Rain & Bioretention Garden Workshop

NNLA Workshop 10/30/18

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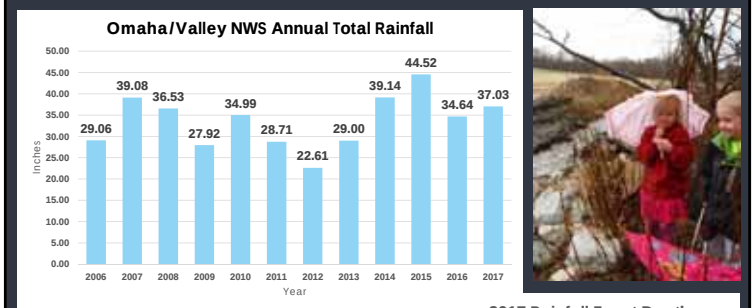
Andy Szatko – City of Omaha Stormwater Program
Tom Franti – University of Nebraska at Lincoln
Kelly Feehan – University of Nebraska Extension

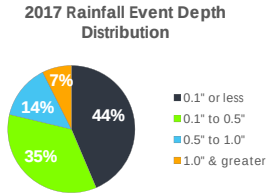
Overview for Today…

- Understanding Stormwater & Green Infrastructure
- Debunking Myths & Assumptions of Rain Gardens
- Bioretention & Rain Garden Design
- Step-by-Step Installation & Maintenance
- Planting Design
- Case Studies

Rain Events for Omaha – past 11 years

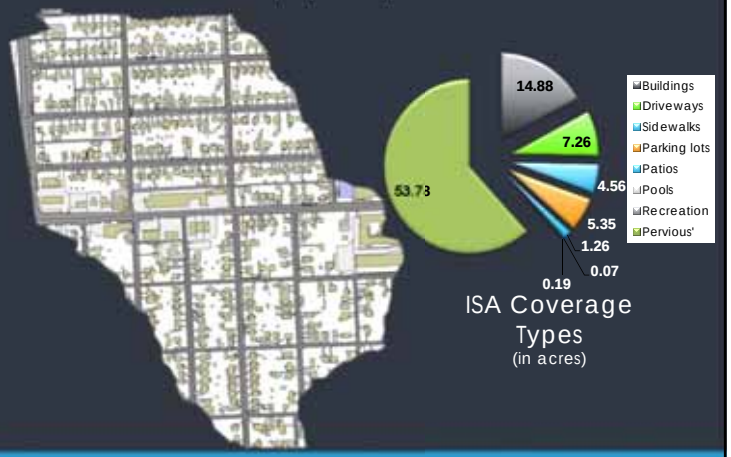


- 21.91" = Total rainfall spread
- 33 = Total event spread
- = you never quite know what you are going to get



Impervious Surface Areas in the City

72nd & Maple (Benson) as an Example



ISA Coverage Types (in acres)

ISAs push water elsewhere instead of soaking in

Stormwater Management Necessary?

1" rain on 1,000 sf impervious surface = 600 gallons

Omaha average rainfall = 30"

Adams Park Wetlands – 35th & Maple

273 acres of a neighborhood drain to park.

6/9/18 saw a 2.4" rain, that's approx:

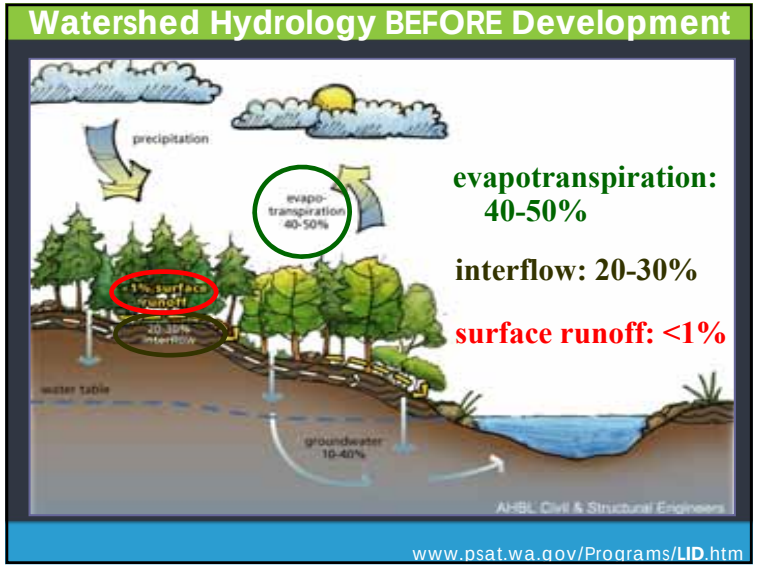
7,200,000

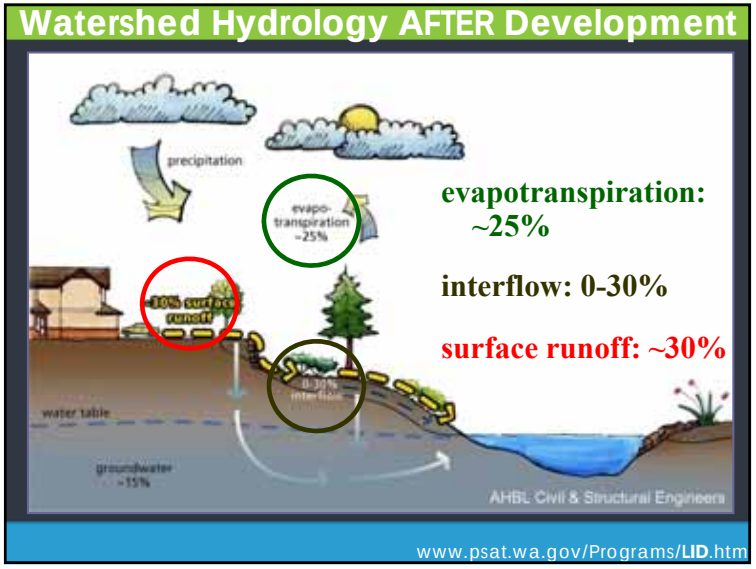
Gallons of runoff

March 6th, 2017 Adams Park

0.07" in 7 minutes


This was just one storm…


Watershed Hydrology BEFORE Development
precipitation
evapo-transpiration 40-50%
~1% surface runoff
20-30% interflow
water table
groundwater 10-40%
evapotranspiration: 40-50%
interflow: 20-30%
surface runoff: <1%
AHBL Civil & Structural Engineers
www.psat.wa.gov/Programs/LID.htm


Watershed Hydrology AFTER Development
precipitation
evapo-transpiration ~25%
~30% surface runoff
0-30% interflow
water table
groundwater ~15%
evapotranspiration: ~25%
interflow: 0-30%
surface runoff: ~30%
AHBL Civil & Structural Engineers
www.psat.wa.gov/Programs/LID.htm

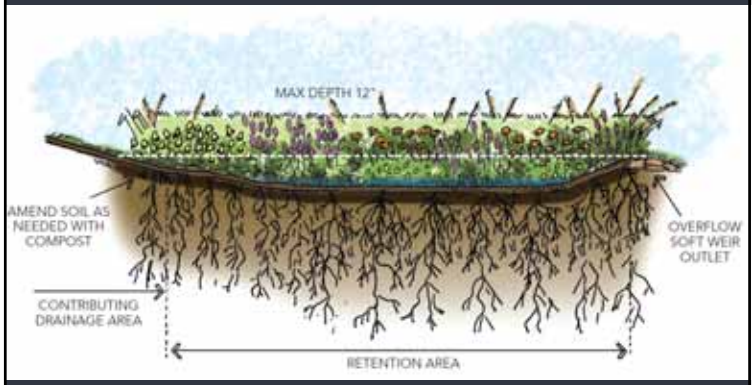
Site Specific GI Practice Types

- Bioretention system
- Rain gardens
- Bioswales
- Xeric gardens
- Soil conditioning
- Green roofs
- Porous/pervious pavement
- Rain barrels
- Urban forest
- Wet & dry ponds
- Wetlands
- Filter strips and level spreaders

GI makes water work hard…

Rain Garden: Definition

A shallow depression that uses native & adapted plants to absorb & filter stormwater



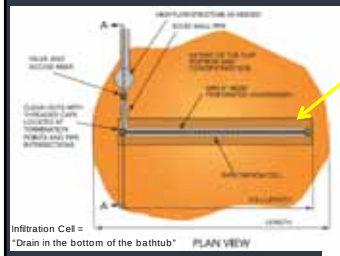
Rain Garden Examples


Omaha, NE


Omaha, NE

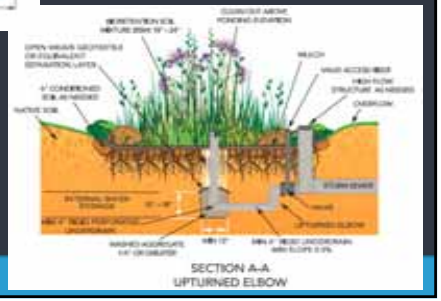

Kansas City, MO

Bioretention System = underdrain


Infiltration Cell = "Drain in the bottom of the bathtub"

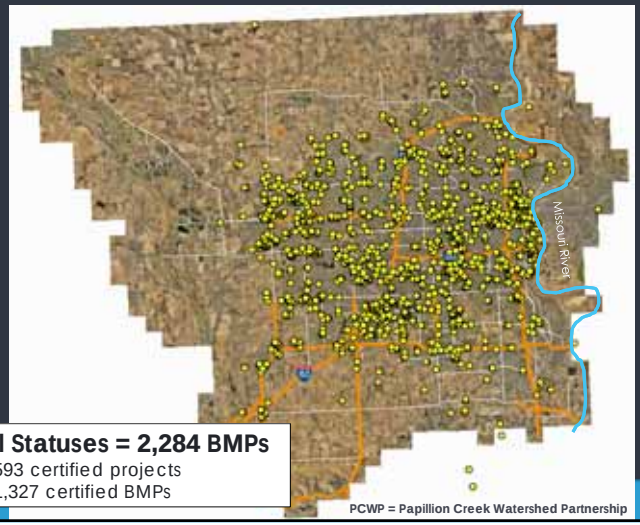
PLAN VIEW

- **Infiltration Cell** 90% length of flat bottom (to ensure drainage)
- **Valve** (to regulate flow)
- **Soil conditioning** outside infiltration cell as needed
- Upward arch to underdrain
- Open weave geotextile

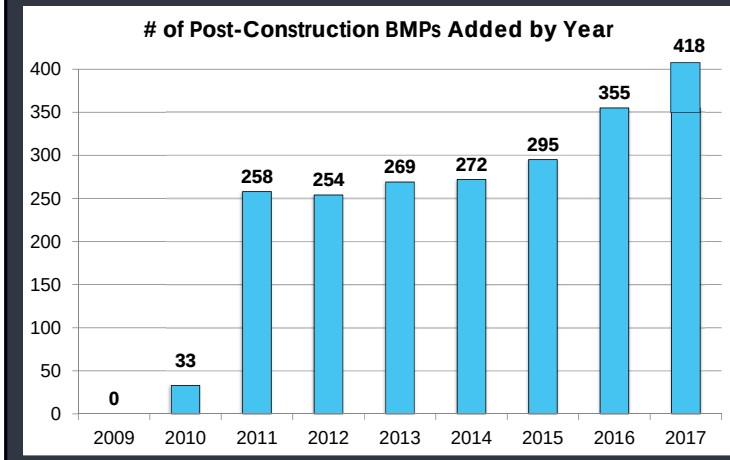


Bioretention System

Post-Construction BMPs - Omaha as of 8/11/18

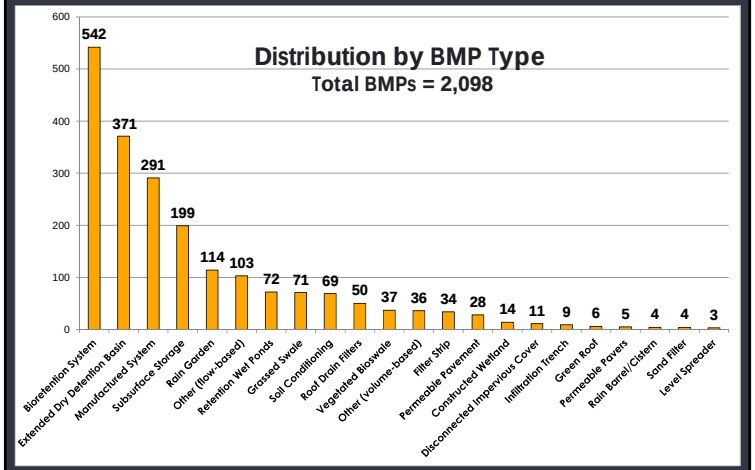


Post-Construction BMPs - PCWP



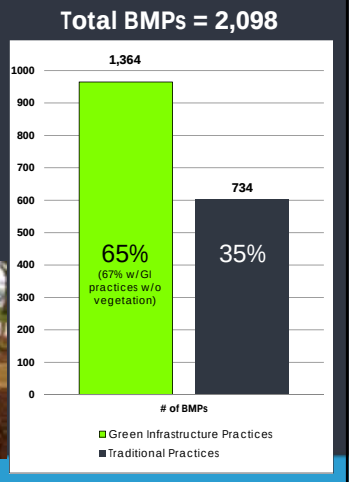
Total BMPs as of 12/5/17 = 2,098

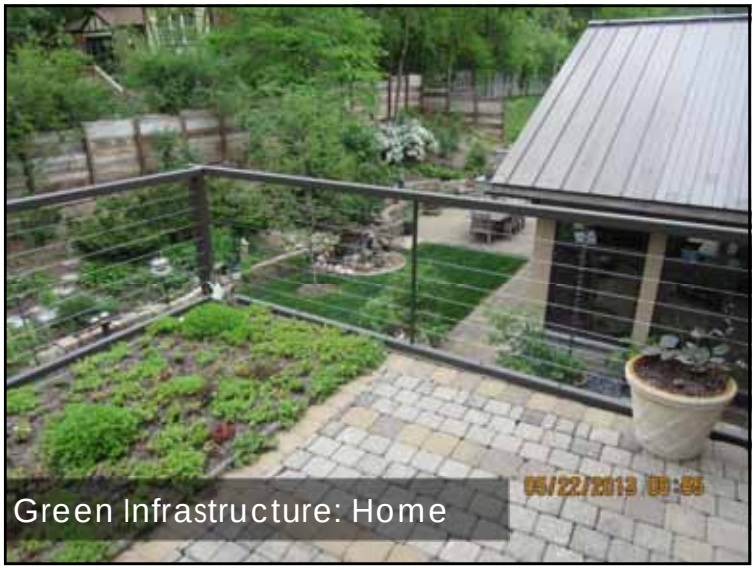
Post-Construction BMPs - Omaha as of 12/5/17



GI Post-Construction BMPs

- Green infrastructure (GI) practices make up majority of PC BMPs
- Strong need for quality design, installation, performance, & maintenance






Green Infrastructure: School
Metro Community College – Fort Omaha Campus


Green Infrastructure: School
Northwest High School


How do we know GI works?
Lots of ways to assess whether it's working or not...

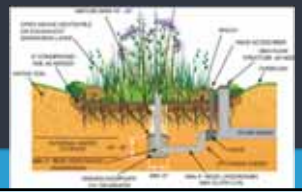

3"total w/0.29" at 2:30pm May 6-7, '15 w/valve ¾ closed
69°F 28.76inHg
MOULTRIECAM
06 MAY 2015 01:10 pm

Infiltration (Ksat) Testing

Bioretention & Rain Garden Assessments
673 infiltration tests performed Fall '17 to Fall '18

Infiltration (Ksat) Assessment

- 9 sites total
- Turf, rain gardens, bioretentions, tree planters
- Plant influence?
- Seasonal variability



Saddle Hills Park Rain Gardens

K_{sat} average:
Turf - 0.09 in/hr
Gardens - 55.31 in/hr

Summary of the 9 Sites

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

Overall Site Results by Season

Site	Install	Fall 2016	N	Spring 2017	N	Summer 2017	N	Fall 2017	N	Average	N
SHP RG	2014	55.31	16	13.92	25	25.59	7	34.15	29	31.20	77
UNO	2012	55.35	6	5.37	20	40.69	17	15.63	18	23.16	61
OP	2009	11.77	4	13.68	13	-	-	15.99	12	14.37	29
FL	2012	18.28	6	8.84	17	-	-	24.61	17	16.96	40
BEN	2013	27.55	6	4.56	18	-	-	25.66	18	16.89	42
UTS	2008	12.57	7	-	-	-	-	16.48	9	20.90	23
CRP	2014	4.01	8	10.12	25	16.47	25	15.57	26	14.95	85
SOIA	2014	29.14	15	17.19	34	-	-	33.31	33	25.86	82
SMF	2014	20.83	7	7.73	11	21.36	13	37.62	13	22.59	45

Summary by Location

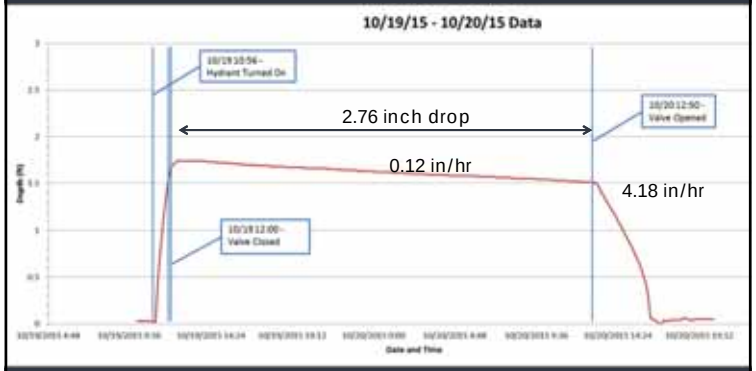
Fall 2016 to Fall 2017

Averages (in/hr)	2016 Fall	N	2017 Spring	N	2017 Summer	N	2017 Fall	N	Collectively	N
Turf with BG	5.57	30	3.23	28	-	-	8.39	30	5.78	88
Tree Planters	33.30	6	14.20	8	-	-	46.89	8	31.30	22
Bioretention	23.00	59	11.62	145	25.11	55	23.94	146	19.55	405
Bioretention Infiltration Cell	19.42	13	14.38	37	22.66	15	20.99	39	18.68	104
Bioretention Basin	24.01	46	10.68	108	26.03	40	25.01	107	19.85	301
Rain Garden	55.31	16	13.92	25	25.59	7	34.15	29	31.20	77

- Increase in infiltration from spring to fall…
- High & consistent infiltration across bioretention system

Simulation Event Monitoring

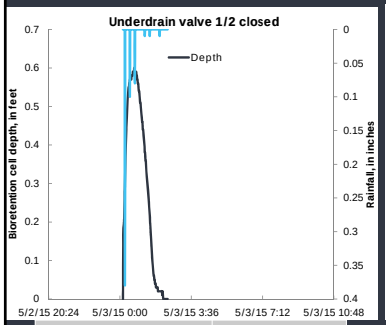
Close valve to assess infiltration across the system over 24 hours



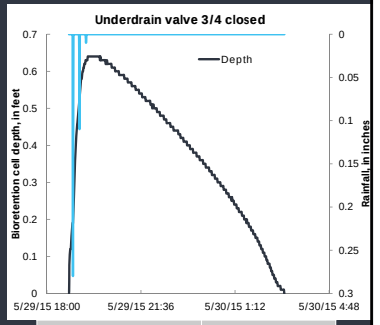
Orchard Park

Bioretention w/valves

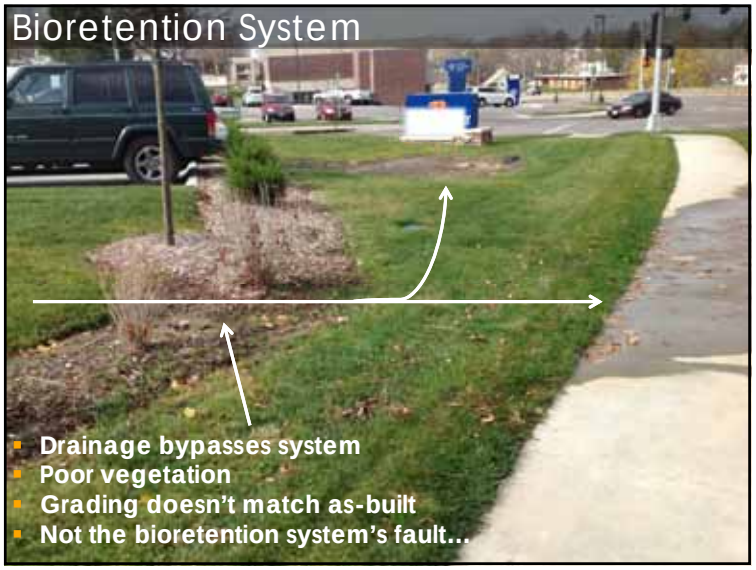
Great for performance but also for maintenance…



Total Rainfall	0.59 inches
Drawdown Duration	1.7 hours
Drawdown rate	4.32 in/hr
Drawdown rate	8.64 feet per day

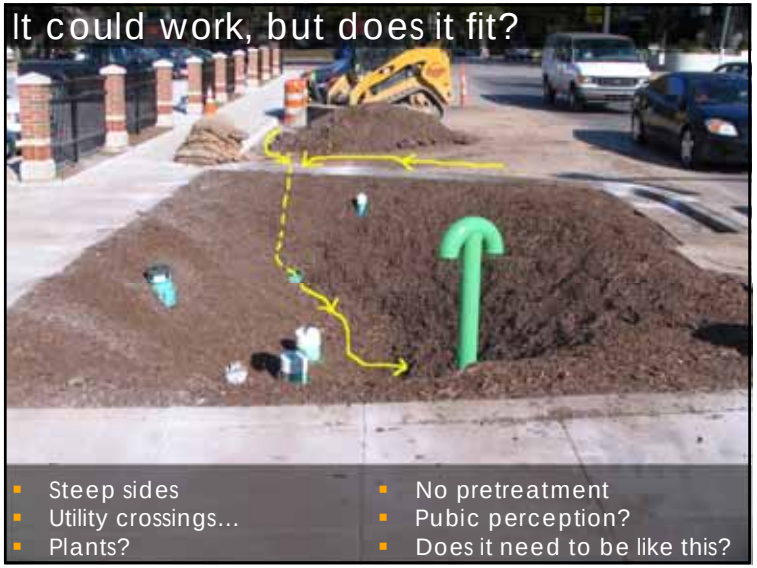


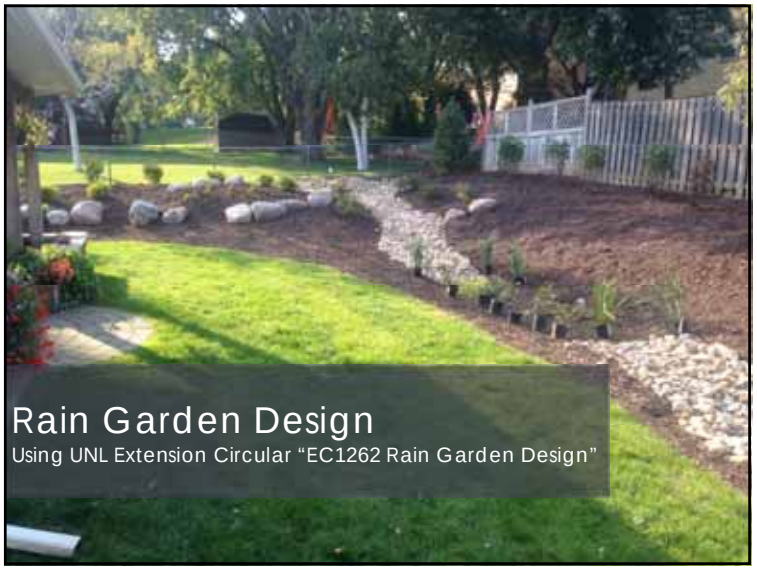
Total Rainfall	0.39 inches
Drawdown Duration	7.0 hours
Drawdown rate	1.08 in/hr
Drawdown rate	2.17 feet per day



Bioretention System

- Inlet – poor design & implementation
- Elevation issues
- No pretreatment
- No maintenance
- Looks horrible





EC1262 Rain Garden Design

Link: extensionpublications.unl.edu/assets/pdf/ec1262.pdf
Google: EC1262 Rain Garden & select PDF

Online Interactive

- Videos
- Animations
- Interactive tools
- Sizing Calculation Worksheet

Extensionpublications.unl.edu/assets/pdf/ec1262.pdf

Rain Garden Design includes…

Components:

- Inlet
- Outlet & overflow
- Basin, created by soil berms
- Soil
- Mulch cover
- Plants
- Underdrain, if it is a bioretention garden

Configuration:

- Location
- Shape
- Orientation
- Aesthetics

Rain Garden Design Made Simple

Rain Garden
Infiltration in native soil

Bowl
(storage area)

General Guiding Factors

- The "*plate*" is the sum of the **impervious areas** draining water to the bowl, e.g.,
  - Roofs
  - Driveways
  - Patios
  - Streets

- Plus the **pervious areas** draining some water to the bowl, e.g.
  - Lawn
  - Landscaped areas
  - Drainage swale

General Guiding Factors

Assume:

- Impervious areas (roofs, et al.) contribute 100% of rainfall
- Pervious areas (lawn, et al.) approximately 10% of rainfall over that area

Therefore:

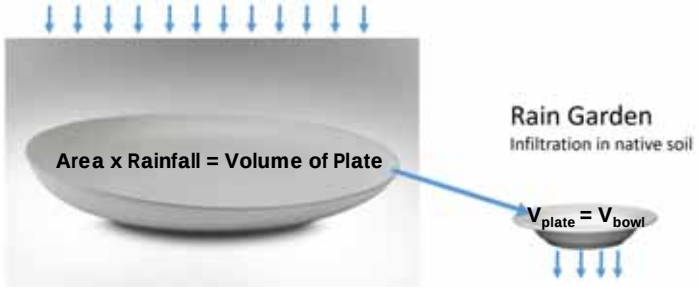
Drainage Area = Impervious Area + 10%* of Pervious area

***can vary significantly due to compaction and soil type**

General Guiding Factors

Design Concept:

the rain garden storage volume (how much the "*bowl*" can hold) is equal to the rainfall depth multiplied by the total drainage area (the "*plate*")



Example: 1,000 sf x (1/12) = 83.3 cubic feet needed
12" deep rain garden would be 83 sf
6" deep rain garden would be 166 sf

General Guiding Factors

Determining depth and area

Simple Rules of Thumb:

- Garden Area = 100 to 300 square feet; Depth = 6 to 8 inches
- Ratio of drain area to garden depth: if garden is 6 inches deep, then is 1/6 area of drainage area; if garden is 10 inches deep, then is 1/10 of drainage area (*calculate depth based on infiltration rate to drain garden in minimum of 24 hours*)

Design Method (preferred):

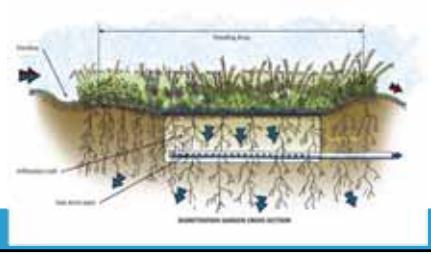
Design Criteria
Rain Garden <= 24 hour drain time
Soil infiltration rate is minimum of 0.25 inches per hour, or 6 inches per day

Next step…determine if soil infiltration rate is acceptable.

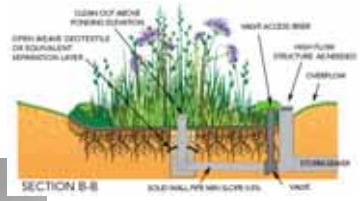
General Guiding Factors

If the soil infiltration rate is not sufficient to drain in 24 hours, then either:

- move the garden to a location with acceptable soil;
- reduce depth of rain garden
- install a drain system to assist drainage from the bowl, i.e. create a bioretention garden



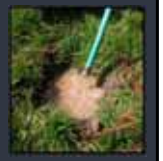
Bioretention garden = rain garden + underdrain



Cross-section
Think of it as a bathtub with a drain

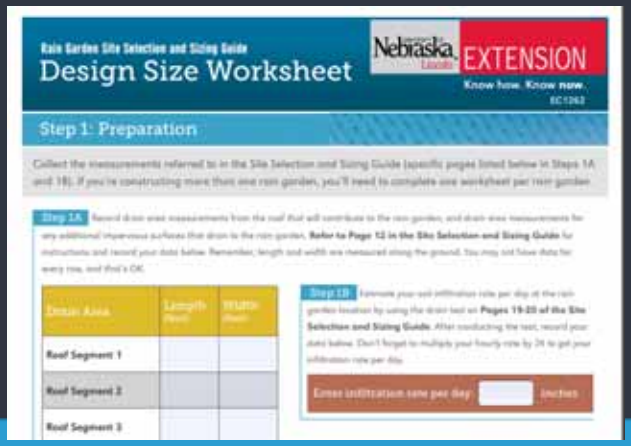
Next step…determine if soil infiltration rate is acceptable

Soil Infiltration Rate

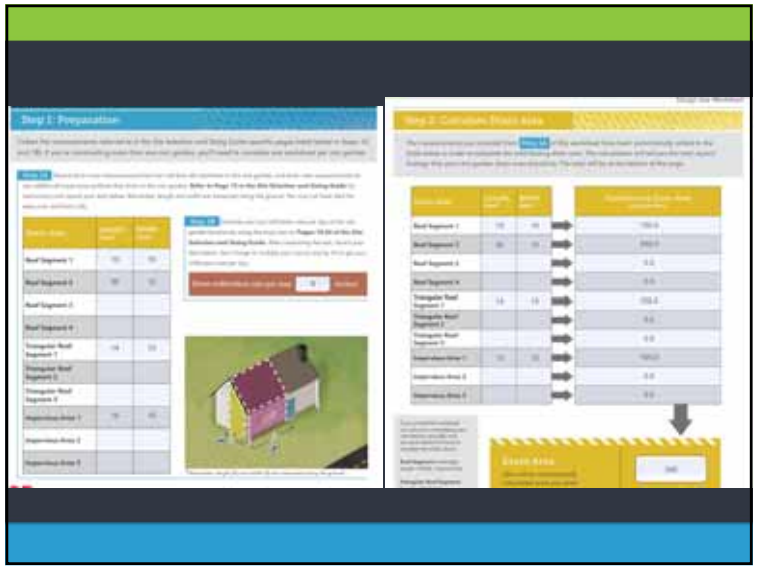


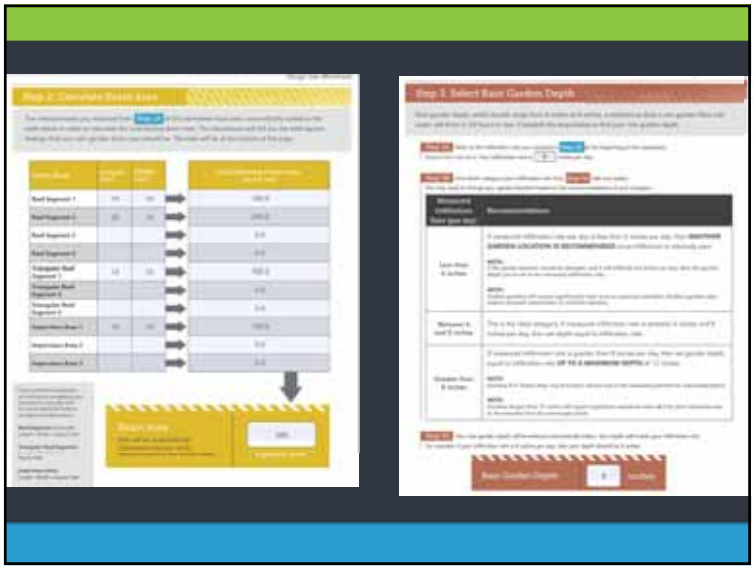
- In general:
  - Silty clay soil and silty soil likely have sufficient infiltration
  - BUT, soil is highly variable, so you must test the site you will use
    - Especially in new developments which likely have topsoil removed.
  - Clay soil may not drain
  - Silty soil is better, drains faster
  - Sand may drain too fast. (Sandy soils near Platte River)
- Two ways to test soil:
  - Ribbon Test – a hand-test to squeeze clay soil into a ribbon. Silts will crack.
  - Drain Test – test using water infiltration into soil at site of garden, preferred.

Now we can look at the Design Size Worksheet

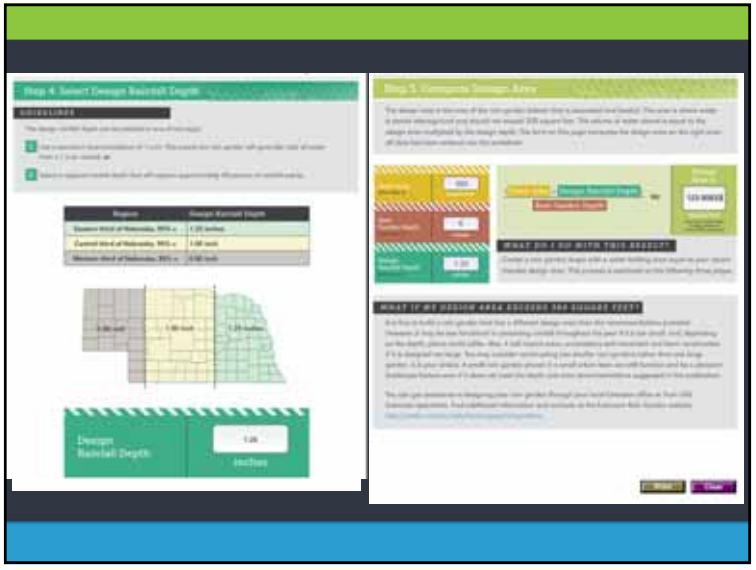


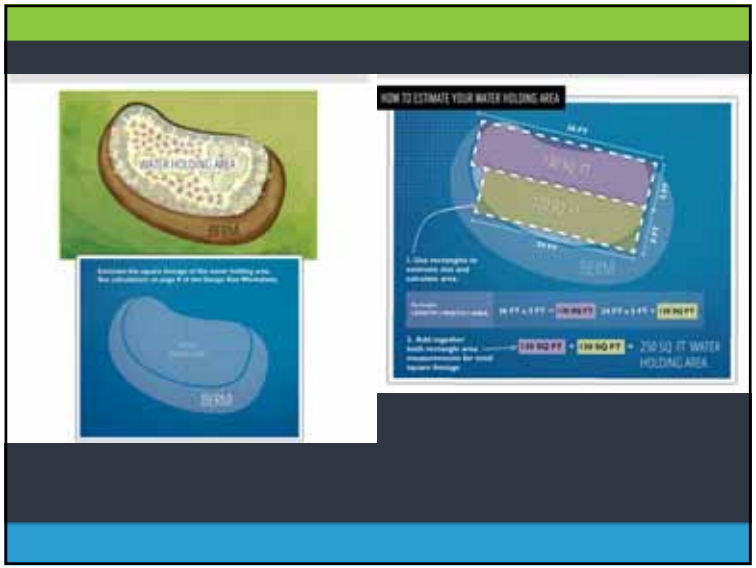
Calculating the Drainage Area





Measured Infiltration Rate (per day)	Recommendation
Less than 6 inches	If measured infiltration rate per day is less than 6 inches per day, then **ANOTHER GARDEN LOCATION IS RECOMMENDED** since infiltration is relatively poor. NOTE: If the garden location cannot be changed, and it will infiltrate 3-6 inches per day, then the garden depth can be set to the measured infiltration rate. NOTE: Shallow gardens will require significantly more area to construct and plant; shallow gardens also require accurate construction to maintain capacity.
Between 6 and 8 inches	This is the ideal category. If measured infiltration rate is between 6 inches and 8 inches per day, then set depth equal to infiltration rate.
Greater than 8 inches	If measured infiltration rate is greater than 8 inches per day, then set garden depth equal to infiltration rate **UP TO A MAXIMUM DEPTH** of 12 inches. NOTE: Gardens 8-12 inches deep may limit plant choices due to the increased potential for submerged plants. NOTE: Gardens deeper than 12 inches will require significant excavation and will limit plant selections due to the extended time for submerged plants.





Use EC1262

- Learn about design
- Learn data needed and how to collect
- Do size calculation
- Help your clients understand

Components:

- Inlet
- Basin, created by soil berms
- Soil in bottom
- Mulch cover
- Plants
- Outlet
- Underdrain, if it is a bioretention garden

Features:

- Location
- Shape
- Orientation
- Aesthetics

Location

- Considerations:
  - Slope (<12%)
  - Drainage
  - Downspouts
  - Ponding
  - Sunlight/Shade
  - Landscape
- Constraints:
  - Utilities
  - Soil type
  - Water table

Location Considerations

- At least 10 feet from buildings
- No more than 30 feet away
- Avoid steep slopes - Build on slopes <= 12%
- Avoid areas where water tends to sit, and not disappear fast
- Avoid large swales that carry water runoff "from the neighborhood"

Inlets

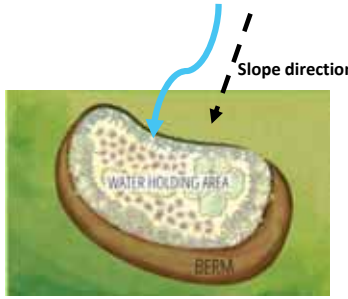

Armoring - limestone


Armoring – river rock


Grassed swale


Pretreatment – utility box

Water Inlet Orientation



Inlets and Outlets


Soft weir inlet/outlet


Armored (dry creek bed) inlet


Armored (dry creek bed) outlet


Riser pipe outlet

Underdrains

- Arch the gravel & geotextile upwards
- Don't use non-woven (140N)
- Washed aggregate
- Underdrain w/perforations on bottom
- Set pipe up in profile…

Valves

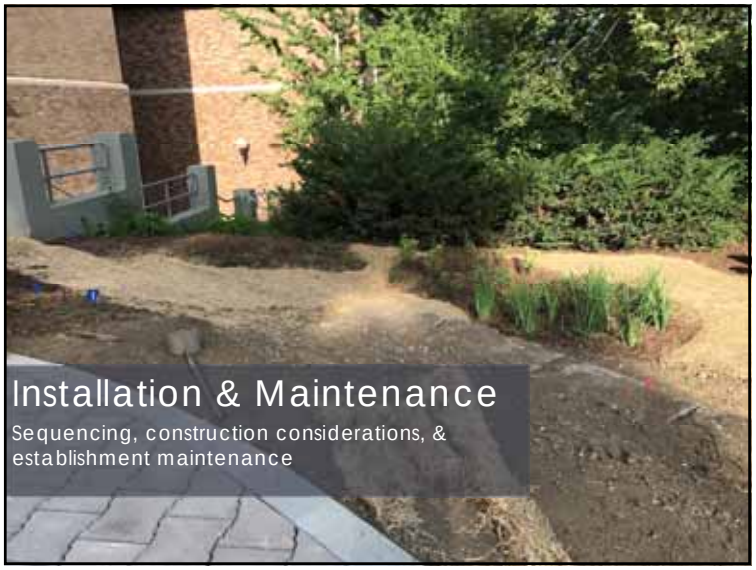
- 4" slide gate w/extension rod – good option
- Access riser outside ponding area
- Open fully to drain faster for maintenance

Bioretention Soil Mix (BSM)

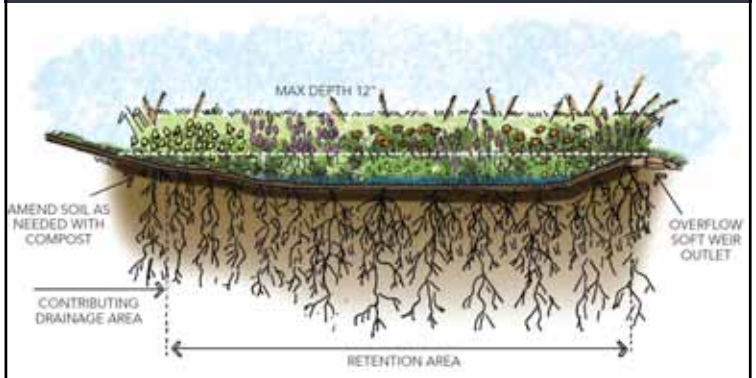
- Don't use 50/50 sand/compost…
- 80/20 sand/compost has proven functional
- Protect it during construction!
- Plant it, seeding is very difficult to establish…

Summary

- **General**
  - Design is sizing the "bowl" to fit the "plate"
  - Size to 1"-1.25" of rainfall, that's 90% of most storms!
  - Soil infiltration effects function and garden depth
    - Design to drain in 24 hours or less (i.e. 6 inches per day).
  - Design versus Rules of Thumb
- **Specific**
  - Design rain garden size using EC1262
  - Location selection needs attention to features, constraints, and soil
  - Shape, orientation, inlets and outlets are part of the "art of design"



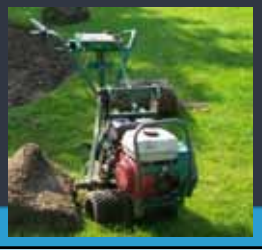
Keep the Concept in Mind When Going into Installation…



The First Steps

Your toolbox should include:

- Tape measure
- Level
- Shovels, rake, pitch fork, broom
- Wheelbarrow
- Wood stakes, 2' long and string level
- 2x4 board, at least 6' long (optional)
- Marking paint
- Hose
- Rent or work for someone who has these pieces of equipment if the project is large enough
  - Small excavator
  - Skid loader
  - Counter-rotating rear-tine tiller



Before Construction Tips

- Plan your access to minimize compaction
- Use excavated soil to build berm
- Watch out for tree roots & avoid if possible
- Stay 10' away from home
- Call Diggers Hotline & know location of private lines

Installation

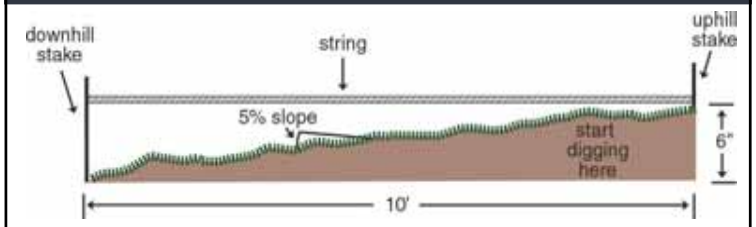
Layout garden & remove vegetation

- Keep a couple rolls for possible repairs
- Use sod cutter if possible

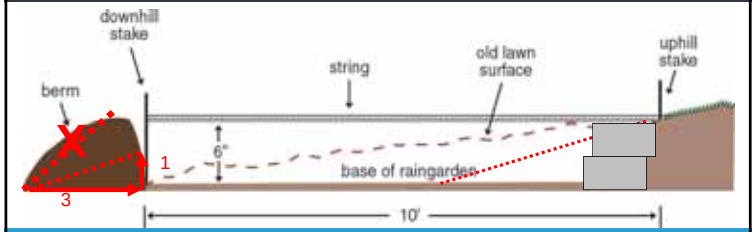
Excavate

- Use excavated soil to build the berm
- Tilling, then shoveling out is an easy strategy
- Till/excavate into 'native' soils at deepest level
- Work from the middle out

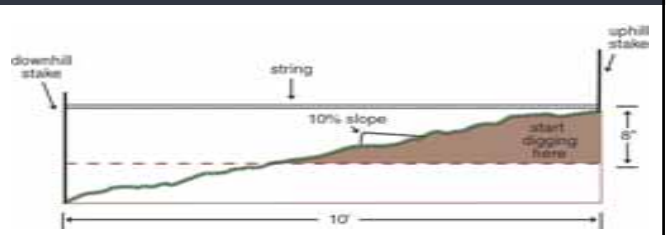
Between 3 and 8% Slope - Before Digging



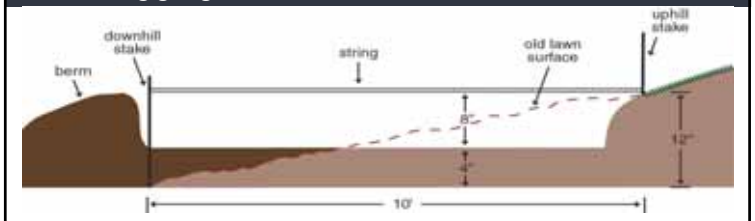
After Digging



Greater than 8% slope – before digging



After Digging



Amend soil

- Amend soil as needed
- Compost is best & readily available

- Critical Step: blend compost into existing soil
- Use tile spade in various areas across bottom

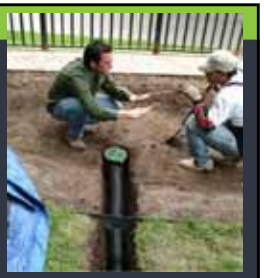
During Construction Tips

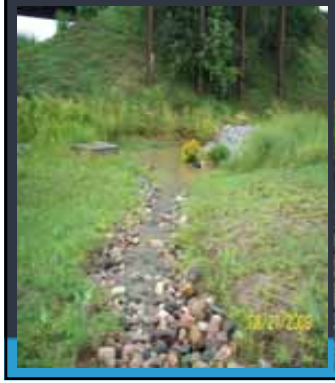
- Use erosion control, especially when it will be more than 1 day (silt fence, straw waddles)
- Ensure the water flows into garden & doesn't bypass
- No added fertilizer necessary

- Don't 'smear' surface, break up soil
- Work inside to outside
- Make sure all the vital features of the garden are there & functioning

Inlets

- Need transition to protect from erosion
- Dry stream beds, buried pipe, etc…
- Ensure water can flow through
- Pretreatment to capture crud…





Pretreatment – plan on it & keep it simple

Pretreatment – simple yet effective

Limestone slab sump at gutter

Flagstone curb cut sump

"Curb-well"

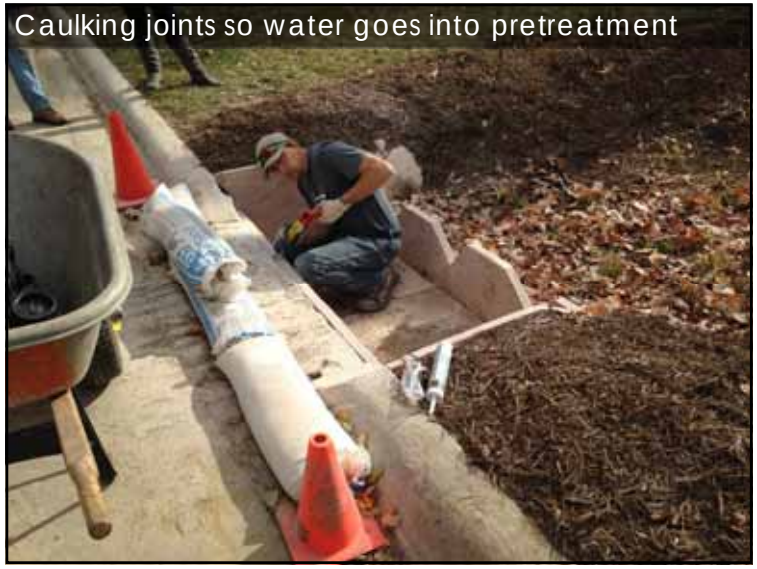
Large screening structure

Off-the shelf pretreatment, utility box, to catch sediment & debris before entering the garden

Regardless of type of pretreatment or inlet, observe it often early to see if any issues arise

Flagstone pretreatment going in 11/6/14

Caulking joints so water goes into pretreatment



Completed pretreatment with V-notched weirs

Outlets

- Don't block accidently
- Set elevations properly
- Have redundancy

- Protect overflow
- Standpipe

Plant Layout & Spacing

- Put spreading plants near inlets & outlets
- Don't skimp on planting the bottom
- Little success seeding rain/bioretention gardens
- Reduced densities possible for self-seeding or suckering plants, or for cost savings (*don't overdo*….)
- Ultimately, nature will decide….

Size of Plant Considerations

- Deep cell-plugs provide small but deep-rooted plants, establish quick, & are cost-effective
- Larger plants give immediate visual impact
- Quality plants significantly enhance quality establishment

Patience is a Requirement

Establishment

- Plants vs. seed
- Offline?
- Timing
- Worst day is the first day

The First Couple of Weeks

- Watering
- Weeding (pre-emergent?)
- Redistributing mulch
- Sediment & trash/debris removal

Spring Time

- Cutting back - March
- Edging/border maintenance
- Top-dressing mulch*
- Weeding (pre-emergent?)
- Plant replacement
- Trash/debris removal

Spring Time & As-Needed

Sediment removal (use pretreatment if there's a lot)

Spring Time & As-Needed

Sediment removal & check on plants

Spring Time & As-Needed

Sediment removal of pretreatment

TIP: Planting pattern helps crew know what is intentional & what isn't

Summer Time

- Irrigate as-needed during drought
- Continue weeding
- Dead-head flowers?
- Trash/debris removal
- Enjoy it

Fall Time

- Replace dead plants/transplant
- Continue weeding
- After 1st frost – cut back select vegetation
- Manage plant debris as-needed, especially pretreatment

Maintenance Take-aways:

- You **have to** maintain it
- It's not new, just **different**
- Easy to keep up with; hard to catch up
- **Entrepreneurial** minded folks needed

Plant Function and Selection for Bioretention/Rain Gardens

Nebraska Resources

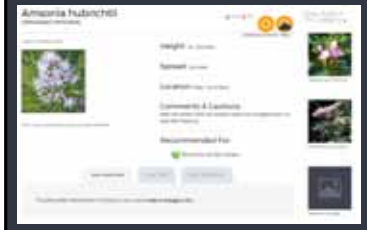
extensionpubs.unl.edu/

marketplace.unl.edu
$15.00

Received today

OmahaPlants.org

- **Green Infrastructure & Urban Landscape Standards focused**
- Search by a variety of characteristics



City of Omaha Stormwater Program & Planning Department, UNO

"Plant function and selection is the same as for any garden" ??

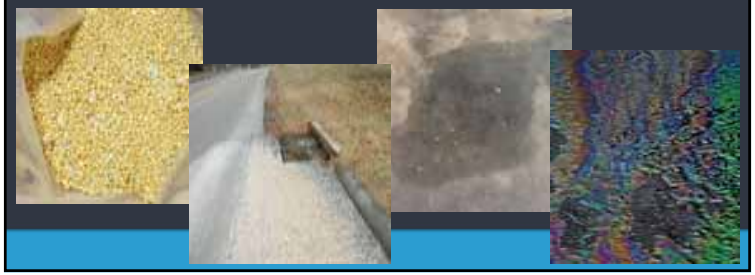
- Adapted to growing conditions of site
- Serve function/s needed
- Provide aesthetics
- Meet "maintenance" level desired
- Minimize inputs
- Added 'value', i.e. pollinator habitats
- Not invasive
  - https://nematode.unl.edu/neinvasives.htm
- Same design principles

However……..

- 3 different moisture zones
- Bottom plants must tolerate inundation for 24 to 48 hours
- Plants may have to tolerate water flow

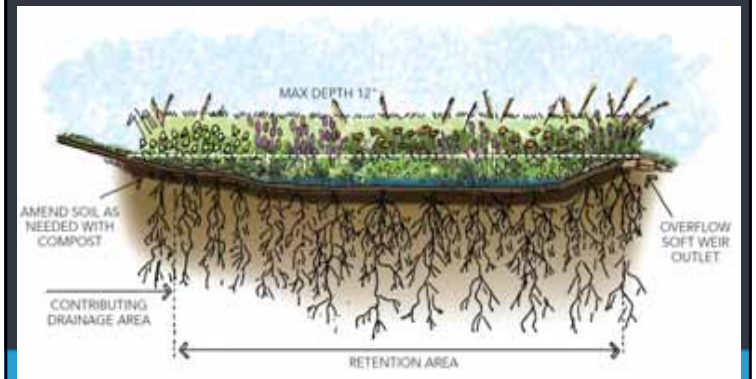
However……..

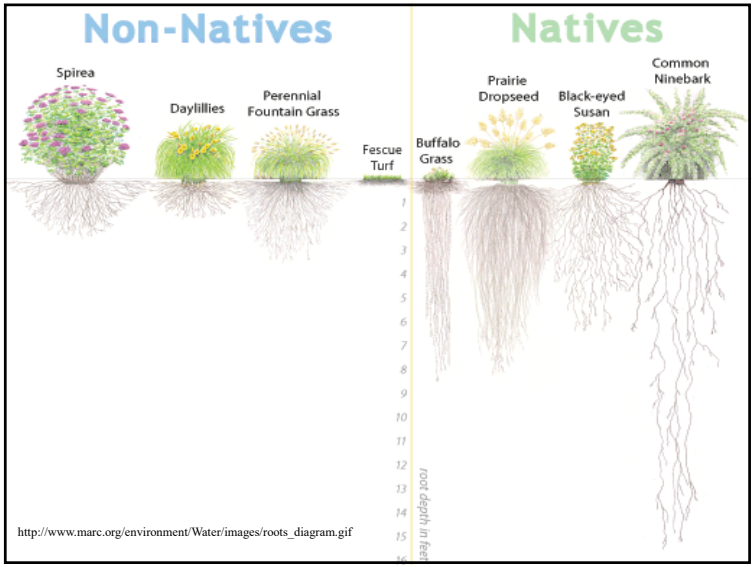
- Water and nutrient stingy
- Increased ecosystem functions
  - Increase infiltration over time
  - Filter pollutants (along with soil): salt, oil, grease from pavement; pesticides and fertilizes from adjacent lawns

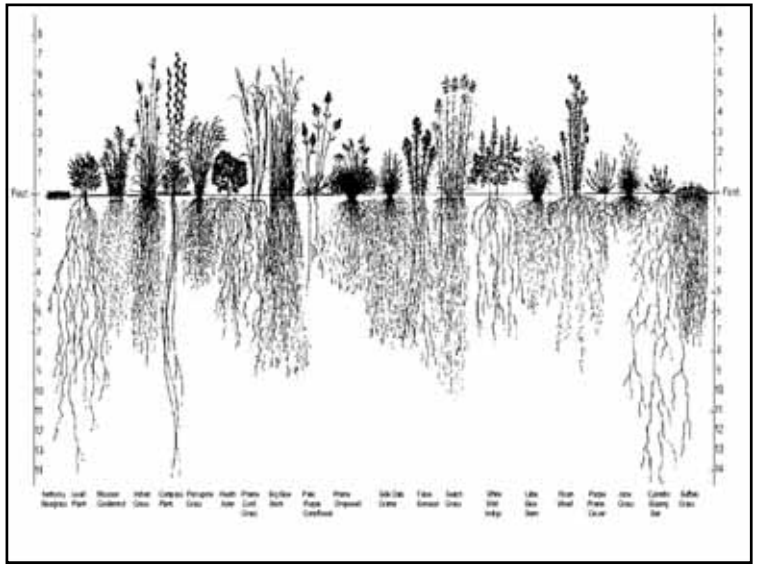


Native (often best) and Well Adapted

- Deep roots create channels in soil as the grow and die, enhancing infiltration and improving soil structure







Native (often best) & Well-Adapted

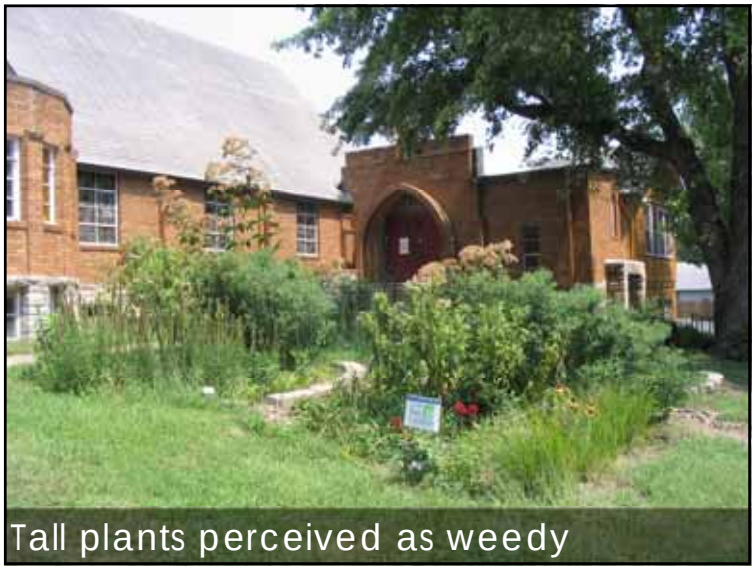
- Habitat value for birds, pollinators, etc. of region
- Typically do not need fertilization/irrigation once established
- Adapted to climate
- Native does not mean a plant grows well in every site or location
- 'Nativars'

Aesthetics important.....

- Flowering
- Foliage texture and color
- Plant form
- Multi-season interest
- Height (bottom is wet (flopping?)
- Scale

Photos: Steve Rodie, UNO


Height, Plant Scale


Tall plants perceived as weedy


More acceptable


Massing, Less is More

Bottom Plants

Carex vulpinoidea
Brown Fox Sedge

Carex muskingumensis
Palm Sedge

Carex grayii
Gray's Sedge

Bottom Plants

Asclepias incarnata
Swamp milkweed

Chelone obliqua
Pink Turtlehead

Bottom Plants

Eutrochium purpureum
Joe-pye Weed
'Gateway'
'Little Joe'

Helenium autumnale
Sneezeweed

Bottom Plants

Pycnanthemum virginianum
Virginia Mountain mint

Liatris pycnostachya
Prairie Blazing Star

Bottom Plants

Lobelia cardinalis
Cardinal Flower
'Monet Moment'

Monarda spp.
Beebalm
'Marshall's Delight'

Bottom Plants

Zizia aurea
Golden Alexanders

May Bloomers

Baptisia australis
Blue False Indigo

Bottom Plants

Sorghastrum nutans Indian grass

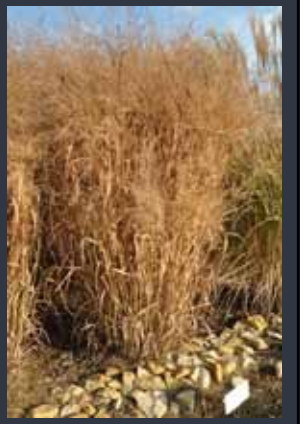
Photo: Missouri Botanical Garden

Bottom Plants

Andropogon gerardii Big Bluestem

Photo: Missouri Botanical Garden

Bottom Plants



Panicum virgatum Switchgrass
'Dallas Blues', 'Shenandoah', 'Heavy Metal'

Photos: Kansas State

Other Plants Working Well (Sides and Tops)

- *Aster* spp. Purple dome, Sapphire, Wood's Purple…
- *Echinacea spp.* Coneflower
- *Iris* spp. Iris
- *Geranium* spp. Cranesbill 'Rozanne'
- *Phlox pilosa* Prairie Phox
- *Penstemon* spp. Penstemon
- *Polygonatum multiflorum* Variegated Soloman's Seal
- *Ratibida columnifera* Prairie Coneflower
- *Rudbeckia* spp. Black Eyed Susan
- *Tradescantia tharpii* Spiderwort

Plants to Use with Caution (no success or invasive)

- *Lilium superbum* Turk's Cap Lily
- *Callirhoe involucrata* Purple Poppy Mallow
- *Ruellia humilis* Wild Petunia
- *Coreopsis tinctoria* Plains Coreopsis
- *Equistetum hyemale* Horsetail Rush
- *Chelone glabra* White Turtle head (hit or miss)
- Cultivars of *Solidago canadensis*
- https://nematode.unl.edu/neinvasives.htm

Photos: Missouri Botanical Garden Plant Finder

Plant Establishment

Norfolk, NE Rain Garden

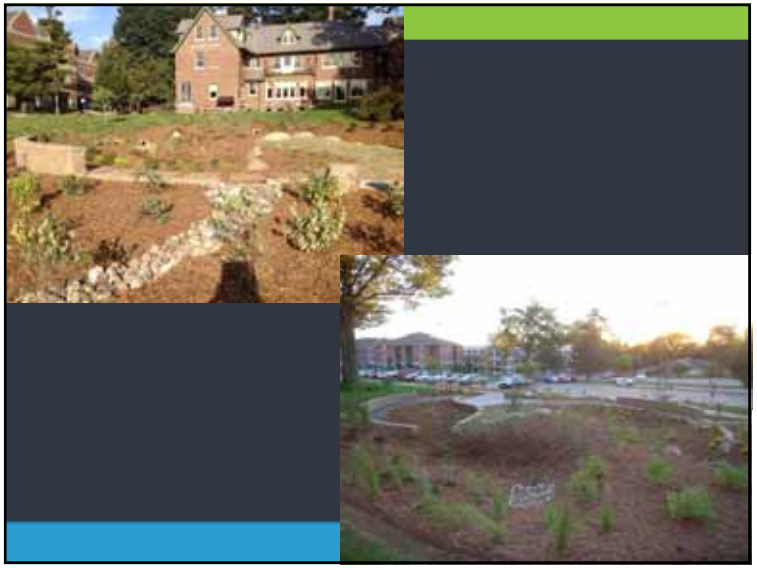
Method	Pros	Cons	Tips
Seed	Less expensive	Consistent moisture Protection from water flow Weed pressure Hard to tell plant seedlings from weed seedlings Longest to maturity	Good seedbed Pre-plant weed treatment Drill High quality seed Rake and roll slightly if broadcasting Use 1" straw or erosion control mat Block inlets
Plugs	Cost effective Rooted	Longer to establish – need moisture Protection from water flow Weed pressure Longer to maturity	Use deep-cell plugs Provide irrigation Block inlets during establishment
Potted	Aesthetics sooner More tolerant of irregular irrigation while establishing Tolerate inundation sooner	Most expensive Root bound may slow rooting	Avoid root bound plants Score root ball

Planting Tips

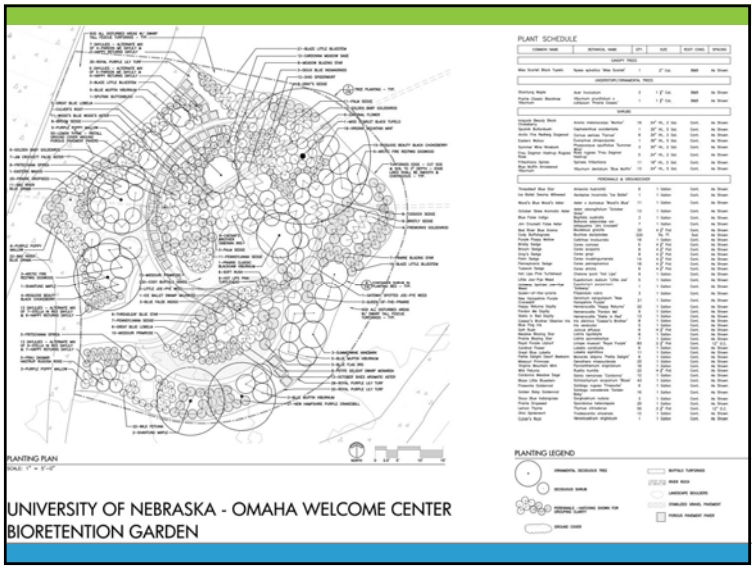
- Avoid soil compaction: Walk/kneel on planks, start planting in middle and work to edge; mulch from edge to middle walking on mulch
- Density: too much + maintenance issues later; too light = mulch displacement, erosion, more weeds
- Fertilizing natives not recommended – promote weeds/flopping

Projects

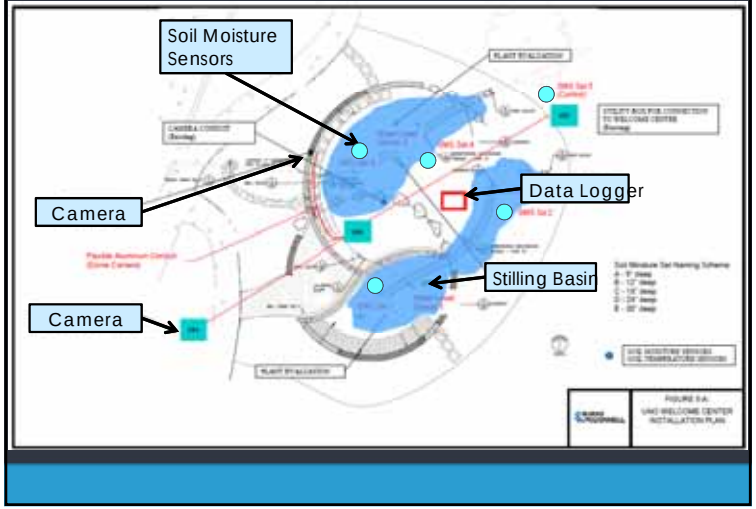
- **UNO Bioretention Garden-**2012
  - Design-Big Muddy Workshop/Steve Rodie
  - Installation-Dostal Construction
  - Funding-NSA/NFS; City of Omaha (approx. $65,000)
- **Benson West Elementary School Rain Garden**-2014/2015
  - Design-UNO Service Learning Project
  - Installation-Outdoor Inspirations
  - Funding-NSA/NFS; OPS/project matching (approx. $35,000)
- **Omaha Northwest High School Rain Garden-**2015/2016
  - Design-UNO Service Learning Project
  - Installation-Outdoor Inspirations
  - Funding-NSA/NFS; OPS/project matchingUNO SLA (approx. $45,000)
- **UNO CEC Rain Garden -**2015/2018
  - Design-UNO student projects; Kinghorn Gardens
  - Installation-Kinghorn Gardens
  - Funding-NRD; UNO CEC; UNO CUS; Wells Fargo Green Team (approx. $16,000)




UNIVERSITY OF NEBRASKA - OMAHA
WELCOME CENTER BIORETENTION GARDEN
UNO WELCOME CENTER BIORETENTION GARDEN - SECTION 'A-A'


PLANT SCHEDULE
PLANTING PLAN
PLANTING LEGEND
UNIVERSITY OF NEBRASKA - OMAHA WELCOME CENTER
BIORETENTION GARDEN

UNO Welcome Center – Monitoring Layout



View from the wall camera 4/18/17

UNO WELCOME CENTER
BIO-RETENTION GARDEN
OMAHA, NE

This student gathering area actually is two adjacent research bioretention gardens designed to test the desirability of using a broad range of trees, shrubs, grasses and perennial flowers, and the use of minimal soil amendments and drainage systems.

Storm Water Solutions
2014 Top Storm Water & Erosion Control Projects Award

SWS

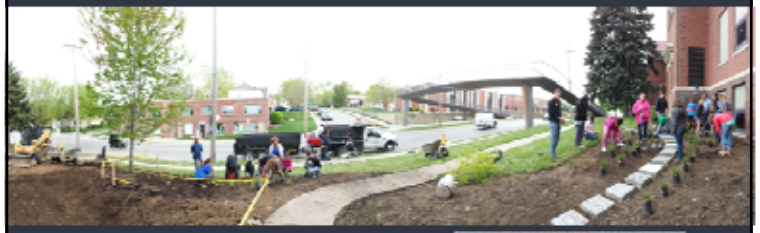
Successes

- Excellent fit for campus – education, people space, front door, sustainability
- Successful function (underdrains closed)
- Use by numerous classes and students for coursework
- Monitoring equipment will provide long-term benefits on understanding function
- Generated trust from UNO Facilities for other similar projects on campus

Challenges

- Some drainage surprises required tweaking
- Long-term maintenance and university budget limitations
- Plants are happy (too happy?)
- Plants growing larger than promised

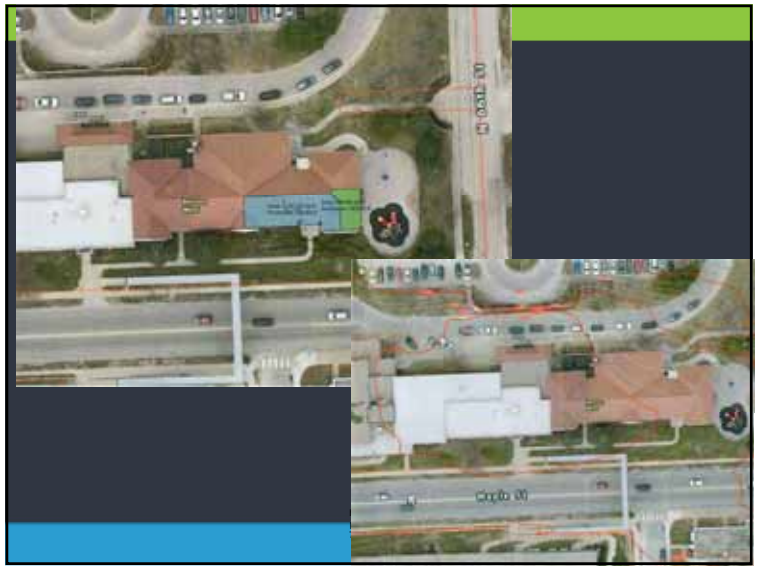
Design Case Study
Benson West Rain Garden

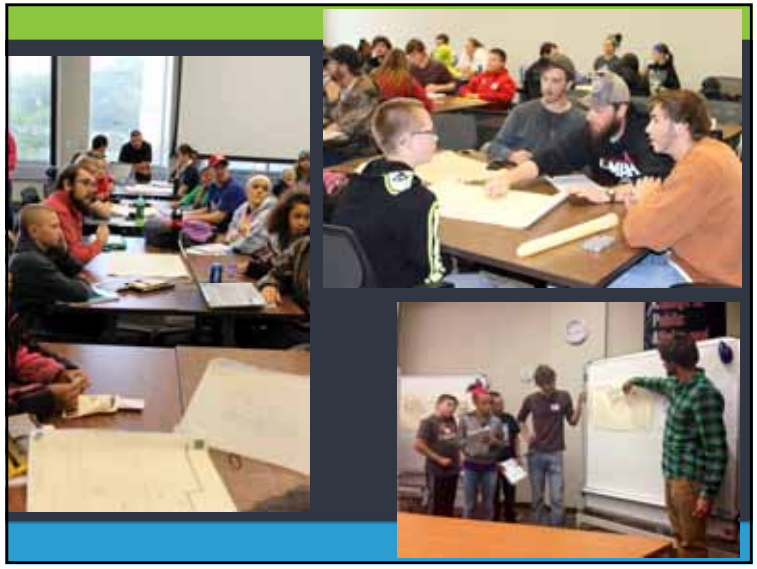


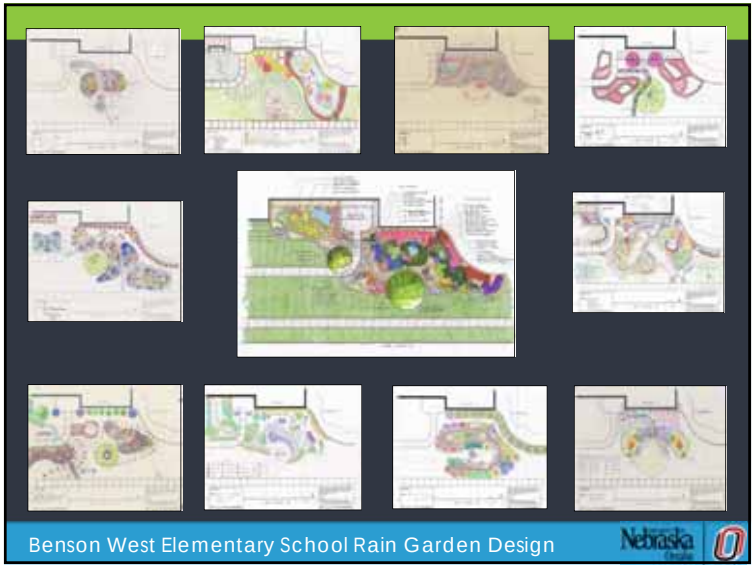
Steven Rodie, FASLA
Professor, Department of Biology

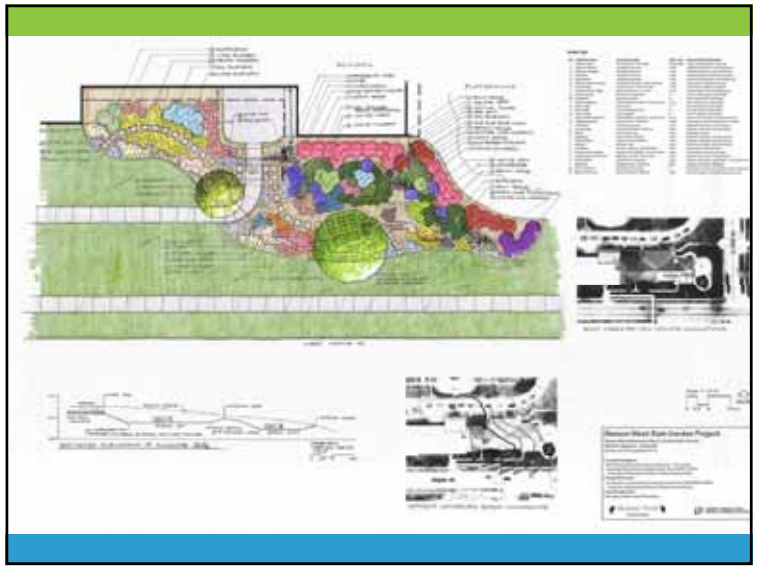
Meg Searl
Assistant Principal

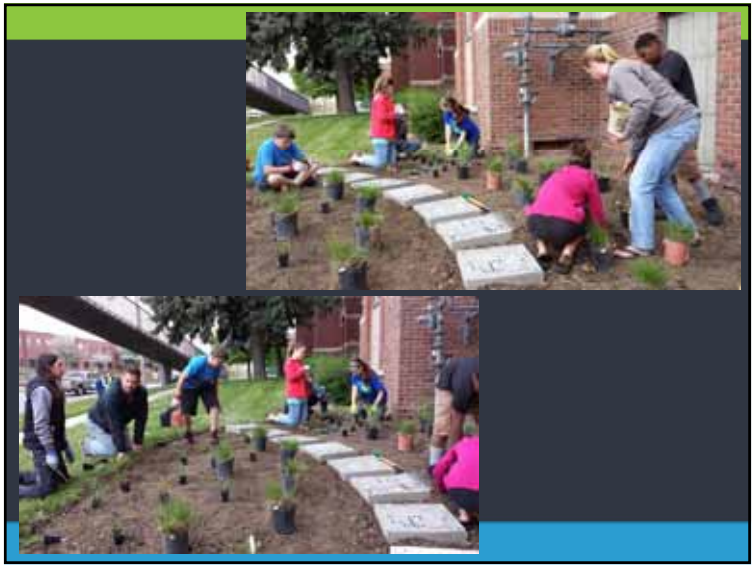
Julie Lassley
6th Grade Teacher






Benson West Elementary School Rain Garden Design





Successes

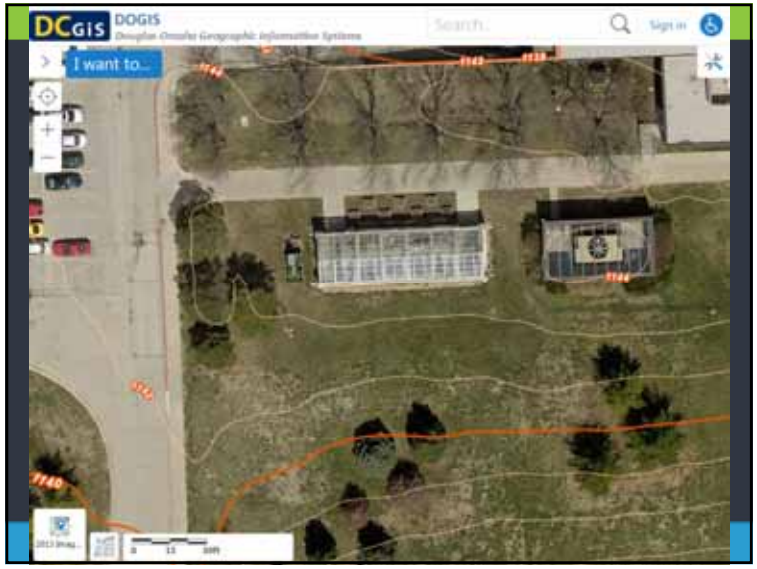
- High visibility project in Benson neighborhood
- Value for “recipe” documentation
- Credibility within OPS for rain gardens
- Valued relationships with Benson West and OPS Career Services
- Project visibility (NE School Board Association bus tour in November 2015)

Challenges

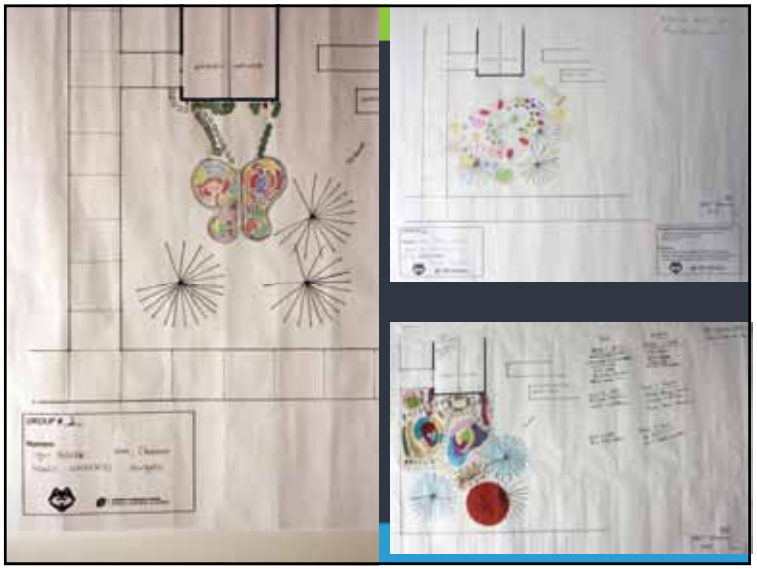
- Limited time to fully develop connection to curriculum
- OPS Facilities has seen rain garden failures
- Time and energy requirements for project follow-through
- Time constraints for student interaction
- Short-term and long-term maintenance

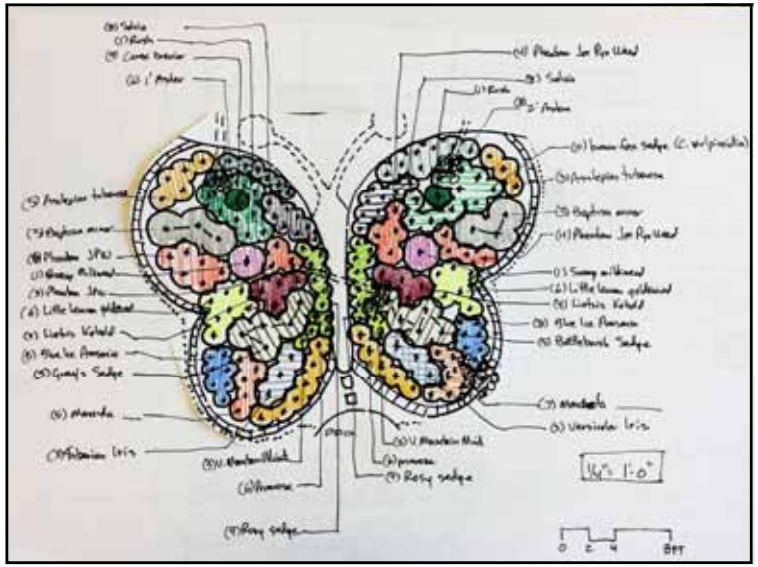
Omaha Northwest High School Rain Garden Project

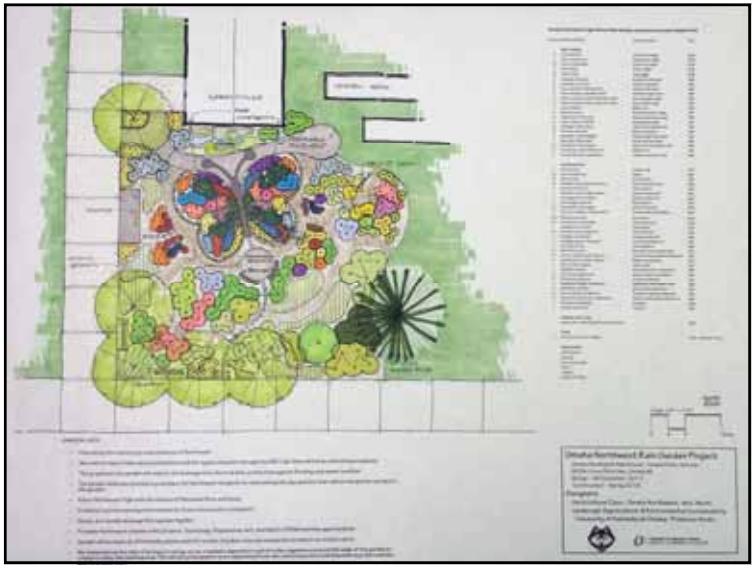
University of Nebraska Omaha



UNO and Omaha Northwest High School students working together to design and assess the site conditions for the ONW rain garden. Personnel from the City of Omaha were on hand to explain their infiltration measurement equipment that was used at the site to verify the functionality of the proposed garden.



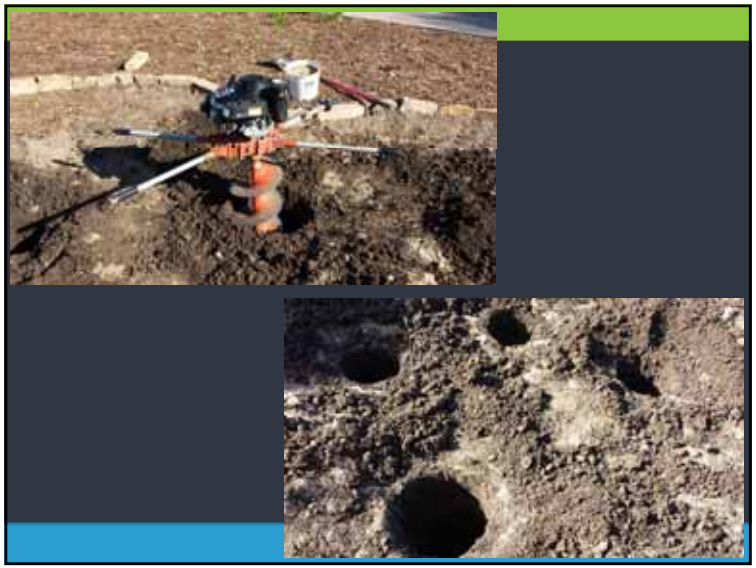


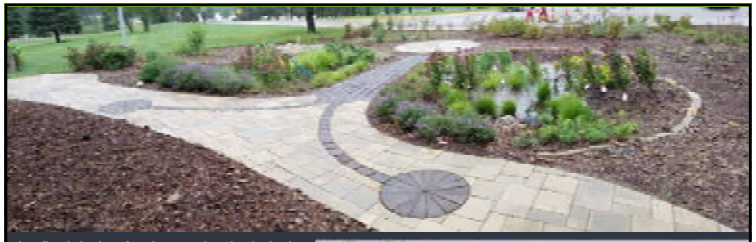


Omaha Northwest High School Rain Garden and Environmental Habitat Area

Quantity	Botanical Name	Common Name	Size
	Rain Garden		
9	Carex brevior	plains oval sedge	plug
5	Carex hystericina	bottlebrush sedge	plug
10	Carex vulpinoidea	brown fox sedge	plug
5	Carex grayi	Gray's sedge	plug
18	Carex rosea	rosy sedge	plug
8	Asclepias tuberosa	butterfly milkweed	1gal
2	Asclepias incarnata	swamp milkweed	1gal
6	Aster dumosus 'Woods Pink'	Wood's Pink aster	1gal
8	Aster dumosus 'Woods Purple'	Wood's Purple Aster	1gal
8	Salvia nemorosa New Dimension Rose	Rose meadow sage	1gal
8	Salvia nemorosa New Dimension Blue	Blue meadow sage	1gal
2	Juncus balticа	Baltic rush	plug
6	Baptisia minor	Dwarf false blue indigo	1gal
17	Eupatorium 'Phantom'	Phantom Joe-pye weed	1gal
8	Liatris spicata 'Kobold'	Kobold gayfeather	1gal
12	Solidago 'Little Lemon'	Little Lemon goldenrod	1gal
16	Amsonia 'Blue Ice'	Blue ice amsonia	1gal
5	Monarda 'Petite Delight'	Petite Delight bee balm	1gal
7	Monarda 'Petite Red'	Petite Red bee balm	1gal
12	Oenothera macrocarpa	Missouri evening primrose	1gal
6	Iris sibirica (two diff colors?)	Siberian iris	1gal
6	Pycnanthemum virginianum	Virginia mountain mint	1gal

	Outlying Areas		
1	Salvia azurea	pitcher sage	1gal
54	Hemerocallis spp.	daylily	1gal
10	Phlox pilosa	prairie phlox	1gal
18	Buddleia davidii dwarf cultivars	dwarf butterfly bush	1gal
7	Spiraea fritschiana	fritsch spirea	1gal
1	Helianthus autumnale cultivar	dwarf sneezeweed	1gal
5	Calamagrostis acutiflora	feather reed grass	1gal
3	Andropogon gerardii	big bluestem	1gal
20	Sporobolus heterolepis	prairie dropseed	plug
5	Panicum virgatum 'Shenandoah'	Shenandoah switchgrass	1gal
120	Bouteloua gracilis	blue grama	plug
20	Bouteloua curtipendula	side oats grama	plug
1	Sorghastrum nutans	indian grass	1gal
30	Schizachyrium scoparium	little bluestem	plug
3	Solidago canadensis	Canada goldenrod	1gal
3	Solidago rugosa 'Fireworks'	Fireworks goldenrod	1gal
3	Monarda fistula	wild bergamot	1gal
14	Diervilla lonicera	Northern bush honeysuckle	1gal
10	Aronia melanocarpa 'Morton'	Iroquois Beauty black chokeberry	1gal
5	Amelanchier alnifolia 'Regent'	Regent serviceberry	1gal
1	Aster novae-angliae	native aster	1gal
1	Ratibida pinnata	grayhead prairie coneflower	1gal
3	Echinacea angustifolia	narrow-leaved coneflower	1gal
6	Echinacea purpurea	purple coneflower	1gal
3	Rudbeckia fulgida 'Goldsturm'	Goldsturm black-eyed susan	1gal
3	Rudbeckia laciniata	green-head coneflower	1gal
15	Cornus sericea 'Firedance'	Firedance redstem dogweed	2gal
3	Viburnum opulus var. americanum	dwarf cranberrybush viburnum	2gal
5	Amorpha canadensis	leadplant	1gal
1	Corylus americana	hazelnut	2gal





The final design for the garden included the butterfly-shaped rain gardens, and a native plant area surrounding the butterfly. The garden design was inspired by a butterfly concept from a ONW student. The garden hardscape was completed by a contractor while many of the plants were installed with the help of ONW and UNO students.

Omaha World-Herald

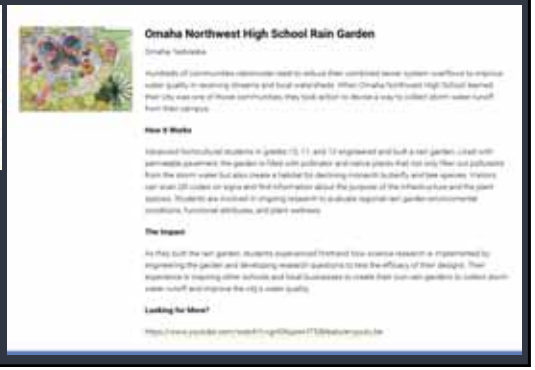
Northwest High students' plan to absorb storm runoff nets state prize, $20,000 worth of gadgets

KETV 7

Northwest High School class wins Samsung's Solve for Tomorrow competition

Omaha Northwest won the 2015 Samsung Solve for Tomorrow Contest, beating out 35 other school project submittals from across the state.

The ONW Rain Garden has received recognition on the National Geographic website as a Next Generation Environmental Leaders Project



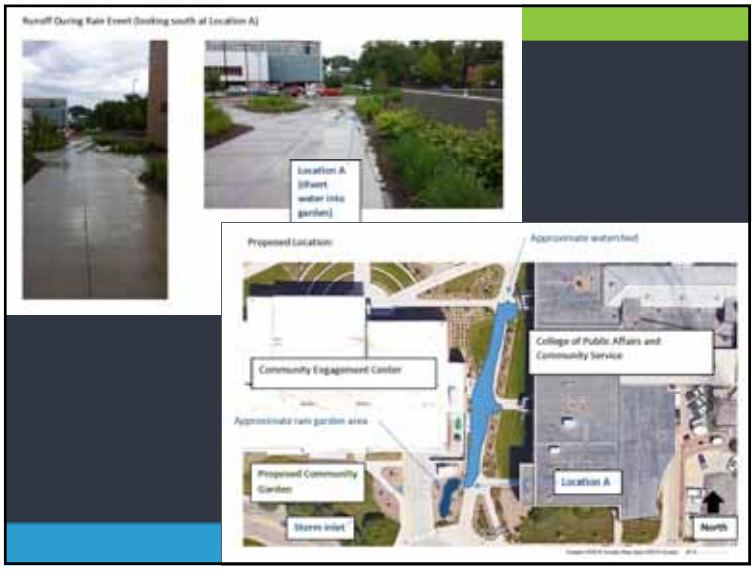
Successes

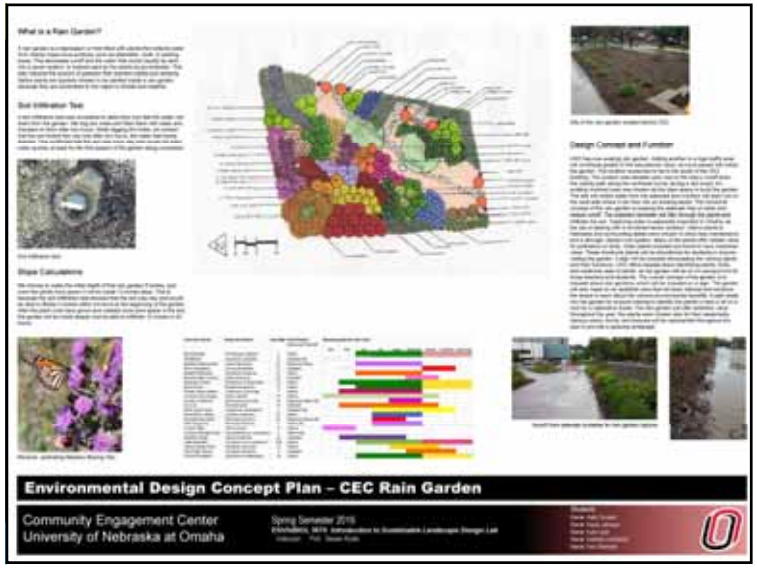
- Educational value accomplished; multiple curriculum benefits
- Additional credibility within OPS for rain gardens
- Project visibility/awards
- Critical mass for additional outdoor classroom and sustainable gardens
- Student involvement with maintenance

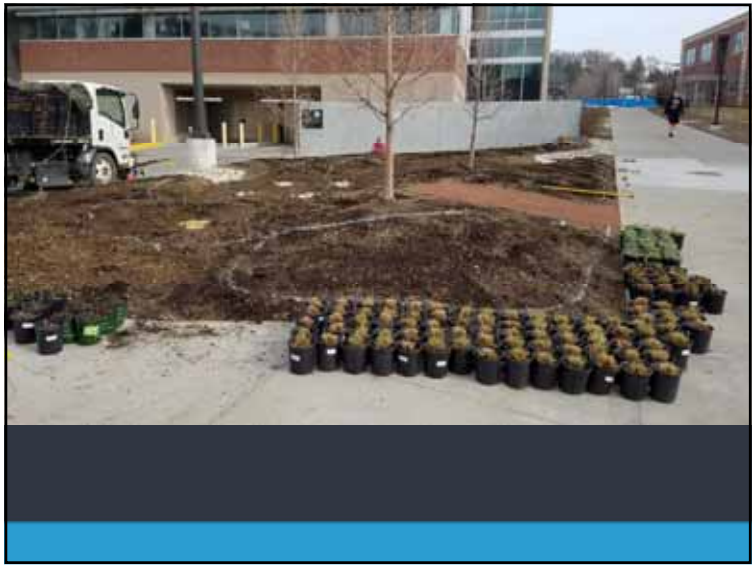
Challenges

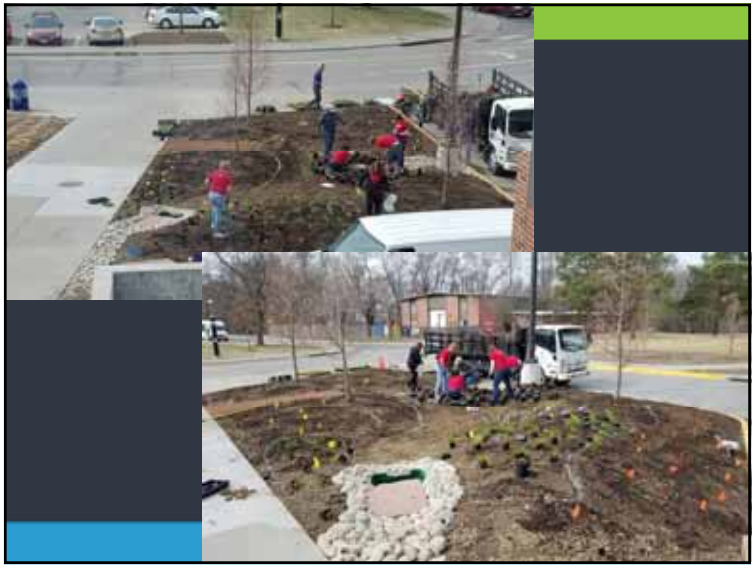
- Construction process (hailstorms, drainage failure, poor weather for planting)
- Completing finishing touches (rain barrel connections, etc.)
- Short-term and long-term maintenance
- So what exactly did we plant? And where?

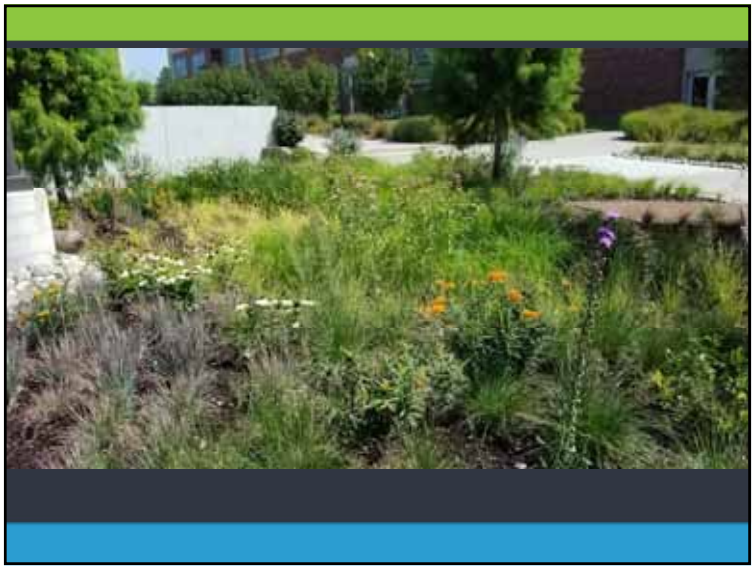
UNO Community Engagement Center Rain Garden


Runoff During Rain Event (looking south at Location A)
Location A (divert water into garden)
Proposed Location:
Approximate watershed
Community Engagement Center
College of Public Affairs and Community Service
Approximate rain garden area
Proposed Community Garden
Storm inlet
Location A
North


What is a Rain Garden?
Design Concept and Function
Environmental Design Concept Plan – CEC Rain Garden
Community Engagement Center
University of Nebraska at Omaha
Spring Semester 2015





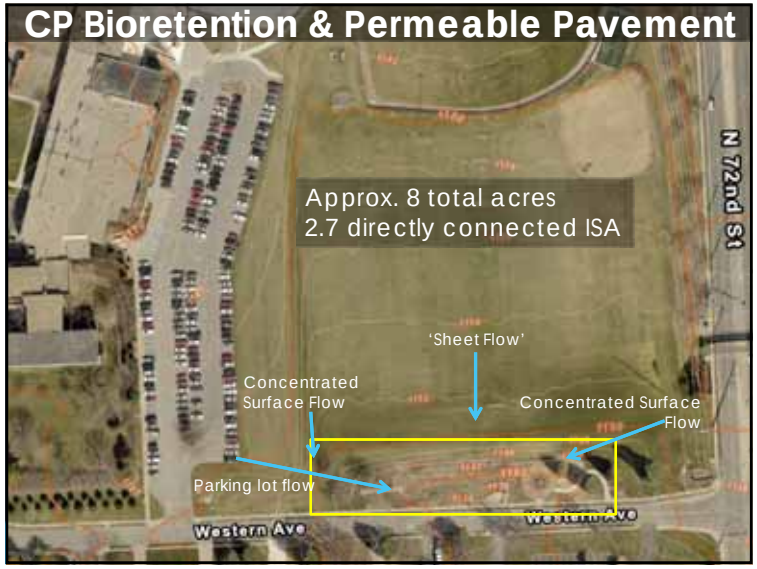


Successes

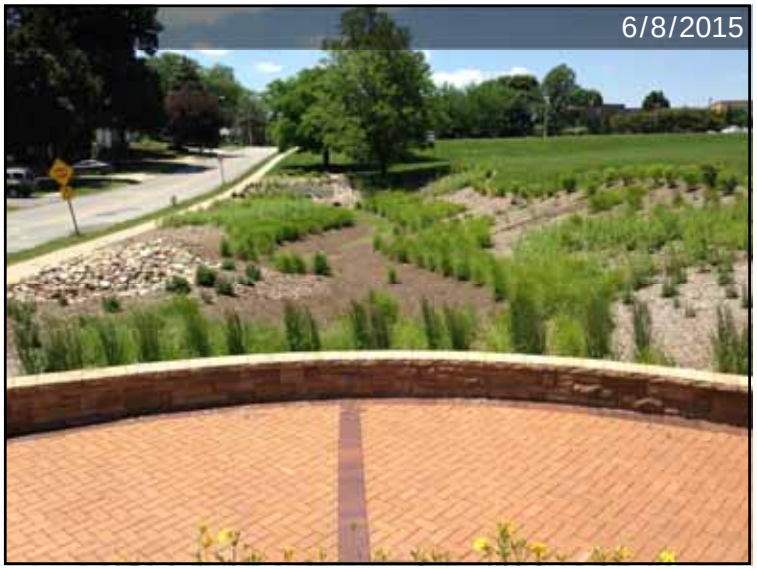
- Educational value; campus aesethetics enhanced
- Community engagement on campus; ideal project adjacent to CEC
- Significant investment of volunteer efforts for initial establishment and maintenance

Challenges

- Very poor site conditions, variable conditions
- Short-term and long-term maintenance




6/23/2014

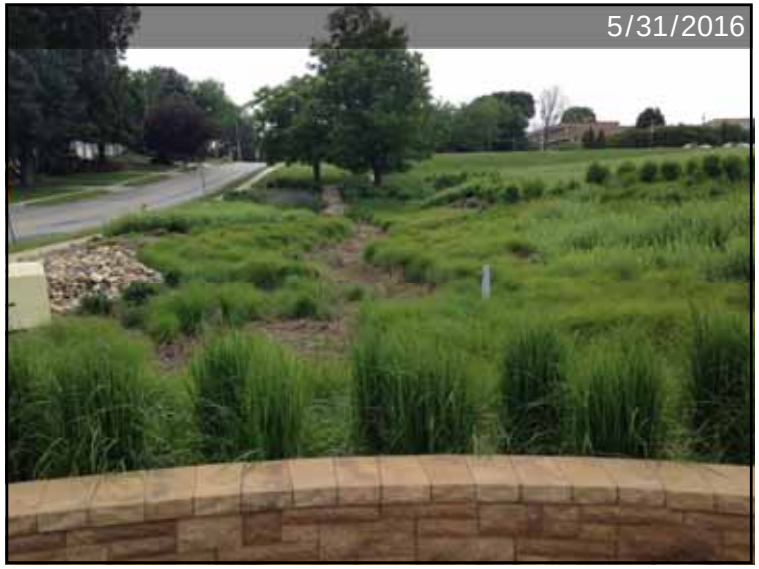

6/8/2015


8/7/2015


9/15/15

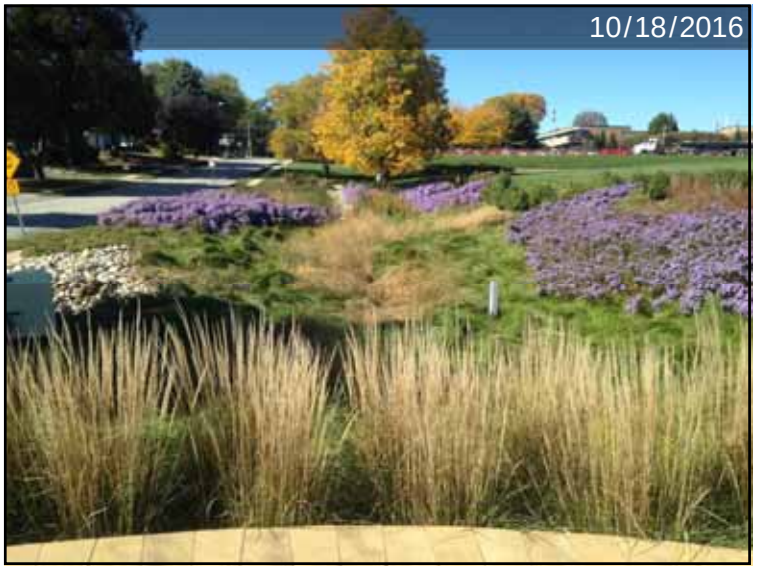

11/13/2015

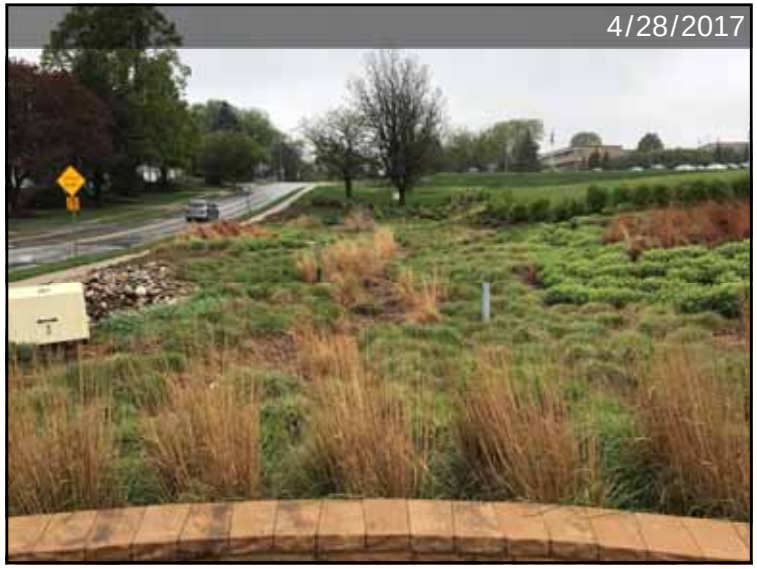

3/29/2016


5/31/2016


6/30/2016

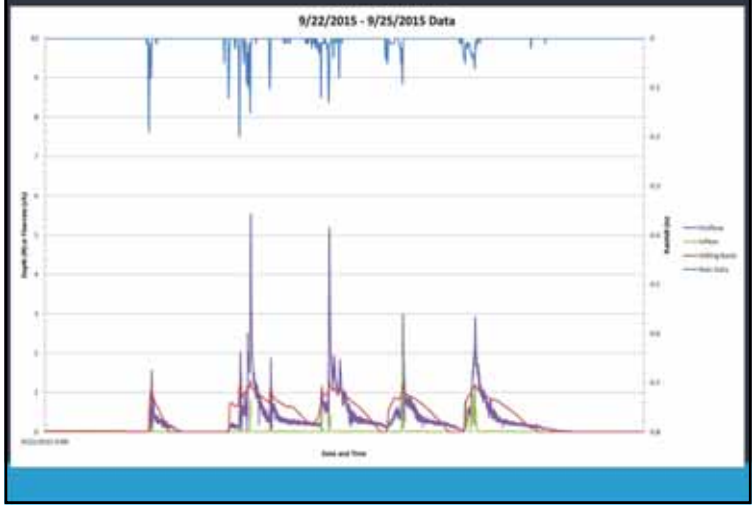

8/1/2016


10/18/2016


4/28/2017


9/17/2017

CP Bioretention - Results



CP Bioretention – 4/26/16 WQ Sample

Initial results, 1st of 3 WQ Samples

		Results							
Sample Label	Time Elapsed from flow start (min)	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.)
Incoming 1	0 - 25	<	0.007	4.02	1.33	0.28	142	57	7.17
Incoming 2	75 - 95	<	0.03	1.69	1.31	0.11	146	10	7.52
Incoming 3	100 - 115	<	0.03	1.36	1.00	0.08	134	13	7.35
Outgoing 1	0 - 30	<	0.03	1.79	2.41	0.13	178	32	7.56
Outgoing 2	45 - 90	<	0.03	1.46	1.77	0.11	166	8	7.43
Outgoing 3	105 - 150	<	0.01	<	2.3	0.11	152	14	7.54
Outgoing 4	285 - 345	<	<	<	0.73	0.13	86	12	7.67
Outgoing 4 - Duplicate	285 - 345	<	<	<	0.67	0.13	96	16	7.57
			Reduction	Reduction	Increase	No change	Increase	Reduction	No change

< Value below detectable limit

- Parameter not tested

Slide 226

KM(1 One WQ Event - show grpah and table; Identify underdrain only event and then calculate mass loadings
Klein, Mitchell (Mitch), 4/14/2017

KM(2 Prefer to compare incoming mass loading to outgoing mass loading
Klein, Mitchell (Mitch), 4/14/2017


Fall 2015


5/20/17


8/18/17

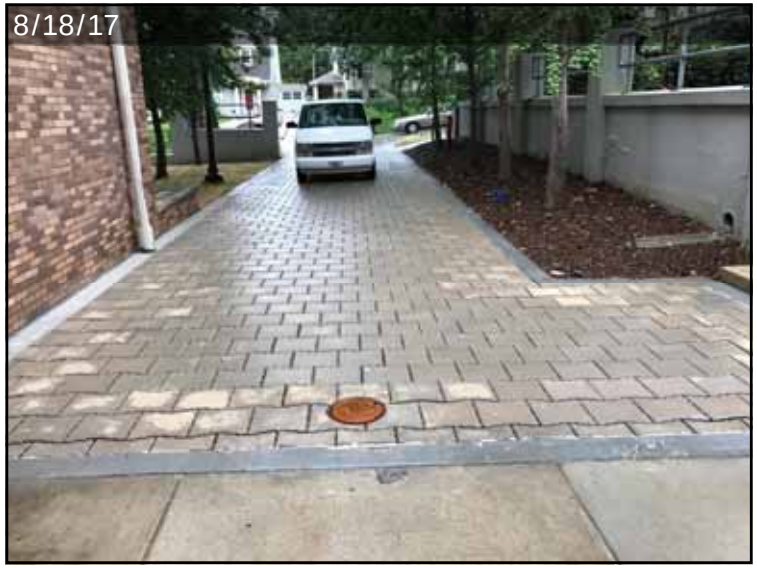

8/18/17
Upper permeable patio

View looking south from Chicago St at driveway

Driveway is very icy through winter due to water & north facing; runoff ends up in combined sewer

5/20/17

8/18/17



8/18/17


8/14/17


8/14/17


8/18/17
500-gallon rain silo


Saddle Hills
Installing rain gardens in a to manage runoff on a neighborhood scale

UNL URBAN WATERS PROJECT

Hands-on rain garden workshops

Front-yard rain garden w/flagstone sediment catch

On-going monitoring indicates they are performing very well; but life presents its challenges…

Currently working with groups to support maintenance…

Florence Streetscape

in the Historic Florence Neighborhood

Project Summary

- Waterwise Grant Project
- Neighborhood revitalization project
- Urban, street-side gardens
- 'Simplistic' approach to overall design
- Innovative pretreatment
  - 'Curb-well' (think window well)

PERCEPTION: Death traps, man pits, liability, etc….

Give me a year or two…

Holes in the ground make for "great" snow storage

This used to go into the sewer & Missouri River…

With maintenance, doing great

Thank you!

Steve Rodie – University of Nebraska at Omaha
Andy Szatko – City of Omaha Stormwater Program
Tom Franti – University of Nebraska at Lincoln
Kelly Feehan – University of Nebraska Extension