CHAPTER 7 – FLOW CONTROL

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7.1 INTRODUCTION

This chapter outlines the minimum requirements for sizing flow control facilities. Standard flow control facilities are detention/retention ponds, drywells, and evaporation ponds. Any other facility is considered a non-standard system, and shall be evaluated individually by the local jurisdiction. Flow control facilities are necessary to mitigate potential adverse impacts on down-gradient properties due to the increase in stormwater runoff caused by land development.

Unless specifically approved by the local jurisdiction, the peak rate and volume of stormwater runoff from any proposed land development to any natural or constructed point of discharge downstream shall not exceed the pre-development peak rate or volume of runoff. A down-gradient analysis demonstrating that there will be no expected adverse impacts on downgradient properties will be required (refer to Section 3.4.5 for down-gradient analysis criteria). Exceptions with regard to rate and volume control can be made for regional facilities planned by the local jurisdiction.

All engineering work for flow control facilities shall be performed by, or under the direction of, a professional engineer currently licensed in the State of Washington.

Refer to Chapter 11 for maintenance requirements.

7.2 APPLICABILITY AND EXEMPTIONS

7.2.1 APPLICABILITY

All projects that meet the regulatory threshold shall comply with this Basic Requirement.

7.2.2 EXEMPTIONS

Projects are exempt from flow control if they discharge to any of the following:

- The Spokane River or other exempt water bodies, which are defined in the *Stormwater Management Manual for Eastern Washington* as fifth-order or greater stream channels, as determined from a 1:150,000 scale map;
- A river or stream that is fifth-order or greater as determined from a 1:24,000 scale map;
- A river or stream that is fourth-order or greater as determined from a 1:100,000 scale map;

- A stream that flows only during runoff-producing events. These streams are defined as those that do not discharge via surface flow to a non-exempt surface water following receipt of the 2-year, NRCS Type 1A, 24 hour rainfall event. In addition, for the stream to be exempt, it shall be able to carry the runoff from an average snowmelt event, but shall not have a period of base flow during a year of normal precipitation;
- A lake or reservoir with a contributing watershed areas greater than 100 square miles;
- A reservoir with outlet controls that are operated for varying discharges to the down-gradient reaches as for hydropower, flood control, irrigation or drinking water supplies (discharges to uncontrolled flow-through impoundments are not exempt).

In order to be exempted the discharge shall meet all of the following requirements:

- The project area must be drained by a conveyance system that consists entirely of manmade conveyance elements (i.e. pipes, ditches, outfall protection); and,
- The conveyance system must extend to the ordinary high water mark line of the receiving water, or (in order to avoid construction activities in sensitive areas) flows are properly dispersed before reaching the buffer zone of the sensitive or critical area; and,
- Any erodible elements of the conveyance system for the project area must be adequately stabilized to prevent erosion; and,
- Surface water from the project area must not be diverted from or increased to an existing wetland, stream, or near-shore habitat sufficient to cause a significant adverse impact. Adverse impacts are expected from uncontrolled flows causing a significant increase or decrease in the 1.5- to 2-year peak flow rate.

Maps shall be standard U.S. Geological Survey (USGS) maps or geographic information system (GIS) data sets derived from USGS base maps.

7.3 DETENTION FACILITIES

7.3.1 INTRODUCTION

A detention system is a storage facility that has a surface discharge. Detention ponds, vaults and underground storage tanks are all considered to be detention facilities. Refer to the *Stormwater Management Manual for Eastern Washington* for design criteria for vaults and underground storage tanks.

A detention facility is intended to control peak stormwater runoff rates, and if designed per the criteria in this chapter, does not control volume. If the subgrade soils meet the drawdown criteria specified in Section 7.8.3, the engineer may choose to propose a system that uses infiltration in conjunction with a detention pond as a means to control volume. Otherwise, the engineer can use evaporation to control volume, in conjunction with a detention pond (refer to Section 7.7.2).

7.3.2 MINIMUM REQUIREMENTS

The following minimum requirements shall be met. Additional requirements are specified in Section 7.8.

Design Criteria

Detention facilities shall be designed such that the release rate does not exceed the pre-developed conditions for multiple storm events. The analysis of multiple design storms is needed to control and attenuate both low and high flow storm events.

The total post-developed discharge rate leaving the site (including bypass flow) shall be limited to the pre-development rates outlined in Table 7-1. Bypass flow is the runoff that leaves the site without being conveyed through the drainage system.

TABLE 7-1
ALLOWABLE DISCHARGE RATES

Design Frequency (24 hr storm)	Post-Developed Discharge Rate[1]
2-year	≤ 2-year pre-developed
25-year	≤ 25-year pre-developed
100-year[2] (Emergency Overflow)	Overflow route only

[1] Post-developed flow is equal to the release from detention facility plus the bypass flow.

[2] The emergency overflow shall direct the 100-year post-developed flow safely towards the downstream conveyance system

Detention systems that store any stormwater below the first overflow shall adhere to the subgrade infiltrative criteria specified in Table 6-1. Unless waived by the local jurisdiction, the subgrade infiltration rate shall be verified through testing.

If the detention facility is also proposed to function as a water quality treatment facility, the following criteria must be met:

- The first orifice or outlet from the facility must be placed 6 inches above the pond bottom; and,

- The treatment zone shall meet the requirements specified in Table 6-1 and be verified through testing, unless waived by the local jurisdiction.

The NRCS Type 1A 24 hour storm event is the design storm to be used for all flow control facilities that use a surface discharge; for flow control facilities that involve infiltration into the subsurface, the NRCS Type II 24 hour storm event can be used for design.

A wetland may also be considered for use as a flow control facility, if approved by Ecology. Refer to Section 7.9.3 for additional information.

Setbacks

When a detention facility is proposed upslope of developed property or at the top of a slope inclined 10% or greater, down-gradient impacts shall be evaluated and the minimum setback from the slope must be greater than or equal to the height of the slope. The distance between the outlet structure and the inlet into the detention facility shall be maximized.

Release Point

Stormwater runoff from a developed site shall leave the site in the same manner and location as it did in the pre-developed condition. Therefore, a detention system may be used only when a well-defined natural drainage course is present prior to development.

7.4 OUTFLOW CONTROL STRUCTURES

7.4.1 INTRODUCTION

Control structures are weirs, orifices, culverts, or manholes with a restrictor device that is used for controlling outflow from a facility to meet a desired standard. This section presents a general overview of flow control structures. For additional information, the engineer should consult a hydraulics reference.

7.4.2 OUTFLOW CONTROL STRUCTURE TYPES

Weirs and Orifices

Weirs and orifices are partial obstructions in an open channel or in a detention facility at the point of discharge, typically used to limit and measure flow rates. Weirs have openings with no top, referred to as a notch, through which the water flows when its surface elevation is above the bottom of the opening (the weir invert). An orifice is typically a circular opening cut into the structure obstructing the stream. The following are common features of weirs:

- Weir Length: The weir length is the length of the notch in the direction perpendicular to the flow:
    - Contracted weirs (see Figure 7-1) have weir lengths less than the channel width or pond wall, and the falling liquid sheet (called the nappe) decreases in width as it falls.
    - Suppressed weirs (see Figure 7-2) extend the full channel width.

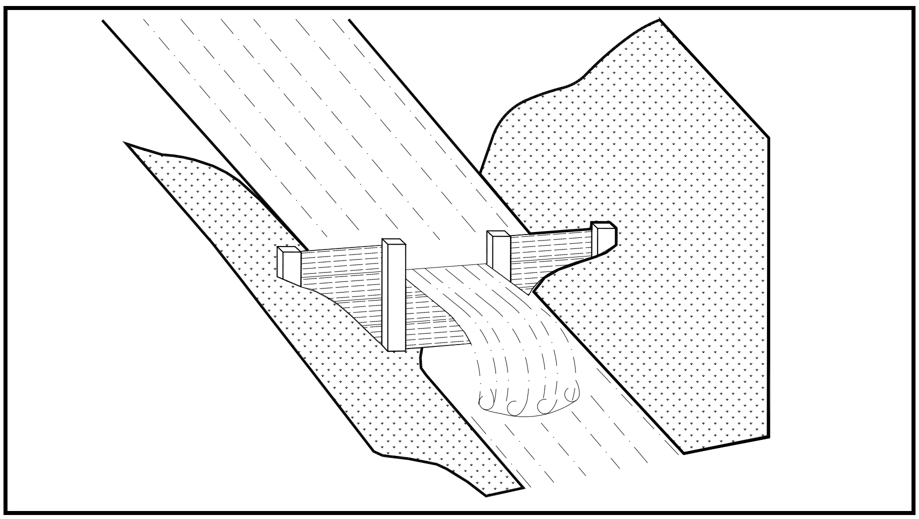

Figure 7-1 – Contracted Weir

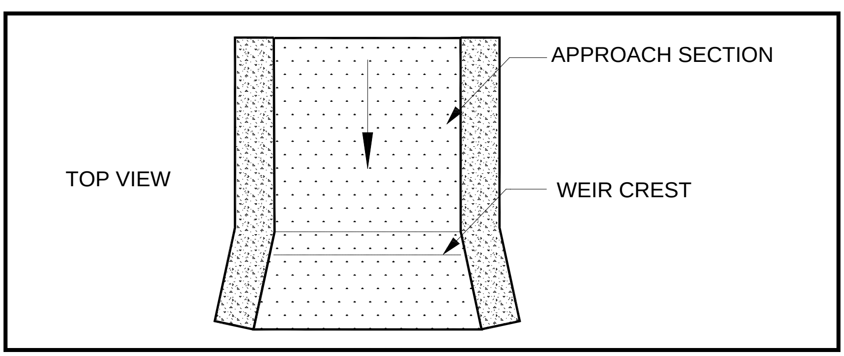

Figure 7-2 – Suppressed Weir

- Weir Crest: The weir crest is the surface of the weir invert in the direction of the flow:
  - o Broad-crested weirs (see Figure 7-3) have a crest that extends horizontally in the direction of flow far enough that the flow leaves the weir in essentially a horizontal direction. A weir is broad-crested if the length of the crest in the direction of flow is greater than half of the head (H).
  - o Sharp-crested weirs (see Figure 7-4) have a narrow crest with a sharp upstream edge so that water flows clear of the crest. The weir invert or top of the crest should be set above the pond bottom a height of at least twice the maximum head, preferably more.

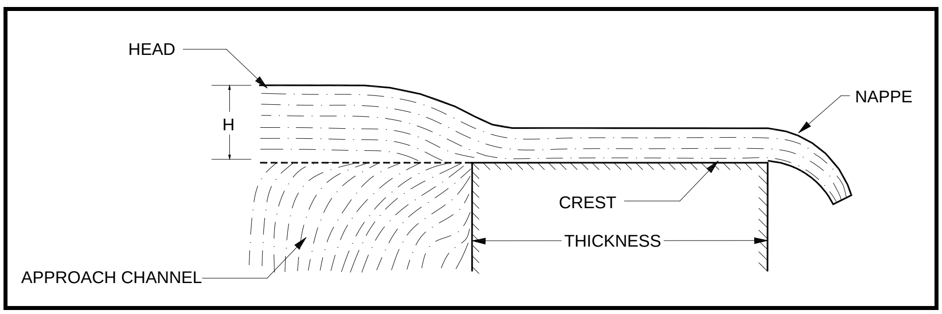

Figure 7-3 – Broad-Crested Weir

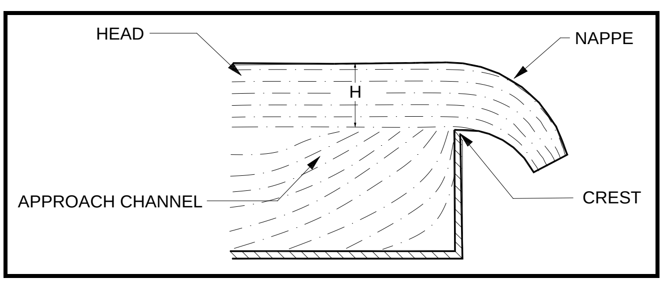

Figure 7-4 – Sharp-Crested Weir

- Weir Notch Shape: The following are the common shapes of weir openings, as viewed looking in the direction of the flow:
  - o V-notch: The opening has two sloped sides coming together at a point at the bottom.
  - o Rectangular: The opening has two vertical sides and a horizontal invert.

- Trapezoidal (Cipoletti): The opening has a horizontal invert and two sloped sides.

Table 7-2 provides equations and coefficients for calculating flow through the most common types of weirs and orifices used for flow control.

TABLE 7-2
FLOW EQUATIONS FOR VARIOUS WEIR AND ORIFICE TYPES

Weir/Orifice Type	Equation	*C*
Sharp Crested V-notch weir[1]	$Q = C\left(Tan\,\theta/2\right)H^{5/2}$	0.60
Broad Crested Suppressed Rectangular weir	$Q = CLH^{3/2}$	0.33
Rectangular Sharp Crested Weirs[1]: Contracted; Suppressed	Contracted: $Q = C\left(L - 0.2H\right)H^{3/2}$; Suppressed: $Q = CLH^{3/2}$	$3.27 + 0.40\frac{H}{Y}$
Sharp Crested Cipoletti (Trapezoidal)[1] Side slopes are 1:4	$Q = CLH^{3/2}$	3.367
Broad Crested Trapezoidal Weir	$Q = C(2g)^{1/2}\left[\frac{2}{3}LH^{3/2} + \frac{8}{15}\left(Tan\,\vartheta\right)H^{5/2}\right]$	0.60
Orifice	$Q = CA\sqrt{2gH}$	0.62

[1] The weir inverts should be set above the pond bottom a height of at least twice the maximum head.

Q = flow (cfs); C = coefficient of discharge; A = area of orifice (square feet); H = hydraulic head (feet); g = gravity (32.2 feet/second^2); θ = angle of side slopes (degrees); Y = storage depth (feet); L = weir length or opening (feet)

Risers

A riser typically consists of a circular pipe or box inlet with its opening oriented parallel to the water surface. A riser operates under three hydraulic flow regimes in this order as the water surface elevation rises: weir, orifice, and full barrel. Full barrel flow occurs when the downstream conduit is undersized with respect to the riser capacity and when the water surface elevation rises high enough.

Figure 7-5 can be used to determine the head (in feet) above a riser of given diameter and for a given flow (usually the 100-year peak flow for developed conditions). For additional information, consult a hydraulics reference.

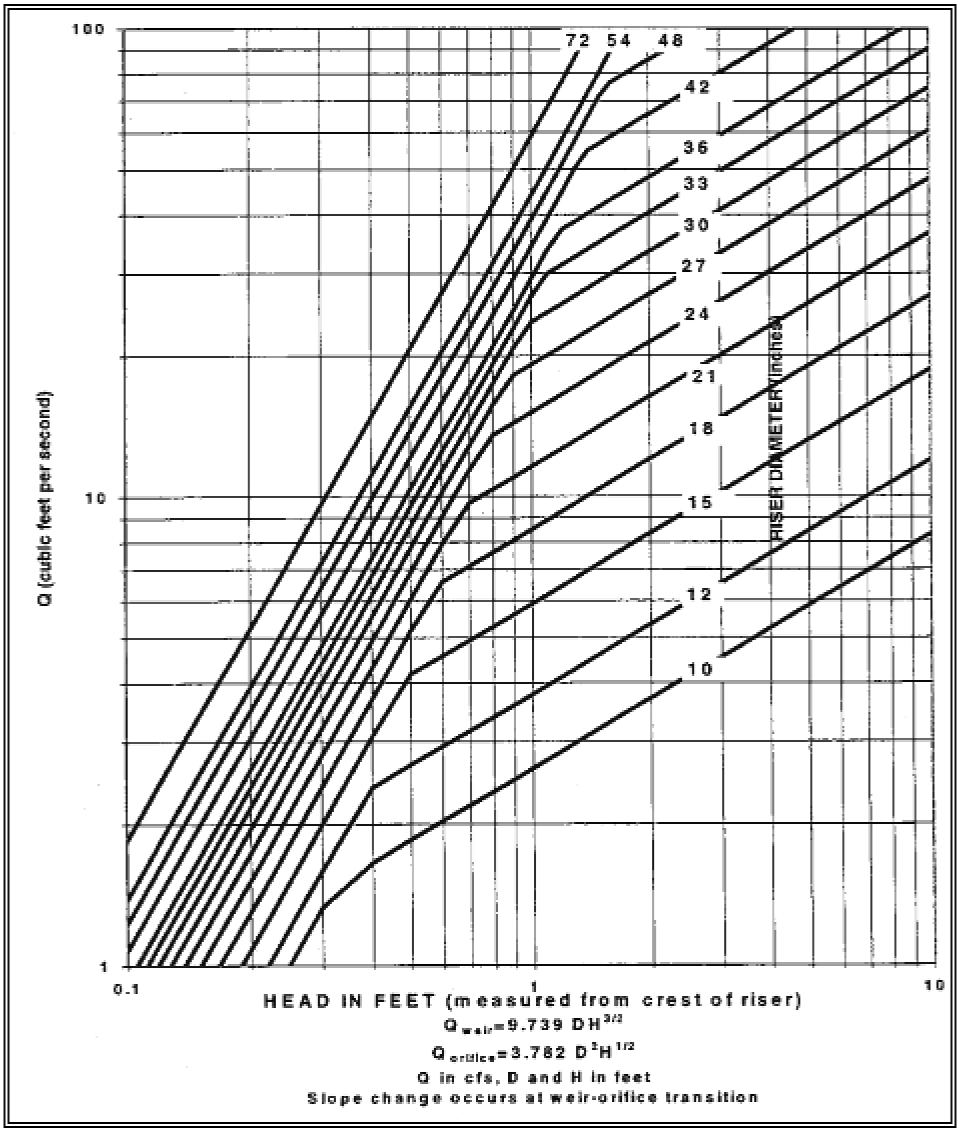

Figure 7-5 – Flow Rates vs. Head (riser)

7.4.3 MINIMUM REQUIREMENTS

Outflow control structures shall meet the following requirements:

- A weir used as a flow control structure shall be made of non-erosive material that is resistant to alteration or vandalism, such as reinforced concrete or metal with a non-corrosive surface. An emergency overflow weir can be made of soil with revetment;

- The inverts for sharp-crested weirs should be set above the pond bottom a height of at least twice the maximum head;
- The crest length for broad-crested weirs should be at least 3 times the maximum head and preferably 4 times the maximum head, or more;
- Runoff shall enter the detention facility through a conveyance system separate from the control and outflow conveyance system. The distance between the inlet and outlet shall be maximized to reduce sediment from accumulating in the outflow structure;
- Flow control structures discharging from a high use site to a drainage facility shall include an oil control BMP that meets the requirements outlined in Chapter 6;
- Control structures shall be selected taking into consideration the expected hydraulic heads. Table 7-3 presents typical control structures and their applicability.

TABLE 7-3
OPTIMAL APPLICATION OF CONTROL STRUCTURES

Control Structure	Pond Head
Outlet Pipe	Very Low
V-Notch Weir	Low
Slotted Weir	Moderate
Multi-Stage Orifice	High

- Circular orifices shall be 3 inches in diameter or greater. Slotted weirs can be used in lieu of smaller orifices to reduce the occurrence of plugging;
- The top of manhole/catch basin grates used for control structures shall be placed 2 inches above the finish grade when located in earth or gravel locations.

Figure 7-6 shows a typical flow control structure.

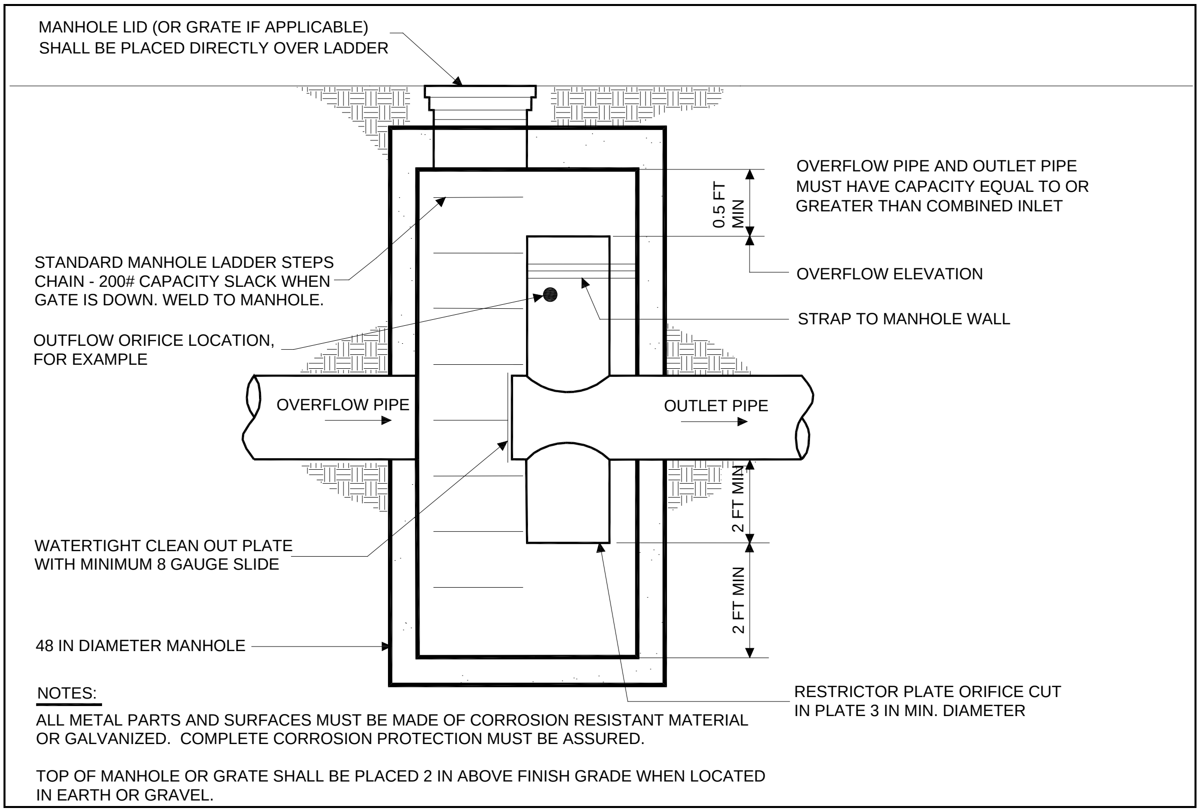

Figure 7-6 – Flow Control Structure Example

7.5 INFILTRATION FACILITIES

7.5.1 INTRODUCTION

An infiltration facility is used for disposing of stormwater runoff into the subsurface and can be used for flow control provided that:

- The discharge is uncontaminated or properly treated so that it does not violate water quality criteria per Chapter 6. For additional information regarding discharges to drywells, refer to Ecology's *Guidance for UIC Wells that Manage Stormwater*;
- The Geotechnical Site Characterization demonstrates the suitability of the soil for subsurface disposal;
- The down-gradient analysis indicates that adverse impacts are not anticipated; and,
- The discharge does not violate UIC regulations.

Drywells are considered standard infiltration facilities. The engineer shall consider the impact of infiltration on groundwater elevations both on site and on down-gradient properties.

For discharges to UIC facilities, the best management practices chosen for the site must remove or reduce the target pollutants to levels that will comply with state groundwater quality standards when the discharge reaches the water table or first comes into contact with an aquifer (see WAC 173-200). Pre-treatment is required prior to discharging to a UIC facility (refer to Chapter 6 for additional information). Discharges to surface waters shall comply with WAC 173-201A, Water Quality Standards for Surface Waters of the State of Washington. Refer to Chapter 6 for BMP selection.

7.5.2 MINIMUM REQUIREMENTS

In addition to the requirements specified in Section 7.8, infiltration facilities shall meet the minimum requirements described below.

Swale Sizing

The methodology for sizing swales is in Section 5.6.

Location

Drywells shall be spaced at least 30 feet center-to-center or twice the depth of the drywell, whichever is greater.

If the site has the potential for contaminated or unstable soil, then these conditions shall be investigated and appropriate mitigating measures taken before designing infiltration facilities in theses areas.

Infiltration facilities shall not be placed on or above a landslide hazard area or slopes greater than 15 percent without evaluation by a geotechnical engineer and jurisdictional approval.

Outflow Rates

Outflow rates shall be determined using the field methods presented in Section 4.3.1.

The active barrel of the drywell shall be installed within the target soil layer. Target soils with more than 12% fines (percent passing the No. 200 sieve) are not suitable for drywells.

The proponent may assume a maximum outflow rate of 0.3 cfs and 1.0 cfs for Type A and Type B drywells, respectively, if all of the following conditions are met:

- The drywells are located within the NRCS Garrison or Springdale soil groups. A full-scale drywell test may still be required;
- The soils are verified by a qualified professional. Field verification should include classifying the target layer soils, obtaining soil gradation data and confirming that the site soils are consistent with the design outflow rates.
- There is no history of drainage problems in the vicinity of the drywell location;
- The anticipated rise in the elevation of the local groundwater table resulting from the disposal facility will not significantly impact adjacent properties or structures; and,
- The local jurisdiction does not have concerns regarding the soil's ability to drain.

Limiting Layer

The optimal separation between the bottom of the drywell and the limiting layer (bedrock, groundwater, clay lens, etc.) shall equal the maximum drywell head, which is 6 feet for single-depth drywells and 10 feet for double-depth drywells. The limiting layer separation can be reduced to 4 feet when the factors of safety specified in Appendix 4A are applied.

For a pond or swale with no infiltrative structure, the separation shall be a minimum of 4.5 feet below the pond bottom, to account for the 6-inch treatment zone and 48 inches of subgrade infiltrative soil.

The local jurisdiction reserves the authority to increase the required depth to the limiting layer should there be evidence that the functionality of the facility will be negatively impacted.

Setback

Drywells shall be placed with the following setback distances:

- At least 100 feet from water wells;
- At least 200 feet from springs used for drinking water supplies,
- At least 100 feet from septic tanks or drainfields;
- At least 100 feet up-slope and 20 feet down-slope from building foundations, unless a reduction is geotechnically justified;
- At least 20 feet from a Native Growth Protection Easement; and,
- Per the geotechnical engineer's recommendations when located up-slope from a structure or behind the top of a slope inclined in excess of 15 percent.

7.6 NATURAL DISPERSION

7.6.1 INTRODUCTION

Natural dispersion attempts to minimize the hydrologic changes created by new impervious surfaces by restoring the natural drainage patterns of sheet flow and infiltration. There are three types of natural dispersion:

- <u>Concentrated Flow Dispersion:</u> Used for steep driveways or other small pavement areas, concentrated flow dispersion uses berms or drains to direct runoff from the paved area to a vegetated pervious area (the “dispersal area”) that slows entry of the runoff into a conveyance system, allows for some infiltration and provides some water quality enhancement.
- <u>Sheet Flow Dispersion:</u> Used for flat or moderately sloped paved or cleared areas, sheet flow dispersion consists of a vegetated buffer zone through which sheet flow from the pavement passes, providing flow attenuation and treatment.
- <u>Full Dispersion:</u> Use for larger areas of new residential or commercial development, full dispersion is the preservation of native vegetation on some portion of the site to allow dispersion of runoff from roofs, driveways and roads within the site.

Natural dispersion can be used for impervious or pervious surfaces that are graded to avoid concentrating flows. This flow control method shall only be considered for use on rural projects, including linear roadway projects, large lot subdivision, short plat roads, driveways, sport courts, parking lots and roofs that are not guttered. This flow control method is not intended for use prior to discharge to a lake, stream or water body.

7.6.2 MINIMUM REQUIREMENTS

This section describes a sheet-flow dispersion technique; concentrated flow dispersion is not allowed in the Spokane Region at this time.

In addition to the requirements specified in Section 7.8, as applicable, the following minimum requirements shall be met:

- The dispersal area shall be well-vegetated;
- A vegetated dispersal width of 10 feet must be provided for every 20 feet of width of impervious surface that drains to the dispersal area, with 10 feet the minimum width in all cases. An additional 0.25 feet of vegetated dispersal width shall be provided for each additional foot of impervious surface;

- A vegetated dispersal width of 1 foot must be provided for every 6 feet of disturbed pervious area (i.e. bare soil and non-native landscaping);
- Natural dispersion areas (perpendicular to the impervious area) shall have a slope no steeper than 14% (7H:1V). If this criterion cannot be met due to site constraints, the dispersal width must be increased 1.5 feet for each percent increase in slope above 14%, and in no case shall the slope exceed 20%;
- The average longitudinal slope (roughly parallel to the road or diagonally away from the road) of the dispersal area shall be no more than 15%;
- The longitudinal slope of the contributing impervious or pervious drainage area (parallel to the edge of the dispersal area) shall be 5% or less;
- The lateral slope of the contributing impervious or pervious drainage area (perpendicular to the dispersal area, typically the road cross-slope) shall be 4.5% or less;
- The sheet flow path leading to the natural dispersal area shall not be longer than 75 feet for impervious areas or 150 feet for pervious areas;
- The longitudinal length of the dispersal area shall be equivalent to or greater than the longitudinal length of impervious area that is contributing the sheet flow;
- A 2-foot-wide transition zone (to discourage channeling) shall be provided between the edge of the impervious surface and the vegetated dispersal area, or under the eaves of a roof that has not been guttered. This may be an extension of the sub-grade material (crushed rock), modular pavement, or drain rock;
- The dispersal area shall have a minimum infiltration rate of 4 inches per hour;
- Clearing and grubbing of native dispersal area shall be minimized in order to help maintain the existing root systems that are vital to the success of natural dispersion;
- The area around the dispersal zones shall not be compacted;
- For sites with septic systems, the dispersal area must be downgradient of the drain field primary and reserve areas. This requirement may be waived by the local jurisdiction if the site topography clearly indicates that flow is prohibited from intersecting the drain field;
- The dispersal area shall be located down-gradient from building sites;
- The dispersal area shall be clearly identified on all construction plans, including grading plans, so that the area is not cleared, grubbed or compacted, and shall be clearly delineated on the site;

- Native vegetation and existing trees should not be removed from the natural growth retention areas except where required to meet sight distance, clear-zone or other traffic-related requirements, or if the vegetation is diseased;
- Dispersal is not allowed across, over or toward a landslide or geohazardous area; and,
- The dispersal area shall be preserved within the road right of way, a separate dedicated tract or an easement in order to ensure that treatment and flow control are not interrupted.

7.7 EVAPORATION FACILITIES

7.7.1 INTRODUCTION

Evaporation systems are used to collect and dispose of stormwater runoff when soils are not conducive to infiltration, shallow groundwater is present, or there is the potential for negative impacts due to post-developed stormwater runoff being injected into the subsurface.

The locally developed spreadsheet described in Section 5.7.3 is the most common tool used to perform evaporative pond capacity calculations.

7.7.2 MINIMUM REQUIREMENTS

Liner

Geosynthetic or natural liners may be required to limit infiltration in areas where there is the potential for down-gradient impacts or where the water table may adversely impact the pond via seepage or mounding. The liner shall be a product suitable for stormwater storage and installed per the geotechnical engineer’s or manufacturer’s recommendation.

When an evaporative pond is proposed, a geotechnical engineer shall provide evaluation of the following:

- Liner materials and installation;
- The potential for groundwater seepage into the pond from the surrounding area;
- The potential for any down-gradient adverse impacts due to the injection of developed stormwater volume into the subsurface; and,
- The potential for groundwater mounding or uplift for a lined pond.

Based upon the information in these evaluations, the geotechnical engineer shall make recommendations regarding the following, if applicable:

- Liner materials and installation; and,
- Any proposed mitigation measures.

Pond Geometry

Evaporative systems designed with the Preferred Method (refer to Section 5.7.2) shall have an evaporation volume separate from the detention volume that provides attenuation of peak flows. Depending on the site conditions and limitations, the proponent can provide separated cells or stacked cells to satisfy this requirement.

Separated system: This type of facility has one evaporation cell (upstream cell) followed by a detention or infiltration cell (downstream cell). The storage volume and design depth of the evaporation cell is determined by a water budget analysis as described in Section 5.7. A factor of safety of at least 1.2 is applied to the required evaporative volume or design depth. The invert of the overflow to the detention or infiltration facility is placed at or above the maximum surface water elevation of the evaporative system (including the factor of safety).

The downstream cell is designed per the criteria for detention facilities (refer to Section 7.3) or infiltration facilities (refer to Section 7.5). In order to allow a point discharge from a detention facility, it must be established that there is an existing, well-defined natural drainage course. A 1-foot freeboard above the maximum surface elevation of the detention or infiltration cell is required. Figure 7-7 shows a typical cross-section of a separated system.

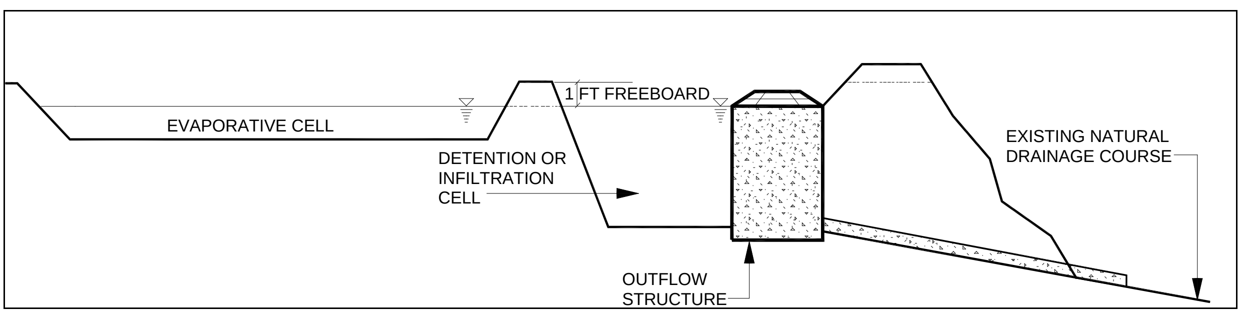

Figure 7-7 – Separated Evaporative/Detention Facility Cross-Section

A stacked system: This type of facility has the evaporative cell (lower cell) below the detention cell (upper cell). The storage volume and design depth of the evaporation cell are determined by a water budget analysis as described in Section 5.7. A factor of safety of at least 1.2 is applied to the required evaporative volume or design depth. Once the dimensions of the lower cell are determined, the upper cell is placed on top of the lower cell. Thus, the detention cell "bottom" and outflow structure must be placed at or above the maximum surface water elevation of the evaporative system (including the factor of safety).

The detention cell is designed per the criteria specified in Section 7.3. In order to allow a point discharge from a detention facility, it must be established that there is an existing, well-defined natural drainage course. A 1-foot freeboard above the maximum surface elevation of the detention or infiltration cell is required. Figure 7-8 shows a typical cross-section of a stacked system.

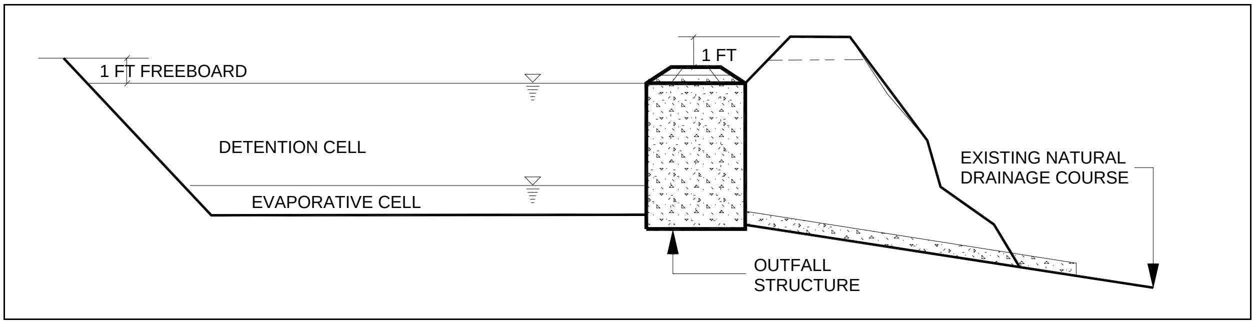

Figure 7-8 – Stacked Evaporative/Detention System Cross-Section

Treatment

Evaporative systems designed with the Alternative Method are not subject to water quality treatment requirements. Evaporative systems designed with the Preferred Method are required to provide water quality treatment per the goals, applicability and criteria specified in Chapter 6.

7.8 ADDITIONAL REQUIREMENTS FOR ALL FACILITIES

The following minimum requirements shall be met for all flow control facilities:

7.8.1 GENERAL

The design of flow control facilities shall adhere to the following:

- Pond bottoms shall be located a minimum of 0.5 feet below the outlet to provide sediment storage; and,
- In general, all pond bottoms shall be flat. Roadside swales are considered flat if the swale bottom slope is 1% or less. When calculating treatment volume, the designer can assume a flat bottom for swale/pond bottom slopes up to 1%. Note that if treatment volume versus area is the methodology used, the volume may be calculated assuming a flat bottom even if the roadside swale bottom has a slope (maximum of 1%).

However, for the calculation of stormwater disposal volume, the grade of the roadside swale bottom shall factor into the geometry used to size the facility. The drainage facility bottom shall slope away from the pond inlet and toward the control structure at 1% for a maximum distance of 20 feet.

- Drainage facilities shall be located within the right of way, within a border easement parallel to the road or within a drainage tract. In unincorporated Spokane County, drainage facilities may also be located in a drainage easement on private property (refer to Chapter 11 for specific information).

7.8.2 SETBACKS

Setbacks for any pond, swale or ditch (measured from the maximum design operating depth) shall be at least 30 feet when located up-gradient or 10 feet when located down-gradient from septic tanks or drainfields.

Pond overflow structures shall be located a minimum of 10 feet from any structure or property line. The toe of the berm or top of bank shall be a minimum of 5 feet from any structure or property line.

7.8.3 DRAWDOWN TIME

Detention and infiltration facilities shall have a minimum subgrade infiltration rate of 0.15 inches/hour and drain completely within 72 hours after a storm event.

7.8.4 SIDE SLOPES

Pond side slopes shall meet one of the following requirements:

- Interior side slopes shall not be steeper than 3:1 (horizontal to vertical);
- Interior side slopes may be increased to a maximum of 2:1 (horizontal to vertical) if the surrounding grade creates a cut or fill with no greater depth than 1.0 foot;
- Exterior side slopes shall not be steeper than 2:1 (horizontal to vertical) unless analyzed for stability by a geotechnical engineer.
- Pond walls may be vertical retaining walls, provided that:
    - A fence is provided along the top of the wall for walls 2.5 feet or taller;
    - A 4-foot-wide access ramp to the pond bottom is provided, with slopes less than 4:1 (horizontal to vertical); and,

- o The design is stamped by an engineer with structural expertise if the wall is surcharged or if it is 4 feet or more in height. A separate building permit may be required by the local jurisdiction if the wall height exceeds 4 feet.

7.8.5 EMERGENCY OVERFLOW SPILLWAY

An emergency overflow spillway shall be provided, whenever reasonable, to bypass the 100-year developed peak flow toward the downstream conveyance system in the event of plugged orifices or high flows that exceed the design storm.

Emergency overflow spillways shall be provided for detention ponds with constructed berms 2 feet or more in height and for ponds located on grades in excess of 5%.

Emergency overflow spillways shall be analyzed as broad crested trapezoidal weirs and comply with the following requirements:

- The spillway shall have the capacity to pass the 100 year-developed peak flow with a 30% freeboard;
- The full width of the spillway shall be armored with riprap and extend downstream to where emergency overflows enter the conveyance system;
- If the detention facility is located on an embankment, the overflow spillway shall be armored to a minimum of 10 feet beyond the toe of the embankment; and;
- The overflow path shall be identified on the construction plans and easements shall be provided as necessary.

Engineers may choose to design the detention pond multi-stage outflow structure with an emergency bypass that can route the 100-year storm through the structure and out of the pond directly into the conveyance channel. However, due to the high potential for sedimentation and plugged orifices within these structures, an emergency overflow spillway shall still be provided in order to reduce the potential for a pond berm breach for detention ponds that require an emergency overflow spillway.

7.8.6 EMBANKMENTS

The height of an embankment is measured from the top of the berm to the catch point of the native soil at the lowest elevation. Embankments shall meet the following minimum requirements:

- Embankments 4 feet or more in height shall be constructed as recommended by a geotechnical engineer. Depending upon the site, geotechnical recommendations may be necessary for lesser embankment heights;

- Embankments shall be constructed on native consolidated soil, free of loose surface soil materials, fill, roots, and other organic debris or as recommended by the geotechnical engineer;
- Energy dissipation and erosion control shall be provided to stabilize the berm and its overflow;
- The embankment compaction shall produce a dense, low permeability engineered fill that can tolerate post-construction settlements with minimal cracking. The embankment fill shall be placed on a stable subgrade and compacted to a minimum of 95% of the Modified Proctor Density (ASTM Procedure D1557);
- Anti-seepage filter-drain diaphragms shall be considered on all outflow pipes and are required on outflow pipes when design water depths are 8 feet or greater;
- Embankments must be constructed by excavating a key. The key width shall equal 50 percent of the berm base width, and the key depth shall equal 50 percent of the berm height; and,
- The berm top width shall be a minimum of 4 feet.

7.8.7 FENCING

Fencing or other barriers may be required to protect the health, welfare and safety of the public. In general, fencing is required for the following:

- Drainage facilities with the first overflow at 2 or more feet above the pond bottom;
- Drainage facilities with retaining walls 2.5 feet high or taller;
- Drainage facilities located at, or adjacent to, schools, nursing homes, day-cares, or similar facilities; and,
- Evaporation Ponds.

Fencing is not required for a typical bio-infiltration swale. However, the local jurisdiction reserves the authority to require a fence along any swale or pond should there be a concern for safety.

At the discretion of the local jurisdiction, if a pond is proposed as an amenity (i.e. enhancements to the disposal facility are proposed, such as rocks, boulders, waterfalls, fountains, creative landscaping or plant materials), the design will be reviewed on a case-by-case basis, such that the fencing requirements may be reduced or waived.

At the discretion of the local jurisdiction, marking fences, terraces, shallower side-slopes, egress bars, etc. may be allowed instead of fencing.

The minimum fencing requirements are as follows:

- The fencing shall be at least 4 feet tall unless otherwise specified by the local jurisdiction, and provide visual access; and,
- Gates are to be provided where drainage facilities are fenced. The gates shall be a minimum of 12 feet wide and have locks.

The City of Spokane Valley reserves the authority to waive any and all fencing in commercial areas, as reviewed and accepted on a case-by-case basis by City staff.

7.8.8 PLANTING REQUIREMENTS

Exposed earth on the pond bottom and interior side slopes shall be sodded, seeded or vegetated in a timely manner, taking into account the current season. Unless a dryland grass or other drought tolerant plant material is proposed, irrigation shall be provided. All remaining areas of the tract or easement shall be sodded or planted with dryland grass or landscaped.

7.8.9 LANDSCAPING

Where space and circumstances allow, the landscaping scheme and common use areas should be integrated with the open drainage features and into the overall stormwater plan. Plants other than turf grass have characteristics that can provide additional stormwater management benefits such as enhanced evapotranspiration and improved soil-holding capabilities.

However, in all cases the landscaping and other uses must be subservient to the primary stormwater needs and functions. Landscaping that does not conflict with the collection, conveyance, treatment, storage, and disposal of stormwater is encouraged. The following general principles should guide the landscaping and selection of plants in conjunction with stormwater facilities:

- Supplemental landscaping areas should be grouped into irregular islands and borders outside of the immediate stormwater facilities and not uniformly dispersed throughout them. The constructed stormwater features should be irregular and curved in shape to look more natural. Avoid straight lines and regular shapes where and when possible;
- Trees and shrubs shall not be planted on pond liners due to potential leakage from root penetration;
- Trees and shrubs shall not be planted near drainage appurtenances such as outlet control structures, manholes, catch basins, inlets, storm drain lines, and underground disposal structures such as drywells or drain-fields. The minimum spacing between the tree or shrub and the drainage structure shall be equal to the crown diameter of the mature plant;

- Trees and shrubs shall not be planted within the treatment, storage, and conveyance zones of swales, ponds, and open channels, unless treatment and storage calculations take into account the mature tree size and allow runoff to reach the drainage facilities;
- Self-limiting plants shall be used, not spreading or self-seeding types.
- Full-size forest trees and trees with aggressive root systems should not be used except where space and circumstances allow. Deciduous trees with heavy shade and leaf-fall should also be avoided to allow the survival of the surrounding grass areas and not plug drainage facilities. Evergreens and smaller ornamental trees are normally better suited to urban conditions;
- Shrubs should be upright in form and groundcovers should have neat growth patterns to assist in their maintenance and that of the surrounding grass areas; and,
- The plant selection needs to consider the native soil conditions and altered moisture conditions created by the stormwater facilities. The plants need to be adaptable to the changes in site conditions. Plants that are self-sufficient and self-limiting, do not require year-round irrigation and require minimal care are encouraged.

7.8.10 MAINTENANCE

Maintenance is of primary importance for drainage facilities to operate as designed. The requirements of Chapter 11 shall be met as applicable.

7.8.11 DAM SAFETY

Detention facilities that can impound 10 acre-feet (435,600 cubic feet) or more with the water level at the embankment crest are subject to the state’s dam safety requirements, even if water storage is intermittent and infrequent (WAC 173-175-020(1)). The principal safety concern is for the downstream population at risk if the dam should breach and allow an uncontrolled stormwater release. Peak flows from dam failures are typically much larger than the 100-year flows which these ponds are typically designed to accommodate.

Dam safety considerations generally apply only to the volume of water stored above natural ground level. Per the definition of dam height in WAC 173-175-030, natural ground elevation is measured from the downstream toe of the dam. If a trench is cut through natural ground to install an outlet pipe for a spillway or low-level drain, the natural ground elevation is measured from the base of the trench where the natural ground remains undisturbed.

Ecology's Dam Safety Office is available to provide written guidance documents and technical assistance for owners and engineers to address dam safety requirements. If the pond exceeds the volume criteria for dam safety, Ecology shall be contacted early in the facilities planning process.

7.9 SPECIAL REQUIREMENTS

7.9.1 SPECIAL DRAINAGE AREAS

Special Drainage Areas (SDAs) are designated areas with shallow soils, bedrock near the surface of the land, and soils or geological features that may make long-term infiltration of stormwater difficult or areas where infiltration may pose potential problems for on-site or adjacent properties. These areas may also contain steep slopes where infiltration of water and dispersion of water into the soils may be difficult or delayed, creating drainage problems such as erosion. Known areas of flooding or areas that historically have had drainage or high groundwater problems (mapped or unmapped) are also SDAs.

SDAs in the City of Spokane are described in SMC 17D.060 "Stormwater Facilities." Additional requirements for development in these areas are included in this ordinance.

Spokane County has mapped several SDAs. Among the mapped SDAs are portions of the Glenrose/Central Park Watershed, the North Spokane Stormwater Planning Area and the West Plains Stormwater Planning Areas. The Spokane County Stormwater Utility Section maintains and updates these maps. At the discretion of the local jurisdiction, an area can be designated as an SDA if it is determined that development may have adverse impacts on existing or future down-gradient or adjacent properties.

Unless specifically approved by the local jurisdiction, the peak rate and volume of stormwater runoff from any proposed land development to any natural or constructed point of discharge downstream shall not exceed the pre-development peak rate or volume of runoff. A down-gradient analysis demonstrating that there will be no expected adverse impacts on downgradient properties will be required. Exceptions with regard to rate and volume control can be made for regional facilities planned by the local jurisdiction.

7.9.2 FLOODPLAINS

In the City of Spokane and the City of Spokane Valley, floodplain requirements are administered by the planning department. Check with the local jurisdiction for more information and specific requirements.

When any property is developed in and around identified Areas of Special Flood Hazard (100-year floodplains) all work must conform to the requirements of the National Flood Insurance Program and the flood ordinance of the local jurisdiction. This section summarizes the general requirements for projects located within a floodplain. Specific requirements and additional information can be obtained from the local jurisdiction.

Land-actions located within a floodplain (A and B Flood Zones only) shall conform with the following requirements:

- A Floodplain Development permit shall be obtained from the local jurisdiction before any development (including structures, manufactured homes, bridges, culverts, grading, excavation or fill) is undertaken, constructed, located, extended, connected or altered on any property that is partly or entirely located in a floodplain;
- The 100-year Base Flood Elevation (BFE) shall not increase at any point by more than 1.0 foot within Unnumbered A Zones and B Zones; increase in other designated flood hazard areas (numbered A zones and floodways) may be further restricted.
- Projects proposing any increases in BFEs or in the way floodwaters enter and exit the property may require approval from the impacted property owners.
- Disposal of increases in stormwater runoff may not be allowed in an identified 100-year floodplain.
- The lowest floor (including basement floor) shall be elevated to a minimum of 1.0 foot above the BFE. Flood Insurance Rate Maps (FIRMs) provide the BFEs for some flood zones. Development in areas without established BFEs may be inspected by the local jurisdiction. When it is not evident that the proposed building will be outside the flood zone or if a subdivision is proposed, a flood study may be required to establish the 100-year BFE and delineate the 100-year floodplain;
- Commercial, industrial, or other nonresidential buildings may be floodproofed to 1 foot above the BFE in lieu of elevating the lowest floor elevation to a minimum of 1.0 foot above the BFE. Floodproofing techniques shall be certified by an engineer or architect licensed in the State of Washington;
- Residential emergency access and egress shall be provided for the 100-year event;
- The plat dedication of all subdivision proposals associated with floodplains shall contain language prescribed by the local jurisdiction.

A floodplain study is required when development impacts floodplains or may impact floodplains in an unnumbered A Flood Zone or when BFEs have not been established. Disturbance to the floodplain may include filling, excavating, etc. The floodplain study shall meet the following requirements:

- The 100-year peak flows and volumes shall be determined for each basin. The engineer shall review FEMA studies, previously accepted floodplain studies, USGS studies and gage data, or watershed plans for already established 100-year flows. If 100-year flows are not available from other sources acceptable to the local jurisdiction, the engineer shall calculate the required flow by comparison with similar watersheds where flows have been determined or the use of regression equations (see USGS Water Resources Investigations Report 97-4277, *Magnitude and Frequency of Floods in Washington* or the most current version), or by running a hydraulic model per the requirements of this Manual. Contact the local jurisdiction for guidance on the appropriate storm type and duration to use.
- The study shall include all relevant calculations for determining the 100-year flow. The study shall be presented in a rational format so as to allow a reviewer to reproduce the same results; a basin map showing the site boundary and the limits of the watershed contributing to the floodplain shall be included. Topographic contours shall extend beyond the floodplain's watershed boundary, as needed, to confirm the basin limits. The basin map shall meet the requirements of Section 3.4.3;
- In determining the BFE, the study shall use field-surveyed cross-sections of the floodplain in the project area. The cross-sections shall extend offsite, as necessary, to delineate the floodplain in the area of the proposal. FEMA-generated cross-sections may be available for use, but these shall be supplemented with field-surveyed cross-sections for the specific site;
- The BFE shall be determined and the floodplain shall be delineated for the pre-developed and post-developed conditions. The BFE shall be tabulated by station in order to estimate any change to the BFE and delineate modifications to the floodplain. The analysis shall calculate the pre-developed and post-developed BFEs as follows:
    - To the nearest 1/10 of a foot in unnumbered A and B zones;
    - To the nearest 1/100 of a foot in numbered A zones; and,
    - To the nearest 1/1,000 of a foot (as required by FEMA) in floodway areas.
- Floodplain analysis maps shall be prepared for the pre-developed and post-developed conditions and shall meet the following requirements:
    - The maps shall show the BFEs on-site to the nearest 1/10th of a foot and clearly delineate the 100-year floodplain;
    - Topographic contours shall be clearly marked, a bench mark shall be identified for the topographic work and the details of the bench mark shall be discussed;

- Maps shall clearly show no violations to the requirements of the local jurisdiction's Flood Ordinance;
- All lots and development, a north arrow, and a scale bar shall be shown on the map; and,
- The map must be stamped and signed by an engineer.

In unincorporated Spokane County, plats, short plats and commercial project floodplain requirements shall be coordinated during the pre-design meeting and submitted with the Drainage Submittal. For single-family residential projects, the engineer shall work directly with the Environmental Programs section of the Engineering Department as soon as possible in the planning process.

7.9.3 WETLANDS AND CLASSIFIED STREAMS

Wetlands and classified streams are regulated by the Department of Ecology, the Department of Fish and Wildlife and the local jurisdiction's critical areas ordinance. Classified streams are those identified and classified under the Washington Department of Natural Resources' water typing system. This section provides criteria for using a wetland for stormwater treatment or disposal. The engineer shall coordinate with the local building and planning department for further requirements.

The term wetland encompasses a variety of aquatic habitats including swamps, marshes, bogs or floodplains. Wetlands have a natural supply of water, from flooding rivers, streams, natural drainage channels, connections to groundwater, or a perched shallow groundwater table, and are typically inundated with water for a portion of the year. Wetlands are often vegetated with aspen, cattails, cottonwoods, willows, reed grasses and other aquatic plants.

Sites with a wetland or a classified stream often feature other Natural Location of Drainage Systems as well. In addition to the requirements in Section 8.3, the following are required for sites with a wetland or classified stream:

- A qualified wetland biologist shall categorize the wetland, according to the local jurisdiction's critical areas ordinance and Ecology's Wetland Rating System for Eastern Washington, and delineate the wetland boundaries and buffer areas. More information can be found at: http://www.ecy.wa.gov/programs/sea/wetlan.html;
- The proponent shall submit to the local jurisdiction a Mitigation Plan, accepted by the Department of Ecology, if the wetland is to be disturbed due to construction activity or if any natural source of recharge to the wetland will be eliminated or altered;
- A Hydraulic Permit shall be obtained when work is proposed within the normal high-water level of classified streams. Site alterations within the buffers of regulated streams are generally limited to essential access and

utility needs or restoration plans as reviewed and accepted by the State Department of Fish and Wildlife and under the local jurisdiction's critical areas ordinance; and,

- The local planning department and state and federal agencies shall be contacted for permitting and buffer requirements, etc.

Requirements for hydrologic modification of a wetland for stormwater treatment or disposal are presented in Section 6.7.5.

7.9.4 CLOSED DEPRESSIONS

Closed depressions are natural low areas that hold a fixed volume of surface water. Depending upon soil characteristics, a closed depression may or may not accumulate surface water during wet periods of the year. Some closed depressions may be classified as wetlands. If so, the engineer shall comply with the wetland criteria specified in this chapter and in Chapter 6. Analysis of closed depressions shall include the following at a minimum:

- Identification of the location of the closed depression on the pre-developed basin map;
- A routing analysis of the drainage basins contributing to the closed depression to estimate the peak flow rates and volumes leaving the site in the pre-developed condition;
- An estimation of the storage capacity of the closed depression for the 100-year storm event;

If the closed depression will be filled in, a facility shall be provided that has the capacity to store the 100-year volume that was historically intercepted by the closed depression. This is in addition to the drainage facilities required for flow control and treatment due to the increase in stormwater runoff. The construction plans shall include a grading plan of any closed depression areas to be filled in. The grading plan shall show both existing and finish grade contours. The plans shall also specify compaction and fill material requirements.

7.10 REGIONAL STORMWATER FACILITIES

Regional stormwater facilities are grass-lined ditches, natural drainageways, ponds, pipes and various other means of conveying, treating and disposing of stormwater runoff that serve as the "backbone" of a system to which smaller drainage elements can be connected. Most regional facilities serve more than a single development within a given contributing drainage basin. Regional facilities have the potential to lessen flooding in existing drainage problem areas and to provide new development with an alternative to on-site stormwater disposal.

If regional facilities consist of pipes or other non-infiltrative conveyance facilities, they have the potential to significantly increase stormwater runoff and contaminants going into selected discharge areas. The location of such discharges, and pretreatment levels, must be carefully considered to avoid adverse impacts on water resources.

Regional facilities may reduce a community's long term costs for stormwater management because they can free up buildable land for development and can be less expensive to build, operate, and maintain than multiple individual facilities. The local jurisdiction may assume responsibility, or form a partnership, for the design, construction, operation and maintenance of regional facilities.

Studies are currently being performed and completed for several planned regional facilities in the Spokane region. In addition, local jurisdictions have begun mapping natural stormwater features that will need to be incorporated into future regional stormwater systems. Due to this recent progress, developments in the near future may be allowed to discharge stormwater into regional systems. As regional facilities come "on-line," the requirements for on-site treatment and detention may vary from the basic requirements in this manual. Close coordination with the local jurisdiction will be required in order to determine the location and timing of any planned regional system, and to learn the specific design criteria for on-site stormwater facilities that may discharge into the system.

All projects shall be reviewed for the presence of natural drainageways, and a determination will be made as to their significance with regard to preservation of natural conveyance and potential use as part of a regional system.

When a local jurisdiction assumes the responsibility for any or all portions of the design, construction, operation, and maintenance of the drainage facilities, project proponents shall be required to contribute a pro-rated share of the cost (via system development charges or other related fees) based on the estimated cost of improvements the project proponent would otherwise have been required to install. The proponent shall supply the information to justify the estimated costs of the foregone individual improvements.

While opportunities may be available for private developments to use public regional stormwater facilities to accommodate runoff, local jurisdictions reserve the authority to limit or restrict discharge to public facilities.

Spokane County has completed Stormwater Management Plans for Chester Creek and the Glenrose, Central Park, North Spokane and West Plains Stormwater Planning Areas. The City of Spokane has completed a City Stormwater Management Plan and the City of Spokane Valley may also identify needed regional stormwater facilities in the near future. Project proponents shall coordinate with the appropriate local jurisdiction early in the project proposal process if the project is in an area for which natural drainage features with potential regional significance have been identified where regional facilities have been proposed, or where capital improvement plans have been adopted.