Water & Sewerage Department

CITY OF DETROIT

Drainage Program Guide

October 2022

The Drainage Program Guide

The purpose of this guide book is to provide a reference for DWSD customers, engineering consultants, landscape architects and other professionals on DWSD's Drainage Charge & Credit Program.

Table of Contents

Chapter 1: Drainage Charge

This chapter describes how the drainage charge is calculated.

Contents

1.1 Drainage Charge Applicability

Parcels that meet the criteria below will receive a drainage charge.

a. The parcel is located within the City of Detroit, or is outside of the City of Detroit, but has a direct connection to a DWSD sewer;

b. The parcel contains 0.02 or more acres of impervious surface(s).

Did You Know?

An acre equals 43,560 square feet

Drainage charges are applied to all parcel ownerships and classifications. The parcel may be owned by a resident, business, governmental, or tax exempt organization. It may be classified by the City Assessor's Office as industrial, commercial, residential, or tax exempt. Drainage charges are billed on all parcels whether or not there is water service provided to the parcel or if the water service is active.

A limited number of parcels outside of the City are also charged for drainage, if they are directly connected to the Detroit Water and Sewerage Department's (DWSD) sewers. This happens in a few isolated locations near the City limits or when a property owner owns land both inside the City and in an adjacent community and it is determined that runoff generated by the property enters the DWSD system.

The Michigan Department of Transportation (MDOT) and the Wayne County roadways that connect to DWSD's sewer system are also assessed a drainage charge for their impervious surface(s).

1.1.1 Properties Exempt from Drainage Charges

Parcels with less than 0.02 acres of impervious area are exempt from the drainage charge.

1.1.2 Drainage Charge Credits

The following properties may be eligible for drainage charge credits:

- Residential and non-residential properties that have downspouts directed to vegetated areas
- Residential and non-residential properties that have flow from impervious areas directed to vegetated areas
- Properties with green infrastructure practices or other stormwater management practices.
- Properties that discharge runoff generated by impervious areas directly to the Detroit or Rouge Rivers

1.2 Parcels and Properties

1.2.1 Parcel Information

DWSD develops the impervious area data from aerial photography and obtains information on parcel configuration and ownership from the City of Detroit Assessor's office.

1.2.2 Parcel Ownership Information

Parcel ownership information is based on assessor data information. Typically, for a parcel that has an existing water and sewer account with DWSD, the drainage charge will be included on the water and sewer account bill. Parcels that do not have an existing water and sewer account with DWSD will be issued a separate drainage charge bill.

Assessor data is used to designate ownership. DWSD obtains information from the Assessor's Office to update ownership and configuration data. See *Chapter 2: Drainage Charge Bill Adjustment* for instructions on how to address incorrect ownership information.

1.2.3 Combined Parcels

In some instances, what functions as a single property may consist of more than one parcel. See Figure 1.

The drainage charge is assessed to a parcel and bills are generated for each parcel. Customers who own several parcels and wish to receive just one bill, are advised to "combine parcels" (the joining of multiple parcels into a single parcel recorded at the Assessor's Office.) Please refer to *Chapter 2: Drainage Charge Bill Adjustment* for information on how to simplify your bill.

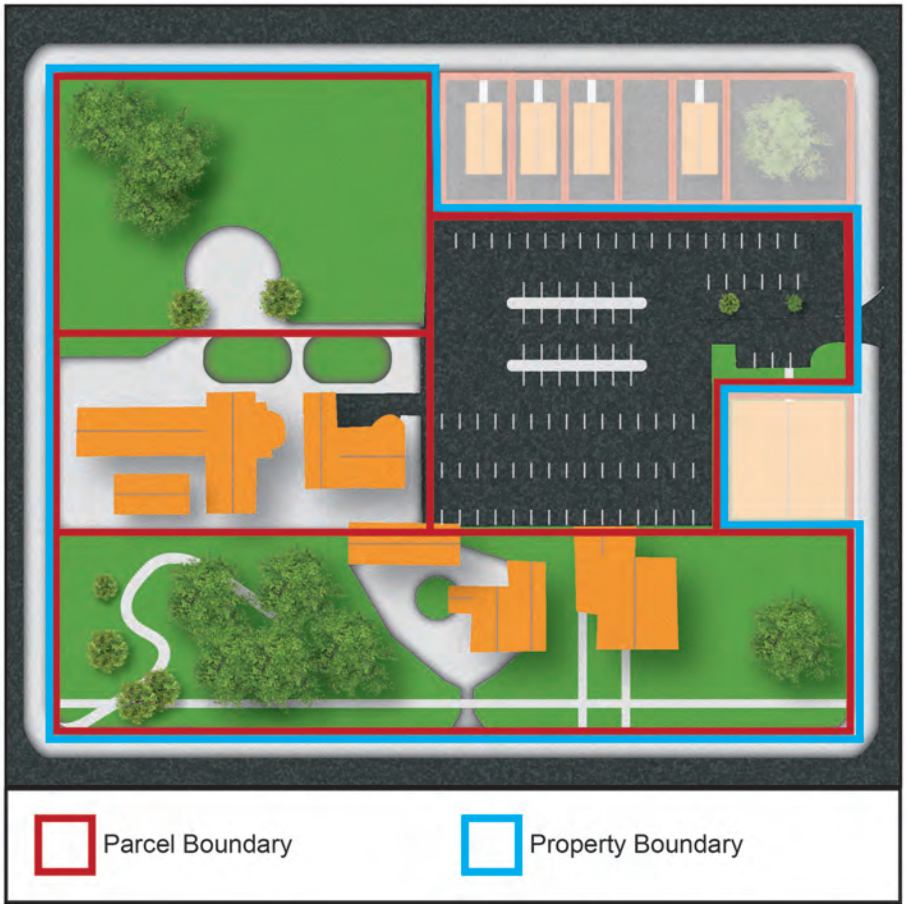


Figure 1: Multiple Parcel Property

1.2.4 Vacated Right-of-Way

A drainage charge will also be assessed for properties that own the vacated Right-of-Way. An example of a property owning a right-of-way is in Figure 2.

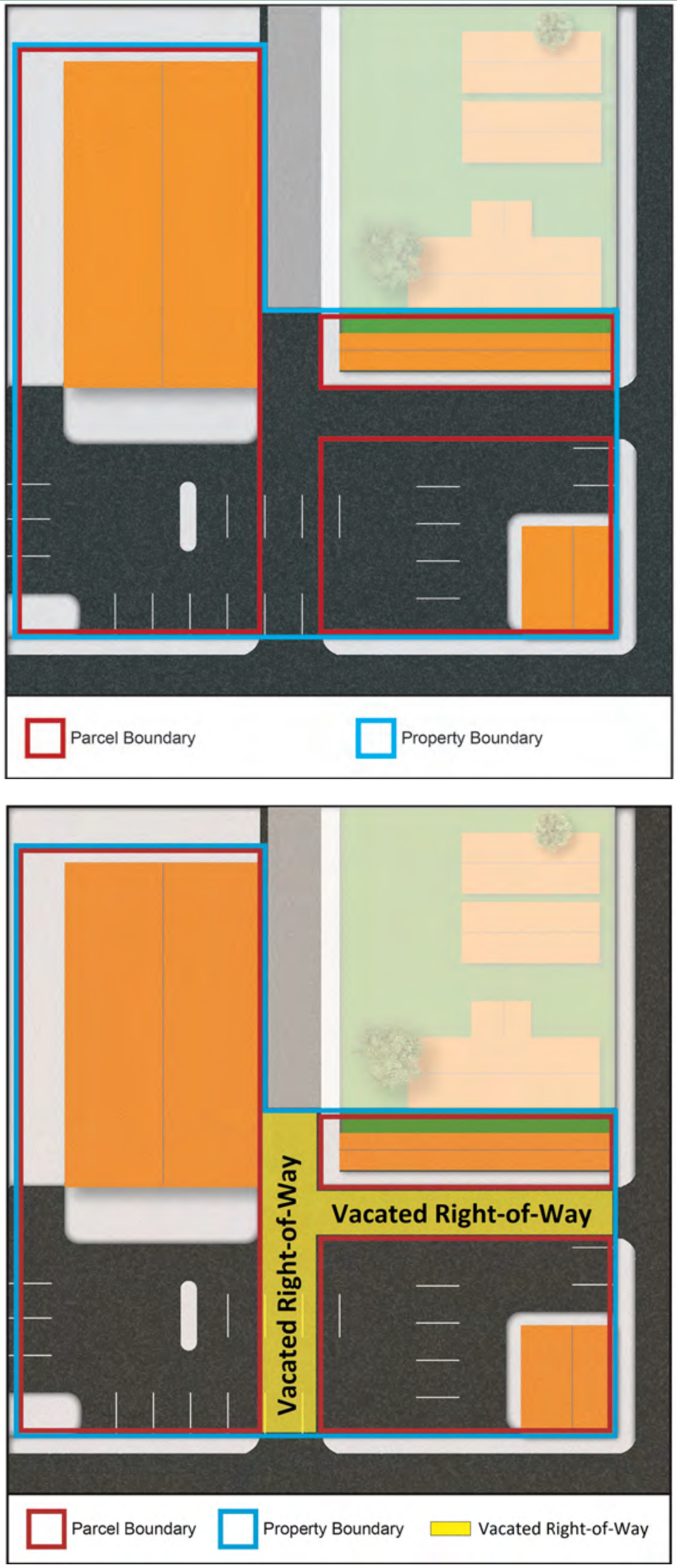


Figure 2: Vacated Right-of-Way vs. Not Vacated Right-of-Way

1.3 How the Drainage Charge is Calculated

The drainage charge applies to any parcel with 0.02 acres or more of impervious surfaces. Customers will be billed based on the total impervious acres of their parcel multiplied by the current fiscal year impervious acre rate approved by the Board of Water Commissioners.

The fundamental drainage charge calculation for customers is:

Drainage charge = Total impervious surface area of the parcel x Impervious acre rate (dollars per acre per month)

See Figure 3 as an example for drainage charge calculation.

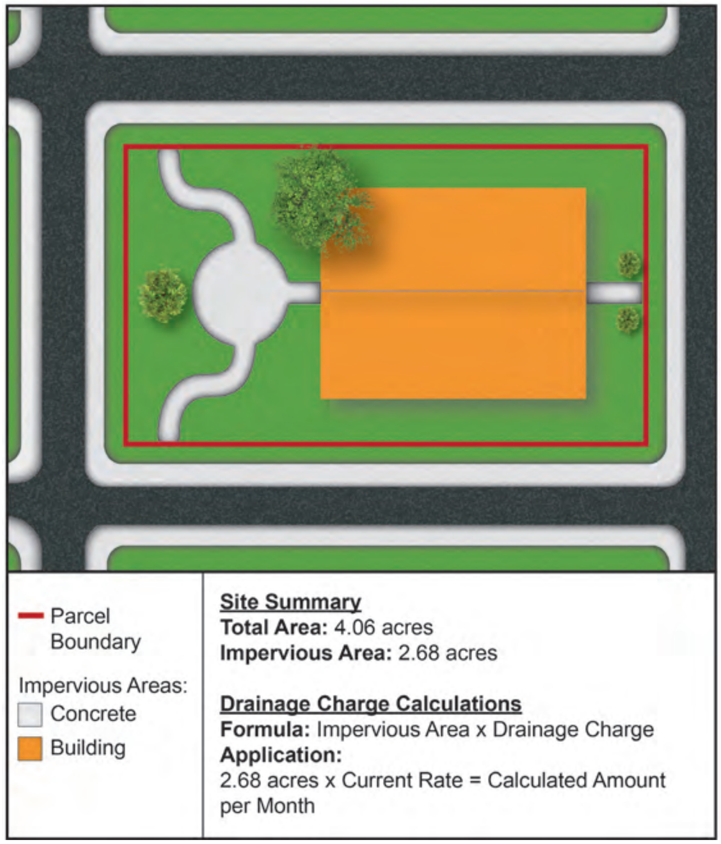
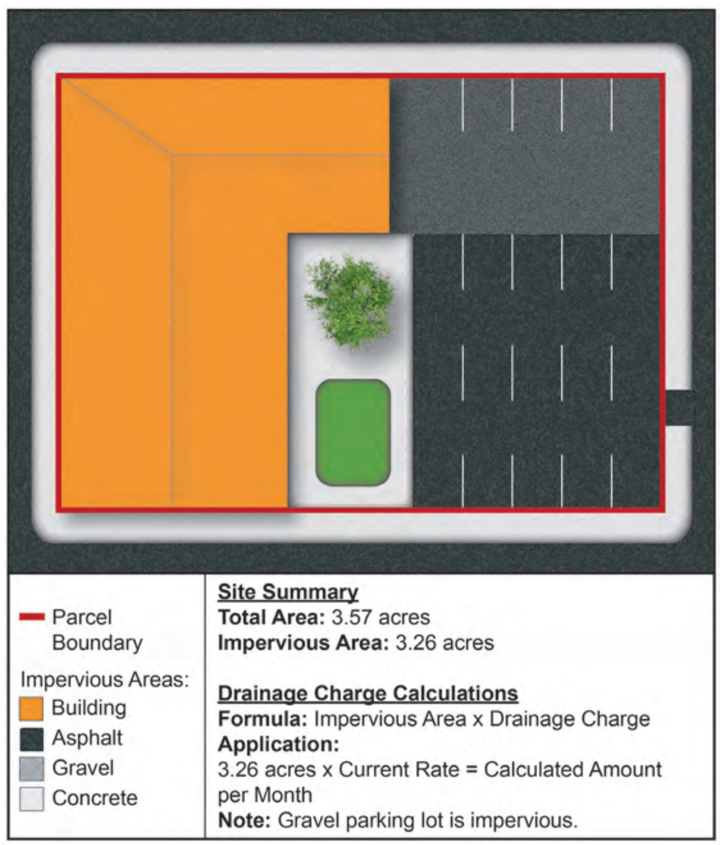


Figure 3: Example Calculation for Drainage Charge



1.4 Impervious Surface Area

The definition of impervious areas is:

Hard surface areas which either prevent or delay the entry of water into the soil in the manner that such water entered the soil under natural conditions pre-existent to development, or which cause water to run off the surface in greater quantities or at an increased rate of flow than that present under natural conditions pre-existent to development, including but not limited to such surfaces as roof tops, gravel, asphalt or concrete paving, driveways and parking lots, walkways and sidewalks, patio areas, storage areas, or other surfaces which similarly affect the natural infiltration or runoff patterns existing prior to development.

Important note: Any surface that experiences routine vehicular traffic (e.g., gravel, dirt, and grass) is considered impervious regardless of surface material as it causes compaction.

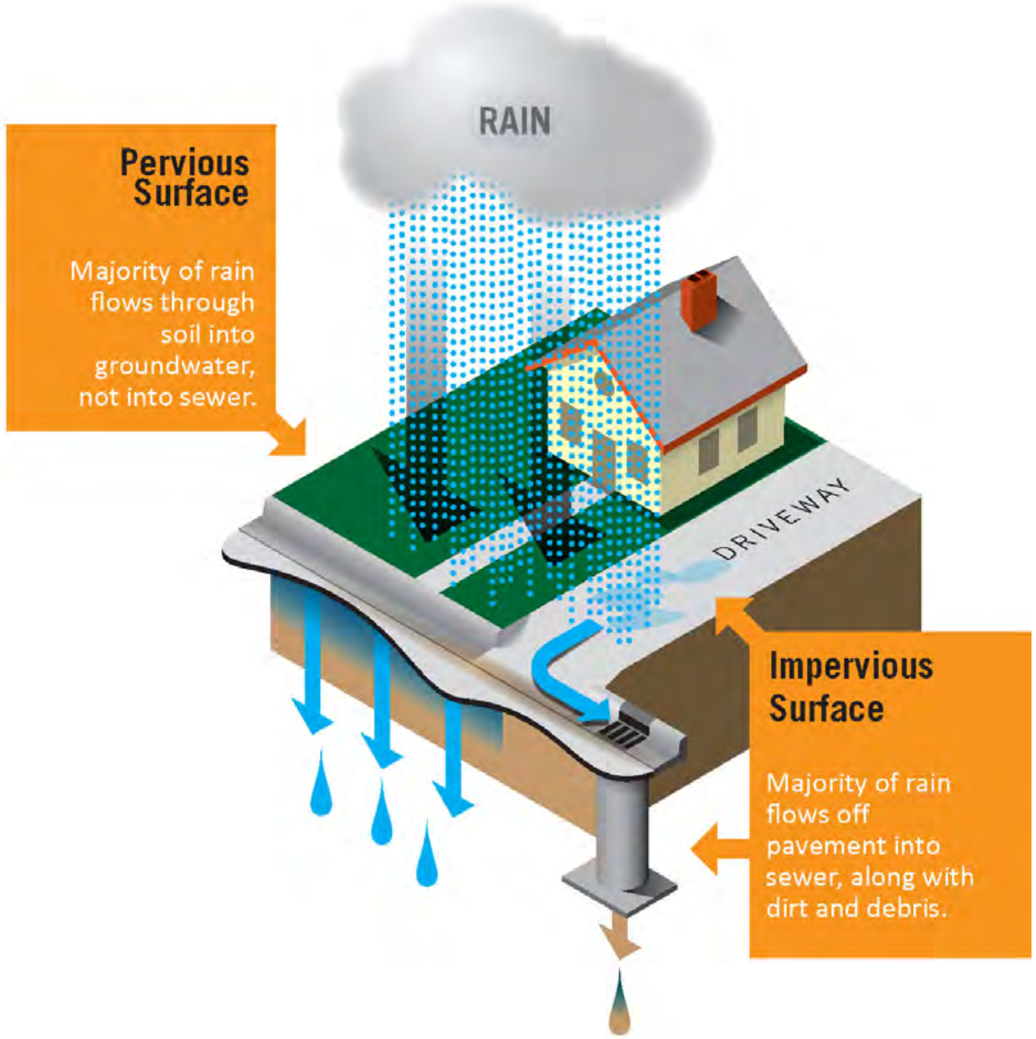
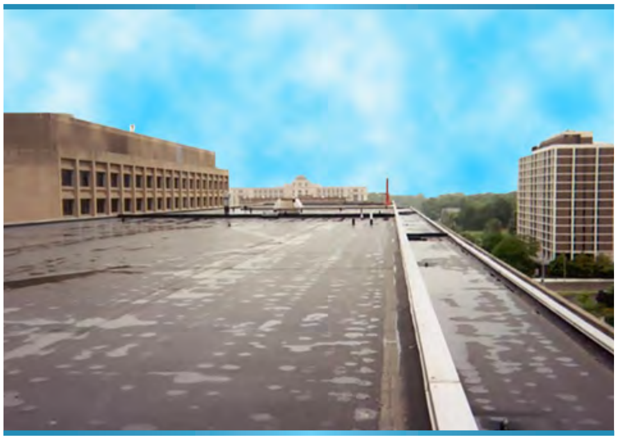


Figure 4: Impervious Area versus Pervious Area

Examples (not an all inclusive list) of impervious surface areas are included in the following table and pictures.

TABLE 2 - Impervious Surface Areas			
Land Cover Type	**Impervious**	**Pervious**	**Stormwater Practice***
Buildings and roofs	✓		
Concrete (parking, driveways, sidewalks, etc.)	✓		
Asphalt (parking, driveways, sidewalks, etc.)	✓		
Brick surface (parking, driveways, sidewalks, etc.)	✓		
Any gravel or dirt surface that is used for vehicular traffic (driving or parking)	✓		
Uncompacted dirt/gravel (no vehicular traffic)		✓	
Decks, pavement below	✓		
Decks, vegetation or earth below		✓	
Stockpiled dirt/gravel/sand/ other materials		✓	
Railroads with gravel ballast		✓	
Gravel or decorative stone used for landscaping (not compacted, open- graded)		✓	
Gravel walkway (No vehicular traffic)		✓	
Impervious area covered with a minimum of 2'-0" dirt surrounded by pervious area		✓	
Lawn, vegetated areas		✓	
Permeable pavement*	✓		✓
Ponds (natural, ornamental)		✓	
Buildings with green roofs*	✓		✓
Swimming pools		✓	

*Eligible for a stormwater management practice credit.



Impervious Roof Area

Impervious Roof Area

Impervious Parking Lot

Impervious Parking Lot

Impervious Gravel Parking Lot

Impervious Gravel Parking Lot

Compacted Gravel Parking Lot

Compacted Gravel Storage Yard

Impervious Driveway

Impervious Sidewalk

Impervious Brick Patio

Impervious Concrete and Brick Plaza

Impervious Pavilion with Roof

Impervious Concrete Patio

Impervious Roof and Concrete on an Industrial Property

Impervious Roof and Concrete at a Gas Station

The following images are examples of areas that are considered PERVIOUS.

Pervious Railroad Ballast

Pervious Railroad Ballast

Pervious Stockpile

Pervious Stockpile

Pervious Gravel and Garden

Pervious Landscaping

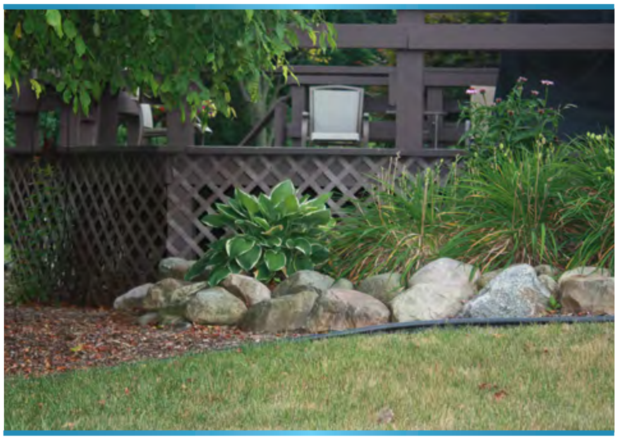
Pervious Walkway Open Aggregate

Pervious Lawn

Pervious Mulch and Garden

Pervious Lawn and Forested Area

Deck with Open Aggregate Undercover



Deck with Vegetative Undercover

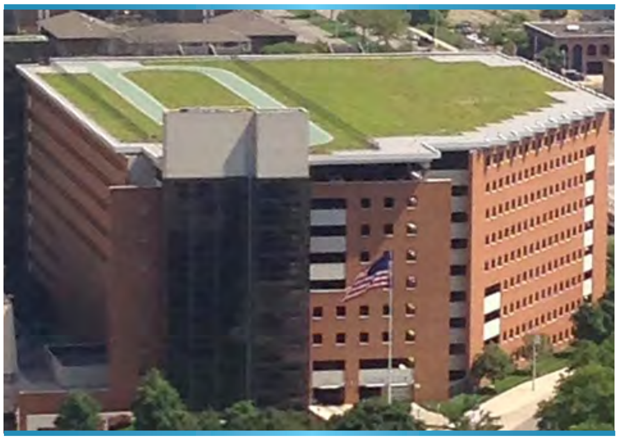
Natural Pond

Ornamental Pond

Ornamental Pond

Swimming Pool

The following images are considered stormwater practices and not pervious areas.



Green Roof

Green Roof

Green Roof

Green Roof

Permeable Pavement

Permeable Pavement

1.4.1 How is Impervious Acreage Determined?

The amount of impervious area for each parcel is determined by examining aerial photography from the latest available flyover. Impervious acreage is determined by overlaying the parcel's legal boundaries with the impervious area delineation from the aerial photography. Property ownership data for each parcel is drawn from data managed by the City Assessor's office. Individual properties may be updated as information becomes available.

The current values used by DWSD for each parcel can be found on the Parcel Viewer at [www.detroitmi.gov/DWSDParcelViewer].

Figure 5: Screen Shot of the Parcel Viewer

DWSD recognizes the limitations of aerial photography to define site characteristics. A mechanism for review of the impervious surface quantification is described in *Chapter 2: Drainage Charge Bill Adjustment*.

1.4.2 Precision of the Measurement

The parcel impervious area is measured in acres, to the 0.01 (hundredth) of an acre. This acreage is equal to approximately 435 square feet or approximately the size of a two-car garage.

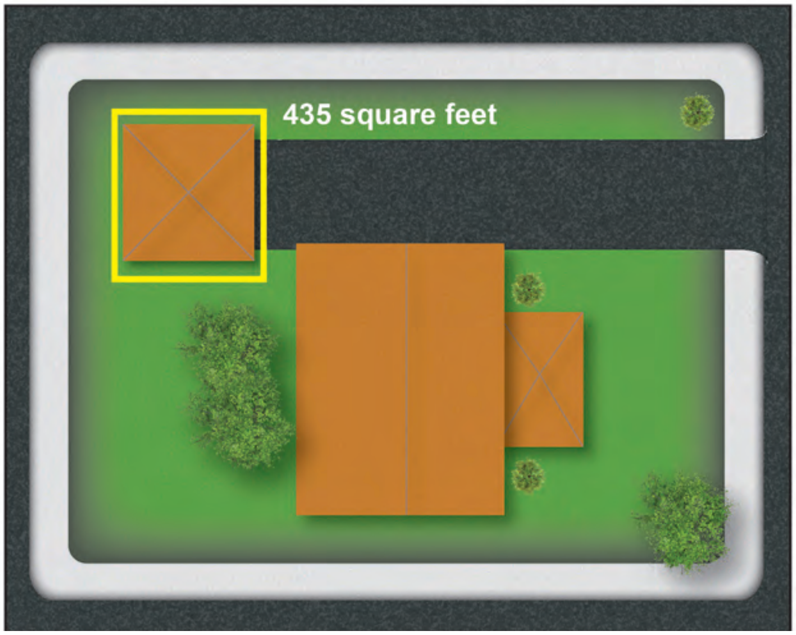


Figure 6: Representation of 435 Square Feet

1.4.3 Billable Impervious Area

For billing purposes, charges will be based on the impervious area in increments of 0.01 acre. The value calculated for acres will be truncated, not rounded. Parcels with an impervious area that truncates to 0.01 acres or 0.00 acres will not be assessed a drainage charge.

Site Characteristic	Area (sf)
Buildings	10,400
Pavement	11,300
Sidewalk	2,500
Green Space	11,000
Total	**35,200 or 0.808 acres**
Impervious Area	**24,200 or 0.558 acres**
Billed Impervious Area	**0.55 acres**

Figure 7: Example of Truncation to 0.01 Acres

Impervious surfaces located within the public right-of-way (sidewalks, driveway approaches) are not charged to the adjacent parcel. An exception to this is when the parcel occupies the adjacent vacated right-of-way. Refer to Figure 2.

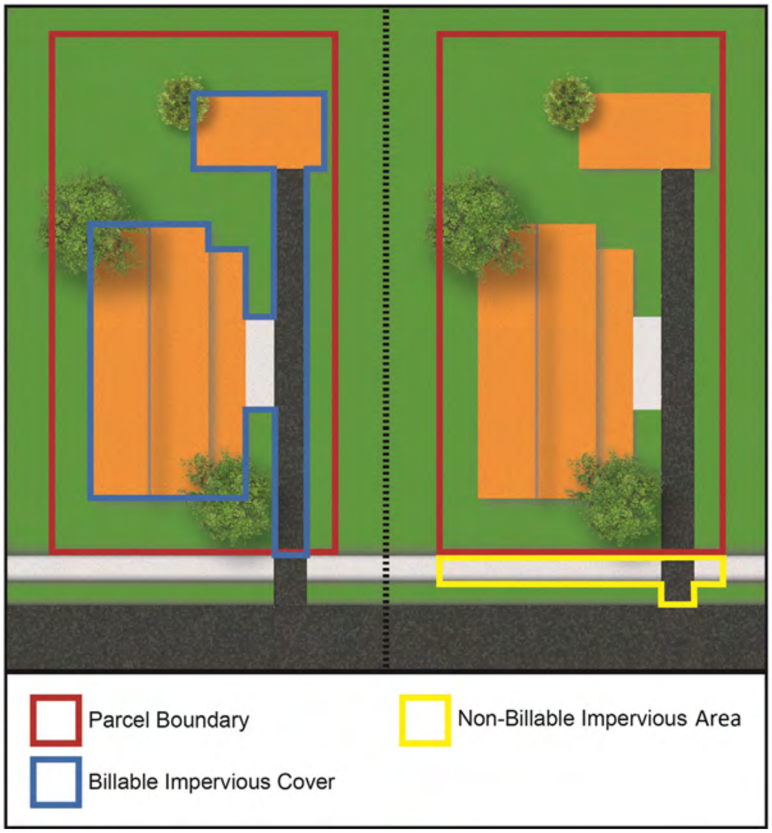


Figure 8: Parcel versus Right-of-Way Impervious Area

1.5 The Linkage Between Accounts and Parcels

Drainage charges are based on the measured impervious area of individual parcels. In many, if not most cases, these drainage charges are a component of a water, sewer, and drainage bill that is the responsibility of the property owner.

In some cases one water/sewer connection may serve multiple parcels. In this case, the property owner will receive multiple drainage charges. The parcels without a water/sewer account would receive a bill that only contains drainage charges.

In other cases, like strip malls or multi-family properties, a single parcel may have more than one water/sewer meter (see Figure 10). In this case, the drainage charge goes to the parcel owner unless requested by the owner to bill to the tenants under the submission owner/tenant agreement.

For condominiums and/or townhouses, DWSD will send one monthly bill to the master homeowners association (HOA) account. It is DWSD's recommendation that the HOA pay the total bill and assess the fees among the HOA's individual unit owners. If the HOA prefers to opt-out of master account billing and wishes for DWSD to send bills to individual unit owners, the association must submit a request in writing, along with a list of owner names, percent ownership, parcel numbers and DWSD billing information for each individual unit. This request and supporting information must be received by March 31 of every year or DWSD will not be able to make this change prior to the fiscal year, beginning July 1.

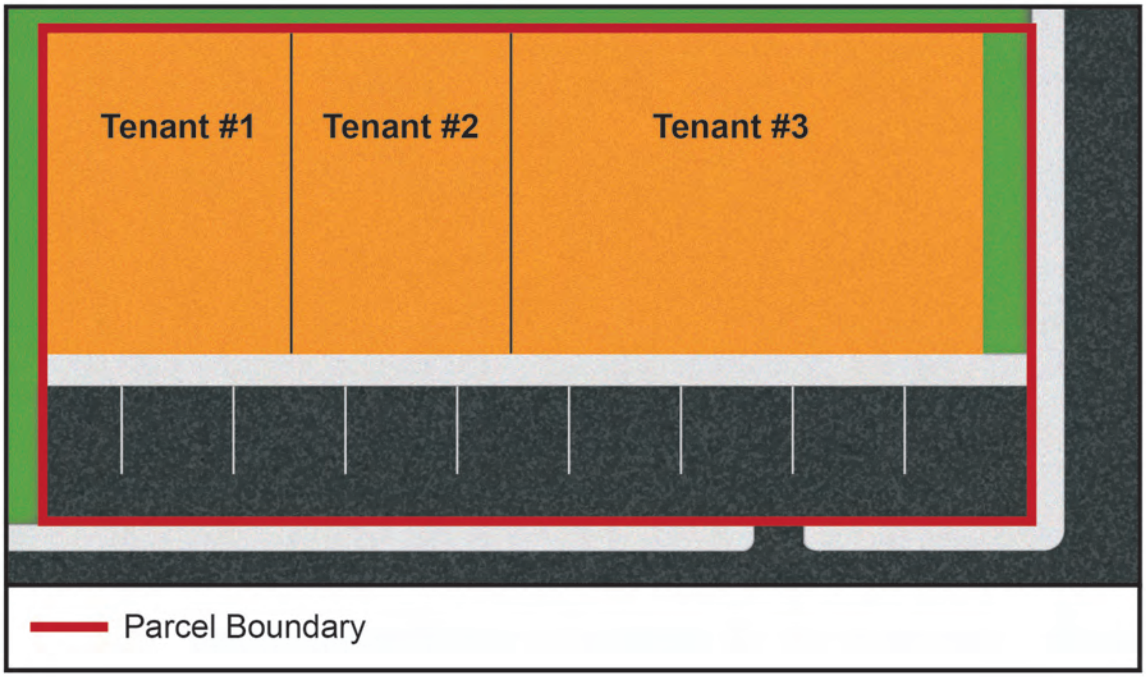


Figure 10: One Owner, Multiple Tenants

1.6 Payment Responsibility

The drainage charge for a property is the responsibility of the property owner. The charge may be assigned to a tenant if the entire parcel or property is leased to the tenant and the tenant is responsible for water and wastewater charges. However, a landlord/tenant agreement must be on file with DWSD for the tenant to be responsible for these charges.

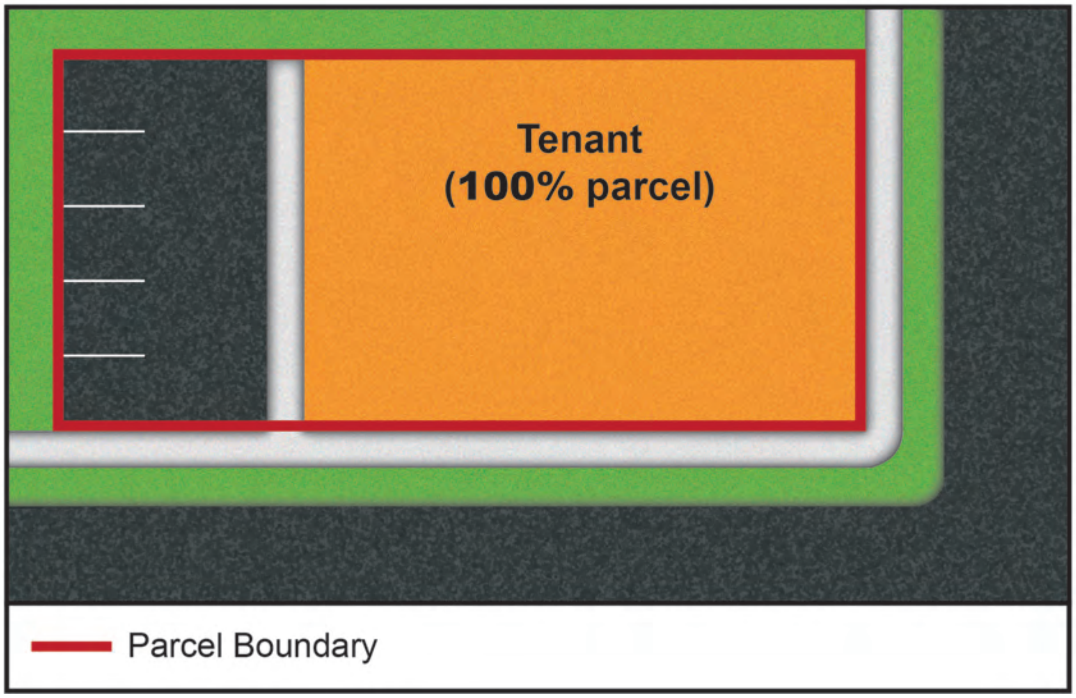


Figure 11: One Owner, One Tenant

Chapter 2: Drainage Charge Bill Adjustment

This chapter describes how customers can either: (a) simplify their bill; or (b) request modifications to the data that the Detroit Water & Sewerage Department (DWSD) uses in computing their charge. DWSD tries to use the best data available to ensure that properties are accurately charged for drainage. However, DWSD recognizes that changes to a parcel can happen at anytime. For customers whose bills are inaccurate because of outdated or incorrect data, DWSD has a process for customers to seek an adjustment of the billing data.

This chapter describes the options available to make adjustments to information about your property that is used by DWSD to generate your drainage charge bill.

Contents

2.1 Adjustments

DWSD will update drainage charge billing information when data is proven to be outdated or incorrect. All customers may apply for applicable adjustments to correct data used in billing. The account must be in the customer's name. A customer may file an application for one or more reasons regarding incorrect parcel information outlined in the following section. Please refer to the section on Adjustment Application Procedures for information on application procedures and for the necessary forms and supporting documentation requirements.

2.1.1 Ownership Adjustments

- If a customer is billed for a parcel that they do not own, the incorrect parcel information is typically due to: 1) an incorrect mailing address; 2) the account is not associated with the correct parcel; or 3) the property has been sold (and the deed has not yet been properly recorded at the Assessor's Office), or the most recent assessor data has not been merged into the DWSD billing system.
- Parcel size or parcel configuration inaccuracies may be due to recent parcel splits, purchase or sale of a portion of a parcel, or consolidations, or otherwise inaccurate parcel boundary delineations. Since adjustments of this nature may affect the legal description of the property, the customer will be referred to the Assessor's office.

2.1.2 Geographic Information System Polygon Orientation Correction

The geographic information system (GIS) is the data management system that contains the parcel shape and is used to determine the impervious acreage of a parcel. A customer may apply for an adjustment if they believe the GIS parcel polygon provided by the Assessor's Office is not aligned correctly and this discrepancy results in a change in the impervious area calculation for the site.

Did You Know?

435 square feet is approximately equal to a two-car garage

NOTE: Impervious area adjustments **435 square feet** or less will not be made to a parcel because the calculations used in determining impervious areas already provides an allowance of this amount of area. Impervious area measures are truncated to 0.01 of an acre in the data management system.

Figure 1: Parcel Boundary and Aerial Image

2.2 Impervious Area Modification

The following sections are for applications related to outdated or incorrect impervious area information.

2.2.1 Impervious Area Adjustments

A customer may apply for an adjustment if the parcel's total impervious area is outdated or incorrect. Impervious area adjustments may result from development or redevelopment projects. For example, the addition or removal of a building or structure.

The impervious area adjustment also applies to modifications made by the customer to their property to reduce the impervious area. An example of this situation is the removal of impervious surfaces such as parking lots replaced with landscaped/planted areas (pervious areas).

2.2.2 Impervious Classification

A customer may apply for an impervious area adjustment if the parcel or a portion of the parcel which is pervious, appears as an impervious area in the parcel viewer. The customer needs to provide site photographs to confirm that areas classified as impervious meet the definition of pervious in order to reclassify the area as a pervious surface. DWSD may perform a site inspection to verify the property data.

NOTE: Customers may not apply for an adjustment to the drainage charge for any routinely driven on surface (e.g., gravel, dirt, and grass areas). Such surfaces impede the infiltration of water and are therefore deemed impervious.

2.3 Adjustment Application Procedures

The purpose of the adjustment application process is to enable customers to seek adjustments for inaccurate parcel boundaries or sizes, incorrect parcel identification, or for errors in the calculation of a parcel's impervious area as outlined in the previous sections.

To view information related to your property, please see the link to the Parcel Viewer at [www.detroitmi.gov/DWSDParcelViewer]. This site includes information for each parcel in DWSD's service area, including pervious, impervious, and total acreage.

Figure 2: Screen Shot of the Parcel Viewer

2.3.1 Adjustment Application

A property owner, owner's authorized representative, or account holder may initiate a Drainage Charge Adjustment Application (Figure 3). The customer may question multiple issues in a single adjustment application.

2.3.2 Supporting Documentation

For all applications, the customer should provide a brief written description of the reason for the drainage charge adjustment request. Additionally, the following documentation must be provided along with the Drainage Charge Adjustment Application.

2.3.2.1 Ownership Adjustments

Supporting documentation recommended for this type of adjustment will depend on the reason for the request.

- Incorrect mailing address: current owner and mailing address for parcel, if known
- Property sale or split/combination: Attach a copy of legal document
- Water account associated with incorrect parcel: copy of water bill

DWSD Drainage Program
6425 Huber Street
Detroit, MI 48211
313-267-8000 (option 6)
drainage@detroitmi.gov

Drainage Charge Adjustment Application
(Please fill out one form per parcel)

Use this application to report updates to parcel information and/or changes to the amount of impervious area for any adjustments to the drainage charge.

Note: The effective date of any adjustments resulting from review of the application will be a maximum of 21 days prior to the date the application was received by the Department depending upon the billing cycle.

Email completed application and supporting documentation to:
drainage@detroitmi.gov **or fax to: 313-842-6495**

Alternatively, application can be mailed to:
DWSD Drainage Program
6425 Huber Street
Detroit, MI 48211

1. **Property Owner:** ______________________
(Must match owner name in the City Assessor's parcel database/records. If owner name is different, provide legal documentation.)
2. **Mailing Address:** ______________________
Street Address City Zip
3. **Phone:** ______________ 4. **Email:** ______________
5. **Authorized Representative, if any (name, address, email, contact number):**
____
6. **Service Address:** ______________________
Street Address City Zip
7. **Parcel ID:** ______________
8. **DWSD Account No.:** ______________
9. **Property Classification:**
   - ☐ Residential
   - ☐ Commercial
   - ☐ Industrial
   - ☐ Faith Based
   - ☐ Tax Exempt

Figure 3: Drainage Charge Adjustment Application

2.3.2.2 GIS Polygon or Impervious Area or Impervious Classification Adjustments

Supporting documentation recommended for this type of adjustment will depend on the reason for the request. Customers must provide adequate evidence supporting the requested impervious area for their site by providing evidence such as:

- Site plan
- Site photographs
- Marked-up image showing correct parcel boundary and/or impervious area (this image could be taken from the Parcel Viewer)
- Other information

2.3.3 Application Forms

The Drainage Charge Adjustment Application is available online at: www.detroitmi.gov/Drainage-Guides-and-Forms.

FACT

If DWSD is unable to make a determination based on the information submitted, then DWSD may request additional information.

2.3.4 Application Submission

The completed application and the supporting documentation can be emailed to: drainage@detroitmi.gov or faxed to: 313-842-6495.

Alternatively, applications can be mailed to:

DWSD Drainage Program
6425 Huber Street
Detroit, MI 48211

Customers with additional questions should call: 313-267-8000, option 6.

Adjustments to the legal description of a property must be made at the Assessor's office located in the Coleman A. Young Building, 2 Woodward Avenue, Detroit, MI 48226. Questions regarding adjustments to a parcel or a property's legal description should call: 313-224-3011.

2.3.5 Adjustment Application Denials

If the customer disagrees with DWSD's adjustment decision, the customer may appeal the decision to the Dispute Review Panel (DRP) within 30 days of the date of the determination letter. To file an appeal of the determination, the customer must submit a written letter requesting an appeal of DWSD's determination and include all of the following:

1. A copy of the decision letter that you are appealing.
2. A copy of any and all documentation that support your appeal.
3. A concise, yet detailed, statement of the basis for your appeal.

Appeal requests can be mailed to the Office of General Counsel:

ATTN: Dispute Review Panel
735 Randolph Street, 9th floor
Detroit, MI 48226

Appeal requests can also be emailed to branchni@detroitmi.gov.

2.3.6 Property Owner Responsibilities

DWSD customers are responsible to provide data that demonstrates that the drainage charge is not accurate. Customers are responsible for the cost incurred in the preparation of any necessary supporting data or required documentation.

Customers are advised to continue paying in full, regardless of the submittal/pending status of an adjustment application. The effective date of any adjustment resulting from review of the application will be a maximum of 28 days prior to the date the application was received by the Department depending upon the billing cycle.

If the customer is notified that an application is incomplete, they will have 30 days to provide the required information or to contact DWSD to request additional time to provide the missing information. If the application is not administratively complete or if DWSD has not been contacted by the customer, the application will be closed 30 days after notification, however the customer may resubmit an application when they have the requested information.

2.3.7 DWSD Responsibilities

It is DWSD's responsibility to review completed applications and notify the customer in a timely fashion of any missing information necessary to process the application and make a decision. DWSD will notify the customer in writing upon completing the technical review of the application.

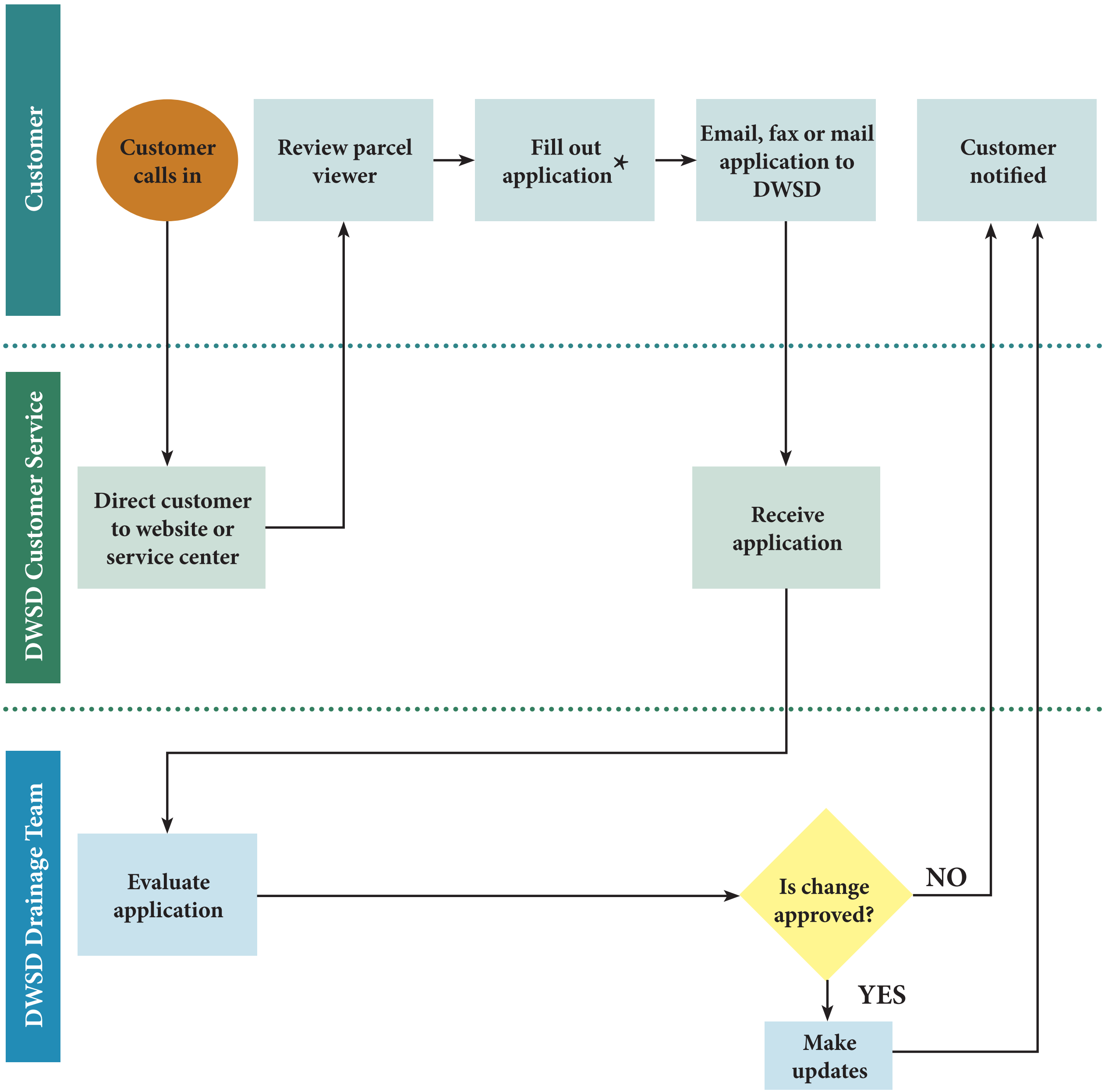
2.3.8 Adjustment Credit Date for Impervious Area Adjustment

Once approved, the effective date of the bill adjustment for parcel application will be a maximum of 28 days prior to the date the application was received by the Department depending upon the billing cycle.

NOTE: Following the submission of an application form, DWSD may need to inspect the subject parcel to verify the accuracy of the information provided in the application form. DWSD will provide sufficient written notice to the customer of their intentions to inspect the property and request access to the parcel. Inspections will be conducted within normal business hours and without unreasonable disruption to business operations. Failure of an applicant to make appointments upon request will result in rejection of the adjustment application.

FACT

Drainage charge adjustments will be based on the information provided and may result in a drainage charge increase. DWSD may revoke the adjustment if they later determine that the information provided in the application is inaccurate.



*Customer must file within 28 days of receipt of monthly bill.

Figure 4: Customer Adjustment Process

Chapter 3: Drainage Charge Credits

A drainage charge credit is a reduction in the drainage charge to a property based on the implementation and continuing proper operation of a stormwater management practice, also referred to as Green Stormwater Infrastructure (GSI) and/or Direct Discharge to surface water (i.e. Detroit and Rouge Rivers). Customers are encouraged to adopt sustainable methods of stormwater management practices that reduce stormwater flows to the drainage system, enhance the natural environment, and protect against flooding and sewer overflows. The installation of stormwater management practices that result in a measurable reduction in volume and/or peak flow rates will qualify the property owner for a credit to their bill.

This chapter provides an overview of the types of credits available for common stormwater management practices.

Contents

3.1 Stormwater Management Practices

Stormwater management practices, such as Green Stormwater Infrastructure (GSI), are designed or constructed to reduce or control the volume and/or rate at which stormwater leaves a site. Stormwater management practices can be structural or non-structural. Stormwater management practices may use vegetation, soils, and other elements to restore some of the natural processes that reduce runoff. Examples of stormwater management practices include disconnected downspouts, rain gardens, bioretention practices, permeable pavement, green roofs, and detention ponds.

1. *Disconnected Downspout*
2. *Bioretention in an Open Space*
3. *Bioretention in Parking Lots*
4. *Subsurface Detention Storage*
5. *Traditional Detention Basin*

3.2 Direct Discharge to Surface Waters

Properties that are located near a surface water, such as the Detroit or Rouge River, have an opportunity to manage their site's stormwater runoff by directly discharging to the surface water. The runoff can be routed to the surface water using conveyance methods such as piping, sheet flow, trench drains, etc. preventing water from entering the DWSD sewer system.

3.3 Removing Impervious Area

Reducing a drainage charge does not necessarily require implementation of a structural stormwater management practice. By simply reducing the impervious area on a property, customers reduce the amount of stormwater leaving their property and thus reduce their drainage charge. Examples of impervious area reduction include removal of asphalt or concrete parking spaces and replacing the impervious area.

Note: Because the drainage charge is calculated using the amount of impervious area on a site, the removal of impervious area is not considered a drainage charge credit but rather an adjustment to the impervious area.

IMPORTANT:
Removal of excess parking requires zoning review by the City's Building Safety Engineering & Environmental Department (BSEED).

3.4 Drainage Charge Credits

A drainage charge credit is a reduction in the drainage charge to a property based on the implementation and continuing proper operation of a stormwater management measure. This can be achieved through the implementation of GSI and/or Direct Discharge to the Detroit or Rouge River.

3.4.1 Drainage Charge Credits - Direct Discharge

For Direct Discharge, the amount of the drainage charge credit is determined based on how much of the total site impervious area is discharging to surface water (Detroit or Rouge River). Direct Discharge credits of up to 100% of the total drainage charge may be earned.

3.4.2 Drainage Charge Credits - GSI

For GSI, the amount of the drainage charge credit is determined based on how well a customer can control the volume and peak flow characteristics of their runoff. Credits of up to 80 percent of the total drainage charge bill may be earned for reductions of:

- Annual Volume of Flow (40%)
- Peak Flow Rate (40%)

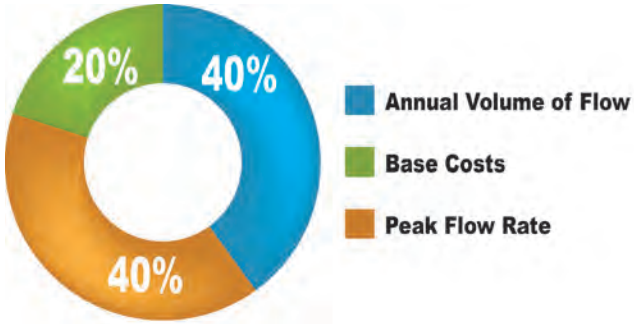


Figure 1: Drainage Charge Credits

3.4.3 Volume-Related Costs

The vast majority of stormwater that enters Detroit's combined sewer system reaches the wastewater treatment plant (WWTP). Detroit's share of the cost associated with running the regional WWTP is based on the total volume of flow from the City. In addition, some components of the cost associated with combined sewer overflow (CSO) control facilities such as chemical use and power use, are also related to flow volume. Efforts that customers make to reduce the total volume of flow that is handled by the sewer system over the course of the year helps to reduce these costs to DWSD.

3.4.4 Peak Flow Rate Related Costs

Detroit has invested approximately $1 billion in CSO facilities since the 1990's. These facilities treat overflows caused by large storm events. Detroit faces the prospect of being mandated to invest up to $2 billion in additional costs (based on 2010 reports) to control additional CSO points along the Detroit and Rouge Rivers if stormwater management practice measures prove insufficient to prevent overflows.

When customers implement measures to limit the peak rate of flow from their properties to the sewer system it helps to reduce the need for these facilities. The majority of peak flow related costs are for the construction and ongoing operation expense of the CSO facilities.

Detroit's Wastewater Treatment Plant

3.4.5 Base Costs

In addition to the costs associated with the WWTP and the CSO facilities, DWSD operates an extensive system of sewers and pump stations. These system elements are necessary to make centralized sewer and stormwater management practice services available. The systems must be maintained in order to be ready to serve each property in the City. In addition, there are various costs associated with administering the drainage charge system such as data management, billing, customer service, and credit administration.

Conner Creek CSO

3.4.6 Volume Credit

Volume-based drainage charge credits are determined based on the average annual volume reductions that result from managing stormwater on-site. The annual runoff volume is computed prior to and after construction of the stormwater management practice. The volume credit is calculated as the fraction of average annual runoff volume that is reduced as a result of implementing stormwater management practices on-site.

$$\% \, Volume \; Credit = \frac{Average \; Annual \; Runoff \; Volume \; Retained}{Total \;\; Average \; Annual \; Runoff \; Volume}$$

As the maximum credit that can be earned for volumetric control is 40 percent, the result of the above equation is multiplied by 40 percent. The site credit is prorated based on how much of the site is managed.

3.4.7 Peak Flow Credit

Peak flow-related drainage charge credits are based on the ability of the site to control peak flows of stormwater. Generally this credit is earned by the construction of an above or below ground detention system. In order to qualify for a peak credit, the detention system MUST have a controlled outlet. Once the system has a controlled outlet, the peak flow credit is calculated as the fraction of the volume associated with a 100-year, 24-hour rain event that is detained.

$$\%\ Peak\ Flow\ Credit = \frac{Storage\ Volume\ Provided}{100 - yr, 24 - hr\ Storage\ Volume\ Required}$$

As the maximum credit that can be earned for peak flow control is 40 percent, the result of the above equation is multiplied by 40 percent. The site credit is prorated based on how much of the site is managed.

In order to earn a peak flow credit, the outlet capacity for the managed portion of the site must be less than or equal to 0.15 cfs/acre.

3.4.8 How Much Credit Will Various Practices Earn?

Various types of stormwater management practices are able to control either annual volume, peak flow or both. Table 1 identifies anticipated ranges of credit that various common stormwater management practices can earn. The credit applies to the area draining to the stormwater management practice. Common stormwater management practices are described in the following sections.

TABLE 1 - Credits for Commonly Used Stormwater Management Practices

Practice Type	Volume Credit	Peak Flow Credit	Potential Credit for Area Managed (%)
Downspout disconnection	✓		**0-40**
Disconnected impervious area	✓		**0-40**
Bioretention	✓	✓	**0-80**
Detention basins		✓	**0-40**
Subsurface detention storage		✓	**0-40**
Permeable pavement	✓	✓	**0-80**
Green roof	✓		**0-40**
Water harvesting*	✓	✓	**0-80**

**For water harvesting, peak flow volume evaluated on a case-by-case basis.*

DID YOU KNOW?

Retention is the process of permanently keeping stormwater from leaving a property. It can be accomplished through infiltration, evaporation, transpiration (water uptake through plants) or water reuse. This process helps to remove volumes of stormwater from the sewer system. ***It is through retention that a site achieves a volumetric credit.***

Detention is the process of temporarily storing stormwater runoff to mitigate sewer overflows. This process helps reduce the flow rate (volume per unit time) of stormwater through the sewer system. This stormwater is released into the system at a slower rate than water is coming in. ***It is through detention that a property qualifies for a peak flow credit.***

3.4.8.1 Downspout Disconnection

Downspout disconnection is the process of disconnecting roof downspouts from the sewer system and redirecting the roof runoff onto pervious surfaces, most commonly a lawn. This reduces the amount of directly connected impervious area in a drainage area.

Typically an existing downspout is cut above ground level. An elbow and an extension are then added to the downspout in order to divert rainwater and snowmelt away from the building or structure and onto the ground. The abandoned drain pipe is then capped. A splash pad may also be attached at the end of the downspout extension to prevent erosion in garden areas and help direct the flow of water.

Required for credit: Disconnected downspouts must be directed to pervious or lawn areas that will not result in flooding, icing hazards or discharge to public right of ways and/or neighboring properties. They must be properly extended away from the building foundation.

Increasing a credit: The credit for downspout disconnection is directly related to the size of the lawn area or the type of outlet location (lawn or bioretention area). Generally, larger lawn areas and more highly designed stormwater management practices may result in a larger credit.

Extended Downspout

3.4.8.2 Disconnected Impervious Area

When impervious surface areas such as roofs, driveways, sidewalks, and parking lots are directed to pervious areas that allow for infiltration, customers may qualify for a disconnected impervious area credit. The pervious area to which stormwater is directed may be a grass lawn or vegetated landscaped area.

Required for credit: Disconnected impervious areas must be directed to pervious or lawn areas that will not result in flooding, icing hazards or discharge to public right of ways and/or neighboring properties.

Increasing a credit: The credit for disconnected impervious areas is directly related to the size of the pervious vegetated area where the stormwater is directed. Larger ratios of pervious area to impervious area will result in higher credit percentages.

3.4.8.3 Bioretention

Bioretention in an Open Space

Bioretention is typically sited in an area of natural or constructed depression and consists of vegetation, a ponding area, mulch layer, and planting or engineered soil media and released through an underdrain. The vegetation may include perennials, grasses, shrubs, and trees. It typically incorporates a vegetated groundcover or mulch that can withstand urban environments and tolerate periodic inundation and dry periods. Runoff intercepted by the practice is temporarily captured in the depression and then infiltrated into the underlying soil. Flow that doesn't infiltrate is filtered through the soil (often engineered soil) media. Pretreatment of stormwater flowing into the bioretention area is recommended to remove large debris, trash, and larger particulates. Pretreatment may include a grass filter strip, sediment forebay, or grass swale. Ponding areas can be designed to provide detention.

Required for credit: Bioretention systems must promote infiltration and evapotranspiration. However the system must also be able to drain below the ground surface within 24 hours.

Increasing a credit: The credit for bioretention systems is most directly related to the size (area and volume) of the bioretention relative to the tributary area. Examples of bioretention can include bioretention planter boxes, bioretention islands in parking lots or parking lot aisles.

Bioretention in Planter Boxes

Bioretention Islands in Parking Lots

Bioretention between Parking Lot Aisles

3.4.8.4 Detention Basins

Detention is a stormwater management practice that temporarily stores runoff volume and slowly releases it to the sewer system with a controlled outlet. Detention systems include dry detention and wet detention where the control structure is offset from the bottom of the basin which creates a landscape feature such as a permanent wet pool.

Traditional Dry Detention Basin

Required for credit: Detention basins must have a controlled outlet to be eligible for a credit.

Increasing a credit: The credit for detention basins is based on the volume of the detention basin relative to the volume of a 100-year, 24-hour event storm. The larger the basin, the larger the credit. Water stored in a detention basin can also be reused for irrigation, which would result in a volume credit.

3.4.8.5 Subsurface Detention Storage

Underground detention performs the same function as a detention basin. Stormwater (and snowmelt) is routed to underground vaults or a system of large-diameter or low-profile storage pipes. Pipe or manufactured systems can be used. As with detention basins, a controlled outlet is required. In some cases where soils have available infiltration capacity, these systems can also function as an infiltration practice for a retention credit. Alternatively, they can function as cisterns for water reuse.

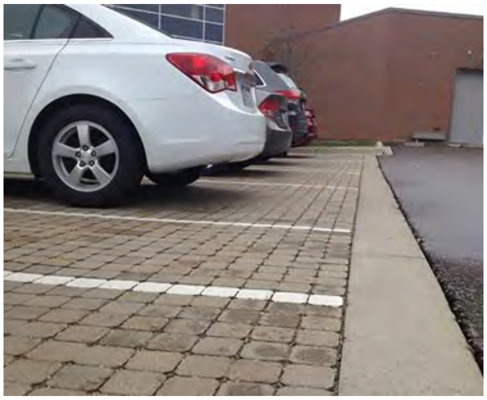
Subsurface Detention Storage

Required for credit: Subsurface detention basins must have a controlled outlet to be eligible for a credit. Pretreatment is required to prevent a buildup of solids and other debris in the subsurface detention.

Increasing a credit: The credit for subsurface detention is based on the volume of the detention relative to the volume of a 100-year, 24-hour event storm. The larger the detention, the larger the credit.

3.4.8.6 Permeable Pavement

Permeable pavement is sometimes used in highly impervious areas to help infiltrate stormwater runoff that would otherwise enter the sewer system. This practice includes an aggregate stone layer to provide both structural support and volume storage, and a porous pavement layer that allows runoff to infiltrate. Because it can replace traditional impervious pavement, permeable pavement is an effective option for parking lots in urban areas.



Permeable Pavement

Required for credit: A stone/aggregate layer to control stormwater. To be eligible for credits, installations must follow important design considerations.

Increasing a credit: The depth of stone under a parking area significantly affects the volume available to manage stormwater. The more storage volume, the larger the credit will be. The stone storage area, if properly sized, can also be used for roof drains and other impervious surfaces.

3.4.8.7 Green Roofs

Green Roof

Green roofs are used to introduce vegetation onto sections of roof tops to absorb and filter rainfall. Between rain events, some of the rain water is held in the plants and evaporates. At a minimum, a green roof consists of a waterproof membrane and root barrier system to protect the roof structure, a drainage layer, filter fabric, a lightweight soil media, and vegetation that filters, absorbs, and retains/ detains the rainfall. The overall thickness of a green roof commonly ranges from two to six inches. A green roof may be connected to other stormwater management practices such as a bioretention, bioswale, or cistern.

Green roofs are most often applied to buildings with flat roofs, but can be installed on roofs with slopes with the use of mesh, stabilization panels, fully contained trays, or battens.

Increasing a credit: The credit associated with a green roof is dependent on size of the green roof area and depth of the media. The larger these two are, the more significant the credit.

3.4.8.8 Water Harvesting (Reuse)

Water harvesting practices are generally used to collect stormwater runoff from impervious areas and store it in large cisterns or ponds. Runoff can then be used in non-potable applications such as watering vegetation or greywater systems. Cisterns as well as smaller rainwater harvesting systems can be constructed above or below ground depending on the space constraints of the site.

Required for credit: Any water reuse system must include a means of using the water on a routine basis and a meter to measure the water used OR measure the residual flow to the sewer system.

Increasing a credit: Reuse systems are only as effective as the ability to use the water. The credit will be increased if more uses for the stored water are identified. For example, some industrial customers are reusing stormwater for the facility's industrial processes. This likely requires sufficient treatment of the water for the desired purpose.

Cistern

Irrigation Pond

3.5 Full or Partial Site Credits

DWSD does not require stormwater from the entire site to be managed in order to take advantage of the credit system. However, drainage charge credits will be calculated for only that fraction of a property that is "managed", meaning the area from where stormwater runoff is directed to a stormwater management practice. Runoff from an "unmanaged" area of a property will not be eligible for a drainage credit. Figure 2 represents these concepts.

For the example in Figure 2, the portion of the site that is tributary to the stormwater management practice would be eligible for a credit. The unmanaged portion (shaded area) would not be eligible for a credit.

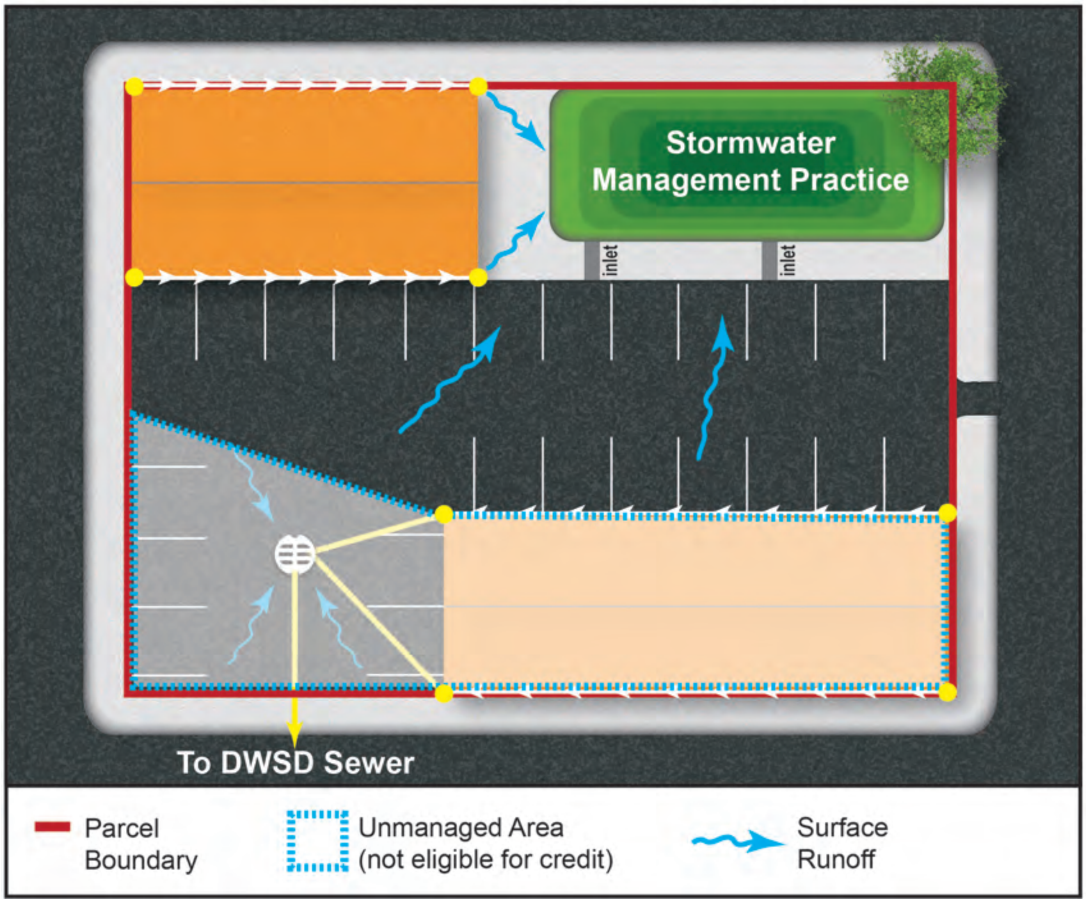


Figure 2: Managed versus Unmanaged Area

Example for partial Site Credits: Due to the layout of the site, 6 of the 10 impervious acres drain to a detention basin. The basin is sized to detain 70 percent of the 100-year, 24-hour storm event's runoff volume for the impervious acres draining to it. This makes it eligible for a peak flow credit, however the practice has no infiltration capabilities, so it cannot earn a volume credit.

The credit is calculated as shown in Table 2:

TABLE 2 - Partial Site Credits					
Area	Credit Type	Practice Performance (%)	Managed Impervious Area (acres)	Credit Calculation	Credit Amount (%)
Managed Area	Volume	70	6	(6/10) * 0.7 * 0.4	17
Non-managed	None	0	0	N/A	0
				Total	17

3.6 Multiple Credits

In cases where more than one stormwater management practice is present, the credit will be determined based on the total site's potential to manage stormwater. The customer can earn multiple drainage charge credits.

Note: While multiple credits can be given to eligible properties, the total drainage charge credit to any property cannot exceed 80 percent for that property. If customer is receiving a transition credit, they get either the transition credit or the stormwater management practice credit, whichever is greater.

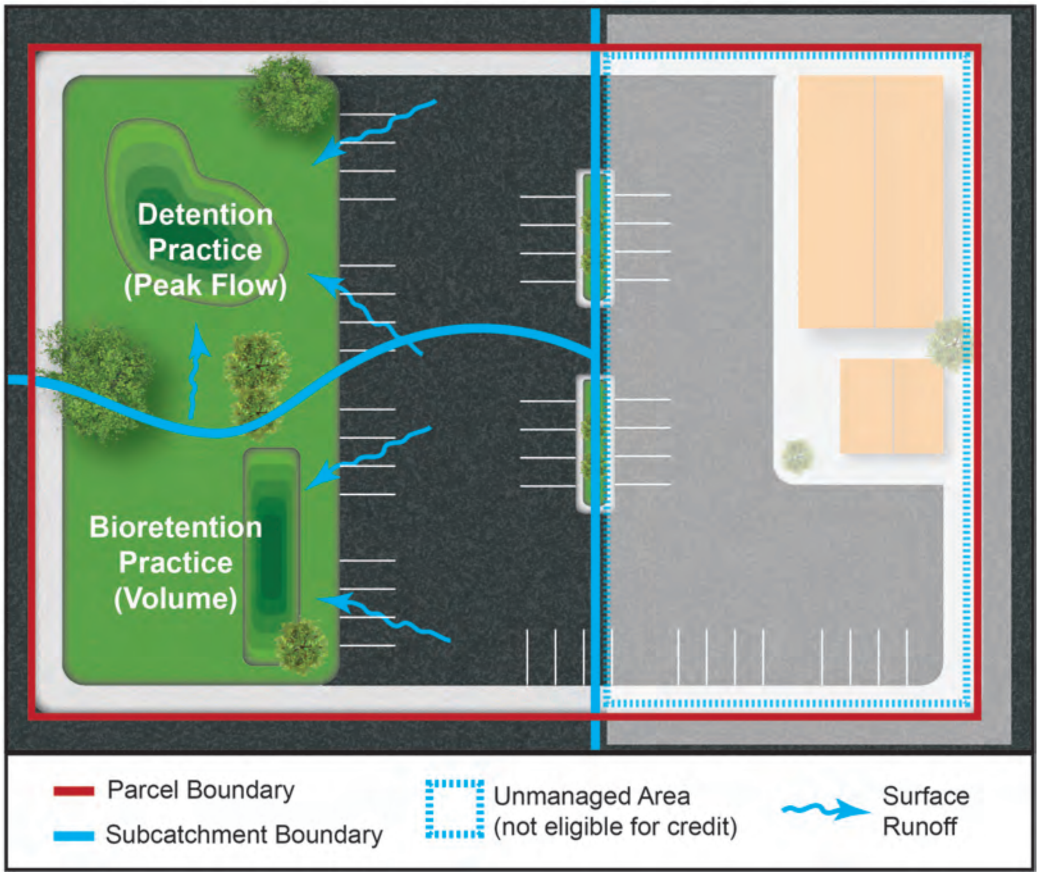


Figure 3: Multiple Credits

Example for Multiple Credits: A site with 8.70 impervious acres drains to 3 different locations. Of the 8.70 impervious acres, 2.71 drain to a detention basin that can detain 80% of the 100 year, 24 hour storm even volume making it eligible for a peak flow credit. Then 2.65 acres of impervious area drain to a separate bioretention practice that retains 90% of the annual rainfall volume; making the second practice eligible for a volume credit. The remaining 3.34 impervious acres drain to a DWSD sewer and are not managed.

The credit that this site can earn is shown in Table 3:

TABLE 3 - Multiple Credits

Subcatchment	Credit Type	Practice Performance (%)	Managed Impervious Area (acres)	Credit Calculation	Credit Amount (%)
Detention Basin	**Peak Flow**	**80**	**2.71**	**(2.71/8.70) * 0.8 * 0.4**	**10**
Bioretention	**Volume**	**90**	**2.65**	**(2.65/8.70) * 0.9 * 0.4**	**11**
Not Managed	**None**	**0**	**3.34**	**N/A**	**0**
Total			**8.70**		**21**

3.7 Shared Stormwater Management Practices

DWSD allows the location of the stormwater management practice to be on a separate parcel from where the stormwater is generated. There are two circumstances where this may happen:

- A single property owner owns multiple parcels
- Multiple property owners construct a shared stormwater practice

Situation #1: Single Property Owner

Required: A single property owner with multiple adjacent parcels must:

- Have consistent owner names and addresses on each parcel

Situation #2: Multiple Property Owners

Required: A legal agreement between the property owners documenting that this is a shared stormwater management practice.

DWSD will assess the practice performance and, if credit requirements are achieved by a joint practice, each property owner will be granted a credit for their contributing impervious area.

Note: DWSD encourages cost-sharing to support the design, construction, and maintenance of shared stormwater management practices. DWSD will not intervene in private transactions associated with financing and maintenance. DWSD will apply credits to the properties whose flow is managed.

EXAMPLE: Four individual properties have entered into an agreement whereby a single detention basin will control peak flow from each of their properties. The detention basin is sized to detain 60 percent of the 100-year, 24-hour event storm runoff volume from all impervious surface on each property. Therefore, the properties are eligible for the peak flow rate credit. Because the detention basin has no infiltration capabilities, no property will receive volume credits. With the information below, the total credits allocated to each property are calculated.

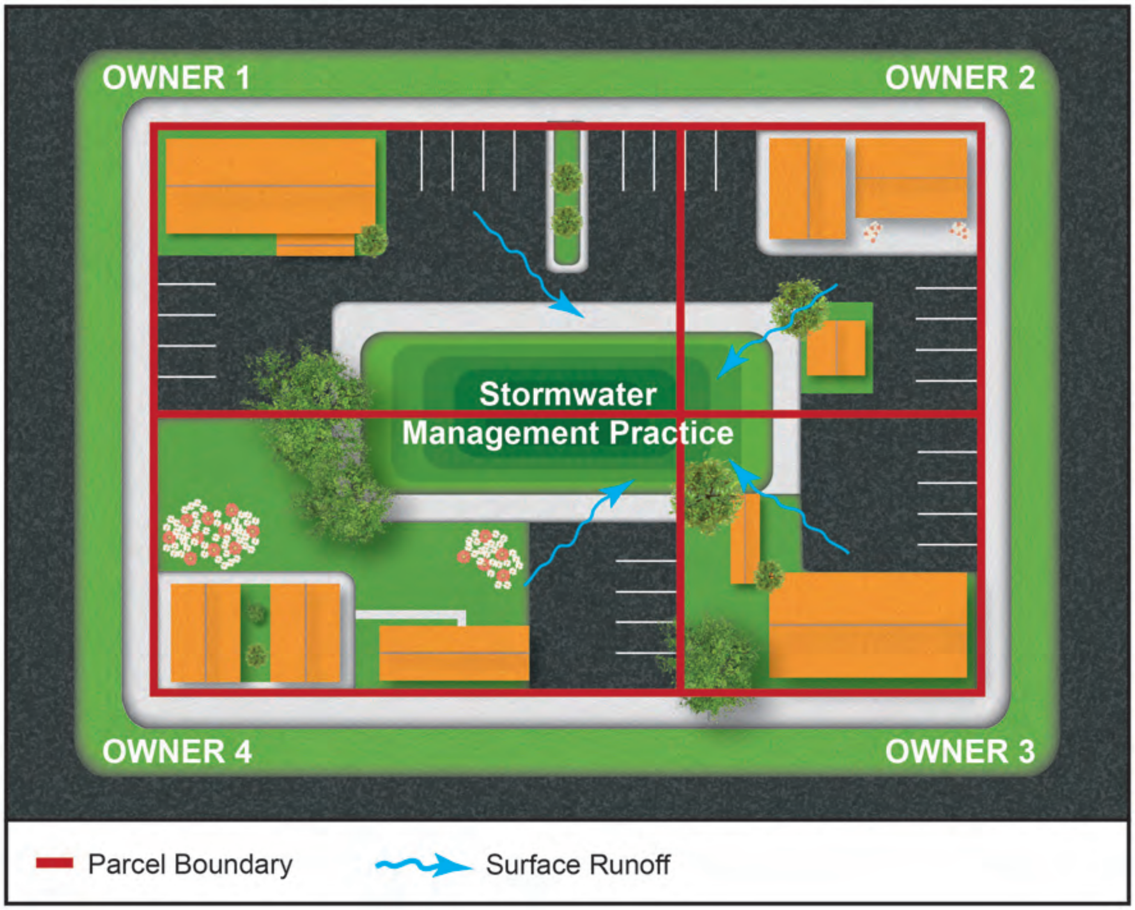


Figure 4: Shared Ownership of Stormwater Management Practice

TABLE 4 - Shared Ownership of a Stormwater Management Practice					
Owner # Calculation	Credit Type	Practice Performance (%)	Managed Impervious Area (acres)	Credit Calculation	Credit Amount (%)
1	Peak	60	3	(3/3) * 0.6 * 0.4	24
2	Peak	60	2	(2/2) * 0.6 * 0.4	24
3	Peak	60	2	(2/2) * 0.6 * 0.4	24
4	Peak	60	2.1	(2.1/2.1) * 0.6 * 0.4	24

Note: All impervious area on each site is controlled.

3.8 How to Get a Drainage Charge Credit

In order to be eligible for a drainage charge credit, the stormwater management practice must be approved by DWSD. To obtain a drainage charge credit, the property owner will need to meet eligibility requirements, apply for and receive an approval from DWSD, and fulfill on-going operations and maintenance (O&M) requirements. The customer's name must be on the account.

To be eligible for a credit, the stormwater management practices must:

- Reduce annual runoff volume and/or control peak flow rate;
- Be documented in terms of design and performance in a manner acceptable to DWSD;
- Comply with all applicable city, county, state, and federal construction, building, and stormwater codes and permits;
- Be fully installed and functioning properly;
- Not create a safety hazard or nuisance; and
- Be located on a property that is geographically located within DWSD's Drainage Service Area.

Chapter 4: Credits for Commonly Used Stormwater Management Practices and Direct Discharge

This chapter discusses the most commonly used stormwater management practices and the credits they can earn. The primary application of this chapter is to non-residential sites, although some of the basic concepts included in this chapter also apply to residential credits. The chapter includes discussions of disconnected imperviousness, bioretention, permeable pavement, detention systems, green roofs and Direct Discharge

Contents

4.1 Introduction

This chapter discusses the most commonly used stormwater management practices, Direct Discharge and the credits that customers can earn for implementing them. The primary application of the practices outlined in this chapter is to non-residential sites, although some of the basic concepts included in this chapter also apply to residential sites. This chapter also identifies critical design features of the stormwater management practices that are necessary in order for customers to earn the credits described. These critical features directly relate to the hydrologic performance of the practice that determines the credit.

"Minimum design standards" as used in this guide are intended ONLY to address those design elements that are directly related to the credit. These should not be interpreted as instructions for engineering design nor be interpreted as minimum standards to satisfy permitting requirements.

The *Southeast Michigan Council of Governments (SEMCOG) Low Impact Development Manual (LID) for Michigan: A Design Guide for Implementers and Reviewers (2008)* provides guidance on how to apply stormwater management practices to new, existing, and redevelopment sites and contains technical guidance and variations for the stormwater management practices eligible for credits. The LID Manual can be used to assist customers in designing their stormwater management practice and should not be construed as requirements. An electronic copy of the Michigan LID Manual can be found on the SEMCOG website: www.semcog.org.

The Detroit Water and Sewerage Department (DWSD) has developed simplified methodologies for quantifying credits that are intended to assist in the evaluation and implementation of stormwater management systems. These methods simplify calculations for the designer. They also streamline review of the projects and associated calculations by DWSD.

More sophisticated hydrologic evaluation may be needed or desired for complex sites. DWSD accepts a wide variety of hydrologic/hydraulic design models and tools common in the engineering industry. Sites with complex configurations and stormwater management practices in series may need to use these more complex tools.

Important notes:

Permits: Projects described in this chapter may require permits for construction. For example, a plumbing permit is required for site piping that later connects to the City sewer. A DWSD permit is required for connections to the DWSD sewer. Modifications to site parking require a zoning review to confirm that they meet parking standards. The property owner will need to ensure that all required permits are applied for and received prior to construction. Design drawings submitted for review will require a design professional's seal as confirmation that they were appropriately prepared.

Application of the Credit: Credits are only applied to the 'Managed' area of a site (see Figure 2 in Chapter 3 and calculation examples in this section). As discussed in Chapter 3, the drainage charge credits are based on the site's ability to manage the average annual runoff volume and the peak flows from large rain events.

4.2 General Quantitative Principles

There are a series of general principles that are used in this guide that apply to the credit calculations. Those common items are described below.

4.2.1 Effective Porosity in Soil and Aggregate Layers

The effective porosity that is available in soil and aggregate layers is a determinant of the performance of the stormwater management practice. Many stormwater management practices rely on the temporary storage of stormwater in these layers. The effective porosity is dependent on the specific media.

In soil, the effective porosity is the porosity less the field capacity. This is the difference between the total void space and the water that is held in the soil particles due to capillary action. Unless independent testing is conducted on the materials used, a value of 0.20 shall be used for the effective porosity of the bioretention soil. In aggregate, the void ratio is the same as the porosity. Unless independent testing is conducted on the materials used, a value of 0.40 shall be used for the effective porosity of the coarse aggregate.

The property owner and their designer will need to identify the material used for soil and aggregate and their actual void ratio in order to quantify performance.

4.2.2 Equivalent Water Depth

Many stormwater management practices rely on the temporary storage of stormwater in designed surface and subsurface storage. This storage occurs on the surface of a practice (such as temporarily ponded water on a bioretention system), and below the surface in layers of soil and aggregate. The performance of the stormwater management practice is directly related to this storage volume.

The Equivalent Water Depth defines the depth of water that can be stored in the mix of surface and subsurface storage.

The Equivalent Water Depth is defined as:

Equivalent Water Depth (in)
*= surface storage (in)+(soil depth(in) * effective porosity)+(aggregate depth (in) * effective porosity)*

Figure 1 illustrates two stormwater management practice cross sections. The aggregate has an effective porosity of 0.30, the soil has an effective porosity of 0.20, and surface storage is fully used. Therefore, the Equivalent Water Depth = surface storage depth + soil depth*0.20 + aggregate depth*0.30.

Equivalent Water Depth (in) Cross Section A
*=3+16*0.20+20*0.30=12.2 inches*
Equivalent Water Depth (in) Cross Section B
*=6+24*0.20+4.7*0.30=12.2 inches*

In general, all surface water must be able to drain below ground within 24 hours and subsurface storage in a stormwater management practice must be able to infiltrate in a 72-hour period. The maximum equivalent water depth in the retention zone of a practice is therefore dependent on the infiltration rate.

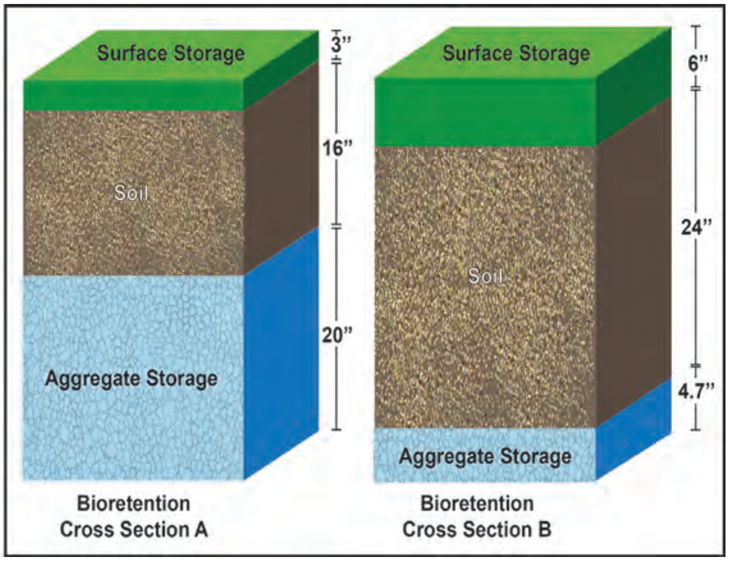


Figure 1: Equivalent Water Depth in Stormwater Practice Cross Section

TABLE 1 - Maximum Equivalent Water Depths in Retention Zone of a Stormwater Management Practice	
Infiltration Rate	Equivalent Water Depth
0.1 inches/hour	7.2 inches
0.2 inches/hour	14.4 inches
0.3 inches/hour	21.6 inches
0.4 inches/hour	28.8 inches

4.2.3 Retention and Detention Concepts

Stormwater management practices may provide retention, detention or both functions. Some practice types are better at controlling volume, while others may be better suited to peak flow rate control. For example, bioretention is generally sized for small storm events, and has a primary function of promoting infiltration. Therefore, bioretention systems typically are better suited to reducing the volume of runoff. In contrast, detention ponds generally don't have a mechanism to reduce volume and would earn only a peak flow credit.

Stormwater management practices can be intentionally designed to provide both volume and peak flow management and include both a retention and detention capability. In stormwater management, the following terms are used:

Retention: The ability to permanently remove stormwater volume. This function results in volume credits.

Detention: The ability to temporarily store stormwater volume. This function results in peak flow credits.

Figure 2 shows how the water storage area in a bioretention practice can include both a retention and detention zone. The volume provided in the retention zone determines the volume credit. The volume provided in the detention zone determines the peak flow credit, provided that the flow rate through the outlet is controlled. In both instances, the volume provided is the equivalent water depth times the area of the bottom of the practice's footprint of the stormwater management practice.

For water storage provided above the side slopes, different methodologies for calculating the volumes detained and retained can be submitted for evaluation as long as the methodology is supported with calculations, justifications, and assumptions. No volume credit will be given for infiltration on the side slopes as typically the side slopes are compacted during construction activities.

There are many ways that dual retention and detention can be accomplished. This may require a larger practice or more complex design. Dual purpose volume and peak flow control can also be accomplished by installing practices in series, such as a bioretention followed by a detention practice.

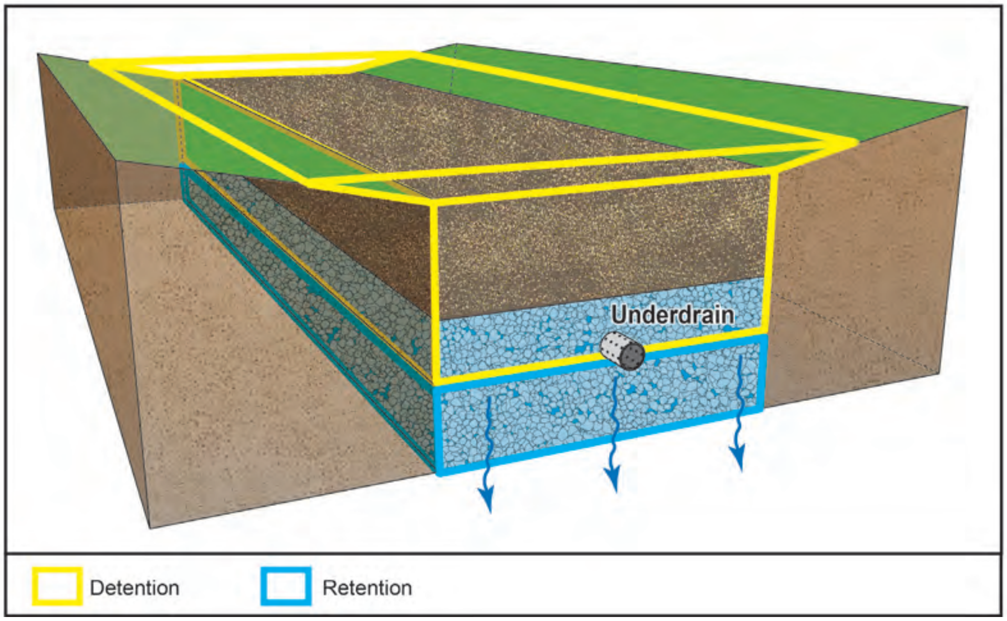


Figure 2: Retention Versus Detention Components of Bioretention Practices

4.2.4 Retention and Detention Determined by Underdrain Outlet Elevation

Most stormwater management practices include an underdrain to ensure satisfactory performance. The outlet elevation of the underdrain determines the portion of the practice that is in the retention and detention zones. The retention zone is below the underdrain outlet elevation, and the detention zone is above it.

Examples of underdrain outlet designs are shown in Figures 3 and 4.

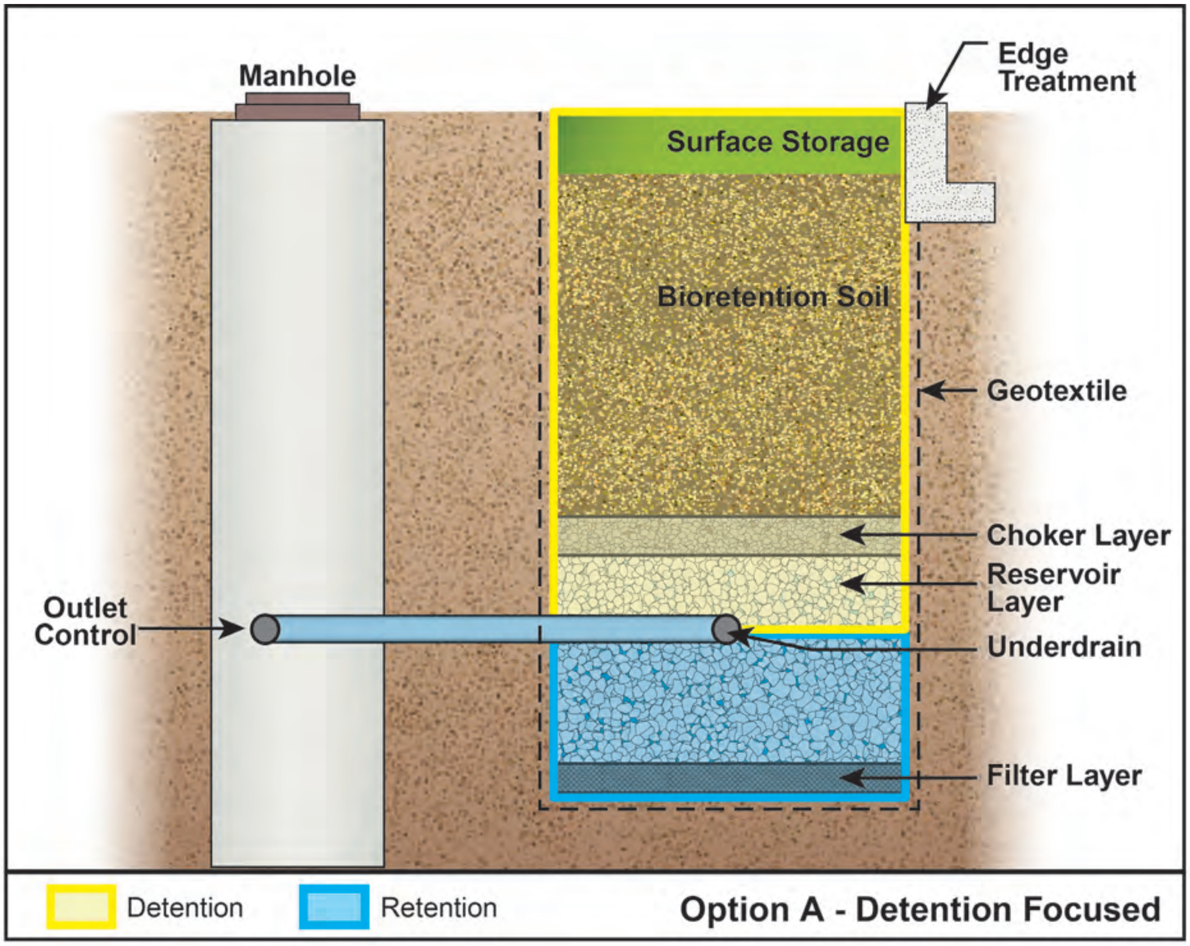


Figure 3: Standard Outlet Underdrain: Majority of Equivalent Water Depth Used for Detention

4.2.5 Determining Outlet Capacity

Outlet capacity for detention practices is a critical data element for determining the credit value. Outlet capacity is based on the hydraulic capacity of the outlet when the storage elevation is full, but below any emergency overflow elevation.

Outlet capacity will most typically be determined using an orifice equation.

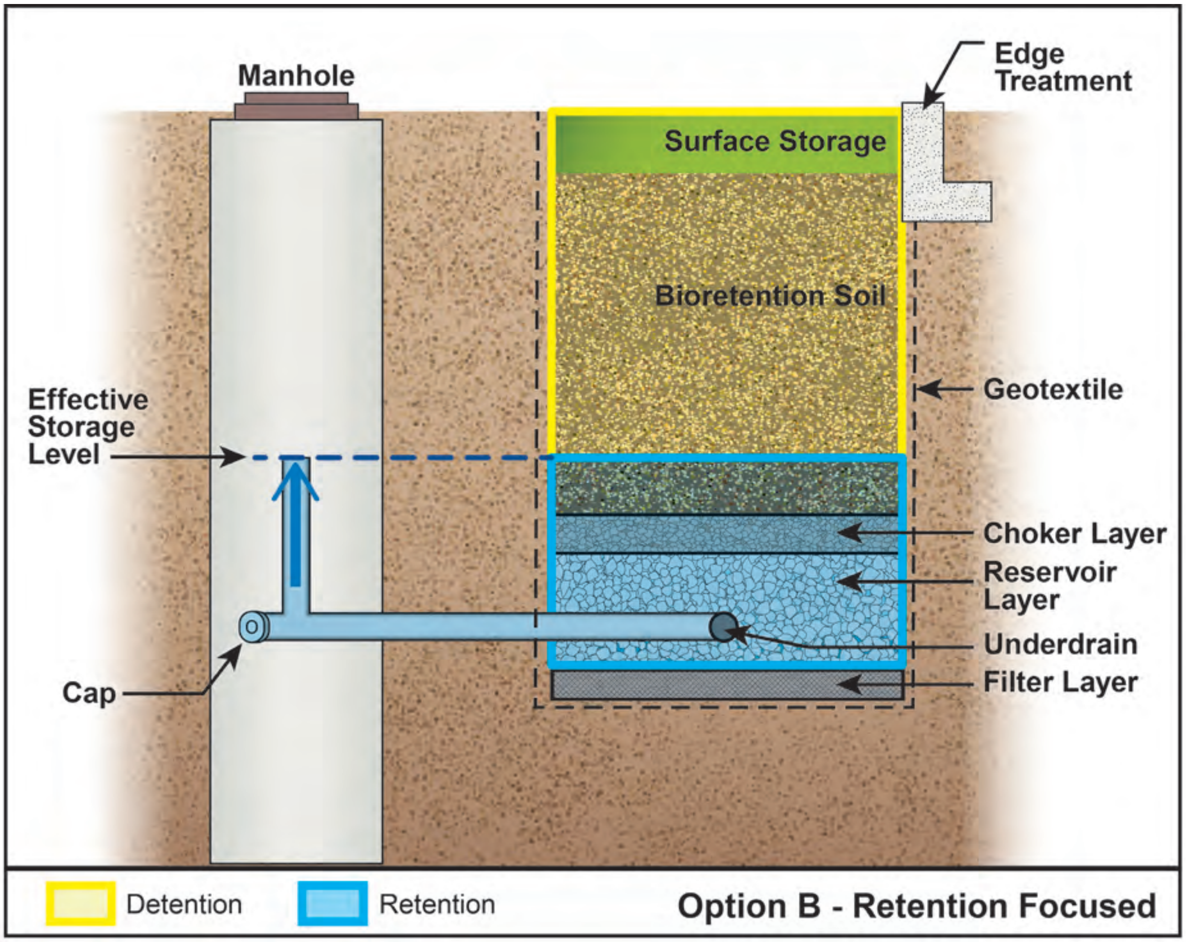


Figure 4: Upturned Elbow Outlet Underdrains: More Equivalent Water Depth Used for Retention

4.2.6 Groundwater and Infiltration Rates

The simplified calculation methodologies for bioretention and permeable pavement are based on certain assumptions for conditions related to groundwater and infiltration. If these conditions are not present, a more extensive engineering analysis is required.

The lowest elevation of an infiltrating stormwater management practice must be two feet above the seasonal groundwater table.

Infiltration rates used in calculating credits should be based on measured values wherever geotechnical testing can be performed. Multiple measurements of infiltration rate at the location of the proposed stormwater management practice(s) are needed to define infiltration rate. The infiltration rate should be tested at a depth consistent with the anticipated depth of excavation for the stormwater management practice. Geotechnical investigations should also determine the depth to groundwater and the depth to the impervious clay soils that are common in Detroit. The infiltration value used in calculations should have a safety factor of two applied to the measured values. Refer to the appendix in the *Michigan LID Manual* for acceptable procedures and methodologies for measuring infiltration rates.

For instances where the infiltration rates are not measured at the practice location, a maximum value of 0.1 inches per hour infiltration rate is permitted.

4.2.7 Stormwater Management Practice Ratio

The practice ratio uses the concept of a stormwater practice area. The "practice ratio" is a comparison of the stormwater practice area to the drainage area. The definition of the stormwater practice area is specific to each practice type (see Table 2). The drainage area is the area draining to the stormwater management practice. This approach is used in the disconnected impervious method. The general formula for the practice ratio is:

Equation1

$$Practice\ Ratio = \frac{Stormwater\ Practice\ Area}{Drainage\ Area}$$

CONSIDER THIS: One way to think about the stormwater management practice ratio is as a percentage. Consider a bioretention example. If the stormwater management practice ratio is 0.10 that's equivalent to the bioretention area sized at 10% of the size of the impervious drainage area.

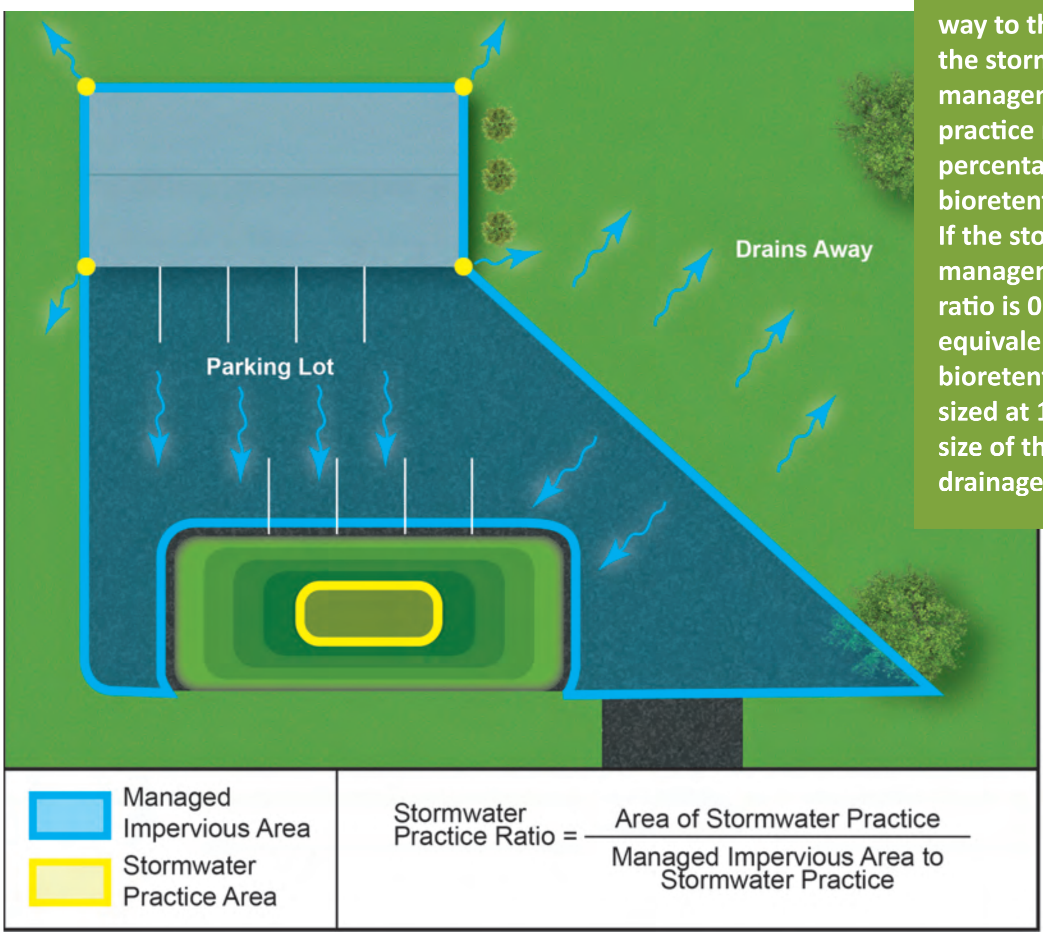


Figure 5: Stormwater Management Practice Ratio

4.2.7.1 Stormwater Practice Area

The stormwater practice area determines the ability of the practice to infiltrate into the underlying soil. It is the effective area from which infiltration can occur. The practice area needs to be identified properly in order to use the tables, equations and charts that are associated with the practice area calculation methods.

Did You Know?

Infiltration/infiltrating practices and open stormwater conveyance systems over a DWSD infrastructure are not allowed.

TABLE 2 - Commonly Used Stormwater Practice Area Definitions

Practice Type	Stormwater Practice Area for Infiltration
Downspout Disconnection	Length from the end of the downspout to the edge of the property measured along the path that water will flow multiplied by an assumed width equal to 5 feet.
Other disconnected impervious surfaces	The surface area over which infiltration will naturally occur. This is based on the width of the sheet flow when it leaves the impervious surface multiplied by the length of the flow path in the pervious area.
Bioretention	Surface area of the bioretention for infiltration, not including the side slopes.
Permeable pavement	The surface area of the aggregate reservoir layer if the equivalent water depth for retention is provided in the aggregate reservoir.

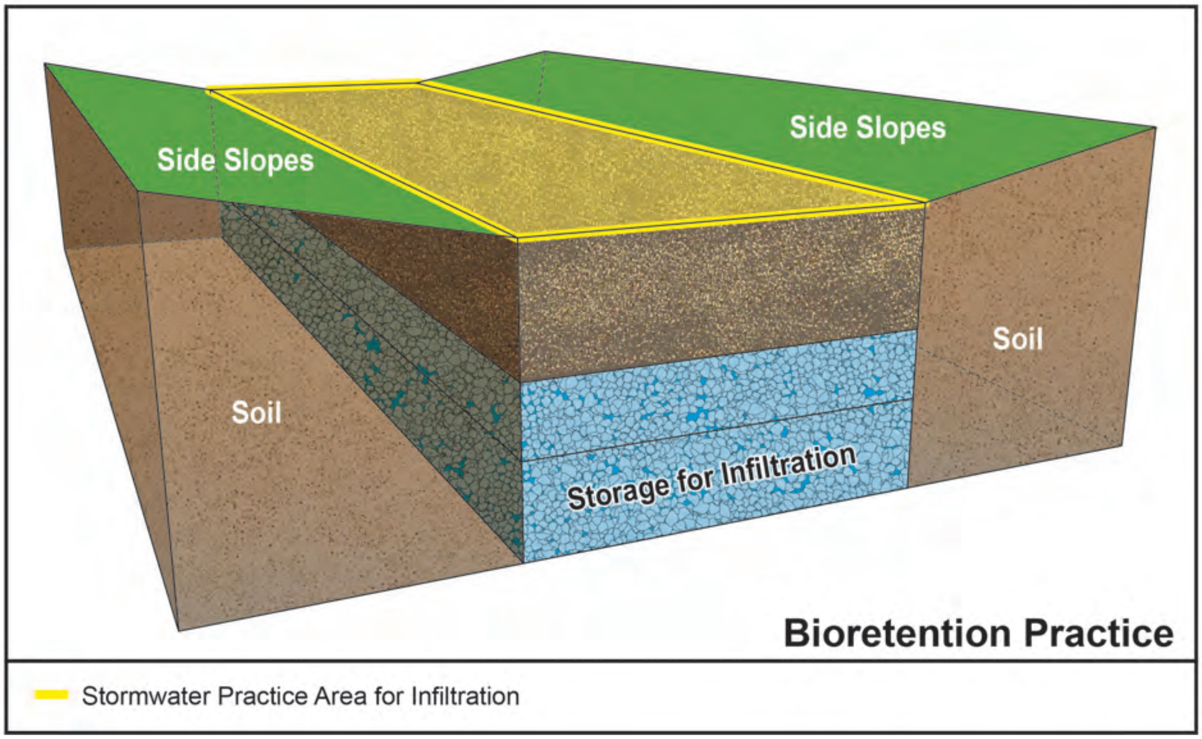


Figure 6: Bioretention Systems Practice Area for Infiltration

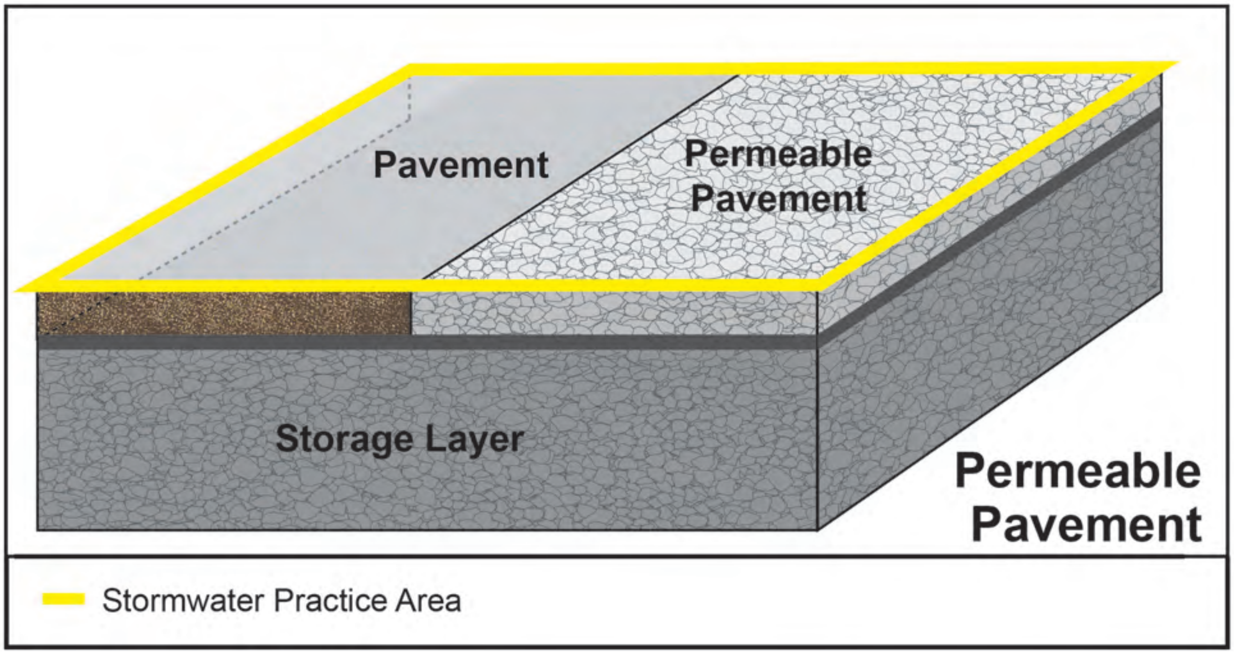


Figure 7: Permeable Pavement Practice Area

4.2.7.2 Drainage Area to the Stormwater Management Practice

The *Drainage Area*, in Equation1 is the area that is tributary to the stormwater management practice. For example:

- For a roof drain disconnection, it is the portion of the roof draining to the downspout that is being disconnected.
- For a bioretention practice located next to a parking lot, the drainage area is that portion of the parking lot sloped to the bioretention.
- The drainage area may include area draining to the practice through a storm sewer.

4.2.8 Impervious and Pervious Drainage Areas

DWSD will accept calculations that ignore the pervious tributary area if the drainage area is predominately impervious. DWSD considers this to be >75% of the drainage area. When calculations ignore the pervious area, 100% of rainfall is assumed to generate runoff from impervious area.

In cases where the drainage area tributary to the practice is <75% impervious, the amount of pervious surface impacts the design. In this case, engineering calculation methods described later in this guide should be used.

An example of drainage area calculation is shown in Figure 8. For this site, a portion of the parking lot is tributary to a bioretention at the edge of the lot. The drainage area used in calculations is the impervious portion of the lot (e.g., pavement). The grassed parking lot islands would be ignored in the drainage area calculation. The stormwater management practice area for bioretention is the surface area of the bioretention not including the side slopes.

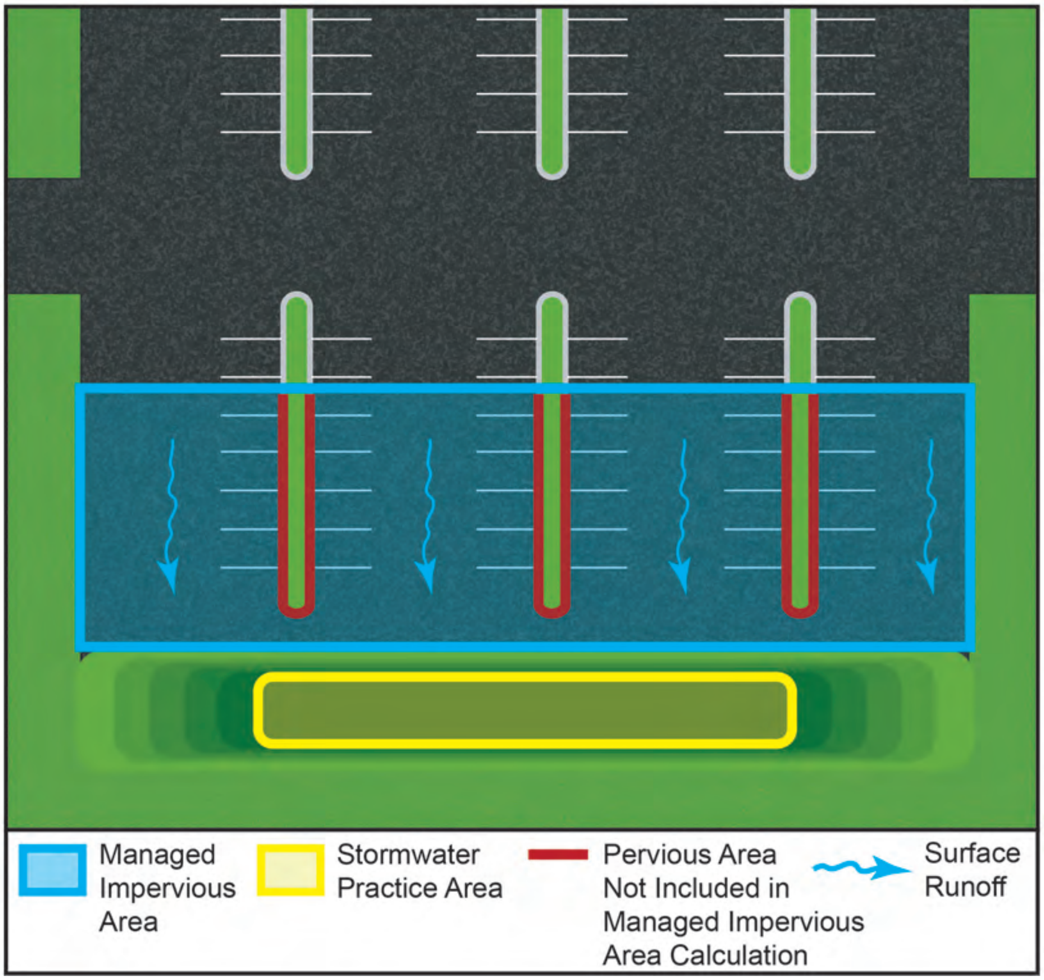


Figure 8: Managed Impervious Area to the Stormwater Management Practice

4.3 Credit Calculation Methods

A wide variety of options are available to quantify credits for the most commonly used stormwater management practices and techniques. In addition to standard engineering methods, DWSD has developed a series of simplified calculation methods which can be applied. These methods were developed based on a variety of robust hydrologic modeling evaluations that have been summarized into a regression equation.

Simplified methods developed by DWSD include:

- **Disconnected Impervious Method:** This method determines **volumetric credits** based on the relative size of the impervious area and the pervious area onto which it discharges. It should be used for all disconnected impervious area analysis.
- **Equivalent Rainfall Depth Method:** This methodology defines **volumetric credits** based on the equivalent rainfall that can be contained in the retention zone of a practice. This approach is flexible to varying cross sections based on design. This method should be used for bioretention and permeable pavement.
- **Water Balance for Water Reuse Systems:** A water balance methodology is provided for those systems that are using various forms of water reuse to limit the annual volume of stormwater discharged to the sewer system.

The standard detention calculation methods are based on the methodology used in a number of southeast Michigan municipalities for sizing of detention facilities:

- **Detention Calculations:** This methodology defines **peak flow credits** based on available detention capacity and standard calculations. This is the preferred methodology for sizing detention basins or detention elements of other practices.

The following methods are standard engineering techniques that may be used to quantify credits:

- **EPA National Stormwater Calculator:** The EPA National Stormwater Calculator can be used for determining the volumetric capture for any stormwater management practice. It is the preferred quantification method for green roofs.
- **Hydrologic and Hydraulic Models:** A variety of engineering calculations can be used for quantifying credits. Such tools include hydrologic and hydraulic models that enable consideration of stormwater management practices in series or complex routing techniques. These may be used for sites where desired by the design professional.

4.3.1 Disconnected Impervious Area: Volume Credit

Disconnected impervious areas are eligible for a volume credit based on the ratio of impervious to pervious area. In this case the practice is the pervious area onto which the runoff drains. The practice area must be as defined in Table 2.

The disconnected impervious area credit was based on the presumption that the pervious area includes top soil and vegetation that can absorb up to 0.8 inches of water column. The runoff from the impervious area is distributed over the practice area until its capacity is exceeded. The ratio of pervious to impervious area determines the performance. A continuous simulation provided the net performance of disconnected impervious on an annualized basis.

The results of this analysis are shown in Equation2. As an alternate to the equation, the corresponding graph may be used. In the simplified methodologies, disconnected imperviousness does not qualify for a peak flow credit, as modeling results do not indicate peak flow rate attenuation during larger storm events.

Equation2

$$Volume\ Credit\ (\%) = 0.94 * \frac{Practice\ Ratio}{0.25 + Practice\ Ratio} * 100$$

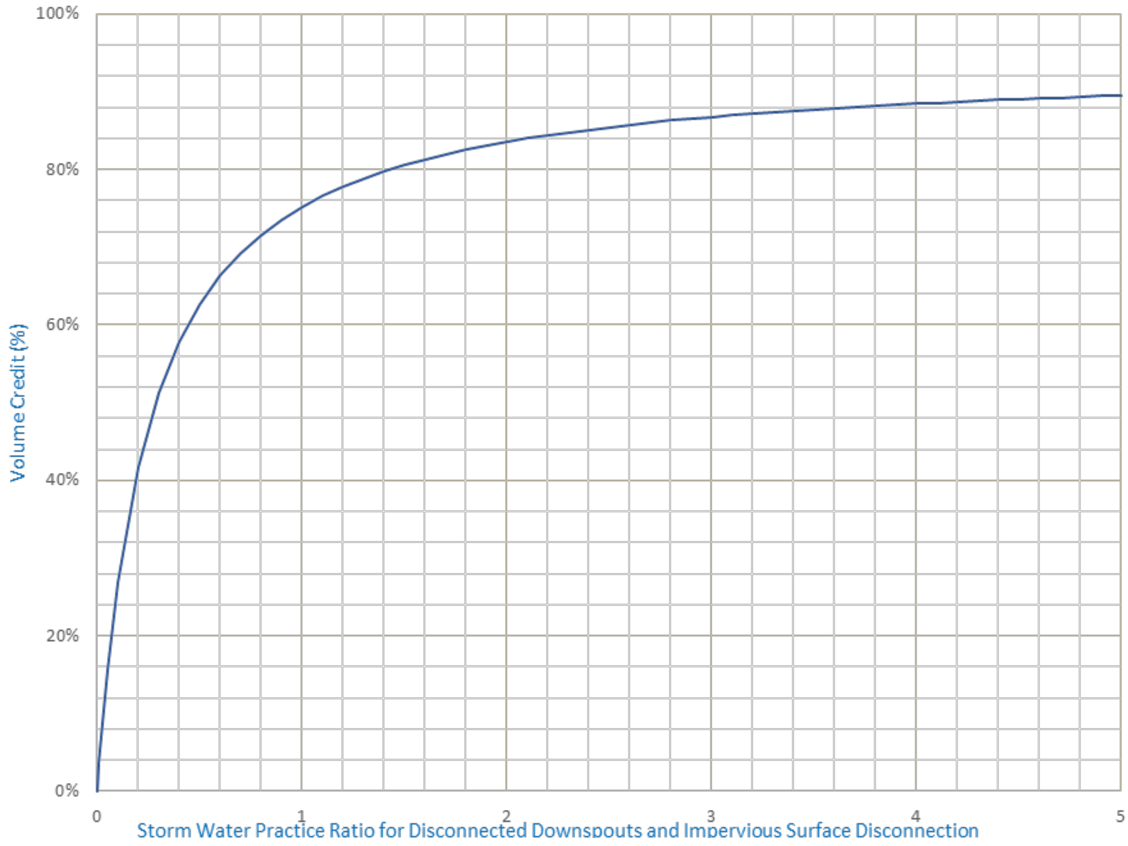


Figure 9: Disconnected Imperviousness Credit

For example, if the practice ratio is 2, then the corresponding volume credit is 84%. A stormwater management practice ratio of 2 indicates that the pervious area is twice the size of the impervious area draining to it.

4.3.2 Equivalent Rainfall Depth Method: Volume Credit

The Equivalent Rainfall Depth method was developed based on the same principles as described for the Practice Ratio Method. Similar to that approach, the anticipated performance is based on ability of the retained volume to infiltrate into the soil. The Equivalent Rainfall Depth method is different in that it works for a wide range of equivalent water depths. Due to ground water elevations, construction feasibility, hydraulic constraints or other site specific issues, the calculated equivalent water depth will often be different than the values shown in Table 1.

The volumetric credit is then determined from the equation:

Equation3

$$\text{Volume Credit (\%)} = (1 - 2.5^{-2.5r}) * 100$$

r = equivalent rainfall depth (inches)

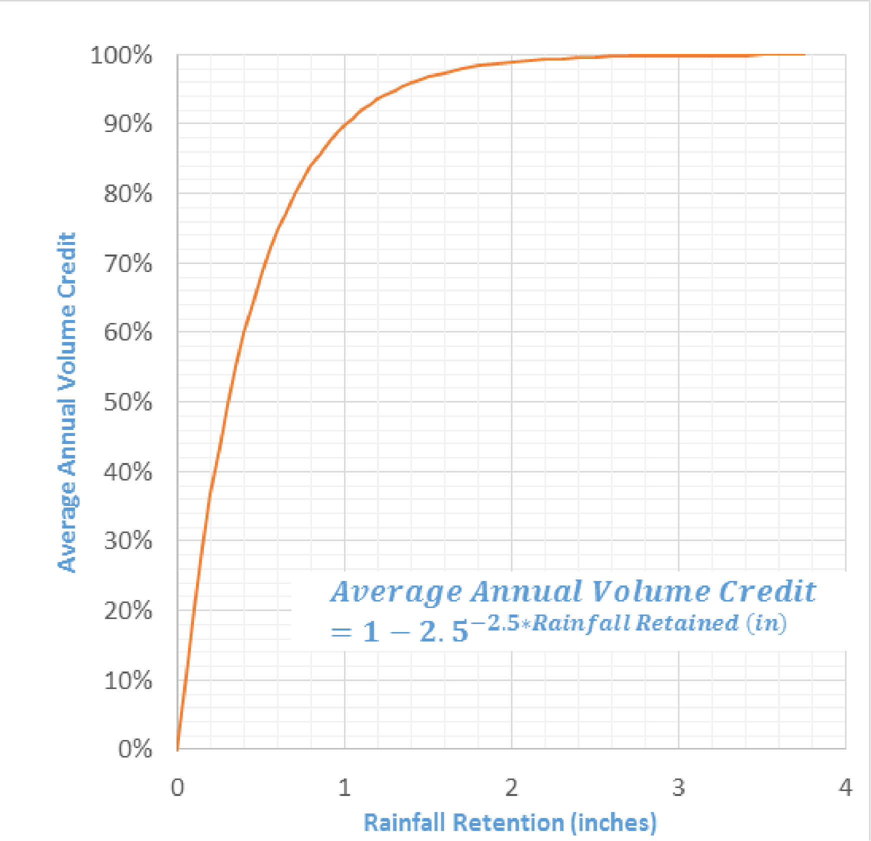


Figure 10: Equivalent Rainfall Depth Credit

The information required to use this methodology includes:

- Drainage Area (if > 75% impervious, include impervious area only);
- Practice Area (reference Table 2 for how this is defined for commonly used practices);
- Measured infiltration rate in the location of the practice;
- Equivalent Water Depth (EWD) in the practice.

With this information, the volumetric credit can be determined.

The method should be used to calculate a practice area for a target volumetric credit.

APPLICATION OF THE EQUIVALENT RAINFALL DEPTH METHOD TO CALCULATE A VOLUME CREDIT

This example assumes that the size of the stormwater management practice is already determined. See the following example for sizing of a practice to achieve a desired credit.

STEP 1 Identify the drainage area and determine the amount of impervious area. Identify the practice area size, infiltration rate, and equivalent water depth (EWD) in the retention zone.

STEP 2 Confirm that the infiltration rate is greater than or equal to the minimum required infiltration rate based on the equation below.

$$\text{Minimum Required Infiltration Rate}\left(\frac{in}{hr}\right) = \frac{\text{EWD Provided (in)}}{\text{Allowable Drain Time (hrs)}}$$

STEP 3 Quantify the retention volume provided based on the practice area and the EWD:

$$\text{Retention Volume (cf)} = \text{Practice Area (sf)} * \frac{\text{EWD (in)}}{12}$$

STEP 4 Determine the equivalent rainfall depth that corresponds to the retention volume identified in Step 3:

$$\text{Equivalent Rainfall Depth (in)} = \frac{\text{Retention Volume (cf)}}{\text{Managed Impervious Area (sf)}} * 12$$

Note: The method shown simplifies runoff as equal to 100% of rainfall on impervious areas and 0% of rainfall on pervious areas.

STEP 5 Determine the volume credit from the regression equation.

$$\text{Volume Credit (\%)} = (1 - 2.5^{-2.5r}) * 100$$

where r is the equivalent rainfall depth (in)

STEP 6 Calculate the practice credit. The volume credit applies to 40% of the bill. Therefore multiply the value in Step 5 by 0.4 to identify the practice credit.

STEP 7 Calculate the site credit. Prorate the practice credit to the fraction of impervious area managed versus total site impervious area.

$$\text{Site Credit (\%)} = \text{Practice Credit (\%)} * \frac{\text{Managed Impervious Area}}{\text{Total Site Impervious Area}}$$

APPLICATION OF THE EQUIVALENT RAINFALL DEPTH METHOD TO CALCULATE A PRACTICE AREA

This example assumes that the designer is working to size the stormwater management practice based on a desired credit. See the preceding example to determine a credit if the size of the stormwater management practice is already determined.

STEP 1 Identify the drainage area and determine the amount of impervious area. Identify the infiltration rate, and EWD in the retention zone. Identify the target volume credit.

STEP 2 Confirm that the infiltration rate is greater than or equal to the minimum required infiltration rate for the EWD provided.

$$\textit{Minimum Required Infiltration Rate}\left(\frac{in}{hr}\right) = \frac{\textit{EWD Provided (in)}}{\textit{Allowable Drain Time (hrs)}}$$

STEP 3 Based on the target volume credit, solve for *r* in the credit equation.

$$\textit{Volume Credit (\%)} = (1 - 2.5^{-2.5r}) * 100$$

where r is the equivalent rainfall depth (in)

STEP 4 Determine the necessary retention volume.

$$\textit{Retention Volume (cf)} = \frac{r}{12} * \textit{Managed Impervious Area (sf)}$$

STEP 5 Determine the required practice area to accomplish the retention volume.

$$\textit{Practice Area (sf)} = \frac{\textit{Retention Volume (cf)}}{\textit{EWD (in)/12}}$$

4.3.3 Standard Detention Calculations: Peak Flow Credit

The standard detention methodology is used to determine peak flow credits for detention ponds and detention components of other stormwater management practices. This methodology is based on the Modified Rational Method, which can be used for detention pond sizing. As a simplified step, the designer has the option to modify the equations to essentially ignore pervious areas. This should only be used if the drainage area is 75% or more impervious.

The information required to use this methodology includes:

- Drainage Area to the detention practice
- Rational Coefficient (can be ignored if >75% impervious)
- Allowable discharge rate for the 100-year, 24-hour storm event (presumed to be 0.15 cfs/acre)

The outlet rate for the practice must be less than or equal to 0.15 cfs/acre at times of discharge to qualify for a peak flow credit.

Nomenclature used in this method includes:

- A, Managed Impervious Area (acres)
- C, Rational Coefficient (dimensionless)
- Q_R, peak allowable discharge rate for the 100-year, 24-hour storm event (cfs/acre)
- D, storm duration (minutes)
- I, rainfall intensity (inches per hour)
- t, recurrence interval (years)
- V_n, required detention volume for the n-year event (ft^3)

Equation 4: Detention Volume (Modified Rational Method)

$$V_n = \text{Runoff Volume - Volume Released}$$
$$\text{where Runoff Volume} = D * C * I * A \text{ and Volume Released} = D * Q_r * A$$

Equation4 is rewritten with variables and shown in Equation 7. Basic calculations of variables are as follows:

The critical storm duration is based on Equation 6.5:

Equation 5: Critical Storm Duration for 2- and 100-Year 24-hour Storm Events

$$D_2 = 21.352 \left(\frac{Q_R}{C}\right)^{-0.998} \qquad D_{100} = 49.988 \left(\frac{Q_R}{C}\right)^{-0.984}$$

Simplified calculation (considering impervious areas only):
Q_R = 0.15 and C = 1, D_{100} = 323 minutes, D_2 = 142 minutes.

The rainfall intensity is calculated from Equation6:

Equation 6: Average Rainfall Intensity for Critical Duration Event

$$I = \frac{38.0708t^{0.2081}}{(12.1177 + D)^{0.8395}}$$

For the simplified calculation, the following values are determined:

100-year, 24-hour storm event, I = 0.75
2-year, 24-hour storm event, I = 0.64

The required detention storage volume for a given recurrence interval event is based on Equation 7:

Equation 7: Volume Required for Selected Event

$$V_n=(60.5 * D * C * A * I) - (60 * D * Q_R * A)$$

Plugging the provided values into Equation 6 and simplifying gives the following Equation for each storm:

Equations 7A and 7B: Volume required for 100-year, 24-hour and 2-year, 24-hour storm events

$$V_{100} = 11{,}750 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

$$V_2 = 4{,}220 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

The peak flow credit for the practice is then:

Equation 8: Detention Peak Flow Credit

$$Peak\ Flow\ Credit = \frac{V_{provided}}{V_{100}} * 100$$

APPLICATION OF THE DETENTION CALCULATION

STEP 1 Identify the following information: drainage area to the detention practice and rational coefficient for that area; OR impervious area to the detention practice.

STEP 2 Confirm that the outlet rate of the detention practice is less than or equal to 0.15 cfs/acre. This applies ONLY to the practice drainage area.

STEP 3 Identify the volume required for the 100-year, 24-hour event, either through the use of Equation 5 through Equation 7, or by using the standard volume for impervious area of V_{100} = 11,750 cf/impervious acre.

STEP 4 Either a) design the practice for the identified 100-year, 24-hour event volume; or b) design for a lesser volume. The minimum volume that qualifies for a peak flow credit is the 2-year, 24-hour event volume (V_2 = 4,220 cf/ impervious acre). The peak flow credit is determined by Equation 8.

$$Peak\ Flow\ Credit = \frac{V_{provided}}{V_{100}} * 100$$

STEP 5 Calculate the practice credit. The peak flow credit applies to 40% of the bill. Therefore multiply the value in Step 4 by 0.4.

$$Practice\ Credit\ (\%) = Peak\ Flow\ Credit\ (\%) * 0.4$$

STEP 6 Calculate the site credit by prorating the practice credit by the fraction of impervious area managed versus total site impervious area.

$$Site\ Credit\ (\%) = Practice\ (\%) * \frac{Managed\ Impervious\ Area}{Total\ Site\ Impervious\ Area}$$

4.4 Minimum Design Criteria for Credit Quantification

Minimum design criteria are identified for each commonly used stormwater management practice. Design criteria are specifically related to credit quantification and are not intended to serve as an engineering design standard.

Important Note: Conditions which constitute a hazard or nuisance are not eligible for credits.

4.4.1 Disconnected Downspouts & Impervious Surfaces

Disconnected impervious surfaces are a stormwater management practice that directs runoff from impervious surfaces onto properly sized, sloped and vegetated surfaces. Both roofs and paved surfaces can be disconnected with slightly differing designs. Disconnected impervious surfaces may already exist on many sites. This is a relatively low cost measure that can be implemented if there is pervious area that can accept runoff. Because there is no control of peak storms, the credit is a volume credit.

4.4.1.1 Disconnected Downspouts

Customers can disconnect downspouts and allow storm runoff to flow over landscaped areas or lawns. Disconnection can be a low-cost option that allows stormwater to infiltrate into the soil.

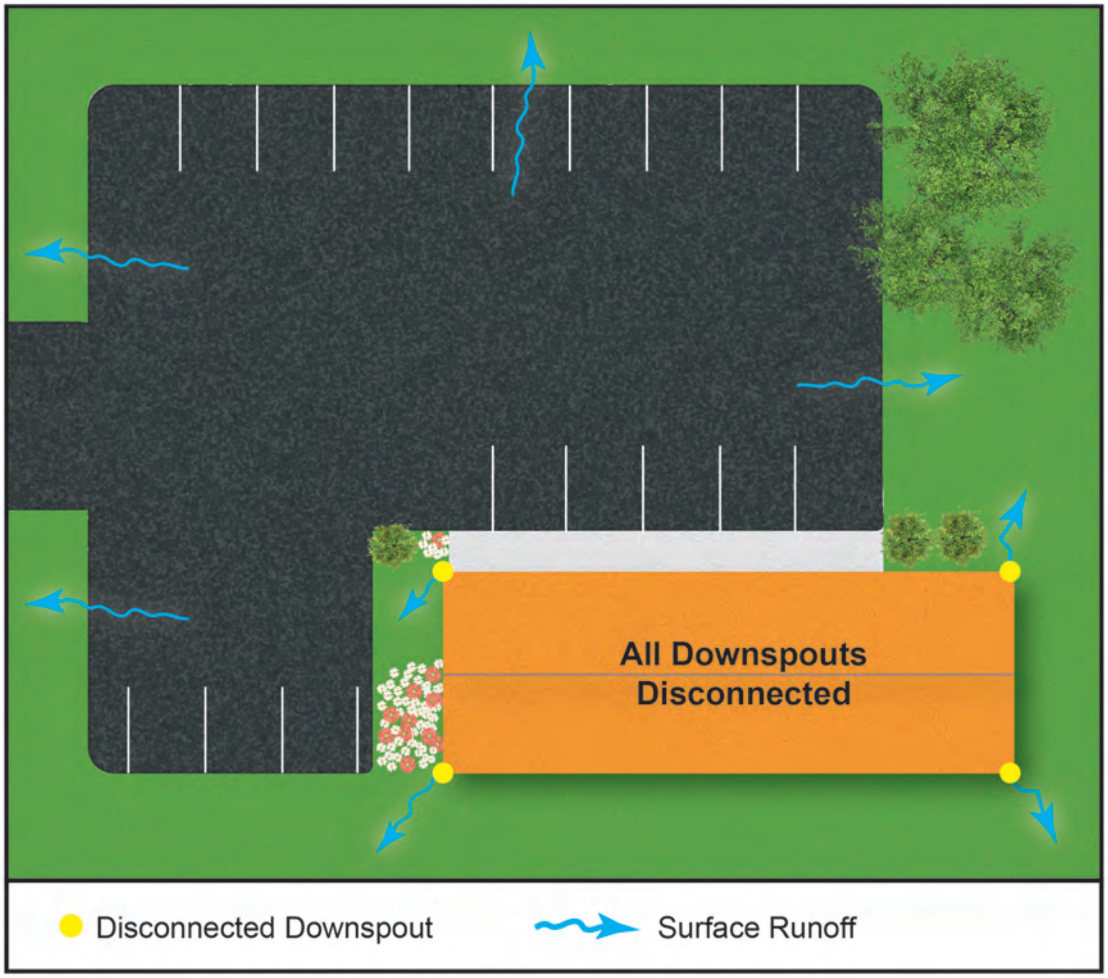


Figure 11: Disconnected Downspouts Draining to Pervious Area

The drainage credit related criteria for design involves the proper size, slope, and vegetation of the area receiving flow from the impervious surface.

The following criteria must be met to be eligible for a downspout disconnection credit:

- Size:
  - **Maximum Drainage Area:** The maximum area tributary to any one individual downspout that may receive credit is 500 sf. If the area is greater than 500 sf, 500 sf must be used in calculations. Special cases may be evaluated by DWSD.
  - **Minimum Flow Path:** The minimum flow path from the end of the downspout to the property line or other impervious surface is 15 feet.
  - **Minimum Practice Ratio:** The minimum practice ratio eligible for credit is 0.1.
  - **Determination of Practice Area:** As noted in Table 2, the standard practice area for the disconnected downspout is the length of the flow path times a width of five feet.
  - **Minimum Distance from Building:** The minimum distance from the structure at which the downspout can discharge is 5 feet. The grade at the point of discharge must be sloped away from the structure.
  - **Nuisance Conditions:** Flow discharged from a downspout cannot lead to nuisance or hazardous conditions.
- Slope: The slope of the pervious area onto which flow is discharged should be less than 5%.
- Vegetation/ Soil Characteristics:
  - **Surface Area Type:** Downspouts must be directed to a pervious area consisting of well-established vegetation. No credit will be given if downspouts are directed to other impervious areas (i.e., driveway, walkway). Soil in the discharge area should not be compacted. Areas which have evidence of vehicular traffic do not qualify as pervious areas.

Properties which cannot achieve the minimum design standards for disconnected imperviousness may be able to install bioretention systems or other practices that can manage roof runoff in a smaller footprint.

The following example calculation is for a commercial site with multiple downspouts. The site meets the minimum criteria for disconnected downspouts in that:

- The drainage area to each downspout is less than 500 square feet.
- The minimum flow path from each downspout is 15 feet or greater.
- The practice ratio is greater than 0.1.

The pervious area to which the downspout is directed must have well established vegetated cover and soils that are not compacted.

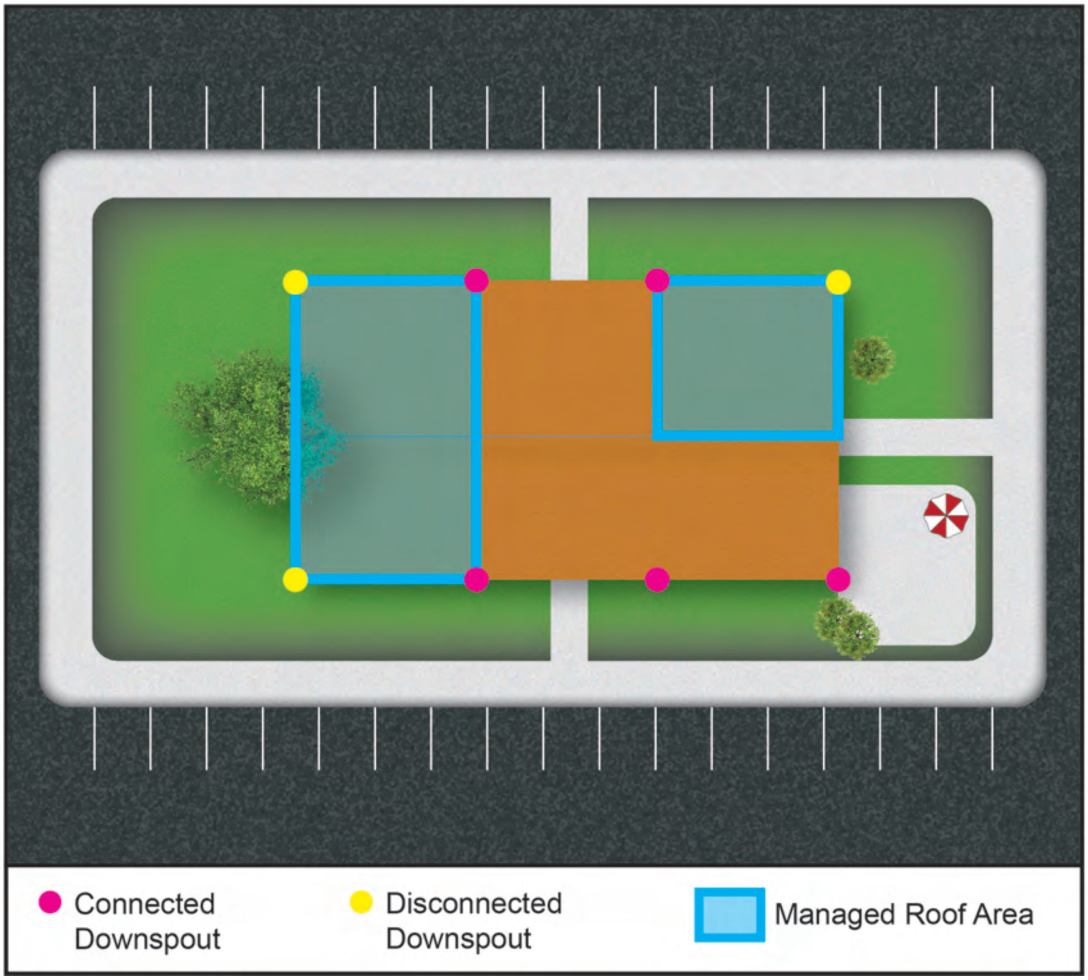


Figure12: Schematic for Downspout Disconnected Example

DOWNSPOUT DISCONNECTION EXAMPLE

A small commercial property owner is applying for a downspout disconnection credit for a property with the following characteristics:

Total Site Impervious Area: 5,300 square feet (sf) (roof and parking lot and sidewalk)
Roof Area: 2,800 sf, assumed evenly divided to each downspout
Total Number of Downspouts: 8
Number of Disconnected Downspouts: 3

STEP 1 Define the individual drainage areas and practice areas:

Length of each disconnection: See Figure12 (varies from 20-25 feet).

- Downspout 1: Drainage area = 350 sf, Practice area = 25*5 = 125 sf
- Downspout 2: Drainage area = 350 sf, Practice area = 25*5 = 125 sf
- Downspout 3: Drainage area = 350 sf, Practice area = 20*5 = 100 sf

STEP 2 Calculate the individual stormwater practice ratios:

$$\textit{Practice Ratio} = \frac{\textit{Practice Area}}{\textit{Managed Impervious Area}}$$

- Downspout 1: Practice Ratio = 125/350 = 0.36
- Downspout 2: Practice Ratio = 125/350 = 0.36
- Downspout 3: Practice Ratio = 100/350 = 0.29

STEP 3 Calculate the volume credit:

$$\textit{Volume Credit (\%)} = 0.94 * \frac{\textit{Practice Ratio}}{0.25 + \textit{Practice Ratio}} * 100$$

- Downspout 1: Volume Credit = 0.94 * (0.36/(0.25+0.36)) * 100 = 55%
- Downspout 2: Volume Credit = 0.94 * (0.36/(0.25+0.36)) * 100 = 55%
- Downspout 3: Volume Credit = 0.94 * (0.29/(0.25+0.29)) * 100 = 50%

DOWNSPOUT DISCONNECTION EXAMPLE (continued)

STEP 4 Determine the practice credit for the managed impervious area:

$$Practice\ Credit\ (\%) = Volume\ Credit * 0.4$$

- Downspout 1: Practice Credit = 55% * 0.4 = 22%
- Downspout 2: Practice Credit = 55% * 0.4 = 22%
- Downspout 3: Practice Credit = 50% * 0.4 = 20%

STEP 5 Calculate the site credit:

$$Site\ Credit\ (\%) = \frac{\sum Managed\ Impervious\ Area * Practice\ Credit}{Total\ Site\ Impervious\ Area}$$

$$Site\ Credit\ (\%) = \frac{350 * 22\% + 350 * 22\% + 350 * 20\%}{5{,}300} = 4.2\%$$

$$Rounded\ Site\ Credit\ (\%) = 5.0\%$$

4.4.1.2 Impervious Surface Disconnection

Customers are eligible to receive an impervious disconnection credit by directing stormwater from impervious surfaces to pervious surface areas. Examples include driveways, impervious walkways and parking areas. Impervious surface disconnection allows stormwater to drain onto a vegetated area and infiltrate into the ground.

Impervious surface disconnection is comparable to downspout disconnection discussed previously. The major difference between impervious surface disconnection and downspout disconnection is that the flows may be distributed (e.g., sheet flow established) allowing for a greater area of pervious surface to be credited as the practice area.

Drainage credit related criteria for impervious surface disconnection design involves proper sizing, slope and vegetation of the area receiving flow from the impervious surface. It also requires the drainage entering the pervious area to be established as sheet flow.

The following criteria must be met to receive a credit for impervious area disconnection:

- Size:

    - **Maximum Drainage Area:** The maximum drainage area is defined as a contributing flow path of impervious area not longer than 75 feet. With a gravel verge or other transition, this can be increased to 100 feet. For areas longer than this, a special determination will be required.

    - **Minimum Flow Path:** The minimum flow path across the pervious surface is equal to the length of the impervious drainage area or 25 feet, whichever is less. With a gravel verge at the transition from impervious to pervious area, the length of the pervious area may be reduced to 15 feet. The flow path must be on parcels, not right-of-way.

    - **Minimum Practice Ratio:** The minimum practice ratio eligible for credit is 0.33 without a gravel verge or other transition and is 0.15 with a gravel verge or other transition.

    - **Sheet Flow Required:** The overland flow to the pervious area must be sheet flow. For example, flow through a swale does not count as disconnected impervious area. Any flow which enters the pervious area as concentrated flow must first be distributed with a level spreader. The level spreader is not considered part of the disconnected impervious practice area.

    - **Determination of Practice Area:** As noted in Table 2, the standard practice area for the disconnected impervious area is the width of the sheet flow multiplied by the length of the flow path across the pervious area.

    - **Nuisance Conditions:** Use of disconnected impervious practices must not lead to a nuisance or hazardous conditions.

- Slope: The slope of the both the contributing impervious area and the pervious area onto which flow is discharged should be less than 5%.

- Vegetation/ Soil Characteristics:

    - **Surface Area Type:** Drainage from the impervious area must be directed to a pervious area consisting of well-established vegetation. No credit will be given if the impervious area is directed to other impervious areas (i.e., driveway, walkway). Soil in the discharge area should not be compacted. Areas which have evidence of vehicular traffic do not qualify as pervious areas.

Figure 13 depicts an example calculation for a parking area that flows onto a pervious area.

IMPERVIOUS SURFACE DISCONNECTION EXAMPLE

The owner of a medium-sized commercial lot is applying for a volume credit for disconnecting a portion of the parking lot.

The property has the following characteristics:

Managed Impervious Area (A): 3,000 square feet (sf)
Total Site Impervious Area: 12,000 sf
Practice Area: 2,500 sf

STEP 1 Calculate the Practice Ratio:

$$Practice\ Ratio = \frac{Practice\ Area}{Managed\ Impervious\ Area} = \frac{2{,}500\ sf}{3{,}000\ sf} = 0.83$$

STEP 2 Calculate the Volume Credit:

$$Volume\ Credit\ (\%) = 0.94 * \frac{Practice\ Ratio}{0.25 + Practice\ Ratio} * 100 = 0.94 * \frac{0.83}{0.25 + 0.83} * 100 = 72\%$$

STEP 3 Calculate the practice credit:

$$Practice\ Credit\ (\%) = Volume\ Credit\ (\%) * 0.4 = 72\% * 0.4 = 28.8\%$$

STEP 4 Prorate the practice credit to the site:

$$Site\ Credit\ (\%) = Practice\ Credit\ (\%) * \frac{Managed\ Impervious\ Area}{Total\ Site\ Impervious\ Area} = 28.8\% * \frac{3{,}000\ sf}{12{,}000\ sf} = 7.2\%$$

$$Rounded\ Site\ Credit\ (\%) = 8.0\%$$

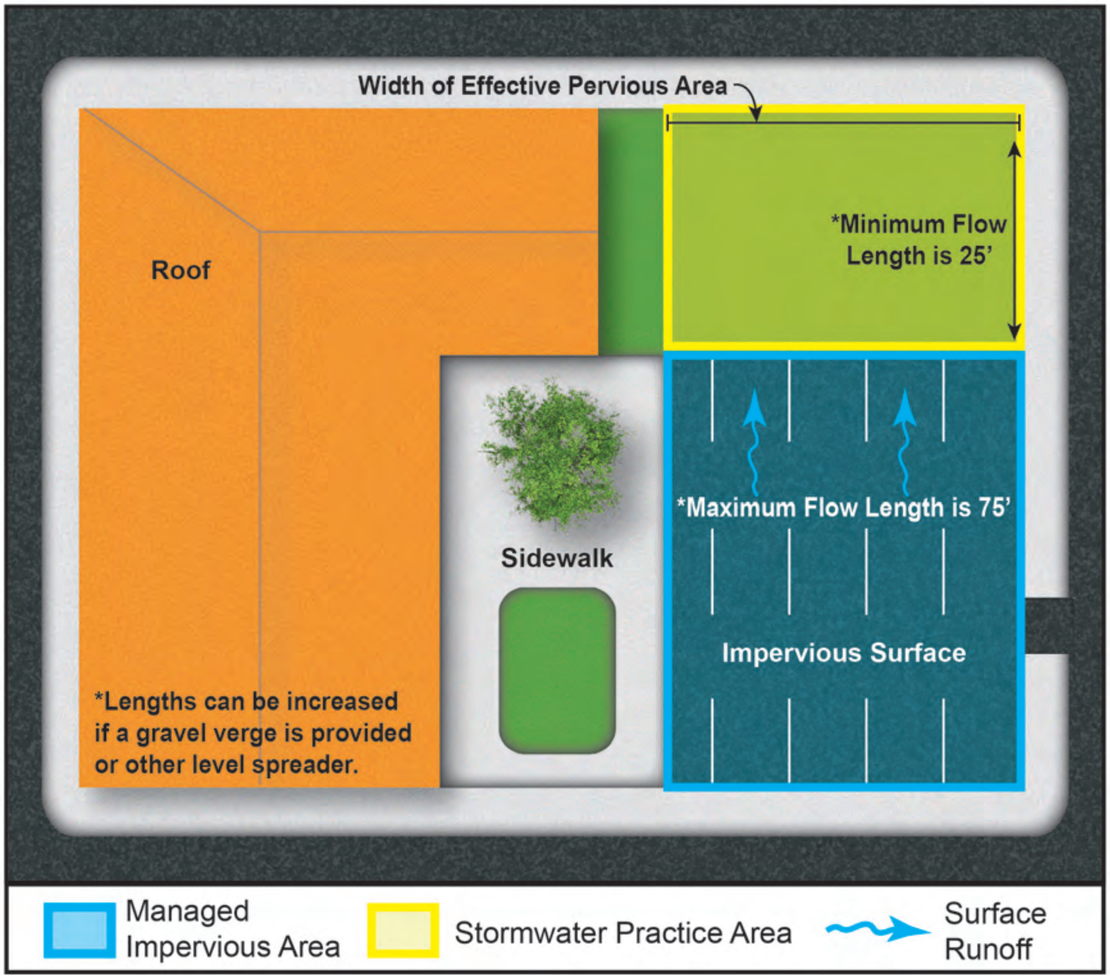


Figure 13: Schematic for Impervious Surface Disconnection Example

4.4.2 Bioretention

Bioretention stormwater management practices include a number of different configurations that temporarily store runoff in an engineered system that will later infiltrate into the soil. The type of bioretention systems most commonly constructed include:

TABLE 3 - Common Bioretention Types and Application

Bioretention Type	Where Used	Comments
Rain garden	Homes and small buildings	Generally less than 1,000 square feet of impervious area, typically less engineered
Bioretention	Nonresidential sites	Typically installed in vegetated areas to manage runoff from surrounding impervious areas
Bioswale	Along roadways	Integrates a bioretention system into a swale that also conveys stormwater
Curb extension	Road rights-of-way or along private driveways	Generally in rights-of-way and manages runoff from streets
Planter boxes	Highly urban areas, sites without lawn	Structural walls, highly compact; usually above ground level and captures runoff from roofs
Tree trenches	Highly urban areas, parking lots, sidewalks	Structural walls, suspended pavement systems; usually below-ground and captures runoff from adjacent surfaces

Other than rain gardens, bioretention systems are engineered stormwater management practices that include such elements as aggregate storage, filter layers, and special planting soils that are specifically designed to manage, treat and store stormwater prior to infiltration into the soil.

Figure 14: Bioretention Illustration

Bioretention systems are typically designed to control annual volume, but they may also be sized for peak flow credits.

Credit related design criteria includes:

- **Retention Volume:** The retention volume provided must be consistent with the credit quantification methodology selected. Retention volume occurs below the underdrain outlet elevation in the constructed soil and aggregate layers, not in the subgrade.
- **Detention Volume:** Detention volume occurs above the underdrain outlet. The detention volume should be determined based on the geometry of the bioretention system.
- **Groundwater Table:** The bottom of the bioretention media (aggregate and engineered soil) must be two feet above the seasonal high groundwater table for best performance and health of the plants used. More advanced design techniques should be used in high groundwater situations.
- **Dewatering:** Bioretention systems in non-residential applications must have a physical outlet that will allow for drainage. This will ensure satisfactory performance if infiltration capacities are significantly reduced due to seasonal conditions or system failure. The Detroit area experiences frozen ground conditions and a seasonally high water table. Bioretention systems therefore should be equipped with an underdrain at an elevation to drain all water that is stored above the ground surface within 24 hours.
- **Overflow or Bypass:** The practice must have a planned overflow or bypass for when the storage volume is full.
- **No Infiltration Over DWSD Pipe:** Current DWSD policy states that stormwater must be managed and sufficiently isolated from the DWSD drainage system to prevent drainage the of the site, through infiltration, into DWSD sewers.

Required design elements when bioretention systems are intended to provide detention and customers want to apply for peak flow credits.

- **Outlet Control:** The outlet capacity from the bioretention (generally the underdrain) must be controlled to less than or equal to 0.15 cfs/acre.
- **Minimum Detention Volume:** The detention volume provided in the bioretention must be sufficient for at least the two year storm event to qualify for a credit.

Bioretention in Planter Boxes

Bioretention Islands in Parking Lots

Bioretention between Parking Lot Aisles

- **No Infiltration Over DWSD Pipe:** Current DWSD policy states that stormwater must be managed and sufficiently isolated from the DWSD drainage system to prevent drainage of the site, through infiltration, into DWSD sewers.

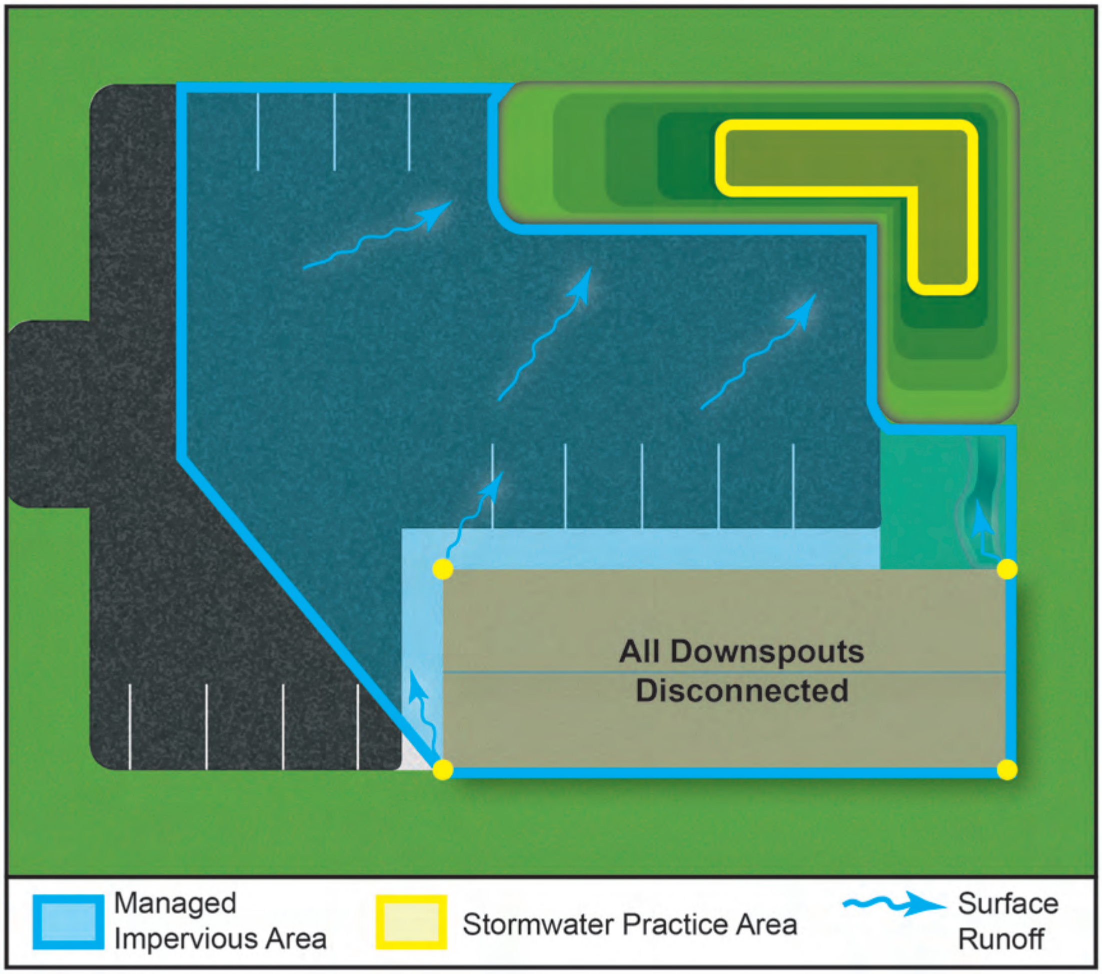


Figure 15: Bioretention Calculation Example

BIORETENTION CALCULATION EXAMPLE – RETENTION ONLY

A small business owner is applying for a volume credit for a bioretention practice; the property has the following characteristics:

Managed Impervious Area (A): 5,000 square feet (sf)
Total Site Impervious Area: 6,500 sf
Practice Area: 750 sf
Soil Infiltration Rate: 0.1 in/hr

The calculation methodology used is the Equivalent Rainfall Depth method.

STEP 1 Determine maximum Equivalent Water Depth (EWD) based on infiltration rate:

The soil has an infiltration rate of 0.1 inches/hour.

$$Max.\ EWD_{(Retention)}\ (in) = Infiltration\ Rate\left(\frac{in}{hr}\right) * Duration\ (hrs) = 0.1 * 72 = 7.2\ in$$

STEP 2 Determine cross section and placement of underdrain. Calculate the EWD (Retention). $EWD_{Retention}$ is the storage below the underdrain.

Many options are available for the cross section. One example would be:

- 18 inches of aggregate with an effective porosity of 0.4 = 7.2 inches
- Underdrain (located 18 inches from bottom of practice)
- 4 inches of aggregate with an effective porosity of 0.4 = 1.6 inches
- 25 inches of soil with an effective porosity of 0.20 = 5 inches
- Unless independent testing is conducted on the materials to be used, a value of 0.40 shall be used for the effective porosity of the coarse aggregate and 0.20 for bioretention soil

$EWD_{Retention}$ = 7.2 inches

STEP 3 Determine the retention volume provided:

$$Retention\ Volume\ (cf) = Practice\ Area\ (sf) * \frac{EWD_{Ret}\ (in)}{12} = 750\ sf * \frac{7.2\ in}{12\ in} = 450\ cf$$

STEP 4 Determine Equivalent Rainfall that corresponds to volume in Step 3.

$$Equivalent\ Rainfall\ Depth\ (in) = \frac{Retention\ Volume\ (cf)}{Managed\ Impervious\ Area\ (sf)} = \frac{450\ cf}{5{,}000\ sf} * 12 = 1.08\ in$$

BIORETENTION CALCULATION EXAMPLE – RETENTION ONLY (continued)

STEP 5 Calculate the volume credit if 1.08 inches of rainfall remained on the site using Equation 6.3: $Volume\ Credit\ (\%) = (1 - 2.5^{-2.5 * Equivalent\ Rainfall\ Depth\ (in)}) * 100$

$$Volume\ Credit\ (\%) = (1 - 2.5^{-2.5 * 1.08}) * 100$$
$$Volume\ Credit\ (\%) = 91.6\%$$

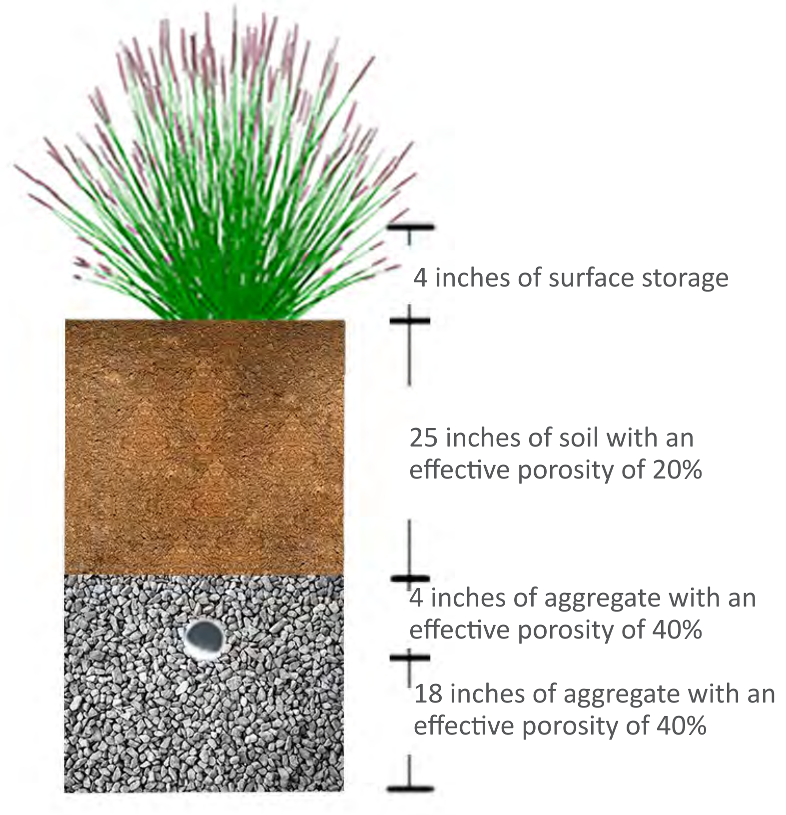
STEP 6 Calculate the practice credit:

$$Practice\ Credit\ (\%) = Volume\ Credit\ (\%) * 0.4 = 91.6\% * 0.4 = 36.6\%$$

STEP 7 Calculate the site credit:

$$Site\ Credit\ (\%) = Practice\ Credit\ (\%) * \frac{Managed\ Impervious\ Area}{Total\ Site\ Impervious\ Area} = 36.6\% * \frac{5{,}000\ sf}{6{,}500\ sf} = 28.1\%$$

$$Rounded\ Site\ Credit\ (\%) = 29.0\%$$



BIORETENTION CALCULATION EXAMPLE – RETENTION AND DETENTION

The same site as in the prior example is being constructed to provide both retention and detention.
Data from prior example:
Managed Impervious Area (A): 5,000 sf (0.11 acre)
Total Site Impervious Area: 6,500 sf
Practice Area: 750 sf
Soil Infiltration Rate: 0.1 in/hr

Cross Section:
- 18 inches of aggregate with an effective porosity of 0.4
- Underdrain (18 inches from bottom of practice)
- 4 inches of aggregate with an effective porosity of 0.4
- 25 inches of soil with an effective porosity of 0.20

STEP 1 Determine the minimum volume required to obtain a detention credit: The detention credit requires adequate volume to store the 2-year, 24-hour event. Refer to Equation 6.7B.

$$V_2 = 4{,}220 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

$$V_2 = 4{,}220 \frac{cf}{Impervious\ Acre} * 0.11\ ac = 464.2\ cf$$

STEP 2 Determine the EWD necessary in the detention zone of the practice: The necessary EWD to achieve a detention credit is:

$$EWD_{detention} = \frac{464.2\ cf}{750\ sf} = 0.62\ ft = 7.4\ in$$

Note: There is no maximum EWD for the Detention Zone.

STEP 3 Consider the potential EWD based on chosen cross section: EWD (in) = surface storage (in) + soil depth (in) * effective porosity + aggregate depth (in) * effective porosity

As part of the practice design, the designer determines that the depth of water on the surface of the practice would be 4 inches. The $EWD_{Detention}$ is the storage space above the underdrain.

$$EWD_{Detention} = 4.0\ in + (4.0\ in * 0.4) + (25\ in * 0.20) = 10.6\ in$$

STEP 4 Determine the actual detention volume:

$$V_{provided} = \frac{10.6\ in}{12\ in/ft} * 750\ sf = 662.5\ cf$$

BIORETENTION CALCULATION EXAMPLE – RETENTION AND DETENTION (continued)

STEP 5 Determine the peak flow credit: Using Equation7A, calculate the percentage of the 100-year, 24-hour storm volume that is provided.

$$V_{100} = 11{,}750 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

$$Peak\ Flow\ Credit = \frac{V_{provided}}{V_{100}} * 100 = \frac{662.5}{0.11 * 11{,}750} * 100 = 51.3\%$$

STEP 6 Calculate the practice credit (for both Retention and Detention credits).

$$Practice\ Credit = Volume\ Credit * 0.4 + Peak\ Flow\ Credit * 0.4 = 91.6\% * 0.4 + 51.3\% * 0.4 = 57.2\%$$

STEP 7 Calculate the site credit:

$$Site\ Credit\ (\%) = Practice\ Credit\ (\%) * \frac{A}{Total\ Site\ Impervious\ Area} = 57.2\% * \frac{5{,}000\ sf}{6{,}500\ sf} = 44.0\%$$

$$Rounded\ Site\ Credit\ (\%) = 44.0\%$$

4.4.3 Permeable Pavement

Several design options are available for using permeable pavements to intercept, contain, filter, and where appropriate infiltrate stormwater on site. Permeable pavements can be installed across an entire street width or an entire parking area. In some cases, permeable and standard pavements are used in the same parking area. For example, a parking lot (see Figure 16) may use permeable pavement in parking stalls to treat runoff from adjacent standard pavements in drive lanes. The aggregate layer may extend under both the permeable and standard pavements.

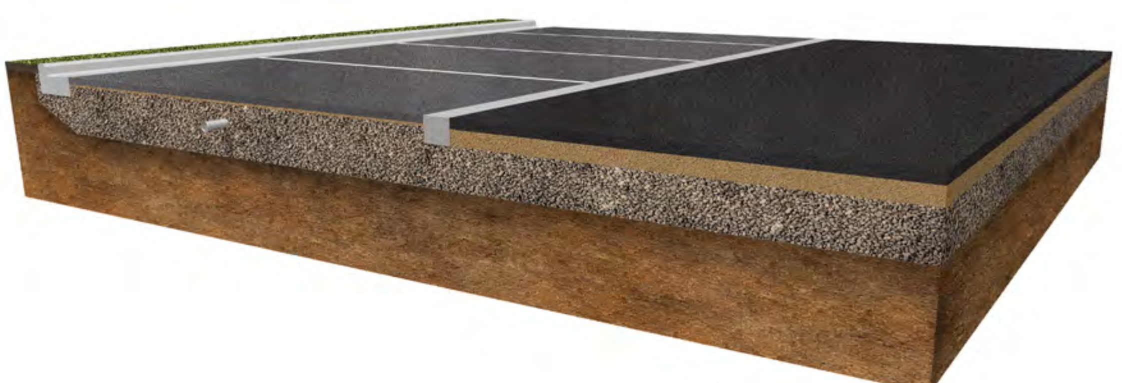


Figure 16: Permeable Pavement Configuration

Similar to bioretention, the placement of the underdrain in the permeable pavement cross section determines the function of the volume provided. As shown in Figure 17, the volume below the underdrain acts as retention while the volume above the underdrain acts as detention (assuming the outlet is controlled).

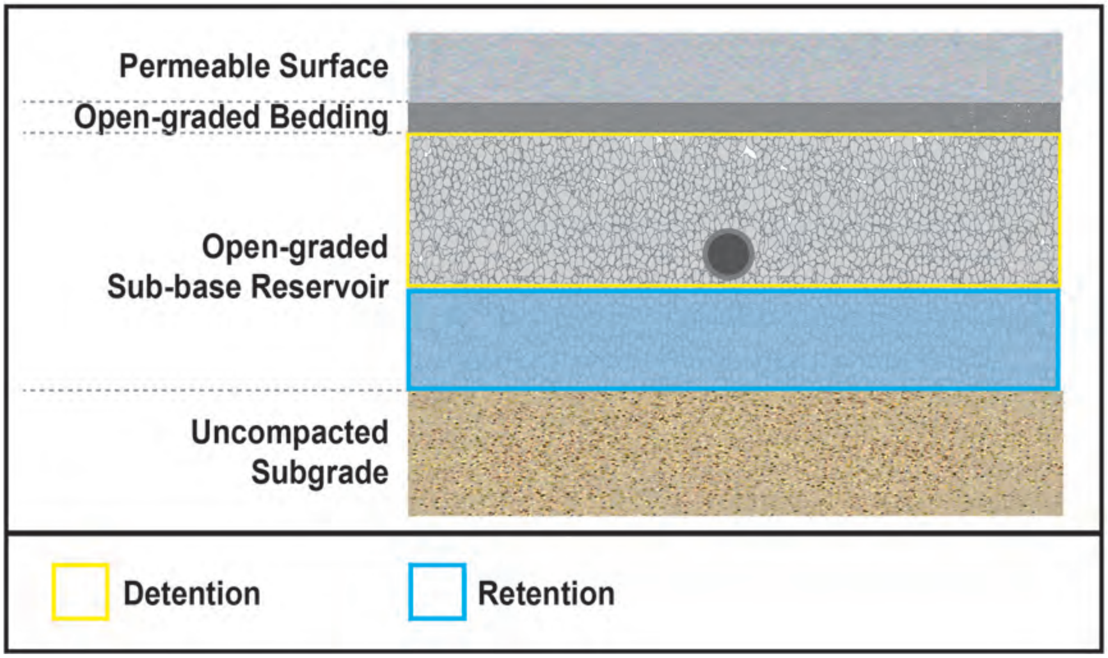


Figure 17: Retention and Detention in Permeable Pavements

Permeable pavement systems result in credits based on their hydrologic performance. The fundamental hydrologic performance is calculated using the same methodology as is used for bioretention. The critical factors include:

- Practice area
- Infiltration rates into the soil
- Available retention volume
- Available detention volume
- **Practice Area:** Practice areas for permeable pavement systems are based on the size of the aggregate storage provided under pavement and not the pavement surface characteristics. To the extent that the aggregate layer receives flows from surfaces other than pervious pavement, the flows need to be well distributed within the aggregate. Generally the ratio of standard to permeable pavement in a parking area should be limited. Dirt and debris from the standard pavement can result in clogging of the permeable surface. A maximum standard to permeable pavement ratio of 2:1 is permitted.
- **Available Retention Volume:** The available retention volume is the equivalent water depth in the aggregate layer below the underdrain. Underdrains in permeable pavement generally do not contain upturned elbows. The maximum retention volume is based on infiltrating within 72 hours.

- **Available Detention Volume:** The available detention volume is the equivalent water depth in the pavement system above the underdrain. It may include any usable void space up to and including the permeable surface. In order to qualify as detention volume, the flow rate leaving the underdrain must be controlled to 0.15 cfs/acres or less. The detention volume is not reduced for solids management as solids control is required independent of the detention volume.
- **Overflow:** Permeable pavement systems should be provided with an overflow in the event of storm systems larger than can be handled by the system. The overflow may include catch basins located in the pavement or adjacent to the pavement.
- **No Infiltration Over DWSD Pipe:** Current DWSD policy states that stormwater must be managed and sufficiently isolated from the DWSD drainage system to prevent drainage the of the site, through infiltration, into DWSD sewers.

Example Calculation

Permeable pavement systems generally provide a highly distributed area for infiltration. The following example calculation illustrates the infiltration component for the volume credit.

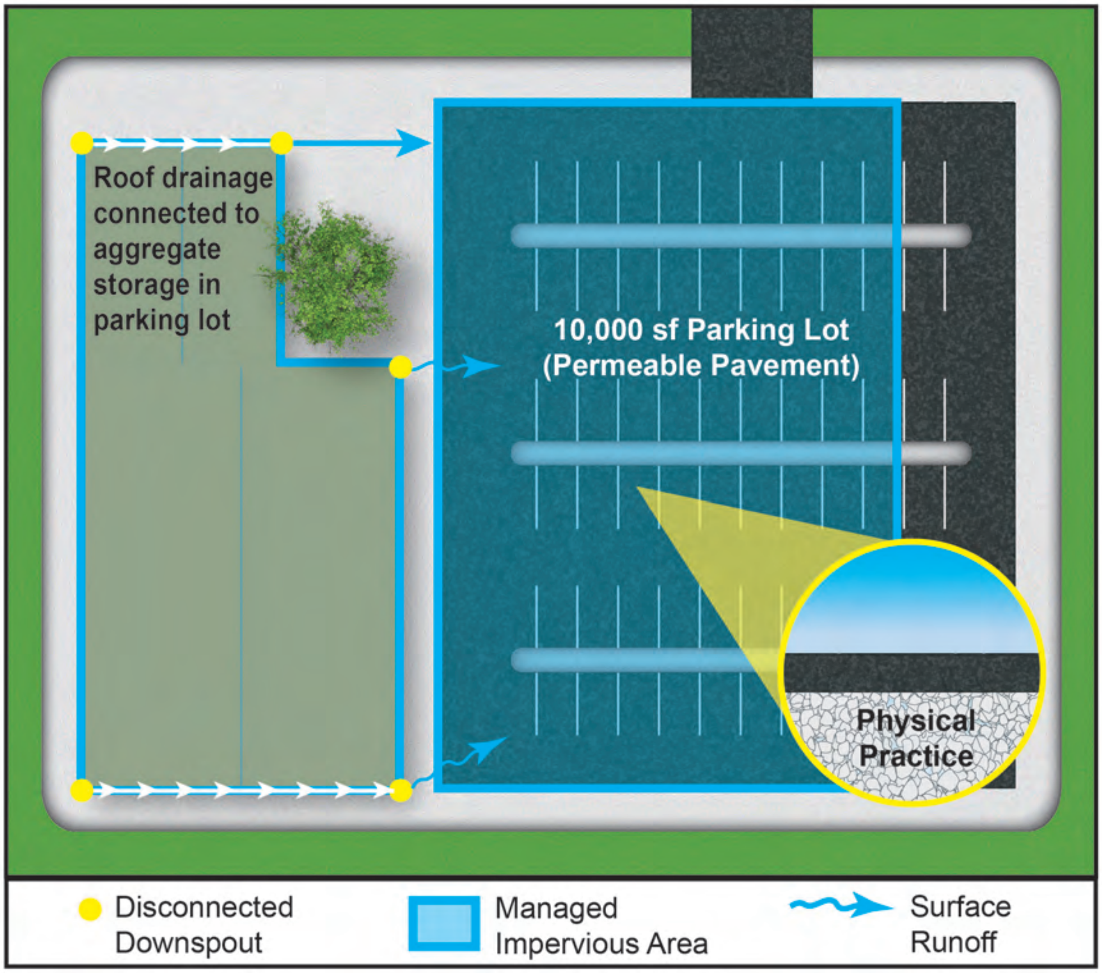


Figure 18: Schematic for Permeable Pavement Example

PERMEABLE PAVEMENT VOLUME CREDIT CALCULATION EXAMPLE

A commercial property is applying for a volume credit for permeable pavement. The site has the following characteristics:

- Managed Impervious Area (A): 10,000 sf from parking lot plus 5,000 from roof runoff = 15,000 sf
- Total Site Impervious Area: 17,500 sf
- Infiltration Rate: 0.1 in/hr
- Allowable Drain Time: 72 hr
- Permeable Pavement: Aggregate Storage Layer: 5,000 square feet of the parking lot. Therefore physical practice: 5,000 sf
- Depth of Aggregate (under the parking lot): 24 inches
- Effective Porosity in Aggregate: 40%
- Unless independent testing is conducted on the materials to be used, a value of 0.40 shall be used for the effective porosity of the coarse aggregate
- Underdrain is located 12 inches off the bottom of the practice

PERMEABLE PAVEMENT VOLUME CREDIT CALCULATION EXAMPLE (continued)

STEP 1 Determine the Equivalent Water Depth (EWD) provided for retention (**below** the underdrain):

$$EWD\ Provided\ (in) = Aggregate\ Depth\ (in) * Effective\ Porosity = 12 * 0.40 = 4.8\ in$$

STEP 2 Determine if the volume under the underdrain will drain in the allotted time by comparing the EWD and infiltration rate to the maximum values in Table 1. The maximum value for a 0.1 in/hr rate is 7.2 inches.

$$EWD\ provided\ (in) = \frac{4.8\ in}{<7.2\ in}\ (max\ EWD\ for\ 0.1 \left(\frac{in}{hr}\right) rate)$$

STEP 3 Determine the retention volume provided:

$$Retention\ Volume\ (cf) = Practice\ Area\ (sf) * \frac{EWD_{Ret}\ (in)}{12} = 5{,}000\ sf * \frac{4.8\ in}{12\ in} = 2{,}000\ cf$$

STEP 4 Determine Equivalent Rainfall Depth that corresponds to volume in Step 3.

$$Equivalent\ Rainfall\ Depth\ (in) * \frac{Retention\ Volume\ (cf)}{Managed\ Impervious\ Area\ (sf)} = \frac{2{,}000\ cf}{15{,}000\ cf} * 12 = 1.6\ in$$

STEP 5 Calculate the volume credit if 1.4 inches of rainfall remained on the site using Equation 6.3: $Volume\ Credit\ (\%) = (1 - 2.5^{-2.5\ *\ Equivalent\ Rainfall\ Depth\ (in)}) * 100$

$$Volume\ Credit\ (\%) = (1 - 2.5^{-2.5\ *\ 1.6}) * 100$$
$$Volume\ Credit\ (\%) = 97.4\%$$

STEP 6 Calculate the practice credit:

$$Practice\ Credit\ (\%) = Volume\ Credit\ (\%) * 0.4 = 97.4\% * 0.4 = 38.9\%$$

STEP 7 Calculate the site credit:

$$Site\ Credit\ (\%) = \frac{Managed\ Impervious\ Area}{Total\ Site\ Impervious\ Area} * Practice\ Credit\ (\%) = \frac{15{,}000\ sf}{17{,}500\ sf} * 38.9\% = 33.4\%$$

$$Rounded\ Site\ Credit\ (\%) = 34.0\%$$

PERMEABLE PAVEMENT PEAK FLOW CREDIT CALCULATION

If permeable pavement meets the requirements for detention (i.e., controlled release rate of 0.15 cfs/acre), the practice is eligible to receive a peak flow credit. The example below is a continuation of the previous permeable pavement volume credit calculation and shows how to earn a peak flow credit. The assumptions and site characteristics are the same from the previous example.

STEP 1 Determine the EWD provided for detention (***above*** the underdrain):

$$EWD\ Provided\ (in) = Aggregate\ Depth\ (in) * Effective\ Porosity = 12 * 0.40 = 4.8\ in$$

Note: There is no maximum EWD for the Detention Zone.

STEP 2 Determine the runoff volume for the 100-year, 24-hour event: As a simplified site, and using Equation 7A, the 100-year, 24-hour event volume is calculated using:

$$V_{100} = 11{,}750 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

$$V_{100} = 11{,}750 \frac{cf}{Impervious\ Acre} * A\ (ac) = 11{,}750 * 0.34\ acres = 3{,}995\ cf$$

STEP 3 Determine the runoff volume for the 2-year, 24-hour event: From Equation 7B, the 2-year, 24-hour event is calculated using:

$$V_2 = 4{,}220 \frac{cf}{Impervious\ Acre} * A\ (ac)$$

$$V_2 = 4{,}220 \frac{cf}{Impervious\ Acre} * A\ (ac) = 4{,}220 * 0.34\ acres = 1{,}435\ cf$$

STEP 4 Determine the actual detention volume and confirm it is sufficient for a 2-year, 24-hour storm event:

$$V_{provided} = Physical\ Size\ of\ Practice\ (sf) * EWD\ (ft) = 5{,}000\ sf * \left(\frac{4.8}{12}\right) = 2{,}000\ cf$$

The actual volume is greater than the 2-year, 24-hour event volume. As a result, this practice is eligible for a peak flow credit.

STEP 5 Calculate the peak flow credit:

$$Peak\ Flow\ Credit\ (\%) = \frac{V_{provided}}{V_{100}} * 100 = \frac{2{,}000\ cf}{3{,}995\ cf} * 100 = 50.1\%$$

PERMEABLE PAVEMENT PEAK FLOW CREDIT CALCULATION (continued)

STEP 6 Determine the practice credit:

*Practice Credit (%) = Volume Credit * 0.4 + Peak Flow Credit * 0.4 = (97.4% * 0.4) + (50.1% * 0.4) = 56.5%*

STEP 7 Determine the site credit:

$$\text{Site Credit (\%)} = \frac{\text{Managed Impervious Area}}{\text{Total Site Impervious Area}} * \text{Practice Credit (\%)} = \frac{15{,}000\text{ sf}}{17{,}500\text{ sf}} * 56.5\% = 48.4\%$$

Rounded Site Credit (%) = 49.0%

4.4.4 Detention Ponds and Detention Volumes Provided in Other Practices

Detention practices target large storms to limit the peak flow rate that discharges into the sewer system. Their primary function is to store a specified volume and release it slowly over a defined period of time.

The two most popular examples of detention practices are open surface detention basins and subsurface storage chambers.

Dry Detention Basin

Underground retention/detention may be useful for developments where land availability and land costs limit the use of surface detention practices and in retrofit and redevelopment settings. Pretreatment is crucial for maintaining proper functionality of the storage practice and should be designed to remove sediment, floatables, and oils if prevalent in the drainage area.

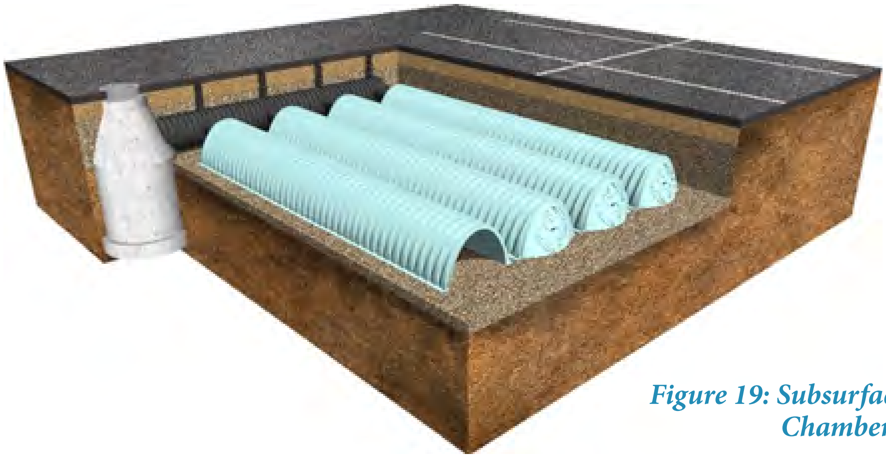


Figure 19: Subsurface Detention Chambers

The peak flow credit is based on the fraction of volume detained relative to the volume associated with a ***100-year, 24-hour storm event***. The detention system must also have a controlled release rate. The ***controlled release rate*** is intended to control flow rates into the combined sewer system, reducing the likelihood of a combined sewer overflow discharge and the risk of flooding. Unless the detention practice provides retention capabilities, detention practices are not eligible for volume credits.

The items that impact the peak flow credit for detention is volume detained and release rate.

- **Volume Detained:** The maximum peak flow credit is provided for detention practices that can store the 100-year, 24-hour storm event. This volume is generally determined using *standard detention calculations*.

The *volume* detained is considered the:

Constructed volume in practice *plus* additional volume in influent sewers minus volume designated for sediment storage

The **minimum** *volume detained* must be sufficient for the two year event to be eligible for a peak flow credit:

- **Volume Eligible for Credit:** The volume to be considered in the calculation may include sewers tributary to the detention practice. Only that volume that is below the emergency overflow will be considered for a peak flow credit. The volume must be provided in an intentional stormwater management practice or its tributary sewers to be considered as detention volume.

- **Sediment Storage:** Detention practices need planned locations to manage sediment so that they do not reduce the performance of the detention area. A sediment trap upstream of the practice can assist in this objective. The designer may either:

    - Install a manufactured treatment device upstream of the practice from which sediment is routinely removed; or

    - Install a sediment forebay and/or sediment storage area upstream of the detention practice.

    - The volume of water that can be stored in the sediment forebay (not including the volume designated for sediment storage) can be included in the total storage volume if the forebay is dewatered between rain events.

- **Outlet:** A requirement associated with the drainage charge credit is that the outlet is controlled to reduce discharge rates to the sewer system during storm events.

    - **Release Rate:** Less than or equal to 0.15 cfs/acre (release rate based on total acres draining to practice, not only impervious acres).

    - **Dewatering:** 24-72 hours.

- **Emergency Overflow or Bypass:** A planned emergency overflow or detention bypass must be provided in the event the system is full.

- **No Infiltration Over DWSD Pipe:** Current DWSD policy states that stormwater must be managed and sufficiently isolated from the DWSD drainage system to prevent drainage the of the site, through infiltration, into DWSD sewers.

Detention Basin Calculations

The primary calculation for the required detention volume and associated peak flow credits is shown in the following detention pond calculation example.

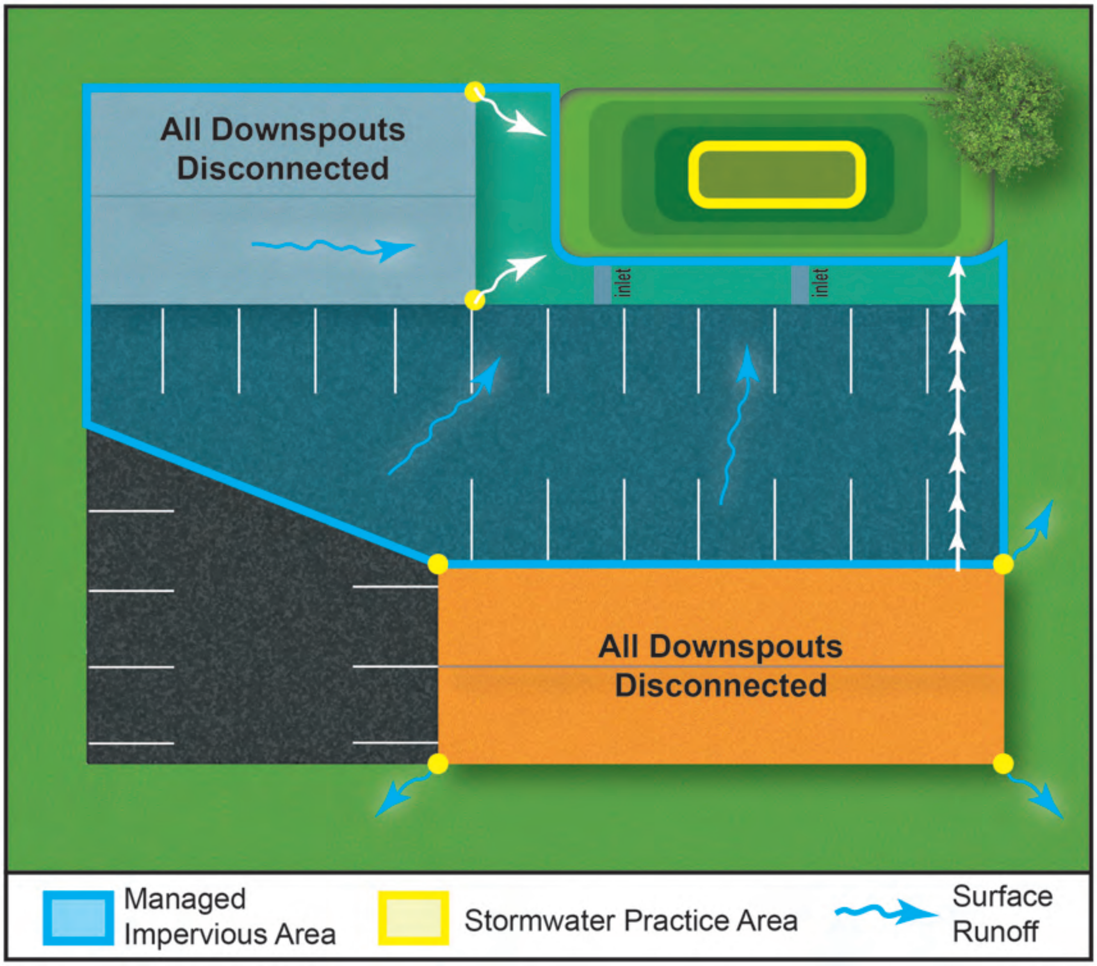


Figure 20: Schematic for Detention Pond Calculation Example

DETENTION POND CALCULATION EXAMPLE

The owner of a commercial shopping center is applying for a peak flow credit for a proposed detention pond on the corner of the property. The owner is able to direct runoff from 3.2 acres of impervious area to a detention practice that has a storage volume of 30,000 cubic feet. The outlet from the practice controls flow to no more than 0.15cfs/acre of tributary area.

- Managed Impervious Area (A) = 3.2 acres (ac) of impervious area
- The total site impervious area is 4.0 acres
- The Rational Coefficient is treated as 1 since pervious area is ignored
- The allowable discharge rate [Qr] for the 100-year, 24-hour storm event (presumed to be 0.15 cfs/acre) is achieved
- The pond has an approved manufactured treatment device to remove solids

STEP 1 Determine the volume required. As the simplified impervious only site is used in this calculation, the volume required per acre for the 100-year, 24-hour and 2-year, 24-hour storms respectively is:

$$V_{100} = 11{,}750 \text{ cf} / (\text{impervious acre}) * A\ (\text{ac}) = 11{,}750 * 3.2 \text{ ac} = 37{,}600 \text{ cf}$$

$$V_{2} = 4{,}220 \text{ cf} / (\text{impervious acre}) * A\ (\text{ac}) = 4{,}220 * 3.2 \text{ ac} = 13{,}504 \text{ cf}$$

STEP 2 Confirm that the volume provided excludes solids management volume. As this site includes a manufactured treatment device on the site, $V_{provided}$ is equal to the volume of the detention practice.

STEP 3 Confirm that the volume provided is sufficient for a 2-year, 24-hour storm event.

$$V_{provided} = 30{,}000 \text{ cf which is greater than } 13{,}504 \text{ cf}$$

STEP 4 Calculate the peak flow credit based on the proposed size of the detention pond.

$$\text{Peak Flow Credit } (\%) = \frac{V_{provided}}{V_{100}} = \frac{30{,}000}{37{,}600} * 100 = 80\%$$

STEP 5 Calculate the practice credit for the detention pond.

$$\text{Practice Credit } (\%) = \text{Peak Flow Credit} * 0.4 = 80\% * 0.4 = 32\%$$

DETENTION POND CALCULATION EXAMPLE (continued)

STEP 6 Calculate the site credit by prorating for the overall impervious area.

$$\text{Site Credit (\%)} = \text{Practice Credit (\%)} * \frac{\text{Managed Impervious Area}}{\text{Total Site Impervious Area}} = 32\% * \frac{3.2 \text{ acres}}{4.0 \text{ acres}} = 25.6\%$$

Rounded Site Credit (%) = 26.0%

4.5 Green Roof

Green roofs are built to a number of different standards that cannot be accommodated in standardized credit methodologies. DWSD recommends that volume reductions resulting from green roof construction be calculated using the EPA National Stormwater Calculator or results of monitoring efforts. Green roofs may offer significant annual volume reductions however they typically do not provide measureable benefits for peak flow control.

4.6 Water Harvesting

Water harvesting and water reuse operations can significantly reduce the average annual volume release from a site. The reduction is primarily a function of the storage volume provided and the amount of water reused on site. The storage volume provided may offer some peak flow control as well if sized and managed properly. The calculations for water harvesting operations are site specific and more advanced.

DWSD has developed a water balance calculator for systems that reuse stored stormwater for irrigation or non-irrigation purposes. The calculator is available for use upon request.

Information that is needed to determine the practice volume credit:

- **Managed Impervious Area to Pond:** The impervious area generating runoff to the stormwater management practice.
- **Managed Pervious Area to Pond:** The pervious area generating runoff to the stormwater management practice.
- **Turf Area for Irrigation:** This is the turf area that is suitable for irrigation and for which a sprinkler system has been installed.
- **Pond Surface Area:** This is the open water area associated with the low pool of the stormwater pond. It is used to calculate evaporation from the pond. If water storage is in a closed system, the pond surface area is zero.
- **Available Pond Volume:** This is the available storage volume of the pond above minimum pool elevation and below the outlet elevation.
- **Flow Capacity of Irrigation System:** This is the capacity of the irrigation system to dewater stored runoff in gallons per minute.

- **Designed Min Stormwater Reuse Flow Rate:** If water is reused for other operation, this is the System's average flow rate during normal operation.

For properties that are seeking a water reuse credit, monitoring of the system is required. Monitoring is intended to confirm continued operation of the reuse system and that the system is performing in reasonable agreement with the expectation at the time of the credit. The example shown in Table 4 and Figure 21 qualifies for a 90.9% annual volume credit.

TABLE 4 - Input Data Required for Water Reuse Calculator		
Input Data		
Uncontrolled Impervious Area to DWSD Sewer	0.00	acres
Impervious Area Tributary to Pond	17.43	acres
Pervious Area Tributary to Pond	21.03	acres
Turf Area for Irrigation	0	acres
Pond Surface Area	1.707	acres
Available Pond Volume	342,378	cu ft
Flow Capacity of Irrigation System	0	gpm
Design of Stormwater Process Reuse Flow Rate	100.0	gpm

OWNER:	XYZ Enterprises	BY:	DWSD
ADDRESS:	1225 Anywhere Street	DATE	October 1, 2016
DESCRIPTION OF SITE:	This property is a manufacturing facility that is installing a detention pond. Water from the detention pond will be reused for process in the manufacturing operation.		

User Instructions: Input the values noted in the "Input Data" section. The spreadsheet will calculate the fraction of annual rainfall that is an accepted reuse/ evaporation volume. This is a prototype tool for use in drainage charge calculations. The property owner may supply alternate calculations if desired.

Input Data			Description
Uncontrolled Impervious Area to DWSD Sewer	0.00	acres	This is the area generating uncontrolled runoff directly discharging to a DWSD combined sewer
Impervious Area Tributary to Pond	17.43	acres	This is the impervious area generating runoff to the stormwater practice
Pervious Area Tributary to Pond	21.03	acres	This is the pervious area generating runoff to the stormwater practice
Turf Area for Irrigation	0	acres	This is the turf area that is suitable for irrigation and for which a sprinkler system has been installed
Pond Surface Area	1.707	acres	This is the open water area associated with the low pool of the stormwater pond.
Available Pond Volume	342,378	cu ft	This is the available storage volume of the pond above minimum pool elevation and below the outlet elevation.
Flow Capacity of Irrigation System	0	gpm	This is the capacity of system to dewater stored runoff in gallons per minute. If unknown, leave blank.
Design Stormwater Process Reuse Flow Rate	100.00	gpm	This is the average process reuse flow rate during normal operation. Assumed to operate 24/7.

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Initial Abstraction Impervious, Inches/Event	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	-
Monthly Excess Precipitation for Impervious Area, Inches	1.57	1.56	2.00	2.76	2.76	3.11	2.94	2.86	2.54	1.99	2.21	2.17	28.46
Conversion Ratio for Impervious Area to Runoff (0-1)	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	0.90	-
Initial Abstraction Pervious, Inches/Event	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	-
Monthly Excess Precipitation for Pervious, Inches	1.03	1.07	1.34	2.04	2.09	2.45	2.24	2.21	1.93	1.44	1.59	1.53	20.97
Conversion Ratio for Pervious Area to Runoff (0-1)	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	-
Monthly Runoff to Pond - Impervious Area, Inches	1.41	1.40	1.80	2.48	2.48	2.80	2.64	2.57	2.29	1.79	1.98	1.95	25.61
Monthly Runoff to Pond - Pervious Area, Inches	0.41	0.43	0.54	0.81	0.84	0.98	0.90	0.89	0.77	0.58	0.64	0.61	-
Monthly Runoff to Pond, Cubic Feet	132,614	132,742	169,269	238,457	240,022	272,871	255,622	249,892	221,143	171,135	189,614	185,683	2,459,064
Monthly Runoff Directly to DWSD, Cubic Feet	0	0	0	0	0	0	0	0	0	0	0	0	0
Manual Discharge All Volume to DWSD, Yes/No	Yes	Yes	No	No	No	No	No	No	No	No	No	Yes	-
Manual Discharge to DWSD, Cubic Feet	132,614	132,742	0	0	0	0	0	0	0	0	0	194,659	460,015
Average Volume in Pond Per Event, Cubic Feet	0	0	2,587	8,038	12,055	22,305	17,999	15,675	21,135	8,079	7,227	0	-
Monthly Runoff in Excess of Pond to DWSD, Cubic Feet	0	0	0	0	0	1,716	2,668	2,442	3,853	761	432	0	11,874
Potential Water Reuse, Gallon/Minute	100	100	100	100	100	100	100	100	100	100	100	100	-
Potential Water Reuse, Cubic Feet/Day	19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250	19,250	-
Water Reuse Cubic Feet/Month	0	0	164,677	230,665	228,890	264,695	252,508	242,852	224,731	170,110	185,572	0	1,964,702
Soil/Plant Irrigation Potential, Inches/Day	0.00	0.00	0.00	0.11	0.21	0.21	0.21	0.21	0.21	0.21	0.11	0.00	-
Soil/Plant Irrigation Potential, Inches/Month	0.0	0.0	0.0	3.2	6.6	6.4	6.6	6.6	6.4	6.6	3.2	0.0	45.86
Soil/Plant Irrigation Potential, Cubic Feet/Month	0	0	0	0	0	0	0	0	0	0	0	0	0
Irrigation System Capacity, Gallon/Minute	0	0	0	0	0	0	0	0	0	0	0	0	-
Irrigation System Potential, Cubic Feet/Month	0	0	0	0	0	0	0	0	0	0	0	0	-
Irrigation Usage, Cubic Feet/Month	0	0	0	0	0	0	0	0	0	0	0	0	0
Monthly Pan Evaporation Rate, Inches/Month	0.87	1.21	2.16	3.69	5.43	6.54	6.85	5.9	4.17	3.07	1.62	1.00	42.51
Pan Evaporation Conversion Factor	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	-
Monthly Evaporation Rate Potential, Inches/Month	0.61	0.85	1.51	2.58	3.80	4.58	4.80	4.13	2.92	2.15	1.13	0.70	29.76
Potential Evaporation from Pond, Cubic Feet	0	0	407	1,650	2,481	5,304	4,891	3,636	2,648	932	524	0	22,473
Total Monthly Runoff Generated, Cubic Feet	132,614	132,742	169,269	238,457	240,022	272,871	255,622	249,892	221,143	171,135	189,614	185,683	2,459,064
Total Monthly Runoff to DWSD Sewer, Cubic Feet	132,614	132,742	0	0	0	1,716	2,668	2,442	3,853	761	432	194,659	471,889

Annual Percent Reduction in Runoff from All Impervious Area:	90.9%	Annual Percent Reduction in Runoff from Controlled Impervious Area:	90.9%

Figure 21: Water Reuse Calculator Spreadsheet

Peak flow credits will be available based on the total volume in the storage, the frequency at which it may be exceeded based on a long term continuous simulation and the median available volume based on a long term continuous simulation.

4.7 Direct Discharge to Surface Waters

Direct Discharge is stormwater runoff directly discharging to the Detroit or Rouge Rivers with or without using DWSD infrastructure. The parcel must be able to manage the 100-year, 24-hour storm event and convey it to either the Detroit or Rouge River.

- If the stormwater discharge flows through a privately owned and operated storm drainage system (rather than a DWSD storm sewer or outfall) from the site to the point where it reaches and discharges to the receiving waters. The maximum Direct Discharge credit the parcel may receive is 100%.
- If the stormwater discharge flows through a privately owned and operated storm drainage system from the site to the point where it reaches the DWSD outfall directly discharging to the receiving waters. In this case, the maximum Direct Discharge credit the parcel may receive is 80%.

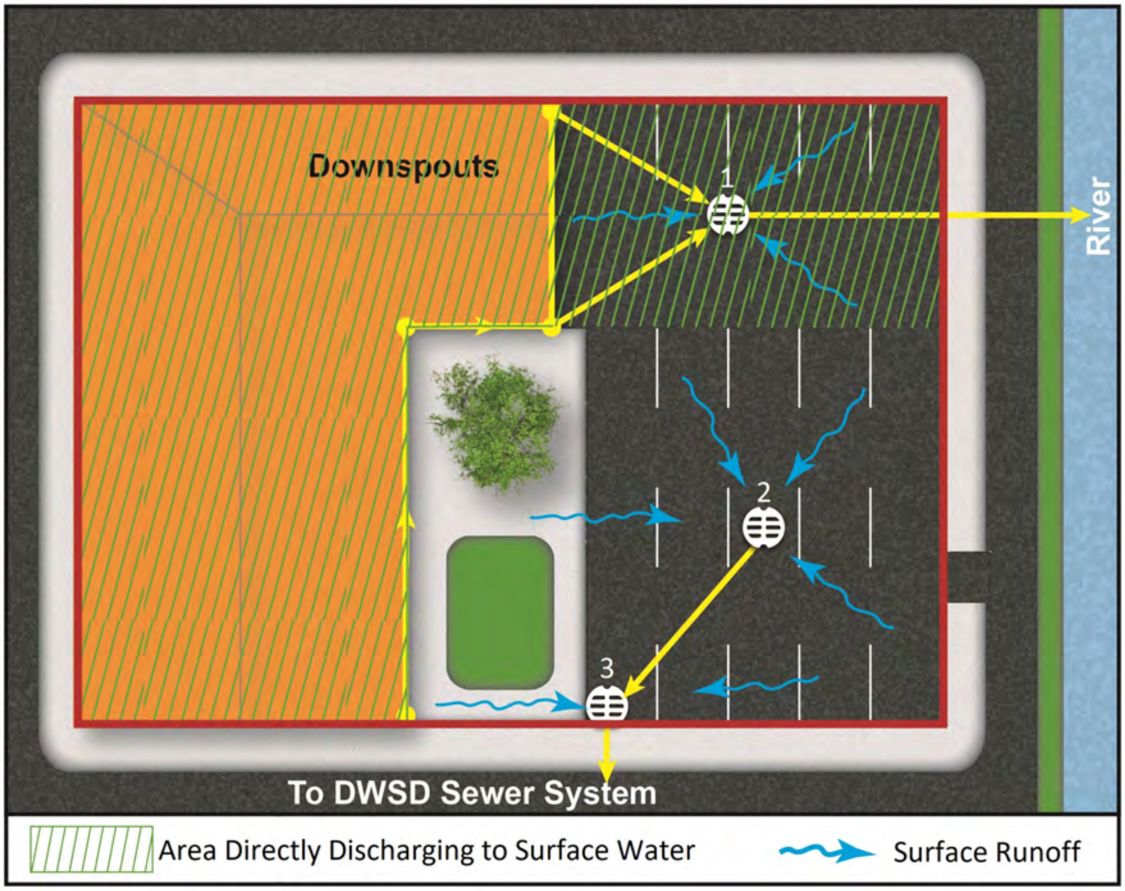


Figure 22: Schematic for Direct Discharge to Surface Waters Calculation Example

DIRECT DISCHARGE CALCULATION EXAMPLE

A commercial property is applying for a direct discharge credit for their site. The site has the following characteristics:

- Total Area = 3.57 acres
- Impervious Area = 3.26 acres
- Catch basin 1 is connected to the Detroit river with a private stormwater pipe and captures runoff from 1.43 acre building via downspouts and 0.53 acres of nearby asphalt parking lot via sheet flow
- Catch basins 2 and 3 are connected to the DWSD sewer system and capture runoff via sheet flow from a 0.39 acre walk path and 0.91 acres of nearby asphalt parking lot via sheet flow

STEP 1 Determine the total impervious acreage that is directly discharging to the Detroit river

$$\text{Total Impervious Acreage Directly Discharging} = 1.43 + 0.53 = 1.96 \text{ acres}$$

STEP 2 Calculate the Direct Discharge credit for the site

$$\text{Direct Discharge Credit (\%)} = \frac{\text{Direct Discharge Impervious Area}}{\text{Total Site Impervious Area}} = \frac{1.96}{3.26} * 100\% = 60.1\%$$

$$\text{Rounded Site Credit (\%)} = 61.0\%$$

4.8 Hydrologic Computational Methods

In addition to the various computational methods previously described, DWSD accepted standard engineering calculations for the determination of stormwater management practice performance. Table 5 lists the common methods, all of which are acceptable to use.

TABLE 5 - Hydrologic Computational Methods	
Method	**Description**
Rational and Modified Rational Method	**The Rational Method dates back to 1889 and was originally used to only estimate the peak discharge from a storm event. More recently it has been applied as a linear relationship between rainfall and runoff. The Modified Rational Method is used for detention storage sizing.**
Curve Number Hydrology	**The Natural Resources Conservation Service (NRCS) curve number (CN) method may be used to estimate the direct runoff volume from a storm event. When coupled with a unit hydrograph approach, the curve number method may be used to estimate a complete runoff hydrograph.**
EPA National Stormwater Calculator (SWC)	**EPA's National Stormwater Calculator (SWC) is a desktop application that estimates the annual amount of rainwater and frequency of runoff from a specific site in the United States. The SWC does not model discrete design storms, flood control storage systems or pipe conveyance. More information and a download for the calculator can be found here:** https://www.epa.gov/water-research/national-stormwater-calculator
EPA Stormwater Management Model (SWMM)	**USEPA's SWMM is a public domain software. SWMM is a comprehensive hydrologic and hydraulic modeling software. Recent updates allow the user to integrate stormwater management practices into a management system. More information and downloads can be found at:** https://www.epa.gov/water-research/storm-water-management-model-swmm

4.8.1 Simple, Moderate and Complex Approaches

EPA SWMM is the preferred hydrologic/hydraulic model for modeling stormwater drainage in an urban setting. Recognizing the inherent complexities of SWMM and the technical expertise required, the simpler approaches previously described have been developed using SWMM simulations which have been simplified into equations. The Rational, Modified Rational and Curve Number methods are typically applied in a spreadsheet calculation. By themselves the methods do not model stormwater management practices such as bioretention and porous pavement. Separate calculations are incorporated to simulate the effects of storage and infiltration.

Sites implementing several practices to manage stormwater, specifically when the practices are arranged in series, may be required to use more sophisticated calculation approaches to demonstrate the net result.

4.8.2 Volume Credit

The volume credit is determined based on long term average rainfall data. DWSD's non-residential credits are based on approximately 50 years of continuous rainfall data. The necessary continuous rainfall data is built into the information presented in earlier sections of this guide.

For applicants using more sophisticated hydrologic tools, such as the National SWC or SWMM, a minimum of 10 years of continuous rainfall data must be used in calculating the volume credit. Necessary rainfall information can be obtained from the National SWC. When using EPA SWMM long term rainfall records will need to be downloaded from the National Weather Service.

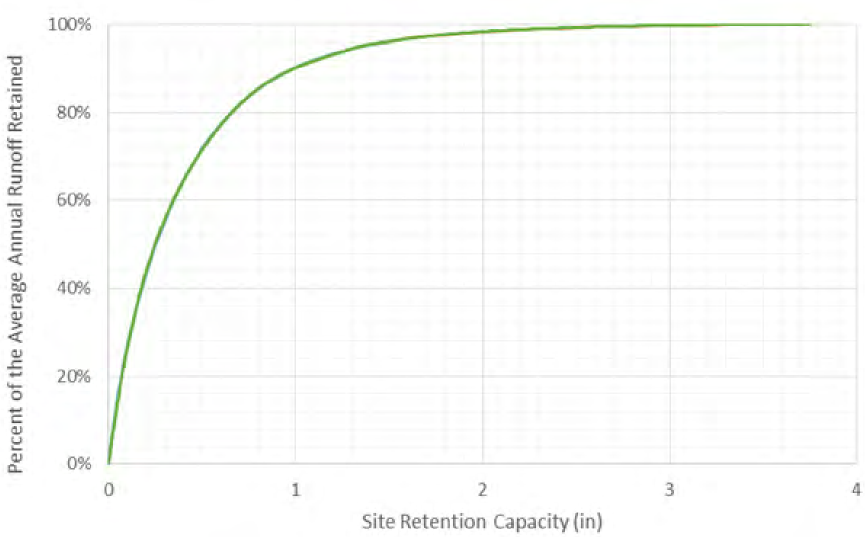


Figure 23: Annual Runoff Retained Relationship

Retention Capacity (in)	Percent Retained
0	0.0
0.1	26.9
0.2	43.5
0.3	55.6
0.4	64.7
0.5	71.8
0.6	77.3
0.7	81.7
0.8	85.3
0.9	88.1
1	90.2
1.1	91.8
1.2	93.2
1.3	94.4
1.4	95.3
1.5	96.1
2	98.3
3	99.8
3.75	100.0

An alternative to explicitly modeling the long term rainfall is to use the non-exceedance rainfall data in the chart for Figure 22. This chart presents the relationship between the Site Retention Capacity and the average annual runoff retained. For example, if the first 1-inch of every rainfall event was retained on site, that is equivalent to retaining 85% of the annual volume. This is the relationship used in the volume credit

4.8.3 Peak Flow Credit

Peak flow credits are based on providing the necessary detention storage volume for a minimum of a 2-year, 24-hour and a maximum of a 100-year, 24-hour storm event. A requirement for obtaining the peak flow credit is that the outlet from the stormwater management practice is controlled at less than or equal to 0.15 cfs/acre. The simplified relationships presented in Section 6.3.4 are based on a variation of the Modified Rational method.

Generally, double counting the retention volume used for volume reduction and the detention volume for the peak flow control is not allowed. However, flexibility is provided for complex systems that use extensive periods of continuous simulation, which is the use of historic rainfall data over an extended period of time. These typically involve some component of stormwater reuse.

Chapter 5: Credit Application Process and Renewals

Customers may qualify for a drainage charge credit through installation and maintenance of an approved stormwater management practice and/or Direct Discharge to surface waters (i.e Detroit and Rouge Rivers). This chapter includes information about applying for and receiving conditional and final approval from the Detroit Water and Sewerage Department (DWSD) for non-residential properties. Once installed, the stormwater management practice and/or Direct Discharge conveyance system must be maintained.

The credit application and renewal process discussed in this chapter is valid for stormwater management measures.

Contents

5.1 Drainage Charge Process Overview

Customers wishing to pursue drainage charge credits will follow a series of steps. Some of the steps are optional, and others are required. Customers can complete many of these steps without professional assistance. Some will require the use of a professional.

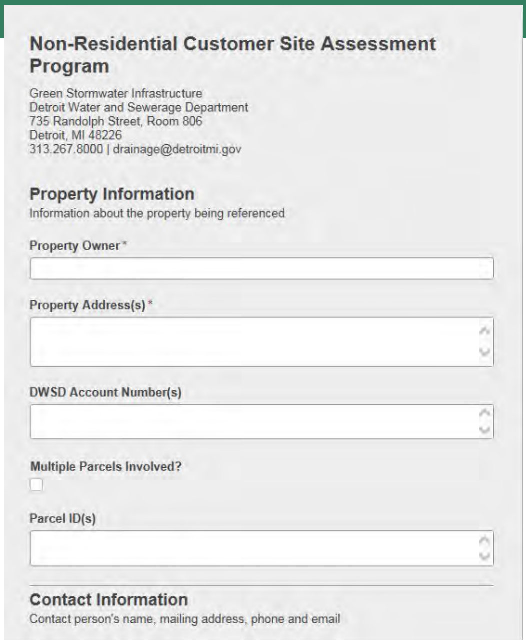
TABLE 1 - Drainage Charge Credit Requirements

Activity	Is it Required?	Is Professional Help Required?
Make a drainage charge credit "consultation" appointment	No	No, but if a customer has hired a professional, it is helpful for them to attend.
Apply for credits for disconnected impervious area	Yes, to receive this credit	No. Most property owners should be able to accomplish without professional help.
Apply for drainage charge credits for installed practices	Yes, to receive a credit	Not required, but helpful.
Apply for Direct Discharge credits for areas discharging to the Detroit and Rouge Rivers	Yes, to receive a credit	Not required, but helpful.
Certify implementation	Yes, to activate credit	A licensed design professional will need to certify that constructed practices have been implemented as designed.
Maintenance inspection	Yes, to maintain credit	Credits are good for three years. A licensed design professional or a certified stormwater operator may be needed to confirm proper operation to renew credit.

5.2 Site Assessment Process for Non-Residential Customers

DWSD provides the opportunity for non-residential customers to work with the DWSD technical team to determine which stormwater management practice may work best on their property. Non-residential customers are responsible to come prepared with data and information. This is a three-step process:

- **Step 1:** Data Validation – DWSD will review your account information to make sure that it is billing correctly.
- **Step 2:** Credit Consultation – DWSD will meet with non-residential customers at the DWSD Huber office location who have gathered back-up documentation, would like information on what stormwater management practices can be implemented at their site, and the process for applying for credits.


Non-Residential Customer Site Assessment Program

Green Stormwater Infrastructure
Detroit Water and Sewerage Department
735 Randolph Street, Room 806
Detroit, MI 48226
313.267.8000 | drainage@detroitmi.gov

Property Information
Information about the property being referenced

Property Owner *

Property Address(s) *

DWSD Account Number(s)

Multiple Parcels Involved?

Parcel ID(s)

Contact Information
Contact person's name, mailing address, phone and email

Figure 1: Non-Residential Customer Site Assessment Program

- **Step 3:** Engineering Analysis – After Step 2, if Step 3 is recommended, this step would include a site visit. The engineering analysis report will include stormwater management practice options, estimated construction costs, estimated credits, and other relevant information.

Customers can request a site assessment by registering through the on-line "Site Assessment' form which is available at www.detroitmi.gov/Drainage-Guides-and-Forms. DWSD will send an email with 48 hours confirming receipt of the site assessment request. DWSD representative will call to conduct the initial interview over the phone.

5.3 Credit Application Procedures

To receive a drainage credit, customers will need to meet certain eligibility requirements, apply for and receive an approval from DWSD, and fulfill on-going operations and maintenance (O&M) requirements.

Eligibility requirements include the following:

- The stormwater management practice must be fully installed and functioning properly;
- The practice must retain stormwater and/or detain peak flows;
- The stormwater management practices and the site must comply with all applicable local, state, and federal construction, City building, codes and permits;
- The stormwater management practice must be properly sized and located;
- Neither the site nor the stormwater management practice may create a safety hazard or nuisance; and

- For a Direct Discharge credit to surface waters, customers should use their own conveyance system or DWSD owned system to directly discharge to the Detroit or Rouge Rivers, which meets the Direct Discharge credit requirements

A complete application must be submitted to DWSD to begin the review process. Applications may only be initiated only by the owner, owner's authorized representative, or account holder.

5.3.1 Stormwater Management Practice Process

Customers that have built or are ready to build a stormwater management practice or practices must submit supporting documentation that fully documents the intended project, including a site plan and drawings, changes in impervious surface, the stormwater management practice design details and specification; sewer system configuration; and soil permeability. Generally, this will include a complete set of construction documents and supporting calculations. Customers are required to fill out the Drainage Charge Credit Application and submit the necessary back-up documentation. DWSD will review the design plans and provide a credit determination. DWSD will honor credits determined at the credit application review and approval stage of the process when the as-built practices matches the design plans.

For the full list of supporting documentation, refer to supporting documentation for each type of practice. Maintenance is required for the "life" of the practice to maintain credits.

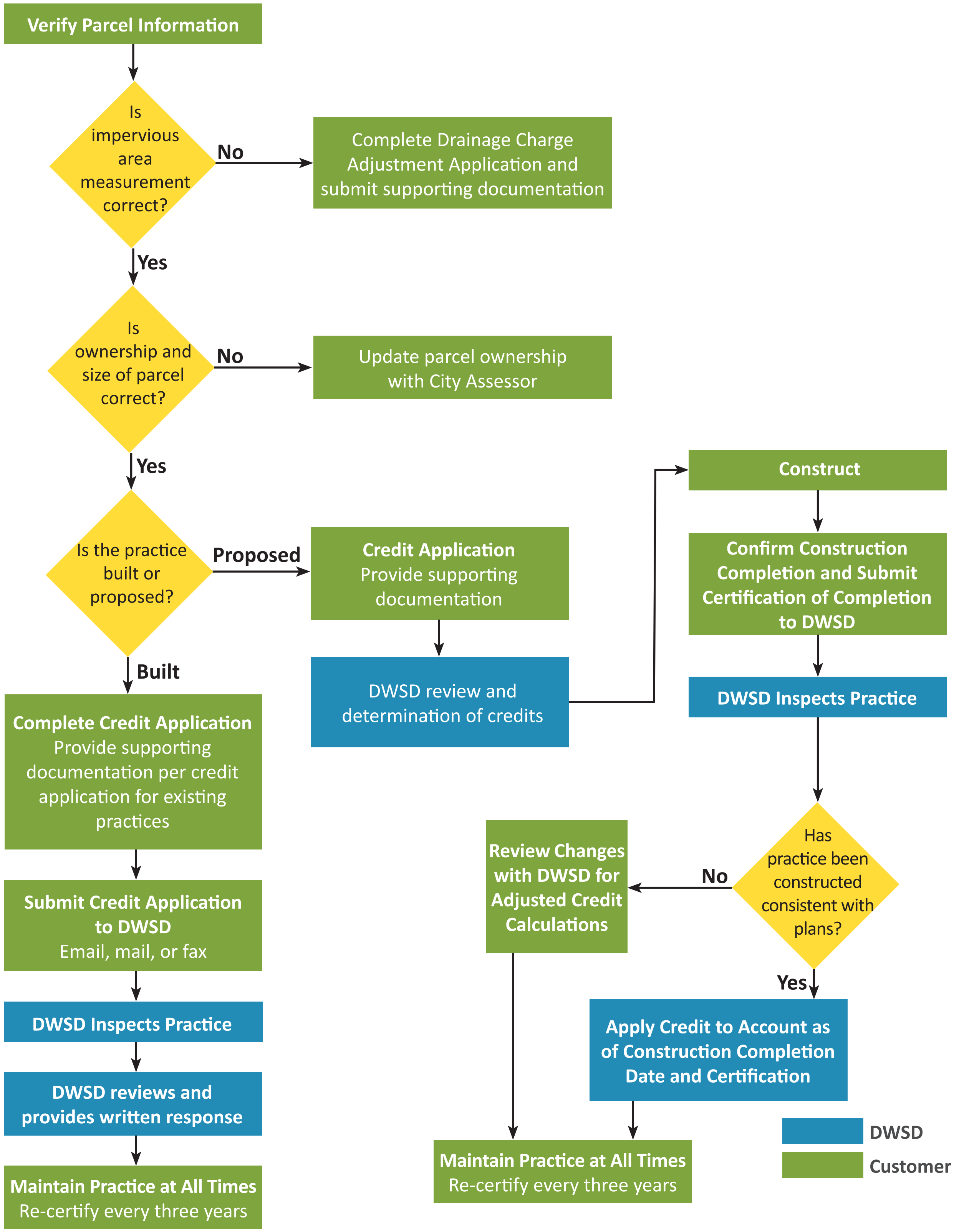


Figure 2: Applying for a Credit - Stormwater Management Practice Process

5.3.2 Supporting Documentation for Downspout Disconnection and Disconnected Impervious Practices

All customers applying for a drainage charge credit are required to fill out the Drainage Charge Credit Application. For downspout disconnection and disconnected impervious practices, the following supporting documentation must be provided with a signed credit application:

- Prepare a map of the property (can use a google earth image, sketch, parcel viewer image, etc.) that identifies the impervious area that generates stormwater runoff, the pervious area accepting the storm water runoff and how the stormwater runoff is transferred.
- Provide site photographs for each disconnected impervious area or downspout disconnection that is discharging to a pervious area.
- Number each of the roofs/impervious areas on the map of the property that discharge to pervious area and fill out Table 2.

Note For Downspout Disconnection: The "total receiving pervious area" typically considered can be measured from the end of the downspout to the edge of the property measured along the path that water will flow multiplied by an assumed width equal to 5 feet.

Note: For Disconnected Impervious: The "total receiving pervious area" typically considered is based on the width of the sheet flow when it leaves the impervious surface multiplied by the length of the flow path in the pervious area.

Table 2 - Downspout Disconnection and Disconnected Impervious Information

Impervious Area Number	Type of Impervious Area	Total Impervious Area	Type of Pervious Area	Total Receiving Pervious Area	Practice Ratio Total Receiving Pervious Area / Total Impervious Area	Individual Site Credit (%)
Area 1						
Area 2						
Area 3						
Area 4						

5.3.3 Supporting Documentation for GSI Engineered Practices

GSI Engineered practices (bioretention, detention basins, subsurface detention storage, permeable pavement, green roof, water harvesting, etc.) are professionally designed and constructed by a Professional Engineer or Landscape Architect. All customers applying for a drainage charge credit are required to fill out the Drainage Charge Credit Application. In addition, certain stormwater management practices will require permits from the City. It is the customer's responsibility to obtain any necessary permits prior to the construction. The following documentation must be provided with the signed credit application for engineered practices:

TABLE 3 - Required Supporting Documentation for Engineered Practices	
Item	**Checklist**
Scaled site plan showing all parcels and surfaces features	✓
Complete engineered drawings stamped by a registered Professional Engineer or Landscape Architect	✓
Existing roof drainage system defined (with drainage areas)	✓
Proposed roof drainage system defined (with drainage areas)	✓
Drainage areas to each practice defined	✓
Existing site drainage and sewer system defined (with drainage areas)	✓
Maintenance plan	✓
Photographs clearly showing existing practices	✓
Environmental history of the site	✓
Identification of proposed connections to DWSD sewers, if applicable	✓
ALTA Survey, if applicable	✓
Complete listing of permits applied for/expected	✓
Geotechnical investigation results, if applicable	✓

5.3.4 Supporting Documentation for Direct Discharge

A credit application will need to be completed to apply for a Direct Discharge credit. The following supporting documentation will be required by DWSD to make a determination for your site:

TABLE 4 - Required Supporting Documentation for Direct Discharge		
Item	**External Stormwater Conveyance System (includes sheet flow)**	**Internal/Underground Stormwater Conveyance System**
Map of the property that clearly identifies all impervious surfaces discharging with the conveyance system and all connections marked	✓	✓
Site photographs (photos of all visible connections and conveyance structures)	✓	✓
Dye test report or engineered drawings of the conveyance system stamped by a registered Professional Surveyor, Professional Engineer or Landscape Architect		✓
Topographic survey, if applicable	✓	✓
MDEQ/EGLE Permit, if available	✓	✓

5.3.5 Application Forms

The Drainage Charge Adjustment Application and the Drainage Charge Credit Application for stormwater management practices are available online at: www.detroitmi.gov/drainage-guides-and-forms.

TABLE 5 - What Forms to Use				
Scenario	Drainage Charge Adjustment Application *(See Chapter 2 for more information)*	Drainage Charge Credit Application	Certification of Completion	Credit Renewal Application Form
Parcel Ownership Issues	✓			
Disagree with Impervious Surface	✓			
Stormwater Management Practices		✓	✓	
Have Operated DWSD Approved Stormwater Management Practice for Three Years				✓
Discharge directly to surface waters		✓		

5.3.6 Application Submission

Email completed application and supporting documentation to: drainage@detroitmi.gov.

Alternatively, applications can be mailed to:

DWSD Drainage Program
6425 Huber Street
Detroit, MI 48211

Customers with additional questions should contact: 313-267-8000, Option 6 and follow prompts for Drainage Program.

5.4 Drainage Charge Credit Policies

5.4.1 Property Owner Responsibilities

If the customer is notified that an application is incomplete, they will have 30 days to provide the required information or to contact DWSD to request additional time to provide the missing information. If the application is not administratively complete or if DWSD has not been contacted by the customer, 30 days after notification, the application will be closed, however the customer may resubmit an application when they have the requested information.

5.4.2 DWSD Responsibilities

It is DWSD's responsibility to review completed applications and notify the customer in a reasonable timeframe of any missing information necessary to process the application and approve the drainage credit application. DWSD will notify the customer in writing on completing the technical review of the application. Applications are effective from the date the Drainage Charge Credit Application form is received if all required supporting documentation is accepted and administratively complete, or is supplied within 30 days of initial notification from DWSD that additional information is needed.

5.4.3 Application Review Priority

If a customer submits an adjustment and a drainage credit application at the same time, the adjustment application will be reviewed and processed first, followed by the credit application.

5.4.4 Drainage Charge Credit Effective Date

A credit application does not relieve the customer of payment of the drainage charge. If the credit is approved after DWSD's review process, the effective date of the credit is either the date of the licensed design professional's certification of completion subject to verification by DWSD or the date of the credit application, whichever is later. Credit will be applied to the next billing cycle.

5.4.5 Credit Renewals

The credit is valid for 3 years provided the stormwater management practice is maintained to function as designed. The customer must submit a Drainage Charge Credit Renewal Application at least 30 days before the expiration date to renew the credit. The approved credit renewal is effective on the expiration date of the original credit. If the credit expires, the drainage charge credit will be eliminated until a new application is submitted and approved.

If the customer fails to submit a renewal application at least 30 days before the expiration date, DWSD cannot guarantee the renewal will be processed prior to the next billing period.

5.4.6 Drainage Credit Application Denials

If the customer disagrees with DWSD's adjustment decision, the customer may appeal the decision to the Dispute Review Panel (DRP) within 30 days of the date of the determination letter. To file an appeal of the determination, the customer must submit a written letter requesting an appeal of DWSD's determination and include all of the following:

1. A copy of the decision letter that you are appealing.
2. A copy of any and all documentation that support your appeal.
3. A concise, yet detailed, statement of the basis for your appeal.

Appeal requests can be mailed to the Office of General Counsel:

ATTN: Dispute Review Panel
735 Randolph Street, 9th floor
Detroit, MI 48226

Appeal requests can also be emailed to branchni@detroitmi.gov.

5.4.7 Data Validation/Site Inspections

Following the submission of an application form, certificate of completion, or credit renewal form, DWSD may need to inspect the subject parcel to verify accuracy of the information provided in the application form. DWSD will provide written notice to the customer of their intentions to inspect the property and request access to the parcel. Inspection times will be conducted within normal business hours and without major disruption to business operations. Failure of a customer to accept an appointment will result in rejection of the credit application.

5.4.8 Termination of Drainage Charge Credits

DWSD may review and terminate approved credits at any time if the stormwater management practices or direct discharge associated with those credits are found to be improperly maintained or not functioning properly. Customers may periodically be asked to submit documentation and/or grant access to the parcel receiving credit. Failure to comply with such requests may result in the termination of the credit.

CITY OF
DETROIT

Water & Sewerage Department

http://www.detroitmi.gov/drainage
drainage@detroitmi.gov
313.267.8000 (follow prompts)

Uncontrolled document when printed. Refer to website for most current version.