Stormwater Management Guidance

WHERE COMMUNITY AND SPIRIT MEET.

City of Kirkwood Green Infrastructure Techniques for Stormwater Management

NOVEMBER 2023

Prepared by:
Wood Environment & Infrastructure Solutions, Inc.

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TECHNIQUES FOR STORMWATER MANAGEMENT

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Acknowledgements and References

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City of Kirkwood Public Services Staff		
Engineering		
Chris Krueger, P.E.		Director of Public Services
Richard Holesinger, P.E.		City Engineer
Jamal Dillahunt		Project Engineer
Cory Meyer		City Forester
Jill Potts		Administrative Assistant
Planning		
Jonathan Raiche		City Planner
Amy Lowry		Assistant Planner
Building Commission		
Jack Schenck, Jr.		Building Commissioner
Tim Smalling		Plans Examiner
TaMara Pelkey		Permit Clerk
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139 South Kirkwood Road Kirkwood, MO 63122 P: 314-822-5819 For an electronic version of this document go to: Web: https://www.kirkwoodmo.org/government/departments/public-services/engineering/stormwater		

BACKGROUND AND PURPOSE

Impervious and Pervious. Land development permanently alters the way in which stormwater flows across a site due to grading, compaction, and the installation of impervious cover. Impervious cover or areas are man-made areas that cannot absorb water from rain or snow. Driveways, rooftops, patios, sport courts, tennis courts, adjustable Pergolas, and pools, for example, are considered impervious; surfaces such as decks, lawn, or gardens, where the rainwater is allowed to soak into the ground, are not considered impervious. Impervious area increases the amount of rainwater runoff and can cause flooding.

Impervious Area Limits. In an attempt to reduce the impacts caused by impervious cover, the City of Kirkwood requires, in accordance with Municipal Code *Chapter 5, Article VI. Infill Development Storm Water Management*, that stormwater management measures be utilized when constructing a new home, driveway or addition that is the greater of one of the following requirements (designated as the Contributing Drainage Area):

1. Creates 1,000 square feet or greater of new impervious surface (Net Additional Impervious = Proposed Impervious Area - Existing Impervious Area) area or
2. Causes the Proposed Impervious Area to be twenty-five (25) percent or greater of the total lot area.

The purpose of this document is to provide guidelines for selecting and installing the appropriate stormwater management measures when constructing a home. The City acknowledges these regulations will not solve all stormwater related issues within the City; however, this is a reasonable effort to reduce impacts of development on stormwater.

Design Standards. This guideline employs simplified design standards more applicable to the homeowner/builder experience, thus avoiding the necessity for complex engineering calculations and analysis. This guideline is meant to complement the use of the Metropolitan St. Louis Sewer District (MSD) Rules and Regulations and Engineering Design Requirements for Sanitary Sewer and Stormwater Drainage Facilities, February 2018, or most current version, which must be used for sites that propose more than one (1) acre of land disturbance.

The City reserves the right to:

- Require a Missouri Licensed Professional Engineer (PE) or Professional Landscape Architect (PLA) seal on the drawings when more complex land disturbances involving any of the following:
    - Cut/fill at or near a property line that could cause erosion, ponding, or other damage to adjoining property
    - Deep cuts and/or fill (exceeding 5 feet)
    - Large quantity of cut and/or fill (exceeding 250 CY)
    - Engineered or compacted fill proposed for future foundation support
    - Alterations to an existing piped drainage system
    - Creation of a new piped drainage system
    - Disturbance and/or drainage may impact a nearby sinkhole
    - Sinkhole evaluation and/or treatment needed
    - Disturbance is close to or within a flood plain or stream buffer
- Require MSD review and approval of certain projects that are less than one (1) acre of land disturbance.

Required Inspections. During and after construction of the stormwater management facilities, the City requires that two inspections (Initial and final) of the facilities take place and will be performed by a City Project Manager, City Engineer, or his or her designee. These inspections, an initial and final, will take place both during and after the construction has commenced. To schedule your inspection(s), contact 314-822-5822 at least 48 hours before.

How do I know when MSD Plan Review and Permitting is Required?

MSD Plan Review and Permitting Required Instances:

1.) MSD has identified a stormwater or sanitary project on the parcel or in the nearby area
2.) Sites where there are downstream storm water problems, flooding, erosion, seepage
3.) Overland flow issues, contours indicate a possible overland flow path, the site is in a "valley" area or low spot, there has never been a house on this lot previously
4.) Lots near low spots/dips in the road
5.) Proposed development is in close proximity to existing sewer facilities and/or easements, the sewer/easement is within a 1:1 zone of influence (see Figure 1) of the proposed building/footing, or there has never been a house on this lot previously
6.) If there are any known issues with shared sewer laterals or sewer laterals that are crossing other properties
7.) There is no public sanitary sewer adjacent/available to directly serve the lot being developed ("directly" means that a sanitary lateral connection can be made to the public sewer without the lateral crossing another property)
8.) Development in or near possible sinkhole areas, or development that will affect or is tributary to sinkhole areas
9.) Any project that disturbs one acre or more
10.) Any project where property line changes are proposed
11.) Other items/instances as determined by the City and/or MSD
12.) If unsure, please contact MSD Development Review, as follows:
    a. For most of the City, it is the West Team (Grand Glaize, Sugar Creek, and Gravois Creek Watersheds) projects, Bob Miller 314-335-2053 or ramill@stlmsd.com;
    b. For the upper Northeastern part of the City, it is the East Team (Deer Creek Watershed) projects, Mark Kuelker 314-335-2064 or mkuelker@stlmsd.com .

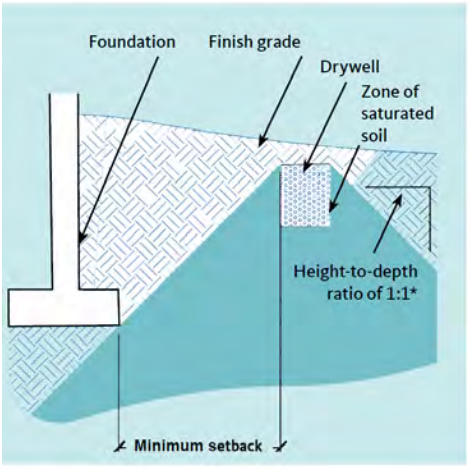


Figure 1
Assessing appropriate setbacks for drywells.
* Height-to-depth ratio varies with soil type. Consult a geotechnical engineer for an appropriate assumption.

For stormwater complaints regarding MSD, please contact their Customer Service by phone at 314-768-6260 or by email at https://msdprojectclear.org/contact-us/ .

What is the estimated plan review time?

The City will take approximately 10 business days after the ARB meeting date to perform an initial review of your submittal and return comments to you. Additional review time will be needed if MSD review is required and for each additional City review. The process flow chart for review can be viewed in Appendix G.

What is the frost depth for the area?

Saint Louis County Department of Transportation states the frost depth as 30 inches. It is strongly suggested that the bottom of aggregate dry wells, underdrains, or Modified French Drains be at least 30 inches below finish grade so that water will continue to drain down during winter weather conditions.

REQUIREMENTS AND PRINCIPLES OF INFILL RESIDENTIAL STORMWATER MANAGEMENT

The following section provides, in a question and answer format, the necessary information for understanding the requirements and process for submittal.

What types of residential projects require Stormwater Management?

The following activities are required to install stormwater management Green Infrastructure Practices / Best Management Practices (BMP) on site (greater of the two):

- Projects creating one thousand (1,000) square feet or more of net additional impervious area, or
- Projects causing the total impervious area on the lot to be twenty-five (25) percent or greater, whichever is greater

These projects can be anything that increases the impervious area of your property that meets the above requirements (for example: new home construction, building an addition, swimming pool, driveway expansion, patio, sport court, or detached garage).

What types of residential projects do not require stormwater management?

As long as Projects create less than one thousand (1,000) square feet of net additional impervious area:

- If a lot's existing impervious area is less than twenty-five (25) percent of the total lot area and a proposed improvement does not increase the total impervious area above twenty-five (25) percent, the lot is exempt from compliance with Municipal Code *Chapter 5, Article VI. Infill Development Storm Water Management*.
- If a lot's existing impervious area is greater than twenty-five (25) percent than the total lot area and a proposed improvement does not increase the total impervious area above the existing impervious area, the lot is exempt from compliance with Municipal Code *Chapter 5, Article VI. Infill Development Storm Water Management*.

What are the principles for managing stormwater on residential developments?

Residential developments are not required to provide the same types of stormwater management as commercial projects; however, certain requirements must be met to ensure that stormwater runoff does not overwhelm existing stormwater infrastructure; impact water quality in our streams; or negatively impact adjacent property. The key principles for managing stormwater from a residential lot are:

- Proper grading and erosion control techniques during construction;
- Reliance on infiltration only where the water table or bedrock layer is at least two feet below the bottom of the practice in use;
- Proper installation and maintenance of downspouts, channels, or any other sources of concentrated flow; and
- Runoff reduction (see section below).

What is Runoff Reduction?

The term 'Runoff Reduction' means the interception, evapotranspiration, infiltration, or capture of stormwater runoff. Examples of runoff reduction techniques on a single-family residential development include any appropriate combination of the following techniques termed Green Infrastructure Practices:

1. Routing downspouts to underground dry wells,
2. Directing sheet flow to adequately sized vegetated filter strips / areas (also known as Amended Soil), or any appropriate combination of techniques,

3. Routing downspouts to Modified French Drains,
4. Replacing traditional impervious surfaces not on public Right-of-Way (driveways, patios, etc.) with pervious paving,
5. Installing a rain garden or bioretention area,
6. Credit for Existing Trees.

The goal of these techniques is to reduce the volume of runoff generated by the first 1.14 inches of rain (the 90th percentile rainfall event as determined by STL MSD -see https://www.stlmsd.com/what-we-do/stormwater-management/bmp-toolbox/stormwater-quality) and is called the "First Flush". **First flush** is the initial surface runoff of a rainstorm. During this phase, water pollution entering storm drains in areas with high proportions of impervious surfaces is typically more concentrated compared to the remainder of the storm. Consequently, these high concentrations of urban runoff result in high levels of pollutants discharged from storm sewers to surface waters . Other BMPs that employ runoff reduction techniques may be used in lieu of these techniques with proper documentation of design criteria, details, and maintenance. When specified, the 2-year and 100-year, 24-hour rainfall amounts of 3.1" and 7.2", respectively, are to be used (source: THE METROPOLITAN ST. LOUIS SEWER DISTRICT RULES AND REGULATI ONS AND ENGINEERING DESIGN REQUIREMENTS FOR SANITARY SEWER AND STORMWATER DRAINAGE FACILITIES FEBRUARY 1, 2018).

How are Runoff Reduction techniques sized on residential developments?

Applicants can meet this requirement by following the practices in this technical guidance document to design an appropriate stormwater management plan. The amount of volume to be reduced on site is directly related to the drainage area contributing runoff to the treatment technology.

What are installation restrictions in BMP construction?

1. During Cold Weather (a period when the average daily ambient temperature is below 40°F (5°C) for more than 3 successive days.):
    a. Do not use frozen materials.
    b. Do not use materials mixed or coated with ice or frost.
    c. Do not build on frozen work.
2. During Wet Weather:
    a. Do not build on wet, saturated, unstable, or muddy subgrade.
3. Ground Water Table and Bedrock:
    a. Must be at least 2 feet of cover above the ground water table or any dense rock from the bottom of any excavated BMP.
4. BMP's must not be constructed:
    a. Over any buried utility line, septic drain fields, or sink holes;
    b. Beneath driveways or structures (i.e., garage, shed, pool, residence, etc.);
    c. Less than the specified setback distance for the BMP
        i. Within a minimum of three (3) feet from all other utilities unless a greater setback is required by the utility company. All utilities (for instance water, sewer, gas, CATV, Fiber-Optic, and electric) must be shown on the plan so setbacks can be verified.
        ii. Discharge from a BMP must a minimum of ten (10) feet from property lines except for:

            (1) House roof or foundation drains, which may be discharged within two feet of the house foundation;

            (2) Discharge into an open natural swale or creek on the same property.

   d. Within 50 feet from the top of any slope 3:1 (H:V) or greater.
5. When discharging water, never:
   a. Route surface water onto adjoining property,
   b. Route surface water into a sanitary sewer,
   c. Cross property lines with any discharge system without an easement, and
   d. Route so that it causes an erosion problem or nuisance.

What materials are used in BMP construction?

While there are some proprietary materials, like dry well tanks, there are common materials used throughout this manual.

Goesynthetics.

Weed Barrier (Optional). The geosynthetic used shall be a needle-punched, heat-treated, polypropylene, nonwoven landscape fabric designed specifically to act as a weed barrier, separator and drainage filter. This geosynthetic shall be inert to biological degradation and resistant to naturally encountered chemicals, alkalis, and acids. Equivalent products are Mirafi® Mscape E, Propex GEOTEX 351, or Thrace-LINQ 130EX or an approved equal is acceptable.

PROPERTY	TEST METHOD	MEASUREMENT
Minimum Weight Typical	ASTM D-5261	3.5 oz/y²
Minimum Grab Tensile Strength	ASTM D-4632	90 lbs
Maximum Elongation @ Break	ASTM D-4632	50 %
Minimum CBR Puncture	ASTM D-6241	260 lbs
Minimum Trapezoidal Tear	ASTM D-4533	40 lbs
Maximum Apparent Opening Size(1,2)	ASTM D-4751	50 US Sieve
Minimum Permittivity(1)	ASTM D-4491	2 Sec^{-1}
Minimum Water Flow Rate(1)	ASTM D-4491	150 g/min/f²
Minimum UV Resistance @ 500 Hours	ASTM D-4355	70 %

(1) At the time of manufacturing. Handling, storage, and shipping may change these properties.
(2) Maximum average roll value (MaxARV).

Separation. The geosynthetic used in this manual to separate materials and allow subsurface drainage are a non-woven AASHTO M 288, Class 3 or an MSD Type 4. This fabric must be a needle-punched nonwoven polypropylene geotextile.

Non-Woven Geotextile should consist of the following properties:
a. Grab Tensile Strength (ASTM-D4632) ≥ 120 lbs
b. Mullen Burst Strength (ASTM-D3786) ≥ 225 psi
c. Flow Rate (ASTM-D4491) ≥ 95 gal/min/ft^2
d. UV Resistance after 500 hrs (ASTM-D4355) ≥ 70%
e. Heat-set or heat-calendared fabrics are not permitted

- Pre-Approved products available in the area are:
    - Mirafi 140 N, Propex GEOTEX 401, SRW NW4.5, or Thrace-LINQ 140EX.

Polyester Filter sock. The filter sock, placed around perforated pipe, acts as a filter barrier that screens out problem-causing sand and sediment to help keep high flowing performance in drainage pipe. Deposits can build up inside, greatly reducing water flow or completely clogging the drain line. Filter socks shall meet ASTM D6707 Standard Specification for Circular-Knit Geotextile for Use in Subsurface Drainage Applications.

- A pre-approved product available in the area is:
    - Drain-Sleeve Filter fabric sock for perforated drain pipe.

Aggregates.
For dry wells, underdrains, base course for permeable pavers, and Modified French Drains the use of a clean and washed ASTM No.57 crushed stone is required. This stone size averages from ½-inch to 1-1/2 inches in diameter and has an assumed porosity of 40 percent.

For permeable paver bedding course, a substitute for leveling purposes in the upper three-inch layer of the base below a prefabricated dry well tank, or backfill over a top of a dry well tank, a clean and washed ASTM No. 8 stone or 1/3-inch to 3/8-inch diameter pea gravel is used.

Mulch Layer. A mulch layer consisting of 2-3 inches of non-floatable organic mulch (fine shredded hardwood (cypress) mulch, pine straw, or leaf compost) should be included on the surface of the rain garden. Pine bark and wood chips should not be used.

Compost. As a component for Vegetated Filter Strip (amended soil option), the following are the compost material requirements.

Compost shall be mature, stable, weed free, and produced by aerobic decomposition of organic matter. Compost feedstock may include, but is not limited to: agricultural, food or industrial residuals; class A biosolids as defined in the EPA CFR Title 40, Part 503; yard trimmings, or source-separated municipal solid waste. The product must not contain any visible refuse or other physical contaminants, substances toxic to plants, or over 5% sand, silt, clay or rock material by dry weight. The product shall possess no objectionable odors. The product must meet all applicable USEPA CFR, Title 40, Part 503 Standards for Class A biosolids. The moisture level shall be such that no visible water or dust is produced when handling the material. The following are a list of products considered pre-approved for use:

COMPOST SUPPLIERS				
Company	**Product**	**Location**	**Email**	**Phone**
Fick Supply Service	**Grow Green Compost**	501 N. Eatherton Rd Wildwood, Missouri 63005	Candice@ficksupply.com	(636) 532-4978
Hansen's Tree Services & Environmental Wood Resources	**Magic Bean Compost**	1628 Kemmar Ct O'Fallon, Missouri 63366	chad@hansenstree.com	(636) 379-1830
		1730 Cecos Lane Arnold, Missouri 63010		(636) 287-1130
St. Louis Composting	**Black Gold**	**– Fort Bellefontaine** 13060 County Park Rd Florissant, Missouri 63034	dgavlick@stlcompost.com	(314) 355-0052
		– Pacific 18900 Franklin Rd. Pacific, Missouri 63069		(636) 271-3352
		– Valley Park 39 Old Elam Ave Valley Park, Missouri 63088		(636) 861-3344
Compost submitted for use must carry the Certified Compost Seal of Testing Acceptance				

Testing. Prior to delivery of any compost to the site and as part of shop drawing review, the contractor shall provide the following documentation at the initial inspection to the Kirkwood City Inspector:

- feedstock percentage in the final compost product
- a statement that the compost meets federal and state health and safety regulations
- a statement that the composting process has met time and temperature requirements
- a copy of the lab analysis, less than four months old, performed by a Seal of Testing Assurance Certified Laboratory verifying that the compost meets the physical requirements as described in Table 1.

Table 1. Physical Requirements for Compost

Parameter	Range	Testing Method
pH	5.0-8.5	TMECC 4.11A
Soluble Salt Concentration	< 10dS/m	TMECC 4.10-A
Moisture	30-60% wet weight basis	SMEWW 2540B
Organic Matter	30-65% dry weight basis	TMECC 5.07-A
Total Nitrogen (N)	>1.00% dry weight basis	TMECC 04.02-D
Phosphate (P_2O_5)	>0.50% dry weight basis	TMECC 04.03-A
Potash (K_2O)	>0.10% dry weight basis	TMECC 04.04-A
Particle Size	95% pass through 5/8" screen or smaller	TMECC 2.02-B
Stability (Carbon Dioxide evolution rate)	>80% relative to positive control	TMECC 5.08-B
Maturity (Seed emergence and seedling vigor)	>80% relative to positive control	TMECC 5.05-A
Physical contaminants (man made inerts)	<1% dry weight basis	TMECC 3.08-A
Chemical contaminants	**Meet or exceed US EPA Class A standard, 40 CFR § 503.13, Tables 1 and 3 levels:**	
Arsenic	< 41 ppm	TMECC 4.06-AS
Cadmium	< 39 ppm	TMECC 4.06-CD
Copper	< 1,500 ppm	TMECC 4.05-CU
Lead	< 300 ppm	TMECC 4.06-PB
Mercury	< 17 ppm	TMECC 4.06-HG
Molybdenum	< 75 ppm	TMECC 4.05-MO
Nickel	< 420 ppm	TMECC 4.06-NI
Selenium	< 100 ppm	TMECC 4.06-SE

Parameter	Range	Testing Method
Zinc	< 2,800 ppm	TMECC 4.06-ZN
Biological contaminants (pathogens)	**Meet or exceed US EPA Class A standard, 40 CFR § 503.32(a) levels:**	
Fecal coliform	< 1,000 MPN per gram, dry weight basis	TMECC 7.01

Recommended compost testing methodologies and sampling procedures are provided in **Test Methods for the Examination of Composting and Compost (TMECC)** and **Standard Methods for the Examination of Water and Wastewater**. See https://www.compostingcouncil.org/page/tmecc and https://www.standardmethods.org/about/ , respectively, for additional information.

Pipe.

For use in dry wells, underdrains and connecting downspouts, pipes are used. Pipes shall be rigid and durable and made of Schedule 40 PVC or HDPE and have either a 4-inch or 6-inch inside diameter. Pipes are solid when connecting downspouts to dry wells or exiting dry wells to a discharge point. Pipes used in an aggregate system, such as a dry well, Modified French Drain, or underdrain are perforated. Pipe with circular perforations are to be located in the trench as per Figure 2. Pipe inside diameters shall be considered 4-inches when the pipe diameter is not specified.

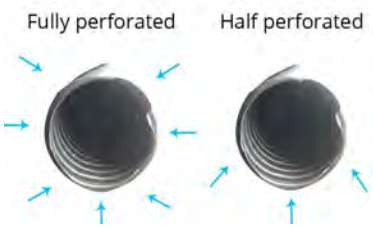


Figure 2

Source: https://www.jdpipes.co.uk/knowledge/land-drainage/perforations-up-or-down.html

Installations Below Frost Line (30" or more below final grade):
PVC Pipe. Schedule 40 Perforated PVC pipe will be constructed of PVC 1120 Type 1 Grade 1, with a cell class of 12454B, per ASTM D1784 (AASHTO M 304-19). Perforated underdrain shall be wrapped with a polyester fabric sock meeting ASTM D6707.

Installations Above Frost Line (Less Than 30" below final grade):
HDPE Pipe. HDPE pipe will be constructed of rigid dual wall smooth interior and annular exterior corrugations HDPE pipe meeting the requirements of ASTM F 810 MS (AASHTO M 252-18, Type S, Class 1 or 2 perforations). Perforated underdrain shall be wrapped with a polyester fabric sock meeting ASTM D6707.

Products Pre-approved for use.

- ADS 3000 Triple Wall pipe.
- ADS N-12 ST IB Dual Wall pipe meeting ASTM F2648.

Exceptions Allowing Schedule 40 PVC pipe. Emitters and vertical extensions for observation wells and dry well tanks as per the manufacturer's guidelines.

Pipe End Treatments. Pipes ends need to be capped when terminated in one of the following methods:

Underdrain Outlet Protection.

- **Daylighted.** Rodent screen shall be press formed of 3 or 4 mesh, 21 gauge or heavier, stainless steel or hot-dipped galvanized wire screen or approved equivalent to provide a cup-shaped screen, which will provide a friction tight fit when inserted into the drain outlet.
- **Connection to Stormwater Inlet or Manhole.** A hole, slightly larger than the outside diameter of the pipe, shall be drilled or precast in structure. The underdrain shall extend a minimum of six (6) inches past the inside wall of the structure. Then the underdrain shall be grouted on both the inside and outside of the structure and allowed to properly cure. Once the grout is properly cured, the underdrain shall be trimmed off as close as possible

to the inside of the structure. A rodent screen shall be installed as per above. MSD pre-approval (permit) is required.

- **All Other.**
  - **Popup Emitter**
    - An emitter is opened by the hydrostatic pressure of water flowing through the drainpipe. As flow diminishes, the Emitter closes again. The special patented design allows the emitter to open with a negligible amount of pressure. Since the emitter is closed during dry weather, debris and rodents cannot enter the drainpipe. The emitter has a 90 degree bend elbow with a ¼-inch leach hole at the bottom. The last 5 feet of pipe before the emitter shall be a perforated underdrain (installed with geosynthetic and drainable aggregate) to allow water to drain and not freeze in the pipe during cold weather conditions (See Appendix D for typical section). **Minimum spacing between multiple emitters is 15 feet.**
  - **Terminal End.**
    - The terminal end on the upstream or downstream pipe (into a dry well) shall be capped with a manufacturer-approved cap.

Permeable Pavers.

The contractor shall obtain the concrete paver manufacturer's certification that the paving units supplied to construct the Permeable Pavers meet the requirements in ASTM C936 Standard Specification for Solid Interlocking Concrete Paving Units. The following Material Suppliers and products are considered pre-approved:

Midwest Block and Brick	ROMANSTONE
Building Product Corp.	ECO BRICK
Belgard Hardscapes	AQUA ROC™, AQUA-BRIC

SUBMITTAL INFORMATION

What needs to be submitted?

1. **Computations.** The first step is to submit computations to verify that a BMP is required. The following information is needed to provide an official determination:
   a. Existing impervious area, square feet
   b. Proposed impervious area, square feet
   c. Net Increase in impervious area, square feet
   d. Lot size, square feet
   e. Lot Size*0.25
   f. The Contributing Drainage Area is the greater of the following:
      i. Proposed Impervious Area – Lot Size*0.25, in square feet; or
      ii. Net Increase in impervious area (1,000 square feet or greater), square feet

Once it is determined that a BMP will be required you can move to the next step.

2. **Plans.** In addition to any submittal requirements as specified by the City's permit submittal process, applicants must develop a site plan that includes the following items:

- Location, configuration and finished elevations for existing and proposed impervious areas;
    - Contributing Roof Drainage Area for each downspout connected to a BMP
- Proposed drainage infrastructure in Right-Of-Way;
- Location of Trees;
- Lot/building layout with dimensions;
- Existing and proposed ground contours and elevations at no more than 2-foot intervals;
    - Direction of flow for swales, overland flow and pipe
    - Percent fall of pipe or BMP
- Sanitary and storm sewer structures and easements;
- All utilities (for instance water, sewer, gas, CATV, Fiber-optic, electric, underground pet fences, irrigation systems) must be shown on the plan so setbacks or conflicts can be verified.
- Location, configuration, and finished floor elevations for existing and proposed building structures;
- Location, configuration, and finished elevations for existing and proposed paved areas;
- Location and type of erosion and sediment control practices in conformance with the City Code;
- Selected and completed Green Infrastructure Control & Practice Tear Sheets;
- Site infiltration test results, when performed. A tear-off sheet is included in Appendix A of this document.

Pertinent to stormwater, the following guidance applies to all designs -

- Stormwater runoff from the first 1.14 inches of rainfall must be captured on site and dissipated through the use of infiltration, evapotranspiration or alternate use (e.g. irrigation). It cannot run off the site.
- No person shall direct stormwater or sump pump water through a pipe, culvert or drain, which discharges within ten (10) feet of the adjacent property line except for:

  (1) House roof or foundation drains, which may be discharged within two feet of the house foundation;

  (2) Discharge into an open natural swale or creek on the same property.

  [SOURCE: Ord. No. 10378, 1-5-2017]
- Details of all Green Infrastructure Controls/BMPs shall be attached to the site plan using, where possible, specification sheets from this document or sets of plans of equal detail and coverage.
- **Default Infiltration Rate (IR).** Should you choose not to perform infiltration testing as outlined in Appendix A, your site infiltration rate will automatically be recorded as **0.05 inches/hour (in/hr)** which excludes some BMP's as being applicable and others will require an underdrain. See Appendix D for details on constructing an underdrain. The following is a list of BMPs for several ranges of infiltration rates:
    - 0.05 in/hr ≤ IR ≤ 0.25 in/hr
        - Dry Well with 10% increase in volume
        - Vegetative Filter Strip (Amended Soil Option) with underdrain
        - Permeable pavers with underdrain
        - Rain Garden with underdrain
        - Tree Credit
    - 0.25 in/hr < IR ≤ 0.50 in/hr
        - Dry Well

- Vegetated Filter Strip (Amended Soil Option)
- Modified French Drain
- Permeable Pavers
- Rain Garden
- Tree Credit

o 0.50 in/hr < IR

- Dry Well
  - If IR > 0.50 in/hr the storage volume may be decreased by 10 percent for every 0.50 in/hr of IR increase above 0.50 in/hr.
- Vegetated Filter Strip (Conventional or Berm option)
- Modified French Drain
- Permeable Pavers
- Rain Garden
- Tree Credit

- **Rounding.** In each of the tear-off calculation sheets, the rounding of values should conform to the following requirements:
  - Volume: Round up to the nearest cubic foot.
  - Length and Width: Round to the nearest whole foot.
  - Depth: Round to the nearest half (0.5) foot.
  - Area: Roundup to the nearest whole square foot.
  - Infiltration Rate: to nearest 0.05 in/hr.

3. **Maintenance Agreement.** Once the plans and computations are approved you will receive an email with the approved plans and a blank copy of the Maintenance Agreement, which is to be completed by you and the City, and then filed by you with the Saint Louis County Recorder of Deeds. A notary is available at City Hall by appointment. Please call 314-822-5822 to schedule either your notarization or City notarization.

What needs to be included in the Stormwater BMP Maintenance Agreement?

The City requires single-sided sheets (8.5"x 11" size for recording) that include the following to be submitted with the Stormwater BMP Maintenance Agreement. All lettering is to be at least eight (8)-point print (#80 "Leroy" lettering guide). Recording fees, paid by the property owner, can be estimated from the Saint Louis County Missouri Recorder of Deeds web site at: https://stlouiscountymo.gov/st-louis-county-departments/revenue/recorder-of-deeds/price-list/.

- Grantor (Landowner) and City Notarized Stormwater BMP Maintenance Agreement
  - Recording Cover Sheet
    - Date of Document
    - Grantor Name(s) (Property Owner(s))
    - Property Address
    - County Locator Number (see St. Louis County Revenue Property Information: https://revenue.stlouisco.com/ias/searchinput.aspx)
    - Subdivision Name and Brief Legal Description
  - Maintenance Agreement:
    - Property Address
    - Date of Document: Day, Month, and Year
    - Grantor Name(s)
    - County Locator Number

- Deed Book and Page Numbers
- Subdivision Name and Brief Legal Description
- Name of Plan (from permit; i.e., New Home Construction, Garage Addition)
- Maintenance Agreement
- Landowner Notarized Signature(s) Page
  - *Bring photo id if using city notary*
- City Notarized Signature Page

- **Supporting Exhibits.** Date of most recent revision of maintenance agreement exhibit is indicated in the lower left corner. Suggest using the worksheets in this manual when possible. Attach to Maintenance Agreement:
  - Drainage Calculations:
    - (L) Lot Size, square feet
    - (EI) Existing impervious area, square feet
    - (II) Improved impervious area, square feet
    - (C) Contributing Drainage Area, square feet
      - C = II-0.25*L
      - For adding new or modifying an existing sump, add 175 square feet to C.
    - Infiltration Rate (See Appendix A), inches / hour (optional)
      - Default Infiltration Rate is 0.05 inches/hour
  - Sizing computations for each BMP
  - Typical Section(s) for each temporary and permanent BMP
  - Site plan, with:
    - North Arrow
    - Scale
    - Property Lines
    - Contour lines (2-foot spacing maximum)
    - Right of Way information; such as name, width, road, street, railroad, creek, etc. is indicated, if applicable.
    - Existing Easements, stormwater and sanitary sewer structures
    - Location and dimension of each BMP:
      - Include temporary erosion control and
    - Slope and location of pipe(s) that connects to BMP or discharges from BMP
    - Setback distance(s) for BMP
    - Direction of water flow and BMP slope, in percent
  - Proprietary BMP
    - Installation and Maintenance Guidelines

What does the applicant do with the completed notarized Stormwater BMP Maintenance Agreement?

- **Recording Options:**
  - **In Person.** The applicant then takes the notarized Maintenance Agreement, with supporting exhibits, to the Saint Louis County Recorder of Deeds and pays the required fees to have it recorded. The Recorder of Deeds published fee schedules are located at https://stlouiscountymo.gov/st-louis-county-departments/revenue/recorder-of-deeds/price-list/. The Recorder of Deeds Division is located on the fourth floor of the Lawrence K. Roos County Government Building located at:
    - 41 South Central Avenue, Clayton, MO 63105-1799.

- Staff will check your Maintenance Agreement document for the minimum statutory requirements for recording, but **cannot**:
    - Verify that the document fulfills the intentions of the party recording the document;
    - Give legal advice;
    - Perform deed searches;
    - Complete or fill out/type deed forms;
    - Supply blank legal forms;
    - Determine ownership of a property.
- **By mail. USPS mail** or **Drop-Off** the **original notarized document**: Recorder of Deeds, 41 S Central Ave, Clayton, MO 63105. Please include a check or money order made payable to 'ROD' for the cost of the deed recording. The original will be returned to you within one week of the recording date.
- **Title Company.** A local title company can record the Maintenance Agreement with the Recorder of Deeds. The title company will charge an additional fee for this service.
- **Electronic Recording.** Follow guidelines on County Web Page: https://stlouiscountymo.gov/st-louis-county-departments/revenue/recorder-of-deeds/erecording/ **.**

- The applicant then returns a copy of the receipt (in-person or by email) to the Assistant City Engineer, who will in turn notify the Deputy Building Commissioner. Make sure the address is on the receipt as the County does not identify the receipt. In 7-14 days, the Recorder of Deeds will issue a hard copy of the recorded agreement. A copy of this agreement is to be submitted by the applicant (in-person or by email) to the Assistant City Engineer. *No initial inspection will be scheduled until the City has received a recorded copy of the maintenance agreement.*
- **Note: BMP inspections are not granted until a recorded maintenance agreement is received. Occupancy permits are not granted until a recorded maintenance agreement is received and all stormwater BMP's have been final-inspected and approved by Engineering. Inspections are to be scheduled on days when the City Hall is open for Business. Please contact 314-822-5822 at least 48 hours prior to date of inspection for scheduling.**

What is in the rest of this manual?

The remainder of the document contains:

(1) A set of six information/specification sheets, one for each of the six recommended Green Infrastructure Controls/BMPs. For each, the last two pages are a tear-off set of specifications that can be filled in and attached to construction plans.
(2) Appendix A that describes how to conduct infiltration testing.
(3) Appendix B that describes the types of vegetation recommended for those Controls that feature vegetation as part of the treatment approach.
(4) Appendix C that describes how to determine adequate flow area.
(5) Appendix D that provides details when an underdrain is required.
(6) Appendix E is the pretreatment detail.
(7) Appendix F is the ordinance these guidelines are based upon.
(8) Appendix G is the stormwater review process.
(9) Appendix H is a graphic displaying stormwater pollution prevention for single-lot residential sites.

MAINTENANCE AND INSPECTIONS

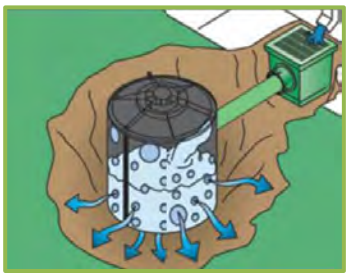
- Each of the six Green Infrastructure Controls/BMPs information/specification sheets contains information regarding general maintenance that is required for each BMP. The property owner is required to maintain their

BMP's in proper working condition. The Maintenance Agreement allows City access at reasonable times for regular or special evaluations to ensure BMP's are properly maintained and in working condition.

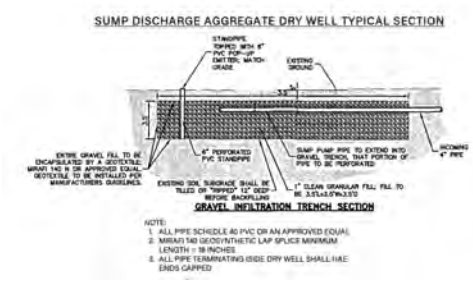
- Inspections will be conducted by the City and scheduled in advance with the property owner at the following intervals:
    - Requested by property owner:
        - During construction (initial and final),
    - Requested by city:
        - One-year after construction of the BMP is completed, and
        - Three-year intervals after the one-year inspection.
- See the Operations & Maintenance Manual for:
    - Construction inspection checklists, for both during construction and after completion;
    - Construction inspection intervals;
    - Additional maintenance information and inspection checklists.

To view Operations & Maintenance Manual and other helpful information visit the City website at: https://www.kirkwoodmo.org/government/departments/public-services/engineering/stormwater.

DRY WELLS



Dry wells are either seepage tanks set in the ground and surrounded with stone or 100 percent stone. They are designed to intercept and temporarily store stormwater runoff until it infiltrates into the soil. Alternatively, the pit can be filled with stone where water will flow in via a perforated standpipe in place of the tank.



Dry wells are well-suited to receive rooftop runoff entering the tank via an inlet grate (shown at right) or a direct downspout connection (below right). When properly sized and laid out, dry wells can provide significant reductions in stormwater runoff and pollutant loads. **If an infiltration rate is not measured or when measured in accordance with Appendix A is less than 0.25 inch/hour, a dry well shall be oversized by 10%.**

Source: www.earthcontactproducts.com

LOCATION

- **Location.** Dry well excavations must be located:
  1. Spacing between drywells shall be a minimum of 30 feet or twice the depth, whichever is greater;
  2. 10 feet from building slab foundations / basements / retaining walls / in-ground swimming pools and property lines;
  3. On slopes flatter than 5% [20:1 (H:V)]; and to not knowingly cause or contribute to slope instability or that will trigger soil movement.
  4. In at least 50% of a cut excavation.
- **Overflow.** An overflow must be incorporated in the dry well such that excess water will flow into the storm drain system or another pervious area away from nearby foundations or neighboring properties. The point of discharge must be at least 10 feet from any property line.
- **Observation Well.** An observation well shall be installed in pure aggregate dry wells to monitor the runoff clearance from the system. The observation well shall consist of an anchored, vertical four (4) inch diameter perforated schedule 40 PVC (or approved equal) pipe with lockable above ground cap.
- **Pretreatment.** To reduce the chance of clogging, dry wells should drain only impervious areas, and runoff pretreated with at least one of the leaf removal options to remove debris and larger particles.
- **Height and Surface Dimension Limits.** A dug hole whose depth shall NOT be greater than the largest surface dimension so as NOT to become an Injection Well (https://www.epa.gov/uic/general-information-about-injection-wells). The bottom of the dry well must be below the frost line
  - **Reinforced Concrete Tank.** The height of the tank should not exceed 60 inches unless infiltration testing has been done to ensure a drain time of 72 hours or less. Tank diameter shall not exceed 72 inches.
  - **Aggregate.** The height of the aggregate dry well (H), in inches: $24 \leq H \leq 72$.
- Dry wells should be located in a lawn or other pervious (unpaved) area and should be designed so that the top of the dry well is located as close to the surface as possible. **Avoid siting dry well in low spots to facilitate proper drainage and on or above slopes greater than 15% (1.8:12)**
- Dry wells should not be located:
  (1) Beneath an impervious (paved) surface or shed;
  (2) Above an area with a water table or bedrock less than two feet below the trench bottom;
  (3) Within an area where the slope exceeds 5%;
  (4) Over other utility lines;

(5) Above a septic field;
(6) Less than 50 feet from slopes at or greater than 15% or that drain into areas prone to landslides; or
(7) In areas where the dry well is in 50% or more of fill.

CONSTRUCTION

- Consider the drainage area size and the soil infiltration rate when determining the size of the dry well, (see Appendix A). A minimum of 50% of the dry wells storage volume must be located within undisturbed (in-situ) soils.
- The sides of the excavation shall be trimmed of all large roots that will hamper the installation of the permeable drainage fabric used to line the sides and top of the dry well.
- The native soils along the bottom of the dry well shall be scarified or tilled to a depth of 3 to 4 inches.
- **Geosynthetic.** Place and secure filter non-woven geosynthetic on the bottom and down sides of the excavation leaving enough to fold over the top below the soil and turf (see graphic). This fabric must be a needle-punched nonwoven polypropylene geotextile Mirafi 140 N or equivalent. Install clean aggregate, installing inflow, observation well, and overflow pipe(s) (solid and polyester filter-sock wrapped perforated) at the desired elevation and location. When the material is cut or is at the end of the roll, overlaps are required. Lap splices must be a minimum of eighteen (18) inches.
- **For a tank installation.**
    - The dry well hole shall be excavated 1 foot deeper and two feet larger in diameter than the tank to allow for a 12-inch stone fill jacket.
    - Precast Concrete and NDS Flow-Well Tanks shall have holes spaced along the side of the tank. Assembly and Installation Guidelines shall be provided. Precast Tank shop drawings shall be submitted for review. Tanks shall be wrapped with landscape fabric.
    - Install non-woven Mirafi 140 N geosynthetic on top, bottom and sides of excavation as specified above
    - Fill below and around dry well tank approximately 12 inches of clean, washed ASTM No. 57 stone. No.57 stone averages ½ inch to 1-½ inches.
- **Proprietary Underground Stormwater Storage and Detention Systems (i.e., R Tank by ACF or ADS Storm Chamber).** These systems, when approved, shall be constructed in accordance with the manufacturer's guidelines.
- **Aggregate.** The washed ASTM No. 57 stone. No.57 stone averages ½ inch to 1-½ inches shall be placed and lightly compacted in up to twelve (12) inch lifts with a plate compactor (to reduce post-construction settlement).
- Place Mirafi 140 N or approved equal Non-woven Geosynthetic over the top of the aggregate. Fill the final 8-12 inches of the excavation with native soil, pea gravel, or ASTM No. 8 stone.
- **Downspout Connection Limitations.** It is acceptable to connect more than one downspout to the dry well as long as the maximum roof drainage area to the dry well of 1,000 square feet is not be exceeded. Pipe shall enter the dry well at 90 degrees to the side wall of the dry well.
- **Pretreatment.** For rooftop runoff, install a leaf screen in the gutter or downspout prior to entering the dry well to prevent leaves and other large debris from clogging the dry well. For non-rooftop runoff, precede the dry well with an in-ground sump grate or inlet leaf trap. Submit completed Pretreatment Detail.
- **Minimum Pipe Slope.** The minimum pipe slope is 1%. A pipe slope of 2% is recommended.
- **Overflow Design Criteria.** In order to prevent backup of water in the downspout, an overflow downspout surcharge pipe must be provided as shown on the Dry Well detail. Discharge from the downspout surcharge pipe must be directed to an above ground splash block and conveyed in a non-erosive manner to a stable outfall. In some cases, it may be desirable to add an additional overflow pipe or pop up emitter

directly out of the dry well. This shall be in addition to the required splash block overflow. The flow from the additional overflow pipe or emitter must be directed to a safe location that is unlikely to contribute to nuisance drainage problems such as a wet lawn areas or seepage across sidewalks. An overflow, such as a vegetated filter area or grass channel, should be designed/provided to safely convey the stormwater runoff generated by larger storm events bypassing the dry well.

- **Observation Well.** The design involves placement of a perforated four (4) inch diameter Schedule 40 PVC vertical standpipe, wrapped with a polyester filter sock, connected to the inlet pipe. When using a tank system this can be omitted.

Sump Discharge. When incorporating sump discharge into a dry well, the sump discharged is sized to treat a minimum of 175 square feet of contributing area (aggregate size: 3.5' X 3.5' X 3.5').

Use the tables below can be used to size a dry well system. For a given tank height and inside diameter the contributing drainage area captured can be read. For example, if a 10 by 50-foot roof is to be treated, the total roof area is 10 x 50 = 500 square feet (contributing drainage area). Using an infiltration rate of 0.25 inches per hour:

- **NDS Tank Option.** This could be handled by one tank 30-inch high, 42-inch diameter, with a 6-inch gravel bed. It can also be handled by two tanks 30-inch high, 30-inch in diameter, with a 6-inch gravel bed.
- **Aggregate Option.** This could be handled by a 60-inch deep excavation, 60-inches square.

Sizing an aggregate dry well. To size an aggregate dry well:

- Minimum Aggregate Dry Well Excavation Volume=
  - [Contributing Drainage Area (square feet) x 1.14 inches of rainfall x (1 foot/12 inches)] / 0.40

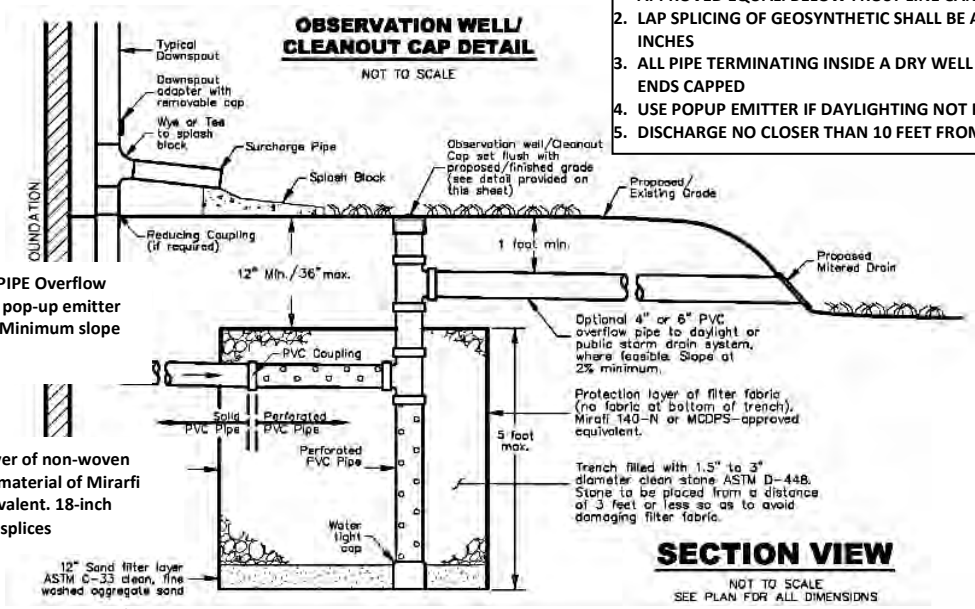
Note: The 0.40 value is the amount of void space the aggregate has (40%) to hold water

- Divide the volume by the excavated depth desired, in feet, to obtain the excavation area of the dry well. You can use different lengths and widths to achieve the minimum dry well area.

Sizing a tank dry well. To size a tank dry well:

- First, convert stormwater volume in cubic feet to gallons using 1 cubic foot of water being equal to 7.48 gallons; Minimum tanks volume, in gallons, needed =
  - [Contributing Drainage Area (square feet) x 1.14 inches of rainfall x (1 foot/12 inches)] x CF x7.48 gal/cf
    - CF = 1.1 if no infiltration test submitted or if infiltration test results are less than 0.25 inches.hour.
  - Consult tank manufacturer for tank capacity
- Number of Tanks = Minimum Tank Volume (Gallons) / Tank Capacity (gallons)
  - Round up to the nearest whole tank

NOTE:
1. **ALL PIPE ABOVE FROST LINE SHALL BE HDPE OR AN APPROVED EQUAL. BELOW FROST LINE CAN BE HDPE OR PVC.**
2. **LAP SPLICING OF GEOSYNTHETIC SHALL BE A MINIMUM OF 18 INCHES**
3. **ALL PIPE TERMINATING INSIDE A DRY WELL SHALL HAVE THE ENDS CAPPED**
4. **USE POPUP EMITTER IF DAYLIGHTING NOT POSSIBLE.**
5. **DISCHARGE NO CLOSER THAN 10 FEET FROM PROPERTY LINE.**



4-inch or 6-inch PIPE Overflow pipe to daylight, pop-up emitter or storm sewer. Minimum slope of 1 percent

Protection layer of non-woven geosynthetic material of Mirarfi 140 N or equivalent. 18-inch minimum lap splices

Infiltration Rate Limits. Measure the site infiltration rate according to Appendix A, if it is less than 0.25 in/hr, a dry well is not suitable for your site (a 10 percent increase in dry well volume

may be permitted. This 10% oversizing is not applied to sump dry wells or when adding the 175 sf sump discharge volume to a larger dry well system). If the infiltration rate is higher than 0.50 in/hr, the size of the dry well can be reduced:

- For every 0.5 in/hr increase in measured infiltration rate above 0.50 in/hr subtract ten percent of the required dry well size as measured in in square feet captured.

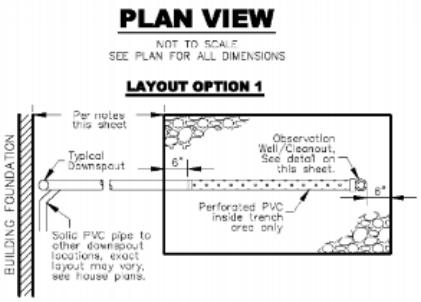
VEGETATION

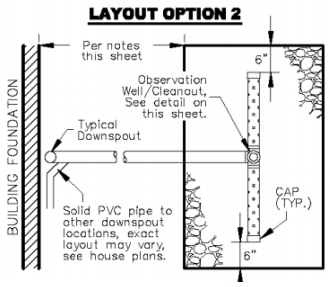
- The landscaped area above the surface of a dry well should be covered with pea gravel if water enters the dry well through surface features rather than a pipe. This pea gravel layer provides sediment removal and additional pretreatment upstream of the dry well and can be easily removed and replaced when it becomes clogged.
- Alternatively, a dry well may be covered with an engineered soil mix, and planted with managed turf or other herbaceous vegetation.

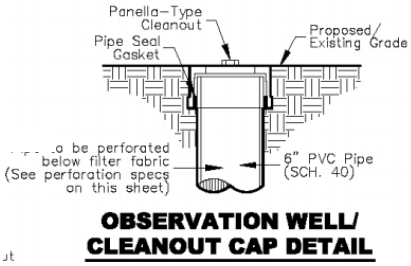
MAINTENANCE

Annual maintenance is important for dry wells to ensure they continue to provide measurable stormwater management benefits over time.

- Inspect gutters and downspouts removing accumulated leaves and debris.
- Inspect dry well following rainfall events.
- If applicable, inspect pretreatment devices for sediment accumulation. Remove accumulated trash and debris.
- Inspect top layer of filter fabric for sediment accumulation. Remove and replace if clogged.

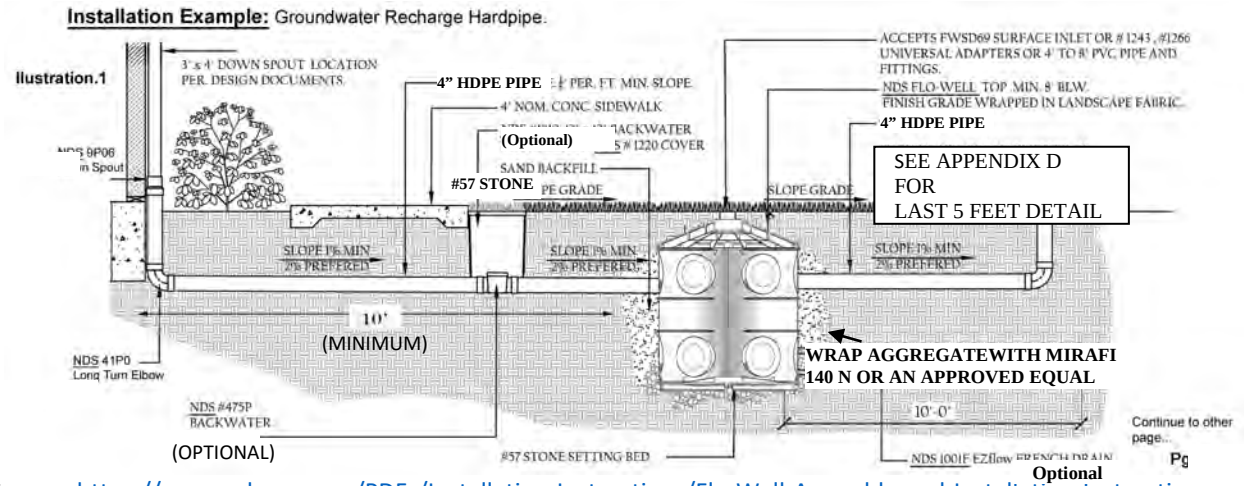






Gravel Bed Depth (inches)	Tank Height (inches)	Tank Inside Diameter (inches)					
		30	36	42	48	60	72
		Contributing Area Captured (square feet)					
6	30	340	440	550	680	960	1310
12	30	380	490	610	750	1060	1430
6	60	-	-	-	-	1790	2430
12	60	-	-	-	-	1890	2560

Hole Depth (inches)	6" Perforated Standpipe Square Gravel Hole (inches)						
	24	30	36	42	48	60	72
	Contributing Area Captured (square feet)						
24	40	60	80	100	130	200	290
30	-	70	100	130	160	250	360
36	-	-	110	150	190	300	430
42	-	-	-	180	230	350	500
48	-	-	-	-	260	400	570
60	-	-	-	-	-	500	710



(Source: https://www.ndspro.com/PDFs/Installation-Instructions/Flo-Well-Assembly-and-Installation-Instructio

(ATTACH TANK MANUFACTURER'S INSTALLATION & MAINTENANCE SPECIFICATIONS)

CONSTRUCTION STEPS:

1. **Drywell Layout.** Review potential dry well areas and layout. Dry wells shall not be located: (1) beneath an impervious (paved) surface or structure; (2) above an area with a water table or bedrock less than two feet below the trench bottom; (3) over other utility lines; (4) above a septic field, (5) closer than ten (10) feet from another dry well, or (6) on slopes greater than 5% (20:1). Ensure outlet daylights or is discharge through a popup emitter (See Appendix D) at least ten (10) feet from property line.
2. **Confirm Area.** Measure the area draining to the dry well and determine required size from the table on the next page.
3. **Infiltration Test.** Prior to submittal, perform an infiltration test according to Appendix A. If the rate is less than 0.25 in/hr increase storage volume by 10%. If the rate is more than 0.50 in/hr the storage volume may be decreased 10% for every 0.50 in/hr of infiltration rate increase above 0.50 in/hr. Default Infiltration test rate is 0.05 inches per hour.
4. **Dry well Excavation.** Measure elevations and dig the hole to the required dimensions. Scarify the bottom soil surface 3-4 inches.
5. **Geosynthetic Lining**. Place and secure Mirafi 140 N non-woven geosynthetic on bottom and down sides of the excavation leaving enough to have an 18-inch lap fold over the top below the soil and turf.
6. **Installation.**
   a. **Tank Option.** Place and tamp 6-inches to 12-inches of #57 gravel in bottom. Pea gravel can be substituted for leveling purposes in the upper three-inch layer below the tank. Place tank and install piping. Bond top of tank in place. Wrap tank with manufacturer's designated geosynthetic material. Strap and support tank as needed.
   b. **Aggregate Dry Well.** Set inflow, outflow and observation well pipes
   c. **Pipe.** Above Frost Line. All piping must be HDPE above frost line. Below frost line pipe can be HDPE or SCH 40 PVC
   d. **Perforated pipe.** All perforated pipe to be wrapped with polyester filter sock.
7. **Pretreatment Device(s).** Cut and route downspouts or other rainwater delivery components; install chosen leaf screen option(s) (circle-selected options in Pretreatment Options Detail figure in Appendix E).
8. **Overflow.** Create a safe overflow at least 10 feet from your property line and ensure it is protected from erosion.
9. **Test System.** Test connections with water flow.
   INITIAL INSPECTION POINT
10. **Backfill**
    a. **Tank Option.** Fill with gravel jacket around tank and place permeable fabric above between gravel and soil.
    b. **Aggregate Dry Well.** Carefully place #57 gravel and place fabric above and between gravel and soil.
    c. 8-inch thick (minimum) backfill over top of aggregate with soil/sod/seed and straw /or pea gravel.
11. Consider aesthetics as appropriate and erosion control for overflow.
    FINAL INSPECTION POINT

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	DRY WELL SPECIFICATIONS PAGE 1 OF 2

DRY WELL – LAYOUT SKETCH

PROVIDE PLAN AND ELEVATION VIEWS OF DRY WELL AND HOUSE SHOWING ROOF AREA DIRECTED TO DRY WELL AND KEY DIMENSIONS, CONNECTIONS AND OVERFLOW RELATIVE TO PROPERTY LINE. Dry Wells shall be setback a minimum of five (5) feet from water and sewer house connections and a minimum of three (3) feet from all other utilities unless a greater setback is required by the utility company. All utilities (for instance water, sewer, gas and electric) must be shown on the plan so setbacks can be verified.

SIZING CALCULATION:

SITE INFILTRATION RATE= _____ IN/HR (SEE SUBMITTED INFILTRATION TEST)

- IS BMP SUITABLE FOR SITE? □ YES □ NO
- CAN BMP SIZE BE REDUCED BY 10%? □ YES □ NO
- IS BMP SIZE TO BE INCREASED BY 10%? □ YES □ NO

Gravel Bed Depth (inches)	Tank Height (inches)	Tank Inside Diameter (inches)					
		30	36	42	48	60	72
		Contributing Area Captured (square feet)					
6	30	340	440	550	680	960	1310
12	30	380	490	610	750	1060	1430
6	60	-	-	-	-	1790	2430
12	60	-	-	-	-	1890	2560

Hole Depth (inches)	6" Perforated Standpipe Square Gravel Hole (inches)						
	24	30	36	42	48	60	72
	Contributing Area Captured (square feet)						
24	40	60	80	100	130	200	290
30	-	70	100	130	160	250	360
36	-	-	110	150	190	300	430
42	-	-	-	180	230	350	500
48	-	-	-	-	260	400	570
60	-	-	-	-	-	500	710

TANK TABLE ABOVE FORE PRECAST CONCRETE ONLY. MEASURE CONTRIBUTING DRAINAGE AREA AND READ AREA FOR GIVEN MEDIA DEPTH.

CONTRIBUTING DRAINAGE AREA= _____ SQ FT SLOPE GRADE (%)= ____

□ **TANK DESIGN:**

PRECAST CONCRETE TANK DIAMETER/WIDTH= _____ INCHES

PRECAST CONCRETE TANK HEIGHT= _____ INCHES

GRAVEL BED DEPTH (INCHES) = □ 6 □ 12

□ **AGGREGATE DESIGN:**

HOLE WIDTH= _____ INCHES HOLE LENGTH= _____ INCHES

HOLE DEPTH= _____ INCHES

MAINTENANCE:

1. INSPECT GUTTERS AND DOWNSPOUTS REMOVING ACCUMULATED LEAVES AND DEBRIS, CLEANING LEAF REMOVAL SYSTEM(S).
2. IF APPLICABLE, INSPECT PRETREATMENT DEVICES FOR SEDIMENT ACCUMULATION. REMOVE ACCUMULATED TRASH AND DEBRIS.
3. INSPECT DRY WELL FOLLOWING A LARGE RAINFALL EVENT (> 1 INCH) TO ENSURE OVERFLOW IS OPERATING AND FLOW IS NOT CAUSING PROBLEMS.
4. ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL

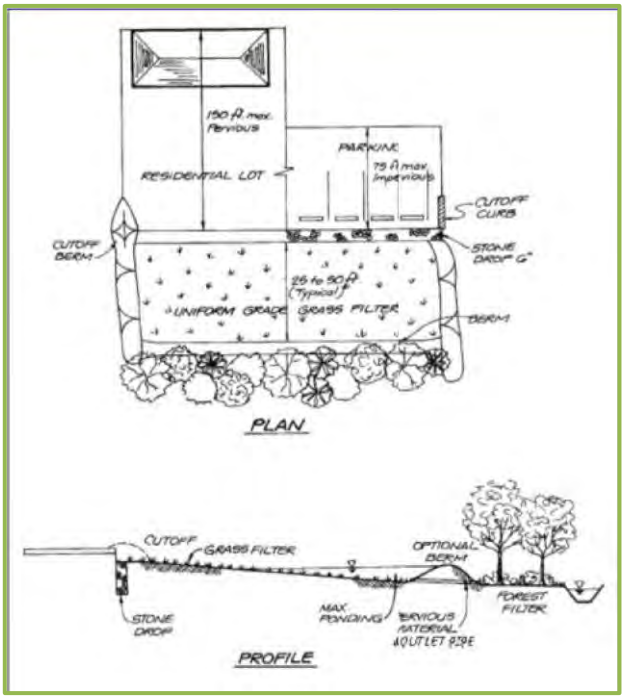
CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	DRY WELL SPECIFICATIONS PAGE 2 OF 2

VEGETATED FILTER STRIP AREAS

*** AMENDED SOIL OR BERM OPTIONS ARE AVAILABLE IN THIS SECTION**

A vegetated filter strip can be an attractive and functional addition to your home landscape. Vegetated filter strip areas (including amended soil) are uniformly graded, vegetated areas of land designed to receive rainwater as sheet flow and to slow and filter stormwater runoff from roof downspouts or parking areas. Vegetated filter strips can provide significant reductions in stormwater runoff and pollutant loads in your local watershed.

LOCATION



- **Ideal Location.** Observe the drainage patterns to determine the best location for a vegetated filter strip area. Assess the drainage area flow paths on your property, and the slope of the drainage area. Ideal locations are places where there is a gentle slope away from the structure or paved area, the area is relatively flat, and where the flow can be evenly distributed along the top of the filter area.
- **Ideal Slope.** The ideal slope of the vegetated filter strip area shall be between 1% (100:1) and 5% (20:1). Greater slopes would encourage the formation of concentrated flow within the filter strip area; lesser slopes would encourage unintended ponding. If the slope is greater, terracing can be used by installing level spreaders between each terrace.

Use vegetated filter strip (VFS) designed to infiltrate in these instances:

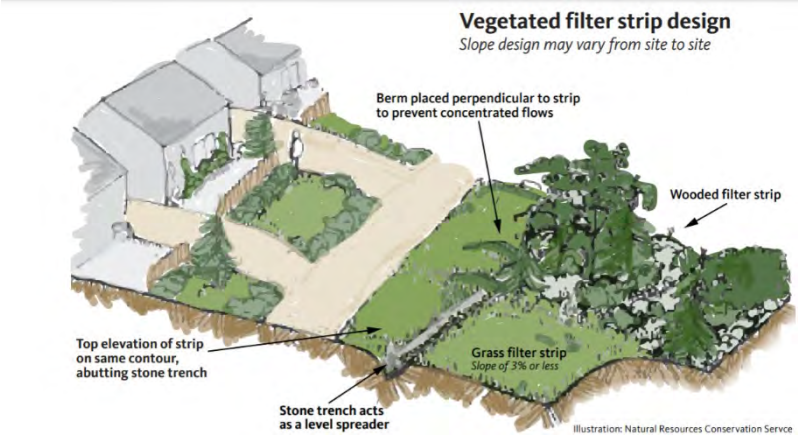
- Where the seasonal-high groundwater table is lower than 24 inches from the bottom of VFS;
- Where the bedrock is lower than 18 inches from the bottom of the VFS;
- 10 feet from a building with a basement or swimming pools;
- **Sump.** Vegetated filter strip sized to treat a minimum of 175 square feet of contributing area and sump pump discharge located a minimum of 20’ from any property line;
- 2 feet from a building without a basement (that is, slab on grade, crawl space, pier, or post foundations);
- Downhill of pervious areas with a maximum flow path of 150 feet;
- In existing forested areas, with some exceptions. Note that additional volumes of water can harm the health of established trees, especially Oregon white oak. Some species that can tolerate additional water after establishment include willow, ash, alder, poplar, and some maples. Consult with an International Society of Arboriculture Certified Arborist® if you have questions about tree species’ water tolerance level; and
- In any location designated by a qualified licensed engineer or geologist who has signed and stamped a geotechnical report, site plan, or letter.

Don't use an amended soil, bermed or conventional vegetated filter strip in these instances:

- Where it would slope over a contaminated groundwater plume;
- Where it would slope toward or flow over septic drain fields; and
- Where it would slope toward neighboring private properties.

Source: https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9208.pdf

- A filter strip area may be placed over utilities except when using the amended soil option. In that case, ensure utility locations are noted and care is taken to avoid them in soil amendment actions.
- The contributing drainage area (area of impervious surface) draining to any one discharge location cannot exceed 5,000 square feet.



Source: Center for Watershed Protection. 2009. Coastal Stormwater Supplement to the Georgia Stormwater Management Manual.

Minimum Length

- The length of the vegetated filter strip area should be no less than 25 feet. If there is a permeable berm at the lower end, the length of the vegetated filter strip area should be no less than 15 feet. Natural forested areas on site can be counted in the total length of the filter area.

CONSTRUCTION

Level Spreader

- **Definition.** An aggregate or prefabricated level spreader must be used at the upstream end of the filter area to evenly distribute stormwater runoff. A level spreader is a small trench filled with 1-inch clean stone installed along a level contour. Larger diameter stone may be required to stabilize entry points for larger contributing impervious areas.

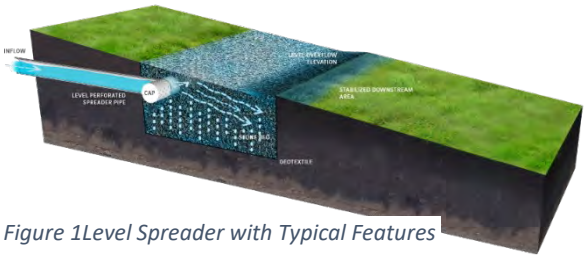


Figure 1Level Spreader with Typical Features

- **Restrictions.** The downstream side of the level spreader must be fully stabilized before the level spreader is installed. The minimum distance between the level spreader and any downslope property boundary must be 15 feet. The first ten (10) feet downslope of the level spreader must not exceed a slope of 4%. It is critical that the edge over which flow is distributed is exactly level.
- **Dimensions.** Level spreaders must safely diffuse flows up to, and including, the 10-year, 24-hour storm event (5.0 inch rainfall). The level spreader should be a minimum of 18" wide and 24" deep depending on the amount of expected flow.
- **Pipe Ends.** Pipe ends shall be either end-capped or connected to a pop-up emitter.
- To help ensure more even distribution of flow into the filter area, notches can be cut in the level spreader at intervals allowing overflowing water to enter at several locations ahead of general overflow.
- The level spreader can be connected, with solid HDPE pipe, to the downspout via a T-connection to the perforated pipes embedded in the level spreader trench (see figure 1). Level spreader pipes must be either 4-inch or 6-inch diameter perforated HDPE or approved equal, wrapped with a polyester filter sock.
- Ensure the overflow points are protected from erosion and not blocked by vegetation.

- **Waiver of Level Spreader.** If the impervious drainage area to any one entry point (e.g. a downspout) is less than 1,000 square feet appropriate level spreaders may be waived if flow will flow as a sheet through the strip area. In this case simple splash blocks (see figure) can be used to introduce flow into turf (yard) areas.

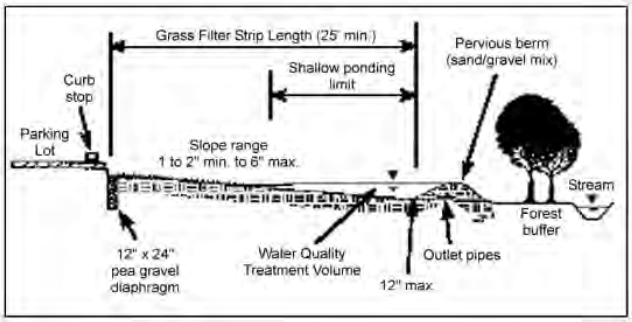
Conventional Design Option

- Conventional vegetated filter strip areas are uniformly graded BMP's that use an area of densely planted vegetation (typically grass) and a flat cross slope to maintain sheet flow and promote infiltration.
- **NOTE: This method cannot be used if the results of the soil infiltration test described in Appendix A are less than 0.50 inch per hour; the amended soil design option must be used instead.**

Berm Design Option

- A greater ability to meet the 1.14-inch rainfall standard can be achieved using a permeable berm at the bottom end of the filter strip. The permeable berm is used to temporarily store stormwater runoff within the filter area, which increases the infiltration and reduces the required width of the filter area.
- Permeable berms should be constructed of well-drained soils (sand, gravels, and sandy loams) that support plant growth, and should be no more than 12" high.

Source: www.neorsd.org



- Appropriately sized outlets should be provided within permeable berms to ensure that vegetated filter areas will drain within 24 hours following the end of a rainfall event.
- A stone-protected overflow area cut through the berm may be used to manage the stormwater runoff generated by large storm events. The overflow point must be at least ten feet from the property line if flow is directed onto an adjoining property. Erosion protection is critical.
- **NOTE: This method cannot be used if the results of the soil infiltration test described in Appendix A are less than 0.50 inch per hour; the amended soil design option must be used instead.**

Terracing (Benching, Slope Stepping, Steps)

- Terraces can be constructed by installing stone, concrete blocks, or other material at the base of the flatter section of a slope to help stabilize the soil above. This practice is similar to constructing a number of small retaining walls up the slope. When terracing is required it shall be in accordance with https://tahoebmp.org/Documents/BMPHandbook/Chapter%204/4.2/e_Terrac.pdf or an engineer-approved method.

Amended Soil Design Option

- Increased infiltration and a doubling of the ability to meet the 1.14-inch rain standard can be achieved by amending the soil within the filter area by tilling the existing soil to a depth of 12 inches and mixing in 4 inches of compost.
- **Compost**. A copy of the lab analysis, less than four months old, performed by a Seal of Testing Assurance Certified Laboratory verifying that the compost meets the physical requirements, shall be provided to the inspector at the time of initial inspection.

Compost Application Procedure.

- Clear surface of obstructions and properly dispose. The soil surface shall be reasonably free of all objects, including stone and rubble, greater than 2 inches, and other material which will interfere with planting and subsequent site maintenance.

- Rototill to a minimum depth of 12 inches for turf cover or deep rooted vegetation. If the soil is too dense for a rototiller, the soil should first be broken up into large aggregates using a soil ripper.
- If obstructions are unearthed during tilling, clear obstructions and properly dispose of. The soil surface shall be reasonably free of all objects, including stone and rubble, greater than 2 inches, and other material which will interfere with planting and subsequent site maintenance.
- Distribute compost evenly to a minimum depth of 4 inches over the soil surface.
    - Cubic Yards of Compost = [Filter Strip Area (square feet) *0.33 feet]/27cubic feet per cubic yard
        - Cubic Yards of Compost = 0.0122*Filter Strip Area (square feet)
        - i.e., for 905 square feet of filter strip you would need 11 cubic yards of compost
- Rototill several times in perpendicular directions to incorporate compost and other soil amendments.
- Complete with fine grading and sodding.
- Water thoroughly. Allow soil to settle for one week.

NOTE: The soil infiltration rate suitable for the Amended Soil Design Option is 0.25 in/hr or greater. If the results of the soil infiltration test described in Appendix A are less than 0.25 in/hr, provide an underdrain leading to daylight or discharged with a popup emitter as described in Appendix D.

Design Table

Measure the rooftop and other areas to be directed to the filter strip area. Depending on the site layout select the size and type of filter strip area from the table at right to meet the 1.14-inch design standard rainfall. For example, for a 1,000 square foot rooftop, a conventional filter strip must have a surface area of at least 2,000 square feet and a minimum flow length of 25 feet. If built with a berm, it can have a surface area of 700 square feet and a minimum flow length of 15 feet.

Contributing Drainage Area (square feet)	Filter Strip Type		
	Conventional	Amended Soil	Berm
	Filter Strip Area (sq ft)		
100	200	100	75
500	1000	500	350
1000	2000	1000	700
2000	4000	2000	1500
3000	6000	3000	2000
4000	8000	4000	3000
5000	10000	5000	3500

VEGETATION

- Vegetation commonly planted on vegetated filter strip area includes turf, shrubs, trees, and other herbaceous vegetation.
- Choose grasses and other vegetation that will be able to tolerate the stormwater runoff rates and volumes that will pass through the vegetated filter strip area.
- Vegetation used in filter strip areas should be able to tolerate both wet and dry conditions.
- Refer to Appendix B for more guidance. **Designate vegetation plan on submitted site plan.**

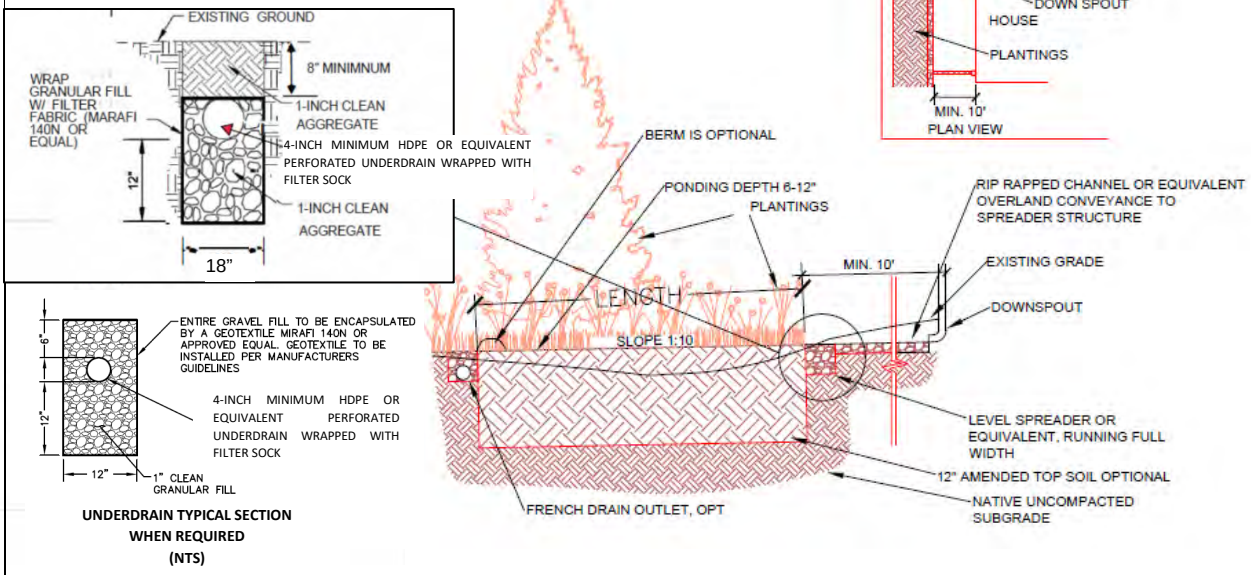
MAINTENANCE

Maintain the vegetated filter strip area so that it will continue to provide measurable stormwater management benefits over time.

- Water as needed to promote plant growth and survival especially in the first two seasons.
- Provide normal turf or garden maintenance - mow, prune, and trim as needed.
- Inspect the vegetated filter strip and terrace areas following rainfall events. Correct erosion issues immediately.
- Remove accumulated trash, sediment, and debris.

VEGETATED FILTER STRIP AREAS
TYPICAL COMPONENTS

RESIDENTIAL LEVEL SPREADER TYPICAL SECTION (NTS)



UNDERDRAIN TYPICAL SECTION WHEN REQUIRED (NTS)

CONSTRUCTION STEPS:

1. Review potential filter strip areas and layout. Filter strips should slope between 1% and 5% away from the structure and should not be located above a septic field. Filter strips may be located over utilities except when using the amended soil option. In that case, be sure to note utility locations and take care when preparing the amended soil. If there is a concentrated overflow, ensure it is at least ten feet from adjacent property.
2. Prior to submittal, perform an infiltration test according to Appendix A. If the rate is less than 0.25 in/hr the amended soil option must be used. If the infiltration rate is less than or equal to 0.05 in/hr, this method can only be used with an underdrain as described in Appendix D.
3. Measure the area draining to the filter strip and determine required surface area and minimum length from the table on the next page. Determine the desired filter strip and level spreader options.
4. Lay out and mark the filter strip area, flow spreader line, and inlets.
5. Construct level spreader by filling trench with appropriate gravel, taking note of overflow points.
6. Construct filter strip option, prepare soil. Construct terracing if necessary.
7. If underdrain required, excavate area, install geosynthetic, install bedding aggregate, and install perforated HDPE (if below frost line: HDPE or PVC) (or equivalent) pipe with polyester filter sock.
   INTIAL INSPECTION POINT
8. Construct erosion control at the flow entrance and exit points as needed.
9. Plant dense vegetation according to plan, or sod/seed. Ensure an irrigation plan is in place.
10. Ensure temporary erosion control is in place as needed until vegetation is well-established.
    FINAL INSPECTION POINT

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	FILTER STRIP SPECIFICATIONS PAGE 1 OF 2

VEGETATED FILTER STRIP – LAYOUT SKETCH

PROVIDE PLAN AND ELEVATION VIEWS OF FILTER STRIP AND STRUCTURE/HOUSE SHOWING ROOF AREA DIRECTED TO FILTER STRIP WITH KEY DIMENSIONS, CONNECTIONS AND OVERFLOW RELATIVE TO PROPERTY LINE. DESIGNATE VEGETATION PLAN ON SITE PLAN.

SIZING CALCULATION:

SITE INFILTRATION RATE= _____ IN/HR

- IS AN UNDERDRAIN REQUIRED? □ YES □ NO
- WHICH OPTION SUITABLE FOR THE SITE?
  □ CONVENTIONAL □ AMENDED SOIL □ BERM

Contributing Drainage Area (square feet)	Filter Strip Type		
	Conventional	Amended Soil	Berm
	Filter Strip Area (sq ft)		
100	200	100	75
500	1000	500	350
1000	2000	1000	700
2000	4000	2000	1500
3000	6000	3000	2000
4000	8000	4000	3000
5000	10000	5000	3500

MEASURE CONTRIBUTING DRAINAGE AREA AND READ AREA FOR GIVEN FILTER STRIP TYPE.

FILTER STRIP TYPE: □ CONVENTIONAL □ AMENDED SOIL □ BERM

CONTRIBUTING DRAINAGE AREA= _____ SQ FT

FILTER STRIP AREA= _____ SQ FT

CONVENTIONAL LENGTH = _____ FT (25' MINIMUM LENGTH)

BERM OPTION = _____ FT (15' MINIMUM LENGTH)

COMPOST OPTION= _____ CUBIC YARDS, MINIMUM

MAINTENANCE:

1. INSPECT GUTTERS AND DOWNSPOUTS, REMOVE ACCUMULATED LEAVES AND DEBRIS, CLEAN LEAF REMOVAL SYSTEM(S).
2. IF APPLICABLE, INSPECT PRETREATMENT DEVICES FOR SEDIMENT ACCUMULATION. REMOVE ACCUMULATED TRASH AND DEBRIS.
3. IF PLANTING SELECTED, SUBMIT PLANTING PLAN AT THE TIME OF THE INITIAL INSPECTION.
4. WATER AS NEEDED TO PROMOTE PLANT GROWTH AND SURVIVAL ESPECIALLY IN THE FIRST TWO SEASONS.
5. PROVIDE NORMAL TURF OR GARDEN MAINTENANCE - MOW, PRUNE, AND TRIM AS NEEDED.
6. INSPECT THE VEGETATED FILTER STRIP AND TERRACES (IF INSTALLED) FOLLOWING RAINFALL EVENTS. CORRECT EROSION ISSUES IMMEDIATELY.

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	FILTER STRIP SPECIFICATIONS PAGE 2 OF 2

MODIFIED FRENCH DRAINS

Modified French Drains (MFD) are shallow trench excavations filled with stone that are designed to intercept and temporarily store storm water runoff until it infiltrates into the soil. MFDs can provide significant reductions in storm water runoff and pollutant loads. They are particularly well suited to receive rooftop runoff, but can also be used to receive storm water runoff from other small impervious areas. In Kirkwood, only the daylighted French Drain version is permitted in residential applications. The perforated pipe is daylighted at its end to allow for overflow of larger storm events as a failsafe mechanism if infiltration is less than anticipated.

LOCATION

- **Setbacks.** MFD trenches should be located at least 5 feet from building with slab foundations and 10 feet from property lines, buildings with basements, and below-ground swimming pools. The top end of the MFD can be adjacent to the building to connect downspouts but should be directed away from the structure.
- **Slope.** MFDs should slope away from the structures. The slope of the MFD pipe should be between 0.5% and 6%. It can be serpentine or multi-pronged in construction if sufficient slope is available and spacing is kept at least 15 feet apart.
- **Pretreatment.** To reduce the chance of clogging, MFDs should drain only impervious areas. Pretreat runoff with at least one of the leaf removal options to remove particulates and larger debris.
- **Dimensions.** MFD gravel depths should be at least 18 inches and no more than 36 inches.
- **Location.** MFDs should be located in a lawn or other pervious (unpaved) area; and should be designed so that the top of the MFD is located as close as possible to the soil surface to reduce digging.

- NOTE: MFDs should **not** be located:
  (1) Beneath an impervious (paved) surface or structure;
  (2) Above an area with a water table or bedrock less than two feet below the trench bottom;
  (3) Over other utility lines; or,
  (4) Above a septic field. Always call Missouri One Call to locate utility lines before you dig.
- **Discharge.** The downstream end of the pipe must daylight (with rodent protection screen) or be discharged with a pop-up emitter for overflows at least ten feet from the property line.

CONSTRUCTION

- **Stone Volume.** As a rule of thumb, there should be about 23 cubic feet of stone for every 100 square feet of rooftop. The table provides MFD length requirements for different depths.
- **Table.** Measurements in the table at right are based on trench width of 24 inches, however the width can be from 18 to 32 inches. Required lengths should be adjusted proportionately if other widths are used.

Rooftop Area (square feet)	Depth of Gravel From Top of Pipe (inches)			
	18	24	30	36
	Required Linear Feet of MFD			
100	7	5	4	4
500	35	25	20	20
1000	70	55	45	35
2000	140	110	90	75
3000	210	160	130	110
4000	280	215	175	150
5000	345	270	220	185

- **Trench Preparation.** The sides of the excavation should be trimmed of all large roots that will hamper the installation of the permeable drainage fabric to be placed part way down the sides and above the gravel layer on top of the MFD.
- Scarify or till the native soils along the bottom of the MFD to a depth of 3-4 inches.
- Fill the MFD with clean, washed ASTM No. 57 stone; embed a four (4) or six (6)-inch diameter HDPE (When below frost line: HDPE or PVC) perforated pipe (WRAPPED WITH POLYESTER FILTER SOCK) in the top top of the stone such that the stone covers the top of the pipe. No. 57 stone averages ½ inch to 1-½ inches.

- The pipe should have 3/8-inch perforations, spaced 6 inches on center, and have a minimum slope of 0.5% and a maximum slope of 6%.
- The perforated pipe must daylight at the downstream end of the trench. The daylighted discharge end shall be capped with a rodent-proof screen or end with a pop-up emitter.
- An overflow, such as a vegetated filter strip area or grass channel, must be designed to safely convey stormwater runoff generated by larger storm events out of the downstream end of the MFD.
- Place permeable landscape fabric over soil/pea gravel to prevent it from migrating into the stone and clogging the pore spaces; leave a four to six-inch space above the pipe to the ground surface.
- Cover with top soil and sod or with pea gravel.
- For rooftop runoff, install one or more leaf screen options upstream from/ahead of the MFD to prevent leaves and other large debris from clogging the MFD. For driveway or parking runoff a screened inlet grate over a sump or pea gravel pit can be used to settle out material prior to entering the pipe.
- **NOTE: This method cannot be used if the results of the soil infiltration test described in Appendix A are less than 0.25 in/hr.**

VEGETATION

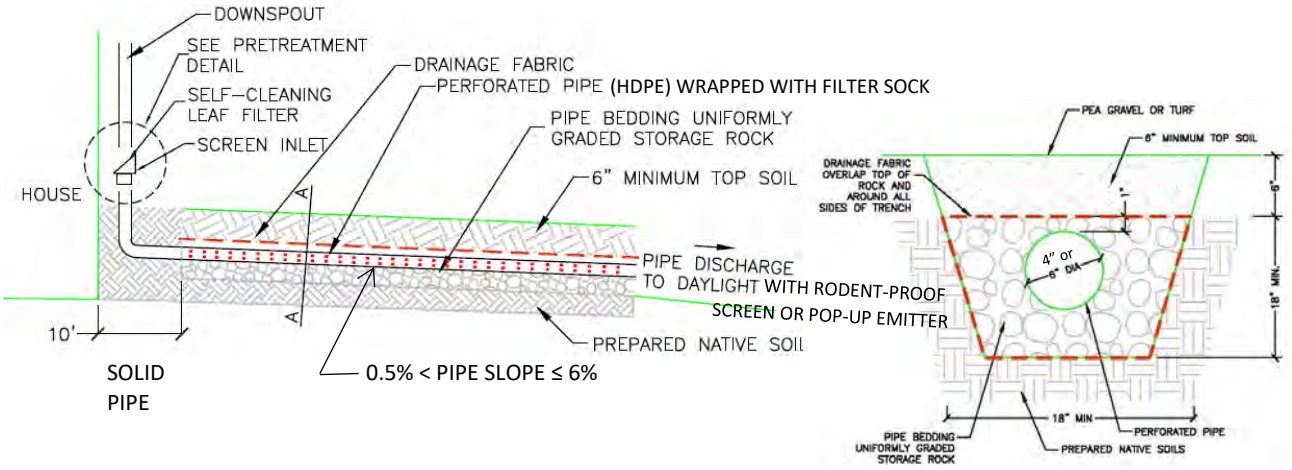
- MFDs are normally covered with topsoil and managed turf or other herbaceous vegetation.
- As an alternative, the area above the surface of a MFD may be covered with pea gravel (or larger depending on the inflow rates) to allow for incidental lateral inflow along the edge of ground level impervious surfaces.
- The downstream end of the pipe must be stabilized and can be landscaped for aesthetics.

MAINTENANCE

Annual maintenance is important for MFDs.

- Inspect gutters and downspouts removing accumulated leaves and debris, and cleaning leaf removal system(s).
- Inspect any pretreatment devices for sediment accumulation. Remove accumulated trash and debris.
- Inspect MFDs following a large rainfall event to ensure overflow is operating and flow is not causing problems.

MODIFIED FRENCH DRAINS



SECTION A-A

CONSTRUCTION STEPS:

1. Prior to submittal, perform an infiltration test according to Appendix A. **If the rate is less than 0.25 in/hr, this method cannot be used.** If the rate is more than 0.50 in/hr, the length of the ditch may be decreased 10% for every 0.50 in/hr infiltration rate increase above 0.50 in/hr.
2. Review potential MFD areas and layout. MFDs should slope between 0.5% and 6% away from structures and should not be located: (1) beneath an impervious (paved) surface or structure; (2) above an area with a water table or bedrock less than two feet below the trench bottom; (3) over other utility lines; or, (4) above a septic field. Ensure outlet daylights or is discharged with a pop-up emitter at least ten feet from property line.
3. Measure the area draining to the MFD and determine required length from the table on the next page using assumed width and gravel depth, and plan route and excavation depth.
4. Measure elevations, lay out the MFD to the required dimensions marking the route, and required excavation depths. Often a level line (torpedo level) is used.
5. Remove sod using a sod cutter if appropriate. Excavate ditch to the depth of the gravel plus six inches for topsoil/pea gravel and three additional inches to accommodate half the pipe depth. Be careful not to compact soils in the bottom. Level the bottom laterally as much as possible to maximize the infiltration area. Roughen bottom to a depth of at least three inches and trim roots.
6. Place Mirafi 140 N or approved equal drainage fabric along the bottom and sides of the trench with enough excess to extend over the top of pipe and stone. This fabric must be a needle-punched nonwoven polypropylene geotextile.
7. Place and tamp gravel in ditch to bottom of pipe elevation. Placing the 4 or 6-inch diameter perforated HDPE (When below frost line: HDPE or PVC pipe), wrapped with polyester fabric, on top of the gravel.
   INITIAL INSPECTION POINT
8. Then place and gently tamp gravel around and over the pipe until it covers the pipe by 1 inch. Lap geosynthetic over gravel a minimum of 18 inches.
9. Place 6-inches of topsoil and cap with sod or pea gravel.
10. **Pretreatment Option.** Cut and route downspouts or other rainwater delivery components, leaf screen option(s) chosen (circle selected option(s) in Pretreatment Options Detail figure in Appendix E). Strap and support as needed.
11. Create a safe overflow at least 10 feet from your property edge and ensure it is protected from erosion.
    FINAL INSPECTION POINT

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MODIFIED FRENCH DRAIN – LAYOUT SKETCH

PROVIDE PLAN AND ELEVATION VIEWS OF MFD AND HOUSE SHOWING ROOF AREA DIRECTED TO MFD AND KEY DIMENSIONS, CONNECTIONS AND OVERFLOW RELATIVE TO PROPERTY LINE.

SIZING CALCULATION:

SITE INFILTRATION RATE= _____ IN/HR

- IS BMP SUITABLE FOR SITE? □ YES □ NO
- CAN BMP SIZE BE REDUCED? □ YES □ NO

Rooftop Area (square feet)	Depth of Gravel From 1-inch above Top of Pipe (inches)			
	18	24	30	36
	Required Linear Feet of MFD			
100	7	5	4	4
500	35	25	20	20
1000	70	55	45	35
2000	140	110	90	75
3000	210	160	130	110
4000	280	215	175	150
5000	345	270	220	185

MEASURE CONTRIBUTING ROOFTOP (DRAINAGE) AREA AND READ AREA FOR GIVEN 18-36 INCH DEPTH of #57 GRAVEL.

CONTRIBUTING DRAINAGE AREA= _____ SQ FT

DEPTH OF GRAVEL= _____ INCHES

WIDTH OF TRENCH= _____ INCHES (18 INCHES, MINIMUM)

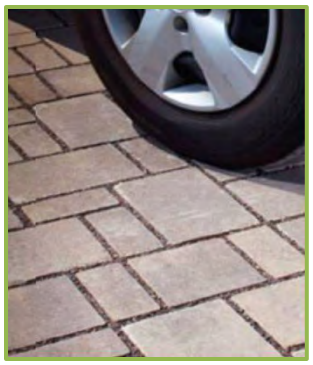
LENGTH OF MFD= _____ FT

MAINTENANCE:

1. INSPECT GUTTERS AND DOWNSPOUTS, REMOVE ACCUMULATED LEAVES AND DEBRIS, CLEAN LEAF REMOVAL SYSTEM(S).
2. IF APPLICABLE, INSPECT PRETREATMENT DEVICES FOR SEDIMENT ACCUMULATION. REMOVE ACCUMULATED TRASH AND DEBRIS.
3. INSPECT MFD FOLLOWING A LARGE RAINFALL EVENT TO ENSURE OVERFLOW IS OPERATING AND FLOW IS NOT CAUSING PROBLEMS.

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	MODIFIED FRENCH DRAIN SPECIFICATIONS PAGE 2 OF 2

PERMEABLE PAVERS



Permeable pavers are an alternative to traditional paving surfaces which can decrease stormwater runoff around your home. They are well-suited for use when constructing sidewalks, parking areas, patios, and driveways not within public right-of-way. Permeable pavers consist of permeable interlocking or grid concrete pavers underlain by a drainage layer. A permeable paver system allows stormwater runoff to pass between the paver surfaces into an underlying stone reservoir, where it is temporarily stored and allowed to infiltrate into the underlying soil. Permeable pavers can provide significant reductions in stormwater runoff and pollutant loads in your watershed.

LOCATION

- Permeable pavers are only allowed when used as a BMP.
- Maximum contributing drainage area to surface area ratio is 4:1.
- Permeable paver systems should be located at least 5 feet from building foundations and 10 feet from buildings with basements.
- NOTE: Permeable pavers should not be located:
  (1) above an area with a seasonally high-water table less than three feet below the gravel bottom. or bedrock less than two feet below the gravel bottom;
  (2) over other utility lines;
  (3) above a septic field; or
  (4) within Right-of-Way.
- Permeable pavers should drain only impervious areas. Drainage from other areas onto the pavers will eventually clog them.
- **Slope Limits.** Permeable paver systems should be installed on slopes less than 6% (16.7:1, H:V) to help ensure even distribution of runoff over the infiltration surface; pavers should slope away from structures.

CONSTRUCTION

The table at the right provides Permeable Paver area size requirements for different depths of the ASTM No. 57 stone layer. This stone averages in size from ½" to 1-½". Example: A roof top measures 1000 square feet. For a stone depth of 8 inches the required area of permeable pavers 310 sq ft.

Contributing Drainage Area (square feet)	Depth of Lower Stone Storage Layer (inches)				
	4	5	6	8	12
	Area of Pavers (square feet)				
100	60	50	40	40	30
500	260	230	200	160	120
1000	520	450	390	310	230
2000	1040	890	780	620	450
3000	1550	1330	1170	930	670
4000	2070	1770	1550	1240	890
5000	2580	2220	1940	1550	1110

- Always call Missouri One Call to locate utility lines before you dig.
- Permeable paver systems require multiple layers. Manufacturer's instructions, if available, should be followed in lieu of these guidelines.
- **Infiltration Limits.** The soil infiltration rate suitable for a paver system is 0.25 inches per hour (in/hr) or greater. Conduct a soil infiltration test per Appendix A. Professional assistance shall be obtained in this case. If the rate is less than 0.25 in/hr, provide an underdrain leading to daylight (with rodent-proof screen) or discharged with a popup emitter as described in Appendix D.
- **Top Course of Aggregate.** The top course consists of the pavers and a crushed aggregate material swept between the paver

joints, such as ASTM No. 8 stone or 1/8" to 3/8" pea gravel. The thickness of this layer varies depending upon the depth of the paver.

- **Bedding Course of Aggregate.** The bedding course consists of 2 to 3 inches of No. 8 stone, or 1/8" to 3/8" pea gravel. The bedding course provides a level bed for setting the pavers evenly.
- **Aggregate Base Course.** The aggregate base course consists of a minimum of 4 inches of No. 57 stone. The aggregate base course acts as a reservoir to provide stormwater storage capacity.
- **Permeable Drainage Geosynthetic.** A permeable drainage geosynthetic must be used to separate the aggregate base course from the subgrade. This fabric must be a needle-punched nonwoven polypropylene geotextile of Mirafi® brand 140N or equivalent material. Lapping of fabric shall be at least 18 inches.

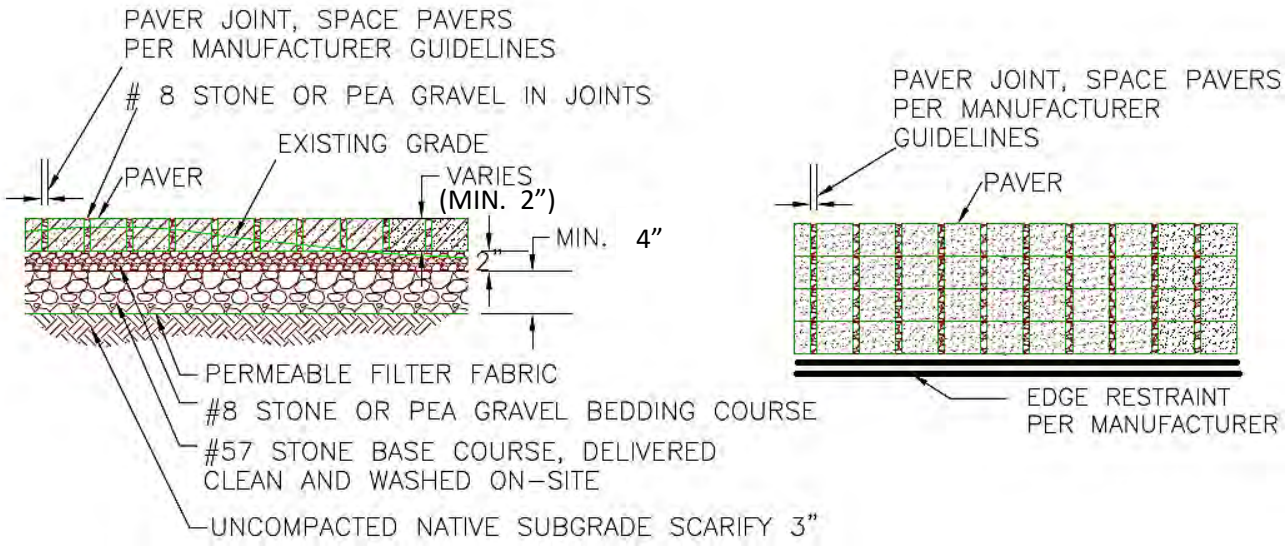
- **Subgrade.** The subgrade layer is the layer of native soils below the gravel and the permeable drainage fabric. Prepare the subgrade soil layer by scarifying or tilling to a depth of 3-4 inches.
- Care should be taken to avoid compaction of the soil in the location planned for the permeable pavers during home construction.
- Excavation to final subgrade elevation should not take place until the pavers are ready to be installed.
- **Subgrade slope.** Even though the permeable pavement surface is sloped, the sub-grade of the treatment measure should be flat and in some cases, terraced where the driveway has a steep slope, in order to promote infiltration. Additionally, this will prevent the stormwater from running along the bottom of the subgrade and discharging at the bottom of the slope.
- **Underdrain.** Prior to submittal, perform an infiltration test according to Appendix A. I If the rate is less than 0.25 in/hr, provide an underdrain leading to daylight (with rodent-proof screen) or discharged with a popup emitter as described in Appendix D.
- **Paver Area Reduction.** If the infiltration rate is more than 0.50 in/hr the paver area may be decreased 10% for every 0.50 in/hr of infiltration rate increase above 0.50 in/hr.

MAINTENANCE

Maintenance is very important for permeable pavers systems, particularly in terms of ensuring that they continue to provide measurable stormwater management benefits over time.

- Remove accumulated sediment and debris from joint spaces monthly.
- Monitor the permeable paver system for excessive ponding during storm events and repair as needed.
- Vacuum, sweep, or blow permeable paver surfaces quarterly to keep the surface free of sediment.
- Sweep new No. 8 stone into the spaces between stones as needed. Inspect permeable paver surface for deterioration annually. Repair or replace any damaged areas as needed.

PERMEABLE PAVERS – LAYOUT SKETCH



TYPICAL COMPONENTS (ATTACH MANUFACTURER'S INSTALLATION GUIDELINES)
CONSTRUCTION STEPS:

1. Prior to submittal, perform an infiltration test according to Appendix A. If the rate is less than 0.25 in/hr this method can only be used with an underdrain as described in Appendix D. If the rate is more than 0.50 in/hr the paver area may be decreased 10% for every 0.50 in/hr of infiltration rate increase above 0.50 in/hr.
2. Review potential paver areas and layout. Pavers should slope less than 6% away from the structure and should not be located: (1) above an area with a water table or bedrock less than two feet below the trench bottom; (2) over other utility lines; or, (3) above a septic field.
3. Measure the area draining to the pavers and determine required paver area from the table on the next page based on the depth of the lower stone storage layer.
4. Excavate area to appropriate depth and scarify soil to 3-4 inches.
5. If underdrain required, excavate area, install geosynthetic, install bedding aggregate, and install perforated HDPE (if below frost line: HDPE or PVC), or equivalent pipe wrapped with polyester filter sock.
6. Place permeable drainage geosynthetic in the excavated area in order to separate the aggregate base course from the subgrade. This geosynthetic must be a needle-punched nonwoven polypropylene geotextile of Mirafi® brand 140N or equivalent material.
   INITIAL INSPECTION POINT
7. Place and tamp No. 57 stone base course to specified depth in no more than six-inch lifts. Four-inch minimum depth.
8. Place and tamp No. 8 stone or pea gravel bedding layer to depth specified. Two-inch minimum depth.
9. Lay paving stone one at a time or using mechanical placement as applicable. Cut stone at edges to fit.
10. Install edge restraints per manufacturer's specifications.
11. Sweep more No. 8 stone or pea gravel into stone joints until filled and even.
12. Cut and route downspouts or other rainwater delivery components, leaf screen option(s) chosen (circle selected options in Pretreatment Options Detail figure in Appendix E). Strap and support as needed.
13. Backfill perimeter of pavers where required and establish vegetation
    FINAL INSPECTION POINT

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	PERMEABLE PAVER SPECIFICATIONS PAGE 1 OF 2

PERMEABLE PAVERS – LAYOUT SKETCH

PROVIDE PLAN AND ELEVATION VIEWS OF PERMEABLE PAVER SYSTEM AND STRUCTURES/HOUSE SHOWING ROOF AREA DIRECTED TO PAVERS AND KEY DIMENSIONS, CONNECTIONS AND ANY APPLICABLE OVERFLOW RELATIVE TO PROPERTY LINE. ATTACH MANUFACTURER'S SPECIFICATIONS IF APPLICABLE. ATTACH INFILTRATION TEST RESULTS WHEN PERFORMED.

SIZING CALCULATION:

SITE INFILTRATION RATE= _____ IN/HR

- IS UNDERDRAIN REQUIRED? □ YES □ NO □ N/A
- CAN BMP AREA BE REDUCED? □ YES □ NO □ N/A

IF YES, BY WHAT %: □ 10 □ 20

Contributing Drainage Area (square feet)	Depth of Lower Stone Storage Layer (inches)				
	4	5	6	8	12
	Area of Pavers (square feet)				
100	60	50	40	40	30
500	260	230	200	160	120
1000	520	450	390	310	230
2000	1040	890	780	620	450
3000	1550	1330	1170	930	670
4000	2070	1770	1550	1240	890
5000	2580	2220	1940	1550	1110

MEASURE CONTRIBUTING DRAINAGE AREA AND READ AREA FOR GIVEN MEDIA DEPTH.

CONTRIBUTING DRAINAGE AREA= _____ SQ FT
DEPTH OF BEDDING COURSE LAYER= _____ INCHES (2 IN, MIN)
DEPTH OF LOWER STORAGE LAYER (INCHES): □ 4 □ 5 □ 6 □ 8 □ 12
PAVER AREA (SF)= _____ ADJUSTED PAVER AREA (SF): _____

MAINTENANCE:

1. REMOVE ACCUMULATED SEDIMENT AND DEBRIS FROM JOINT SPACE MONTHLY.
2. MONITOR THE PERMEABLE PAVER SYSTEM FOR EXCESSIVE PONDING DURING STORM EVENTS AND REPAIR AS NEEDED.
3. VACUUM, SWEEP, OR BLOW PERMEABLE PAVER SURFACE QUARTERLY TO KEEP THE SURFACE FREE OF SEDIMENT. SWEEP NEW STONE INTO THE JOINTS AS NEEDED.
4. INSPECT PERMEABLE PAVER SURFACE FOR DETERIORATION ANNUALLY. REPAIR OR REPLACE ANY DAMAGED AREAS AS NEEDED.

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	PERMEABLE PAVER SPECIFICATIONS PAGE 2 OF 2

RAIN GARDENS

Rain gardens are small, landscaped depressions that are filled with a mix of native soil and compost, and are planted with trees, shrubs and other garden-like vegetation. They are designed to temporarily store storm water runoff from rooftops, driveways, patios and other areas around your home while reducing runoff rates and pollutant loads in your local watershed. A rain garden can be a beautiful and functional addition to your landscape.

LOCATION

- Rain gardens should be located to receive the maximum amount of storm water runoff from impervious surfaces, and where downspouts or driveway runoff can enter garden flowing away from the home.
- Swales, berms, or downspout extensions may be helpful to route runoff to the rain garden.
- Locate at least 10 feet from foundations, not within the public right of way, away from utility lines, not over septic fields, and not near a steep bluff edge. Call Missouri One Call before you dig to locate the utility lines on your property.
- **Terracing.** Rain gardens on steep slopes (>10% or 10:1) may require an alternative design with terracing.

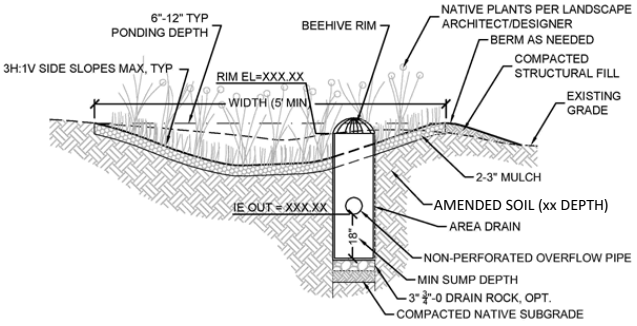
DESIGN

- The size of the rain garden will vary depending on the impervious surface draining to it and the depth of the amended soils. Use the table to determine the required surface area. A good rule of thumb is that the rain garden should be about twice as long (perpendicular to the slope) as it is wide.
- **Ponding Depth / Berm.** The rain garden ponding depth (settling basin) is determined by the slope of the lawn. For up to 4% slopes, construct a 4-inch-deep rain garden ponding depth. For a maximum 5% (20:1) slope, construct a 6-inch-deep rain garden ponding depth. A maximum ponding depth of 6 inches is allowed within rain gardens. On average, rain gardens drain within a day, which will not create a mosquito problem. A berm is not required when the lawn slope is flat (≤ 2% or 50:1). The berms shall have side slopes no steeper than a 33% or 3:1 (H:V).

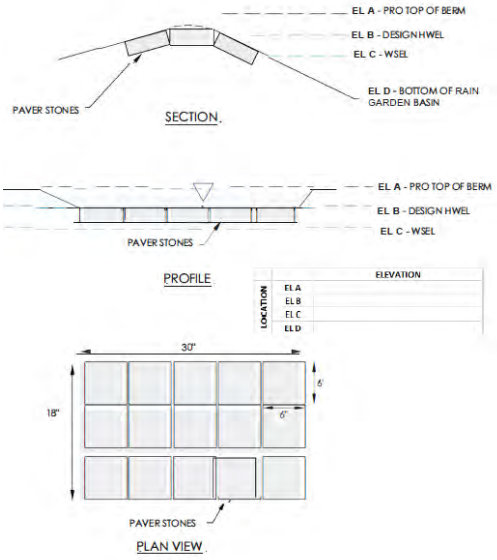
Source: https://www.quartoknows.com/blog/quartohomes/howtomakearaingarden

- **Entrance.** Design the rain garden entrance to immediately intercept stones, dense hardy vegetation or by other means.
- **Side Slope.** If sides are to be mowed, rain gardens should be designed with side slopes of 33% or 3:1(H:V) or flatter.
- **Soil Characteristics.** For best results, it is suggested to test your soil characteristics as you would for a garden, or contact your local County Extension Service for help (https://extension2.missouri.edu/counties/st-louis/services). Soils for rain gardens should be amended native soils containing: 2/3 native soils and 1/3 compost.
- **Mulch Layer.** A mulch layer consisting of 2-3 inches of non-floatable organic mulch (fine shredded hardwood (cypress) mulch, pine straw, or leaf compost) should be included on the surface of the rain garden. Pine bark and wood chips should not be used.
- **Defined Edge.** Often rain gardens have a better appearance and can be more easily maintained if they have defined edges similar to a normal garden.

- **Resilient Overflow Spillway / Inlet Grate (Catch Basin or Atrium Grate).** An resilient overflow spillway is a small indentation in the berm of a rain garden that serves as the point where excess water will flow out of the garden should it overfill during a major rain storm. This indentation is filled with non-erodible material (i.e., paving stones-see detail to left). The indentation should be made on the downhill side and is used to direct water flow towards the traditional rainwater system (culverts, etc.). The overflow from the rain garden can also incl ude an inlet grate (catch basin) set at the proper elevation in the garden instead of the indentation. The grate should be set at a slant or be domed (atrium grate) to allow clogging debris to fall off.



Source: https://extension.oregonstate.edu/node/119221/printable/print



- **Underdrain Requirement. NOTE: This method can only be used with an infiltration rate greater than 0.25 in/hr. If the rate is less than 0.25 in/hr, this method can only be used with an underdrain as described in Appendix D.** Provide an infiltration test (See Appendix A) with your plan and computation submittal that results in an infiltration rate greater than 0.25 in/hr or include an underdrain in your rain garden. An underdrain shall span the width of the rain garden and discharge to daylight or through a pop-up emitter. The discharge point shall be at least 10 feet from the property line and should not cause a nuisance or result in erosion.

VEGETATION

- Vegetation commonly planted in rain gardens includes native trees, shrubs and other herbaceous vegetation (See **Appendix B Recommended Plants**). When developing a landscaping plan, you should choose vegetation that will be able to stabilize soils, handle the expected amount of sunlight, and tolerate the storm water runoff rates and volumes that will pass through the rain garden.**How many Plants?** When deciding how many plants to get for your rain garden a good estimate is that you will need one-plant-per-square-foot (square spacing). However, keep in mind how large the plants that you chose will be at maturity. Many plants have their own spacing recommendations so check these out and plant accordingly. If a plant needs more than a square foot then give it more room, and if one requires less space then don't leave it as much room.

Single-Plant Rain Garden Not Permitted. An aesthetically pleasing, low-maintenance landscape can be attained using a plant palette of regionally-native plants. Choose a diversity of hardy native plants—they offer a palette of plants that are well-adapted, beautiful, reliably hardy, enhance

much-needed biodiversity while allowing for more opportunities to observe nature. A single plant with a large plant-spacing that meets the spacing requirements will not be aesthetically pleasing and not meet the planting requirement.

Rule of Thumb. Your selection of plants and their recommended spacing (square or triangular grid) will dictate the number of plants required. For estimating purposes it is suggested to use one plant per square foot of rain garden (Some plants selected may need more than one square foot and some plants need less, so the plants actually chosen should average out to one-plant-per-square-foot rule as a guide (square spacing). Your ultimate selection will govern).* This means to estimate the quantity of plants needed use one plant per square footage of the rain garden. So;

square feet of my garden = number of plants I will need
My rain garden is _____ square feet, so I will need _____ plants.

*If you will be planting trees or shrubs in your rain garden then do not use the one-plant-per-square-foot rule. Instead, go by the spacing recommendations for each plant, making sure the garden is aesthetically pleasing.

Note to first-time gardeners:
Your garden will probably look kind of sparse at first, but give it time and it will fill in nicely - all gardens take a a minimum of three years to mature and look their best. You can also add more plants and replace plants that do not survive or that you decide you don't like later.

- Vegetation used in rain gardens should also be able to tolerate both wet and dry conditions. A Plant Spacing Plan shall be included in BMP submittal. Please refer to **Appendix B Recommended Plants** for additional information on spacing and plants appropriate for rain gardens.
- As with any garden, in the first season the vegetation may require irrigation to become well established.
- It may be appropriate to plant more densely than a normal garden to obtain the benefit of plant soil stabilization and evapotranspiration as soon as possible.

MAINTAIN

Routine garden maintenance should include weeding, deadheading, replacing dead plants, and replenishing mulch when depleted. Catching areas of erosion is also important as is correcting standing water problems. If standing water persists it may be necessary to place a perforated underdrain in the garden daylighting downstream.

Lay out the plants according to the design. This is the time to double-check spacing, arrangement and any other considerations such as texture, height and bloom time. When planting, gently remove the plant from its container and loosen the roots if they are root-bound. If the planting is in weed-barrier landscape fabric (Mirafi® Mscape E or an approved equal), cut an ×-shaped hole in the netting large enough to adequately set the plant in the soil beneath. Each planting hole should be dug approximately twice as wide as the root mass and deep enough to allow for the crown (junction of roots and green shoots) to be set at ground level. Firm the soil both in the planting hole and around the plant after planting. Do not leave root ball/potting soil exposed to air.

Applying 2–3" of non-floating cypress shredded hardwood bark mulch to your rain garden will help lessen the compaction of the soil thereby improving the functioning of your rain garden. When mulching, apply a 2–3" thick layer around the plants, but not on top of the crowns. This will help keep moisture around the root zone as the plants become established.

Note: In rain gardens with high water volume, high water velocity, and/or steep slopes, organic mulches such as shredded bark are not recommended since they easily wash away and expose the soil to erosion. Instead, use non-floating cypress mulch or stone and gravel in areas with high-energy water such as these.

Use of name labels on plants will help with identification and tracking which plants are doing well. You may want to add them for general knowledge and understanding of the garden.

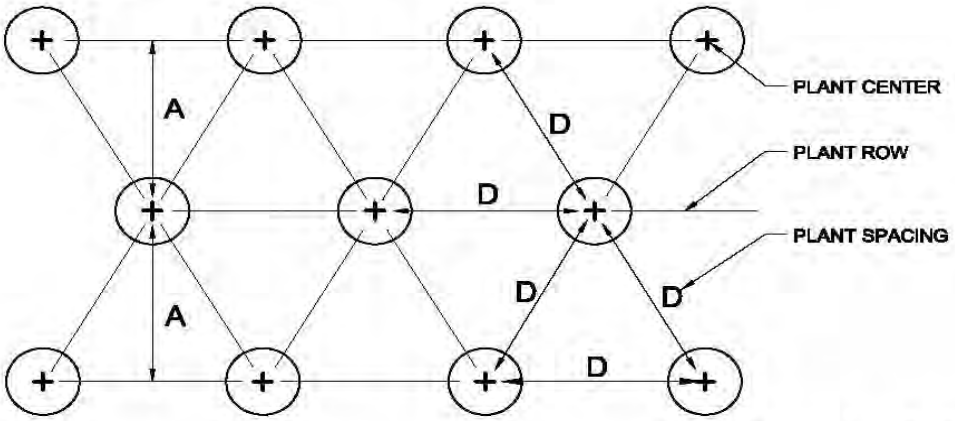
Source: https://www.missouribotanicalgarden.org/sustainability-conservation/sustainable-living/at-home/rainscaping-guide/design-and-build-a-rain-garden/plant.aspx

The following page provides a typical section for layout of a rain garden.

RAIN GARDEN – LAYOUT SKETCH

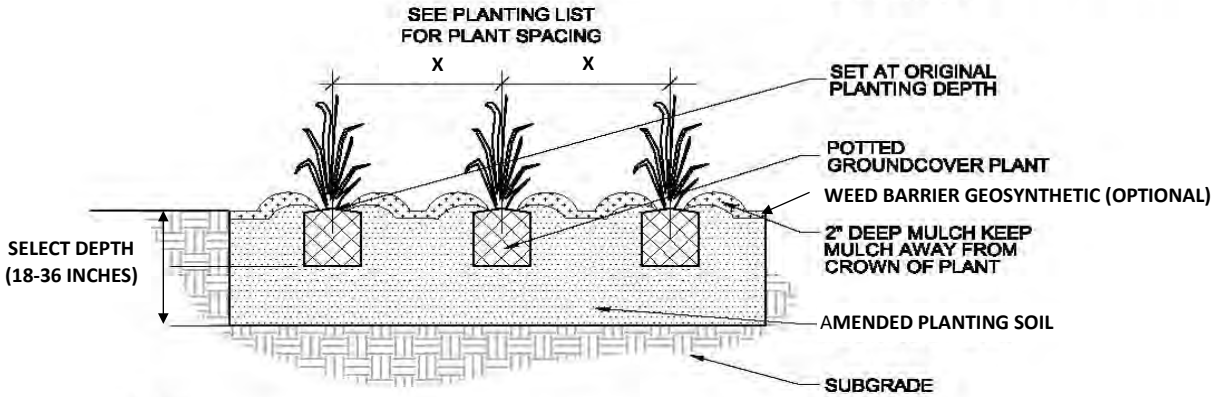
SPACING "D"	ROW "A"	NUMBER OF PLANTS/SQ. FT.
30"	26"	.160
24"	20.8"	.25
18"	15.6"	.450
15"	13.0"	.640
12"	10.4"	1.00
10"	8.66"	1.44
8"	6.93"	2.25

NOTE: PLANT QUANTITIES WERE DETERMINED BY MULTIPLYING AREA (SQ. FT.) BY NUMBER OF PLANTS/SQ. FT. FOR REQUIRED SPACING.



Quantity of plants as noted in planting schedule.

GROUNDCOVER SPACING



NOTES:
1. REMOVE SPENT FLOWERS PRIOR TO PLANTING.
2. LOOSEN ROOT MASS AT BOTTOM OF ROOTBALL.
3. TOP OF ROOTBALL STRIPPED OF ¼" SURFACE GROWING MEDIA AND COVEREDWITH ¼" LANDSCAPE BED MIX PLUS SURFACE MULCH.

Plant Spacing Plan

N.T.S.

Planting Detail Courtesy of Ted Spaid
SWT Design, St. Louis, MO

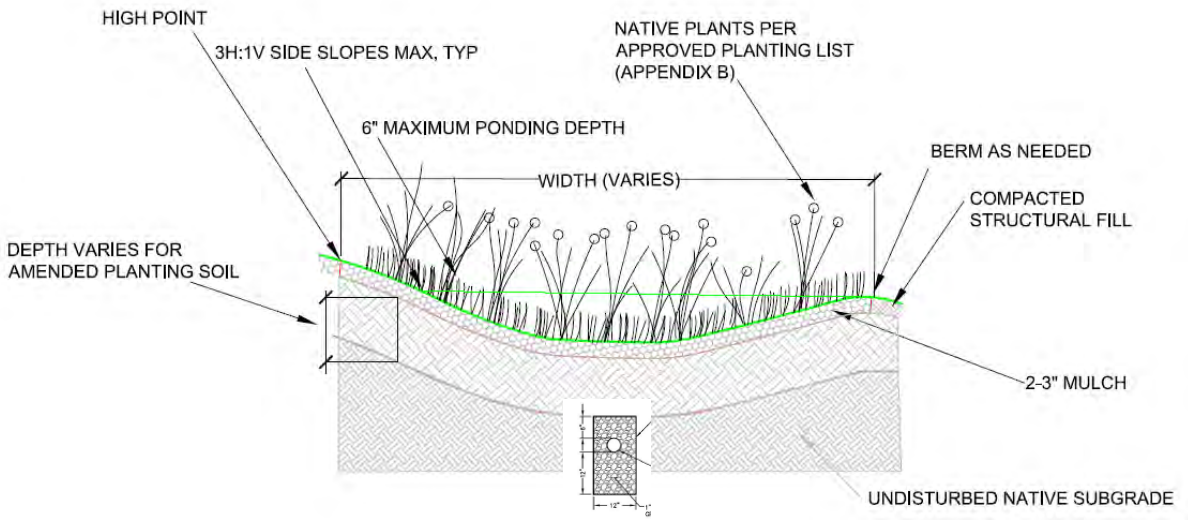


Figure 1 UNDERDRAIN (AS REQUIRED)

CONSTRUCTION STEPS:

1. Locate rain garden(s) where downspouts or driveway runoff can enter garden flowing away from the home. Locate at least 10 feet from foundations, not within the public right of way, away from buried utility lines, not over septic fields, and not near a steep bluff edge.
2. Measure the area draining to the planned garden and determine required rain garden surface area from the table on the next page and your planned excavation depth.
3. Prior to submittal, perform an infiltration test according to Appendix A, if the rate is less than 0.25 in/hr an underdrain will be necessary. If the rate is more than 0.50 in/hr the size of the garden may be decreased 10% for every 0.50 in/hr infiltration rate increase above 0.50 in/hr.
4. Measure elevations and stake out the garden to the required dimensions insuring positive flow into the garden, the overflow elevation allows for desired depth of ponding (six inches maximum), and the perimeter of the garden is higher than the overflow point. If the garden is on a gentle slope a berm at least two feet wide can be constructed on the downhill side and/or the garden can be dug into the hillside taking greater care for erosion control at the garden inlet(s).
5. Remove turf or other vegetation in the area of the rain garden. Excavate garden being careful not to compact soils in the bottom of the garden. Level bottom of garden as much as possible to maximize infiltration area.
6. If underdrain required, excavate area, install geosynthetic, install bedding aggregate, and install perforated HDPE (or equivalent) pipe wrapped with polyester filter sock. Below the frost line, HDPE or PVC pipe may be used (30-inches below top of finished grade).

   INITIAL INSPECTION POINT
7. Mix compost, topsoil, and some of the excavated subsoil together to make the 'amended soil'. The soil mix should be 1/3 compost, 2/3 native soil (topsoil and subsoil combined). The following table can be used to estimate compost quantity:

Depth of Amended Soil, (Inches)	18	24	30	36
Volume of Compost per 100 Square Feet of Rain Garden, (Cubic Yards)	1.83	2.47	3.09	3.70

8. Fill rain garden with the amended soil, leaving the surface eight inches below your highest surrounding surface. Eight inches allows for 6 inches ponding and 2" of non-floating cypress mulch. The surface of the rain garden should be as close to level as possible.
9. Build a berm at the downhill edge and sides of the rain garden with the remaining subsoil. The top of the berm needs to be level, and set at the maximum ponding elevation.
10. Plant the rain garden using a selection of plants from Appendix B Plantings. **Submit planting list at the time of initial inspection**.
11. Mulch the surface of the rain garden with two to three inches of non-floating organic mulch. The best choice is finely shredded hardwood cypress mulch.
12. Water all plants thoroughly. As in any new garden or flowerbed, regular watering will likely be needed to establish plants during the first growing season.
13. During construction build the inlet feature as a pipe directly connected to a downspout or use a rock lined swale with a gentle slope. Use of an impermeable liner under the rocks at the end of the swale near the house is recommended to keep water from soaking in at that point. Test the drainage of water from the source to the garden prior to finishing.
14. Create an overflow at least 10 feet from your property edge and ensure it is protected from erosion.

    FINAL INSPECTION POINT

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS THREE-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	RAIN GARDEN SPECIFICATIONS PAGE 1 OF 3

SKETCH LAYOUT

PROVIDE PLAN VIEWS OF RAIN GARDEN AND HOUSE SHOWING DRAINAGE AREA DIRECTED TO RAIN GARDEN AND KEY DIMENSIONS AND OVERFLOW AREA RELATIVE TO PROPERTY LINE.

SIZING CALCULATION:

SITE INFILTRATION RATE= _____ IN/HR (0.05 IN/HR, MIN.)

- IS UNDERDRAIN REQUIRED? □ YES □ NO □ N/A
- CAN BMP SIZE BE REDUCED? □ YES □ NO □ N/A

IF YES, BY WHAT %: □ 10 □ 20

Contributing Drainage Area (square feet)	Depth of Amended Soil (inches)			
	18	24	30	36
	Area of Rain Garden (square feet)			
100	7.7	6.7	6.0	5.3
500	40	35	30	28
1000	80	70	60	55
2000	155	135	120	110
3000	235	205	180	160
4000	310	270	240	215
5000	390	340	300	270

MEASURE CONTRIBUTING DRAINAGE AREA AND READ AREA FOR GIVEN MEDIA DEPTH.

CONTRIBUTING DRAINAGE AREA= _____ SQUARE FEET
DEPTH OF AMENDED SOIL (INCHES)= □ 18 □ 24 □ 30 □ 36
RAIN GARDEN AREA= _____ SQUARE FEET
COMPOST VOLUME = _____ CUBIC YARDS

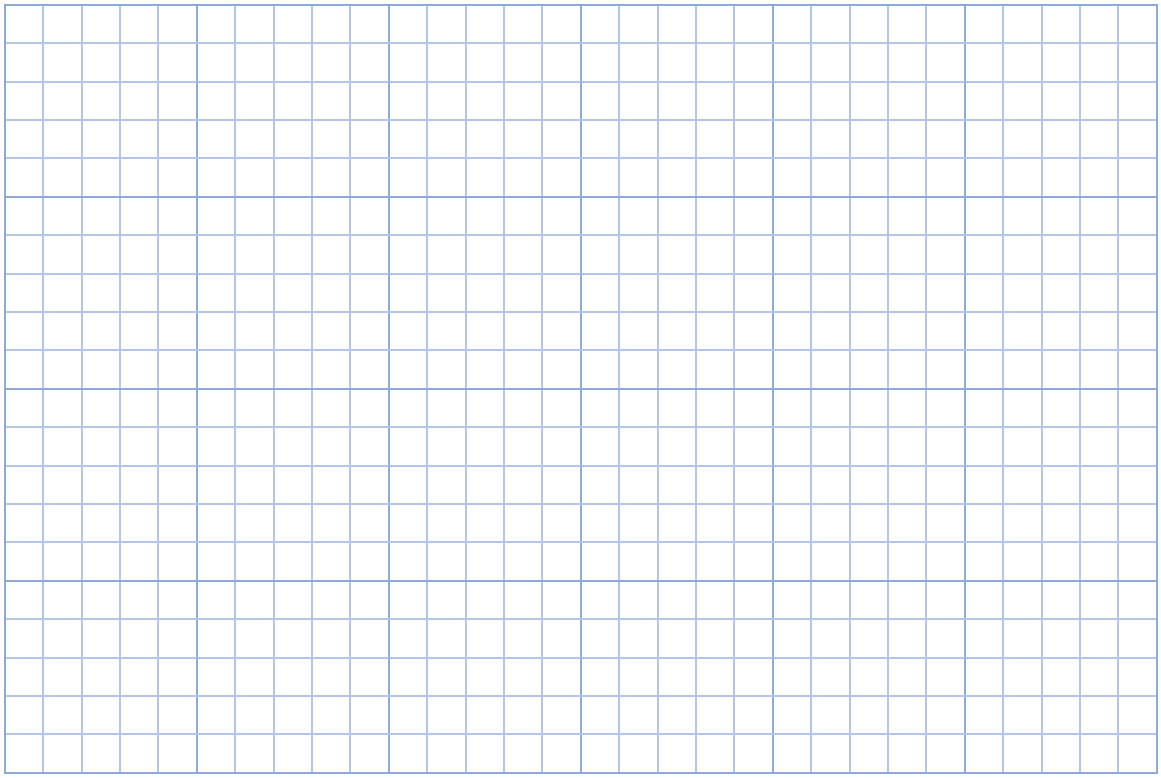
MAINTENANCE:

1. IRRIGATE VEGETATION AS NEEDED IN FIRST SEASON
2. REMOVE WEEDS
3. REPLACE UNSUCCESSFUL PLANTINGS
4. REPLENISH MULCH
5. REPAIR ERODED AREAS
6. RAKE CLOGGED SURFACE TO RESTORE INFILTRATION
7. MONITOR RAIN GARDEN FOR APPROPRIATE DRAINAGE TIMES. IF GARDEN DOES NOT DRAIN, AN UNDERDRAIN MAY BE NECESSARY

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS THREE-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	RAIN GARDEN SPECIFICATIONS PAGE 2 OF 3

PLANTING LAYOUT

PROVIDE PLAN VIEWS OF RAIN GARDEN PLANTING PLAN SHOWING KEY DIMENSIONS AND PLANTING SCHEDULE.



Select Planting Pattern: □ Triangular □ Square

PLANTING SCHEDULE- Use Appendix B to complete

PLANT ID	DESCRIPTION	SPACING (IN FEET)	NUMBER	AREA (SQUARE FEET)
A				
B				
C				
D				
E				
F				
G				
H				
I				
			TOTAL NUMBER OF PLANTS:	
			RAIN GARDEN AREA (SQUARE FEET):	
			PLANTING AREA SUMMARY:	

NOTE: PLANTING AREA MUST BE GREATER THAN OR EQUALTO RAIN GARDEN AREA

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS THREE-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	RAIN GARDEN SPECIFICATIONS PAGE 2 OF 3

CREDIT FOR EXISTING TREES

Trees located on a residential lot can provide some benefit to storm water runoff reduction and can be used for credit in reducing the total net impervious area on a residential infill sites. Trees reduce runoff through rainfall interception by the tree canopy, by releasing water into the atmosphere through evapotranspiration, and by promoting infiltration and storage of water in the soil.

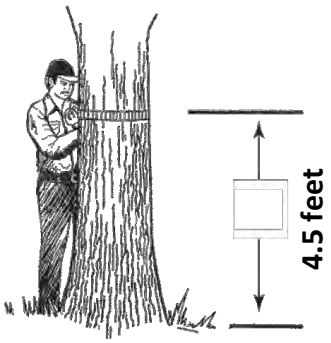
CRITERIA

Each tree with an Adjusted Diameter Breast Height (ADBH) of 8 inches or greater can reduce the impervious area by 50 square feet if certain conditions are met:

- No more than 20% of the net added impervious area (IA = Net Increase in impervious area) can be mitigated with the credit. Maximum Tree Credit rounded down to nearest 50 square feet.
- The location, species, and size of each tree being counted for credit is shown on the plan of record. A picture of the tree should be included with the application. For tree identification: https://mdc.mo.gov/field-guide/search?fgSpeciesType=1009
- The tree is protected as per **Kirkwood Tree Manual** during construction: (https://www.kirkwoodmo.org/home/showpublisheddocument/3719/637630007386600000)
- With the exception of the Vegetated Filter Strip Green Infrastructure Control, trees that are located within the boundaries of the constructed stormwater infrastructure features cannot be counted for Infill Stormwater Credit.

If the protected tree(s) dies or is removed, the property owner may be subject to enforcement and will be responsible for providing impervious area treatment. This may include planting and maintaining additional trees or installing Green Infrastructure Controls.

MEASURING DBH



DBH refers to the tree diameter measured at 4.5 feet above the ground.

- If tree is at an angle or on a slope, measurement is taken from the midpoint of the different ground levels of the tree along the center of the trunk.
- If the tree forks at or below the 4.5 feet point, or if a bulge occurs at this point, take the measurement at a location lower on the trunk where the tree resumes its normal size or taper. For a root bulge, begin measurement at the point where the root mass ends.

To properly determine the diameter, measure the length (circumference) around the trunk (to nearest inch) and divide by 3.14; report to nearest inch. Be sure tape measure is straight and not caught in any branches or other obstacles. DBH and ADBH are reported to nearest 0.1 of inch.

Figure 1: Measuring DBH (INDNR: Forestry: How to Measure and Identify Big Trees)

ADJUSTED DIAMETER

To calculate the tree's ADBH, the DBH is multiplied by the tree's condition rating.

- The Condition Rating is the numerical expression of a tree's condition expressed as a percentage from zero (a dead tree) to 100 (a perfectly healthy tree as described in the manual Guide for Plant Appraisal published by the International Society of Arboriculture). Use table below (20%, 40%, 60%, 80%, or 100%).
- For example, if a tree has a DBH of 32 inches in diameter and is in relatively poor health with a condition rating of 40%, its ADBH is 12.8 inches. (32" x 0.40 = 12.8")

CONDITION RATING FOR LANDSCAPE TREES

Condition Rating	Tree Structure Consider root condition/formation, trunk condition and branch assemblyand arrangement	Tree Health Consider crown indicators including vigor, density, leaf size, quality and stem shoot extensions	Formula Values (% Used)
Excellent	Root plate undisturbed and clear of any obstructions. Root flare has normal development. No visible trunkdefects or cavities. Branch spacing/structure and attachments are free of any defects.	Perfect specimen with excellent form and vigor, well-balanced crown. Trunkis sound and solid. No apparent pest problems. Normal to exceeding shoot length on new growth. Leaf size and color normal. Exceptional life expectancy for the species.	1.0-.90 (100%)
Good	Root plate appears normal; only minordamage may be found. Possible signs of root dysfunction around trunk flare.Minor trunk defects from previous injury, with good closure; less than 25% of bark section is missing. Good branch habit, minor dieback with some signs of previous pruning. Codominant stem formation may bepresent. Minor corrections required.	Imperfect canopy density in few parts of the tree, 10% or less, lacking natural symmetry. Less than half normal growth rate and minor deficiency in leaf development. Few pest issues or damage, controllable. Normal branch and stem development with healthy growth. Typical life expectancy for the species.	.90-.75 (80%)
Fair	Root plate reveals previous damage ordisturbance and dysfunctional roots may be visible around main stem. Evidence of trunk damage or cavities with decay or defects present. Less than 30% of bark sections missing ontrunk. Codominant stems are present. Branching habit and attachments indicate poor pruning or damage, which requires moderate corrections.	Crown decline and dieback up to 30% of the canopy. Overall poor symmetry. Leaf color somewhat chlorotic with smaller leaves. Shootextensions indicate some stunting and stressed growing conditions. Obvious signs of pest problems contributing tolesser condition. Some decay areas found in main stem and branches. Below averagelife expectancy.	.75-.50 (60%)
Poor	Root plate disturbance and defects indicate major damage with girdling roots around the trunk flare. Trunk reveals more than 50% of bark section missing. Branch structure haspoor attachments, with several structurally important dead or broken. Canopy reveals signs of damage or previous topping or lion-tailing, with major corrective actions required.	Lacking full crown, more than 50% decline and dieback, especially affecting larger branches. Stunting obvious with little evidence of growth on smaller stems. Leaf size and color reveals overall stress in the plant. Insect or disease infestation may besevere. Extensive decay or hollow. Life expectancy is low.	.50-.30 (40%)
Very Poor	Severe damage within the root plateand root collar exhibits major defectwhich could lead to death or failure.A majority of the bark or trunk is affected with decay or missing. Branching is extremely poor or severely topped with severe dieback in canopy. Little or no opportunity formitigation of any tree parts.	More than 70% of the canopy is in severe decline or dead. Canopy density is extremely low with chlorotic and necrotic tissue dominating the canopy. Severe decay in the trunk and major branches. Root plate damage with a majority ofroots damaged, diseased or missing.	.30-.10 (20%)

Source: https://tcimag.tcia.org/business/an-introduction-to-tree-appraisal/

EXISTING TREES – LAYOUT SKETCH

PROVIDE PLAN VIEW OF TREE LOCATIONS AND HOUSE SHOWING DRAINAGE AREA DIRECTED TO THE LOCATION. INCLUDE PROPOSED AREA TO BE MITIGATED BY TREE CREDIT (NOT TO EXCEED MAXIMUM TREE CREDIT).

Address:
Permit Number: P
Net Imperious Area (SF):
Mitigated Area: SF (square feet)
Max Tree Credit: Lowest 50 SF (square feet)

Tree ID	Tree Common Name	Circumference (inches)	DBH (inches)	Condition (percentage)	ADBH (inches)	Tree Credt (Square feet)
				Total Available Tree Credit:		

Notes:
1.Net Impervious Area = Proposed Inpervious Area - Exisitng Impervious Area, in square feet
2. Maximum Tree Credit = 20% x (Net Impervious Area), in square feet
3. Diameter Breast Height (DBH) = Circumference / 3.14, to nearest 0.1 of an inch (Cirumference measured 4.5 feet above the ground)
4. Condition rating is one of the following: 20%, 40%, 60%, 80%, or 100%. No dead trees are permitted for use (0% rating)
5. ADBH = Adjusted DBH = Condition Rating % x DBH, to nearest 0.1 of an inch
6. Tree credit of 50 square feet applies only to a tree with an ADBH ≥ 8 inches

CONSTRUCTION STEPS:

1. THERE IS NO INITIAL INSPECTION.IDENTIFY TREES TO BE COUNTED.

FINAL INSPECTION POINT

MAINTENANCE:

2. MULCH.
   a. MULCH TREE WITH A 2-4 INCH LAYER OF MULCH IN A DOUGHNUT-SHAPED RING. THE RING SHOULD EXTEND 2’ TO 4’ BEYOND THE TRUNK.
   b. DO NOT PILE MULCH AGAINST THE TREE TRUNK. PULL MULCH BACK SEVERAL INCHES FROM THE TRUNK SO THE BASE OF THE ROOT CROWN IS EXPOSED. AVOID A “MULCH VOLCANO”.
3. PRUNING. (see City of Kirkwood Tree Manual)
   a. AVOID OVER-PRUNING OF TREE BY ONLY REMOVING A SMALL PERCENTAGE OF THE LIVE TREE AT ONE TIME TO A MAX OF 25% IN ONE YEAR.
   b. HEAVY PRUNING SHOULD BE PERFORMED IN THE WINTER MONTHS.
   c. AVOID LIGHT PRUNING IN EARLY SPRING.
   d. DEAD AND DYING BRANCHES CAN BE PRUNED ANYTIME.

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS ONE-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	TREE INCENTIVE SPECIFICATIONS PAGE 1 OF 1

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APPENDIX A

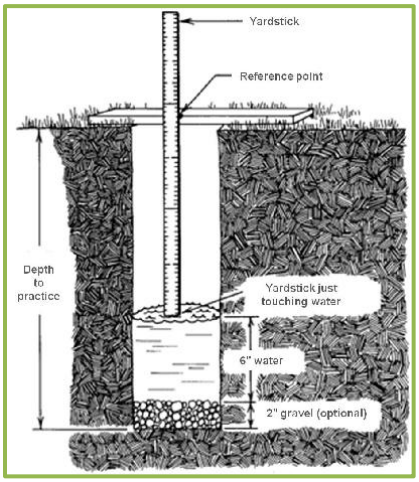
Site Infiltration Rate

Should you choose not to perform infiltration testing, your site infiltration rate will be 0.05 in/hr which excludes some BMP's as being applicable and others will require an underdrain. See Appendix D for details on constructing an underdrain.

Testing Limitations. Field infiltration tests must **not** be conducted in the rain or within 24 hours of significant rainfall events (>0.5 inches), or when the ground is frozen. NOTE: Always call Missouri One Call to locate utility lines before you dig.

Testing Infiltration: the Simple Approach

It is assumed that an infiltration rate of 0.05 to 0.25 inches per hour exists on residential sites. The sizing criteria are set for this rate. However, if the soils have a higher infiltration rate the size of the features could be reduced.



Source: modified from www.ag.ndsu

If the following infiltration test is conducted, and if it returns a higher infiltration rate than 0.25 inches per hour, suitable reductions in the size of the infiltration-based facilities can be made. Any allowable reduction in BMP size requires that the infiltration test results be verified by a PE, geologist, or other qualified individual. See each BMP for the adjustment procedure.

1. Infiltration features (rain gardens, dry wells, permeable paver gravel layers) should reliably drain within the recommended time limit. Here is how to test if your soils can handle this type of feature.
2. Locate the approximate center of the area where you expect to build your feature.
3. Dig an access pit down to the bottom of the amended soils or gravel layer in the feature.
4. At that elevation dig a narrow test hole at least eight inches deep. You can optionally place 2" of coarse gravel in the bottom. The test hole can be excavated with small excavation equipment or by hand using a spade shovel or post-hole digger.
5. If you run into a hard layer that cannot be penetrated with a shovel or, you come across water in the hole, stop. Infiltration features should not be sited over impenetrable rock surfaces or over high water tables. If this occurs, your site is inappropriate for these improvement measures.
6. Place a flat board across the hole to serve as a measuring point (see figure).
7. Fill the hole with water to a depth of twelve inches. Measure from the flat board to the water surface. Record the exact time you stop filling the hole and the height of the water, in inches, in Table I for every 10 minutes for fast draining soils for a minimum of one hour, or In Table 2 every 30 minutes for slow draining soils for a minimum of two hours. Most sites within the City limits will fall under the slow draining soils category. If the soil on your site appears sandy, it will be categorized as fast draining.
8. Refill the hole again and repeat step 7 twice more. The third test will give you the best measure of how quickly your soil absorbs water when it is fully saturated.
9. If on the third test the water is dropping at least ½" per hour the soil will work for the infiltration features.

Source: www.learntogrow.com

INFILTRATION TESTING CHECKLIST

(IF REQUIRED)

Project Information:

Date of Test: _____ Time of Test: _____

This Infiltration Test Was Performed by: ☐ Homeowner ☐ Other (specify below)

Company Name: _____ Contact Name: _____

Phone Number: _____ Email Address: _____

The intent of this checklist is to provide a summary of stormwater Best Management Practices (BMP) subsurface investigation and infiltration requirements. All projects and associated plans are also subject to the minimum requirements outlined this guideline. This checklist does not preclude the use of professional judgment to evaluate and manage risk associated with design, construction, and operation of infiltration BMPs.

Part I. SUBSURFACE INVESTIGATION

1. Dig a hole using a post hole digger to a depth of 2-ft below proposed facility and approximate center of the proposed infiltration facility.
2. Record total depth of hole from surrounding ground surface: _____ feet
3. While digging the hole, did you:
    a. Encounter rock larger than gravel? □ YES □ NO
    b. Encounter standing water or seepage into the hole? □ YES □ NO
4. If you answered "yes" to either 3a or 3b, the infiltration is not feasible for this site. **No further testing is required. Stop Here.**

Part 2. INFILTRATION TEST

1. Is the infiltration test within the footprint of the proposed infiltration facility? □ YES □ NO
2. If "no," is testing being conducted within 50 feet of the proposed infiltration facility? □ YES □ NO
   Explain why: _____
3. ☐ Dig an infiltration test hole to the bottom of the BMP.
4. Describe soil type and texture (e.g., sand, clay, gravel.): _____
5. ☐ Place a flat board across the hole to serve as a measuring point.
6. ☐ Fill the hole with water to a depth of six inches. Measure from the flat board to the water surface. Record the exact time you stop filling the hole and height of the water, in inches, In Table I, every 10 minutes for fast draining, sandy soils for a minimum of one hour or in Table 2 (most silty/clayey soils in Kirkwood), every 30 minutes for slow draining soil for a minimum of 2 hours.
7. ☐ Repeat step 6 two more times. The third test will govern. Record results in the appropriate tables, below.

TABLE 1. USE ONLY FOR RAPIDLY DRAINING SANDY SOILS

Table 1 (10-minute intervals)									
Time	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)
10		---	---		---	---		---	---
20									
30									
40									
50									
60									

The Difference in Water Depth is the difference between the depths of the current time minus the depth of the previous time. (i.e. $60\ minute\ depth - 30\ minutes\ depth$)

TABLE 2 USE FOR ALL OTHER SOIL TYPES (CLAYEY / SILTY SOILS)

Table 2 (30-minute intervals)									
Time	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)	Depth of water (in)	Difference in Water Depth (in)	Infiltration Rate (in/hr)
30		---	---		---	---		---	---
60									
90									
120									

The Difference in Water Depth is the difference between the depths of the current time minus the depth of the previous time. (i.e. $60\ minute\ depth - 30\ minutes\ depth$)

8. Record the **lowest** infiltration rate from the third test in the tables above = _____ in/hr

(Infiltration rate $= \frac{\text{difference in water depth (inches)}}{\text{time (minutes)}} \times \frac{60 \text{ minutes}}{\text{hour}} =$ in/hr)

SIGNATURES ARE REQUIRED

I certify that I followed the procedures outlined in this document to determine the site infiltration rate.

Print Name: _____

Signature: _____ Date: _____

CITY OF KIRKWOOD PROPERTY ADDRESS: DATE:	ATTACH THIS TWO-PAGE SPECIFICATION TO SITE PLAN SUBMITTAL	INFILTRATION TESTING PAGE 1 OF 2

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APPENDIX B

RECOMMENDED PLANTS – RAIN GARDENS

Recommended Plants for rain gardens and other vegetated storm water practices must be able to tolerate both wet and dry conditions. This list, while not exhaustive, includes many plants that will tolerate conditions in rain gardens. The plants in this list do have different preferences for both moisture and light, as shown in the columns labeled 'Moisture' and 'Sun'. Additionally, these plants are native to Missouri and thus contribute the added benefit of providing habitat and food for native pollinators and wildlife. Native plant species are preferred over non-native species, but some ornamental species may be used for a landscaping effect if they are not aggressive or invasive.

Nuisance Trees. Nuisance (invasive) trees cannot be used in rain gardens. The following trees will not be counted for planting: Box elder, Red maple, Silver maple, Freeman maple, Tree of Heaven, Mimosa, White birch, Paper mulberry, Russian olive, Autumn olive, all Ash species, Honey locust, Golden rain tree, Honeysuckle, White mulberry, Red mulberry, Empress tree, Austrian pine, Scotch pine, Poplars, Cottonwood, Lombardy poplar, Aspen, Edible-fruited cherries, peaches and plums, Crabapple species, Callery pear and all varieties of Bradford pear, Pin oak, Black locust, White willow, Weeping willow, Mountain ash, American elm, or Siberian elm.

PLANT SPACING

Figure 1. Triangular and Square Patterns. Typical plant spacing where x equals distance on center (O.C.) of plant species.

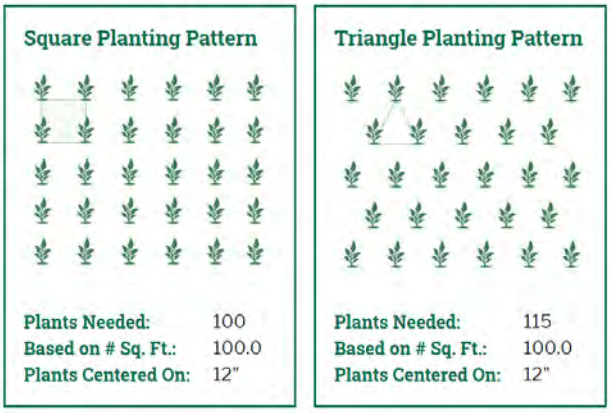


Table 1. is for use only when plants are spaced equidistant from each other as shown in **Figure 1**.

Table 1. Plant Spacing for Perennials, Grasses, Sedges and Shrubs[1]

Spacing (X), inches (On Center)	Square Pattern Plants per 100 square feet	Triangular Pattern Plants per 100 square feet
4	900	1039
6	400	462
12	100	115
16	56	65
18	44	51
24	25	29
30	16	18
36	11	13
48	6	7
60	4	5
72	2	3

Plant Calculator: https://www.midwestgroundcovers.com/index.cfm
Note: Actual plants needed may vary slightly.

PLANT LISTS

Plant material size and grade to conform to "American Standards for Nursery Stock" American Association of Nurserymen, Inc. latest approved revision, ANSI Z-60-1. The plants listings below are not exhaustive of all plants that will thrive in a rain garden or other vegetated storm water practices, and are only meant as a guide.

- Perennials and grasses/sedges should be planted with plugs or 1 gallon containers or equivalent, seed is not allowed. While it is less expensive to plant areas with seed, it is much more difficult and it takes about three years for most seedlings to mature and flower.
- Shrubs should be planted with 3 gallon containers or equivalent.
- Trees should be minimum 2" caliper.
- Tree and shrub planting typical sections are included at end of this section.

Table 2 : Native Perennials– Full Sun

Latin Name	Common Name	Spacing	Moisture	Color	Height
Amsonia illustris	Shining Blue Star	24" o.c.	Wet-Moist	White/Blue	3-4'
Asclepias incarnata	Swamp / Marsh Milkweed	24" o.c.	Wet	Pink	3-4'
Asclepias tuberosa	Butterfly Milkweed	18" o.c.	Dry-moist	Orange	2'
Asclepias verdicillata	Whorled Milkweed	18" o.c.	Moist	White	2.5'
Asclepias verdis	Green Milkweed	18" o.c.	Moist	Green	2'
Aster novae-angliae	New England Aster	24" o.c.	Moist-wet	Violet	3-4'
Baptisia australis	Blue False Indigo	24" o.c.	Moist-Dry	Blue	3-4'
Baptisia bracteata	Cream Wild Indigo	18" o.c.	Dry	Yellow	1-2'
Baptisia sphaerocarpa	Yellow Wild Indigo	24" o.c.	Dry-moist	Yellow	2-3'
Blephilia ciliate	Ohio Horsemint	18" o.c.	Dry-moist	Pink	1-2'
Chelone glabra	White Turtlehead	24" o.c.	Wet	White	2-4'
Chelone obliqua	Rose Turtlehead	18" o.c.	Wet	Rose	2-4'
Chrysopsis camporum	Golden Aster	18" o.c.	Dry	Yellow	2-3'
Coreopsis lanceolata	Lance-leaf Coreopsis	18" o.c.	Moist-dry	Yellow	6-8'
Coreopsis palmata	Finger Coreopsis	12" o.c.	Dry-moist	Yellow	2'
Coreopsis triptris	Tall Coreopsis	24" o.c.	Dry-moist	Yellow	2-8'
Echinacea pallida	Pale purple Coneflower	18" o.c.	Dry	Purple	2-3'
Echinacea paradoxa	Yellow Coneflower	18" o.c.	Dry	Yellow	2-3'
Echinacea purpurea	Purple Coneflower	18" o.c.	Moist-dry	Purple	3-4'

Table 2 : Native Perennials– Full Sun					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Equisetum hyemale	Horsetail	30" o.c.	Wet-moist	Green	2-4'
Eryngium yuccifolium	Rattlesnake Master	18" o.c.	Dry-moist	Green	4-5'
Eupatorium coelestinum	Mist Flower	18" o.c.	Moist	Purple	1-2'
Eupatorium perfoliatum	Boneset	24" o.c.	Wet	White	3-5'
Eupatorium purpureum	Joe-Pye Weed	24" o.c.	Wet-moist	Purple	3-6'
Eurybia paludosa	Southern Prairie Aster	18" o.c.	Dry-Moist	Purple	1-2'
Gentiana andrewsii	Bottle Gentian	18" o.c.	Moist-wet	Blue	1-2'
Helenium autumnale	Sneezeweed	24" o.c.	Moist-wet	Yellow	2-4'
Helianthus salicifolius	Willow-leaved Sunflower	24" o.c.	Dry-moist	Yellow	4-6'
Heliopsis helianthoides	Ox-eye Sunflower	24" o.c.	Wet-dry	Yellow	3-5'
Heuchera americana	American Alumroot	18" o.c.	Dry-moist	Cream	1'
Heuchera parviflora	Late-flowering Alumroot	18" o.c.	Dry-moist	White	1'
Heuchera richardsonii	Prairie Alumroot	18" o.c.	Dry-wet	Cream	1'
Heuchera villosa	Maple-leaf Alumroot	18" o.c.	Dry-moist	White	1'
Hibiscus lasiocarpos	Rose Mallow	24" o.c.	Wet	White/Pink	3-4'
Iris brevicaulis	Zig-zag Iris	12" o.c.	Wet-dry	Purple	0.5-1'
Iris cristata	Dwarf Crested Iris	12" o.c.	Dry	Violet	1'
Iris fulva	Copper Iris	12" o.c.	Wet	Red	2'
Iris virginica	Southern Blue Flag Iris	18" o.c.	Moist-Wet	Blue/Purple	2'
Lespedeza virginica	Slender Bush Clover	18" o.c.	Dry-moist	Pink	1-2'
Liatris aspera	Rough Blazingstar	18" o.c.	Moist-dry	Purple	2-5'
Liatris pycnostachya	Prairie Blazingstar	18" o.c.	Wet-Moist	Purple	1-4'
Liatris scariosa	Eastern Blazingstar	12" o.c.	Moist-dry	Purple	2-4'
Liatris spicata	Marsh Blazingstar	18" o.c.	Wet-dry	Purple	2-3'
Lobelia cardinalis	Cardinal Flower	18" o.c.	Wet-moist	Red	2-4'
Lobelia siphilitica	Blue Lobelia	12" o.c.	Wet-moist	Purple	2-3'
Mimulus ringens	Allegheny Monkey Flower	18" o.c.	Moist-wet	Lavender	1-2'
Monarda didyma	Bee Balm	24" o.c.	Wet-moist	Red	3'

Table 2 : Native Perennials– Full Sun					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Monarda fistulosa	Wild Bergamot	18" o.c.	Moist	Purple	1-3'
Packera obovata	Golden Groundsel (Squaw Weed)	12" o.c.	Wet-Moist	Yellow	1'
Parthenium integrifolium	Wild Quinine	18" o.c.	Dry-moist	White	2-4'
Penstemon cobaea	Purple Beard Tongue	12" o.c.	Moist-Dry	Purple	1-2'
Penstemon digitalis	Foxglove Beard Tongue	18" o.c.	Moist-Dry	White	2.5-4'
Phlox maculata	Meadow Phlox	12" o.c.	Wet-Moist	Pink/Rose	2-3'
Phlox paniculata	Garden Phlox	24" o.c.	Wet-Moist	Pink/Rose	3-4'
Pycnanthemum pilosum	Hairy Mountain Mint	18" o.c.	Moist-Dry	White	2-4'
Pycanthemum tenuifolium	Slender mountain mint	18" o.c.	Moist	White	1.5-2.5'
Ratibida pinnata	Yellow/Grey Coneflower	18" o.c.	Dry-Moist	Yellow	3-5'
Rudbeckia fulgida	Orange Coneflower	24" o.c.	Wet-Moist	Yellow	1.5-2.5'
Rudbeckia hirta	Black-eyed Susan	18" o.c.	Moist-dry	Yellow	3'
Rudbeckia subtomentosa	Sweet Coneflower	24" o.c.	Wet-Dry	Yellow	4-6'
Salvia azurea	Blue Sage	24" o.c.	Moist-Dry	Blue	3-4'
Sagittaria latifolia	Arrowleaf	30" o.c.	Wet	White	1-4'
Scutellaria incana	Downy Skullcap	18" o.c.	Dry-moist	Blue	2-3'
Senna (cassia) marilandica	Wild Senna	24" o.c.	Moist-dry	Yellow	3-5'
Silene regia	Royal Catchfly	12" o.c.	Moist-Dry	Red	2-3'
Silphium perfoliatum	Cup Plant	36" o.c.	Wet-dry	Yellow	7-10'
Solidago nemoralis	Old Field Goldenrod	18" o.c.	Dry-moist	Yellow	4-6'
Solidago rigida	Stiff Goldenrod	12" o.c.	Moist-dry	Yellow	3-4'
Solidago rugosa	Rough-Leaved Goldenrod	18" o.c.	Dry-moist	Yellow	2-3'
Solidago speciosa	Showy Goldenrod	18" o.c.	Moist-dry	Yellow	3-4'
Symphyotrichum laeve	Smooth Aster	18" o.c.	Wet-dry	Blue/ Purple	2-3'
Symphyotrichum novae-angliae	New England Aster	24" o.c.	Wet-moist	Purple	2.5-5'
Symphyotrichum oblongifolium	Aromatic Aster	24"	Dry-moist	Purple	1-3'
Symphyotrichum oolentangiense (azureus)	Sky Blue Aster	18" o.c.	Moist-dry	Blue	2-3'

Table 2 : Native Perennials– Full Sun					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Tephrosia virginiana	Goatsbeard	12" o.c.	Dry-moist	Green	1-2'
Verbesina helianthoides	Yellow Wingstem	18" o.c.	Dry-moist	Yellow	2-3'
Veronacastrum virginicum	Culver's Root	24" o.c.	Dry	White	3-6'
Zizia aptera	Golden Alexander	12" o.c.	Wet-moist	Yellow	1-1.5'

Table 3 : Native Perennials– Shade					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Asarum canadense	Wild Ginger	12" o.c.	Moist	Green	4"
Cimifuga racemosa	Black Cohosh	24" o.c.	Moist	White	5-7'
Claytonia virginica	Spring Beauty	4" o.c.	Wet-dry	White	5-10"
Coreopsis palmata	Prairie Coreopsis	12" o.c.	Moist-dry	Yellow	1.5-2.5'
Erythornium americanum	Yellow Trout Lily	4" o.c.	Moist	Yellow	6-12"
Isopyrum biternatum	False Rue Anemone	6" o.c.	Moist-wet	White	5-8"
Mertensia virginica	Virginia Bluebells	12" o.c.	Moist	Blue/Purple /White	1-2'
Packera aurea	Golden Ragwort	12" o.c.	Moist	Yellow	0.5-1'
Packera obovata	Golden Groundsel	12" o.c.	Moist	Yellow	1'
Phlox divaricate	Wild Sweet William	12" o.c.	Moist-dry	Purple	1'
Polemonium reptans	Jacob's Ladder	12" o.c.	Moist	Blue	1'
Polygonatum biflorum	Solomon's Seal	12" o.c.	Moist-dry	White	2-4'
Spigelia marilandica	Indian Pink	12" o.c.	Moist-dry	Green	1.5-2.5'
Stylophorum diphyllum	Celandine Poppy	18" o.c.	Moist	Yellow	1-1.5'

Table 4 : Native Grasses and Sedges					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Andropogon gerardii	Big Bluestem	24" o.c.	Moist-Dry	Green	5-9'
Andropogon virginicus	Broomsedge	18" o.c.	Dry	Green	1-2'
Andropogon ternarius	Splitbeard Bluestem	18" o.c.	Dry	Green	1-2'
Bouteloua curtipendula	Sideoats Grama	12" o.c.	Dry-moist	Yellow	1-2'

Table 4 : Native Grasses and Sedges					
Latin Name	**Common Name**	**Spacing**	**Moisture**	**Color**	**Height**
Bouteloua gracilis	Blue Gamma Grass	18" o.c.	Moist-Dry	Green/Yellow	1-2'
Carex albicans	Oak Sedge	18" o.c.	Moist	Green	1'
Carex annectans	Yellow Fruited Sedge	18" o.c.	Wet-moist	Green	2-3'
Carex crinite	Fringed Sedge	18" o.c.	Wet-moist	Green	2-3'
Carex grayii	Globe Sedge	18" o.c.	Moist-wet	Green	1-1.5'
Carex eburnea	Bristle-leaf Sedge	12" o.c.	Moist	Green	1'
Carex hirsutella	Fuzzy Wuzzy Sedge	12" o.c.	Dry-moist	Green	1'
Carex pennsylvanica	Pennsylvania Sedge	18" o.c.	Moist	Green	1'
Carex muskingumensis	Palm Sedge	18" o.c.	Moist-wet	Green	2-3'
Carex praegracilis	Tollway Sedge	24" o.c.	Dry-Wet	Green	2'
Carex shortiana	Short's Sedge	18" o.c.	Dry-wet	Green	1-2'
Carex stricta	Tussock Sedge	18" o.c.	Wet	Green	1-1.5'
Carex vulpinoidea	Fox Sedge	18" o.c.	Moist-wet	Green	2-3'
Chasmanthium latifolium	Northern Sea Oats / River Oats	24" o.c.	Wet-moist	Green	2-2.5'
Diarrhena obovate	American Beakgrain	16" o.c.	Wet-dry	Green	1.5-2.5'
Elymus canadensis	Canada Wild Rye	24" o.c.	Dry	Green	3-5'
Juncus biflorus	Bog rush	12" o.c.	Moist-wet	Green	2'
Juncus effuses	Soft Rush	18" o.c.	Moist-wet	Green	2-3'
Juncus tenuis	Path Rush	12" o.c.	Wet-moist	Green	6-12"
Panicum virgatum	Switch Grass	24" o.c.	Moist-dry	Green	3-6'
Scirpus atrovirens	Great Green Bullrush	18" o.c.	Wet	Green	2-3'
Scirpus cyperinus	Wool Grass	18" o.c.	Wet	Green	3-4'
Schizachyrium scoparium	Little Bluestem	12" o.c.	Moist-dry	Green/Blue	2-3'
Sorghastrum nutans	Indian Grass	24" o.c.	Moist-dry	Green/Blue	3-6'
Spartina pectinate	Prairie Cordgrass	30" o.c.	Moist-wet	Green	4-5'
Sporobolus heterolepis	Prairie Dropseed	24" o.c.	Moist-dry	Green	1.5-2.5'
Tripsacum dactyloides	Eastern Gama Grass	4' o.c.	Wet	Green	4-8'

Table 5 : Native Medium Shrubs							
Latin Name	**Common Name**	**Spacing**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Aronia melanocarpa	Black Chokeberry	5-9’		Dry-Wet	White	5-9’	Food for Birds and Small Animals
Callicarpa Americana	American Beautyberry	3’	Full Sun/ Avg Shade	Dry-moist	Purple	4-5’	Ornamental Fresh-cut Flowers Berries attract songbirds
Ceanothus americanus	New Jersey Tea	2’	Full Sun/ Avg Shade	Dry-moist	White	2-4’	Edible leaves can be brewed into tea when dried. Food for Birds and Small Animals
Cephalanthus occidentalis	Buttonbush	6’	Full Sun/ Avg Shade	Wet	White	6-10’	Fragrant flowers attract butterflies and other pollinators
Dirca palustris	Leatherwood	3’	Shade	Wet-moist	-	4-7’	Food for birds
Euonymus americanus	Strawberry Bush	5’	Shade	Wet-moist	Red	6-8’	Food for birds Attracts songbirds and butterflies
Hydrangea arborescent	Wild Hydrangea	4’	Full Sun/ Shade	Moist-dry	White	4-5’	Fresh cut flowers Attracts butterflies and other pollinators
Hypericum prolificum	Shrubby St. Johns Wort	2’	Full Sun/ Avg Shade	Dry-moist	Yellow	3-5’	Fresh cut flowers Attracts butterflies and other pollinators
Ilex verticillate	Winterberry Holly	4’	Full Sun/ Avg Shade	Wed-dry	Green	6-10’	Ornamental Food for birds and small animals
Lindera benzoin	Spicebush	6’	Full Sun/ Avg Shade	Wet-moist	Yellow	6-12’	Attracts butterflies and other pollinators
Physocarpus opulifolius	Ninebark	6’	Full Sun	Wet-moist	White	5-10’	Attracts butterflies and other pollinators
Rhus aromatica	Fragrant Sumac	6’	Full Sun/ Avg Shade	Dry-moist	Red	2-6’	Food for birds and small animals
Ribes odoratum	Golden Currant	5’	Full Sun/ Avg Shade	Dry-moist	Yellow	4-6’	Edible fruit Attracts butterflies and other pollinators
Sambucus Canadensis	Elderberry	5’	Full Sun/ Avg Shade	Wet-moist	White	5-12’	Edible fruit Attracts butterflies and other pollinators

Table 6 : Native Large Shrubs							
Latin Name	**Common Name**	**Spacing**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Amelanchier arborea	Serviceberry	10’		Dry-moist	White	15-25’	Large shrub can be pruned into small tree. Attracts songbirds Edible fruit
Cornus racemose	Gray Dogwood	10’	Full Sun/ Shade	Dry-moist	Red/ White	10-15’	Attracts songbirds
Corylus Americana	American Hazelnut	8’	Full Sun/ Avg Shade	Dry-moist	Yellow	8-12’	Edible nuts
Euonymus atropurpureus	Wahoo	8’	Full Sun/ Avg Shade	Dry-moist	Purple	12-20’	Food for birds
Hamamelis virginiana	Witch Hazel	15’	Full Sun/ Shade	Dry-moist	Yellow	15-20’	Food for birds Attracts butterflies and other pollinators
Ilex decidua	Deciduous Holly	5’	Full Sun/ Avg Shade	Dry-moist	Red/ White	10-15’	Ornamental Food for birds and small animals
Prunus virginiana	Chokeberry	15’	Shade/ Avg Shade	Wet-dry	White	20-30’	Edible Fruit Attracts butterflies and other pollinators
Viburnum prunifolium	Black Haw Vibernum	8’	Full Sun	Wet-dry	White	12-15’	Food for birds and small animals Attracts butterflies and other pollinators

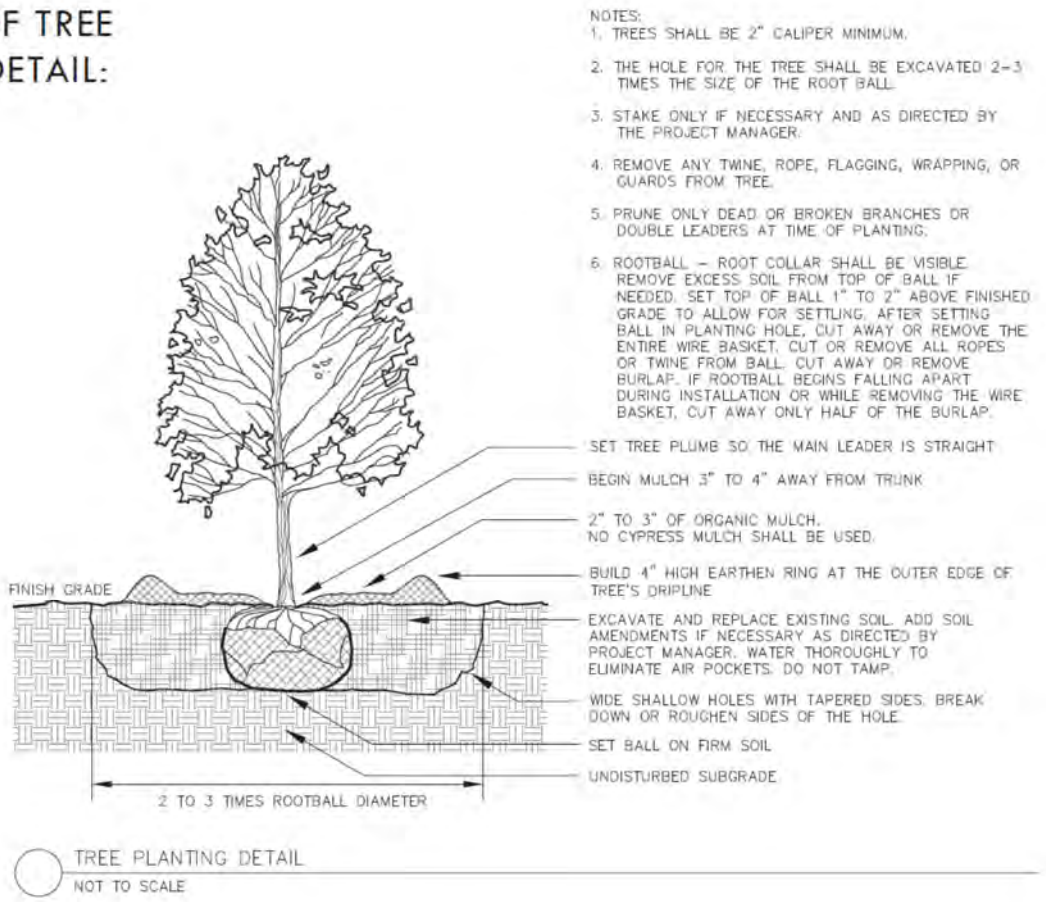
Table 7 : Native Small-Medium Trees							
Latin Name	**Common Name**	**Spread**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Acer saccharum	Sugar Maple	50-60’	Full Sun/ Avg Shade	Dry		40-75’	
Asimina trilobal	Paw Paw	15-20’	Full Sun/ Avg Shade	Moist-wet	Purple	15-30’	Edible fruit Plant is larval food of Zebra Swallowtail butterfly
Carpinus caroliniana	American Hornbeam	20-50’	Full Sun/ Shade	Moist-wet		20-40’	
Cercis canadensis	Eastern Redbud	25-35’	Full Sun/ Avg Shade	Moist-dry	Pink/ Rose	20-30’	Ornamental

Table 7 : Native Small-Medium Trees							
Latin Name	**Common Name**	**Spread**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Chionanthus virginicus	Fringetree	5-8’	Full Sun/ Avg Shade	Dry-moist	White	8-10’	Plants of Merit winner by Missouri Botanical Garden. Shimmering, white frothy flowers Can be grown as a large shrub.
Cornus drummondii	Roughleaf Dogwood	6-12’	Full Sun/ Avg Shade	Dry-moist	White	8-15’	Can be grown as a large shrub Food for birds and small animals
Cornus florida	Flowering Dogwood	15-30’	Full Sun/ Avg Shade	Moist	White	15-30’	Missouri State Tree Ornamental
Crataegus mollis	Downy Hawthorn	20-30’	Full Sun/ Avg Shade	Dry-moist	White	20-30’	Ornamental Food for birds and small animals
Crataegus viridis	Green Hawthorn	20-35’	Full Sun	Wet-Moist	White	20-35’	Ornamental Food for birds and small animals

Table 8 : Native Medium-Large Trees							
Latin Name	**Common Name**	**Spread**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Acer saccharum	Sugar Maple	50-60’	Full Sun/ Avg Shade	Dry		40-75’	
Asimina trilobal	Paw Paw	15-20’	Full Sun/ Avg Shade	Moist-wet	Purple	15-30’	Edible fruit Plant is larval food of Zebra Swallowtail butterfly
Betula nigra	River Birch	40-60’	Full Sun	Dry-wet		40-70’	Peeling bark
Carya ovata	Shagbark Hickory	40-60’	Full Sun/ Shade	Dry-moist		60-80’	Edible nuts Bark peels off in thin sections, curling at the ends while staying attached in the middle
Celtis occidentalis	Hackberry	40-60’	Full Sun	Dry-wet		40-60’	Use as a shade tree in large areas
Diospyros virginiana	Persimmon	20-35’	Full Sun/ Avg Shade	Moist		35-60’	Edible fruit

Table 8 : Native Medium-Large Trees							
Latin Name	**Common Name**	**Spread**	**Sun**	**Moisture**	**Flower Color**	**Height**	Notes
Platanus occidentalis	Sycamore	75-100’	Full Sun	Wet-moist		75-100’	Shade Tree
Quercus alba	White Oak	50-90’	Full Sun	Dry-moist		50-80’	Shade tree
Quercus bicolor	Swamp White Oak	50-70’	Full Sun/ Avg Shade	Wet-dry		50-80’	Shade tree
Quercus macrocarpa	Bur Oak	70-80’	Full Sun/ Avg Shade	Wet-dry		70-80’	Shade tree
Taxodium distichum	Bald Cypress	20-30’	Full Sun/ Avg Shade	Wet-moist		50-70’	Tolerates a wide range of conditions ranging from relatively dry soil to wet soil and standing water

EXAMPLE OF TREE PLANTING DETAIL:



RELATED LINKS AND RESOURCES

[1] https://www.missouribotanicalgarden.org/Portals/0/Shaw%20Nature%20Reserve/PDFs/horticulture/NLM%20Ch4.pdf

For an up-to-date list of native plant sources:

- Grow Native! www.grownative.org, by the Missouri Prairie Foundation

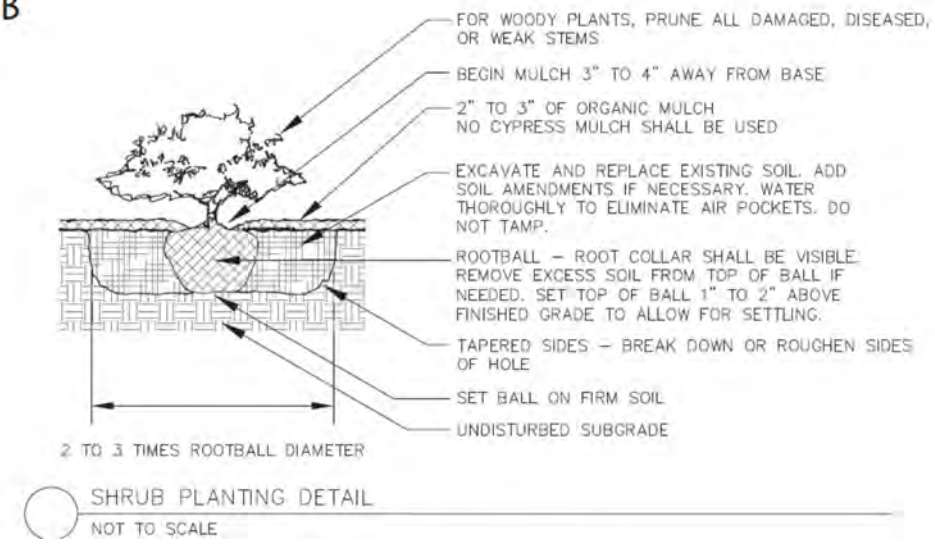
Additional Web Resouces:

- Missouri Department of Conservation, mdc.mo.gov/trees-plants
- Missouri Prairie Foundation, www.moprairie.org
- Shaw Nature Reserve, www.shawnature.org
- Show Me Rain Gardens, www.showmeraingardens.org
- Ten Thousand Rain Gardens, www.rainkc.com
- The Green Center, www.thegreencenter.org
- Missouri Botanical Garden Plant Finder, www.missouribotanicalgarden.org

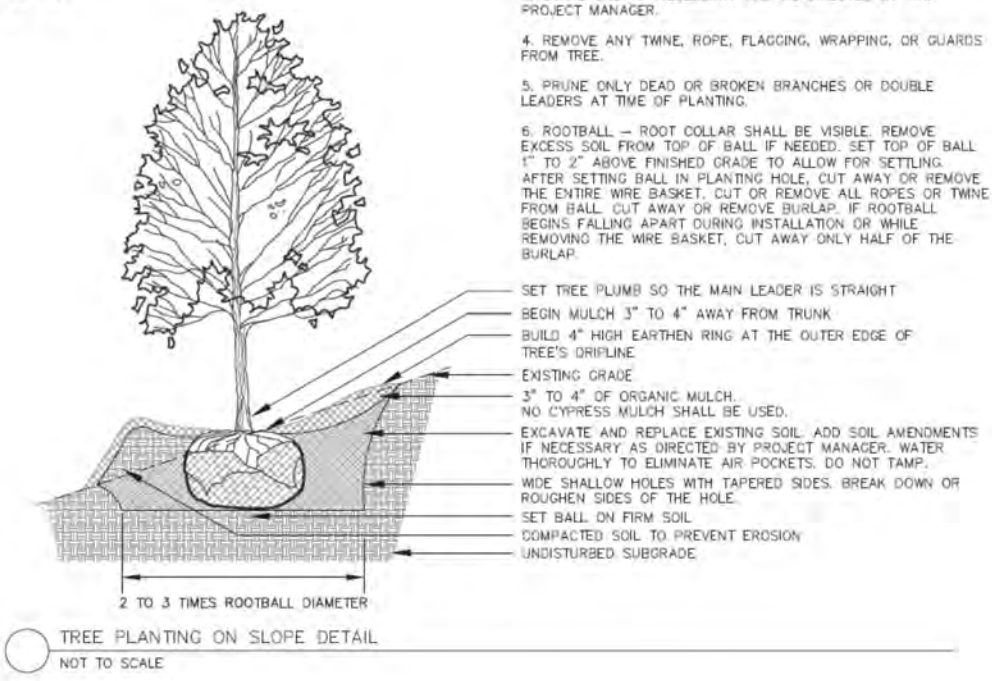
Publications:

- Metropolitan St. Louis Sewer District (2014). *Landscape Guide for Stormwater Best Management Practice Design*, St. Louis, MO. www.stlmsd.com/sites/default/files/engineering/442680.PDF
- Shaw Nature Reserve, a division of the Missouri Botanical Garden (2011). *A Guide to Native Landscaping*, Gray Summit, MO.
- Missouri Department of Natural Resources (2012). *Missouri Guide to Green Infrastructure*, Jefferson City, MO. dnr.mo.gov/env/wpp/stormwater/mo-gi-guide.htm

EXAMPLE OF SHRUB PLANTING DETAIL:



EXAMPLE OF SLOPE TREE PLANTING DETAIL:



APPENDIX C

The Simple Method of Determining Adequate Flow Area

This method is only to be used to determine adeqate flow area required for projects that add more than 15,000 square feet of impervious area (IA = Contributing Drainage Area). Beginning at the point of discharge from the site, the surface conveyance facility must have the capacity to convey flows from all contributing upstream drainage areas.

Step 1: Determine flow patterns on your project site, specifically where flow exits the project.

Step 2: Where flow exits the site, determine existing flow area of the exiting drainage channels on your site using the schematic and equation below in Figure 1. Mark on the plans where flow area was determined.

Step 3: Once flow area has been calculated, determine the impervious area (IA) of the project and the nearest lot area to determine the required flow area for your site.

Step 4: A) If the result of **Step 2** is *less* than **Step 3** adequate drainage is not present and the developer must follow current MSD guidelines. B) If the result of **Step 2** is *greater* than **Step 3** adequate drainage is present. If B, then the developer must submit engineering calculations and site plan to the Director of Public Services Director for verification.

Figure 1 Simple Method - Flow Area Calculation

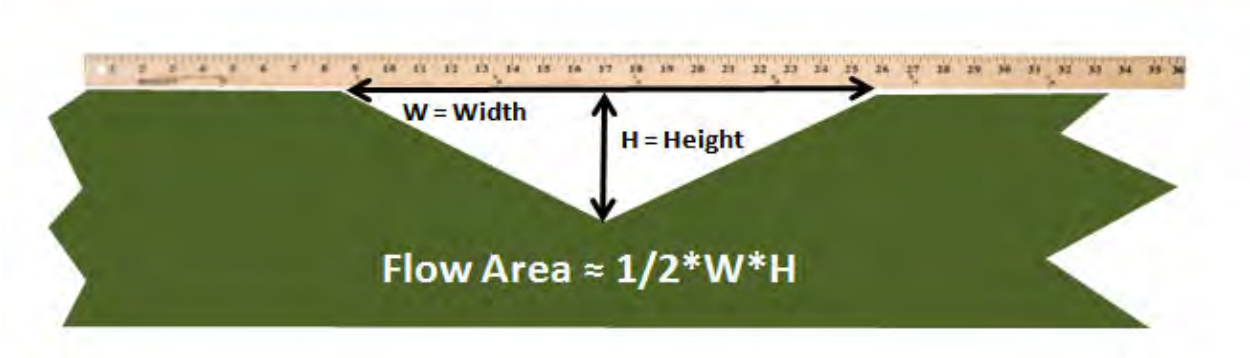


Table 1 Simple Method - Flow Area Required

Flow Area in Square Feet

IA (sq ft).	Total lot area --> 1,000	5,000	1/4 Acre 10,890	15,000	1/2 Acre 21,780	30,000	1 Acre 40,000
1,200	0.12	0.19	0.29	0.36	0.48	0.62	0.80
2,500	0.23	0.30	0.40	0.47	0.59	0.73	0.91
3,000	0.27	0.34	0.44	0.51	0.63	0.78	0.95
4,000	0.35	0.42	0.53	0.60	0.72	0.86	1.03
5,000	0.44	0.51	0.61	0.68	0.80	0.94	1.12
7,500	0.65	0.72	0.82	0.89	1.01	1.15	1.33
10,000	0.86	0.93	1.03	1.10	1.22	1.36	1.54
30,000	2.53	2.60	2.71	2.78	2.90	3.04	3.21
40,000	3.37	3.44	3.54	3.62	3.74	3.88	4.05

Read impervious area on the left then read across to right the nearest TOTAL lot size

Concrete channel flow area is 2/3 of the vegetated channel

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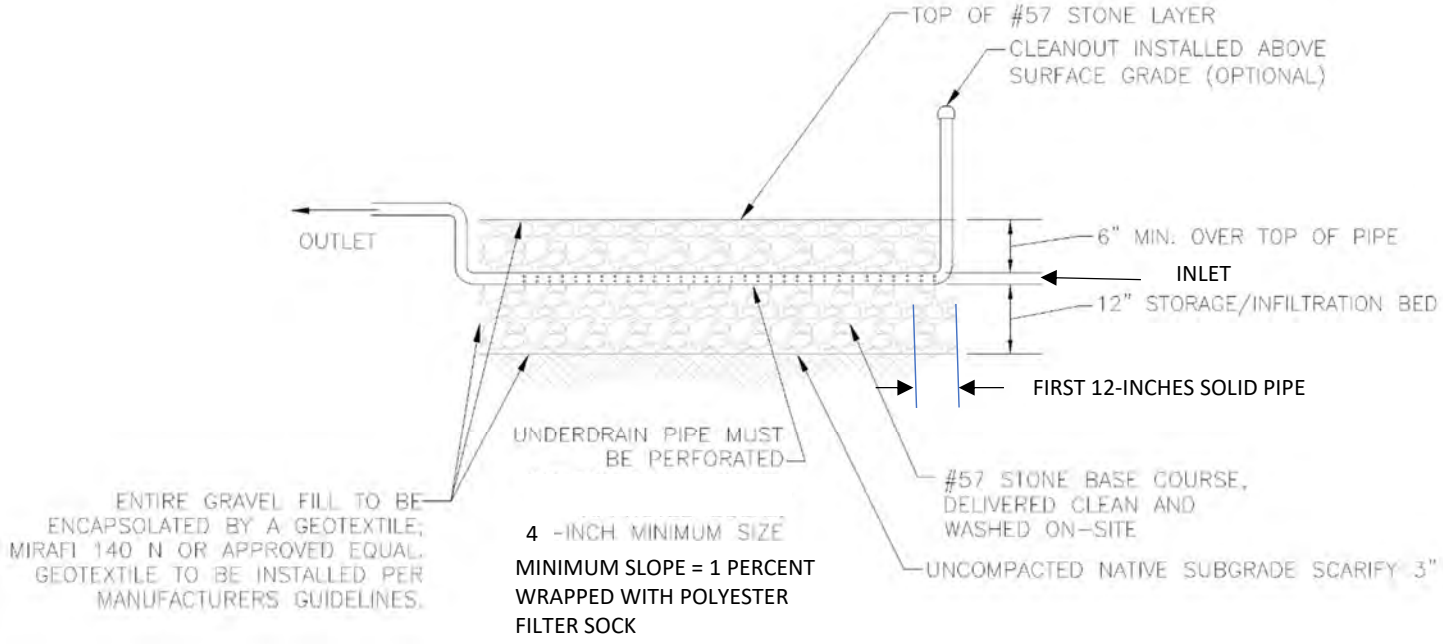
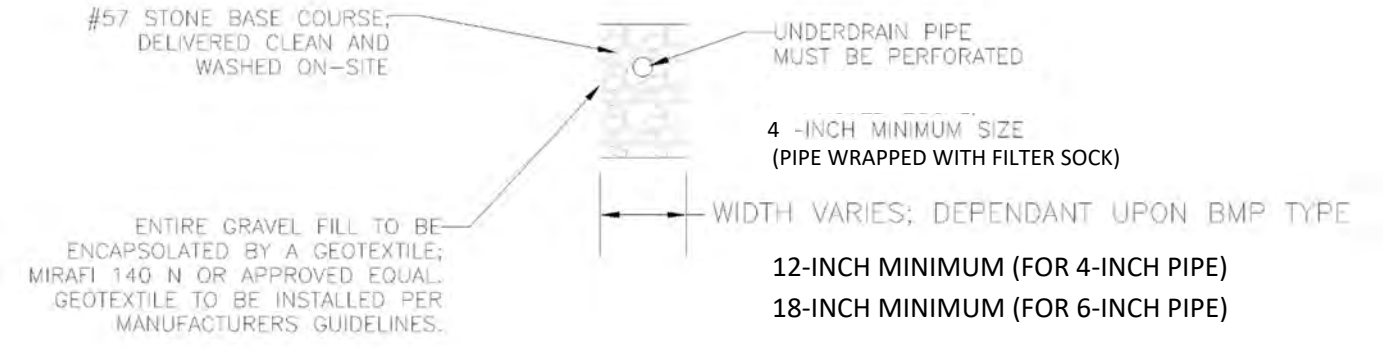
APPENDIX D

Underdrain Requirements

Some sites within the City have very low infiltration rates due to existing soil conditions and other factors. If your site has an infiltration rate that is less than required for your selected BMP, an underdrain will be required. An underdrain is a perforated pipe that is installed along the center of the BMP that will help the BMP to drain. The underdrain should be perched to allow some storage of water within the BMP before it drains out through the perforated pipe. See the detail below. All pipe BELOW FROST LINE shall be either HDPE or PVC or the equivalent. All horizontal drain pipe above the frost line shall be HDPE. Vertical pipe is to be Schedule 40 PVC.

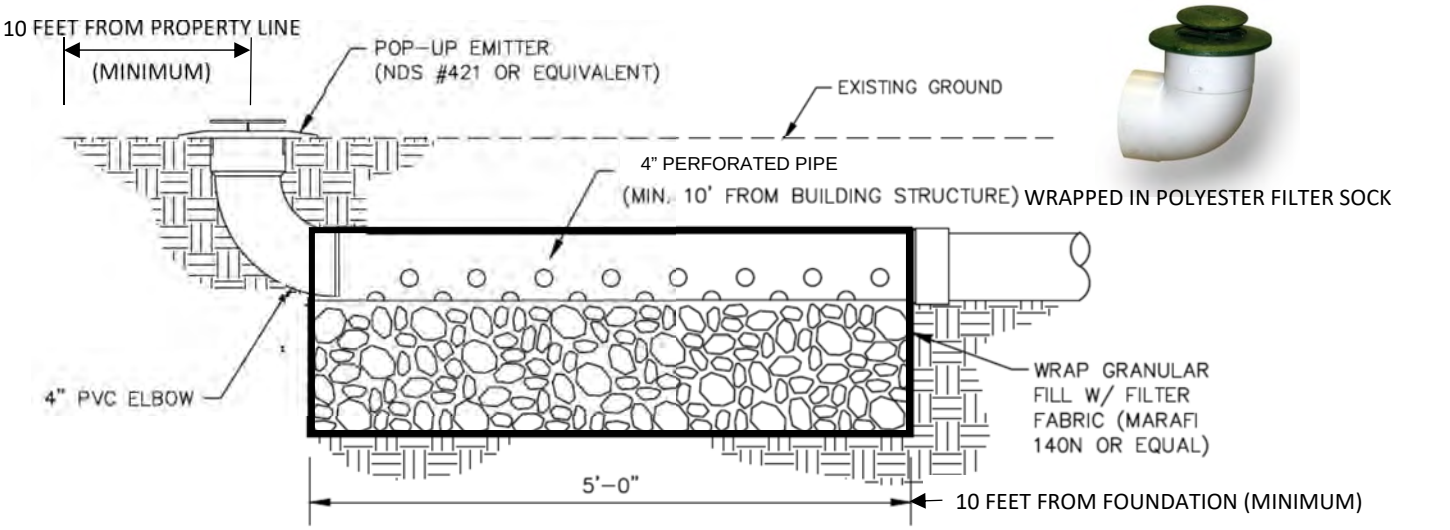


This detail consists of the general configuration of a perched underdrain system, the underdrain within your BMP may vary in size and position. Trench depth will increase due to pipe slope to maintain 12-inch infiltration bed.

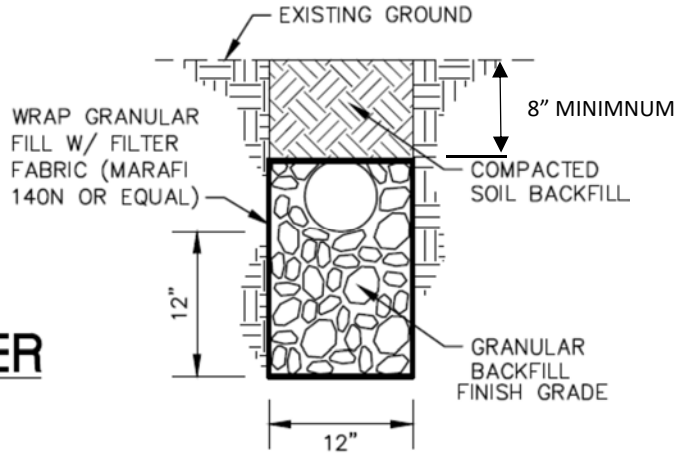


The outlet pipes must conform to the following requirements:

1. **Emitter.** The BMP outlet pipe can drain to a pop-up emitter. The last 5 feet of pipe shall be perforated AND WRAPPED WITH FILTER SOCK, surrounded by gravel (for a 4-inch inside diamter pipe, 16-inch deep by 12-inch wide) and encapsolated with geosythetic material (see detail BELOW) ; or



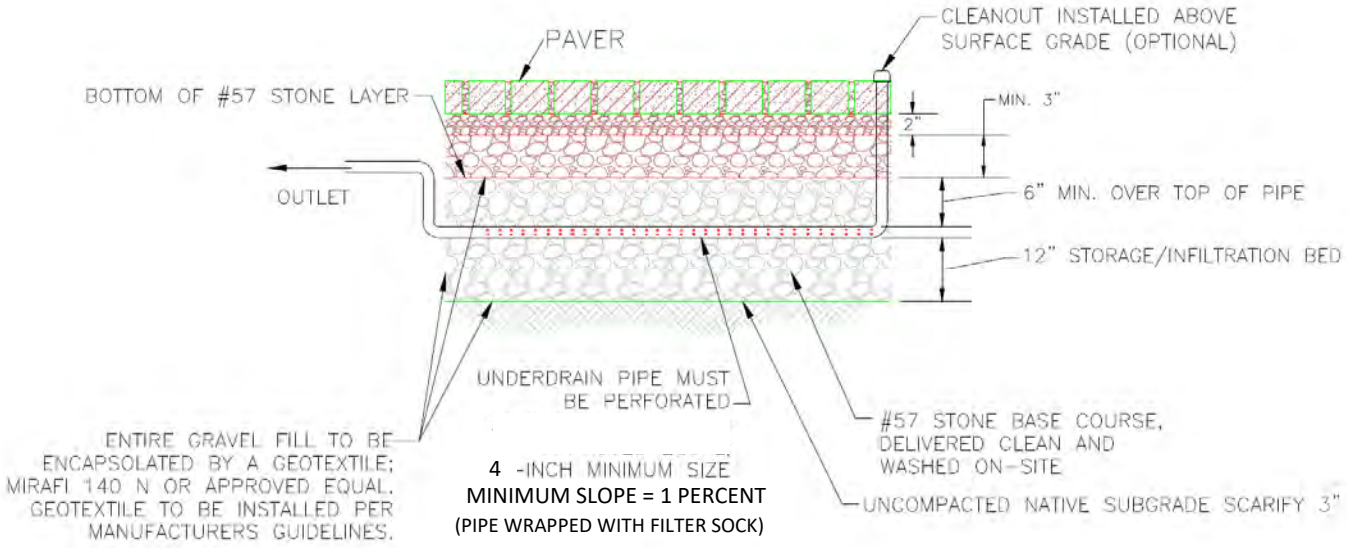
NOTES:
1. GRANULAR FILL SHALL BE 1" MIN. CLEAN DRAINAGE ROCK.
2. COMPACT SOIL MATERIAL UNDER LAWNS TO 85% MAXIMUM DENSITY AS DETERMINED BY THE MODIFIED PROCTOR COMPACTION TEST. (ASTM D 1557)
3. 4-INCH MINIMUM HDPE PERFORATED UNDERDRAIN OUTLET PIPE WRAPPED WITH FILTER SOCK
4. SLOPE PIPE TO DRAIN 1/8" PER FOOT OR 1%



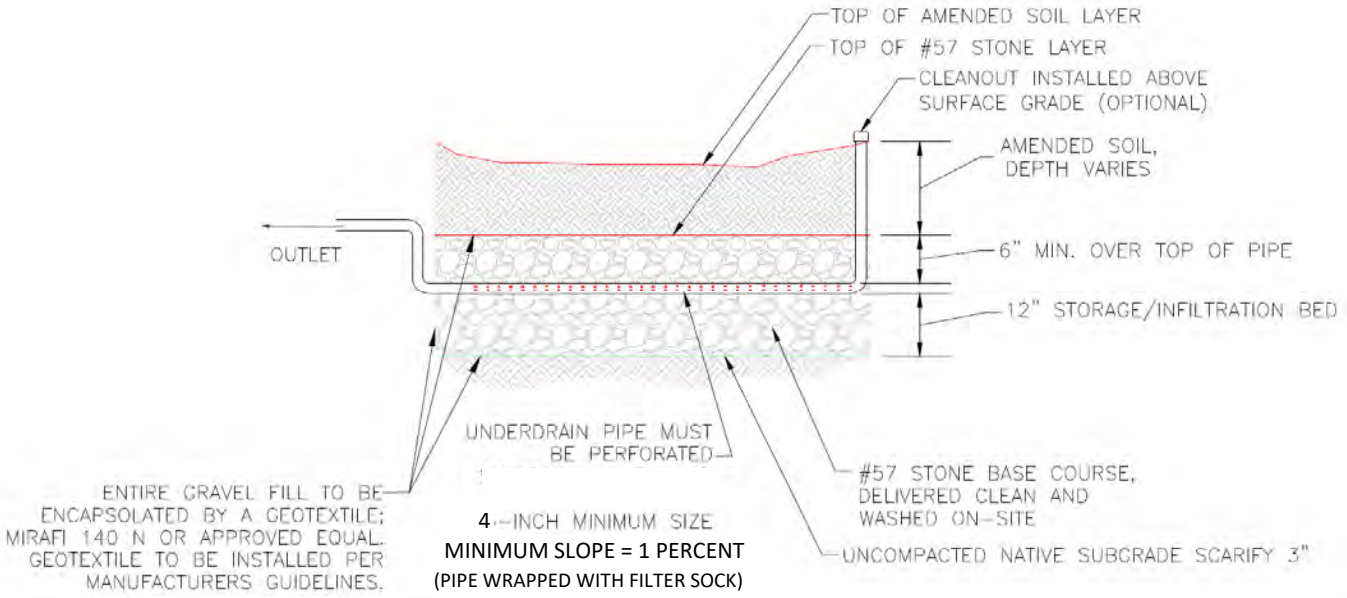
POP-UP EMITTER

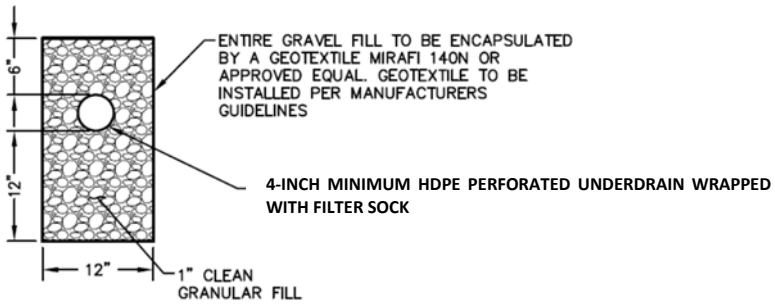
2. **Daylight (Rodent Screen).** Secure day lighted pipe ends with an end cap fitted with a rodent screen manufactuered for the pipe used. The rodent screen shall be press formed of #3 or #4 mesh, 21 gauge or heavier, Type 304 stainless steel to provide a cup-shaped screen which will provide a friction tight fit when inserted into the drain outlet.

Permeable Paver Detail



Rain Garden / Vegetated Filter Strip Detail





OUTLET PIPE SECTION

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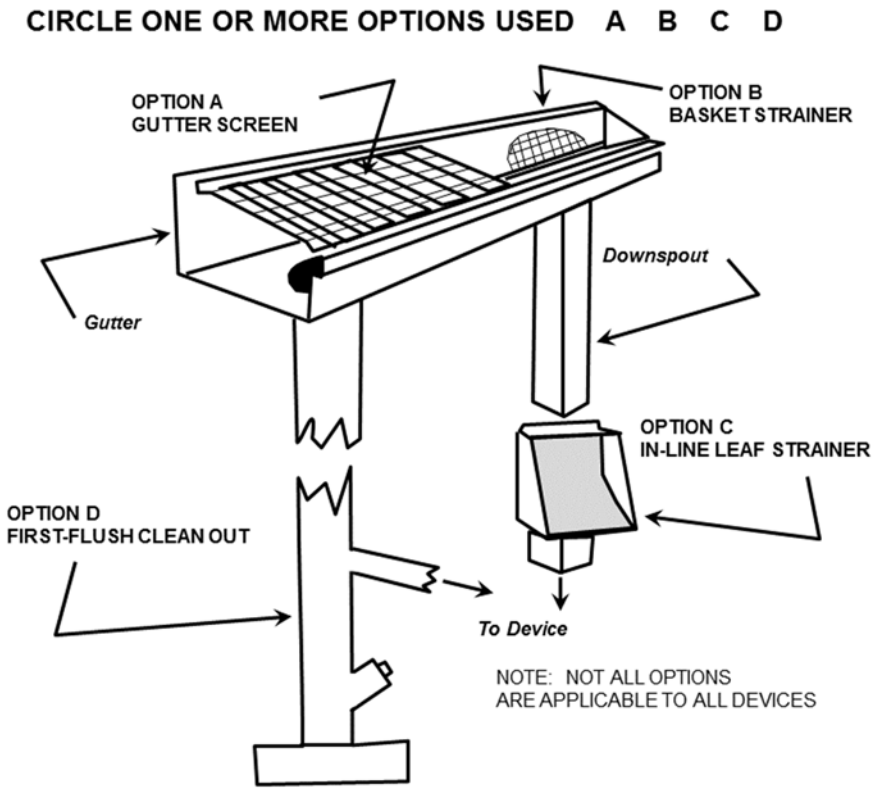
APPENDIX E

Pre-Treatment Options

Some BMPs require that a pretreatment device be installed in order to prevent clogging of the BMP. These pretreatment devices need to be cleaned out periodically to ensure that they are still functioning and to remove any buildup of debris. See the detail below. Complete and submit with plan when required.



PRETREATMENT OPTIONS DETAIL

This detail consists of the general configuration of pretreatement options, the pretreatment within your BMP may vary in size and position.

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APPENDIX F

Municipal Code Chapter 5, Article VI. Storm Water Management

The contents of this manual provide guidelines for meeting the Infill Development Storm Water Management regulations as stated in the municipal code. A copy of the ordinance in its entirety begins on the following page.

BILL 10702

ORDINANCE

AN ORDINANCE AMENDING CHAPTER 5 BY CREATING A NEW ARTICLE VI. "INFILL DEVELOPMENT STORM WATER MANAGEMENT", REDESIGNATING ARTICLE VI "FEE SCHEDULE" TO A NEW ARTICLE VII. AND AMENDING VARIOUS SECTIONS OF THE CODE FOR CONSISTENCY.

WHEREAS, the City has been working with a consultant on the best management practices for storm water management for infill development, and

WHEREAS, the City Council believes it is in the best interest of Kirkwood citizens to amend the Code to include a section entitled an "Infill Development Storm Water Management."

NOW, THEREFORE, BE IT ORDAINED BY THE COUNCIL OF THE CITY OF KIRKWOOD, MISSOURI, AS FOLLOWS:

SECTION 1. Chapter 5, Article VI "Fee Schedule" is hereby redesignated as Article VII. and a new Chapter 5, Article VI "Infill Development Storm Water Management" is hereby created as follows:

ARTICLE VI. INFILL DEVELOPMENT STORM WATER MANAGEMENT

Sec. 5-200. Purpose

The purpose of this ordinance is to provide storm water rules, regulations and standards to establish best management practices (BMP's) for infill development within the City of Kirkwood, Missouri, in order to promote the public health, safety, convenience and general welfare of the municipality.

Sec. 5-201. Definitions

Best Management Practice (BMP) means a structural device, measure, facility, or activity that helps to achieve storm water management control objectives at a designated site.

Impervious Area (IA) means the portion of a parcel of property that is covered by any material, including without limitation roofs, streets, sidewalks and parking lots paved with asphalt, concrete, compacted sand, compacted gravel or clay, that substantially reduces or prevents the infiltration of storm water. Impervious area shall not include natural undisturbed surface rock.

Infill Development Storm Water Guidance Document means the latest edition of the manual "Storm Water Management Guidance, City of Kirkwood Green Infrastructure Techniques for Storm Water Management" maintained by the Department of Public Services.

Lot means a tract, plot or portion of a subdivision or parcel of land intended as a unit for the purpose, whether immediate or future, for transfer of ownership or for building development.

Maintenance Agreement means an agreement between the current property owner and the City where the property owner agrees to maintain any installed BMPs on the property.

Net Additional Impervious Area means the impervious area calculated by subtracting the present impervious area in the most currently available aerial photography data or current site survey from the proposed post-

development impervious area and maintaining the original property boundary as the regulated project boundary, regardless of subdivision, re-plat, horizontal property regime, or any other modification of property boundaries by deed or plat.

Plan means a document approved at the site design phase that outlines the measures and practices used to control storm water runoff at a site.

Regulated Infill Development means the creation of Net Additional Impervious Area of at least 1,000 square feet or causing the total impervious area on the lot to be twenty-five (25) percent or greater of the total lot area for commercial, industrial, or residential real property through new development, redevelopment, or rehabilitation of existing lots.

Storm Water means any surface flow, runoff and drainage consisting entirely of water from any form of natural precipitation and resulting from such precipitation.

Vacant Lot means any lot containing no current permanent structure(s) and no permanent structures visible on the aerial photography dated 2001 maintained by the City.

Sec. 5-202. Regulated Infill Development – Requirements

All Regulated Infill Development shall not proceed without a permit and shall meet the requirements of this section.

(a) All Regulated Infill Development creating one thousand (1,000) square feet or more of Net Additional Impervious area is required to treat, by means of capture, the first 1.14” of rainfall runoff, for impervious area equal to the Net Additional Impervious Area. Vacant Lots shall be subject to this requirement.

(b) All Regulated Infill Development causing the total impervious area on the lot to be twenty-five (25) percent or greater of the total lot area are required to treat, by means of capture, the first 1.14” of rainfall runoff, for the amount of impervious area greater than twenty-five (25) percent of the total lot area or the Net Additional Impervious Area, whichever is greater.

(c) All Regulated Infill Development required to provide storm water quality or quantity control BMP’s by the Metropolitan St. Louis Sewer District MSD shall be exempt from the requirements of items (a) and (b) of this section.

(d) All new development and redevelopment sites that disturb greater than or equal to one (1) acre, including projects that are part of a larger common parcel or project that is greater than one (1) acre shall have development plans submitted to the Metropolitan St. Louis Sewer District (MSD) for review and approval prior to the issuance of any building permits.

(e) All development proposed for commercial, industrial, or multi-family use regardless of disturbed area shall have development plans submitted to the Metropolitan St. Louis Sewer District (MSD) for review and approval prior to the issuance of any building permits.

(f) Construction of an approved storm water BMP(s) shall not require a separate permit if installed in conjunction with associated construction activities requiring a permit from the Department of Public Services.

(g) Approved storm water BMP(s) constructed in association with any permitted work not requiring a Residential Site Restoration Escrow or Performance Guarantee shall require a Storm Water BMP Construction Escrow as set forth in Chapter 5, Article VII Fee Schedule.

(h) All Regulated Infill Development shall comply with the provisions of Chapter 5, Article V of this code.

(i) All Regulated Infill Development shall comply with all applicable provisions of Appendix A – Zoning Ordinance §10103

The owner/developer of a project qualifying as Regulated Infill Development shall endeavor to treat the first 1.14" of rainfall runoff from the net added impervious area using methods from the Infill Development Storm Water Guidance Document. If this treatment proves impractical, improving downstream drainage to mitigate a known flooding problem with assistance from a professional engineer may be considered for all or part of the 1.14" treatment requirement. Final determination of allowable alternate method to be made by Director of Public Services.

Sec. 5-203. Sump Pumps

(a) All projects which include the installation of sump pumps or existing sump pumps with discharges causing a nuisance per Chapter 16 Section 2 of this code must discharge to one of the following BMP's per the Infill Development Storm Water Guidance Document:

(1) Drywell sized to treat a minimum of 175 square feet of contributing area and located a minimum of 10' from any property line, or

(2) Vegetated filter strip sized to treat a minimum of 175 square feet of contributing area and sump pump discharge located a minimum of 20' from any property line.

(b) BMP's for sump pump discharges listed in this section may contribute to the required BMP's for Regulated Infill Development by section 5-202.

Sec. 5-204. Storm Water Design Manual

The Director of Public Services shall maintain the "Storm Water Management Guidance, City of Kirkwood Green Infrastructure Techniques for Storm Water Management" as adopted by resolution by the City Council. The latest version as adopted by resolution by the City Council shall be followed by all persons planning or constructing Regulated Infill development within the city limits.

Sec. 5-205. BMP Maintenance and Inspection

(a) Prior to the issuance of any permit for a development involving any Regulated Infill storm water BMP, the owner(s) of the site must execute a maintenance agreement that shall be binding on all subsequent owners of land served by the storm water BMP. The agreement shall provide for access to the BMP and the land it serves at reasonable times for periodic inspection by City or City's designee and for regular or special evaluations of property owners to ensure that the BMP is maintained in proper working condition to meet City storm water requirements. The maintenance agreement shall be recorded with St. Louis County Recorder of Deeds and a recorded copy of the agreement shall be provided to the City by the owner prior to issuance of any permit.

(b) The owner(s) of every regulated infill development site shall be responsible for maintaining storm water BMPs in an effective state as determined in the sole judgment of City after completion of construction.

(c) Occupancy permits shall not be granted until all storm water BMPs have been inspected and approved by City.

Sec. 5-206. Enforcement – Notice of Violation

Whenever the Director or the Director's designees, including inspectors within the City's Department of Public Services, find that a person has violated the terms of the maintenance agreement or failed to meet a requirement of this Chapter, the Director or his or her designee may order compliance in accordance with procedures set forth in Chapter 5, Article III Property Maintenance Code.

Sec. 5-207. Violation Penalties

Violation of the provisions of this ordinance or failure to comply with any of its requirements (including violations of conditions and safeguards established in connection with granting of variances) shall be subject to penalties in accordance with Chapter 5, Article III Property Maintenance Code.

SECTION 2. Chapter 5, Article VII "Fee Schedule" is hereby amended to add the following table to Section 5-109:

TABLE 3 – ESCROWS

Item	Amount	Remark
Residential Site Restoration Escrow	$5,000.00	100% refundable upon final inspection and acceptance by the Department of Public Services
Storm Water BMP Construction Escrow	$1,000.00	100% refundable upon final inspection and acceptance by the Department of Public Services

SECTION 3. Amend Chapter 5, Section 5-21 is hereby amended to add the following to the 2009 International Property Maintenance Code:

PM 302.11 –Storm water BMP's: All storm water BMP facilities shall be maintained in an effective state and operate as designed per the City of Kirkwood Infill Development Storm Water Guidance Document and per the recorded Storm Water Management BMP facilities maintenance agreement.

PM 202 – General Definitions:

Best Management Practice (BMP) means a structural device, measure, facility, or activity that helps to achieve storm water management control objectives at a designated site.

Storm Water means any surface flow, runoff and drainage consisting entirely of water from any form of natural precipitation and resulting from such precipitation.

Storm Water Management BMP Facilities Maintenance Agreement means an agreement between the current property owner and the City where the property owner agrees to maintain any installed BMPs on the property.

SECTION 4. Chapter 16 is hereby amended to include the following:

Sec. 16-2. Nuisances enumerated.

(q) Any water discharge causing dirt, mud, ice or filth, caused or permitted on any private sidewalk, driveway, or patio creating a hazard to users of the premises.

SECTION 5. Chapter 17, is hereby amended by deleting Section 17-242 (a) and (c) in its entirety and inserting the following:

Sec. 17-242 Water Control.

(a) No person shall direct storm water or sump pump discharge water through a pipe, culvert, or drain, which discharges within ten feet of the adjacent property line except for (1) house roof or foundation drains, which may be discharged within two feet of the house foundation, (2) discharge into an open natural swale or creek on the same property.

(c) No person shall direct water through a pipe, culvert, drain, or sump pump across a public sidewalk, private driveway, walkway, or patio. Water may be directed to the street pavement or a pipe may be connected to a public storm sewer inlet providing the system is maintained by the property owner and received approval from the Metropolitan St. Louis Sewer District.

SECTION 6. This Ordinance shall be in full force and effect after its passage and approval, as provided by law.

PASSED AND APPROVED THIS 3rd DAY OF JANUARY, 2019

Tim Griffin

_____

Mayor, City of Kirkwood

ATTEST:

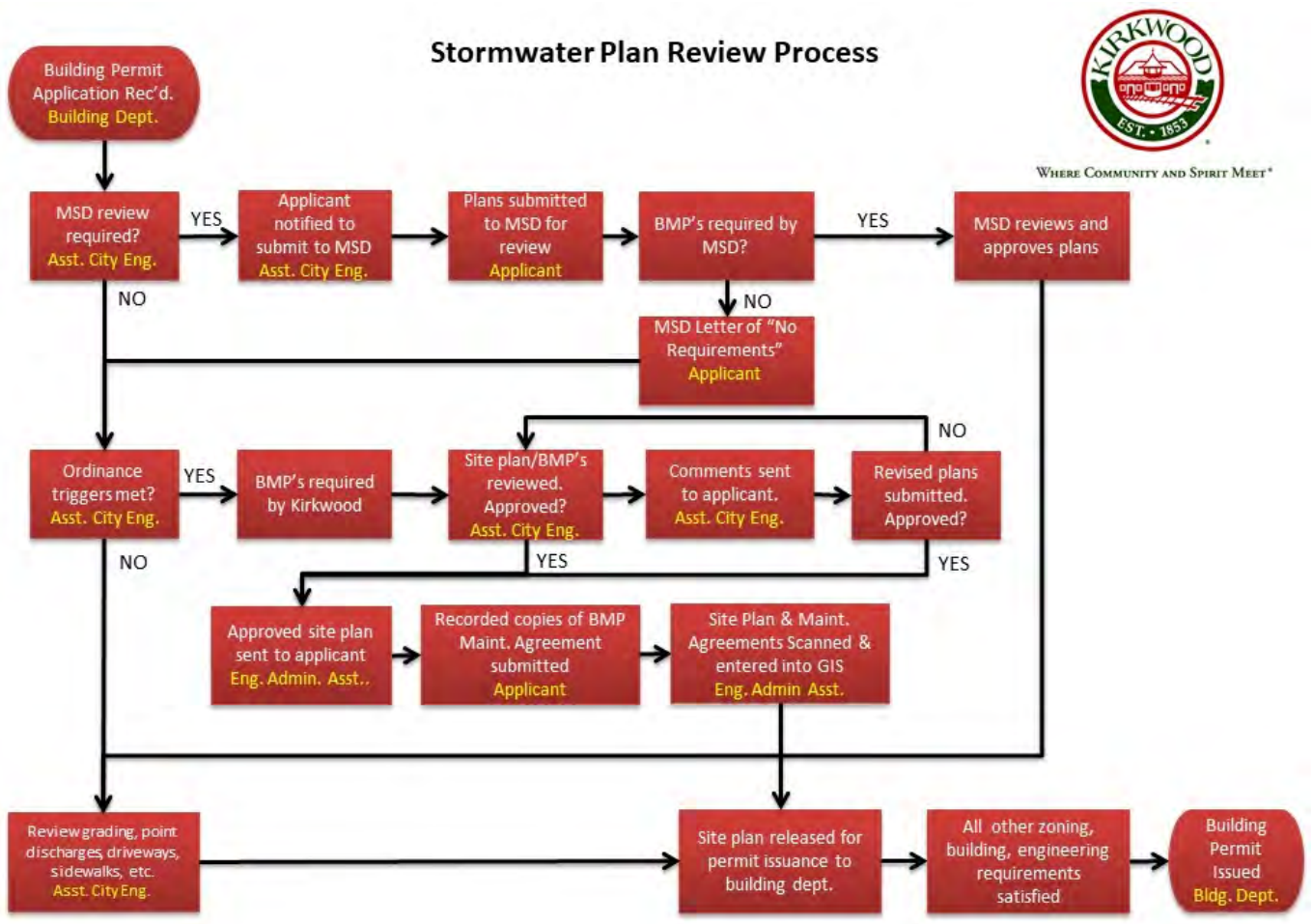
Laurie Asche

_____

City Clerk
1st Reading: December 20, 2018
2nd Reading: January 3, 2019

APPENDIX G

Stormwater Plan Review Process



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APPENDIX H

Stormwater Pollution Prevention for Small Residential Construction Sites

Why do stormwater discharges from construction activities matter?

When it rains, stormwater washes over the loose soil on a construction site, along with various materials and products being stored outside. As stormwater flows over the site, it can pick up pollutants like sediment, debris, and chemicals from that loose soil and transport them to nearby storm sewer systems or directly into rivers, lakes, or coastal waters. EPA works with construction site operators to make sure they have the proper stormwater controls in place so that construction can proceed in a way that protects your community's clean water and the surrounding environment.

What Defines a Small Residential Construction Site?

A small residential construction site is a residential lot is a lot or grouping of lots being developed for residential purposes that will disturb less than 1 acre of land, but that is part of a larger residential project that will ultimately disturb greater than or equal to 1 acre.

What are ten steps to Stormwater Pollution Prevention on Small Residential Construction Sites?

The purpose of good housekeeping is to prevent daily construction activities from causing pollution. The following steps and detailed graphic on the next page are ten steps, some used in Kirkwood's Tree and Residential Infill programs, which are good practices to reduce stormwater pollution.

1. Protect any areas reserved for vegetation or infiltration and preserving existing trees
2. Stockpile you soil
3. Protect construction materials from run-on and runoff
4. Designate waste disposal areas
5. Install perimeter controls on downhill lot line
6. Install inlet controls
7. Install a concrete / stucco washout basin
8. Maintain a stabilized exit pad
9. Post your stormwater BMP site plan
10. Site stabilization

10 Steps to Stormwater Pollution Prevention on Small Residential Construction Sites

Stormwater management on small residential construction sites need not be complicated.

1 Protect Any Areas Reserved for Vegetation or Infiltration and Preserve Existing Trees

If you will be installing infiltration-based features such as rain gardens or bioswales, make sure these areas are designated as off limits to avoid compaction.

Save time and money by preserving existing mature trees during construction. Preserving mature trees minimizes the amount of soil that needs to be stabilized once construction is complete, and minimizes the amount of runoff during and after construction activity.

2 Stockpile Your Soil

EPA's CGP requires operators to preserve native topsoil on site unless infeasible and protect all soil storage piles from run-on and runoff. For smaller stockpiles, covering the entire pile with a tarp may be sufficient.

3 Protect Construction Materials from Run-On and Runoff

At the end of every workday and during precipitation events, provide cover for materials that could leach pollutants.

4 Designate Waste Disposal Areas

Clearly identify separate waste disposal areas on site for hazardous waste, construction waste, and domestic waste by designating with signage, and protect from run-on and runoff.

5 Install Perimeter Controls on Downhill Lot Line

Install perimeter controls such as sediment filter logs or silt fences around the downhill boundaries of your site.

6 Install Inlet Controls

Sediment control logs, gravel barriers, and sand or rock bags are options for effective inlet controls. Make sure to remove accumulated sediment whenever it has reached halfway up the control.

7 Install a Concrete/Stucco Washout Basin

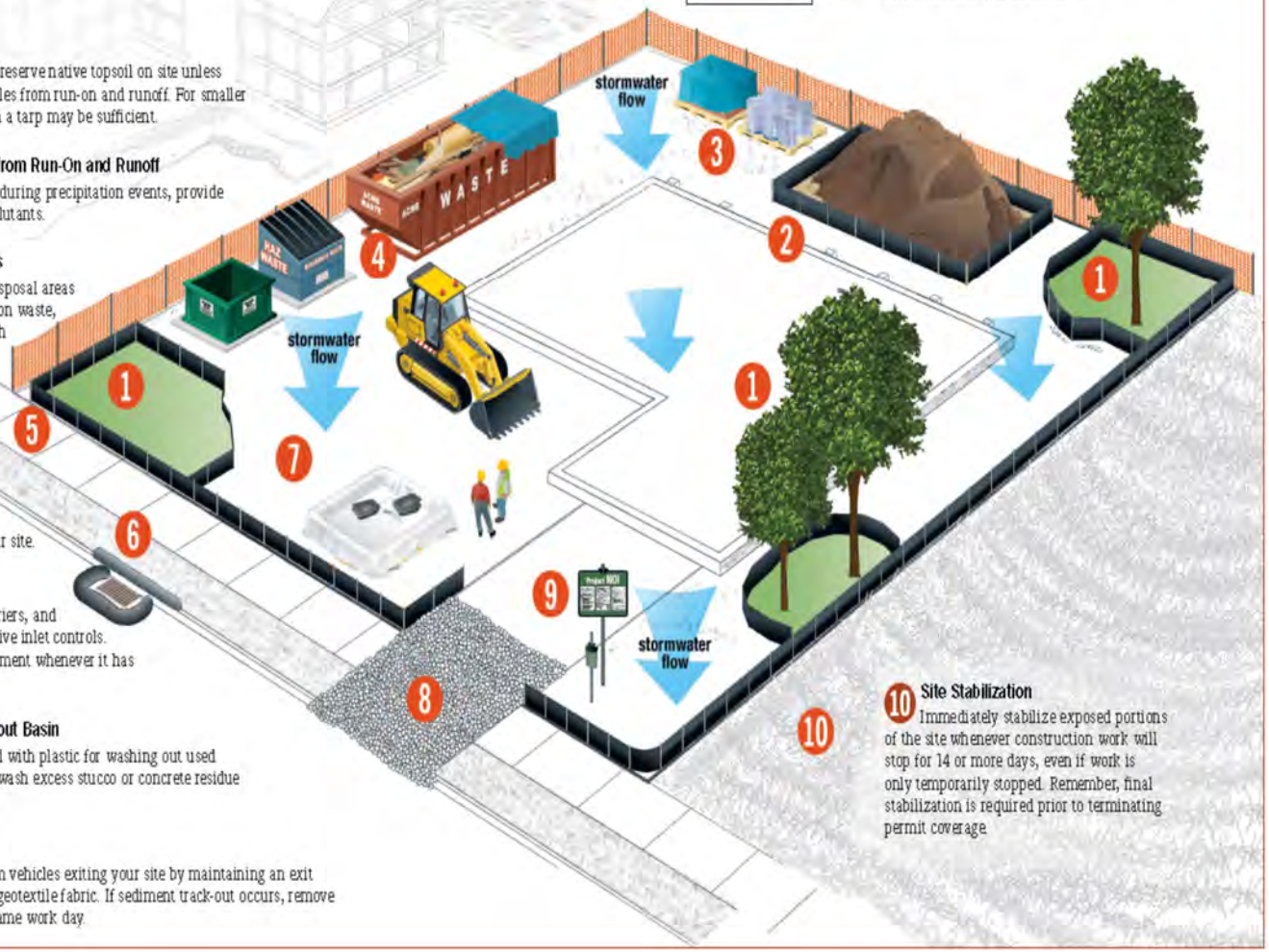
Designate a leak-proof basin lined with plastic for washing out used concrete and stucco containers. Never wash excess stucco or concrete residue down a storm drain or into a stream!

8 Maintain a Stabilized Exit Pad

Minimize sediment track-out from vehicles exiting your site by maintaining an exit pad made of crushed rock spread over geotextile fabric. If sediment track-out occurs, remove deposited sediment by the end of the same work day.

9 Post Your NOI and Keep an Up-to-Date Copy of Your SWPPP on Site

Post a sign or other notice of your permit coverage, including your NPDES tracking number and site contact information. Also, keep a copy of your complete and up-to-date SWPPP on site and easily accessible, including site maps showing where each BMP is or will be installed.



10 Site Stabilization

Immediately stabilize exposed portions of the site whenever construction work will stop for 14 or more days, even if work is only temporarily stopped. Remember, final stabilization is required prior to terminating permit coverage.