United States Environmental Protection Agency

2014 GREEN INFRASTRUCTURE TECHNICAL ASSISTANCE PROGRAM
City and County of Denver
Denver, CO

Green Infrastructure Checklists and Renderings

Tools to Assist Local Governments in Promoting and Implementing Green Infrastructure Practices

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About the Green Infrastructure Technical Assistance Program

Stormwater runoff is a major cause of water pollution in urban areas. When rain falls in undeveloped areas, soil and plants absorb and filter the water. When rain falls on our roofs, streets, and parking lots, however, the water cannot soak into the ground. In most urban areas, stormwater is drained through engineered collection systems (storm sewers) and discharged into nearby water bodies. The stormwater carries trash, bacteria, heavy metals, and other pollutants from the urban landscape, polluting the receiving waters. Higher flows also can cause erosion and flooding in urban streams, damaging habitat, property, and infrastructure.

Green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, *green infrastructure* refers to the patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the scale of a neighborhood or site, *green infrastructure* refers to stormwater management systems that mimic nature by soaking up and storing water. Green infrastructure can be a cost-effective approach for improving water quality and helping communities stretch their infrastructure investments further by providing multiple environmental, economic, and community benefits. This multibenefit approach creates sustainable and resilient water infrastructure that supports and revitalizes urban communities.

The U.S. Environmental Protection Agency (EPA) encourages communities to use green infrastructure to help manage stormwater runoff, reduce sewer overflows, and improve water quality. EPA recognizes the value of working collaboratively with communities to support broader adoption of green infrastructure approaches. Technical assistance is a key component to accelerating the implementation of green infrastructure across the nation and aligns with EPA's commitment to provide community focused outreach and support in the President's *Priority Agenda Enhancing the Climate Resilience of America's Natural Resources*. Creating more resilient systems will become increasingly important in the face of climate change. As more intense weather events and dwindling water supplies stress the performance of the nation's water infrastructure, green infrastructure offers an approach to increase resiliency and adaptability.

For more information, visit *http://www.epa.gov/greeninfrastructure*.

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Cover Photo and Rendering: Tetra Tech

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Acronyms

DWR	Colorado Division of Water Resources
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
ROW	right-of-way
UDFCD	Urban Drainage and Flood Control District
USDCM	Urban Storm Drainage Criteria Manual
WQCV	water quality control volume

1 Overview

The City and County of Denver (Denver) is making green infrastructure a fundamental part of the city's long-term stormwater management strategy by looking at ways to integrate small, site-scale, and subregional green infrastructure practices into the existing large-scale network of parks and open space. To further this goal, Denver developed the *City and County of Denver Ultra-Urban Green Infrastructure Guide* (*Green Infrastructure Guide*) (City and County of Denver 2016) to provide a technical resource and design information for green infrastructure practitioners.

The U.S. Environmental Protection Agency (EPA), through its Green Infrastructure Technical Assistance Program, helped Denver to develop a set of tools to streamline review, approval, and implementation of green infrastructure practices. Specifically, EPA developed the following:

- **Green infrastructure plan review checklists** (section 2 and Appendices A–C) to assist planning review boards in evaluating both public and private development projects that seek to implement green infrastructure designs. These checklists will ensure that all required information is included in design plans and submittals and that plan submittals meet Denver's Storm Drainage Design and Technical Criteria (City and County of Denver 1992) and Urban Drainage and Flood Control District (UDFCD) criteria for green infrastructure projects on Colorado's Front Range. UDFCD criteria are published in *Urban Storm Drainage Criteria Manual (USDCM) Volume 3* (UDFCD 1992).

- **Green infrastructure inspection checklists** (section 3) for two types of inspections: **post-construction inspections** (Appendix D) to assist local planning authorities in ensuring that green infrastructure facilities are installed as specified in approved plans using the appropriate materials, and **maintenance inspections** (Appendix E) to assist owners and operators of green infrastructure facilities in determining when maintenance is needed (i.e., maintenance triggers) and what needs to be done to ensure the facilities continue to function as designed over the long term.

- **Renderings of green infrastructure practices** (Figures 1–5) to enhance Denver's *Green Infrastructure Guide*. The renderings show green infrastructure practices integrated into Denver streetscapes; the specific combinations of practices shown can provide stormwater storage for different types of road rights-of-way (ROWs). The renderings are included throughout this report with descriptions of roadway types and expected water quality control volumes (WQCVs).

2 Guidance for Reviewing Green Infrastructure Components in Development Project Plans

Design, construction, and implementation of green infrastructure in Denver, and throughout the Front Range, are influenced by the state's semiarid climate and the system of administering surface water rights:

- **Semiarid climate.** Denver's semiarid climate requires modifying green infrastructure practices adopted from other U.S. locations. Stormwater controls typically must be xeriscaped with a focus on native plants, because they use less water and perform better in a semiarid environment. Though native species will likely need supplemental irrigation during establishment, nonnative plants generally will not survive without irrigation (Taupe infrastructure 2014). Rain events in Denver tend to be high intensity and infrequent, resulting in a water quality event that is heavy with sediments and other pollutants that have accumulated since the previous storm. As a result, forebays, presedimentation basins, or other forms of pretreatment are recommended to remove some of the particulate matter before it reaches a green infrastructure facility.

- **Surface water rights.** Surface water in Colorado is administered through a priority system, the Doctrine of Prior Appropriation, in which "first in time" equals "first in right." Water users with earlier water rights decrees (i.e., senior rights) have first right in times of short supply and can fill their needs before the junior rights users can begin to use water. The Colorado Division of Water Resources (DWR) administers this program and in 2011 circulated a memorandum on the subject of DWR's administrative approach to storm water management. That document details administrative allowances the state is currently willing to make to accommodate detention, infiltration, and green roofs as stormwater management activities. Under the program, only three green infrastructure practices are allowed: detention areas, infiltration areas, and green roofs. Specific limitations on these practices include the following:

    - Stormwater detention areas must release all of the water detained from the site within 72 hours of the end of a precipitation event, should be designed to release the water from the site as quickly as downstream conditions allow, and must be designed to minimize consumption from vegetation.
    - Infiltration areas must be designed to infiltrate the water into the underlying aquifer as quickly as possible, not result in an exposed water surface beyond 72 hours after the end of a precipitation event, and must be designed to minimize consumption from vegetation.
    - Green roofs may intercept only precipitation that falls directly onto the landscaped portion of the roof. The landscaping may not intercept and consume concentrated flow and may not store water below the root zone.
    - Stormwater may not be diverted from detention, infiltration, or green roof areas for any beneficial uses.

    In 2014, the DWR clarified that these administrative allowances are made expressly for an *individual site,* being defined as a discrete area that has been developed through one development effort, and do not extend beyond that narrow definition. Most Colorado stormwater and floodplain managers disagree with this interpretation, and a concerted effort is underway to seek a legislative solution that will broaden the scope of allowable stormwater management activities and protect those activities from lawsuits by water rights holders.[1] Meanwhile, property owners can employ practices that detain or infiltrate stormwater if that water will either be completely released or infiltrated within 72 hours of the end of the precipitation event that generated the runoff.

2.1 Green Infrastructure Practice Selection, Design, and Maintenance

Green infrastructure practice selection and design are driven by a site's physical characteristics, including soils, contributing drainage area, ground water, and development conditions in the tributary watershed (e.g., construction activity). UDFCD describes physical site characteristics that support or constrain the selection of green infrastructure practices:

- **Soils.** Soils with good permeability, typically associated with hydrologic soil groups A and B, provide opportunities for infiltration of runoff and are well suited for infiltration-based practices—such as streetside stormwater planters, bump-out stormwater planters, green gutters, tree trenches and pits, and green alleys—often without the need for an underdrain system. Even when soil permeability is low, these types of practices might be feasible if soils are amended to increase permeability or an underdrain system is used. In some cases, however, soils limit the use of infiltration-based practices. When soils with moderate-to-high swell potential are present, infiltration should be avoided to minimize damage to adjacent structures from water-induced swelling. In some cases, infiltration-based designs can still be used if an impermeable liner and underdrain system are included in the design; however, if the risk of damage to adjacent infrastructure is high, infiltration-based practices might not be appropriate. In all cases, a geotechnical engineer should be consulted when designing infiltration practices near structures to evaluate the suitability of soils for different practice types and establish minimum distances between infiltration practices and structures (UDFCD 1992).

- **Contributing drainage area.** The contributing drainage area is an important consideration both on the site level and at the regional level. On the site level, there is a practical minimum size for certain practices, largely related to the ability to drain the WQCV over the required drain time. For example, it is technically possible to size the WQCV for an extended detention basin for a half-acre site; however, designing a functional outlet to release the WQCV over a 40-hour drain time is practically impossible due to the very small orifices that would be required. For a half-acre site, a filtering practice such as bioretention would be more appropriate. At the other end of the spectrum, there should be a limit on the maximum drainage area for a regional facility to ensure adequate treatment of rainfall events that could produce runoff from only a portion of the area draining to the practice. If the overall drainage area is too large, runoff from only a portion of the contributing area will pass through the practice outlet sized for the full drainage area without adequate residence time in the practice. As a practical limit, the maximum drainage area contributing to a water quality facility should be no larger than 1 square mile (UDFCD 1992).

[1] For example, in 2016 state law was amended to allow the use of rain barrels and other collection devices on certain residential properties.

Figure 1. Rendering of a combination of a streetside stormwater planter and a mid-block streetside bump-out stormwater planter along the 60-foot ROW of a typical local street. This combination is estimated to provide 525 cubic feet of stormwater storage, assuming a WQCV depth of 12 inches.

- **Ground water.** Shallow ground water on a site presents challenges both for green infrastructure practices that rely on infiltration and for facilities that are intended to be dry between storm events. Shallow ground water could limit the ability to infiltrate runoff or result in unwanted subsurface storage of ground water in areas intended for storage of the WQCV (e.g., the porous subbase of a permeable pavement system or in the bottom of an otherwise dry facility such as an extended detention basin). Conversely, for some types of practices such as wetland channels or constructed wetland basins, shallow ground water can be beneficial by providing saturation of the root zone and/or a source of base flow. Protection of ground water quality is an issue that should be considered for infiltration-based practices.

  Infiltration practices might not be appropriate for land uses that involve storage or use of materials that have the potential to contaminate ground water underlying a site (e.g., *hot spot* runoff from fueling stations, materials storage areas). If ground water or soil contamination exists on a site (i.e., a brownfield) and the contamination will not be remediated or removed as part of construction, it might be necessary to avoid infiltration-based practices or to use a durable liner to prevent infiltration into areas contaminated with pollutants that could be mobilized by stormwater (UDFCD 1992).

- **Watershed development activities.** When development in the watershed is phased or when erosive conditions—such as steep slopes, sparse vegetation, and sandy soils—exist in the watershed, a treatment train approach might be appropriate. Practices that use filtration should follow other measures to collect sediment loads (e.g., a forebay). For phased developments, these measures must be in place until the watershed is completely stabilized. When naturally erosive conditions exist in the watershed, the measures should be permanent. The designer should consider existing, interim, and future conditions in selecting the most appropriate practices (UDFCD 1992).

In addition to recognizing that practices must be appropriate to a site's physical characteristics, designers, planners, and reviewers must recognize that for practices to function effectively, meet performance expectations, and provide for public safety, they must be:

1. **Designed according to Denver and UDFCD criteria,** taking into account site-specific conditions.

2. **Constructed as designed.** This is important for all practices but is particularly critical for the practices included in this document as many of the critical components are subsurface. This requires more frequent construction observation compared to other practices, which can typically be inspected postconstruction (e.g., extended detention basins).

3. **Properly maintained to function as designed.** Although all stormwater management practices require maintenance, infiltration-oriented facilities are particularly susceptible to clogging without proper maintenance. Underground facilities can be vulnerable to maintenance neglect because maintenance needs are not evident from the surface without special diagnostic tools and procedures for access. Maintenance is not only essential for proper functioning, but also for aesthetic and safety reasons. Inspection of facilities is an important step in identifying and planning for needed maintenance.

Source: Tetra Tech, Inc.

Figure 2. Rendering of a combination of two tree trenches (three trees with three water quality control structures at 2% slope) along the 60-foot ROW of a typical local street. This combination is estimated to provide 492 cubic feet of stormwater storage, assuming a WQCV depth of 12 inches.

Public access to green infrastructure practices also should be considered from a safety perspective. The highest priority of engineers and public officials is to protect public health, safety, and welfare. Green infrastructure practices must be designed and maintained in a manner that does not pose health or safety hazards to the public. Safety features such as rails and curbs should be incorporated as appropriate. Facilities should be designed to reduce the likelihood and extent of shallow standing water that can allow mosquitoes to breed, which can be a nuisance and a public health concern. The potential for nuisances, odors, and prolonged soggy conditions should be evaluated for green infrastructure practices, especially in areas with high pedestrian traffic or visibility.

Maintenance should be considered early in the planning and design phase. Clear, legally binding written agreements assigning maintenance responsibilities and committing adequate funds for maintenance also are critical.

Source: Tetra Tech, Inc.

Figure 3. Rendering of a combination of two streetside stormwater planters and one corner streetside bump-out stormwater planter along the 110-foot ROW of a typical 4-lane arterial street with no parking. This combination is estimated to provide 822 cubic feet of stormwater storage, assuming a WQCV depth of 12 inches.

2.2 Green Infrastructure Components for Plan Review

This section presents an overview of components that every project development plan containing green infrastructure should incorporate. It does not discuss all of the components included on the full plan submittal checklists that Denver uses (i.e., Concept Submittal Checklist or Formal Site Development Plan Submittal Checklist), but identifies items that would help city staff in performing plan reviews for green infrastructure designs.

2.2.1 Basic Components

- ☐ Vicinity map showing project boundary, adjacent streets and nearby hydrologic features (e.g., streams, reservoirs), and Federal Emergency Management Agency (FEMA) floodplain delineations (if applicable).
- ☐ Total project area within the site boundary in acres or square feet.
- ☐ Description of existing site drainage, including conveyance network; discharge locations, size, and capacity for each discharge point; contributing drainage area and design flow; and off-site drainage areas, design flows, and locations.
- ☐ Description of proposed project site drainage, including conveyance network; discharge locations, size, and capacity for each discharge point; contributing drainage area and design flow; and off-site drainage areas, design flows, and locations.
- ☐ Increase or decrease in impervious area in the proposed condition as compared to the preproject condition.
- ☐ Total planned impervious area within the site boundary, expressed in acres or square feet and as a percentage of the total project area.
- ☐ Receiving waters to which the project site discharges, whether the waters are listed as impaired on the EPA-approved 303(d) list or an EPA-approved TMDL applies to the water bodies.
- ☐ Identification and description of all source control measures implemented on the project site.
- ☐ Sizing calculation for each proposed practice, including water quality design flow, design volume, outlet design, overflow design, drawdown, and ponding depth.
- ☐ Map or source identifying justification for rainfall data selection.

2.2.2 Plan Sheet Components

- ☐ Vicinity map showing project boundary, adjacent streets, and nearby hydrologic features (e.g., streams, reservoirs).
- ☐ Mapped FEMA floodplain limits in relation to the project site, if applicable.
- ☐ Locations where off-site drainage enters the project site, if applicable.
- ☐ The total planned impervious area within the site boundary.
- ☐ Details regarding the proposed project site drainage network, including storm drains, concrete channels, swales, detention facilities, stormwater treatment facilities, natural and constructed channels, and the method for conveying off-site flows through or around the proposed project.
- ☐ All discharge locations from the proposed project site with appropriately sized energy dissipation, if applicable.

- ☐ Areas within the site designated for preservation, such as stream corridors, open space, coarse sediment areas, and other natural resources.
- ☐ Areas of high infiltration potential.
- ☐ Details of planned slope protection measures to improve geotechnical stability and mitigate potential erosion.
- ☐ Downspout disconnections with standard detail.
- ☐ Areas of active landscaping that will require irrigation.
- ☐ Invert elevation and opening width for curb cuts.
- ☐ Invert elevation and overflow elevation for each identified treatment control, flow control practice, and low-flow diversion practice.
- ☐ All orifice invert elevations when multistage outlets are proposed.
- ☐ Invert elevation and outlet elevation for each pretreatment facility, if applicable.
- ☐ Sufficient grading details so runoff is properly directed to the design inflow location.

Source: Tetra Tech, Inc.

Figure 4. Rendering of a combination of a streetside stormwater planter and a mid-block streetside bump-out stormwater planter along the 60-foot ROW of a typical local street. This combination is estimated to provide 525 cubic feet of stormwater storage, assuming a WQCV depth of 12 inches.

2.3 Specific Green Infrastructure Design Components

Successful construction, effectiveness, and long-term operation of green infrastructure are a result of sound design and engineering. Design components are specific to green infrastructure type, volume of runoff treated, and intended removal efficiency (if applicable). The design must satisfy applicable regulatory requirements that could vary locally. In Denver, green infrastructure design specifications are outlined in the *USDCM Volume 3* (UDFCD 1992). The checklists presented in Appendices A, B, and C for three green infrastructure types—bioretention, tree trenches/pits, and permeable pavement—are intended to provide guidance to development plan reviewers in determining whether design requirements are met. The checklists should be used in combination with the *USDCM Volume 3*, which provides more detailed design specifications and calculations (UDFCD 1992).

Source: Tetra Tech, Inc.

Figure 5. Rendering of a combination of four streetside stormwater planters along the 110-foot ROW of a typical 4-lane arterial street with no parking. This combination is estimated to provide 936 cubic feet of stormwater storage, assuming a WQCV depth of 12 inches.

3 Guidance for Inspecting and Maintaining Green Infrastructure Practices

Proper inspection and ongoing maintenance are essential for green infrastructure to be effective. A postconstruction inspection should occur as soon as construction is complete, and maintenance inspections should occur regularly at least once or twice per year for the life of the practice. This inspection and maintenance guidance focuses on both types of inspection for bioretention and permeable pavement green infrastructure practices.

An inspector undertaking a postconstruction inspection evaluates the ability of a newly installed green infrastructure practice to perform effectively and as planned. The inspector evaluates the constructed green infrastructure practice against approved design drawings and plans. The postconstruction inspection checklist provided in Appendix D can be used to ensure that green infrastructure is properly constructed as designed and that stormwater management will be effective.

Ongoing maintenance of green infrastructure includes both routinely scheduled activities (e.g., landscape maintenance) and nonroutine activities that might be required after large storms (e.g., sediment removal and redistribution of mulch). UDFCD presents maintenance considerations, in addition to specifications and standards, in *USDCM Volume 3* (UDFCD 1992). A summary of maintenance considerations and maintenance activities and their frequency is presented in section 3.1, and a maintenance checklist is provided in Appendix E.

3.1 Maintenance Guidelines for Green Infrastructure

Maintenance considerations for bioretention, tree trench and tree pits, and permeable pavement are presented in the following sections. Bioretention maintenance considerations are applicable to streetside stormwater planters, bump-out stormwater planters, and green gutters. The permeable pavement maintenance considerations can be applied to green alley applications and permeable pavement areas integrated into tree trench/pit and bioretention configurations.

3.1.1 Bioretention

The primary maintenance requirement for bioretention is regular plant, soil, and mulch layer (if applicable) maintenance to ensure a healthy vegetation system that promotes infiltration, storage, and pollutant removal. A healthy and densely vegetated system should be free of excess sediment and trash, and the system typically should drain within 12 hours of a storm. Replacement of vegetation might be necessary to maintain optimal performance. Bioretention maintenance requirements are applicable to all forms of bioretention. Maintenance is typical of general landscape care and consists of the following:

- ☐ **Sediment removal.** Sweep or shovel sediment from the sediment collection pad/forebay approximately two times per year, and dispose of sediment outside the planter.
- ☐ **Watering.** Vegetation must be drought-tolerant and not require watering after a 2–3-year establishment period. Watering could be required during prolonged dry periods after vegetation has been established.
- ☐ **Debris and litter removal.** Remove debris and litter from the infiltration surface to minimize clogging of the media. If applicable, remove debris and litter from the overflow structure. The degree of debris and litter accumulation is variable and is influenced by surrounding land uses, pedestrian traffic or activities, and the presence of trees.

- ☐ **Landscaping.** Mow grasses as desired or needed for weed control. Native or drought-tolerant grasses should be maintained at a height of at least 6 inches; mowing might not be necessary. Occasional pruning or removal of dead plant or tree material (e.g., leaf litter) and periodic weeding might be necessary depending on the selected plants. Periodic weeding might be necessary during the establishment period until the soil media is covered with mulch or dense vegetation.
- ☐ **Mulch.** In areas where heavy metal deposition is likely (e.g., contributing areas that include industrial and auto-related businesses, parking lots, and roads), replace mulch annually. In areas where metal deposition is not a concern, add mulch as needed to maintain a mulch depth of up to 3 inches. Mulch should be replaced every 2–5 years where metal deposition is not a concern.
- ☐ **Nutrients and pesticides.** Bioretention soil mix and plants are selected for optimum fertility, plant establishment, and growth. Nutrients and pesticides should not be applied, as they can degrade the pollutant removal capability of the bioretention system and contribute pollutant loads to receiving waters.
- ☐ **Inlet.** Inspect inlets for sediment accumulation and signs of erosion. Excess sediment can accumulate at inlets where curb cuts or bypass structures are used and should be inspected regularly. Any accumulated sediment that impedes flow into the bioretention area should be removed and disposed of properly (not placed elsewhere in the planter). When the system is first installed, inlets should be inspected after each storm event to identify any potential inflow and sediment issues that require design modifications. After an initial period, inlets should be inspected quarterly and after a significant storm event.
- ☐ **Overflow and underdrains.** Sediment accumulation in the overflow device or underdrain system can cause prolonged ponding and potential flooding. Excess ponding can damage vegetation and create mosquito-breeding habitat. Inspect overflow and underdrain systems to ensure that cleanouts are watertight and there is no visible debris inside the overflow structure.

Inspection of bioretention practices should occur at least twice annually following runoff-generating storms to determine if each practice is providing acceptable infiltration. If standing water persists for more than 24 hours after runoff has ceased, the possibility of clogging should be investigated and remedied. Areas where erosion has occurred should be inspected, as they are potential sources of sediment if not repaired.

3.1.2 Tree Trenches and Pits

Maintenance for tree trenches and pits is necessary for tree health and to ensure a functioning system in which water is conveyed through the inlet and throughout the system effectively. Typical maintenance of tree trenches and pits consists of the following:

- ☐ **Debris and litter removal.** Remove debris and litter from the infiltration surface to minimize clogging of the media. The degree of debris and litter accumulation is variable and is influenced by surrounding land uses, pedestrian traffic or activities, and season (e.g., tree litter is expected each fall).
- ☐ **Landscaping.** Occasional pruning, removal of dead tree material (e.g., leaf litter), and periodic weeding might be necessary.
- ☐ **Inlet.** Inspect inlets for sediment accumulation and signs of erosion. Excess sediment can accumulate at inlets where curb cuts or bypass structures are used and should be inspected

regularly. Any accumulated sediment that impedes flow into the tree trench or pit should be removed and disposed of properly (not placed elsewhere in the planter). When the system is first installed, inlets should be inspected after each storm event to identify any potential inflow and sediment issues that require design modifications. After an initial period, inlets should be inspected quarterly and after a significant storm event.

- ☐ **Forebay.** The aggregate in the forebay should be vacuumed regularly (monthly during the wet season is recommended) and replaced routinely (when significant clogging is observed). Maintenance frequency is dependent on the rate at which the media clogs. Media clogging is a function of drainage area size, presence or amount of construction activity, and pollutant loads in the runoff. Inspections are recommended once or twice per year to detect early visual signs of clogging.
- ☐ **Overflow and underdrains.** Sediment accumulation in the overflow device or underdrain system can cause prolonged ponding and potential flooding. Excess ponding can damage the soil media and create mosquito-breeding habitat. Inspect overflow and underdrain systems to ensure that cleanouts are watertight and there is no visible debris inside the overflow structure.

Inspection of tree trenches and pits should occur at least twice annually following runoff-generating storms to determine if runoff is flowing through the system properly. If standing water persists for more than 24 hours after runoff has ceased, the possibility of clogging should be investigated and remedied. Areas where erosion has occurred should be inspected, as they are potential sources of sediment if not repaired.

3.1.3 Permeable Pavement

The key maintenance objective for permeable pavement systems is to prevent void spaces from becoming clogged or requiring sediment removal. Infiltration issues can be identified when runoff ponds on the surface or is no longer infiltrating into the surface rapidly. Key maintenance considerations and procedures consist of the following (refer to *USDCM Volume 3* for further details regarding specific permeable pavement types):

- ☐ **Debris removal, sweeping, and vacuuming.** Remove debris routinely as a source control measure. Sweeping with a regenerative air sweeper (not a broom sweeper) should be performed approximately two times per year. Frequency can be adjusted according to the run-on ratio and deposition rate on the permeable pavement surface. Frequent sweeping is an excellent measure to prevent clogging, and sweeping with a vacuum sweeper has proven to be effective for removing solids and debris from the void space of permeable pavement.
- ☐ **Weed control.** Use weed control applications on any weeds that grow in the permeable pavement. Where underdrains provide a hard connection to a storm drain, either burn weeds or spot treat them with an herbicide that does not contain polyethoxylated amine. Weeds should *not* be pulled, as doing so can damage the fill media.
- ☐ **Snow removal.** Plowing is a recommended snow removal process. Conventional liquid treatments (deicers) will not stay at the surface of a permeable pavement long enough to be effective. Sand should never be applied to a permeable pavement, as it will reduce infiltration.

Inspection of pavement condition and verification of infiltration should be performed at least annually, either during a rain event or with a garden hose to ensure that water infiltrates into the surface.

4 References

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Appendix A: Development Plan Review Checklist for Bioretention

BIORETENTION
Streetside Stormwater Planters, Bump-Out Stormwater Planters, and Green Gutters

Green Infrastructure Design Plan Review Checklist

Bioretention is an engineered, depressed landscape area designed to capture and filter or infiltrate the water quality capture volume (WQCV). Bioretention areas typically consist of a flow regulating structure, a pretreatment element, an engineered soil mix planting bed, vegetation, and an outflow regulating structure. Bioretention areas are designed to hold and remove stormwater pollutants through a variety of chemical, physical and biological processes in a manner similar to natural ecosystems. Bioretention systems are flexible, adaptable and versatile stormwater management facilities that can fit readily into parking lot islands; street medians; residential, commercial and industrial campus landscaping; and urban and suburban green spaces and corridors. Bioretention is a type of green infrastructure that can be configured as streetside stormwater planters, bump-out stormwater planters, and green gutters to fit in ultra-urban settings.

Technical guidance is provided in italics below, including references to the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual Volume 3*, which is available online at http://udfcd.org/volume-three.

Plan Review Checklist for Bioretention

Questions	Yes	No	N/A	Notes
Site Applicability and Considerations				
Siting				
Is the site location and size reasonable for the drainage area to be treated? For example, a green gutter is appropriate for treating runoff from public ROW only; inclusion of runoff from adjacent development would require a stormwater planter.	☐	☐	☐	
Is the practice installed at the downstream end of the block, if possible?	☐	☐	☐	
Is there a nearby inlet or manhole that would provide a convenient location to discharge the underdrain to?	☐	☐	☐	
Pedestrian Considerations				
Are pedestrian edge barriers appropriately sized to provide pedestrian safety (i.e., 6 inches minimum along long sides parallel to street and 15 inches minimum along short sides)? This requirement is not applicable to green gutters.	☐	☐	☐	
Maximum depth to the surface of the bioretention media does not exceed 20 inches.	☐	☐	☐	
Are access paths a minimum of 4 feet wide and in compliance with ADA design guidelines?	☐	☐	☐	
Are step-out zones appropriately sized between the curb and bioretention per City and County of Denver requirements? This requirement is not applicable to green gutters.	☐	☐	☐	
Geometry				
Is the bioretention no longer than 40 feet?	☐	☐	☐	
Is the top of the bioretention horizontal in longitudinal profile, regardless of street slope?	☐	☐	☐	
Other				
Was a soil investigation performed by a registered geologist, soil scientist, or professional engineer?	☐	☐	☐	
Were recommendations in a geotechnical report followed?	☐	☐	☐	
Is there positive drainage away from adjacent buildings at all locations?	☐	☐	☐	

Questions	Yes	No	N/A	Notes
Design Considerations				
Water Quality Capture Volume Zone				
Does the design allow for the recommended storage volume (above the surface) per *USDCM Volume 3*?	☐	☐	☐	
Does the design filter area (bottom surface of facility) meet or exceed the minimum calculated filter area per *USDCM Volume 3*?	☐	☐	☐	
Inlet and Outlet Controls				
Is the inlet sized to convey the water quality event assuming an appropriate amount of debris blockage (i.e., debris factor)?	☐	☐	☐	
Is energy dissipation provided at concentrated points of inflow?	☐	☐	☐	
Is the outlet control orifice sized to drain the design volume in 12 hours or more and is a minimum orifice size of 3/8-inch used (to avoid clogging)?	☐	☐	☐	
Pretreatment				
Is pretreatment provided (forebay in conjunction with the inlet)?	☐	☐	☐	
Does pretreatment allow for sediment deposition without bypass of the practice and is this clearly detailed in section on the plans?	☐	☐	☐	
Underdrain System				
Does the facility design include an underdrain system? *An underdrain system may be necessary if infiltration tests show percolation drawdown rates slower than two times the rate needed to drain the WQCV over 12 hours, or where required to divert water away from structures as determined by a professional engineer.*	☐	☐	☐	
Do all references to the underdrain clearly call for slotted pipe (not perforated) and are the slot widths included in the plan?	☐	☐	☐	
Are cleanouts provided to enable underdrain inspection and maintenance?	☐	☐	☐	
Is the underdrain system placed within a section of CDOT Class C filter material (not bioretention media) and is this material specified on the plans?	☐	☐	☐	
Do the plans specifically state that no geotextile fabric shall be placed between the underdrain and the filter material or between the filter material and the bioretention media?	☐	☐	☐	
Walls and Spillway				
Are subgrade conditions necessary to ensure suitable foundation for the walls and reduce potential settling specified?	☐	☐	☐	
Does the design provide an outlet or other means of overflow (spillway) at the elevation of maximum ponding depth?	☐	☐	☐	

Design Considerations (continued)				
Impermeable Liners				
If a liner is not required, is the facility at least 10 feet away from any structure?	☐	☐	☐	
If a liner is required, are the following conditions met:				
• Is a 30 mil (minimum) PVC liner installed on the bottom and sides of the basin, extending up at least to the top of the underdrain layer?	☐	☐	☐	
• Does the liner have a minimum of 9 inches of cover over the membrane to protect the membrane from UV deterioration?	☐	☐	☐	
• Is the attachment of the liner to a solid reinforced concrete wall detailed on the plans?	☐	☐	☐	
• Do the plans call for heat welding and testing of all seams and specify to contact the engineer to be present during testing of all seams?	☐	☐	☐	
• Does the liner meet the physical requirements presented in Table B-5 of the USDCM Volume 3?	☐	☐	☐	
Bioretention Media and Vegetation				
For bioretention media, is a minimum of 18 inches of growing medium provided to support the establishment of vegetation roots?	☐	☐	☐	
If trees are to be installed, is the filter media depth at least 2 feet? (3 to 4 feet recommended)	☐	☐	☐	
Is the identified growing medium (per Volume 3 requirements) for bioretention structures and is this clearly referred to as bioretention media (not "growing media") in all locations referenced?	☐	☐	☐	
Is the bioretention media specified on the plans?	☐	☐	☐	
Does the design incorporate drought tolerant vegetation that thrives in sandy soil and is non-invasive?	☐	☐	☐	
Additional Comments				

Additional Comments

Appendix B: Development Plan Review Checklist for Tree Trench/Pit

TREE TRENCH/PIT	Green Infrastructure Design Plan Review Checklist

A tree trench provides stormwater quality treatment for streets and adjacent pedestrian zones. Stormwater enters the tree trench through a curb opening, passes through a pea gravel filter for pretreatment and is conveyed through an underdrain to one or more tree plantings. Treatment processes include filtration, soil adsorption, and uptake by the roots of the trees. A tree trench that features a single tree is called a tree pit.

Technical guidance is provided in italics below. Note that the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual Volume 3* does not contain a practice description for infiltration trenches. Specifications on this Plan Review Checklist were obtained from the Colorado Department of Transportation's *Drainage Design Manual* (see (*http://www.coloradodot.info/programs/environmental/water-quality/documents/drainage-design-manual*).

Plan Review Checklist for Tree Trench/Pit

Questions	Yes	No	N/A	Notes
Site Applicability and Considerations				
Siting				
Are the trees sited in the amenity zone between the step-out zone and sidewalk?	☐	☐	☐	
Are the trees sited in a manner that preserves sidewalk width and will not hinder high pedestrian traffic?				
Are City and County of Denver requirements for step-out zones followed and appropriately considered when adjacent parking exists and does not exist?	☐	☐	☐	
Is the bottom of the tree trench at least five feet above the seasonal high water table or bedrock?	☐	☐	☐	
Is there a nearby inlet or manhole that would provide a convenient location to discharge the underdrain to?	☐	☐	☐	
Pedestrian Considerations				
Are tree grates or paver grates designed to meet ADA requirements?	☐	☐	☐	
Will the pretreatment filter and inlet be covered by removable or accessible grate panels meeting ADA requirements?	☐	☐	☐	
Geometry				
Tree trench sections do not have more than three trees.	☐	☐	☐	
Other				
Was a soil investigation performed by a registered geologist, soil scientist, or professional engineer?	☐	☐	☐	
Were recommendations in a geotechnical report followed?	☐	☐	☐	
Is there positive drainage away from adjacent buildings at all locations?	☐	☐	☐	

Design Considerations				
Water Quality Capture Volume Zone				
Does the design allow for the recommended storage volume (above the surface) per *USDCM Volume 3*?	☐	☐	☐	
Is the tree trench designed as a flow-through system to provide equal to or greater capacity than peak discharge during the water quality storm event?	☐	☐	☐	
Inlet and Outlet Controls				
Is an inlet and water control structure provided for every trench section (or every three trees)?	☐	☐	☐	
Will the street inlet be located at the upstream end of the tree trench?	☐	☐	☐	
Will the inlet convey runoff from the curb and gutter and across the step-out zone?				
Is the inlet sized to convey the water quality event assuming an appropriate amount of debris blockage (i.e., debris factor)?	☐	☐	☐	
Is the outlet control orifice sized to drain the design volume in 12 hours or more and is a minimum orifice size of 3/8-inch used (to avoid clogging)? See USDCM Volume 3 for appropriate release rate.	☐	☐	☐	
Does the outlet control structure provide an adjustable control weir to assist with the wetting of the structural media and tree roots?	☐	☐	☐	
Is an observation well/clean out provided? *CDOT recommends an observation well of 100-150 mm perforated PVC pipe.*	☐	☐	☐	
Pretreatment				
Is pretreatment provided to function in conjunction with the inlet?	☐	☐	☐	
Is the pretreatment filter designed with media (e.g., pea gravel) that allows for relatively high-flow through capacity?	☐	☐	☐	
Is the sizing of the pre-treatment filter based on an infiltration rate of 4 inches per minute?	☐	☐	☐	
Underdrain System				
Does the facility design include an underdrain system (recommended)? *An underdrain system may be necessary if infiltration tests show percolation drawdown rates slower than two times the rate needed to drain the WQCV over 12 hours, or where required to divert water away from structures as determined by a professional engineer.*	☐	☐	☐	
Is the underdrain system designed to meet the capacity required to convey the peak discharge of the water quality event?	☐	☐	☐	
Do all references to the underdrain clearly call for slotted pipe (not perforated) and are the slot widths included in the plan?	☐	☐	☐	
Are cleanouts provided to enable underdrain inspection and maintenance?	☐	☐	☐	

Design Considerations (continued)				
Is the underdrain system placed within a section of CDOT Class C filter material (not bioretention media) and is this material specified on the plans?	☐	☐	☐	
Do the plans specifically state that no geotextile fabric shall be placed between the underdrain and the filter material or between the filter material and the bioretention media?	☐	☐	☐	
Impermeable Liners				
Is a liner required? (if yes, select the type below) ☐ One trench sidewall ☐ Both trench sidewalls ☐ Fully lined installation (constraints on tree root system are expected and considered in tree selection)	☐	☐	☐	
If a liner is required, are the following requirements met: • Is a 30 mil (minimum) PVC liner installed on the bottom and sides of the basin, extending up at least to the top of the underdrain layer?	☐	☐	☐	
• Does the liner have a minimum of 9 inches of cover over the membrane to protect the membrane from UV deterioration?	☐	☐	☐	
• Is the attachment of the liner to a solid reinforced concrete wall detailed on the plans?	☐	☐	☐	
• Do the plans call for heat welding and testing of all seams and specify to contact the engineer to be present during testing of all seams?	☐	☐	☐	
• Does the liner meet the physical requirements presented in Table B-5 of the USDCM Volume 3?	☐	☐	☐	
Bioretention Media and Vegetation				
Is the bioretention media (placed above the root ball and in structural media) consistent with the criteria outlined in the Bioretention Section in USDCM Volume 3 and specified on all plans?	☐	☐	☐	
Is the structural media composition supportive of tree growth and tree grate and pavers? (one part bioretention media with two parts 1-1/2 inch crushed gravel is recommended)	☐	☐	☐	
Is the total bioretention media and structural media depth at least 2 feet? (3 to 4 feet recommended)	☐	☐	☐	
Are appropriate trees and tree spacing used per City of Denver Forestry Department's list of approved street trees?	☐	☐	☐	
If magnesium chloride de-icer is used on the streets adjacent to a proposed tree trench, will trees with a tolerance to saline soils be planted?	☐	☐	☐	
If shade trees will be used, are trees with strong central leaders that branch out 6 feet high or higher planned to avoid creating barriers and hazards to pedestrians?	☐	☐	☐	
In areas with overhead powerlines, has the height of the tree been considered?	☐	☐	☐	

Additional Comments

Appendix C: Development Plan Review Checklist for Permeable Pavement

PERMEABLE PAVEMENT				**Green Infrastructure Design Plan Review Checklist**
Permeable pavement allows streets, parking lots, sidewalks, and other impervious covers to maintain their structural and functional features while restoring natural infiltration capacity. Permeable pavement contains small voids that allow rainfall and runoff to drain through the pavement and eventually into the underlying soils. It can be used at various sites with low traffic frequency such as parking lots, sidewalks, and driveways. Many permeable pavement surfaces are available, including pervious concrete, porous asphalt and permeable interlocking concrete pavers. As an example, the following plan review checklist is intended for reviewing green alleys where permeable pavement is the primary green infrastructure reviewed. A green alley is designed to provide water quality treatment and infiltration of runoff though the use of permeable pavement. Green alleys may include other green infrastructure applications. Technical guidance is provided in green text below, including references to the Urban Drainage and Flood Control District (UDFCD) *Urban Storm Drainage Criteria Manual (USDCM) Volume 3*, which is available online at http://udfcd.org/volume-three.				
Plan Review Checklist for Permeable Pavement				
Questions	**Yes**	**No**	**N/A**	**Notes**
Site Applicability and Considerations				
Siting				
Has the appropriate application of pervious pavement (e.g., use, traffic loading, slopes) been considered? *Permeable pavement is not appropriate for runoff from erosive areas such as steep slopes and/or areas of sparse vegetation where sediment-laden runoff could clog the system.*	☐	☐	☐	
Is there a nearby inlet or manhole that would provide a convenient location to discharge the underdrain to?	☐	☐	☐	
Pedestrian Considerations				
Does the design meet ADA guidelines?	☐	☐	☐	
Is the permeable surface constructed with the heaviest duty materials and interlocking patterns to withstand the heavy truck traffic common to most alleys?	☐	☐	☐	
Geometry				
Is the minimum width of permeable pavement equal to one third of the alley width?	☐	☐	☐	
Is the permeable pavement the central flow line of the alley? *The longitudinal slope should match the alley's gradient.*	☐	☐	☐	
Other				
Was a soil investigation performed by a registered geologist, soil scientist, or professional engineer?	☐	☐	☐	
Were recommendations in a geotechnical report followed?	☐	☐	☐	
Is there positive drainage away from adjacent buildings at all locations?	☐	☐	☐	
Design Considerations				
Is the ratio of upstream impervious area to permeable pavement area 2:1 (as recommended in USDCM Volume 3)?	☐	☐	☐	
Is a perimeter barrier installed where appropriate and detailed in section based on permeable pavement type?	☐	☐	☐	
Does the design include an observation well to monitor drain time of the pavement system over time?	☐	☐	☐	

Underdrain System and Filter Material				
Does the facility design include an underdrain system (recommended)? *An underdrain system may be necessary if infiltration tests show percolation drawdown rates slower than two times the rate needed to drain the WQCV over 12 hours, or where required to divert water away from structures as determined by a professional engineer.*	☐	☐	☐	
Do all references to the underdrain clearly call for slotted pipe (not perforated) and are the slot widths included in the plan?	☐	☐	☐	
Are cleanouts provided to enable underdrain inspection and maintenance?	☐	☐	☐	
Is the underdrain system placed within a section of CDOT Class C filter material (not bioretention media) and is this material specified on the plans?	☐	☐	☐	
Do the plans specifically state that no geotextile fabric shall be placed between the underdrain and the filter material or between the filter material and the bioretention media?	☐	☐	☐	
Does the design section provide specific and appropriate filter layer details?	☐	☐	☐	
Impermeable Liners				
If a liner is required, are the following conditions met: • Is a 30 mil (minimum) PVC liner installed on the bottom and sides of the basin, extending up at least to the top of the underdrain layer?	☐	☐	☐	
• Does the liner have a minimum of 9 inches of cover over the membrane to protect the membrane from UV deterioration?	☐	☐	☐	
• Is the attachment of the liner to a solid reinforced concrete wall detailed on the plans?	☐	☐	☐	
• Do the plans call for heat welding and testing of all seams and specify to contact the engineer to be present during testing of all seams?	☐	☐	☐	
• Does the liner meet the physical requirements presented in Table B-5 of the USDCM Volume 3?	☐	☐	☐	
If a liner is not required, do subgrade soils have a minimum infiltration rate of 2 times the rate needed to drain the WQCV over 12 hours?	☐	☐	☐	

Additional Comments

Appendix D: Post-Construction Inspection Checklist for Green Infrastructure

PROJECT INFORMATION	Green Infrastructure Post-Construction Inspection Checklist
Project name:	**Inspection date:**
Site address:	**Weather at time of inspection (rainy, cloudy, sunny, etc.):**
Inspector(s):	**Date of last rainfall:**

Bioretention

Type(s) present: ☐ Streetside Stormwater Planter ☐ Bump-Out Stormwater Planter ☐ Green Gutter

Inspection summary:

Tree Trench/Tree Pit

Type(s) present: ☐ Tree Trench ☐ Tree Pit

Inspection summary:

Permeable Pavement (Green Alley)

Type(s) present:
☐ Permeable Interlocking Concrete Pavers (PICP) ☐ Porous Gravel
☐ Concrete Grid Pavement ☐ Reinforced Grass

Inspection summary:

BIORETENTION **Streetside Stormwater Planters, Bump-Out Stormwater Planters, and Green Gutters**				**Green Infrastructure Post-Construction Inspection Checklist**
Inspection Item	**Yes**	**No**	**N/A**	**Corrective action (if “no”)**
1. Will site runoff enter the practice as intended?	☐	☐	☐	
2. Will flow be evenly dispersed following the inlet? Are there signs of or potential for concentrated flow?	☐	☐	☐	
3. Is pretreatment in place according to construction drawings?	☐	☐	☐	
4. Do the bioretention dimensions match those specified in the construction drawings?	☐	☐	☐	
5. Are step-out zone dimensions (if applicable) according to plans?	☐	☐	☐	
6. Are pedestrian barriers in place and sized according to plans?	☐	☐	☐	
7. Are underdrains installed? If so, are the slots oriented and sized according to the plans?	☐	☐	☐	
8. If applicable, are underdrain cleanouts visible and sealed? If in a valve box, ensure filter material has also been placed between the valve box and cleanout.	☐	☐	☐	
9. If applicable, are cleanouts configured according to plans and located a maximum of every 300 feet? Are riser pipes solid (not slotted)?	☐	☐	☐	
10. Are walls and spillway constructed as planned?	☐	☐	☐	
11. Is the distance from the surface of the filter area to the outflow (spillway and top of the weir inside the water control structure) appropriate to provide the ponding depth per the construction drawing?	☐	☐	☐	
12. Is the outlet control weir set to the elevation shown on the construction drawings?	☐	☐	☐	
13. Does the bioretention media match the description of the media provided in the submittal?	☐	☐	☐	
14. Has the bioretention media infiltration rate been tested according to the plans and specifications? Verify infiltration rate test records.	☐	☐	☐	
15. If applicable, is mulch finely shredded hardwood and 3 inches in depth?	☐	☐	☐	
16. If plans include a liner, is it sufficiently covered by media and not visible?	☐	☐	☐	
17. If applicable, ensure weed barrier is not used under mulch or rock.	☐	☐	☐	
18. Is the vegetation the type, size, and maturity as specified in the plans? (e.g., grasses versus plantings, seed versus sod)	☐	☐	☐	
19. If sod is used, it is sand-grown sod?	☐	☐	☐	
20. Is the vegetation planted and staked properly according to the plans? (e.g., orientation, proximity, overall placement)	☐	☐	☐	
21. Does vegetation appear healthy?	☐	☐	☐	

TREE TRENCH/PIT				Green Infrastructure Post-Construction Inspection Checklist
Inspection Item	**Yes**	**No**	**N/A**	**Corrective action (if "no")**
1. Will site runoff enter the practice as intended?	☐	☐	☐	
2. Is pretreatment filter in place according to construction drawings? Is there at least 6 inches of fall from the invert of the chase to the top of the aggregate?	☐	☐	☐	
3. Do dimensions of the tree trench/tree pit match those specified in the construction drawings?	☐	☐	☐	
4. Are step-out zone dimensions according to plans?	☐	☐	☐	
5. Are underdrains installed? If so, are the slots oriented and sized according to the plans?	☐	☐	☐	
6. If applicable, are underdrain cleanouts visible and sealed? If in a valve box, ensure filter material has also been placed between the valve box and cleanout.	☐	☐	☐	
7. If applicable, are cleanouts configured according to plans and located a maximum of every 300 feet, with cleanouts at every junction and bend in the pipe? Are riser pipes solid (not slotted)?	☐	☐	☐	
8. Is the distance from the surface of the tree area (filter area) to the tree gate as specified in the plans?	☐	☐	☐	
9. Is the outlet control weir set to the elevation shown on the construction drawings?	☐	☐	☐	
10. Does the bioretention media match the description of the media provided in the submittal?	☐	☐	☐	
11. Has the bioretention media infiltration rate been tested according to the plans and specifications? Verify infiltration rate test records.	☐	☐	☐	
12. If applicable, is mulch finely shredded hardwood and 3 inches in depth?	☐	☐	☐	
13. If plans include a liner, is it sufficiently covered by media and not visible?	☐	☐	☐	
14. If applicable, ensure weed barrier is not used under mulch or rock.	☐	☐	☐	
15. Is the tree type, size, and maturity as specified in the plans?	☐	☐	☐	
16. If multiple trees, are the trees spaced according to the plans?	☐	☐	☐	
17. Does the tree(s) appear healthy?	☐	☐	☐	

PERMEABLE PAVEMENT
Green Alley

Green Infrastructure Post-Construction Inspection Checklist

	Inspection Item	Yes	No	N/A	Corrective action (if "no")
Common Elements	1. Does the alley drainage area appear to drain centrally towards the permeable pavement (away from buildings)?	☐	☐	☐	
	2. Is the width of the permeable pavement as specified in the plans?	☐	☐	☐	
	3. Is the surface even with no evidence of cracks or depressions?	☐	☐	☐	
	4. Is the storage or structural layer firm and unyielding?	☐	☐	☐	
	5. Is a transition strip of standard concrete provided at all transitions from asphalt to permeable pavement unless otherwise specified in the plans?	☐	☐	☐	
	6. Are underdrains installed? If so, are the slots oriented and sized according to the plans?	☐	☐	☐	
	7. If applicable, are underdrain cleanouts visible and sealed? If in a valve box, ensure filter material has also been placed between the valve box and cleanout.	☐	☐	☐	
	8. If applicable, are cleanouts configured according to plans and located a maximum of every 300 feet, with cleanouts at every junction and bend in the pipe? Are riser pipes solid (not slotted)?	☐	☐	☐	
	9. Is the outlet constructed per construction drawings?				
Permeable Interlocking Concrete Pavers (PICP)	1. Is a leveling layer of washed No. 8 stone included between the structural layer and the permeable interlocking concrete paver?	☐	☐	☐	
	2. Are all voids filled with washed No. 8 stone to the surface of the interlocking concrete paver?	☐	☐	☐	
	3. Is the pavement surface firm and unyielding?	☐	☐	☐	
	4. If for vehicular use, is the outer edge of PICP area bordered by concrete, and are uncut blocks used adjacent to the concrete border?	☐	☐	☐	
	5. Are cut pavers at least 40% of their uncut size?	☐	☐	☐	
	6. Is a herringbone pattern used for PICP areas intended for vehicular traffic?	☐	☐	☐	
Concrete Grid Pavers	1. Is the outer edge of the paver area bordered by concrete?	☐	☐	☐	
	2. If uncut blocks are used, are they adjacent to the concrete border?	☐	☐	☐	
	3. If visible, does the bedding layer consist of No. 8 stone unless otherwise specified in the plans?	☐	☐	☐	
	4. If vegetation is specified, is the grid paver filled with a soil media or seeded according to the plan?	☐	☐	☐	

Appendix E: Maintenance Checklist for Green Infrastructure

GREEN INFRASTRUCTURE	**Ongoing Maintenance Inspection Checklist**
Facility Information	
Property owner:	**Inspection date:**
Property address:	**Inspection type:** ☐ After first rainfall event of season ☐ Monthly (during wet season) ☐ Other: ______________________
Inspector(s):	

Bioretention			
Type(s) present:	☐ Streetside Stormwater Planter	☐ Bump-Out Stormwater Planter	☐ Green Gutter
Post-inspection summary:			

Tree Trench/Tree Pit		
Type(s) present:	☐ Tree Trench	☐ Tree Pit
Post-inspection summary:		

Permeable Pavement (Green Alley)		
Type(s) present:	☐ Permeable Interlocking Concrete Pavers (PICP) ☐ Concrete Grid Pavement	☐ Porous Gravel ☐ Reinforced Grass
Post-inspection summary:		

Additional Notes

BIORETENTION			**Streetside Stormwater Planter, Bump-Out Stormwater Planter, Green Gutter**
Defect and Conditions Indicating Maintenance is Needed	**Maintenance Needed?**		**Results Expected When Maintenance is Performed**
	Y/N	**Comments**	
1. Standing water Water ponds in the bioretention area between storms and does not drain within 24 hours after rainfall.			There should be no areas of standing water once inflow has ceased. This is typically an issue of sediment or debris accumulation on top of the media or when flow to the underdrain is inhibited.
2. Sediment Evidence of accumulated sediment in the bioretention area or forebay.			Forebay should be cleaned out regularly so that material does not accumulate in the forebay or bioretention area.
3. Erosion Channels have formed around inlets, there are areas of bare soil, or there is other evidence of erosion.			Obstructions and sediment should be removed and disposed of properly so that water flows freely and disperses evenly.
4. Debris and litter Debris and litter accumulated in the bioretention area and around the inlet and outlet.			Debris and litter removed from the bioretention area and disposed of properly.
5. Vegetation Vegetation is dead, diseased or overgrown.			Vegetation is healthy and attractive. If applicable, grass is maintained at least 3 inches in height.
Vegetation is maintained and clear of leafy debris.			Bioretention area should be clear of leafy debris (dead leaves and plant matter) and trimmed, as needed. Leafy debris (litter) will require removal each fall (October). Perennials and grasses require cutting in late winter/early spring (March).
Soils have sufficient moisture to support growth during the growing season (March – October).			Based on plant type, soil moisture should be sufficient for healthy plant growth. Soil moisture should be inspected as needed throughout the growing season (March – October).
Prevalent weeds.			Weeds need to be extracted and physically removed (not sprayed or pulled and left to wither) to prevent deep rooted infestations (monthly).
6. Mulch (if applicable) Mulch is displaced, missing or patchy. Areas of bare earth are exposed or mulch layer is less than 3 inches deep. Mulch is clogging the overflow or in the gutter.			All bare earth is covered, except mulch is kept 6 inches away from trunks of trees and shrubs. Mulch is even at a depth of 3 inches. Upon inspection, if vegetation is healthy without mulch, mulch may be removed as it may not be necessary.
7. Inlet/outlet Sediment accumulations.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
8. Other Any condition not covered above that needs attention for the bioretention area to function as designed. Any impairment of surrounding structures (e.g., buildings, pavement) as a result of poor drainage or uprooting.			The design specifications are met and no effects on surrounding structures.

Describe maintenance that was completed; if the needed maintenance was not conducted, note when it will be done.

Notes:

TREE TRENCH/TREE PIT			
Defect and Conditions Indicating Maintenance is Needed	Maintenance Needed?		Results Expected When Maintenance is Performed
	Y/N	Comments	
1. Standing water Water in the observation well under the tree grate does not drain within 24 hours after rainfall.			Water should not remain stagnant in the observation well under the tree grate beyond 24 hours after a rainfall. There should also be no areas of standing water in the forebay. Standing water is typically an issue of clogging in the forebay or poor flow through the system underdrain.
2. Debris and litter Debris and litter accumulated in tree area and around the inlet and outlet.			Debris and litter should be removed from the tree area and disposed of properly.
3. Sediment Slow drainage in the forebay indicating that the stone is clogged with sediment.			Forebay should be cleaned out regularly so that material does not accumulate in the stone. Forebay should be vacuumed about monthly during the wet season, and replacement of material can be expected every 2–3 years.
4. Tree Tree is dead, diseased or unkempt. Are there dead tree limbs, odd colors on leaves or bark, or trunk damage?			Tree maintenance (e.g., pruning) may be required on a regular basis in early years based on tree type.
Prevalent weeds.			Weeds need to be extracted and physically removed (not sprayed or pulled and left to wither) to prevent deep rooted infestations (monthly).
5. Inlet/outlet Slow drainage due to sediment accumulation.			Inlet/outlet is clear of sediment and debris and allows water to flow freely.
6. Other Any condition not covered above that needs attention for the tree trench/pit to function as designed. Any impairment of surrounding structures (e.g., buildings, pavement) as a result of poor drainage or tree uprooting.			The design specifications are met and no effects on surrounding structures.
Describe maintenance that was completed; if the needed maintenance was not conducted, note when it will be done.			

TREE TRENCH/TREE PIT

Notes:

PERMEABLE PAVEMENT			PICP, Concrete Grid Pavement, Porous Gravel, Reinforced Grass
Defect and Conditions Indicating Maintenance is Needed	Maintenance Needed?		Results Expected When Maintenance is Performed
	Y/N	Comments	
1. Standing water Water ponds or runs off of the surface. Areas of ponding can be observed during snow melt.			There should be no areas of ponded/standing water during snow melt. This is typically a result of poor maintenance; restoration may be required.
2. Debris and litter Leaves, grass clippings, trash, etc., are preventing water from draining into the permeable pavement and are unsightly.			Area is free of all debris and the permeable pavement is draining properly.
3. Vegetation Weeds are growing on the surface of the permeable pavement.			Area adjacent to pavement is well-maintained and no bare soil/exposed areas exist. No weeds present in the pavement area.
4. Deteriorating surface The pavement is cracked; paver blocks are misaligned or have settled.			The surface area is stabilized, exhibiting no signs of cracks or uneven areas in the pavement area.
5. Other Any condition not covered above that needs attention for the permeable pavement area to function as designed.			The design specifications are met.

Describe maintenance that was completed; if the needed maintenance was not conducted, note when it will be done.

Notes: