CITY OF TOPEKA UTILITIES

Stormwater BMP Design Handbook

CITY OF TOPEKA

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1 Introduction

1.1 NEGATIVE IMPACTS OF INCREASED STORMWATER RUNOFF

Like most cities, the growth of Topeka and the surrounding region profoundly alters the natural drainage systems and local water resources. The addition of impervious surfaces on the land (buildings, pavement, etc.) changes the natural hydrologic cycle. Native soil is compacted or removed reducing the amount of water that can soak into the ground. Mature trees and undergrowth are cut down and replaced by immature, ornamental species which do not soak up or intercept rainfall to the degree of the mature, native vegetation. The result is a significant increase in stormwater volumes and peak flows than what was encountered before development. These increases cause flooding and erosion.

Impervious surfaces added by land developments are covered with many different types of pollutants, primarily due to normal human activities. Litter, gasoline, and motor oil (and other petroleum-based products), brake dust, fertilizer, pesticides, and herbicides are all commonly found in stormwater discharging from developed land. Even the naturally occurring substances (e.g., sediment, base metals, nitrogen, phosphorus) often occur in higher concentrations on developed land than in a natural, undeveloped setting. The increased peak flows and runoff volumes caused by land development wash these pollutants from the impervious surfaces and carry them to local receiving waters and, ultimately, to the Kansas River. This causes additional negative impacts, such as harmful algal blooms, destruction of aquatic habitat, and increased costs to produce potable water for Topeka's residents and businesses.

Increases in impervious surface result in increased runoff partly due to reduced infiltration into the soil. In natural systems, this water seeps into the soil profile and moves through the landscape to become baseflow for streams. Decreased base flows significantly alter stream flow regimes.

Many negative impacts from increased peak flows and runoff volumes, and from decreased base flows, are listed in **Table 1-1**. Note from the table that many of the impacts can lead to consequences for the community. For example, polluted water resulting from greater runoff volumes can significantly increase costs for the collection and treatment of drinking water. These costs will be passed on to the consumer. Alternately, the loss of recreational opportunities resulting from decreased base flows can reduce the influx of tourism dollars that many communities depend on for support. The resulting decrease in local services will also be felt by the consumer. Clearly, proper management of stormwater from land developments, or the lack thereof, has significant financial implications to community residents and businesses.

Table 1-1. Impacts of Stormwater from Land Developments

	Increased Peak Flows	Greater Runoff Volumes	Decreased Base Flows
Negative Impacts	- Stream bed and bank erosion - Loss of riparian trees & plants - Degraded aquatic habitat - Increased floodplain elevations - Wider regulatory floodplains - Developable land loss - Nuisance flooding - Street and building flooding - Public safety problems	- Loss of developable land - Nuisance flooding - Street and building flooding - Public safety problems - Increased pollution - Degraded aquatic habitat - Higher costs for drinking water collection and treatment - Public health problems	- Degraded wildlife habitat - Aquatic & riparian species loss - Drinking water shortages - Public health problems - Loss of, or limitations on, recreational areas - Temporary loss of navigable waters

1.2 THE BENEFITS OF STORMWATER MANAGEMENT

Proper management of stormwater runoff on developed properties can eliminate or alleviate many of the flood, erosion, and pollutant impacts described in the previous Section. Traditionally, site designers were taught that stormwater management primarily involved the reduction of post-development peak flows, namely matching post-development peak discharges to pre-development peak discharges for a series of design storms. Detention basins became the norm. However, as stormwater practitioners began discovering that detention requirements invoked blindly (i.e., without consideration of volume and hydrologic timing) were, in some drainage basins, causing more harm than good. Additionally, detention basins did not address streambank erosion caused by high velocity flows, which is now known to be one of the main sources of sediment pollution in natural waterbodies.

Today, stormwater management approaches are much more diverse, and are often keyed into community watershed characteristics and site hydrology. Stormwater green infrastructure (GI) best management practices (BMPs) and Low Impact Development (LID) techniques are the norm to minimize the effects of land development on site hydrology (see **Figure 1-1**). These approaches (defined below) attempt to mimic the natural hydrology by reducing the volume of runoff generated from a development. With TMC Chapter 13.35 and this Handbook, the City of Topeka is embracing these innovations by providing strong encouragement and design rewards for the use of LID and GI-BMPs.

Low Impact Development (LID) *is a development approach that, in the context of stormwater management, employs specific planning and design techniques to manage rainfall naturally, avoid significant increases in stormwater peak flows and volumes, and preserve a more natural baseflow in local streams. For purposes of this Handbook, LID techniques are non-structural (i.e., natural, not constructed) approaches to stormwater management.*

Green Infrastructure BMPs (GI-BMPs) *are structural BMPs which infiltrate, evapotranspire, or harvest and reuse stormwater for the purpose of runoff volume reduction and stormwater quality control. GI-BMPs may also use filtration through an engineered soil media to treat stormwater quality. In practice, GI-BMPs are aligned with, and support the principles of, LID. Rain gardens, bioretention, infiltration basins, green roofs, and cisterns are examples of GI-BMPs.*

Figure 1-1. Using LID Techniques and GI-BMPs in Non-Residential Developments.

Left: Pocket green spaces and maturing trees combined with small rain gardens manage stormwater at in a schoolyard. *(Source: Wikimedia Commons;* ***Credit:*** *The Episcopal School of Dallas staff photographer)*

Right: Medical Center development limits maximizes green space with parking lot bioretention islands and a preserved, mature, green buffer area between the site and nearby river. *(Source: Creative Commons; www.streets.nm)*

Two guiding principles behind the use of stormwater LID techniques are: 1) preserve or re-create natural landscape features (native, uncompacted soil and native, mature plants) on a developed site; and 2) minimize the amount of impervious surface area. Second, most GI-BMPs mimic natural hydrologic processes by infiltrating, evaporating, and transpiring stormwater, like the roles in the hydrologic cycle played by natural, uncompacted soil (infiltration), native plants, and mature trees (evaporation and transpiration) on property that has never been developed. At the site level, these approaches allow designers to create functional and appealing site drainage systems that treat stormwater as a resource, rather than a waste product. Moreover, routine use of LID techniques at the project site level will result in comparatively less "demand" placed on the public stormwater system and, at the community level, a more resilient, sustainable, and financially manageable public stormwater system.

Both LID techniques and GI-BMPs moderate the change in runoff caused by land development. For LID techniques, this moderation is measured by a less dramatic change in curve number from the pre-development condition (prior to any land development) to the post-development conditions. For GI-BMPs, this moderation is measured in the volume of runoff managed by the BMP and thus not discharged from the developed property.

LID techniques and GI-BMPs can be used independently of each other. However, when used together they create an overall onsite stormwater management approach that can help maintain more natural hydrologic conditions, thereby reducing onsite stormwater management infrastructure, and ultimately, downstream impacts. Further connection of multiple GI-BMPs, such as a green roof and bioretention area, can keep greater volumes of stormwater from routing to the stormwater drainage system.

Implementation of LID techniques and GI-BMPs provides numerous benefits and advantages over conventional stormwater management approaches. The following paragraphs describe the benefits that can be achieved by applying LID and GI-BMP to new development, redevelopment, and capital improvement projects.

- **Volume control and pollutant removal.** Traditional flood-focused stormwater management overlooks the importance of volume control from smaller storms and from the first flush of larger storms. Reducing the amount of stormwater runoff, however, is one of the most effective stormwater pollution controls possible. LID techniques and GI-BMPs help reduce runoff volume and decrease the amount of stormwater discharged directly to public drainage systems and local streams. In addition to reducing runoff volumes, some GI-BMPs address specific pollutant removal efficiencies through settling, filtration, adsorption, and biological uptake. Thus, GI-BMPs can help improve the receiving water's aquatic and terrestrial wildlife habitat and enhance recreational uses (see **Figure 1-2**).

Figure 1-2. Retention Basin

Retention ponds combined with aesthetic and pedestrian features reduce stormwater volume and can create a welcoming public space. *Source: City of Atlanta*

- **Recharge groundwater and stream base flows.** Land development tends to increase imperviousness leading to increased direct stormwater runoff and reduced rainfall infiltration. However, groundwater helps feed lakes and streams. Significant reductions or loss of groundwater recharge as a result of reduced rainfall infiltration can reduce base flow in receiving waters, negatively impacting biological habitat and recreational opportunities. Many GI-BMPs listed in this Handbook infiltrate runoff, thus promoting ground water recharge.

- **Stream channel restoration and protection**. LID techniques and GI-BMPs can protect or reduce stream channel degradation from accelerated erosion and sedimentation during and immediately after storm events by reducing and capturing stormwater volume and lowering stormwater peaks. By protecting stream channels, stream and riparian ecosystems have the potential to be improved and restored.

- **Other environmental benefits**. LID techniques and GI-BMPs can provide additional benefits such as improved aesthetics using attractive landscaping features (trees, shrubs, and flowering plants). Not only can these features increase property aesthetics; they can also attract desirable wildlife critical to overall ecological balance. This includes butterflies, worms, and caterpillars (important sources of food for bats and birds), bees (critical to pollination of crops), and bats and birds (critical to pollination and mosquito/pest control) (see **Figure 1-3a**). Other environmental benefits of GI-BMPs include increased public awareness of stormwater management and water quality issues since GI-BMPs are dispersed throughout a site and are typically more visible (see **Figure 1-3b**). GI-BMP, such as green roofs, bioretention, and urban trees, can also help mitigate the urban heat island effect and decrease the energy required to heat and cool buildings.

Figures 1-3a and b: Examples of Other Environmental Benefits of LID Techniques and GI-BMPs

Using native plants in bioretention areas and rain gardens may attract beneficial pollinators. *Source: Wood E&IS, Inc.*

Bioretention in visible areas increases public awareness of stormwater management. *Source: Wood E&IS, Inc.*

In addition to effectively managing stormwater on a developed site, there are many other benefits that can be realized by a community when a proactive approach is taken for stormwater management and the implementation of LID techniques and GI-BMP.

- **Assist with regulatory compliance.** The inclusion of LID techniques and GI-BMPs in both private and public land developments will help Topeka comply with its *Kansas Water Pollution Control Municipal Separate Storm Sewer System (MS4) Permit and Authorization to Discharge Under the National Pollutant Discharge Elimination System (NPDES)* (henceforth, NPDES-MS4 permit). Not only do these approaches reduce stormwater pollutant discharges to local waterways, but they are also anticipated to be a formal requirement by the Kansas Department of Health and the Environment (KDHE) in future NPDES-MS4 permits.

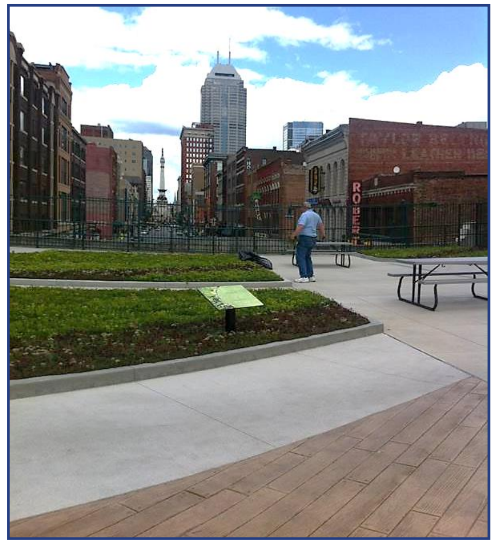
- **Mitigate federal and state regulated stream impairments.** Runoff reduction via LID techniques and GI-BMPs leads to nutrient and other pollutant reductions, which is vital to the stream impairments for sediment, nutrients, and bacteria already recognized by the United State Environmental Protection Agency (USEPA) and KDHE in Topeka's waterways.

- **Assist with Community Rating System (CRS) credits.** The Federal Emergency Management Agency (FEMA) offers reductions in flood insurance premiums for private property owners in communities that have earned credit for flood resiliency activities, including stormwater projects. Along with a myriad of other required activities, the inclusion of LID techniques and GI practices in Topeka's stormwater design requirements for public and private projects can help keep insurance premiums across the City as low as practicable.

- **Beautify land developments.** Use of LID techniques and GI-BMPs creates additional greenspace in communities, which can improve the aesthetic qualities of urban and suburban areas. This is especially so in urban redevelopments, where tree planters and urban bioretention basins can add significant quality to a highly impervious landscape.

- **Create and enhance public spaces.** Some LID techniques and GI-BMPs, such as a green roof, can be designed to include or lead to public gathering spaces. Early and thoughtful design of these controls to provide value to the context of the site design allows them to provide multiple benefits. See **Figure 1-4**.

Figure 1-4: An Urban Green Roof



Green roofs can both manage stormwater and enhance urban settings. *Source: Wood E&IS, Inc.*

- **Preserve recreational waterways.** Rivers, lakes, and streams provide opportunities for recreation and enjoyment. The removal of debris, prevention of contamination by pollutants, and support of a natural baseflow provided by LID techniques and GI-BMPs can improve recreational experiences for all water-goers.

- **Support disaster preparedness, resiliency, and flood control.** Communities that plan and implement projects to meet their stormwater management needs are generally better able to convey stormwater from flood events to detention facilities or receiving water bodies, and away from sensitive properties and infrastructure. Topeka's inclusion of, and encouragement for, LID techniques and GI-BMPs on private developments is in keeping with the latest practices for community resiliency.

- **Support waterway resiliency.** LID techniques and GI-BMPs that reduce stormwater volumes and increase infiltration can reduce the intensity of flooding events while at the same time increasing base flows between storm events, leading to healthier, more resilient waterways.

- **Support water supply/source waters protection and resiliency.** LID techniques such as the conservation of land, preservation of open space, and protection of mature trees reduces the threat of contaminants being introduced to drinking water supplies.

- **Support healthy receiving waters.** Runoff reduction via LID techniques and GI-BMPs can help reduce erosion and sedimentation in our waterways, as well as a reduce nutrient loads that contribute to algal blooms and fish kills.

- **Support public health and reduce public health risks.** Provision of greenspace and pedestrian connectivity within and between land developments allows for more opportunities for people to recreate and exercise, which can encourage people to be more physically active. Improved access to nature also contributes to improved overall health and wellness. Moreover, preserving water quality and reducing pollution using approaches that prevent pollutant discharges and promote a natural, sustaining baseflow can allow for safe recreation in local streams.

Careful consideration of stormwater management with an eye toward opportunities for implementation of LID techniques and GI-BMPs is critical for City of Topeka elected officials and City staff, businesses, homeowners, developers, and land development designers; however, it is rare that these groups have an opportunity to work together in planning for Topeka's future development and redevelopment. LID is an interdisciplinary approach to stormwater management planning that, when coupled with GI-BMP design, construction, and maintenance, can result in improved stormwater quality, improved health of local streams and rivers, and reduced flooding. LID techniques and GI-BMPs can also provide more attractive landscapes, wildlife habitat benefits, and improved quality of life for our citizens. The wide variety of stakeholder benefits that can stem from the use of LID and GI-BMP use in Topeka are listed in **Figure 1-5**.

Figure 1-5. Benefits of Stormwater LID Techniques and GI-BMPs on Land Development Stakeholders

	Benefits
City of Topeka	• Effective tool for stormwater management • Balances sustainability and economic growth needs with environmental protection • Reduces the City's infrastructure and utility maintenance costs (streets, curbs, gutters, sidewalks, storm drainage system) • Decreases flooding risks for small storms • Creates attractive and multifunctional public spaces • Encourages private sector participation in sustainable stormwater infrastructure at residential, commercial, and industrial properties • Supports stormwater pollution reduction requirements of the NPDES-MS4 permit
Land Developer	• Reduces land clearing and grading costs • May reduce infrastructure costs (streets, curbs, gutters, sidewalks) • May reduce construction, materials, and maintenance costs • Reduces stormwater management costs • May increase lot yields • Increases lot and community marketability
Property Owner	• May reduce stormwater utility fee and SCM maintenance costs • Can increase a property's landscape/hardscape aesthetic • Can provide functional greens spaces for recreation and enjoyment of the natural environment • Increases property marketability
Community	• Preserves integrity of ecological and biological systems • Protects site and regional water quality by reducing sediment, nutrients, and pollutant loads to local waterways • Reduces impacts to terrestrial and aquatic plants and animals • Preserves trees and natural vegetation • Mitigates the heat island effect and reduces energy use

1.3 HANDBOOK OVERVIEW

The *City of Topeka Stormwater Management BMP Design Handbook* (henceforth referred to as the "Handbook") provides Topeka's requirements and supporting guidance for the design and construction of stormwater quality and quantity best management practices (BMPs) at land developments subject to Topeka Municipal Code (TMC)

Chapter 13.35 (i.e., *Stormwater Management)*. More specifically, this Handbook establishes requirements (i.e., policies) and guidance pertaining to the following subjects:

- Required plans and related documents for planning, design, and construction termination relevant to the above stated city code sections
- Performance criteria and design and compliance calculation policies for stormwater quality BMPs, such as bioretention, rain gardens, permeable pavements, and quantity BMPs (i.e., detention and retention facilities)
- Soil test requirements for GI-BMPs
- Guidance on best practices for stormwater BMP design
- LID techniques for stormwater runoff volume reduction

This Handbook is written explicitly for land developers and site designers (i.e., civil engineers and landscape architects). It has all the information required to design and construct stormwater quality and quantity BMPs using an integrated approach to land development.

The City of Topeka has a companion manual to this Handbook to address the inspection and maintenance of stormwater quality and quantity BMPs after their construction. The *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance* is written explicitly for property owner's and those charged with inspecting and or maintaining stormwater BMPs. Policies and guidance in the *Property Owner's Guide* support TMC Chapter 13.40 (*Stormwater BMP Maintenance*). Land developers and site designers who wish to learn more about the maintenance activities required for the BMPs they select on new developments and redevelopments are encouraged to consult the *Property Owner's Guide* for more information.

1.4 HANDBOOK RELATIONSHIP WITH CITY CODE

This Handbook is authorized by TMC Chapter 13.35 as a reference document for stormwater management design. This Handbook establishes rules, regulations, and technical guidelines consistent with the requirements of, and for the purpose of facilitating compliance with, TMC Chapter 13.35. **This Handbook will be enforced by the Director of the Utilities Department (the director), consistent with the authorities and enforcement provisions of TMC Chapters 13.15 and 13.35.**

The information contained in this Handbook is also consistent with Section 1.3 of the City of Topeka's *Design Criteria and Drafting Standards*. In 2020, the stormwater quality performance standards and design requirements for stormwater quantity BMPs (detention and/or retention facilities) at public and private projects, originally provided in *Design Criteria and Drafting Standards*, were updated and moved to this Handbook (see Chapter 3). As well, requirements for stormwater management plan preparation and submittal, including the drainage report, were moved from the *Design Criteria and Drafting Standards* to this Handbook (see Chapter 2). Relevant to stormwater design, the *Design Criteria and Drafting Standards* now address only the design of linear stormwater conveyance systems (i.e., curb inlets, catch basins, pipes, ditches, etc.) such as might be used for a linear transportation design project.

Table 1-2 lists the basic content of Topeka Municipal Code relevant to stormwater management on public and private projects, along with the *Design Criteria and Drafting Standards*, this Handbook, and the *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance*. The table is provided to help land developers and designers understand the full breadth of Topeka's stormwater and related requirements and guidance.

Table 1-2. Basic Contents of the City of Topeka's Stormwater and Related Code and Guidance

Topeka Municipal Code	Design Criteria & Drafting Standards	Stormwater BMP Design Handbook
• TMC Chapter 13.15 authorizes regulation of stormwater drainage, construction activities, and stream buffers. • TMC Chapter 13.30 regulates stormwater and pollution during construction activities • TMC Chapter 13.35 regulates the design and construction of post-construction stormwater quality and quantity BMPs • TMC Chapter 13.40 regulates the inspection and maintenance of post-construction stormwater quality and quantity BMPs • TMC Chapter 17.10 regulates stream buffer areas • TMC Chapter 17.30 regulates land development in floodplains	• Drainage system design (inlets pipes, culverts, channels, etc.) • Refers to the *Stormwater BMP Design Handbook* for design of stormwater quantity BMPs (detention and retention facilities) • Refers to the *Stormwater BMP Design Handbook* for plan preparation and submittal requirements • Requirements and guidance for erosion prevention and sediment control practices	• Supports the requirements of TMC Chapter 13.35 • Stormwater quality BMP design • Stormwater quantity BMP design (detention and retention facilities) • Stormwater management plan (i.e., drainage report) requirements • Stormwater BMP Record Drawing requirements
		Property Owner's Guide to Stormwater BMP Maintenance
		• Supports the requirements of TMC Chapter 13.40 • Requirements and guidance for stormwater quality and quantity BMP protection, inspection, and maintenance • Performance standards for stormwater quality and quantity BMP inspections • Stormwater quality and quantity BMP inspection checklists

1.5 OBJECTIVES

The primary objectives of this Handbook are listed below. The Sections that follow describe how each of these objectives are met.

- The Handbook will provide land developers and site designers with detailed policies and guidance to facilitate their compliance with Topeka Municipal Code and to effectively manage stormwater quality and quantity using an integrated approach to land development.

- The Handbook will encourage land developers and site designers to use stormwater LID techniques and provide detailed information on various techniques. *(LID is a holistic design approach to reduce the stormwater volume discharged from their site by the preservation of natural site hydrology and optimization of a site's impervious surfaces (i.e., buildings and pavement). Ideally, the use of LID will maximize the environmental, social, and economic benefits of land development while reducing long-term costs for stormwater management for the property owner and City of Topeka.)*

- The Handbook supports the vision and pillars for quality urban growth established in the *City of Topeka Land Use and Growth Management Plan 2040*.

1.6 ALIGNMENT WITH THE COMPREHENSIVE AND LAND USE PLANS

Land development in, and the land growth of, the City of Topeka is defined and directed by Topeka's *Land Use and Growth Management Plan* (LUGMP), which is an element of the Topeka's Comprehensive Plan. The LUGMP contains major themes, goals, and policies regarding where and how land and infrastructure are developed within and around Topeka, primarily to support the economic and fiscal health goals of the City's Comprehensive Plan. The Comprehensive Plan is updated approximately every 10 years. The LUGMP is similarly updated on occasion to ensure its alignment with the Comprehensive Plan, and to refresh, condense, and better articulate growth management, land use and annexation policies for Topeka. The LUGMP in effect at the time of development of this Handbook is the LUGMP 2040 (adopted in 2015). Excerpts from the LUGMP 2040 establishing Topeka's vision and pillars (i.e., policies) for growth are provided below.

VISION FOR FUTURE GROWTH

Future growth for Topeka should be:

Fiscally Responsible

- *Cost-effective with all 5 city services*
- *Make development decisions that don't fiscally harm the City and its residents*

Sustainable

- *Compact pattern that economically benefits the existing population without compromising future needs*
- *Make choices that are long-lasting and benefit most people*

Planned

- *Consider many factors and impacts when making land use decisions*
- *Ensure development follows public investments that align with the overall goals for the LUGMP 2040*

PILLARS FOR A PROSPEROUS COMMUNITY

The LUGMP directs and encourages quality urban growth by promoting:

Compact Development

- *Maintain an efficient shape and footprint at urban densities rather than a low density or sprawl pattern*

Invest in Place/Add Value Where We Are

- *Fiscally responsible growth happens where Topeka has already invested. Grow value in Topeka's existing neighborhoods with strategic investments and incentives*

Return on Investment

- *Topeka's infrastructure and service investments are down payments for the future. It is imperative to develop those areas with existing investments at a level that seeks the greatest return on those initial investments.*

Urban Development Follows Infrastructure and Happens Inside the City

- *Land use decisions should be made after an area is annexed and investments in infrastructure and services have been made.*

Connected, Mixed Use, Walkable Neighborhoods

- *Mixing together residential, commercial, and jobs, along with open space and other amenities is to provide a balanced mix of land uses in an efficient and compact pattern.*

- *Connected and walkable neighborhoods promote a compact shape and are an amenity for retaining and attracting residents.*

Focus on Making Topeka a Place People Want to Live First

- *Job seekers often pick a city to live before picking a job. Topeka should be a place where people want to live first.*

Transportation/Housing Choices

- *Offering complete streets and multi-modal options are important elements for the livability of our community and extending the capacity of our street system. Neighborhoods shouldn't be only low density single-family. There should be a range of housing types built throughout the community.*

Economic Diversity

- *A diverse economy will help weather economic downturns. Look beyond the traditional large fringe-located manufacturing business to support building up small businesses and entrepreneurs from within Topeka.*

The stormwater management approach established in TMC Chapter 13.35 and this Handbook support the Comprehensive Plan and the vision and pillars of Topeka's LUGMP (listed above) by:

- **Remaining generally consistent with stormwater requirements in other regional metropolitan communities**, such as Kansas City and Wichita. From a stormwater perspective, this will keep land development costs in line with surrounding communities.

- **Placing a high value on the preservation of natural hydrology and runoff volume reduction through strong encouragement for stormwater LID techniques and GI-BMPs.** This approach to stormwater management focuses on the reduction of stormwater runoff, preservation of natural hydrology, and use of stormwater as a resource, rather than a wastewater. When thoughtfully and properly applied, LID techniques and GI-BMPs can generally create more livable, interactive, multi-modal, and aesthetically pleasing developments. Additionally, the use of LID techniques and GI-BMPs can reduce the amount of stormwater infrastructure needed, and thus its life-cycle costs to both private property owners and the City of Topeka.

- **Identifying and clearing hurdles from planning and codes to facilitate the use of LID techniques and GI-BMPs more easily.** There is the potential for overlapping, and possibly conflicting, existing City regulations or inconsistencies among departments for project design approval(s) that may affect various aspects of LID techniques and GI-BMPs. Prior to development of this Handbook, the City completed a comprehensive evaluation to remove any hurdles and revise conflicts.

- **Recognizing that the redevelopment of existing, improved properties as a first-tier stormwater LID technique is preferable to the development of green space** (which contributes to higher volumes of runoff). Redevelopment is often challenging from a stormwater design perspective. However, Topeka's approach provides a high degree of flexibility for site designers and does not impose unattainable requirements.

- **Providing waivers of stormwater requirements where they are unnecessary.** This allows the use of existing infrastructure when feasible, thus limiting unnecessary increases in private and public infrastructure that must be maintained.

- **Linking stormwater management requirements to Topeka's desire for "Complete Streets" designs,** thus further encouraging the use of multi-objective, low-runoff urban and suburban transportation corridors.

When considering the vision and pillars adopted in the LUGMP, it is important to understand that many other factors influence why and how stormwater must be managed on an individual land development. These factors vary in scale, from project level (e.g., topography, grading, proposed land use), to local (e.g., zoning and subdivision regulations, land use plans, City services, stream impairments, areas of flooding), to regional or state (e.g., floodplain and levee management requirements). When considered together, these factors can seem like a complex web of objectives, sometimes with conflicting objectives, that must be addressed. However, TMC Chapter 13.35 and this Handbook strive to untangle the web into a comprehensive and coherent set of requirements for stormwater design at the site level. Toward this end, TMC Chapter 13.35 and the policies and guidance provided in this Handbook were developed after extensive analysis and review of:

- Topeka's requirements for stormwater quality as defined by its NPDES-MS4 Permit
- Stream pollutant impairments and Total Maximum Daily Loads (TMDLs) published by the USEPA and/or the KDHE
- Topeka's participation in the National Flood Insurance Program (NFIP) program
- The *Land Use and Growth Management Plan 2040*
- Land development approaches and practices and City land development codes, considering all the above, to eliminate hurdles and identify opportunities for the use of LID techniques and GI-BMPs

1.7 HOW TO USE THIS HANDBOOK

This Handbook must be used together with the city code sections it supports. In general, the codes sections establish the primary (and largely non-technical) requirements for stormwater management designs, buffer areas, and floodplains. The Handbook sets forth the technical requirements in the form of design or planning policies to support the code sections. Where necessary, this Handbook also provides design guidance to further assist site designers in site planning and stormwater design and provides explanatory text to allow full understanding of a particular requirement or concept.

Table 1-3 presents an overview of the design requirements, policies and guidance provided by the relevant codes and this Handbook, respectively. **Table 1-4** provides a description of each Handbook chapter.

Table 3-3: Summary of Code Requirements and Supporting Information Provided in the Handbook

Provision Established in Topeka Municipal Code	*Supporting Policies and Guidance Provided in the Handbook*
TMC Chapter 13.35 - Stormwater Management	
• Code applicability and waivers	• Provides technical information for stormwater quantity performance criteria and justification to support waiver for criteria by the director
• Requirement to comply with stormwater quality performance criteria	• Provides ample guidance for implementation of LID techniques, especially those identified in the *MARC/APWA BMP Manual* • Refers to *MARC/APWA BMP Manual* for compliance calculations and stormwater quality BMP design specifications
• Requirement to comply with stormwater quantity performance criteria	• Provides policies and guidance for compliance and design of stormwater quantity (detention/retention) BMPs

Provision Established in Topeka Municipal Code	Supporting Policies and Guidance Provided in the Handbook
• Requirement to select and design stormwater BMPs properly	• Provides detailed policies and guidance for the protection, selection, and design of BMPs
• Requirement for stormwater management plan approval	• Defines and describes the stormwater management plan, and references a detailed checklist of required plan elements
• Requirements for the Stormwater BMP Record Drawing	• Defines and describes the record drawing requirement and includes a detailed list of required record drawing elements • Defines the criteria for approval of record drawing
TMC Chapter 13.40 – Inspection and Maintenance of Stormwater BMPs	
• Requirements for inspection and maintenance of stormwater BMPs	• Directs the reader to the *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance*

Table 1-4: Summary of Handbook Chapters

Chapter and Description *(Regulatory = Enforceable Policy, Guidance = Design Assistance Information)*
Chapter 1. Introduction - Chapter 1 provides general information on the objective, purpose and use of the Handbook, and how it supports City codes for which it was developed.
Chapter 2. Stormwater Compliance Process and Plans *(Regulatory)* - Chapter 2 presents the process for design and construction compliance with Topeka Municipal Code pertaining to stormwater management, buffer area, and floodplain management. Relevant plans are described in detail along with enforceable policies on how each plan must be submitted to the City for approval.
Chapter 3. Stormwater Quality Design *(Regulatory and Guidance)* - Chapter 3 establishes the performance standard for stormwater quality design, and provides enforceable policies pertaining to the selection and design of stormwater quality BMPs. Extensive guidance with many pictorial examples is given on the considerations and best practices that site designers are encouraged to follow when developing a site plan and designing their stormwater BMPs.
Chapter 4. Stormwater Quantity Design *(Regulatory)* - Chapter 4 establishes the performance standards for stormwater quantity design, and provides enforceable policies pertaining to the design of detention and retention BMPs to meet these criteria.
Chapter 5. Low Impact Development *(Guidance)* - Chapter 5 provides substantial information and links to other resources pertaining to stormwater LID techniques. It outlines detailed guidance on the LID process and on specific techniques and the incentives associated with using them.
Appendices *(Regulatory and Guidance)* - The appendices provide a variety of design support tools and policies to be used for the preparation of plans and BMP designs. This includes regulatory definitions, record drawing checklists, and design procedure and certification forms.

1.8 COMPANION MANUALS FOR STORMWATER DESIGN

Relevant to the design, construction, protection and maintenance of stormwater quality BMPs, the policies and guidance in this Handbook refer to the *Mid-America Regional Council and American Public Works Association Manual of Best Management Practices for Stormwater Quality*, henceforth referred to as the *MARC/APWA BMP Manual*. **Where referenced, the latest version of the *MARC/APWA BMP Manual* shall be used.**

Relevant to the design of stormwater quantity BMPs (detention and retention facilities), significant portions of this Handbook were adapted or copied from the *Kansas City Metro Chapter of the America Public Works Association Specifications, Section 5600 Storm Drainage Systems and Facilities*, henceforth called *APWA 5600*. The text from *APWA 5600* was suitably modified to meet the City of Topeka's stormwater goals. This paragraph serves as an acknowledgement of the use of text from *APWA 5600,* and a reference to it as a source of information provided in the reference Section of this Handbook. References to *APWA 5600* specifically will not be made individually within the text of his Handbook.

1.9 CITY CONTACT INFORMATION

This Handbook was developed and is administered by the City of Topeka Department of Utilities. Questions about this Handbook and/or TMC Chapter 13.35 should be directed to the email address below. Please provide sufficient detail to enable the email to be routed to the appropriate City staff.

Stormwater Management Section
City of Topeka Utilities Department
Email: stormwater@topeka.org

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2 Stormwater Design Process & Plans

2.1 PURPOSE

The purpose of this chapter is to define the City of Topeka's regulatory process for stormwater site planning, design, and construction termination. This chapter was developed to advise and support developers and site designers as they create site designs that comply with the City's stormwater regulations.

2.2 KEY CONCEPTS FOR THE STORMWATER DESIGN PROCESS

Effective stormwater management on a land development requires a site designer's forethought and sound knowledge of:

- ✓ The regulations, plans, and other initiatives that regulate or influence stormwater system design
- ✓ The hydrology and hydraulics of the land development site
- ✓ The site's potential stormwater impacts on downstream properties

It also requires consideration of the needs of all relevant stakeholders:

- ✓ The developer (and sometimes investors), who has the vision and purpose for the development, as well as a significant financial stake in its success
- ✓ The site designer, who is tasked with carrying out the developer's vision in accordance with applicable City codes and policies
- ✓ The City of Topeka, who oversee public health and safety concerns and ensures compliance with the Comprehensive and Land Use Plans by determining whether the design/construction complies with city codes and policies
- ✓ State and federal regulatory agencies, who ensure compliance with relevant state and federal regulations and permits
- ✓ Future property owners, who will be responsible for the inspection and maintenance of onsite stormwater systems after they are constructed

To meet the needs of all stakeholders, several questions must be considered and answered before the site layout and stormwater designs for a land development take shape:

- ✓ How can the site be designed to meet Topeka's stormwater management requirements most effectively without negatively impacting the overall vision and economic model of the developer/investor?
- ✓ What are the opportunities for utilizing stormwater LID and/or GI-BMPs? Are there incentives, such as a landscape credit, offered by the City for these opportunities? Are they feasible? Do they make sense for the developer's cost model? Are they appropriate for future property owners?
- ✓ Which BMPs for stormwater quality and quantity control are most practicable for the future land use and owners, given that future owners will be responsible for their continued protection, inspection, and maintenance?

The stormwater management planning and design process described in this Chapter is designed to achieve the goals for the key stakeholders of stormwater design and construction. The stakeholders and goals are described in **Table 2-1**.

Table 2-1: Stormwater Design Process Support for Land Development Stakeholders

Key Stakeholder Group	Process Goal
Developers and Site Designers	• Provide an organized way to answer the key stormwater design questions (see above) and plan, design, and construct land developments that are cost-effective, value-optimized, and compliant with City code • Provide a fair, consistent, and documented process for design and construction of stormwater BMPs
City of Topeka	• Provide a reasonable level of consistency and uniformity in site planning and plan preparation and approval • Encourage designs that result in less stormwater runoff • Comply with state and federal stormwater and floodplain management requirements • Set the stage for City's administration of long-term stormwater system maintenance requirements
Future Property Owner	• Provide a clear starting point for long-term protection, inspection and maintenance of stormwater BMPs in a manner that assures the site's stormwater system is properly constructed and functional upon the completion of construction

To achieve these goals, the City uses a comprehensive site planning, design, and construction process that involves the following key components:

1. A **pre-design hydrologic characterization activity** for early evaluation of 1) a site's existing site hydrology; 2) opportunities for cost-saving LID techniques; and 3) feasibility for the use of GI-BMPs for stormwater quality treatment and volume reduction. *This activity is strongly encouraged but is not required by the City for stormwater management plan approval.*

2. A **stormwater management plan checklist** provides clear direction to the site designer for plan preparation and will result in consistent, comprehensive, and readable design plans for City plan reviewers, resulting in a focused, efficient plan approval process.

3. A **stormwater as-built plan checklist and final approval process** documents the constructed stormwater BMPs and ensures they are in proper functional condition prior to takeover by a subsequent property owner. An as-built drawing checklist and final inspection checklist is provided in this Handbook to facilitate and document this process.

2.3 PROCESS FLOWCHARTS

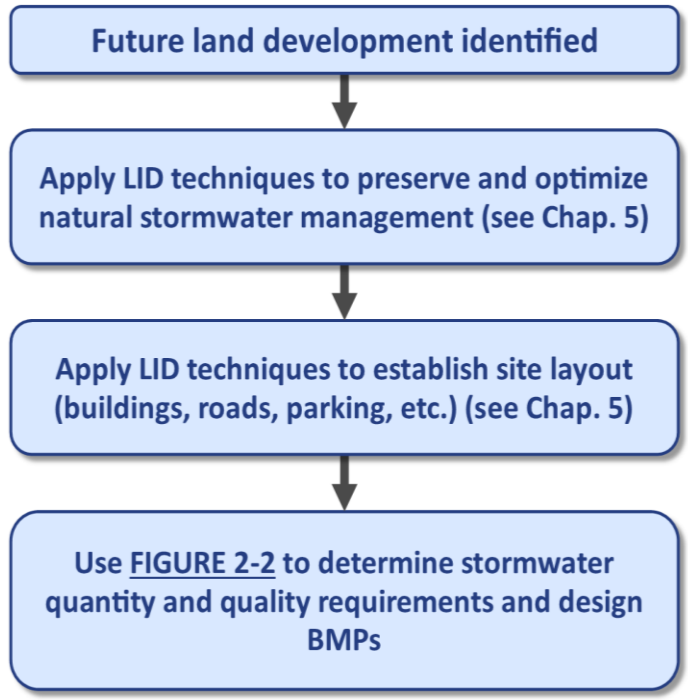
The general process for stormwater planning, design, and construction in the City of Topeka is shown graphically in this Section using flowcharts. Key details within the process, such as project applicability to TMC Chapter 13.35, are shown in greater detail to facilitate reader understanding. The flowcharts start at the point of initial consideration of the property by a developer to the time that a Certificate of Occupancy is obtained after construction is complete.

2.3.1 The Pre-Design Process (Hydrologic Characterization)

Site designers are strongly encouraged to perform a stormwater pre-design process targeting the use of stormwater LID techniques. **Figure 2-1** presents the general concept of the process, while much more detail is provided in Chapter 5. Using a pre-design process, designers can potentially reduce the cost of stormwater management on an applicable development by characterizing the hydrology of a site *prior* to its design.

Pre-design hydrologic characterization should occur very early in the site planning process, ideally before the layout of future buildings, pavement, and pervious areas is prepared, and before clearing, grading, and construction begin. This allows designers to maximize the use of stormwater LID techniques and natural features for stormwater management. This also keeps the stormwater volume generated by a future development as low as possible. In turn, lower volumes can mean the stormwater quality and quantity BMPs and conveyance system can be smaller and less costly to construct and maintain. Lower stormwater volumes can also minimize the ever-increasing demand placed on an aging, and often undersized, public stormwater conveyance system. Further, for non-residential developments, the use of LID techniques for site designs often results in smaller amounts of impervious areas, and thus smaller stormwater utility fees (since the fees are proportional to the amount of impervious area).

Figure 2-1. Stormwater Pre-Design Process Flowchart



Performing a pre-design hydrologic characterization of an applicable development is not mandatory. However, as a best practice for stormwater management design, it is strongly encouraged by the City of Topeka. More information on pre-design hydrologic characterization, stormwater LID techniques, and the use of natural areas for stormwater management are provided in Chapter 5 of this Handbook.

2.3.2 Stormwater Performance Standard Applicability

Figure 2-2 depicts the flow of criteria, exemptions, and waivers that determine whether stormwater quality and quantity performance standards are applicable to a specific land development project. The figure is a graphical depiction of TMC Chapter 13.35.010 and portions of TMC Chapter 13.35.020.

2.3.3 The Stormwater Plan Approval and Construction Process

Figure 2-3 depicts the process for City review and approval of stormwater management (i.e., design) plans submitted by designers, construction inspection and enforcement, and the construction termination process. More information on the plan requirements are provided in Section 2.4.

Figure 2-2. Stormwater Performance Standard Applicability Flowchart

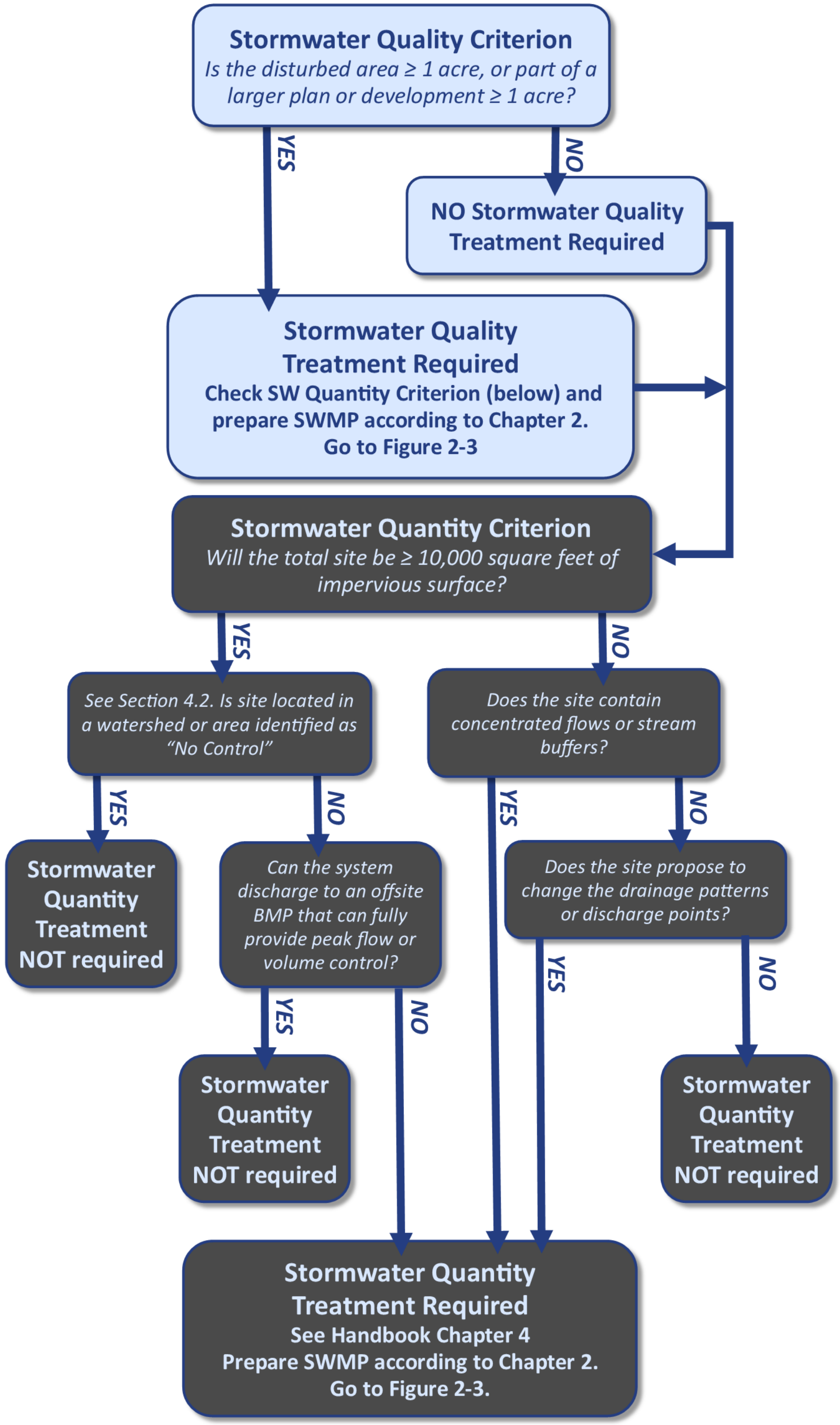
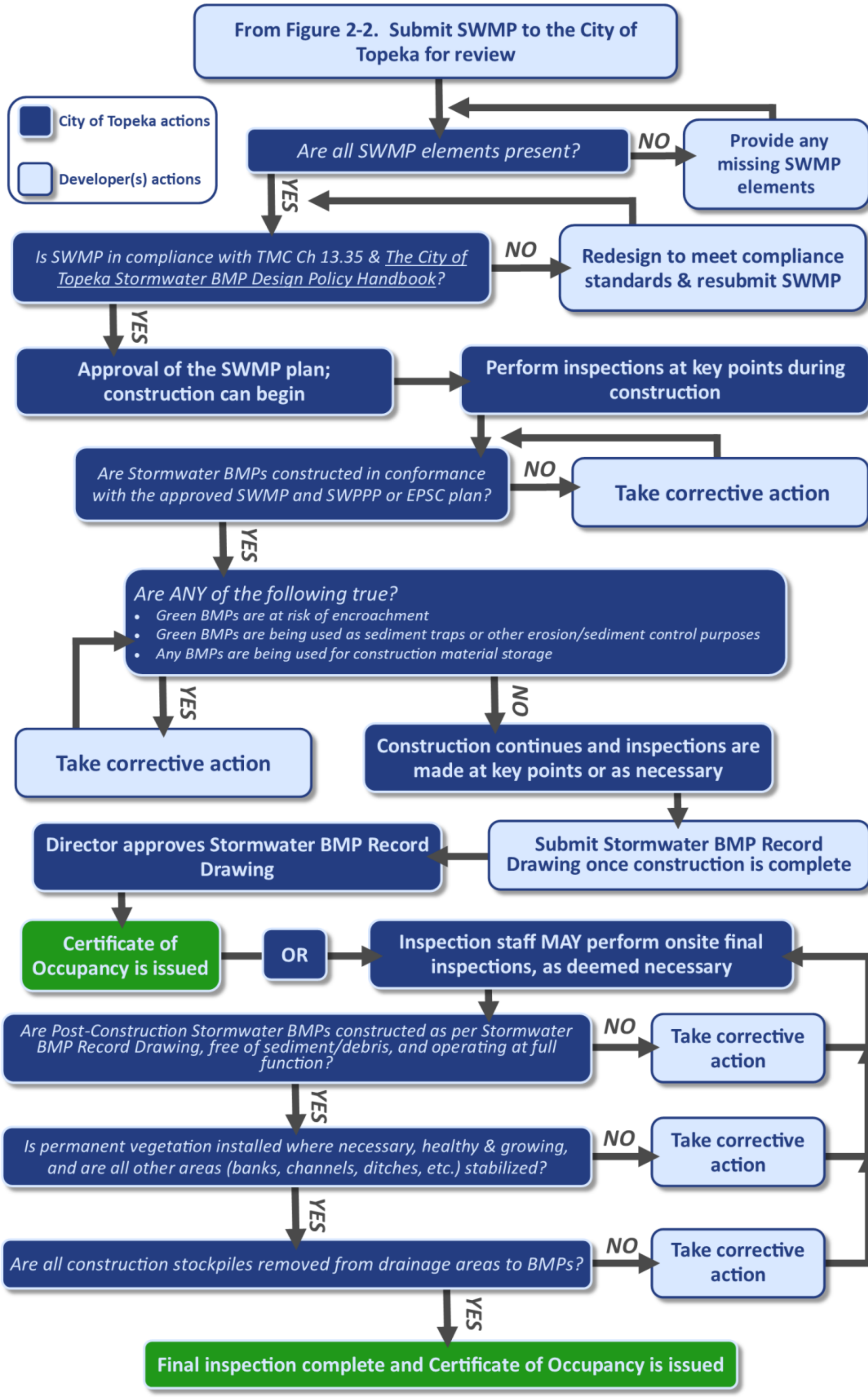


Figure 2-3. Topeka Stormwater Design and Construction Process Flowchart



2.4 THE STORMWATER MANAGEMENT PLAN

2.4.1 Description

The Stormwater Management Plan (SWMP) is the engineering plan that describes the site designer's approach for achieving the stormwater performance standards established in Chapters 3 (quality) and 4 (quantity) of this Handbook. It is submitted and must be approved by the director prior to the commencement of construction of a project. The SWMP includes what (in Topeka) has traditionally been called "the drainage report," addressing stormwater quality (pollutants) and/or quantity (peak flow, volume) designs. Generally, a fully completed SWMP will provide: descriptions and technical data on how the hydrologic characteristics of the site will change as a result of the proposed land development; descriptions, data, and calculations showing how the performance standards for stormwater will be achieved (or proof of eligibility for a performance standard waiver); and, detailed descriptions and design information for the stormwater BMP(s) and conveyance system to be permanently located onsite once construction is complete.

2.4.2 Policies

The following policies shall apply to the preparation, submittal, and approval of SWMP, and are established pursuant to TMC Chapter 13.35.

1. **Requirement for complete plan.** A complete SWMP is necessary for plan review. Omission of any required elements of a SWMP may delay plan review and issuance of a related local permit or authorization to commence land disturbance. In the event an incomplete plan is submitted, the applicant will be advised of SWMP deficiency(s) and requested to supply the missing elements.
2. **Required plan elements.** A complete SWMP consists of the elements listed in the Stormwater Management Plan Checklist provided by the City (see Utilities Department website), as are applicable to the project shown in the SWMP. The checklist lists the required narrative reports and maps and includes specific and detailed lists of required elements for each plan section. A SWMP prepared in keeping with the checklist will facilitate an efficient plan review. Applicants are encouraged to use the checklist to prepare their SWMPs.
3. **Approval.** A SWMP will be approved upon confirmation by the director that it and the maps, data, designs, and calculations, as applicable, provided therein comply with applicable codes and policies set forth in this Handbook.

2.5 STORMWATER BMP RECORD DRAWING

2.5.1 Description

Proper maintenance of stormwater quality and quantity BMPs is one of the most important factors in the long-term performance and effectiveness of the design presented in an approved SWMP. BMPs constructed on private property are not owned nor maintained by the City. Rather, TMC Chapters 13.35 and 13.40 establish the responsibility for their protection, inspection, and maintenance with the property owner.

To facilitate the maintenance of stormwater BMPs by a property owner, TMC Chapter 13.35 requires Stormwater BMP Record Drawing for every project that includes BMPs. The record drawing is submitted to the director for review and approval at the completion of project construction. It is recorded as a covenant running with the land. As a recorded covenant, the Stormwater BMP Record Drawing is the legal documentation of the BMPs on the property. It will be used by the City of Topeka to track and enforce BMP maintenance, as is required of the City by the Kansas Water Pollution Control Municipal Separate Storm Sewer System (MS4) Permit (Kansas Permit No. M-KS72-SO01). As private property is transferred, the legal covenant will also transfer to the new owner during a property's title closing. Owners can also access the Stormwater BMP Record Drawing via the Shawnee County Register of Deeds. Periodically, they may also receive a reminder of their responsibilities for BMP inspection and maintenance by the City of Topeka.

The Stormwater BMP Record Drawing includes several major components summarized below. More detail on each component is provided in the Stormwater BMP Record Drawing Checklist, provided in Appendix B.

- The **BMP location map** is a clear and accurate map showing the type and location of all stormwater BMPs constructed or installed on a property, and all stream buffers and natural or man-made waterbodies. It must be easily read by a layperson as this will be the primary map used by future property owners to understand what BMPs exist on their property and where. An example BMP location map is provided in **Figure 2-4**.
- The **Stormwater BMP Certification Statement** is the document signed and stamped by the Kansas-licensed professional Landscape Architect or Civil Engineer responsible for the project to certify proper construction, function and cleanliness of each BMP shown in the record drawing. The template to be used for the certification statement is included in Appendix D.
- **As-built plans** fully and accurately depict the "as-constructed" condition of every stormwater BMP constructed on the project. It will include significant technical detail, similar to a construction drawing. An as-built plan will be provided for each stormwater BMP on the property.
- **BMP planting plans** provide a detailed description of the vegetation composition and arrangement for each vegetated BMP. Like the BMP location map, the planting plans must be easily readable, and free of unnecessary or overly technical detail other than specification of particular plant species. A BMP planting plan will be provided for each vegetated BMP on the property. More information about BMP planting plans is provided in the next Section.

The level of detail required in each component should facilitate the understanding by future property owners about the stormwater BMPs they own and where they are located. In turn, the owner can determine the inspection and maintenance requirements of each BMP using TMC Chapter 13.40 and its reference manual, *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance*.

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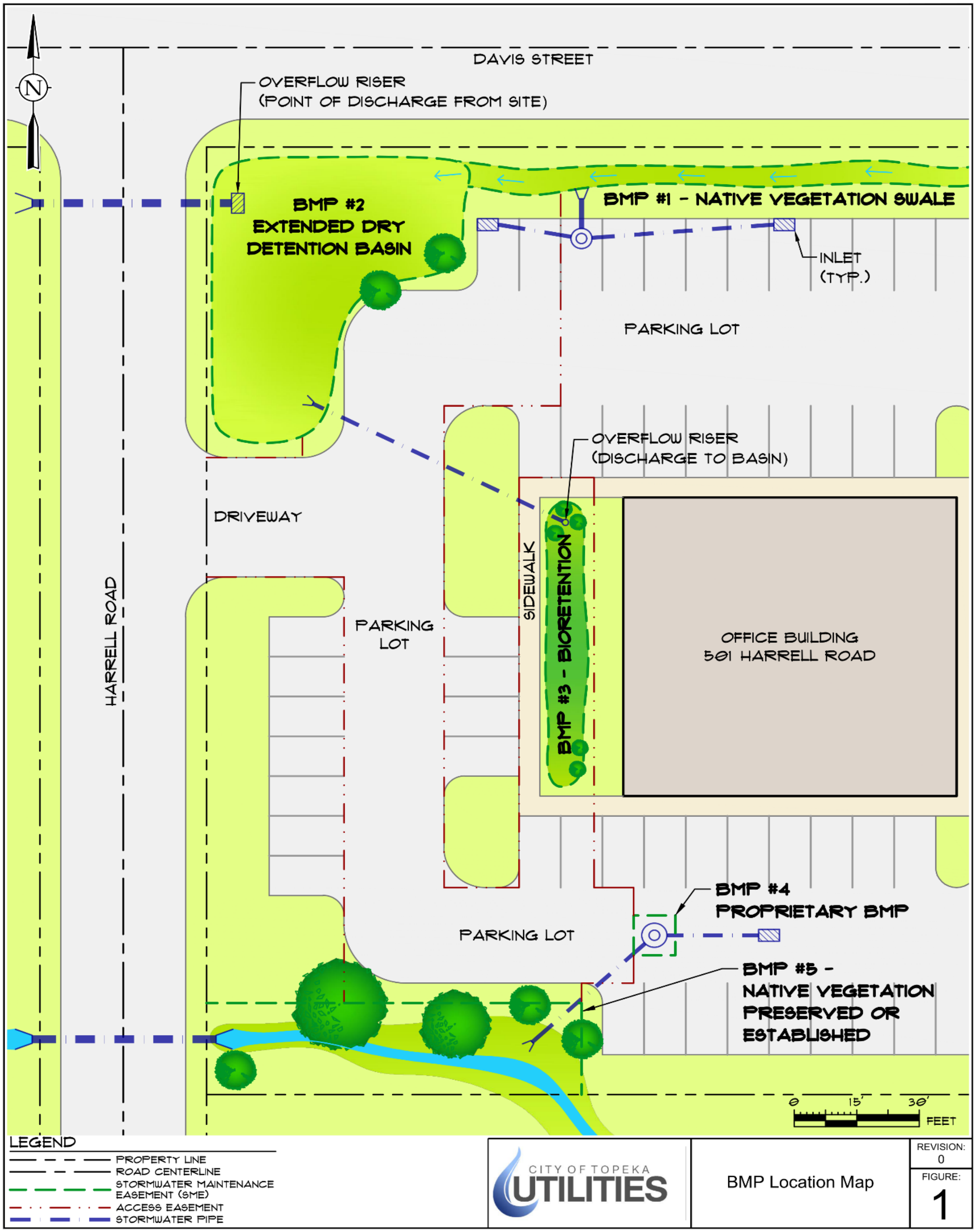
Figure 2-4. Example of a BMP Location Map



2.5.2 Policies

The following policies shall apply to the Stormwater BMP Record Drawing and are established pursuant to TMC Chapter 13.35.

1. **Requirement to include all stormwater BMPs**. The Stormwater BMP Record Drawing shall describe all the following BMPs:
    a. Stormwater quality BMPs constructed or installed for purposes of meeting the stormwater quality performance standard (see Chapter 3)
    b. Stormwater quantity BMPs (detention or retention basins) constructed or installed to meet the stormwater quantity performance standard (see Chapter 4)
    c. Existing stormwater BMPs located on the property that will remain and function after stormwater is complete
2. **Submittal timeframe**. A Stormwater BMP Record Drawing shall be submitted after construction of the project is, at a minimum, substantially complete as defined below:
    a. Construction of all outdoor areas is finished, including excavation, grading, paving, and exterior landscaping
    b. The stormwater conveyance system and permanent stormwater quality and quantity BMPs are fully installed, fully vegetated (if appropriate for the BMPs), are clean, free of sediment, trash, and debris, undamaged, and are operating at fully functional design capacity
    c. All pervious areas draining to GI-BMPs shall be 100% stabilized, while areas draining to conventional BMPs or manufactured BMPs shall be at least 70% stabilized
    d. Any remaining construction materials stockpiles and waste storage areas are not exposed to rainfall or stormwater
    e. Construction in the building interior may still be ongoing
3. **Required elements.** A complete Stormwater BMP Record Drawing consists of the elements listed in the Stormwater BMP Record Drawing Checklist provided in Appendix B, as applicable to project. A drawing prepared in keeping with the checklist will facilitate an efficient review. Omission of any required, applicable elements of a drawing may delay its review and issuance of a related local permit, inspection, or authorization. Submittal of the checklist itself with the record drawing is not required.
4. **Approval.** A SWMP will be approved upon confirmation by the director that it and the maps, data, designs, and certification, as applicable, provided therein comply with applicable codes and policies set forth in this Handbook.

2.5.3 Stormwater BMP Planting Plan

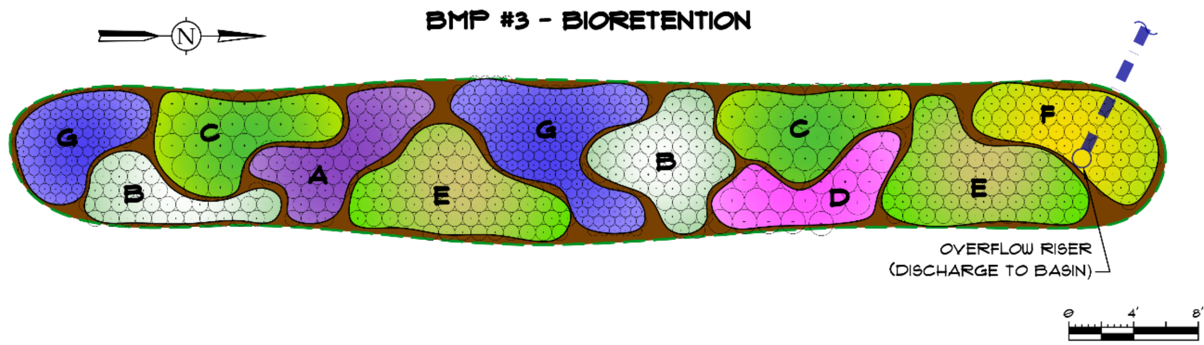
Many stormwater BMPs are vegetated. The overall goals for the vegetation are stormwater pollution treatment and erosion prevention. For this reason, the *MARC/APWA BMP Manual* includes extensive information on planting and managing vegetation for BMPs, especially native plants. The coverage and types of plants that a designer specifies for use within and around a BMP depend as much on the stormwater management mechanisms employed by the BMP as the desired landscape aesthetic for the property. General BMP policies are addressed in Section 3.5 of this Handbook.

A stormwater BMP planting plan is required for every vegetated BMP. The plan is submitted as part of the SWMP and then again as part of the Stormwater BMP Record Drawing. The required elements for a BMP Planting Plan are listed in the SWMP Checklist (provided on the Utilities Department website) and the Stormwater Record Drawing Checklist (provided in Appendix B). At a minimum, the plan must describe the plant materials used, by both the common and scientific names. However, there is no set format for a planting plan, provided they include the required elements. The detail of each plan will depend on the type of vegetated BMP selected, and the diversity of plants within the BMP.

For example, BMPs such as bioretention and rain gardens are planted with a mix of shrubs, grasses, and in some cases, one or more trees. This plant diversity allows the BMP to reduce runoff and manage stormwater pollutants through infiltration, evapotranspiration, and erosion prevention. This diversity is shown in **Figures 2-5** and **2-6**, which are example BMP planting plans for two of the BMPs in the location map shown previously. Other BMPs, such as an extended dry detention basin, require much less diverse vegetation, usually just a managed native vegetation, such as a sedge. The stormwater quality management goals for this BMP are pollutant settling and erosion prevention. An example of a sufficiently detailed planting plan for a vegetated BMP (not a GI-BMP) is provided in **Figure 2-7**.

Figure 2-5. BMP Planting Plan Example 1 (Bioretention)

BMP #3 - BIORETENTION



PLANT SCHEDULE

IDEN.	SCIENTIFIC NAME	COMMON NAME	NATIVE	QUANTITY	COLOR	SPACING	HEIGHT
A	BAPTISIA AUSTRALIS	BLUE FALSE INDIGO	YES	50	PURPLE	12" OC	2-4 FT
B	PENSTEMON DIGITALIS	FOXGLOVE BEARDTONGUE	YES	90	WHITE	12" OC	2-3 FT
C	SPOROBOLUS HETEROLEPSIS	PRAIRIE DROPSEED	YES	43	GREEN	18" OC	1-3 FT
D	ASCLEPIAS INCARNATA	SWAMP MILKWEED	YES	20	PINK/PURPLE	18" OC	3-5 FT
E	CAREX VULPINOIDEA	FOX SEDGE	YES	142	TAN	12" OC	2-3 FT
F	RUDBECKIA FULGIDA SPECIOSA	SHOWY BLACK-EYED SUSAN	YES	54	YELLOW	12" OC	2-3 FT
G	GENTIANA ANDREWSII	BOTTLE GENTIAN	YES	262	BLUE	8" OC	1-2 FT

NOTES:

1. PLANTING SHALL TAKE PLACE IN THE SPRING (APRIL 1 TO JUNE 1) OR IN THE FALL (SEPT 1 TO OCT 1). REMOVE UNWANTED VEGETATION PRIOR TO PLANTING.
2. APPLICANTS ARE ENCOURAGED TO OBTAIN PLANT WARRANTIES (TYPICALLY THROUGH 2 GROWING SEASONS). THE WARRANTY PERIOD, TERMS, AND CONDITIONS SHOULD BE STATED IN WRITING (E.G. "THE WARRANTY PERIOD FOR ALL PLANTS IN BMP #2 IS PROVIDED BY <INSERT NAME OF WARRANTOR> AND COVERS TWO YEARS FROM PURCHASE DATE OF <MONTH, DAY, YEAR>"). BE SURE TO PRESERVE ANY WARRANTY INFORMATION NEEDED TO ACTUATE THE WARRANTY (E.G., PURCHASE RECEIPTS, PLANT INSTALLATION CONTACTOR WARRANTY STATEMENT, ETC.).

LEGEND

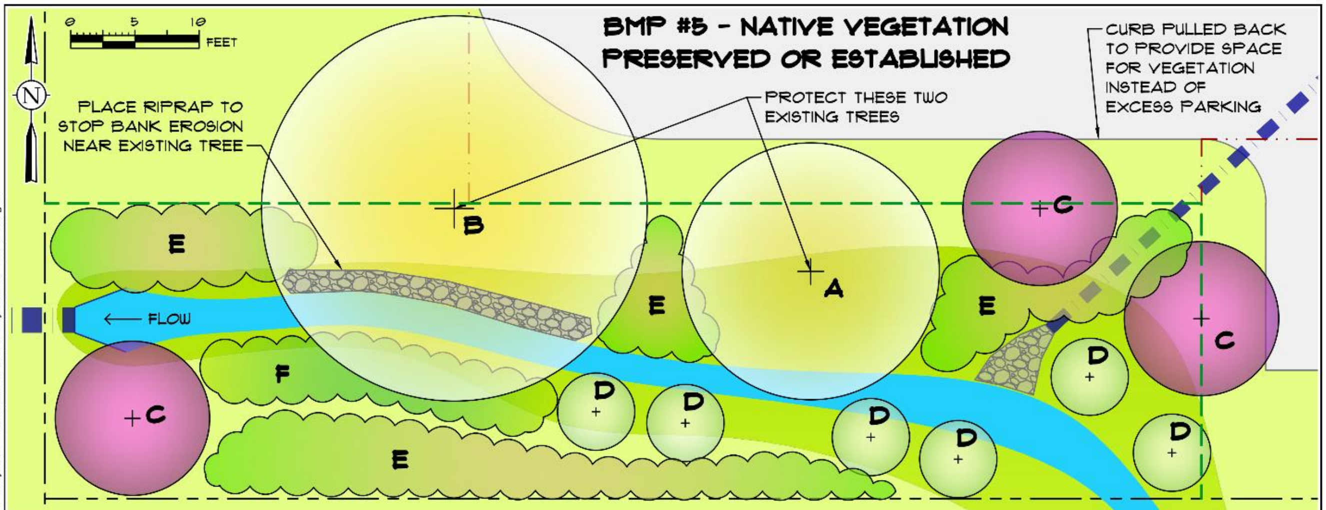
- STORMWATER MAINTENANCE EASEMENT (SME)
- STORMWATER PIPE
- PLANTS (REFER TO SCHEDULE FOR TYPE AND SPACING)

CITY OF TOPEKA UTILITIES

Planting Plan
BMP #3
Bioretention

REVISION: 0
FIGURE: 2

Figure 2-6. BMP Planting Plan Example 2 (Native Vegetation Swale)



PLANT SCHEDULE

TREES / SHRUBS

IDEN.	SCIENTIFIC NAME	COMMON NAME	NATIVE	QUANTITY	COLOR	SPACING	HEIGHT
A	BETULA NIGRA	RIVER BIRCH	YES	1 (EXIST.)	CREAM	20 FT OC	30-40 FT
B	TILIA AMERICANA	AMERICAN LINDEN	YES	1 (EXIST.)	CREAM	30 FT OC	50-60 FT
C	CERCIS CANADENSIS	REDBUD	YES	3	PINK	15 FT OC	10-20 FT
D	CEPHALANTHUS OCCIDENTALIS	BUTTONBUSH	YES	6	WHITE	7.5 FT OC	5 - 10 FT

GRASSES / SEDGES

IDEN.	SCIENTIFIC NAME	COMMON NAME	NATIVE	QUANTITY	COLOR	SPACING	HEIGHT
E	CAREX VULPINOIDEA	FOX SEDGE	YES	250	TAN	1.5 FT OC	2-3 FT
F	SCIRPUS ATROVIRENS	GREAT GREEN BULLRUSH	YES	50	GREEN	1.5 FT OC	2-3 FT

NOTES:

1. PLANTING SHALL TAKE PLACE IN THE SPRING (APRIL 1 TO JUNE 1) OR IN THE FALL (SEPT 1 TO OCT 1). REMOVE UNWANTED VEGETATION PRIOR TO PLANTING.
2. APPLICANTS ARE ENCOURAGED TO OBTAIN PLANT WARRANTIES (TYPICALLY THROUGH 2 GROWING SEASONS). THE WARRANTY PERIOD, TERMS, AND CONDITIONS SHOULD BE STATED IN WRITING (E.G. "THE WARRANTY PERIOD FOR ALL PLANTS IN BMP #2 IS PROVIDED BY <INSERT NAME OF WARRANTOR> AND COVERS TWO YEARS FROM PURCHASE DATE OF <MONTH, DAY, YEAR>"). BE SURE TO PRESERVE ANY WARRANTY INFORMATION NEEDED TO ACTUATE THE WARRANTY (E.G., PURCHASE RECEIPTS, PLANT INSTALLATION CONTACTOR WARRANTY STATEMENT, ETC.).

LEGEND

- PROPERTY LINE
- STORMWATER MAINTENANCE EASEMENT (SME)
- ACCESS EASEMENT
- STORMWATER PIPE
- RIPRAP / STONE
- TREE OR SHRUB PLANTING (REFER TO SCHEDULE FOR TYPE AND SPACING)
- AREA OF SMALL PLANTINGS (REFER TO SCHEDULE FOR TYPE AND SPACING)

CITY OF TOPEKA UTILITIES

Planting Plan
BMP #5
Native Vegetation
Preserved or Established

REVISION: 0

FIGURE: 3

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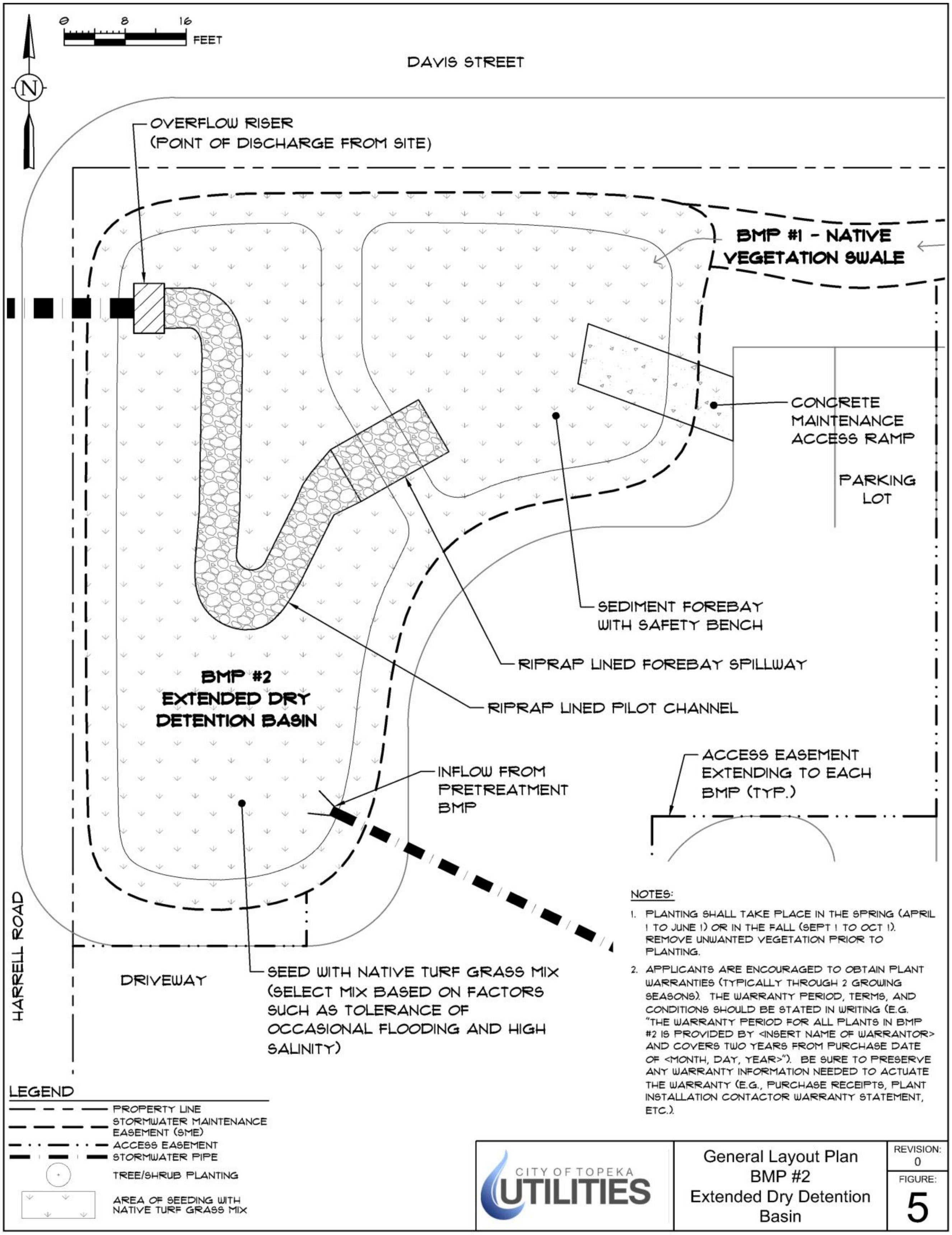
Figure 2-7. BMP Planting Plan Example 3 (Extended Dry Detention Basin with Native Grasses)



2.6 STORMWATER BMP RECORD DRAWING INSPECTION

2.6.1 Description

An inspection of the constructed stormwater quality and quantity BMPs and stormwater conveyance system may be conducted by the City ***after*** the director's satisfactory desktop review of the Stormwater BMP Record Drawing. When performed, the purpose of this inspection is two-fold:

1) The inspection will generally verify the accuracy of information provided in the record drawing.

2) The inspection will evaluate the cleanliness and functionality of the constructed stormwater BMPs and drainage system.

TMC Chapter 13.35 requires all stormwater BMPs and onsite stormwater conveyance system "*be clean, free of sediment, trash and debris, undamaged and operating at fully functional design capacity*" at the time the developer considers construction to be (substantially) complete. A final inspection based on this requirement ensures that the property owner will have a clean and properly functioning BMP at the time they assume responsibility for post-construction maintenance of stormwater BMPs.

2.6.2 Policies

The following policies shall apply to the Stormwater BMP Record Drawing inspection and are established pursuant to TMC Chapter 13.35.

1. **Criteria for Stormwater BMP Record Drawing inspection.** The receipt of a Stormwater BMP Record Drawing indicates to the director that construction of the project is complete, or substantially so, and the project is ready for an inspection of stormwater quality and quantity BMPs and the stormwater conveyance system. The director may perform such an inspection. The director will examine the stormwater BMPs and the stormwater conveyance system to determine if they meet the criteria below:

    a. Said BMPs and systems must be fully constructed, undamaged, and free of construction sediment, debris, and other items that can cause blockages, reduce functionality, or pollute BMPs and/or system capacity and/or discharges, or attract mosquitos or other nuisance animals.

    b. Sediment must be removed from stormwater BMPs used during construction as a sediment trap (typically, this will be detention or retention basins). The BMP must have full storage capacity at the time of final inspection as indicated in the approved SWMP.

    c. Permanent vegetation must already be installed in all vegetated areas, including in vegetated BMPs. Vegetation must appear healthy and growing. Areas of bare soil cannot be present.

    d. Construction and landscape materials stockpiles are not allowed, and must not present, within the drainage areas to stormwater BMPs or within the BMPs themselves.

    e. None of the prohibited conditions for stormwater BMPs, as established in TMC Chapter 13.35, can be present unless such conditions are included (by variance) in the approved SWMP.

2. **When corrective actions are required.**

    a. Any of the following circumstances shall result in the requirement(s) for corrective action(s), either to modify the Stormwater BMP Record Drawing and/or correct an issue with the stormwater BMPs or conveyance systems. The applicant is responsible for making all corrective actions:

i. The as-built plan indicates a BMP or drainage system has not been constructed in accordance with an approved SWMP, or the BMP or system does not comply with the stormwater performance standards required for the project.

ii. The inspection indicates the BMP or drainage system has not been constructed in accordance with an approved SWMP.

iii. The inspection indicates the BMP or drainage system or any area draining to the BMP or system requires cleaning, maintenance, or repair to ensure their full functionality and proper operating condition. The BMP and system must be clear of sediment, debris, trash and other items.

iv. The inspection indicates the pervious areas of the land development are not fully vegetated or sufficiently stabilized to prevent soil erosion and control sediment discharges into stormwater BMPs or the conveyance system, whether located onsite or offsite.

v. Other conditions that could negatively affect the operation or function of the BMPs and systems.

b. When corrections to the record drawing are required, the entire revised drawing must be resubmitted, unless the director specifies otherwise.

c. When corrective actions are required and result in alteration of a stormwater BMP or the conveyance system, the applicant may be required to revise and resubmit a stormwater record drawing and/or SWMP. It is not necessary to resubmit the record drawing for corrective actions that clean or repair a BMP or system component and do not result in an alteration from the approved design of the BMP or system.

d. The director may require a follow-up inspection to confirm satisfactory results of corrective actions.

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3 Stormwater Quality Design

3.1 PURPOSE

TMC Chapter 13.35 requires applicable developments to be designed to meet or exceed a stormwater quality performance standard. This chapter establishes the performance standard and other requirements for stormwater quality management, and provides detailed policies and guidance on the selection, location, protection, and design of stormwater quality BMPs.

3.2 ENCOURAGEMENT FOR LOW IMPACT DEVELOPMENT

TMC Chapter 13.35 encourages the use of LID techniques to preserve or promote the natural infiltration of stormwater. Further encouragement is provided by the stormwater quality performance standard, which relies on the Level of Service (LS) Method described in the *MARC/APWA Manual of Best Management Practices for Stormwater Quality*. Using the LS method, a less intensive mitigation design package is needed for developments that have site plans with low impervious surface area and large areas of preserved, natural land cover.

Infiltration of rainfall and stormwater through minimal use of impervious surfaces and preservation of uncompacted native soil and vegetation is ultimately beneficial to applicable developments, City residents, and businesses. Natural infiltration reduces the stormwater volume and peak flows that must be managed onsite and delivered offsite to the public stormwater system, and ultimately to local streams and rivers. LID techniques are most successful when applied early in site design, ideally when the designer begins to determine the locations and extents of the buildings and pavements to be constructed. More detailed information on LID is provided in Chapter 5 of this Handbook.

The City of Topeka would like to know when a designer uses LID techniques in a project design as a way to reduce stormwater volume. This knowledge can be used by the City to understand which techniques are most useful to Topeka designers and potentially find ways to incentivize these techniques in the future. It should be noted that the MARC Manual provides the highest Value Rating (VR) for the use of the non-structural or LID technique of "Native Vegetation Preserved or Established." **Designers that use LID techniques are encouraged to document the techniques in the LID Technique Form and provide it with the SWMP.** A blank copy of the LID Technique Form is provided in Appendix C.1.

3.3 PERFORMANCE STANDARD AND GENERAL POLICIES

The following policies govern the design of stormwater BMPs for purposes of stormwater quality control. These policies can be enforced pursuant to TMC Chapter 13.35.

1. **Stormwater quality performance standard defined.** Applicable developments shall be designed and constructed to meet or exceed the Level of Service (LS) required for the site as evaluated using the Level of Service Method described in the most recent version of the *MARC/APWA Manual of Best Management Practices for Stormwater Quality* (henceforth *MARC/APWA BMP Manual*). The Overall Value Rating established in **Table 3-1** shall be used to develop a project's design mitigation package.
2. **Required design specifications and design procedure.** Stormwater quality BMPs shall be designed in accordance with the requirements of this Handbook, the design specifications in the *MARC/APWA BMP Manual* (most recent version), and the BMP Design Procedure Forms located in Appendix E of this Handbook.

3. **Alternative designs allowed.** Methods, designs, or technologies for stormwater quality BMPs not included in the *MARC/APWA BMP Manual* may be submitted for approval if the applicant can show, by submittal of an engineering study, such alternative methods, designs, or technologies will meet or exceed the stormwater quality performance standard.

Table 3-1. Stormwater Quality BMP Value Ratings (adapted from *MARC/APWA BMP Manual*, 2012)

Cover Type or BMP	Median Expected Effluent EMC TSS (mg/L)*	Value Ratings				Overall Value Rating
		Water Quality Value	Volume Reduction	Temp. Reduction	Oils/ Floatables Reduction	
Native Vegetation Preserved/Established	N/A	5.25	2	1	1	**9.25**
Rain Garden	< 10	4	2	1	2	**9.0**
Infiltration Basin	< 10	4	2	1	2	**9.0**
Infiltration Trench	< 10	4	2	1	2	**9.0**
Bioretention	< 10	4	1.5	1	2	**8.5**
Pervious Concrete	10 - 20	3	1.5	1	2	**7.5**
Porous Asphalt	10 - 20	3	1.5	1	2	**7.5**
Modular Concrete Block	10 - 20	3	1.5	1	2	**7.5**
Extended Detention Wetland	< 10	4	2	0	1	**7.0**
Surface Sand Filter	< 10	4	0	0	2	**6.0**
Underground Sand Filter	< 10	4	0	0	2	**6.0**
Pocket Sand Filter	< 10	4	0	0	2	**6.0**
Perimeter Sand Filter	< 10	4	0	0	2	**6.0**
Extended Wet Detention Basin	10 - 20	3	2	-1	1	**5.0**
Vegetated Filter Strip	10 - 20	3	1	0	1	**5.0**
Extended Dry Det. Basin (Native Veg.)	20 - 50	3	1	0	0	**4.0**
Extended Dry Det. Basin (Non-Native Veg.)	20 - 50	2	0	0	0	**2.0**
Native Vegetation Swale	10 - 20	3	1	0	0	**4.0**
Non-Native Grass Vegetation Swale	10 - 20	1.5	0	0	0	**1.5**
Other Systems ***(Manufactured Treatment Devices)***	10 - 100	1 – 3	0	0	2	**3.0 - 5.0**
- Proprietary Media Filtration Devices **- Hydrodynamic Devices** **- Baffle Boxes** **- Catch Basin Inserts**	Approved on a case-by-case basis. See Section 3.6 for design requirements.					
Green Roofs	No VR; Post-construction CN credit; See *MARC/APWA Manual*					
Cisterns	No VR; Post-construction CN credit; See Appendix F					

* TSS (Total Suspended Solids); mg/L (milligrams per liter); EMC (Event Mean Concentration); See *MARC/APWA BMP Manual* for more information on the derivation of the Value Ratings and source of TSS EMC data for most BMPs.

3.4 GUIDANCE ON GREEN INFRASTRUCTURE BMPS

3.4.1 Encouragement for Use of GI-BMPs

The use of a performance standard based on the Level of Service Method defined in the *MARC/APWA BMP Manual* intrinsically encourages the use of GI-BMPs by assigning them higher Value Rating as compared to more traditional stormwater quality BMPs. This is due to the focus of GI-BMPs on the reduction of stormwater runoff volume (and thus pollutants) over the more traditional pollutant removal method of conventional and manufactured BMPs. When GI-BMPs are employed, many small, high-frequency rainfalls will result in no runoff or pollutant discharges from a developed property. Runoff reduction also reduces the amount of stormwater that must be carried through the private (onsite) and public (offsite) drainage systems, potentially lowering costs for construction and maintenance of these systems. For these reasons, **the City of Topeka encourages site designers to consider GI-BMPs on every development where they are determined to be feasible (see Sections 3.4.3 and 3.5)**.

Like LID techniques, GI-BMPs are most successful when considered along with LID techniques very early in the site design process, ideally when the designer begins to determine the locations and extents of the buildings and pavements to be constructed. This will allow the designer to place infiltration-based GI-BMPs in areas where the surrounding native soils can better infiltrate runoff. More detailed information on the selection of GI-BMPs is provided later in this chapter and in the BMP design specifications provided in the *MARC/APWA BMP Manual*.

3.4.2 Available Landscape Credits for Stormwater BMPs

The City of Topeka recognizes the importance of creating regulations that work concurrently with each other, aligning the goals and objectives of multiple City departments. This is not only beneficial to the City, but also to the development community. Thus, TMC Chapter 18.235.090 (*stormwater BMP credits*) provides a landscape credit for certain BMPs. The landscape credits are shown in **Table 3-2**. BMPs that meet the objectives of both the City's landscape *and* stormwater goals are provided a credit. In general, GI-BMPs planted with native vegetation are provided a higher credit than other vegetated BMPs because GI-BMPs:

- ✓ Meet the objectives of TMC Chapter 18.235 to provide green space and aesthetic benefit (i.e., desirable landscape)
- ✓ Meet the objectives of TMC Chapter 13.35 for stormwater volume and pollutant control
- ✓ Support the vision of Topeka's land use plan for future community growth and prosperity
- ✓ Provide additional multiple objectives for creation of habitat for desirable wildlife (pollinators, etc.) and the other benefits described in Chapter 1 of this Handbook.

Thus, the landscape credits provide consistency and clarity between the City's landscaper requirements, stormwater regulations (TMC Chapter 13.35), and the City's general desire to encourage GI-BMPs.

To qualify for the credit:

1. The BMP must occupy a minimum of 150 square feet of land and a have a minimum diameter, width, or length dimension of 3 feet.
2. For vegetated, infiltration, or detention BMPs that consume a large portion of the property (i.e., 25% or more of the property, or one quarter of an acre), up to 100% of the area occupied by the BMP may be deducted from the "developed area" in lieu of applying the credit, if doing so results in a larger reduction in landscaping required and the objectives of the landscape regulations are met.

Table 3-2. Landscape Credits Provided as Incentives for BMPs

BMP Type	Stormwater BMP Credit (see TMC Chapter 18.235.090)
VEGETATED BMPS[1]	
Native Vegetation Preserved/Established	20%
Rain Garden	
Bioretention	
Vegetated Filter Strip	
Native Vegetation Swale[2]	
BMPS THAT REDUCE IMPERVIOUS AREA	
Green Roof	10%
Pervious Concrete	
Porous Asphalt	
Modular Concrete Block	
Cistern	
INFILTRATION BMPS	
Infiltration Basin	10%
Infiltration Trench	
DETENTION BMPS[1]	
Extended Wet Detention	10%
Extended Dry Detention (native vegetation)[2]	
MEDIA FILTRATION BMPS	
Surface Sand Filtration	0%
Underground Sand Filter	
Pocket Sand Filter	
Perimeter Sand Filter	
OTHER SYSTEMS (Manufactured Treatment Devices)	
Proprietary Media Filtration	0%
Hydrodynamic Devices	
Baffle Boxes	
Catch Basin Inserts	

[1] Note: TMC Chapter 13.35 prohibits areas of bare soil in stormwater BMPs. Therefore, areas of vegetated BMPs not fully covered by plants must be covered by landscape rocks, mulch, or other ground cover in keeping with the design specifications for the BMP provided in the *MARC/APWA BMP Manual*.

[2] The extended dry detention and grass vegetation swale must be planted with <u>native</u> species to qualify for the 10% credit. When planted with non-native grasses (turf), these BMPs do not qualify for a credit.

3.5 POLICIES AND GUIDANCE FOR INFILTRATION BMPS

3.5.1 Highly Adaptable BMPs

It is a common misconception that GI-BMPs that use infiltration to function (herein called "infiltration BMPs") cannot be used for redevelopments, which have compacted fill soils, or for greenfield sites with native, poorly-draining soils. This belief is generally wrong. **In fact, infiltration BMPs (rain gardens, bioretention, infiltration practices, porous pavement) are highly versatile and have a variety of design modifications that make them adaptable to just about any site.** These design modifications largely pertain to the presence (or not) of an underdrain, but also include significant flexibility with BMP vegetation, shape, setting, aesthetic, and functional objectives. The remainder of Section 3.5 pertains to in situ soil characterization and the use (or not) of an underdrain.

3.5.2 In Situ Soil Characteristics and BMP Underdrains

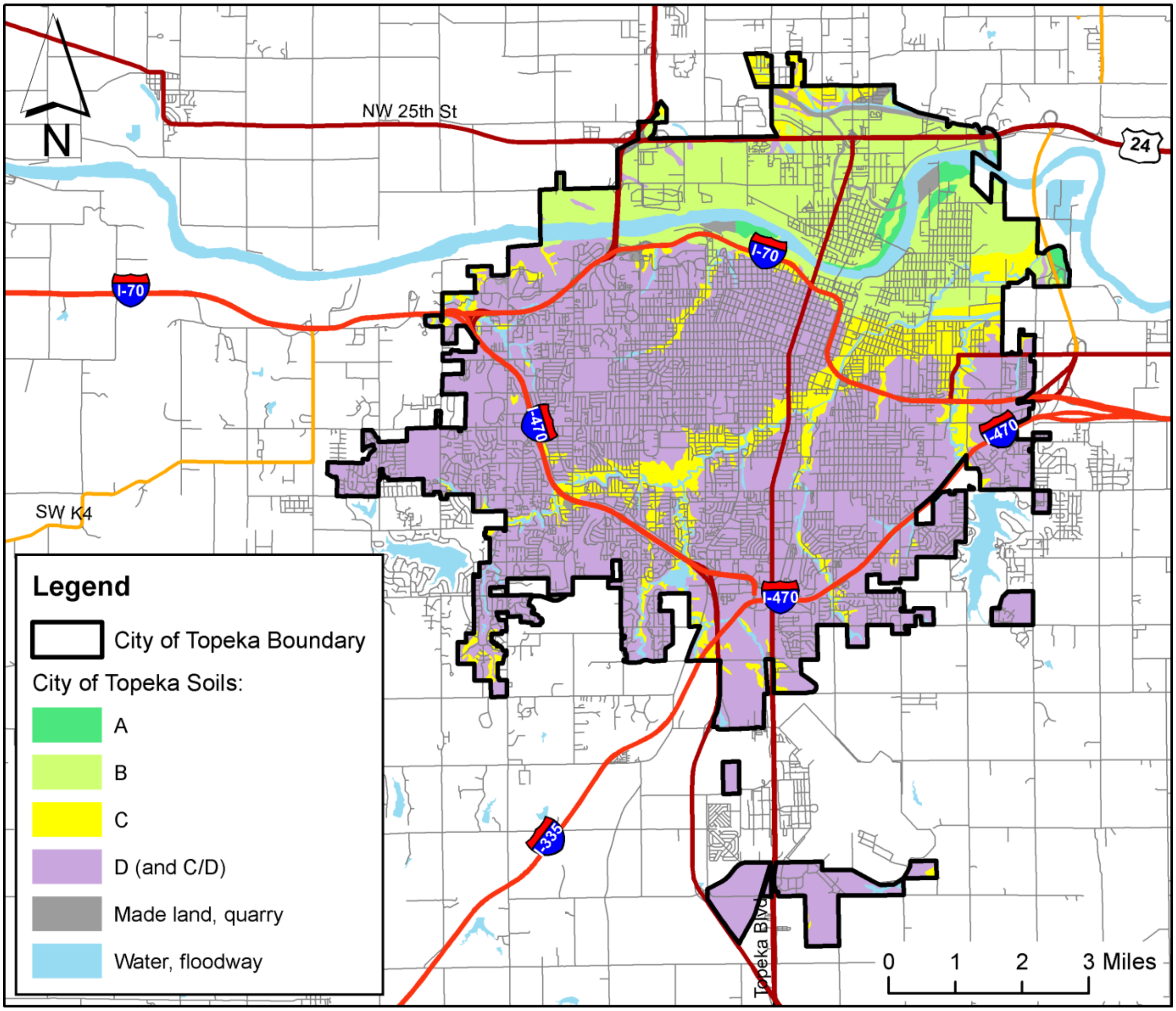
When selecting and designing infiltration BMPs, the characteristics of the in situ (i.e., in place) soil are critical factors that determine BMP design. Greenfield developments (i.e., projects being constructed on a previously undeveloped property) will often have <u>native</u> in situ soils. For native soils, designers can gain initial insight into the future design of an infiltration BMP by determining the Hydrologic Soil Group (HSG) of the area where the BMP will be located using the *USDA-NRCS Soil Survey*. A well-drained native soil (HSG designation of A or B) <u>*may*</u> be designed without an underdrain, thus allowing the selection of the infiltration BMPs included in the *MARC/APWA BMP Manual* that do not require and underdrain (i.e., rain gardens, infiltration basins, and infiltration trenches). In-field infiltration tests performed as the design proceeds will further confirm if an underdrain is required.

However, infiltration BMPs can also be highly effective in managing stormwater when constructed in poorly drained (HSG C or D) or non-native soils, too, <u>*provided they have an underdrain*</u>. This is especially important in Topeka, where HSG D soil types are highly prevalent south of the Kansas River (see **Figure 3-1**). As an urban city, Topeka also sees a lot of redevelopment. Typically, the soil at an urban redevelopment site is either not native to the site (i.e., fill) or has been graded and compacted so significantly that the soil characteristics defined in the *USDA-NRCS Soil Survey* are significantly altered. For a redevelopment, the designer can count on designing the infiltration BMP with an underdrain.

When designed with an underdrain, a BMP can still infiltrate water to some degree, especially if the soil is covered with dense, healthy vegetation that keeps the soil loose and uncompacted. But much of the BMPs pollutant removal functionality is provided by filtration of stormwater through the BMP's engineered soil media before discharge through the underdrain, rather than infiltration into the surrounding soil. Soil restoration is also a viable option for these BMPs, improving the infiltration capacity and overall ecological health of the in situ soil to support plants and the wildlife beneficial to plants (e.g, worms, birds, pollinators, etc.). The underdrain will ensure the BMP is effective in managing stormwater quality without increasing the potential for flooding of the BMP and its surrounding area during intense rainfalls or lengthy rainy/snowy periods of time.

Thus, underdrains provide flexibility for designers so they can take advantage of the high Value Rating (VR) of infiltration-based GI-BMPs during design, and property owners can take advantage of the multi-objective functionality of most GI-BMPs. Policies for in situ infiltration rate determination and underdrain usage are provided in Section 3.5.4.

Figure 3-1. Hydrologic Soil Group (HSG) Map of the City of Topeka KS



3.5.3 Infiltration Rate vs. Percolation Rate

Infiltration BMPs require a maximum drawdown time to avoid nuisance flooding issues. Alternately, when they are vegetated, their soil needs to retain some moisture for a period of time to support the plants growing in the BMP. These design needs are contingent on a specific knowledge of the permeability of the "in situ" soil layers beneath the proposed bottom elevation of the BMP; therefore, this Handbook requires that **infiltration tests** be performed to ascertain the vertical infiltration rate of the in situ soil. A common misunderstanding is that a "percolation rate" obtained from a percolation test is equivalent to the "infiltration rate" obtained from a single or double ring infiltrometer test. While the two rates are related, percolation rates tend to overestimate infiltration rates and can be off by a factor of ten or more. Use of a percolation rate can result in BMPs that are doomed to fail. Therefore, the percolation rate is not an appropriate data parameter for design of infiltration BMPs.

3.5.4 Design Policies

The policies and procedures provided below do not preclude the use of professional judgment to evaluate and manage risk associated with design, construction, and operation of infiltration BMPs. Designers that are unsure about how or whether to apply these policies should consult the director.

The following policies shall apply to infiltration BMPs (i.e., BMPs that will rely on the infiltration of stormwater into the ground) as identified in Table 3-1. Infiltration BMPs are listed below:

- Rain garden
- Bioretention
- Infiltration basin
- Infiltration trench
- Pervious concrete
- Porous asphalt
- Native vegetated swale
- Modular concrete block

1. **BMP protection measures required.** All designs for infiltration BMPs, whether designed with or without and underdrain, shall include permanent measures, whether active or passive, to protect the BMP from unwarranted encroachments after construction. More information on BMP protection measures is provided in Section 3.9 of this Handbook.
2. **Underdrain required.** An underdrain shall be included in the design of an infiltration BMP unless **all** the Site Suitability Criteria for Full Infiltration listed in Policy 3 (immediately below) are met. Stated otherwise, if any one of the Site Suitability Criteria are not met, then an underdrain is required regardless of the infiltration rate of the in-situ soil.
3. **Requirements for BMPs designed without an underdrain.** The following policies shall be followed for infiltration BMPs designed without an underdrain.
   a. All the Site Suitability Criteria listed below shall be met to all design and construction of an infiltration BMP without an underdrain.

      SITE SUITABILITY CRITERIA FOR INFILTRATION WITHOUT AN UNDERDRAIN

      i. The in situ soil beneath the proposed bottom elevation of the BMP must be greater than 1.0 inch/hour and less than 11 inches/hour. (For preliminary planning purposes, this is generally a native, well-drained soil characterized as Hydrologic Soil Group A or B). *Designers that wish to locate an infiltration BMP without an underdrain on fill soil are strongly encouraged to confirm the infiltration rate of the fill material using the infiltration test protocol defined below to confirm design feasibility.*)
      ii. The BMP must not be located in areas of predominately Hydrologic Soil Group D (clay) soils.
      iii. The BMP must be located more than 100 feet from a drinking water supply well in a sensitive aquifer, or more than 50 feet from a drinking water well in a non-sensitive aquifer.
      iv. There must be more than three (3) feet of separation distance from the bottom of the BMP to the elevation of the seasonally saturated soils or the top of bedrock.
      v. The BMP must be located more than 1,000 feet up-gradient, or 100 feet down-gradient of active karst features.
      vi. The BMP must be located more than 10 feet away from a building or structure, unless a mounding analysis confirms that the building or structure, if located less than 10 feet away from the BMP, will not be impacted by the BMP.

vii. The BMP must be located more than 35 feet away from a septic drainfield, unless a mounding analysis confirms that the drainfield, if located less than 35 away from the BMP, will not be impacted by the BMP.

viii. The BMP must be located more than 200 feet from the toe of a slope that is greater than or equal to 20 percent.

ix. The BMP must not receive stormwater discharges from a stormwater hotspot (e.g. vehicle fueling yard, brownfield site, etc.) or area of known soil contamination.

x. A groundwater mound forming beneath the infiltration practice must not extend into the BMP.

b. An Infiltration BMP Feasibility Form shall be completed for the BMP and provided with the SWMP. A blank copy of the Infiltration BMP Feasibility Form is included Appendix C.2.

c. The native soil shall remain in-place and uncompacted during project and BMP construction. BMP protection measures shall be provided during clearing, grading, and construction to ensure adherence to this requirement.

4. **Determining the in-situ infiltration rate.** Site designers have two options for designing of the in-situ soil infiltration rate(s) used for design of the infiltration BMP, as follows. The use of one of these options is required, regardless of whether the BMP is designed with an underdrain.

   a. Field infiltration tests of the in-situ soil located beneath the bottom elevation of the infiltration BMP may be used to determine the design infiltration rate for the BMP. *This is the preferred approach to determining the in-situ infiltration rate.* Field tests will yield results that reflect actual site conditions and allow the design to be optimized to these conditions. Tests shall be performed using the standard test protocols described in Section 3.5.5.

   b. In lieu of field infiltration tests, designers may use infiltration rates provided in the most current *USDA-NRCS Soil Survey for Shawnee County, Kansas*. The survey identifies a range of expected infiltration rates for each soil type. Designers who opt to use the NRCS soil survey must use the most conservative infiltration rate (i.e., the lowest infiltration rate of the range) provided for the soil type). A digital copy is available at: https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.

5. **Multiple infiltration rates.** When multiple soil types are present in situ in a BMP, the designer shall use the most conservative soil infiltration rate determined for the in-situ soils as the design infiltration BMP.

6. **Minimum required infiltration rate.** The design infiltration rate shall not be less than the minimum required infiltration rate specified in the *MARC/APWA BMP Manual*. If the in-situ soil cannot meet this requirement, the designer must select a more appropriate BMP for the project.

3.5.5 Field Infiltration Test Requirements

The requirements established below shall be followed for field tests performed to determine the in-situ infiltration rate.

1. **Professional required.** Infiltration tests shall be completed by a qualified, registered professional civil engineer, soil scientist, or geologist licensed in the State of Kansas.

2. **Suitable weather conditions.** Infiltration tests shall not be conducted in the rain, within 24 hours of significant rainfall events (> 0.5 inch), or when temperatures are below freezing.

3. **Required number of tests.** At least **two infiltration tests** shall be conducted for every infiltration BMP using the test spacing criteria established below. See **Figure 3-2** for example spacing and location of required tests.

   c. Two infiltration tests shall be conducted for every 3,000 to 10,000 square feet of BMP area. Tests shall be spaced appropriately to provide sufficient infiltration rate information across the length and width of the BMP.

   d. For small BMPs (<3,000ft), at least one test shall be located within the BMP's footprint. The second test can be performed outside the footprint but must be located within 20 feet of the perimeter of the BMP and in soil formations that are representative of the conditions within the footprint of the BMP.

   e. For BMPs that have an area greater than 10,000 square feet, one infiltration test shall be conducted for every additional 10,000 square feet of surface area up to a maximum of five infiltration tests. The director may require additional tests for BMPs greater than 10,000 square feet, or when unique soil or geological conditions are known or suspected at the site.

4. **Required test elevation.** The elevation of all infiltration tests shall be at or below the bottom (lowest planned infiltration elevation) of the BMP.

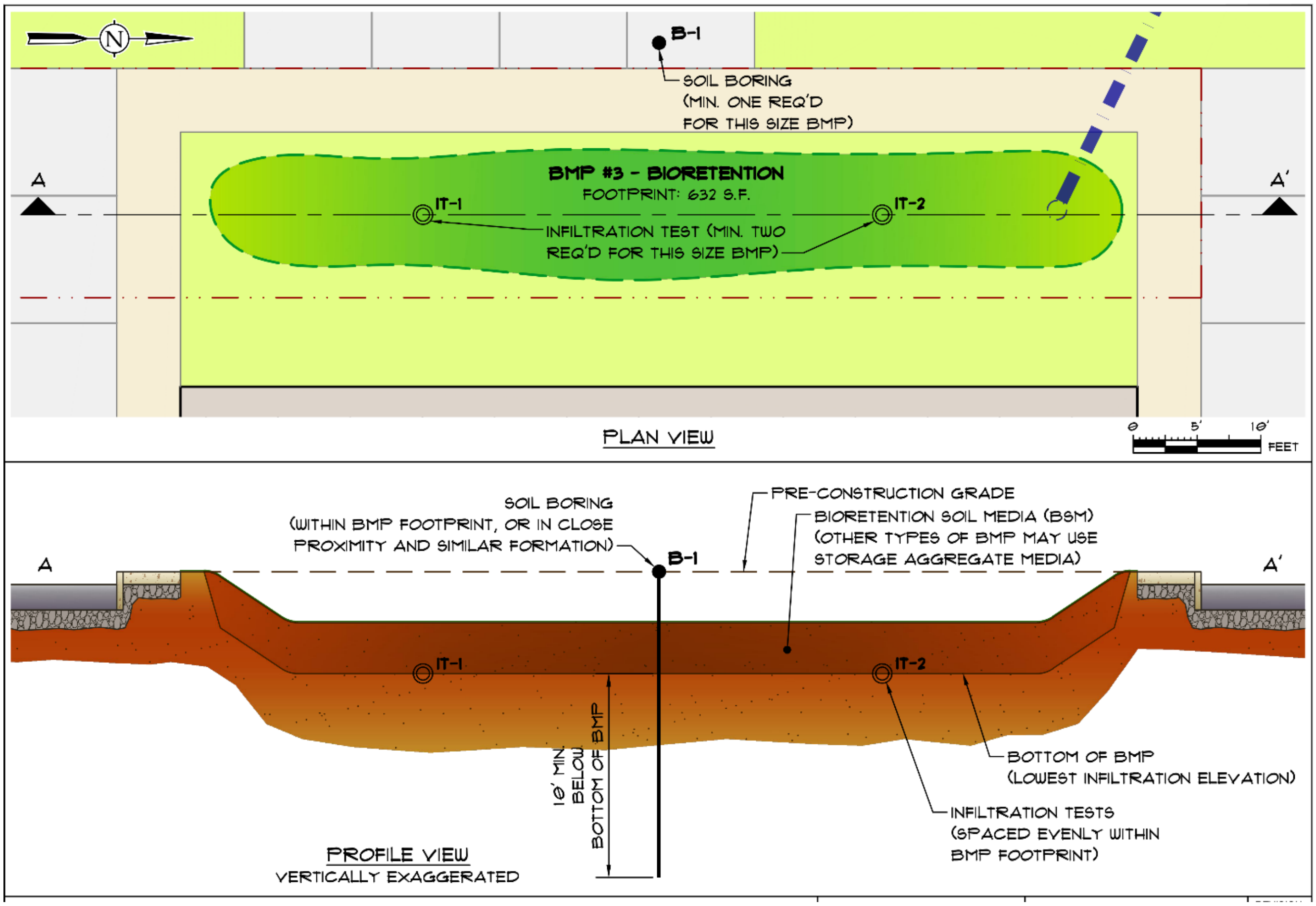
5. **Soil borings required.** Soil borings aid in interpretation of infiltration test results by providing information on groundwater conditions and soil stratification. Therefore, each infiltration test shall be accompanied by a soil boring test to a depth of 10 feet below the lowest planned infiltration elevation (the bottom of the infiltrating BMP). Soil borings performed for a civil site geotechnical analysis that are located within close proximity (less than 50 feet) to the footprint of the BMP may be used. An interpretation of soil boring test results with respect to infiltration shall be provided for each test. This description shall include an assessment of the anticipated seasonal high-water table based on date of soil boring with respect to rainfall patterns, and the presence of hydric soils, redoximorphic features, or other indicator of water table variation, and depth to bedrock if encountered.

6. **Allowed infiltration test methods.** Field infiltration tests shall utilize a double-ring infiltrometer or modified Philip Dunne infiltrometer following the specifications of ASTM D3385 or ASTM 8152, respectively. A double ring infiltrometer test estimates the vertical movement of water through the bottom of the test area. The results from this test, generally reported in inches per hour (in/hour), are appropriate for use in sizing the BMP. This is the preferred methodology for soil infiltration testing, appropriate factor of safety shall be applied to field verified infiltration rates. Key points are summarized below:

   - Double ring infiltrometer testing methodology is provided in ASTM D 3385.
   - Two concentric metal rings are driven into the ground and filled with water. The outer ring helps to reduce lateral movement of water in the soil, while the inner ring is used to calculate an infiltration rate.
   - Test holes must be presoaked immediately prior to testing. The presoaking procedure is intended to simulate saturated condition in the environment and to minimize the influence of unsaturated flow.
   - The tests must be performed for at least 6 hours or a length of time adequate for the infiltration rate to stabilize.

7. **Post-construction field infiltration tests.** The director may require field infiltration tests to confirm infiltration rates after construction is complete if soil compaction or clogging is known or suspected during construction. When required, field infiltration test information shall be provided with the as-built plan portion of the Stormwater BMP Record Drawing.

Figure 3-2. Example of Appropriate Spacing and Depth for Soil Infiltration Tests



3.6 POLICIES FOR VEGETATED BMPS

3.6.1 Native vs. Non-Native Species

Many designers leave the specifics of the project landscape (e.g., desired aesthetic, plant types, plant placement, etc.) up to a landscape contractor. However, this cannot be done for stormwater BMPs, which rely on vegetation for infiltration, evapotranspiration, nutrient and other pollutant removal, and/or erosion control. As discussed in Chapter 2, designers must now submit a detailed planting plan with the SWMP and Stormwater BMP Record Drawing for all vegetated BMPs. This is important not only for the design of the BMP, but also for the future property owner(s) who will be responsible for maintenance of the BMP, including the upkeep of healthy, thriving vegetation.

The City of Topeka prefers the use of native species for all vegetated BMPs (see **Figure 3-3**). Native plants are trees, shrubs, and grasses that have been historically located in the local geographic area as part of the plant community. They have not undergone change nor improvement by humans and are still found growing in uncultivated or relatively undisturbed areas in the region. Due to their historic presence, native plant species are well-adapted to the climate and natural disturbances (e.g., fire, grazing, and/or flooding) of the region. Furthermore, these species have co-evolved with a suite of native insects, microbes, and other wildlife. As a result, native plants, are typically drought tolerant, disease and insect resistant, and hardy, and therefore typically easy to keep healthy and thriving. Some native species are also well-suited to the varying degrees of moisture that occur in GI-BMPs, from inundated to dry conditions. They can play an important role in runoff volume reduction, especially when growing in undisturbed, native soil.

Figure 3-3. Native Plants in a Bioretention BMP

Source: City of Topeka KS

Regardless, it is not uncommon for property owners to be more familiar with the care of non-native plants, trees, and turf grasses than they are with plant species native to Kansas. Non-native species, especially ornamentals, can widen the variety of textures and colors to a landscape, making them popular choices for landscape contractors and do-it-yourself landscapers.

It is important for the designer to understand that some vegetated BMPs allow the use of non-native plants, while others do not. Policies are provided in the next section. Regardless, the use of native plants is strongly encouraged for every vegetated BMP since native species are best suited to local conditions. The resources listed below can provide designers with more information on plant species native to Kansas.

- The Kansas Native Plant Society (www.kansasnativeplantsociety.org)
- Kansas Wildflowers and Grasses website (www.kswildflower.org)
- Kansas Native Plants Plant Guide (www.kansasnativeplants.com)
- Appendix A of the *MARC/APWA BMP Manual (http://kcmetro.apwa.net/PageDetails/439)*

3.6.2 Policies and Resources

1. **BMP Planting Plan required.** A BMP Planting Plan shall be prepared for every vegetated BMP and included with the SWMP and Stormwater BMP Record Drawing. A detailed list of required elements for the planting plan are provided in the checklists for the SWMP and Stormwater BMP Record Drawing, respectively.

2. **Native plant species required.** Native plant species shall be required when:

    a. open space areas of the project are intended to remain in a natural setting. Such areas include meadows, prairies, and wooded areas.

    b. the BMP design specification provided in the *MARC/APWA BMP Manual* indicates the use of native plant species to achieve the *Manual*-specified Value Rating. These BMPs are: Native Vegetation preserved or established; Rain Garden; Native Vegetation Swale; and Extended Dry Detention Basin. There are two local variations to this policy to allow the use of non-native grasses in Vegetation Swales and Extended Dry Detention Basins. Design conditions for these variations are set forth in Policy 3 below). Native plant species selected for stormwater BMPs must be able to withstand the inundated to dry conditions of a stormwater BMP.

3. **Requirements for non-native plant species within stormwater BMPs.** When included in an approved SWMP, the non-native plant species selected for use in stormwater BMPs must be able to withstand the inundated to dry conditions of a stormwater BMP and remain healthy and thriving in the climatic conditions found in Topeka.

   a. **Plant species considered by the Natural Resources Conservation Service (NRCS) as "noxious weeds" in the State of Kansas are prohibited for use in a stormwater BMP.** An up-to-date list of Kansas State-listed noxious weeds can be found in the NRCS PLANTS database, located at https://plants.sc.egov.usda.gov/java/noxiousDriver#state.

   b. **Non-native grasses in Vegetation Swale and Dry Extended Detention BMPs.** The *MARC/APWA BMP Manual* specifies the use of native plant species for the Native Vegetation Swale and Dry Extended Detention BMPs. Non-native grasses (i.e., turf) may be used in place of native vegetation for these BMPs. When non-native plant species are used, the Value Rating must be adjusted as indicated below. Landscape credits are not available for turf planted BMPs.

BMP	*Value Rating with Native Vegetation*	*Value Rating with Non-Native Grasses*
Vegetation Swale	4.0	1.5
Dry Extended Detention	4.0	2.0

3.7 POLICIES FOR MANUFACTURED TREATMENT DEVICES

3.7.1 General Information

Manufactured Treatment Devices (MTDs) are called "Other Systems" in the *MARC/APWA BMP Manual*. These BMPs are stormwater treatment systems available for purchase (and sometimes design) from commercial vendors. MTDs are constructed offsite, then installed by the vendor or site contractor as instructed by the manufacturer. MTDs rely primarily on "flow-through" technology to remove pollutants. Stormwater flows through the device without significant detention time, and pollutants are removed using some internal mechanism that separates, filters, or baffles certain "target" pollutants from stormwater. There are many types of MTDs that generally fall under the "Other Systems" categories listed in the *MARC/APWA BMP Manual*:

- Proprietary Media Filtration Devices
- Hydrodynamic Devices
- Baffle Boxes
- Catch Basin Inserts

MTDs tend to be much better at removing gross solids (e.g., trash, debris, etc.) from stormwater with less propensity to clog (when they are properly maintained) than non-manufactured BMPs. MTDs are usually very compact and often located below ground, under or within a stormwater inlet or system manhole. Their limited or hidden footprint can be especially useful for meeting stormwater quality treatment requirements in small, highly impervious, space-limited areas where there is not enough room for larger BMPs. MTDs can be especially well-suited for use on hotspot land uses, where pollutants (such as nutrients, oils, greases, and petroleum) can be specifically targeted by the MTD. In certain situations, they can be used as the upstream pretreatment measure in a treatment train. When designed as a pretreatment measure, they are typically intended to remove gross solids, special pollutants (e.g., oil), or heavy sediment, preventing these pollutants from discharging to, and potentially clogging or contaminating, the downstream BMP.

In contrast, there are disadvantages to MTDs that must be considered when selecting BMPs for a project. First and foremost, most MTDs require very high levels of inspection and maintenance to ensure proper operation. Some require routine removal, purchase, and replacement of BMP parts, such as filter cartridges. Depending upon the MTD used, routine maintenance costs can be significant. Second, there is a limited amount of performance data for MTDs when located in the hydrologic and pollutant conditions of Topeka (or even mid-western states). Yet, to meet State of Kansas municipal stormwater permit requirements, the City of Topeka must be assured that each BMP included in a design demonstrates adequate capability to treat stormwater quality in keeping with the water quality protection criteria of the *MARC/APWA BMP Manual*. Therefore, the City evaluates the appropriateness and capability of MTDs on a case-by-case basis.

3.7.2 Use and Design Policies

The following policies shall apply to the selection, design, and construction of MTDs in the City of Topeka.

1. **MTD approval.** MTDs will only be approved by the director on a case-by-case basis. The City will evaluate both the appropriateness and capability of selected MTDs for the development, as well as the design of the MTD, and compliance with the policies set forth by the City in this Manual and/or in separate value rating memorandums provided on the Utilities Department website. Previously approved MTDs will be identified in a memorandum. ***To avoid plan approval delays, designers are strongly encouraged to consult the director regarding MTD acceptance in Topeka prior to developing the MTD design.***
2. **Plan requirements for MTDs.** Each MTD shall be located and fully identified in SWMPs and BMP Record Drawings. The MTD make, model name and number, size, flow rate, and name, address, and contact information for the manufacturer and vendor (if different) must be included. Design, inspection, and maintenance requirements, guidance, and calculations provided by the manufacturer/vendor shall be included in full. Replacement parts shall be identified by part number, vendor name(s), cost per part and cost per annum, and expected frequency of replacement. Special inspection and maintenance items, such as cleaning or parts replacement instructions, shall be clearly stated and highlighted.
3. **MTD construction.** Projects must be constructed using the exact MTD(s) included in in the approved SWMP. MTD substitutions during construction are prohibited without prior approval by the director. A revised SWMP (or portion of the SWMP) may be required.

3.8 BMP SELECTION GUIDANCE

Thoughtful BMP selection is key to preventing stormwater BMP failure. The BMP choices made by a designer can significantly influence whether a BMP is properly constructed and how the BMP will be maintained by future property owners[1]. This statement applies especially to stormwater (quality) BMPs because they are so diverse in both how they are constructed and what is required for maintenance.

Factors that should be considered by the designer when selecting stormwater BMPs include:

- ✓ Technical criteria and onsite construction feasibility
- ✓ Operation and maintenance costs, as opposed to just construction costs

[1] TMC Chapter 13.40 establishes long-term (post-construction) maintenance of stormwater BMPs as the responsibility of the property owner where the BMP is located. Maintenance requirements transfer to subsequent owners as the property changes hands in the future. Long-term BMP maintenance is not necessarily a simple task, as property owners are often not well-versed in stormwater management and the types, operation, and maintenance of BMPs.

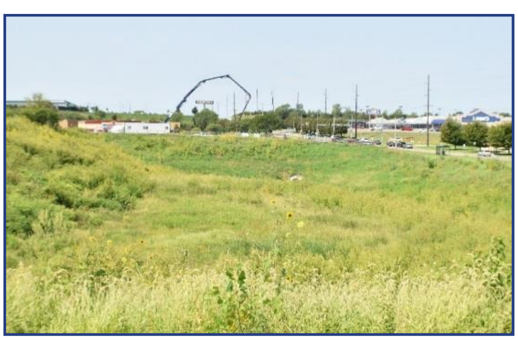
- ✓ The intended land use and probable ownership/tenancy property maintenance arrangement
- ✓ Future occupants' ability to maintain the BMP (technical, physical, and financial feasibility)

The tables on the following pages can be helpful in guiding designers in their initial BMP selection. **Table 3-3** provides guidance on the selection of stormwater quality BMPs based on land use. Typical land ownership schemes, and land management/property tenancy situations were considered in building this table for the City of Topeka. **Table 3-4** is a much more extensive guide on the selection of stormwater BMPs, providing physical site and BMP constraints and long-term cost information. This guidance is by no means definitive. Designers can propose BMP selections that differs from the guidance shown in the table, provided they can show sound judgement in their choice of appropriate BMPs. **Figures 3-4, 3-5,** and **3-6** show examples of appropriate BMP selection.

Figures 3-4a and b. Example of BMP Selection Based on Immediate Surroundings

Left: Pervious pavements are not easily clogged by plant debris making them good choice to enhance urban and suburban landscapes. *Source: St. Louis Metropolitan Sewer District.* **Above:** In contrast, proprietary media filters, baffle boxes, and similar BMPs may become clogged quickly in these areas. *Source: City of Maple Valley, WA.*

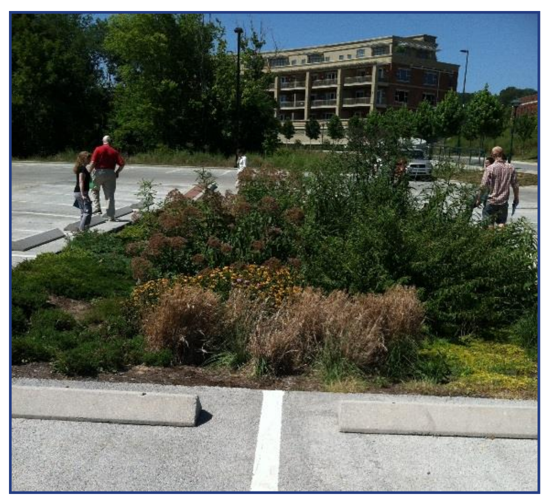
Figures 3-5a, b, and c. Examples of BMP Selection Based on Land Use and Ownership



Vegetated BMPs are a good choice for neighborhood parks and common spaces, or when the BMP will be managed by commercial owners, property managers, or landscape companies.

Left top: This dry extended detention BMP doubles an attractive, and easily maintained landscape. *Source: KH Consulting*

Left bottom: Large, natural bioretention BMP in Topeka, KS. *Source: City of Topeka*



Above: Native bioretention BMP combined with permeable concrete in an urban bus stop parking area in Chattanooga, TN. *Source: City of Chattanooga TN*

Table 3-3. Stormwater Quality BMP Selection Based on Land Use *(for BMPs used for TMC 13.35 compliance)*

Stormwater Quality BMP	***Value Rating***	***Land Use of Project or Areas Within a Project***								
		Com-mercial	**Indus-trial**	**Parking Lots**	**Roadways**		**Parks & Open Space**	**Residential**		
					Shoulder & Medians	**Travel-ways**		**SFR Indiv. Lots**	**SFR Common Lots**	**Multi-Family Res.**
Native Veg. Preserved/Estab.	9.25	●	◉	◉	●	✖	●	○	◉	◉
Rain Garden	9.0	◉	●	✖	○	✖	●	○	●	●
Infiltration Basin	9.0	●	●	○	●	✖	●	✖	●	●
Infiltration Trench	9.0	●	●	◉	●	✖	●	✖	●	●
Bioretention	8.5	●	●	●	●	✖	●	○	●	●
Pervious Concrete	7.5	●	◉	●	●	○	●	○	●	●
Porous Asphalt	7.5	●	◉	●	●	○	●	○	●	●
Mod. Concrete Block	7.5	●	◉	●	●	○	●	○	●	●
ED Wetland	7.0	●	●	○	○	✖	●	✖	◉	◉
Surface Sand Filter	6.0	●	●	○	●	✖	●	✖	●	●
Underground Sand Filter	6.0	●	●	●	●	✖	●	✖	●	●
Pocket Sand Filter	6.0	●	●	◉	●	✖	●	✖	●	●
Perimeter Sand Filter	6.0	●	●	●	●	✖	●	✖	●	●
Ext. Wet Detention	5.0	●	●	○	◉	✖	●	✖	●	●
Vegetated Filter Strip	5.0	●	●	◉	●	✖	●	●	●	●
Native Vegetation Swale	4.0	●	●	◉	●	✖	●	○	●	●
Vegetation Swale (Turf)	1.5	●	●	◉	●	✖	●	○	●	●
ED Detention Basin (Native Veg.)	4.0	●	●	○	◉	✖	●	✖	●	●
ED Detention Basin (Turf)	2.0	●	●	○	◉	✖	●	✖	●	●
Prop. Media Filter	*	◉	●	●	○	✖	○	✖	○	○
Hydrodynamic Device	*	◉	●	●	○	✖	○	✖	○	○
Baffle Boxes	*	◉	●	●	○	✖	○	✖	○	○
Catch Basin Inserts	*	◉	●	●	○	✖	○	✖	○	○
Green Roof	*	●	●	✖	✖	✖	●	✖	◉	◉
Cistern	*	◉	●	✖	✖	✖	●	✖	◉	◉

● = Usually very well suited for application on this land use. Check design specifications.
◉ = May be suitable for application on this land use, if project or hydrologic conditions allow. Check design specifications.
○ = Usually not for application on this land use but may be appropriate in limited situations. Check design specifications.
✖ = Not suitable for land use.
* = See Value Rating information on City website.

Table 3-4. Stormwater Quality BMP Selection Based on Physical Constraints, Costs and Other Criteria *(for BMPs used for TMC 13.35 compliance. Table footnotes are on the next page.)*

BMP Type	Value Rating[1]	Stormwater Quantity Impact		Physical Constraints[2]					Cost Considerations			Other Policies of Note	
		Volume Reduction	Peak Flow Control	Max. Drainage Area	In Situ (Underlying) Soils Requirement	Engineered Media Required	Min Head (Elevation Difference)	Ground Level Encroachment (or Space Needed)	Construction Cost	Operation & Maintenance Cost	Triple Bottom Line Benefits	BMP Type *(Handbook sections with relevant policies shown in parenthesis)*	Landscape Credit Available for BMP[4]
Native Vegetation Preserved or Established	**9.25**	Yes	No	NA	no restriction	No	NA	High	Low	Med	High	• Green Infrastructure BMP • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20%
Rain Garden	**9.0**	Yes	Minimal	< 1 acre	A or B required	No	1-2ft	Low	Low	Med	High	• Green Infrastructure BMP • Infiltration BMP *(See Section 3.4.2)* • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20%
Infiltration Basin	**9.0**	Yes	Yes	< 5 acres	A or B required if not using an underdrain	Yes	2-10ft	Med	Med	High	Med	• Green Infrastructure BMP • Infiltration BMP *(See Section 3.4.2)*	10%
Infiltration Trench	**9.0**	Yes	Minimal	< 5 acres	A or B required if not using an underdrain	Yes	2-10ft	Med	Med	High	Med	• Green Infrastructure BMP • Infiltration BMP *(See Section 3.4.2)*	10%
Bioretention	**8.5** Underdrain required	Yes	Yes	< 4 acres	No restriction, underdrain always required	Yes	3 ft	Med	Med	Med	High	• Green Infrastructure BMP • Infiltration BMP *(See Section 3.4.2)* • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20%
Pervious Concrete, Porous Asphalt, Mod. Concrete Block	**7.5** Underdrain required	No	Yes	Impervious area draining to BMP ≤ 2/3 the total drainage area	No restriction, underdrain always required	Yes	2-10ft	NA	High	Varies	High	• Green Infrastructure BMP • Manufactured BMP[3]	10%
Extended Detention Wetland	**7**	No	Yes	2 to 1,000 acres	Do water budget analysis	No	6-10ft	High	Med	High	High	• Green Infrastructure BMP • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20%
Sand Filters: Surface, Underground, Pocket, & Perimeter	**3-5**	No	Yes	Varies (see design specifications)	No restriction	Yes	Varies	Med	Low	High	Low	• Conventional BMP	0%
Extended Wet Detention	**5**	No	Yes	2 to 1,000 acres	Do water budget analysis	No	6-10ft	High	Low	Med	Med	• Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	10%
Vegetated Filter Strip	**5**	Yes	No	As large as needed	No restriction	No	3ft	Med	Low	Low	Med	• Green Infrastructure BMP • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20%
Vegetation Swale	**4** (native) **1.5** (turf)	Yes	No	< 5 acres	No restriction	No	3ft	Med	Low	Low	Med	• Green Infrastructure BMP • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	20% (native plants) 0% (turf)
Extended Dry Detention	**4**	No	Yes	2 to 1,000 acres	Do water budget analysis	No	6-10ft	High	Low	Med	Low	• Vegetated BMP *(see Sections 2.6.3 & 3.4.3)*	10% (native plants) 0% (turf)
Proprietary Media Filtration Device	**3-5**	No	No	Manufacturer's specs	No restriction	Sometimes	Manufacturer's specs	Low	Low	High	Low	• Manufactured BMP[3]	0%
Hydrodynamic Device **Baffle Boxes**	**3-5**	No	No	Manufacturer's specs	No restriction	No	Manufacturer's specs	Low	Low	High	Low	• Manufactured BMP[3]	0%
Catch Basin Insert	**3-5**	No	No	Manufacturer's specs	No restriction	No	Manufacturer's specs	Low	Low	Med	Low	• Manufactured BMP[3]	0%
Green Roof	Roof area has CN=79	Yes	No	NA	NA	No	NA	NA	High	Med	High	• Green Infrastructure BMP • Vegetated BMP *(see Sections 2.6.3 & 3.4.3)* • Manufactured BMP[3]	10%
Cistern/Rainwater Harvesting	Volume credit[5]	Yes	No	NA	NA	No	NA	Low	Low	Med	Med	• Green Infrastructure BMP • Manufactured BMP[3]	10%

Table 3-4 Footnotes

1. "NA" means the constraint is not applicable to the BMP
2. Vendor name, make, model, and other relevant information is required with SWMP and Stormwater BMP Record Drawing. See checklists for SWMP and Stormwater BMP Record Drawing.
3. See TMC Chapter 18.235.090 and Handbook Section 3.4.2. for more information on stormwater BMP credits.
4. See Design Specification for Cistern/Rainwater Harvesting BMP provided in Appendix F for more information.

Figures 3-6a, b, and c. Examples of BMP Selections Based on Operation and Maintenance

Above: Pervious concrete requires minimal routine maintenance. *Source: City of Lenexa KS Fire Station #5;* **Right** – *Source: Kansas City Zoo*

Above: Cisterns can be paired with irrigation systems for more sustainable maintenance practices. *Source: Lake County, IL*

3.9 BMP LOCATION GUIDANCE

Location of stormwater BMPs is a decision that can influence the owner's ability and costs to maintain a BMP after construction is finished. As stated previously, private property owners are often at a loss in their maintenance understanding and ability. Owners will look to property managers and landscape companies for assistance. Therefore, locating BMPs where they can be easily accessed for inspection and maintenance can simplify maintenance and potentially reduce costs. Examples are below:

- **"Front and center" is better than "out of sight, out of mind."** Avoid placing ground level BMPs in places they will be forgotten, such as behind a building and behind a chain link or privacy fence (see **Figure 3-7**). This often allows owners to forget they have a BMP, or makes it difficult to maintain, thus eliminating BMP upkeep. Generally, ground level BMPs placed in full view of the people who frequent the property will be better maintained (see **Figures 3-8a and b**).

Figure 3-7. Poorly Maintained Ext. Detention BMP

This fenced retention BMP is located behind a neighborhood, where it was not maintained. BMPs like this become an eyesore and source of complaints. *Source: WRDW Augusta GA*


Figures 3-8a and b. BMPs in Front

Far left: The native bioretention and pervious pavement BMPs located in front of an Indianapolis office building are a part of the maintained landscape.

Near left: A bioretention area installed in front of a City of Bloomington IN office is never forgotten.

Source: Heather Williams, LEED-AP

- **Make stormwater BMPs a part of the maintained landscape.** When thoughtfully designed and/or landscaped, BMPs may not look like part of the site's stormwater infrastructure. For example, GI-BMPs, such as rain gardens and bioretention, can often provide aesthetic value onsite and for adjacent properties (see **Figure 3-9a and b**). Detention basins can be located and landscaped in a way which allows a property to look neat and clean (see **Figure 3-10a and b**). Permeable pavement comes in many different colors and configurations, adding interesting designs and looks to parking lots and roadways (see **Figures 3-11a and b**). In addition, TMC 18.235.090 provides a credit for the use of some stormwater BMPs (see Section 3.4.2 for more information).

Figures 3-9a and b. Stormwater BMPs That Also Function as Landscape


Left: Bioretention and permeable paver BMPs integrated into property walkways add interest to landscape aesthetics. *Source: City of Portland, OR*. **Right:** A centrally-located, well-designed, and well-maintained extended detention BMP is a beautiful part of the community landscape. *Source: City and County of Denver CO*

Figures 3-10a and b. Decorative and Maintained Detention BMPs

Left: A detention BMP also functions as an amphitheater, ensuring its maintenance, and giving it a neat and tidy appearance. *Source: City of Philadelphia PA*; **Right**: Experienced landscape professionals can make a detention basin an attractive landscape feature. *Source: Urban Drainage and Flood Control District Manual, Volume 2*.

Figures 3-11a and b. Multi-Functional Permeable Pavers

Left: Permeable pavers create a decorative, functional parking lot located on a large corporate campus in Indianapolis IN. *Source: Heather Williams, LEED-AP*. **Middle and Right:** Different colors, patterns, and configurations of permeable pavements are used in urban Atlanta GA neighborhoods to manage local drainage and add to the character of the community. *Source: City of Atlanta GA*

- **Avoid obstructions.** Avoid creating site designs that create obstructions around the perimeter of BMPs (e.g., planting trees, installing fences, walls, ditches, etc.), unless the obstructions are compensated by a specific maintenance access location designed into the BMP. This design technique must be balanced with any passive or active measures used for BMP protection (see Section 3.10.) But generally, designers should stay away from designing obstacles to BMP maintenance that are difficult and costly to remove as it can unnecessarily increase the cost of maintenance and repair.

- **Access easements should be fully traversable.** TMC Chapter 13.35 requires an access easement for stormwater BMPs that do not have a stormwater management easement bounded by a

Figure 3-12. Access Easement

The mowed strip of land around these Topeka area retention BMPs indicate the location of the unobstructed access easement. *Source: City of Topeka* public street. Access easements should be designed such that maintenance equipment, including vehicles and motorized equipment (such as compact excavators, loaders, and tractors), can travel through the easement. Generally, this means maintaining a minimum of 20 feet in *unobstructed* width (see **Figure 3-12**). Do not locate utility poles, fences, trees, property support elements (e.g., HVAC units, equipment storage areas, etc.), or other permanent obstructions in an access easement.

3.10 BMP PROTECTION GUIDANCE

3.10.1 Why Protect?

Protecting a stormwater BMP from damage is essential to ensuring its long-term proper operation, providing stormwater quality and/or quantity management on a property. Adequate protection will reduce the potential for unintentional damage resulting from inadvertent disturbances and may lessen damage caused by intentional encroachments into the facility. This is especially important for GI-BMPs, where the plants and soil within the BMP are critical to the function of the BMP. For these reasons, TMC Chapter 13.40 includes a general requirement for the owner to **protect**, as well as **inspect** and **maintain**, the stormwater BMPs located on their property. This means the owner must take reasonable steps to safeguard their BMPs from damage and loss of functionality. This requirement is relevant to BMPs both during and after construction of an applicable development is complete.

The most effective protection measures are often those considered during site design and implemented during construction. Therefore, the site designer plays a critical role in ensuring the long-term proper operation of a BMP by including protective measures in the BMP/site design. This Section provides guidance for site designers on the need and selection of BMP protection measures.

3.10.2 Protection During Construction

During construction, the BMP owner is often the property developer. Providing adequate protection for the LID technique areas and stormwater quality and quantity BMPs being constructed onsite should be relatively straightforward at this stage, since site designers (engineers or landscape architects) and construction contractors should be familiar with the functionality and necessary protection of the BMPs under construction. If they are not, they can be educated through review of the site's SWPPP, relevant sections of the *MARC/APWA BMP Manual*, and use of TMC Chapter 13.30 (*Erosion and Sediment Control*) to select, plan, and design appropriate temporary protection measures.

Special care must be taken with GI-BMPs, especially those which function via healthy plants (evapotranspiration) and uncompacted soil (infiltration). **Infiltration-based GI-BMPs (or the areas where they will be located after construction) cannot be used as temporary sediment basins/traps or as construction equipment, materials, or waste storage areas (see TMC Chapter 13.35). These BMPs must also be protected from construction traffic and other encroachments which could damage the native or restored soil.** Common activities that damage GI-BMPs before and during construction are listed in **Table 3-5**.

Table 3-5. Examples of Construction Related Activities that Occur Due to a Lack of Protection

Example Undesirable Encroachments	*Example Undesirable Uses*
- Grubbing and clearing activities occur unmarked areas and stream buffers where native vegetation will remain - Heavy equipment travels through unmarked areas that will become infiltration-based GI-BMPs - Uninformed landscape installers run bobcats through the soil media of a bioretention BMPs so they can install plants more quickly - Underground cable/phone installers trench into unprotected curbside bioretention BMPs	- Construction vehicles park in an unmarked bioretention BMP *(infiltration-based GI-BMPs only)* - A rain garden is used as a sediment trap *(GI-BMPs only)* - A dry extended detention BMP is used to temporarily store construction materials, stockpiles, or waste - Heavy, dirty construction equipment is parked on unprotected permeable pavement - Uninformed landscape contractors place topsoil and mulch stockpiles on unprotected permeable pavement

Education of all those who will be onsite during construction can prevent inadvertent BMP damage. Prior to accessing the site, contractors and subcontractors should be educated on the location and protection of stormwater BMPs and other sensitive areas. Temporary protection measures will often include physical signs and barriers on the site (e.g., staked orange fencing, staking, and flagging, tree protection boxes, etc.). **Figures 3-13a and b** show examples of good protection for mature trees on a construction site. Poor protection or maintenance of newly constructed facilities during, or at the end of, construction can lead to facility failure before it ever has a chance to operate in the post-construction condition.

Figures 3-13a and b. Mature Tree Protection During Construction

Left: Protective fencing prevents encroachment within the canopy drip line of this mature tree. Orange fencing and signage make this protective measure easy to see and understand. *Source: The City of Calgary, Canada;* **Right:** Chain link and signs are used to protect trees during construction. *Source: Miami Univ. of Ohio*

3.10.3 Protection After Construction

After construction, the protection of stormwater BMPs becomes more difficult, especially for the soil and vegetation in GI-BMPs. Developed sites will typically be more accessible to more people (i.e., the public) and often GI-BMPs are designed to be an approachable and inviting part of the landscape (See **Figures 3-14a and b**).

Figure 3-14a and b. GI-BMPs Can Create an Inviting Landscape

Protective measures for these bioretention BMPs include curbing, signage, tall dense shrubbery, and a recessed ground surface within the BMP treatment area. *Sources: (left) US Green Building Council, (right) University of Tennessee Agricultural Extension*

However, in general, the public does not understand the importance of stormwater BMPs, how they function, and what they look like. The wide variety of BMP types, designs, and aesthetics can make identifying one difficult, even for someone with a relevant technical background. These issues often inexplicably lead to encroachments and uses that can damage a BMP and lead to flooding, erosion, or pollutant discharges. **Table 3-6** lists the activities and uses prohibited for stormwater BMPs that are identified in TMC Chapter 13.40. Designers should be familiar with this list and take care not to include or imply support for a prohibited activity or use in their project's designs. For example, a design that includes an allowance for overflow parking within a Grass Vegetation Swale violates TMC Chapter 13.40.

Table 3-6. Prohibited Activities and Uses of Stormwater BMPs per TMC Chapter 13.40

Prohibited Activities	*Prohibited Uses*
X Spraying, filling, and dumping of any material, household/commercial waste, or sewage	X Sewage storage or treatment area/system
X Sewage or waste storage or disposal	X Storage of vehicles, equipment, materials, pesticides, herbicides, fertilizers, or wastes
X Use of heavy equipment during maintenance activities *(infiltration GI-BMP only)*	X Storage of vehicles or equipment under repair *(e.g., an auto repair shop)* or in disrepair *(e.g., a junk yard)*
X Foot traffic unrelated to maintenance activities *(infiltration GI-BMP only)*	X Vehicle traffic or parking *(allowed for permeable or porous pavement)*
X Incorrectly parked vehicles	X Materials or waste storage areas
X Pet and livestock feeding, relief or play areas	X Dog parks, pet kennels and livestock corrals, even on a limited/temporary basis
X Installation of impervious surfaces unrelated to the BMP	X Home or commercial gardens *(beyond plant requirements for vegetated BMPs)*
	X Playgrounds and sports fields *(unless the stormwater management facility is designed for such use as a multi-purpose stormwater management facility, like an underground detention system beneath a soccer field)*

3.10.4 Types of BMP Protection Measures

There are many different types of protective measures. Examples of different types of stormwater BMP protection measures include, but are not limited to, the passive and active measures described below. Site designers are encouraged to think beyond this list when considering their site. Landscape architects, landscape contractors, hardscape contractors, and plant nurseries can also provide recommendations for appropriate designs, materials, and plants to suit the aesthetic and function desired for the BMP.

3.10.4.1 Passive Protection

Passive protection measures do not bar people from entering or using a BMP. Rather, they educate, advise, or direct people away from inappropriate activities and uses. At a minimum, passive measures will raise awareness of a stormwater BMP to those in close proximity. However, passive measures can do so much more, like educate the public or landscapers/property managers. Depending on design, they can even imperceptibly move people through or around a BMP, such as a lushly landscaped bioretention area, while dissuading them from entering or impacting the BMP's critical areas. Examples of common passive protective measures are described below:

- **Signs and Boundary Markers.** After construction, signs are a first level protection for stormwater BMPs. At a minimum, they make people aware of the presence and location of a BMP. Even the most basic sign (e.g., "keep out") can convey the need to avoid disturbance and remind maintenance staff to avoid damaging activities, such as mowing. Signs can also be used for education about a BMP. In fact, educational signs can provide Value Rating credit for stormwater quality BMPs (see the *MARC/APWA BMP Manual*). **Figures 3-15a, b, and c** provide examples of stormwater BMP signs in practice.

Figures 3-15a, b, and c. Examples of Signage for Stormwater BMPs

BMP signs can educate the public and those who maintain the landscape. **Left:** Bioretention BMPs on Jackson St. *Source: City of Topeka KS;* **Middle:** Sign for a native vegetation swale. *Source: City of Columbia MO;* **Right:** Sign for a wetland BMP. *Source: Harris County TX*

- **Education for People Who Work In, Near or Around the BMP.** During construction, site contractors will have their own staff and hire sub-contractors for onsite activities. Additionally, the site designer will have identified protection measures in the development's approved SWPPP and SWMP. After construction, property owners will often use a property manager or landscape contractor to perform landscape maintenance services. These people will likely perform much of the routine maintenance of vegetated BMPs. Whether during or after construction, education of those who are regularly at the property on the location, type, function, protection, and maintenance of onsite stormwater BMPs can be a vitally important protection measure. TMC Chapter 13.40, the *MARC/APWA BMP Manual,* and the *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance* can be used to facilitate education.

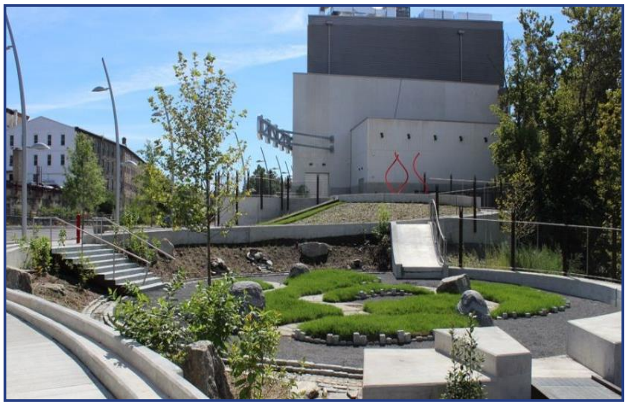
- **Benches, Pet Waste Stations, Trash Cans, and Similar Features.** Many vegetated BMPs are design as part of, or to enhance, the surrounding landscape. Some are even designed to invite people near the BMPs, using walking paths to create a quiet, natural area setting. These BMPs can be viewed as amenities for the property. However, they are also more susceptible to inadvertent and inappropriate activities. A designer who creates these "showcase" BMPs should also consider measures that direct human and pet activities within or near the BMP. Examples include pet waste stations for BMPs adjacent to sidewalks (**Figure 3-16a**), and benches and trash cans for pathways that enter BMPs (**Figure 3-16b**).

Figures 3-16a and b. Examples of BMP Passive BMP Protection Measures

Far left: Pet waste station on the Shunga Trail. *Source: City of Topeka KS;* **Left:** Sidewalks, gravel footpaths, and benches in the Pope John Paul II Memorial Garden keep visitors out of bioretention BMPs. *Source: Mahan Rykiel Associates, Inc.*

- **Walking Paths and Accessways.** For the public, walking paths can be used to guide people safely through, or around or away from, the critical areas of stormwater BMPs. Paths can be as simple as stepping-stones or as constructed as sidewalks. Using landscaping to transition pedestrians from parking lots and buildings, to pedestrian walkways, and finally to usable green spaces (such as picnic and flower garden areas), can be used as a passive approach to avoid BMP disturbances. For GI-BMPs, walking paths can provide a way to both avoid damaging encroachments and enhance property landscaping. Pathways, combined with appropriate fencing or vegetated barriers, can even be used to bring people into the GI-BMP to enjoy its plantings and landscaping (see **Figures 3-17a and b**). With the right plants, GI-BMPs can even be used as part of a healthy wildlife ecosystems, such as a butterfly or pollinator garden. Accessways to be used for inspection and maintenance of the BMP should also be provided to allow maintenance without soil compaction and plant damage. Ideally, any paths and accessways should be constructed of pervious materials, but this is not required. Every pathway should be clearly visible and well-maintained.

Figures 3-17a and b. Pedestrian Pathways as a BMP Protection Measure



Above: Pathways along and through a bioretention BMP. *Source: City of Philadelphia PA Water Dept.*

Above: A walkway allows pedestrians to go into a stormwater wetland BMP. *Source: City of Portland, OR*

- **Interior and Exterior Hardscaping.** From pervious pavers and colorful permeable pavements, to landscaping stone and boulders, hardscaping is another effective protection measure for stormwater BMPs. Rounded or angle-edged cobblestones placed in the pre-treatment and main treatment areas of bioretention, rain gardens, and infiltration practices can keep pedestrians from entering these areas and damaging soil and vegetation. Stones should be sizeable enough so that they will not compact into a more traversable or relatively flat surface if an encroachment occurs. Alternately, permeable and porous pavements work extremely well with vegetated BMPs, providing a highly functional landscape that allows pedestrians into or around the BMP. **Figures 3-18a and b** show how permeable surfaces can be used to protect GI-BMPs.

Figures 3-18a and b. Hardscaping as BMP Protection Measures

Left: Concrete curbs limit intrusions, while pea gravel prevents soil erosion within bioretention BMPs located on a downtown sidewalk. *Source: City of Indianapolis IN.* **Right**: Seating, permeable walkways, hardy shrubs, and a playset keep people out of a Chicago schoolyard's bioretention BMP. *Source: centerforgreenschools.org.*

3.10.4.2 Active Measures

Active protection measures are designed to physically prevent unwanted encroachments and disturbances into stormwater BMPs. Examples of active protection measures are described below:

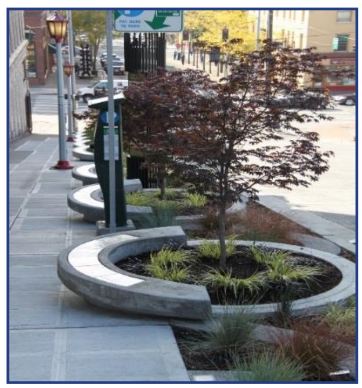
- **Fencing.** Fencing is an obvious choice as a physical deterrent to encroachment by people and pets. Fences can be an attractive landscape feature because they can be constructed in a variety of materials for many different looks (see **Figures 3-19a and b**). If included in a design, fences must be in compliance with the fencing requirements for the property's zoning designation (see the City of Topeka Zoning Regulation, TMC 18.50 through 18.275). Further, fences cannot impede access to the BMP by maintainers and inspectors.

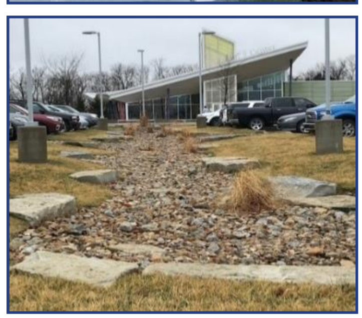
- **Vegetative and Hardscape Barriers.** Plants and rocks can be used in place of fencing and still have the desired effect of protection the soil and vegetation and limiting disturbances (see **Figures 3-20a through d**). Vegetation should be dense or otherwise uninviting to touch (e.g., prickly) to dissuade encroachments through the plants. Medium to large boulders can add a dramatic aesthetic, especially when combined with water features. However, rocks can be perceived by children as an invitation to climb and play in the nearby area, so site designers should consider this when considering them as protection measures. Curbing made of concrete or other materials are also effective physical barriers.

Figures 3-19a and b. BMP Fencing Examples

Right: Decorative fencing and curbing can enhance the BMP aesthetic and protect it from encroachments by both pedestrians and vehicles. *Top source: Green Inf. Coalition of Rhode Island; Bottom source: NY Dept. of Env. Protection*

Figures 3-20a through d. Protecting BMPs with Hardscape Barriers





Top left: Riprap placed at the bottom of a dry ext. detention BMP protects the bottom from erosion & damage. *Source: City of Alpharetta GA.*

Top right: Bench seats and curbing around sidewalk bioretention planters. *Source: SvR Design.*

Lower left: Concrete curbing around a parking lot bioretention island keeps vehicles and people out while allowing stormwater in. *Source: Sacramento State University*

Lower right: Large stones and cobbles protect a swale at the Children's Discovery Center. *Source: City of Topeka KS.*

3.10.5 Choosing the Right Protection Measures

The City of Topeka does not prescribe specific protection measures to be used for stormwater BMP protection. The designer has the flexibility to use protections they deem most appropriate for the property, the BMPs, and for desired aesthetic. In general, the level and types of safeguards best employed for BMP protection often depend on 1) the type of BMP, and 2) the status of construction (during or after). These two factors are discussed below.

3.10.5.1 Protection Measures Based on the Type and Function of the Stormwater BMP

A solid understanding of the type of stormwater BMPs selected for a property and how they function is critical to determining the level and type of BMP protection needed. The BMP protection meter in **Figure 3-21** graphically displays how the level of BMP protection changes with BMP type. Ground level GI-BMPs that rely on infiltration (via uncompacted soil) typically require the highest levels of protection. Alternately, BMPs that are often located out of reach of passers-by, such as green roofs and proprietary manufactured devices (e.g., baffle boxes, catch basin inserts), require the lowest levels of protection, if any. **Table 3-7** expands upon the information provided by the protection meter by presenting the damage that can result from a lack of protection, by BMP type.

Figure 3-21. Stormwater BMP Protection Meter

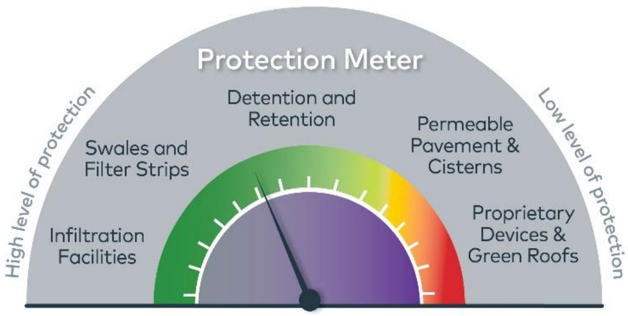


Table 3-7: Impacts Caused by Inadequate BMP Protection by BMP Type

Stormwater BMP	*Potential Result of Lack of Protection*	*Potential Impacts of Damage*
Rain Garden Bioretention Infiltration Practices Vegetated Filter Strip Native Vegetation Swale Green Roof	Soil media and/or mulch compaction	Reduced infiltration (volume/pollutant reduction); pollutant discharges; standing water; flooding
	Plant damage or death *(only in vegetated facilities)*	Reduced evapotranspiration (volume/pollutant reduction); erosion; pollutant (sediment) discharges
Ext. Detention Wetland Ext. Wet/Dry Detention Retention	Plant damage or death	Reduced evapotranspiration and filtration (volume/pollutant reduction); erosion; pollutant discharges
Pervious Concrete Porous Asphalt Modular Concrete Block	Damage to paved surface	Reduced infiltration or filtration (volume/pollutant reduction); pollutant discharges; standing water; flooding
All of the above, and: Prop. Media Filtration Hydrodynamic Devices Baffle Boxes Catch Basin Inserts Cisterns	Damage to pretreatment area	Reduced stormwater capture (volume/pollutant removal); pollutant discharges; sedimentation in the facility, standing water; flooding
	Damage to structural components (inlets, outlets, underdrain, etc.)	Inflow channelization, facility erosion, downstream erosion; pollutant discharges, clogging; reduced storage capacity

Figure 3-21 indicates a high level of protection is typically needed for infiltration-based GI-BMPs. Matching that with the infiltration-based BMPs listed in the first row of Table 3-7, it follows that soil/mulch compaction and plant damage are primary BMP components in need of protection. Additionally, many vegetated GI-BMPs tend to be small and distributed around a property, blending into the landscape. They are often located in easily accessible areas and overlooked as part of the site's stormwater conveyance infrastructure. As a result, a relatively high level of protection is needed to avoid soil compaction and plant damage.

Moving from left to right around the "dial" in the figure and down the rows of the table, plants and soil become less of a factor in BMP function for BMPs that are don't have plants or manage stormwater using filtration, settling, or other means. As the dial moves the right, the designer to focuses more on protective measures on the BMP's structural components, as opposed to soil and vegetation. As one moves away from vegetated GI-BMPs, which tend to blend into the landscape, BMPs either become more visually obvious as a part of site infrastructure (e.g., detention basins), or, in the case of proprietary devices and green roofs, are largely inaccessible to the public. Thus, the level of protection needed for these BMPs lessens considerably.

3.10.5.2 Protection Based on Land Use and Setting

Another key to evaluating the type and level of protection needed for a stormwater BMP is thoughtful consideration of encroachments and uses that are likely given the land use and setting of the development. Fitting the protection measures to the land use and setting, as opposed to fencing off BMPs with chain link, can provide value to the property owner. First, the protection measures can meet the BMP's need for protection. Second, the protection measures can add to (or at least, do not detract from) the aesthetic and use of the property. Examples are shown in **Figure 3-22 and 3-23a and b**. Tailoring the level and tone of permanent protection measures to the location and circumstance of the BMP can help support the long-term functionality of the BMP as designed.

Figure 3-22. Signs to Assist Maintenance Staff

Heavily landscaped GI-BMPs, such as rain gardens and bioretention, may not look like stormwater BMPs. This leads to improper management by landscapers and damage by utility installers. Use signs to alert to the presence of a BMP. *Source: NY Dept of Environmental Protection*

Figures 3-23a and b. Protection for BMPs Located Along Roads and Sidewalks

Above: Stormwater BMPs located along sidewalks are more likely to have encroachments by people and pets. Use signs and decorative fencing to limit encroachments. *Source: City of Portland, OR.* **Right:** Use signs, curbs, and/or wheel stops to limit encroachments into BMPs bounded by streets and parking areas. *Source: Kentucky Waterways Alliance*

3.11 ALIGNING STORMWATER QUALITY AND QUANTITY DESIGNS

In most countries with advanced infrastructure and socioeconomic systems, interest in, and awareness of, the need to better manage stormwater in urban and suburban areas has increased in recent decades. In the United States, this need may be the greatest at the local level. Traditional urban to suburban development patterns, established automobile-based transportation systems, and conventional stormwater management techniques have resulted in large amounts of impervious surfaces (e.g., roads, sidewalks, and rooftops) in most major cities. Topeka is no different. Standard civil engineering design approaches for stormwater management use practices that quickly and efficiently convey water away from buildings and roadways into ditches and pipes. This results in large volumes of stormwater, and therefore pollutants, flowing directly to local streams and rivers.

The current need for both drainage/flood control *and* stormwater pollution control has caused local governments to adopt regulations that address both stormwater quality and stormwater quantity. Site designers must now find ways to manage the increased volume, velocity, intensity, and quality of stormwater in one stormwater control facility or via multiple facilities, typically one discharging into another. For many local governments, this often results in the "loss" or dedication of a portion of the development to the sole purpose of managing stormwater in a large extended detention/retention facility. Neither the developer nor property owner needs the facility for anything other than stormwater volume, velocity, intensity, and quality control. As such, the facility is located behind the buildings and is not seen as a useful feature of the development. Typically, such facilities are forgotten over time and often become overgrown eyesores due to lack of proper maintenance. This cycle then leads to facilities that do not function as designed, and their intention as a viable part of stormwater infrastructure is lost (see **Figure 3-24**).

Figure 3-24. Unmaintained Stormwater BMPs

Overgrown and unmaintained extended detention BMPs like the one above can prevent pollutant removal and cause localized flooding. *Source: City of Topeka KS*

With the growing popularity of green infrastructure, local governments and site designers are finding an alternative to the scenario described above in green infrastructure. When thoughtfully considered early in the planning of a new development or redevelopment, GI-BMPs can provide new ways to address the multi-pronged problem of stormwater management. This is because they maximize the functionality of property spaces by combining stormwater management functions with other property needs, such as landscaping, parking, a building roof, or a non-potable water source. See **Figures 3-25a, b, and c**.

Meeting Topeka's stormwater quality performance standard requires use of the stormwater BMPs identified in the *MARC/APWA BMP Manual*. These BMPs are generally regarded by KDHE as an acceptable approach to meet their municipal stormwater quality requirements, established in KDHE's Kansas NPDES-MS4 permit. The *MARC/APWA BMP Manual* also promotes the USEPA's current vision for the encouragement of GI-BMPs as a viable post-construction site design option. Additionally, Topeka promotes the use of stormwater LID techniques (see Chapter 5) and GI-BMPs, as these tools can collectively reduce the overall volume of pollutants and stormwater discharged to local waterways. However, beyond stormwater quality, these methods can be used to meet multiple objectives on a development. Thus, designers should steer away from single BMP designs and toward comprehensive, all-inclusive stormwater solutions. Examples of multi-functional (stormwater quality and quantity) BMPs are presented in **Figures 3-26a and b**.

Figures 3-25a, b, and c. Examples of Multi-functional Green Infrastructure BMPs

Left: The green roof at The Pinnacle at Symphony Place office and retail building serves three functions: rooftop, stormwater BMP, and outdoor social space. *Source: Nashville-Davidson County Metro Water Services*; **Center:** This Topeka bioretention BMP provides stormwater management and property landscaping. *Source: City of Topeka*. **Right:** Permeable pavers on an Evansville IN street provide stormwater management and parallel parking. *Source: Heather Williams LEED-AP*.

Figures 3-26a and b. Combination Stormwater Quality and Quantity BMPs

Above: A combination bioretention and detention BMP provide full stormwater management capability for a residential subdivision in Fort Bend County, TX. *Source: Eco Construction Services*; **Right:** Permeable interlocking pavers, such as these in Jefferson City MO, can detain water and reduce the need for onsite detention basins. *Source: Lesia Tatarsky, The Missourian*.

The list of GI-BMPs and examples of how they may achieve multiple objectives is provided in **Table 3-8**. Note that these facilities also reduce runoff volume, thus potentially reducing the overall need for, and size of, stormwater quantity (detention and retention) and drainage conveyance systems.

Early and thoughtful consideration of the pre-construction condition of an applicable development and the optimal use of LID techniques is key to reducing stormwater runoff volume naturally. This, combined with the knowledge that many stormwater management facilities can meet multiple objectives for a proposed development, can lead to designs that align stormwater quality and quantity goals, and possibly many more objectives for the site. This holistic approach to stormwater management allows flexibility for developers within a framework that minimizes the development's negative impact on both the quality and quantity of stormwater leaving the site.

Table 3-8. Multi-Objective GI-BMPs

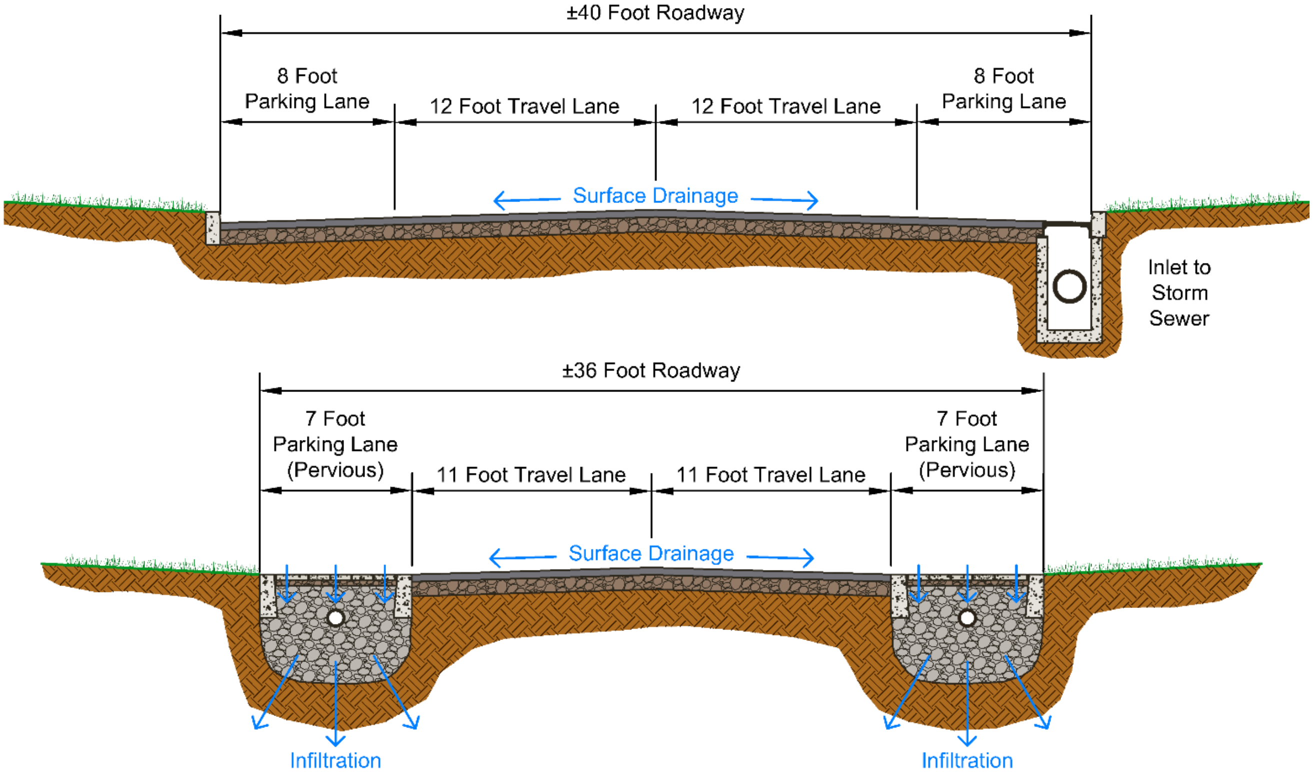
GI-BMP Name & Treatment Approach	*Possible Design Objectives in Addition to Stormwater Quality Management*
Rain garden & native vegetation swale **Treatment approach: infiltration & evapotranspiration*	❖ Visually attractive landscaping ❖ Meeting City code landscape requirements ❖ Public education/support for sustainable practices
Infiltration basin & infiltration trench **Treatment approach: infiltration*	❖ Visually attractive landscaping ❖ Meeting City code landscape requirements ❖ Discharge receiving area for roof drains & parking lots ❖ Public education/support for sustainable practices
Bioretention **Treatment approach: infiltration & evapotranspiration*	❖ Visually attractive landscaping ❖ Meeting City code landscape requirements ❖ Discharge receiving area for roof drains & parking lots ❖ Landscaped parking lot islands ❖ Stormwater quantity control *(limited)* ❖ Public education/support for sustainable practices
Pervious concrete, porous asphalt, & modular concrete block **Treatment approach: infiltration & filtration*	❖ Driveways and parking lots ❖ Discharge receiving area for roof drains ❖ Attractive hardscaping ❖ Stormwater quantity control *(limited)* ❖ Public education/support for sustainable practices
Green roofs **Treatment approach: infiltration & evapotranspiration*	❖ Building rooftop ❖ Visually attractive "roofscaping" ❖ Green space for picnics, meetings, or relaxation of building tenants or workers ❖ Public education/support for sustainable practices
Cisterns **Treatment approach: capture and reuse*	❖ Non-potable water source for landscape or garden watering, toilet-water, etc. ❖ Public education/support for sustainable practices

3.12 INTRODUCTION TO GREEN STREET DESIGN

The alignment of stormwater quality and quantity control is especially critical in street design. Streets and parking areas make up a large amount of the total impervious surface area within any community. Traditional street designs direct stormwater runoff from impervious surfaces into storm sewer systems (gutters, drains, pipes) that discharge directly into surface waters, rivers, and streams. In contrast, streets can be designed with one or more levels of interconnected GI-BMPs to minimize the generation of stormwater and capture, manage, and in some cases reuse, stormwater within and along the street itself. These types of street designs are called "green streets." A comparison of a green street design to a traditional street design is presented in **Figure 3-27.** The traditional street cross-section sends the stormwater directly to the street's stormwater conveyance system (top), whereas the green street utilizes a pervious pavement parking lane to infiltrate stormwater (bottom).

The City of Topeka has already embraced the concept of green streets, having developed a Complete Streets Guide that supports green street design. The guide can be found at: https://s3.amazonaws.com/cot-wp-uploads/wp-content/uploads/planning/MTPO/TSC_CompleteStreets.pdf

Figure 3-27. Typical Design Cross-Sections of a Traditional Street (top) and Green Street (bottom)
Source: Wood E&IS, Inc.



In addition to stormwater quality management, green streets can reduce peak stormwater flows, free-up capacity in the subsurface wastewater system (for combined sewer systems) and reduce or stop sewer overflows in areas where the storm and sanitary sewer systems are inadvertently connected. Green streets can also reduce the need for installation and maintenance of expensive underground infrastructure for collection, conveyance, and treatment of stormwater runoff, as the water can often be reused for landscape watering purposes. **Figure 3-28** lists the many potential benefits of green streets.

Figure 3-28. Potential Benefits of Green Street Designs

Green streets

Benefits

- Decrease in negative stormwater impacts through a natural system approach that incorporates a variety of water quality, energy-efficiency, and other environmentally beneficial practices
- Increase in infiltration and/or filtration of runoff, reduction of flows, and enhancement of watershed health
- Reduction in the amount of water that is piped and discharged directly to streams and rivers
- Can provide tree canopy for stormwater interception, as well as temperature mitigation and air quality improvement
- Mitigation or prevention of localized flooding
- Improvements to pedestrian and bicycle access and the community's livability
- Improvements to street and community aesthetics

The great value of green streets does not necessarily lie in stormwater management, but rather the use of multi-objective stormwater management features to enhance the street aesthetic and provide multi-modal opportunities. This broadens both the look and function of the street for the community. Examples of green street designs are presented in **Figures 3-29a and b** and **Figure 3-30**.

Figures 3-29a and b. 10th Street Urban Streetscape Concepts in Cedar Rapids IA

Left: Streetscape ground surface rendering. **Right:** Rendering of underground design shows street water is sued to irrigate street trees. Also note the multi-modal features. *Graphics source and designer: Sasaki Landscape Architects*

Figure 3-30. Example of a Multi-Objective Green Street

Green boulevard at Butler University in Indianapolis IN. Low-maintenance vegetated swales are used for landscaping and runoff conveyance. Bike lanes add a multi-modal element to the overall design. *Source: Heather Williams LEED-AP*

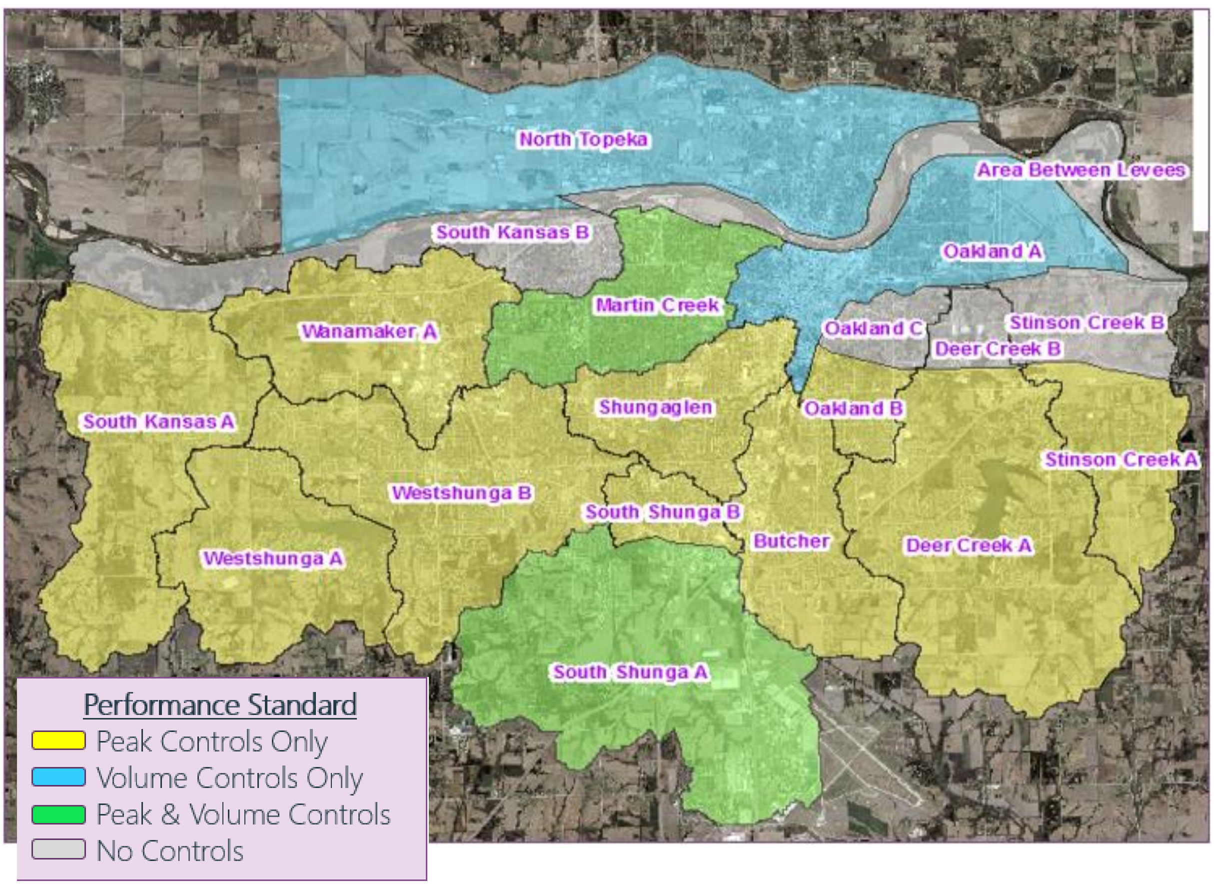
4 Stormwater Quantity Design

TMC Chapter 13.35 requires applicable developments to be designed and constructed to meet the stormwater quantity performance standards established in this Handbook unless such standards are waived (see TMC Chapter 13.35 for waiver information). This Chapter defines the various design performance standards, establishes performance standard applicability, and sets forth the policies and design specifications and methods to support the standards. While stormwater quantity is the focus of the following design criteria, potential water quality impacts should be considered throughout the stormwater facility design process.

4.1 THE STORMWATER QUANTITY STANDARDS BASINS MAP

Three different performance standards are established in this Chapter for the purpose of onsite and offsite flood protection: 1) peak control; 2) limited peak control; and 3) volume control. These standards were developed through modeling of the hydrologic and hydraulic conditions of Topeka drainage basins and streams. The models tested stream sensitivity to peak discharge and volume changes resulting from onsite stormwater quantity controls. Model results were used to develop the stormwater quantity performance standards and the associated Topeka Stormwater Quantity Standards Basin Map (see **Figure 4-1**). Site designers will use the map in conjunction with the policies set forth in the next Section to determine which stormwater quantity performance standard is applicable to their project.

Figure 4-1. City of Topeka Stormwater Quantity Performance Standards Basin Map



4.2 PERFORMANCE STANDARDS

The following policies govern the design of stormwater quantity BMPs to meet the requirements of TMC Chapter 13.35.

Peak control standard defined. Applicable developments shall be designed and constructed so the post-development condition peak discharge calculated for the 2-, 5-, 10-, 25-, 50- and 100-year return frequency, 24-hour duration storm events shall not exceed the pre-development condition peak discharge calculated for the 2-, 5-, 10-, 25-, 50- and 100-year return frequency, 24-hour duration storm events. Compliance is typically achieved through design and construction of adequately sized stormwater quantity BMPs (detention or retention storage BMPs).

Volume control standard defined. Applicable developments shall be designed and constructed to adequately manage the increased volume of runoff for the 100-year return frequency, 24-hour duration storm event in the post-development condition, as compared to the pre-developed condition. If the development has the ability to connect to a receiving storm system that can sufficiently convey stormwater downstream, the development shall delay the timing of releases by the use of an extended-release detention facility. The outlet control structure should be designed to meet water quality requirements, if applicable, or with a maximum discharge rate of 0.05 cfs/acre of drainage into the structure, up to a depth of the increased 100-year runoff volume due to the development. If the development does not have the ability to connect to a receiving storm system that can sufficiently convey stormwater downstream, the increased volume of runoff for the 100-year return frequency, 24-hour duration storm event in the post-development condition, as compared to the pre-developed condition, should be retained and disposed entirely onsite through the use of retention facilities and/or green infrastructure facilities.

Performance standard applicability. Stormwater quantity performance standards shall be applied based on the drainage basin in which the applicable development is located, as established below. Figure 4-1 must be used to determine the drainage basin(s) for the project. A digital copy of Figure 4-1 is provided on the City website.

a) Applicable developments located in any of the drainage basins listed below shall be designed and constructed in accordance with the ***peak control standard***.

- Butcher Creek
- Deer Creek A
- Oakland Creek B
- Shungaglen
- South Shunga B
- Stinson Creek A
- South Kansas A
- Wanamaker A
- Wanamaker B
- Westshunga A
- Westshunga B

b) Applicable developments located in any of the drainage basins listed below shall be designed and constructed in accordance with the ***volume control standard***.

- North Topeka
- Oakland A

c) Applicable developments located in any of the drainage basins listed below shall be designed and constructed in accordance with both ***peak*** **and** ***volume control standards***.

- South Shunga A
- Martin Creek

d) Adherence to stormwater quantity performance standards ***is waived*** for applicable developments located in any of the drainage basins listed below. No stormwater quantity controls are required. Please note, stormwater quality BMPs may still be required.

- South Kansas B
- Deer Creek B
- Oakland C
- Stinson Creek B
- Area between levees

e) When the area of an applicable development crosses the boundary of two or more drainage basins, the applicable flood protection standard(s) shall be determined based on the location of the stormwater outfall(s) from the project site in the post-development condition. Note: Project sites having multiple outfalls may be required to comply with different flood performance standards if the outfalls are located in different drainage basins.

Example policy application. *A commercial development project is located on the boundary of two drainage basins. Seventy percent of the project's drainage area is located in the Martin Creek drainage basin, and the other 30% is located in the Wanamaker A drainage basin. The proposed grading of the project shows the entire project will drain to one outfall in the post-development condition. It also shows the outfall will be located in the Wanamaker A drainage basin. Since the only outfall of the project is located in the Wanamaker A basin and Policy 4.A above establishes that peak control standard is required in the Wanamaker A basin, the peak control standard shall be applied to project.*

Alternatives to detention and retention. Under very limited circumstances, the director may allow flood protection to be provided by downstream conveyance improvements in lieu of providing onsite detention or retention BMPs, subject to the satisfaction of **all** the following requirements:

a) The applicant provides a detailed hydrologic and hydraulic model-based analysis showing the alternative approach will offer adequate protection from downstream increased flooding for all potentially affected downstream properties.

b) The applicant is responsible for obtaining approval of any floodplain-related analyses and requirements, such as No-Rise analyses, a Conditional Letter of Map Revision (CLOMR) prior to construction, and/or a Letter of Map Revision (LOMR) upon completion of construction.

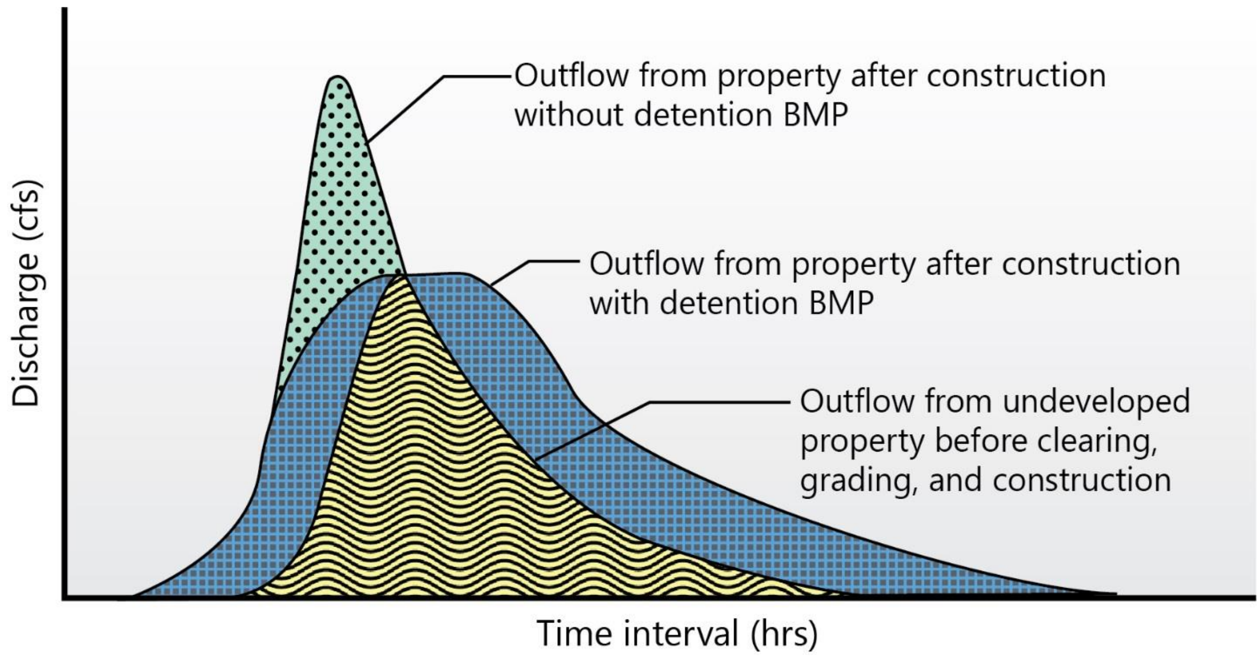
c) The applicant is responsible for obtaining all state and federal permits that may be applicable to the site including KDHE construction stormwater and other state required permits or conditions and US Army Corps of Engineers Section 404 permits.

Alternately, the applicant is free to negotiate with downstream property owners to obtain/purchase drainage easements in lieu of detention/retention BMPs. Proof of easements held must be provided to the director, along with an engineering study indicating the downstream storage capacity or conveyance limits provided by the easements is sufficient to safely control the required design storm events (i.e., peak flow or volume) without flooding or erosion.

4.3 BMP DESIGN SPECIFICATIONS

Urban stormwater quantity (storage) BMPs are often referred to as either detention or retention facilities. For the purposes of this Section, detention BMPs are those that are designed to reduce the peak discharge and only detain runoff for some short period of time. These BMPs are designed to completely drain after the design storm has passed. Detention BMPs detain stormwater for a period of time and release it at a reduced peak discharge (see **Figure 4-2**). Whereas retention BMPs intended for stormwater quantity control are designed to retain stormwater and allow it to evaporate and/or infiltrate without release. Since most of the design procedures are the same for detention and retention BMPs with respect to storage calculations, unless specified, the term "storage BMPs" will be used in this Section to include dry detention and wet retention BMPs. Where a policy or special procedure is needed for design of only one type of storage BMP, the BMP type will be specifically identified (i.e., dry detention or wet retention).

Figure 4-2. Graphical Depiction of Peak Flow Control Using a Detention Pond



4.3.1 General Policies

The following additional criteria shall be applied in the design of storage BMPs:

1. **Maximum drainage area.** The drainage area to any single storage BMP shall generally not exceed 1,000 acres. This does not prevent the City from approving larger regional BMPs to serve multiple sites.
2. **Design of dams.** Dams that are greater than 10 feet in height but do not fall into state or federal requirement categories shall be designed in accordance with the latest edition of *SCS Technical Release No. 60* as Class "C" structures or KSA 82-a 301 - 305a requirements, whichever is most stringent.
3. **Lake and pond developments.** All lake and pond development shall conform to local, state, and federal regulations. Legal definitions and regulations for dams and reservoirs can be found in the State of Kansas Rules and Regulations, KSA 82a 301 - 305a.

4. **Storage volume reduction provided by upstream stormwater BMPs.** The stormwater volume captured and stored by retention BMPs or captured and infiltrated by GI-BMPs implemented on a project site upstream of a storage BMP may be deducted from the required storage volume for the storage BMP.

5. **Hydrologic calculations and storage BMP sizing.** The hydrologic procedures established in Section 4.3.3 shall be used to determine pre- and post-development hydrology for compliance with the peak control standard, and to size storage BMPs. Use of the Rational Method is prohibited for these purposes.

6. **Energy dissipation for receiving channels:** Primary outlet works, emergency spillways, and drain works, as well as conveyance system entrances to storage BMPs, shall be equipped with energy dissipating devices as necessary to limit shear stresses on receiving channels. See **Tables 4-1, 4-2a and 4-2b** and **Figures 4-3 and 4-4** for shear stress criteria.

Table 4-1. Permissible Shear Stresses for Lining Material *(Source: Table 5607-1, MARC/APWA BMP Manual)*

Lining Category	Lining Type	Permissible Shear Stress (lbs/ft^2)
General	Erosion Control Blankets	1.55 – 2.35
	Turf-Reinforced Matrix (TRMs):	- - -
	Unvegetated	3.0
	Vegetated	8.0
	Geosynthetic Materials	3.01
	Cellular Containment	8.1
	Woven Paper Net	0.15
	Jute Net	0.45
	Fiberglass Roving:	- - -
	Single	0.60
	Double	0.85
	Straw with Net	1.45
	Curled Wood Mat	1.55
	Synthetic Mat	2.00
Vegetative	Class A (see Table 4-2a)	3.70
	Class B (see Table 4-2a)	2.10
	Class C (see Table 4-2a)	1.00
	Class D (see Table 4-2a)	0.60
	Class E (see Table 4-2a)	0.35
Gravel Riprap	25 mm	0.33
	50 mm	0.67
Rock Riprap	150 mm	2.00
	300 mm	4.00
Bare Soil	Non-Cohesive	See Figure 4-3
	Cohesive	See Figure 4-4

Table 4-2a. Classification of Vegetal Covers as to Degree of Retardance *(Adapted from Table 5607-2, MARC/APWA BMP Manual)*

Retardance Class	Cover	Condition	Usage Policies and Other Notes
A	Weeping lovegrass	Excellent stand, tall (avg. 30”)	Non-native species. Stormwater BMP credit is not available if used in a dry ED basin. See Section 3.4.2.
	Yellow bluestem	Excellent stand, tall (avg. 36”)	
B	Kudzu	Very dense growth, uncut	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Bermuda grass	Good stand, tall (avg. 12”)	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Native grass mix (little bluestem, big bluestem, blue grama, other long & short Midwest grasses	Good stand, unmowed	See Retardance Class B in Table 4-2b.
	Weeping lovegrass	Good stand, tall (avg. 24”)	Non-native species. Stormwater BMP credit is not available if used in a dry ED basin. See Section 3.4.2.
	Lespedeza sericea	Good stand, not woody, tall (avg. 19”)	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Alfalfa	Good stand, uncut (avg. 11”)	Non-native species. Stormwater BMP credit is not available if used in a dry ED basin. See Section 3.4.2 Not appropriate for regular submergence/flooding or areas of high water table.
	Weeping Lovegrass	Good stand, unmowed (avg. 13”)	Non-native species. Stormwater BMP credit is not available if used in a dry ED basin. See Section 3.4.2.
	Kudzu	Dense growth, uncut	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Blue grama	Good stand, uncut (avg.11”)	Not appropriate for regular submergence/flooding or areas of high water table.
C	Crabgrass	Fair stand, uncut 10”-47”	Annual weed
	Bermuda grass	Good stand, mowed (avg. 6”)	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Common lespedeza	Good stand, uncut (avg. 11”)	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Grass/legume mix – summer (orchard grass, redtop, Italian ryegrass, common lespedeza)	Good stand, uncut (avg. 6”-8”)	See Retardance Class C in Table 4-2b.
	Centipede grass	Very dense cover (avg. 6”)	Grows in Southeastern U.S., Texas, and California
	Kentucky bluegrass	Good stand, headed (6”-12”)	Perennial, cool-season, sod-forming, vigorous root development

Retardance Class	Cover	Condition	Usage Policies and Other Notes
D	Bermuda grass	Good stand, cut to 2.3"	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Common lespedeza	Excellent stand, uncut (avg. 4.3")	
	Buffalo grass	Good stand, uncut (3"-6")	Not well-suited for Topeka conditions and is generally not appropriate for use in stormwater BMPs.
	Grass/legume mix – fall, spring (orchard grass, redtop, Italian ryegrass, common lespedeza)	Good stand, uncut (4"-5")	See Retardance Class D in Table 4-2b.
	Lespedeza sericea	After cutting to 2". Very good stand before cutting.	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
E	Bermuda grass	Good stand, cut to 1.5"	Invasive species. Prohibited in stormwater BMPs in the City of Topeka.
	Bermuda grass	Burned stubble	

Note: Species information was obtained from the USDA Plant Database.

Table 4-2b. Additional Information for Grass Mixes Identified in Table 4-2a.

Retardance Class	Cover	Condition	Notes
B	**NATIVE GRASS MIX** Little bluestem Big bluestem Blue grama Other long/short Midwest grasses	Good stand, unmowed	Blue grama does not tolerate high water table and frequent submergence.
C	**GRASS/LEGUME MIX - summer** Orchard grass Redtop (Agrostis gigantea) Italian ryegrass Common lespedeza	Good stand, uncut (avg 6"-8")	Orchard grass may become invasive, develops dense root system on adapted soils. Redtop is a cool-season, sod-forming perennial grass, commonly used for erosion control in plantings along riparian zones and wetlands, germinates rapidly Common lespedeza is an invasive species. Prohibited in stormwater BMPs in the City of Topeka. Do not include in grass/legume mix.
D	**GRASS/LEGUME MIX – fall, spring** Orchard grass Redtop (Agrostis gigantea) Italian ryegrass Common lespedeza	Good stand, uncut (avg 4"- 5")	Orchard grass may become invasive, develops dense root system on adapted soils. Redtop is a cool-season, sod-forming perennial grass, commonly used for erosion control in plantings along riparian zones and wetlands, germinates rapidly Common lespedeza is an invasive species. Prohibited in stormwater BMPs in the City of Topeka. Do not include in grass/legume mix.

Note: Species information was obtained from the USDA Plant Database.

Figure 4-3. Permissible Shear Stresses for Non-Cohesive Soils *(Source: Figure 5607-1, MARC/APWA BMP Manual)*

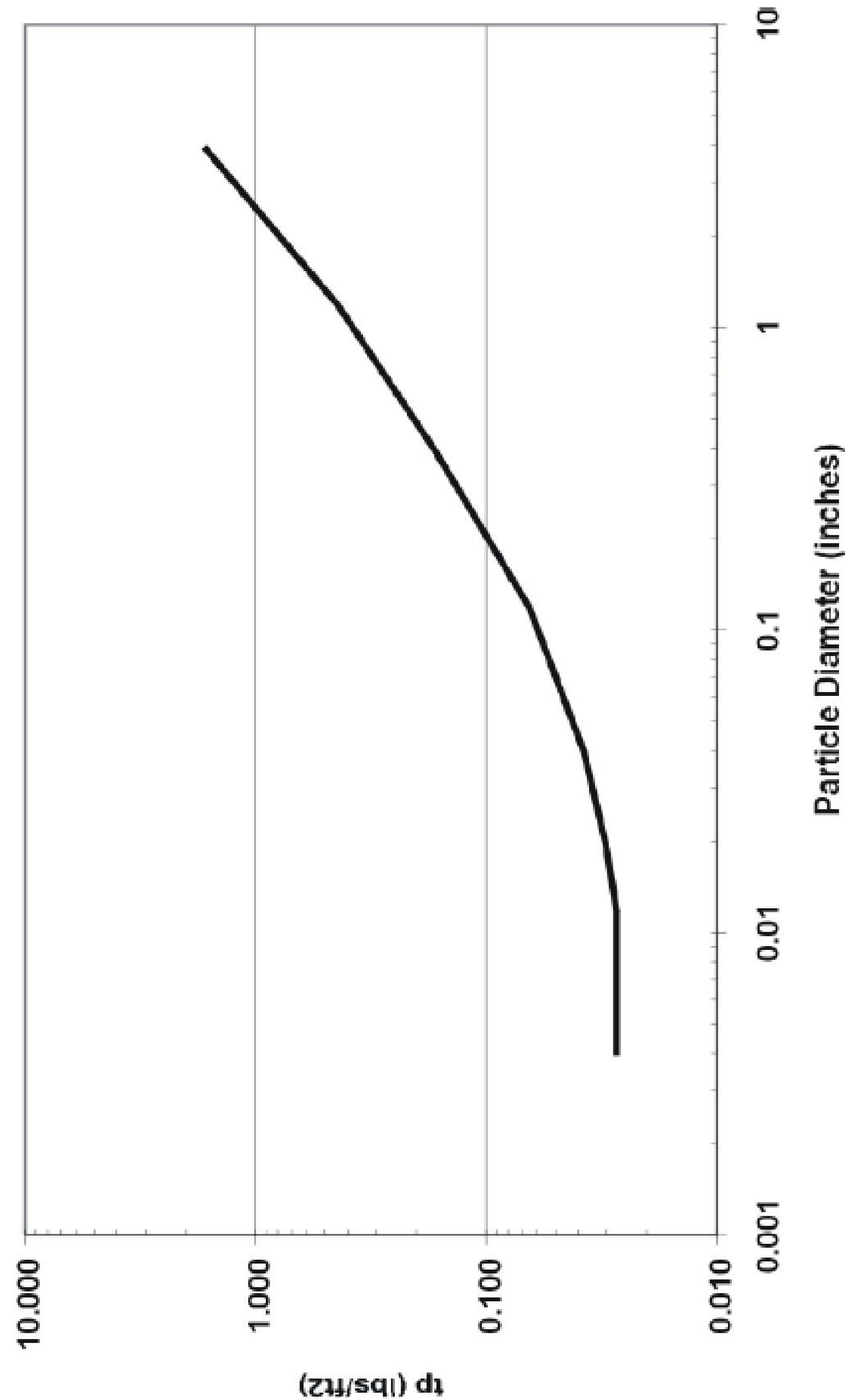
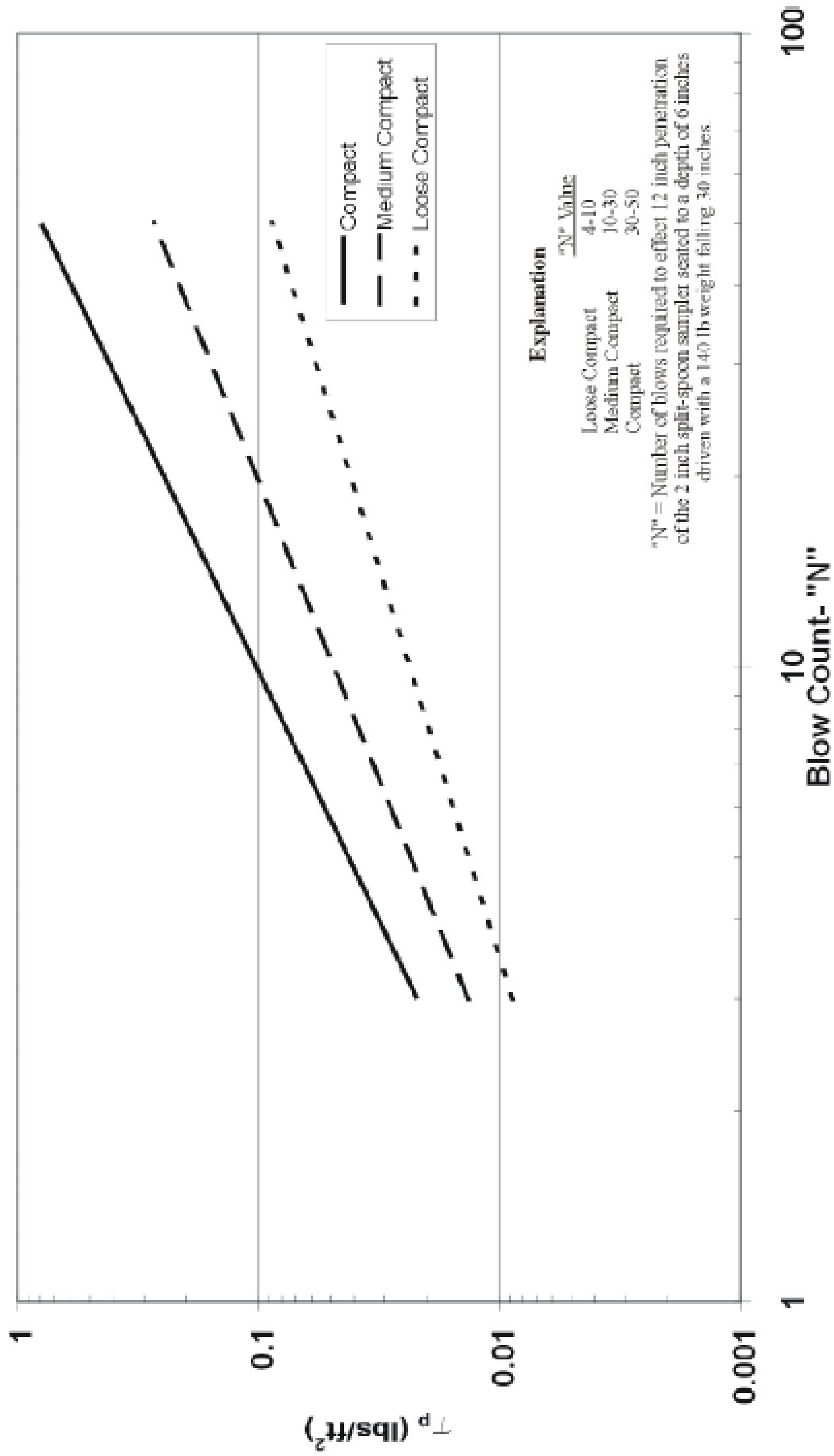


Figure 4-4. Permissible Shear Stresses for Cohesive Soils *(Source: Figure 5607-2, MARC/APWA BMP Manual)*



7. **Primary outlet design.** The primary outlet of a storage BMP shall be designed to meet the following requirements:

   a) The outlet shall be designed to function without requiring attendance or operation of any kind, or requiring use of equipment or tools, or any mechanical devices to function properly. The director may approve automated or "real-time" outlet controls (RTC) that utilize internet-based forecasting resources to operate a facility based on instantaneously updated meteorological data. Designers are strongly encouraged to discuss the use of RTC with the director prior to including it in a storage BMP design.

   b) All discharge from the storage BMP when inflow is equal to or less than the 100-year return frequency, 24-hour duration storm event shall be via the primary outlet system.

   c) The design discharge rate via the primary outlet of the BMP shall continuously increase with increasing head and shall have hydraulic characteristics similar to weirs, orifices or pipes.

   d) For dry detention BMPs not designed for extended detention, the design shall allow for discharge of at least 80 percent of the detention storage volume within 24 hours after the peak or center of mass of the inflow has entered the detention basin. Extended wet detention and other BMP types implemented for purposes of water quality control shall comply with the policies established in Section 3.1 of this Handbook and the BMP design specifications in *MARC/APWA BMP Manual*.

   e) Storage BMPs shall be designed with a non-clogging outlet, such as a reverse-slope pipe or a weir outlet with a trash rack. A reverse-slope pipe draws from below the permanent pool, extending in a reverse angle up to the riser, and establishes the water elevation of the permanent pool. Because these outlets draw water from below the level of the permanent pool, they are less likely to be clogged by floating debris.

   f) All openings shall be protected by trash racks, grates, stone filters, or other approved devices to allow the outlet works to remain functional. Low flow orifice size shall be based on the specifications for detention outlets provided in the *MARC/APWA BMP Manual* with a minimum internal diameter of 2 inches. Low flow pipes should have a minimum slope of 1%. A reverse slope outlet pipe attached to a riser is acceptable to draw water from below the permanent pool of a wet BMP. A downturned drawdown orifice can also be considered for reducing clogging potential. See also *MARC/APWA BMP Manual* Sections 8.6, 8.10, and 8.12 for design guidance and typical details for low-flow outlets and trash rack designs. Note that multiple design options are available for non-clogging low flow outlets and debris collection, and designers are encouraged to select the best design for their site.

8. **Auxiliary spillways:** The auxiliary spillway may either be combined with the outlet works or be a separate structure or channel meeting the following criteria:

   a) Elevation: Auxiliary spillways shall be designed so that their crest elevation is at or above the 1% chance maximum water surface elevation (100-yr maximum WSEL) in the detention or retention facility. It shall be assumed that the primary spillway has zero flow when setting the elevation of the auxiliary spillway.

   b) Capacity: In cases where the impoundment/auxiliary spillway is not regulated by either state or federal agencies, the auxiliary spillway shall be designed to pass the 1% chance flood event with 1 foot of freeboard from the design stage to the top of dam, assuming zero flow through the primary outlet. This design provides an added level of protection in the event of a clogged primary outlet or a subsequent 1% storm event that occurs before the flood pool from the initial storm event recedes to the principal outlet elevation.

c) Velocity: In cases where the impoundment/auxiliary spillway is not regulated by either state or federal agencies, the auxiliary spillway shall be designed to pass the spillway flows with one foot of depth at a velocity of 6 ft/s or less in vegetated spillways with clay soils, 4 ft/s or less in vegetated spillways with sandy soils, or 12 ft/s or less in properly designed rip-rap spillways. These allowable velocities may be exceeded if a stability analysis is provided based on proposed vegetation, existing soils and geologic conditions using a software designed for this purpose such as the USDA-NRCS SITES program. In these types of analysis, average maintenance conditions shall be assumed in the analysis, and the model must show that no erosion or sod stripping occurs. For manufactured spillway liners, the maximum velocities shall not exceed 70% of the maximum allowable manufacturer's recommendations.

9. **Drawdown provision:** For storage BMPs with dams greater than 10 feet in height, drain works consisting of valves, gates, pipes, and other devices as necessary to completely drain the facility in 72 hours or less when required for maintenance or inspection shall be provided.

4.3.2 BMP Specific Policies

In addition to the foregoing criteria, the following shall be applicable, depending on the detention alternative(s) selected. Juicer

4.3.2.1 Retention and Wet Detention BMP Design:

For storage BMPs designed with permanent pools:

a) Sediment forebay: A sediment forebay shall be provided to trap coarse particles. Refer to the *MARC/APWA BMP Manual* for typical design specifications and configurations of sediment forebays.

b) Minimum depth: The minimum normal depth of water before the introduction of excess stormwater shall be four feet plus a sedimentation allowance of not less than 5 years accumulation. Sedimentation shall be determined in accordance with the procedures shown in **Figure 4-5**.

c) Depth for fish: If the pond is to contain fish, at least one-quarter of the area of the permanent pool must have a minimum depth of 10 feet plus sedimentation allowance.

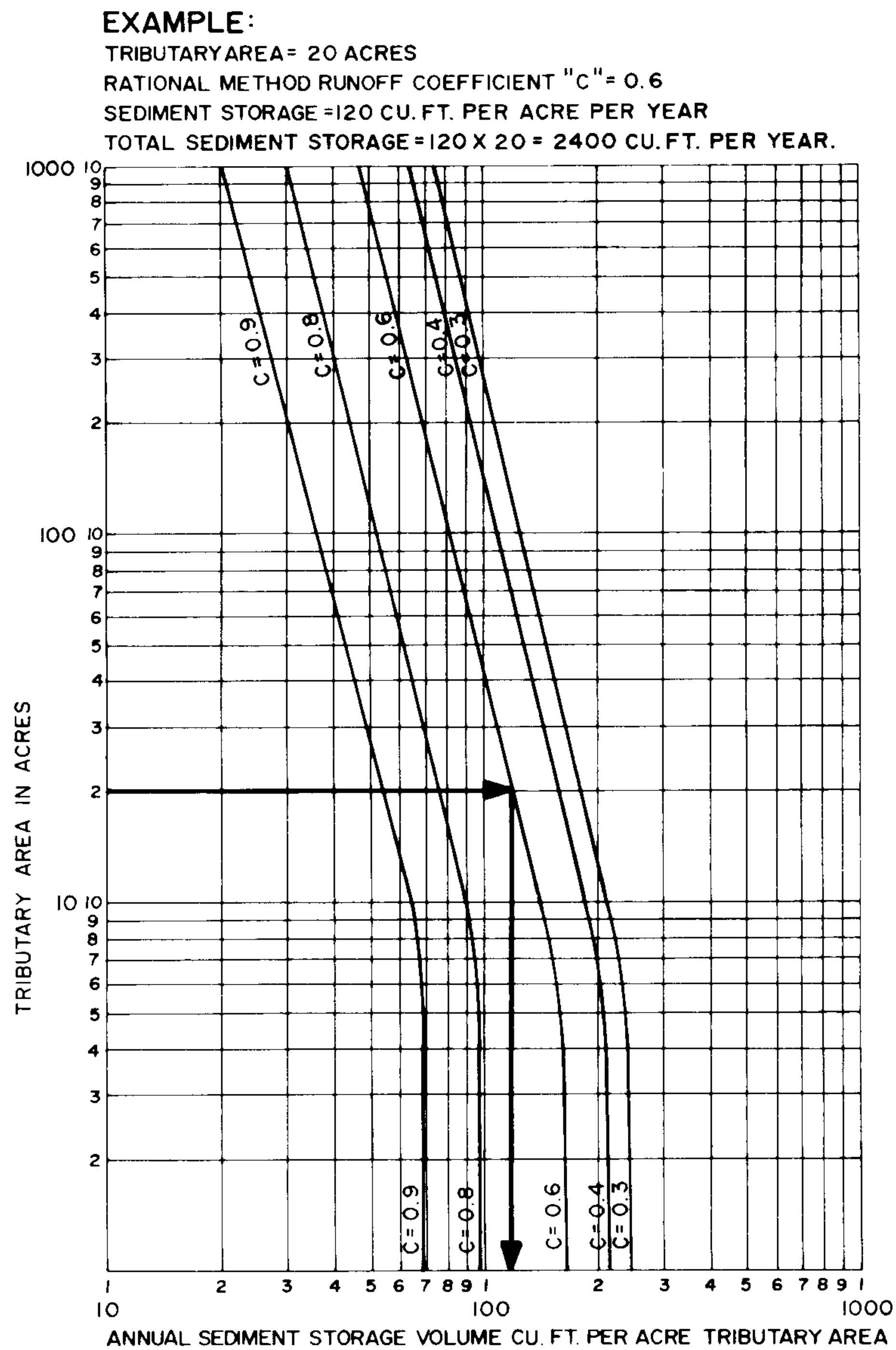
d) Side slopes: The side slopes shall conform as closely as possible to regraded or natural land contours and should not exceed 3:1 (H:V). Slopes exceeding this limit shall require erosion control and safety measures and a geotechnical analysis.

e) Vegetation: The facility's berm shall be fully vegetated with a thick stand of grass or other ground cover, preferably native vegetation. A natural buffer area is another option around the pond, provided access for maintenance and to the outlet structure is not impeded. Areas of erosion or bare soil shall not be present. Trees are not permitted on the berm to eliminate root effects on berm structure and stability.

f) Waterfowl management: Wet stormwater BMPs can attract waterfowl. The presence of ducks and other desirable waterfowl can be a factor in turning a stormwater BMP into an attractive and interesting amenity in a development. However, a lack of waterfowl management measures can cause problems. Canada Geese can be particularly destructive because they can defoliate the area surrounding the BMP, causing erosion and e. Coli issues in the BMP itself. A key factor in managing waterfowl is to discourage foraging and residence along the shoreline. Select a tall grass for the BMP or plant a native, tall grass species buffer along the shoreline and place signs to identify this area as a "no mow" zone (see **Figures 4-6a and b**). This lush, watery landscape attracts waterfowl to the water, but does not encourage them to exit the water and take up residence. Signs discouraging waterfowl feeding may also be warranted in areas where sidewalks or trails are in close proximity to a wet BMP.

g) Refer to the current version *MARC/APWA BMP Manual (Comprehensive and Frequent Event Strategies)* for design requirements on detention/retention facilities designed to also provide control of the water quality volume (WQ_v).

Figure 4-5. Procedure for Determining Sedimentation in Wet Detention Facilities ***(Source: APWA 5600)***



Figures 4-6a and b. Waterfowl Deterrence for a Wet Stormwater BMPs

Left: Tall grass buffer help to create a "naturalized" stormwater pond that deters waterfowl residence. *Source: Lake County, IL*. **Right:** A "no mow" sign stands in a tall grass stormwater BMP buffer in Merrillville IN. *Source: Municipal Sewer & Water Magazine*.

4.3.2.2 Dry Detention BMP Design

1. **General.** For detention BMPs designed to be normally dry:
   a) Interior drainage: Provisions must be incorporated to facilitate interior drainage to outlet structures. Grades for drainage components shall not be less than two percent on turf. Concrete, low-flow channels are discouraged but may be permitted at the director's discretion.
   b) Vegetation: Earth bottoms and berms shall be fully vegetated with a thick stand of grass or other ground cover. Native vegetation is encouraged. Areas of erosion or bare soil shall not be present. Trees are not permitted as these can undermine the available storage in the facility and have negative effects on berm structure and stability.
   c) Side slopes: The side slopes of dry ponds should be relatively flat to reduce safety risks and to help lengthen the effective flow path. Slopes shall not be steeper than 3:1 (H:V) and at least 25% of the perimeter shall have a slope of 5:1 (H:V) or flatter.
   d) Refer to the current version *MARC/APWA BMP Manual (Comprehensive and Frequent Event Strategies)* for design requirements on facilities providing control of the water quality volume (WQ_v).
2. **Rooftop storage.** Detention storage may be met in total or in part by detention on roofs. Details of such designs shall include the depth and volume of storage, details of outlet devices and down drains, elevations and details of overflow scuppers, and emergency overflow provisions. Connection of roof drains to sanitary sewers is prohibited. Design loadings and special building and structural details shall adhere to all applicable building codes and shall be subject to approval by the director (Utilities), and the Director of Development Services.
3. **Parking lot storage.** Paved parking lots may be designed to provide temporary detention storage of stormwater on a portion of their surfaces. Generally, such detention areas shall be in the more remote portions of such parking lots. Depths of storage shall be limited to a maximum depth of six (6) inches above the crown of the lot/street for the 100-year storm event. Parking lot storage areas shall be located so that access to and from parking areas is not impaired.

4. **Other storage.** All or a portion of detention storage may also be provided in underground or surface detention areas, including, but not limited to, oversized storm sewers, vaults, tanks, swales, etc. Underground detention BMPs must be vented to prevent accumulation of toxic or explosive gases.

4.3.3 Computational Requirements and Methods

In addition to the foregoing criteria, the following shall be applicable to the design of detention and retention facilities:

1. **Accepted computational methods.** Stormwater discharge shall be calculated using Baseline Unit Hydrograph Method often referred to as the SCS Unit Hydrograph Method: For more information, see *SCS Technical Release No. 55, Urban Hydrology for Small Watersheds,* 2nd Edition, June 1986. The Rational Method and regressions formulas may not be used for stormwater discharge determination.

2. **Rainfall.** Rainfall depths shall be determined using *NOAA Atlas 14, Volume 8* rainfall data. Hydrologic analysis shall be based on Antecedent Moisture Condition II. A 24-hour duration rainfall depth, using NRCS MSE4 nested rainfall distribution shall be used in developing the storm hyetographs. These incremental rainfall depths are provided in Table 4-3 below. Hydrologic analysis shall be based on Antecedent Moisture Condition II.

Table 4-3. Incremental Rainfall Hyetographs for Topeka, KS

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.100	0.001	0.002	0.002	0.002	0.003	0.003	0.004
0.200	0.001	0.002	0.002	0.003	0.003	0.003	0.004
0.300	0.002	0.002	0.002	0.003	0.003	0.003	0.004
0.400	0.002	0.002	0.002	0.003	0.003	0.004	0.005
0.500	0.002	0.002	0.002	0.003	0.003	0.004	0.005
0.600	0.002	0.002	0.003	0.003	0.003	0.004	0.005
0.700	0.002	0.002	0.003	0.003	0.004	0.004	0.005
0.800	0.002	0.002	0.003	0.003	0.004	0.004	0.006
0.900	0.002	0.002	0.003	0.003	0.004	0.004	0.006
1.000	0.002	0.003	0.003	0.004	0.004	0.005	0.006
1.100	0.002	0.003	0.003	0.004	0.004	0.005	0.006
1.200	0.002	0.003	0.003	0.004	0.004	0.005	0.006
1.300	0.002	0.003	0.003	0.004	0.005	0.005	0.007
1.400	0.002	0.003	0.003	0.004	0.005	0.005	0.007
1.500	0.002	0.003	0.004	0.004	0.005	0.006	0.007
1.600	0.002	0.003	0.004	0.004	0.005	0.006	0.007
1.700	0.003	0.003	0.004	0.005	0.005	0.006	0.007
1.800	0.003	0.003	0.004	0.005	0.005	0.006	0.008
1.900	0.003	0.003	0.004	0.005	0.005	0.006	0.008
2.000	0.003	0.003	0.004	0.005	0.006	0.006	0.008
2.100	0.003	0.004	0.004	0.005	0.006	0.006	0.008
2.200	0.003	0.004	0.004	0.005	0.006	0.007	0.008
2.300	0.003	0.004	0.004	0.005	0.006	0.007	0.009
2.400	0.003	0.004	0.004	0.005	0.006	0.007	0.009

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
2.500	0.003	0.004	0.005	0.006	0.006	0.007	0.009
2.600	0.003	0.004	0.005	0.006	0.006	0.007	0.009
2.700	0.003	0.004	0.005	0.006	0.007	0.007	0.010
2.800	0.003	0.004	0.005	0.006	0.007	0.008	0.010
2.900	0.003	0.004	0.005	0.006	0.007	0.008	0.010
3.000	0.004	0.004	0.005	0.006	0.007	0.008	0.010
3.100	0.004	0.004	0.005	0.006	0.007	0.008	0.010
3.200	0.004	0.005	0.005	0.006	0.007	0.008	0.011
3.300	0.004	0.005	0.005	0.007	0.008	0.008	0.011
3.400	0.004	0.005	0.006	0.007	0.008	0.009	0.011
3.500	0.004	0.005	0.006	0.007	0.008	0.009	0.011
3.600	0.004	0.005	0.006	0.007	0.008	0.009	0.011
3.700	0.004	0.005	0.006	0.007	0.008	0.009	0.012
3.800	0.004	0.005	0.006	0.007	0.008	0.009	0.012
3.900	0.004	0.005	0.006	0.007	0.008	0.010	0.012
4.000	0.004	0.005	0.006	0.007	0.009	0.010	0.012
4.100	0.004	0.005	0.006	0.008	0.009	0.010	0.013
4.200	0.004	0.005	0.006	0.008	0.009	0.010	0.013
4.300	0.004	0.006	0.007	0.008	0.009	0.010	0.013
4.400	0.005	0.006	0.007	0.008	0.009	0.010	0.013
4.500	0.005	0.006	0.007	0.008	0.009	0.010	0.013
4.600	0.005	0.006	0.007	0.008	0.009	0.011	0.014
4.700	0.005	0.006	0.007	0.008	0.010	0.011	0.014
4.800	0.005	0.006	0.007	0.009	0.010	0.011	0.014
4.900	0.005	0.006	0.007	0.009	0.010	0.011	0.014
5.000	0.005	0.006	0.007	0.009	0.010	0.011	0.014
5.100	0.005	0.006	0.007	0.009	0.010	0.011	0.015
5.200	0.005	0.006	0.008	0.009	0.010	0.012	0.015
5.300	0.005	0.006	0.008	0.009	0.010	0.012	0.015
5.400	0.005	0.007	0.008	0.009	0.011	0.012	0.015
5.500	0.005	0.007	0.008	0.009	0.011	0.012	0.015
5.600	0.005	0.007	0.008	0.010	0.011	0.012	0.016
5.700	0.006	0.007	0.008	0.010	0.011	0.012	0.016
5.800	0.006	0.007	0.008	0.010	0.011	0.013	0.016
5.900	0.006	0.007	0.008	0.010	0.011	0.013	0.016
6.000	0.006	0.007	0.008	0.010	0.012	0.013	0.017
6.100	0.006	0.007	0.009	0.010	0.012	0.013	0.017
6.200	0.006	0.007	0.009	0.010	0.012	0.013	0.017
6.300	0.006	0.007	0.009	0.011	0.012	0.014	0.017
6.400	0.006	0.008	0.009	0.011	0.012	0.014	0.018
6.500	0.006	0.008	0.009	0.011	0.012	0.014	0.018
6.600	0.006	0.008	0.009	0.011	0.012	0.014	0.018
6.700	0.006	0.008	0.009	0.011	0.013	0.014	0.018
6.800	0.006	0.008	0.009	0.011	0.013	0.014	0.018

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
6.900	0.006	0.008	0.009	0.011	0.013	0.015	0.019
7.000	0.006	0.008	0.009	0.011	0.013	0.015	0.019
7.100	0.007	0.008	0.010	0.012	0.013	0.015	0.019
7.200	0.007	0.008	0.010	0.012	0.013	0.015	0.019
7.300	0.007	0.008	0.010	0.012	0.013	0.015	0.019
7.400	0.007	0.008	0.010	0.012	0.014	0.015	0.020
7.500	0.007	0.009	0.010	0.012	0.014	0.016	0.020
7.600	0.007	0.009	0.010	0.012	0.014	0.016	0.020
7.700	0.007	0.009	0.010	0.012	0.014	0.016	0.020
7.800	0.007	0.009	0.010	0.013	0.014	0.016	0.021
7.900	0.007	0.009	0.010	0.013	0.014	0.016	0.021
8.000	0.007	0.009	0.011	0.013	0.015	0.016	0.021
8.100	0.007	0.009	0.011	0.013	0.015	0.017	0.021
8.200	0.007	0.009	0.011	0.013	0.015	0.017	0.021
8.300	0.007	0.009	0.011	0.013	0.015	0.017	0.022
8.400	0.007	0.009	0.011	0.013	0.015	0.017	0.022
8.500	0.008	0.009	0.011	0.013	0.015	0.017	0.022
8.600	0.008	0.010	0.011	0.014	0.015	0.017	0.022
8.700	0.008	0.010	0.011	0.014	0.016	0.018	0.022
8.800	0.008	0.010	0.011	0.014	0.016	0.018	0.023
8.900	0.008	0.010	0.012	0.014	0.016	0.018	0.023
9.000	0.008	0.010	0.012	0.014	0.016	0.018	0.023
9.100	0.012	0.015	0.018	0.022	0.025	0.028	0.035
9.200	0.012	0.015	0.018	0.022	0.025	0.028	0.036
9.300	0.013	0.016	0.018	0.022	0.025	0.028	0.036
9.400	0.013	0.016	0.019	0.022	0.026	0.029	0.037
9.500	0.013	0.016	0.019	0.023	0.026	0.029	0.037
9.600	0.013	0.016	0.019	0.023	0.026	0.030	0.038
9.700	0.013	0.016	0.019	0.023	0.027	0.030	0.038
9.800	0.013	0.017	0.020	0.024	0.027	0.030	0.039
9.900	0.014	0.017	0.020	0.024	0.027	0.031	0.039
10.000	0.014	0.017	0.020	0.024	0.028	0.031	0.040
10.100	0.014	0.017	0.020	0.025	0.028	0.031	0.040
10.200	0.014	0.017	0.020	0.025	0.028	0.032	0.041
10.300	0.014	0.018	0.021	0.025	0.029	0.032	0.041
10.400	0.014	0.018	0.021	0.025	0.029	0.033	0.042
10.500	0.015	0.018	0.021	0.026	0.029	0.033	0.042
10.600	0.021	0.026	0.031	0.037	0.042	0.048	0.061
10.700	0.024	0.029	0.034	0.042	0.047	0.053	0.068
10.800	0.026	0.032	0.038	0.046	0.052	0.059	0.075
10.900	0.028	0.036	0.042	0.050	0.057	0.064	0.082
11.000	0.031	0.039	0.045	0.055	0.062	0.070	0.090
11.100	0.033	0.042	0.049	0.059	0.067	0.076	0.097
11.200	0.036	0.045	0.052	0.063	0.072	0.081	0.104

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
11.300	0.038	0.048	0.056	0.068	0.077	0.087	0.111
11.400	0.041	0.051	0.060	0.072	0.082	0.092	0.118
11.500	0.043	0.054	0.063	0.076	0.087	0.098	0.125
11.600	0.060	0.075	0.088	0.107	0.121	0.137	0.175
11.700	0.080	0.100	0.117	0.141	0.161	0.181	0.232
11.800	0.110	0.137	0.160	0.194	0.220	0.248	0.318
11.900	0.153	0.191	0.223	0.270	0.308	0.346	0.443
12.000	0.281	0.351	0.411	0.496	0.565	0.637	0.815
12.100	0.499	0.623	0.729	0.882	1.004	1.131	1.447
12.200	0.153	0.191	0.223	0.270	0.308	0.346	0.443
12.300	0.110	0.137	0.160	0.194	0.220	0.248	0.318
12.400	0.080	0.100	0.117	0.141	0.161	0.181	0.232
12.500	0.060	0.075	0.088	0.107	0.121	0.137	0.175
12.600	0.043	0.054	0.063	0.076	0.087	0.098	0.125
12.700	0.041	0.051	0.060	0.072	0.082	0.092	0.118
12.800	0.038	0.048	0.056	0.068	0.077	0.087	0.111
12.900	0.036	0.045	0.052	0.063	0.072	0.081	0.104
13.000	0.033	0.042	0.049	0.059	0.067	0.076	0.097
13.100	0.031	0.039	0.045	0.055	0.062	0.070	0.090
13.200	0.028	0.036	0.042	0.050	0.057	0.064	0.082
13.300	0.026	0.032	0.038	0.046	0.052	0.059	0.075
13.400	0.024	0.029	0.034	0.042	0.047	0.053	0.068
13.500	0.021	0.026	0.031	0.037	0.042	0.048	0.061
13.600	0.015	0.018	0.021	0.026	0.029	0.033	0.042
13.700	0.014	0.018	0.021	0.025	0.029	0.033	0.042
13.800	0.014	0.018	0.021	0.025	0.029	0.032	0.041
13.900	0.014	0.017	0.020	0.025	0.028	0.032	0.041
14.000	0.014	0.017	0.020	0.025	0.028	0.031	0.040
14.100	0.014	0.017	0.020	0.024	0.028	0.031	0.040
14.200	0.014	0.017	0.020	0.024	0.027	0.031	0.039
14.300	0.013	0.017	0.020	0.024	0.027	0.030	0.039
14.400	0.013	0.016	0.019	0.023	0.027	0.030	0.038
14.500	0.013	0.016	0.019	0.023	0.026	0.030	0.038
14.600	0.013	0.016	0.019	0.023	0.026	0.029	0.037
14.700	0.013	0.016	0.019	0.022	0.026	0.029	0.037
14.800	0.013	0.016	0.018	0.022	0.025	0.028	0.036
14.900	0.012	0.015	0.018	0.022	0.025	0.028	0.036
15.000	0.012	0.015	0.018	0.022	0.025	0.028	0.035
15.100	0.008	0.010	0.012	0.014	0.016	0.018	0.023
15.200	0.008	0.010	0.012	0.014	0.016	0.018	0.023
15.300	0.008	0.010	0.011	0.014	0.016	0.018	0.023
15.400	0.008	0.010	0.011	0.014	0.016	0.018	0.022
15.500	0.008	0.010	0.011	0.014	0.015	0.017	0.022
15.600	0.008	0.009	0.011	0.013	0.015	0.017	0.022

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
15.700	0.007	0.009	0.011	0.013	0.015	0.017	0.022
15.800	0.007	0.009	0.011	0.013	0.015	0.017	0.022
15.900	0.007	0.009	0.011	0.013	0.015	0.017	0.021
16.000	0.007	0.009	0.011	0.013	0.015	0.017	0.021
16.100	0.007	0.009	0.011	0.013	0.015	0.016	0.021
16.200	0.007	0.009	0.010	0.013	0.014	0.016	0.021
16.300	0.007	0.009	0.010	0.013	0.014	0.016	0.021
16.400	0.007	0.009	0.010	0.012	0.014	0.016	0.020
16.500	0.007	0.009	0.010	0.012	0.014	0.016	0.020
16.600	0.007	0.009	0.010	0.012	0.014	0.016	0.020
16.700	0.007	0.008	0.010	0.012	0.014	0.015	0.020
16.800	0.007	0.008	0.010	0.012	0.013	0.015	0.019
16.900	0.007	0.008	0.010	0.012	0.013	0.015	0.019
17.000	0.007	0.008	0.010	0.012	0.013	0.015	0.019
17.100	0.006	0.008	0.009	0.011	0.013	0.015	0.019
17.200	0.006	0.008	0.009	0.011	0.013	0.015	0.019
17.300	0.006	0.008	0.009	0.011	0.013	0.014	0.018
17.400	0.006	0.008	0.009	0.011	0.013	0.014	0.018
17.500	0.006	0.008	0.009	0.011	0.012	0.014	0.018
17.600	0.006	0.008	0.009	0.011	0.012	0.014	0.018
17.700	0.006	0.008	0.009	0.011	0.012	0.014	0.018
17.800	0.006	0.007	0.009	0.011	0.012	0.014	0.017
17.900	0.006	0.007	0.009	0.010	0.012	0.013	0.017
18.000	0.006	0.007	0.009	0.010	0.012	0.013	0.017
18.100	0.006	0.007	0.008	0.010	0.012	0.013	0.017
18.200	0.006	0.007	0.008	0.010	0.011	0.013	0.016
18.300	0.006	0.007	0.008	0.010	0.011	0.013	0.016
18.400	0.006	0.007	0.008	0.010	0.011	0.012	0.016
18.500	0.005	0.007	0.008	0.010	0.011	0.012	0.016
18.600	0.005	0.007	0.008	0.009	0.011	0.012	0.015
18.700	0.005	0.007	0.008	0.009	0.011	0.012	0.015
18.800	0.005	0.006	0.008	0.009	0.010	0.012	0.015
18.900	0.005	0.006	0.008	0.009	0.010	0.012	0.015
19.000	0.005	0.006	0.007	0.009	0.010	0.011	0.015
19.100	0.005	0.006	0.007	0.009	0.010	0.011	0.014
19.200	0.005	0.006	0.007	0.009	0.010	0.011	0.014
19.300	0.005	0.006	0.007	0.009	0.010	0.011	0.014
19.400	0.005	0.006	0.007	0.008	0.010	0.011	0.014
19.500	0.005	0.006	0.007	0.008	0.009	0.011	0.014
19.600	0.005	0.006	0.007	0.008	0.009	0.010	0.013
19.700	0.005	0.006	0.007	0.008	0.009	0.010	0.013
19.800	0.004	0.006	0.007	0.008	0.009	0.010	0.013
19.900	0.004	0.005	0.006	0.008	0.009	0.010	0.013
20.000	0.004	0.005	0.006	0.008	0.009	0.010	0.013

Time (hrs)	Incremental Rainfall Hyetographs for Topeka, KS						
	2-year	5-year	10-year	25-year	50-year	100-year	500-year
20.100	0.004	0.005	0.006	0.007	0.009	0.010	0.012
20.200	0.004	0.005	0.006	0.007	0.008	0.010	0.012
20.300	0.004	0.005	0.006	0.007	0.008	0.009	0.012
20.400	0.004	0.005	0.006	0.007	0.008	0.009	0.012
20.500	0.004	0.005	0.006	0.007	0.008	0.009	0.011
20.600	0.004	0.005	0.006	0.007	0.008	0.009	0.011
20.700	0.004	0.005	0.006	0.007	0.008	0.009	0.011
20.800	0.004	0.005	0.005	0.007	0.008	0.008	0.011
20.900	0.004	0.005	0.005	0.006	0.007	0.008	0.011
21.000	0.004	0.004	0.005	0.006	0.007	0.008	0.010
21.100	0.004	0.004	0.005	0.006	0.007	0.008	0.010
21.200	0.003	0.004	0.005	0.006	0.007	0.008	0.010
21.300	0.003	0.004	0.005	0.006	0.007	0.008	0.010
21.400	0.003	0.004	0.005	0.006	0.007	0.007	0.010
21.500	0.003	0.004	0.005	0.006	0.006	0.007	0.009
21.600	0.003	0.004	0.005	0.006	0.006	0.007	0.009
21.700	0.003	0.004	0.004	0.005	0.006	0.007	0.009
21.800	0.003	0.004	0.004	0.005	0.006	0.007	0.009
21.900	0.003	0.004	0.004	0.005	0.006	0.007	0.008
22.000	0.003	0.004	0.004	0.005	0.006	0.006	0.008
22.100	0.003	0.003	0.004	0.005	0.006	0.006	0.008
22.200	0.003	0.003	0.004	0.005	0.005	0.006	0.008
22.300	0.003	0.003	0.004	0.005	0.005	0.006	0.008
22.400	0.003	0.003	0.004	0.005	0.005	0.006	0.007
22.500	0.002	0.003	0.004	0.004	0.005	0.006	0.007
22.600	0.002	0.003	0.004	0.004	0.005	0.006	0.007
22.700	0.002	0.003	0.003	0.004	0.005	0.005	0.007
22.800	0.002	0.003	0.003	0.004	0.005	0.005	0.007
22.900	0.002	0.003	0.003	0.004	0.004	0.005	0.006
23.000	0.002	0.003	0.003	0.004	0.004	0.005	0.006
23.100	0.002	0.003	0.003	0.004	0.004	0.005	0.006
23.200	0.002	0.002	0.003	0.003	0.004	0.004	0.006
23.300	0.002	0.002	0.003	0.003	0.004	0.004	0.006
23.400	0.002	0.002	0.003	0.003	0.004	0.004	0.005
23.500	0.002	0.002	0.003	0.003	0.003	0.004	0.005
23.600	0.002	0.002	0.002	0.003	0.003	0.004	0.005
23.700	0.002	0.002	0.002	0.003	0.003	0.004	0.005
23.800	0.002	0.002	0.002	0.003	0.003	0.003	0.004
23.900	0.001	0.002	0.002	0.003	0.003	0.003	0.004
24.000	0.001	0.002	0.002	0.002	0.003	0.003	0.004
SUM:	**3.470**	**4.330**	**5.070**	**6.130**	**6.980**	**7.860**	**10.060**

As an alternative to using the 24-hour duration, NRCS MSE4 nested rainfall distribution hyetographs, a shorter duration rainfall distribution can be utilized with a non-nested temporal rainfall distribution using the 2nd quartile, 50% probability curves; however, in this case all frequency events and all duration events (minimum of 2-, 3-, 4-, 6-, 12-, and 24-hour) must be analyzed. The maximum peak flow and maximum volume of this multi-duration analysis must be selected for each storm frequency.

3. **Volume estimation.** A preliminary value of the storage volume may be estimated using any standard method including the Rational Method. However, the volume shall be checked during hydrograph routing through the basin and adjusted accordingly. See additional policies to follow regarding detention basin sizing.

4. **Routing.** Hydrograph routing shall be performed using the Modified Puls level pool routing method. If using a 2-dimensional (2D) model, routing the excess rainfall can be accomplished using appropriate 2D rain or excess rainfall on surface routing methodology. Note: The water quality orifice is designed to store the water quality storm and drain it within 40-hours. Routing of the 2-, 5-, 10-, 25-, 50- and 100-year storms is done independently assuming the water quality storm is not present but using the water quality orifice as part of the rating curve.

5. **Curve numbers.** SCS Curve Numbers shall be determined using *SCS Technical Release No. 55* and the following policies:

   a) Fill soil and soil disturbed by prior or proposed construction shall be assigned Hydrologic Soil Group class of "D". Disturbed areas that are restored with engineered soils as part of a stormwater BMP, that do not contain compacted fill, that encourage infiltration, and that meet performance specifications approved by the director can be assigned a class of "C."

   b) Undeveloped areas with a current agricultural land use (crops, pasture, meadow) shall be assigned a maximum CN equivalent to good condition pasture, grassland, or rangeland (CN = 74).

6. **Time of concentration and lag time.** Use the procedures identified in the *Design Criteria and Drafting Standards* to calculate the time of concentration (T_c) and lag time (T_L).

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5 Low Impact Development Techniques

5.1 BACKGROUND

TMC Chapter 13.35 states that reduction of adverse stormwater impacts through the use of stormwater LID techniques should be the first consideration of the site designer. Operationally, economically, and aesthetically, the use of LID techniques offers significant benefits over treating and controlling stormwater downstream. Therefore, feasible opportunities for using these methods should be explored and exhausted before considering the use of GI and other BMPs.

Land developments can be designed to reduce their stormwater impacts when careful efforts are made to conserve natural areas, reduce impervious cover, and better integrate stormwater management techniques. By implementing a combination of these non-structural approaches, collectively known as stormwater LID practices, it is possible to reduce the amount of stormwater, and therefore pollutants, that are generated from a development after construction. This overall reduction in stormwater can yield multiple benefits, including the minimization of costs for infrastructure construction and long-term post-construction maintenance. An inherent minimization of a property's stormwater utility fee may also be a benefit of LID practices, given the fee is calculated based on the impervious area of a property.

In general, stormwater LID techniques are based on the following general goals:

- ✓ Early communication and coordination between the design team and the City of Topeka
- ✓ Managing stormwater (quality and quantity) as close to the point of origin as possible, and minimizing collection and conveyance
- ✓ Preventing negative impacts that can result from post-development stormwater rather than mitigating them
- ✓ Utilizing simple, non-structural methods for stormwater management that are lower cost and lower maintenance than structural BMPs
- ✓ Creating a multi-functional landscape that can manage stormwater and address or benefit other development needs
- ✓ Using hydrology as a framework for land development design

Stormwater LID techniques include a number of site design techniques, such as preserving natural features and resources, effectively laying out the site elements to reduce impact, reducing the impervious surface area, and utilizing natural features on the site for stormwater management. The aim is to reduce the environmental impact "footprint" of the site while retaining and enhancing the owner or developer's purpose and vision for the site.

5.2 INCENTIVES

Many of the LID techniques presented in this Chapter can reduce the cost of infrastructure while maintaining or even increasing the value of the property. The reduction in stormwater and pollutants using LID techniques can also reduce the required peak discharges and volumes that must be conveyed and controlled on a site and, therefore, the size and cost of necessary drainage infrastructure and GI other BMPs. In some cases, the use of

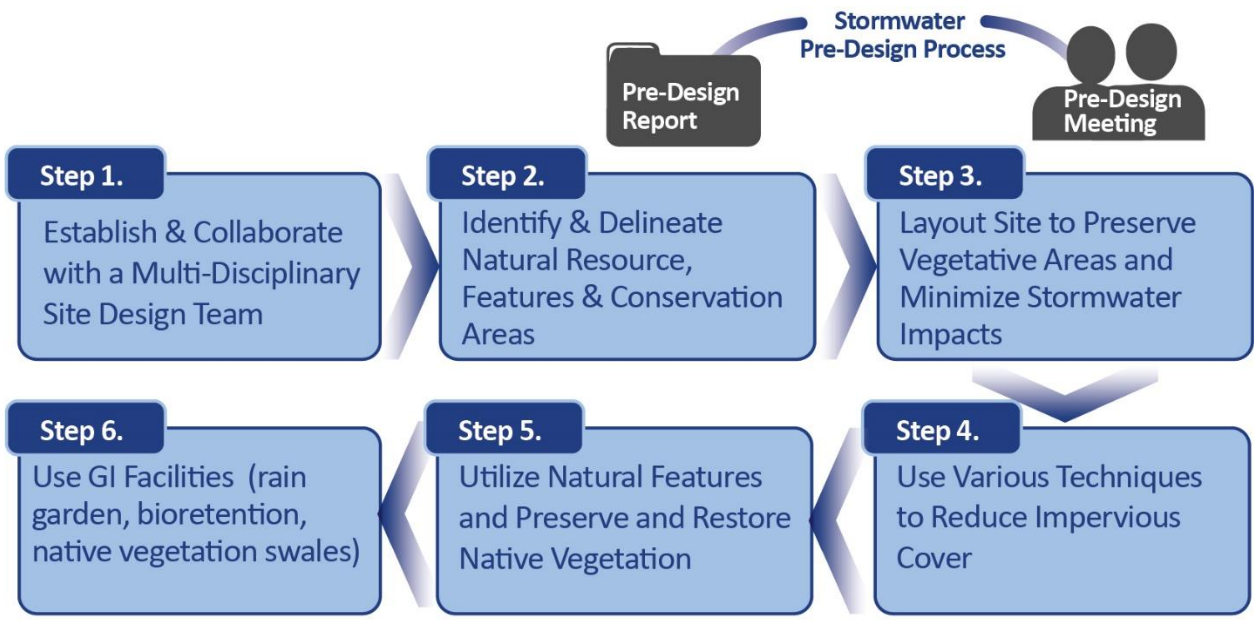
LID techniques may eliminate the need for structural BMPs entirely. Hence, LID techniques can be viewed as both a water quantity and water quality management tool. They can also have several other ancillary benefits for the property owner, developer or business/residents, as follows:

- Reduced construction costs through lower overall costs for land clearing and total infrastructure materials and construction
- Improved overall marketability and property values
- More open space for recreation
- More pedestrian-friendly neighborhoods
- Protection of sensitive forests, wetlands, and habitats
- More aesthetically pleasing and naturally attractive landscape
- Easier compliance with wetland and other resource protection regulations
- Possibility to obtain Leadership in Energy & Environmental Design (LEED) points
- Minimization of a property's stormwater utility fee

5.3 LID PROCESS AND CONCEPTS

Figure 5-1 depicts the ideal process for stormwater design which incorporates early evaluation and implementation of opportunities for stormwater LID techniques. There are several significant elements in the figure that should be noted by the site designer.

Figure 5-1: Stormwater Design Process Using LID Techniques



The most important concept conveyed by the Figure 5-1 is realized moving step-wise through the process. That is, **successful LID implementation *ends* when a designer begins the analyses and computations for infrastructure design**. Stated differently, all of the effort in planning using LID techniques takes place very early, so the site layout (i.e., the relative placement of buildings and roads to preserved areas and conservation areas) is established ***USING*** stormwater LID concepts. This holistic approach is critical for the successful use of LID techniques because it strives to fit the development's buildings and pavement to the existing property's topography and hydrology, thus taking advantage of natural features and processes to do the work of stormwater management. In contrast, site designers who want to fit the property to a pre-conceived or "cookie-cutter" layout that does not consider the site's existing hydrology, or who wait to consider LID techniques until after the site layout or grading is established, are not likely to have a high degree of success.

Each step in the stormwater LID practice implementation process is summarized below:

Step 1	**Begin with a multi-disciplinary design team.** Stormwater LID techniques and GI-BMPs demand that soil and vegetation be considered design elements for stormwater volume reduction and pollutant management. As a result, stormwater management design is no longer the sole domain of the civil engineer. Professionals knowledgeable in several key disciplines can add great value to a site design. Such disciplines include hydrology, ecology, landscape architecture, land use planning, soil science, geomorphology, horticulture and even forestry. This multi-disciplinary design team should be used throughout the site stormwater planning, design, and construction process.
Step 2	**Identify natural and sensitive features.** The identification of hydrologic and natural features, conservation areas, and other resources on a development site is vital to understanding the existing hydrology of the area. Some natural features should be avoided (such as jurisdictional wetlands), while others can serve a stormwater management function after development. Features to be inventoried include undisturbed forest areas, stream buffers, steep slopes, and other sensitive areas. Section 5.5.2 provides a more detailed list of features. As indicated by the figure, this should be done before any site design activities occur.
Step 3	**Layout the site to minimize stormwater runoff.** After inventorying and mapping of the natural and sensitive features, the site layout can begin to take shape as the site design team collaborates. A number of stormwater LID techniques (see Section 5.4) can be considered and applied in this step to preserve vegetated and sensitive areas, locate buildings and pavement on soils that are less porous, minimize plans for clearing/grading, and make use of an open space layout.
Step 4	**Reduce impervious surface area.** The site design team collaborates further to consider and apply additional LID techniques that target minimization of runoff volume stormwater will be generated from the development. Parking areas, roadway and driveway widths, and rooftop areas are primary focuses of this step to determine where the overall imperviousness of the development site can be reduced.
Step 5	**Use natural features for stormwater management.** In this step, the site design team considers and applies LID techniques that use natural features, conservation areas, and other pervious surfaces to manage stormwater discharged from the site's impervious surfaces. For example, runoff from a small parking area can discharge into a well-draining forested area or through natural, vegetated swales. The use of natural, non-structural options to manage and/or convey stormwater is less expensive than the construction and maintenance of BMPs, ditches, and pipes. Improving the quality of soils and vegetation through amendments and planting native vegetation can provide additional benefits.

Step 6 **Design GI-BMPs.** After all feasible LID techniques are applied, the site design team should have a layout that effectively minimizes the volume (and in many cases the peak discharges) of stormwater that will be discharged from the development, and maximizes the use of less costly, lower maintenance techniques to manage stormwater. At this point, the team can begin the data preparation and analyses required for the design and specification of GI-BMPs.

5.4 OVERVIEW OF LID TECHNIQUES

Table 5-1 presents the stormwater LID techniques addressed in this Chapter. The figure groups the techniques into three categories which generally fit with Steps 1, 2, and 3 of the site planning process defined in the previous Section. More detail on each technique is provided in the Sections that follow. For some techniques, detailed guide sheets are provided to explain the key benefits of the technique and provide examples and details on how to apply them in land development design.

Table 5-1. LID Categories and Techniques

Early Coordination, Collaboration, and Communication	
❖ Work with a multi-disciplinary design team ❖ Pre-design hydrologic characterization	
Conservation of Natural Features & Resources	***"Build with the Land" Design Techniques***
❖ Preserve undisturbed natural areas ❖ Preserve/Restore stream buffers ❖ Avoid developing in floodplains ❖ Avoid developing on steep slopes ❖ Minimize siting on porous or erodible soils ❖ Soil management – preservation ❖ Soil management – restoration ❖ Restoration of native vegetation	❖ Redevelopment ❖ Fit the design to the terrain ❖ Reduce limits of clearing and grading ❖ Locate development in less sensitive areas ❖ Utilize open space development ❖ Consider creative development design

5.5 EARLY COORDINATION, COLLABORATION, AND COMMUNICATION

As discussed previously in this Handbook, early coordination, collaboration, and communication is critical to successful implementation of LID techniques. Two LID practices are recognized and are discussed in detail in the following guidance sheets.

5.5.1 Work with a Multi-Disciplinary Design Team

The use of multifunctional stormwater spaces at a Chicago school demonstrate that stormwater design can be a community asset. *Source: US Green Building Council*

Incorporating a multi-disciplinary design approach into the overall site design can yield numerous benefits to the developer and the community creating unique community assets. *Source: Wood E&IS, Inc.*

Incentive:

- Utilizing a knowledgeable team with diverse backgrounds in surface and sub-surface hydrology and land planning benefits both the developer and the community.

Description:

A multi-disciplinary design team is used throughout the site stormwater planning, design, and construction process to optimize multi-functional spaces and stormwater designs, and potentially minimize the need for costly grading and stormwater infrastructure. The members of the multi-disciplinary design team need to be selected based on the technical needs of the site and may include stormwater managers, engineers, hydrologists, ecologists, landscape architects, land use planners, soil scientists, geomorphologists, horticulturalists, and foresters.

Benefits:

With the implementation of LID practices and GI-BMP, stormwater management design is no longer the sole domain of the civil engineer and a multi-disciplinary approach is needed. The main benefits of utilizing a multi-disciplinary design team include:

- Optimization/maximization of multi-functional LID practices and GI-BMP designs
- Robust understanding of how local, state, and federal requirements can be creatively met
- Reduction of the use of, and costs associated with, constructed stormwater GI-BMPs and infrastructure
- More robust stormwater design and lower maintenance stormwater management system
- Preservation of the site's natural character and aesthetic features

Additional Resources:

USGBC Central Plains: https://www.usgbc.org/chapters/usgbc-central-plains
Prairie Gateway Chapter of the American Society of Landscape Architects: http://www.pgasla.org/
Kansas Society of Professional Engineers: https://www.kansasengineer.org/
Kansas Native Plant Society: http://www.kansasnativeplantsociety.org/
Kansas Stormwater Consortium Educational Web Site: http://www.ksstormwater.com/
Friends of the Kaw: https://kansasriver.org/stormwater-resources/
Stormwater Training Resource Locator: https://www.envcap.org/srl/srl.php?srl=16&state=KS

Planning and Physical Feasibility:

Impervious surfaces, pervious surfaces, soil, and vegetation are multi-functional site elements which must comply with design specifications to ensure their proper stormwater function. As a result, several other technical disciplines are training professionals on stormwater management, including engineering, hydrology, ecology, landscape architecture, land use planning, soil science, geomorphology, horticulture and forestry.

Table 5-2 presents the disciplines and knowledge of a well-rounded site design team. While all these disciplines may not be necessary for every site design, developers who use multi-disciplinary teams to craft a site's stormwater management approach may produce more cost-effective *and* highly-functional drainage designs. At a minimum, the site design team should include an engineer and landscape architect. However, expanding the team beyond these professionals will likely provide substantial benefits, as the team can better maximize the use of natural features for stormwater management, possibly minimizing constructed features and their associated construction and maintenance costs. All team members should have knowledge of, and preferably have experience in, stormwater management mechanisms, LID approaches, and GI-BMPs. Local technical knowledge is preferred. The following tips can aid in facilitating the use of a multi-disciplinary design team:

- ✓ Involve the whole team very early in the process, ideally before the site layout is developed (see Section 5.5.2 of this Handbook for more information on pre-design planning).
- ✓ Ensure that the team stays involved throughout design and construction. That way, they can assist with construction changes that impact, or can be influenced by, their parts of the site design.

Table 5-2. Land Development Design Team Disciplines and Relevant Knowledge

Discipline	*Stormwater & Construction Knowledge*
Engineering	❖ Hydrology, hydraulics, infrastructure design, GI-BMP design, stormwater quality and quantity control, design plan preparation
Landscape architecture	❖ Multi-functional space design, open space function and design, hydrology, landscape design, planting templates
Soil science	❖ Soil health, profiles, textures, porosity, storage capacity, restoration techniques
Horticulture	❖ Functional landscape planning, local temperate conditions, plant varieties and needs, native plants, plant/soil health, stream buffer restoration and long-term plant management
Forestry and Ecology	❖ Existing tree stand management, stream buffer restoration/enhancement, reforestation, wildlife/pest management
Geomorphology	❖ Stream restoration, stream bank stability and management in a built environment

5.5.2 The Stormwater Pre-Design Process (Hydrologic Characterization)

Performing a pre-design hydrologic characterization allows the design to identify any opportunities or limitations for LID techniques and GI-BMPs.

Incentives:

- Utilizing the pre-design process benefits both the developer and the community
- Early interaction with City staff can result in more efficient SWMP reviews

Description:

A pre-design hydrologic characterization activity is the identification and mapping of known and readily available information on the site's existing hydrology. Information gathered for this effort includes topography, general land cover, Hydrologic Soil Groups, natural areas, and sensitive environmental features, etc. **Figure 5-2** shows an example of land cover that might be referenced for characterization.

Pre-design hydrologic characterization should occur very early in the site planning process, ideally before the layout of future buildings, pavement, and pervious areas is prepared, and definitely before clearing, grading, and construction begin. Once a site layout is drawn-up by the designer, changes to it to incorporate LID techniques are less likely to occur. Moreover, opportunities for the use of low-cost, preservation-focused LID techniques decline significantly once a site is cleared and graded.

Performing a pre-design hydrologic characterization of an applicable development is not mandatory. However, because it is a best practice for stormwater management design, it is strongly encouraged by the City of Topeka.

Benefits:

The main benefits of utilizing the pre-design process include:

- Early identification of opportunities or limitations for LID techniques and GI-BMPs
- Optimize the stormwater infrastructure design by taking full advantage of, or avoiding, natural hydrologic features
- Potentially reduce grading, construction, and maintenance costs through early planning of LID practices
- Low stormwater volume resulting from optimized use of LID and GI-BMPs can lead to smaller stormwater BMPs and conveyance systems, and less cost for construction and maintenance.

Planning and Physical Feasibility:

To effectively characterize the hydrology of a parcel under consideration for development, the site design team must identify and locate natural and man-made features of the property that are important for, or will influence, effective stormwater management. These features include, but are not limited to, the list shown in **Table 5-3**.

Data readily available from the list below should be mapped or, at a minimum, scaled to allow effective comparison/overlay with each other. Design calculations, engineering studies or analyses, and onsite soil and other tests are not required. When combined with the site design team's knowledge of the other LID techniques and the GI-BMPs identified in this Handbook, opportunities and limitations for natural stormwater management techniques will become more apparent. Areas can be marked for preservation, restoration, avoidance, and impervious placement – and a site layout can begin to take place, optimized to include natural stormwater management processes.

Table 5-3. Key Information for Existing Condition Hydrologic Characterization

• Topography • Drainage basin boundaries • Land cover (delineated between native, non-native woods and meadow, crop/farm, pervious and impervious areas) • Natural soils vs other soils[1] • Hydrologic soil groups (for native soil only) • Areas where wet conditions or flooding regularly occur	• Streams, regulatory floodplains, stream buffers • Wetlands, springs, seeps • Sinkholes • Slopes greater than 15% • Areas of shallow bedrock, high water table, hardpan, clay lenses • Water supply basins, groundwater recharge areas, wellhead protection areas	• Land, water, and wildlife conservation areas • Existing utility corridors • Areas with geotechnical concerns, contractive or expansive soils, etc. • Soil borings, infiltration tests, and other soil data • Areas of cultural, historical, archeological, or wildlife significance

1 – "Natural" means native, uncompacted soil. "Other" means soils used for crops or livestock, or on previously developed land.

Figure 5-2. Different Types of Pervious Land Cover for Hydrologic Characterization (Woods & Meadow) (*Source: Wikimedia)*

5.6 CONSERVATION OF NATURAL FEATURES AND RESOURCES

Conservation of natural features is integral to successful implementation of many stormwater LID techniques. These techniques involve the identification and preservation (or restoration) of natural features and hydrologic resources on a site for the purposes of reducing stormwater volume, pollutants and peak flow, providing stormwater storage, reducing flooding, preventing soil erosion, and promoting infiltration and evapotranspiration. Thus, the conservation of natural features and resources should be a first thought for site design teams who are focused on ease of compliance with stormwater standards.

Some of the natural features that should be considered for conservation or restoration are listed below. All of these should be inventoried as part of the pre-design hydrologic characterization described in Section 5.5.2:

- ✓ Areas of undisturbed vegetation
- ✓ Floodplains and riparian areas
- ✓ Ridgetops and steep slopes
- ✓ Natural drainage pathways
- ✓ Intermittent and perennial streams
- ✓ Wetlands
- ✓ Aquifers and recharge areas
- ✓ Well-draining native soils
- ✓ Shallow bedrock or high water table
- ✓ Other natural features or critical areas

Several stormwater LID techniques are available to site design teams who wish to conserve (or restore) natural features and resources. These are described in the following Sections.

5.6.1 Preserve Undisturbed Natural Areas

Site designs can preserve existing natural areas as buffers, open space, or landscaping. Pervious cover, especially vegetation, allows water infiltration that minimizes runoff, erosion, and potential for downstream pollution. Vegetation helps reduce erosion and filter sediment and other pollutants from stormwater runoff by creating a natural buffer to reduce velocity of surface water. Native vegetation and open space provide aesthetic and habitat benefits. Site development practices can also protect soils from compaction and maintain high-quality native soil characteristics.

Natural areas on a developed site preserves, in part, natural infiltration and the water holding capacity of the soil, as well as evapotranspiration. As such, preserving natural areas allows a lower Hydrologic Soil Group (HSG) to be used in calculating the post-development curve number (CN). This, in turn, may result in a lower Level of Service being required for compliance with stormwater quality requirements.

Impacts to natural areas should be minimized by reducing the extent of construction and development practices that adversely impact pre-development hydrology functions. Considerations include the following:

- ✓ Identify natural areas for preservation early in the design phase. Sensitive environmental areas, historically undisturbed vegetation, native trees, sloped areas, etc. may be appropriate locations for preserved natural areas.
- ✓ Watershed, conservation, and open space plans are good resources for identifying potential natural areas for preservation.
- ✓ Preserving natural areas can help create contiguous, interconnected green infrastructure corridors on development sites by connecting reforested or revegetated areas with one another and with other primary and secondary conservation areas through the use of nature trails, bike trails and other "greenway" areas (see **Figure 5-3**).

Figure 5-3. Example of Native Vegetation Preserved or Established

Left: Wooded area preserved in a residential subdivision. *Source: Wood E&IS, Inc.* **Right:** Native flowering grass meadow in residential common space. *Source: Kansas State University*

5.6.2 Preserve/Restore Stream Buffers

Stream buffer vegetation performs important natural functions including, but not limited to, slowing runoff velocities, creating diffuse flow, and reducing non-point source pollution. Stream buffer protection and restoration refer to the practices of maintaining and restoring a minimal width of native vegetation along a stream and ensuring its benefits to stormwater. Trees, shrubs, and other native vegetation are planted or protected to restore areas to their pre-development conditions (see **Figure 5-4**). The process can be used to establish or maintain mature native plant communities (e.g., forests) in pervious areas on disturbed sites or in buffer areas adjacent to development sites. Soil and vegetation restoration along stream buffers can improve post-development hydrology functions by stabilizing stream banks, preventing erosion, improving soil infiltration, and providing native vegetation. Topeka's Buffer Area Ordinance (TMC Chapter 17.10) requires the protection of local waterways.

Figure 5-4. Example of Stream Buffer Preservation in Subdivision Plan *(Source: McKelvey Homes)*

5.6.3 Avoid Developing in Floodplains

Floodplains are the low-lying flat lands that border streams and rivers. When a stream reaches its capacity and overflows its channel after storm events, the floodplain provides for storage and conveyance of these excess flows. In their natural state, they reduce flood velocities and peak flow rates by the passage of flows through dense vegetation. Floodplains also play an important role in reducing sedimentation, filtering runoff, and providing habitat for both aquatic and terrestrial life.

Development in floodplain areas can reduce the ability of the floodplain to convey stormwater, potentially causing safety problems or significant damage to the site in question, as well as to both upstream and downstream properties. This has been experienced in the City of Topeka with catastrophic consequences (see **Figure 5-5**). By avoiding development in floodplains, the developer is able to more easily meet floodplain regulations and provides many of the same benefits as buffer areas. The City of Topeka participates in the National Floodplain Insurance Program (NFIP) and therefore has taken steps to define regulatory floodplains and elevations in many areas of the City. City requirements pertaining to land development in and near floodplains are provided in the Floodplain Management Ordinance (TMC Chapter 17.30).

Figure 5-5. Flooding on the Kansas River, Topeka KS *(Source: Anderson Photo Co., Kansas Historical Society)*

5.6.4 Avoid Developing on Steep Slopes

Existing areas of the development site with steep slopes can be incorporated into the site design to reduce the need for excessive cut and fill and prevent the need for expensive slope stabilization techniques. Maintaining native vegetation and soil on steep slopes prevents these areas from erosion or slope failure. Steep slopes are also more difficult to revegetate and may require the planting of live perennial plants or hydroseeding, as opposed to seeding. Using site design techniques that "build with the land" position the elements of the development project in such a way that the site design (i.e. placement of buildings, parking, streets and driveways, lawns, undisturbed vegetation, buffers, etc.) is optimized for effective stormwater management and accounts for obstacles, such as steep slopes.

5.6.5 Minimize Siting on Porous or Erodible Soils

Using site design techniques that "build with the land" also allow a development to avoid placing structures or impervious surfaces on porous or erodible soils. When buildings and pavement are sited on soils that are less porous, soils that are more porous can be preserved. The site designer should strive to have a site layout that effectively minimizes the volume (and, in many cases, the peak discharges) of stormwater that will be discharged from the development and maximizes the use of less costly, lower maintenance techniques to manage stormwater.

As the site layout is established, the site designer should also consider those LID practices that target the use of preserved natural features, conservation areas and other pervious surfaces for the management of stormwater discharged from impervious surfaces. For example, discharging stormwater from a small parking area into a well-draining forested area or using natural, vegetated swales to convey stormwater are both less expensive stormwater management options than the construction and maintenance of ditches and pipes (see **Figure 5-6**). In addition, structural BMPs that are sited on more porous soils will require less soil restoration and will ultimately provide more benefits to the site's stormwater management.

Figure 5-6. Bioretention BMP with a Pervious Concrete Apron

Placement of bioretention areas and pervious concrete on porous soils will allow for better infiltration. *Source: Wood E&IS, Inc.*

5.6.6 Soil Management - Preservation

Preserving native soils on a development site maintains the infiltration capacity of the soil. Soil preservation allows the site to maintain a lower CN for portions of the development site.

Soil preservation refers to protecting portions of the site from development and compaction to maintain their pre-development conditions. This allows the soil to maintain its ability to reduce post-construction stormwater runoff rates, volumes and pollutant loads through infiltration of stormwater into the soil. The preserved soil will also support the native plant community.

Structural BMPs can also be directed to areas of preserved soil as part of a treatment train. By preserving soils with higher infiltration rates, this non-structural BMP reduces post-construction stormwater runoff rates, volumes, and pollutant loads. Chapter 7 of the *MARC/APWA BMP Manual* provides the criteria required to evaluate, restore, and maintain soils for this non-structural BMP.

5.6.7 Soil Management - Restoration

Stormwater runoff volume and water quality are heavily influenced by the infiltration capacity of the soil. Soil restoration is a way to improve infiltration and improve the CN of portions of the development site.

Soil restoration refers to the process of tilling and adding compost and other amendments to soils to restore them to their pre-development conditions, which improves their ability to reduce post-construction stormwater runoff rates, volumes, and pollutant loads. The soil restoration process can be used to improve the hydrologic conditions of pervious areas that have been disturbed by clearing, grading, and other land disturbing activities.

Organic compost and other amendments can be tilled into soils in these areas to help create healthier, uncompacted soil matrices that have enough organic matter to support a diverse community of native trees, shrubs, and other herbaceous plants.

Soil restoration can also be used to increase the stormwater management benefits provided by other BMPs on sites that have soils with low permeabilities (i.e., Hydrologic Soil Group C or D soils). The soil restoration process can be used to help increase soil porosity and improve soil infiltration rates on these sites, which improves the ability of these and other low impact development practices to reduce post-construction stormwater runoff rates, volumes and pollutant loads. Chapter 7 of the *MARC/APWA BMP Manual* provides the criteria required to evaluate, restore, and maintain soils for this non-structural BMP.

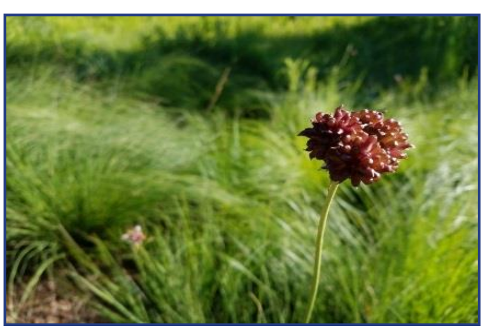
5.6.8 Restoration of Native Vegetation

Stormwater runoff volume and water quality are heavily influenced by the cover and established root systems of the site's vegetation. Restoring native vegetation is a way to improve infiltration and improve the curve number of portions of the development site.

Native vegetation refers to plant types historically located in Topeka's geographic area and which are well adapted to the region, climate, and ecology. Per the *MARC/APWA BMP Manual*, the establishment of native vegetation includes the establishment and maintenance of native plant types and plant associations historically present. Establishment of native plant materials is required if soil treatment is utilized as a non-structural BMP.

Chapter 7 of the *MARC/APWA BMP Manual* provides the criteria required to evaluate, restore, and maintain native vegetation for this non-structural BMP.

Figure 5-7. Native Vegetation for Stormwater Management



Native plants provide both stormwater management and aesthetic benefits to a site.

*Source (**left**): Wood E&IS, Inc.*
*Source (**right**): Topeka & Shawnee County Library*

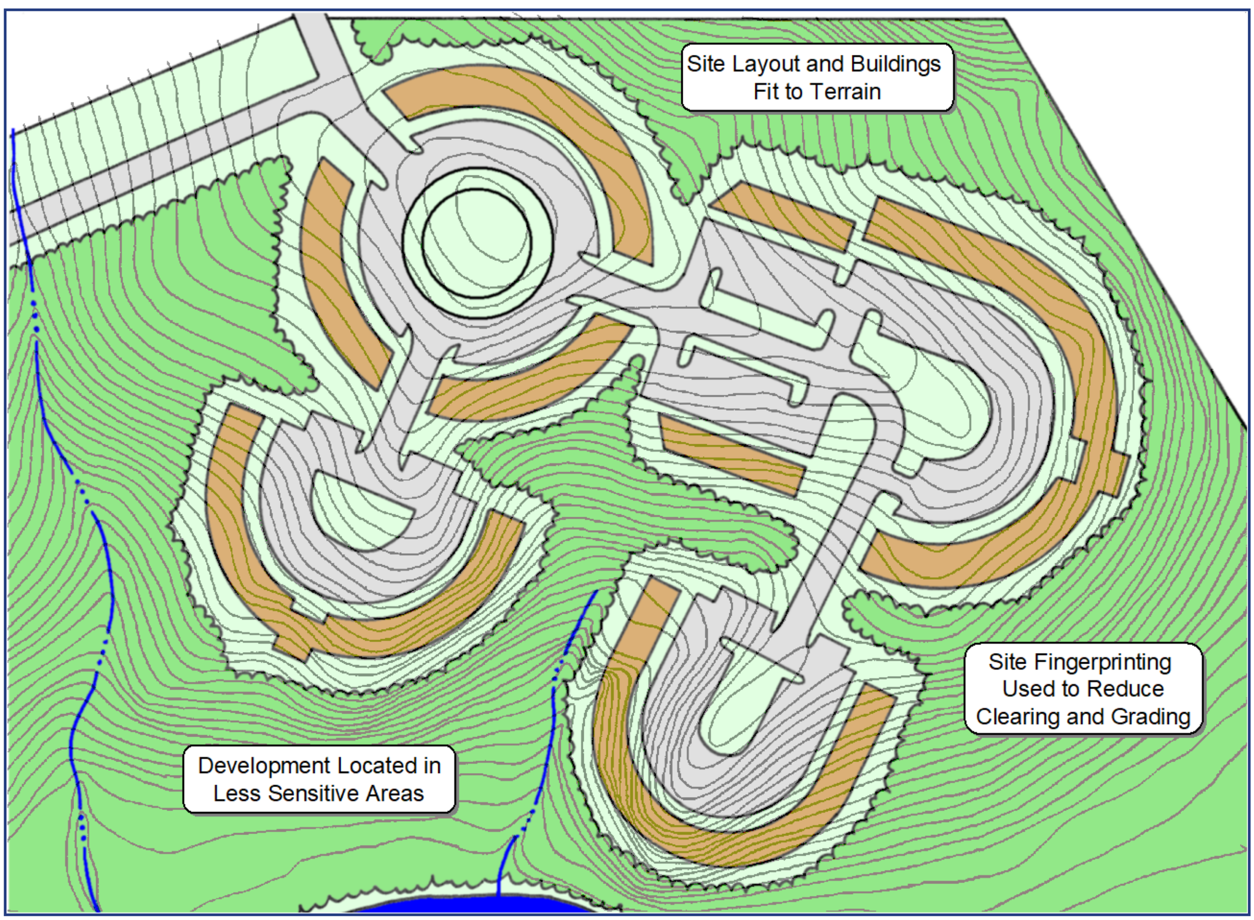
5.7 "BUILD WITH THE LAND" SITE DESIGN TECHNIQUES

After a pre-design hydrologic characterization has been performed and conservation areas have been delineated, there are numerous opportunities to reduce both stormwater quality and quantity impacts as the site layout is prepared. The stormwater LID techniques used at this stage primarily deal with the location and configuration of impervious surfaces or structures on the site, and their location relative to natural features and preservation/conservation areas.

- Redevelopment
- Reduce imperviousness
- Fit the design to the terrain
- Consider creative development design
- Locate development in less sensitive areas
- Utilize open space development
- Reduce the limits of clearing & grading

The goal of site design techniques that "build with the land" is to position the elements of the development project in such a way that the site design (i.e., placement of buildings, parking, streets and driveways, lawns, undisturbed vegetation, buffers, etc.) is optimized for effective stormwater management. That is, the site design takes advantage of the site's natural features, including those placed in conservation areas, as well as any site constraints and opportunities (topography, soils, natural vegetation, floodplains, shallow bedrock, high water table, etc.) to prevent both onsite and downstream stormwater impacts. This concept is shown in **Figure 5-8**. In the figure, several "build with the land" LID techniques were used to develop the overall layout and design.

Figure 5-8. Site Design Resulting from the Use of "Build with the Land" LID Techniques



5.7.1 Redevelopment

Redevelopment or infill is defined as new development that is sited on vacant or undeveloped land within an existing community, and that is enclosed by other types of development. The term "urban infill" illustrates that the existing area is mostly built-out, and what is being built is "filling in" the gaps. The term refers to building single-family homes in existing neighborhoods, building multi-family homes in existing neighborhoods, and building new development in commercial, office or mixed-use areas.

- Redevelopment and infill development include:
    - Developing one or more sites on an undeveloped or underutilized site within an existing, established urban area
    - Redeveloping an existing neighborhood
    - Subdividing an existing lot into two or more building lots and adding development on the newly created lots
    - Demolishing an existing structure on a lot and building a new structure in its place
- The main benefits of infill development include:
    - More efficient use of existing infrastructure, such as roads, sidewalks, water, sewer, storm sewers and electric lines
    - Lower costs of public services, such as schools, police, fire, and ambulance service
    - Better use of urban land supplies while reducing consumption of forest and agricultural land (*this, in turn, facilitates conservation of non-urban land*)
    - Increased access of people to jobs, and jobs to labor force
    - Less time, money, energy, and air pollution associated with commuting
    - Replacement of brownfields, abandoned industrial areas, and vacant buildings with functioning assets
    - Stronger real estate markets and property values
    - Renewal of older areas of the City
    - Support of cultural, arts, educational and civic functions, such as museums, theaters, and universities by locating new businesses near these attractions

For Topeka's SWMP review process, a project is classified as a redevelopment when the existing total impervious surface is 20% or more of the total land area of the site. Per the *APWA/MARC BMP Manual*, the stormwater management BMPs and GI-BMPs used to meet the required Level of Service should be located within the disturbed area of the redevelopment site to the maximum extent practicable.

5.7.2 Reduce Imperviousness

The practices of reducing and disconnecting impervious surface increase the rainfall that infiltrates into the ground. Impervious areas should be reduced by maximizing landscaping and using green roofs and pervious pavements. In addition, the amount of impervious areas hydraulically connected to impervious conveyances (e.g., driveways, walkways, culverts, streets, or storm drains) should be reduced as much as possible. Runoff from remaining impervious surfaces should be directed to pervious areas and GI-BMPs.

Minimizing impervious surface benefits the City, the developer, and the community. Less impervious surface means less stormwater runoff to manage both onsite and downstream. Reducing and promoting green space can also facilitate recreational and community activities and enhance people's quality of life. The main benefits of reducing impervious surface include:

- A holistic approach to stormwater management that minimizes water velocity, runoff, and stormwater pollutants
- Less stormwater runoff to manage with onsite BMPs and GI-BMPs
- Reduction of onsite erosion and associated maintenance
- Reduction in the size and cost of BMPs and stormwater infrastructure
- Increased green space and improved aesthetics
- Reduction in the stormwater utility fee for non-residential properties

5.7.3 Fit the Design to the Terrain

The layout of roadways and buildings on a site should generally conform to the landforms on a site. Natural drainageways and stream buffer areas should be preserved by designing road layouts around them. Buildings should be sited to utilize the natural grading and drainage system and avoid the unnecessary disturbance of vegetation and soils.

Roadway patterns on a site should be chosen to provide access schemes that match the terrain. In rolling or hilly terrain, streets should be designed to follow natural contours to reduce clearing and grading. Street hierarchies with local streets branching from collectors in short loops and cul-de-sacs along ridgelines help to prevent the crossing of streams and drainageways. In flatter areas, a traditional grid pattern of streets or "fluid" grids which bend and may be interrupted by natural drainageways may be more appropriate. In either case, buildings and impervious surfaces should be kept off of steep slopes, away from natural drainageways, and out of floodplains and other lower lying areas. In addition, the major axis of buildings should be oriented parallel to existing contours.

5.7.4 Locate Development in Less Sensitive Areas

In much the same way that a development should be designed to conform to terrain of the site, a site layout should also be designed so that the areas of development are placed in the locations of the site that minimize the hydrologic impact of the project. This is accomplished by steering development to areas of the site that are less sensitive to land disturbance or have a lower value in terms of hydrologic function using the following methods:

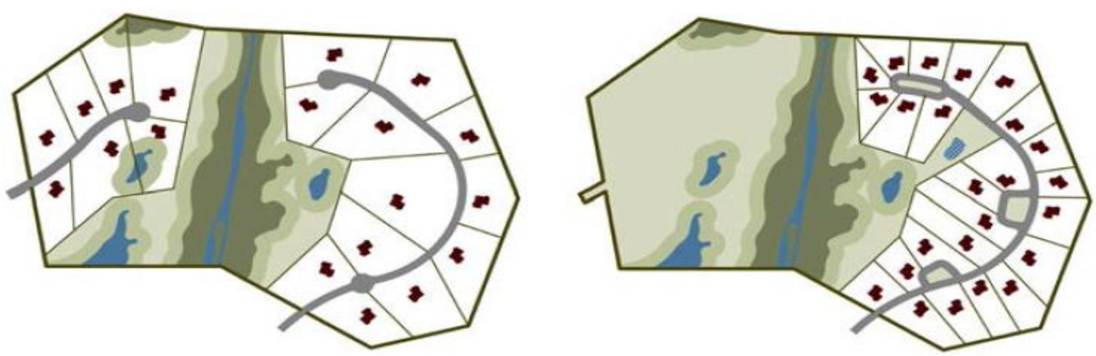
- ✓ Locate buildings and impervious surfaces away from stream corridors, wetlands and natural drainageways. Use buffers to preserve and protect riparian areas and corridors.
- ✓ Areas of the site with porous soils should be left in an undisturbed condition and/or used as stormwater runoff infiltration zones. Buildings and impervious surfaces should be located in areas with less permeable soils.
- ✓ Avoid land disturbing activities or construction on areas with steep slopes or unstable soils.
- ✓ Minimize the clearing of areas with dense tree canopy or thick vegetation, and ideally preserve them as natural conservation areas.
- ✓ Ensure that natural drainageways and flow paths are preserved, where possible. Avoid the filling or grading of natural depressions and ponding areas.

5.7.5 Utilize Open Space Development

Open space development, also known as conservation development or clustering, is a better site design technique that concentrates structures and impervious surfaces in a compact area in one portion of the development site in exchange for providing open space and natural areas elsewhere on the site. Typically, smaller lots and/or nontraditional lot designs are used to cluster development and create more conservation areas on the site. Open space developments have many benefits compared with conventional commercial developments or residential subdivisions; they can reduce impervious cover, stormwater pollution, construction costs, and the need for grading and landscaping, while providing for the conservation of natural areas. **Figure 5-9** demonstrates examples of a conventional subdivision design and an open space/cluster design demonstrating the above concepts.

Along with reduced imperviousness, open space designs provide a host of other environmental benefits lacking in most conventional designs. These developments reduce potential pressure to encroach on conservation and buffer areas because enough open space is usually reserved to accommodate these protection areas. As less land is cleared during the construction process, alteration of the natural hydrology and the potential for soil erosion are also greatly diminished. Perhaps most importantly, open space design reserves 25% to 50% of the development site in conservation areas that would not otherwise be protected. Open space developments can also be significantly less expensive to build than conventional projects. Most of the cost savings are due to reduced infrastructure cost for roads, utilities, and stormwater management controls and conveyances. While open space developments are frequently less expensive to build, developers find that these properties often command higher prices than those in more conventional developments. Several studies estimate that residential properties in open space developments garner premiums that are higher than conventional subdivisions and moreover, sell or lease at an increased rate.

Figure 5-9. Example of Typical Subdivision Design Concept (Left) and Open Space/Cluster Design (Right)



5.7.6 Reduce the Limits of Clearing and Grading

Minimal disturbance methods should be used to limit the amount of clearing and grading that takes place on a development site, preserving more of the undisturbed vegetation and natural hydrology of a site. These methods include:

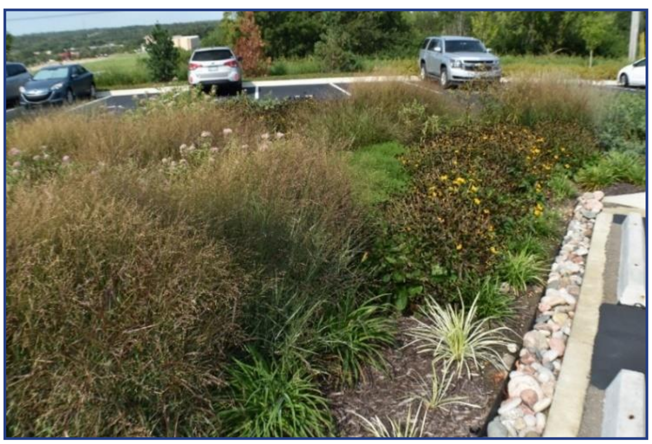
- ✓ Establishing a limit of disturbance (LOD) based on maximum disturbance zone radii/lengths. These maximum distances should reflect reasonable construction techniques and equipment needs together with the physical situation of the development site such as slopes or soils. LOD distances may vary by type of development, size of lot or site, and by the specific development feature involved.
- ✓ Using site “footprinting,” which maps all the limits of disturbance to identify the smallest possible land area on a site which requires clearing or land disturbance

- ✓ Fitting the site design to the terrain
- ✓ Using special procedures and equipment which reduce land disturbance

5.7.7 Consider Creative Development Designs

There are many creative approaches to integrate stormwater management into meeting existing development regulations. For example, landscaping is an important component of traditional site design. Landscaped islands (i.e., raised vegetated areas with vertical curbs) are typically interspersed throughout parking lots to provide visual relief and shade or to otherwise soften the appearance of the development. Perimeter landscaping is also used to buffer developments from adjacent sites, add visual interest, and create barriers when screening is needed. Landscaping has not traditionally been used as areas for stormwater management, and landscaping codes often discourage this practice because landscaping placed within stormwater management areas often doesn't count toward required landscape area minimums. Code requirements for trees and vegetation, the placement and frequency of use, and preferred type and species can also discourage using landscape areas for stormwater management, as certain types of landscaping are not compatible with inundation of stormwater. However, City landscape code TMC 18.235.090 creates an incentive for utilizing stormwater management BMPs to meet the landscape requirements. Specific GI-BMPs (e.g., bioretention in a landscape island – see **Figure 5.10**) will receive more credit than a manufactured treatment device (MTD). Landscape credits are discussed in Chapter 3.

Figure 5-10. Examples of Bioretention BMPs in Landscaped Parking Lot Islands
(Sources: left – City of Topeka; right - The Metropolitan Government of Nashville and Davidson County TN)



A Planned Unit Development (PUD) is a type of planning approval available in Topeka which provides greater design flexibility by allowing deviations from the typical development standards required by the local zoning code, with additional variances or zoning hearings. The intent is to encourage better designed projects through the relaxation of some development requirements, in exchange for providing greater benefits to the community. PUDs can be used to implement many of the other stormwater better site design practices covered in this Handbook and to create site designs that maximize natural non-structural approaches to stormwater management. **Figure 5-11** demonstrates a PUD that has maximized stormwater management with LID practices and GI-BMPs placed throughout the development.

Figure 5-11. Example of a PUD with LID and GI-BMs *(Source: Wood E&IS, Inc.)*

Examples of the types of zoning deviations allowed in Topeka through a PUD process include the following.

- Allowing uses not listed as permitted, conditional, or accessory by the zoning district where the property is located
- Modifying lot size and width requirements
- Reducing building setbacks and frontages from property lines
- Altering parking requirements
- Increasing building height limits

Appendix A. Key Acronyms and Definitions

Acronyms

BMP – Best Management Practice

GI – Green Infrastructure

KDHE – Kansas Department of Environment and Conservation

LID – Low Impact Development

MS4 – Municipal Separate Storm Sewer System

NPDES – National Pollutant Discharge Elimination System

SWMP – Stormwater Management Plan

TMC – Topeka Municipal Code

TMDL – Total Maximum Daily Load

Definitions

As-Built Plan presents the "as-constructed" condition of every stormwater BMP constructed on the project. It will include significant technical detail, similar to a construction drawing. The as-built plan is provided with the Stormwater BMP Record Drawing.

Best Management Practice or BMP means, in the context of this Handbook, a structural facility design and constructed (or installed) to reduce stormwater runoff pollutant loads, discharge volumes, and/or peak flow discharge rates.

BMP Location Map is a map which shows the type and location of all stormwater BMPs constructed or installed on a property, and all stream buffers and natural or man-made waterbodies. It is provided with the Stormwater BMP Record Drawing.

BMP Planting Plan is the portion of the SWMP or Stormwater BMP Record Drawing which provides a detailed description of the vegetation composition and arrangement for each vegetated BMP.

Designer or site designer, when used generally, means the qualified person who creates the site layout or the plan for stormwater management at a proposed land development. When referring specifically to the SWMP or the Stormwater BMP Record Drawing, "designer" means the professional civil engineer or landscape architect licensed in the State of Kansas who has responsible charge of the stormwater management information conveyed in the SWMP or Stormwater BMP record drawing.

Green Infrastructure BMP or GI-BMP means a structural (constructed or installed) BMP that functions primarily, but not always solely, through the infiltration and/or evapotranspiration and/or capture and reuse of stormwater runoff.

Low Impact Development techniques or LID techniques means non-structural site planning and construction techniques intended to preserve or closely mimic a site's natural or pre-developed hydrologic response to precipitation thus reducing or preventing adverse impacts from stormwater runoff.

Pollutant means anything which causes or contributes to pollution including, but not limited to, paints, varnishes, and solvents; oil and other automotive fluids; nonhazardous liquid and solid wastes and yard wastes; refuse, rubbish, garbage, litter, or other discarded or abandoned objects, articles, and accumulations, so that some may cause or contribute to pollution; floatables; pesticides, herbicides, and fertilizers; hazardous substances and wastes; sewage, fecal coliform and pathogens; dissolved and particulate metals; animal wastes; wastes and residues that result from constructing a building or structure (including but not limited to sediments, slurries, and concrete rinsates); and noxious or offensive matter of any kind.

Stormwater BMP Certification Statement is the document signed and stamped by the Kansas-licensed professional landscape architect or civil engineer responsible for the project to certify proper construction, function, and cleanliness of each BMP shown in the record drawing. It is provided with the Stormwater BMP Record Drawing.

Stormwater BMP Record Drawing means the set of documents prepared and signed by the owner and recorded as a covenant running with the land at the time of construction termination that documents the locations, types, and constructed condition of the stormwater BMPs located on the property and certifies that the owner is responsible for the proper operation and maintenance of those facilities.

Stormwater Management Plan or SWMP means the set of documents prepared and signed by the owner (or his/her designee) that documents the intended design of a proposed development from the perspective of stormwater management and conveys how the design will meet City of Topeka stormwater management requirements. Generally, the SWMP will show the intended land covers and specific layout of pervious and impervious surfaces and the locations, types, and design of the stormwater BMPs and stormwater conveyance system to be located on the property.

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City of Topeka, KS
Stormwater BMP Record Drawing Checklist

*This list presents the required elements of a Stormwater BMP Record Drawing. Elements included in this list are required if applicable to the project. Applicants **are not required** to submit this checklist with the Record Drawing.*

General Information: Submittal of the Stormwater BMP Record Drawing signifies to the City of Topeka that construction of the applicable development is substantially complete[2] and the project's stormwater BMPs and conveyance system is fully and permanently constructed and functional. The Utilities Director may wish to perform an inspection as part of their review of the Record Drawing. See Section 2.6 of the *Stormwater BMP Design Handbook* for more information.

Provide all maps at a scale of 1" = 50' unless otherwise noted.

1. STORMWATER BMP LOCATION MAPS

REQUIREMENTS: The map shall clearly and accurately indicate the location, extent, and identity (by proper name as provided in this Handbook) of each stormwater quality and quantity BMP constructed on the project, and all easements related to stormwater BMPs, conveyance system, and stream buffers. Locate each labeled BMP by depicting their location relative to easily identifiable, permanent, labeled landmarks, such as roads, buildings, sidewalks, parking areas and waterbodies. A single map is sufficient for BMP location map if it can clearly depict all required information and can easily be read.

GUIDANCE: The BMP location map will be used by future property owners, many of whom will not have professional or specialized knowledge in engineering or construction drawings. Therefore, it must be accurate and easily readable, and free of unnecessary or overly technical detail such as grade lines, geographical data, survey points, etc. ***See example BMP Location map in Handbook Section 2.5.***

____ a. Project/development name and street address

____ b. North arrow

____ c. Location, extent, and type of stormwater BMPs located on the property -- denote BMP type using the proper name as used in the City of Topeka Stormwater BMP Design Handbook

____ d. Easement boundaries, labeled by easement type, including stormwater management easements (SMEs), public and private drainage easements, stream buffer easements, utility easements, and SME access easements

____ e. Water bodies and the stream buffer boundaries (label inner and outer buffers)

____ f. Building and pavement footprints, cross-roads, adjacent properties, and other information (all labeled) to orient the reader and facilitate map understanding by non-technical readers

[2] Substantially complete means the construction of outdoor areas is finished, the stormwater conveyance system and permanent post-construction BMPs are fully installed and functional, 100% of all pervious areas have been permanently stabilized from sediment erosion, and any remaining construction materials stockpiles and waste storage areas are not exposed to rainfall or stormwater. Construction in the building interior may still be ongoing.

2. CERTIFICATIONS, LEGAL DOCUMENTS, AND AGREEMENTS

____ a. Signed original Engineers and Landscape Architects Certification Statement (see Appendix D)

____ b. If applicable, signed originals of any other legal agreements or certifications pertaining to the stormwater BMPs or stormwater conveyance system (e.g., agreement with downstream property owner for use of offsite BMPs or drainage easements, etc.)

____ c. Copy of recorded plat with accurate description of constructed stormwater BMPs, their stormwater management easements, and all other easements. Plats must include statement: "***Stormwater BMPs shall be maintained in accordance with TMC Chapter 13.40.***"

3. AS-BUILT PLAN

A. General Information

____ a. Name and contact information of developer

____ b. Name and contact information of person preparing the Stormwater BMP Record Drawing

____ c. Name and contact information of responsible State of Kansas professional engineer or landscape architect

____ d. Common address and parcel/lot number of the applicable development

____ e. Vicinity map showing parcel boundaries, adjacent properties, and cross streets, appropriately labeled to locate the applicable development

____ f. List, describe, and explain all elements of the constructed site that differ from what is shown in the approved SWMP

B. Topographical Maps

____ g. Title block with project name, address, and contact person(s) *(all pages)*

____ h. Seals and signatures for the certifying Kansas Professional Engineer or Landscape Architect and the certifying Kansas Registered Land Surveyor *(all pages)*

____ i. Survey benchmarks or other reference points *(all pages)*

____ j. North arrow, bar scale, and coordinates *(all pages)*

____ k. Topographical map clearly indicating the property boundaries, cross-streets, and bounding roadways with names, building and pavement footprints of the applicable development, waterbodies, stormwater BMP locations, stream buffers, and general extents and boundaries

____ l. Stormwater and grading map indicating as-constructed grading of the property using maximum 2-foot contours, drainage basin boundaries, waterbodies, stream buffers, stormwater BMPs, stormwater conveyance system (inlets, connections, outlets, and flow directions) and stormwater outfalls to adjacent properties or waterbodies, and easement boundaries (labeled by easement type)

____ m. Stormwater, stream buffer, and landcover map indicating drainage basin boundaries, waterbodies, stormwater BMPs, pavement and rooftop footprints, and general types of pervious land covers (e.g., woods, unmaintained meadow, crop, grazing area, managed turf, landscaped area, etc.)

C. Stormwater BMP Information/Diagram (one for each BMP)

(Provide BMP schematics at a scale of 1" = 50' or smaller.)

____ n. For each BMP, provide a plan view map of the BMP as it is constructed, properly labeled in keeping with the BMP names identified in the *MARC/APWA BMP Manual*, and depicting the BMP boundary and extent, topography (if relevant). Use max. of 2-ft contours with 1-ft contours where detail is needed. Locate and label all areas of inflow, pretreatment, outflow, emergency overflow or bypass, and energy dissipation measures

____ o. For each BMP, provide at least one cross-section view of the BMP as it is constructed, properly labeled showing relevant elevations, depths, layers/details of subsurface layers and underdrains (i.e., for infiltration based GI-BMPs), multi-outlet structure(s), spillways, berm, dam, etc.

____ p. For each BMP, as applicable, provide the proper label, structure, and current condition (as constructed) of the following. For each provide elevations, length, width, diameter, depth, material, vendor schedule, or other as appropriate for the construction detail being described.

____ i. Inlet structures, including filtration bed, vegetated or rock aprons, trash racks, baffles, curbs, curb cuts, headwalls, grate inlet, pipe, etc.

____ ii. Outlet structures, including all orifices, weirs and emergency spillways, properly labeled with size, diameter, invert elevation, means of anchoring, underdrain systems, and method(s) of receiving system protection/energy dissipation measures

____ iii. Pretreatment areas, stilling basins, rock, vegetation, or baffle aprons, etc.

____ iv. Subsurface layers, including soil media layers, rock and other layers, fabric/textile wraps/layer, underdrains, outlet drains, and observation wells,

____ v. Surface level stormwater treatment or detention areas

____ vi. Dams and berms, include geotechnical information

____ q. Stormwater calculations (signed & stamped by the engineer or landscape architect) indicating that the as-constructed conditions meet the approved design as indicated by the approved SWMP. Include all inputs and methods

____ r. For each proprietary BMP (i.e., green roofs, cisterns, proprietary filtration media, hydrodynamic devices, baffle box, catch basin inserts, and similar devices), provide the vendor name and contact information, the manufacturer name and contact information (if different from the vendor), the make, model number, and date of manufacture of the BMP, a list of BMP parts that must be removed/replaced as part of normal BMP inspection maintenance (such as filtration cartridges) with each part's make and model number, design-related information provided by the manufacturer or developed by the site designer, and all inspection and maintenance instructions and information supplied by the manufacturer or vendor

D. BMP Planting Plans (one for each vegetated BMP)

____ s. For each vegetated BMP, provide a labeled map with a plant legend depicting the as-constructed vegetation of the BMP (see examples in Handbook Section 2.5)

____ t. Provide the following for each plant species installed:

____ i. The plant type (denote both common name and the genus & species) or turf seed mix, and whether species is native or non-native

____ ii. Planting location(s), spacing, and expected spread upon plant maturation

____ iii. Plant installation or seeding schedule and requirements *(e.g., seeding shall take place in the spring (April 1 to June 1) or in the fall (Sept 1 to Oct 1). Remove unwanted vegetation prior to planting.)*

____ iv. Required growing conditions *(e.g., full sun, partial shade, full shade, loose soil, etc.)*

____ v. Watering and fertilization schedule *(i.e., continuous moisture for 4-6 weeks after seeding is required for proper germination. Water to a full soak of each plants roots at least once per week thereafter.)*

____ vi. Other weed control and general care requirements, as appropriate

____ vii. Plant warranty information *(recommended)* as listed below. Applicants are encouraged to obtain plant warranties (typically through 2 growing seasons)

- A statement of the warranty periods *(e.g., "The warranty period for all plants in BMP #2 is provided by insert name of warrantor and covers two years from purchase date of Sep 7, 2019.")*
- Any warranty information needed to actuate the warranty (e.g., purchase receipts, plant installation contactor warranty statement, etc.)

E. Stormwater Hotspot Maps/Information

____ u. Locate and identify land uses and/or areas which have the potential to cause higher than normal concentrations of hydrocarbons, metals, or other pollutants to stormwater due to the activities that are expected for the project, once constructed *(See Section 4.4 of the APWA/MARC Manual, e.g., litter can be expected around a fast food restaurant)*

____ v. For each hotpot, locate and identify the management practices installed to mitigate pollutant discharges for these areas *(e.g., dumpsters/trash cans installed to reduce litter)*

F. Stormwater Conveyance System Maps/Information

____ w. Map and provide a schedule of all drainage pipes, channels, and other conveyances properly labeled with slope, length, shape, size or diameter, material, invert elevation, and the hydraulic grade line (HGL) for the 25-year storm event in the post-construction condition

____ x. Map and provide a schedule of all drainage structures related to the conveyance system (not stormwater BMPs in Part C above) such as inlets, catch basins, manholes, headwalls, wing walls, and culverts. Provide top and invert elevations, size, material, detail #, and other relevant information

____ y. Locate and identify pumps and provide pump system data, including unique identifier, pump make and model, capacity, switch design, inlet and discharge sizes, maximum and minimum water surface, and head-flow curves

____ z. Provide a narrative describing the stormwater conveyance system and special conditions encountered that changed the approved design

City of Topeka, KS
LID Technique Form

This form should be completed and included with the Stormwater Management Plan for projects that employ LID techniques.

Project Name: ______________________

Address: ______________________

Date Prepared: ____________ **Designer Name:** ____________

Design Firm/Company: ______________________

Check (✓) the appropriate boxes to indicate which Low Impact Development (LID) techniques are included in the Stormwater Management Plan. Note the superscript 1 or 2 and the requirement associated with each stated below the list.

EARLY COORDINATION, COLLABORATION, AND COMMUNICATION

- ☐ Multi-disciplinary design team[1]
- ☐ Stormwater pre-design process[1]

CONSERVATION OF NATURAL FEATURES AND RESOURCES

- ☐ Preserve undisturbed natural areas[2]
- ☐ Preserve or restore stream buffers[2]
- ☐ Avoid developing in floodplains[2]
- ☐ Avoid developing on steep slopes (> 15%)[2]
- ☐ Minimize siting on porous or erodible soils[2]
- ☐ Soil management - Preservation[2] *(MARC 7.1)*
- ☐ Soil management - Restoration[2] *(MARC 7.2)*
- ☐ Restoration of Native Vegetation[2] *(MARC 7.3)*

"BUILD WITH THE LAND" DESIGN TECHNIQUES

- ☐ Redevelopment
- ☐ Fit the design to the terrain[1]
- ☐ Reduce limits of clearing and grading[2]
- ☐ Locate development in less sensitive areas[1]
- ☐ Utilize open space development[1]
- ☐ Reduce imperviousness[1]
- ☐ Consider creative development design[1] (describe) ______________________

[1] – Please provide a short narrative with the SWMP describing how the LID technique was applied for the proposed design.

[2] – Please show LID technique location by hatching LID areas on the SWMP that were preserved, restored, or avoided.

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City of Topeka, KS
Infiltration BMP Feasibility Statement

This form must be included with the SWMP for each Infiltration BMP to be employed onsite without an underdrain.

Project Name: ______________________

Address: ______________________

Date Prepared: ____________ **Designer Name:** ____________

Design Firm/Company: ______________________

What is the design infiltration rate determined via infiltration tests? ____________ in/hr

What is the minimum required infiltration rate for the BMP? ____________ in/hr

Note: These questions pertain to the in-situ soil located beneath the BMP. The in situ design infiltration rate must be greater than 1.0 in/hr and less than 11 in/hr, keeping with the required minimum rate in the MARC/APWA BMP Manual.

SITE FEASIBILITY CRITERIA	YES	NO
1. Will the in-situ soil (after site preparation) have an infiltration that meets the requirements of the *MARC/APWA BMP Manual*.	☐	☐
2. Will the BMP be located more than 100 ft from a drinking water supply well in a sensitive aquifer or more than 50 ft from a drinking water well in a non-sensitive aquifer?	☐	☐
3. Will there be more than three (3) feet of separation distance from the bottom of the BMP to the elevation of the seasonally saturated soils or the top of bedrock?	☐	☐
4. Will the BMP be located more than 10 feet away from a building or structure? *If no, a groundwater mounding analysis that confirms the building or structure will not be impacted by the BMP must be provided.*	☐	☐
5. Will the BMP be located more than 35 feet of a septic drainfield? *If no, provide a groundwater mounding analysis that confirms the BMP will not impact the drainfield.*	☐	☐
6. Does a groundwater mounding analysis confirm that a mound formed beneath the BMP will not extend into the BMP?	☐	☐
7. Will the BMP be located more than 200 feet from the toe of a slope that is greater than or equal to 20 percent?	☐	☐
8. The BMP will not receive stormwater discharges from a hotspot land use (e.g. vehicle fueling yard, brownfield, etc.) or area of known soil contamination.	☐	☐

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Utilities Department
215 SE 7th Street
Topeka, KS 66603

Bob Sample
Utilities Director

APPENDIX D

Stormwater BMP Certification Statement

Date:

ATTN: Director of Utilities Department
City of Topeka, KS

Project Name:
Project Street Address:
Project Parcel No:

I, ____, a licensed *(check one below)*

☐ Civil Engineer ☐ Landscape Architect

in the State of Kansas, certify that, in my professional opinion, the Stormwater BMP Record Drawing, identified by address above:

- includes a complete and accurate representation of all of the stormwater quality and quantity BMPs located on the property; and,
- represents the as-constructed and fully functional condition for said stormwater BMPs in conformance with the project's approved Stormwater Management Plan, including all revisions made necessary by change orders, design modifications, request for information and/or field orders.

I further state that, based on my calculations and analyses performed using the as-constructed conditions shown in the Record Drawing(s), that the stormwater BMPs installed for this project meet the stormwater performance standards required for the project.

Signature of Licensed Individual ____

Kansas License No. _____________________

Affix stamp or seal here

Date ____________________

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Appendix E. Stormwater BMP Design Procedure Forms

E.1 Infiltration Basin

E.2 Infiltration Trench

E.3 Permeable Pavement

E.4 Sand Filter

E.5 Vegetated Filter Strip

E.6 Native Vegetation Swale

E.7 Cisterns

E.8 Green Roofs

Stormwater BMP Design Handbook
Appendix F

City of Topeka, KS
Design Specifications
Cisterns

Cistern with overflow pipe to a green roof.
Source: City of Atlanta GA

Incentives:

- Retaining stormwater on site reduces the scale of stormwater management needs.

Description:

Cisterns and other tanks with similar functions, such as rain barrels, stormwater reservoirs, and rainwater harvesting systems, are designed to directly intercept and store runoff from impervious areas, like rooftops. Cisterns are best utilized where stormwater can be recycled for identified non-potable uses (e.g., irrigation). They can be incorporated into stormwater management plans where there is sufficient, regular demand to empty the reservoir by supplementing non-potable water usage between storm events. The design of these systems is flexible in size, shape, materials, location, and reuse purpose.

For cisterns and other tanks to provide effective stormwater management, an opportunity for reuse or infiltration of the stormwater must exist. This opportunity might be provided by a garden or landscaped area that needs to be watered, by routing the stored volume to another GI facility, or by pumping to an irrigation tank or water truck for use in other locations.

Storing water for emergency purposes, such as fire protection, is not considered a suitable reuse opportunity, because the storage volume will not be emptied between each storm.

Benefits:

The capture and reuse of rainwater can significantly reduce stormwater runoff volume and velocity. The main benefits of cisterns and water reuse include:

- Providing a water source for non-potable uses (e.g., toilet flushing, irrigation)
- Relatively easy to install and maintain, and are flexible to site conditions (above ground)
- Reductions in stormwater runoff volume and peak discharge rate through retention

Application:

Cisterns are not assigned a Value Rating as part of the Level of Service calculations. Their benefit in Level of Service calculations is a decreased Curve Number (CN), whereby impervious areas draining to the cistern are assigned a CN of 79 (HSG "C", Turf, Fair). **This CN is for Level of Service calculations only (i.e., for purposes of stormwater quality management only). This CN shall not be used in detention/retention design.**

Location:

Cisterns and other stormwater reuse facilities can be used on a wide range of sites. Guidance for locating the cistern is below.

- When determining the location of the cistern, consider the following factors.
  - ✓ The ease in connecting roof drains to the cistern
  - ✓ The location and direction of stormwater overflow to downslope areas
  - ✓ The location of a level area for the cistern or tank pad

- ✓ The cistern's location relative to its intended water uses
- ✓ Location of hoses or other water distribution components
- ✓ Possible conflicts of the cistern location with buildings, roadways, or utilities
- ✓ The locations of necessary electrical connections, if applicable
- ✓ Emergency ingress/egress needs from the building, site, or cistern area
- ✓ Surrounding or nearby foliage and the need for a leaf screen option
- ✓ Aesthetic considerations

- Ensure adequate space is provided for appropriate foundation and structural support for the cistern or tank structure.
- Choose an adequate discharge location and overflow route to a vegetated landscaped area or additional GI facility (e.g., green roof, bioretention, etc.). Remember that overflow is stormwater and must be considered as a part of the land development for purposes of meeting stormwater quantity management requirements.

Design:

Cisterns must be designed to meet a specific and consistently repeatable water reuse demand. Multiple devices can be used to increase available storage and simplify routing for reuse. Devices should be of the appropriate type and have sufficient capacity for the intended application as noted.

- ✓ Rain barrel (50 to 150 gallons)
- ✓ Cistern (500 to 7,000 gallons)
- ✓ Large aboveground tank (3,000 to 12,000 gallons)

Photo: Cistern used to capture runoff from the rooftop and irrigate a nearby bioretention BMP. (*Source: Wood E&IS)*

In order to include the retained volume in stormwater design calculations, **the stormwater captured in the cistern must be fully re-used in the first 72 hours after the storm event**. Prepare a rainwater reuse schedule to confirm that the cistern:

- ✓ is allowed by City code;
- ✓ is appropriately sized to meet the demand for the intended reuse application;
- ✓ sufficiently draws down stored water within 72 hours after capture to maintain available cistern storage for the next storm event;
- ✓ accommodates the variation in storage demand as a result of season or high/low use periods;
- ✓ accounts for bypass and overflow runoff volumes in overall site design.

Other design requirements are as follows.

- ✓ Include one or more pretreatment measures to remove debris, dust, leaves, and other materials before stormwater enters the cistern.
- ✓ Fully cover or enclose the stored water to avoid potential mosquito breeding.

- Storage tank(s) must be made of material that is appropriate for the reuse application and sealed with a water safe, non-toxic substance (typically, a commercial design intended for cistern use is chosen).
- For indoor reuse applications, follow relevant codes, which may include the following.
    - Provide proper signage distinguishing non-potable water from potable water.
    - Use appropriate plumbing fittings, backflow prevention, and pumps.
    - Incorporate appropriate filtration and treatment if reuse application connects to non-potable indoor water system.
- Install a bypass/overflow system to accommodate the conveyance of runoff when the system is full.
- If appropriately designed, a CN of 79 (HSG "C", Turf, Fair) can be utilized for Level of Service calculation purposes. **This CN shall not be used for detention/retention (i.e., peak flow) design.**

Maintenance:

Routine operation and maintenance are essential to ensure proper functioning cistern systems:

- Clean leaf screens, gutters, and downspouts.
- Ensure that overflow runoff is safely conveyed and there are no signs of erosion - stabilize and remedy overflow erosion if necessary.
- Replace or repair overflow devices if obstructions or debris prevent proper drainage when the cistern's storage capacity is exceeded.
- Disconnect, drain, and clean aboveground systems at the start of the winter season.
- A stormwater BMP maintenance plan shall be completed as part of the SWMP. Refer to the *City of Topeka Property Owner's Guide to Stormwater BMP Maintenance* for detailed maintenance requirements and information.

Above: Cistern used to capture overflow from a green roof for site irrigation is installed at the Kansas City Performing Arts Center garage. (*Photo: Courtesy of Jeffrey L. Bruce & Co., Kansas City MO)*; **Right:** Cistern used for site irrigation at a Chattanooga Area Food Bank in Chattanooga, TN. *(Photo: Wood E&IS)*