IOWA STORM WATER MANAGEMENT MANUAL

9.01 STORMWATER DETENTION BEST MANAGEMENT PRACTICES

IOWA DEPARTMENT OF NATURAL RESOURCES

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Refer to the glossary for words in **bold black text.**
Some items of emphasis are in **bold blue text.**

9.01-1 OVERVIEW

A. INTRODUCTION

This section provides a general overview of the broad category of **stormwater best management practices (BMPs)** that are most suited to provide downstream flowrate reduction through stormwater detention. This is the first in a series of sections devoted to the planning, site selection and design of these types of practices.

B. OBJECTIVES OF STORMWATER DETENTION

Stormwater detention is the temporary storage of runoff to reduce the peak rate of runoff from a given area. To accomplish this, runoff is collected in a location where there is sufficient space to provide the volume needed to temporarily store (detain) excess runoff. An outfall structure is designed and constructed to limit the **rate** of flow being sent downstream. Since the outflow runoff rate from the storage area is lower than the inflow rate, stormwater will build up in the storage area until such a time during or after the **storm event** when the outflow rate exceeds the inflow rate. At that time, the water elevation in the storage practice will begin to recede, or drawdown.

These graphs show the expected inflow vs. outflow rates of flow from a stormwater management practice designed to meet the Unified Sizing Criteria.

Note the dramatic reduction in outflow during the CPv event (>95%) and the extended period that flow is released (**extended detention**).

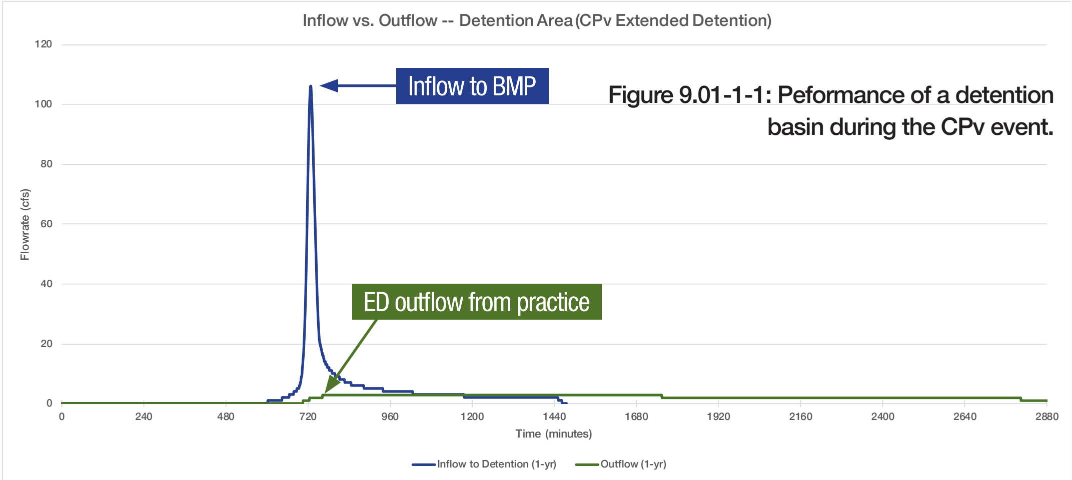


Figure 9.01-1-1: Peformance of a detention basin during the CPv event.

For the 100-year event, outflow is still dramatically reduced from inflow, but not by as large of a percentage.

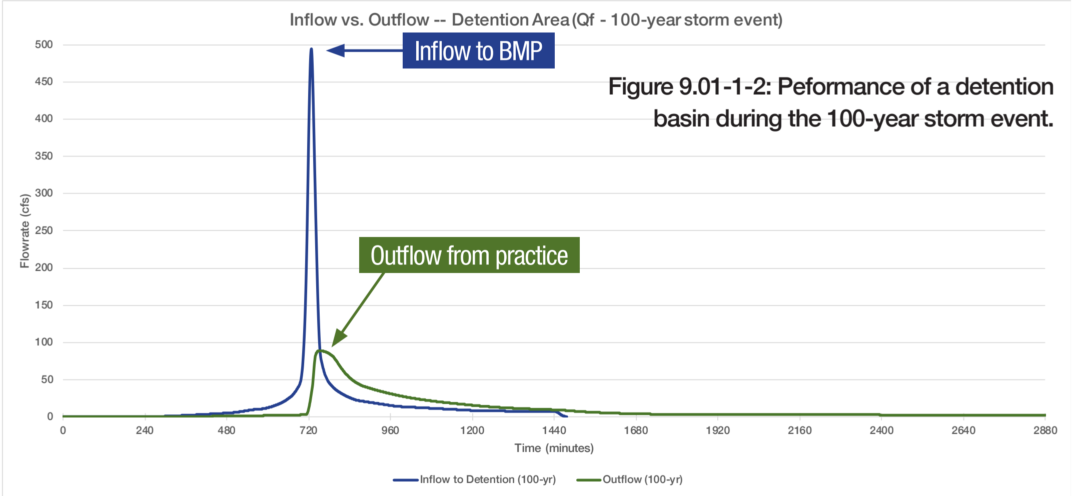


Figure 9.01-1-2: Peformance of a detention basin during the 100-year storm event.

For all storm events, the Unified Sizing Criteria attempts to mimic a more natural peak rate of flow and shape of the outflow curve.

Stormwater detention is most often used in developed, developing or redeveloping areas to counter the effects of land use change on local hydrology. Installation of **impervious surfaces** (roofs, driveways, parking lots, streets, etc.) and soil compaction through grading activities reduce the ability of the land surface to absorb and infiltrate rainfall. This leads to an increase in the frequency and **volume** of runoff created during a rainfall event.

In developed areas, water moves across or through paved surfaces, gutters, storm sewer systems and engineered swales more quickly. As a greater portion of the runoff reaches a given point, this leads to a higher peak rate of flow leaving a given area. **These effects cause the changes in the hydrology of a given watershed area, making higher flow rates and volumes occur more frequently than in pre–project conditions.**

These graphs show the differences in flow rates based on natural (prairie), agricultural and developed conditions (typical suburban development featuring a blend of residential and higher intensity land uses).

Changes are most dramatic for smaller storm events, where peak rates of flow are dramatically increased.

For larger storms, the changes are still very notable, but the rate of increase is less than for smaller storms.

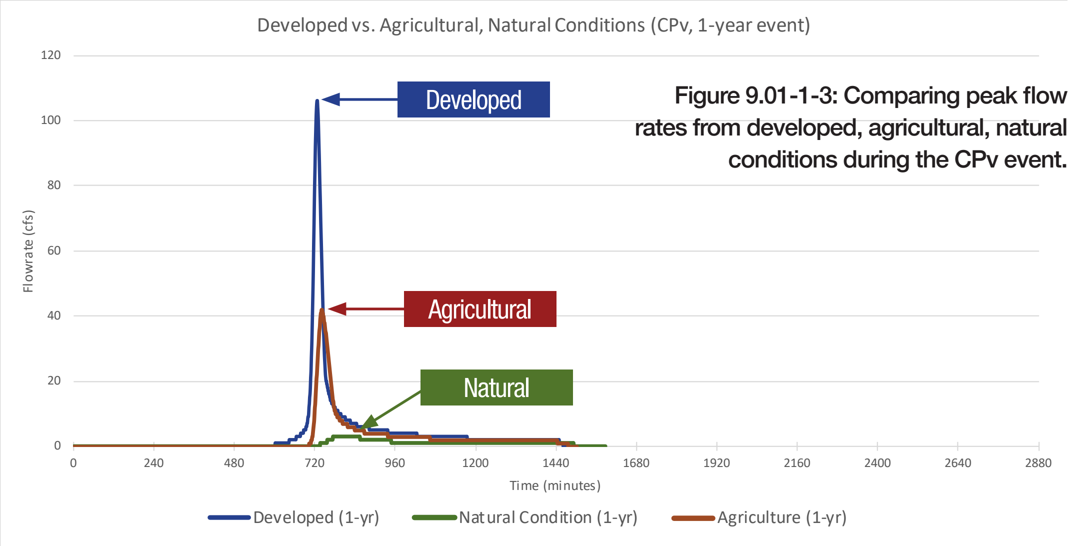


Figure 9.01-1-3: Comparing peak flow rates from developed, agricultural, natural conditions during the CPv event.

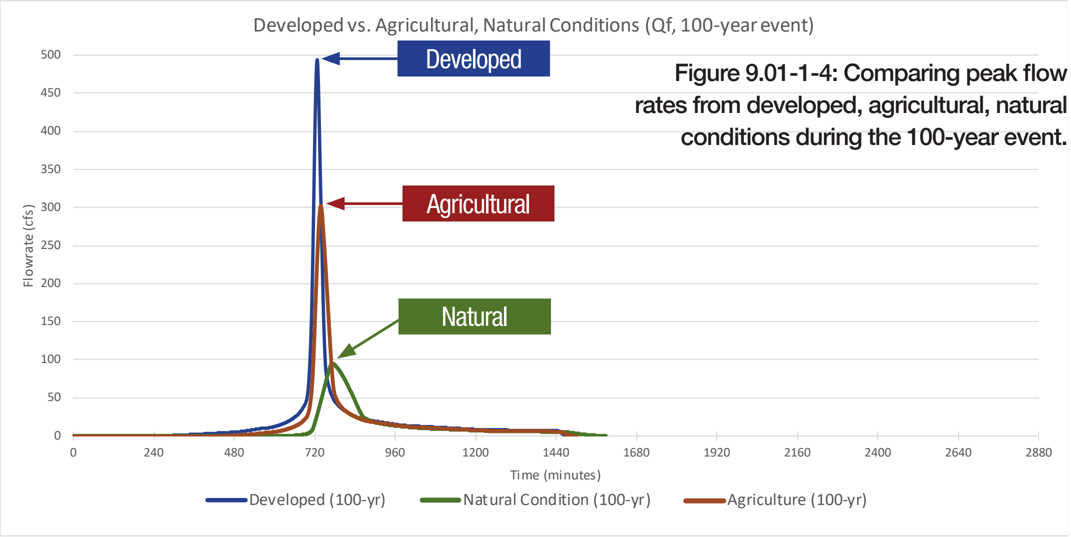


Figure 9.01-1-4: Comparing peak flow rates from developed, agricultural, natural conditions during the 100-year event.

Without stormwater detention, downstream areas can be expected to receive flashy flows more frequently after storm events. This often results in channel erosion and flash flooding which can impact public and private properties and infrastructure. These impacts can lead to further issues related to sediment transport, deposition and poor **water quality**. Addressing channel erosion and infrastructure impacts after they have occurred can be extremely expensive and invasive. These types of repairs often require construction near existing homes, tree removal and often are made more challenging by lack of space for equipment access. For these reasons, it is best to mitigate these effects at the time land use changes are made, to reduce the potential post-project impacts. Each project should include a review of these effects and formulation of a plan to address the need for stormwater detention.

NOTE

Example is for an 80 acre site, changing to a mix of single and multi–family residential land uses.

TABLE 9.01-1.1: EXAMPLE OF RUNOFF VOLUME CHANGES IN A DEVELOPING AREA

			VOLUME					
	TC	CN	1-YEAR		10-YEAR		100-YEAR	
	(MIN)		(CF)	INCREASE	(CF)	INCREASE	(CF)	INCREASE
Natural	95	58	59,000		298,000		898,000	
Agricultural	38	74	221,000	275%	623,000	109%	1,417,000	58%
Developed	22	83	364,000	517%	846,000	184%	1,715,000	91%

TABLE 9.01-1.2: EXAMPLE OF PEAK FLOW RATE CHANGES IN A DEVELOPING AREA

			PEAK FLOW RATE					
	TC	CN	1-YEAR		10-YEAR		100-YEAR	
	(MIN)		(CFS)	INCREASE	(CFS)	INCREASE	(CFS)	INCREASE
Natural	95	58	3		26		95	
Agricultural	38	74	42	1300%	131	404%	303	219%
Developed	22	83	106	3433%	249	858%	494	420%

Impacts in an area without or with inadequate stormwater detention

Photo 9.01-1-1: Example of Streambank and Channel Erosion caused by hydrologic changes in an urbanizing area in Central Iowa

C. GENERAL RELATIONSHIP TO UNIFIED SIZING CRITERIA

The following information is a general overview on how stormwater detention BMPs can be used to address Unified Sizing Criteria (USC) requirements. Refer to the ISWMM Section for each individual practice to see how it can be applied to address aspects of the USC and the details of the design process.

Recharge Volume (Rev)

Recharge Volume is focused on reducing the volume of stormwater surface runoff from a site. It is accomplished by eliminating runoff from the 1" event through the use of practices that reduce, infiltrate, capture, reuse or evaporate water. TARGET

Water Quality Volume (WQv)

The Water Quality Volume is addressed by using best management practices to capture and treat the runoff expected to be generated by the 1.25" rainfall event. Addressing these USC criteria effectively treats runoff from 90% of the rainfall events in Iowa. ESSENTIAL

Some types of detention practices are more effective than others at addressing runoff from the most frequently occurring, small-storm events. Some BMPs selected to provide stormwater detention may need to be paired with other practices to meet any requirements for Rv and WQv.

Channel Protection Volume (CPv)

This criteria reduces the potential for downstream channel erosion by reducing peak outflow rates for a 1-year, 24-hour storm event to more natural levels. This mitigates extreme increases in peak flow rates that would typically be expected from developed sites.

Most detention practices can be used to meet CPv requirements by providing extended detention of this event, with a drawdown period of at least 24 hours. ESSENTIAL

Overbank Flood Protection (Qp) and Extreme Flood Protection (Qf)

These criteria address runoff from larger storm events, up to a 100-year, 24-hour storm event. The goal is to reduce peak runoff rates to mimic natural conditions (or achieve local stormwater management goals). This reduces the potential for storm sewer surcharge, flooding and damage to property and infrastructure downstream of a practice.

Detention practices can be sized to meet these requirements through **temporary storage** of runoff to limit outflow release rates to required levels. ESSENTIAL

Photo 9.01-1-2: Bank erosion caused by detention basin frequently overtopping

NOTE

A brief description of each aspect of the USC is provided here. For more detail on how these are defined and measured, refer to Section 3.01 (Unified Sizing Criteria).

Refer to Section 3.01–7 for definitions of "Essential," "Target" and "Advisory" guidelines.

TABLE 9.01-1-3: APPLICATION OF BEST MANAGEMENT PRACTICES TO ADDRESS UNIFIED SIZING CRITERIA					
	SMALL STORM			LARGE STORM	
PRACTICE	RV	WQV	CPV	QP	QF
Infiltration Basins	PR	PR	PR	PO	PO
Constructed Stormwater Wetlands	PO	PR	PO	PO	PO
Traditional Dry Detention	NA	NA	NA	PR	PR
Extended Dry Detention	NA	NA	PR	PR	PR
Wet Ponds	PO	PR	PR	PR	PR
Combinations of Water Quality and Quantity Practices	PR	PR	PR	PR	PR
Underground Chamber Systems	AD	AD	PR	PR	PR
Detention Retrofits	AD	AD	AD	AD	AD

PR = Primary Application
PO = Possible Application
AD = May be Adapted to Address
NA = Not Typically Applicable or Little Impact

D. PRE-DESIGN CONSIDERATIONS

Before using this section, and those that follow related to the design of detention practices, the following items should be considered:

- How is stormwater to be managed early in the process of site design? Review drainage patterns. Understand if there is off-site water to be managed. Do the terrain or soils at a given site affect whether a practice is located in a certain part of the site?
- Minimize the need for stormwater management through better site design.
- Are there opportunities to develop a "treatment train" approach, where multiple practices are used in a series to achieve the desired stormwater treatment goals?
- Can the stormwater management practices be located in ways that make them more accessible or aesthetically pleasing? Reducing slopes around the perimeter of a practice, providing paths for access (for public use and maintenance) and selecting, establishing and maintaining desirable vegetation can turn a stormwater management feature into a site amenity.
- How will selected practices be maintained?
  - Who will be the responsible parties for this maintenance?
  - What types of activities will be required?
  - Where will pre-treatment areas be located?
  - What type of maintenance equipment will be necessary?
  - What space will be required to access the site and perform those activities?

E. REFERENCES TO OTHER SECTIONS

This section is intended to be used with other portions of the ISWMM through the planning, practice selection and design process. When planning, designing or reviewing potential stormwater detention practices, users of this manual should refer to these other sections of ISWMM for additional design guidance and information:

Section 1 - Background Information and Reporting

Section 2 - Hydrology

Section 3 - Managing for Water Quality and Quantity

Section 4 - Best Management Practices Overview

Section 5 - Pretreatment Practices

Section 6 - Rainfall Collection and Reuse

Section 7 - Infiltration Best Management Practices

Section 8 - Permeable Pavement Systems

Section 9.02 - Methods to Estimate Required Detention Storage

Section 9.03 - Storage Routing for Final Detention Design

Section 9.04 - Design and Modeling of Outlet Controls

Section 9.05 - Water Balance Calculations

Section 9.06 - Channel Routing

Section 9.07 - Downstream Hydrologic Assessment

Section 9.08 - Stormwater Wetlands

Section 9.09 - Traditional Dry Detention

Section 9.10 - Extended Dry Detention

Section 9.11 - Wet Ponds

Section 9.12 - Detention Retrofits and Hybrid BMPs

Section 9.13 - Underground Chamber Systems

Section 9.14 - Glossary for Detention BMPs

Section 9.15 - References and Resources for Detention BMPs

9.01-2 TYPES OF STORMWATER MANAGEMENT PRACTICES

There are a variety of stormwater BMPs that generally will have sufficient ability to provide temporary storage of runoff that meet stormwater detention requirements. While stormwater for larger storm events has typically been addressed in Iowa through the use of basins and ponds that did not address the increased runoff volume or water quality initiatives, there are a variety of other options that can be considered to collectively meet the objectives of the USC.

A. STORMWATER WETLANDS

Stormwater wetlands are a constructed stormwater management practice that is capable of supporting native wetland vegetation. The wetland is graded in a fashion to maximize the path of flow through a mix of shallow and deep water areas. **Microtopography** (creation of low berms and shallow depressions) can create a "stormwater maze" that forces water to flow along a longer path during most storm events. During larger events, the volume above the wetland is available for temporary detention storage.

Note that stormwater wetlands are designed and constructed for stormwater management. **Existing or natural wetlands should not be used to meet the stormwater management requirements for developing or redeveloping areas.**

Suitable applications of this practice:

- Possible to manage for WQv, CPv, Qp and/or Qf
- Can be integrated into parks and open spaces where a **permanent pool** is desirable and can be used as an amenity or resource
- In **watersheds** of sufficient size and character to maintain the permanent pool
- In areas with high groundwater levels and/or where soils are present that can sustain the permanent pool
- Where ongoing management is planned to maintain the diversity of desired vegetation and control the growth of **invasive species**
- At sites where there is adequate space to include methods of pretreatment, to prevent sedimentation of shallow ponding areas

Figure 9.01-2-1: Illustration of a stormwater wetland

NOTE

Refer to Section 9.08 for more detailed design information

B. TRADITIONAL DRY DETENTION

Dry detention basins are surface depressions created through excavation or construction of a dam where runoff can be captured and held temporarily during large rainfall events. These practices do not include a permanent pool of water. The bottom of the basin is designed with enough slope to provide positive drainage to a pipe outlet or storm inlet structure. The surface is usually stabilized with **native vegetation** or turf grasses. In some cases, swales may be used to direct concentrated flows through the footprint of the basin (from inflow points to the outlet controls). Basins may be designed with flatter areas at higher elevations to serve recreational uses (e.g., playing fields, unprogrammed open spaces, etc.). Such features are usually set so they won't be inundated during a 5-year storm event.

Dry detention basins have been used to manage stormwater for several decades. Historically, these systems have been intended to prevent flash flooding caused by the largest, more infrequent events. These basins, as traditionally designed, often lack features to manage water quality or provide extended detention of CPv. These practices are not expected to achieve pollutant removal at a level considered to be a water quality practice. **When used, traditional dry detention basins will typically need to be paired with other practices to meet local requirements to manage Rv, WQv and CPv.** ADVISORY

Some computational methods used in the past (such as the modified rational method) to size these types of basins may have resulted in these practices having insufficient storage, potentially resulting in overtopping during large rainfall events. (Refer to Section 2.04 for expanded information on this issue). **Designers should review the design of existing traditional dry detention systems when designing new practices downstream.** ADVISORY

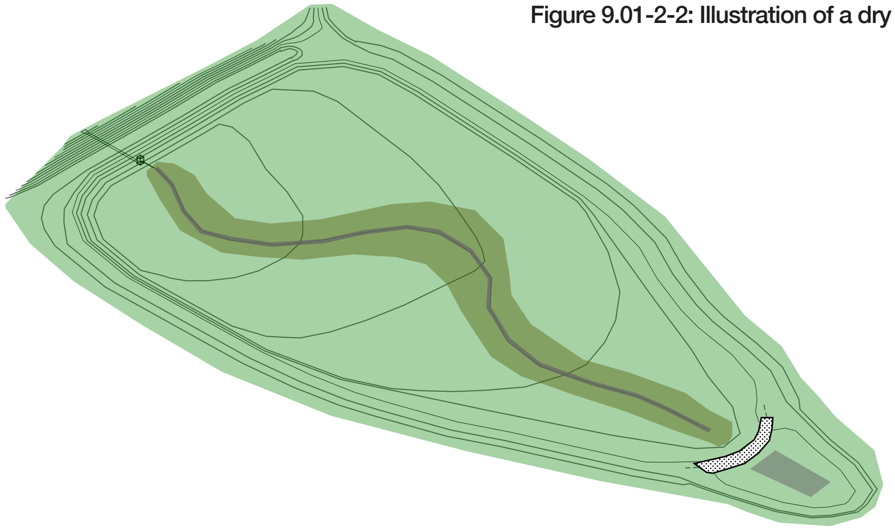
Suitable applications of this practice:

- When management of Rv, WQv and CPv is not required or is managed by other practices
- Where turf grass is preferred
- Where a permanent pool of water is not desired
- Where higher elevations of the basin may be used for athletic fields, trails or other recreational purposes

NOTE

Refer to Section 9.09 for more detailed design information

Figure 9.01-2-2: Illustration of a dry detention basin



C. DRY EXTENDED DETENTION (ED)

Dry detention basins can be adapted to feature a **multi-stage outlet** structure sized to restrict flow to provide an extended drawdown period during a 1-year, 24-hour storm event. This extended drawdown better mimics natural hydrology during smaller storm events, reducing the potential for channel erosion downstream. To provide the minimum 24-hour drawdown of this event, outflow rates will need to be significantly reduced, to better mimic runoff rates from natural conditions (peak rate is often required to be reduced by more than 95% from inflow rates to the basin). Due to more frequent temporary ponding after smaller storm events, these basins often have wetter soils in the bottom surface area. Areas expected to be inundated during the 1-year event are usually stabilized with native perennial vegetation (e.g., native prairie grasses and forbs) which are selected to be sustainable in such moisture conditions.

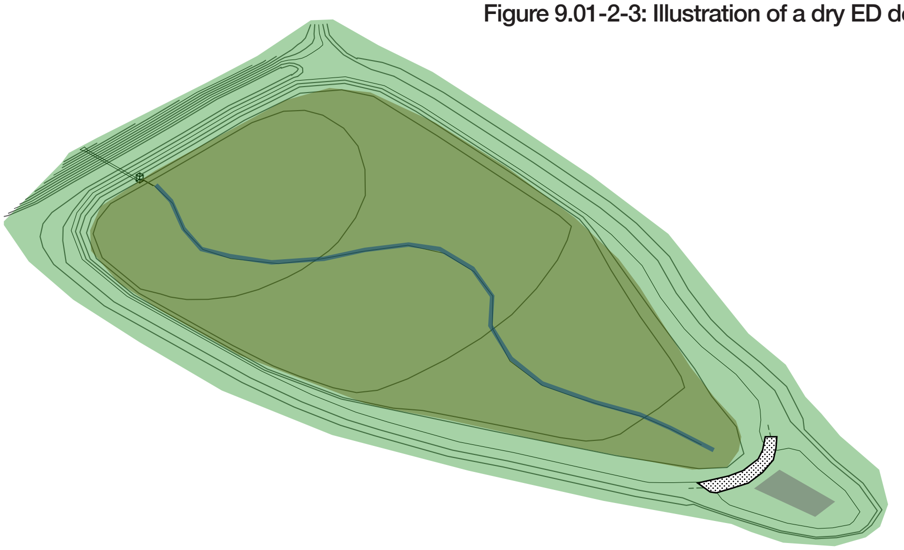
Dry ED basins still lack features that support infiltration, **absorption**, **settling** or other biological processes that raise the quality of outflow runoff to desired levels. Therefore, while dry ED basins may be used to address CPv requirements, it is not recommended to use extended drawdown of the WQv event as a method of providing water quality treatment. **When used, dry ED basins will typically need to be paired with other practices to manage Rv and WQv.** ADVISORY

Suitable applications of this practice:

- When management of Rv and WQv is not required or is managed by other practices
- Where management of CPv or larger storm events is desired
- Where native vegetation is preferred for low-lying areas and ongoing maintenance is planned
- Higher elevations of the basin may be used for athletic fields, trails or other recreational purposes

Dry ED basins should release runoff from small storms over a longer period of time. The bottom surfaces of the basin may remain too wet to effectively mow and maintain turf grass vegetation. A mix of wet mesic and upland native vegetation may be more appropriate to use.

Figure 9.01-2-3: Illustration of a dry ED detention basin



NOTE

The 95% rate reduction mentioned here is merely an estimate used to describe the performance of extended detention. Detailed calculations need to be performed to determine the actual required release rate reductions to achieve extended detention goals.

D. WET DETENTION

Wet detention basins are ponds that support a permanent pool of water. Like dry detention basins, wet ponds have been used as a stormwater detention practice for many years. While historically used to address runoff from larger storm events, their design can be adapted to address smaller storm events. The permanent pool volume may be used to address WQv requirements (to fully address WQv, the pool volume of a wet detention pond must have a volume of at least two times WQv). The temporary storage above the permanent pool may be dedicated to meeting extended detention requirements of the CPv and/or detention of Qp and Qf events. With proper site selection and perimeter grading, these wet detention ponds can be designed to be amenities within public or private open spaces.

Some local jurisdictions have adopted standards requiring WQv to be addressed through infiltration–based practices. In such circumstances, wet detention may not be used to address WQv requirements. ADVISORY

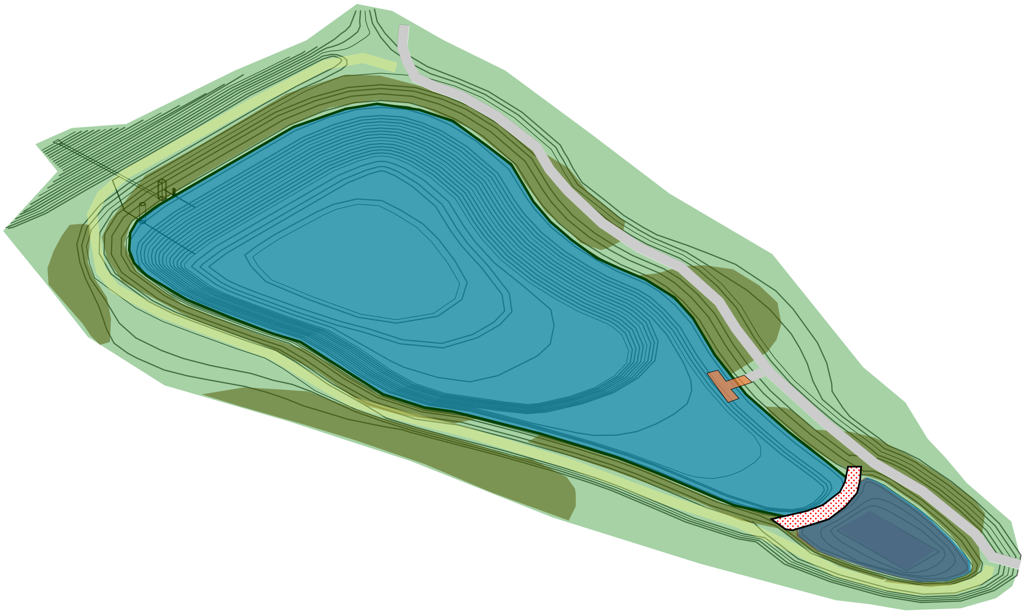
NOTE

Refer to Section 9.11 for more detailed design information

Suitable applications of this practice:

- When management of Rv is not required or is managed by other practices
- Possible to manage for WQv, CPv, Qp and/or Qf
- Within parks and open spaces where a permanent pool is desirable and can be used as an amenity or resource
- In watersheds of sufficient size and character to maintain the permanent pool
- In areas with high groundwater levels and/or where soils are present that can sustain the permanent pool

Figure 9.01-2-4: Illustration of a wet detention pond



E. UNDERGROUND CHAMBER SYSTEMS

Underground chambers are systems of pipes, structures or other devices used to create open volumes below grade that can be used for stormwater detention. **On their own, these systems are similar to dry ED basins, as they lack filtration, settling or methods to provide adequate pollutant removal, to the extent desired, to be used as a stand–alone water quality practice.** ADVISORY

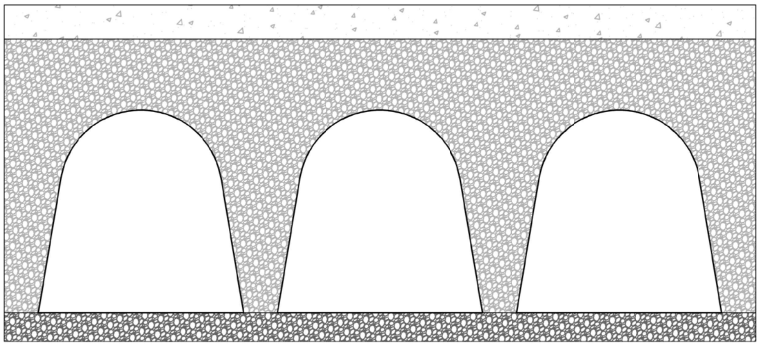
However, an adaptation of these systems could use aggregate layers set below the flowlines of the chambers to infiltrate Rv and/or WQv into the surrounding soils, thereby meeting those requirements. These systems could also be paired with other water quality practices (e.g., a permeable pavement system placed over the chamber system or an upstream bioretention cell) which could be used in combination to address the Rv and WQv requirements.

Suitable applications of this practice:

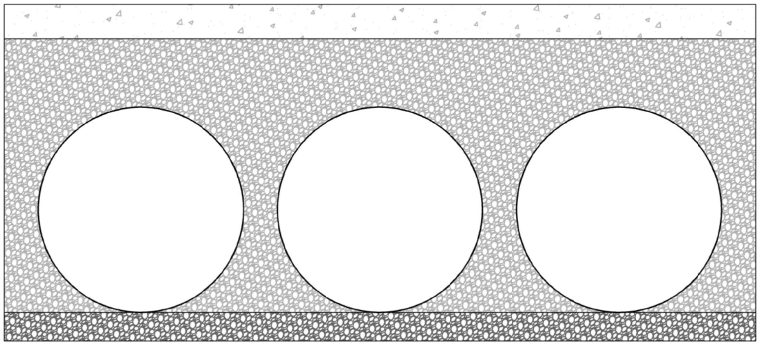
- When management of Rv and WQv is not required or is managed by other practices, or where the system can be adapted to infiltrate these volumes
- The chambers themselves may use an outfall structure featuring a multi-stage design to manage for WQv, CPv, Qp and/or Qf
- Most often used on small sites, redevelopment areas or other locations where there is insufficient open space to meet management requirements above grade
- Where owners have made arrangements for ongoing inspections, removal of sediments and other debris from the underground system, and other maintenance

Figure 9.01-2-5: Illustration of underground chamber systems

STORMWATER CHAMBERS



CMP PIPES



NOTE

Refer to Section 9.13 for more detailed design information

F. HYBRIDS AND STORMWATER RETROFITS

Hybrid systems combine water quality practices with detention practices to meet more of the USC requirements than either practice might be able to achieve as a standalone feature. Water quality practices might be nested within a detention basin or placed upstream of the detention facility. While this can be done, proper planning and design should be done to reduce the potential for compaction of soils or erosion within the water quality practice due to deep or frequent ponding and high-velocity flows.

A few examples of many potential hybrid system applications:

- Bioretention cells on smaller sites with sufficient storage above the footprint to provide detention of larger events
- Bioretention cells or bioswales nested within a larger regional dry ED basin
- Permeable paver systems placed above an underground chamber system
- Green roofs and bioretention cells placed above a traditional dry detention basin
- Underground chamber systems with aggregate storage infiltration layer

Stormwater retrofits will most often be an adaptation of existing dry or wet detention practices to better address aspects of the USC. In some cases, this could involve installing multi-stage outlet structures so that small storms are better managed. Other adaptations may involve conversion of one type of practice into another to more broadly address USC requirements. At some locations, detention areas that were designed with past methods, which appear to have insufficient storage to adequately manage large events, could be adapted to primarily address WQv and/or CPv. In any case, these designs would need to consider the expected changes during both small and large storm events, to ensure that such conversions would not negatively impact surrounding and/or downstream properties.

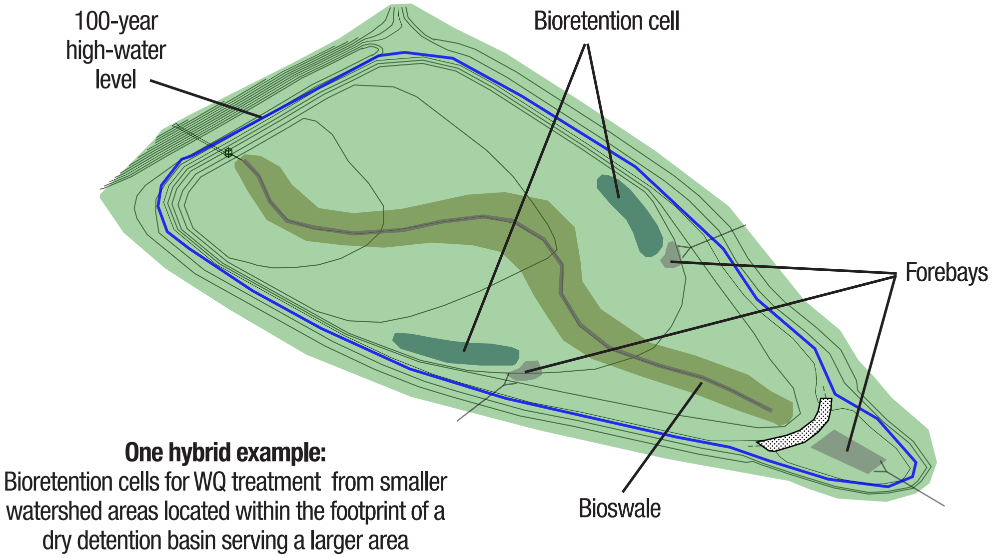
NOTE

Refer to Section 9.12 for more detailed design information

A few examples of many potential stormwater retrofit applications:

- Multi-stage outlet structure retrofits
- Conversion of undersized detention basins into bioretention cells
- Conversion of traditional dry detention systems into wet detention or constructed stormwater wetlands

Figure 9.01-2-6: An example of water quality BMPs placed inside of a dry ED detention basin



G. INFILTRATION BASINS

Infiltration basins are designed to have a large, flat-bottom surface area, constructed within soils with high permeability or where infiltration potential is improved through installation of amended soils. The basin slope is graded fairly flat to increase retention time and absorption rates. Infiltration basins may serve detention functions to reduce runoff rates to downstream areas. However, as they are categorized as an infiltration-based BMP, details of their design are addressed in other sections of ISWMM.

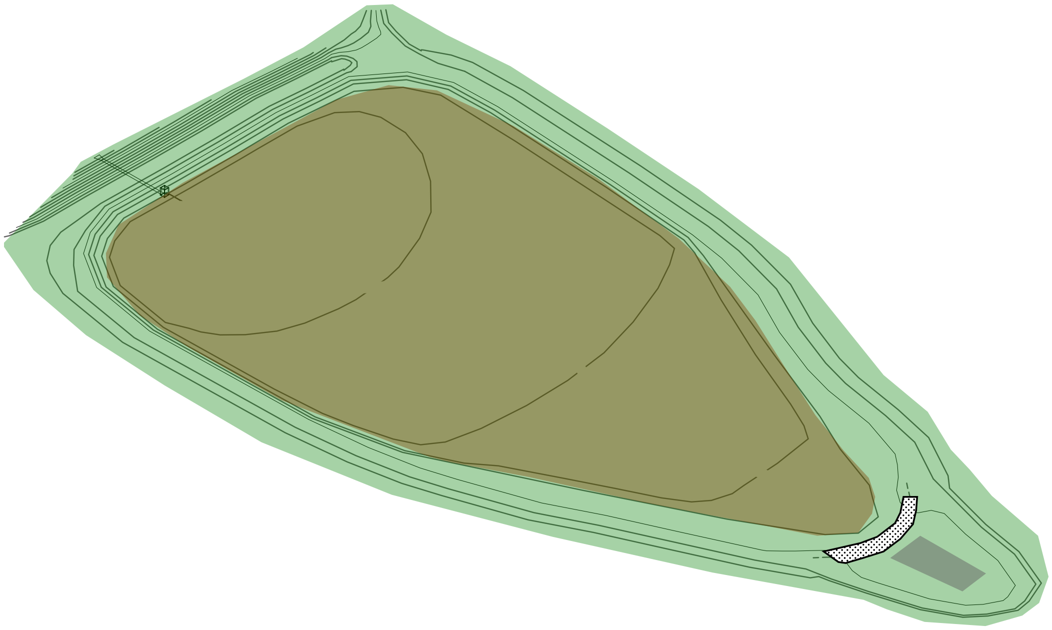
Suitable applications of this practice:

- Where existing or engineered soils have the capacity to infiltrate the desired volume of runoff
- Where turf grass or native vegetation is preferred
- Where a permanent pool of water is not desired

NOTE

Refer to Section 7.09 for more detailed design information

Figure 9.01-2-6: Illustration of an infiltration basin



9.01-3 PLANNING CONSIDERATIONS

Too often, designers jump into sizing and design before considering the purpose of a practice and how it can be best implemented to achieve the desired goals. The following categories should be reviewed early in the planning and site selection process.

A. DEFINE PRACTICE GOALS AND OBJECTIVES

Before selecting the type of practice at a given location, designers should review the goals and objectives this practice is expected to achieve.

Key questions to address:

- What aspect(s) of the USC is the new practice expected to achieve?
  - Managing for water quality, **quantity** or both?
  - Will this practice achieve USC management goals on its own or is it designed to be one of a series of practices to meet those goals?
  - Are there site-specific reasons that management beyond USC requirements is required?
    - Are there reasons why certain aspects of the USC are exempted?
- Is there a local watershed plan (or other watershed goals) that should be considered in the design process?
- Is public or private recreational access desired as part of this facility?
- What level of maintenance will be required to achieve the desired objectives?
- Are there ways to pick or design a practice that has multiple benefits?

NOTE

This may seem obvious, but there have been cases where designers have focused too early on using a specific practice at a certain site. This can lead to designing a practice that by its nature or the site area available, is not able to efficiently address the aspects of the USC that would be most critical at that location.

B. SITE/DEVELOPMENT SCALE VS. REGIONAL MANAGEMENT

Detention practices can be designed to manage runoff from an individual site or a common plan of development. This is referred to as Site or Development Scale. Detention areas can also serve larger areas, managing runoff from multiple developments or tracts of land.

NOTE

An extensive discussion of Site/ Development vs. Regional stormwater management and the benefits and challenges of the scale of the practice and its ownership of best management practices is included in the Unified Sizing Criteria Section, 3.01.

C. PUBLIC OR PRIVATE OWNERSHIP

Determining if a detention practice is to be publicly or privately owned is often related to whether the practice is intended to manage runoff from an individual site or serve a larger regional purpose. Site-/ development-scale practices are most frequently owned and maintained by private property owners or a homeowners association. One exception to this arrangement could be if the local jurisdiction determines that a detention area could be successfully integrated into the design of a publicly owned park or open space within or adjacent to the development area being treated.

NOTE

Local jurisdictions are not required to accept such an arrangement. It is just noted here as an option that might be considered in certain situations.

Ownership and maintenance of regional detention areas is typically beyond the responsibility of an individual property owner. Either a private group will be established that is financially supported by multiple property owners (like a home owner's association) or the local jurisdiction will take on these responsibilities.

Key questions to address:

- Will the detention facility be used to manage runoff from an individual site or development, or will it serve a larger watershed area?
- Does a local jurisdiction have any additional requirements to address?
- Who will own and maintain the facility after it is constructed?
  - Is the site to be located within a public park or other open space which may be accessible to the public?
  - What is the vision for maintenance and management of this area?
    - What entity will be responsible for carrying these out?
    - What access paths need to be reserved for future equipment access?

D. SERVICE AREA OF THE PRACTICE

To properly design a practice, the watershed it serves and its properties (impervious cover, soil types, etc.) need to be understood. It also needs to be defined whether other areas that would drain to a BMP are considered to be beyond the responsibility of the entity constructing the practice.

Key questions to address:

- For what area is the proposed BMP responsible for meeting the various USC requirements?
- Are there stormwater flows entering the proposed BMP from areas upstream of the area of responsibility?
  - How is stormwater managed in these areas?
  - How do these conditions affect the design of the proposed BMP?
- What are the properties of the service area (and other upstream areas)?
  - What is the total watershed (or subwatershed) size?
  - What soil types are present in the area?
  - How much impervious cover is expected when all areas are fully developed?

As part of this analysis, a detailed watershed map should be created that defines watershed and subwatershed areas to be used in stormwater models. A refined version of this map should be included with the final stormwater management plan for the given project.

NOTE

Refer to Section 3.01 for more information about the Stormwater Management Plan

E. SITE LOCATION AND PROPERTIES

The characteristics of the land within and around potential locations for stormwater practices will influence what type of practice should be selected at a given site and its ultimate design.

- What other land uses are proposed within, around and upstream of the proposed practice area?
- What land uses exist or are proposed downstream?
- Is additional development or redevelopment planned upstream of the proposed practice area?
- What are the timelines for local developments or other land use changes?
  - How are these related to the expected timeline of construction of the proposed BMP?
- What are the slopes and existing surface conditions in and around the project area?
- Are there wetlands, habitat or other resources that are located within or near the project area?
- Is the project located near a stream or along (or within) an area subject to flooding? Is the practice to be located within an area of flood risk, based on FEMA Flood Insurance Rate Maps?

- What type of vegetation is desired within and around the practice?
- Have preliminary estimates of required stormwater storage volume been developed (see Section 9.02)? The estimate procedure can be used to determine the potential area that will need to be devoted to stormwater management.

F. PUBLIC ACCESS AND AESTHETICS

Some detention practices, such as wet ponds and stormwater wetlands, can be constructed as central features within parks or other open spaces. Similarly, dry detention and ED basins can be constructed to provide spaces for recreation and native planting restorations. These areas can be made accessible to the public through trails and walking paths. **The general public may simply see the pond where they fish, the natural area where they birdwatch or the field where they play—without fully realizing that these areas are serving a stormwater management function.** Implementing stormwater management facilities in ways that serve a function beyond managing water quality and quantity is always encouraged.

Careful planning is required during grading design and site selection to create a surface that is approachable and usable by the public. Use of steep slopes around the perimeter of these facilities may reduce the potential for public access and negatively impact the aesthetics of their design. These concepts are explored in greater detail in the sections related to each type of practice. ADVISORY

G. ESTABLISHING DESIRED VEGETATION AND MAINTENANCE

The desired permanent vegetation will vary based on practice type. **Seed and plant materials should be carefully selected based on expected levels of sunlight and soil moisture conditions.** A "one mix fits all" approach will likely be unsuccessful). Plans should identify various zones within and around the practice where various seed mixes or plant materials are to be located. Proper staging and scheduling will be required to make sure that permanent vegetation is delayed until after (or protected from disturbance during) the construction period.

Various activities are required during the first few growing seasons to establish desired vegetation. After that, more routine maintenance is necessary to control weeds, make repairs and maintain plant diversity and aesthetics. Providing adequate space for equipment to access and move around each practice should be considered early in the practice selection process, and will go a long way toward reducing growth of invasive and aggressive species.

H. ONLINE VERSUS OFFLINE SYSTEMS

Detention systems are typically constructed in an "online" configuration—all runoff generated from a given area will pass through the practice. In some cases, a detention area may be constructed "offline." For example, if a dry ED basin is primarily designed to manage runoff from the CPv event, systems may be designed to allow flow from larger events to bypass that facility entirely. Another style of offline configuration is applicable to sites that have a waterway or swale passing through which has a larger watershed area. In such a case, practices designed to treat runoff from smaller areas may be installed on either side of the drainageway so that the flows from the larger watershed aren't required to pass through those practices.

The first type of offline systems described may require designing a diversion structure to direct low flows to the BMP, but allow larger flows to bypass. Details on how to design and size these types of diversion structures can be found in Section 7.07.

I. DISCOURAGED DESIGN APPROACHES

The following design practices reduce the ability of stormwater detention systems to address runoff quality and quantity from small storm events. **Stormwater management practices should be designed to avoid these types of practices:**

1. Passive detention systems.

These systems direct captured runoff through a storm sewer network to the outlet from the site. At that point, a restriction such as an orifice plate is placed, which causes water to surcharge and back up out of an intake into a surface depression for temporary storage during large storm events. **This design method allows runoff from smaller storm events to leave the site directly, without the opportunity to reduce runoff volumes or remove suspended pollutants and debris.** ADVISORY

At this site, stormwater usually bypasses the surface of the detention area. Flow goes down through the intake in the parking area and connects to the larger intake by storm sewer below grade. Water only enters the basin when the downstream pipe capacity is reached, allowing the water to "back up" or surcharge into the basin above.

Photo 9.01-3-1: Passive Detention System Example

NOTE

At this site, water flow from the parking area enters this inlet and flows below ground to the basin outlet where a restriction to control large storm events has been placed.

Since most flow bypasses the surface of the basin, there is little opportunity for flow volume reduction or to capture and filter pollutants before they are piped downstream.

Passive detention systems could be used in applications where a practice is only needed to provide temporary detention of large storm events (small storm/water quality considerations are being addressed by other practices).

Photo 9.01-3-2: Example of passive detention at Sunset Park in Denver, Colorado (photo credit Google Maps)

2. Low-flow flumes and directly connected impervious areas.

These systems prevent infiltration of stormwater runoff and reduce or eliminate the possibility of providing water quality treatment or small--storm management. Virtually any storm event will direct surface runoff from paved areas to the receiving storm sewer system or stream. ADVISORY

In this detention area, concrete flumes convey water between storm sewer segments. There is no area for filtration or absorption of runoff during small events. Flumes can often crack and heave, causing maintenance issues. In this picture, lawn clippings, sediment and algal growth can be seen. Sections of concrete with algal growth can be very slippery, leading to safety concerns

Photo 9.01-3-3: Low-Flow Flume Example

The concrete flumes at this location do not allow for any filtration or infiltration of runoff.

In addition, they make it very easy for lawn clippings and other debris to be washed downstream.

In some conditions, algae growth can make the surface of the flume very slippery.

3. Flow path shortcutting.

When runoff enters a basin or treatment practice at nearly the same point where it outlets from the practice, the opportunity for absorption, infiltration or treatment of stormwater runoff is severely reduced. For this reason, it is recommended that stormwater runoff enter a basin or other treatment practice as far from the outlet as possible. **Pipe outlets, flumes or other points of concentrated stormwater flows should enter a treatment practice or basin at a distance from the outlet of no less than twice the width of the practice,** if feasible (a pipe entering a 30' wide detention basin should be located no closer than 60' from the point where water would leave the treatment area). ADVISORY

Water leaves a parking area through a curb opening and directly enters the storm inlet that collects runoff from the detention area. Runoff does not have to flow across any length of permeable surfaces, which would have allowed for filtration and absorption (see Photo 9.01-3-4, next page).

At this site, flow from a parking area bypasses the detention area that is to the left of the outlet structure and is directed directly into the structure.

This reduces opportunities for infiltration of runoff or filtration of pollutants.

Photo 9.01-3-4: Flow path shortcutting

4. Lack of early planning or practices with insufficient space.

As noted previously, proper space is required for access and to achieve desired aesthetics, potentially creating site amenities from stormwater practices. **However, when stormwater management is not considered early enough in the design process, practices are often crammed into spaces that are too small.** This makes proper access for maintenance difficult, creates barriers for public use and can turn stormwater management areas into a visual liability. ADVISORY

Photo 9.01-3-5: Retaining walls are used at this site to maximize storage within a smaller footprint. The presence of the walls limits access and makes maintenance more difficult.