IOWA STORM WATER MANAGEMENT MANUAL

9.10 EXTENDED DRY DETENTION

IOWA DEPARTMENT OF NATURAL RESOURCES

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Refer to the glossary for words in **bold black text**.

9.10-1 LAYOUT AND DESIGN

A. SUMMARY

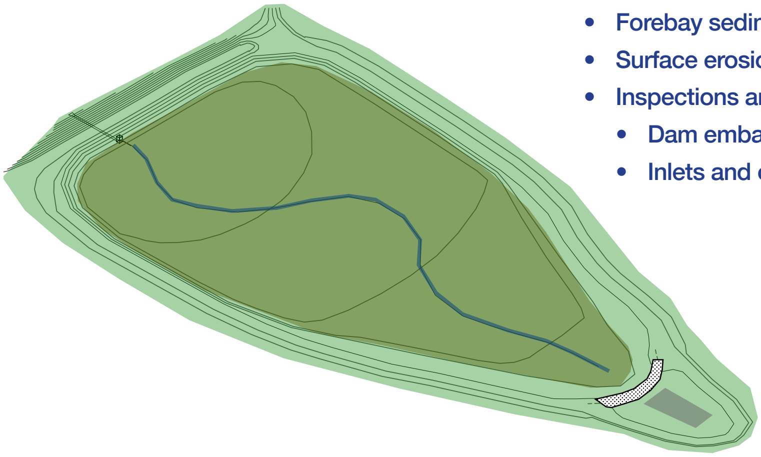
Extended Dry Detention Basins are an adaptation of Traditional Dry Detention practices. Storage volume in the detention area is created by excavation and/or construction of a dam. These basins are still called “dry” because they do not retain a permanent pool of water between rainfall events. The entire basin surface is designed to drain out after rainfall events.

These types of basins feature an outlet structure that is designed to provide **extended detention** of the CPv event (1-year, 24-hour storm). This is accomplished by providing a lower first stage of an outlet structure that is smaller, restricting flow to a point where it is slowly released over a period of no less than 24 hours. These practices still do not include features that capture and clean runoff to address the WQv **storm event**.

DESIGN PROCESS OVERVIEW

1. Investigate Site Feasibility
2. BMP selection early in site design process
3. Review permitting requirements
4. Perform preliminary sizing calculations
5. Estimate required practice footprint
6. Verify sizing through more detailed calculations
7. Develop maintenance and establishment plans
8. Prepare final design, routing calculations and project specifications

Figure 9.10-1-1: Dry ED Detention Perspective Illustration



KEY MAINTENANCE CONSIDERATIONS

Depends on type of perennial vegetation cover

Short-term

- Weed control, re-seeding, replanting
- Surface erosion repair

Long-term (ongoing)

- Keep inlets and outlets clear of debris
- Remove invasive species and less desirable vegetation
- Turf grass areas
  - Routine mowing
  - Weed control
  - Re-sodding, re-seeding and/or repairs
- Native planted areas
  - Annual mowing or prescribed burns
  - Weed/invasive species control
  - Re-planting, re-seeding and/or repairs
- Forebay sediment removal
- Surface erosion repair
- Inspections and maintenance
  - Dam embankment
  - Inlets and outlets

NOTE

See Section 9.10–4 for more detail on maintenance requirements.

B. APPLICATION

Extended dry detention may be applied in **watersheds** of any size. It is often used to mitigate increased stormwater flow rates that are expected when **impervious** cover is created and soil compaction occurs in **urbanized** or developing watersheds.

ABILITY TO ADDRESS THE UNIFIED SIZING CRITERIA

Recharge Volume (Rev) and Water Quality Volume (WQv)

Extended dry detention basins are not constructed with features that maximize capture, infiltration or treatment of stormwater. **Therefore, they are not intended to meet these aspects of the USC. These practices will need to be paired with other BMPs to meet these USC requirements.** ADVISORY

Channel Protection Volume (CPv)

Outlet structures of these types of basins are designed with multi–stage outfall structures that are intended to slowly release runoff from the CPv event. Often, this results in a rate reduction of 95% or greater when comparing inflow to outflow rates. ESSENTIAL

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

Extended dry detention basins can be sized to meet these requirements, through temporary storage of runoff to limit outflow release rates to required levels. The goal of this sizing criteria is to reduce peak outflow rates during these types of events to levels resembling natural levels (rates prior to pioneer settlement), unless a more restrictive standard has been established by a local jurisdiction. ESSENTIAL

To reduce risks for vegetation, public safety and erosion, avoiding extreme ponding depths is recommended. Refer to the table below: TARGET

NOTE

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

NOTE

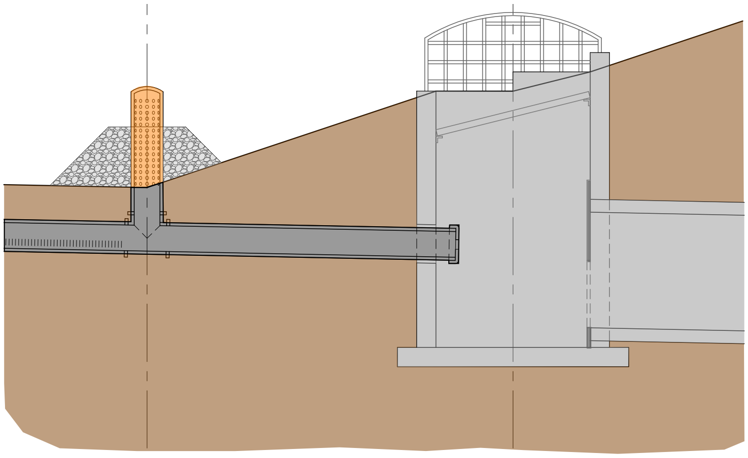
Meeting CPv storage requirements often controls the bottom area required for the basin.

TABLE 9.10-1.1: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	2.0 feet	2.5 feet
10-year, 24-hour duration	3.0 feet	4.0 feet
100-year, 24-hour duration	5.0 feet	6.0 feet

* Measured above the surface inlet elevation of lowest stage of outfall structure

Figure 9.10-1-2: Multi-stage outlet example



C. SITE FEASIBILITY

SOILS

There are no specific restrictions based on soil type or HSG classification. However, it may be difficult to maintain the dry basin surface in areas with steady sources of flow such as sump pump discharges or where seasonal groundwater levels are close to the surface in upstream areas. Lower stages of the basin may be planted with native vegetation acclimated to wetter conditions, or a pilot channel may convey daily **base flows** through the footprint of the basin. (A concrete pilot channel should not be used; see Section 9.01.3-I.) Certain soil types might also influence the maximum surface slopes within the basin that can be maintained without erosion or slope failures. Consult a geotechnical engineer on a case-by-case basis for guidance.

MINIMUM DEPTH TO WATER TABLE

There are no constraints at most sites, however as noted above, a dry bottom surface and stable side slopes may be difficult to maintain in areas where pre-project groundwater levels are close to or above the expected finished grades within the basin. This could result in growth of undesirable vegetation or side slope erosion.

EXISTING VEGETATION

Impacts to prairie remnants, established native vegetation or well–maintained savanna woodland areas should be avoided or limited to the maximum extent possible. TARGET

EXISTING WETLANDS

Disturbing existing, functional wetlands to create new stormwater management areas is strongly discouraged and may not be permitted by regulatory agencies. Initial screening may be completed by review of National Wetland Inventory maps of the site areas. **As part of the preliminary design process, more detailed ecological investigations should be completed to delineate the presence of wetlands and determine if any such identified wetlands are considered jurisdictional.** ESSENTIAL

TRIBUTARY DRAINAGE AREA

There are no set minimums or maximums, although sources of steady flow are more likely as watersheds grow in size. It also may be difficult to meet the maximum high-water depth and minimum surface slope criteria for practices with larger tributary areas.

SPACE REQUIRED

Practices will vary in size based on watershed size, shape and land cover. They need to have sufficient space to provide temporary storage to reduce outflow rates to required levels. For management of the Extreme Flood Event, 6–12% of the tributary drainage area may be required. ***This value is only an estimate to be used very early in the design process. Section 9.10–2 details methods to determine the actual space a practice may require.***

SITE TOPOGRAPHY

Site grading costs may be elevated at sites with steeper **topography**. Designers should consider whether the basin can be constructed by excavation into the existing surface, creation of a dam embankment or some combination of these grading methods.

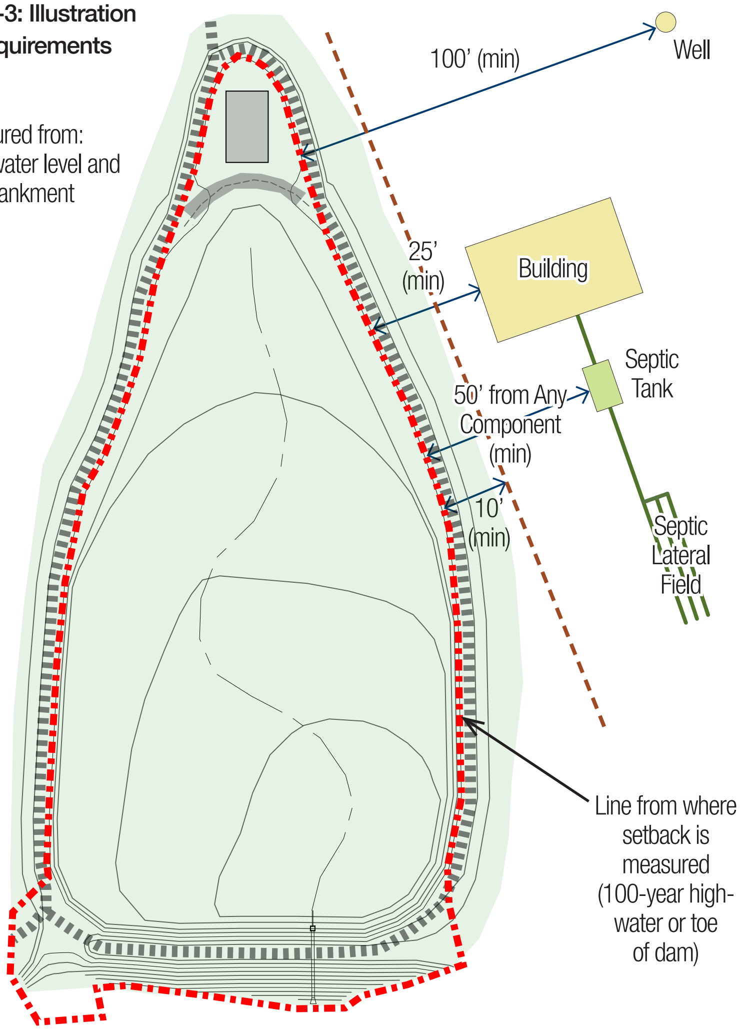
D. SETBACKS

The following **setbacks** should be provided, measured horizontally from the perimeter of the detention area (defined as the area inundated within the basin during the 100-year storm event within the basin) and the upstream side of any dam and the toe of the embankment on the downstream side of the basin: ESSENTIAL

Perimeter building setback envelopes	25 feet
Property line (unless common ownership, easement or other right of access granted)	10 feet
Septic system tank or leach field drain	50 feet
Separation from wells	100 feet

Figure 9.10-1-3: Illustration of setback requirements

Setbacks measured from: 100-Year high water level and toe of dam embankment

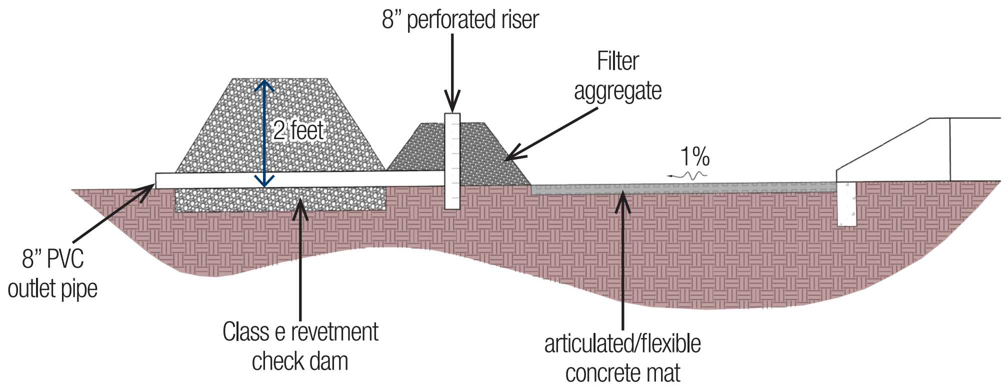


E. DESIGN ELEMENTS AND PARAMETERS

PRE-TREATMENT

Sediment forebays (or other equivalent pre–treatment practices) should be located at all points of concentrated inflow, to capture heavier sediment particles from incoming runoff. Without pretreatment, sediment deposition across the basin will reduce storage over time. Desired vegetation may be lost and **invasive species** may establish in deposition areas. **Forebays** provide a place where sediment can be captured and more efficiently removed.

Figure 9.10-1-4: Illustration of Dry Forebay Option



Pretreatment practices should be sized to contain 10% of the WQv. Pretreatment at the detention site may be omitted for those portions of its watershed that have passed through an adequately sized pretreatment or **water quality** practice upstream. ESSENTIAL

When forebays are used:

- To increase sediment capture by slowing water entry into the detention pond, each forebay should be physically separated from the detention basin in some fashion, such as a berm, reinforced low-head crossing, check dam or pipe. This separation is simply intended to slow flow and increase deposition within the forebay. ESSENTIAL
- Paths for maintenance access should be provided to and from the forebay from adjacent streets or other points of access. ESSENTIAL
- The forebay should create a permanent pool of water that is no more than four feet deep. TARGET
- A fixed vertical sediment depth marker or hard armored bottom is recommended to be placed in the bottom of the forebay to monitor the depth of sediment to be removed. TARGET
- Inflow and outflow velocities should be checked during the design process to make sure that erosive conditions are not expected. ESSENTIAL
- A method of **dewatering** the forebay for sediment removal (such as gated or valved maintenance drawdown pipe, wet well for temporary pump system, etc.) should be provided. TARGET

Other options for pre-treatment include grass swales, vegetative filter strips, mechanical separators, etc. Vegetative filter strips are most effective where stormwater is approaching as **sheet flow**, so that water spreads evenly through the filter strip. Swales and mechanical separators are often used along paths of concentrated flow.

Refer to Section 5.01 for additional design information related to pretreatment practices.

NOTE

Forebays designed to contain 10% of WQv are not sized to intercept sediment–laden runoff from active construction sites. Additional sediment basins or an enlarged forebay should be installed above any detention area where **active construction** (involving grading or other land disturbing activities) is expected to start or continue after the detention basin is completed. Such temporary sediment controls should provide 3,600 **cubic feet** of storage per **disturbed acre** drained.

NOTE

Pre–treatment may be omitted in cases where a drainage area entering the detention facility is less than 0.50 acres in size and is already fully stabilized with permanent vegetation, and no further land–disturbing activities are expected.

BASIN SHAPE AND SIZE

The detention area should be designed to work with site topography, to minimize grading as much as possible and to create shapes and finished grades that appear more natural. As feasible, a basin should be longer than it is wide, to promote greater flow length through the pond and reduce flow path shortcutting. **A minimum length–to–width ratio of 2:1 is desired.** TARGET

PILOT CHANNELS

Pilot channels are recommended in most applications [that may be constructed in areas] where more constant surface flow is anticipated to direct such flows through the footprint of the basin. Pilot channels may be less needed where constant flow is not expected, such as basins managing parking lot runoff. There are many options for pilot channels, which are shown in Figure 9.10-1-5. Articulated or flexible concrete mats may also be used to stabilize the channel lining, provided that the selected material features an open cell design that allows vegetation to be established between or within the concrete elements. The pilot channel should follow a meandering path to maximize flow length through the basin.

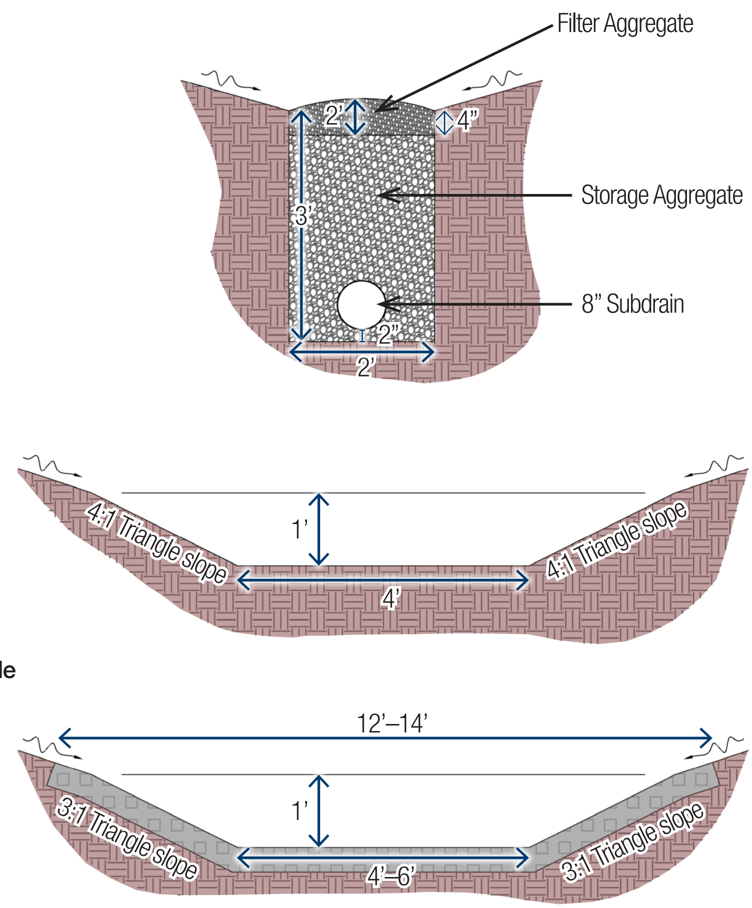
Pilot channels should have a minimum slope of 0.5% (infiltration trenches with subdrains may be flatter), with side slopes as noted on details. Channels will typically be only as deep as needed to convey daily baseflows, allowing flow to quickly spread across the bottom of the basin during storm events. TARGET

Figure 9.10-1-5: Pilot Channel Alternatives

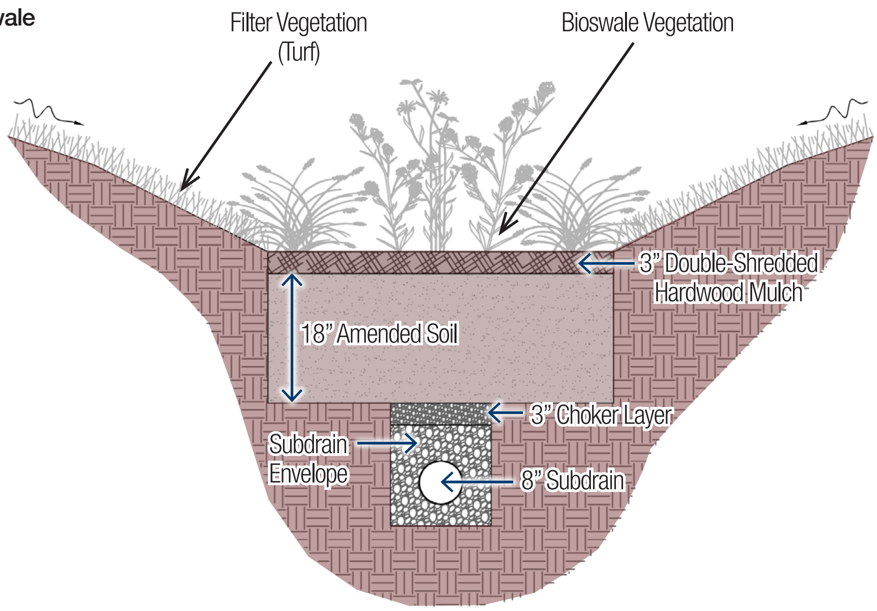
Infiltration Trench

Wet Swale

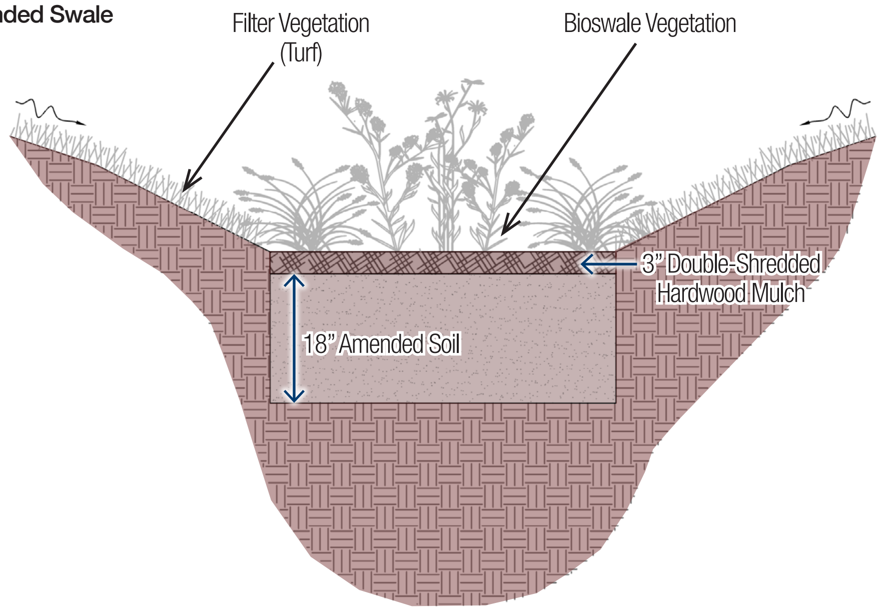
Articulated/Flexible Concrete Mats



Bioswale



Amended Swale



NOTE

Flatter bottoms may require careful plant selections.

BASIN FLOOR

The basin floor should be graded with a minimum slope of 1.5% on finished surfaces to be maintained as turf grass. For areas to be maintained as **native vegetation**, the minimum slope may be reduced to 0.5%. TARGET

PERIMETER SLOPES

Perimeter areas of the basin should be graded with slopes that are stable and mowable. Slopes of 6:1 or flatter are recommended on side slope areas located below the expected high-water elevation caused by the CPv event (1-year, 24-hour storm).

- It is recommended that slopes should be 4:1 or flatter. TARGET
- However slopes may be as steep as 3:1 in select areas. ESSENTIAL
- Flatter slopes may be required based on site-specific soil conditions.

Use of walls or earth–retaining structures within and around the perimeter of the detention area should be limited to the greatest extent possible. Such features restrict access for maintenance, may be negatively impacted by rapidly changing water levels and can be detrimental to the aesthetics around the basin. TARGET

Figure 9.10-1-6: Typical Features of a Dry ED Detention Basin

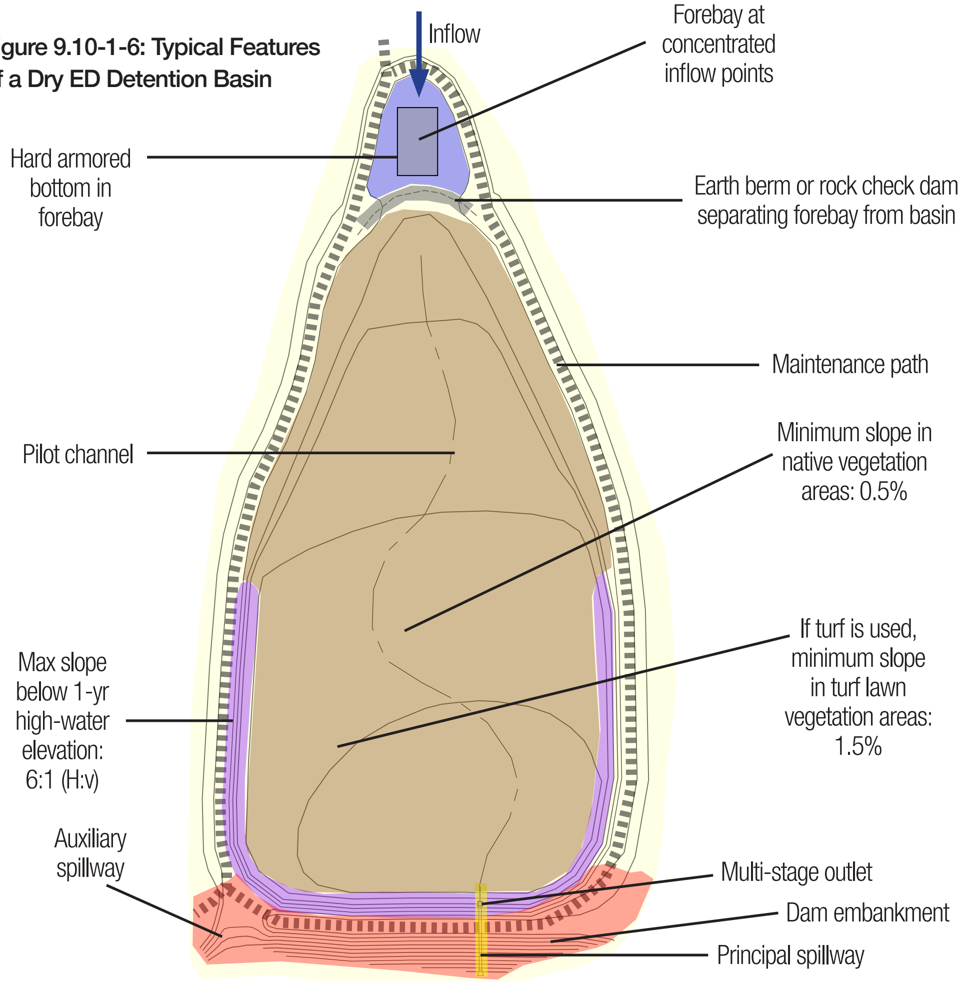
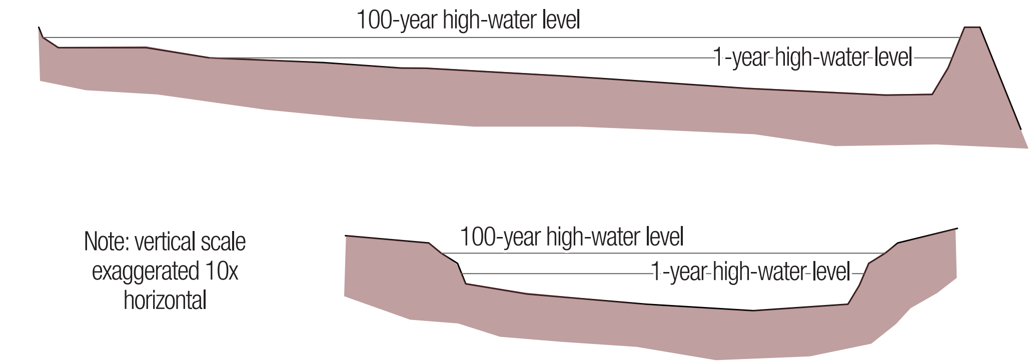


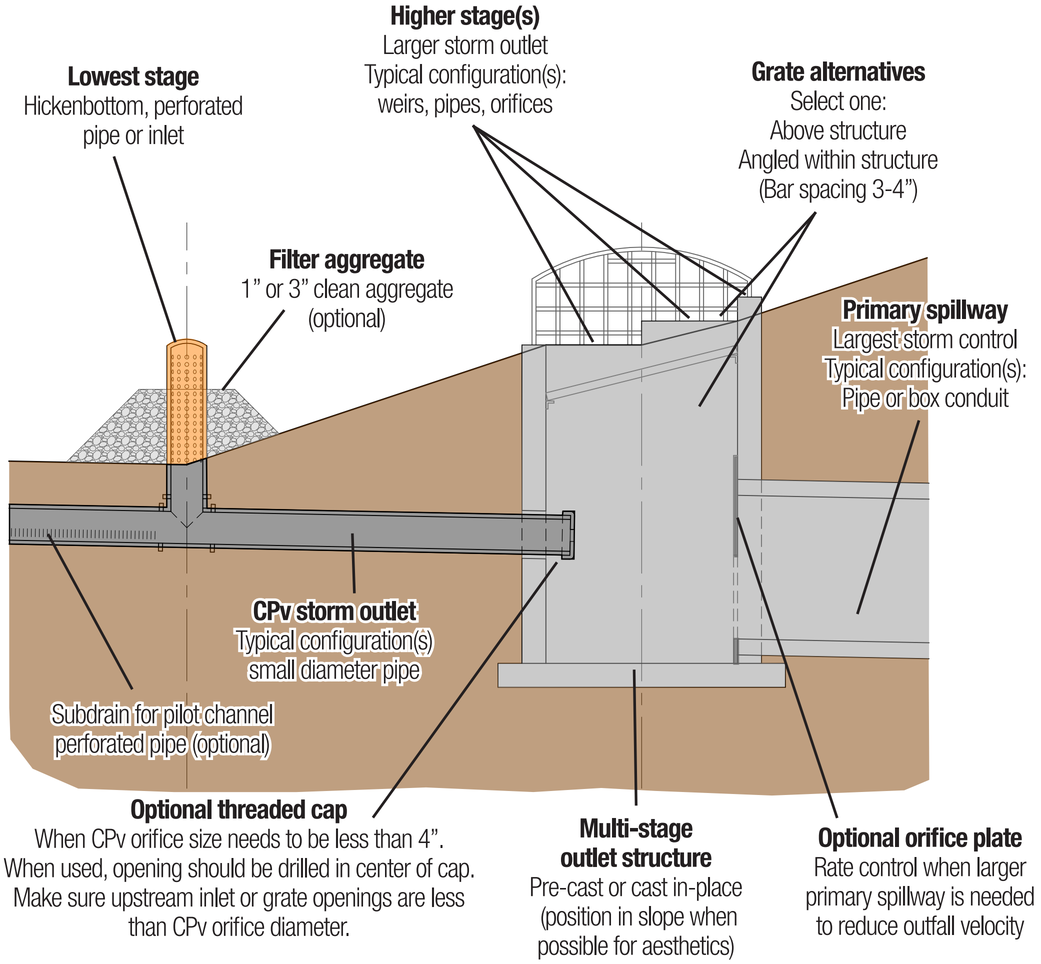
Figure 9.10-1-7: Cross-Section View Graphic of Detention Features



OUTLET STRUCTURES

Multi-stage outlets may be needed to meet release rate reduction targets for various storm events. TARGET

Figure 9.10-1-8: Multi-Stage Outlet Elements



TEMPORARY STORAGE VOLUME

Storage volume for stormwater detention is created through excavation (cut) or creation of a dam embankment (fill) to store water as needed to limit release rates.

DAM CONSTRUCTION AND AUXILIARY SPILLWAY

The dam should be constructed of suitable embankment materials, typically less permeable clay materials. The crest of the dam should be at least 10 feet in width, with a 0.1' rise in elevation from the center to the exterior of the crest. For smaller detention areas—where the entire basin can be reached from an adjacent paved surface—the crest of the dam width may be reduced to 6 feet, with the same rise in elevation provided. Side slopes of the dam below the crest should be no steeper than 3:1 (4:1 recommended).

An emergency overflow spillway is best located at one end of the dam (on the downstream side of the basin) and preferably not located in an area of fill. ESSENTIAL

- The crest of the auxiliary spillway should be generally level as it runs along the centerline of the dam to allow it to spread over a longer width. ESSENTIAL
- The spillway should be protected from surface erosion, based on the expected velocities and frequency of overtopping. ESSENTIAL
- The spillway should be directed to a location where downstream properties, buildings or infrastructure will not be negatively impacted. ESSENTIAL
- Surface water flowage easements may be required to prevent construction of buildings, fences and other obstructions that would prevent flows from being safely conveyed across off-site areas downstream. ESSENTIAL

The crest of the dam should be set at an elevation with at least one foot of **freeboard** between the top of the dam and the expected high-water elevation during the 100-year, 24-hour storm event. The dam crest should also be set at least 1.5 feet above the crest of the auxiliary spillway. ESSENTIAL

NOTE

Check with local jurisdictions and Iowa DNR (as applicable) about freeboard requirements, which may be more restrictive.

Figure 9.10-1-9: Dam Crest Parameters

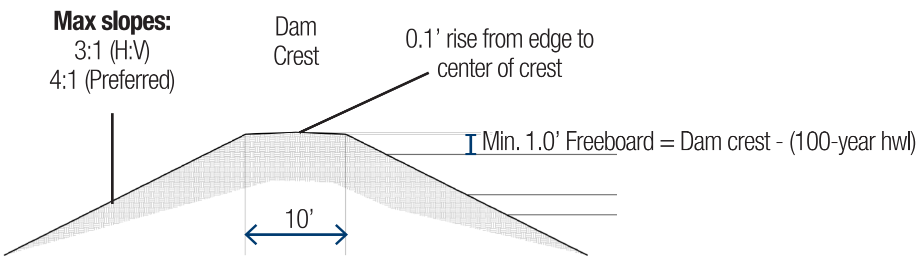
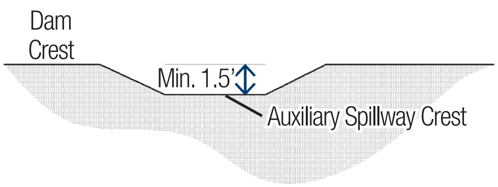


Figure 9.10-1-10: Auxiliary Spillway Parameters



OUTFALLS

Outfalls from the basin should be placed in stable locations, with adequate protection from erosion. Some options are:

- Pipe outfall to the surface, to a swale or to a **level spreader**
- Connection to a local storm sewer system or to a culvert
- An outfall to a waterway, such as a stream or river TARGET

Figure 9.10-1-11: Unstable outfall

Figure 9.10-1-11-A: Level spreader outlet structure

Heritage Park in Minneapolis, MN.
(photo courtesy - Mississippi Watershed Management Organization mwmo.org)

NOTE

When designing outfalls to waterways, pay careful attention to signs of bank erosion or **stream migration**. Avoid placement of outfalls on the outside bends of streams, where higher levels of shear stress frequently occur. Outfalls should be placed as close to the normal flow elevation as possible to reduce the potential for surface erosion or downcutting below the outlet. Revetment storm materials or other protection methods can minimize opportunities for soil erosion below or around the pipe.

Figure 9.10-1-11-B: Concrete level spread

Concrete level spread with grass basin on upstream side. Flow enters from pipe that runs parallel to the spreader and leaves by filling the basin and flowing across the level concrete strip.
(photo coutesy - NC State University "Urban Waterways - Level Spreader Update")

NOTE

Some options listed within the FEMA Technical Manual to control seepage and erosion through dams are:

- Concrete cradles may be cast below circular pipe spillways to avoid problems with soil compaction along the undersides of the pipe.
- Use of waterstop pipe materials at pipe joints.
- Construct chimney filters to control internal seepage or erosion within the dam structure

Revetment materials or other erosion protection measures should be placed at pipe outlets. Check expected velocities at outfalls during a 100-year storm event. **If necessary, consider increasing the diameter of the outfall pipe to lower expected velocities (outlet structure would need to be designed so that allowable release rates are still not exceeded)**. Alternatively, a stilling basin could be constructed to dissipate energy below the outfall. ESSENTIAL

Water seepage can easily occur along pipe conduits through dams. In extreme cases, water movement can lead to erosion along the outside of the pipe, potentially breaching the dam itself. **Pipe conduits through spillways must include seepage control measures to prevent these issues.** In the past, seepage collars were used to address this issue; however, these have proven ineffective in many situations. ESSENTIAL

Refer to the following standards for design of dams and outlet conduit spillways:

- FEMA Technical Manual: Conduits Through Embankment Dams (September 2005).
- IDNR Technical Bulletin No. 16: Design Criteria and Guidelines for Iowa Dams (December 1990).

E. MAINTENANCE, ACCESS AND SAFETY

PLANNING FOR MAINTENACE ACCESS

A maintenance path shall be provided around the perimeter of the facility, with paths of access to forebays, pre–treatment devices, spillways, outlet structures and pipe outfalls. ESSENTIAL

- **The path of access shall be at least 12 feet wide with a maximum cross–slope of 8%** (5% preferred). For smaller detention areas, a perimeter path is optional, provided that all areas of the basin can be accessed within 40 feet (measured horizontally) from a point where maintenance equipment can be staged.
- **The path should be kept clear of trees or other woody vegetation.** (This mowed or paved access may also serve as a fire break, if fire is planned for vegetation maintenance.)

- **It should be constructed to withstand maintenance vehicles and equipment.** (While not required, shared-use paths and multi-use trails can serve a dual purpose for maintenance access.)
- **The path should have access to a public or private road for a point of entry**, and should be completely within the property owned by the party responsible for maintenance, or within an easement recorded to grant such access.

Figure 9.10-1-13:
Maintenance Path Needs

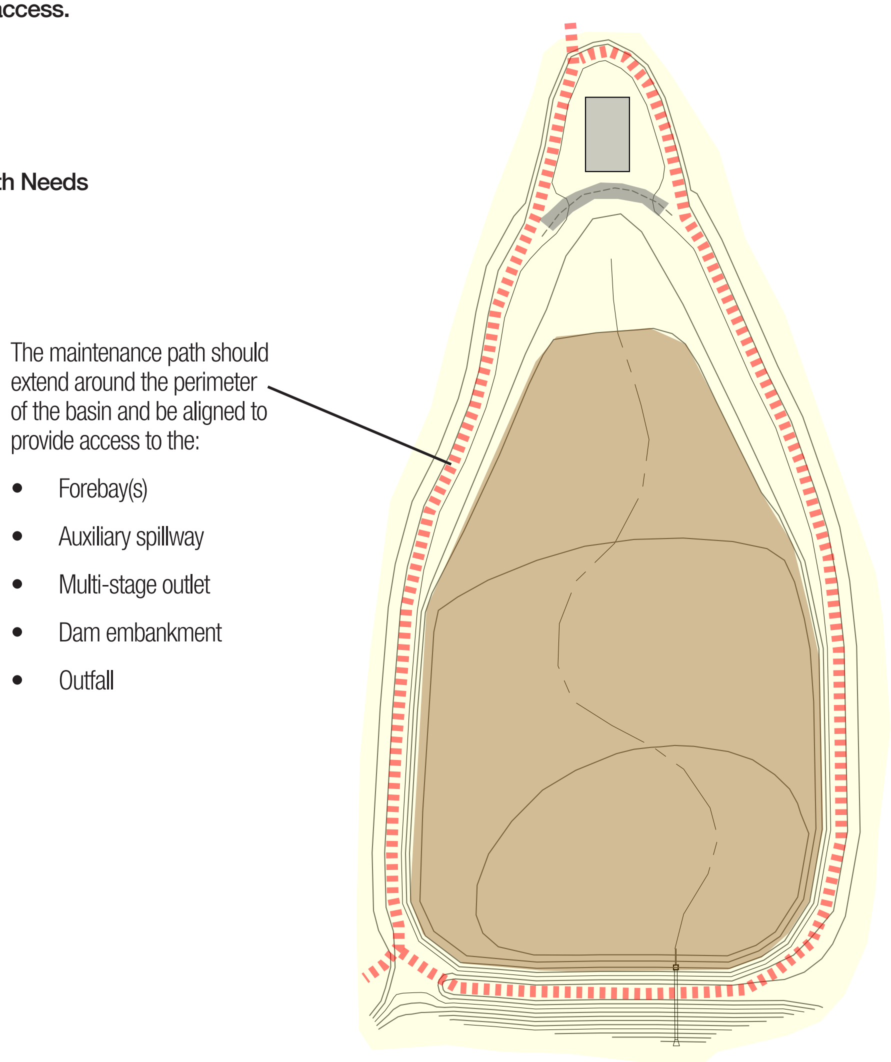
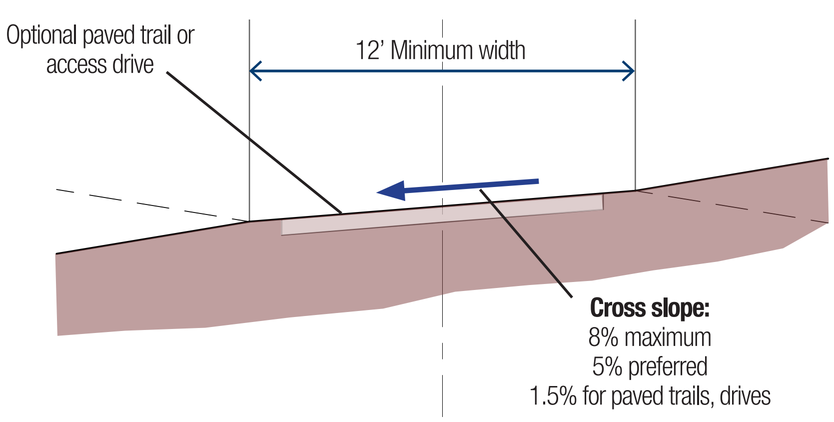


Figure 9.10-1-14:
Cross-section of maintenance path



SAFETY FEATURES

A. All embankments and spillways shall be designed to State of Iowa guidelines for dam safety, as applicable. ESSENTIAL

B. Fencing of stormwater detention areas is not generally desirable, but may be required by the local review authority. TARGET

C. A grate or trash rack on larger openings of the multi-stage outlet structure should deter access by small children. ESSENTIAL

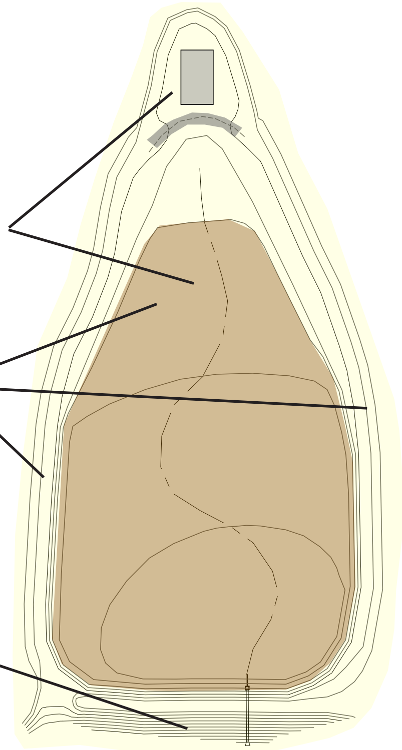
D. Pipe outfalls of greater than 48 inches in height may require a fence or railing to reduce fall risks. ESSENTIAL

F. LANDSCAPING

A landscaping plan should be provided that indicates the methods used to establish and maintain desired permanent vegetation. Minimum elements of a plan include: delineation of landscaping zones, selection of corresponding plant species, planting plan, sequence for preparing planting bed (including soil amendments, if needed) and sources of plant material. The designer should consider the frequency and duration of inundation for various zones within the basin when selecting plant materials.

- Separate landscaping zones may be considered for areas expected to be inundated more frequently (e.g., below the **high water** of the CPv event).
- Woody vegetation may not be planted on the dam embankment or allowed to grow within 25 feet of the toe of the embankment or the principal and emergency spillway structures, to prevent damage from root growth.
- When possible, existing healthy, native tree species should be preserved in the buffer area during construction.
- Over-compaction of site soils may require excavation of pits, to be backfilled with less compacted topsoil materials in tree and shrub planting areas.

Figure 9.10-1-15: Landscaping Zones



G. DESIGN ALTERNATIVES

RECREATIONAL FEATURES WITHIN BASIN

Extended detention facilities may be constructed with recreational features (such as soccer/football fields), playgrounds or other open spaces set on a higher plateau. These areas may be inundated by moderate to large storm events (5-year, 24-hour storm or larger), but would remain dry in most circumstances. Building structures would need to be located outside of areas expected to be inundated by the 100-year storm event.

The lower elevations of the basin would typically be maintained as native perennial vegetation, with plant selection zones determined by frequency and depth of inundation.

In these circumstances, the maximum storage depths would be amended as follows:

TABLE 9.10-1.2: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

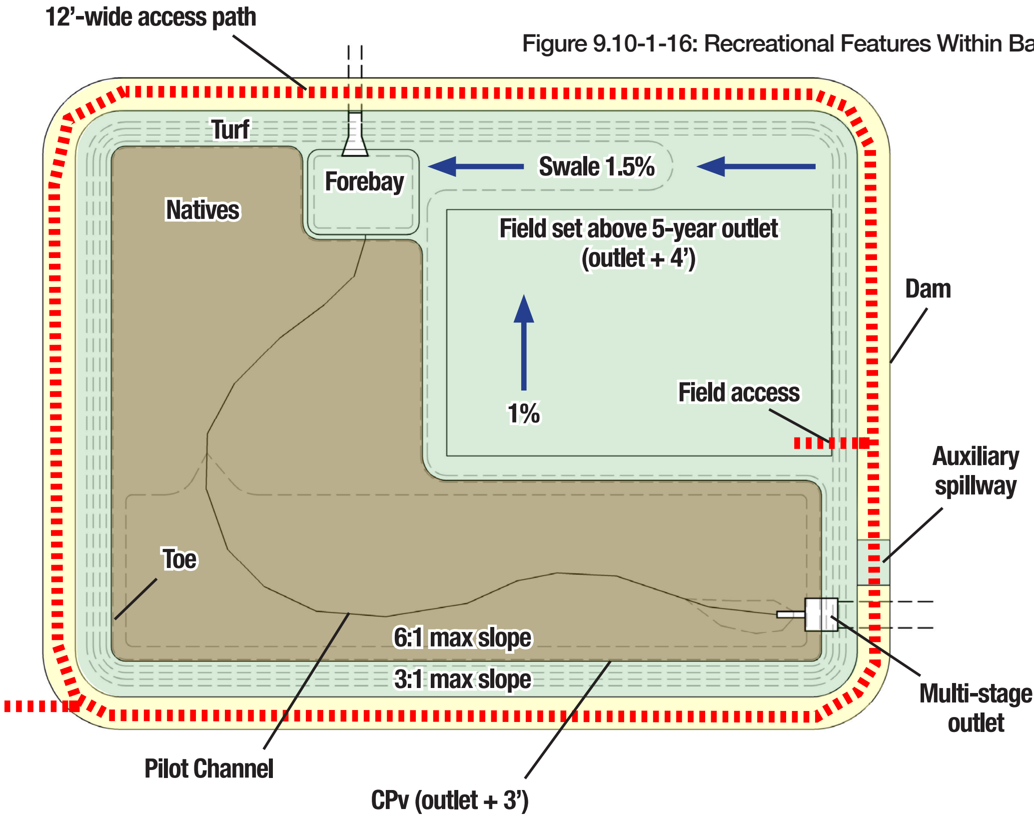
STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	3.0 feet	3.5 feet
5-year, 24-hour duration*	4.0 feet	5.0 feet
10-year, 24-hour duration	5.0 feet	6.0 feet
100-year, 24-hour duration	7.0 feet	8.0 feet

* Measured above the surface inlet elevation of lowest stage of outfall structure

** All recreational features should be set above the expected high-water elevation of the 5-year, 24-hour duration storm event.

URBAN FLOOD STORAGE RETROFITS

Figure 9.10-1-16: Recreational Features Within Basin



In the past, some detention facilities have been constructed in flood-prone areas to provide local flood control. These systems were often designed without thought of providing management of small storm events. These sites may be candidates for retrofits to provide extended detention.

There may be other heavily developed areas in which new stormwater facilities could be constructed to provide additional flood storage. Many of these types of practices were/are constructed with deeper ponding depths, so they can maximize flow reduction within the available surface area.

In such circumstances, the maximum storage depths would be amended as follows:

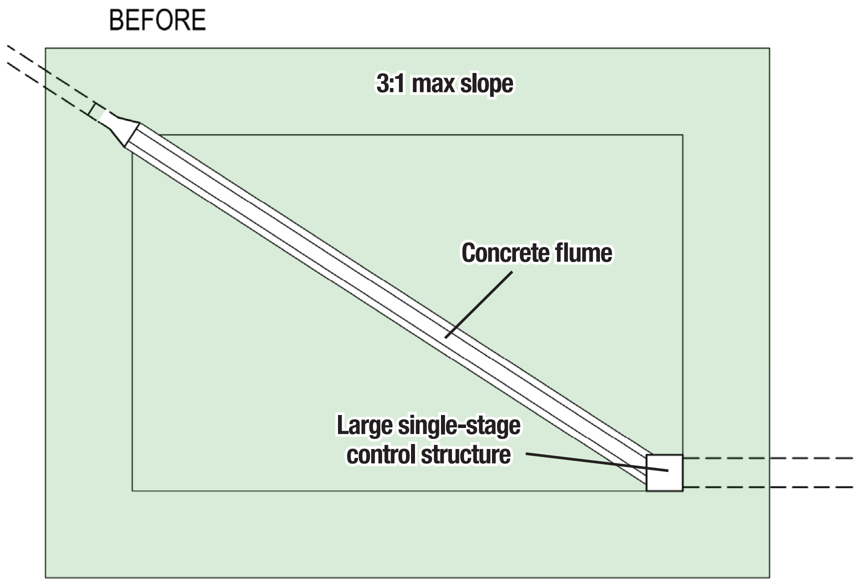
TABLE 9.10-1.3: MAXIMUM TEMPORARY STORAGE DEPTHS FOR EXTENDED DRY DETENTION

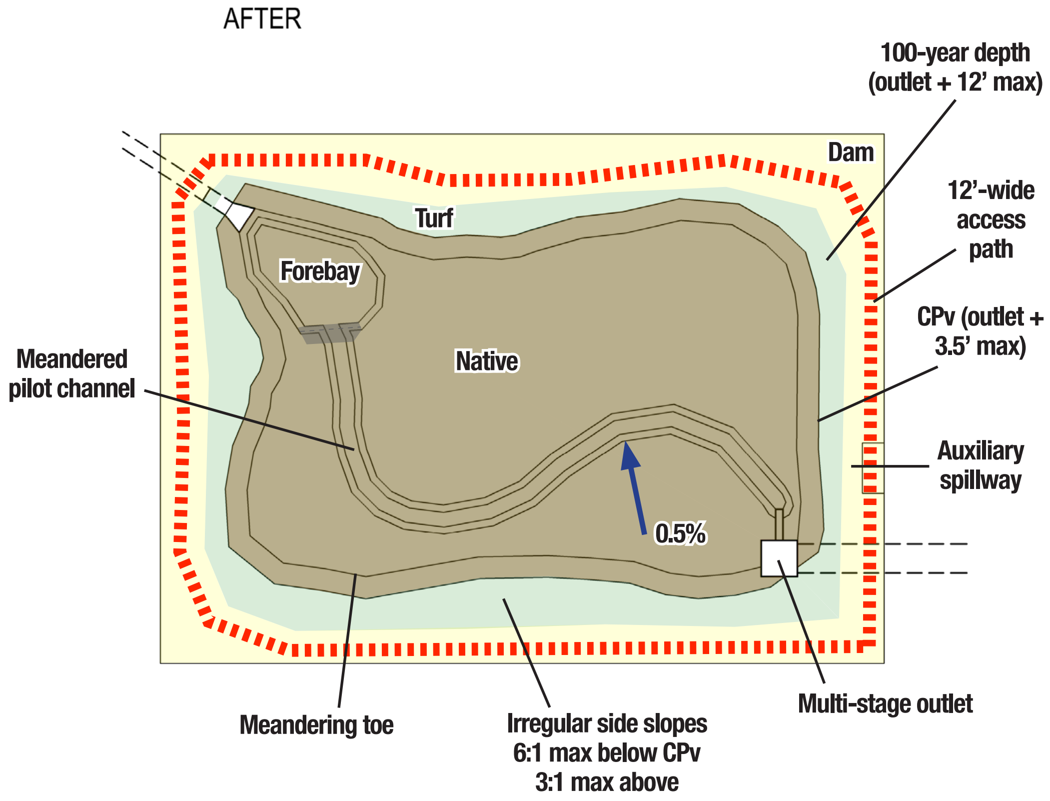
STORM RECURRENCE INTERVAL	PREFERRED HIGH-WATER DEPTH *	ALLOWABLE HIGH-WATER DEPTH *
CPv event	3.0 feet	3.5 feet
10-year, 24-hour duration	6.0 feet	7.0 feet
100-year, 24-hour duration	10.0 feet	12.0 feet

* Measured above the surface inlet elevation of lowest stage of outfall structure

Due to the potential for deeper water occurring more frequently, signage should provide the public with information about the potential for rapidly rising water levels. Alternatively, access could be restricted by fencing or other means. However, it is always encouraged, to the greatest extent possible, to develop stormwater management systems that treat water as a valuable resource and encourage safe public access to make the best use of that resource.

Figure 9.10-1-17: Flood Control Basin Retrofit





NOTE

Locating dry ED basins within flood prone areas is discouraged.

Exceptions:

- Retrofits of existing BMPs
- On–line BMP: stream routed through basin
- BMP is constructed by excavation: no dam or berm that creates barrier to the floodplain

H. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

It is preferred that dry ED basins be located outside of the extent of the mapped 1% chance **annual recurrence** (AR) flood event (100-year flood). Exceptions can be made for retrofits or existing sites that are already located within a flood plain, or if the basin is located "on-line," so that the stream with the mapped flood zone will be routed through the basin for the purpose of reducing downstream flowrates. Exceptions are also allowed if the storage for the basin is to be constructed by excavating within the floodplain, without creation of a dam or berm that would effectively remove the basin from the floodplain. Any earth-moving activities to construct dams or create excavated areas will need to comply with local, state and federal floodplain regulations. Changes in surface elevation that result in increased high-water elevations across the floodplain should be avoided.

Basins located within flood-prone areas may require more frequent or extensive maintenance. When evaluating site locations within flood-prone areas, evidence of deposition or debris collection should be noted. **If a basin is constructed in an area expected to collect sediment or debris, available storage could be reduced over time and additional maintenance to remove trapped materials would be necessary.** ADVISORY

STREAM MORPHOLOGY

Stormwater detention areas should be located with adequate buffer space from adjacent streams. The designer should review historic photographs or use other information to understand past stream movement adjacent to a proposed basin. During site selection, it should be determined if a nearby stream is demonstrating active bank erosion, has shown lateral migration over a period of time or is actively incising. In such cases, the practice should be located so that such movement will not impact the basin, its related elements or points of access.

A stream migration buffer limit should be set beyond any projected future movement and beyond a line drawn from the toe of the closest adjacent streambank (either current or future location) at a 4:1 slope to the finished surface.

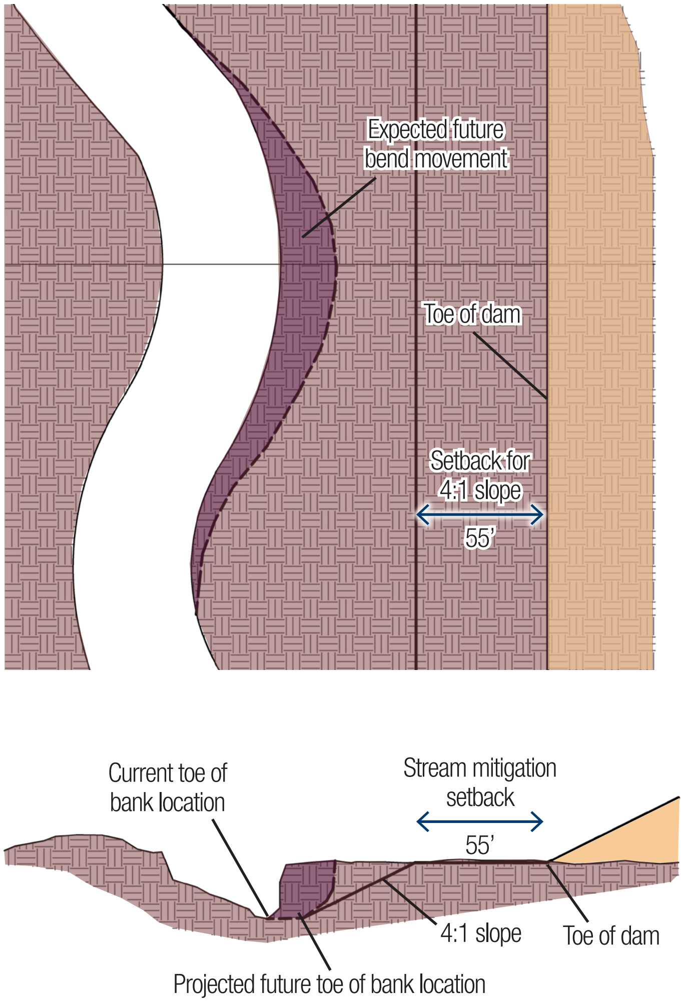


Figure 9.10-1-18: Stream Morphology Considerations

9.10-2 SIZING CALCULATIONS

A. CALCULATION PROCEDURE

Step 1. Determine if the development site and conditions are appropriate for the use of a stormwater detention basin. Consider the Application and Feasibility criteria in Section 9.10–1.

Step 2. Confirm any state, federal or local jurisdiction design criteria and applicability standards.

- Review need for state and federal permits (NPDES, Joint Permit application)
- Consider any special site-specific design conditions/criteria listed in this section.
- Check with local officials and other agencies to determine if there are additional restrictions and/or surface water or watershed requirements that may apply. (State Dam Safety requirements will be checked in Step 8).

Step 3. Develop a stormwater model (TR–55) for the watershed area for the practice. The model should determine peak flow rates and volumes for the **natural**, existing and proposed conditions. Refer to Section 9.02-2.A for the events to be studied and Section 9.03 for use of modeling software. Note that the release rate for the CPv event is determined by methods outlined in Section 3.02.

TABLE 9.10-2.1: TR-55 MODEL INPUT/OUTPUT

		PRE-SETTLEMENT		EXISTING		POST-DEVELOPMENT	
		CN = 58	TC = 94.8 M	CN = 74	TC = 37.9 M	CN = 83	TC = 22.1 M
EVENT	RAINFALL*	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice. For extended dry detention practices, this is typically the CPv through 100-year storm events. Designers are strongly encouraged to use the procedure in Section 9.02-3 to estimate required storage very early in the planning process for any new development or stormwater facility. Estimated storage values can project the area that should be set aside for stormwater detention, allowing other development plans to be planned around that reserved open space.

Step 5. Determine pretreatment measures.

- The pretreatment volume should be 10% of WQv. Pretreatment is required even for facilities that aren't managing the WQv. Pretreatment may be omitted in some areas (refer to Section 9.01-1.E).
- Determine the preliminary location, size and depth of forebays (where required).

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage–storage relationships that provide the estimated storage volumes required as calculated in Step 4. Refer to Table 9.10-1.1 for maximum storage depth requirements for key storm events.

NOTE

Refer also to IDNR Form 542–1014.

Step 7. Investigate potential pond/wetland hazard classification. The design and construction of stormwater management ponds are required to follow the current version of the Iowa Technical Bulletin 16 related to embankment dam safety rules.

- The height of the dam and the stage-storage relationships (both above and below the permanent pool elevation) are necessary to complete this step.

Step 8. Enter the preliminary stage–storage relationships and outlet configurations into a TR–55 software program and route inflow hydrographs through the preliminary detention basin design. Identify the projected release rates for each event studied.

NOTE

Use perforated risers or other features with multiple small openings in lieu of single orifice openings that are less than 4 inches in diameter. Alternatively, provide guards or screens to protect the smaller opening from being plugged by debris or animal activity.

Step 9. Review projected release rates from Step 8 for the preliminary design. Verify that the projected rates are less than the allowable rates calculated as part of the estimation procedure referred to in Step 4. Iterate as needed, adjusting staged outlet controls or stage-storage relationships within the software program to meet required release rate restrictions. Maintain compliance with maximum storage depths listed in Table 9.10-1.1.

Step 10. Finalize practice location and refine the grading plan and outlet design. Alter the model that was developed and adjusted in Steps 8 and 9 to reflect the stage-storage and outlet conditions included in the final plan. Re-check that peak release rates are less than allowable levels and maximum storage depths are not exceeded.

Step 11. Check outflow velocities at pipe outfalls and spillways. Adjust sizing or geometry, or add erosion protection features as needed for the 100-year, 24-hour event.

- From the continuity equation, determine pipe velocity based on flow rate (Q) and area (A) [V = Q/A]
- Using the same equation, check for velocity across the crest of the emergency spillway (if any overflow occurs during the 100-year storm event).

Step 12. Complete design checklists at the end of this section to verify that sizing design criteria have been satisfied. Proceed to development of detailed plans and specifications. After completion of final design, make any adjustments as needed so that final plan information matches the finished calculation report.

B. CALCULATION DESIGN EXAMPLE

PROJECT WATERSHED DATA

TABLE 9.10-2.2: SITE LOCATION: IOWA REGION ZONE 8 (SOUTH CENTRAL)

PROPOSED LAND USE	AREA	HYDROLOGIC SOIL GROUP	% IMPERVIOUS	SQR DEPTH
Commercial	20 acres	B	73%	4”
Multi-family	15 acres	B	65%	< 4”
Single Family*	45 acres	B	43%	8”
Total	**80 acres**			

* Wetland footprint included in this area

Existing conditions: Row crop, contoured with crop residue (C + CR) in good condition, HSG B (CN=74).

Step 1. Determine if the development site and conditions are appropriate for the use of a an extended dry detention basin. Consider the Application and Feasibility criteria in Section 9.10-1.

For this example, assume site feasibility criteria have been reviewed and the site is suitable for an extended dry detention basin. The recharge and water quality volume are treated upstream.

Step 2. Confirm any state, federal or local jurisdiction design criteria and applicability standards.

A. Review the need for state and federal permits (NPDES, Joint Permit application)

For this example, assume that no **jurisdictional wetlands**, habitat for endangered or threatened species or regulated flood risk areas are present.

B. Consider any special site-specific design conditions/criteria listed in this section.

Refer to Section 9.10-1.H. For this example, the basin is proposed to be outside of areas of known flood risk. It may still be wise to look for evidence of significant sediment deposition under existing conditions within the site area (assumed this was done and no such indications were observed).

This example is not adjacent to a stream, but if it were, the basin should be set back from the edge of the stream to account for anticipated bank erosion, stream migration or stabilization methods.

C. Check with local officials and other agencies to determine if there are any additional restrictions and/or surface water or watershed requirements that may apply (State Dam Safety requirements will be checked in Step 8).

For this example, assume that the local jurisdiction has adopted the use of ISWMM and requires the following related to application of the Unified Sizing Criteria.

Stormwater management and release rate criteria may vary between municipalities. Verify local design requirements prior to proceeding further with design.

- Release rates for larger events (up to the 100-year, 24-hour storm event) will be limited to the lesser of the following:
  - Peak flow rates similar to pre-settlement conditions (meadow in good condition, based on local soil types and historic times of concentration) for similar storm events (i.e. post-project peak flow from 2-, 5-, 10-, etc., year events shall be equal to or less than pre-settlement conditions for the same rainfall event).
  - Peak flow rates similar to existing conditions for a 5-year, 24-hour storm event.

Step 3. Develop a stormwater model (TR-55) for the watershed area for the practice. The model should determine peak flow rates and volumes for the natural, existing and proposed conditions. Refer to Section 9.02-2.A for the events to be studied and Section 9.03 for use of modeling software. Note that the release rate for the CPv event is determined by methods outlined in Section 3.02.

Refer to ISWMM Chapter 3, Section 3 for guidance on calculating time of concentration.

It is recommended that the NRCS Lag equation be used for pre–settlement conditions.

Calculate time of concentration for pre-settlement, existing and developed conditions.

Pre-development conditions: Use NRCS Lag Equation [Eqs. C3-S3-5 & 6]

Watershed length (L) = 3,675 feet
Average watershed land slope (Y) = 3%, CN = 58 (meadow in good condition, HSG B)

Tc = 94.8 minutes

For existing and developed conditions, use the **NRCS TR-55 method.**

TABLE 9.10-2.3: TABLE C8-3: EXAMPLE PROJECT TIME OF CONCENTRATION DATA

	SHEET		SHALLOW CONCENTRATED		PIPE	CHANNEL	
	LENGTH	SLOPE	LENGTH	SLOPE	5 FPS*	3 FPS*	TC
Existing	100 ft	1%	500 ft	2%	0 ft	3,075 ft	37.9 min
Developed	50 ft	4%	250 ft	2%	1,450 ft	1,730 ft	22.1 min

* Assumed since exact pipe size, length and slope are not known

A *Water Quality Volume*

- Calculate the WQv volume required to be treated to size forebay

TABLE 9.10-2.4: TABLE C8-4: CALCULATION OF EFFECTIVE IMPERVIOUS AREA

LAND USE	AREA (ACRES)	% IMPERVIOUS	% OPEN SPACE WITH <4" SQR	ADJUSTED % IMPERVIOUS	EFFECTIVE IMPERVIOUS AREA
Commercial	20	73%	0%	73.0%	14.600 acres
Multi-Family	15	65%	35%	82.5%	12.375 acres
Single-Family	45	43%	0%	43.0%	19.350 acres
Total	**80**				**46.325 acres**
		Impervious % to use in Calculating WQv			**57.9%**

NOTE

For previously developed areas, refer to local requirements that were in place at the time of construction. If not known, assume less than 4" of SQR was performed.

Refer to ISWMM Chapter 3, Section 6 for information on Small Storm Hydrology calculations for WQv, CPv

From Chapter 3, Section 6 --- Calculate Rv (runoff coefficient), Qa (WQv runoff volume in inches), WQv (in cubic feet)

Rv = 0.05 + 0.009 (57.9) = **0.571** [Eq. C3-S6-1]

Qa = Rv x 1.25”= 0.571 x 1.25” = **0.714 watershed-inches** [Eq. C3-S6-2]

WQv = Qa x (1 ft / 12 inches) x A (acres) x (43,560 SF / 1 acre) = 0.714 x (1/12) x 80 x (43,560 / 1) = **207,330 CF**

B *Channel Protection Volume*

- Use TR-55 software to generate inflow hydrographs for the CPv and larger events to be studied
  - Prepare these for pre-developed, existing and proposed conditions
  - The peak rate of flow and runoff volume for each event will be needed

TABLE 9.10-2.5: FULLY DEVELOPED WATERSHED CN CALCULATION

		IMPERVIOUS	OPEN SPACE			
			POOR < 4” SQR	FAIR >/= 4” SQR	GOOD >/= 8” SQR	
	CN	98	79	69	61	
LAND USE	AREA	% OF LAND USE AREA				WEIGHTED CN
Commercial	20 acres	73%	0%	27%	0%	90.17
Multi-Family	15 acres	65%	35%	0%	0%	91.35
Single-Family	45 acres	43%	0%	0%	57%	76.91
Total	**80 acres**			**Total Weighted CN**		**83**

TABLE 9.10-2.6: TR-55 MODEL INPUT/OUTPUT

		PRE-SETTLEMENT		EXISTING		POST-DEVELOPMENT	
		CN = 58	TC = 94.8 M	CN = 74	TC = 37.9 M	CN = 83	TC = 22.1 M
EVENT	RAINFALL*	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)	RATE (CFS)	VOLUME (CF)
WQv	1.25”					61	205,900
CPv (1-year)	2.77”	3.1	59,100	42	221,000	106	364,000
2-year	3.20”	6.3	98,900	59	300,000	136	463,000
5-year	3.99”	15	191,000	95	459,000	193	655,000
10-year	4.74”	26	298,000*	131	623,000	249	846,000
25-year	5.90”	48	491,000	191	896,000	336	1,150,000
50-year	6.90”	70	678,000	243	1,140,000	412	1,420,000
100-year	7.98”	95*	898,000	303	1,420,000	494	1,710,000

* Rainfall depths are for Iowa Region 8 (South Central Iowa)

- Use the procedure in Chapter 3, Section 6 to estimate the required CPv volume and calculate the allowable release rate for extended detention of CPv

NOTE

Providing less than 8” of **soil quality restoration** is not encouraged. This example includes “< 4–in” and “4–in SQR” scenarios only to demonstrate how to perform the calculations in such circumstances.

Open space Curve Numbers (CNs) in this table are based on HSG B soils, as given for this project example.

Curve Numbers are always rounded to the nearest whole number.

NOTE

Designers may use other software to calculate PRELIMINARY ESTIMATES of storage volume to be used in initial site design; however, the maximum outflow rate from the final basin design should not exceed the values calculated by Steps 4 and 5 as shown here, in order to ensure that Extended Detention of the CPv event with a 24–hour minimum drawdown has been provided.

Since we are treating the channel protection volume, follow steps A-F below to determine the storage requirements to provide the extended detention. For the other storm events, (qo / qi) is determined by the jurisdictional release rate requirements (i.e. qo is the minimum of the pre-settlement conditions and the 5-year existing outflow rates). For events larger than the 1-year, 24-hour, skip steps A-D.

A. For CPv, the total runoff volume (Qa) from Table C8-6. Convert this value to watershed-inches:

Qa = 364,000 CF x (1 acre / 43,560 SF) x (1 watershed / 80 acres) x (12 inches / 1 foot) = 1.25 watershed – inches

B. The unit peak discharge is calculated by:

qu = (peak runoff rate in cfs) x [(640 ac/mi2) / (watershed area in acres)] x [1 / (Qa in watershed inches)]

qu = 106 cfs x [(640 ac/mi^2) / 80 acres] x [1 / 1.25 watershed-inches] = 678 cfs / mi^2-inch (csm/in)

C. Using Figure C3-S6-1, with qu = 678 csm/in…

The ratio of allowable outflow to inflow (qo / qi) = 0.03. (see figure below, from C3-S6-1)

D. Therefore, the maximum allowable outflow from the extended dry detention to achieve the 24-hour extended detention is:

qo = (qo / qi) x qi = 0.03 x 106 = 3.2 cfs

E. The estimated storage required can be calculated using the equation below…

$$\frac{Vs}{Vr} = 0.683 - 1.43\left(\frac{qo}{qi}\right) + 1.64\left(\frac{qo}{qi}\right)^2 - 0.804\left(\frac{qo}{qi}\right)^3$$

For the CPv event, Vr = Volume of runoff = 364,000 CF and (qo / qi) = 0.03.

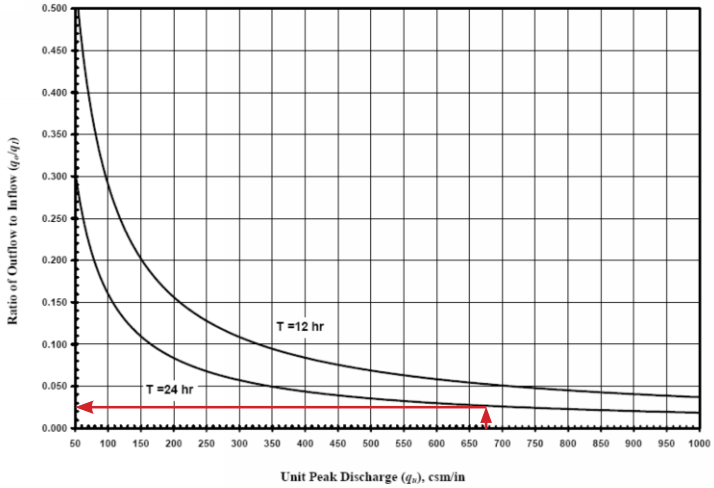


Figure C3-S6- 1: Detention time vs. discharge ratios (qo/qi)

F. Vs / Vr = 0.683 – 1.43 (0.03) + 1.64 (0.03)^2 – 0.804 (0.03)^3 = 0.6416
Vs = (Vs / Vr) x Vr = 0.6416 x 364,000 CF = 234,000 CF

Step 4. Estimate required storage volumes to meet the aspects of the Unified Sizing Criteria to be managed by the practice.

For extended dry detention practices, this is typically the CPv through 100-year storm events. Designers are strongly encouraged to use the procedure in Section 9.02-3 to estimate required storage very early in the planning process for any new development or stormwater facility. Estimated storage values can project the area that should be set aside for stormwater detention, allowing other development plans to be planned around that reserved open space.

The estimated storage volumes for each storm event are summarized below. Note that for all events except the 100-year, the outflow will be restricted to the pre-settlement conditions. The 100-year event will be restricted to the 5-year, 24-hour existing conditions.

TABLE 9.10-2.7: INITIAL ESTIMATES OF REQUIRED DETENTION

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF)	VS (CF)	VS *1.15 (CF)
1-year	3.1	106	0.03	0.6431	364,000	234,000	269,200
2-year	6.3	136	0.05	0.6203	463,000	287,195	330,300
5-year	15	193	0.08	0.5808	655,000	380,406	437,500
10-year	26	249	0.11	0.5489	846,000	464,338	534,000
25-year	48	336	0.14	0.5095	1,150,000	585,970	673,900
50-year	70	412	0.17	0.4837	1,420,000	686,806	789,800
100-year	95	494	0.19	0.4633	1,710,000	792,231	911,100

The same equation used to estimate storage required for CPv can be used to calculate estimated storage for other larger events.

$$\frac{Vs}{Vr} = 0.683 - 1.43\left(\frac{qo}{qi}\right) + 1.64\left(\frac{qo}{qi}\right)^2 - 0.804\left(\frac{qo}{qi}\right)^3$$

Step 5. Determine pre-treatment measures.

- The pretreatment volume should be 10% of WQv. Pretreatment is required even for facilities that aren't managing the WQv. Pretreatment may be omitted in some areas (refer to Section 9.01-1.E).
- Determine the preliminary location, size and depth of forebays (where required).

Pre-Treatment Measure #1 – Sediment Forebays

For this design, it is assumed that the remainder of the watershed area enters the basin through two outfall pipes. The forebay volume can then be calculated as:

207,330 CF	(total watershed WQv)
x 10%	
= 20,733 CF	*(total pre-treatment volume required)*

- The forebay should be no more than 4 feet deep. Determine the proposed storage volume at each concentrated inflow point.

For this example, if flow is equally split to each outfall, each forebay will need to have at least 10,367 CF of storage (20,733 CF / 2). In reality, the outflow rates from each subwatershed should be calculated seperately and the forebays should be sized proportionately.

NOTE

For simplicity of this example we are assuming that flow is equally distributed to each of these pipes. However, in most cases it will be necessary to determine the WQv directed to each pipe separately, then multiply that volume by 10% to determine the size of each forebay.

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage-storage relationships that provide the estimated storage volumes required as calculated in Step 4. Refer to Table 9.10-1.1 for maximum storage depth requirements for key storm events.

- To start, select a preliminary elevation for the basin bottom.

For this example, we are using elevation 100 as the expected basin bottom.

- Next, figure the area required to provide the estimated CPv calculated in Step 4 at the recommended depth of 2 feet, then work inward at a 6:1 slope to establish an initial value for the surface area of the permanent pool. We will use native vegetation, so the minimum basin bottom slope is 0.5%.

Develop a preliminary stage-storage relationship that yields greater storage than the estimates of required storage at the desired temporary ponding depths. For this example, we will try the following relationships.

Start with a desired footprint shape; in this case, the basin is generally triangular to align with the sub-watershed boundaries. This basin must drain down completely, so the area of the first contour at elevation 100.00' is effectively 0 square feet. We intend to plant native Iowa species, so the minimum slope is 0.5%. The maximum recommended slope is 6:1. Use this range to set the next two contours, maintaining the desired footprint shape.

NOTE

The lowest elevation at this site has been selected as elevation 100 for a fictional site topography.

For a real project, the designer will need to consider many factors including site topography and potential utility conflicts, as well as inflow and outflow conditions to determine the best elevation for the basin bottom.

TABLE 9.10-2.8: ESTIMATED CONTOUR AREA/STORAGE BELOW CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
0	100	-	-	-	-
1	101	30,515	15,402	15,402	-
2	102	129,674	80,095	95,497	269,200

The storage provided at the 2-ft stage is less than the CPv. Since there the minimum basin slope is 0.5%, it may be difficult to acquire additional storage in the given footprint shape. Check the storage provided at 3 feet; if the storage is still insufficient, consider a different footprint shape. Since the high-water mark from the CPv is expected to be above the 2-ft contour, the basin side slopes should continue to be no steeper than 6:1.

TABLE 9.10-2.9: ESTIMATED CONTOUR AREA/STORAGE ABOVE CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
3	103	290,000	210,540	306,037	534,000

The total storage at 3 feet satisfies the CPv, but not the 10-year event. Set the next 2 contours at slopes no steeper than the recommended 4:1, and check the storage provided.

TABLE 9.10-2.10: COMPARISON OF ESTIMATED REQUIRED / PRELIMINARY DESIGN STORAGE VOLUMES

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
4	104	307,135	296,548	602,584	-
5	105	315,247	311,191	913,775	911,100

The 10-year storage is provided between the 3- and 4-ft contours, and the 100-year is satisfied below the 5-ft contour. Accept this as the preliminary stage-storage relationship. We will provide an auxiliary spillway at elevation 105.00’ to allow flows in excess of the 100-year to pass without overtopping the embankment.

Step 7. Investigate potential pond/wetland hazard classification.

From the information given for this example it is understood that:

- The site is located outside of any regulated flood plain.
- No jurisdictional wetlands have been located within the site area.
- No habitat for endangered or threatened species has been observed at this site.

Reviewing criteria within IDNR Form 542-1014:

- The dam has an emergency spillway, and has a sum of 914,000* CF of temporary storage (nearly 21.0 **acre-feet**). For this grading plan, the dam has a height of less than 5 feet (basin primarily created through excavation). Neither of these parameters related to item (a) of that form reach the levels that would require a permit (50 acre-feet, 5 feet dam height).

- The basin provides no permanent storage and the dam height is less than 5 feet, so again neither of these parameters related to item (b) of that form is to the level where a permit is required (18 acre-feet and 5 feet dam height).
- The watershed area is 80 acres, which is much less than 10 square miles as per item (c), so again no permit is required. (also, item (c) does not apply to urban areas)
- Item (d) is related to facilities planned within 1 mile of an incorporated municipality. Let us assume for this example, that this basin is within an incorporated area. The total storage is 21.0 acre-feet and is situated so that discharge from the dam will flow through the incorporated area. Both of these parameters would require a permit (threshold is 10 acre-feet), however in this case the dam height is less than 10 feet, so again not all three parameters are met, so no permit is required.
- The facility would not be considered a low-head dam, modification to an existing dam or be related to maintenance of pre-existing dams, so none of these criteria would apply in this situation.

So, it appears that no permit for dam embankment construction would be required from IDNR in this case. However, it should be noted that for a basin of this size, a taller dam height and/or an increase in overall storage volume could result in all the parameters for items (a) or (d) to be met.

For this example, using all the criteria above, it appears that a Joint Permit application would not be required for this project. However, it is often worthwhile to review such issue with permit agency staff to validate that a permit is not required under the given site conditions.

DNR

Iowa Department of Natural Resources
Flood Plain Management Program

Do I need a Flood Plain Permit? – Earth Embankment Dams

This form has been developed to help you determine if a flood plain permit will be required from the Iowa DNR. You must also obtain approval from the Iowa DNR Sovereign Lands Program (515) 725-8464, the US Army Corps of Engineers (309) 794-5371, and your local flood plain manager (if applicable) before beginning construction. You are legally responsible if you proceed with a project without obtaining all required permits.

When is a DNR Flood Plain Permit Required?
The thresholds for when a Flood Plain Permit from this department is required are outlined in Iowa Administrative Code 567-71.3 and are listed below. The thresholds are primarily based on both dam height and water storage volumes. The height of a dam is defined as the vertical distance from the top of the dam to the lowest elevation at the downstream toe of the dam, typically the streambed.

Step 8. Enter the preliminary stage-storage relationships and outlet configurations into a TR-55 software program and route inflow hydrographs through the preliminary detention basin design. Identify the projected release rates for each event studied.

Use perforated risers or other features with multiple small openings in lieu of single orifice openings that are less than 4 inches in diameter. Alternatively, provide guards or screens to protect the smaller opening from being plugged by debris or animal activity.

"Work from the bottom up."

A. Calculate the approximate size of the primary spillway outfall pipe to be used to control the 100-year storm event, based on an approximate elevation of the outfall pipe and the recommended high-water surface elevation.

For this example, the flowline of the outfall pipe as it leaves the main outfall structure will be set at elevation 93.0' (to provide sufficient cover). Using the orifice equation, we will start with an assumption of a 36" outfall pipe. Our goal is to limit outflow from the 100-year event to 95 cfs (from Step 3c). Re-arranging the formula for flow through an orifice restriction:

$$A = \frac{Q}{C\sqrt{2gh}}$$

Where: Q = flow (cfs)
C = orifice coefficient (0.60)
g = 32.2 ft/s^2
h = head measured from high-water to center of opening (feet)

h (feet) = *102.0* *(CPv target high-water)*
– 93.0 *(flowline of pipe)*
– 1.5 *(assumed radius of pipe)*
= 7.5 feet

A = *95 cfs / [0.6 x (2 x 32.2 x 7.5)$^{1/2}$] =* **7.2 SF**

Area of 36" pipe = πr^2 = π(1.5 feet)^2 = 7.07 SF (good for initial estimate)

B. Compute the approximate size of the perforated riser or outfall pipe needed to provide extended detention of the CPv (or WQv if extended detention is being used to manage part of the WQv).

Our goal is to limit outflow from the CPv (1-year, 24-hour) event to 3.2 cfs (from Step 4).

$$A = \frac{Q}{C\sqrt{2gh}}$$

Where: Q = flow (cfs)
C = orifice coefficient (0.60)
g = 32.2 ft/s^2
h = head measured from high-water to center of opening (feet)

h (feet) = *102.0* *(CPv target high-water)*
– 100.0 *(centerline of orifice)*
= 2.0 feet

A = *3.2 cfs / [0.6 x (2 x 32.2 x 2.0)$^{1/2}$] =* **0.470 SF**

r = *(A / π)$^{1/2}$ = (0.470 SF / π)$^{1/2}$ =* **0.386 feet, OK**

d = *2r = 0.764 feet (use 9" as initial trial)*

- Use the software program to iterate the design as needed to refine the design to meet the maximum release rate and water surface elevation.

For this example, inputting the 36" outfall pipe (Culvert A) and the 9" CPv orifice (Culvert B) into a third-party software program running the TR-55 model (Hydraflow Hydrographs was used) and performing a stage-storage-discharge routing yields an expected outflow rate of 3.46 cfs during the CPv event (< 3.2 cfs, **NOT OK**) The orifice was adjusted down to 8" to reduce the outflow rate further.

CULVERT/ORIFICE	A	B	C
Rise	36"	9"	8"
Span	36"	9"	8"
Invert Elevation	93.00'	99.63'	99.67
Length	100'	40'	40'
Slope	0.50%	0.00%	0.00%
N-Value	0.013	0.013	0.013
Orifice Coefficient	0.6	0.6	0.6
Multi-Stage	NA	Yes	Yes
Active	Yes	Iteration 1	Iteration 2

NOTE

For culvert "B," the elevation has been set one pipe radius length below the proposed permanent pool, to force the program to measure head across that orifice as the difference between high–water and permanent pool.

C. Set a second stage for larger storms above the expected high-water elevation of the CPv event.

Try setting a second stage at elevation 102.80—a 4'-long rectangular weir (could be the front face of a 4' x 4' inlet structure).

NOTE

Software packages like Hydraflow and HydroCAD use these "Multi–stage" and "Active" designations. They must be selected properly in order for the software to model outflow correctly.

D. Adjust the type or size of the second control stage to meet the maximum release rate and water surface elevation for the 10-year storm event.

TABLE 9.10-2.11: ITERATIONS OF WEIR LENGTHS, GIVEN WATER SURFACE TARGETS

WEIR	A	B	C	D
Weir Type	Rectangular	Rectangular	Rectangular	Broad-Crested
Crest Elevation	102.80'	103.80'	104.30'	105.00'
Crest Length	Varies per iteration			40.0'
Weir Coefficient	3.33			2.6
Multi-Stage	Yes			No
Active (Iteration No.)	3–7	4–7	5–7	Yes

Entering the 4' weir (Weir A) into the software program yields an outflow rate of 14.4 cfs during the 10-year event (< 26.4 cfs from Step 4, **OK**)

E. Select a preliminary type, size and elevation of upper stages above the expected high-water elevation of the 10-year event to control larger storms.

Try setting a third stage at elevation 103.80'—A 12' long rectangular weir (remaining three sides of the 4' X 4' inlet structure). For this example, we will set the emergency spillway above the desired high-water elevation for the 100-year event.

Entering the 12' weir (Weir B) and emergency spillway (Weir C) into the software program yields an outflow rate of 108 cfs during the 100-year event (> **95** cfs from Step 3c, **NOT OK**) Since the emergency spillway is designed to only pass events larger than the 100-year event, the multi-stage outfall must limit the outflow to the 100-year release rate of 95 cfs. Downsize the outfall pipe to 33" in diameter.

Try setting a fourth stage elevation at 104.30'—a 4' rectangular wier (the remaining side of the 4' x 4' inlet structure).

Iteration 5: Enter the length of Weir B as 8'. Add a third weir to the multistage outlet (Weir C) at elevation 104.30' and try 4' long. This iteration has an acceptable flow rate of 88.25 cfs (< 95) but has a high water surface elevation at 105.04 (> 105.00', **NOT OK**)

For Iteration 5, raising the emergency spillway slightly so it would not be overtopped would be another option that could have been pursued.

Iteration 6: Adjust the weir sizes to 8' for Weir A, 4' for Weir B, and 4' for Weir C. This configuration does not overtop (104.97' < 105.00', OK), but the 50-year flow rate is 71 cfs (> 70 cfs, **NOT OK**)

Iteration 7: Adjust the weir sizes to 6' for Weir A, 6' for Weir B, and 4' for Weir C. This configuration does not overtop (105.00' is right at the overflow weir, Weir D) and passes 89 cfs (< 95 cfs, **OK**). The smaller events also pass less than the maximum allowable for each event. Accept this outfall configuration.

The design iterations are summarized in the table below. For the final iteration (iteration 7), the projected release rates for each event are below the maximum allowable release rate.

TABLE 9.10-2.12: SUMMARY OF OUTFALL DESIGN ITERATIONS 2-4 AND RESULTS

		RESULTS OF DESIGN ITERATIONS							
ITERATION		1	2	3	4	5	6	7	
Culvert A		36"	36"	36"	36"	33"	33"	33"	Elev = 93.00'
Culvert B		9"							Elev = 99.63' *
Culvert C			8"	8"	8"	8"	8"	8"	Elev = 99.67' *
Weir A				4'	4'	4'	8'	6'	Elev = 102.80'
Weir B					12'	8'	4'	6'	Elev = 103.80'
Weir C						4'	4'	4'	Elev = 104.30'
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	OUT (CFS)	HIGH-WATER ELEV. (ITERATION #7)
1-year (CPv)	3.1	3.5	2.8	2.8	2.8	2.8	2.8	2.8	Elev = 102.73'
2-year	6.3	3.7	3.0	4.3	4.3	4.3	5.1	4.7	Elev = 103.00'
5-year	15	4	3	9	9	9	12	10	Elev = 103.31'
10-year	26	4	3	14	14	14	21	18	Elev = 103.62'
25-year	48	5	overtop	26	33	33	44	37	Elev = 104.12'
50-year	70	overtop	overtop	38	61	33	71	63	Elev = 104.54'
100-year	95	overtop	overtop	overtop	99	overtop	90	89	Elev = 105.00'

* Actual invert elevation is intended at 100.00', and set lower in the software program to evaluate the routing at pipe centerline

Step 9. Review projected release rates from Step 8 for the preliminary design.

Verify that the projected rates are less than the allowable rates calculated as part of the estimation procedure referred to in Step 4. Iterate as needed, adjusting staged outlet controls or stage-storage relationships within the software program to meet required release rate restrictions. Maintain compliance with maximum storage depths listed in Table 9.10-1.1.

The high-water elevations are in compliance for the 10-year year and 100-year design storms, but not for the CPv. Adjust the stage storage relationships to provide maximum water surface elevations within the acceptable range. The slopes around the perimeter (above the CPv) may not be steeper than 4:1.

TABLE 9.10-2.13: ESTIMATED CONTOUR AREA/STORAGE ABOVE CPV TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)	TARGET VOLUME VS X1.15 (CUBIC FT)
0	100	-	-	-	
1	101	75,195	37,742	37,742	
2	102	231,890	153,542	191,284	269,200
3	103	395,569	313,729	505,013	534,000
4	104	404,701	400,135	905,148	
5	105	413,935	409,318	1,314,466	911,100

The high water elevations and outflows indicate that the fourth weir stage is not necessary. The final multi-stage configuration and routing results are listed in the following table:

NOTE

The temporary storage depth of 2.73' found in Step 8, exceeds the required level of 2.50'.

TABLE 9.10-2.14: RESULTS OF DESIGN ITERATIONS

ITERATION		8	
Culvert A		33"	Elev = 93.00'
Culvert C		8"	Elev = 99.67' *
Weir A		4'	Elev = 102.80'
Weir B		12'	Elev = 103.80'
STORM EVENT	ALLOWED (CFS)	OUT (CFS)	HIGH-WATER ELEVATION (ITERATION #7)
1-year (CPv)	3.1	2.5	Elev = 102.21'
2-year	6.3	2.6	Elev = 102.49'
5-year	15	4	Elev = 102.98'
10-year	26	9	Elev = 103.24'
25-year	48	14	Elev = 103.65'
50-year	70	24	Elev = 103.99'
100-year	95	43	Elev = 104.32'

* Actual invert elevation is intended at 100.00’, and set lower in the software program to evaluate the routing at pipe centerline

Step 10. Finalize practice location and refine the grading plan and outlet design.

Alter the model that was developed and adjusted in Steps 8 and 9 to reflect the stage-storage and outlet conditions included in the final plan. Re-check that peak release rates are less than allowable levels and maximum storage depths are not exceeded.

Since the final release rates in this design example for larger events are well below what is allowed to be discharged. The basin outlet controls could be adjusted to allow more flow which might allow the basin size to be reduced.

Step 11. Check outflow velocities at pipe outfalls and spillways.

Adjust sizing or geometry, or add erosion protection features as needed for the 100-year, 24-hour event.

- From the continuity equation, determine pipe velocity based on flow rate (Q) and area (A) [V = Q/A]
- Using the same equation, check for velocity across the crest of the emergency spillway (if any overflow occurs during the 100-year storm event).

From the continuity equation, check the velocity of the outfall pipe based on the 100-year rate of 43.57 cfs and the design diameter 33 inches.

43.57 cfs = 5.9 square feet x V
43.57 cfs / 5.9 square feet = V = 7.34 fps

In this example, flow is connecting to a storm sewer system, and this velocity is acceptable. If this pipe were directed to the ground surface, some protections against erosion may be necessary. Refer to resources such as HEC-14 “Hydraulic Design of Energy Dissipators for Culverts and Channels” or Iowa SUDAS Chapter 7E-10. In the case of some energy dissipators, such as a stilling basin, an expected tailwater elevation (of the stream, for example) is necessary.

- Using the same equation, check for velocity across the emergency spillway (if any overflow occurs during the 100-year event). In this example, the emergency spillway has been set above the expected high-water elevation caused by a 100-year, 24-hour storm event. No overflow is expected, so no velocity check is necessary.

Step 12. Complete design checklists at the end of this section to verify that sizing design criteria have been satisfied.

Proceed to development of detailed plans and specifications. After completion of final design, make any adjustments as needed so that final plan information matches the finished calculation report.

9.10-3 CONSTRUCTION

A. POLLUTION PREVENTION

STORMWATER POLLUTION PREVENTION PLAN AND NPDES PERMIT REQUIREMENTS

If the site's total disturbed area exceeds one acre (including all parts of a common plan of development) a stormwater pollution prevention plan (SWPPP) shall be prepared.

Prior to construction, coverage under the State of Iowa's NPDES General Permit No. 2 shall be obtained (or, if required, coverage through an individual permit).

The SWPPP document will meet state and local regulatory requirements and will detail the structural and non-structural pollution prevention **best management practices** (BMPs) that are to be employed at the site.

Exterior Protection

All perimeter and site exit controls should be installed prior to any land-disturbing activities. Such controls may include (but are not limited to) site construction exits, perimeter sediment controls, construction limit fencing, waste collection, sanitary facilities and concrete washout containment systems.

Interior Protection

As construction activities commence, internal controls will be added to prevent erosion and sediment loss from the site area.

Erosion controls (mulches, rolled erosion control products, turf reinforcement mats, etc.) prevent detachment of soil particles from the surface. Sediment controls (wattles, filter socks, silt fences, sediment basins, etc.) capture sediments after they have become suspended in runoff. Installation of controls may need to be staged to be implemented immediately after construction operations have ceased or are paused in a certain area.

After the utility installation construction stage, a skimmer or perforated riser might be connected to the outlet works to reduce the potential for suspended sediments from being washed downstream during grading operations until finished grades are stabilized with permanent vegetation.

Project phasing can also be used as a form of protection. This is accomplished by staging construction operations to limit the amount of surface area that is disturbed or left unprotected by erosion controls at any given time.

Figure 9.10-3-1A: Construction Stage Features and Controls

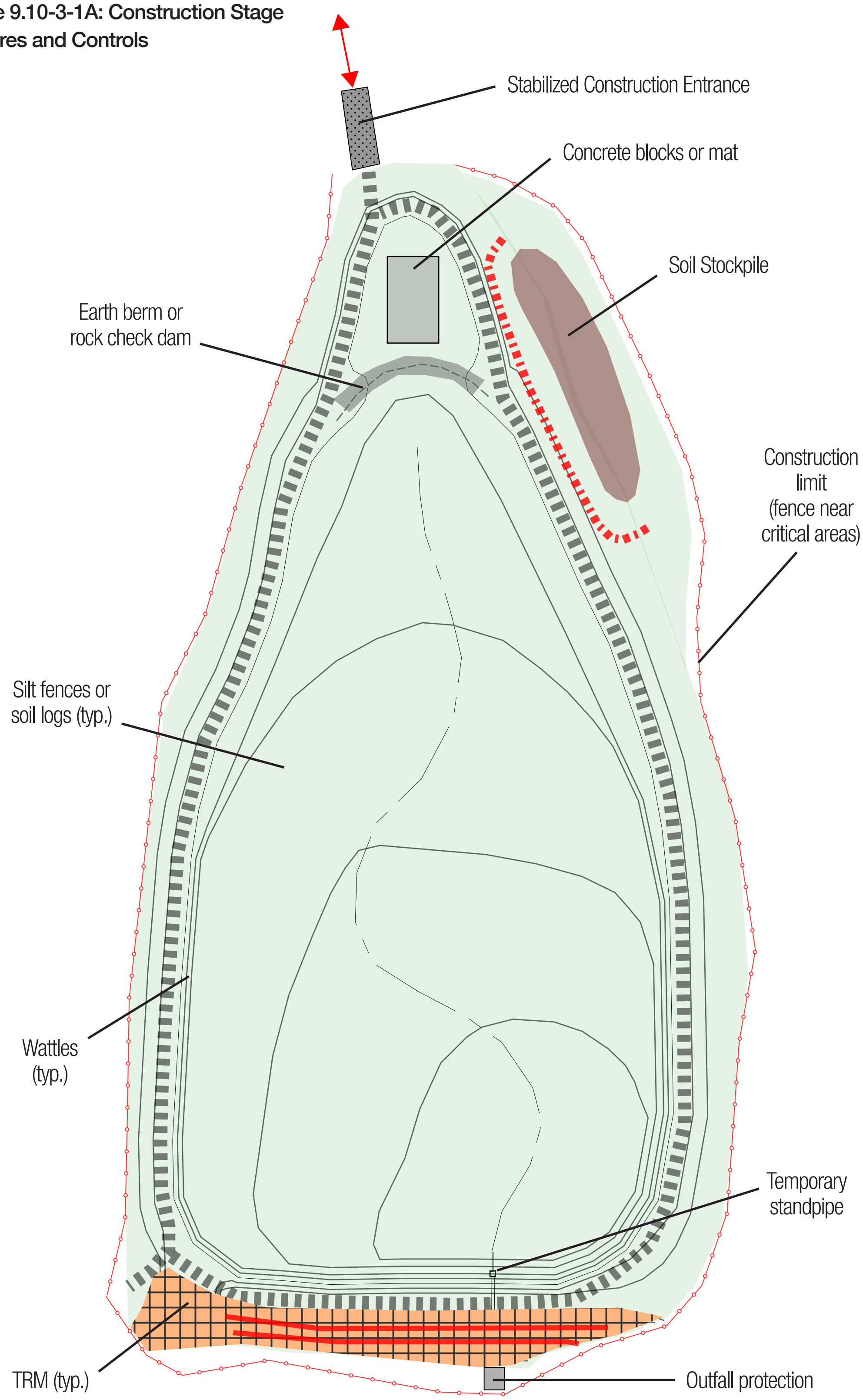
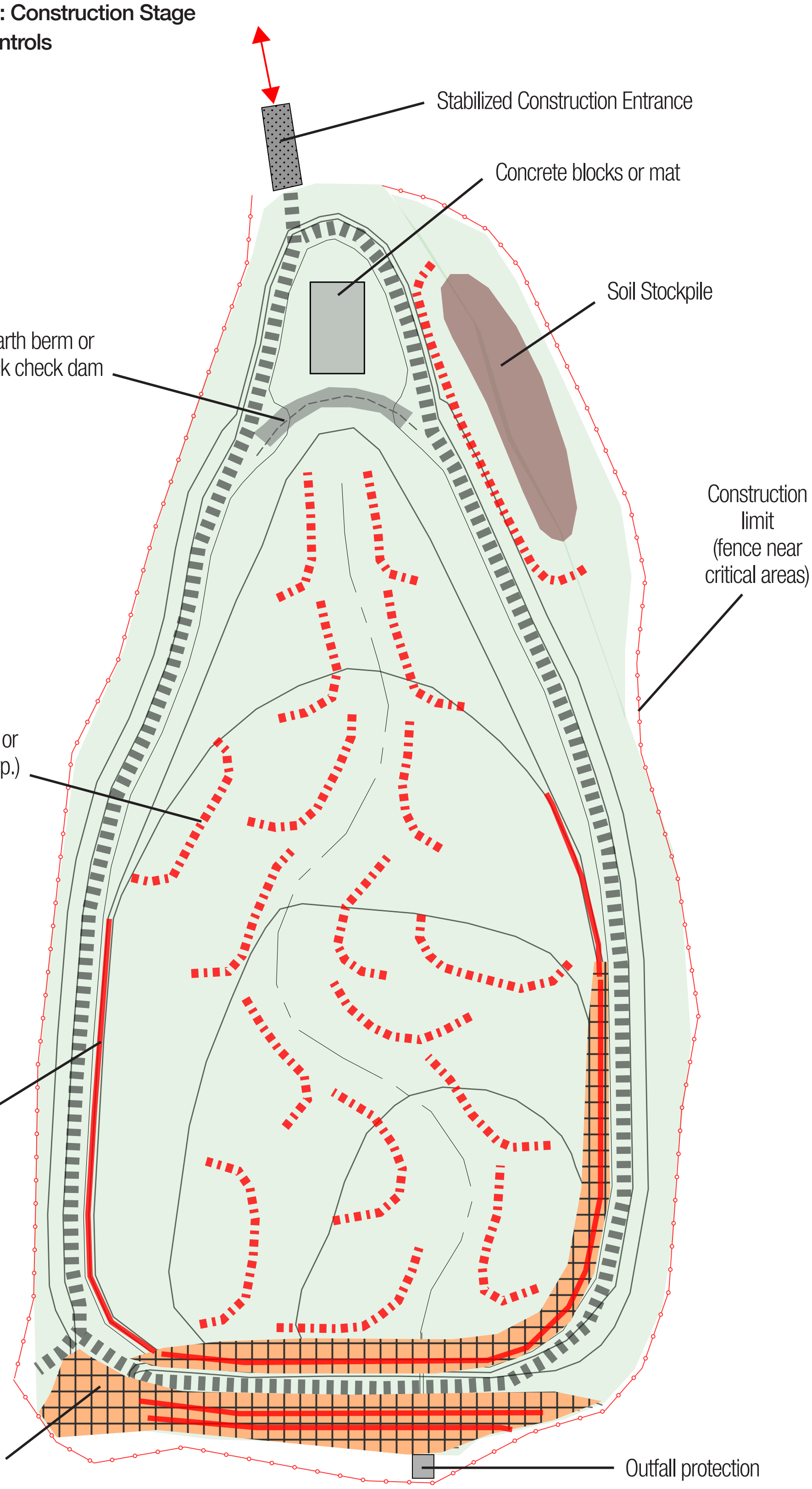


Figure 9.10-3-1B: Construction Stage Features and Controls



B. CONSTRUCTION SEQUENCING

Major construction operations to create extended dry detention practices will usually be staged in this manner:

1. Demolition and Clearing

In some cases, trees, shrubs, fences, structures, etc. may need to be removed prior to construction. Tree removals may need to be limited to certain periods of time, due to restrictions related to habitat for endangered species. Comply with any permit requirements related to staging of tree removals.

2. Topsoil stripping and stockpiling

One of the initial site-disturbing activities is typically removing topsoil materials from the area to be graded, and stockpiling them for use. In some cases, this step can be skipped, if grading operations are expected to be subtle enough to not extend below existing topsoil depths. In these circumstances, earthwork will involve only the moving and shaping of the topsoil materials.

3. Rough Grading (Major Earthwork Operations)

The primary movement of earth materials adjusts graded surfaces to approximate elevations (within 6 inches) as needed to allow for placement of topsoil materials. As the dam is constructed, a temporary standpipe could be placed to allow the basin to operate as a sediment basin.

Figure 9.10-3-2: Construction phase

4. Surface Roughening

Equipment creates grooves and loosens the surface of soil materials after placement. These grooves limit the potential for sheet and rill erosion across slopes.

5. Storm Structure and Pipe Installation

Installation of the outlet structures and pipes allows for control of the water level, providing for drier soil conditions for finished (or fine) grading and seeding.

Installation of storm pipes and structures to divert runoff to the basin should be staged as late in the construction process as possible.

6. Verify Elevations

Complete a site survey to verify "as-built" elevations of structures and the surface of the basin. Confirm that structures meet the intent of the plan and that it appears the storage provided in the basin will meet project requirements, considering that soil quality restoration (SQR) techniques are yet to be completed. Make grading adjustments as needed prior to proceeding with SQR operations.

7. Soil Quality Restoration (SQR)

If an adequate supply of topsoil is available, SQR can be accomplished by re-spreading the materials that were stockpiled in earlier phases of construction. Topsoil materials should be free of rocks, debris and rubble and should generally be loosely placed across the finished surfaces to a minimum depth of 8 inches. Do not move, grade or place wet topsoil materials.

If topsoil resources are insufficient, compost materials may be used to enhance organic matter to build the required depth of healthy soil.

Refer to ISWMM Section 7.03 for additional information.

8. Surface Roughening

Surface roughening may be re-completed after placement of topsoil materials to de-compact soils, limit the potential for sheet and rill erosion across slopes and prepare the soil for seedbed preparation.

9. Landscaping

Completion of seedbed preparation and installation of temporary and permanent seeding, plugs, shrubs and trees as specified within the construction documents.

10. Establishment and Maintenance Period

This period follows the end of major construction operations. Weed removal, re-seeding and invasive species control are needed during this period to foster establishment of desired permanent vegetation and a diverse system of desired native vegetation.

Where native vegetation is specified, a separate contract for establishment of permanent vegetation and maintenance service for a period of three years following the end of construction operations is recommended.

C. CONSTRUCTION OBSERVATION

A designated representative of the owner should observe construction operations on a frequent basis to confirm the following:

- Topsoil stripping, stockpiling and re-spread activities have been completed as specified.
- Rough grading generally conforms to plan elevations and test results have been provided that demonstrate that compaction requirements have been met. (Compaction tests are often performed by a geotechnical engineer and provided for owner review.)
- Storm sewer and pipe structures are installed to the dimension, location and elevations specified on the plans. Verify that proper installation techniques and trench compaction techniques have been followed. (Compaction tests are often performed by a geotechnical engineer and provided for owner review.)
  - Any seepage protection devices or features should be directly observed during construction.
  - Proper compaction around all storm structures should be verified.
  - Storm facilities should be kept free of sediment and debris during construction and inspected again at a final site walk-through.
- Verify that the required methods of soil quality restoration are completed and that surface roughening and seedbed preparation are completed prior to seeding.
- Confirm that seed, plug and other landscape materials (trees, shrubs, etc.) delivered to the site are in accordance with the contract documents.
- Observe that the rate of temporary and permanent seed and mulch materials is in compliance with the contract documents.
- Verify that the surface elevation of the basin matches the proposed design.
- Complete a walk-through with the designer and contractor to identify any items which are not in compliance with project requirements. Document said issues in a punch list and confirm when all such items are installed.
- As needed by the local jurisdiction, author a letter of acceptance noting either conformance with construction documents, or any allowed deviation thereof.
- Be present during establishment and maintenance operations to verify that required duties are completed.

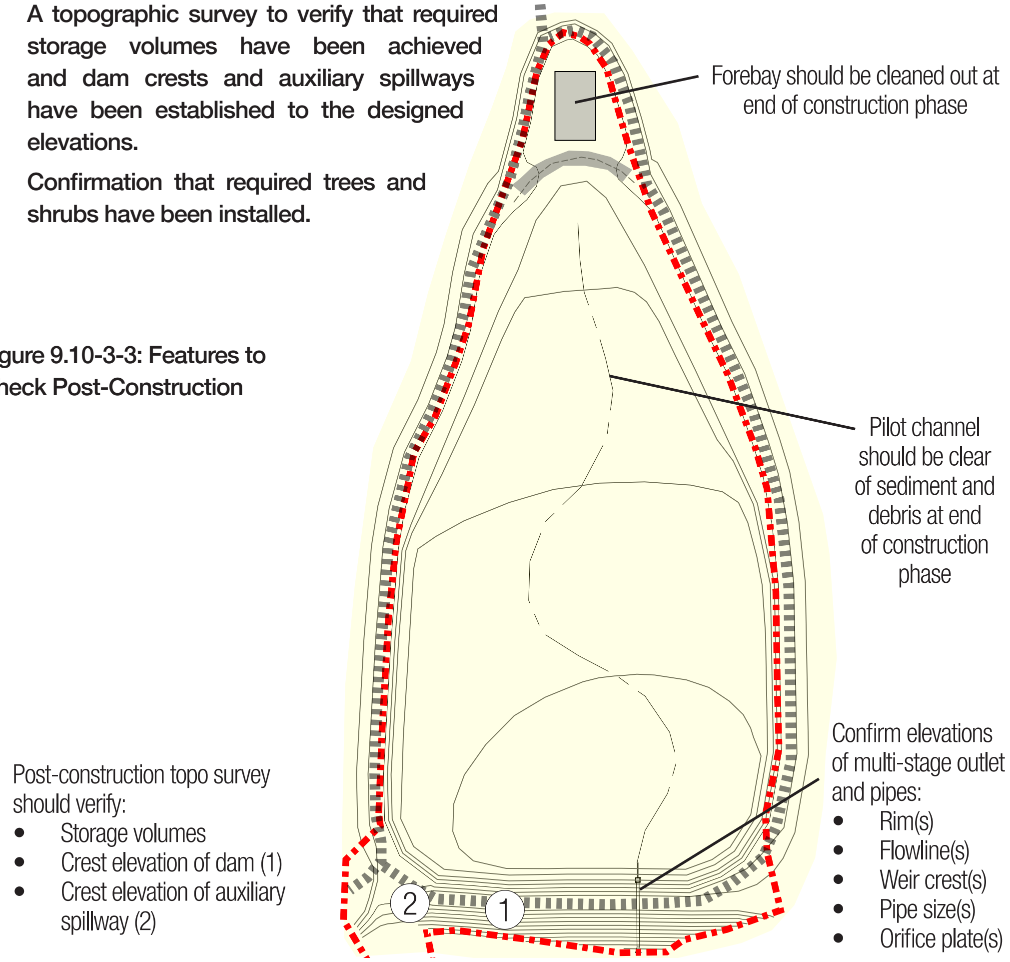
If the project is required to be permitted under the State of Iowa's NPDES General Permit No. 2, qualified personnel shall be employed to complete the following until final establishment:

- Maintain and update the SWPPP document and retain records.
- Conduct site inspections as required by the general permit.
- Verify that exterior sediment and erosion BMPs are in place prior to initiation of site-disturbing activities.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- As per Construction Sequencing item #6, review results of an as-built or record survey to verify that exterior sediment and erosion BMPs are in place prior to initiation of site-disturbing activities.
- Observe that interior BMPs are implemented as site work progresses.
- Complete site inspection reports, make recommendations for additional BMPs as necessary.
- Upon final establishment of permanent vegetation (as defined by the permit), recommend to the owner that the site Notice of Discontinuation be completed and submitted to the IDNR.

POST-CONSTRUCTION DOCUMENTATION

- During construction, records should be kept by the contractor (and site observer) that will allow record drawings of constructed improvements to be provided to the owner. To demonstrate that the project has complied with contract documents, these records should include, but not be limited to, the following:
- All rim and flow-line elevation of storm structures and pipes, or any other utilities included as part of the project.
- A topographic survey to verify that required storage volumes have been achieved and dam crests and auxiliary spillways have been established to the designed elevations.
- Confirmation that required trees and shrubs have been installed.

Figure 9.10-3-3: Features to Check Post-Construction



9.10-4 MAINTENANCE

A. ESTABLISHMENT PERIOD (SHORT-TERM MAINTENANCE)

Where native vegetation is proposed, a more intense maintenance program is required for a period of at least three years, to support full establishment of desired vegetation and prevent growth of invasive species (especially cattails and volunteer woody growth). It is recommended that these activities should be completed by personnel with experience (three years or more preferred) in performing maintenance of native vegetation.

These short-term activities can be included into a separate contract for "Establishment and Maintenance Activities." In such a case, the contract would include the initial installation of permanent vegetation (by seeding, plugging or planting) and a set of routine maintenance trips (quarterly trips recommended after initial installation, for a period of three years).

The contract documents should detail the expected maintenance schedule, including the month and year the required activities are to occur.

YEAR ONE—MAINTENANCE ACTIVITIES

Maintenance activities to be performed during each maintenance trip should include:

- Maintain erosion and sediment controls until full establishment of perennial vegetation.
- Weed suppression by cutting native seeding areas with mowers (if accessible) or string-type trimmers to prevent weeds from developing seeds. No cutting or trimming shall be closer than 8 inches to ground surface.
- Do not mow over mulched areas, plugs or other planted native perennials; only trim around these features.
- Systemic herbicide treatment of areas larger than 20 square feet where weeds are the dominant plant material.
- Hand-wiping systemic herbicide on invasive weeds and woody species where native plants are the dominant plant material, taking care not to damage nearby native plants.
- Removing above-ground portion of previously treated dead or dying weeds and woody species from planting areas.
- Adding topsoil and raking to restore grade in areas where poor germination, erosion or weed removal have left rills deeper than 3 inches and longer than 10 feet, or areas in excess of 20 square feet depressed or below finished grade.
- Re-seeding areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Applying mulch to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Pruning dead or dying material in trees or shrubs.
- Removal of weeds from the mulched areas around trees and shrubs.
- Application of appropriate insecticides and fungicides as necessary to trees and shrubs, only to maintain plants that are free of insects and disease. Follow manufacturer's instructions on any herbicide application.

NOTE

When applying herbicides on turf areas adjacent to native planting areas, be careful not to overspray or allow applied chemicals to wash into native planting areas.

YEAR TWO AND THREE—MAINTENANCE ACTIVITIES

Maintenance activities to be performed during each maintenance trip should include:

- Remove all temporary erosion and sediment controls upon full establishment of perennial vegetation.
- Weed suppression by cutting portions of native planting areas where weeds comprise more than 1/4 of the plants within an area. Use string-type trimmers to prevent weeds from developing seeds. No cutting or trimming shall be closer than 12 inches to ground surface.
- Do not mow over-mulched areas, plugs or other planted native perennials; only trim around these features.
- As allowed, add controlled burns by qualified personnel in appropriate areas on an annual or every-other-year basis to control weeds, starting in YEAR THREE.
- Systemic herbicide treatment of areas larger than 20 square feet where weeds are the dominant plant material.
- Hand-wiping systemic herbicide on invasive weeds and woody species where native plants are the dominant plant material, taking care not to damage nearby native plants.
- Removing above-ground portion of previously treated dead or dying weeds and woody species from planting areas.
- Adding topsoil and raking to restore grade in areas where poor germination, erosion or weed removal have left rills deeper than 3 inches and longer than 10 feet, or areas in excess of 20 square feet depressed or below finished grade.
- Re-seeding areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Applying mulch to areas where poor germination, erosion or weed removal have left areas in excess of 20 square feet bare or sparsely vegetated.
- Pruning dead or dying material in trees or shrubs.
- Removal of weeds from the mulched areas around trees and shrubs.
- Application of appropriate insecticides and fungicides as necessary to trees and shrubs, only to maintain plants that are free of insects and disease.
- On final trip: remove staking wires from trees but leave stakes in place. Follow manufacturer's instructions on any herbicide application.

B. ROUTINE OR LONGER-TERM MAINTENANCE ACTIVITIES

During the design process, the entity responsible for routine and long-term maintenance should be established. These tasks are necessary to maintain the dry ED basin's ability to function and support the desired diverse native vegetation. Invasive growth, storage loss, surface erosion and outlet control failures may occur if these tasks are not completed.

ACTIVITY	SCHEDULE
Inspect storm inlets, outlets for debris. Look for signs of sediment accumulation, flow channelization, erosion damage, local streambank instability. Check the outfall for signs of surface erosion, seepage or tunneling along outfall pipe.	At least annually AND after rain events of 1.25” or larger
Inspect forebays and other pretreatment areas.	At least twice annually
Remove accumulated sediment from forebay.	When forebay is 1/2 full OR at least once every 5 years
Clean and remove debris from inlet and outlet structure.	At least three times annually
• Inspect for invasive vegetation and remove where possible. • Inspect for damage to the embankment and inlet/outlet structures; repair as necessary. • Note any signs of hydrocarbon build-up and remove accordingly.	Annually
Repair undercut or eroded areas.	When observed
Harvest plants that have been “choked out” by sediment accumulation.	Annually

- Sediments excavated from stormwater detention areas that do not receive runoff from designated hotspots are not considered toxic or hazardous material and can be safely disposed of by either land application or at a permitted landfill.
- Sediment testing may be required prior to sediment disposal when a hotspot land use is present.
- Sediment removed from stormwater detention during construction should be disposed of according to an approved SWPPP.

9.10-5 SIGNAGE RECOMMENDATIONS

Signage could be provided as an educational tool to explain the area's purpose and stormwater management function to the general public. Signage can also be used to advise maintenance staff against discouraged practices, such as frequent mowing of native planting areas and broad application of herbicides.

Figure 9.10-5-1: Signage example