IOWA STORM WATER MANAGEMENT MANUAL

9.11 WET DETENTION PONDS

IOWA DEPARTMENT OF NATURAL RESOURCES

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

9.11-1 LAYOUT AND DESIGN

A. SUMMARY

Wet detention ponds have been a common practice to manage stormwater runoff. Typically they have been designed as an aesthetic feature or to reduce runoff from larger **storm events**. These practices can improve **water quality**, provide valuable habitat and create opportunities for recreation.

These features are intended to maintain a permanent pool of water. For this reason, the practice must receive runoff from a large enough **watershed** to fill and sustain that pool.

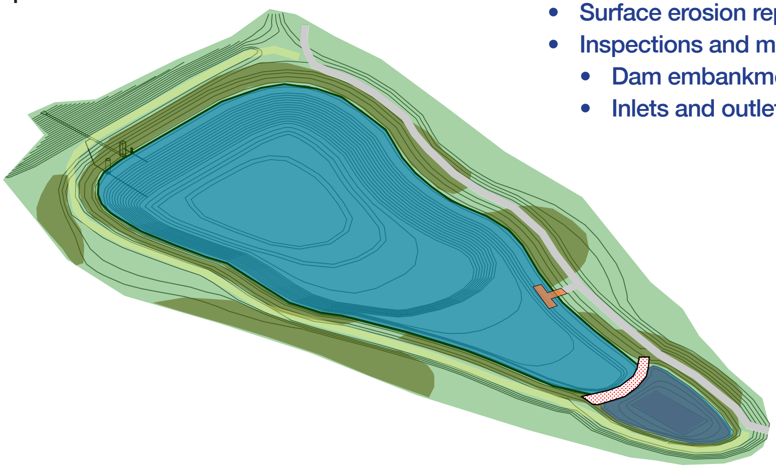
Wet ponds use water as a resource, creating amenities in parks or other spaces open to the public. People might see these areas as a place to fish, birdwatch or go for a walk, without understanding the stormwater management function of the practice. These practices address the "triple bottom line"—features that provide social, environmental and financial benefits to the community. To realize these benefits, a number of skill sets and disciplines may be involved in their planning, design, construction and maintenance.

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 9.11-1-1: Wet 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 9.11–4 for more detail on maintenance requirements.

B. APPLICATION

Wet detention ponds must have enough watershed area to maintain a permanent pool and must maintain a proper ratio of watershed area to pond surface area. They can address most aspects of the Unified Sizing Criteria.

ABILITY TO ADDRESS THE UNIFIED SIZING CRITERIA

Recharge Volume (Rev)

Wet basins do not include features to reduce overall runoff volume. Therefore, they will need to be paired with other BMPs to meet Recharge Volume requirements. ADVISORY

Water Quality Volume (WQv)

Wet detention ponds have a demonstrated ability to improve water quality through **settling** and biological processes. **WQv requirements are addressed by providing storage of 2 x WQv in the permanent pool** (dead storage). ESSENTIAL

Channel Protection Volume (CPv)

These types of basins are designed with multi–stage outfall structures that are intended to slowly release runoff from the CPv event. This often 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)

Wet ponds typically have sufficient surface area 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

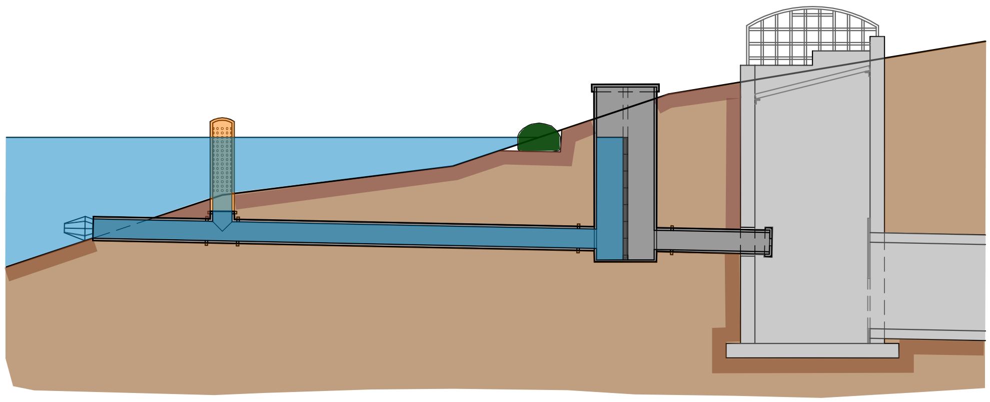
To reduce risks for vegetation, public safety and erosion, avoiding extreme ponding depths is recommended. Refer to the table below: TARGET

TABLE 9.11-1.1: MAXIMUM TEMPORARY STORAGE DEPTHS FOR WET PONDS

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 9.11-1-2: Multi-Stage Outlet Example



C. SITE FEASIBILITY

SOILS

Native soils of **hydrologic** soil groups C and D can often create a clay **liner** to maintain the permanent pool. In some cases, selective removals and replacements may be needed to seal off sand seams or other paths for water loss. **Bentonite** materials and synthetic liners can sustain the permanent pool at sites without sufficient native soil materials to create an adequate liner. County soil map information (NRCS Web Soil Survey) may be used for initial site screening. Consult a geotechnical engineer or a soil scientist on a case-by-case basis for final design.

MINIMUM DEPTH TO WATER TABLE

There are no constraints at most sites. At locations within an underlying water supply aquifer or when receiving runoff from a hotspot site, a separation distance of 2 feet is recommended between the bottom of the pond and the elevation of the seasonally high water table. In areas of Karst topography, a bentonite or clay liner or a synthetic impermeable liner should be provided.

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

Wet ponds should have a minimum drainage area of 10 acres. The recommended minimum watershed-to-pond surface area ratio is 12:1 (especially for recreational lakes where fishing is desired), with 20:1 being preferable. Ratios lower than these values are desirable. TARGET

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 and to meet the watershed to pond surface area ratios, 5–12% of the tributary drainage area may be required. ***This value is only an estimate to be used very early in the design process. Section 9.11–2 details methods to determine the actual space a practice may require.***

NOTE

Final designs should take care not to plan excavation too close to what will be the core trench of the dam.

SITE TOPOGRAPHY

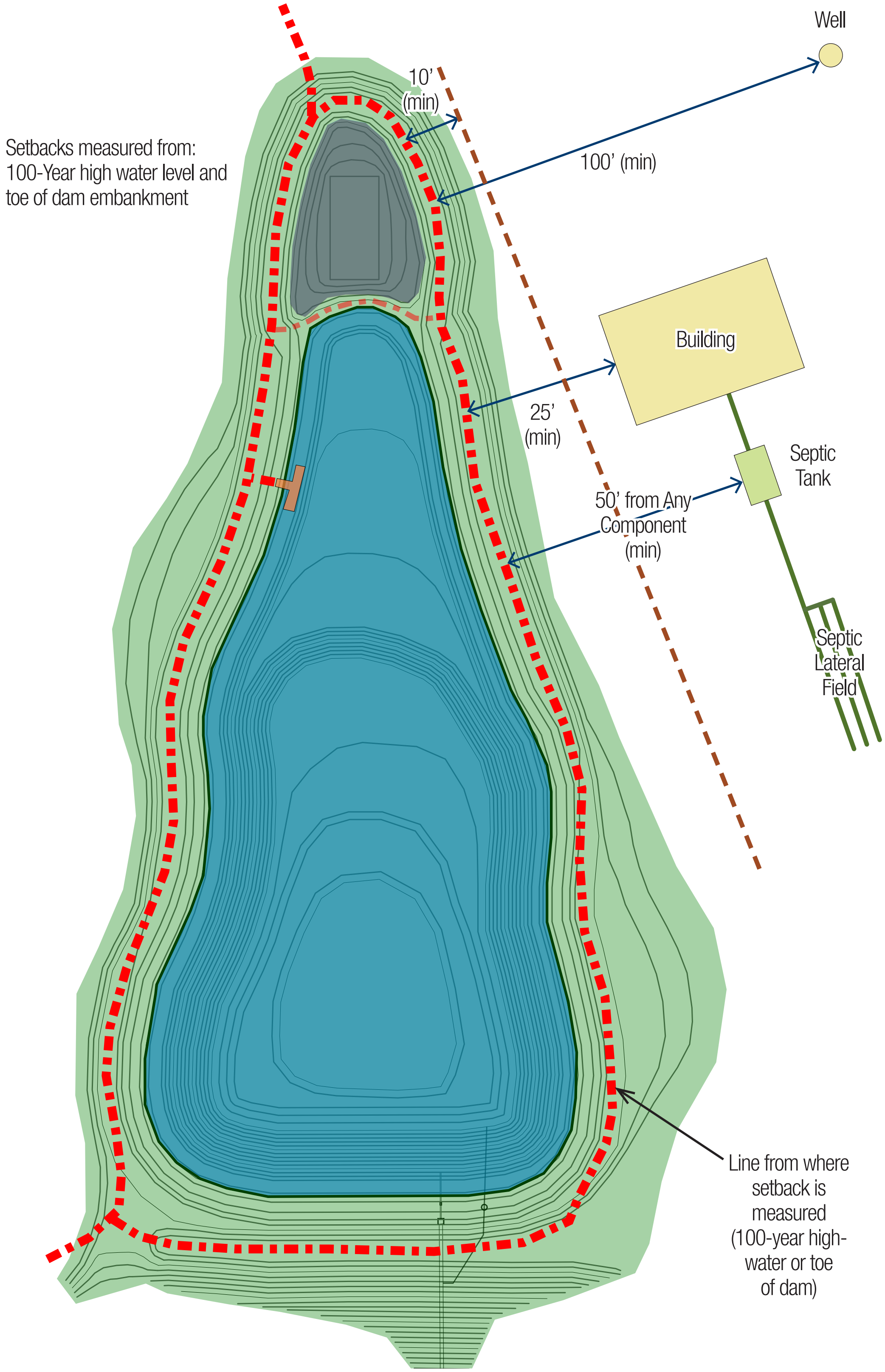
Site grading costs may be elevated at sites with extreme **topography** (either very steep or very flat). Sites with a natural valley or depression may require less earthwork to achieve required pool storage volumes. Designers should consider if the basin can be constructed by excavation into the existing 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 9.11-1-3: Illustration of Setback Requirements



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.

E. DESIGN ELEMENTS AND PARAMETERS

PRE-TREATMENT

Sediment **forebays** (or other equivalent pre-treatment practices) should be located at 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.

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 pond, each forebay should be physically separated from the wet pond 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.

TEMPORARY STORAGE VOLUME

The empty space above the permanent pool is the storage volume for stormwater detention (live storage). This is created through excavation (cut) or creation of a dam embankment (fill) to store water as needed to limit release rates.

POND SHAPE AND SIZE

The pond 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, pond should be longer than it is wide, to promote greater flow length through the pond and reduce flowpath shortcutting. **A minimum length to width ratio of 2:1 is desired.** TARGET

Where fishing is desired, the surface area of the permanent pool should not be less than 0.5 acres. ESSENTIAL

POOL DEPTH AND SLOPES

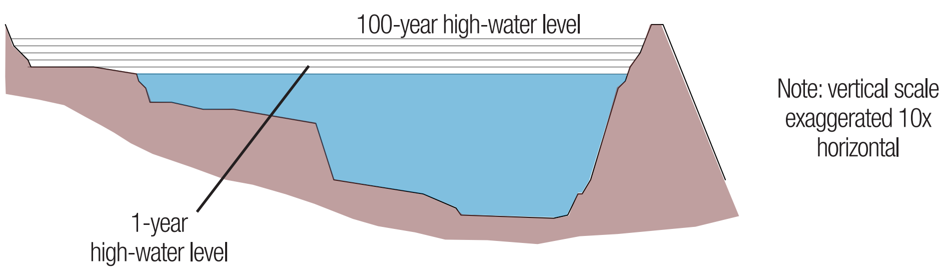
The pool depth should be designed to maintain a deepest depth of 8–10 feet after construction. For this reason, the design depth of the pond should be 12 feet or greater to account for the potential for sedimentation caused by construction in the upstream area. At least 25% of the surface area of the pond should have a depth exceeding 8 feet after construction. In the northern two tiers of counties in Iowa, this criteria should be increased to 10 feet. **These depth requirements are set to ensure sufficent volume remains unfrozen through the winter months to preserve a fish population.** ESSENTIAL

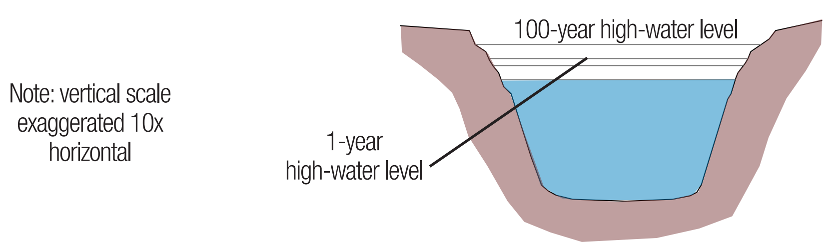
Deeper depths are preferable, where feasible. Greater maximum depths are expected to increase the potential for phosphorus retention over the long term. **Ideally, the pool would have an average depth of 8–10 feet, with a maximum depth of 15–30 feet.** The IDNR does not recommend stocking a pond with fish that has a maximum depth of less than 10 feet. TARGET

Most of the pond should be as deep as possible, as feasible working with local terrain. Shallower depths of 4–6 feet are more desirable near the inlet points to the pond from forebays to concentrate any remaining sediment deposition in a smaller, more concentrated area that may be easier to access.

Below the water surface, the slope of the soil materials along bottom of the pond should not exceed 3:1. ESSENTIAL

FIgure 9.11-1-4: Cross-Section View Graphic of Detention Features





NOTE

Even if ponds are not planned to be stocked with fish, it is advisable they be designed to sustain fish populations.

It may be desired to stock them at a later date. It is also possible that they may be illegally stocked by local residents or other persons.

Fish kills have been frequently reported to the IDNR in the spring in urban ponds that were not intended to be stocked.

For these reasons it is advisable to design wet ponds as if they were planned to be stocked.

Stocking of ponds should only be done in coordination with the IDNR.

FIgure 9.11-1-5: Typical Features of a Wet Detention Basin

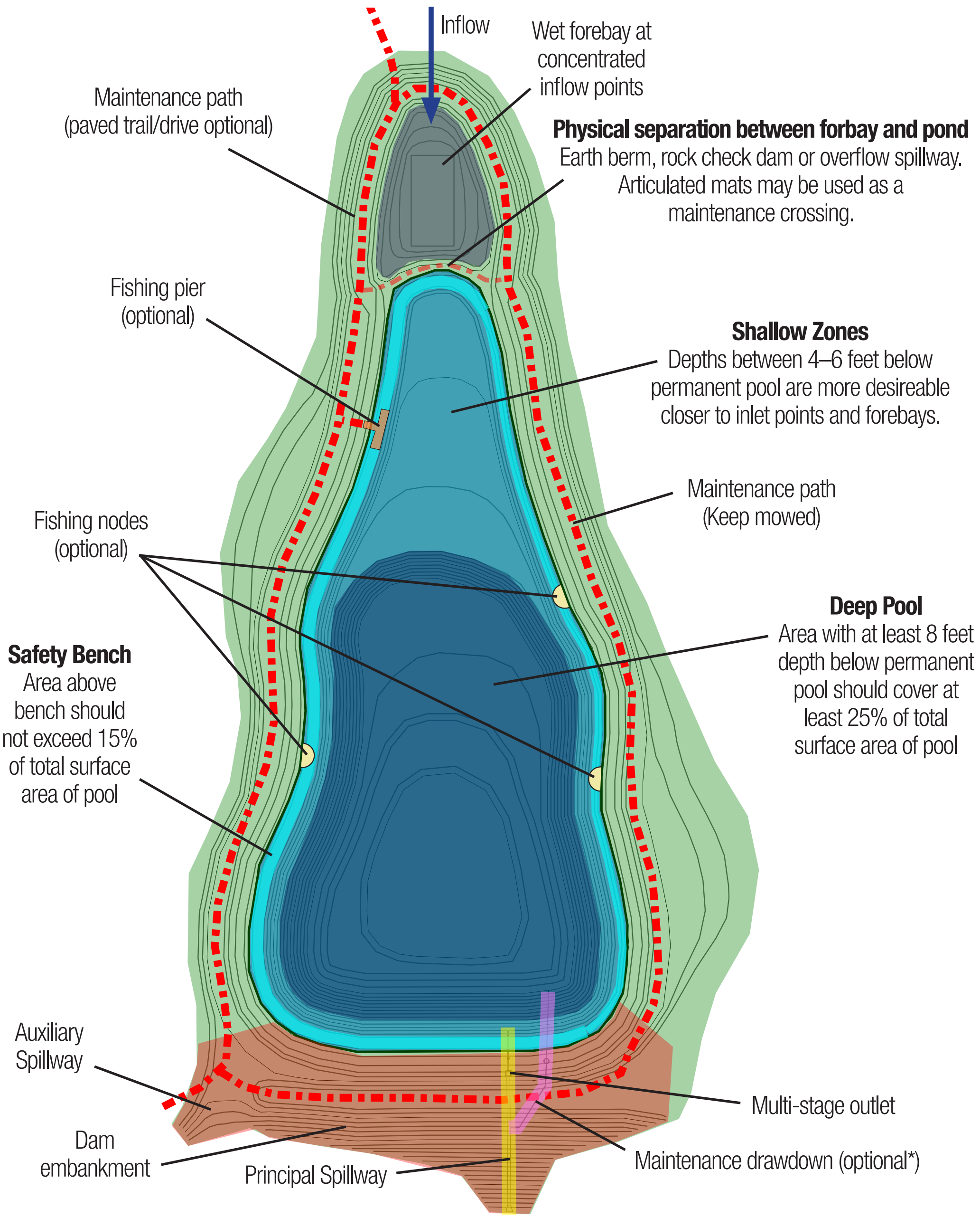


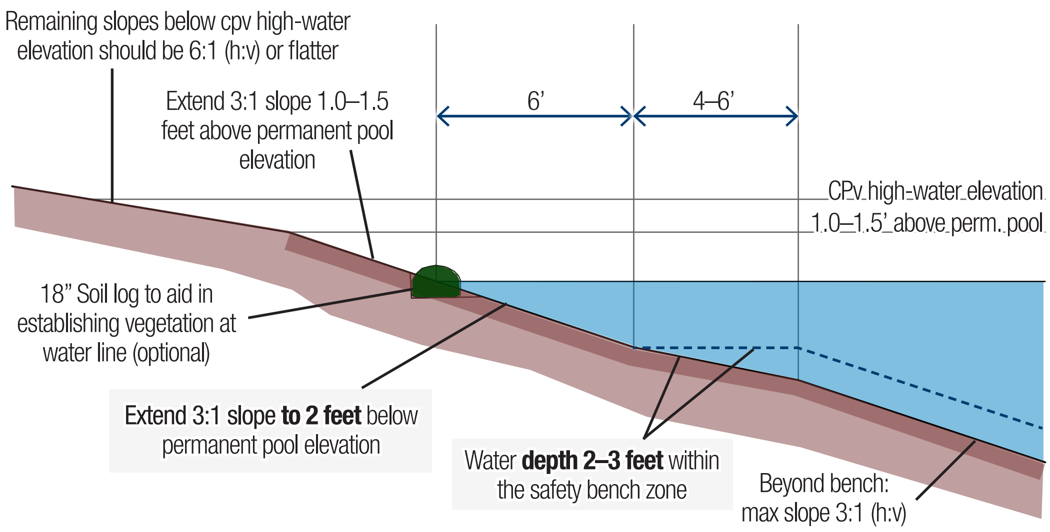
FIgure 9.11-1-6: Habitat improvements

SAFETY BENCH/POND EDGE

Along the edge of the pond, a safety bench should be provided to reduce the potential of someone falling into deep water, and also to promote growth of aquatic vegetation to aid in water quality improvement. This safety bench also reduces the potential of shoreline erosion. There are two types of safety benches that may be provided: ESSENTIAL

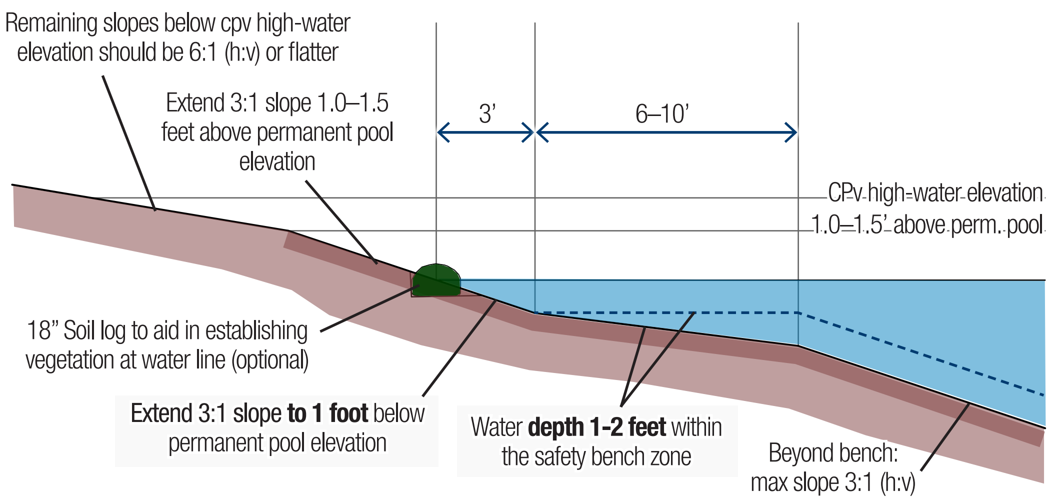
Narrow bench (fishing option): **A smaller bench can be provided to make it easier for fishing, with lines cast across the bench. For this option the bench should be 4–6 feet wide, measured from toe of the steeper slope along the shoreline. Water depth above the bench should be 2–3 feet deep.**

Figure 9.11-1-7: Narrow bench cross section



Wider bench (wetland edge option): **If a wider edge of wetland vegetation is desired, the safety bench can be wider, from 6–10 feet in width, measured from the toe of the steeper shoreline slope. Water depth for this option can be reduced to 1–2 feet above the safety bench.**

Figure 9.11-1-8: Wider bench cross section



Using either option, the shallow water portion of the pond should not exceed 15% of the total surface area covered by the permanent pool. TARGET

For either option, the slope of the shoreline along the perimeter of the safety bench should not be steeper than 3:1. This steeper slope should extend up no more than 1.5 feet above the normal pool elevation (measured vertically), before transitioning to the flatter perimeter slopes. ESSENTIAL

SHORELINE EROSION PROTECTION

The safety bench and taller, erosion-resistant **native vegetation** can be an effective prevention measure against shoreline erosion. However, protection with revetment stone, reinforcement matting or boulders may be needed where the shoreline passes along the face of the dam, or where wind is expected to drive across a longer length of the lake, causing increased wave action. In some areas, a soil-filled log may be considered to promote initial establishment of vegetation along the shoreline, where wave action may impede the ability of seeding to take hold. TARGET

NOTE

If used, the type of reinforcement matting should be selected that would not inhibit the growth of native forbs and wildflowers.

FISHING NODES

When promoting fishing is desired, stone outcroppings can lure fishers to select access points that extend further out across the safety bench. These features generally project out into the water in an arc or other natural shape. The safety bench may be omitted along the points of these features. A mowed path or other means of access should be provided to these locations. TARGET

SUBSURFACE HABITAT IMPROVEMENTS

When ponds are intended to be stocked with fish, subsurface habitat improvements are recommended. Gravel spawning beds, rock piles, woody materials and other features can be installed during or after lake construction to enhance habitat for fish. Other features such as humps, points and channels can be created through finished grading techniques. TARGET

NOTE

One resource for the selection and design of fish habitat improvements is *Nebraska Pond Management,* Nebraska Game and Parks Commission, May 2006.

FIgure 9.11-1-9:
Habitat improvements

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 10% annual recurrence event (10-year, 24-hour storm). To improve access and aesthetics, it is strongly encouraged to make slopes within 20 feet (measured horizontally) of the edge of the normal pool, 8:1 or flatter (except as noted for shoreline edge). TARGET

Above the high-water elevation of the 10-year 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.
- Grading designs should include flatter paths for access, especially to areas intended for more frequent public access (such as fishing piers, trails, walking paths and fishing nodes).
- To improve aesthetics and access, it is recommended that slopes be 6:1 or flatter for a minimum of 40% of the area between the high-water elevations of the 10% and 1% AR events (100-year, 24-hour event). TARGET

To improve public access, slopes should be flatter than maximum levels at multiple locations to allow people to walk more easily to the water's edge, especially to access key features (such as fishing nodes). ESSENTIAL

Use of walls or earth-retaining structures within and around the perimeter of the detention area should be as limited as 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

OUTLET STRUCTURES

Multi-stage outlets will typically be needed to meet release rate reduction targets for various storm events. These types of structures are preferred over single-stage culverts or weirs.

The first stage (typically controlling flow to provide extended detention of the CPv event) should provide a method to draw water out of the pond from 3–4 feet below the permanent pool. A water level control structure can be installed along this pipe, which uses stop logs to maintain the desired normal pool elevation of the pond. TARGET

Higher stages are generally set above the high-water elevation of the CPv event. These are often weirs, orifices or other openings cast or cut into storm intake structures. For most watersheds, precast storm intake structures can be modified for use as a multi-stage structure. More unique outfall structures may be needed in larger watersheds. TARGET

Fish loss through outfall structures is a concern. Smaller orifices (especially those below the surface) should include bar guards, perforated risers or trash racks. Spacing of 3 inches is preferred to prevent adult fish passage, while reducing the potential for clogging. When area intakes are used for higher inlet stages, horizontal bars are preferable over vertical bars, with a clear bar spacing of 3 inches. TARGET

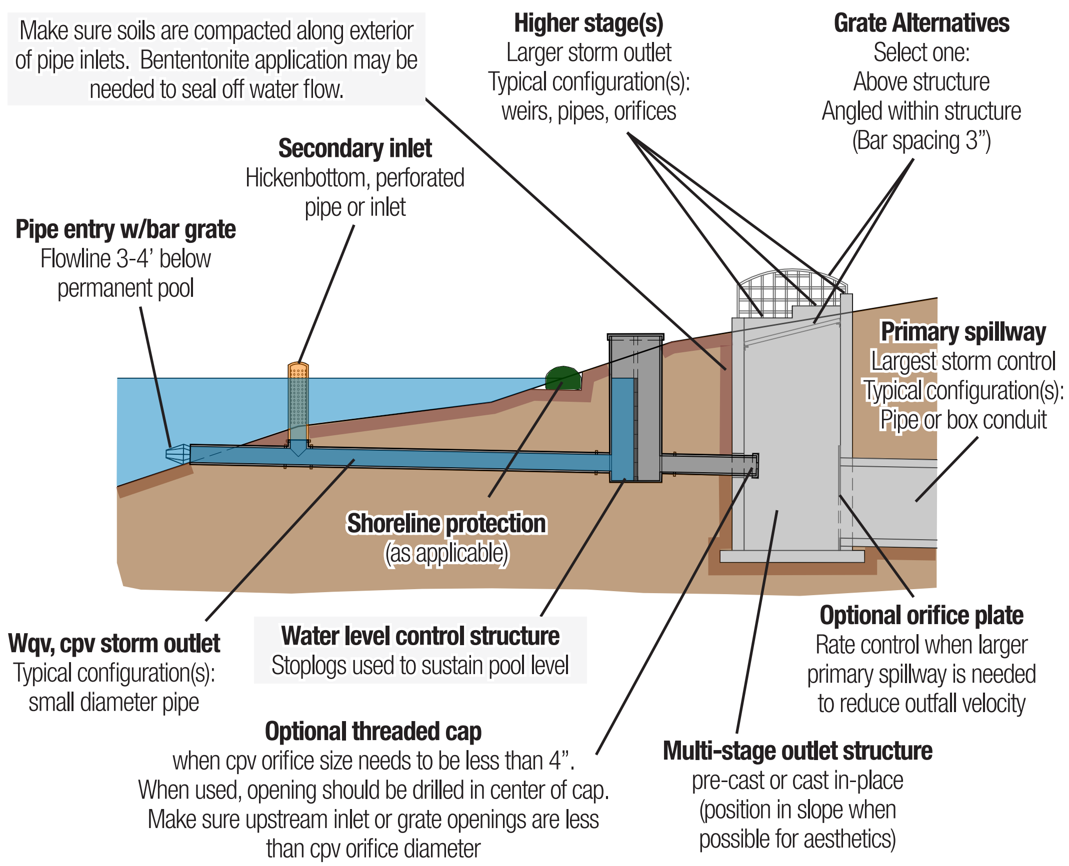
NOTE

Subsurface water withdrawal reduces the potential for floatables to clog the outlet, minimizes discharge of water near the surface which may be warmest (less desirable to discharge) and have higher dissolved oxygen content (desirable to keep in pond).

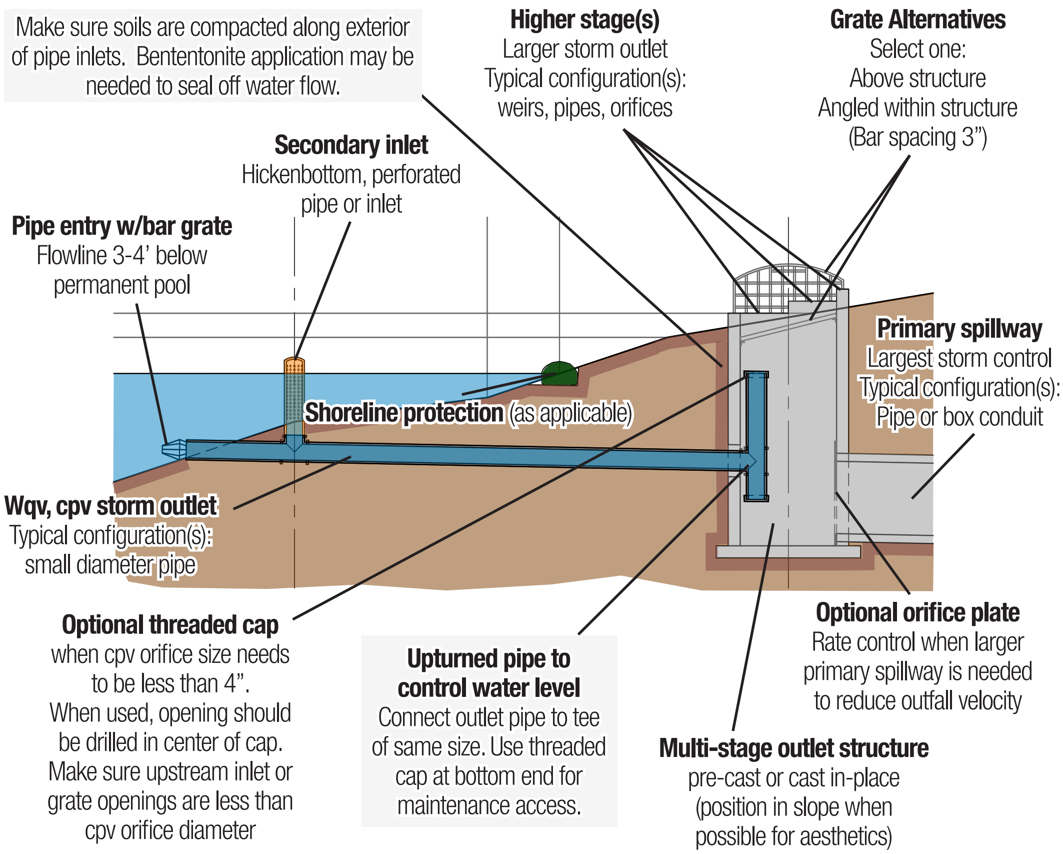
Figure 9.11-1-10: Grates

Figure 9.11-1-11: Multi-Stage Outfall Structure Example Elements

PREFERRED OPTION -- WATER LEVEL CONTROL STRUCTURE



ALTERNATIVE OPTION -- UPTURNED PIPE WITHIN MULTI-STAGE OUTLET



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. 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

NOTE

Drawing water from below the surface has two key benefits:

- Leaves the water near the surface that typically has higher oxygen content in the pond.
- Reduces thermal effects downstream, as surface water temperature may be elevated by sunlight.

NOTE

Check with local jurisdictions about freeboard requirements, which may be more restrictive.

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.

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

Figure 9.11-1-12: Dam Crest Parameters

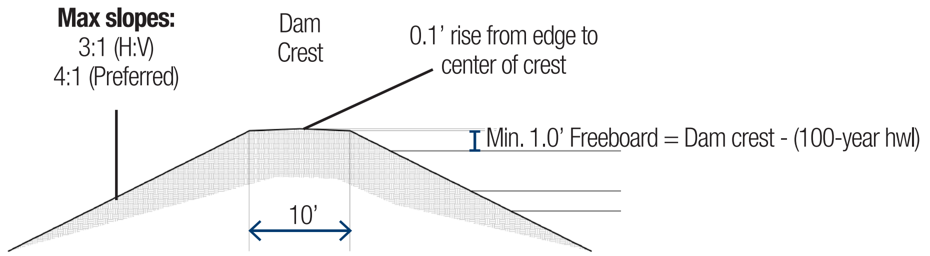
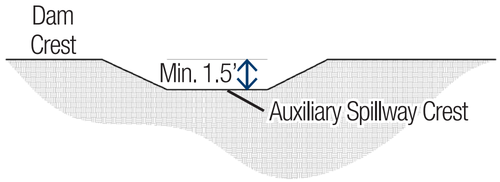


Figure 9.11-1-13: Auxiliary Spillway Parameters



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 9.11-1-14: Unstable outfall photo

Level spreader outlet structure at Heritage Park in Minneapolis, MN.
(photo courtesy - Mississippi Watershed Management Organization mwmo.org)

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

Figure 9.11-1-16: Stilling Basin

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).
- **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.
- In some cases, turn-around areas, low-head crossings, culverts or bridges may be needed for ingress and egress of equipment.

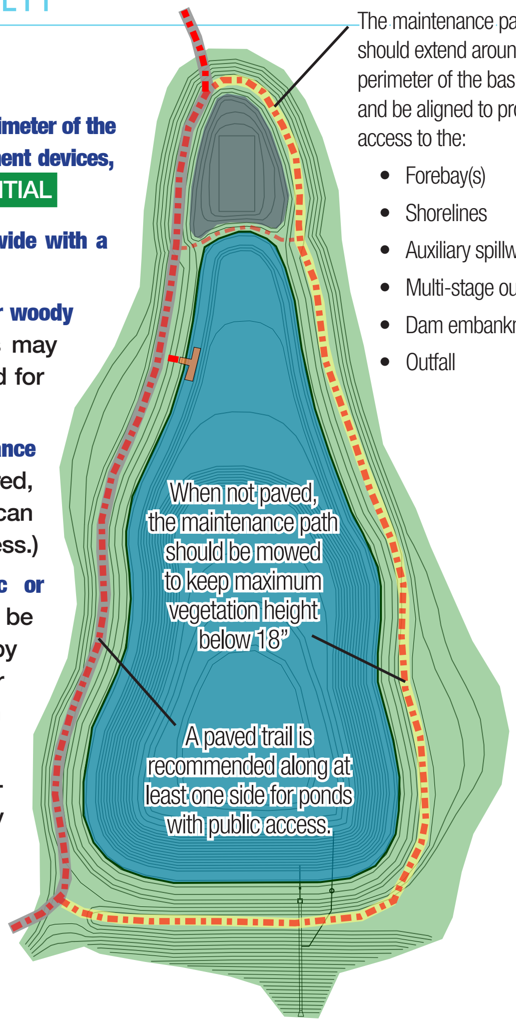
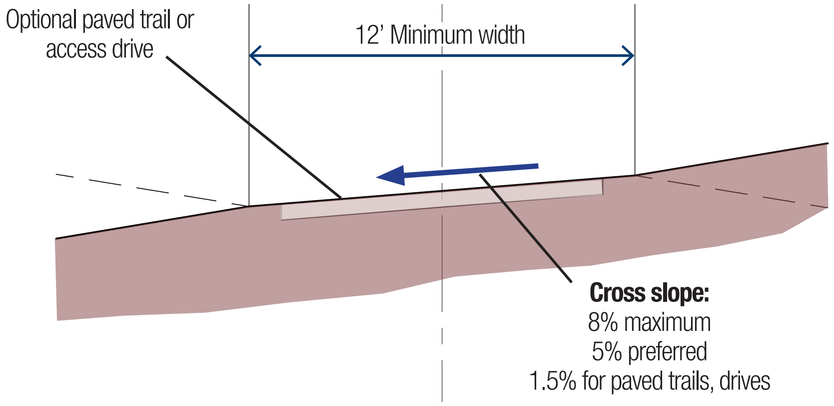


Figure 9.11-1-15:
Maintenance Path Needs

Figure 9.11-1-17: Cross-section of maintenance path



SAFETY FEATURES

A. 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. The safety bench around the perimeter of deep pool areas eliminates rapid drop-offs into deep water, reducing the potential for accidental drowning. ESSENTIAL

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

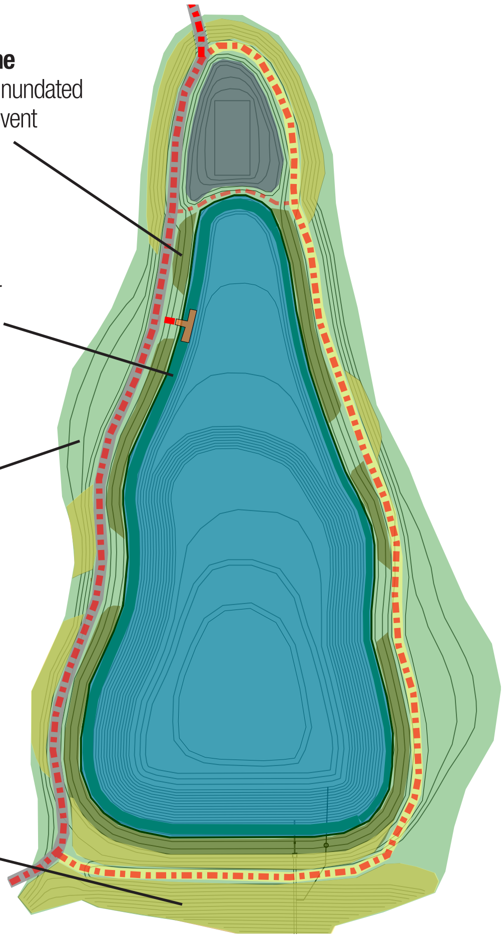
E. Pipe outfalls of greater than 48 inches in height may require a fence or railing to reduce fall risks. ESSENTIAL

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 should be considered for areas expected to be inundated more frequently (e.g., below the **high water** of the CPv event).
- Woody vegetation should 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. Any new tree and shrub plantings should be species that are native to Iowa and appropriate to the climate region at a given site.
- 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 9.11-1-18: Landscaping Zones



G. DESIGN ALTERNATIVES

None detailed in this section.

H. SPECIAL CASE ADAPTATIONS

FLOOD PLAINS

It is preferred that wet detention ponds 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. However, 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.

NOTE

Locating wet detention ponds 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

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 pond 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. For this reason, wet ponds should not be constructed in areas where such deposition is frequently observed.

STREAM MORPHOLOGY

Stormwater wet ponds 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.

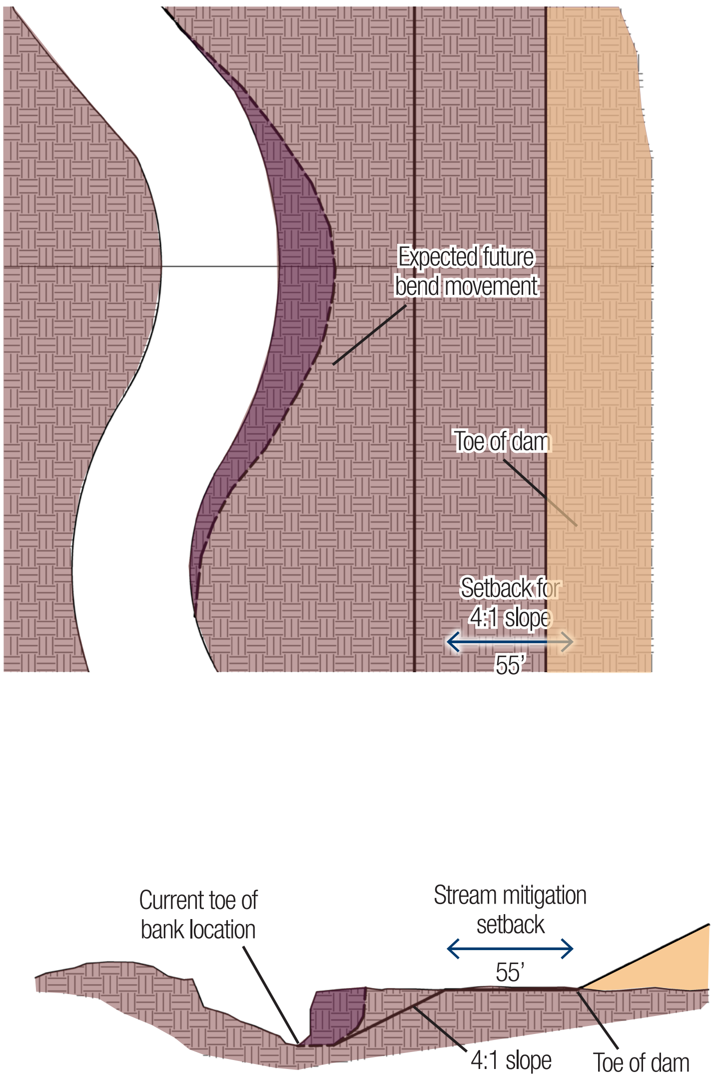


Figure 9.11-1-19: Stream Morphology Considerations

9.11-2 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.

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

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

C. 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 3a. Calculate the Water Quality volume to be treated by the stormwater pond.

Step 3b. Develop a stormwater model (TR–55) for the watershed area for the practice. The model should determine peak flowrates 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.

TABLE 9.11-2.1: EVENTS TO BE STUDIED, DATA OUTPUT TO COLLECT

		PRE-SETTLEMENT		EXISTING		POST-DEVELOPMENT	
		CN	TC	CN	TC	CN	
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 wet pond 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 goals to be planned around that reserved open space.

NOTE

This procedure assumes that evapotranspiration from the pond is not being counted toward meeting the Recharge Volume (Rev) criteria. If the pond is being used to meet that criteria, refer to Section 9.05 for Water Balance calculations.

NOTE

The procedure assumes that the pond is providing extended detention of the CPv event. If that is the case, no separate control structure for the WQv event is needed. (ED of the CPv event is assumed to also effectively control outflow during the WQv event.)

If a pond is not proposed to meet the CPv extended detention criteria, a separate calculation would be needed to design an outlet to limit outflow rates for the WQv event. Outflow rates would be set to provide 24–hour extended detention of that event.

A process similar to the CPv procedure can be used, except that the TR–55 model used to calculate flow rates and volumes for the 1.25” event would need to use adjusted CNs, as per Section 3.02.

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).

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage–storage relationships that provide a pool volume of double the WQv calculated in Step 3 and the estimated temporary detention storage volumes required as calculated in Step 4. Refer to Table 9.11-1.1 for maximum storage depth requirements for key storm events.

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.

Refer also to IDNR Form 542-1014.

- 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.

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 9.11-1.1.

Step 10. Finalize practice location and refine the grading plan and outlet design. Confirm that the pool retains at least double the required WQv treatment volume. Check that the footprint area of the safety bench does not exceed 15% of the surface area of the normal pool. Verify that 25% of the normal pool area meets the minimum depth criteria (8 feet in most locations, 10 feet in the northern two tiers of counties in Iowa). Alter the model 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 maximum allowable levels and that 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.

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.

B. DESIGN EXAMPLE

TABLE 9.11-2.2: EXAMPLE PROJECT WATERSHED DATA

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 wet detention pond. Consider the Application and Feasibility criteria in this section.

For this example, assume that the site feasibility criteria have been reviewed and the site is suitable for a wet detention pond.

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

A. Review 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 food risk areas are present.

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

Refer to Section 9.11-1H. For this example, the detention basin is assumed to be outside areas of known food risk and away from expected impacts that could be caused by stream movement.

C. 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).

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

» The requirements for Recharge Volume (Rev)are being achieved by upstream practices (as part of site development).

» Peak outfow rates from larger storm events will need to be limited to the lesser of the following:

- Natural conditions for the same rainfall event, based on HSG B soils (CN=58).
- Existing conditions for the 5-year, 24-hour rainfall event.

Step 3. Calculate the Water Quality volume to be treated by the stormwater pond.

Calculate the Water Quality Volume using the method recommended in the Unified Sizing Criteria chapter.

TABLE 9.11-2.3: 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%

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**

Step 4. Develop a stormwater model (TR-55) for the watershed area for the practice.

The model should determine peak flowrates 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.

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 9.11-2.4: 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

NOTE

This example assumes that evapotranspiration from the pond is not being counted toward meeting the Recharge Volume (Rev) criteria. If the pond is being used to meet that criteria, refer to Section 9.05 for Water Balance calculations.

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.

TABLE 9.11-2.5: EXAMPLE PROJECT "STANDARD" CN CALCULATIONS

		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 9.11-2.6: TR-55 RUNOFF MODEL TO DETENTION SITE

		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)
1-year	2.77"	3.1	59,100	42	221,000	106	364,000
2-year	3.20"	6.2	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)

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

For wet pond 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 following initial estimates of required detention using the procedure described in Section 9.02-3.

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, (q_o / q_i) is determined by the jurisdictional release rate requirements (i.e. q_o 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 (Q_a) from Table C8-6. Convert this value to watershed-inches:

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

NOTE

The procedure in this example assumes that the pond is providing extended detention of the CPv event. If that is the case, no separate control structure for the WQv event is needed.

If that would not be the case, a separate calculation would be needed to design an outlet to limit outflow rates for the WQv event. Outflow rates would be set to provide 24–hour extended detention of that event.

A process similar to the CPv procedure can be used, except that the TR–55 model used to calculate flow rates and volumes for the 1.25" event would need to use adjusted CNs, as per Section 3.02.

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.

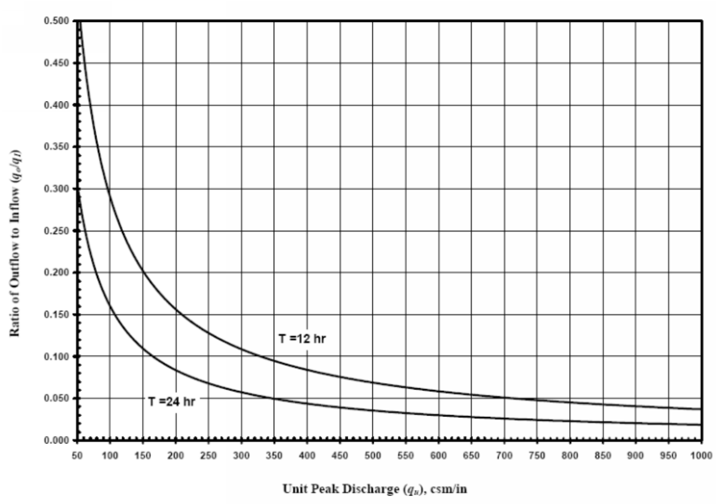


Figure C3-S6- 1: Detention time vs. discharge ratios (qo/qi)

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

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.

TABLE 9.11-2.7: INITIAL ESTIMATES OF REQUIRED DETENTION

STORM EVENT	QO (CFS)	QI (CFS)	QO/QI	VS/VR	VR (CF, 000s)	VS (CF, 000s)	VS *1.15 (CF, 000s)
1	3.2	106	0.03	0.642	364	233,526	268.6
2	6.3	136	0.05	0.620	463	287,195	330.3
5	15	193	0.08	0.581	655	380,406	437.5
10	26	249	0.11	0.549	846	464,338	534.0
25	48	336	0.14	0.510	1,150	585,970	673.9
50	70	412	0.17	0.484	1,420	686,806	789.8
100	95	494	0.19	0.463	1,710	792,231	911.1

For this calculation example, assume that sufficient space has been reserved to afford the preferred high-water depths from Table 9.11-1.1. The initial storage volume targets are the CPv (1-year) event in 2 feet of depth, the 10-year event in 3 feet of depth, and the 100-year in 5 feet of depth.

TABLE 9.11-2.8: INITIAL ESTIMATES OF REQUIRED FOOTPRINT

STORM EVENT	TARGET DEPTH (FEET)	EST. FOOTPRINT (SF)
CPv	2	134,600
10	3	178,000
100	5	182,220

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).

The pre-treatment volume (Ptv) is 10% of the WQv:

Ptv = 10% x WQv = 0.1 x 207,330 = 20,733 CF

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.

Pre-Treatment Measure #1—Sediment Forebays

For this design, it is assumed that all of the watershed area enters the wetlands through two outfall pipes.

- 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).

Step 6. Review site topography and develop a preliminary grading plan to identify preliminary stage-storage relationships that provide a pool volume of double the WQv calculated in Step 3 and the estimated temporary detention storage volumes required as calculated in Step 4. Refer to Table 9.11-1.1 for maximum storage depth requirements for key storm events.

- To start, select a preliminary elevation for the outlet.

For this example, we are using elevation 100.00 as the permanent pool elevation.

- Develop a preliminary stage-storage relationship for the temporary (live) storage above the permanent pool.

Next, figure the average area required to provide the estimated CPv calculated in Step 4 at the recommended depth of 2 feet. That area will be used as the initial design contour 1 foot above the permanent pool (1/2 of the target CPv depth), which is elevation 101.00 for this example. As per figure 9.11-1-5, the slope along the pond edge immediately above the water surface should be 3:1, so that slope will be assumed for the area between the 101.00 and 100.00 (normal pool) elevations. Above the 101 contour, a slope of 10:1 is assumed up to the CPv high-water elevation. The storage provided with this configuration at the 2-ft depth is 275,450 CF. The CPv (Vs * 1.15 = 268,600 CF) fits entirely within the 2-ft depth. Grade so that it will not exceed the maximum allowable depth of 3 feet.

TABLE 9.11-2.9: ESTIMATED CONTOUR AREA/STORAGE BELOW CPV-EVENT TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0	100	130,500		
1	101	134,600	132,550	132,550
2	102	151,200	142,900	275,450

* Stage 0 is normal pool

The slope should be no steeper than 6:1 up to the high-water elevation of the CPv event, so for this example we will plan on extending 6:1 grade up to at least elevation 103. Above that, we will assume a 4:1 slope is provided to check the storage provided to the 10- and 100-year storm events. The 10-year (Vs * 1.15 = 534,000 CF) does not fit entirely within the 3-ft depth, but will not exceed the 4-ft maximum allowable depth. The 100-year (911,100 CF) will fit within the 5-ft target depth. Check that it will not exceed the maximum allowable depth of 6 feet.

TABLE 9.11-2.10: ESTIMATED CONTOUR AREA/STORAGE BETWEEN THE CPV-EVENT AND 10-YEAR EVENT TARGET ELEVATION

STAGE (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
3	103	168,000	159,600	435,050
4	104	178,400	173,200	608,250
5	105	189,200	183,800	792,050
6	106	196,500	192,850	984,900

* Stage 0 is normal pool

The 100-year should fit within the maximum allowable 6 ft depth.

- Develop a preliminary relationship for the storage in the permanent pool (dead storage):

NOTE

Elevation 100.00 is used as a reference datum for this design example.

For a real project, the designer would need to consider site topography and other factors when selecting the best permanent pool elevation for a given site.

TABLE 9.11-2.11: COMPARISON OF ESTIMATED REQUIRED / PRELIMINARY DESIGN STORAGE VOLUMES

STAGE* (FT)	ELEVATION (FT)	CONTOUR AREA (SQ FT)	INCREMENTAL STORAGE (CUBIC FT)	TOTAL STORAGE (CUBIC FT)
0.0	100.0	130,500		
1.0	101.0	126,100	128,300	128,300
-2.0	98.0	115,800	120,950	249,250
-3.0	97.0	112,000	113,900	363,150
-4.0	96.0	82,324	97,162	460,312
-5.0	95.0	76,339	79,332	539,644
-6.0	94.0	68,000	72,170	611,813
-7.0	93.0	60,679	64,340	676,153
-8.0	92.0	54,300	57,490	733,642
-9.0	91.0	52,100	53,200	786,842
-10.0	90.0	51,800	51,950	838,792
-11.0	89.0	48,900	50,350	889,142
-12.0	88.0	46,200	47,550	936,692
-13.0	87.0	43,600	44,900	981,592
-14.0	86.0	41,600	42,600	1,024,192
-15.0	85.0	38,700	40,150	1,064,342
-16.0	84.0	26,900	32,800	1,097,142
-17.0	83.0	21,300	24,100	1,121,242
-18.0	82.0	18,500	19,900	1,141,142
-19.0	81.0	10,600	14,550	1,155,692
-20.0	80.0	8,200	9,400	1,165,092

* Stage 0 is normal pool

The preliminary pool design should consider the perimeter bench requirements outlined in 9.11-1-5 with a slope no steeper than 3:1 below the perimeter benches.

The required WQv calculated in Step 3 is 207,330 CF. Any storage provided in the forebay can be credited toward meeting that requirement. The permanent pool must store at least twice the remaining WQv volume.

Using this preliminary design, the permanent pool will hold 1,165,092 (more than twice the WQv). This pond design has sufficient depth to support a fish population, with a permanent pool design depth of 20.0'.

- Check that the shallow water depths above the perimeter bench do not exceed 15% of the water surface area. For this example, we will check that the area within the contour 3 feet below the permanent pool (100 – 3 = 97) is at least 85% of the contour area that defines the permanent pool.
  - The 100-ft and 97-ft contour areas are 130,500 SF and 112,000 SF, respectively.
  - **112,000 / 130,500 SF = 0.859 (>0.85 OK)**
- Since the pond is meant to support a fish population, check that the water depths of at least 8 feet are in excess of 25% of the water surface area (assume site is not in upper two tiers of counties in Iowa). For this example, we will check that the area within the contour 8 feet below the permanent pool (100 – 8 = 92) is at least 25% of the contour area that defines the permanent pool.
  - The 8-ft depth contour (92-ft contour) area is 54,300 SF.
  - **54,300 / 130,500 = 0.416 (>0.25 OK)**

Step 7. Investigate potential dam hazard classification. The design and construction of stormwater management ponds and wetlands 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.

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 2,170,727 CF of combined temporary and permanent storage (49.8 **acre-feet**). For this grading plan, the dam has a height of less than 5 feet (wetland 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 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 49.8 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.

*Volumes of forebay storage added to the basin.

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.

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.

NOTE

Setting the outfall several feet below the permanent pool allows the primary spillway pipe to be used to draw down the water surface for future maintenance activities.

REMEMBER

The 100–year allowable release rate in this example is the lesser of the peak rate from the 100–year event under pre–settlement conditions and the 5–year event under existing conditions.

NOTE

For a submerged orifice, the head condition is the difference in water surface elevations measured on either side of the orifice.

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.

"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' (7 feet below the bottom of the basin). 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 4). 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 = $\pi r^2 = \pi(1.5 \text{ feet})^2$ = 7.07 SF (good for initial estimate)

B. We will use a multi-stage outfall to address the release rates of the 2-year, 10-year, and 100-year events. Compute the approximate size of the orifice needed to discharge for the 2-year event.

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

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 2-year event target high-water)*
	– 100.0	*(permanent pool)*
	= 2.0	feet

A = *3.2 cfs / [0.6 x (2 x 32.2 x 2.0)$^{1/2}$]* = 0.47 SF

r = *(A / π)$^{1/2}$ = (0.47 SF / π)$^{1/2}$* = 0.386 feet

d = *2r = 0.774 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 2.9 cfs during the CPv event (< 3.2 cfs, 0K)

C. Set a second stage for larger storms above the expected high-water elevation of the CPv 2-year event.

CULVERT/ORIFICE	A	B
Rise	36"	9"
Span	36"	9"
No. Barrels	1	1
Invert Elevation	93'	99.63'
Length	100'	40'
Slope	0.5%	0.0%
N-Value	0.013	0.013
Orifice Coefficient	0.6	0.6
Multi-Stage	NA	Yes
Active	Yes	Yes

The high-water elevation for the CPv event with the 9" orifice in place is 101.83'. Set the second stage at 102.00' and try a 3'-long rectangular weir (could be in the front face of a 4' x 4' inlet structure). Since the weir is set above the maximum water surface elevation of the CPv, the CPv expected outflow should still be acceptable.

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.

WEIR	A
Weir Type	Rectangular
Crest Elevation	102.00'
Crest Length	3'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

Entering the 3' weir (Weir A) into the software program yields a 10-year storm event outflow rate of 20cfs (< 26 cfs, OK). The 10-year water surface elevation is 103.35 (above the target, but less than the maximum 4-ft depth, OK). The CPv remains unchanged , so no further adjustment of the second control stage is necessary..

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.

Enter a second 3' weir (Weir B) at elevation 104.25'—above the 10-year maximum water surface elevation (103.35'). The stage-storage-discharge routing yields an expected outflow rate of 93 cfs for the 100-year storm event (< 95, OK). The maximum water surface elevation is 105.79.

F. For this example, provide a third weir for events greater than the 100-year storm event. This is not required, but may reduce the instances of flow over the emergency spillway throughout the life of the basin.

WEIR	B
Weir Type	Rectangular
Crest Elevation	104.25'
Crest Length	3'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

Set a 10' weir (Weir C) at 105.75'—right above the 100-year maximum water surface elevation (105.35'). Since the weir is above the maximum water surface elevation, we can move on to adding the emergency overflow.

G. Set the emergency spillway elevation higher than the last weir.

WEIR	C
Weir Type	Rectangular
Crest Elevation	105.75'
Crest Length	10'
Weir Coefficient	3.33
Multi-Stage	Yes
Active	Yes

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.

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.

NOTE

The 10' weir would be the remainder of the sides of the 4' x 4' inlet structure.

(16' – 3' – 3' = 10')

For this example, the emergency spillway is set at 106.00’. The outfall design program entires are summarized in Table 9.11-2.11.

TABLE 9.11-2.12: SUMMARY OF OUTFALL DESIGN ITERATIONS AND RESULTS

ITERATION		1	2	3	4	ELEVATION
Culvert A		36"	36"	36"	36"	93.00'
Culvert B		9"	9"	9"	9"	99.63' *
Weir A			3'	3'	3'	102.00'
Weir B				3'	3'	104.25'
Weir C					10'	105.75'
Weir D					40'	106.00'
STORM EVENT	ALLOWED	OUT	OUT	OUT	OUT	HIGH WATER ELEVATION (ITERATION #4)
1-year (CPv)	3.2	2.9	2.9	2.9	2.9	101.83'
2-year	6.3		4.5	4.5	4.5	102.25'
5-year	15		11	11	11	102.81'
10-year	26		20	20	20	103.35'
25-year	48		38	38	38	104.23'
50-year	70		56	62	62	104.96'
100-year	95		79	93	93	105.71'

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

If needed, alter the stage-storage relationship to provide additional storage to meet these requirements.

For this preliminary design, it appears that required outflow conditions are met at the high-water stages for the CPv, 10-year and 100-year and are reasonably close to the target depths of 2, 3 and 5 feet, respectively. This design information can be used to advance a more detailed grading plan.

DETAILED DESIGN OF FOREBAY

In the forebays, a perforated standpipe will be installed, allowing the basin to drain dry. The riser will be a 12” PVC pipe with ½” holes spaced along the pipe. The outfall pipe will be a 12” PVC pipe without perforations. The outlet invert of the 12” PVC pipe should be set equal to the pilot channel.

The forebays are sized to capture 10% of WQv before overtopping an earth berm, protected by an articulated concrete mat. Generally, forebays should be longer than they are wide to provide sufficient length for **settling** sediment. Specific guidance for pretreatment design can be found in Sections 5.01–5.07.

The earth berm can be approximated as a broad-crested weir. Use the weir equation to check the velocity over the berm during the 100-year peak flow to evaluate the potential for erosion.

$Q = C \times L \times H^{3/2}$

Where: Q = inflow (cfs)
C = 2.6 (coefficient for broad crested weir)
L = length (feet)
H = height of flow over weir (feet)

Rearranged to solve for H:

$H = [Q / (C \times L)]^{2/3}$
$H = [247 \text{ cfs} / (2.6 \times 30 \text{ feet})]^{2/3}$
H = 2.1 feet

Using the 100-year peak inflow, 494 cfs, and the design weir length of 30 feet, solve for the depth of water over the weir. For this example, it assumed that the flow is split equally between the two sediment basins. In application, the expected inflows should be calculated for the two subcatchments separately. The treatment volume and velocity into the detention basin from each basin should be designed separately.

The flow area is then
30 feet x 2.1 feet = 62 square feet

Using the continuity equation, Q = A x V
247 cfs = 62 square feet x V
247 cfs / 62 square feet = V = **4.0 fps**

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 9.09-1.1.

The outlet design has sufficient capacity to pass all of the events within the maximum allowable release rates, and to keep the maximum water surface elevations near the target elevations (below the maximum allowable). The routed storage and depth values are summarized in Table 9.11-2.12.

TABLE 9.11-2.13: DESIGNED STORAGE SUMMARY

STORM EVENT	TARGET DEPTH (FEET)	DESIGN DEPTH (FEET)	MAX. ALLOWABLE DEPTH (FEET)	VR (CF)	VS (CF)	VS *1.15 (CF)	MAXIMUM STORAGE USED (CF)
CPv	2	1.83	3	364,000	234,076	269,200	251,638
10-YEAR	3	3.35	4	846,000	464,338	534,000	495,518
100-YEAR	5	5.71	6	1,710,000	792,231	911,100	928,659

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 sufficient space was set aside during initial development, finalizing the practice location and refining the grading plan is possible without changes to the calculated storage. No additional adjustments were necessary, but if there were limits to grading extents or other utility constraints, this step would address those changes.

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, check the velocity of the outfall pipe based on the 100-year flow rate of 93 cfs and the design diameter 36 inches.

93 cfs = 7.1 square feet x V
93 cfs / 7.1 square feet = V = **13.1 fps**

In this example, flow is connecting to a storm sewer system, so this velocity is acceptable. However, if this pipe were directed to the ground surface, it may need to be enlarged so that the expected flow velocity would not exceed 10 fps. This could be accomplished using an orifice plate or other flow restriction over the enlarged outlet at the outfall structure, or by placing a manhole or other structure downstream where the change in pipe size would occur. If such a change is made, go back and adjust modeling in previous steps to reflect this revised design.

Where the storm system is directed to the surface, requirements for additional erosion protection would need to be checked. 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 crest of the emergency spillway (if any overfow occurs during the 100-year storm 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 overfow 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.

Proceed to development of detailed plans and specifications. After completion of final design, verify information in Steps 9–11 is accurate. Make any adjustments as needed so that final plan information matches finished calculation report.

9.11-3 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

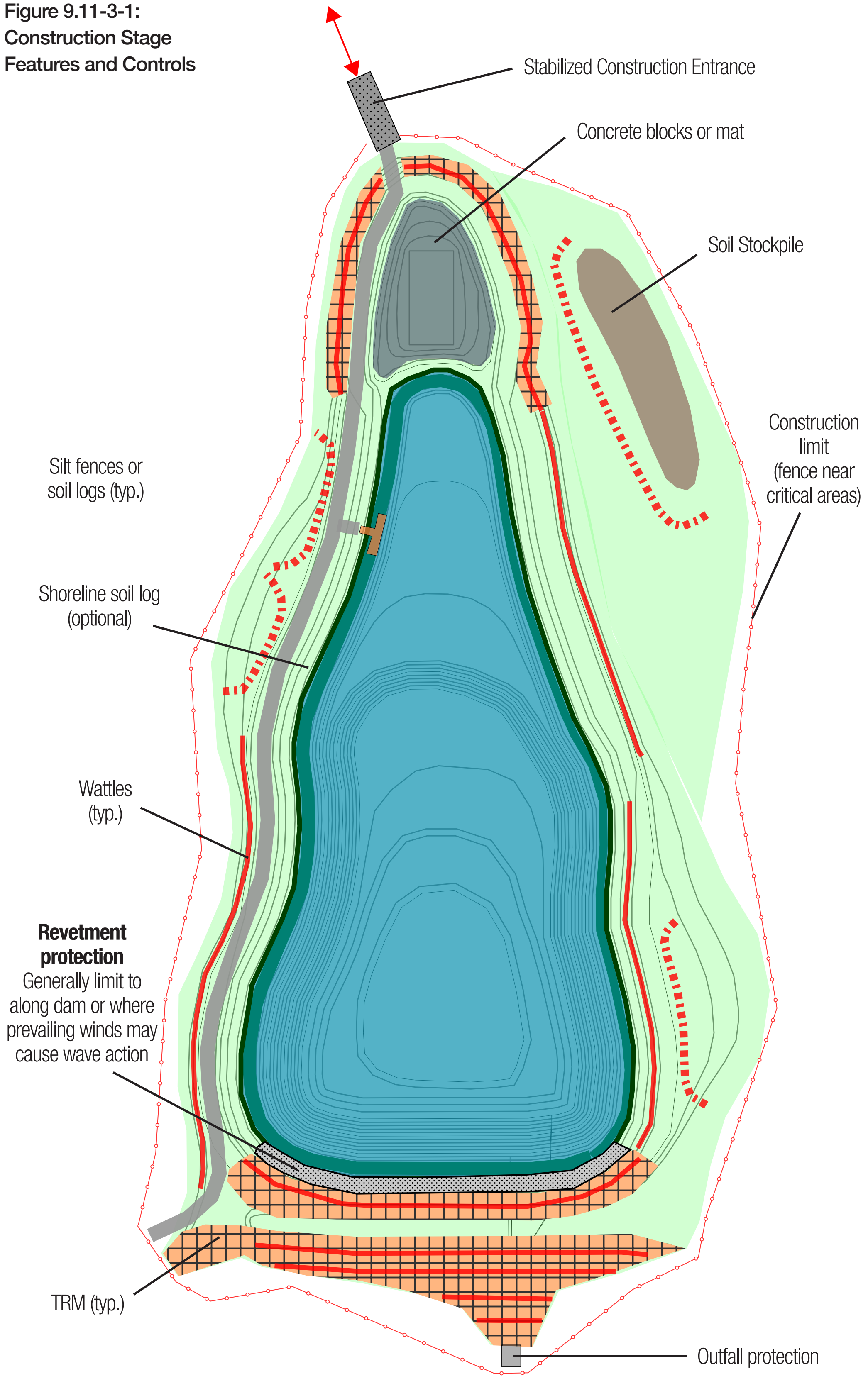
As construction activities commence, internal controls will be added to prevent erosion and sediment loss from the site area.

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 9.11-3-1: Construction Stage Features and Controls



B. CONSTRUCTION SEQUENCING

Major construction operations to create constructed wetlands 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 9.11-3-2: Construction phase

4 – Storm Structure and Pipe Installation

Installation of the maintenance drawdown, outlet structures and pipes allows for control of the water level, providing drier soil conditions for finish grading and seeding and allowing staged filling of the pond after installation.

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

5 – 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 liner installation and **soil quality restoration** (SQR) techniques are yet to be completed. Make grading adjustments as needed prior to proceeding with liner construction and/or SQR operations.

6 – Liner Installation

Placement of impermeable materials supports storage of a permanent pool of water at the desired elevation and coverage area.

The contract documents need to defne the type of liner (if necessary) to be used and the methods and details of its installation.

7 – Finish Grading

Fine grading, usually accomplished with smaller equipment, may be needed to establish subtle variations of the finished surface near habitat features. Care needs to be taken to not disturb the liner during finish grading operations.

8 - Habitat Features

Subsurface fish habitat structures, anchored logs or other habitat features may be installed at this stage.

9 - Surface Roughening

Equipment creates grooves and loosens the surface of soil materials after placement. These grooves limit the potential for sheet and rill erosion. This would typically be omitted in areas where the liner has been prepared; however, the liner should be protected from surface erosion until the pond is filled to its normal pool elevation.

10 - Soil Quality Restoration

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 for areas outside of the pool zone 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.

11 - 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.

12 - Landscaping

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

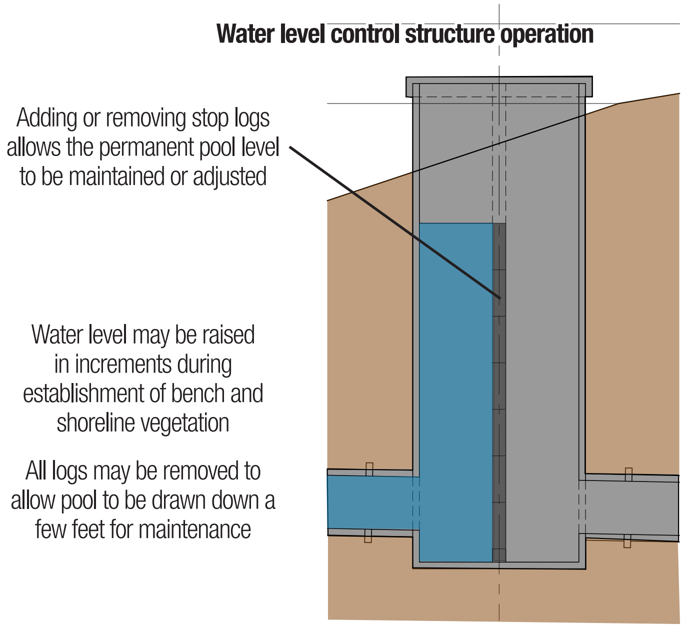
13 - Staged Filling

To promote better establishment of desired vegetation, it is recommended to use outlet controls that allow the water surface to be adjusted. This will allow the pond area to be filled in stages.

It can be more difficult to establish vegetation (either by seeding or plugs) in areas of ponding water. Staged filling allows vegetation in these zones to get started before they are permanently inundated. As vegetation in the lower marsh zones begins to establish, the water level can be raised in increments.

It is recommended to wait 2–3 weeks after initial establishment of vegetation within the safety bench zone, to raise water levels to the final design permanent pool elevation.

Figure 9.11-3-3: Using Water Level Control Structure During Establishment



14 – 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 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.

- Verification that the liner (if required) has been constructed as per construction documents. Collect any test results needed to document its proper construction. (Such tests are often performed by a geotechnical engineer.)
- Observe that finished grading has created the desired features.
- Observe that habitat features have been constructed properly. Verify that the gradation of stone or other materials to construct these features is in compliance with the contract documents.
- 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.
- Inspect outlet control structures to ensure that stop logs, valves or other control structures are operated to allow for staged filling of the permanent pool.
- As per Construction Sequencing item #5, review results of an as-built or record survey to verify that the final elevation of the permanent pool matches the proposed design.
- 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.
- Throughout construction, work with the erosion and sediment control contractor to coordinate proper installation of all BMPs.
- 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.
- The final permanent pool elevation established by the installation of stop logs or other control devices.

- A topographic survey to verify that required storage volumes have been achieved in a manner similar to plan elevations.
- Footprint of check dams or grade control features and their crest width and top-over elevation.
- Confirmation that required trees and shrubs have been installed.

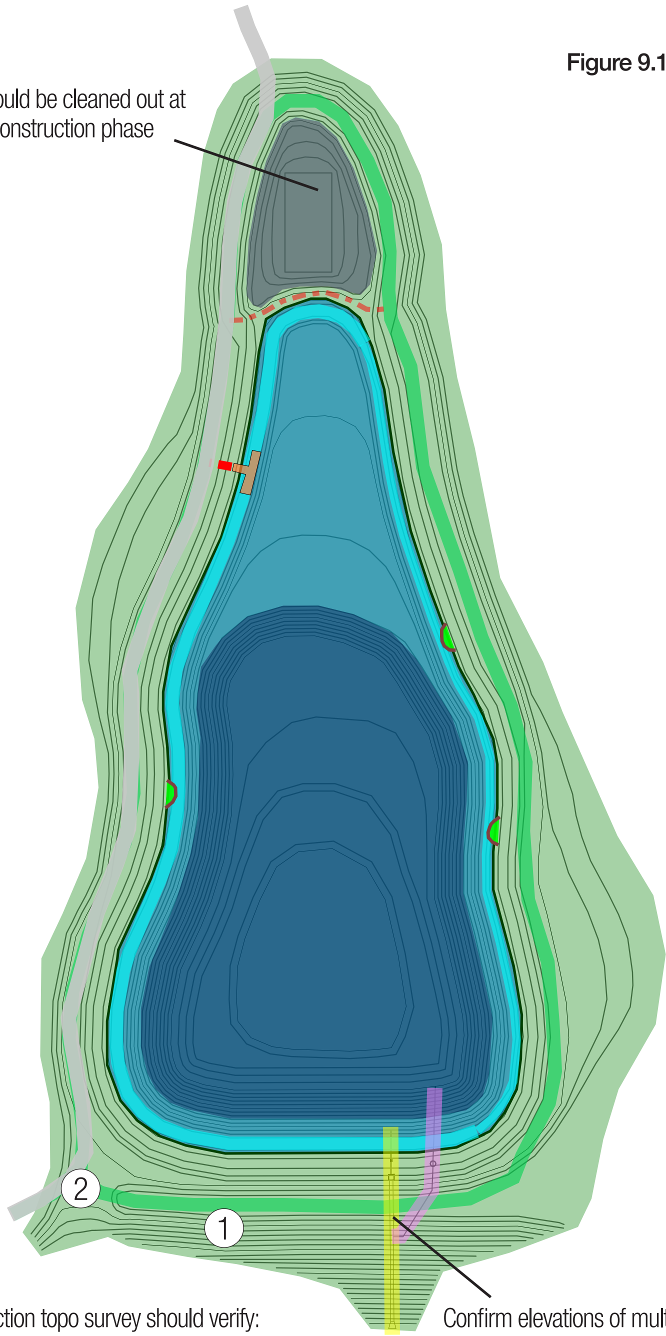


Figure 9.11-3-4: Features to Check Post-Construction

9.11-4 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.

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.

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.
- Removal of cuttings longer than 8 inches that fall within 20 feet of the edge of water or cover areas larger than 20 square feet to off-site location.
- 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.

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.
- Removal of cuttings longer than 8 inches that fall within 20 feet of the edge of water or cover areas larger than 20 square feet to off-site location.
- 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 wet pond'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
Monitor vegetation and perform replacement planting as necessary.	Annually (after short-term establishment period)
• Examine stability of the safety bench and shoreline edge. • 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.	Annual Inspection
Repair undercut or eroded areas.	When observed
Harvest wetland plants that have been "choked out" by sediment accumulation.	Annually
Remove sediment when total pool volume has become reduced significantly (~25%), when plants along pond edge are "choked" with sediment or the pond becomes eutrophic. (Estimated time: every 10–20 years)	As needed; when approximately 25% of the total pool volume has been lost, or as noted

- 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.

9.11-5 SIGNAGE RECOMMENDATIONS

Signage may be provided as an educational tool to explain the area's purpose and stormwater management function to the general public. Signage may also be used to advise maintenance staff against discouraged practices, such as frequent mowing of native planting areas and broad application of herbicides. It may also be used to direct the public along access paths or provide warnings about any safety risks, or limitations of public use.

Figure 9.11-5-1: Signage example