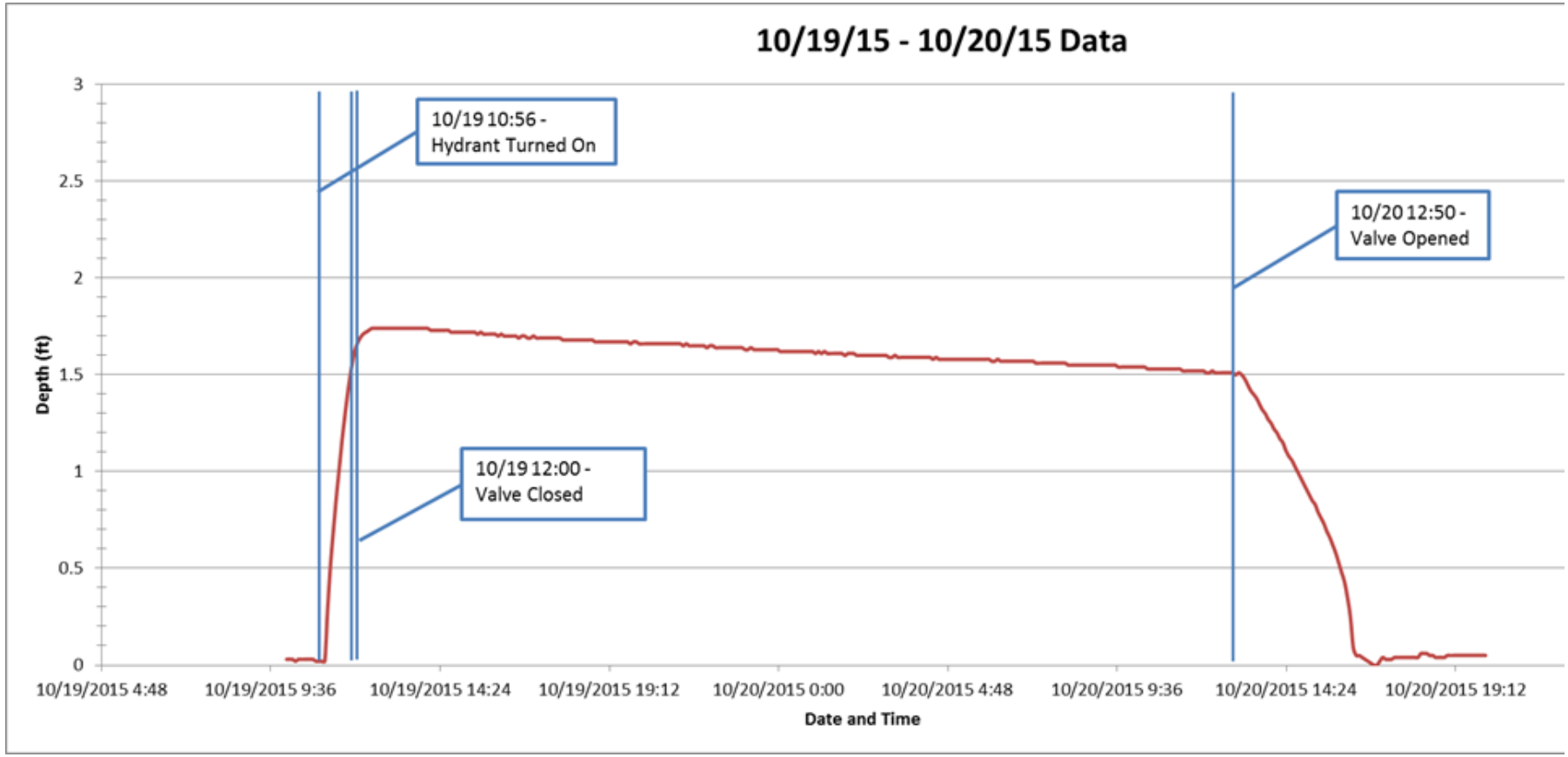
0 10 20 40 60 80 100

BURNS McDONNELL

OMAHA STORMWATER PROGRAM

Orchard Park Simulation
Event - Ponding

10/19/2015

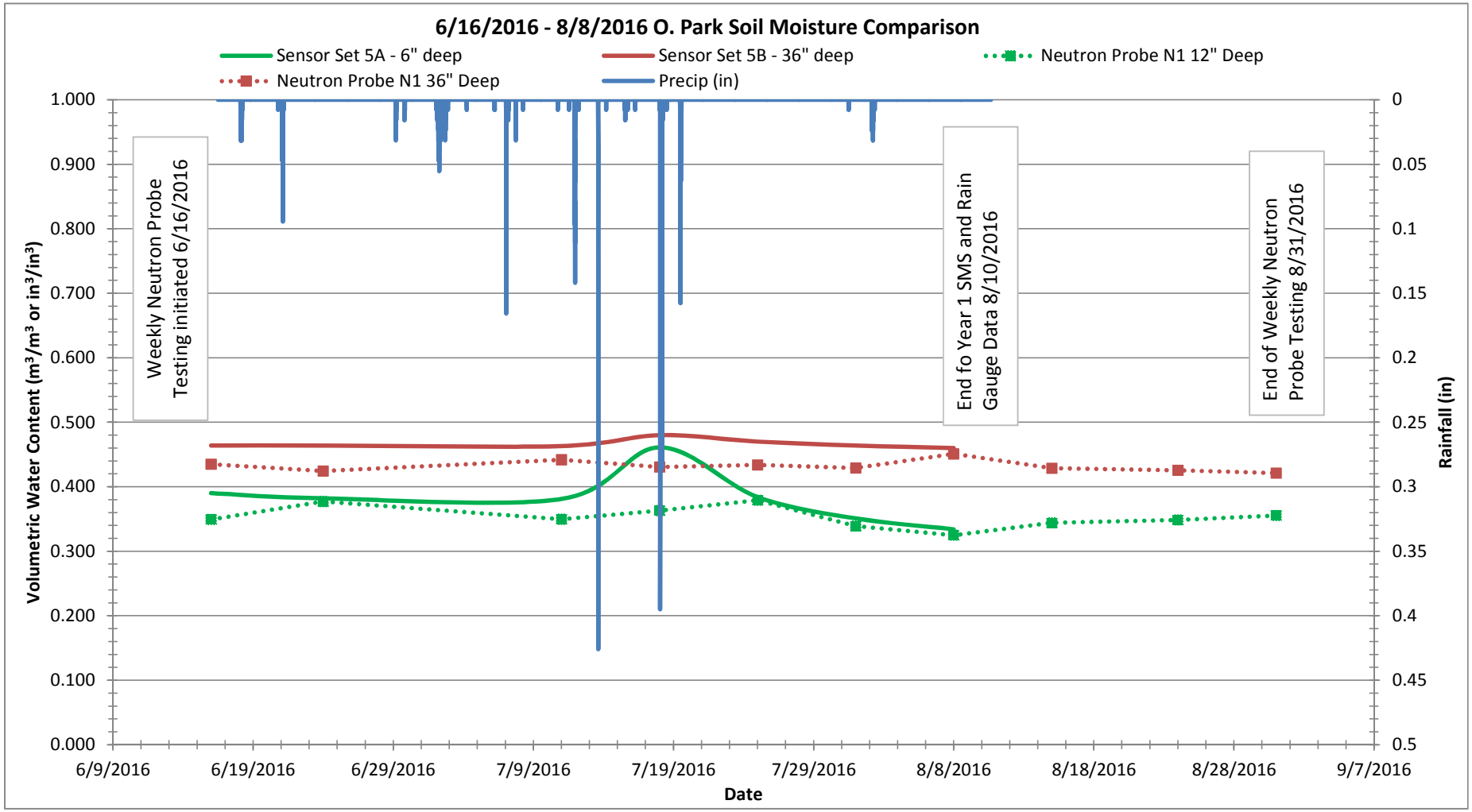


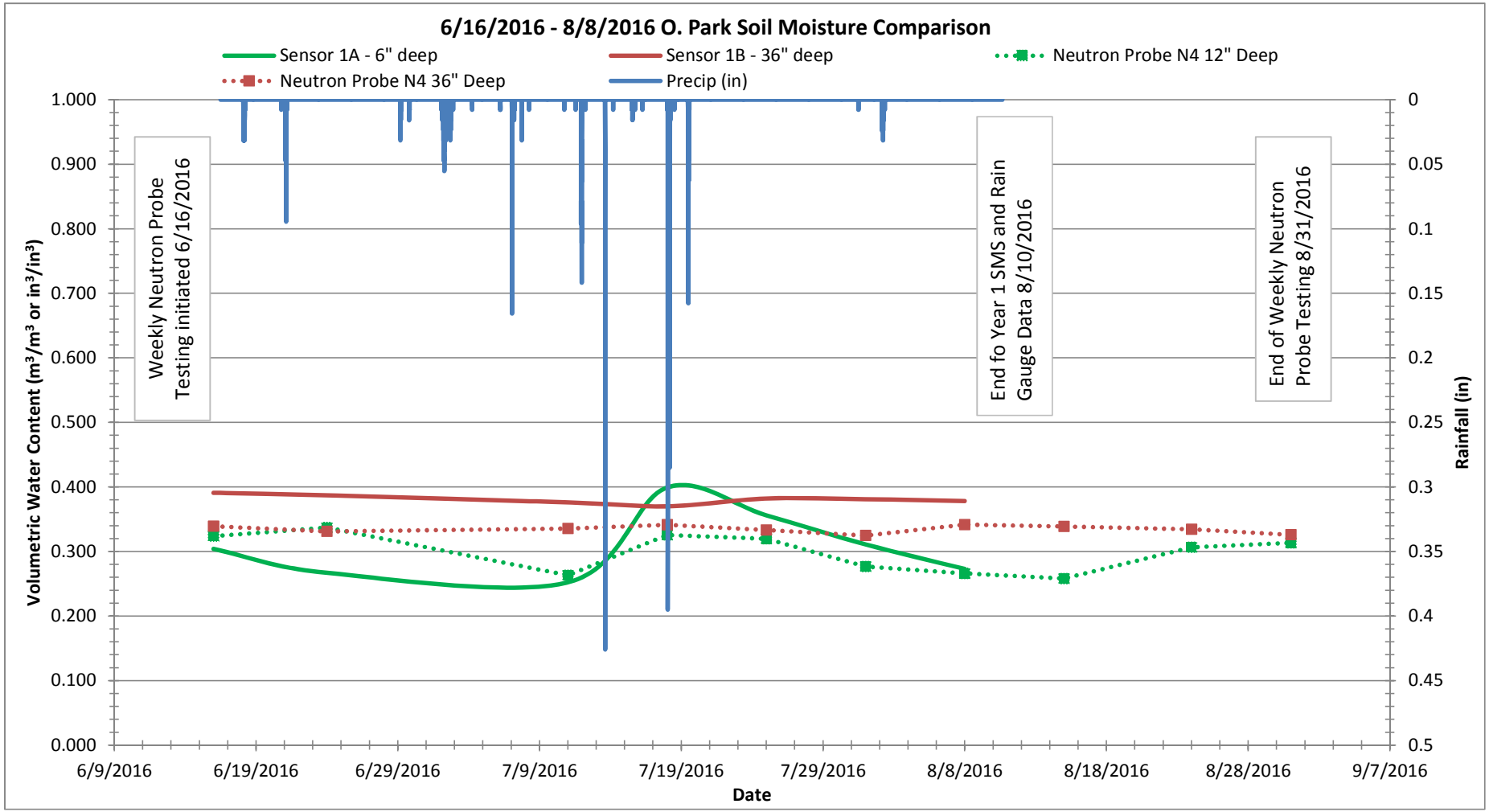
Orchard Park Simulation Event
10/19/2015

Water Quality Samples

Beginning of Simulation Event: 10:56 AM
End of Simulation Event: 11:53 AM

				Results							
Sample Label	**Time Collected**	**Date Collected**	**Location**	**Cadmium (mg/L)**	**Zinc (mg/L)**	**TKN (mg/L)**	**Nitrate Nitrite Nitrogen (mg/L)**	**Phosphorus (mg/L)**	**TDS (mg/L)**	**TSS (mg/L)**	**pH (S.U.)**
1	10:57 AM	10/19/2015	Fire Hydrant	<	0.36	0.82	0.89	<	550	<	8.96
2	10:57 AM	10/19/2015	Forebay	0.003	0.54	14.7	1.3	3.42	764	3930	7.49
3	11:12 AM	10/19/2015	Forebay	<	<	0.87	0.84	<	562	15	8.99
4	11:31 AM	10/19/2015	Forebay	<	<	0.73	0.84	<	530	11	9
5	11:10 AM	10/19/2015	Basin Inflow	<	<	2.79	0.99	0.19	546	33	8.94
6	11:18 AM	10/19/2015	Basin Inflow	<	0.01	0.57	0.92	<	564	100	8.96
7	11:45 AM	10/19/2015	Basin Inflow	<	<	0.59	0.81	<	558	9	8.98
8	12:35 PM	10/19/2015	Center of Basin	<	0.01	1	0.82	0.14	564	37	8.93
9	11:21 AM	10/19/2015	Underdrain Outfall	<	<	1.41	5.33	0.24	454	<	7.2
10	11:37 AM	10/19/2015	Underdrain Outfall	<	<	0.75	2.34	0.15	512	<	7.38
11	11:53 AM	10/19/2015	Underdrain Outfall	<	<	0.77	2.02	0.14	532	<	7.45
12	11:56 AM	10/19/2015	Creek - Downstream	<	<	<	3.19	<	778	<	7.81
13	12:01 PM	10/19/2015	Creek - Upstream	<	<	<	3.31	<	728	17	7.82
14	12:24 PM	10/19/2015	Blank	<	<	<	<	<	48	<	6.12
15	12:55 PM	10/20/2015	Underdrain Outfall	<	0.01	0.97	0.7	0.26	550	12	7.15


6/16/2016 - 8/8/2016 O. Park Soil Moisture Comparison
Sensor Set 5A - 6" deep
Sensor Set 5B - 36" deep
Neutron Probe N1 12" Deep
Neutron Probe N1 36" Deep
Precip (in)
Weekly Neutron Probe Testing initiated 6/16/2016
End fo Year 1 SMS and Rain Gauge Data 8/10/2016
End of Weekly Neutron Probe Testing 8/31/2016
Volumetric Water Content (m³/m³ or in³/in³)
Rainfall (in)
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
6/9/2016
6/19/2016
6/29/2016
7/9/2016
7/19/2016
7/29/2016
8/8/2016
8/18/2016
8/28/2016
9/7/2016
Date


6/16/2016 - 8/8/2016 O. Park Soil Moisture Comparison
Sensor 1A - 6" deep
Sensor 1B - 36" deep
Neutron Probe N4 12" Deep
Neutron Probe N4 36" Deep
Precip (in)
Weekly Neutron Probe Testing initiated 6/16/2016
End fo Year 1 SMS and Rain Gauge Data 8/10/2016
End of Weekly Neutron Probe Testing 8/31/2016
Volumetric Water Content (m³/m³ or in³/in³)
Rainfall (in)
1.000
0.900
0.800
0.700
0.600
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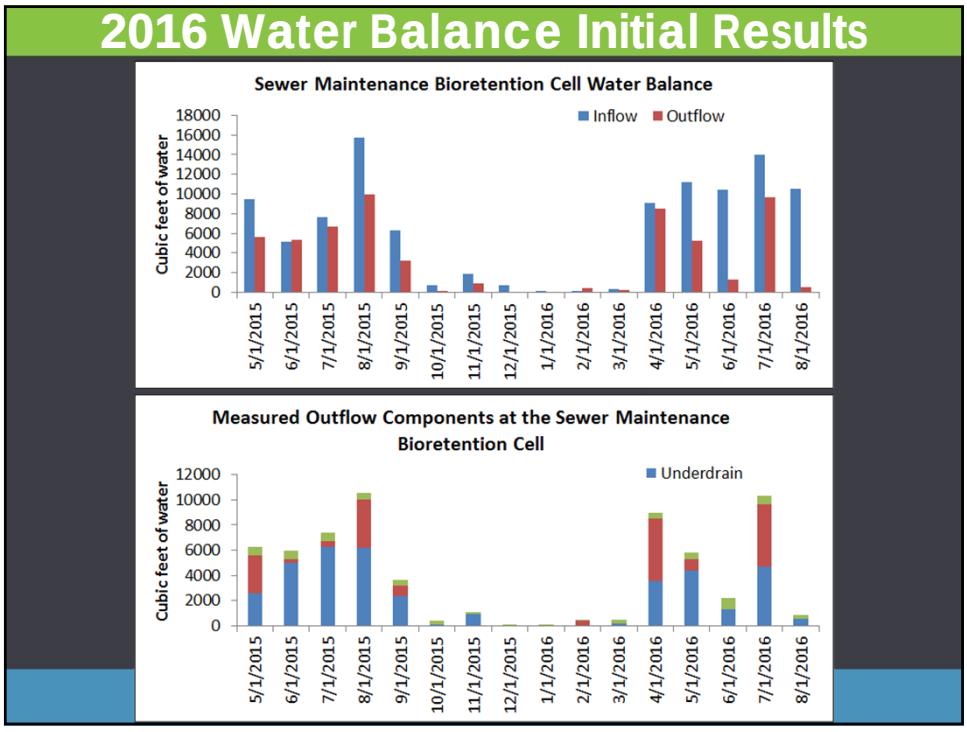
9/7/2016
Date


City of Omaha
SEWER MAINTENANCE
FACILITY
OMAHA STORMWATER PROGRAM
Sewer Maintenance Research Project
EPA ORD, University of Nebraska – Omaha, & City of Omaha Stormwater
& CSO Programs


2016 Water Balance Initial Results
Sewer Maintenance Bioretention Cell Water Balance
Inflow
Outflow
Cubic feet of water
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
1/1/2016
2/1/2016
3/1/2016
4/1/2016
5/1/2016
6/1/2016
7/1/2016
8/1/2016
Measured Outflow Components at the Sewer Maintenance Bioretention Cell
Underdrain
Cubic feet of water
12000
10000
8000
6000
4000
2000
0
5/1/2015
6/1/2015
7/1/2015
8/1/2015
9/1/2015
10/1/2015
11/1/2015
12/1/2015
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8/1/2016

SATURATED HYDRAULIC CONDUCTIVITY ASSESSMENT OF BIORETENTION AND RAIN GARDENS IN OMAHA, NEBRASKA

A REPORT COMPLETED BY THE CITY OF OMAHA, NEBRASKA

BY

JOHN O'DONNELL
AND
ANDY SZATKO

FEBRUARY 2017

Abstract

Bioretention systems and rain gardens are an effective measure for mitigating the effects of stormwater runoff in urban environments. Scheduled maintenance and continuous monitoring efforts are necessary to ensure these systems are performing properly. Additionally, measuring the hydraulic characteristics of these systems provides adequate information to determine their infiltration capacity and overall efficiency. A Modified Philip-Dunne (MPD) infiltrometer was used to estimate infiltration rates via saturated hydraulic conductivity (K_{sat}) measurements for rain gardens, bioretention systems, and turf lawns. A total of 112 samples were collected from nine sites in Omaha, Nebraska to assess the performance of both rain gardens and bioretention systems in comparison with adjacent turf areas. The mean K_{sat} values for the rain gardens and bioretention systems sampled ranged from 4.01 to 76.46 in/hr. Across all survey sites, average measurements of saturated hydraulic conductivity in rain gardens (55.31 in/hr) and bioretention systems (23.00 in/hr) were significantly higher than those acquired over adjacent turf grasses (2.53 in/hr).

1. Introduction

Stormwater runoff has significant impacts on the water quality of local streams and rivers in the United States (US EPA, 1996; US EPA, 2009). In an effort to mitigate these damaging effects, local governments (City of Omaha) have incorporated the use of green infrastructure as a best management practice (BMP) within their stormwater management programs. These BMPs significantly reduce stormwater volumes, peak flows, pathogens, sediment loading, erosion, and nutrient concentrations through infiltration into the soil subsurface (Winogradoff, 2002; Dietz and Clausen, 2005; Collins et al., 2010; Beutel and Larson, 2015).

Green infrastructure is a powerful and beneficial approach to stormwater management that aims to preserve natural areas and mimic natural processes through the use of local soils, native vegetation, and land features to capture and manage rain close to where it falls. Green infrastructure practices can range in scale from regional (floodplains and wetlands) to local (urban and residential) landscapes. Examples of more common green infrastructure practices include green roofs, bioswales, rain harvesting systems (rain barrels), rain gardens, and bioretention systems.

Within urban environments, bioretention systems are one of the most implemented green infrastructure practices (Hartsig and Rodie, 2016). These features are shallow vegetative depressions designed to capture and treat water collected from impervious surfaces by slowly infiltrating stormwater through amended soils and various root layers. Native vegetation is tolerant of local climate conditions and used to increase water absorption, filtration capacity, and permeability of soils within the system. Bioretention systems incorporate the use of an infiltration cell to collect water and promote slow drainage over a set period of time (Figure 1). The infiltration cell spans 90% of the length of the bioretention system bottom and is composed of a Bioretention Soil Mix (BSM) which facilitates drainage to the under-drain. The under-drain consists of an open-graded, washed aggregate that surrounds rigid piping which connects to the storm sewer system or another predetermined area, draining excess water that is not absorbed (Figure 1). The addition of a valve or outflow control device to the under-drain can provide flexibility in setting water retention times within the bioretention system (Figure 1). Finally, bioretention systems incorporate the use of an overflow and/or high flow structures in the event of excess stormwater volumes. If water is flowing through the bioretention system it is considered an inline system, but if water bypasses the system once it has reached capacity, it is considered an offline system.

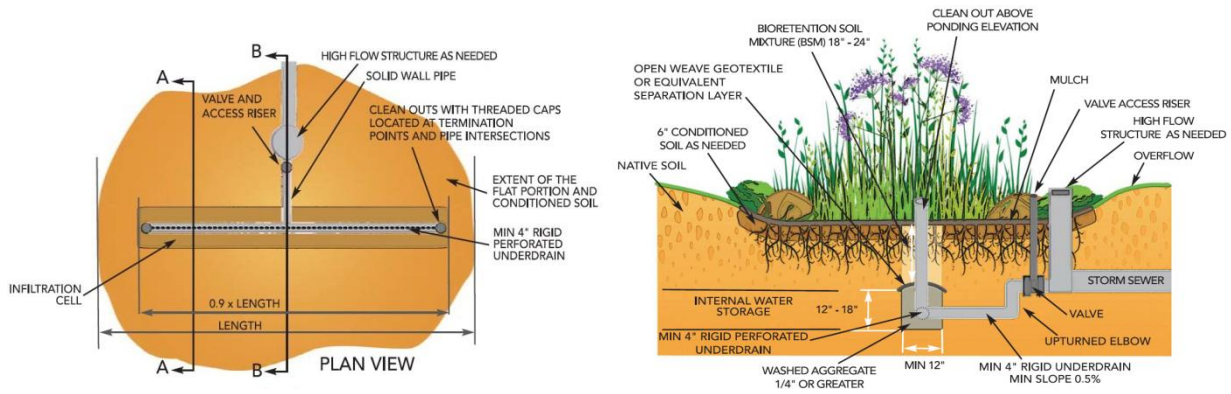

Figure 1. Schematic of bioretention system highlighting infiltration cell and under-drain (left) and cross-sectional profile of bioretention system showing upturned elbow and control valve (right).

Bioretention systems and rain gardens have proved a useful tool for mitigating stormwater impacts and improving water quality. In July 2008, the City of Omaha adopted their post-construction stormwater runoff ordinance which states that, at a minimum, low impact development (LID, often used interchangeably with the term green infrastructure) BMPs be utilized to provide water quality control of the first one-half inch of runoff from the site and shall maintain the peak discharge rates during the two-year storm event to baseline land use conditions. Today, there are over 1,800 post-construction BMPs within the Papillion Creek Watershed Partnership area, this includes those BMPs in design, construction and certified. Of those 1,800, over 490 of them are bioretention systems or rain gardens.

1.1 Purpose

The purpose of this study was to estimate infiltration rates via saturated hydraulic conductivity (K_{sat}) measurements within bioretention systems, rain gardens, and adjacent traditional turf areas. K_{sat} is a quantitative measure of the maximum water transmission rate of a saturated soil. Data generated from this study will provide current assessment of these projects and baseline measurements for comparison with future monitoring efforts of the sites measured and others. Understanding how these living systems function over time will help improve overall stormwater management.

An additional objective of this study was to create a Standard Operating Procedure (SOP) for measuring K_{sat} to be used in addition to visual inspections during annual assessments. Visual inspections of BMPs are necessary to identify any impediments to inlet and outlet structures, erosion within and around gardens, sediment accumulation, and vegetative health. However, visual inspections overlook actual infiltration rates, which dictate the amount/volume of stormwater that can be treated. Furthermore, examination of the spatial distribution of K_{sat} values can be used to determine areas of low permeability within a garden that require amending (Asleson et al., 2009).

Making regular observations of bioretention systems, rain gardens, and other green infrastructure practices help catch issues (erosion, vegetation health, sediment and debris build up, etc.) early. If not addressed promptly, issues can require significant effort to repair along with an increased expense. Therefore, proper maintenance and monitoring efforts are necessary for the longevity of these BMPs.

2. Site Descriptions

Nine sites throughout Omaha, Nebraska were selected for this study: Saddle Hills Park, University of Nebraska at Omaha (UNO) Welcome Center, Orchard Park, Florence Streetscape, The Benson East Gateway, Under the Sink Facility, Creighton Prep, South Omaha Industrial Area (SOIA) Lift Station, and Omaha Sewer Maintenance Facility (Figure 2). A quick summary of site details can be found in Table 1.

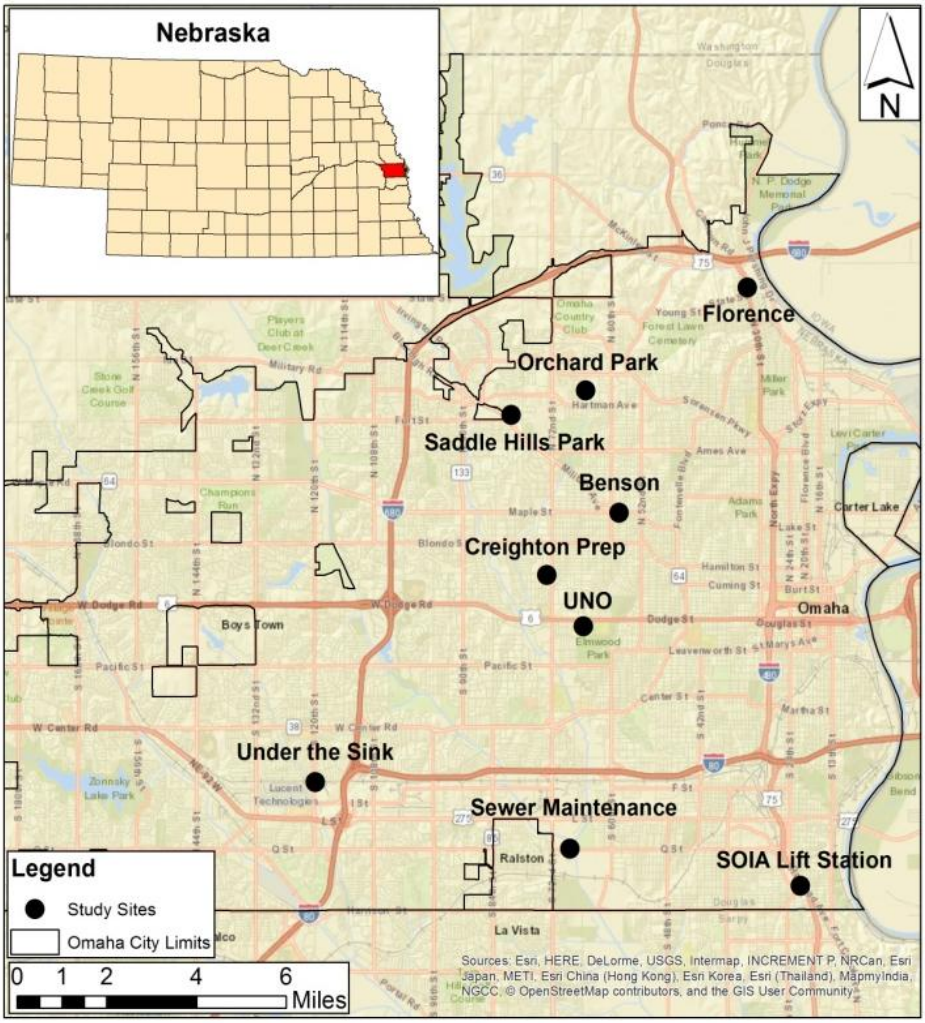

Figure 2. Map of the City of Omaha, Douglas County, highlighting the nine study sites in our study.

Table 1. Summary of project details for each of the nine study sites examined in this study.

Site	Install	Type*	Footprint (ft^2)	Contributing Area (acres)	% Footprint to Contributing Area	Design Volume (gal)	Pretreatment	Under-drain Outlet Control	Under-drain	Overflow	Bioretention Soil Mix
Saddle Hills Park	2014	RG	2,310	2.5	2.2	N/A	Utility box curb-wells	None	None	Soft weir in berm	Compost amended in-situ soils
University of Nebraska-Omaha	2012	B	1,345	0.6	5.5	2,469	None	4" Polyball valve	4" perforated HDPE	Soft weir in berm	50/50 sand/compost
Orchard Park	2009	B	3,180	0.8	9.2	14,270	Vegetated Forebay	2" Brass Curb-Stop Valve	4" perforated PVC	Offline system	50/50 sand/compost
Florence	2012	B	440	0.7	1.5	2,825	Stainless steel sediment trap w/ Permeable Base	2" Brass Curb-Stop Valve	4"perforated HDPE	Offline system	50/50 sand/compost
Benson	2013	B	1,225	1.0	2.8	5,535	2 Forebays & Dry Creek Bed	2" Brass Curb-Stop Valve	4" perforated PVC	High flow structure & soft weir	50/50 sand/compost
Under the Sink Facility	2008	B	1,540	2.5	1.4	9,620	Bioswale	4" Polyball valve	4" perforated HDPE	Soft weir in berm	50/50 sand/compost
Creighton Prep	2014	B	5,720	2.7	4.9	40,395	Permeable patio (East) & manhole sump w/Envirohood (West)	4" Slide Gate Valve	4" perforated PVC	Soft weir in berm	80/20 sand/compost
South Omaha Industrial Area	2014	B	3,400	0.7	11.5	25,430	Turf swale	4" Polyball valve	4" perforated PVC	High flow structure & soft weir	100% 1" washed limestone
Sewer Maintenance Facility	2014	B	2,200	0.95	5.3	39,085	Permeable paver parking lot (East) & Forebay (West)	4" Slide Gate Valve	4" perforated PVC	High flow structure	100% pea gravel

*RG = Rain Garden; B= Bioretention System

2.1 Saddle Hills Park

Saddle Hills Park (SHP) is located within the Saddle Hills Neighborhood near North 78th Street and Crown Point Avenue. The neighborhood consists of two distinct sub-watersheds (north and south) covering a total of 160 acres. Saddle Hills Park is set in the south watershed, a suburban residential area, and contains two rain gardens in the northeast corner of the park. These rain gardens, in conjunction with four others in the neighborhood, were completed in the fall of 2014 as part of a collaborative effort with the City of Omaha Stormwater Program, local residents, the Nebraska Department of Environmental Quality (NEDQ) 319 Program, the University of Nebraska at Omaha (UNO) Center for Urban Sustainability, and the Nebraska Statewide Arboretum (NSA) to improve water quality and reduce stormwater runoff volume and erosion through green infrastructure practices. The two rain gardens in Saddle Hills Park cover a combined area of 2,310 ft^2 (820 ft^2 east and 1,490 ft^2 west) and are connected via a 6-inch diameter PVC pipe (Figure 3). The east and west rain gardens contain a 1-foot max ponding depth and have a total contributing area of 2.5 acres. Stormwater runoff primarily flows down Arlington Drive and enters the east garden through a curb cut with pretreatment, a sump structure created with a modified utility vault box. After the east garden fills up, it then spills into the west rain garden through a PVC pipe that goes underneath the adjacent sidewalk. Both rain gardens have soft outlet weirs allowing excess water to spill out of the gardens during heavy flows.

Figure 3. Photographs at Saddle Hills Park showing the east rain garden with utility box curb-well pretreatment (left) and the west rain garden fully inundated during a rain event (right).

2.2 University of Nebraska at Omaha Welcome Center

The University of Nebraska at Omaha (UNO) bioretention system was constructed in 2012. The bioretention system is located on the west end of the University's campus, providing an interactive display with the University's Welcome Center (Figure 4). The project was part of a

multi-institution collaboration with the City of Omaha Stormwater Program, UNO, and NSA to provide a teaching tool and an amenity to the UNO Campus. The bioretention system is split into two different bioretention systems allowing for significant volumes of landscape and rooftop rainwater to be captured. The North bioretention system covers approximately 625 ft^2, with the South bioretention system covering a larger footprint of 720 ft^2. Both systems contain an *in-situ* mixture of silty clay loam and fine-silty loess soil with 4-inch perforated PVC under-drains and a 4-inch Polyball valve. However, the south bioretention system is fitted with an upturned elbow (Figure 1). In total, the contributing area is 0.6 acres (north 0.25 acres and south 0.35 acres). The North and South bioretention systems have a ponding depth of 12 inches allowing a holding capacity of ~ 2,469 gallons. Stormwater runoff enters these bioretention systems via surface flow and storm drain outfalls on the east side of each system. Additional monitoring efforts at this site include soil temperature and soil moisture levels, water levels, and use of time-lapse photography (Figure 1A - Appendix).

Figure 4. Photographs of the bioretention systems in front of the UNO Welcome Center (left) and the North bioretention system entirely inundated (right).

2.3 Orchard Park

Orchard Park is located within a predominately residential area in northwest Omaha near North 66th Street and Sorensen Parkway. The site is a part of the Cole Creek restoration project which was implemented to improve habitat and water quality within Cole Creek through stream realignment and streambank stabilization. In addition, the project features five bioretention systems which are intended to capture and treat runoff from the adjacent residential areas and impervious surfaces within the park prior to entering Cole Creek. These bioretention systems were installed in 2009. This study only examined the bioretention system located at the north end of Orchard Park. This particular bioretention system consists of two cells (3,180 ft^2) and collects and treats stormwater runoff from a contributing area of 0.8 acres. Stormwater enters

the first cell through a curb cut pretreatment forebay along North 66th Street and then spills into the larger cell through three PVC pipes. Both systems contain infiltration cells which are drained by a 4-inch perforated PVC pipe and fitted with a 2-inch brass curb-stop valve to regulate flow. Prior to 2011, the bioretention system did not have an under-drain valve installed, resulting in shorter retention periods. The larger cell has a ponding depth of 30 inches with a design volume capacity of 1,290 gallons (Figure 5). Current monitoring efforts at the site examine hydrologic flow through the use of a rain gauge, soil moisture probes, water pressure transducers, and periodic simulation of flooding events (Figure 2A).

Figure 5. Photographs of the bioretention system at Orchard Park exhibiting vigorous summer growth (left) and fully inundated during a rain event (right).

2.4 Florence Streetscape

The Florence Streetscape Project consists of seven bioretention systems along a two-block stretch of North 30th Street, from Clay to Willit Streets. The bioretention systems were finished in 2012 and designed to capture and treat runoff from surrounding street and sidewalk surfaces. The under-drain for the bioretention systems runs the length of the system and is composed of a dual-wall perforated HDPE pipe. A 2-inch curb-stop valve is installed on the downstream side to regulate the flow of the system. For this study, two of the bioretention systems were studied, located (1) on the west side of N 30th Street, at the southwest corner of N 30th Street and Clay Street and (2) on the east side of N 30th Street, parallel with the No More Empty Pots business, between Tucker and Willit Streets (Figure 6). Both bioretention systems use a stainless steel sediment trap with a permeable base as a pretreatment. This pretreatment allows water to gradually fill up and spill into the system causing sediment and debris to settle out and cleaner water to enter. Combined, the two bioretention systems have a footprint of 440 ft^2 with a contributing area of 0.7 acres, with a total design volume of 2,825 gallons.

Figure 6. The east (left) and west (right) bioretention systems from the Florence Streetscape Project showing the stainless steel sediment traps pretreatments.

2.5 The Benson East Gateway

The Benson East Gateway bioretention system was established in 2013 and is located in North Omaha at the intersection of Northwest Radial Highway, Maple, and 58th Streets. The bioretention system replaced a portion of 58th Street between Maple and Corby Streets, providing a beautiful landscape that filters, slows and infiltrates stormwater runoff before it enters the sewer system. Stormwater runoff from 58th street enters the system through two forebays capturing sediment and debris. Runoff then flows through a dry creek bed with layer of aggregate before slowly moving into the bioretention system (Figure 7). The bioretention system contains a 4-inch PVC under-drain and a 2-inch curb-stop valve. The Benson bioretention system occupies an area of 1,225 ft^2, draining 1-acre of the adjacent roads and residential landscape. With a maximum ponding depth of 18 inches, the bioretention system is capable of holding 5,535 gallons (Figure 7).


Figure 7. Photographs of the Benson East Gateway bioretention system showcasing the layered dry creek bed (left), strong summer growth (center), and inundated system (right).

2.6 Under the Sink

Under the Sink (UTS) is a city operated facility collecting household hazardous waste. Located at 4001 South 120th Street, the site occupies 5.1 acres with a primary recycling building, parking lots, drive lanes, and turf lawns. The Under the Sink facility is one of the earliest demonstration project showcasing stormwater best management practices through the incorporation of bioretention systems, bioswales, a level spreader, and rain barrels into the landscape. In 2008, 15 bioretention systems were installed on the property with the majority of them situated adjacent to South 120th Street. This study focused on the four bioretention systems located in the northwest corner of the Under the Sink facility (Figure 8). Each of these four systems has a ponding depth of 12 inches and are capable of holding a total of 9,620 gallons. Combined, the four bioretention systems have a footprint of 1,540 ft^2 and drain a 2.5-acre area. The bioretention systems are constructed out of a silt clay loam soil with 6-inch perforated HDPE pipe for the under-drain and fit with 4-inch Polyball valves. Stormwater flows into the bioretention systems via a bioswale lying to the northeast. During high runoff volumes, water spills into each bioretention system over a series of soft weirs. To the north of the UTS property is an 11.5-acre tract of land owned by the Union Pacific Railroad Company (UPRR) containing active railroad lines. A portion of this property, slightly northeast of the bioretention systems, has seen significant erosion of the subsoil underneath the track foundation (Figure 9a and 9b).

Figure 8. Photographs of the bioretention systems at the Under the Sink facility (left) and the bioswale that drains into bioretention system 1 (right).

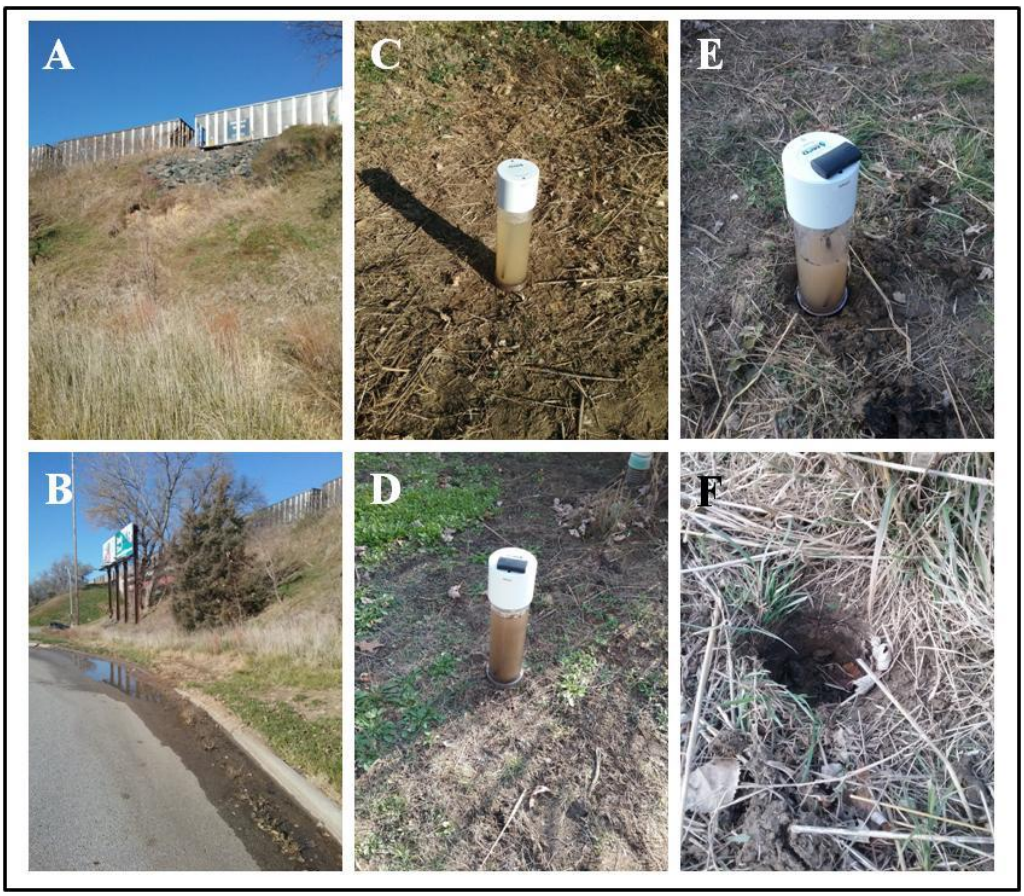

Figure 9. Photographs were taken at Under the Sink documenting A) erosion occurring on UPRR property, B) build up of sediment in gutter which flows to the bioretention systems, C) heavy silt in B 1, D) little to no silt in B 4, and E-F) example of removing silt layer to run infiltrometer test in B 2.

2.7 Creighton Prep

Creighton Prep High School is located in the center of Omaha at North 72nd Street and Western Avenue. The Creighton Prep bioretention system was construction in 2014 on the south end of the Creighton Prep Campus, running parallel with Western Ave. The bioretention system consists of an infiltration cell spanning the length of the system with a 4-inch perforated PVC under-drain and a 4-inch Slide-Gate Valve. There are two points of entry where stormwater runoff flows into the system. First, stormwater enters from the west through a storm sewer that collects runoff from the adjacent parking lot and athletic fields. The second point of entry into the bioretention system is through a permeable patio located on the east side of the system, which also collects sheet flow from the athletic fields. Spanning a total of 5,720 ft^2, with a max ponding depth of 18 inches, the Creighton Prep bioretention system drains 2.7 acres and is capable of holding 40,395 gallons. Monitoring equipment has been installed to assess the performance of the bioretention system regarding volume reduction, infiltration rates, water quality, and plant performance (Figure 3A).

Figure 10. Creighton Prep bioretention system exhibiting summer growth (left) and inundated during rain event (right).

2.8 South Omaha Industrial Area Lift Station

South Omaha Industrial Area (SOIA) Lift Station, located at 2214 Washington Street, is a project of the City of Omaha's Clean Solutions for Omaha (CSO) program. The SOIA Lift Station collects industrial waste from meat packing facilities, removing it from the combined sewer system. Once separated, the industrial waste is then sent to the Missouri River Wastewater Treatment Plant for treatment before entering the Missouri River. After completion of the SOIA Lift Station, a bioretention system was installed on the south end of the property. Completed in 2014, the bioretention system covers an area of 3,400 ft^2 and drains an area of 0.7 acres. The under-drain within the bioretention system contains a 4-inch perforated PVC pipe with a 4-inch Polyball valve. Stormwater runoff primarily enters the system on the northwest side and through the northeast most corners via turf swales. With a maximum ponding depth of 12 inches, the bioretention system has a design volume capable of holding 25,430 gallons of stormwater runoff over a 24-hour period.

Figure 11. Photographs of the bioretention system at SOIA Lift Station exhibiting rapid growth from August 2014 (left) to August 2015 (right).

2.9 Omaha Sewer Maintenance Facility

The City of Omaha Sewer Maintenance Facility, located at 6880 Q Street, sits adjacent to the confluence of the Big Papillion and Little Papillion Creeks. The Sewer Maintenance Facility is home to a demonstration project which consists of a multi-agency collaboration between the Environmental Protection Agency (EPA) Office of Research and Development, the United States Geological Survey (USGS), the University of Nebraska, and the City of Omaha CSO and Stormwater programs incorporating the design and installation of green infrastructure practices through a pervious paver parking area and a bioretention system. Completed in 2014, the bioretention system covers an area of 2,200 ft^2, draining roughly 0.95 acres. With a maximum ponding depth of 12 inches, this system has a design volume of 39,085 gallons (Figure 12). The under-drain within the bioretention system contains a 4-inch PVC pipe regulated by a 4-inch Slide Gate Valve. Runoff flows into the bioretention systems through a forebay on the west side of the system and permeable pavement on the east side of the system. Additional monitoring efforts have been designed to evaluate system performance by studying water retention and infiltration over time with inflow and outflow flumes and soil moisture sensors (Figure 4A).

Figure 12. Bioretention system at Sewer Maintenance Facility partially inundated after a rain event (center), with West forebay (left), and permeable paver parking lot (right).

3. Data Collection

Measurements were collected at all sites using Modified Philip-Dunne (MPD) Infiltrometers (Upstream Technologies, Inc., www.upstreamtechnologies.us). The MPD infiltrometer is a falling head device used to measure the saturated hydraulic conductivity (K_{sat}) at the soil surface. K_{sat} is important for modeling infiltration rates within BMPs. The device consists of three parts; (1) a 3-inch long steel bottom or "collar," (2) 14.5-inch tall graduated cylinder, and (3) an MPD Head (Figure 13). The steel collar and graduated cylinder are connected with a silicone bead to eliminate leakage between the inner surface of the collar and the outer face of the cylinder. The MPD Head records pressure changes within the cylinder as the water level drops and then transmits that data via Bluetooth to an Android tablet. See Ahmed and Gulliver

(2010) for further details on MPD infiltrometer setup and equations used for the K_{sat} calculation.

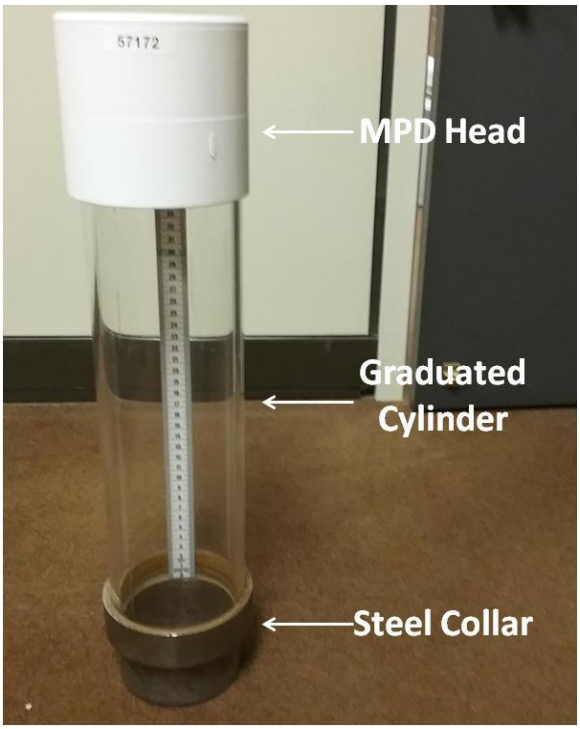

Figure 13. Modified Philip-Dunne Infiltrometer.

Samples were collected from mid-November through early December prior to the ground freezing. For each sample, the steel collar and graduated cylinder were inserted into the soil surface at a depth of 2 inches. Any mulch or plant materials were brushed aside before inserting the device into the soil. Soil moisture readings were collected pre and post test using a Rapitest Moisture Meter (Luster Leaf, www.lusterleaf.com). The graduated cylinder was filled with water to a predetermined height (~ 12 inches, 30 cm). An MPD Head was placed on top of the full graduated cylinder to record the water level drop over time. After completion of each test, recorded data were uploaded to the Upstream Technologies website where it is run through an automated program to calculate K_{sat} values. K_{sat} calculation requires a minimum of 2-4 inches (5 - 10 cm) of drop in water level within the MPD infiltrometer. Therefore, if the test is stopped before the drop in water level occurs a NULL value is obtained. GPS coordinates (Garmin GLO, Garmin, Ltd, www.garmin.com) were collected at each sample location. Vegetation type and proximity to each sample location was noted across all sites.

Data generated were compared within site and against non-BMPs (nearby turf and landscape areas) adjacent to each site. Data were compared across sites for evaluation of pretreatment effect on K_{sat} within the bioretention systems, distribution of K_{sat} across the entire system, and plant influence.

4. Results and Discussion

4.1 Saddle Hills Park

The Saddle Hills Park site consisted of two rain gardens, containing a silty clay loam soil, located in the northeast corner of the park. Saturated hydraulic conductivity measurements were collected within both rain gardens and adjacent turf grass areas (Figure 2). A total of 22 samples were acquired at the site (Table 1A). The site average K_{sat} (for both gardens) was 55.31 in/hr with average K_{sat} values of 38.5 and 65.4 in/hr for the west and east rain gardens, respectively. Collectively, the Saddle Hills Park site had the second highest site average K_{sat} (Table 2A). Some of the highest observed K_{sat} values (65.65 – 152.59 in/hr) were obtained adjacent to Fox Sedge and Dogwood plant species. Additionally, these samples were located above inlet/ pretreatment areas.

The lowest observed K_{sat} values (5.77 and 5.27 in/hr) were in the east rain garden, near the inlet. Similarly, the west rain garden saw its lowest K_{sat} value (7.26 in/hr) adjacent to the inlet pipe connecting the East garden to the West garden. While there wasn't clear visual evidence, low K_{sat} values could be attributed to sediment accretion and/or soil compaction. During periods of high stormwater runoff, sediment can be carried over the inlet pretreatment and deposited within the rain garden. Annual site inspections have documented sediment build up in the pretreatment curb-well and litter debris clogging the connecting inlet pipe, thus stressing the importance of routine maintenance to keep these gardens functioning properly.

Comparative measurements of nearby soil conditions were taken adjacent to the west and east rain gardens. Samples were collected in areas with turf grass as representative measurements for the surrounding park and conditions prior to rain garden installation. Only one out of the six samples acquired on turf grass returned a valid K_{sat} value (0.09 in/hr), which was the lowest observed K_{sat} value across all turf grasses sampled within our study. The remaining five turf grass samples returned NULL K_{sat} values.

4.2 University of Nebraska at Omaha Welcome Center

Measurements of saturated hydraulic conductivity were collected within two bioretention systems in front of the University of Nebraska-Omaha Welcome Center and nearby turf grass areas (Figure 15). Six samples were collected from the bioretention systems and four from turf areas, ten tests in total (Table 3A). The site average K_{sat} value was 55.35 in/hr, which was the highest site average K_{sat} value across all nine sites sampled (Table 2A). Average K_{sat} values for the north and south bioretention systems were 76.46 and 34.25 in/hr, respectively. Samples ranged from 6.37 to 146.55 in/hr in the north bioretention system and 6.23 to 58.4 in/hr in the south bioretention system.

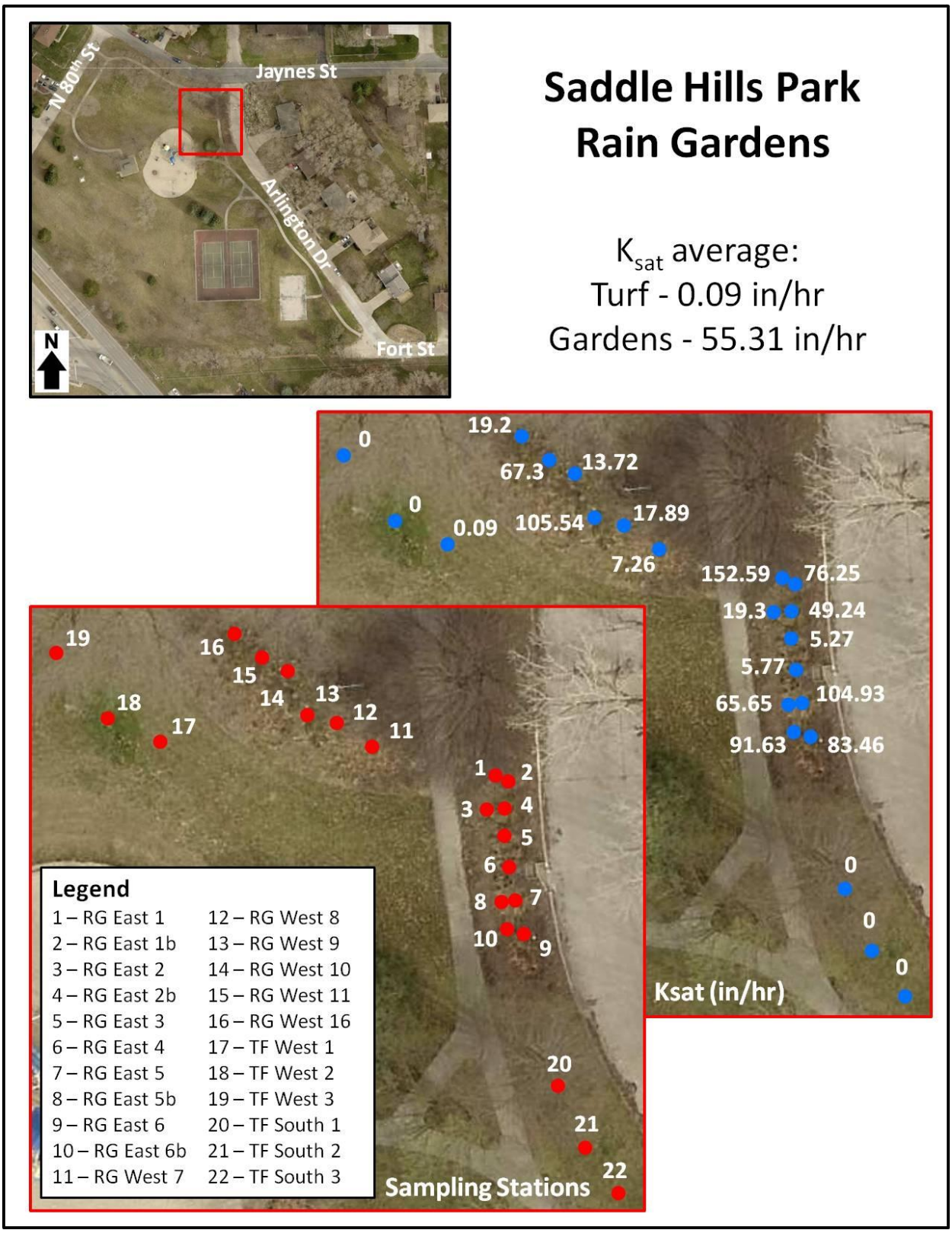

Figure 14. K_{sat} measurement locations and values at Saddle Hills Park. Note that NULL values are represented as zero (0).

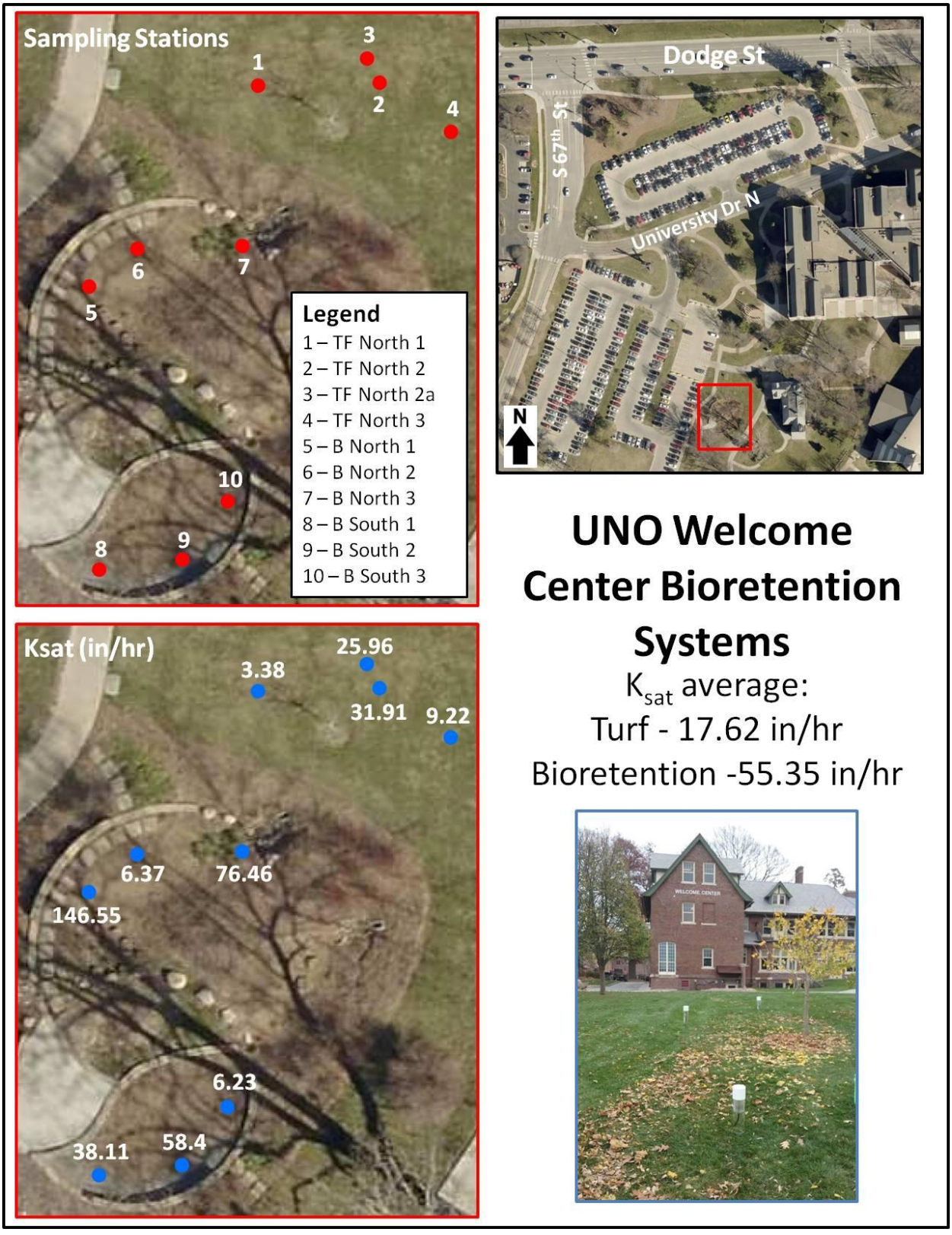

Figure 15. K_{sat} measurement locations and values at the University of Nebraska-Omaha Campus. Note that NULL values are represented as zero (0).

No spatial patterns of K_{sat} values were observed within the two systems.

Turf grass samples acquired north of the bioretention systems at UNO ranged from 3.38 to 31.91 in/hr. Turf K_{sat} values were highest at stations TF North 2 and TF North 2a (Figure 15). These stations fell within the closest proximity (~ 10 ft) to an adjacent tree, potentially falling within the tree's lateral root zone, which could lead to increased soil permeability. These were the highest observed K_{sat} values when compared to other turf grass samples across all nine sites.

4.3 Orchard Park

Saturated hydraulic conductivity measurements were collected at Orchard Park within the larger cell of northern bioretention system (Figure 16). A total of seven samples were acquired from both the bioretention system and adjacent turf grass area (Table 4A). The site average K_{sat} value for all four samples collected within the bioretention system was 11.77 in/hr, which ranked as the second lowest across all sites (Table 2A). Two samples, collected within the bioretention system, were taken adjacent to Little Bluestem (B 1 & B 4) and the remaining two samples were collected over bare ground (B 2 & B 3). Samples acquired next to native vegetation had higher K_{sat} values (16.53 and 22.3 in/hr) than those acquired over bare ground (1.68 and 6.58 in/hr). Native vegetation plays an important role in increasing infiltration rates as root structures break apart compacted soil layers. Three turf samples were acquired south of the bioretention system. Two of the three turf samples returned K_{sat} values averaging 1.81 in/hr.

4.4 Florence Streetscape

Measurements of saturated hydraulic conductivity were collected within two bioretention systems and adjacent tree planters from the Florence Streetscape Project on either side of North 30th Street between Clay and Willit Streets (Figure 17). The site average K_{sat} value, for both bioretention systems, was 18.28 in/hr, which was the fourth lowest site average K_{sat} value across all nine sites sampled (Table 2A). A total of 12 samples were collected at this site, three in each bioretention system and three in each adjacent tree planter (Table 5A). Tree planters were used as controls for nearby bioretention systems due to commercial development and limited access to turf grass. Collectively, the sampled tree planters outperformed both bioretention systems with a site average K_{sat} value of 33.30 in/hr. Higher K_{sat} values within the tree planters can be attributed to amended soils and no sediment loading. Samples were collected on the street side of each system to avoid sampling over the infiltration cell. The West bioretention system had the second lowest average K_{sat} value of 6.0 in/hr when comparing

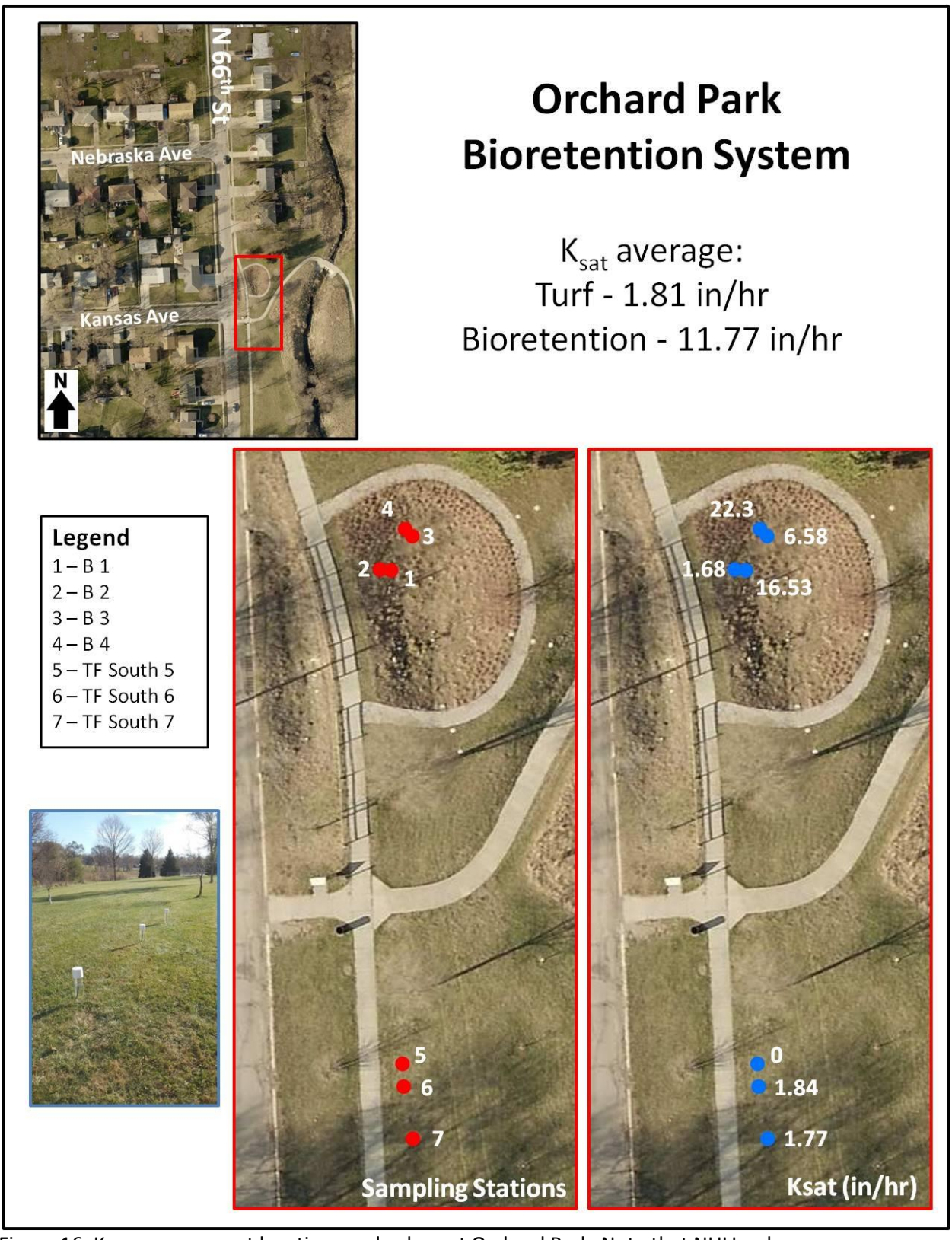

Figure 16. K_{sat} measurement locations and values at Orchard Park. Note that NULL values are represented as zero (0).

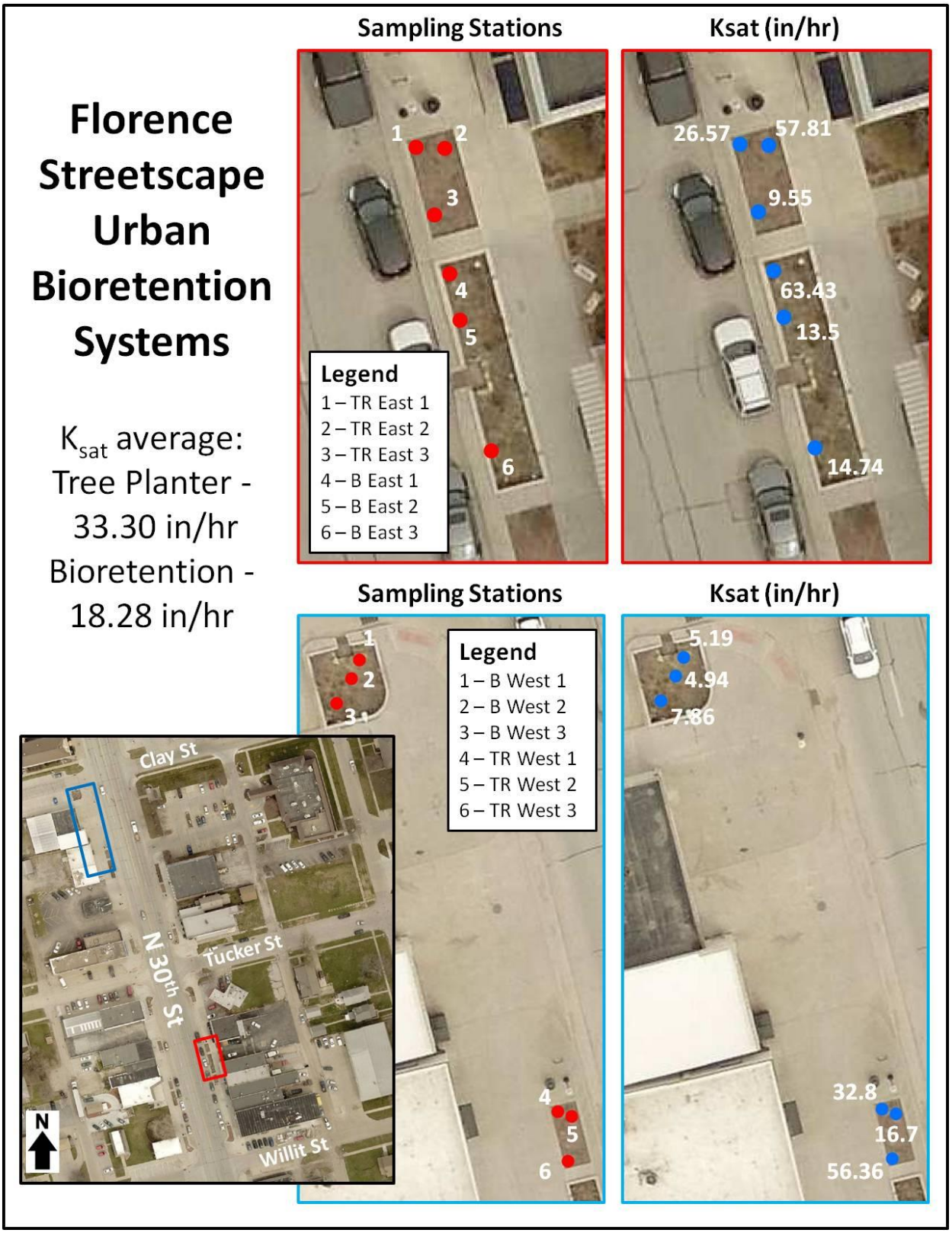

Figure 17. K_{sat} measurement locations and values at the Florence Streetscape Project.

each bioretention system and rain garden from all sites (Table 6A). The lowest K_{sat} values within the West bioretention system were near the inlet (Figure 17). These low K_{sat} values can be attributed to heavy sediment build up near the inlet, which was observed during sampling. The west system is located at the bottom of a hill on the corner of N 30th Street and Clay Street and experiences heavy sediment loading during high flows from an unimproved alleyway and vacant lot with little to no vegetative cover. Such influence caused severe build up of sediment within the bioretention system limiting infiltration rates/soil permeability. The East bioretention system had a higher average K_{sat} value (30.55 in/hr) compared to the west system (Table 6A). Again, the lowest observed K_{sat} values were located closest to the inlet in both systems (Figure 17).

4.5 The Benson East Gateway

Measurements of saturated hydraulic conductivity were taken within the Benson bioretention system, on the upper rim of bioretention system, and in an adjacent turf lawn (Figure 18). Eight samples were acquired at this site (Table 7A). The Benson bioretention system had a site average K_{sat} value of 27.55 in/hr, which was the fourth highest site average across all nine sites (Table 2A). K_{sat} values within the bioretention system ranged from 21.13 to 50.1 in/hr and were significantly higher than the adjacent turf and upper rim values. Lack of spatial trends within the bioretention systems could be attributed to the pretreatments installed above the system. The use of two forebays, a retaining wall, and a dry stream bed significantly reduces sediment deposition and water velocity prior to flowing into the bioretention system. The lowest K_{sat} value obtained (4.12 in/hr) was located on the edge of the bowl where soils were susceptible to compaction from construction and local foot traffic. Only one sample collected from the upper rim of the bioretention system returned a NULL value. The adjacent turf measurement was observed to have a K_{sat} value of 6.47 in/hr.

4.6 Under the Sink Facility

Saturated hydraulic conductivity measurements were collected from four bioretention systems located in the northwest corner of the Under the Sink property (Figure 19). In total, 14 samples were collected from the bioretention systems and adjacent turf grass areas (Table 8A). The site average K_{sat} for all four bioretention systems was 12.57 in/hr, which ranked as the third lowest K_{sat} value across all sites (Table 2A). This site was susceptible to heavy sediment build up (fine silt) from an eroding easement on the south side of the Union Pacific Rail Road (UPRR) Property and north of the bioretention systems (Figures 9 & 19). Bioretention systems 1 and 2 had the largest accumulation of sediment, which significantly impacted K_{sat} measurements resulting in NULL values (Figure 19). Within the second bioretention system, sample UTS B 2-3 produced a

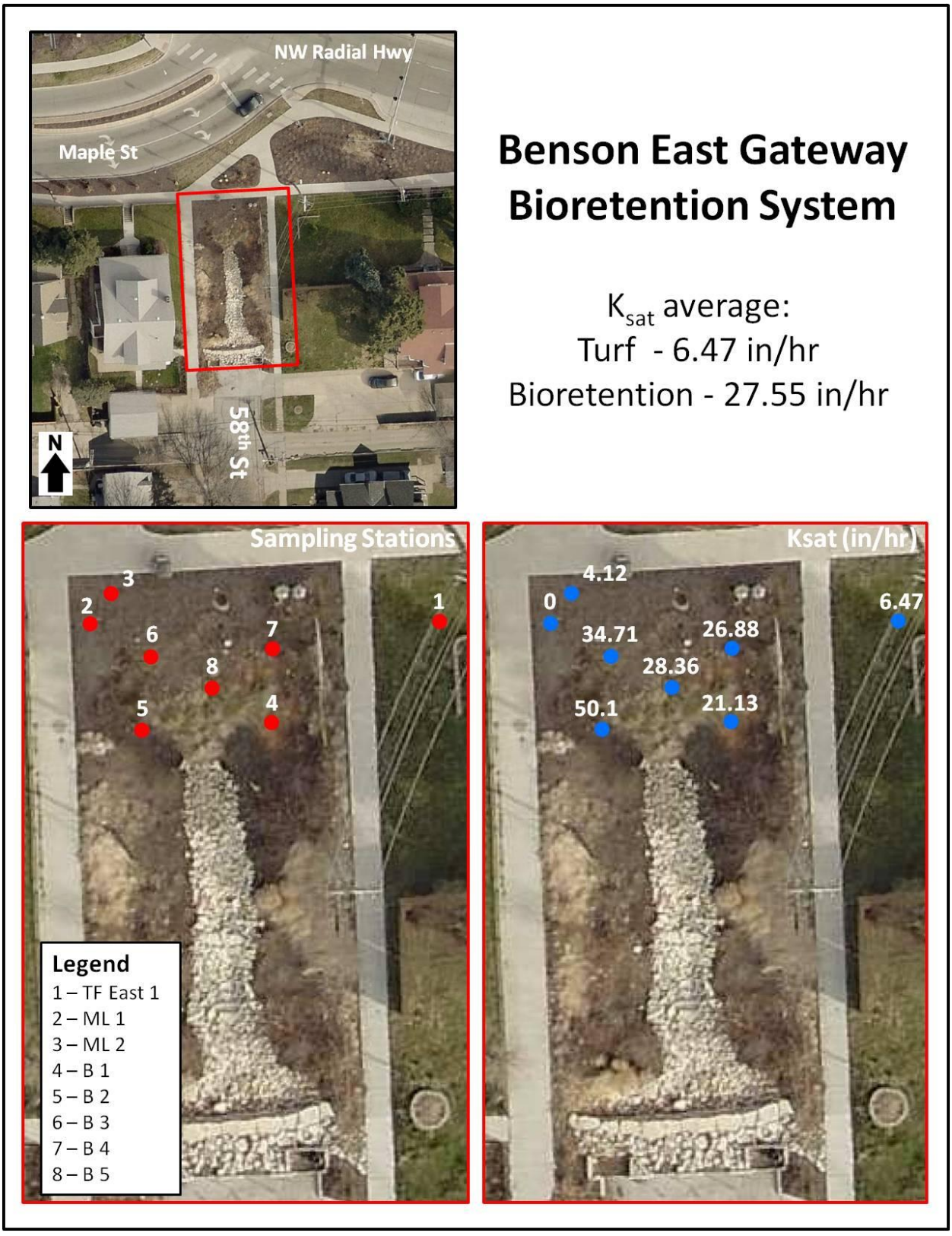

Figure 18. K_{sat} measurement locations and values at Benson East Gateway. Note that NULL values are represented as zero (0).

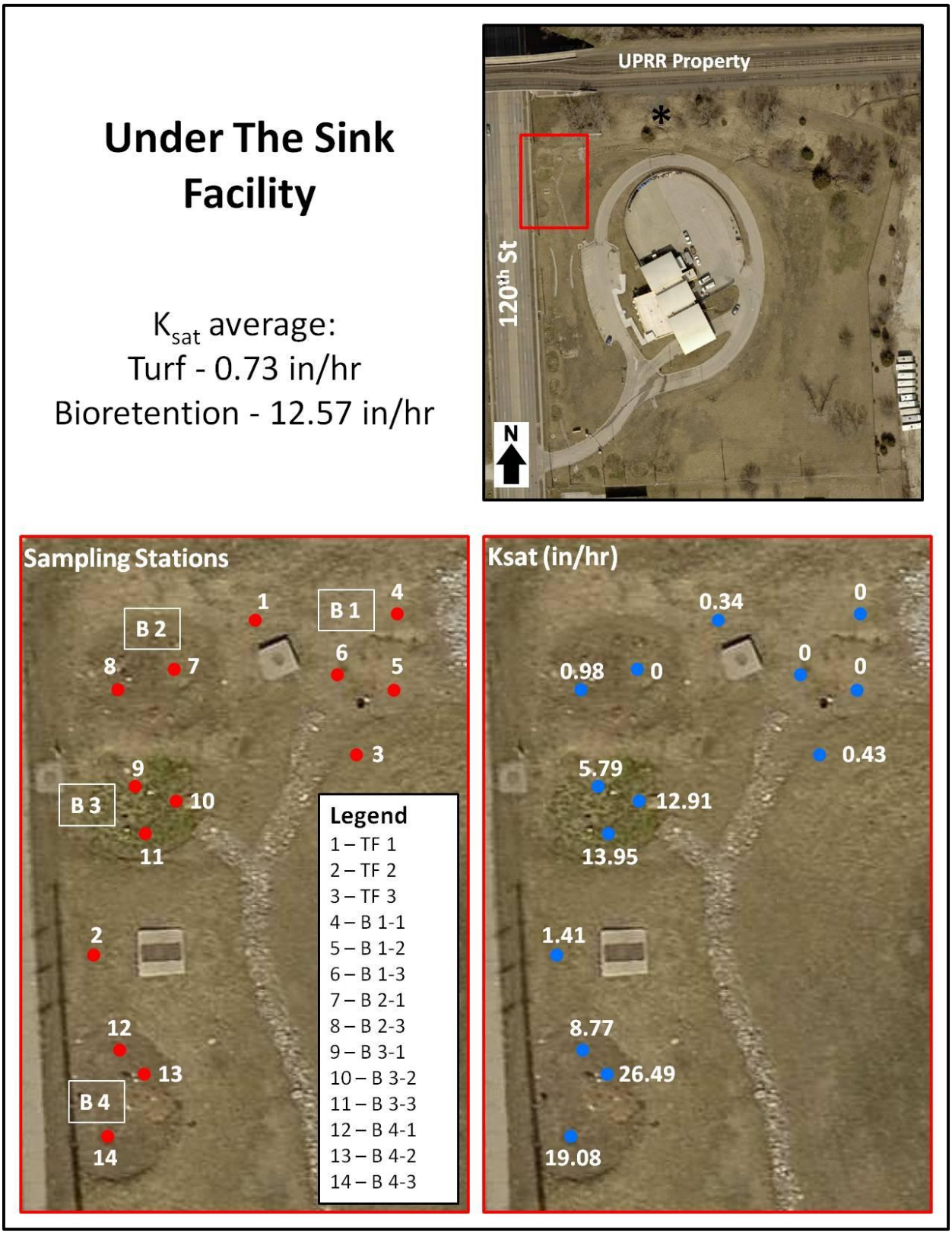

Figure 19. K_{sat} measurement locations and values at the Under the Sink Facility. Note that NULL values are represented as zero (0).* Denotes area of erosion causing silt accumulation in B-1 & B-2.

K_{sat} value of 0.98 in/hr, but only after 5 inches of the clogged top soil was removed (Figure 9c). Bioretention systems 3 and 4 did not have any observable impact from sediment build up and yielded average K_{sat} values of 10.88 and 18.12 in/hr, respectively (Table 6A). K_{sat} values for nearby turf measurements averaged 0.73 in/hr.

4.7 Creighton Prep

Saturated hydraulic conductivity measurements were collected on the west and east ends of the Creighton Prep bioretention system, located on the southern edge of the Creighton Prep campus (Figure 20). A total of 12 samples were collected at Creighton Prep, ten within the bioretention system and two in the adjacent turf lawn (Table 9A). Average K_{sat} values for the west and east bioretention samples were 3.09 and 4.93 in/hr, respectively. Two of the highest K_{sat} values (9.35 and 6.59 in/hr) collected within the bioretention system were adjacent to native vegetation (Switch grass and Fox sedge). The second highest measurement recorded for K_{sat} (6.75 in/hr) was adjacent to a Fox sedge plant, but located over the infiltration cell. The lowest K_{sat} value (0.81 in/hr) observed within the bioretention system was located closest to the inlet on the west side of the system, an area documented with heavy sediment build up and fine silt. Only one sample out of the 12 collected at Creighton Prep returned a NULL value. Turf grass measurements collected north of the bioretention system averaged 1.81 in /hr.

Creighton Prep's bioretention system had the lowest site average for K_{sat} at 4.01 in/hr (Table 2A). The presence of cattails was documented on the west side of the bioretention system and may be indicative of hydric soils resulting from periods of prolonged saturation. Observations made at the bioretention system noted significant sediment accretion on both the west and east ends. Heavy sediment accretion is a result of the nearby athletic fields which deposits infield topdressing into a nearby inlet that drains directly into the bioretention system (Figure 20). Infield topdressing is preventative measure used to reduce erosion on baseball fields but is often washed away during heavy rain events. It is important to note that this system has the largest drainage area when compared to the other sites that were sampled.

4.8 South Omaha Industrial Area Lift Station

In total, 17 measurements of saturated hydraulic conductivity were collected within the bioretention system and adjacent turf grass at the southern end of the SOIA Lift Station property (Figure 21, Table 10A). This site average K_{sat} value was 29.14 in/hr, which was the third highest site average across all nine sites (Table 2A). The lowest K_{sat} values (0.03 and 0.76 in/hr) observed at this site were those that were placed directly on top of native vegetation (Karl Foerster) within the bioretention system. However, samples collected adjacent to and between Karl Foerster plants saw anywhere from a 50 to 640-fold increase in K_{sat} values. Samples

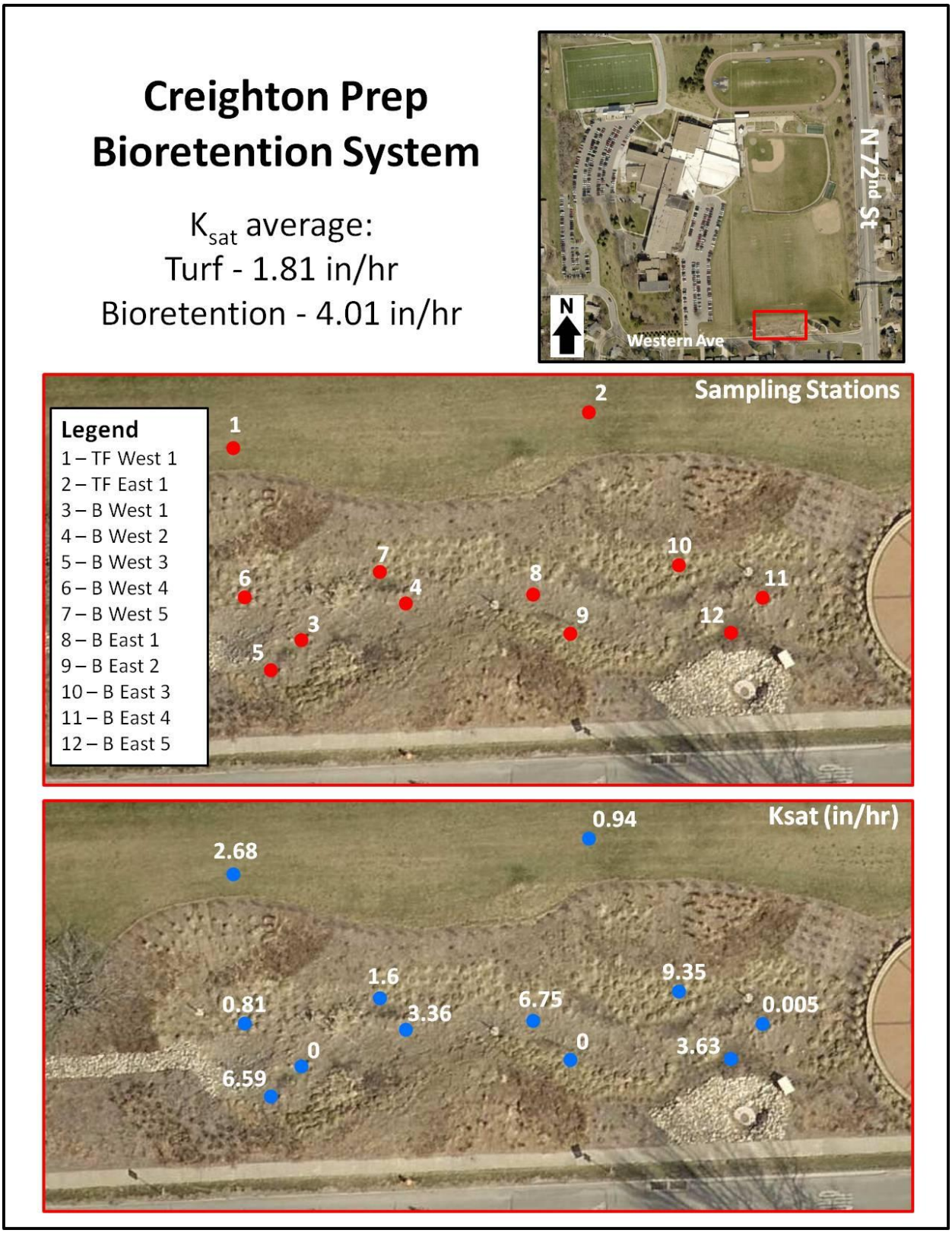

Figure 20. K_{sat} measurement locations and values at Creighton Prep. Note that NULL values are represented as zero (0).

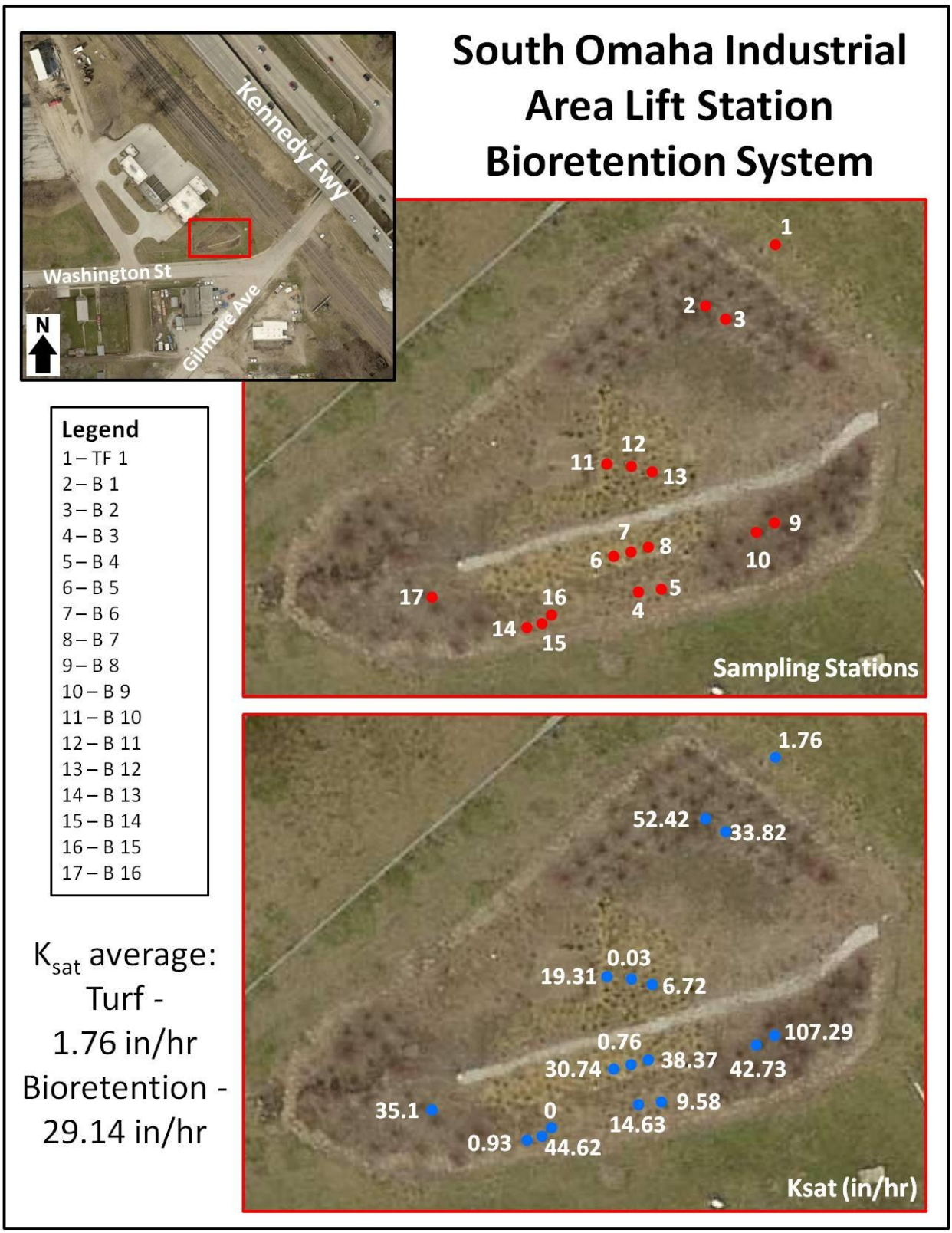

Figure 21. K_{sat} measurement locations and values at the South Omaha Industrial Area. Note that NULL values are represented as zero (0).

collected adjacent to or between Dogwood plants documented some of the highest K_{sat} values within site, ranging from 35.1 to 107.29 in/hr. One measurement of saturated hydraulic conductivity was acquired over turf grass, northeast corner above the bioretention system, with an observed K_{sat} value of 1.76 in/hr. Only one out of the 17 samples collected from the bioretention system returned a NULL value for unknown reasons. No observed spatial patterns of K_{sat} values were documented with respect to inlet structures (pretreatments) and stormwater entry into the bioretention system.

4.9 Omaha Sewer Maintenance Facility

Measurements of saturated hydraulic conductivity were collected at the Omaha Sewer Maintenance Facility (SMF) from within the bioretention system and an adjacent turf lawn composed of Buffalo Grass. In total, ten samples were collected from this site (Table 11A). The bioretention system had a site average K_{sat} value of 20.83 in/hr, which was slightly skewed from measurements obtained from stations 7 and 8 (Figure 22). The SMF site average was ranked the median value when compared across all nine sites (Table 2A). Stations 7 and 8, collected within the bioretention system, had the highest K_{sat} values with 100.17 and 25.88 in/hr, respectively. These samples were acquired over the infiltration cell which is constructed with pea gravel to promote rapid infiltration/high permeability. Observations made at station 8 during sample collection noted medium to heavy sediment build up and propagation of plants into the infiltration cell, which could attribute to reduced permeability and a lower K_{sat} value when compared to station 7.

Additional measurements collected on the rim and within the basin of the bioretention system ranged from 0.02 to 8.7 in/hr (Figure 22). The lowest observed K_{sat} values (1.22 and 1.32 in/hr) within the bioretention basin were located closest to the inlet in areas that have experienced build up of fine silt and sediment. This accumulation of debris is due to erosion of the inlet structure and accompanying vegetation. Measurements collected at stations 9 and 10 saw large discrepancies in K_{sat} values despite their close proximity. Observations noted in the field with respect to vegetation or soil conditions could not be attributed to the fluctuation of these values, concluding that soil compaction or an impartial seal when inserting the MPD infiltrometer was to blame.

Only one sample collected at this site (station 4) returned a NULL valve, which could be attributed to the samples proximity to the inlet structure and observed sediment build up noted at the sample location. Two turf measurements were acquired over native Buffalo Grass and observed an average K_{sat} value of 0.43 in/hr.

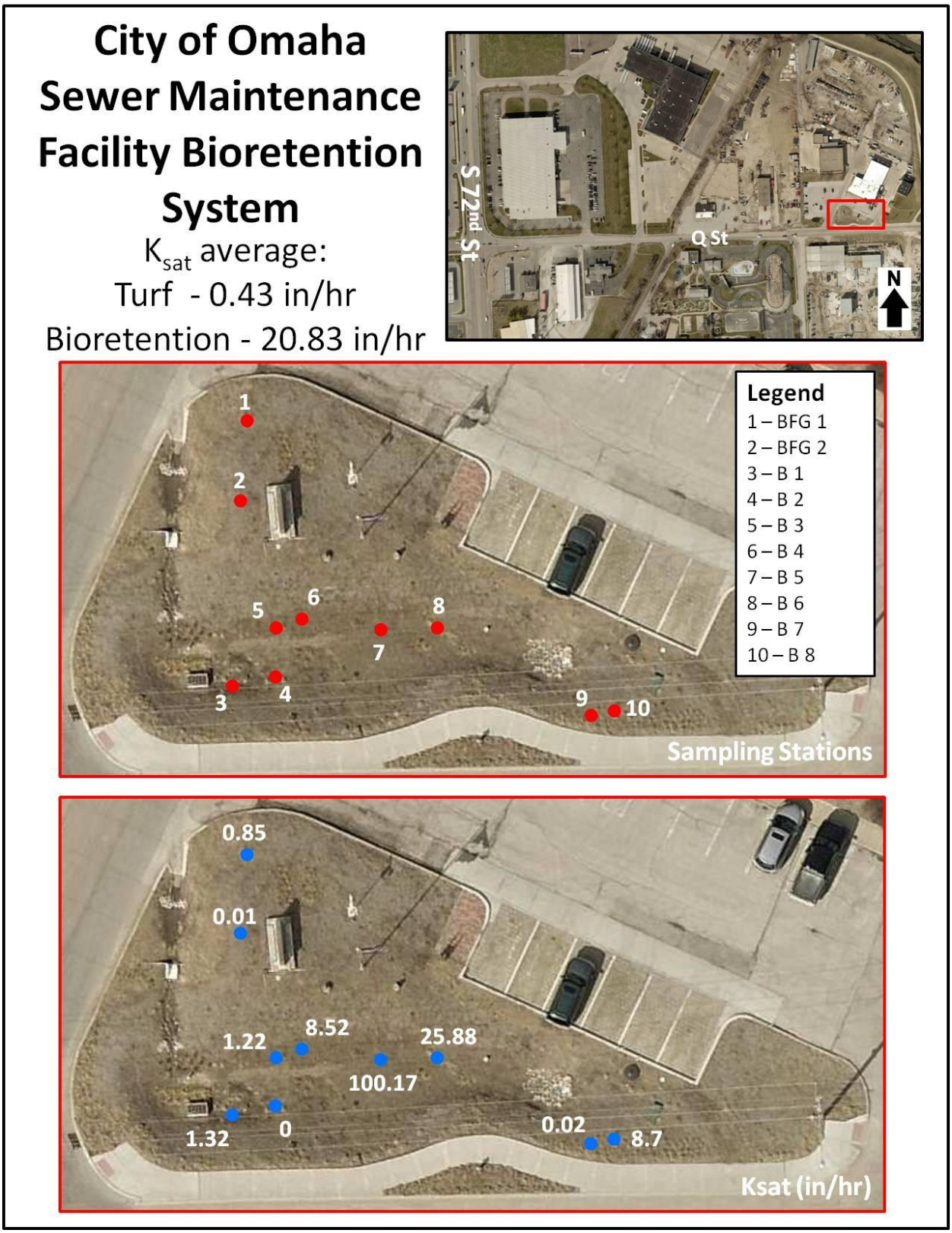

Figure 22. K_{sat} measurement locations and values at the Omaha Sewer Maintenance Facility. Note that NULL values are represented as zero (0).

5. Conclusion

Bioretention systems and rain gardens are an effective measure for mitigating the effects of stormwater runoff in urban environments. Emphasis can be placed on the increased filtration and permeability properties of these green infrastructure practices when compared to traditional turf areas or impervious surfaces (Table 12A). To ensure these systems are performing properly, regular inspection and testing of soil infiltration properties are necessary. MPD Infiltrometers provided useful and accurate information with respect to saturated hydraulic conductivity measurements collected at a site.

This study noted significant spread of saturated hydraulic conductivity measurements within and across sites. Due to the spatial and temporal variation of soil properties within rain gardens and bioretention systems it is recommended that larger sample sizes be obtained (appropriate to each system) and at regular intervals. Such information can easily identify spatial trends, seasonal variability, and identify areas with reduced permeability. Furthermore, increased sample size provides appropriate information for estimation of a system-wide (median) value for saturated hydraulic conductivity, accurately testing system performance.

While the MPD infiltrometer provides quick and accurate information, it is only designed to measure the saturated hydraulic conductivity of the top 8-12 inches of media. During construction of these green infrastructure practices typically 1-2 inches of compost is tilled into the *in-situ* soil to a minimum depth of 6 inches. Therefore, sampling these amended soils does not accurately reflect *in-situ* subsurface soil properties surrounding the system nor does it capture infiltration processes of the system as a whole. To better understand overall infiltration processes of rain gardens and bioretention systems it is recommended to test at various depths within the amended soils, but most importantly testing at different depths within the subsurface *in-situ* soils. Such sampling efforts would provide a greater understanding of amended and *in-situ* soil infiltration rates and how these properties could improve or diminish over time as a result of root propagation, freeze/thaw cycles, and soil compaction.

Vegetation has been shown to increase infiltration rates by increasing pore spaces within soil via root growth. This study noted several systems in which saturated hydraulic conductivity measurements were higher when collected adjacent to vegetation as opposed to measurements collected away from vegetation, which had slower rates of saturated hydraulic conductivity. Observations were pooled across all sites to identify plant specific saturated hydraulic conductivity measurements (Table 13A). Future work should focus on collecting measurements within proximity or adjacent to various plant species used in green infrastructure practices. This information would prove beneficial in understanding how plants could improve soil permeability and infiltration rates over time.

Finally, the results of this study highlight the significance of implementing pretreatment structures within inlet areas of rain gardens and bioretention systems. Several sites (Saddle Hills Park, Creighton Prep, & Under the Sink) yielded significantly lower k_{sat} values for samples collected within proximity of the inlet pretreatment structure. These observed values were attributed to the accumulation of fine silt and sediment. Pretreatment structures vary in design but are significant in reducing sediment loads and other debris from entering rain gardens and bioretention systems. Effective pretreatments significantly reduce sedimentation from occurring within structures and mitigating clogging potential of the soils. With proper maintenance and installation, pretreatment structures will properly trap sediment and decrease water velocity, reducing erosion within the system. Pretreatment structures can include bioswales, filter strips, “curb-wells”, other sump structures, and forebays.

Results from this study helped with the overall assessment of these established bioretention systems and rain gardens and will provide the necessary baseline data for future monitoring efforts.

Essential findings of this study:

1. MPD Infiltrometers provide quick and quantifiable measurements of saturated hydraulic conductivity (K_{sat}). These infiltrometers allow for rapid generation of site-specific K_{sat} values. In addition, MPD Infiltrometers provide necessary data required to evaluate and monitor stormwater infiltration practices seasonally.
2. Amended soils and vegetation within rain gardens and bioretention systems demonstrated better infiltration properties (saturated hydraulic conductivity) than adjacent turf grasses.
3. Measurements acquired within proximity to inlet structures showed lower values of saturated hydraulic conductivity when compared to other measurements in the same system. Installation and proper maintenance of pretreatment structures in inlet areas is essential for eliminating the build up of fine silt, sediment, and other debris that reduces the saturated hydraulic conductivity within rain gardens and bioretention systems.
4. Measurements acquired adjacent to vegetation in bioretention systems exhibited larger K_{sat} values compared to samples collected over bare ground. Data were aggregated to generate species-specific values of K_{sat} (Table 13A).

Recommendations for future:

1. Continue monitoring with MPD Infiltrometers to better characterize the spatial distribution of K_{sat} values across all sites. Additional sampling can be done throughout the growing season to better identify (if any) seasonality in K_{sat} with response to vegetative growth.

2. While using MPD Infiltrometers care should be taken when inserting cylinders into the soil in order to avoid settings that allow for inaccurate or NULL tests.
3. Use of soil core monitoring to determine rates of sedimentation within rain gardens and bioretention systems. Additional focus could be placed on installation of horizon markers and/or erosion pins to document rates of sediment accretion or erosion within these systems. Both options provide a low cost, efficient, and quick means of measuring sedimentation rates and effectiveness of pretreatment.
4. Further examination of the relationship between observed K_{sat} values and adjacent plant species. Identify which plant species (if any) significantly increase infiltration rates through development of their rhizosphere.
5. Monitor rain gardens and bioretention systems saturated hydraulic conductivity rates and performance seasonally. If saturated hydraulic conductivity rates are falling below acceptable performance levels, adjustments to the structure should be made. Structure adjustments can include modification of soil conditions (sediment removal, tilling, and plowing), increasing plant density and diversity, or further inspection of the system to determine a site-specific issue.

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Appendix

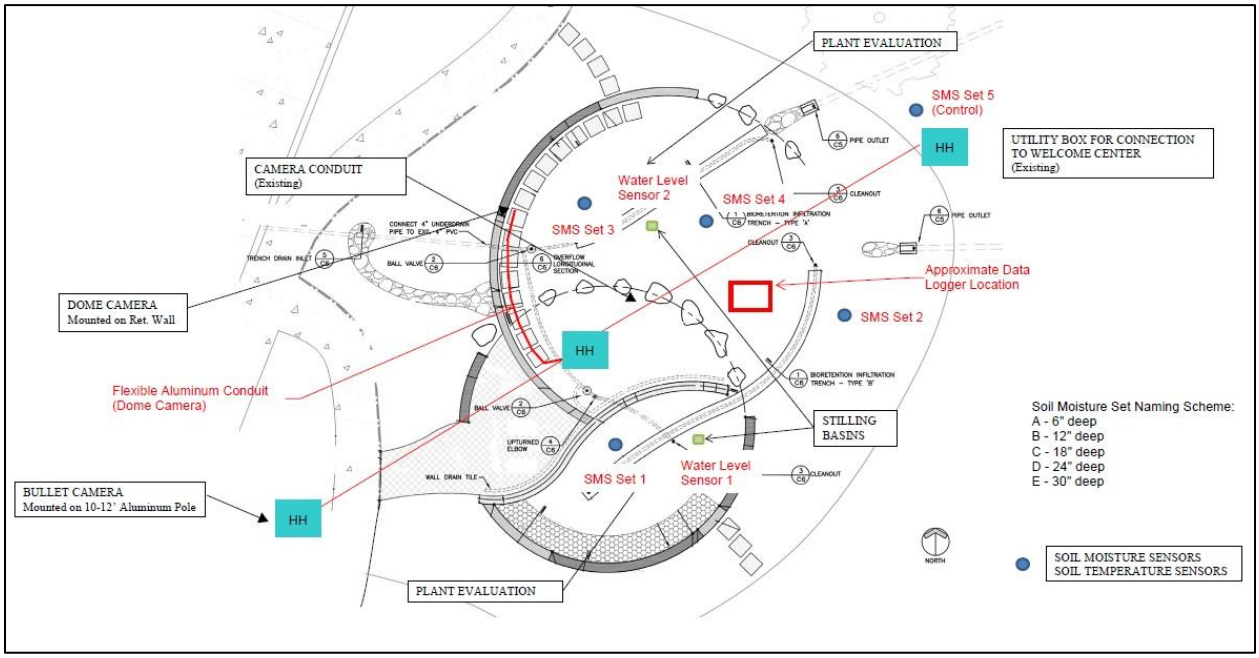


Figure 1A. Site plan for UNO bioretention system monitoring equipment.

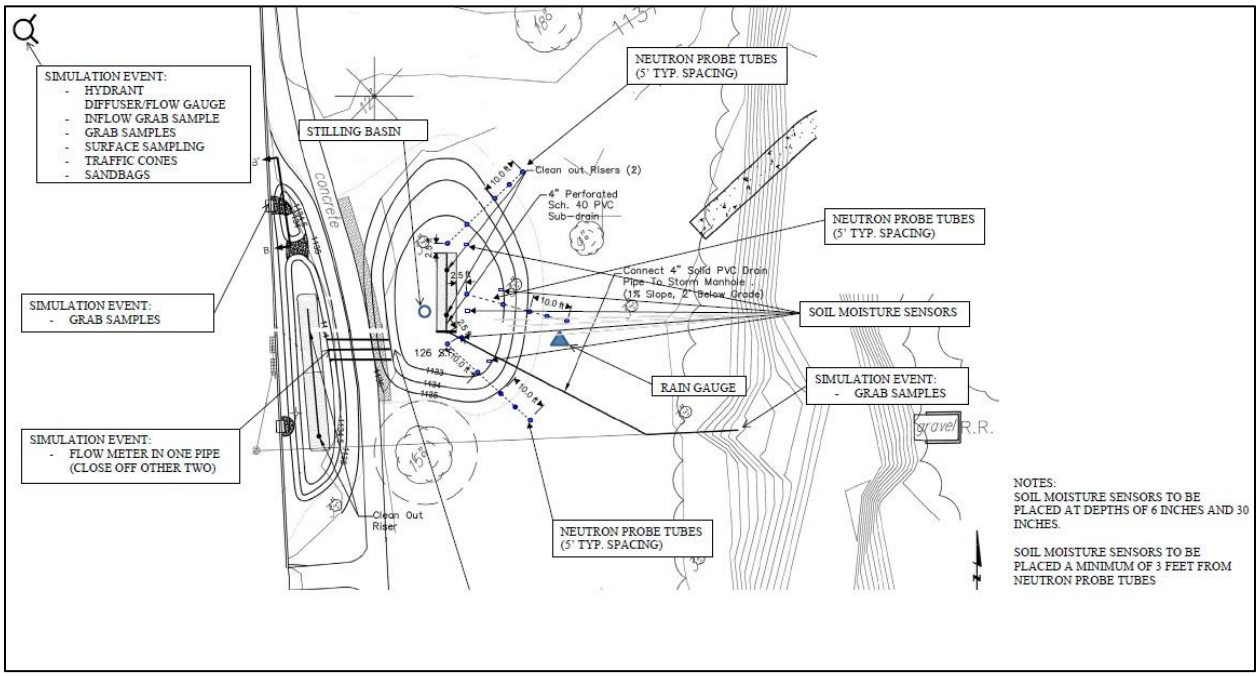


Figure 2A. Site plan for Orchard Park bioretention system monitoring equipment.

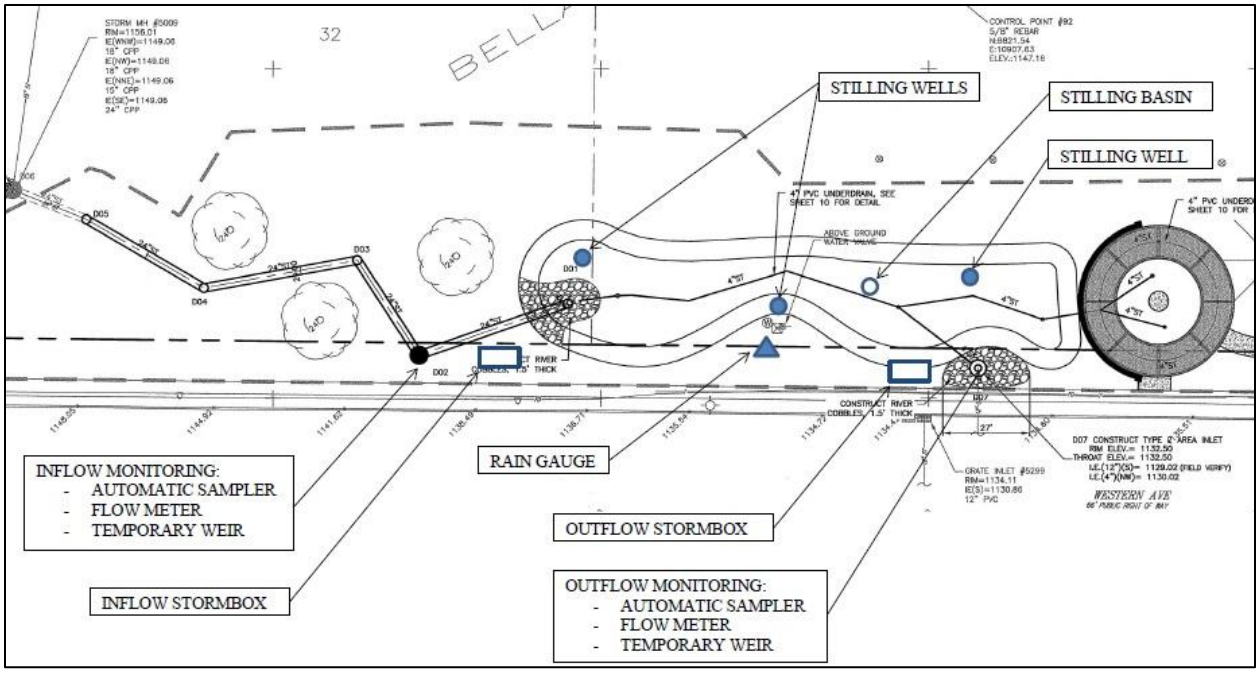


Figure 3A. Site plan for Creighton Prep bioretention system monitoring equipment.

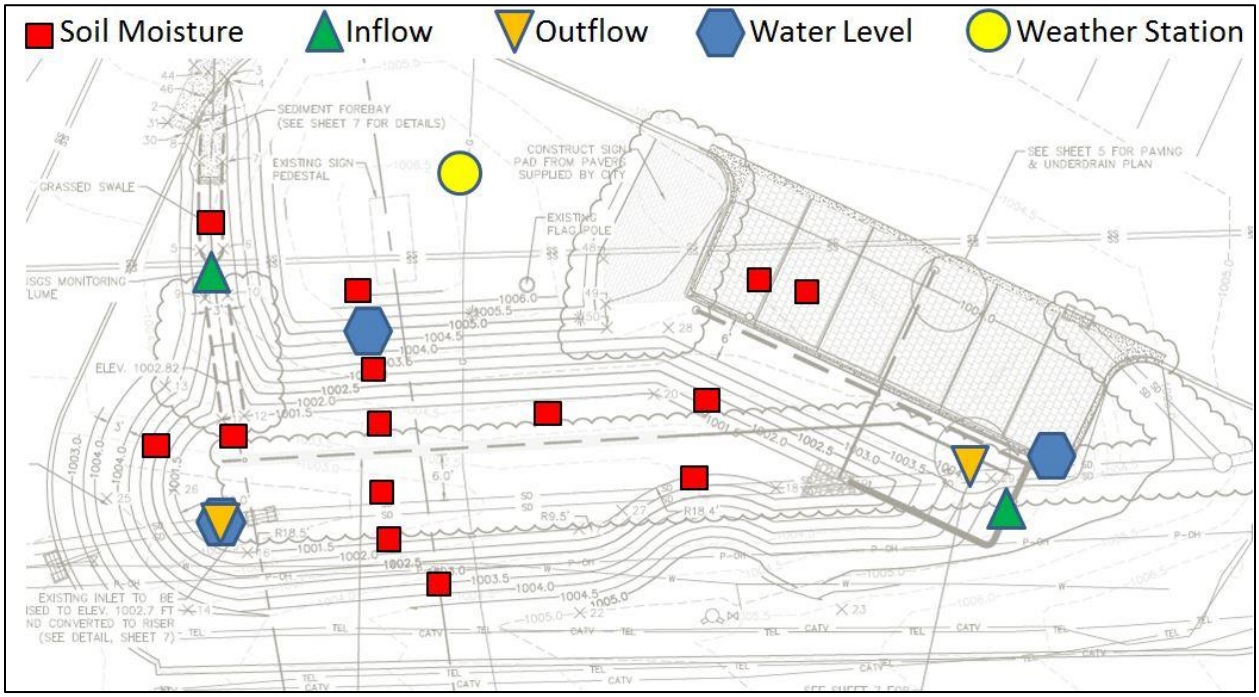


Figure 4A. Site plan for Sewer Maintenance Facility bioretention system monitoring equipment.

Table 1A. Summary of saturated hydraulic conductivity measurements collected from the Saddle Hills Park (SHP) Rain Gardens.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
SHP	16	55.31	44.93	5.27	152.59	147.32
SHP RG East	10	65.41	46.97	5.27	152.59	147.32
SHP RG West	6	38.49	39.27	7.26	105.54	98.28
SHP TF	1	0.09	-	-	-	-

*RG = Rain Garden; TF= Turf grass

Table 2A. Ranked mean site values for saturated hydraulic conductivity for bioretention systems and rain gardens from all nine study sites.

Site	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
UNO	6	55.35	52.69	6.23	146.55	140.33
SHP	16	55.31	44.93	5.27	152.59	147.32
SOIA	15	29.14	27.85	0.03	107.29	107.27
Benson	6	27.55	15.17	4.12	50.10	45.98
SMF	7	20.83	36.10	0.02	100.17	100.15
Florence	6	18.28	22.50	4.94	63.43	58.49
UTS	7	12.57	8.50	0.98	26.49	25.52
OP	4	11.77	9.35	1.68	22.30	20.61
CRP	8	4.01	3.28	0.005	9.35	9.34

Table 3A. Summary of saturated hydraulic conductivity measurements collected from the University of Nebraska at Omaha (UNO) Bioretention Systems.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
UNO B	6	55.35	52.69	6.23	146.55	140.32
UNO B North	3	76.46	70.09	6.37	146.55	140.18
UNO B South	3	34.25	26.30	6.23	58.4	52.17
UNO TF	4	17.62	13.50	3.38	31.91	28.53

*B = Bioretention System; TF= Turf grass

Table 4A. Summary of saturated hydraulic conductivity measurements collected from the Orchard Park (OP) Bioretention System.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
OP B	4	11.77	9.35	1.68	22.3	20.62
OP TF	2	1.81	0.05	1.77	1.84	0.07

*B = Bioretention System; TF= Turf grass

Table 5A. Summary of saturated hydraulic conductivity measurements collected from the Florence (FL) Streetscape Bioretention Systems.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
FL B	6	18.28	22.50	4.94	63.43	58.49
FL TR	6	33.30	20.09	9.55	57.81	48.26
FL B East	3	30.56	28.48	13.5	63.43	49.93
FL B West	3	6.00	1.62	4.94	7.86	2.92
FL TR East	3	31.31	24.48	9.55	57.81	48.26
FL TR West	3	35.29	19.95	16.7	56.36	39.66

*B = Bioretention System; TR= Tree Planter

Table 6A. Summary of saturated hydraulic conductivity measurements collected from each rain garden and bioretention system.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
UNO B North	3	76.46	70.09	6.37	146.55	140.19
SHP RG South	10	65.41	46.97	5.27	152.59	147.32
SHP RG West	6	38.48	39.27	7.26	105.54	98.29
UNO B South	3	34.25	26.30	6.23	58.40	52.17
FL B East	3	30.56	28.48	13.50	63.43	49.93
SOIA B	15	29.14	27.85	0.03	107.29	107.27
Benson B	6	27.55	15.17	4.12	50.10	45.98
SMF B	7	20.83	36.10	0.02	100.17	100.15
UTS B 4	3	18.12	8.90	8.77	26.49	17.72
OP B	4	11.77	9.35	1.68	22.30	20.61
UTS B 3	3	10.88	4.44	5.79	13.95	8.16
FL B West	3	6.00	1.62	4.94	7.86	2.92
CRP B	8	4.01	3.28	0.00	9.35	9.34

*B = Bioretention System; RG = Rain Garden

Table 7A. Summary of saturated hydraulic conductivity measurements collected from the Benson East Gateway Bioretention System.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
Benson B	6	27.55	15.17	4.12	50.1	45.98
Benson B[1]	5	32.24	11.09	21.13	50.1	28.97
Benson ML	1	4.12	-	-	-	-
Benson TF	1	6.47	-	-	-	-

*B = Bioretention System; ML = Mulch; TF= Turf grass

[1] Removed outlier measurement Benson ML

Table 8A. Summary of saturated hydraulic conductivity measurements collected from the Under the Sink (UTS) Facility Bioretention Systems.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
UTS B	7	12.57	8.49	0.98	26.49	25.51
UTS[1]	6	14.50	7.43	5.79	26.49	20.70
UTS B 2	1	0.98	-	-	-	-
UTS B 3	3	10.88	4.44	5.79	13.95	8.16
UTS B 4	3	18.12	8.90	8.77	26.49	17.72
UTS TF	3	0.73	0.59	0.34	1.41	1.07

*B = Bioretention System; TF= Turf grass

[1] Removed outlier measurement from bioretention system UTS B 2

Table 9A. Summary of saturated hydraulic conductivity measurements collected from the Creighton Prep (CRP) Bioretention System.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
CRP B	8	4.01	3.28	0.005	9.35	9.35
CRP B West	4	3.09	2.56	0.81	6.59	5.78
CRP B East	4	4.93	4.04	0.005	9.35	9.35
CRP TF	2	1.81	1.23	0.94	2.68	1.74

*B = Bioretention System; TF= Turf grass

Table 10A. Summary of saturated hydraulic conductivity measurements collected from the South Omaha Industrial Area (SOIA) Lift Station Bioretention System.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
SOIA B	15	29.14	27.85	0.03	107.29	107.26
SOIA TF	1	1.76	-	-	-	-

*B = Bioretention System; TF= Turf grass

Table 11A. Summary of saturated hydraulic conductivity measurements collected from the Omaha Sewer Maintenance Facility (SMF) Bioretention System.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
SMF B	7	20.83	36.10	0.02	100.17	100.15
SMF BFG	2	0.43	0.59	0.01	0.85	0.84

*B = Bioretention System; BFG= Buffalo grass

Table 12A. Summary of saturated hydraulic conductivity measurements from all nine sites sampled in this study.

	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
RG	16	55.31	44.93	5.27	152.59	147.32
B	59	23.00	28.86	0.005	146.55	146.55
TF	14	6.30	9.98	0.09	31.91	31.82
TF[1]	12	2.53	2.72	0.09	9.22	9.13
TR	6	33.30	20.09	9.55	57.81	48.26
BFG	2	0.43	0.59	0.01	0.85	0.84

* RG = Rain Garden; B = Bioretention System; TF= Turf grass; TR= Tree Planter; BFG= Buffalo grass

[1] Removed two outlier measurements sampled at UNO

Table 13A. Summary of species-specific saturated hydraulic conductivity measurements collected from all nine study sites.

Plant Species	N	Mean (in/hr)	Std Dev (in/hr)	Minimum (in/hr)	Maximum (in/hr)	Range (in/hr)
Dogwood	13	69.36	38.98	5.77	152.59	146.82
Pennsylvania Sedge	4	36.87	22.63	13.72	67.30	53.59
Fox Sedge	11	26.92	38.38	0.005	105.54	105.54
Blue Flag Iris	6	23.17	21.23	6.23	63.43	57.20
Palm Sedge	6	17.04	17.13	0.81	49.24	48.44
Karl Foerster	6	15.99	16.14	0.03	38.37	38.34
Little Bluestem	9	13.69	13.54	0.93	44.62	43.69
Switch grass	5	12.87	9.64	3.63	26.49	22.86
Turf Grass	14	6.30	9.98	0.09	31.91	31.82

UNIVERSITY OF NEBRASKA AT OMAHA

Evaluating Regional Rain Garden Environmental Conditions, Functional Attributes, and Costs/Benefits

Rachael Burns and Steve Rodie - Department of Biology, University of Nebraska at Omaha, Omaha, NE 68182
Andy Szatko - City of Omaha Stormwater Management and Ted Hartsig - Olsson Associates

Background

Rain gardens are shallow depressions planted with native flowering plants and grasses that can survive in soil soaked with water from rain storms. Rain gardens allow stormwater runoff from homes and businesses to infiltrate into the soil, which reduces the runoff to storm drains. This protects streams and lakes from pollutants that are washed from house roofs and paved areas and from channel and bank erosion. An important element of Omaha's Long Term Control Plan will be the continued operation of green infrastructure. These programs assist Omaha in addressing water quality and water quantity management issues and reducing the amount of pollutants entering the sewer system or receiving streams.

Project Workflow

- Thorough background research of rain gardens and previous assessment protocols
- Meeting with UNO and Omaha Stormwater Program personnel
- Discussion of hypotheses and methods
- Allocation of funds for supplies
- Data collection
- Omaha Stormwater Tour
- Data Analysis

Project Limitations

- Limited time
- Potentially more accurate infiltrometer (modified Philip Dunne Infiltrometer) arriving in August; comparison testing planned
- Plants not yet established
- Limited background research available
- Some plants in gardens did not match engineering design (in placement or species)
- Weather

Results

- Site #14 rain garden had slowest infiltration rates. As a result, many plant species suffered most in this garden.
- Sites #12 and 12a are the healthiest. Fast infiltration rates and proper location of plants.
- No trends between infiltration rates of sedges. Sedges are not yet established so this data will be more useful in coming years.
- No trends between forebay infiltration and other areas in the garden. Sedges are not yet established and not enough time has passed to allow a large buildup of sediment due to forebay overflow, so this data will be more useful in coming years.
- Chemical results currently being analyzed by Midwest Labs.
- Plant species assessments can be accessed upon request.

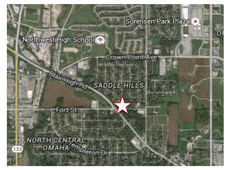
Hypotheses

- The rain gardens located lower in the watershed will have more pollutants accumulated in the forebay sediment, garden soil and garden mulch than the gardens located higher in the watershed.
- The soil next to the forebays will have a slower infiltration rate due to sediment buildup.
- The soil near forebays are still infiltrating at an acceptable rate even though they have a buildup of sediment.
- Established sedges with deep root systems will increase the rate of infiltration in areas immediately within plant groupings.
- Plants with fibrous root systems will increase the rate of infiltration.
- Rain gardens that contain street runoff will have more heavy metals accumulated in soil/mulch.
- Rain gardens that contain residential lawn and vegetated surface runoff will have more phosphates and nitrates in the soil/mulch.
- The levels of pollutants in the soil will not exceed safety limits.

Materials/Methods

Testing 6 gardens (2 park, 4 residential) in the Saddle Hills Neighborhood in northwest Omaha

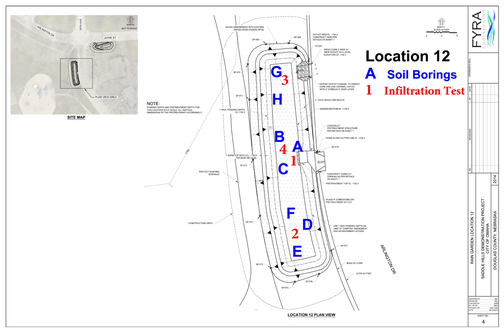
1. Chemical testing
   - Scrape forebay sediments
   - Obtain soil via soil-sampling probe
   - Collect mulch
   - Send to Midwest Lab for chemical analysis of salts, phosphates, nitrates, heavy metals, hydrocarbons, etc.
2. Assess infiltration rates using Turf-Tec mini double-ring infiltrometer
   - Compare between gardens
   - Differences of locations within individual gardens
   - Differences between various sedge species (Do species vary in affecting infiltration rates?)
3. Overall plant assessment – tie to original planting designs
   - What conditions does each plant species prefer in the garden (sun/shade/water preferences)?



Location of rain gardens

Site 10 rain garden showing infiltration tests using double-ringed infiltrometers

Typical Rain Garden Assessment (Site 12)



Grading and layout engineering plan. Blue letters indicate locations of soil samples and red numbers indicate infiltration test locations.

Metered water fill from hydrant to assess designed capacity

Black Chokeberry (*Aronia melanocarpa*) plants received a rating of 5 on the BMP Plant Evaluation Form

Soil Boring Locations

12A

Soil probe test at approx. 9.25 inches (23.5 cm) depth for each location

12B

12C

12D

12E

12F

12G

12H

Soil tests in multiple locations using soil probes

Summary

Rain gardens collect stormwater runoff from homes and streets and alleviate the amount being emptied into our storm drains. They further collect pollutants and prevent erosion. The Saddles Hills rain gardens were constructed at the end of 2014, so plants are not well established to properly compare infiltration rates and understand the full benefits the gardens will provide. However, this data serves as a starting point for a continuous analysis over the impact of the Saddle Hills rain gardens. Furthermore, the plant assessments will be used to determine which plants are best used for future rain gardens and the best locations for each plant species.

Impact of Research on My Teaching

- Bring awareness of green infrastructure in Omaha and NW neighborhoods to students.
- Teach students native NE plants.
- Teach students how to take soil and infiltration tests.
- Teach students how to take plant assessments.
- Allow students to conduct own mini-projects/ inquiry in gardens.
- Enhance STEM (Science, Technology, Engineering and Math) education and curriculum - rain garden design requires calculations for runoff and garden sizing, soil infiltration testing, slope calculations, selection of proper plants, garden access for people, and aesthetic beauty and maintainability.

References

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- Liebsch, M. K. (2011). *Hydrologic effectiveness and plant survivability in the Holmes Lake rain garden pilot program: Year three, Lincoln, Nebraska*. (Master's thesis).
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Omaha Stormwater

University of Nebraska Omaha

Zoning by Square Mile

Omaha & ETJ		Omaha Only	
Zone	Sq Mi	Zone	Sq Mi
<Null>	0	<Null>	0
AG	64.1	AG	4.6
AV	4.3	AV	4.2
CBD	0.8	CBD	0.8
CC	5.3	CC	5
CH	0	CH	0
DR	33.3	DR	13.4
DS	0.5	DS	0.5
GC	1.3	GC	1.3
GI	10.1	GI	9.1
GO	1.4	GO	1.4
HI	2.8	HI	2.8
LC	0.2	LC	0.2
LI	0.4	LI	0.4
LO	0.3	LO	0.3
MH	0.5	MH	0.2
MU	4.3	MU	3.4
NBD	0.2	NBD	0.2
R1	3.9	R1	2.8
R2	10.6	R2	9.5
R3	11.2	R3	10.5
R4	20	R4	10.7
R4(35)	15.8	R4(35)	15.5
R5	4.6	R5	3.4
R5(35)	1.9	R5(35)	1.9
R6	3.6	R6	2.8
R7	3.8	R7	3.6
R8	0.6	R8	0.6
RR	1.8	RR	1.5

Land Use by Square Mile

Land Use	Omaha	ETJ	Total
Agricultural	4.6	59.5	64.1
Commercial	14	0.5	14.4
Industrial	12.3	1	13.3
Mixed-Use	3.4	0.9	4.3
Residential	24.5	19.8	44.3

N

Agricultural
Commercial
Industrial
Mixed-Use
Residential
City Limits

DCGIS

Omaha Land Use

Printed: 1/25/2016 Source: Douglas County

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City of Omaha Stormwater Program Public Education and Outreach Activities					
EVENT	**DATE**	**ACTIVITY**	**TARGET MARKET**	**PEOPLE**	**COMMENTS**
Indian Hill Science Night	1/21/2016	Presentation/ Demonstration	Community	200	Gave presentation on stormwater runoff using the interactive watershed model
Annual Sediment and Erosion Control Seminar	2/5/2016	Presentation	Industry	285	Annual seminar regarding erosion and sediment control
Landscape Expo Show	2/16/2016	Presentation	General Public/Industry	60	Presentation to a variety of contractors (i.e. landscape) regarding stormwater and green infrastructure practices
UNL Urban Soils lecture	2/17/2016	Presentation	Community	16	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha
2016 Omaha Home and Garden Expo	2/21/2016	Presentation/ Booth	General Public	750	Handed out brochures on green infrastructure strategies for homeowners, rain barrel display, and shared other info on stormwater during this three day event at the Century Link Center.
Great Plains LID Symposium	3/7/2016	Workshop	General Public/Industry	42	Half-day workshop on permeable pavement
Great Plains LID Symposium and Design Competition Awards Event	3/8/2016	Presentation/ Demonstration	General Public/Industry	138	Full day conference with three tracks presenting on many low impact development practices and stormwater topics. Design competition to design a low impact development driven project. Public presentation, scoring, and awards for competition
Great Plains Symposium tour	3/9/2016	Tour	General Public/Industry	42	Tour of multiple green infrastructure practices across Omaha, this was the second day of the Great Plains LID Symposium
South HS tour of Spring Lake Park	4/2/2016	Tour	Community	1	Tour Spring Lake Park with the South High Green Team leader
UNL GI Tour	4/7/2016	Tour	Community	9	Tour of multiple Omaha GI projects w/UNL Landscape Architecture class

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City of Omaha Stormwater Program Public Education and Outreach Activities					
2016 National Watershed & Stormwater Conference	4/12/2016	Workshop	Industry	25	Hub location for the Center of Watershed Protection's national webcast conference. Local presentations given during the day.
Earth Day Omaha	4/16/2016	Presentation/ Booth	General Public	5,000	Handed out frisbees, answered people's inquiries, distributed brochures on green infrastructure practices for homeowners and information about stormwater pollution
NWEA presentation	4/20/2016	Presentation	Industry	125	Presentation on stormwater management strategies & performance observed by the City of Omaha
Graham Environment Day	4/22/2016	Presentation/ Booth	Industry	30	Presentation on stormwater, sediment and erosion control, and sharing resources with Graham Construction field crews
Florence meeting	4/25/2016	Presentation	General Public	30	Provide information regarding bioretention gardens along 30th Street (demonstration project)
Nebraska Medical Center Sustainability Fair	4/28/2016	Educational Booth	General Public	250	Staff a booth to discuss stormwater and things you can do to limit pollution, provide green infrastructure information, and hand information on other stormwater topics
Spring into Summer - Parks Dept	5/6/2016	Educational Booth	General Public	700	Staff a booth to discuss stormwater and things you can do to limit pollution, provide green infrastructure information, and hand information on other stormwater topics
Lauritzen Gardens Spring into Spring	5/13-14/2016	Educational Booth	General Public	400	Staff a booth to discuss stormwater and things you can do to limit pollution, provide green infrastructure information, and hand information on other stormwater topics
Pecha Kucha - GOC	5/18/2016	Presentation	General Public	40	Presentation on what the Omaha Stormwater Program is and does

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City of Omaha Stormwater Program Public Education and Outreach Activities					
SAFE 2016	6/4/2016	Educational Booth	General Public	750	Have an interactive frisbee game to discuss recycling and stormwater pollution. Also hand out information on other stormwater topics
Rain barrel workshop - City Sprouts & Big Garden	6/15/2016	Workshop	General Public	8	Hands-on workshop for construction a rain barrel
Adams Park - Omaha NorthStar Outreach	6/21/2016	Presentation	Community	25	Provide support for a scavenger hunt at Adams Park green infrastructure project with the NorthStar after-school program
Bark in the Park	6/25/2016	Educational Booth	General Public	200	Staff a booth to discuss stormwater and things to limit pollution, including picking up after your pet. Distribute pet waste bag dispensers and information on other stormwater topics
USGBC Educational Lunch presentation	6/28/2016	Presentation	Industry	20	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha
NeFSMA Annual Conference	7/21/2016	Presentation	Industry	40	Presentation on stormwater management, green infrastructure practices, & performance observed by the City of Omaha
OPPD/Peter Kiewit Institute Tour of Blackburn	7/27/2016	Tour	Community	20	Tour of residential home and how they have used green infrastructure to manage stormwater to students in a summer education program
NNLA Field Trip	8/5/2016	Tour	General Public/Industry	25	Tour of multiple green infrastructure practices across Omaha with Nebraska Nursery and Landscape Association
International LID Conference	8/29/2016	Presentation	Industry	100	Presentation on Omaha's use of green infrastructure in City parks
World O! Water	9/10/2016	Presentation/ Demonstration	General Public	2,419	Half-day family event with over 50 organizations with act ivies and information all centered around water

City of Omaha Stormwater Program Public Education and Outreach Activities					
Green Infrastructure Tour	9/15/2016	Tour	General Public/Industry	94	Annual tour of multiple green infrastructure practices in the Omaha Metro area, in conjunction with the Extension Office and UNO
Fly into Fall	9/24/2016	Educational Booth	General Public	400	Staff a booth to discuss stormwater and things you can do to limit pollution, provide green infrastructure information, and hand information on other stormwater topics
Walk for the animals	10/2/2016	Educational Booth	General Public	1,000	Staff a booth to discuss stormwater and things to limit pollution, including picking up after your pet. Distribute pet waste bag dispensers and information on other stormwater topics

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENTATIONS**	**COMMENTS**
School Presentation	1/14/2016	Presentation/ Demonstration	King Science & Technology Magnet Center (3720 Florence Blvd)	Community	68	5	Brochures provided to adult attendees & for staff not in attendance
School Presentation	1/15/2016	Presentation/ Demonstration	Fontenelle Elementary School (3905 N 52nd St)	Community	49	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	2/8/2016	Presentation/ Demonstration	Roncalli Catholic High School (6401 Sorensen Pkwy)	Community	10	1	Brochures provided to adult attendees & for staff not in attendance
School Presentation	2/10/2016	Presentation/ Demonstration	St. Margaret Mary's Catholic School (123 N 61st St)	Community	65	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	2/12/2016	Presentation/ Demonstration	St. Margaret Mary's Catholic School (123 N 61st St)	Community	101	4	Returned for additional presentations for 4th and 6th grade classes
Community Presentation	2/15/2016	Presentation/ Demonstration	Community of Grace Christian Lutheran Church (3434 N 204th St)	Community	11	1	Academy of Science 4-H; brochures provided to adult attendees
Omaha Spring Cleanup Kickoff Meeting	2/17/2016	Meeting	Columbus Park Community Center (1515 S 24th St)	Residential	73	0	Brochures included with attendee packets
School Presentation	3/3/2016	Presentation/ Demonstration	Monroe Middle School (5105 Bedford Ave)	Community	98	6	Brochures provided to adult attendees & for staff not in attendance

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENTATIONS**	**COMMENTS**
UNO College of PA&CS Volunteer Fair	3/4/2016	Education Booth	UNO College of Public Affairs & Community Service (6320 Maverick Plaza)	Community	70	1	Brochures distributed to interested booth participants
Community Presentation	3/5/2016	Presentation/ Demonstration	Rose Theater (2001 Farnam St)	Community	300	1	Presentation prior to Drastic Plastic, brochures distributed before/after
Low Impact Development Symposium	3/8/2016	Education Booth	UNO Community Engagement Center (6100 Dodge Street)	General Public/ Industry	120	1	Green infrastructure / volunteer opportunity brochures distributed per Meridith
School Presentation	3/11/2016	Presentation/ Demonstration	Sandoz Elementary (5959 Oak Hills Dr)	Community	50	2	Brochures provided to adult attendees & for staff not in attendance
Community Presentation	3/11/2016	Presentation/ Demonstration	Rose Theater (2001 Farnam St)	Community	500	1	Presentation prior to Drastic Plastic, brochures distributed before/after
Community Presentation	3/13/2016	Presentation/ Demonstration	Rose Theater (2001 Farnam St)	Community	800	1	Presentation prior to Drastic Plastic, brochures distributed before/after
Community Presentation	3/14/2016	Presentation/ Demonstration	Marian High School (7400 Military Ave)	Community	17	1	Brochures provided to attendees and for staff/students not in attendance
WCA Girls Leadership Academy Community Day	3/16/2016	Presentation/ Demonstration	Women's Center for Advancement (222 S 29th St)	Community	7	1	Brochures provided to adult attendees & for staff not in attendance

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENTATIONS**	**COMMENTS**
School Presentation	3/17/2016	Presentation/ Demonstration	King Science & Technology Magnet Center (3720 Florence Blvd)	Community	92	5	Brochures provided to adult attendees & for staff not in attendance
School Presentation	3/18/2016	Presentation/ Demonstration	St.Cecilia Cathedral Grade School (3869 Webster St)	Community	44	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	3/22/2016	Presentation/ Demonstration	Our Lady of Lourdes School (2124 S 32nd Ave)	Community	32	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	3/25/2016	Presentation/ Demonstration	Belle Ryan Elementary School (1807 S 60th St)	Community	27	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	3/30/2016	Presentation/ Demonstration	Mercy High School (1501 S 48th St)	Community	21	1	Brochures provided to attendees and for staff/students not in attendance
Dundee Elementary PTA Meeting	4/2/2016	Presentation/ Demonstration	Dundee Elementary School (310 N 51st St)	Community	15	1	Brief presentation & brochures provided to PTO members attending the meeting
The Big Garden 50th Anniversary Celebration	4/7/2016	Education Booth	First United Methodist Church (7020 Cass St)	Community	60	1	Brochures distributed to interested booth participants
Community Presentation	4/11/2016	Presentation/ Demonstration	St. Martin De Porres Center (2111 Emmet Street)	Community	13	1	Brochures distributed to Catholic Charities Employees/Case Workers

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENT ATIONS**	**COMMENTS**
School Presentation	4/11/2016	Presentation/ Demonstration	Spring Ridge Elementary School (17830 Shadow Ridge Dr)	Community	26	1	Brochures provided to adult attendees & for staff not in attendance
School Presentation	4/12/2016	Presentation/ Demonstration	Omaha Northwest High School (8204 Crown Point Ave)	Community	11	1	Brochures provided to attendees and for staff/students not in attendance
Union Pacific Earth Day Fair	4/13/2016	Education Booth	Union Pacific Headquarters (1400 Douglas St)	General Public	120	1	Brochures distributed to interested booth participants
Earth Day Omaha	4/16/2016	Education Booth	Elmwood Park (Elmwood Park Dr. & Jones St.)	General Public	500	1	Brochures distributed to interested booth participants
School Presentation	4/20/2016	Presentation/ Demonstration	Brownell-Talbott School (400 N Happy Hollow Blvd)	Community	29	1	Brochures provided to adult attendees & for staff not in attendance
School Presentation	4/20/2016	Presentation/ Demonstration	Dundee Elementary School (310 N 51st St)	Community	26	1	Brochures provided to adult attendees & for staff not in attendance
STEM Girl Power Club Meeting	4/21/2016	Presentation/ Demonstration	Gomez Heritage Elementary School (5101 S 17th St)	Community	24	1	Brochures provided to adult attendees & for staff not in attendance
Nebraska Science Festival	4/22/2016	Education Booth	Durham Museum (801 S 10th St)	Community	900	1	Brochures distributed to interested adults who stopped by the booth
Zoo's Party for the Planet	4/23/2016	Education Booth	Omaha's Henry Doorly Zoo & Aquarium (3701 S 10th St)	General Public	500	1	Brochures distributed to interested adults who stopped by the booth

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENT ATIONS**	**COMMENTS**
School Presentation	4/26/2016	Presentation/ Demonstration	Metropolitan Community College (5300 N 30th St)	Community	7	1	Brochures distributed to attendees
School Presentation	4/27/2016	Presentation/ Demonstration	Dundee Elementary School (310 N 51st St)	Community	48	2	Brochures distributed to adult attendees
Arbor Day Event	4/28/2016	Education Booth	Lauritzen Gardens (100 Bancroft St)	General Public	450	1	Brochures distributed to interested adults who stopped by the booth
School Presentation	5/5/2016	Presentation/ Demonstration	Central Middle School (12801 L St)	Community	280	1	Presentation & service learning storm drain labeling project; brochures to adults
School Presentation	5/19/2016	Presentation/ Demonstration	Joslyn Elementary School (11220 Blondo St)	Community	53	2	Brochures provided to adult attendees & for staff not in attendance
School Presentation	6/1/2016	Presentation/ Demonstration	Benson High School (5120 Maple St)	Community	42	1	Presentation & service learning cleanup project; brochures to adults
School Presentation	6/7/2016	Presentation/ Demonstration	Beals Elementary	Community	88	3	Brochures provided to adult attendees & for staff not in attendance
School Presentation	6/9/2016	Presentation/ Demonstration	UNMC (42nd St & Emile St)	Community	83	1	UNMC Summer/Volunteer Program; brochures provided to attendees
School Presentation	6/13/2016	Presentation/ Demonstration	Dundee Elementary School (310 N 51st St)	Community	111	3	Dundee Summer School Program; no brochures distributed

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Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENTATIONS**	**COMMENTS**
Community Presentation	6/17/2016	Presentation/ Demonstration	Jewish Community Center (333 S 132nd St)	Community	67	3	Summer camp; brochures to adult attendees & for staff/members not in attendance
School Presentation	6/20/2016	Presentation/ Demonstration	Castelar Elementary School (2316 S 18th St)	Community	123	3	Castelar Summer School Program; brochures given to adults in attendance
Community Presentation	6/21/2016	Presentation/ Demonstration	YMCA Southwest Omaha Branch (13010 Atwood Ave)	Community	75	3	Summer camp; brochures to adult attendees & for staff/members not in attendance
School Presentation	6/24/2016	Presentation/ Demonstration	Lewis & Clark Middle School (6901 Burt St)	Community	76	2	Castelar Summer School Program; brochures given to adults in attendance
Girls Leadership Academy Volunteer Day	7/1/2016	Presentation/ Demonstration	Liberty Elementary School (2021 St Marys Ave)	Community	21	1	Presentation & service learning firework waste cleanup project; brochures to adults
UNO Service Learning Academy Seminar	7/12/2016	Education Booth	UNO Community Engagement Center (6100 Dodge Street)	Community	150	1	Brochures distributed to interested individuals who stopped by the booth
UNO Fall Volunteer Fair	8/25/2016	Education Booth	UNO Academic & Career Development Center (6100 Dodge St)	General Public	120	1	Brochures distributed to interested individuals who stopped by the booth
South Omaha Tire Recycling Event	8/27/2016	Distribution	South Omaha High Magnet School (4519 S 24th St)	General Public	150	0	Volunteers distributed brochures to cars in line until we ran out
Boy Scout Troop Meeting	8/29/2016	Presentation/ Demonstration	St. Vincent de Paul Elementary School	General Public	37	1	Brief presentation & brochures provided to adult attendees

Keep Omaha Beautiful Public Education and Outreach Activities							
EVENT	**DATE**	**ACTIVITY TYPE**	**LOCATION**	**TARGET AUDIENCE**	**PEOPLE**	**# OF PRESENTATIONS**	**COMMENTS**
			14330 Eagle Run Dr				
Dundee Elementary PTA Meeting	9/8/2016	Presentation/ Demonstration	Dundee Elementary School (310 N 51st St)	General Public	40	1	Presentation on stormwater and green infrastructure project; no brochures
World O! Water Festival	9/10/2016	Education Booth	Chalco Hills Recreation Area (8901 S 154th St)	General Public	500	1	Brochures distributed to interested adults who stopped by the booth
Creighton University Volunteer Fair	9/14/2016	Education Booth	Creighton University's Harper Center (602 N 20th St)	General Public	150	1	Brochures distributed to interested individuals who stopped by the booth
UNO Common Reading Experience Service Day	9/17/2016	Presentation/ Demonstration	UNO Sapp Field House (6001 Dodge St)	General Public	77	1	Presentation & service learning cleanup project; brochures distributed
Boy Scout Troop Meeting	9/22/2016	Presentation/ Demonstration	Castelar Elementary School (2316 S 18th St)	General Public	59	1	Brief presentation & brochures provided to adult attendees
Annual Teachers' Night	10/7/2016	Education Booth	Durham Museum (801 S 10th St)	General Public	500	1	Brochures distributed to interested individuals who stopped by booth
Goldenrod Festival	10/7/2016	Education Booth	Lauritzen Gardens (100 Bancroft St)	General Public	600	1	Brochures distributed to interested adults who stopped by the booth

Target Markets

Community – Schools, non-profit groups, homeowner associations, etc...
Industry – Applies to those in the regulated community
General Public – Applies to citizens of the community & the general public

ATTACHMENT E

Omaha Stormwater Website		
2016 Month	**Users**	**Page Views**
January	490	4,501
February	535	4,539
March	586	5,184
April	593	4,774
May	544	4,785
June	518	4,389
July	471	4,175
August	453	4,314
September	427	3,340
October	415	3,734
November*	118	287
December*	422	1,572
Totals	**5,572**	**45,594**
*Analytics were down for most of November and part of December		

Stormwater Facebook Page	
2016 Month	**Total Post Reach**
January	55,109
February	99,574
March	11,601
April	4,945
May	1,916
June	5,057
July	756
August	1,709
September	4,900
October	2,559
November	492
December	791
Totals	**189,409**
Total Posts	**120**