ARTICLE 16 – Retention Best Management Practices

§ T1600 Introduction

This section provides guidance on a number of retention based stormwater BMP's that can be used to meet the Kane County 0.75-inch retention standard. The BMP's outlined in this Article include:

§ T1601 Permeable Interlocking Concrete Pavements

§ T1603 Rain Gardens

§ T1604 Infiltration Trenches

§ T1605 Level Spreader and Filter Strips

§ T1606 Naturalized Stormwater Basins

Guidance for each of these BMP's is provided in subsequent sections of this chapter. For each of the BMP's, the following are provided.

Design guidance: Describes site suitability, design parameters, hydrologic analysis, and sizing.

Example specification: Written specifications that can be used within construction documents.

Standard detail: A standard detail that may be used within construction drawings or inform the production of construction drawings.

The Technical Guidance Manual is not an exhaustive list of best management practices that can be used to provide a water quality and quantity benefits. Each practice will need to be evaluated on a case by case basis. Appropriate documentation shall be required to insure the proposed practice shall function as designed.

Before any BMP is proposed on a site it is important to determine what site conditions are present and will the proposed BMP have a negative impact to on and off site resources. An example would be if the proposed project is located in a ground water recharge area it would be critical to prevent any ground water contamination due to infiltration of deicing materials or similar that would contaminate the water supply.

The guidance in this manual does not relieve the designer of responsibility for meeting all federal, state, and local requirements.

§ T1600(a) Terminology

There are many terms used to describe the various stormwater management practices that are in use today. To avoid confusion caused by local variations in terminology, the following abbreviated glossary is provided. Because this glossary is short, the terms are not arranged alphabetically. Rather the terms are arranged in a progression from the most commonly understood to the least.

§ T1600(a)(1) Detention:

The temporary storage of stormwater runoff with a slow, controlled release. Detention is typically provided in detention basins that use orifices, weirs, and other structures to control the discharge rate from the storage facility. The Kane County 0.10 cfs/acre 100-year allowable release rate is a detention standard. There are a number of types of detention basins.

Dry detention basins: Detention basins that remain dry between events. This is typically due to the outlet control structure being located at the bottom of the basin and the basin having adequate bottom slope to drain all runoff water.

Wet detention basins: Detention basins that include a permanent pool of water that is intended not to drain. The permanent pool is provided by locating the outlet control structure above the bottom of the excavation. In addition to providing detention of runoff water, wet detention basins are often constructed to provide aesthetic benefits, water quality benefits, and to reduce space requirements. (No storage is lost to the sloping bottom often necessary within dry detention basins.) Wet detention basins are sometimes, incorrectly referred to as retention basins (see “retention” below).

Wetland detention basins: Detention basins constructed with appropriate morphology (cross-sectional shape) and hydrology to provide habitat for wetland vegetation. Neither the Kane County stormwater management ordinance, nor the Corps of Engineers allow detention basins to be located within natural wetlands. Thus, wetland detention basins are created wetlands. Wetland detention basins can take on a variety of forms from a generally wet detention basin with a wetland shoreline to a shallow marsh with little or no permanent pool but sufficiently flat bottom and sufficiently wet conditions to support wetland plant species.

§ T1600(a)(2) Retention:

In relation to stormwater, retention is the opposite of surface discharge. With retention, runoff water does not leave the site and is instead infiltrated, evaporated, or reused within the site. Although there may be storage associated with retention facilities, the runoff water is not permanently stored on the site. In relation to stormwater, retention is the opposite of surface discharge. Retention strategies mimic the natural water cycle and release runoff back to the environment as groundwater recharge or evaporation or both but not as surface runoff. Reuse of collected rainwater for later irrigation or grey water reuse could also be considered a retention strategy. Although there may be storage associated with retention facilities, the runoff water is not permanently stored on the site. The Kane County requirement that 0.75- inches of runoff per impervious acre be retained is a retention standard. It is intended that this first 0.75-inches of runoff from impervious surfaces not leave the site as surface water.

Wet detention basins are often referred to as retention basins. However, because the permanent pool is ever-present, the only retention is the small amount of drawdown that may occur between events due to evaporation or mild infiltration.

The Best Management Practices outlined in this chapter are all at least partially retention practices. While many of these practices can be designed to retain most any volume of runoff, the design guidance provided here is specifically targeted to meeting the 0.75-inch retention standard.

<u>Infiltration:</u>

Infiltration refers to the introduction of runoff water into the underlying soil. Infiltration facilities typically provide temporary storage to allow slow infiltration of runoff water from a particular size event.

<u>Bioretention:</u>

Bioretention is a special class of retention BMP. Bioretention facilities temporarily store runoff water within soil or vegetation for later evaporation. With a bioretention facility, the stored water is used by the vegetation and evaporated or transpired but not infiltrated. Examples of bioretention include rain gardens located on impervious soils and green roofs.

<u>Bioinfiltration:</u>

Bioinfiltration is a special class of retention BMP. Bioinfiltration facilities temporarily store runoff water for infiltration.

		Retention		
BMP	Detention	Infiltration	Bioretention	Bioinfiltration
Detention basin	√			
Infiltration basin		√		
Infiltration trench		√		
Permeable pavement	√	√		
Green roof	√		√	
Rain garden		√	√	√
Bioswale		√	√	√
Filter strip			√	√

Table 1 – Classification of Typical Stormwater BMPs

<u>Combination Facilities:</u>

Many BMP's do not fall into only one category as evidenced in Table 1. For example, permeable pavement systems are both detention and infiltration. These systems temporarily store runoff water in the aggregate below the paving surface.

Some of that water infiltrates into the subgrade and some is slowly drained (and therefore detained) by an edge drain that discharges to the surface.

As can be seen in the table, there are many BMP's that fall into the categories of bioinfiltration and bioretention; in particular, rain gardens and bioswales. Rain gardens are shallow depressions lined with amended topsoil that are often underlain with a gravel storage/drainage layer. Bioswales are essentially the same as rain gardens except they tend to be long and linear and sometimes provide conveyance as well as storage. Because bioswales often provide both retention in the topsoil and infiltration through the bottom, the term bioswale is conveniently used rather than the more limiting terms of bioinfiltration swale and bioretention swale.

Although guidance for green roofs is not included in this document, a green roof is a bioretention BMP. A green roof (or vegetated roof) does not provide infiltration (for obvious reasons) but can retain significant runoff. Rain water that falls onto the engineered green roof soil hydrates the soil where the water is retained for later evaporation and transpiration by plants. Most green roofs are capable of retaining 0.75-inches and more runoff. Thus, with approval from the enforcement officer, green roofs can be assumed to meet the Kane County 0.75-inch retention standard.

§ T1600(b) BMP Systems

Although it is convenient to discuss individual BMP's, it is best to design stormwater management systems to provide necessary retention, conveyance, and detention. It is also best to distribute those systems throughout a site (decentralization of the stormwater treatment system) rather than using the more typical end-of-pipe approach to mitigating stormwater runoff. With a decentralized system, no one facility or one location of the site must manage all of the runoff and therefore greater volumes of retention are possible to better mimic natural hydrology. The Blackberry Creek Alternative Futures Analysis report

(http://www.co.kane.il.us/kcstorm/blackberry/FinalReport.pdf)

provides example BMP systems for various development types and densities and documents potential site and watershed scale benefits of implementing decentralized, retention based stormwater management systems.

§ T1600(c) Guidance Organization

Although a systems approach is recommended, this guidance is organized by BMP for purposes of providing design guidance and specifications. Each BMP section provides guidance on suitable applications, limitations to their use, site data requirements, hydrologic design criteria and sizing guidance, guidance on vegetation selection and establishment, construction considerations, and maintenance and operation requirements. Sample construction details and specifications are also provided for each BMP.

§ T1601 Permeable Interlocking Concrete Pavements

§ T1602 Definition and Examples

Permeable interlocking concrete pavement represents one type of porous pavement. These pavers are pre-cast units that have openings or large crevices (expanded joints) formed into them. The crevices (or expanded joints) are created through tabs or spacers that are cast onto the concrete unit block paver. The cast-on tabs or spacers lock into each other to create a flexible pavement system. Simple openings in the paver unit are provided by removing or adding a section from/to the cast.

The width and size of the crevices or opening in the interlocking pavers varies by the products and yields different ratios of openings per square foot. The crevices are filled with an open graded permeable material to allow water to infiltrate through the pavement. The gradation and permeability of this material will ultimately determine the rate at which water can be infiltrated through the porous paver surface.

Porous pavers can be combined with other BMP's in this guidance manual. Biofiltration measures, such as rain gardens (see Section § T1603) with or without infiltration trenches (see Section § T1604), can be used in parking lot islands to treat and convey runoff that may be discharged from the porous pavement surface during very intense rainfalls. Small rain gardens (see Section § T1603) can be used at the downstream end of porous pavements to treat and infiltrate surplus runoff that may be generated.

Other porous pavement options, although not addressed in this manual, are porous asphalt and porous cast-in-place concrete.

§ T1602(a) Suitable Applications

Porous pavers are an important structural BMP tool and valuable alternative to conventional pavements. Their application is ideal for small sites where surface detention is not feasible due to space constraints. Porous pavement systems may further be used on sites with high permeability soils where there is no drainage system to accept pavement runoff. They can be integrated into new developments and can be retrofitted into existing developments. Suitable areas or development types in which porous pavements can be incorporated are:

Paths, sidewalks, and walkways

Patios, terraces, and plazas

Driveways

Parking lots

Main and service drives

Emergency access areas

Small subdivision roads and alleyways

Non-commercial boat ramps and landings

§ T1602(b) Benefits

The purpose and concept behind porous unit block pavers is to offer a decentralized stormwater management tool. It provides retention and detention. The former allows for stormwater infiltration through the pavement wearing course, its base, and into the subgrade. It thus can be used to meet the Kane County 0.75-inch retention standard. Depending on the subgrade infiltration rates, use of permeable pavement can help to maintain the natural water cycle, recharging local aquifers and supporting groundwater driven base flows in streams and other water bodies. Permeable pavement systems can also improve water quality through filtration and a reduction in runoff temperatures[1].

Ancillary benefits:

Increased longevity when compared to conventional asphalt and concrete pavements[2]

Can reduce downstream detention needs

Efficient land use through combination of stormwater management and vehicular infrastructure

Can increase aesthetic value of the property

Can reduce the need for costly stormwater infrastructure

§ T1602(c) Limitations

It is recommended that the contributing watershed not exceed 20% of the area of the porous pavement installation[3].

The drain time for porous pavements should be limited to approximately 24-hours[4] to ensure the structural integrity of the pavement subgrade. Where soil permeability is insufficient and/or the volume of runoff is too great, a lateral subsurface drain must be installed to meet the 24-hour drainage requirement (see Section § T1602(e)(12)).

Porous pavement systems must provide adequate separation above the seasonal high ground water table (see also Section § T1602(e)(3)) and should be located at least 10-feet down slope and 100-feet up slope from building foundations unless adequate waterproofing is provided and direct drainage to footing drains can be prevented[5].

Soils on bed rock with very high infiltration rates may be unsuitable for porous pavement installations. Infiltration under such conditions may lead to sink holes and potential groundwater contamination.

Highly expansive clay soils are unsuitable for porous pavement installation[6] unless adequate drainage is provided to prevent saturation of the expansive subgrade soils. An appropriate drainage system is necessary to collect and dispose of excess stormwater in a controlled manner.

Unless the system is lined, use of porous pavers is not recommended over contaminated soils and in areas with land uses such as:

Gas stations, recycling facilities, salvaging yards, vehicle storage, service and cleaning facilities and other uses with risk of stormwater coming into contact with hazardous materials.

Land uses where there is storage of agricultural contaminants (e.g. pesticides, fertilizers, sediments) that could come into contact with stormwater.

Commercial marina services where there is a risk of fuel or other spills.

Outdoor loading and storage facilities where hazardous materials are being managed.

Well fields (see also Section § T1602(e)(4)).

Land uses within the recharge zone of sensitive wetlands, such as fens and other areas where the impact of potential increased volumes of groundwater recharge could be detrimental unless the amount of infiltration is controlled.

Locations where construction site runoff (that could clog the system) and other risks of sedimentation cannot be controlled.

Interlocking paver systems are not suitable for roadways that exceed the Average Daily Traffic (ADT) of 2000 and the speed limit of 30 miles/hour (i.e. collector roads, arterial roads, freeways).

§ T1602(d) Required Design Data

Infiltration capacity / suitability of subgrades:

The infiltration capacity of the subsoils under the porous pavement will determine the volume of runoff that can be exfiltrated from the pavement base/subbase into the ground over a given time. The infiltration capacity, along with the contributing watershed and subgrade strength will help to determine the drainage and structural design for the porous pavement.

The Kane County Soil Survey provides some guidance with regards to soil permeability and subgrade strength. It is, however, recommended to commission a soil report with density test reports and classification. The report should further include results of a hydraulic conductivity test performed at the location and elevation of the proposed bottom of the pavement to establish the site-specific permeability rate (double ring infiltrometer test per ASTM D3385, lab test per ASTM D2434 through a Shelby tube sample, or have a Certified Professional Soil Classifier conduct an on-site soil investigation to determine soil suitability or a Falling Head Percolation Test (described in Appendix A).

Seasonal high water table:

If the site in question for the porous pavement is known to have a relatively high water table, data on the elevation of the seasonal high water table is needed. The bottom of the porous pavement should be at least three feet above the seasonal high water table[7] to reduce the potential for shallow ground water contamination.

Contributing drainage area:

Along with the infiltration capacity, the drainage area and level of imperviousness contributing to the porous pavement, if any, will determine the drainage design of the porous pavement. In generally, pervious areas should not be drained toward permeable pavement to minimize the risk of sediment clogging

§ T1602(e) Porous Unit Pavement Design

§ T1602(e)(1) Porous unit paver design principles:

Permeable interlocking concrete pavements behave as flexible pavements[8]. The surface is composed of tightly placed high-strength concrete pavers. The tight placement in combination with appropriate edge restraint, the laying pattern, and granular fill in the crevices allows the pavers to interact and function as a unified structure rather than individual units. This flexible pavement behavior mandates a flexible pavement design.

Permeable interlocking concrete pavements constitute a high strength, long-lived wearing course set into a setting bed. The purpose of the setting bed is to provide an accurate leveling course that allows the paver to be set at the specified elevations. The base and subbase course are the major load-carrying element. They distribute the loads to the level where it can be tolerated by the subgrade without failure. An additional function of the subbase in porous pavement systems is to laterally drain the water that is infiltrated through the pavement surface as well as store water temporarily to allow additional time for infiltration and/or to provide detention. It should also perform as a capillary barrier. This prevents water from moving upwards into the pavement base. It helps to secure the pavement's structural integrity and prevents ice lenses from forming in the pavement. The subbase may be followed by a layer of improved or stabilized subgrade if the structural properties of the soil prove insufficient.

Design for porous paving has to reconcile structural and drainage objectives. To assure structural integrity of the pavement and prevent frost heave damage, a properly designed subbase with the appropriate drainage characteristics is of critical importance[9]. Good pavement design for porous unit pavers results in water infiltration and particle filtration combined with structural strength.

§ T1602(e)(2) Load bearing strength:

The subgrade strength is a dominant factor in flexible pavement design[10]. Soil, or subgrade strength, is sometimes expressed by the Modulus of Elasticity (E), but more typically by the California Bearing Ratio (CBR) as defined in the ASTM D 1883 specification. The CBR of soils, particularly those that are finer graded, varies with moisture content. This is important in porous pavement design, where the subgrade is expected to be wet. Soils with permeability lower than 0.8-inch/hour can be used for exfiltration as long as the subgrade remains stable while saturated. The saturated subgrade CBR in porous pavement must be at least 5% after a minimum of 96-hours of soaking if used for vehicular traffic[11]. Other empirical design specifications require a 6,550 psi Modulus of Elasticity in porous pavement design[12], which translates into 4.3% CBR for relatively soft, fine grained soils[13].

Most subgrades will require some compaction or other stabilization treatment to assure sufficient load bearing capacity. This may greatly reduce or eliminate the infiltration capacity on finer graded soils. In some instances, the use of a geotextile can help to balance structural with infiltration objectives. The use of a woven-monofilament geotextile will spread loads over a wider area and allows for bridging of weak spots in the subgrade. An increase in depth of the base or subbase is an alternative to the use of a geotextile. The increased depth of base or subbase spreads the load over a larger area. By using these methods, the need for compaction on finer graded soils can be reduced or eliminated to preserve infiltration rates. It is recommended to consult a geotechnical engineer to evaluate soils for their CBR and suitability under porous pavements.

§ T1602(e)(3) Seasonal high water table:

On installations where the main objective is to exfiltrate stormwater into the ground, the bottom of the pavement must be a minimum of three-feet[14] above the seasonal high groundwater table. This distance provides a filter to remove pollutants from the runoff and to prevent shallow ground water contamination.

Staying a minimum required distance above the seasonal high ground water table also has a structural rational. It prevents groundwater from entering into the pavement and allows for efficient subsurface drainage and exfiltration during storm events. Controlling the moisture content of the subgrade allows for improved load bearing capacity and reduces the potential for frost heave.

§ T1602(e)(4) Well field set back:

Porous pavement systems should not be used in the immediate proximity of a well or a well field. The State of Illinois requires a minimum setback of 200-feet for potential primary or potential secondary sources of contamination to any existing or permitted community water supply wells.

§ T1602(e)(5) Freezing conditions and frost depth:

The depth of frost penetration is an important factor in porous pavement design on soils with high silt content. Footing and foundation design frost depth is typically specified by local code (generally 42-inches in Kane County). A porous pavement base does not need to extend to the design frost depth. Silty soils, however, should be adequately drained before frost penetrates through the pavement to minimize the potential for frost heave. Frost heave in porous pavement is, however, not necessarily a failure-causing factor. The unit block pavement system is able to withstand modest amounts of frost heave without damage because of its flexible nature.

§ T1602(e)(6) Edge restraint:

A rigid, stationary edge restraint is of critical importance to permeable interlocking concrete pavements due to the modular nature of the block system. The edge restraint prevents lateral creep, holds the pavers tightly together, and provides load transfer between blocks. Modular pavements without an edge restraint will move laterally, fail along the edges and cease to provide load transfer between blocks, which compromises the structural integrity of the pavement.

Methods of edge restraint include abutting existing structures, cast-in-place concrete curbs (see also Figure 4) or slabs, pre-cast concrete curbs, or soldier courses set into concrete (see also Figure 5). Recommended minimum dimensions for edge restraints are 6-inches wide and 12-inches deep[15]. The more structurally sound the edge (i.e. concrete products with stable footer and/or concrete haunch), the less the opportunity for pavement failure at the edges. No matter what edge restraint is used, it must remain stationary under stress or it is of no value to the porous block pavement system.

§ T1602(e)(7) Traffic categories:

General roadway classification as defined in the AASHTO 'A Policy on Geometric Design of Highways and Streets'; also know as the "Green Book", distinguishes between:

local roads, collector roads, arterial roads, and freeways.

For the purpose of these guidelines, categories are created that reflect additional uses and traffic types at lower traffic volumes, loads and repetitions than those of 'local roads', including:

Paths + patios (pedestrian and bicycle applications)

Driveways + small parking (personal automobiles)

Large parking (personal automobiles and some truck and bus traffic)

Local roads

Porous pavement applications are suitable for traffic volumes up to those defined in the 'local road' category (ADT 2000 or less) and where the posted speed limit does not exceed 30 miles/hour. Typical examples for the 'local road' category are alleyways and small subdivision roads. The foremost rational behind the 'local road' restriction is concerns over stormwater runoff quality and pollution. It also attempts to reduce the most common cause of pavement failure, which are heavy, repetitive loads. The occasional school bus, garbage truck, or fire engine represents an acceptable load at acceptable repetitions.

§ T1602(e)(8) Typical cross sections:

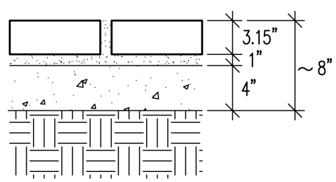
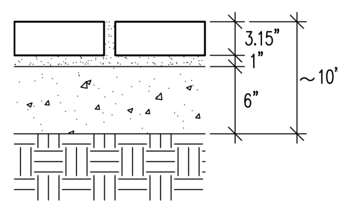
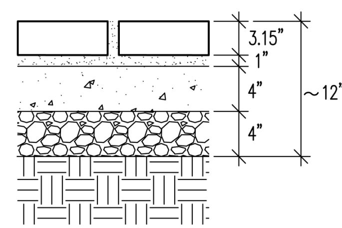
Table 2, Table 3, Table 4, and Table 5 show recommended cross section designs for different interlocking porous paver applications. Porous pavement installations on subgrades with an infiltration capacity less than 0.1-inch/hour should be designed and evaluated by a qualified civil engineer.

The indicated depths of the subbase in Table 2, Table 3, Table 4, and Table 5 may be increased if additional storage and detention of runoff is required, or if low subgrade strength requires additional subbase structure. The indicated infiltration rates must be based on the subgrade at the depth of the subbase-subgrade interface after compaction or soil treatment. It is highly recommended that a qualified civil engineer with porous paving experience be consulted if conditions vary from those represented below.

Some porous pavement design software is available by paver vendors to assist the design. An example is the software product Lockpave ® Pro.

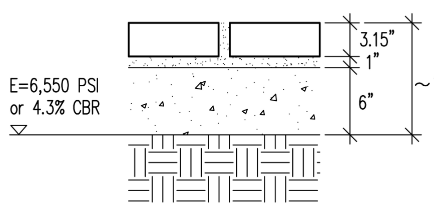
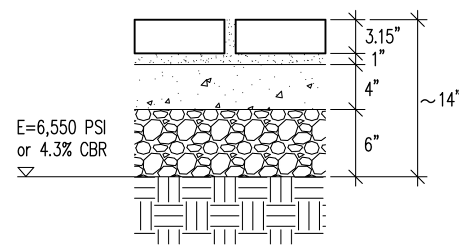
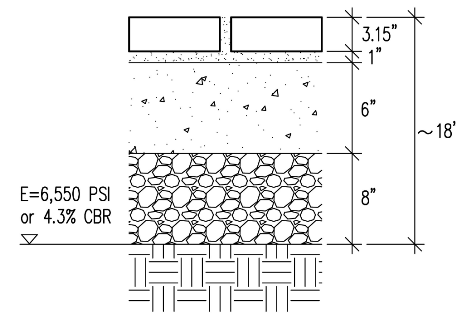
§ T1602(e)(8)(a) Paths and patios

Table 2 Cross section design for **PATHS** and **PATIOS** (pedestrian and bicycle applications)

	Subgrade infiltration rate (after compaction or soil treatment) >8.0-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 8.0- to 0.8-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 0.8- to 0.1-inches/hour
Block	3.15-inches	3.15-inches	3.15-inches
Setting	1-inch	1-inch	1-inch
Base	4-inches	6-inches	4-inches
Subbase	n/a	n/a	4-inches
Total	~ 8-inches	~ 10-inches	~ 12-inches
			
Drainage	No drainage required	No drainage required	Allow for pavement base to drain within 24-hours, may require drainage at pavement edge)

§ T1602(e)(8)(b) Driveways and small parking

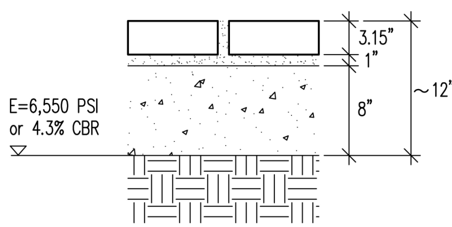
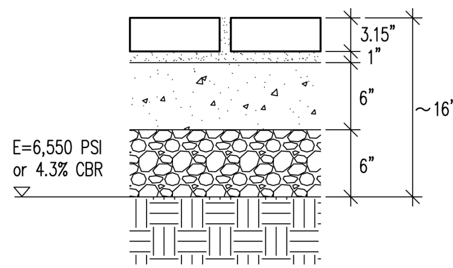
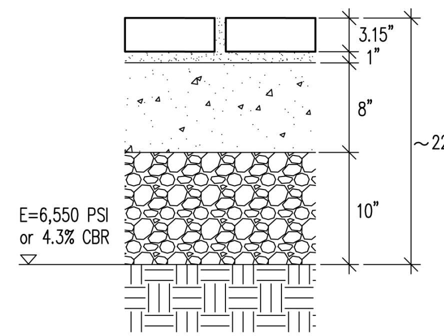
Table 3 Cross section design for **DRIVEWAYS** and **SMALL PARKING** (personal automobiles)

	Subgrade infiltration rate (after compaction or soil treatment) >8.0-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 8.0- to 0.8-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 0.8- to 0.1-inches/hour
Block	3.15-inches	3.15-inches	3.15-inches
Setting	1-inch	1-inch	1-inch
Base	6-inches	4-inches	6-inches
Subbase	n/a	6-inches	8-inches
Total	~ 10-inches	~ 14-inches	~ 18-inches
			
Drainage	No drainage required	Allow for pavement base to drain within 24-hours, may require drainage at pavement edge	Allow for pavement base to drain within 24-hours, may require drainage at pavement edge

CBR = California Bearing Ratio in % (soaked)
E = Modulus of Elasticity (in psi) on soaked subgrade for relatively soft, fine grained soils

§ T1602(e)(8)(c) Large parking

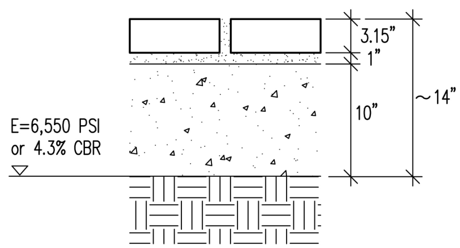
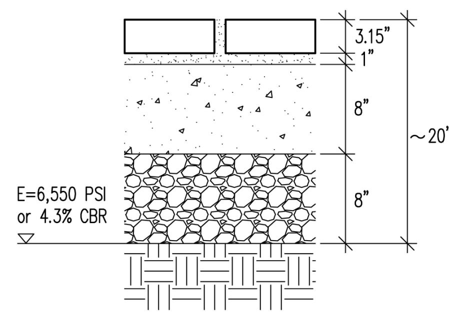
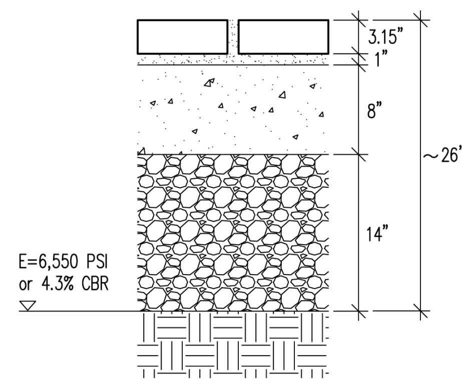
Table 4 Cross section design for **LARGE PARKING** (personal automobiles and some truck and bus traffic)

	Subgrade infiltration rate (after compaction or soil treatment) >8.0-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 8.0- to 0.8-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 0.8- to 0.1-inches/hour
Block	3.15-inches	3.15-inches	3.15-inches
Setting	1-inch	1-inch	1-inch
Base	8-inches	6-inches	8-inches
Subbase	n/a	6-inches	10-inches
Total	~ 12-inches	~ 16-inches	~ 22-inches
			
Drainage	No drainage required	Allow for pavement base to drain within 24-hours, include drainage at pavement edge	Allow for pavement base to drain within 24-hours, include drainage at pavement edge

CBR = California Bearing Ratio in % (soaked)
E = Modulus of Elasticity (in psi) on soaked subgrade for relatively soft, fine grained soils

§ T1602(e)(8)(d) Local roads

Table 5 Cross section design for **LOCAL ROADS**

	Subgrade infiltration rate (after compaction or soil treatment) >8.0-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 8.0- to 0.8-inches/hour	Subgrade infiltration rate (after compaction or soil treatment) from 0.8- to 0.1-inches/hour
Block	3.15-inches	3.15-inches	3.15-inches
Setting	1-inch	1-inch	1-inch
Base	10-inches	8-inches	8-inches
Subbase	n/a	8-inches	14-inches
Total	~ 14-inches	~ 20-inches	~ 26-inches
			
Drainage	No drainage required	Allow for pavement base to drain within 24-hours, include drainage at pavement edge	Allow for pavement base to drain within 24-hours, include drainage at pavement edge

CBR = California Bearing Ratio in % (soaked)
E = Modulus of Elasticity (in psi) on soaked subgrade for relatively soft, fine grained soils

§ T1602(e)(9) Material/aggregate selection, function and performance:

A porous unit block paver system must be designed and constructed with open graded materials in the paver crevices or openings, the bedding layer, the base, and subbase to ensure and sustain good drainage and infiltration characteristics.

Typical road construction aggregates (including sharp sands) are unsuitable due to their percentage of fines (Sieve No. 16 to 200). These aggregates have small voids and tend to trap fine dust particles that wash into the pavement. This will lead to clogging and formation of an impervious “pan” over time. Infiltrated runoff will accumulate on the pan, which compromises the stormwater objectives of the porous pavement. A reduction in permeability in the base or subbase will also compromise structural objectives. Trapped water in the base can cause high pore-water pressure and result in pumping under dynamic traffic loads[16]. Only non-plastic, open-graded aggregates (plasticity index of 0) that sustain their strength in the presence of water should be used in porous pavement installations[17].

Open-graded materials for porous pavements should originate from a hard, durable crushed rock with 90% fractured face and a Los Angeles (LA) Abrasion of <40. A design CBR of 80% is recommended[18].

Crevice fill:

An IDOT CA16 (or ASTM C33 No. 8) crushed stone should be used to fill the paver openings and crevices. The IDOT CA16 is also commonly referred to as 3/8-inch stone chips. The size and porosity of this material allows accumulated dust particles to flush out during heavier storm events. This helps to prevent clogging and sustain good infiltration rates over time. The infiltration rate of the IDOT CA16 should be at least 1,000-inches/hour[19]. Because the crevice fill material is much finer than the base and subbase materials, the crevice material also creates a design failure point in a readily remediated location (see also Section § T1602(g)(2)). The crevice fill material will clog rather than pass material that could clog the base or subbase

Bedding layer:

Besides filling the paver openings and crevices, the IDOT CA16 (or ASTM C33 No. 8) crushed stone should be used for the bedding layer. As with the paver openings and crevices, the size and porosity of this material allows accumulated dust particles to flush out during heavier storm events. The infiltration rate of the IDOT CA16 should be at least 1,000-inches/hour[20].

Base course:

This structural/load bearing component of the pavement should be constructed using an IDOT CA7 (or ASTM C33 No. 57) crushed stone. The infiltration rate of the IDOT CA7 should be at least 1,000-inches/hour[21].

Subbase course:

This pavement component has several objectives: capillary break, structural support of the pavement, and storage and drainage. The latter is essential, although a drainage rate (hydraulic conductivity) greater than necessary will reduce detention time and amount of runoff infiltrated unless other means are used to slow drainage of this layer. A crushed rock, such as the IDOT CA7 (or ASTM C33 No. 57) or larger rock, such as the IDOT CA1 (or ASTM C33 No. 2) has good porosity and structural characteristics and provides both excellent drainage and an effective capillary barrier.

§ T1602(e)(10) Filter criteria:

It is of critical importance to specify and use materials that are resistant to migration within the pavement and thus meet filter criteria. Finer-graded materials that wash out (migrate) and erode into underlying coarser graded materials do not meet the filter criteria and lead to settlement and pavement failure. The installation of an IDOT CA16 (bedding layer) over an IDOT CA7 (base course) installed over an IDOT CA1 (subbase course) meets the filter criteria.

If materials are used that differ from the above stated gradations, it is recommended that their filter criteria be verified. The following method is commonly applied in geotechnical analysis[22]:

$$\frac{D_{15}}{d_{85}} \leq 5$$

Another method, recommended by the International Concrete Pavement Institute (ICPI) is as follows[23]:

$$\frac{D_{15}}{d_{50}} < 5 \text{ and } \frac{D_{50}}{d_{50}} > 2$$

Where:

D = coarser aggregate (open graded stone)

d = finer aggregate (choke stone)

A coarse, open-graded subbase placed over a subgrade of fine material may not meet the filter criteria. In this case, subgrade material can migrate up into the subbase, choking it and leading to failure. Wet subgrade (expected in porous pavement systems) in combination with dynamic traffic loads (causing vibration) can lead to pumping, which compromises the structural performance of the pavement.

Pumping can be prevented and the filter criteria met by placing an appropriate geotextile between the subbase and subgrade. Both woven monofilament and non-woven, needle-punched fabrics will provide an adequate filter. Woven monofilament fabrics may be less subject to blinding that non-woven, needle-punch fabrics. Further, woven monofilament fabrics generally have lower elongation than non-woven products and therefore provide superior bridging capability. However, many woven fabrics have relatively low permittivity and it is therefore critical that a high permittivity (>1.2/sec) be specified (see Section § T1602(i)). Standard woven (tape) filter fabrics should not be used as they are insufficiently permeable and do not pass sufficient volumes of water.

Aggregates must be kept clean and protected from soil contamination throughout the construction process. This is to preserve their porosity and drainage characteristics. All installed porous block paver systems must be protected from siltation during and during construction. Eroding soils that wash onto the pavement will clog the crevices and effectively eliminate the infiltration capacity of the paver surface.

§ T1602(e)(11) Surface drainage design:

Runoff onto the porous paver surface from the contributing drainage area must be free of sediment, such as construction site runoff to prevent clogging of the crevices and loss of infiltration capacity. This requires thorough erosion control throughout the installation process, including the re-establishment of the vegetation on disturbed soils in the contributing drainage area. Porous pavements should be designed and installed in a manner that eliminates or reduces the risk of erosion contamination for the life of the pavement.

The porous unit block pavement in itself is a drainage tool since it transmits water through the pavement surface. The infiltration capacity of the pavement surface is not determined by the percentage of openings, rather it is determined by the infiltration capacity of the crevice fill material since runoff water is routed to the openings by the paver surface. That fill material must be open-graded with no or a limited amount of fines (see also Section § T1602(e)(9)). Use of the proper fill material will sustain a good infiltration capacity and surface drainage over the lifetime of the pavement and reduce or eliminate the need for catch basins and other drainage structures.

Field test data is available on the infiltration capacity of porous pavements that were constructed similar to the recommendations in these guidelines. One research project shows that virtually all water was infiltrated on permeable parking stalls for a number of monitored storms[24]. Data from a six year old porous paver installation from Havre de Grace (MD) yielded average infiltration rates of 40 cfs/ac (~40 in/h)[25]. In another instance, two and five year old installations were tested. The two year old installation infiltrated 2.8-inches/hour after 60-minutes of constant sprinkling, whereas the five year old installation infiltrated 5.7-inches/hour after the same loading. The lower infiltration capacity of the more recent installation (two years of age) is explained with a higher percentage or organic substances and fine particles in the crevice fill[26]. This data illustrates the importance of clean and open-grade materials in porous pavement construction.

Data on the infiltration capacity through the pavement surface of permeable interlocking concrete pavements further shows that 2.5-inches/hour is a conservative design infiltration capacity for mature systems. It is, however, imperative that the open-graded materials meet the specifications. A significantly more conservative approach recommends the use of a surface infiltration capacity of 1-inch/hour over a 20-year life for porous pavements[27]. This design infiltration capacity though is based on data from infiltration trenches and therefore may not be applicable to permeable pavement surfaces. One research project on pavement systems found that surface infiltration capacity of interlocking concrete paver systems was restored to near full capacity through remedial maintenance[28] (see Section § T1602(g)(1)).

As with most pavements, it is recommended that the porous unit block pavers be installed with at least 1% slope[29]. Because a properly installed porous pavement will only generate surface runoff during very heavy storms, conventional catch basin and stormwater pipe installations can be reduced in number, substituted by vegetated swales or eliminated all together[30]. The use of vegetated swales instead of catch basins reduces costs relative to conventional drainage infrastructure. Vegetated swales have the added advantage of treating and filtering the surface runoff. Provisions for frequent curb cuts should be made if the pavement edge is a raised curb. These curb cuts can be as frequent as one for every parking stall; this frequency allows any excess surface water to drain into adjacent vegetated swales with nominal energy dissipation such as a splash pad or small amount of stone. For large flow rates through the curb cuts, larger stone material, level spreaders (see Section § T1605), or inflow chambers may be necessary (see also Section § T1603(f)(6)).

§ T1602(e)(12) Subsurface drainage:

The subsurface drainage design of porous pavements is largely determined by the infiltration capacity of the subgrade soils. A porous pavement installation can tolerate temporary storage of runoff in the base and subbase without compromising its structural integrity. Maintaining structural integrity under periodic wet conditions is contingent on subgrade strength, sufficient base and subbase depth, and the use of appropriate aggregates and geotextiles[31]. The stored runoff will ultimately be exfiltrated into the ground, or collected and discharged through a drainage system.

Porous pavements on freely draining soils with an infiltration capacity that equals or exceeds 8.0-inches/hour and have adequate depth to groundwater do not require any additional drainage infrastructure. The soil permeability should be measured at the proposed depth of the subgrade and under compacted conditions.

The same also applies to paths, patios, driveways and small parking installations on soils with infiltration capacities between 8.0- and 0.8-inches/hour. However, it is important to ensure that water in the pavement base is drained within sufficient time to prevent weakening of the subgrade soils. Pavements designed based on the

California Bearing Ratio (CBR) should be designed to drain within 72 hours to not exceed the conditions under which CBR testing is conducted.[32] (see also Table 2 and Table 3). A geotechnical engineer should be consulted if a drainage time longer than 72-hours is required. Under no circumstances should the maximum ponding time under the pavement exceed 72-hours to ensure that the volume is available for subsequent events and to avoid sealing of the subgrade soils due to growth of biological slimes. To meet these drainage requirements, subsurface drainage may be necessary in many cases. For large parking lots and local roads, the same standard applies and, at a minimum, subsurface drainage should be provided at the pavement edge (see also Table 4 and Table 5). This requires that the subgrade of the installation is graded with a minimum of 1% slope towards the pavement edge.

Soils with an infiltration rate of 0.8- to 0.1-inch/hour may exhibit a reduction in their structural capacity when saturated for extended periods. The pavement base of paths, patios, driveways, and small parking installed on such soils should drain within 72-hours (see also Table 2 and Table 3). To meet the 72-hour requirement, subsurface drainage will be necessary in most cases, particularly at the low end of the permeability range. The same 72-hour drain time applies to porous pavement on large parking lots and local road installations. The traffic load on the latter two further necessitates subsurface drainage at the pavement edge (see also Table 4 and Table 5), which requires that the subgrade of the installation is graded with a minimum of 1% slope towards the edge and other locations of subsurface drainage.

Where drainage is required, adequately sized perforated pipe should be used to ensure drainage within 72-hours. In most cases 4-inch pipe will be adequate. The openings should be sufficiently small to prevent migration of subbase material. No sock should be used as it may clog over time.

To provide detention within the pavement subbase and base, the perforated pipe may be fitted with an orifice(s) to control the rate of drainage. Provided that there is no surface inlet to the drain, very small orifices may be used since there is no access for debris that could clog the orifice. Never the less, cleanouts should be provided at all orifice locations. Cleanouts should also be provided at both ends of each drain and at all significant changes in direction.

Building foundation and basements:

Porous pavement installations should be a minimum of 10-feet down slope from building foundations and 100-feet upslope unless adequate waterproofing is provided and direct drainage to footing drains can be prevented. Another rule that can be applied to protect building basements is to set back the porous pavement 1.5 times the distance of the building foundation depth[33].

Retention volume and detention volume:

The runoff stored in porous pavements can be divided into the retention volume and detention volume. The retention volume represents the runoff in the porous pavement that is exfiltrated into the underlying subgrade. The detention volume represents the runoff that is removed from the pavement base through perforated drain pipes or other drainage structures to meet the 72-hour drainage requirement. Most porous pavements will have a combination of retention and detention volume, with the invert of the perforated drain pipe set at an elevation that allows the retention volume to exfiltrate in 72-hours.

To meet the Kane County retention standards, porous pavements should be sized for 0.75-inch retention volume. However, porous pavements that contain the 1- to 2-year event prevent increases in runoff volumes for these storms that are most affected by urbanization. The storage in porous pavement can be sized for larger events to increase retention and reduce downstream detention needs. The sizing and drainage design for porous pavements is further described under Section § T1602(e)(13).

On subgrade soils with low or no infiltration capacity that require that an additional subsurface drain be located at the bottom of the subbase, it may be difficult to demonstrate that the 0.75-inch retention standard is being met. However, due to wetting of the aggregate and other losses that occur for small storms, it may be assumed for purposes of the Kane County Stormwater Ordinance, that the 0.75-inch retention standard is being met for permeable interlocking concrete paver systems designed and installed according to this guidance.

With the large aggregate specified for the subbase, the subbase will drain quickly, providing only nominal detention. As described in Section § T1602(e)(12) above, orifices may be placed in the drains to extend the detention time to 24-hours.

Monitoring well:

In some instances a monitoring well may be installed with the system, which will provide for access to bottom of system for observation for rate of exfiltration. The monitoring well also could be used to take water samples to permit runoff water quality analysis.

§ T1602(e)(13) Hydrologic analysis:

There are two components to the hydrologic analysis: the required size to meet the Kane County retention standard and the impact of the porous pavement on downstream detention requirements.

Retention standard:

Assuming that the only drainage to the pavement base is from the rainfall onto the pavement surface, only 0.75-inches of retention depth would be required under the pavement. Assuming a porosity of the base material of 40%, 1.9-inches of base depth would be required to provide the retention storage. If the drainage area to the permeable paving is greater than the area of the paving itself, the base depth allocated to the retention storage will need to be increased accordingly.

The drainage time of the retention volume is:

$$T_r = \frac{D_r}{i}$$

Where:

T_r = retention drain time in hours

D_r = depth of retention storage volume in inches

i = infiltration capacity of subgrade soils in inches/hour

In most cases the retention depth will be 0.75-inches. The total drain time should not exceed 72-hours unless a geotechnical analysis or the measured CBR-value indicates that longer durations would be acceptable.

Impact on downstream detention sizing:

The critical duration for detention sizing is typically 24-hours. Thus, the volume of runoff exfiltrated from a permeable pavement system during a 24-hour detention design storm will often be significant. For example, for a pavement system that is only managing its own runoff and has a subgrade permeability equal to 0.1-in/hr, the volume of infiltrated runoff during a 24-hour period would be 2.4-inches, which would reduce the runoff volume associated with the 2-year event by over 75%.

Permeable pavement systems can be modeled as storage reservoirs in standard hydrologic models such as TR20 or HEC-1.

Rainfall intensities that exceed the infiltration capacity of the paver surface should be diverted away from the under paver storage reservoir as indicated in Figure 1. To represent mature pavement systems that may have received little or no maintenance, the diversion rate should be the equivalent of 2.5- inches per hour.

The rate of infiltration Qi through the subgrade is equal to:

$$Q_i = i * A_p$$

Where:

Q_i = the volumetric flow rate through the pavement subgrade in cubic feet per second (cfs)

i = infiltration capacity of subgrade soils in inches/hour

A_p = Area of permeable pavement in acres

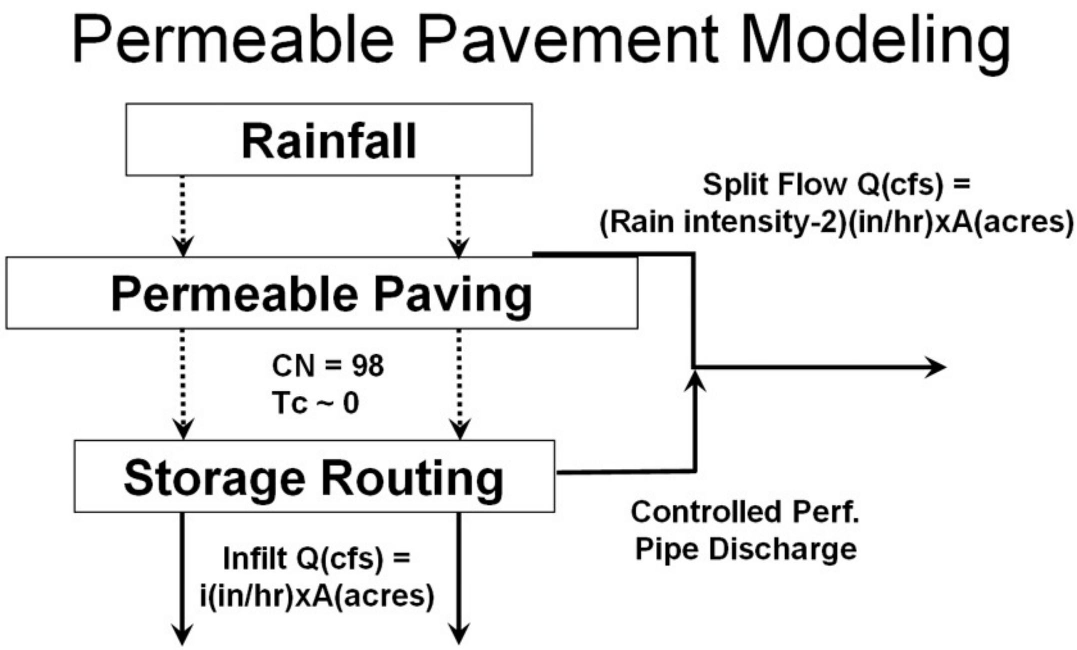


Figure 1 – Permeable Pavement Modeling Diagram

The rate of drainage by the perforated drains will depend on the characteristics of the aggregate material and the drain pipe. To more reliably predict the rate of drainage and to fully utilize the available volume within the base and subbase, the drains can be fitted with an orifice(s).

For models that allow multiple outlets, infiltration outflow can be treated as a separate outlet that does not contribute downstream. For models that only allow a single outlet, the total subbase outflow is equal to the infiltration outflow plus the surface outflow through the perforated drains (if any). The infiltration outflow rate can then be diverted out of the system so that it does not contribute to the downstream detention facility.

The diverted flow from the pavement surface should then be combined with the perforated pipe discharge to obtain the permeable pavement discharge hydrograph.

§ T1602(f) Construction Considerations

Construction of porous pavements requires special care and changes to normal construction practice and schedules for the optimal functioning of the porous pavement and its long-term viability.

It is recommended that the consultant meet with the contractor prior to construction to debrief him/her on preventative measures and to coordinate proper execution of the pavement installation. The consultant should further routinely visit the site to review and observe the installation process. This proactive approach can avoid pavement failure due to poor construction practices.

§ T1602(f)(1) Excavation:

Unless the pavement can be protected from all construction site runoff, the excavation of the porous pavement area should be scheduled after the completion of other site work, such as all other earthwork, landscaping operations, and other heavy construction[34]. This is to prevent soil compaction and clogging of the porous pavement system or contamination of the porous pavement aggregates (see also Section § T1602(f)(2)). It is recommended to use methods and mean during final excavation of the porous pavement base that minimizes soil compaction and thus preserves the infiltration capacity of the natural soils.

§ T1602(f)(2) Soil erosion and sediment control:

Runoff from the contributing watershed must be free of sediment, such as construction site runoff to prevent clogging of the subgrade, base, or crevices and loss of infiltration capacity. This requires thorough erosion control throughout the installation process, including the re-establishment of the vegetation on disturbed soils in the contributing watershed. Porous pavements should be designed and installed in a manner that eliminates or reduces the risk of erosion contamination for the life of the pavement. It is further recommended to limit the runoff from the contributing watershed onto the porous pavement.

Soil erosion and sediment control practices should be maintained and inspected on a regular basis. Accumulated sediments within on-lot sediment traps and along silt fences should be promptly removed. All disturbed areas shall be promptly stabilized and compromised erosion and sediment control devises should be promptly repaired.

Stockpiles should be located downstream of the porous pavement; if unable to do so, stockpiles shall have a double row of silt fence that surrounds the perimeter of the stockpile.

Before the porous pavement goes online, the contributing drainage area (if any beyond the surface of the pavement) must be stabilized/fully vegetated.

§ T1602(f)(3) Aggregate installation principles:

Woven monofilament or non-woven, needle-punched fabrics should be placed over the subgrade to provide an adequate filter and prevent soil migration and pumping (see also Section § T1602(e)(2) and Section § T1602(e)(10)). Standard woven (tape) filter fabrics should not be used as they are insufficiently permeable and do not pass sufficient volumes of water.

The open graded subbase and base course must be installed in lifts that do not exceed 12-inches to assure sufficient compaction. Compaction equipment should be approved by the project engineer. Depending on the size of the installation, a Steel Drum Compactor (min. 60-inch drum) or Vibratory Plate Compactor (min, 42-inch plate), both capable of controlled frequency, can be used. Full particle interlock of the open-graded material must be achieved, which requires three passes with an approved compactor. More than three passes may lead to over compaction, which may result in particle abrasion. The process of particle abrasion will add undesired fine matter to the open graded material.

The bedding layer is typically not compacted until after the paver installation. A plate compactor with 3000 to 5000 lbs of centrifugal compaction force that operates at 80-90 Hz should be used across the installed pavement[35]. This operation sets the pavers firmly into place and also compacts the underlying bedding layer.

§ T1602(g) Operation and Maintenance

It is recommended that permeable interlocking concrete pavements be inspected on an annual basis, preferably in spring after a major rain storm to verify that the stormwater is infiltrating into the system. Areas that have pooled water standing on the surface need to be addressed through remedial maintenance as opposed to routine maintenance. A monitoring well may be installed with the system in some instances and will provide for access to the bottom of the system for observation for rate of exfiltration. The monitoring well also could be used to take water samples to permit runoff quality analysis.

§ T1602(g)(1) Routine maintenance:

It is imperative that permeable interlocking concrete pavements be designed and installed in a manner that eliminates or reduces the risk of sedimentation and erosion contamination for the life of the pavement. If the permeable pavement is connected to a contributing watershed (i.e. other pavements or lawn areas) it should be monitored on an annual basis to insure that run-off from these sources is not depositing sediments and debris on the porous pavement. Areas near construction traffic, agricultural land (no ground cover), beaches, and areas subject to high winds that will carry fine particles will require more frequent monitoring and sweeping.

Sweeping:

Routine maintenance involves normal street sweeping, similar to that used on standard asphalt and concrete paving. While high efficiency vacuum sweepers are more effective at capturing and removing fine sediment than mechanical broom sweepers, mechanical sweeper equipment is sufficient to dislodge surface encrusted sediment. Permeable paving surfaces should be dry-swept (water should be turned off) in dry weather to remove encrusted sediment that appears as small curled "potato chips". When vacuum equipment is used, vacuum settings should be adjusted to prevent uptake of aggregate from the pavement openings and joints. Sweeping porous pavements once a year (preferably in spring) is normal; if excessive silts and fines are present, additional monitoring of the surface to determine silt build-up and additional sweeping may be needed (i.e. late fall and spring) to remove accumulated debris.

Closed joint permeable interlocking pavements may be pressure washed if desired. Care should be exercised to keep wand at an angle and away from the surface to prevent abrading and blasting of void material from joints and void openings. It is not recommended to utilize a pressure washer on open-jointed systems.

Winter maintenance:

As with any pavement, snow plowing is required after snowstorms. Four season parking surfaces, streets, and plaza areas may be plowed with truck-mounted blades, power brooms, snow-blowers, or manually shoveled. Rubber or nylon, rather than steel, are recommended for the replaceable snowplow tip, if bladed snow plowing equipment is used. However, steel tips are used for plowing many installations, particularly where plowing speeds are low. Manufacturers of permeable interlocking concrete pavements state that the chamfered top edges minimize chipping and allows for normal plowing procedures. Shoes at the edges of the blade and rubber nylon tipped blades are recommended for all pavements to protect the equipment and driver from impact at manholes, pavement joints, etc. that are common to asphalt and poured concrete roads.

Due to the short flow distance from the paver surface to a joint opening, the opportunity for ice formation is greatly reduced. Also, researchers state that the underlying stone bed tends to absorb and retain heat, further reducing ice formation. For these reasons, regular deicing should not be necessary and is not recommended for water quality protection reasons. However, for occasions when icing does occur, a mild application of deicing salt may be used. If abrasives are necessary, stone chips that are preferably of the same quality and specification as the void material should be used rather than sand. The application of stone chips may require sweeping and removal in the spring. If sand is used, it will tend to clog the openings and lead to the premature need for remedial maintenance.

Void filling:

The open graded stone ships in the voids and joints are subject to settling, particularly during the first year after installation. If necessary, additional voids materials may be added by manually sweeping into joints and voids. Refer to specifications for type and grade.

§ T1602(g)(2) Remedial maintenance:

Studies have shown a high initial infiltration capacity of permeable interlocking concrete pavements with a decrease and leveling off over time[36]. The decrease in infiltration capacity over time is due to deposition of fine material such as silt, organic debris, and subsequent vegetation in the joint aggregate.

The need for remedial maintenance can be determined by visual inspection. Areas that pond water on the surface will require remedial maintenance. Remediation can be achieved using a vacuum sweeper with water jets, sweeper, and vacuum bar attachment to evacuate clogged joint material. The evacuated joint material can either be washed and replaced or new joint material can be used to refill the joints (refer to specifications for size and grade). Jointing materials are to be swept into joints and voids until full, typically to the bottom of the chamfer. The frequency of required remedial maintenance depends on the degree of sediment and debris loading as well as the level of routine maintenance. Experiences from older installations show, however, that permeable interlocking concrete pavements continue to function many years after installation, which makes remedial maintenance operation more an exception. The need for remedial maintenance is also a function of sediment and erosion control during construction of the site and during the lifetime of the pavement. Proper erosion control will be necessary during construction of the homes and remedial maintenance should be performed after the home sites have been built out.

One research project on pavement systems found that surface infiltration capacity of interlocking concrete paver systems was restored to near full capacity after remedial maintenance[37].

Structural maintenance:

Settlement/ruts in pavement surface, access for utility repair, and removal of broken or damaged pavers may be performed by an experienced paver installer. Pavers should be removed, and the setting bed and void materials can be salvaged and kept separate. Base materials are to be removed if access for utilities is required. Settlement repair depending on depth should be restored with additional base materials if settlement exceeds 0.5-inch. The setting bed should be made level and pavers re-instated with void materials replaced in the joints and voids with compaction bringing the pavers to flush condition and ready for use.

§ T1602(h) Porous Pavement Easement Protection

The Kane County ordinance requires that stormwater features (such as the permeable pavement) are protected by an easement. All permeable pavement areas that are part of the submitted and approved stormwater management system thus are required to be in an easement. If the permeable pavement is not part of the stormwater management system, such as a parking stall installed by a homeowner on his or her own accord, it is exempt from the easement requirement.

§ T1602(i) Specifications

The ICPI (Interlocking Concrete Pavement Institute) provides “Guide Specifications” for the construction of interlocking concrete pavement” (1997 ICPI Tech Spec No. 9) that generally address most permeable interlocking concrete pavement issues. A guide specification is listed below that addresses the various porous pavement components more specifically.

PART 1 – GENERAL

1.01 SECTON INCLUDES

A. Concrete units

B. Bedding Materials

C. Geotextiles

1.02 RELATED SECTIONS

A. Section [_____-_______]: Curbs.

B. Section [_____ - ______]: Open-graded base materials.

C. Section [_____ - ______]: Stabilized aggregate base.

D. Section [_____ - ______]: Impermeable liner.

E. Section [_____ - ______]: Edge restraints.

F. Section [_____ - ______]: Drainage pipes and appurtenances.

G. Section [_____ - ______]: Earthworks/excavation/soil compaction.

1.03 REFERENCES

A. American Society of Testing Materials (ASTM)

1. C 936, Standard Specification for Solid Interlocking Concrete Pavements.

2. C 33, Specification for Concrete Aggregates.

3. D 2490, Standard Specification for Graded Aggregate Material for Bases or Subbases for Highways or Airports.

1.04 QUALITY ASSURANCE

A. The contractor shall have experience with placement of permeable interlocking concrete pavements. The contractor shall have completed [ ] projects comprising of not less than [ ] sy (m^2) of permeable interlocking concrete pavements within the last [24] months. The contractor shall submit a list of projects, the area of permeable paving for each, locations, and details on the type of permeable interlocking concrete pavement(s) built.

B. As applicable by state/provincial and local laws, contractor shall hold a current contractor's and business license in the state/province and locality where work is to be performed.

1.05 SUBMITTALS

A. Shop or product drawings data.

B. Samples of paving units to indicate shape selections and color(s).

C. Sieve analysis of aggregates for base and bedding materials.

D. Test results for compliance of paving units to ASTM C 936 or CSA A231.2 as applicable.

E. Soils report indicating density test reports, classification, and infiltration rate measured on-site under compacted conditions, and suitability for the intended project.

F. Erosion and sediment control plan.

G. Stormwater management (quality and quantity) calculations.

1.06 MOCK UPS

A. Install a 6 ft. x 6 ft. (2 m x 2 m) paver area as described in Article 3.02. This area will be used to determine surcharge of the sand layer, joint sizes, lines, laying pattern(s), and texture of the job. This area shall be the standard form which the work will be judged.

B. Mock up approved by [engineer] [architect] [landscape architect] shall be part of the work.

1.07 DELIVERY, STORAGE AND HANDLING

A. Deliver concrete pavers to the site in steel banded, plastic banded, or plastic wrapped cubes capable of transfer by fork lift or clamp lift. Unload pavers at job site in such a manner that no damage occurs to the product.

B. [Protect sand and top soil with waterproof covering to prevent exposure to rainfall, removal by wind, or contamination from any source. Secure covering in place.]

1.08 ENVIRONMENTAL CONDITIONS

A. Do not install pavers during rain or snowfall.

B. Do not install frozen base materials.

PART 2 – PRODUCTS

2.01 PAVING UNITS

A. Manufactured/supplied by a member(s) of the Interlocking Concrete Pavement Institute (ICIP). The ICIP manufacturer/supplier shall be:

[name:]

[address:]

[phone:]

[fax:]

B. Product name/shape, overall dimensions, and thickness of the paver (s):

_____mm/in. x _____ mm/in and _____mm/in thick.

_____mm/in. x _____ mm/in and _____mm/in thick

C. Meet the requirements of ASTM C 936 or CSA A231.2 as applicable.

1. When testing 3 1/8 in. (80mm) thick units for conformance to ASTM C 936, comprehensive strength tests shall be corrected by multiplying the results by 1.18.

2. When testing 4 in. (100mm) thick units for conformance to ASTM C 936, comprehensive strength tests shall be corrected by multiplying the results by 1.24.

D. Certified by the ICPI.

2.02 MATERIALS FOR BEDDING AND OPENINGS

Grading Requirements for ASTM C33 No.8

Sieve Size	Percent Passing
½ in. (12.5 mm)	100
3/8 in. (9.5 mm)	85 to 100
No. 4 (4.75 mm)	10 to 30
No. 8 (2.36 mm)	0 to 10
No. 16 (1.16 mm)	0 to 5

2.03 MATERIALS FOR BASE

Grading Requirements for ASTM C33 No. 57

Sieve Size	Percent Passing
1 ½ in. (37.5 mm)	100
1 in. (25mm)	95 to 1000
½ in. (12.5 mm)	25 to 60
No. 4 (4.75 mm)	0 to 10
No. 8 (2.36 mm)	0 to 5

2.04 MATERIALS FOR SUBBASE

Grading Requirements for ASTM C33 No. 57

Sieve Size	Percent Passing
1 ½ in. (37.5 mm)	100
1 in. (25mm)	95 to 1000
½ in. (12.5 mm)	25 to 60
No. 4 (4.75 mm)	0 to 10
No. 8 (2.36 mm)	0 to 5

or

Grading Requirements for ASTM C33 No. 2

Sieve Size	Percent Passing
3in. (75 mm)	100
2 ½ in. (63 mm)	90 to 100
2 in. (50 mm)	35 to 70
1 ½ in. (37.5 mm)	0 to 15
¾ in. (19 mm)	0 to 5

2.05 GEOTEXTILES

A. Per [manufacturer, product name/number] as supplied by [source].

PART 3 – EXECUTION

3.01 EXAMINATION

A. Verify that base is free from standing water, uniform, even, free from any organic material or debris, ready to accept bedding materials, pavers and imposed loads.

B. Verify correct gradients and elevations of open-graded base.

C. Verify placement of geotextile [impermeable liner].

D. Verify compaction of soil to specified density and moisture content.

E. Verify location, type, installation and elevations of edge restraints around the perimeter area to be paved.

F. Beginning of installation means acceptance of base, edge restraints, drain pipes, and overflow devices.

3.02 INSTALLATION

A. Keep area where pavement is to be constructed free from sediment during entire job. Geotextiles, base and bedding materials contaminated with sediment shall be removed and replaced with clean materials.

B. Place and compact the No. 8 bedding material. Compact with a minimum [10] ton static roller. Make at least [4] passes. No visible movement should occur in the base material when compaction is complete.

C. The elevation of the compacted surface should not deviate more than ±1/2 in. (± 13 mm) over a 10 ft. (3 m) straightedge.

D. Loosen and evenly smooth ¾ to 1 in. (20 to 25 mm) of the compacted surface of the No. 8 bedding material. Maintain smooth, even surface during paver installation.

E. Lay the pavers [and spacers] in the pattern(s) and joint widths shown on the drawings. Maintain straight pattern lines.

F. Fill gaps at the edges of the paved area with cut pavers [edge units].

G. Cut pavers to be placed along the edges with a double-bladed splitter or masonry saw.

H. Compact and seat the pavers into the bedding material using a low amplitude, 75-90 Hz plate compactor capable of at least 5,000 lbs. (22kN) centrifugal compaction force. For units thicker than 4 in. (100 mm) use a compactor capable of at least 6,800 lbf (30 kN).

I. Vibrate and compact the pavers again, sweeping No. 8 aggregate into the openings until it is within ½ inch (13 mm) from the top surface. This will require at least two or three passes with the compactor.

J. Do not compact within 3 ft (1m) of the unrestrained edges of the paving units.

K. Remove excess aggregate by sweeping pavers clean.

L. All pavers within 3 ft (1 m) of the laying face must be left fully compacted at the completion of each day.

M. The final surface elevations shall not deviate more than ± 3/8 in. (± 10mm) under a 10 ft (3 m) long straightedge.

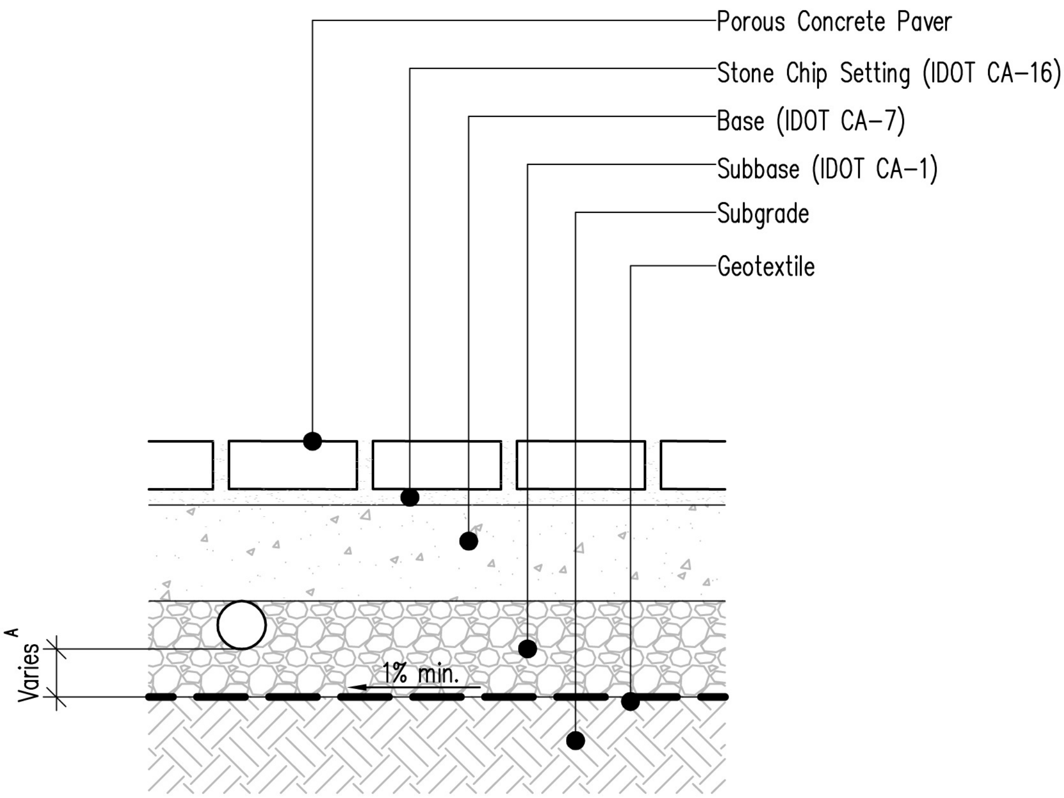
N. The surface elevation of pavers shall be 1/8 to ¼ inch (3 to 7 mm) above adjacent drainage inlets, concrete collars or channels.

3.03 FIELD QUALITY CONTROL

A. After removal of excess aggregate, check final elevations for conformance to the drawings.

END OF SECTION

§ T1602(j) Typical Detail



A) Maximum draintime not to exceed 24 hours.

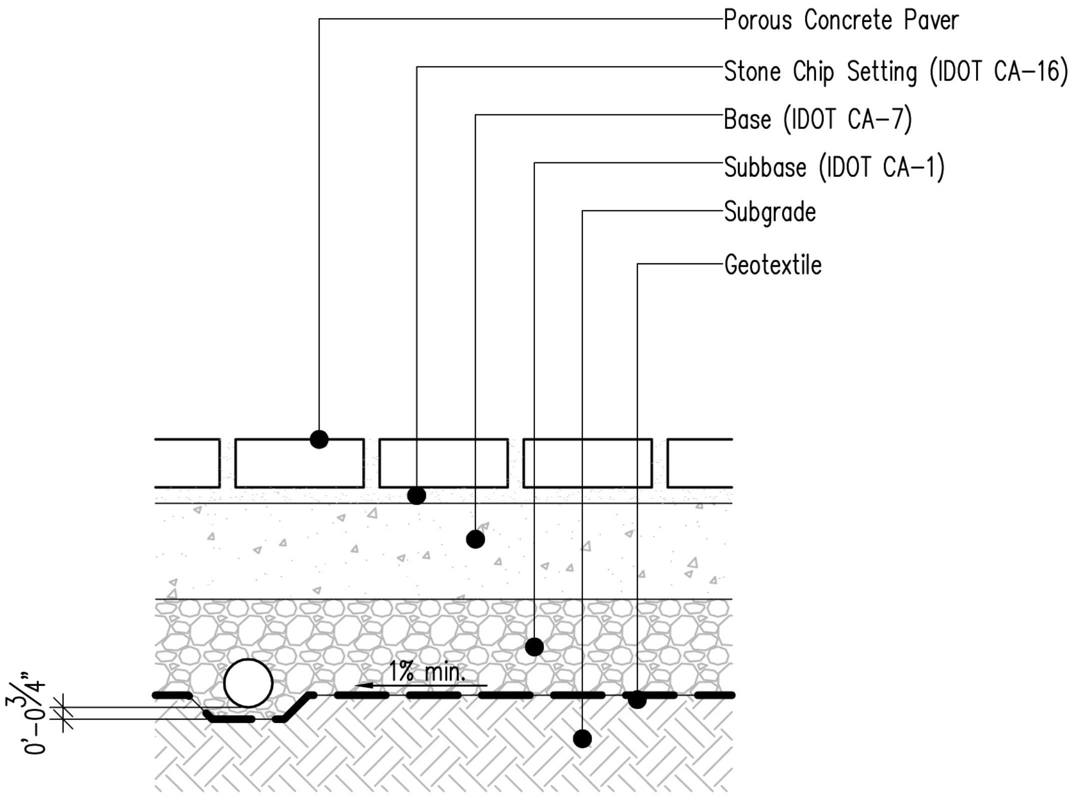
Notes:

1. Depth of base and subbase varies based on structural requirements and/or detention storage needs.

Porous Pavement with Retention Cross Section

Not to Scale

Figure 2 – Porous Pavement Detail (with retention storage volume)



Notes:

1. Depth of base and subbase varies based on structural requirements and/or detention storage needs.

Porous Pavement Cross Section

Not to Scale

Figure 3 – Porous Pavement Detail (without retention storage volume)

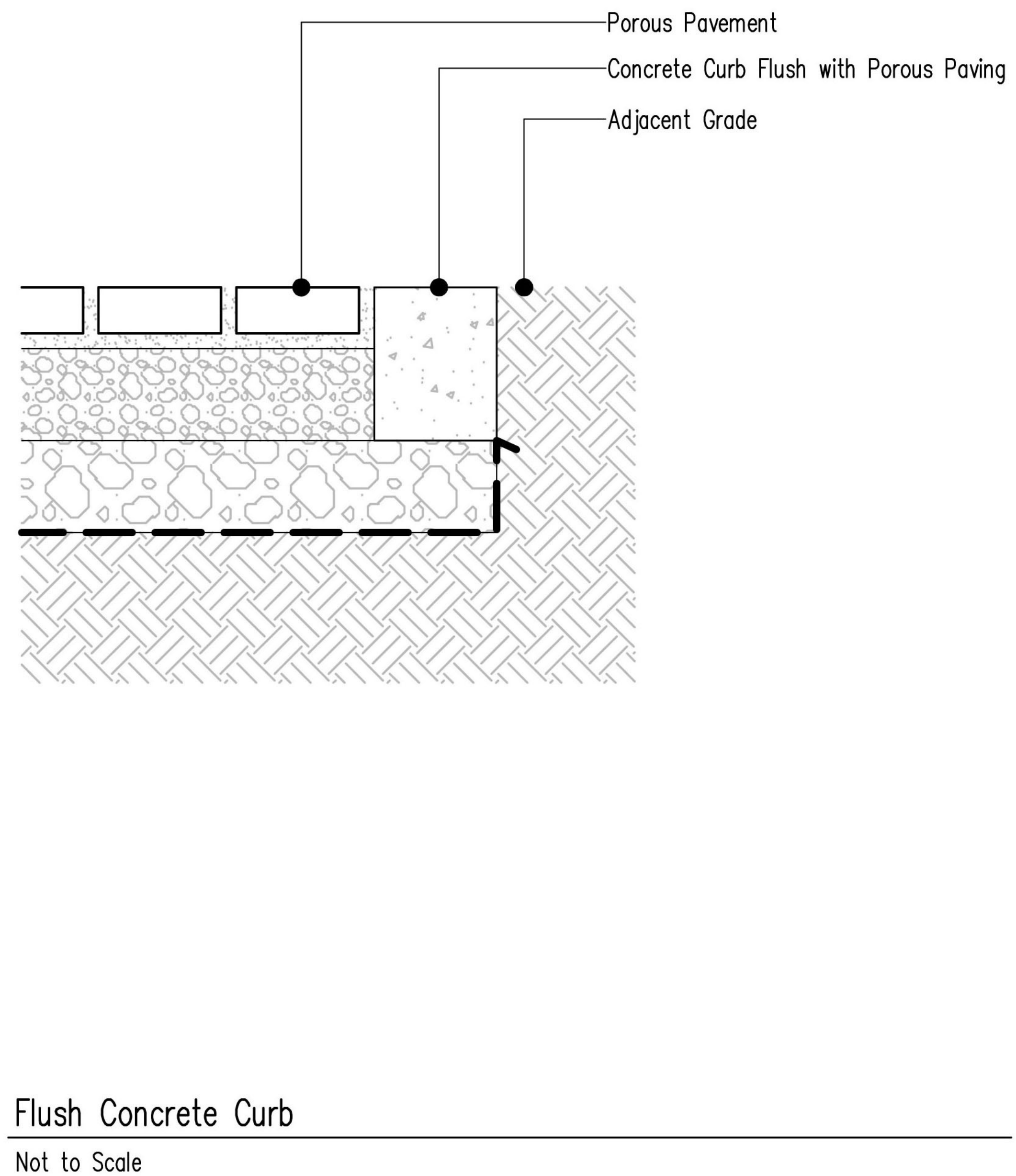


Figure 4 – Porous pavement edge restraint: Flush Concrete Curb

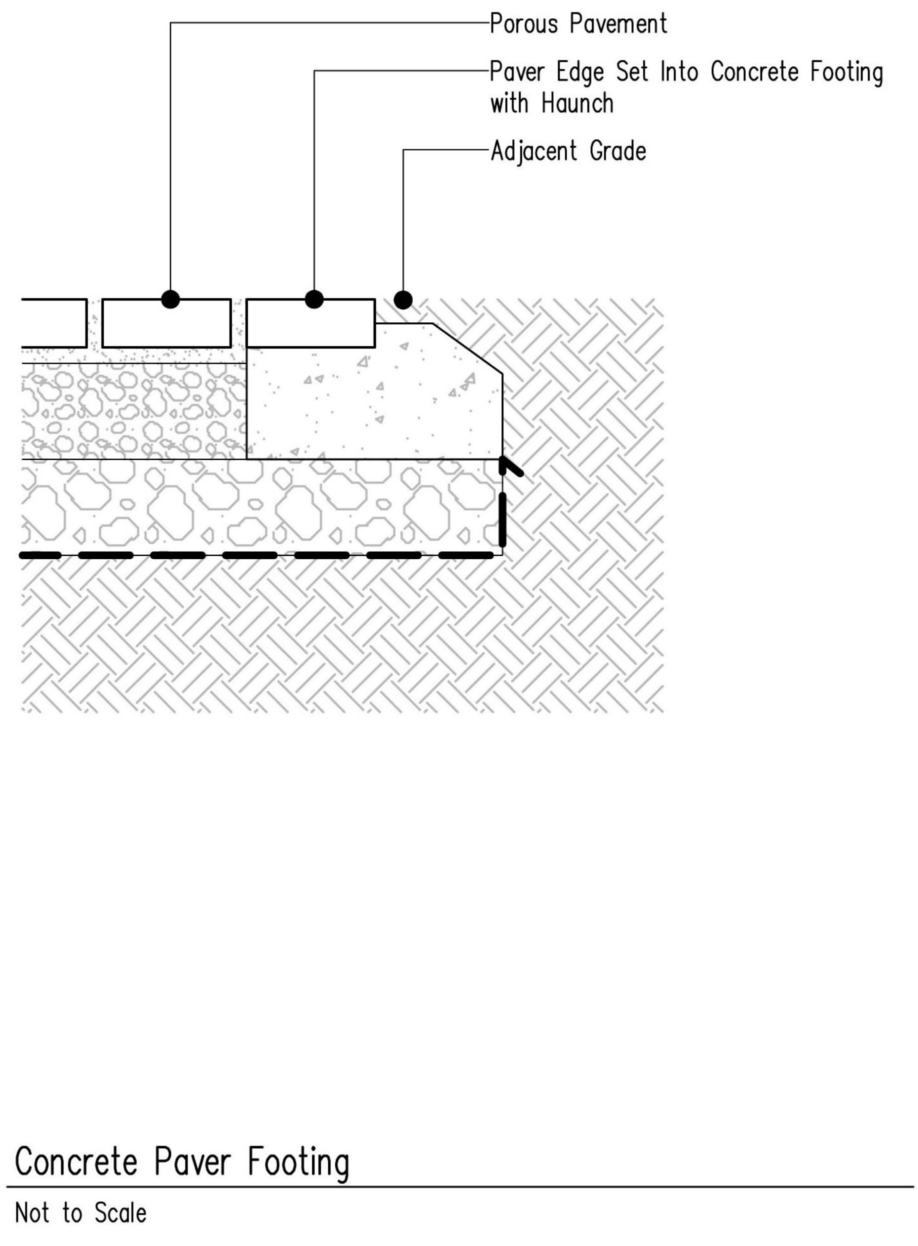


Figure 5 – Porous pavement edge restraint: Concrete Paver Footing

[1] Smith (2001); Smith (2003)
[2] JEGEL (2000)
[3] Smith (2001); Smith (2003)
[4] EPA (1999)
[5] Smith (2001); Smith (2003)
[6] Rollings *et al*. (1993)
[7] Schueler (1987); Horner *et al*. (1994); EPA (1998)
[8] Rollings *et al*. (1992)
[9] Borgwardt *et al.* (2000); Rollings *et al*. (1992); Yoder *et al*. (1975)
[10] Rollings *et al*. (1993)
[11] Smith (2001)
[12] Borgwardt *et al.* (2000)
[13] Dorman *et al*. (1964)
[14] Schueler (1987); Horner *et al*. (1994); EPA (1998)
[15] Smith (2001)
[16] Borgwardt *et al.* (2000)
[17] Rollings *et al*. (1993)
[18] Smith (2001)
[19] Smith (2001)
[20] Smith (2001)
[21] Smith (2001)
[22] Dunn *et al.* (1980); Rollings *et al*. (1992); Borgwardt *et al.* (2000)
[23] Smith (2001)
[24] Brattebo (in print)
[25] Bean *et al.* (2004)
[26] Borgwardt (1994)
[27] Smith (2001)
[28] Bean *et al.* (2004)
[29] Smith (2003); Borgwardt *et al.* (2000)
[30] Backstrom (2000)
[31] Hansen *et al.* (1997)
[32] EPA (1999)
[33] Mahabadi (2001)
[34] Cahill *et al.* (2004)
[35] Rollings *et al*. (1992)
[36] Borgwardt(1994); Bean *et al.* (2004)
[37] Bean *et al.* (2004)

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§ T1603 Rain Gardens

§ T1603(a) Definition and Examples

Rain gardens are shallow excavated garden areas designed to retain stormwater runoff from individual lots and associated impervious areas. They provide an effective runoff filtering mechanism through the vegetation and microorganisms in the root zone. Rain gardens should receive evenly distributed sheet flow, but can also receive point discharge runoff. The latter has to be specifically addressed in the rain garden design to prevent erosion and scour. Rain gardens are sized to drain or fully infiltrate the received runoff within approximately 12-hours and are typically planted with grasses and perennials, which help to improve and maintain stormwater infiltration over time.

The term “rain garden” is used here to denote a variety of biofiltration measures designed to filter and/or infiltrate runoff through a vegetated soil surface. For example, linear rain gardens located within parking lot islands are often referred to as biofiltration swales or simply bioswales.

Rain gardens can be combined with other BMP’s in this guidance manual. For example, many rain gardens are combined with infiltration trenches (see Section § T1604) to provide for greater infiltration than a rain garden alone and improved water quality and resistance to clogging than an infiltration trench alone. Rain gardens can also be combined with vegetated swales to provide both infiltration and conveyance.

§ T1603(b) Suitable Applications

Rain gardens are a cost-effective stormwater management application if strategically placed near impervious surfaces such as roof areas (downspout discharge points) and pavements, or other areas that generate runoff, such as lawn areas. Rain gardens can be integrated into new developments and can be retrofitted into existing developments. Suitable areas or development types in which rain gardens can be incorporated are:

Residential gardens/yards

Commercial development plantings

Parking lot landscape islands (often referred to as bioswales)

Parkway/right-of-way areas along streets

Median strips

§ T1603(c) Benefits

By minimizing the amount of stormwater that drains to the local storm sewer drainage system, rain gardens help to reduce the potential for flooding and associated bank and shoreline erosion in areas where stormwater discharges into wetlands, streams, and lakes. Rain garden benefits can be summarized as follows:

Reduces runoff volumes and rates from roofs, pavements, and lawns

Recharges groundwater and sustains base flows to natural water bodies

Reduces sediment, nutrient runoff, and other pollutants

Can be used to meet Kane County 0.75-inch retention standard

Ancillary benefits:

Reduces maintenance requirements compared to conventional lawn surfaces or other irrigated plantings

Can reduce detention needs

Effective land use through combination of stormwater management and ornamental planting

Can increase aesthetic value for the property

Can diversify site habitat

Can reduce the need for costly stormwater infrastructure

§ T1603(d) Limitations

The following considerations are necessary to sustain the long term performance of rain gardens:

The rain garden surface-area should generally be a minimum 10% to 15% of the contributing impervious area.

Rain gardens should not be used for areas with high sediment loadings such as plant nurseries, material storage yards, etc. unless the sediment load can be reduced using filters strips or other measures prior to release to the rain garden. The high sediment load can cause clogging.

Rain gardens and other infiltration measures should not be used for areas with potential for contaminated runoff to avoid groundwater contamination. Areas to be avoided include fueling and vehicle maintenance facilities (gas stations) and hazardous materials storage facilities. Runoff from parking lots, roofs and other typical urban surfaces should not lead to groundwater contamination, provided the design recommendations within the manual are followed.

Rain gardens must be protected from construction site runoff and/or the garden must be rehabilitated once the site is stabilized.

The drain time for rain gardens should be limited to approximately 12-hours to ensure longevity of the vegetation and prevent complaints. Where soil permeability is insufficient and/or the volume of runoff is too great, an infiltration trench can be placed below the rain garden to increase the available storage volume (see also Section § T1604).

Rain gardens should not be placed over septic systems and should be located at least 100-feet from well heads.

Rain gardens must have an adequate separation above the seasonal high ground water table (see also Section § T1603(e)(2)).

Rain gardens should not be placed over contaminated soils.

Rain gardens should be located at least 10-feet down slope from building foundations unless adequate waterproofing is provided and direct drainage to footing drains can be prevented.

§ T1603(e) Required Design Data

§ T1603(e)(1) Soil type and permeability:

The infiltration capacity of the subsoils under the rain garden will determine the volume of runoff that can be exfiltrated from the rain garden into the ground over a given time. The infiltration capacity, along with the contributing watershed will help to determine the rain garden size.

The Kane County Soil Survey provides some guidance with regards to soil permeability. It is, however, recommended that a hydraulic conductivity test be performed at the location and elevation of the proposed rain garden bottom to establish the site-specific permeability rate (double ring infiltrometer test per ASTM D3385, lab test per ASTM D2434 through a Shelby tube sample, or have a Certified Professional Soil Classifier conduct an on-site soil investigation to determine soil suitability or a Falling Head Percolation Test (described in Appendix A). The data from the infiltration test will allow for adequate sizing and design of the rain garden.

§ T1603(e)(2) Seasonal high water table:

If the site in question for the rain garden placement is known to have a relatively high water table, data on the elevation of the seasonal high water table is needed. The invert of the rain garden shall be at least three feet above the seasonal high water table[1] to provide adequate runoff treatment prior to discharge into shallow ground water.

§ T1603(e)(3) Contributing drainage area and imperviousness:

Along with the infiltration capacity, the drainage area and level of imperviousness contributing to the rain garden are needed to determine its size.

§ T1603(f) Rain Garden Design

§ T1603(f)(1) Rain garden location:

As a general rule, rain gardens should be located adjacent to or near the impervious surfaces they are designed to treat.

Topography:

Place the rain garden in flat areas to maximize the surface area for infiltration. Construct the rain garden with a shallow slope at the edges and flat invert to allow for even runoff distribution and infiltration. Avoid low areas with a longer ponding time, which may cause sediment accumulation and sealing. If the rain garden must be constructed in sloping terrain, give it a linear shape and place it along a contour, or terrace the rain garden along the slope.

Building foundation and basements:

Some references call for a minimum set back of 10-feet from any building foundation. Another rule that can be applied to protect building basements is to set back the rain garden 1.5-times the distance of the building foundation depth[2]. These rules may not apply to foundation that are water proofed and where no leakage into the footing drain is assured.

Light level conditions:

An important component of rain garden design is the planting of grasses and sedges with strong fibrous root systems. Such root systems contribute to the build up of soil organic carbon that ensures the longevity of the rain garden's filtration and infiltration capacity. In order to maximize the production of soil organic carbon, the grasses and sedges need to be 'fueled' by sufficient sunlight. The placement of the rain garden in full sun or partial sun conditions is preferable. Sites that are exposed to full sun for about half the day are suitable for a rain gardens.

Seasonal high water table:

The rain garden invert will need to be a minimum of three feet[3] above the seasonal high water table to provide adequate runoff treatment prior to discharge into shallow ground water. The greater the separation between the seasonal high water table and rain garden invert, the more effective the runoff treatment.

§ T1603(f)(2) Rain garden ponding depth and drain time:

The drain time for rain gardens should be limited to 12-hours and the depth of ponding should generally be limited to 18-inches. However, greater depths may be appropriate if the duration can be limited to less than 12-hours.

The time necessary to drain the rain garden should be no more than approximately 12-hours to ensure the health of the vegetation in the rain garden and to avoid complaints. In many cases, the drain time and soil permeability will determine the maximum depth of ponding. For example, if the infiltration capacity of the soils is 1-inch/hour, the maximum depth would be 12-inches, if the infiltration capacity is 0.5-inches/hour, the maximum depth would be 6-inches.

In higher permeability soils, it may be feasible to support greater depths of ponding without exceeding the 12-hour duration. However, to protect the health of the vegetation, the depth should generally be limited to 18-inches unless the duration can be reduced to less than 12-hours. For example, certain areas of Kane County have permeability rates as high as 5- inches/hour. In these areas, it may be appropriate to use greater depths since even a 24-inch deep rain garden would drain in less than 5-hours.

Where greater depths of ponding are necessary due to space constraints, rain gardens can be placed over infiltration trenches for which the maximum recommended drain time is 72-hours[4] (see also Section § T1604(f)(3)).

§ T1603(f)(3) Rain garden area:

Although the term rain garden conjures images of small backyard gardens, there is really no size limit to the area of a rain garden. Thus, a rain garden could be as large as what is commonly known as an infiltration basin provided the guidance in this document is followed, including ponding depth and drain time described above.

To minimize the potential for clogging at the bottom of the rain garden and to maximize the runoff volume potential, the rain garden area should not be less than 10% to 15% of the impervious drainage area.

§ T1603(f)(4) Rain garden sizing:

To meet the Kane County retention standards, rain gardens should be sized for 0.75-inches of runoff over the impervious area draining to the rain garden. However, rain gardens in other regions are often sized to contain the 1- to 2-year event to prevent increases in runoff volumes for these storms that are most affected by urbanization. Rain garden sizing is described further under Section § T1603(f)(9).

In general, the surface area of a rain garden will need to increase and the depth will need to decrease with lower permeability soils. In other words, the lower the soil permeability, the shallower the depth and the larger the surface area needed to retain and infiltrate runoff within the recommended maximum drain time of 12-hours.

Depending on site limitations (e.g. soils with a very low infiltration rate, limited available space, etc.), it may be difficult or impossible to meet the 0.75-inch retention standard with a rain garden alone. In this case, rain gardens can be underlain with gravel filled infiltration trenches to provide additional storage without exceeding the surface ponding depth and duration standards. Also, rain gardens can be combined or sequenced in the watershed with other decentralized stormwater tools, such as porous pavements, to meet the retention standard.

§ T1603(f)(5) Runoff treatment:

High runoff temperatures and poor water quality can stress the rain garden vegetation and their root systems that are important to ensure the system's long term performance and aesthetics. Runoff water quality can be improved and temperatures reduced by routing impervious runoff through level spreaders and vegetated filter strips (see Section § T1605).

High runoff temperatures can also be mitigated through the point discharge dissipation approaches, which are described in Section § T1603(f)(6), below.

§ T1603(f)(6) Flow energy dissipation:

Energy dissipation is often necessary to prevent scour where runoff enters the rain garden. At curb cuts along a street or within a parking lot or for residential downspouts, only nominal energy dissipation such as a splash pad or small amount of stone may be necessary. For large flow rates (entering larger rain gardens), larger rip rap material, level spreaders or inflow chambers may be necessary.

Level spreader (see also Section § T1605):

Level spreaders can be as simple as a gravel edge where the parking surface meets the rain garden or can be more complex such as long gravel trenches containing perforated pipe to distribute the runoff over the length of the spreader. In addition to dissipating energy and distributing the runoff, level spreaders provide cooling of the first flush runoff from high temperature paved or roof surfaces.

Inflow-chamber:

Route point discharge to an inflow-chamber in the rain garden. The inflow-chamber functions like a drywell in reverse, allowing the runoff to slowly rise by head pressure and flow into the rain garden.

§ T1603(f)(7) Rain garden top soil:

Eight to 12-inches of loamy sand / sandy loam topsoil should be placed in the bottom of the rain garden to provide filtration and a growing media for the vegetation.

The topsoil should generally conform to the following specifications to ensure adequate permeability and growing conditions.

70% medium to coarse sand (IDOT FA2)

8 to 10% organic content

Less than 10% clay

Compaction of 70% (modified) to 75% (standard) max. dry density

In some cases, the existing site topsoil may meet the specifications above. In other cases, site topsoil may need to be amended with coarse sand (IDOT FA2) and/or organic material such as leaf compost. The specifications section provides detail on the amended topsoil (see Section § T1603(i)).

Where a rain garden is located above an infiltration trench, the minimum amended topsoil depth should be 8-inches. Where the rain garden is located directly on subgrade soils, the amended topsoil depth should be increased to 12-inches unless the subgrade soils have a tested infiltration capacity greater than 1-inch/hour.

§ T1603(f)(8) Vegetation design:

The use of perennials, fibrous rooted grasses, and sedges will enhance the rain garden's longevity and improve water quality benefits. The extensive root system of native grasses and forbs contribute to the sustainability of soil organic carbon that ensures the longevity of the rain garden's filtration and infiltration capacity. Native grasses alone will achieve the rain garden objectives. However, forbs are often added to achieve certain aesthetic objectives. The vegetation of a rain garden depends on a number of factors:

Soil type and soil moisture content:

In spite of the name "rain garden" the vegetation should be that which flourishes in soils that are neither particularly wet nor particularly dry. Appendix B – Species Guide lists recommended native plant species. Rain gardens located over infiltration trenches or high permeability soils must be tolerant of dry conditions.

Light level conditions:

As described in Section § T1603(f)(1) native grasses and sedges need to be 'fueled' by sufficient sunlight to produce soil organic carbon. The placement of the rain garden in full sun or partial sun conditions is thus preferable.

Aesthetic objectives:

Use of the recommended native grasses, forbs, and sedges in a rain garden does not mean that the appearance automatically translates into a "naturalistic" look. Midwestern native vegetation provides sufficient variation in flowering color, flowering time, textures, and plant heights to create rain garden plantings that provide an ornamental “flowering border” appearance, or even a formal design. The latter two options will require more maintenance than a “naturalistic” planting (see Section § T1603(h)(1)).

If mowed more often than once a year or planted with a low ratio of grasses and sedges, soil organic carbon will deplete over time. This may reduce the water quality benefits of the rain garden over time. It may also lead to a slow loss of infiltration capacity that may need to be restored by tilling in additional organic material.

§ T1603(f)(9) Hydrologic analysis:

There are two components to the hydrologic analysis: the required size to meet the Kane County retention standard and the impact of the rain garden on downstream detention requirements.

Retention standard:

The Kane County retention standard states that 0.75-inches over the impervious area must be retained. To ensure that the retention standard is met for all storm durations, a one-hour design storm should be used to size the rain garden. Except on soils with very high permeability, the volume of water infiltrated during a 1-hour event will be small. Thus, the required surface volume of the rain garden (Vr) is:

$$V_R = 0.75 * A_i * 0.083$$

Where:

V_R = retention storage volume in acre-feet

0.75 = retention volume standard in inches

A_i = impervious area (acres)

0.083 = conversion from acre-inches to acre-feet

If there is insufficient space to provide the required volume without exceeding the maximum ponding depth or duration, the rain garden may be supplemented with an infiltration trench below or with downstream retention features such as additional rain garden and native filter strips.

Impact on downstream detention sizing:

The critical duration for detention sizing is typically 24-hours. Thus, the volume of runoff infiltrated within a rain garden during a 24-hour detention design storm will often be significant. For example, with a watershed to rain garden area ratio of 8:1 and soil permeability equal to 0.5-in/hr, a properly sized rain garden, designed according to these guidelines can reduce the runoff volume associated with the 2-year event by 50%.

Rain gardens can be modeled as storage reservoirs in standard hydrologic models such as TR20 or HEC-1. The rate of infiltration Qi is equal to:

$$Q_i = i * A_g$$

Where:

Q_i = the volumetric flow rate through the rain garden subgrade in cubic feet per second (cfs)

i = infiltration capacity of subgrade soils in inches/hour

A_g = bottom area of the rain garden in acres

For models that allow multiple outlets, infiltration outflow can be treated as a separate outlet that does not contribute downstream. For models that only allow a single outlet, the total rain garden outflow is equal to the infiltration outflow plus the surface outflow. The infiltration outflow rate can then be diverted out of the system so that it does not contribute to the downstream detention facility.

§ T1603(g) Construction Considerations

Construction of rain gardens requires special care and changes to normal construction practice and schedules for the optimal functioning of the rain garden facility and its long-term viability.

§ T1603(g)(1) Soil erosion and sedimentation control:

Soil erosion and sediment control practices should be maintained and inspected on a regular basis. Accumulated sediments within on-lot sediment traps and along silt fences should be promptly removed. All disturbed areas shall be promptly stabilized and compromised erosion and sediment control devises should be promptly repaired.

Stockpiles should be located downstream of rain garden facility; if unable to do so, stockpile shall have a double row of silt fence that surrounds the perimeter of the stockpile.

Before the rain garden goes online, the contributing drainage area must be stabilized/fully vegetated.

Rain garden facility shall be stabilized with vegetation and erosion blanket prior to facility receiving stormwater runoff.

§ T1603(g)(2) Avoidance of soil compaction and contamination:

Soil compaction in the rain garden area must be avoided to conserve the permeability rate of the existing subsoils.

Areas where rain gardens are to be located should be protected from construction traffic using construction fencing or other barriers.

Avoid working on or with soils that are excessively wet or saturated.

Excavation of the rain garden should be performed using a backhoe or other equipment that can be staged outside the rain garden facility during excavation operations. Where the rain garden is too large to be excavated from outside the garden, low ground pressure equipment should be used and the area tracked by the equipment should be minimized (see also sample specifications in Section § T1603(i)).

§ T1603(g)(3) Amended soil mix:

After placement of topsoil, the rain garden facility must be protected from construction impacts, including placement of building materials and foot and vehicle traffic.

When onsite topsoil needs to be amended to meet the specifications of Section § T1603(f)(7) the recommended method of amended soil mix placement is:

Mixing of the amended soil outside of the rain garden area.

Unloading of the amended soil at the rain garden edge.

Spreading of the amended soil with a backhoe or other equipment that can be staged outside the rain garden facility.

Manual fine grading, such as raking.

Compaction using a roller or other equipment that will provide adequate compaction to support moderate foot traffic but not exceed 80 to 85% compaction.

§ T1603(g)(4) Vegetation installation:

Prepare seed bed through manual means or use low ground pressure equipment.

Hand broadcast seed or use low ground pressure seeding equipment.

Install erosion control blanket and plant live material by carefully slitting slots into the erosion blanket.

The success of a rain garden installation can be assured by simple proactive measures. It is recommended that the consultant meet with the contractor prior to construction to discuss the above listed items, construction sequencing and construction schedules. Supervisory construction staff, such as the foreman, should participate in the meeting. Construction inspections should be mandatory at crucial junctures to verify compliance with design parameters and specifications.

§ T1603(h) Operation and Maintenance

Rain garden maintenance can be greatly reduced by taking a proactive approach during construction. The greater the care taken during construction, the fewer items there will be to look after or to repair. Care during construction will also assure a smooth and shortened establishment period, which reduces intensive maintenance requirements.

The following activities should be completed routinely in the first two to three years of establishment: erosion repair, weed control, and supplemental watering. After full vegetation establishment, the required maintenance within rain gardens that use native grasses, sedges, and perennials in a naturalistic fashion should be minimal. More intensive maintenance may be required in rain gardens that use ornamental and non-native species but no greater than the maintenance required of a typical perennial garden.

§ T1603(h)(1) Vegetation management:

Initially, plant plugs and other live material should be watered immediately after planting and continue to be watered as necessary until plugs are rooted into the ground, unless there is adequate rainfall.

During the plant establishment period – up to 3-years after installation – monthly site visits during the growing season (April – October) should be undertaken to identify and carry out maintenance requirements.

If a rain garden is seeded and plugged, the establishment period may be only 1.5 to 2-years, depending upon the success of the initial weed and weed seed bank treatment and the vigilance of the initial weed control.

Due to the typical size of a rain garden, the most effective manner of weed control will be hand weeding and/or use of appropriate herbicide (by licensed applicator). To determine the appropriate weed control, one has to distinguish between annual weeds and perennial weeds. The former requires a less intense control than the latter.

Annual weeds:

Annual weeds do not need to be pulled but only to be cut/trimmed back to prevent them from flowering and setting seed. In rain gardens that use native prairie vegetation, control of annual weeds can also be achieved in the first growing season through mowing, cutting vegetation to a height of 6- to 8-inches. A string trimmer may also be used to cut vegetation to this same height. Where vegetation growth is heavy, cuttings should be removed to prevent smothering of the desirable rain garden vegetation. Mowing should be conducted when the weed vegetation reaches a height of 12 to 15-inches and before any noxious weeds set seed.

Perennial weeds:

Perennial weeds should be hand pulled or spot treated with herbicide (by licensed applicator). Hand pulling should include the removal of all above ground and belowground stems, roots, and flower masses prior to the development of seeds. Care should be taken to disturb as little soil as possible during hand pulling to avoid exposure of additional weed seed in the soil layer, and to protect adjacent emerging seedlings. Care must be taking during herbicide spot treatment to avoid damaging surrounding vegetation.

After sufficient graminoid (grasses and sedges) development to provide an adequate fuel source in rain gardens with native prairie vegetation, annual burn management should be implemented. Burning dead plant material reduces weed growth, stimulates native grass and forb growth, and increases nutrients available to the plants. In rain gardens where burning is difficult or impossible, the vegetation should be mowed annually in fall or spring. To mimic the burn cycle all clippings and thatch must be removed after mowing. Please note that mowing does not provide the full benefit to native prairie vegetation that fire provides and will often result in a lower ratio of wildflowers (forbs) relative to the grasses.

Rain gardens planted with ornamental plants and/or non-native species may require cutting back and winter protection of individual species as part of winter preparations typical of any ornamental garden. These rain gardens may also require thinning of some plants to encourage the development of other species.

§ T1603(h)(2) Debris removal:

In those systems where there is no burn regime, dead plant debris, trash, leaves and any other material that may obstruct infiltration or smother desired vegetation should be removed. Dead plant stalks should be cut back or mowed each spring.

§ T1603(h)(3) Sedimentation removal:

If the rain garden is properly designed and protected from sedimentation through use of an adequate pretreatment area, the rain garden basin is likely to maintain its effectiveness for many years (20+ years). The rain garden basin should be scraped and replanted when accumulated sedimentation is one-quarter of the basin depth.

The initial erosion and sediment control inspections should identify and initiate remediation of any early signs of erosion or sedimentation within the rain garden basin. Thereafter, annual inspections for sediment accumulation within the pretreatment area and basin should occur.

§ T1603(h)(4) Rain garden easement protection:

The Kane County ordinance requires that stormwater features (such as a rain garden) are protected by an easement. All rain garden areas that are part of the submitted and approved stormwater management system thus are required to be in an easement. If rain gardens are not part of the stormwater management system, such as a rain garden installed by a homeowner on his or her own accord, it is exempt from the easement requirement.

§ T1603(i) Specifications

(see next page)

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the testing, mixing, and installation of topsoil material in conjunction with a rain garden installation.

1.3 RELATED DOCUMENTS

A. AASHTO T 194 Standard Method of Test for Determination of Organic Matter in Soils by Wet Combustion.

B. ASTM D 4972 Standard Test Method for pH of Soils.

C. ASTM D 422-63 Standard Test Method for Particle-Size Analysis of Soils.

D. ASTM D 698 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

E. ASTM D 1557 Standard Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

F. Solvita by Woods End Research: Guide to Solvita Testing for Compost Maturity Index.

1.4. QUALITY ASSURANCE

A. Field Control Tests:

1. Organic Content and pH measurement of amended soil mix shall be in accordance with AASHTO T 194 and ASTM D 4972, respectively.

2. Sand and clay content of amended soil mix shall be measured in accordance with ASTM D 422-63.

3. One test per 300 square feet of rain garden.

PART 2 – PRODUCTS

2.1. ON-SITE LOAMY SAND/SANDY LOAM TOPSOIL

A. Topsoil for use in a rain garden shall be a sandy loam that conforms to the following specifications.

Proportion of Sand	70%
Proportion of Organic Material	8% - 10%
pH	$6.0 \leq pH < 8.0$
Maximum Clay Content	10%

B. If the onsite topsoil does not conform to the above specifications, it may be amended with sand and/or organic material to create Amended Rain Garden Topsoil as described in Section 2.2.

2.2. AMENDED RAIN GARDEN TOPSOIL

A. Sand: Shall be clean and free of toxic materials and shall be per IDOT specifications. Gradation shall conform to IDOT FA2. The sand mix constitutes approximately 70% of the rain garden amended soil mix.

B. Silt-Clay-Loam Planting Soil: Planting soil shall be used to create amended soil, but after mixing of amended soil, clay shall not constitute more than 10% of the amended rain garden soil mix. Soils for use in the amended rain garden soil mix shall be obtained from A-horizon soils without admixture of subsoil. Planting soil shall be fertile, friable, (i.e., not pulverized), free from subsoil, clay lumps, brush, litter, stones, weed propagules (seeds, rhizomes, and plants), roots, or similar objects larger than 1-inch in any dimension, or deleterious materials, including any toxic materials.

C. Organic Matter: Organic matter shall constitute a minimum of 8% and maximum 10% of the amended rain garden soil mix. The organic matter shall be well-composted, stable, and weed-free with a pH range of 6.0 to 8.0. The organic matter or hereafter, referred to as the compost, shall also meet the following requirements:

1. The compost shall be derived of material that consists of chipped, shredded, or ground vegetation or clean, processed, recycled wood products.

2. The compost shall be processed or completed to reduce weed seeds, pathogens, and deleterious material, and shall not contain paint, petroleum products, herbicides, fungicides, or other chemical residues that would be harmful to plant or animal life. Other deleterious material, plastic, glass, metal, or rocks shall not exceed 0.1 percent by weight or volume.

3. A minimum internal temperature of 57°C shall be maintained for at least 15 continuous days during the composting process. The compost shall be thoroughly turned a minimum of 5 times during the composting process and shall go through a minimum 90-day curing period after the 15-day thermophilic compost process has been completed. Compost shall be screened through a maximum 9.5-mm screen.

4. The moisture content of the compost shall not exceed 35 percent. Compost products with a higher moisture content may be used provided the weight of the compost is increased to equal the compost with a moisture content of 35-40 percent.

5. The compost shall measure a minimum of 6 on the maturity and stability scale by Solvita (Woods Research).

6. Compost shall be tested for maturity and stability and a certificate shall be provided that indicates the organic material meets the specified requirements.

D. The onsite and/or amended rain garden topsoil mix shall be friable, free of clumps of clay, brush, weed propagules (seeds, rhizomes, and plants) including but not limited to Circium arvense, Arctium minus, Lythrum salicaria, Phalaris arundinacea, Phragmites australis, Typha latifolia, and Typha angustifolia, roots, stones larger than 1”, other extraneous or toxic matter harmful to plant growth.

E. Erosion blanket, North American Green (NAG) S75, or equivalent, if rain garden execution is completed between April 1st and October 1st; or NAG S150, or equivalent, if work is completed after October 1st.

PART 3 – EXECUTION

3.1. AMENDED RAIN GARDEN SOIL PREPARATION

A. Verify sand, clay, organic content, and pH measurement of amended soil mix via field control tests. Refer to Quality Assurance of this Section for required field control tests.

B. If amended topsoil is placed over an infiltration trench, mixing of the amended soil must be done outside of the infiltration trench.

3.2. RAIN GARDEN EXCAVATION

A. Excavation shall be achieved via backhoe or other similar excavation equipment that shall be situated outside the boundary of the rain garden. If the rain garden scale is too large to accommodate this requirement, use low ground pressure excavation equipment, which shall be confined to a “one-track” alignment within the rain garden to accomplish the excavation, placement of the amended soil, or reapplication of topsoil into the rain garden basin.

3.3. EXAMINATION OF SUBGRADE

A. Subgrade shall be examined by the Contractor prior to start of amended rain garden soil mixture placement and planting. All subgrade elevations shall be approved by the Construction Manager prior to placement of amended soil mix.

B. Compaction Mitigation – If compaction occurs during basin excavation (within “one-track” area), a chisel plow or rotary device with the capability of reaching a depth of 12 inches below the surface shall be used within the compacted area.

3.4. AMENDED RAIN GARDEN SOIL PLACEMENT

A. Installation of amended topsoil must be done in a manner that will ensure adequate infiltration. Place amended soil mix in 8” –12” lifts. Lifts shall not be compacted. Overfill above the proposed final grade to accommodate natural settlement to meet finish grades. Do not spread if amended soil or subgrade is frozen, muddy, or excessively wet.

1. Placement of amended soil should be sequenced with seed and erosion blanket installation to prevent traffic over amended soil mix lifts and final grading to prevent undesirable soil compaction.

2. Seed installation shall be by method that minimizes compaction to soil.

B. Light Compaction of Amended Rain Garden Soil. Avoid over compaction by allowing time for natural settlement and compaction. Amended Rain Garden Soil shall have a maximum dry density of 70% (ASTM D 1557) or 75% (ASTM D 698) after completion of the Rain Garden installation. If time does not allow for natural settlement of soil, light compaction methods as specified below, may be implemented; if needed, additional amended soil mix shall be placed as previously stated to meet final grades.

1. Amended soil mix may be compacted by presoaking the placed soil until water flows from an underdrain (if present). Water for saturation shall be applied by spraying or sprinkling. Additional settlement may occur subsequent to the initial wetting.

2. Roll the entire rain garden area with a hand roller weighing no more than 100 pounds per foot of width. During the rolling, all depressions caused by settlement of rolling shall be filled with additional amended rain garden soil mix and the surface shall be re-graded and rolled until a smooth and even finish to the required grade is achieved.

C. If amended soil becomes contaminated by construction site runoff during the construction of the facility, the contaminated material shall be removed and replaced with uncontaminated material at no additional cost to the Owner.

D. Contractor shall place construction fencing or other approved barriers to prevent compaction of amended rain garden soil mix from vehicle, equipment, or foot traffic.

3.5. FINE GRADING

A. Carefully prepare the amended rain garden soil bed by scarifying and hand raking after amended soil mix has been spread.

3.6. VEGETATION COVER

A. Permanent seed matrix installation shall be conducted during installation seasons normally recognized in the job locality for the native species that are proposed, and shall be approved by the Design Professional.

B. A cover crop shall be installed in conjunction with the seeding of the permanent vegetation if the timing of the installation is appropriate. Otherwise, a cover crop shall be installed immediately following fine grading and the permanent seed matrix shall be installed at the next installation season.

C. Plant live material after seeding and placement of erosion control blanket. Contractor will be required to carefully slit installed erosion control blanket for plug installation. Contractor shall ensure minimal disturbance to the erosion control blanket.

3.7. MAINTENANCE

A. Maintain and establish native vegetation by watering, weeding, mowing, trimming, reseeding, and other operations. Re-grade and replant bare or eroded areas.

B. Dependent upon the timing of installation, a provision for watering for the establishment of the native species may be required. Water the seeded/planted areas a minimum rate of 1/2 inch per week for 8 weeks after installation, and thereafter as needed for successful establishment of native vegetation.

C. During the first couple growing seasons, occasional mowing may be needed to reduce weed height to provide direct sunlight for the establishing native species. Mowing heights and dates should be adjusted to maximize weed control and minimize damage to native species. The mower blade height should be set at a minimum, to six (6) to eight (8) inches. For areas not accessible with mowing equipment, the rain garden may be cut to the minimum specified height with a string trimmer or equivalent.

3.8. PERFORMANCE CRITERIA

A. Satisfactory performance by the end of the first full growing season shall consist of the following criteria:

1. Complete vegetative cover. A minimum 95% cover shall be achieved and no area greater than one (1) square meter within the seeded/planted rain garden shall be devoid of vegetation.

2. At a minimum, 95% of the planted plugs and container-grown plants shall be alive and growing in a healthy condition.

3. No less than 25% occurrence of the seeded species shall be present within the rain garden.

4. None of the following shall be among the five most dominant plant species in the overall vegetative cover:

a. Common reed (Phragmites australis)

b. Sandbar willow (Salix interior)

c. Box elder (Acer negundo)

d. Giant ragweed (Ambrosia trifida)

e. Common ragweed (Ambrosia artemisiifolia elatior)

f. Non-native species

END OF SECTION

§ T1603(j) Typical Detail

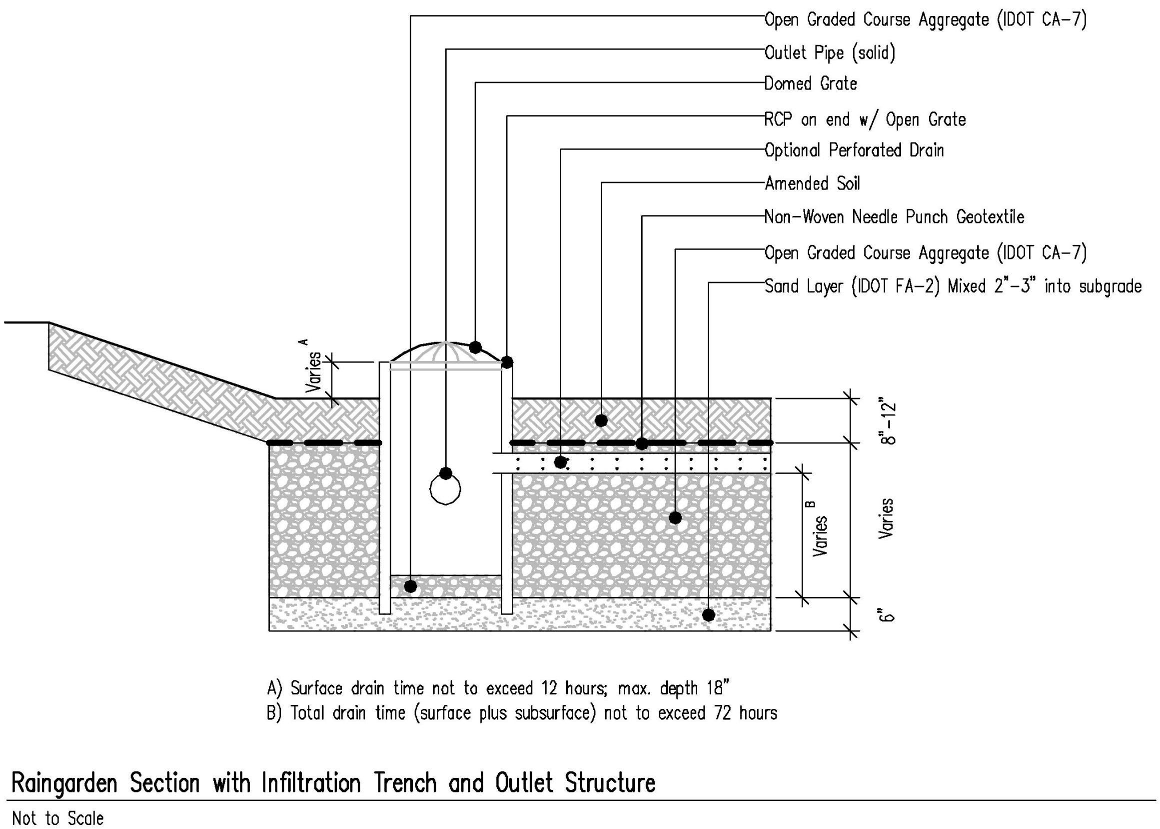

Figure 6 – Rain Garden Section with Infiltration Trench (in profile) and Outlet Structure

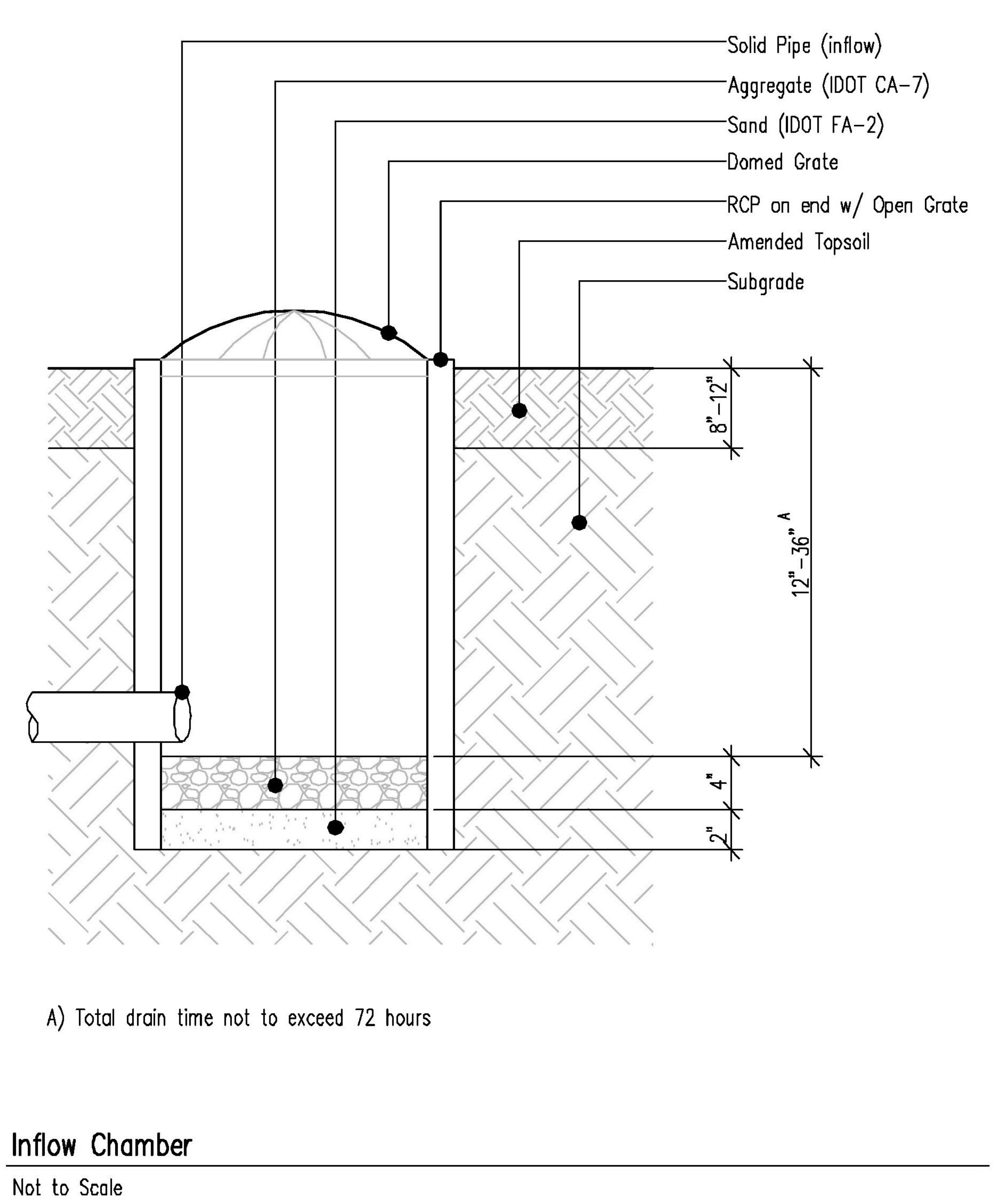

Figure 7 – Inflow Chamber Detail

[1] Barr Engineering Company (2001)
[2] Mahabadi (2001)
[3] Barr Engineering Company (2001)
[4] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); MA Department of Environmental Protection (1997); Lowndes, M.A. (2000); Los Angeles County Department of Public Works (2002)

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§ T1604 Infiltration Trenches

§ T1604(a) Definition

Infiltration trenches are excavations filled with open graded aggregate for temporary stormwater runoff storage. Although many stormwater manuals describe stand-alone infiltration trenches, within Kane County, infiltration trenches must be overlain with rain gardens or vegetated swales constructed with amended topsoil. The vegetated amended topsoil media (see Section § T1603(g)(3)) filters the runoff, protecting the trench and subgrade soils from clogging with sediments. The soil filter must be amended to meet the specified permeability rate and be planted with native grasses and sedges to sustain soil organic carbon and hence the infiltration capacity.

Although the term "trench" implies a linear feature, the aggregate reservoir may occupy any shape.

The stored runoff in the aggregate reservoir must be partially or fully exfiltrated into the ground within 48 to 72-hours[1]. The infiltration trench thus provides runoff volume control, recharges shallow ground water and helps to sustain base flows. In the case of partial exfiltration, excess runoff is collected through a perforated pipe or other drain and conveyed to additional BMP's downstream.

Infiltration trenches are combined with other BMP's in this guidance manual, such as rain gardens (see Section § T1603) to meet the Kane County 0.75-inch retention standard.

§ T1604(b) Suitable Applications

Infiltration trenches are a suitable application where the 0.75-inch Kane County retention standard can not be met with rain gardens or vegetated swales alone. They improve the retention capacity by increasing the storage volume available for infiltration, increasing the allowable drain time, and may facilitate connection to a lower lying soil horizon that has a better infiltration capacity. In this case the infiltration trench will function as a linear dry well. It is critical, though, to insure that the invert of the infiltration trench has sufficient separation from the seasonal high water table to reduce the risk of ground water contamination (see also Section § T1604(e)(2)).

Infiltration trenches are ideal for residential, commercial and mixed-use developments. Their physical configuration allows integration into narrow areas, such as along parking lot edges and within parking lot islands and medians. The contributing area should not exceed five-acres[2].

§ T1604(c) Benefits

Suitable for narrow and small spaces that cannot accommodate larger conventional treatments

Good pollutant removal capabilities[3]

Facilitates decentralization of the stormwater system, particularly when incorporating detention into the aggregate reservoir

Potential increase in retention capacity through penetration of shallow soil horizons that have a low permeability rate

Shallow and deep groundwater recharge and subsequent improved and sustained base flows to natural water bodies

Reduction of the total runoff volume and subsequent reduction of potential flooding and associated bank and shoreline erosion in areas where stormwater discharges into wetlands, streams, and lakes

Can be used to meet Kane County 0.75-inch retention standard

§ T1604(d) Limitations

Infiltration trenches are subject to clogging by high sediment loads (even with an amended soil filter) and, therefore, are not suitable for areas such as construction sites, agricultural sites, or plant nurseries. In short, infiltration trenches should not be used if the sediment load in upstream areas cannot be controlled.

Infiltration trenches are not suitable for manufacturing and industrial sites, automobile service facilities, and other land uses with potential for high concentrations of pollutants due to accidental or other releases, or for sites that may receive high levels of pesticides or pathogens.

To minimize the risk of pollution, the invert of the infiltration trench must have adequate separation from the seasonal high ground water table (see also Section § T1604(e)(2)).

Infiltration trenches require a minimum separation from private and public wells. It is recommended that the designer reference the private and public water supply standards to determine current standards. It is further recommended that infiltration trenches be located at least 10-feet down-slope and 100-feet up-slope from building foundations[4] unless the invert of the trench is below the footing elevation, adequate waterproofing is provided and direct drainage to footing drains can be prevented.

The contributing watershed to the infiltration trenches should not exceed 2-acres[5].

Infiltration devices should not be located adjacent to high and steep slopes where seepage could destabilize the slope.

Infiltration trenches should not be located on soil fill to avoid excessive settlement and loss of fill stability. However, the trench may be located on granular fill that will remain stable when saturated.

§ T1604(e) Required Design Data

§ T1604(e)(1) Soil type and permeability:

The infiltration capacity of the subsoils under the infiltration trench will determine the volume of runoff that can be exfiltrated into the ground over a given period of time. The infiltration capacity, along with the porosity of the open graded aggregate fill, the required drain time, and contributing watershed will determine the infiltration trench dimensions (see Section § T1604(f)(7)).

The Kane County Soil Survey provides some guidance with regard to soil permeability. In general terms, soils with a 30% or greater content of clay or 40% or greater content of silt and clay combined tend to have insufficient infiltration capacity[6]. Likewise, soils with an infiltration rate greater than 5-inches/hour or a combined silt/clay content less than 5% may not be suitable because of limited capacity to remove pollutants[7].

It is recommended that a hydraulic conductivity test be performed at the location and elevation of the proposed infiltration trench invert to establish the site-specific permeability rate (double ring infiltrometer test per ASTM D3385, lab test per ASTM D2434 through a Shelby tube sample, or have a Certified Professional Soil Classifier conduct an on-site soil investigation to determine soil suitability or a Falling Head Percolation Test (described in Appendix A). A minimum of two soil investigations should be performed per infiltration trench. If the trench is longer then 100-feet, one additional sampling for each 100-foot increment is recommended[8]. On sites with cohesive soils the lowest recorded infiltration rate should be used for the sizing and design[9]. On sites with varying soils (and varying hydraulic conductivity) the lowest recorded infiltration rate per soil type should be used. The data from the hydraulic conductivity test will allow for adequate sizing and design of the infiltration trench.

§ T1604(e)(2) Seasonal high water table:

The invert of the infiltration trench should be at least three-feet[10] to above the seasonal high water table to reduce the potential for shallow ground water contamination.

§ T1604(e)(3) Contributing drainage area:

It is recommended that the drainage area to the infiltration trench be limited to two acres[11] to protect the device from excess sediment loads and high flow rates at inflow points. A larger number of smaller devices is less likely to fail than a single facility treating a large area.

§ T1604(f) Infiltration Trench Design

Infiltration trenches should be combined with rain gardens and vegetated swales where these systems, by themselves, do not meet the 0.75-inch Kane County retention standard or where a higher degree of retention is desired.

Runoff to the rain gardens or vegetated swales passes through an amended top soil with high hydraulic conductivity into the top of the infiltration trench. This process improves the runoff quality entering the trench by removing suspended solids and pollutants from the runoff. When underlain with a geotextile it protects the infiltration trench from sediment accumulation and subsequent clogging (see also Section § T1604(f)(2)). The vegetated amended top soil must be designed to sustain its hydraulic conductivity over time[12]. It should generally conform to the following specifications to ensure adequate permeability (2- to 5-inches/hour) and growing conditions (see also Section § T1603(g)(3)):

70% medium to coarse sand (IDOT FA2)

8 to 10% organic content

less than 10% clay

compaction of 70% (modified) to 75% (standard) max. dry density

The following subsections describe the various key design elements.

§ T1604(f)(1) Site selection:

The infiltration trench must be located down gradient from the contributing drainage area. The placement must further allow for overflow of excess runoff with a suitable outfall. Areas that become unstable under saturated conditions, such as locations close to cut or fill slopes, are unsuitable for infiltration trenches. Furthermore, infiltration trenches shall not be placed over fill, but must exfiltrate into natural, undisturbed soils with adequate infiltration capacity.

Soils:

The first step in the design process is to determine the suitability of the soils and their hydraulic conductivity. It is not uncommon to find very low infiltration rates in the A-horizon (either because of the soil type or compaction), while soils in the underlying horizons offer a higher infiltration capacity. Part of the design process is to seek permeable soil horizons that allow the infiltration trench to drain within the specified time. The elevation of the permeable horizon partially determines the depth of the infiltration trench. Other factors are adequate separation from the seasonal high water table and the infiltration rate, which determines the volume that can be exfiltrated. The latter is further influenced by the surface area over which the exfiltration takes place – in other words – the surface area of the infiltration trench invert. As a general rule, the invert area of the trench must increase with lower permeability soils to achieve the retention standard without exceeding the allowable drain time. The trench invert should be flat to allow for uniform distribution and infiltration of the runoff.

Topography and access:

Infiltration trenches should not be located adjacent to steep slope where seepage could destabilize the slope. The placement of infiltration trenches should take into consideration the need for vehicular maintenance access.

Foundation protection:

Infiltration trenches should be placed at least 10-feet down-slope and 100-feet up-slope from building foundations[13] unless the invert of the trench is below the elevation of the foundation. Another rule that can be applied to protect building basements is to set back the infiltration trench 1.5 times the distance of the building foundation depth[14].

Groundwater protection:

To avoid contamination of shallow groundwater, infiltration trenches should not be applied on sites such as automobile service facilities and sites where there is potential for stormwater to come in contact with hazardous materials (see also Section § T1604(d)). The invert of the infiltration trench shall be at least 3-feet [15] above the seasonal high water table.

To protect public water supplies, infiltration trenches require a minimum separation of 100-feet from private wells[16] and 1,200-feet from public well[17].

§ T1604(f)(2) Permanent sedimentation control and protection:

Infiltration trench design requires provisions for sedimentation control to prevent failure through clogging. Any design that incorporates infiltration trenches must have an erosion and sedimentation control plan in place and the practices must be maintained. It is imperative that stormwater bypass the infiltration trench area during construction until the contributing watershed is fully stabilized.

If a temporary sedimentation pond is placed in the area of the planned infiltration trench, a minimum 12-inches separation between the bottom of the sedimentation pond and the final invert of the infiltration trench is necessary[18].

To protect the infiltration trench from clogging over its lifetime, there can be no direct discharge of runoff into the trench. Instead, the runoff must be filtered through vegetated amended top soil (see also Section § T1603).

§ T1604(f)(3) Infiltration trench drain time:

The duration of ponding within an infiltration trench should not exceed 72- hours to ensure that the volume is available for subsequent events and to avoid sealing of the subgrade soils due to growth of biological slimes. The duration that water will be contained within in the trench is approximately equal to the storm duration plus the drain time. (Drain time is equal to the time required to drain the trench from full assuming no inflows.) For a 24-hour storm duration, the drain time should be limited to 48-hours.

The maximum allowable drain time, along with the subgrade permeability will control the maximum depth of the infiltration trench. (see Section § T1604(f)(8) for more information on maximum depth and drain time.)

§ T1604(f)(4) Overflow and subsurface drainage design:

To assure safe bypass for excess runoff flows, infiltration trenches require an overflow.

Infiltration trenches in combination with vegetated swales or rain gardens may or may not require a subsurface drainage mechanism to dispose of excess water when the retention storage capacity is exceeded.

If the infiltration trench is combined with a vegetated swale and sized for the 0.75-inch retention standard only, no subsurface drain structure is needed. The trench can be allowed to fill up through the vegetated amended top soil, where excess runoff is drained through surface conveyance in the vegetated swale. If the infiltration trench is sized for both retention and detention, a perforated drain pipe must be placed above the retention volume elevation to provide drainage for the detention volume.

If the infiltration trench is combined with a rain garden and sized to drain the 0.75-inch retention standard within the required time frame, no subsurface drain structure is needed since the excess runoff can drain through the rain garden overflow. If the in infiltration trench is sized for both retention and detention, a perforated drain pipe must be placed above the retention volume elevation.

The outfall of any subsurface drainage system must be designed to prevent erosion, scour and concentrated flows.

A backflow prevention flap valve may be necessary to prevent sediment laden runoff from entering the system.[19]

§ T1604(f)(5) Observation wells and clean outs:

It is recommended that all infiltration trenches be outfitted with an observation well (four to six-inch perforated pipe with a cap on an anchor plate) located in the center of the trench.

Infiltration trenches with subsurface drainage structures (perforated pipes) should have a cleanout at each end, which can also be modified to serve as observation wells. Cleanouts should also be provided at each significant change in direction. Another function of the observation wells and cleanouts is to provide air vents while the trench fills with runoff[20].

§ T1604(f)(6) Materials:

The infiltration trench should be lined with a 6-inch sand layer (IDOT FA2) at the bottom[21]. The sand will act as a filter layer and prevent compaction of the trench invert during the aggregate fill placement. The bottom 2-inches of the sand should be vertically mixed 2-inches into the subgrade[22].

The aggregate fill shall consist of open graded IDOT CA1 or CA7, preferably washed to prevent the introduction of remaining fines. The porosity for these open graded aggregates is approximately 0.40. Rigid perforated pipes or storm chambers can be integrated into the infiltration trench to reduce the amount of gravel and increase the trench storage.

The vertical sides of the infiltration trench should be lined with a non-woven needle punch geotextile to prevent migration of the adjacent soils into the open graded aggregate. A separate piece of non-woven needle punched geotextile should be placed on top of the open graded aggregate fill as a filter and sediment barrier. It is further recommended to place a one-inch sand layer (IDOT FA2) on top of the geotextile, prior to the placement of the amended top soil. The sand layer will reduce the risk of "blinding" the geotextile and sustain the capacity to pass runoff into the infiltration trench[23].

§ T1604(f)(7) Infiltration trench sizing:

To meet the Kane County retention standards, infiltration trenches should be sized for 0.75-inches of runoff over the impervious area draining to the trench. Trenches may also be sized for larger events to increase retention and reduce downstream detention needs.

Trenches may also be used for detention where the retention volume is located below a perforated drain pipe and the detention volume is located above the drain. As with the retention-only trench, the total duration of ponding for both the retention and detention portions should not exceed 72-hours. The drain pipe can be fitted with a restrictor for controlled and slow release. The restrictor shall be located at a cleanout or manhole for easy maintenance access.

This combination of retention and detention volumes effectively decentralizes the stormwater management system and allows for downsizing of detention facilities downstream. Infiltration trench sizing is described further under Section § T1604(f)(8).

§ T1604(f)(8) Hydrologic analysis:

There are two components to the hydrologic analysis: the required size to meet the Kane County retention standard and the impact of the infiltration trench on downstream detention requirements.

Retention standard:

The Kane County retention standard states that 0.75-inches over the impervious area must be retained. To ensure that the retention standard is met for all storm durations, a one-hour design storm should be used to size the infiltration trench. Except on soils with very high permeability, the volume of water infiltrated during a 1-hour event will be small. Thus, the required runoff storage volume (Vr) is:

$$V_R = 0.75 * A_i * 0.083$$

Where:

V_R = retention storage volume in acre-feet

0.75 = retention volume standard in inches

0.083 = conversion from acre-inches to acre-feet

Because the infiltration trench is backfilled with gravel, the excavation volume must be increased to accommodate the storage lost to the aggregate material. Thus, the volume of the trench (Vt) must be:

$$V_t = \frac{V_r}{n}$$

Where:

V_t = volume of trench or excavation required to provide V_r

V_r = retention storage volume

n = the volume of the voids divided by the total volume of the aggregate material. For clean, open aggregate materials such as IDOT CA1 or CA7 the porosity is typically 0.40.

As described in Section § T1604(f)(3) the drain time for the infiltration trench should not exceed 48-hours and this limitation will determine the maximum depth of the infiltration trench. For example, if the infiltration capacity of the soils is 1-inch/hour and the porosity of the aggregate in the trench is 40%, the maximum depth would be 120-inches, if the infiltration capacity is 0.5-inches/hour, the maximum depth would be 60-inches.

Impact on downstream detention sizing:

The critical duration for detention sizing is typically 24-hours. Thus, the volume of runoff infiltrated within an infiltration trench during a 24-hour detention design storm will often be significant. For example, with a watershed to infiltration trench area ratio of 8:1 and soil permeability equal to 0.5-in/hr, a properly sized infiltration trench, designed according to these guidelines (volume equal to 0.75-inches/impervious acre) can reduce the runoff volume associated with the 2-year event by more than 50% and the runoff volume associated with the 100-year event by over 20%. For the same 8:1 drainage area ratio and 0.5-in/hr infiltration capacity, an infiltration trench sized to make full use of a 48-hour drain time, could eliminate surface runoff for the 2-year event and reduce the surface runoff volume associated with the 100-year event by over 60%.

In addition to the retention storage, detention can be included within the trench through use of a perforated drain pipe located above the retention volume. The outlet of the drain can be outfitted with an orifice(s) to control the rate of drainage and maximize utilization of the detention volume.

Infiltration trenches can be modeled as storage reservoirs in standard hydrologic models such as TR20 or HEC-1. The rate of infiltration Qi is equal to:

$$Q_i = i * A_t$$

Where:

Q_i = the volumetric flow rate through the infiltration trench subgrade in cubic feet per second (cfs)

i = infiltration capacity of subgrade soils in inches/hour

A_t = bottom area of the infiltration trench in acres

For models that allow multiple outlets, infiltration outflow can be treated as a separate outlet that does not contribute downstream. For models that only allow a single outlet, the total rain garden outflow is equal to the infiltration outflow plus the surface outflow through the perforated drain (if any). The infiltration outflow rate can then be diverted out of the system so that it does not contribute to the downstream detention facility.

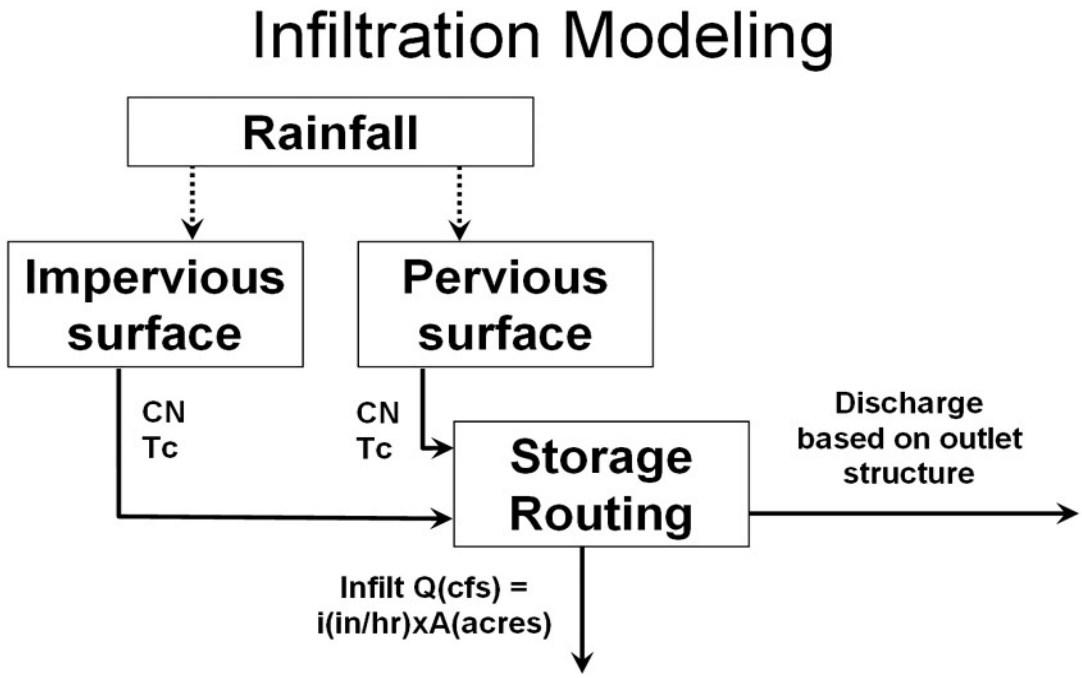

Figure 8 – Infiltration Trench Modeling Diagram

§ T1604(g) Construction considerations:

The area set aside for infiltration trenches should be protected with construction fencing during grading operations to protect it from construction traffic and compaction[24].

Sedimentation control:

Construction of the infiltration trench should not start until the all erosion and sedimentation control measures are in place or the contributing watershed is stabilized and/or runoff diverted from the infiltration trench site. It is imperative that stormwater bypass the infiltration trench area during construction until the contributing watershed is fully stabilized. Furthermore, the infiltration trench should not go into service until the entire contributing watershed is stabilized and the risk of erosion and sedimentation eliminated.

An excavated infiltration trench should never be used as a temporary sediment trap for construction site runoff[25]. If a temporary sedimentation pond is placed in the area of the planed infiltration trench prior to excavation, a minimum of 12-inches of undisturbed soil between the bottom of the sedimentation pond and the final invert of the infiltration trench are necessary[26].

Excavation:

To preserve the infiltration capacity of the infiltration trench, it is imperative that the invert is not compacted or smeared during the excavation process. Suitable excavation equipment is backhoes (with toothed buckets) or similar equipment that can be staged outside the infiltration trench area. Bulldozers or front end loaders are not suitable for infiltration trench excavation.

The excavated material should be placed 10-feet away and to the downstream side of the trench to prevent re-deposition during storm events[27]. Larger tree roots should be cut flush with the walls to protect the geotextile from puncturing and tearing during placement and filling of the infiltration trench.

Geotextile placement:

The vertical infiltration trench walls should be lined with a non-woven needle punch geotextile. The geotextile must be installed flush with the vertical trench walls. It is recommended to cut the geotextile to the appropriate dimensions prior to placement. Allow for six inch overlap at the top of the trench. The overlap between two ends should be at least two feet, where the upstream section must overlap the downstream section[28] (shingle effect). A separate precut geotextile should be placed horizontally over the aggregate prior to covering the infiltration trench with torpedo sand and amended top soil layers. The horizontally placed geotextile must be installed as an individual unit to allow for easy removal in case of remedial maintenance (see Figure 9 – Infiltration Trench Detail).

It is imperative that the geotextile is placed properly, with the indicated overlaps to prevent immediate and future sedimentation and subsequent clogging of the infiltration trench.

Filling of infiltration trench:

It is recommended to line with infiltration trench with a 6-inch torpedo sand layer (IDOT FA2) at the bottom[29]. The sand will act as a filter layer and reduce the risk of compaction of the trench invert during the aggregate fill placement. In case of a very broad trench, all sand must be placed ahead of the loader to prevent compaction and smearing of the trench invert. The first three inches of sand should be vertically mixed with the subgrade soils to a minimum depth of 2-inches prior to placing the remaining three inches.

As with the sand, the aggregate should be placed with a low ground pressure backhoe or front loader and the gravel should be placed ahead of the equipment to minimize compaction. The aggregate should be placed in lifts of 12-inches and compacted lightly with plate compactor.

All aggregate must be kept clean and uncontaminated at all times. Materials contaminated with soil, silt, or sediments must be removed and replaced.

§ T1604(h) Operation and Maintenance

Once the infiltration trench is online, it should be inspected several times after rain events to assure proper functioning and drain times. Routine maintenance inspections should be conducted on an annual basis[30], preferably after a significant rain event. The observation well should be inspected for proper drainage and the surface should be inspected for sediment accumulation, vegetation health, and proper drainage through the amended top soil.

If the subsurface trench is continuing to hold water long after the design drain time, the trench bottom has likely become clogged with sediments. Provided that the trench was properly installed and protected from construction site runoff, this is a very unlikely scenario. However, if clogging occurs the infiltration trench will need to be reconstructed to remove the sediments and restore the exfiltration capacity.

If water is ponding for extended periods on top of the amended topsoil (but not within the subsurface trench), there two are likely causes:

If water is found ponding on top of the amended top soil, whereas the bottom of the amended top soil does not seem as saturated (as determined with a soil probe), it is likely that sediment accumulation on top of the amended top soil has clogged the soil. Removal of the sediments and replacement of the top inch of the amended top soil may suffice to restore the infiltration rate.

If water is ponded and the amended topsoil is saturated throughout its profile (as determined using a soil probe), it is likely that the geotextile on top of the infiltration trench is clogged. This will require replacement of the geotextile and reapplication of the amended top soil and vegetation. The placement of a one-inch torpedo sand layer (IDOT FA2) on top of the geotextile, prior to the placement of the amended top soil will reduce the risk of blinding the geotextile and sustain its capacity to pass runoff through to the infiltration trench[31].

For vegetation maintenance refer to (Section § T1603(h).

§ T1604(i) Infiltration Trench Easement

The Kane County Stormwater Management Ordinance requires that stormwater features (such as infiltration trenches) be protected by an easement. Thus, all infiltration trenches that are part of the submitted and approved stormwater management system are required to be in an easement. If infiltration trenches are not part of the stormwater management system, such as a trench installed by a homeowner on his or her own accord, it is exempt from the easement requirement.

§ T1604(j) Infiltration Trench Specifications

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the installation of infiltration trench materials.

1.2 RELATED SECTIONS

A. Section [_____ - ______]: Open-graded base materials.

B. Section [_____ - ______]: Drainage pipes and appurtenances.

C. Section [_____ - ______]: Earthworks/excavation/soil compaction.

D. Section [_____ - ______]: Rain Garden.

1.3 RELATED DOCUMENTS

A. ASTM C 136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

B. ASTM D 2239 Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

C. ASTM D 3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method.

D. ASTM D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

E. ASTM D 4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

F. ASTM D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

G. ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.

H. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

1.4 SUBMITTALS

A. Product Data: For Geotextile.

B. Sieve Analyses: For sand and open graded aggregate according to ASTM C 136.

C. Samples for Verification:

1. Four by four-inch sample of geotextile

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

B. Geotextiles labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

C. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants.

D. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geotextile.

PART 2 – PRODUCTS

2.1 AGGREGATES

A. Coarse sand: Illinois Department of Transportation Standard Specifications for Road and Bridge Construction (latest edition), Section 1003.01 (c) FA-2.

B. Open graded aggregate: Illinois Department of Transportation Standard Specifications for Road and Bridge Construction (latest edition), Section 1004.01 (c) CA-7.

2.2 NON-WOVEN NEEDLE PUNCHED GEOTEXTILE

A. Mechanical properties:

1. Grab Tensile Strength (ASTM D 4632)

a. Strength at ultimate (lbs) 205

b. Elongation at ultimate (%) 50

2. Mullen Burst Strength (ASTM D 3786) (psi) 380

3. Trapezoidal Tear Strength (ASTM D 4833) (lbs) 80

4. Puncture Strength (ASTM D4833) (lbs) 130

5. UV Resistance after 500 hrs. (ASTM D 4355) (%) 70

B. Hydraulic properties:

1. Apparent Opening Size (ASTM D 4751) (US sieve #) 80

2. Permittivity (ASTM D 4491) (sec-1) 1.2

3. Flow Rate (ASTM D 4491) (gal/min/ft2) 95

C. Selected non-woven needle punched Geotextile shall be approved by Engineer or Construction Manager.

2.3 PIPES

A. Perforated HDPE distribution pipes shall conform to ASTM D 2239. The perforated pipe should have ½ inch slot openings, 6 inches center to center, along two to three longitudinal rows.

2.4 CLEAN OUTS

A. The clean out/observation well is to consist of 6-inch diameter rigid HDPE pipe and conform to ASTM D 2239. A rigid perforated 6-inch diameter HDPE pipe that conforms to ASTM D 2239PVC shall be provided and placed vertically within the gravel portion of the infiltration trench.

PART 3 – EXECUTION

3.1 INSTALLATION, GENERAL

A. The infiltration trench systems may not receive run-off until the entire contributing drainage area to the infiltration system has received final stabilization.

B. Heavy equipment and traffic shall be restricted from traveling over the location of the infiltration trench to minimize compaction of the soil.

3.2 EXCAVATION

A. Excavate the infiltration trench to the design dimensions and elevations. Excavated materials shall be located a minimum 10-feet away and to the downstream side of the trench to prevent re-deposition of excavated soils during storm events and to enhance trench wall stability. Large tree roots shall be trimmed flush with the trench sides in order to prevent fabric puncturing or tearing of the filter fabric during subsequent installation procedures. The side walls of the trench shall be roughened where smeared and sealed during excavation.

3.3 COARSE SAND PLACEMENT

A. Place 6-inch sand filter layer (IDOT FA-2) at the bottom of the infiltration trench.

B. First 3-inches of sand shall be vertically mixed with the subgrade soils to a minimum depth of 2-inches prior to placing the remaining 3-inches.

3.4 GEOTEXTILE PLACEMENT

A. The width of the geotextile must include sufficient material to conform to trench perimeter irregularities and for a 6-inch minimum top overlap. The filter fabric shall reach to the sand layer on the bottom of the infiltration trench. Stones or other anchoring objects should be placed on the fabric at the edge of the trench to keep the fabric in place during construction. When overlaps are required between rolls, the uphill roll shall lap a minimum of 2-feet over the downhill roll in order to provide a shingled effect.

B. Following the stone aggregate placement, the filter fabric shall be folded over the stone aggregate to form a 6-inch minimum longitudinal lap.

C. A separate precut geotextile shall be placed horizontally over the aggregate prior to covering the infiltration trench with sand and amended top soil layers. The horizontally placed geotextile shall be installed as an individual unit to allow for easy removal in case of remedial maintenance.

3.5 PIPES

A. Perforated pipe shall be provided as indicated in the drawings and shall terminate 1-foot short of the infiltration trench end wall. Free ends of perforated pipe, where no clean-outs are specified, shall be capped.

3.6 CLEAN OUTS

A. The clean out/observation well shall be fitted with a cap set 6-inches above ground level and located near the lateral center of the infiltration trench as indicated in the drawings. The pipe shall have a plastic collar or ribs to prevent lifting when removing cap. The screw top lid of the cleanout/observation well shall be fitted with a locking mechanism or special bolt to discourage vandalism. The cap shall be open or closed as indicated on the drawings. The pipe shall have a cap at the bottom of the pipe. The bottom of the cap shall rest on the infiltration trench bottom.

3.7 AGGREGATE PLACEMENT

A. The stone aggregate (IDOT CA-7) shall be placed in lifts and lightly compacted using plate compactors. The maximum loose lift thickness is 12-inches.

B. All aggregates must be kept clean and uncontaminated at all times. All contaminated aggregates shall be removed and replaced with uncontaminated aggregates (IDOT CA-7).

END OF SECTION

§ T1604(k) Typical Detail

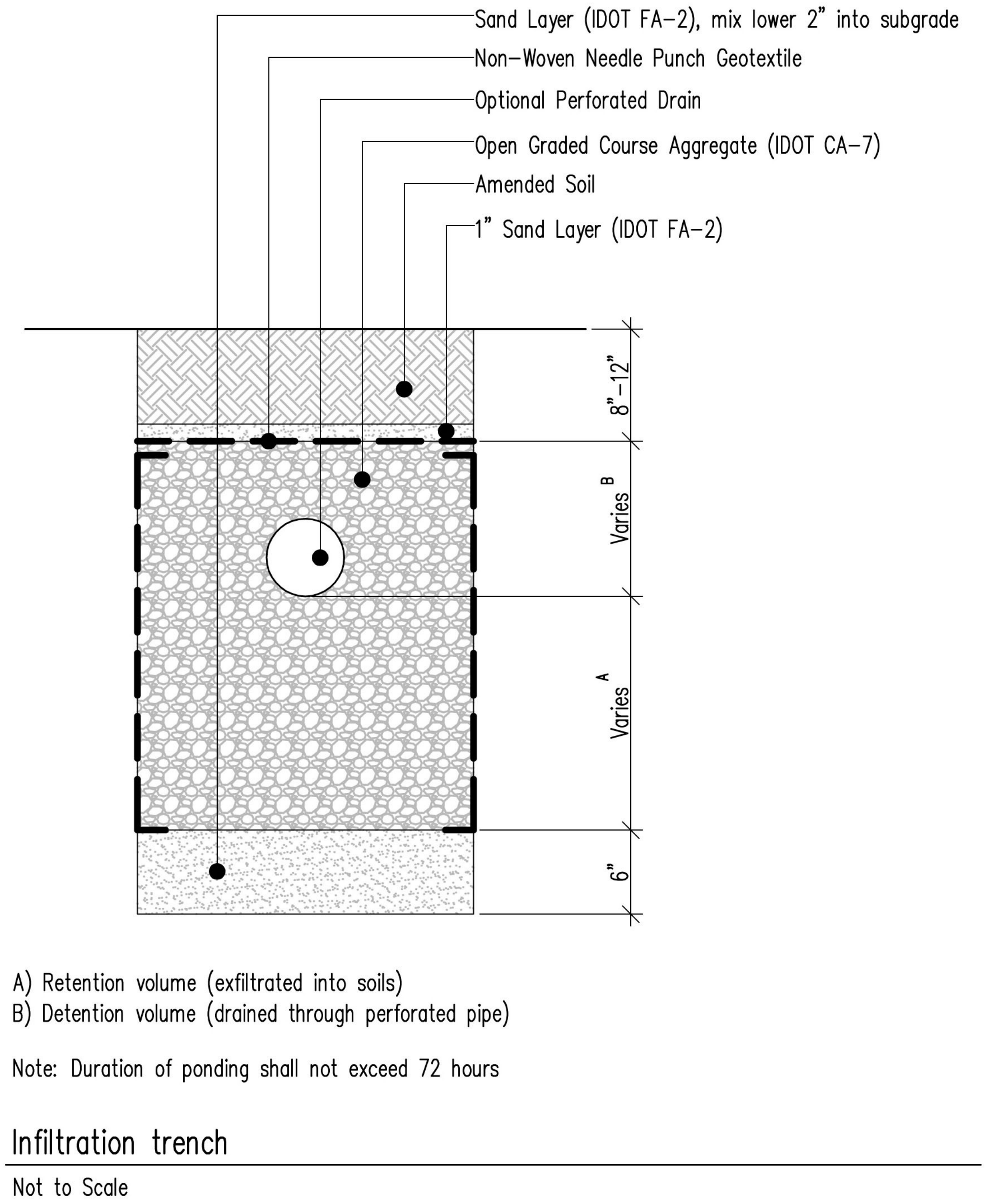

Figure 9 – Infiltration Trench Detail

[1] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); MA Department of Environmental Protection (1997); Lowndes (2000); Los Angeles County Department of Public Works (2002)
[2] Schueler (1987); Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); Schueler *et al.* (1992)
[3] Schueler (1987)
[4] Schueler (1987); Lowndes (2000)
[5] WDNR (2004b)
[6] MA Department of Environmental Protection (1997); Lowndes (2000)
[7] Lowndes, M.A. (2000)
[8] WDNR (2004a)
[9] MA Department of Environmental Protection (1997)
[10] Schueler (1987); Horner et al. (1994); EPA (1998); Barr Engineering Company (2001)
[11] WDNR (2004b)
[12] Mahabadi (2001)
[13] Schueler (1987); Lowndes (2000)
[14] Mahabadi (2001)
[15] Schueler (1987); Horner et al. (1994); EPA (1998); Barr Engineering Company (2001)
[16] Schueler (1987); Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); Lowndes (2000)
[17] Lowndes, M.A. (2000)
[18] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992)
[19] Mahabadi (2001)
[20] Mahabadi (2001)
[21] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); MA Department of Environmental Protection (1997); Los Angeles County Department of Public Works (2002); WDNR (2004b)
[22] WDNR (2004b)
[23] Mahabadi (2001)
[24] MA Department of Environmental Protection (1997)
[25] MA Department of Environmental Protection (1997)
[26] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992)
[27] Lowndes (2000)
[28] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992)
[29] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); MA Department of Environmental Protection (1997); Los Angeles County Department of Public Works (2002)
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Wisconsin Department of Natural Resources (2004b), Bioretention for Infiltration, Conservation Practice Standard, (1004) 10/04.

§ T1605 Level Spreader and Filter Strips

§ T1605(a) Definition

Level spreaders and filter strips represent two separate BMP's that have been combined for more effective stormwater management treatment. The effectiveness of filter strips alone in urban applications is often compromised by concentration of runoff that causes erosion. This problem can be resolved through use of a level spreader that directs runoff evenly over the filter strip[1]. Level spreaders and filter strips can also be combined with other BMP's. They can, for instance, receive discharge from rain gardens, porous pavement areas, and naturalized detention for further treatment, infiltration, and de-concentration of flow.

Level spreader:

A level spreader is a device used to dissipate concentrated runoff into uniform surface sheet flow. The concentrated runoff may be received through subsurface structures (such as perforated pipes) or surface structures (such as parking lot curb cuts). The conversion of concentrated flow into sheet flow greatly reduces the risk of erosion and scouring and creates conditions for proper filter strip function. The uniform sheet flow from the level spreader is released to an adjacent filter strip on the downstream side.

Filter strip:

The filter strip receives evenly distributed overland sheet flow, typically from either a level spreader or a level pavement edge. The filter strip is sloped such that the overland runoff drains slowly, providing an opportunity for runoff treatment (pollutant removal) and infiltration (surface ground water recharge)[2]. Preferably, filter strips are vegetated with native prairie grasses and forbs that will improve the water quality and infiltration performance of the strip. However, filter strips can be vegetated with turf and still provide a benefit. (Where filter strips are used to offset hydraulically impervious area for the Kane County ordinance, they must be vegetated with native species.)

§ T1605(b) Suitable Applications

Filter strips can be applied to a variety of urban land uses. They are particularly well suited for residential developments[3] and campus type commercial and industrial developments. Since these developments usually have large expanses of areas that can readily be planted with native vegetation and used to accept runoff from impervious surfaces or other BMP's. The strips can easily be incorporated into the site layout and landscape designs. However, smaller filter strips can also be used to treat runoff from almost any parking lot.[4]

Vegetated filter strips function best on gradual slopes, ideally less than 5%. Slopes steeper than 15% should be avoided[5]. Only smaller drainage areas (e.g. roadway pavement draining across a vegetated embankment) should be connected to filter strips with slopes of 5% to 15% to prevent erosion and scour of the filter strip.

Urban stormwater systems often produce concentrated discharges that require a level spreader to disperse flows to the filter strip[6]. The level spreader can be applied as a flow interceptor device at small culverts or other surface discharges to redistribute the flow. Another application is within a filter strip (mid slope) where re-concentrated runoff can be intercepted and redistributed (see also Section § T1605(g) and Section § T1605(g)(3)).

In other applications, concentrated runoff is discharged to a perforated distribution pipe within the level spreader trench. The perforated pipe distributes the runoff over the length of the level spreader and the flow wells up out of the trench over the length of the spreader. In many cases, impervious surfaces, such as small parking lots and roads that produce unconcentrated sheet flow can drain directly onto the filter strip with no level spreader.[7]

§ T1605(c) Benefits

In addition to dissipating energy and distributing the runoff, level spreaders provide cooling of the first flush runoff from high temperature paved or roof surfaces. Filter strips also help to reduce runoff temperature[8] prior to the introduction of excess runoff into local waterways.

The uniform sheet flow of level spreaders and filter strips can provide effective infiltration and filtration. Filter strips with native vegetation serve as effective buffers between developments and sensitive features such as streams, lakes, and wetlands[9].

Level spreaders and filter strips can reduce both the rate and volume of stormwater runoff on a site. In addition to dispersing concentrated flows, level spreaders can also serve as infiltration trenches (without the vegetated cover), if sized accordingly. The majority of smaller rain events are exfiltrated through the bottom of the trench, whereas larger flows are discharged as sheet flow onto the filter strip. However, it should be recognized that the infiltration performance of level spreaders may be lost over time due to the lack of sediment filtration prior to introducing runoff into the trench.

Filter strips provide a level of rate control by increasing the length of flow paths and reducing the velocity to the primary drainage system[10]. This can reduce runoff volumes by providing greater opportunity for infiltration of runoff into the soil[11]. Well maintained filter strips can be very effective in reducing runoff volumes, particularly when the impervious drainage area is less than two to three times the filter strip area[12]. NIPC[13] found that annual storm runoff volumes could be reduced by up to 40 to 45% with conservatively designed and maintained filter strips.[14]

Filter strips can be used to meet the 0.75-inch Kane County retention standard since hydraulically connected impervious surfaces can be reduced by the area of filter strips planted with native vegetation.

Level spreaders, and even more so filter strips, are low cost BMP's. Filter strips further provide cost savings through ease of maintenance compared to other conventional landscape treatments such as turf grass.

§ T1605(d) Limitations

Impervious areas connected to the filter strip should be no more than two or three times the filter strip area to assure runoff filtering and volume reduction unless the flow rates are controlled upstream of the filter. The length of the imperious area (parallel to the flow) should not exceed 200-feet[15].

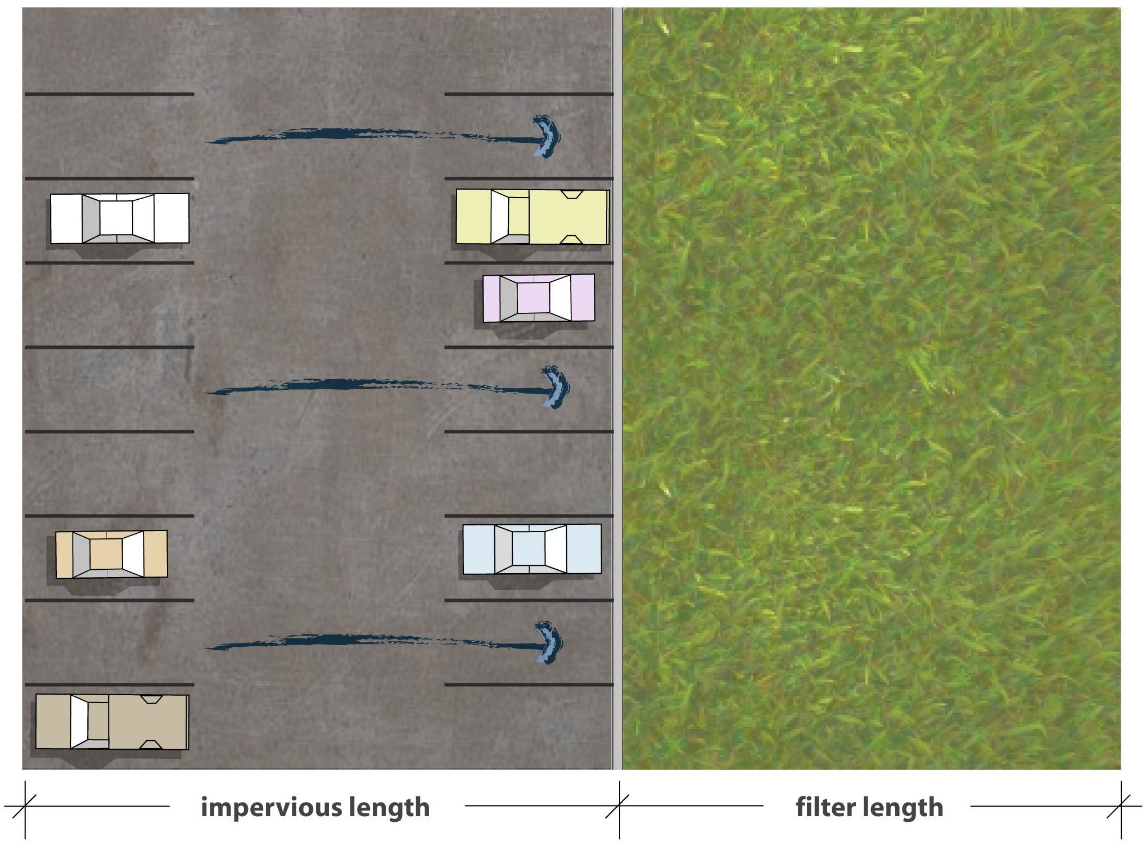


Figure 10 – Filter strip schematic

Filter strips should be located such that they do not conflict with the project site programming and are protected from heavy foot or any vehicular traffic. This will protect the native vegetation and prevents soil compaction[16].

Filter strips are not suitable for hilly or highly paved areas because of high runoff velocities[17]. Some topographic challenges, however, may be resolved with frequent level spreader placement within the filter strip to intercept re-concentrated flows. The area considered for the filter strip application must be free of gullies and rills[18].

Areas considered for a filter strip application that will be subject to applications of fertilizers and pesticides are not suitable as filter strips[19].

Level spreaders and filter strips may not be economically suitable for dense developments with high land values due to the limited availability of space for the filter strip.

§ T1605(e) Required Design Data

The ultimate design objective is to maintain evenly distributed sheet flow and very low runoff velocities. Design parameters are the length and slope of the filter, surface area and nature of the drainage area, existing soil types, type of planned vegetation cover, and runoff velocity[20]. The following data should be collected to inform the design process:

Character, geometry, and size of the impervious area tributary to the level spreader and filter strip.

Topographic information, including slopes, for the planned filter strip area.

Soil type information, from county soil survey to assess erosion risk and type composition of native vegetation mix.

§ T1605(f) Level Spreader Design

Level spreaders are similar to infiltration trenches (see also Section § T1604). Typical differences include the trench size (level spreaders tend to be smaller) and the trench cover. Level spreaders are not covered with a vegetated amended top soil, but rather with an open graded aggregate (IDOT CA 7).

The primary performance objective of level spreaders is to convert concentrated flows into uniform overland sheet flows. They may further provide nominal retention through runoff exfiltration through the trench bottom.

Level spreader function can, however, be combined with infiltration trench function and sized for retention. With this combination, only excess runoff that exceeds the capacity of the infiltration/level spreader trench is released into the adjacent filter strip. For infiltration trench details refer to Section § T1604(k). It should be recognized that since level spreaders are not protected from sediment by a topsoil filter as recommended in Section § T1604(f), they will be more prone to subgrade clogging and the infiltration benefit of the level spreader will be reduced over time.

The minimum depth of the level spreader should be 6-inches[21] when there is no distribution pipe, and the minimum width should be 6- to 12-inches or greater. The level spreader will need to be deeper and wider when it includes a distribution pipe. The bottom of the level spreader trench should be lined with 2- to 4-inches of torpedo sand (IDOT FA 2) vertically mixed into the subgrade. The vertical infiltration trench walls should be lined with a non-woven needle punch geotextile to prevent migration of the adjacent soils into the open graded aggregate. The overlap between two ends of the fabric should be at least two feet (shingle effect). The level spreader is filled to 2-inches inches above the surrounding grade and the gravel should extend minimum 6-inches downstream of the trench to protect the downstream lip of the trench from erosion. The trench should be filled with open graded, preferably washed, aggregated (IDOT CA7). A separate piece of non-woven needle punched geotextile should be placed near the top of the open graded aggregate fill but below the top of the trench as a filter and sediment barrier. This piece can be removed and replaced as part of remedial maintenance if necessary. The remaining depth of the level spreader is filled with the same aggregate (IDOT CA7) as in the lower trench portion.

Runoff can be conveyed into the level spreader through surface flow, or a perforated distribution pipe.

§ T1605(f)(1) Level spreader surface inflow design:

Parking lots without curbs or with curb cuts and small culverts (see also Section § T1605(b)) are examples of surface discharge option into a level spreader. Parking lots with a level edge and flush curb should not need a level spreader. The surface flow runoff into the level spreader should be free of sediments to prevent clogging of the trench and premature failure. Another surface inflow application is within a filter strip (mid-slope) where re-concentrated runoff is intercepted and redistributed.

§ T1605(f)(2) Level spreader subsurface inflow design:

Runoff is conveyed to the level spreader through a stormwater sewer pipe that connects to a standard perforated pipe or slot drain in the level spreader. A standard perforated pipe allows runoff to uniformly fill the level spreader trench and overflow at the downstream edge onto the filter strip. A slot drain will drain water out of the slot. The base of the slot drain should be perforated to allow drainage between events. The discharge to the level spreader should be free of sediments to prevent clogging of the trench and premature failure.

It is essential that the level spreader be surveyed level. If a slot drain is used, the rim of the slot that must be level. If a slot drain is not used, the downstream lip of the level spreader trench and the low gravel mound must be level. If grades are such that the full length of the spreader cannot be installed on the same contour, the spreader should be broken into multiple reaches with each reach located on its own contour.

The first pipe reach of level spreader pipe from the inflow pipe (minimum of five pipe diameters or five feet, whichever is less) should be solid pipe with no slot drain. This is necessary to prevent excessive surface discharge at an elbow or tee where there may be significant head loss associated with the change in direction in flow.

Slot drains or perforated pipes within the level spreader should include cleanouts at the ends and at significant changes in direction to allow for maintenance. Cleanouts may also be required at intermediate points for long level spreader lengths. The cleanout covers should be located at a higher elevation than the rim of the level spreader such that hydraulic head will not lift the cap.

§ T1605(f)(3) Level spreader discharge:

The pipe within the level spreader (slot drain or standard perforated pipe) should be sized for less than 0.1-foot of head loss from the inflow to the end of the pipe under the design flow. If there is greater head loss, the runoff will discharge from less than the full length of the level spreader. Level spreaders should not be constructed on a slope to compensate for a smaller pipe as this will cause most of the flow to discharge at the far end of the spreader during events less than the design event.

The allowable flow rate per foot of level spreader is determined by the downstream slope, the allowable flow velocity on the slope, and the allowable depth of flow on the slope. The flow should not exceed 1-inch[22] in depth during the design event under full vegetative cover, which translates roughly into 0.01 to 0.02 cfs per linear foot of level spreader, depending on slope. Also, to prevent scour, the velocity should not exceed the allowable velocity for the soil type, vegetation, and slope, assuming dormant season vegetative cover.

§ T1605(g) Filter Strip Design

The most important design factors for a filter strip are the drainage area tributary to the filter strip, width, length, and slope of the filter, and the permeability of the soils. Filter strips should be designed to promote shallow, slow velocity, sheet flow (see also Section § T1605(f) and Section § T1605(h)) through the filter to allow for settling and infiltration. The health and density of the vegetation will also significantly affect the in-situ performance of the filter strip[23].

During growing season storm events, velocities across the strip will be very low which will promote settling and infiltration. However, during the dormant season, when vegetative cover may be less dense and lower height, velocities may be greater but must not exceed the maximum permissible velocity for the soil and vegetation being used on the filter strip (see also Section § T1605(f)(3), Section § T1605(h), and Table 7)[24].

If at least temporary vegetative cover cannot be established prior to discharge of runoff to the level spreader, erosion control blanket should be applied over the area of the filter strip.

Longitudinal slopes up to 5% are ideal for level spreaders. Such slopes reduce the risk of re-concentrating flows and erosion and gully formation[25]. Slopes of 5% to maximum 15% may be acceptable for shorter flow lengths. Flow lengths can be reduced through placement of additional level spreaders within the filter strip.

§ T1605(g)(1) Vegetation:

Native prairie grasses, sedges, and forbs that achieve a good, dense stand at the soil interface are preferred over turf grass and should be the first choice for vegetate filter strips. Prairie vegetation has the distinct advantage of a deep fibrous root system that can significantly enhance infiltration[26]. Native vegetation further reduces maintenance needs compared to turf vegetation and eliminates the introduction of pollutants through turf pesticides and fertilizers.

Furthermore, when the drainage area is relatively large, slopes flatter than 2% could lead to periods of prolonged inundation and difficulty in maintaining healthy turf[27]. Slope concerns are less critical for filter strips planted with prairie vegetation tolerant to temporarily saturated soil conditions[28].

The filter strip vegetation should be fully stabilized with cover crop and erosion blanket before the contributing impervious surface is created and its runoff directed onto the filter strip[29].

For further information on vegetation design, refer to Section § T1603 and the Species Guide in Appendix B.

§ T1605(g)(2) Filter strip area:

Under the Kane County Stormwater Ordinance, filter strips can be used to reduce the hydraulically connected impervious area that must meet the 0.75-inch retention standard. To eliminate the need for the 0.75-inch retention volume, the area of the filter strip must equal the area of impervious cover tributary to it. However, filter strips with less area can still be effective in removing sediments and other pollutants and reducing annual runoff volumes. Filter strips whose area is 50% or more of the tributary impervious area, should remove up to 80% of the total suspended solids load and reduce annual runoff volumes by 40% to 45%[30].

§ T1605(g)(3) Filter strip length:

The required filter strip area and the limitations on flow rates (see Section § T1605(h)) will generally determine the length of the filter strip. However, the maximum length of the filter will be determined by the length over which sheet flow can be maintained. Level spreaders should be installed every 50-feet of filter strip length on slopes greater than 5% and every 100-feet of filter strip length on slopes 5% or less[31]. Filter strips exceeding 100- to 150-feet without any flow interception and redistribution should be avoided to prevent concentration of flow that naturally occurs as the length of flow increases[32].

§ T1605(h) Hydraulic and Hydrologic Analysis

Depth of flow:

The depth of flow within filter strips should not exceed approximately one inch under full vegetative cover to prevent re-concentration of flow and submergence of the vegetation, which will lead to reduced filter strip effectiveness. The depth of flow within the filter strip will depend on the slope, vegetation, and discharge rate within the filter strip. Because flow depths will be very shallow, retardance should be used to determine the appropriate n-value (see also Table 6 and Figure 11). For shallow flow, under native vegetative cover, retardance A or B should be used, which translates into an n-value of 0.30 or higher for determining the depth of flow.

Level spreader pipe size:

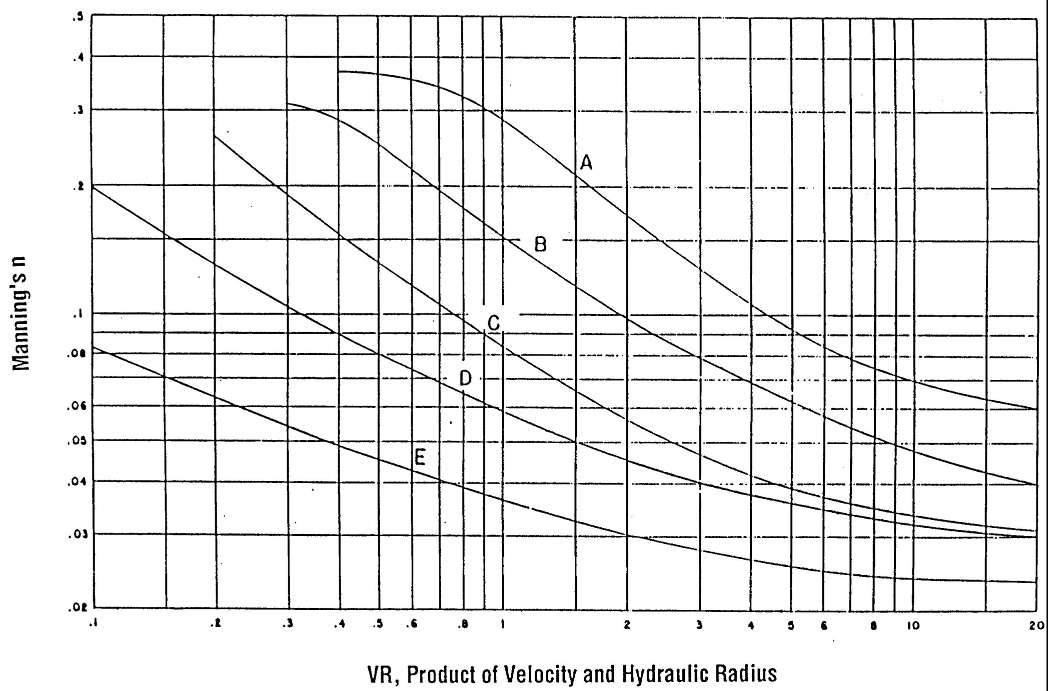
The perforated pipe located within the level spreaders is intended to distribute the inflow over the length of the level spreader, ensuring uniform discharge over the length of the level spreader. The perforated pipe must be adequately sized such that the head loss from the upstream to the downstream end of the pipe is less than 0.1-feet to avoid concentration of flow at the upstream end.

Growing Season Retardance Factors for Vegetated Swales[1]		
Retardance	Cover	Conditions
A Very High	Cattail Smooth Brome River Bulrush Hard-stem Bulrush	Excellent stand, tall Excellent stand, tall (avg. 30") Excellent stand, tall Excellent stand, tall
B High	Smooth Brome Tall Fescue Alfalfa Native grasses	Good stand, mowed (avg. 12–15") Good stand, unmowed (avg. 18") Good stand, uncut (avg. 15") Good stand, unmowed
C Moderate	Kentucky Blue Grass Red Fescue Redtop Smooth Brome	Good stand, headed (12–18") Good stand, headed (12–18") Good stand, headed (15–20") Good stand, mowed (6–8")
D Low	Kentucky Blue Grass Red Fescue Redtop Smooth Brome	Good stand, mowed (3–4") Good stand, mowed (3–4") Good stand, mowed (3–4") Good stand, mowed (3–4")
E Very Low	Kentucky Blue Grass	Good stand, cut (2" or less)
[1] For turf and other low growing grasses, a dormant season retardance factor one less than the growing season factor should be used. For native vegetation and other tall growing vegetation mowed or burned in the fall, a dormant season factor two less than the growing season factor should be used. Adapted from Natural Resource Conservation Service (NRCS)		

Table 6 – Growing Season Retardance Factors for Vegetated Swales

Figure 5.1.6

Manning's "n" Related to Velocity, Hydraulic Radius, and Vegetal Retardance



Source: USDA, SCS-FL

5.1 Vegetated Swales
Page 15

Figure 11 – Manning's "n" Related to Velocity, Hydraulic Radius, and Vegetal Retardance

<u>Maximum permissible velocity:</u>

To avoid scour within the filter strip, the velocity should not exceed the maximum permissible velocity for the slope, vegetation, and soils of the filter strip (see Table 7). For native landscapes, the dormant season, after burn management has occurred, will be the conditions under which retardance will be lowest and the potential for exceeding permissible velocities will be the greatest. Under these conditions, retardance E should be used, which translates into a Manning's n value of 0.08 to 0.10 for shallow flow.

Permissible Velocities for Channels Lined with Vegetation[1]		
Channel Slope[2]	Lining	Permissible Velocity (ft/sec)[3]
0 to 5%	Tall Fescue Kentucky Blue Grass Smooth Brome	4
	Grass-legume mixture Native grass mixture	3
	Red Fescue Redtop	2.5
	Small grains[4]	2
5 to 10%	Tall Fescue	4
	Kentucky Blue Grass Smooth Brome	3
	Grass-legume mixture Native grass mixture	2.5
Greater than 10%	Tall Fescue Kentucky Blue Grass Smooth Brome	2.5

[1] Use velocities exceeding 4 to 5 ft/s only where good cover and proper maintenance can be assured.
[2] Slopes greater than 10% should be avoided unless it is for a short distance or the flow rate is low.
[3] Cohesive (clayey) fine-grained soils and course grained soils with cohesive fines and a plasticity index of 10 to 40 (CL, CH, SC, and GC) are erosion resistant. Soils that do not meet this criteria should be considered easily erodible.
[4] For temporary seedings.
Source: IL Natural Resource Conservation Service (NRCS)

Table 7 – Permissible Velocities for Channels Lined with Vegetation

Maximum flow rate:

The maximum flow rate will typically be determined by the allowable maximum depth, slope, and vegetation of the filter strip. However, under some conditions, maximum permissible velocity may control. For native vegetation cover with a Manning's n of 0.30 and an allowable flow depth of one inch, the flow rate would be 0.01 to 0.02 cfs/foot of level spreader, depending on filter strip slope.

Impact on downstream detention sizing:

Filter strips can be used to meet the 0.75-inch Kane County retention standard since hydraulically connected impervious surfaces can be reduced by the area of filter strips planted with native vegetation (see also Section § T 203(g) and Figure 8, and Kane County Stormwater Ordinance Section § 203(g)(2).

Because filter strips contain no storage and runoff spends relatively little time on the filter strip, the runoff volume reduction for the 100-year detention design storm may be relatively small. However, the increase in time of concentration due to the low velocity may serve to reduce detention requirements to some degree.

Typically, the combined impervious and filter strip area would be represented by a composite curve number and a relatively long time of concentration based on the travel time through the filter strip.

A filter strip can also be modeled as a storage reservoir. In this case, the total tributary area, including the area of the filter strip itself would discharge to the "reservoir". The surface discharge-elevation rating curve for the reservoir would be determined by slope, roughness, and width of the filter strip. The volume-elevation rating curve for the reservoir would be based on the area of the filter strip (length and width) and depth of flow. The subsurface (infiltration) discharge from the "reservoir" would be based on the saturated hydraulic conductivity of the filter strip soils. Only the surface discharge would be routed to the downstream detention basin. Also see Section § T1604(f)(8) for a discussion of modeling infiltration practices.

§ T1605(i) Construction Considerations

Sediment laden construction site runoff should not be discharged to the level spreader as it will clog the gravel trench and cause premature failure. For additional construction considerations on level spreader trenches, refer to Section § T1604(g).

Areas where level spreaders and filter strips are to be located should be protected from construction traffic using construction fencing or other barriers to prevent compaction. Maintenance of the soil permeability will both protect the infiltration potential and facilitate the establishment and maintenance of a dense, deep-rooted vegetative cover[33].

Filter strips should be cleared of stumps, brush, rocks and similar obstacles that may lead to runoff flow concentration. Machinery used to work on the filter strip and level spreaders should be low ground pressure equipment.

Vegetation must be established on the filter strip as soon as possible to prevent erosion and scour. Filter strips should be graded and vegetated early in the construction schedule, preferably before paving increases the rate of runoff. If the latter is impossible, runoff from the hydraulically connected area must bypass the level spreader and filter strip until they are fully stabilized with cover crop and erosion blanket.

§ T1605(j) Operation and Maintenance

Proper maintenance of the filter strip to prevent loss of vegetation and erosion of the strip may be as important as the initial design. Vegetation should be inspected and replaced as necessary during the first year after construction[34].

Filter strips and level spreaders should further be inspected for proper distribution of flows and signs of rilling and other erosion during and after major storm events, particularly during the first one or two years. After the first one or two years, the strip and spreader may be inspected annually. If erosion is discovered, the eroded areas should be filled, reseeded, and mulched. Then the causes for the erosion should be determined and prevented from recurring[35].

After sufficient graminoid (grasses and sedges) development to provide an adequate fuel source on the filter strip with native prairie vegetation, annual burn management should be implemented. Burning dead plant material reduces weed growth, stimulates native grass and forb growth, and increases nutrients available to the plants. On filter strips where burning is difficult or impossible, the vegetation should be mowed annually in fall or spring. To mimic the burn cycle all clippings and thatch must be removed after mowing. If the filter strip is mown, low ground pressure equipment should be used to prevent compaction. Mowing should not be conducted under saturated soil conditions to prevent rutting. Note that mowing does not provide the full benefit to native prairie vegetation that fire provides and will often result in a lower ratio of wildflowers (forbs) relative to the grasses.

For further operation and maintenance guidance refer to Section § T1603(h) and the Species Guide in Appendix B.

§ T1605(k) Easement

The Kane County Stormwater Ordinance requires that stormwater features (such as level spreaders and filter strips) be protected by an easement. All level spreader and filter strip areas that are part of the submitted and approved stormwater management system thus are required to be in an easement. If level spreaders and filter strips are not part of the permitted stormwater management system, such as those installed by a homeowner on his or her own accord, they are exempt from the easement requirement.

§ T1605(l) Specifications

PART 1 – GENERAL

1.1 SUMMARY

A. This section includes the installation of level spreader materials.

1.2 RELATED SECTIONS

A. Section [_____ - ______]: Open-graded base materials.

B. Section [_____ - ______]: Drainage pipes and appurtenances.

C. Section [_____ - ______]: Earthworks/excavation/soil compaction.

D. Section [_____ - ______]: Rain Garden

1.3 RELATED DOCUMENTS

A. AASHTO M252 Corrugated Polyethylene Drainage Pipe.

B. AASHTO M294 Corrugated Polyethylene Pipe, 300- to 1200-mm Diameter.

C. ASTM D 1117 Standard Guide for Evaluating Nonwoven Fabrics.

D. ASTM C 136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

E. ASTM D1388 Standard Test Method for Stiffness of Fabrics.

F. ASTM D 2239 Standard Specification for Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter.

G. ASTM D 3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method.

H. ASTM D 4355 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

I. ASTM D 4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity.

J. ASTM D 4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

K. ASTM D 4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile.

L. ASTM D 4833 Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products.

M. ASTM D5035 Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method).

N. ASTM D 6475 Standard Test Method for Measuring Mass Per Unit Area of Erosion Control Blankets.

O. ASTM D 6525 Standard Test Method for Measuring Nominal Thickness of Permanent Rolled Erosion Control Products.

P. ASTM F 405 Standard Specification for Corrugated Polyethylene (PE) Tubing and Fittings.

Q. Erosion Control Technology Council (ECTC) Guidelines.

1.4 SUBMITTALS

A. Product Data:

1. For Geotextile.

2. Slot drain with perforated base pipe or perforated pipe.

B. Sieve Analyses: For sand and open graded aggregate according to ASTM C 136.

C. Samples for Verification:

1. Four by four-inch sample of geotextile.

2. One-foot section of slot drain with perforated base or perforated pipe.

1.5 QUALITY ASSURANCE

A. Source Limitations: Obtain each type of material from one source with resources to provide materials and products of consistent quality in appearance and physical properties.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Store aggregates where grading and other required characteristics can be maintained and contamination avoided.

B. Geotextiles labeling, shipment, and storage shall follow ASTM D 4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

C. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants.

D. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames including welding sparks, excess temperatures, and any other environmental conditions that may damage the physical property values of the geotextile.

PART 2 – PRODUCTS

2.1 AGGREGATES

A. Coarse sand: Illinois Department of Transportation Standard Specifications for Road and Bridge Construction (latest edition), Section 1003.01 (c) FA-2.

B. Open graded aggregate: Illinois Department of Transportation Standard Specifications for Road and Bridge Construction (latest edition), Section 1004.01 (c) CA-7.

2.2 NON-WOVEN NEEDLE PUNCHED GEOTEXTILE

A. Mechanical properties:

1. Grab Tensile Strength (ASTM D 4632)

a. Strength at ultimate (lbs)	205
b. Elongation at ultimate (%)	50
2. Mullen Burst Strength (ASTM D 3786) (psi)	380
3. Trapezoidal Tear Strength (ASTM D 4833) (lbs)	80
4. Puncture Strength (ASTM D4833) (lbs)	130
5. UV Resistance after 500 hrs. (ASTM D 4355) (%)	70

B. Hydraulic properties:

1. Apparent Opening Size (ASTM D 4751) (US sieve #)	80
2. Permittivity (ASTM D 4491) (sec-1)	1.2
3. Flow Rate (ASTM D 4491) (gal/min/ft2)	95

C. Selected non-woven needle punched Geotextile shall be approved by Engineer or Construction Manager.

2.3 PIPES

A. HDPE Solid pipe: Pipe shall meet AASHTO Type S specifications, with soil-tight couplings. Fittings and couplers shall be fabricated HDPE with fitting and coupling hardware as supplied by pipe manufacturer. Perforated and solid piping shall be provided of the size and locations as shown on the drawings.

B. Slot drain: Manufactured from corrugated polyethylene pipe with a smooth interior wall, pipe and fittings conforming to AASHTO M252 and/or M294. A grate frame that forms a slot shall be mounted in the pipe so as to provide a linear outlet to the top of the pipe to distribute sheet flow. The slot shall be manufactured from 0.063 tempered commercial aluminum and shall have two parallel plates separated by vertical spacers spanning the slot on 6-inch centers. The grating within the slot opening shall be1/2 - #13 galvanized steel. The slot shall be painted with a zinc chromate primer to protect the aluminum when installed in concrete. The flange at the bottom of the slot shall be riveted to the pipe with a minimum of two rivets per linear foot. The pipe shall have a section removed to accept the slot so as to maintain the original diameter, providing ease in transition to conventional systems. The pipe should have 0.5-inch slot openings, 6-inches center to center, along two to three longitudinal rows.

1. Size and dimensions:

a. Pipe diameter: refer to drawings

b. Slot height: 2 ½-inch or 6-inches

c. Slot opening: 1 ¼-inch wide for 4-inch pipe, 1 ¾-inch wide for 6 and 8-inch diameter pipe

C. Perforate pipe: Perforated HDPE distribution pipes shall conform to ASTM F 405, AASHTO M252, and AASHTO M252 and/or M294. The perforated pipe should have ½ inch slot openings, 6 inches center to center, along two to three longitudinal rows.

1. Roughness (Manning's "n") shall not exceed the following values

a. 3"-6"	0.015
b. 8"	0.016
c. 10"	0.017
d. 12"-15"	0.018
e. 18"-24"	0.020

2.4 CLEAN OUTS

A. Clean outs shall consist of 6-inch diameter rigid HDPE pipe and conform to ASTM D 2239.

2.5 EROSION CONTROL BLANKET

A. Straw erosion control blanket constructed with 100% agricultural straw fiber matrix and a functional longevity of approximately 12 months. The straw fiber shall be evenly distributed over the entire area of the mat. The blanket shall be covered on the top and bottom with a lightweight photodegradable polypropylene net having an approximate 0.20 x 0.50 inch mesh size. The blanket shall be sewn together on 1.50 inch centers with degradable thread.

1. Thickness - ASTM D6525 - 0.32 inch (8.13 mm)

2. Resilience - ECTC Guidelines - 80.50%

3. Mass per Unit Area - ASTM D6475 - 7.59 oz/square yard (257 g/square meter)

4. Water Absorption - ASTM D1117/ECTC - 327%

5. Swell - ECTC Guidelines - 14.90%

6. Stiffness/Flexibility - ASTM D1388/ECTC - 6.06 oz-inch (67.699 mg-cm)

7. Ground Cover - ECTC Guidelines - 89%
8. Smolder Resistance - ECTC Guidelines - Yes (according to ECTC test)
9. MD Tensile Strength - ASTM D5035 - 156 lbs/ft (2.27 kN/m)
10. MD Elongation - ASTM D5035 - 23%
11. TD Tensile Strength - ASTM D5035 - 108 lbs/ft (1.57 kN/m)
12. TD Elongation - ASTM D5035 - 22%

(MD – Machine direction)

(TD – Traverse direction)

PART 3 – EXECUTION

3.1 INSTALLATION, GENERAL

A. The level spreader and filter strip systems may not receive run-off until the entire contributing drainage area to the level spreader and filter strip system has received final stabilization.

B. Heavy equipment and traffic shall be restricted from traveling over the location of the level spreader and filter strip to minimize compaction of the soil.

3.2 EXCAVATION

A. Excavate the level spreader trench to the design dimensions and elevations. Excavated materials shall be located a minimum 10-feet away and to the downstream side of the trench to prevent re-deposition of excavated soils during storm events and to enhance trench wall stability. Large tree roots shall be trimmed flush with the trench sides in order to prevent fabric puncturing or tearing of the filter fabric during subsequent installation procedures. The side walls of the trench shall be roughened where smeared and sealed during excavation.

3.3 COARSE SAND PLACEMENT

A. Place 4-inch sand filter layer (IDOT FA-2) at the bottom of the infiltration trench.

B. First two-inches of sand shall be vertically mixed with the subgrade soils to a minimum depth of 2-inches prior to placing the remaining 2-inches.

3.4 GEOTEXTILE PLACEMENT

A. The width of the geotextile must include sufficient material to conform to trench perimeter irregularities and for a 6-inch minimum top overlap. The filter fabric shall reach to the sand layer on the bottom of the level spreader trench. Stones or other anchoring objects should be placed on the fabric at the edge of the trench to keep the fabric in place during construction. When overlaps are required between rolls, the uphill roll shall lap a minimum of 2-feet over the downhill roll in order to provide a shingled effect.

B. Following the stone aggregate placement, the filter fabric shall be folded over the stone aggregate to form a 6-inch minimum longitudinal lap.

C. A separate precut geotextile shall be placed horizontally over the aggregate prior to covering the level spreader trench with the final aggregate layer. The horizontally placed geotextile shall be installed as an individual unit to allow for easy removal in case of remedial maintenance.

3.5 PIPES / SLOT DRAINS

A. Perforated pipe / slot drain shall be provided as indicated in the drawings and shall terminate 1-foot short of the level spreader trench end wall. Free ends of perforated pipe, where no clean-outs are specified, shall be capped.

1. Use of slot drain: The grate of the slot drain shall be installed level along one elevation for the entire continuous length of the level spreader.

2. Use of perforated pipe: The downstream lip of the level spreader trench shall be installed level along one elevation for the entire continuous length of the level spreader.

3.6 CLEAN OUTS

A. The clean outs shall be fitted with a cap located near the lateral center of the level spreader trench, and located at the ends of the distribution pipe as indicated on drawings. The pipe shall have a plastic collar or ribs to prevent lifting when removing cap. It shall withstand water head pressure of 10-feet and be manufactured with Hostalloy 731™ high density polyethylene. The screw top lid shall contain a magnet capable of being detected with a standard magnetic pipe and cable locator. The top shall include a locking mechanism or special bolt to discourage vandalism. The cap shall be open or closed as indicated on the drawings.

3.7 AGGREGATE PLACEMENT

A. The stone aggregate (IDOT CA-7) shall be placed in lifts and lightly compacted using plate compactors without damaging the distribution pipe. The maximum loose lift thickness is 12-inches.

B. Aggregate shall extend a minimum of six inches beyond the edge of the trench, on the downstream side and shall mound a minimum of 2- inches above the prevailing slope such that it will intercept runoff from upslope.

C. All aggregates must be kept clean and uncontaminated at all times. All contaminated aggregates shall be removed and replaced with uncontaminated aggregates (IDOT CA-7).

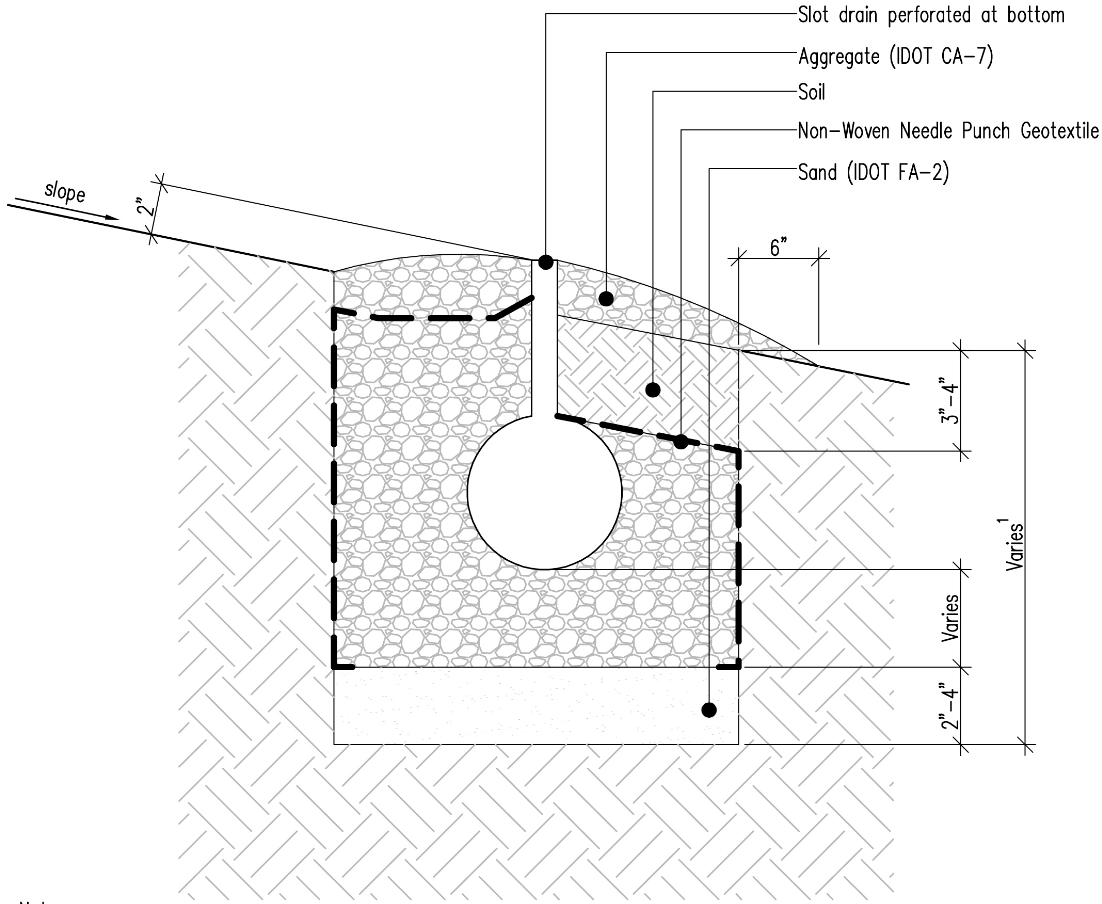
3.8 EROSION CONTROL BLANKET

A. Immediately following seed installation on the filter strip adjacent to the level spreader, install specified erosion control blanket as indicated on plan documents following manufacturer's specifications and installation procedures for areas as indicated on the plan documents. Erosion blanket shall be maintained as specified by manufacturer and as necessary for compliance with Kane County soil erosion and sediment control standards.

B. Uphill edge of erosion blanket shall be keyed into infiltration trench.

END OF SECTION

§ T1605(m) Typical Detail



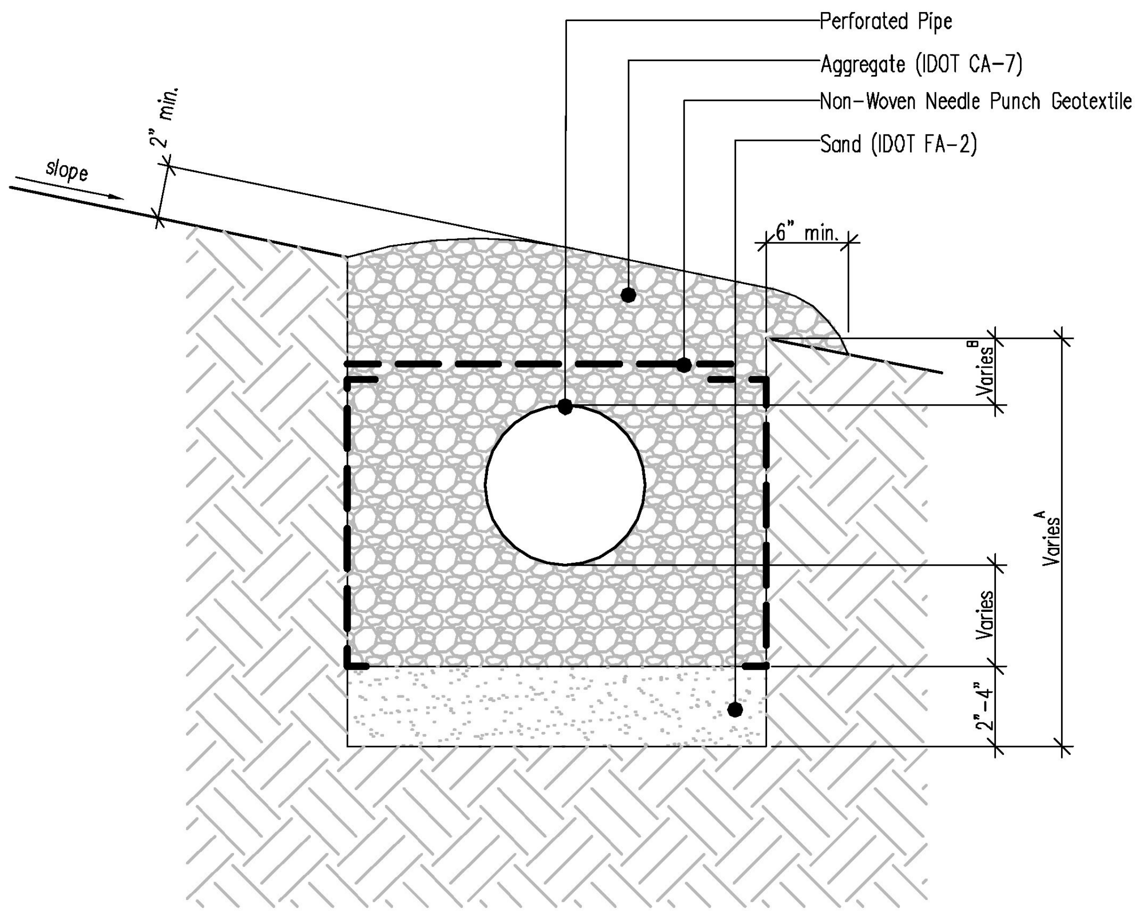
Notes:

1. Depth shall not exceed that which will drain in 72 hours.

Level Spreader with Inflow via Slot Drain

Not to Scale

Figure 12 – Level Spreader Detail (with slot drain)



A) Depth shall not exceed that which will drain in 72 hours.
B) Perforated Pipe located minimum of one pipe diameter below grade.

Level Spreader with Inflow via Perforated Pipe

Not to Scale

Figure 13 – Level Spreader Detail (with perforated pipe)

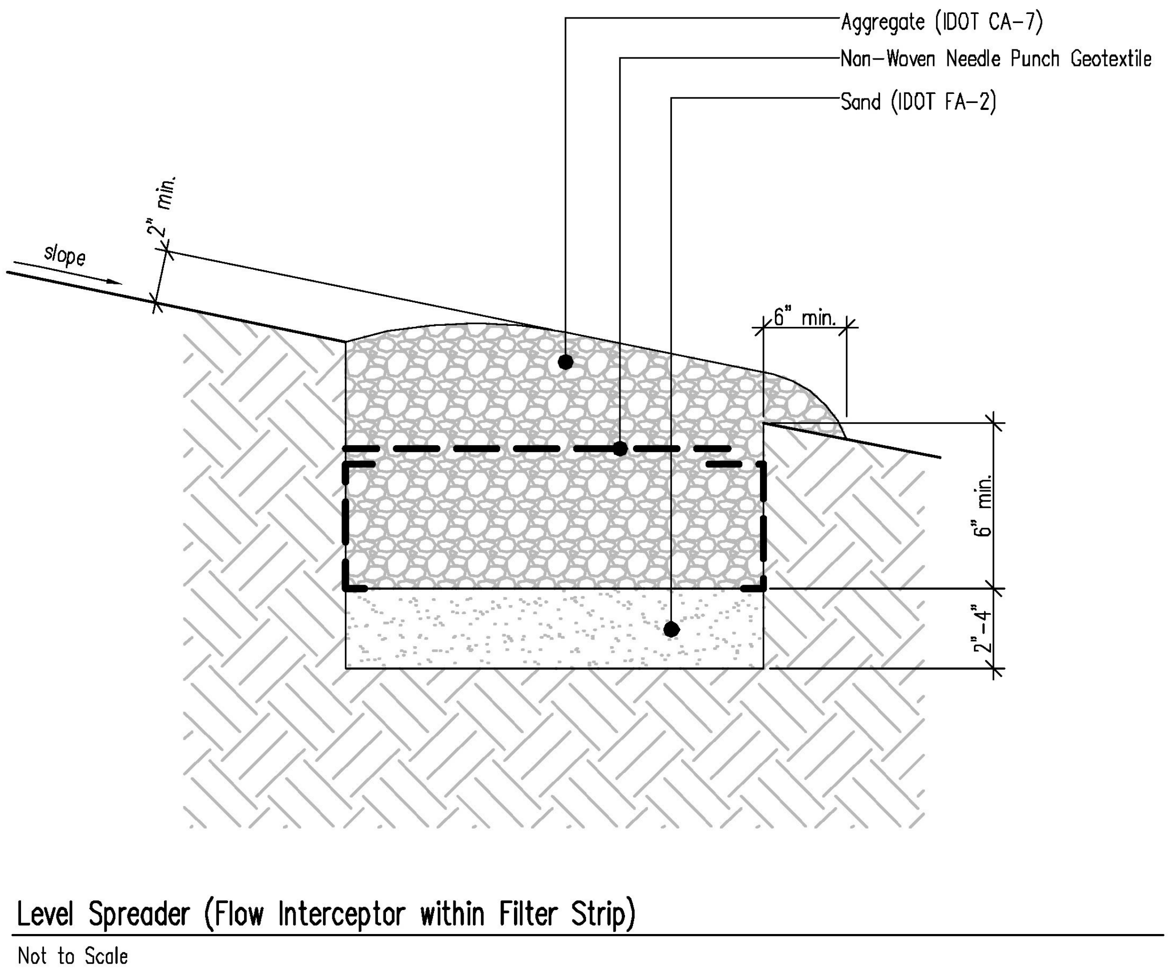


Figure 14 – Level Spreader Detail (within filter strip (mid-slope)

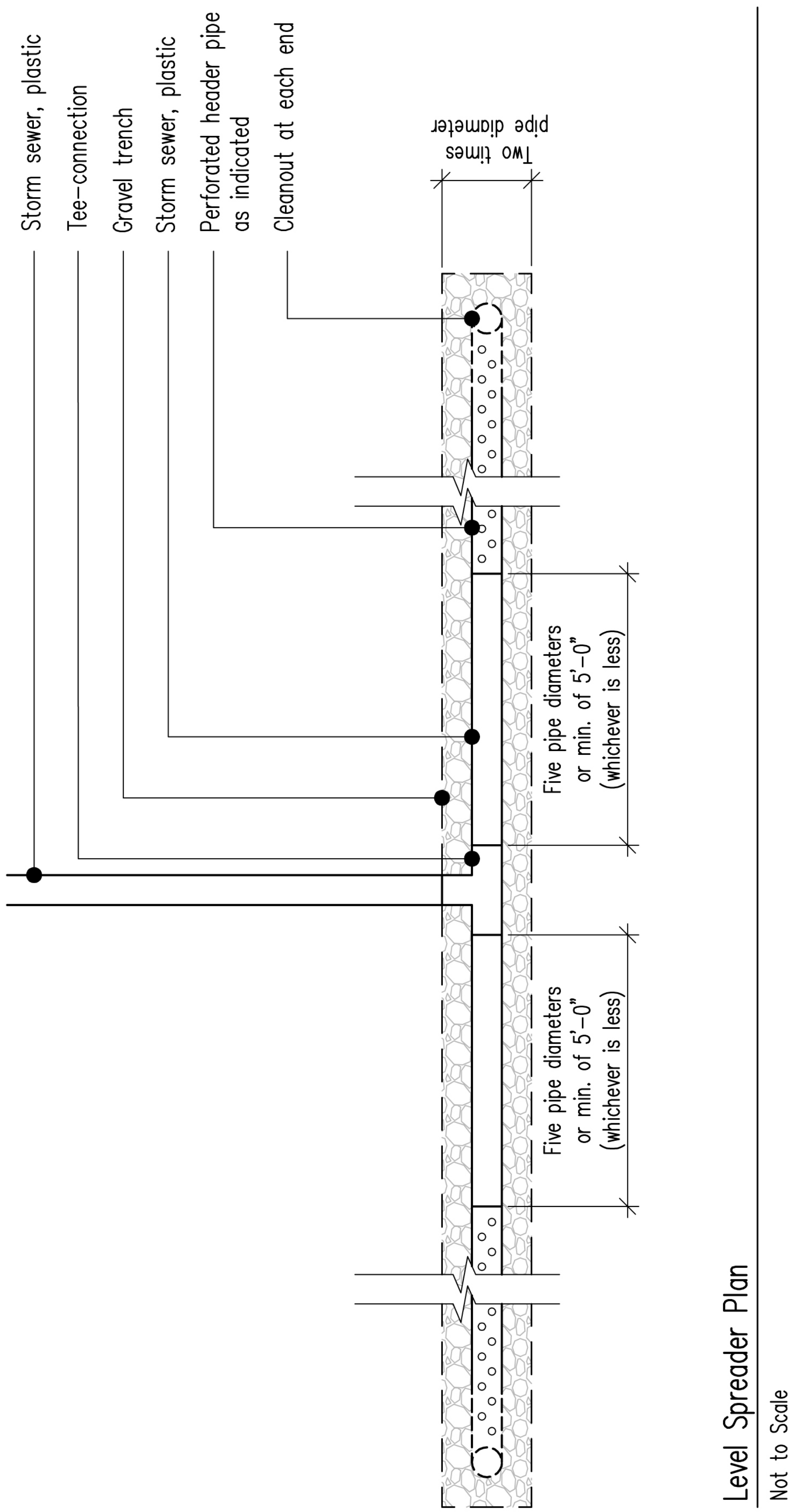


Figure 15 – Level spreader plan view

[1] Yu *et al.* (1992)
[2] Schueler (1987); Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); Lowndes (2000)
[3] Lowndes (2000)
[4] Price *et al.* (1998)
[5] Horner (1993); NRCS-II (2001); Los Angeles County Department of Public Works (2002)
[6] Price *et al.* (1998); NRCS-II (2001)
[7] Price *et al.* (1998)
[8] USDA (1994)
[9] Schueler *et al.* (1992); Price *et al.* (1998)
[10] Price *et al.* (1998); Lowndes (2000)
[11] Schueler (1987); NRCS-II (2001)
[12] Price *et al.* (1998)
[13] Price *et al.* (1994)
[14] Price *et al.* (1998)
[15] Price *et al.* (1998)
[16] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992); NRCS-II (2001)
[17] USDA (1994)
[18] Schueler (1987)
[19] Northern Virginia Planning Commission and Engineers and Surveyors Institute (1992)
[20] Lowndes (2000)
[21] NRCS-II (2001)
[22] Minton (2005)
[23] Price *et al.* (1998)
[24] Price *et al.* (1998)
[25] Md DNR ((1984)
[26] Price *et al.* (1998)
[27] Price *et al.* (1998)
[28] NRCS-II (2001)
[29] NRCS-II (2001)
[30] Price *et al.* (1998)
[31] NRCS-II (2001)
[32] Price *et al.* (1998)
[33] Price *et al.* (1998)
[34] Price *et al.* (1998)
[35] Price *et al.* (1998)

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§ T1606 Naturalized Stormwater Basins

§ T1606(a) Definition

Naturalized stormwater basins, for purposes of this technical manual, are wet detention basins or constructed wetland systems designed to provide greater water quality and habitat benefits relative to standard detention basin designs. Naturalized stormwater basins incorporate native vegetation on shallow emergent shelves as well as the side slopes of the basin. Appropriate native vegetation used within a naturalized basin can tolerate inundation and modest water level fluctuations, has deeper root systems to better stabilize side slopes, and typically deters usage of upland areas by geese.

Two basic naturalized basin designs will be discussed: wet basins that consist primarily of open water with shallow emergent wetland shelves around the perimeter of the open water habitat; and constructed wetland systems that consist of a shallow marsh habitat. Naturalized stormwater basins can also be designed as variations on these two basic designs (e.g., open water interspersed with shallow emergent marsh, combination of pond and shallow marsh habitat as separate zones, etc.).

Naturalized stormwater basins can and should be combined with other BMP's in this guidance manual, such as rain gardens, infiltration trenches, and filter strips as pretreatment measures to reduce sediment loads and water level fluctuations within the basin. Level spreaders and filter strips can also be located downstream of the naturalized basin to deconcentrate runoff prior to discharge to a stream or wetland buffer.

§ T1606(b) Suitable Applications

Stormwater detention basins have been used for stormwater management for decades in Kane County and Northeastern Illinois. Naturalized stormwater basins are essentially just a variation on the basic detention basin. As such, naturalized basins can be applied virtually anywhere that standard basins can be applied. When drainage areas are small, it may be difficult to maintain permanent water and therefore the vegetation may need to be adjusted for small drainage areas and/or for more permeable soils. Since on-stream detention basins are generally not allowed per the Kane County Stormwater Ordinance, this will tend to limit the maximum drainage area to detention basins.

Naturalized stormwater basins are appropriate for residential, commercial and mixed-use developments. The naturalized aspect of these basins is most suitable for an overall landscape plan that is less formal. However, due to their relatively large size, naturalized basins are often located within more formalized landscape plans as well.

§ T1606(c) Benefits

Enhancement of vegetation diversity and wildlife habitat in urban settings[1].

Increased pollutant removal efficiencies due to settling of particulate pollutants and biological uptake by wetland plants[2]; wet basins are better able to prevent settled pollutants from resuspending and washing out of the basin during subsequent storms[3].

Downstream environmental benefits include improved water quality, attenuation of runoff rates, and prevention of increased downstream flooding associated with development.

Improved aesthetics; can provide value to community open space.

Passive recreation opportunities.

Relatively low maintenance costs.

§ T1606(d) Limitations

Large land area requirement for generally single purpose facility (stormwater management).

Can be expensive when land costs are considered since detention basins are not as readily integrated into site plans as other BMPs such as permeable paving, rain gardens, and infiltration trenches that typically do not displace developable land.

Pollutant removal efficiencies are limited until vegetation is established[4].

Less pollutant removal/assimilation during non-growing season[5].

Potential habitation by undesirable vegetative species if pollutant load and water level fluctuations are not controlled[6].

Naturalized stormwater basins and other urban stormwater BMPs are typically not intended to address runoff with very high sediment concentrations, such as construction sites, agricultural fields or plant nurseries. However, sediment basins used to address construction site runoff can often be converted to naturalized stormwater basins once the site is stabilized.

Naturalized stormwater basins are not a substitute for adequate source controls on manufacturing, industrial, refueling, and other sites where toxic and other pollutants are used or stored.

Per the Kane County Stormwater Ordinance, naturalized stormwater basins should not be constructed within natural wetland systems or constructed as on-stream facilities.

§ T1606(e) Required Design Data

§ T1606(e)(1) Soil type:

Determine on-site soils within area proposed for naturalized stormwater basin. If soils are relatively permeable or well drained, such as soil types A and B, it may be difficult to maintain a permanent pool. Usage of a clay liner or adequate compaction of bottom soils may be necessary[7]. A preferred option may be to construct the detention basin as a combined retention and detention facility that infiltrates a portion of the runoff and releases the remaining runoff (see also Section § T1603).

§ T1606(e)(2) Contributing drainage area:

The contributing drainage area and level of imperviousness will determine size requirements to meet the Kane County allowable release rate of 0.1 cfs/acre. The drainage area will also partially determine the ability to maintain a permanent pool of water.

§ T1606(e)(3) Placement of naturalized stormwater basin in landscape:

If a naturalized stormwater basin is to be located in close proximity to a natural wetland, a hydrologic evaluation of the existing wetland system should be performed to ensure that placement of the naturalized stormwater basin will not significantly increase or decrease the water balance of the natural wetland.

§ T1606(f) Naturalized Stormwater Basin Design

As previously mentioned, a naturalized stormwater basin can have many variations to its design. The primary features or characteristics that all naturalized basins should include are:

some type of settling feature that also dissipates the energy of incoming flows, such as a forebay, settling basin, or open water area;

slopes (above and below water) that are more gradual than standard detention basins to create greater habitat opportunities;

pool depths that encourage particulate pollutant removal and prevent resuspension;

pool depths that vary to provide a range of habitat opportunities;

native vegetation that is tolerant of the designed hydrologic conditions (depth and duration).

These primary naturalized stormwater basin design features, as well as other design considerations, are further discussed in the following sections.

§ T1606(f)(1) Site selection:

Naturalized stormwater basins should not be located within existing wetland habitat nor negatively affect the hydrologic regime of an existing wetland. Wetland basins should also not be located on-stream such that they cause impoundment of flowing water and change the basic character of the stream habitat.

If a permanent pool is to be maintained, the drainage area should be sufficient to support the pool against evaporation and infiltration losses. Wet detention basins can be lined to prevent infiltration, if necessary.

§ T1606(f)(2) Release rate:

The design release rate should meet the local criteria and requirements for flood prevention. In most of Kane County, the maximum allowable release rate for the 100-year design event is 0.10 cfs/acre.

§ T1606(f)(3) Storage volume:

Sizing of the naturalized stormwater basin to meet the release rate requirements should follow standard detention design techniques as outlined in S T203(c), (e.g. TR55, TR20, HEC-1, etc.).

§ T1606(f)(4) Water level fluctuation and flow velocity:

Although the Kane County Stormwater Ordinance places no restriction on the amount of water level fluctuation within detention basins, it is recommended that stormwater basins be designed with a 100-year stage less than 4-feet above the normal water level (NWL) and 2-year stage less than 2-feet above NWL.

It is also recommended that the 0.75-inch Kane County Ordinance runoff retention standard be located upstream of the detention facility, distributed throughout the watershed via rain gardens, porous pavement, infiltration trenches, etc. If it is necessary to incorporate the 0.75-inch runoff volume within the detention facility, the water level fluctuation within the retention zone should be designed to be 6-inches or less. Water fluctuations that are greater than these may result in poor vegetation establishment and/or persistence and low vegetation and habitat diversity.

The flow velocity through a shallow constructed wetland marsh system can be high at the beginning of the event before there is a pool of water to slow the flow. Flow velocities through a shallow marsh should not exceed 1.5 ft/s, and, ideally, should be 0.6 ft/s or less during the beginning portion of the event before the basin begins to significantly fill[8]. High velocities can stress and potentially dislodge rooted vegetation and scour previously deposited sediments.

§ T1606(f)(5) Pretreatment/energy dissipation:

Pre-treatment and/or energy dissipation should be provided at all concentrated discharges to detention basins. An open water forebay provides both energy dissipation and provides an opportunity for settling of the heaviest sediment in an easily maintainable location. A separate forebay is not necessary for a wet basin. However, to concentrate the settled material within one area for ease of clean out, an underwater berm may be constructed to create a "forebay" near the inlet. Constructed wetland systems that consist only of shallow marsh, however, will require a forebay to prevent scour at the inlet and to minimize disturbance of established vegetation during dredging of accumulated sediments. The forebay should be designed following recommendations for settling basins. The NIPC recommendations state that the forebay should be designed with both active storage and a permanent pool. The permanent pool volume should include both treatment volume and sediment storage[9]. In general, the forebay should have the following features:

Inlet stabilization, such as rip rap, to prevent scour.

Length to width ratio that provides a flow path length of at least two to three times the width of the forebay.

Side slopes from 6-inches below the NWL to 6-inches above NWL should be 5:1 or flatter to facilitate the establishment of emergent vegetation. Side slopes below this zone should be no greater than 4:1 to prevent potential slope failure and improve safety.

The forebay should be located for easy access by sediment removal equipment.

The permanent pool volume within the forebay should be sized for treatment as well as sediment storage.

The treatment volume should be a minimum 500 cubic feet/impervious acre.

The sediment storage volume should be a minimum 100 cubic feet/impervious acre. For a stabilized watershed, this should provide for approximately 10-years of sediment storage.

The forebay should be designed with a minimum depth of 3-feet to prevent resuspension of sediments.

To distribute discharge from the forebay, a 1-foot high berm of rip rap should be installed between the forebay and the constructed wetland to create a small amount of active storage. The low berm will prevent scour and act as a level spreader (see also Section § T1605).

§ T1606(f)(6) Basin/marsh depths (below normal water level):

The basin/marsh permanent pool depth can vary based on the desired appearance of the stormwater facility. In general, a basin with permanent pool depths of 2- to 3-foot may be populated by rooted aquatic vegetation. Deeper open water design with greater than 6-foot depths will deter establishment of rooted aquatics and will tend to provide less structure for aquatic habitat. A mixture of emergent, rooted aquatic, and open water zones will provide the greatest habitat and visual diversity.

§ T1606(f)(7) Naturalized stormwater basin configuration:

To minimize short circuiting between the basin inlet(s) and outlet, the basin inflow point(s) should be as far from the outlet structure as possible and the configuration of the naturalized stormwater basin should provide a flow path at least 3 times longer than the average basin width. This can be accomplished by a basin length to width ratio of 3:1, and/or through the addition of design features such as shallow berms. This will ensure that inflow runoff is distributed throughout the basin and there are no stagnant zones. For example, wet basins may include underwater berms that can be designed as emergent shelves and positioned to increase the flow path length. In addition to preventing short circuiting, these emergent shelves can provide habitat opportunities. Increasing emergent shelf area also increases runoff water/soil substrate contact area, improving water quality.

§ T1606(f)(8) Slopes:

The side slopes at the shoreline, from 0.5- to 1.0-foot above to 1.0-foot below NWL, should be no steeper than 10:1. The flatter the slope is graded, the greater the potential for vegetation establishment and habitat opportunities. The side slopes above the shoreline should be 5:1 to facilitate establishment of native vegetation, prevent slumping during drawdown, improve safety, and improve maintainability (e.g. mow management along slope during early stages of plant establishment). Where space is constrained or due to site topography, a 3:1 side slope above the shoreline may be used. At no time should the side slope be designed with a slope steeper than 3:1.

§ T1606(f)(9) Vegetation selection and planting:

Native vegetation should be integrated into the design as much as possible. Certain conditions or situations may warrant use of non-native species, which is discussed in further detail later in this section. Selection of vegetation should consider hydroperiod and light conditions, with preference given to species that are adaptable to the broadest ranges of depth, frequency, duration of ponding, and at least moderate tolerance to nutrient loads[10]. Where possible, water level fluctuation should be controlled to minimize excessive inundation during the first growing season, particularly after seed installation[11]. This may be accomplished by delaying the installation of the restrictor until the seeded material has established through a growing season. Delayed installation of the restrictor will require coordination with construction schedules related to installation of impervious cover and may need approval by the regulatory body.

Generally, three to four planting zones can be created based on slope, NWL, and anticipated water level fluctuations. The following tables illustrate water depth planting zones. The given elevation ranges are generalized; the actual design elevation ranges should consider the proposed water fluctuations for the specific stormwater facility, in particular, the 2-year stage elevation. It is not uncommon to have some species overlap between zones as they sort out to those areas that provide their optimal growing conditions. And as previously discussed, gradual slopes will provide more microclimate conditions that will favor vegetation establishment and a diversity of vegetation habitats. Given the typically unnatural conditions of a stormwater facility, it is recommended to limit plant species to those that are known to grow in such conditions, are native to Kane County, and are considered less conservative (i.e. those species with a coefficient of conservatism (C value) of 5 or less as described in Plants of the Chicago Region. It is recommended to also refer to the Native Plant Guide for Streams and Stormwater Facilities in Northeastern Illinois and Plants for Stormwater Design Species Selection for the Upper Midwest for selection of species and placement within the stormwater facility (see also References at the end of this Section).

Zone	Elevation Range
Submergent	3 – 6 feet below NWL
Deeper Emergent	NWL – 6-inches below NWL
Shallow Emergent	2” above NWL – 2” below NWL
Wetland Fringe	12” above NWL – NWL
Mesic Prairie	> 12” above NWL

Table 8 - General Planting Zones and Water Depth Elevation Ranges

Submergent Zone:

The following are two recommendations for planting within a submergent zone: Coontail (Ceratophyllum demersum) and Sago Pondweed (Potamogeton pectinatus). Other submergent species, however, may volunteer. Most of the available plant nursery species that are appropriate for a submergent zone are fairly conservative (C value ≥ 6) and may not be conducive to a stormwater facility environment.

Emergent Zone:

The following are recommendations for planting within an emergent zone. Some species are tolerant of deeper water conditions, e.g., 6-12 inches below NWL; these have been identified in the Deeper Emergent category. Although most of these identified species will tolerate deeper water depths than indicated, these emergent species generally should be planted in water depths no greater than 6-inches. As they become established, many will migrate into deeper water depths. Other emergent species prefer shallower water depths, e.g., 2- to 3-inches to mudflat conditions; these species have been identified in the Shallow Emergent category.

Those portions of the emergent zone that are below the NWL should be plugged rather than seeded. The shallow emergent zone above the NWL can be plugged and/or seeded and protected with an erosion blanket. Plugging rates may vary depending on budget constraints. The minimum installation rate should be approximately 2-foot on centers. Some species, however, have a slow rate of spread and therefore should be planted at a higher frequency rate. The following table provides several recommended species for the emergent planting zones.

Typical Planting Zone Water Depths	Scientific Name	Common Name
Deeper Emergent: NWL – 6-inches below nwl	Polygonium amphibium	Marsh Smartweed
	Sagittaria latifolia	Common Arrowhead
	Scirpus fluviatilis	River Bulrush
	Scirpus validus creber	Great Bulrush
Other species that can tolerate this water depth, but are less tolerant of nutrient and/or siltation loads and considered more conservative (C value ≥ 6)	Acorus calamus	Sweet Flag
	Carex lacustris	Common Lake Sedge
	Pontederia cordata	Pickerel Weed
	Scirpus acutus	Hard-stem Bulrush
	Sparganium eurycarpum	Common Bur Reed
Typical Planting Zone	Scientific Name	Common Name

Water Depths		
Shallow Emergent: 2" above NWL – 2" below NWL	Alisma subcordatum	Common Water Plantain
	Bidens cernua	Nodding Bur Marigold
	Carex hystericina	Porcupine Sedge
	Carex pellita	Wooly Sedge
	Carex stricta	Tussock Sedge
	Carex vulpinoidea	Brown Fox Sedge
	Eleocharis obtusa	Blunt Spike Rush
	Iris virginica shrevei	Blue Flag
	Scirpus atrovirens	Dark Green Rush
	Scirpus pungens	Chairmaker's Rush
	Spartina pectinata	Prairie Cord Grass
Other species that can tolerate this water depth, but are less tolerant of nutrient and/or siltation loads and are considered more conservative (C value ≥ 6)	Acorus calamus	Sweet Flag
	Calamagrostis canadensis	Blue Joint Grass
	Carex comosa	Bristly Sedge
	Eupatorium maculatum	Spotted Joe Pye Weed
	Glyceria striata	Fowl Manna Grass
	Juncus effusus	Common Rush

Table 9 - Recommended Species for Emergent Planting Zones

Wetland Fringe Zone:

The wetland fringe zone can be installed as a combination of plug and seed material. This zone should be seeded with a cover crop and protected with an erosion blanket. Table 3 provides a list of recommended species for the wetland fringe zone. The specific species identified to be installed within this zone as well as the elevation of the zone will depend on the proposed water fluctuations for the designed stormwater facility. A variety of species that are tolerant of periodic wetness as well as mesic conditions should usually be considered for this fringe zone. If, however, the designed slope for the wetland fringe zone is too steep (3:1 or more), and/or the proposed water fluctuation for the 2-year storm event is greater than 2-feet, an alternative planting scheme may be necessary. Designed planting plans, for these conditions or others that pose severe growing conditions, should focus on usage of a few species that may grow under these constraints. An example would be to seed Creeping Bent as the dominant species within a wetland fringe zone, along with typical annual species, such as Bidens, Rice Cut Grass, and other species typically found along mudflats or eroded slope habitats such as Common Water Horehound, Spike rushes, etc.

Typical Planting Zone Water Depths	Scientific Name	Common Name
Wetland Fringe: 12” above NWL - NWL	Actinomeris alternifolia	Wingstem
	Agrostis alba palustris	Creeping Bent
	Asclepias incarnata	Swamp Milkweed
	Aster novae-angliae	New England Aster
	Aster simplex	Panicled Aster
	Bidens cernua	Nodding Bur Marigold
	Carex cristatella	Crested Oval Sedge
	Carex stipata	Common Fox Sedge
	Elymus virginicus	Virginia Wild Rye
	Eupatorium perfoliatum	Common Boneset
	Helenium autumnale	Sneezeweed
	Helianthus grosseserratus	Sawtooth Sunflower
	Juncus dudleyi	Dudley’s Rush
	Juncus torreyi	Torrey Rush
	Leersia oryzoides	Rice Cut Grass
	Lycopus americanus	Common Water Horehound
	Penthorum sedoides	Ditch Stonecrop
	Rudbeckia laciniata	Wild Golden Glow
	Silphium perfoliatum	Cup Plant
	Spartina pectinata	Prairie Cord Grass
	Thalictrum dasycarpum	Tall Meadow Rue
	Verbena hastata	Blue Vervain
	Vernonia fasciculata	Ironweed

Typical Planting Zone Water Depths	Scientific Name	Common Name

Other species that can tolerate this water depth, but less tolerant of nutrient and/or siltation loads and are considered more conservative species (C value ≥ 6)	Calamagrostis canadensis	Blue Joint Grass
	Liatris pycnostachya	Prairie Blazing Star
	Liatris spicata	Marsh Blazing Star
	Lobelia siphilitica	Great Blue Lobelia
	Lythrum alatum	Winged Loosestrife
	Mimulus ringens	Monkey Flower
	Panicum virgatum	Switch Grass
	Physostegia virginiana	Obedient Plant
	Pycnanthemum virginianum	Common Mountain Mint
	Rudbeckia subtomentosa	Sweet Black-eyed Susan
	Scirpus cyperinus	Wool Grass
	Scirpus pendulus	Red Bulrush
	Solidago graminifolia	Grass-leaved Goldenrod
	Solidago riddellii	Riddell's Goldenrod
	Veronicastrum virginicum	Culver's Root
	Zizia aurea	Golden Alexanders

Table 10 - Recommended Species for Wetland Fringe Planting Zone

<u>Mesic Prairie Zone:</u>

A prairie zone should be established for the remaining slope of the naturalized stormwater basin. The prairie zone will provide additional habitat value, as well as stabilization and filtration functions. The prairie area should also be established using native vegetation. Typically, a mesic prairie seed mix is used for this zone as is provided below in Table 11. The mesic prairie zone should be seeded at rates standard for the native landscape industry – usually, grasses seeded at 8- to 10-pounds per acre, forbs seeded at 2- to 3-pounds per acre. Applicable cover crop rates should be used based on whether it is installed during the growing season or as a dormant seed installation.

Mesic Prairie	Scientific Name	Common Name
>12” above NWL	Andropogon gerardii	Big Bluestem Grass
	Andropogon scoparius	Little Bluestem Grass
	Aster azureus	Sky-blue Aster
	Aster laevis	Smooth Blue Aster
	Aster novae-angliae	New England Aster
	Astragalus canadensis	Canada Milk Vetch
	Baptisia leucantha	White Wild Indigo
	Bouteloua curtipendula	Side-oats Grama
	Coreopsis palmata	Prairie Coreopsis
	Desmodium canadense	Showy Tick Trefoil
	Echinacea purpurea	Broad-leaved Purple Coneflower
	Elymus canadensis	Canada Wild Rye
	Heliopsis helianthoides	False Sunflower
	Lespedeza capitata	Round-headed Bush Clover
	Monarda fistulosa	Wild Bergamot
	Panicum virgatum	Switch Grass
	Parthenium integrifolium	Wild Quinine
	Penstemon digitalis	Foxglove Beard Tongue
	Petalostemum purpureum	Purple Prairie Clover
	Ratibida pinnata	Yellow Coneflower
	Rudbeckia hirta	Black-eyed Susan
	Silphium integrifolium deamii	Deam’s Rosin Weed
	Silphium laciniatum	Compass Plant
	Silphium terebinthinaceum	Prairie Dock
	Solidago rigida	Stiff Goldenrod
	Sorghastrum nutans	Indian Grass
	Veronicastrum virginicum	Culver’s Root
	Zizia aurea	Golden Alexanders

Table 11 - Recommended Species for Mesic Prairie Planting Zone

Burn/No Burn Management:

The vegetation recommendations above are predicated on the assumption that the area will be maintained via burn management as the primary long-term maintenance activity. If burn management is not or cannot be used, the planting palette should be modified to incorporate a matrix of species that will provide better slope stabilization than standard turf grass but will persist in the absence of fire. The following table provides a list of species that may be used for the planting zones above NWL.

Typical Planting Zone Water Depths	Scientific Name	Common Name
2-yr Stage Elevation – NWL:	Agrostis alba palustris	Creeping Bent
Above 2-yr Stage Elevation: Meadow Mix	Dactylis glomerata	Orchard Grass
	Festuca rubra	Red Fescue
	Lolium perenne	Perennial Rye Grass
	Phleum pratense	Timothy Grass
	Poa pratensis	Kentucky Blue Grass
	Trifolium pratense	Red Clover
	Trifolium repens	White Clover

Table 12 - Recommended Species When Burn Management Will NOT Be Used

The emergent zone should be planted with the hardiest of species – River Bulrush, Great Bulrush, etc. The area may revert to cattails over time.

§ T1606(f)(10) Outlet control structure and outlet protection:

There are various outlet control structures that may be used. A submerged orifice outlet located within a wet basin or, for a constructed wetland within a permanent pool, will provide clog protection, an important issue that must be considered in the design. A permanent pool or micropool at the outlet should be at least 4-feet deep[12]. A deeper micropool at the outlet may provide for cooler water discharges that may help to alleviate downstream impacts to temperature sensitive aquatic life[13]. The restrictor, which controls the flow rate, should be located at least 1-foot below the NWL.

The outlet pipe that controls the NWL, should be set above the normal groundwater table elevation to prevent continuous flow through the naturalized stormwater basin. Continuous flow through the basin significantly reduces the residence time and pollutant removal performance[14].

Outlet protection must be provided for detention discharges to prevent scour. Discharges from a basin that are directed to a stream, lake, or wetland should be directed to the buffer adjacent to the water body rather than to the water body itself[15]. The discharge to the buffer must be distributed and the velocity dissipated using a level spreader (see Section § T1605) or other BMP's (Section § T1603(f)(6)).

§ T1606(f)(11) Maintenance access:

Maintenance access to the forebay, safety shelf (if applicable), and outflow structure should be provided. Any access routes located on top of berms used to impound the detention volume must be designed and constructed to carry the load associated with maintenance equipment (e.g. small backhoe and dump truck).

§ T1606(g) Construction Considerations

Soil Preparation:

Topsoil should be stripped and stockpiled prior to grading. If invasive species or weed seed are expected to be an issue, the top 2-inches of surface soil should be removed/scrapped to remove primary weed seed source prior to stripping of topsoil. The topsoil should be a silt loam based on the U.S.D.A. classification system; uniformly obtained from the A-horizon of the soil profile without admixture of subsoil.

Soil compaction should be kept to a minimum within the areas to be planted. If soil compaction occurs or if the soils have a high clay content, the area(s) should be deep disked prior to placement of topsoil.

Stockpiling of topsoil should be kept to a minimum. The longer topsoil is stockpiled, the greater the loss of organic carbon, which is needed for soil fertility and friability. Topsoil should contain 6-10% organic content. At the time of placement, topsoil should be tested for organic content and amended with additional organic matter if the content is less than 6%. The loss of organic carbon will diminish the quality of the topsoil as a growing medium and will affect its ability to absorb runoff.

Topsoil should be spread to a minimum thickness of 6-inches over the entire area to be planted. The topsoil should be blended with the top 2-inches of subsoil to avoid creation of a potential root barrier and to prevent potential slope failure due to slippage at the subsoil/topsoil interface.

Timing of Planting/Seeding:

To provide optimal growing conditions and allow the roots to become established prior to warmer and drier conditions, live plantings should be installed in spring prior to June 1st. Planting can occur later, until August 1st, if provisions are made for adequate watering to ensure plant and root establishment.

Seeding may occur in spring, March 1st (or when the soil thaws) through May 31st. Many of the native seeds require moist, cool conditions for germination, which is generally the condition during this time period. A late fall/winter dormant seeding, however, may also be done. A dormant seeding should not occur prior to November 1st, but prior to frozen ground or snow cover conditions. A dormant seeding is more appropriate for those portions of the naturalized stormwater basin that are unlikely to flood and flush the seed from the basin[16].

Erosion and sedimentation control:

Immediately following seed installation of the wetland fringe and mesic prairie zones, a biodegradable erosion blanket should be installed. It is recommended that a double net erosion blanket with a 100% straw matrix, (e.g. North American Green (NAG) S150 or equivalent) be used from the NWL up to the 2-year stage elevation. A single net erosion blanket with a 100% straw matrix (e.g. NAG S75 or equivalent) may be used from the 2-year stage elevation up to the top of slope. Clean straw mulch applied at a 2000 lbs/acre rate and crimped in place may be used instead of an erosion blanket above the 2-year stage elevation. The usage of an erosion blanket or straw mulch has been noted to have benefits that typically outweigh the additional cost factor. These benefits include increased slope stabilization until vegetation is established, seed protection, and enhancement of seedling development.

Predation protection:

Most newly planted areas will need some type of predation protection. Various herbivore predation protection methods are readily available and should be incorporated into the design.

§ T1606(h) Operation and Maintenance

Annual inspections:

The naturalized stormwater basin should be inspected, at a minimum, twice a year for the first three years after construction, and once a year thereafter. The following items should be noted during each inspection:

Presence of erosion rills and gullies, as well as sedimentation deposits.

Sediment accumulation within forebay. When the portion of the forebay volume allocated to sediment accumulation is full (typically corresponds to a sediment depth of approximately one foot), removal of sediment is necessary.

Vegetation species distribution/survival that includes dominant plant species; presence of installed species within the intended zones and if their aerial coverage has increased; what volunteer species have established and are they considered invasive; and what percent of the naturalized stormwater basin remains unvegetated, excluding designed open water areas.

Determine if the depth zones and microtopographic features are still persistent[17].

Inspect the condition of outlet structure – removal of debris or trash that may cause blockages.

From these inspections, various activities may be warranted such as erosion repair through various stabilization methods, clean out debris and trash that may clog the outlet structure, vegetation management of invasive species, removal of accumulated sediments, repair herbivore predation exclosures, etc.

<u>Accumulated sediment removal:</u>

The frequency of removal of accumulated sediments will depend on the adequacy of soil erosion and sediment control during construction and on the presence of BMP's within the upstream watershed[18]. If adequate controls are present, sediment removal may not be necessary for 10 years or longer depending upon the designed sediment storage volume. Sediments should be tested prior to removal to determine the appropriate method of disposal.

<u>Vegetation maintenance:</u>

Native vegetation maintenance should include mow management for the first 2 growing seasons following installation. Mowing should be limited to that portion of the side slope that is less frequently inundated. Mowing frequency and blade height should be adjusted to optimize control of annual and biennial weeds and minimize impact to native perennial species. Generally, mowing for the first full growing season after installation should begin early May and continue through the growing season at approximately 4- to 6-week intervals. The blade height should generally be set at 6- to 8-inches above the ground.

A non-native meadow installation should also be mowed the first growing season following installation at the frequency and blade height specified for the native vegetation. Beginning the second growing season, however, a meadow area should only be mowed once a year after approximately July 15th to a height of 4- to 6-inches.

Other weed control methods, including spot herbicide treatment and hand weeding, should be employed as necessary to control invasive species. Herbicide treatment should only be performed by a licensed applicator.

Burn management should be implemented as a maintenance activity generally after the third full growing season or as soon as an adequate fuel source is present. Burn management should be used as the primary maintenance activity for the long-term care of the naturalized stormwater basin. Although there are varying opinions as to the recommended frequency of a burn, annual burning will typically remove trash and burnable debris within the facility and reduce the intensity of the fire (potentially less damaging) relative to burns conducted every three to four years (minimum frequency).

Reinforcement plantings:

Reinforcement plantings should be planned and budgeted for implementation after the second or third growing season. Regardless of the care taken during the early stages of development, it is likely that various portions of the initial plantings will not survive. This may be caused by various factors such as predation, drought, various changes in water levels, or other unforeseen factors[19]. The selection of the reinforcement species should be based on information obtained during the site inspections. Species should include those that have persisted and increased in aerial coverage.

§ T1606(i) Easement

The Kane County Stormwater Ordinance requires that stormwater features (such as naturalized stormwater basins) be protected by an easement. All naturalized stormwater basin areas that are part of the submitted and approved stormwater management system thus are required to be in an easement. If naturalized stormwater basins are not part of the permitted stormwater management system, such as those installed by a homeowner on his or her own accord, they are exempt from the easement requirement.

§ T1606(j) Typical Detail

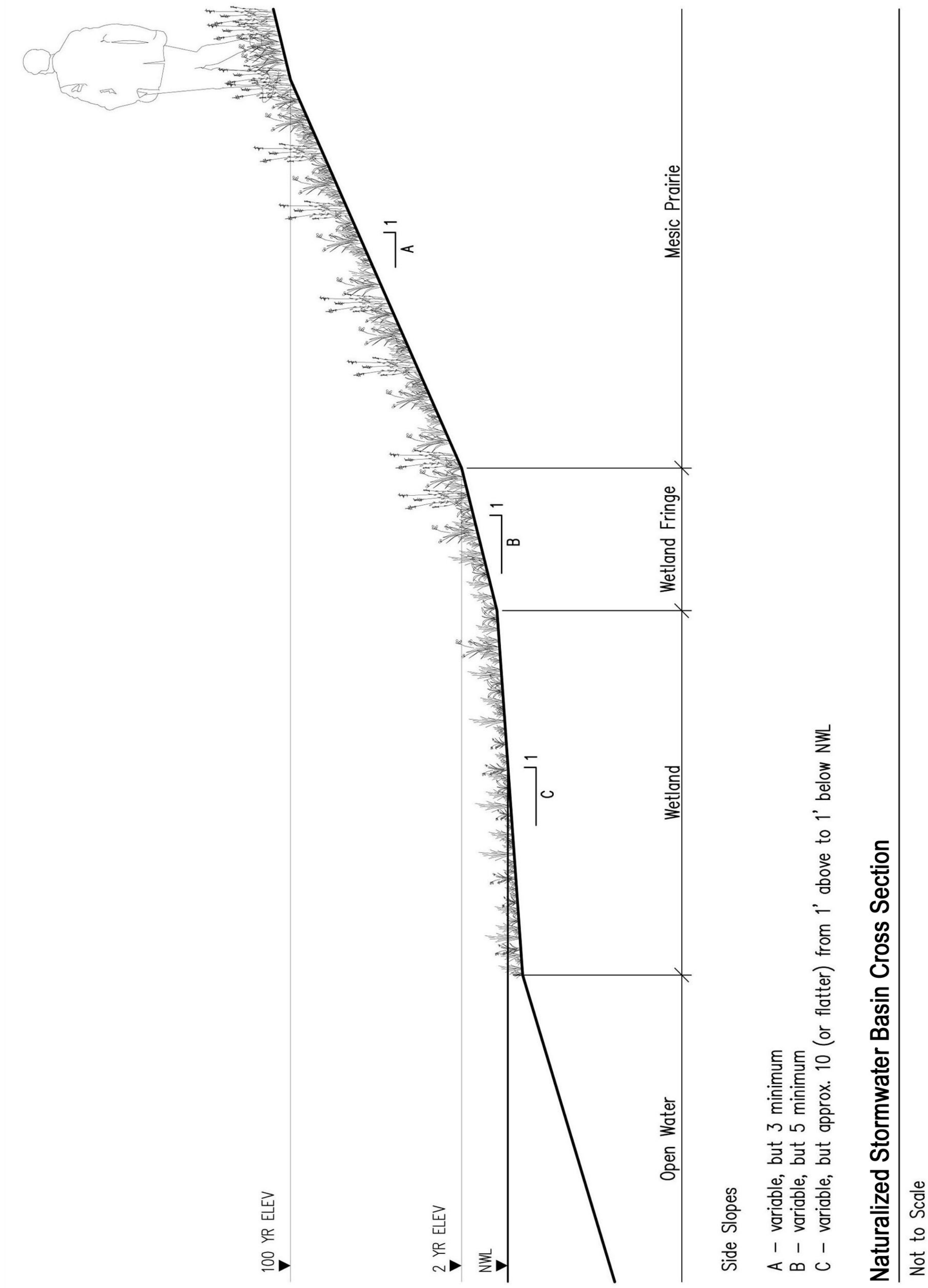


Figure 16 – Naturalized Stormwater Basin Cross Section

[1] Barr Engineering Company (2001)
[2] MA Department of Environmental Protection (1997); Barr Engineering Company (2001); Schueler (1992)
[3] NIPC (2000)
[4] MA Department of Environmental Protection (1997); Barr Engineering Company (2001); Schueler (1992)
[5] EPA (1999)
[6] EPA (1999)
[7] MA Department of Environmental Protection (1997); NIPC (2000)
[8] Soil & Water Conservation Society of Metro Halifax (2004)
[9] NIPC (2000)
[10] MA Department of Environmental Protection (1997); Barr Engineering Company (2001)
[11] NIPC (2000)
[12] Barr Engineering Company (2001)
[13] EPA (1999)
[14] NIPC (2000)
[15] NIPC (2000)
[16] NIPC (2000)
[17] Schueler (1992)
[18] NIPC (2000)
[19] Schueler (1992)

Barr Engineering Company (2001), Minnesota Urban Small Sites BMP Manual Stormwater Best Management Practices for Cold Climates, Metropolitan Council Environmental Services.
EPA (1999) Storm Water Technology Fact Sheet Storm Water Wetlands.
MA Department of Environmental Protection (1997), Stormwater Management, Volume Two: Stormwater Technical Handbook.
Northeastern Illinois Planning Commission (2000) Urban Stormwater Best Management Practices for Northeastern Illinois.
Schueler, T.R. (1992), Design of Stormwater Wetland Systems, Anacostia Research Team, Department of Environmental Programs, Metropolitan Washington Council of Governments, Washington, D.C.
Soil & Water Conservation Society of Metro Halifax (2004), Stormwater Treatment.

Appendix A – Falling Head Percolation Test Procedure[127]

Number and Location of Tests

Commonly a minimum of three percolation tests are performed within the area proposed for an absorption system. They are spaced uniformly throughout the area. If soil conditions are highly variable, more tests may be required.

Preparation of Test Hole

The diameter of each test hole is 6-inches, dug or bored to the proposed depths at the infiltration systems or to the most limiting soil horizon. To expose a natural soil surface, the sides of the hole are scratched with a sharp pointed instrument and the loose material is removed from the bottom of the test hole. Two-inches of ½- to ¾-inch gravel are placed in the hole to protect the bottom for scouring action when the water is added.

Soaking Period

The hole is carefully filled with at least 12-inches of clear water. This depth of water should be maintained for at least 4-hours and preferably overnight if clay soils are present. A funnel with and attached hose or similar device may be used to prevent water from washing down the sides of the hole. Automatic siphons of float valves may be employed to automatically maintain the water level during the soaking period. It is extremely important that the soil be allowed to soak for a sufficiently long period of time to allow the soil to swell if accurate results are to be obtained.

In sandy soils with little or no clay, soaking is not necessary. If, after filling the hole twice with 12-inches of water, the water seeps completely away in less than 10-minutes, the test can proceed immediately.

Measurement of the Percolation Rate

Except for sandy soils, percolation rate measurements are made 15-hours but not more than 30-hours after the soaking period began. Any soil that sloughed into the hole during the soaking period is removed and the water level is adjusted to 6-inches above the gravel (or 8-inches above the bottom of the hole). At no time during the test is the water level allowed to rise more than 6-inches above the gravel.

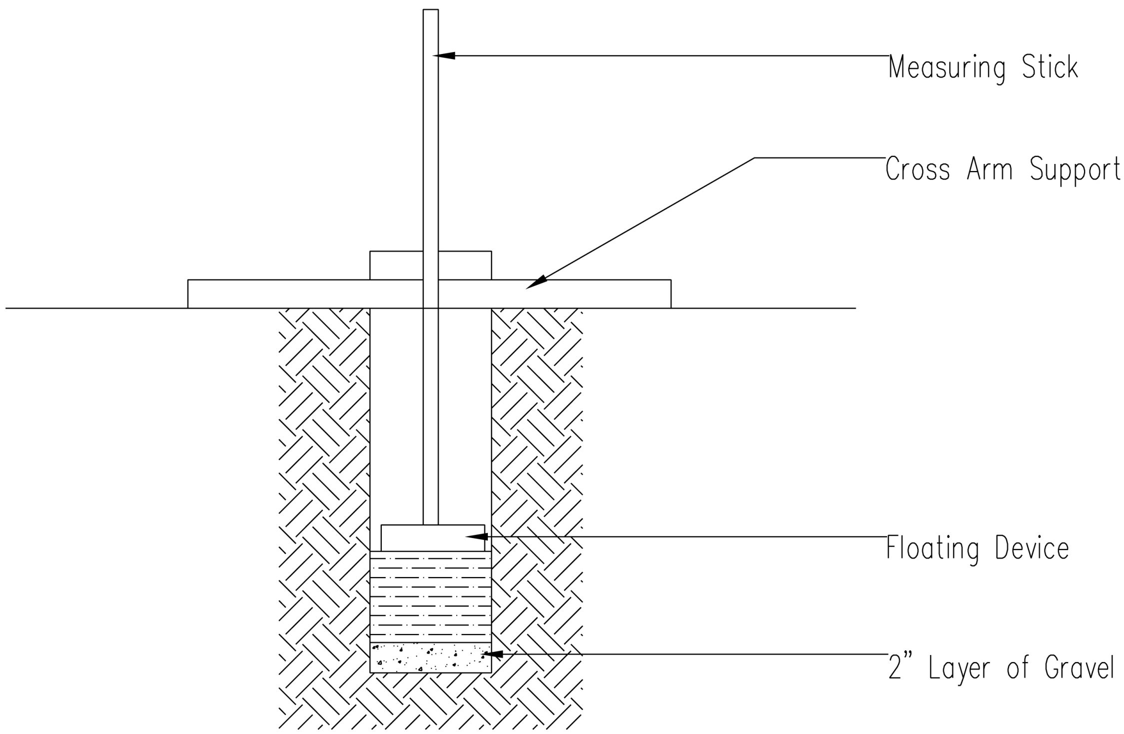
After each measurement, the water level is readjusted to the 6-inches level. The last water level drop is used to calculate the percolation rate.

In sandy soils or soils in which the first 6-inches of water added after the soaking period seep away in less than 30-minutes, water level measurements are made at 10-minute intervals for a 1-hour period. The last water level drop is used to calculate the percolation rate.

Calculation of the Percolation Rate

The percolation rate is calculated for each test hole by dividing the time interval used between measurements by the magnitude of the last water level drop. This calculation results in a percolation rate in terms of minutes/inch. To determine the percolation rate for the area, the rates obtained from each hole are averaged. (if tests in the area vary by more than 20-minutes/inch variations in soil type are indicated. Under these circumstances, percolation rates should not be averaged.)

Example: if the last measurement drop in water level after 30-minutes is 5/8-inch the percolation rate = (30-minutes)/(5/8-inch)= 48-minutes/inch.



[127] Design Manual – Onsite Wastewater Treatment and Disposal System, EPA, 1980

Percolation Test Data Form

Location:	
Test hole #:	

Depth to bottom of hole:		Diameter of hole:	

Depth, inches	Soil texture

Percolation test by:	
Date of test:	

Time	Time intervals, minutes	Measurement, inches	Drop in water level, inches	Percolation rate, minutes per inch	Remarks

Percolation rate =		minutes per inch

Appendix B – Species Guide

The following species may be included in a seed / plant list. Suggested seed rates may need to be adjusted based on the specific site conditions. Further more, each list will have to be modified based upon the specific site conditions and circumstances that are associated with a project. As a general rule of thumb, species with a C-Value (level of conservatism[128]) equal to or greater than 6 may be difficult to establish from seed and are generally more successfully introduced as live material (i.e. plugs). It is strongly recommended to develop a seed / plant list on a project-by-project basis and to consult a Landscape Architect, Botanist, or Ecologist knowledgeable on the specifics of selecting and establishing native vegetation in stormwater systems. The last column provides the designated wetland category for each species. The wetland category expresses each plant's preference of wetness (OBL) to dryness (UPL).

Species	Common Name	Seed Qty. Lbs/Acre	C-value	Wetland Category
COVER CROP				
Agrostis alba	Red Top	10.0		NA
Avena sativa	Seed Oats	20.0		NA
Lolium multiflorum	Annual Rye Grass	20.0		NA
TOTAL LBS/ACRE OF COVER CROP SEED		50.0		

Table 13 – Cover crop list

Species	Common Name	Seed Qty. Lbs/Acre	C-value	Wetland Category
GRASSES				
Andropogon gerardii	Big Bluestem Grass	1.0	5	FAC-
Andropogon scoparius	Little Bluestem Grass	2.0	5	FACU-
Bouteloua curtipendula	Side-oats Gramma	2.0	8	UPL
Carex bicknellii	Copper-shouldered Oval Sedge	plug	10	UPL
Carex pensylvanica	Common Oak Sedge	plug	5	UPL
Carex rosea	Curly-style Wood Sedge	plug	4	UPL
Carex sprengelii	Long-beaked Sedge	plug	9	FACU
Carex vulpinoidea	Brown Fox Sedge	0.25	2	OBL
Elymus canadensis	Canada Wild Rye	1.0	4	FAC-
Panicum virgatum	Switch Grass	1.0	5	FAC+

Sorghastrum nutans	Indian Grass	1.0	5	FACU+
TOTAL LBS/ACRE OF GRASS SEED		8.0		

Table 14 – Grass and sedge list

Species	Common Name	Seed Qty. Oz/Acre	C-value	Wetland Category
FORBS				
Allium cernuum	Nodding Wild Onion	2.0	7	FAC-
Aster ericoides	Heath Aster	1.0	5	FACU-
Aster laevis	Smooth Blue Aster	2.0	9	UPL
Aster novae-angliae	New England Aster	2.0	4	FACW
Astragalus canadensis	Canada Milk Vetch	2.0	10	UPL
Coreopsis lanceolata	Sand Coreopsis	3.0	5	FACU
Desmodium canadense	Showy Tick Trefoil	2.0	4	FAC-
Echinacea pallida	Pale Purple Coneflower	3.0	8	UPL
Echinacea purpurea	Broad-leaved Purple Coneflower	2.0	3	UPL
Helianthus mollis	Downy Sunflower	2.0	9	UPL
Heliopsis helianthoides	False Sunflower	3.0	5	UPL
Lespedeza capitata	Round-headed Bush Clover	3.0	4	FACU
Liatris spicata	Gay Feather	2.0	6	FAC
Monarda fistulosa	Wild Bergamot	3.0	4	FACU
Parthenium integrifolium	Wild Quinine	2.0	8	UPL
Penstemon digitalis	Foxglove Beard Tongue	1.0	4	FAC-
Petalostemum purpureum	Purple Prairie Clover	2.0	9	UPL
Physostegia virginiana	Obedient Plant	2.0	6	OBL
Pycnanthemum virginianum	Common Mountain Mint	2.0	5	FACW+
Ratibida pinnata	Yellow Coneflower	3.0	4	UPL
Rudbeckia hirta	Black-eyed Susan	3.0	1	FACU

Silphium integrifolium	Rosin Weed	2.0	5	UPL
Silphium laciniatum	Compass Plant	2.0	5	UPL
Silphium terebinthinaceum	Prairie Dock	2.0	5	FACU
Solidago graminifolia	Grass-leaved Goldenrod	2.0	3	FACW-
Solidago rigida	Stiff Goldenrod	3.0	4	FACU-
Verbena hastata	Blue Vervain	2.0	4	FACW+
Vernonia fasciculata	Common Ironweed	2.0	7	FACW
Veronicastrum virginicum	Culver's Root	2.0	7	FAC
Zizia aurea	Golden Alexanders	2.0	7	FAC+

Table 15 – Forb list

128 Swink, F., and Wilhelm, G. (1994), Plants of the Chicago Region. Indiana Academy of Science.

Bibliography:

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Swink, F. and Wilhelm, G. (1994), Plants of the Chicago Region. Indiana Academy of Science.

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Notes: