LOW IMPACT DEVELOPMENT

HANDBOOK

2020

Prepared by:

Daniel Schuler
Plain City Public Works Director

Table of Contents

Appendices

1. Introduction

1.1 Purpose

The purpose of this handbook is to aide in understanding and complying with the Requirements of the Plain City Stormwater Program and fulfilling the regulations outlined in Utah's Municipal Separate Storm Sewer System (MS4) permit. This information is to provide guidance for individuals involved in new development and redevelopment projects. Specific audiences include developers, designers, contractors, homeowners, and City staff that are responsible for plan-checking, permitting, and inspections. Material covered in this handbook provides information on the City's project review and permitting process, identifies stormwater low impact development practices, and references source and treatment control BMP information.

1.2 Background

Polluted storm water runoff is often transported to municipal separate storm sewer systems (MS4s) and ultimately discharged into local rivers and streams without treatment. EPA's Storm Water Phase II Rule establishes an MS4 storm water management program that is intended to improve the Nation's waterways by reducing the quantity of pollutants that are introduced into storm sewer systems during storm events. Common pollutants include oil and grease from roadways, roadway salts and deicing materials, pesticides and fertilizers from lawns, sediment from construction sites, and carelessly discarded trash, such as cigarette butts, paper wrappers, and plastic bottles. When deposited into nearby waterways through MS4 discharges, these pollutants can impair the waterways, thereby discouraging use of the resource, contaminating water supplies, and interfering with the habitat for fish, other aquatic organisms, and wildlife.

In 1990, EPA promulgated rules establishing Phase I of the National Pollutant Discharge Elimination System (NPDES) storm water program. The Phase I program for MS4s requires operators of "medium" and "large" MS4s, that is, those that generally serve populations of 100,000 or greater, to implement a storm water management program as a means to control polluted discharges from these MS4s. The Storm Water Phase II Rule extends coverage of the NPDES storm water program to certain "small" MS4s but takes a slightly different approach to how the storm water management program is developed and implemented. Phase II communities are currently under regulations outlined in the general permit for discharge form Small Municipal Separate Storm Sewer Systems.

1.3 Scope

The scope of this handbook is to provide information relative to the State of Utah UPDES permit section 4.2.5.3.2 which states ""…the program shall include a process which requires the evaluation of Low Impact Development (LID) approach…", furthermore, "If an LID approach cannot be utilized, the Permittee must document an explanation of the reasons preventing this approach and the rationale for the chosen alternative controls on a case by case basis for the project."

2. Low Impact Development Principles and Stormwater Management Measures

2.1 What is Low Impact development

Low Impact development minimizes runoff and utilizes natural processes such as infiltration, evapotranspiration, stormwater harvesting, and natural filters. LID may also incorporate man made treatment or a combination of processes. This approach treats stormwater runoff as a beneficial resource and is intended to be utilized as close to the source as possible. LID use and planning is a systematic approach to stormwater management that when planned, designed, constructed, and maintained appropriately, can result in improved stormwater quality, improved local water bodies, result in more attractive landscapes, improved wildlife habitats, and elevated life style for all.

2.2 Why use Low Impact development

Good LID planning generally focuses on reduced runoff within the site and ultimately require fewer structural best management practices. These practices reduce the amount of runoff generated during a storm event, alleviate downstream erosion and filter out pollutants such as oil, bacteria, sediment, and nutrients. Proper planning for use of LID is essential for future land use and sustainable growth of the community. In developing a handbook, input from several disciplines such as planners, engineers, elected officials, developers, contractors and other design professionals can be incorporated to allow proper planning.

2.3 Developing a Low Impact Development Plan

Project applicants for all developments and redevelopments will be required to incorporate stormwater mitigation measures into their design plans and submit the plans and supporting documentation to the City for review and approval. The design plans will be subjected to a review process as indicated in Section 2, prior to the issuance of approvals for permits.

Projects are managed by two different categories. Small scale residential developments and large scale residential/commercial developments.

2.3.1 Small Scale Residential Developments

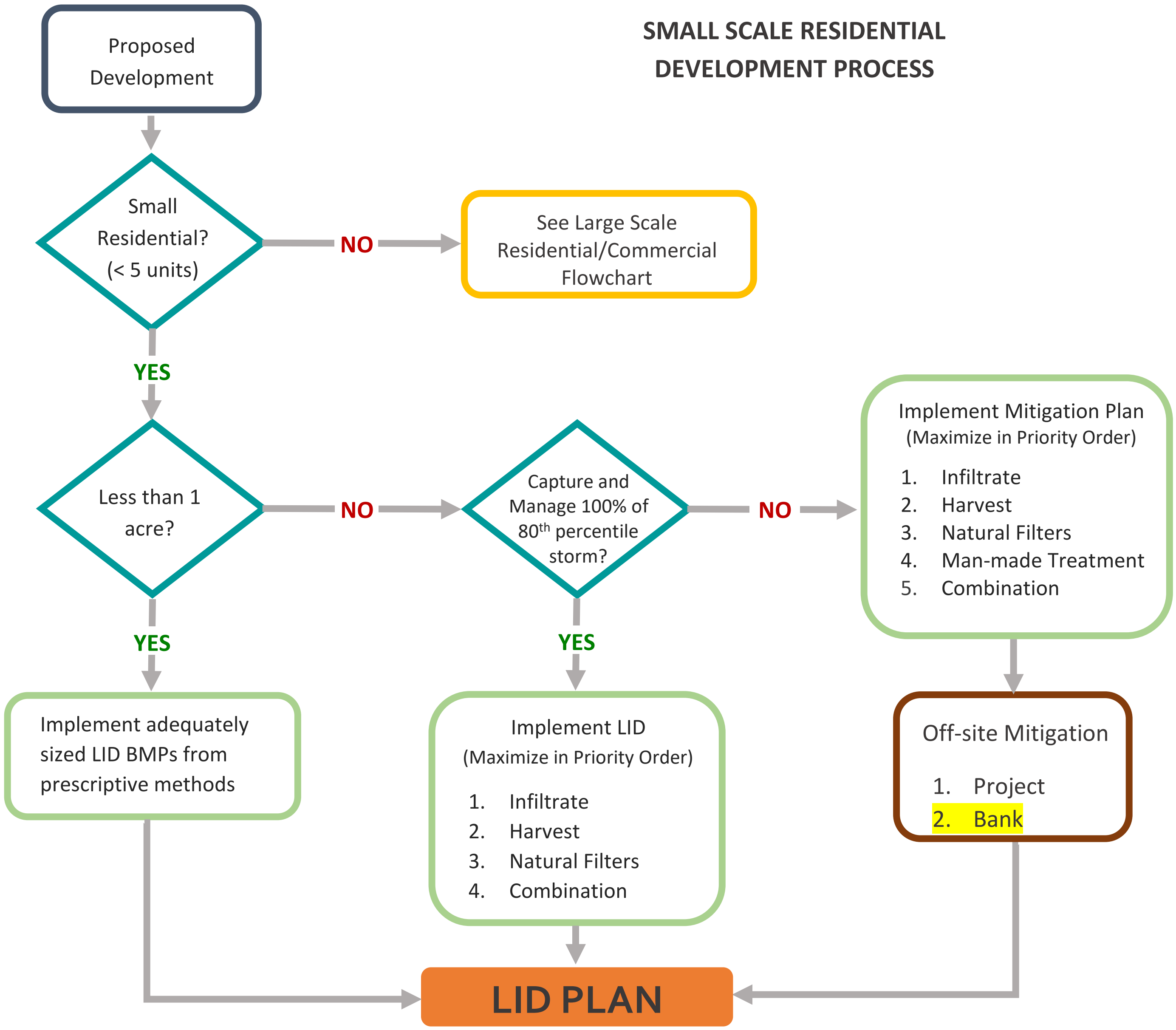
Small scale residential developments will generally include developments with five (5) building units or less. With small developments a simplified approach is adopted. Collecting stormwater on a development level and preparing a regional system is less beneficial with small developments. Approaching things on a building lot by building lot basis is the preferred approach.

Upon filing an application for a Building Permit, a separate plot plan identifying the LID BMPs that are used (including size) and drainage area tributary to each BMP shall be shown.

The following LID BMPs have been established as prescriptive LID improvement features to be employed on a qualifying small scale project. These BMPs are presented in the form of Fact Sheets in Appendix E, with the intent of providing self-contained BMP background context and sizing requirements to facilitate a permit applicant to follow and comply with the requirements outlined in section 2. Applicants may choose from one or more of the prescriptive BMPs to comply.

The prescriptive specific small scales BMPs (see Appendix E for details) include the following:

1. Rain Barrels
2. Permeable Pavements
3. Planter Boxes
4. Rain Gardens
5. Injection Wells


SMALL SCALE RESIDENTIAL DEVELOPMENT PROCESS
Proposed Development
Small Residential? (< 5 units)
NO
See Large Scale Residential/Commercial Flowchart
YES
Less than 1 acre?
NO
Capture and Manage 100% of 80th percentile storm?
NO
Implement Mitigation Plan (Maximize in Priority Order)
1. Infiltrate
2. Harvest
3. Natural Filters
4. Man-made Treatment
5. Combination
YES
Implement adequately sized LID BMPs from prescriptive methods
YES
Implement LID (Maximize in Priority Order)
1. Infiltrate
2. Harvest
3. Natural Filters
4. Combination
Off-site Mitigation
1. Project
2. Bank
LID PLAN

2.3.2 Large Scale Residential/Commercial Developments

Any new development or redevelopment project that does not meet the requirements of Section 3.1.2 – Small Scale Residential Development Projects, shall comply with this section.

An LID Plan shall be prepared to comply with the following:

1. Stormwater runoff will be infiltrated, evapotranspired, harvested, treated through natural filters, or through man made filters or a combination or processes as identified in Section 4. The onsite LID practices must be properly sized, at a minimum, to handle stormwater without any runoff leaving the site to the maximum extent feasible, for at least the volume of water produced by the 80^{th} percentile storm event.

2. Pollutants shall be prevented from leaving the development site for a water quality design storm event as defined above unless it has been treated through an onsite high removal efficiency biofiltration/biotreatment system.


Proposed Development
LARGE SCALE RESIDENTIAL/COMMERCIAL DEVELOPMENT PROCESS
Large Residential? (> 5 units)
NO
Commercial/ Industrial?
NO
See Small Scale Residential Flowchart
YES
YES
YES
Capture and manage 100% of 80th percentile storm?
Infeasible
Implement Mitigation Plan
(Maximize in Priority Order)
1. Infiltrate
2. Harvest
3. Natural Filters
4. Man-made Treatment
5. Combination
YES
Implement LID
(Maximize in Priority Order)
1. Infiltrate
2. Harvest
3. Natural Filters
4. Combination
Off-site Mitigation
3. Project
4. Bank
LID PLAN

2.4 Conserving Natural areas and protecting natural flow paths

Each project site possesses unique topographic, hydrologic and vegetative features, some of which are more suitable for development than others. Locating development on the least sensitive portion of a site and conserving naturally vegetated areas and natural flow paths can minimize environmental impacts in general and stormwater runoff impacts specifically.

2.5 Minimizing disturbed areas

If applicable and feasible for the given site conditions, the following measures are required and should be included in the project site layout:

1. Concentrate or cluster improvements on the least-sensitive portions of the site, while leaving the remaining land in a natural undisturbed state;
2. Limit clearing and grading of native vegetation at the site to the minimum area needed to build the home, allow access, and provide fire protection;
3. Maximize trees and other vegetation at the site by planting additional vegetation, clustering tree areas, and promoting the use of native and/or drought-tolerant plants; and preserve riparian areas and wetlands

3. BMP Prioritization and Selection

3.1 Best Management Practice Categories

BMPs shall be designed to manage and capture stormwater runoff. Infiltration systems are the first priority type of BMP improvements as they provide for infiltration of the stormwater into the ground, which not only reduces the volume of stormwater runoff entering the MS4, but in some cases, can contribute to groundwater recharge. If stormwater infiltration is not possible based on one or more of the project site conditions listed below, the developer shall utilize the next priority BMP.

The order of priority specified below shall apply to all projects categorized as large scale residential/commercial developments. Each type of BMP shall be implemented to the maximum extent feasible when determining the appropriate BMPs for a project.

1. Infiltration
2. Harvesting
3. Natural Filters
4. Combination of any of the above

If partial or complete onsite compliance of any type is infeasible, the project Site and LID Plan shall be required to document an explanation of the reasons preventing this approach and the rationale for the chosen alternative controls on a case by case basis for the project. The order of the priority below shall apply in mitigating runoff.

1. Infiltrate
2. Harvesting
3. Natural Filters
4. Man-made treatment
5. Combination of any of the above

Any remaining runoff that cannot feasibly be managed onsite must be mitigated under the offsite mitigation option in section 5.

3.1.1 Preservation

Preservation BMP are typically Non-structural. The following Non-structural BMPs have been adopted by the city

- Narrow Roads
- Cluster Development
- Open Space Preservation
- Minimum Landscape Requirements
- Eliminate Directly Connected Impervious Areas
- Minimize Disturbance

- Minimize Soil Compaction
- Natural Buffers

3.1.2 Infiltration Feasibility

When considering the feasibility of infiltration the following criteria shall be met:

- The lowest elevation of all retention facilities shall be a minimum of 5 feet above the seasonal high water table
- Retention volumes must infiltrate or evaporate within 3 days after a storm has subsided
- Retention facilities can be no closer than 15 feet from the nearest structural foundation
- Retention facilities can be no closer to the edge of asphalt for roads or parking lots than 5 feet unless the road section has been specifically designed to accommodate retention storage
- Retention facilities can be no closer than 50 feet horizontally from live streams or water bodies
- Retention facilities must be setback from the top of steep slopes (slopes exceeding 20%) at least 20 feet.
- Retention facilities cannot be placed on slopes exceeding 5%
- Retention shall not be allowed in areas where a licensed geotechnical engineer determines that infiltration would adversely impact the potential for geological hazards on the project site or on neighboring parcels of land

3.1.3 Retention/Infiltration

3.1.3.1 Infiltration basin

Infiltration basin consists of an earthen basin constructed in naturally pervious soils with a flat bottom typically vegetated with dry-land grasses or irrigated turf grass. An infiltration basin functions by retaining the design runoff volume in the basin and allowing the retained runoff to percolate into the underlying native soils over a specified period of time.

3.1.3.2 Infiltration Trenches

Infiltration trenches, which are similar to basins, are long, narrow, gravel-filled trenches, often vegetated, that infiltrate stormwater runoff from small drainage areas. Infiltration trenches may include a shallow depression at the surface, but the majority of runoff is stored in the void space within the gravel and infiltrates through the sides and bottom of the trench.

3.1.3.3 Underground Infiltration galleries

Infiltration galleries are open-bottom, subsurface vaults that store and infiltrate stormwater. A number of vendors offer prefabricated, modular infiltration galleries that provide subsurface storage and allow for infiltration. Infiltration galleries come in a variety of material types, shapes and sizes.

3.1.3.4 Pervious Surfaces

Pervious surfaces contain small voids that allow water to pass through to a stone base. They come in a variety of forms; they may be a modular paving system (concrete pavers, modular grass or gravel grids) or poured-in-place pavement (porous concrete, permeable asphalt). All pervious surfaces with a stone reservoir base treat stormwater and remove sediments and metals to some degree by allowing stormwater to percolate through the pavement and enter the soil below.

3.1.3.5 Dry Wells

A dry well is defined as an excavated, bored, drilled, or driven shaft or hole whose depth is greater than its width. Dry wells are similar to infiltration trenches in their design and function, as they are designed to temporarily store and infiltrate runoff, primarily from rooftops or other impervious areas with low pollutant loading. A dry well may be either a drilled borehole filled with aggregate or a prefabricated storage chamber or pipe segment.

3.1.3.6 Combined Measures

Any of the above infiltration type BMPs may be combined with any other BMPs to fit the site and to meet the allowable discharge requirements.

3.1.4 Stormwater Harvesting and Reuse

Stormwater harvesting and reuse refers to a specific type of BMP that operates by capturing stormwater runoff and holding it for efficient use at a later time. In the State of Utah to collect, store, and place the captured stormwater to a beneficial use a person must register the use with the Utah Division of Water Rights. BMPs sized to capture the runoff produced from the 80th percentile storm event, or BMPs designed to capture less than this volume, if being used in conjunction with other BMPs, must therefore drawdown their entire captured volume within 3 days of a likely storm event.

Stormwater harvesting BMPs designed for storm events larger than the 80th percentile storm event are required to disperse enough water from the BMP within 3 days of a likely storm event to ensure that adequate capacity is available to capture the next storm event up to 80th percentile storm event. In instances where the quantity of runoff from the 80th percentile storm event exceeds the volume of the collection tank, partial capture and use can also be achieved as part of a treatment train by directing the overflow to stable vegetated areas where erosion or suspension of sediment is not a factor or through a high flow natural filter type BMP to provide additional volume reduction and water quality treatment. Overflow from the tank into the storm drain system is not allowed.

Capture and use BMPs designed for these extended holding times will require additional treatment such as filtration or disinfection to protect the collection tanks from fouling, to prevent the breeding of vectors, and/or to improve the quality of water for reuse applications. These scenarios will be reviewed on a case-by-case basis

3.1.4.1 Rain Barrels

Rain Barrels are structures designed to intercept and store runoff from rooftops to allow for its reuse and volume reduction. As storm water is stored it is typically reused for irrigation or other water needs. Rail barrels are typically above ground small structures that are directly connected to rooftop downspouts. In the State of Utah a person may collect and store rain water without registering in no more than two covered storage containers if neither covered container has a maximum storage capacity of greater than 100 gallons.

3.1.4.2 Cisterns

Cisterns are similar to rain barrels and are designed to intercept and store runoff from rooftops to allow for its reuse and volume reduction. As storm water is stored it is typically reused for irrigation or other water needs. Cisterns are typically larger than rain barrels and have more storage capacity. In the State of Utah the total allowed storage capacity with registration is no more than 2,500 gallons. Collection and use are limited to the same parcel of land on which the water is captured and stored. Cisterns can be designed as either above or below ground structures. Above ground cisterns are to be secured in place and meet all applicable building standards.

3.1.4.3 Non-potable use

Typically, the use of collected stormwater will primarily be limited to irrigation purposes however there is potential for other uses of collected stormwater to be considered. Stormwater harvesting BMPs that are designed with the intent to use captured rain water for indoor or consumptive purposes will be reviewed on a case-by-case basis to ensure that all treatment, plumbing, and Building and Safety codes are met. May also require state department of environmental quality approval.

3.1.5 Natural Filters

Natural Filter facilities are landscaped shallow depressions that capture and filter stormwater runoff. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. Because they are not contained within an impermeable structure, they may allow for infiltration.

Projects that have demonstrated they cannot manage 100% of the water quality design volume onsite through infiltration and/or stormwater harvesting BMPs may manage the remaining volume through the use of a high removal efficiency natural filter BMP. A high removal efficiency natural filter BMP shall be sized to adequately capture **1.5** times the volume not managed through infiltration and/or capture and use. These systems often include an underdrain system to capture water after it has been filtered and keep from flooding localized areas.

3.1.5.1 Biofilter

Most natural filter systems can be classified as biofilters. They normally consist of a ponding area, mulch layer, planting soils, plants, and in some cases an underdrain. Runoff that passes through a biofiltration system is treated by the natural absorption and filtration characteristics of the plants, soils, and microbes with which the water contacts.

3.1.5.2 Rain Gardens

Rain gardens are simply gardens designed to capture and treat runoff. They are generally small in size and should not be used to treat impervious areas exceeding 4,000 square feet. Rain gardens most often utilize native plant species and soil amendments to encourage absorption of stormwater. For projects with impervious areas exceeding 4,000 square feet biofilters, planter boxes with infiltration, vegetated swales or natural buffer strips should be considered.

3.1.5.3 Planter Boxes with infiltration

Planter boxes with infiltration are natural filtration treatment control measures located in and around structures and facilities to handle larger volumes of water than a typical rain garden. They typically are constructed with vertical or near vertical sides and above ground. They can be equipped with underdrains if necessary. Planter boxes with infiltration should maintain setbacks from adjacent buildings, other structures, sidewalks or roadways.

3.1.5.4 Bio-Infiltration

Bio-infiltration facilities are designed for partial infiltration of runoff and partial biotreatment. These facilities are similar to bioretention devices with underdrains but they include a raised underdrain above a gravel sump designed to facilitate infiltration and nitrification/denitrification. These facilities can be used in areas where there are little to no hazards associated with infiltration, but infiltration screening does not allow for infiltration BMPs due to low infiltration rates or high depths of fill.

3.1.5.5 Vegetated Swales

Vegetated swales are open, shallow channels with dense, low-lying vegetation covering the side slopes and bottom that collect and slowly convey runoff to downstream discharge points. An effective vegetated swale achieves uniform sheet flow through the densely vegetated area for a period of several minutes. The vegetation in the swale can vary depending on its location and is the choice of the designer. Most swales are grass-lined.

3.1.5.6 Vegetated strips

Vegetated strips are vegetated areas designed to treat sheet flow runoff from adjacent impervious surfaces such as parking lots and roadways, or intensive landscaped areas such as golf courses. While some assimilation of dissolved constituents may occur, filter strips are generally more effective in trapping sediment and particulate-bound metals, nutrients, and pesticides. Filter strips are more effective when the runoff passes through the vegetation and thatch layer in the form of shallow, uniform flow. Filter strips are primarily used to pretreat runoff before it flows to an infiltration BMP or another natural filtration BMP.

3.1.5.7 Velocity Dissipaters

Velocity dissipaters are BMPs designed to slow the velocity and minimize erosive action of flowing water. Check dams and level spreaders are two kinds of velocity dissipaters that are commonly used. Check dams are designed to create a series of step-downs with pools in between while level spreaders are designed like weirs to spread the flow out and to control water levels. Level spreaders are commonly used in wetland areas to maintain a uniform distribution of water and keep the flows from channelizing.

3.1.6 Man-made Treatment

3.1.6.1 Planter boxes (no infiltration)

Planter boxes are bioretention treatment control measures that are completely contained within an impermeable structure with an underdrain (they do not infiltrate). They are similar to bioretention facilities with underdrains except they are situated at or above ground and are bound by impermeable walls. Planter boxes may be placed adjacent to or near buildings, other structures, or sidewalks.

3.1.6.2 Filtration Cartridges

Passing stormwater through a filtration fabric, plate, membrane or device is a viable option for treating stormwater. It is generally expensive to purchase and maintain and is therefore not frequently used. Forcing the water through the medium also usually results in head loss. Various fabrics or media will be considered on a case by case basis to meet the needs of a project.

3.1.6.3 Hydrodynamic Separators

Hydrodynamic separators are stormwater management devices that work primarily based on vortex and gravity principles to separate stormwater from the pollutants. They are generally designed as flow-through systems with either on-line or off-line storage of pollutants. They include chambers for settling and storage of pollutants and are often used in conjunction with other BMPs as pretreatment. They are not especially effective for the removal of fine materials or dissolved pollutants. On-line separators are more susceptible to scour or re-suspension of pollutants than systems that incorporate off-line storage. They are generally not designed to treat stormwater flows exceeding 25 cfs.

3.1.6.4 Safl Baffle

Safl Baffles are a brand name product designed primarily as a post-construction retrofit pretreatment system. They require a sump structure. A specially designed perforated metal plate is installed inside a sump manhole or vault. Water flows through the plate. This action facilitates improved settling and re-suspension characteristics. Sediment removal rates are generally less than with hydrodynamic separators. These baffles are a fair low cost alternative that require a minimal footprint. Sediments are stored in the lower reaches of the manhole or vault. Safl Baffles are not effective for floatables.

3.1.6.5 Skimmer

Skimmers are designed to trap floatables in a holding facility until they can be removed by absorbent materials or a vactor truck. They can take many shapes and sizes. They can be prefabricated or custom built to fit the needs of almost any project. They generally require a certain amount of standing water to maintain a seal so the floatables cannot escape. They also require relatively frequent inspection and maintenance because of small storage capacity. They work on the principle of baffles

3.1.6.6 Chemical Treatment

Chemical treatment of stormwater is difficult to do. Stormwater flowrates are highly variable as are pollutant concentration levels. Matching the chemical doses to the stormwater needs is very difficult and complex. Chemical treatment is not recommended for permanent long-term stormwater quality use. Chemical treatment will only be considered in extreme situations and on a case by case basis.

3.2 Sample Calculations

3.2.1 Calculating Size Requirements for Infiltration BMPs

The main challenge associated with infiltration BMPs is preventing system clogging and subsequent infiltration inhibition. In addition, infiltration BMPs must be designed to drain in a reasonable period of time so that storage capacity is available for subsequent storms and so that standing water does not result in unwanted conditions. Infiltration BMPs should be designed according to the requirements listed in Table 4.1 and outlined in the following text:

Infiltration facilities must be sized to completely infiltrate the water quality volume within **48 hours**.

Step 1: Calculate the Water Quality Volume

Infiltration facilities shall be sized to capture and infiltrate the water quality volume (WQV) based on the runoff produced from a 80^{th} percentile storm event. The 80^{th} percentile storm event is 0.48 inches or 0.04 feet.

WQV (cf) = (R_v * d * A)

Where:

R_v = Runoff Coefficient as determined in *"A Guide to Low Impact Development Within Utah"* *https://www.utah.gov/pmn/files/430229.pdf*

d = Rainfall depth in feet – equivalent to the 80^{th} percentile storm (0.48" or 0.04 feet)

A = BMP drainage area in square feet

Table 3-1: Infiltration BMP Design Criteria

Design Parameter	Unit	Basins and Trenches	Galleries	Permeable Pavement	Dry Well	Hybrid Bioretention/ Dry Well
Water Quality Volume, WQV	cubic feet	WQV = Rv x d x A				
Runoff Coefficient Rv	-	See "A Guide to Low Impact Development within Utah" https://www.utah.gov/pmn/files/430229.pdf				
d - Rainfall Depth	feet	80th percentile precipitation depth 0.04 ft (0.48")				
A - BMP drainage area	sf	Total gross square footage draining into BMP				
Design Surface Drawdown Time	hr	72				
Setbacks and Elevations	feet	In accordance with the Infiltration Feasibility Criteria, Section 3.1.2				
Pretreatment	-	Appropriate Treatment Control Measure shall be provided as pretreatment for all tributary surfaces other than roofs				
Hydraulic Conductivity, $K_{sat,measured}$	in/hr	NRCS Table 9.2 or field measured hydraulic conductivity at the location of the proposed BMP at the depth of the proposed infiltrating surface using a method approved by the City Engineer (5 in/hour max.)				
Factor of Safety, FS	-	5 if using NRCS Table 9.2; 3 if using field measurements				
Facility geometry	-	Bottom slope ≤ 3% (basins); side slope shall not exceed 3:1 (H:V)	Flat bottom slope	Pavement slope ≤ 5%; If ≥ 2%, area shall be terraced	Typical 18 – 36 inch diameter; flat bottom slope	Bioretention: Bottom slope ≤ 3%; side slope shall not exceed 3:1 Drywell: flat bottom
Ponding Depth	inch	18 (maximum)[a]				
Media Depth	feet	2 (min) 4 (max)	-	2 (min) 4 (max)	-	2 (min) 4 (max)
Gravel media diameter	inch	1 – 3	-	1 - 2	3/8 – 1	3/8 - 1
Inlet erosion control	-	Energy dissipater to reduce velocity				
Overflow device	-	Required if system is on-line and does not have an upstream bypass structure. Shall be designed to handle the peak storm flow in accordance with the Building and Safety code and requirements				

a: Ponding depth may vary for galleries (which have a storage depth) and may be different from one vendor to another. Ponding depth is not necessarily applicable to permeable pavement.

Step 2: Determine Infiltration Rate

The infiltration rate will decline between maintenance cycles as the surface becomes clogged with particulates and debris. It is important that adequate conservatism is incorporated in the sizing of facilities depending on a site's infiltration rate and expected surface loading. Where applicable, the measured infiltration rate discussed here is the infiltration rate of the underlying soils and not the infiltration rate of the filter media bed or engineered surface soils.

$$K_{sat,design} = K_{sat,measured}/FS$$

Where:

FS = Infiltration factor of safety, see Table 3-1

Step 3: Calculate the BMP Surface Area

Determine the size of the required infiltrating surface by assuming the water quality volume will fill the available ponding depth plus the void spaces based on the porosity of the gravel fill (normally about 30 - 40%) or amended soil (normally about 20 – 30%).

Determine the minimum infiltrating surface area necessary to infiltrate the design volume

$$A_{min} = (WQV \times 12 \text{ in/ft}) / (T \times K_{sat,\,design})$$

Where:

A_{min} = Minimum infiltrating surface area (sf),

WQV = Water Quality Volume (cf), see table 3-1 for calculation

T = Drawdown time (hours), 72 hours

$K_{sat,\,design}$ = design hydraulic conductivity determined in step 2 above

For infiltration basins, the surface area should be calculated as the surface area at mid-ponding depth. For infiltration trenches, the surface area should be calculated at the bottom of the trench.

Step 4: Calculate the Total Storage Volume

Determine the storage volume of the infiltration unit to be filled with media for capturing the water quality volume.

$$V_{storage} = WQV / n$$

Where:

Vstorage = Minimum media storage of the infiltration facility (cf)

WQV = Water Quality Volume (cf), see table 3-2 for calculation

n = void ratio

Step 5: Calculate the Media Storage Depth

Determine the depth of the infiltration unit to be filled with media for capturing the water quality volume.

$$Dmedia = Vstorage / Amin$$

Where:

Dmedia = Minimum media storage depth of the infiltration facility (ft)

Vstorage = Minimum media storage of the infiltration facility (cf), calculated in step 4 above

Amin = Minimum infiltrating surface area (sf), calculated in step 3 above

3.2.2 Stormwater Harvesting Calculations

Step 1: Perform site assessment to determine if harvesting is feasible such that the draw down can occur within 3 days. A site investigation may be necessary to understand if there is sufficient landscape to accommodate use.

Step 2: Determine storage volume

WQV (gallons) = (R_v * d * A) * 7.4805 gallons/ft^3

Where:

R_v = Runoff Coefficient as determined in *"A Guide to Low Impact Development Within Utah"* *https://www.utah.gov/pmn/files/430229.pdf*

d = Rainfall depth in feet – equivalent to the 80^{th} percentile storm (0.48" or 0.04 feet)

A = BMP drainage area in square feet

3.2.3 Natural Filter Calculations

Natural filter facilities can be sized using one of two methods: a simple sizing method or a hydrologic routing modeling method. With either method the water quality volume must be completely infiltrated within the drawdown time shown in Table 3-2. Steps for the simple sizing method are provided below. BMPs should be designed according to the requirements listed in Table 3-2 and outlined in the following text. Swales and filter strips must be handled as indicated in the following sections.

Table 3-2: Natural Filter BMP Design Criteria

Design Parameter	Unit	Rain Garden	Planter Box	Bioinfiltration	Vegetated Swale	Filter Strip
Design Volume, Vdesign	cubic feet	1.5 * WQV			-	-
Water Quality Volume, WQV	cubic feet	Rv x d x A				
Runoff Coefficient Rv	-	See "A Guide to Low Impact Development within Utah" https://www.utah.gov/pmn/files/430229.pdf			-	-
d - Rainfall Depth	feet	80th percentile precipitation depth 0.04 ft (0.48")			-	-
A - BMP drainage area	sf	Total gross square footage draining into BMP			-	-
Design – Surface Drawdown Time	hr	48			-	-
Factor of Safety	-	3			-	-
Soil Media Infiltration Rate	in/hr	5 (max)			-	-
Design Contact Time	min	-			≥ 7	
Slope in Flow Direction	%	-			1% (min) 6% (max)	2% (min) 33% (max)
Design Flow Velocity	ft/sec	-			≤ 1	
Maximum Ponding/Flow Depth	inch	18	12	18	5	1
Minimim Width	ft	6			2	15
Soil Depth	ft	2 (3 preferred) Topped with 3” of mulch			2	-
Underdrain	-	Slotted PVC pipe embeded in 12” gravel section and located 1” from bottom of facility		Slotted PVC pipe at least 2’ above bottom of facility	N/A	Not required

Step 1: Calculate Design Volume

Biofiltration facilities shall be sized to capture and treat 150% of the water quality volume (*WQV*) based on the runoff produced from a 0.48-inch (0.04 ft) storm event.

*Vdesign = 1.5*WQV* (cf) = 1.5* (R_v * d * A)

Where:

WQV(cf) = R_v * d * A

R_v = Runoff Coefficient as determined in *"A Guide to Low Impact Development Within Utah"* *https://www.utah.gov/pmn/files/430229.pdf*

d = Rainfall depth in feet – equivalent to the 80^{th} percentile storm (0.48" or 0.04 feet)

A = BMP drainage area in square feet

Step 2: Determine Infiltration Rate

The infiltration rate will decline between maintenance cycles as the surface becomes clogged with particulates and debris. It is important that adequate conservatism is incorporated in the sizing of facilities depending on a site's infiltration rate and expected surface loading. Where applicable, the measured infiltration rate discussed here is the infiltration rate of the underlying soils and not the infiltration rate of the filter media bed or engineered surface soils.

Ksat,design = Ksat,measured/FS

Step 3: Calculate Ponding Depth

Select a ponding depth (*dp*) that satisfies geometric criteria and is congruent with the constraints of the site. The ponding depth must satisfy the maximum ponding depth constraint shown in Table 4.2 as well as the following:

dp (ft) = (Ksat,design x T) / 12

Where: *dp* = Ponding depth (ft)

Ksat,design= Design infiltration rate of filter media (in/hr)

T = Required surface drain time (hrs), from Table 4.2

Step 4: Calculate Surface Area

Amin = (Vdesign) / (Tfill x Ksat/12)+ d)

Where:

Vdesign = Design Volume, see step 1 above

Amin = Design infiltrating area (ft2)

Tfill= Time to fill to max ponding depth with water (hrs) [unless a hydrologic routing model is used, assume a maximum of 3 hours]

Ksat,design= Design infiltration rate of filter media (in/hr)

The calculated BMP surface area only considers the surface area of the BMP where infiltration through amended media can occur. The total footprint of the BMP should include a buffer for side slopes and freeboard.

3.2.4 Swale Sizing

Swales shall be designed with a trapezoidal channel shape with side slopes of 3:1 (H:V). They shall incorporate at least two feet of soil beneath the vegetated surface. Swale sizing will be determined on a case-by-case basis. As is the case with other biofiltration BMPs, the sizing criteria presented in Table 4-2 must be met.

3.2.5 Filter Strip Sizing

Because filter strips are most often used for pretreatment purposes, their design will depend on the desired flow-rate to be treated and the type of BMP downstream, among other factors. As a result, filter strip sizing is not covered in this handbook, but will be determined on a case-by-case basis.

4. Offsite Mitigation Measures

4.1 Offsite Mitigation Measures

Offsite mitigation shall only be utilized after on-site mitigation opportunities are exhausted. If on-site mitigation meets the minimum requirements no off-site mitigation will be required. The following criteria shall be implemented in considering off-site mitigation:

1. Locate off-site projects as close as possible to the project site.
2. Locate off-site projects within the same sub-watershed as the proposed project.
3. Off-site projects may be completed on either private or public land.
4. Secure needed easements and rights to the property on which off-site projects are completed.
5. Demonstrate that same level of water quality protection is achieved as if all the runoff were retained on-site.
6. Demonstrate that the off-site project when combined with on-site mitigation addresses the same volume of water that would have been addressed if BMPs were all constructed on-site.
7. The developer shall execute an Agreement in Perpetuity with the city and recorded with the property, for on-going maintenance and upkeep of both on-site and off-site BMP(s).

4.2 Regional Facilities

In lieu of an independent off-site mitigation project designed specifically to meet the needs of a given project, the developer may be able to work together with the City and/or other groups to construct a larger regional water quality mitigation project. If a regional project is pursued, the following criteria should be considered:

1. An agreement shall be obtained with the City and/or other partners for the design, sizing, construction and maintenance of the regional facility.
2. The regional facility shall be sized to accommodate the water quality needs of all interested parties.
3. The same net level of water quality protection shall be achieved for the combined facility as would be required for each separate entity as if they were separate and distinct facilities.
4. The same total volume of water required to be addressed at each individual and independent site shall be addressed as the accumulated total volume at the regional facility.
5. All Maintenance Agreements in Perpetuity that would have been required for each separate facility shall be addressed in agreement(s) for the regional facility and shall be recorded with each parcel encompassed as part of the regional facility.

4.3 Mitigation Banking

If neither an off-site mitigation project nor a regional mitigation project can be feasibly constructed at the time of development, the City may consider allowing the purchase of credits in a water quality treatment mitigation bank. Mitigation banking is intended to allow for the restoration, creation, enhancement and, in exceptional circumstances, preservation of wetlands and/or other aquatic resources expressly for the purpose of providing compensatory mitigation in advance of authorized impacts to similar resources.

The objective of the mitigation bank is to provide for the replacement of the functions of the previously undisturbed natural ground and habitat as it relates to stormwater discharge volumes and water quality as a result of authorized impacts. Using appropriate methods, the newly established functions are quantified as mitigation “credits” which are available for use by the bank sponsor or by other parties to compensate for adverse impacts. The use of credits may only be authorized when adverse impacts are unavoidable. Credits may only be authorized when on-site compensation is either not practicable or use of a mitigation bank is environmentally preferable to on-site compensation.

Mitigation banks provide greater flexibility to applicants needing to comply with mitigation requirements and can have several advantages over individual mitigation projects, some of which are listed below:

- It may be more advantageous for maintaining the integrity of the aquatic ecosystem to consolidate compensatory mitigation into a single large parcel or contiguous parcels when ecologically appropriate;
- Establishment of a mitigation bank can bring together financial resources, planning and scientific expertise not practicable to many project-specific compensatory mitigation proposals. This consolidation of resources can increase the potential for the establishment and long- term management of successful mitigation that maximizes opportunities for contributing to biodiversity and/or watershed function;
- Use of mitigation banks may reduce permit processing times and provide more cost-effective compensatory mitigation opportunities for projects that qualify;
- Compensatory mitigation is typically implemented and functioning in advance of project impacts, thereby reducing temporal losses of aquatic functions and uncertainty over whether the mitigation will be successful in offsetting project impacts;
- Consolidation of compensatory mitigation within a mitigation bank increases the efficiency of limited agency resources in the review and compliance monitoring of mitigation projects, and thus improves the reliability of efforts to restore, create or enhance wetlands for mitigation purposes.

The overall goal of the mitigation bank is to provide economically efficient and flexible mitigation opportunities, while fully compensating for water quality and quantity impacts in a manner that contributes to the long-term hydrological functioning of the natural watershed within which the bank is located. In some cases, banks may also be used to address resource objectives that have been identified in a storm water quality Master Plan or Retrofit Plan. It is desirable to set the particular objectives for a mitigation bank (i.e., the volume and peak flow rate for a given sub-watershed, sediment or other pollutant removal rates, and/or volume reductions) in advance of site selection. The site selected should support achieving the goals and objectives.

Policies and considerations for establishing mitigation banks are found in supporting documents found in Appendix F.

The Developer shall work with the City to identify or establish an appropriate mitigation bank and associated credits and fees. Fees typically will be established based on peak flow rate and/or total volume of stormwater discharge being mitigated for. If contributing to an established mitigation bank, credit and fee structure should be previously established.