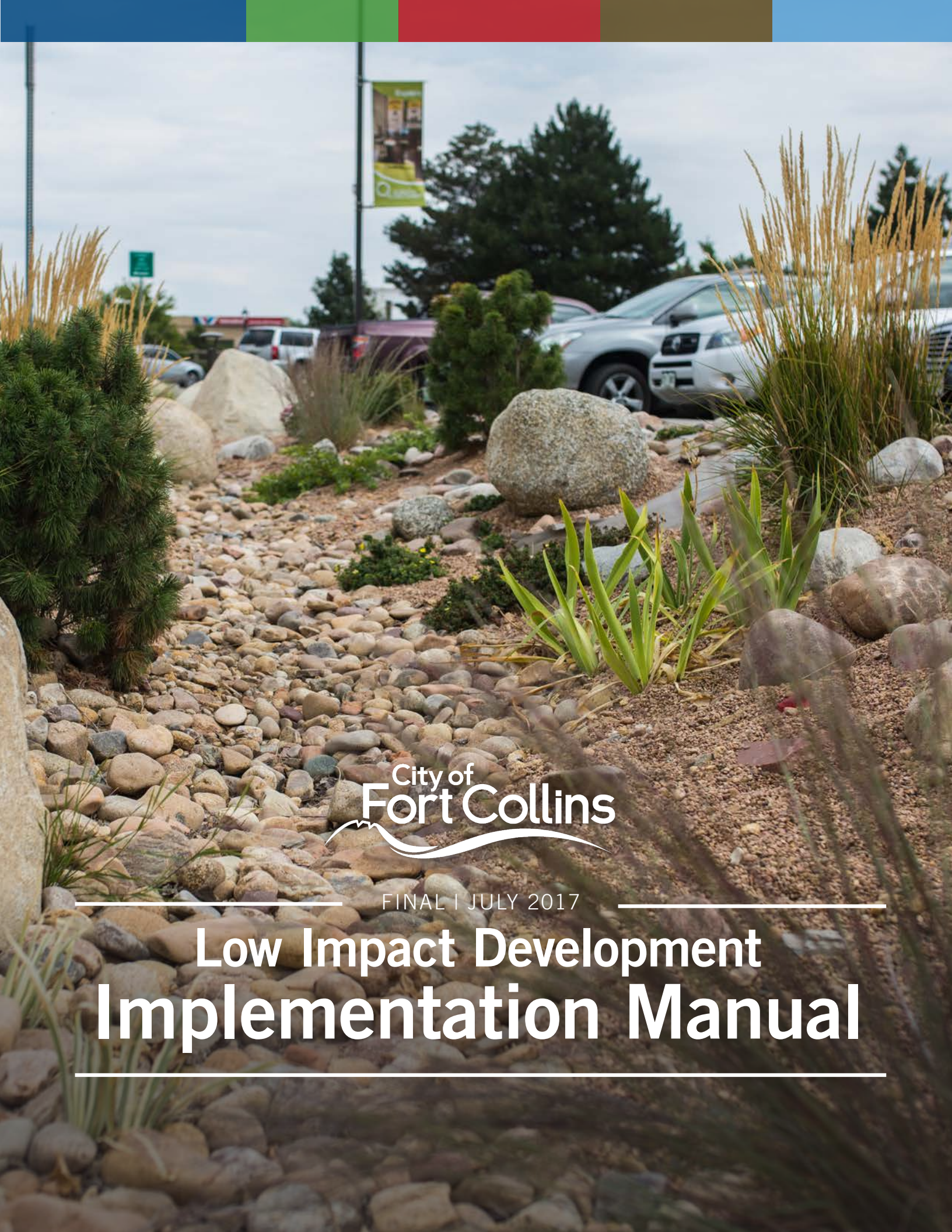
Appendix C:
LID Implementation Manual



City of Fort Collins

FINAL | JULY 2017

Low Impact Development Implementation Manual

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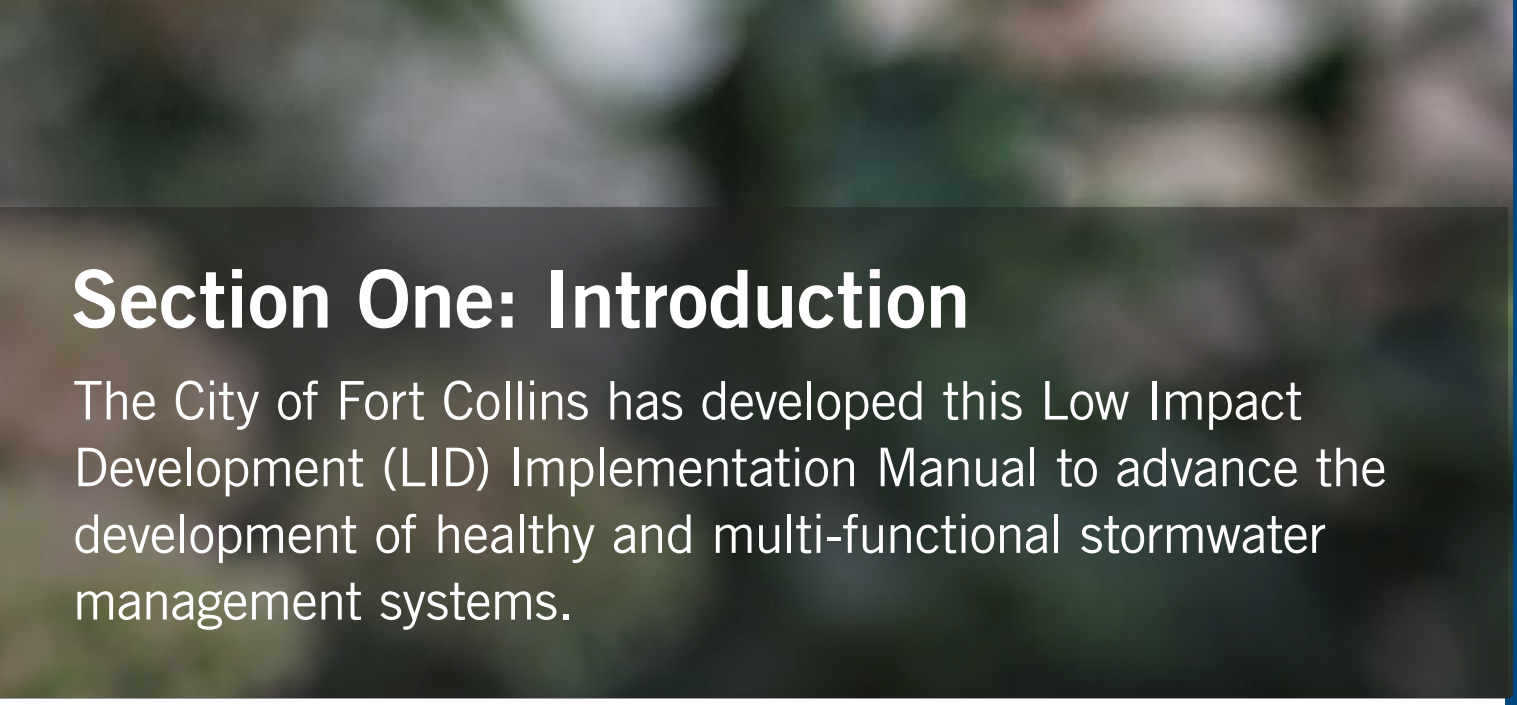
Table of Contents

City of Fort Collins

1



Section One: Introduction

The City of Fort Collins has developed this Low Impact Development (LID) Implementation Manual to advance the development of healthy and multi-functional stormwater management systems.

Purpose

Low Impact Development (LID) in stormwater management is used to restore the natural relationships of water, soil and vegetation, minimizing and mitigating the impacts of development on watershed resources. LID practices, sometimes referred to as Green Infrastructure (GI), manage and treat stormwater in a distributed manner at a site scale near areas where rain falls.

Our City is anticipating an increasing population, up to 250,000 by 2040, resulting in increased urbanization, development and redevelopment. Traditionally these activities increase the amount of impervious surfaces and reduce the ability of natural systems to maintain local and historical water patterns. To that end, Fort Collins and other communities are increasingly turning to LID practices to help maintain, restore and rehabilitate watershed services. The Fort Collins Low Impact Development Implementation Manual is intended to be a practical resource for planners, developers, homeowners, design professionals and community groups that will be designing, installing and maintaining LID facilities at the site scale.

In February 2013, Fort Collins City Council adopted Ordinance No. 152, 2012, amending Chapter 26 of the Municipal Code to incorporate provisions implementing LID principles. The goal is to declare that the purpose of the City Stormwater Utility is to provide an integrated, sustainable stormwater management program that reflects the community's values of protecting and restoring the City's watersheds.

Click to see full text of the updated 2016 Ordinance 007, 2016.

As stormwater crosses both jurisdictional and property boundaries, the City of Fort Collins is creating a unified community throughout the watershed by making stormwater treatment an accessible strategy for each citizen. The intent of this manual is to guide professional designers and citizens in the development and preservation of a healthy environment and ecosystem that promotes a vibrant community.

Multiple Goals with a Single Investment: The Many Benefits of LID

LID principles and practices are truly synergistic in their approach. They provide multiple benefits on a personal, societal, and ecological level. For example, landscapes that use LID practices can incorporate stormwater management as part of a site's open space and amenity areas, helping to meet code requirements, reduce greenhouse gases, provide shade and beauty, create habitat corridors for local wildlife, improve water quality, and protect streams and creeks from erosion.

Additional information about the benefits of LID can be viewed at The City of Fort Collins Storm Water Quality page. Watch a video example about how LID practices work at Library Park.

HUMAN HEALTH & WELLBEING

- Provides places of aesthetic beauty for personal and community enjoyment
- Improves public health by enhancing water quality and reducing pollutants
- Encourages pedestrian activity

SOCIETY & THE ECONOMY

- Design with visibility and ease of inspection as a goal
- Increases property values through enhanced community green space and attracts investment
- Improves aesthetics
- Benefits developers by meeting multiple code requirements
- Provides green jobs

NATURE & THE ENVIRONMENT

- Treats water at the source with less energy inputs
- Improves water quality and availability (recharging our aquifers, lakes, and rivers)
- Supports biodiversity and creates natural habitats within city proximity
- Minimizes pollution runoff
- Reduces irrigation consumption

RESILIENCY & REDUCTION OF EXTREME IMPACTS FROM CLIMATE CHANGE

- May provide relief from localized flooding
- Reduces the effect of heat island
- Cools ambient air temperature

The Water Cycle

Rain that falls on undisturbed, vegetated areas is soaked up into plants and soil; this water recharges underground aquifers, creeks, rivers, and lakes, creating natural and ecologic benefits. When development activities result in portions of the watershed being turned into impervious surfaces, less water is absorbed into the ground or evaporates. Instead rainfall is converted into runoff. This system-wide response to rainfall events contributes to increased flooding, erosion and less water in aquifers. Stormwater runoff can also collect pollutants such as pet waste, oil, fertilizers, dissolved metals and sand that not only harms aquatic habitats, it also impairs the beneficial uses of riparian corridors, rivers, streams and other water bodies.

A thorough technical explanation of the interconnectedness of development and watershed resources can be found in Volume 3 of the Urban Drainage and Flood Control District (UDFCD) Stormwater Criteria Manual and in the Fort Collins Stormwater Criteria Manual. The UDFCD Stormwater Criteria Manual also describes some of the historical challenges of trying to manage stormwater without applying LID principles.

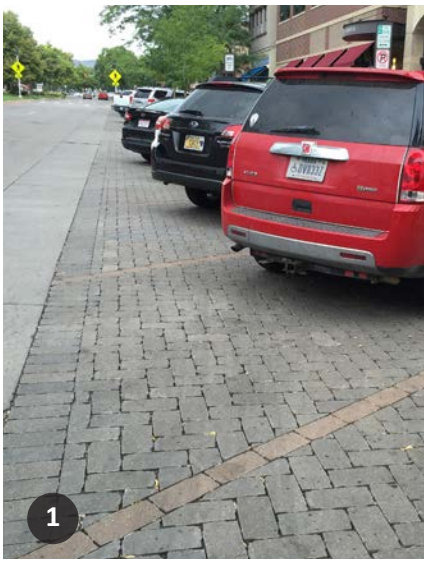
Development Review Process

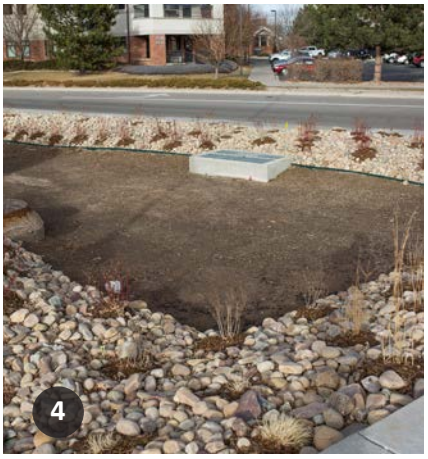
In accordance with the Land Use Code, all development and redevelopment projects are required to use LID Best Management Practices (BMPs) to manage a percentage of impervious surface runoff. Detailed LID criteria are incorporated in Chapter 7 of the Fort Collins Stormwater Criteria Manual. All of the LID BMPs described in this manual - with the exception of non-engineered rain gardens - may be used to meet the LID Criteria. The details and design considerations provided in this manual are intended to assist permit applicants develop complete plans for permit review. Additional information about how to document compliance with LID criteria is provided in Chapter 7.

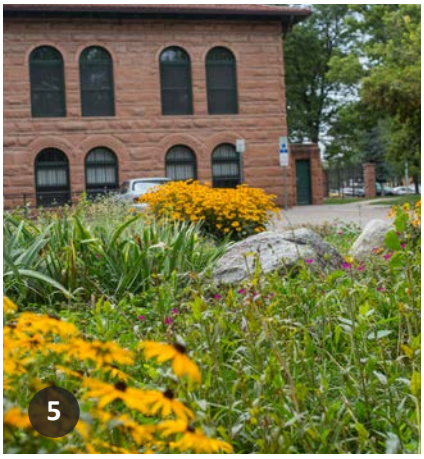
Public improvement projects within the rights-of-way are not covered under the LID ordinance. LID is encouraged when feasible for these projects, but not required.

LID Practices

1. Permeable Pavement
2. Bioretention / Bioswales
3. Vegetated Buffer
4. Sand Filter
5. Rain Garden
6. Underground Infiltration
7. Tree Filter
8. Constructed Wetland Channel
9. Constructed Wetland Pond







Commitment to Sustainability

Our City is a national leader in achieving sustainable development. It engages every City department and the philosophy is enumerated in a range of City plans, from Transportation to Nature in the City. In previous plans, the City identified the community values and critical issues for building a framework that combines traditional planning principles and land development practices through planning directives and a community vision.

The Fort Collins City Council has charged the Utilities department with the following Stormwater Purpose Statement:

"The City Council hereby finds, determines and declares the City's integrated stormwater management program is for the mutual economic, social and environmental benefits of public safety, flood mitigation, water quality and public welfare while protecting natural areas and their features, protecting and restoring the City's watersheds, its tributaries and the Cache la Poudre River."

How to Use the LID Implementation Manual

The LID Implementation Manual is organized into four sections. This document is best viewed electronically with quick links to additional information.

SECTION 1: INTRODUCTION

Section 1 is an overview of LID and this manual.

SECTION 2: LID APPLICABILITY

Section 2 is an illustrative table of contents. The illustrations show how BMPs can be incorporated in projects with various land uses. Links embedded in the illustrations can be used to jump to BMP fact sheets for additional information.

SECTION 3: LID BMP FACT SHEETS

Section 3 provides detailed information on each BMP. Each BMP fact sheet includes planning, design, construction and maintenance considerations. The fact sheets provide links to permitting and regulatory compliance including references to the Fort Collins Stormwater Criteria Manual and other City of Fort Collins standards. Typical details are provided as a reference for designers developing construction documents.

SECTION 4: DESIGN APPROACH

Section 4 provides a guide for planning and design of LID practices. This section is intended to be a reference for those who are new to LID practices.

SECTION 5: APPENDICES

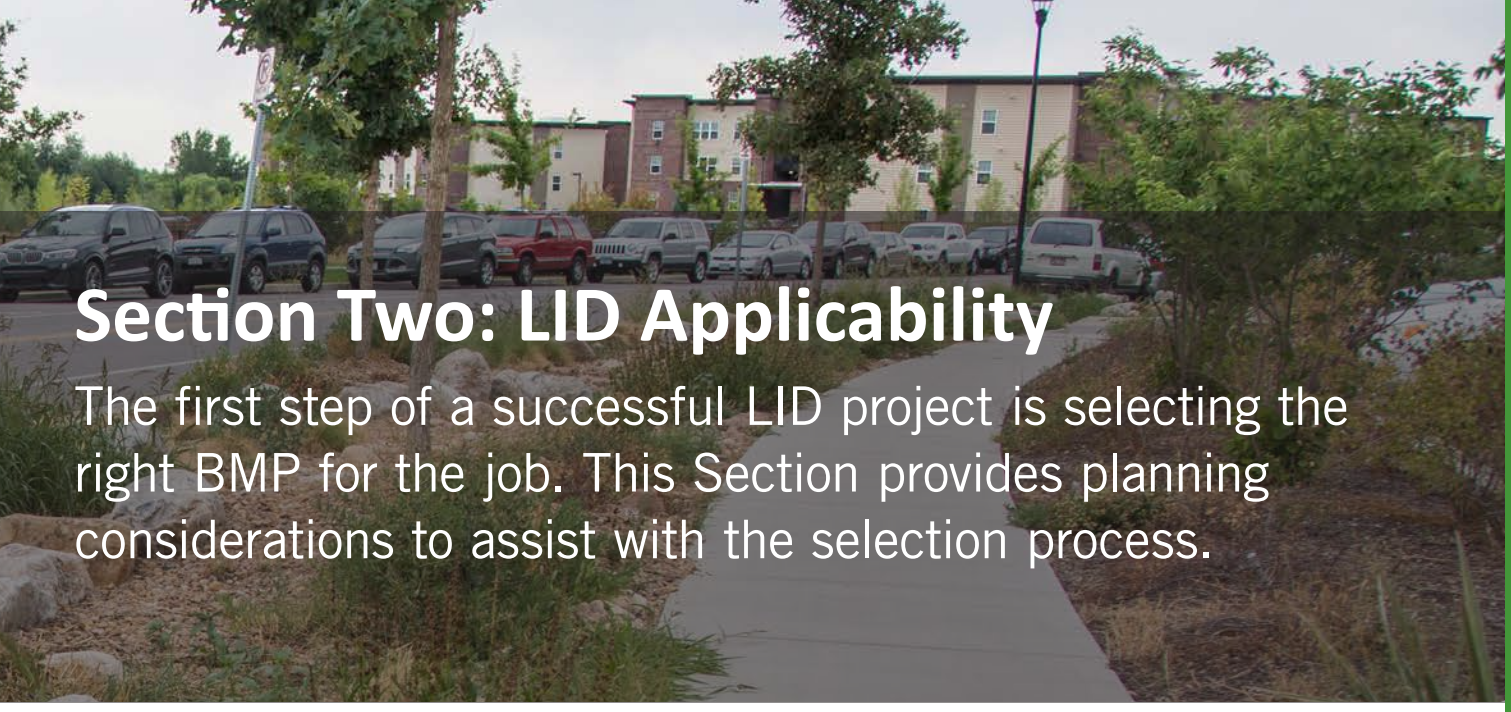
Section 5 provides additional resources.

The LID Implementation Manual is designed to be updated periodically to reflect results from ongoing research and on-the-ground experience.

What strategies can I use to make my LID attractive and welcoming?

City of Fort Collins

2



Section Two: LID Applicability

The first step of a successful LID project is selecting the right BMP for the job. This Section provides planning considerations to assist with the selection process.

Site Planning Considerations

Special consideration in the planning stage is critical for the success of LID projects. LID projects often require a more holistic design effort that responds to the site's natural features, soil and subsurface conditions, integrating all aspects of the project early in the design phase.

Explicit understanding of surface and subsurface soil conditions of the site and surrounding area is critical to the process. A reliable and accurate base map is also necessary.

LID PRINCIPLES

The City of Fort Collins encourages designers, developers, and anyone using this Manual to regard it as a starting point for creatively developing solutions to a wide variety of stormwater management challenges. There is no one solution to mitigate the impacts of stormwater on developed land. However, a core set of principles can guide everyone from the engineer to the homeowner on how a successful LID design can be incorporated into a development plan or retrofitted into an existing site.

These principles include:

- Conserve Resources
- Minimize Impact and Use Site Topography
- Maximize Water Infiltration
- Create Areas for Local Storage and Treatment
- Build Capacity for Maintenance

The project constraints and development site elements can be thoughtfully delineated to optimize as many of these principles as possible.

Considerations for Designing and Implementing LID Facilities

The following items should be considered early to promote project success and reduce conflicts during detailed design.

Topography and Hydrology

- Fitting the development into the existing topography
- Existing drainage patterns
- Upstream and downstream conditions
- Groundwater conditions

Soils

- Early soils investigation
- Stormwater facility estimate during feasibility analysis
- Soil infiltration capacity
- Minimize soil disturbance (cut and fill areas)

Climate

- Extended dry periods
- Intense rain events
- Snow Storage
- Annual Precipitation

Vegetation & Habitat

- Protection of exceptional vegetation and habitat
- Protected areas for flow dispersion
- Protection of trees

Utilities

- Location of any utilities and future needs
- Connection to existing stormwater infrastructure

Surrounding Land Use

- Match the character of surrounding land uses and subsurface soil conditions

Access

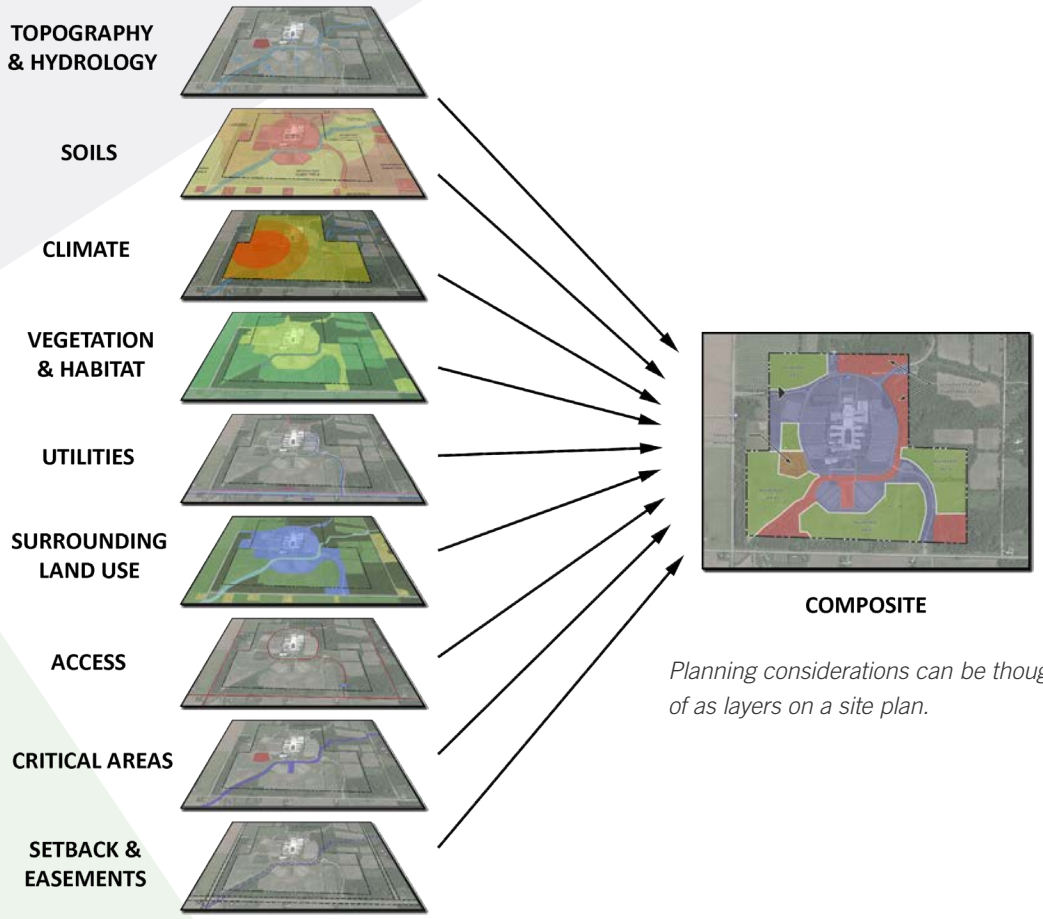
- Accessibility for inspection and maintenance
- Accessibility for users

Critical Areas

- Wetlands or steep slopes that may require setbacks
- Flood plains and riparian areas

Setbacks and Easements

- Building and property line setback requirements
- Easements



Planning considerations can be thought of as layers on a site plan.

LID Applicability Matrix

Each site is unique in both its natural characteristics and its programming needs for development. Different LID BMPs will apply for each site. The table below breakdowns the various land uses and indicates if each BMP is typically applicable or not applicable. Applicability for a specific project may vary based on site conditions.

The City of Fort Collins encourages innovative design and regular collaboration between developer, design team and the City to develop the most efficient and effective solutions.

LID APPLICABILITY MATRIX TABLE	PERMEABLE PAVEMENT	BIORETENTION	SAND FILTER	TREE FILTER	UNDERGROUND INFILTRATION	NON-ENGINEERED RAIN GARDEN	VEGETATED BUFFER	CONSTRUCTED WETLAND CHANNEL	CONSTRUCTED WETLAND POND
Right-of-Way – Arterial Street*		$$		$$$					
Right-of-Way – Non-Arterial Street*	$$$	$$		$$$					
High Density	$$$			$$$	$$$				
Medium Density	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$
Low Density	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$
Single Family Residential Development	$$$	$$	$$	$$$	$$$	$	$	$$$	$$$

$-$$$ Indicates relative construction cost. Does not include site specific considerations such as land value and maintenance.
** Applicability of BMPs within the rights-of-way shall be approved by the engineering department.*
*** Within parking lanes along non-arterial streets only.*

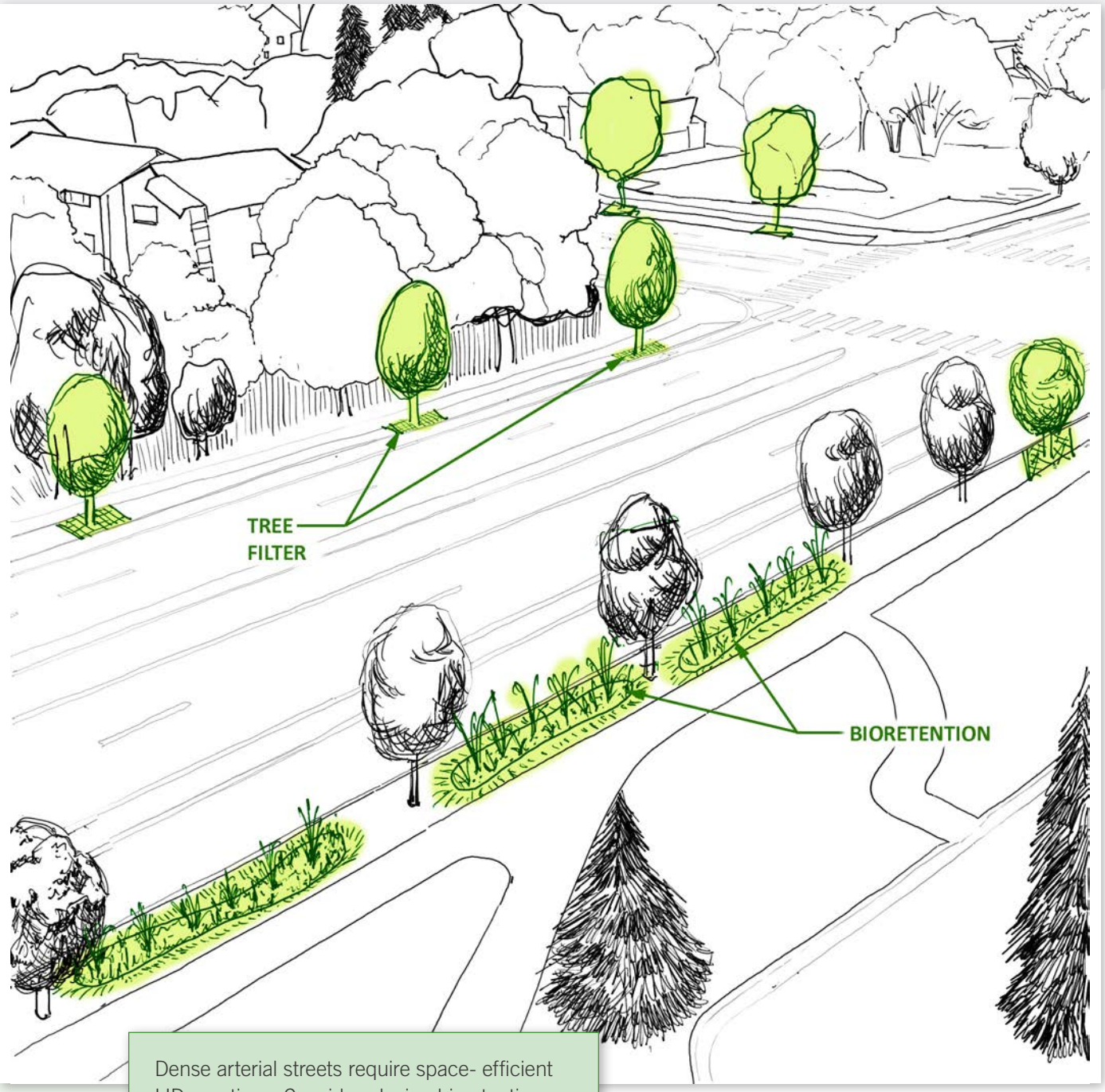
Land Use Illustrative Examples

The following pages show how land use Illustratives can be applied.

1. Right-of-Way – Arterial Street
2. Right-of-Way – Non-Arterial Street
3. High Density
4. Medium Density
5. Low Density
6. Single Family Residential Development

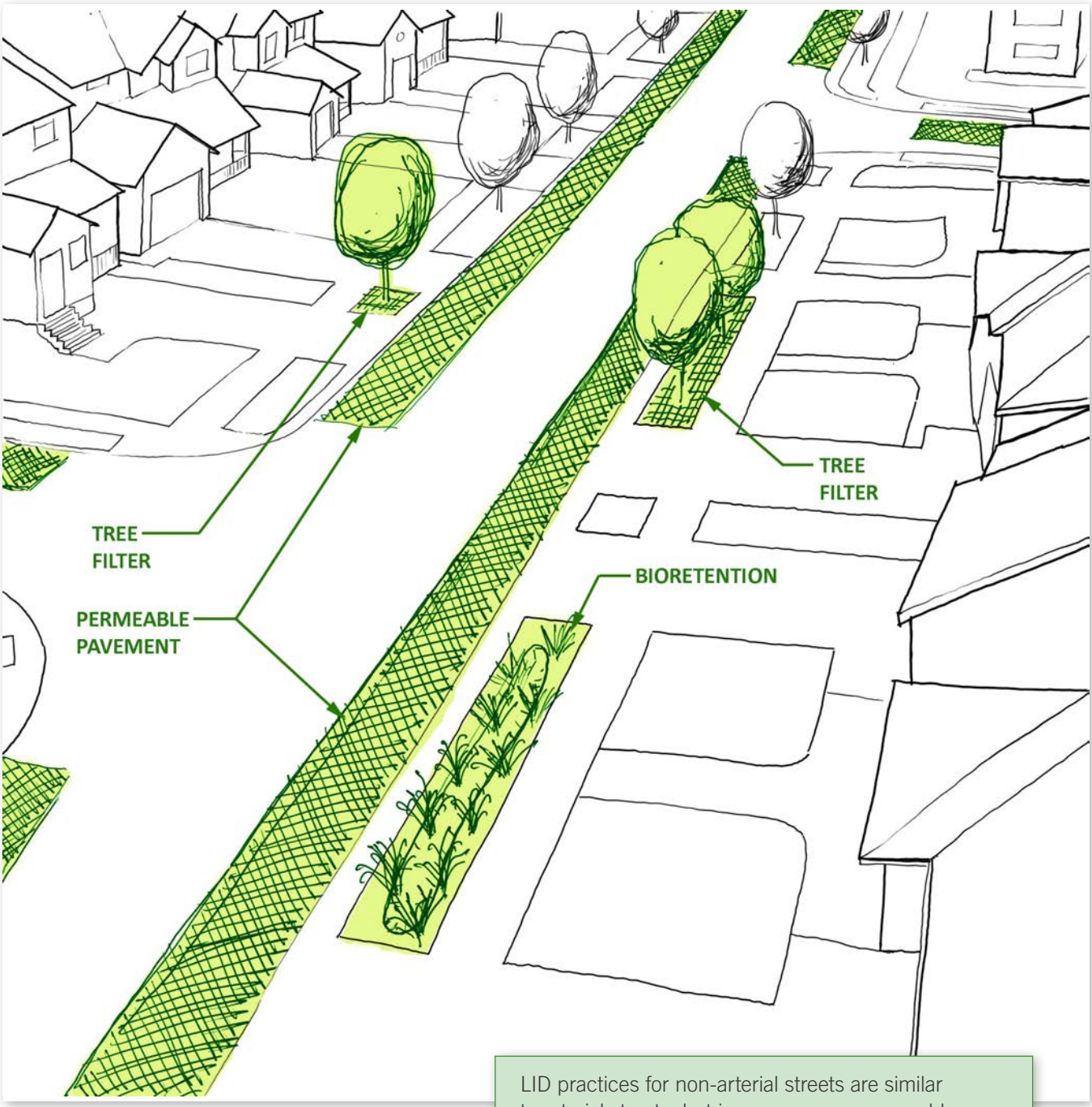
Land Use Illustrative Examples

Right-of-Way – Arterial Street



Dense arterial streets require space- efficient LID practices. Consider placing bioretention between trees and using tree filters where parkways are paved.

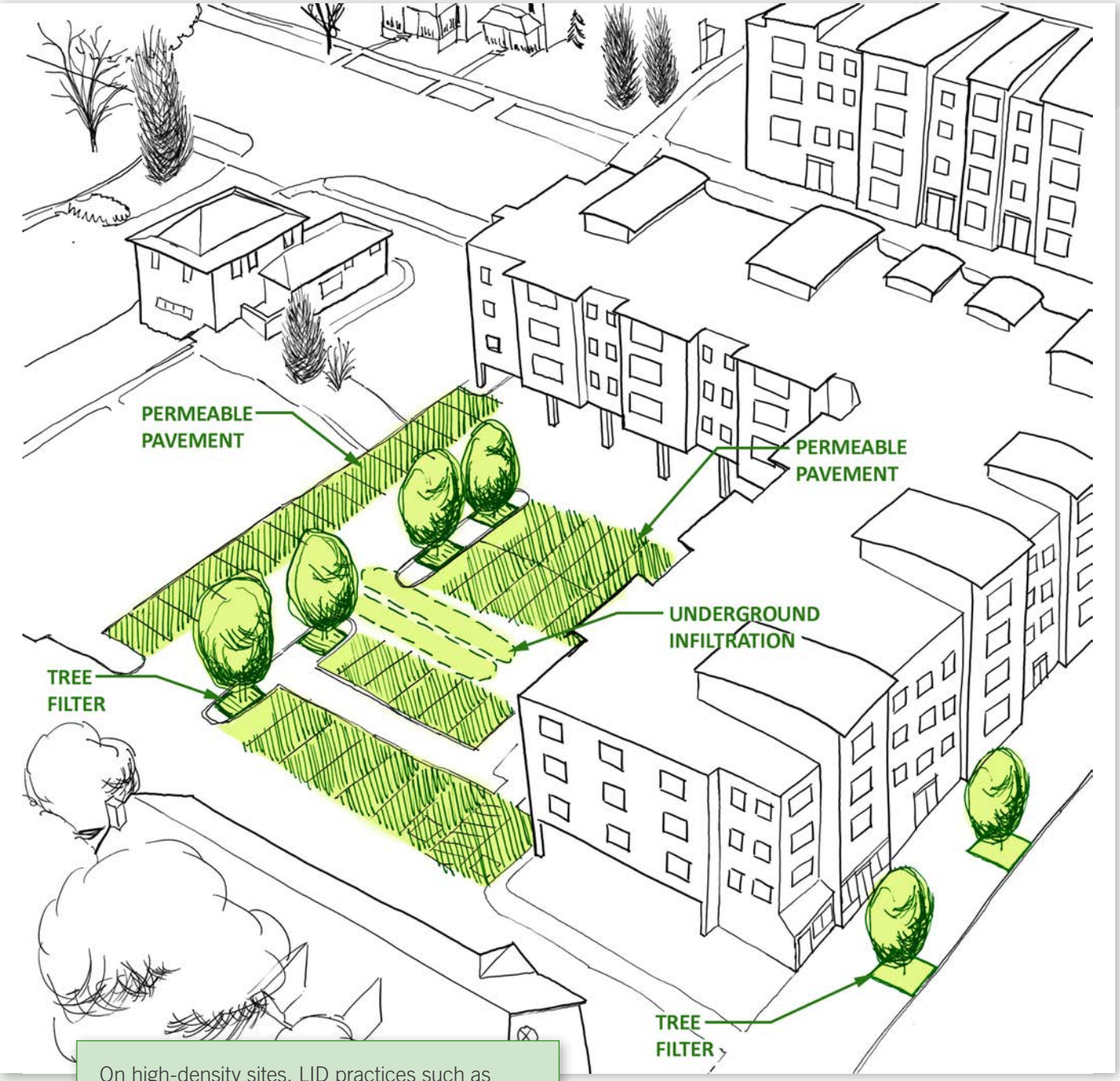
Right-of-Way – Non-Arterial Street



LID practices for non-arterial streets are similar to arterial streets, but in some cases, permeable pavement may be used in the parking lane. Coordinate with the Engineering Department early on to determine which LID practices are applicable for your project.

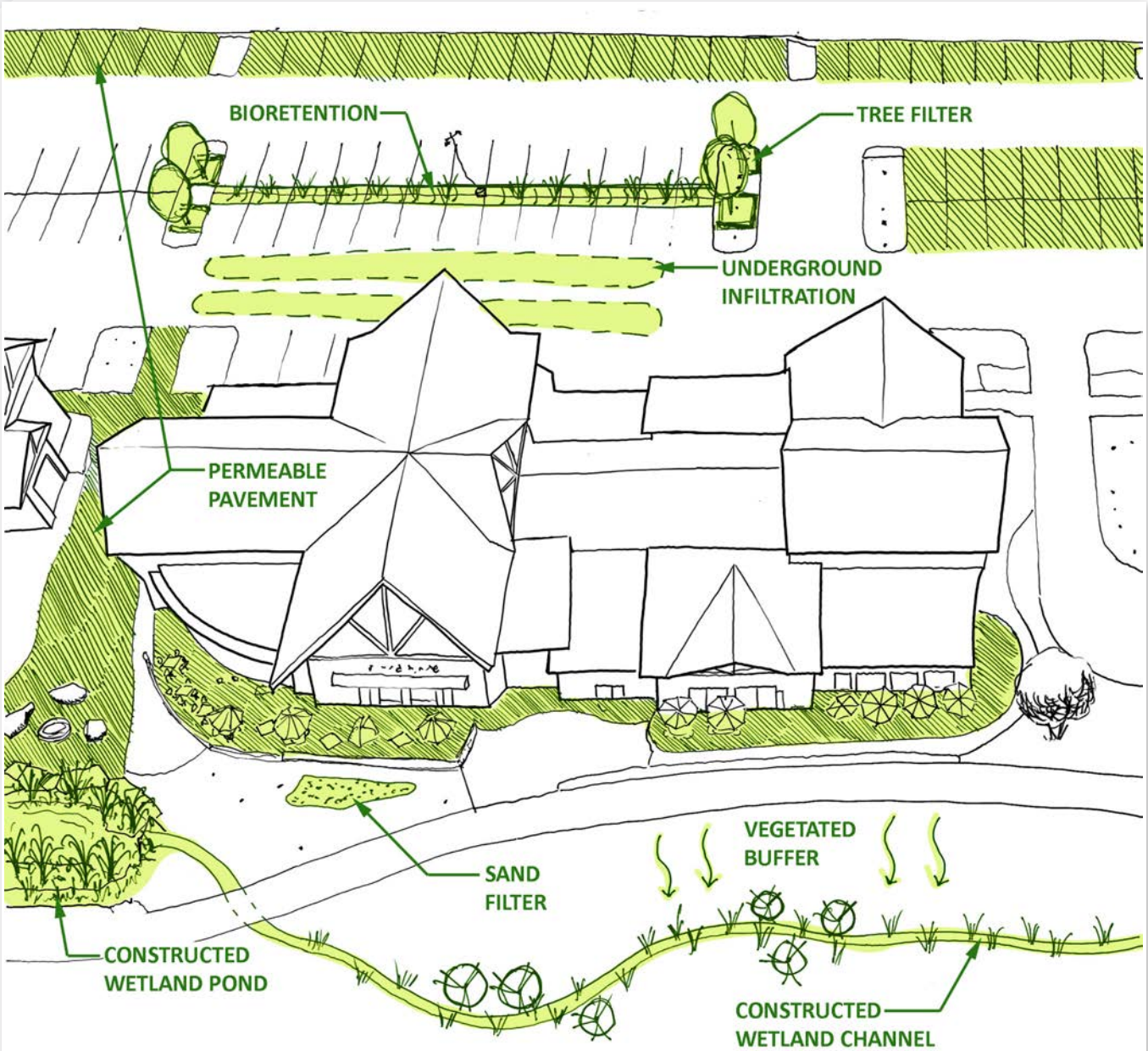
Land Use Illustrative Examples, *continued*

High Density



On high-density sites, LID practices such as underground infiltration allow for infiltration while also providing build over for pavement areas.

Medium Density



Medium-density sites have more options when selecting LID practices. Developing the stormwater plan will involve consideration of which LID practices will match the site use and context.

Land Use Illustrative Examples, *continued*

Low Density

On low density sites, stormwater management can truly became an integrated part of the site design. Stormwater facilities can be almost imperceptible when not storing water.

Single Family Residential Development

For single family residential development LID practices are located in shared tracts which can be maintained by a Home Owners Association, taking responsibility off individual property owners.

3

Section Three: LID BMP Fact Sheets

Each of the following fact sheets provides an overview of an LID BMP, facilitating easy comparisons of how each BMP works. The information and typical details are provided to assist with final design and planning for maintenance.

LID Best Management Practices

People involved in project implementation use a variety of specific tools to meet development requirements using LID principles. These tools are referred to as LID Best Management Practices (BMP). LID is focused on picking the right tools for the project and designing based on site context. With proper planning, analysis, design and construction, the LID BMPs described in this manual may be used to meet City of Fort Collins' LID criteria and stormwater criteria.

Two categories of LID BMPs may be used to meet the LID criteria: 1) Conveyance BMPs, which convey runoff across a Receiving Pervious Area and reduce the Water Quality Capture Volume and 2) Storage BMPs, which provide detention of the Water Quality Capture Volume. Combinations of multiple BMPs are encouraged.

LID CONVEYANCE BMPS:

- Vegetated Buffer
- Constructed Wetland Channel
- Green Roof *

** BMP Fact Sheet is not provided in this manual, refer to UDFCD Stormwater Criteria Manual.*

LID STORAGE BMPS:

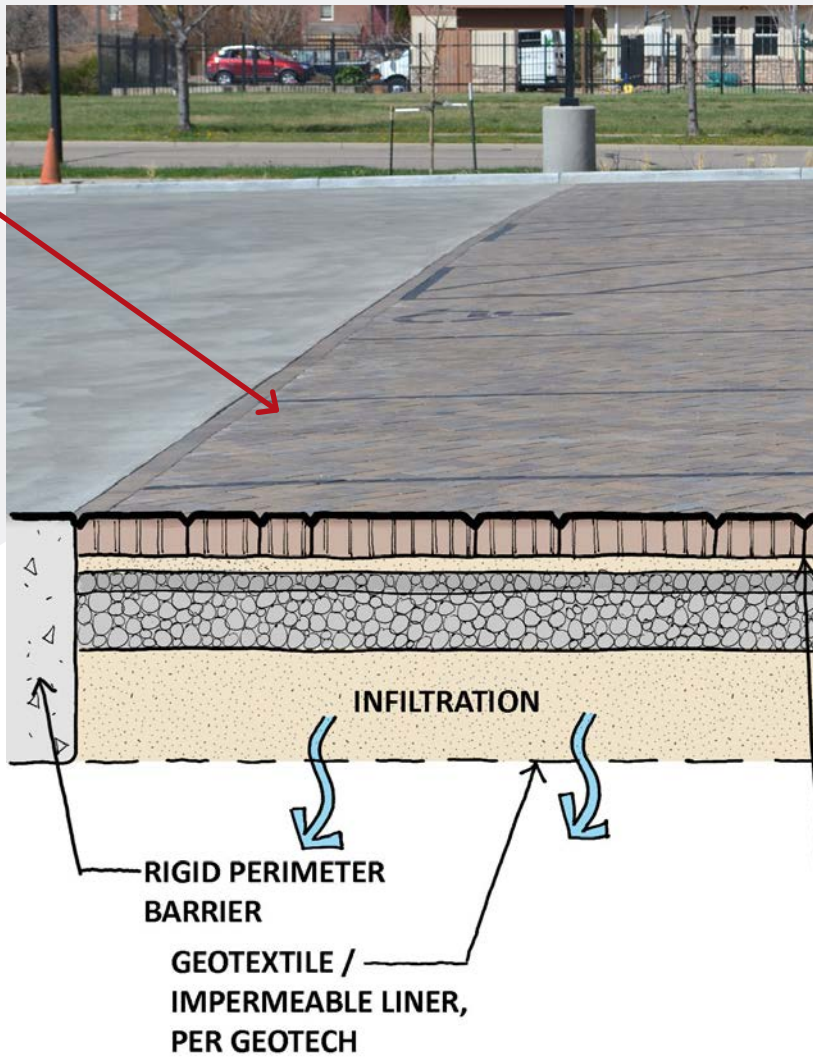
- Permeable Pavement
- Bioretention
- Sand Filter
- Tree Filter
- Underground Infiltration

Permeable Pavement

This space-saving BMP can be used for walking or driving surfaces just like concrete or asphalt pavement. Porosity in the area between pavers allows rain water to flow into a subsurface storage layer for treatment and infiltration. Set your permeable pavements up for success by limiting sources of sediment. The following permeable pavements are not currently accepted by the City of Fort Collins: porous concrete, porous asphalt.

COST AND BENEFIT CONSIDERATIONS

- **Provides durable surface and stormwater benefit in the same footprint.**
- Permeable pavements can be intermixed with different colored pavers to create varied and interesting paving patterns.
- With proper design, installation and maintenance, permeable pavements match or exceed conventional pavement life.
- Reduces sound and splash, particularly from wet weather driving, compared to concrete pavement.



MAINTENANCE CONSIDERATIONS

- Do not sand permeable pavements or areas that run on to permeable pavements.
- Permeable pavements typically accumulate less snow and melt faster but de-icers are discouraged because they are less effective since they will not stay on the surface.
- Plan for semi-annual pavement vaccuming regeneration. More frequent maintenance may be required for high use sites.
- Regularly remove debris from the pavement surface before it breaks down.
- Identify and eliminate sediment sources.
- Pavers may be salvaged and reused for utility work.
- **Plan for redistribution of aggregates when using grid pavements.**
- Provide observation ports for inspections.

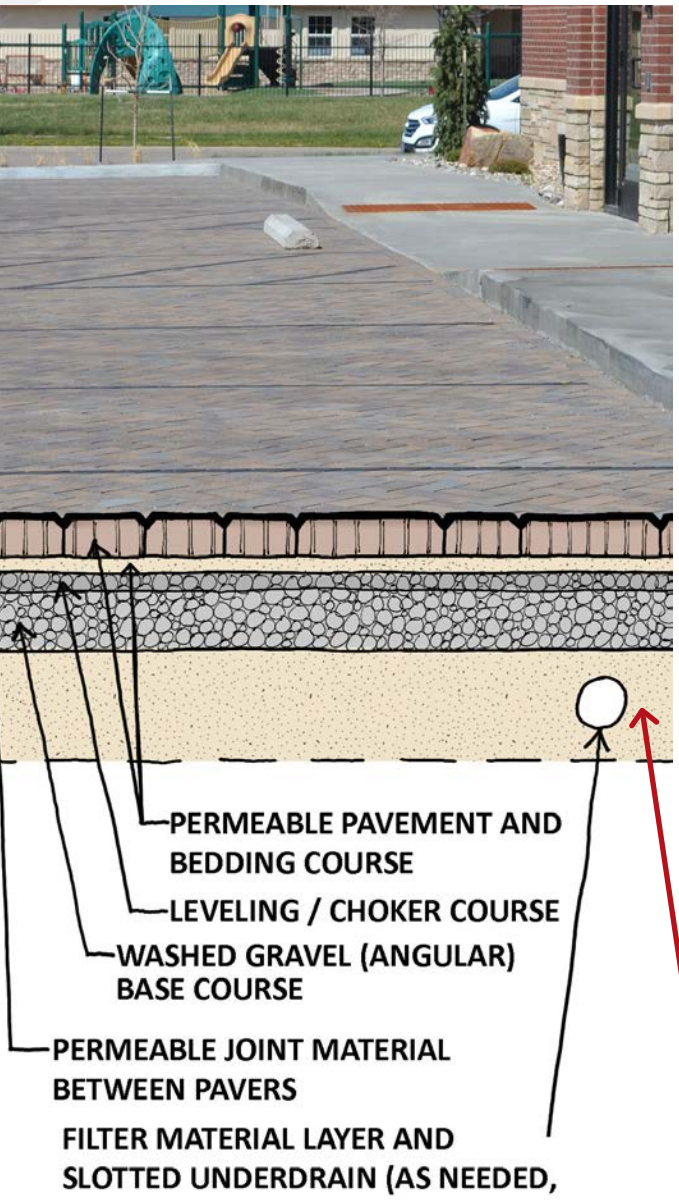
Gravel Grid Pavement Example

Notes and References

- UDFCD Treatment BMP Fact Sheet T-10
- LCUASS Appendix A - Standard Drawings

Precedent Projects

- Odell Brewery Parking Lot
- Senior Center



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- Minimize run on from areas which might carry sediment such as exposed soil or gravel parking areas.
- Distribute run on across a wide area rather than having concentrated flow sources which might overload a portion of the pavement.
- Sloped pavements may require special design such as subsurface check dams to allow water to infiltrate downward.
- Refer to Fort Collins Stormwater Criteria Manual for maximum allowable slope.
- Separate control structures may be required for each check dam.
- Coordinate design with material industry representative.
- Maximum recommended run on from other surfaces should not exceed 2:1.
- Public right-of-way may not be used to meet LID requirements for private property development.
- When BMP is allowed to be used in the public right-of-way, it may be used in parking lanes only, not in traffic lanes.
- Gravel grid pavement systems are not applicable for Right-of-Way applications.
- For public projects maintenance responsibility shall be determined during the design phase.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate permeable pavement areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished pavements from construction sediment including landscape installation and construction traffic.
- **Avoid geotextile wrapping of underdrain pipes.**
- Identify minimum installer experience in contract, ICPI certification recommended. In lieu of experienced installers, specify test panels with material industry representative oversight.

Bioretention

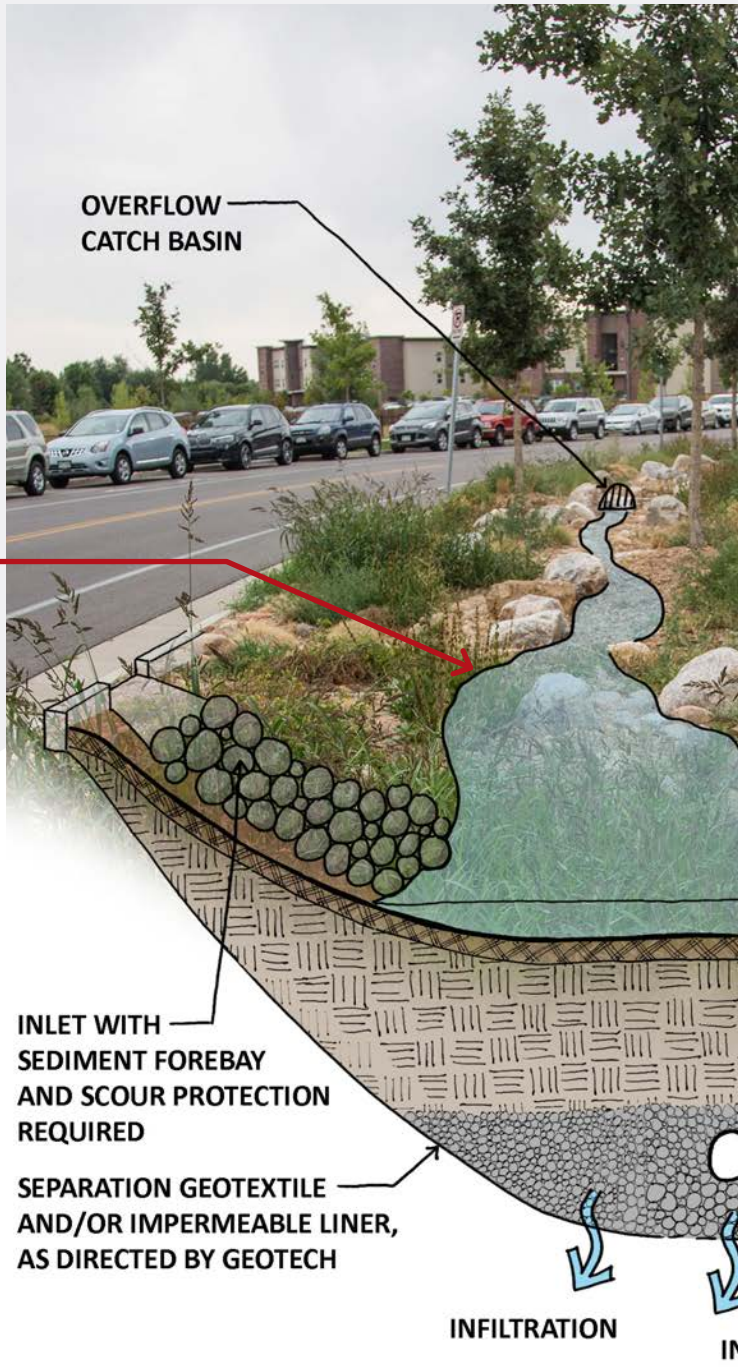
Bioretention areas (often called Rain Gardens) are depressed landscape features that are designed to collect and treat stormwater. These areas can be linear or free form depending on the site context. Bioretention areas primarily treat stormwater by filtering sediment as the water travels downward through the soil, but it is also a living system where plants and micro-organisms maintain the soil structure and break down dissolved pollutants.

COST AND BENEFIT CONSIDERATIONS

- May be used to meet landscape requirements.
- Accept concentrated flow sources.
- **Flexibility in size and shape (linear or basin) make this a popular BMP.**
- Can be combined with underground infiltration BMPs for maximizing performance in a small footprint.
- In dry weather bioretention can serve other uses such as open space.
- Sometimes used to buffer pedestrian and cyclists from roadways.
- Easier to observe and access for maintenance than underground BMPs.

MAINTENANCE CONSIDERATIONS

- Smaller cells may require more frequent maintenance and sediment removal.
- Consider maintenance practices when specifying mulchs. Floatable materials are not allowed.
- BMPs that are used for snow storage or receive flow from sanded areas require more frequent sediment removal.
- **Size forebay accordingly to maintenance frequency and adjacent context.**
- When adjacent to parking and sidewalks provide a flat level step out zone for pedestrian comfort next to the graded slope or wall.
- Group plantings of similar needs or type to simplify maintenance.
- Choose plants to fit conditions e.g. low plants along parking.
- Keep inlets clear of vegetation.



Presettling forebay example at Library Park

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Notes and References

- UDFCD Treatment BMP Fact Sheet T-03
- Soil Media Specification (Appendix C)
- LCUASS Appendix A - Standard Drawings

Precedent Projects

- North College Market Place
- Woodward Commercial Development

DESIGN CONSIDERATIONS

- For concentrated flow applications, armor inlets against scour.
- **Scale the depth of drop from walking areas to the top of bioretention according to the site use and aesthetics, generally <18".**
- Check dams provide ponding depth and slow velocities for linear bioretention.
- Consider size, location and material of inlet pipes and overflow structures and how they affect aesthetics and impact to impervious area footprint.
- In the right-of-way, street tree requirements must be met. Trees are to be located outside of bioretention and positioned adequate distance from curb and sidewalk. Consider placing bioretention between street trees.
- Use landscape areas / islands to encourage multiple uses of space.
- Use plantings that are appropriate for the site. Native plants are encouraged.
- Public right-of-way may not be used to meet LID requirements for private property development.
- Developer-installed bioretention areas shall be maintained by the developer.
- For public projects maintenance responsibility shall be determined during the design phase.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate bioretention areas prior to site disturbance to protect subgrade from construction-related compaction.
- Plants will likely require permanent irrigation.
- Protect finished BMPs from construction sediment, including during landscape installation.
- During establishment protect BMPs from washout.
- Avoid geotextile wrapping of underdrain pipes.
- Provide adequately-sized and armored-overflow for high flow conditions.
- Ensure that rock and plant material placed near inlets do not block flow.

Sand Filter

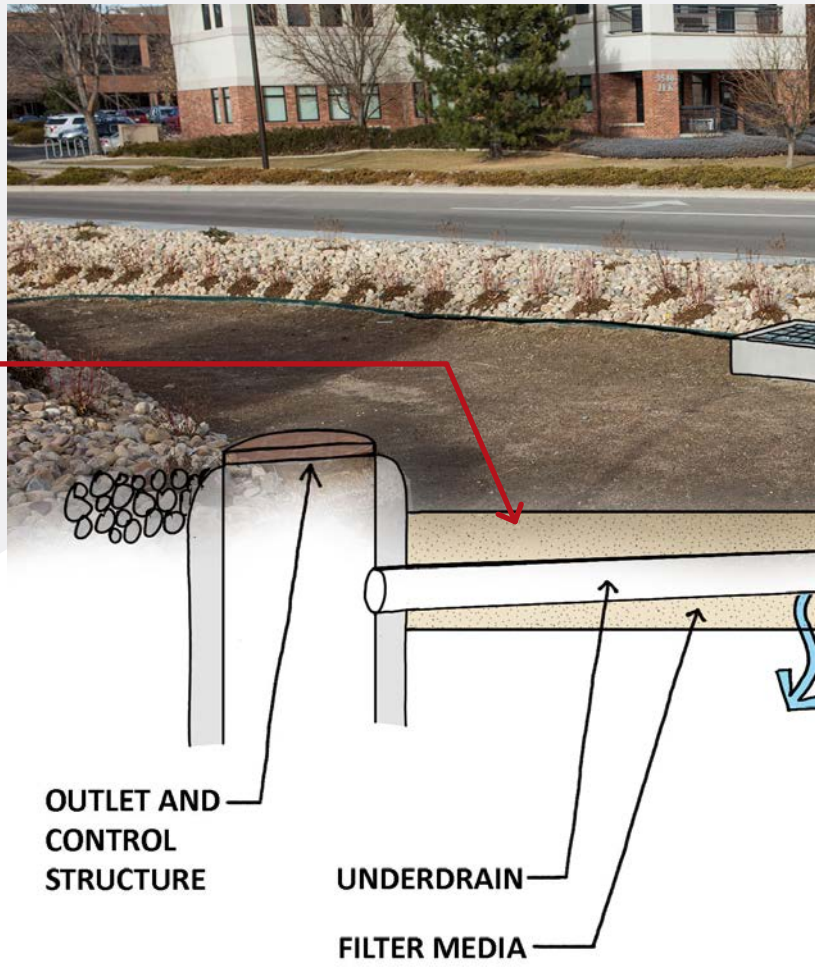
Sand Filters are a simple system that treat stormwater by passing it through a bed of clean sand. They rely on a single treatment process and do not provide as many of the multifunctional habitat and aesthetic benefits as bioretention areas.

COST AND BENEFIT CONSIDERATIONS

- Accept concentrated flow sources.
- Can be designed for deeper ponding depth and larger tributary areas than bioretention. In some cases sand filters may be used to provide the flood control volume.
- Easier to observe and access for maintenance than underground BMPs.
- **Simple design for installation.**
- Relies more heavily on mechanical cleaning and replacement of media to maintain filter rates vs bioretention which is aided by biological processes.
- Vegetation will be more difficult to establish.

MAINTENANCE CONSIDERATIONS

- Remove plant debris frequently.
- Smaller cells may require more frequent maintenance and sediment removal.
- BMPs that are used for snow storage or receive flow from sanded areas require more frequent sediment removal.
- Size forebays accordingly to maintenance frequency and context.
- **Consider using a pretreatment BMP such as vegetated buffer or vegetated conveyance swale upstream to capture sediment.**

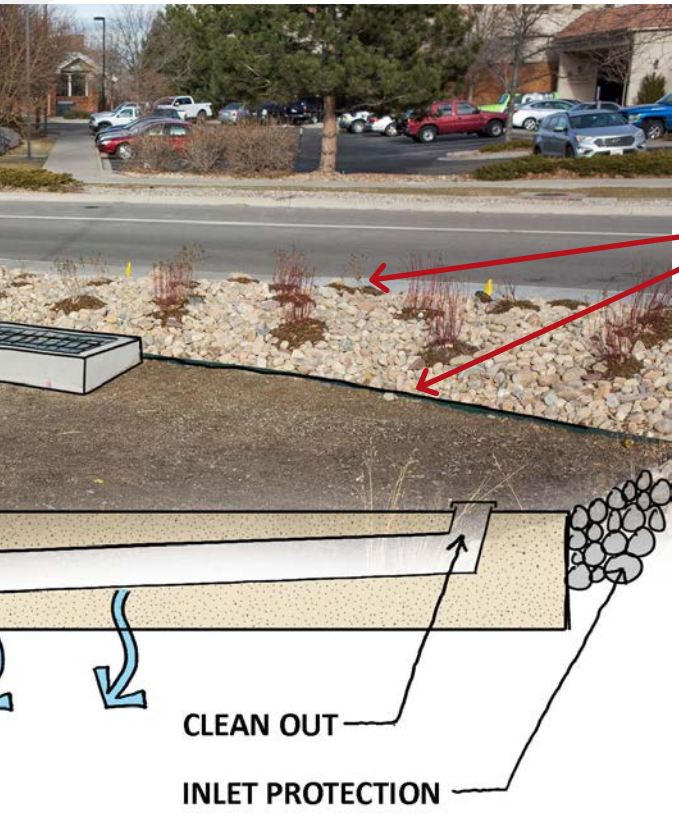


Notes and References

- UDFCD Treatment BMP Fact Sheet T-06

Precedent Projects

- Foothills Mall (south side)
- CSU Parking Structure



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- For concentrated flow applications, armor inlets against scour.
- **Scale the depth of drop from walking areas to the top of sand filter according to the site use and aesthetics, generally <18".**
- For sites with infiltration limitations BMPS are drained by underdrains.
- BMP is not applicable for right-of-way applications.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate sand filter areas prior to site disturbance to protect subgrade from construction related compaction
- Protect finished BMPs from construction sediment including during landscape installation.
- Provide adequately sized and armored overflow for high flow conditions.

Tree Filter

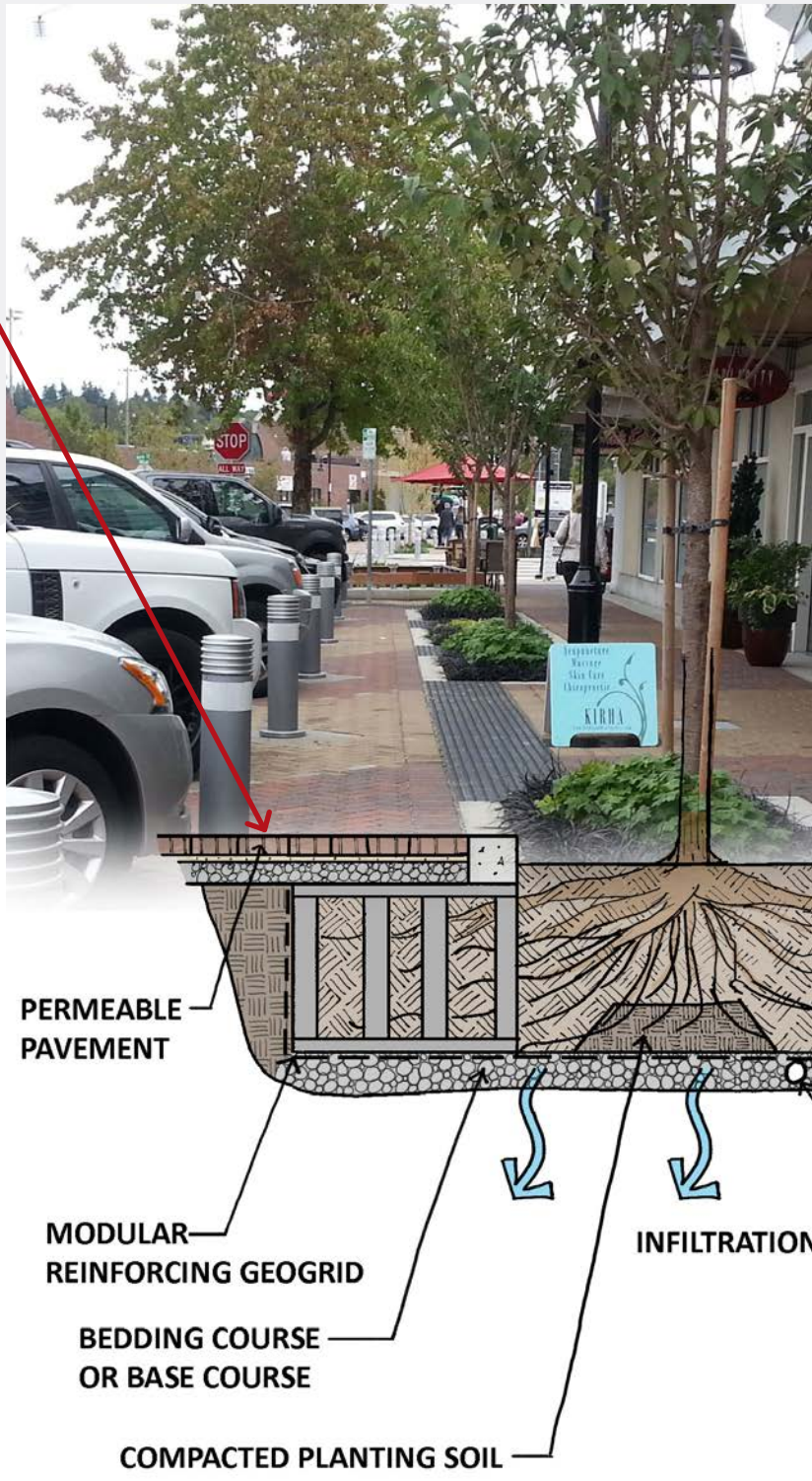
Tree Filters typically consist of a proprietary structural support system that allows uncompacted soil to be placed around the tree roots. Compared to urban trees planted in pavement settings, tree-filter trees grow faster and live longer. Tree filters also provided stormwater treatment through filtration and infiltration.

COST AND BENEFIT CONSIDERATIONS

- Tree filters cost more than traditional tree planting methods but also provide better growing conditions, promoting healthier and higher value trees.
- **Can be combined with permeable pavement to provide additional air and water transfer.**
- May be used to meet landscape requirements.
- Can be designed to accept flow through an inlet or downspout pipe.
- Applicable to dense urban applications where pavement surrounds the tree zone.
- Tree filters may also be used in situations where an underdrain is not feasible.

MAINTENANCE CONSIDERATIONS

- **Design for the lifetime of the tree. Pretreatment that protects the quality of the tree soil is therefore particularly important for this BMP.**
- Provide access to pretreatment filter for inspections and filter material replacement.
- Provide observation ports to facilitate inspection.
- Trees will require permanent irrigation.

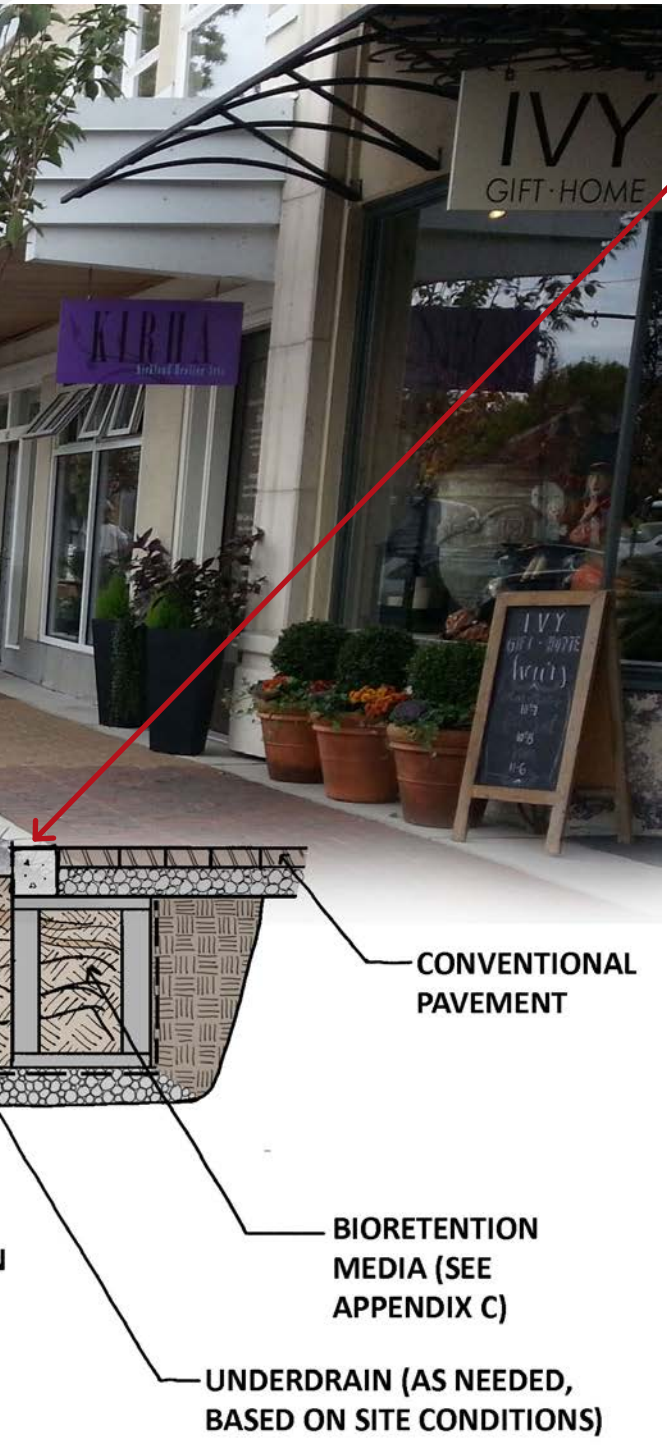


Notes and References

- Denver Ultra Urban Green Infrastructure Guidelines "Tree Trench/ Pit Fact Sheet."
- Soil Media Specifications (Appendix C)
- LCUASS Appendix A - Standard Drawings

Precedent Projects

- City of Fort Collins Utilities
- Parking Garage



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- **Consider the relationship to the tree filter surface to the surrounding pavement. Provide edge protection as needed.**
- Consult with manufacturer to provide sufficient soil volume for tree species.
- Refer to manufacturers guide for guidance on how to calculate the WQCV for this BMP.
- Maximize lateral infiltration and distribution of water.
- Right-of-way may not be used to meet LID requirements for parcel impervious area.
- BMPs shall be located in such a way as not to conflict with street tree requirements.
- Coordinate utility setback/sleeving requirements with Engineering Department during feasibility analysis.
- Work with utility providers to determine if sleeves are needed for existing or future utilities.
- For public projects maintenance responsibility shall be determined during the design phase.
- Impermeable liner is required along vertical sides of the tree filter to the bottom of excavation if located in public right-of-way.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate tree filter areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished BMPs from construction sediment including landscape installation. During establishment protect BMPs from washout.
- Follow manufacturer's recommendations for installation.
- Products may require protection from sunlight exposure when stockpiled.
- Place the root flare of the tree slightly higher than the overflow to prevent fungal growth.

Underground Infiltration

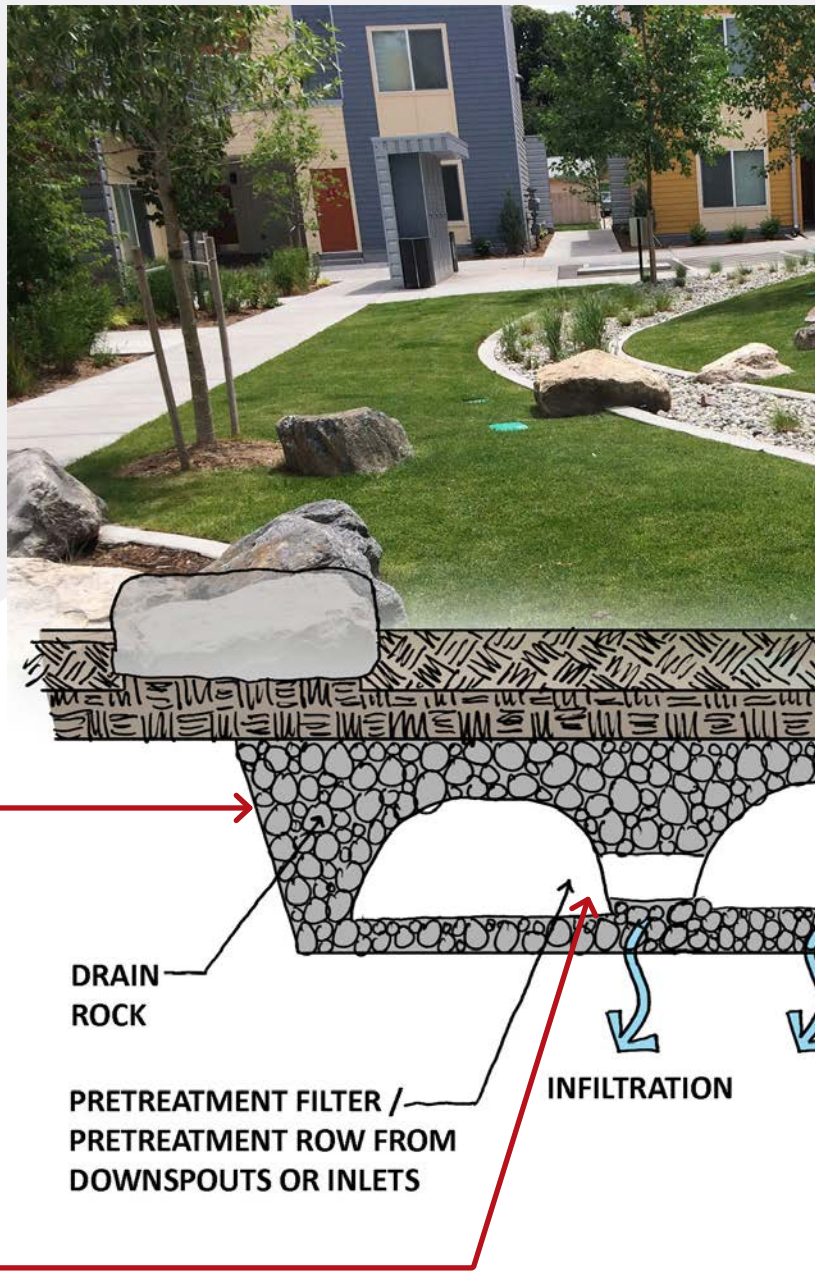
Often used at sites with little open space. It can also be used to augment other BMPs since it allows for a large amount of stormwater storage in a small footprint and allows for multiple uses in the same space.

COST AND BENEFIT CONSIDERATIONS

- Projects typically use proprietary products.
- Used as space saving technique that allows for multi-use such as in parks or below parking.
- For additional space savings, this BMP is often located in combination with other techniques such as permeable pavement or bioretention.
- Many manufacturers offer shallow units for flat sites with low drop.
- **When comparing the cost of different products, consider also the cost of excavation and gravel backfill.**

MAINTENANCE CONSIDERATIONS

- Providing inspection and maintenance access is especially critical for the long-term performance of this type of BMP since it cannot be observed from the surface.
- Inspections and maintenance may require a confined space entry per local and OSHA rules.
- **Some products require specialized cleaning equipment such as isolator row sets.**
- Reduce maintenance by presettling or filtering sediment at the inlet. Other LID BMPs can sometimes perform this function, in a 'treatment train' approach.

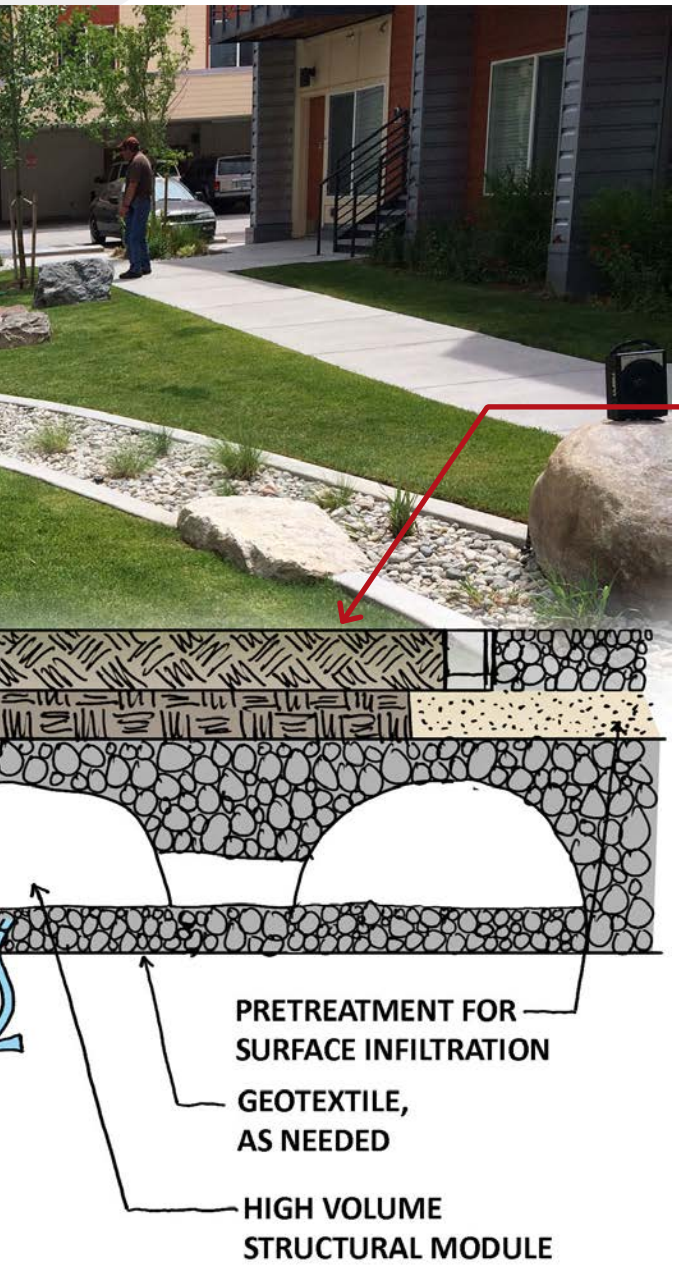


Notes and References

- Ft Collins Stormwater Criteria Manual
- UDFCD Treatment BMP Fact Sheet T-11

Precedent Projects

- The Exchange: 200 Block of N. College Avenue
- Brickstone Apartments: 201 E. Harmony Road



DESIGN CONSIDERATIONS

- Each product has different load capacities and cover requirements.
- Check-in with the manufacturer's representative often. Manufacturers may require plan review prior to construction, as well as a pre-construction meeting.
- On sloped sites modules may need to be stepped.
- **Products may have load and planting limitations over the units.**
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Protect inlets from construction sediment.
- Route construction traffic around the BMP to avoid exceeding load rating and protect the surface from construction sediment.
- Follow manufacturer's recommendations for installation.
- Products may require protection from sunlight exposure when stockpiled.

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Non-Engineered Rain Garden

Rain Garden areas may also be installed voluntarily where they are not required by City code. Homeowners or businesses may choose to install non-engineered rain gardens for their own benefit or to support the larger City ecosystem. Non-engineered rain gardens can collect water from downspouts, patios and driveways and allow it to filter into the ground.

COST AND BENEFIT CONSIDERATIONS

- **This BMP may not be used to meet the LID Criteria. It is for voluntary installations only.**
- Does not require specialized design or engineering.
- Does not require permit or City inspection.
- Used to diversify and beautify landscaping while benefiting the environment.
- Can be used to alleviate problem drainage areas.
- Multiple rain gardens may be used to capture water from each downspout.
- May be applied to individual single family lots.

MAINTENANCE CONSIDERATIONS

- **Adjacent to paving provide a level step out zone that also prevents undermining of pavement when bioretention soil settles.**
- If erosion is causing sediment to accumulate in the rain garden, identify the source and stabilize it with mulch or plants.
- The first couple of years may require more weeding as the rain garden plants establish.
- Plants will require permanent irrigation, but may require less water than conventional planting beds.
- Size forebay according to maintenance frequency.

Notes and References

- Soil Media Specification (Appendix C)
- "Building a Rain Garden in Colorado" Colorado Stormwater Center

Precedent Projects

- Poudre River Drive & Hoffman Mill Road
- Library Park

DESIGN CONSIDERATIONS

- Use a bed of stones around inlet pipes to protect against erosion.
- **For sites with infiltration limitations, use an underdrain to prevent standing water that doesn't infiltrate in 48 hours. Orifice controls are not required.**
- Ensure a clear flow path to the existing drainage system is provided, in case of overflow.
- Provide at least 10' setback from buildings.
- Select plants that can thrive in both wet and dry conditions.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Residents should call before digging, Dial 8-1-1, to locate existing utilities.
- Roughen the soil at the bottom of your excavation and minimize walking in the rain garden to prevent soil compaction.
- Allow time for plants to establish before connecting downspouts.
- **Avoid geotextile wrapping of underdrain pipes due to clogging.**

** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Vegetated Buffer

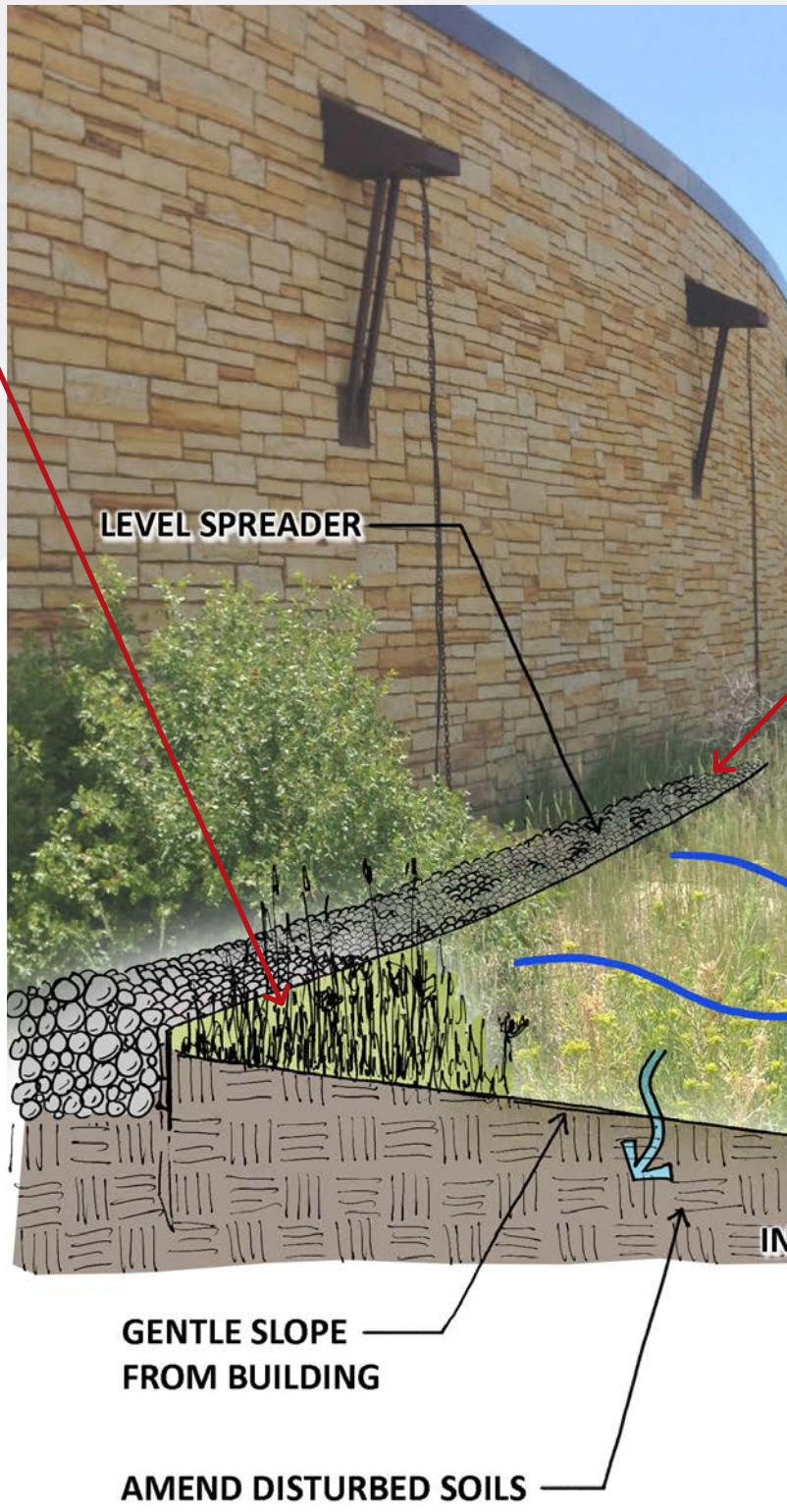
The vegetated buffer cleans stormwater runoff by catching sediment and debris between the stalks and leaves of dense vegetation. It is often used to reduce directly connected impervious areas, allow water to infiltrate and provide pretreatment for other BMPs.

COST AND BENEFIT CONSIDERATIONS

- Reduces directly connected impervious areas.
- May be used to meet landscape requirements.
- Low construction cost.
- Flexible space for recreation and snow storage.
- **Vegetated buffers require gently sloping sites, 2% minimum to 10% maximum.**
- Applicable to sites with large open spaces.
- Uses existing areas, which reduces land consumption.

MAINTENANCE CONSIDERATIONS

- **Dense cover is required to maintain the function of this BMP. Ensure at least 80% vegetated cover.**
- Protect vegetated buffers from compaction. Prevent cars from driving onto the buffer. Amend soils that become compacted.
- Provide wheel stops or similar barrier adjacent to parking and drives.
- Trim and maintain vegetation along edges where impervious area flows to buffer.
- Monitor for invasive species and remove as needed.
- Remove accumulated sediment in level spreader to maintain dispersed flow.

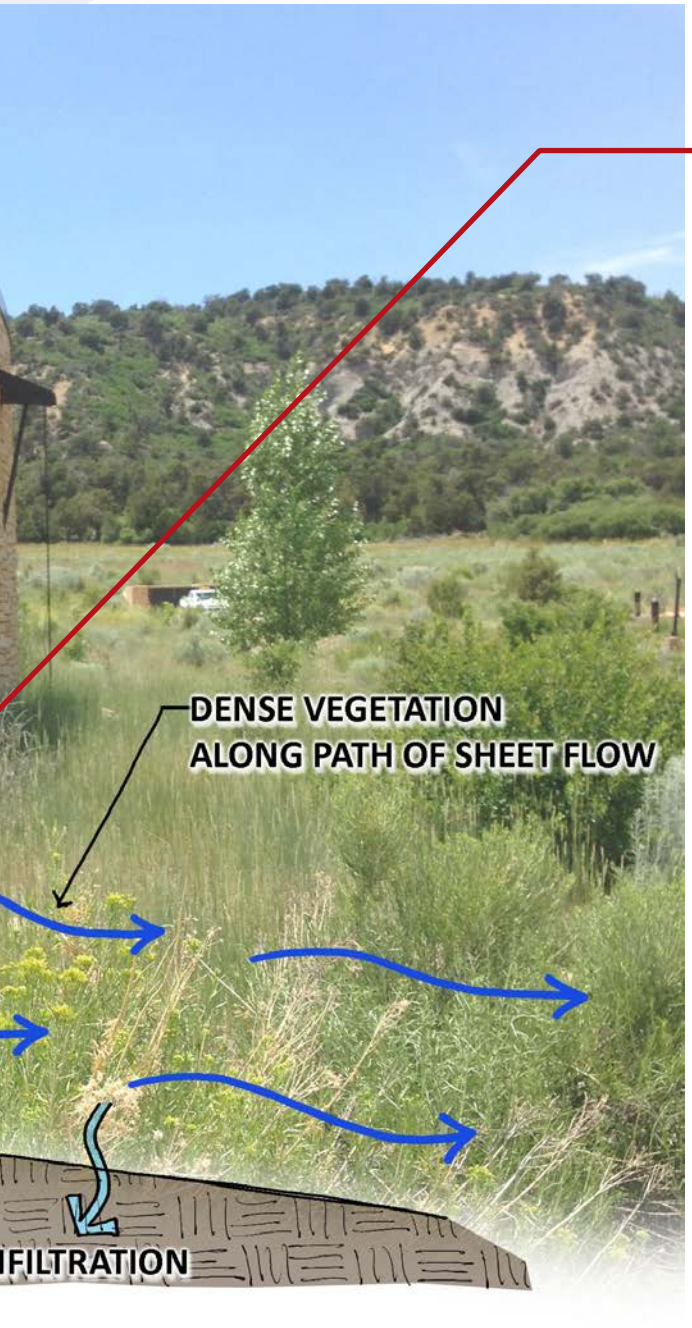


Notes and References

- UDFCD Treatment BMP Fact Sheet T-01
- Grass Buffer Seed Mix Specification (Appendix D)

Precedent Projects

- Bucking Horse Apartments



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- **Level spreaders are required for concentrated flow applications and recommended for sheet flow applications.**
- Select vegetation with uniform cover characteristics. Avoid bunch type vegetation that can result in concentrated flow between plants.
- Where feasible provide a 2-3" drop between the top of the vegetated buffer and the contributing impervious area. This drop prevents vegetation from growing against the impervious area and concentrating flow.
- Confirm vegetated flow path is not within footprint of future development.
- Permaculture techniques such as keyline design may be used to increase infiltration.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Plan and delineate buffer areas prior to site disturbance to protect subgrade from construction related compaction.
- Protect finished BMPs from construction sediment including landscape installation. During establishment protect BMPs from washout.
- Construct level spreaders parallel to site contours.
- Plants will require establishment irrigation during and for a time following construction.

Constructed Wetland Channel

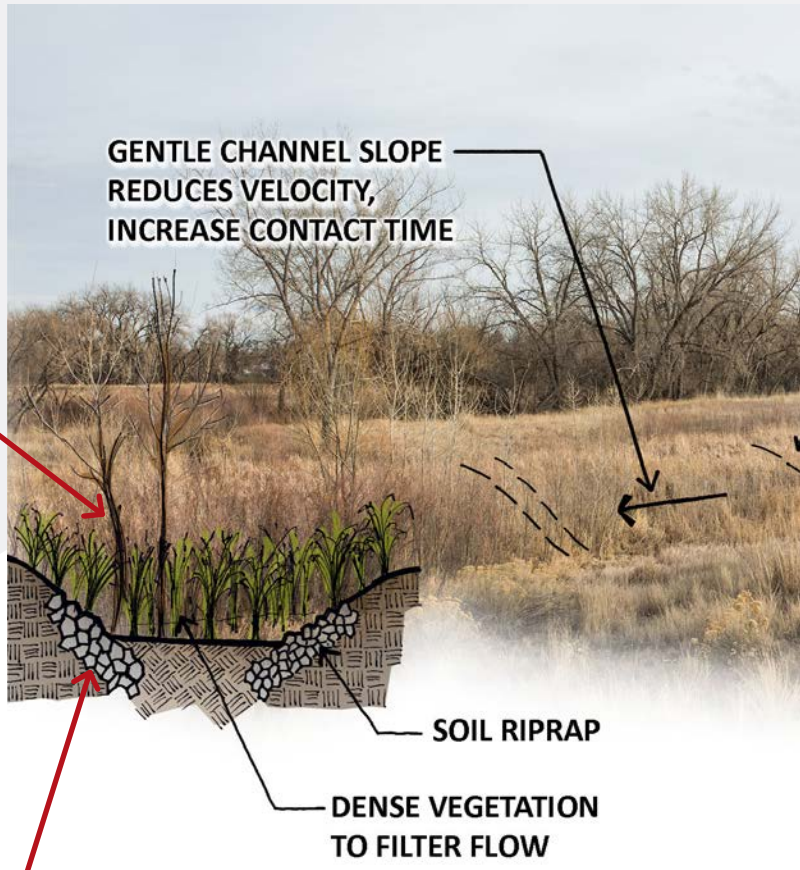
Constructed wetlands support a wide variety of vegetation and wildlife. While a primary process for pollutant removal is sediment settling, plants and microorganisms also have an extended contact time with the water allowing for removal of dissolved pollutants. This elaborate ecosystem provides high levels of stormwater treatment.

COST AND BENEFIT CONSIDERATIONS

- Not applicable to sites that do not have a sufficient baseflow.
- Provides high levels of stormwater treatment, including dissolved pollutants and nutrients.
- Channel may provide conveyance for major and minor storms.
- In addition to stormwater benefit, wetland channels also provide high habitat value.
- **Wetland plants add interest and diversity to the vegetation of the site.**
- Do not use an existing natural channel to treat stormwater.
- In some cases, can be used to mitigate impacts to existing wetlands.
- Applicable in areas close to existing natural areas, water bodies and streams.

MAINTENANCE CONSIDERATIONS

- Provide an access path along the length of the channel, at forebays, at inlets and at outlets.
- **After large storms inspect grade control structures and side slopes for erosion or scour.**
- If sediment accumulation becomes an issue, identify the source and stabilize it or install a pretreatment device.
- Vegetation should remain clear of inlets and outlets at all times.
- Providing a vegetated buffer between the active portion of the site and the channel can reduce trash accumulation.
- Monitor for invasive species and remove as needed.



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

Notes and References

- UDFCD Treatment BMP Fact Sheet T-09

Precedent Projects

- Udall Natural Area
- Bucking Horse Apartments

DESIGN CONSIDERATIONS

- Ensure baseflow is sufficient to maintain year round saturated soil.
- **Wetland channels rely on gentle channel profiles in order to promote settling. Grade control structures are required for steeper sites.**
- Since channels can be difficult to access and dredge, pretreatment is required to remove most sediment.
- When placed downstream of detention, constructed wetland channels benefit from both pretreatment and attenuation.
- Nutrient removal typically increases with hydraulic residence time.
- When used to meet wetland mitigation requirements, stormwater must be pretreated prior to entering the wetland area.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Divert baseflows during construction to allow for establishment.
- Protect finished BMPs from construction sediment including landscape installation.
- During establishment protect BMPs from washout.
- Plants (particularly upland) will require establishment irrigation during and for a time following construction.

Grade control example for a small channel.

Constructed Wetland Pond

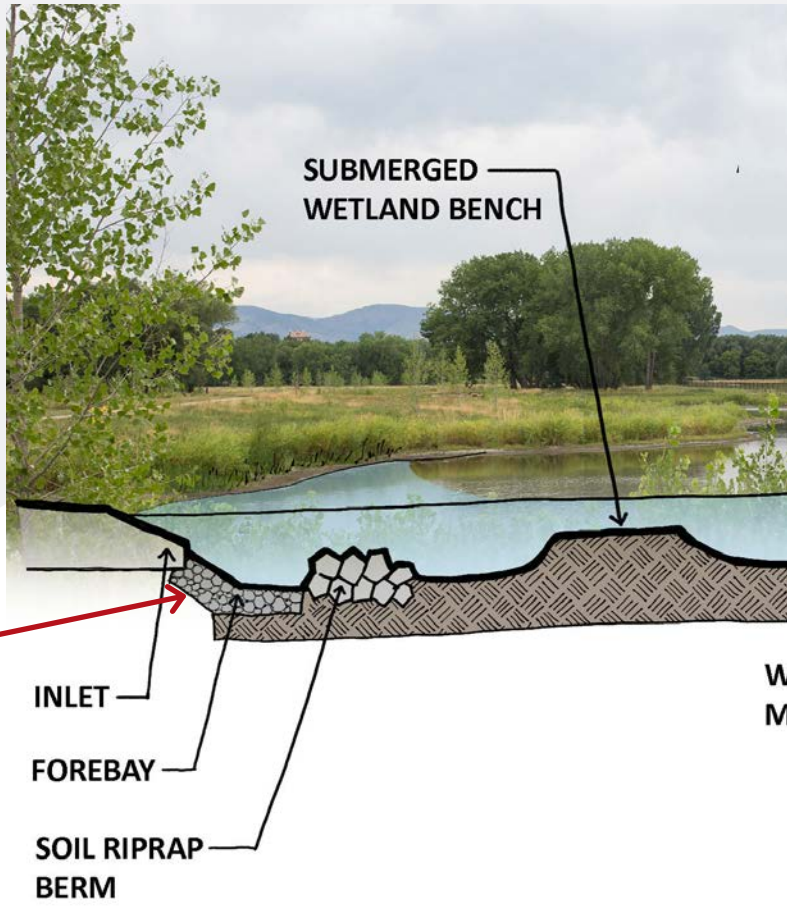
Constructed wetland ponds function similar to constructed wetland channels, by removing pollutants through a combination of settling and biological processes. They are often incorporated as site amenities and can be surrounded by walking trails.

COST AND BENEFIT CONSIDERATIONS

- Wetland are considered a retention facility and require water rights.
- Not applicable to sites that do not have a sufficient baseflow.
- May be designed to also provide detention volume.
- Provides high levels of stormwater treatment, including dissolved pollutants and nutrients.
- In addition to stormwater benefit, wetland ponds also provide high habitat value.
- Do not use an existing natural wetland to treat stormwater.
- In some cases, can be used to mitigate impacts to existing wetlands.

MAINTENANCE CONSIDERATIONS

- **Provide maintenance access, particularly at forebays and micropools.**
- Nutrient rich runoff can create algae blooms. Limit algae growth by managing fertilizer use and other nutrient sources.
- Vegetation should remain clear at inlets and outlets at all times.
- Providing a vegetated buffer between the active portion of the site and the wetland can reduce trash accumulation.
- Monitor for invasive species and remove as needed.

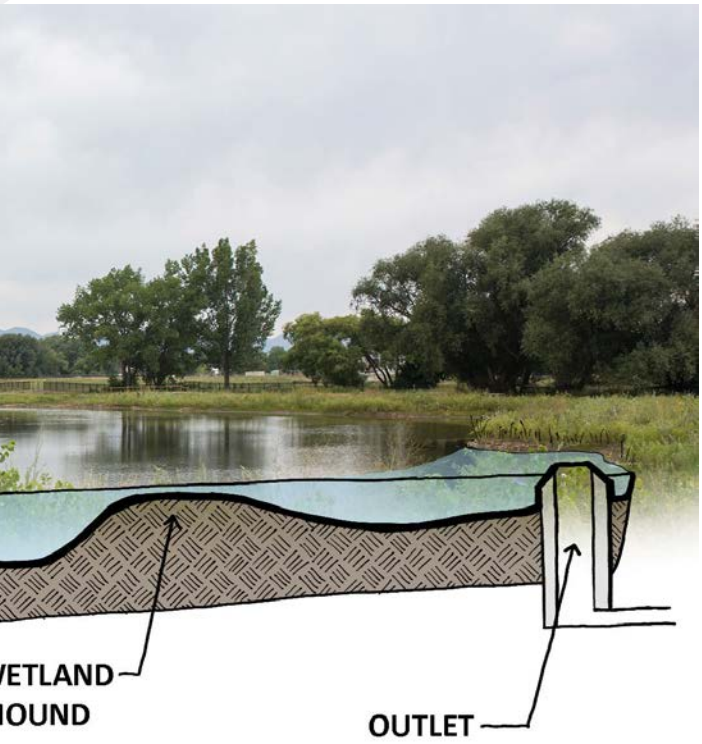


Notes and References

- UDFCD Treatment BMP Fact Sheet T-08

Precedent Projects

- Udall Natural Area
- Woodward Commercial Development



** This is a graphic representation. For more technical guidance, refer to the construction detail.*

DESIGN CONSIDERATIONS

- Ensure baseflow is sufficient to maintain year round permanent pool.
- Since ponds can be difficult to access and dredge, proper forebay sizing and maintenance access is necessary.
- Separate inlet and outlet to minimize "short circuiting."
- Provide a mechanism to drain down the pond for maintenance access.
- Nutrient removal typically increases with hydraulic residence time.
- When used to meet wetland mitigation requirements, stormwater must be pretreated prior to entering the wetland area.
- BMP is not applicable to rights-of-way.

CONSTRUCTION CONSIDERATIONS

- Construct the pond using diverse horizontal and vertical forms to create a natural looking site amenity.
- Divert baseflows during construction to allow for establishment.
- Protect finished BMPs from construction sediment including landscape installation.
- Plants (particularly upland) will require establishment irrigation during and for a time following construction.

4

Section Four: Design Approach

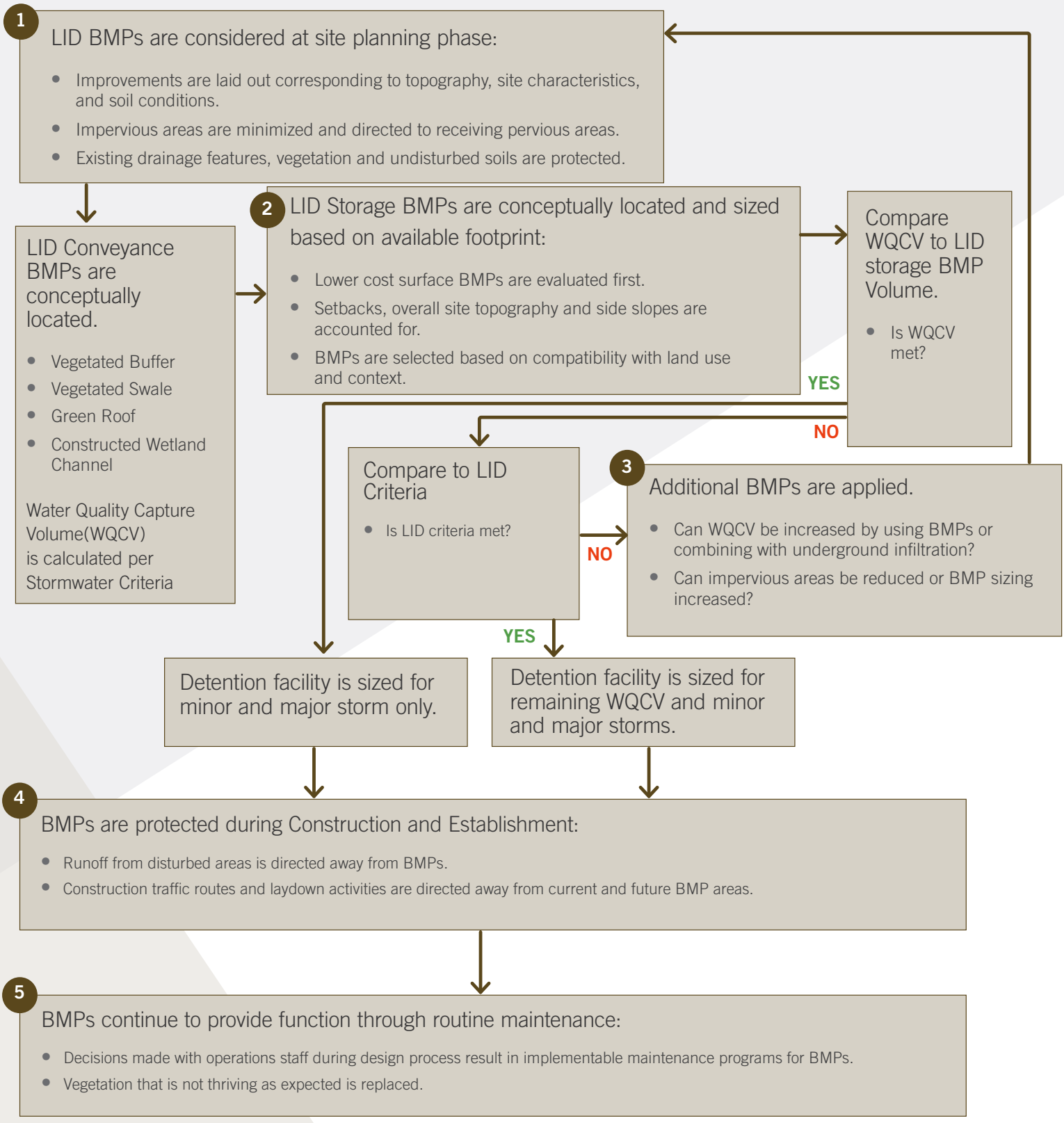
An integrated stormwater management plan that maximizes the multiple benefits of LID practices can be achieved by carefully considering stormwater impacts at each phase of the project.

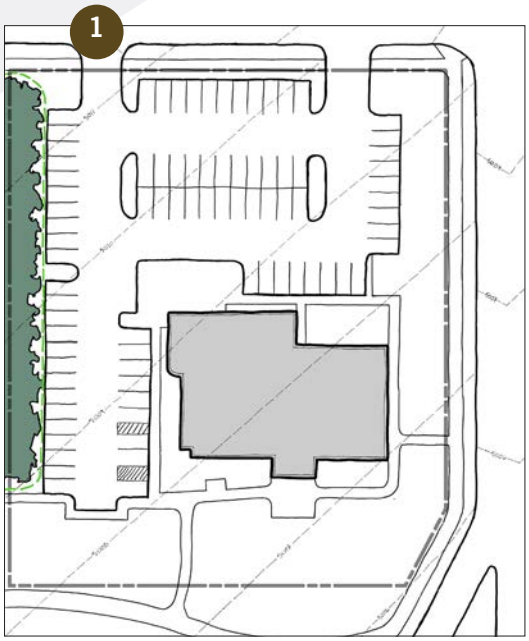
Overview

The following flow chart illustrates LID considerations for each of the planning, design, construction and operations phases of a project life-cycle. This approach allows for LID practices to be used that:

- Meet multiple code requirements (stormwater criteria, landscape code, etc.).
- Are relevant to the building architecture.
- Are part of a cohesive site design.
- Increase public awareness and stewardship of rain water.

LID Consideration Flow Chart

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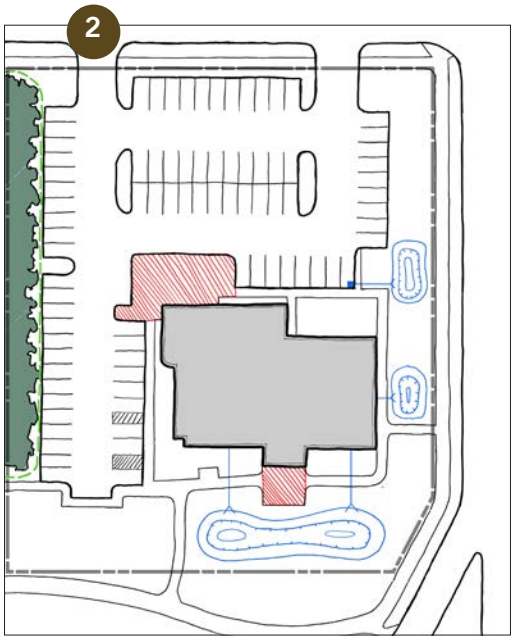
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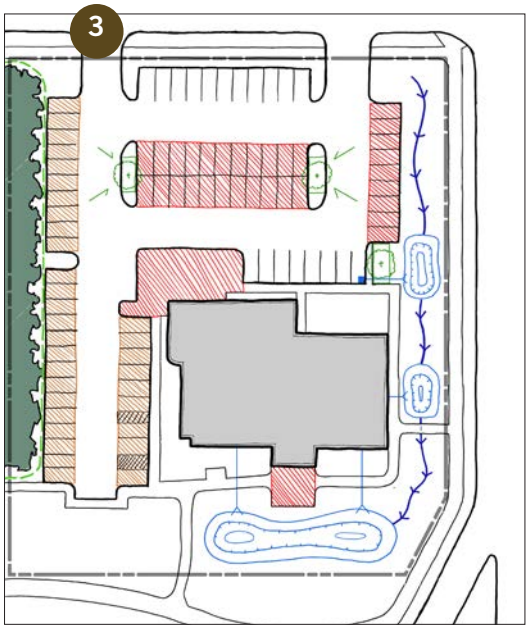
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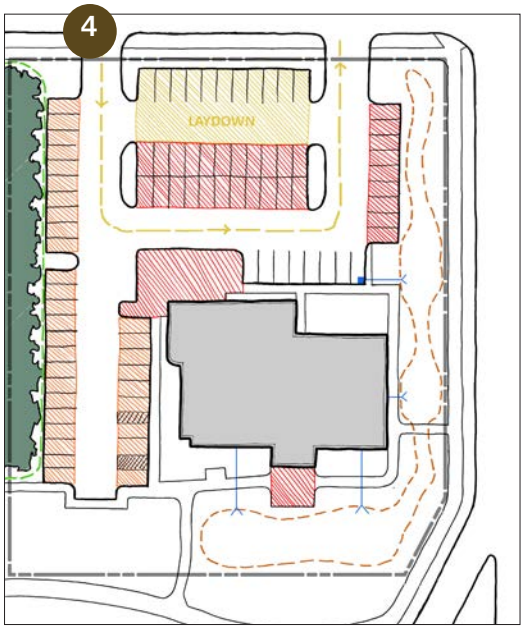
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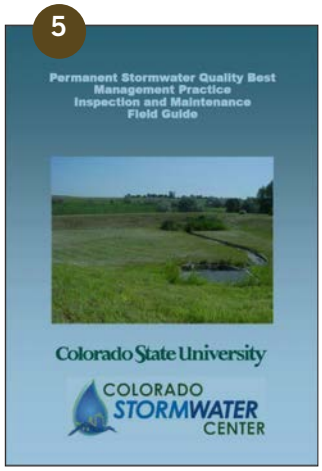
LAYDOWN


5
Permanent Stormwater Quality Best Management Practice Inspection and Maintenance Field Guide
Colorado State University
COLORADO STORMWATER CENTER

City of Fort Collins

5

Section Five: Appendices

LID Manual Notes and Resources

- Appendix A: Glossary
- Appendix B: LID Project Locations
- Appendix C: Soil Mixes
- Appendix D: Plant Lists

Appendix A: Glossary

Note: This glossary is not intended to provide regulatory or legal definitions of terms. Instead, it is intended to provide users with a basic understanding of terms used in this manual.

Best Management Practice (BMP)
A technique, process, activity, or structure used to reduce pollutant discharges in stormwater. BMPs include source control practices (non-structural BMPs) and engineered structures designed to treat runoff. BMPs are most effective when used in combination and selected and designed based on site-specific characteristics.

Check Dam
Small dam constructed in a gully or other small watercourse to decrease the streamflow velocity, minimize channel scour, and promote deposition of sediment. Subsurface check dams retain water on sloped sites within the subsurface storage reservoir.

Detention
The storage and slow release of stormwater from an excavated pond, enclosed depression, subsurface reservoir, or tank. Detention is used for pollutant removal, stormwater storage, and peak flow reduction.

Directly Connected Impervious Area (DCIA)
The impervious portion of a site that drains directly to the storm sewer system. DCIA is a key component of the conceptual model used in the volume reduction calculations in the UDFCD Stormwater Criteria Manual.

Erosion
Process by which soil particles are detached and transported by wind, water, and gravity to a downslope or downstream location.

Forebay
Storage space located near a stormwater BMP inlet designed to trap incoming coarse sediments and other gross solids before they accumulate in the main treatment area of the BMP.

Fort Collins LID Criteria
Detailed LID criteria are incorporated in Volume 3, Chapter 3 of the Stormwater Criteria Manual.

Fort Collins Stormwater Criteria Manual
The Stormwater Criteria Manual sets stormwater policies and provides drainage criteria for all new stormwater design and construction activities.

Impervious Surface
A hard surface area (e.g., parking lot or rooftop) that prevents or retards the infiltration of water into the soil, thus causing water to run off the surface in greater quantities and at an increased rate of flow relative to pervious areas.

Infiltration
The percolation of water from the land surface into the ground.

LID Practices or LID BMPs
Individual practices used as part of overall LID developments or integrated into traditional developments. For the purposes of meeting the Stormwater Criteria the following practices are considered LID: permeable pavements, bioretention areas/rain gardens, sand filters, tree filters, underground infiltration facilities, vegetated buffers, constructed wetland channels and constructed wetland ponds.

LID Conveyance BMP
An LID BMP which conveys runoff across a receiving pervious area. LID Conveyance BMPs reduce the Water Quality Capture Volume.

LID Principles
Land use management strategies that emphasize conservation, use of on-site natural features, and site planning to minimize impervious surfaces, native vegetation loss, and stormwater runoff.

LID Storage BMP
An LID BMP which provides detention of the Water Quality Capture Volume.

Low Impact Development (LID)
LID is an overall land planning and engineering design approach to managing stormwater runoff. LID emphasizes conservation and use of on-site natural features to protect water quality. This approach implements engineered small-scale hydrologic controls to mimic the pre-development hydrologic regime of watersheds through infiltrating, filtering, storing, evaporating, and detaining runoff close to its source. The term Green Infrastructure (GI) may also be used, particularly in areas with combined sewer overflow (CSO) issues.

Pretreatment
The removal of material such as solids, grit, grease, and scum from flows prior to physical, biological, or physical treatment processes to improve treatability. Pretreatment may include screening, grit removal, settling, oil/water separation, or application of a basic treatment BMP prior to infiltration.

Receiving Pervious Area (RPA)
The pervious portion of a site that receives runoff from an upgradient impervious area prior to draining to the storm sewer system. RPA is a key component of the conceptual model used in the volume reduction calculations in Chapter 3 of this manual.

Runoff
Water from rain, melted snow, or irrigation that flows over the land surface.

Sediment
Fragmented material that originates from weathering and erosion of rocks or unconsolidated deposits, and is transported by, suspended in, or deposited by water.

Stormwater
That portion of precipitation that does not naturally percolate into the ground or evaporate, but flows via overland flow, interflow, pipes and other features of a stormwater drainage system into a defined surface waterbody, or a constructed infiltration facility.

UDFCD Stormwater Criteria Manual
A Stormwater Criteria Manual for the Urban Drainage and Flood Control District. Portions of the UDFCD Stormwater Criteria Manual are adopted by reference in the Fort Collins Stormwater Criteria Manual.

Underdrain
A perforated pipe, typically 4- to 6-inches in diameter, placed longitudinally at the invert of a stormwater facility for the purposes of achieving a desired discharge rate and controlling nuisance ponding.

Water Quality Capture Volume (WQCV)
The quantity of stormwater runoff that must be treated in stormwater quality BMPs in Denver. This volume is equivalent to the runoff from an 80th percentile storm, meaning that 80 percent of the most frequently occurring storms are fully captured and treated and larger events are partially treated.

Appendix B: LID Project Locations

Permeable Pavement

1. Odell Brewery Parking Lot: 800 E Lincoln Avenue, 80524
2. Senior Center: 1200 Raintree Drive, 80526

Bioretention

3. North College Market Place: 1820 & 1842 N College Avenue, 80624
4. Woodward Commercial Development: 1041 Woodward Way, 80524

Sand Filter

5. Foothills Mall (south side): E Monroe Drive & JFK Parkway,
6. CSU Parking Structure: S College Avenue & W Pitkin Street, 80524

Tree Filter

7. City of Fort Collins Utilities: 222 LaPorte Avenue, 80521
8. Parking Garage: 363 Jefferson Street, 80524

Underground Infiltration

9. The Exchange: 200 Block of N. College Avenue
10. Brickstone Apartments: 201 E. Harmony Road

Non-Engineered Rain Garden

11. Poudre River Drive & Hoffman Mill Road: 1199 Poudre River Drive, 80525
12. Library Park: 201 Peterson Street, 80524

Vegetated Buffer

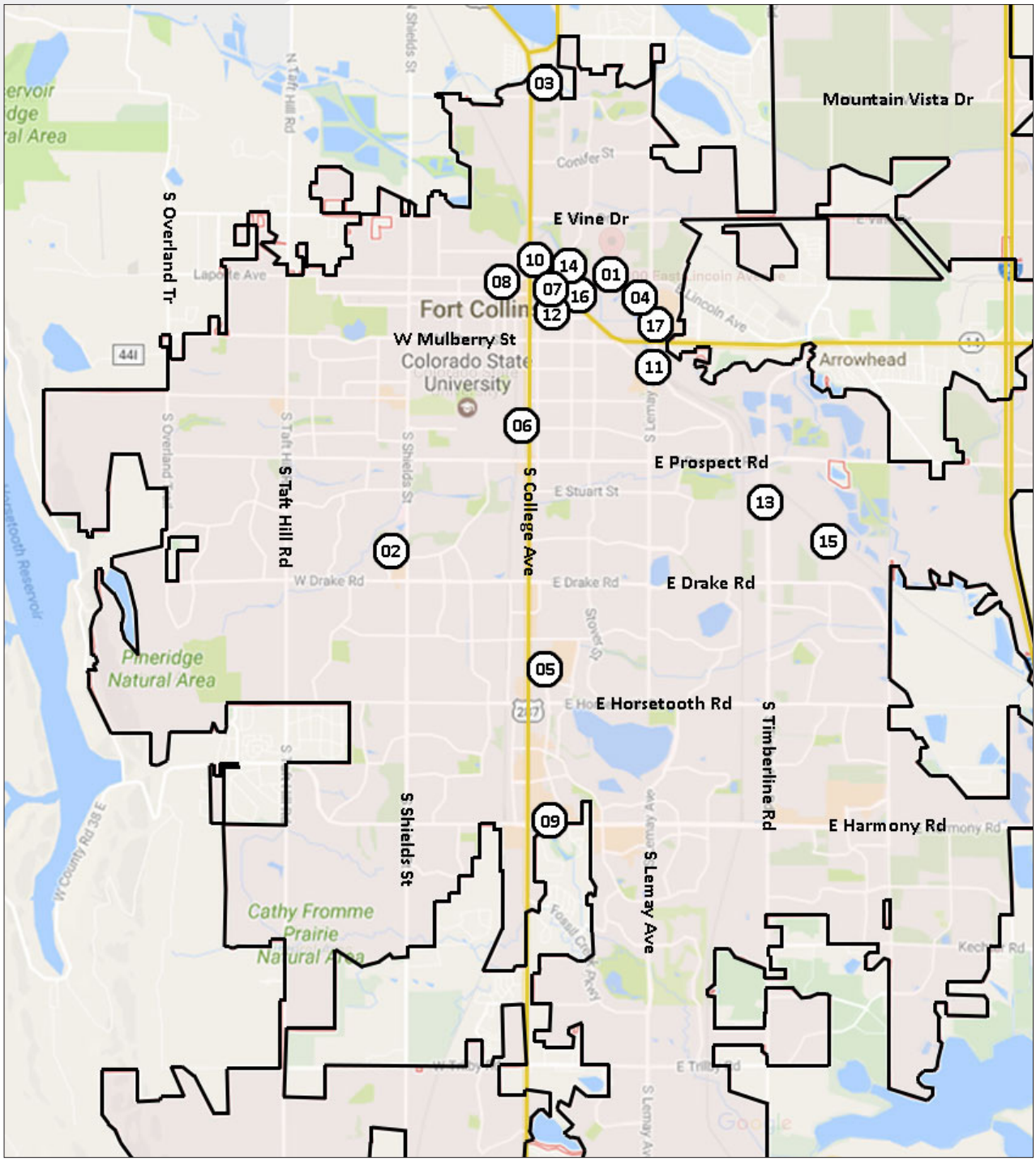
13. Bucking Horse Apartments: 1903 S Timberline Road, 80525

Constructed Wetland Channel

14. Udall Natural Area: E Lincoln Avenue & Willow Street, 80524
15. Bucking Horse Apartments: 1903 S Timberline Road, 80525

Constructed Wetland Pond

16. Udall Natural Area: E Lincoln Avenue & Willow Street, 80524
17. Woodward Commercial Development: 1041 Woodward Way, 80524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Mountain Vista Dr
Conifer St
E Vine Dr
10
14
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16
04
12
17
Fort Collins
W Mulberry St
Colorado State University
11
Arrowhead
06
E Prospect Rd
E Stuart St
13
15
02
S College Ave
E Drake Rd
W Drake Rd
Pineridge Natural Area
05
E Horsetooth Rd
S Timberline Rd
S Shields St
09
E Harmony Rd
S Lemay Ave
Cathy Fromme Prairie Natural Area
S Overland Tr
S Taft Hill Rd
441
Google

Appendix C: Soil Mixes

Soil mixes for bioretention areas and tree filters are specially engineered to support plant growth while promoting infiltration. The following mixes shall be used for projects in the public right-of-way:

Fort Collins Bioretention/Rain Garden Soil Mix

- Washed Sand: 60%
- Top Soil: 30%
- Leaf / Yardpride Compost: 5%
- Mulch: 5%

For full specifications see:
https://www.fcgov.com/utilities/img/site_specific/uploads/Bioretention_Sand_Media_Specs_12-2017.pdf

Fort Collins Tree Filter Soil Mix

- Glacier Rock Sand: 55%
- Top Soil: 30%
- Ground Mulch: 5%
- Yard Pride Compost: 10%

Appendix D: Plant Lists

The following plant lists shall be consulted for every project.

Fort Collins Streetscape Standards
https://www.fcgov.com/planning/streetscapedesign.php
Provides planting and layout standards for streetscapes and rights-of-way within Fort Collins.

State of Colorado Noxious Weeds List
https://www.colorado.gov/pacific/sites/default/files/NoxiousWeedList.pdf
State-wide list of List A, B and C noxious weeds, with images and key points for identification, maintained by the Colorado Department of Agriculture. Website also provides weed maps, eradication suggestions and Weed Watch List.

Fort Collins Native Plants
http://www.fcgov.com/naturalareas/pdf/nativeplants2013.pdf

Fort Collins Plant List for Development
https://www.fcgov.com/forestry/plant_list.pdf

Fort Collins Native Seed Mixes
https://www.fcgov.com/developmentreview/pdf/seed-mixes.pdf?1516225380

The following documents provide additional information about what plants are applicable for LID facilities.

Colorado Native Plant Society Database
http://intermountainbiota.org/portal/checklists/checklist.php?cl=4172&pid=77
Alphabetical database of hundreds of plants commonly found in the Front Range biome, with links to detailed fact sheets, images and plant origins.

Colorado State University: Colorado Plant Database
http://jeffco.us/coopext/intro.jsp
Searchable database with photographs and information on plant origins.

Denver Green Infrastructure Guide
https://www.denvergov.org/content/dam/denvergov/Portals/705/documents/ultra-urban-green-infrastructure-guidelines.pdf
Metro-area-based resource that provides extensive plant lists as well as planting design suggestions for Low Impact Development.

Fort Collins Residential Parkway Landscaping
http://www.fcgov.com/utilities/img/site_specific/uploads/Parkway_landscape_brochure_2015_Web.pdf
Plant suggestions and design tips for planting within the parkways along residential streets.

Fort Collins Xeriscape Demonstration Garden
https://www.fcgov.com/utilities/img/site_specific/uploads/Xeriscape_Garden_Plant_List_Brochure_KS3).pdf
Brochure with a list of suggested xeric and low-water-use plants for Xeric installations in Fort Collins. Also includes a list of demonstration gardens in the City.

Fort Collins Xeriscape Design Brochure
http://www.fcgov.com/utilities/img/site_specific/uploads/xeriscape_design_booklet.pdf
Guide to laying out rain gardens with a palette of plant materials specifically selected for each design.

PlantSelect.org Planting Database
http://plantselect.org/plants/find-a-plant/
Plant database maintained by Colorado State University and the Denver Botanic Garden on plants uniquely suited for low-water and xeric growing conditions.

Rocky Mountain Plant Matrix
https://www.harvestingrainwater.com/wp-content/uploads/2015/11/Rocky-Mountain-Plant-Matrix.pdf
Require for selecting rain garden plantings.